

The Great Lakes Construction Co.

TRANSMITTAL
No. 180

925 Laidlaw Ave.
Cincinnati, Ohio 45237

PROJECT: ODOT 150085 HAM 71-1.34 **DATE:** December 13, 2017

TO: ODOT District 8 **REF:** Tunnel Lighting O&M
505 South SR 741 Line Item: #169.00, 9029.00,
Lebanon, OH 45036 9030.00 & 9031.00

ATTN: Marvin Lennon

WE ARE SENDING		SUBMITTED FOR:		ACTION TAKEN:	
<input type="checkbox"/>	Shop Drawings	<input type="checkbox"/>	Approval	<input type="checkbox"/>	Approved as Submitted
<input type="checkbox"/>	Letter	<input checked="" type="checkbox"/>	Your Use	<input type="checkbox"/>	Approved as Needed
<input type="checkbox"/>	Prints	<input type="checkbox"/>	As Requested	<input type="checkbox"/>	Returned after Loan
<input type="checkbox"/>	Change Order	<input type="checkbox"/>	Review and Comment	<input type="checkbox"/>	Resubmit
<input type="checkbox"/>	Plans	<input type="checkbox"/>		<input checked="" type="checkbox"/>	Submit
<input type="checkbox"/>	Samples	SENT VIA:		<input type="checkbox"/>	Returned
<input type="checkbox"/>	Specifications	<input checked="" type="checkbox"/>	Attached	<input type="checkbox"/>	Returned for Correction
<input checked="" type="checkbox"/>	Other: LV Transformer O&M	<input type="checkbox"/>	Separate Cover:	<input type="checkbox"/>	Due Date:

<u>SUBMITTAL</u>	<u>COPIES</u>	<u>DATE</u>	<u>DESCRIPTION</u>
TR85.15-180	1 pdf	12/13/2017	Tunnel Lighting O&M, per sheet 187/555, Section 1.04.D, 1.04.K, 1.04.L, 1.04M

REMARKS

CC: Joe Smithson, ODOT D8

Signed:



Jacob D. Elmore.



BECKER ELECTRIC SUPPLY
11310 Mosteller Rd.
Cincinnati, Ohio 45241- 0837

Lytle Tunnel Owners Manual

<u>TYPE</u>	<u>MFR</u>	<u>DESCRIPTION</u>	<u>LAMPS</u>
SPARES	KENALL	LTS1-A2-C-CM10-2-8-295SL-50K7-DCC-MV-304-1KF-SP	LED INCLUDED

Class CC Fuseblocks

600 Volt, 30 Amps

BC Series



Catalog Symbol: BC Series

Class CC Fuseblocks

For use with Class CC Fuses (Bussmann LP-CC, KTK-R, and FRQ-R)

Ampere Rating: 1/10 to 30A

Voltage Rating: 600V

Withstand Rating: 200,000A RMS Sym.

Agency Information:

UL Listed, UL 512, Guide IZLT, File E14853

CSA Certified, C22.2 No. 39, Class 6225-01, File 47235

UL Flammability: 94VO

Materials: Base - Thermoplastic

Clips - Bright tin-plated bronze

DIN-RAIL Adapters: DRA-1 and DRA-2

Catalog Data

		Terminal Type				
Amps	Poles	Screw	Screw with Quick Connect*	Pressure Plate	Pressure Plate w/ Quick Connect*	Box Lug
1/10	1	BC6031S	BC6031SQ	BC6031P	BC6031PQ	BC6031B
to	2	BC6032S	BC6032SQ	BC6032P	BC6032PQ	BC6032B
30	3	BC6033S	BC6033SQ	BC6033P	BC6033PQ	BC6033B

Wire Range
CU Only

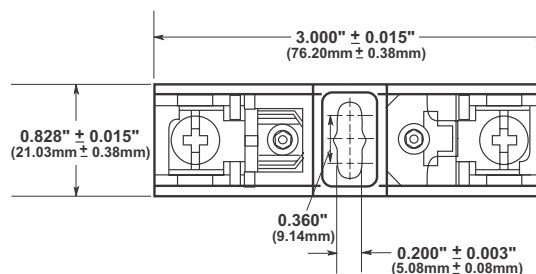


* QUICK CONNECT RATED FOR 20A MAXIMUM.

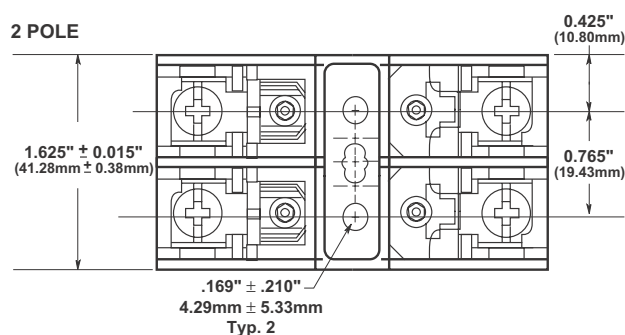
CE logo denotes compliance with European Union Low Voltage Directive (50-1000 Vac, 75-1500 Vdc). Refer to Data Sheet: 8002 or contact Bussmann Application Engineering at 636-527-1270 for more information.

Dimensional Data

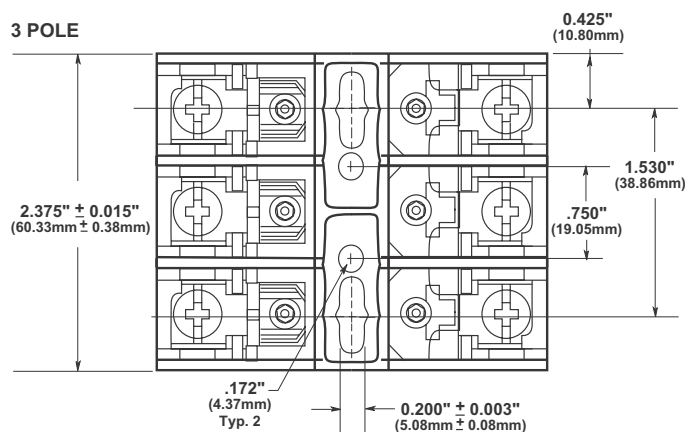
1 POLE



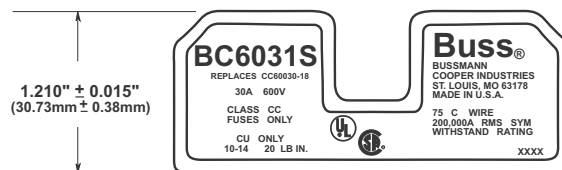
2 POLE



3 POLE



FUSEBLOCK LABEL (EXAMPLE SHOWN)

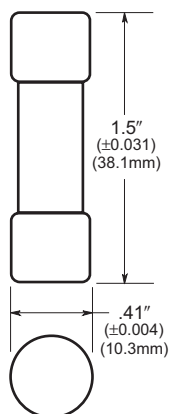


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LIMITRON® Fast-Acting Fuses 600 Volt, 1/10 - 30 Amps

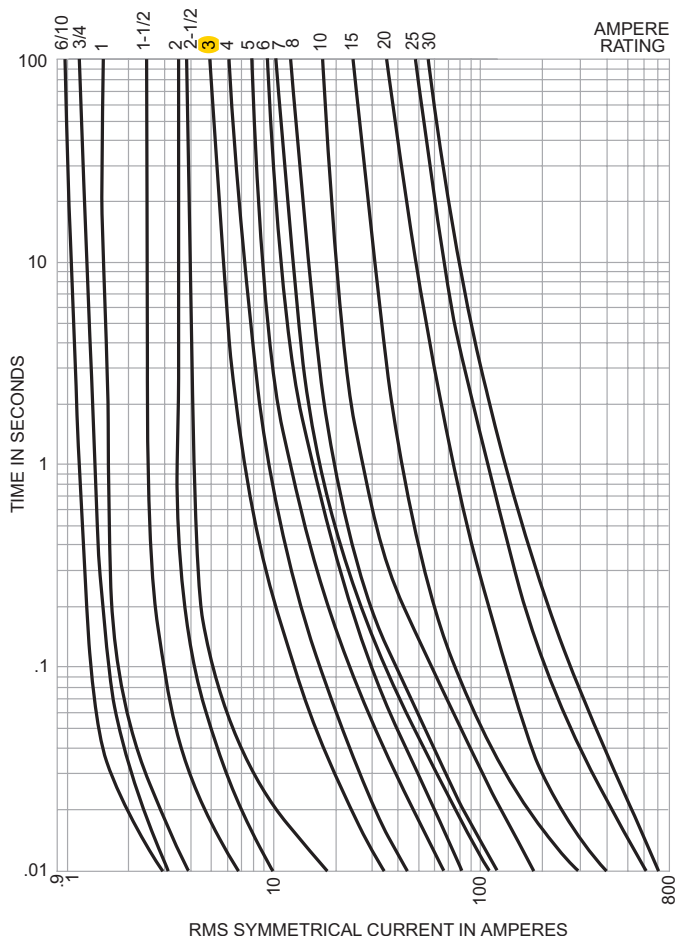


Dimensional Data



- LIMITRON® fast-acting fuse.
- Melamine tube.
- Nickel-plated bronze endcaps.

Time-Current Characteristic Curves—Average Melt



Catalog Symbol: KTK

Fast-Acting

1/10 TO 30A

600Vac (or less)

Interrupting Rating: 100,000A RMS Sym. (UL)

UL Listed, STD. 248-14, (Guide #JDYX, File #E19180)

CSA Certified: C22.2 NO. 248.14

(File #53787—Class #1422-01)

HRC-MISC

Electrical Ratings (Catalog Symbol and Amperes)

600Vac - UL Listed and C.S.A.

KTK-1/10	KTK-1	KTK-6	KTK-25
KTK-1/8	KTK-1-1/4	KTK-7	KTK-30
KTK-2/10	KTK-1-1/2	KTK-7-1/2	—
KTK-1/4	KTK-2	KTK-8	—
KTK-3/10	KTK-2-1/2	KTK-9	—
KTK-4/10	KTK-3	KTK-10	—
KTK-1/2	KTK-3-1/2	KTK-12	—
KTK-6/10	KTK-4	KTK-15	—
KTK-3/4	KTK-5	KTK-20	—

Carton Quantity and Weight

Ampere Ratings	Carton Qty.	Weight*	
		Lbs.	Kg.
1-30	10	.180	.082

*Weight per carton.

Recommended fuseblocks/fuseholders for 13/32" x 1-1/2" fuses
See Data Sheets listed below

- Open fuseblocks - 1104, 2104
- Finger-safe fuseholders - 1109, 1102, 1103, 1151
- Panel-mount fuseholders - 2114, 2113, 2108, 2112, 2109, 2140
- In-line fuseholders - 2127, 2126

CE logo denotes compliance with European Union Low Voltage Directive (50-1000Vac, 75-150Vdc). Refer to Data Sheet: 8002 or contact Bussmann Application Engineering at 636-527-1270 for more information.

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Type 304, Type 304L UNS S30400, UNS S30403

The basic austenitic stainless steel, a versatile corrosion resistant material for general purpose applications.

Description

Type 304/304L is the modern evolution of the original "18-8" austenitic stainless steel. It is an economical and versatile corrosion resistant stainless steel suitable for a wide range of general purpose applications.

Type 304/304L is non-magnetic in the annealed condition but may become slightly magnetic as a result of cold working or welding.

Dual certification

It is common for 304L to be dual certified as 304 and 304L when the material meets both the lower carbon limit of Type 304L and the slightly higher strengths of Type 304. The producer of the steel must certify the material as Type 304 if it is to be used as Type 304 instead of Type 304L.

Specifications

Type 304/304L can be supplied to meet AMS, ASTM, ASME, QQS, and MIL-S specifications.

Product forms available

- Plate
- Sheet
- Tubular Products
- Bar
- Angle
- Wire Rod
- Billet
- Fittings

Corrosion resistance

Type 304/304L is a versatile, general purpose stainless steel with good resistance to atmospheric corrosion, to many organic and inorganic chemicals, and to foods and beverages.

Mechanical Properties

Table 1

	Typical*	ASTM	
		304	304L
Ultimate Tensile Strength, ksi	87	75 min	70 min
0.2% Offset Yield Strength, ksi	42	30 min	25 min
Elongation in 2 inches, %	58	40 min	40 min
Reduction in Area, %	70	—	—
Hardness, Rockwell B	82	92 max	92 max

*0.375 inch plate

Chemical Composition, wt. pct.

Table 2

	304	304L
Carbon	0.08 max	0.030 max
Manganese	2.00 max	2.00 max
Phosphorus	0.045 max	0.045 max
Sulfur	0.030 max	0.030 max
Silicon	0.75 max	0.75 max
Chromium	18.0-20.0	18.0-20.0
Nickel	8.0-10.5	8.0-12.0
Nitrogen*	0.10 max	0.10 max

*flat-rolled products only

Physical Properties

Table 3

Density, lb/in ³	0.285
Modulus of Elasticity, psi	29 x 10 ⁶
Coefficient of Thermal Expansion, 68-212°F, /°F	9.4 x 10 ⁻⁶
Thermal Conductivity, Btu/ft hr°F	8.7
Heat Capacity, Btu/lb°F	0.12
Electrical Resistivity, Ω-inch	27.6 x 10 ⁻⁶

Heat treatment

Annealing

Type 304/304L should be heated to 1900°F minimum and water quenched or rapidly cooled by other means.

Hardening

Type 304/304L cannot be hardened by heat treatment. However, Type 304/304L can be hardened by cold working.

Workability

Cold Working

Type 304/304L is readily formed and fabricated through a full range of cold working operations. It can be used in heading, drawing, bending, and upsetting. Any cold working operations will increase the strength and hardness of the material, and may leave it slightly magnetic.

Hot Working

Type 304/304L can be forged in the 1700-2200°F range. For maximum corrosion resistance, forgings should be annealed at 1900°F minimum and water quenched or rapidly cooled by other means after hot working operations.

Welding

Type 304/304L is readily welded by a full range of conventional welding procedures (except oxyacetylene). AWS E308L/ER308L filler metals should be used with Type 304/304L steel, but the molybdenum-containing austenitic stainless steel filler metals may also be considered.

Machinability

Type 304/304L is a tough austenitic stainless steel subject to work hardening during deformation and, unless modified for improved machining response, is resistant to chip breaking. The best machining results are achieved with slower speeds, heavier feeds, excellent lubrication, sharp tooling, and powerful, rigid equipment.

Technical support

Outokumpu assists users and fabricators in the selection, qualification, installation, operation, and maintenance of Type 304/304L stainless steel. Technical personnel, supported by the research laboratory of Outokumpu, draw on years of field experience with Type 304/304L to help you make the technically and economically correct materials decision.

Outokumpu is prepared to discuss individual applications and to provide data and experience as a basis for selection and application of Type 304/304L.

Outokumpu works closely with its distributors to ensure timely availability of Type 304/304L in the forms, sizes, and quantities required by the user. For assistance with technical questions and to obtain top quality Type 304/304L, call Outokumpu at 1-800-833-8703.

Lowest Temperature (°F) at Which the Corrosion Rate Exceeds 5 mpy

Table 4

Corrosion Environment	654 SMO®	254 SMO®	904L	Type 316L (2.7 Mo)	Type 304	2507	2205 Code Plus Two®	2304
0.2% Hydrochloric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
1% Hydrochloric Acid	203	158	122	86	86p	>Boiling	185	131
10% Sulfuric Acid	158	140	140	122	—	167	140	149
60% Sulfuric Acid	104	104	185	<54	—	<57	<59	<<55
96% Sulfuric Acid	86	68	95	113	—	86	77	59
85% Phosphoric Acid	194	230	248	203	176	203	194	203
10% Nitric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
65% Nitric Acid	221	212	212	212	212	230	221	203
80% Acetic Acid	>Boiling	>Boiling	>Boiling	>Boiling	212p	>Boiling	>Boiling	>Boiling
50% Formic Acid	158	212	212p	104	≤50	194	194	59
50% Sodium Hydroxide	275	239	Boiling	194	185	230	194	203
83% Phosphoric Acid + 2% Hydrofluoric Acid	185	194	248	149	113	140	122	95
60% Nitric Acid + 2% Hydrochloric Acid	>140	140	>140	>140	>140	>140	>140	>140
50% Acetic Acid + 50% Acetic Anhydride	>Boiling	>Boiling	>Boiling	248	>Boiling	230	212	194
1% Hydrochloric Acid + 0.3% Ferric Chloride	>Boiling, p	203ps	140ps	77p	68p	203ps	113ps	68p
10% Sulfuric Acid + 2000ppm Cl ⁻ + N ₂	149	104	131	77	—	122	95	<55
10% Sulfuric Acid + 2000ppm Cl ⁻ + SO ₂	167	140	122	<<59p	—	104	<59	<<50
WPA1, High Cl ⁻ Content	203	176	122	≤50	<<50	203	113	86
WPA2, High F ⁻ Content	176	140	95	≤50	<<50	167	140	95

p = pitting can occur
ps = pitting/crevice corrosion can occur

WPA	P ₂ O ₅	Cl ⁻	F ⁻	H ₂ SO ₄	Fe ₂ O ₃	Al ₂ O ₃	SiO ₂	CaO	MgO
1	54	0.20	0.50	4.0	0.30	0.20	0.10	0.20	0.70
2	54	0.02	2.0	4.0	0.30	0.20	0.10	0.20	0.70

Corrosion performance of stainless steels

Table 4 compares Type 304 with other stainless steels in a variety of common corrosive environments. The table shows the lowest temperature at which the corrosion rate exceeds 5 mpy. All testing was done in accordance with the requirements of the Materials Technology Institute of the Chemical Process Industries (MTI).

Working towards forever.

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: clean energy, clean water and efficient infrastructure. Because we believe in a world that lasts forever.

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Outokumpu High Performance Stainless
2275 E. Half Day Road, Suite 300, Bannockburn, IL 60015 USA
Tel. 1-847-317-1400 Fax 1-847-317-1404
outokumpu.com

Type 316, Type 316L UNS S31600, UNS S31603

A molybdenum-containing austenitic stainless steel with improved resistance to chlorides relative to Type 304/304L stainless steel.

Description

Type 316/316L is a molybdenum-containing austenitic stainless steel intended to provide improved corrosion resistance relative to Type 304/304L in moderately corrosive process environments, particularly those containing chlorides or other halides.

Type 316/316L is non-magnetic in the annealed condition but may become slightly magnetic as a result of welding.

Dual certification

It is common for Type 316L to be dual certified as Type 316 and Type 316L when the material meets both the lower carbon limit of Type 316L and the slightly higher strengths of Type 316. The producer of the steel must certify the material as Type 316 if it is to be used as Type 316 instead of Type 316L.

Specifications

Type 316/316L can be supplied to meet AMS, ASTM, ASME, QQS, and MIL-S specifications.

Product forms available

- Plate
- Sheet
- Tubular Products
- Bar
- Angle
- Wire Rod
- Billet
- Fittings

Corrosion Resistance

The addition of molybdenum provides improved resistance to pitting and crevice corrosion in environments containing chlorides and other halides.

Type 316/316L has been used in handling many chemicals used by the process industries, including pulp and paper, textile, food, pharmaceutical, medical, and other chemical processing.

Mechanical Properties at Room Temperature Table 1

	Typical*	ASTM	
		316	316L
Ultimate Tensile Strength, ksi	85	75 min	70 min
0.2% Offset Yield Strength, ksi	44	30 min	25 min
Elongation in 2 inches, %	56	40 min	40 min
Reduction in Area, %	69	—	—
Hardness, Rockwell B	81	95 max	95 max

*0.375 inch plate

Chemical Composition, wt. pct. Table 2

	316	316L
Carbon	0.08 max	0.030 max
Manganese	2.00 max	2.00 max
Phosphorus	0.045 max	0.045 max
Sulfur	0.03 max	0.03 max
Silicon	0.75 max	0.75 max
Chromium	16.0-18.0	16.0-18.0
Nickel	10.0-14.0	10.0-14.0
Molybdenum	2.00-3.00	2.00-3.00
Nitrogen*	0.10 max	0.10 max

*flat-rolled products only

Heat treatment

Annealing

Type 316/316L should be heated to 1900°F and water quenched or rapidly cooled by other means.

Hardening

Type 316/316L cannot be hardened by heat treatment. However, Type 316 can be hardened by cold working.

Physical Properties

Table 3

Density, lb/in ³	0.285
Modulus of Elasticity, psi	29 x 10 ⁶
Coefficient of Thermal Expansion, 68-212°F, /°F	8.9 x 10 ⁻⁶
Thermal Conductivity, Btu/ft hr°F	8.7
Heat Capacity, Btu/lb°F	0.12
Electrical Resistivity, Ω-inch	29.5 x 10 ⁻⁶

Lowest Temperature (°F) at Which the Corrosion Rate Exceeds 5 mpy

Table 4

Corrosion Environment	654 SMO®	254 SMO®	904L	Type 316L (2.7 Mo)	Type 304	2507	2205 Code Plus Two®	2304
0.2% Hydrochloric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
1% Hydrochloric Acid	203	158	122	86	86p	>Boiling	185	131
10% Sulfuric Acid	158	140	140	122	—	167	140	149
60% Sulfuric Acid	104	104	185	<54	—	<57	<59	<<55
96% Sulfuric Acid	86	68	95	113	—	86	77	59
85% Phosphoric Acid	194	230	248	203	176	203	194	203
10% Nitric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
65% Nitric Acid	221	212	212	212	212	230	221	203
80% Acetic Acid	>Boiling	>Boiling	>Boiling	>Boiling	212p	>Boiling	>Boiling	>Boiling
50% Formic Acid	158	212	212p	104	≤50	194	194	59
50% Sodium Hydroxide	275	239	Boiling	194	185	230	194	203
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50% Acetic Acid + 50% Acetic Anhydride	>Boiling	>Boiling	>Boiling	248	>Boiling	230	212	194
1% Hydrochloric Acid + 0.3% Ferric Chloride	>Boiling, p	203ps	140ps	77p	68p	203ps	113ps	68p
10% Sulfuric Acid + 2000ppm Cl ⁻ + N ₂	149	104	131	77	—	122	95	<55
10% Sulfuric Acid + 2000ppm Cl ⁻ + SO ₂	167	140	122	<<59p	—	104	<59	<<50
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WPA2, High F ⁻ Content	176	140	95	≤50	<<50	167	140	95

p = pitting can occur
ps = pitting/crevice corrosion can occur

WPA	P ₂ O ₅	Cl ⁻	F ⁻	H ₂ SO ₄	Fe ₂ O ₃	Al ₂ O ₃	SiO ₂	CaO	MgO
1	54	0.20	0.50	4.0	0.30	0.20	0.10	0.20	0.70
2	54	0.02	2.0	4.0	0.30	0.20	0.10	0.20	0.70

Workability

Cold Working

Type 316/316L is readily formed and fabricated through a full range of cold working operations. It can be used in heading, drawing, bending, and upsetting. Any cold working operations will increase the strength and hardness of the material.

Hot Working

Type 316/316L can be forged in the 1700-2200°F range. For maximum corrosion resistance, forgings should be annealed at 1900°F minimum and water quenched or rapidly cooled by other means after hot working operations.

Corrosion performance of stainless steels

Table 4 compares several Outokumpu stainless steels in a variety of common corrosive environments. The lowest temperature at which the corrosion rate exceeds 5 mpy was determined. All testing was done in accordance with the requirements of the Materials Technology Institute of the Chemical Process Industries (MTI).

Welding

Type 316/316L is readily welded by a full range of conventional welding procedures (except oxyacetylene). AWS E316L/ER316L and other filler metals with molybdenum content higher than that of the base metal should be used with Type 316/316L stainless steel.

Machinability

Type 316/316L is a tough austenitic stainless steel subject to work hardening during deformation and, unless modified for improved machining response, is resistant to chip breaking. The best machining results are achieved with slower speeds, heavier feeds, excellent lubrication, sharp tooling, and powerful, rigid equipment.

Technical support

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Working towards forever.

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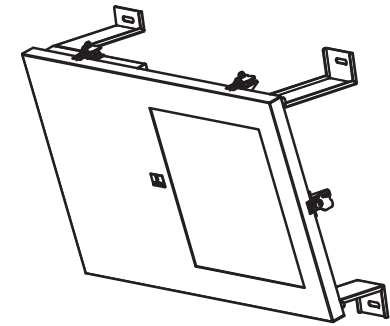
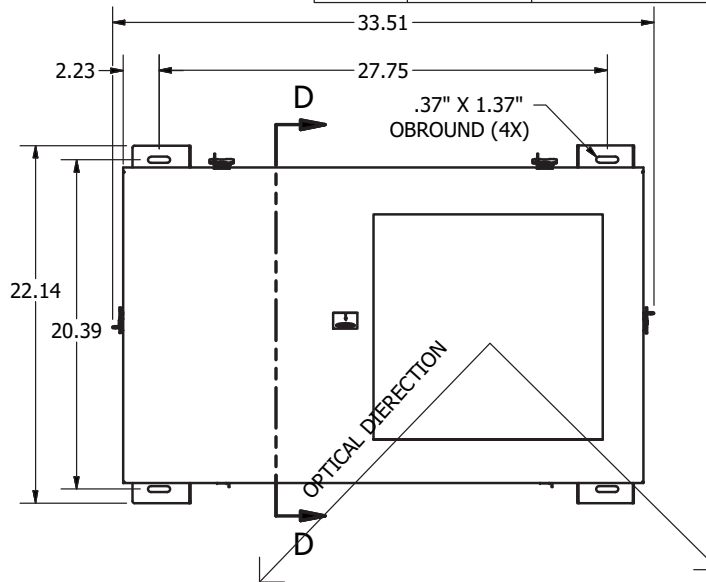
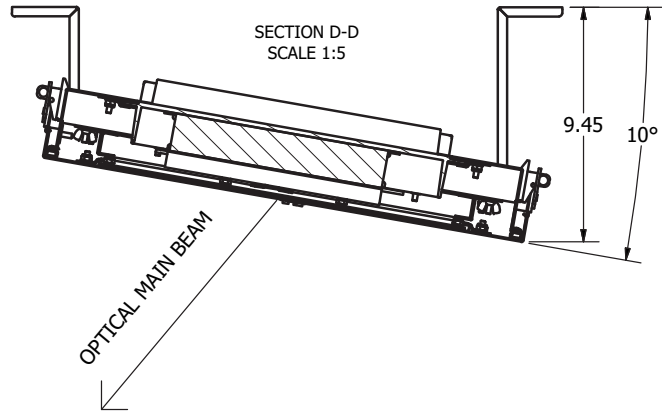
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Tel. 1-847-317-1400 Fax 1-847-317-1404
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8 7 6 5 4 3 2 1

REVISIONS				
REV	ECN NO.	REV. DESCRIPTION	APPROVED	ENG APPRO
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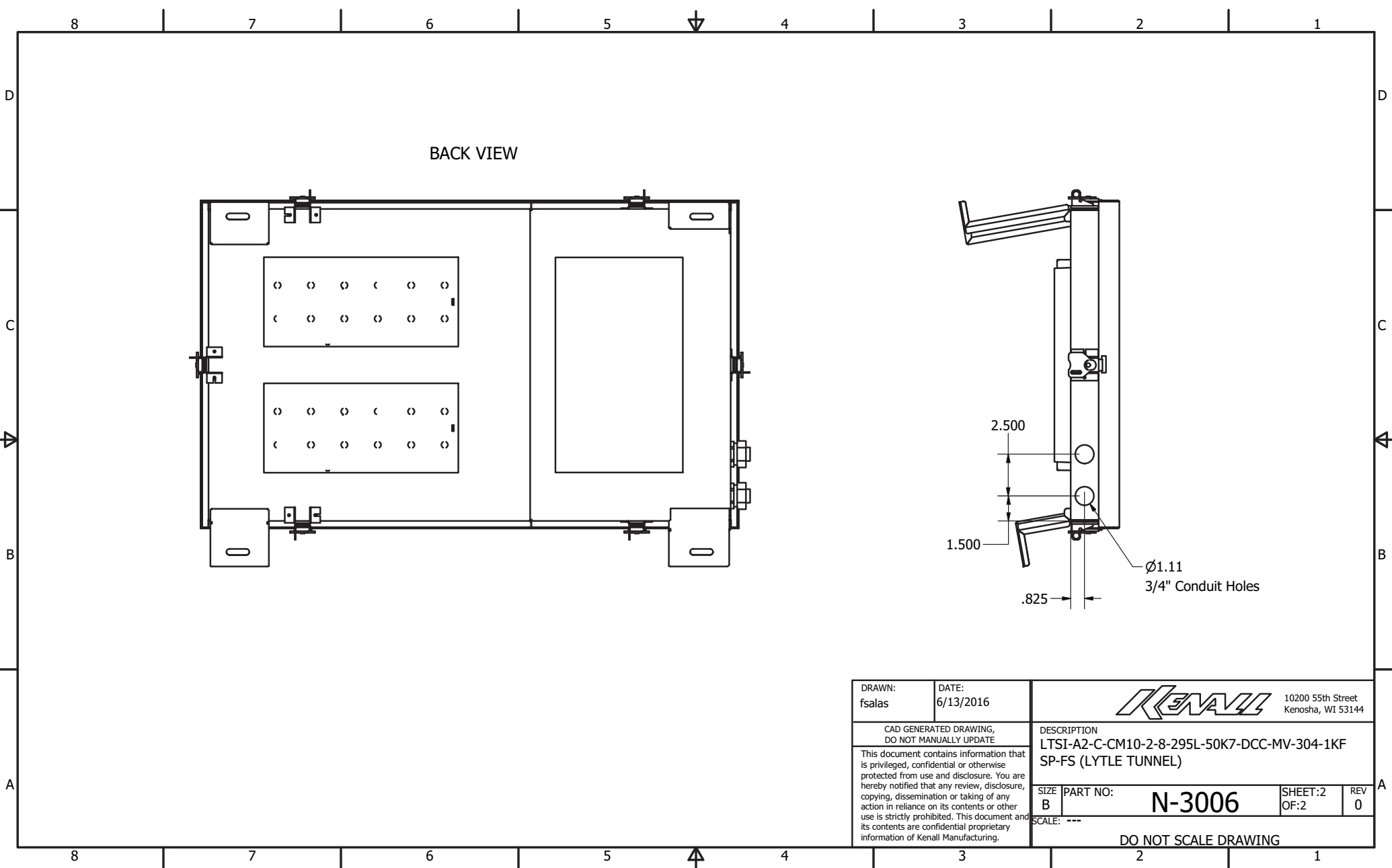



SPECIFICATIONS

- 1) **CHASSIS:** 16-gauge 304 stainless steel enclosure with 14-gauge fixed-welded (non-adjustable) mounting brackets (10° Tilt).
- 2) **HEAT SINKS:** (1KF) 413 marine-grade die-cast aluminum, 1,000 hour finish. Electrically insulated from stainless steel chassis.
- 3) **DOORFRAME:** 16-gauge 304 stainless steel doorframe with stainless steel safety cables attach to chassis. 304 stainless steel lockable rotary latches (lock not included).
- 4) **GASKETING:** One-piece extruded solid silicone with molded corners.
- 5) **LENS:** One (1) .188" clear tempered glass.
- 6) **OPTICS:** Type II, optical distribution.
- 7) **ELECTRICAL:**
 - One (1) 240-480V Mean Well driver.
 - Two (2) 48 LEDs, 5000K/70 CRI modules.
 - One (1) Surge Protector (for 277V branch circuit). Surge Protector provides a positive indication of end-of-life by opening voltage to the load, and turning off the fixture (Thomas Research Products, FSP3-277-20KA).
 - One (1) 3.0 AMP Fuse (for 277V branch circuit).
 - Conduit connectors and wire pigtails (furnished by contractor) factory-installed.

DRAWN: fsalas	DATE: 6/13/2016	 10200 55th Street Kenosha, WI 53144		
CAD GENERATED DRAWING, DO NOT MANUALLY UPDATE		DESCRIPTION LTISI-A2-C-CM10-2-8-295L-50K7-DCC-MV-304-1KF SP-FS (LYTLE TUNNEL)		
SIZE B	PART NO: N-3006	SHEET:1 OF:2	REV 0	
SCALE: ---		DO NOT SCALE DRAWING		

8 7 6 5 4 3 2 1



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CAD GENERATED DRAWING, DO NOT MANUALLY UPDATE		DESCRIPTION LTSI-A2-C-CM10-2-8-295L-50K7-DCC-MV-304-1KF SP-FS (LYTLE TUNNEL)		
This document contains information that is privileged, confidential or otherwise protected from use and disclosure. You are hereby notified that any review, disclosure, copying, dissemination or taking of any action in reliance on its contents or other use is strictly prohibited. This document and its contents are confidential proprietary information of Kenall Manufacturing.		SIZE B	PART NO: N-3006	SHEET:2 OF:2
SCALE: ---		DO NOT SCALE DRAWING		
		REV 0		

THE PROCESS

Part of Pioneer's Family of Finishes for Aluminum Die

The EnduraGuard™ process combines conventional anodizing with a proprietary sealing process to produce a coating that resists creep corrosion while exhibiting superior adhesion qualities. EnduraGuard is recommended particularly when corrosion resistance conditions are demanding.

PERFORMANCE BENEFITS

3000+ hrs of salt spray w/ a Crosshatch test is achievable in some applications.

Guards against Acid and Alkaline attacks.

Fights filiform corrosion.

Improves appearance and has a non-aging finish.

Unmatched color consistency.

PERFORMANCE TESTS

<u>PROPERTY</u>	<u>ALUMINUM ALLOY</u>
Appearance	Gloss to semi-gloss
Hardness (Pencil) (ASTM 8 3363)	3H - 5H
Thickness (Eddie Current)	0.5-0.2 mils
Salt Spray (with cross hatch)	>1000 hours
Acid Resistance (H ₂ SO ₄ 5% @ 68°F)	>300 hours
Alkaline Resistance (NaOH 5% @ 68° F)	>300 hours
Solvent Resistance (MIBK)	>20 double rubs
QUV UVB Test	500 hours

THE OVERVIEW

EnduraGuard™

Pioneer's Research and Development experts engineered a diverse portfolio of processes capable of satisfying a broad range of aluminum finishing needs. EnduraGuard provides the highest level of chemical and corrosion resistance of all the Pioneer anodize coatings. While EnduraGuard is suitable for all aluminum alloys, this process specifically improves aesthetics and corrosion resistance for die cast aluminum parts.

[CLICK HERE TO VIEW IMAGES OF THIS PROCESS](#)

RECEPTIVE METALS

Aluminum Alloys

THICKNESS

.0001 - .001"

MAX PART SIZE

55" X 36" x 23"

SPECIFICATIONS

Proprietary Process



PRINT PRINTER FRIENDLY PDF



CONTACT A REPRESENTATIVE ABOUT THIS SERVICE

FOR OTHER PIONEER FINISHING SOLUTIONS VISIT

WWW.PIONEERMETAL.COM

METAL FINISHING



FSP3-277-20KA / FSP3-480-20KA

Patent-pending 3-Pole Fused In-Line Surge Protectors for LED Drivers & Electronic Ballasts, with or without Operating Indicator LED

Features

- FSP3-277-20KA is a 4-leaded device primarily for universal input Phase to Neutral applications and provides protection that includes Line to Neutral, Line to Ground and Neutral to Ground possible couplings
- FSP3-480-20KA is a 5-leaded device for 480VAC Phase to Phase applications and provides protection that includes one Phase to a second Phase, one Phase to Ground, and second Phase to Ground possible couplings
- Provides a positive indication of End-of-Life by opening voltage to the load, and turning off the fixture
- Versions available with and without a green LED indicator - when on, it indicates that the FSP3 is fully functional and providing protection and when off, it indicates that the FSP3 has reached End-of-Life and needs to be replaced
- Protects against surges and transients per ANSI C62.41-2002 category C high (10KV, 1.2/50µS & 10KA, 8/20µS) standard Combo waves and (6KV, 100KHz) Ring wave
- Protects against surges and transients per new ANSI C82.77-5 2015 category C high (20KV, 1.2/50µS & 10KA, 8/20µS) standard Combo waves and (6KV, 100KHz) Ring wave
- UL Recognized Component in the United States and Canada (UL1449)
- Complies with IEC 61643-11; 8.3.4.3
- High temp, flameproof plastic enclosure with 85°C max surface temp rating
- Operating temperature range: -40°C to +85°C ambient
- Patent Pending

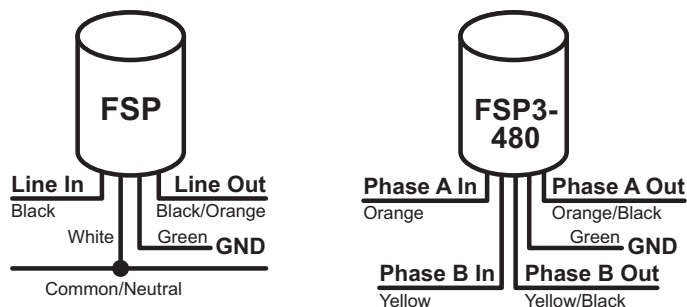
FSP3 Surge Protectors are designed for use in conjunction with LED Drivers to provide an additional level of protection against powerline disturbances in industrial and commercial applications. Also protects electronic fluorescent and HID ballasts.

***UL Certified for Factory or Field Wiring**

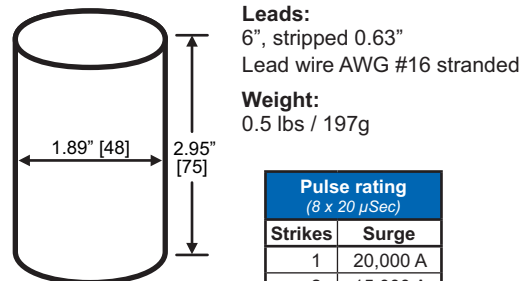


Part Number	Mains Voltage	Continuous Max Current Rating	Continuous Max Voltage Rating		Max Clamping Voltage 8/20 µS @ 20kA	UL1449	UL935/ UL1029	CE	LED Indicator
			AC	DC					
FSP3-277-20KA	100-277V	7.0A	320V	420V	2100V	•	•	•	•
FSP3-277-20KA-NI	100-277V	7.0A	320V	420V	2100V	•	•	•	
FSP3-480-20KA	480V	4.0A	550V	745V	3800V	•	•		•
FSP3-480-20KA-NI	480V	4.0A	550V	745V	3800V	•	•		

Wiring



Dimensions (Nom.)



Pulse rating (8 x 20 µSec)	
Strikes	Surge
1	20,000 A
2	15,000 A
15	10,000 A
120	3,000 A

★ **MADE IN USA** ★
Of Imported And Domestic Components



Specifications subject to change without notice.

Rev 5-13-16





■ Features

- Wide input range 180 ~ 528VAC
- Constant Current mode output
- Metal housing with Class I design
- Built-in active PFC function
- IP67 / IP65 design for indoor or outdoor installations
- Function options: output adjustable via potentiometer; 3 in 1 dimming (dim-to-off) ; Smart timer dimming
- Typical lifetime > 50000 hours
- 5 years warranty

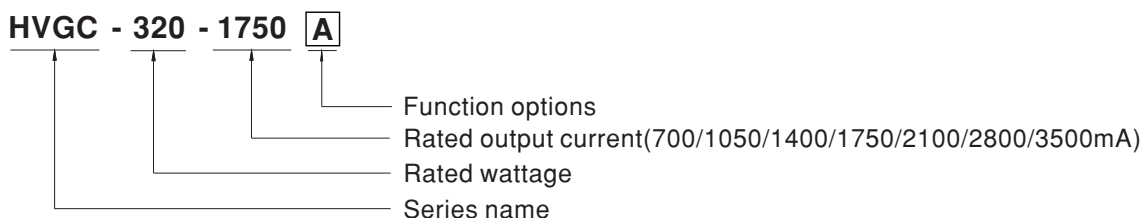
■ Applications

- LED street lighting
- LED high-bay lighting
- Parking space lighting
- LED fishing lamp
- Type "HL" for use in Class I , Division 2 hazardous (Classified) location.

■ Description

HVGC-320 series is a 320W LED AC/DC LED power supply featuring the constant current mode and high voltage output. HVGC-320 operates from 180~528VAC and offers models with different rated current ranging between 700mA and 3500mA. Thanks to the high efficiency up to 93.5%, with the fanless design, the entire series is able to operate for -40°C ~ +90°C case temperature under free air convection. The design of metal housing and IP67/IP65 ingress protection level allows this series to fit both indoor and outdoor applications. HVGC-320 is equipped with various function options, such as dimming methodologies, so as to provide the optimal design flexibility for LED lighting system.

■ Model Encoding



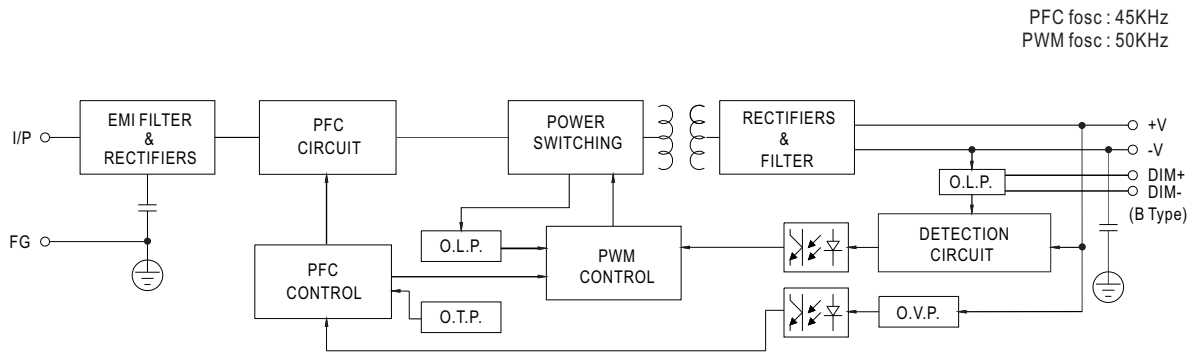
Type	IP Level	Function	Note
A	IP65	I _o adjustable through built-in potentiometer.	In Stock
B	IP67	3 in 1 dimming function (0~10Vdc, 10V PWM signal and resistance)	In Stock
Dx	IP67	Built-in Smart timer dimming function by user request.	By request
D2	IP67	Built-in Smart timer dimming and programmable function.	By request



SPECIFICATION

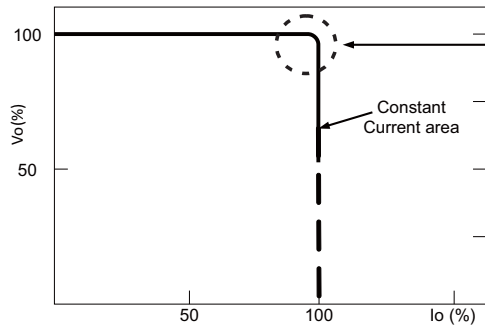
MODEL		HVGC-320-700	HVGC-320-1050	HVGC-320-1400	HVGC-320-1750	HVGC-320-2100	HVGC-320-2800	HVGC-320-3500
OUTPUT	RATED CURRENT	700mA	1050mA	1400mA	1750mA	2100mA	2800mA	3500mA
	RATED POWER	300W	320W	320W	320W	320W	320W	320W
	CONSTANT CURRENT REGION <small>Note.2</small>	214 ~ 428V	152.4 ~ 304.8V	114.3 ~ 228.6V	91.4 ~ 182.8V	76.2 ~ 152.4V	57 ~ 114.3V	45.7 ~ 91.4V
	OPEN CIRCUIT VOLTAGE (max.)	442V	311V	234V	187V	156V	118V	94V
	CURRENT ADJ. RANGE	Adjustable for A-Type only (via built-in potentiometer)						
		350~700mA	525~1050mA	700~1400mA	875~1750mA	1050~2100mA	1400~2800mA	1750~3500mA
	CURRENT RIPPLE	5.0% max. @rated current						
	CURRENT TOLERANCE	±5%						
SET UP TIME <small>Note.4</small>	500ms/230VAC, 347VAC, 480VAC							
INPUT	VOLTAGE RANGE <small>Note.3</small>	180 ~ 528VAC 254VDC ~ 747VDC (Please refer to "STATIC CHARACTERISTIC" section)						
	FREQUENCY RANGE	47 ~ 63Hz						
	POWER FACTOR (Typ.)	PF ≥ 0.98/230VAC, PF ≥ 0.97/277VAC, PF ≥ 0.95/347VAC, PF ≥ 0.93/480VAC @full load (Please refer to "POWER FACTOR (PF) CHARACTERISTIC" section)						
	TOTAL HARMONIC DISTORTION	THD < 20% (@ load ≥ 50%/230VAC, 277VAC, 347VAC, @ load ≥ 60%/480VAC) (Please refer to "TOTAL HARMONIC DISTORTION (THD)" section)						
	EFFICIENCY (Typ.)	93.5%	93.5%	93.5%	93.5%	93.5%	93.5%	93%
	AC CURRENT (Typ.)	1.1A / 347VAC	0.8A / 480VAC					
	INRUSH CURRENT(Typ.)	COLD START 50A(twidth=920μs measured at 50% I _{peak}) at 480VAC; Per NEMA 410						
	MAX. NO. of PSUs on 16A CIRCUIT BREAKER	2 unit(circuit breaker of type B) / 4 units(circuit breaker of type C) at 480VAC						
LEAKAGE CURRENT	<0.75mA / 480VAC							
PROTECTION	SHORT CIRCUIT	Constant current limiting, recovers automatically after fault condition is removed						
	OVER VOLTAGE	445 ~ 455V	320 ~ 351V	240 ~ 263V	192 ~ 210V	160 ~ 175V	120 ~ 131V	96 ~ 105V
	OVER TEMPERATURE	Shut down o/p voltage with re-power on to recovery						
ENVIRONMENT	WORKING TEMP.	Tcase=-40 ~ +90°C (Please refer to "OUTPUT LOAD vs TEMPERATURE" section)						
	MAX. CASE TEMP.	Tcase=+90°C						
	WORKING HUMIDITY	20 ~ 95% RH non-condensing						
	STORAGE TEMP., HUMIDITY	-40 ~ +80°C, 10 ~ 95% RH						
	TEMP. COEFFICIENT	±0.03%/°C (0 ~ 60°C)						
	VIBRATION	10 ~ 500Hz, 5G 12min./1cycle, period for 72min. each along X, Y, Z axes						
SAFETY & EMC	SAFETY STANDARDS	UL8750 (type"HL"), CSA C22.2 No. 250.13-12, IP65 or IP67 approved						
	WITHSTAND VOLTAGE	I/P-O/P:3.75KVAC I/P-FG:2KVAC O/P-FG:1.5KVAC						
	ISOLATION RESISTANCE	I/P-O/P, I/P-FG, O/P-FG:100M Ohms / 500VDC / 25°C / 70% RH						
	EMC EMISSION	Compliance to FCC Part 15 Subpart B						
EMC IMMUNITY	Compliance to EN61000-4-2,3,4,5,6,8,11, EN61547, light industry level (surge immunity Line-Earth 4KV, Line-Line 2KV), criteria A							
OTHERS	MTBF	141.2K hrs min. MIL-HDBK-217F (25°C)						
	DIMENSION	262*90*43.8mm (L*W*H)						
	PACKING	2Kg; 8pcs/17Kg/0.92CUFT						
NOTE	<ol style="list-style-type: none"> All parameters NOT specially mentioned are measured at 347VAC input, rated current and 25°C of ambient temperature. Please refer to "DRIVING METHODS OF LED MODULE". De-rating may be needed under low input voltages. Please refer to "STATIC CHARACTERISTIC" sections for details. Length of set up time is measured at first cold start. Turning ON/OFF the power supply may lead to increase of the set up time. The driver is considered as a component that will be operated in combination with final equipment. Since EMC performance will be affected by the complete installation, the final equipment manufacturers must re-qualify EMC Directive on the complete installation again. This series meets the typical life expectancy of >50,000 hours of operation when Tcase, particularly (T_c) point (or TMP, per DLC), is about 80°C or less. Please refer to the warranty statement on MEAN WELL's website at http://www.meanwell.com 							

Block Diagram



DRIVING METHODS OF LED MODULE

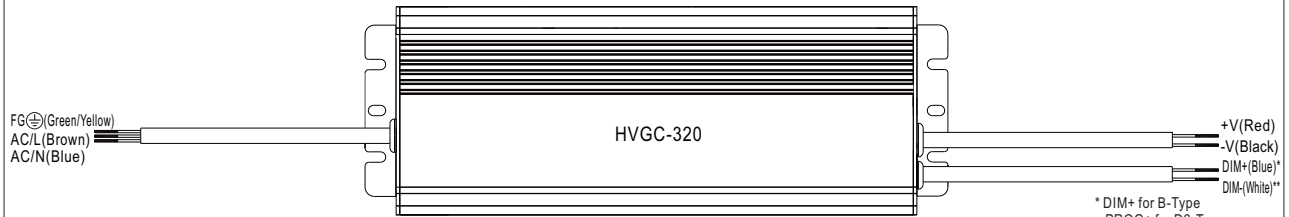
※ This series works in constant current mode to directly drive the LEDs.



Typical output current normalized by rated current (%)

In the constant current region, the highest voltage at the output of the driver depends on the configuration of the end systems.
Should there be any compatibility issues, please contact MEAN WELL.

DIMMING OPERATION

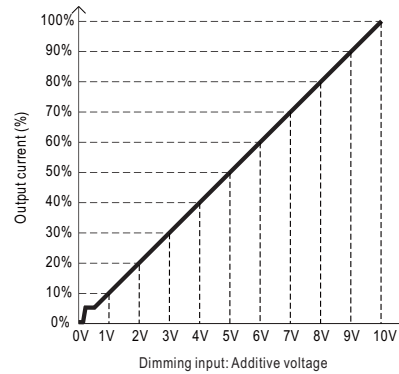
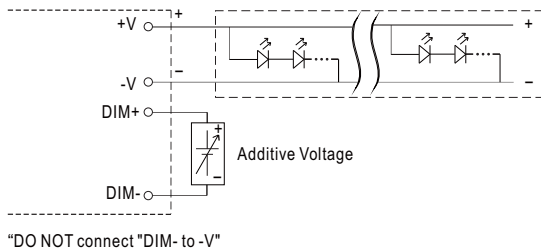


※ 3 in 1 dimming function (for B-Type)

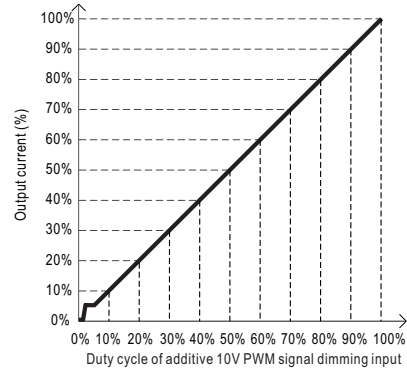
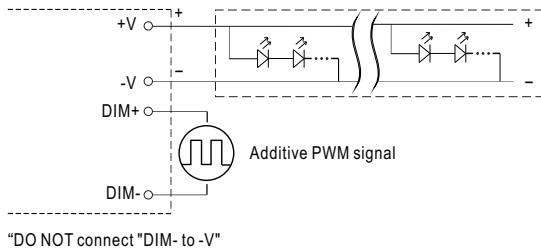
- Output constant current level can be adjusted by applying one of the three methodologies between DIM+ and DIM-: 0 ~ 10VDC, or 10V PWM signal or resistance.
- Direct connecting to LEDs is suggested. It is not suitable to be used with additional drivers.
- Dimming source current from power supply: 100 μ A (typ.)

* DIM+ for B-Type
 PROG+ for D2-Type
 * DIM- for B-Type
 PROG- for D2-Type

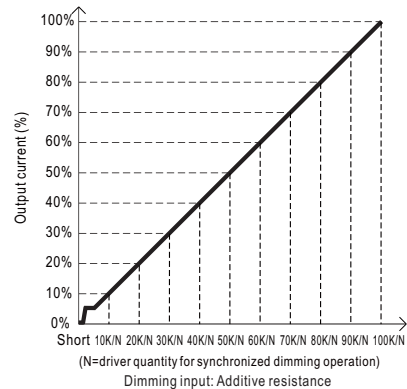
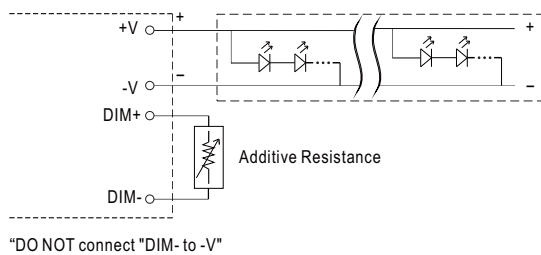
◎ Applying additive 0 ~ 10VDC



◎ Applying additive 10V PWM signal (frequency range 100Hz ~ 3KHz):



◎ Applying additive resistance:

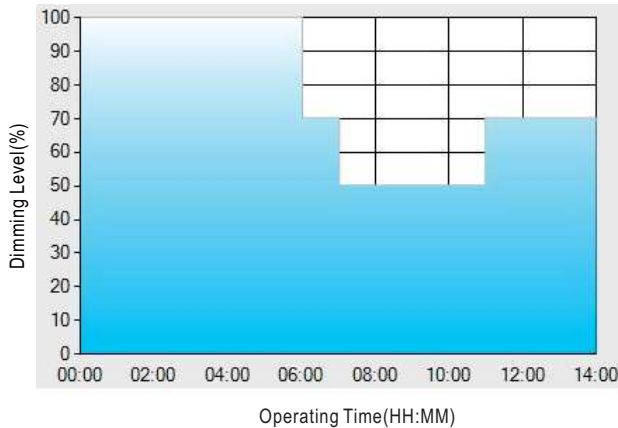


- Note : 1. Min. dimming level is about 5% and the output current is not defined when 0% < I_{out} < 5%.
 2. The output current could drop down to 0% when dimming input is about 0kΩ or 0Vdc, or 10V PWM signal with 0% duty cycle.

※ **Smart timer dimming function (for Dxx-Type by User definition)**

MEAN WELL Smart timer dimming primarily provides the adaptive proportion dimming profile for the output constant current level to perform up to 14 consecutive hours. 3 dimming profiles hereunder are defined accounting for the most frequently seen applications. If other options may be needed, please contact MEAN WELL for details.

Ex : ☉ D01-Type: the profile recommended for residential lighting



Set up for D01-Type in Smart timer dimming software program:

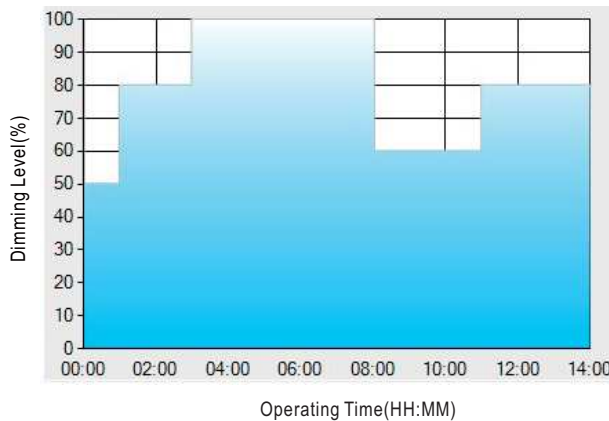
	T1	T2	T3	T4
TIME**	06:00	07:00	11:00	---
LEVEL**	100%	70%	50%	70%

** : TIME matches Operating Time in the diagram whereas LEVEL matches Dimming Level.

Example: If a residential lighting application adopts D01-Type, when turning on the power supply at 6:00pm, for instance:

- [1] The power supply will switch to the constant current level at 100% starting from 6:00pm.
 - [2] The power supply will switch to the constant current level at 70% in turn, starting from 0:00am, which is 06:00 after the power supply turns on.
 - [3] The power supply will switch to the constant current level at 50% in turn, starting from 1:00am, which is 07:00 after the power supply turns on.
 - [4] The power supply will switch to the constant current level at 70% in turn, starting from 5:00am, which is 11:00 after the power supply turns on.
- The constant current level remains till 8:00am, which is 14:00 after the power supply turns on.

Ex : ☉ D02-Type: the profile recommended for street lighting



Set up for D02-Type in Smart timer dimming software program:

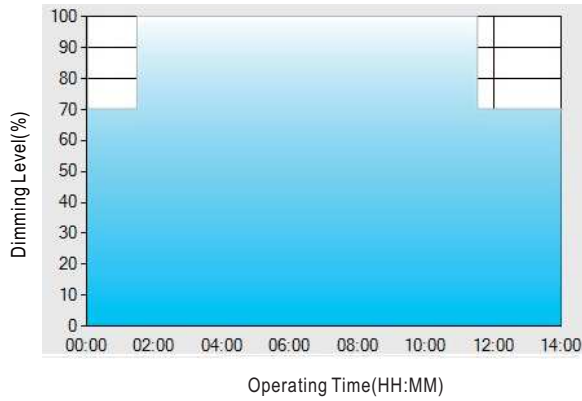
	T1	T2	T3	T4	T5
TIME**	01:00	03:00	8:00	11:00	---
LEVEL**	50%	80%	100%	60%	80%

** : TIME matches Operating Time in the diagram whereas LEVEL matches Dimming Level.

Example: If a street lighting application adopts D02-Type, when turning on the power supply at 5:00pm, for instance:

- [1] The power supply will switch to the constant current level at 50% starting from 5:00pm.
- [2] The power supply will switch to the constant current level at 80% in turn, starting from 6:00pm, which is 01:00 after the power supply turns on.
- [3] The power supply will switch to the constant current level at 100% in turn, starting from 8:00pm, which is 03:00 after the power supply turns on.
- [4] The power supply will switch to the constant current level at 60% in turn, starting from 1:00am, which is 08:00 after the power supply turns on.
- [5] The power supply will switch to the constant current level at 80% in turn, starting from 4:00am, which is 11:00 after the power supply turns on. The constant current level remains till 6:30am, which is 14:00 after the power supply turns on.

Ex: ☉ D03-Type: the profile recommended for tunnel lighting



Set up for D03-Type in Smart timer dimming software program:

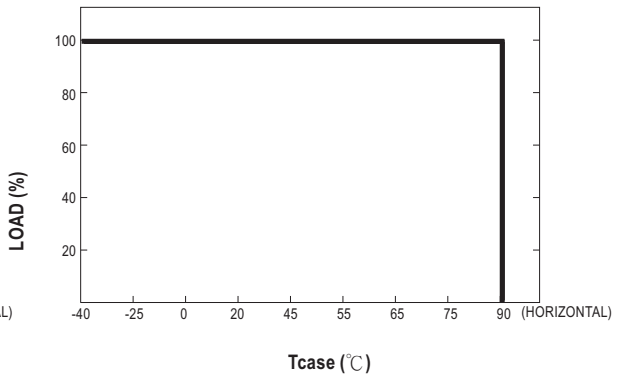
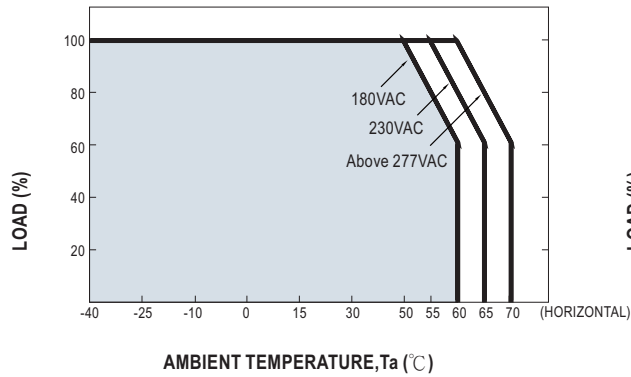
	T1	T2	T3
TIME**	01:30	11:00	---
LEVEL**	70%	100%	70%

** : TIME matches Operating Time in the diagram whereas LEVEL matches Dimming Level.

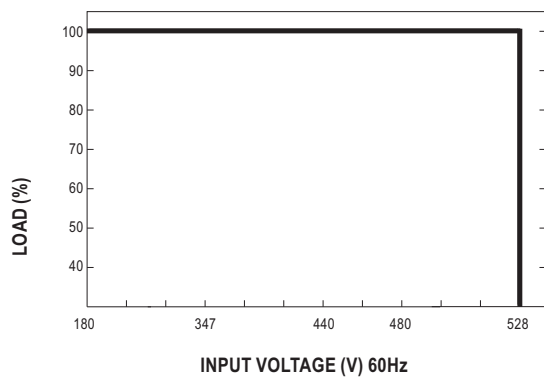
Example: If a tunnel lighting application adopts D03-Type, when turning on the power supply at 4:30pm, for instance:

- [1] The power supply will switch to the constant current level at 70% starting from 4:30pm.
 - [2] The power supply will switch to the constant current level at 100% in turn, starting from 6:00pm, which is 01:30 after the power supply turns on.
 - [3] The power supply will switch to the constant current level at 70% in turn, starting from 5:00am, which is 11:00 after the power supply turns on.
- The constant current level remains till 6:30am, which is 14:00 after the power supply turns on.

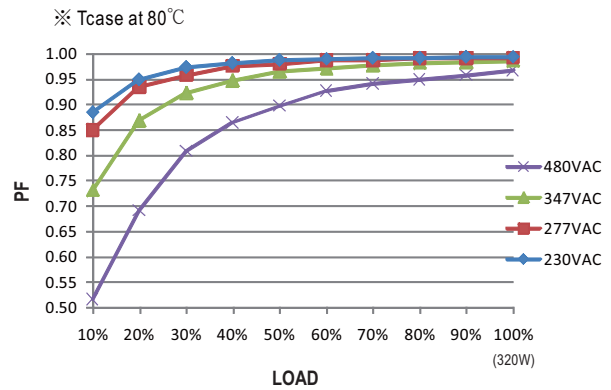
OUTPUT LOAD vs TEMPERATURE



STATIC CHARACTERISTIC

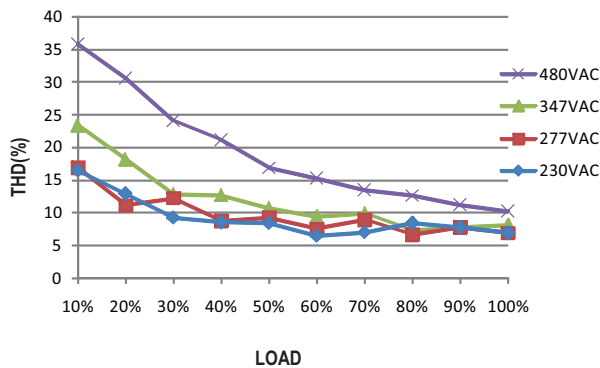


POWER FACTOR (PF) CHARACTERISTIC



TOTAL HARMONIC DISTORTION (THD)

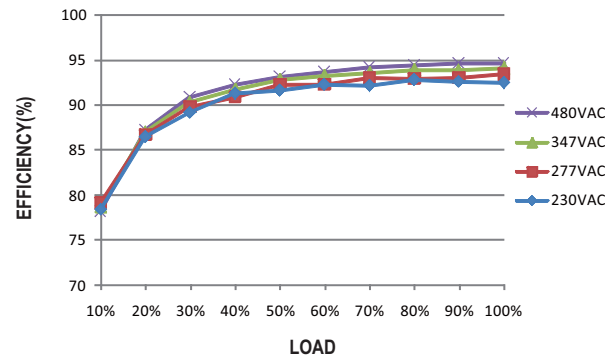
※ 700mA Model, Tcase at 80°C



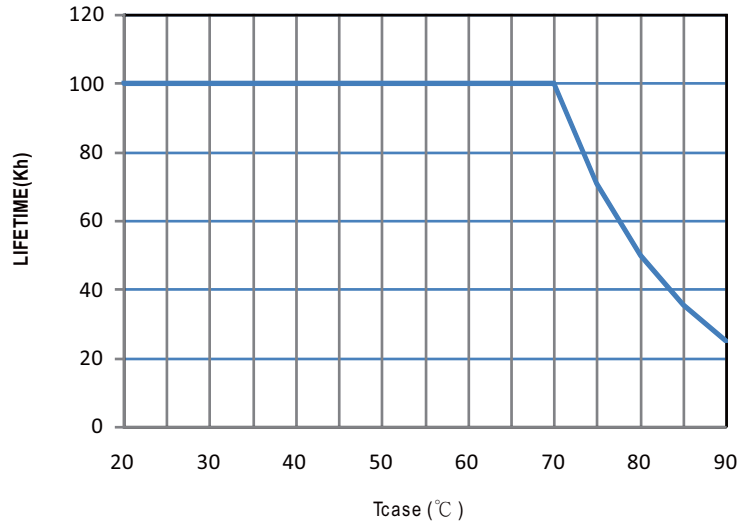
EFFICIENCY vs LOAD

HVGC-320 series possess superior working efficiency that up to 93.5% can be reached in field applications.

※ 700mA Model, Tcase at 80°C



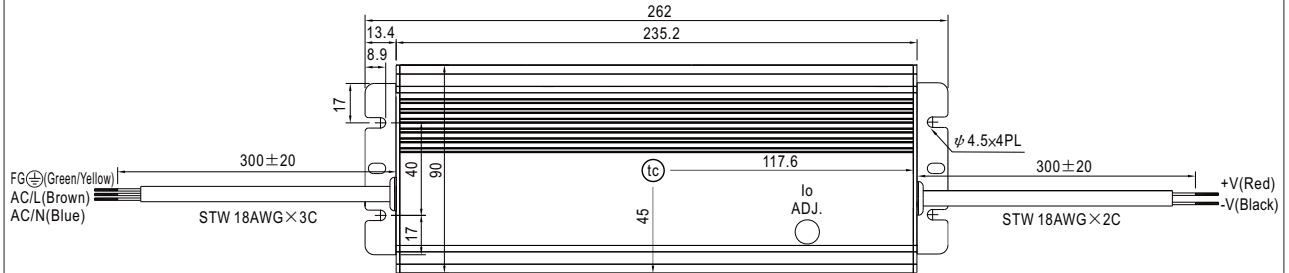
■ LIFE TIME



MECHANICAL SPECIFICATION

Case No. 228 Unit:mm

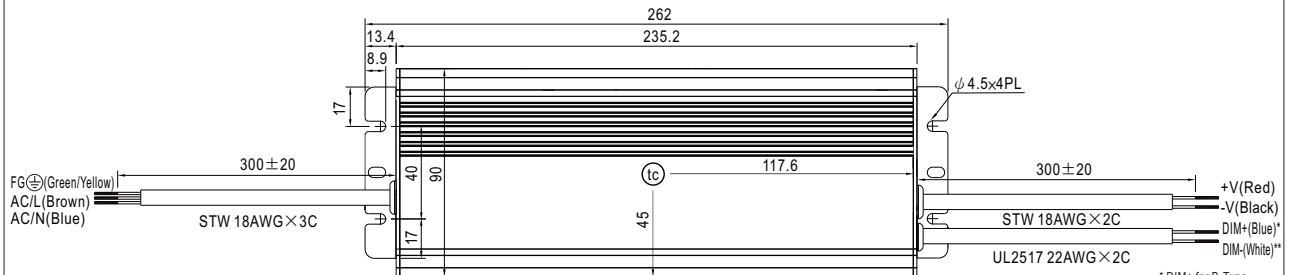
※ **A-Type**



• t_c : Max. Case Temperature

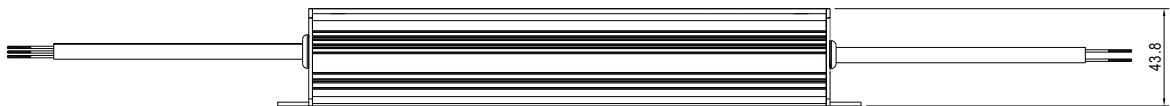


※ **B/D2-Type**



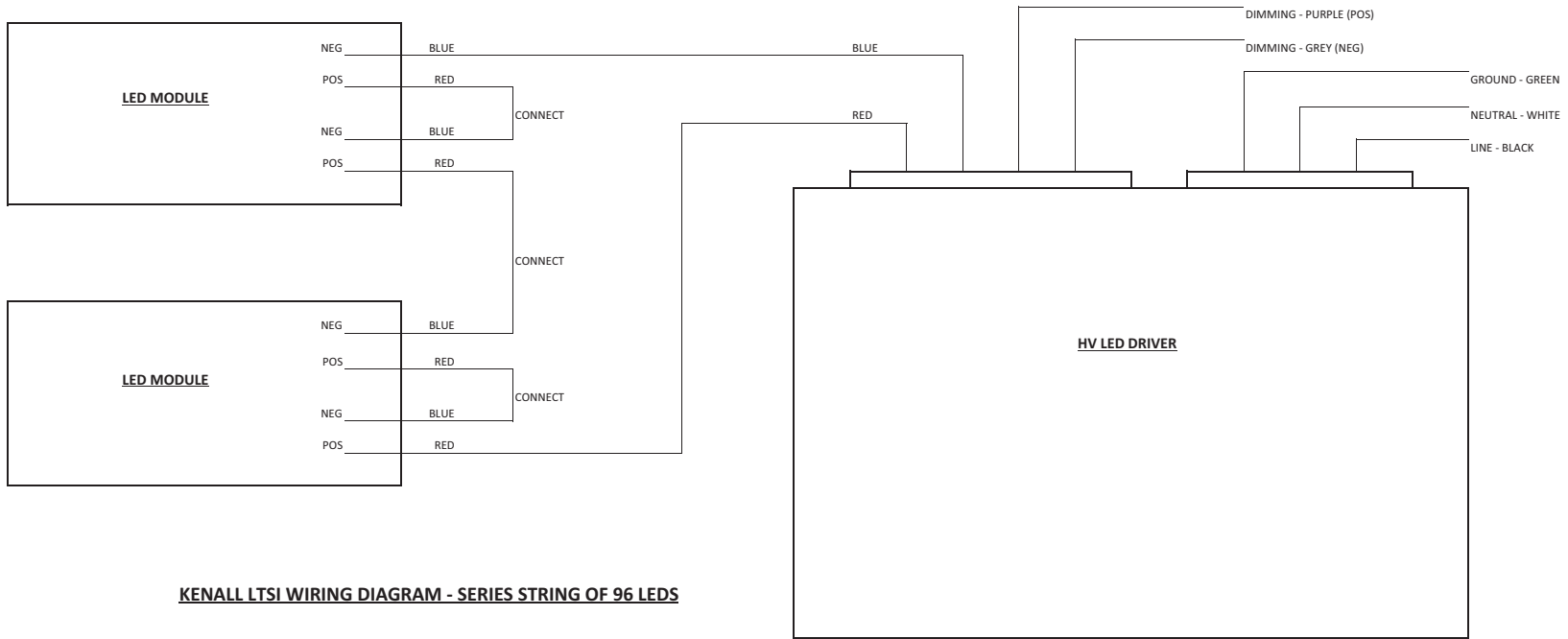
• t_c : Max. Case Temperature

* DIM+ for B-Type
PROG+ for D2-Type
** DIM- for B-Type
PROG- for D2-Type



INSTALLATION MANUAL

Please refer to : <http://www.meanwell.com/webnet/search/InstallationSearch.html>



KENALL LTSI WIRING DIAGRAM - SERIES STRING OF 96 LEDs

LTSI SERIES

IMPORTANT SAFEGUARDS

When using electrical equipment, basic safety precautions should always be followed, including the following:

THIS PRODUCT MUST BE INSTALLED IN ACCORDANCE WITH THE APPLICABLE INSTALLATION CODE BY A PERSON FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THE PRODUCT AND THE HAZARDS INVOLVED. CE PRODUIT DOIT ÊTRE INSTALLÉ SELON LE CODE D'INSTALLATION PERTINENT, PAR UNE PERSONNE QUI CONNAÎT BIEN LE PRODUIT ET SON FONCTIONNEMENT AINSI QUE LES RISQUES INHÉRENTS. DISCONNECT POWER TO ALL CIRCUITS BEFORE WIRING FIXTURE. INSTALL IN ACCORDANCE WITH ALL NATIONAL, STATE, AND LOCAL CODES. DO NOT CONNECT TO AN UNGROUNDED SUPPLY. READ ALL FIXTURE MARKINGS AND LABELS TO ENSURE CORRECT INSTALLATION OF FIXTURE. SUPPLEMENTAL INSTRUCTIONS MAY BE LOCATED ON THE FIXTURE, IN ADDITION TO THIS INSTRUCTION SHEET, REGARDING ORIENTATION, OR MOUNTING RESTRICTIONS.

SAVE THESE INSTRUCTIONS

The LuxTran LTSI series luminaires contains sensitive electronics. Take care to avoid damage by improper handling or static electricity discharge (ESD). Either type of damage could render the system inoperable or cause latent failure.

INSTALLATION INSTRUCTIONS

1. Secure fixture to wall or ceiling using user supplied hardware. 3/8 × 1-3/8 slots in mounting brackets are provided. See Figure 1.

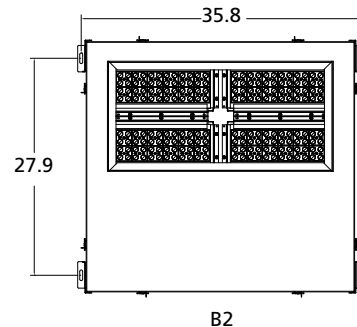
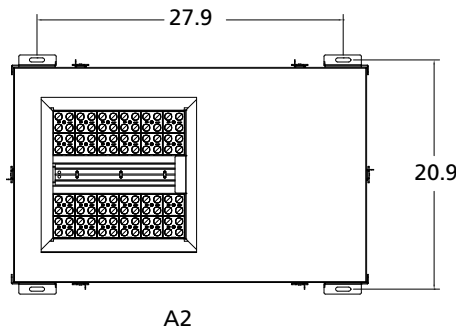


Figure 1

NOTE: If the fixture has directional optics, note the label indicating the direction of light and install appropriately.

2. Rotate latches and open door, which is retained by stainless steel cables.
3. Loosen wing nuts and remove Wiring Cover. See figure 2.

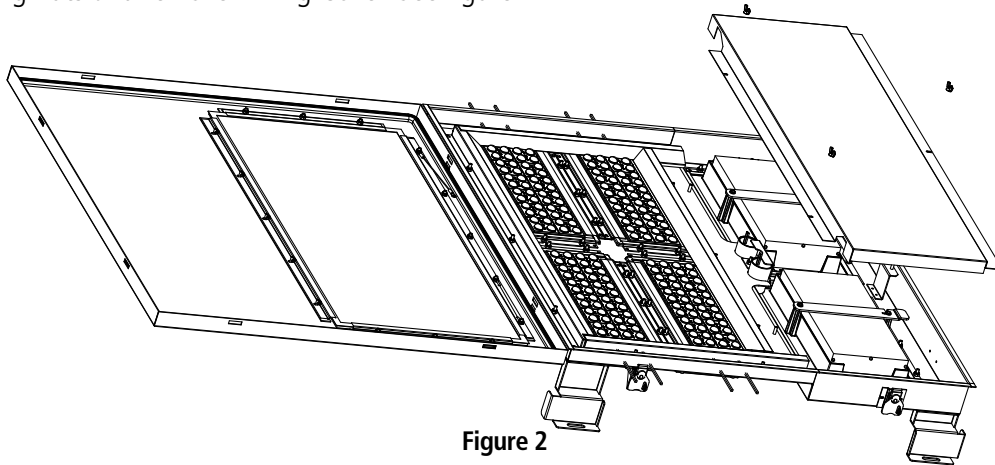


Figure 2

4. Connect weather tight electrical service to 7/8 dia. opening provided.
5. Connect electrical service:
 - Black- input line, 277-480VAC
 - White- Neutral
 - Copper- ground
6. Replace Wiring Cover and secure with wing nuts.
7. Close door and secure rotating latches.

SERVICE INSTRUCTIONS

LTS series LED modules are not field replaceable.

LED module replacement may be done after the fixture is removed from service.

Before beginning any service operation, be sure the power to the fixture is off.

To replace an LED driver-

1. Open door, which is retained by stainless steel cables.
2. Loosen wing nuts and remove Wiring Cover. See Figure 2.
3. Unplug the driver to be replaced.

- Loosen the latch screw and rotate the retaining latch bracket up or down to free the driver. See figure 3.

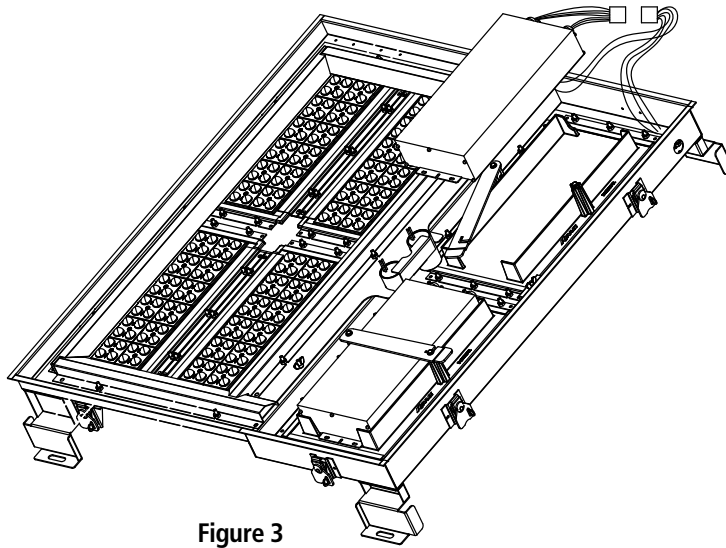


Figure 3

- Replace the driver and secure by reversing steps 1-4 above.

To replace LED modules-

- Open door, which is retained by stainless steel cables.
- Loosen wing nuts and remove Wiring Cover. See Figure 2.
- Remove reflectors and disconnect LED module leads. See Figure 4.

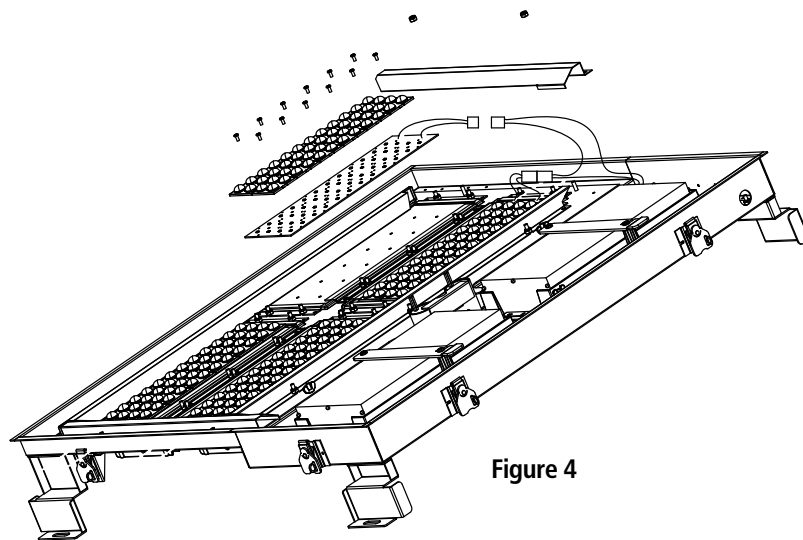


Figure 4

- Remove screws securing LED module.
- Secure new LED module by re-installing removed screws.
- Attach leads and secure reflectors.
- Re-install wiring cover and door.



CUSTOMER SERVICE

For technical assistance, call 1-800-4KENALL (1-800-453-6255).

WARRANTY

This limited warranty is provided by Kenall (the Seller) to you (the Purchaser) as original purchaser of the LED lighting product. This limited warranty may be transferred to subsequent purchasers of the product as long as it is in its original packaging. Qualifying Kenall LED products shall be warranted by Kenall, for a period of ten (10) years from the date of manufacture, to be free of defects in workmanship, materials, LED lamps and internal power regulation components against defects that result in an excessive lumen depreciation, as defined by L70 Luminaire Lifetime (L70) or when at least 10% of the discrete LED sources fail to illuminate. L70 shall be defined as 70% of the published warranty luminous flux at time of manufacture using IESNA LM-79-08 testing methods.

Kenall reserves the right to issue a credit or to repair or replace the defective product, at its discretion, upon notification and confirmation by an authorized Kenall agent of the defect. Kenall also reserves the right to test and examine the product if the defect is questionable. This limited warranty will not apply to loss or damage caused by: any product alteration, mishandling, vandalism, civil disturbances, acts of God, electrical surge, improper electrical supply, fluctuations of electrical current or voltage, electrostatic discharge, natural or induced mechanical oscillation, corrosive environments or failure to follow applicable electrical codes. This warranty shall be void for luminaires installed into an application for which it is not intended, or intentionally damaged, or installed in abnormal environmental conditions as prescribed by Kenall. Accumulation of particulates on the optical surfaces shall not be factored into the lumen depreciation.

Kenall assumes no responsibility for labor or freight costs incurred in connection with the installation, removal or replacement of products determined to be defective. To the maximum extent permitted by applicable law, Kenall hereby disclaims all warranties and conditions, whether express, implied or statutory, including, but not limited to, merchantability or fitness for a particular purpose, other than those explicitly provided by Kenall hereunder.

To the maximum extent permitted by applicable law, Kenall shall, in no event, be liable for any special, incidental, indirect or consequential damages whatsoever, including, but not limited to, loss of profits. Kenall further reserves the right to change the terms of this warranty on future sales of Luminaires without prior notification and without incurring obligation and expressly disclaim all warranties not stated in this limited warranty.





XIAMETER[®] RBB-2003-70 Base

70 Shore A, Translucent, Good Demoulding, Suitable for Pt or Peroxide Cure System, Uncatalyzed Silicone Rubber Base

FEATURES

- 70 Shore A Hardness
- Good translucent
- Good demoulding
- Suitable for Pt or peroxide cure system
- Formulated to meet BfR Recommendation XV and FDA 21 CFR 177.2600

APPLICATIONS

- Cake mold and kitchen ware
- Extrusion, tubing and profiles
- Molding parts
- Wire & Cable
- Calendering and sheeting

TYPICAL PROPERTIES

Specification Writers: These values are not intended for use in preparing specifications.

Formulation:

XIAMETER[®] RBB-2003-70 Base, phr 100
RC-4(50P), phr 1

ASTM*	Property	Unit	Value
	Appearance		Translucent
D792	Specific gravity	g/cm ³	1.21
D2240	Durometer	Shore A	74
D412	Tensile strength	MPa	10.0
D412	Elongation	%	380
D624 DIE B	Tear strength	kN/m	18.0
D395	Compression set after 22 hours at 177°C (35 1°F)	%	25

Properties obtained using 1.0 phr RC-4(50P) on 2mm thick slabs, press cured 10 minutes at 170°C, and post cured 4 hours at 200°C.

*ASTM: American Society for Testing and Materials.

Materials were tested according to Dow Corning Corporate Test Methods (CTM), which in most cases are similar to the ASTM standard listed above. Copies of CTMs are available on request.

HOW TO USE

Vulcanization

XIAMETER[®] RBB-2003-70 Base requires the addition of a vulcanizing agent. XIAMETER[®] or Dow Corning[®] RC-4(50P) and Pt catalysts are recommended for molding and extrusion.

Pigmentation

This Silicone Rubber Base can be pigmented with standard XIAMETER[®] or Dow Corning[®] pigment master batches.

Property Modification

The physical properties of this product can be modified using a range of Dow Corning[®] additives.

This Silicone Rubber Base can be blended with other durometer silicone rubber bases to produce materials with intermediate durometers and properties.

FOOD CONTACT

This product has been formulated to meet applicable food contact regulations and recommendations (for example: FDA 21.CFR 177.2600 and BfR Recommendation XV).

Note: It remains the manufacturers' responsibility to test the final product.

For further details on the suitability of this product for food contact applications, please refer to the Food Regulatory Profile.

This information is available from your local XIAMETER Representative.

PRODUCT SAFETY INFORMATION

PRODUCT SAFETY INFORMATION REQUIRED FOR SAFE USE IS NOT INCLUDED IN THIS DOCUMENT. BEFORE HANDLING, READ PRODUCT AND MATERIAL SAFETY DATA SHEETS AND CONTAINER LABELS FOR SAFE USE, PHYSICAL, ENVIRONMENTAL, AND HEALTH HAZARD INFORMATION. THE MATERIAL SAFETY DATA SHEET IS AVAILABLE ON THE XIAMETER WEBSITE AT WWW.XIAMETER.COM.

USABLE LIFE AND STORAGE

When stored at or below 32°C in the original unopened containers, this product has a usable life of 9 months from the date of production.

LIMITATIONS

This product is neither tested nor represented as suitable for medical or Pharmaceutical uses.

LIMITED WARRANTY INFORMATION – PLEASE READ CAREFULLY

The information contained herein is offered in good faith and is believed to be accurate. However, because conditions and methods of use of our products are beyond our control, this information should not be used in substitution for customer's tests to ensure that Dow Corning® and XIAMETER® products are safe, effective, and fully satisfactory for the intended end use. Suggestions of use shall not be taken as inducements to infringe any patent.

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Your exclusive remedy for breach of such warranty is limited to refund of purchase price or replacement of any product shown to be other than as warranted.

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DOW CORNING DISCLAIMS LIABILITY FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.



Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

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TAB 2	OPERATOR INTERFACE TERMINAL
TAB 3	BILL OF MATERIALS
TAB 4	MANUALS
TAB 5	DRAWINGS
TAB 6	TESTING





Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

SEQUENCE OF OPERATIONS

Lytle Tunnel Cincinnati Lighting Control System

SEQUENCE OF OPERATIONS

PL  Transportation
Control Systems
Tunnel Lighting Controls

3101 112th St. SW #F Everett,
WA 98204

Project: 16T17630
Rev. 1.0
Date: 11/07/16

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1. GENERAL

1.1. Physical Layout of Tunnels

The Lyle Tunnel consists of two one way tunnels, one is southbound, with its entrance at the north portal, one is northbound with its entrance at the south portal. Additionally there is a southbound ramp that also has lighting controls similar to the tunnels, the entrance of which is at the north portal.

1.2. Control Cabinets Location and function

Two provide the lighting controls there are two tunnel lighting control cabinets (south bound control and north bound control). These control panels work independent of each other but are networked on the same Lan. As such both panels can report lighting status to the SCADA system.

1.3. Luminance Meters

The panel at the north portal controls both the southbound tunnel and the ramp and uses a Luminance meter positioned at the entrance of the north portal entrance. Likewise the panel at the south portal controls the northbound tunnel and also has a Luminance meter positioned at the entrance of the south portal. The Luminance meter connects to the plc's using a 4-20ma signal wired to an analog input card in the plc rack, the signal represents a 0 to 10,000 cd/m² light reading. This reading reflects what the driver sees as that driver approaches the entrance of both tunnels and ramp.

1.4. Means of Control

The control cabinets use a combination of digital and analog control to adjust the lighting in the tunnels. This is referred to as dimming control, the control is achieved by using.

- 1) A digital output to switch power to a panel board using an interposing relay
 - 2) An analog output to send a 4-20ma signal to remote dimming enclosures
- Which in turn converts the signal to 0-10vdc and therefor allows the light level for the Led fixtures to be adjusted so the correct roadside luminance is obtained.

1.5. Lytle Control Design

The tunnels and ramp use the same basic control strategy, each tunnel has fixtures mounted on the east and west walls in the hierarchy shown below.

1.6. Southbound Tunnel Lighting Control Organization

Southbound Tunnel East Wall Lighting Control Organization

Controller	Bore	Level	Contactactor	Panelboard	Remote Dim Encl
TLCP-S	Tunnel	1/2		SE-DN	RDE-SE1
TLCP-S	Tunnel	3/4	SE-C1	SE-LP1	RDE-SE2
TLCP-S	Tunnel	5/6	SE-C2	SE-LP2	RDE-SE3 RDE-SE4

Southbound Tunnel West Wall Lightng Control Organization

Controller	Bore	Level	Contactactor	Panelboard	Remote Dim Encl
TLCP-S	Tunnel	1/2		S-EM, SW-DN	RDE-SW1
TLCP-S	Tunnel	3/4	SW-C1	SW-LP1	RDE-SW2
TLCP-S	Tunnel	5/6	SW-C2	SW-LP2	RDE-SW3 RDE-SW4

Southbound Ramp East Wall Lighting Control Organization

Controller	Bore	Level	Contactactor	Panelboard	Remote Dim Encl
TLCP-S	Ramp	1/2		R-EM, RE-DN	RDE-RE1
TLCP-S	Ramp	3/4	RE-C1	RE-LP1	RDE-RE2
TLCP-S	Ramp	5/6	RE-C2	RE-LP2	RDE-RE3 RDE-RE4

Southbound Ramp West Wall Lighting Control Organization

Controller	Bore	Level	Contactactor	Panelboard	Remote Dim Encl
TLCP-S	Ramp	1/2		RW-DN	RDE-RW1
TLCP-S	Ramp	3/4	RW-C1	RW-LP1	RDE-RW2
TLCP-S	Ramp	5/6	RW-C2	RW-LP2	RDE-RW3 RDE-RW4

1.7. Northbound Tunnel Lighting Control Organization

Northbound Tunnel East Wall Lighting Control Organization

Controller	Bore	Level	Contactactor	Panelboard	Remote Dim Encl
TLCP-N	Tunnel	1/2		NE-DN	RDE-NE1
TLCP-N	Tunnel	3/4	N-E1	NE-LP1	RDE-NE2
TLCP-N	Tunnel	5/6	N-E2	NE-LP2	RDE-NE3 RDE-NE4

Northbound Tunnel West Wall Lighting Control Organization

Controller	Bore	Level	Contactactor	Panelboard	Remote Dim Encl
TLCP-N	Tunnel	1/2		N-EM, NW-DN	RDE-NW1
TLCP-N	Tunnel	3/4	N-W1	NW-LP1	RDE-NW2
TLCP-N	Tunnel	5/6	N-W2	NW-LP2	RDE-NW3 RDE-NW4

1.8. Emergency Power Lighting/Day Night Lighting

The day and night fixtures have no panel board switching associated with them and the emergency lighting is on all the time and is UPS powered. The day/night or DN lighting is controlled by dimming only so two analog outputs are used one for the west and one for the east wall fixtures. The night lighting is referred to at stage 1, and daytime lighting is referred to at stage 2. In this design an Astro clock is used to determine sun set and sunrise, this is achieved by wiring a dry contact from the standalone Astro clock to a digital input in the plc. The luminance meter is not used to determine nighttime.

1.9. Day Contrast Lighting Levels

The daytime contrast lighting is achieved by combining the switching of power to the panel boards and the use of dimming fixtures.

The control scheme calls for four levels of contrast lighting, as the light level outside the entrance of the tunnel increases the system increases the stages from 3 through 6. The light fixtures are both switched on using contactors and then their light output is increased using dimmable Led lighting.

The diagram above shows the panel board switching, for both east and west walls.

E-LP1,E-LP2,W-LP1,W-LP2 these are the panel boards and they are controlled by the PLC digital outputs that are wired to interposing relays E-C1,E-C2,W-C1,W-C2. Once the power is switched to the fixtures, then the PLC analog outputs that send the 4-20ma signal to the RDE's can be driven to a value that achieves the necessary lighting level. The PLC has the following analog outputs E-DN,W-DN,E-PL1,W-LP1,E-LP2,W-LP2.

Stage Description	Stage Light Level	PLC IO		Panel Board
		DIGITAL	ANALOG	
Night	1	n/a	E-DN,W-DN	
Day	2	n/a	as above	
Contrast Band 1	3	E-C1,W-C1	E-LP1,W-LP1	LP1
Contrast Band 2	4	as above	as above	LP1
Contrast Band 3	5	E-C2,W-C2	E-LP2,W-LP2	LP2
Contrast Band 4	6	as above	as above	LP2

The table above shows the PLC IO that effectively achieved the six levels of control, using the digital and analog PLC outputs.

Stage 1 & 2

Day and Night are controlled by analog outputs E-DN and W-DN

Stage 3 & 4

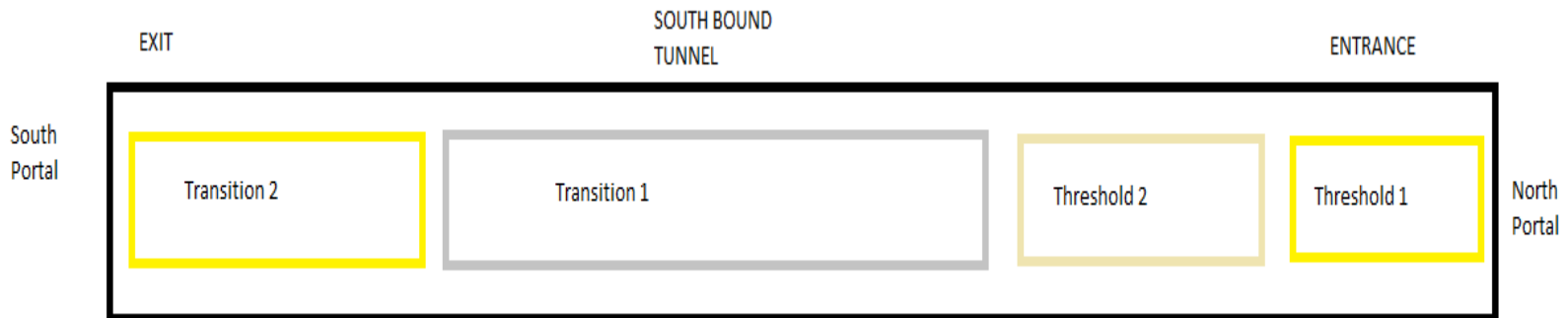
Contrast band 1 and 2 are controlled by analog outputs E-LP1 and W-LP1 and the corresponding contactors that switch power to the panel boards, which are controls by relays wired to digital outputs E-C1 and W-C1.

Stage 5 & 6

Contrast band 3 and 4 are controlled by analog outputs E-LP2 and W-LP2 and the corresponding contactors that switch power to the panel boards, which are controls by relays wired to digital outputs E-C2 and W-C2.

1.10. Tunnel Zones

It should be noted that each tunnel is divided into zones, there are two transition zones and two threshold zones in each tunnel, as well as emergency lighting and of course night lighting. A zone is a specific length of the tunnel. The diagram below shows a typical zoning.



For safety the entrance or threshold 1 must try and match the light level seen by the driver as the vehicle approached the tunnel. Normally this section has the most stages of lighting, in some cases up to six. Once the driver is in the tunnel the light level can be reduced, these are the transition zones. In many cases the center section of a tunnel would only have day and night light levels. The chart below shows the maximum zone and light level for all the tunnels at Lytle.

Northbound Tunnel Design Luminance

Zone	Length FT	Maximum Luminance CD/m ²
Threshold Zone 1	270	202
Threshold Zone 2	147	126
Transition Zone 1	220	82
Transition Zone 2	219	22
Interior	856	6

Southbound Tunnel Design Luminance

Zone	Length FT	Maximum Luminance CD/m ²
Threshold Zone 1	366	242
Threshold Zone 2	161	142
Transition Zone 1	241	99
Transition Zone 2	49	26
Interior	817	6

Southbound Ramp Design Luminance

Zone	Length FT	Maximum Luminance CD/m ²
Threshold Zone 1	287	249
Threshold Zone 2	161	154
Transition Zone 1	242	101
Transition Zone 2	150	27
Interior	840	6

The light system as a whole is designed for specific speed of entry as shown below

Tunnel	NB	SB	SB Ramp
Design Speed mph	50	55	50
Average Annual Daily Traffic	72,000	65,000	7,000
Safe Sight Stopping Distance FT	474	553	474

The following chart shows the relationship between the zones and the light stages.

NORTHBOUND TUNNEL LEVEL CONTROL

Level	Photometer Setting CD/M ²	Threshold #1 CD/M ²	Threshold #2 CD/m ²	Transition #1 CD/M ²	Transition #2 CD/m ²
1	<100	6	6	6	6
2	101-250	10	10	10	10
3	250-1500	50	31	20	10
4	1500-3000	90	55	37	10
5	3000-6000	130	80	53	14
6	6000-10000	202	125	85	22

SOUTHBOUND TUNNEL LEVEL CONTROL

Level	Photometer Setting CD/M ²	Threshold #1 CD/M ²	Threshold #2 CD/m ²	Transition #1 CD/M ²	Transition #2 CD/m ²
1	<100	6	6	6	6
2	101-250	10	10	10	10
3	250-1500	50	31	20	10
4	1500-3000	100	59	41	10
5	3000-6000	150	88	51	16
6	6000-10000	242	142	99	26

SOUTHBOUND TUNNEL LEVEL CONTROL

Level	Photometer Setting CD/M ²	Threshold #1 CD/M ²	Threshold #2 CD/m ²	Transition #1 CD/M ²	Transition #2 CD/m ²
1	<100	6	6	6	6
2	101-250	10	10	10	10
3	250-1500	50	31	20	10
4	1500-3000	100	62	41	10
5	3000-6000	150	93	51	16
6	6000-10000	249	154	101	27

1.11. Contrast Band Control

The transition of light level from one stage to the next is dictated as follows

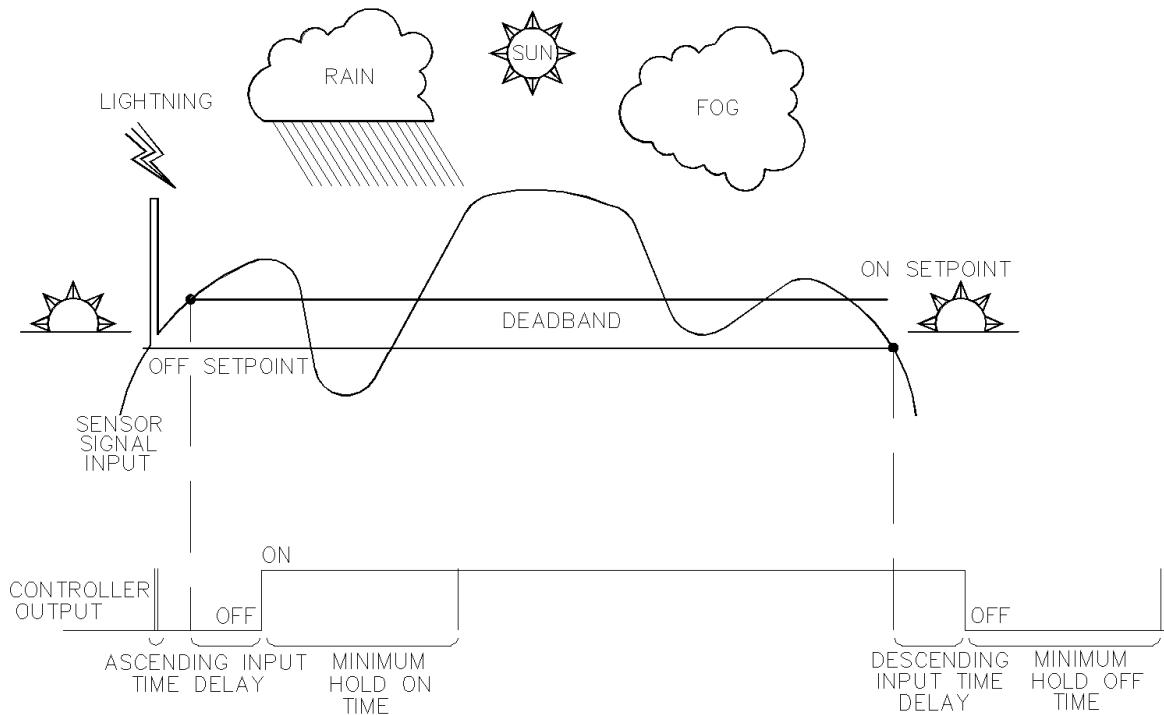
1) An Astro clock dry contact wired to a PLC input signals that it is now day or sunrise as such the stage 2 dimming control begins. A portion of the analog output bandwidth for any of the stages, will be used to drive the led lighting associated with each stage. (Eg. Stages 2 to 6). The controlling variable that determines the transition from one stage to the next will be the luminance meter analog input, as it increases the lighting stages will also increase, until such time that it will be maxed out at stage 6. Inherent in this process is the On delay, off delay, hold on time, hold off time, and Luminance meter reading averring or filter.

1.11.1. Stage Switching Time Delays

At each stage of operation, the T57-4 system moderates the signal input from the luminance sensor before acting upon it.

As the ambient roadway light level rises above an "ON" setpoint, it must remain stable and above it for an input time delay period. The recommended input time delay is 5 minutes. Once the stage is turned on, the controller commits the lights to remain on for a hold-on period. The recommended hold-on period is 30 minutes.

As the ambient roadway light level drops below an "OFF" setpoint, it must remain stable and below it for another input time delay period. The recommendation for this input time delay is 5 minutes long. Once the stage is turned off, the controller keeps the lights off for a hold off period, recommended at 5 minutes.



1.12. Photo Lighting control panel switching

The photo sensor lighting controls is capable of independently switching six levels of lighting circuits in response to the available daylight. The controls are capable of utilizing luminance sensor input, measuring Cd/m².

Level	GRP	Mode	Control	Operation	TLUM	Hi	Low	Tin	Thold	Tdn	THoff	Contactor
1	night	Run	Auto	night	ASTRO	na	na	5	5	5	5	N/A
2	day	Run	Auto	Cont.	1	100	250	5	5	5	5	N/A
3	Z1/2	Run	Auto	Cont.	1	250	1500	5	5	5	5	C1
4	Z1/2	Run	Auto	Cont.	1	1500	3000	5	5	5	5	C1
5	Z1/2	Run	Auto	Cont.	1	3000	6000	5	5	5	5	C2
6	Z1/2	Run	Auto	Cont.	1	6000		5	5	5	5	C2

1.13. Stages 3 to 4

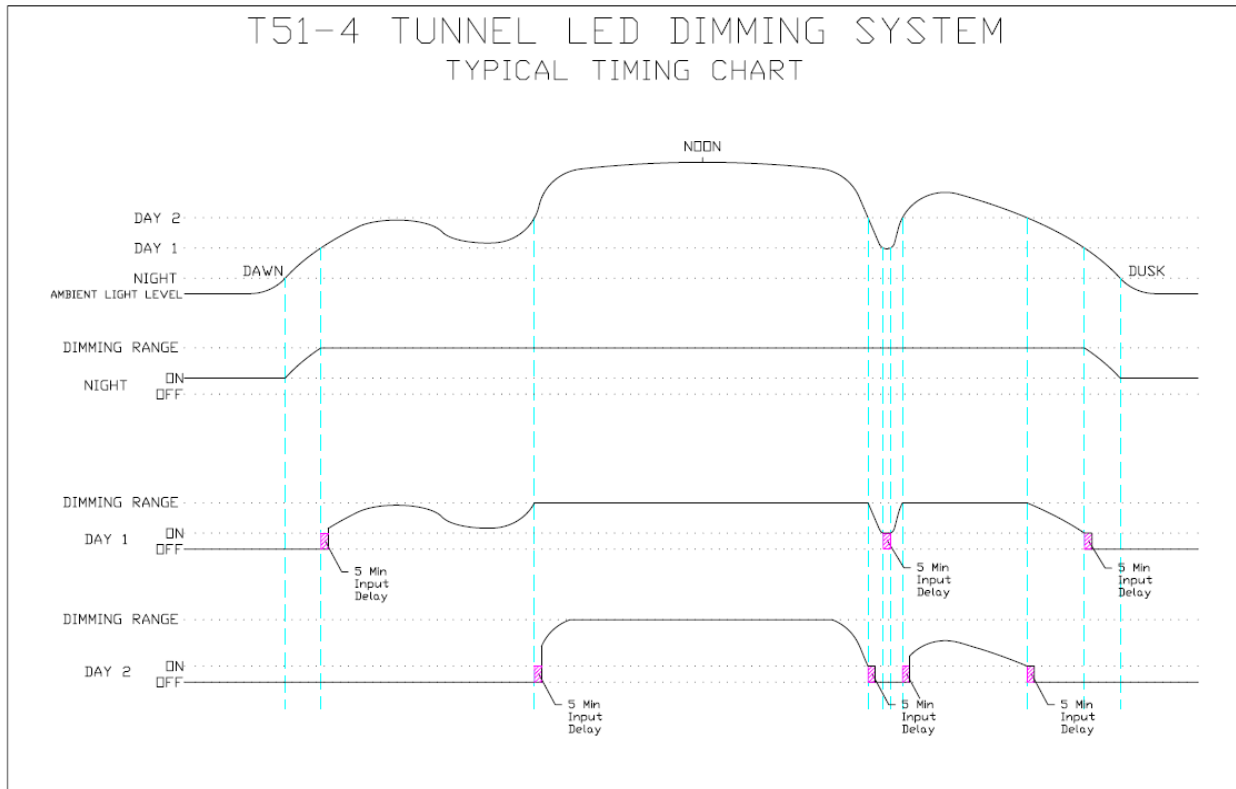
Stage 3 to 4 dimming begins once stage 3 on set point is reached and the on delay is complete. The a portion of the band width of the stage ¼ lighting analog outputs will be used to drive the led lighting associated with stage ¼ in conjunction with the C1 contactor. The controlling variable will be the luminance meter analog input, which results in the transition from one stage to the next. Inherent is this process is the On delay, off delay, hold on time, hold off time, and Luminance meter reading averring or filter as mentioned above.

1.14. Stages 5 to 6

Stage 5 to 6 dimming begins once stage 5 on set point is reached out and the on delay is complete. The a portion of the band width of the stage 5/6 lighting analog outputs will be used to drive the led lighting associated with stage 5/6 in conjunction with the C2 contactor. The controlling variable will be the luminance meter analog input, which results in the transition from one stage to the next. Inherent is this process is the On delay, off delay, hold on time, hold off time, and Luminance meter reading averring or filter as mentioned above.

1.15. Dimming control example

Dimming is accomplished after a level has been switched on. The light level is read by the controller and the output is ramped to a preset level. The rate of range is determined by the sensor luminance measurement averaging.



2. PhotoSensor

The Photo-sensors supply a linearly analog input signal to the controllers proportional to the light measured. The luminance sensor has an adjustable sensitivity of 0 to 10,000 Cd/m². The sensors 4 to 20mA output can be mounted within 1300 meters from each tunnel portal without voltage drop.

2.1. Luminance Measurement

The luminance sensor is capable of measuring outdoor ranges of 0 to 10,000 Cd/m². The sensors are factory calibrated, but can be field adjusted. The scaling has been entered into the Operator Interface Terminal.

3. Controller

The lighting controller/receiving unit is capable of field adjusting the six light level operating points from 0 to 10,000 Cd/m² in steps of 1 Cd/m². The controller averages 5 readings at 1 second intervals and uses the calculated value as the basis for switching and dimming control. The operating mode for each level is selectable for use as night approach/facade lighting or day contrast lighting control. Time delays for turn off/on for each level are selectable in 1-minute steps from 0-99 minutes. Each level has separate off and on setpoints that form a deadband. A hold-on timer provides a minimum operating time for the control output, regardless of any changes in the illumination level. The hold-on time is adjustable from 0 to 240 minutes. The lighting parameters are pre-programmed and stored in active RAM, battery backed RAM, and non-volatile flash EEPROM - for the original commissioning settings. The input voltage is 120VAC.

3.1. Operator Interface

A door mounted Touch Screen display on the control unit is provided to display the program parameters controlled. Adjustments are made by means of touch screen. The current status of the system is displayed, showing the luminance level and the output response. The front panel display allows for each level's mode of operation to be selected between manual on/ off override or automatic control. Programming adjustments can only be made to a level's parameters when its output has been placed in a manual mode.

3.2. Sensor Scaling

Sensor analog input range and calibration are configured through the configuration software. Luminance engineering units of Cd/m² are used. The full scale range of the luminance meter is 10,000 cd/m².

3.3. Mode Control

Three modes of operation are used.

Automatic- lighting is controlled based on the luminance meter readings.

Local - Manual mode from the lighting control panel.

Off Mode-Contactors left in last state and dim level set to maximum.

3.3.1. Automatic Mode:

- 1) All HOA switches are in "Auto"
- 2) "Auto" is selected from the System Utilities screen
- 3) Each of the six Levels of control are in "Run" mode and "Auto" selection of control mode is done through the operator screen with the required password.

3.3.2. Local Mode

- 1) All HOA switches are in "Auto"
- 2) "Local" is selected from the system utilities screen
- 3) Any one or all of the six Levels of control are in "Program" mode and "Manual On" or "Manual Off" control. This is done through the operator screen with the required password. The operator will also enter a desired dimming level if applicable for that particular stage.

3.3.3. Off Mode

- 1) All HOA switches are in "Auto"
- 4) "Off" is selected from the system utilities screen
- 2) The operator selects the "Off Mode" this is done through the operator screen with the required password. This disables the Led dimming sequence for all levels, and leaves the contactors in their last state. The luminaires or sent to their full luminous output state.

3.3.4. Run or Automatic Mode

Automatic mode operation of the tunnel lighting controller includes input time delay to prevent transient lighting events, such as lightning or fast moving clouds, from affecting the controller. Each level is switched on at its high setpoint. The output remains on for the hold-on timer period to prevent short cycling of fixtures. The light level switches off at the low setpoint, after its time delay.

3.3.5. Test

A Test mode bypasses the time delays, allowing immediate response of the controller for checkout and troubleshooting.

3.3.6. Program

Program mode allows for changes to a light level's parameters. The sequence includes forcing the level's output to an on or off state and setting the level parameters.

3.4. Operational Parameters

Each of the five individual switching channels has parameter adjustments of:

Switching Parameter	Range:
Contrast/Night	1 or 2
Time Delay	0-99 minutes
Low Setpoint	0-2,000 cd/m ²
High Setpoint	0-2,000 cd/m ²
Hold On Timer	0-240 minutes

Each of the four dimming channel outputs has operational parameters italicized. The resultant outputs are translated to dimming outputs.

Dimming Parameters	Range
Channel Output	<i>0-100%</i>
Numerical Output	0-32000 counts
Signal Output	4-20mA
Dimming Output	0-10VDC

3.5. Controller Switching Outputs

Each discrete output circuit has a 2 Amp inductive load rating, capable of operating electrically held interposing relays. Each output has a 15A interposing relay with a 24VDC coil to drive electrically-operated, electrically-held 30A lighting contactors. Controller indication displays individual output status, power on, and sensor readings.

3.6. Controller Dimming Outputs

Each 4-20mA analog output circuit is converted to 0-10Vdc through the SX signal converters and then amplified through the DA-4 dimming units. The SX signal converters also utilize programmable dry contacts to ensure that all dimming fixtures will fail to a state of 100% bright in the case of a loss of dimming signal.

4. Control Panel Enclosure

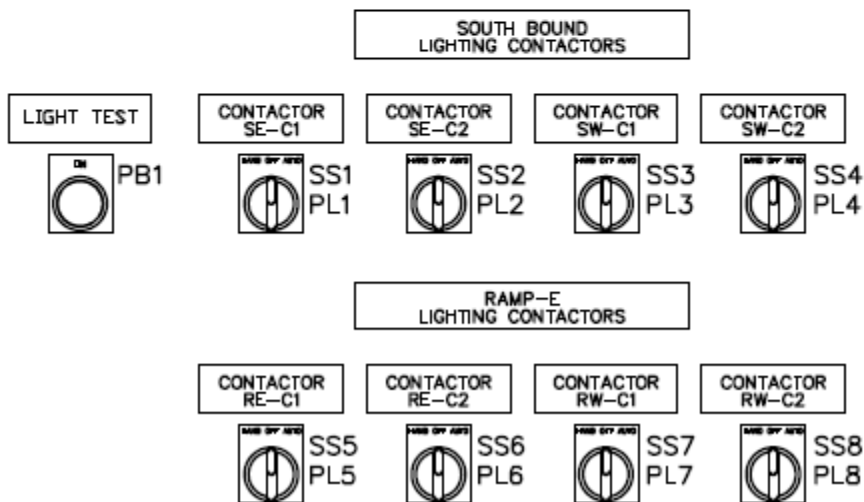
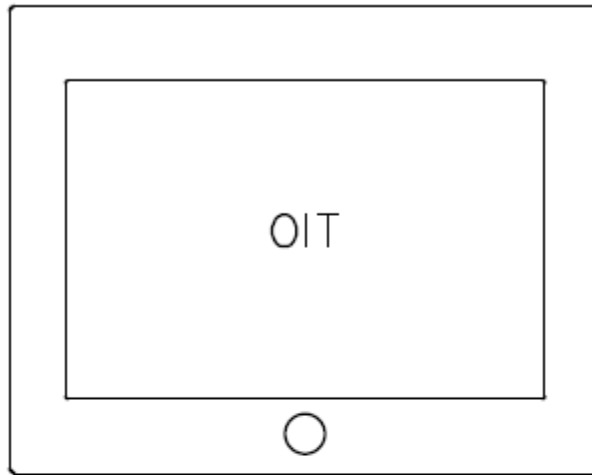
The T57-4 controllers are housed in surface or wall mounted, single door, NEMA 4X enclosures of sufficient size to include all input power, operator interface, and low voltage controls. All components are pre-wired, factory tested and configured in the control panel enclosures.

4.1. Control Power Distribution

Each controller's input power is 277VAC. It is immediately converted to 120VAC. Low voltage control is 24VDC. Control power supply is appropriately protected with power distributed using 14ga wire. Incoming power is surge protected for the circuits connected to the controller.

4.2. Control Panel Operators and Indicators

In addition to the controller operator interface screen, the front panel includes a 22mm HAND/OFF/AUTO switch for each of panel board power switching contactors for LP1 and LP2. Operator legends and indication nameplates are provided. HAND or OFF provide permanent override control to each contactor. AUTO allows automatic lighting control to switch the lighting levels. There is also light indicators for each HOA, a panel light test push button. Below shows the southbound front panel.



5. FRONT PANEL SWITCHES AND LIGHTS

5.1. OPERATOR INTERFACE TERMINAL

The Operator Interface Terminal allows several modes of operation through the use of touch screens. Information is shown on a color Display. The menu system allows for selection current system status, operating parameter review and editing, as well as sensor scaling.

The main menu.

System status, showing for each stage:

- Light level,**
- Output stage,**
- Accumulated Runtime Hours.**
- Contactors Status**
- SCADA/Local Operation**
- Sensor/Power Alarms**

Review and the editing of each switching stage's operating parameters:

- Day or Contrast modes of operation,**
- High setpoint**
- Low setpoint**
- Ascending input time delay**
- Hold on time**
- Descending input time delay**
- Hold off time**

Scaling of the sensor.

- Zero**
- Span**

Stagger start between levels

Dimming Setup

- Channel Output %**
- Channel Output Numeric value**

Alarm Handling

- View Alarm history or summary**
- Group types of alarms**

Trend

- View luminance meter readings**
- View switching and dimming response graphs**

System Utilities

- Miscellaneous settings.**

5.2. H/O/A Selector Switches

Each lighting level has its own Hand/Off/Auto switch that allows mode selection. The manual modes of HAND or OFF bypass the light level controls and switch the lighting level circuit output directly. The AUTO selection includes the Astro control circuit to provide for completely automatic nighttime and daytime contrast lighting control. The HAND position operates the corresponding dimming circuits at 100% output

6. Equipment

The tunnel lighting control system is factory tested to ensure proper operation of all switching controls, analog and digital transmissions, and operator interface.

7. Certification

The tunnel lighting control system is ETL certified to comply with the standards of CAN/CSA STD C22.2 NO 14-M91 for industrial control equipment.

7.1. Start-Up

A factory-authorized technician will perform system start-up including sensor calibration, loop checkout and commissioning. Two hours of customer training shall review system components, sequence of operation, maintenance and troubleshooting.

7.2. Warranty

The lighting control system is warranted for two years.
See Warranty Statement for full details

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1.2 DIMMING CONTROL	
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5.2 HAND/OFF/AUTO SELECTOR SWITCHES	
6 EQUIPMENT	
7 CERTIFICATION	



Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

OPERATOR INTERFACE TERMINAL

Lytle Tunnel, Cincinnati Lighting Control System

OPERATOR INTERFACE TERMINAL



3101 111th St. SW #F Everett,
WA 98204

Project: 16T17630

Rev. 1.0

Date: 11/21/17

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1. OPERATOR INTERFACE TERMINAL

The **Operator Interface Terminal** allows the user to set the operating parameters of the system, monitor current operating status of the tunnel lighting control system, as well as control the operating modes of the controller.

Screen selections are initiated by touch screen technology. The system provides the operator with a main overview screen with touch sensitive buttons that allow the use to navigate to any screen. The screens allow the operator to both review and view data and status as well as adjust and enter set points. All data is read from the PLC Controller using the native GE Ethernet driver, passwords are used to restrict the editing of data.

All screens shown in this document reference the I71 Southbound control system, which includes two tunnels – one with two general purpose lanes and the other with two lanes of exit ramp. The Northbound control system is similar.

1.1. Operator Display Functionality

The **Operator Interface Terminal** is meant as a means for an operator to determine what the lighting system is currently doing by displaying the status of Luminance meters, contactors, dimming outputs, and alarms. It also gives the operator the tools needed to make any necessary adjustments to the operation of the system, as such the operator can change system set points and operational parameters. Finally the display provides historical Trends and both current Alarms and historical Alarms. The PLC does all the control the displays only reflect the actions and parameters of the currently active in the PLC Controller.

2. MAIN MENU

The default screen on the **Operator Interface Terminal** is the main menu for the **T57-6** controller. This menu presents the selections available to the operator. Depressing the function key moves to the screen selected.

The main menu is shown below.



2.1. MAIN MENU FUNCTION KEYS

The selection keys are grouped as follows:

LIGHT STATUS	View current operating status for all Lighting levels
REVIEW LIMIT	Review operating parameters
EDIT	Edit operating mode, control and limits, Dimming parameters.
SENSOR CAL	Enter and review sensor-engineering units.
STAGGER	Stagger on time delays
TRENDS	System Trends
SYSTEM	System Information and Utility Status, Mode Status
ALARMS	System Alarms
LOG IN	Operator can log into the system
SOUTH BOUND	Navigate to the southbound screens

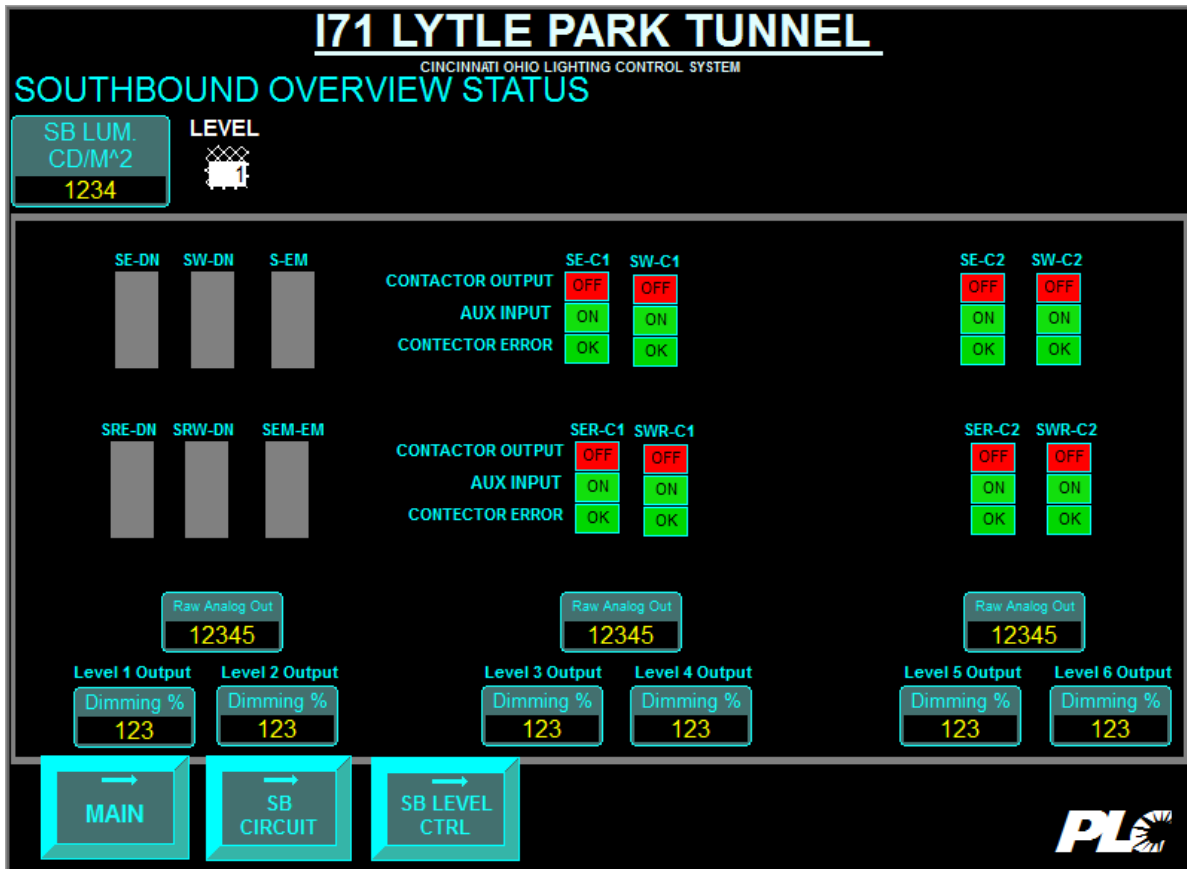
Note: Pressing button moves you to the desired screen.

3. LIGHT STATUS

LIGHT STATUS shows the current status of the tunnel lighting control system.

3.1. TUNNEL SOUTHBOUND OVERVIEW STATUS

The first screen is the Tunnel Southbound Overview Status



SB LUM CD/M^2 displays the Southbound luminance meter reading

LEVEL displays the current output level (1-6)

CONTACTOR Feeder lighting contactors are used to switch panelboards containing branch circuit breakers. The status of the contactors is shown as:

OUTPUT: The control command to the lighting contactor.
ON Energizes the contactor
OFF De-energizes the contactor

AUX INPUT: An auxiliary contact indicating the whether the contactor is:
ON and energizing the lighting circuits or

OFF and de-energizing the lighting circuits

CONTACTOR ERROR An alarm which is activated if there is a mismatch of the contactor and its auxiliary contact after 5 seconds

OK indicates there is no error

ERROR indicates there is an error..

LUMINANCE: The current reading of the light sensor is shown in cd/m^2 ,

DIMMING: The current dimming output is displayed

COLORS

The color convention used is

GREEN = On is activated

RED = Off is de-activated or in the case of the operational error it reflects that the error is present.

NAVIGATION

MAIN returns to the **MAIN MENU**

SB LEVEL CTRL displays the **CONTACTOR LEVEL CONTROL**

SB CIRCUIT Displays the **CONTACTOR HOA etc.**

3.2. SOUTHBOUND CONTACTOR STATUS

I71 LYTLE PARK TUNNEL

CINCINNATI OHIO LIGHTING CONTROL SYSTEM

SOUTHBOUND CIRCUIT STATUS

SB LUM.
CD/M²
1234

LEVEL

TUNNEL	SE-C1	SE-C2	SW-C1	SW-C2
HOA	H O A	H O A	H O A	H O A
CONTACTOR	OFF	OFF	OFF	OFF
AUX CONTACT	OPEN	OPEN	OPEN	OPEN
CONTACTOR ERR	OK	OK	OK	OK
RAMP	SER-C1	SER-C2	SWR-C1	SWR-C2
HOA	H O A	H O A	H O A	H O A
CONTACTOR	OFF	OFF	OFF	OFF
AUX CONTACT	OPEN	OPEN	OPEN	OPEN
CONTACTOR ERR	OK	OK	OK	OK
	L3/L4	L5/L6	L3/L4	L5/L6
RUNTIME HRS				

←

MAIN

←

SB OVER
VIEW

SB LUM CD/M² displays the Southbound luminance meter reading

LEVEL displays the current output level (1-6)

The Contactor Status screen has the additional information of the Hand/Off/Auto selector status which is located on the front of the control panel.

H: Hand position is an electrical override to energize the lighting contactor

O: Off position is an electrical override to de-energize the lighting contactor

A: Auto position allows the tunnel lighting controller to operate the lighting contactor

CONTACTOR Indicates the control output of the contactor
ON energizes the contactor
OFF de-energizes the contactor

AUX CONTACT An auxiliary contact indicates:
ON and energized lighting circuits or
OFF and de-energized lighting circuits

CONTACTOR ERROR An alarm which is activated if there is a mismatch of the contactor and its auxiliary contact after 5 seconds.

RUNTIME HRS The runtime hours for each contactor is also shown.
The **RUNTIME HRS** can be reset after maintenance.

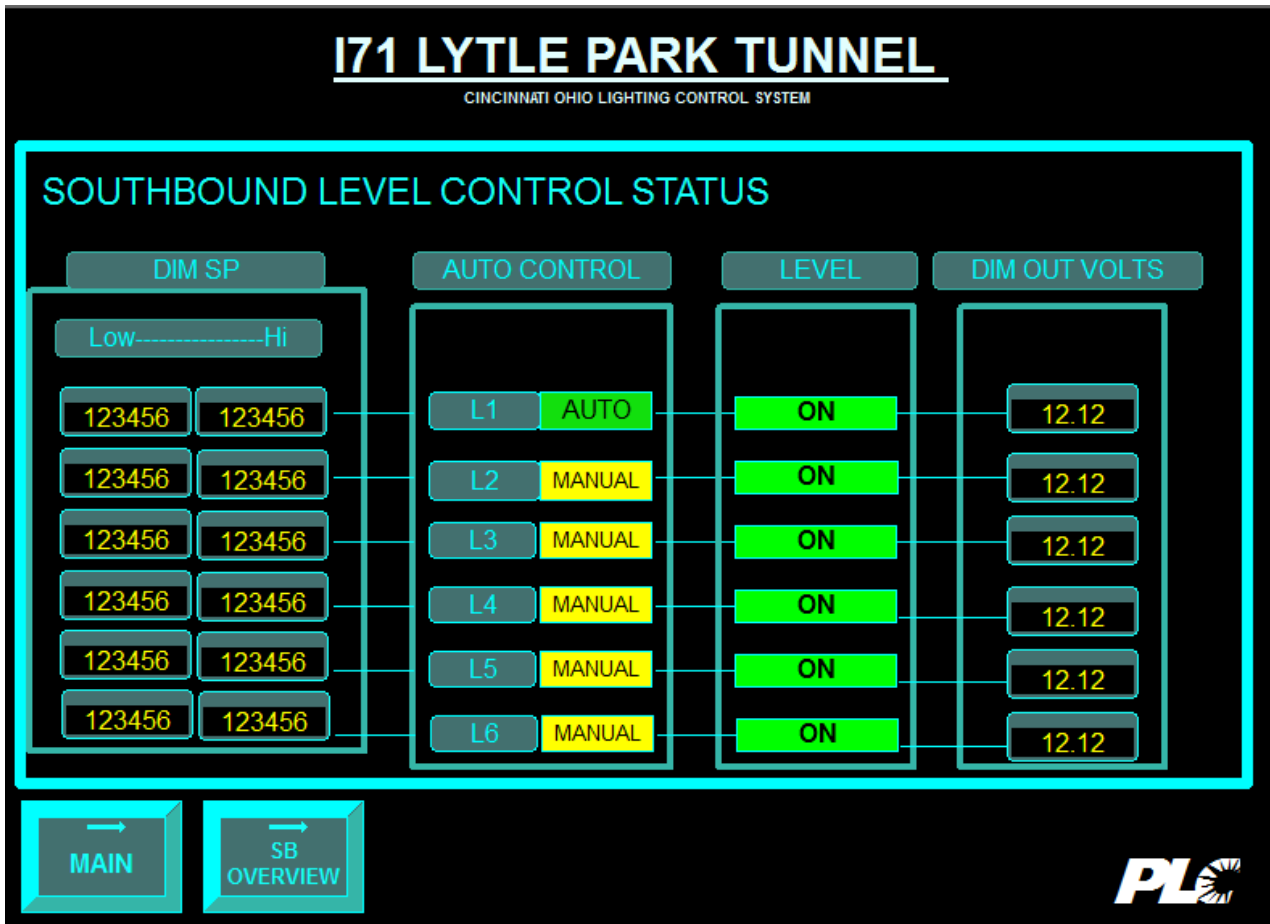
NAVIGATION

MAIN Returns to the **MAIN** menu

SB OVERVIEW displays the **TUNNEL SOUTHBOUND OVERVIEW** screen

3.3. SOUTHBOUND CONTROL LEVEL STATUS

The summary of dimming control status is shown on the following screen.



This screen shows the Hi and Low level set points for the six stages of control.

Each stage is additive upon the next lower level.

DIM SP are the low and high set points for dimming within a range.

AUTO CONTROL has two states

AUTO for automatic dimming response within a dimming setpoint range.

MANUAL for manually setting the dimming output level percentage

STAGE OUTPUT is either *ON* or *OFF*.

DIMMING OUTPUT holds the percentage 0-100% of the level.

NAVIGATION

MAIN returns to the Main Menu

SB OVERVIEW displays the **TUNNEL SOUTHBOUND OVERVIEW** screen

3.4. CONTACTOR STATUS

Each contactor has several status fields associated with it. The contactors control groups of lights within zones of the tunnel. The first three fields contain fixed information, including the control level, contactor number and location.

LVL	CON	LOC
3/4	C1	E/W. (East/West wall Threshold1&2/Transition1&2)
5/6	C2	E/W. (East/West wall Threshold1&2/Transition1&2)

Green or Red current ON/OFF output of contactor from controller.

STATUS Normal and alarm status of lighting contactors. Valid when Hand/Off/Auto Selector switch for contactor is in AUTO position.

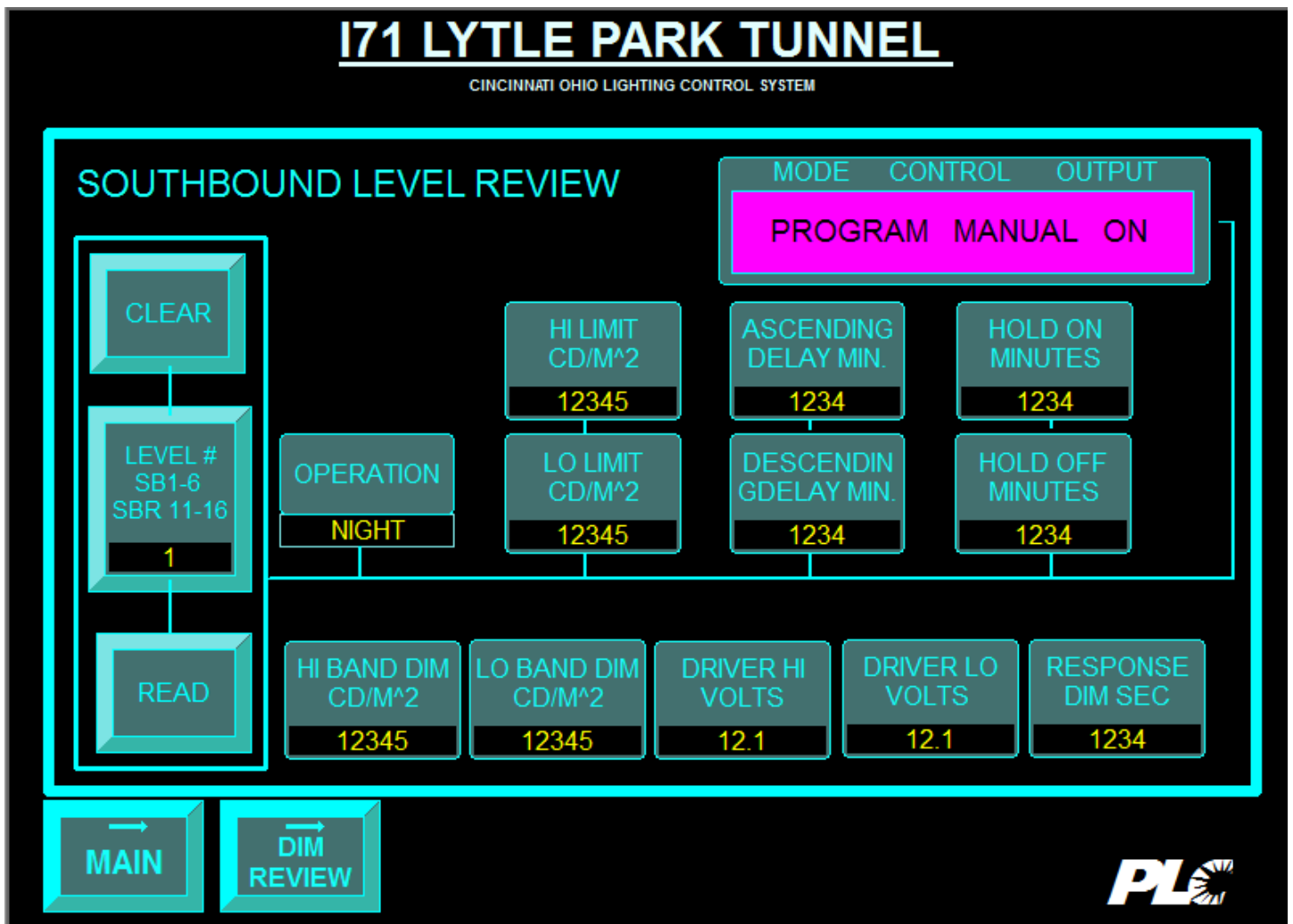
Normal: When contactor is OFF, auxiliary contacts are read as open
When contactor is ON, auxiliary contacts are read as closed

Alarm When contactor is ON, auxiliary contacts are read as open
When contactor is OFF, auxiliary contacts are read as closed

4. REVIEW

REVIEW allows the operator to view the operating parameters of the tunnel lighting control system. The system can be run in several modes of operation, and can also be overridden. Each level's parameters are then displayed summarized. Press clear to remove current selection. Select the level for review 1 to 6, then press read. The current level parameters will be shown.

Pressing CLEAR, entering level numbers 1-6 and pressing READ will load the current level configuration of the switching control.



4.1. PROGRAM MODE

The **PROGRAM** mode is used to force a level to a known output state while making programming changes. This ensures that no changes in the output will immediately occur when new parameters are entered. The program mode has only one control option - manual. The display then shows the selected ON or OFF output position.

OR

LVL X	MODE	CONTROL	OUTPUT
	PROGRAM	MANUAL	ON
	PROGRAM	MANUAL	OFF

4.2. TEST MODE

The **TEST** mode bypasses all of the timing features in the system, allowing for immediate changes in the level outputs. Test has only one control option - AUTO. Then display then shows the selected ON of OFF output position.

OR

LVL X	MODE	CONTROL	OUTPUT
	TEST	AUTO	ON
	TEST	AUTO	OFF

4.3. RUN MODE

The **RUN** mode is the normal operation of the system. **RUN** has two control options, **MANUAL** or **AUTO**. Manual mode bypasses the automatic functions, displaying the forced output of either on or off. **AUTO** displays the full automatic operation of the level, with all setpoint, deadband, and timing algorithms executed. The output state displays the current controller output status of the level.

OR

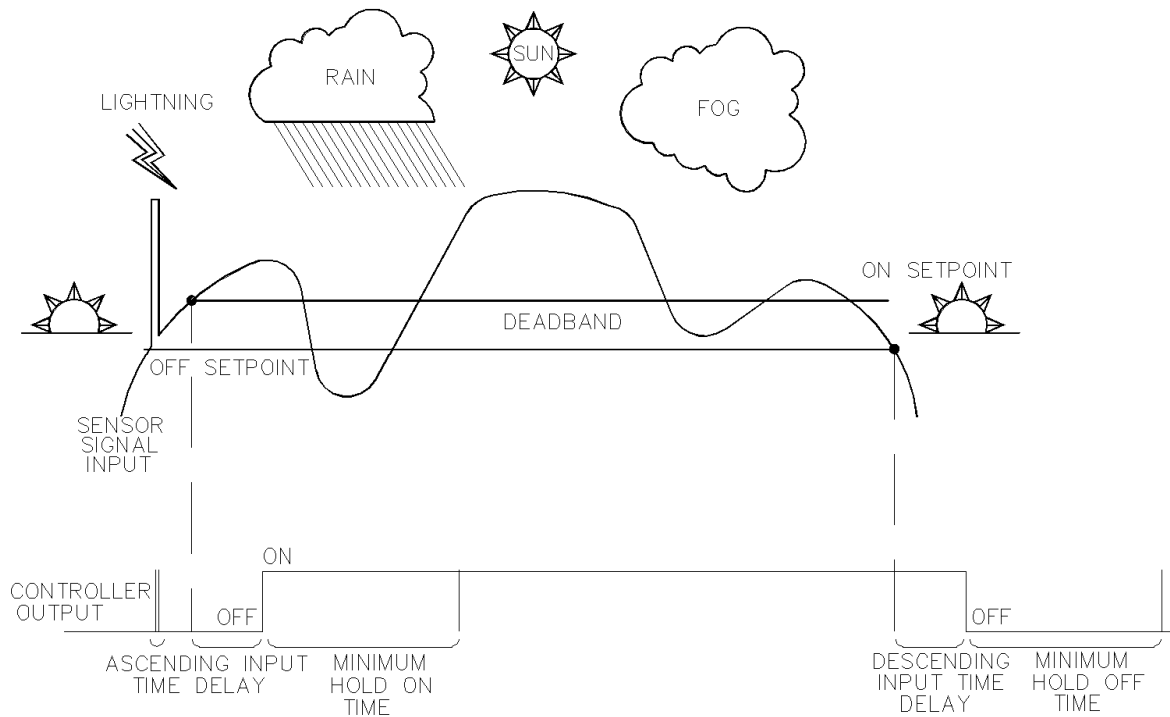
LVL X	MODE	CONTROL	OUTPUT
	RUN	MANUAL	ON
	RUN	MANUAL	OFF

OR

LVL X	MODE	CONTROL	OUTPUT
	RUN	AUTO	ON
	RUN	AUTO	OFF

4.1. LEVEL SETPOINT & TIMER SUMMARY

The REVIEW display shows the operating parameters of the switching level.
The figure below shows the effect of setpoints, deadbands and timing on the switching control response.



The abbreviations are decoded as follows:

LVL **LEVEL**
 The step level being reviewed.

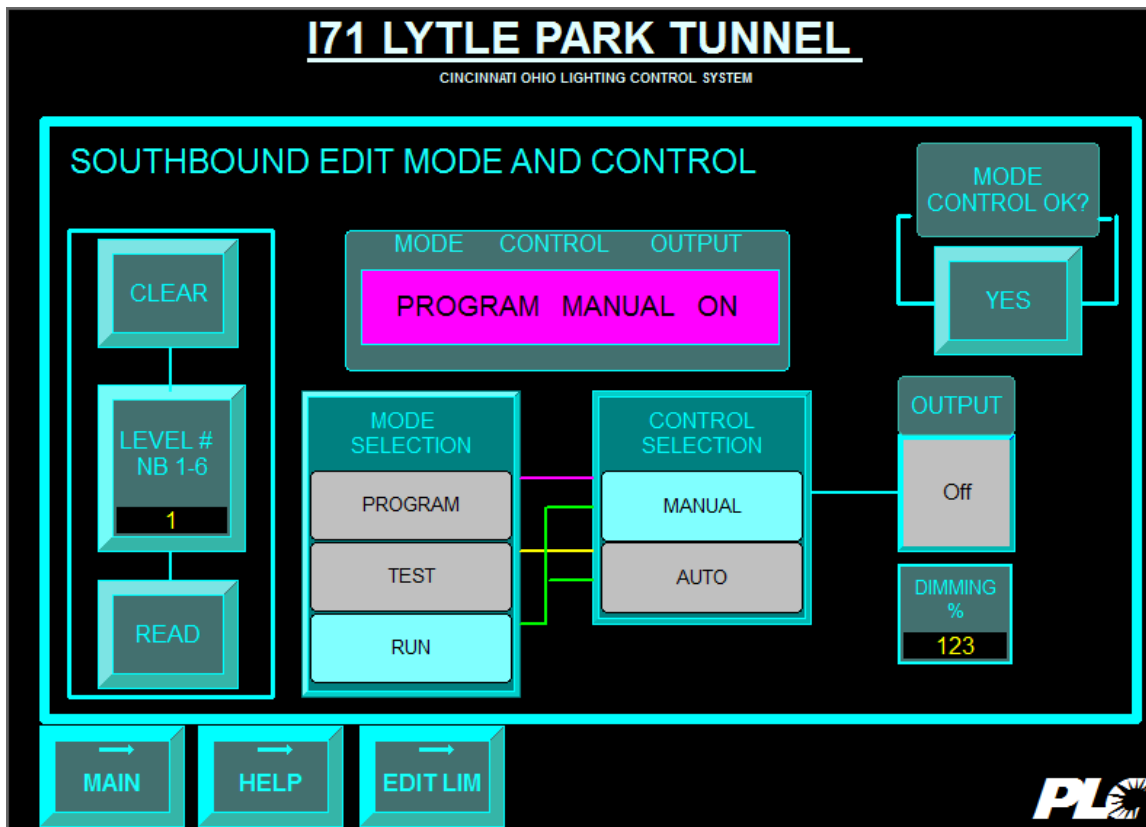
NIGHT/

CONTRAST	Defines Day contrast or night lighting operation
HI	HIGH LIMIT CD/M² The high limit setpoint defined to: Turn the output ON for Contrast lighting or Turn the output OFF for Night Lighting
LO	LOW LIMIT CD/M² The low limit setpoint defined to: Turn the output OFF for Contrast lighting or Turn the output ON for Night Lighting
TIN	ASCENDING INPUT TIME DELAY MINUTES The light level signal must be above the HIGH LIMIT for the period of time defined by TIN , before the controller will use the signal. TIN prevents the controller from reacting to bright transient light level changes detected by the sensor.
TDN	DESCENDING LIGHT INPUT DELAY MINUTES The light level signal must be below the LOW LIMIT for the period of time defined by TDN , before the controller will use the signal. TDN prevents the controller from reacting to dark transient light level changes detected by the sensor.
THON	HOLD ON TIMER MINUTES The HOLD ON TIMER keeps the lights ON for the minimum time defined by THON . Should the light level change below the LO limit, even for a time beyond the DESCENDING LIGHT INPUT DELAY - the output remains ON until THON times out. After THON expires, a level change is permitted.
THOF	HOLD OFF TIMER MINUTES The HOLD OFF TIMER keeps the lights OFF for the minimum time defined by THOF . Should the light level change above the HI limit, even for a time beyond the ASCENDING INPUT TIME DELAY - the output remains OFF until THOF time out. After THOF expires, a level change is permitted.
DIMMING	DIMMING OUTPUT % Displays the current dimming output level in AUTO or Allows a preset dimming mode in MANUAL

5. EDIT

EDIT allows the operator to change the operating parameters of the tunnel lighting control system. Each level can be individually programmed. The system can be run in several modes: with program, test, and automatic operation. When all of a level's parameters are entered, the information is summarized for approval before being downloaded to the PLC.

After clearing the old level, a new level is entered. The display shows the current mode of the level. Several menu paths are available, each with a different outcome.



NAVIGATION

MAIN returns to the **MAIN** menu

HELP brings up a **HELP** screen which contains configuration information.

EDIT LIM displays the switching limit configuration screen.

EDIT DIM displays the dimming configuration screen

171 LYTLE PARK TUNNEL

OHIO CINCINNATI LIGHTING CONTROL SYSTEM

EDIT LIMITS HELP

LEVEL # IS CARRIED OVER FROM MODE/CONTROL SCREEN
OPERATION TOGGLES BETWEEN NIGHT AND CONTRAST

TAP TO CHANGE LEVEL AND TIMERS, KEYPAD WILL APPEAR
ENTER NEW VALUE AND PRESS "YES" TO RETURN
PRESS "YES" PUSHBUTTON FOR LIMITS OK

REMEMBER TO RETURN TO MODE/CONTROL WHEN FINISHED TO
CHANGE BACK TO RUN AND AUTO CONTROL



LIMITS HELP SCREEN

The information on the screen reads:

Level # is carried over from mode/control screen. Operation toggles between night and contrast

Tap to change level and timers, keypad will appear

Enter new value and press "yes" to return.

Press "yes" pushbutton for limits OK?

Remember to return to mode/control when finished to change back to run and auto control

NAVIGATION:

MAIN:: Return to Main Menu

PREVIOUS PANEL: Returns to Edit limits display.

5.1. OVERVIEW

The **PROGRAM** mode is used to force a level to a known output state before making programming changes. This ensures that no changes in the output will immediately occur when new parameters are entered.

The program mode has only one control option - manual. The display then allows the selection of an ON or OFF output position.

The parameters are entered one at a time as responses to prompts. Each response is checked against a range of acceptable values. The operator display will not allow data entry that is not within the internally defined ranges.

Once all of the values are entered, then the display summarizes the parameters, allowing a final check of the proposed changes before updating the controller.

After a level's changes have been made, the controller needs to be taken out of PROGRAM mode, and either into TEST mode if necessary or back to RUN mode for full automatic or manual bypass operation.

The **TEST** mode bypasses all of the timing features for a level, allowing for immediate changes in the level outputs. Test has only one control option - AUTO.

After a test is accomplished, the display can be changed back to the PROGRAM mode for further changes or back to the RUN mode for full automatic or manual bypass operation.

The **RUN** mode is the normal operation of the system. **RUN** has two control options, **MANUAL** or **AUTO**. Manual mode bypasses the automatic functions, displaying the forced output of either on or off. **AUTO** allows the full automatic operation of the level, with all setpoint, deadband, and timing algorithms executed.

5.2. PROGRAM SEQUENCE

The program mode sequence is shown as follows. Clear previous selections. Enter level of interest. Now select the Mode and Control desired plus the Dimming output or the On/Off if applicable. When complete select the mode control ok button to load values to PLC.

5.3. FORCE OUTPUT ON OR OFF

Before making program changes, the level being edited is forced to ON or OFF. This prevents program mode changes from causing the system to immediately react.

OR

LEVEL	MODE	CONTROL
X	PROGRAM	MANUAL ON
X	PROGRAM	MANUAL OFF

5.4. SWITCHING OPERATION

Contrast lighting is the normal mode of operation for tunnel portal, threshold, and transition lighting. As the sensed light level increases during the day, additional stages of fixtures are turned on at different setpoints. As the sensed light level decreases, the fixtures are turned off, until at night the minimum number of fixtures remain on.

5.5. NIGHT/CONTRAST LIGHTING

Night lighting is always on. Contrast Lighting switches tunnel threshold and transition lighting on. As the sensed light level increases during the day, daytime fixtures are turned on with fixtures dimmed. As light levels continue to increase, the dimming levels are brought up proportionally until the next level needs to be switched on. As the sensed light level decreases towards the evening the fixtures are dimmed back down and/or turned off as required.

5.6. SWITCHING CONFIGURATION SETPOINTS

The High and Low limits for a level form a deadband of operation. The difference between the two setpoints is usually 10%, so that the controller has more stability at the level. Without a deadband, the controller could switch fixtures on and off in a short cycle, accelerating ballast and lamp wear, especially if the other timing parameters are relatively short.

Select the Edit Lim button the following screen is displayed. Enter the level desired 1 to 6.

171 LYTLE PARK TUNNEL

CINCINNATI OHIO LIGHTING CONTROL SYSTEM

SOUTHBOUND SOUTHBOUND EDIT LIMITS

LEVEL 1	EDIT LEVEL LIMITS		EDIT DIMMING LIMITS	
READ	ASCENDING TIME DELAY 123	DESCEND TIME DELAY 123	BAND LO CD/M ² 12345	BAND HI CD/M ² 12345
OPERATION	HI LIMIT CD/M ² 12345	LO LIMIT CD/M ² 12345	DRIVER LO VOLTS DC 12.1	DRIVER HI VOLTS DC 12.1
CONTRAST	HOLD ON MINUTES 123	HOLD OFF MINUTES 123	RESPONSE SEC 123	Dimming % 123
LIMITS OK?				
YES				

→ MAIN → HELP → EDIT MC



NAVIGATION

MAIN returns to the **MAIN** menu.

HELP displays a **HELP** configuration screen

EDIT MC displays **MODE** and **CONTROL** screen.

5.7. ASCENDING INPUT TIME DELAY

The light level signal must be above the **HIGH LIMIT** for the **ASCENDING INPUT TIME DELAY** period, before the controller will use the signal. The delay prevents the controller from reacting to bright transient light level changes detected by the sensor.

<p>LEVEL X ASCENDING LIGHT INPUT-DELAY ENTER 0-99 MINUTES</p>
--

5.8. HOLD ON TIMER

The **HOLD ON TIMER** keeps the lights **ON** for the minimum time entered. Should the light level change below the **LO** limit, even for a time beyond the **DESCENDING INPUT TIME DELAY** - the output remains **ON** until the **HOLD ON TIMER** times out. After it expires, a level change is permitted.

<p>LEVEL X HOLD ON TIMER ENTER 0-240 MINUTES</p>

5.9. DESCENDING LIGHT INPUT DELAY

The light level signal must be below the **LOW LIMIT** for the period of time defined by **DESCENDING LIGHT INPUT DELAY**, before the controller will use the signal. The **DESCENDING LIGHT INPUT DELAY** prevents the controller from reacting to dark transient light level changes detected by the sensor.

<p>LEVEL X DESCEND. LIGHT INPUT DELAY ENTER 0-99 MINUTES</p>

5.10. HOLD OFF TIME DELAY

The **HOLD OFF TIMER** keeps the lights **OFF** for a minimum time. Should the light level change above the **HIGH** limit, even for a time beyond the **ASCENDING INPUT TIME DELAY** - the output remains **OFF** until the **HOLD OFF TIME DELAY** time out. After it expires, a level change is permitted.

LEVEL X HOLD OFF TIME DELAY ENTER 0-240 MINUTES

5.11. SWITCHING CONFIGURATION SUMMARY.

This overview screen of the operating parameters allows for a final check before the information is downloaded to the controller. The display shows the same information as the **REVIEW LIMIT** screen.

5.12. PARAMETER CONFIRMATION

Selecting YES Button downloads the information to the controller.

6. TEST

The **TEST** mode bypasses all of the timing features in the system, allowing for immediate changes in the level outputs. Test has only one control option - AUTO.

6.1. TEST MODE SEQUENCE

Select the "Test" mode then select "Auto"

6.2. TEST CONFIRMATION

Select "Mode Control Ok" button

7. RUN

The **RUN** mode is the normal operation of the system. **RUN** has two control options, **MANUAL** or **AUTO**. Manual mode bypasses the automatic functions, displaying the forced output of either on or off. **AUTO** allows the full automatic operation of the level, with all setpoint, deadband, and timing algorithms executed.

7.1. RUN MODE SEQUENCE

Select the “Run” mode then select “Auto” or “Manual”

7.1.1. MANUAL ON CONTROL

Selecting **MANUAL ON** will force the controller output to a constant ON state. The output will remain ON until changed. The associated dimming output will be set to a percentage output between 0 and 100% entered. The level operating hours will still accumulate in **MANUAL ON**.

7.1.2. MANUAL OFF CONTROL

Selecting **MANUAL OFF** will force the controller output to a constant OFF state. The output will remain OFF until changed.

7.1.3. AUTO CONTROL

Selecting **AUTO** will implement the full control algorithm, with ascending and descending input time delays, high and low limit setpoints with deadband operation, hold on and hold off timers. **AUTO** is the normal **RUN** mode control option.

7.1.4. Dimming Parameters

The same screen allows the dimming parameters to edited.



Operator Adjustable

The display shows the dimming variable parameters, the operator can adjust the “Driver Hi” “Driver Lo” and “Response Time”

Driver Hi/Low

The driver low is the minimum voltage output that is required to cause the LED to emit light, any value less than this will cause the LED to emit no light. The Driver High is the maximum voltage that the LED will respond to, any value greater than this will result in no increase in light emitted.

Response Time Damping

The response time is used to limit the ramping of the dimming band, to smooth out any sudden changes in the luminance meter reading. It is the minimum length of time that the dimming band can go from 0 to 100%.

Band Base

The Base band is the start point for each level or stage.

Band Width

The Band width is the difference between the base band and the high level set point for any particular stage.

Response Rate

This is the rate of increase of CD/M2 expected from the system or dimming response rate.

Actual Output Volts

This is the actual volts being sent to the LED Driver for a level at any particular point in time.

7.1.4.1.1. Review Dimming Parameters

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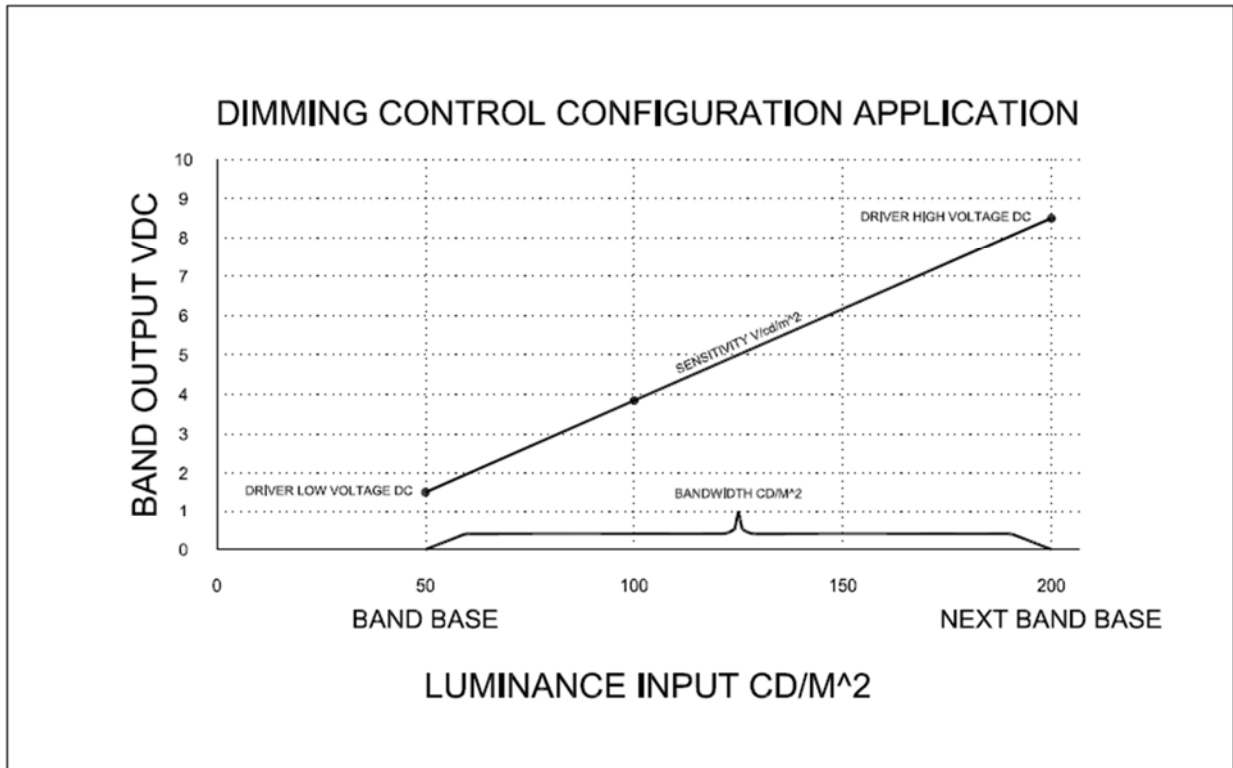
SOUTHBOUND SYSTEM DIMMING REVIEW

STAGE BAND NO.	BAND Lo CD/M^2	BAND Hi CD/M^2	DRIVER HI VOLTS DC	DRIVER LO VOLTS DC	DESIRED OUTPUT %	RESPONSE SEC	OUTPUT VOLTS DC
1	123456	123456	12.1	12.1	12345	123	12.12
2	123456	123456	12.1	12.1	12345	123	12.12
3	123456	123456	12.1	12.1	12345	123	12.12
4	123456	123456	12.1	12.1	12345	123	12.12
5	123456	123456	12.1	12.1	12345	123	12.12
6	123456	123456	12.1	12.1	12345	123	12.12

←
MAIN

→
LEVEL
REVIEW

The operator can review the current dimming settings from the Review Dim screen.



NAVIGATION

MAIN returns to the **MAIN** menu

8. CALIBRATION

The **CALIBRATION** display converts the transmitted sensor signal to the units displayed. The **T57-6** uses only one of the two available analog input channels..

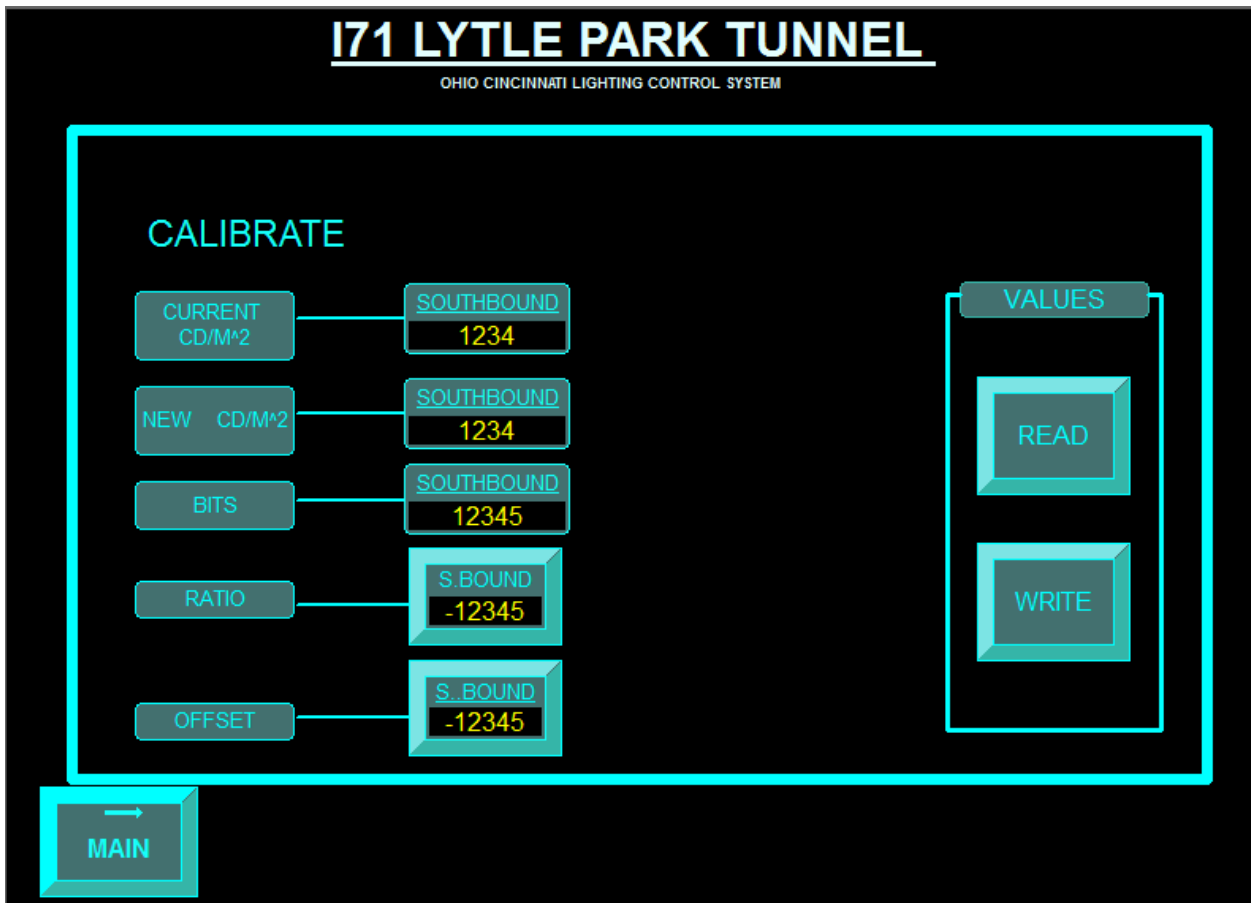
The signal conversion to engineering units is accomplished using a ratio and offset. The ratio is defined as the Candelas per square meter (Cd/m²) per controller resolution bit. The offset is defined as the bit value when the sensor sees 0 Cd/m².

8.1. CALIBRATION SEQUENCE

. Select "Read". Now adjust the "Ratio" and "Offset" as desired.

8.2. CALIBRATION CONFIRMATION

Select "write" to down load the new values.



CURRENT CD/M²

Shows the current value of the luminance sensor scaled in candelas per meter square.

NEW CD/M²

The **NEW CD/M²** is used in the calibration calculation to preview the changes.

BITS:

The bits columns are the raw data that are inside the analog/digital converter. The values will be in between 0 and 32,000.

RATIO:

The ratio are utilize to divide the bits into Scaled engineering units.

OFFSET:

ALLOWS THE OPERATOR TO ADJUST THE SENSORS

To trim to zero at night

READ:

Pressing the **Read** pushbutton allows the operator to view current controller calibration settings.

To change the calibration setpoint:

1. Press **Read** pushbutton to retrieve the current scaling values.
2. Enter a new ratio, using the Data Keypad followed by **Enter** key and **Done** key.
3. Enter a new offset, using the Data Keypad followed by **Enter** key and **Done** key.
4. The display returns to the CALIBRATE screen, where the NEW CD/M² values are updated.

WRITE:

Changes the calibration data in the controller to the new value.

NAVIGATION

MAIN: Back to the Main menu screen.

9. STAGGER

The **STAGGER** times are used to prevent all level outputs from starting and stopping simultaneously, especially after the resumption of power during a bright day, when the maximum contrast level is called by the controller. Each level's stagger timer is additive based on the transition event.

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STAGGER **SECONDS DELAY**

	SB TUNNEL		SB RAMP				
LEVEL 1	123	LEVEL 4	123	LEVEL 11	123	LEVEL 14	123
LEVEL 2	123	LEVEL 5	123	LEVEL 12	123	LEVEL 15	123
LEVEL 3	123	LEVEL 5	123	LEVEL 13	123	LEVEL 16	123

VALUES: READ, WRITE

MAIN

PI

9.1. STAGGER ON

The **STAGGER ON** times are used to delay the output from operating upon resumption of power. Select the stagger to be adjusted and enter new value.

10. TREND

The trending shows the level multiplied by the stage on/off status. This is trended in CD/M2, and allows the operator to visually see the time when the a light level is activated or deactivated in the tunnel.



The second set of Trends show the dimming output for all levels. This allows the operator to see how the lighting is being ramped up and down as the outside luminance meter reacts to weather conditions.



10.1. COMMON TREND FEATURES

At the top of the screen are two displays.

LUM CD/M²

Luminance sensor reading in Candela per square meter.

LEVEL

Automatic Controller Output level.

DIMMING

Output of current dimming level.

Current trend for Lighting Levels with different colored lines.

Each trend is scaled by each level's ON setpoint.

Note: The Trend graph only samples 1 point every 30 seconds. For each single graph only holds 6 hours of activity. Trends graph line will stay at 5,000 cd/m² when exceeded. Exterior Luminance CD/m² value will indicate current value.

NAVIGATION

Each of the trend screens navigates to other displays.

MAIN: Back to the Main menu screen.

LUM TREND shows the luminance meter trend

11. ALARM DISPLAYS

The **Alarm** screen is displayed when the **MAIN MENU ALARM** pushbutton is pressed. Alarms monitor specific information in the controller.

When the alarm is active, is it displayed on the screen. The screen buffers 200 alarms.

There are two types of alarm screens -
Alarm Summary and Alarm History.

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ALARM HISTORY ACTIVE ALARM ACK ALARM RETURN TO NORMAL EVENT

PRIORITY	DATE	TIME	DESCRIPTION	VALUE
999	MM/DD/YY	HH:MM	XXX	9999.99
999	MM/DD/YY	HH:MM	XXX	9999.99
999	MM/DD/YY	HH:MM	XXX	9999.99
999	MM/DD/YY	HH:MM	XXX	9999.99

NORTHBOUND MAIN MENU SOUTHBOUND MAIN MENU HELP ALARM SUMMARY TOUCH MESSAGES FOR ALARM CONSOLE

PLC

11.1. ALARM HISTORY

Alarm History will log all alarm events, their acknowledgements, and return to normal as a date and time stamped log. If an alarm is intermittent, and is reset, it will appear again with a separate date and time. The history shows logs all alarm transactions.

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CINCINNATI OHIO LIGHTING CONTROL SYSTEM

ALARM SUMMARY

ACTIVE ALARMACK ALARMRETURN TO NORMALEVENT

PRIORITY	DATE	TIME	DESCRIPTION	VALUE
999	MM/DD/YY	HH:M	XX	9999.9
999	MM/DD/YY	HH:M	XX	9999.9
999	MM/DD/YY	HH:M	XX	9999.9
999	MM/DD/YY	HH:M	XX	9999.9

→
NORTHBOUND
MAIN MENU→
SOUTHBOUND
MAIN MENU→
HELP→
ALARM
HISTORY

TOUCH
MESSAGES FOR
ALARM CONSOLE



11.2. ALARM SUMMARY

Alarm Summary shows only the last state of current alarms in the system. When is active, it is shown on the alarm summary. After it is acknowledged and returns to normal, it no longer appears in the summary.

ALARM DEFINITIONS

ACTIVE ALARM:

Yellow Text on Background. Intermittent alarms are latched by the controller, and displayed as active. The intermittent condition may have cleared, but the first instance of the alarm is logged.

ACKNOWLEDGED ALARM:

Red Solid Text. Alarms which have been acknowledged, but still have the activating condition are shown.

RETURN TO NORMAL

Blue solid text. Alarms, which have been acknowledged and the underlying condition has been cleared are shown.

EVENT

Non Alarms, White solid text.

Events are non-alarm activities, which are logged.



Figure 19.4 Alarm Manager Console

11.3. ALARM MANAGER CONSOLE

Pressing anywhere inside the alarm messages will pop up the alarm manager console as shown in Figure 8.4. Scrolling buttons on the right side allows the operator to go to the beginning of the alarm list, up a page, or up a single message line. Likewise buttons allow the operator to navigate down a message, down a page, or to the end of the list. Along the bottom of the display buttons allow individual alarms to be acknowledged and cleared, as well as all alarms to be cleared.

ALARM HELP

.Directional buttons: Click to move the selection within the message list
 Scroll to the beginning of the list.
 Scroll the selection up one page.
 Scroll the selection up.
 Scroll the selection down.
 Scroll the selection down one page.
 Scroll to the end of the list.
 The Acknowledge and Clear Current buttons apply to the currently selected message.
 Acknowledge: Click to acknowledge the currently selected alarm message.
 Clear Current: Click to remove the currently selected alarm message from the alarm display.
 Clear All: Click to remove all messages in the currently selected queue.
 Set Filter: Click to change the Alarm Group associated with this Alarm Display.
 Set Priority: Not used
 Print: Not used.
 Exit: Click to close the Alarm Manager screen.

11.4. ALARM COCONNSOLE HELP

The Alarm Console Help summarizes alarm keys for alarm manager console operation.

*Directional buttons: Click to move the selection
Within the message list.*

Scroll to the beginning of the list.

Scroll the selection up one page.

Scroll the selection up.

Scroll the selection down

Scroll the selection down one page.

Scroll to the end of the list

The acknowledge and clear current buttons apply to the currently selected message.

Acknowledge: Click to acknowledge the current selected alarm message.

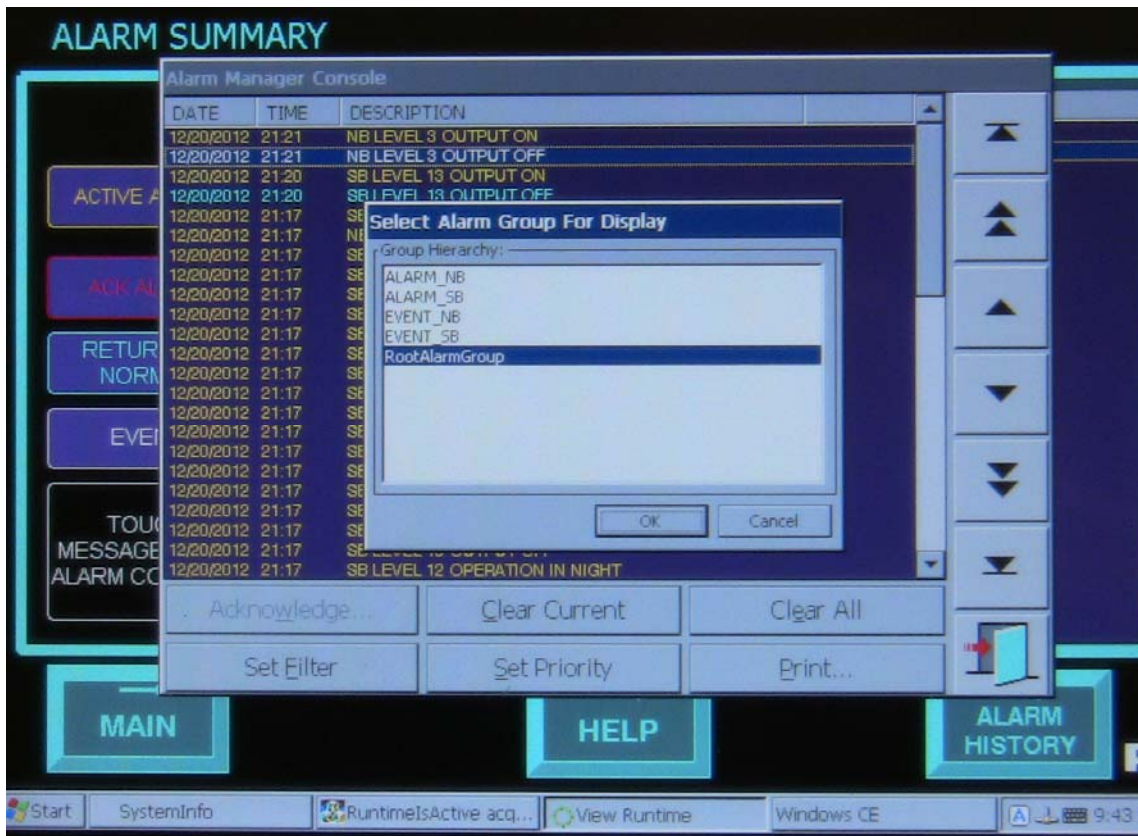
Clear Current: Click to remove the currently selected alarm message from the alarm display.

Set Filter: Click to change the Alarm Group associated with this alarm display.

Set Priority: Not used.

Print: Not used.

Exit: Click to close the Alarm Manager screen.



11.5. SET ALARM GROUPS FILTER

Pressing the Set Filter button on the Alarm Manager Console brings up a second pop up screen. The alarm groups are shown and one can be selected to filter the alarms as shown in Figure 8.5.

The groups are:

Alarms NB – Northbound Operational Alarms

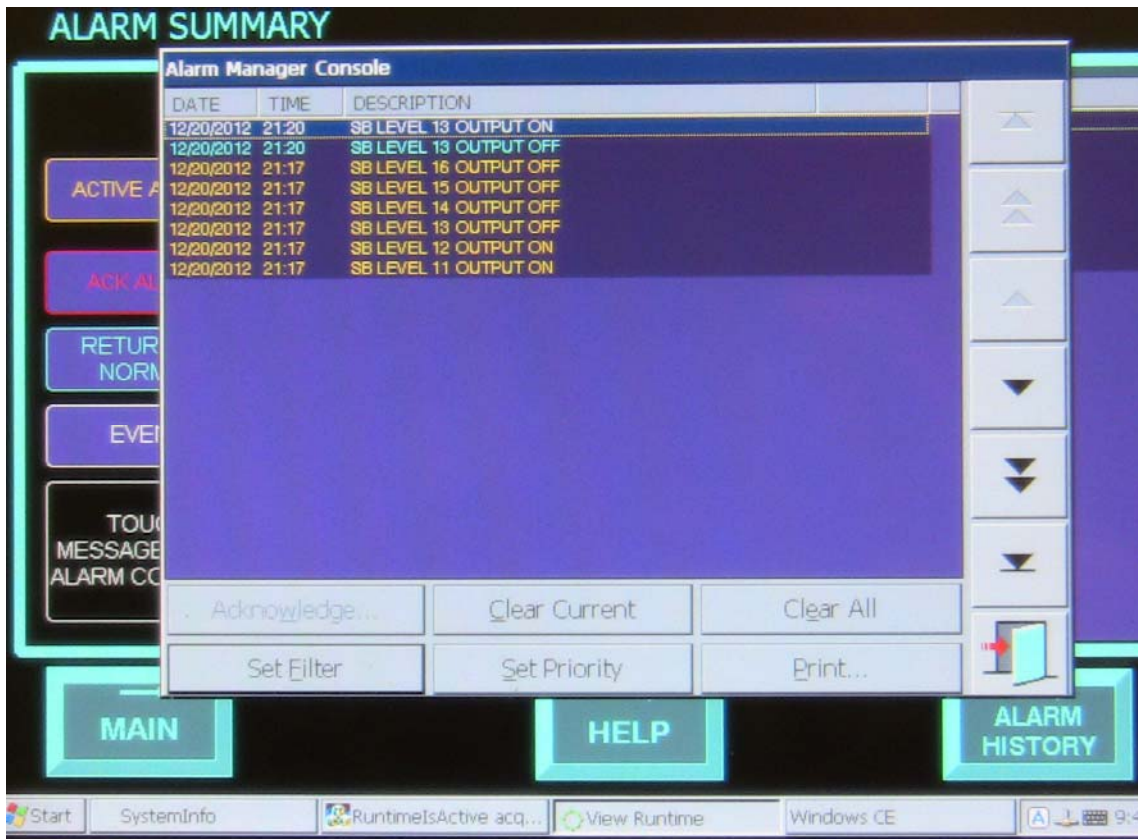
Alarms WB – Southbound Operational Alarms

Alarm Gen – General Alarms

Events NB- Northbound Normal Events

Events WB – Southbound Normal Events

Rootalarmgroup – Internal diagnostic & configuration messages.



The above screen shows a filtered group of messages.

NAVIGATION:

EXIT DOOR: Returns to previous alarm screen

MAIN: Returns to Main Menu

HELP: Alarm display and alarm Manager Console Help

ALARM HISTORY: Toggles to Alarm History

ALARM SUMMARY: Toggles to Alarm Summary

12. SYSTEM UTILITIES

The system UTILITY screen shows the status for Wash Tank, UPS Failure, Luminance meter health, PLC Battery alarm, PLC Heart beat or watch dog timer. The set point for the contactor alarm timers can also be adjusted from this screen. The lighting system can operate in one of three modes this screen allows the operate to select the mode of operation, Local, Off, Auto. A full explanation of these modes is given in the sequence of operations. The current mode that the system is in is displayed and is also shown on the Main OIT screen.

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CINCINNATI OHIO LIGHTING CONTROL SYSTEM

SOUTHBOUND SYSTEM MODE AND STATUS

	Current Selection	Select Mode
SYSTEM MODE	AUTO	LOCAL OFF AUTO
Contactorm Alarm Timer	Seconds 1234	
WASH TANK	OK	
UPS FAILURE	OK	
NB LUM SENSOR	OK	
ASTRO	DAY	
PLC BATTERY	OK	
PLC WDT	PLC HEARTBEAT 1234	



12.1. SYSTEM OPERATING MODE

Pressing System from the MAIN menu displays the System Operating Mode screen. The following indicators and selections are available:

12.2. SYSTEM MODE

SYSTEM MODE supersedes individually edited lighting levels. All **SYSTEM MODE** actions only apply to contactors with selector switches in their AUTO position and their respective dimming circuits.

12.2.1. MODE CONTROL

Three modes of operation are used.

Automatic- lighting is controlled based on the luminance meter readings.

Local – Manual mode from the lighting control panel.

Off Mode-Contactors left in last state and dim level set to maximum.

SCADA – The levels can be read from the scada at any time

12.2.2. AUTOMATIC MODE

- 1) All HOA switches are in “Auto”
- 2) Each of the six Levels of control are in “Run” mode and “Auto” control this is done through the operator screen with the required password.

12.2.3. LOCAL MODE

- 1) All HOA switches are in “Auto”
- 2) Any one or all of the six Levels of control are in “Program” mode and “Manual On” or “Manual Off” control. This is done through the operator screen with the required password. The operator will also enter a desired dimming level if applicable for that particular stage.

12.2.4. OFF MODE

- 1) All HOA switches are in “Auto”
- 2) The operator selects the “Off Mode” this is done through the operator screen with the required password. This disables the Led dimming sequence for all levels, and leaves the contactors in their last state. The luminaires or sent to their full luminous output state.

12.2.5. SCADA

- 1) Any of the data listed in the Scada Interface section can read by the SCADA.

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CINCINNATI OHIO LIGHTING CONTROL SYSTEM

NORTHBOUND ASTRO WIPER

ASTRO BYPASS OK?

Bypass Off

BYPASS

Astro Force to Day

YES

Astro Force to Night

YES

Day On

RESET RUNTIME HOURS?

Reset Off

RESET

Start Lens Clean

YES

Clean Started

Stopped

Clean Time Sec.

Seconds

123

→
MAIN

→
SYS MODE
STATUS



12.3. ALARM TIMER

Alarm Timer allows the operator to adjust the time delays used in creating ALARMS for the contactor feed back errors.

12.4. WASH TANK

Indicates that the wash tank reservoir is low or OK.

12.5. UPS FAILURE

UPS power is supplied to the tunnel lighting controller.

OK indicates that UPS power is available.

FAULT indicates that UPS power is not present.

12.6. NB AND SB LUMIANCE SENSOR.

Each luminance sensor is monitored to determine whether it is providing a signal within its normal range.

If a luminance sensor doesn't provide a signal for 16 hours, then the indicator shows and alarm state.

OK indicates that the luminance sensor is operating within its normal range.

FAULT indicates that the luminance sensor has not operated for at least 16 hours.

12.7. PLC BATTERY

The health of the PLC battery is monitored.

When the battery charge becomes low, an alarm is generated and the battery must be replaced.

OK indicates that the PLC battery is charged above its low limit.

FAULT indicates that the PLC battery is charged below its low limit and should be replaced.

12.8. ASTRO BYPASS

Allows the operator to bypass the Astro input forcing the input to the desired state.

12.9. RESET RUNTIME HOURS

Allows the operator to reset runtime hours to zero.

12.10. LENS CLEAN

Allows the operator to start a lens clean for a specified amount of time which is adjustable. When the clean is complete the status will show "Stopped".

13. LOG IN

There are four users defined in the system

User	Password	Level
Master	9824	Admin
Admin	7777	3
Engineer	6666	2
Operator	5555	1

To log on select the "Log in" button enter in the User name and Password. The access level will be displayed once you have successfully logged on. Admin and Engineers can change set points modes etc.. Operators are restricted to view only. The Master can change users and passwords.



14. PARAMETER SUMMARY

The following list is the summary of parameters used in the tunnel lighting control system.

Function										
Stage	Level	Mode	Control	Operation	Hi	Low	Tin	Thold	Tdn	THoff
	1	Run	Auto	Contrast	0	100	5	5	5	5
	2	Run	Auto	Contrast	101	250	5	5	5	5
	3	Run	Auto	Contrast	251	1500	5	5	5	5
	4	Run	Auto	Contrast	1501	3000	5	5	5	5
	5	Run	Auto	Contrast	3001	6000	5	5	5	5
	6	Run	Auto	Contrast	6001	10000	5	5	5	5
	Sensor	Ratio	Offset	Range						
Sen Cal	TLUM1	3.20	0	10,000Cd/m ²						
	L1	L2	L3	L4	L5	L6				
Stagger	0	5	10	15	20	25				
	Level or Stage	Band Low	Band Width	Driver Hi	Driver Low	Resp. Time	Out-put %	Out-put VDC		
	1	0	100	8.5	1.5	30	30	3.6		
	2	100	150	8.5	1.5	30	40	4.3		
	3	250	1250	8.5	1.5	30	50	5.0		
	4	1500	1500	8.5	1.5	30	70	6.4		
	5	3000	3000	8.5	1.5	30	80	7.1		
	6	6000	4000	8.5	1.5	30	100	8.5		

15. SCADA INTERFACE

The tunnel lighting controller communicates with the Supervisory Control and Data Acquisition (SCADA) system, allowing for configuration, monitoring. The interface uses MODBUS registers to map information, Modbus TCP as the communication protocol and Ethernet 10 Mb/s as the physical connection.

15.1. MODBUS OFFSET.

The tunnel lighting controller's use GE Address %R1000, there is an offset of 1 when polling the PLC for Modbus registers in the 4x range. Example: SCADA polls address 401000 the data is read from GE address %R1001.

Typical Mapping:

401000 = %R1001
401001 = %R1002
401002 = %R1003

ETC.

15.2.3. SOUTHBOUND CONTACTOR STATUS

Each contactor has two states, On or Off, and is initiated from either the Auto or Local control Domain.

NORMAL. Control output and contactor feedback match after 5 seconds.

ALARM Control output and contactor feedback mismatch after 5 seconds.

When contactor Hand or Off switch position is selected, Contactor Status is not valid.

MODBUS ADDRESS #	SCADA R/W	CONTACTOR ERROR	LEVEL	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
401040	R	NOT USED	NA	NA	1, 2	NORMAL	ALARM
401041	R	SE C1 CONTACTOR STATUS	3/4	SE-C1	1, 2	NORMAL	ALARM
401042	R	SE C2 CONTACTOR STATUS	5/6	SE-C2	1, 2	NORMAL	ALARM
401043	R	SW C1 CONTACTOR STATUS	3/4	SW-C1	1, 2	NORMAL	ALARM
401044	R	SW C2 CONTACTOR STATUS	5/6	SW-C2	1, 2	NORMAL	ALARM
401045	R	RE C1 CONTACTOR STATUS	3/4	RE-C1	1, 2	NORMAL	ALARM
401046	R	RE C2 CONTACTOR STATUS	5/6	RE-C2	1, 2	NORMAL	ALARM
401047	R	RW C1 CONTACTOR STATUS	3/4	RW-C1	1, 2	NORMAL	ALARM
401048	R	RW C2 CONTACTOR STATUS	5/6	RW-C2	1, 2	NORMAL	ALARM

15.2.4. SOUTHBOUND LEVEL LIGHTING CONTROLLER OUTPUT

The Tunnel lighting control output displays the initiation signal to the lighting contactors in each of the D1, D2, D3, and D4 groups. The Tunnel Lighting controller output has two states ON or OFF. The state is determined by either the Run state of the controller, Manual ON, Manual OFF or Auto.

MODBUS ADDRESS	SCADA R/W	DESCRIPTION	LEVEL	RANGE	VALUE=1	VALUE=2
401060	R	NOT USED				
401061	R	LEVEL 1 LTG CTRL OUTPUT	1	1, 2	ON	OFF
401062	R	LEVEL 2 LTG CTRL OUTPUT	2	1, 2	ON	OFF
401063	R	LEVEL 3 LTG CTRL OUTPUT	3	1, 2	ON	OFF
401064	R	LEVEL 4 LTG CTRL OUTPUT	4	1, 2	ON	OFF
401065	R	LEVEL 5 LTG CTRL OUTPUT	5	1, 2	ON	OFF
401066	R	LEVEL 6 LTG CTRL OUTPUT	6	1, 2	ON	OFF

15.2.5. SOUTHBOUND DIMMING STATUS

Each level's dimming output is a number in the range of 0-100%.

MODBUS ADDRESS #	SCADA R/W	CONTACTOR ERROR	LEVEL	RANGE	UNITS
401080		NOT USED			
401081	R	LEVEL 1 DIMMING STATUS	1	0-100	%
401082	R	LEVEL 2 DIMMING STATUS	2	0-100	%
401083	R	LEVEL 3 DIMMING STATUS	3	0-100	%
401084	R	LEVEL 4 DIMMING STATUS	4	0-100	%
401085	R	LEVEL 5 DIMMING STATUS	5	0-100	%
401086	R	LEVEL 6 DIMMING STATUS	6	0-100	%

15.2.6. SOUTHBOUND LUMINANCE SENSOR STATUS

If the TLUM sensor does not rise above .03% of its range during a period of 16 hours (generally longest continental US night), an ALARM is generated .The alarm is automatically reset and the state returns to NORMAL when TLUM sensor rises above .03% of the sensor range.

MODBUS ADDRESS #	SCADA R/W	TLUM ALARM	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
401090	R	LUMINANCE SENSOR STATUS	N/A	1, 2	NORMAL	ALARM

15.2.7. SOUTHBOUND LUMINANCE SENSOR READING

The TLUM reading is an average of 5 one second samples. It is calculated and updated every 5 seconds.

MODBUS ADDRESS #	SCADA R/W	DESCRIPTION	RANGE	UNITS
401091	R	LUMINANCE SENSOR READING	0-10,000	CD/M ²

15.2.1. SOUTHBOUND SYSTEM MODE

The Southbound SYSTEM MODE overrides individually configured levels and their associated contactors and dimmers. It is an enumerated value with the following definition

MODBUS ADDRESS #	SCADA R/W	DESCRIPTION	RANGE	DEFINITION
401092	R	SYSTEM MODE	1-3	1=Auto 2=Local

				3=Off
--	--	--	--	-------

15.3. NORTHBOUND MODBUS READ STATUS MEMORY MAP

The following tables include tunnel lighting controller status which is read by the SCADA system. Each Modbus value is an integer. Nominally, the normal or active value is 1, and the alarm or off value is 2.

15.3.1. NORTHBOUND HAND/OFF/AUTO SELECTOR SWITCH STATUS

The Auto Position of the Hand/Off/Auto Selector switches is monitored. Hand and Off electrically override all auto commands.

MODBUS ADDRESS	SCADA R/W	DESCRIPTION	LEVEL	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
401000	R	NOT USED	NA	NA	1, 2	AUTO	MANUAL
401001	R	NE C1 HOA SWITCH	3/4	NE-C1	1, 2	AUTO	MANUAL
401002	R	NE C2 HOA SWITCH	5/6	NE-C2	1, 2	AUTO	MANUAL
401003	R	NW C1 HOA SWITCH	3/4	NW-C1	1, 2	AUTO	MANUAL
401004	R	NW C2 HOA SWITCH	5/6	NW-C2	1, 2	AUTO	MANUAL
401005	R	NOT USED	NA	NA			
401006	R	NOT USED	NA	NA			

15.3.2. NORTHBOUND CONTACTOR OUTPUT

Contactor Output command has two states, On or Off, and is initiated from Auto or Local control Domain.

MODBUS ADDRESS #	SCADA R/W	DESCRIPTION	LEVEL	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
------------------	-----------	-------------	-------	------------	-------	---------	---------

401020	R	NOT USED	NA	NA	1, 2	ON	OFF
401021	R	NE C1 CONTACTOR OUTPUT	3/4	NE-C1	1, 2	ON	OFF
401022	R	NE C2 CONTACTOR OUTPUT	5/6	NE-C2	1, 2	ON	OFF
401023	R	NW C1 CONTACTOR OUTPUT	3/4	NW-C1	1, 2	ON	OFF
401024	R	NW C2 CONTACTOR OUTPUT	5/6	NW-C2	1, 2	ON	OFF
401025	R	NOT USED	NA	NA	1, 2	ON	OFF
401026	R	NOT USED	NA	NA	1, 2	ON	OFF

15.3.3. NORTHBOUND CONTACTOR STATUS

Each contactor has two states, On or Off, and is initiated from either the Auto or Local control Domain.

NORMAL. Control output and contactor feedback match after 5 seconds.

ALARM Control output and contactor feedback mismatch after 5 seconds.

When contactor is in Hand or Off switch position is selected, Contactor Status is not valid.

MODBUS ADDRESS #	SCADA R/W	CONTACTOR ERROR	LEVEL	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
401040	R	NOT USED	NA	NA	1, 2	NORMAL	ALARM
401041	R	NE C1 CONTACTOR STATUS	3/4	NE-C1	1, 2	NORMAL	ALARM
401042	R	NE C2 CONTACTOR STATUS	5/6	NE-C2	1, 2	NORMAL	ALARM
401043	R	NW C1 CONTACTOR STATUS	3/4	NW-C1	1, 2	NORMAL	ALARM
401044	R	NW C2 CONTACTOR STATUS	5/6	NW-C2	1, 2	NORMAL	ALARM
401045	R	NOT USED	NA	NA	1, 2	NORMAL	ALARM
401046	R	NOT USED	NA	NA	1, 2	NORMAL	ALARM

15.3.4. NORTHBOUND LEVEL LIGHTING CONTROLLER OUTPUT

The Tunnel lighting control output displays the initiation signal to the lighting contactors in each of the D1, D2, D3, and D4 groups. The Tunnel Lighting controller output has two states ON or OFF. The state is determined by either the Run state of the controller, Manual ON, Manual OFF or Auto.

MODBUS ADDRESS	SCADA R/W	DESCRIPTION	LEVEL	RANGE	VALUE=1	VALUE=2
401060	R	NOT USED				
401061	R	LEVEL 1 LTG CTRL OUTPUT	1	1, 2	ON	OFF
401062	R	LEVEL 2 LTG CTRL OUTPUT	2	1, 2	ON	OFF
401063	R	LEVEL 3 LTG CTRL OUTPUT	3	1, 2	ON	OFF
401064	R	LEVEL 4 LTG CTRL OUTPUT	4	1, 2	ON	OFF
401065	R	LEVEL 5 LTG CTRL OUTPUT	5	1, 2	ON	OFF
401066	R	LEVEL 6 LTG CTRL OUTPUT	6	1, 2	ON	OFF

15.3.5. NORTHBOUND DIMMING OUTPUT

Each level's dimming output is a number in the range of 0-100%.

MODBUS ADDRESS #	SCADA R/W	CONTACTOR ERROR	LEVEL	RANGE	UNITS
401080		NOT USED			
401081	R	LEVEL 1 DIMMING STATUS	1	0-100	%
401082	R	LEVEL 2 DIMMING STATUS	2	0-100	%
401083	R	LEVEL 3 DIMMING STATUS	3	0-100	%
401084	R	LEVEL 4 DIMMING STATUS	4	0-100	%
401085	R	LEVEL 5 DIMMING STATUS	5	0-100	%
401086	R	LEVEL 6 DIMMING STATUS	6	0-100	%

15.3.6. NORTHBOUND LUMINANCE SENSOR STATUS

If the TLUM sensor does not rise above .03% of its range during a period of 16 hours (generally longest continental US night), an ALARM is generated. The alarm is automatically reset and the state returns to NORMAL when TLUM sensor rises above .03% of the sensor range.

MODBUS ADDRESS #	SCADA R/W	TLUM ALARM	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
401090	R	LUMINANCE SENSOR STATUS	N/A	1, 2	NORMAL	ALARM

15.3.7. NORTHBOUND LUMINANCE SENSOR READING

The TLUM reading is an average of 5 one second samples. It is calculated and updated every 5 seconds.

MODBUS ADDRESS #	SCADA R/W	DESCRIPTION	RANGE	UNITS
401091	R	LUMINANCE SENSOR READING	0-10,000	CD/M ²

15.3.8. NORTHBOUND SYSTEM MODE

The Southbound SYSTEM MODE overrides individually configured levels and their associated contactors and dimmers. It is an enumerated value with the following definition

MODBUS ADDRESS #	SCADA R/W	DESCRIPTION	RANGE	DEFINITION
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15.3.10.NORTHBOUND CONTACTOR STATE

Each contactor can be switched on off from the SCADA.

Override: This take control of the contactor and will result in the contactor being driven to the selected desired state on or off as selected by the state property.

State: This specifies what state to drive the contactor to either on or off

When contactor Hand or Off switch position is selected, Contactor CAN not be overridden.

MODBUS ADDRESS #	SCADA R/W	CONTACTOR STATE	LEVEL	CONT-ACTOR	RANGE	VALUE=1	VALUE=2
401121	R/W	NE DN OVERRIDE	DN	NE-DN	1, 2	ON	OFF
401122	R/W	NW DN OVERRIDE	DN	NW-DN	1, 2	ON	OFF
401123	R/W	NE C1 CONTACTOR STATE	3/4	NE-C1	1, 2	ON	OFF
401124	R/W	NE C2 CONTACTOR STATE	5/6	NE-C2	1, 2	ON	OFF
401125	R/W	NW C1 CONTACTOR STATE	3/4	NW-C1	1, 2	ON	OFF
401126	R/W	NW C2 CONTACTOR STATE	5/6	NW-C2	1, 2	ON	OFF

15.3.11.NORTHBOUND DIMMING SELECTION

Each dimming output is a number in the range of 0-100%.

MODBUS ADDRESS #	SCADA R/W	DIMMING	LEVEL	RANGE	UNITS
401151	R/W	DN-NE DIMMING SELECTION	DN-NE	0-100	%
401152	R/W	DN-NW DIMMING SELECTION	DN-SW	0-100	%
401153	R/W	NE C1 DIMMING SELECTION	3-4 NE-C1	0-100	%
401154	R/W	NE C2 DIMMING SELECTION	5-6 NE-C2	0-100	%
401155	R/W	NW C1 DIMMING SELECTION	3-4 NW-C1	0-100	%
401156	R/W	NW C2 DIMMING SELECTION	5-6 NW-C2	0-100	%



Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

BILL OF MATERIAL

IT.	QTY	TAG	DESCRIPTION	MFR.	CAT.NO.
1	1		ENCLOSURE, 47x32x16, NEMA 12 INCLUDING MOUNTING PANEL, 46x31	HOFFMAN	G1200800400G
	1		SIDE MOUNTING PAN, 46x14	HOFFMAN	G1200SMP400
	1		SIDE MOUNTING PAN, HALF, 23x14	HOFFMAN	G1200SMP400H
	1		MOUNTING RAILS, FRONT & BACK	HOFFMAN	GAMR1200
	1		MOUNTING RAILS, SIDE	HOFFMAN	G50SMR400
	1		SWING PANEL, ALUMINUM	HOFFMAN	GSP1200800A
	1		WINDOW, 23X15	HOFFMAN	APWK2315NF
	1		HANDLE, PADLOCK	HOFFMAN	GPDLOCKHDL
2	1	F1	KIT, COOLING FAN, 4", TYPE 12, 120VAC	HOFFMAN	TFP41UL12
	1		KIT, EXHAUST, 4"	HOFFMAN	TEP4UL12
	1	F1	THERMOSTAT	HOFFMAN	ATEMNO
	1	H1	100W 120V HEATER W/T-STAT	HOFFMAN	DAH1001A
	1	CL	LED LIGHT FIXTURE W/SWITCH	HOFFMAN	LEDA1S35
	1	DS	DOOR SWITCH ASSEMBLY	HOFFMAN	ALFSWD
	1	GFCI	OUTLET, GFCI, 15A, DIN-MNT, EM-DUO120/15/GFI	PHOENIX CONTACT	5600462
3	2		WIREWAY 3X4 WHITE	PANDUIT	F3X4WH6
	2		WIREWAY COVER 3" WHT	PANDUIT	C3WH6
	2		WIREWAY 2X4 WHITE	PANDUIT	F2X4WH6
	2		WIREWAY COVER 2" WHT	PANDUIT	C2WH6
	1		BARRIER, HI/LO VOLTAGE	PLC	A016P
4	7	TB1,2,N-DB	TB,ST 2.5	PHOENIX CONTACT	3031212
	3	TB1,2,N-DB	END SECTION,D-ST 2.5	PHOENIX CONTACT	3030417
	1	SW1	TB,SPRING-CAGE,SWITCH	PHOENIX CONTACT	3036343
	1	SW1	END SECTION, GREY	PHOENIX CONTACT	3030488
	13	TB3,4	TB, ST 2.5-3L	PHOENIX CONTACT	3036042
	5	N24,P24	TB,ST 2.5-3PV	PHOENIX CONTACT	3036068
	4		END SECTION,D-ST 2.5-3L	PHOENIX CONTACT	3036660
	11	TB5	TB, STTB 2.5	PHOENIX CONTACT	3031270
	1	TB5	END SECTION, D-STTB 2.5	PHOENIX CONTACT	3030459
	4	TB6	TB,STTB 4	PHOENIX CONTACT	3031429
	1	TB6	END SECTION,D-STTB 4	PHOENIX CONTACT	3030462
	19		END BRACKET, CLIPFIX 35	PHOENIX CONTACT	3022218
	1	G-BUS	GROUND BAR	SQD	PK23GTA-L
	3		DIN RAIL	DUNN	B C103PM
5	1	CB1	CIRC. BKR. 5A-1P 120V	SQD	9080-GCB50
	2	CB2,4	CIRC. BKR. 1A-1P 120V	SQD	9080-GCB10
	1	CB3	CIRC. BKR. 2A-1P 120V	SQD	9080-GCB20
6	2	FU1,13	FUSE HLDR,1-P,10X38mm,32A@600V	OMEGA	ASK-4-1
	11	FU2-12	FUSE HOLDER, SCREW-CAP	PHOENIX CONTACT	3005109
	1	FU10	FUSE 63mA,FAST ACTING,5X20	BUSSMANN	GMA 63mA
	1	FU5	FUSE 200mA,FAST ACTING,5X20	BUSSMANN	GMA 200mA
	1	FU11	FUSE 500mA,FAST ACTING,5X20	BUSSMANN	GMA 500mA
	1	FU12	FUSE 500mA,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 500mA
	1	FU13	FUSE 500mA,TIME DELAY,500V	BUSSMANN	FNQ-1/2
	2	FU4,6	FUSE 800mA,FAST ACTING,5X20	BUSSMANN	GMA 800mA
	1	FU8	FUSE 1A,FAST ACTING,5X20	BUSSMANN	GMA 1A
	1	FU3	FUSE 1.5A,FAST ACTING,5X20	BUSSMANN	GMA 1.5A
	1	FU7	FUSE 3A,SLOW BLOWING,5X20	BUSSMANN	GMD 3A
	1	FU9	FUSE 3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 3A
	1	FU2	FUSE 6.3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 6.3A
	1	FU1	FUSE 15A,TIME DELAY,500V	BUSSMANN	FNQ-15
7	1	T1	XFMR,1.5kVA,277/120	SQD	9070-T1500D4
	1	T1	KIT, FINGERSAFE COVER	SQD	9070FSC2
	1	T2	XFMR,50VA,120/24	SQD	9070-T50D23
	1	T2	FINGER-SAFE COVER	SQD	9070FSC1

IT.	QTY	TAG	DESCRIPTION	MFR.	CAT.NO.
8	1	DC PS	POWER SUPPLY, 24VDC, 240W	PHOENIX CONTACT	2903149
	1	UPS	UPS, 24V, 10A	PHOENIX CONTACT	2320225
	1	B1	AGM, 24V, 12Ah	PHOENIX CONTACT	2320322
9	1	PWR.COND.	SURGE SUPPRESSOR,120V,5kA SASD	TRANSTECTOR	1104-15-001
	1	DC-SS1	SURGE SUPPRESSOR,24VDC	TRANSTECTOR	DRDC-24
	1	AC-SS1	277V SURGE SUPPRESSOR	TRANSTECTOR	1101-826
	3	AC-SS2-4	SURGE SUPPRESSOR,24VAC	SUPERIOR ELECTRIC	DIN1P-10-24-1G-15
10A	1	T57-6	TUNNEL LIGHTING CONTROL SYSTEM	PLC	T57-6
11	1	OIT	12" QUICKPANEL PLUS TOUCHSCREEN	GE	IC755CSS12CDB
12	1	ESW N-C	ETHERNET SWITCH, 5 PORT, FL SWITCH 5TX	PHOENIX CONTACT	2891152
	1	TLCP N-C	CISCO TYPE IE-2000-4TS	CISCO	IE-2000-4TS-G-B
14	1	TC N-C	LCM 8I/4O A/D CONTROLLER,24VDC,XD10	CROUZET	88970142
	1	TC N-C	EXTENSION, ETHERNET	CROUZET	88970270
15	6	R1-4,A,B	RELAY, 1-POLE 24VDC COIL, 15A	SCHNEIDER	RPM12BD
	7	R1-4,A-C	SOCKET BASE, RELAY, 1-POLE, MIXED	SCHNEIDER	RPZF1
	7	R1-4,A-C	RETAINER, SPRING CLIP, METAL	SCHNEIDER	RPZR235
	1	R5	RELAY, 4-POLE 24VDC COIL, 15A	SCHNEIDER	RPM42BD
	1	R5	SOCKET BASE, RELAY, 4-POLE, MIXED	SCHNEIDER	RPZF4
	1	RC	RELAY, 1-POLE 24VAC COIL, 15A	SCHNEIDER	RPM12B7
16	4	SS1-4	3 POS SEL SW, RED LENS,22mm	SQD	ZB4BK1343
	4	PL1-4	LIGHT MODULE, 120V LED	SQD	ZB4BW0G43
	8	SS1-4	NO CONTACT BLOCK	SQD	ZBE101
	4	SS1-4	LEGEND: HAND/OFF/AUTO	SQD	ZB2BY2387
	4				Engraving
	1	PB1	OPERATOR, P.B., BLACK, 22mm	SQD	XB4BA21
	1	PB1	LEGEND: ON	SQD	ZB2BY2311
	1				Engraving
NAMEPLATES					
17			NAMEPLATES	SEA' ENGRAV	
	1		BLACK W/WHITE LETTERS, #4-40 SCREW MNT 2"X8", 1-LINE ENGRAVE:		
			"TLCP N-C"		
	1		1"X7", 2-LINE ENGRAVE:		
			"NORTHBOUND / LIGHTING CONTACTORS"		
	1		1"X3", 1-LINE ENGRAVE:		
			"LIGHT TEST"		
	4		1"X3", 2-LINE ENGRAVE:		
			"CONTACTOR / NE-C1" CONTACTOR / NE-C2" "CONTACTOR / NW-C1" "CONTACTOR / NW-C2"		
PHOTODIODE LUMINANCE SENSOR					
18	1	TLUM N-C	TUNNEL LUMINANCE SENSOR	PLC MULTIPOINT	TLUM2
	1	TLUM N-C	ADJUSTABLE MOUNTING BRACKET, POLE	PELCO	EM2000
	1	TLUM N-C	WATER RESEVOIR AND PUMP,101,12m	2BSECURITY	BW1/10-12 (AC24V) EUR
	1	TLUM N-C	ALARM SIGNAL OPTION, WATER RESERVOIR	2BSECURITY	100525 EUR
19	1	TU24C	TLUM REMOTE POWER SUPPLY, 24VAC	PLC MULTIPOINT	TU24C
SPARES					
20	6		FUSE 63mA,FAST ACTING,5X20	BUSSMANN	GMA 63mA
	6		FUSE 200mA,FAST ACTING,5X20	BUSSMANN	GMA 200mA
	6		FUSE 500mA,FAST ACTING,5X20	BUSSMANN	GMA 500mA
	6		FUSE 800mA,FAST ACTING,5X20	BUSSMANN	GMA 800mA
	6		FUSE 1A,FAST ACTING,5X20	BUSSMANN	GMA 1A
	6		FUSE 1.5A,FAST ACTING,5X20	BUSSMANN	GMA 1.5A
	6		FUSE 3A,SLOW BLOWING,5X20	BUSSMANN	GMD 3A
	6		FUSE 500mA,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 500mA
	6		FUSE 3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 3A
	6		FUSE 6.3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 6.3A
	6		FUSE 500mA,TIME DELAY,500V	BUSSMANN	FNQ-1/2
	6		FUSE 15A,TIME DELAY,500V	BUSSMANN	FNQ-15
	1		RELAY, 1-POLE 24VDC COIL, 15A	SCHNEIDER	RPM12BD
	1		RELAY, 4-POLE 24VDC COIL, 15A	SCHNEIDER	RPM42BD
	1		LIGHT MODULE, 120V LED	SQD	ZB4BW0G43

BILL OF MATERIAL
10/4/2017

IT.	QTY	TAG	DESCRIPTION	MFR.	CAT.NO.
1	1		ENCLOSURE, 47x32x16, NEMA 12 INCLUDING MOUNTING PANEL, 46x31	HOFFMAN	G1200800400G
	1		SIDE MOUNTING PAN, 46x14	HOFFMAN	G1200SMP400
	1		SIDE MOUNTING PAN, HALF, 23x14	HOFFMAN	G1200SMP400H
	1		MOUNTING RAILS, FRONT & BACK	HOFFMAN	GAMR1200
	1		MOUNTING RAILS, SIDE	HOFFMAN	G50SMR400
	1		SWING PANEL, ALUMINUM	HOFFMAN	GSP1200800A
	1		WINDOW, 23X15	HOFFMAN	APWK2315NF
	1		HANDLE, PADLOCK	HOFFMAN	GPDLCKHDL
2	1	F1	KIT, COOLING FAN, 4", TYPE 12, 120VAC	HOFFMAN	TFP41UL12
	1		KIT, EXHAUST, 4"	HOFFMAN	TEP4UL12
	1	F1	THERMOSTAT	HOFFMAN	ATEMNO
	1	H1	100W 120V HEATER W/T-STAT	HOFFMAN	DAH1001A
	1	CL	LED LIGHT FIXTURE W/SWITCH	HOFFMAN	LEDA1S35
	1	DS	DOOR SWITCH ASSEMBLY	HOFFMAN	ALFSWD
	1	GFCI	OUTLET,GFCI,15A,DIN-MNT,EM-DUO120/15/GFI	PHOENIX CONTACT	5600462
3	2		WIREWAY 3X4 WHITE	PANDUIT	F3X4WH6
	2		WIREWAY COVER 3" WHT	PANDUIT	C3WH6
	2		WIREWAY 2X4 WHITE	PANDUIT	F2X4WH6
	2		WIREWAY COVER 2" WHT	PANDUIT	C2WH6
	1		BARRIER,HI/LO VOLTAGE	PLC	A016P
4	5	TB1,N-DB	TB,ST 2.5	PHOENIX CONTACT	3031212
	1	TB1	TB,ST 2.5-PE	PHOENIX CONTACT	3031238
	2	TB1,N-DB	END SECTION,D-ST 2.5	PHOENIX CONTACT	3030417
	1	SW1	TB,SPRING-CAGE,SWITCH	PHOENIX CONTACT	3036343
	1	SW1	END SECTION, GREY	PHOENIX CONTACT	3030488
	20	TB3-5	TB, ST 2.5-3L	PHOENIX CONTACT	3036042
	4	N24,P24	TB,ST 2.5-3PV	PHOENIX CONTACT	3036068
	5		END SECTION,D-ST 2.5-3L	PHOENIX CONTACT	3036660
	32	TB6-8	TB,STTB 4	PHOENIX CONTACT	3031429
	3	TB6-8	END SECTION,D-STTB 4	PHOENIX CONTACT	3030462
	21		END BRACKET, CLIPFIX 35	PHOENIX CONTACT	3022218
	1	G-BUS	GROUND BAR	SQD	PK23GTA-L
	3		DIN RAIL	DUNN	B C103PM
5	1	CB1	CIRC. BKR. 5A-1P 120V2	SQD	9080-GCB50
	2	CB2,4	CIRC. BKR. 1A-1P 120V	SQD	9080-GCB10
	1	CB3	CIRC. BKR. 2A-1P 120V	SQD	9080-GCB20
6	2	FU1,15	FUSE HLDR,1-P,10X38mm,32A@600V	OMEGA	ASK-4-1
	11	FU2-14	FUSE HOLDER,SCREW-CAP	PHOENIX CONTACT	3005109
	1	FU10	FUSE 63mA,FAST ACTING,5X20	BUSSMANN	GMA 63mA
	1	FU5	FUSE 200mA,FAST ACTING,5X20	BUSSMANN	GMA 200mA
	2	FU11,12	FUSE 500mA,FAST ACTING,5X20	BUSSMANN	GMA 500mA
	2	FU13,14	FUSE 500mA,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 500mA
	1	FU15	FUSE 500mA,TIME DELAY,500V	BUSSMANN	FNQ-1/2
	2	FU4,6	FUSE 800mA,FAST ACTING,5X20	BUSSMANN	GMA 800mA
	1	FU8	FUSE 1A,FAST ACTING,5X20	BUSSMANN	GMA 1A
	1	FU3	FUSE 1.5A,FAST ACTING,5X20	BUSSMANN	GMA 1.5A
	1	FU7	FUSE 3A,SLOW BLOWING,5X20	BUSSMANN	GMD 3A
	1	FU9	FUSE 3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 3A
	1	FU2	FUSE 6.3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 6.3A
	1	FU1	FUSE 15A,TIME DELAY,500V	BUSSMANN	FNQ-15
7	1	T1	XFMR,1.5kVA,277/120	SQD	9070-T1500D4
	1	T1	KIT, FINGERSAFE COVER	SQD	9070FSC2
	1	T2	XFMR,50VA,120/24	SQD	9070-T50D23
	1	T2	FINGER-SAFE COVER	SQD	9070FSC1

BILL OF MATERIAL
10/4/2017

IT.	QTY	TAG	DESCRIPTION	MFR.	CAT.NO.
8	1	DC PS	POWER SUPPLY, 24VDC, 240W	PHOENIX CONTACT	2903149
	1	UPS	UPS, 24V, 10A	PHOENIX CONTACT	2320225
	1	B1	AGM, 24V, 12Ah	PHOENIX CONTACT	2320322
9	1	PWR.COND.	SURGE SUPPRESSOR,120V,5kA SASD	TRANSTECTOR	1104-15-001
	1	DC-SS1,2	SURGE SUPPRESSOR,24VDC	TRANSTECTOR	DRDC-24
	1	AC-SS1	277V SURGE SUPPRESSOR	TRANSTECTOR	1101-826
	3	AC-SS1-4	TLCP-S-C	SUPERIOR ELECTRIC	DIN1P-10-24-1G-15
10B	1	T57-6	TUNNEL LIGHTING CONTROL SYSTEM	PLC	T57-6
11	1	OIT	12" QUICKPANEL PLUS TOUCHSCREEN	GE	IC755CSS12CDB
12	1	ESW S-C	ETHERNET SWITCH, 5 PORT, FL SWITCH 5TX	PHOENIX CONTACT	2891152
	1	TLCP S-C	CISCO TYPE IE-2000-4TS	CISCO	IE-2000-4TS-G-B
14	1	TC S-C	LCM 8I/4O A/D CONTROLLER,24VDC,XD10	CROUZET	88970142
	1	TC S-C	EXTENSION, ETHERNET	CROUZET	88970270
15	10	R1-8,A,B	RELAY, 1-POLE 24VDC COIL, 15A	SCHNEIDER	RPM12BD
	11	R1-8,A-C	SOCKET BASE, RELAY, 1-POLE, MIXED	SCHNEIDER	RPZF1
	11	R1-8,A-C	RETAINER, SPRING CLIP, METAL	SCHNEIDER	RPZR235
	2	R9,10	RELAY, 4-POLE 24VDC COIL, 3A	SCHNEIDER	792XDX3C-24D
	2	R9,10	SOCKET BASE, RELAY, 4-POLE	SCHNEIDER	70-782E14-1
	2	R9,10	HOLD-DOWN CLIP, PLASTIC	SCHNEIDER	16-782PC-1
	1	RC	RELAY, 1-POLE 24VAC COIL, 15A	SCHNEIDER	RPM12B7
16	8	SS1-8	3 POS SEL SW, RED LENS,22mm	SQD	ZB4BK1343
	8	PL1-8	LIGHT MODULE, 120V LED	SQD	ZB4BW0G43
	16	SS1-9	NO CONTACT BLOCK	SQD	ZBE101
	8	SS1-9	LEGEND: HAND/OFF/AUTO	SQD	ZB2BY2387
	8				Engraving
	1	PB1	OPERATOR, P.B., BLACK, 22mm	SQD	XB4BA21
	1	PB1	LEGEND: ON	SQD	ZB2BY2311
	1				Engraving
NAMEPLATES					
17			NAMEPLATES	SEA' ENGRAV	
			BLACK W/WHITE LETTERS, #4-40 SCREW MNT		
	1		2"X8", 1-LINE ENGRAVE:		
			"TLCP S-C"		
	2		1"X7", 2-LINE ENGRAVE:		
			"SOUTHBOUND / LIGHTING CONTACTORS" "RAMP-E / LIGHTING CONTACTORS"		
	1		1"X3", 1-LINE ENGRAVE:		
			"LIGHT TEST"		
	8		1"X3", 2-LINE ENGRAVE:		
			"CONTACTOR / SE-C1" CONTACTOR / SE-C2" "CONTACTOR / SW-C1" "CONTACTOR / SW-C2"		
			"CONTACTOR / RE-C1" CONTACTOR / RE-C2" "CONTACTOR / RW-C1" "CONTACTOR / RW-C2"		
PHOTODIODE LUMINANCE SENSOR					
18	1	TLUM-BE,BW	TUNNEL LUMINANCE SENSOR	PLC MULTIPOINT	TLUM2
	1	TLUM-BE,BW	ADJUSTABLE MOUNTING BRACKET, POLE	PELCO	EM2000
	1	TLUM N-C	WATER RESEVOIR AND PUMP,101,12m	2BSECURITY	BW1/10-12 (ACEUR
	1	TLUM N-C	ALARM SIGNAL OPTION, WATER RESERVOIR	2BSECURITY	100525 EUR
19	1	TU24C	TLUM REMOTE POWER SUPPLY, 24VAC	PLC MULTIPOINT	TU24C
SPARES					
20	6		FUSE 63mA,FAST ACTING,5X20	BUSSMANN	GMA 63mA
	6		FUSE 200mA,FAST ACTING,5X20	BUSSMANN	GMA 200mA
	6		FUSE 500mA,FAST ACTING,5X20	BUSSMANN	GMA 500mA
	6		FUSE 800mA,FAST ACTING,5X20	BUSSMANN	GMA 800mA
	6		FUSE 1A,FAST ACTING,5X20	BUSSMANN	GMA 1A
	6		FUSE 1.5A,FAST ACTING,5X20	BUSSMANN	GMA 1.5A
	6		FUSE 3A,SLOW BLOWING,5X20	BUSSMANN	GMD 3A
	6		FUSE 500mA,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 500mA
	6		FUSE 6.3A,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 6.3A
	6		FUSE 15A,TIME DELAY,500V	BUSSMANN	FNQ-15
	1		RELAY, 1-POLE 24VDC COIL, 15A	SCHNEIDER	RPM12BD
	1		RELAY, 4-POLE 24VDC COIL, 15A	SCHNEIDER	792XDX3C-24D
	1		LIGHT MODULE, 120V LED	SQD	ZB4BW0G43

IT.	QTY	TAG	DESCRIPTION	MFR.	CAT.NO.
RDE-3					
ALL QUANTITIES X 18 EXCEPT AS NOTED*					
30	1		16X14X6 NEMA 4X 304SS ENCLOSURE	HOFFMAN	A1614CHNFSS
	1		16X14X6 MOUNTING PAN	HOFFMAN	A16P14
31	2	TB1	TB, ST 4-TWIN	PHOENIX CONTACTS	3031393
	1	TB1	TB, ST 4-TWIN-PE	PHOENIX CONTACTS	3031416
	1	TB1	END SECTION, D-ST 4-TWIN	PHOENIX CONTACTS	3030491
	16	TB2, 3	TB, ST 2.5-3L	PHOENIX CONTACTS	3036042
	108	TB4	TB, ST 2.5-PE/L/L	PHOENIX CONTACT	3036097
	3	TB2-4	END SECTION, D-ST 2.5-PE/L/L	PHOENIX CONTACTS	3036660
	10		END BRACKET, CLIPFIX 35	PHOENIX CONTACTS	3022218
	1		DIN RAIL	PLC	B C103PM
32	1	PS	POWER SUPPLY,30W 277/120-24VDC	TDK	DSP30-24/277A
33	1	FU1	FUSE HOLDER,DIN MOUNT, 10x38mm	OMEGA	ASK 4-1
	8	FU2-9	FUSE HOLDER,KNIFE-SW,UK 5-HESI	PHOENIX CONTACT	3004100
	1	FU1	FUSE 250mA, TIME-DELAY, 500V, 10x38mm	BUSSMANN	FNQ 1/4
	3	FU2-4	FUSE 400mA,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 400mA
	3	FU5-7	FUSE 250mA,FAST ACTING,5X20	BUSSMANN	GMA 250mA
34	3	I/V	UNIVERSAL TRANSMITTER, 0-20mA/0-10V	AUTOMATION DIRECT	884116
	1		DISPLAY/PROGRAMMING FRONT	AUTOMATION DIRECT	884501
35	3	DA4	DIMMING DRIVER MODULE	PLC	DA-4
	2	R1,2	RELAY, 4-POLE 24VDC COIL, 6A	SCHNEIDER	RXM4AB2BD
	2	R1,2	SOCKET BASE, RELAY, 4-POLE, SEPARATE	SCHNEIDER	RXZE2S114M
RDE-2					
ALL QUANTITIES X 6 EXCEPT AS NOTED*					
30	1		16X14X6 NEMA 4X 304SS ENCLOSURE	HOFFMAN	A1614CHNFSS
	1		16X14X6 MOUNTING PAN	HOFFMAN	A16P14
31	2	TB1	TB, ST 4-TWIN	PHOENIX CONTACTS	3031393
	1	TB1	TB, ST 4-TWIN-PE	PHOENIX CONTACTS	3031416
	1	TB1	END SECTION, D-ST 4-TWIN	PHOENIX CONTACTS	3030491
	6	TB2	TB, ST 2.5-3L	PHOENIX CONTACTS	3036042
	24	TB4	TB, ST 2.5-PE/L/L	PHOENIX CONTACT	3036097
	2	TB2-4	END SECTION, D-ST 2.5-PE/L/L	PHOENIX CONTACTS	3036660
	9		END BRACKET, CLIPFIX 35	PHOENIX CONTACTS	3022218
	1		DIN RAIL	Allied Elec	B C103PM
32	1	PS	POWER SUPPLY,30W 277/120-24VDC	TDK	DSP30-24/277A
33	1	FU1	FUSE HOLDER,DIN MOUNT, 10x38mm	OMEGA	ASK 4-1
	8	FU2-9	FUSE HOLDER,KNIFE-SW,UK 5-HESI	PHOENIX CONTACT	3004100
	1	FU1	FUSE 250mA, TIME-DELAY, 500V, 10x38mm	BUSSMANN	FNQ 1/4
	2	FU2, 3	FUSE 400mA,MEDIUM TIME LAG,5X20	BUSSMANN	GMC 400mA
	2	FU4, 5	FUSE 250mA,FAST ACTING,5X20	BUSSMANN	GMA 250mA
34	2	I/V	UNIVERSAL TRANSMITTER, 0-20mA/0-10V	AUTOMATION DIRECT	884116
	1		DISPLAY/PROGRAMMING FRONT	AUTOMATION DIRECT	884501
35	2	DA4	DIMMING DRIVER MODULE	PLC	DA-4
NAMEPLATES					
36			NAMEPLATES	SEA' ENGRAV	
	24	*	BLACK W/WHITE LETTERS, #4-40 SCREW MNT 1.5"X6", 1-LINE ENGRAVE:		
			"RDE-NE1" "RDE-NE2" "RDE-NE3" "RDE-NE4"		
			"RDE-NW1" "RDE-NW2" "RDE-NW3" "RDE-NW4"		
			"RDE-SRE1" "RDE-SRE2" "RDE-SRE3" "RDE-SRE4"		
			"RDE-SRW1" "RDE-SRW2" "RDE-SRW3" "RDE-SRW4"		
			"RDE-SE1" "RDE-SE2" "RDE-SE3" "RDE-SE4"		
			"RDE-SW1" "RDE-SW2" "RDE-SW3" "RDE-SW4"		
	24	*	ORANGE W/BLACK LETTERS, #4-40 SCREW MNT 1.5"X6", 1-LINE ENGRAVE:		
			"277 VAC"		



Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

MANUALS

FUSION G7™, TYPE 4, 12
FUSION G7™

INDUSTRY STANDARDS

Wall-mounting brackets required to maintain UL/CSA external mounting requirement.

UL 508A Listed; Type 4, 12; File No. 61997
 cUL Listed per CSA C22.2 No. 94; Type 4, 12; File No. 61997

NEMA/EEMAC Type 4, 12, 13
 CSA File No. 42186: Type 4, 12
 IEC 60529, IP66

APPLICATION

Innovative, metric-dimensioned wall-mount enclosure designed to house and protect electrical and electronic components in industrial environments. Provides traditional enclosure functionality with scalable internal component mounting capability using the optional internal mounting system and accessory components.

FEATURES

- Ninety-degree external formed flange trough collar around body opening
- Three-point latching on enclosures 1000-mm high and taller
- Door alignment device on doors with 3-point latching and 800 mm or wider
- Pre-cut gland plate opening(s) in enclosure bottom

- Quarter-turn latch(es) with 3-mm double-bit insert
- Corner-formed door
- Simple, easy-to-remove and install hinge pins with captivation clip
- High-torque threadless studs and fasteners on door
- Wide assortment of user-friendly internal accessories to increase internal mounting area capability and design flexibility
- Includes hardware package with grounding and sealing hardware and illustrated instruction sheet

SPECIFICATIONS

- Constructed from 1.2-mm, 1.5-mm and 2-mm thick steel (18, 16 and 14 gauge) (see table)
- Seamless foam-in-place gasket
- Reversible door with sealed hinges and hinge brackets
- Gland plate(s) for enclosure bottom
- Bonding provision on door; grounding studs (2) on body
- Full-height galvanized steel back panel included

FINISH

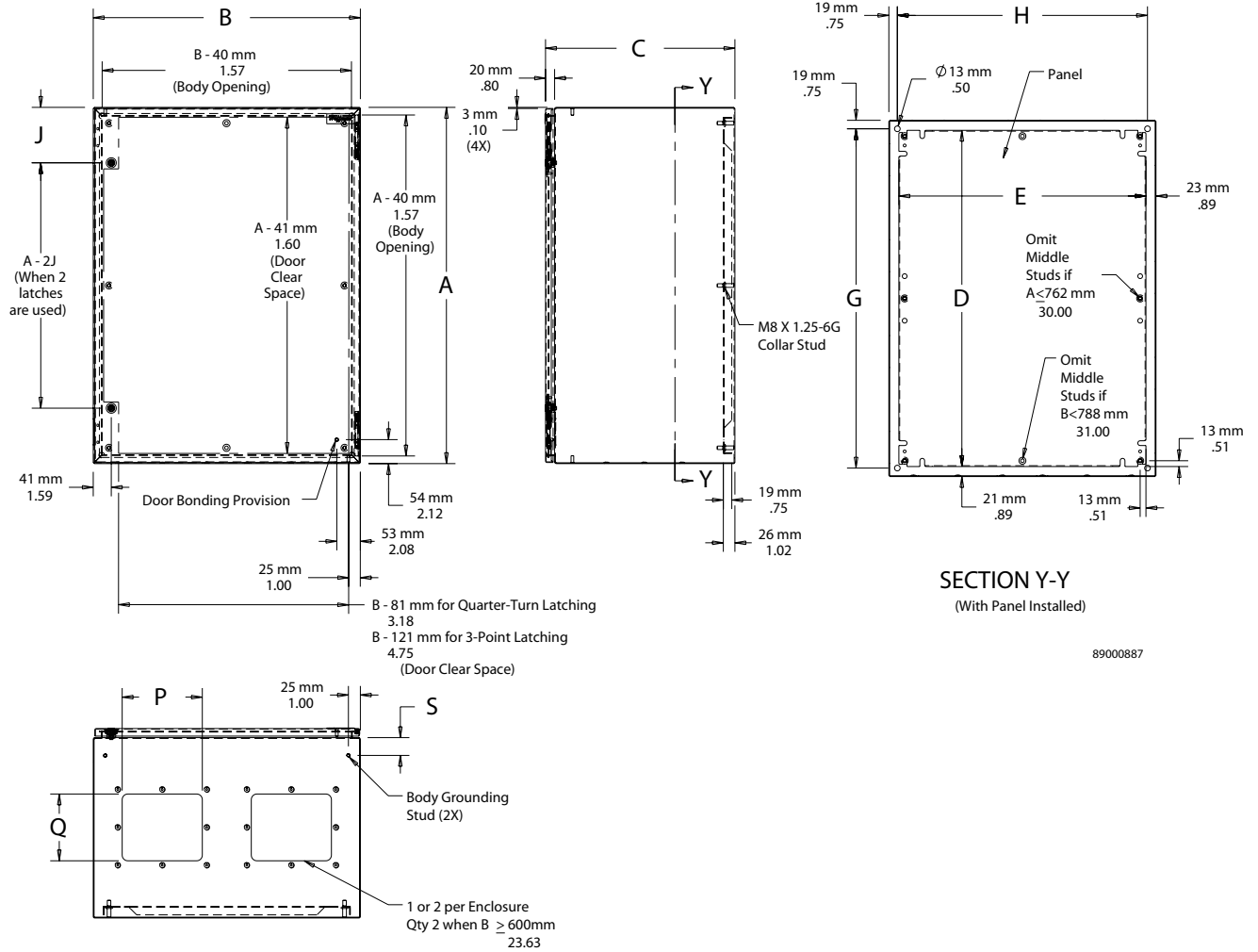
RAL 7035 textured, light-gray polyester powder paint inside and out
 Panel is galvanized

BULLETIN: A4G

Standard Product

Catalog Number	AxBxC mm/in.	Body Thickness mm	Body Thickness Gauge	Door Thickness mm	Door Thickness Gauge	Latch Type	D x E mm/in.	G x H mm/in.	J mm/in.	P x Q mm/in.	S mm/in.
G300300225G	300 x 300 x 225 11.81 x 11.81 x 8.86	1.2	18	1.2	18	Quarter-turn	255 x 255 10.04 x 10.04	262 x 262 10.31 x 10.31	150 5.91	180 x 90 7.09 x 3.54	39 1.55
G300400200G	300 x 400 x 200 11.81 x 15.75 x 7.87	1.2	18	1.2	18	Quarter-turn	255 x 355 10.04 x 13.98	262 x 362 10.31 x 14.25	150 5.91	280 x 90 11.02 x 3.54	39 1.55
G400300150	400 x 300 x 150 15.75 x 11.81 x 5.91	1.2	18	1.2	18	Quarter-turn	355 x 255 13.98 x 10.04	362 x 262 14.25 x 10.31	200 7.87	— —	39 1.55
G400300225G	400 x 300 x 225 15.75 x 15.75 x 8.86	1.2	18	1.2	18	Quarter-turn	355 x 255 13.98 x 10.04	362 x 262 14.25 x 10.31	200 7.87	180 x 90 7.09 x 3.54	39 1.55
G400400225G	400 x 400 x 225 15.75 x 15.75 x 8.86	1.2	18	1.2	18	Quarter-turn	355 x 355 13.98 x 13.98	362 x 362 14.25 x 14.25	200 7.87	280 x 90 11.02 x 3.54	39 1.55
G400600225G	400 x 600 x 225 15.75 x 23.62 x 8.86	1.2	18	1.2	18	Quarter-turn	355 x 555 13.98 x 21.85	362 x 562 14.25 x 22.13	200 7.87	180 x 90 7.09 x 3.54	39 1.55
G500400225G	500 x 400 x 225 19.69 x 15.75 x 8.86	1.2	18	1.2	18	Quarter-turn	455 x 355 17.91 x 13.98	462 x 362 18.19 x 14.25	250 9.84	280 x 90 11.02 x 3.54	39 1.55
G500500225G	500 x 500 x 225 19.69 x 19.69 x 8.86	1.2	18	1.2	18	Quarter-turn	455 x 455 17.91 x 17.91	462 x 462 18.19 x 18.19	250 9.84	280 x 90 11.02 x 3.54	39 1.55
G500500300G	500 x 500 x 300 19.69 x 19.69 x 11.81	1.5	16	1.2	18	Quarter-turn	455 x 455 17.91 x 17.91	462 x 462 18.19 x 18.19	250 9.84	280 x 150 11.02 x 5.91	39 1.55
G600400225G	600 x 400 x 225 23.62 x 15.75 x 8.86	1.2	18	1.2	18	Quarter-turn	555 x 355 21.85 x 13.98	562 x 362 22.13 x 14.25	300 11.81	280 x 90 11.02 x 3.54	39 1.55
G600500200G	600 x 500 x 200 23.62 x 19.69 x 7.87	1.2	18	1.5	16	Quarter-turn	555 x 455 21.85 x 17.91	562 x 462 22.13 x 18.19	300 11.81	280 x 90 11.02 x 3.54	39 1.55
G600500300G	600 x 500 x 300 23.62 x 19.69 x 11.81	1.5	16	1.5	16	Quarter-turn	555 x 455 21.85 x 17.91	562 x 462 22.13 x 18.19	300 11.81	280 x 150 11.02 x 5.91	39 1.55
G600600225G	600 x 600 x 225 23.62 x 23.62 x 8.86	1.5	16	1.5	16	Quarter-turn	555 x 555 21.85 x 21.85	562 x 562 22.13 x 22.13	125 4.92	180 x 90 7.09 x 3.54	39 1.55
G600600325G	600 x 600 x 325 23.62 x 23.62 x 12.80	1.5	16	1.5	16	Quarter-turn	555 x 555 21.85 x 21.85	562 x 562 22.13 x 22.13	125 4.92	180 x 150 7.09 x 5.91	39 1.55
G600600400G	600 x 600 x 400 23.62 x 23.62 x 15.75	2.0	14	1.5	16	Quarter-turn	555 x 555 21.85 x 21.85	562 x 562 22.13 x 22.13	125 4.92	180 x 150 7.09 x 5.91	39 1.55
G600800300G	600 x 800 x 300 23.62 x 31.50 x 11.81	1.5	16	1.5	16	Quarter-turn	555 x 755 21.85 x 29.72	562 x 762 22.13 x 30.00	125 4.92	180 x 150 7.09 x 5.91	102 4.02
G700500250G	700 x 500 x 250 27.56 x 19.69 x 9.84	1.5	16	1.5	16	Quarter-turn	655 x 455 25.79 x 17.91	662 x 462 26.06 x 18.19	125 4.92	280 x 90 11.02 x 3.54	39 1.55
G800600225G	800 x 600 x 225 31.50 x 23.62 x 8.86	1.5	16	1.5	16	Quarter-turn	755 x 555 29.72 x 21.85	762 x 562 30.00 x 22.13	125 4.92	180 x 90 7.09 x 3.54	39 1.55
G800600325G	800 x 600 x 325 31.50 x 23.62 x 12.80	1.5	16	1.5	16	Quarter-turn	755 x 555 29.72 x 21.85	762 x 562 30.00 x 22.13	125 4.92	180 x 150 7.09 x 5.91	39 1.55
G800600425G	800 x 600 x 425 31.50 x 23.62 x 16.73	2.0	14	1.5	16	Quarter-turn	755 x 555 29.72 x 21.85	762 x 562 30.00 x 22.13	125 4.92	180 x 150 7.09 x 5.91	39 1.55
G800800225G	800 x 800 x 225 31.50 x 31.50 x 8.86	1.5	16	2.0	14	Quarter-turn	755 x 755 29.72 x 29.72	762 x 762 30.00 x 30.00	125 4.92	280 x 90 11.02 x 3.54	39 1.55
G800800300G	800 x 800 x 300 31.50 x 31.50 x 11.81	2.0	14	2.0	14	Quarter-turn	755 x 755 29.72 x 29.72	762 x 762 30.00 x 30.00	125 4.92	180 x 150 7.09 x 5.91	102 4.02
G1000600250G	1000 x 600 x 250 39.37 x 23.62 x 9.84	2.0	14	2.0	14	3-pt. Quarter-turn	955 x 555 37.60 x 21.85	962 x 562 37.87 x 22.13	500 19.68	180 x 90 7.09 x 3.54	39 1.55
G1000800300G	1000 x 800 x 300 39.37 x 31.50 x 11.81	2.0	14	2.0	14	3-pt. Quarter-turn	955 x 755 37.60 x 29.72	962 x 762 37.87 x 30.00	500 19.68	180 x 150 7.09 x 5.91	102 4.02
G1000800400G	1000 x 800 x 400 39.37 x 31.50 x 15.75	2.0	14	2.0	14	3-pt. Quarter-turn	955 x 755 37.60 x 29.72	962 x 762 37.87 x 30.00	500 19.68	180 x 150 7.09 x 5.91	102 4.02
G1200800300G	1200 x 800 x 300 47.24 x 31.50 x 11.81	2.0	14	2.0	14	3-pt. Quarter-turn	1155 x 755 45.47 x 29.72	1162 x 762 45.75 x 30.00	600 23.62	180 x 150 7.09 x 5.91	102 4.02
G1200800400G	1200 x 800 x 400 47.24 x 31.50 x 15.75	2.0	14	2.0	14	3-pt. Quarter-turn	1155 x 755 45.47 x 29.72	1162 x 762 45.75 x 30.00	600 23.62	180 x 150 7.09 x 5.91	102 4.02
G1200900325G	1200 x 900 x 325 47.24 x 35.43 x 12.80	2.0	14	2.0	14	3-pt. Quarter-turn	1155 x 855 45.47 x 33.66	1162 x 862 45.75 x 33.94	600 23.62	280 x 150 11.02 x 5.91	102 4.02
G1500900325G	1500 x 900 x 325 59.06 x 35.43 x 12.80	2.0	14	2.0	14	3-pt. Quarter-turn	1455 x 855 57.28 x 33.66	1462 x 862 57.57 x 33.94	750 29.53	280 x 150 11.02 x 5.91	102 4.02
G1500900425G	1500 x 900 x 425 59.06 x 35.43 x 16.73	2.0	14	2.0	14	3-pt. Quarter-turn	1455 x 855 57.28 x 33.66	1462 x 862 57.57 x 33.94	750 29.53	280 x 150 11.02 x 5.91	102 4.02

G400300150 does not have a gland plate.



SECTION Y-Y
(With Panel Installed)

89000887

Accessory Selection Matrix

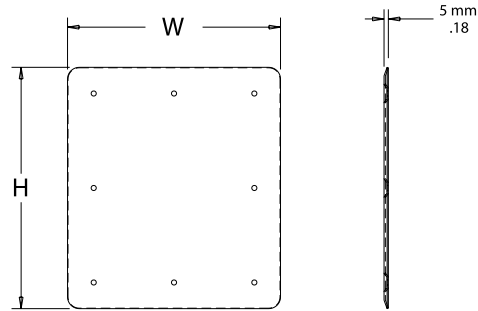
FUSION G7™	Full Back Panel	Half Back Panel	Full Side Panel	Half Side Panel	Side-Mount Accessory Rail	Horizontal Separator	100-mm Plinth Base	Aluminum Swing Panel	Front and Back Vertical Accessory Mounting Rails	Top/Bottom Mounting Brackets
G300300225G	G300P300	G300P300H	G300SMP225	G300SMP225H	G50SMR225	GHS300225	—	—	GAMR300	GTBMTBKT300
G300400200G	G400P300	G300P400H	G300SMP200	G300SMP200H	G50SMR200	GHS400200	—	—	GAMR300	GTBMTBKT400
G400300150	G400P300	G400P300H	G400SMP150	G400SMP150H	G50SMR150	—	—	—	GAMR400	GTBMTBKT300
G400300225G	G400P300	G400P300H	G400SMP225	G400SMP225H	G50SMR225	GHS300225	—	GSP400300A	GAMR400	GTBMTBKT300
G400400225G	G400P400	G400P400H	G400SMP225	G400SMP225H	G50SMR225	GHS400225	—	—	GAMR400	GTBMTBKT400
G400600225G	G600P400	G400P600H	G400SMP225	G400SMP225H	G50SMR225	GHS600225	—	—	GAMR400	GTBMTBKT600
G500400225G	G500P400	G500P400H	G500SMP225	G500SMP225H	G50SMR225	GHS400225	—	GSP500400A	GAMR500	GTBMTBKT400
G500500225G	G500P500	G500P500H	G500SMP225	G500SMP225H	G50SMR225	GHS500225	—	GSP500500A	GAMR500	GTBMTBKT500
G500500300G	G500P500	G500P500H	G500SMP300	G500SMP300H	G50SMR300	GHS500300	—	GSP500500A	GAMR500	GTBMTBKT500
G600400225G	G600P400	G600P400H	G600SMP225	G600SMP225H	G50SMR225	GHS400225	—	—	GAMR600	GTBMTBKT400
G600500200G	G600P500	G600P500H	G600SMP200	G600SMP200H	G50SMR200	GHS500200	—	GSP600500A	GAMR600	GTBMTBKT500
G600500300G	G600P500	G600P500H	G600SMP300	G600SMP300H	G50SMR300	GHS500300	—	GSP600500A	GAMR600	GTBMTBKT500
G600600225G	G600P600	G600P600H	G600SMP225	G600SMP225H	G50SMR225	GHS600225	—	GSP600600A	GAMR600	GTBMTBKT600
G600600325G	G600P600	G600P600H	G600SMP325	G600SMP325H	G50SMR325	GHS600325	—	GSP600600A	GAMR600	GTBMTBKT600
G600600400G	G600P600	G600P600H	G600SMP400	G600SMP400H	G50SMR400	GHS600400	—	GSP600600A	GAMR600	GTBMTBKT600
G600800300G	G800P600	G600P800H	G600SMP300	G600SMP300H	G50SMR300	GHS800300	GPB800300	—	GAMR600	GTBMTBKT800
G700500250G	G700P500	G700P500H	G700SMP250	G700SMP250H	G50SMR250	GHS500250	—	GSP700500A	GAMR700	GTBMTBKT500
G800600225G	G800P600	G800P600H	G800SMP225	G800SMP225H	G50SMR225	GHS600225	—	GSP800600A	GAMR800	GTBMTBKT600
G800600325G	G800P600	G800P600H	G800SMP325	G800SMP325H	G50SMR325	GHS600325	—	GSP800600A	GAMR800	GTBMTBKT600
G800600425G	G800P600	G800P600H	G800SMP425	G800SMP425H	G50SMR425	—	—	GSP800600A	GAMR800	GTBMTBKT600
G800800225G	G800P800	G800P800H	G800SMP225	G800SMP225H	G50SMR225	—	—	—	GAMR800	GTBMTBKT800
G800800300G	G800P800	G800P800H	G800SMP300	G800SMP300H	G50SMR300	GHS800300	GPB800300	—	GAMR800	GTBMTBKT800
G1000600250G	G1000P600	G1000P600H	G1000SMP250	G1000SMP250H	G50SMR250	GHS600250	—	GSP1000600A	GAMR1000	GTBMTBKT600
G1000800300G	G1000P800	G1000P800H	G1000SMP300	G1000SMP300H	G50SMR300	GHS800300	GPB800300	GSP1000800A	GAMR1000	GTBMTBKT800
G1000800400G	G1000P800	G1000P800H	G1000SMP400	G1000SMP400H	G50SMR400	GHS800400	GPB800400	GSP1000800A	GAMR1000	GTBMTBKT800
G1200800300G	G1200P800	G1200P800H	G1200SMP300	G1200SMP300H	G50SMR300	GHS800300	GPB800300	GSP1200800A	GAMR1200	GTBMTBKT800
G1200800400G	G1200P800	G1200P800H	G1200SMP400	G1200SMP400H	G50SMR400	GHS800400	GPB800400	GSP1200800A	GAMR1200	GTBMTBKT800
G1200900325G	G1200P900	G1200P900H	G1200SMP325	G1200SMP325H	G50SMR325	GHS900325	GPB900325	GSP1200900A	GAMR1200	GTBMTBKT900
G1500900325G	G1500P900	G1500P900H	G1500SMP325	G1500SMP325H	G50SMR325	GHS900325	GPB900325	GSP1500900A	GAMR1500	GTBMTBKT900
G1500900425G	G1500P900	G1500P900H	G1500SMP425	G1500SMP425H	G50SMR425	GHS900425	GPB900425	GSP1500900A	GAMR1500	GTBMTBKT900

GLAND PLATE



Constructed of 1.5-mm thick (16 gauge) steel and designed for use with FUSION G7™ enclosures. Provides a removable cable egress and entry plate while maintaining IP/UL/CSA integrity of the enclosure. RAL 7035 textured, light-gray polyester powder paint finish. Foam-in-place gasket, fasteners and instructions provided. Maintains IP66/UL/CSA Type 4 and 12 when properly installed on a Hoffman enclosure.

BULLETIN: A4GY



89000888

Catalog Number	Cutout Size (mm)	Cutout Size (in.)	W x H (mm)	W x H (in.)
GGP90180	90 x 180	3.54 x 7.09	165 x 255	6.50 x 10.04
GGP90280	90 x 280	3.54 x 11.02	165 x 355	6.50 x 13.98
GGP150180	150 x 180	5.91 x 7.09	225 x 255	8.86 x 10.04
GGP150280	150 x 280	5.91 x 11.02	225 x 355	8.86 x 13.98

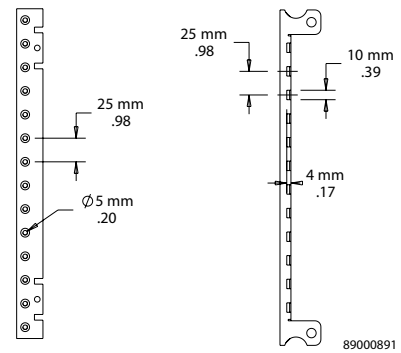
FRONT AND BACK VERTICAL ACCESSORY MOUNTING RAILS



Constructed of galvanized steel. Front rail is 2.0-mm thick (14 gauge) and back rail is 1.5-mm thick (16 gauge). Package includes two front and two back rails and mounting screws.

Required for side-mount and adjustable-depth accessory installation.

BULLETIN: A4GY

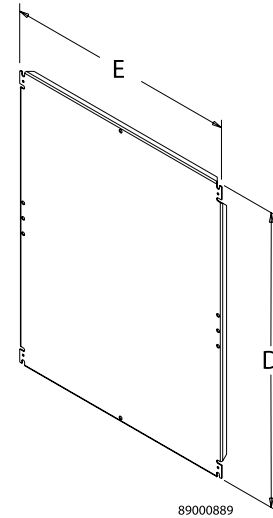


Front Rail

Back Rail

Catalog Number	Fits A (mm)	Fits A (in.)
GAMR300	300	11.81
GAMR400	400	15.75
GAMR500	500	19.68
GAMR600	600	23.62
GAMR700	700	27.56
GAMR800	800	31.50
GAMR1000	1000	39.37
GAMR1200	1200	47.24
GAMR1500	1500	59.05

FULL-HEIGHT BACK PANEL



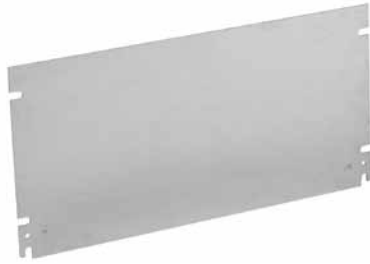
89000889

Galvanized steel full-height panels. See table for thickness.
 M8 panel mounting nuts provided with 50-mm front-to-back side-mount
 accessory rails and side-mount accessory rail brackets.

BULLETIN: A4GY

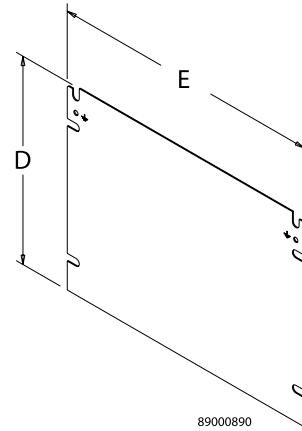
Catalog Number	D x E (mm)	D x E (in.)	Thickness (mm)	Thickness (Gauge)	Fits A x B (mm)	Fits A x B (in.)
G300P300	255 x 255	10.04 x 10.04	1.5	16	300 x 300	11.81 x 11.81
G400P300	355 x 255	13.98 x 10.04	1.5	16	400 x 300 or 300 x 400	15.75 x 11.81 or 11.81 x 15.75
G400P400	355 x 355	13.98 x 13.98	1.5	16	400 x 400	15.75 x 15.75
G500P400	455 x 355	17.91 x 13.98	1.5	16	500 x 400	19.68 x 15.75
G600P400	555 x 355	21.85 x 13.98	1.5	16	600 x 400 or 400 x 600	23.62 x 15.75 or 15.75 x 23.62
G500P500	455 x 455	17.91 x 17.91	1.5	16	500 x 500	19.68 x 19.68
G600P500	555 x 455	21.85 x 17.91	1.5	16	600 x 500	23.62 x 19.68
G700P500	655 x 455	25.79 x 17.91	2.0	14	700 x 500	27.56 x 19.68
G600P600	555 x 555	21.85 x 21.85	2.0	14	600 x 600	23.62 x 23.62
G800P600	755 x 555	29.72 x 21.85	2.0	14	800 x 600 or 600 x 800	31.50 x 23.62 or 23.62 x 31.50
G1000P600	955 x 555	37.60 x 21.85	2.5	12	1000 x 600	39.37 x 23.62
G800P800	755 x 755	29.72 x 29.72	2.5	12	800 x 800	31.50 x 31.50
G1000P800	955 x 755	37.60 x 29.72	2.5	12	1000 x 800	39.37 x 31.50
G1200P800	1155 x 755	45.47 x 29.72	2.5	12	1200 x 800	47.24 x 31.50
G1200P900	1155 x 855	45.47 x 33.66	2.5	12	1200 x 900	47.24 x 35.43
G1500P900	1455 x 855	57.28 x 33.66	2.5	12	1500 x 900	59.05 x 35.43

HALF-HEIGHT BACK PANEL



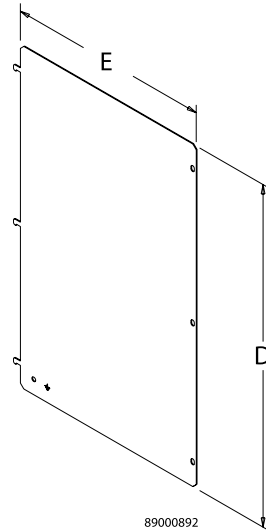
Galvanized steel half-height back panels. See table for thickness.
M8 panel mounting nuts provided with 50-mm front-to-back side-mount accessory rails and side-mount accessory rail brackets.

BULLETIN: A4GY



Catalog Number	D x E (mm)	D x E (in.)	Thickness (mm)	Thickness (Gauge)	Fits A x B (mm)	Fits A x B (in.)
G300P300H	120 x 255	4.72 x 10.04	1.5	16	300 x 300	11.81 x 11.81
G300P400H	120 x 355	4.72 x 13.98	1.5	16	300 x 400	11.81 x 15.75
G400P300H	170 x 255	6.69 x 10.01	1.5	16	400 x 300	15.75 x 11.81
G400P400H	170 x 355	6.69 x 13.98	1.5	16	400 x 400	15.75 x 15.75
G400P600H	170 x 555	6.69 x 21.85	1.5	16	400 x 600	15.75 x 23.62
G500P400H	220 x 355	8.66 x 13.98	1.5	16	500 x 400	19.68 x 15.75
G500P500H	220 x 455	8.66 x 17.91	1.5	16	500 x 500	19.68 x 19.68
G600P400H	270 x 355	10.63 x 13.98	1.5	16	600 x 400	23.62 x 15.75
G600P500H	270 x 455	10.63 x 17.91	1.5	16	600 x 500	23.62 x 19.68
G600P600H	270 x 555	10.63 x 21.85	1.5	16	600 x 600	23.62 x 23.62
G600P800H	270 x 755	10.63 x 29.72	1.5	16	600 x 800	23.62 x 32.50
G700P500H	320 x 455	12.60 x 17.91	1.5	16	700 x 500	27.56 x 19.68
G800P600H	370 x 555	14.57 x 21.85	1.5	16	800 x 600	31.50 x 23.62
G800P800H	370 x 755	14.57 x 29.72	1.5	16	800 x 800	32.50 x 32.50
G1000P600H	470 x 555	18.50 x 21.85	1.5	16	1000 x 600	39.37 x 23.62
G1000P800H	470 x 755	18.50 x 29.72	2.0	14	1000 x 800	39.37 x 31.50
G1200P800H	570 x 755	22.44 x 29.72	2.0	14	1200 x 800	47.24 x 31.50
G1200P900H	570 x 855	22.44 x 33.66	2.0	14	1200 x 900	47.24 x 35.43
G1500P900H	720 x 855	28.35 x 33.66	2.0	14	1500 x 900	59.05 x 35.43

FULL-HEIGHT SIDE PANEL



Galvanized steel full-height side panels. Panel mounting hardware is furnished with the panel. See table for thickness.

BULLETIN: A4GY

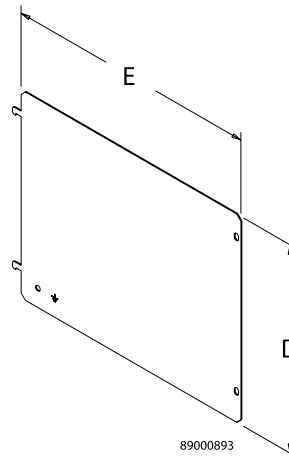
Catalog Number	D x E (mm)	D x E (in.)	Thickness (mm)	Thickness (Gauge)	Fits A x C (mm)	Fits A x C (in.)
G300SMP200	255 x 142	10.04 x 5.59	1.5	16	300 x 200	11.71 x 7.87
G300SMP225	255 x 167	10.01 x 6.57	1.5	16	300 x 255	11.71 x 10.04
G400SMP150	355 x 92	13.98 x 3.62	1.5	16	400 x 150	15.75 x 5.91
G400SMP225	355 x 167	13.98 x 6.57	1.5	16	400 x 225	15.75 x 10.04
G500SMP225	455 x 167	17.91 x 6.57	1.5	16	500 x 255	19.68 x 10.04
G500SMP300	455 x 242	17.91 x 9.53	1.5	16	500 x 300	19.68 x 11.71
G600SMP200	555 x 142	21.85 x 5.59	1.5	16	600 x 200	23.62 x 7.87
G600SMP225	555 x 167	21.85 x 6.57	1.5	16	600 x 225	23.62 x 10.04
G600SMP300	555 x 242	21.85 x 9.53	1.5	16	600 x 300	23.62 x 11.71
G600SMP325	555 x 267	21.85 x 10.51	1.5	16	600 x 325	23.62 x 12.80
G600SMP400	555 x 342	21.85 x 13.46	1.5	16	600 x 400	23.62 x 15.75
G700SMP250	655 x 192	25.79 x 7.56	1.5	16	700 x 250	27.56 x 9.84
G800SMP225	755 x 167	29.72 x 6.57	1.5	16	800 x 225	31.50 x 10.04
G800SMP300	755 x 242	29.72 x 9.53	1.5	16	800 x 300	31.50 x 11.71
G800SMP325	755 x 267	29.72 x 10.51	1.5	16	800 x 325	31.50 x 12.80
G800SMP425	755 x 367	29.72 x 14.45	1.5	16	800 x 425	31.50 x 16.73
G1000SMP250	955 x 192	37.60 x 7.56	1.5	16	1000 x 250	39.37 x 9.87
G1000SMP300	955 x 242	37.60 x 9.53	1.5	16	1000 x 300	39.37 x 11.71
G1000SMP400	955 x 342	37.60 x 13.46	1.5	16	1000 x 400	39.37 x 15.75
G1200SMP300	1155 x 242	45.47 x 9.53	1.5	16	1200 x 300	47.24 x 11.71
G1200SMP325	1155 x 267	45.47 x 10.51	1.5	16	1200 x 325	47.24 x 12.80
G1200SMP400	1155 x 342	45.47 x 13.46	1.5	16	1200 x 400	47.24 x 15.75
G1500SMP325	1455 x 267	57.28 x 10.51	1.5	16	1500 x 325	59.05 x 12.80
G1500SMP425	1455 x 367	57.28 x 14.45	1.5	16	1500 x 425	59.05 x 16.73

HALF-HEIGHT SIDE PANEL



Galvanized steel half-height side panels are 1.5-mm thick (16 gauge). Panel mounting hardware is furnished with the panel.

BULLETIN: A4GY



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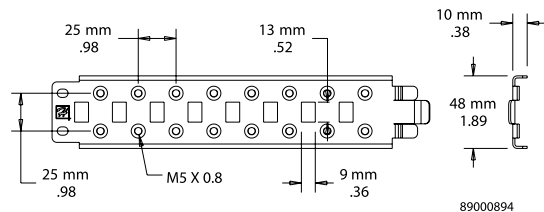
Catalog Number	D x E (mm)	D x E (in.)	Fits A x C (mm)	Fits A x C (in.)
G300SMP200H	120 x 142	4.72 x 5.59	300 x 200	11.81 x 7.87
G300SMP225H	120 x 167	4.72 x 6.57	300 x 225	11.81 x 8.86
G400SMP150H	170 x 92	6.69 x 3.62	400 x 150	15.75 x 5.91
G400SMP225H	170 x 167	6.69 x 6.57	400 x 225	15.75 x 8.86
G500SMP225H	220 x 167	8.66 x 6.57	500 x 225	19.68 x 8.86
G500SMP300H	220 x 242	8.66 x 9.53	500 x 300	19.68 x 11.81
G600SMP200H	270 x 142	10.63 x 5.59	600 x 200	23.62 x 7.87
G600SMP225H	270 x 167	10.63 x 6.57	600 x 225	23.62 x 8.86
G600SMP300H	270 x 242	10.63 x 9.53	600 x 300	23.62 x 11.81
G600SMP325H	270 x 267	10.63 x 10.51	300 x 325	11.81 x 12.76
G600SMP400H	270 x 342	10.63 x 13.46	600 x 400	23.62 x 15.75
G700SMP250H	320 x 192	12.60 x 7.56	700 x 250	27.56 x 9.84
G800SMP225H	370 x 167	14.57 x 6.57	800 x 225	31.50 x 8.86
G800SMP300H	370 x 242	14.57 x 9.53	800 x 300	31.50 x 11.81
G800SMP325H	370 x 267	14.57 x 10.51	800 x 325	31.50 x 12.76
G800SMP425H	370 x 367	14.57 x 14.45	800 x 425	31.50 x 16.73
G1000SMP250H	470 x 192	18.50 x 7.56	1000 x 250	39.37 x 9.84
G1000SMP300H	470 x 242	18.50 x 9.53	1000 x 300	39.37 x 11.81
G1000SMP400H	470 x 342	18.50 x 13.46	1000 x 400	39.37 x 15.75
G1200SMP300H	570 x 242	22.44 x 9.53	1200 x 300	47.24 x 11.81
G1200SMP325H	570 x 267	22.44 x 10.51	1200 x 325	47.24 x 12.76
G1200SMP400H	570 x 342	22.44 x 13.46	1200 x 400	47.24 x 15.75
G1500SMP325H	720 x 267	28.35 x 10.51	1500 x 325	59.05 x 12.80
G1500SMP425H	720 x 367	28.35 x 14.45	1500 x 425	59.05 x 16.73

SIDE-MOUNT ACCESSORY RAIL



Easy-to-install side (front-to-back) mounting rails provide side and depth mounting capability using minimal tools. Rails are 1.5-mm thick (16 gauge) galvanized steel. Qty. 4 per package. Includes panel-mount brackets, nuts and screws.

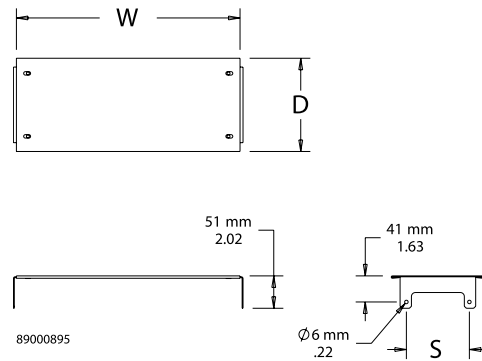
BULLETIN: A4GY



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Catalog Number	Fits Depth (mm)	Fits Depth (in.)
G50SMR150	150	5.91
G50SMR200	200	7.87
G50SMR225	225	8.86
G50SMR250	250	9.84
G50SMR300	300	11.81
G50SMR325	325	12.80
G50SMR400	400	15.75
G50SMR425	425	16.73

HORIZONTAL SEPARATOR

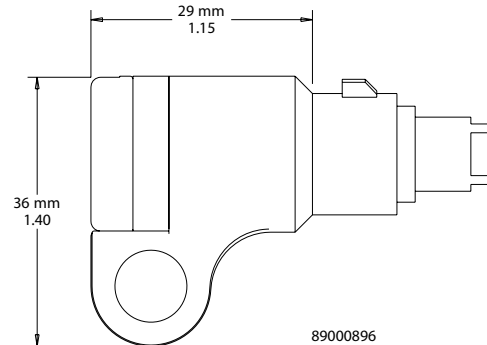


Horizontal Separator mounts onto side-mount accessory rails to divide the FUSION G7™ into separate compartments. Galvanized 1.5-mm thick (16 gauge) steel. Mounting hardware provided.

BULLETIN: A4GY

Catalog Number	Fits B x C (mm)	Fits B x C (in.)	W x D (mm)	W x D (in.)	S (mm)	S (in.)
GHS300225	300 x 225	11.81 x 8.86	255 x 148	10.04 x 5.83	100	3.94
GHS400200	400 x 200	15.75 x 7.87	355 x 123	13.98 x 4.84	75	2.95
GHS400225	400 x 225	15.75 x 8.86	355 x 148	13.98 x 5.83	100	3.94
GHS500200	500 x 200	19.68 x 7.87	455 x 123	17.91 x 4.84	75	2.95
GHS500225	500 x 225	19.68 x 8.86	455 x 148	17.91 x 5.83	100	3.94
GHS500250	500 x 250	19.68 x 9.84	455 x 173	17.91 x 6.81	125	4.92
GHS500300	500 x 300	19.68 x 11.81	455 x 223	17.91 x 8.87	175	6.89
GHS600225	600 x 225	23.62 x 8.86	555 x 148	21.85 x 5.83	100	3.94
GHS600250	600 x 250	23.62 x 9.84	555 x 173	21.85 x 6.81	125	4.92
GHS600325	600 x 325	23.62 x 12.80	555 x 248	21.85 x 9.76	200	7.78
GHS600400	600 x 400	23.62 x 15.75	555 x 323	21.85 x 12.72	275	10.83
GHS800300	800 x 300	32.50 x 11.81	755 x 223	29.72 x 8.78	175	6.89
GHS800400	800 x 400	32.50 x 15.75	755 x 323	29.72 x 12.72	275	10.83
GHS900325	900 x 325	35.43 x 12.50	855 x 248	33.66 x 9.76	200	7.87
GHS900425	900 x 425	35.43 x 16.73	855 x 348	33.66 x 13.70	300	11.81

PADLOCK INSERTS



Padlock Inserts fit into standard quarter-turn latches. They are made of black composite material (PBT) with zinc insert and replace the standard 3-mm double-bit insert when padlocking security is required. Available with 3-mm double bit or slotted screwdriver tool to open. Accommodate up to 5/16-in. diameter padlock shank.

BULLETIN: A4GY

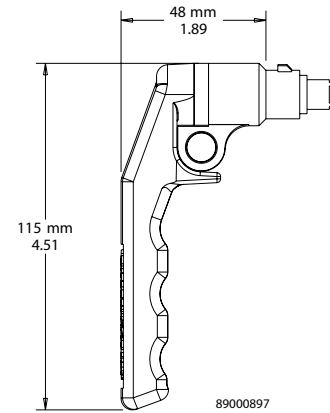
Catalog Number	Description
GPDLOCK3MM	3-mm double-bit padlock insert
GPDLOCKSLOT	Slotted screwdriver padlock insert

HANDLES



These black composite handles with zinc insert can replace the standard quarter-turn 3-mm double bit insert on all FUSION G7™ wall-mount enclosures. The keylocking handle is available for applications requiring quick access and keylocking security. The padlocking handle accommodates up to a 5/16-in. diameter padlock shank. Each latch system can be converted from clockwise to counter-clockwise opening. Maintains IP66 and UL/CSA Type 4 and 12 when properly installed in a Hoffman FUSION G7 enclosure.

BULLETIN: A4GY



Catalog Number	Description
GKEYLOCKHDL	Key-Locking Handle
GPDLOCKHDL	Padlocking Handle

HINGE PIN KITS



Easy-to-remove and replace hinge pins facilitate door removal or reversing. Available in plated or stainless steel.

BULLETIN: A4GY, VM3

Catalog Number	Description	Pkg. Qty.
GHPINSS	Stainless steel	2
GHPINMS	Plated steel	2

DIN RAIL MOUNTING ADAPTER



Allows quick and simple installation of TS35 x 7.5 DIN (DIN3) rail. Black composite (PBT) material. DIN rail not included.

BULLETIN: A4GY

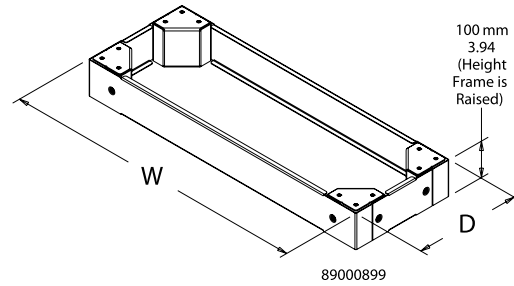
Catalog Number	Pkg. Qty.
GDINRAILBKT	10

100-MM PLINTH BASE



Install 100-mm Plinth Base under FUSION G7™ enclosure to provide space for cables to enter from below. Constructed of 1.5-mm thick (16 gauge) steel sides and 2.5-mm thick (12 gauge) corners with textured RAL 9005 black finish. Mounting hardware included with base.

BULLETIN: A4GY



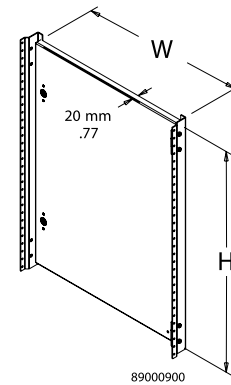
Catalog Number	Fits B x C (mm)	Fits B x C (in.)	W x D (mm)	W x D (in.)
GPB800300	800 x 300	31.50 x 11.81	800 x 279	31.50 x 10.98
GPB800400	800 x 400	31.50 x 15.75	800 x 379	31.50 x 14.92
GPB900325	900 x 325	35.43 x 12.80	900 x 304	35.43 x 11.97
GPB900425	900 x 425	35.43 x 16.73	900 x 404	35.43 x 15.91

ALUMINUM SWING PANEL



2.5-mm (.100-in.) thick Aluminum Swing Panel provides a convenient way to install controls and instruments near the front of the FUSION G7™ enclosure while providing access and security. Mounting hardware and 3-mm double-bit key included with panel.

BULLETIN: A4GY



Catalog Number	Fits A x B (mm)	Fits A x B (in.)	H x W (mm)	H x W (in.)
GSP400300A	400 x 300	15.75 x 11.81	315 x 233	12.40 x 9.16
GSP500400A	500 x 400	19.68 x 15.75	415 x 333	16.34 x 13.11
GSP500500A	500 x 500	19.68 x 19.68	415 x 433	16.34 x 17.05
GSP600500A	600 x 500	23.62 x 19.68	515 x 433	20.27 x 17.05
GSP600600A	600 x 600	23.62 x 23.62	515 x 533	20.27 x 20.98
GSP700500A	700 x 500	27.56 x 19.68	615 x 433	24.21 x 17.05
GSP800600A	800 x 600	32.50 x 23.62	715 x 533	28.15 x 20.98
GSP1000600A	1000 x 600	39.37 x 23.62	915 x 533	36.02 x 20.98
GSP1000800A	1000 x 800	39.37 x 31.50	915 x 733	36.02 x 28.86
GSP1200800A	1200 x 800	47.24 x 31.50	1115 x 733	28.24 x 28.86
GSP1200900A	1200 x 900	47.24 x 35.43	1115 x 833	28.24 x 32.80
GSP1500900A	1500 x 900	59.05 x 35.43	1415 x 833	55.71 x 32.80

DOUBLE-BIT KEYS



Black non-metallic 3-mm double-bit keys. Package of two.

BULLETIN: A4GY

Catalog Number	Description	Pkg. Qty.
GKEY3MMDB	3-mm black, non-metallic	2

SCREW PACKAGE



5-mm screws for FUSION G7™ internal accessories. Package of 20.

BULLETIN: A4GY

Catalog Number	Description	Pkg. Qty.
GSM5	5-mm screw M5 x 0.8 x 10	20

PANEL MOUNTING BRACKETS

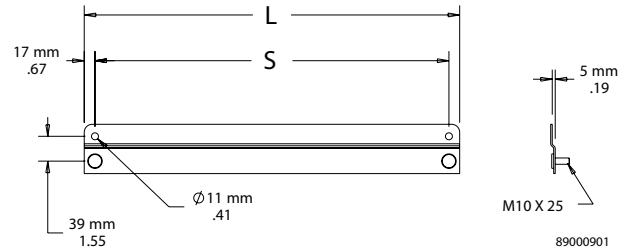


Package includes four mounting brackets, four M8 nuts and eight 5-mm screws.

BULLETIN: A4GY

Catalog Number	Description
GSMRBKTS	Panel mounting brackets; fit side-mount accessory rails

FULL-WIDTH TOP AND BOTTOM MOUNTING-BRACKET KITS WITH STUDS



Use to mount FUSION G7™ to a wall or another enclosure. Includes two 2.5-mm thick (12 gauge) steel external mounting brackets and mounting hardware. Finished with RAL 7035 textured light-gray polyester powder paint.

Mounting brackets are required to maintain UL/CSA external mounting requirement.

BULLETIN: A4GY

Catalog Number	Fits B (mm)	Fits B (in.)	L (mm)	L (in.)	S (mm)	S (in.)
GTBMTBKT300	300	11.81	296	11.65	262	10.31
GTBMTBKT400	400	15.75	396	15.59	362	14.25
GTBMTBKT500	500	19.68	496	19.53	462	18.19
GTBMTBKT600	600	23.62	596	23.46	562	22.12
GTBMTBKT800	800	31.50	796	31.34	762	30.00
GTBMTBKT900	900	35.43	896	35.62	862	33.93

FUSION G7™ DOOR STOP KIT



Designed for use on FUSION G7 enclosures to secure the door in the open position. Door Stop Kit can be mounted at the top or bottom of the door opening, as well as left- or right-hand hinged. Door stop is stainless steel with plated and stainless steel mounting hardware. Maintains IP66 and UL/CSA Type 4 and 12 when properly installed in a Hoffman FUSION G7 enclosure.

BULLETIN: A4GY

Catalog Number	Description
GDSTOPK	FUSION G7 Door Stop Kit

LOCK INSERTS



Lock inserts can be substituted for the standard 3-mm double-bit latch insert. Inserts have a chrome finish. Matching key is zinc die-cast.

BULLETIN: A4GY, CWY

Catalog Number	Description
CLKTM7	Triangular 7-mm insert with key
CLKSM7	Square 7-mm insert with key
CLKDBM3	Double bit with key
CLKSLOT	Slotted Insert no key

MOUNTING-BRACKET KITS



Mounting-Bracket Kits are field installable. Composite and stainless steel brackets are rated to Type 4X. Set of four (4) brackets can support 500 lb. maximum load. All hardware is included. Four brackets per kit.

Mounting brackets are required to maintain UL/CSA external mounting requirement.

BULLETIN: A80

Catalog Number	Description
CMFK	Steel
CMFKSS	Stainless Steel
CMTGFT	Composite

DOOR BARS

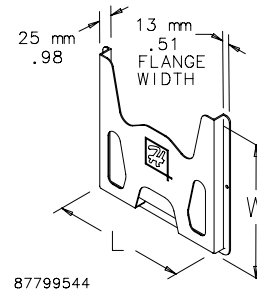


Non-metallic door bar includes pressure-sensitive tape adhesive.

BULLETIN: CWY

Catalog Number	Description	Length	Qty.
ADB305MM	Door Bar	8 in. (203 mm)	4

THERMOPLASTIC DATA POCKET



87799544

Provides a convenient place to store wiring diagrams, operation manuals and other documentation inside the enclosure. Adhesive-backed pockets mount inside the solid enclosure cover. Mounting hardware included. Thermoplastic pockets are dark gray and have cut-away areas for easy inspection of contents.

BULLETIN: UX1Y

Catalog Number	Description	Size L x W in./mm
ADP1	Small pocket	6.00 x 6.00 152 x 152
ADP2	Large pocket	12.00 x 12.00 305 x 305

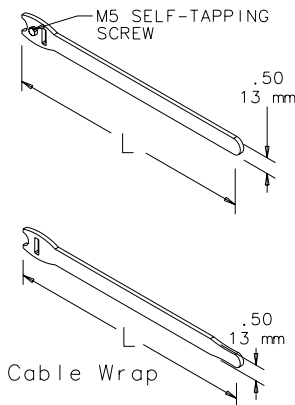
VELCRO® CABLE WRAP



Securely holds cable to cable manager and unfastens easily for cable maintenance. VELCRO® is 0.5-in. (12.7-mm) wide. Available in 8- and 12-in. (203- and 305-mm) lengths in both screw fastener and wrap styles. M5 self-tapping screw is used on Net Series or PROLINE™ frames.

VELCRO is a trademark of Velcro Industries B.V.

BULLETIN: DACCY



Cable Wrap

87951397

Catalog Number	Description	L (in.)	L (mm)	Color	Pkg. Qty.
ECWTD8B	Screw fastener style. Includes M5 mounting screw.	8.00	203	Black	10
ECWTD12B	Screw fastener style. Includes M5 mounting screw.	12.00	305	Black	10
ECW8B	Wrap style	8.00	203	Black	10
ECW8R	Wrap style	8.00	203	Red	10
ECW8BL	Wrap style	8.00	203	Blue	10
ECW8Y	Wrap style	8.00	203	Yellow	10
ECW12B	Wrap style	12.00	305	Black	10
ECW12R	Wrap style	12.00	305	Red	10
ECW12BL	Wrap style	12	305	Blue	10
ECW12Y	Wrap style	12	305	Yellow	10

Notes

Electric Heaters



INTRODUCTION

1. Before installing the electric heater, read these instructions carefully. Failure to follow these instructions could damage the product or cause a hazardous condition.
2. Check the ratings on the heater label to assure the product is suitable for your application.



WARNING



To avoid electric shock and equipment damage, disconnect any power supplies to the enclosure before installing the electric heater. Do not energize any circuits before all internal and external electrical and mechanical clearances are checked to assure that all assembled equipment functions safely and properly.

GENERAL SAFETY INFORMATION

1. Protect the lead wires from coming in contact with sharp objects, hot surfaces, and/or chemicals.
2. If continuous operation of the heater is essential to the safe functioning of any other equipment, adequate warning devices must be installed to assure safe operation at all times.



CAUTION

Do not use these electric heaters in dusty, dirty, corrosive, or hazardous locations.

Reduce the thermostat from factory setting to a recommended setting not to exceed 75 F for most applications.

Portions of the heater can get hot. Adequate protection must be taken to protect people from potential burns and to protect other components from this heat. Always allow the heater to cool before touching it.

Thermal sensitive devices or materials may need to be located further from the heater than the minimum recommended distance.

Heaters must not be installed on wood or other combustible surfaces.

This heater must only be installed in a totally enclosed enclosure.

English

LOCATION AND MOUNTING

1. Hoffman electric heaters should be centered as low as possible in the enclosure for optimum heat distribution.
2. It is recommended that the heater be installed on a non-combustible metal panel for optimum performance. It may, however, be mounted on any metal surface.

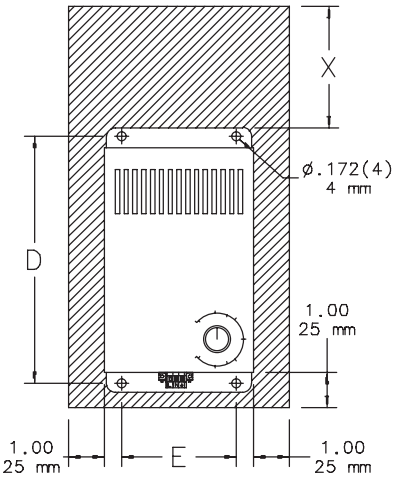
WARNING: Heaters must not be installed on wood or other combustible surfaces.

3. The heater should be mounted in a vertical position with the terminal block at the bottom and the air outlet openings at the top as shown.
4. The recommended clearances shown by the shadowed area indicates the space that should be kept free of components for safe operation of the heater.

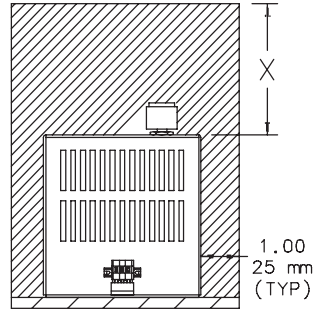
WARNING: Heat sensitive components must not be placed above the heater discharge area.

5. Four 10–32 UNF, self-tapping screws are included for installation.

Vertical Surface Mounting

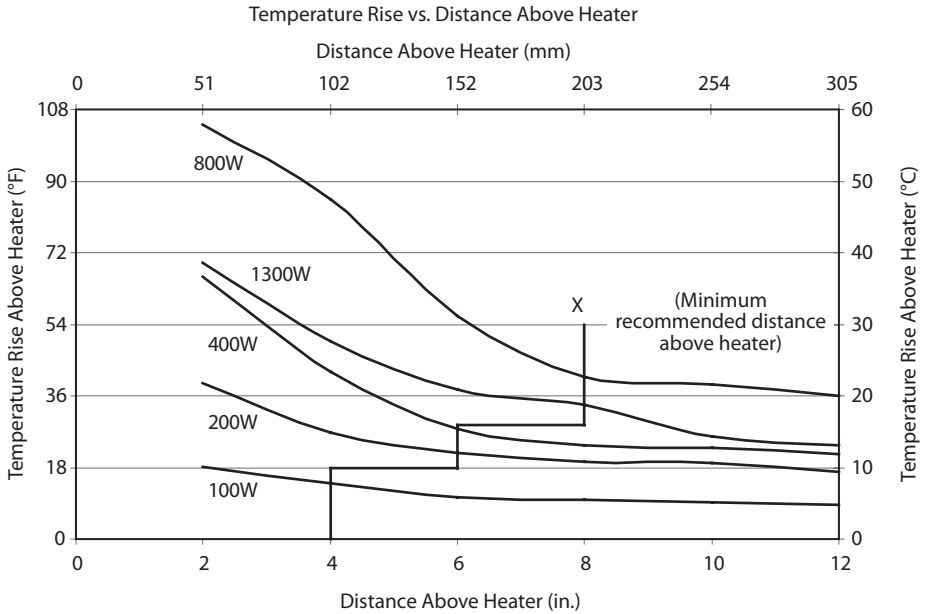


Optional Horizontal Surface Mounting



	Watts	X	D	E
DAH1001A, DAH1002A	100	4	5.00 (127 mm)	3.25 (83 mm)
DAH2001A, DAH2002A	200	6		
DAH4001B, DAH4002B	400	6	7.00 (178 mm)	3.50 (89 mm)
DAH8001B, DAH8002B	800	8		
DAH13001C, DAH13002C	1300	8		

English



WIRING

Reference Wiring Illustration on page 6

1. All wiring must comply with applicable local codes and ordinances.
2. Connect the heater lead wires to the proper A.C. power source. Power source for 800 and 1300 watt heaters should be continuous.
3. The heater must be properly grounded.

NOTE: Exposed wires should not come in contact with the heater housing.

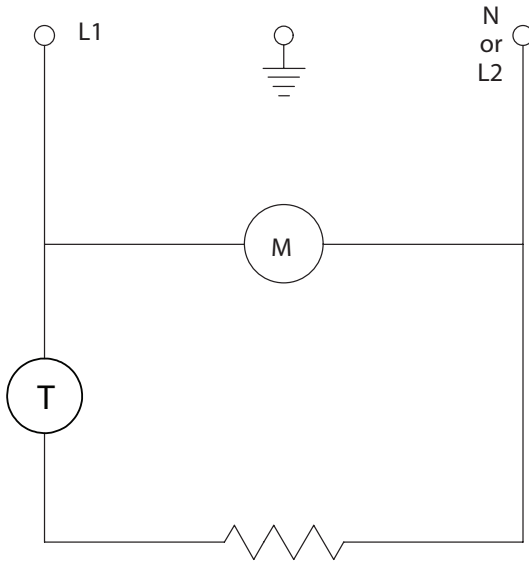
SETTING THE THERMOSTAT

1. The heater is controlled by an adjustable thermostat. Set the thermostat to the desired temperature. It is recommended not to exceed 75 F for most applications.

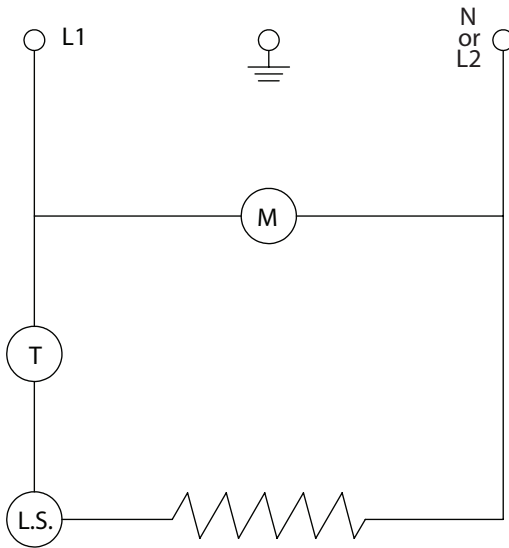
MAINTENANCE

1. Always disconnect power supply before inspecting or working on the heater.
2. Generally the unit requires no maintenance since the fan bearings are permanently lubricated and sealed.

English

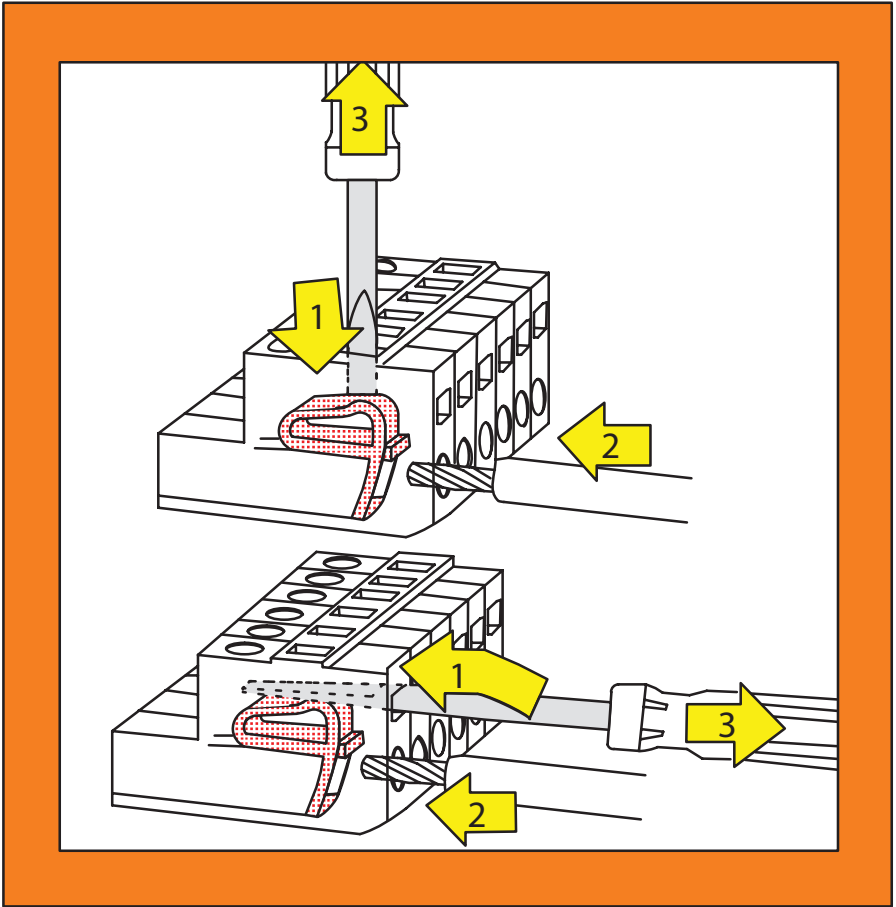


100-800 Watt Schematic



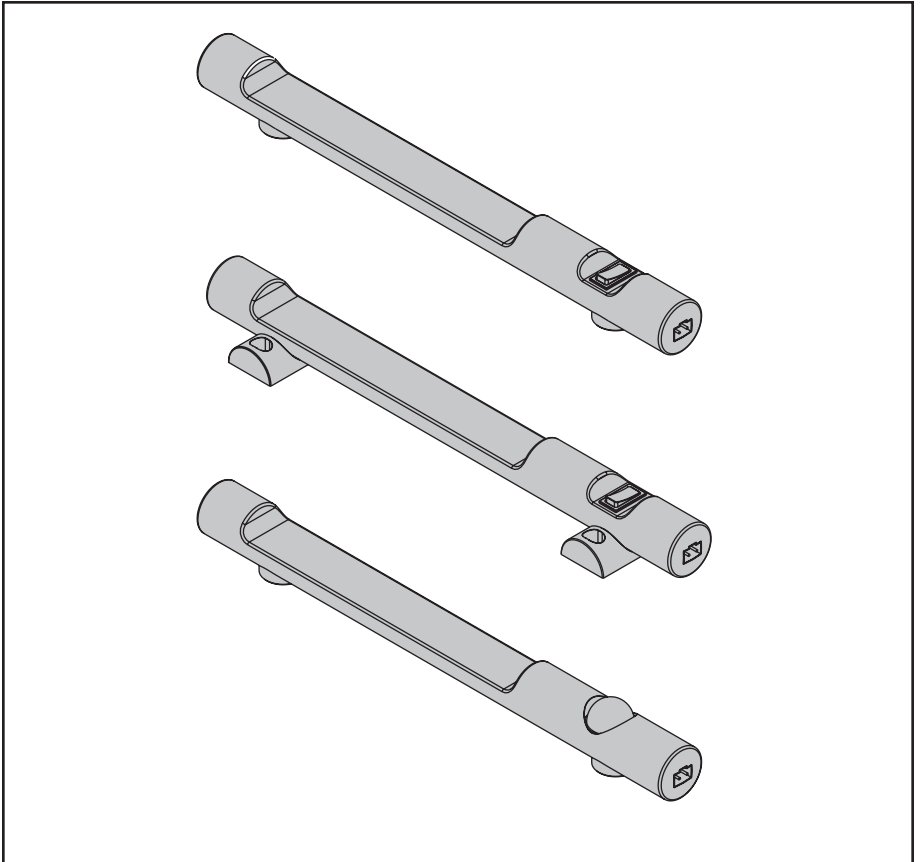
1300 Watt Schematic

Wiring Illustration



Notes

Notes



**WARNING****AVERTISSEMENT****PRECAUCION**

- To avoid electric shock and equipment damage, disconnect any power supplies to the enclosure before installing the light.
- The lighting package must be properly grounded.
- The lighting package is not designed for use in hazardous or wet locations.
- To avoid electric shock, do not energize any circuits before all internal and external electrical and mechanical clearances are checked to assure that all assembled equipment functions safely and properly.

- Pour éviter la décharge électrique et les dommages aux équipements, débranchez toutes les alimentations d'énergie à la clôture avant d'installer la lumière.
- Les paquets d'éclairage doivent être correctement fondus.
- Ces paquets d'éclairage ne sont pas conçus pour l'usage dans des endroits dangereux ou humides.
- Pour éviter la décharge électrique, n'activez aucun circuit avant que des dégagements électriques et mécaniques tout internes et externes soient vérifiés pour s'assurer que tout l'équipement assemblé fonctionne sans risque et correctement.
- Para evitar descarga eléctrica y daño de equipo, desconecte cualquier fuente de alimentación al recinto antes de instalar la luz.
- Los paquetes de la iluminación deben ser puestos a tierra correctamente.
- Estos paquetes de la iluminación no se diseñan para el uso en localizaciones peligrosas o mojadas.
- Para evitar descarga eléctrica, no energice ninguna circuitos antes de que las separaciones eléctricas y mecánicas todo internas y externas se comprueben para asegurar que funcione todo el equipo montado con seguridad y correctamente.

Introduction

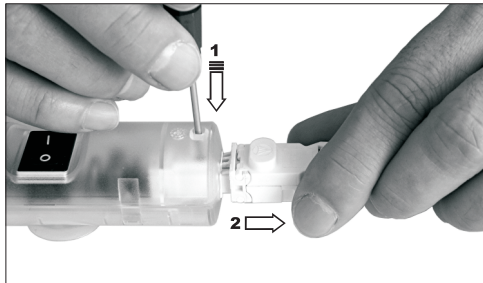
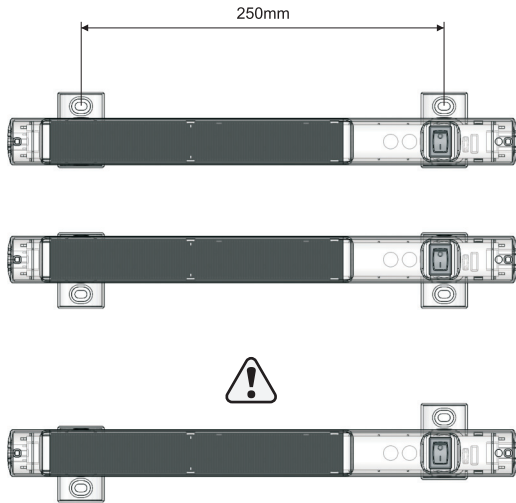
1. Before installing fixture, read these instructions carefully. Failure to follow these instructions could damage the product or cause a hazardous condition.
2. The light package is designed to operate on single phase power and at the voltage and frequency listed on the product label only.

Introduction

1. Avant d'installer le montage, lisez ces instructions soigneusement. Le manque de suivre ces instructions a pu endommager le produit ou causer un état dangereux.
2. Des paquets légers sont conçus pour opérer la puissance monophasé et à la tension et à la fréquence énumérées sur l'étiquette de produit seulement.

Introducción

1. Antes de instalar el accesorio, lea estas instrucciones cuidadosamente. La falta de seguir estas instrucciones podía dañar el producto o causar una condición peligrosa.
2. Los paquetes ligeros se diseñan para funcionar encendido energía la monofásico y en el voltaje y frecuencia enumerada en la etiqueta del producto solamente.



2 ... 10

Wiring

All wiring must comply with applicable national and local electrical codes; all authorities have jurisdiction.

Connect the fixture to a power supply consistent with the voltage and frequency information found on the product label.

Câblage

Tout le câblage doit être conforme aux codes électriques nationaux et locaux applicables; toutes les autorités ont la juridiction.

Reliez le montage à une alimentation d'énergie conformée à la tension et à l'information de fréquence trouvées sur l'étiquette de produit.

Cableado

Todo el cableado debe conformarse con códigos eléctricos nacionales y locales aplicables; todas las autoridades tienen jurisdicción.

Conecte el accesorio con una fuente de alimentación constante con el voltaje y la información de la frecuencia encontrados en la etiqueta del producto.

Commissioning The Lamp With Motion Detector

The test run is activated by disconnecting from mains and then reconnecting. The lamp flashes briefly twice and then switches off again. Upon reactivation of the motion detector, the lamp switches on for 5 seconds and then switches off again; the lamp is ready for operation.

Mise En Service De L'éclairage Avec Détecteur D'approche

Un débranchement/rebranchement active le test. L'éclairage clignote deux fois rapidement, puis s'éteint. Après réactivation du détecteur d'approche, l'éclairage s'allume pendant 5 secondes et s'éteint à nouveau, l'éclairage est prêt à fonctionner.

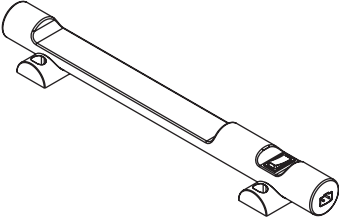

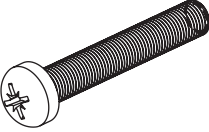
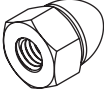
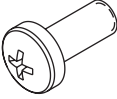

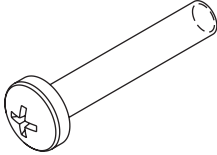
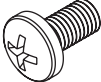
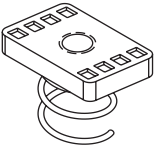
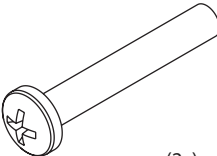
Puesta en funcionamiento de la lámpara con detector de movimiento

La marcha de prueba se activa mediante corte/conexión de la alimentación. La lámpara parpadea brevemente dos veces y se apaga. Cuando se active de nuevo el detector de movimiento, la lámpara lucirá durante 5 segundos y se volverá a apagar, la lámpara está entonces lista para funcionar.

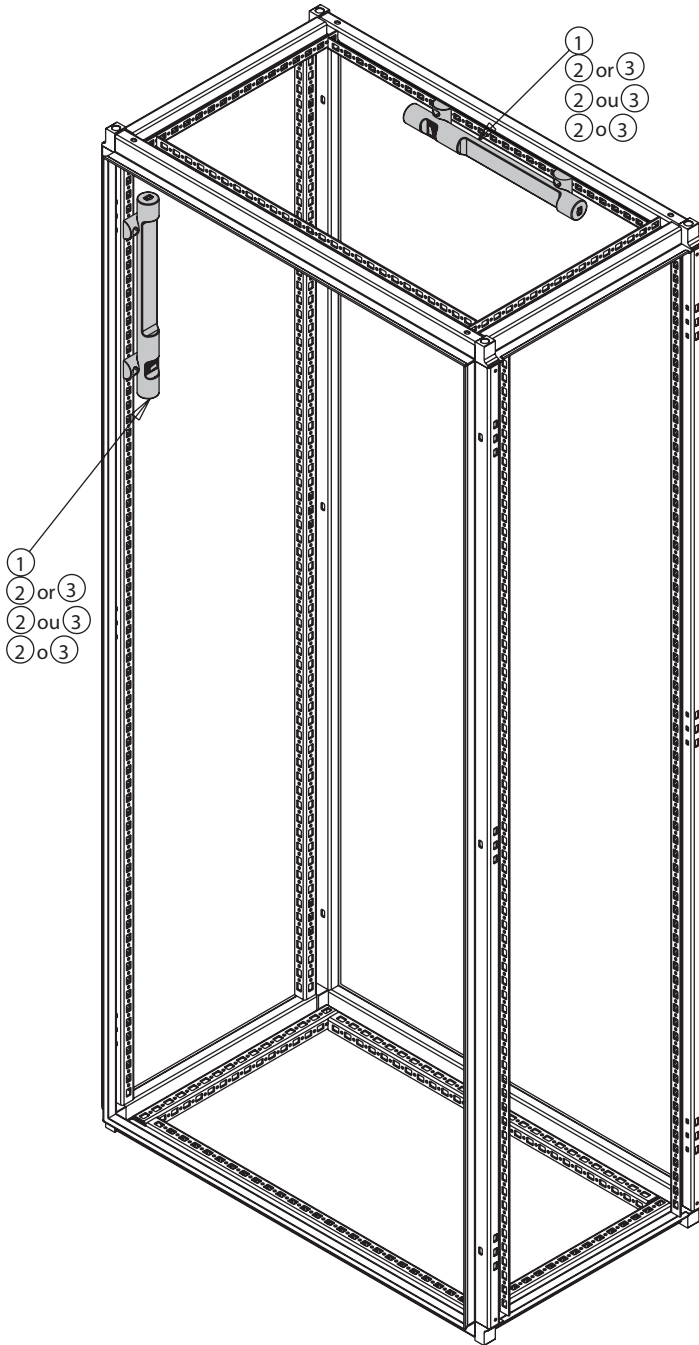
This accessory maintains UL/CSA Type 12,3R,4,4X when installed per these instructions.

Cet accessoire maintient UL/CSA Type 12,3R,4,4X une fois installé par ces instructions.

Este accesorio mantiene el Tipo 12,3R,4,4X de UL/CSA cuando está instalado por estas instrucciones.

<p>1</p> 			(1x)
<p>2</p> <p>M5x12</p>  <p>(2x)</p>	<p>3</p> <p>M5x30</p>  <p>(2x)</p>	<p>4</p> <p>M5 x .8</p>  <p>(2x)</p>	
<p>5</p> <p>M5x12 SST</p>  <p>(2x)</p>	<p>6</p>  <p>(2x)</p>	<p>7</p> <p>M5x30 SST</p>  <p>(2x)</p>	
<p>8</p> <p>10-32x.38</p>  <p>(2x)</p>	<p>9</p> <p>10-32</p>  <p>(2x)</p>	<p>10</p> <p>10-32x1.25</p>  <p>(2x)</p>	

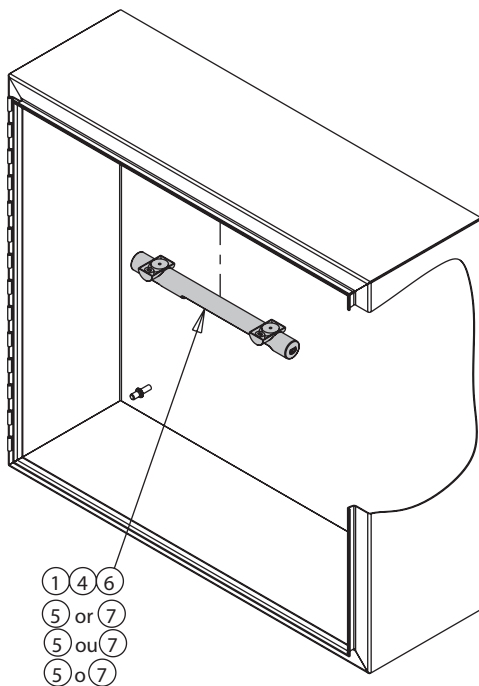
PROLINE Frame Mounting
Support D'Armature PROLINE
Montaje Del Marco PROLINE

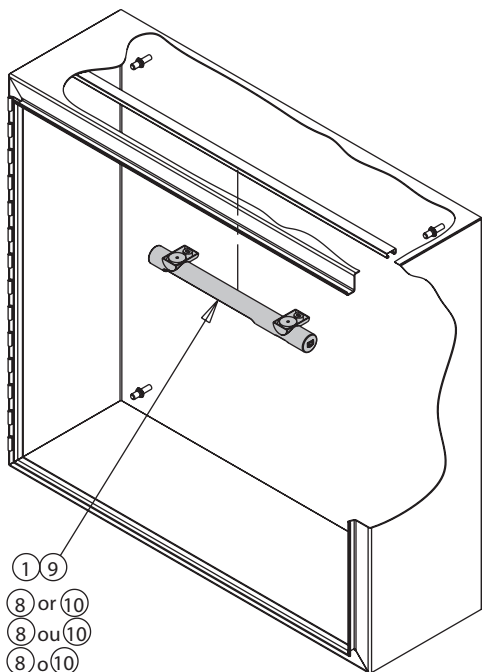


Enclosure Top Mounting

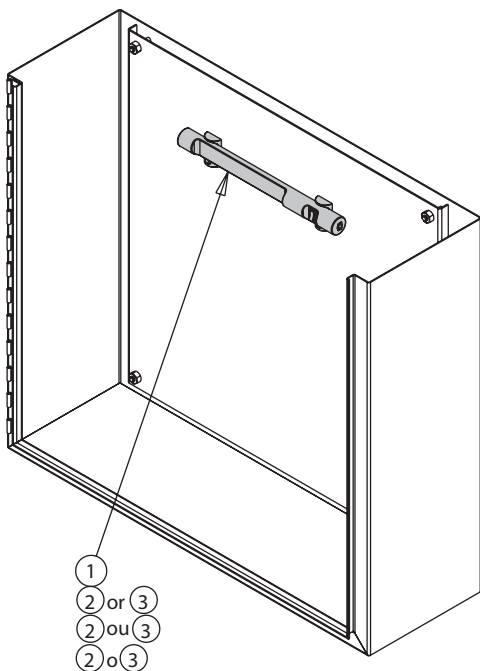
Bâti De Dessus De Clôture

Montaje De la Tapa Del Recinto



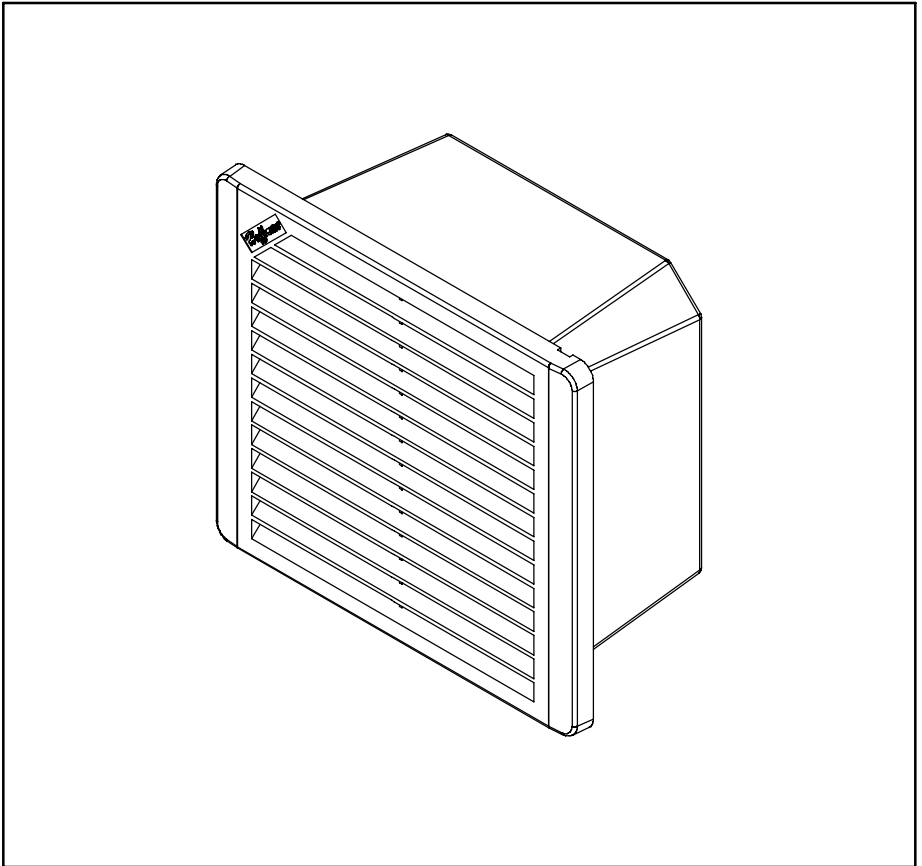


Enclosure Channel Mounting
Bâti De la Manche De Clôture
Montaje Del Canal Del Recinto



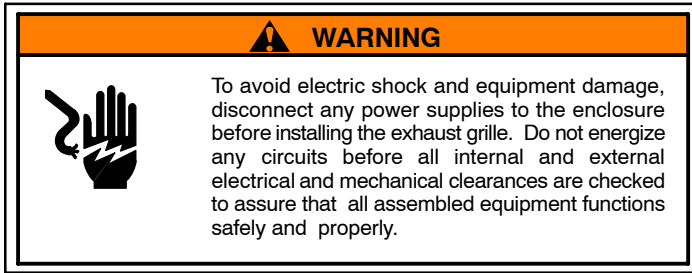
Enclosure Channel Mounting
Bâti De la Manche De Clôture
Montaje Del Canal Del Recinto

Cooling Fan Package, Type 12
Ventilateur de refroidissement, Type 12
Paquete de Ventilador, Tipo 12



Introduction

1. Before installing cooling fan package, read these instructions carefully. Failure to follow these instructions could damage the product or cause a hazardous condition.
2. Check the ratings on the fan label to assure the product is suitable for your application. Catalog numbers TFP41UL12, TFP61UL12, and TFP101UL12 operate on 115 VAC, 50/60 Hz, single phase input power. Catalog numbers TFP42UL12, TFP62UL12, and TFP102UL12 operate on 230 VAC, 50/60Hz, single phase input power.



General safety information

1. Protect the fan power cord (or lead wires) from coming in contact with sharp objects, hot surfaces, and/or chemicals.
2. If continuous operation of the fan is essential to the safe functioning of any other equipment, adequate warning devices must be installed to assure safe operation at all times. Hoffman temperature switch (catalog number ATEMNO) can be used to activate an alarm or warning light to indicate high enclosure temperatures. This temperature switch can also be used to cycle the cooling fans as cooling requirements change.



Wiring



1. All wiring must comply with applicable local codes and ordinances.
2. Connect the two fan leadwires to the proper voltage power source.
3. All fan wires should be strain relieved with tension clips.

Maintenance

1. Always disconnect power supply before inspecting or working on the fan package.
2. Generally the fan unit requires no maintenance since the bearings are permanently lubricated and sealed. The fan cannot be field serviced; it should be replaced if defective.
3. The foam filter inside the fan package should be periodically removed and washed with soap and warm water to keep it clean.

Introduction (Français)

1. Avant d'installer le ventilateur de refroidissement, bien lire ces instructions. Le défaut de lire ces instructions peut entraîner des dommages au produit ou un danger.
2. Vérifier les valeurs nominales sur l'étiquette du ventilateur pour s'assurer que le produit convient à l'usage prévu. Les numéros de catalogue TFP41SS, TFP61SS et TFP101SS sont alimentés par courant à phase simple de 115 V c.a., 50/60 Hz. Les numéros de catalogue TFP42SS, TFP62SS et TFP102SS sont alimentés par courant à phase simple de 230 V c.a., 50/60 Hz.

 AVERTISSEMENT	
	Afin d'éviter les chocs électriques et les dommages matériels, débrancher toute alimentation de l'enceinte avant d'installer la grille d'échappement. Ne pas mettre de circuits sous tension avant d'avoir vérifié tous les dégagements électriques et mécaniques internes et externes pour s'assurer que tout l'équipement assemblé fonctionne correctement et en toute sécurité.

Renseignements généraux sur la sécurité

1. Protéger le cordon d'alimentation du ventilateur (ou les fils de raccordement) pour éviter qu'ils n'entrent en contact avec des objets tranchants, des surfaces chaudes et/ou des produits chimiques.
2. Si le ventilateur doit fonctionner en continu pour assurer le fonctionnement sécuritaire de tout autre équipement, il faut installer des dispositifs de mise en garde adéquats pour garantir le fonctionnement sécuritaire en tout temps. On peut utiliser un thermocontact Hoffman (numéro de catalogue ATEMNO) pour actionner une alarme ou un voyant d'avertissement pour indiquer les températures élevées de l'enceinte. On peut aussi utiliser ce thermocontact pour faire fonctionner les ventilateurs de refroidissement en cycle selon les besoins.

 ATTENTION	
Ces ventilateurs ne sont pas conçus pour être utilisés dans les endroits dangereux.	

Câblage


1. Tous les câbles doivent être conformes aux codes et ordonnances locaux applicables.
2. Brancher les deux fils de raccordement du ventilateur dans la source d'alimentation appropriée.
3. Tous les fils du ventilateur doivent être équipés de serre-câbles réducteurs de tension.

Entretien

1. Toujours couper l'alimentation avant d'inspecter ou de réparer le ventilateur.
2. En règle générale, le ventilateur n'exige aucun entretien puisque les roulements sont lubrifiés et scellés en permanence. Le ventilateur ne peut être réparé sur place ; il faut le remplacer s'il devient défectueux.
3. Le filtre de mousse à l'intérieur du ventilateur doit être périodiquement retiré et lavé à l'eau tiède et au savon.

Introducción (Español)

1. Antes de instalar el ventilador, lea estas instrucciones cuidadosamente. El no seguir estas instrucciones podría dañar el producto o causar una condición peligrosa.
2. Lea la información contenida en la etiqueta del ventilador para asegurar que el producto es conveniente para su aplicación. Los números de catálogo TFP41UL12, TFP61UL12, y TFP101UL12 funcionan a 115 VAC, 50/60 Hz, energía de entrada monofásica. Los números de catálogo TFP42UL12, TFP62UL12, y TFP102UL12 funcionan a 230 VAC, 50/60 Hz, energía de entrada monofásica.

⚠ ADVERTENCIA	
	Para evitar descarga eléctrica y daño del equipo, desconectar cualquier fuente de energía a la caja antes de instalar la Rejilla del extractor. No energizar ningún circuito antes de que las separaciones eléctricas y mecánicas internas y externas se comprueben para asegurar que el equipo instalado correctamente y con seguridad.

Información General de Seguridad

1. Asegúrese que el cable del ventilador no entre en contacto con objetos afilados, superficies calientes, y/o productos químicos.
2. Si la operación continua del ventilador es esencial para el funcionamiento seguro de algún otro equipo, se deben instalar sistemas de alarma como luces o sirenas para asegurar una operación segura siempre. El interruptor de temperatura de Hoffman (Número de Catálogo ATEMNO) se puede utilizar para activar una alarma o una luz para indicar altas temperaturas en la caja. Este interruptor de temperatura se puede también utilizar para completar un ciclo de ventiladores cuando las condiciones ambientales cambian.

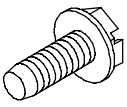
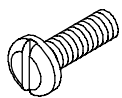

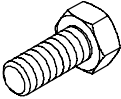


⚠ Precaución	
Estos ventiladores no están diseñados para uso en zonas clasificadas	

Cableado

1. Todo el cableado debe hacerse de acuerdo a los códigos y ordenanzas locales aplicables.
2. Conectar las dos puntas de los cables del ventilador a la fuente apropiada de energía.
3. La tensión sobre los cables del ventilador debe ser aliviada por los cips de tensión.

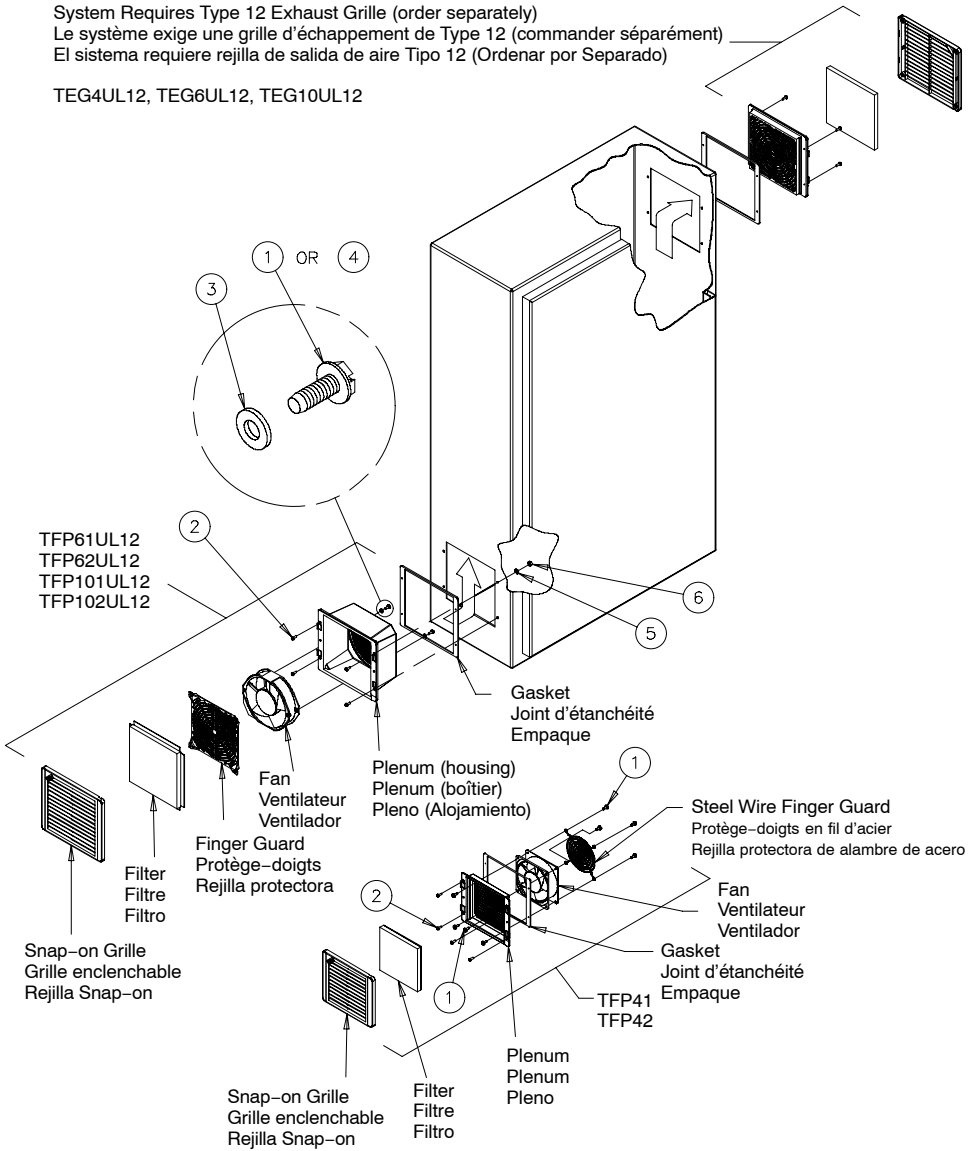
Mantenimiento

1. Desconectar siempre la fuente de energía antes de inspeccionar o trabajar en el ventilador.
2. La unidad de ventilación generalmente no requiere mantenimiento alguno, ya que los cojinetes están lubricados y sellados permanentemente. El ventilador no puede ser reparado en campo. Si este estuviera defectuoso, deberá reemplazarse.
3. El filtro de espuma dentro del ventiladores se debe quitar y lavar periódicamente con jabón y agua caliente para mantenerlo limpio.

<p>1 10-32x.50</p>  <p>(2x) (8x)</p>	<p>2 8-32x.50</p>  <p>(4x)</p>
<p>3</p>  <p>(4x)</p>	<p>4 M5x12</p>  <p>(4x)</p>
<p>5</p>  <p>(4x)</p>	<p>6 No. 8</p>  <p>(4x)</p>

System Requires Type 12 Exhaust Grille (order separately)
 Le système exige une grille d'échappement de Type 12 (commander séparément)
 El sistema requiere rejilla de salida de aire Tipo 12 (Ordenar por Separado)

TEG4UL12, TEG6UL12, TEG10UL12



NOTE: To maintain UL type 12 rating, the airflow must be in the direction shown.

NOTE: Pour maintenir la valeur nominale UL de type 12, l'air doit circuler dans le sens indiqué.

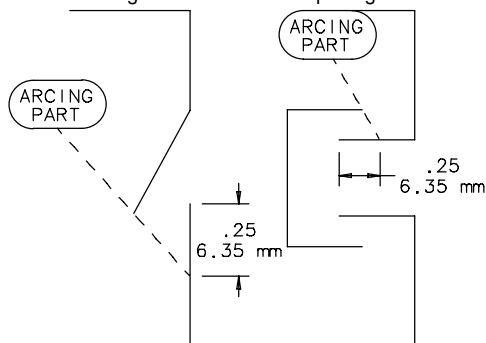
NOTA: Mantener el grado del tipo 12 de la UL, la circulación de aire debe estar en la dirección demostrada.

Location and Mounting

1. Determine the fan package location on the enclosure. This location depends on the available space within the enclosure and on the airflow pattern desired. Allow clearance for the electrical panel and mounting studs. Follow the general fan package application guidelines outlined in the Hoffman catalog. Note: Type 12 cooling fan package and exhaust grille are designed to be installed on the vertical sides of the enclosure only. Do not install these product on top of the enclosure.
2. UL Arc Barrier Requirement: If a ventilation opening is less than 12 inches (305 mm) from an arcing part, a barrier shall be interposed between the ventilation opening and a possible source of arcing, such as a power-circuit switch, a fuse, the vent openings of a circuit breaker, a conductor, or an overload relay.

Barrier Material	Minimum Thickness	
Steel	0.053 in.	1.35 mm
Aluminum	0.075 in.	1.9 mm
Polycarbonate	0.125 in.	3.2 mm
Other Non-metallic	0.250 in.	6.35 mm

A barrier shall be of such dimension and so located that any straight line drawn from any arcing part past the edge of the barriers intersects a point in the ventilation opening plane that is at least 0.25 inches (6.35 mm) outside the edge of the ventilation opening.



A barrier shall be secured in place by mechanical means such as mechanical fasteners.

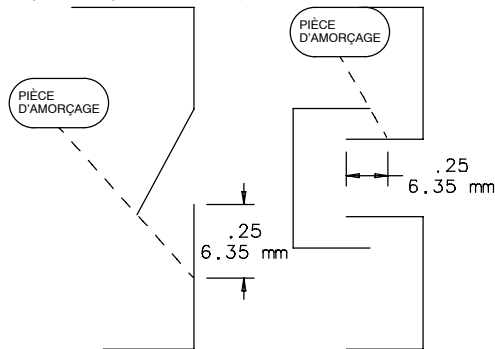
3. Clear all wires and components out of the way and make the proper size cutout. See the following hole pattern and table.
4. If electrical grounding is required, ground the fan housing using a lead wire sized per N.E.C. standards. Use the green grounding screw provided to connect the separate ground wire (not supplied) to the fan grounding pad.
5. Establish the airflow direction through the fan. Arrows marked on the fan housing indicate the airflow direction and blade rotation. Reference the exploded view and note on the previous page.
6. Guide the lead wires and the grounding wire through wire access hole in rear wall of plenum. (models: TFP61UL12, TFP62UL12, TFP101UL12, TFP102UL12 only)
7. Mount the fan to the plenum with the supplied thread cutting screws.
8. Mount steel wire finger guard to fan with supplied thread cutting screws. (models: TFP41UL12, TFP42UL12 only)
9. Insert the assembled fan package into the enclosure cutout with the gasket located between the plenum and enclosure wall as shown.
10. Secure the fan package in place using the supplied screws, lockwashers, and nuts.
11. For models TFP61UL12, TFP62UL12, TFP101UL12, and TFP102UL12, snap-in finger guard and insert filter over finger guard. For models TFP41UL12 and TFP42UL12, insert filter into plenum.
12. Insert the filter (AFLTRXXUL12) so that the white fabric side is facing into the enclosure and the foam side is facing out.
13. Snap-on grille over fan package.

Emplacement et Mounting (Français)

- Déterminer l'emplacement du ventilateur sur l'enceinte. Cet emplacement dépend de l'espace disponible dans l'enceinte et du débit d'air désiré. Prévoir un dégagement pour le panneau électrique et les tiges de fixation. Suivre les lignes directrices générales sur l'installation du ventilateur contenues dans le catalogue Hoffman. Note : Le ventilateur de refroidissement de Type 12 et la grille d'échappement sont conçus pour être installés sur les parois verticales de l'enceinte seulement. Ne pas installer ce produit sur le dessus de l'enceinte.
- Exigences de coupe-arc UL : Si une prise d'air de ventilation se trouve à moins de 12 pouces (305 mm) d'une pièce d'amorçage, un coupe-arc doit être placé entre la prise d'air de ventilation et une source possible d'arc, comme un interrupteur de circuit d'alimentation, un fusible, les prises d'air de ventilation d'un disjoncteur, un conducteur ou un relais de surcharge.

Matériau du coupe-arc	Épaisseur minimale	
Acier	0,053 po	1,35 mm
Aluminium	0,075 po	1,9 mm
Polycarbonate	0,125 po	3,2 mm
Non métallique	0,250 po	6,35 mm

Les dimensions et l'emplacement d'un coupe-arc feront en sorte qu'une ligne droite tracée d'une pièce d'amorçage au-delà du bord des coupe-arc traverse un point du plan de la prise d'air de ventilation d'au moins 0,25 pouce (6,35 mm) le bord de la prise d'air de ventilation.



Un coupe-arc doit être fixé en place à l'aide de dispositifs mécaniques comme des attaches mécaniques.

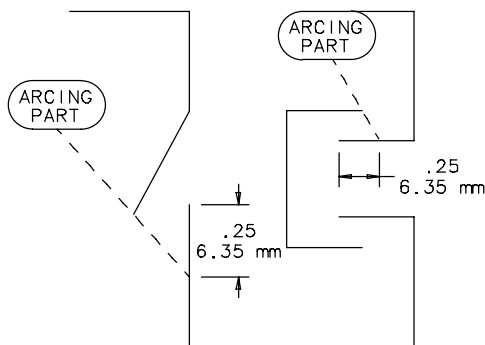
- Éloigner tous les fils et composants et découper à la dimension appropriée. Voir le gabarit et le tableau de découpe qui suit.
- S'il faut effectuer une mise à la terre électrique, mettre le boîtier du ventilateur à la terre à l'aide d'un fil de raccordement de calibre conforme aux normes du Code canadien de l'électricité. Utiliser la vis de mise à la terre verte prévue pour raccorder le fil de terre distinct (pas fourni) à la prise de masse du ventilateur.
- Déterminer le sens du débit d'air dans le ventilateur. Les flèches sur le boîtier du ventilateur indiquent le sens du débit d'air et de la rotation des lames. Se reporter à la vue éclatée et à la note à la page précédente.
- Guider les fils de raccordement et le fil de terre dans le trou d'accès sur la paroi arrière du plenum. (modèles : TFP61UL12, TFP62UL12, TFP101UL12, TFP102UL12 seulement)
- Monter le ventilateur sur le plenum à l'aide des vis autotaraudeuses fournies.
- Installer le protège-doigts à fil d'acier sur le ventilateur à l'aide des vis autotaraudeuses fournies. (modèles : TFP41UL12, TFP42UL12 seulement)
- Insérer le ventilateur assemblé dans l'ouverture de l'enceinte, le joint d'étanchéité situé entre le plenum et la paroi de l'enceinte, tel qu'illustré.
- Fixer le ventilateur en place à l'aide des vis, des rondelles de blocage et des écrous fournis.
- Pour les modèles TFP61UL12, TFP62UL12, TFP101UL12 et TFP102UL12, enclencher le protège-doigts en place et insérer le filtre sur le protège-doigts. Pour les modèles TFP41UL12 et TFP42UL12, insérer le filtre dans le plenum.
- Insérer le filtre (AFLTRXXUL12) de sorte que le côté en tissu blanc soit face à l'intérieur de l'enceinte et que le côté mousse soit face à l'extérieur.
- Enclencher la grille en place sur le ventilateur.

Ubicación y Montaje (Español)

- Determine la ubicación del ventilador en la caja. La ubicación dependerá del espacio disponible dentro de la caja y del patrón de circulación de aire deseado. Permitir la separación para el panel y las superficies de montaje eléctrico. Seguir las pautas generales para la utilización del paquete de ventilador señaladas en el catálogo de Hoffman. Nota: El paquete de Ventilador y rejilla de salida Tipo 12 están diseñados para ser instalados únicamente en los costados verticales de un gabinete. No instalar este producto en la parte superior de un gabinete.
- Requerimiento de aislamiento de arco eléctrico. – Si el corte para instalar el ventilador está a menos de 12 pulgadas (305 milímetros) de un elemento que genere arco eléctrico, deberá contar con aislamiento de la fuente que lo genera tales como supresores de picos, interruptor termo magnético o fusibles.

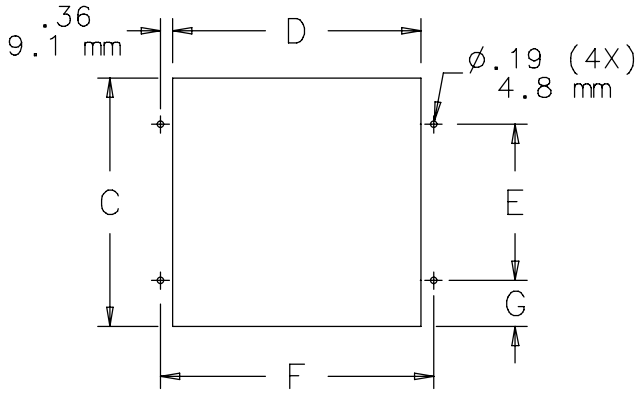
Barrera Material	Minimizar del Espesor	
Acero	0.053 in.	1.35 mm
Aluminio	0.075 in.	1.9 mm
Policarbonato	0.125 in.	3.2 mm
No-metálico	0.250 in.	6.35 mm

El aislamiento deberá ser de la capacidad adecuada y separado al menos .25 pulgadas (6.35 mm) del hueco hecho para la instalación del ventilador.



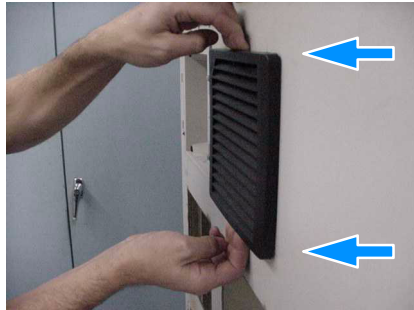
El elemento de aislamiento debe ser fijado mecánicamente.

- Despejar el área de corte de cables y componentes para hacer el corte del tamaño apropiado. Ver el patrón de corte y tabla anexos.
- En caso de requerir aterrizaje eléctrico, aterrizar el alojamiento del ventilador utilizar cable de acuerdo a los estándares de N.E.C. Utilizar el tornillo verde de aterrizaje para conectar el cable separado de la tierra (no incluido) a la plataforma de aterrizaje del ventilador.
- Establecer la dirección de circulación de aire a través del ventilador. Las flechas marcadas en el alojamiento del ventilador indican la dirección de la circulación de aire y la rotación de las aspas del ventilador. Referirse a la vista detallada y a la nota en la página anterior.
- Dirigir los cables a través del orificio de acceso del cable en la pared posterior del pleno. (Modelos TFP61UL12, TFP6UL12, TFP101UL12, TFP10UL12 únicamente).
- Montar el ventilador en el pleno con los tornillos provistos.
- Montar la rejilla al ventilador con los tornillos provistos. (Modelos: TFP41UL12, TFP42UL12 únicamente)
- Inserte el paquete de ventilador ya ensamblado en el corte hecho al gabinete con el sello ubicado entre el pleno y la pared del gabinete. Como se muestra en la imagen.
- Asegurar el paquete de ventilador en su ubicación con los tornillos, tuercas y rondanas provistas.
- Para los modelos TFP61UL12, TFP6UL12, TFP101UL12 y TFP10UL12, instalar la rejilla protectora e insertar el filtro sobre ésta. Para los modelos TFP41UL12 y TFP4UL12, insertar el filtro en el pleno.
- Insertar el filtro (AFLTRXXUL12) de modo que el lado blanco de la tela sea instalado viendo hacia el gabinete y el lado de espuma hacia fuera del gabinete.
- Instalar la rejilla al paquete de ventilador.

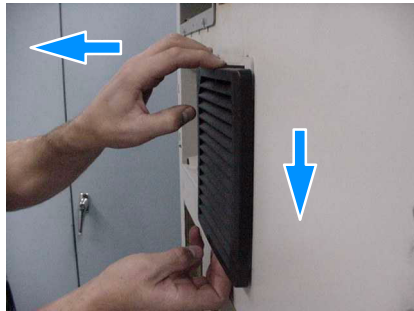


Catalog Number	C	D	E	F	G
TFP41UL12 TFP42UL12	5.66 in. (144)	5.66 in. (144)	4.12 in. (105)	6.39 in. (162)	.77 in. (20)
TFP61UL12 TFP62UL12	7.16 in. (182)	7.16 in. (182)	4.50 in. (114)	7.89 in. (200)	1.33 in. (34)
TFP101UL12 TFP102UL12	11.16 in. (283)	11.16 in. (283)	6.88 in. (175)	11.89 in. (302)	2.14 in. (54)

Grille Removal
Retrait de la grille
Retiro De la Rejilla



1. Grasp the top and bottom of the grille.
Saisir les parties supérieure et inférieure de la grille.
Agarre la rejilla de la parte superior e inferior como lo muestra la foto.



2. While pulling out, push down.
Tirer vers l'extérieur et le bas en même temps.
Mientras esta sacando la rejilla, empuje hacia abajo al mismo tiempo.



3. Grille releases.
La grille se dégage.
La rejilla estará desprendida

Hoffman Enclosures Inc.

2100 Hoffman Way
Anoka, MN 55303-1745
(763) 422-2211
www.hoffmanonline.com

Pentair Electronic Packaging

170 Commerce Drive
Warwick, RI 02886
(401) 732-3770
www.pentair-ep.com

Mexico

Hoffman Enclosures Mexico
Federico T. de la Chica No. 8 Piso 4 A
Circuito Comercial Plaza Satélite
Ciudad Satélite,
Naucalpan, México C.P. 53100
011-52-55-5393-8263

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47 022 76 33 60

Socket - EM-DUO/120/15/GFI - 5600462

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Rail-mounted dual power outlet with two 120 V AC/15 A receptacles equipped with ground fault circuit interruption (GFCI) for 35 mm DIN rail per EN 60715. GFCI protects against shock hazards associated with ground shorts. For enhanced safety, the grounding pin is located at the top to prevent shorting between the hot and neutral blades.
Housing color: ivory. National version: USA. Connection type: screw.



Key Commercial Data

Packing unit	1 pc
Weight per Piece (excluding packing)	280.0 g
Custom tariff number	85366990
Country of origin	United States

Technical data

Dimensions

Width	82 mm
Height	135 mm
Depth	49 mm

Ambient conditions

Ambient temperature (operation)	-35 °C ... 60 °C
---------------------------------	------------------

General

Nominal voltage U_N	125 V AC
Nominal current I_N	15 A
For country-specific use in	USA
	Canada
	Mexico
	Bahamas

Socket - EM-DUO/120/15/GFI - 5600462

Technical data

General

	Bermuda
	Columbia
	Costa Rica
	Ecuador
	El Salvador
	Panama
	Puerto Rico
	Taiwan
	Venezuela
	Virgin Islands
Color	ivory
Insulating material	Polycarbonate & ABS blend
Standards/regulations	UL 508
	UL 943
	CSA 22.2

Connection data

Conductor cross section solid max.	6 mm ²
Conductor cross section flexible max.	4 mm ²
Conductor cross section AWG max.	10
Connection method	Screw connection
Stripping length	8 mm
Screw thread	M3

Standards and Regulations

Standards/regulations	UL 508
	UL 943
	CSA 22.2

Classifications

eCl@ss

eCl@ss 4.0	27142305
eCl@ss 4.1	27142305
eCl@ss 5.0	27143412
eCl@ss 5.1	27143412
eCl@ss 6.0	27143412
eCl@ss 7.0	27440519

Socket - EM-DUO/120/15/GFI - 5600462

Classifications

eCl@ss

eCl@ss 8.0	27142305
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ETIM

ETIM 2.0	EC001325
ETIM 3.0	EC001325
ETIM 4.0	EC001663
ETIM 5.0	EC001663

UNSPSC

UNSPSC 6.01	30211806
UNSPSC 7.0901	39121406
UNSPSC 11	39121406
UNSPSC 12.01	39121406
UNSPSC 13.2	39121406

Approvals

Approvals

Approvals

UL Listed / cUL Listed / cULus Listed

Ex Approvals


Approvals submitted

Approval details

UL Listed	
mm ² /AWG/kcmil	30-10
Nominal current I _N	15 A
Nominal voltage U _N	125 V

Socket - EM-DUO/120/15/GFI - 5600462

Approvals

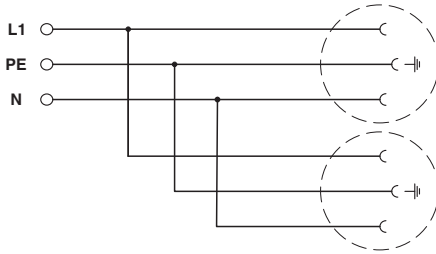
cUL Listed 	
mm ² /AWG/kcmil	30-10
Nominal current I _N	15 A
Nominal voltage U _N	125 V

cULus Listed 	
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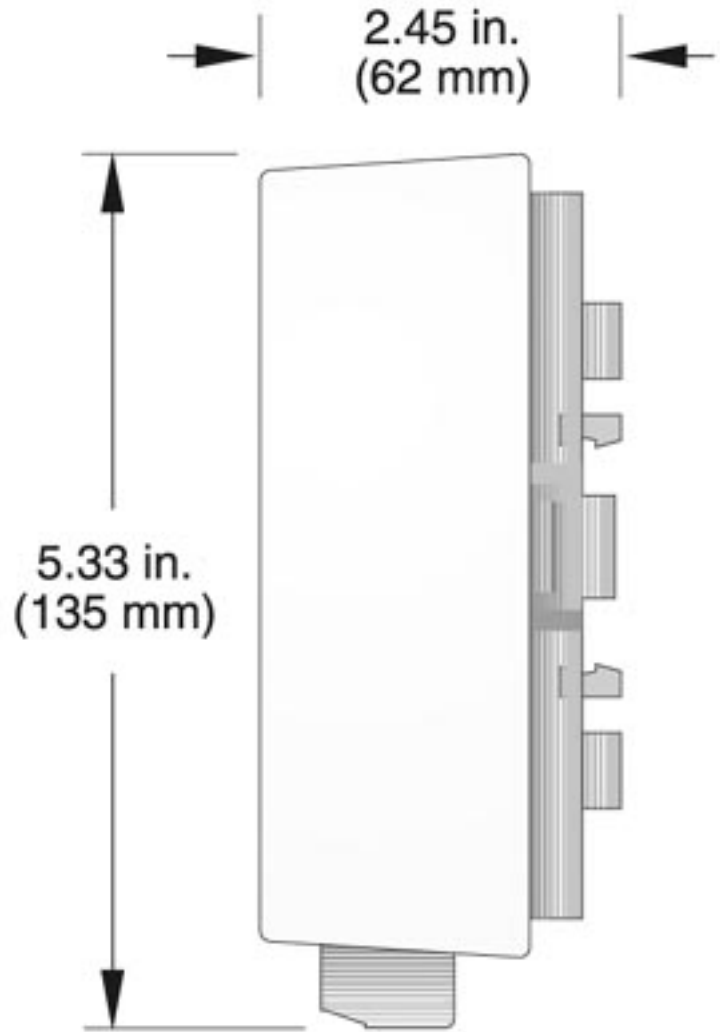
Drawings

Socket - EM-DUO/120/15/GFI - 5600462

Circuit diagram



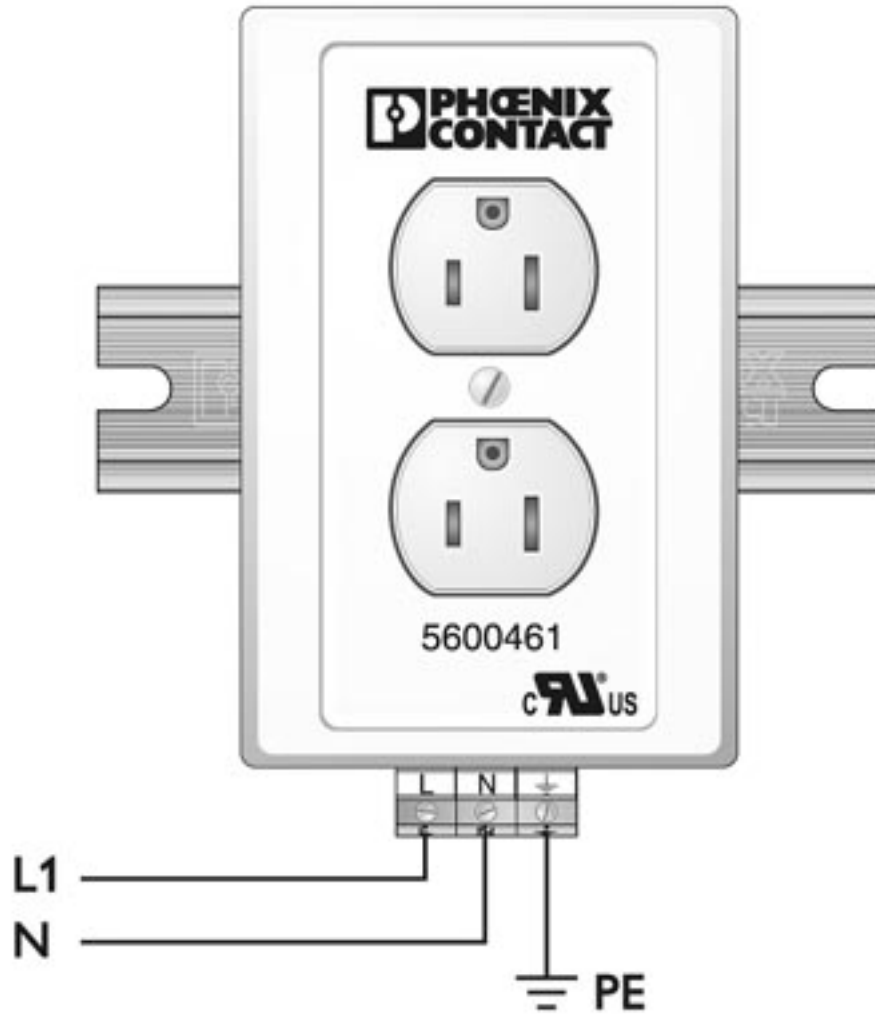
Dimensional drawing



Side view

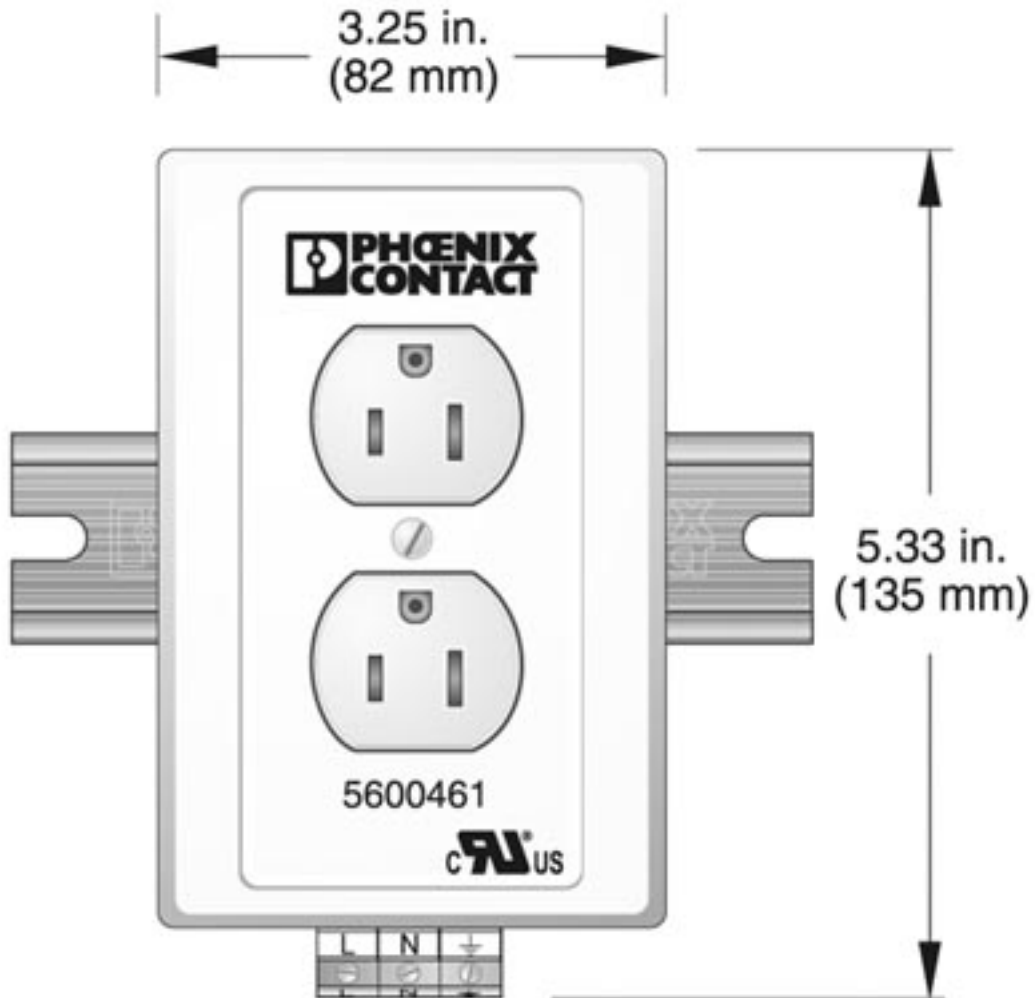
Socket - EM-DUO/120/15/GFI - 5600462

Connection diagram



Socket - EM-DUO/120/15/GFI - 5600462

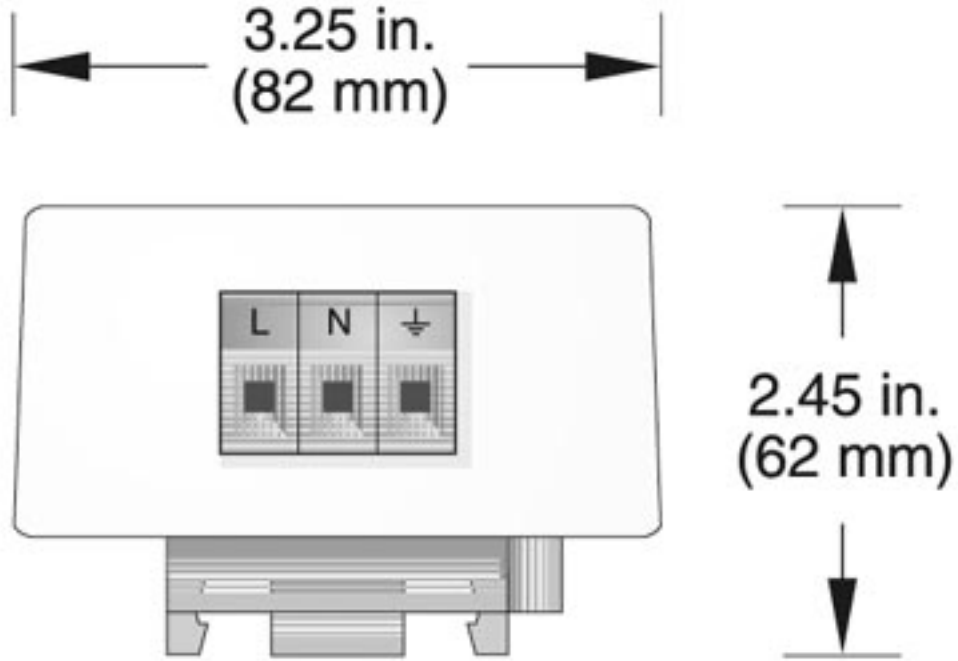
Dimensional drawing



Front view

Socket - EM-DUO/120/15/GFI - 5600462

Dimensional drawing



Bottom view

Mouser Electronics

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Thermal-Magnetic Circuit Protectors Protectores de circuitos termomagnéticos Protections de circuits thermomagnétiques

Class Clase Classe	Type Tipo Type	Series Serie Série
9080	GCB	C



INTRODUCTION

The Class 9080 Type GCB Series C thermal-magnetic circuit protector is a trip-free, track-mountable device with current ratings from 0.1 to 15 amperes. The following pages describe the product specifications and give instructions for mounting and removal.

TECHNICAL DATA

Tables 1 through 5 list the physical and electrical characteristics of the circuit protectors.

Table 1: General Characteristics

Weight	2.2 oz. (62.4 g)
Types of terminals	Box lug, screw terminals, UL and CSA field-approved
Recommended tightening torque	8 to 10 lb-in (0.9 - 1.1 N•m)
Approvals	CSA certified (File LR 25490)
	CE
	NOM
	UL component recognized (File E152841) 0.05-8 amps @ 250 V AC 65 V DC 9 - 15 amps @ 125 V AC 65 V DC

Table 2: Electrical Characteristics

Maximum voltage rating	250 V AC 65 V DC
Maximum interrupting capacity	200 A
Dielectric strength	1500 V AC
Insulation resistance	100 MΩ

1. Not exceeding 10,000% of rated current.

INTRODUCCION

El protector de circuitos termomagnético clase 9080 tipo GCB serie C es un dispositivo de disparo libre que se monta en un riel con valores nominales de corriente de 0,1 a 15 A. Las siguientes páginas contienen las especificaciones del producto así como las instrucciones para su montaje y desmontaje.

DATOS TECNICOS

Las tablas 1 a 5 presentan las características físicas y eléctricas de los protectores de circuitos.

Tabla 1: Características generales

Peso	62,4 g (2,2 oz.)
Tipos de terminales	Zapata tipo caja, terminales tipo tornillo, aprobadas por UL y CSA para uso en campo.
Par de apriete recomendado	0,9 a 1,1 N•m (8 a 10 lb-pulg)
Aprobaciones	Certificados por CSA (archivo LR 25490)
	CE
	NOM
	Componente reconocido por UL (archivo E152841) 0,05 - 8 A a 250 V ~ (ca) 65 V --- (cd) 9 - 15 A a 125 V ~ (ca) 65 V --- (cd)

Tabla 2: Características eléctricas

Valor nominal máximo de tensión	250 V~ (ca) 65 V --- (cd)
Valor nominal máximo de interrupción	200 A ¹
Resistencia dieléctrica	1500 V~(ca)
Resistencia de aislamiento	100 MΩ

1. Sin exceder 10 000% de la corriente nominal.

INTRODUCTION

La protection de circuits thermomagnétiques, classe 9080, type GCB série C, est un dispositif à déclenchement libre, qui se monte sur rail, avec des valeurs nominales de courant allant de 0,1 à 15 A. Les pages suivantes décrivent les caractéristiques du produit et donnent les directives de montage et démontage.

CARACTÉRISTIQUES TECHNIQUES

Les tableaux 1 à 5 indiquent les caractéristiques physiques et électriques des protections de circuits.

Tableau 1 : Caractéristiques générales

Poids	62,4 g (2,2 onces)
Types de bornes	Borne carré, bornes à vis, homologuées par UL et CSA pour usage sur place
Couple de serrage recommandé	0,9 à 1,1 N•m (8 à 10 lb-po)
Approbations	Homologué CSA (fichier LR 25490)
	CE
	NOM
	Composant reconnu par UL (fichier E152841) 0,05 à 8 A à 250 VCA 65 VCC 9 à 15 A à 125 VCA 65 VCC

Tableau 2 : Caractéristiques électriques

Tension nominale maximale	250 VCA 65 VCC
Capacité maximale d'interruption	200 A ¹
Rigidité diélectrique	1 500 VCA
Résistance d'isolement	100 MΩ

1. Ne dépassant pas 10 000% du courant nominal.

Table / Tabla / Tableau 3 : Current Versus Resistance / Corriente/resistencia / Courant par rapport à la résistance

Standard Current (A) / Corriente estándar (A) / Courant standard (A)	Internal Resistance (Ω) / Resistencia interna (Ω) / Résistance interne (Ω)
0.10 (0,10)	133
0.50 (0,50)	6.6 (6,6)
0.80 (0,80)	2.55 (2,55)
1.00 (1,00)	1.97 (1,97)
1.20 (1,20)	1.27 (1,27)
1.50 (1,50)	0.86 (0,26)
2.00 (2,00)	0.49 (0,49)
2.50 (2,50)	0.313 (0,313)
3.00 (3,00)	0.205 (0,205)
4.00 (4,00)	0.104 (0,104)
5.00 (5,00)	0.082 (0,082)
7.00 (7,00)	0.034 (0,034)
10.00 (10,00)	< 0.02 (0,02)
15.00 (15,00)	< 0.02 (0,02)

Table / Tabla / Tableau 4 : Tripping Times at 70 °F (21 °C) / Tiempos de disparo a 21°C (70°F) / Temps de déclenchement à 21 °C (70 °F)

Rated Current / Corriente nominal / Courant nominal	Tripping Time (seconds) / Tiempo de disparo (en segundos) / Temps de déclenchement (secondes)
100%	No trip ¹ / Sin disparo ¹ / Sans déclenchement ¹
200%	7 - 60
300%	2 - 15
400%	0.9 - 7.5 (0,9 - 7,5)
500%	0.5 - 5.0 (0,5 - 5,0)
600%	0.2 - 3.7 (0,2 - 3,7)
1000%	0.003 - 1.5 (0,003 - 1,5)
≥ 2000%	.01 maximum (0,01 máximo / 0,01 maximum)

1. When several breakers are channel-mounted adjacent to each other, the "no trip" current will be 80% of rated current at 70 °F. /
 Cuando se montan varios interruptores automáticos en canal, adyacentes uno con el otro, la corriente "sin disparo" será el 80% de la corriente nominal a 21°C (70°F). /
 Lorsque plusieurs disjoncteurs sont montés sur rail de façon contiguë, le courant « sans déclenchement » est de 80 % du courant nominal à 21 °C (70 °F).

Table / Tabla / Tableau 5 : Current Rating Factors / Factores del valor nominal de corriente / Facteurs de courant nominal

Temperature / Temperatura / Température		Factor / Factor / Facteur
°F	°C	
100	37.8 (37,8)	1.1 (1,1)
120	48.9 (48,9)	1.2 (1,2)
140	80	1.3 (1,3)
160	71.1 (71,1)	1.4 (1,4)
180	82.2 (82,2)	1.5 (1,5)
200	93.3 (93,3)	1.6 (1,6)

For each elevated ambient temperature, you can find the proper current rating of the circuit protector by multiplying the actual full load current with the appropriate factor listed in Table 5. Select the closest higher amp rating.

MOUNTING AND REMOVAL

To attach the circuit protector assembly to the mounting track, hook either leg of the adaptor beneath one side of track and snap adaptor onto the other side of the track (see Figure 1).

Para cada grado de elevación de temperatura podrá encontrar la corriente nominal adecuada del protector de circuitos, multiplicando la corriente de plena carga real por el factor apropiado que se indica en la tabla 5. Seleccione el valor nominal en amperes superior más cercano.

MONTAJE Y DESMONTAJE

Para instalar el ensamble del protector de circuitos en el riel de montaje, enganche cualquiera de las bases del adaptador debajo de un lado del riel y encaje el adaptador en el otro lado del riel (vea la figura 1).

Pour chaque élévation de température ambiante, il est possible de trouver le courant nominal approprié du dispositif de protection de circuits, en multipliant le courant de pleine charge réel par le facteur approprié indiqué au tableau 5. Sélectionner l'intensité nominale supérieure la plus proche.

MONTAGE ET DÉMONTAGE

Pour fixer l'assemblage de protection de circuits au rail de montage, accrocher n'importe quelle base de l'adaptateur sous un côté du rail et engager l'adaptateur sur l'autre côté (voir la figure 1).

⚠ DANGER / PELIGRO / DANGER

HAZARDOUS VOLTAGE

Turn off all power supplying this equipment before working on it.

Electric shock will result in death or serious injury.

TENSION PELIGROSA

Desenergice el equipo antes de realizarle servicio.

Una descarga eléctrica podrá causar la muerte o lesiones serias.

TENSION DANGEREUSE

Coupez l'alimentation avant de travailler sur cet appareil.

Une électrocution entrainera la mort ou des blessures graves.

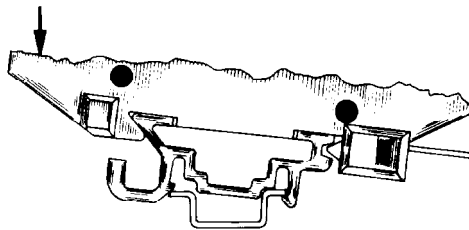


Figure / Figura / Figure 1 : Mounted Circuit Protector / Protector de circuitos montado /
Montage de la protection de circuits

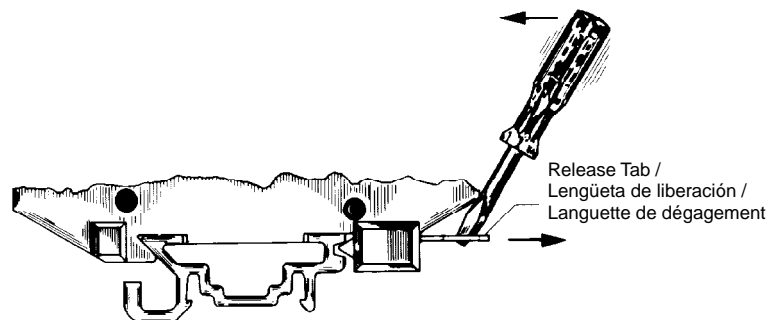


Figure / Figura / Figure 2 : Removing the Circuit Protector / Desmontaje del protector de circuitos /
Démontage de la protection de circuits

To remove the circuit protector from the adaptor, insert a screwdriver blade into the release-tab slot and pry the tab outward (see Figure 2).

To remove the adaptor from the mounting track, remove the circuit protector as described above, then insert a screwdriver blade behind the adaptor's release arm and pry the arm outward (see Figure 3).

Para desmontar el protector de circuitos del adaptador, inserte la punta de un desarmador en la ranura de la lengüeta de liberación y haga palanca para sacar la lengüeta hacia afuera (vea la figura 2).

Para desmontar el adaptador del riel de montaje, retire el protector de circuitos como se describe a continuación, luego inserte la punta de un desarmador detrás del brazo de liberación del adaptador y haga palanca para sacar el brazo hacia afuera (vea la figura 3).

Pour démonter la protection de circuits de l'adaptateur, insérer la lame d'un tournevis dans la fente de la languette de dégagement et forcer sur la languette vers l'extérieur (voir la figure 2).

Pour démonter l'adaptateur du rail de montage, retirer la protection de circuits comme décrit ci-dessus, puis insérer la lame d'un tournevis derrière le bras de dégagement de l'adaptateur pour le sortir vers l'extérieur (voir la figure 3).

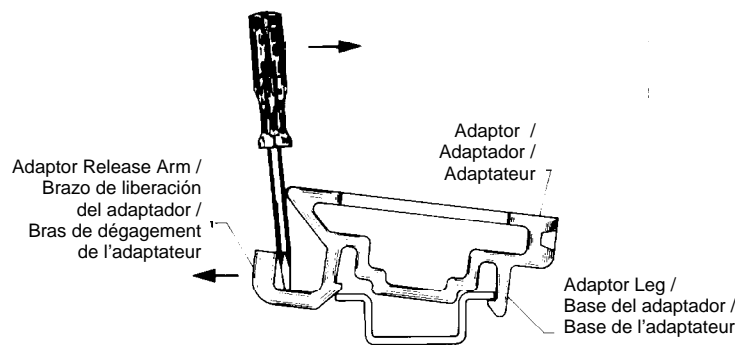


Figure / Figura / Figure 3 : Removing the Adaptor / Desmontaje del adaptador / Démontage de l'adaptateur

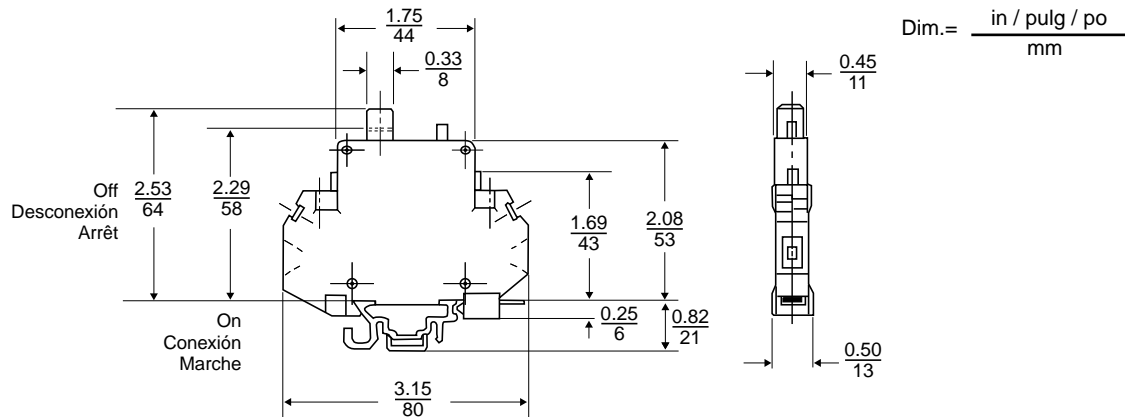




Figure / Figura / Figure 4 : Circuit Protector Dimensions / Dimensiones del protector de circuitos / Dimensions du dispositif de protection de circuits

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Square D Company
 8001 Hwy 64 East
 Knightdale, NC 27545 USA
 (919) 266-3671

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Importado en México por:
 Schneider Electric México, S.A. de C.V.
 Calz. J. Rojo Gómez 1121
 Col. Gpe. del Moral 09300 México, D.F.
 Tel. 686-30-00

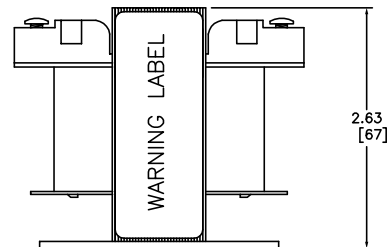
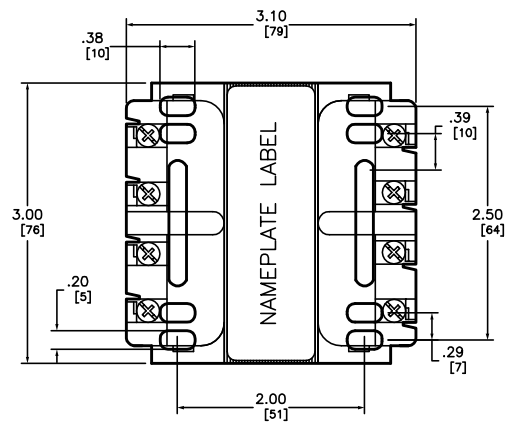
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Schneider Canada Inc.
 19 Waterman Avenue, M4B 1 Y2
 Toronto, Ontario
 (416) 752-8020

J:\wip\209\control online\5840.DWG 07/22/2008 12:13:06 PM

CATALOG NUMBER	PRIMARY VOLTAGE	SECONDARY VOLTAGE	50/60 Hz 1 PHASE		APPROXIMATE WEIGHT (Lbs/Kg)
			UL/cUL/CSA/NOM RATINGS (VA)	CE RATINGS (VA)	
9070T50D1	220/440 230/460 240/480	110 115 120	50	50	2.5 / 1.1
9070T50D2	240/480	24	50	50	2.5 / 1.1
9070T50D3	208	120	50	50	2.5 / 1.1
9070T50D4	277	120	50	50	2.5 / 1.1
9070T50D5	550 575 600	110 115 120	50	50	2.5 / 1.1
9070T50D12	440 460 480	220 230 240	50	50	2.5 / 1.1
9070T50D13	120	12/24	50	50	2.5 / 1.1
9070T50D14	208	24	50	50	2.5 / 1.1
9070T50D15	240/480	24/120	50	50	2.5 / 1.1
9070T50D22	480	277	50	50	2.5 / 1.1
9070T50D23	120/240	24	50	50	2.4 / 1.0
9070T50D24	110 115 120	110 115 120	50	50	2.5 / 1.1
9070T50D25	277	24	50	50	2.5 / 1.1
9070T50D31	220/440 230/460 240/480	110/220 115/230 120/240	50	50	2.5 / 1.1
9070T50D33	380/400/415	115/230	50	50	2.5 / 1.1
9070T50D36	600	12/24	50	50	2.5 / 1.1
9070T50D37	550 575 600	110/220 115/230 120/240	50	50	2.5 / 1.1
9070T50D52	380/400/415	12/24	50	50	2.5 / 1.1
9070T50D54	120/240	12/24	50	50	2.5 / 1.1
9070T50D55	110/220 115/230 120/240	110/220 115/230 120/240	50	50	2.5 / 1.1
9070T50D59	240/480	12/24	50	50	2.3 / 1.0
9070T50D60	277	120/240	50	50	2.5 / 1.1
9070T50D62	600	240	50	50	2.5 / 1.1



FILES/STANDARDS:
 UL/cUL FILE: E61239
 CSA FILE: LR37055
 CE: TUV CERTIFIED TO 61558
 NOM 117

50VA-CONTROL POWER TRANSFORMER
 9070 TYPE T
 CATALOG NUMBERS: FROM CHART

SQUARE D
 Schneider Electric

DWG# 5840
 NO.

Uninterruptible power supply - QUINT-UPS/ 24DC/ 24DC/10 - 2320225

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Uninterruptible power supply with IQ technology for DIN rail mounting, input: 24 V DC, output: 24 V DC/10 A, including mounted universal DIN rail adapter UTA 107/30

Why buy this product

- Easy handling thanks to automatic battery detection, tool-free battery replacement during operation, and communication via the IFS interface
- Reliable starting of difficult loads with the static POWER BOOST power reserve with up to 1.5 times the nominal current permanently
- Fast tripping of standard circuit breakers with SFB (selective fuse breaking) technology
- Device suitable for universal use thanks to comprehensive license package and extensive parameterization and diagnostics options



Key Commercial Data

Packing unit	1 STK
Weight per Piece (excluding packing)	680.0 g
Custom tariff number	85371091
Country of origin	China

Technical data

Dimensions

Width	35 mm
Height	130 mm
Depth	125 mm
Width with alternative assembly	123 mm
Height with alternative assembly	130 mm
Depth with alternative assembly	39 mm

Ambient conditions

Degree of protection	IP20
----------------------	------

Uninterruptible power supply - QUINT-UPS/ 24DC/ 24DC/10 - 2320225

Technical data

Ambient conditions

Ambient temperature (operation)	-25 °C ... 70 °C
Ambient temperature (storage/transport)	-40 °C ... 85 °C
Max. permissible relative humidity (operation)	≥ 95 % (25°C, non-condensing)
Noise immunity	EN 61000-6-2:2005

Input data

Input voltage	24 V DC
Nominal input voltage	24 V DC
Current consumption (maximum)	19 A (Maximum, mains operation)
Current consumption (charging process)	4 A (Charging, mains operation)
Fixed connect threshold	≤ 22 V DC
Variable connect threshold	1 V/0.1 s

Output data (24 V DC mains operation)

Nominal output voltage	24 V DC
Output voltage range (depends on the input voltage)	18 V DC ... 30 V DC
Nominal output current (I_N)	10 A (-25 °C ... 60 °C)
POWER BOOST (I_{Boost})	15 A (-25°C ... 40°C)
Selective Fuse Breaking (I_{SFB})	60 A (-25 °C ... 60 °C)

Output data (24 V DC battery operation)

Nominal output voltage	24 V DC
Output voltage range (depends on the input voltage)	19.2 V DC ... 27.6 V DC ($U_{OUT} = U_{BAT} - 0.5 \text{ V DC}$)
Nominal output current (I_N)	10 A (-25 °C ... 60 °C)
POWER BOOST (I_{Boost})	15 A (-25°C ... 40°C)
Selective Fuse Breaking (I_{SFB})	65 A (-25 °C ... 60 °C)

General output data

Efficiency	> 98 % (Mains operation, with charged power storage)
------------	--

General

IQ technology	Yes
Net weight	0.5 kg
Protection class	III
MTBF (IEC 61709, SN 29500)	> 500000 h (40°C)
Mounting position	horizontal DIN rail NS 35, EN 60715
Assembly instructions	Can be aligned: horizontal 5 mm, vertical 50 mm

Connection data, input

Connection method	Pluggable screw connection
-------------------	----------------------------

Uninterruptible power supply - QUINT-UPS/ 24DC/ 24DC/10 - 2320225

Technical data

Connection data, input

Conductor cross section solid min.	0.2 mm ²
Conductor cross section solid max.	2.5 mm ²
Conductor cross section flexible min.	0.2 mm ²
Conductor cross section flexible max.	2.5 mm ²
Conductor cross section AWG min.	16
Conductor cross section AWG max.	12
Stripping length	7 mm
Screw thread	M4

Connection data, output

Connection method	Pluggable screw connection
Conductor cross section solid min.	0.2 mm ²
Conductor cross section solid max.	2.5 mm ²
Conductor cross section flexible min.	0.2 mm ²
Conductor cross section flexible max.	2.5 mm ²
Conductor cross section AWG min.	16
Conductor cross section AWG max.	12
Stripping length	7 mm
Screw thread	M4

Connection data for signaling

Conductor cross section solid min.	0.2 mm ²
Conductor cross section solid max.	2.5 mm ²
Conductor cross section flexible min.	0.2 mm ²
Conductor cross section flexible max.	2.5 mm ²
Conductor cross section AWG min.	24
Conductor cross section AWG max.	12
Screw thread	M4

Standards and Regulations

Electromagnetic compatibility	Conformance with EMC Directive 2004/108/EC
Shock	18 ms, 30g, in each space direction (according to IEC 60068-2-27)
Noise immunity	EN 61000-6-2:2005
Connection in acc. with standard	CUL
Standards/regulations	EN 61000-4-2
	EN 61000-4-3
	EN 61000-4-4
	EN 61000-4-5
	EN 61000-4-6

Uninterruptible power supply - QUINT-UPS/ 24DC/ 24DC/10 - 2320225

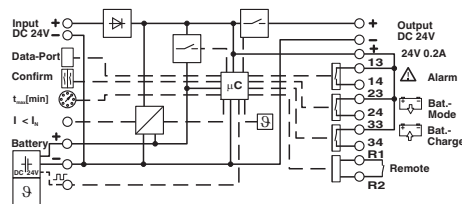
Technical data

Standards and Regulations

Standard - Electrical safety	EN 60950-1/VDE 0805 (SELV)
Standard – Electronic equipment for use in electrical power installations and their assembly into electrical power installations	EN 50178/VDE 0160 (PELV)
UL approvals	UL Listed UL 508
	UL/C-UL Recognized UL 60950
	UL ANSI/ISA-12.12.01 Class I, Division 2, Groups A, B, C, D (Hazardous Location)
Vibration (operation)	< 15 Hz, amplitude ± 2.5 mm (according to IEC 60068-2-6)
	15 Hz ... 150 Hz, 2.3g $t_v = 90$ min.
Low Voltage Directive	Conformance with LV directive 2006/95/EC
Rail applications	EN 50121-4

Drawings

Block diagram



Classifications

eCl@ss

eCl@ss 4.0	27040702
eCl@ss 4.1	27040603
eCl@ss 5.0	27040603
eCl@ss 5.1	27040603
eCl@ss 6.0	27040603
eCl@ss 7.0	27040603
eCl@ss 8.0	27040603
eCl@ss 9.0	27040705

ETIM

ETIM 3.0	EC001039
ETIM 4.0	EC000382
ETIM 5.0	EC000382

Uninterruptible power supply - QUINT-UPS/ 24DC/ 24DC/10 - 2320225

Classifications

UNSPSC

UNSPSC 6.01	30211510
UNSPSC 7.0901	39121011
UNSPSC 11	39121011
UNSPSC 12.01	39121011
UNSPSC 13.2	39121011

Energy storage - UPS-BAT/VRLA/24DC/12AH - 2320322

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Energy storage device, lead AGM, VRLA technology, 24 V DC, 12 Ah, tool-free battery replacement, automatic detection, and communication with QUINT UPS-IQ

Why buy this product

- Tool-free battery replacement
- Communication with QUINT UPS IQ



Key Commercial Data

Packing unit	1 STK
Weight per Piece (excluding packing)	10135.0 g
Custom tariff number	85072080
Country of origin	China

Technical data

Dimensions

Width	202 mm
Height	202 mm
Depth	110 mm

Ambient conditions

Degree of protection	IP20
Ambient temperature (operation)	0 °C ... 40 °C
Ambient temperature (storage/transport)	0 °C ... 40 °C
Max. permissible relative humidity (operation)	≤ 95 %

Input data

Nominal input voltage	24 V DC
Buffer period	22.5 min. (20 A)

Energy storage - UPS-BAT/VRLA/24DC/12AH - 2320322

Technical data

Input data

	9 min. (40 A)
--	---------------

Output data

Nominal output voltage	24 V DC
Output current I_{max}	50 A
Connection in parallel	5
Connection in series	No
Output fuse	2x 25 A

General

IQ technology	Yes
Disposal	Used batteries must not be thrown away with household waste, they should instead be disposed of in accordance with applicable national regulations. They can also be returned to Phoenix Contact or the manufacturer.
Net weight	8.9 kg
Memory medium	Lead rechargeable battery module
Protection class	III
Mounting position	horizontal DIN rail NS 35, EN 60715

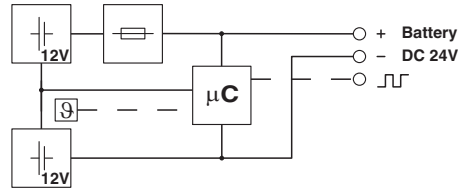
Standards and Regulations

Shock	18 ms, 30g, in each space direction (according to IEC 60068-2-27)
Connection in acc. with standard	CUL
Standard - Electrical safety	EN 60950-1/VDE 0805 (SELV)
Standard – Electronic equipment for use in electrical power installations and their assembly into electrical power installations	EN 50178/VDE 0160 (PELV)
UL approvals	UL/C-UL listed UL 508
	UL/C-UL Recognized UL 60950
	UL ANSI/ISA-12.12.01 Class I, Division 2, Groups A, B, C, D (Hazardous Location)
VdS approval	G 100001
Vibration (operation)	< 15 Hz, amplitude ± 2.5 mm, 15 - 150 Hz, 2.3g/2.3g according to IEC 60068-2-6
	15 Hz ... 150 Hz, 2.3g, 90 min.

Drawings

Energy storage - UPS-BAT/VRLA/24DC/12AH - 2320322

Block diagram



Classifications

eCl@ss

eCl@ss 4.0	27040603
eCl@ss 4.1	27040603
eCl@ss 5.0	27040603
eCl@ss 5.1	27040603
eCl@ss 6.0	27040603
eCl@ss 7.0	27049201
eCl@ss 8.0	27050403
eCl@ss 9.0	27050403

ETIM

ETIM 2.0	EC000382
ETIM 3.0	EC000382
ETIM 4.0	EC000357
ETIM 5.0	EC000357

UNSPSC

UNSPSC 6.01	30211510
UNSPSC 7.0901	39121011
UNSPSC 11	39121011
UNSPSC 12.01	39121011
UNSPSC 13.2	39121011

Power supply unit - TRIO-PS-2G/1AC/24DC/10 - 2903149

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Primary-switched TRIO POWER power supply with push-in connection for DIN rail mounting, input: single phase, output: 24 V DC/10 A


Product description

TRIO POWER power supplies with standard functionality

The TRIO POWER power supply range with push-in connection has been perfected for use in machine building. All functions and the space-saving design of the single and three-phase modules are optimally tailored to the stringent requirements. Under challenging ambient conditions, the power supply units, which feature an extremely robust electrical and mechanical design, ensure the reliable supply of all loads.



Key commercial data

Packing unit	1 pc
GTIN	 4 046356 960854
Sales Key	H1 - Power supply units
Note	Made to Order (non-returnable)

Technical data

Dimensions

Width	42 mm
Height	130 mm
Depth	160 mm

Ambient conditions

Degree of protection	IP20
Ambient temperature (operation)	-25 °C ... 70 °C (> 60 °C derating, 2.5 %/K, startup at -40°C type-tested)
Ambient temperature (storage/transport)	-40 °C ... 85 °C
Max. permissible relative humidity (operation)	≤ 95 % (at 25 °C, non-condensing)
Noise immunity	EN 61000-6-2:2005

Input data

Nominal input voltage range	100 V AC ... 240 V AC -15 % ... +10 %
Input voltage range	85 V AC ... 264 V AC

Power supply unit - TRIO-PS-2G/1AC/24DC/10 - 2903149

Technical data

Input data

Short-term input voltage	≤ 300 V AC
AC frequency range	50 Hz ... 60 Hz
Inrush surge current	≤ 25 A (typical)
Power failure bypass	> 15 ms (120 V AC)
	> 15 ms (230 V AC)
Input fuse	6.3 A ()
Choice of suitable fuses	6 A ... 16 A (Characteristics B, C, D, K)
Type of protection	Transient surge protection
Protective circuit/component	Varistor

Output data

Nominal output voltage	24 V DC ±1 %
Setting range of the output voltage	24 V DC ... 28 V DC (> 24 V constant capacity)
Output current	10 A
	15 A (5 s)
Derating	> 60 °C ... 70 °C (2.5%/K)
Connection in parallel	Yes, for redundancy and increased capacity
Connection in series	Yes
Control deviation	< 1 % (change in load, static 10 % ... 90 %)
	< 3 % (Dynamic load change 10 % ... 90 %, 10 Hz)
	< 0.1 % (change in input voltage ±10 %)
Residual ripple	≤ 10 mV _{PP}
Maximum power dissipation NO-Load	< 5.1 W
Power loss nominal load max.	< 25 W

General

Net weight	1 kg
Efficiency	> 91 % (for 230 V AC and nominal values)
Insulation voltage input/output	4 kV AC (type test)
	1.5 kV AC (routine test)
Protection class	I (in closed control cabinet)
MTBF (IEC 61709, SN 29500)	> 1800000 h (25 °C)
	> 1000000 h (40°C)
	> 480000 h (60°C)
Mounting position	horizontal DIN rail NS 35, EN 60715
Assembly instructions	Can be aligned: Horizontally 0 mm (≤ 40 °C) 10 mm (≤ 70 °C), vertically 50 mm
Electromagnetic compatibility	Conformance with EMC Directive 2004/108/EC
Noise emission	EN 50081-2
Low Voltage Directive	Conformance with LV directive 2006/95/EC
Standard – Electrical equipment of machines	EN 60204-1
Standard - Electrical safety	IEC 60950-1/VDE 0805 (SELV)

Power supply unit - TRIO-PS-2G/1AC/24DC/10 - 2903149

Technical data

General

Shipbuilding approval	GL applied for
Standard – Electronic equipment for use in electrical power installations and their assembly into electrical power installations	EN 50178/VDE 0160 (PELV)
Standard – Safety extra-low voltage	IEC 60950-1 (SELV) and EN 60204 (PELV)
Standard - Safe isolation	DIN VDE 0100-410
Standard – Protection against electric shock	DIN 57100-410
Standard – Limitation of mains harmonic currents	EN 61000-3-2
UL approvals	UL Listed UL 508
	UL/C-UL Recognized UL 60950-1

Connection data, input

Connection method	Push-in connection
Conductor cross section solid min.	0.2 mm ²
Conductor cross section solid max.	4 mm ²
Conductor cross section stranded min.	0.2 mm ²
Conductor cross section stranded max.	2.5 mm ²
Conductor cross section AWG/kcmil min.	24
Conductor cross section AWG/kcmil max	12
Stripping length	10 mm

Connection data, output

Connection method	Push-in connection
Conductor cross section solid min.	0.2 mm ²
Conductor cross section solid max.	4 mm ²
Conductor cross section stranded min.	0.2 mm ²
Conductor cross section stranded max.	2.5 mm ²
Conductor cross section AWG/kcmil min.	24
Conductor cross section AWG/kcmil max	12
Stripping length	8 mm

Signaling

Output name	LED status indicator
Conductor cross section solid min.	0.2 mm ²
Conductor cross section solid max.	1.5 mm ²
Conductor cross section stranded min.	0.2 mm ²
Conductor cross section stranded max.	1.5 mm ²
Conductor cross section AWG/kcmil min.	24
Conductor cross section AWG/kcmil max	16

Classifications

eCl@ss

eCl@ss 4.0	27040702
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Power supply unit - TRIO-PS-2G/1AC/24DC/10 - 2903149

Classifications

eCl@ss

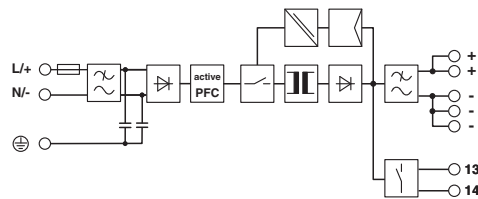
eCl@ss 4.1	27040702
eCl@ss 5.0	27049002
eCl@ss 5.1	27049002
eCl@ss 6.0	27049002
eCl@ss 7.0	27049002
eCl@ss 8.0	27049002

ETIM

ETIM 4.0	EC002540
ETIM 5.0	EC002540

Drawings

Block diagram



VRLA HANDBOOK

ENGLISH

INDUSTRIAL BATTERIES



PANASONIC BATTERIES



PANASONIC INDUSTRIAL EUROPE

Panasonic Corporation, founded in Osaka 1918, is one of the world's largest manufacturers of quality electronic and electrical equipment. Its subsidiary, Panasonic Industrial Europe GmbH (PIE) deals with a wide diversified range of industrial products for all European countries. This company was formed in 1998 to strengthen Panasonic's Pan-European industry operation, and today is active in such different business fields as Automotive, Audio/Video & Communication, Appliance and Industry & Devices to satisfy its customer's needs.



Panasonic quality - certified by authorised companies.

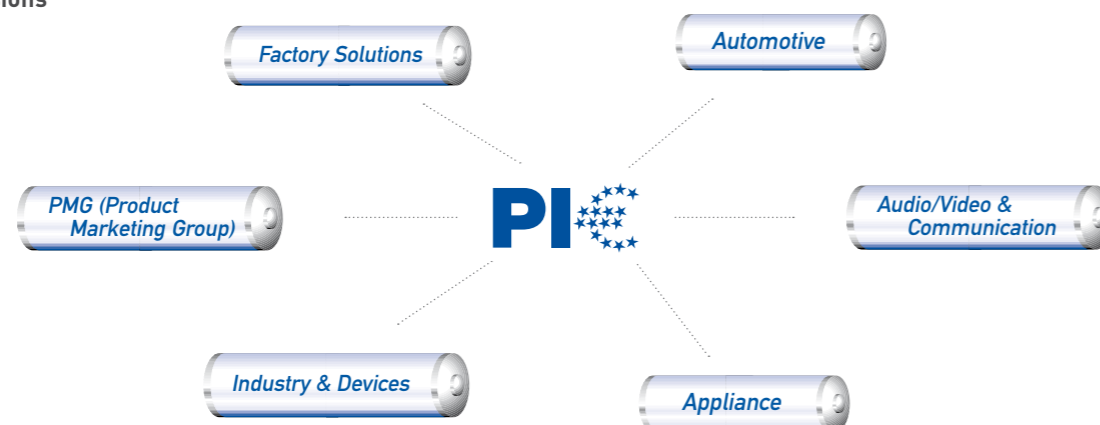
We are able to offer you a wide range of individual power solutions for portable and stationary applications. Our product range includes high reliability batteries such as Lithium-Ion, Lithium, Nickel-Metal-Hydride, Valve-Regulated-Lead-Acid (VRLA), Alkaline and Zinc-Carbon. Based on this battery range we can power your business in virtually all applications.

Panasonic Energy Company (PEC) started its battery production in 1931. Today PEC is the most diversified global battery manufacturer with a network of 20 manufacturing companies in 14 countries. More than 16,000 employees are dedicated to the research & development and in the production of new batteries for a new world.

When it comes to production our facilities employ leading edge manufacturing processes meeting the highest quality standards. Our factories are certified to ISO standards. This means that each factory has its own quality and environmental management. The ISO 9000 and ISO 14000 series are the minimum benchmarks that ensure our excellent product reliability.

Furthermore the majority of our factories is also certified to OHSAS 18001 (Occupational Health and Safety Assessment Series), an international standard for assessing a management system for occupational safety. This confirms that our factories have been proactive in putting the occupational health and safety of its staff at the centre of the company's dealings. In addition our VRLA batteries are for example approved to German VdS standard and U.S. UL standard.

PIE Organisation Divisions





PANASONIC LEADS THE WAY ... WITH 'ECO IDEAS'

Pursuing coexistence with the global environment in its business vision, Panasonic places reduction of the environmental impact in all its business activities as one of the important themes in its mid-term management plan. In its 'eco ideas' Strategy, which focuses in particular on rapid implementation of measures to prevent global warming and global promotion of environmental sustainability management, Panasonic is advancing three key initiatives: 'eco ideas' for Manufacturing, 'eco ideas' for Products, and 'eco ideas' for Everybody, Everywhere.

i

Our energy will Drive eco Innovation.

THE PANASONIC 'ECO IDEAS' HOUSE

We are approaching a global turning corner and it would not be an exaggeration to call it the 'Environmental Industrial Revolution'. Based on this recognition, Panasonic has built an 'eco ideas' House on the premise of our showroom, Panasonic Center Tokyo in April 2009 in order to help create a carbon-free society and reduce CO₂ emissions from a household sector.

The concept of this 'eco ideas' House can be described as follows:

1. Virtually zero CO₂ emissions in an entire house envisaged in three to five years into the future
 2. Synergy of technology and nature
- Aforementioned concepts shows that Panasonic is not only aware of it's environmental responsibility moreover this Panasonic takes action.

'ECO IDEAS' FOR MANUFACTURING

Our Plans

We will reduce CO₂ emissions across all our manufacturing sites.

Our Goals

In each of our factories a CO₂ emissions of 10% reduction till 2010.

Our Measures

Our factories are evaluated with regard to CO₂ emission, waste disposal, recycling measures as well as chemical and water consumption within the scope of the 'Clean Factory' program and they are set performance targets according to these indicators.

Example

The Wakayama Plant of the Energy Company is strengthening its management structure to cut CO₂ emissions from the main production bases for Lithium-Ion batteries, which are a core component of Panasonic's energy business. As a result, it has succeeded in roughly halving CO₂ emissions per production unit, as well as sharply curbing an increase in CO₂ emissions even as production has expanded.

'ECO IDEAS' FOR PRODUCTS

Our Plans

We will produce energy-efficient products.

Our Goals

In March 2010 at least 20 products with the 'Superior Green Products' classification should be available.

Our Measures

The developers at Panasonic carry out an environmental impact assessment for all our products. Products that meet the highest environmental requirements in the branch with regard to conservation of energy and energy efficiency are classified as a 'Superior Green Product' and awarded the Panasonic logo 'eco ideas'.

Example

We have dispensed with the use of highly toxic Lithium Thionyl Chloride in the production of our Lithium batteries. This is quite rightly classified as highly toxic and should never under any circumstances be released into the environment.

'ECO IDEAS' FOR EVERYBODY, EVERYWHERE

Our Plans

We will encourage the spread of environmental activities throughout the world.

Our Goals

Intensive commitment on the part of the company owners, international cooperations and involvement of the employees.

Our Measures

Not only do we sponsor the work of the WWF for the Arctic, Panasonic has also launched a couple of other environmental initiatives such as the ECO RELAY initiative in which hundreds of colleagues the world over take part voluntarily for several days in environmental campaigns.

Example

With the support of the GRS Batterien (German Battery Recycling Association) Panasonic arranged a battery collection day with the aim of collecting as many of these spent energy sources as possible and giving out information about the recycling loop of batteries from which valuable raw materials such as Zinc, Manganese and Iron can be recovered.

Index

1 Precautions for Handling	page	7 – 12
2 General Information	page	13 – 15
3 Characteristics	page	16 – 18
4 Charging Methods	page	19 – 23
5 Terminal Data	page	23
6 Safety	page	24
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1 | Precautions for Handling VRLA-Batteries

This document should be read in its entirety and its contents fully understood before handling or using Panasonic rechargeable sealed Lead-Acid batteries. If there are any questions, please contact Panasonic. Please keep this document available for reference. Due to the potential energy stored in the batteries, improper handling or use of the batteries without understanding this document may result in injury caused by electrolyte leakage, heat generation, or explosion.

* All descriptions are subject to change without notice.

Degree of danger

1. DANGER

When the batteries are handled or used improperly, death or severe injury may occur.

2. WARNING

When the batteries are handled or used improperly, death or severe injury may occur, and sight injury or loss of products often occur.

3. CAUTION

When the batteries are handled or used improperly, slight injury may occur and damage to the batteries and equipment may occur.

4. REQUEST

When the batteries are handled or used improperly, damage to quality or performance may occur.

Note (1):

Improper handling and use of the batteries may cause dangerous conditions to arise. All precautions should be taken to prevent any harmful effects from the use of the batteries.

Note (2):

“Severe injury” as a result of improper handling or use of the batteries may include but are not limited to loss of eyesight, injury/burn/electric shock/fracture of a bone/poisoning with after effect, or injury that requires long-term medical treatment. “Slight injury” covers such conditions as burns or electric shock that do not require long-term medical treatment. Damage to products is defined as extensive damage to a house, a house hold effects, a livestock, or pets.

Note (3):

“Requests” are meant to prevent a decrease in the quality or the performance of the batteries.

1 | Precautions for Handling VRLA-Batteries

1. Environment and Condition

DANGER

(1) Do not put the batteries into airtight containers or bags. The batteries tend to generate inflammable gas upon excess charge which may cause an explosion if enclosed in an airtight container.

WARNING

(1) The batteries must be charged using the specified charger or by maintaining the charging conditions indicated by Panasonic. If the batteries are charged under conditions other than those specified by Panasonic, they may leak, generate excessive heat, or explode.

(2) When using the batteries in medical equipment, incorporate a back-up system other than the main battery in the event of power failure.

(3) Insert insulation that is resistant to heat and sulfuric acid between the batteries and any metallic housing. Failure to do so may cause the batteries to smoke or burn in case of electrolyte leakage.

(4) Do not place the batteries near a device that may generate sparks (such as a switch or fuse) and do not place the batteries close to fire. The batteries may generate an inflammable gas when charged excessively that may ignite upon contact with a spark or they may burn or explode due to sparks or fire.

CAUTION

(1) Use or store the batteries in the temperature range: Discharge (operating in application): -15°C ~ 50°C.

Charge: 0°C to 40°C. Storage: -15°C to 40°C.

Temperatures above or below those recommended could result in damage or deformity of the batteries.

(2) Avoid placing batteries near a heat-generating device (such as a transformer) which may cause the batteries to generate excessive heat, leak or explode.

(3) Do not allow the batteries to be exposed to rain or sea water. If the battery terminals should get wet, they may corrode.

(4) Do not use or store the batteries in a car under the blazing sun, in direct sunlight. To do so may cause the batteries to leak, generate excessive heat, or explode.

(5) Do not use or store the batteries in a dusty place as dust may cause them to short between their terminals. When using the batteries in a dusty place, check them periodically.

(6) In applications requiring more than one battery, first connect the batteries together and then connect the batteries to the charger or the load. Be careful to connect the (+)pole of the batteries to the (+)terminal of either the charger or the load. Improperly connecting the batteries, charger, or load may cause an explosion or fire to occur. In some cases, bodily injury may occur.

(7) When handling the batteries, wear steel-tipped shoes to prevent possible injury to the feet if the batteries are accidentally dropped.

REQUEST

(1) Dropping a battery may cause a strong physical shock that may damage the performance of the battery.

(2) Confirm the life of the batteries using the real load and charger. Differences in the charging and the discharging conditions may cause a big difference in the life of the batteries.

2. Installation

DANGER

(1) Tools such as wrenches used to install the batteries should be insulated. Bare metal tools may cause an abnormal short circuit accident to occur resulting in bodily injury, damage to the batteries, explosion or fire.

(2) Do not install the batteries in a room without ventilation. The batteries tend to generate an inflammable gas upon excess charge resulting in an explosion or fire if the room is closed.

WARNING

(1) **Do not contact any plastic or resin (*) which contains a migrating plasticizer with the batteries. Furthermore, avoid using organic solvents such as thinner, gasoline, lamp oil, benzine and liquid detergent to clean the batteries.** The use of any of above materials may cause the containers and/or the covers (ABS resin) of the batteries to crack and leak. This may cause a fire in the worst scenario. Need to make sure the use of material will not cause the containers and/ or the covers (ABS resin) of the batteries to crack due to the migration of plasticizer within the material by asking the manufacturer of the material if necessary.

* Examples for plastic or resin which should be avoided using:

Vinyl chloride, Oily rubber.

* Examples for plastic or resin which is proper for the use:

Polyolefin resin such as polypropylene, polyethylene.

1 | Precautions for Handling VRLA-Batteries

(2) Always use such as rubber gloves when handling batteries with the voltages higher than 45 volts in order to prevent severe bodily injury from occurring.

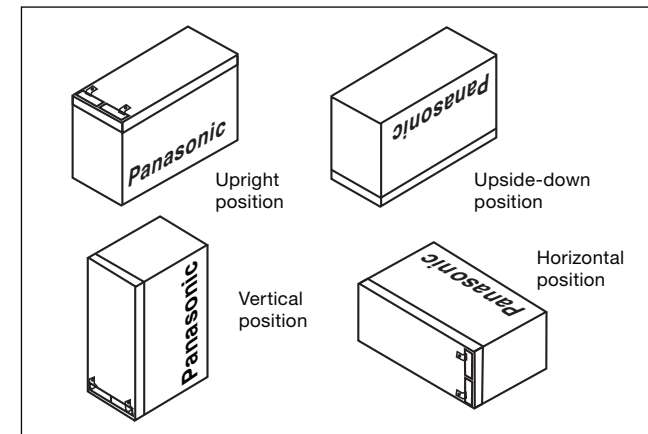
(3) Do not install the batteries in areas where they may come in contact with water. If the batteries come in contact with water, an electric shock may occur.

CAUTION

(1) During unpacking, handle the batteries carefully and check for cracks, breakage, or electrolyte leakage. Failure to handle carefully may result in damage due to physical shock.

(2) When the batteries are being mounted in the equipment, consider the best position for easy checking, maintenance and replacement. In addition, the batteries should be located in the lowest part of the equipment as possible. The Rechargeable Sealed Lead-Acid batteries, mentioned in this document, are designed for use in any position, but charging the batteries in the upside-down position should be avoided. When these batteries are charged excessively in the upside-down position, leakage of electrolyte from the rubber vents may occur. The upside-down is shown on the left side of the next drawings. In this upside-down position, the mark "Panasonic" on the battery are turned upside down. The drawings are only for explanation of the battery's position; therefore these are not equal to the real appearance of the battery that the specifications describe.

Can be used in the vertical position and the sidedown position (maximum angle of 90 degrees from the normal position).



(3) Do not carry the batteries by picking up them by their terminals or lead wires. To do so may damage the batteries.

(4) Be careful not to jolt the batteries as it may result in damage to them.

(5) Be aware the batteries are relatively heavy compared to their volume. Please be careful to carry these batteries in order to avoid injury and/or lumbago.

(6) Do not cover the batteries with plastic sheet as it may cause a fire or an explosion by conducting static electricity.

(7) Fasten the bolts and the nuts with the torque as shown below: Not to do so may cause the battery terminals to break.

Bolt (nut) size (mm)			Fastening torque Nm
Diameter	Pitch	Length	
M5 (5)	0.8	15 ± 1	2.0 – 3.1
M6 (6)	1.0	20 ± 1	4.1 – 5.6
M8 (8)	1.25	20 ± 1	8.2 – 10.2
M10 (10)	1.5	25 ± 1	14.7 – 19.7

(8) Place the necessary insulating covers over the terminals, the connecting bars, and bolts and nuts to prevent a dangerous electric shock.

(9) Please consult Panasonic prior to using the batteries in applications such as a motor bicycle, an engine driven lawn mower, etc. which may generate severe vibration.

(10) Fasten the batteries firmly to the equipment to avoid the influence of vibration and/or physical shock.

REQUEST

(1) The batteries should be installed by a certified technician.

3. Preparation Prior to Operation

DANGER

(1) Be sure to provide enough insulation around the lead wires and/or plates used between the batteries and the application. Insufficient insulation may cause an electric shock heat generating from a short circuit (or excess current) may result in an injury, burn, smoke or fire.

CAUTION

(1) Do not plug the batteries directly into the outlet or the cigarette receptacle of a car without inserting a charger between the batteries and the outlet or the receptacle. To do so may cause electrolyte leakage, heat generation, or explosion of the battery.

(2) Turn off the circuit switch when the connections between the batteries and the charger/load are made.

1 | Precautions for Handling VRLA-Batteries

(3) When using the batteries for the first time, check for rust, heat generation, or any other abnormalities. If found, do not use as it may cause electrolyte leakage, heat generation, or explosion.

REQUEST

(1) Since the batteries tend to lose a part of their capacity due to self-discharge during shipment and storage, recharge the batteries before you use them after purchase or long-term storage in order to restore their full capacity. Check for the following conditions before to recharge:

Charging method	Charging condition (at 20°C)
Constant voltage	<ul style="list-style-type: none"> Regulation range of the controlled voltage: 7.25V to 7.45V / 6V battery, 14.5V to 14.9V / 12V battery; Initial current: 0.1CA to 0.4CA; Maximum charging time: 24 hours. Short-time charge is possible when several batteries of the same model, under the same storage conditions can be charged in series. Otherwise they can be charged separately.
Constant current	<ul style="list-style-type: none"> Charging current: 0.1CA Charging time (hours) = [Amount of self-discharge (Ah)/0.1CA] x 120% Rough estimation of amount of self-discharge is as follows (for an example): When the storage ambient temperature is lower than 20°C, and storage time is known, assume the following amount of self-discharge: [5%/month] x storage months Multiply this by the rated capacity (at 20 hour rate) of the battery. Regardless of the above calculation, the charge time for a refresh charge must be less than 12 hours. When the storage ambient temperature is higher than 20°C, please consult Panasonic.

4. Unspecified Use

CAUTION

(1) Do not place the batteries in an unspecified use or they may leak, generate heat, or explode.

5. Method of Handling and Operation

DANGER

(1) Do not directly connect the positive and negative terminals with a conductive material such as a wire. Be careful

while using a metal tool such as a wrench and/or carrying the batteries with metallic necklaces and hairpins not to make a short circuit. A short of the battery's terminals may cause heat generation, an explosion or a fire.

WARNING

- (1) Never dispose of the batteries in a fire as it may cause them to explode or generate a toxic gas.
- (2) Do not attempt to disassemble the batteries as it could cause leakage of sulfuric acid that could cause injury.

CAUTION

- (1) To prevent accidents from happening, change any battery that is found to have an abnormality such as a crack, a deformity, or leakage. The batteries must be kept clean and free from dust to prevent loss of capacity or accident.
- (2) If any abnormality of the charge voltage or the discharge voltage is detected replace the batteries with new ones.
- (3) Charging the batteries with an inverse polarity connection between the batteries and the charger could cause electrolyte leakage, heat generation, or a fire.
- (4) Do not solder directly on the batteries' terminal tabs. Soldering directly on the batteries' terminals may cause a leak of electrolyte. Consult Panasonic when soldering is necessary.
- (5) Avoid the use of the batteries differing in capacity, type, history of use (charge/discharge operation). These differences could cause electrolyte leakage or heat generation.
- (6) Do not remove or scratch the outer tube of the battery or it may cause an electrolyte leakage or electrical leakage.
- (7) Do not allow the batteries to be subjected to any strong physical shocks or jolts while moving them. Treating the batteries roughly could cause leaks, heat generation, or explosions.
- (8) Do not charge the batteries beyond the amount of the time indicated in the specifications, or do not charge after the charge indication lamp indicates a full charge. Take the batteries off the charger if the charge is not finished after the specified charge time. Over-charging can cause leakage, heat generation, or explosions.
- (9) Children should be taught how to handle and use the batteries correctly.
- (10) Keep the batteries out of the reach of small children at all times.

1 | Precautions for Handling VRLA-Batteries

REQUEST

(1) The cut-off voltage during discharge should vary depending on the discharge current. Do not discharge the batteries lower than the recommended cut-off voltage shown in Panasonic specifications or Panasonic technical handbooks. Recharging a battery which was once discharged below the recommended cut-off voltage may generate heat, resulting in the deformation of the battery or in condensation around the battery cover caused when moisture within the battery evaporates. In addition, the efficiency of the battery would eventually decrease.

Overdischarging a battery may result in reduced performance. Always recharge the batteries immediately after discharge even if the batteries were not discharged to the recommended cut-off voltage. If the batteries are not charged soon after discharge, the batteries performance may be reduced due to the so-called "sulfation phenomena".

Note: The cut-off device to prevent overdischarge should cut off all discharge current including any weak current.

(2) Thoroughly study the charge methods and the conditions of the batteries before adopting other charge methods which are not shown in the Panasonic specifications or the Panasonic technical handbook, for safety reasons.

(3) When the batteries are used in a cyclic application, it is important to charge the batteries for the proper amount of time. A timer should be incorporated into the charging circuit that will disconnect the charging current to prevent overcharging. Also, it is important to allow the battery to completely charge before removing the battery from the charger.

(4) Avoid parallel charging of the batteries in cycle use. This may shorten the life of the batteries by causing an imbalance in the charge/discharge operation of the batteries.

(5) Measure the total voltage of the batteries during trickle charge (or float charge), using a voltage meter. If the total voltage of the batteries provide an indication deviating from the specified voltage range, be sure to investigate the cause. If the total voltage is lower than that specified, the batteries may lose their capacity because of a lack of sufficient charge. However, if the total voltage is higher than that specified, the batteries may lose their capacity by damage due to overcharge and may suffer from "thermal runaway" and other accidents.

(6) Switch off the equipment after use to prevent loss of performance or shortened life of the batteries due to damage overdischarge.

(7) When storing the batteries, be sure to remove them from the equipment or disconnect them from the charger and the load to prevent overdischarge and loss of capacity. Before storing batteries, charge the batteries fully. Do not store batteries in a highly humid place to prevent rust from forming on the terminals.

6. Maintenance

WARNING

(1) When cleaning the batteries, use a soft damp cloth. A dry cloth may cause static electricity which could result in a fire or explosion.

(2) Replace batteries with the new ones before the end of their useful life as determined in the specifications. When the batteries near the end of their life (50% state of their initial discharge duration time) the remaining life will shorten remarkably. Finally the batteries will lose their available capacity by either drying out their electrolyte (causing increase in their internal resistance) or an internal short-circuit. In such case, if the batteries go on charging, thermal runaway and/or leakage of electrolyte may occur. The batteries should be replaced before reaching these conditions.

The expected life of the batteries (in trickle or float use) will decrease to half (50%) with each 10°C rise in temperature above 20°C. In particular, the life of the batteries will be shortened remarkably at approximately 40°C. Accordingly, precautions are required to prevent the use of batteries at high temperatures.

CAUTION

(1) Avoid using organic solvents such as thinner, gasoline, lamp oil or benzene and liquid detergent to clean the batteries. These substances may cause the battery containers to crack or leak.

REQUEST

(1) Keep the battery terminals clean in order to avoid interruption in the discharge and/or to maintain the charge.

1 | Precautions for Handling VRLA-Batteries

7. Treatment at Emergency

WARNING

(1) The batteries have toxic liquid - dilute sulfuric acid solution in them. If the acid comes into contact with skin or clothes, wash skin or cloth with lots of clean water to prevent scalding from occurring. If the acid should come into contact with the eyes, wash the eyes with lots of clean water and consult a physician immediately to prevent possible loss of sight.

CAUTION

(1) Check the batteries visually for any sign of irregularities in appearance. If any damage exists such as cracks, deformation, leakage of electrolyte, or corrosion, the batteries must be replaced with the new ones. Irregularities in the batteries could result in bodily injury, electrolyte leakage, excessive heat generation or explosion, if used. Furthermore, make sure the batteries are clean and free from dirt and dust.

8. Storage

CAUTION

(1) Store the batteries in a fixed position separate from metal or other conductive materials.

(2) Keep the batteries from rain water that could cause corrosion on the terminals of the batteries.

(3) Keep the batteries right-side-up during transportation and do not give any abnormally strong shock and jolt to the batteries. Transporting the batteries in an abnormal position or handling them roughly could destroy the batteries or cause their characteristics to deteriorate.

(4) When storing the batteries, be sure to remove them from the equipment or disconnect them from the charger and the load, then store them at room temperature or lower temperature. Do not store the batteries at direct sunlight, higher temperature or high humidity. To do so cause the batteries short life, performance deterioration or corrosion on terminals.

REQUEST

(1) Charge the batteries at least once every twelve months if they are stored at 20°C. Use the charge method specified in "3. Preparation Prior to Use". The interval of this charge should be reduced to 50% by each 10°C rise in temperature above 20°C. The self-discharge rate doubles for each 10°C in temperature. If they are stored for a long time in a discharged state, their capacity may not recover even after charge. If the batteries are stored for more than a year at room temperature, the life of the batteries may be shortened.

(2) Store the batteries starting from the fully charged state to prevent the life of the batteries being shortened.

(3) Use the batteries as quickly as possible after receiving them as they gradually deteriorate even under proper storage conditions.

9. Disposal and Recycling

CAUTION

(1) Please write the information about battery recycling on the equipment, the package, the carton, the instruction manual etc. in countries where legal or voluntary regulations on battery recycling are applicable.

(2) Design the equipment such that exchange and disposal of the batteries can be undertaken easily.

(3) Used batteries should be recycled. When returning used batteries, insulate their terminals using adhesive tape, etc. Even used batteries still have electrical charge and an explosion or a fire may occur, if proper insulation is not given on the terminals of the used batteries.

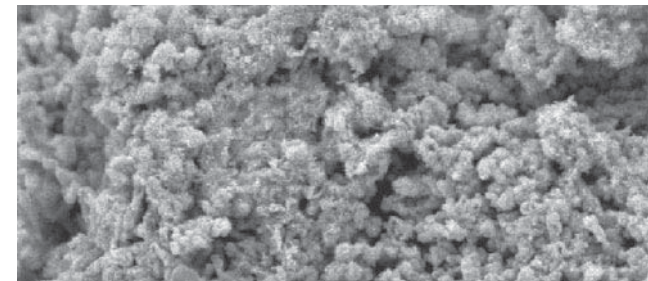
2 | General Information

1. Battery Construction

Positive plates

Positive plates are plate electrodes of which a grid frame of lead-tin-calcium alloy holds porous lead dioxide as the active material. The magnification of a positive active material is shown on following figure (1).

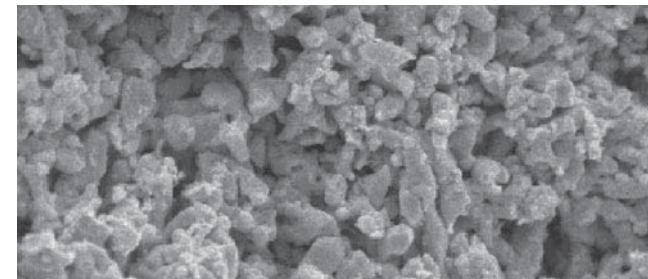
Fig. 1 Magnification of positive active material



Negative plates

Negative plates are plate electrodes of which a grid frame of lead-tin-calcium alloy holds spongy lead as the active material. The magnification of a negative active material is shown on following figure (2).

Fig. 2 Magnification of negative active material



Electrolyte

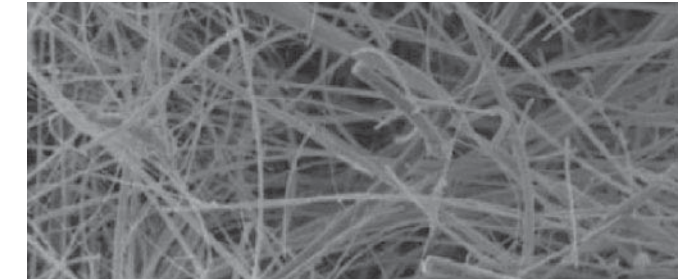
Diluted sulfuric acid is used as the medium for conducting ions in the electrochemical reaction in the battery. Some additives are included to keep good recovery performance after deep discharge.

Separators

Separators, which retain electrolyte and prevent shorting between positive and negative plates, adopt a non-woven fabric of fine glass fibers which is chemically stable in the diluted sulfuric acid electrolyte. Being highly porous, separators retain electrolyte for the reaction of active materials

in the plates. Typical magnification of separator is shown in following figure (3).

Fig. 3 Typical magnification of separator



Vent (One way valve)

The valve is comprised of a one-way valve made of material such as neoprene. When gas is generated in the battery under extreme overcharge condition due to erroneous charging, charger malfunctions or other abnormalities, the vent valve opens to release excessive pressure in the battery and maintain the gas pressure within specific range (7.1 to 43.6 kPa). During ordinary use of the battery, the vent valve is closed to shut out outside air and prevent oxygen in the air from reacting with the active material in the negative electrodes.

Positive and negative electrode terminals

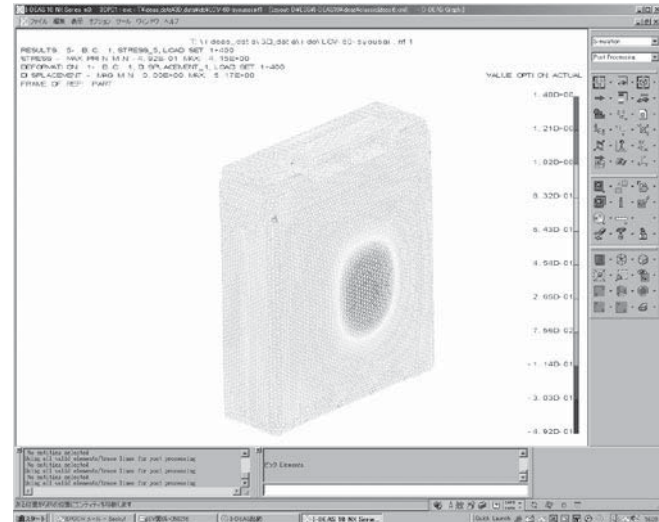
Positive and negative electrode terminals may be faston tab type, bolt fastening type or threaded post type, depending on the type of the battery. Sealing of the terminal is achieved by a structure which secures long adhesive-embedded paths and by the adoption of strong epoxy adhesives. For specific dimensions and shapes of terminals, see page 23.

Battery case materials and the design

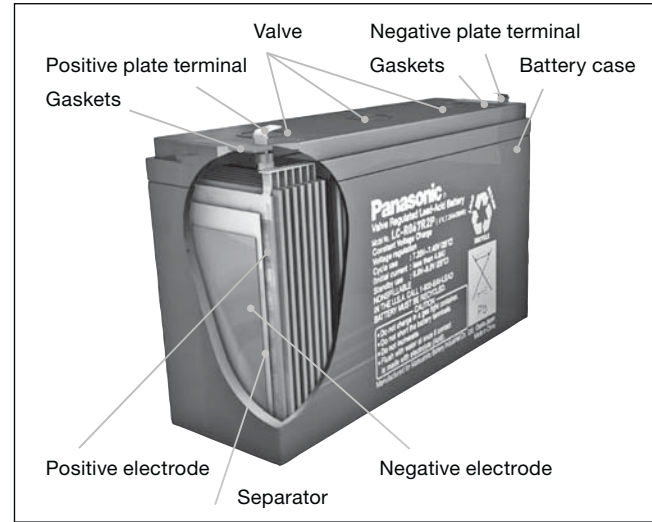
Materials of the body and cover of the battery case are ABS resins, unless otherwise specified. Since the inside of VRLA battery is pressurized and depressurized, stress occurs at the container and cover. The design according to the stress is designed to accommodate the fluctuations in stress in the event the battery becomes deformed. The thickness of container, form, material and stress analysis are determined by utilization of computer aided engineering (CAE). This depicts the container design & strength. Destructive examinations using the molded container are also carried out. In other cases in which water in electrolysis liquid may penetrate through container in service life, the container design is put through

2 | General Information

water penetration tests.



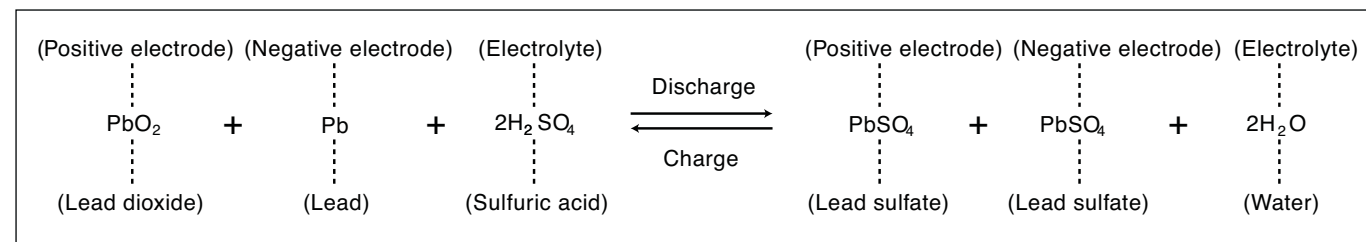
Battery case materials (example LC-R Series)



2. Electrochemical Reactions on Electrodes

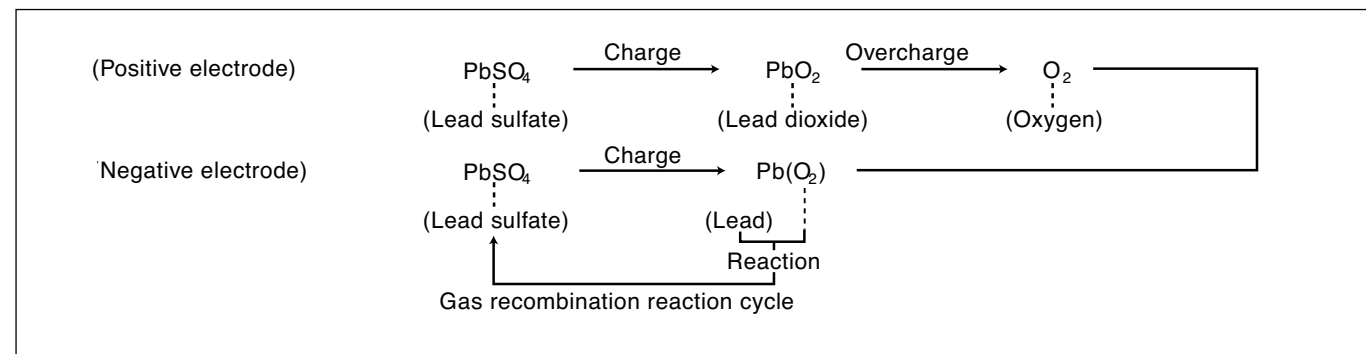
The electrochemical reaction processes of the sealed lead-acid battery (negative electrode recombination type) are described below. Where “charge” is the operation of supplying the rechargeable battery with direct current from an external power source to change the active material in the negative

plates chemically, and hence to store in the battery electric energy in the form of chemical energy. “Discharge” is the operation of drawing out electric energy from the battery to operate external equipment.



In the final stage of charging, an oxygen-generating reaction occurs at the positive plates. This oxygen transfers inside the battery, then is absorbed into the surface of the negative

plates and consumed. These electrochemical reaction processes are expressed as follows.



2 | General Information

3. Applications

Stand-by/Back-up power applications

- Communication equipment: base station, PBX, CATV, WLL, ONU, STB, etc.
- Back-up for power failure: UPS, ECR, computer system back-up, sequencers, etc.
- Energy saving: solar and/or wind powered lanterns, wind powered advertising displays etc.
- Emergency equipment: lights, fire and burglar alarms, radios, fire shutters, stop-position controls (for machines and elevators), etc.

Main power applications

- Electrically operated vehicles: picking carts, automated transports, electric wheelchairs, cleaning robots, electric automobiles, electric lawnmowers, etc.
- Tools and engine starters: grass shears, hedge trimmers, scouters, jet-skis, electric saws, etc.
- Industrial equipment/instruments and non life-critical medical equipment*: measuring equipment, non life-critical medical equipment (electrocardio-graph), etc.
- Photography: camera strobes, VTR/VCR, movie lights, etc.
- Toys and hobby: radio-controllers, motor drives, lights, etc.
- Miscellaneous uses: integrated VTR/VCR, tape recorders, other portable equipment, etc.

* (Note) When any medical equipment incorporating a Panasonic VRLA battery is planned, please contact Panasonic.

4. Features

Leak-resistant structure

A required-minimum quantity of electrolyte is impregnated into, and retained by, the positive and negative plates and the separators; therefore electrolyte does not flow freely. Also, the terminal has a sealed structure secured by long adhesive-embedded paths and by the adoption of strong epoxy adhesives which makes the battery leak-resistant. (Note) In stand-by/back-up uses, if the battery continues to be used beyond the point where discharge duration has decreased to 50% of the initial (i.e. life judgment criteria), cracking of the battery case may occur, resulting in leakage of the electrolyte.

Long service life

Service life of our long-life series (LC-P, LC-X series) is approximately double that of the conventional (LC-R and LC-L series) batteries (Temperature 20°C, discharge rate 0.25 CA/1.75V/cell, discharge frequency every 6 months, 2.30V/cell charge).

Easy maintenance

Unlike conventional batteries in which electrolyte can flow freely, VRLA batteries do not need the specific-gravity check of the electrolyte or the water top up maintenance, this allows the battery to function fully with the minimum of maintenance.

No sulfuric acid mist or gases

Unlike conventional batteries in which electrolyte can flow freely, VRLA batteries generate no Sulphuric acid mist or gases under Panasonic recommended use conditions. If used under conditions other than recommended then gas generation may occur, therefore do not design the battery housing in a closed structure.

Exceptional deep discharge recovery

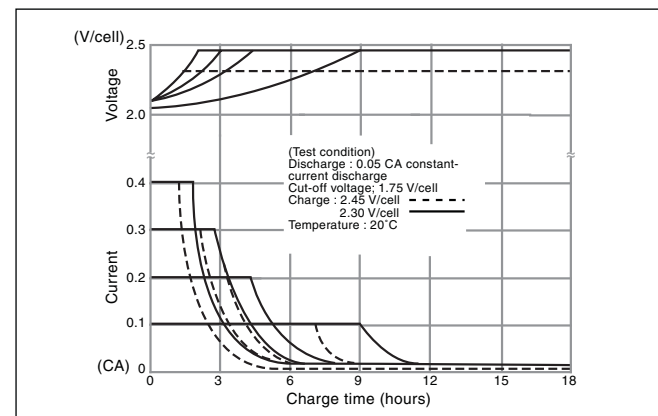
Our VRLA batteries show exceptional rechargeability even after deep discharge, which is often caused by failure to turn off the equipment switch, followed by standing (approx. 1 month at room temperature is assumed).

3 | Characteristics

1. Charging

Charge characteristics (constant voltage-constant current charging) of VRLA batteries are exemplified below.

Example of constant-voltage charge characteristics by current



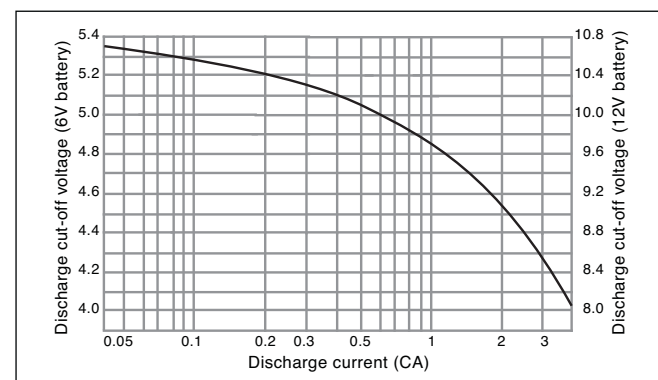
In order to fully utilize the characteristics of VRLA batteries, constant-voltage charging is recommended. For details of charging see pages 19 – 23.

2. Discharging

a) Discharge current and discharge cut-off voltage

Recommended cut-off voltages for 6V and 12V batteries consistent with discharge rates are given in the figure below. With smaller discharge currents, the active materials in the battery work effectively, therefore discharge cut-off voltages are set to the higher side for controlling overdischarge. For larger discharge currents, on the contrary, cut-off voltages are set to the lower side. (Note) Discharge cut-off voltages given are recommended values.

Discharge current vs. Cut-off voltage



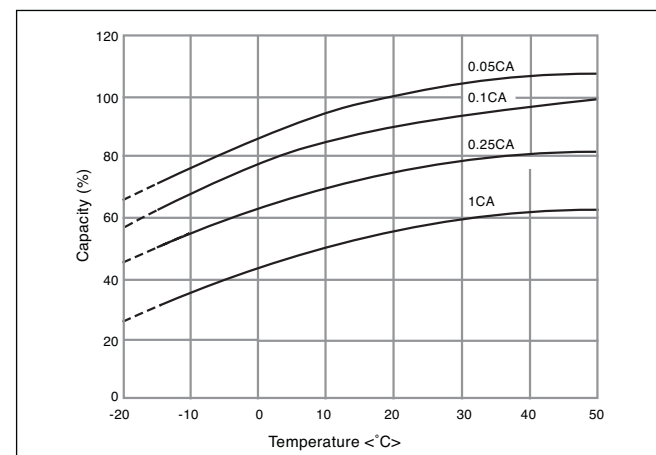
b) Discharge temperature

(1) Control the ambient temperature during discharge within the range from -15°C to 50°C for the reason described below.
 (2) Batteries operate on electrochemical reaction which converts chemical energy to electric energy. The electrochemical reaction is reduced as the temperature lowers, thus, available discharge capacity is greatly reduced at temperatures as low as -15°C. For the high temperature side, on the other hand, the discharge temperature should not exceed 50°C in order to prevent deformation of resin materials which house the battery or deterioration of service life.

c) Effect of temperature on discharge characteristics

Available discharge capacity of the battery varies with ambient temperature and discharge current as shown in the figure below.

Discharge capacity by temperature and by discharge current



d) Discharge current

Discharge capability of batteries is expressed by the 20 hour rate (rated capacity). Select the battery for specific equipment so that the discharge current during use of the equipment falls within the range between 1/20 of the 20 hour rate value and 3 times that (1/20 CA to 3 CA): discharging beyond this range may result in a marked decrease of discharge capacity or reduction in the number of times of repeatable discharge. When discharging the battery beyond said range, please consult Panasonic in advance.

e) Depth of discharge

Depth of discharge is the state of discharge expressed by the ratio of amount of capacity discharged to the rated capacity.

3 | Characteristics

3. Storage

a) Storage condition

Observe the following condition when the battery needs to be stored.

- (1) Ambient temperature: -15°C to 40°C (preferably below 30°C)
- (2) Relative humidity: 25 to 85%
- (3) Storage place free from vibration, dust, direct sunlight, and moisture.

b) Self discharge and refresh charge

During storage, batteries gradually lose their capacity due to self discharge, therefore the capacity after storage is lower than the initial capacity. For the recovery of capacity, repeat charge/discharge several times for the battery in cycle use; for the battery in trickle use, continue charging the battery as loaded in the equipment for 48 to 72 hours.

c) Refresh charge (Auxiliary charge)

When it is unavoidable to store the battery for 3 months or longer, periodically recharge the battery at the intervals recommended in the table below depending on ambient temperature. Avoid storing the battery for more than 12 months.

Storage temperature	Interval of auxiliary charge (refresh charge)
Below 20°C	12 months
20°C to 30°C	9 months
20°C to 40°C	6 months

d) Residual capacity after storage

The result of testing the residual capacity of the battery which, after fully charged, has been left standing in the open-circuit state for a specific period at a specific ambient temperature is shown in the figure below. The self discharge rate is very much dependent on the ambient temperature of storage. The higher the ambient temperature, the less the residual capacity after storage for a specific period. Self discharge rate almost doubles by each 10°C rise of storage temperature (Figure 1).

e) Open circuit voltage vs. residual capacity

Residual capacity of the battery can be roughly estimated by measuring the open circuit voltage as shown in the figure (2).

Fig. 1 Residual capacity test result

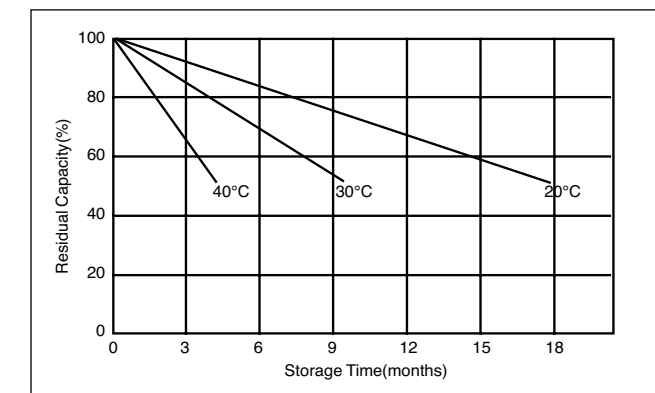
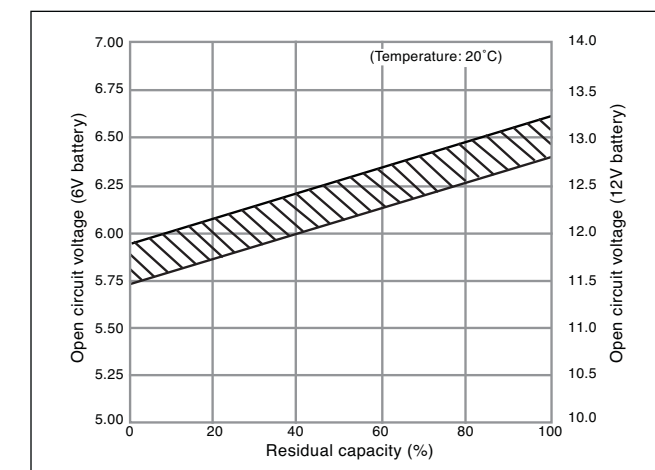
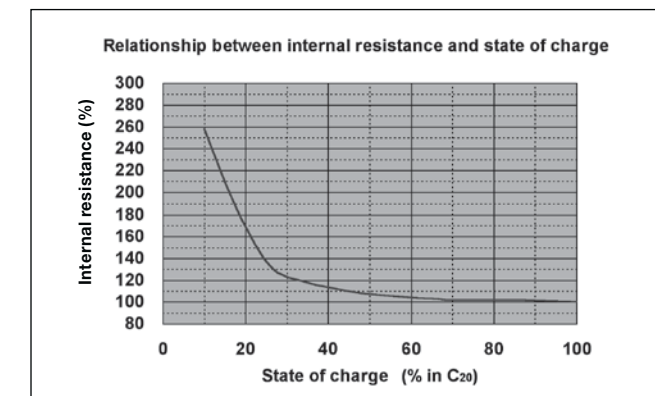


Fig. 2 Open circuit voltage vs. Residual capacity 20°C

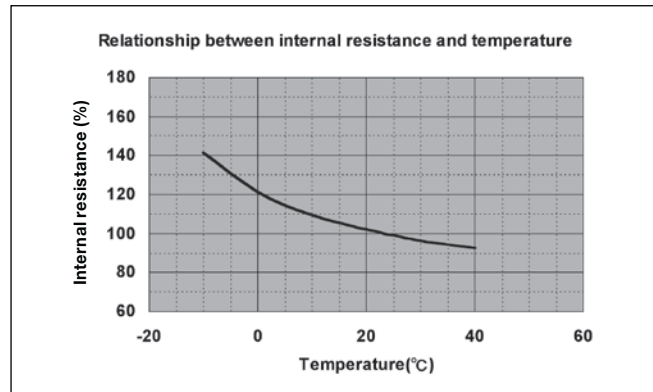


4. Internal Resistance

The internal resistance is an important parameter of batteries. Internal resistance varies with the state of charge of the battery and temperature as shown on the chart below.



3 | Characteristics



5. Temperature conditions

Recommended temperature ranges for charging, discharging and storing the battery are tabulated below.

Charge	0°C ~ 40°C
Discharge	-15°C ~ 50°C
Storage	-15°C ~ 40°C

6. Battery life

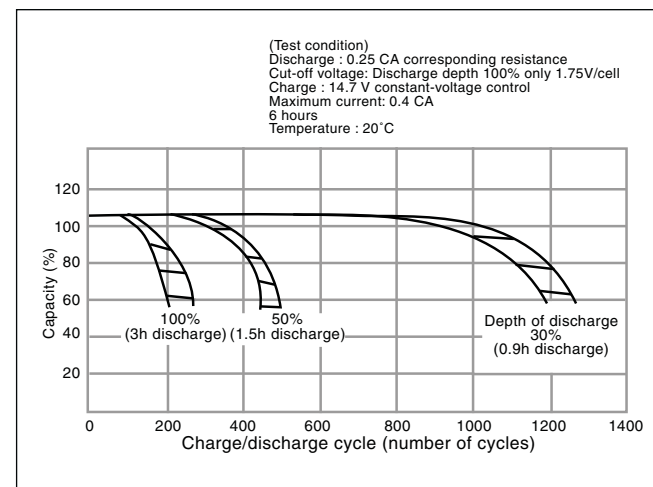
a) Cycle life

Cycle life (number of cycles) of the battery is dependent on the depth of discharge in each cycle. The deeper the discharge is, the shorter the cycle life (smaller number of cycles), providing the same discharge current. The cycle life (number of cycles) of the battery is also related to such factors as the type of the battery, charge method, ambient temperature, and rest period between charge and discharge. Typical cycle-life characteristics of the battery by different charge/discharge conditions are shown by the below figures. This data is typical and tested at a well-equipped laboratory. Cycle times are different for each battery model. Cycle times are also different from this data when using batteries under real conditions.

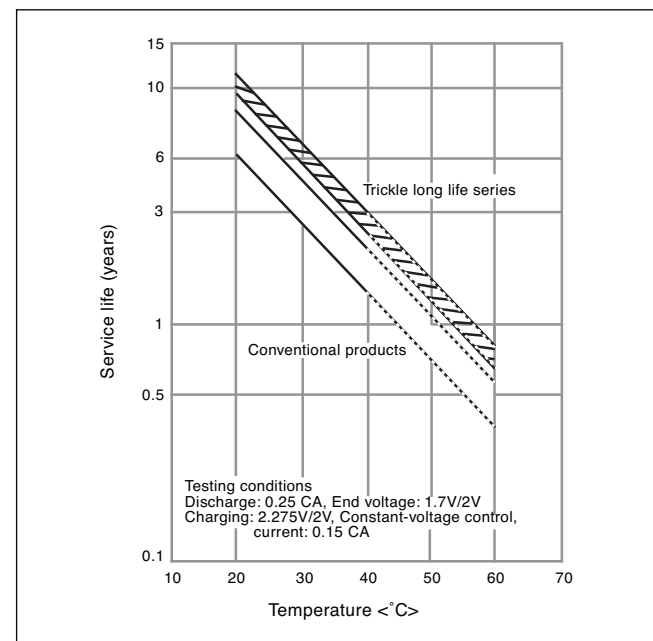
b) Trickle (Float) life

Trickle life of the battery is largely dependent on the temperature condition of the equipment in which the battery is used, and also related to the type of the battery, charge voltage and discharge current. The respective Figures show the influence of temperature on trickle life of the battery, an example of trickle (float) life characteristics of the battery, and the test result of the battery life in an emergency lamp.

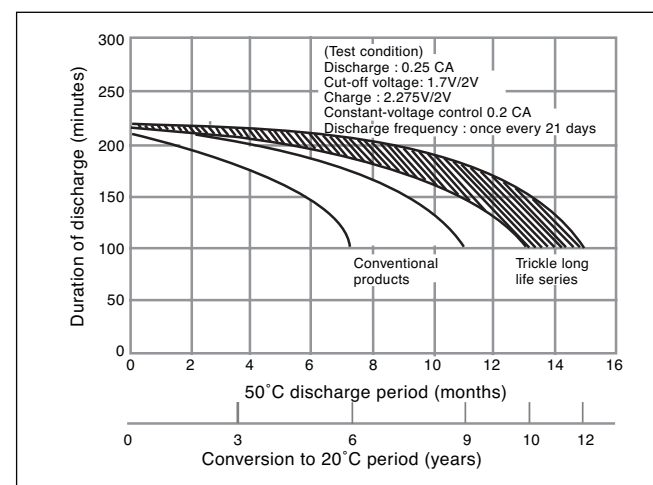
Cycle life vs. Depth of discharge



Influence of Temperature on Trickle life



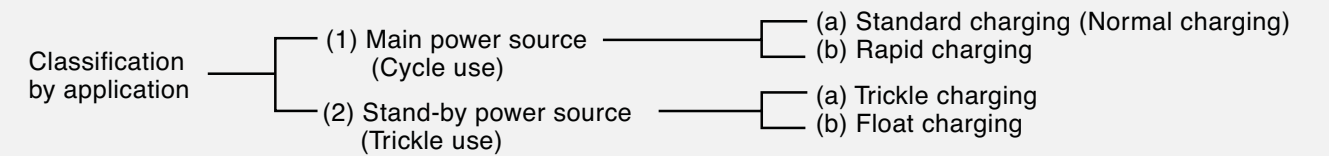
Trickle life characteristics at 50°C



4 | Charging Methods

Methods of Charging the Valve Regulated Lead-Acid Battery

For charging the valve regulated lead-acid battery, a wellmatched charger should be used because the capacity and life of the battery is influenced by ambient temperature, charge voltage and other parameters. Charging methods are dependent on battery applications and are roughly classified into main power applications and stand-by/back-up power applications.



(1) Main Power cycle use

Cycle use is to use the battery by repeated charging and discharging.

(a) Standard charging (Normal charging)

For common applications of the battery, the constant voltage charge method is advantageous as it allows the battery to exert full performance.

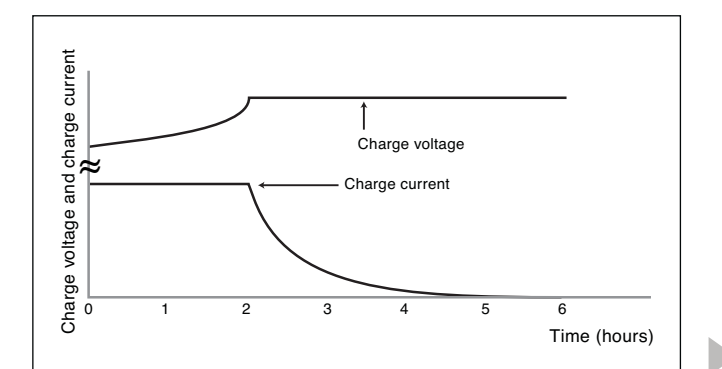
• Constant voltage charging method

This method is to charge the battery by applying a constant voltage between the terminals. When the battery is charged by applying a voltage of 2.45 V per cell (unit battery) at a room temperature of 20°C to 25°C, charging is complete when the charge current continues to be stable for three hours. Valve regulated lead-acid batteries can be overcharged without constant voltage control. When the battery is overcharged, the water in the electrolyte is decomposed by electrolysis to generate more oxygen gas than what can be absorbed by the negative electrode. The electrolyte is changed to oxygen gas and hydrogen gas, and lost from the battery system. As the quantity of electrolyte is reduced, the chemical reactions of charge and discharge become inefficient and hence the battery performance is severely deteriorated. Therefore, exact voltage control and proper charging time in constant voltage charging are essential for securing the expected life of the battery.

• Constant voltage and constant-current charging method

This method is to charge the battery by controlling the current at 0.4 CA and controlling the voltage at 2.45 V / per cell at a room temperature of 20°C to 25°C. Proper charging time is 6 to 12 hours depending on depth of discharge.

Constant voltage constant-current charge characteristics



(b) Rapid charging

When rapidly charging the battery, a large charge current is required in a short time for replenishing the energy which has been discharged. Therefore, some adequate measures such as the control of charge current is required to prevent overcharging when the rapid charging is complete. Basic requirements for rapid charging are as follows:

- Sufficient charging should be made in a short time for fully replenishing the amount discharged.
 - Charge current should be automatically controlled to avoid overcharge even on prolonged charging.
 - The battery should be charged adequately in the ambient temperature range of 0°C to 40°C.
 - Reasonable cycle life of charge/discharge should be secured.
- Typical methods to control charging so as to satisfy the above requirements follow.

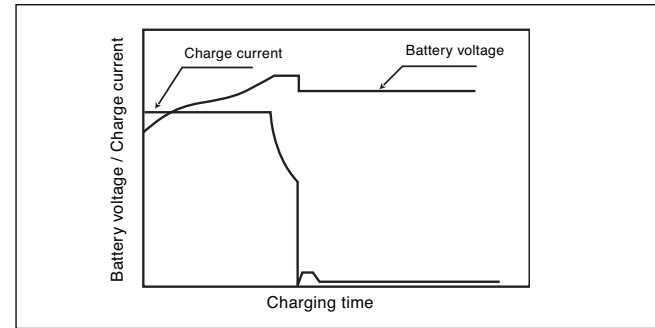
• Two-step constant voltage charge control method

Two-step constant voltage charge control method uses two constant-voltage devices. At the initial stage, the battery is charged by the first constantvoltage device SW(1) of high setup voltage (setup for cycle charge voltage). When the

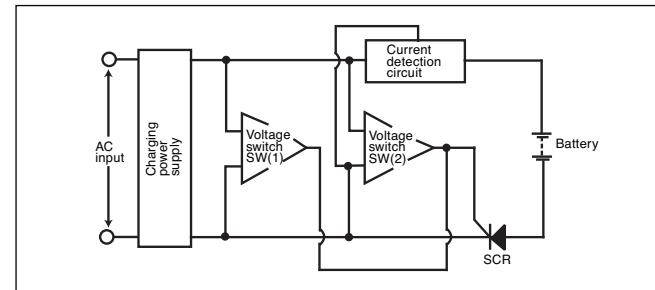
4 | Charging Methods

charge current has reduced to the preset value, the device is switched over to the second SW(2) of low set-up voltage (setup for trickle charge voltage). This method has the advantage that the battery in trickle use can be charged in a comparatively short time for the next discharge.

Charging characteristics of the two-step constant voltage control charger



Block diagram of the two-step constant voltage control charger



(2) Stand-by/Back-up use (Trickle use)

The application load is supplied with power from AC sources in normal state. Stand-by/back-up use is to maintain the battery system at all times so that it can supply power to the load in case the AC input is disrupted (such as a power failure). There are two methods of charging for this use.

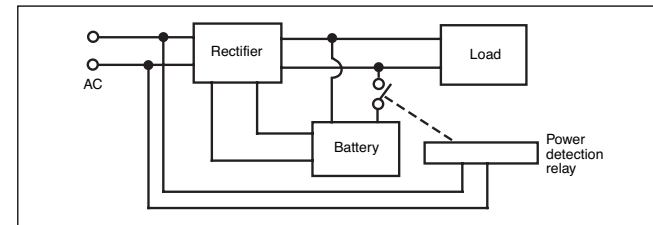
(a) Trickle charge (Compensating charge)

Trickle charge

In this charge system, the battery is disconnected from the load and kept charged with a small current only for compensating self discharge while AC power is alive. In case of power failure, the battery is automatically connected to the load and battery power is supplied. This system is applied mainly as a spare power source for emergency equipment. In this use, if rapid recovery of the battery after discharge is required, it is necessary to consider the recovery charge with a comparatively large current followed by trickle charge, or alternative measures. While the type and capacity of the battery is de-

termined by the back-up time and the load (current consumption) during power failure, some reserve power should be taken into account considering such factors as ambient temperature, capability of the charger and depth of discharge.

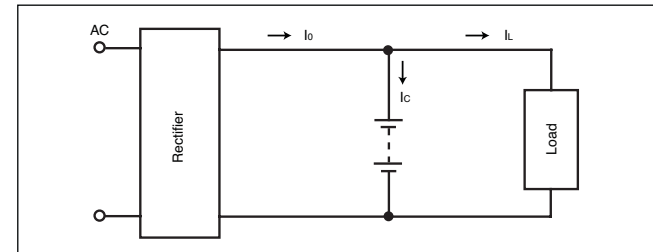
Trickle charge system model



(b) Float charge

Float system is the system in which the battery and the load are connected in parallel to the rectifier, which should supply a constant power.

Float charge system model



In the above-illustrated model, output current of the rectifier is expressed as: $I_o = I_c + I_L$ where I_c is charge current and I_L is load current. Consideration should be given to secure adequate charging because, in fact, load current is not constant but irregular in most cases.

In the float system, capacity of the constant-voltage power source should be more than sufficient against the load. Usually, the rectifier capacity is set at the sum of the normal load current plus the current needed in order to charge the battery.

(Precautions on charging)

- As the battery continues to be charged over a long period, a small difference in charging voltage may result in a significant difference in the battery life. Therefore, charge voltage should be controlled within a narrow range and with little variation for a long period.
- As charge characteristics of the battery are dependent on temperature, compensation for temperature variation is required when the battery is used over a broad temperature range, and the system should be designed so that the battery and the charger are kept at the same temperature.

4 | Charging Methods

Charging Methods and Applications of VRLA-Batteries

Application/Charging Method	Normal charging in 6 or more hours; Constant voltage control	Two-step constant voltage control	Constant Current Control
Cycle Use	Control voltage: 7.25 to 7.45V / 6V battery 14.5 to 14.9V / 12V battery Initial current: 0.4 CA or smaller		
Trickle Use	Control voltage: 6.8 to 6.9 / 6V battery 13.6 to 13.8V / 12V battery	Initial charging with current of approx. 0.15 CA, followed by switching voltage to trickle charge	
Float Use	Control voltage: 6.8 to 6.9/6V battery; 13.6 to 13.8V / 12V battery. Float charging compensates for load fluctuations.		
Refresh charge (Auxiliary charge)*	When charging two or more batteries at a time, select only those which have been left under the same condition.		Charging with current of approx. 0.1 CA
Application example	General uses, Cellular phones (bag phones), UPS, Lanterns, Electric tools	Medical equipment, Personal radios	

Note * Refresh (auxiliary) charge amount should be 120 to 130% of self-discharge amount. For details, please contact us.

(Precautions on charging)

- (a) in constant voltage charging (cycle use): Initial current should be 0.4 CA or smaller (C: rated capacity)
(b) in constant voltage charging (trickle use): Initial current should be 0.15 CA or smaller (C: rated capacity)
- Relation between standard voltage value in constant voltage charging and temperature is given in the Table.

Relation between standard voltage value in constant voltage charging and temperature

		0°C	20°C	40°C
Cycle use	6V	7.7	7.4	7.1
	12V	15.4	14.7	14.2
Trickle use	6V	7.1	6.8	6.7
	12V	14.1	13.7	13.4

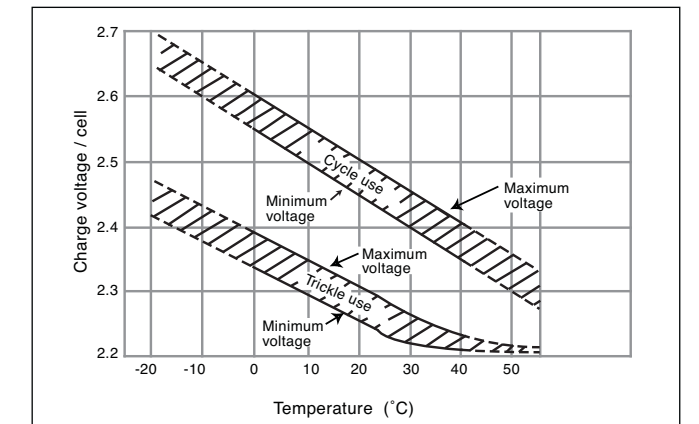
a) Temperature compensation of charge voltage

Charge voltage should be compensated to the ambient temperature near the battery, as shown by the figure below. Main reasons for the temperature compensation of charge voltage are to prevent the thermal runaway of the battery when it is used in high temperature conditions and to secure sufficient charging of the battery when it is used in low temperature conditions. Prolongation of service life of the battery by the above-described temperature compensation is expected as follows

- At 30°C: prolonged by approx. 5%
- At 35°C: prolonged by approx. 10%
- At 40°C: prolonged by approx. 15%

In low temperature zones below 20°C, no substantial prolongation of the battery life can be expected by the temperature compensation of charge voltage.

Compensated voltage value



b) Charging time

Time required to complete charging depends on factors such as depth of discharge of the battery, characteristics of the charger and ambient temperature. For cycle charge, charging time can be estimated as follows:

- when charge current is 0.25 CA or greater:

$$Tch = Cdis / I + (3h \text{ to } 5h)$$

- when charge current is below 0.25 CA:

$$Tch = Cdis / I + (6h \text{ to } 10h), \text{ where}$$

Tch : Charging time required (hours),

Cdis : Amount of discharge before this charging (Ah)

I : Initial charge current (A)

Time required for trickle charge ranges from 24 to 48 hours.

4 | Charging Methods

c) Charging temperature

- Charge the battery at an ambient temperature in the range from 0°C to 40°C.
- Optimum temperature range for charging is 5°C to 35°C.
- Charging at 0°C or below and 40°C or higher is not recommended: at low temperatures, the battery may not be charged adequately; at high temperatures, the battery may become deformed.
- For temperature compensation values, see a).

d) Reverse charging

Never charge the battery in reverse, as it may cause leakage, heating or bursting of the battery.

e) Overcharging

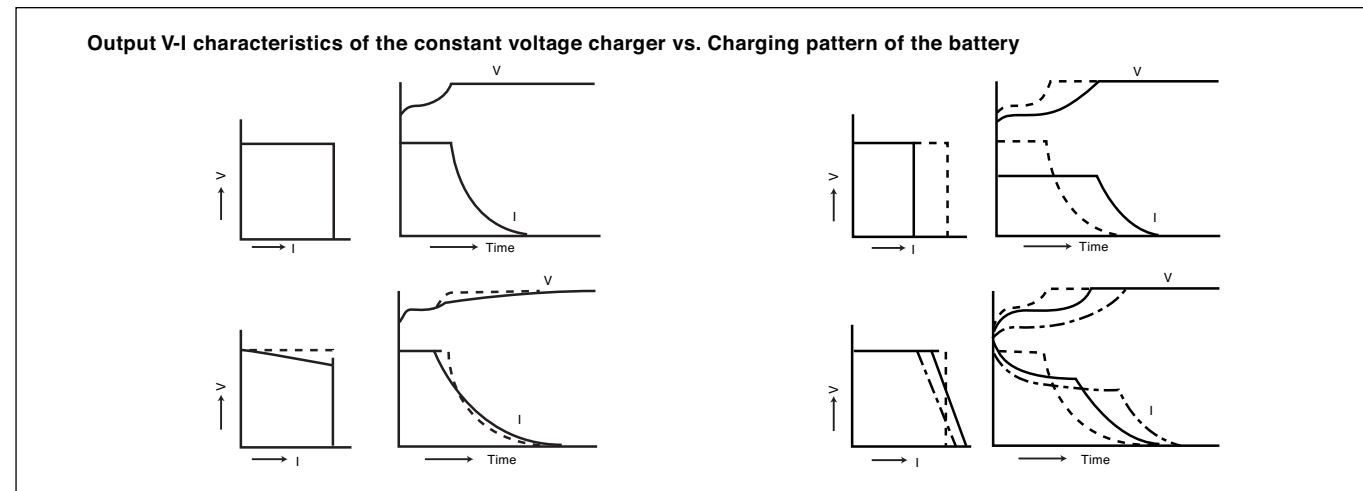
Overcharge is an additional charge after the battery is fully charged. Continued overcharging shortens the battery life. Select a charge method which is specified or approved for each application.

f) Charging before use

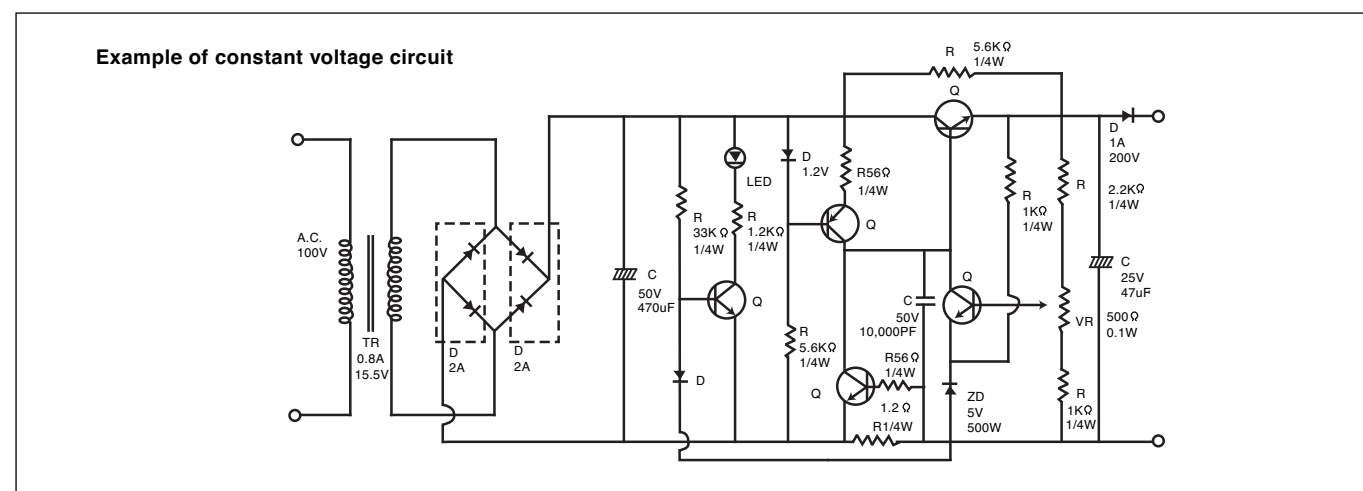
Recharge the battery before use to compensate for capacity loss due to self-discharge during storage. (See "Refresh charge" (auxiliary charge) table on page 15.)

Characteristics of constant voltage chargers

Even with the same voltage set-up, charging time varies with output V-I characteristics.



Constant voltage charger circuitry (Concept diagram)



4 | Charging Methods

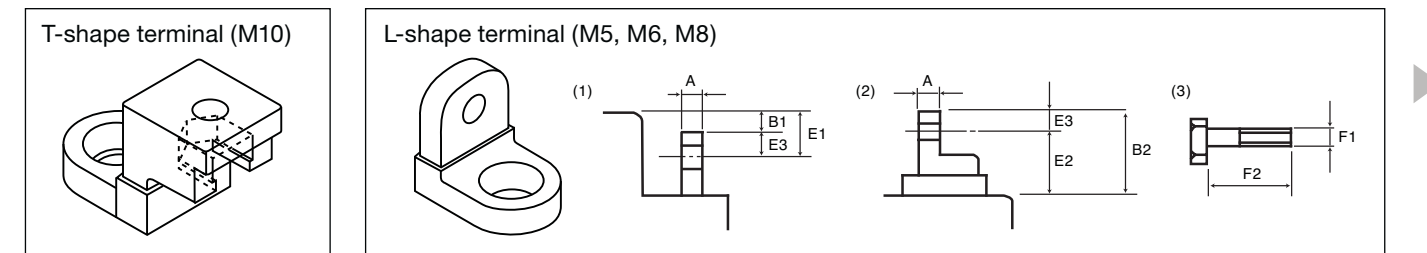
Precautions

- When adopting charging methods and charging conditions other than those described in the specifications or the brochures, thoroughly check charging/discharging characteristics and life characteristics of the battery in advance. Selection of appropriate methods and conditions of charging is essential for safe use of the battery and for fully utilizing its discharge characteristics.
- In cyclic use of the battery, use a charger equipped with a charging timer or a charger in which charging time or charge amount is controlled by other means; otherwise, it will be difficult to judge the completion of the charge. Use of a charger as described above is recommended to prevent undercharge or overcharge which may cause deterioration of the battery characteristics.

- Continue charging the battery for the specified time or until the charge completion lamp, if equipped, indicates completion of charging. Interruption of charging may cause a shortening of service life.
- Do not recharge the fully charged battery repeatedly, as overcharge may accelerate deterioration of the battery.
- In cyclic use of the battery, do not continue charging for 24 hours or longer, as it may accelerate deterioration of the battery.
- In cyclic service of the battery, avoid charging two or more batteries connected in parallel simultaneously: imbalance of charge/discharge amount among the batteries may shorten the life of batteries.

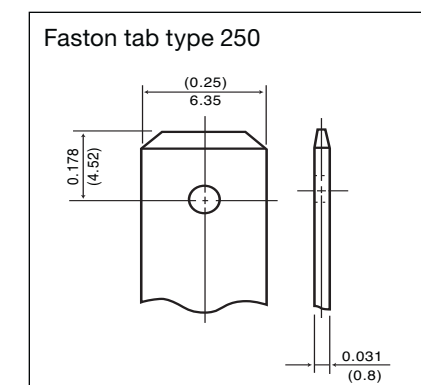
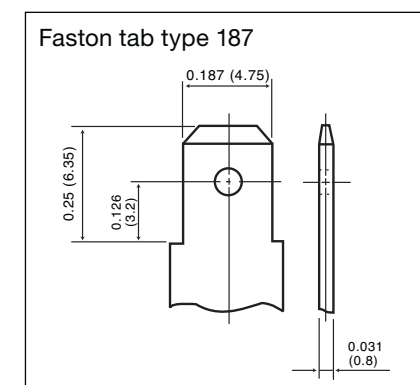
5 | Terminal Data

1. Bold and Nut type

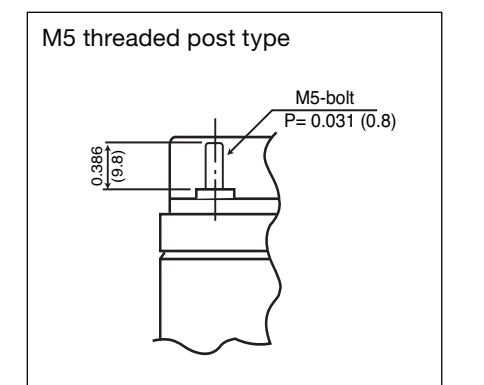


Type of Terminal	Terminal thickness A (1)	Height from battery case top		Terminal width	Hole diameter	Hole Position			Bolt		
		B1 (1)	B2 (2)			Distance from top: E1 (1)	Distance from top: E2 (2)	Distance from terminal top: E3 (2)	Diameter F1 (3)	Pitch	Length F2 (3)
M5 bolt and nut	5.0 ± 0.3	1.0	-	11 ± 0.4	5.5 ± 0.3	6.5	-	5.5 ± 0.3	M5	P = 0.8	15 ± 1.0
M6 bolt and nut	8.0 ± 0.5	5.0	16.5 ± 1.5	16 ± 0.8	6.5 ± 0.4	-	9 ± 1.0	7.5 ± 0.4	M6	P = 1.0	20 ± 1.0
M8 bolt and nut	8.0 ± 0.5	-	24 ± 1.5	-	6.5 ± 0.4	-	14 ± 1.0	10 ± 0.4	M8	P = 1.25	20 ± 1.0

2. Faston tab type



3. Threaded post type



6 | Safety

VRLA battery safety test items

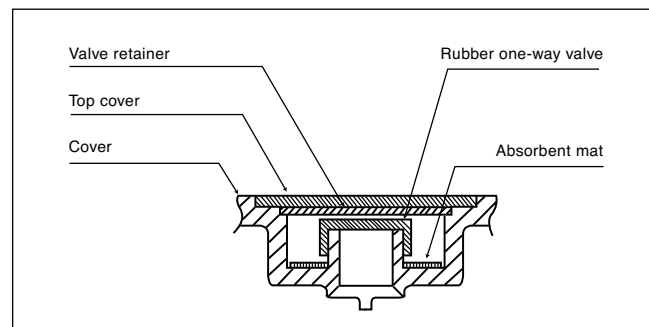
Item	Test method	Check point
1. Shock test (Drop test) IEC 61056-1 and JIS C 8702 (These specifications are harmonized each other)	A fully charged battery is allowed to drop in the upright position from the height of 20 cm onto a hard board having a thickness of 10 mm or more. Test is repeated three times.	The battery should be free from noticeable breakage or leaks; and its terminal voltage should be held higher than the nominal voltage.
2. Vibration test IEC 61056-1 and JIS C 8702 (These specifications are harmonized each other)	A vibration frequency 1000 times/minute and amplitude 4 mm is applied to the X-, Y- and Z-axis directions of a fully charged battery for 60 minutes respectively.	No battery part should be broken; the battery should be free from leaks; and its terminal voltage should be held higher than the nominal voltage.
3. Oven test Panasonic internal standard	A fully charged battery is left standing in an atmosphere of 70°C for 10 hours.	The battery case should not be deformed; the battery should be free from leaks.
4. Coldproof test Panasonic internal standard	A fully charged battery is connected to a resistor equivalent to 60 hour rate discharge and left for 4 days; then the battery is left standing in an atmosphere of -30°C for 24 hours.	No crack should develop in the battery case; the battery should be free from leaks.
5. Heat cycle test Panasonic internal standard	A fully charged battery is exposed to 10 cycles of 2 hours at -40°C and 2 hours at 65°C.	No crack should develop in the battery case; the battery should be free from leaks.
6. Short circuit test Panasonic internal standard	A fully charged battery connected with a small resistor of 10 ohms or less is allowed to discharge.	The battery must not burn nor bust.
7. Large current discharge test Panasonic internal standard	A fully charged battery is allowed to discharge at 3CA to 4.8V / 6V battery level. (This test is not applicable to batteries having built-in thermostat.)	The battery should not burn or bust, and it should be free from battery case deformation, leaks and any irregularity internal connections.
8. Vent valve function test UL1998	A fully charged battery is submerged in liquid paraffin in a container, then overcharged at 0.4CA. (UL1989)	Release of gas from the vent should be observed.
9. Overcharge test Panasonic internal standard	A fully charged battery is overcharged at 0.1CA for 48 hours, left standing for one hour, and allowed to discharge at 0.05CA to 5.25V / 6V.	No irregularity should be noticed in the battery appearance; the battery should retain 95% or more of the initial capacity.

(Note) The above safety notes apply only to standalone batteries, not to embedded batteries.

7 | Safety Design

Vent (One way valve)

If the internal pressure of the battery is raised to an abnormal level, the rubber one way valve opens to release excessive pressure; thus the valve protects the battery from danger of bursting. Since the rubber valve is instantly resealable, the valve can perform its function repeatedly whenever required.



Example of Valve Construction

7 | Safety Design

VRLA batteries are inherently safe. However, there are some risks when VRLAs are used beyond a reasonable replacement time span, misapplied or abused. There are two main failure mode of VRLA battery used for trickle (float) application. In high temperatures and/or high voltage charging, dry-out is accelerated. This leads to loss of capacity and eventually the cell will fail open. Grid growth due to grid corrosion causes loss in mechanical strength and eventually leads to loss of contact with the grid. Battery should be replaced before these failures. If VRLA batteries are used after the end of life, the grid growth may cause a crack of container. Capillary action can result in a slight film of conductive electrolyte forming around the crack even though VRLA batteries contain significantly lower volumes of electrolyte and the electrolyte is immobilized. This electrolyte film will be in contact with an un-insulated metal component and this ground fault current could result in thermal runaway of a portion of the string or even a fire. And the grid growth may cause internal short between positive grid and negative strap in a cell. Continuing to charge a string of cells when one or more of the cells exhibit internal shorts, can result in thermal runaway. For example, assume a string of 12 cells is being charged at 27.3V (2.275V/cell) and the string continues in operation with two cells shorted. In this situation the average charging voltage on the remaining 10 good cells is 2.73V/cell. This will result in very high float current and cause thermal runaway.

Figure 1 is the mechanism of above phenomena.

Panasonic VRLA battery minimizes these risks by using less corrosive lead alloy and expanded positive grid. Figure 2 shows an example of cast grid and expanded grid. Expanded grid does not have enough strength to crack container case by grid growth. And an insulator between positive grid and negative strap is installed in the models as necessary.

Furthermore, Panasonic uses flame retardant battery container case for the models used for stand-by application. The cases are designed to be self-extinguishing and meet minimum flammability standards of UL94 V-0 and 28 L.O.I. (limiting oxygen index).

Figure 3 is the picture of self-extinguishing phenomenon.

Fig. 1 Mechanism of thermal runaway caused by grid growth

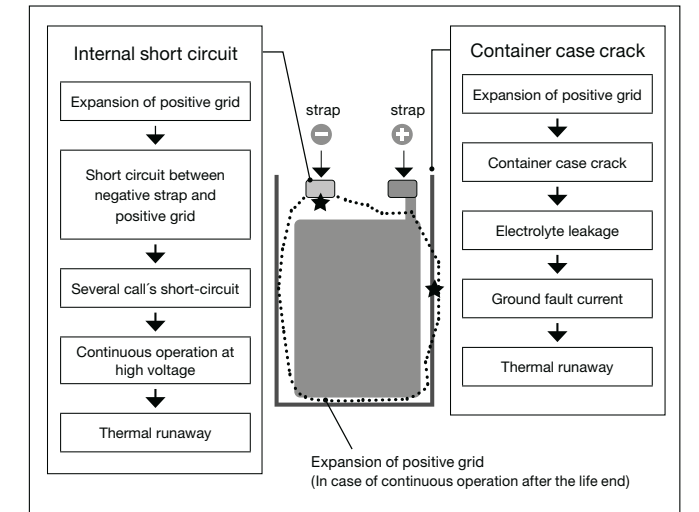


Fig. 2 Cast grid and expanded grid

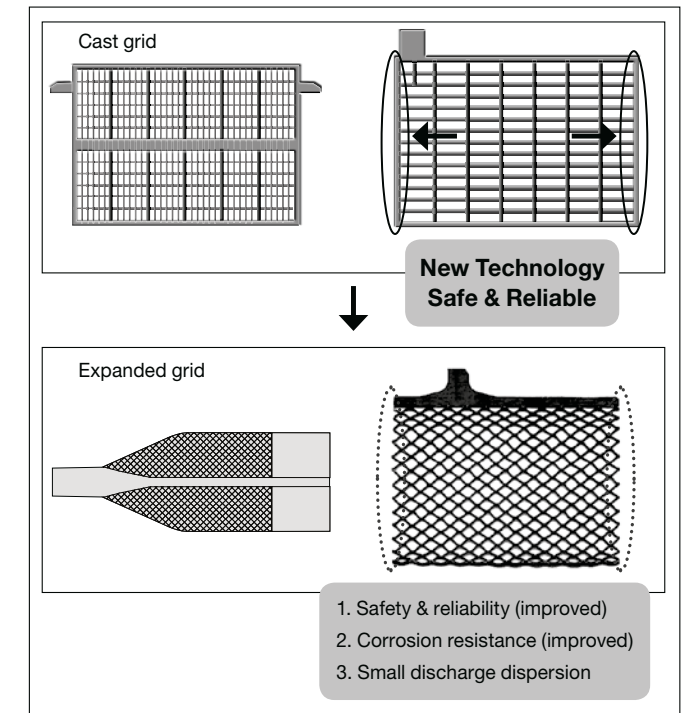
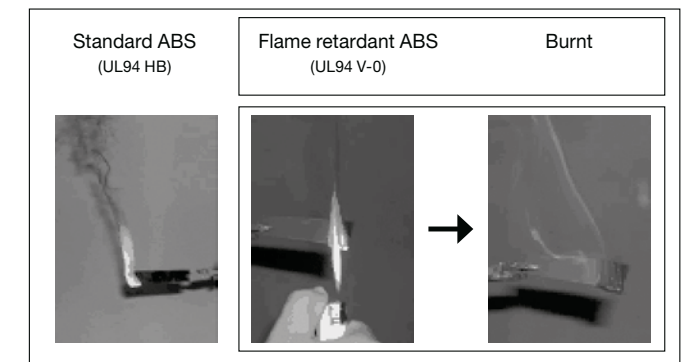


Fig. 3 Flame retardant case (Self-extinguish phenomenon)



8 | Model Numbers of VRLA-Batteries

Composition of Model Numbers

Figure No.	1	2	3	4	5	6	7	8	9	10	11	12
Model No.	L	C	-	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗

⊗ Corresponding model number descriptions are listed below.
Please refer to the battery indexes for listings of available models.

No. 1 to 3

Product division codes (all of which are assigned by Panasonic). "LC" means Panasonic Valve Regulated Lead-Acid batteries.

No. 4

Fixed single-figure code (alphabetic letter) indicating properties, shape, etc. of the battery

- XC: Cycle long life products**
- X: Trickle long life products**
- P: Products combining trickle long life and flameretardant battery case**
- R: Small-sized common products (Under 17Ah)**
- V: Products of "R" and "L" types with flameretardant battery case (option)**

No. 5

Single code (alphabetic letter) for dividing products of the same type and the same capacity but having different shapes. (This figure may be omitted when not applicable, then the proceeding codes are advanced.)

Examples: LC-RD LC-XB

No. 5 to 7

Double-figure fixed codes indicating nominal voltage by numerical value.

Examples: 6V = 06, 12V = 12, etc.

No. 7 to 10

One- through four-figure (maximum) codes indicating capacity by numbers: decimal point is expressed by R (When some codes are not applicable, the proceeding codes are advanced.)

Examples:				
Capacity (20 hour rate)	4Ah	7.2Ah	12Ah	100Ah
	↓	↓	↓	↓
Model Number	4	7R2	12	100

No. 8 to 12

One- through five-figure (maximum) alphanumeric code for classifying products by terminal type, package form, destination code, etc.

- Examples:**
- P: English label**
 - J: Japanese label**
 - G: VdS certified products**

(Note) 1) Country codes are subject to change.

8 | Model Numbers of VRLA-Batteries

Composition of Model Numbers

UP-RW series (High power batteries for UPS)

Figure No.	1	2	3	4	5	6	7	8	9	10	11	12
Model No.	U	P	-	*	W	□	□	◇	◇	◇	◇	◇

No. 1 to 3

Production division codes of high power batteries for UPS.

No. 4

Alphanumeric code indicates properties, shape, etc. of the battery.

R: Back-up power sources series.

No. 5

Indication of wattage.

No. 6

Single alphabetic letter for dividing products of the same type and the same capacity but having different shapes. (This figure may be omitted when not applicable, then the proceeding codes are advanced.)

Examples: UP-RW, UP-RWA

No. 6 to 8

Double-figure fixed codes indicating nominal voltage by numerical value.

Examples: 12V = 12, 24V = 24

No. 8 to 10

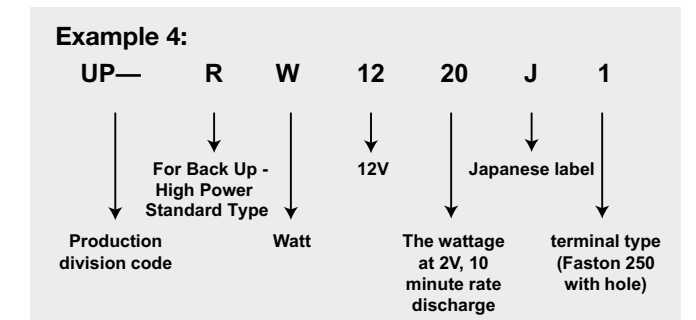
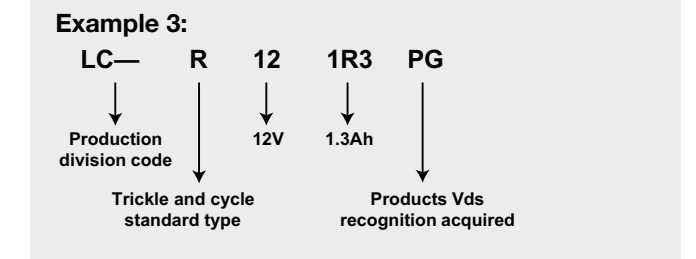
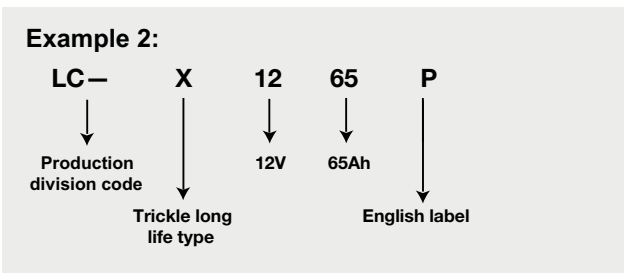
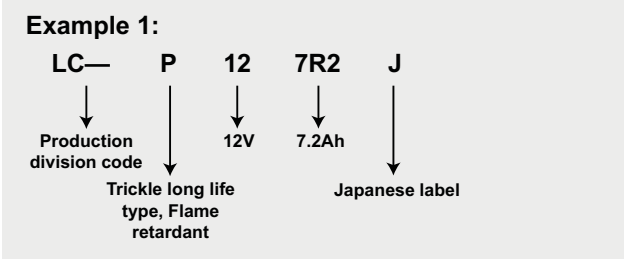
Indicating wattage at 2V, 10 minute rate discharge.

No. 10 to 12

One-through five-figure (maximum) alphanumeric code for classifying products by terminal type, package form, destination code, etc.

Examples: J: Japanese label
P: English label
1: Faston 250

(Note) The last numbers of model number changes depending on the country of destination. Please consult Panasonic for more details. Division codes are subject to change.



9 | Battery Selection Chart

Method of battery selection (Estimation of initial discharge time)

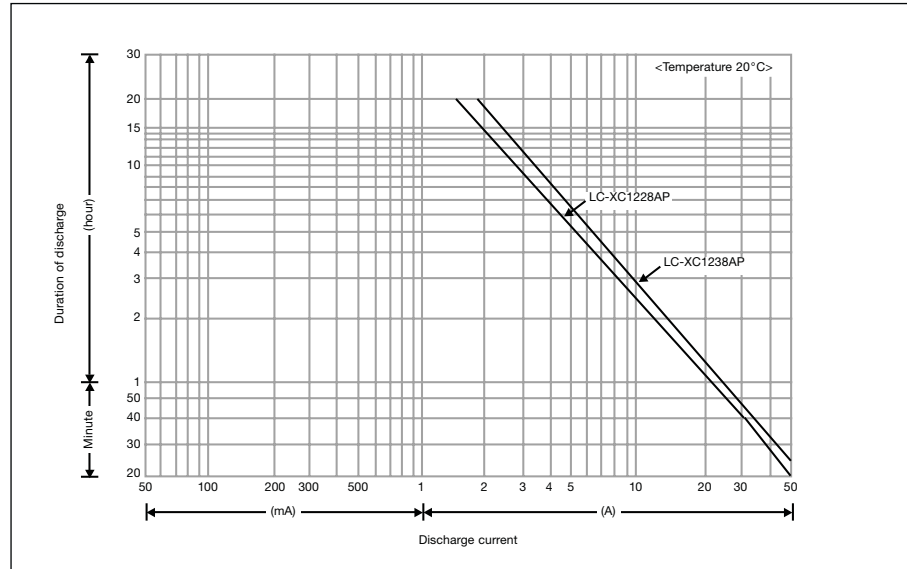
- (1) Determine discharge current.
- (2) Determine duration of discharge required.
- (3) Select batteries from the selection chart below. Then, select a battery which meets the specification of the equipment in which the battery is loaded such as voltage, dimensions and mass, from the "Battery Index" on page 28 to 29.

(4) Example

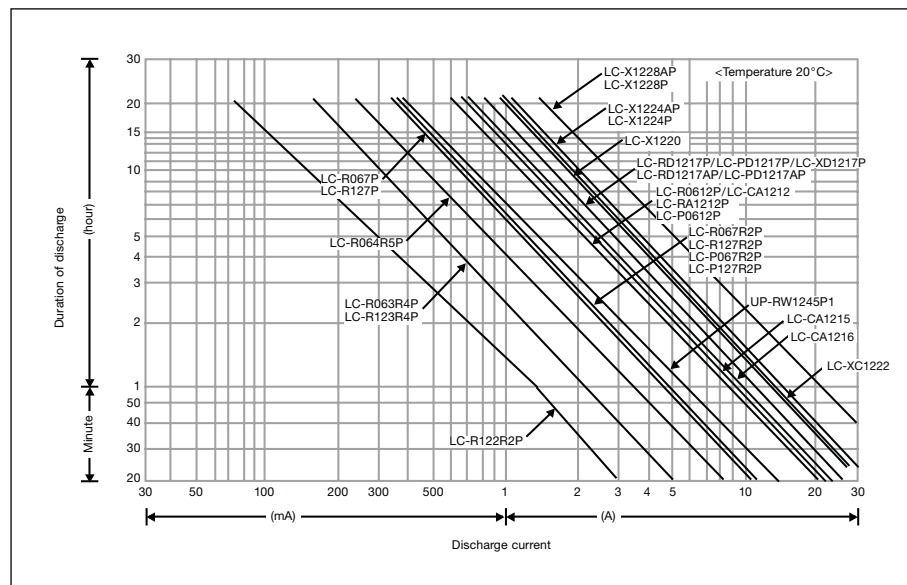
- Use condition: 2.9 A, 1.5 hours, 12 V; space allowable 100 mm x 160 mm x 105 mm
- 7.2 Ah is selected in the step (3).
- LC-R127R2P 94 mm x 151 mm x 100 mm is selected in the step (4).

(5) Refer to individual data sheets for detailed discharge characteristics of the battery.

(Note) Data given are the average values obtained within three cycles of charge/discharge, not the minimum values.

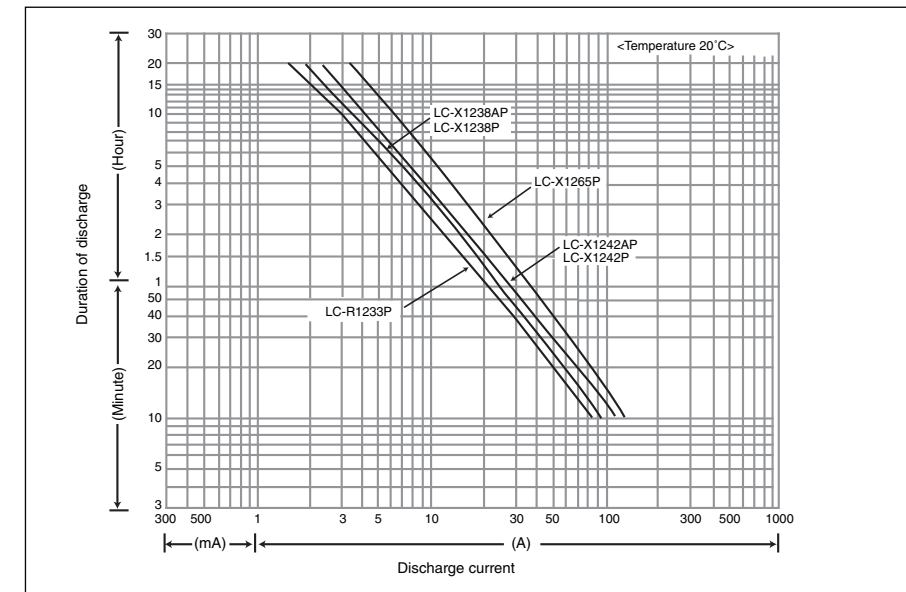


VRLA battery for main power applications

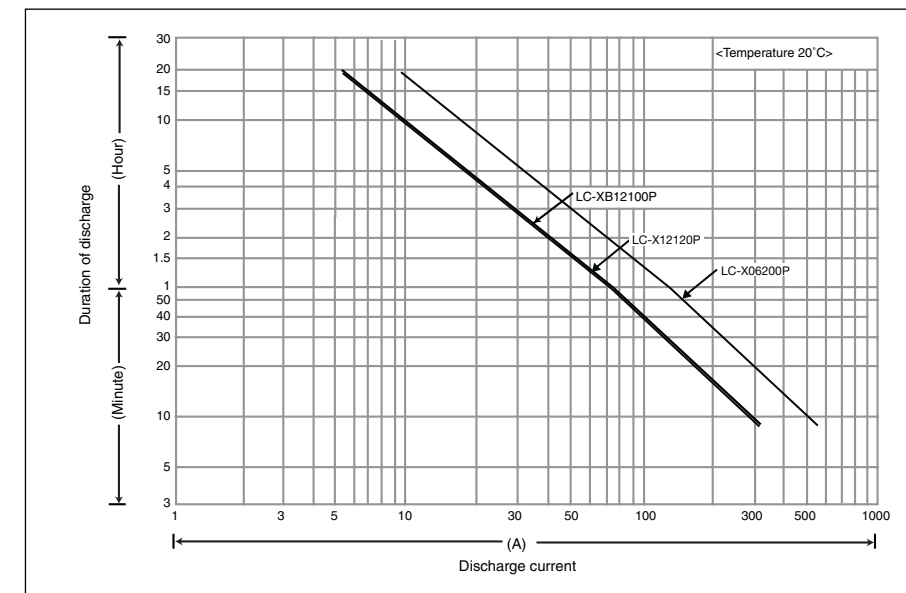


VRLA battery for standby power applications (2.2 Ah to 28 Ah)

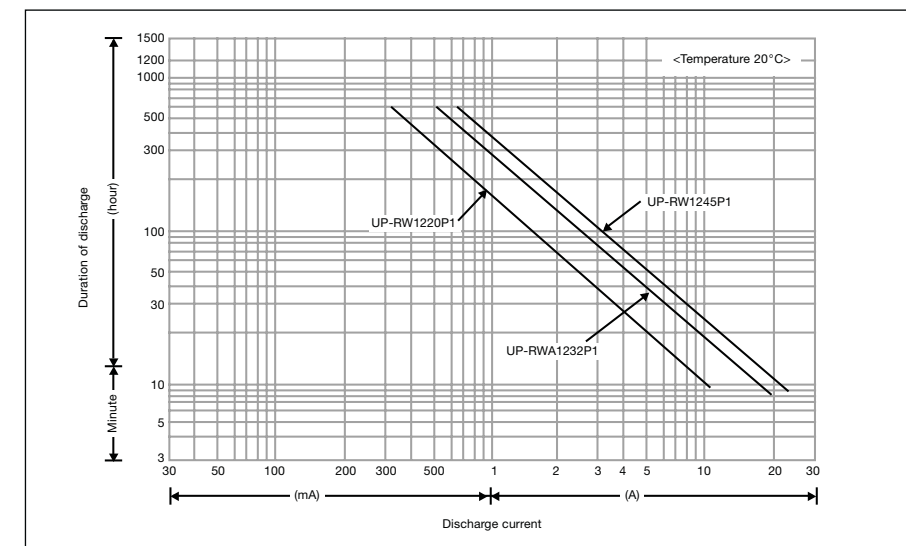
9 | Battery Selection Chart



VRLA battery for standby power applications (33Ah to 65Ah)



VRLA battery for standby power applications (100Ah)



VRLA battery for standby power applications (high-power for UPS)

10 | Battery Selection Guide

Steps for selecting batteries are described below.

Study of required specifications (draft)

Study the required specifications (draft) by checking the requirements for the battery with the battery selection criteria. Technical requirements for selecting the battery are presented below.

Battery selection

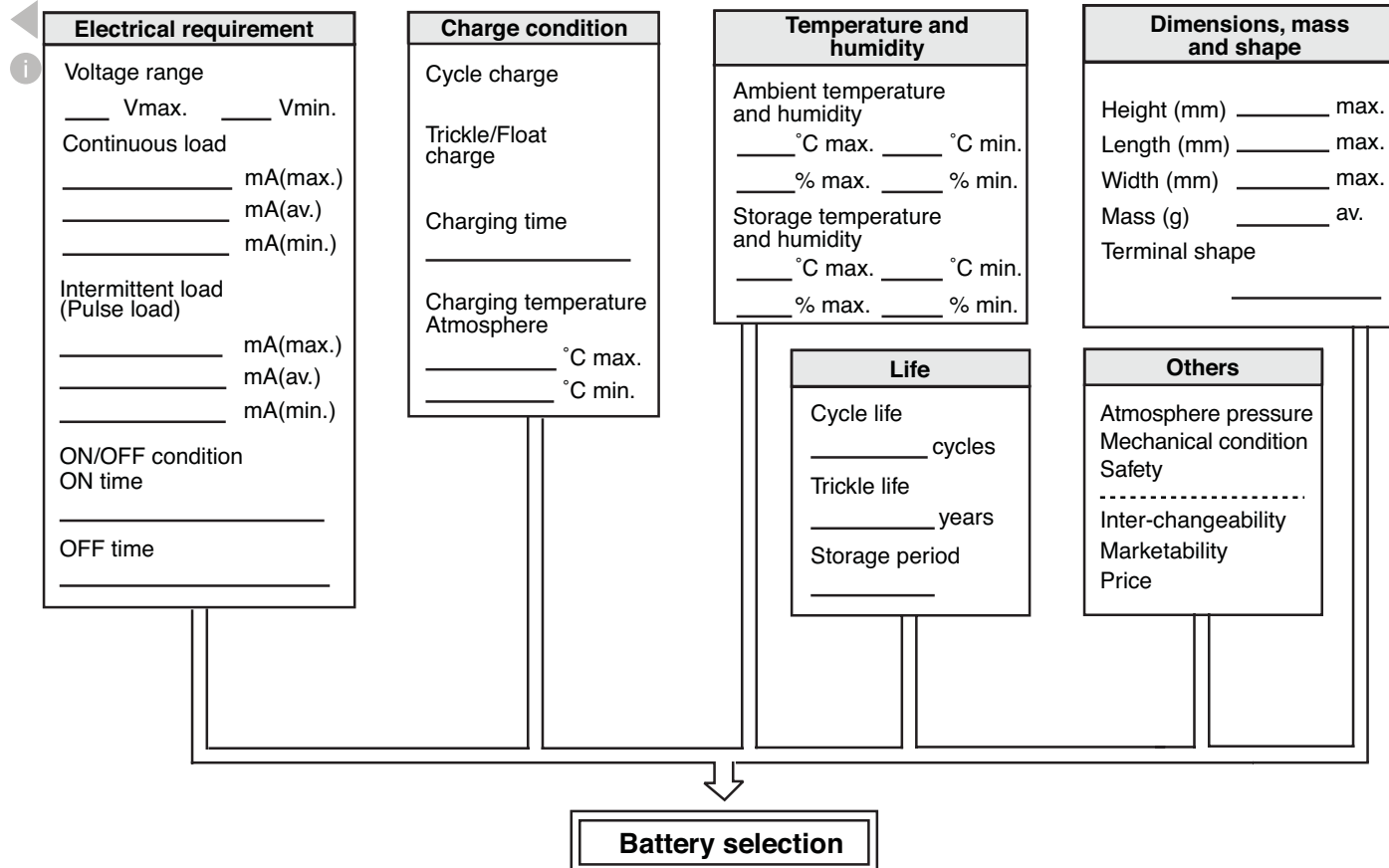
First, select several candidate batteries by referring to the technical brochures and data sheets of the batteries presently available. Then from the candidates select a battery which can meet as many of the ideal requirements as possible. In fact, however, battery selection can be seldom made so smoothly. Practically, possible removal or easing of the requirements should be considered first; then depending on the result, a proper battery should be selected from those presently available. This way of proceeding

enables economic selection of the battery. Any questions at this stage should be asked to battery engineers in depth. Sometimes, new or improved batteries which are not carried in the brochures have become available, and an appropriate battery may be found among them. Usually, required specifications are finalized at this stage.

Request for improving or developing batteries

If no battery which will satisfy special requirements can be found by the above-described approach, requests for improving or developing new batteries should be made to our technical department, and these requests should be coordinated as quickly as possible to allow enough time for studying: the study takes usually 6 to 12 months or even longer depending on the request. In this section, guidelines for selecting appropriate batteries for specific equipment were mentioned. If further information regarding the battery selection is required, please contact us.

Technical requirements for battery selection



11 | Battery Index

Battery Types and Model Numbers

Application	Series	Trickle Design Life (at 20°C)	Category	Standard ABS (UL94 HB)	FR ABS = Flame Retardant ABS (UL94 V-0)
Back Up	LC-V	6 – 9 years	Trickle standard type		●
	LC-X	10 – 12 years	Trickle long life type	●	
	LC-P	10 – 12 years	Trickle long life type		●
	LC-QA	15 years	Trickle super long life type		●
	UP-RW	6 – 9 years	High power standard type	●	
UP-PW	10 – 12 years	High power long life type		●	
Back Up and Main Power	LC-R	6 – 9 years	Trickle and cycle standard type	●	
Main Power	LC-CA	-	Cycle long life type	●	
	LC-XC	-	Cycle long life type	●	

LC Series – Trickle Design Life 6 – 9 Years

Model Number	Nominal Voltage (V)	Rated Capacity (Ah) 20 hour rate	Dimensions (mm)				Mass approx. (kg)	Page	VdS VdS N°
			Length	Width	Height	Approx. Total Height			
LC-R061R3P*1	6	1.3	97	24	50	55	0.3	36	-
LC-R063R4P*1	6	3.4	134	34	60	66	0.6	38	-
LC-R064R5P*1	6	4.5	70	48	102	108	0.7	40	-
LC-R067R2P*1	6	7.2	151	34	94	100	1.3	42	-
LC-R0612P*1	6	12	151	50	94	100	2.0	44	-
LC-R0615P	6	15	151	50	94	100	2.1	46	-
LC-R121R3PG	12	1.3	97	47.5	50	55	0.6	48	G196049
LC-R122R2PG	12	2.2	177	34	60	66	0.8	50	G188151
LC-R123R4PG	12	3.4	134	67	60	66	1.2	52	G191053
LC-R124R5P	12	4.5	70	97	102	108	1.5	54	-
LC-R127R2PG*2	12	7.2	151	64.5	94	100	2.5	56	G193046
LC-RA1212PG	12	12	151	98	94	100	3.8	58	G100001
LC-RA1215P	12	15	151	98	94	100	4.2	60	-
LC-R1233P	12	33	195.6	130	155	180	12.0	62	-
LC-V1233P	12	33	195.6	130	155	180	11.1	64	-

LC Series – Trickle Design Life 10 – 12 Years

Model Number	Nominal Voltage (V)	Rated Capacity (Ah) 20 hour rate	Dimensions (mm)				Mass approx. (kg)	Page	VdS VdS N°
			Length	Width	Height	Approx. Total Height			
LC-P067R2P	6	7.2	151	34	94	100	1.30	66	-
LC-P0612P	6	12	151	50	94	100	2.00	68	-
LC-X06200P*1	6	200	407	173	210	250	41.00	70	-
LC-P122R2P	12	2.2	177	34	60	66	0.80	72	-
LC-P123R4P	12	3.4	134	67	60	66	1.20	74	-
LC-P127R2P	12	7.2	151	64.5	94	100	2.50	76	-
LC-PA1212P	12	12	151	98	94	100	3.80	78	-
LC-XD1217PG/APG	12	17	181	76	167	167	6.50	80	G104101

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).
*2 LC-R127R2P is available with flame retardant case resin (UL94 V-0) but with no VdS certification.

11 | Battery Index

LC Series – Trickle Design Life 10 – 12 Years

Model Number	Nominal Voltage (V)	Rated Capacity (Ah)	Dimensions (mm)				Mass approx. (kg)	Page	VdS VdS N°
		20 hour rate	Length	Width	Height	Approx. Total Height			
LC-X1220P/AP*1	12	20	181	76	167	167	6.6	82	-
LC-X1224PG/APG	12	24	165	125	175	179.5/175	9.0	84	G198049
LC-X1228P/AP*1	12	28	165	125	175	179.5/175	11.0	86	-
LC-X1238PG/APG	12	38	197	165	175	180/175	13.0	88	G100002
LC-X1242P/AP*1	12	42	197	165	175	180/175	16.0	90	-
LC-X1265PG	12	65	350	166	175	175	20.0	92	G199090
LC-X1275P*1	12	75	350	166	175	175	24.0	94	-
LC-XB12100P*1	12	100	407	173	210	236	37.0	96	-
LC-X12120P*1	12	120	407	173	210	236	37.0	98	-

LC Series – Cycle Long Life

Model Number	Nominal Voltage (V)	Rated Capacity (Ah)	Dimensions (mm)				Mass approx. (kg)	Page	VdS VdS N°
		20 hour rate	Length	Width	Height	Approx. Total Height			
LC-CA1212P	12	12	151	98	94	100	3.8	100	-
LC-CA1215P	12	15	151	98	94	100	4.2	102	-
LC-CA1216P	12	16	151	98	99	105	4.7	104	-
LC-XC1222P	12	22	181	76	167	167	6.6	106	-
LC-XC1228P	12	28	165	125	175	179.5	10.0	108	-
LC-XC1238P	12	38	197	165	175	179.5	15.0	110	-

UP-RW / PW Series – Trickle Design 6 – 9 and 10 – 12 Years

Model Number	Nominal Voltage (V)	Rated Power (W)	Dimensions (mm)				Mass approx. (kg)	Page	VdS VdS N°
		10 minute rate	Length	Width	Height	Approx. Total Height			
UP-RW0645P*1,2	6	135	151	34	94	100	1.3	112	-
UP-RW1220P*1,2	12	120	140	38.5	94	100	1.4	114	-
UP-RW1228P*1,2	12	200	151	64.5	94	100	1.9	116	-
UP-RWA1232P1/P2*1,2	12	192	151	51	94	100	2.0	118	-
UP-RW1236P*1,2	12	224	151	64.5	94	100	2.1	120	-
UP-RW1245P*1,2	12	270	151	64.5	94	100	2.6	122	-
UP-PW1245P*3	12	270	151	64.5	94	100	2.6	124	-

LC-QA Series – Trickle Design Life 15 Years

Model Number	Nominal Voltage (V)	Rated Capacity (Ah)	Dimensions (mm)				Mass approx. (kg)	Page	VdS VdS N°
			Length	Width	Height	Approx. Total Height			
LC-QA06210TP	6	210	407	173	210	250	36.5	126	-
LC-QA1224AP	12	24	165	125	175	175	10.0	128	-
LC-QA1242P/AP	12	42	197	165	175	180	16.0	130	-
LC-QA1270P	12	70	350	166	175	175	23.5	132	-
LC-QA12110TP	12	110	407	173	210	236	36.0	134	-

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0). *2 Trickle Design Life 6 – 9 Years. *3 Trickle Design Life 10 – 12 Years.

12 | Standards

Product Standards

Alarm security market / VdS approved batteries

Model Number	Nominal Voltage (V)	Rated Capacity (Ah)	VdS VdS N°	Country of origin
LC-R121R3PG	12	1,3	G196049	China
LC-R122R2PG	12	2,2	G188151	China
LC-R123R4PG	12	3,4	G191053	China
LC-R127R2PG	12	7,2	G193046	China
LC-RA1212PG	12	12	G100001	China
LC-XD1217PG/APG	12	17	G104101	China
LC-X1224PG/APG	12	24	G198049	China
LC-X1238PG/APG	12	38	G100002	China
LC-X1265PG	12	65	G199090	China

UL Standard

All our VRLA batteries are in compliance with UL 1989 (Standby Batteries) – file number MH 13723. UL 1989 requires that the battery is free from the hazard of bursting, that is, when the battery is overcharged the vent valve opens to release internal pressure.

JIS (Japan Industrial Standard)

All our VRLA batteries are in compliance with JIS C 8702 (almost harmonized with IEC 61056).

Factory Standards

ISO 9001 / ISO 14001

Quality Management System (ISO 9001) defines what the organization does to ensure that its products or services satisfy the customer's quality requirements and comply with any regulations applicable to those products or services. ISO 14000 is primarily concerned with "environmental management". In plain language, this means what the organization does to minimize harmful effects on the environment caused by its activities.

OHSAS 18001

OHSAS 18001 is an Occupation Health and Safety Assessment Series for health and safety management systems. It is intended to help organizations to control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which to be certified and assessed.

Other applicable Standards

Following documents are established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.

NOTE: Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

IEC standards cover a vast range of technologies from power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, solar energy, nanotechnology and marine energy as well as many others.

IEC standards are also being adopted as harmonized standards by other certifying bodies such as BSI (Great Britain), CSA (Canada), UL & ANSI/INCITS (USA), SABS (South Africa), SAI (Australia), SPC/GB (China), DIN (Germany) and JIS (Japan). IEC standards harmonized by other certifying bodies generally have some noted differences from the original IEC standard.

12 | Standards

IEC 61056

Specifies the general requirements, functional characteristics and methods of test for all general purpose lead acid cells and batteries of the valve regulated type for either cyclic or float charge application; in portable equipment, for instance, incorporated in tools, toys, or in static emergency, or uninterruptible power supply and general power supplies.

The cells of this kind of lead-acid battery may either have flat-plate electrodes in prismatic containers or have spirally wound pairs of electrodes in cylindrical containers. The sulfuric acid in these cells is immobilized between the electrodes either by absorption in a microporous structure or in a gelled form.

IEC 61056-1

General purpose lead acid batteries (valve-regulated types)
Part 1: General requirements, functional characteristics-
Method of test

IEC 61056-2

General purpose lead acid batteries (valve-regulated types)
Part 2: Dimensions, terminals and marking

IEC 60896-21

Stationary lead-acid batteries. Valve regulated types.
Methods of test.

This part of IEC 60896 applies to all stationary lead-acid cell and monobloc batteries of the valve regulated type for float charge applications, (i.e. permanently connected to a load and to a d.c. power supply), in a static location, (i.e. not generally intended to be moved from place to place) and incorporated into stationary equipment or installed in battery rooms for use in telecom uninterruptible power supply (UPS), utility switching, emergency power or similar applications.

Following standards are adopted as harmonized standards.

EN 50272-2 [DIN VDE 0510 Part 2]

Safety Requirements for Secondary Batteries and Battery Installations. Safety requirements for batteries and battery systems-stationary batteries. The ventilation requirements for safety rooms are specified herein. Apply the VRLA formula together with our batteries.

GOST-R (GOSSTANDART of RUSSIA)

Certifies quality of actually supplied goods and their compliance with contractual terms. A quality certificate contains a profile of goods or confirms their compliance with certain standards or specifications of a delivery order. A certificate of compliance is intended for certification of goods produced by Russian companies or shipped to Russia by an importer-company.

13 | Individual Data Sheets

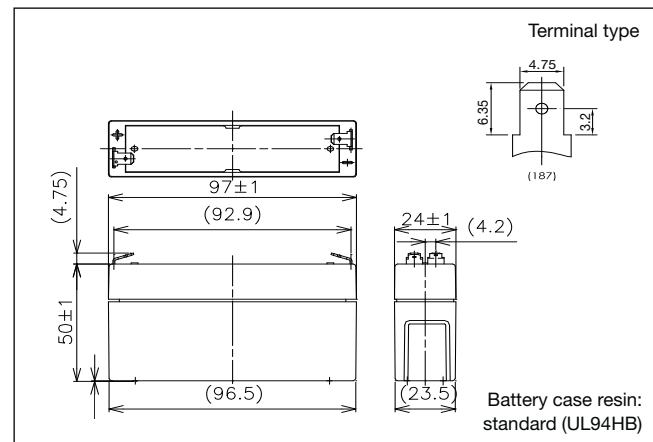
LC-R061R3P*1



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

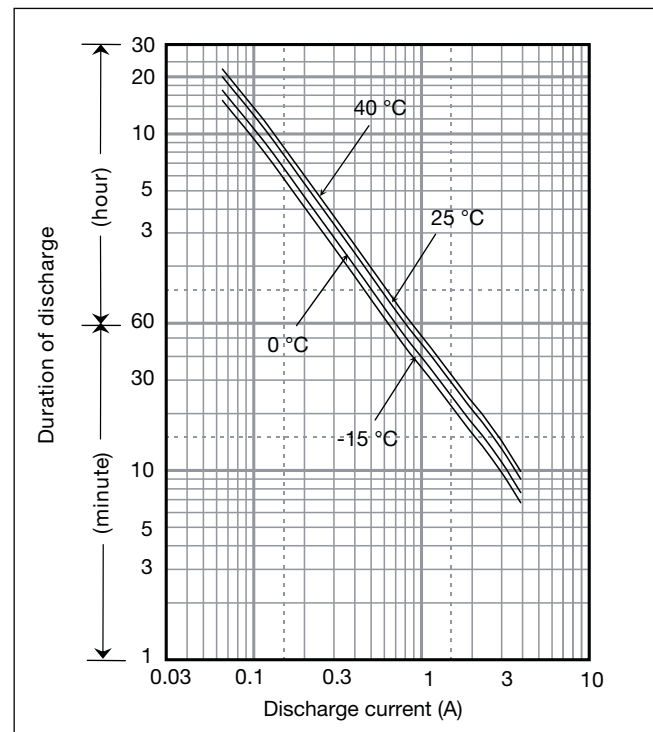
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	1.3Ah	
Dimensions	Length	97mm
	Width	24mm
	Height	50mm
	Total Height	55mm
Approx. mass	0.3kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	1.3Ah 1.2Ah 1.05Ah 0.85Ah
Internal resistance	Fully charged battery (25°C)	50mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
4.8V	39.1	30.8	20.1	15.4	12.9	9.61	6.78	5.42	3.73	2.89	2.15	1.65	1.36	1.10	0.726	0.393	0.328							
4.95V	36.2	28.9	19.7	15.3	12.7	9.51	6.74	5.42	3.66	2.86	2.14	1.64	1.35	1.09	0.723	0.392	0.327							
5.1V	33.4	27.1	19.2	15.0	12.5	9.40	6.68	5.32	3.58	2.79	2.12	1.63	1.34	1.08	0.715	0.391	0.326							
5.25V	29.7	24.3	17.8	13.9	11.8	9.19	6.57	5.21	3.51	2.69	2.08	1.62	1.33	1.07	0.712	0.390	0.325							
5.4V	25.1	21.4	15.9	13.0	11.5	8.87	6.47	5.10	3.41	2.57	2.04	1.60	1.30	1.05	0.704	0.388	0.323							

Ampere Table

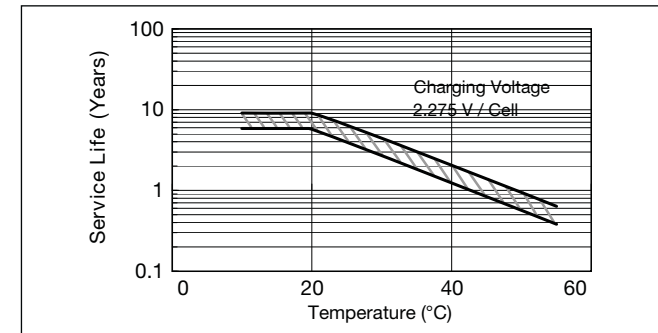
Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
4.8V	7.02	5.53	3.59	2.67	2.22	1.64	1.16	0.921	0.632	0.488	0.361	0.276	0.228	0.183	0.121	0.0655	0.0547							
4.95V	6.52	5.18	3.52	2.65	2.18	1.63	1.15	0.921	0.619	0.484	0.359	0.274	0.226	0.182	0.120	0.0654	0.0545							
5.1V	6.01	4.86	3.43	2.60	2.15	1.61	1.14	0.903	0.607	0.471	0.356	0.273	0.224	0.181	0.119	0.0652	0.0543							
5.25V	5.34	4.35	3.18	2.42	2.04	1.57	1.12	0.885	0.594	0.455	0.350	0.271	0.222	0.178	0.119	0.0650	0.0542							
5.4V	4.51	3.85	2.83	2.26	1.99	1.52	1.10	0.867	0.578	0.433	0.343	0.267	0.217	0.176	0.117	0.0646	0.0538							

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

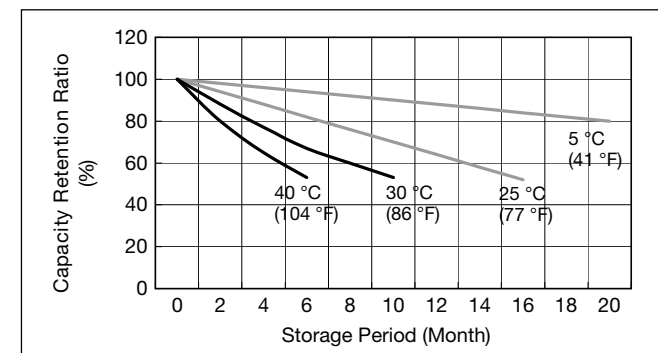
Charging Method

Cycle use	Control voltage: 7.25 - 7.45V; Initial current: 0.52A or smaller
Trickle use	Control voltage: 6.8 - 6.9V; Initial current: 0.195A or smaller

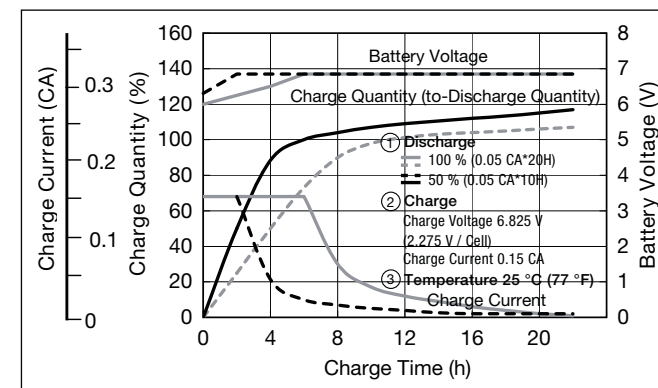
Influence of Temperature on Trickle life



Residual capacity vs storage period



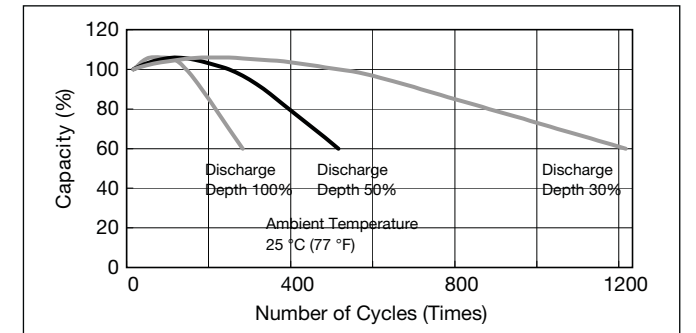
Constant-voltage and constant-current charge characteristics for Trickle use



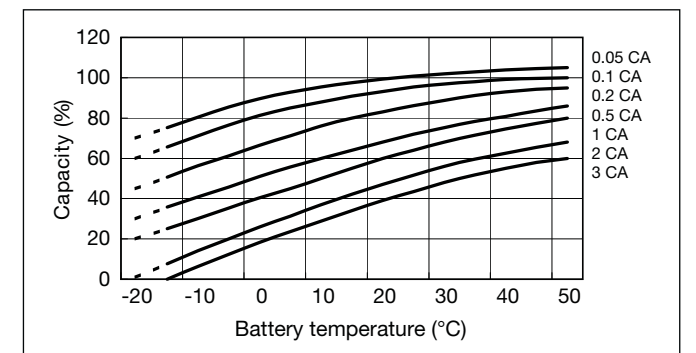
Cut off voltage

Discharge current	0.065A - 0.26A	0.26A - 0.65A	0.65A - 1.3A	1.3A - 2.6A	2.6A - 3.9A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

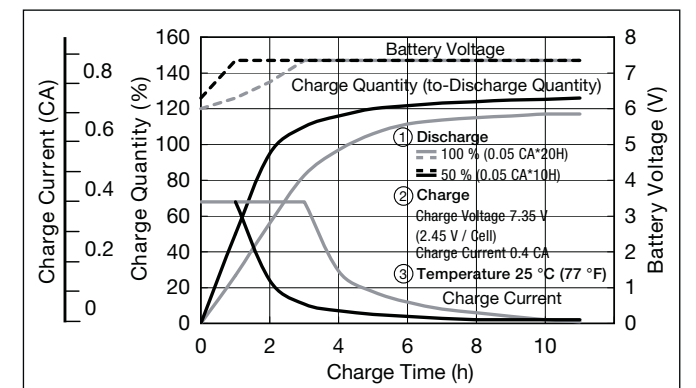
Cycle life vs Depth of discharge



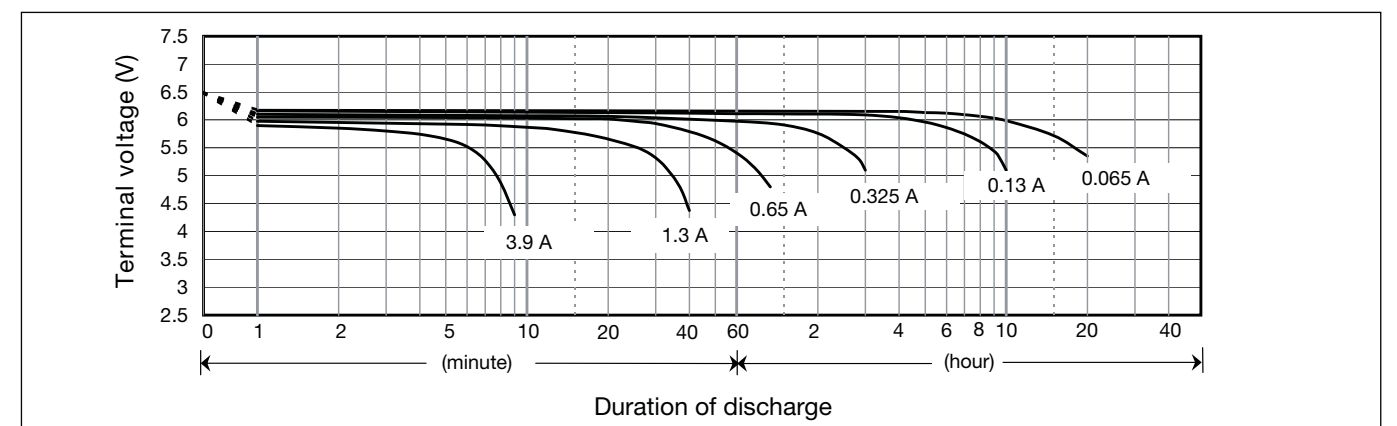
Discharge capacity by temperature and by discharge current



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics

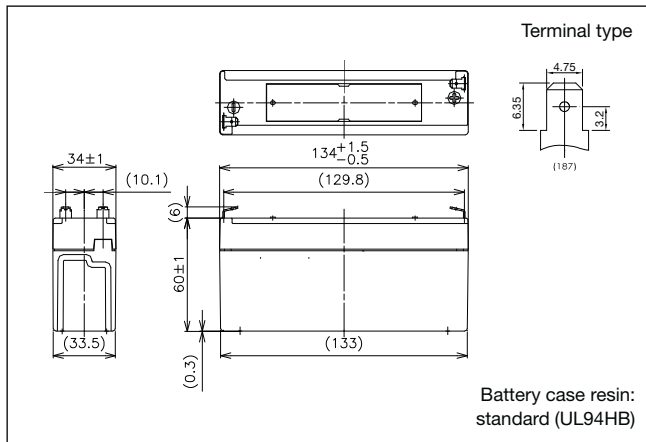


LC-R063R4P*1



For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

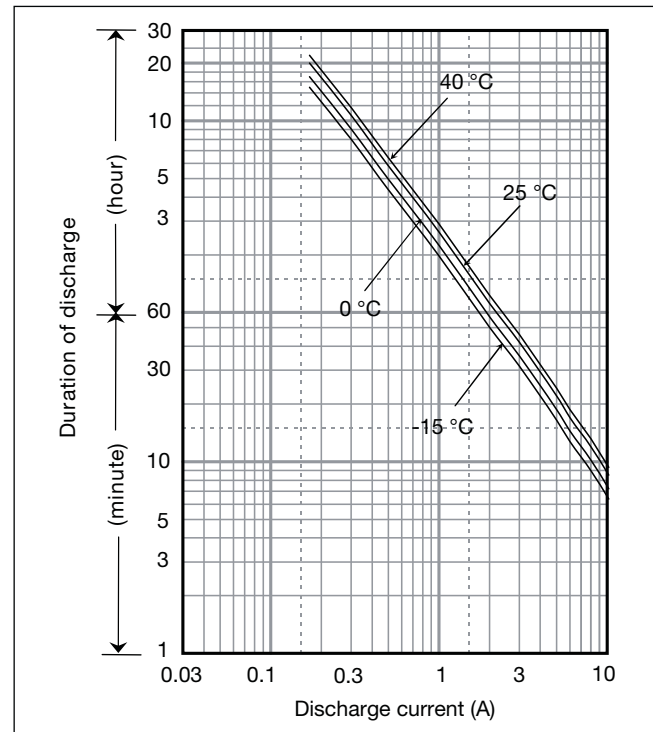
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	3.4Ah	
Dimensions	Length	134mm
	Width	34mm
	Height	60mm
	Total Height	66mm
Approx. mass	0.62kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	3.4Ah
	10 hour rate	3.0Ah
	5 hour rate	2.7Ah
	1 hour rate	2.1Ah
Internal resistance	Fully charged battery (25°C)	30mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
4.8V	102	80.6	52.6	40.2	33.7	25.1	17.7	14.2	9.76	7.55	5.62	4.32	3.56	2.86	1.90	1.03	0.858							
4.95V	94.8	75.6	51.6	39.9	33.1	24.9	17.6	14.2	9.56	7.49	5.59	4.29	3.54	2.85	1.89	1.03	0.856							
5.1V	87.4	70.8	50.2	39.1	32.6	24.6	17.5	13.9	9.37	7.30	5.54	4.26	3.51	2.83	1.87	1.02	0.853							
5.25V	77.7	63.4	46.5	36.4	30.9	24.0	17.2	13.6	9.17	7.04	5.45	4.23	3.48	2.80	1.86	1.02	0.850							
5.4V	65.6	56.1	41.5	33.9	30.1	23.2	16.9	13.4	8.92	6.71	5.34	4.18	3.39	2.75	1.84	1.01	0.844							

Ampere Table

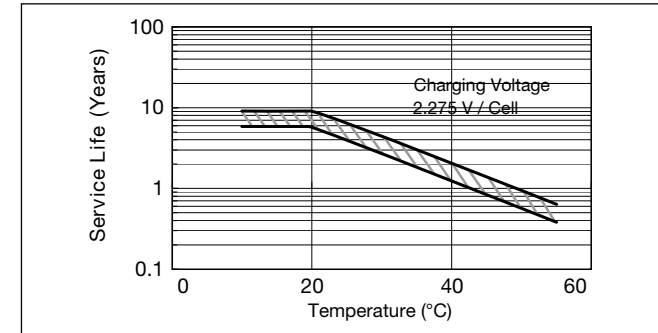
Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
4.8V	18.4	14.4	9.40	6.99	5.81	4.30	3.02	2.41	1.65	1.27	0.944	0.722	0.595	0.478	0.316	0.171	0.143							
4.95V	17.0	13.6	9.21	6.94	5.71	4.25	3.00	2.41	1.62	1.27	0.940	0.718	0.590	0.476	0.315	0.171	0.143							
5.1V	15.7	12.7	8.97	6.80	5.62	4.20	2.97	2.36	1.59	1.23	0.930	0.713	0.586	0.472	0.312	0.170	0.142							
5.25V	14.0	11.4	8.31	6.33	5.34	4.11	2.93	2.31	1.55	1.19	0.916	0.708	0.581	0.467	0.310	0.170	0.142							
5.4V	11.8	10.1	7.41	5.90	5.19	3.97	2.88	2.27	1.51	1.13	0.897	0.699	0.567	0.459	0.307	0.169	0.141							

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Cycle use	Control voltage: 7.25 - 7.45V; Initial current: 1.36A or smaller
Trickle use	Control voltage: 6.8 - 6.9V; Initial current: 0.51A or smaller

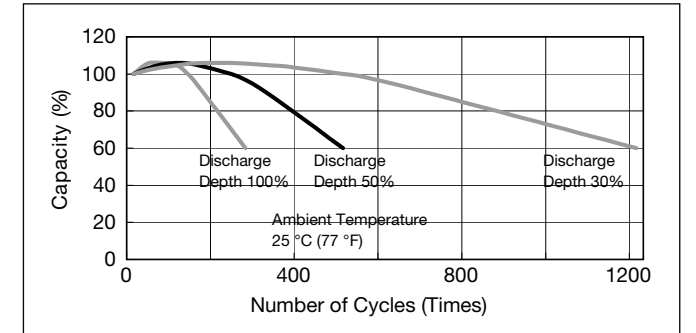
Influence of Temperature on Trickle life



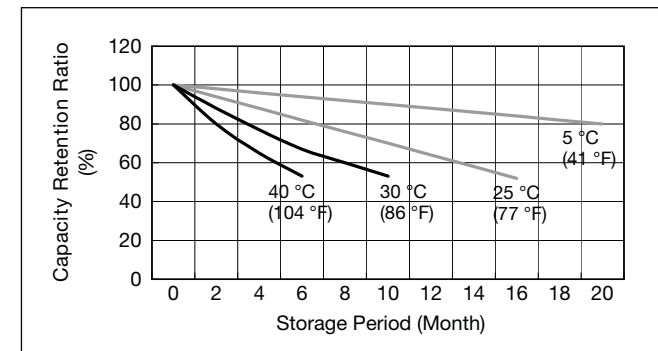
Cut off voltage

Discharge current	0.17A - 0.68A	0.68A - 1.7A	1.7A - 3.4A	3.4A - 6.8A	6.8A - 10.2A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

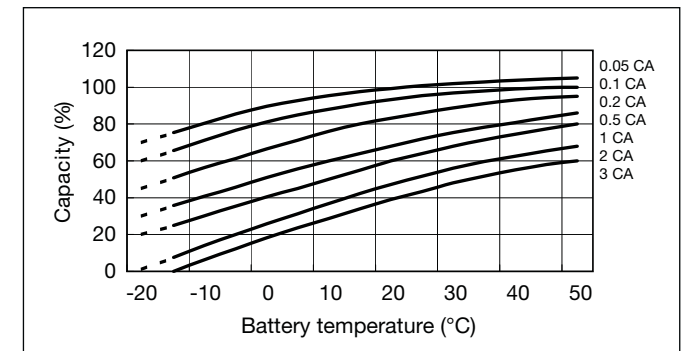
Cycle life vs Depth of discharge



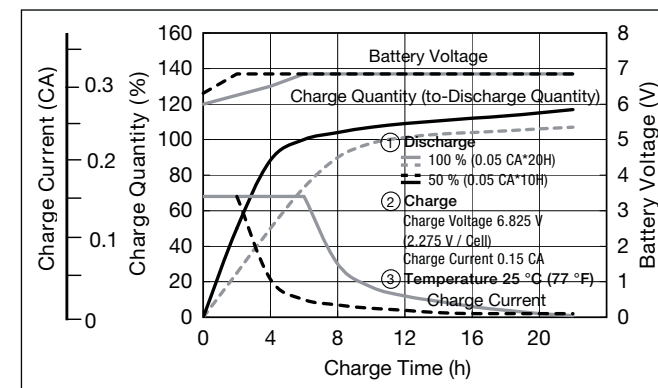
Residual capacity vs storage period



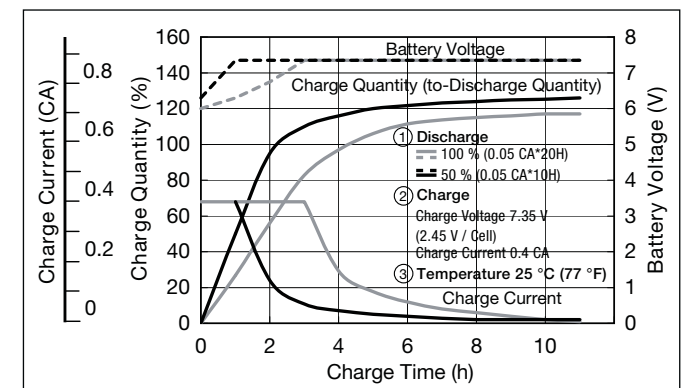
Discharge capacity by temperature and by discharge current



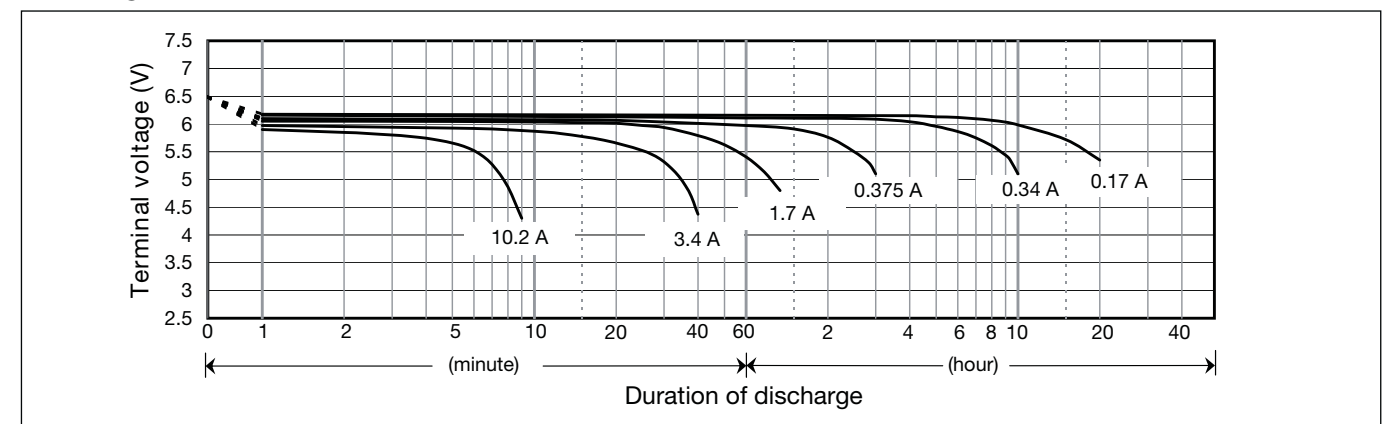
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



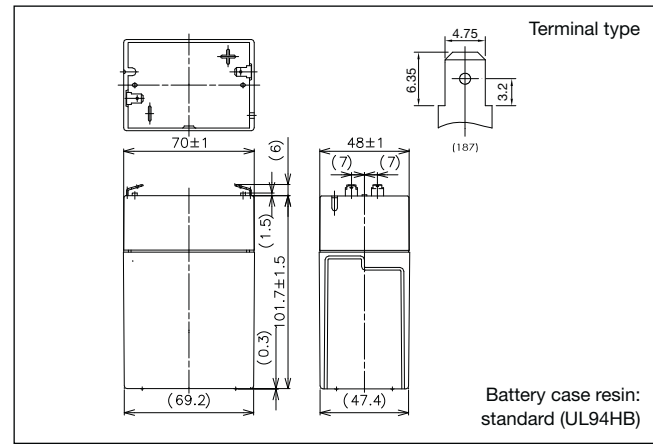
LC-R064R5P*1



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

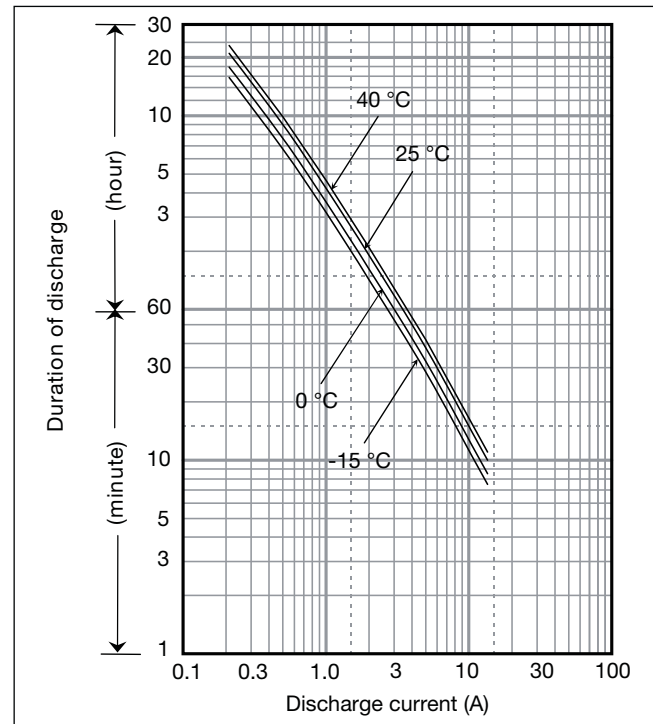
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	4.5Ah	
Dimensions	Length	70mm
	Width	48mm
	Height	102mm
	Total Height	108mm
Approx. mass	0.72kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	4.5Ah
	10 hour rate	4.0Ah
	5 hour rate	3.6Ah
	1 hour rate	2.8Ah
Internal resistance	Fully charged battery (25°C)	20mΩ
	Temperature dependency of capacity (20 hour rate)	40°C: 102%, 25°C: 100%, 0°C: 85%, -15°C: 65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
4.8V	135	107	69.7	53.2	44.6	33.3	23.5	18.8	12.9	9.99	7.44	5.71	4.72	3.79	2.51	1.36	1.136	
4.95V	125	100	68.3	52.8	43.9	32.9	23.3	18.8	12.7	9.92	7.40	5.68	4.68	3.78	2.50	1.36	1.133	
5.1V	116	94	66.5	51.8	43.1	32.5	23.1	18.4	12.4	9.66	7.33	5.64	4.64	3.75	2.48	1.35	1.129	
5.25V	103	84	61.6	48.2	41.0	31.8	22.7	18.0	12.1	9.32	7.21	5.60	4.60	3.70	2.46	1.35	1.125	
5.4V	87	74	55.0	44.9	39.9	30.7	22.4	17.7	11.8	8.88	7.07	5.53	4.49	3.64	2.44	1.34	1.118	

Ampere Table

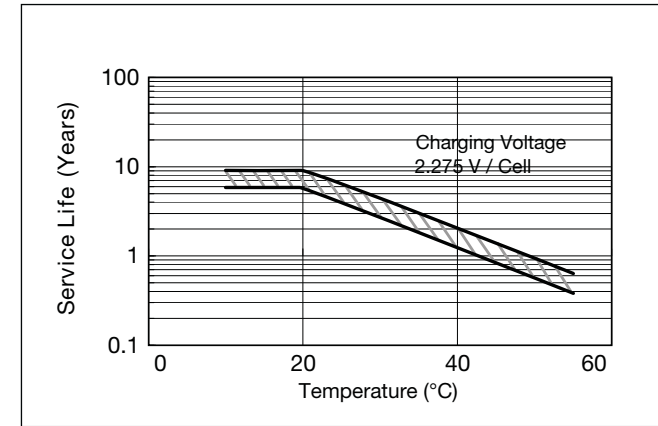
Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
4.8V	24.3	19.13	12.44	9.25	7.69	5.69	4.00	3.19	2.19	1.69	1.25	0.956	0.788	0.633	0.419	0.227	0.189	
4.95V	22.6	17.94	12.19	9.19	7.56	5.63	3.98	3.19	2.14	1.68	1.24	0.950	0.781	0.630	0.417	0.226	0.189	
5.1V	20.8	16.81	11.88	9.00	7.44	5.56	3.94	3.13	2.10	1.63	1.23	0.944	0.775	0.625	0.413	0.226	0.188	
5.25V	18.5	15.06	11.00	8.38	7.06	5.44	3.88	3.06	2.06	1.58	1.21	0.938	0.769	0.618	0.411	0.225	0.188	
5.4V	15.6	13.31	9.81	7.81	6.88	5.25	3.81	3.00	2.00	1.50	1.19	0.925	0.750	0.608	0.406	0.224	0.186	

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use	Control voltage: 6.8 - 6.9V; Initial current: 0.675A or smaller
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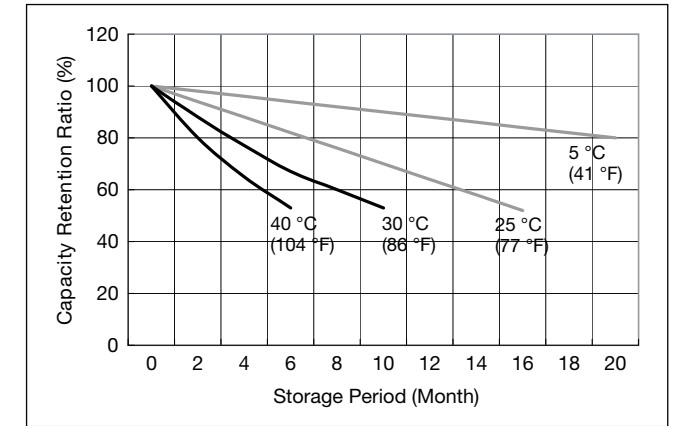
Influence of Temperature on Trickle life



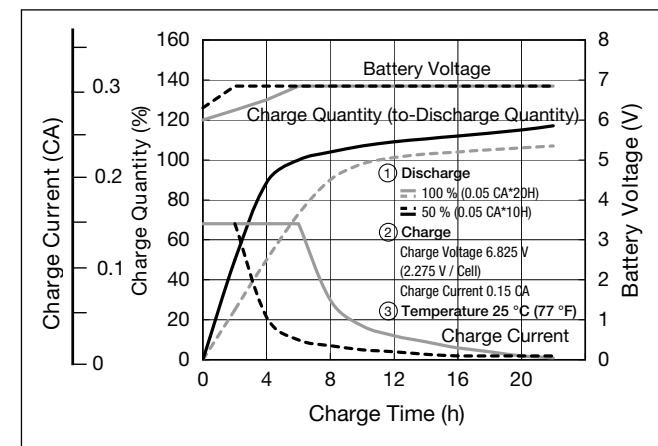
Cut off voltage

Discharge current	0.225 A - 0.9A	0.9A - 2.25A	2.25A - 4.5A	4.5A - 9A	9A - 13.5A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

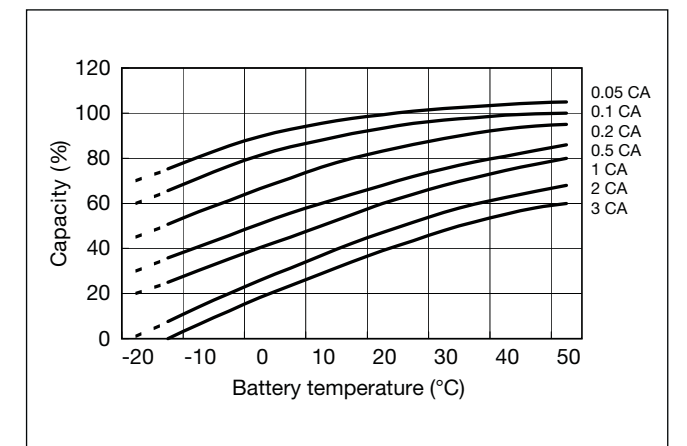
Residual capacity vs storage period



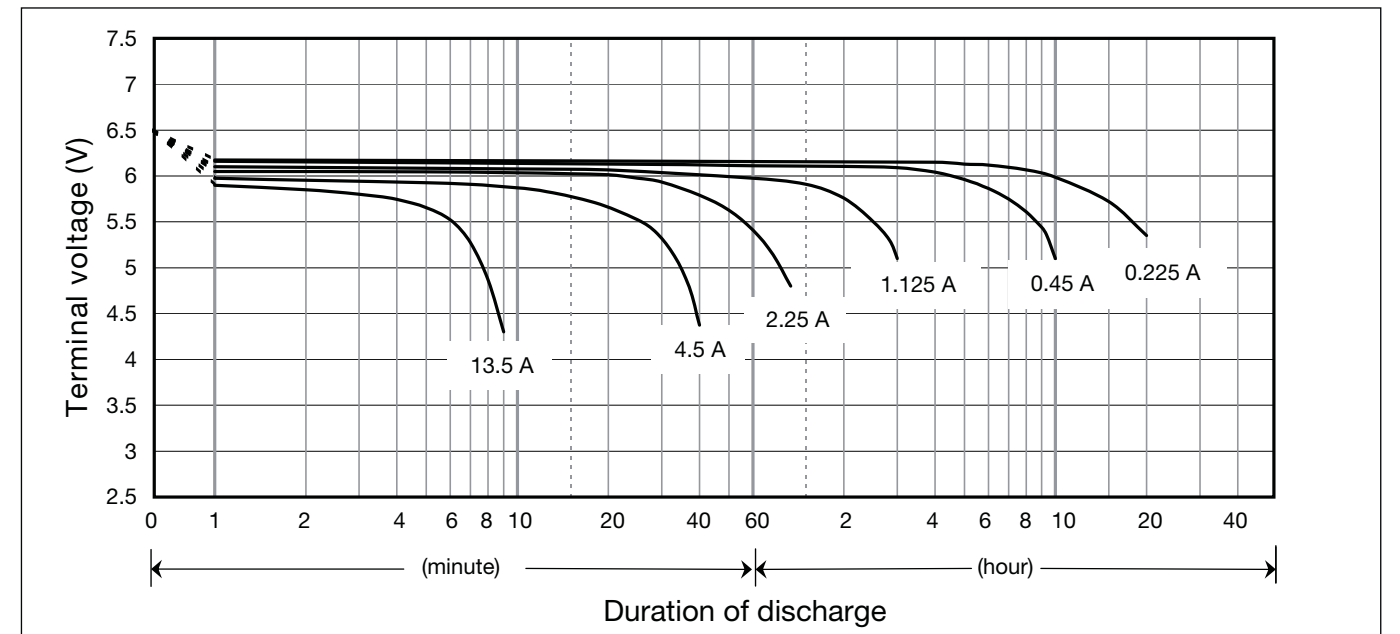
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics



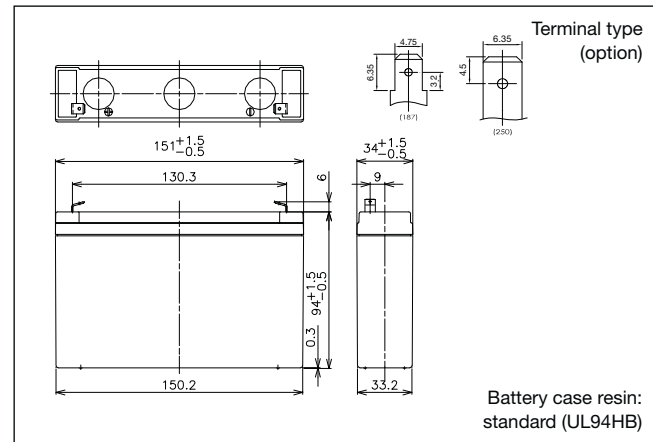
LC-R067R2P*1



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

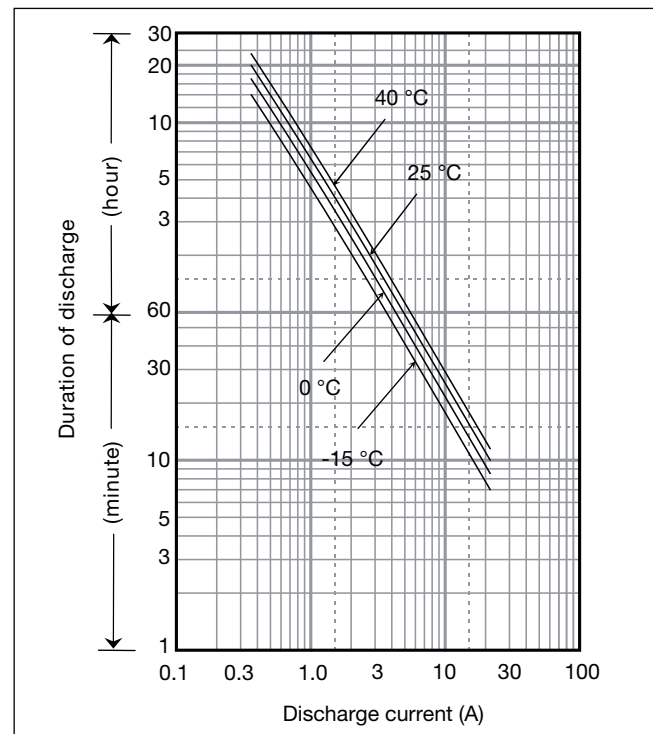
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	7.2Ah	
Dimensions	Length	151mm
	Width	34mm
	Height	94mm
	Total Height	100mm
Approx. mass	1.26kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	7.2Ah 6.8Ah 6.3Ah 4.9Ah
Internal resistance	Fully charged battery (25°C)	11mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	216	171	111	85.1	71.3	53.2	37.6	30.0	20.7	16.0	11.9	9.14	7.55	6.07	4.02	2.18	1.82
4.95V	201	160	109	84.5	70.2	52.7	37.3	30.0	20.3	15.9	11.8	9.08	7.49	6.04	4.00	2.17	1.81
5.1V	185	150	106	82.8	69.0	52.1	37.0	29.5	19.8	15.5	11.7	9.02	7.43	6.00	3.96	2.17	1.81
5.25V	165	134	99	77.1	65.5	50.9	36.4	28.9	19.4	14.9	11.5	8.96	7.37	5.92	3.94	2.16	1.80
5.4V	139	119	88	71.9	63.8	49.1	35.8	28.3	18.9	14.2	11.3	8.84	7.19	5.83	3.90	2.15	1.79

Ampere Table

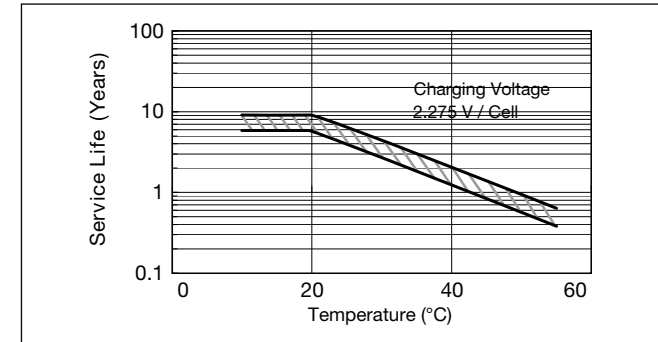
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	38.9	30.6	19.9	14.8	12.3	9.1	6.4	5.1	3.5	2.7	2.00	1.50	1.26	1.00	0.67	0.36	0.30
4.95V	36.1	28.7	18.5	14.8	12.1	9.0	6.4	5.1	3.4	2.6	2.00	1.50	1.25	1.00	0.67	0.36	0.30
5.1V	33.3	26.9	19.0	14.4	11.9	8.9	6.3	5.0	3.3	2.5	1.95	1.50	1.24	1.00	0.66	0.36	0.30
5.25V	29.6	24.1	17.6	13.4	11.3	8.7	6.2	4.9	3.3	2.5	1.95	1.50	1.23	1.00	0.66	0.36	0.30
5.4V	25.0	21.3	15.7	12.5	11.0	8.4	6.1	4.8	3.2	2.4	1.90	1.50	1.20	1.00	0.65	0.35	0.30

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

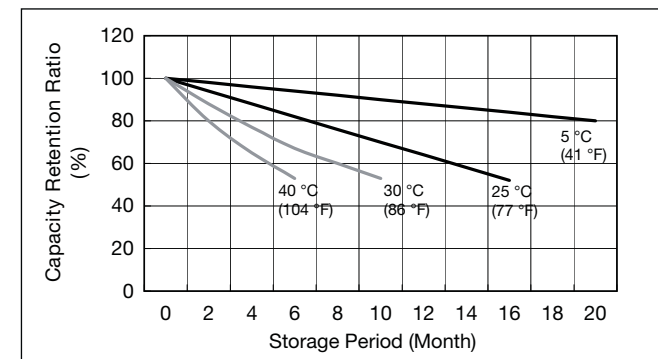
Charging Method

Cycle Use	Control voltage: 7.25 - 7.45V; Initial current: 2.88A or smaller
Trickle Use	Control voltage: 6.8 - 6.9V; Initial current: 1.08A or smaller

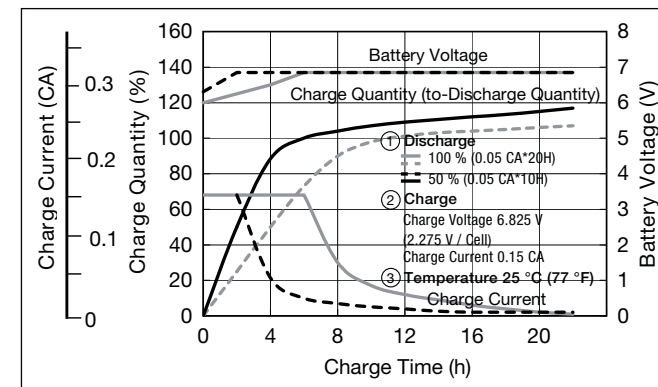
Influence of Temperature on Trickle life



Residual capacity vs storage period



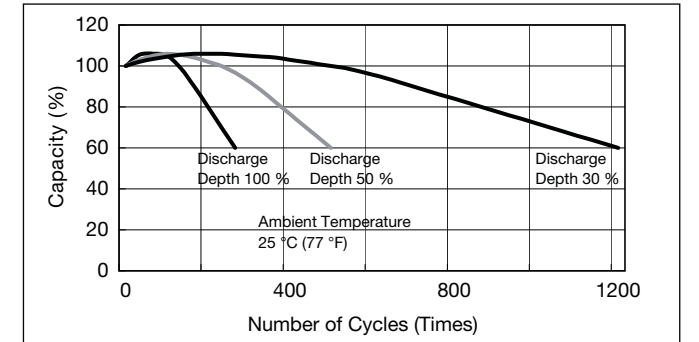
Constant-voltage and constant-current charge characteristics for Trickle use



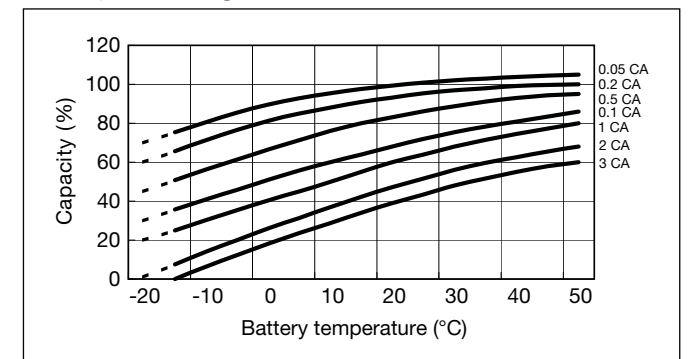
Cut off voltage

Discharge current	0.36A - 1.44A	1.44A - 3.6A	3.6A - 7.2A	7.2A - 14.4A	14.4A - 21.6A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

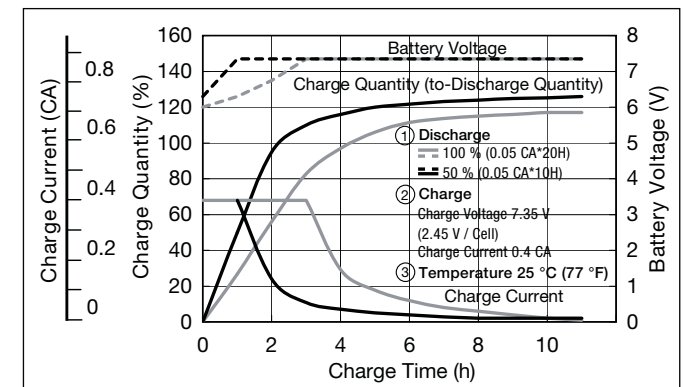
Cycle life vs Depth of discharge



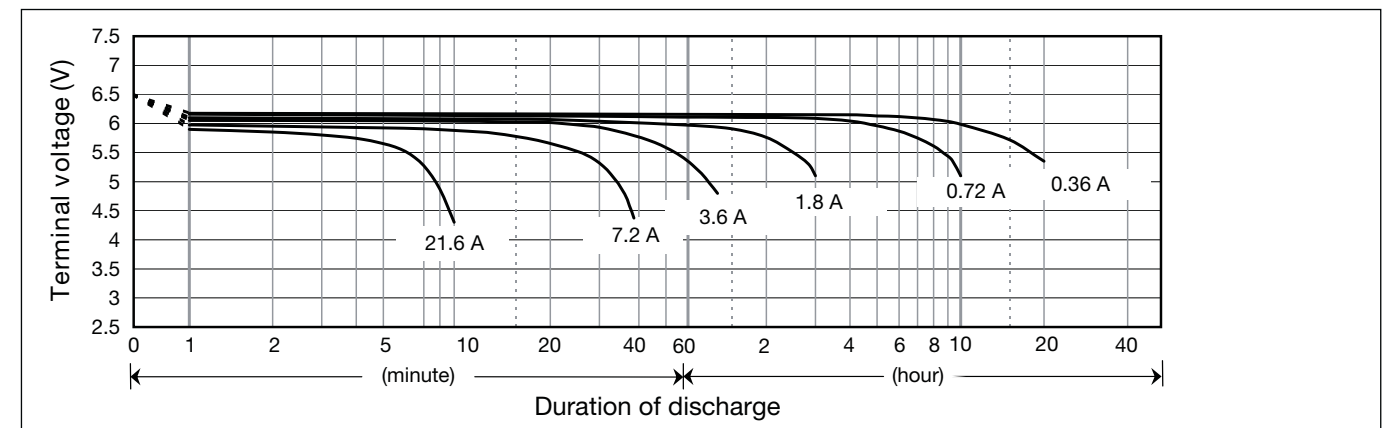
Discharge capacity by temperature and by discharge current



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics

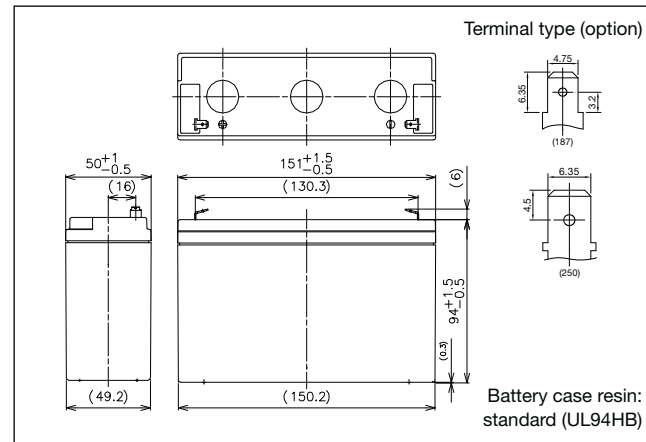


LC-R0612P*1

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.



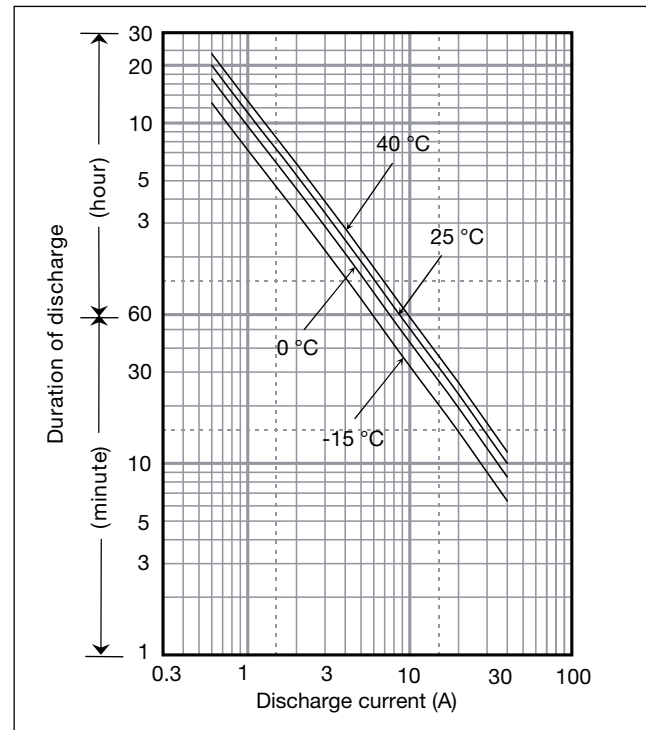
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	12Ah	
Dimensions	Length	151mm
	Width	50mm
	Height	94mm
	Total Height	100mm
Approx. mass	2.00kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	12.0Ah
	10 hour rate	11.3Ah
	5 hour rate	10.4Ah
	1 hour rate	8.1Ah
Internal resistance	Fully charged battery (25°C)	15mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
4.8V	340	279	192	149	124	91.3	68.7	52.4	35.1	27.2	19.0	14.4	12.0	10.9	6.66	3.61	3.01							
4.95V	325	269	186	144	121	88.3	67.5	51.8	35.0	27.1	18.9	14.4	12.0	10.9	6.66	3.61	3.01							
5.1V	304	253	181	141	118	88.3	66.9	51.2	34.5	26.9	18.7	14.4	12.0	10.8	6.60	3.61	3.01							
5.25V	278	237	171	136	115	86.0	66.3	50.1	34.2	26.6	18.4	14.3	12.0	10.8	6.60	3.60	3.00							
5.4V	247	217	161	131	113	83.1	61.6	48.9	33.1	26.0	18.1	14.2	11.9	10.7	6.54	3.59	2.99							

Ampere Table

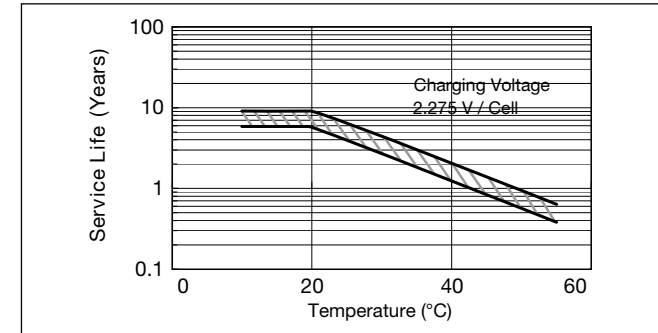
Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
4.8V	61.1	50.1	34.3	25.9	21.3	15.6	11.7	8.90	5.95	4.60	3.20	2.41	2.01	1.81	1.11	0.602	0.502							
4.95V	58.4	48.2	33.3	25.0	20.8	15.1	11.5	8.80	5.92	4.58	3.18	2.41	2.01	1.81	1.11	0.602	0.502							
5.1V	54.6	45.4	32.4	24.5	20.3	15.1	11.4	8.70	5.85	4.55	3.15	2.41	2.00	1.80	1.10	0.601	0.501							
5.25V	50.0	42.6	30.6	23.6	19.9	14.7	11.3	8.50	5.80	4.50	3.10	2.40	2.00	1.80	1.10	0.600	0.500							
5.4V	44.5	38.9	28.7	22.7	19.4	14.2	10.5	8.30	5.60	4.40	3.05	2.38	1.99	1.79	1.09	0.598	0.498							

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Cycle use	Control voltage: 7.25 - 7.45V; Initial current: 4.8A or smaller
Trickle use	Control voltage: 6.8 - 6.9V; Initial current: 1.8A or smaller

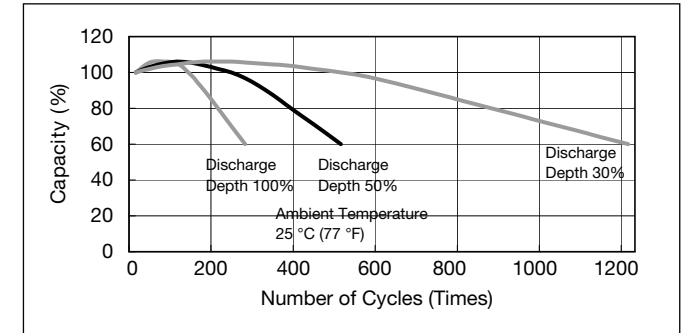
Influence of Temperature on Trickle life



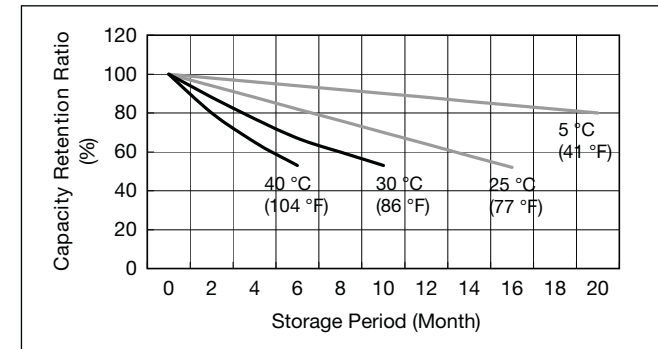
Cut off voltage

Discharge current	0.6A - 2.4A	2.4A - 6A	6A - 12A	12A - 24A	24A - 36A
Cut off voltage (V)	5.25	5.1	4.95	5.65	4.35

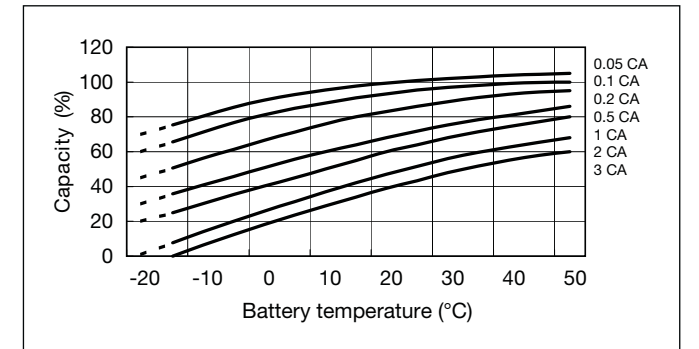
Cycle life vs Depth of discharge



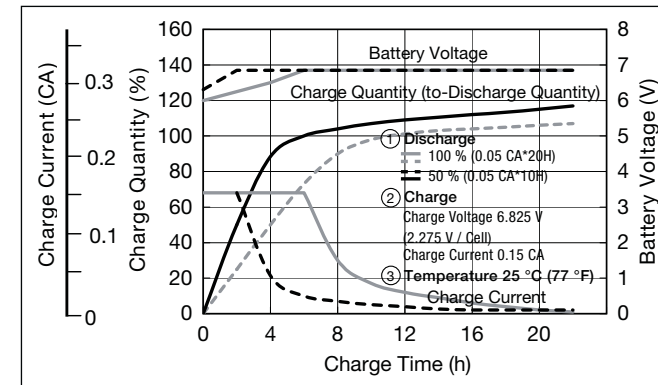
Residual capacity vs storage period



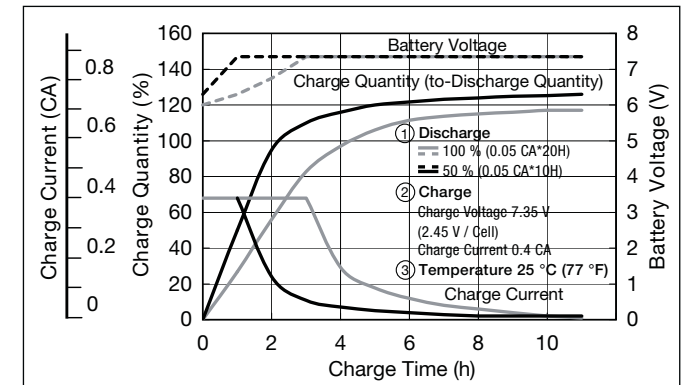
Discharge capacity by temperature and by discharge current



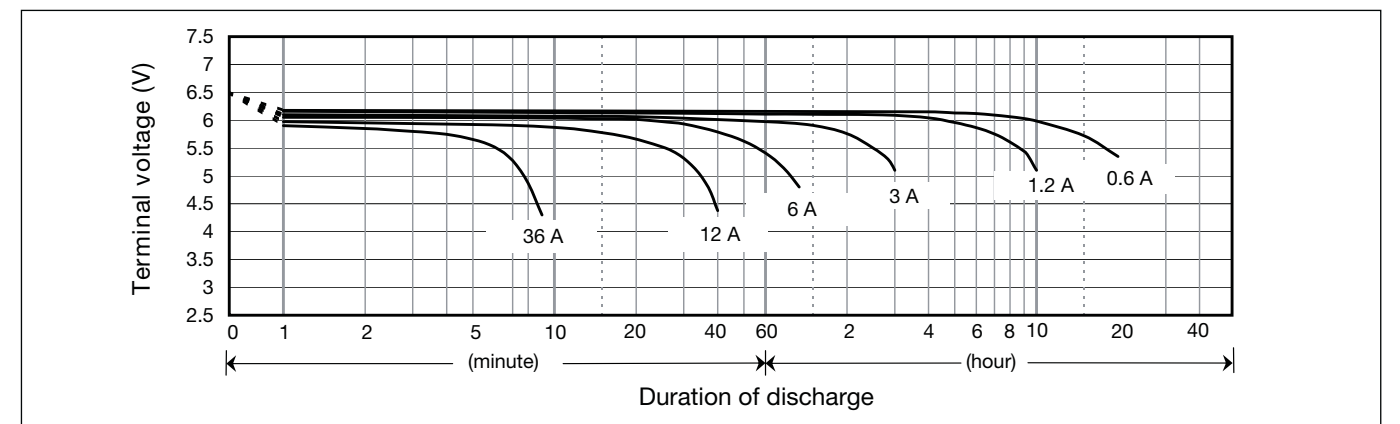
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics

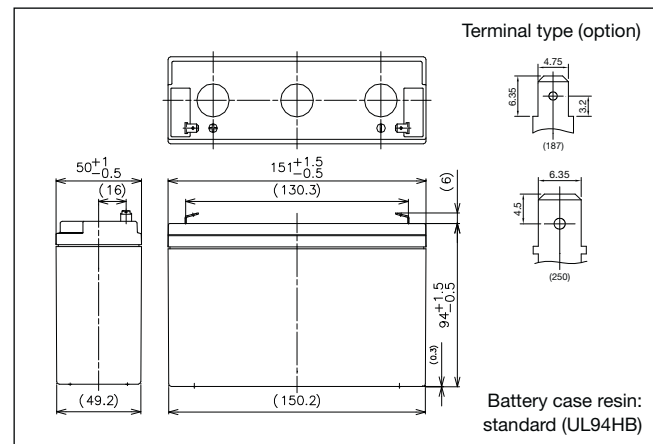


LC-R0615P



For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

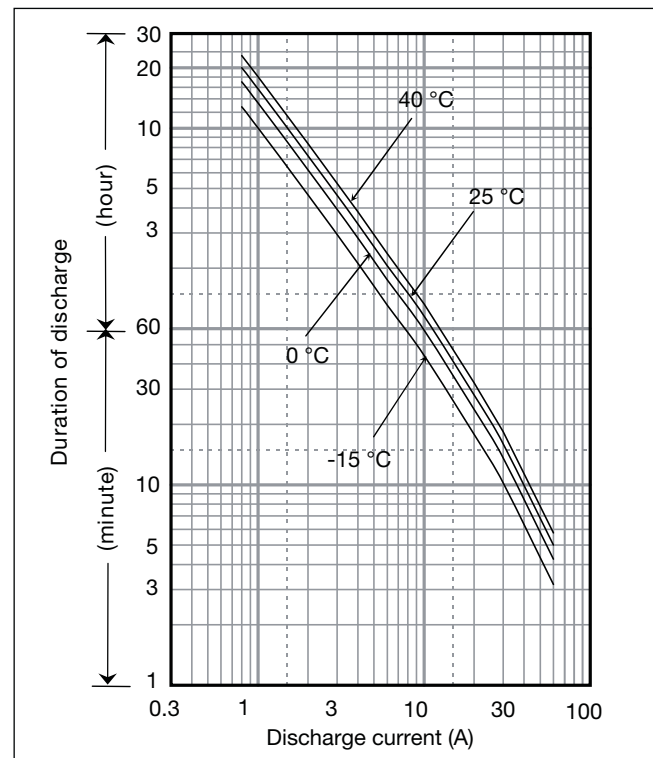
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	15Ah	
Dimensions	Length	151mm
	Width	50mm
	Height	94mm
	Total Height	100mm
Approx. mass	2.10kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	12.0Ah
	10 hour rate	11.3Ah
	5 hour rate	10.4Ah
Internal resistance	Fully charged battery (25°C)	15mΩ
	1 hour rate	8.1Ah
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	425	341	228	175	146	108	78.7	61.7	42.0	32.5	23.6	18.0	14.9	12.6	8.08	4.38	3.65
4.95V	399	323	222	172	143	106	77.8	61.4	41.4	32.3	23.4	17.9	14.9	12.6	8.05	4.37	3.65
5.1V	370	304	216	168	140	106	77.1	60.4	40.7	31.7	23.2	17.9	14.8	12.5	7.97	4.36	3.64
5.25V	333	277	202	159	135	103	76.1	59.1	40.1	30.9	22.8	17.8	14.7	12.4	7.95	4.35	3.62
5.4V	288	249	184	150	132	100	73.1	57.8	38.8	29.8	22.4	17.5	14.4	12.2	7.87	4.33	3.60

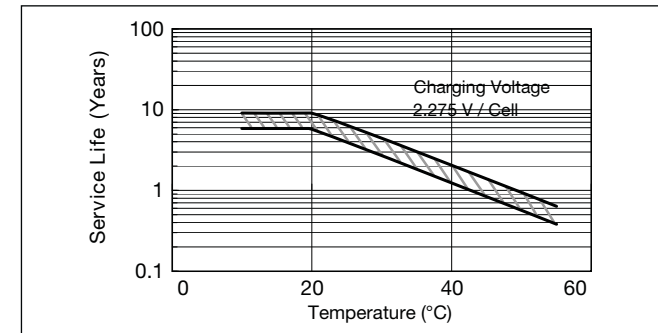
Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	76.5	61.2	40.6	30.4	25.2	18.5	13.4	10.5	7.11	5.49	3.96	3.01	2.49	2.10	1.35	0.730	0.609
4.95V	71.8	58.0	39.7	29.9	24.7	18.2	13.3	10.4	7.01	5.45	3.94	3.00	2.48	2.09	1.34	0.728	0.608
5.1V	66.6	54.5	38.6	29.2	24.2	18.1	13.1	10.3	6.89	5.36	3.90	2.99	2.46	2.08	1.33	0.727	0.606
5.25V	59.9	49.8	36.1	27.6	23.3	17.6	13.0	10.0	6.78	5.22	3.84	2.97	2.45	2.07	1.33	0.725	0.604
5.4V	51.8	44.6	32.9	26.1	22.7	17.0	12.5	9.82	6.58	5.03	3.77	2.94	2.41	2.04	1.31	0.722	0.601

Charging Method

Cycle use	Control voltage: 7.25 - 7.45V; Initial current: 6A or smaller
Trickle use	Control voltage: 6.8 - 6.9V; Initial current: 2.25A or smaller

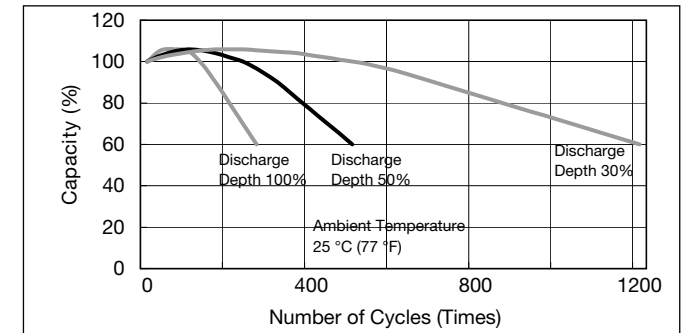
Influence of Temperature on Trickle life



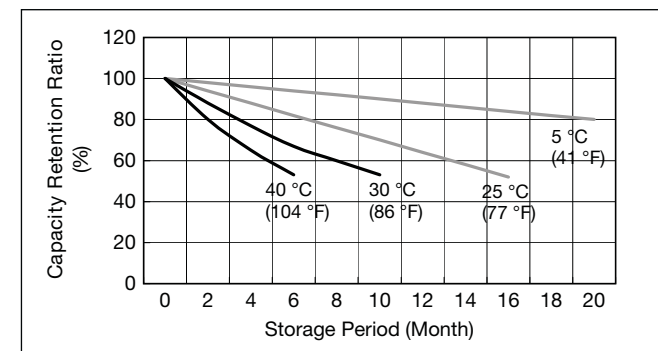
Cut off voltage

Discharge current	0.75A - 3A	3A - 7.5A	7.5A - 15A	15A - 30A	30A - 45A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

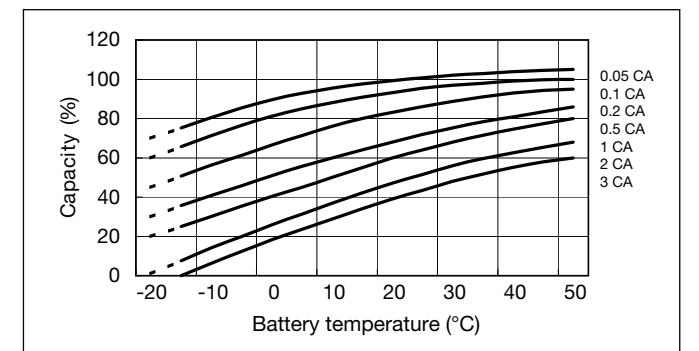
Cycle life vs Depth of discharge



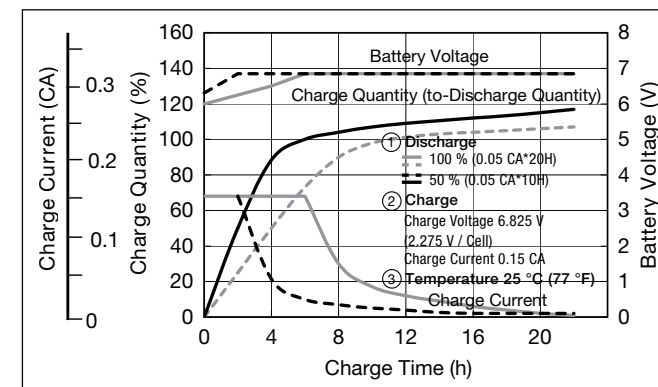
Residual capacity vs storage period



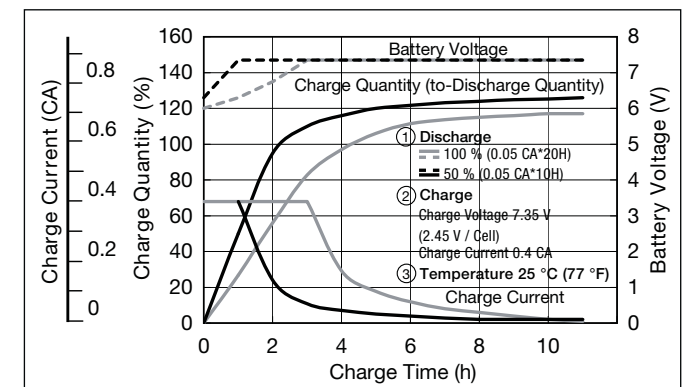
Discharge capacity by temperature and by discharge current



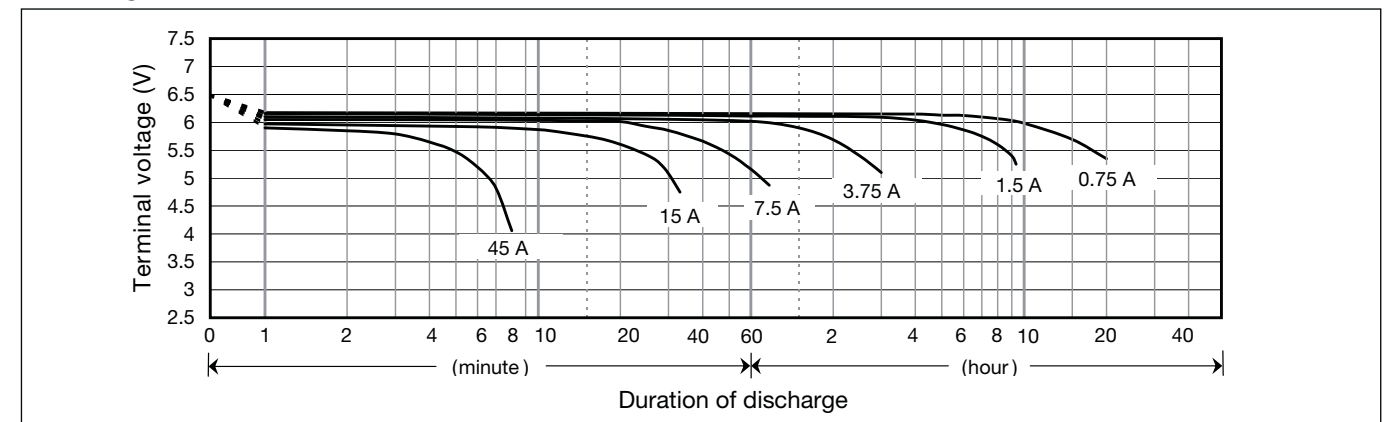
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



LC-R121R3PG

For main and standby power supplies. Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

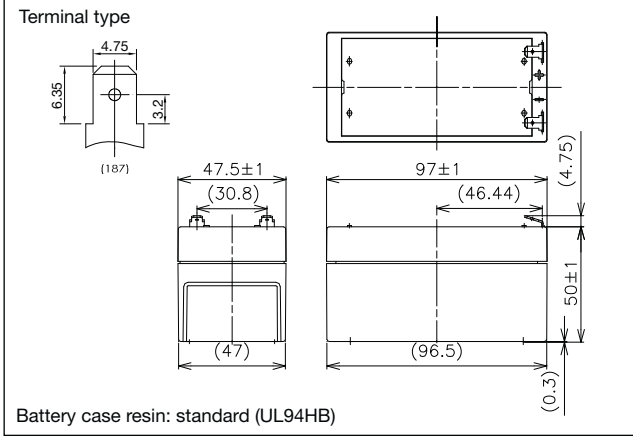
VdS

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Contents indicated (including the recycle marking, etc.) are subject to change without notice.

Dimensions (mm)

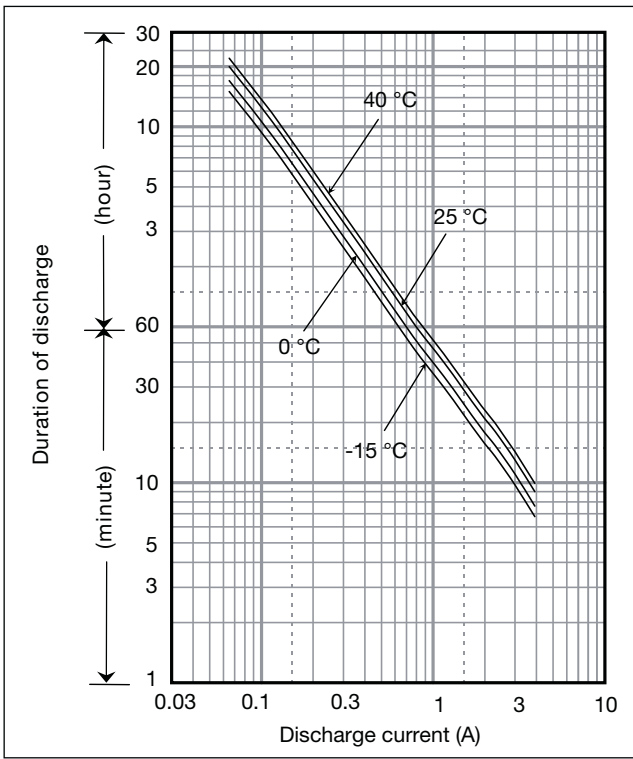


Battery case resin: standard (UL94HB)

Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	1.3Ah	
Dimensions	Length	97mm
	Width	47.5mm
	Height	50mm
	Total Height	55mm
Approx. mass	0.59kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	1.3Ah
	10 hour rate	1.2Ah
	5 hour rate	1.05Ah
	1 hour rate	0.85Ah
Internal resistance	Fully charged battery (25°C)	90mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	78.1	61.6	40.2	30.7	25.8	19.2	13.6	10.8	7.49	5.73	4.32	3.30	2.73	2.22	1.46	0.787	0.657
9.9V	72.5	57.8	39.4	30.5	25.3	19.0	13.5	10.8	7.34	5.68	4.30	3.28	2.70	2.21	1.45	0.784	0.654
10.2V	66.9	54.2	38.4	29.9	24.9	18.8	13.4	10.6	7.19	5.54	4.25	3.26	2.68	2.19	1.44	0.782	0.652
10.5V	59.4	48.5	35.6	27.8	23.7	18.4	13.1	10.4	7.04	5.34	4.19	3.24	2.66	2.16	1.43	0.780	0.650
10.8V	50.2	42.9	31.7	26.0	23.0	17.7	12.9	10.2	6.82	5.13	4.08	3.24	2.60	2.16	1.41	0.758	0.650

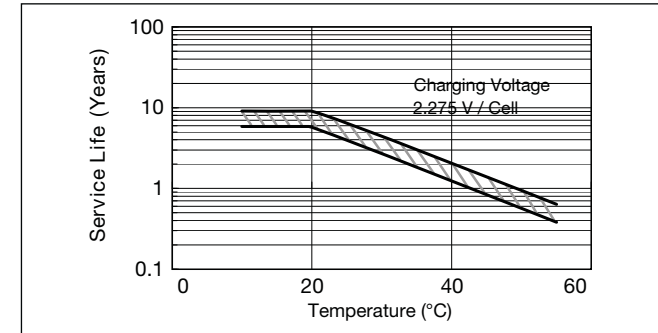
Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	7.02	5.53	3.59	2.67	2.22	1.64	1.16	0.921	0.634	0.484	0.363	0.276	0.228	0.185	0.122	0.0655	0.0655
9.9V	6.52	5.18	3.52	2.65	2.18	1.63	1.15	0.921	0.621	0.480	0.361	0.274	0.226	0.184	0.121	0.0654	0.0545
10.2V	6.01	4.86	3.43	2.60	2.15	1.61	1.14	0.903	0.609	0.468	0.358	0.273	0.224	0.183	0.120	0.0652	0.0543
10.5V	5.34	4.35	3.18	2.42	2.04	1.57	1.12	0.885	0.596	0.451	0.352	0.271	0.222	0.181	0.119	0.0650	0.0542
10.8V	4.51	3.85	2.83	2.26	1.99	1.52	1.10	0.867	0.578	0.433	0.343	0.271	0.217	0.181	0.117	0.0632	0.0542

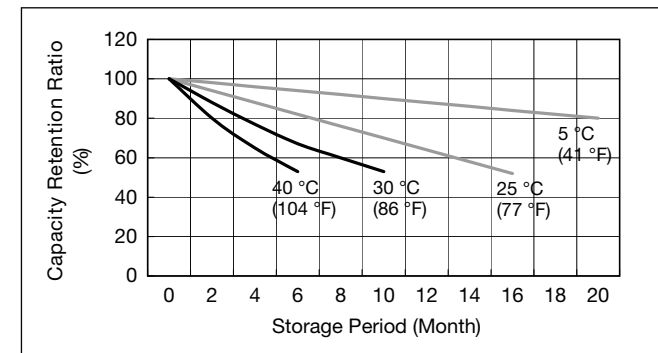
Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current 0.52A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 1.08A or smaller

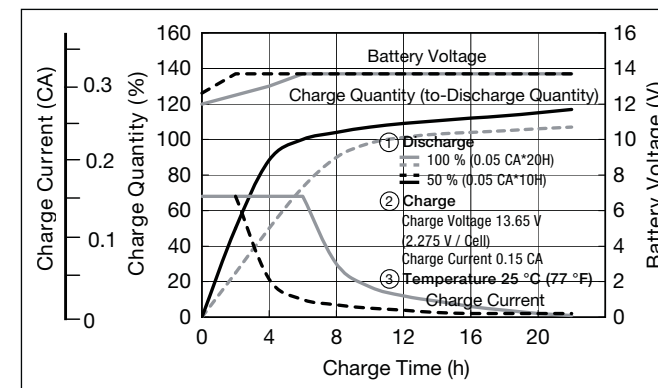
Influence of Temperature on Trickle life



Residual capacity vs storage period



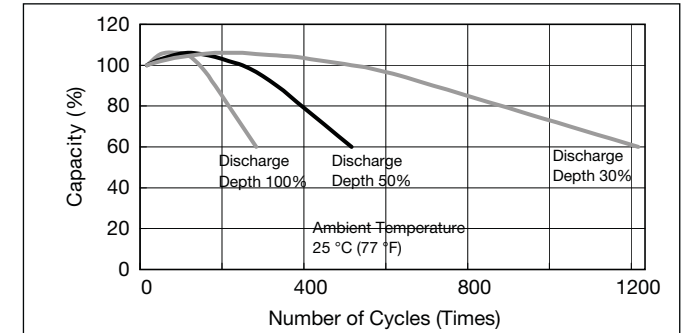
Constant-voltage and constant-current charge characteristics for Trickle use



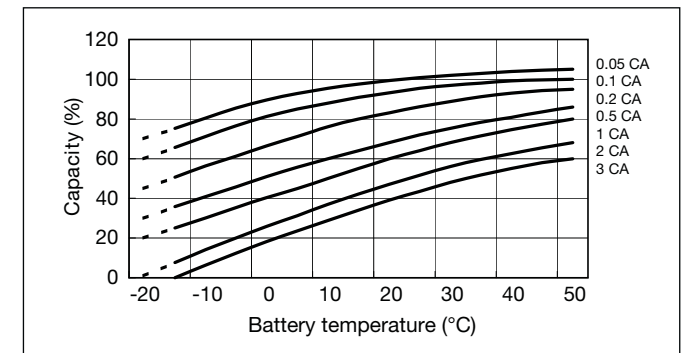
Cut off voltage

Discharge current	0.065 A - 0.26A	0.26A - 0.65A	0.65A - 1.3A	1.3A - 2.6A	2.6A - 3.9A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

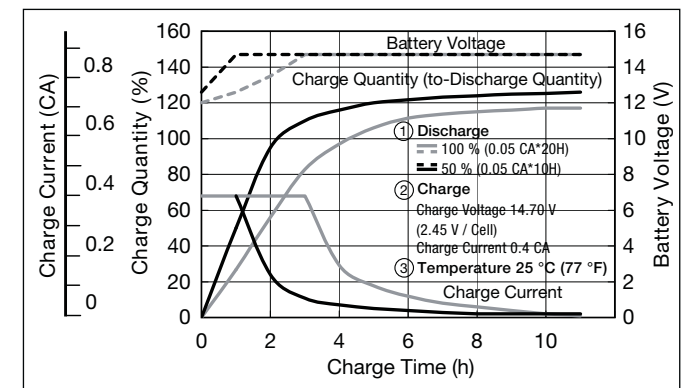
Cycle life vs Depth of discharge



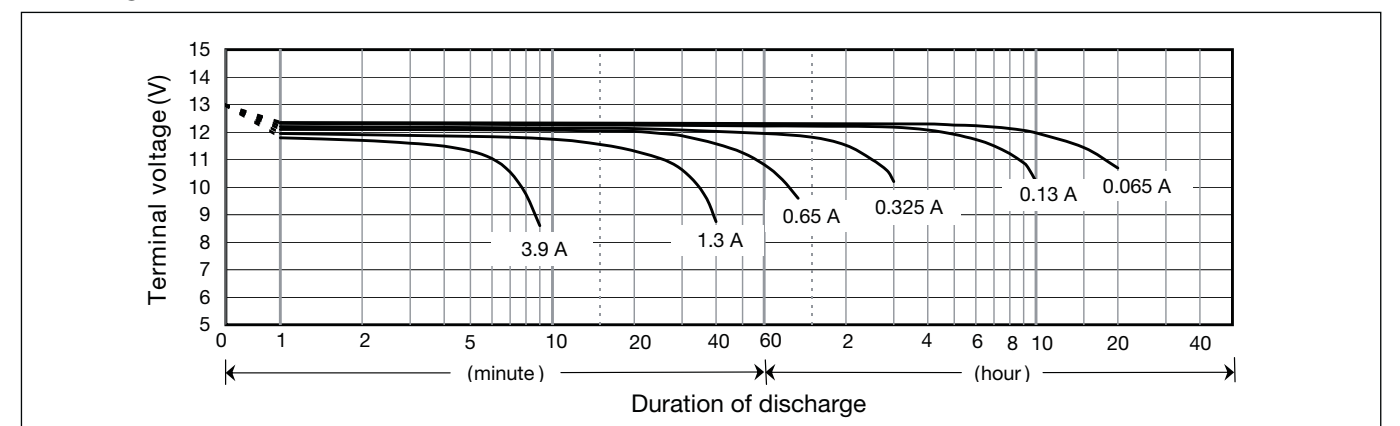
Discharge capacity by temperature and by discharge current



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



LC-R122R2PG

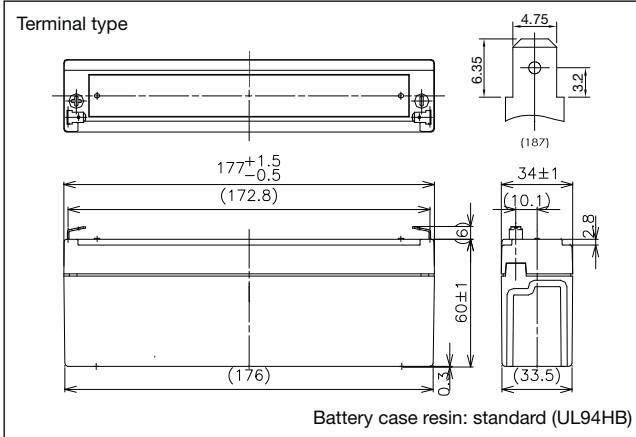
For main and standby power supplies. Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

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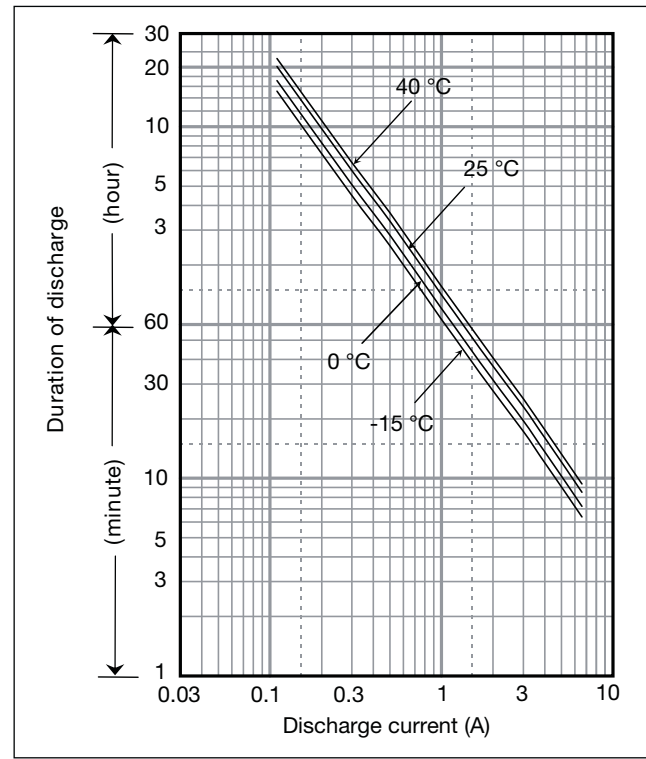
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	2.2Ah	
Dimensions	Length	177mm
	Width	34mm
	Height	60mm
	Total Height	66mm
Approx. mass	0.8kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	2.2Ah
	10 hour rate	2.0Ah
	5 hour rate	1.8Ah
	1 hour rate	1.3Ah
Internal resistance	Fully charged battery (25°C)	70mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

(Wattage/Battery)

Cut-off V	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	132	104	68.1	52.0	43.6	32.5	23.0	18.4	12.6	9.77	7.27	5.59	4.61	3.71	2.46	1.33	1.11
9.9V	123	97.8	66.7	51.7	42.9	32.2	22.8	18.4	12.4	9.70	7.24	5.55	4.58	3.69	2.45	1.33	1.11
10.2V	113	91.6	65.0	50.6	42.2	31.8	22.6	18.0	12.1	9.44	7.16	5.51	4.54	3.66	2.42	1.32	1.10
10.5V	101	82.1	60.2	47.1	40.1	31.1	22.2	17.6	11.9	9.12	7.05	5.48	4.50	3.62	2.41	1.32	1.10
10.8V	85	72.6	53.7	43.9	39.0	30.0	21.9	17.3	11.5	8.68	6.91	5.40	4.39	3.56	2.38	1.31	1.09

Ampere Table

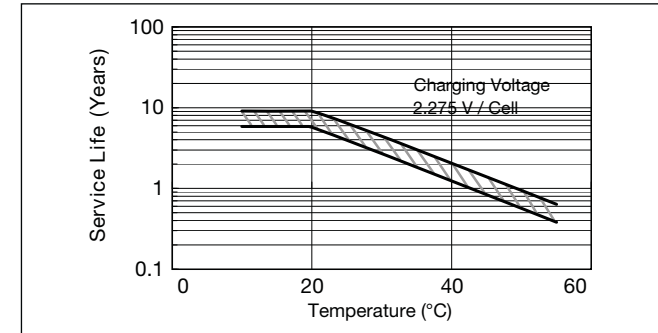
(Ampere/Battery)

Cut-off V	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	11.9	9.35	6.08	4.52	3.76	2.78	1.96	1.56	1.07	0.825	0.611	0.468	0.385	0.309	0.205	0.111	0.0926
9.9V	11.0	8.77	5.96	4.49	3.70	2.75	1.94	1.56	1.05	0.819	0.608	0.464	0.382	0.308	0.204	0.111	0.0923
10.2V	10.2	8.22	5.81	4.40	3.64	2.72	1.93	1.53	1.03	0.798	0.602	0.461	0.379	0.306	0.202	0.110	0.0920
10.5V	9.0	7.36	5.38	4.09	3.45	2.66	1.89	1.50	1.01	0.770	0.593	0.458	0.376	0.302	0.201	0.110	0.0917
10.8V	7.6	6.51	4.80	3.82	3.36	2.57	1.86	1.47	0.98	0.733	0.581	0.452	0.367	0.297	0.199	0.109	0.0911

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 0.88A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 0.33A or smaller

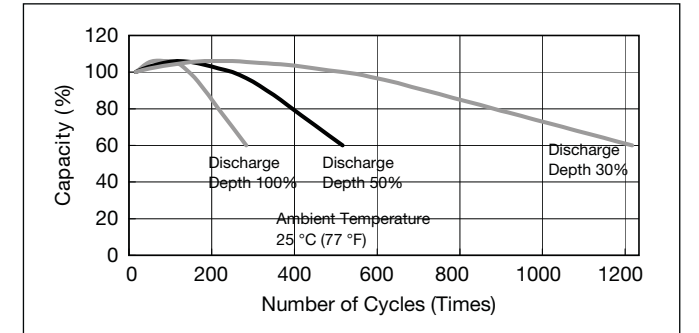
Influence of Temperature on Trickle life



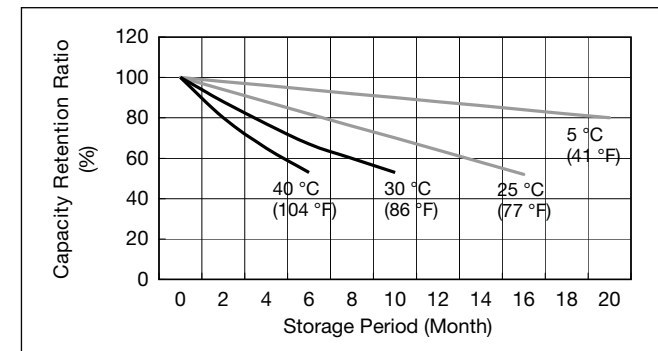
Cut off voltage

Discharge current	0.011 A - 0.44A	0.44A - 1.1A	1.1A - 2.2A	2.2A - 4.4A	4.4A - 6.6A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

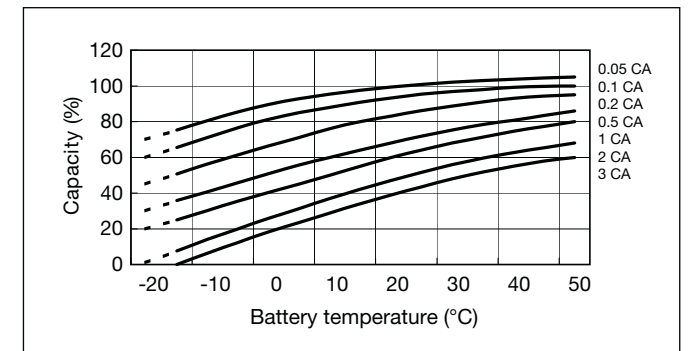
Cycle life vs Depth of discharge



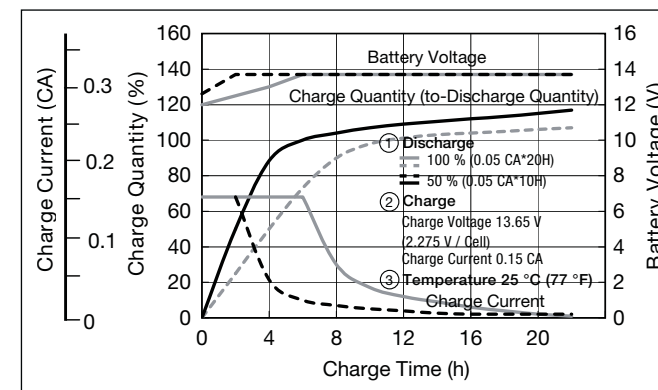
Residual capacity vs storage period



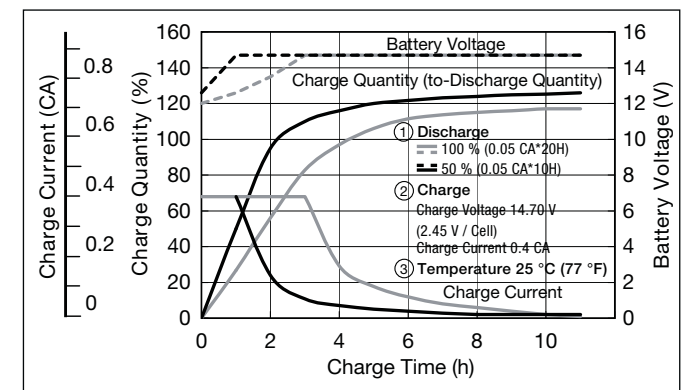
Discharge capacity by temperature and by discharge current



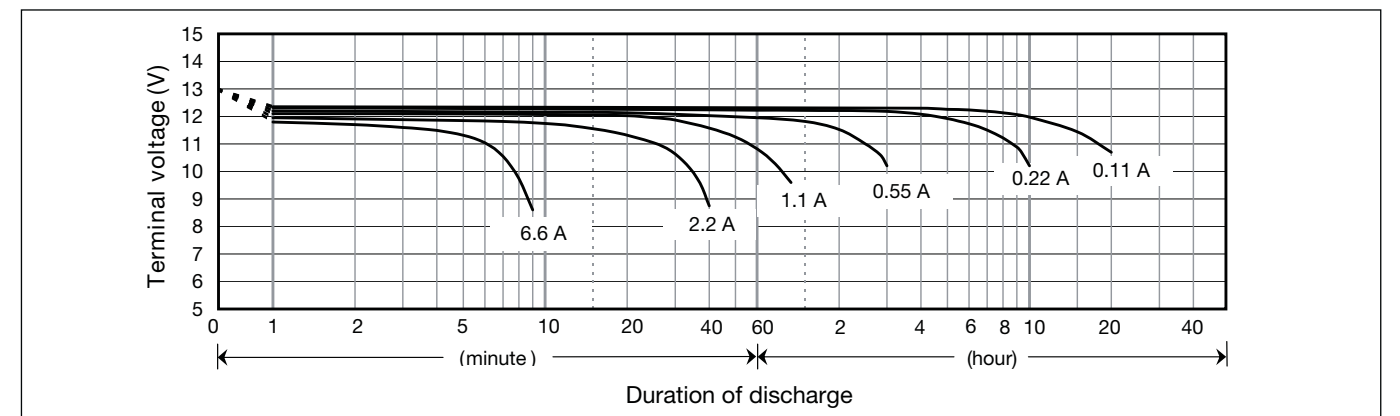
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



LC-R123R4PG

For main and standby power supplies. Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

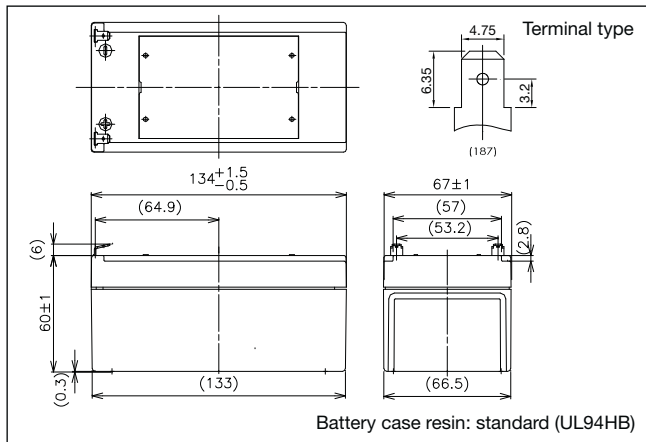
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Contents indicated (including the recycle marking, etc.) are subject to change without notice.

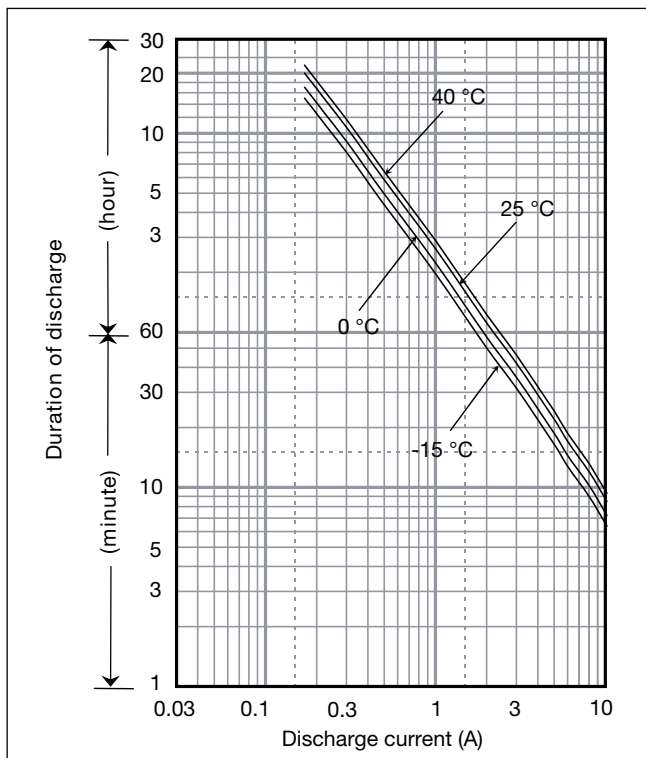
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	3.4Ah	
Dimensions	Length	134mm
	Width	67mm
	Height	60mm
	Total Height	66mm
Approx. mass	1.2kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	3.4Ah
	10 hour rate	3.0Ah
	5 hour rate	2.7Ah
Internal resistance	Fully charged battery (25°C)	60mΩ
	Temperature dependency of capacity (20 hour rate)	40°C: 102% 25°C: 100% 0°C: 85% -15°C: 65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	204	161	105	80.4	67.4	50.3	35.5	28.4	19.6	15.0	11.3	8.63	7.13	5.80	3.81	2.06	1.72
9.9V	190	151	103	79.8	66.3	49.7	35.3	28.4	19.2	14.9	11.2	8.58	7.07	5.78	3.80	2.05	1.71
10.2V	175	142	100	78.2	65.2	49.2	34.9	27.8	18.8	14.5	11.1	8.52	7.01	5.73	3.76	2.05	1.71
10.5V	155	127	93	72.8	61.9	48.1	34.4	27.3	18.4	14.0	11.0	8.46	6.96	5.66	3.74	2.04	1.70
10.8V	131	112	83	67.9	60.3	46.4	33.8	26.7	17.8	13.4	10.7	8.46	6.79	5.66	3.68	1.98	1.70

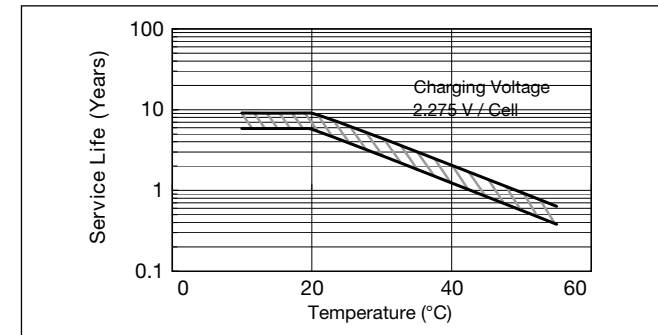
Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	18.4	14.4	9.40	6.99	5.81	4.30	3.02	2.41	1.66	1.26	0.949	0.722	0.595	0.484	0.318	0.171	0.143
9.9V	17.0	13.6	9.21	6.94	5.71	4.25	3.00	2.41	1.62	1.26	0.945	0.718	0.590	0.482	0.316	0.171	0.143
10.2V	15.7	12.7	8.97	6.80	5.62	4.20	2.97	2.36	1.59	1.22	0.935	0.713	0.586	0.478	0.313	0.170	0.142
10.5V	14.0	11.4	8.31	6.33	5.34	4.11	2.93	2.31	1.56	1.18	0.921	0.708	0.581	0.472	0.312	0.170	0.142
10.8V	11.8	10.1	7.41	5.90	5.19	3.97	2.88	2.27	1.51	1.13	0.897	0.708	0.567	0.472	0.307	0.165	0.142

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 1.36A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 0.51A or smaller

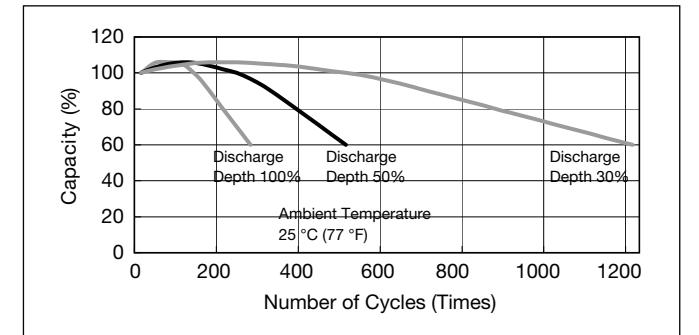
Influence of Temperature on Trickle life



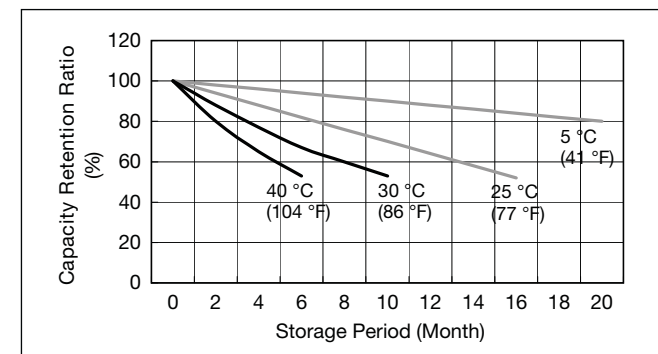
Cut off voltage

Discharge current	0.17A - 0.68A	0.68A - 1.7A	1.7A - 3.4A	3.4A - 6.8A	6.8A - 10.2A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

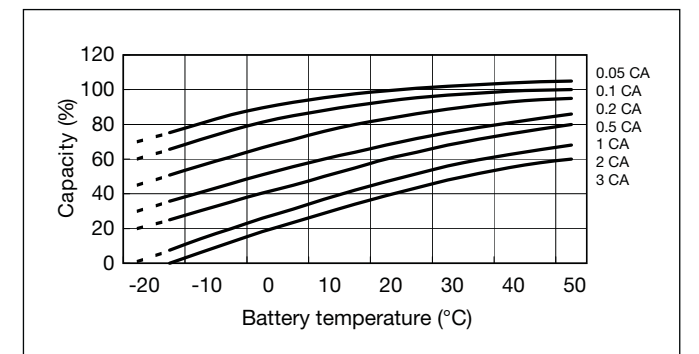
Cycle life vs Depth of discharge



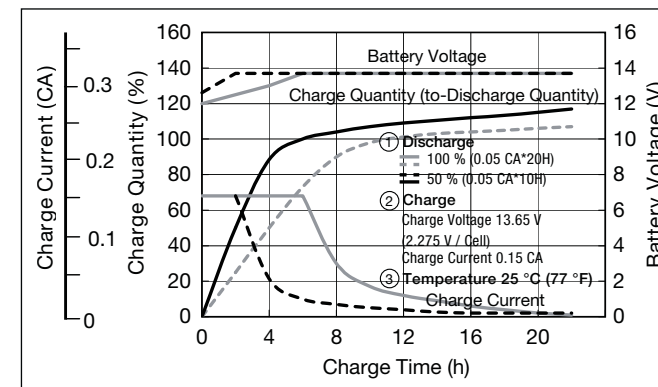
Residual capacity vs storage period



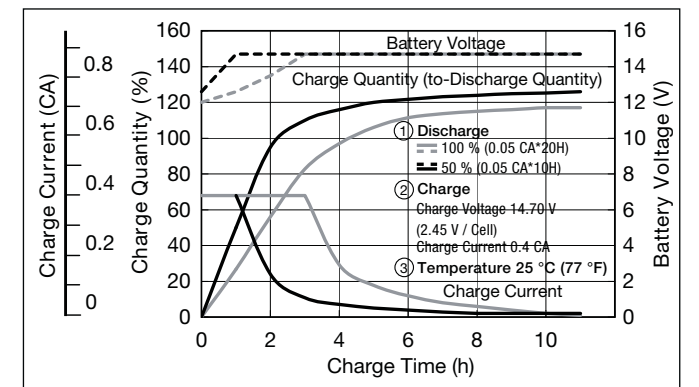
Discharge capacity by temperature and by discharge current



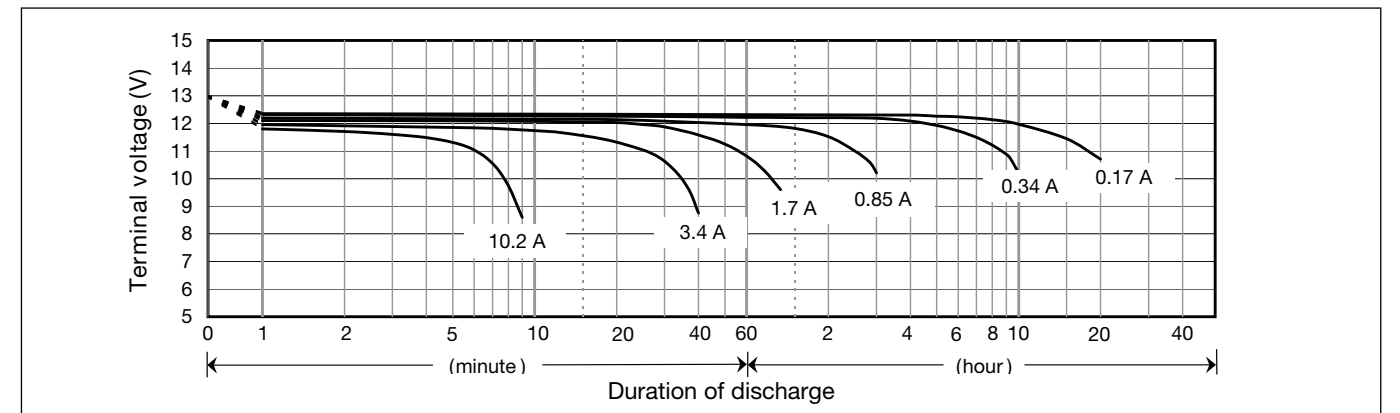
Constant-voltage and constant-current charge characteristics for Trickle use



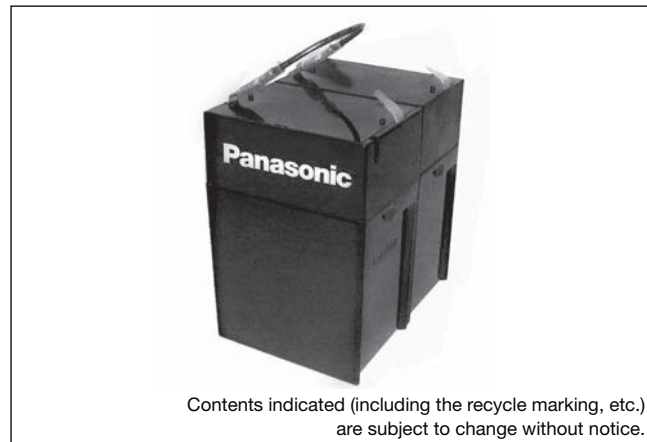
Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



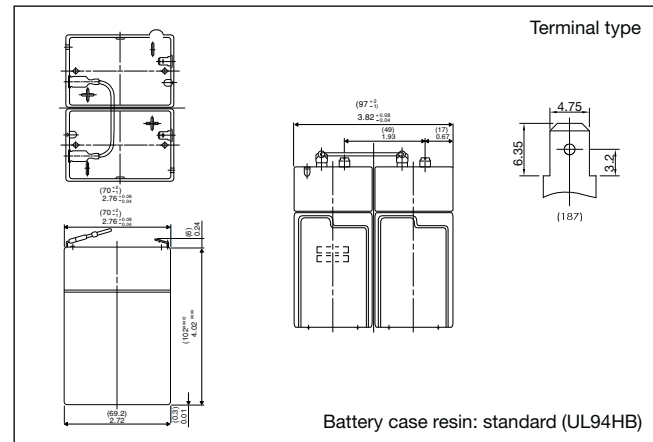
LC-R124R5P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

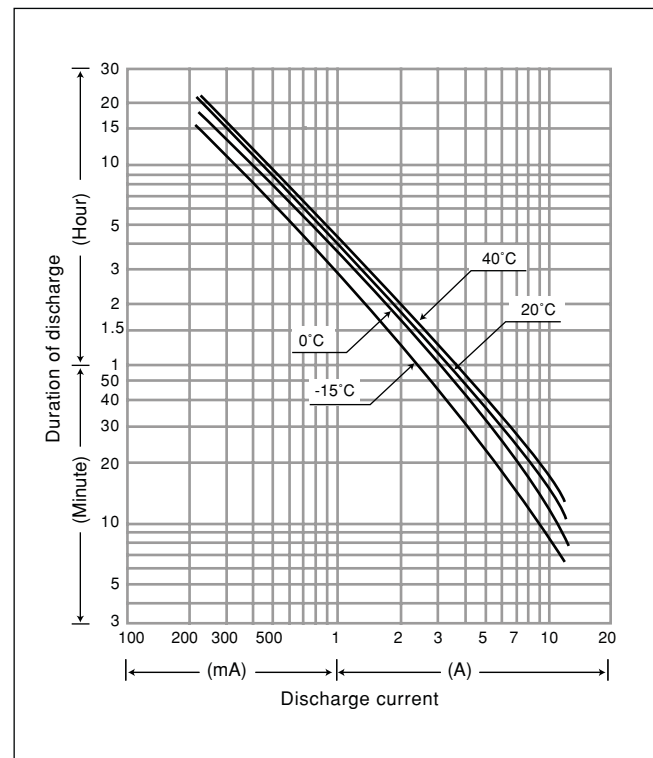
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	4.5Ah	
Dimensions	Length	70mm
	Width	97mm
	Height	102mm
	Total Height	108mm
Approx. mass	1.45kg	
Terminal	Faston 187	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	4.5Ah
	10 hour rate	3.9Ah
	5 hour rate	3.5Ah
	1 hour rate	2.8Ah
Internal resistance	Fully charged battery (25°C)	40mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	83%
	After 12 months	66%

Watt Table

Cut-off V	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	270	214	139.4	106.4	89.2	66.6	47	37.6	25.8	19.98	14.88	11.42	9.44	7.58	5.02	2.72	2.272
9.9V	250	200	136.6	105.6	87.8	65.8	46.6	37.6	25.4	19.84	14.8	11.36	9.36	7.56	5	2.72	2.266
10.2V	232	188	133	103.6	86.2	65	46.2	36.8	24.8	19.32	14.66	11.28	9.28	7.5	4.96	2.7	2.258
10.5V	206	168	123.2	96.4	82	63.6	45.4	36	24.2	18.64	14.42	11.2	9.2	7.4	4.92	2.7	2.25
10.8V	174	148	110	89.8	79.8	61.4	44.8	35.4	23.6	17.76	14.14	11.06	8.98	7.28	4.88	2.68	2.236

Ampere Table

Cut-off V	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	24.3	19.13	12.44	9.25	7.69	5.69	4.00	3.19	2.19	1.69	1.25	0.956	0.788	0.633	0.419	0.227	0.189
9.9V	22.6	17.94	12.19	9.19	7.56	5.63	3.98	3.19	2.14	1.68	1.24	0.950	0.781	0.630	0.417	0.226	0.189
10.2V	20.8	16.81	11.88	9.00	7.44	5.56	3.94	3.13	2.10	1.63	1.23	0.944	0.775	0.625	0.413	0.226	0.188
10.5V	18.5	15.06	11.00	8.38	7.06	5.44	3.88	3.06	2.06	1.58	1.21	0.938	0.769	0.618	0.411	0.225	0.188
10.8V	15.6	13.31	9.81	7.81	6.88	5.25	3.81	3.00	2.00	1.50	1.19	0.925	0.750	0.608	0.406	0.224	0.186

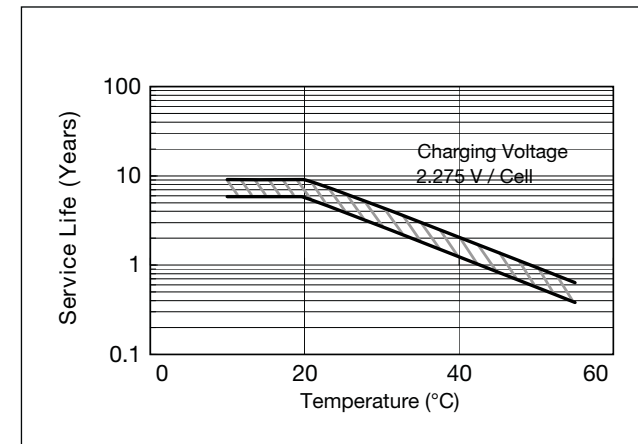
Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 0.675A or smaller
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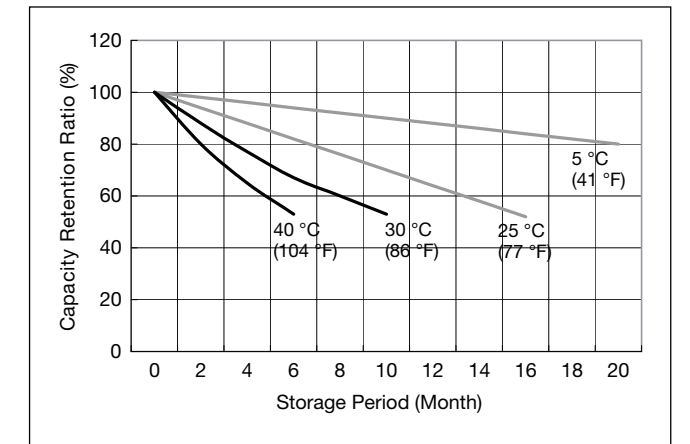
Cut off voltage

Discharge current	0.225 A - 0.9A	0.9A - 2.25A	2.25A - 4.5A	4.5A - 9A	9A - 13.5A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

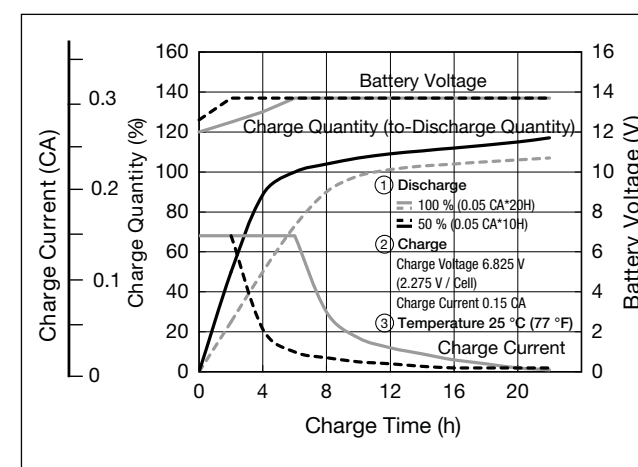
Influence of Temperature on Trickle life



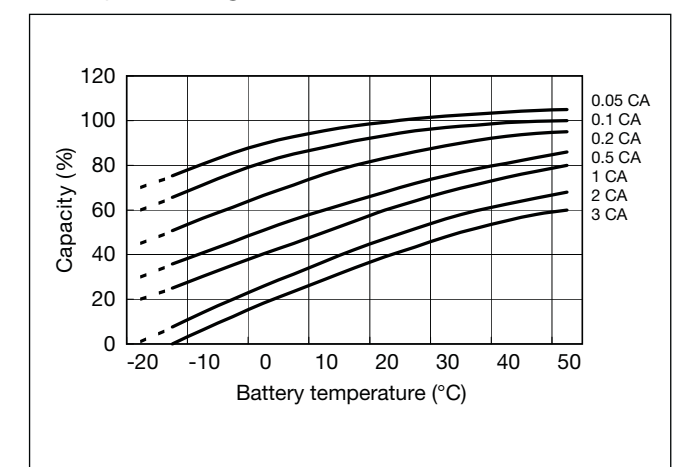
Residual capacity vs storage period



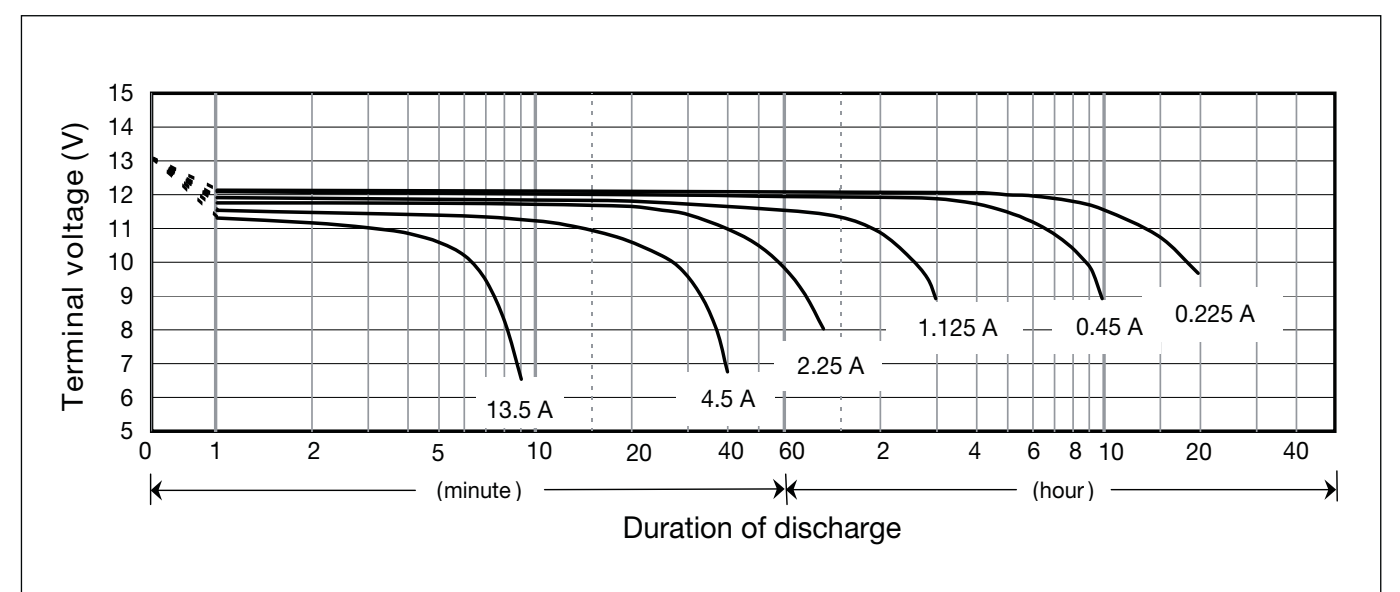
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics



LC-R127R2PG*1

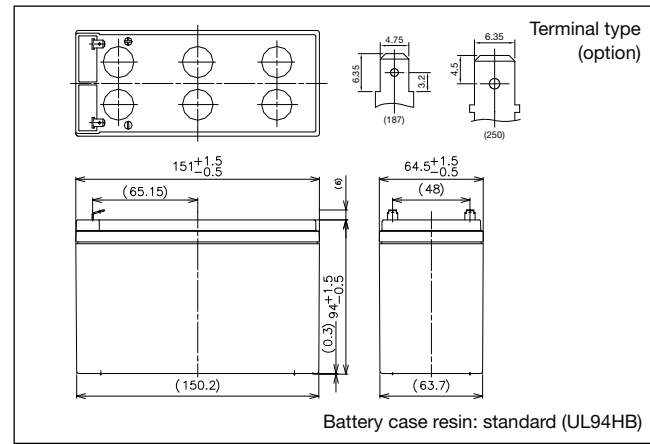
For main and standby power supplies. Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

VdS

G193046



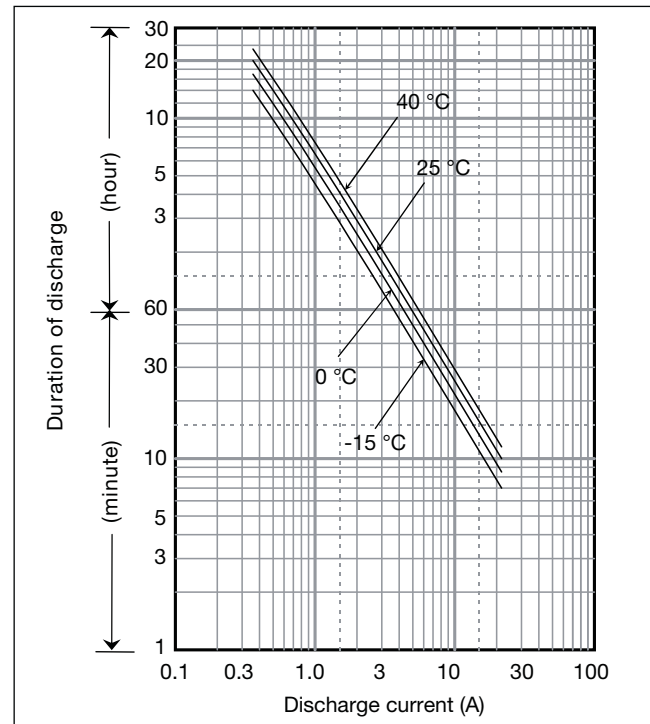
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	7.2Ah	
Dimensions	Length	151mm
	Width	64.5mm
	Height	94mm
	Total Height	100mm
Approx. mass	2.47kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	7.2Ah
	10 hour rate	6.8Ah
	5 hour rate	6.3Ah
	1 hour rate	4.9Ah
Internal resistance	Fully charged battery (25°C)	21mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	433	341	223	170	143	106	75.1	60.1	41.3	32.0	23.8	18.3	15.1	12.1	8.04	4.36	3.64							
9.9V	401	320	218	169	140	105	74.7	60.1	40.5	31.7	23.7	18.2	15.0	12.1	8.00	4.34	3.62							
10.2V	370	300	213	166	138	104	74.0	58.9	39.7	30.9	23.4	18.0	14.9	12.0	7.92	4.33	3.61							
10.5V	329	269	197	154	131	102	72.8	57.7	38.9	29.8	23.1	17.9	14.7	11.8	7.88	4.32	3.60							
10.8V	278	237	176	144	128	98	71.6	56.5	37.8	28.4	22.6	17.7	14.4	11.7	7.80	4.30	3.58							

Ampere Table

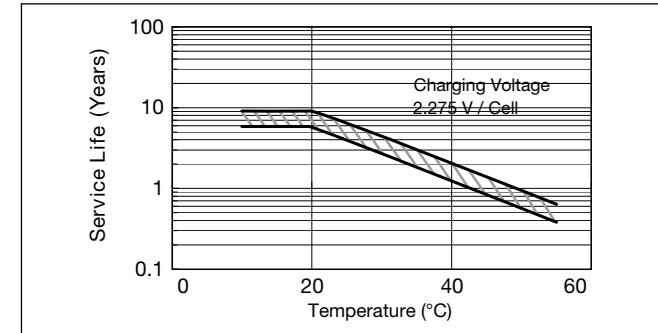
Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	38.9	30.6	19.9	14.8	12.3	9.1	6.4	5.1	3.50	2.70	2.00	1.53	1.26	1.012	0.670	0.363	0.303							
9.9V	36.1	28.7	19.5	14.7	12.1	9.0	6.4	5.1	3.43	2.68	1.99	1.52	1.25	1.008	0.667	0.362	0.302							
10.2V	33.3	26.9	19.0	14.4	11.9	8.9	6.3	5.0	3.36	2.61	1.97	1.51	1.24	1.000	0.660	0.361	0.301							
10.5V	29.6	24.1	17.6	13.4	11.3	8.7	6.2	4.9	3.29	2.52	1.94	1.50	1.23	0.988	0.657	0.360	0.300							
10.8V	25.0	21.3	15.7	12.5	11.0	8.4	6.1	4.8	3.20	2.40	1.90	1.48	1.20	0.972	0.650	0.358	0.298							

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0) but with no VdS certification.

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 2.88A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 1.08A or smaller

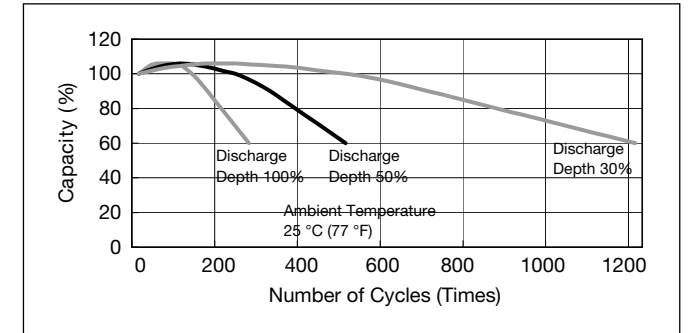
Influence of Temperature on Trickle life



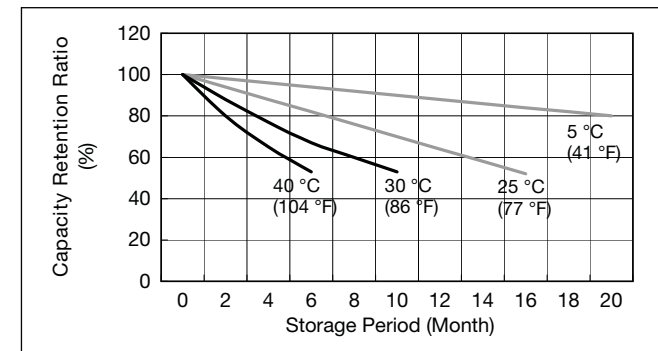
Cut off voltage

Discharge current	0.36A - 1.44A	1.44A - 3.6A	3.6A - 7.2A	7.2A - 14.4A	14.4A - 21.6A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

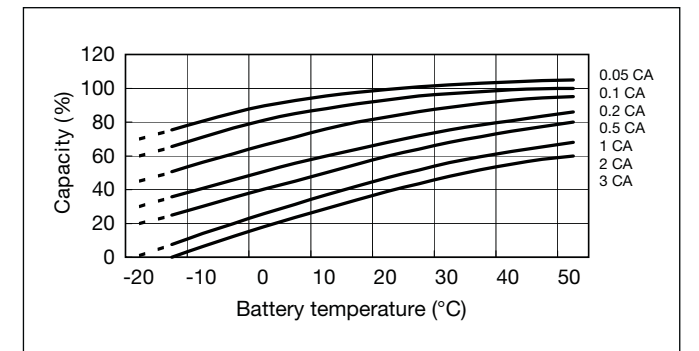
Cycle life vs Depth of discharge



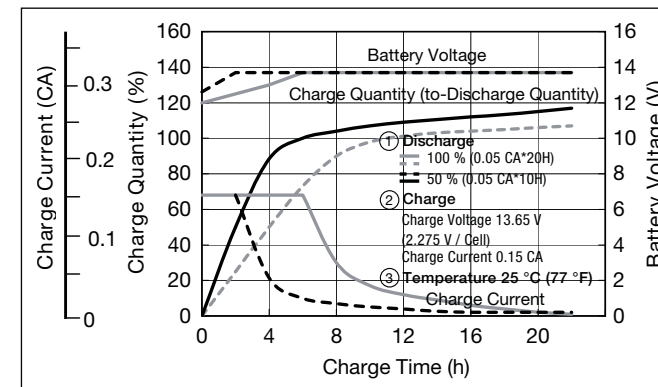
Residual capacity vs storage period



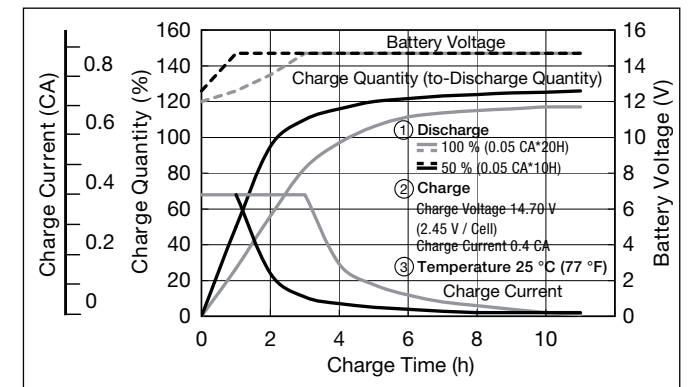
Discharge capacity by temperature and by discharge current



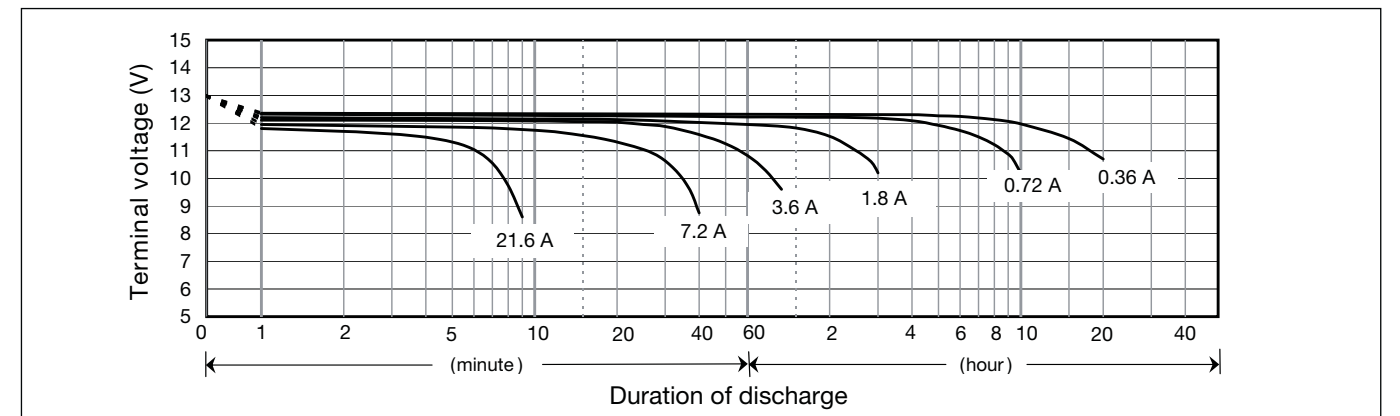
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



LC-RA1212PG

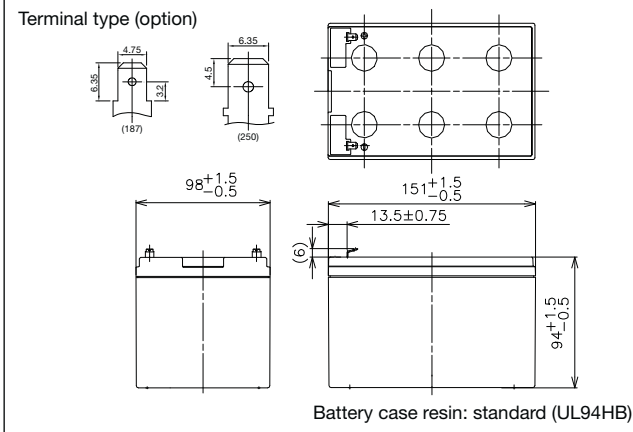
For main and standby power supplies. Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

VdS

G100001



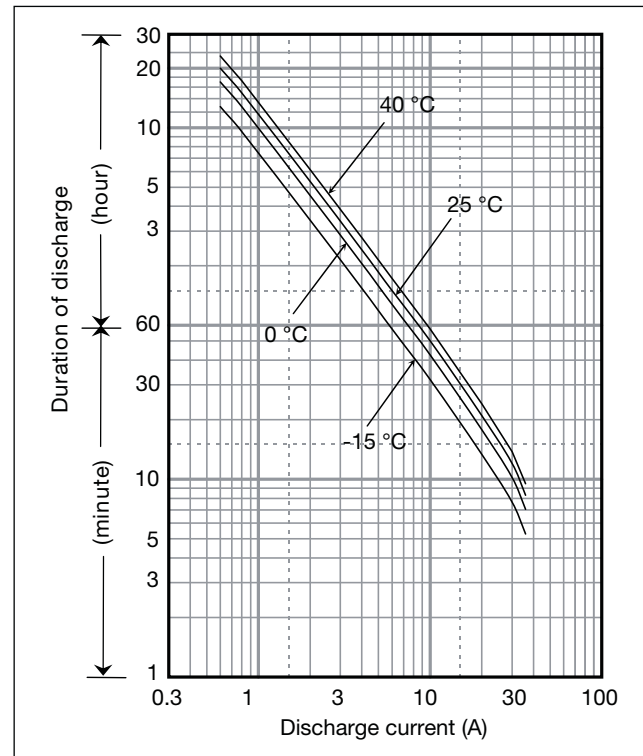
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	12Ah	
Dimensions	Length	151mm
	Width	98mm
	Height	94mm
	Total Height	100mm
Approx. mass	3.8kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	12.0Ah
	10 hour rate	11.3Ah
	5 hour rate	10.4Ah
Internal resistance	Fully charged battery (25°C)	30mΩ
	1 hour rate	8.1Ah
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	679	559	384	298	247	183	137	105	70.3	54.5	38.1	28.8	24.1	21.7	13.3	7.22	6.02							
9.9V	649	537	373	288	241	177	135	104	69.9	54.2	37.8	28.8	24.1	21.7	13.3	7.22	6.02							
10.2V	607	506	363	282	235	177	134	102	69.1	53.9	37.5	28.8	24.0	21.6	13.2	7.21	6.01							
10.5V	556	475	343	271	231	172	133	100	68.5	53.3	36.9	28.7	24.0	21.6	13.2	7.20	6.00							
10.8V	495	434	321	261	225	166	123	98	66.1	52.1	36.3	28.4	23.8	21.5	13.1	7.18	5.98							

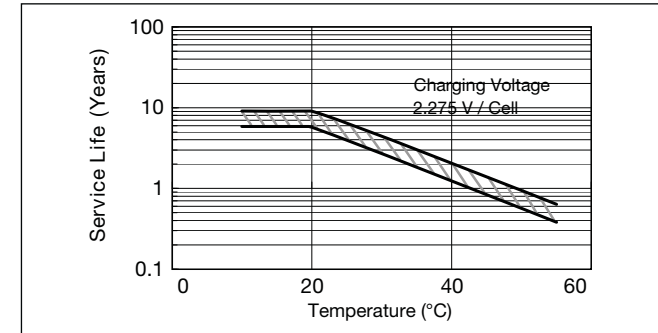
Ampere Table

Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	61.1	50.1	34.3	25.9	21.3	15.6	11.7	8.90	5.95	4.60	3.20	2.41	2.01	1.81	1.11	0.602	0.502							
9.9V	58.4	48.2	33.3	25.0	20.8	15.1	11.5	8.80	5.92	4.58	3.18	2.41	2.01	1.81	1.11	0.602	0.502							
10.2V	54.6	45.4	32.4	24.5	20.3	15.1	11.4	8.70	5.85	4.55	3.15	2.41	2.00	1.80	1.10	0.601	0.501							
10.5V	50.0	42.6	30.6	23.6	19.9	14.7	11.3	8.50	5.80	4.50	3.10	2.40	2.00	1.80	1.10	0.600	0.500							
10.8V	44.5	38.9	28.7	22.7	19.4	14.2	10.5	8.30	5.60	4.40	3.05	2.38	1.99	1.79	1.09	0.598	0.498							

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 4.8A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 1.8A or smaller

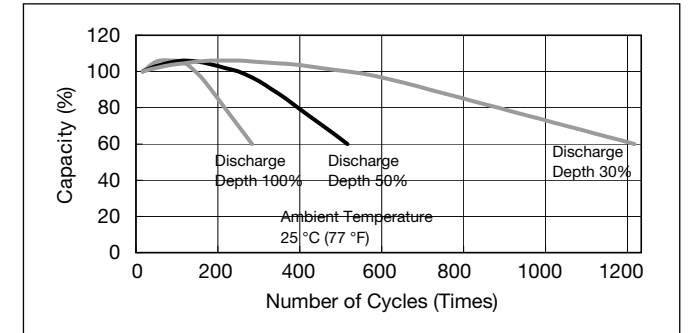
Influence of Temperature on Trickle life



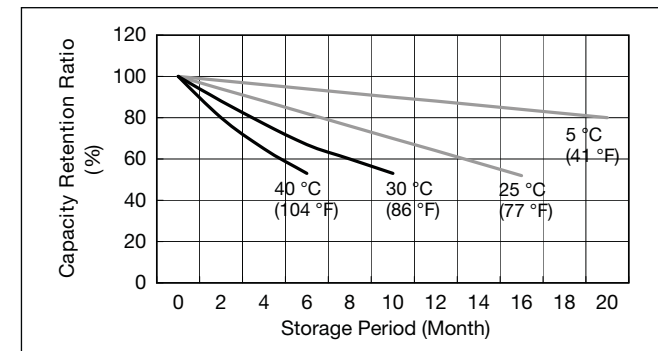
Cut off voltage

Discharge current	0.6A - 2.4A	2.4A - 6A	6A - 12A	12A - 24A	24A - 36A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

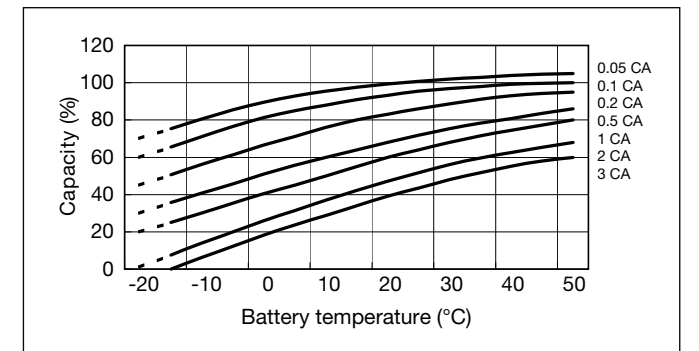
Cycle life vs Depth of discharge



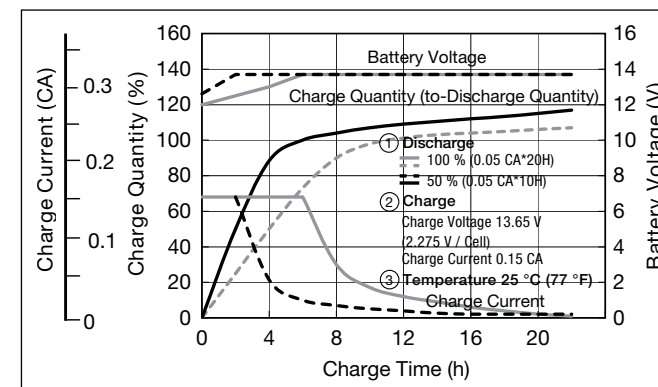
Residual capacity vs storage period



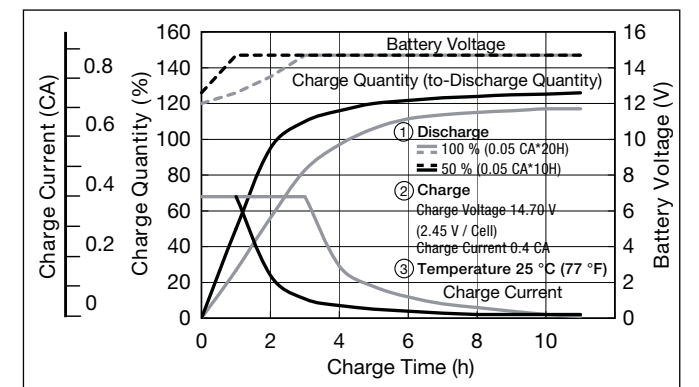
Discharge capacity by temperature and by discharge current



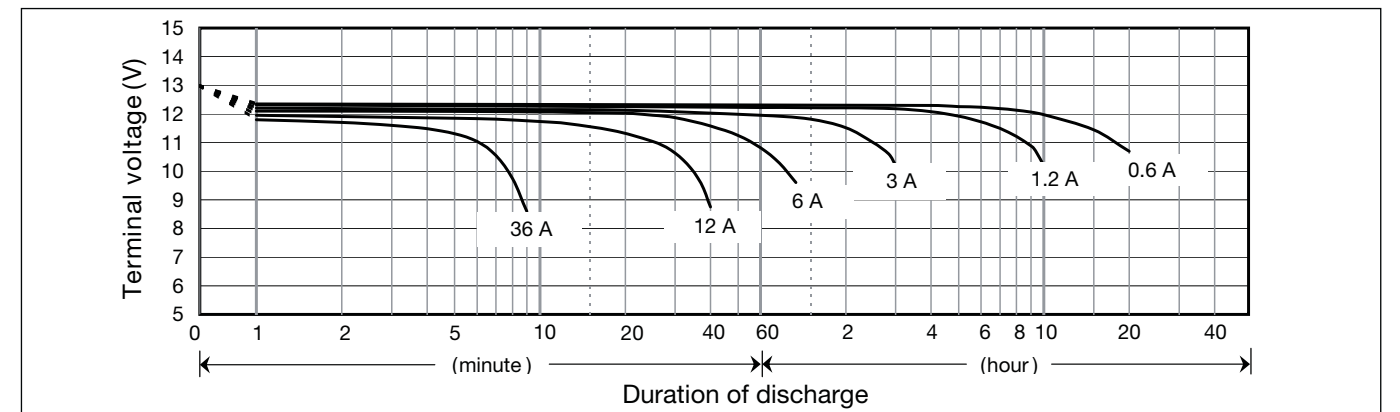
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics

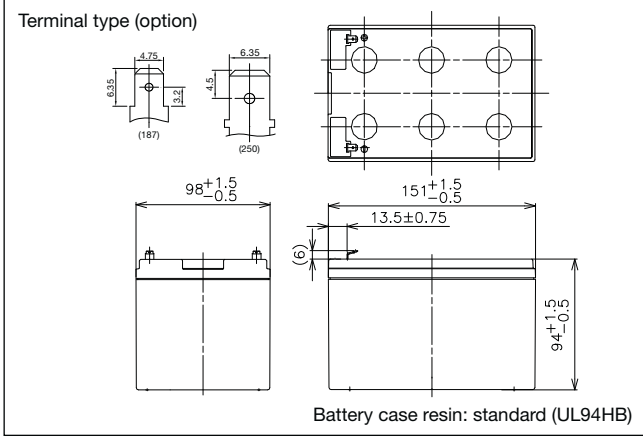


LC-RA1215P



For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

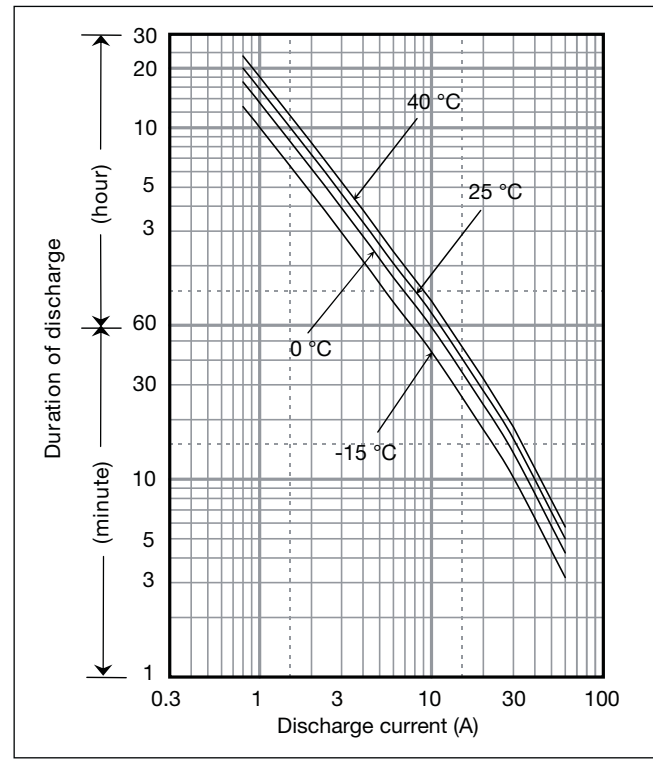
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	15Ah	
Dimensions	Length	151mm
	Width	98mm
	Height	94mm
	Total Height	100mm
Approx. mass	4.2kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	15.0Ah
	10 hour rate	14.0Ah
	5 hour rate	12.9Ah
	1 hour rate	10.0Ah
Internal resistance	Fully charged battery (25°C)	30mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	850	682	455	350	292	217	157	123	83.9	65.0	47.1	36.0	29.9	25.2	16.2	8.75	7.30
9.9V	799	646	444	343	286	213	156	123	82.8	64.6	46.9	35.8	29.7	25.1	16.1	8.74	7.29
10.2V	741	607	433	336	281	211	154	121	81.4	63.4	46.4	35.7	29.5	24.9	15.9	8.72	7.27
10.5V	667	555	404	318	270	206	152	118	80.1	61.9	45.7	35.5	29.4	24.8	15.9	8.70	7.25
10.8V	576	497	368	300	263	199	146	116	77.7	59.6	44.8	35.1	28.9	24.5	15.7	8.66	7.21

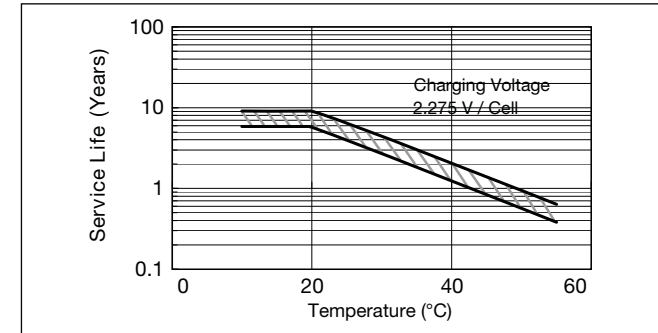
Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	76.5	61.2	40.6	30.4	25.2	18.5	13.4	10.5	7.11	5.49	3.96	3.01	2.49	2.10	1.35	0.730	0.609
9.9V	71.8	58.0	39.7	29.9	24.7	18.2	13.3	10.4	7.01	5.45	3.94	3.00	2.48	2.09	1.34	0.728	0.608
10.2V	66.6	54.5	38.6	29.2	24.2	18.1	13.1	10.3	6.89	5.36	3.90	2.99	2.46	2.08	1.33	0.727	0.606
10.5V	59.9	49.8	36.1	27.6	23.3	17.6	13.0	10.0	6.78	5.22	3.84	2.97	2.45	2.07	1.33	0.725	0.604
10.8V	51.8	44.6	32.9	26.1	22.7	17.0	12.5	9.82	6.58	5.03	3.77	2.94	2.41	2.04	1.31	0.722	0.601

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 6A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 2.25A or smaller

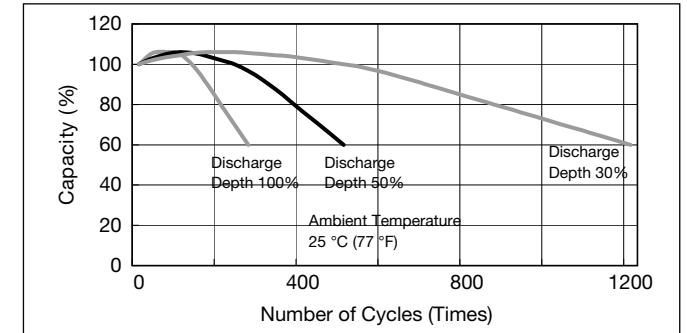
Influence of Temperature on Trickle life



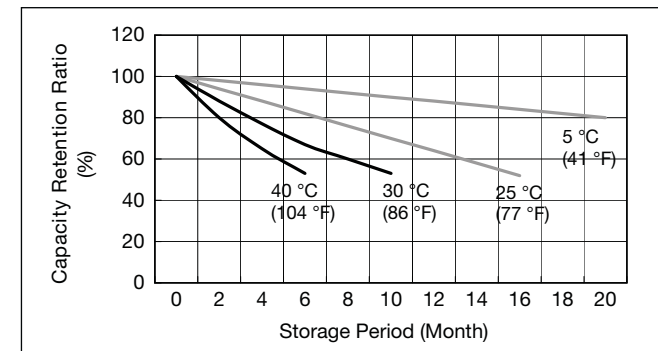
Cut off voltage

Discharge current	0.75A - 3A	3A - 7.5A	7.5A - 15A	15A - 30A	30A - 45A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

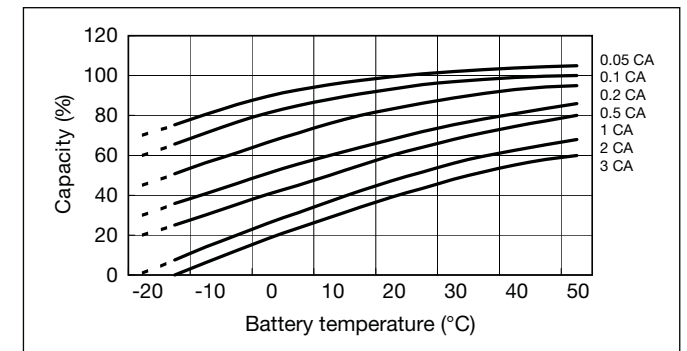
Cycle life vs Depth of discharge



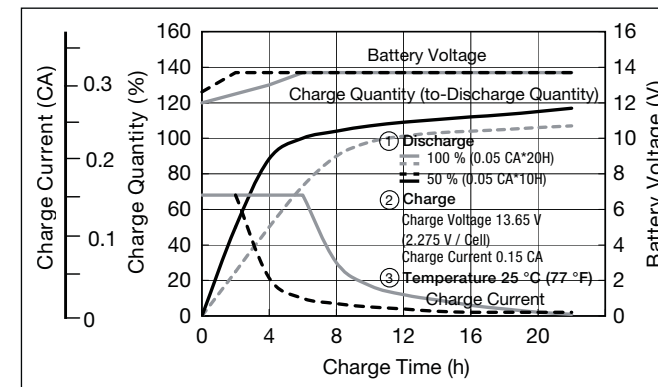
Residual capacity vs storage period



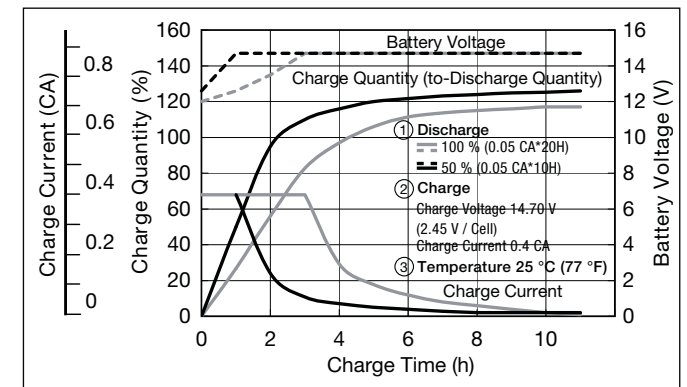
Discharge capacity by temperature and by discharge current



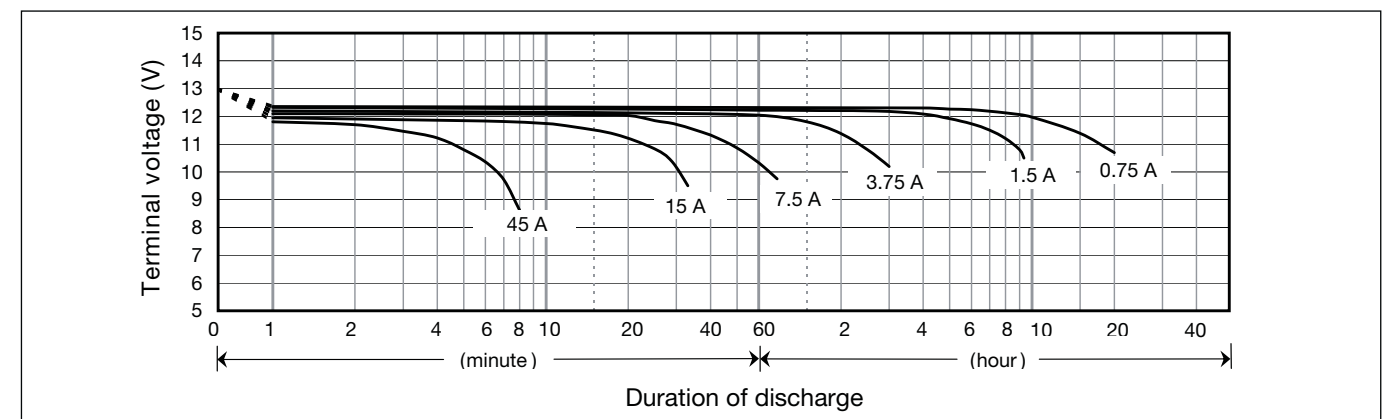
Constant-voltage and constant-current charge characteristics for Trickle use



Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



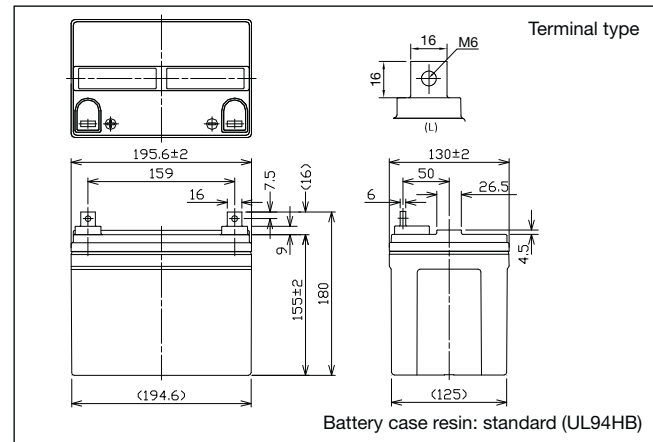
LC-R1233P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

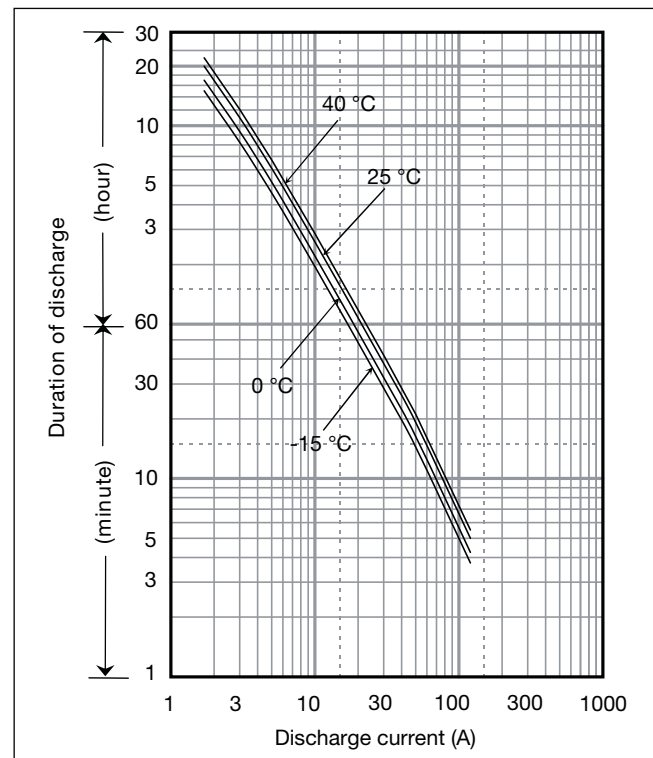
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	33Ah	
Dimensions	Length	195.6mm
	Width	130mm
	Height	155mm
	Total Height	180mm
Approx. mass	12kg	
Terminal	M6 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	33Ah
	10 hour rate	30Ah
	5 hour rate	27Ah
	1 hour rate	20Ah
Internal resistance	Fully charged battery (25°C)	7mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	1546	1254	948	732	635	457	328	268	187	149	107	86.6	69.5	60.5	36.9	19.8	16.5	
9.9V	1446	1182	928	721	630	452	322	262	182	148	105	85.4	68.3	60.0	36.9	19.8	16.5	
10.2V	1379	1115	899	706	619	443	321	259	170	147	104	84.2	67.7	60.0	36.9	19.8	16.5	
10.5V	1323	1051	868	684	603	433	314	256	168	146	104	84.2	67.7	60.0	36.9	19.8	16.5	
10.8V	1182	1001	823	663	590	421	281	233	162	137	99	82.5	67.1	58.8	36.9	19.8	16.3	

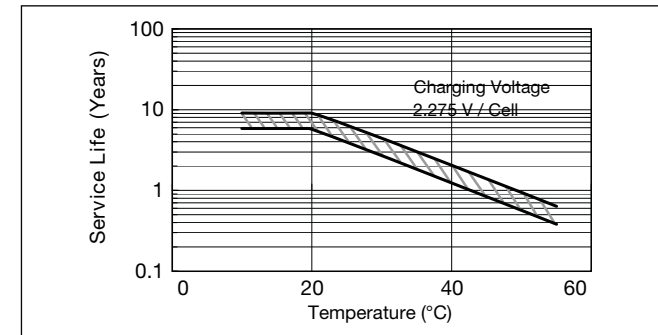
Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	139	113	84.6	63.7	54.8	39.1	27.9	22.8	15.8	12.6	9.00	7.25	5.80	5.10	3.08	1.65	1.38	
9.9V	130	106	82.9	62.7	54.4	38.6	27.4	22.2	15.5	12.5	8.85	7.15	5.70	5.00	3.08	1.65	1.38	
10.2V	124	100	80.3	61.4	53.4	37.9	27.4	22.0	14.4	12.4	8.75	7.05	5.65	5.00	3.08	1.65	1.38	
10.5V	119	94	77.5	59.5	52.0	37.0	26.8	21.8	14.3	12.3	8.70	7.05	5.65	5.00	3.08	1.65	1.38	
10.8V	106	90	73.5	57.7	50.9	36.0	24.0	19.8	13.7	11.6	8.35	6.90	5.60	4.90	3.08	1.65	1.36	

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 13.2A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 4.95A or smaller

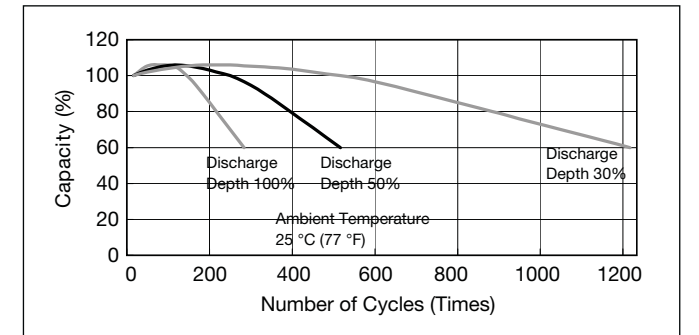
Influence of Temperature on Trickle life



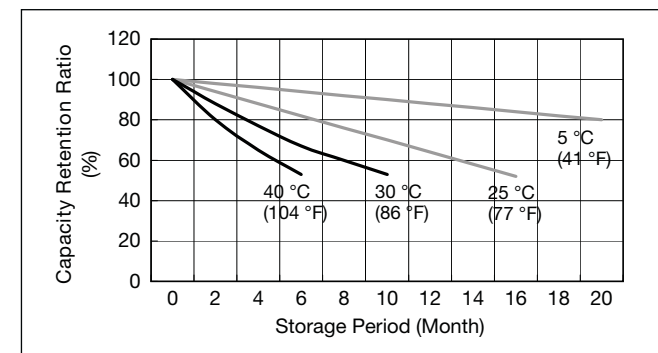
Cut off voltage

Discharge current	1.65A - 6.6A	6.6A - 16.5A	16.5A - 33A	33A - 66A	66A - 99A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

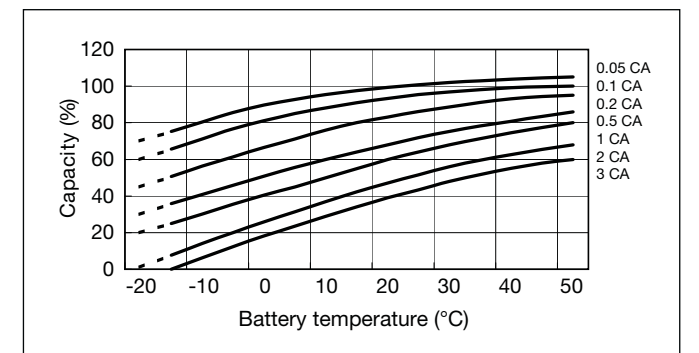
Cycle life vs Depth of discharge



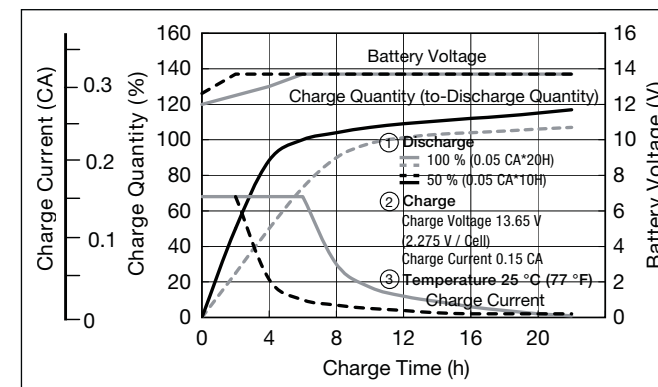
Residual capacity vs storage period



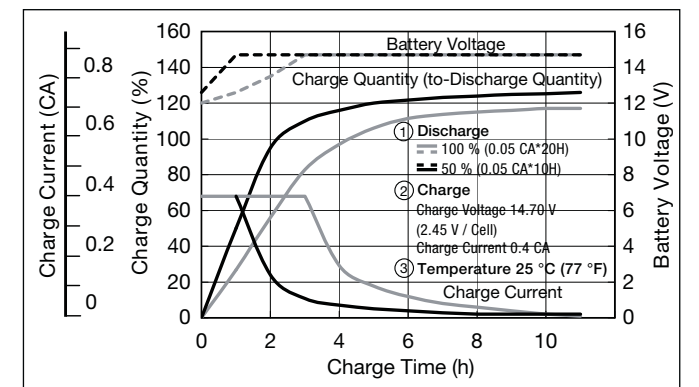
Discharge capacity by temperature and by discharge current



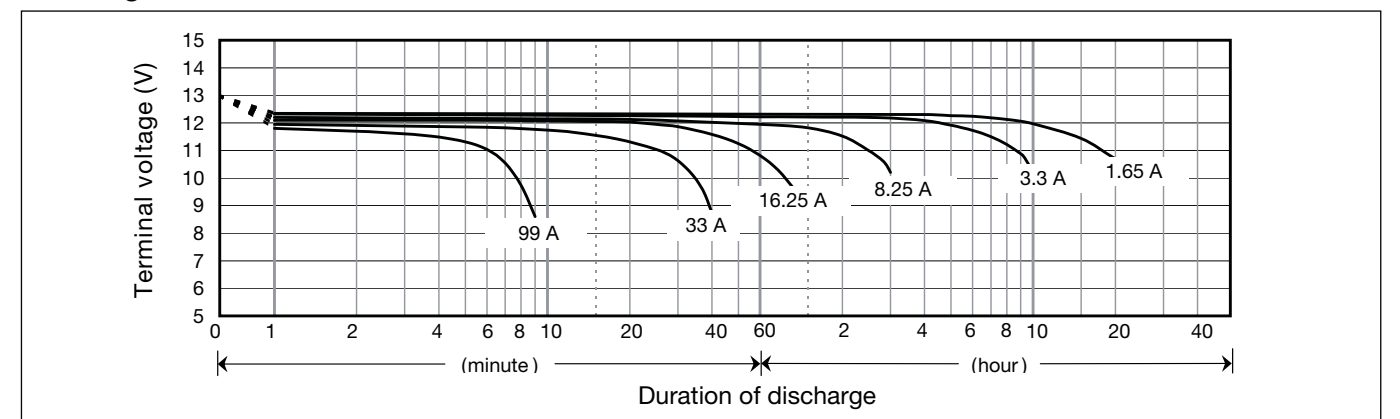
Constant-voltage and constant-current charge characteristics for Trickle use



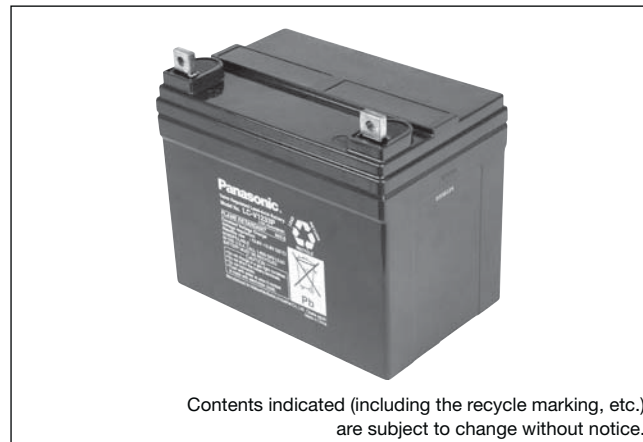
Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



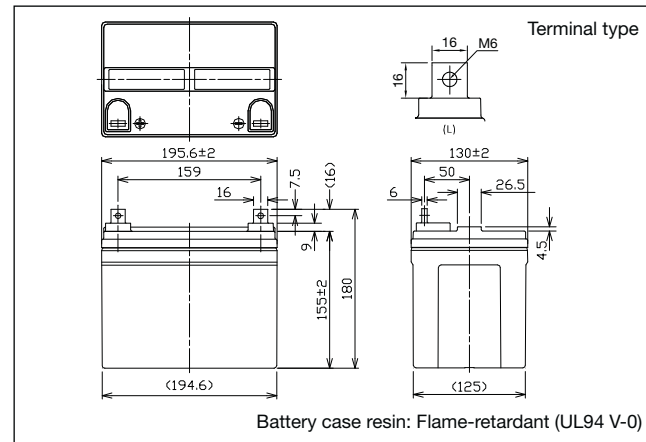
LC-V1233P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For main and standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

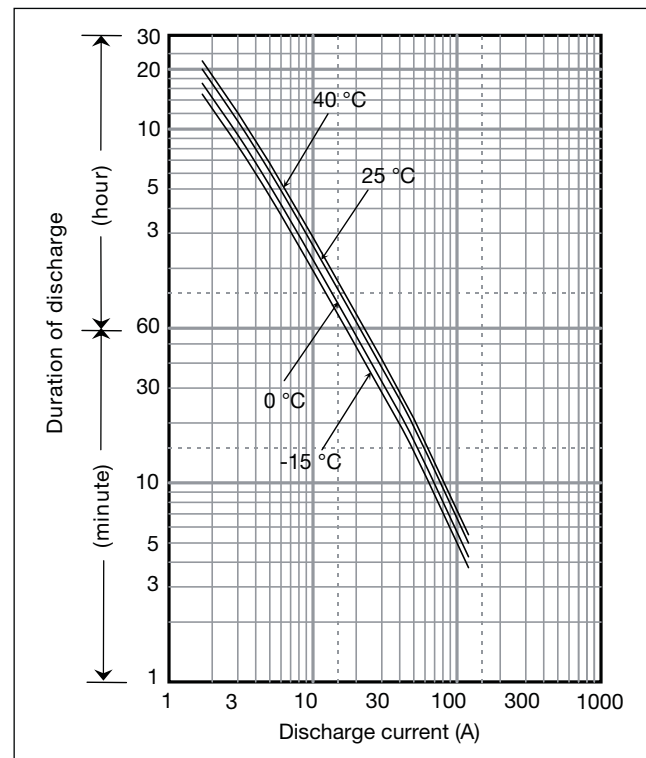
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	33Ah	
Dimensions	Length	195.6mm
	Width	130mm
	Height	155mm
	Total Height	180mm
Approx. mass	11.1kg	
Terminal	M6 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	33Ah 30Ah 27Ah 20Ah
Internal resistance	Fully charged battery (25°C)	7mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	1546	1254	948	732	635	457	328	268	187	149	107	86.6	69.5	60.5	36.9	19.8	16.5	
9.9V	1446	1182	928	721	630	452	322	262	182	148	105	85.4	68.3	60.0	36.9	19.8	16.5	
10.2V	1379	1115	899	706	619	443	321	259	170	147	104	84.2	67.7	60.0	36.9	19.8	16.5	
10.5V	1323	1051	868	684	603	433	314	256	168	146	104	84.2	67.7	60.0	36.9	19.8	16.5	
10.8V	1182	1001	823	663	590	421	281	233	162	137	99	82.5	67.1	58.8	36.9	19.8	16.3	

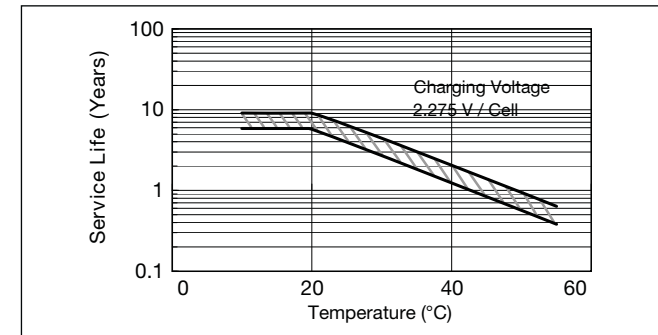
Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	139	113	84.6	63.7	54.8	39.1	27.9	22.8	15.8	12.6	9.00	7.25	5.80	5.10	3.08	1.65	1.38	
9.9V	130	106	82.9	62.7	54.4	38.6	27.4	22.2	15.5	12.5	8.85	7.15	5.70	5.00	3.08	1.65	1.38	
10.2V	124	100	80.3	61.4	53.4	37.9	27.4	22.0	14.4	12.4	8.75	7.05	5.65	5.00	3.08	1.65	1.38	
10.5V	119	94	77.5	59.5	52.0	37.0	26.8	21.8	14.3	12.3	8.70	7.05	5.65	5.00	3.08	1.65	1.38	
10.8V	106	90	73.5	57.7	50.9	36.0	24.0	19.8	13.7	11.6	8.35	6.90	5.60	4.90	3.08	1.65	1.36	

Charging Method

Cycle use	Control voltage: 14.5 - 14.9V; Initial current: 13.2A or smaller
Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 4.95A or smaller

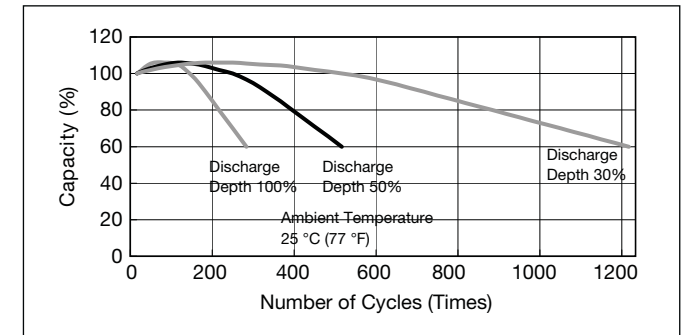
Influence of Temperature on Trickle life



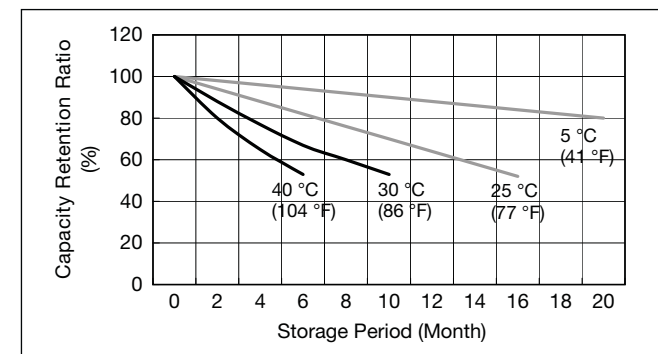
Cut off voltage

Discharge current	1.65A - 6.6A	6.6A - 16.5A	16.5A - 33A	33A - 66A	66A - 99A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

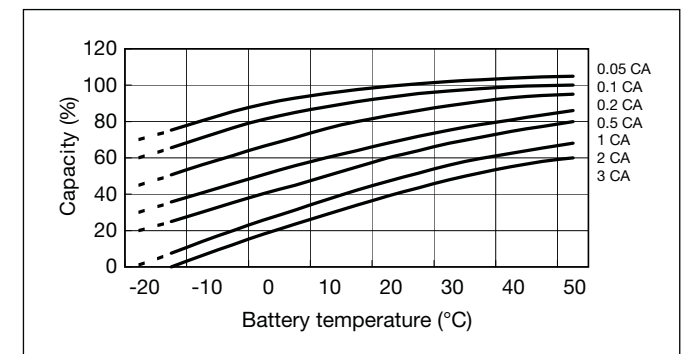
Cycle life vs Depth of discharge



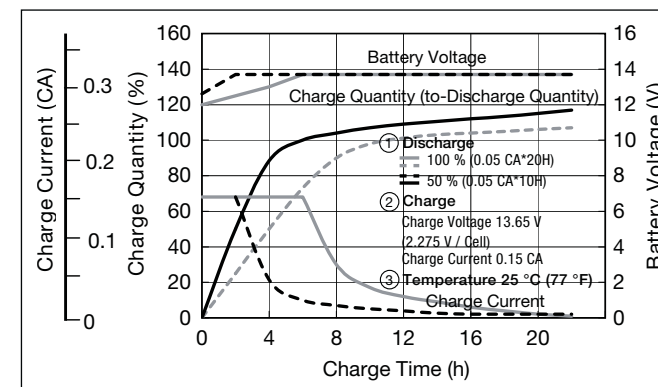
Residual capacity vs storage period



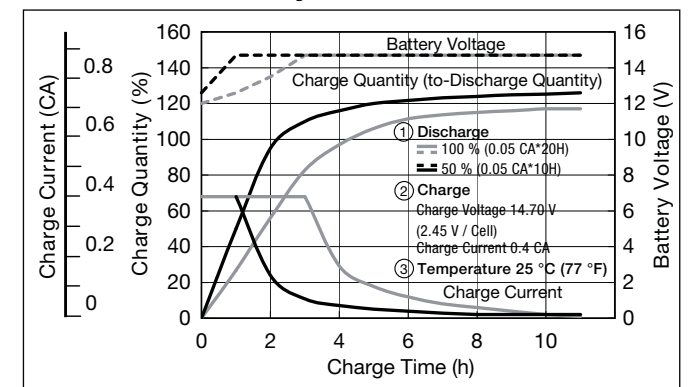
Discharge capacity by temperature and by discharge current



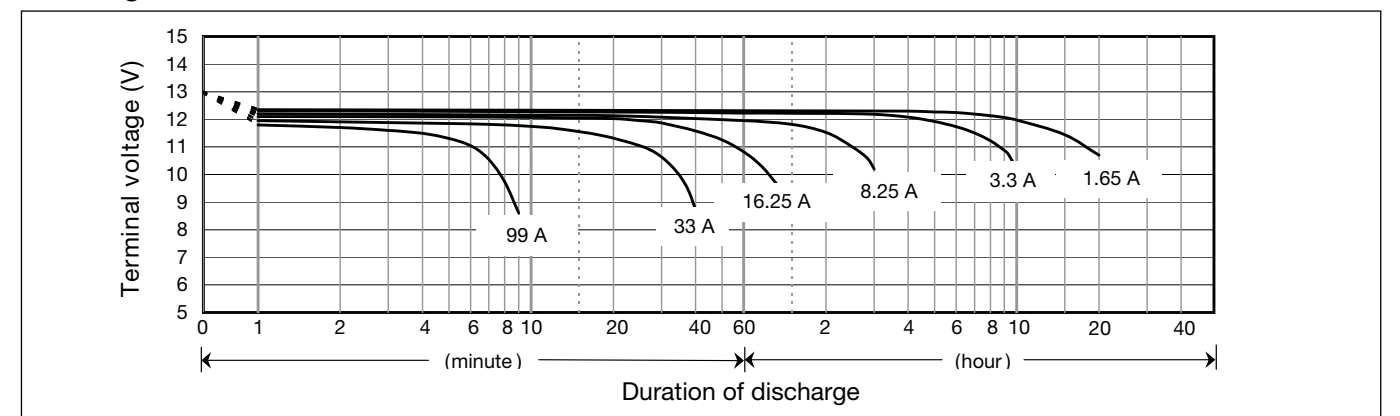
Constant-voltage and constant-current charge characteristics for Trickle use



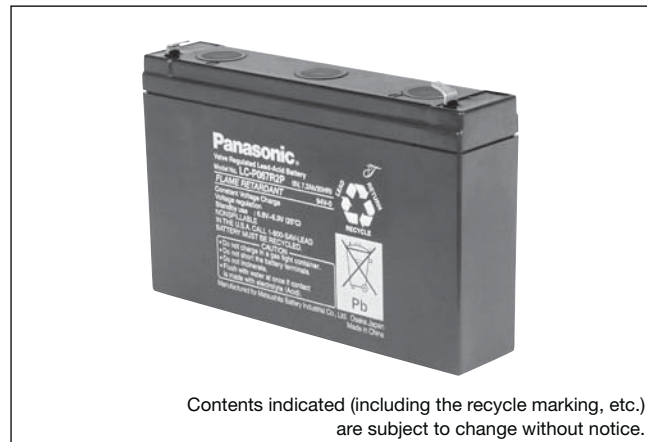
Constant-voltage and constant-current charge characteristics for Cycle use



Discharge characteristics



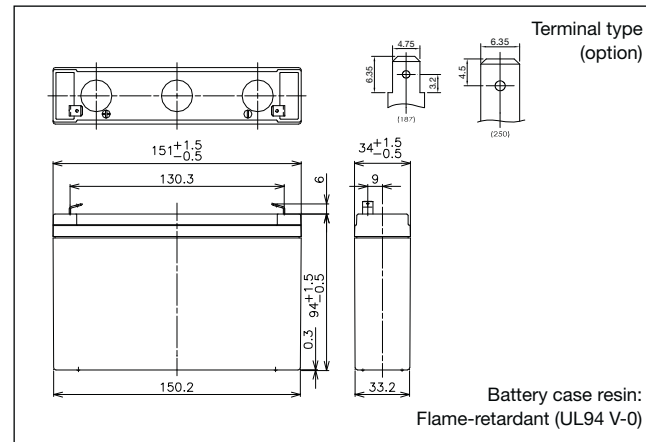
LC-P067R2P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

Dimensions (mm)



Battery case resin:
Flame-retardant (UL94 V-0)

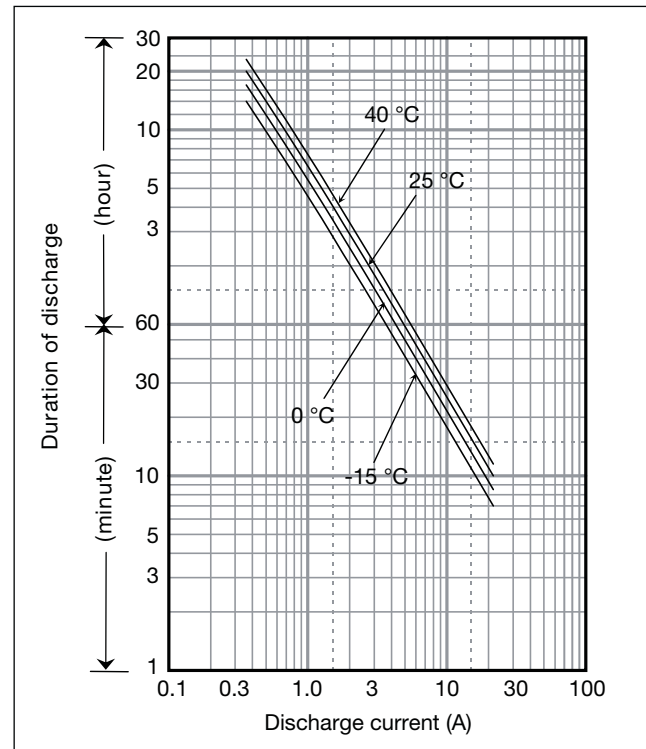
Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	7.2Ah	
Dimensions	Length	151mm
	Width	34mm
	Height	94mm
	Total Height	100mm
Approx. mass	1.30kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	7.2Ah
	10 hour rate	6.8Ah
	5 hour rate	6.3Ah
	1 hour rate	4.9Ah
Internal resistance	Fully charged battery (25°C)	11mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	216	171	111	85.1	71.3	53.2	37.6	30.0	20.7	16.0	11.9	9.14	7.55	6.07	4.02	2.18	1.82
4.95V	201	160	109	84.5	70.2	52.7	37.3	30.0	20.3	15.9	11.8	9.08	7.49	6.04	4.00	2.17	1.81
5.1V	185	150	106	82.8	69.0	52.1	37.0	29.5	19.8	15.5	11.7	9.02	7.43	6.00	3.96	2.17	1.81
5.25V	165	134	99	77.1	65.5	50.9	36.4	28.9	19.4	14.9	11.5	8.96	7.37	5.92	3.94	2.16	1.80
5.4V	139	119	88	71.9	63.8	49.1	35.8	28.3	18.9	14.2	11.3	8.84	7.19	5.83	3.90	2.15	1.79

Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	38.9	30.6	19.9	14.8	12.3	9.1	6.4	5.1	3.5	2.7	2.00	1.50	1.26	1.00	0.67	0.36	0.30
4.95V	36.1	28.7	18.5	14.8	12.1	9.0	6.4	5.1	3.4	2.6	2.00	1.50	1.25	1.00	0.67	0.36	0.30
5.1V	33.3	26.9	19.0	14.4	11.9	8.9	6.3	5.0	3.3	2.5	1.95	1.50	1.24	1.00	0.66	0.36	0.30
5.25V	29.6	24.1	17.6	13.4	11.3	8.7	6.2	4.9	3.3	2.5	1.95	1.50	1.23	1.00	0.66	0.36	0.30
5.4V	25.0	21.3	15.7	12.5	11.0	8.4	6.1	4.8	3.2	2.4	1.90	1.50	1.20	1.00	0.65	0.35	0.30

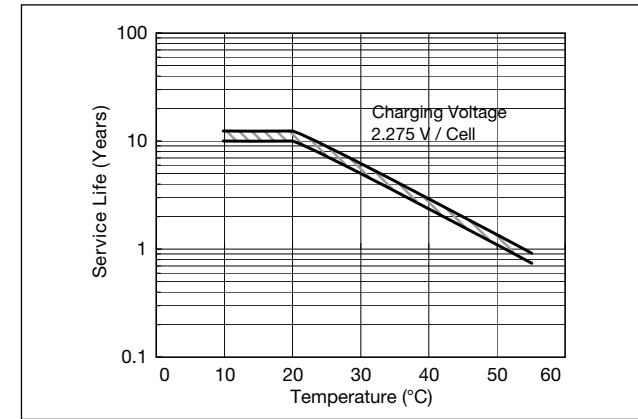
Charging Method

Trickle Use	Control voltage 6.8 - 6.9V; Initial current 1.08A or smaller
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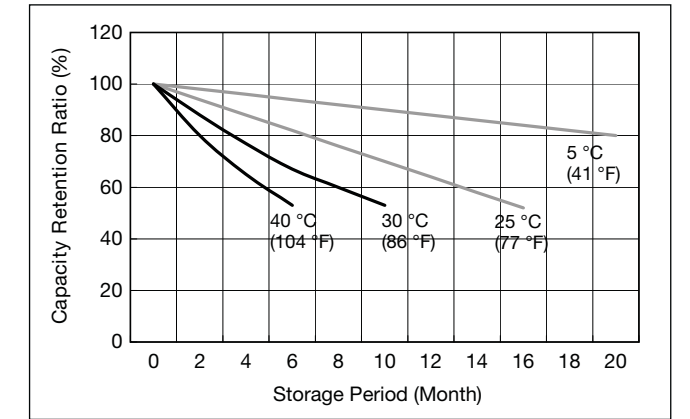
Cut off voltage

Discharge current	0.36A - 1.44A	1.44A - 3.6A	3.6A - 7.2A	7.2A - 14.4A	14.4A - 21.6A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

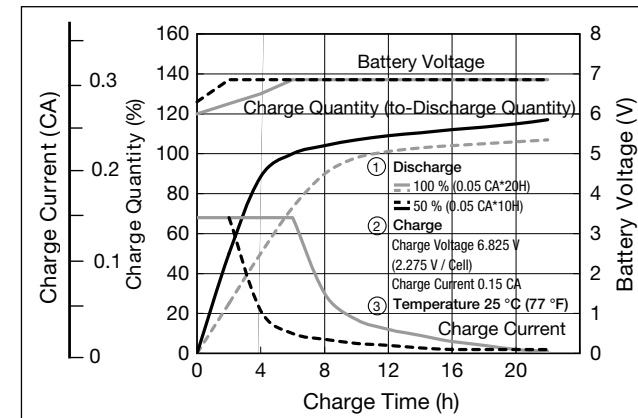
Influence of Temperature on Trickle life



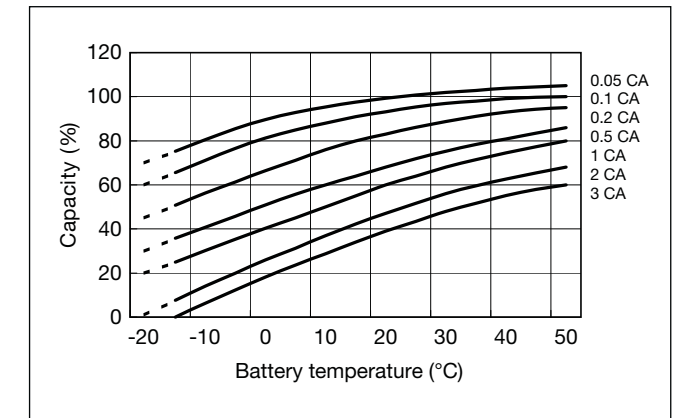
Residual capacity vs storage period



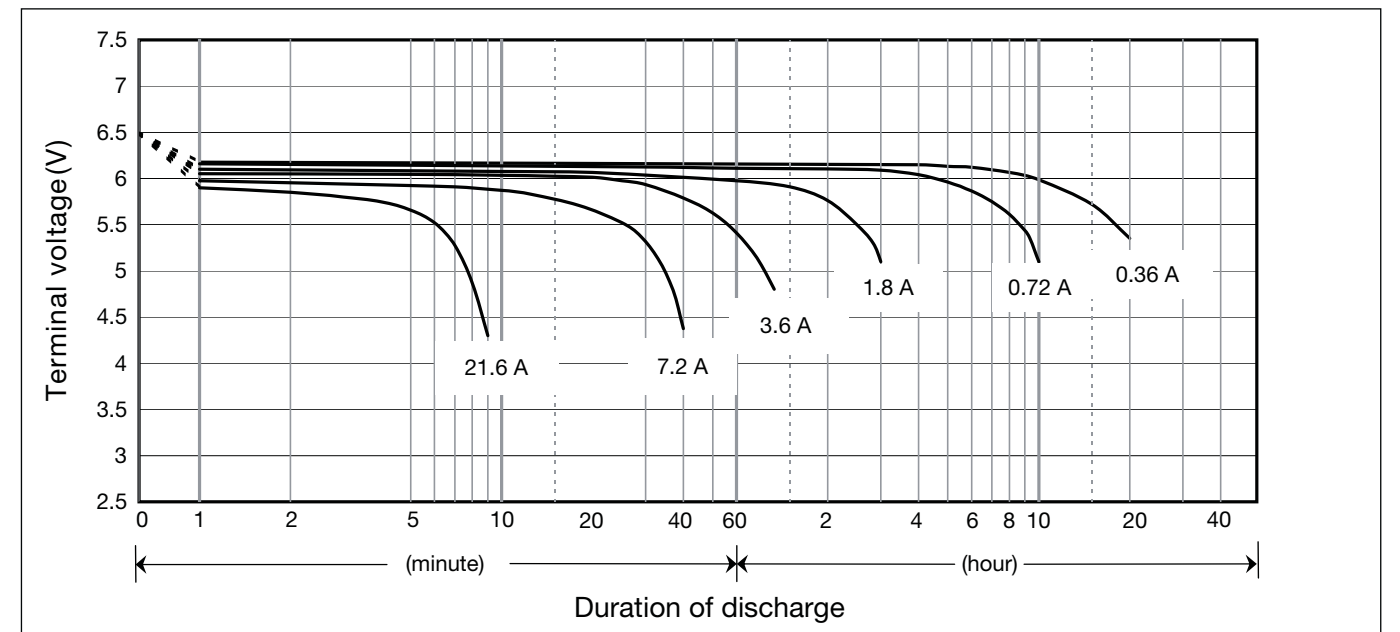
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics



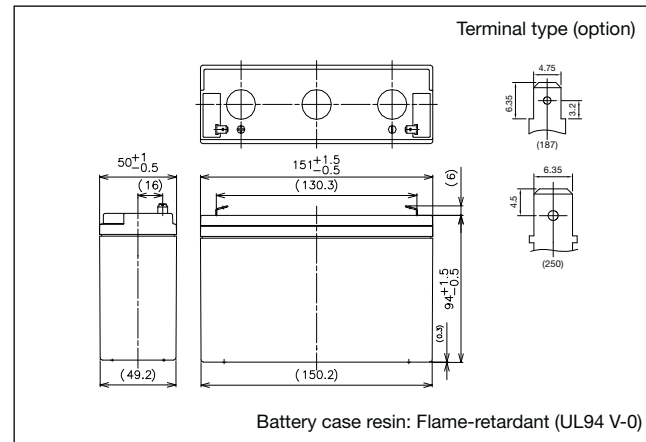
LC-P0612P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

Dimensions (mm)



Battery case resin: Flame-retardant (UL94 V-0)

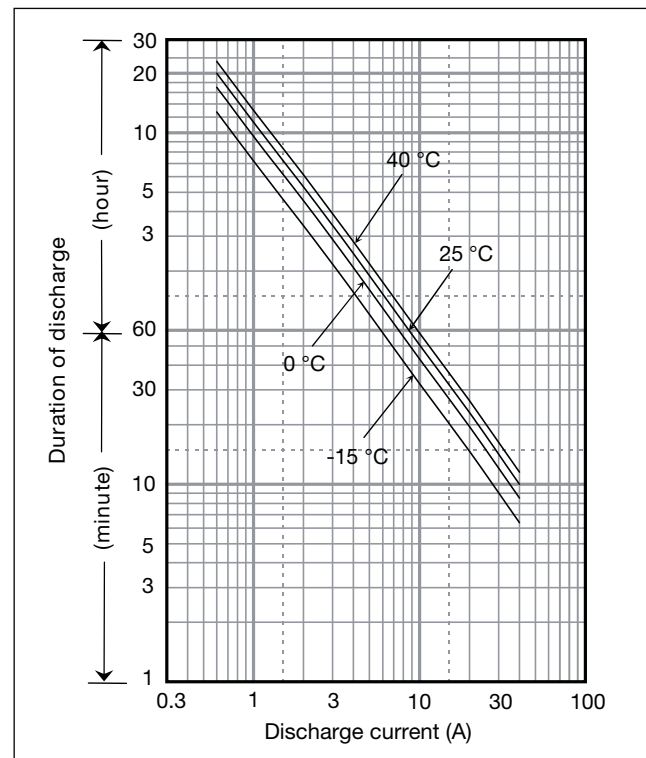
Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	12Ah	
Dimensions	Length	151mm
	Width	50mm
	Height	94mm
	Total Height	100mm
Approx. mass	2kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	12.0Ah
	10 hour rate	11.3Ah
	5 hour rate	10.4Ah
	1 hour rate	8.1Ah
Internal resistance	Fully charged battery (25°C)	15mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	340	279	192	149	124	91.3	68.7	52.4	35.1	27.2	19.0	14.4	12.0	10.9	6.66	3.61	3.01
4.95V	325	269	186	144	121	88.3	67.5	51.8	35.0	27.1	18.9	14.4	12.0	10.9	6.66	3.61	3.01
5.1V	304	253	181	141	118	88.3	66.9	51.2	34.5	26.9	18.7	14.4	12.0	10.8	6.60	3.61	3.01
5.25V	278	237	171	136	115	86.0	66.3	50.1	34.2	26.6	18.4	14.3	12.0	10.8	6.60	3.60	3.00
5.4V	247	217	161	131	113	83.1	61.6	48.9	33.1	26.0	18.1	14.2	11.9	10.7	6.54	3.59	2.99

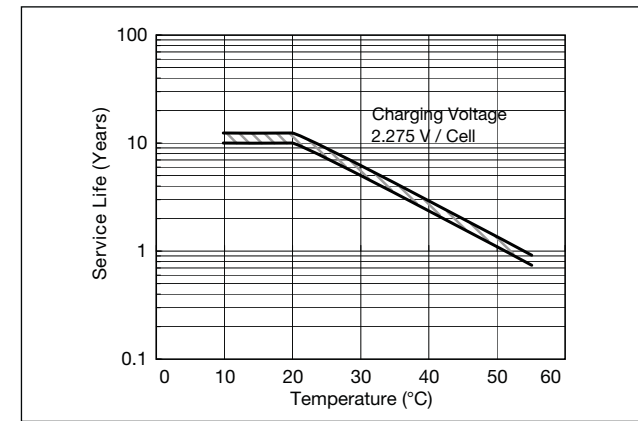
Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	61.1	50.1	34.3	25.9	21.3	15.6	11.7	8.90	5.95	4.60	3.20	2.41	2.01	1.81	1.11	0.602	0.502
4.95V	58.4	48.2	33.3	25.0	20.8	15.1	11.5	8.80	5.92	4.58	3.18	2.41	2.01	1.81	1.11	0.602	0.502
5.1V	54.6	45.4	32.4	24.5	20.3	15.1	11.4	8.70	5.85	4.55	3.15	2.41	2.00	1.80	1.10	0.601	0.501
5.25V	50.0	42.6	30.6	23.6	19.9	14.7	11.3	8.50	5.80	4.50	3.10	2.40	2.00	1.80	1.10	0.600	0.500
5.4V	44.5	38.9	28.7	22.7	19.4	14.2	10.5	8.30	5.60	4.40	3.05	2.38	1.99	1.79	1.09	0.598	0.498

Charging Method

Trickle Use	Control voltage: 6.8 - 6.9V; Initial current: 1.8A or smaller
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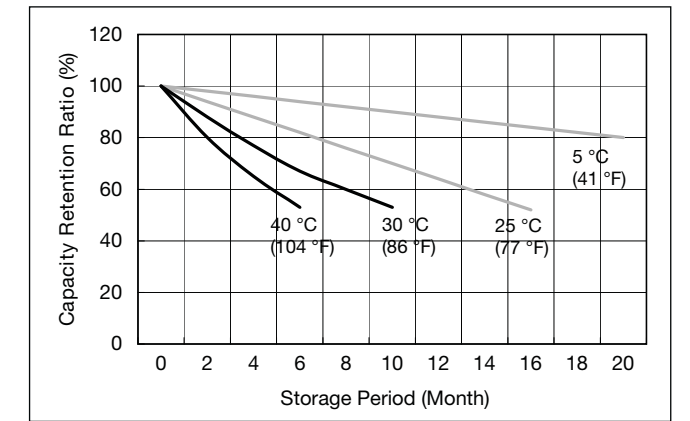
Influence of Temperature on Trickle life



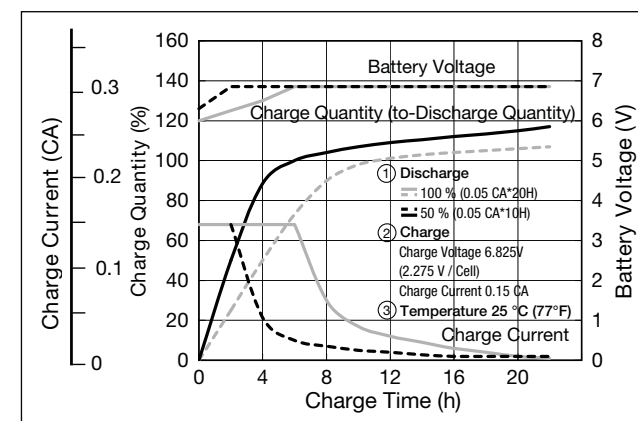
Cut off voltage

Discharge current	0.6A - 2.4A	2.4A - 6A	6A - 12A	12A - 24A	24A - 36A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

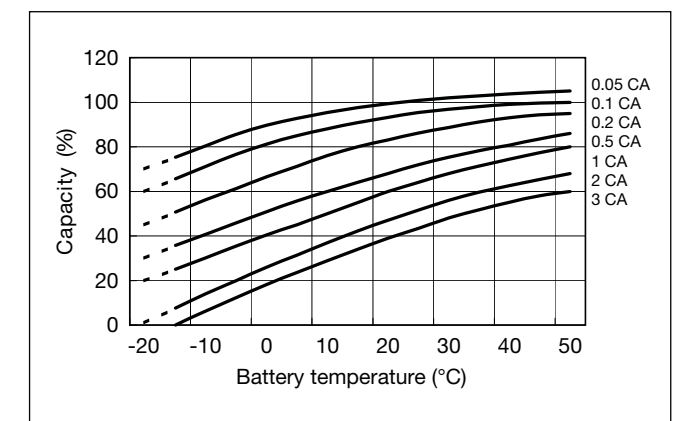
Residual capacity vs storage period



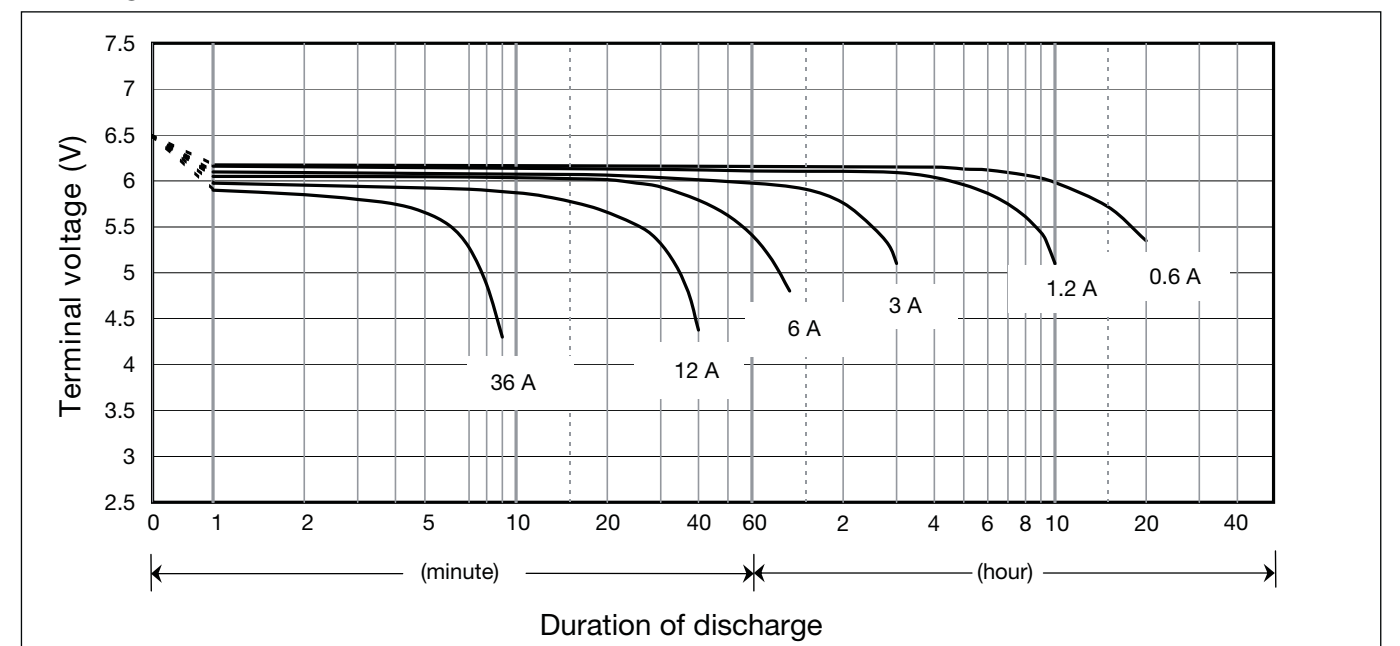
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

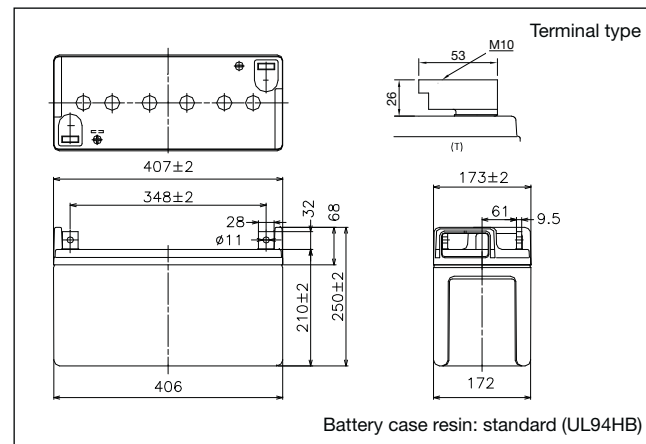


LC-X06200P*1



For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

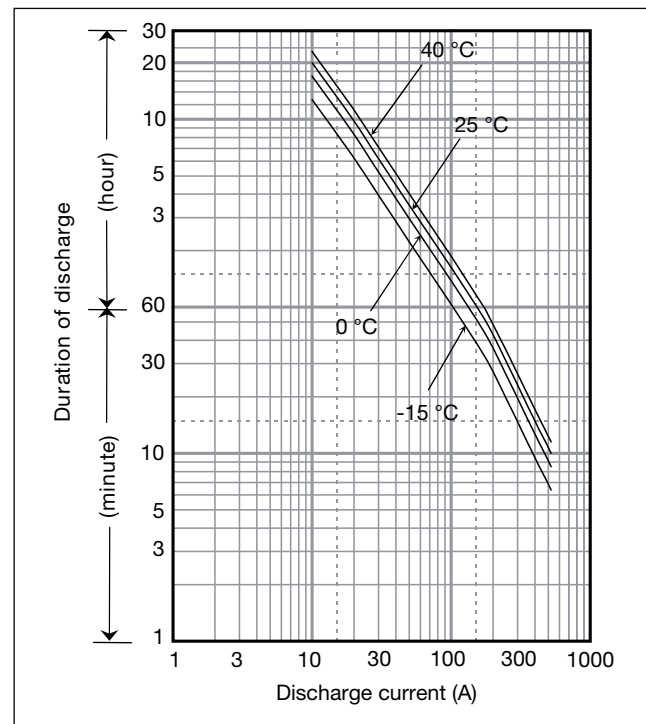
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	200Ah	
Dimensions	Length	407mm
	Width	173mm
	Height	210mm
	Total Height	250mm
Approx. mass	41kg	
Terminal	M10 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	200Ah 194Ah 184Ah 120Ah
Internal resistance	Fully charged battery (25°C)	2mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	2306	1834	1592	1206	892	733	582	430	281	226	170	154	88.3	47.0	38.5
4.95V	2254	1790	1554	1177	869	714	567	419	276	221	165	149	85.3	47.0	38.5
5.1V	2204	1726	1498	1139	877	694	551	413	272	216	160	145	84.3	46.5	38.0
5.25V	2134	1705	1487	1130	852	675	536	405	267	213	160	145	83.3	46.5	38.0
5.4V	1947	1624	1479	1094	840	666	528	395	262	208	155	150	82.3	45.5	37.2

Ampere Table

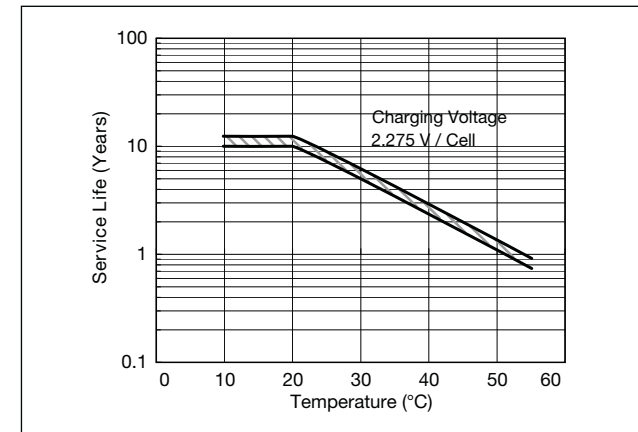
Cut-off V	(Ampere/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	530	402	348	260	184	153	104	82.6	55.4	42.8	37.2	31.2	19.8	10.0	8.4
4.95V	524	400	346	258	179	152	102	82.0	54.4	42.4	36.6	31.2	19.8	10.0	8.4
5.1V	522	398	342	254	178	151	101	81.0	54.0	42.0	36.0	31.0	19.6	10.0	8.4
5.25V	476	376	326	250	176	150	100	80.0	54.0	42.0	36.0	31.0	19.6	10.0	8.4
5.4V	452	364	318	246	152	130	90	76.0	51.6	41.0	35.6	30.0	19.4	9.8	8.4

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

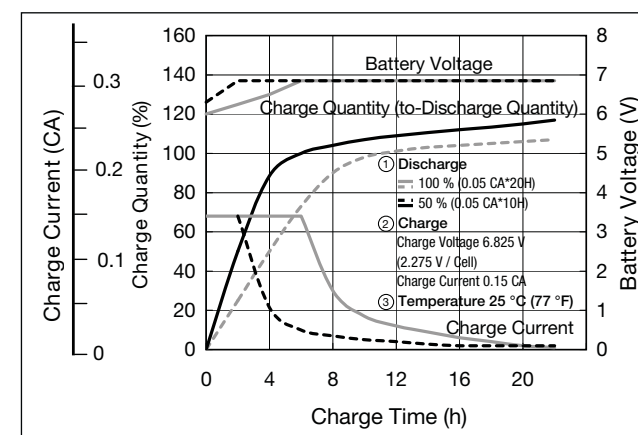
Charging Method

Trickle use	Control voltage: 6.8 - 6.9V; Initial current 30A or smaller
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Influence of Temperature on Trickle life



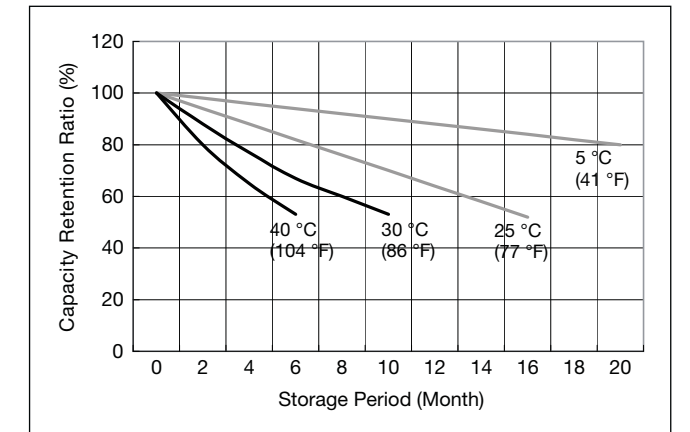
Constant-voltage and constant-current charge characteristics for Trickle use



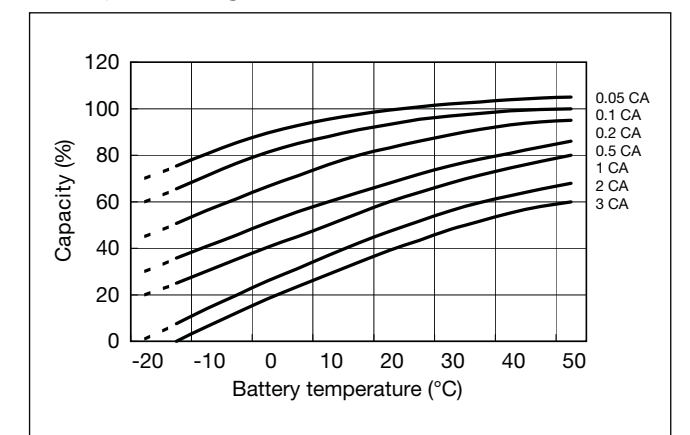
Cut off voltage

Discharge current	10A - 40A	40A - 100A	100A - 200A	200A - 400A	400A - 600A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

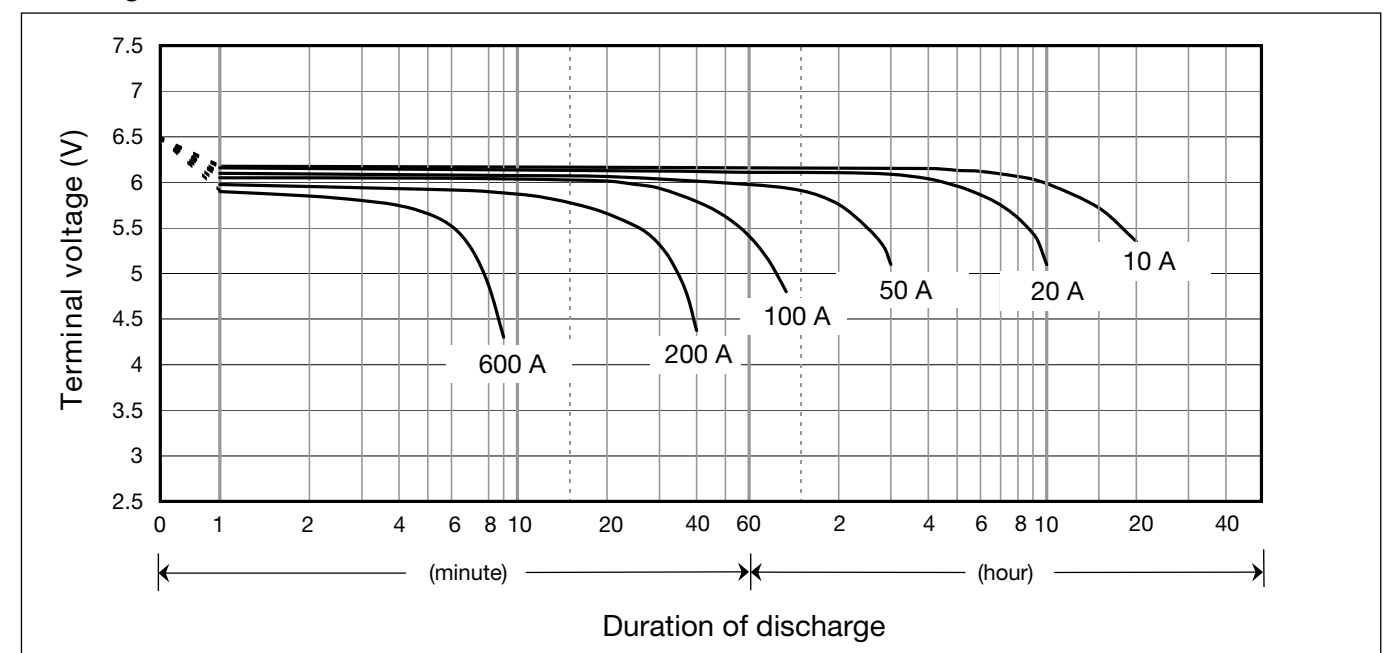
Residual capacity vs storage period



Discharge capacity by temperature and by discharge current



Discharge characteristics

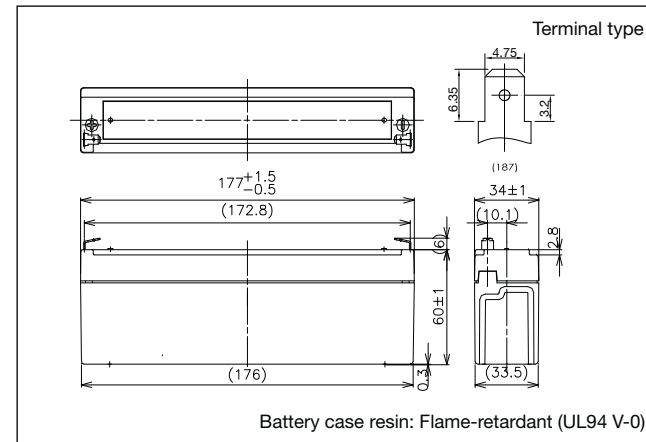


LC-P122R2P



For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

Dimensions (mm)



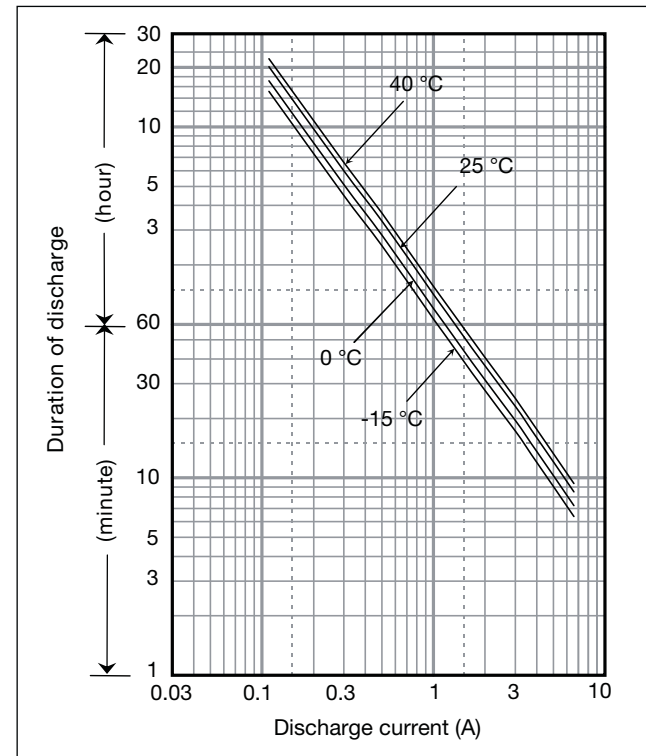
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	2.2Ah	
Dimensions	Length	177mm
	Width	34mm
	Height	60mm
	Total Height	66mm
Approx. mass	0.8kg	
Terminal	Faston 187	

Characteristics

Capacity (25°C)	20 hour rate	2.2Ah
	10 hour rate	2.0Ah
	5 hour rate	1.8Ah
	1 hour rate	1.3Ah
Internal resistance	Fully charged battery (25°C)	70mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	132	104	68.1	52.0	43.6	32.5	23.0	18.4	12.6	9.77	7.27	5.59	4.61	3.71	2.46	1.33	1.11
9.9V	123	97.8	66.7	51.7	42.9	32.2	22.8	18.4	12.4	9.70	7.24	5.55	4.58	3.69	2.45	1.33	1.11
10.2V	113	91.6	65.0	50.6	42.2	31.8	22.6	18.0	12.1	9.44	7.16	5.51	4.54	3.66	2.42	1.32	1.10
10.5V	101	82.1	60.2	47.1	40.1	31.1	22.2	17.6	11.9	9.12	7.05	5.48	4.50	3.62	2.41	1.32	1.10
10.8V	85	72.6	53.7	43.9	39.0	30.0	21.9	17.3	11.5	8.68	6.91	5.40	4.39	3.56	2.38	1.31	1.09

Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	11.9	9.35	6.08	4.52	3.76	2.78	1.96	1.56	1.07	0.825	0.611	0.468	0.385	0.309	0.205	0.111	0.0926
9.9V	11.0	8.77	5.96	4.49	3.70	2.75	1.94	1.56	1.05	0.819	0.608	0.464	0.382	0.308	0.204	0.111	0.0923
10.2V	10.2	8.22	5.81	4.40	3.64	2.72	1.93	1.53	1.03	0.798	0.602	0.461	0.379	0.306	0.202	0.110	0.0920
10.5V	9.0	7.36	5.38	4.09	3.45	2.66	1.89	1.50	1.01	0.770	0.593	0.458	0.376	0.302	0.201	0.110	0.0917
10.8V	7.6	6.51	4.80	3.82	3.36	2.57	1.86	1.47	0.98	0.733	0.581	0.452	0.367	0.297	0.199	0.109	0.0911

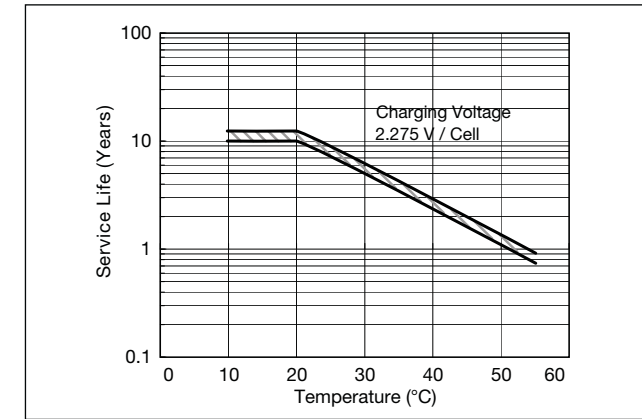
Charging Method

Trickle Use	Control voltage: 13.6 - 13.8V; Initial current: 0.33A or smaller
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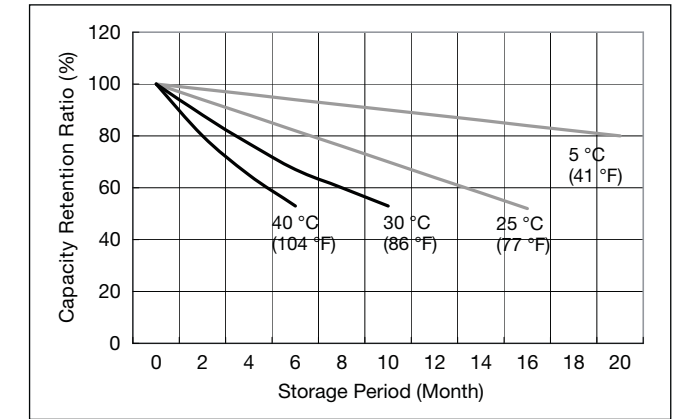
Cut off voltage

Discharge current	0.011A - 0.44A	0.44A - 1.1A	1.1A - 2.2A	2.2A - 4.4A	4.4A - 6.6A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

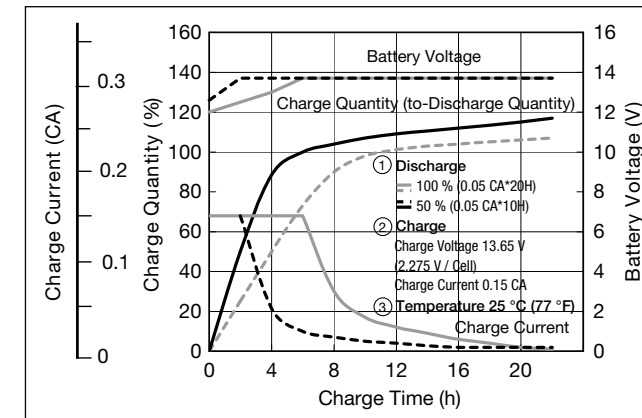
Influence of Temperature on Trickle life



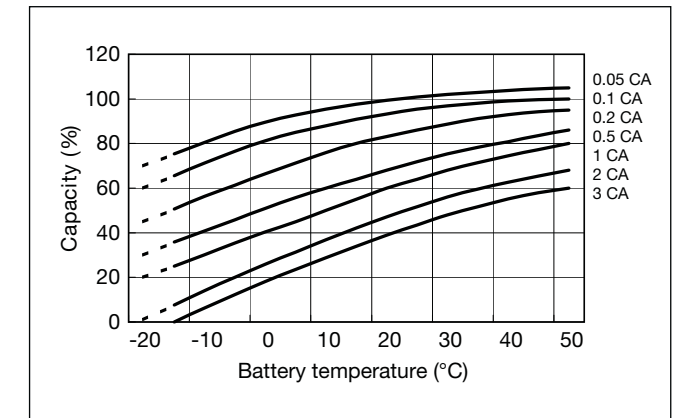
Residual capacity vs storage period



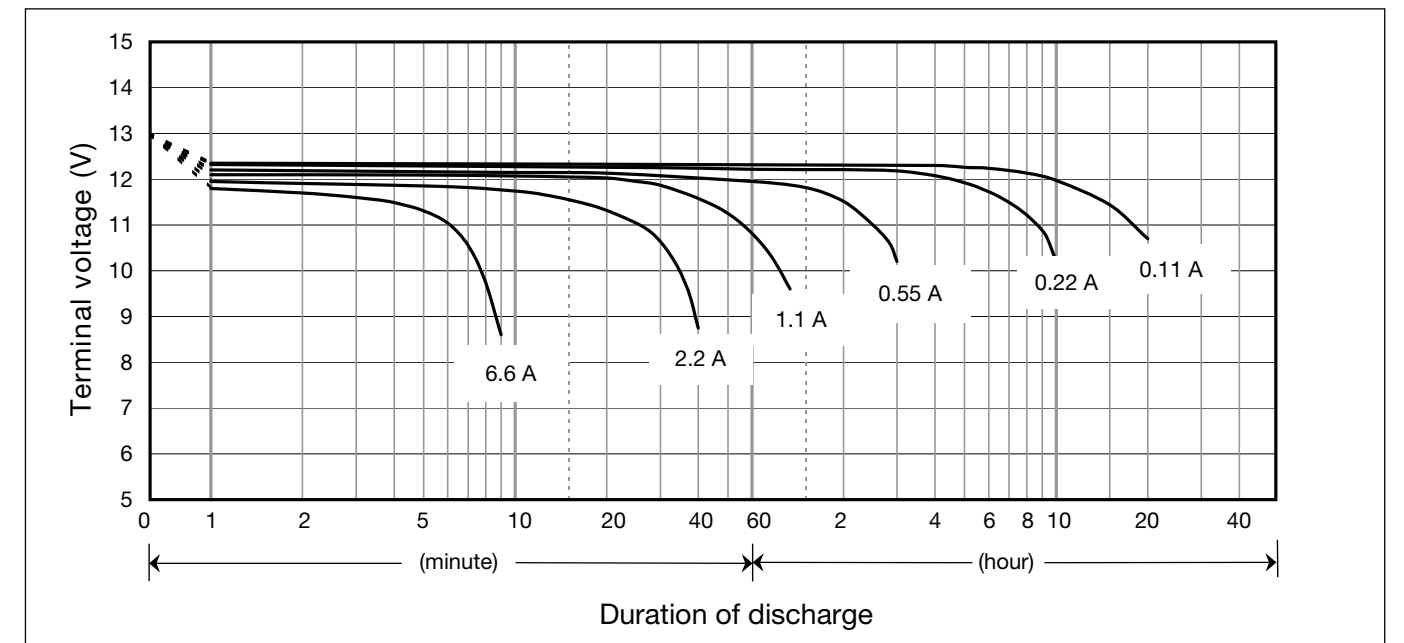
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

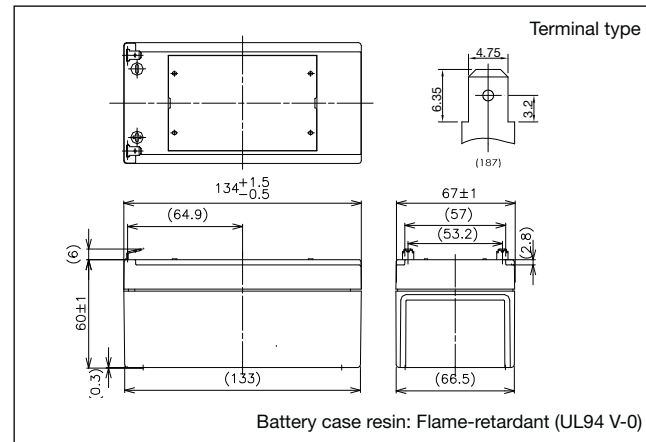


LC-P123R4P



For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

Dimensions (mm)



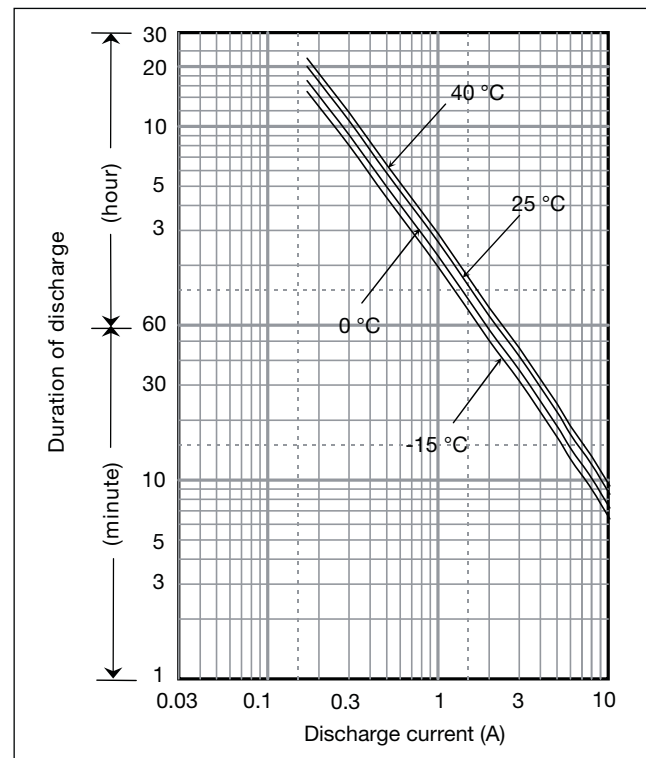
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	3.4Ah	
Dimensions	Length	134mm
	Width	67mm
	Height	60mm
	Total Height	66mm
Approx. mass	1.2kg	
Terminal	Faston 187	

Characteristics

Capacity (25°C)	20 hour rate	3.4Ah
	10 hour rate	3.0Ah
	5 hour rate	2.7Ah
	1 hour rate	2.1Ah
Internal resistance	Fully charged battery (25°C)	60mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	204	161	105	80.4	67.4	50.3	35.5	28.4	19.6	15.0	11.3	8.63	7.13	5.80	3.81	2.06	1.72
9.9V	190	151	103	79.8	66.3	49.7	35.3	28.4	19.2	14.9	11.2	8.58	7.07	5.78	3.80	2.05	1.71
10.2V	175	142	100	78.2	65.2	49.2	34.9	27.8	18.8	14.5	11.1	8.52	7.01	5.73	3.76	2.05	1.71
10.5V	155	127	93	72.8	61.9	48.1	34.4	27.3	18.4	14.0	11.0	8.46	6.96	5.66	3.74	2.04	1.70
10.8V	131	112	83	67.9	60.3	46.4	33.8	26.7	17.8	13.4	10.7	8.46	6.79	5.66	3.68	1.98	1.70

Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	18.4	14.4	9.40	6.99	5.81	4.30	3.02	2.41	1.66	1.26	0.949	0.722	0.595	0.484	0.318	0.171	0.143
9.9V	17.0	13.6	9.21	6.94	5.71	4.25	3.00	2.41	1.62	1.26	0.945	0.718	0.590	0.482	0.316	0.171	0.143
10.2V	15.7	12.7	8.97	6.80	5.62	4.20	2.97	2.36	1.59	1.22	0.935	0.713	0.586	0.478	0.313	0.170	0.142
10.5V	14.0	11.4	8.31	6.33	5.34	4.11	2.93	2.31	1.56	1.18	0.921	0.708	0.581	0.472	0.312	0.170	0.142
10.8V	11.8	10.1	7.41	5.90	5.19	3.97	2.88	2.27	1.51	1.13	0.897	0.708	0.567	0.472	0.307	0.165	0.142

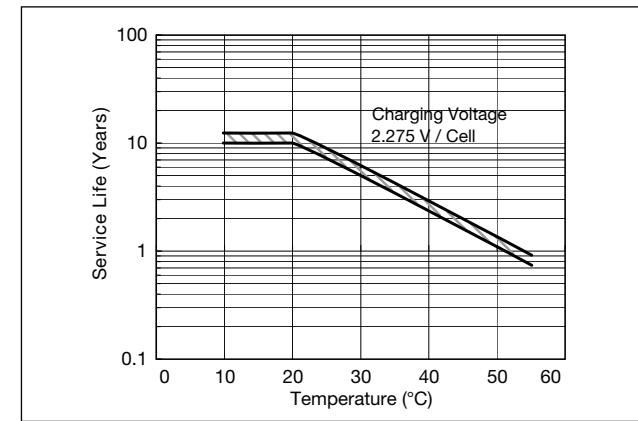
Charging Method

Trickle Use	Control voltage: 13.6 - 13.8V; Initial current: 0.51A or smaller
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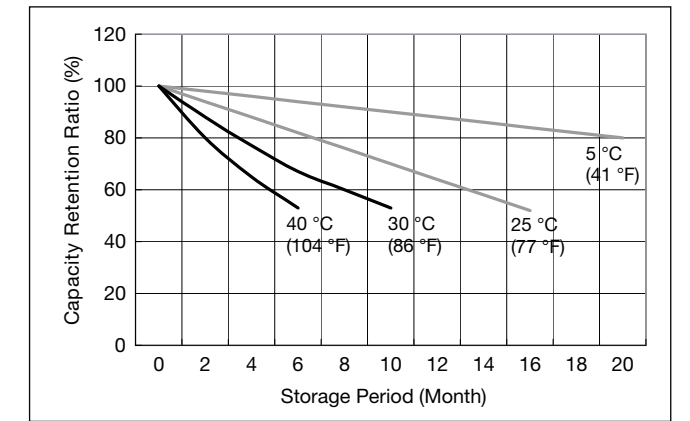
Cut off voltage

Discharge current	0.17A - 0.68A	0.68A - 1.7A	1.7A - 3.4A	3.4A - 6.8A	6.8A - 10.2A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

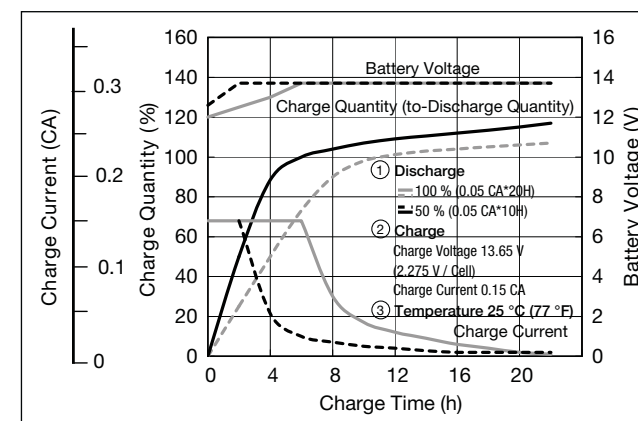
Influence of Temperature on Trickle life



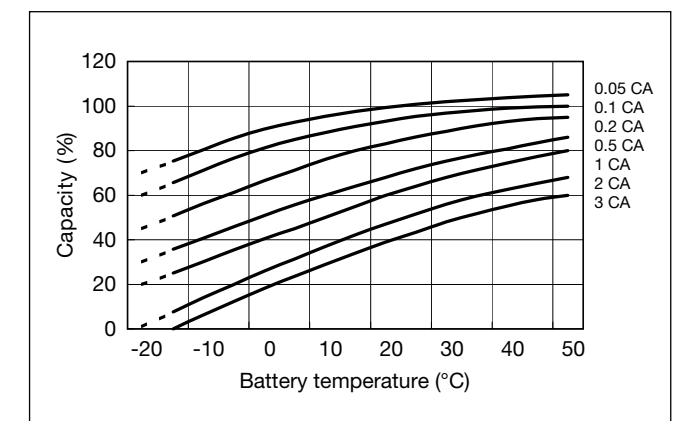
Residual capacity vs storage period



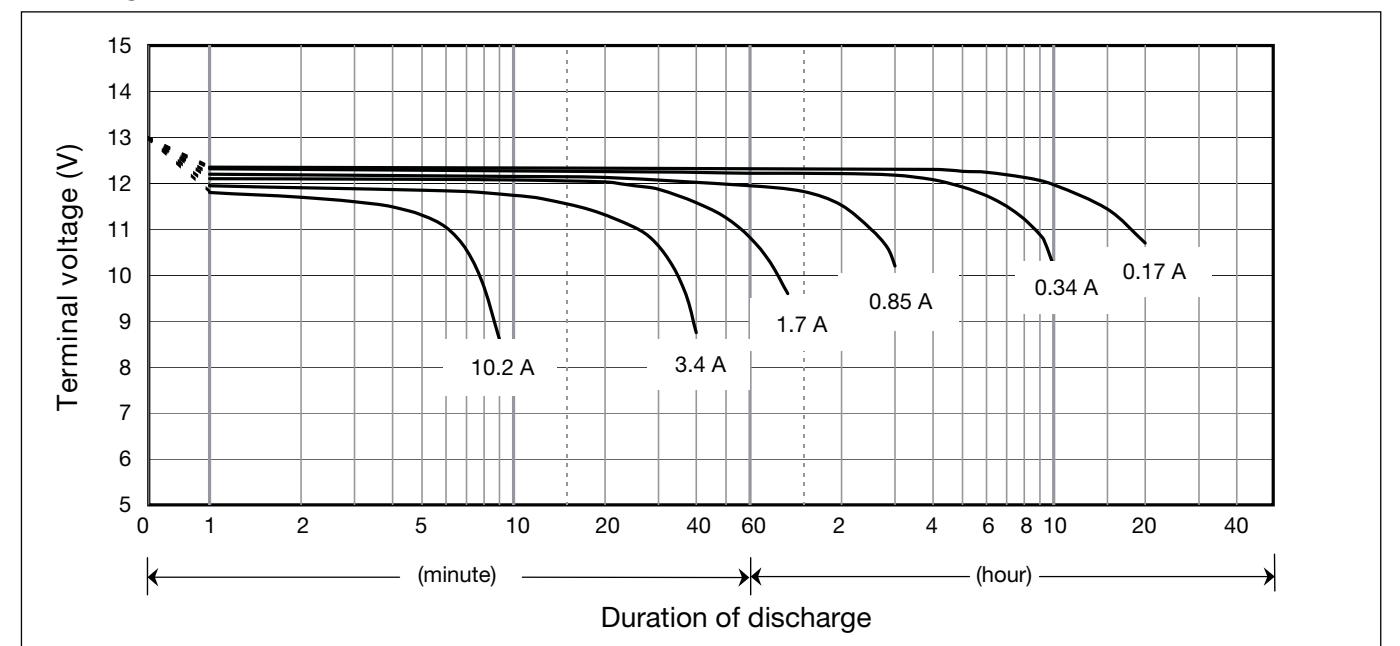
Constant-voltage and constant-current charge characteristics for Trickle use



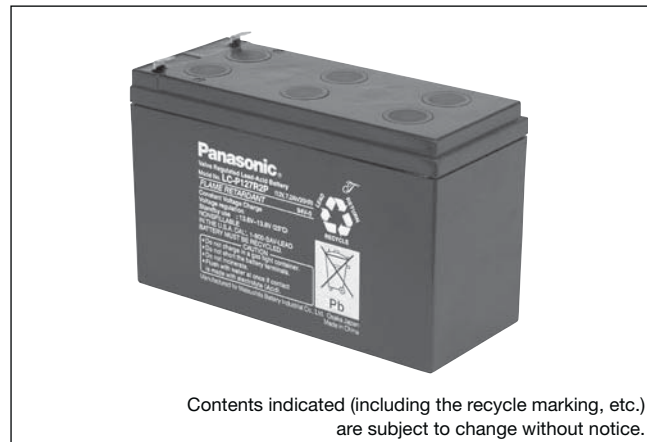
Discharge capacity by temperature and by discharge current



Discharge characteristics



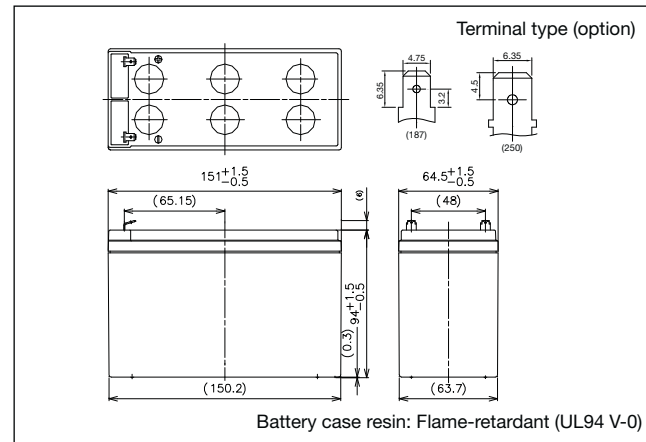
LC-P127R2P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

Dimensions (mm)



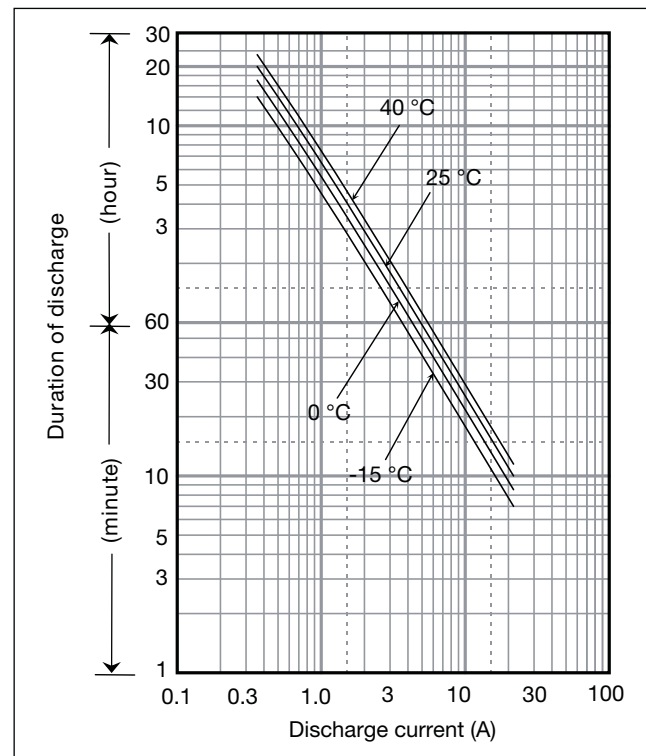
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	7.2Ah	
Dimensions	Length	151mm
	Width	64.5mm
	Height	94mm
	Total Height	100mm
Approx. mass	2.5kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	7.2Ah
	10 hour rate	6.8Ah
	5 hour rate	6.3Ah
	1 hour rate	4.9Ah
Internal resistance	Fully charged battery (25°C)	21mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	433	341	223	170	143	106	75.1	60.1	41.3	32.0	23.8	18.3	15.1	12.1	8.04	4.36	3.64							
9.9V	401	320	218	169	140	105	74.7	60.1	40.5	31.7	23.7	18.2	15.0	12.1	8.00	4.34	3.62							
10.2V	370	300	213	166	138	104	74.0	58.9	39.7	30.9	23.4	18.0	14.9	12.0	7.92	4.33	3.61							
10.5V	329	269	197	154	131	102	72.8	57.7	38.9	29.8	23.1	17.9	14.7	11.8	7.88	4.32	3.60							
10.8V	278	237	176	144	128	98	71.6	56.5	37.8	28.4	22.6	17.7	14.4	11.7	7.80	4.30	3.58							

Ampere Table

Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	38.9	30.6	19.9	14.8	12.3	9.1	6.4	5.1	3.50	2.70	2.00	1.53	1.26	1.012	0.670	0.363	0.303							
9.9V	36.1	28.7	19.5	14.7	12.1	9.0	6.4	5.1	3.43	2.68	1.99	1.52	1.25	1.008	0.667	0.362	0.302							
10.2V	33.3	26.9	19.0	14.4	11.9	8.9	6.3	5.0	3.36	2.61	1.97	1.51	1.24	1.000	0.660	0.361	0.301							
10.5V	29.6	24.1	17.6	13.4	11.3	8.7	6.2	4.9	3.29	2.52	1.94	1.50	1.23	0.988	0.657	0.360	0.300							
10.8V	25.0	21.3	15.7	12.5	11.0	8.4	6.1	4.8	3.20	2.40	1.90	1.48	1.20	0.972	0.650	0.358	0.298							

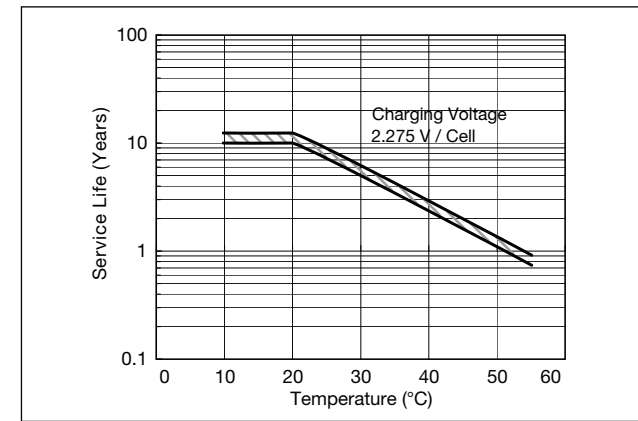
Charging Method

Trickle Use	Control voltage: 13.6 - 13.8V; Initial current: 1.08A or smaller
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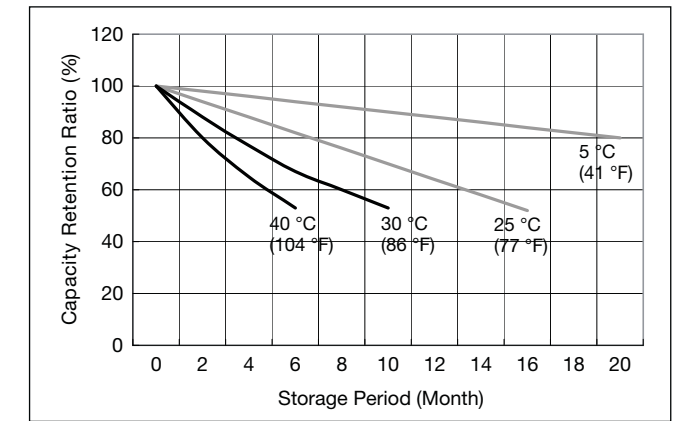
Cut off voltage

Discharge current	0.36A - 1.44A	1.44A - 3.6A	3.6A - 7.2A	7.2A - 14.4A	14.4A - 21.6A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

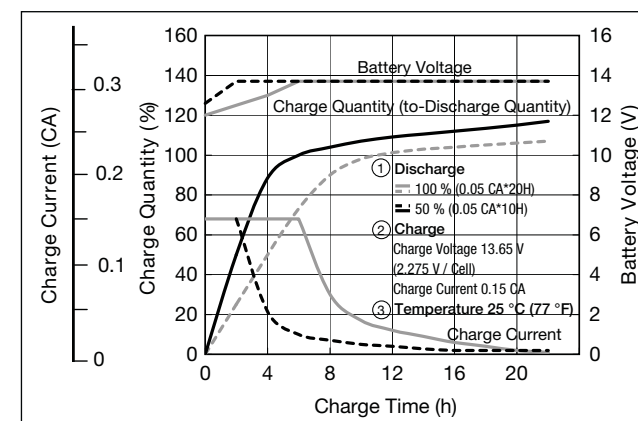
Influence of Temperature on Trickle life



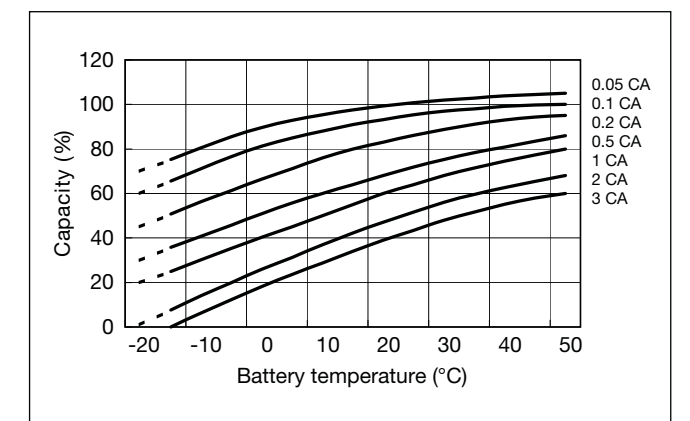
Residual capacity vs storage period



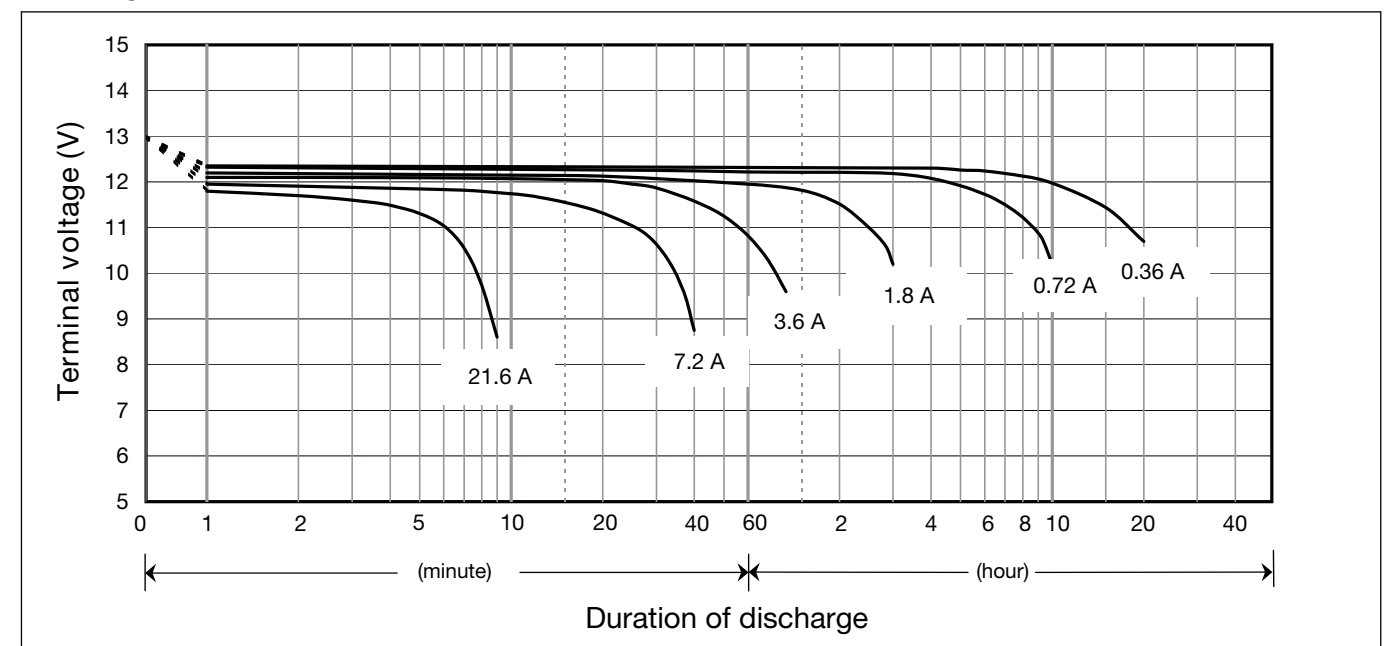
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

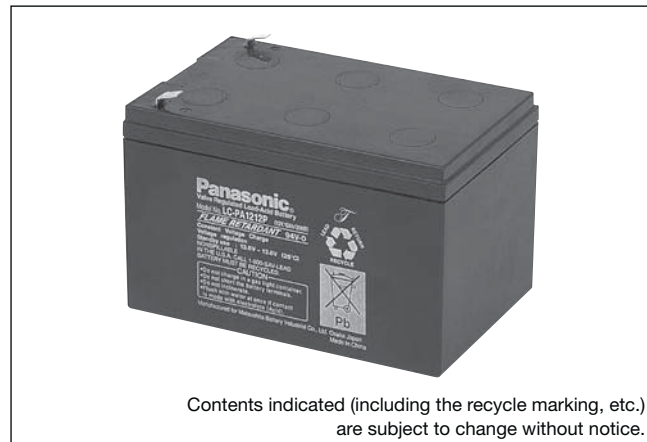


Discharge characteristics

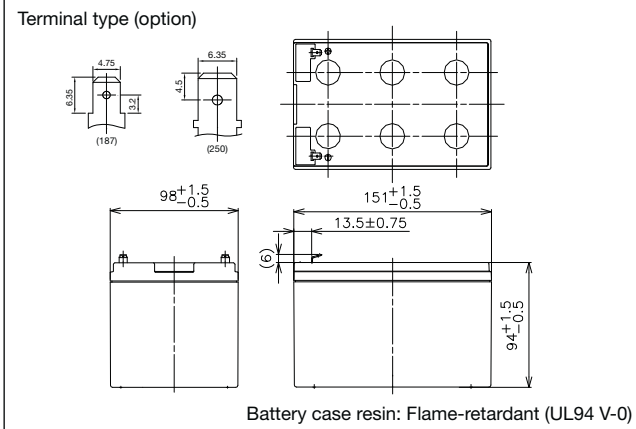


LC-PA1212P

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.



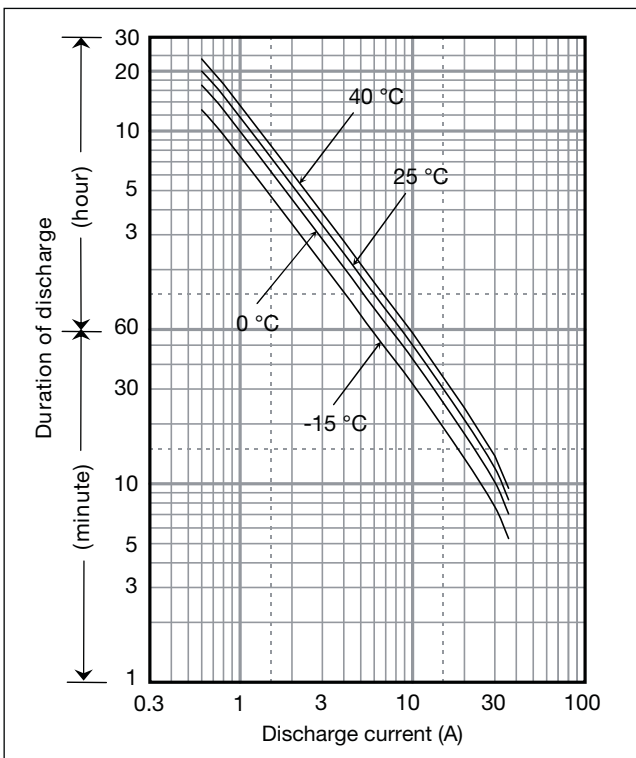
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	12Ah	
Dimensions	Length	151mm
	Width	98mm
	Height	94mm
	Total Height	100mm
Approx. mass	3.8kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	12.0Ah
	10 hour rate	11.3Ah
	5 hour rate	10.4Ah
	1 hour rate	8.1Ah
Internal resistance	Fully charged battery (25°C)	30mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	679	559	384	298	247	183	137	105	70.3	54.5	38.1	28.8	24.1	21.7	13.3	7.22	6.02	
9.9V	649	537	373	288	241	177	135	104	69.9	54.2	37.8	28.8	24.1	21.7	13.3	7.22	6.02	
10.2V	607	506	363	282	235	177	134	102	69.1	53.9	37.5	28.8	24.0	21.6	13.2	7.21	6.01	
10.5V	556	475	343	271	231	172	133	100	68.5	53.3	36.9	28.7	24.0	21.6	13.2	7.20	6.00	
10.8V	495	434	321	261	225	166	123	98	66.1	52.1	36.3	28.4	23.8	21.5	13.1	7.18	5.98	

Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	61.1	50.1	34.3	25.9	21.3	15.6	11.7	8.90	5.95	4.60	3.20	2.41	2.01	1.81	1.11	0.602	0.502	
9.9V	58.4	48.2	33.3	25.0	20.8	15.1	11.5	8.80	5.92	4.58	3.18	2.41	2.01	1.81	1.11	0.602	0.502	
10.2V	54.6	45.4	32.4	24.5	20.3	15.1	11.4	8.70	5.85	4.55	3.15	2.41	2.00	1.80	1.10	0.601	0.501	
10.5V	50.0	42.6	30.6	23.6	19.9	14.7	11.3	8.50	5.80	4.50	3.10	2.40	2.00	1.80	1.10	0.600	0.500	
10.8V	44.5	38.9	28.7	22.7	19.4	14.2	10.5	8.30	5.60	4.40	3.05	2.38	1.99	1.79	1.09	0.598	0.498	

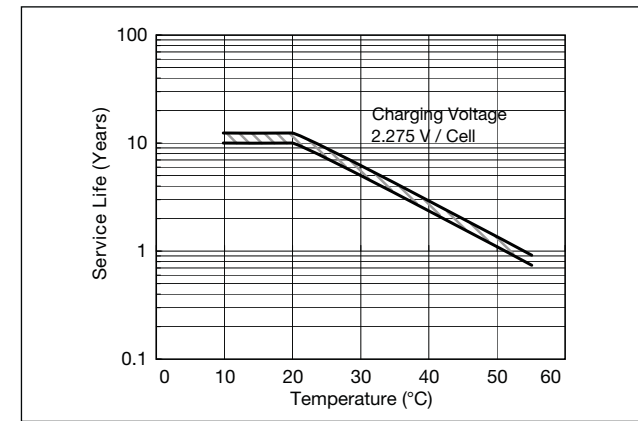
Charging Method

Trickle Use	Control voltage: 13.6 - 13.8V; Initial current: 1.8A or smaller
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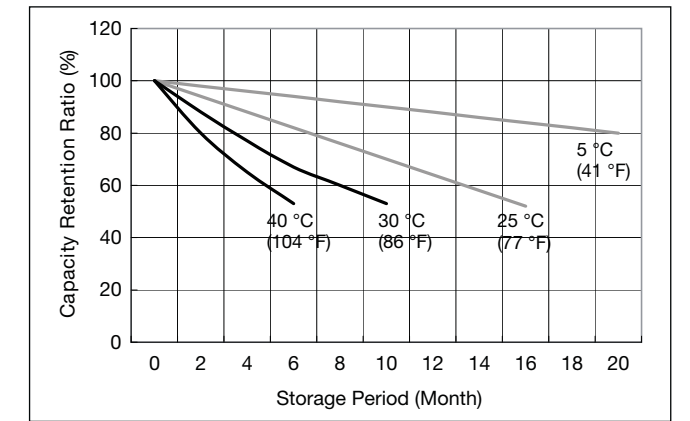
Cut off voltage

Discharge current	0.6A - 2.4A	2.4A - 6A	6A - 12A	12A - 24A	24A - 36A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

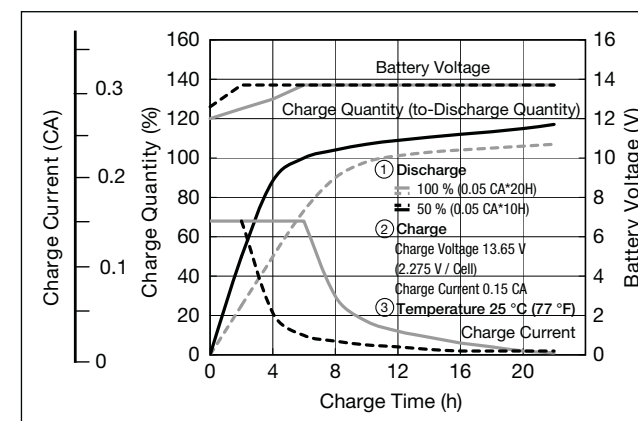
Influence of Temperature on Trickle life



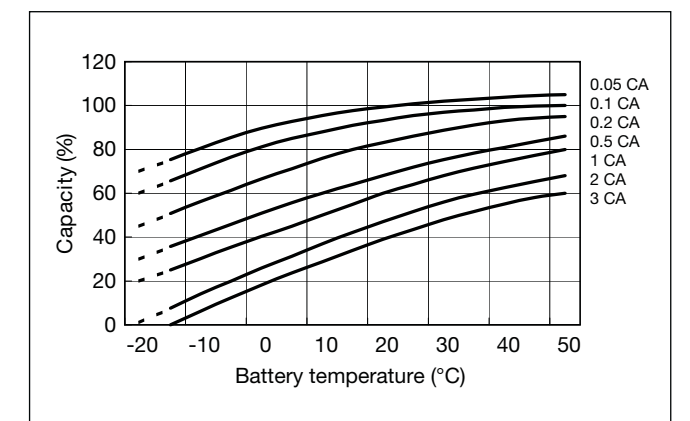
Residual capacity vs storage period



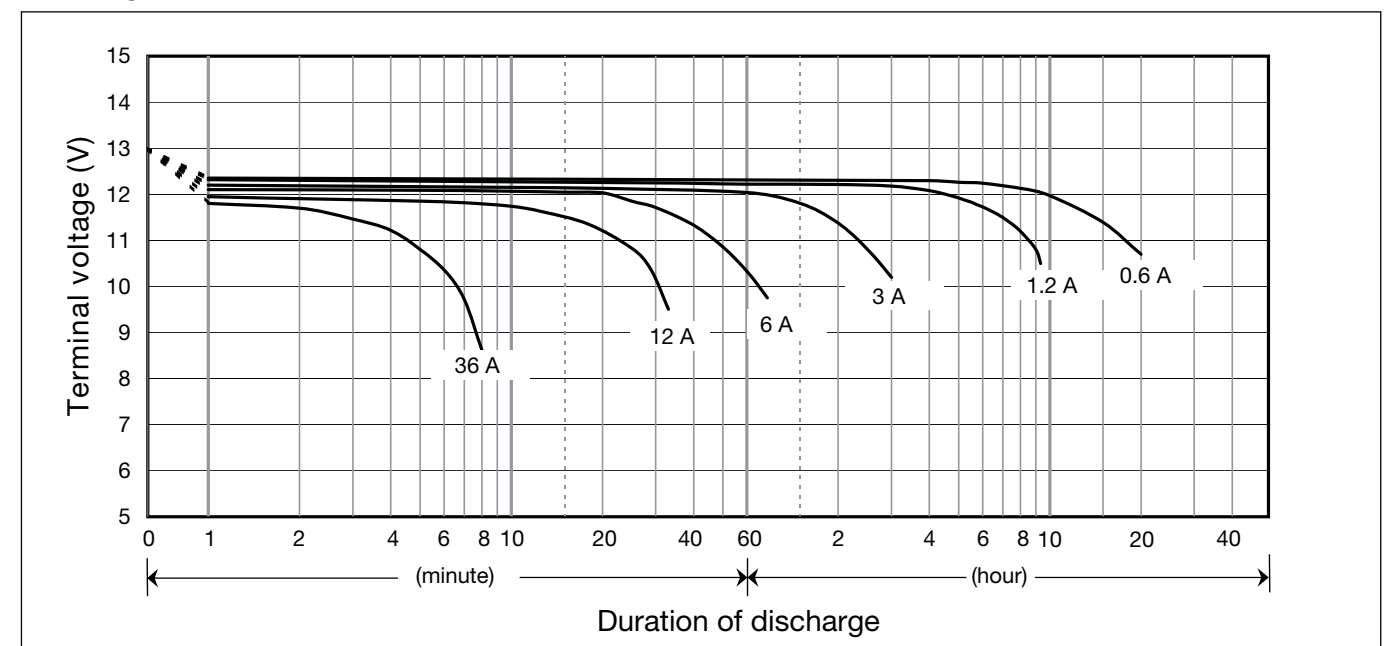
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics



LC-XD1217PG/APG

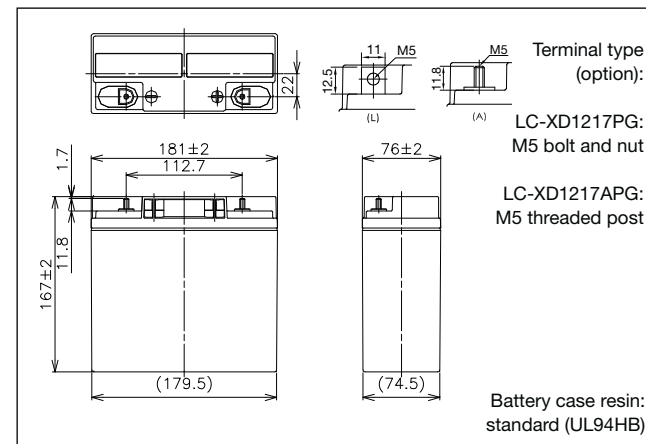
For standby power supplies. Expected trickle design life:
10 – 12 years at 20°C according to Eurobat.

VdS

G104101



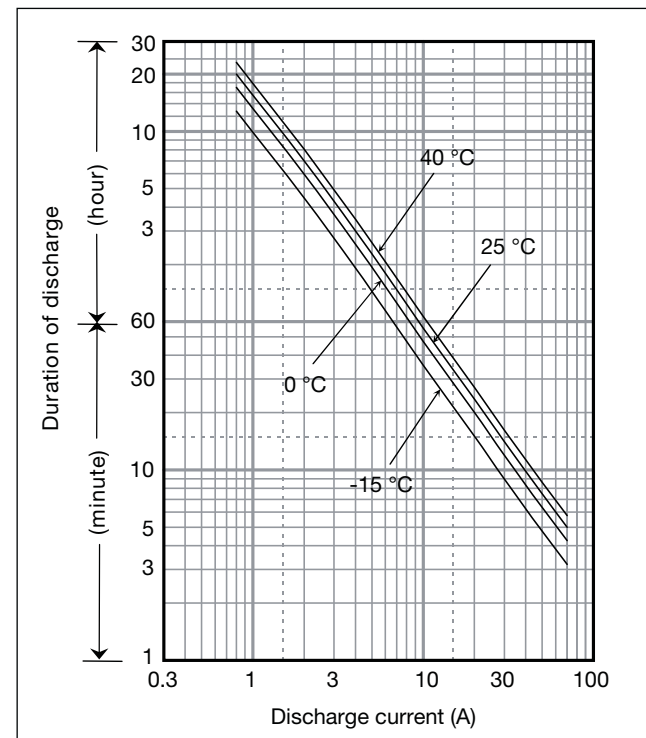
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	17Ah	
Dimensions	Length	181mm
	Width	76mm
	Height	167mm
	Total Height	167mm
Approx. mass	6.5kg	
Terminal	M5 Bolt and Nut type/ M5 threaded post	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	17Ah
	10 hour rate	15Ah
	5 hour rate	13Ah
	1 hour rate	10Ah
Internal resistance	Fully charged battery (25°C)	12mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	1021	806	526	402	337	251	177	142	97.6	75.5	56.2	43.2	35.6	28.6	19.0	10.3	8.58							
9.9V	948	756	516	399	331	249	176	142	95.6	74.9	55.9	42.9	35.4	28.5	18.9	10.3	8.56							
10.2V	874	708	502	391	326	246	175	139	93.7	73.0	55.4	42.6	35.1	28.3	18.7	10.2	8.53							
10.5V	777	634	465	364	309	240	172	136	91.7	70.4	54.5	42.3	34.8	28.0	18.6	10.2	8.50							
10.8V	656	561	415	339	301	232	169	134	89.2	67.1	53.4	41.8	33.9	27.5	18.4	10.1	8.44							

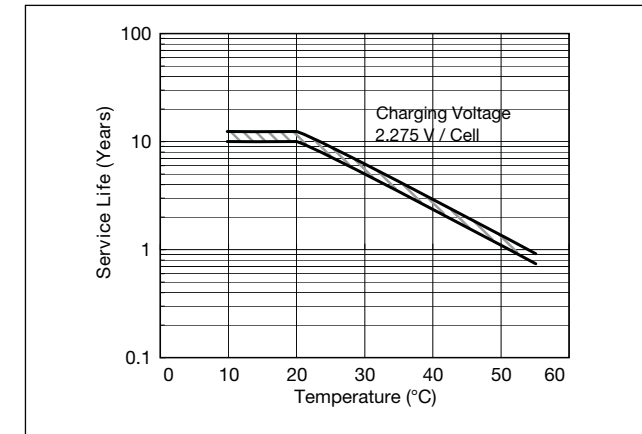
Ampere Table

Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	91.8	72.2	47.0	34.9	29.0	21.5	15.1	12.0	8.26	6.37	4.72	3.61	2.97	2.39	1.58	0.86	0.72							
9.9V	85.2	67.8	46.0	34.7	28.6	21.2	15.0	12.0	8.10	6.33	4.70	3.59	2.95	2.38	1.57	0.85	0.71							
10.2V	78.6	63.5	44.9	34.0	28.1	21.0	14.9	11.8	7.93	6.16	4.65	3.57	2.93	2.36	1.56	0.85	0.71							
10.5V	69.9	56.9	41.6	31.6	26.7	20.5	14.6	11.6	7.77	5.95	4.58	3.54	2.90	2.33	1.55	0.85	0.71							
10.8V	59.0	50.3	37.1	29.5	26.0	19.8	14.4	11.3	7.56	5.67	4.49	3.49	2.83	2.29	1.53	0.85	0.70							

Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 2.55A or smaller
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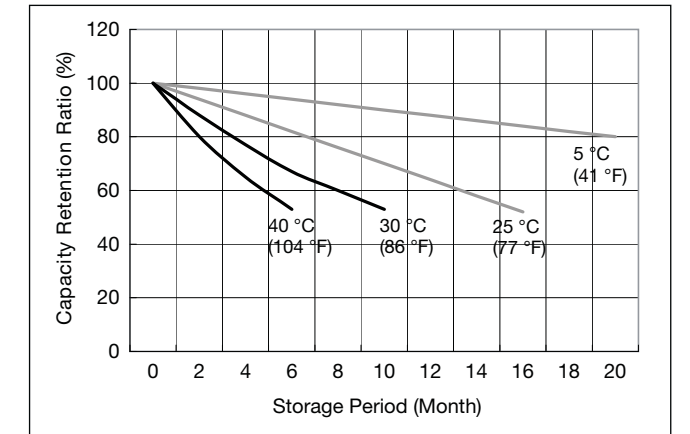
Influence of Temperature on Trickle life



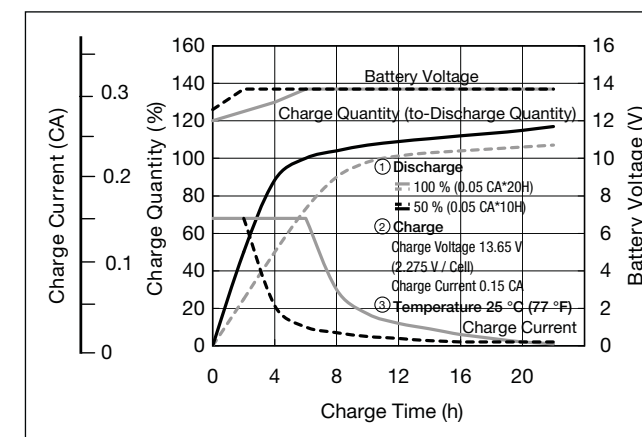
Cut off voltage

Discharge current	0.85A - 3.4A	3.4A - 8.5A	8.5A - 17A	17A - 34A	34A - 51A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

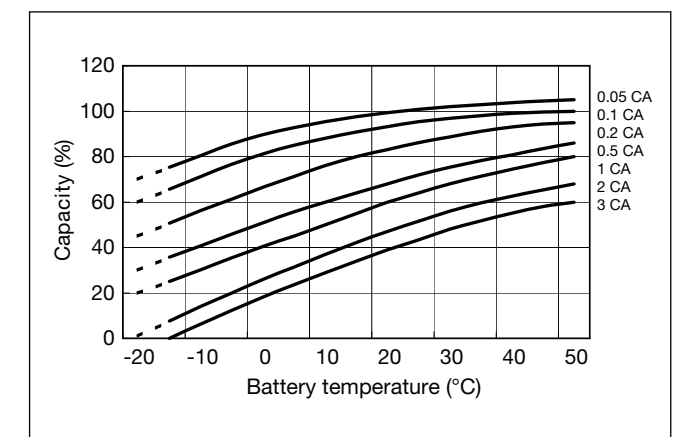
Residual capacity vs storage period



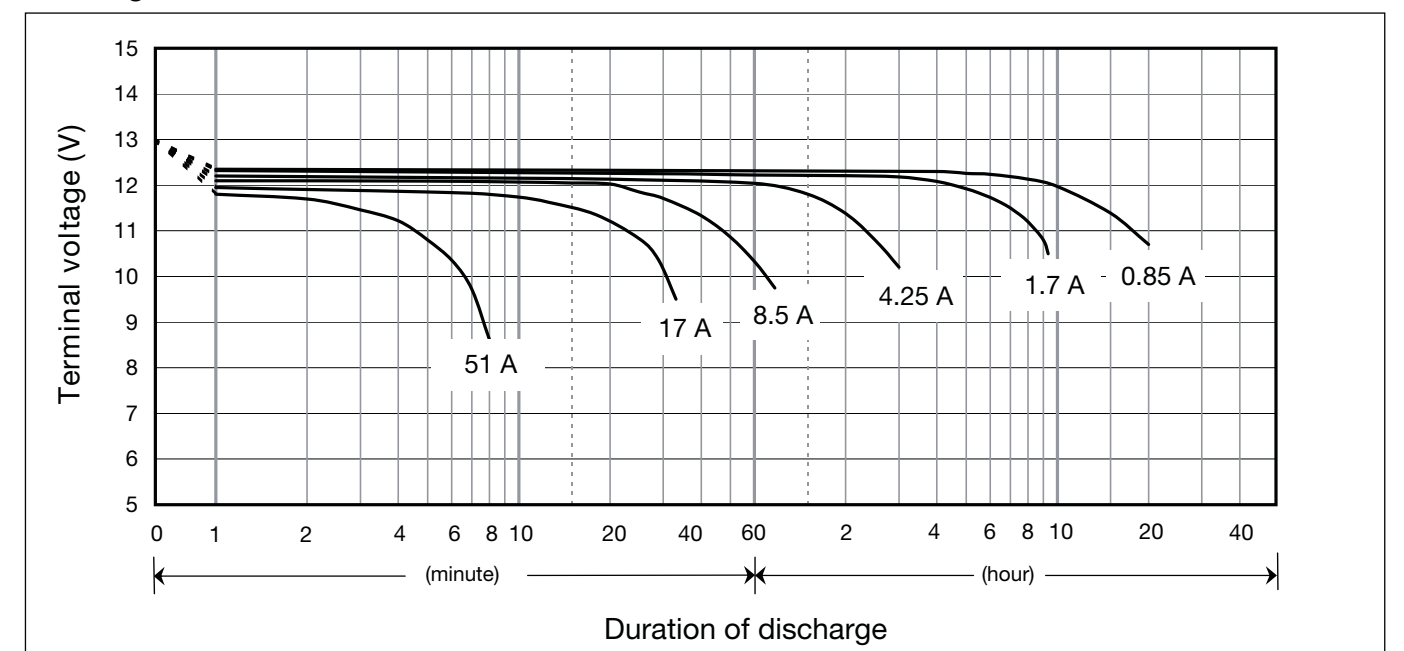
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

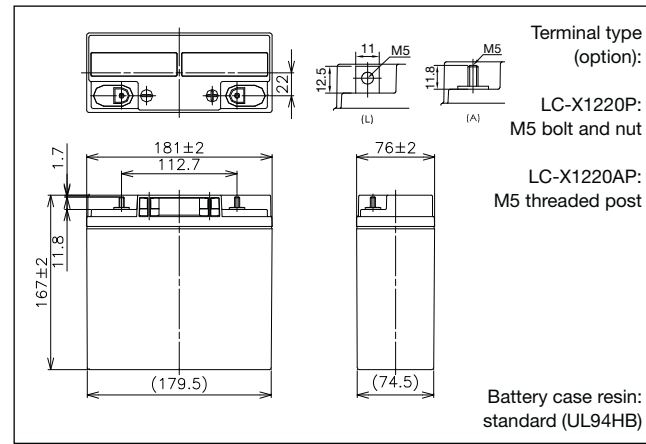


LC-X1220P/AP*1

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.



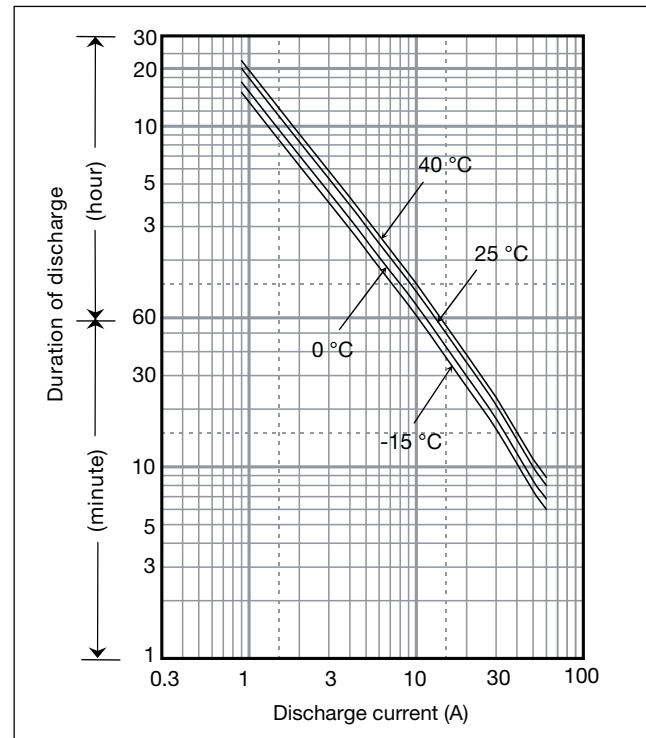
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	20Ah	
Dimensions	Length	181mm
	Width	76mm
	Height	167mm
	Total Height	167mm
Approx. mass	6.6kg	
Terminal	M5 Bolt and Nut type/ M5 threaded post	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	20Ah
	10 hour rate	18Ah
	5 hour rate	16Ah
	1 hour rate	12Ah
Internal resistance	Fully charged battery (25°C)	11mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1202	948	619	473	396	296	209	167	115	88.8	66.1	50.8	41.9	33.7	22.3	12.1	10.1
9.9V	1115	889	607	470	390	293	207	167	113	88.1	65.8	50.5	41.6	33.6	22.2	12.1	10.1
10.2V	1029	833	591	460	383	289	205	164	110	85.8	65.1	50.1	41.3	33.3	22.0	12.0	10.0
10.5V	914	746	548	428	364	283	202	160	108	82.9	64.1	49.8	40.9	32.9	21.9	12.0	10.0
10.8V	772	660	488	399	354	273	199	157	105	78.9	62.8	49.1	39.9	32.4	21.7	11.9	9.93

Ampere Table

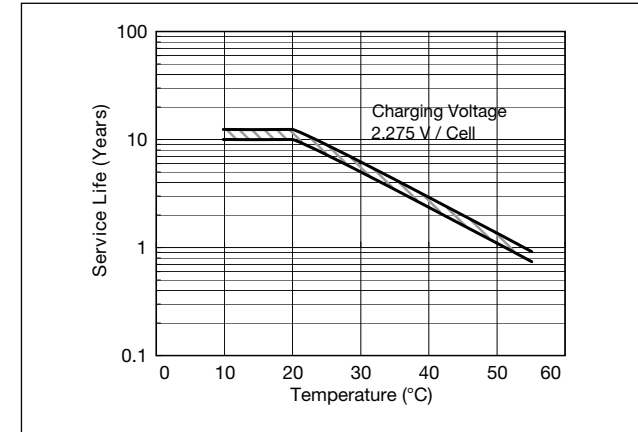
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	108	85.0	55.3	41.1	34.2	25.3	17.8	14.2	9.72	7.50	5.56	4.25	3.50	2.81	1.86	1.01	0.84
9.9V	100	79.7	54.2	40.8	33.6	25.0	17.7	14.2	9.53	7.44	5.53	4.22	3.47	2.80	1.85	1.01	0.84
10.2V	92.5	74.7	52.8	40.0	33.1	24.7	17.5	13.9	9.33	7.25	5.47	4.19	3.44	2.78	1.83	1.00	0.84
10.5V	82.2	66.9	48.9	37.2	31.4	24.2	17.2	13.6	9.14	7.00	5.39	4.17	3.42	2.74	1.83	1.00	0.83
10.8V	69.4	59.2	43.6	34.7	30.6	23.3	16.9	13.3	8.89	6.67	5.28	4.11	3.33	2.70	1.81	0.99	0.83

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use Control voltage: 13.6 - 13.8V; Initial current: 3A or smaller

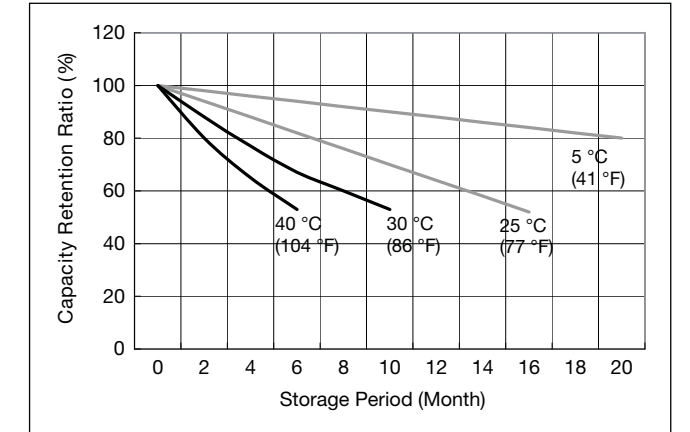
Influence of Temperature on Trickle life



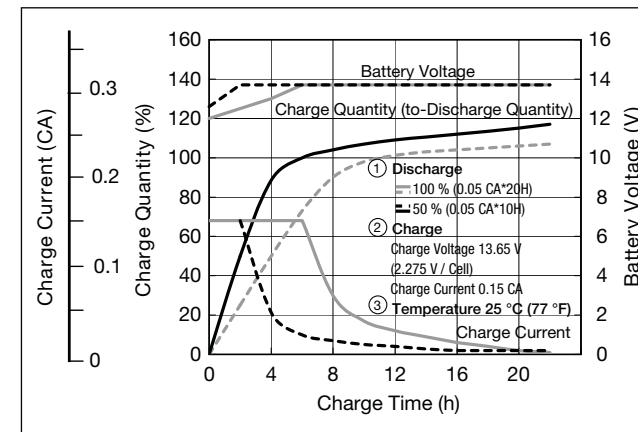
Cut off voltage

Discharge current	1A - 4A	4A - 10A	10A - 20A	20A - 40A	40A - 60A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

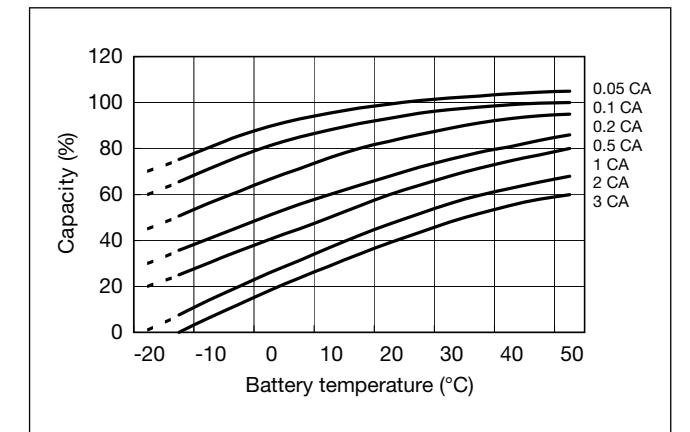
Residual capacity vs storage period



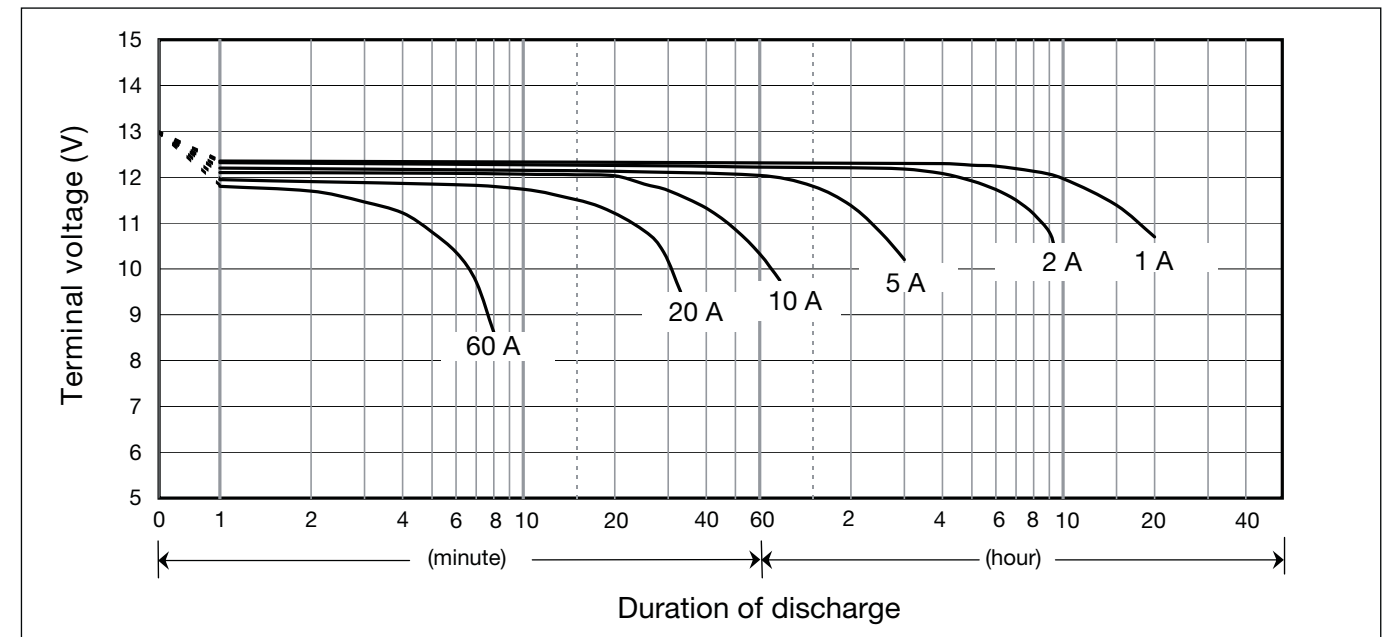
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

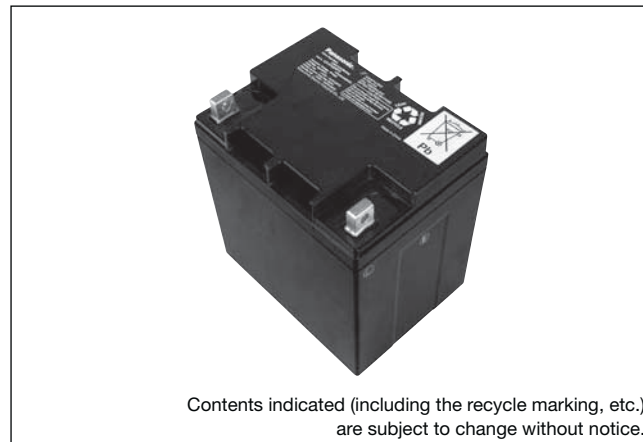


LC-X1224PG/APG

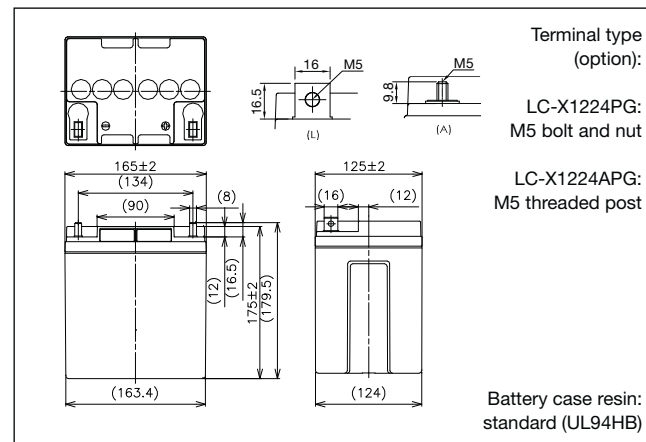
For standby power supplies. Expected trickle design life:
10 – 12 years at 20°C according to Eurobat.

VdS

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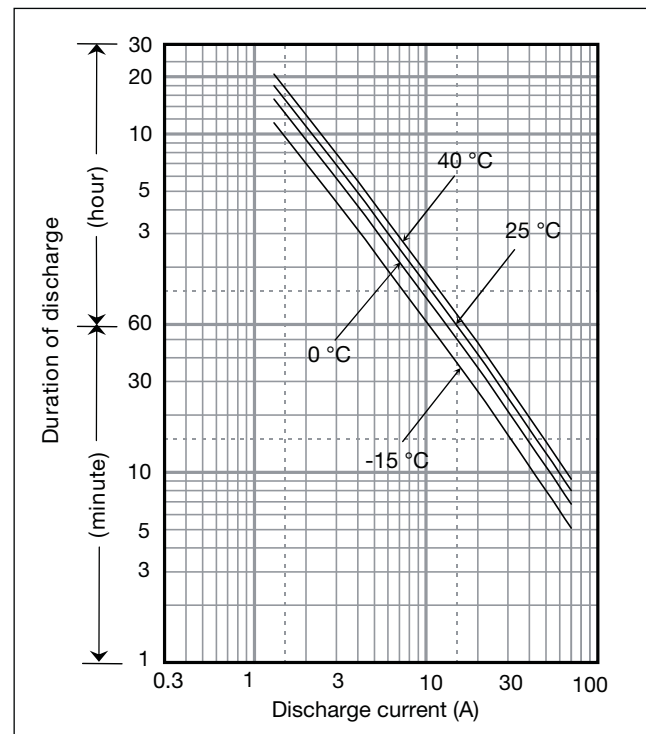
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	24Ah	
Dimensions	Length	165mm
	Width	125mm
	Height	175mm
	Total Height	LC-X1224PG: 179.5mm LC-X1224APG: 175mm
Approx. mass	9kg	
Terminal	M5 Bolt and Nut type/ M5 threaded post	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	24Ah
	10 hour rate	22Ah
	5 hour rate	19Ah
	1 hour rate	14Ah
Internal resistance	Fully charged battery (25°C)	11mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1290	992	739	523	441	317	234	183	118	104	73.8	58.6	47.9	40.8	26.4	14.6	12.0
9.9V	1197	931	724	520	434	314	232	183	116	103	73.4	58.2	47.5	40.6	26.3	14.6	12.0
10.2V	1104	872	706	509	426	310	230	179	113	101	72.7	57.8	47.2	40.3	26.0	14.6	11.9
10.5V	982	782	654	474	405	303	226	175	111	97.2	71.6	57.4	46.8	39.8	25.9	14.4	11.9
10.8V	829	691	583	442	394	293	223	172	108	92.6	70.1	56.6	45.6	39.2	25.6	14.3	11.8

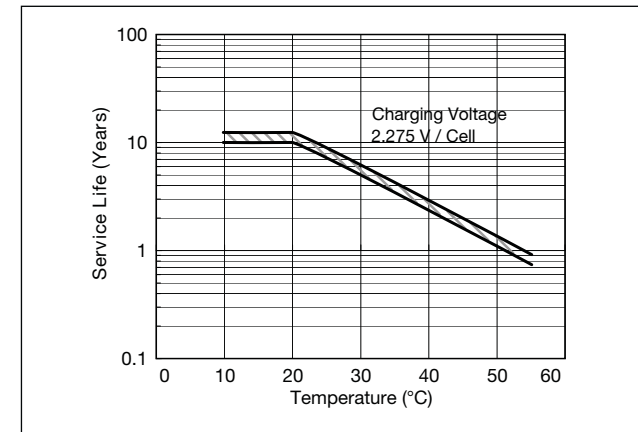
Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	116	89.0	66.0	45.5	38.0	27.1	19.9	15.5	10.0	8.80	6.20	4.90	4.00	3.40	2.20	1.22	1.00
9.9V	108	83.5	64.7	45.2	37.4	26.8	19.8	15.5	9.80	8.73	6.17	4.87	3.97	3.39	2.19	1.22	1.00
10.2V	99.3	78.2	63.0	44.3	36.8	26.5	19.6	15.2	9.60	8.51	6.11	4.84	3.94	3.36	2.17	1.21	0.99
10.5V	88.3	70.1	58.4	41.2	34.9	25.9	19.3	14.9	9.40	8.21	6.01	4.80	3.90	3.32	2.16	1.20	0.99
10.8V	74.6	62.0	52.1	38.4	34.0	25.0	19.0	14.6	9.14	7.82	5.89	4.74	3.81	3.27	2.13	1.19	0.98

Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 3.6A or smaller
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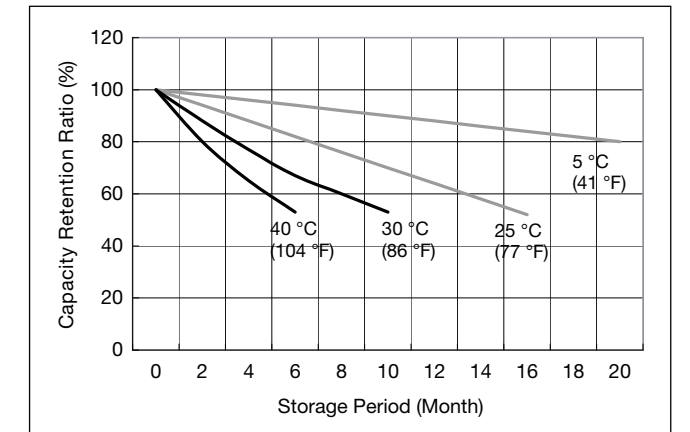
Influence of Temperature on Trickle life



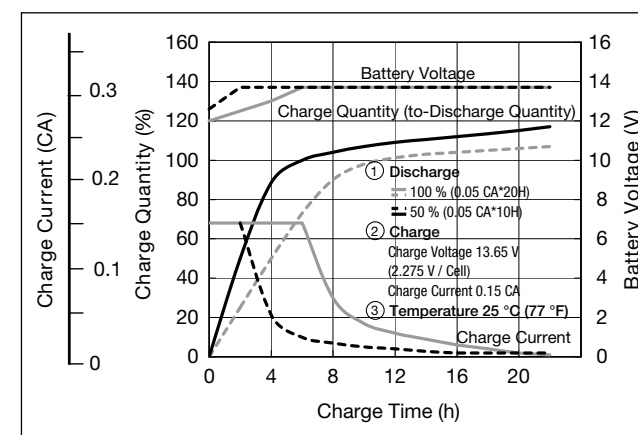
Cut off voltage

Discharge current	1.2A - 4.8A	4.8A - 12A	12A - 24A	24A - 48A	48A - 72A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

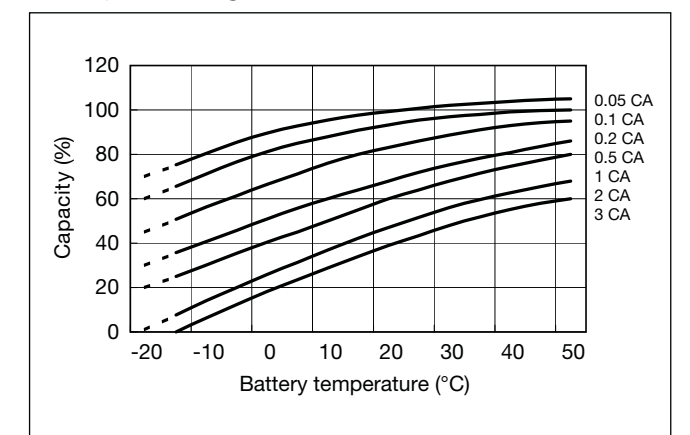
Residual capacity vs storage period



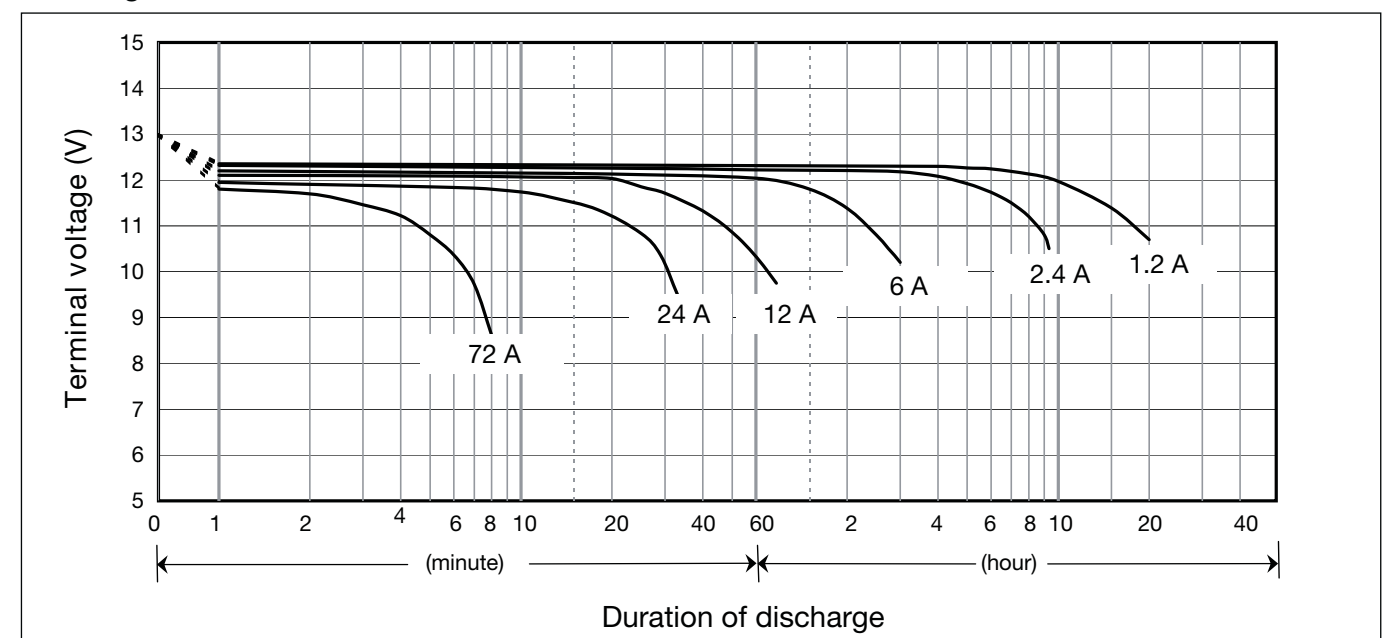
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

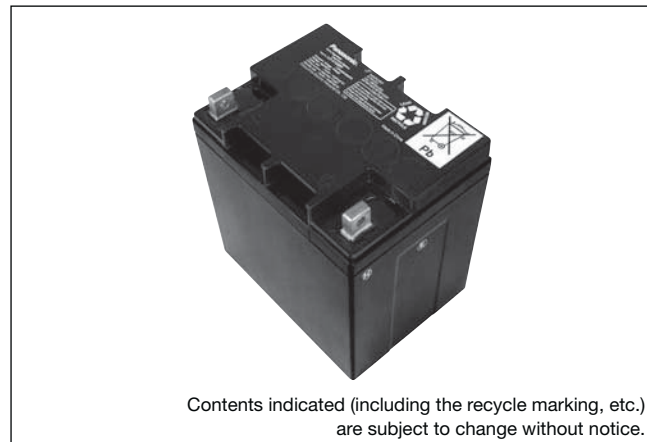


Discharge characteristics

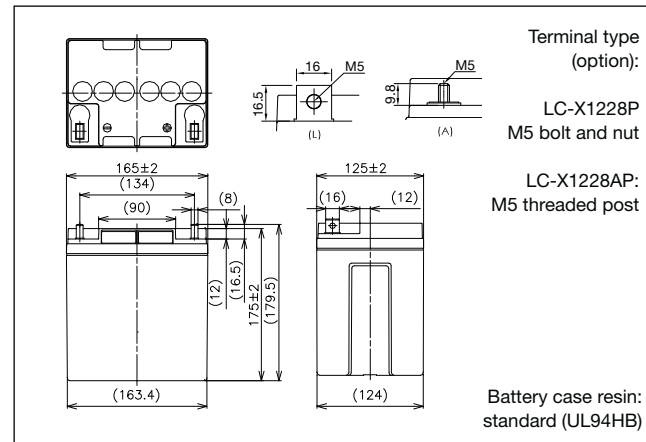


LC-X1228P/AP*1

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.



Dimensions (mm)



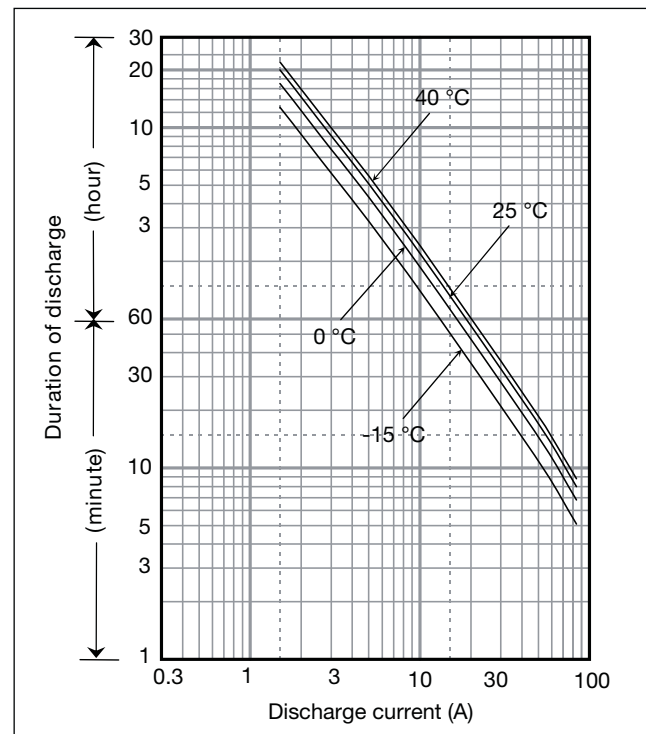
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	28Ah	
Dimensions	Length	165mm
	Width	125mm
	Height	175mm
	Total Height	LC-X1228P: 179.5mm LC-X1228AP: 175mm
Approx. mass	11kg	
Terminal	M5 Bolt and Nut type/ M5 threaded post	

Characteristics

Capacity (25°C)	20 hour rate	28.0Ah
	10 hour rate	26.5Ah
	5 hour rate	25.0Ah
	1 hour rate	21.0Ah
Internal resistance	Fully charged battery (25°C)	8mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1423	1160	865	664	585	410	304	260	159	129	91.6	74.1	61.1	40.8	31.8	16.8	14.0
9.9V	1357	1093	849	654	579	404	294	254	156	128	90.4	72.9	59.9	51.6	31.8	16.8	14.0
10.2V	1301	1026	818	643	567	397	294	251	155	127	89.3	71.7	59.9	51.6	31.8	16.8	14.0
10.5V	1201	976	784	621	545	386	282	247	154	126	88.1	71.7	59.9	51.6	31.8	16.8	14.0
10.8V	1052	903	773	610	539	374	255	218	149	118	84.5	70.5	59.9	50.4	31.8	16.8	13.9

Ampere Table

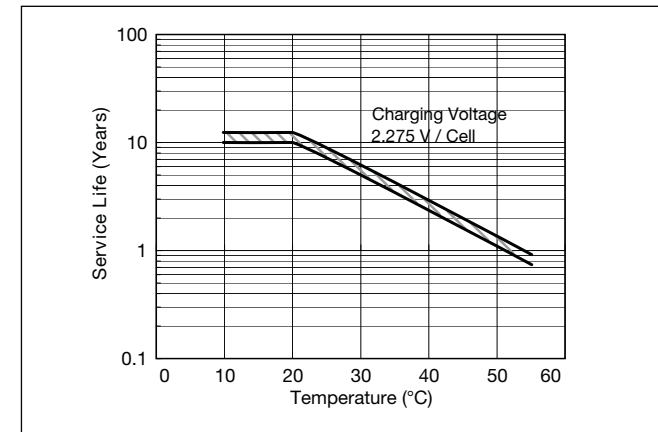
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	128	104	77.2	57.7	50.4	35.0	25.9	22.1	13.5	10.9	7.7	6.2	5.1	3.4	2.65	1.40	1.17
9.9V	122	98.0	75.8	56.9	49.9	34.5	25.0	21.6	13.2	10.8	7.6	6.1	5.0	4.3	2.65	1.40	1.17
10.2V	117	92.0	73.0	55.9	48.9	33.9	25.0	21.3	13.1	10.7	7.5	6.0	5.0	4.3	2.65	1.40	1.17
10.5V	108	87.5	70.0	54.0	47.0	33.0	24.0	21.0	13.0	10.6	7.4	6.0	5.0	4.3	2.70	1.40	1.17
10.8V	94.6	81.0	69.0	53.0	46.5	32.0	21.7	18.5	12.6	10.0	7.1	5.9	5.0	4.2	2.65	1.40	1.16

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 4.2A or smaller
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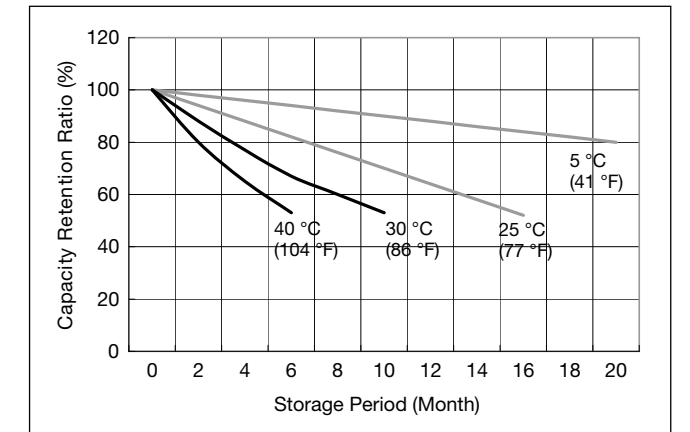
Influence of Temperature on Trickle life



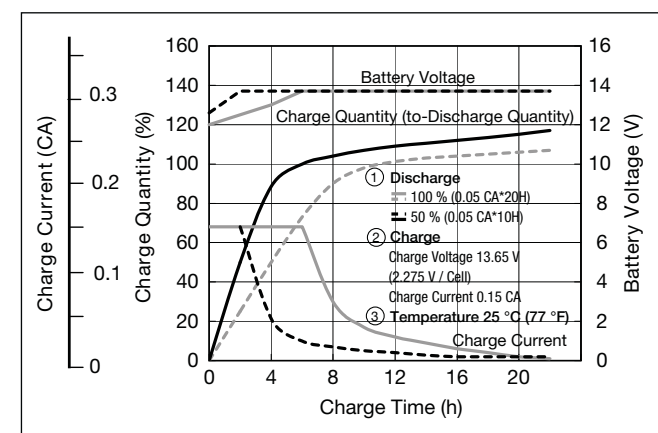
Cut off voltage

Discharge current	1.4A - 5.6A	5.6A - 14A	14A - 28A	28A - 56A	56A - 84A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

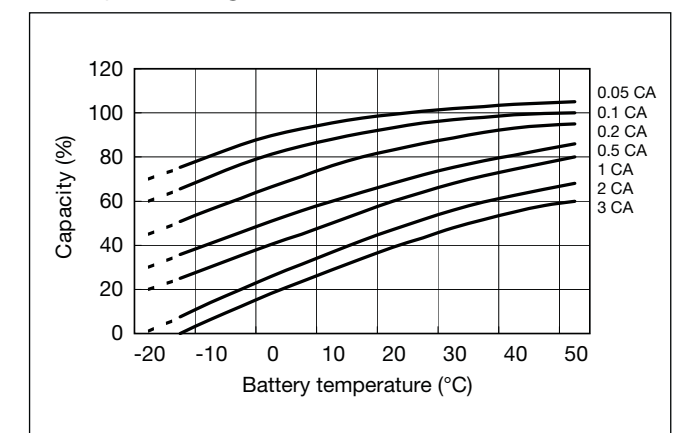
Residual capacity vs storage period



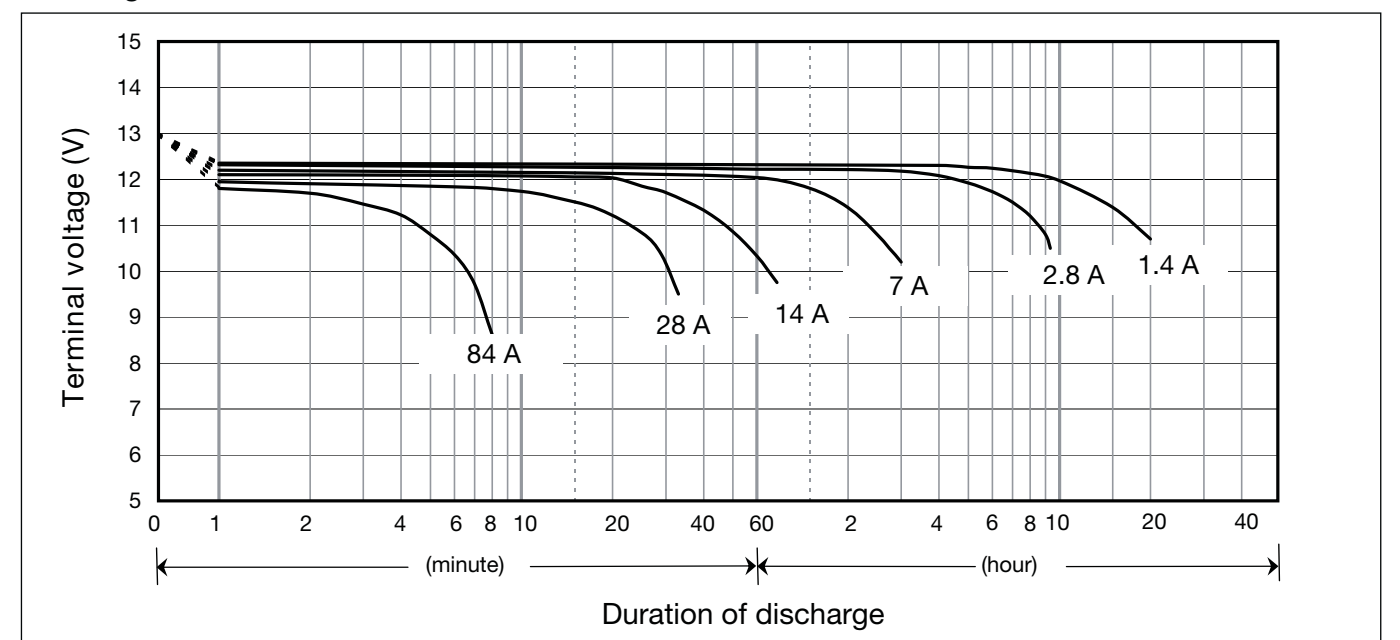
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

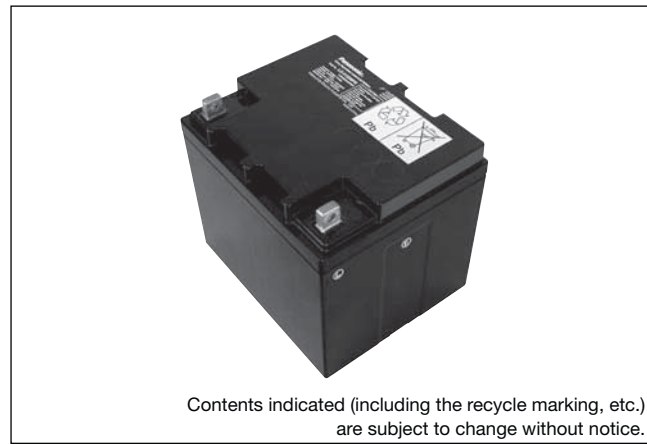


LC-X1238PG/APG

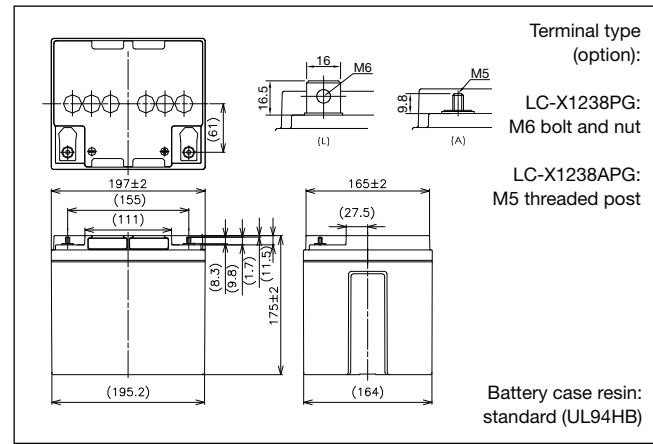
For standby power supplies. Expected trickle design life:
10 – 12 years at 20°C according to Eurobat.

VdS

G100002



Dimensions (mm)



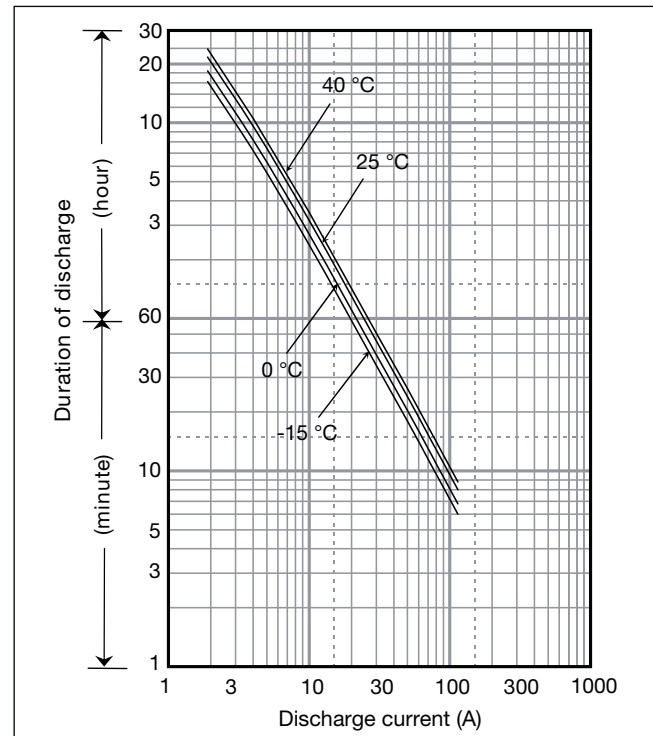
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	38Ah	
Dimensions	Length	197mm
	Width	165mm
	Height	175mm
	Total Height	LC-X1238PG: 180mm LC-X1238APG: 175mm
Approx. mass	13kg	
Terminal	M6 Bolt and Nut type/ M5 threaded post	

Characteristics

Capacity (25°C)	20 hour rate	38.0Ah
	10 hour rate	35.0Ah
	5 hour rate	31.5Ah
	1 hour rate	22.5Ah
Internal resistance	Fully charged battery (25°C)	8mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	1668	1349	1030	800	686	505	351	276	214	169	123	99.2	77.9	68.3	42.0	22.8	19.0							
9.9V	1535	1271	1008	788	682	500	350	269	209	168	120	98.0	76.7	68.3	42.0	22.8	19.0							
10.2V	1457	1204	980	768	672	489	349	267	185	167	119	96.8	75.5	68.3	42.0	22.8	19.0							
10.5V	1446	1126	952	748	661	480	346	265	183	166	119	96.8	75.5	68.3	42.0	22.8	19.0							
10.8V	1311	1098	874	716	640	468	308	247	175	155	114	94.4	74.3	67.1	42.0	22.8	18.7							

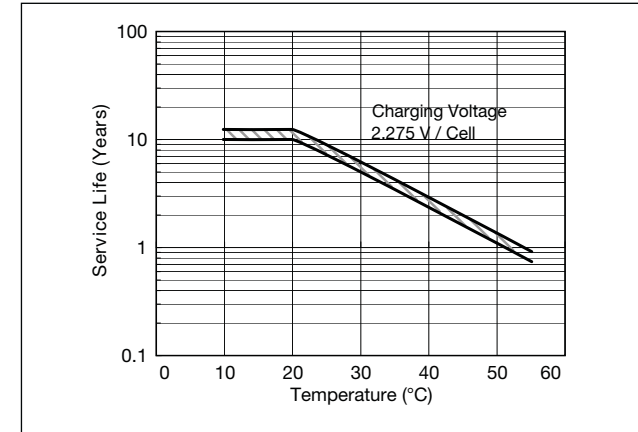
Ampere Table

Cut-off V	(Ampere/Battery)																							
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h							
9.6V	150	121	92.0	69.6	59.1	43.2	29.9	23.4	18.1	14.3	10.3	8.3	6.5	5.7	3.50	1.90	1.58							
9.9V	138	114	90.0	68.5	58.8	42.7	29.8	22.8	17.7	14.2	10.1	8.2	6.4	5.7	3.50	1.90	1.58							
10.2V	131	108	87.5	66.8	57.9	41.8	29.7	22.7	15.7	14.1	10.0	8.1	6.3	5.7	3.50	1.90	1.58							
10.5V	130	101	85.0	65.0	57.0	41.0	29.5	22.5	15.5	14.0	10.0	8.1	6.3	5.7	3.50	1.90	1.58							
10.8V	118	98.5	78.0	62.3	55.2	40.0	26.2	21.0	14.8	13.1	9.6	7.9	6.2	5.6	3.50	1.90	1.56							

Charging Method

Trickle use Control voltage: 13.6 - 13.8V; Initial current: 5.7A or smaller

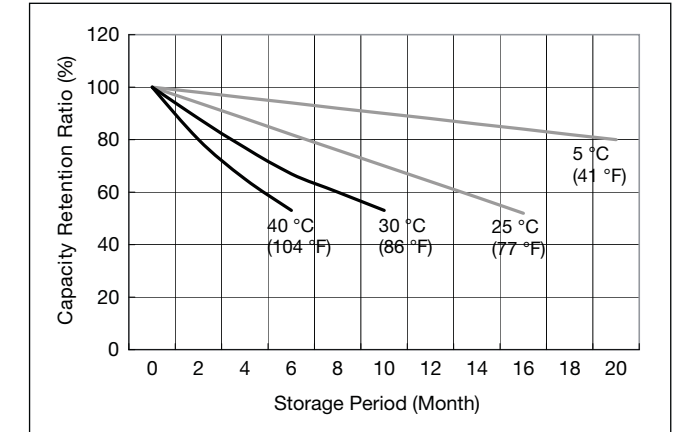
Influence of Temperature on Trickle life



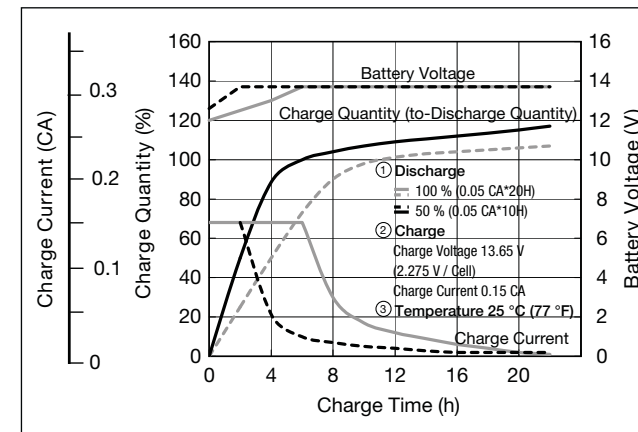
Cut off voltage

Discharge current	1.9A - 7.6A	7.6A - 19A	19A - 38A	38A - 76A	76A - 114A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

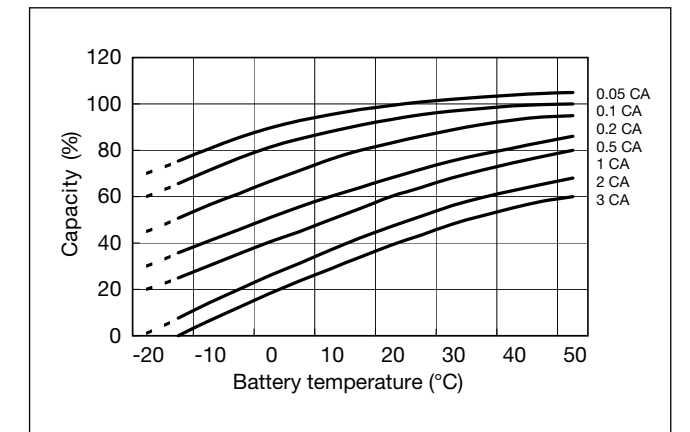
Residual capacity vs storage period



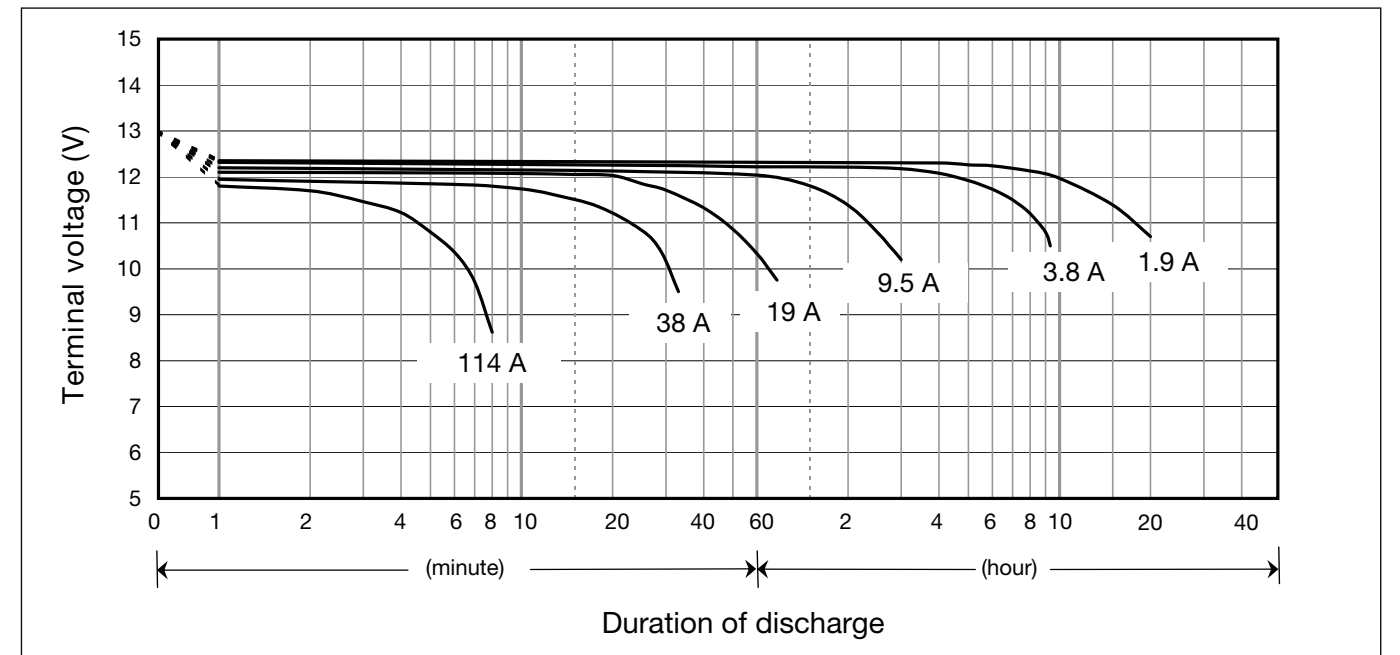
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

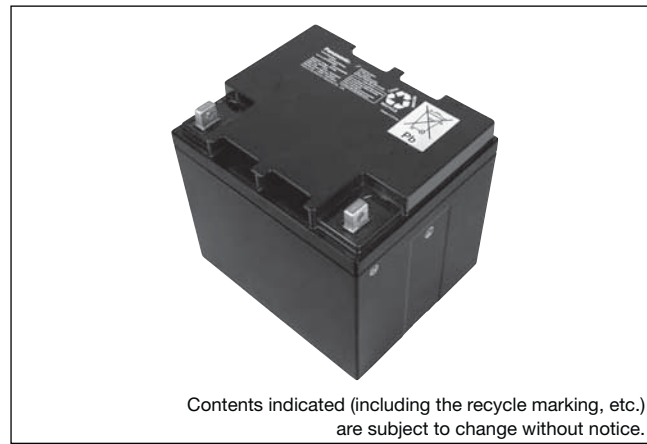


Discharge characteristics

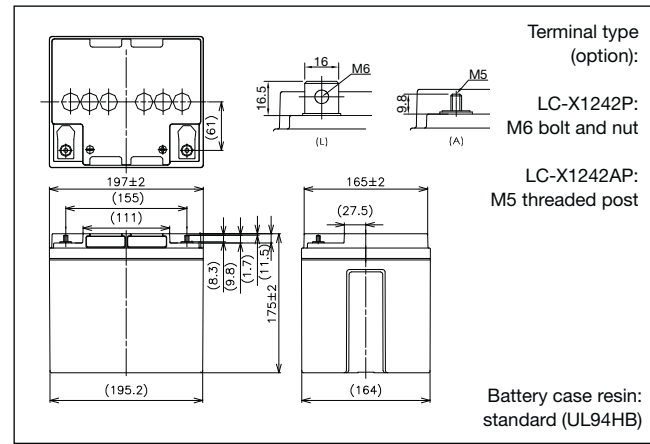


LC-X1242P/AP*1

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.



Dimensions (mm)



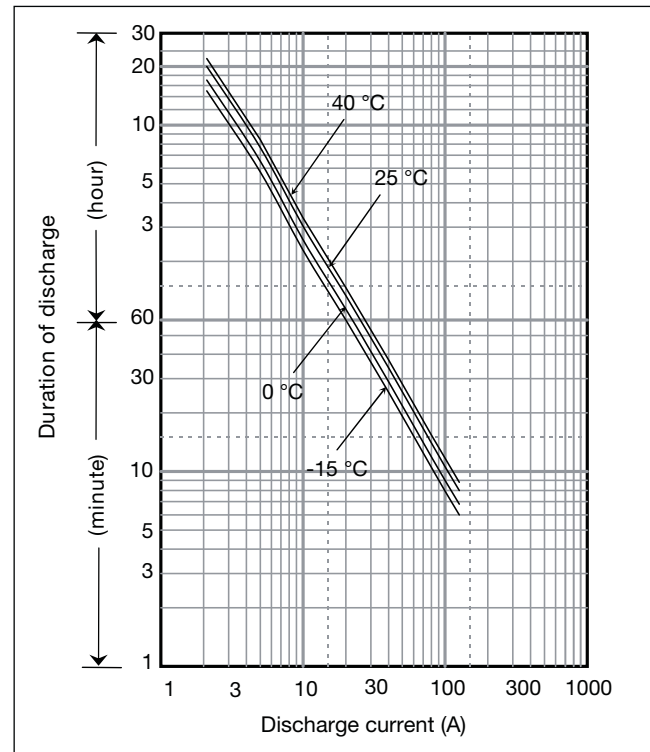
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	42Ah	
Dimensions	Length	197mm
	Width	165mm
	Height	175mm
	Total Height	LC-X1242P: 180mm LC-X1242AP: 175mm
Approx. mass	16kg	
Terminal	M6 Bolt and Nut type/ M5 threaded post	

Characteristics

Capacity (25°C)	20 hour rate	42Ah
	10 hour rate	40Ah
	5 hour rate	37Ah
	1 hour rate	26Ah
Internal resistance	Fully charged battery (25°C)	8mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	1846	1483	1254	966	835	625	410	312	241	187	132	110	89.9	79.1	48.0	25.2	21.0	
9.9V	1701	1405	1232	966	824	607	407	310	234	186	130	109	88.7	79.1	48.0	25.2	21.0	
10.2V	1612	1327	1210	943	812	596	406	307	217	184	127	108	88.7	77.9	48.0	25.2	21.0	
10.5V	1590	1249	1176	920	800	585	405	306	211	184	126	108	88.7	77.9	48.0	25.2	21.0	
10.8V	1449	1215	1086	886	777	573	390	295	201	173	121	105	87.5	75.5	48.0	25.2	20.8	

Ampere Table

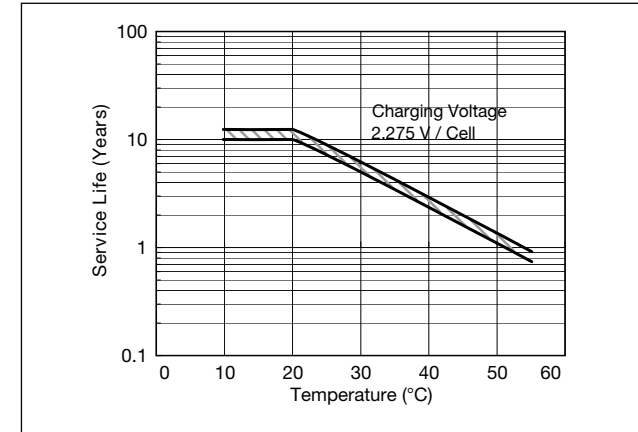
Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	166	133	112	84	72	53.4	34.9	26.5	20.4	15.8	11.1	9.2	7.5	6.6	4.0	2.1	1.75	
9.9V	153	126	110	84	71	51.9	34.7	26.3	19.8	15.7	10.9	9.1	7.4	6.6	4.0	2.1	1.75	
10.2V	145	119	108	82	70	50.9	34.6	26.1	18.4	15.5	10.7	9.0	7.4	6.5	4.0	2.1	1.75	
10.5V	143	112	105	80	69	50.0	34.5	26.0	17.9	15.5	10.6	9.0	7.4	6.5	4.0	2.1	1.75	
10.8V	130	109	97	77	67	49.0	33.2	25.0	17.0	14.6	10.2	8.8	7.3	6.3	4.0	2.1	1.73	

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use Control voltage: 13.6 - 13.8V; Initial current: 6.3A or smaller

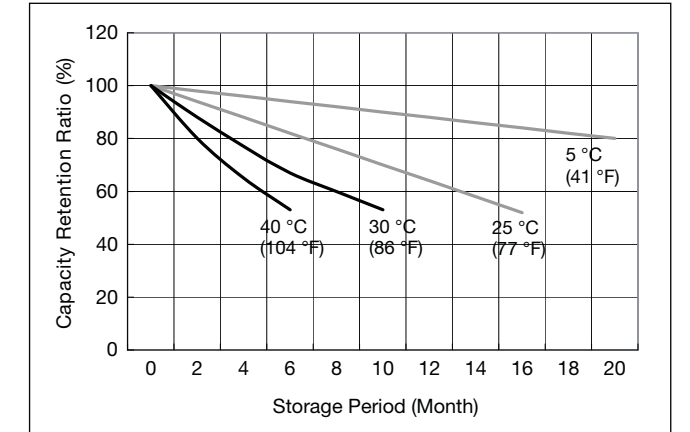
Influence of Temperature on Trickle life



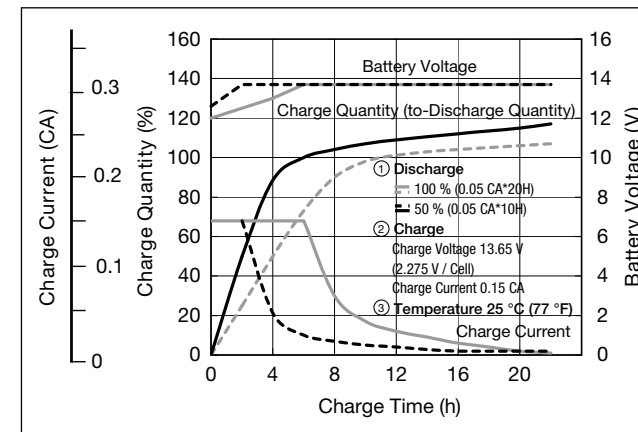
Cut off voltage

Discharge current	2.1A - 8.4A	8.4A - 21A	21A - 42A	42A - 84A	84A - 126A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

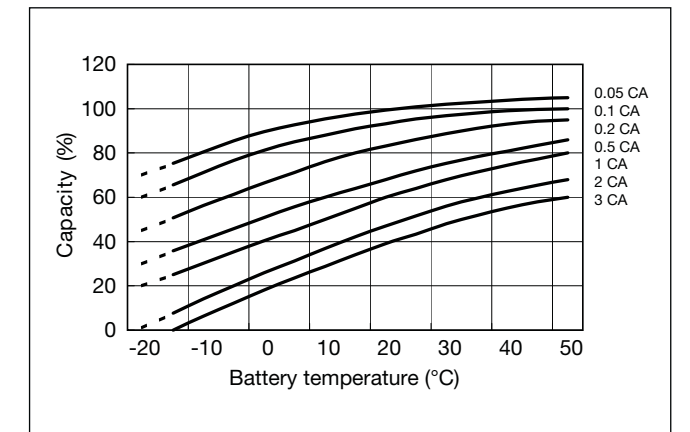
Residual capacity vs storage period



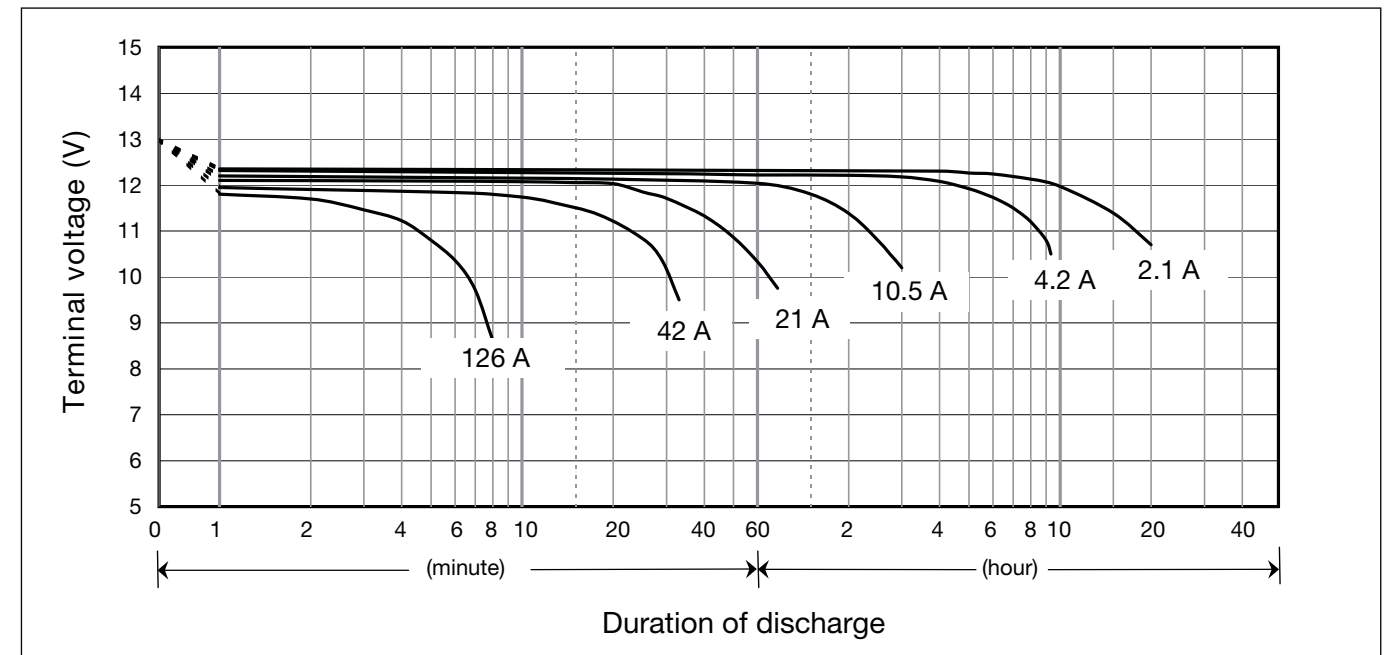
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

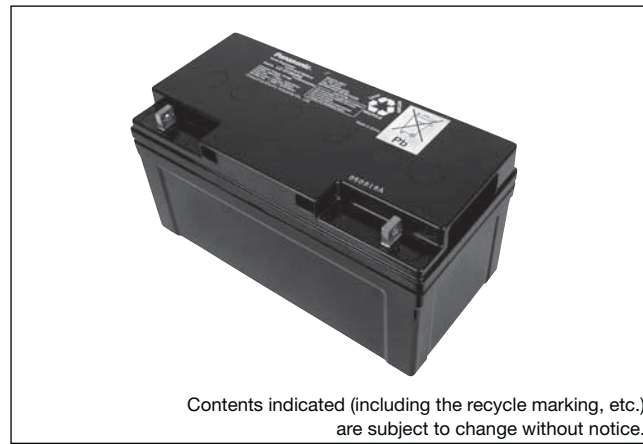


LC-X1265PG

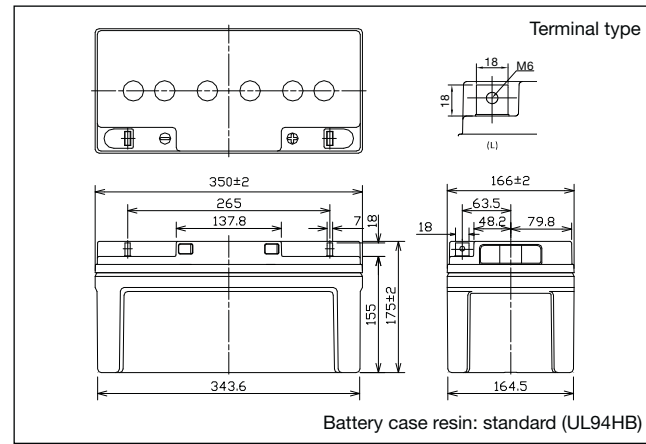
For standby power supplies. Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

VdS

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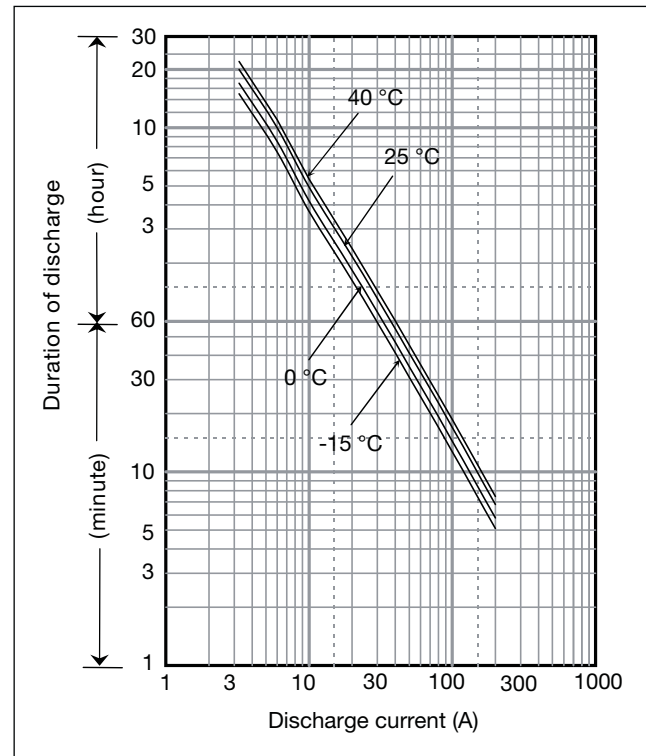
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	65Ah	
Dimensions	Length	350mm
	Width	166mm
	Height	175mm
	Total Height	175mm
Approx. mass	20kg	
Terminal	M6 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	65Ah
	10 hour rate	59Ah
	5 hour rate	53Ah
	1 hour rate	40Ah
Internal resistance	Fully charged battery (25°C)	7mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																		
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h		
9.6V	2235	1884	1439	1127	956	742	533	501	321	290	201	158	131	115	70.8	39.0	32.4		
9.9V	2180	1851	1422	1116	951	734	520	494	313	289	198	157	127	115	70.8	39.0	32.4		
10.2V	2010	1735	1386	1093	935	725	515	484	307	281	196	156	126	114	70.1	38.9	32.3		
10.5V	1787	1554	1284	1017	888	709	507	474	300	272	193	154	125	113	69.7	38.8	32.2		
10.8V	1509	1374	1145	949	865	685	499	465	292	259	189	152	122	111	69.0	38.6	32.0		

Ampere Table

Cut-off V	(Ampere/Battery)																		
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h		
9.6V	201	169	129	98.0	82.4	63.4	45.4	42.5	27.2	24.5	16.9	13.2	10.9	9.6	5.90	3.25	2.70		
9.9V	196	166	127	97.0	82.0	62.7	44.3	41.9	26.5	24.4	16.6	13.1	10.6	9.6	5.90	3.25	2.70		
10.2V	181	156	124	95.0	80.6	62.0	43.9	41.1	26.0	23.8	16.4	13.0	10.5	9.5	5.84	3.24	2.69		
10.5V	161	139	115	88.4	76.6	60.6	43.2	40.3	25.4	22.9	16.2	12.9	10.4	9.4	5.81	3.23	2.68		
10.8V	136	123	102	82.5	74.5	58.5	42.5	39.4	24.7	21.9	15.8	12.8	10.2	9.3	5.75	3.21	2.66		

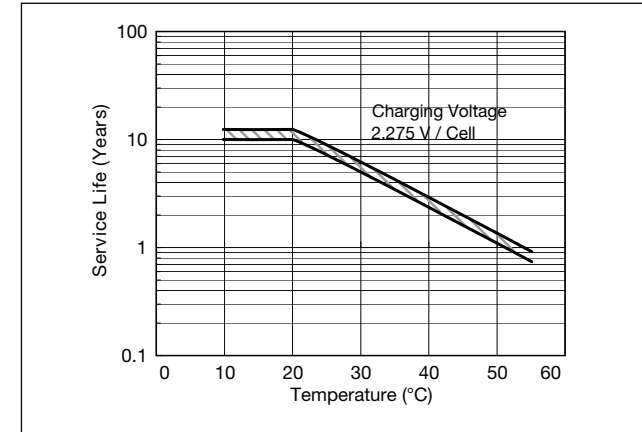
Charging Method

Trickle use Control voltage: 13.6 - 13.8V; Initial current: 9.75A or smaller

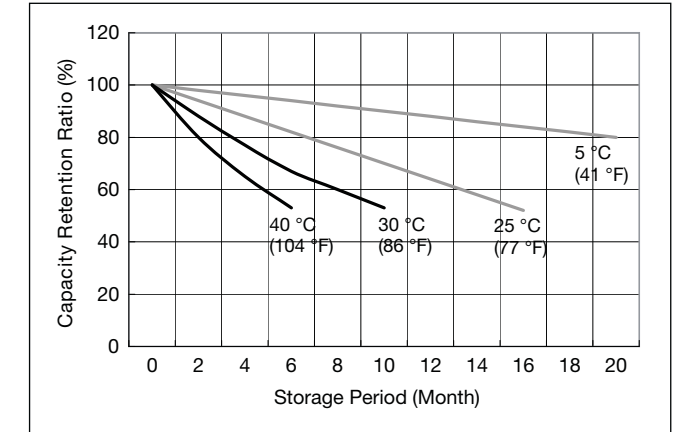
Cut off voltage

Discharge current	3.25A - 13A	13A - 32.5A	32.5A - 65A	65A - 130A	130A - 195A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

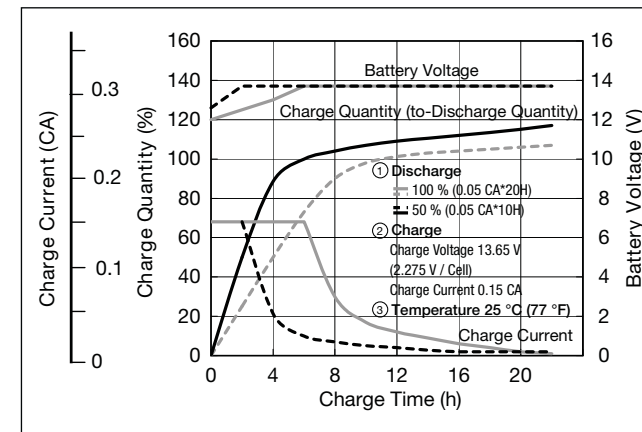
Influence of Temperature on Trickle life



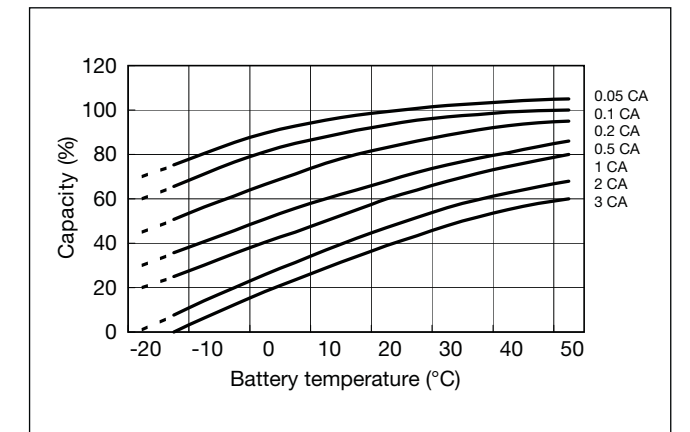
Residual capacity vs storage period



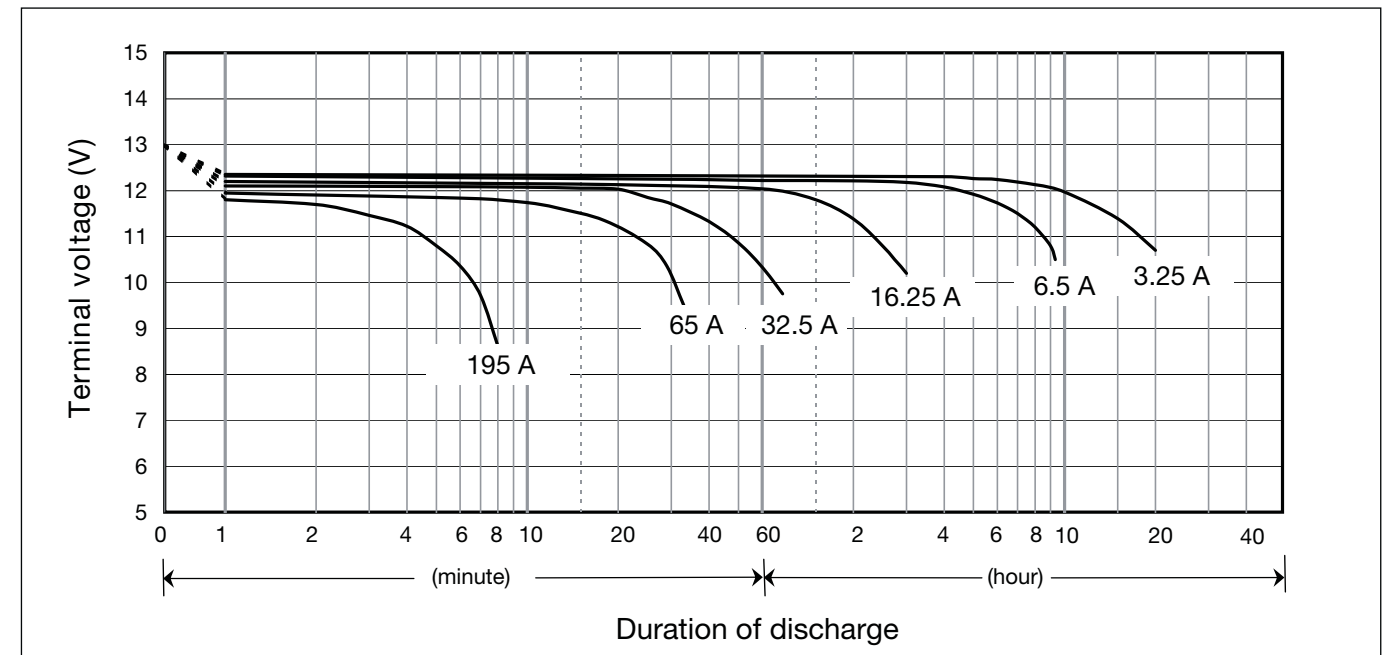
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

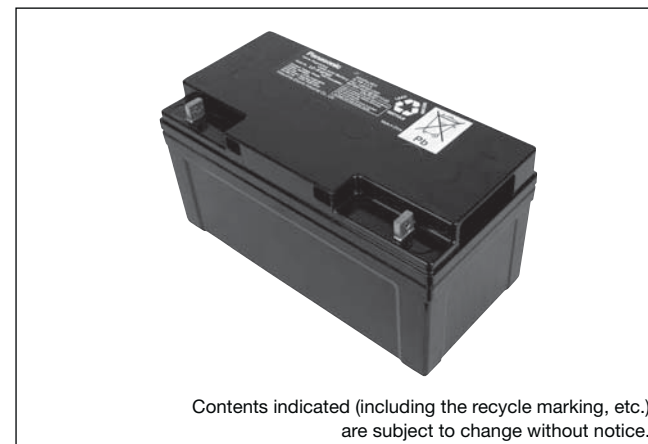


Discharge characteristics

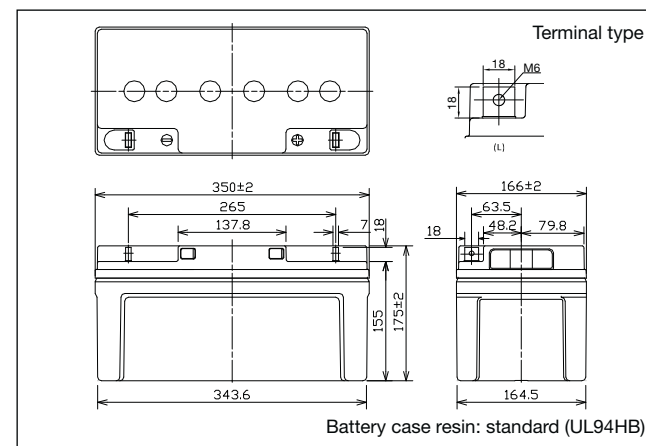


LC-X1275P*1

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.



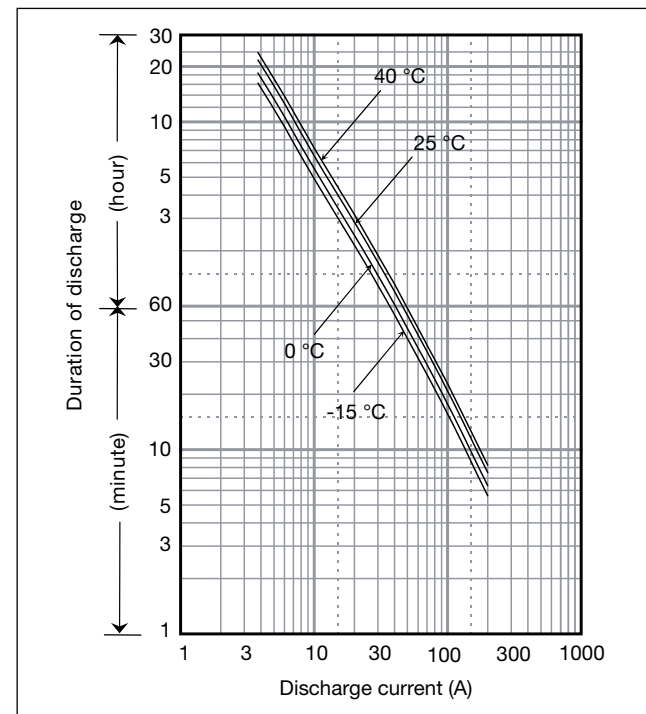
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	75Ah	
Dimensions	Length	350mm
	Width	166mm
	Height	175mm
	Total Height	175mm
Approx. mass	24kg	
Terminal	M6 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	75Ah
	10 hour rate	68Ah
	5 hour rate	61Ah
Internal resistance	Fully charged battery (25°C)	5mΩ
	40°C	102%
	25°C	100%
Temperature dependency of capacity (20 hour rate)	0°C	85%
	-15°C	65%
	Self discharge (25°C)	After 3 months
	After 6 months	82%
	After 12 months	64%

Watt Table

(Wattage/Battery)

Cut-off V	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1985	1546	1350	1017	722	601	411	327	220	171	149	125	79.5	45.0	37.2
9.9V	1962	1538	1342	1009	703	599	403	325	216	169	147	125	79.5	45.0	37.2
10.2V	1955	1531	1327	994	699	595	400	321	215	168	144	124	78.6	45.0	37.2
10.5V	1783	1446	1265	978	691	591	395	317	215	168	144	124	78.6	45.0	37.2
10.8V	1693	1400	1234	962	597	512	355	301	205	164	143	120	77.8	44.1	37.2

Ampere Table

(Ampere/Battery)

Cut-off V	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	177	134	116	86.9	61.5	51.0	34.8	27.6	18.5	14.3	12.4	10.4	6.62	3.75	3.10
9.9V	175	134	116	86.3	59.9	50.8	34.1	27.4	18.2	14.2	12.2	10.4	6.62	3.75	3.10
10.2V	175	133	114	84.9	59.5	50.5	33.8	27.1	18.1	14.0	12.0	10.4	6.55	3.75	3.10
10.5V	159	126	109	83.6	58.9	50.2	33.4	26.8	18.1	14.0	12.0	10.4	6.55	3.75	3.10
10.8V	151	122	106	82.3	50.8	43.5	30.1	25.4	17.3	13.7	11.9	10.0	6.49	3.68	3.10

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

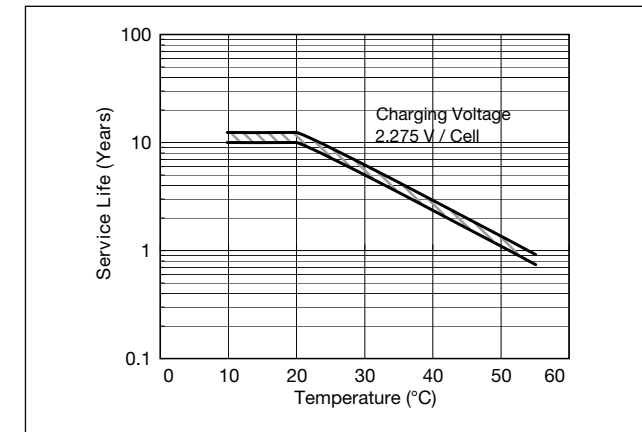
Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 11.25A or smaller
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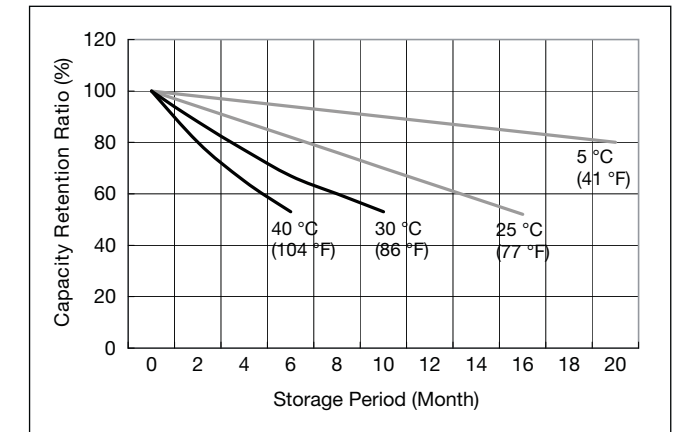
Cut off voltage

Discharge current	3.75A - 15A	15A - 37.5A	37.5A - 75A	75A - 150A	150A - 225A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

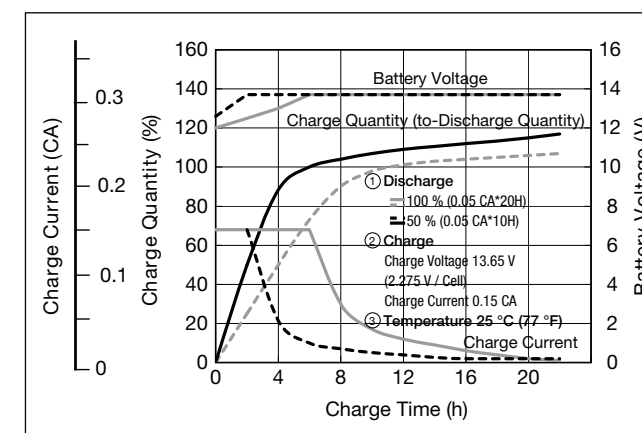
Influence of Temperature on Trickle life



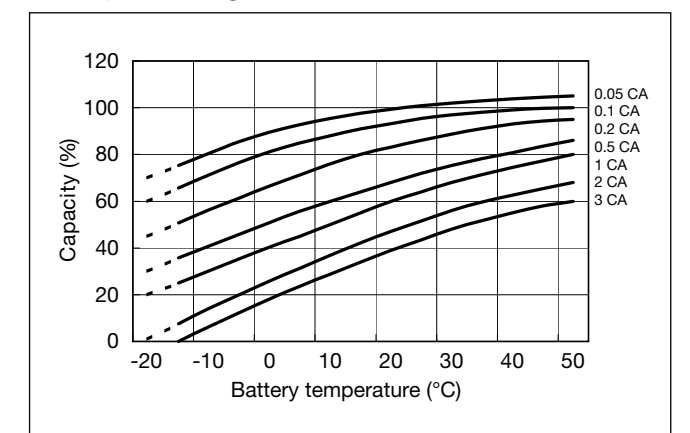
Residual capacity vs storage period



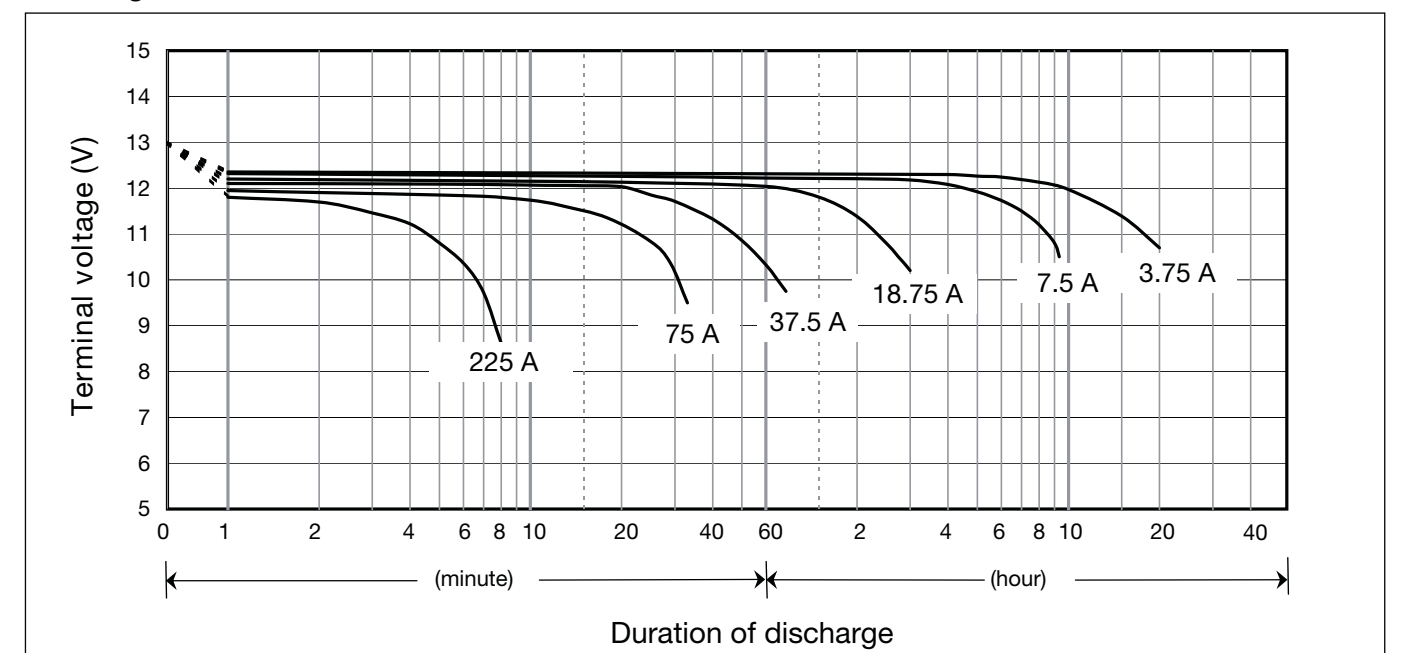
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

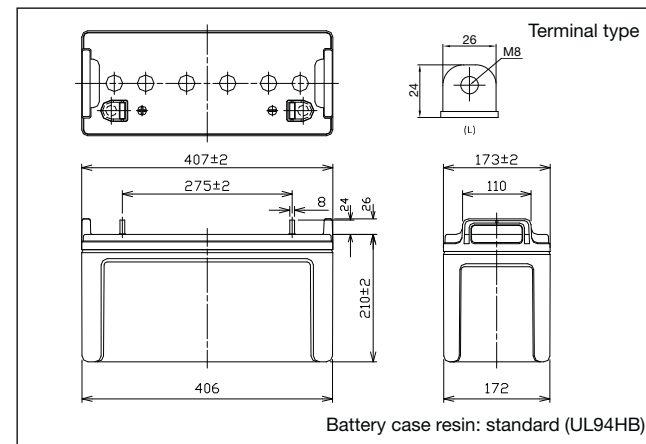


LC-XB12100P*1

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.



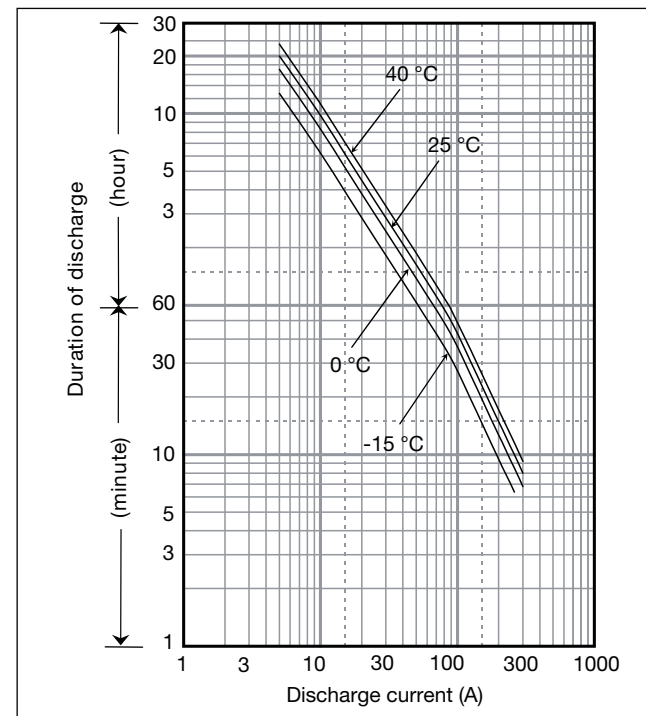
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	100Ah	
Dimensions	Length	407mm
	Width	173mm
	Height	210mm
	Total Height	236mm
Approx. mass	36.5kg	
Terminal	M8 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	100Ah 98Ah 90Ah 70Ah
Internal resistance	Fully charged battery (25°C)	4.5mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

(Wattage/Battery)

Cut-off V	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	2306	1834	1592	1206	892	733	582	430	281	226	170	154	88.3	47.0	38.5
9.9V	2254	1790	1554	1177	869	714	567	419	276	221	165	149	85.3	47.0	38.5
10.2V	2204	1726	1498	1139	877	694	551	413	272	216	160	145	84.3	46.5	38.0
10.5V	2134	1705	1487	1130	852	675	536	405	267	213	160	145	83.3	46.5	38.0
10.8V	1947	1624	1479	1094	840	666	528	395	262	208	155	150	82.3	45.5	37.2

Ampere Table

(Ampere/Battery)

Cut-off V	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	265	201	174	130	92.0	76.3	52.0	41.3	27.7	21.4	18.6	15.6	9.9	5.0	4.2
9.9V	262	200	173	129	89.5	76.0	51.0	41.0	27.2	21.2	18.3	15.6	9.9	5.0	4.2
10.2V	261	199	171	127	89.0	75.5	50.6	40.5	27.0	21.0	18.0	15.5	9.8	5.0	4.2
10.5V	238	188	163	125	88.0	75.0	50.0	40.0	27.0	21.0	18.0	15.5	9.8	5.0	4.2
10.8V	226	182	159	123	76.0	65.0	45.0	38.0	25.8	20.5	17.8	15.0	9.7	4.9	4.2

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

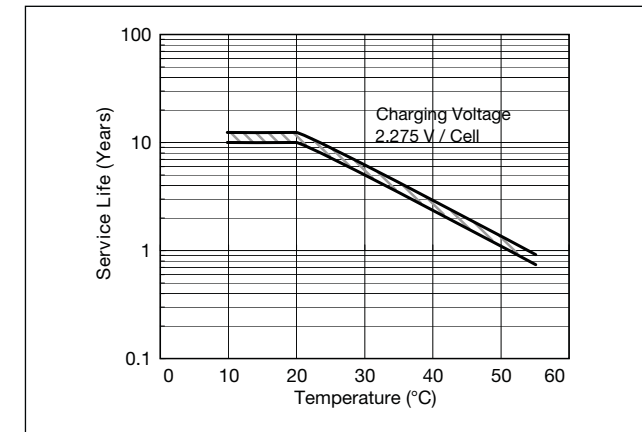
Charging Method

Trickle use Control voltage: 13.6 - 13.8V; Initial current 15A or smaller

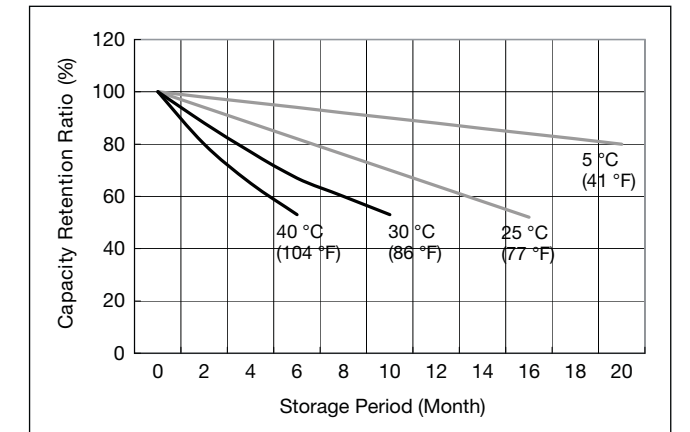
Cut off voltage

Discharge current	5A - 20A	20A - 50A	50A - 100A	100A - 200A	200A - 300A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

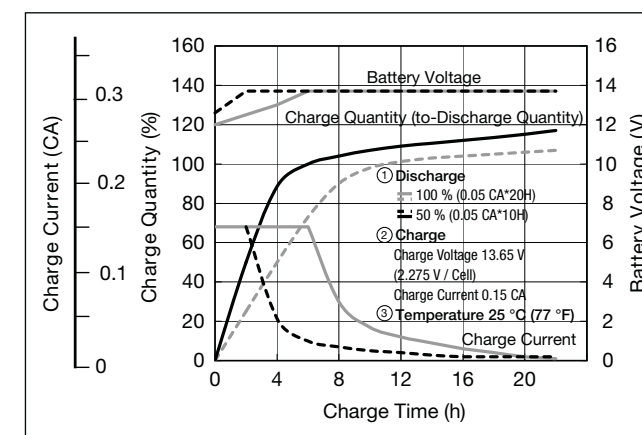
Influence of Temperature on Trickle life



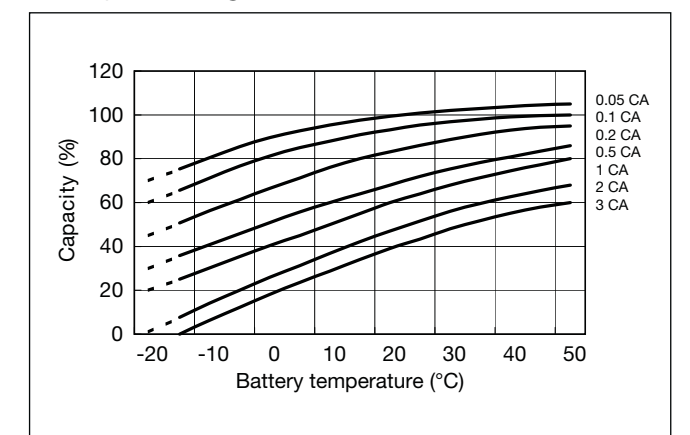
Residual capacity vs storage period



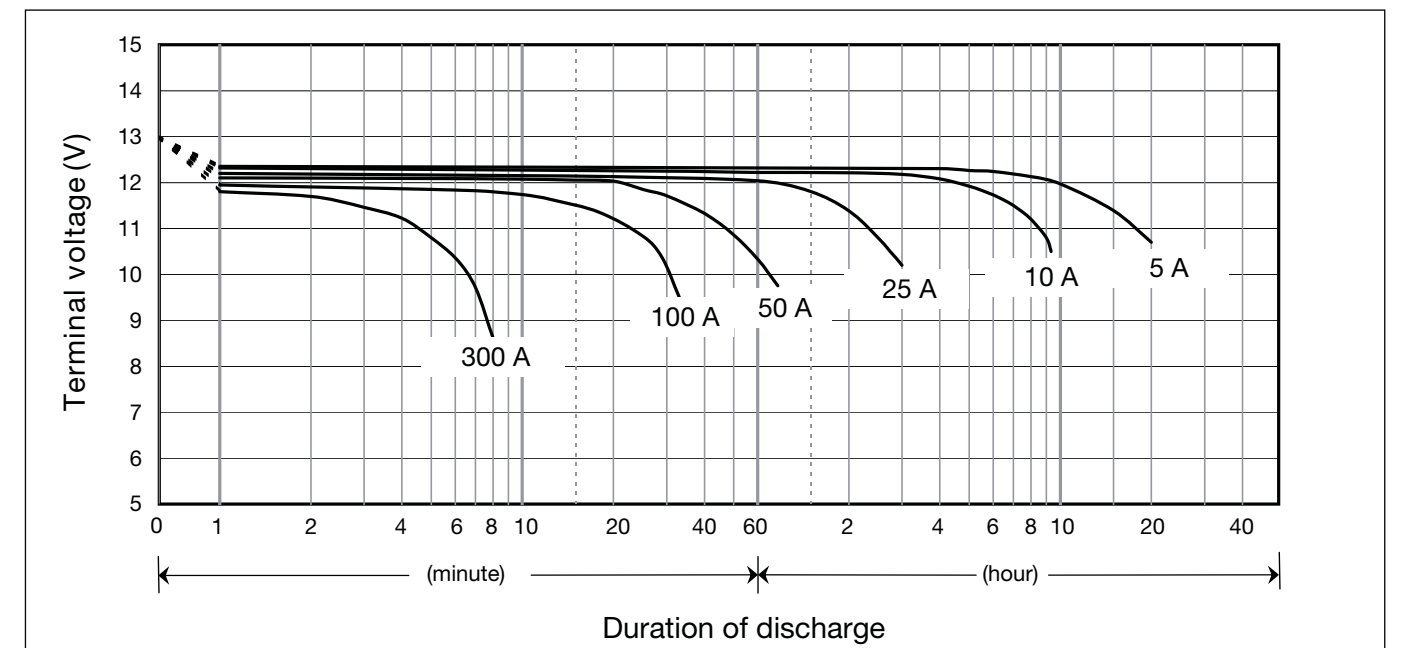
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics

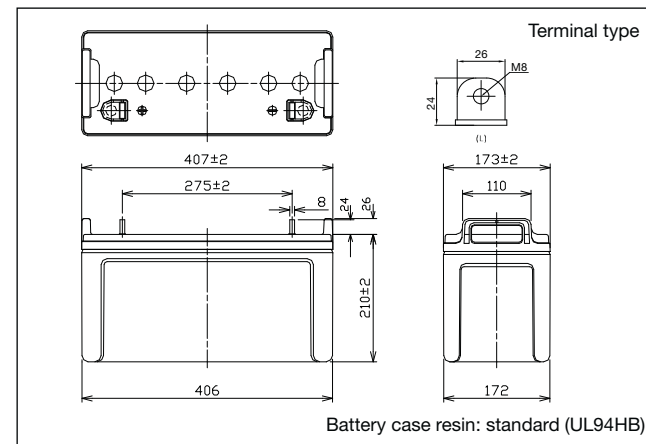


LC-X12120P*1



For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

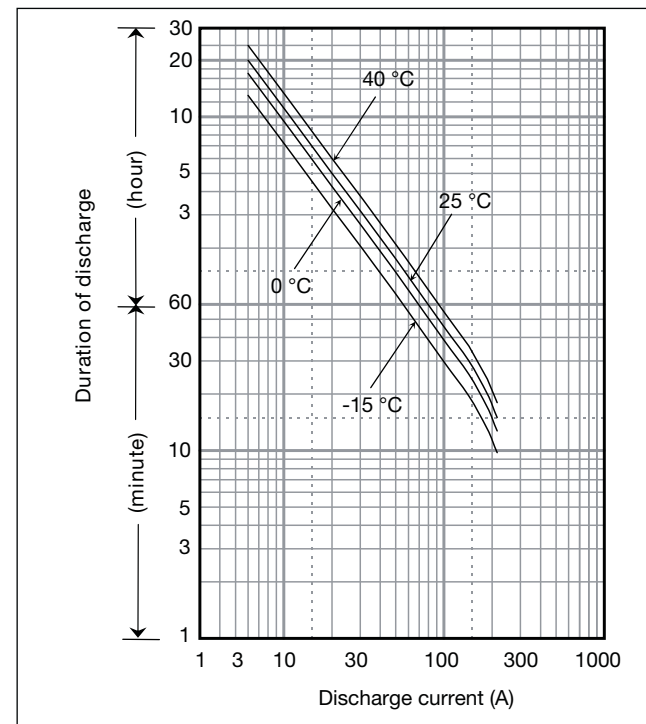
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	120Ah	
Dimensions	Length	407mm
	Width	173mm
	Height	210mm
	Total Height	236mm
Approx. mass	35.5kg	
Terminal	M8 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	120Ah
	10 hour rate	109Ah
	5 hour rate	99Ah
	1 hour rate	74Ah
Internal resistance	Fully charged battery (25°C)	3.5mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)													
	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1920	1677	1409	1095	835	663	499	326	261	197	179	104	60.2	46.8
9.9V	1910	1667	1370	1062	820	662	486	322	255	191	177	103	60.1	46.8
10.2V	1901	1648	1322	1040	805	642	479	315	249	185	168	101	60.0	46.7
10.5V	1796	1571	1316	1025	764	629	470	310	246	184	166	101	60.0	46.6
10.8V	1739	1532	1281	980	672	559	458	306	240	180	163	100	59.9	46.6

Ampere Table

Cut-off V	(Ampere/Battery)													
	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	229	198	149	105	86.9	59.3	47.9	32.1	23.7	20.6	17.4	11.1	6.00	5.04
9.9V	228	197	148	102	86.6	58.1	47.5	31.5	23.4	20.4	17.4	11.1	6.00	5.04
10.2V	227	195	146	102	85.9	57.7	46.9	31.2	23.2	20.0	17.3	11.0	6.00	5.04
10.5V	215	186	143	101	85.4	56.9	46.3	31.3	23.2	20.0	17.3	11.0	6.00	5.04
10.8V	208	181	141	87	74.0	51.2	44.0	29.9	22.7	19.8	16.7	10.9	5.88	5.00

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

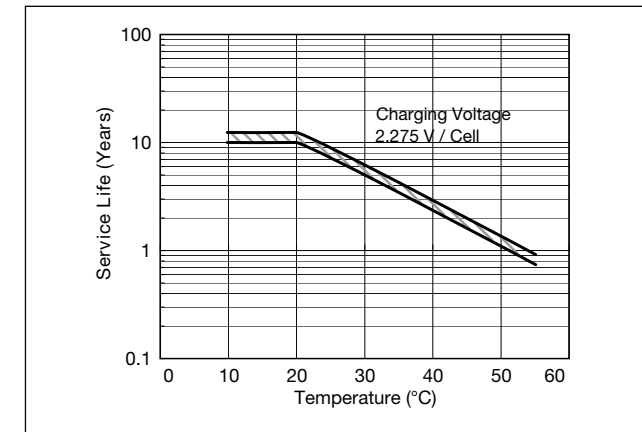
Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current 18A or smaller
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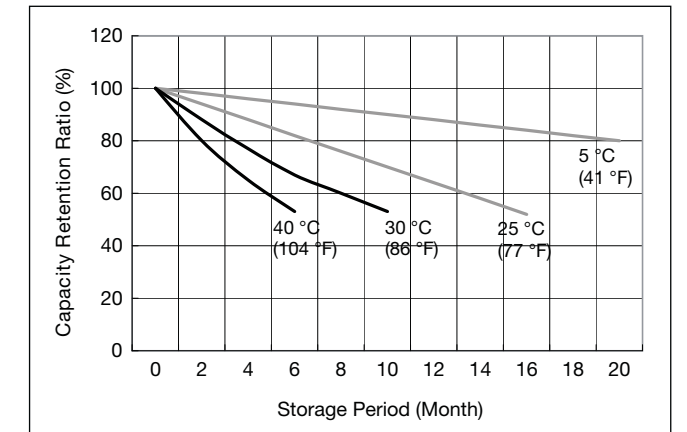
Cut off voltage

Discharge current	6A - 24A	24A - 60A	60A - 120A	120A - 240A
Cut off voltage (V)	10.5	10.2	9.9	9.3

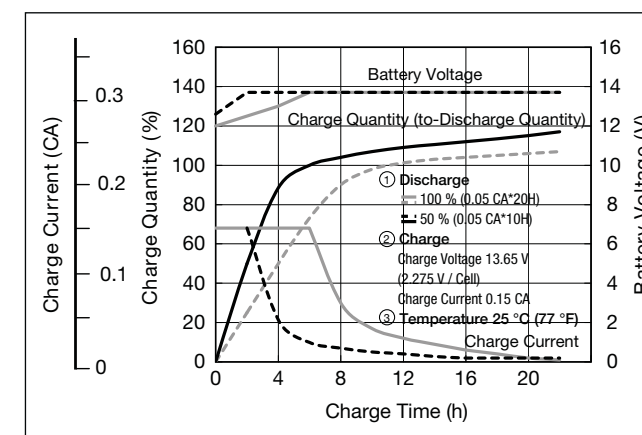
Influence of Temperature on Trickle life



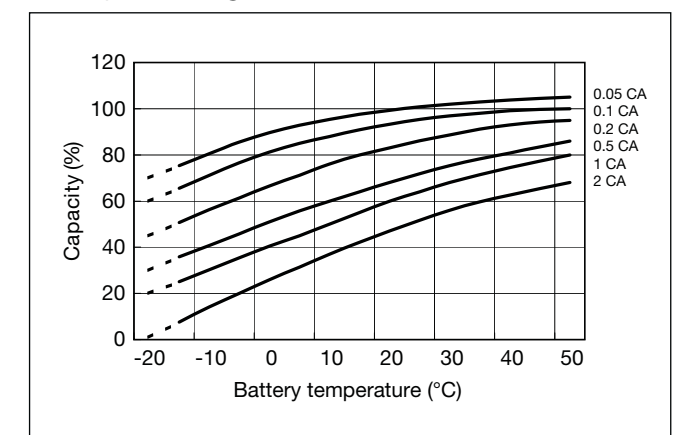
Residual capacity vs storage period



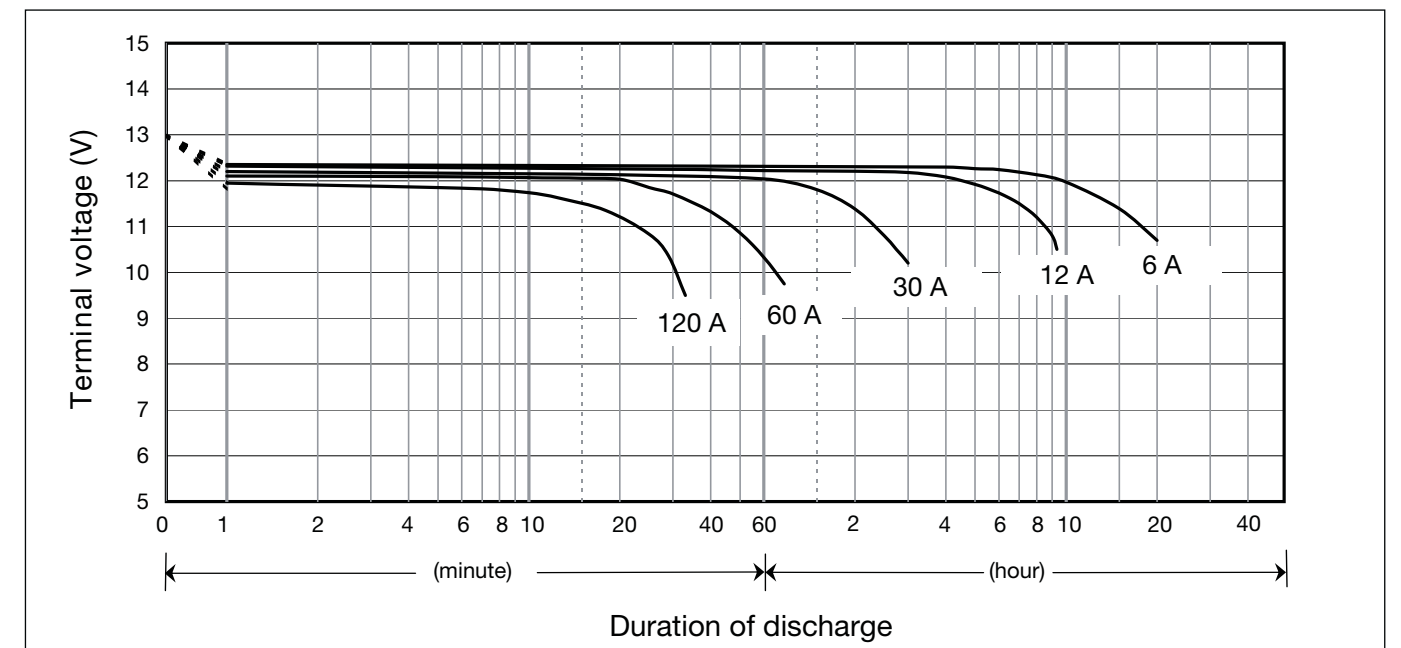
Constant-voltage and constant-current charge characteristics for Trickle use



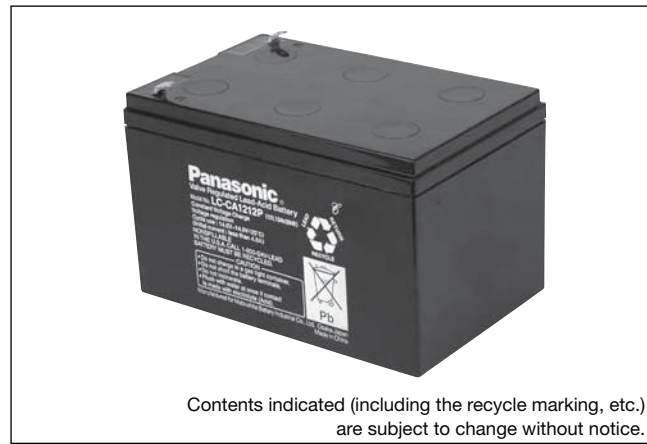
Discharge capacity by temperature and by discharge current



Discharge characteristics

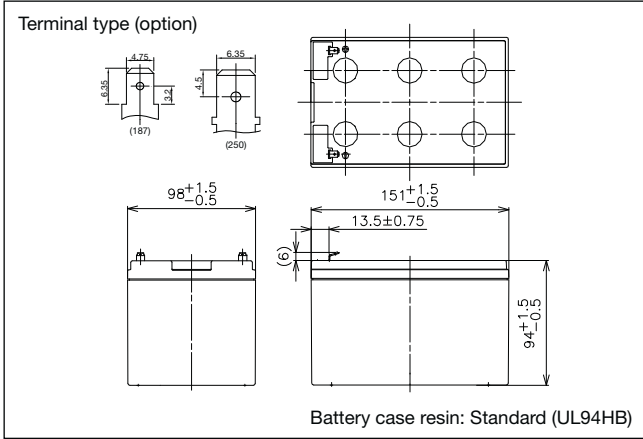


LC-CA1212P



For main power supplies.
Cycle long life type.

Dimensions (mm)



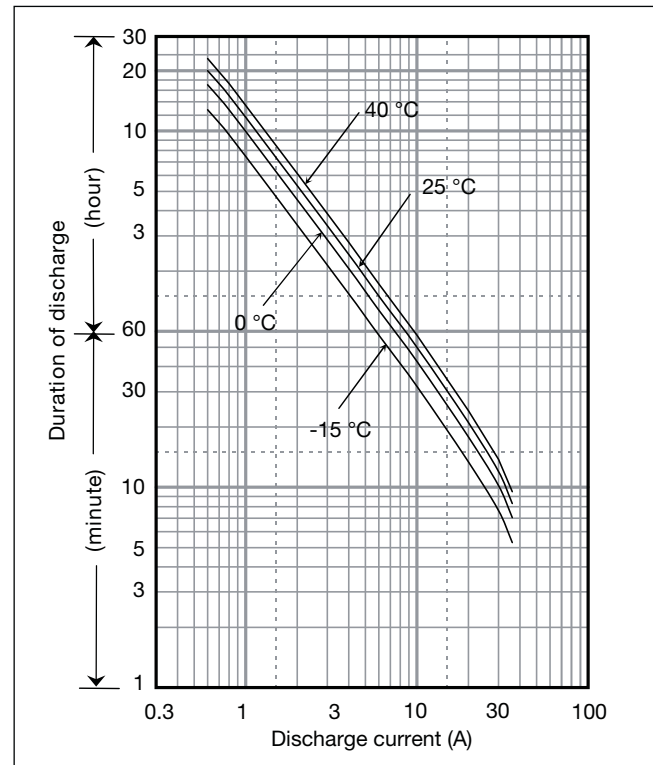
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	12Ah	
Dimensions	Length	151mm
	Width	98mm
	Height	94mm
	Total Height	100mm
Approx. mass	3.8kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	12.0Ah
	10 hour rate	11.3Ah
	5 hour rate	10.4Ah
	1 hour rate	8.1Ah
Internal resistance	Fully charged battery (25°C)	30mΩ
	Temperature dependency of capacity (20 hour rate)	40°C: 102% 25°C: 100% 0°C: 85% -15°C: 65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	679	559	384	298	247	183	137	105	70.3	54.5	38.1	28.8	24.1	21.7	13.3	7.22	6.02	
9.9V	649	537	373	288	241	177	135	104	69.9	54.2	37.8	28.8	24.1	21.7	13.3	7.22	6.02	
10.2V	607	506	363	282	235	177	134	102	69.1	53.9	37.5	28.8	24.0	21.6	13.2	7.21	6.01	
10.5V	556	475	343	271	231	172	133	100	68.5	53.3	36.9	28.7	24.0	21.6	13.2	7.20	6.00	
10.8V	495	434	321	261	225	166	123	98	66.1	52.1	36.3	28.4	23.8	21.5	13.1	7.18	5.98	

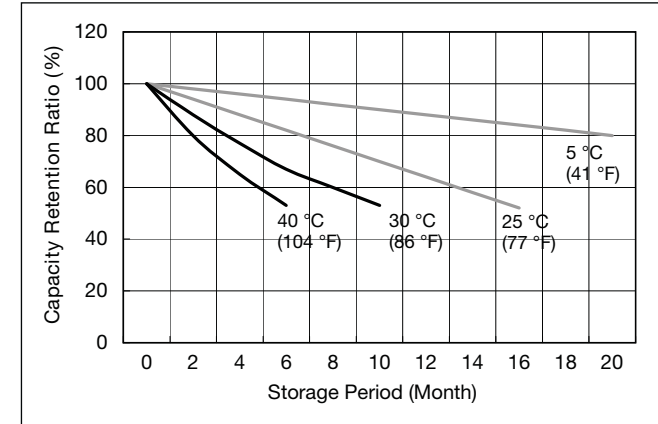
Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	61.1	50.1	34.3	25.9	21.3	15.6	11.7	8.90	5.95	4.60	3.20	2.41	2.01	1.81	1.11	0.602	0.502	
9.9V	58.4	48.2	33.3	25.0	20.8	15.1	11.5	8.80	5.92	4.58	3.18	2.41	2.01	1.81	1.11	0.602	0.502	
10.2V	54.6	45.4	32.4	24.5	20.3	15.1	11.4	8.70	5.85	4.55	3.15	2.41	2.00	1.80	1.10	0.601	0.501	
10.5V	50.0	42.6	30.6	23.6	19.9	14.7	11.3	8.50	5.80	4.50	3.10	2.40	2.00	1.80	1.10	0.600	0.500	
10.8V	44.5	38.9	28.7	22.7	19.4	14.2	10.5	8.30	5.60	4.40	3.05	2.38	1.99	1.79	1.09	0.598	0.498	

Charging Method

Cycle Use	Control voltage 14.5 - 14.9V; Initial current 4.8A or smaller
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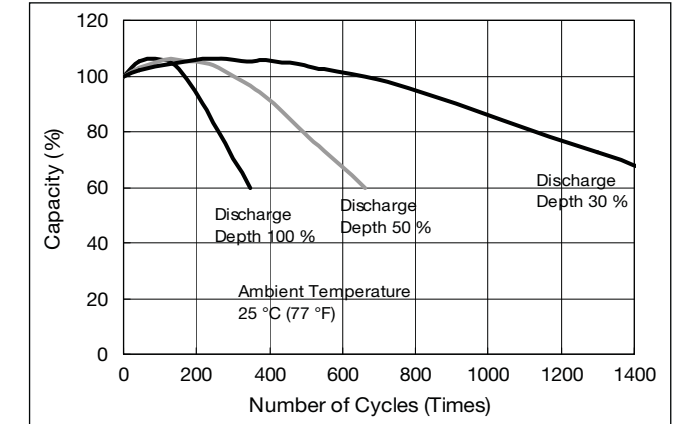
Residual capacity vs storage period



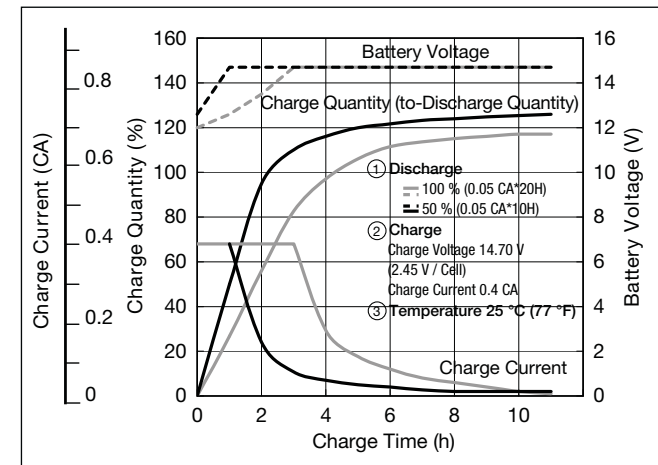
Cut off voltage

Discharge current	0.6A - 2.4A	2.4A - 6A	6A - 12A	12A - 24A	24A - 36A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

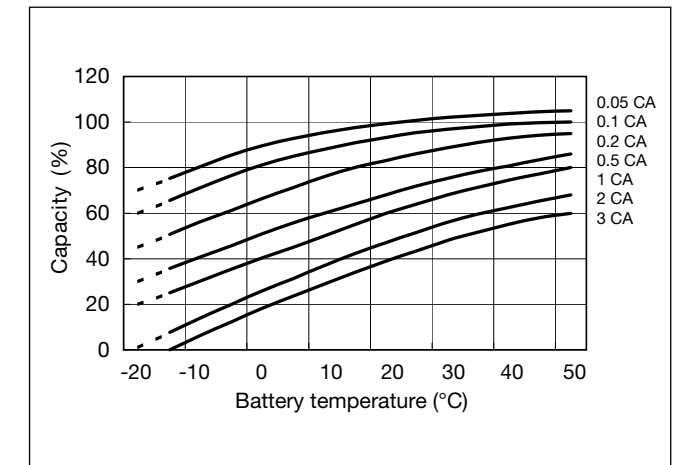
Cycle life vs Depth of discharge



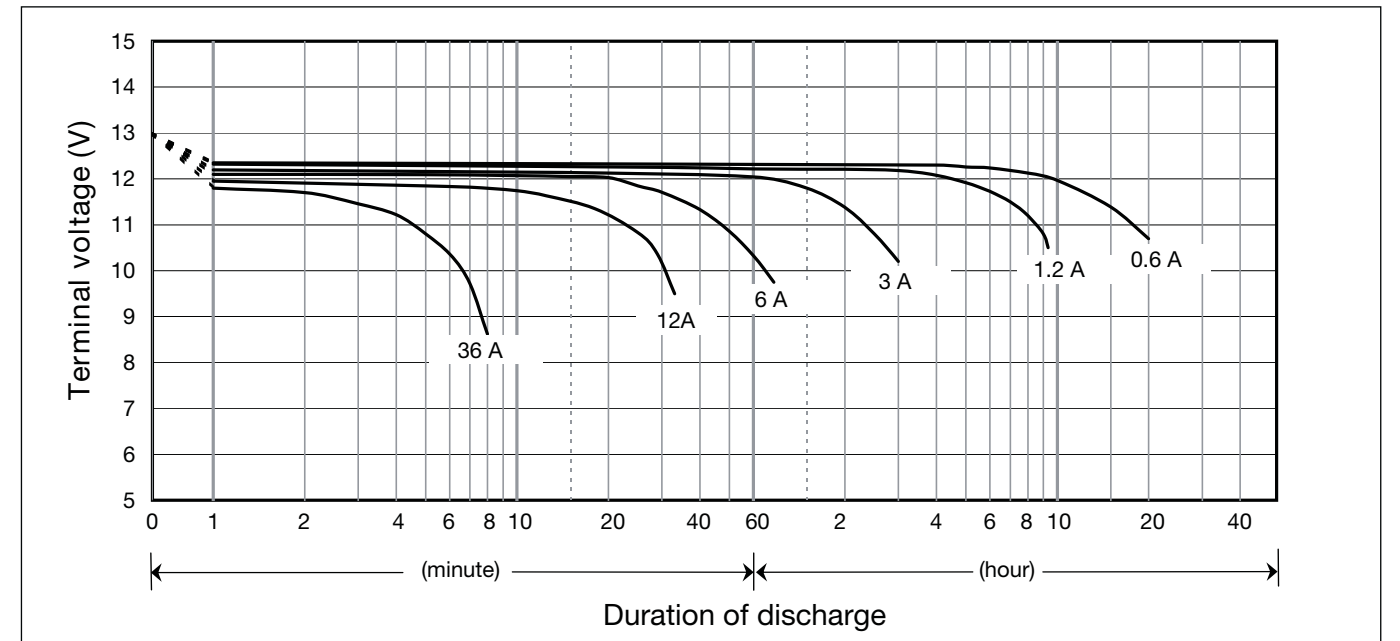
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current



Discharge characteristics

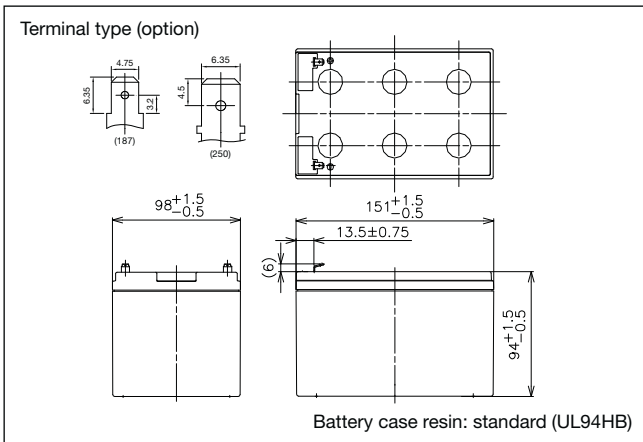


LC-CA1215P



For main power supplies.
Cycle long life type.

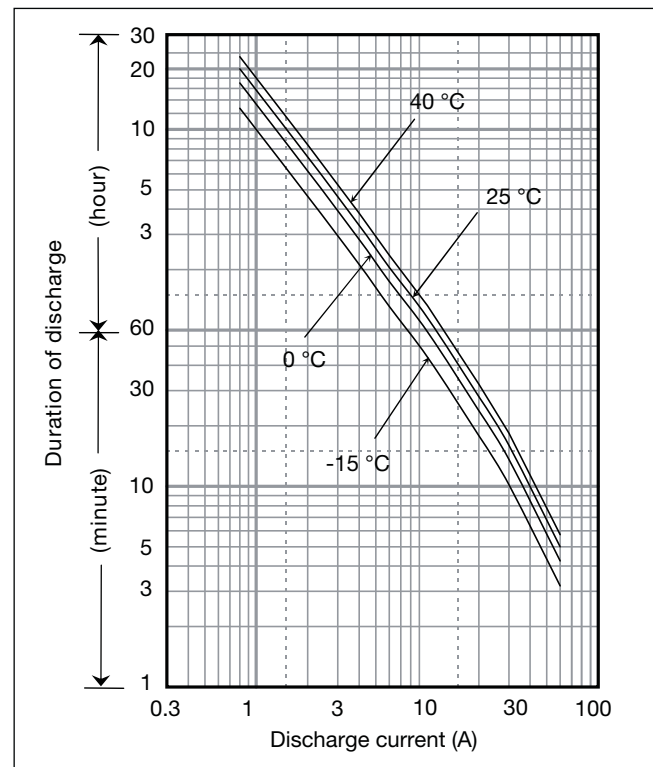
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	15Ah	
Dimensions	Length	151mm
	Width	98mm
	Height	94mm
	Total Height	100mm
Approx. mass	4.2kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25 °C)	20 hour rate	15.0Ah
	10 hour rate	14.0Ah
	5 hour rate	12.9Ah
	1 hour rate	10.0Ah
Internal resistance	Fully charged battery (25 °C)	30mΩ
Temperature dependency of capacity (20 hour rate)	40 °C	102%
	25 °C	100%
	0 °C	85%
	-15 °C	65%
Self discharge (25 °C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	850	682	455	350	292	217	157	123	83.9	65.0	47.1	36.0	29.9	25.2	16.2	8.75	7.30	
9.9V	799	646	444	343	286	213	156	123	82.8	64.6	46.9	35.8	29.7	25.1	16.1	8.74	7.29	
10.2V	741	607	433	336	281	211	154	121	81.4	63.4	46.4	35.7	29.5	24.9	15.9	8.72	7.27	
10.5V	667	555	404	318	270	206	152	118	80.1	61.9	45.7	35.5	29.4	24.8	15.9	8.70	7.25	
10.8V	576	497	368	300	263	199	146	116	77.7	59.6	44.8	35.1	28.9	24.5	15.7	8.66	7.21	

Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	76.5	61.2	40.6	30.4	25.2	18.5	13.4	10.5	7.11	5.49	3.96	3.01	2.49	2.10	1.35	0.73	0.61	
9.9V	71.8	58.0	39.7	29.9	24.7	18.2	13.3	10.4	7.01	5.45	3.94	3.00	2.48	2.09	1.34	0.73	0.61	
10.2V	66.6	54.5	38.6	29.2	24.2	18.1	13.1	10.3	6.89	5.36	3.90	2.99	2.46	2.08	1.33	0.73	0.61	
10.5V	59.9	49.8	36.1	27.6	23.3	17.6	13.0	10.0	6.78	5.22	3.84	2.97	2.45	2.07	1.33	0.72	0.60	
10.8V	51.8	44.6	32.9	26.1	22.7	17.0	12.5	9.82	6.58	5.03	3.77	2.94	2.41	2.04	1.31	0.72	0.60	

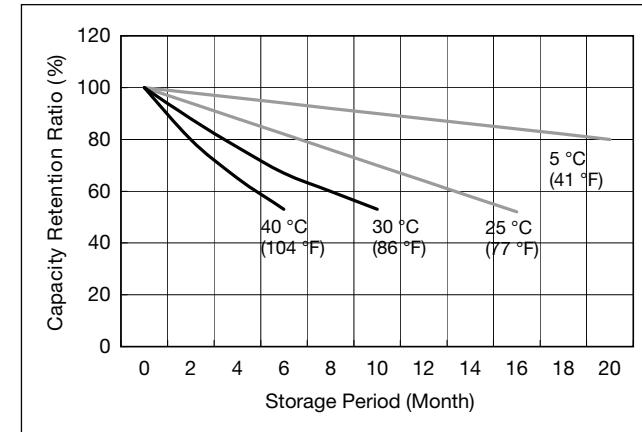
Charging Method

Cycle Use	Control voltage 14.5 - 14.9V; Initial current 6A or smaller
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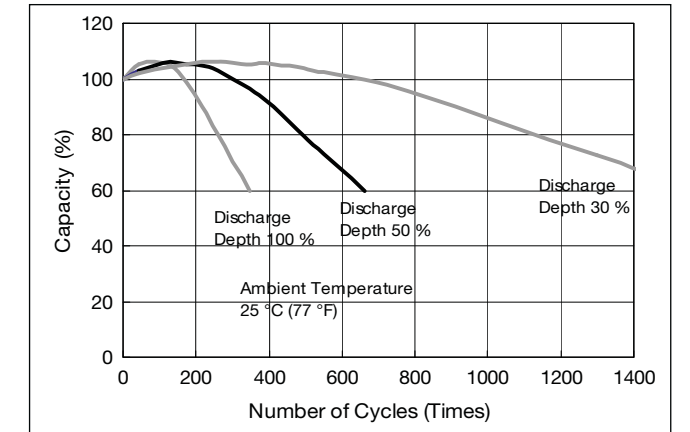
Cut off voltage

Discharge current	0.75A - 3A	3A - 7.5A	7.5A - 15A	15A - 30A	30A - 45A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

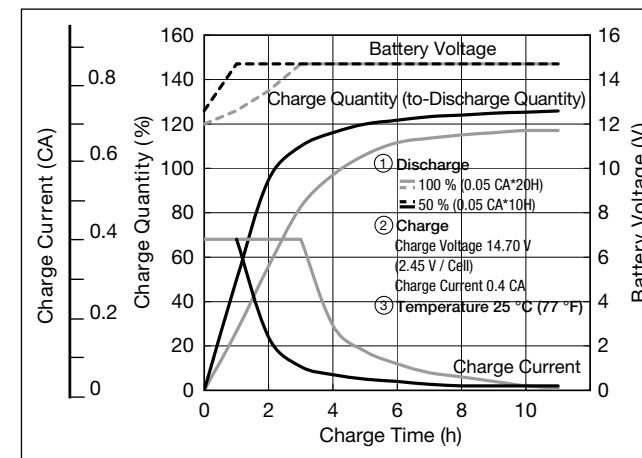
Residual capacity vs storage period



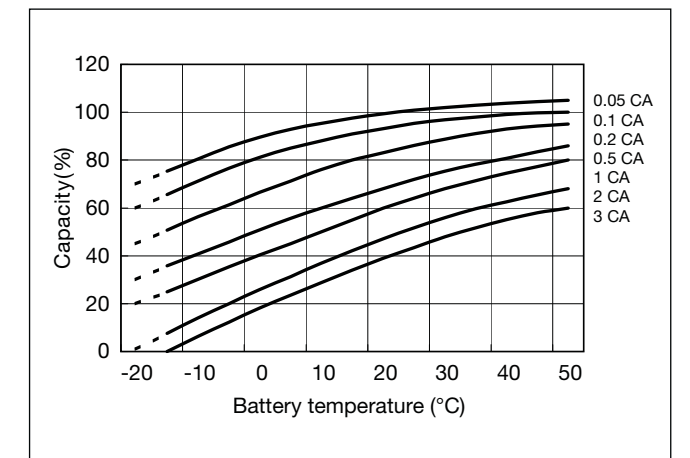
Cycle life vs Depth of discharge



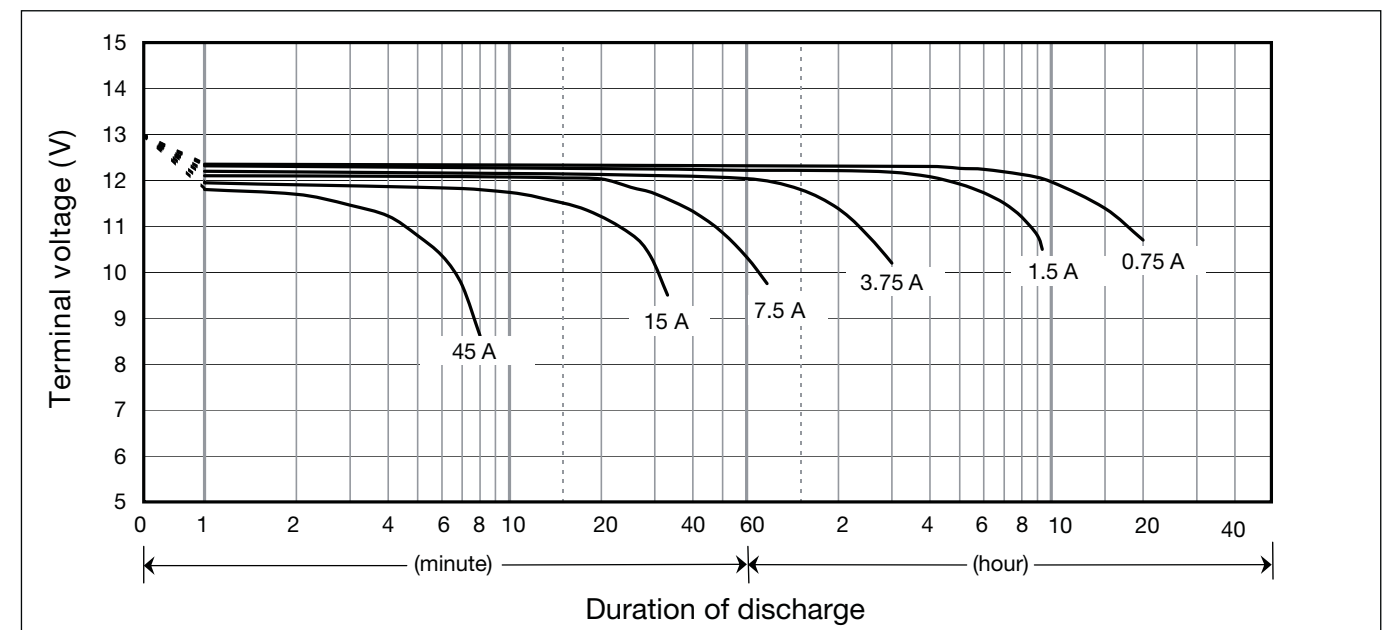
Constant-voltage and constant-current charge characteristics



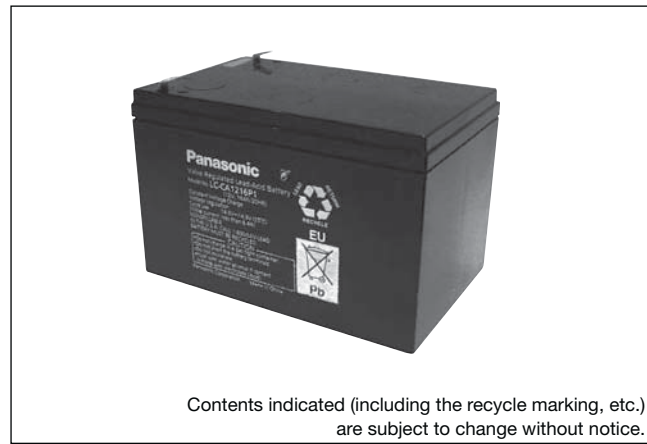
Discharge capacity by temperature and by discharge current



Discharge characteristics

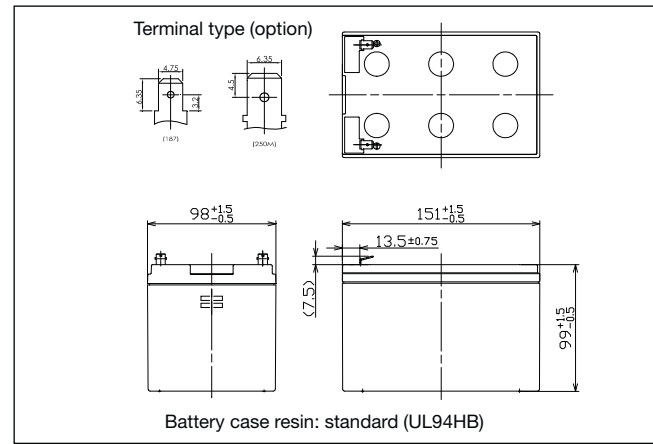


LC-CA1216



For main power supplies.
Cycle long life type.

Dimensions (mm)



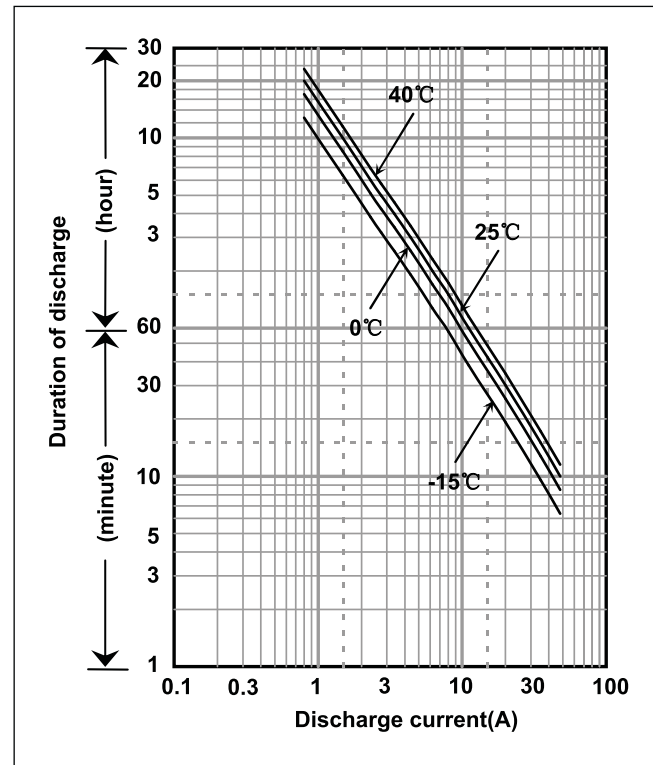
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	16Ah	
Dimensions	Length	151mm
	Width	98mm
	Height	99mm
	Total Height	105mm
Approx. mass	4.70kg	
Terminal	Faston 187 & 250M	

Characteristics

Capacity (25°C)	20 hour rate	16Ah
	10 hour rate	14Ah
	5 hour rate	12Ah
	1 hour rate	11Ah
Internal resistance	Fully charged battery (25°C)	11mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)															
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h
9.6V	879	721	517	381	308	225	165	132	94.2	74.7	53.1	40.5	33.0	28.1	17.8	9.54
9.9V	825	683	505	374	302	220	163	131	92.9	74.2	52.8	40.4	32.9	28.0	17.8	9.52
10.2V	766	642	491	366	296	219	162	129	91.3	72.9	52.3	40.2	32.7	27.8	17.6	9.50
10.5V	689	586	459	346	285	213	160	126	89.9	71.1	51.5	40.0	32.5	27.6	17.5	9.48
10.8V	595	526	418	327	277	206	153	123	87.2	68.5	50.6	39.5	32.0	27.3	17.4	9.43

Ampere Table

Cut-off V	(Ampere/Battery)															
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h
9.6V	83.3	68.7	48.0	35.0	28.1	20.5	14.9	11.6	8.07	6.70	4.64	3.47	2.84	2.35	1.51	0.800
9.9V	77.3	64.4	46.9	34.3	27.6	20.1	14.8	11.5	7.96	6.66	4.61	3.45	2.83	2.34	1.50	0.800
10.2V	71.4	60.4	45.6	33.6	27.0	19.9	14.6	11.3	7.83	6.54	4.57	3.44	2.81	2.33	1.49	0.800
10.5V	63.4	54.1	42.6	31.8	26.0	19.5	14.5	11.1	7.71	6.38	4.49	3.42	2.80	2.32	1.48	0.800
10.8V	53.6	47.8	38.8	30.0	25.3	18.8	13.9	10.8	7.47	6.15	4.41	3.38	2.75	2.29	1.47	0.800

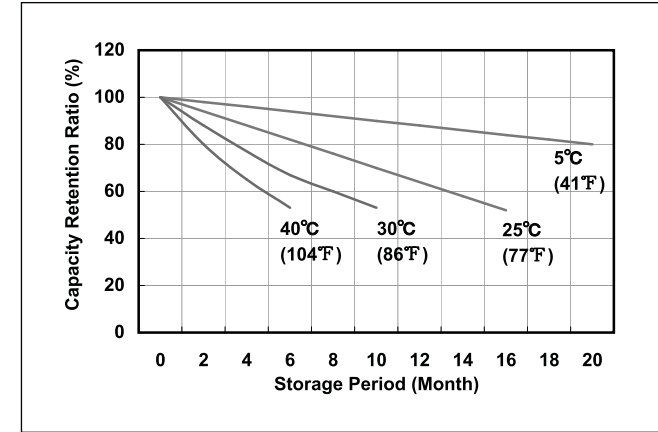
Charging Method

Cycle Use	Control voltage 14.5 - 14.9V; Initial current 6.4A or smaller
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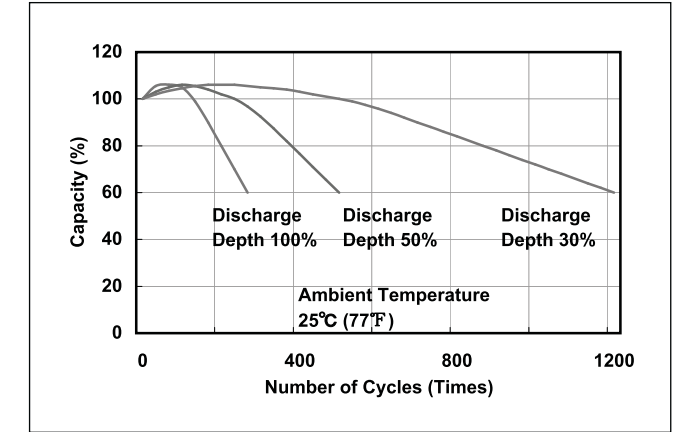
Cut off voltage

Discharge current	0.800A - 3.20A	3.20A - 8A	8A - 16A	16A - 32A	32A - 48A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

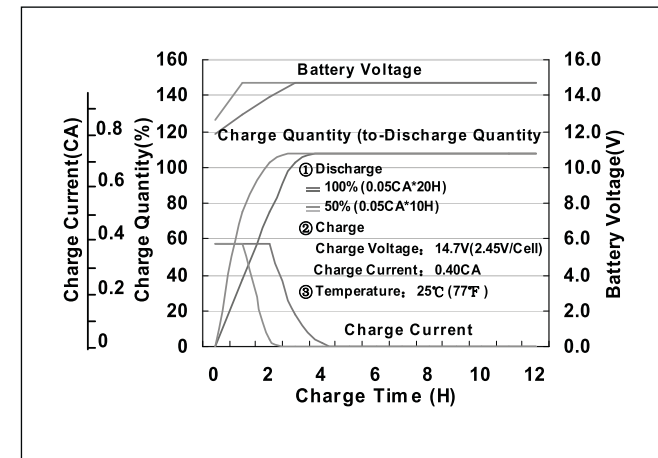
Residual capacity test result



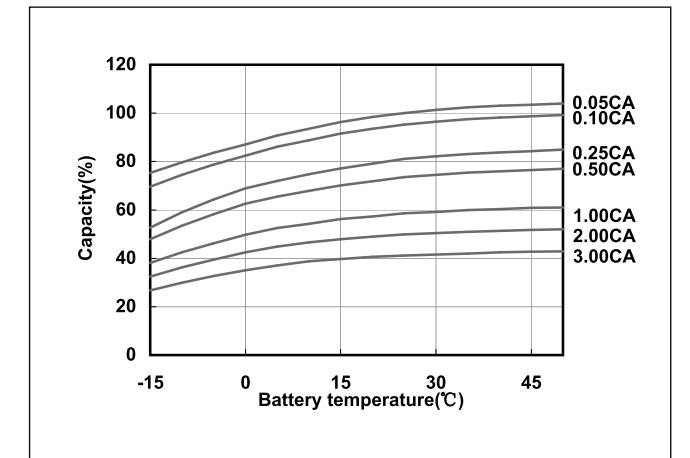
Cycle life vs. Depth of discharge



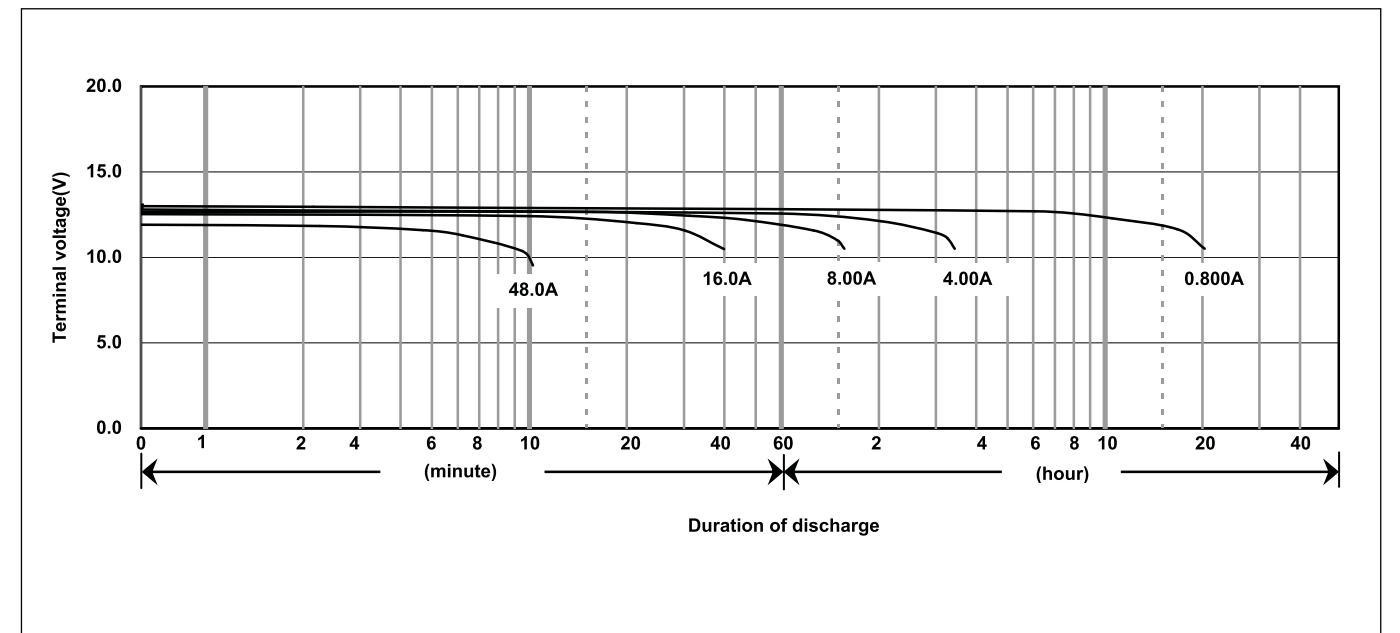
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current



Discharge characteristics (25°C)



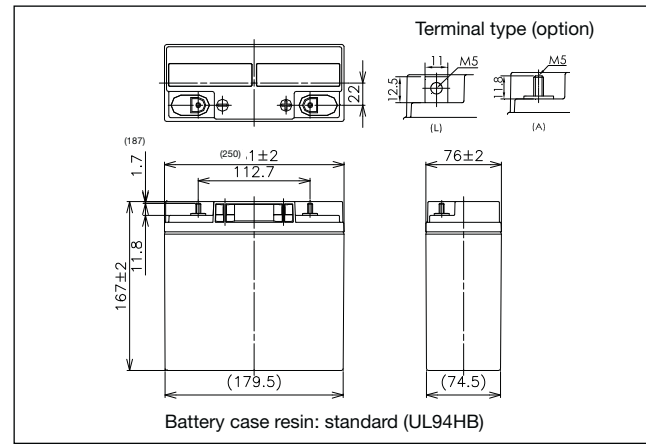
LC-XC1222P

For main power supplies.
Cycle long life type.



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

Dimensions (mm)

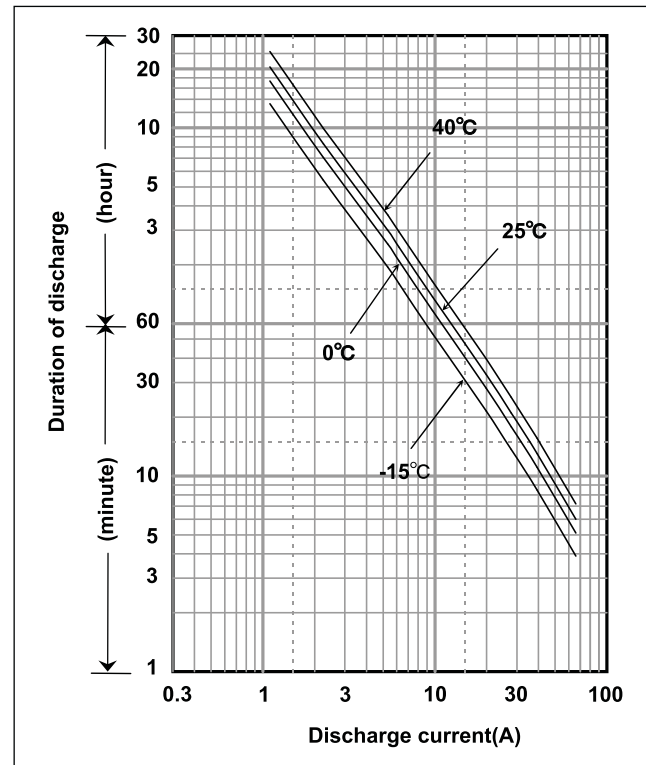


Battery case resin: standard (UL94HB)

Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	22Ah	
Dimensions	Length	181mm
	Width	76mm
	Height	167mm
	Total Height	167mm
Approx. mass	6.55kg	
Terminal	M5 threaded post Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	22.0Ah
	10 hour rate	19.5Ah
	5 hour rate	17.5Ah
	1 hour rate	13.0Ah
Internal resistance	Fully charged battery (25°C)	12mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

(Wattage/Battery)

Cut-off V	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	618	472	396	295	213	170	117	93.2	69.4	53.3	44.0	35.4	24.0	13.0	10.8
9.9V	605	469	389	292	211	170	115	92.5	69.0	53.0	43.7	35.2	23.9	13.0	10.8
10.2V	590	459	383	289	209	167	112	90.1	68.3	52.6	43.3	35.0	23.6	12.9	10.8
10.5V	546	427	363	282	206	163	110	87.0	67.3	52.3	43.0	34.5	23.5	12.9	10.7
10.8V	487	399	354	272	203	160	107	82.8	65.9	51.6	41.9	34.0	23.3	12.8	10.7

Ampere Table

(Ampere/Battery)

Cut-off V	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	59.4	43.0	36.7	25.4	18.8	14.5	9.79	7.55	5.85	4.48	3.69	2.96	2.05	1.11	0.926
9.9V	58.2	42.7	36.1	25.1	18.7	14.5	9.59	7.49	5.82	4.45	3.66	2.95	2.04	1.11	0.923
10.2V	56.7	41.8	35.5	24.8	18.5	14.2	9.40	7.30	5.76	4.42	3.63	2.93	2.02	1.10	0.920
10.5V	52.6	38.9	33.7	24.3	18.2	13.9	9.20	7.05	5.68	4.39	3.60	2.89	2.01	1.10	0.917
10.8V	46.9	36.3	32.8	23.4	17.9	13.6	8.95	6.71	5.56	4.33	3.51	2.84	1.99	1.09	0.911

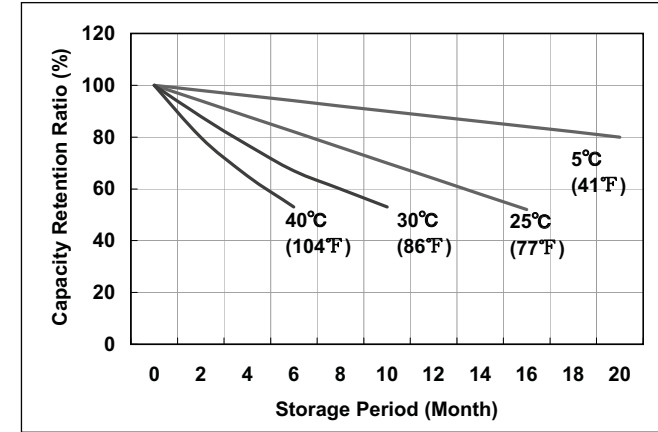
Charging Method

Cycle Use	Control voltage 14.5 - 14.9V; Initial current 8.8A or smaller
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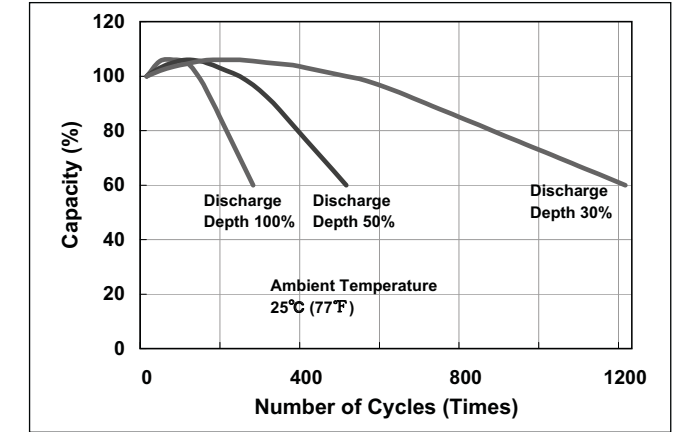
Cut off voltage

Discharge current	1.1A - 4.4A	4.4A - 11A	11A - 22A	22A - 44A	44A - 66A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

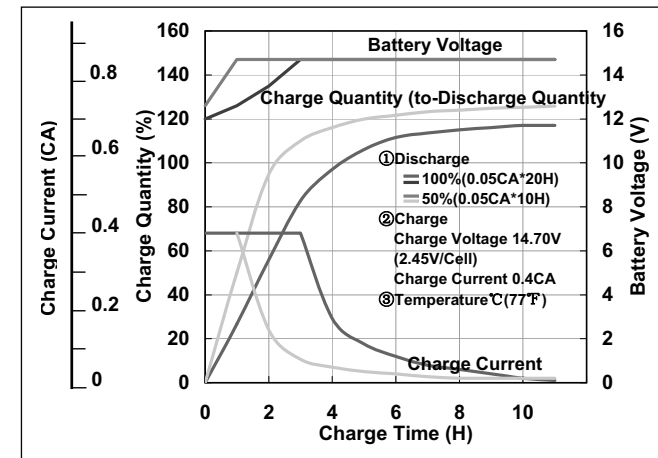
Residual capacity test result



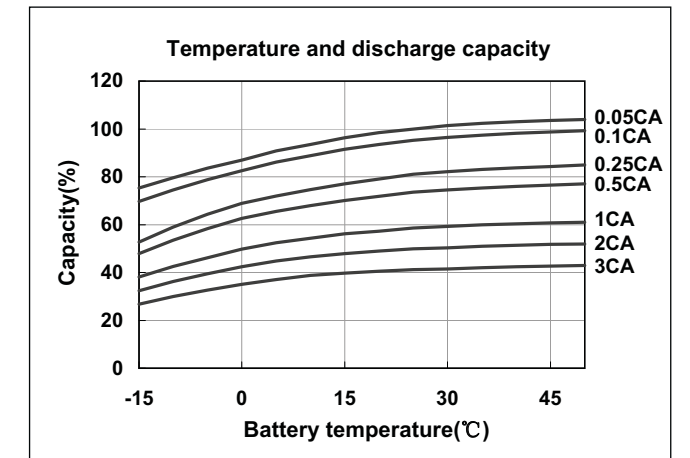
Cycle life vs. Depth of discharge



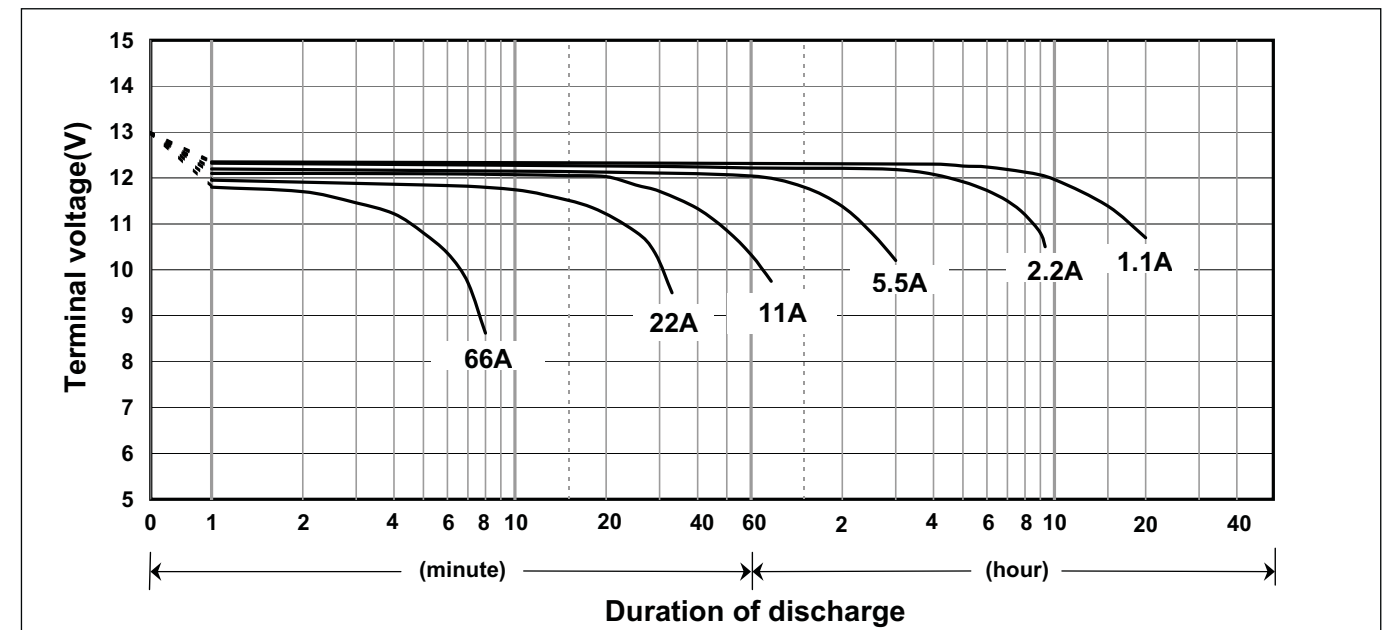
Constant-voltage and constant-current charge characteristics



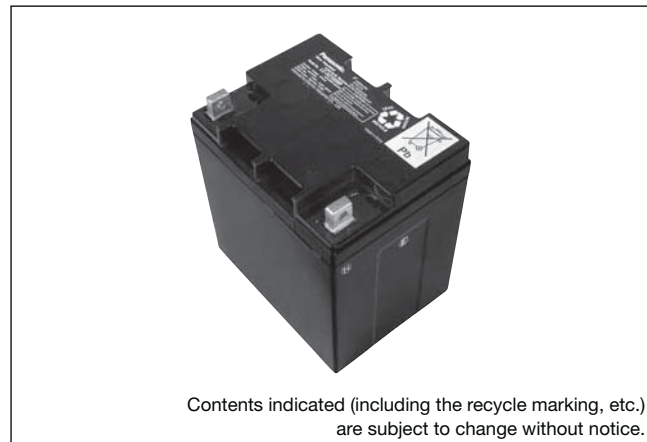
Discharge capacity by temperature and by discharge current



Discharge characteristics (25°C)

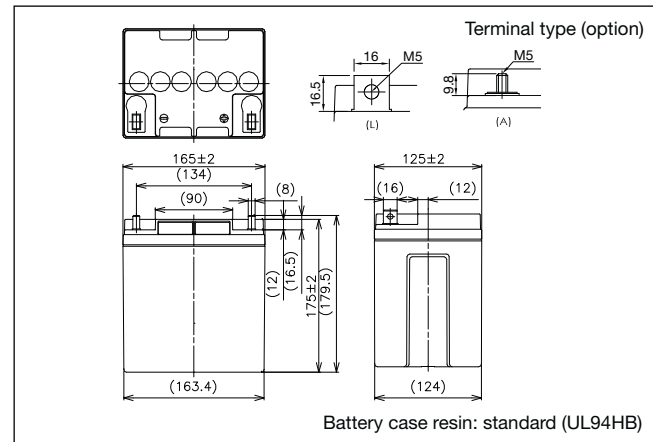


LC-XC1228P



For main power supplies.
Cycle long life type.

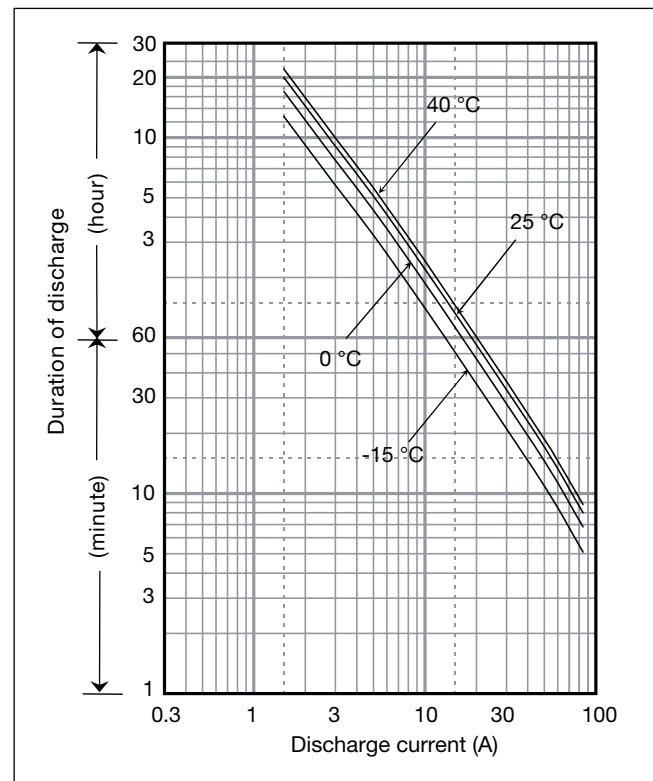
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	28Ah	
Dimensions	Length	165mm
	Width	125mm
	Height	175mm
	Total Height	179.5mm
Approx. mass	10kg	
Terminal	M5 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	28.0Ah 26.5Ah 25.0Ah 21.0Ah
Internal resistance	Fully charged battery (25°C)	8mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	1423	1160	865	664	585	410	304	260	159	129	91.6	74.1	61.1	52.8	31.8	16.8	14.0	
9.9V	1357	1093	849	654	579	404	294	254	156	128	90.4	72.9	59.9	51.6	31.8	16.8	14.0	
10.2V	1301	1026	818	643	567	397	294	251	155	127	89.3	71.7	59.9	51.6	31.8	16.8	14.0	
10.5V	1201	976	784	621	545	386	282	247	154	126	88.1	71.7	59.9	51.6	31.8	16.8	14.0	
10.8V	1052	903	773	610	539	374	255	218	149	118	84.5	70.5	59.9	50.4	31.8	16.8	13.9	

Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	128	104	77.2	57.7	50.4	35.0	25.9	22.1	13.5	10.9	7.7	6.20	5.10	3.40	2.65	1.40	1.17	
9.9V	122	98	75.8	56.9	49.9	34.5	25.0	21.6	13.2	10.8	7.6	6.10	5.00	4.30	2.65	1.40	1.17	
10.2V	117	92	73.0	55.9	48.9	33.9	25.0	21.3	13.1	10.7	7.5	6.00	5.00	4.30	2.65	1.40	1.17	
10.5V	108	88	70.0	54.0	47.0	33.0	24.0	21.0	13.0	10.6	7.4	6.00	5.00	4.30	2.70	1.40	1.17	
10.8V	95	81	69.0	53.0	46.5	32.0	21.7	18.5	12.6	10.0	7.1	5.90	5.00	4.20	2.65	1.40	1.16	

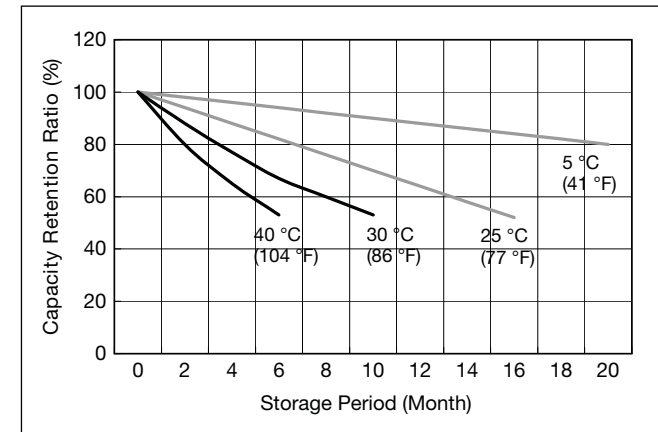
Charging Method

Trickle use Control voltage: 14.5 - 14.9V; Initial current 11.2A or smaller

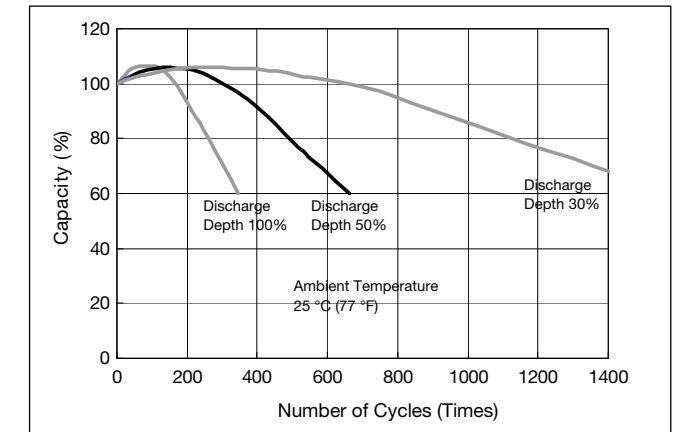
Cut off voltage

Discharge current	1.4A - 5.6A	5.6A - 14A	14A - 28A	28A - 56A	56A - 84A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

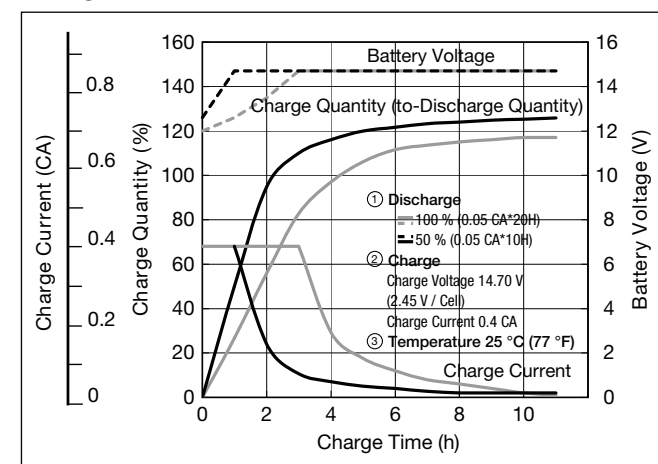
Residual capacity vs storage period



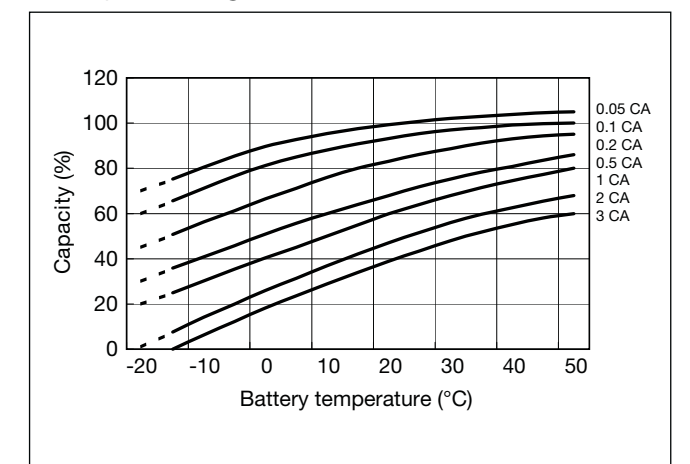
Cycle life vs Depth of discharge



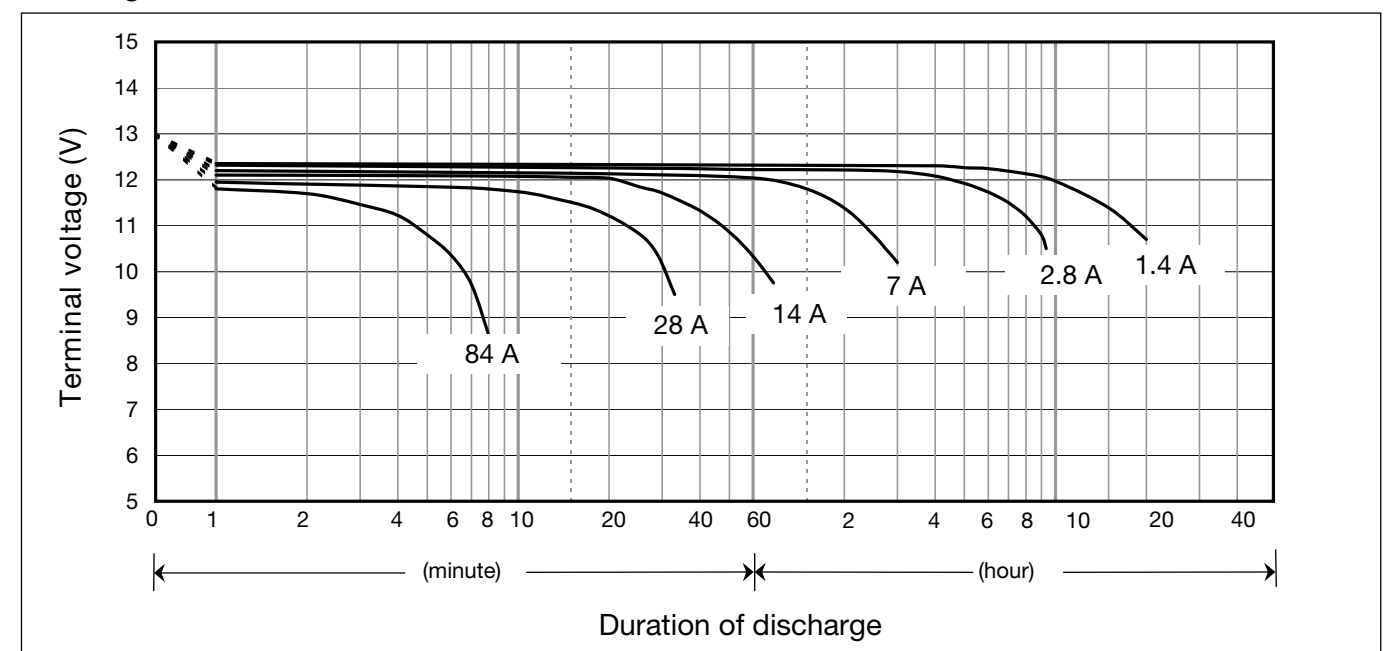
Constant-voltage and constant-current charge characteristics



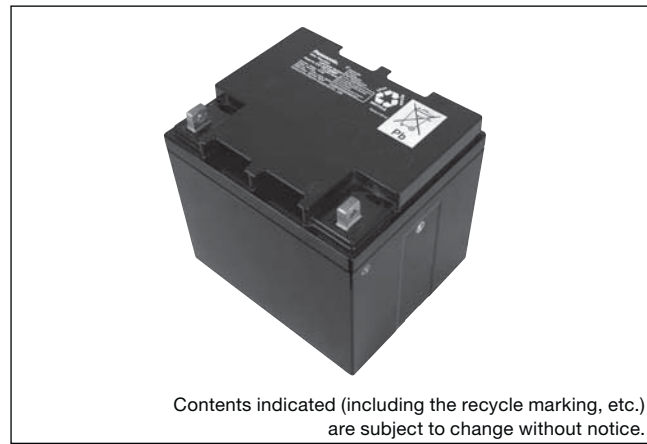
Discharge capacity by temperature and by discharge current



Discharge characteristics

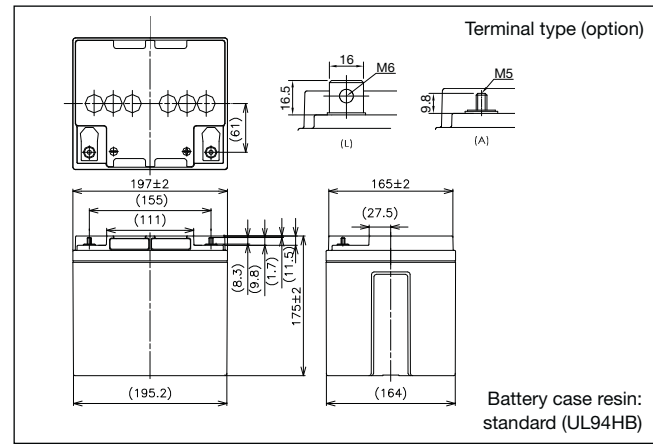


LC-XC1238P



For main power supplies.
Cycle long life type.

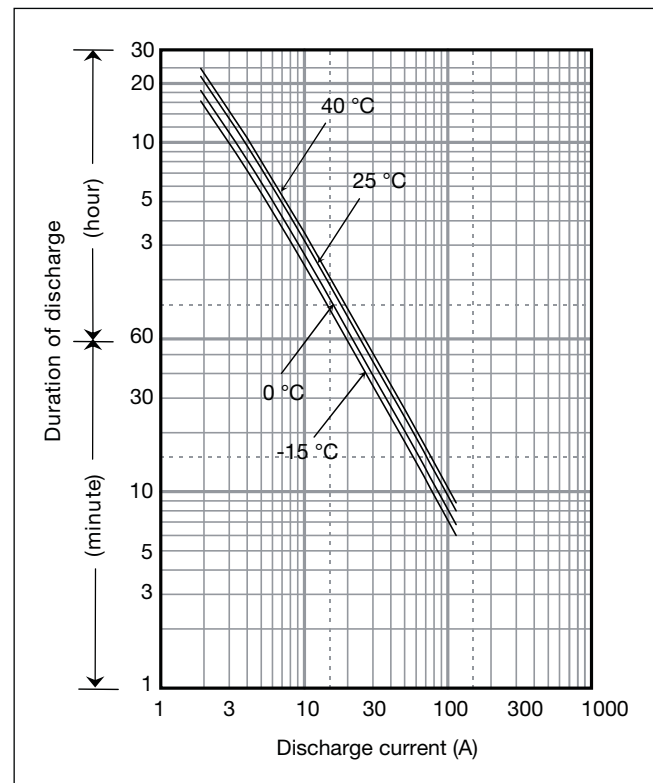
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	38Ah	
Dimensions	Length	197mm
	Width	165mm
	Height	175mm
	Total Height	179.5mm
Approx. mass	15kg	
Terminal	M6 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	38Ah 36Ah 35Ah 23Ah
Internal resistance	Fully charged battery (25°C)	9mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1668	1349	1030	800	686	505	351	276	214	169	123	99.2	77.9	68.3	42.0	22.8	19.0
9.9V	1535	1271	1008	788	682	500	350	269	209	168	120	98.0	76.7	68.3	42.0	22.8	19.0
10.2V	1457	1204	980	768	672	489	349	267	185	167	119	96.8	75.5	68.3	42.0	22.8	19.0
10.5V	1446	1126	952	748	661	480	346	265	183	166	119	96.8	75.5	68.3	42.0	22.8	19.0
10.8V	1311	1098	874	716	640	468	308	247	175	155	114	94.4	74.3	67.1	42.0	22.8	18.7

Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	150	121	92.0	69.6	59.1	43.2	29.9	23.4	18.1	14.3	10.3	8.30	6.50	5.70	3.50	1.90	1.58
9.9V	138	114	90.0	68.5	58.8	42.7	29.8	22.8	17.7	14.2	10.1	8.20	6.40	5.70	3.50	1.90	1.58
10.2V	131	108	87.5	66.8	57.9	41.8	29.7	22.7	15.7	14.1	10.0	8.10	6.30	5.70	3.50	1.90	1.58
10.5V	130	101	85.0	65.0	57.0	41.0	29.5	22.5	15.5	14.0	10.0	8.10	6.30	5.70	3.50	1.90	1.58
10.8V	118	98.5	78.0	62.3	55.2	40.0	26.2	21.0	14.8	13.1	9.6	7.90	6.20	5.60	3.50	1.90	1.56

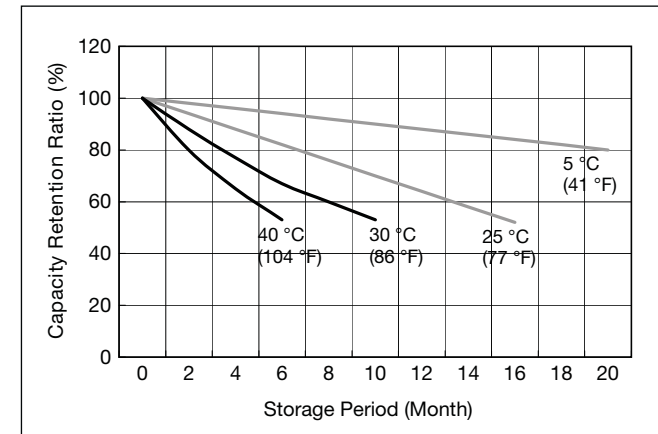
Charging Method

Trickle use	Control voltage: 14.5 - 14.9V; Initial current 15.2A or smaller
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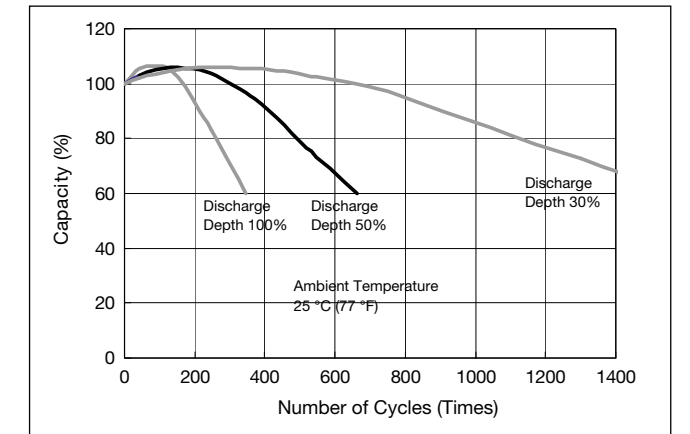
Cut off voltage

Discharge current	1.9A - 7.6A	7.6A - 19A	19A - 38A	38A - 76A	76A - 114A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

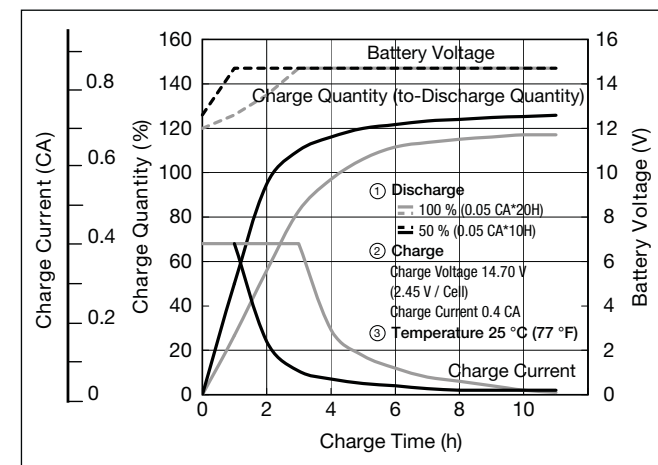
Residual capacity vs storage period



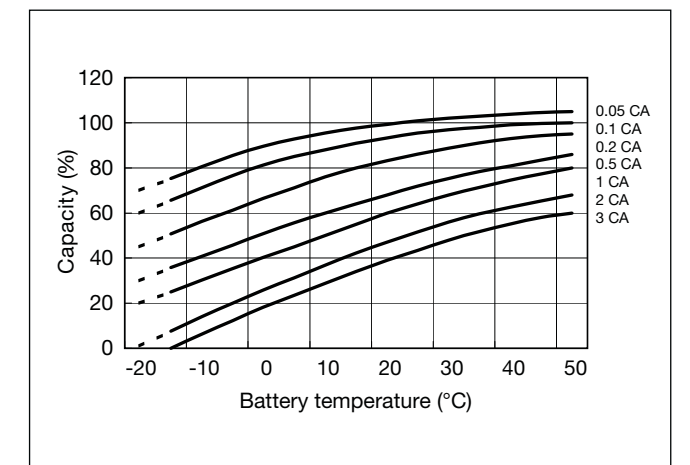
Cycle life vs Depth of discharge



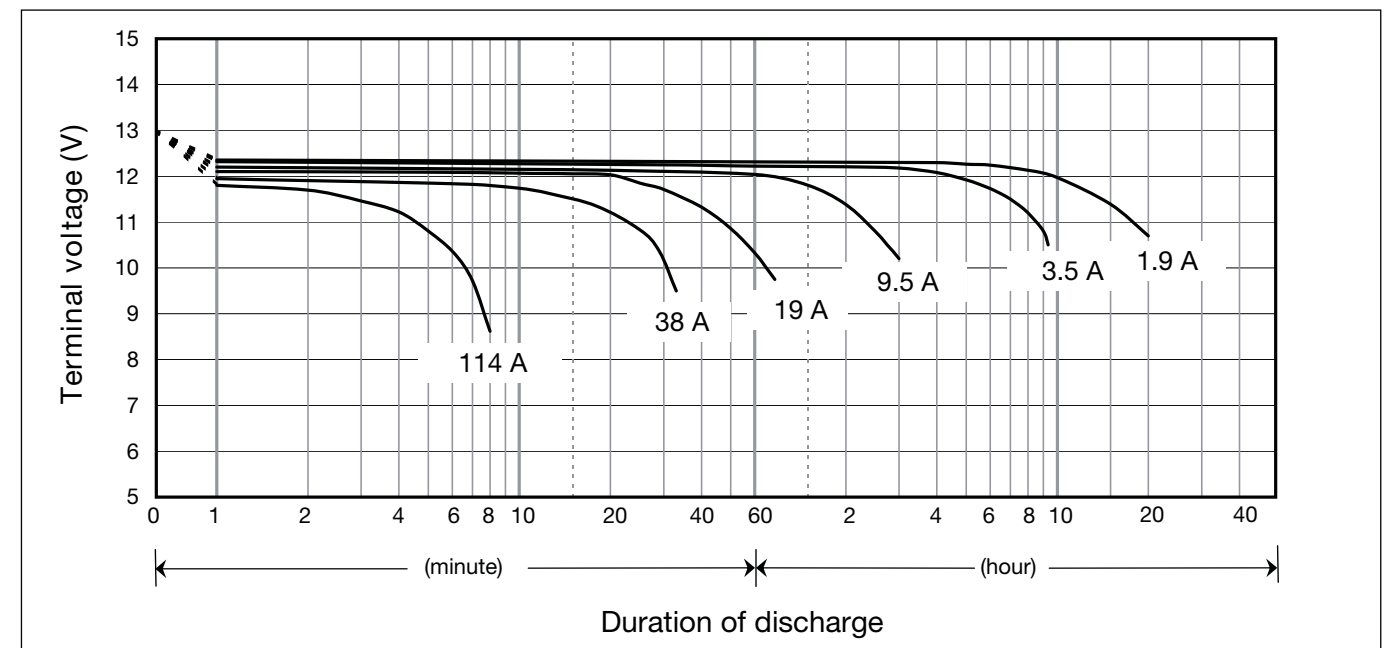
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current



Discharge characteristics



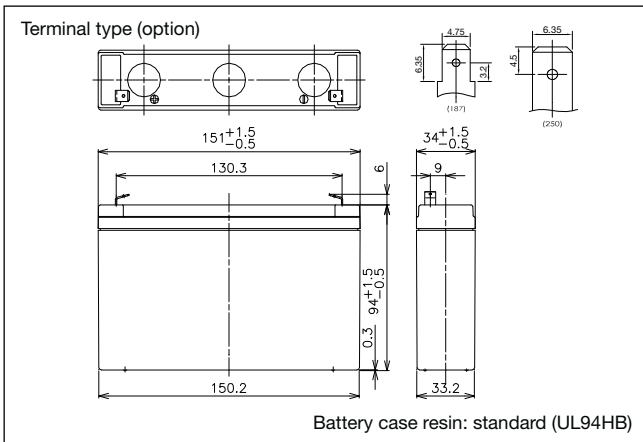
UP-RW0645P*1



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.

Dimensions (mm)



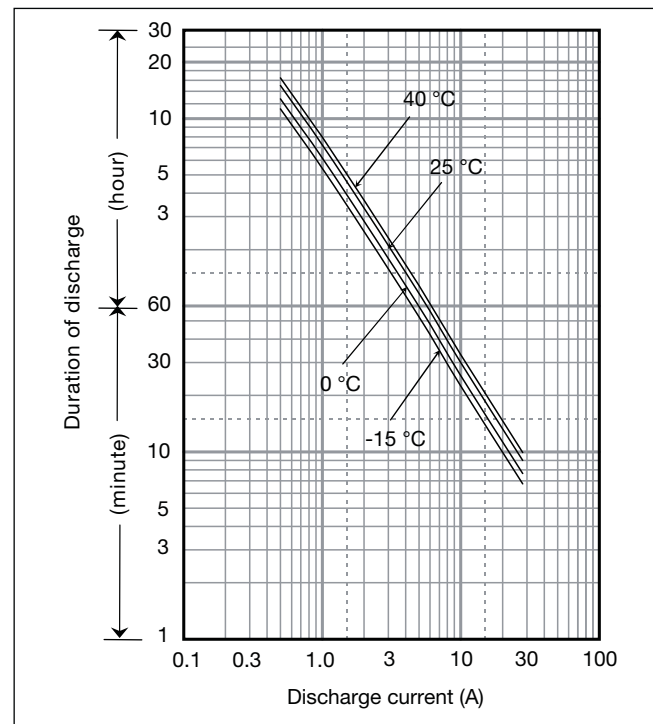
Specifications

Nominal voltage	6V	
Nominal capacity (10 minute rate)	135W	
Dimensions	Length	151mm
	Width	34mm
	Height	94mm
	Total Height	100mm
Approx. mass	1.3kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	56W
	10 hour rate	97W
	5 hour rate	134W
	1 hour rate	205W
Internal resistance	Fully charged battery (25°C)	10mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	265	205	134	97.5	79.5	56.0	41.1	32.8	22.6	17.5	13.0	10.0	8.25	6.63	4.39	2.38	1.99
4.95V	254	200	131	97.2	78.9	55.9	40.8	32.8	22.1	17.3	12.9	9.92	8.18	6.60	4.37	2.37	1.98
5.1V	245	195	129	96.5	78.0	55.5	40.4	32.2	21.7	16.9	12.8	9.86	8.12	6.55	4.33	2.37	1.97
5.25V	231	180	123	93.4	75.4	55.0	39.3	31.5	20.8	16.4	12.8	9.85	8.07	6.48	4.31	2.36	1.97
5.4V	217	165	117	90.0	73.0	54.5	39.1	30.9	20.6	15.5	12.4	9.66	7.85	6.37	4.26	2.35	1.95

Ampere Table

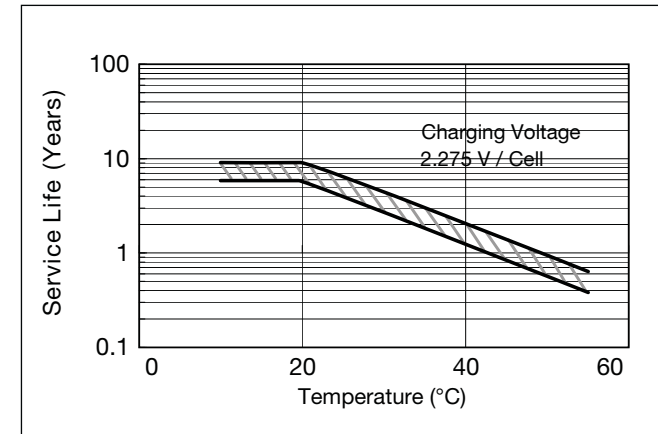
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	47.7	36.8	23.9	17.0	13.7	9.6	6.99	5.57	3.82	2.95	2.19	1.67	1.38	1.11	0.732	0.397	0.331
4.95V	45.8	35.9	23.5	16.9	13.6	9.6	6.95	5.57	3.75	2.93	2.17	1.66	1.37	1.10	0.729	0.396	0.330
5.1V	44.1	35.0	23.0	16.8	13.5	9.5	6.88	5.46	3.67	2.86	2.15	1.65	1.36	1.09	0.721	0.394	0.329
5.25V	41.6	32.3	22.0	16.3	13.0	9.4	6.70	5.35	3.53	2.77	2.16	1.65	1.35	1.08	0.718	0.393	0.328
5.4V	39.0	29.6	20.9	15.7	12.6	9.3	6.67	5.25	3.50	2.62	2.08	1.62	1.31	1.06	0.710	0.391	0.326

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use	Control voltage: 6.8 - 6.9V; Initial current: 1.2A or smaller
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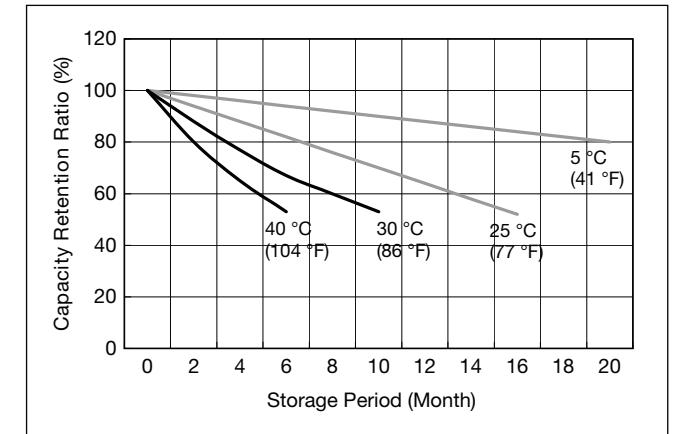
Influence of Temperature on Trickle life



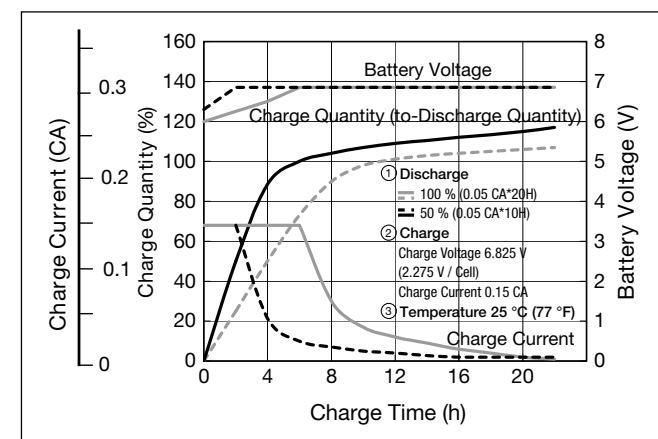
Cut off voltage

Discharge current	0.4A - 1.6A	1.6A - 4A	4A - 8A	8A - 16A	16A - 24A
Cut off voltage (V)	5.25	5.1	4.95	4.65	4.35

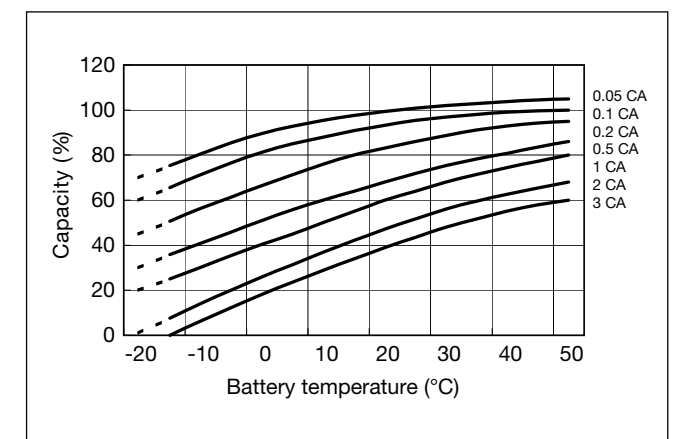
Residual capacity vs storage period



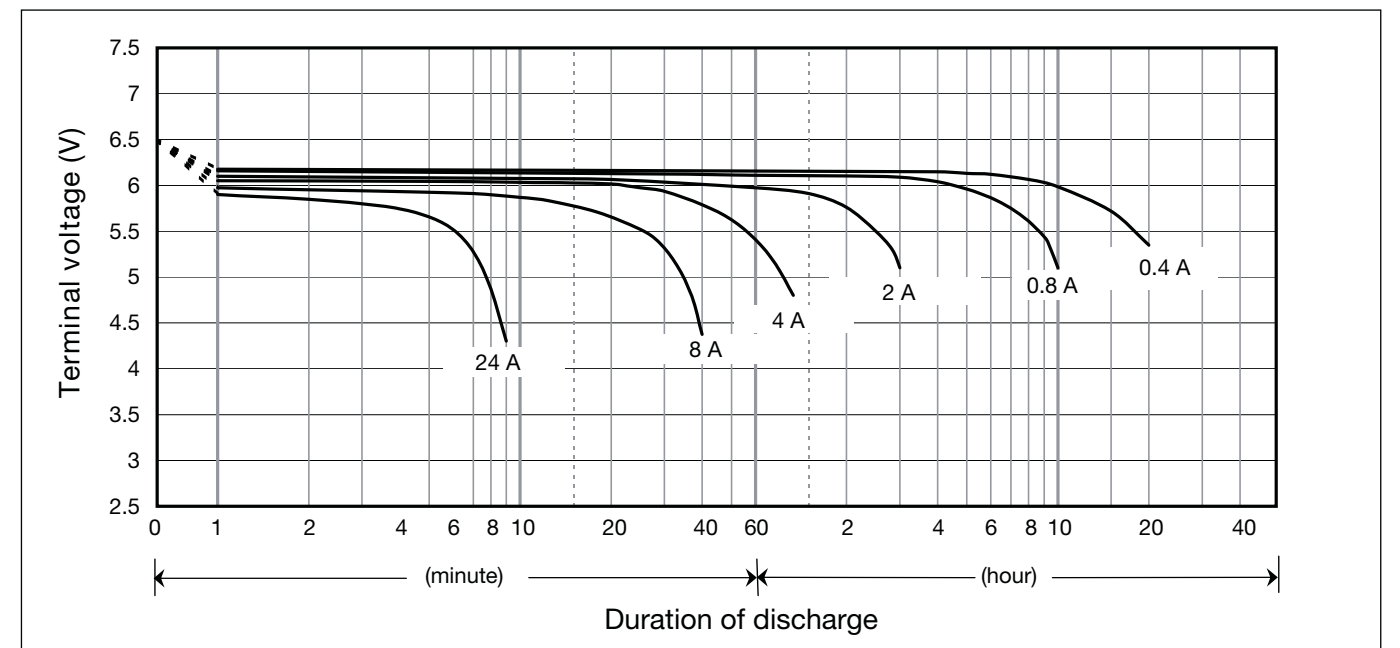
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

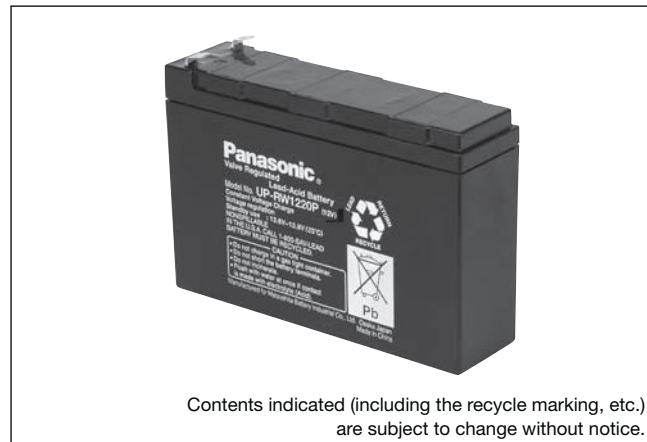


Discharge characteristics

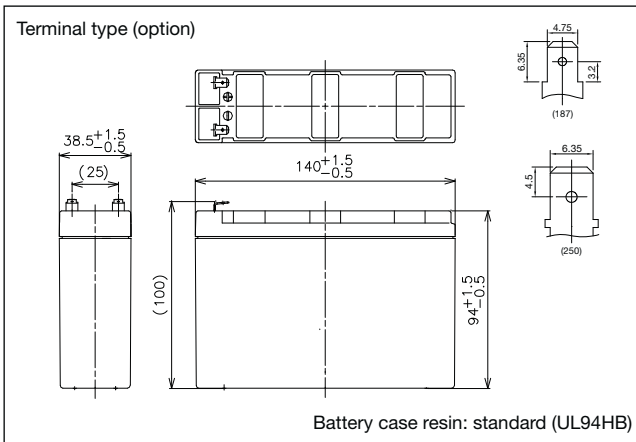


UP-RW1220P*1

For standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.



Dimensions (mm)



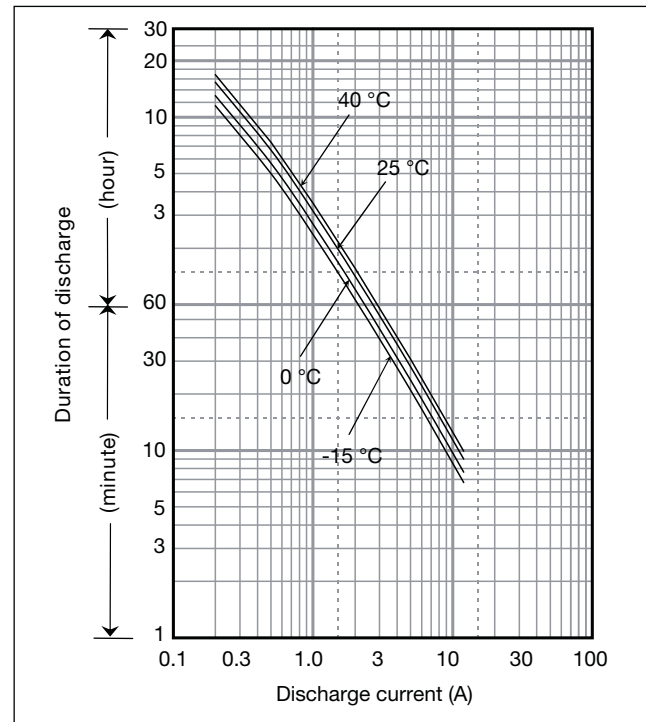
Specifications

Nominal voltage	12V	
Nominal capacity (10 minute rate)	120W	
Dimensions	Length	140mm
	Width	38.5mm
	Height	94mm
	Total Height	100mm
Approx. mass	1.35kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	57W
	10 hour rate	91W
	5 hour rate	120W
	1 hour rate	180W
Internal resistance	Fully charged battery (25°C)	44mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	237	180	120	91.0	75.0	57.0	41.8	33.4	23.0	17.8	13.2	10.2	8.39	6.75	4.47	2.42	2.02
9.9V	227	173	116	89.1	74.0	58.4	39.3	31.6	21.3	16.7	12.5	9.56	7.88	6.36	4.21	2.29	1.91
10.2V	217	167	113	87.0	73.0	52.0	37.9	30.2	20.3	15.9	12.0	9.24	7.60	6.14	4.05	2.22	1.85
10.5V	197	152	108	84.5	69.5	49.5	35.4	28.3	18.7	14.8	11.6	8.86	7.26	5.83	3.88	2.12	1.77
10.8V	177	137	102	82.0	66.0	47.0	33.7	26.6	17.8	13.4	10.7	8.33	6.77	5.49	3.68	2.02	1.69

Ampere Table

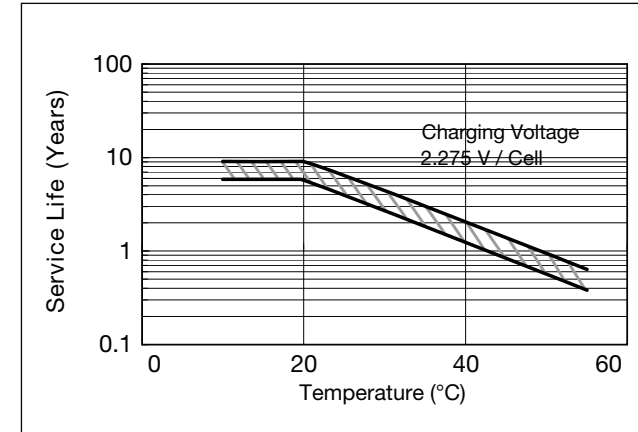
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	21.3	16.1	10.7	7.91	6.47	4.87	3.56	2.84	1.95	1.50	1.11	0.85	0.70	0.56	0.373	0.202	0.169
9.9V	20.4	15.6	10.4	7.75	6.38	4.99	3.35	2.68	1.80	1.41	1.05	0.80	0.66	0.53	0.351	0.190	0.159
10.2V	19.5	15.0	10.1	7.57	6.29	4.44	3.23	2.56	1.72	1.34	1.01	0.77	0.63	0.51	0.338	0.185	0.154
10.5V	17.7	13.7	9.60	7.35	5.99	4.23	3.02	2.41	1.59	1.25	0.97	0.74	0.61	0.49	0.323	0.177	0.148
10.8V	15.9	12.3	9.11	7.13	5.69	4.02	2.87	2.26	1.51	1.13	0.90	0.70	0.57	0.46	0.306	0.169	0.140

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use Control voltage: 13.6 - 13.8V; Initial current: 0.6A or smaller

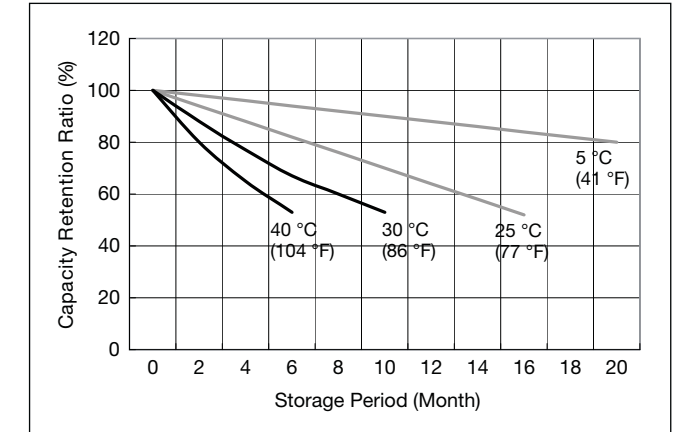
Influence of Temperature on Trickle life



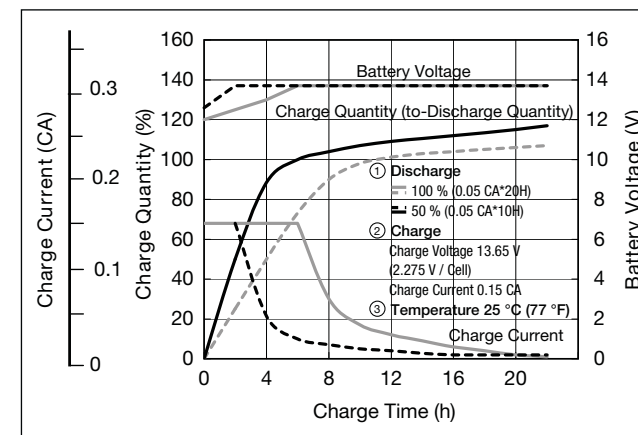
Cut off voltage

Discharge current	0.2A - 0.8A	0.8A - 2A	2A - 4A	4A - 8A	8A - 12A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

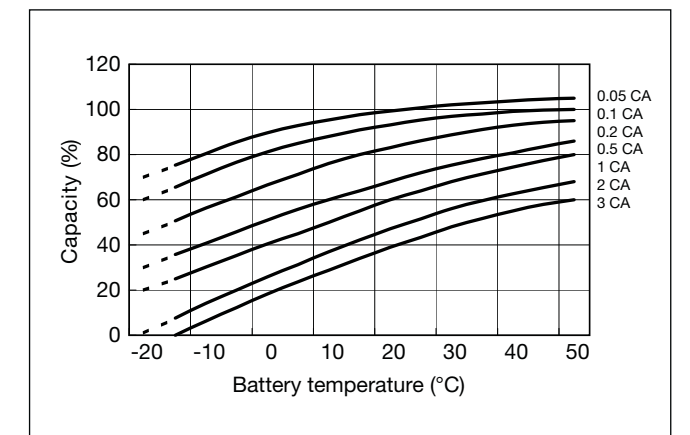
Residual capacity vs storage period



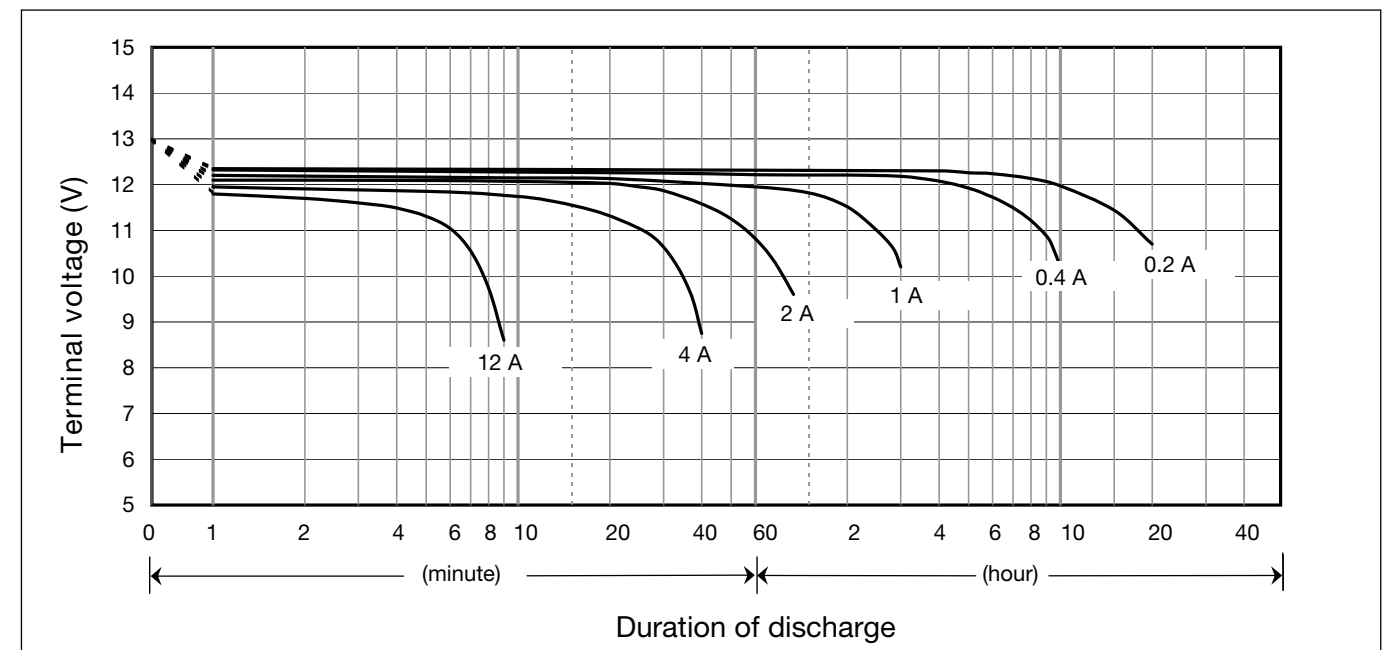
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

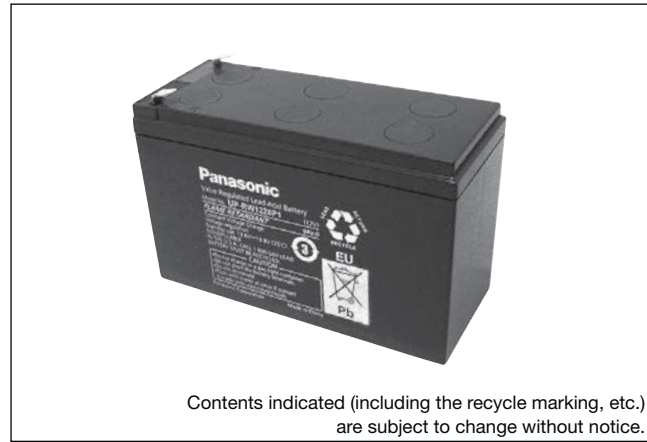


Discharge characteristics

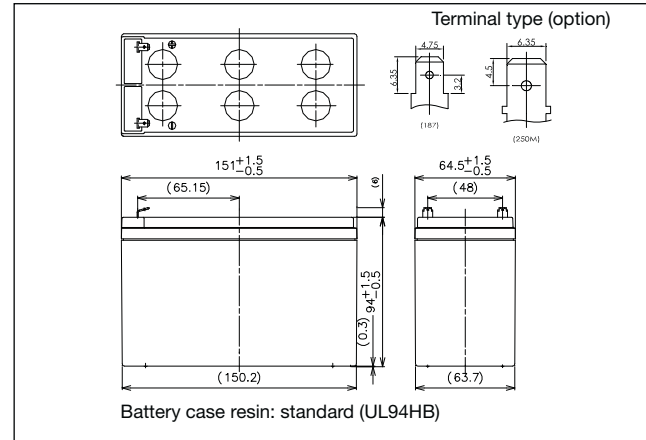


UP-RW1228P*1

For standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.



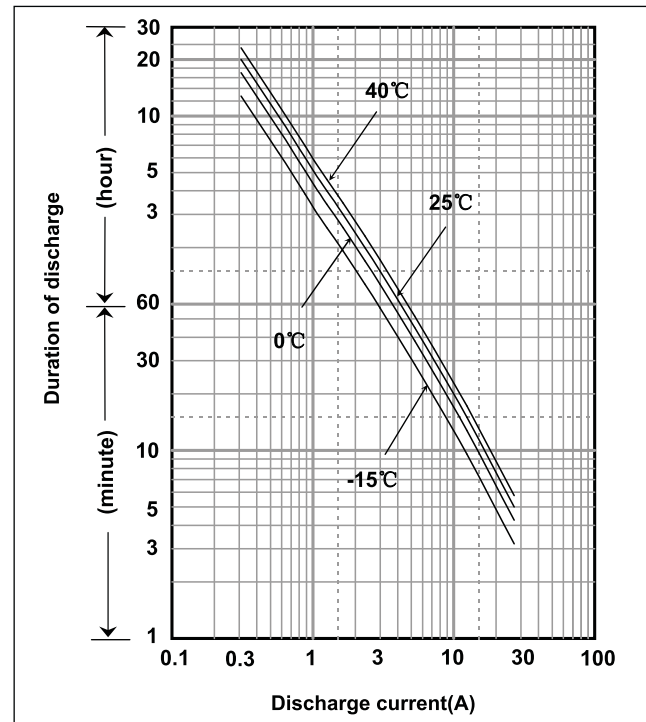
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (10 minute rate)	200W	
Dimensions	Length	151mm
	Width	64.5mm
	Height	94mm
	Total Height	100mm
Approx. mass	1.85kg	
Terminal	Faston 187 & 250M	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	30 minute rate	80W
	15 minute rate	151W
	10 minute rate	200W
	5 minute rate	210W
Internal resistance	Fully charged battery (25°C)	23mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	415	320	200	151	113	80.4	60.0	50.4	37.2	28.8	20.1	15.2	12.5	10.3	6.26	3.01	2.46
9.9V	391	274	170	144	109	78.7	59.6	49.2	36.4	28.6	20.0	15.1	12.4	10.1	6.23	3.00	2.46
10.2V	365	261	165	137	106	77.0	57.1	47.8	34.5	27.0	19.2	14.8	11.9	9.85	5.97	2.90	2.37
10.5V	331	237	158	131	101	74.1	55.6	46.8	33.2	26.2	18.8	14.5	11.8	9.75	5.94	2.89	2.36
10.8V	298	213	149	125	96.9	71.2	52.1	43.2	31.0	23.3	17.4	13.4	10.8	9.02	5.53	2.71	2.21

Ampere Table

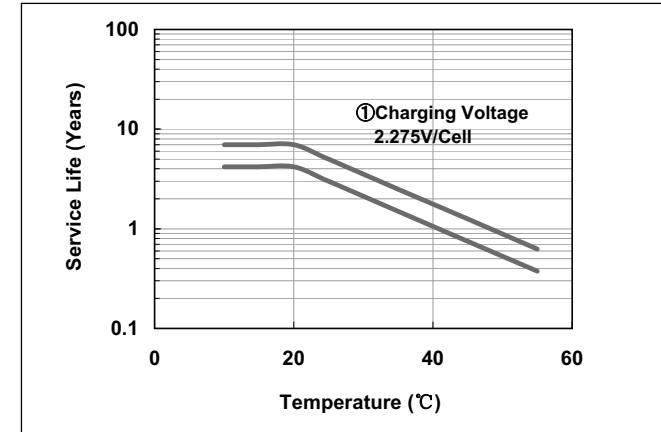
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	35.6	26.9	16.6	13.2	10.7	8.01	5.86	4.67	3.20	2.47	1.83	1.40	1.15	0.926	0.613	0.332	0.277
9.9V	33.5	25.6	16.1	12.6	10.3	7.85	5.82	4.55	3.14	2.45	1.82	1.39	1.14	0.922	0.610	0.331	0.276
10.2V	31.4	24.4	15.7	11.9	10.0	7.68	5.58	4.43	2.97	2.32	1.74	1.34	1.10	0.885	0.584	0.320	0.266
10.5V	28.5	22.1	15.0	11.4	9.57	7.40	5.43	4.33	2.86	2.24	1.68	1.29	1.05	0.876	0.581	0.310	0.257
10.8V	25.6	19.9	14.2	10.9	9.17	7.11	5.08	4.00	2.67	2.00	1.58	1.23	1.00	0.810	0.542	0.298	0.248

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 0.87A or smaller
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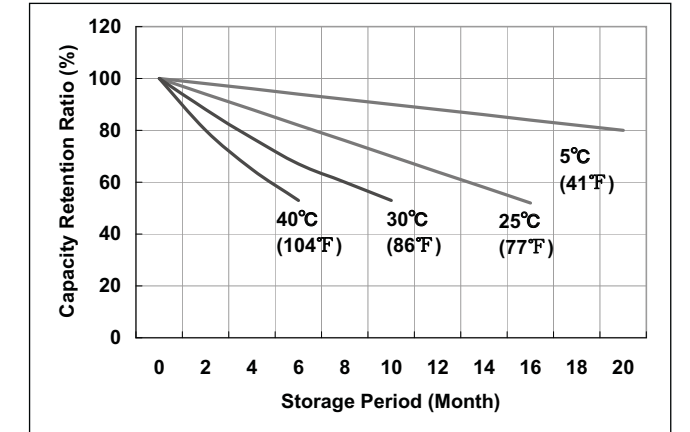
Influence of Temperature on Trickle life



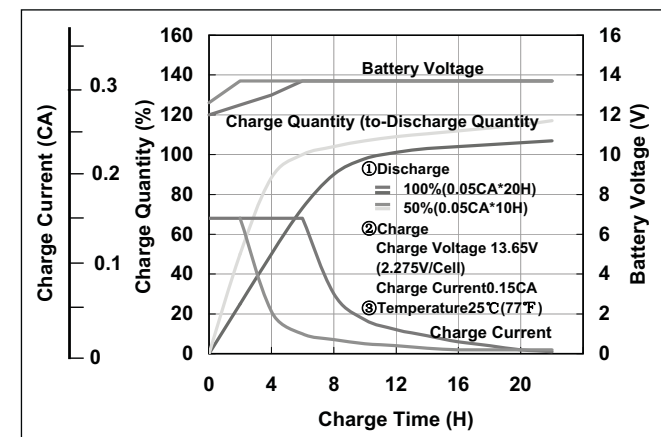
Cut off voltage

Discharge current	0.29A - 1.16A	1.16A - 2.9A	2.9A - 5.8A	5.8A - 11.6A	11.6A - 17.4A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

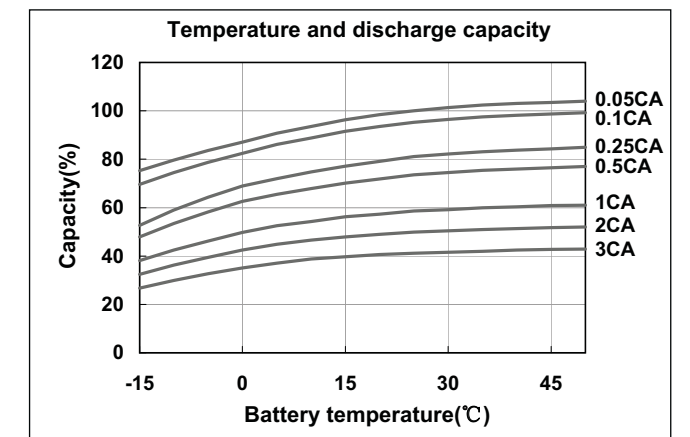
Residual capacity test result



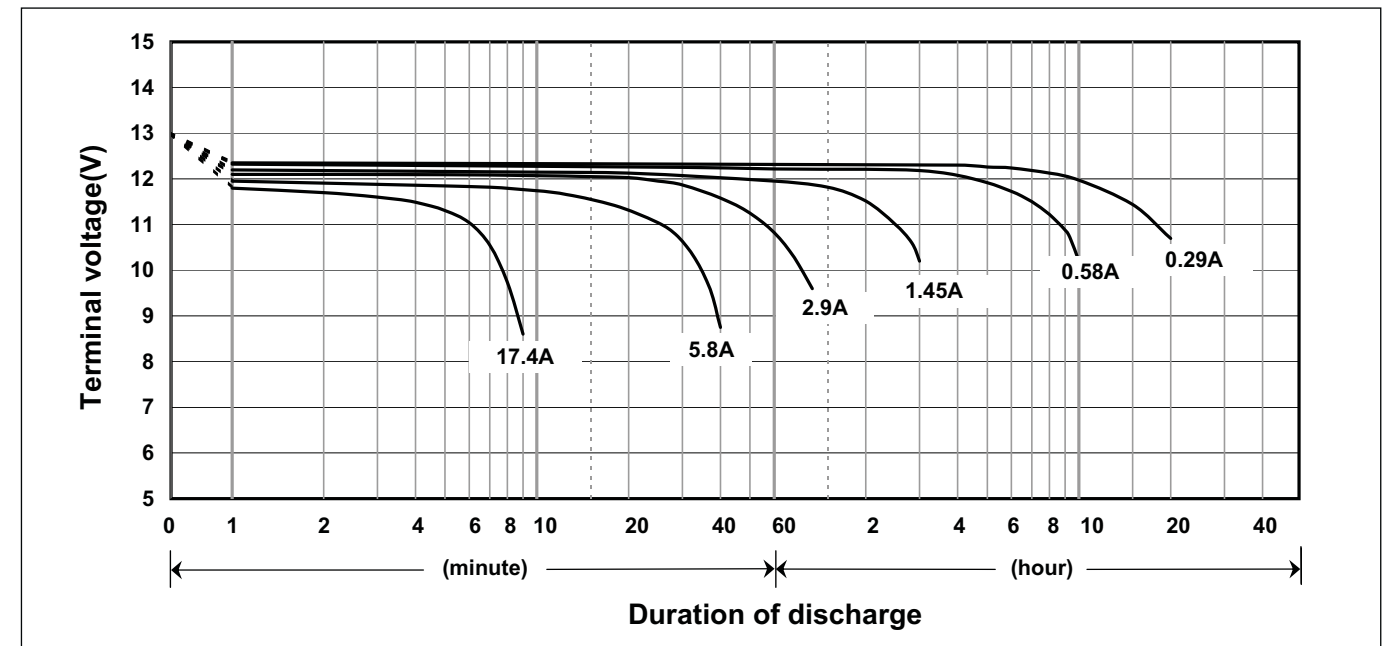
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current

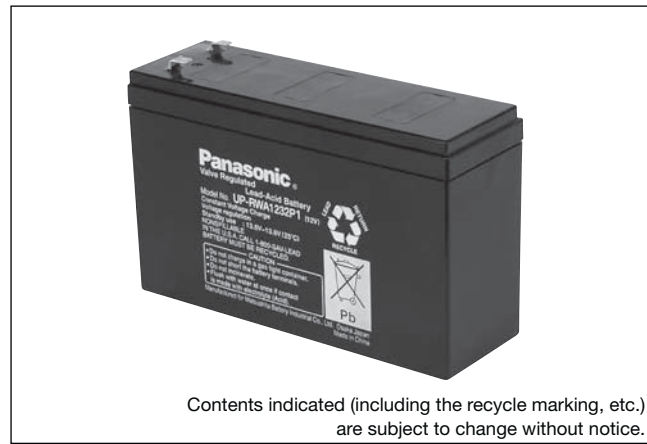


Discharge characteristics

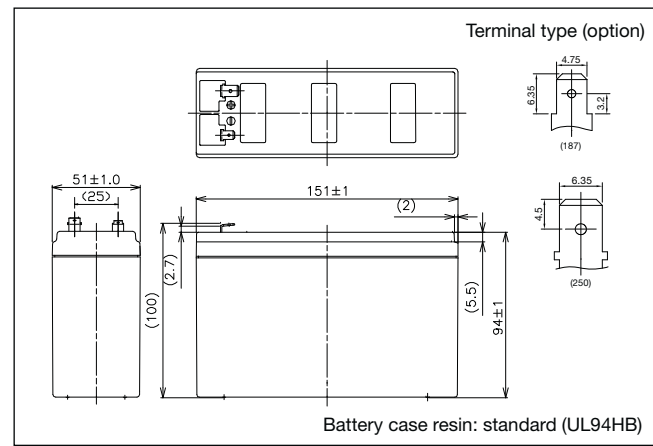


UP-RWA1232P1/P2*1

For standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.



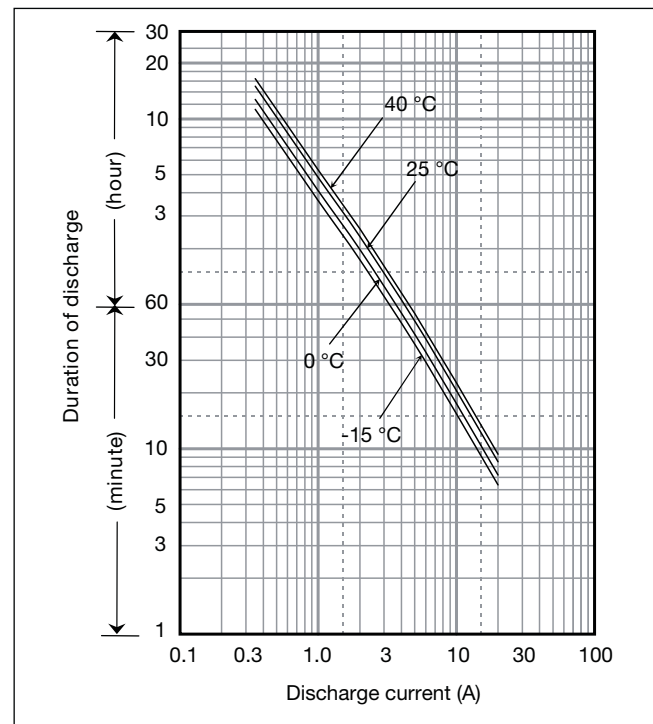
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (10 minute rate)	192W	
Dimensions	Length	151mm
	Width	51mm
	Height	94mm
	Total Height	100mm
Approx. mass	2kg	
Terminal	Faston 250 with hole or Faston 187/250 mixed	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	97W
	10 hour rate	157W
	5 hour rate	192W
	1 hour rate	310W
Internal resistance	Fully charged battery (25°C)	33mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	410	310	192	157	128	97.0	71.1	56.9	39.1	30.3	22.5	17.3	14.3	11.5	7.61	4.12	3.44
9.9V	386	295	187	150	124	95.0	70.7	56.9	38.3	30.0	22.4	17.2	14.2	11.4	7.58	4.11	3.43
10.2V	361	281	182	142	120	93.0	67.7	53.9	36.3	28.4	21.5	16.5	13.6	11.0	7.25	3.97	3.31
10.5V	327	255	174	136	115	89.5	65.9	52.8	34.9	27.5	21.5	16.5	13.5	10.9	7.22	3.96	3.30
10.8V	294	230	164	130	110	86.0	61.7	48.8	32.6	24.5	19.5	15.2	12.4	10.0	6.73	3.70	3.08

Ampere Table

Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	36.9	27.8	17.1	13.7	11.0	8.29	6.06	4.83	3.31	2.56	1.89	1.45	1.19	0.96	0.634	0.344	0.287
9.9V	34.7	26.5	16.7	13.0	10.7	8.12	6.02	4.83	3.25	2.54	1.88	1.44	1.18	0.95	0.631	0.343	0.286
10.2V	32.5	25.2	16.3	12.3	10.3	7.95	5.77	4.58	3.08	2.40	1.80	1.38	1.14	0.92	0.604	0.331	0.276
10.5V	29.5	22.9	15.5	11.8	9.9	7.65	5.61	4.48	2.96	2.32	1.81	1.38	1.13	0.91	0.602	0.330	0.275
10.8V	26.4	20.6	14.6	11.3	9.5	7.35	5.26	4.14	2.76	2.07	1.64	1.28	1.03	0.84	0.560	0.309	0.257

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

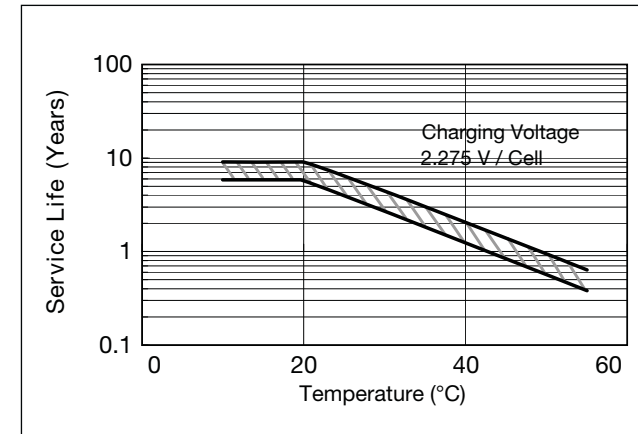
Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 1.05A or smaller
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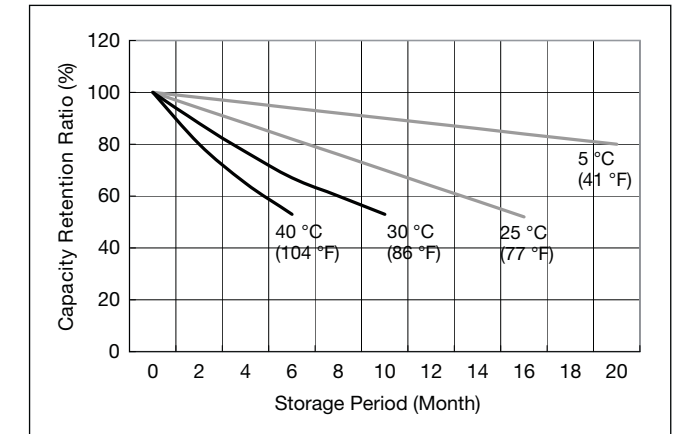
Cut off voltage

Discharge current	0.35A - 1.4A	1.4A - 3.5A	3.5A - 7A	7A - 14A	14A - 21A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

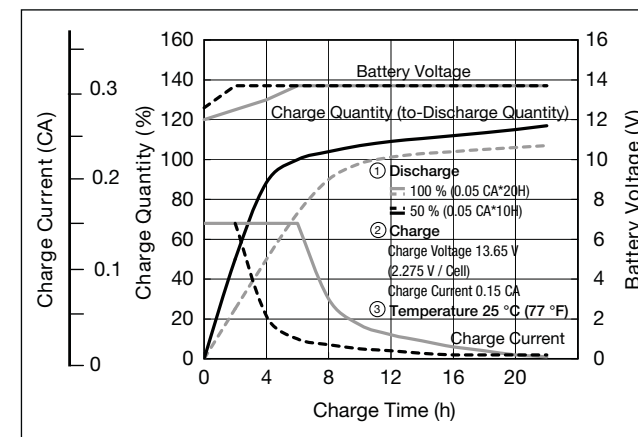
Influence of Temperature on Trickle life



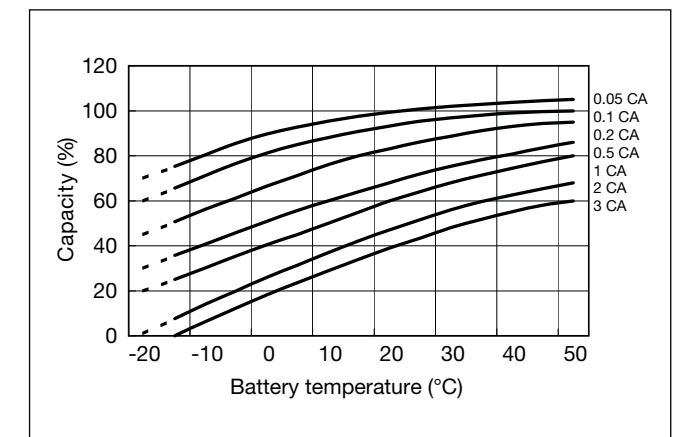
Residual capacity vs storage period



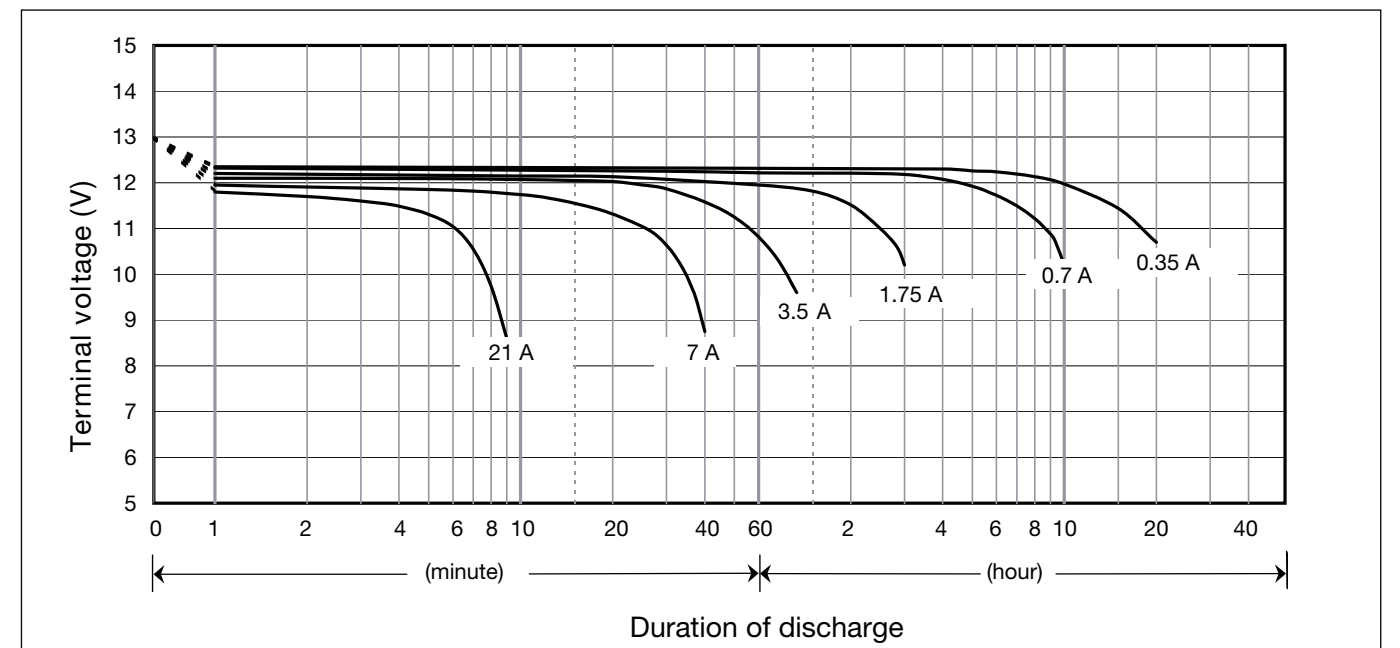
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current

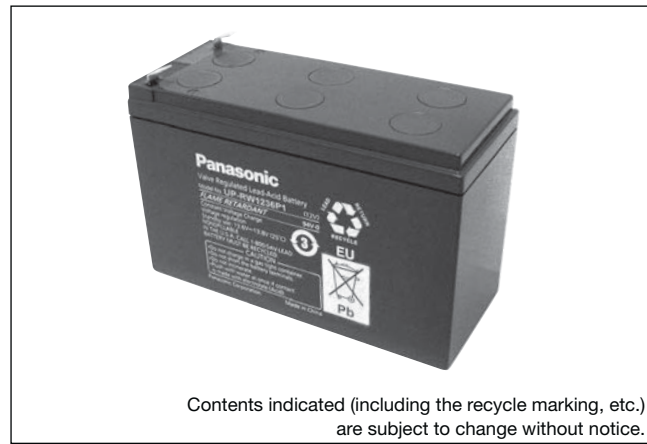


Discharge characteristics

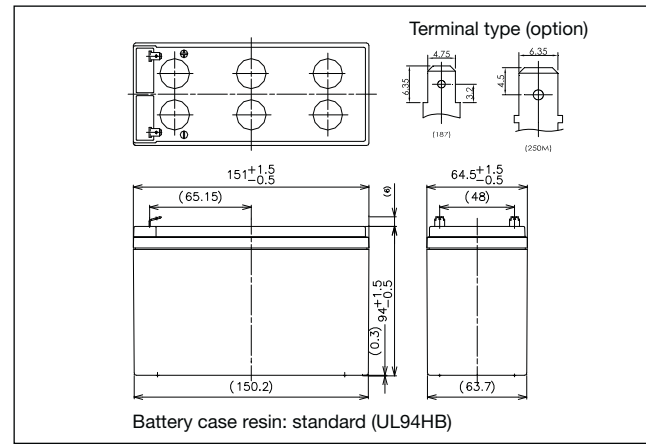


UP-RW1236P*1

For standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.



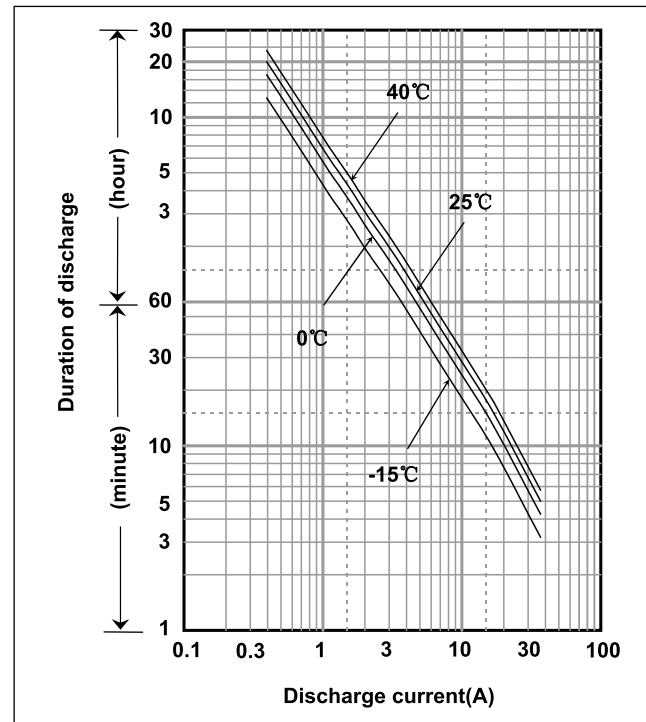
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (10 minute rate)	192W	
Dimensions	Length	151mm
	Width	51mm
	Height	94mm
	Total Height	100mm
Approx. mass	2kg	
Terminal	Faston 250 with hole or Faston 187/250 mixed	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	97W
	10 hour rate	157W
	5 hour rate	192W
	1 hour rate	310W
Internal resistance	Fully charged battery (25°C)	33mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																		
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h		
9.6V	461	348	224	169	140	102	73.3	58.3	44.1	34.5	24.3	18.6	15.1	12.7	7.60	4.02	3.33		
9.9V	434	298	190	161	135	99.5	72.8	56.9	43.3	34.2	24.2	18.4	15.0	12.4	7.56	4.01	3.32		
10.2V	406	283	185	153	131	97.4	69.8	55.3	41.0	32.3	23.1	18.1	14.4	12.1	7.24	3.87	3.20		
10.5V	368	258	177	146	125	93.7	67.9	54.1	39.4	31.3	22.6	17.7	14.3	12.0	7.21	3.86	3.19		
10.8V	331	232	167	140	120	90.1	63.6	50.0	36.8	27.9	21.0	16.4	13.1	11.1	6.72	3.61	2.98		

Ampere Table

Cut-off V	(Ampere/Battery)																		
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h		
9.6V	38.1	28.7	17.7	14.1	11.4	8.57	6.26	4.99	3.42	2.64	1.96	1.50	1.23	0.990	0.655	0.355	0.296		
9.9V	35.9	27.4	17.3	13.4	11.0	8.39	6.22	4.85	3.35	2.62	1.95	1.49	1.22	0.986	0.652	0.354	0.295		
10.2V	33.5	26.0	16.8	12.8	10.7	8.21	5.96	4.73	3.18	2.48	1.86	1.43	1.17	0.946	0.624	0.342	0.285		
10.5V	30.4	23.7	16.0	12.2	10.2	7.91	5.80	4.63	3.05	2.40	1.82	1.37	1.10	0.936	0.622	0.330	0.284		
10.8V	27.3	21.3	15.1	11.7	9.80	7.60	5.43	4.28	2.85	2.14	1.69	1.32	1.07	0.866	0.579	0.319	0.265		

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

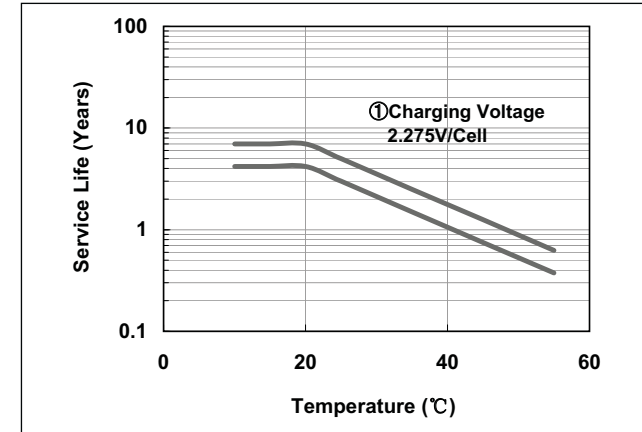
Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 0.93A or smaller
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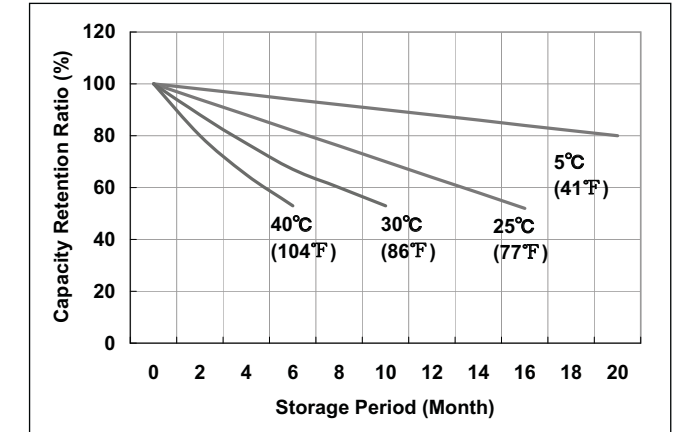
Cut off voltage

Discharge current	0.31A - 1.24A	1.24A - 3.1A	3.1A - 6.2A	6.2A - 12.4A	12.4A - 18.6A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

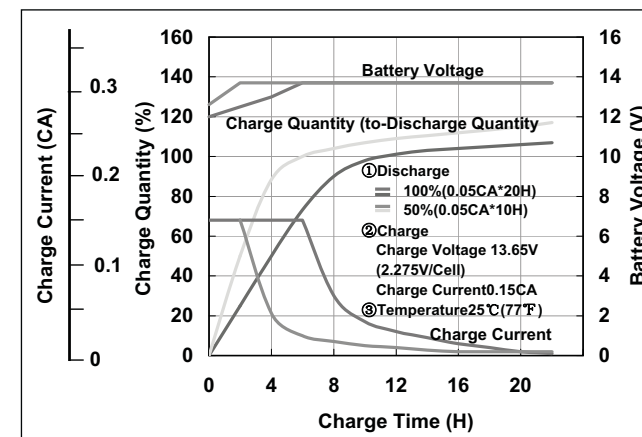
Influence of Temperature on Trickle life



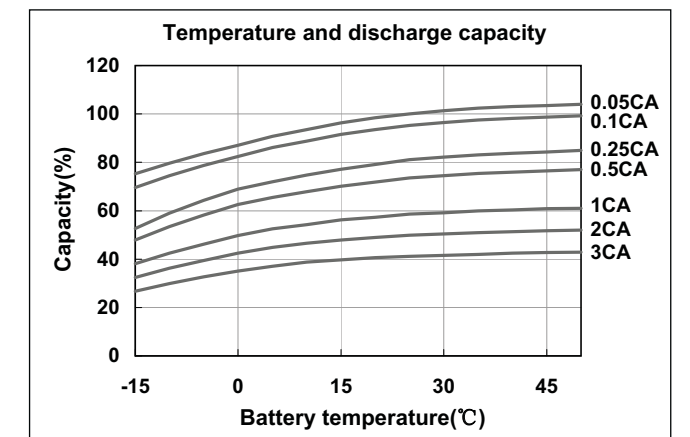
Residual capacity test result



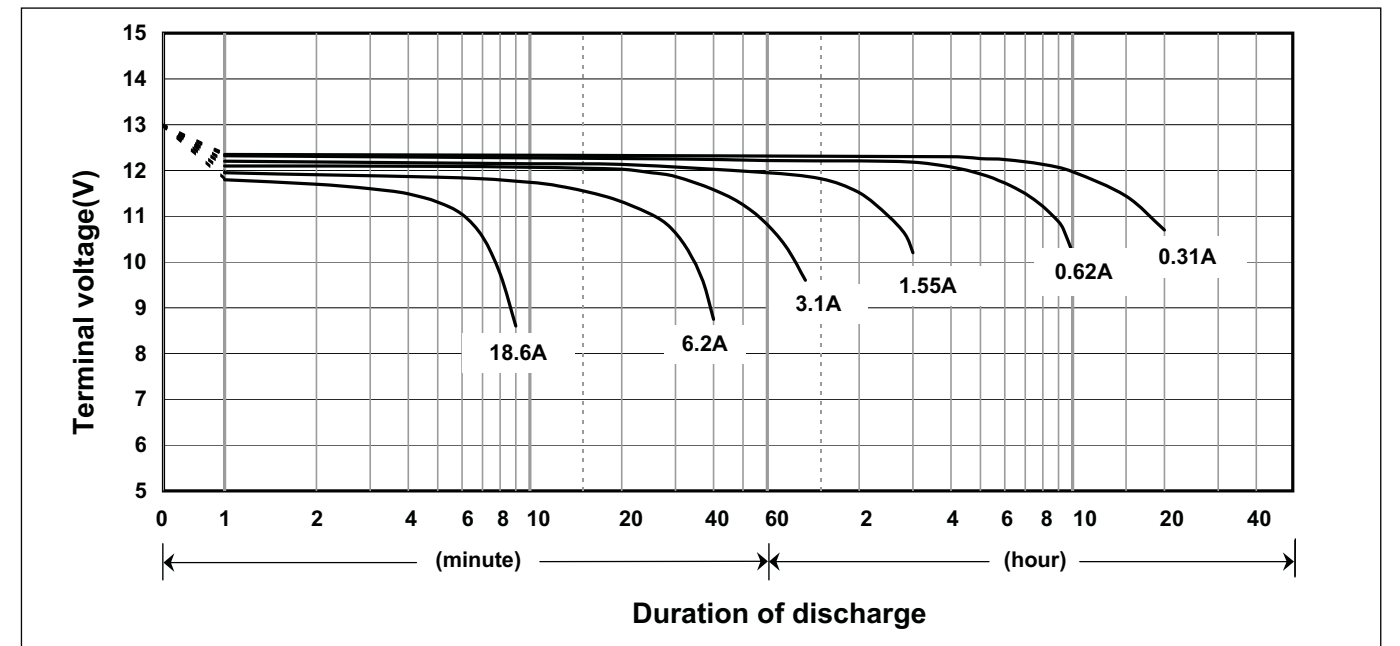
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current

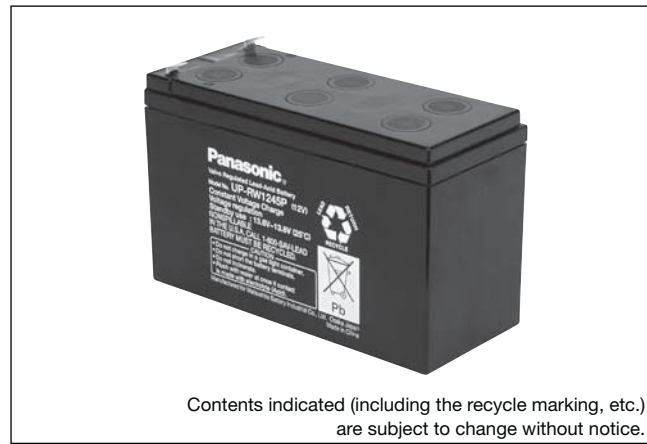


Discharge characteristics

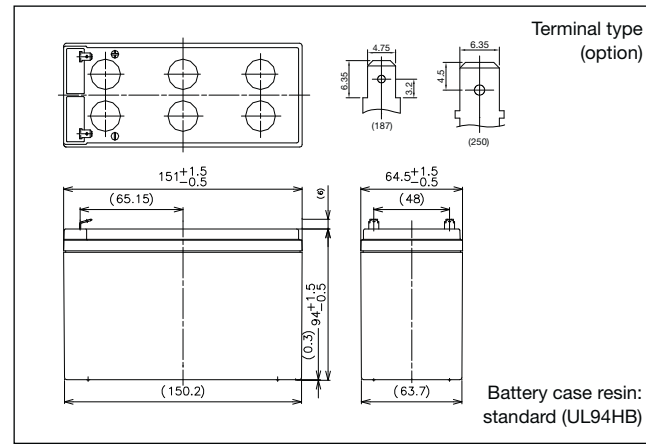


UP-RW1245P*1

For standby power supplies.
Expected trickle design life: 6 – 9 years at 20°C according to Eurobat.



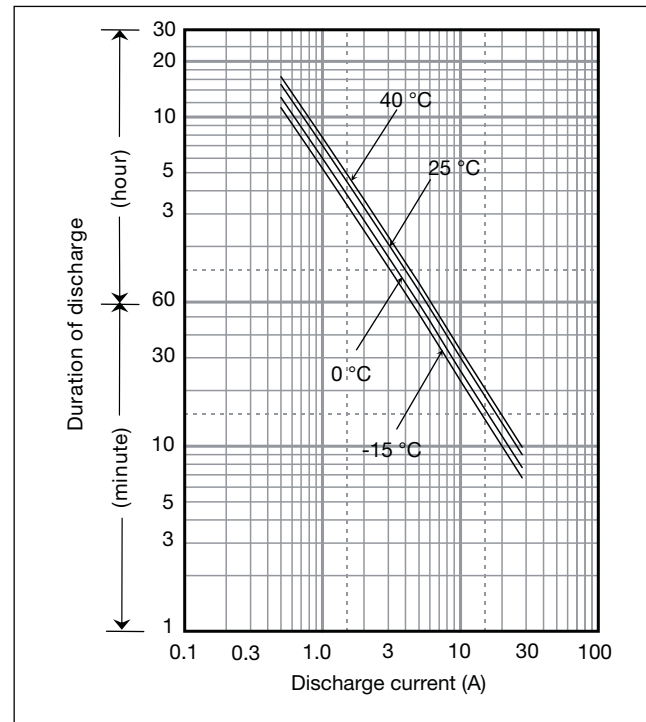
Dimensions (mm)



Specifications

Nominal voltage	12V	
Nominal capacity (10 minute rate)	270W	
Dimensions	Length	151mm
	Width	64.5mm
	Height	94mm
	Total Height	100mm
Approx. mass	2.6kg	
Terminal	Faston 187 or Faston 250 with hole	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate	112W
	10 hour rate	195W
	5 hour rate	268W
	1 hour rate	410W
Internal resistance	Fully charged battery (25°C)	20mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Watt Table

Cut-off V	(Wattage/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	530	410	268	195	159	112	82.1	65.7	45.2	34.9	26.0	20.0	16.5	13.3	8.79	4.76	3.97
9.9V	509	400	263	194	158	112	81.6	65.7	44.3	34.7	25.9	19.8	16.4	13.2	8.75	4.75	3.96
10.2V	490	390	258	193	156	111	80.8	64.4	43.4	33.9	25.6	19.7	16.2	13.1	8.65	4.73	3.95
10.5V	463	360	246	187	151	110	78.7	63.0	41.7	32.8	25.7	19.7	16.1	13.0	8.62	4.72	3.93
10.8V	434	330	234	180	146	109	78.3	61.8	41.3	31.1	24.7	19.3	15.7	12.7	8.52	4.69	3.91

Ampere Table

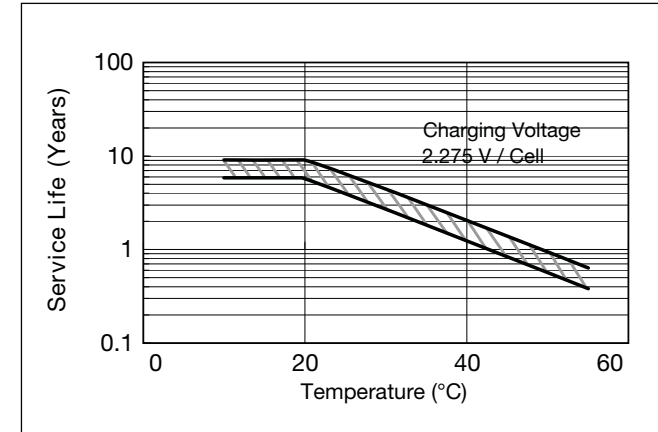
Cut-off V	(Ampere/Battery)																
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	47.7	36.8	23.9	17.0	13.7	9.6	6.99	5.57	3.82	2.95	2.19	1.67	1.38	1.11	0.732	0.397	0.331
9.9V	45.8	35.9	23.5	16.9	13.6	9.6	6.95	5.57	3.75	2.93	2.17	1.66	1.37	1.10	0.729	0.396	0.330
10.2V	44.1	35.0	23.0	16.8	13.5	9.5	6.88	5.46	3.67	2.86	2.15	1.65	1.36	1.09	0.721	0.394	0.329
10.5V	41.6	32.3	22.0	16.3	13.0	9.4	6.70	5.35	3.53	2.77	2.16	1.65	1.35	1.08	0.718	0.393	0.328
10.8V	39.0	29.6	20.9	15.7	12.6	9.3	6.67	5.25	3.50	2.62	2.08	1.62	1.31	1.06	0.710	0.391	0.326

*1 This battery is also available with a flame retardant battery case resin (UL94 V-0).

Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 1.2A or smaller
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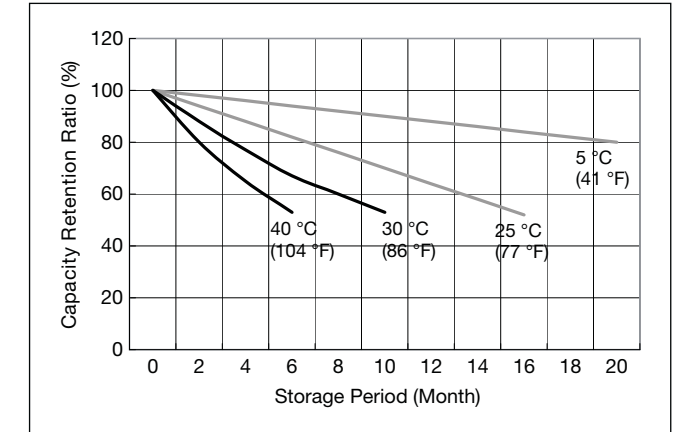
Influence of Temperature on Trickle life



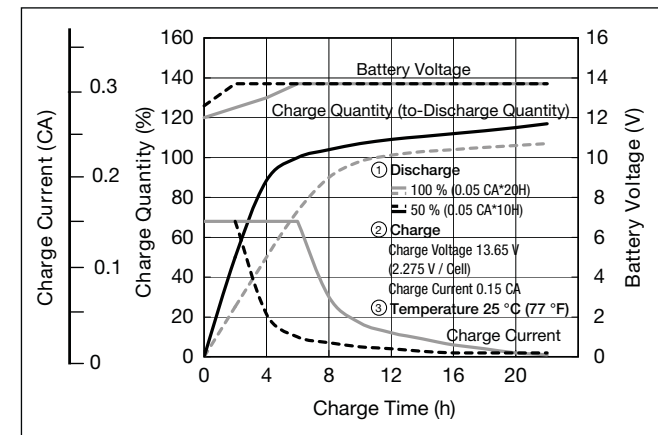
Cut off voltage

Discharge current	0.4A - 1.6A	1.6A - 4A	4A - 8A	8A - 16A	16A - 24A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

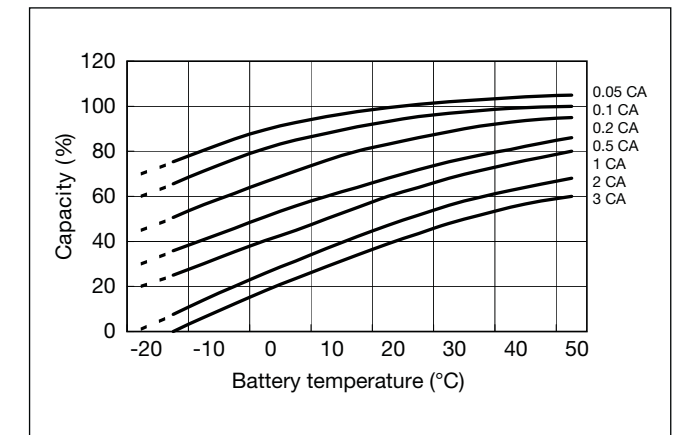
Residual capacity vs storage period



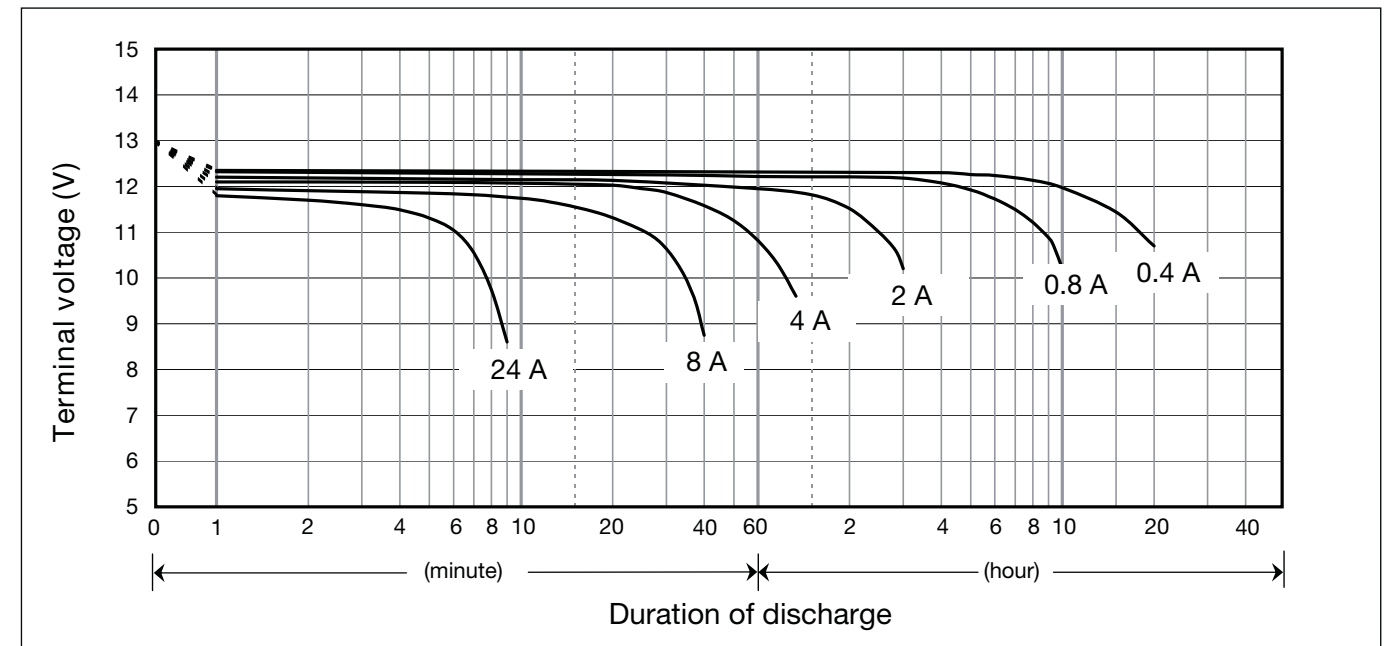
Constant-voltage and constant-current charge characteristics for Trickle use



Discharge capacity by temperature and by discharge current



Discharge characteristics



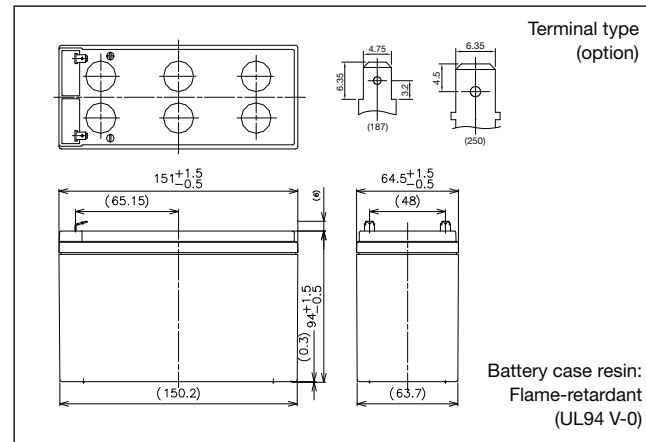
UP-PW1245P



Contents indicated (including the recycle marking, etc.) are subject to change without notice.

For standby power supplies.
Expected trickle design life: 10 – 12 years at 20°C according to Eurobat.

Dimensions (mm)



Battery case resin:
Flame-retardant
(UL94 V-0)

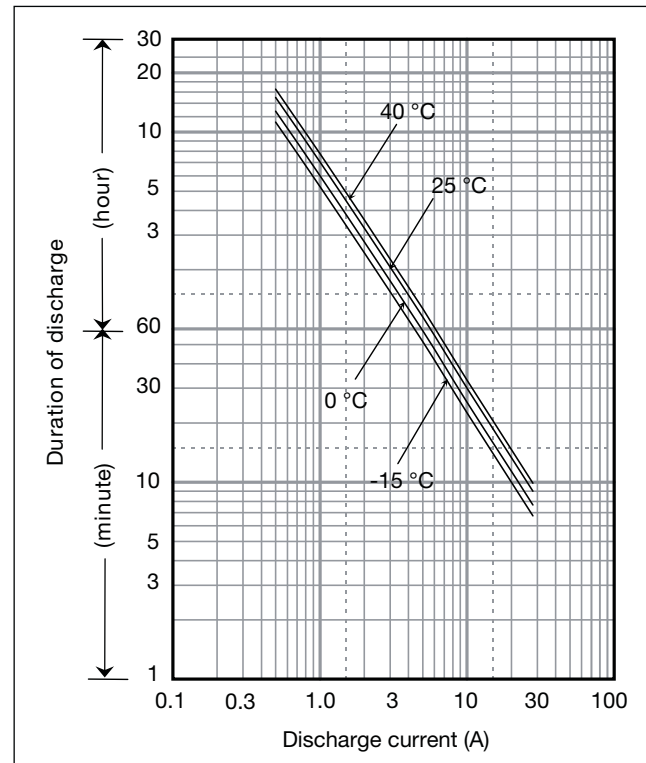
Specifications

Nominal voltage	12V	
Nominal capacity (10 minute rate)	270W	
Dimensions	Length	151mm
	Width	64.5mm
	Height	94mm
	Total Height	100mm
Approx. mass	2.6kg	
Terminal	Faston 187 or Faston 250 with hole	

Characteristics

Capacity (25°C)	20 hour rate	112W
	10 hour rate	195W
	5 hour rate	268W
	1 hour rate	410W
Internal resistance	Fully charged battery (25°C)	20mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	530	410	268	195	159	112	82.1	65.7	45.2	34.9	26.0	20.0	16.5	13.3	8.79	4.76	3.97	
9.9V	509	400	263	194	158	112	81.6	65.7	44.3	34.7	25.9	19.8	16.4	13.2	8.75	4.75	3.96	
10.2V	490	390	258	193	156	111	80.8	64.4	43.4	33.9	25.6	19.7	16.2	13.1	8.65	4.73	3.95	
10.5V	463	360	246	187	151	110	78.7	63.0	41.7	32.8	25.7	19.7	16.1	13.0	8.62	4.72	3.93	
10.8V	434	330	234	180	146	109	78.3	61.8	41.3	31.1	24.7	19.3	15.7	12.7	8.52	4.69	3.91	

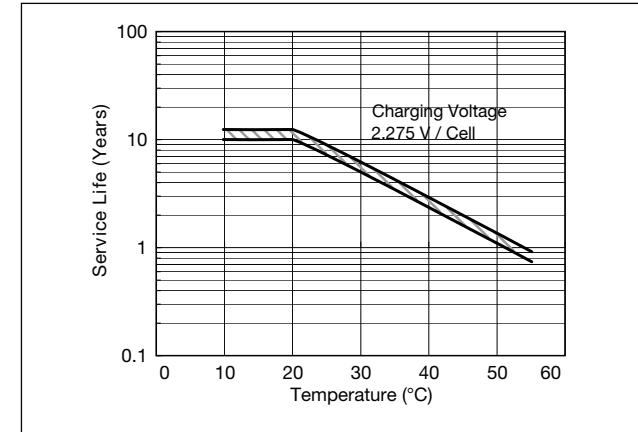
Ampere Table

Cut-off V	(Ampere/Battery)																	
	3min	5min	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	47.7	36.8	23.9	17.0	13.7	9.57	6.99	5.57	3.82	2.95	2.19	1.67	1.38	1.11	0.732	0.397	0.331	
9.9V	45.8	35.9	23.5	16.9	13.6	9.55	6.95	5.57	3.75	2.93	2.17	1.66	1.37	1.10	0.729	0.396	0.330	
10.2V	44.1	35.0	23.0	16.8	13.5	9.49	6.88	5.46	3.67	2.86	2.15	1.65	1.36	1.09	0.721	0.394	0.329	
10.5V	41.6	32.3	22.0	16.3	13.0	9.40	6.70	5.35	3.53	2.77	2.16	1.65	1.35	1.08	0.718	0.393	0.328	
10.8V	39.0	29.6	20.9	15.7	12.6	9.32	6.67	5.25	3.50	2.62	2.08	1.62	1.31	1.06	0.710	0.391	0.326	

Charging Method

Trickle use	Control voltage: 13.6 - 13.8V; Initial current: 1.2A or smaller
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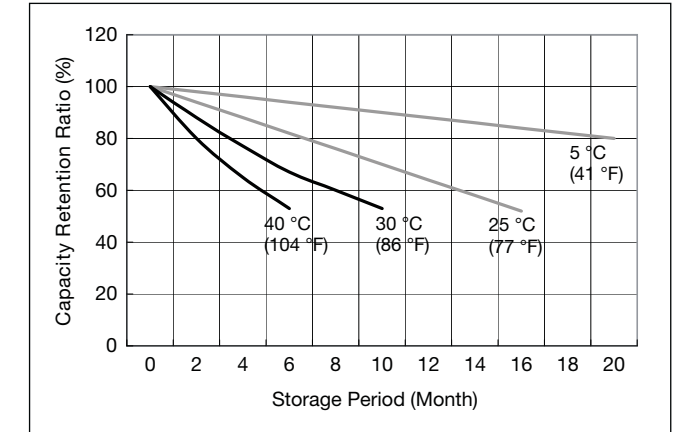
Influence of Temperature on Trickle life



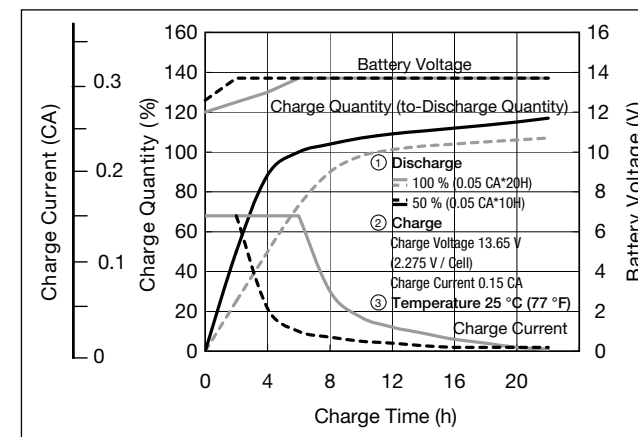
Cut off voltage

Discharge current	0.4A - 1.6A	1.6A - 4A	4A - 8A	8A - 16A	16A - 24A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

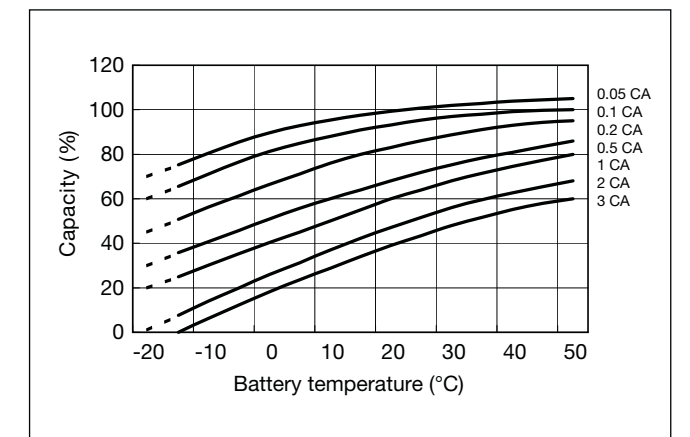
Residual capacity vs storage period



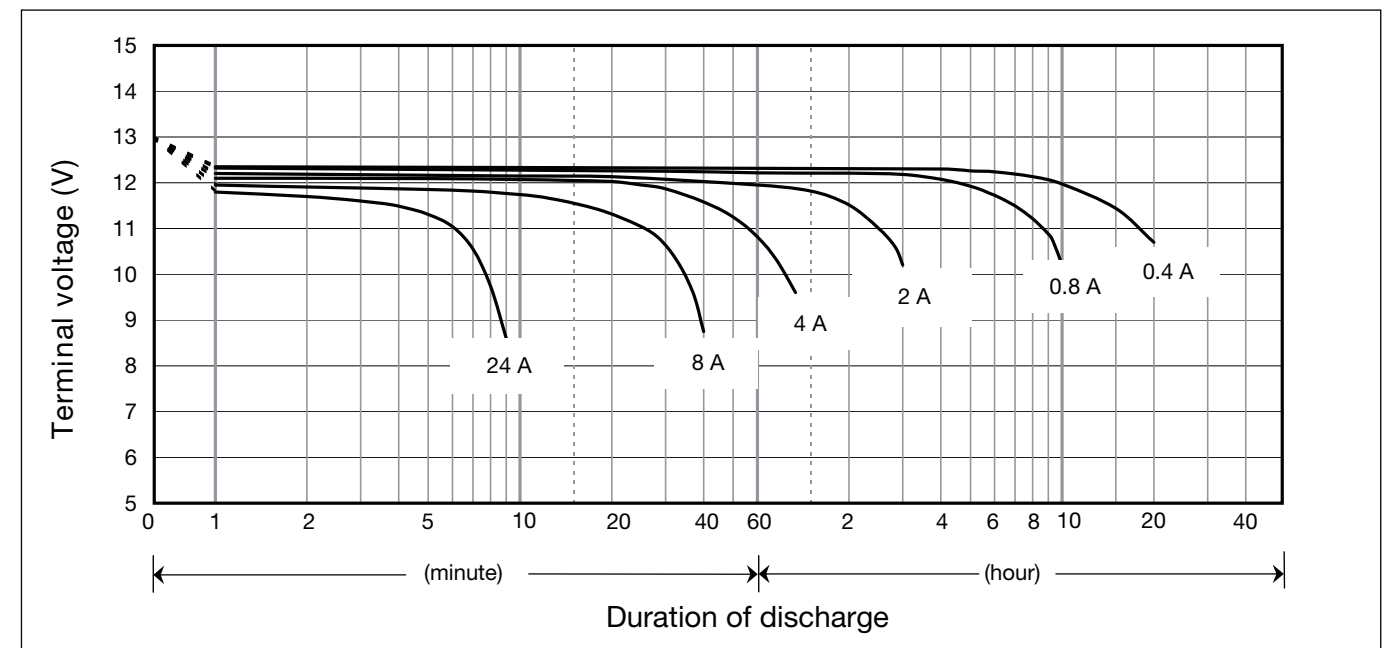
Constant-voltage and constant-current charge characteristics for Trickle use



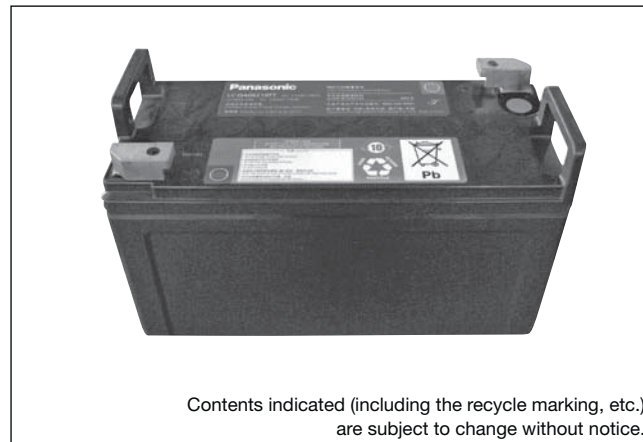
Discharge capacity by temperature and by discharge current



Discharge characteristics

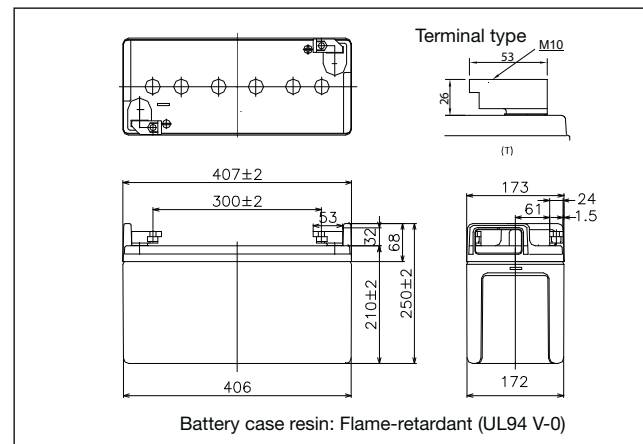


LC-QA06210TP



For standby power supplies.
Expected trickle design life: 15 years at 20°C according to Eurobat.

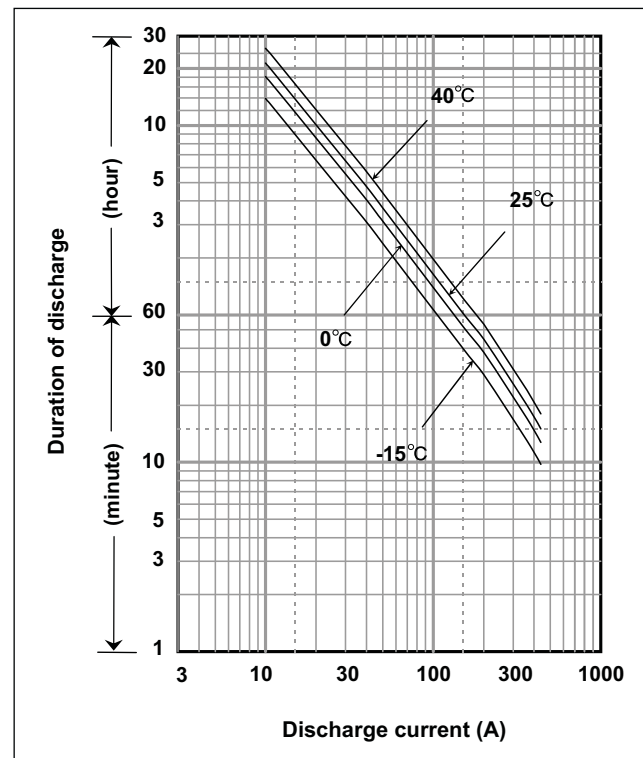
Dimensions (mm)



Specifications

Nominal voltage	6V	
Nominal capacity (20 hour rate)	210Ah	
Dimensions	Length	407mm
	Width	173mm
	Height	210mm
	Total Height	250mm
Approx. mass	36.5kg	
Terminal	M10 Bolt and Nut type	

Duration of discharge vs Discharge current



Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	210Ah 200Ah 190Ah 150Ah
Internal resistance	Fully charged battery (25°C)	1.5mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Watt Table

Cut-off V	(Wattage/Battery)													
	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	2220	1816	1349	986	769	561	467	343	274	222	191	121	61.8	52.3
4.95V	2167	1773	1317	964	749	546	454	337	268	215	185	117	61.8	52.3
5.1V	2089	1709	1274	954	729	531	448	331	262	209	180	115	61.1	51.7
5.25V	2063	1696	1264	939	708	517	439	325	260	209	180	114	61.1	51.7
5.4V	1966	1687	1223	905	698	509	428	319	254	203	177	113	59.8	50.6

Ampere Table

Cut-off V	(Ampere/Battery)													
	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
4.8V	440	364	274	200	153	107	88.1	61.5	47.6	39.5	32.3	20.5	10.6	9.12
4.95V	438	362	272	195	153	105	87.5	60.4	47.1	38.8	32.3	20.5	10.6	9.12
5.1V	436	358	268	193	152	104	86.4	60.0	46.7	38.2	32.1	20.3	10.6	9.12
5.25V	412	341	263	191	151	103	85.4	60.0	46.7	38.2	32.1	20.3	10.6	9.12
5.4V	398	333	259	165	131	92.3	81.1	57.3	45.6	37.8	31.0	20.1	10.4	9.12

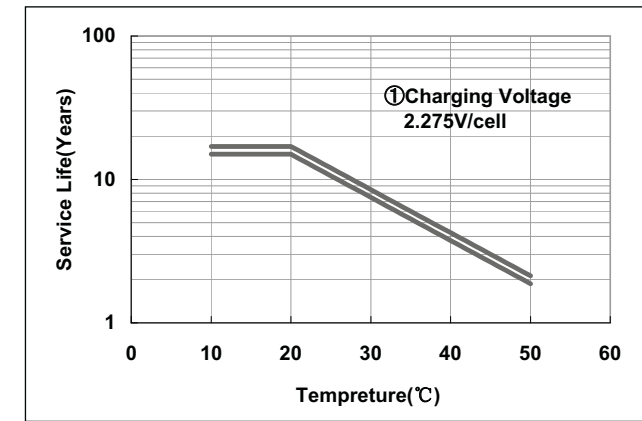
Charging Method

Trickle Use	Control voltage: 6.80 - 6.90V; Initial current: 31.5A or smaller
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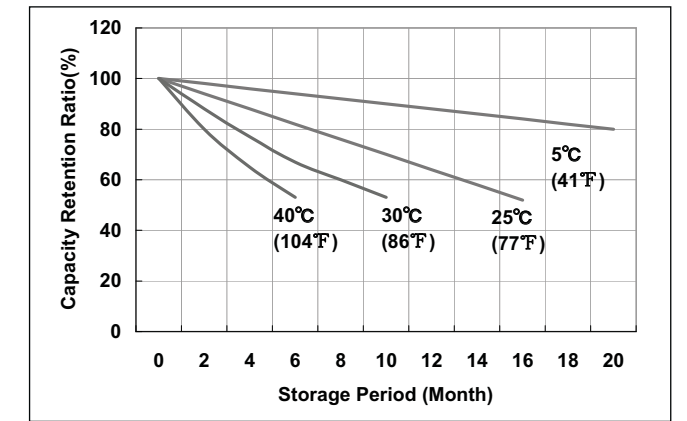
Cut off voltage

Discharge current	10.5A - 42A	42A - 105A	105A - 210A	210A - 420A
Cut off voltage (V)	5.25	5.1	4.95	4.65

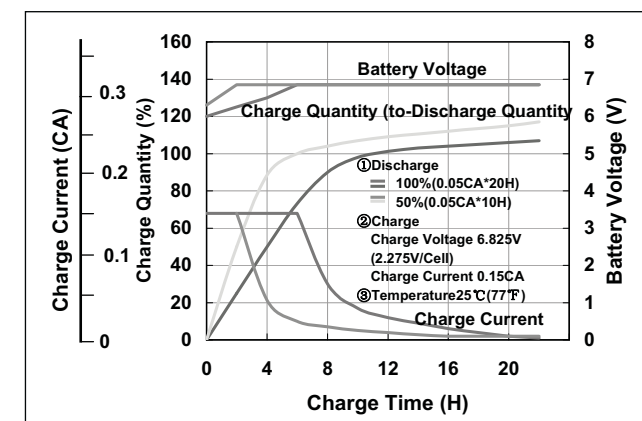
Influence of Temperature on Trickle life



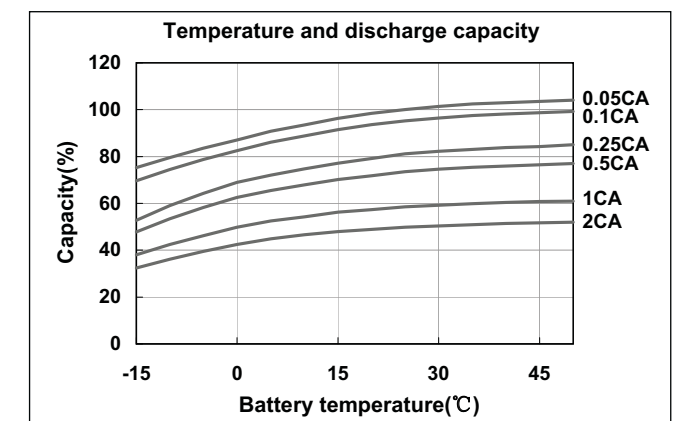
Residual capacity test result



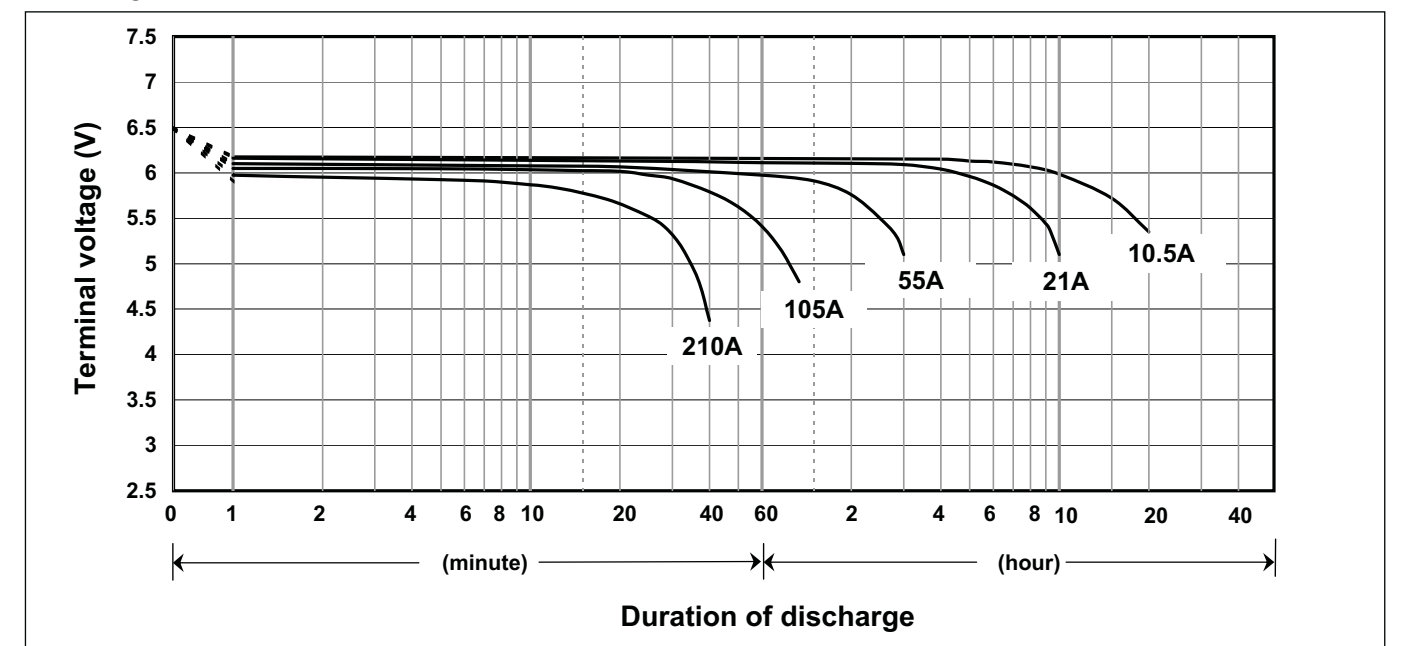
Constant-voltage and constant-current charge characteristics



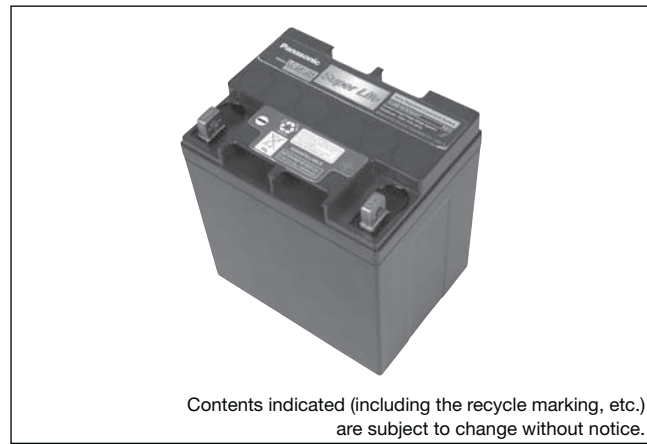
Discharge capacity by temperature and by discharge current



Discharge characteristics

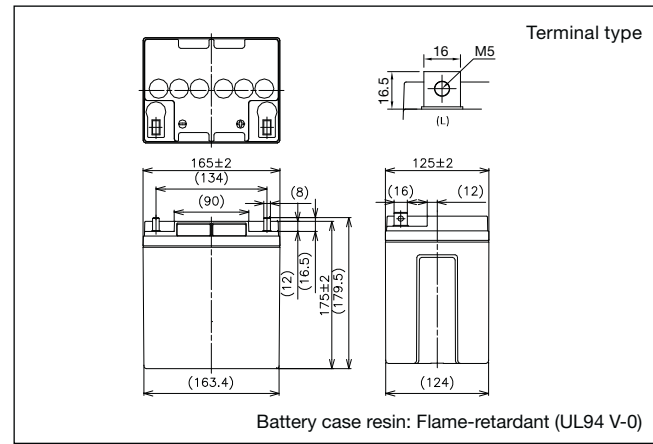


LC-QA1224AP



For standby power supplies.
Expected trickle design life: 15 years at 20°C according to Eurobat.

Dimensions (mm)



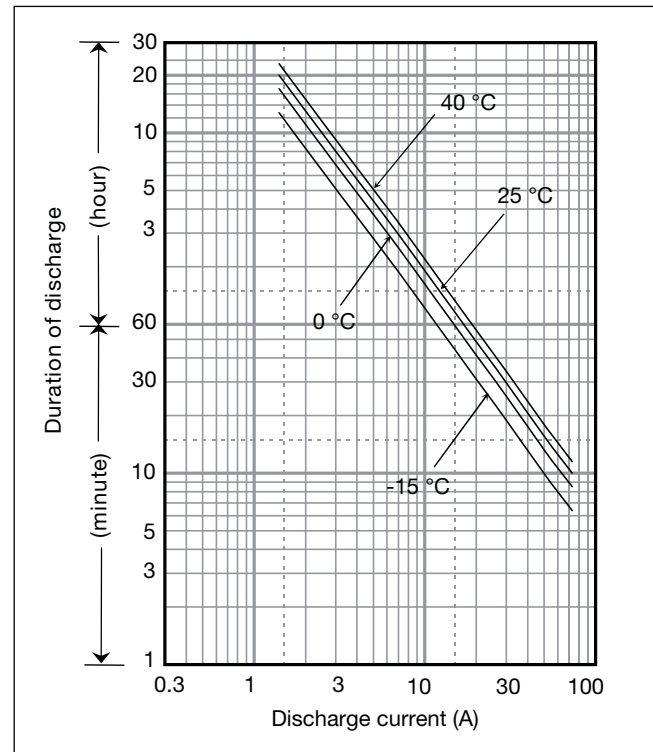
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	24Ah	
Dimensions	Length	165mm
	Width	125mm
	Height	175mm
	Total Height	175mm
Approx. mass	10kg	
Terminal	M5 Bolt and Nut type	

Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	24Ah 22Ah 19Ah 14Ah
Internal resistance	Fully charged battery (25°C)	8mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	773	605	521	401	280	215	167	113	79.9	65.8	51.8	46.8	27.0	13.5	11.5
9.9V	760	600	512	396	274	210	163	113	79.7	65.3	50.9	46.0	26.8	13.5	11.5
10.2V	746	591	503	390	268	205	159	111	79.3	64.7	50.1	45.3	26.4	13.4	11.5
10.5V	724	575	479	372	261	200	155	107	78.2	64.0	49.7	44.8	26.1	13.3	11.5
10.8V	701	558	456	344	256	196	152	104	77.1	63.2	49.5	44.3	25.9	13.3	11.5

Ampere Table

Cut-off V	(Ampere/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	72.6	51.2	42.8	30.5	22.4	17.4	11.3	9.90	6.98	5.51	4.50	3.83	2.48	1.35	1.13
9.9V	70.3	50.1	42.3	30.3	21.8	17.0	11.1	9.79	6.86	5.40	4.39	3.71	2.48	1.35	1.13
10.2V	67.7	49.2	41.3	30.0	21.4	16.7	11.1	9.68	6.75	5.40	4.28	3.71	2.48	1.35	1.13
10.5V	64.9	47.3	39.5	29.3	20.3	15.8	11.0	9.56	6.64	5.29	4.28	3.71	2.48	1.35	1.13
10.8V	63.8	46.4	38.8	28.2	18.0	13.8	10.3	9.00	6.41	5.18	4.28	3.60	2.48	1.35	1.13

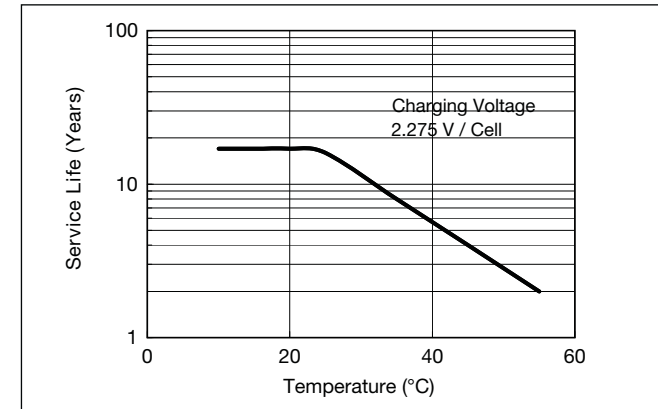
Charging Method

Trickle Use	Control voltage 13.6 - 13.8V; Initial current 3.6A or smaller
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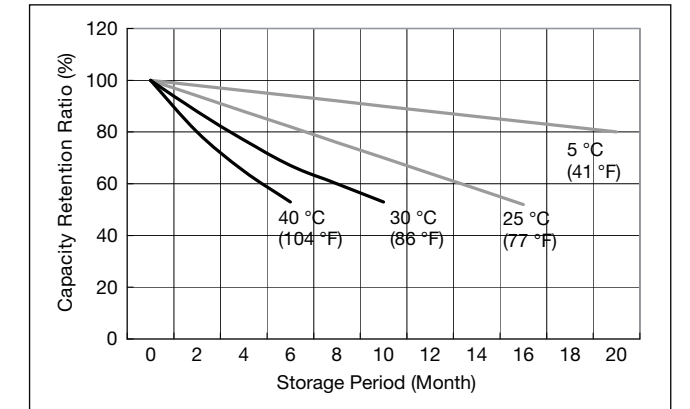
Cut off voltage

Discharge current	1.2A - 4.8A	4.8A - 12A	12A - 24A	24A - 48A	48A - 72A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

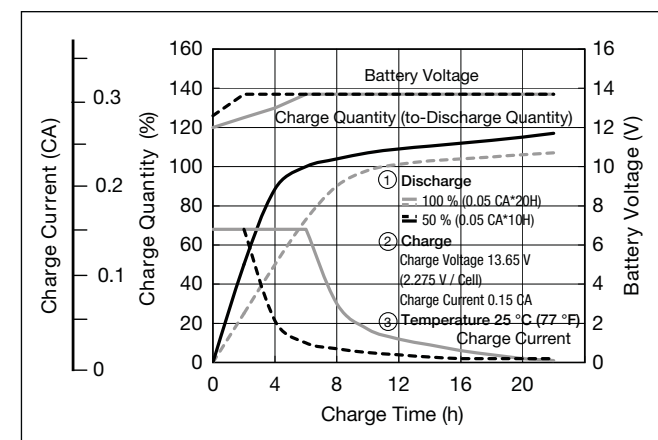
Influence of Temperature on Trickle life



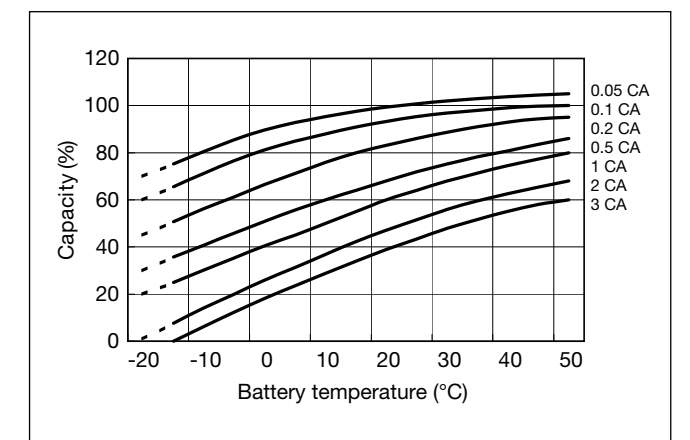
Residual capacity vs storage period



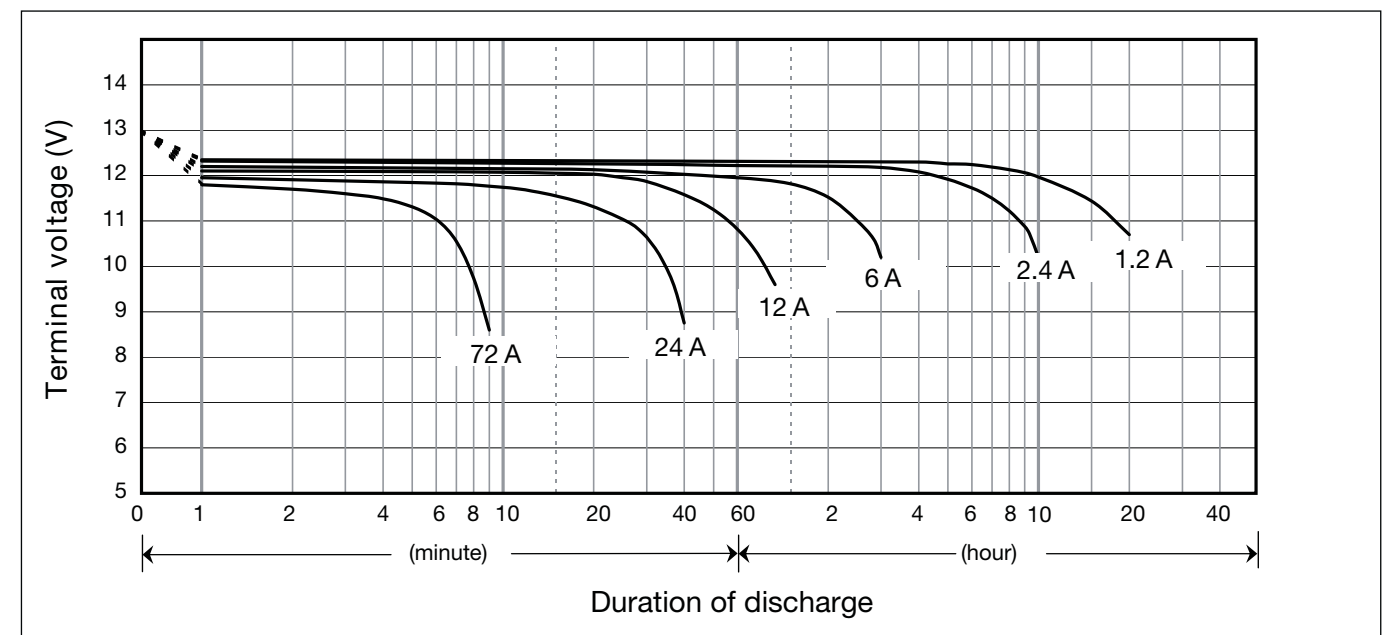
Constant-voltage and constant-current charge characteristics for Trickle use



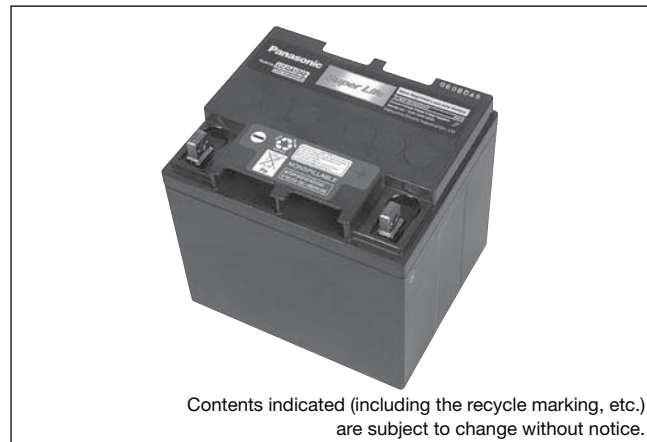
Discharge capacity by temperature and by discharge current



Discharge characteristics

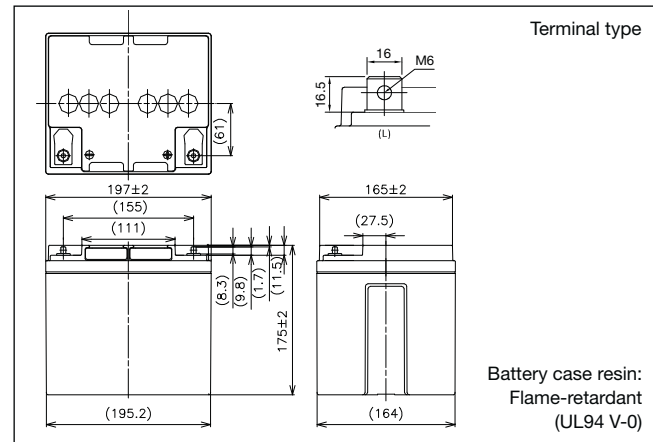


LC-QA1242P/AP



For standby power supplies.
Expected trickle design life: 15 years at 20°C according to Eurobat.

Dimensions (mm)



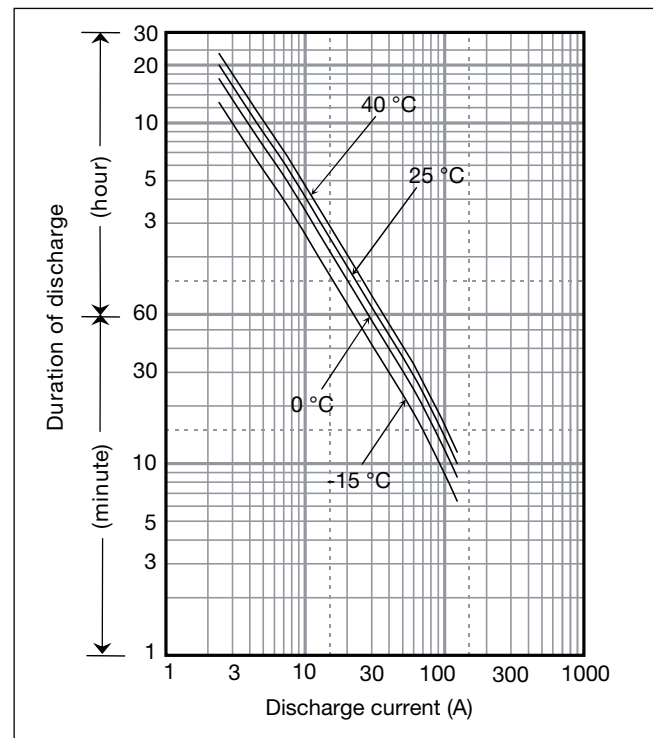
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	42Ah	
Dimensions	Length	197mm
	Width	165mm
	Height	175mm
	Total Height	180mm
Approx. mass	16kg	
Terminal	M6 Bolt and Nut type	

Characteristics

Capacity (25°C)	20 hour rate	42Ah
	10 hour rate	40Ah
	5 hour rate	37Ah
	1 hour rate	26Ah
Internal resistance	Fully charged battery (25°C)	8mΩ
Temperature dependency of capacity (20 hour rate)	40°C	102%
	25°C	100%
	0°C	85%
	-15°C	65%
Self discharge (25°C)	After 3 months	91%
	After 6 months	82%
	After 12 months	64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)															
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	1202	1015	862	655	486	393	284	230	156	128	100	90.1	49.2	25.1	20.7	
9.9V	1146	951	829	630	476	387	279	224	152	124	98.4	88.5	48.4	25.1	20.7	
10.2V	1087	887	775	606	465	382	276	214	148	123	97.1	87.2	48.0	25.1	20.7	
10.5V	1072	866	743	575	453	363	262	210	145	119	92.9	83.3	44.9	24.0	20.7	
10.8V	1077	844	720	546	444	355	256	203	142	116	89.8	80.6	43.8	22.4	20.7	

Ampere Table

Cut-off V	(Ampere/Battery)															
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h	
9.6V	123	94.5	81.0	60.1	39.3	29.8	23.0	17.8	12.5	10.4	8.44	7.43	4.50	2.36	1.97	
9.9V	121	94.5	79.9	58.4	39.0	29.6	22.3	17.7	12.3	10.2	8.33	7.43	4.50	2.36	1.97	
10.2V	119	92.3	78.8	57.3	38.9	29.4	20.7	17.4	12.0	10.1	8.33	7.31	4.50	2.36	1.97	
10.5V	116	90.0	77.6	56.3	38.8	29.3	20.1	17.4	11.9	10.1	8.33	7.31	4.50	2.36	1.97	
10.8V	107	86.6	75.4	55.1	37.4	28.1	19.1	16.4	11.5	9.9	8.21	7.09	4.50	2.36	1.95	

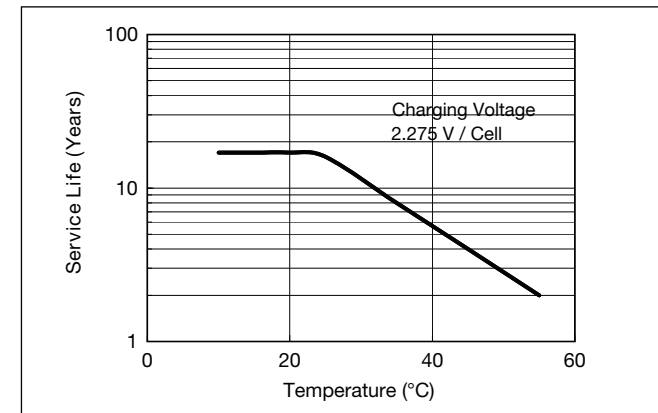
Charging Method

Trickle Use	Control voltage 13.6 - 13.8V; Initial current 6.3A or smaller
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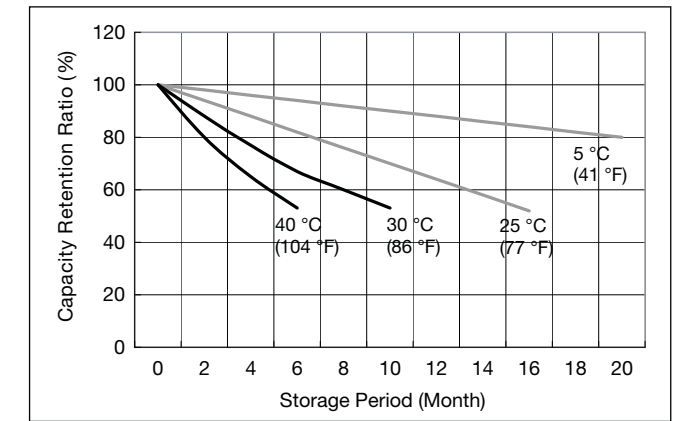
Cut off voltage

Discharge current	2.1A - 8.4A	8.4A - 21A	21A - 42A	42A - 84A	84A - 126A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

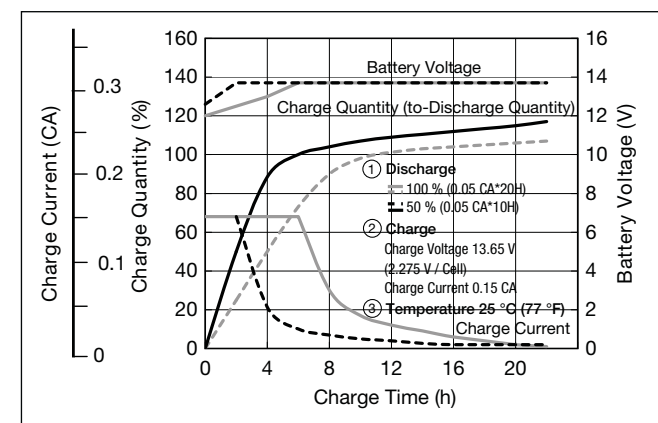
Influence of Temperature on Trickle life



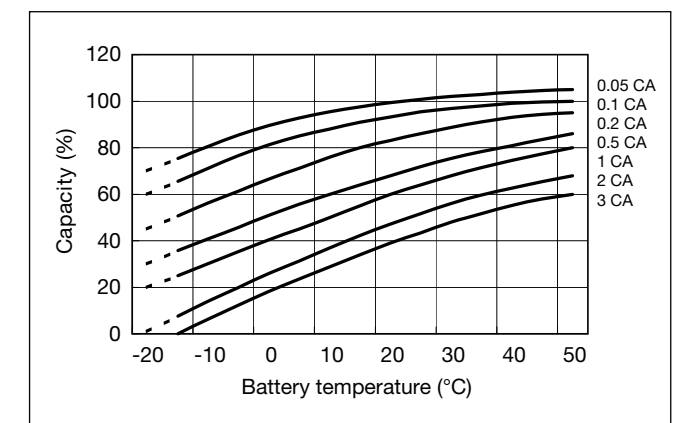
Residual capacity vs storage period



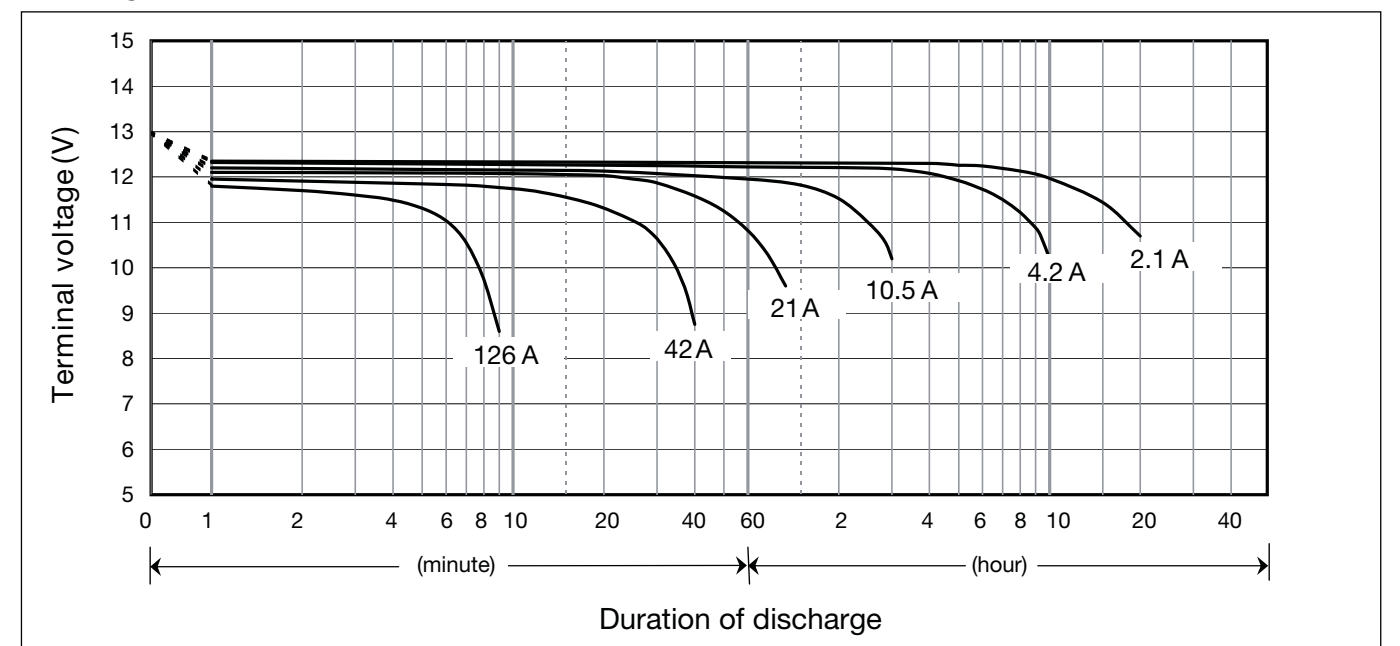
Constant-voltage and constant-current charge characteristics for Trickle use



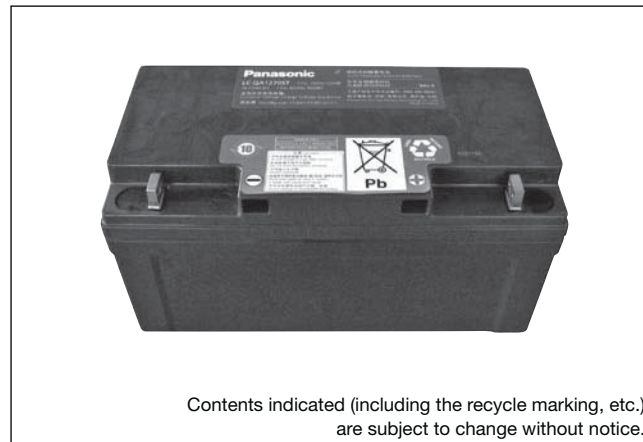
Discharge capacity by temperature and by discharge current



Discharge characteristics

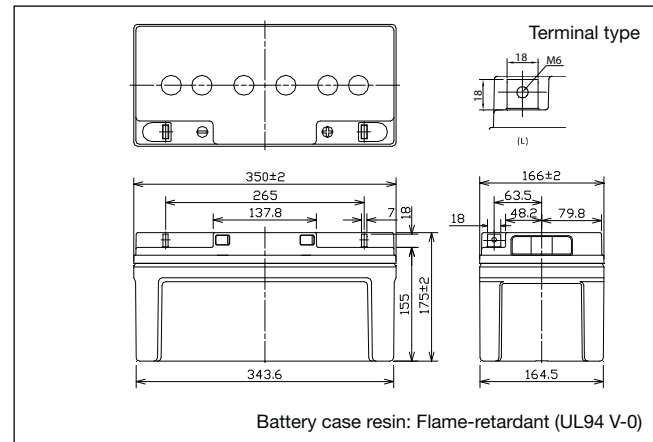


LC-QA1270P



For standby power supplies.
Expected trickle design life: 15 years at 20°C according to Eurobat.

Dimensions (mm)



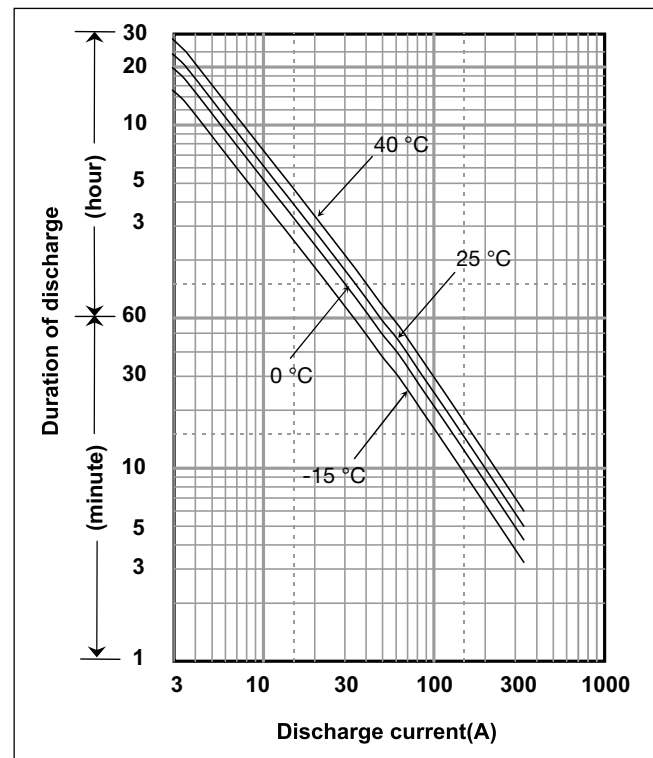
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	70Ah	
Dimensions	Length	350mm
	Width	166mm
	Height	175mm
	Total Height	175mm
Approx. mass	23.5kg	
Terminal	M6 Bolt and Nut type	

Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	70Ah 65Ah 60Ah 45Ah
Internal resistance	Fully charged battery (25°C)	5mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	1977	1504	1234	916	676	549	386	333	240	181	148	130	75.5	41.7	34.7
9.9V	1947	1491	1227	909	660	520	367	323	234	177	146	127	74.0	41.5	34.7
10.2V	1867	1463	1197	899	655	519	365	311	224	168	138	122	73.1	41.2	34.3
10.5V	1814	1436	1173	884	641	509	358	306	221	166	135	119	73.0	39.8	33.8
10.8V	1704	1357	1153	865	626	499	351	299	219	165	135	119	73.0	39.4	33.6

Ampere Table

Cut-off V	(Ampere/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	200	146	118	85.9	62.8	48.4	34.8	27.1	19.4	15.0	12.5	10.4	6.50	3.53	2.94
9.9V	199	144	118	85.0	61.2	47.7	33.9	27.0	19.1	14.8	12.1	10.4	6.50	3.53	2.94
10.2V	197	146	116	83.8	60.9	47.3	33.7	26.8	18.9	14.8	12.1	10.3	6.50	3.53	2.94
10.5V	187	136	110	82.7	59.5	45.6	33.3	26.7	18.9	14.7	12.1	10.3	6.50	3.53	2.94
10.8V	177	132	108	81.4	51.1	41.0	29.4	24.9	17.8	14.4	12.0	10.1	6.50	3.47	2.94

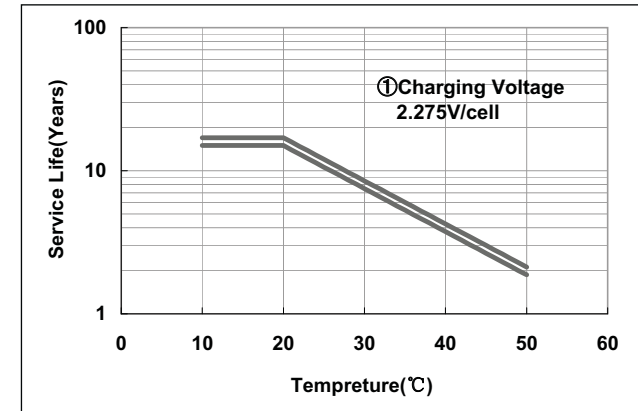
Charging Method

Trickle Use	Control voltage: 13.6 - 13.8V; Initial current: 10.5A or smaller
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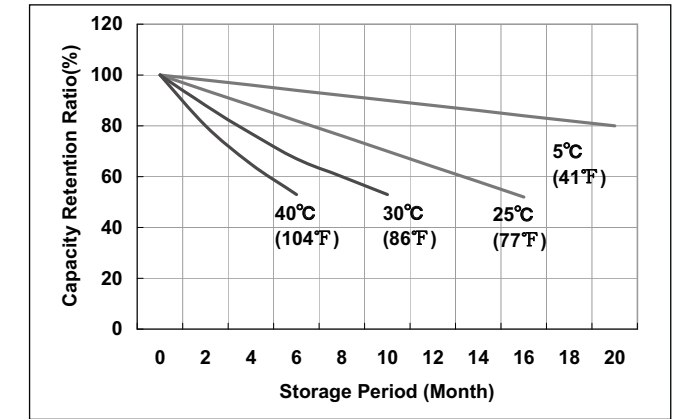
Cut off voltage

Discharge current	3.5A - 14A	14A - 35A	35A - 70A	70A - 140A	140A - 210A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

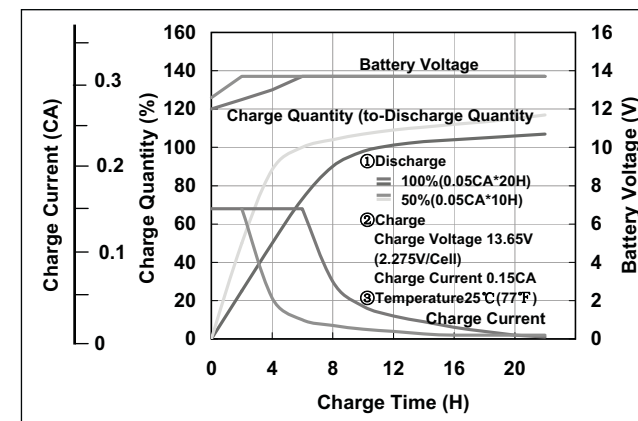
Influence of Temperature on Trickle life



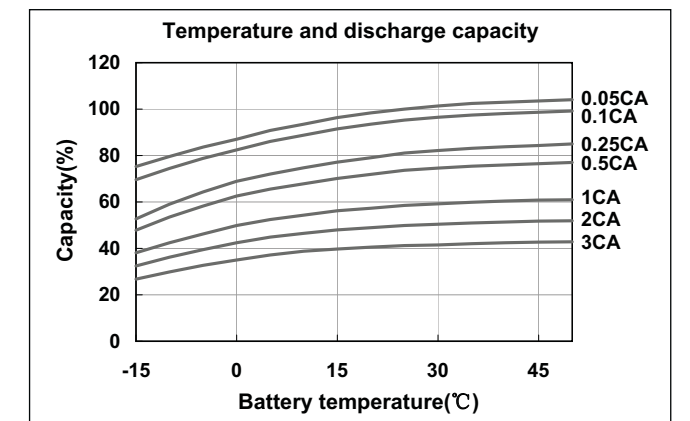
Residual capacity test result



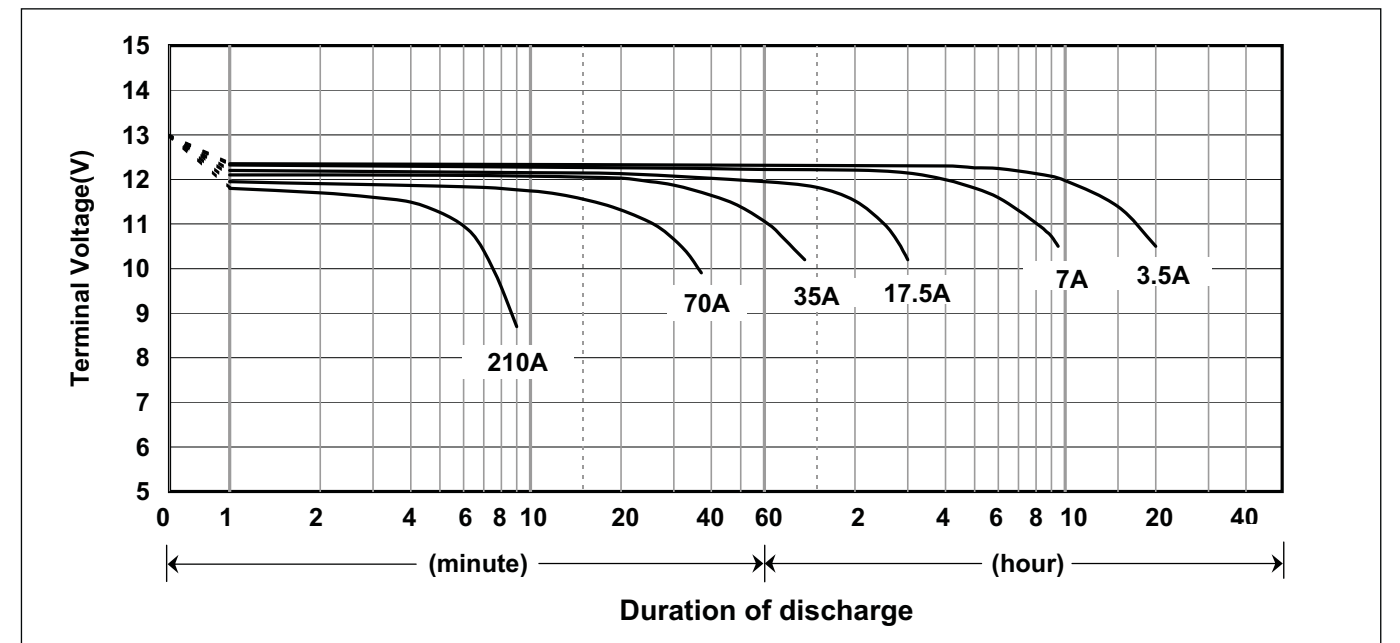
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current



Discharge characteristics

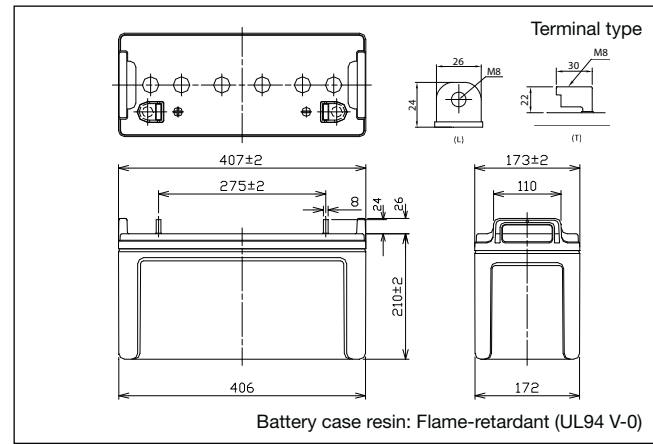


LC-QA12110TP



For standby power supplies.
Expected trickle design life: 15 years at 20°C according to Eurobat.

Dimensions (mm)



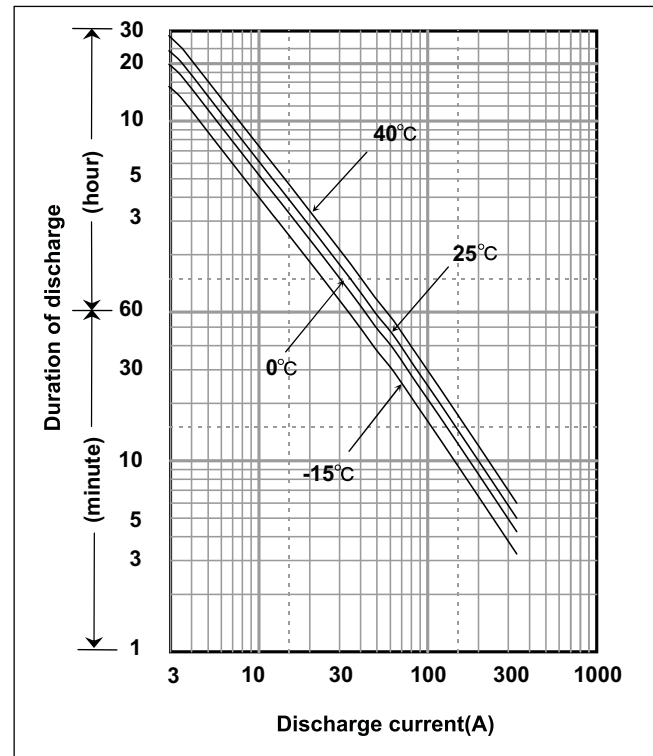
Specifications

Nominal voltage	12V	
Nominal capacity (20 hour rate)	110Ah	
Dimensions	Length	407mm
	Width	173mm
	Height	210mm
	Total Height	236mm
Approx. mass	36kg	
Terminal	M8 Bolt and Nut type	

Characteristics

Capacity (25°C)	20 hour rate 10 hour rate 5 hour rate 1 hour rate	110Ah 100Ah 95Ah 75Ah
Internal resistance	Fully charged battery (25°C)	4mΩ
Temperature dependency of capacity (20 hour rate)	40°C 25°C 0°C -15°C	102% 100% 85% 65%
Self discharge (25°C)	After 3 months After 6 months After 12 months	91% 82% 64%

Duration of discharge vs Discharge current



Watt Table

Cut-off V	(Wattage/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	2987	2270	1872	1391	1017	793	578	482	353	279	232	197	124	63.7	54.4
9.9V	2920	2215	1827	1358	995	772	563	469	346	273	225	192	120	63.7	54.4
10.2V	2855	2136	1761	1314	984	751	548	463	340	267	218	186	118	63.0	53.7
10.5V	2764	2110	1748	1303	968	730	532	453	334	264	218	186	117	63.0	53.7
10.8V	2522	2010	1739	1261	933	720	525	442	328	258	212	183	116	61.6	52.6

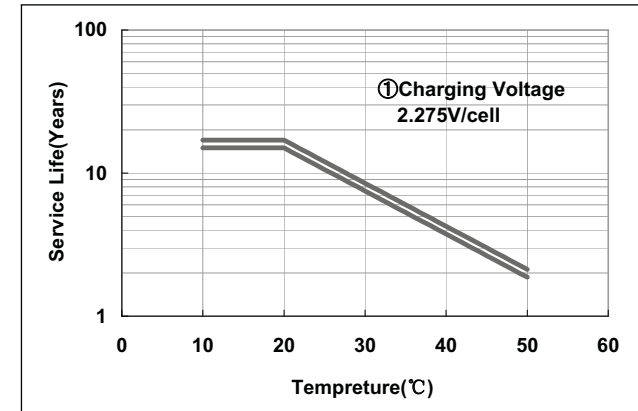
Ampere Table

Cut-off V	(Ampere/Battery)														
	10min	15min	20min	30min	45min	1h	1.5h	2h	3h	4h	5h	6h	10h	20h	24h
9.6V	272	212	175	133	96.7	76.7	53.6	43.2	30.2	23.3	19.7	16.1	10.2	5.50	4.51
9.9V	269	211	174	132	94.0	76.4	52.6	42.8	29.6	23.1	19.4	16.1	10.2	5.50	4.51
10.2V	268	210	172	130	93.5	75.9	52.1	42.3	29.4	22.9	19.1	16.0	10.1	5.50	4.51
10.5V	245	198	164	128	92.5	75.4	51.5	41.8	29.4	22.9	19.1	16.0	10.1	5.50	4.51
10.8V	232	192	160	126	79.9	65.4	46.4	39.7	28.1	22.3	18.9	15.5	9.99	5.39	4.51

Charging Method

Trickle Use	Control voltage: 13.6 - 13.8V; Initial current: 16.5A or smaller
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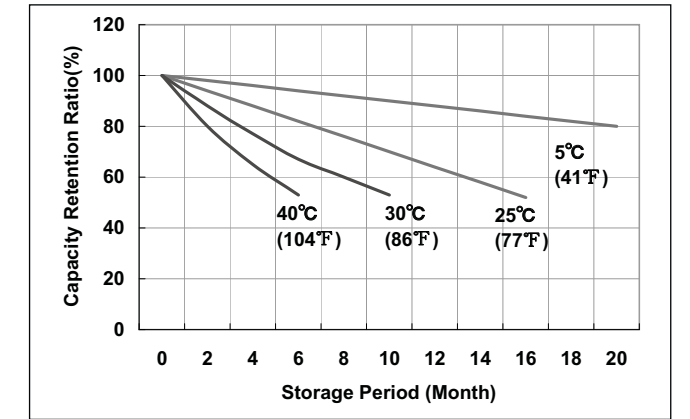
Influence of Temperature on Trickle life



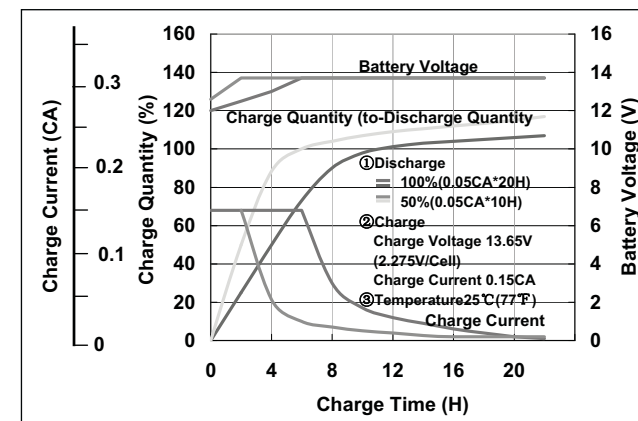
Cut off voltage

Discharge current	5.5A - 22A	22A - 55A	55A - 110A	110A - 220A	220A - 330A
Cut off voltage (V)	10.5	10.2	9.9	9.3	8.7

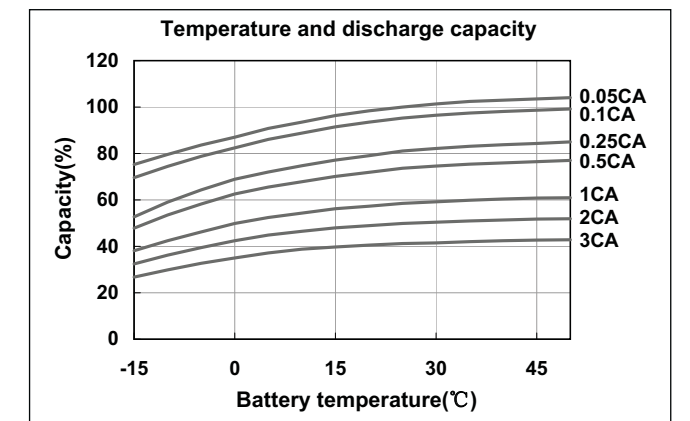
Residual capacity test result



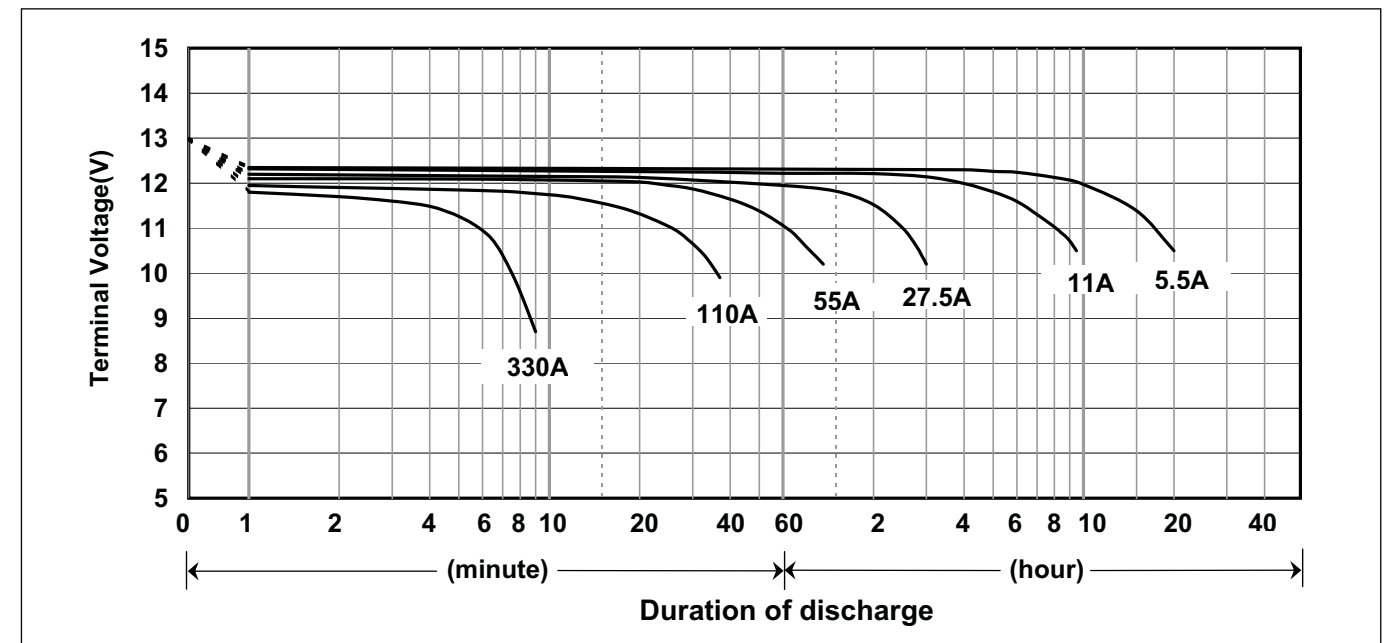
Constant-voltage and constant-current charge characteristics



Discharge capacity by temperature and by discharge current



Discharge characteristics



14 | Glossary of Main Battery Terms

ABS RESIN

A plastic material largely used for the case and cover of batteries.

ACTIVE MATERIAL

The substance which electrochemically reacts in the electrode of batteries. Lead-acid batteries adopt lead dioxide for the positive electrode and spongy lead for the negative electrode.

AMBIENT TEMPERATURE

Average temperature in the vicinity of the battery.

AVAILABLE CAPACITY

The capacity actually available from a cell/battery. The available capacity is the capacity of a battery when it discharges at a specified hour rate, and expressed in hour rate andAh.

BOLT FASTENING TERMINAL

A type of battery terminals, to which lead wires are connected with bolts.

BUILT-IN THERMOSTAT

The built-in thermostat is a resettable switch built in a battery for temporarily cut off the battery circuit when the temperature of the battery exceeds a preset value or when the battery charges/discharges at a higher rate than predetermined.

CAPACITY

The electric capability of a battery. It usually means ampere-hour capacity expressed inAh or C (coulomb).

CELL

The minimum battery unit which composes a storage battery. Nominal voltage of the cell of the lead-acid battery is 2V.

CHARGE

The operation of supplying a battery with a DC current from an external power source to have the electrode active materials conduct chemical reactions then to store electric energy as chemical energy in the battery.

CHARGEACCEPTANCE TEST

Test of batteries to check whether or not they are adequately recharged after discharge.

CHARGING EFFICIENCY

General term for ampere-hour efficiency and watthour efficiency. In many cases, however, it means the ampere-hour efficiency.

CONSTANT CURRENT CHARGE

A method of charging: to charge a battery with a constant current.

CONSTANT VOLTAGE CHARGE

A method of charging: to charge a battery by applying a constant voltage to the terminals.

C-RATE

A charge or discharge current rate expressed inA or mA. It is numerically the same as the hour rate capacity of a battery expressed inAh of the rated capacity.

CUT-OFF VOLTAGE OF DISCHARGE

The terminal voltage of a battery at which discharging should be discontinued. This voltage depends on discharge current, type of electrodes and construction of battery.

CYCLE LIFE

The number of charge/discharge/rest cycles a cell/battery can provide. Cycle life is usually expressed by the number of cycles available before duration of discharge decreases to a half of the initial value.

DEPTH OF DISCHARGE

A value to express the state of discharge of a battery. The depth of discharge is generally expressed by the ratio of discharge amount to rated capacity of the battery.

DISCHARGE

To draw off the electric energy stored in a cell/battery.

DISCHARGE RATE

The term to express the magnitude of discharge current. When assuming discharge current and time to discharge cut-off voltage t hours, this discharge is called t hour rate (tHR) discharge, and the current is called t-hour rate discharge current. When time t is minutes instead of hours, tMR is used.

DUTY CYCLE TEST

Test of batteries in ordinary use including charge, discharge and rest.

ELECTROLYTE

The medium which serves to conduct ions in the electrochemical reactions in batteries. The leadacid battery adopts diluted sulfuric acid as the electrolyte.

ENERGY DENSITY

Energy available per unitApprox. mass or unit volume of a cell/ battery. Energy density is expressed in Wh/kg or Wh/l.

FLOAT CHARGE

The system in which a constant voltage is continuously applied to a battery connected to a rectifier in parallel with a load to maintain the battery in charged state: on occurrence of power failure or load variation, the battery supplies power to the load without any short break.

GAS RECOMBINATIONABILITY

Capability of a battery to recombine (or absorb) internally generated oxygen gas at the negative plate. The greater this capability is, the larger the available charge current.

HIGH RATE DISCHARGE

A very rapid discharge of a battery. (In many cases it means discharging at approx. 1 CA or higher rate.)

INTERNAL PRESSURE

The pressure within a sealed battery. Internal pressure of a battery is increased by oxygen gas which is generated from the positive plate at the end of charging.

INTERNAL RESISTANCE

The resistance within a battery: it is the total of individual resistances of the electrolyte and the positive and negative plates. Internal resistance is simply measured with the current four-terminal method (1,000 Hz) and expressed in the composite value of resistance component and capacitor component.

INTERNAL SHORT-CIRCUIT

Touching of the positive and negative plates within a cell.

LIFE

The time period until a cell/battery loses its expected characteristics.

LOW MAINTENANCE

Low maintenance means that no watering nor equalizing charge is required in operating batteries.

LOW-VOLTAGE CUT-OFF

A circuitry designed to discontinue discharge of a battery at a predetermined voltage level.

MALE TAB

The metallic pieces which are attached to a SLA battery as the terminals.

MEMORY EFFECT

A phenomenon where a temporary drop of discharge voltage is observed during deep discharge of an alkaline rechargeable battery which has been subjected to shallow charge/discharge. Cycles or trickle charging over long time.

14 | Glossary of Main Battery Terms

NEGATIVE PLATE

The battery electrode into which a current from the external circuit flows during discharging. The negative plate has lower electric potential than the positive plate to the electrolyte. The negative plate is incorporated with connection parts such as the electrode pole.

RATED CAPACITY

A nominal value of capacity of a cell/battery, which is a measure of electric capability. Rated capacity is rather approximate compared with rated capacity.

NOMINAL VOLTAGE

A nominal value to indicate the voltage of a cell battery. Generally, nominal voltage value of a battery is somewhat lower than its electromotive force. Nominal voltage of the lead-acid battery is 2.0V per unit cell.

OPEN CIRCUIT VOLTAGE

Measured voltage of a cell/battery which is electrically disconnected from the external circuit.

OVERCHARGE

Continued charging of a fully charged cell/battery. With batteries which require watering, overcharge causes electrolysis of water, resulting in rapid decrease of electrolyte. Generally, overcharge adversely influences battery life.

OVERDISCHARGE

Discharge of a battery to a voltage below a predetermined cut-off voltage.

PARALLEL CHARGE

Simultaneous charging of two or more batteries connected in parallel. In cyclic use of batteries, specifically, the parallel charge tends to cause an imbalance in charge state among the batteries, which may shorten their service life.

POLYPROPYLENE RESIN

A plastic material which is often used for the case and cover of batteries.

POSITIVE PLATE

The battery electrode from which a current flows to the external circuit during discharging. The positive plate has higher electric potential than the negative plate to the electrolyte. The positive plate is incorporated with connection parts such as the electrode pole.

QUICK CHARGE (RAPID CHARGE)

Charging in a short time with a large current.

RATED CAPACITY

The stated capacity of a battery; namely, the ampere-hour amount which can be drawn from the battery in fully charged state at a specified temperature, at a specified discharge rate, and to a specified cut-off voltage. The symbol CN may be used to express the rated capacity of N-hour rate.

RECHARGEABLE BATTERY

The rechargeable battery is a system comprising two different electrodes and an ion-conductive medium, which is capable of converting chemical energy to electric energy, and vice versa. It is also called a secondary battery.

REFRESH CHARGE (AUXILIARY CHARGE)

Charging of a battery mainly to compensate for its self discharge.

RESIDUAL CAPACITY

Residual capacity of a battery after partial discharge or after storage for long time.

RETAINER TYPE

A method to control flowing electrolyte in a battery with the retainer mat, etc...

REVERSE CHARGE

Charging of a battery with its polarity reversed. Namely, the battery discharges.

SELF DISCHARGE

Reduction in capacity of a battery while no current is drawn by the external circuit. Self discharge depends on temperature: amount of discharge approximately doubles by each (10°C) rise of ambient temperature.

VALVE REGULATED LEAD-ACID BATTERY (VRLA-BATTERY)

Valve regulated lead-acid battery.

SEPARATOR

A porous or microporous liquid-absorbent material which is installed between the battery electrodes for preventing short-circuit, securing the separation of the electrodes and retaining electrolyte. The separator should be resistant to oxidation and chemicals; it should excel in electric insulation and liquid-retention; and it should not disturb diffusion of the electrolyte and ionic conduction.

STANDBY USE

General term of constant stand-by battery systems. Batteries are kept charged by trickle/float method at all times in preparation for unforeseen power disruptions.

TEMPERATURE COMPENSATION

Compensation of charge voltage for temperature variation of a cell/battery or in its vicinity. Qualitatively, charge voltage should be corrected to higher side for low temperatures and to lower side for high temperatures.

TERMINAL VOLTAGEAT DISCHARGE

The voltage of a battery during discharging.

THERMAL RUNAWAY

Such phenomena as an excessively high set-up voltage in constant-voltage charging of a battery and a very high battery temperature cause charge current to increase, which then raises the temperature further: this vicious cycle is called thermal runaway, which may, in the worst case, result in breakage of the battery due to heat.

TRICKLE CHARGE

To charge a battery in the state of disconnection from the load to compensate for its self discharge.

TRICKLE LIFE

The service life of a battery in the trickle use. Usually, the trickle life is the time expressed in years before the dischargeable time of the battery decreases to a half of the initial value.

UL

Abbreviation of Underwriters Laboratories Inc. in USA. The UL establishes various safety standards, and performs official recognition of materials, parts and products.

UPS (Uninterruptible Power Supply)

Equipment or system which is automatically connected to the load to supply power if the main power fails.

VENT (ONE WAY VALVE)

A valve on each battery which automatically releases gas from the battery when internal pressure of the battery exceeds a predetermined value: it prevents breakage of the battery due to excessive internal pressure caused by the gas generated by charging or other reasons. The valve also serves to prevent outside air from entering batteries.

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Power Supplies



User Manual

UPS-CONF

Order No.: -

Configuration and Management Software
UPS-CONF

Power Supplies

User Manual

Configuration and Management Software UPS-CONF

2012-07-02

Designation: UPS-CONF

Revision: 01

Order No.: -

This manual is valid for:

Designation
UPS-CONF

Order No.
2320403

Please observe the following notes

In order to ensure the safe use of the product described, you have to read and understand this manual. The following notes provide information on how to use this manual.



The pictured products do always exemplify the concerned topic.

Target audience for this documentation

The use of products described here solely addresses persons, who are qualified and familiar with electrical equipment and the appropriate and relevant safety concepts. Please also read the section titled "Qualified personnel" in the topic titled "Important safety notes (see page 10)".

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Explanation of symbols used and signal words



DANGER

The danger symbol is used to indicate instructions where non-compliance may result in damage to hardware/software or personal injury (in indirect connection with dangerous process peripherals).



NOTE

The note symbol precedes notes that must be strictly observed in order to ensure error-free operation. It also gives you tips and advice on the efficient use of hardware and on software optimization to save you extra work.



The "Additional Details" symbol indicates cross references (hypertext links or bibliographical references) which lead to detailed descriptions of a term or additional details on the context in question.

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1 Functional overview

UPS-CONF is a management software to configure and monitor QUINT-UPS devices, that come with the IQ technology.

This technology with continuous battery monitoring and intelligent management provides you with information about the charging state, remaining runtime, and service life of your battery at all times. Intelligent communication informs you when a situation becomes critical. This reduces the amount of maintenance involved and increases your system availability.

IQ technology means

- Intelligent Battery Control: automatically detects the connected battery type and maximizes the remaining service life of the battery unit via an optimally adapted charging characteristic.
- Intelligent Battery Management: continuous status information is shown for
 - SOC (State of Charge): current charging state and remaining back-up time of the battery unit
 - SOH (State of Health): remaining life expectancy of the battery unit, provides early warning for a potential battery unit failure
 - SOF (State of Function): determines the current performance of the battery unit.
- Intelligent Charging: adapts the charging current and thereby ensures the fastest possible recharging and availability.
- Intelligent communication: the communication of UPS and PC allows configuration, extensive signaling and parameterization.



The IQ technology also works without UPS-CONF. With this software you have an easier monitoring and configurations can be done.



The UPS-CONF software is intended for a PC as well as an IPC (Industrial PC). In this documentation the term "PC" is used to address both.



The configurable QUINT-UPS device is also referred to as the "UPS" in this documentation.

Features supported by the UPS-CONF software

In order to optimally support the IQ technology, UPS-CONF provides the following features:

- Clear overview about condition of mains, battery, UPS device and connection from PC to UPS
- Automatic PC shutdown and restart functionality while the UPS runs in PC-Mode
- Start of application specific programs for system shutdown
- Configuration of switching outputs
- Chronological event logging
- Setting of customized parameters like the maximum charging current
- Choice of user interface language in the Software settings (see page 5).
Currently supported languages: English, German



The topic titled Application samples (see page 52) guides through some typical scenarios.

2 Software setup

The UPS-CONF software has to be installed on a PC in order to configure and monitor an UPS system. If the buffered load is a PC, the UPS can be operated in the PC-Mode to additionally enable the automatic PC shutdown and restart functionality.

To setup the software, the following steps have to be executed:

1. Make sure all system requirements (see page 4) for the hardware and software are met.
2. Download and install the software (see page 5).
3. Follow the steps in the hardware setup (see page 11).
4. Start the software (see page 15).
5. Become familiar with the software settings (see page 5) supported by the UPS-CONF software and carry out the required settings.

2.1 System requirements

In order to run the UPS-CONF software, your computer must meet the following software and hardware requirements:

Software requirements

- Supported operating systems:
 - Windows 7, 32bit and 64bit
 - Windows Vista SP1
 - XP SP3 (requires .NET Framework 3.5 SP1)
- Supported browser: Internet Explorer version 6 or later

Hardware requirements		
CPU	1 GHz min. 2 GHz recommended	Windows 7 Windows Vista SP1
	Pentium III 1GHz min. 2 GHz recommended	Windows XP SP3
Main memory	1 GB RAM min. 2 GB RAM recommended	Windows 7 Windows Vista SP1
	512 MB RAM min. 1 GB RAM recommended	Windows XP SP3
Main memory used by UPS-CONF	max. 96 MB	
Hard disk drive (recommended)	850 MB	
Hard disk used by UPS-CONF	max. 50 MB	
CD-ROM drive	not necessarily needed	
Interfaces	1 x USB 2.0	
Monitor	VGA, resolution 800 x 600 pixels minimum, 256 colors	
Network	Internet connection needed for program download	

2.2 Installation



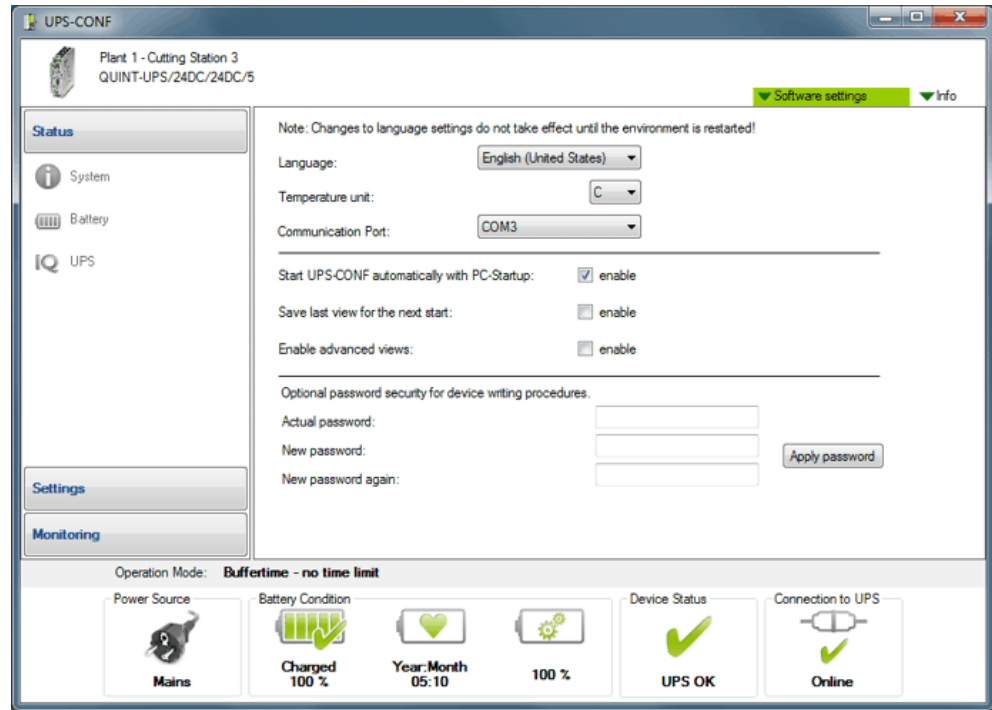
The UPS-CONF configuration and management software can be downloaded free of charge at www.phoenixcontact.net/catalog.

To install the software, proceed as follows:

1. Find UPS-CONF at www.phoenixcontact.net/catalog.
2. Save the UPS-CONF_Setup_v....exe file to the preferred download folder.
3. Make sure the IFS-USB-DATACABLE is unplugged.
4. Install UPS-CONF from the selected download folder. Simply follow the screen instructions.
Read the EULA (End User License Agreement) carefully when it is displayed and agree it to continue the installation.
5. After having completed the UPS-CONF installation, connect the UPS device to the PC (see page 14). If required, select PC-Mode as operating mode (see page 12).
6. As soon as Windows detects the new USB hardware follow the instructions of the driver installation.

2.3 Software settings

The software settings can be shown by clicking the "Software settings" item in the system menu.



The following settings can be defined:

- Language of the user interface (English, German)



NOTE

To apply the changed language setting, you have to restart the UPS-CONF software.

- Temperature unit (Celsius, Kelvin, Fahrenheit)
- Communication (USB) port at the PC for the IFS-USB-DATACABLE (COMx)



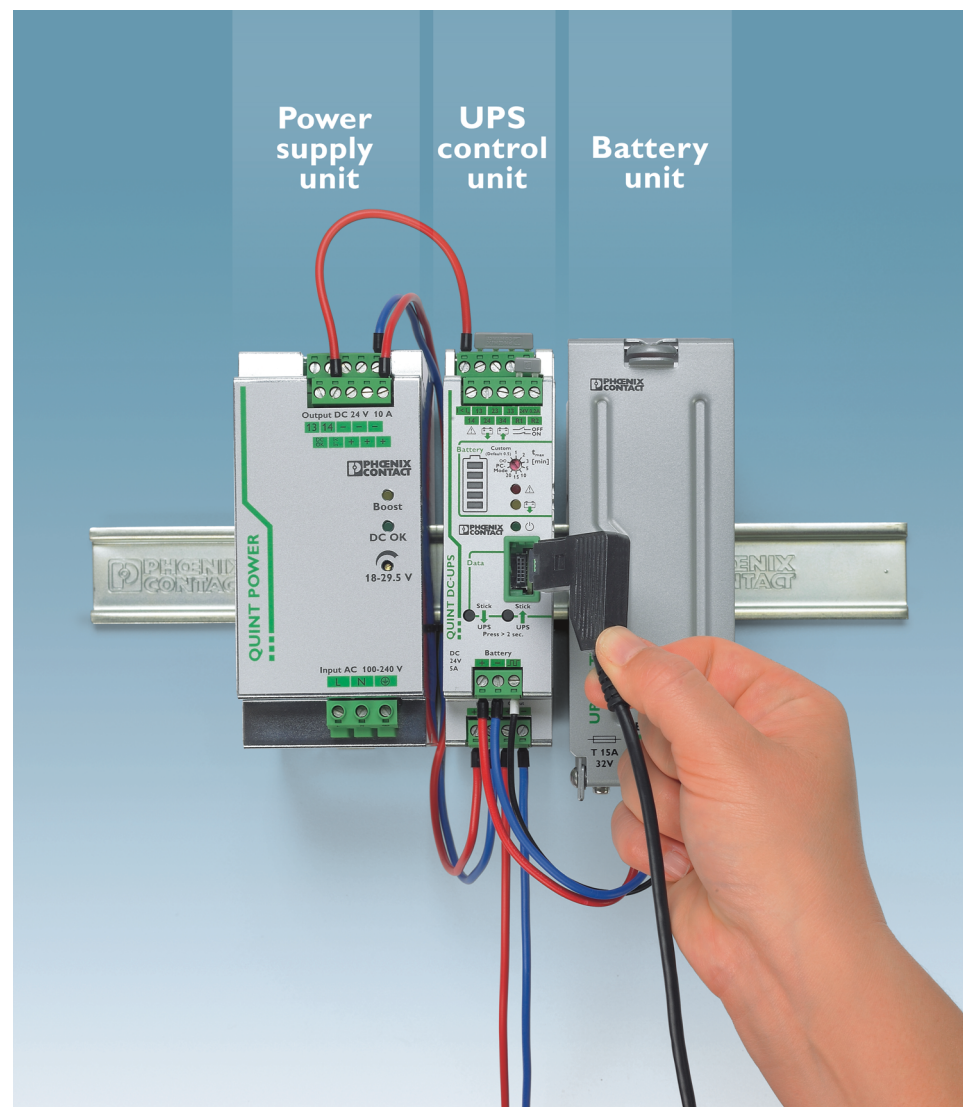
Normally, the communication port is set automatically by the UPS-CONF software when connecting the UPS devices. Under normal conditions there is no need to change this setting. If it has not been set automatically during the software installation, refer to the section Communication port (see page 56) in the Troubleshooting topic.

- Enable/disable automatic UPS-CONF startup after PC startup. This option must be checked if the UPS device shall buffer this PC.
- Restore the last view after the next software start.
- Hide or show the advanced views ("Battery Advanced" and "UPS Advanced" in the "Status" group and "Advanced" in the "Settings" group).
- An optional password, when parameters are written to the UPS device.

3 Hardware overview

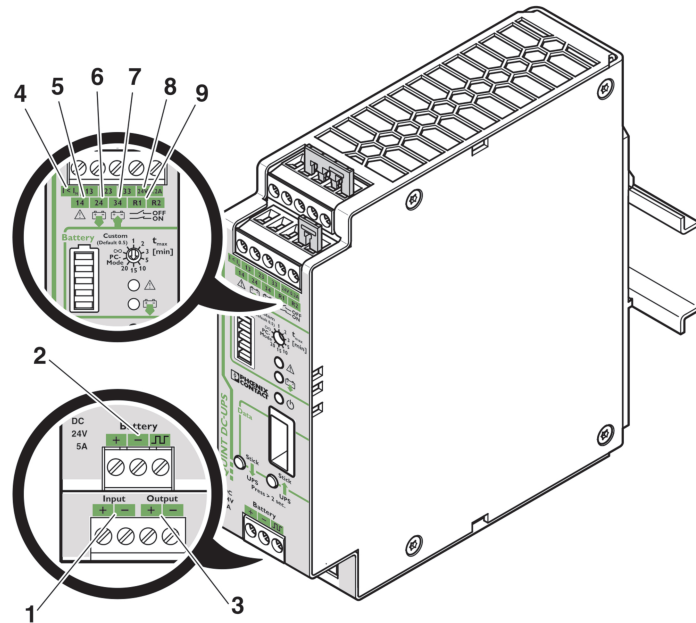
Choose your customized solution - for your application.

1. Choose your power supply.
2. Choose your UPS unit.
3. Choose your energy storage.

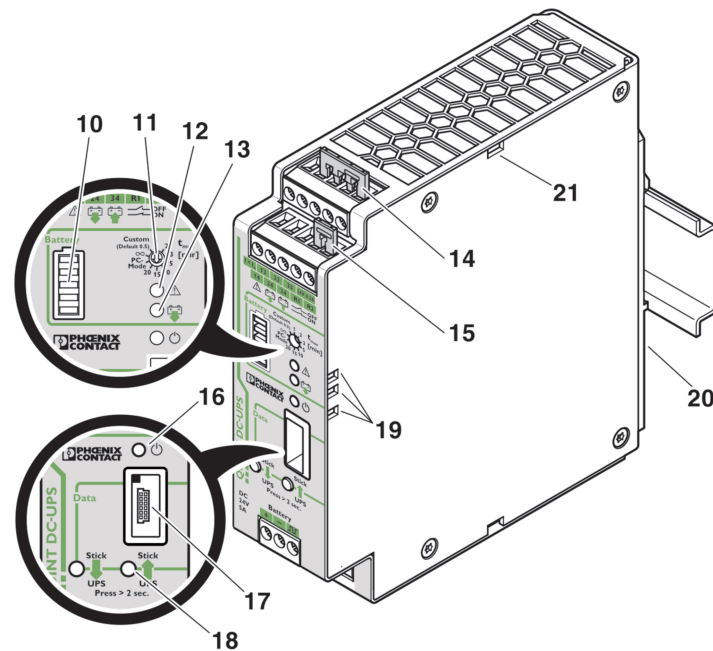


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In the next two graphics and their corresponding lists you can see the location of the main parts of the QUINT DC-UPS.



No.	Connections / Operating elements
1	DC input 18 V DC ... 30V DC
2	Power storage device connection, 24V DC (+,-, communication between UPS and power storage device)
3	DC output, 24 V DC, buffered
4	$I < I_N$, fast battery charging
5	Floating relay contact 13/14: alarm (Related parameter settings are provided in the "Reporting" view (see page 31).)
6	Floating relay contact 23/24: battery mode (Related parameter settings are provided in the "Reporting" view (see page 31).)
7	Floating relay contact 33/34 : battery charge (Related parameter settings are provided in the "Reporting" view (see page 31).)
8	24 V DC supply voltage, maximum current limit 0.2 A for the signal contacts 13, 23, 33
9	Remote control (R1, R2). (Related UPS parameter "Remote Status" (see page 27).)



No.	Connections / Operating elements
10	Bar graph for displaying the current charging state of the power storage device
11	Buffer time setting: unlimited ∞ , 1 ... 20 mins., customized (customized default: 0.5), PC mode (refer to topic Buffer time selection (see page 12)).
12	Red LED: alarm (Corresponding indicators are displayed in the software's "Status" view (see page 20).)
13	Yellow LED: battery mode (Corresponding indicators are displayed in the software's "Status" view (see page 20).)
14	Plug-in bridge for signal contact supply voltages, pre-installed
15	Remote control plug-in bridge, pre-installed
16	Green LED: Power In OK, mains mode (Corresponding indicators are displayed in the software's "Status" view (see page 20).)
17	Data port (see page 13) for data linking to the PC or the use of a memory block
18	Button for use of the memory block
19	LED windows for flat mounting position
20	Universal snap-on foot for DIN rails
21	Accommodation for cable binders

3.1 Important safety notes



Please observe all the safety notes outlined in this topic when using UPS-CONF together with the QUINT-UPS device.

Requirements

Knowledge of the following is required:

- QUINT-UPS system
- UPS-CONF configuration software
- Safety regulations in the field of application

Qualified personnel

In the context of using the QUINT-UPS system and the UPS-CONF configuration software described in this documentation, the following operations may only be carried out by qualified personnel:

- Planning, configuration
- Installation, startup, servicing
- Maintenance, decommissioning

This documentation is therefore aimed at:

Qualified personnel who plan and design electrical equipment for machines and systems and are familiar with regulations governing safety in the workplace and accident prevention.

Within the context of the safety notes in this documentation, qualified personnel are persons who, because of their education, experience and instruction, and their knowledge of relevant standards, regulations, accident prevention regulations, and service conditions, have been authorized to carry out any required operations, and who are able to recognize and avoid any possible dangers.

4 Hardware setup

**NOTE**

Before setting up the hardware, install the software (see page 5).

Regarding the communication with the PC and the UPS operation mode, it needs only three steps to setup the hardware:

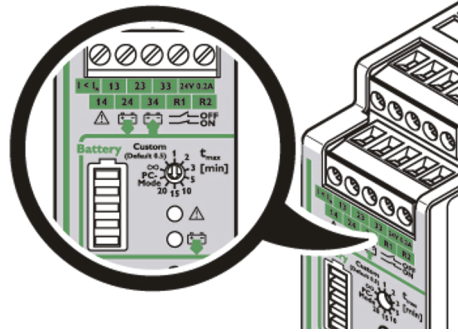
1. Set the buffer time at the buffer time potentiometer, as described in the topic Buffer time selection. (see page 12)
2. Connect the Data port either with a PC or plug in a configuration stick, as described in the topic Data port (see page 13).
3. Connect the load to be supplied by the UPS (see technical datasheet for each QUINT-UPS).

**NOTE**

For further information about the hardware installation (connecting the battery module, etc.) please refer to the QUINT DC-UPS technical datasheet.

4.1 Buffer time selection

The buffer time potentiometer at the front of the QUINT-UPS has to be switched to the desired mode with a screwdriver.



The following settings are available:

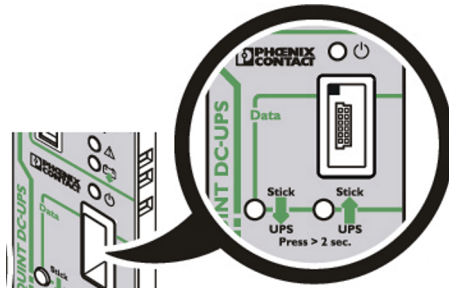
Operating mode	Description
Custom (default 0.5)	Buffer time can be set to a user-defined value; if no value is set 0.5 minutes is used, as described in the topic Custom Mode (see page 37).
1, 2, 3, 5, 10, 15, 20	Buffer time 1, 2, 3, 5, 10, 15, 20 minute(s).
PC-Mode	This mode is intended to buffer a PC and to initiate a controlled shutdown in battery mode. The buffer time depends on the "Shutdown Delay" time and on the "PC-Shutdown" time, as described in the PC-Mode (see page 38).
∞	No time limit, buffering is continued until the battery is empty (deep discharge security).



The current set buffer time is shown as "Operation mode" in the status bar (see page 17).

4.2 Data port

The Data port is located at the front of the UPS. Via this port, configuration and maintenance of the UPS is done.



The configuration can be done in 2 different ways, depending on what is connected to the Data port:

- Connect the PC (see page 14) with the installed UPS-CONF software, if you want to configure by software.
- Plug in a memory stick which is declared as configuration stick, if you want to configure by configuration stick (see page 46).

In order to perform maintenance tasks (such as changing a battery), a service stick can be plugged into the Data port, so the UPS switches to service mode (see page 47).

4.3 Connecting the PC

A PC has to be connected to the UPS in one of the following cases:

- You want to configure or monitor the UPS by the UPS-CONF software.
- You want to display currently set QUINT-UPS parameters or modify them using UPS-CONF.
- You want to initiate a controlled PC shutdown in case of a mains failure and if battery runs low.



NOTE

First, install the software (see page 5) and then connect the PC afterwards.

To connect the PC to the QUINT-UPS, proceed as follows:

1. Connect the USB connector of the IFS-USB-DATACABLE to a free USB connector of your PC. After detecting the device, the used USB port is entered automatically in the software settings of UPS-CONF.



2. Connect the other side of the IFS-USB-DATACABLE to the Data port of the UPS:



5 Software overview

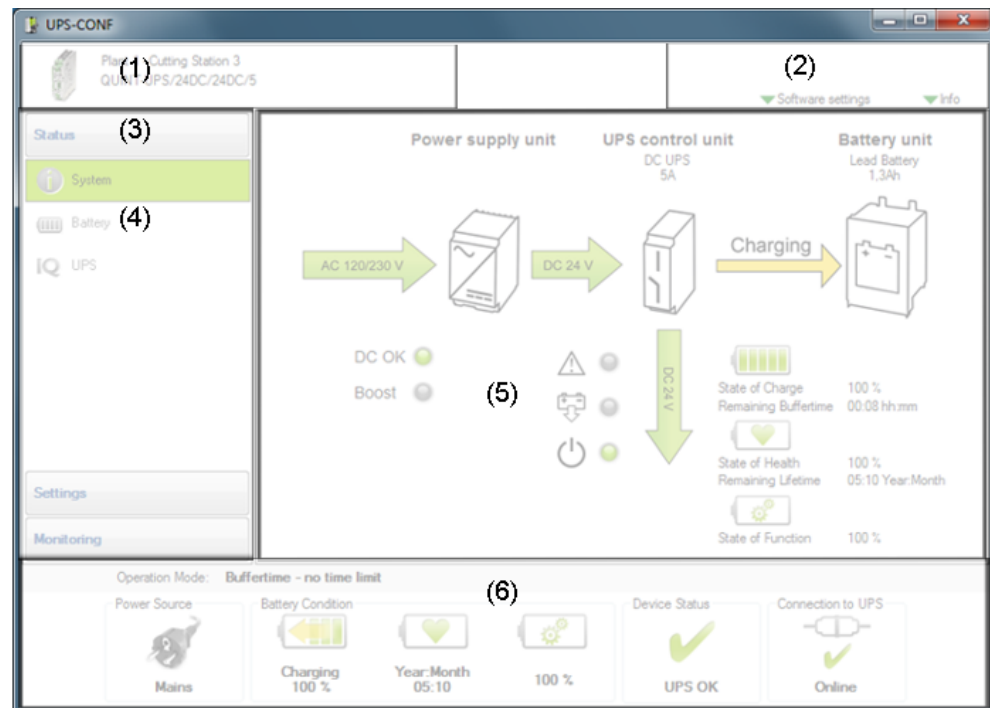
After installing the UPS-CONF software, the program starts up automatically.

As long as you do not change the related default software setting (see page 5), UPS-CONF always starts automatically after every PC reboot.

In the following sections you can get an overview about the screen areas of the UPS-CONF software and you can learn about the different status bar (see page 17) symbols and their meanings.

5.1 User interface

The screen layout consists of the following areas:



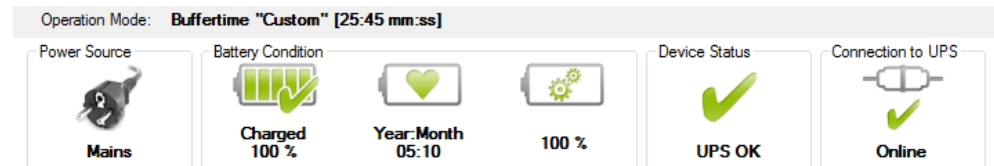
The following table explains the several areas.

Area	Description
(1)	<p>Device information: Here, the type of the connected UPS is displayed. If text has been entered for the advanced UPS parameter "Place of installation" (see page 41), it is displayed above the UPS type.</p>
(2)	<p>System menu: Software settings (see page 5): A mouse click leads to the screen, where various software settings can be made. Info: A mouse click shows the contact information of Phoenix Contact.</p>
(3)	<p>Software menu: The Software menu provides various topic buttons such as status information display, parameter settings or monitoring values. A software menu button is expanded/collapsed by simply clicking it. When a software menu button is expanded the corresponding navigation items are listed.</p>
(4)	<p>Navigation items: After clicking a navigation item the corresponding information and parameters are displayed in the action area.</p>
(5)	<p>Action area: The content of the action area depends on the currently selected navigation item. This can be, for example, information, read from the device, or a parameterization table used for configuring the connected UPS.</p>
(6)	<p>Status bar (see page 17): Displays the status of all involved components thus providing a quick system overview. The status bar is always visible, also if the navigation and action area change.</p>

5.2 Status bar

The status bar in the lower part of the screen shows information about the current system state.

When the power supply is available and the system is online and the battery is fully charged, the status bar looks like this:



The operation mode in the upper part of the status bar shows the current setting of the buffer time potentiometer of the UPS, as described in topic Buffer time selection (see page 12).

If it looks different, e.g. Power Source status "UPS off" or no connection to UPS ("Offline"), verify the following:

- All UPS components (QUINT-UPS, battery, power supply) are functional and properly connected.
- The QUINT-UPS is supplied with 24 V DC.
- The IFS-USB-DATACABLE is properly connected between QUINT-UPS and PC.



If an alarm is detected or an existing online connection between the PC and the QUINT-UPS is interrupted, the UPS-CONF software automatically becomes the active window. The status is queried every 5 seconds.




If your system status is like described, you can






- evaluate the UPS system status by displaying the various views contained in the software menu "Status" (see page 20) and/or
- start configuring the UPS by modifying the default parameter settings in the various views of the software menu "Settings" (see page 29) and/or
- monitor your system.








In the topic Application samples (see page 52), some typical application scenarios are described.



The following tables explain the different status symbols that can be visible in the status bar:

Power Source	Symbol meaning
	The status "Mains" is shown, if the power supply is switched on and available.
	The status "Battery" is shown, if the power supply is switched off or not available. That means, the battery is discharging.
	The status "UPS off" is shown in either case: <ul style="list-style-type: none"> • The UPS is off, because battery mode is finished. The set buffer time has elapsed. • The power supply is available, but delivers an invalid output voltage.

Battery Condition	Symbol meaning
State of charge: 	Battery is "Fully charged".
State of charge: 	"Charging" is shown, if the battery is currently charging and not yet fully charged.
State of charge: 	The "Discharging" status is shown, if the battery is currently discharging because the system runs in battery mode. Usually, this status is shown in combination with the power source status "Battery".
State of charge: 	"Uncharged" is shown, if the battery mode is finished and the battery is empty.
State of health: 	The "State of Health" status shows the remaining lifetime of the battery. The lifetime value is shown below the symbol.

Battery Condition	Symbol meaning
State of function: 	The "State of Function" status shows the current performance of the battery. This efficiency value is measured in percent and is shown below the symbol.
	During battery charging the battery conditions "State of Charge", "State of Health" and "State of Function" are shown as "unknown".

Device Status	Symbol meaning
	The "UPS OK" status is shown during normal UPS operation, i.e., when mains is available (battery mode not active) and no other event is currently upcoming.
	"Bat.-Mode deactivated" is shown, if the bridge is removed from the terminals R1 and R2. Refer to the parameter "Remote Status" in the topic UPS (see page 27).
	The "Alarm" status is shown, when a failure or critical situation exists, for example: <ul style="list-style-type: none"> • battery almost empty • battery not detected • battery replacement required

Connection to UPS	Symbol meaning
	This status informs about the communication connection between UPS-CONF and the QUINT-UPS device. The "Online" status is shown, if the IFS-USB-DATACABLE is connected. Normally, this status is automatically entered after connecting the UPS to the PC via the IFS-USB-DATACABLE.
	"Offline" means that no communication connection is established via the IFS-USB-DATACABLE.

6 Status - Reported information

If the "Status" group is selected, the following navigation items are available:

- "System (see page 20)": overview on the current system status
- "Battery (see page 25)": status information for all connected batteries
- "Battery Advanced (see page 26)": advanced status information for all connected batteries
- "UPS (see page 27)": status information for the connected UPS
- "UPS Advanced (see page 28)": advanced status information for the connected UPS





6.1 System

If the "System" item is selected in the software menu "Status", an overview on the current system status is visible in the action area. The values shown here are read cyclically from the UPS device, as long as a communication connection to the UPS is established.

The system components and their status information are arranged on the screen as "Power supply unit" on the left hand side, "UPS control unit" in the middle and "Battery unit" on the right hand side. The tables explain the symbols corresponding to the units.



Power supply unit symbols:

Icon	Meaning of LEDs
DC OK	 Green LED on: DC output is available.  LED off: DC output is not available.
Boost	 Yellow LED on: Boost signal is ON (power supply delivers additional current for a connected load).  LED off: Boost signal is OFF.



UPS control unit symbols:

Icon	Meaning of LEDs
	<p> Red LED on: UPS alarm due to one of the reasons:</p> <ul style="list-style-type: none"> • battery almost empty • battery not detected • battery replacement required <p> LED off: No UPS alarm, power supply available, normal operation.</p>
	<p> Yellow LED on: Battery mode is ON, battery is discharging because power supply failed.</p> <p> LED off: Battery mode is OFF, i.e. mains available.</p>
	<p> Green LED on: Mains is ON.</p> <p> LED off: Mains is OFF.</p>



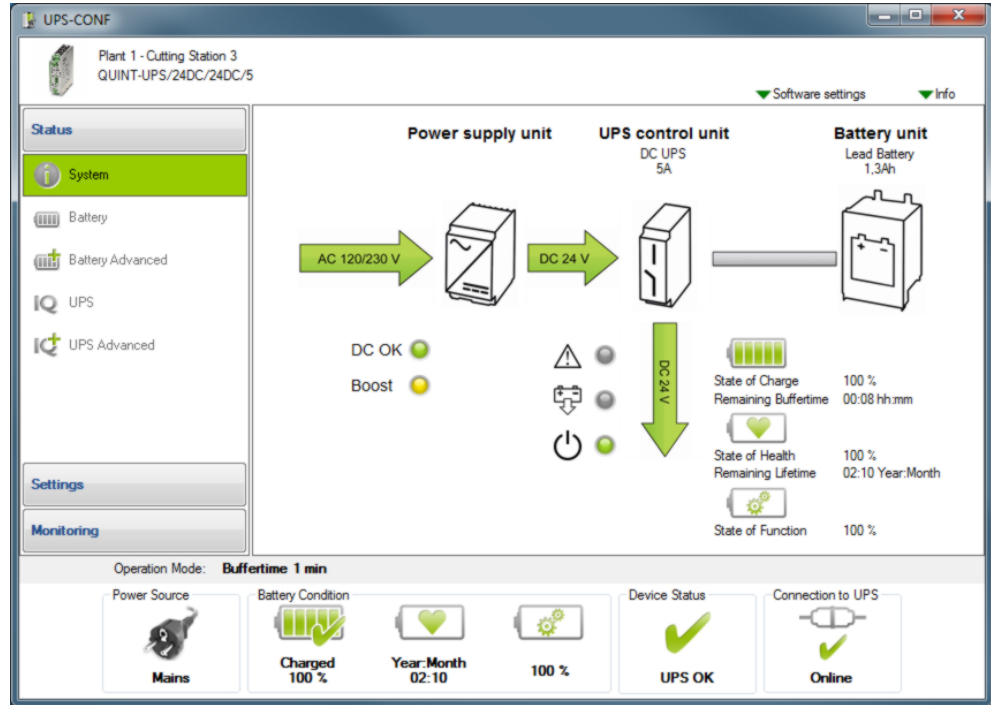
Battery unit symbols:

Icon	Meaning of LEDs
	SOC (State Of Charge) – current charging state and remaining back-up time of the battery unit.
	SOH (State Of Health) – remaining life expectancy of the battery unit, provides early warning for a potential battery unit failure.
	SOF (State Of Function) – determines the current performance of the battery unit.

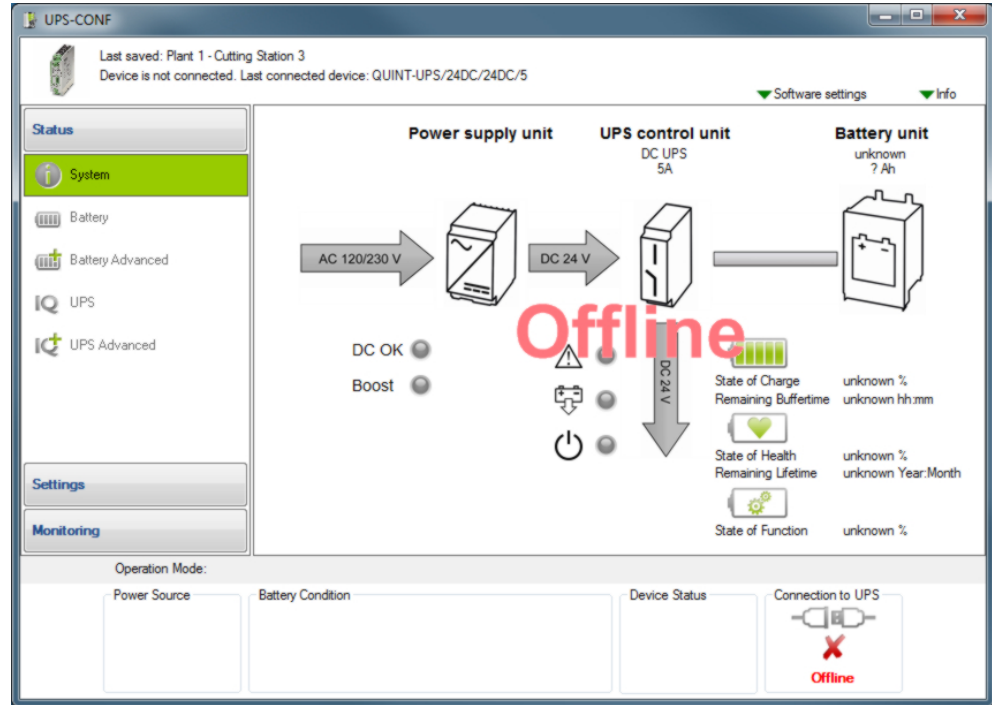


NOTE
While charging the battery the status is "unknown".

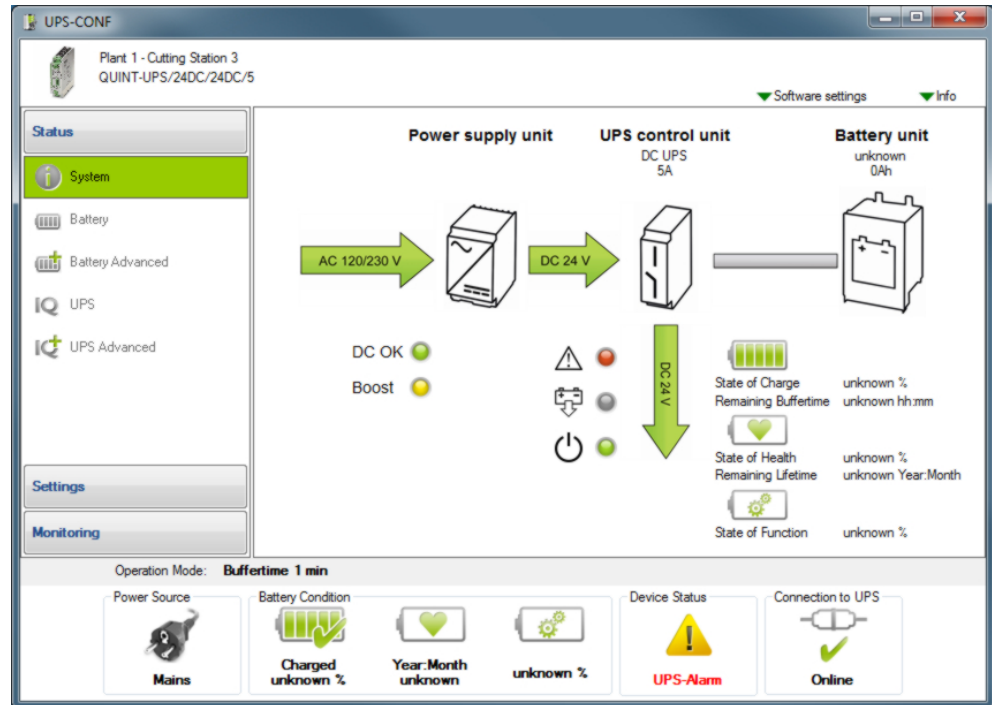
When the system is in normal operation (online and running), the screen looks like this:



When the UPS is offline and has no connection to the PC, the screen looks like this:



When the system status shows an alarm, the screen looks like this:



In such case refer to the topic Troubleshooting (see page 53).

6.2 Battery


If the "Battery" item is selected in the software menu "Status", status information for all connected batteries is shown in the action area.

The information is headed by "General information" for all connected batteries, such as "Number of detected battery units" or "Total nominal capacity".

Individual information for every battery follows.

If several battery units are installed, the data of the individual units can be displayed by clicking on the battery icons on top of the action area:

The status information in the action area could for instance look similar like this:




General information

Name	Value	Unit
Quantity check - Number of installed battery units?	3	
Number of detected battery units	3	
Quantity check o.k.	Yes	
Total nominal capacity	3,9	Ah
Actual battery charging current	1,37	A
Actual battery discharging current	0,00	A

Battery 1

Name	Value	Unit
Nominal battery capacity	1,3	Ah
Actual battery temperature	21	°C
Actual battery voltage	27,70	V
Serial-No.	3011355145	

Battery parameters	Meaning
	Except of some parameters explained here, the status information is self-explanatory, this is why it is not explained in detail.
Quantity check - Number of installed battery units?	This value can be set to the amount of batteries, that were built in.
Number of detected battery units	Number of batteries detected by the QUINT-UPS.

Battery parameters	Meaning
Quantity check o.k.	Shows "Yes", if the number of installed battery units complies with the number of detected batteries. Otherwise "No" is displayed.

6.3 Battery Advanced



This navigation item is only available if the "Enable advanced views" checkbox is marked in the software settings (see page 5).

If the "Battery Advanced" item is selected in the software menu "Status", advanced status information for all connected batteries is shown in the action area.

In normal operation it looks something like this:


Name	Value	Unit
Actual state of charge	100	%
Remaining backup time	00:08	hh:mm
Remaining battery life time	01:03	Year:Month
Actual battery performance	100	%
Actual battery voltage	27,57	V
Actual battery temperature (Average of all units)	26	°C

6.4 UPS

If the "UPS" item is selected in the software menu "Status", status information for the connected UPS is shown in the action area.

In normal operation it looks like this:

Name	Value	Unit
Actual Alarm	No Alarm	
Last Alarm	No Alarm	
Remote Status	UPS ready	
UPS in battery operation (Battery-Mode)	No	
Selected operation mode	Buffertime - no time limit	
Battery is charging (Battery-Charge)	No	

Parameter	Meaning
	Except of some parameters explained here, the status information is self-explanatory, this is why it is not explained in detail.
Remote Status	<p>Remote control (contact R1, R2) The module can be switched on and off via a signal to contacts R1 / R2. Shutdown can take place in mains mode or while battery mode is active.</p> <p>Remote shutdown is deactivated UPS in function (delivery state) – The "R1" and "R2" terminal points are short circuited (delivery with plug-in bridge) OR 24 V DC is present at terminal point "R2". – In the event of a voltage supply failure, the UPS switches over to battery mode.</p> <p>Remote shutdown is activated – The "R1" and "R2" terminal points are not short circuited AND 0 V is present at terminal point "R2". – In the event of a voltage supply failure, the UPS does not switch over to battery mode and the device shuts down.</p>
Selected operation mode	Shows the operation mode that is set via the buffer time potentiometer, as described in topic Buffer time selection (see page 12).

6.5 UPS Advanced



This navigation item is only available if the "Enable advanced views" checkbox is marked in the software settings (see page 5).

If the "UPS Advanced" item is selected in the software menu "Status", advanced status information for the connected UPS is shown in the action area.



The status information is self-explanatory, this is why it is not explained in detail here.

In normal operation it looks something like this:

Name	Value	Unit
Device type	QUINT-UPS/24DC/24DC/5	
Actual input voltage	23,91	V
Actual output voltage	23,66	V
Actual Device Temperature	30	°C
Shutdown event started	No	
UPS serial number	3012001033	
Device firmware	0x00000110	

7 Settings - Defining UPS device parameters

The navigation items contained in the "Settings" group allow access to the various UPS device parameters.

Parameter values can be entered in UPS-CONF and written to the device (see page 29) with only one click of the mouse.

If the software menu "Settings" is selected, the following navigation items are available:

- Reporting (see page 31): Trigger thresholds, switching outputs for UPS alarm, battery mode and battery charging as well as Email settings
- Time Setting (see page 36): Buffer times, (delay) times and programs to execute for PC shutdown
- Service (see page 39): Service mode activation and rights granting, declaration of service stick and configuration stick
- Advanced (see page 41): Battery charging values, wire sizes, thresholds, signaling times and others

How to write parameters

In each of the navigation items, different settings can be made in the action area in order to write it to the UPS.

Beneath settings, that can be made by checking a checkbox or by entering data into an input box, also numerical or textual values contained in the parameter tables can be changed.

In these parameter tables, changeable parameter values have a white background color. Read-only values, i.e. the ones that are read from the device for monitoring purposes, are shown on a gray background.

To enter a new value for a parameter and write it to the UPS, proceed as follows:

1. Double-click the line, where the parameter text is located or click the "Write..." button in the lower right corner.
An input box opens showing the currently set value.
2. Enter a value into the input box. Make sure that the chosen value is within the allowed value range and is suitable for your UPS system!
3. Click the "Write to device" button.
4. Verify that the new value is now displayed in the parameter table, i.e., has been accepted by the device.

Sample:

Select the "Reporting" navigation item in the "Settings" group and click the "Trigger Thresholds" tab in the action area.

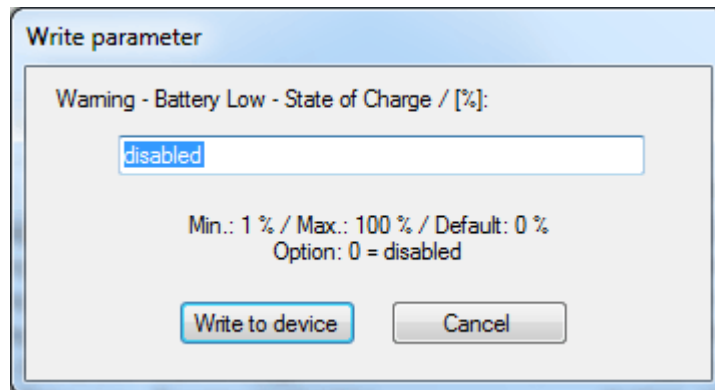
In this tab, you can set a trigger value, at which battery charging level a "battery low" warning should be generated (first entry in the tab Trigger Thresholds (see page 31)). The value is entered as percentage, see below. By default, the trigger is "disabled", i.e. no warning is reported.

Name	Value	Unit
Warning - Battery Low - State of Charge	disabled	%
Warning - Battery Low - Remaining backup time	disabled	hh:mm
Warning - Battery Low - Battery voltage	disabled	V
Warning - Battery End of Lifetime - Remaining life time	disabled	Year:Month
Alarm - Battery Low - State of Charge	90	%
Alarm - Battery Low - Remaining backup time	disabled	hh:mm
Alarm - Battery Low - Battery voltage	20,4	V
Alarm - Battery End of Lifetime - Remaining life time	00:05	Year:Month

Set the trigger to 20% as follows:

1. Double-click the marked line, as shown in the figure above or left-click the line and then press the "Write..." button in the lower right corner.

The following dialog appears:



Below the text field you can see the allowed input range.

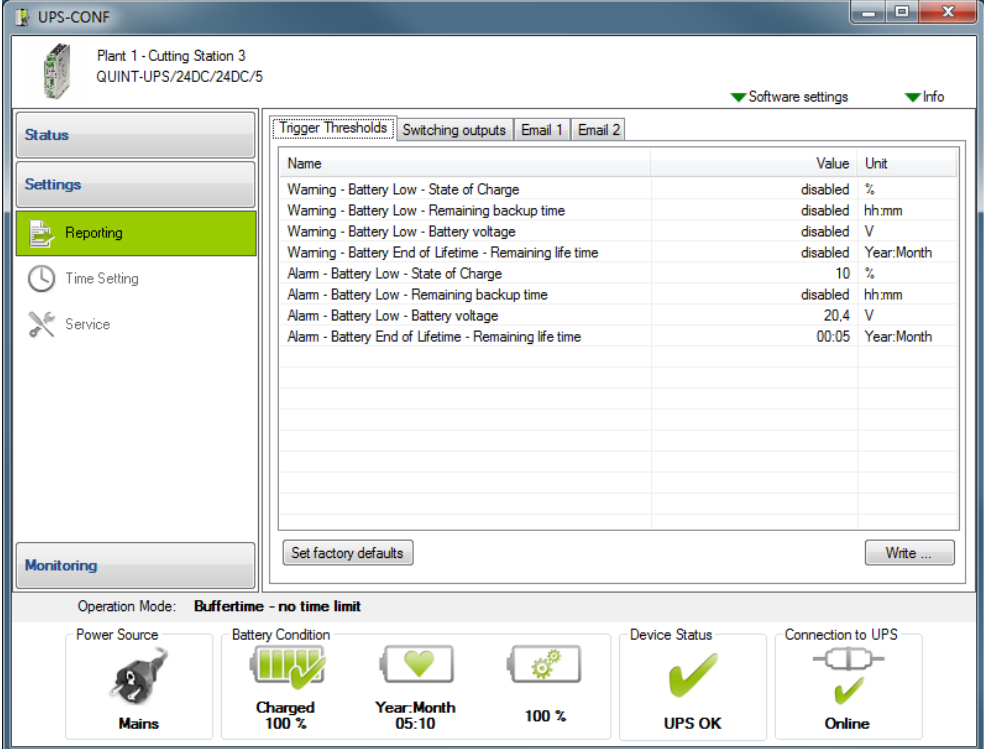
2. Enter 20 in the input box and click the "Write to device" button.
3. Verify that the new value is shown in the table.

7.1 Reporting

If the "Reporting" item is selected in the software menu "Settings", the tabs "Trigger Thresholds", "Switching outputs", "Email 1" and "Email 2" are visible in the action area.

Trigger Thresholds

On the "Trigger Thresholds" tab you can define, whether warnings or alarms shall be reported by the UPS and define the threshold values which must be exceeded in order to trigger a message.



UPS-CONF

Plant 1 - Cutting Station 3
QUINT-UPS/24DC/24DC/5

▼ Software settings ▼ Info

Trigger Thresholds | Switching outputs | Email 1 | Email 2

Name	Value	Unit
Warning - Battery Low - State of Charge	disabled	%
Warning - Battery Low - Remaining backup time	disabled	hh:mm
Warning - Battery Low - Battery voltage	disabled	V
Warning - Battery End of Lifetime - Remaining life time	disabled	Year:Month
Alarm - Battery Low - State of Charge	10	%
Alarm - Battery Low - Remaining backup time	disabled	hh:mm
Alarm - Battery Low - Battery voltage	20,4	V
Alarm - Battery End of Lifetime - Remaining life time	00:05	Year:Month

Set factory defaults Write ...

Operation Mode: **Buffertime - no time limit**

Power Source: Mains

Battery Condition: Charged 100%

Year:Month: 05:10

100 %

Device Status: UPS OK

Connection to UPS: Online

For each of the following conditions, both a warning and an alarm threshold value can be defined:

- Battery is low and the state of charge falls below a certain percentage number.
- Battery is low and the remaining backup time falls below a defined time.
- Battery is low and the battery voltage falls below a certain voltage.
- Battery is at it's end of lifetime and the remaining life time falls below a defined time.

If a warning or alarm is reported, you can define that a switching output must be triggered. For some of the warnings or alarms an Email to be sent can also be defined.

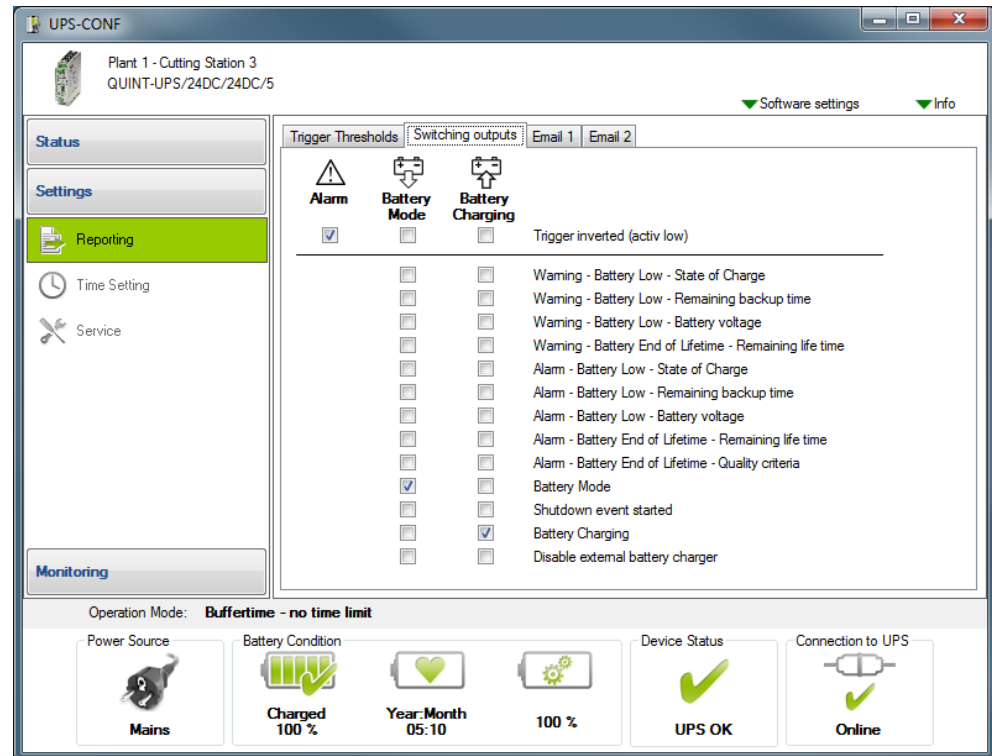
A reported alarm is additionally signaled by the LED at the front of the UPS device as well as in the status bar of the UPS-CONF software.

By means of warnings and alarms you can implement a two-level detection system:

1. Report a warning, when the first threshold value is exceeded.
Example: battery lifetime is still one year.
2. Report an alarm, when the second threshold value is exceeded.
Example: remaining lifetime of the battery is only some few months or weeks. Now an Email is additionally sent to the responsible person to ensure that a new battery is ordered in time.

Switching outputs

On the "Switching outputs" tab you can define a QUINT-UPS device output signal to be switched, when a certain trigger occurs. With such an output signal you can, for example, control a buzzer, that sounds, if the battery is low or the shutdown has been initiated.



Three different outputs are available to be switched:

- "Alarm",
- "Battery Mode"
- "Battery Charging"

All switching outputs can be triggered inverted, i.e., active low.

The "Battery Mode" and "Battery Charging" output signals can be switched with the following triggers:

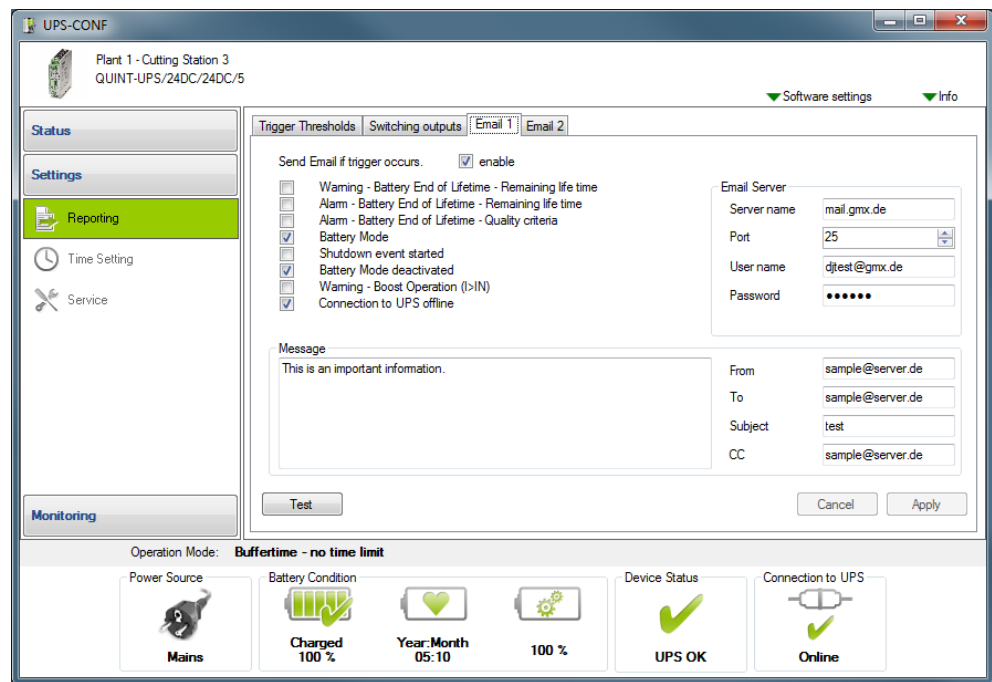
- The same triggers as described in section "Trigger Thresholds" for warning and/or alarm, e.g. triggers that are released by an exceeded or underrun threshold.
- The quality criteria is no more fulfilled. The IQ-Technology of the QUINT-UPS-IQ is able to calculate it's own save remaining lifetime for the battery. Based on this calculation, the quality criteria is evaluated as met or not.
- The system switches to battery mode.

- A shutdown event started.
- The battery switches to the "Battery Charging" status.
- For the "Disable external battery charger" trigger, see technical datasheet for the QUINT-UPS.

For "Alarm" switching output, no further options can be defined.

Email 1 / Email 2

On the "Email 1" and "Email 2" tabs you can define two separate Email addresses, to which Emails can be sent if certain events occur. To access the input fields, mark the "enable" checkbox in the upper part of the screen.



The available triggers to initiate Emails to be sent are:

- A warning occurs as battery is at it's end of lifetime and the remaining life time falls below a defined time.
- An alarm occurs as battery is at it's end of lifetime and the remaining life time falls below a defined time.
- An alarm occurs as the quality criteria is no more met.
- The battery switches to battery mode.
- A shutdown event started.
- The battery switches to "Battery Charging" status (battery mode deactivated).

- A warning occurs because boost operation was activated. The power supply now delivers BOOST current, which is up to 1.5 times the nominal current of the power supply (only available with QUINT POWER).
- The connection to the UPS was interrupted ("Offline" status).

In the Email Server area, you have to enter:

- "Server name" for the server managing your outgoing mail. Ask your administrator for details.
- "Port" for outgoing Emails is usually 25. The predefined port 25, however, can be changed.
- "User name" and "Password" of your Email account. In some accounts the "User name" is the Email address.

The Message area contains:

- Messagebox: A short explanation of the trigger, that caused the Email, is sent as default message. You can enter additional text, that will be appended to the default text.
- "From" textbox: Any Email address can be entered here.
- "To" textbox: A valid Email address has to be entered here, where the Email is sent to; it must be an Email address, that exists in the Email server's configuration.
- "Subject" textbox: the title of your Email is user-defined; it is only used with the Email "Test" button. When the Email is successfully sent, click the "Apply" button.
- "CC" textbox: you can enter an Email address, where a copy is sent to.

You can test your settings by clicking on the "Test" button.

Sample Email:

A sample Email would look like this:

Email part	Content of Email part	Explanation
Subject	[UPS CONF: Parameters change notification]	
Message	*** UPS Status Mail ***	Header of the status mail message
	Hall 125	Place of installation, refer to the topic Advanced (see page 41)
	QUINT-UPS/24DC/24DC/5	Type of connected UPS, refer to the device information area in the User interface (see page 15)
	Trigger: Battery Mode Trigger	Kind of active trigger
	Threshold: -	Threshold (if applicable)
	This is an important information.	User defined text from the message textbox

7.2 Time Setting

If the "Time setting" navigation item is selected in the "Settings" group, the action area provides various settings for two different UPS operating modes:

- The upper part (above the separation line) specifies the "Custom" mode.

Buffertime of Switch Setting „Custom“: mm:ss Max.: 1 h

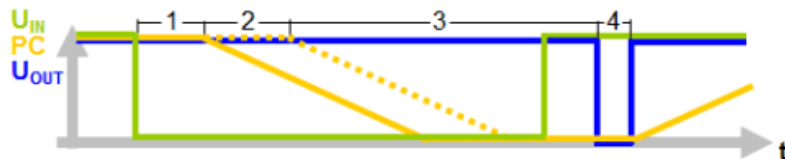
- In the lower part (below the separation line), four different parameter categories can be set concerning the PC-Mode.

1 State of Charge based Shutdown Delay: enable
 Shutdown Delay: h:mm Max.: 2 h

2 Program Startup if „Shutdown Delay“ expired: enable
 Max. Program Runtime: mm:ss Max.: 5 min
 Program path:
 Program arguments:

3 PC-Shutdown: mm:ss Max.: 5 min
 Countdown (15 seconds) till PC-Shutdown: enable

4 PC-Restart Delay: seconds Max.: 60 seconds



Custom mode









NOTE
These settings only apply if the UPS runs in Custom mode. To set this mode, the buffer time potentiometer located at the device front must be set to "Custom" (refer to topic buffer time selection (see page 12)).

In Custom mode the buffer time for the battery can be set to a maximum of 1 hour (30 seconds default).

When the power supply was interrupted the load will loose it's power after the user-defined buffer time has elapsed. The battery will buffer exactly the set buffer time. If no user-defined time is entered, the buffer time selected by the potentiometer is used.

The set time is displayed in the "Operation Mode" of the status bar. An example with 25 minutes and 45 seconds set, shows the following status bar and operation mode:

Operation Mode: **Buffertime "Custom" [25:45 mm:ss]**

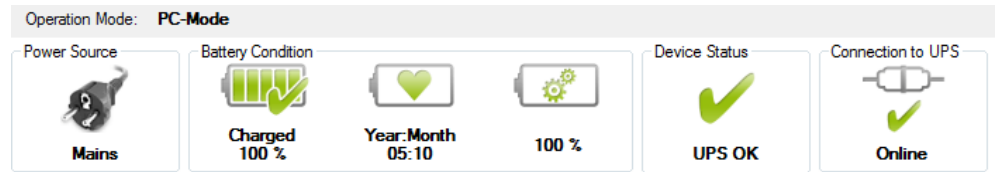
Power Source  Mains	Battery Condition  Charged 100 %	Year:Month  05:10	100 % 	Device Status  UPS OK	Connection to UPS  Online
--	---	--	--	--	--

PC-Mode

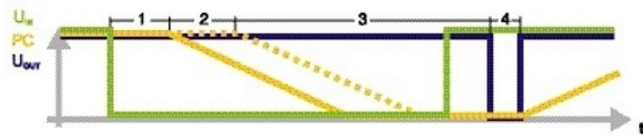


NOTE
 These settings only apply if the UPS runs in PC-Mode. To set this mode, the buffer time potentiometer located at the device front must be set to "PC-Mode" (refer to topic buffer time selection (see page 12).

When the PC-Mode is set, the status bar shows the operation mode "PC-Mode", as shown in the following screenshot:



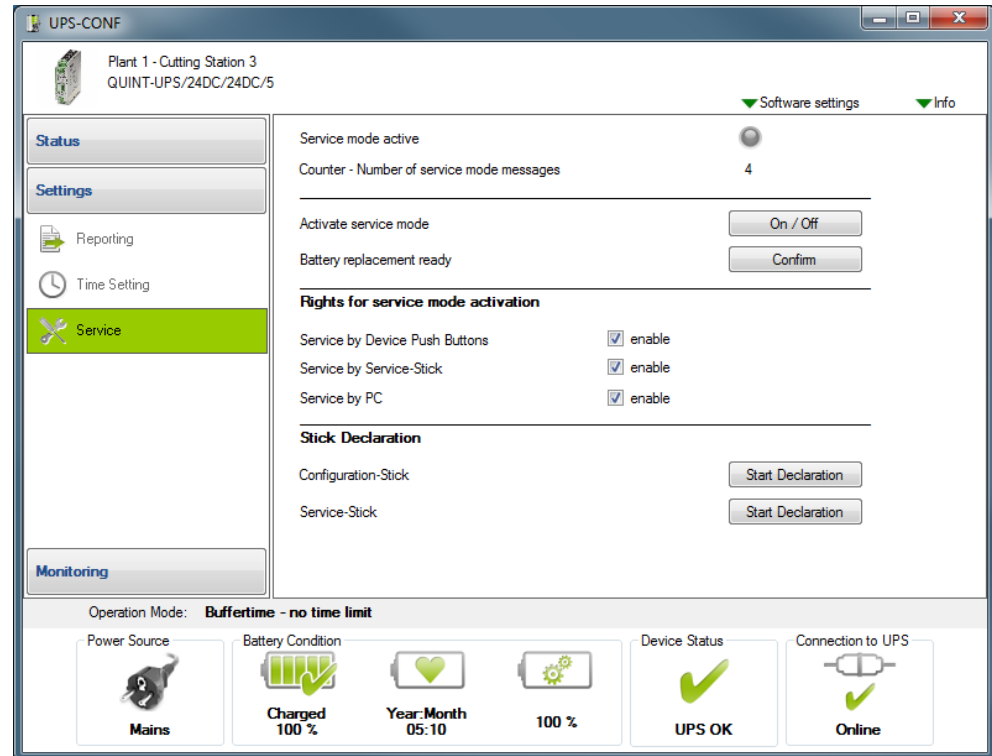
In the "PC Mode" setting on the UPS potentiometer, the UPS functionality follows a chronological sequence that can be parameterized via software, and is thus individually customized to the respective application.



Parameter	Meaning / Possible settings
1 Shutdown delay	Delay time is calculated automatically from the current remaining battery life minus the time required by the PC to shutdown. Alternatively, a fixed delay time may be chosen.
2 Program startup	After the delay time has expired it is possible to start a program. Example: a software starts that gradually backs up system data. <div style="border: 1px solid black; padding: 5px; display: inline-block;"> You can test your settings by clicking on the "Test" button. </div>
3 PC shutdown	The time required by the PC/IPC to shut down is set here.
4 PC restart delay	Only if the PC/IPC is shut down, and the mains has returned in the meantime, the output voltage will be interrupted for the reset time. The PC/IPC is then automatically restarted.

7.3 Service

If the "Service" item is selected in the software menu "Settings", all parameters of switching the UPS to service mode are accessible in the action area.



Here, you can:

- Operate the UPS in service mode (see page 47).
- Grant or deny rights for the service mode activation (see section below).
- Declare memory sticks as either configuration sticks or service sticks, as described in the topic Stick usage (see page 45).

Rights for service mode activation

The rights for all possible methods to activate or terminate the service mode can be defined in the "Rights for service mode activation" part of the "Service" navigation item's action area.

Possible activation methods are:

- Pressing both push buttons ("Stick -> UPS" and "UPS -> Stick") on the device front simultaneously.
- Plugging a service stick into the Data port of the UPS device.

- Clicking the service mode activation button in the "Service" navigation item's action area in UPS-CONF.

When allowing a service stick for activating the service mode and disabling the use of the push buttons at the same time, the stick can be considered as a kind of hardware key: Only authorized persons who possess a service stick are allowed to switch the device to service mode. For that purpose, a memory stick must be declared accordingly as described in Stick usage (see page 45).



For further information please refer to the "Service stick usage - service mode (see page 47)".

7.4 Advanced



This navigation item is only available if the "Enable advanced views" checkbox is marked in the Software Settings (see page 5).

The "Advanced" navigation item within the "Settings" group allows to set more specific parameters. These are in detail:

Name of parameter:	Sample value:	Unit:	Explanation:
Place of installation (user defined)	Hall 125	(none)	The text entered here is displayed in the device information area of the User interface (see page 15).
Initial charging current	1.36	A	The battery is charged with this current, when the power supply is available.
Absorption charging end voltage	28.00	V	An equalizing charge, that increases charging voltage to a higher value than the nominal capacity for a short period. This prevents battery stratification and reduces sulfation. When the battery is fully loaded, this voltage is tolerated as a maximum, before the voltage level gets a stable end value.
Float charging end voltage	27.60	V	The charger adjusts the end voltage based upon battery temperature. During high temperature periods, the actual battery voltage will be reduced and during low temperature periods it will be increased.
Temperature compensation	42	mV/K	High ambient temperatures have a negative impact on the service life of the battery. Therefore, the charging voltage should be lower with higher ambient temperatures. The adjustable values relate to one battery cell each.
Wire distance to the battery unit	300	mm	The maximal wire length from the UPS control unit to the battery unit.
Wire cross section to the battery unit	6.0	qmm	The wire cross section from the UPS control unit to the battery unit.

Name of parameter:	Sample value:	Unit:	Explanation:
Fast battery charging	On	(none)	Boost mode is allowed or not.
Dynamic backup threshold	Off	(none)	This parameter can be defined additionally to the overvoltage and undervoltage related parameters, see below. If set to On the voltage increase or decrease within a certain time period is watched (dynamically). The UPS switches to battery mode, if the relative increase/decrease is too much. In contrast the overvoltage and undervoltage parameters have static values. They can become active regardless the dynamic backup threshold did not trigger, because the voltage was alright.
Undervoltage backup threshold	19.00	V	When the DC voltage falls under this threshold (undervoltage), the system switches to battery mode.
Overvoltage backup threshold	30.00	V	When the DC voltage exceeds this threshold (overvoltage), the system switches to battery mode.
Return to mains time	3	seconds	After this time the system returns to mains, when it is in battery mode and the power supply is available again.
Discharging end voltage	19.20	V	The battery voltage may not sink below this voltage value, otherwise it would be deeply discharged and become defective.
Signaling time after battery low cutoff	00:10	hh:mm	When the battery low status has arrived, the UPS cuts off and the status of the power source firstly switches to "UPS off (see page 27)". After the time set here no more power or battery status is displayed, but only the Connection to UPS (see page 17) is offline.
Signaling time after time cutoff	00:10	hh:mm	When the buffer time has elapsed, the UPS cuts off and the status of the power source firstly switches to "UPS off (see page 27)". After the time set here no more power or battery status is displayed, but only the Connection to UPS (see page 17) is offline.

Name of parameter:	Sample value:	Unit:	Explanation:
Battery type (imported item)	"No value assigned"	(none)	The type of battery delivered by the manufacturer. This value is read by the UPS-CONF software.
Nominal capacity (imported item)	"No value assigned"	Ah	The nominal capacity of the battery delivered by the manufacturer. This value is read by the UPS-CONF software.



You can restore the default settings anytime by clicking the "Set factory defaults" button.



You can import / export the list in a .csv file by clicking the button "Import " or "Export".

8 Monitoring - Statistics and logging

If the "Monitoring" group is selected, the navigation items "Statistic (user defined)", "Statistic (system defined)" and "Logging" are available.

The items inform about counted and time measured statistic values and show logged information.

Statistic (user defined)

The "Statistic (user defined)" navigation item shows counter values which start at a user-defined value. If, for example, batteries have been replaced, you can set the values manually to "0" in order to start a new logging period. The following values are displayed and can be reset:

- Number of battery modes: How often did the UPS already change to battery mode?
- Total time of battery mode: How long altogether did the UPS stay in battery mode?
- Number of operation startups: How often was the UPS started?
- Total operation time: How long altogether did the UPS run?

Statistic (device defined)

The "Statistic (system defined)" navigation item shows counter values which always start from the value "0" with the initial device installation. Beneath the same values as shown in the "Statistic (user defined)" navigation item, additional values are displayed:

- Runtime of the current battery operation: How long does the current battery operation (if relevant) already last?
- Number of battery low cutoffs: How often was the battery completely discharged?
- Number of all messages: How many warnings and alarms were signaled altogether?
- Number of remaining lifetime messages: How often was a remaining lifetime signaled?
- Number of quality criteria messages: How often was signaled, that the quality criteria is no more met?
- Number of battery presence messages: How often was a battery unit not detected, e.g. no fuse plugged or circuit broken?

Logging

The logging is done by the software itself.

The "Logging" navigation item lists events like "Offline", "Online" or "UPS in battery mode" with date and time stamp. The event colors differ between green and red depending on the type of event. They are chronologically sorted, the latest uppermost.



You can delete the list by clicking the button "Delete history".
You can export the list in a .csv file by clicking the button "Export".

9 Stick usage

At the Data port of the UPS device, a memory stick can be connected (see image below). After plugging in, the UPS either acts as configuration stick or as service stick, depending on how the respective stick has been declared before in the "Service" screen of the UPS-CONF software.



A configuration stick is used to copy parameterization data from/to the UPS device, as described in the topic Configuration stick usage (see page 46).

A service stick can be used to switch the device to service mode (see page 47) in order to perform maintenance tasks.

To declare a memory stick proceed as follows:

**NOTE**

When declaring a stick, its current content is deleted, i.e. already stored configuration data are lost.

1. Open the software menu "Settings".
2. Click the "Service" navigation item.
3. In the "Stick declaration" area of the action area, click the appropriate "Start declaration" button.

After this declaration, the UPS device automatically formats the stick after plugging it into the Data port the next time and then acts accordingly.

9.1 Configuration stick usage

A configuration stick stores UPS configurations, i.e. complete parameter sets. Configurations can be copied from the UPS to the stick and vice versa. This way, the stick can be used to transfer configurations from one UPS to another.

**NOTE**

The configuration stick cannot be used, while the UPS runs in battery mode. The power supply must be available.

The usage of configuration sticks is explained by the following steps:

1. Make sure that the used memory stick is already declared as configuration stick as described in the topic Stick usage (see page 45).
2. To transfer parameters between the stick and the UPS, execute one of the following steps:
 - To copy parameters from the stick to the QUINT-UPS push the "Stick -> UPS" button for more than 2 seconds.
 - To copy parameters from the QUINT-UPS to the stick push the "UPS -> Stick" button for more than 2 seconds.
3. Connect the configuration stick to the Data port of the UPS under consideration of the plug direction.
The parameter transfer is started automatically and the progress is signalled by the LEDs:
 - While data is transferred they flash red - yellow - green.
 - A successful transfer completion is signalled by a permanent green LED.
 - A faulty transfer completion is signalled by a permanent red LED.
4. Remove the stick from the Data port.
5. After copying a parameter set from an UPS to the stick you can "clone" this configuration by plugging this stick into another UPS and copying the stored data from the stick into this UPS.

9.2 Service stick usage - service mode

The service mode is used, when installation and maintenance work has to be achieved, such as a battery has to be replaced.

There are several possibilities to switch the UPS to service mode.



The corresponding activation rights have to be granted for service mode activation and deactivation, as described in the topic Rights for service mode activation (see page 39).

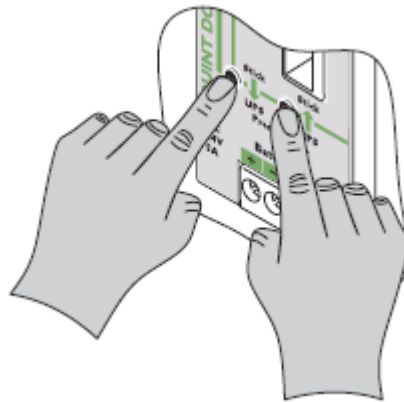
Service mode activation



The service mode cannot be activated, while the QUINT-UPS runs in battery mode. The power supply must be available.

Depending on the granted activation rights, the service mode can be activated in three different ways:

- By holding down both push buttons on the QUINT-UPS named "Stick -> UPS" and "UPS -> Stick" for at least 6 seconds.

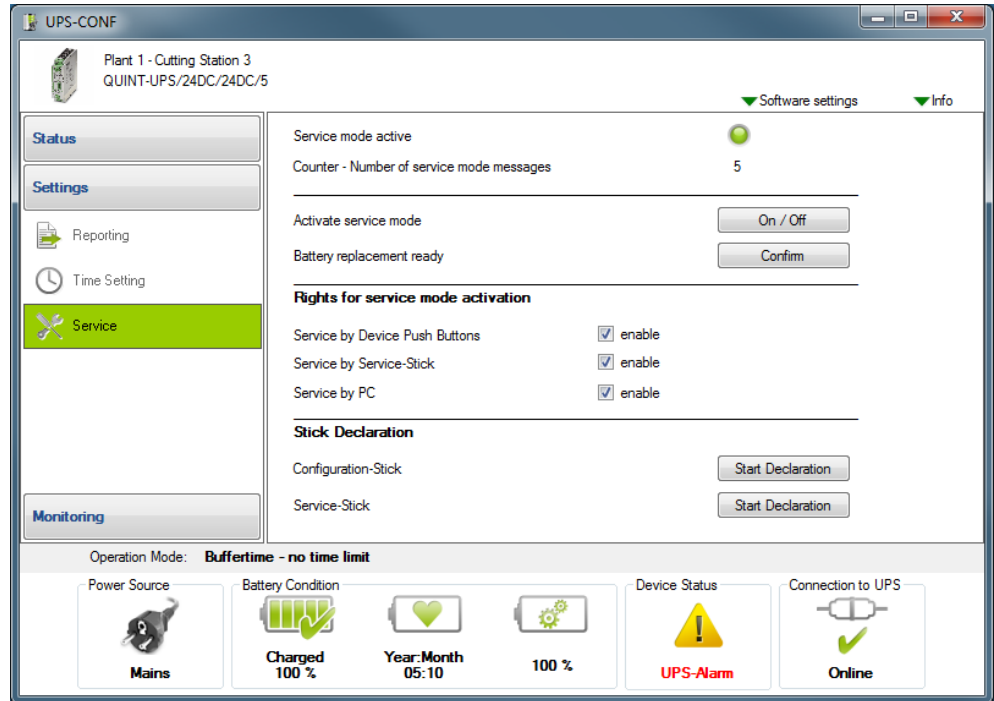


- By connecting a service stick (see page 45) to the Data port (see page 13) of the UPS.
- By using the UPS-CONF software as follows:
In the "Settings" group, select the "Service" item, and click the "On / Off" button near the "Activate service mode" text.

While the service mode is active

- the alarm status is activated,

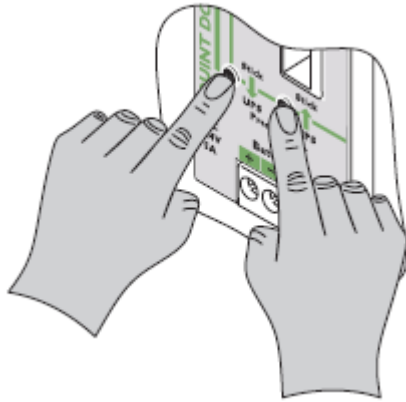
- the charging current is interrupted,
- the status LED "Service mode active" in the UPS-CONF software ("Settings" group / "Service" item) is green.



Service mode deactivation

The service mode can be deactivated in different ways:

- By holding down both push buttons on the QUINT-UPS named "Stick -> UPS" and "UPS -> Stick" for at least 6 seconds.



- By removing the service stick from the Data port of the UPS.
- By using the UPS-CONF software as follows:
In the "Settings" group, select the "Service" item, and click the "On / Off" button near the "Activate service mode" text.

After the service mode is deactivated, the status LED "Service mode active" in the UPS-CONF software ("Settings" / "Status") switches back from green to gray.

Service mode operation

To operate the QUINT-UPS in the service mode in order to replace a battery for example, execute the steps described below.



DANGER

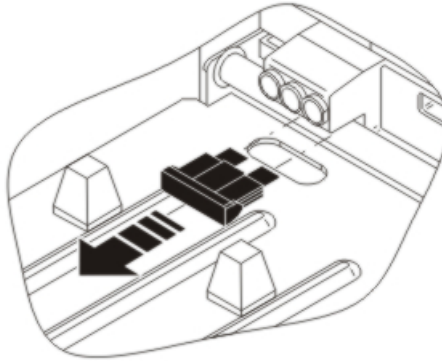
Before activating the service mode read and obey carefully the safety instructions in the topic Important safety notes (see page 10).



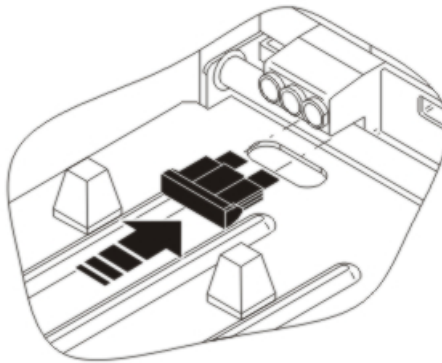
DANGER

Watch polarity when connecting cables!

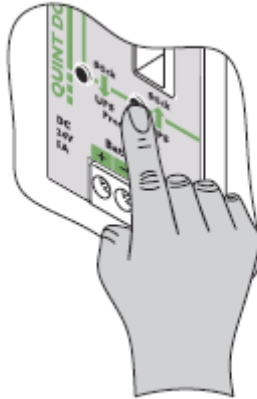
1. Activate the service mode by one of the ways described above.
2. Replace the battery as follows:
 - i. Open battery housing.
 - ii. Remove fuses.



- iii. Remove cabling.
- iv. Change battery.
- v. Connect cabling.
- vi. Insert fuses.



- vii. Close battery housing.
3. As soon as the work is finished, the parameters of the new battery have to be read into the UPS, so it's status information is available. To introduce this battery registration, do one of the following actions:
- Push one of the push buttons on the QUINT-UPS named "Stick -> UPS" or "UPS -> Stick" and hold it down for more than 6 seconds.



or

- In the "Settings" group of the UPS-CONF software select the "Service" item, locate the text "Battery replacement ready" and click the "Confirm" button near the text.



The bar graph at the QUINT-UPS flashes, the alarm status is still active.



NOTE

If the service mode has been deactivated by removing the service stick from the Data port before the battery replacement has been confirmed, it can be confirmed by the UPS-CONF software. A popup window will remind the user to confirm the battery replacement.

4. Deactivate the service mode as described above.

10 Application samples



For further information, please take a look at the Software Tutorials or the Quick Start Poster on www.phoenixcontact.net/catalog. You will find the data if you link to UPS-CONF or QUINT-UPS.

10.1 Functional test

One of the main functions of the QUINT-UPS is to supply the load, when the mains fails. To test, if the UPS buffers the load, follow these steps:

1. Switch off the power supply of the QUINT-UPS.
2. Check if the QUINT-UPS buffers the load as long as set with the buffer time potentiometer, refer to Buffer time selection (see page 12).

10.2 PC-Mode: PC shutdown and restart

The IQ technology of the QUINT-UPS is able to control the power supply for a PC. For that purpose the PC with the UPS-CONF software installed has to be connected to the UPS and the PC-Mode activated. The PC-Mode enables the automatic PC shutdown and restart functionality.

To test the PC shutdown and restart functionality in the PC-Mode, proceed as follows:

1. Switch the buffer time potentiometer to "PC-Mode", as described in the topic Buffer time selection (see page 12).
2. Connect the UPS device to a USB port of the PC where UPS-CONF is installed (refer to topic Hardware setup (see page 11)).
3. Open the software menu "Settings" and click "Time Settings".
4. Set the parameters for the four different parameter categories, as described in the topic PC-Mode (see page 38).
5. Check if the PC shuts down and restarts corresponding to the set parameters. If a program execution has been set, verify that it is executed.

11 Troubleshooting

If your system does not work properly for any reason, approach the problem in the following manner:

1. Check the system status:
 - If the UPS-CONF software is installed, check the status bar (see page 17) and take a look at the system status.
 - If the UPS-CONF software is not installed, take a look at the front side of the UPS and check the LEDs (see page 20).
2. Proceed with the section Unexpected status symbols (see page 54) to find out, what is wrong.














The section Unexpected status symbols (see page 54) will lead you closer to the solution of the problem. If there are specific solutions for a single problem, you will be lead to the section, that describes the problem solving.

11.1 Unexpected status symbols

The meaning of status symbols showing an unexpected status is explained in the following topic.

The first table lists the symbols for the system status, that you can find in the action area and the second table lists the symbols from the status bar.

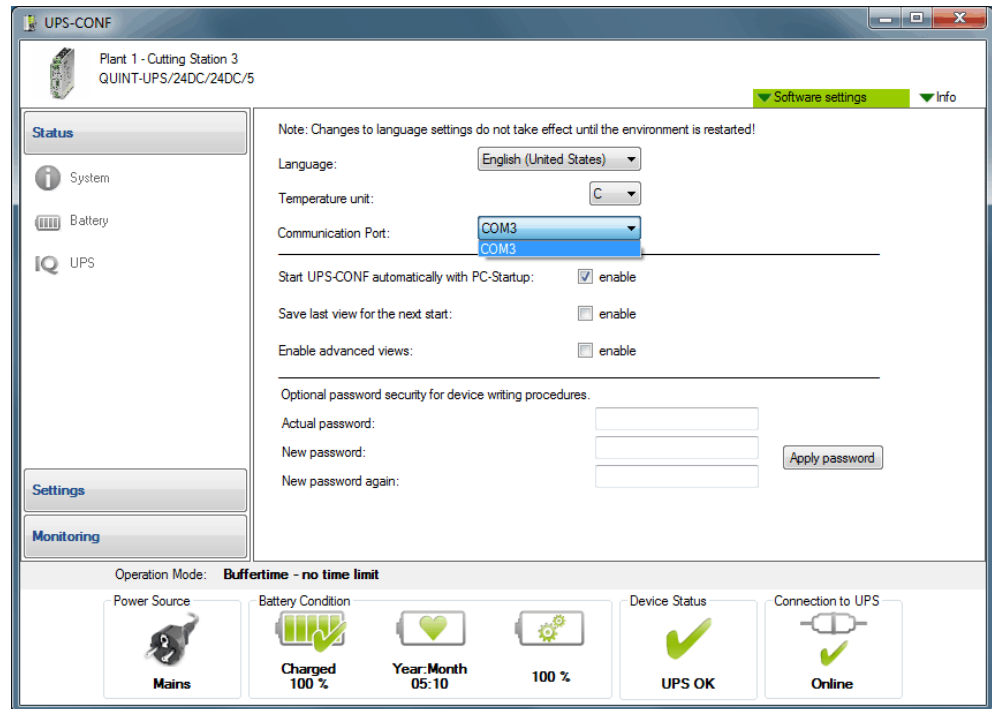
System status Symbol	Current situation and possible reason	Possible correction
 Gray: Mains OFF	There is no current available. Probably the Mains is switched OFF.	<ul style="list-style-type: none"> • Switch the Mains ON. • Take care that the power supply is available again.
 Gray: DC output not available	The power supply unit cannot deliver DC. Either the power supply is not available or the Mains switch is set to OFF.	<ul style="list-style-type: none"> • Switch the Mains ON. • Take care that the power supply is available again.
 Yellow: Battery mode	No current is available, thus the load gets it's power supply from the battery.	<ul style="list-style-type: none"> • Switch the Mains ON. • Take care that the power supply is available again.
 Red: UPS alarm	There may be different reasons: <ul style="list-style-type: none"> • No power supply is available. • The battery is soon empty. • The battery has to be replaced. • The battery cannot be detected. • There is another battery problem. • A set threshold has been reached. 	<ul style="list-style-type: none"> • Switch the Mains ON. • Take care that the power supply is available again. • Check the set thresholds and compare with the current status. • Solve the battery problem. • Replace the battery. • Check the cables between UPS and battery. • Verify that the fuse is installed in the battery.

Status bar Symbol	Current situation and possible reason	Possible correction
	The UPS is in battery mode, because no power supply is available.	<ul style="list-style-type: none"> Switch the Mains ON. Take care that the power supply is available again.
	The bridge between the UPS terminals R1 and R2 is removed. Battery is deactivated therefore. Refer to the parameter "Remote Status" in the topic UPS (see page 27).	If you want the battery to be activated and the battery mode to be introduced, when the mains fail, bridge the terminals R1 and R2. Refer to the hardware overview (see page 7).
	<p>There is no power supply available. One of these states is ongoing:</p> <ul style="list-style-type: none"> The UPS is off, because battery mode is finished. The set buffer time has elapsed. The power source is not ok, because input voltage is in an invalid range. 	<p>If the UPS is off, because battery mode is finished, but the battery is functional:</p> <ul style="list-style-type: none"> Switch the Mains ON. Take care that the power supply is available again. <p>If the UPS is off, because battery mode is finished, and the battery is no more functional or at it's end of lifetime:</p> <ul style="list-style-type: none"> Change the battery. <p>If the power source is not ok, because input voltage is in an invalid range:</p> <ul style="list-style-type: none"> Check the power supply.
	The battery is discharging, because no power supply is available.	<ul style="list-style-type: none"> Switch the Mains ON. Take care that the power supply is available again.
	The battery mode is finished, because the battery is empty.	<ul style="list-style-type: none"> Take care that the power supply is available again to reload the battery. Change the battery, if battery lifetime is exhausted.
	(see UPS alarm in the table above)	(see UPS alarm in the table above)
	<ul style="list-style-type: none"> The connection between PC and UPS via the IFS-USB-DATACABLE is interrupted. The communication port is not set. 	<ul style="list-style-type: none"> Connect the UPS and PC via the IFS-USB-DATACABLE. Check if the communication port is set, as described in the topic Communication port (see page 56).

11.2 Communication port

The PC USB communication port for the communication between the UPS and the PC is automatically set during software installation. In case the communication port has not been set, the status bar shows the "Connection to UPS: Offline" status.

Although the communication port has not been set, it is detected automatically. Thus you can set it manually. You just have to select it in the software settings of the system menu.




If you click the combo box near the text "Communication port" the correct port is shown and you can select it.

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Location:  US

English

Login | Register | Help



Part Number/Keywords



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Phoenix Contact 2320500

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IFS to USB Data Cable for QUINT UPS or TRIO UPS

Mfr. Part#: 2320500

Allied Stock#: 70235758

 RoHS Compliant Part

Quantity

[Add to Cart](#)[View larger image](#)

*Image may be a representation.
See specs for product details.*

Resources

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Specifications

Cable end 1, Connector Angle	:	Right-Angle
Cable end 1, Connector Type	:	IFS Data Port
Cable end 2, Connector Angle	:	Straight
Cable end 2, Connector Type	:	USB Type-A

Pricing (USD) & Availability

Standard Pricing

\$67.32 (Each)

1 \$67.320

Availability

36 can ship immediately.

[Request Lead Time](#)

Minimum Quantity: 1 | Multiples Of: 1

Cable, Length	: 9.8' (3m)
Color, Jacket	: Black
Type	: USB

Overview

Data cable for communication between the UPS CONF configuration software and the QUINT UPS-IQ and TRIO UPS uninterruptible power supply units.

People Also Bought



Phoenix Contact
Battery; Rechargeable; UPS; VRLA; 24VDC; 60Ah; IP20

\$735.32 each

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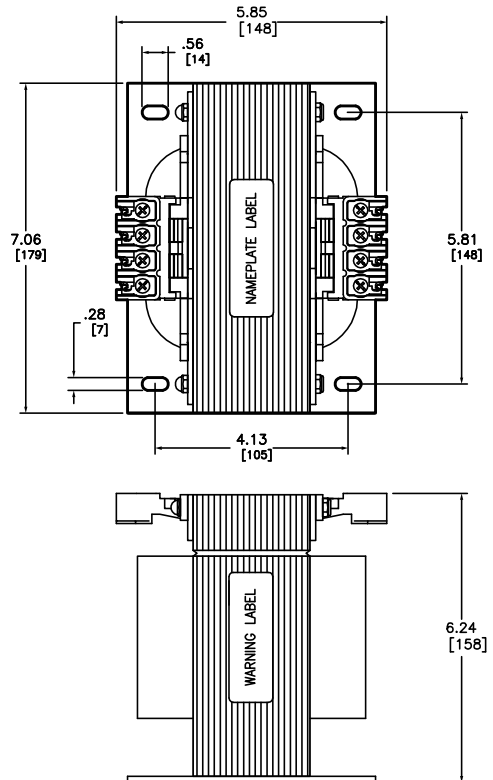
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J:\wip\209\control online\5873.DWG 07/22/2008 12:15:44 PM

CATALOG NUMBER	PRIMARY VOLTAGE	SECONDARY VOLTAGE	50/60 Hz 1 PHASE		APPROXIMATE WEIGHT (Lbs/Kg)
			UL/cUL/CSA/NOM RATINGS (VA)	CE RATINGS (VA)	
9070T1500D1	220/440 230/480 240/480	110 115 120	1500	1000	34.6 / 15.7
9070T1500D3	208	120	1500	1000	34.7 / 15.7
9070T1500D4	277	120	1500	1000	34.1 / 15.4
9070T1500D5	550 575 600	110 115 120	1500	1000	33.9 / 15.3
9070T1500D12	440 480 480	220 230 240	1500	1000	33.4 / 15.1
9070T1500D15	240/480	24/120	1500	N/A	34.5 / 15.6
9070T1500D22	480	277	1500	1000	33.6 / 15.2
9070T1500D24	110 115 120	110 115 120	1500	1000	34.1 / 15.4
9070T1500D31	220/440 230/480 240/480	110/220 115/230 120/240	1500	1000	33.4 / 15.1
9070T1500D37	550 575 600	110/220 115/230 120/240	1500	1000	34.6 / 15.7
9070T1500D51	208/277	120	1500	1000	34.7 / 15.7
9070T1500D55	110/220 115/230 120/240	110/220 115/230 120/240	1500	1000	33.7 / 15.7
9070T1500D60	277	120/240	1500	1000	34.8 / 15.7
9070T1500D62	600	240	1500	1000	33.6 / 15.2



FILES/STANDARDS:
 UL/cUL FILE: E61239
 CSA FILE: LR37055
 CE: TUV CERTIFIED TO 61558
 NOM 117

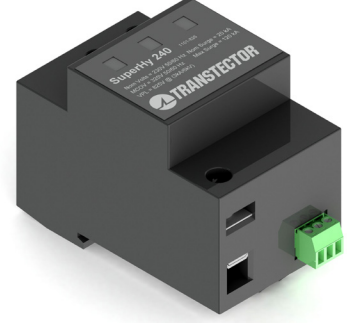
1500VA--CONTROL POWER TRANSFORMER
 9070 TYPE T
 CATALOG NUMBERS: FROM CHART



DWG# 5873
 NO.

Installation Instructions

SuperHy 240



an INFINIT[®] company

800.882.9110 | 208.772.8515 | www.transtector.com

Warning

1. Risk of electrical shock.
2. Ensure power is disconnected prior to installation.

Thank you for your recent purchase of our surge protection solution. Your satisfaction with our product and service is important to us. If you have any questions, comments or concerns, please contact us at 800.882.9110 or visit our website at www.transtector.com. We look forward to continuing to serve your protection needs.

Installation Instructions

SuperHy 240

SPD offers hybrid bidirectional silicon avalanche diode and MOV suppression technology and is typically installed to protect 240 Vac power supplies from over-voltage caused by or switching transients. The SPD features visual status indication; the normally black indicator turns red if module needs replacement. Electrically isolated Form C dry contacts provide remote monitoring capability. If the lightning protection zone concept is used, this SPD installs at the boundary of LPZ1 and LPZ2.

Protection mode: L-N

INSTALLATION AND WIRING

1. Install only in a restricted access power distribution cabinet that requires a key or tool to open.
2. The SPD should only be installed by a licensed electrician.
3. All local and national electric codes must be observed.
4. Kelvin or 'V' connections are recommended.
5. Keep wires as short as possible (maximum length ≤ 0.5 m) and free of sharp bends.
6. Before installation, shut off power to prevent accidental electrical shock or injury.
7. The ground conductor should be insulated stranded copper greater than 10 mm^2 (#6 AWG) diameter. The power conductors should be insulated stranded copper greater than 6 mm^2 (#10 AWG) diameter. The load capacity of the conductor must be sized according to the load. Reference IEC 60364-5-532.

USAGE AND MAINTENANCE

The SPD should be scheduled for periodic inspection to ensure the SPD is operational, the module is secure in the base and all wire connections are tight.

If SPD is damaged, contact Transtector for replacement at +1.208.772.8515 or 1.800.882.9110, or online at www.transtector.com.

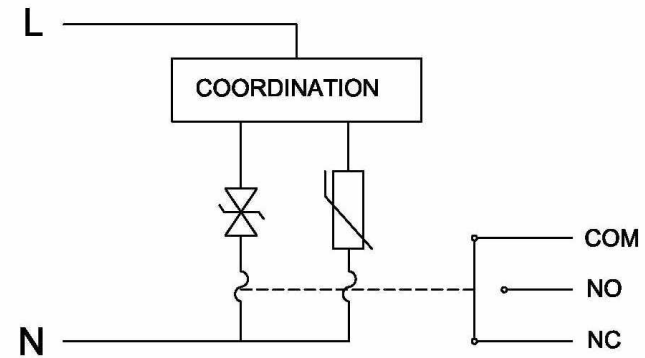


Figure 1 - Schematic

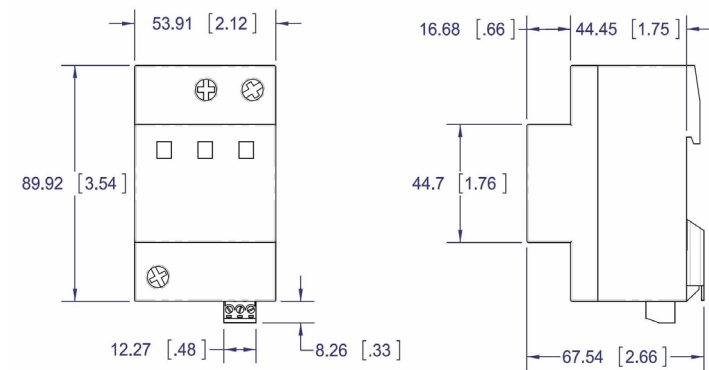


Figure 2 - Structure

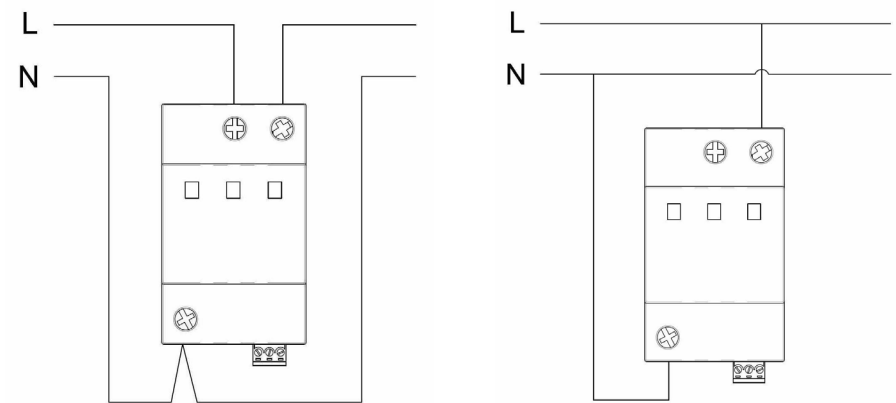


Figure 3 - Wiring Diagrams

I²R Storm 120 -10

Part# 1104-15-001



The I²R Storm 120 -10 is a Type 2 SPD used to protect 120 Vac power supplies from over-voltage caused by transients. This SPD offers bidirectional silicon avalanche diode suppression technology and is intended for installation on the load side of the service equipment over current device. The SPD is installed in parallel with the load. The SPD features visual status indication. The normally black indicator turns red if module needs replacement. Electrically isolated Form C dry contacts provide remote monitoring capability.

Main Technical Data

Electrical Performance	
Tested To	UL 1449 3 rd Edition
UL File	E321582
SPD Type	Type 2 Component Assembly VZCA2, VZCA8
Number Of Ports	Single port device
Technology	Silicon Avalanche Suppression Diode
Nominal Operating Voltage U _n	120 Vac
Maximum Continuous Operating Voltage U _c	150 Vac
Nominal Discharge Surge Current I _n (8x20μs)	5 kA
Maximum Discharge Surge Current I _{max} (8x20μs)	10 kA
Voltage Protection Level U _p (6 kV / 3 kA / 8x20μs Combination Wave)	≤ 600 V
Short Circuit Current Rating	22 kA
Leakage Current	< 10 μA
Response Time	< 5 ns
Status Monitoring	Visual indication ; Black = Normal, Red = Replace Contact switch: Closed = Normal, Open = Replace
Maximum Contact Switch Rating	125 Vac / 1 A
Mechanical	
Location Category	Indoor only
Method Of Mounting	Fixed 35mm DIN rail
Dimension (H x W x D)	90 mm x 18 mm x 66.5 mm (3.6" x 0.7" x 2.66")
Weight (Max)	0.33 kg (0.74 lb)
Maximum Wire Size	Stranded: 16 mm ² (#6 AWG); Solid: 25 mm ² (#4 AWG)
Stripping Length Terminals	10 mm (0.375")
Torque Terminals	4.5 N*m (3.3 ft-lb)
Maximum Wire Size Contacts	1.5 mm ² (#16 AWG)
Stripping Length Contacts	7 mm (0.25")
Torque Contacts	1 N*m (0.75 ft-lb)
Environmental	
Operating Temperature	-40°C to +70°C
Relative Humidity	≤ 95% non condensing
Enclosure Protection Level	IP20
Housing Inflammability Rating	PA66; UL94 V-0
Certifications	RoHS compliant

Installation Guide

DANGER

Electric Shock or Burn

- Install only in a restricted access enclosure or control cabinet that requires a key or tool to open.
- This SPD should only be installed and serviced by qualified electrical personnel.
- All National and Local Electric Codes must be observed.
- Confirm that the SPD is rated for the voltage of the application.
- Before installation, turn off all power to equipment to prevent accidental electrical shock or injury.
- Replace all covers and doors before restoring power to this equipment.

Structure and Dimensions

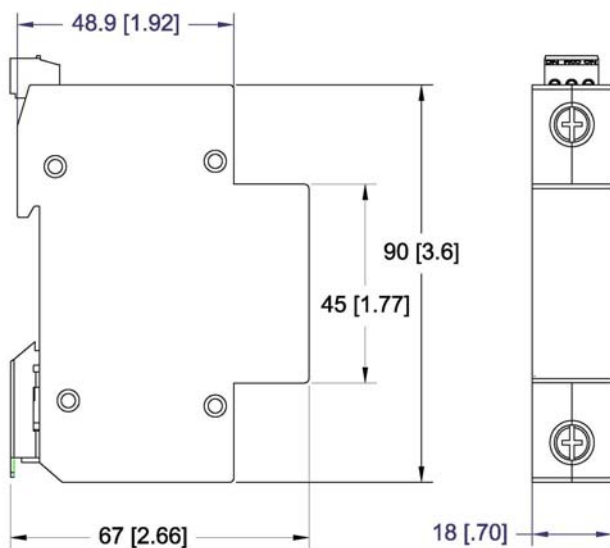


Figure 1. I²R Storm 120 -10

Attaching the SPD to the DIN Rail

Position the SPD on the top edge of the 35mm DIN rail, then press down until a 'click' is heard.

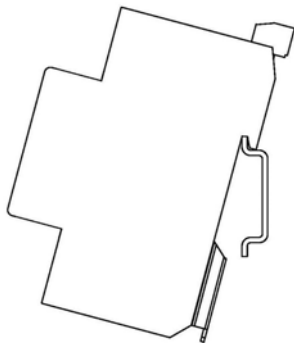


Figure 2. Locating on DIN Rail

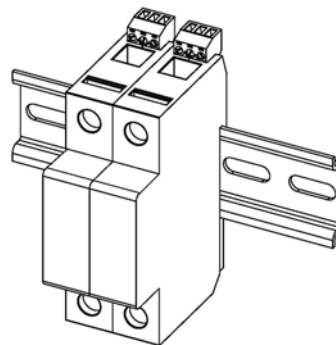


Figure 3. Ready for Wiring

Installation Guide

General Wiring Instructions

- The SPD is installed in parallel with the load.
- Kelvin or 'V' connections are recommended.
- Keep wires as short as possible (maximum length ≤ 0.5 m) and free of any sharp bends or loops.
- All conductors should be insulated stranded copper. The ground conductor should be greater than 16 mm^2 (#6 AWG) diameter. The power conductors should be greater than 6 mm^2 (#10 AWG) diameter. The load capacity of the conductor must be sized according to the load.

System Configurations

Determine the electrical voltage configuration and then install per the appropriate wiring illustrations

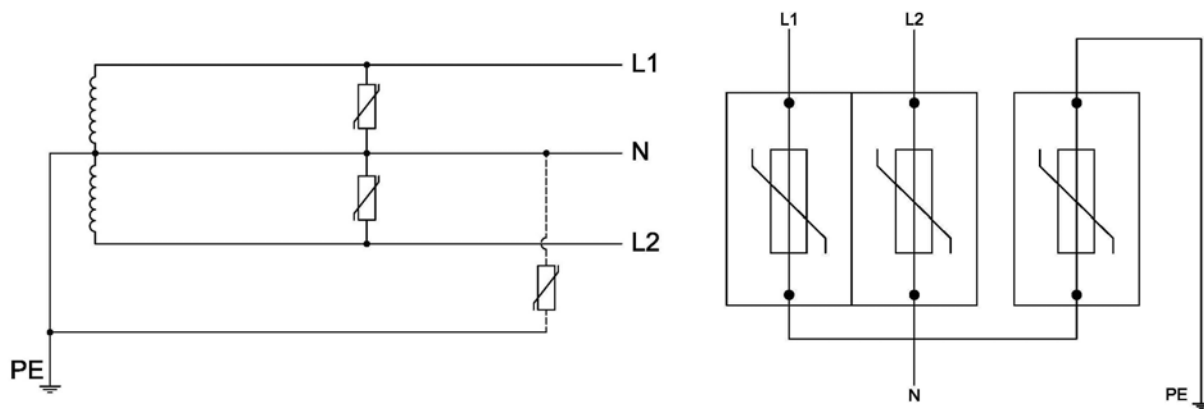


Figure 4. 120/240 Two Phase

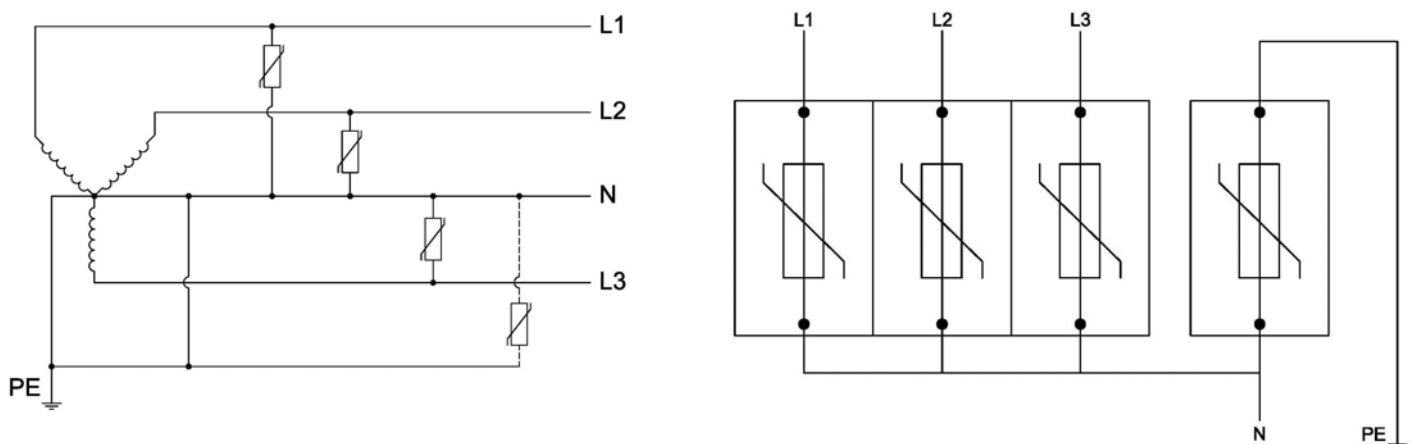


Figure 5. 120/208 Three Phase WYE

Installation Guide

Remote Annunciation

Electrically isolated Form C dry contacts provide remote monitoring capability. The removable plug accepts #16 - #30 AWG wire. The maximum continuous current rating for the remote indicator is 3A. Strip the wire 0.25", and torque the terminal screw 0.75 ft-lb.

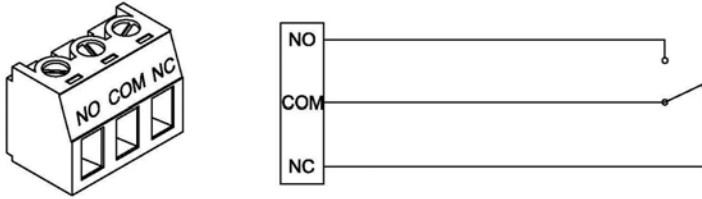


Figure 6. Remote Contact Connections

Usage and Maintenance

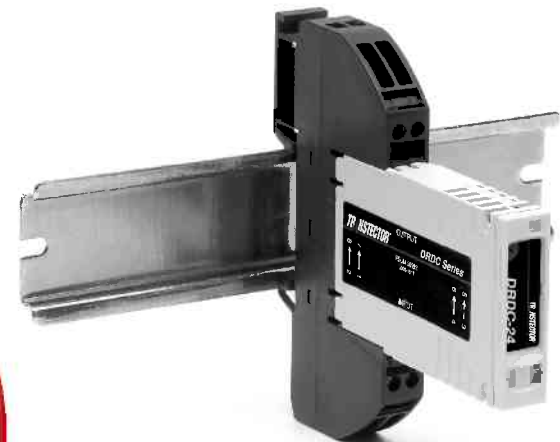
The SPD should be scheduled for periodic inspection to ensure the SPD is operational and all wire connections are tight.

If SPD is damaged, contact Transtector for replacement at +1.208.772.8515 or 1.800.882.9110, or online at www.protectiongroup.com.

Advancing the Science of Surge Suppression

DRDC Series

Model	MCOV
DRDC-7	13VDC
DRDC-12	16VDC
DRDC-24	32VDC
DRDC-48	64VDC
DRDC-70	118VDC



10701 Airport Drive, Hayden ID 83835
208.772.8515 800.882.9110

1200-144 REV C

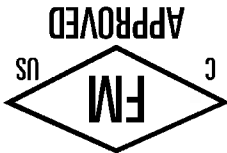
(DRDC 7V, 12V, 24V & 48V MODELS)



II 3 G Ex nA IIC
T4 Tamb = -40°C to +65°C
FM10ATEX0002X



AEX/Ex nA IIC T4 Tamb = -40°C to +65°C
Class I, Division 2, Groups A, B, C, D;
T4A Tamb = -40°C to +65°C



For questions or comments, please contact us at 800.882.9110 or visit our website at www.transector.com.

Thank you for purchasing a surge suppression product from Transector, the industry leader.

WARNING

1. Use each model on specified data application only!
2. The suppressor will interrupt communications in the event of self sacrifice.
3. For Class I Div2 Hazardous Locations: The DRDC shall be installed in an enclosure which provides an ingress protection rating of at least IP54.

Installation Instructions

DRDC Series

1. These products are intended for use only on data & power circuits with operating voltage not to exceed the product rating (see chart on reverse), and operating currents not to exceed 10A.

2. Installing the DRDC Series

2.1 For Class I Div 2 Hazardous Locations: The DRDC shall be installed in an enclosure which provides an ingress protection rating of at least IP54.

2.2 Mount the device as close as possible to the equipment to be protected.

2.3 Mounting, Mechanical: Install the product onto standard 35mm DIN-Rail using the Self Grounding foot. Engage the metal grounding clip onto the rail first, then snap into place. To remove the device, apply force on the lever provided on the foot using a flathead screw driver.

Note: Din-Rail must be connected to a solid Earth ground for proper suppressor operation.

2.4 Wiring: Connect each DC power or signal pair to the numbered 24-12AWG screw terminals according to the following legend (Input->Output):

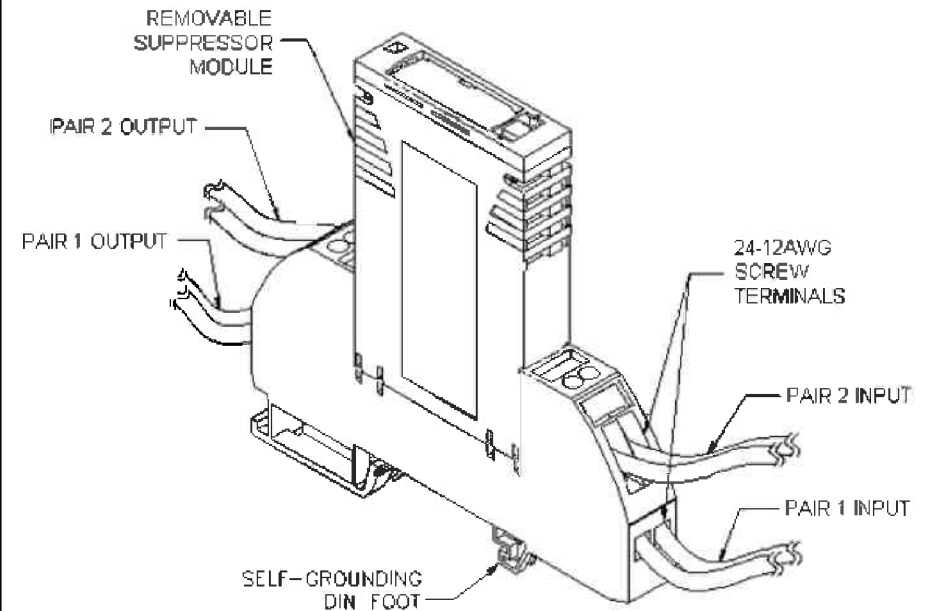
<u>Pair 1</u>	<u>Pair 2</u>
1->7	3->5
2->8	4->6

2.5 Wiring the Shield: If a shielded cable is utilized, use the pass-thru terminal blocks contained in the packaging supplies to secure the shield for each pair.

3. Replacing DRDC Series Suppressor Modules

3.1 Annunciation: In the case of failure, the suppressor module will interrupt the DC power or signal path.

3.2 Replacing the module: To replace the suppressor module, simply pull the failed module out of the base and reinstall a new one assuring that the module is correctly oriented with the slot in the base.



GE Fanuc Intelligent Platforms
Programmable Control Products

TCP/IP Ethernet Communications

for PACSystems™

User's Manual , GFK-2224F

November 2007



Warnings, Cautions, and Notes as Used in this Publication

Warning

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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Field Control	Motion Mate	Series 90	VersaPro
GEnet	PACSystems	Series Five	VuMaster
	Proficy	Series One	Workmaster

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Chapter *Introduction*

1

This chapter includes basic information about Ethernet Interfaces for the PACSystems™ family of controllers. It describes features of the Ethernet Interfaces in both conventional and redundancy systems.

The rest of this manual provides instructions for installing and applying the PACSystems Ethernet Interfaces:

Chapter 2, *Installation* describes user features and basic installation procedures for a PACSystems Ethernet Interface.

Chapter 3, *Configuration* describes assigning a temporary IP address, configuring the Ethernet interface, configuring Ethernet Global Data, and setting up the RS-232 port for Local Station Manager operation.

Chapter 4, *Ethernet Global Data* describes basic Ethernet Global Data operation for a PACSystems Ethernet Interface.

Chapter 5, *EGD Commands* describes a set of commands that can be used in the application program to read and write PLC data or Ethernet Global Data exchange data over the network.

Chapter 6, *Programming SRTP Channel Commands* explains how to implement PLC to PLC communications over the Ethernet network using SRTP Channel commands.

Chapter 7, *Modbus/TCP Server* describes the implementation of the Modbus/TCP Server feature for the PACSystems family of products.

Chapter 8, *Modbus/TCP Client* explains how to program communications over the Ethernet network using Modbus/TCP Channel commands.

Chapter 9, *RX7i PLC Monitoring Via the Web* describes the Web browser feature provided by a PACSystems RX7i CPU with Embedded Ethernet.

Chapter 10, *Diagnostics* describes diagnostic techniques for a PACSystems Ethernet Interface. This chapter also lists COMMREQ Status codes.

Chapter 11, *Network Administration* discusses how devices are identified on the network and how data is routed among devices.

Appendix A, *Configuring Advanced User Parameters* describes optional configuration of internal operating parameters used by the Ethernet interface. For most applications, the default Advanced User Parameters should not be changed.

Other PACSystems Manuals

The manuals listed below provide more information about the PACSystems family of products.

- *PACSystems CPU Reference Manual, GFK-2222*
- *PACSystems RX7i Installation Manual, GFK-2223*
- *PACSystems RX3i System Manual, GFK-2314*
- *PACSystems Hot Standby CPU Redundancy User's Guide, GFK-2308*
- *TCP/IP Ethernet Communications for PACSystems™ Station Manager Manual, GFK-2225*
- *PACSystems RX7i User's Guide to Integration of VME Modules, GFK-2235*
- *C Programmer's Toolkit for PACSystems™ User's Manual, GFK-2259*
- *Proficy™ Logic Developer-PLC Getting Started, GFK-1918*
- *Installation Requirements for Conformance to Standards, GFK-1179*
- *PACSystems RX3i Ethernet NIU User Manual), GFK-2434.*

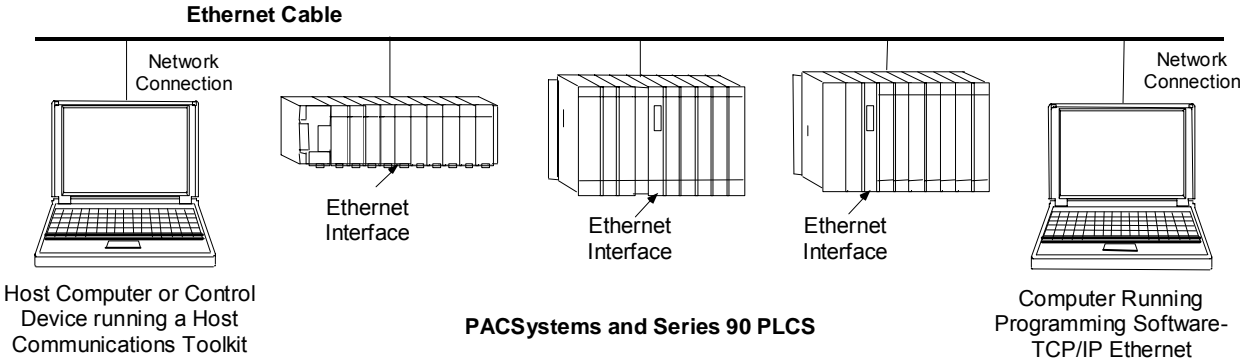
In addition to these manuals, datasheets and update documents describe individual modules and product revisions. The most recent PACSystems documentation is available online at www.gefanuc.com.

The *Infolink for PLC* CD set of documentation for GE Fanuc PLC products is updated periodically. It can be ordered as part number IC690CDR002.

Ethernet Interfaces for PACSystems Controllers

A PACSystems Ethernet Interface enables a PACSystems controller to communicate with other PACSystems equipment and with Series 90 and VersaMax controllers. The Ethernet Interface provides TCP/IP communications with other PLCs, host computers running the Host Communications Toolkit or CIMPLICITY software, and computers running the TCP/IP version of the programming software. These communications use the GE Fanuc SRTP and Ethernet Global Data (EGD) protocols over a four-layer TCP/IP (Internet) stack.

The Ethernet Interface has SRTP server capability. As a *server*, the Ethernet Interface responds to requests from devices such as PLC programming software, a Host computer running an SRTP application, or another PLC acting as a client.



The PACSystems RX7i product family includes two types of Ethernet Interfaces: embedded and rack-based. The embedded Ethernet Interface is an integral part of RX7i CPU models IC698CPE010, IC698CPE020, and IC698CRE020. The rack-based Ethernet Module plugs into a single-width slot in an RX7i PLC rack. Both types of Interfaces are configured using the Machine Edition PLC programming software.

In addition to the Ethernet interface within an RX7i CPU module, up to three additional Ethernet Modules (for a total of four Ethernet interfaces) can be installed in an RX7i PLC CPU rack.

PACSystems Ethernet Interface Communications Features

- Full PLC programming and configuration services
- Periodic data exchange using Ethernet Global Data (EGD)
- EGD Commands to read and write PLC and EGD exchange memory over the network.
- TCP/IP communication services using SRTP
- SRTP Client (Channels)
- Modbus/TCP Server, supporting Modbus Conformance classes 0, 1, and 2.
- Modbus/TCP Client, supporting Modbus Conformance classes 0, 1, and Function Codes 15, 22, 23, and 24 for Conformance class 2.
- Redundant IP Addressing capability.
- Basic remote PLC monitoring from a web browser (RX7i CPU Ethernet interface only)
- Comprehensive station management and diagnostic tools
- Extended PLC connectivity via IEEE 802.3 CSMA/CD 10Mbps and 100Mbps Ethernet LAN port connectors.
- Network switch that has Auto negotiate, Sense, Speed, and crossover detection.
- Direct connection to BaseT (twisted pair) network switch, hub, or repeater without an external transceiver.
- Protocol is stored in flash memory in the Ethernet interface and is easily upgraded through the CPU serial port.
- Communications with remote PLCs and other nodes reachable through routers. The gateway IP address must be configured.
- Internet access via web pages served up to standard web browsers, for the Ethernet interface embedded in the PACSystems CPU.

Ethernet Interface Specifications

Ethernet processor speed	200 MHz
Connectors	- Station Manager (RS-232) Port: 9-pin female D-connector - Two 10BaseT / 100BaseTX Ports: 8-pin female shielded RJ-45
LAN	IEEE 802.2 Logical Link Control Class I IEEE 802.3 CSMA/CD Medium Access Control 10/100 Mbps
Number of IP addresses	One
Number of Ethernet Port Connectors	Two, both are 10BaseT / 100BaseTX with auto-sensing RJ-45 connection.
Embedded Ethernet Switch	Yes – Allows daisy chaining of Ethernet nodes.
Serial Port	Station Mgr Port: RS-232 DCE, 1200 - 115200 bps.

Ethernet Interface Ports

Each PACSystems Ethernet interface provides two auto-sensing 10Base T / 100Base TX RJ-45 shielded twisted pair Ethernet ports for connection to either a 10BaseT or 100BaseTX IEEE 802.3 network.

The port automatically senses the speed (10Mbps or 100Mbps), duplex mode (half duplex or full duplex) and cable (straight-through or crossover) attached to it with no intervention required.

Ethernet Media

The Ethernet Interface can operate directly on 10BaseT/100BaseTX media via its network ports.

10BaseT: 10BaseT uses a twisted pair cable of up to 100 meters in length between each node and a switch, hub, or repeater. Typical switches, hubs, or repeaters support 6 to 12 nodes connected in a star wiring topology.

100BaseTX: 100BaseTX uses a cable of up to 100 meters in length between each node and a switch, hub, or repeater. The cable should be data grade Category 5 unshielded twisted pair (UTP) or shielded twisted pair (STP) cable. Two pairs of wire are used, one for transmission, and the other for collision detection and receive. Typical switches, hubs, or repeaters support 6 to 12 nodes connected in a star wiring topology.

Station Manager

The built-in Station Manager function of the Ethernet Interface provides on-line supervisory access to the Ethernet Interface, through the Station Manager port or over the Ethernet cable. Station Manager services include:

- An interactive set of commands for interrogating and controlling the station.
- Unrestricted access to observe internal statistics, an exception log, and configuration parameters.
- Password security for commands that change station parameters or operation.

For remote Station Manager operation over the Ethernet network, the Ethernet Interface uses IP addressing. A PACSystems Ethernet Interface cannot send or receive remote Station Manager messages sent to a MAC address.

Refer to the *PACSystems TCP/IP Ethernet Communications Station Manager Manual*, GFK-2225 for complete information on the Station Manager.

Firmware Upgrades

PACSystems Ethernet interfaces receive their firmware upgrades indirectly from the PLC CPU using the WinLoader software utility. WinLoader is supplied with any updates to the Ethernet Interface software. The user connects WinLoader to the PLC CPU serial port and specifies the target module by its Rack/Slot location in the PLC.

For the CPU module, the embedded Ethernet interface firmware is upgraded along with the rest of the CPU firmware. WinLoader seamlessly upgrades first the CPU firmware and then the embedded Ethernet firmware without user intervention. Each Ethernet Interface module's firmware must be explicitly upgraded by specifying the rack and slot location of the module to the WinLoader utility.

Built-In Web Server

The embedded RX7i CPU Ethernet Interface provides Web Server capability. Each IC698 Ethernet interface supports World Wide Web access via FTP and HTTP to allow web pages to be stored and maintained on the Ethernet interface and served up via the web to standard web browsers. GE Fanuc provides a standard API so that you can generate customized web pages that display desired PLC data in a desired format. You store the web pages to the Ethernet interface via FTP. A basic set of predefined web pages in English are provided; they include a home page, Reference Table data, PLC Fault Table, and I/O Fault Table. Rack-based Ethernet Interface modules do not provide Web Server capability.

SRTP Client (Channels)

SRTP channels can be set up in the PLC application program. SRTP supports COMMREQ-driven channel commands to establish new channels, abort existing channels, transfer data on an existing channel, and retrieve the status of an existing channel.

The PACSystems Ethernet interface supports up to 32 simultaneous Client connections shared between all Client protocols. For example, if 16 Client connections are used for SRTP Channels, there are 16 Client connections available for Modbus/TCP Channels. Any given channel can be assigned to only one protocol at a time.

SRTP Client allows the PACSystems PLC to initiate data transfer with other SRTP-capable devices on the network.

Modbus/TCP Client (Channels)

Modbus/TCP channels can be set up in the PLC application program. The Modbus/TCP Client supports COMMREQ-driven channel commands to open new channels, close existing channels, and transfer data on an existing channel.

The PACSystems Ethernet interface supports up to 32 simultaneous Client connections shared between all Client protocols. For example, if 16 Client connections are used for SRTP Channels, there are 16 Client connections available for Modbus/TCP Channels. Any given channel can be assigned to only one protocol at a time.

Modbus/TCP Client allows the PACSystems PLC to initiate data transfer with other Modbus/TCP server devices on the network.

Ethernet Global Data (EGD)

Each PACSystems CPU supports up to 255 simultaneous Ethernet Global Data (EGD) exchanges. EGD exchanges are configured using the programmer and stored into the PLC. Both Produced and Consumed exchanges can be configured. PACSystems Ethernet Interfaces support both selective consumption of EGD exchanges and EGD exchange production and consumption to the broadcast IP address of the local subnet.

The PACSystems Ethernet interface can be configured to use SNTP to synchronize the timestamps of produced EGD exchanges.

Beginning with PACSystems Release 2.00, PACSystems Ethernet interfaces implement the capabilities of a Class 1 and Class 2 device. COMMREQ-driven EGD Commands can be used in the application program to read and write data into PACSystems PLCs or other EGD Class 2 devices.

Ethernet Redundancy Operation

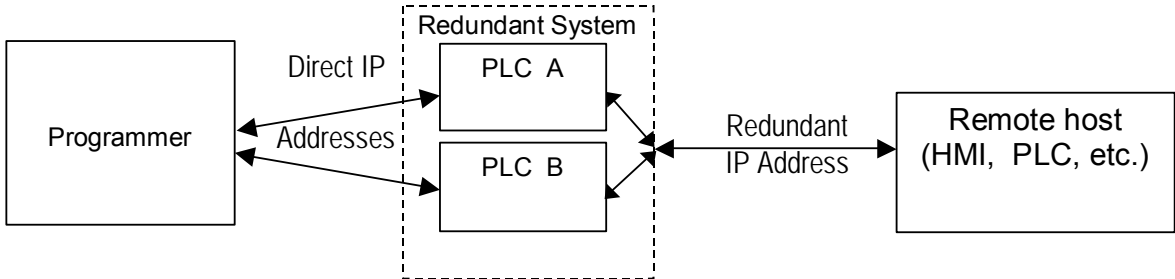
The Redundant IP feature of the Ethernet Interface allows a single IP address called the Redundant IP address to be assigned to two Ethernet modules. The two modules are in two different PLCs that are configured as a redundant system.

The Redundant IP Address is configured *in addition* to the normal unique (direct) IP address of each interface.

Only one of the two Ethernet interfaces that share the Redundant IP address may use the Redundant IP address at any time; this is the “active” unit. When commanded by its PLC CPU, this Ethernet interface activates the Redundant IP address and starts responding to the Redundant IP address in addition to its direct IP address. The active unit continues responding to the Redundant IP address until it is commanded to deactivate the Redundant IP or until the Ethernet interface determines that it has lost communications with the PLC CPU.

The other unit (the “backup” unit) does not initiate communications or respond on the network using the Redundant IP address. It can only use the Redundant IP address if it is commanded by its CPU to become the active unit.

Both the active and backup unit may continue to use their individual direct IP addresses, permitting programmer connection to the active or backup PLC at any time.



The Redundant IP feature is supported by Hot Standby (HSB) CPUs and non-HSB CPUs.

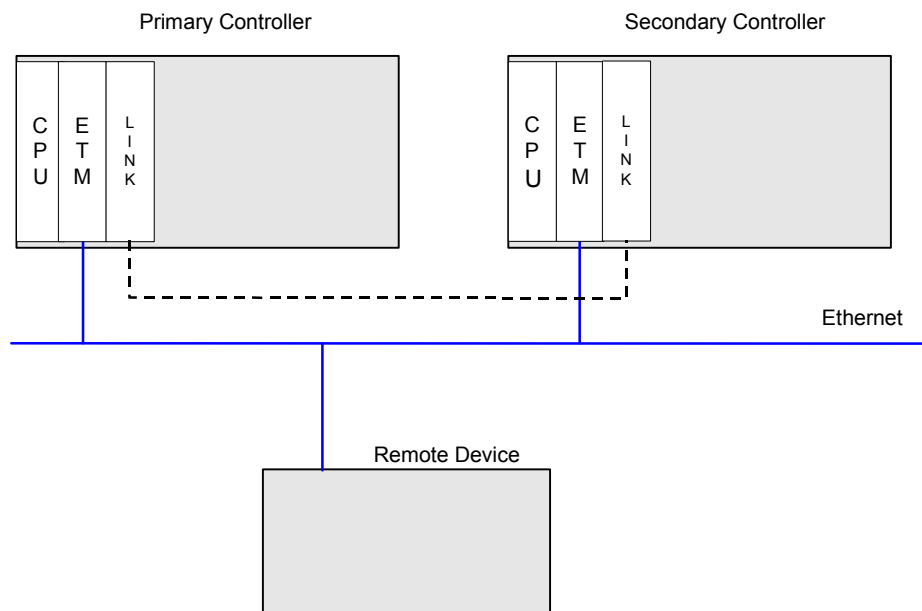
HSB CPU Redundancy

An HSB system uses redundancy CPUs that provide the coordination between the PLC units in the system and determine which is the active unit and which is the backup unit. HSB redundancy requires dedicated links to provide communications between the units in a redundancy system. Redundancy CPUs that include an embedded Ethernet Interface have a “CRE” designation, for example IC698CRE040. For information about HSB architectures, refer to the *PACSystems Hot Standby CPU Redundancy User’s Guide*, GFK-2308.

Non-HSB Redundancy

Non-HSB redundancy systems use RX7i or RX3i CPUs that do not have specialized firmware for controlling redundancy operations. (These CPUs have a “CPE” or “CPU” designation.) In these systems, the application logic coordinates between CPUs that act as redundant partners, and determines which CPU is the active unit and which are backup units. The figure below illustrates the use of the redundant IP feature in a non-HSB redundancy system. Two non-HSB CPUs (designated primary and secondary) are linked by a communications connection. An Ethernet interface in each controller is configured with Redundant IP enabled so that they share a Redundant IP address. As in an HSB system, only the active Ethernet interface can communicate through the Redundant IP address to produce EGD exchanges or to initiate Channel operations.

The application logic must monitor the status of the Ethernet modules in the system to manage the active/backup status of each controller.



Basic non-HSB System with Redundant IP

Effect of Redundancy Role Switching on Ethernet Communications

When a redundancy role-switch occurs, Ethernet communications switch to the backup unit, which has no knowledge of any communication state at the previously-active unit. The application must include logic to detect loss of communication during a redundancy role switch and to then reinitiate communication.

To remote hosts on the network, the redundant system is viewed as a single PLC with high reliability; the remote host neither knows nor cares which PLC is the active unit. By using the Redundant IP address, the remote host always communicates with the active unit. When a redundancy role switch occurs, the formerly-active PLC gives up ownership of the Redundant IP address and takes down all connection-oriented communications currently using the Redundant IP address. The applications in the redundant system and remote hosts must reestablish any such communications; the new Redundant IP connections will use the newly active PLC.

The programmer can still communicate directly with each PLC in the redundant system (for example, to store new logic or configuration) using the direct IP address of each Ethernet Interface.

Role Switching In HSB Redundancy Systems

In HSB redundancy systems, a role switch is initiated automatically by the redundancy CPU when the active unit detects a fatal fault, is placed in Stop mode, or is powered off. An HSB role switch can also be initiated manually or by the application logic. For additional information about role switches in HSB systems, refer to the *PACSystems Hot Standby CPU Redundancy User's Guide*, GFK-2308.

Role Switching in Non-HSB Redundancy Systems

When redundant IP is enabled for an Ethernet module in a non-HSB CPU system, it is the responsibility of application logic to set the redundancy mode of the Ethernet module. The *Set Application Redundancy Mode Service Request* (SVC_REQ 55) instruction is used to inform the Ethernet module of the current redundancy role of the host CPU. This SVC_REQ should be used to provide redundancy role switch notification to all Ethernet interfaces in the controller that are configured for redundant IP operation.

After commanding a role switch for an Ethernet interface, the application logic can monitor the module's LAN Interface Status (LIS) block to determine when it has activated the Redundant IP address. For details about the LIS, refer to "Monitoring the Ethernet Interface Status Bits" in chapter 10.

Note: The application must allow sufficient time for Redundant IP activation (at least 120 msec) before commanding another redundancy role switch.

When an Ethernet interface recognizes that a redundant IP address has been configured for it, the module sends a mail message to the CPU to register for redundancy role switch notification. In non-HSB systems, the Ethernet interface is initially put into backup mode. After power up, the application logic must use a SVC_REQ to set the redundancy state to the desired value. Once running, the CPU remembers the last commanded redundancy role sent to that Ethernet interface. When an Ethernet interface is restarted, the CPU automatically commands the Ethernet interface to its last redundancy state without explicit action by the application logic.

Going to Stop Mode

When a non-HSB CPU goes to Stop mode, Ethernet interfaces that are configured for redundant IP are automatically set to backup mode. When the CPU is subsequently returned to Run mode, the Ethernet interfaces remain in backup mode until the application logic sets the redundancy mode to active.

Stop/IO Scan Enabled Mode

In this mode, I/O scanning including EGD service continues when the non-HSB CPU is stopped. However, Ethernet interfaces configured for redundant IP operation are automatically set to backup mode and normal EGD production for those interfaces is stopped. Only the EGD exchanges with *Produce in backup mode* enabled are produced while the CPU is in Stop/IO Scan Enabled mode. To stop production for all EGD produced exchanges including *Produce in backup mode* exchanges, choose the Stop/IO Scan Disabled mode of operation.

Commanding a Role Switch in a Non-HSB Redundancy System

Use the Set Application Redundancy Mode service request (SVC_REQ 55) with non-HSB CPUs to request that the CPU send redundancy role switch commands to all Ethernet interfaces in that PLC that are configured for redundant IP operation. For details on using the Service Request function, refer to the *PACSystems CPU Reference Manual*, GFK-2222.

This function has an input parameter block with a length of one word.

address	0=Backup redundancy role
	1=Active redundancy role

SVC_REQ 55 is recognized in non-HSB CPUs only. This service request sends a role switch command to all Ethernet interfaces in the PLC that are configured for redundant IP operation. The application must monitor the LAN Interface Status (LIS) word for each Ethernet interface to determine whether the Redundant IP address is active at that interface.

SVC_REQ 55 has no effect on Ethernet interfaces that are not configured for redundant IP operation.

SRTP Server Operation in a Redundancy System

Only the active unit maintains SRTP Server connections *at the Redundant IP address* and is able to respond to SRTP requests. The backup unit does not respond to the Redundant IP address. When an Ethernet interface changes from active to backup state, it takes down all SRTP Server connections and their underlying TCP connections that use the Redundant IP address.

Both the active and backup units maintain SRTP Server connections at the direct IP address for network communication with the programmer. Other remote hosts should use the Redundant IP address when communicating to a redundant system. Existing SRTP Server connections at the direct IP address are not disturbed when the Ethernet interface switches between active and backup states.

SRTP Client Operation in a Redundancy System

Only the active unit establishes and maintains SRTP Client connections (channels). The backup unit does not initiate any SRTP Client operations. If SRTP Client operations are attempted, a COMMREQ error status is returned to the local logic program. When the Ethernet interface changes from active to backup state, it takes down all SRTP Client connections and their underlying TCP connections.

Because it can take some time to take down a TCP connection, the redundant system should reserve a spare SRTP Client connection for each connection using the Redundant IP address. That will prevent temporary resource problems when establishing new SRTP Client connections to the new active unit while the previous connections to the old active unit are being taken down.

Modbus/TCP Server Operation in a Redundancy System

Only the active unit maintains Modbus/TCP Server connections *at the Redundant IP address* and is able to respond to Modbus/TCP requests. The backup unit does not respond to the Redundant IP address. When an Ethernet interface changes from active to backup state, it takes down all Modbus/TCP Server connections and their underlying TCP connections that use the Redundant IP address.

Remote hosts should use the Redundant IP address when communicating to a redundant system. Existing Modbus/TCP Server connections at the direct IP address are not disturbed when the Ethernet interface switches between active and backup states.

Modbus/TCP Client Operation in a Redundancy System

Only the active unit establishes and maintains Modbus/TCP Client connections (channels). The backup unit does not initiate any Modbus/TCP Client operations. If Modbus/TCP Client operations are attempted, a COMMREQ error status is returned to the local logic program. When the Ethernet interface changes from active to backup state, it takes down all Modbus/TCP Client connections and their underlying TCP connections.

Because it can take some time to take down a TCP connection, the redundant system should reserve a spare Modbus/TCP Client connection for each connection using the Redundant IP address. That will prevent temporary resource problems when establishing new Modbus/TCP Client connections to the new active unit while the previous connections to the old active unit are being taken down.

EGD Class 1 (Production & Consumption) in a Redundancy System

The active unit produces Ethernet Global Data exchanges to the network. The backup unit produces only the EGD exchanges for which Produce in Backup Mode is enabled. When the active Ethernet interfaces changes to backup, it stops production of all EGD exchanges.

When configured for Redundant IP operation, the active and backup Ethernet interfaces should be configured to consume EGD exchanges via multicast host groups or the local subnet broadcast address. This permits both the active and backup units to receive the latest data from the network. Unicast operation is not recommended. The backup unit does not consume any unicast exchanges at the Redundant IP address.

EGD Class 2 Commands in a Redundancy System

Remote hosts should use the Redundant IP address when communicating to a redundant system. Only the active unit responds to EGD commands. The backup unit does not respond to the Redundant IP address. When the active Ethernet interface changes to backup, any EGD command currently in process over the Redundant IP address is ended.

When configured for Redundant IP operation, only the active unit sends EGD commands on the network. If the backup unit tries to initiate any EGD commands, a COMMREQ error status is returned to its application program. When the active Ethernet interfaces changes to backup, any EGD commands in process are ended.

Although not recommend, EGD commands may be issued to the direct IP address. Both the active and backup units will respond to EGD commands received at the direct IP address.

Web Server Operation in a Redundancy System

Only the active unit processes Web Server requests at the Redundant IP address and responds to web page requests. The backup unit does not respond to the Redundant IP address. When the active Ethernet interface changes to backup, it takes down all Web Server connections and their underlying TCP connections. The Web Server maintains its underlying TCP connection only long enough to process each web page request; a new TCP connection is opened, used, and closed for each subsequent web page display or update. So unless a web page change or update is requested during the redundancy role switch, the operation of the Redundant IP address is transparent to the Web remote browser. Any web page request in process over the Redundant IP when a role switch occurs is terminated.

Although not recommended, the remote browser may issue Web Server requests to the direct IP address. Both the active and backup units respond to Web server requests received at the direct IP address. Remote web browsers are expected to use the Redundant IP address when communicating to a redundant system.

FTP Operation in a Redundancy System

FTP operations are used to transfer setup and configuration data to the Ethernet interface, not for communication with the actual PLC application. Therefore, FTP operations should only be performed using the direct IP address.

SNTP Operation in a Redundancy System

A PACSystems Ethernet Interface can operate as an SNTP client only, so it only receives broadcast time messages from an SNTP Server on the network. SNTP operation is unaffected by the current Ethernet redundancy state or by redundancy role switches.

Remote Station Manager Operation in a Redundancy System

The remote Station Manager should respond to the direct IP address regardless of whether the unit is active or backup, or whether or not Redundant IP is configured.

Only the active unit responds to remote Station Manager commands at the Redundant IP address. The backup unit does not respond to the Redundant IP address. (Station Manager responses from the Redundant IP address can be misleading because it is difficult to determine which Ethernet interface is actually responding.)

IP Address Configuration in a Redundancy System

Redundancy systems should explicitly configure both the direct IP address and the Redundant IP address. Do not set up the direct IP address via BOOTP.

The Redundant IP address must be configured on the same local sub-network as the direct IP address and gateway IP address (if used).

Chapter Installation and Startup

2

This chapter describes the Ethernet Interface's user features and basic installation procedures:

- Ethernet Interface Controls and Indicators
- Ethernet LEDs
- Ethernet Restart Pushbutton
- Module Installation
 - RX7i CPU with Embedded Ethernet Interface
 - Rack-based Ethernet Interface Module
- Ethernet Port Connectors
 - Embedded Switch
 - Connection to a 10Base T / 100Base Tx Network
- Station Manager Port
- Verifying Proper Power-Up of the Ethernet interface After Configuration
- Pinging TCP/IP Ethernet Interfaces on the Network

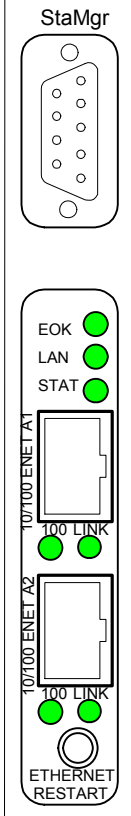
Features of the embedded CPU Ethernet Interface and the rack-based Ethernet Interface Module are the same unless noted otherwise.

Ethernet Interface Controls and Indicators

The Ethernet Interface provides:



























- 1. Seven light emitting diode (LED) indicators
 - Ethernet Module OK (EOK)
 - LAN Online (LAN)
 - Status (STAT)
 - Two Ethernet network activity LEDS (LINK)
 - Two Ethernet network speed LEDS (100)
- 2. Ethernet Restart Pushbutton
- 3. Two 10BaseT/100BaseTX Ethernet Network Port Connectors. There is only one interface to the network (only one Ethernet address and only one IP address).
- 4. Station Manager (RS-232) Serial Port

Features of the RX7i embedded CPU Ethernet Interface and the RX7i and RX3i rack-based Ethernet Interface Modules are the same unless noted otherwise.



Ethernet LEDs

The **EOK**, **LAN**, and **STAT** LEDs indicate the state and status of the Ethernet Interface. (The LEDs on the RX3i Ethernet module are labeled **ETHERNET OK**, **LAN OK**, and **LOG EMPTY**, respectively.)

LED State			Indicates
 On	 Blinking	 Off	
	EOK	Fast Blink	Performing Diagnostics
	LAN	Off	
	STAT	Off	
	EOK	Slow Blink	Waiting for Ethernet configuration from CPU
	LAN	Off	
	STAT	Off	
    	EOK LAN STAT	Slow Blink* On/Traffic/Off Slow Blink*	Waiting for IP Address
(* EOK and STAT blink in unison)			
     	EOK LAN STAT	On On/Traffic/Off On/Off	Operational
(* EOK and STAT blink in unison)			
	EOK	Blink error code	Hardware failure. See chapter 10 for blink code definitions.
	LAN	Off	
	STAT	Off	
  	EOK LAN STAT	Slow Blink* Slow Blink* Slow Blink*	Firmware Update
(* All LEDs blink in unison; pattern same for awaiting or performing load)			

LAN LED Operation

The LAN LED (LAN OK on the RX3i Ethernet module) indicates access to the Ethernet network. During normal operation and while waiting for an IP address, the LAN LED blinks when data is being sent or received over the network directed to or from the Ethernet interface. It remains on when the Ethernet interface is not actively accessing the network but the Ethernet physical interface is available and one or both of the Ethernet ports is operational.

It is off otherwise unless firmware update is occurring.

STAT LED Operation

The STAT LED (LOG EMPTY on the RX3i Ethernet module) indicates the condition of the Ethernet interface in normal operational mode. If the STAT LED is off, an event has been entered into the exception log and is available for viewing via the Station Manager interface. The STAT LED is on during normal operation when no events are logged.

In the other states, the STAT LED is either off or blinking and helps define the operational state of the module.

EOK LED Operation

The EOK LED (ETHERNET OK on the RX3i Ethernet module) indicates whether the module is able to perform normal operation. This LED is on for normal operation and flashing for all other operations. When a hardware or unrecoverable runtime failure occurs, the EOK LED blinks a two-digit error code identifying the failure. For a list of blink codes and their meanings, see chapter 10.

Ethernet Port LEDs Operation (100Mb and Link/Activity)

Each of the two Ethernet ports (Ports 1A and 1B) has two LED indicators, **100** and **LINK**. The **100** LED indicates the network data speed (10 or 100 Mb/sec). This LED is lit if the network connection at that network port is 100 Mbps.

The **LINK** LED indicates the network link status and activity. This LED is lit when the link is physically connected. It blinks when traffic is detected at that network port. Traffic at the port does not necessarily mean that traffic is present at the Ethernet interface, since the traffic may be going between ports of the switch.

Ethernet Restart Pushbutton

The Ethernet Restart pushbutton is used to manually restart the Ethernet firmware without power cycling the entire system. It is recessed to prevent accidental operation.

Restart Pushbutton Operation for Version 3.6 and Later

For PACSystems Ethernet interfaces version 3.6 and later, an Ethernet restart occurs when the Restart pushbutton is released. The duration that the Restart pushbutton is pressed determines the operation after the restart occurs. In all cases, the EOK, LAN and STAT LEDs briefly turn on in unison as an LED test. The Ethernet port LEDs are not affected by a manual restart of the Ethernet firmware.

To restart the Ethernet interface normally, press the Ethernet Restart pushbutton for less than 5 seconds.

If the Ethernet interface uses any optional Ethernet plug-in applications, these applications are ordinarily started upon each powerup or restart. To restart the Ethernet interface without starting any Ethernet plug-in applications, press and hold the Ethernet Restart pushbutton between 5 and 10 seconds.

To restart the Ethernet interface into firmware update operation, press and hold the Ethernet Restart pushbutton for more than 10 seconds. This is typically done during troubleshooting to bypass possibly invalid firmware and allow valid firmware to be loaded using WinLoader.

Pushbutton-controlled restart operations are listed below, with the LED indications for each.

<i>Restart Operation</i>	<i>Depress Ethernet Restart pushbutton for</i>	<i>Ethernet LEDs Illuminated</i>
Restart the Ethernet interface normally, and start any optional Ethernet plug-in applications that are being used.	Less than 5 seconds	EOK, LAN, STAT
Restart the Ethernet interface without starting any Ethernet plug-in applications.	5 to 10 seconds	LAN, STAT
Restart the Ethernet interface into firmware update operation.	More than 10 seconds	STAT

When forced into firmware update operation, but before the firmware update actually begins, pressing the Ethernet Restart pushbutton again exits the firmware update mode and restarts with the existing firmware. Once the firmware update actually begins, the existing firmware is erased and the Ethernet Restart pushbutton is disabled until the firmware update is complete.

Restart Pushbutton Operation Prior to Version 3.6

For PACSystems Ethernet interfaces earlier than version 3.6, pressing the Ethernet Restart pushbutton restarts the module immediately. The EOK, LAN and STAT LEDs briefly turn on in unison as an LED test. These three LEDs are turned on for ½ second and are then turned off when the firmware is restarted. The Ethernet port LEDs are not affected by a manual restart of the Ethernet firmware.

Module Installation

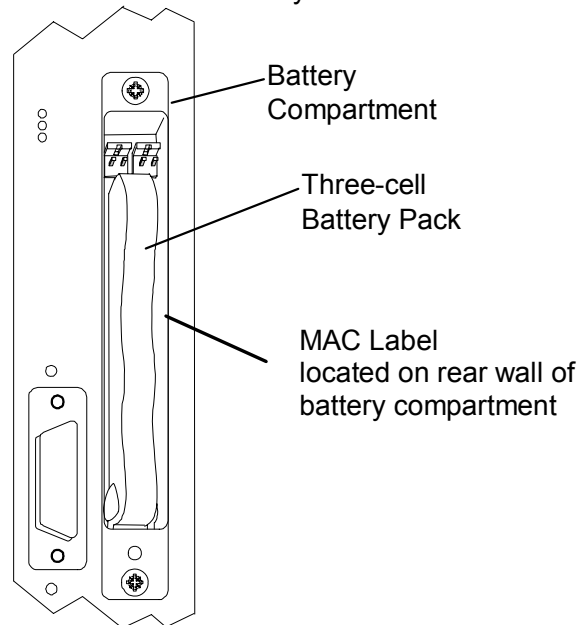
For general information about module and system installation, or if the installation requires CE Mark compliance, refer to the *PACSystems RX7i Hardware Installation Manual*, GFK-2223 or the *PACSystems RX3i Hardware Installation Manual*, GFK-2314.

Installing an RX7i CPU with Embedded Ethernet Interface

Warning

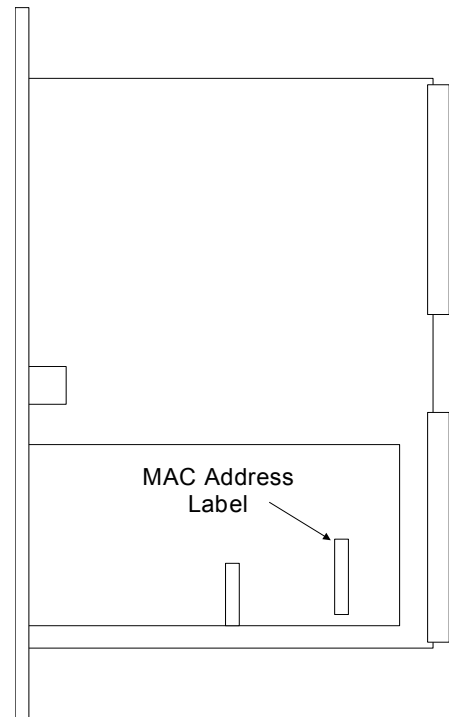
Do not insert or remove modules with power applied. This could cause the CPU to Stop, damage the module, or result in personal injury.

1. Record the 12-digit hexadecimal MAC Address from the printed label located on the rear wall of CPU battery compartment. The label is visible when the battery is removed from its compartment. (The battery does not need to be disconnected to temporarily remove it from the compartment.)
2. Connect the battery to either of the battery connectors on the module.
3. Put the toggle switch in the STOP position.
4. Make sure that rack power is off.
5. Install the CPU module in slot 1 of rack 0. Press the module firmly in place, but do not force the board. Tighten the screws on the top and bottom tabs.
6. Connect one or both of the Ethernet ports on the Ethernet Interface to the network.
7. Turn on power to the PACSystems rack.
8. Set the PLC to Stop mode via the Run/Stop switch or the programming software.



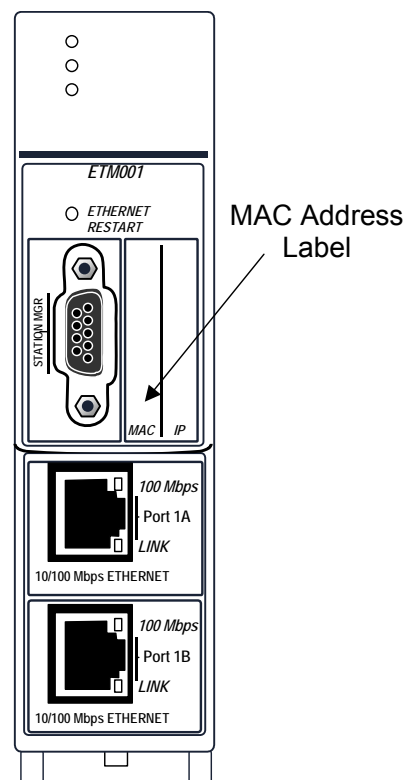
Installing an RX7i Ethernet Interface Module

1. Record the 12-digit hexadecimal MAC Address from the printed label on the Ethernet Interface. The label is visible only with module out of the rack.
2. Be sure the rack power is OFF.
3. Slide the module into the slot for which it was configured in the system. (Must go into main rack.)
4. Press the module firmly in place, but do not force the module. Tighten the screws on the top and bottom tabs.
5. Connect one or both of the network ports on the Ethernet Interface to the Ethernet network.
6. Turn on power to the PACSystems rack.
7. Set the PLC to Stop mode via the Run/Stop switch or the programming software.



Installing an RX3i Ethernet Interface Module

1. Record the 12-digit hexadecimal MAC Address from the printed label located on the front of the Ethernet Module.
2. PLC rack power may off of on ("hot insertion"). For hot insertion, be sure that all cables are disconnected from the Ethernet module
3. Slide the module into the slot for which it was configured in the system. (Must go into main rack.)
4. Press the module firmly in place, but do not force.
5. Connect one or both of the network ports on the Ethernet Interface to the Ethernet network.
6. Unless this is a hot insertion, turn on power to the PACSystems rack.
7. Set the PLC to Stop mode via the Run/Stop switch or the programming software.

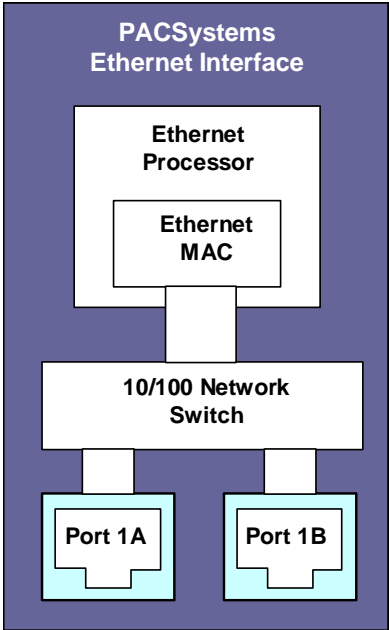


Ethernet Port Connectors

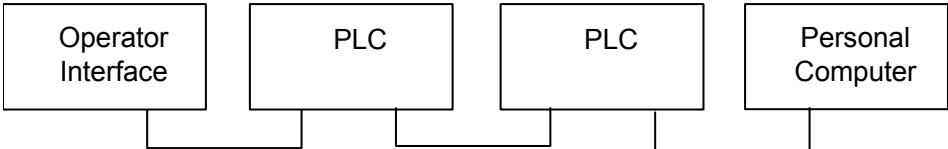
The Ethernet Interface has two Ethernet port connectors, each of which supports both 10Base-T and 100Base-Tx operation using either full duplex or half duplex operation. These 8-pin RJ-45 connectors are used to connect the Ethernet Interface to a hub, repeater, switch, or other Ethernet device.

Embedded Switch

The two Ethernet port connectors are controlled by an embedded network switch in the module. The module has only one interface to the network (one Ethernet address and one IP address).



For simple installations, the embedded switch allows devices to be connected without additional components.



It is possible to daisy-chain PLCs together without additional components, but that should be done with great care. Power loss or reset at an Ethernet interface causes loss of communication to any devices downstream from that Ethernet interface in the daisy chain. Restarting the Ethernet interface (via the Ethernet Restart pushbutton, for example) disrupts daisy chain communication.

Each switch port auto-negotiates (by default) to the correct link speed and duplex mode for the device connected to the other end of the link. Each port operates independently, so devices at two different speeds and/or duplex modes may be attached to the two ports. Each port also automatically detects the attached cable and will work properly with either straight-through or crossover cables (by default).

Caution

The two Ethernet ports on the Ethernet Interface must not be connected, directly or indirectly, to the same device. The connections in an Ethernet network based on twisted pair cabling must form a tree and not a ring, otherwise duplication of packets and network overload may occur.

Caution

The IEEE 802.3 standard strongly discourages the manual configuration of duplex mode for a port (as would be possible using Advanced User Parameters). Before manually configuring duplex mode for an Ethernet Interface port using advanced user parameters (AUP), be sure that you know the characteristics of the link partner and are aware of the consequences of your selection. Setting both the speed and duplex AUPs on an IC698 Ethernet Interface port will disable the port's auto-negotiation function. If its link partner is not similarly manually configured, this can result in the link partner concluding an incorrect duplex mode. In the words of the IEEE standard: "Connecting incompatible DTE/MAU combinations such as full duplex mode DTE to a half duplex mode MAU, or a full-duplex station (DTE or MAU) to a repeater or other half duplex network, can lead to severe network performance degradation, increased collisions, late collisions, CRC errors, and undetected data corruption."

Note: If both speed and duplex mode of an Ethernet interface port are forced using the Advanced User Parameters file, that port will no longer perform automatic cable detection. This means that if you have the Ethernet interface port connected to an external switch or hub port you must use a crossover cable. If you have the Ethernet interface port connected to the uplink port on an external switch or hub, or if you have the Ethernet interface port directly connected to another Ethernet device, you must use a normal cable.

Connection to a 10Base-T / 100Base Tx Network

Either shielded or unshielded twisted pair cable may be attached to a port. The 10Base-T/100Base Tx twisted pair cables must meet the applicable IEEE 802 standards. Category 5 cable is required for 100BaseTX operation.

Each Ethernet port automatically senses whether it is connected to a 10BaseT or 100BaseTX network, half duplex or full duplex. (The automatic negotiation of speed and/or duplex mode can be explicitly overridden using Advanced User Parameter settings).

10Base-T/100Base Tx Port Pinouts

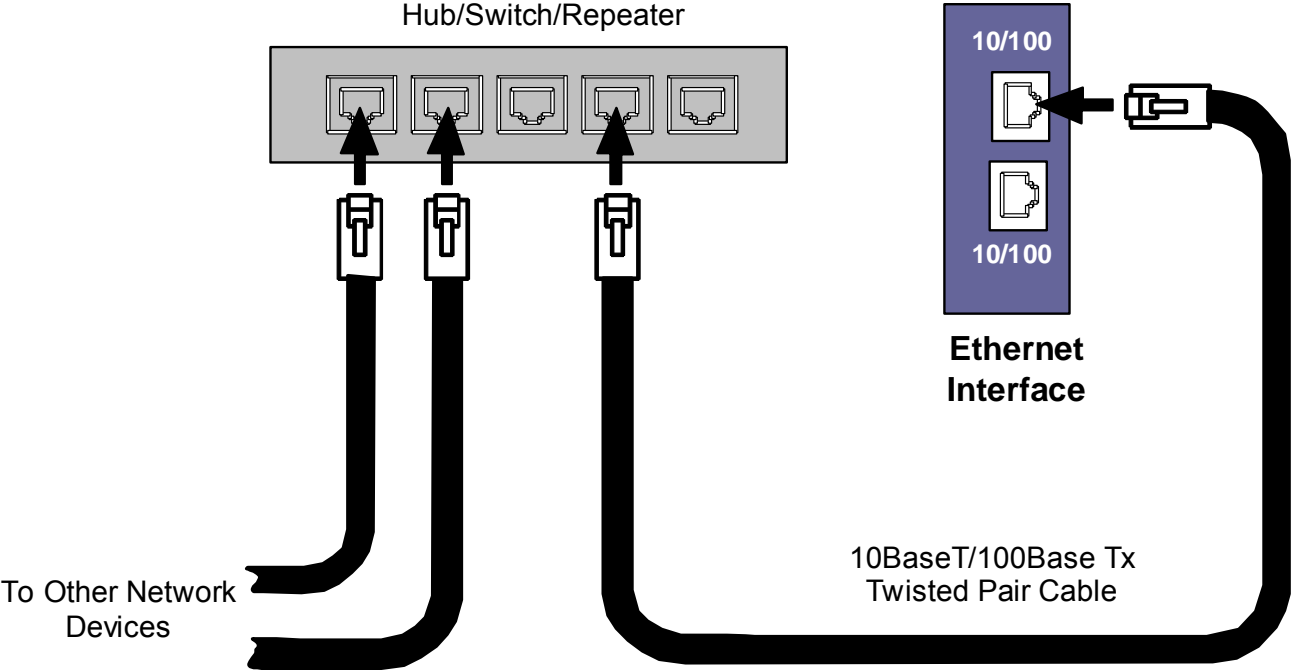
<i>Pin Number</i>	<i>Signal</i>	<i>Description</i>
1*	TD+	Transmit Data +
2	TD-	Transmit Data -
3	RD+	Receive Data +
4	NC	No connection
5	NC	No connection
6	RD-	Receive Data -
7	NC	No connection
8	NC	No connection

* Pin 1 is at the bottom of the Ethernet port connector as viewed from the front of the module.

Note: Pin assignments are provided for troubleshooting purposes only. 10Base-T/100Base-Tx cables are readily available from commercial distributors. GE Fanuc recommends purchasing rather than making 10Base-T/100Base-Tx cables.

Connection Using a Hub/Switch/Repeater

Connection of the Ethernet Interface to a 10Base-T or 100Base-Tx network is shown below.

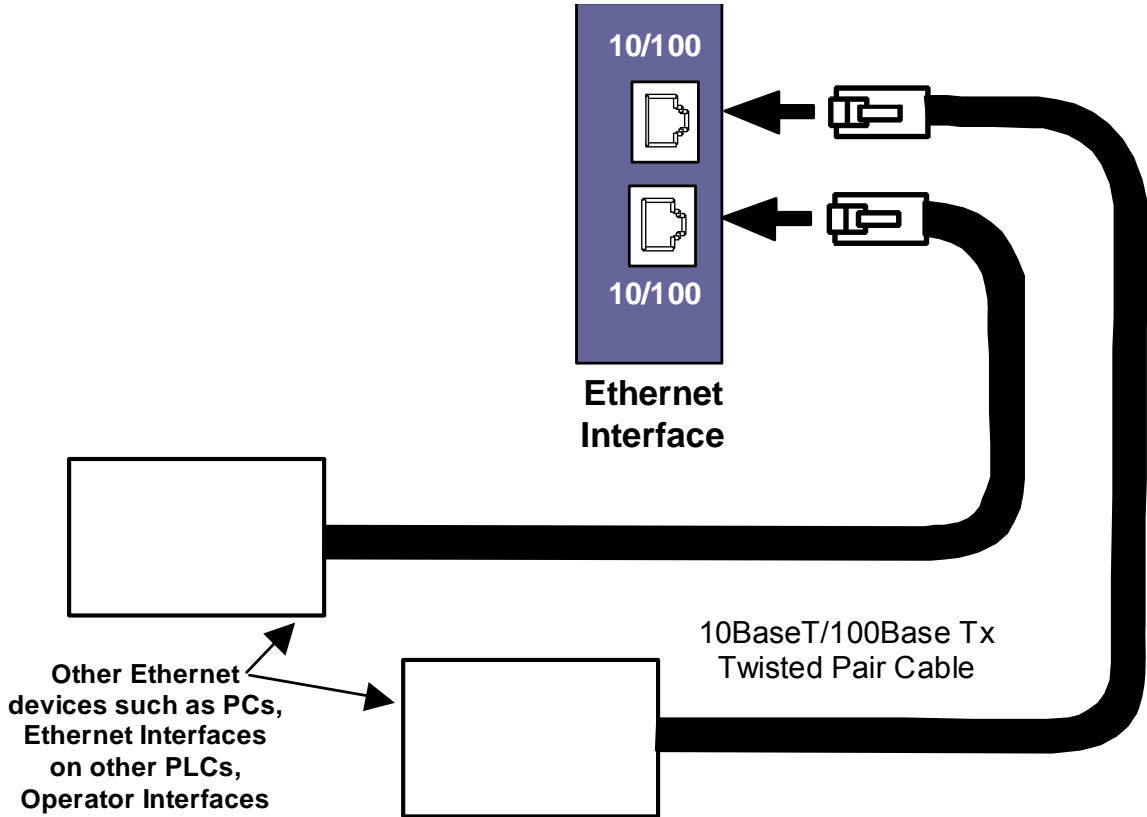


NOTE

Care must be taken with the use of active network control devices, such as managed switches. If a device inserts excessive latency, especially in regards to the ARP protocol, produced EGD exchanges may generate PLC Fault Table entries indicating the loss of a consumer when the PLC transitions from STOP to RUN. EGD data will be successfully transferred after an initial delay.

Direct Connection to the PACSystems Ethernet Interface

Connection of Ethernet devices directly to the Ethernet Interface is shown below:



Station Manager Port

Each PACSystems Ethernet interface provides a dedicated RS-232 serial port for local Station Manager use. This nine-pin D connector accepts a standard straight-through nine-pin RS-232 serial cable to connect to a standard AT-style RS-232 port.

The following cable is available from GE Fanuc:

IC200CBL001 Cable, CPU Programming

Port Settings

The serial (COM) port of the terminal or computer that is connected to the Ethernet Interface must use the same communications parameters as the Ethernet Interface.

The default values for the Station Manager port are 9600 bps, 8 bits, no parity, and 1 stop bit. If the Ethernet Interface is configured with default values for this port, or the Ethernet Interface has not been configured, use these default values. If the Ethernet Interface is configured with non-default values for this port, use those values for the serial port settings of the terminal or computer.

Station Manager (RS-232) Port Pin Assignment

<i>Pin No</i>	<i>Signal</i>	<i>Direction</i>	<i>Description</i>
1*	DCD	IN	Data Carrier Detect
2	TX	OUT	Transmit Data
3	RX	IN	Receive Data
4	DSR	IN	Data Set Ready
5	GND		Signal Ground
6	DTR	OUT	Data Terminal Ready
7	CTS	IN	Clear to Send
8	RTS	OUT	Ready to Send
9	RI	IN	Ring Indicator

* Pin 1 is at the bottom right of the Station Manager port connector as viewed from the front of the module.

Verifying Proper Power-Up of the Ethernet Interface after Configuration

After configuring the Interface as described in the next chapter, turn power OFF to the CPU for 3–5 seconds, then turn the power back ON. This starts a series of diagnostic tests. The EOK LED will blink indicating the progress of power-up.

The Ethernet LEDs will have the following pattern upon successful power-up. At this time the Ethernet Interface is fully operational and on-line.

LED	Ethernet Interface Online	
EOK	●	On
LAN	● ✚ ○	On, Off, or blinking, depending on network activity
STAT	●	On

If a problem is detected during power-up, the Ethernet Interface may not transition directly to the operational state. If the Interface does not transition to operational, refer to “Diagnostics,” chapter 10 for corrective action.

Pinging TCP/IP Ethernet Interfaces on the Network

PING (Packet InterNet Grouper) is the name of a program used on TCP/IP networks to test reachability of destinations by sending them an ICMP echo request message and waiting for a reply. Most nodes on TCP/IP networks, including the PACSystems Ethernet Interface, implement a PING command.

You should ping each installed Ethernet Interface. When the Ethernet Interface responds to the ping, it verifies that the interface is operational and configured properly. Specifically it verifies that acceptable TCP/IP configuration information has been downloaded to the Interface.

Pinging the Ethernet Interface from a UNIX Host or Computer Running TCP/IP Software

A *ping* command can be executed from a UNIX host or computer running TCP/IP (most TCP/IP communications software provides a *ping* command) or from another Ethernet Interface. When using a computer or UNIX host, you can refer to the documentation for the *ping* command, but in general all that is required is the IP address of the remote host as a parameter to the *ping* command. For example, at the command prompt type:

```
ping 10.0.0.1
```

Determining if an IP Address is Already Being Used

Note: This method does not guarantee that an IP address is not duplicated. It will not detect a device that is configured with the same IP address if it is temporarily off the network.

It is very important not to duplicate IP addresses. To determine if another node on the network is using the same IP address:

1. Disconnect your Ethernet Interface from the LAN.
2. Ping the disconnected Interface's IP address. If you get an answer to the ping, the chosen IP address is already in use by another node. You *must* correct this situation by assigning unique IP addresses.

Ethernet Plug-in Applications

Ethernet interface versions 3.6 and later support the use of additional firmware images called *Ethernet plug-in applications*, which may implement additional communication protocols. Up to three Ethernet plug-in applications may be loaded into the Ethernet interface along with the Ethernet firmware via the WinLoader utility. Each plug-in application is identified by a number (1-3). Once loaded, each Ethernet plug-in application is stored in non-volatile memory where it is preserved until it is overwritten by WinLoading another Ethernet plug-in application with the same number, or it is explicitly deleted via the *pluginapp* Station Manager command (see *TCP/IP Ethernet Communications for PACSystems™ Station Manager Manual*, GFK-2225).

All Ethernet plug-in applications are started during normal Ethernet powerup or restart. During troubleshooting, the Ethernet Restart pushbutton may be used to startup the Ethernet interface without the plug-in applications (see “Ethernet Restart Pushbutton” in chapter 2).

The functional operation, PLC interfaces, and Station Manager support for each Ethernet plug-in application will be supplied separately from this user manual.

Chapter *Configuration*

3

Before you can use the Ethernet Interface, you must configure it using Machine Edition Logic Developer-PLC software. The configuration process for a PACSystems Ethernet Interface includes:

- Assigning a temporary IP address for initial network operation, such as connecting the programmer to download the hardware configuration.
- Configuring the characteristics of the Ethernet interface.
- Configuring Ethernet Global Data (if used).
- (Optional, not required for most systems). Setting up the RS-232 port for Local Station Manager operation. This is part of the basic Ethernet Interface configuration.
- (Optional, not required for most systems). Configuring advanced parameters. This requires creating a separate ASCII parameter file that is stored to the PLC with the hardware configuration. The Ethernet Interface has a set of default Advanced User Parameter values that should only be changed in exceptional circumstances by experienced users. The Advanced User Parameters definitions and configuration are described in appendix A.
- (Optional) Setting up the PLC for Modbus/TCP Server operation. See chapter 7 for information about configuring Modbus/TCP Server operation.

This chapter discusses only the configuration of the PACSystems Ethernet Interface. Information about overall system configuration is available in other PACSystems documentation and in the Logic Developer online help.

Configuration Data

The PACSystems PLC is configured exclusively by the Machine Edition PLC Logic Developer-PLC programmer. The Programmer can be connected over the Ethernet network. For initial programmer connection, an initial IP address must be manually assigned to the Ethernet interface as described next in this chapter. The PACSystems PLC does not support autoconfiguration.

Generating / Storing / Loading the Configuration

The PACSystems Ethernet interfaces use several types of configuration data: Ethernet Configuration, optional Ethernet Global Data Configuration, and optional Advanced User Parameter (AUP) Configuration. All of these configuration parameters are generated at the programmer, stored from the programmer to the PLC CPU as part of the hardware configuration Store sequence and may be loaded from the PLC CPU into the programmer as part of the Configuration Load sequence. The optional AUP file must be manually generated with a text editor and then imported into the programmer. The programmer then stores any AUP files to the PLC within the Configuration Store operation. Once stored to the PLC, the PACSystems main CPU maintains the configuration data over power cycles.

Backup Configuration Data

The PACSystems Ethernet interface saves a backup copy of the most recent Ethernet Configuration and AUP Configuration in non-volatile memory for use when the PLC is cleared. (Ethernet Global Data configuration is maintained only in the PLC CPU.) The PACSystems Ethernet interfaces maintain the backup configuration data in nonvolatile memory without battery power. (A PLC Configuration Clear does not affect the backup configuration data in the Ethernet interface.)

When the PLC configuration was not stored from the programmer, the Ethernet interface uses its backup configuration data if valid. If that data is invalid or has never been configured, factory default configuration values are used.

Locally-Edited Configuration Data

If the PLC configuration was not stored from the programmer, the CHSOSW and CHPARM Station Manager commands can be used to locally edit Ethernet configuration or AUP configuration data. These Station Manager commands are not active if the PLC configuration has been stored from the programmer.

Locally edited configuration changes cannot be retrieved into the PLC and loaded to the programmer. Locally edited configuration changes are always overwritten when a PLC configuration is stored into the PLC from the programmer.

Initial IP Address Assignment

Each PACSystems Ethernet Interface comes from the factory with a default IP address (0.0.0.0). Because this default address is not valid on any Ethernet network, an initial IP address must be assigned for initial network operation, such as connecting the programmer to download the first hardware configuration. The initial IP address must be selected for proper operation with your network and application; see your network administrator for the proper initial IP address value.

One way to assign the initial IP address is via the CHSOSW command from a local serially-connected Station Manager terminal. See *PACSystems TCP/IP Communications Station Manager Manual*, GFK-2225, for details.

Alternately, an IP address can be set using the “Set IP” method if the PLC is not in a RUN state, even if the Ethernet interface already has a valid configured IP Address. If the Ethernet interface has the factory default IP Address 0.0.0.0, a temporary IP address can be set using BOOTP over the Ethernet network, if a BOOTP server is present. Both temporary IP address assignment methods are described here.

Assigning a Temporary IP Address Using the Programming Software

To initiate Ethernet communications with the programmer, you first need to set up a temporary IP address. After the programmer is connected, the actual IP address for the Ethernet interface (as set up in the hardware configuration) should be downloaded to the PLC. The temporary IP address remains in effect until the Ethernet interface is restarted, power-cycled or until the hardware configuration is downloaded or cleared.

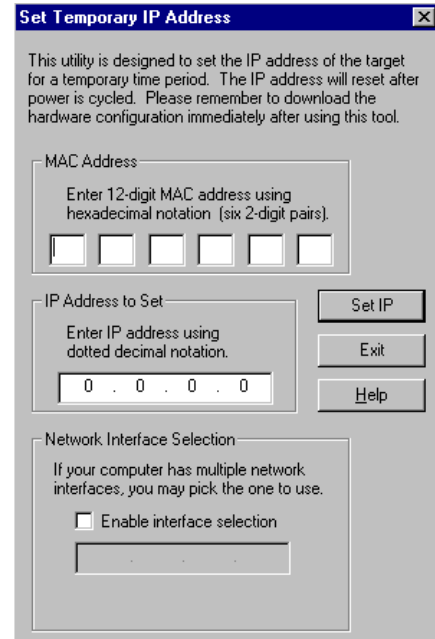
- To use the Set Temporary IP Address utility, the PLC CPU must not be in RUN mode. IP address assignment over the network will not be processed until the CPU is stopped and is not scanning outputs.
- The current user logged on to the PC running the Set Temporary IP Address utility must have full administrator privileges.
- The Set Temporary IP Address utility can be used if communications with the networked PACSystems target travel across network switches and hubs. It does not work if communications travel through a router.
- The target must be located on the same sub-network (subnet) as the computer running the Set Temporary IP Address utility. The sub-network is specified by the computer's subnet mask and the IP addresses of the computer and the PACSystems Ethernet Interface.

To set the IP address, you need the MAC address of the Ethernet Interface. The MAC address is located on a label on the module, as shown in chapter 2, Installation. Connect the PACSystems Ethernet Interface to the Ethernet network.

1. In the Project tab of the Navigator, right-click the PACSystems target. Choose Offline Commands, then Set Temporary IP Address. The Set Temporary IP Address dialog box appears.

2. In the Set Temporary IP Address dialog box, do the following:

- Specify the MAC address of the Ethernet Interface.
- In the IP Address to Set box, specify the temporary IP address you want to assign to the Ethernet Interface.
- If the computer has multiple Ethernet network interfaces, select the Enable Network Interface Selection check box and specify the network interface on which the PACSystems Ethernet Interface being set up is located.



3. When the fields are properly configured, click the Set IP button.
4. The Set Temporary IP Address utility verifies that the specified IP address is not already in use, then it sets the target Ethernet Interface to the specified IP address. Finally, the utility verifies that the target Ethernet Interface responds at the selected IP address. Any error or successful completion is reported. These operations may take up to a minute.

Cautions

The temporary IP address set by the Set Temporary IP Address utility is not retained through a power cycle. To set a permanent IP Address, you must set configure the target's IP Address and download the hardware configuration to the PACSystems target.

The Set Temporary IP Address utility can assign a temporary IP address even if the target Ethernet Interface has previously been configured to a non-default IP address. (This includes overriding an IP address previously configured by the programmer.)

Use this IP Address assignment mechanism with care.

Assigning a Temporary IP Address Using BOOTP

When the PACSystems Ethernet Interface receives the default IP address (0.0.0.0), either from hardware configuration or from internal backup configuration, it attempts to obtain a temporary IP address from a BOOTP server on the Ethernet network. The Ethernet Interface acts as a BOOTP client. The Ethernet Interface issues a BOOT Request to the network. If any BOOTP server on the network recognizes the Ethernet Interface, that server will return a BOOT Reply containing an IP address (and optionally a subnet mask and gateway IP address) to the requesting Ethernet Interface.

Typically, the BOOTP server must be manually configured with the MAC address and IP address (and possibly other information such as subnet mask and gateway) for each supported client device. Each supported client must be identified by its globally unique MAC address. The Ethernet Interface's MAC address is specified on its MAC Address Label as described in chapter 2, Installation.

The BOOTP server must not be separated from the PACSystems Ethernet Interface by a router. BOOTP uses broadcast messages, which typically do not pass through routers. Consult your network administrator for more details.

Caution

The temporary IP address set by BOOTP is not retained through a power cycle. To set a permanent IP Address, you must configure the Ethernet Interface's IP Address at the programmer and download the hardware configuration to the PLC.

Redundancy systems using should explicitly configure both the direct IP address and the Redundant IP address. For redundancy operation, do not set up the direct IP address via BOOTP.

Assigning a Temporary IP Address Using Telnet

The temporary IP address assignment performed by the programmer's Set Temporary IP Address utility can be performed manually from a computer's DOS command window if the programming software is not available. This method uses an attempted Telnet connection to transfer the IP address, even though the PACSystems target Ethernet Interface does not support normal Telnet operation.

Caution

The Telnet method can assign a temporary IP address whether or not the Ethernet Interface already has an IP address, even if the Ethernet interface has been previously configured to a non-default IP address. (This includes overriding an IP address previously configured by the programming software.)

Use this IP Address assignment mechanism with care.

To temporarily set the IP address over the network, the PLC CPU must not be running. IP address assignment over the network will not be processed until the CPU is stopped and is not scanning outputs.

1. Obtain the Ethernet Interface's MAC address from its MAC Address Label as shown in chapter 2, Installation.
2. On the computer, open a standard DOS command window. Associate the desired IP address for the Ethernet Interface with the MAC address of the Ethernet Interface using the following method. In the DOS command window, enter:

```
> ARP -s ip_address mac_address
```

for *ip_address* enter the IP address being assigned to the Ethernet interface, and for *mac_address* enter the MAC address of the Ethernet interface.

3. Issue a Telnet command to the IP address (*ip_address*) being assigned to the Ethernet interface via the following command:

```
> telnet ip_address 1
```

(This command is always sent to port 1.) This Telnet command will fail, but the IP address provided with the Telnet command will be passed to the Ethernet interface and will be temporarily activated.

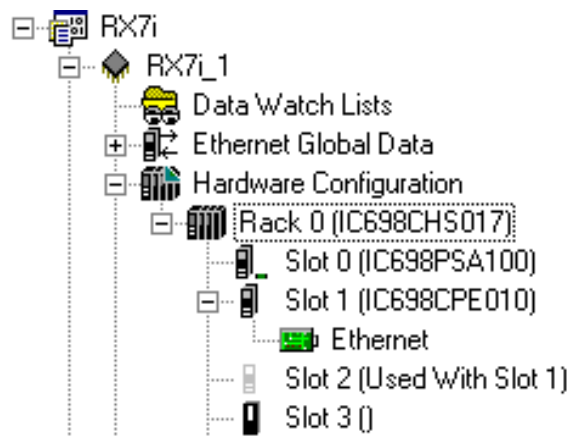
The IP address assigned over the network remains in effect until the Ethernet interface is restarted, power-cycled or until the configuration is downloaded or cleared. Once connected, the intended IP address should be permanently downloaded to the Ethernet interface via the hardware configuration data.

Configuring the Ethernet Interface

This section describes how to configure the parameters of an Embedded or Rack-based PACSystems Ethernet Interface.

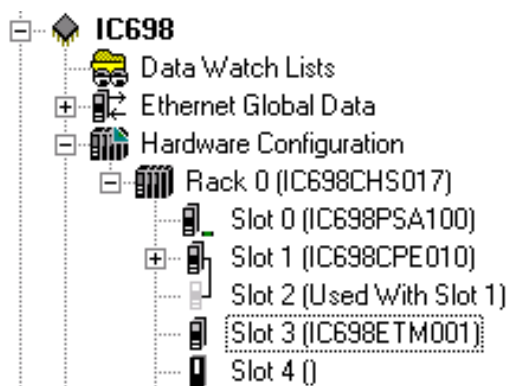
Configuring an Embedded Ethernet Interface

1. In the Project tab of the Navigator, expand the PACSystems Target, the hardware configuration, and the main rack (Rack 0).
2. Expand the CPU slot (Slot 1). The Ethernet Interface daughterboard is displayed as “Ethernet”.
3. Right click the daughterboard slot and choose Configure. The Parameter Editor window displays the Ethernet Interface parameters.
4. To display the Ethernet Global Data component, right-click the PLC icon. Select ‘Add Component’ and then ‘Ethernet Global Data’.
5. Select the desired tab, then click in the appropriate Values field.



Configuring a Rack-based Ethernet Interface Module

1. In the Project tab of the Navigator, expand the PACSystems Target, the hardware configuration, and the main rack (Rack 0).
2. Right click an empty slot and choose Add Module. The Module Catalog opens.
3. Click the Communications tab, select the IC698ETM001 module (for RX7) or IC695ETM001 module (for RX3i) and click OK. The Ethernet module is placed in the rack and its parameters are displayed in the Parameter Editor window.
4. To display the Ethernet Global Data component, right-click the PLC icon. Select ‘Add Component’ and then ‘Ethernet Global Data’.



5. Select the desired tab, then click in the appropriate Values field. (To edit parameters of a module that is already configured in the rack, right click the slot containing the module and choose Configure.)

Ethernet Parameters (Settings Tab)

Parameters	Values
Configuration Mode	TCP/IP
Adapter Name	0.1.0
Use BOOTP for IP Address	False
IP Address	0.0.0.0
Subnet Mask	0.0.0.0
Gateway IP Address	0.0.0.0
Name Server IP Address	0.0.0.0
Maximum Web Connections	2
Maximum FTP Connections	2
Network Time Sync	None
Status Address	%I0001
Length	80
Redundant IP	Enable
Redundant IP Address	0.0.0.0
I/O Scan Set	1

Configuration Mode: This is fixed as TCP/IP.

Adapter Name: This is automatically generated based upon the rack/slot location of the Ethernet interface.

Use BOOTP for IP Address: This selection specifies whether the Ethernet must obtain its working IP address over the network via BOOTP. When set to False (= do not use BOOTP), the IP Address value must be configured (see IP Address parameter, below). When set to True, the IP Address parameter is forced to 0.0.0.0 and becomes non-editable.

IP Address: These values should be assigned by the person in charge of your network (the network administrator). TCP/IP network administrators are familiar with these parameters. It is important that these parameters are correct, otherwise the Ethernet Interface may be unable to communicate on the network and/or network operation may be corrupted. It is especially important that each node on the network is assigned a *unique* IP address.

If you have no network administrator and are using a simple *isolated network* with no gateways, you can use the following range of values for the assignment of local IP addresses:

- 10.0.0.1 First Ethernet interface
- 10.0.0.2 Second Ethernet interface
- 10.0.0.3 Third Ethernet interface
- .
- .
- .
- 10.0.0.255 Programmer TCP or host

Also, in this case, set the subnet mask, and gateway IP address to 0.0.0.0.

Note: If the isolated network is connected to another network, the IP addresses 10.0.0.1 through 10.0.0.255 must not be used and the subnet mask, and gateway IP address must be assigned by the network administrator. The IP addresses must be assigned so that they are compatible with the connected network.

Name Server IP Address: This parameter must be set to 0.0.0.0

Max Web Server Connections: (Available only when the Ethernet Interface supports web server operation.) The maximum number of web server connections. This value corresponds to the number of TCP connections allocated for use by the web server, rather than the number of web clients. Valid range is 0 through 16. Default is 2.

Max FTP Server Connections: This value corresponds to the number of TCP connections allocated for use by the FTP server, rather than the number of FTP clients. Each FTP client uses two TCP connections when an FTP connection is established. Valid range is 0 through 16. Default is 2.

Note: The sum of Max Web Server Connections and Max FTP Server Connections must not exceed 16 total connections.

Network Time Sync: Selection of the method used to synchronize the real-time clocks over the network. The choices are None (for no network time synchronization) and SNTP (for synchronization to remote SNTP servers on the network).

If None is selected, the time stamp value for a consumed EGD exchange is obtained from the local clock of the producing Controller or PLC. Time stamps of exchanges produced by a PLC with this setting are not synchronized with the time stamps of exchanges produced by other PLCs.

See “Timestamping of Ethernet Global Data Exchanges” in chapter 4 for more information.

Status Address: The Status Address is the reference memory location for the Ethernet Interface status data. The Ethernet Interface will automatically maintain 16 LAN Interface Status (LIS) bits in this location and 64 Channel Status bits in this location for a total of 80 bits. The Status address can be assigned to valid %I, %Q, %R, %AI, %AQ or %W

memory. The default value is the next available %I address. See chapter 10, Diagnostics, for definitions of the LAN Interface Status (LIS) portion of the Ethernet Status data.

The meaning of the Channel Status portion of the Ethernet Status depends upon the type of operation for each channel. See chapters 6 and 8 for the meaning of the Channel Status bits for SRTP channels and Modbus/TCP channels operation.

Note: Do not use the 80 bits configured as Ethernet Status data for other purposes or data will be overwritten.

Note: If the Ethernet interface's Variable Mode property is set to true, the Status Address parameter is removed from the Settings tab. Instead, Ethernet Status references must be defined as I/O variables on the Terminals tab (see Terminals Tab, below).

Length: This is the total length of the Ethernet Interface status data. This is automatically set to either 80 bits (for %I and %Q Status address locations) or 5 words (for %R, %AI, %AQ and %W Status address locations).

Redundant IP: Selects whether Redundant IP operation is Enabled or Disabled. This parameter is available only when the PLC CPU supports Redundancy operation. When this parameter is set to Enabled, the Redundant IP address must be entered via the Redundant IP Address parameter, below. The default value is False.

Redundant IP Address: An optional IP Address that will be shared with another device on the network in a Redundant System. Both devices must use the same subnet mask. This parameter is available only when the Redundant IP parameter (above) is set to Enabled. This address defaults to 0.0.0.0, which is not a valid IP address; a valid Redundant IP address must be explicitly configured. See chapter 1, Introduction, for more information about Ethernet redundancy. This IP address is assigned in addition to the device's primary IP address.

I/O Scan Set: Specifies the I/O scan set to be assigned to the Ethernet Interface. Scan sets are defined in the CPU's Scan Sets tab. The valid range is 1 through 32; the default value is 1.

Note: The Ethernet interface delivers its Ethernet Status (including Channel Status bits) during its input scan. Each channels data transfer updates the Channels Status bits, so channels performance may be reduced if the Ethernet interface is configured to use an I/O Scan Set than runs more slowly than the PLC logic sweep.

If the Ethernet interface is configured to use an inactive I/O Scan Set, the Channels Status bits will not be transferred and channel operations will not complete.

RS-232 Port (Station Manager) Tab

These parameters are for the RS-232 Station Manager serial port. These defaults should be used for most applications.

Parameters	Values
Baud Rate	9600
Parity	None
Flow Control	None
Stop Bits	One

Baud Rate: Data rate (bits per second) for the port. Choices are 1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k. The default value is 9600.

Parity: Type of parity to be used for the port. Choices are None, Even, or Odd; the default value is None.

Flow Control: Type of flow control to be used for the port. Choices are None or Hardware. (The Hardware flow control is RTS/CTS crossed). The default value is None.

Stop Bits: The number of stop bits for serial communication. Choices are One or Two; the default value is One.

Terminals Tab

This configuration tab is displayed only when the Ethernet interface's Variable Mode property is set to True. When Variable Mode is selected, the Ethernet Status bits are referenced as I/O variables that are mapped to the Ethernet status bits on this configuration tab.

The use of I/O variables allows you to configure the Ethernet interface without having to specify the reference addresses to use for the status information. Instead, you can directly associate variable names with the status bits. For more information, refer to "I/O Variables" in the *PACSystems CPU Reference Manual*, GFK-2222.

Configuring Ethernet Global Data

For more information about Ethernet Global Data, see chapter 4.

Ethernet Global Data can be configured in two ways. The most convenient way is to use the Ethernet Global Data server that is provided with the PLC programming software. This server holds the EGD configurations for all the devices in the EGD network. When the Configuration Server is used, the EGD configuration for the entire EGD network can be validated for accuracy before the configuration is stored into the devices of the network. This can greatly decrease the time needed to commission a network or implement changes in a network.

EGD exchanges can also be configured without using the server. Both methods are described in this chapter. The choice of whether to use the Configuration Server can be made individually for each device.

Basic EGD Configuration

Whether or not the EGD Configuration Server is used, certain steps will need to be taken to use EGD. These steps are described below.

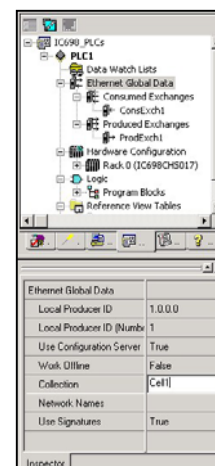
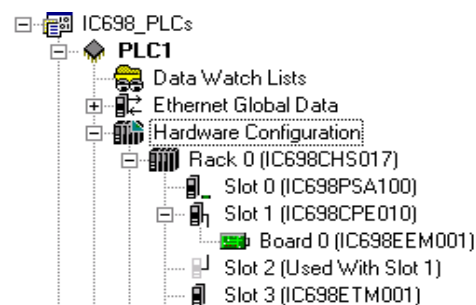
If Ethernet Global Data does not appear as shown, right-click the PLC icon (**PLC1** in this example). Select 'Add Component' and then select 'Ethernet Global Data'.

For each PLC:

1. In the PLC programming software, open the Project folder and expand the target node for the PLC.
2. To configure the Local Producer ID, right-click the Ethernet Global Data node and choose Properties. The Local Producer ID is shown in the properties Inspector window. This parameter must be unique on the network.

The **Local Producer ID** is a 32-bit value that uniquely identifies this Ethernet Global Data device across the network. It can either be expressed as a dotted-decimal value in the same way an IP address value is specified or specified as an integer number. This value defaults to the IP address of the Ethernet Interface with the lowest rack/slot location in the system. The same Producer ID applies to all exchanges produced by this CPU, regardless of which Ethernet Interface is used to send the exchange to the network.

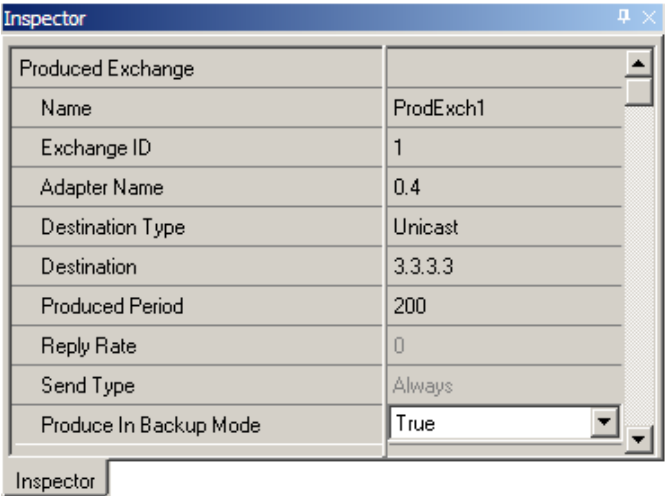
While the form of the Producer ID is sometimes the same as that of an IP address and an IP address is used as its default value, the Producer ID is **not** an IP address. See Chapter 4, Ethernet Global Data, for more information on how the Producer ID is used.



EGD Configuration for Redundancy Systems

For exchanges that are produced in backup mode, an offset must be added to the Exchange ID. This ensures that the Exchange ID is unique for those exchanges that are produced simultaneously by the active and backup controllers.

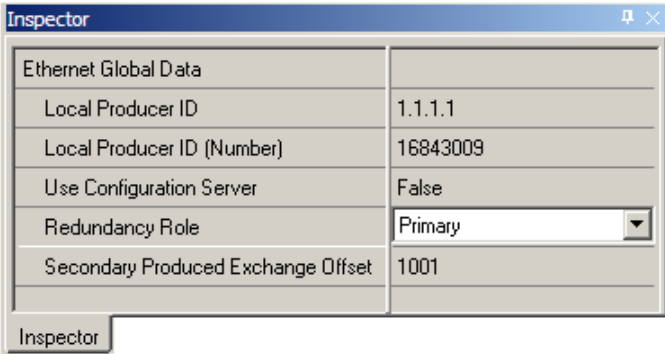
The Produce in Backup Mode parameter appears in the properties for each produced exchange.



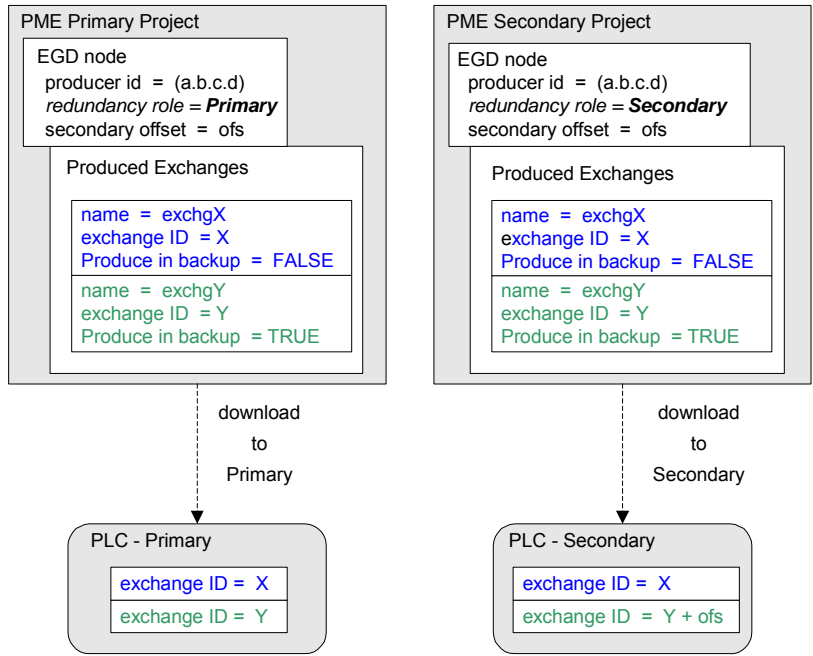
The Secondary Produced Exchange Offset parameter is available in the Ethernet Global Data properties when redundancy is enabled and at least one produced exchange is configured to produce in backup mode. The use of the offset is illustrated on page 3-14.

Non-HSB targets have an additional parameter, Redundancy Role, which appears when any Ethernet interface in the system is configured for redundant IP operation. This parameter is used only within the programming software and is not delivered to the PLC. The Redundancy Role parameter is not displayed for HSB systems.

Note: It is the user’s responsibility to ensure that the same offset value is specified in both the primary and secondary target projects.



Exchange ID Offset in an Ethernet Redundancy System



Using Signatures in Ethernet Global Data

Ethernet Global Data signatures can be used to make sure that the format of the data from the producer matches that expected by the consumer.

The EGD signature is a numeric value that has two parts: the major number and the minor number. The major number reflects the “primary format” of the data. The minor number reflects backward-compatible changes made to the Ethernet Global Data exchange (such as adding data to the end of the exchange).

The primary format of the data is first established when the EGD exchange is defined. At that time the signature is assigned the value of 1.0. Any change that reorders, removes, renames or changes the type or offset of a variable in the exchange is a primary format change that causes the signature major number to be incremented. The signature major number must match between the producer and the consumer for the consumer to consume the data.

The signature minor number is incremented when backward-compatible changes are made in the format of the produced data. Backward-compatible changes are made by adding data to unused areas of the exchange including adding data to the end of the exchange. After checking the signature major number, the consumer checks the signature minor number. If the signature minor number in a sample is greater than the signature minor number configured for the exchange in the consumer then the consumer can consume the data truncating any unexpected data at the end of the sample. The consumer can do this because the minor number change guarantees that only backward-compatible changes have been made in the format of the data.

If the signature of a produced exchange is specified as zero, then consumers will not check it. If the signature of a consumed exchange is configured as zero, then any signature from a producer will be accepted and the data used if the length of the data exactly matches the expected length.

Only the PACSystems RX7i and RX3i support non-zero signatures. All other targets force the signature for both produced and consumed exchanges to be zero.

Use of signatures is enabled by default for new RX7i or RX3i projects and is disabled for other targets and for existing projects.

Configuring EGD Signatures

To select the signature option for a device, right-click the Ethernet Global Data node and choose Properties. The Use Signatures option is displayed in the properties Inspector window. This parameter may be set to True to enable signature support or to False to disable signature support in the device.

Configuring Ethernet Global Data Using the EGD Configuration Server

The EGD Configuration Server is supplied with the Machine Edition software, but it is not automatically installed with Machine Edition. To use the EGD Configuration Server and its associated tools, the server must be installed on the computer as described below.

Installing the EGD Configuration Server

To install the EGD Configuration Server, go to the directory where the machine Edition software is installed and open the folder named “EGD Installs”. Select the file “EgdCfgServerSetup.msi”. Double-click on the file to install the EGD Configuration Server.

Configuring the EGD Configuration Server

To configure the Ethernet Global Data server in Machine Edition, click on the Options tab in the Navigator window. In the Machine Edition folder, select the EGD item to display the configuration options for the configuration server. For example:

EGD Preferences	
Local Server Cache Path	C:\Program Files\DIMPLICITY Machine Edition
Base Path	/EGD
Host Name	172.131.1.25
Server Port	7938
Timeout	20000
Configuration Server	Located

Local Server Cache Path : This parameter sets the path to be used for caching data from the configuration server. This cache is used if the server becomes inaccessible (for example, if the server is on another machine and that machine is inaccessible due to loss of network communications). You can also choose to work offline from the server and use this cache. This mode of operation is explained below.

Base Path : Typically this field should not be changed from the default of /EGD. This is the path portion of the URL used to get to the server.

Host Name : The host name for the computer on which the configuration server runs. This can be specified as “localhost” if the server is on the local machine.

Server Port : This parameter typically is left at the default of 7938. If changed, it must be changed on both the programming software and on the server. This value is not stored in the project but is stored in the computer. It will be used as the default by other projects created on that computer and by other tools such as the EGD Management Tool that require access to the server.

Timeout : The number of milliseconds the programming software will wait for a reply from the server before deciding that the server is not going to respond.

Configuration Server : This read-only parameter displays the value “Located” if the configuration server can be accessed and “Unable to Locate” if the server is not accessible.

When using the configuration server, the producer of data normally defines the exchange. See below for a step-by-step description of defining an exchange in the producer. After the producer of the data defines the exchange, consumers may make use of the exchange. Each consumer selects the desired exchange from the list of produced exchanges and defines the local PLC memory to be used for the variables of interest from the exchange. Consumers can be resynchronized with any changes in the producer on request. Consistency between the producer and consumer(s) is verified during the build and validate process.

Enabling the use of the EGD Configuration Server for a Device

To enable the use of the configuration server for a device, right-click the Ethernet Global Data node and choose Properties. The Use Configuration Server option is displayed in the properties Inspector window. This parameter may be set to True to enable using the configuration server for the device or to False to not use the server.

In some cases you may want to work offline from the configuration server for a while, for example when you want to work disconnected from the network and the configuration server is located on another computer. In this case, you can select the Work Offline parameter and set it to True. The programmer keeps a local copy or cache of the EGD configuration information at a configurable path. Setting this path to a location on the local machine and selecting Work Offline to True allows EGD configuration data to be updated using the cached information without accessing the server. Setting the Work Offline parameter to False and performing a Validate will synchronize the server with the data from the cache.

Network Names and Collections

In order to perform validation between producers and consumers, it is necessary to know whether the producer and the consumer are on the same network. The EGD Configuration Server and its validation libraries use the network name to perform this check. The validation assumes that two devices that have the same network name are connected to the same network. To set the network name, right-click the Ethernet Global Data node and choose Properties. The Network Name option is displayed in the properties Inspector window. This parameter may be set to the name of the network to which the device is connected.

Setting up Collections for the EGD Management Tool

The EGD Management Tool is an optional utility that can be used to provide a system-level look at all the Ethernet Global Data devices in a system. Installation and use of the EGD Management Tool are described in chapter 10.

The EGD Management Tool can look at subsets of EGD devices, called collections. A collection is a logical grouping of EGD devices (for example a manufacturing cell or a machine). To make an EGD device part of a collection, right-click the Ethernet Global Data node and choose Properties. The Collection option is displayed in the Properties Inspector window. This parameter may be set to the name of the collection for the device (by default the collection for a device is the Machine Edition project name).

Configuring an Ethernet Global Data Exchange for a Producer

The information to be sent by the producer and the exchange details are defined in the Properties for each produced exchange. When an individual produced exchange is selected, the Properties Inspector window permits user configuration of the following information:

Name	A name assigned for this exchange. Defaults to “ProdExchX” where X is a sequential number.
Exchange ID	A number that identifies a specific exchange to be sent by the producing device.
Adapter Name	The specific Ethernet Interface, identified by its rack and slot location within the producing PLC.
Destination Type	Specifies whether the data’s destination will be: <ul style="list-style-type: none"> ▪ An IP address (Unicast) ▪ A Group ID (Multicast) ▪ All EGD nodes on the subnet (Broadcast). Choosing broadcast will cause the EGD packets to be received by any node on the network. This can impact performance if there are non-EGD devices on the network. Check with the system’s network administrator if you are unsure about whether to use Broadcast.
Destination	Identifies the data’s consuming device, based on the Destination Type selected above: <ul style="list-style-type: none"> ▪ a dotted-decimal IP address if Destination Type is IP Address ▪ the group’s ID (1–32) if Destination Type is Group ID ▪ the value 255.255.255.255 if Broadcast IP is the Destination Type.
Produced Period	The scheduled repetition period at which the data is produced on the network. Configure a value in the range of 0 or 2–3,600,000 (2 milliseconds to 1 hour). The value zero means data will be produced at the end of each PLC scan, but not less than 2 milliseconds from the previous production. Set the production period to ½ the period at which the application needs the data in this exchange. Round this value up to the nearest 2 milliseconds.
Send Type	Fixed at “always.” In the PLC, production of EGD is controlled by the I/O state: when enabled, EGD production is enabled, and when disabled, EGD production is disabled.
Reply Rate	Not used.

Configuring the Exchange Variables

Double-clicking on the produced exchange opens a window for configuring the variables within the exchange. Each exchange has its own variable list. These variables contain the data that is produced to the network. Each variable contains the following information

Offset (Byte.Bit)	The location within the data area for this exchange where the start of the data for this variable is located. The offset is expressed as Byte.Bit , where <i>Byte</i> is a zero-based byte offset and <i>Bit</i> is a zero-based bit position within that byte. (Valid bit values are 0-7. Bit 0 is the least-significant bit within the byte; bit 7 the most significant.)
Variable	The name defined for this variable. It may be an existing variable or it may be defined using the variable declaration facilities of the programmer such as the variable list in the Navigator.
Ref Address	The PLC memory reference address that contains the start of the data for this variable.
Ignore	Not used for Produced exchange.
Length	Size of the data for this variable, expressed in units of the data type.
Type	Data type of the variable.
Description	An optional text description of this variable.

To add a new variable to the end of the exchange, click the **'Add'** button. This does not change the data offsets of any existing variables within that exchange.

To insert a new variable among the existing variables, click on an existing variable. When you click the **'Insert'** button, a new variable will be created *ahead* of the selected existing variable. This changes the data offsets of all following variables in the exchange and will change the signature major number if you are using signatures.

Once a new variable has been entered, double-click a data field within the row to edit that value.

To delete an existing variable, click on the variable row and then click the **'Delete'** button. If you are using signatures, this will cause the signature major number to change.

The sum of the length for all variables in the exchange must not exceed 1400 bytes. The total length of the exchange is displayed as **'Length (Bytes):'** above the variable list. PACSystems CPUs with firmware version 5.0 and later support a maximum of 30,000 variables for all exchanges. Earlier firmware versions support approximately 12,000 variables for all exchanges.

A variable is automatically created for the local exchange status that is returned to the PLC logic application. The exchange status is not part of the produced exchange data and is not available to the network.

Configuring an Ethernet Global Data Exchange for a Consumer

To create a new consumed exchange, right-click the “Consumed Exchanges” node and select “New”. A dialog box lists all produced exchanges in the EGD network that have been published to the EGD Configuration Server. Select the exchange to be consumed. Once selected, the exchange is populated with the variable, length, type and description information defined in the producer. The variable name consists of the target name, an underscore, and the variable name in the producer. (See below for information about name generation.) You must either enter a reference address or select “ignore” for each variable in the exchange. You must also assign an adapter name and a timeout for the exchange. With these steps, the configuration of the consumer is complete.

When an individual consumed exchange is selected, the following parameters can be configured in the Properties Inspector window. Typically, only the adapter name and the update timeout need to be specified for the exchange and the reference address specified for the variables in the exchange. Changing any other values in a consumed exchange should only be done with expert help.

Name	A name assigned for this exchange. Defaults to the target name of the producer, an underscore, and the exchange ID in the producer. Changing this name may make resynchronization of the variable with the server impossible.
Producer ID	The ID of the PLC producing the exchange. Producer ID is defined by the producer; changing here it may make resynchronization with the server impossible.
Group ID	Used only if the produced exchange has been configured with a Destination Type of Group ID. Group ID is defined by the producer; changing it here may make it impossible to consume the data from the producer.
Exchange ID	Identifies a specific data exchange to be received by the consuming device. Exchange ID is defined by the producer; changing it here may make resynchronization with the server impossible.
Adapter Name	The specific Ethernet Interface, identified by its rack and slot location within the consuming PLC.
Consumed Period	Not used. (Always displayed as 200 milliseconds; not editable.)
Update Timeout	A value in the range 0 to 3,600,000 milliseconds (1 hour). The Ethernet Interface will declare a refresh error if the first or subsequent packet of data does not arrive within this time. The Update Timeout should be at least double the producer period, and should allow for transient network delays. The default is 0 indicates no timeout. Resolution is in 2ms increments.

Name Generation for Consumed Variables

Consumed variables are created automatically. They are based on the variable name in the producer. The name consists of up to seven characters of the beginning of the target name of the producer followed by an underscore character “_” followed by up to 21 characters of the beginning of the variable name of the variable in the producer. Since the PLC programming software allows names of up to 32 characters, it is possible that the generated name for a consumed variable will not be unique. This can occur when the target names of producers have the same first seven characters and variable names have the same first 21 characters. When the generated variable is not unique, the variable in the consumer has an underscore character and a two-digit number appended to it to make it unique.

Synchronizing a Consumed Exchange with Changes in the Producer

If a produced exchange is changed, it is necessary to reflect these changes in the consumers. This can be done very quickly with the EGD configuration server. Once the new definition of the produced exchange has been published to the server, select the consumed exchange in each consumer, right-click and select synchronize to server. The new definition of the produced exchange will be brought in from the server. Any variables that have been added to the producer must have reference addresses assigned if they are to be used or they must be selected as “ignore”. No other action is necessary in the consumer.

Validating the EGD for a Device

One advantage of using the EGD configuration server is the ability to validate the EGD configuration before downloading the configuration to the device. If you right-click on the Ethernet Global Data node in the Navigator, you will see a selection for “Bind and Build”. Selecting this menu item causes the EGD definitions for the target to be cross-checked against the definitions in the server. Each consumed exchange is compared to the produced exchange published by the producer and any discrepancies are noted (see above for how to correct any errors detected in the consumer).

It is also possible, by selecting the menu item “Unconsumed Data Report”, to generate a report listing any variables in produced exchanges that are not being used by a consumer. Producing data that is not being consumed is not necessarily an error; the consumer may not be able to publish its information to the EGD configuration server or the application design may have chosen to publish data that is not needed immediately. However, each unconsumed variable may be an indication of an error or oversight in one or more consumers in the application.

Looking at the Entire EGD Network

The EGD Management Tool can be used to display information about the entire EGD network both offline and online to that network. You can launch the EMT by right clicking on the Ethernet Global Data node in the Navigator and selecting “Launch EGD Management Tool”. The EGD Management Tool will come up in separate frame. It allows you to visualize, analyze and debug an EGD network. See Chapter 10, Diagnostics, for more information on the online capabilities of the EMT. Also see the EMT help for information about running the EMT.

Configuring EGD Devices Not Supported by the EGD Configuration Server

Some devices, for example, certain Ethernet NIUs cannot be configured using the EGD configuration server. Configuration tools for third-party devices that support Ethernet Global Data may not support the EGD configuration server. Rather than not using the server in applications that contain these devices, there is an alternative that allows the EGD configuration for such devices to be put into the server so that it can be used for consumption and validation in other devices.

The programmer distribution includes a tool called the EGD Generic Device Editor. This tool allows you to describe the EGD configuration of a device and publish it to the EGD configuration server. Configuration tools for other devices can use the EGD configuration published by the EGD Generic Device Editor for consumption or validation purposes.

Installing the EGD Generic Device Editor

The EGD Generic Device Editor is not automatically installed when you install the Programmer. To install the GDE, look in the directory where you installed the programmer and you will find a subdirectory named “EGD Installs”. In that directory, you will find a file named “EgdGenericEditorSetup.msi”. Double-click on this file to install the EGD Generic Device Editor.

Running the EGD Generic Device Editor

Installing the EGD Generic Device Editor adds it to the Start – Programs menu of the computer’s Windows system. You will find it under Programs - GE Industrial Systems-EGD Generic Editor. The Windows help for this tool describes its operation.

Configuring Ethernet Global Data Without Using the EGD Configuration Server

If the EGD Configuration Server is not used, each Ethernet Global Data exchange must be configured in both the producer and the consumer. To add exchanges, expand the Ethernet Global Data node in the Project tab. Right click the Consumed Exchanges or the Produced Exchanges node and choose New. The new exchange appears under the selected list node.

1. For each Consumed and Produced Exchange, configure the parameters described in this section.
2. To specify the variable ranges for each exchange, right click the exchange and choose Configure Ranges. The EGD Variable Range Editor window opens.

Configuring an Ethernet Global Data Exchange for a Producer

The information to be sent by the producer and the exchange details are defined in the Properties for each Produced exchange (also called a “page”).

When an individual produced exchange is selected, the Properties inspector window permits user configuration of the following information:

Name	A name assigned for this exchange. Defaults to “ProdExchX” where X is a sequential number.
Exchange ID	A number that identifies a specific exchange to be sent by the producing device.
Adapter Name	The specific Ethernet Interface, identified by its rack and slot location within the producing PLC.
Destination Type	Specifies whether the data’s destination will be: <ul style="list-style-type: none"> ▪ An IP address (Unicast) ▪ A Group ID (Multicast) ▪ All EGD nodes on the subnet (Broadcast IP).
Destination	Identifies the data’s consuming device, based on the Destination Type selected above: <ul style="list-style-type: none"> ▪ a dotted-decimal IP address if Destination Type is IP Address ▪ the group’s ID (1–32) if Destination Type is Group ID ▪ the value 255.255.255.255 if Broadcast IP is the Destination Type.
Produced Period	The scheduled repetition period at which the data is produced on the network. Configure a value in the range of 0 or 2–3,600,000 (2 milliseconds to 1 hour). The value zero means at the end of the next PLC scan, but not less than 2 milliseconds from the previous production. Set the production period to ½ the period at which the application needs the data in this exchange. Round this value to the nearest 2 milliseconds.
Send Type	Fixed at “always.” In the PLC, production of EGD is controlled by the I/O state: when enabled, EGD production is enabled, and when disabled, EGD production is disabled.
Reply Rate	Not used.

Double-clicking on the produced exchange opens a window for configuring the variables within the exchange. Each exchange has its own variable list. These variables contain the data that is produced to the network. Each variable contains the following information:

Offset (Byte.Bit)	The location within the data area for this exchange where the start of the data for this variable is located. The offset is expressed as Byte.Bit , where <i>Byte</i> is a zero-based byte offset and <i>Bit</i> is a zero-based bit position within that byte. (Valid bit values are 0-7. Bit 0 is the least-significant bit within the byte; bit 7 the most significant.)
Variable	The name defined for this variable.
Ref Address	The PLC memory reference address that contains the start of the data for this variable.
Ignore	Not used for Produced exchange.
Length	Size of the data for this variable, expressed in units of the selected PLC reference memory type.
Type	Data type of the selected PLC reference memory type. (Automatically set up by the Ref Address selection.)
Description	An optional text description of this variable.

To add a new variable to the end of the exchange, click the **'Add'** button. This does not change the data offsets of any existing variables within that exchange.

To insert a new variable among the existing variables, click on an existing variable. When you click the **'Insert'** button, a new variable will be created *ahead* of the selected existing variable. This changes the data offsets of all following variables in the exchange.

Once a new variable has been entered, double-click a data field within the row to edit that value.

To delete an existing variable, click on the variable row and then click the **'Delete'** button.

The sum of all variables in the exchange must not exceed 1400 bytes. The total length of the exchange (in bytes) is displayed as **'Length (Bytes):'** at the top of the exchange window above the variable list. PACSystems CPUs with firmware version 5.0 and later support a maximum of 30,000 variables for all exchanges. Earlier firmware versions support approximately 12,000 variables for all exchanges.

A variable is automatically created for the required Status variable. This variable contains the local exchange status that is returned to the PLC logic application. The exchange status is not part of the produced exchange data and is not available to the network.

Configuring an Ethernet Global Data Exchange for a Consumer

The exchange details are defined in the Properties for each Consumed exchange.

When an individual consumed exchange is selected, the Properties inspector window permits user configuration of the following information:

Name	A name assigned for this exchange. Defaults to "ConsExchX" where X is a sequential number.
Producer ID	The PLC producing the exchange. This value, conventionally expressed as a dotted-decimal number, uniquely identifies the Ethernet Global Data device across the network.
Group ID	Used only if the produced exchange has been configured with a Destination Type of Group ID. This Group ID (1-32) must match that of the producer.
Exchange ID	Identifies a specific data exchange to be received by the consuming device. It must match the Exchange ID specified in the produced exchange.
Adapter Name	The specific Ethernet Interface, identified by its rack and slot location within the consuming PLC.
Consumed Period	Not used in PACSystems. (Always displayed as 200 milliseconds; not editable.)
Update Timeout	A value in the range 0 to 3,600,000 milliseconds (1 hour). The Ethernet Interface will declare a refresh error if the first or subsequent packet of data does not arrive within this time. The Update Timeout should be at least double the producer period, and should allow for transient network delays. The default is 0 indicates no timeout. Resolution is in 2ms increments.

Double-clicking on the consumed exchange opens a window for this exchange for configuring the variables within the exchange. Each exchange has its own variable list. These variables contain the data that is consumed from the network. Each variable contains the following information

Offset (Byte.Bit)	The location within the data area for this exchange where the start of this data for this variable is located. The offset is expressed as Byte.Bit , where <i>Byte</i> is a zero-based byte offset and <i>Bit</i> is a zero-based bit position within that byte. (Valid bit values are 0-7. Bit 0 is the least-significant bit within the byte; bit 7 the most significant.)
Variable	The name defined for this variable.
Ref Address	The PLC memory reference address that contains the start of the data for this variable. For consumed exchanges, %S memory types and override references are not allowed. (This field is non-editable when the Ignore selection is set to True.)
Ignore	Allows consumer to ignore this variable. Setting Ignore to True means this variable is not sent to the PLC reference table. Defaults to False.
Length	Size of the data for this variable, expressed in units of the selected PLC reference memory type.
Type	Data type of the selected PLC reference memory type. (Automatically setup by the Ref Address selection.)
Description	An optional text description of this variable.

To add a new variable to the end of the exchange, click the **'Add'** button. This does not change the data offsets of any existing variables within that exchange.

To insert a new variable among the existing variables, click on an existing variable. When you click the **'Insert'** button, a new variable will be created *ahead* of the selected existing variable. This changes the data offsets of all following variables in the exchange.

Once a new variable has been entered, double-click a data field within the row to edit that value.

To delete an existing variable, click on the variable row and then click the **'Delete'** button.

The sum of all variables in the exchange must not exceed 1400 bytes. The total length of the exchange (in bytes) is displayed as **'Length (Bytes):'** at the top of the exchange window above the variable list. PACSystems CPUs with firmware version 5.0 and later support a maximum of 30,000 variables for all exchanges. Earlier firmware versions support approximately 12,000 variables total for all exchanges.

A variable is automatically created for the required Status variable. This variable contains the local exchange status that is returned to the PLC logic application. The exchange status is not part of the consumed exchange data.

A variable is automatically created for the optional Timestamp variable. This variable contains the timestamp of the last received data packet (generated when the exchange was produced) that is returned to the PLC logic application. Set the Ref Address to NOT USED to ignore the timestamp variable.

Any consumed data variable may be ignored by setting the Ignore selection to True. See Selective Consumption, below.

Note: If the total data length of a consumed exchange does not match the length of the produced exchange received from the network, PLC Faults and Ethernet exceptions will occur.

Selective Consumption

Not all data ranges within a produced exchange need to be consumed by each PLC. For example, a producer is producing an exchange consisting of a 4-byte floating point value, followed by a 2-byte integer, followed by a 2-byte analog value. If the consuming PLC wants to consume only the analog value and place it into %AI003, the consumer might be configured as shown below.

Offset	Variable	Ref Address	Ignore	Length	Type	Description
0.0		Ignore	True	6	Byte	Ignore float and integer
6.0	Var01	%AI0003		1	WORD	

Note that where EGD signatures are not used the total length of the exchange must be the same in producer and consumer, even if the consumer is ignoring a portion of the exchange. Failure to configure any ignored bytes in the consumed exchange will result in exchange exception log and fault table entries, error status in the exchange status data, and no data being transferred for the exchange.

This chapter describes basic Ethernet Global Data features for a PACSystems Ethernet Interface.

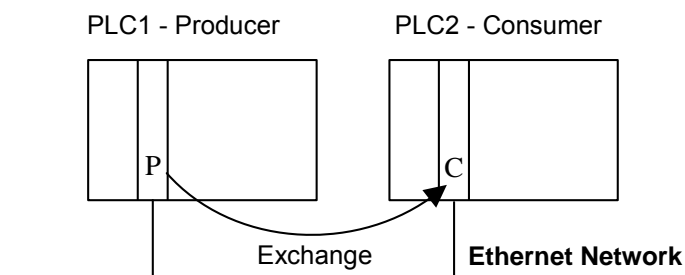
- Ethernet Global Data Operation
- EGD Exchanges
- The Content of an EGD Exchange
 - The Data Ranges (Variables) in an EGD Exchange
 - Valid Memory Types for Ethernet Global Data
 - Planning Exchanges
 - Using Ethernet Global Data in a Redundancy System
- Sending an Ethernet Global Data Exchange to Multiple Consumers
 - Multicasting Ethernet Global Data
 - Broadcasting Ethernet Global Data
- Ethernet Global Data Timing
 - Configurable Producer Period for an EGD Exchange
 - Consumer Update Timeout Period
 - EGD Synchronization
 - Timestamping for Ethernet Global Data Exchanges
 - Effect of PLC Modes and Actions on EGD Operations
- Valid PLC Memory Types for Ethernet Global Data
- Monitoring Ethernet Global Data Exchange Status

Ethernet Global Data Operation

Ethernet Global Data is data that is automatically sent from one Ethernet device to one or more others. Once Ethernet Global Data has been configured, the data is sent automatically during system operation. No program interaction is necessary to produce or consume the global data.

The device that sends the Ethernet Global Data is called the *producer*. Each device that receives Ethernet Global Data is called a *consumer*. Each unique Ethernet Global Data message is called an *exchange* (also sometimes referred to as a *page*).

An Ethernet Interface can be configured to both produce and consume Ethernet Global Data at the same time, using separate exchanges.



The EGD Producer

The producer of an exchange periodically sends new samples of data from its local internal memory. The producer of an exchange is uniquely identified by its Producer ID. The Producer ID can be expressed as a dotted-decimal number (for example, 0.0.0.1). Even when expressed in IP address form, it is not used as an IP address. It is used to identify a particular PLC on the network. Since the Producer ID identifies only the PLC producing the exchange, it doesn't matter how many Ethernet Interfaces are installed in that PLC.

When using the EGD configuration server, each PLC that transfers EGD must be assigned a Producer ID even if that PLC produces no exchanges. The Producer ID uniquely identifies each EGD device in the configuration server and must be present if the server is used.

EGD Consumers

A consumer is a device that will update its local internal memory based on the data in an exchange. The consumer is identified at the producer by an IP Address, a Group ID, or a Subnet Mask, depending on the Destination Type selected.

The Consumed Exchange configuration allows "selective consumption" of a produced EGD exchange. The consumer takes in the whole exchange from the network but does not need to send all of the exchange to the PLC memory. This feature is called Selective Consumption. A Consumed Exchange can be set to ignore the data ranges (variables) that are not needed.

EGD Exchanges

Each exchange in EGD is identified by its Producer ID and Exchange ID. Up to 255 exchanges can be configured for a PACSystems Ethernet Interface. They can be divided into any combination of produced and consumed exchanges. Each exchange can be up to 1400 bytes in length.

Different produced exchanges can include some or all of the same data even though the exchanges are produced at different rates and sent to different consumers. Consumed Exchanges should not duplicate where the data is put as variable conflicts will occur and data will be overwritten by the multiple exchanges

Caution

Ethernet Global Data is designed for simple, efficient communication of sampled data between devices. It is not intended for event notification where the possible loss of a sample of data would be significant.

Some EGD devices support the concept of an EGD “page”. An EGD page consists of one or more exchanges that are produced on the same schedule to the same destination. Pages remove the 1400 byte size limitation of EGD exchanges. Machine Edition does not currently show information about EGD pages; you will instead see the constituent exchanges for each page.

The Content of an Ethernet Global Data Exchange

Each Ethernet Global Data exchange is composed of one or more data ranges transmitted as a sequence of 1 to 1400 bytes of data. The data ranges are commonly called variables; they may be configured to correspond to PLC variables. The content of the data is defined for both the producer and consumers of the data. In this example, a producer sends an 11-byte exchange consisting of the current contents of %R00100 through %R00104 followed by the current contents of %I00257 through %I00264:

Address	Length	Type	Description
%R00100	5	WORD	Conveyor1 in PLC1
%I00257	1	BYTE	Conveyor1 limit switch in PLC1

The same exchange can be configured at each consumer to suit the needs of the application.

The Data Ranges (Variables) in an Ethernet Global Data Exchange

The variables within an exchange are defined in the Ethernet Global Data configuration in hardware configuration. There can be:

- A length of 1 byte to 1400 bytes per exchange. The total size of an exchange is the sum of the data lengths of all of the data ranges configured for that exchange.
- A maximum of 30,000 data ranges for all exchanges in the target, for CPUs with firmware version 5.0 or later. (Earlier firmware versions allow approximately 12,000 EGD data ranges per target.)

Different produced exchanges may share some or all of the same data ranges even if the exchanges are produced at different rates. A consumer does not have to consume all of the data from a produced exchange. A consumed exchange may be configured to ignore specified data ranges. (See “Selective Consumption” in chapter 3, Configuration.)

Valid PLC Memory Types for Ethernet Global Data

The PLC memory types listed below can be included in EGD exchanges.

	<i>Description</i>	<i>P-Producer C-Consumer</i>
%R	Register memory in word mode	P/C
%W	Word memory in word mode	P/C
%AI	Analog input memory in word mode	P/C
%AQ	Analog output memory in word mode	P/C
%I	Discrete input memory in byte mode	P/C
%Q	Discrete output memory in byte mode	P/C
%T	Discrete temporary memory in byte mode	P/C
%M	Discrete momentary memory in byte mode	P/C
%SA	Discrete system memory group A in byte mode	P/C
%SB	Discrete system memory group B in byte mode	P/C
%SC	Discrete system memory group C in byte mode	P/C
%S	Discrete system memory in byte mode	P
%G	Discrete global data table in byte mode	P/C

Discrete point references such as %I or %Q are configured as Byte-Array, Word-Array, or Dword-Array variables. That means a variable with discrete point references must be defined in blocks of 8 points if it is defined as a Byte-Array, 16 points if Word-Array, and 32 points if Dword-Array. Discrete memory must be byte-aligned.

Boolean type and Boolean-Array variables are not allowed.

Planning Exchanges

It is possible to configure more Ethernet Global Data than a PLC can transfer (especially on 10Mbit networks). If high levels of consumer timeouts occur in some or all of the consumed exchanges, the EGD load can be reduced by:

- Increasing the production period (especially if the period is more frequent than double the minimum time in which the data is needed).
- Defining fewer exchanges, each with more data.
- Using EGD groups or broadcasting to subnets. Rather than producing a directed exchange to several destinations, a single exchange can contain all the data and each consumer can transfer only the data it needs from the exchange.
- Adding another Ethernet Interface module to the rack and spreading the EGD exchanges.

Using Ethernet Global Data in a Redundancy System

When configured for Redundant IP operation, the active unit produces all EGD exchanges to the network. The backup unit produces only EGD exchanges that have their Produce in Backup Mode property set to True. When the active Ethernet interfaces changes to backup, it stops production of all EGD exchanges except those that are configured to produce in backup mode.

When configured for Redundant IP operation, the active and backup Ethernet interfaces should be configured to consume EGD exchanges via multicast host groups or the local subnet broadcast address. This permits both the active and backup units to receive the latest data from the network. Unicast operation is not recommended. The backup unit does not consume exchanges at the Redundant IP address.

For additional information about redundancy systems, refer to “Ethernet Redundancy Operation” in chapter 1.

Sending an Ethernet Global Data Exchange to Multiple Consumers

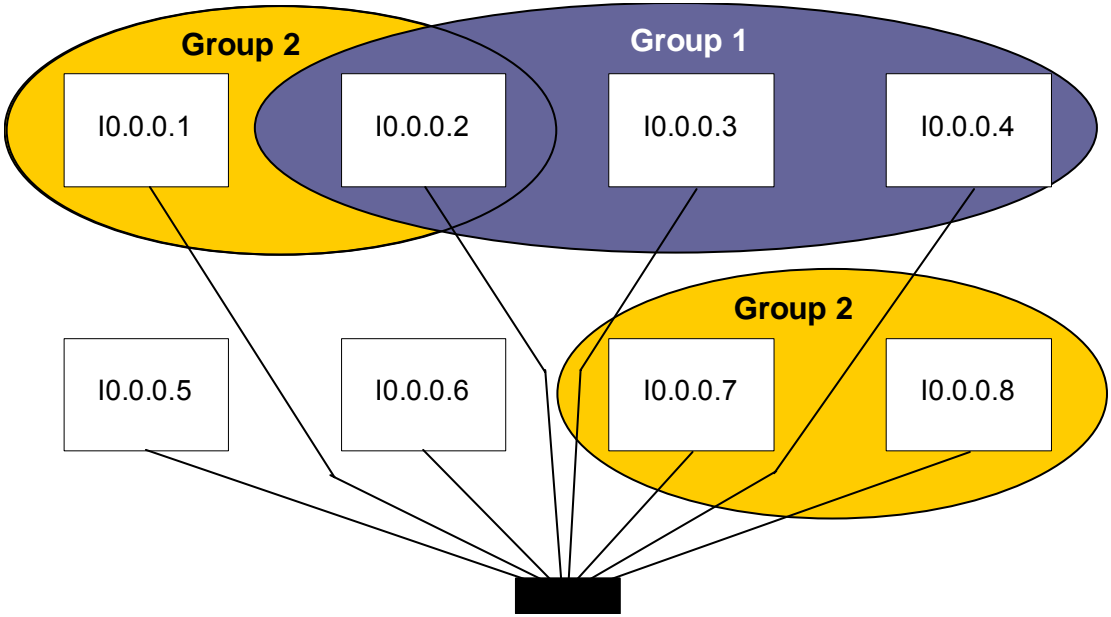
There are two ways to send an EGD Exchange to multiple consumers at the same time: by Multicasting it to a predefined group of consumers or by Broadcasting it to all of the consumers on a subnet. Both methods allow many consumer devices to simultaneously receive the same data from one producing EGD device. If an exchange is Broadcast or Multicast, the same exchange must be configured at the producer and at each consumer. Each consumer can use all of the data or just a selected portion, as configured for the consumed exchanges.

For more information about Multicasting and Broadcasting, refer to chapter 11, Network Administration.

Multicasting Ethernet Global Data

If more than one device on the network should consume a Global Data exchange, those devices can be set up as a group. The network can include up to 32 numbered groups. Groups allow each sample from the producer to be seen simultaneously by all consumers in the group.

A device can belong to more than one group, as illustrated below. In the following example, device 10.0.0.2 consumes exchanges from Group 2 and from Group 1.



Each device in a group responds to the group's assigned ID number from 1 to 32.

Note: Each device on the network using EGD should have a unique local producer ID. If the devices using multicast EGD do not have unique local producer IDs, unexpected results can occur when using group addressing for EGD exchanges.

Each Group ID corresponds to a Multicast (Class D) IP address reserved by the Internet authorities. The default Multicast IP addresses used by Ethernet Global Data are:

<i>Group ID</i>	<i>IP Address</i>
1	224.0.7.1
2	224.0.7.2
.	.
.	.
.	.
32	224.0.7.32

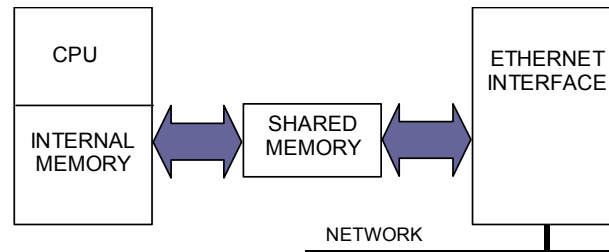
Group Multicast IP Addresses used by Ethernet Global Data should not be changed unless the defaults would cause a network conflict. If necessary, they can be changed within the reserved range of multicast IP addresses (224.0.0.0 through 239.255.255.255). The change must be made using an Advanced User Parameter File.

Broadcasting Ethernet Global Data

The same Ethernet Global Data exchange can be sent to all of the consumers on a subnet by configuring the Produced Exchange to use a Destination Type of "Broadcast". The "Destination" of that exchange then changes to the value 255.255.255.255. (The Ethernet Interface converts this value to the appropriate subnet broadcast mask for this network.) As with a Group ID, each consumer on the subnet can be configured to use some or all of the exchange.

Ethernet Global Data Timing

The Ethernet Interface and PLC CPU share internal memory for Ethernet Global Data operations.



In the producing PLC, the CPU updates its shared internal memory with a data sample when requested by its Ethernet Interface. The update affects the length of the PLC sweep only for that particular exchange; it has little effect on the PLC average sweep time. When the Ethernet Interface's producer period expires, it produces the data sample from shared internal memory onto the network.

In a consuming PACSystems PLC, shared internal memory is updated as soon as the Ethernet Interface gets a data sample from the network. There is no user-configurable consumer period. The CPU updates its reference tables from shared internal memory at the end of the sweep after it is notified by the Ethernet Interface that fresh data has arrived for a specific exchange. The data is made available to the application on the next PLC sweep after it is received. Some other types of Ethernet Interfaces implement a consumption period timer.

EGD Synchronization

Ethernet Global Data attempts to provide the most up-to-date process data, consistent with the configured schedule.

The Ethernet interface maintains a timer for each produced exchange. When the timer for the exchange expires, the Ethernet interface requests that the data for the exchange be transferred from reference memory during the output scan portion of the CPU sweep. At the output portion of the sweep, the CPU puts the data into the shared memory. Once the data has been transferred by the CPU sweep, the Ethernet interface immediately formulates a sample and transfers the sample on the network. (If updated data is not available at the next production timer expiration, the Ethernet interface produces a sample containing the previous data to the network.)

As soon as a sample for a consumed exchange is received, it is transferred to the CPU during the next input scan portion of the CPU sweep.

The result of this scheduling method for Ethernet Global Data is a variability of up to one producer CPU sweep time in the interval between samples produced on the network. This

variability in the time between samples is present to assure that the most up-to-date data is being transferred.

In general, it is not useful or necessary to configure the production period to be less than the CPU sweep time. If the producer period for an exchange is set lower than the CPU sweep time, the Ethernet interface will send a “stale” sample (a sample containing the same data as previously sent) at the configured interval. When the fresh CPU data becomes available at the end of the sweep, the Ethernet interface will immediately send another sample with the fresh data. The timer of the produced exchange is not reset when this sample is sent. This can result in more samples in the network than would be expected from the configured period.

Configurable Producer Period for an EGD Exchange

The Producer period for an EGD exchange can be 2 milliseconds to one hour. In the PLC, the Ethernet Interface attempts to produce the data at this interval. As explained above, the exchange production may vary from the configured interval by up to one production period or one producer CPU sweep period, whichever is smaller.

Producer period is configurable in increments of 2 milliseconds. If the Producer Period is set to zero, production is scheduled every scan or every 2ms, whichever is slower. In a PLC with rapid scan times, scheduling a produced exchange at zero results in a very high load on the network and on the Ethernet Interface, which can degrade overall Ethernet performance. Scheduling multiple exchanges for a zero period in a PLC with a low scan time can result in the Ethernet Interface being unable to produce all the required data, and will also degrade SRTP communication.

Consumer Update Timeout Period

For each consumed exchange, an Update Timeout period can be configured. It determines how long the Ethernet Interface will wait for the starting or subsequent packet of data in the exchange before declaring a refresh error. The update timeout period for the consumer should be set to at least twice the producer period. At very small producer periods, the update timeout should also allow for network transfer variation. Otherwise, the PLC may occasionally falsely report refresh faults. Use zero for the update timeout period of a consumed exchange to disable timeout detection.

Producer Period Guidelines for PLCs

Do not produce and consume data faster than is required by your application. This reduces the load on the network and on the devices, providing capacity for other transfers.

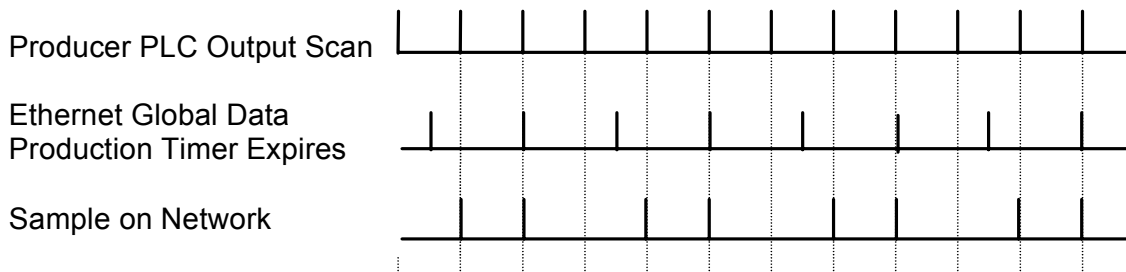
Timing Examples

The following illustrations show the relationship between the PLC output scan time, the produced exchange timer, and data samples on the network.

Example 1

Only one sample is produced on the network per producer period expiration. The variability between samples can be up to producer CPU sweep time.

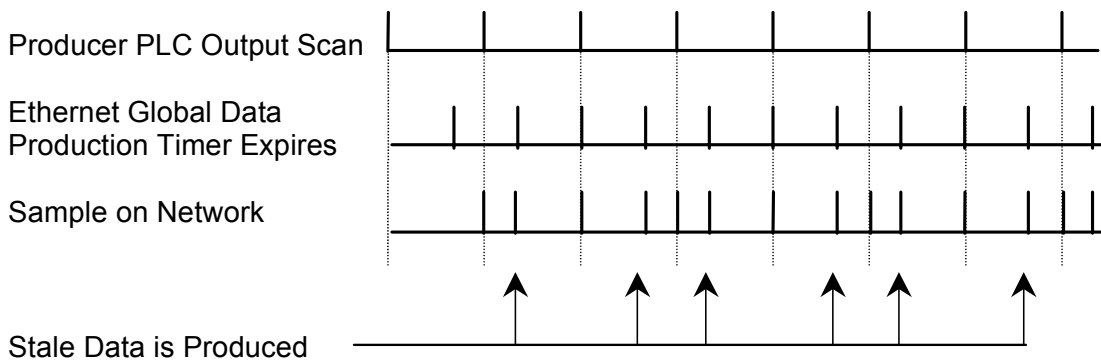
Producer Period = 1.5 Times CPU Sweep



Example 2

More than one sample can be produced per producer period expiration and stale samples are produced to the network.

Producer Period = 2/3 Time of CPU Sweep



Timestamping of Ethernet Global Data Exchanges

The CPU adds a timestamp to each Ethernet Global Data Message it produces. The timestamp indicates when the data was transferred from the producing PLC's CPU to its Ethernet interface for transmission over the network.

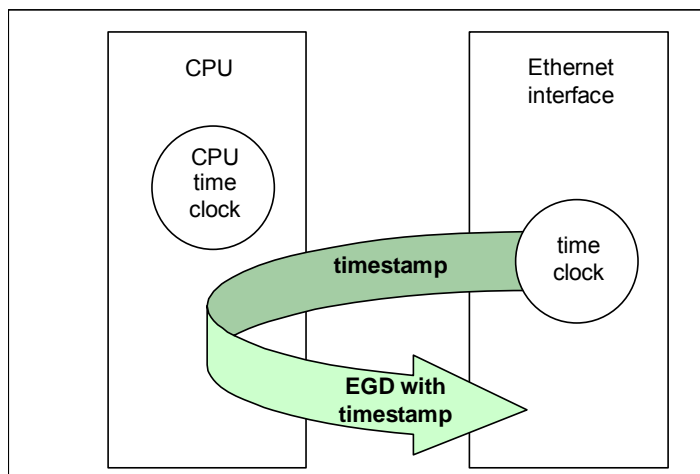
The timestamp is an 8-byte value representing the time elapsed since midnight, January 1, 1970. The first four bytes contain a signed integer representing seconds and the next four bytes contain a signed integer representing nanoseconds. This value can be examined to determine whether a packet received from the network has a new data sample or if it is the same data received previously.

In its default operating mode, the PLC CPU obtains the timestamp data from the time clock in the Ethernet interface, which can be synchronized to either the clock in the CPU or an external SNTP server on the network. For details on SNTP operation, see page 4-22.

Alternatively, the timestamp data can be obtained from the CPU TOD clock when the CPU TOD clock is synchronized with an SNTP server. Synchronizing the CPU TOD clock to an SNTP server allows you to set a consistent PLC time across multiple systems. This operating mode must be configured by an Advanced User Parameter and enabled from the application logic. For additional information, see "Obtaining Timestamps from the CPU TOD Clock" on page 4-13.

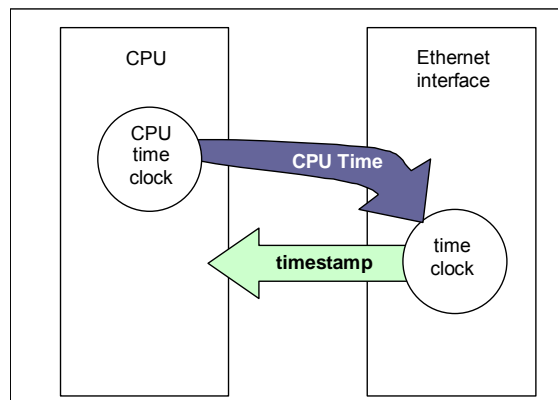
Obtaining Timestamps from the Ethernet Interface Clock

In this operating mode, the PLC CPU obtains the timestamp data from the time clock in the Ethernet interface. The CPU only uses this timestamp for Ethernet Global Data exchanges. The timestamp from the Ethernet interface does not affect the time of the CPU's internal time clock.

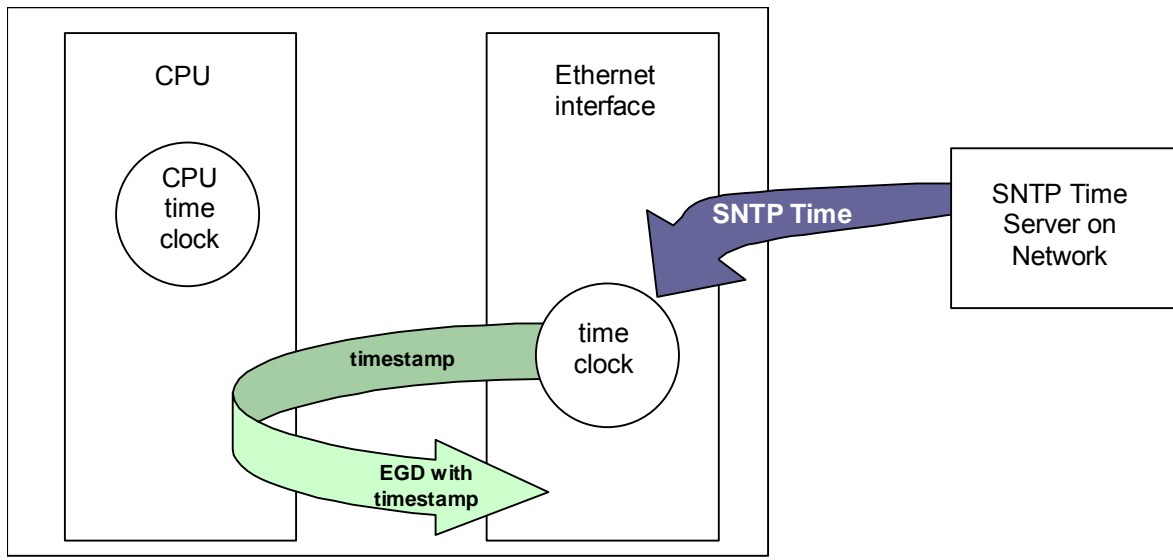


The time clock in the Ethernet Interface is synchronized to either the clock in the CPU or an external SNTP server on the network. Selection of the timestamp source for Ethernet Global Data is part of the basic configuration of the Ethernet Interface, as explained in chapter 3, "Configuration."

PLC's Time Clock: If this source is selected, the Ethernet Interface's built-in time clock is synchronized at power-up or at restart to the clock in the PLC CPU. The timestamp information produced by the PLC has a resolution of 100 microseconds. Because the time clocks in the PLCs on the network are not synchronized, EGD timestamps produced by different PLCs cannot be compared accurately.



SNTP Server's Time Clock: If this source is selected, the Ethernet Interface's built-in clock is periodically synchronized to the clock on an SNTP server on the network. All Ethernet Interfaces configured to use SNTP will have updated, synchronized timestamps. Therefore, accurate timing comparisons between exchanged data can be made. If SNTP is used to perform network time synchronization, the timestamp information typically has ± 10 millisecond accuracy between PLCs on the same network.



Obtaining Timestamps from the CPU TOD Clock

Synchronizing the CPU TOD clock to an SNTP server allows you to set a consistent time across multiple systems. Once the CPU TOD clock is synchronized with the SNTP time, all produced EGD exchanges will use the CPU's TOD for the time stamp.

Synchronizing the CPU TOD clock to a network timeserver requires CPU firmware version 5.00 or greater. Each participating Ethernet interface must use firmware version 5.00 or greater. Older firmware versions do not support the necessary COMMREQ commands.

Synchronizing the CPU TOD Clock to an SNTP Server

The CPU TOD clock is set with accuracy within ± 2 ms of the SNTP time stamp.

CPU TOD clock synchronization is enabled on an Ethernet module by setting the Advanced User Parameter (AUP) *ncpu_sync* to 1. For details on configuring an AUP file, refer to Appendix A.

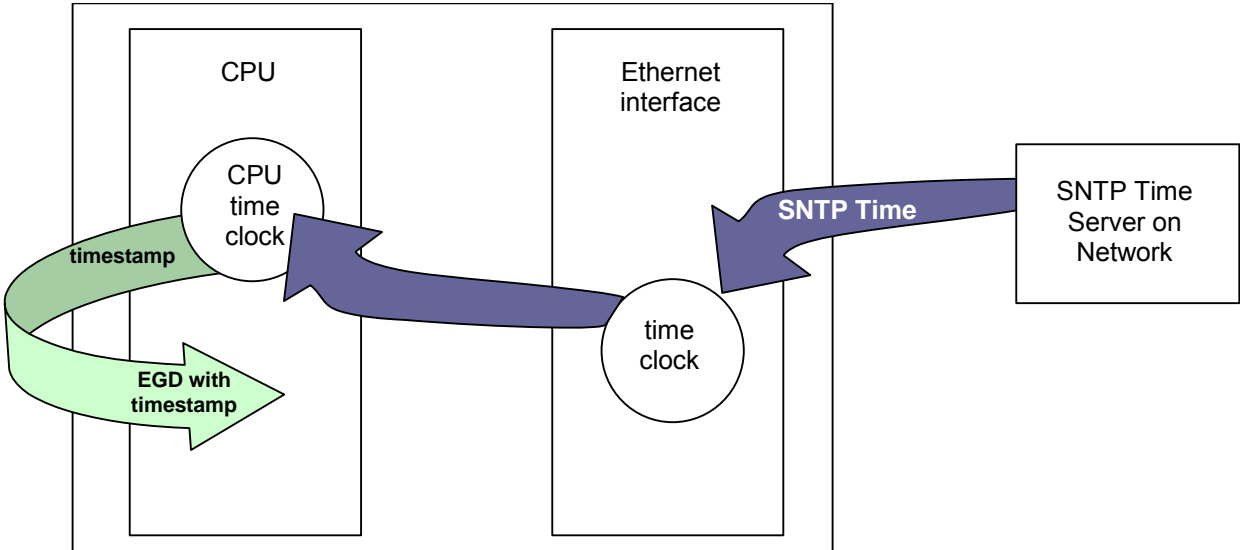
Within a PLC, only one Ethernet interface at a time can be selected as the time master for CPU time synchronization. If multiple Ethernet modules are configured for CPU time synchronization, the PLC application logic should issue a *Read Ethernet Clock Status and Stratum COMMREQ (5001)* to each configured module. The application logic must examine

the stratum number at each Ethernet module to determine which Ethernet module to select. When the application has determined which module to use as the time master, it must send an *Enable PLC Time Update COMMREQ (5002)* to that module.

When the CPU TOD is used for EGD time stamps, it continues until a STOP transition occurs. On a RUN to STOP transition, the CPU disables CPU TOD clock synchronization. The PLC application logic must enable CPU TOD clock synchronization by sending an Enable PLC Time Update COMMREQ (5002) on every STOP to RUN transition.

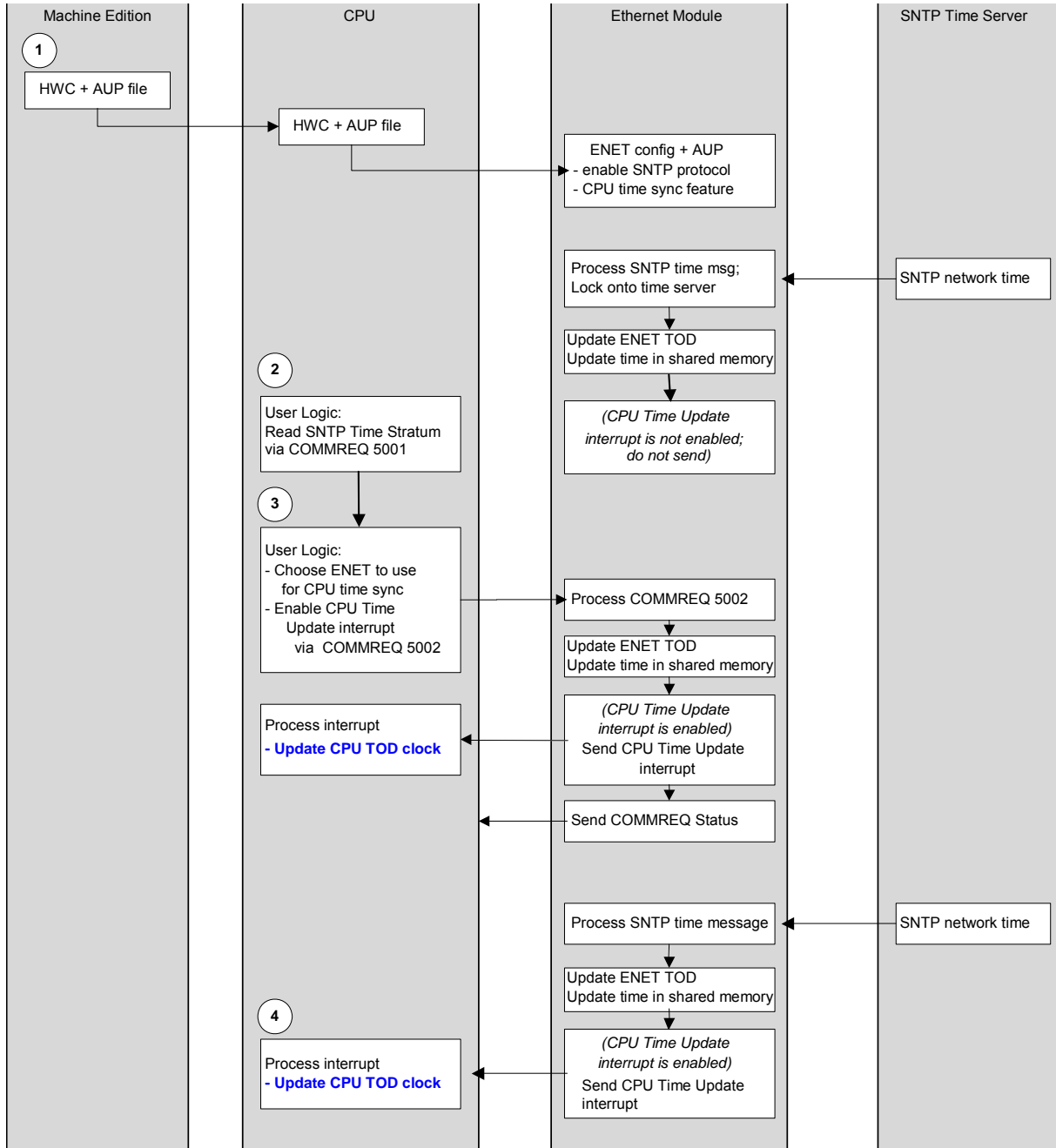
For an overview of this operating sequence, see page 4-15.

Note: With the AUP parameter `ncpu_sync =1`, the Ethernet modules get their time from the SNTP network server regardless of the Network Time Sync setting in the Ethernet module's hardware configuration.



Operating Sequence for CPU Clock Synchronization

The following diagram illustrates the sequence of events for setup and operation of a system that uses clock synchronization.



Steps to Synchronize the CPU TOD Clock to an SNTP Server

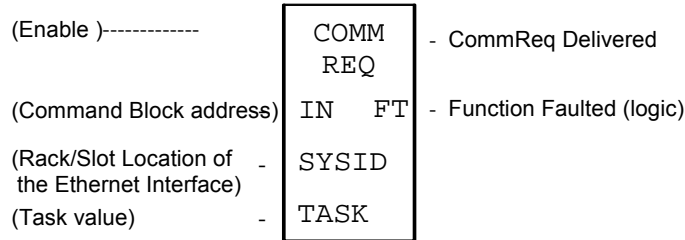
These steps correspond to the numbers in the operating sequence illustrated on page 4-15.

1. The user configures an AUP file to enable the CPU Time Sync feature and imports AUP file(s) into the PLC configuration. The user stores HWC containing AUP file(s) to PLC.
2. The user logic program uses the *Read Ethernet Clock Status and Stratum COMMREQ (5001)* to obtain clock status and stratum for each feature-enabled Ethernet interface. The user logic program selects the Ethernet interface advertising the lowest SNTP stratum value to use for CPU time synchronization.
3. The application logic program enables CPU time update for the selected Ethernet interface via the *Enable PLC Time Update COMMREQ (5002)*. If the Ethernet interface is already locked to an SNTP timeserver on the network, the CPU immediately updates its TOD clock.
4. At every subsequent periodic network time message from the locked SNTP timeserver, the CPU receives the network time and immediately updates its TOD clock.

Note: In a PLC with only one Ethernet interface, the logic program may skip step 2. There is no need to select between multiple Ethernet interfaces.

SNTP Time Transfer COMMREQs

The PLC application logic uses the following Communication Requests (COMMREQ) functions to control CPU TOD clock synchronization. The Communications Request is triggered when the logic program passes power to the COMMREQ Function Block.



The parameters of the COMMREQ are:

Enable: Control logic for activating the COMMREQ Function Block.

IN: The location of the Command Block. It can be any valid address within a word-oriented area of (%R, %AI, %AQ, %P, %L, or %W).

SYSID: A hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet Interface. For the PACSystems CPU embedded Ethernet interface, enter the rack/slot location of the CPU module.

<i>Rack</i>	<i>Slot</i>	<i>Hex Word Value</i>
0	4	0004H
3	4	0304H
2	9	0209H
4	2	0402H

TASK: For the PACSystems Ethernet module, Task must be set to 98 (62H).

For the PACSystems CPU embedded Ethernet interface, Task must be set to the value 65634 (10062H) to address the CPU's Ethernet daughterboard.

Caution

Entering an incorrect TASK value may cause the Ethernet Interface to fail.

FT Output: The FT output is set if the PLC CPU (rather than the Ethernet Interface) detects that the COMMREQ fails. In this case, the other status indicators are not updated for this COMMREQ.

Read Ethernet Clock Status and Stratum COMMREQ (5001)

This COMMREQ is used to read the clock status and stratum from the specified Ethernet Interface.

If multiple Ethernet modules are enabled for TOD Clock Synchronization, the application logic must examine the stratum at each Ethernet module to determine which Ethernet module to select.

Command Block for Read Ethernet Clock Status and Stratum COMMREQ

Word Offset	Value	Description
Word 1	Length of command data block.	Always 3.
Word 2	0	Always 0 (Wait/No Wait mode request).
Word 3	For a list of memory type codes, see “COMMREQ Status for the EGD Commands” in chapter 5.	Memory type of the COMMREQ status word.
Word 4	0-based	Offset of COMMREQ status word. For CRS word values, refer to page 4-21.
Word 5	0	Always 0.
Word 6	0	Always 0.
Word 7	5001	Read Clock Status and Stratum command number.
Word 8	For a list of memory type codes, see “COMMREQ Status for the EGD Commands” in chapter 5.	Memory type of the storage location for the clock status and stratum values retrieved from the Ethernet interface.
Word 9	Any valid offset within memory type specified in Word 8. This is a 1-based number.	Ethernet Clock Status and Stratum reference address offset

The Ethernet clock status and stratum values from the locked time server (if any) are returned as two consecutive words.

Clock Status and Stratum Format

Clock Status and Stratum PLC memory address	Clock Status
Clock Status and Stratum PLC memory address + 1	Clock Stratum

An Ethernet Interface can maintain timing information from up to four SNTP servers at a time. Each server assigns a stratum number that determines its priority.

When locked to a network timeserver, the Ethernet clock stratum value indicates the accuracy of the time value provided by the server. A stratum value of 1 indicates the highest accuracy time; a value of 15 indicates the lowest accuracy. A stratum value of 255 indicates that the Ethernet clock is not locked to any timeserver. Before using this stratum value, always check that the corresponding clock status indicates that the Ethernet clock is locked to a network timeserver.

The **Status** word indicates whether the Ethernet clock is locked to a network timeserver.

Clock Status Word Values

<i>Value</i>	<i>Description</i>
0	Ethernet interface is not configured for SNTP operation
1	Ethernet clock is currently locked to network timer server
2	Ethernet clock is not locked to network timer server

Note: Bit 5 in the LAN Interface Status (LIS) block indicates whether the Ethernet module is currently locked to an SNTP timeserver on the network. The logic application can periodically examine this bit to determine when an Ethernet module has lost its lock with a network timeserver. For details of the LIS block, refer to “Monitoring the Ethernet Interface Status Bits” in chapter 10.

Enable or Disable PLC Time Update COMMREQ (5002)

This COMMREQ is used to enable or disable a specific Ethernet interface to update the CPU's TOD clock. When enabled, the Ethernet interface updates the TOD clock each time that a time update message is received from an SNTP server on the network. If the Ethernet interface is locked to a timer server when this COMMREQ command is issued, the Ethernet interface immediately updates the TOD clock with the current synchronized clock value.

Command Block for Enable/Disable PLC Time Update COMMREQ

Word Offset	Value	Description
Word 1	Length of command data block.	Always 2
Word 2	0	Always 0 (Wait/No Wait mode request).
Word 3	For a list of memory type codes, see "COMMREQ Status for the EGD Commands" in chapter 5.	Memory type of the COMMREQ status word.
Word 4	0-based	Offset of COMMREQ status word. For CRS word values, refer to page 4-21.
Word 5	0	Always 0.
Word 6	0	Always 0.
Word 7	5002	Enable/Disable Time Update command number
Word 8	1 = Enable PLC time update 0 = Disable PLC time update	This word contains the value to enable or disable this Ethernet interface to update the PLC clock. This word must be set to 0 to disable PLC clock updates, and set to 1 to enable PLC clock updates. All other values will cause COMMREQ to return a failure status.

COMMREQ Status Word Values

The following table lists the CRS values returned by the SNTP Time Transfer commands. For a discussion of CRS major and minor codes, refer to “Communication Request” in the *PACSystems CPU Reference Manual, GFK-2222*.

Before executing a COMMREQ, the application logic should set the CRS word to 0. After executing a COMMREQ, the application logic should monitor the CRS word to determine the completion and success of that command.

Minor (Hex)	Major (Hex)	Description
00	01	Successful completion.
04	01	Successful completion. The Ethernet interface is not locked to an SNTP server at this time, so the CPU clock was not updated.
05	01	Successful completion. The CPU clock was already synchronized to the SNTP server via this Ethernet interface, so the CPU clock was not updated again.
11	0C	Internal error reading clock status or stratum value from this Ethernet interface. The clock status/stratum values were not returned.
12	0C	Internal error enabling CPU time synchronization. The CPU clock will not be synchronized to an SNTP server at this Ethernet interface.
13	0C	Internal error disabling CPU time synchronization.
07	0D	COMMREQ data block length (COMMREQ word 1) is too short.
08	0D	COMMREQ command code (COMMREQ word 7) is not recognized.
10	0D	CPU and/or ENET firmware version does not support SNTP Time Transfer feature.
12	0D	Attempted to enable CPU time sync on this Ethernet interface while already enabled on another Ethernet interface. The logic application must first disable CPU time sync on the original Ethernet interface before enabling on another Ethernet interface.
13	0D	Attempted to disable CPU time sync that was not previously enabled at this Ethernet interface.
14	0D	Invalid COMMREQ command data.
15	0D	COMMREQ not allowed because SNTP Time Transfer feature was not configured.
16	0D	COMMREQ data block length (COMMREQ word 1) is too long.

SNTP Operation

In an SNTP system, a computer on the network (called an SNTP server) sends out a periodic timing message to all of the SNTP-capable Ethernet Interfaces on the network, which keep their internal clocks synchronized with this SNTP timing message.

In a redundancy system, SNTP operation is unaffected by the current Ethernet redundancy state or by redundancy role switches.

SNTP server dates before January 1, 1989 are not supported.

Normal SNTP Operation

The Ethernet Interface will synchronize to a remote SNTP timeserver after receiving two broadcast clock values within a 150-second period. The Station Manager can be used to view server status information.

Multiple SNTP Servers

To guard against loss of SNTP timing messages, multiple SNTP timeservers can be tracked on a network. An Ethernet Interface can maintain timing information from up to four total SNTP timeservers at a time. Each server assigns a stratum number that determines its priority. The Ethernet Interface uses the message from the server with the lowest stratum number until communication with that server is lost. Then the server with the next lowest stratum number becomes the server of choice and the Ethernet Interface synchronizes to it if it receives two of its timing messages within a 150-second period. A server is considered "lost" if more than 150 seconds elapse between timing messages.

Loss or Absence of SNTP Timing Signals

If an Ethernet Interface is configured for SNTP, but does not receive two timing messages from an SNTP network timeserver within a 150-second period, the following will happen:

- A fault entry will be placed in the PLC Fault Table.
- A fault entry will be placed in the Ethernet Interface's exception log. This log can be read using the Station Manager.
- The Status word within a consumed exchange will indicate new data with a value of 3, instead of the normal 1 value, indicating that SNTP is selected, but the Ethernet Interface is not synchronized to an SNTP server. This Status word value can be obtained from the PLC register configured for the particular exchange.

Note: The SNTP error condition is considered the least important of all possible error codes. Therefore, if another error condition exists, its status code will appear in the Status word instead of the SNTP error code.

Upon loss or absence of synchronization, the Ethernet Interface's built-in clock will operate as follows:

- If the Ethernet Interface, after its last power-up/restart cycle, has never received an SNTP server's timing message, it will continue to use the PLC CPU's local clock value that it received at power-up/restart for its time base.
- If the Ethernet Interface has been synchronized to an SNTP server but lost its signal, it will use the most recently received SNTP time message as its time base.

The Ethernet Interface will continue supplying time values to the PLC CPU for timestamping, while it "listens" for SNTP timing messages from the network. If SNTP messages are received later, the Ethernet Interface will then synchronize to them.

Effect of PLC Modes and Actions on EGD Operations

The configuration and operation of Ethernet Global Data may be affected by the PLC's current mode and by certain PLC actions:

- The normal PLC mode for EGD operation is RUN with Outputs enabled. In this PLC mode, Ethernet Global Data remains configured and exchanges are both produced and consumed.
- If the PLC mode is set to STOP with I/O disabled, the Producer ID remains configured, but production and consumption stop. Note that while consumed data is not transferred to the PLC memory in this mode, data from the network is still transferred to the shared memory so that the latest data is available immediately when the PLC transitions out of STOP with I/O disabled mode.
- If configuration is lost, the Ethernet Global Data configuration must be stored again.

PLC Mode or Action	Producer ID remains configured	Configuration-Based Exchanges continue to be		
		Configured	Produced	Consumed
PLC Mode				
RUN-Outputs Enabled	YES	YES	YES	YES
RUN-Outputs Disabled	YES	YES	NO	YES
RUN-SUSPEND I/O ¹	YES	YES	NO	NO
STOP-I/O Enabled	YES	YES	YES	YES
STOP-I/O Disabled	YES	YES	NO	NO
PLC Action				
RUN-Store Logic	YES	YES	YES	YES
STOP-Store Logic	YES	YES	*	*
STOP-Clear Logic	YES	YES	*	*
STOP-Config Store	Replaced ²	Replaced ²	NO ³	NO ³
STOP-Clear Config	NO	NO	NO	NO
PLC Power Cycle	YES	YES	*3	*3
Ethernet Interface Restart	YES	YES	*3	*3

* Production and consumption is controlled by the PLC Mode as described above.

¹ RUN-SUSPEND I/O refers to the SUSIO logic function. (The DOIO logic function does not affect EGD production or consumption.)

² Producer ID and exchange definitions are replaced.

³ Producer ID and exchange states depend on the PLC mode and configuration prior to the action.

Monitoring Ethernet Global Data Exchange Status

The Exchange Status word is used to store status information about an EGD exchange. A unique Exchange Status word location must be configured for each exchange.

The PLC writes status codes into the Exchange Status word whenever an exchange is transferred or a consumer timeout occurs

The Exchange Status word is typically set to 1, indicating that data transfer occurred successfully. The application program can monitor for error conditions reported in the Exchange Status word by setting it to 0 once a non-zero value is written to it. In all cases, if the least significant bit of the exchange status is set to a 1, then data was transferred successfully. Status values other than 1 with the least significant bit set (e.g. 3, 5 and 7) give information about the data that was transferred, the producer or the network that are noteworthy in the application.

The program should also monitor the “LAN Interface OK” Status bit (see chapter 10, Diagnostics) for each of the Ethernet Interfaces performing EGD. The Exchange Status word is invalid if the bit is 0.

Note that when an EGD exchange message received from the network contains an invalid Protocol Version Number, the Ethernet Interface cannot decode the message in order to identify the exchange. In this case, the Exchange Status Word cannot be updated.

Exchange Status Word Error Codes

The following table shows the error codes that can be written to the Exchange Status word in the Producer (P) and Consumer. The Exchange Status Word value for each exchange may be displayed via the STAT G Station Manager command. The Exchange Status Word values are displayed within parentheses.

Value (Dec.)	P / C	Error	Description
0	P/C	No new status event has occurred.	Produced: Initial value until the first producer period refresh occurs. Consumed: The data has not been refreshed since the previous consumption scan and the consumer timeout has not expired.
1	P	No error currently exists.	The exchange is producing data. This value should be ignored in the Output Disabled PLC modes.
1	C	No error, data consumed.	The data has been refreshed on schedule since the previous consumption.
3	C	SNTP error.	The Ethernet Interface in the producer is configured for network time synchronization, but is not synchronized to an SNTP server. The data was refreshed on schedule.
4	P/C	Specification error.	During exchange configuration, an invalid configuration parameter was received by the Ethernet Interface or an error occurred in communication with the PLC CPU.
5	C	Stale or invalid data sample	Consumed: The producer has indicated that the data sent was stale or otherwise not valid at the time it was produced.
6	C	Refresh timeout without data.	The exchange's timeout period is configured to a non-zero value and the data has not been refreshed within the timeout period.
7	C	Data after refresh timeout.	The data has been refreshed since the previous consumption, but not within the timeout period.
10	P/C	IP Layer not currently initialized.	This status can be set during exchange configuration* if the Ethernet Interface detects that it cannot currently access a network. This temporary status can change if successful network access becomes possible.
12	P/C	Lack of resource error.	Local resources are not available to establish the exchange during exchange configuration*. The PLC Fault Table may provide more detail on the specific error.
14	C	Data size mismatch error	The data size of a consumed exchange does not match the exchange definition. The exchange is ignored.

Note: PACSystems does not support EGD exchange status values 16, 18, 22, 26, 28, and 30. These exchange status values were used in Series 90 products only.

* Exchange configuration occurs when either 1) Hardware Configuration containing EGD is stored to the PLC, 2) a PLC containing EGD configuration powers up, or 3) an Ethernet Interface configured for EGD is restarted.

Chapter *Programming EGD Commands*

5

This chapter describes a set of commands that can be used in the application program to read and write data over the Ethernet network:

- Read PLC Memory
- Write PLC Memory
- Read EGD Exchange
- Write EGD Exchange
- Masked Write to EGD Exchange

General Use of EGD Commands

COMMREQ-driven EGD Commands can be used in the application program to read and write data into PACSystems PLCs or other EGD Class 2 devices.

The Ethernet interface supports a maximum of 10 simultaneous EGD commands.

Using EGD Commands in a Redundancy System

When two Ethernet Interfaces are configured for Redundant IP operation (see chapter 1, "Introduction," for more information), only the active unit sends or responds to EGD commands. The backup unit does not send or respond to the Redundant IP address. If the backup unit tries to send an EGD command, a COMMREQ error status is returned to its application program.

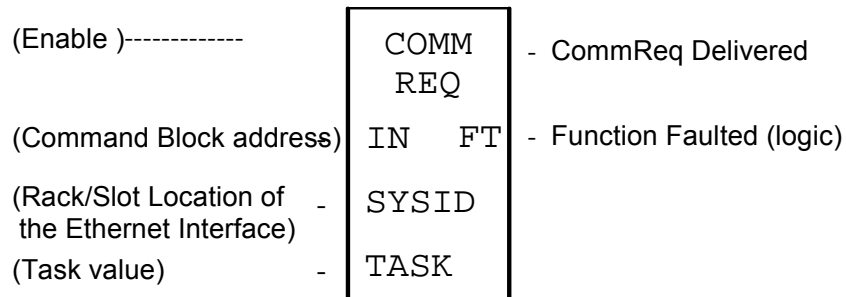
If the active Ethernet interface changes to backup status, it takes down all reliable datagram services (RDS) sessions that use the Redundant IP address. Any EGD command currently in process over the Redundant IP address when a role switch occurs is ended.

Although not recommend, EGD commands may be issued to the direct IP address. Both the active and backup units will respond to EGD commands received at the direct IP address. (Remote hosts should use the Redundant IP address when communicating to a redundant system.)

COMMREQ Format for Programming EGD Commands

The EGD commands described in this chapter are sent using the Communications Request (COMMREQ) function.

The Communications Request is triggered when the logic program passes power to the COMMREQ Function Block.



For the EGD commands, the parameters of the COMMREQ are:

Enable: Control logic for activating the COMMREQ Function Block.

IN: The location of the Command Block. The Command Block contains the parameters of the COMMREQ request. It can be located at any valid address within a word-oriented memory area (%R, %AI, %AQ, %P, %L, or %W) in the PACSystems PLC. Parameters for the EGD commands are described on the following pages.

SYSID: A hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet Interface. For example, an Ethernet Interface in rack zero, slot six would use the value 6 for this parameter. For the PACSystems CPU embedded Ethernet interface, enter the rack/slot location of the CPU module.

TASK: For the PACSystems CPU embedded Ethernet interface, Task must be set to the value 65536 (10000H) to address the CPU's Ethernet daughterboard. For a PACSystems Ethernet module, Task must be set to zero.

FT Output: The FT output is set if the PLC CPU is unable to deliver the COMMREQ to the Ethernet interface. When the FT output is set, the Ethernet Interface is unable to return a COMMREQ status word to the PLC logic application.

COMMREQ Status for the EGD Commands

Words 3 and 4 of every COMMREQ Command Block specify a memory type and location to receive status information about the execution of the command.

Word 3 specifies the memory type for the COMMREQ status word. The memory types are listed in the table below:

Type	Value (Decimal)	Value (Hex.)	Description
%R	8	08H	Register memory (word mode)
%AI	10	0AH	Analog input memory (word mode)
%AQ	12	0CH	Analog output memory (word mode)
%I	16	10H	Discrete input memory (byte mode)
	70	46H	Discrete input memory (bit mode)
%Q	18	12H	Discrete output memory (byte mode)
	72	48H	Discrete output memory (bit mode)
%T	20	14H	Discrete temporary memory (byte mode)
	74	4AH	Discrete temporary memory (bit mode)
%M	22	16H	Discrete momentary internal memory (byte mode)
	76	4CH	Discrete momentary internal memory (bit mode)
%G	56	38H	Discrete global data table (byte mode)
	86	56H	Discrete global data table (bit mode)
%W	196	C4H	Word memory (word mode; limited to %W1-%W65536)

Word 4 of the COMMREQ Command Block specifies the offset within the memory type selected. **The status word address offset is a zero-based number.** For example, if %R1 should be the location of the status word, you must specify a zero for the offset. The offset for %R100 would be 99 decimal. (When using %W memory, the maximum offset value that can be entered is 65535, signifying %W65536.)

COMMREQ Status Values

The Ethernet Interface reports the status of the COMMREQ back to the status location. See chapter 10, Diagnostics, for COMMREQ status values that may be reported for the EGD commands.

Read PLC Memory (4000)

The Read PLC Memory command can be used to read memory locations from a remote PACSystems PLC. This command does not require configuration of a produced / consumed exchange in the PLCs. The Read PLC Memory command can only be sent to an individual IP Address; it cannot be sent to a Group ID (multicast).

Read PLC Memory Command Block

Word Offset	Value	Description
Word 1	Length of command data block	Always 22
Word 2	0	Always 0 (no-wait mode request)
Word 3	(See previous page)	Memory type of COMMREQ Status Word
Word 4	0-based.	Offset of COMMREQ Status Word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	4000 (fa0H))	Read PLC Memory command number.
Word 8	Retry time, in milliseconds	The time between retries of command transfers, in 10-millisecond increments. Default is 1000ms.
Word 9	Local read buffer memory type	Memory type for the data to be placed in the local PLC.
Word 10	Local read buffer reference table starting address (least significant word)	1-based offset in the local PLC
Word 11	Local read buffer reference table starting address (most significant word)	
Word 12	Remote read location memory type	Memory type from which data will be read in the remote PLC
Word 13	Remote reference table read location starting address (least significant word)	1-based offset in the remote PLC
Word 14	Remote reference table read location starting address (most significant word)	
Word 15	Remote reference table length (in remote memory units)	Number of remote memory units to be read.
Word 16	Network address type	Must be 1. Indicates an IP address will be used.
Word 17	Network address length	Must be 4 for IP address. Group ID (multicast) is not permitted.
Word 18 – Word 21	IP Address of the remote PLC	Four integers, specified as one integer per word of the dotted-decimal IP address of the remote PLC. May not be a group IP address.
Word 22	Reserved	Always 0

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) EGD Command Number: Word 7 requests that a read PLC memory operation occur. If the command is processed successfully, it will result in PLC reference memory data being retrieved from the server to the client.

(Word 8) Command Retry Time: Word 8 specifies the time (in milliseconds) the Ethernet Interface will wait between retries when transferring the command. A total of four tries will be made to send the command. If no response is received after the four tries (i.e. after four times the retry time value), an error status will be returned in the COMMREQ status word. If the command retry is specified as zero, the default value of one second is used.

(Word 9) Local PLC - Memory Type: Words 9-11 specify the location in the local PLC where the Ethernet Interface will store data received from the remote PLC. Valid values for Word 9 are listed below. The amount of data to be transferred is specified by the number of memory units of the data read from the remote PLC (Word 15).

<i>Type</i>	<i>Value (Decimal)</i>	<i>Description</i>
%W *	196	Word memory (word mode)
%R	8	Register memory (word mode)
%AI	10	Analog input memory (word mode)
%AQ	12	Analog output memory (word mode)
%I	16	Discrete input memory (byte mode)
	70	Discrete input memory (bit mode)
%Q	18	Discrete output memory (byte mode)
	72	Discrete output memory (bit mode)
%T	20	Discrete temporary memory (byte mode)
	74	Discrete temporary memory (bit mode)
%M	22	Discrete momentary internal memory (byte mode)
	76	Discrete momentary internal memory (bit mode)
%SA	24	Discrete system memory group A (byte mode)
	78	Discrete system memory group A (bit mode)
%SB	26	Discrete system memory group B (byte mode)
	80	Discrete system memory group B (bit mode)
%SC	28	Discrete system memory group C (byte mode)
	82	Discrete system memory group C (bit mode)
%S †	30	Discrete system memory (byte mode)
	84	Discrete system memory (bit mode)
%G	56	Discrete global data table (byte mode)
	86	Discrete global data table (bit mode)

† Read-only memory, cannot be written to.
 * %W memory is supported on PACSystems clients and servers only.

(Words 10 - 11) Local PLC - Memory Starting Address: Words 10 and 11 determine the starting address in the local PLC in which the data from the remote PLC is to be stored. The value entered is the 32-bit offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 9. Word 10 contains the least significant 16 bits of the offset; word 11 contains the most significant 16 bits of the offset. This offset will be either in bits, bytes, or words depending on the mode specified. (For example, if Word 9=16 and Words 10,11 = 2, 0 then the starting address will be %I9.) Valid ranges of values depend on the PLC's memory ranges. The user is responsible for assuring that this area is large enough to contain the requested data without overwriting other application data.

(Word 12) Remote PLC - Memory Type: Words 12–14 specify the memory type and starting address in the remote PLC from which the data is to be read. Valid values for Word 12 are listed above.

(Words 13 - 14) Remote PLC - Memory Starting Address: Words 13,14 determine the starting address in the remote PLC from which the data is to be read. The value entered is the 32-bit offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 12. Word 13 contains the least significant 16 bits of the offset; word 14 contains the most significant 16 bits of the offset. This offset will be either in bits, bytes, or words depending on the mode specified (for example, if Word 12=16 and Words 13,14 =9, 0, then the starting address will be %I65). Valid ranges of values depend on the remote PLC's memory ranges.

(Word 15) Remote PLC - Number of Memory Units: Word 15 specifies the amount of data to be transferred. The value entered is the number of memory units to be transferred, where the size of the remote PLC memory type (bit, byte, or word) is specified in Word 12. For example, if Word 12=16 and Word 15=4, then 4 bytes (32 bits) of %I memory will be transferred. For Read PLC Memory, the maximum length is 11200 bits, 1400 bytes, or 700 words of data, or the amount of memory available in the PLC for the selected memory type, whichever is less.

(Word 16) Remote PLC - Network Address Type: Word 16 specifies the format of the remote PLC address. Word 16 must contain the value 1. This indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 17) Remote PLC - Network Address Length: Word 17 specifies the length in words of the remote PLC IP address in this COMMREQ Command Block. Word 17 must contain 4.

(Words 18 – 21) Remote PLC - IP Address: Words 18–21 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

Write PLC Memory (4001)

The Write PLC Memory command can be used to write memory locations to one remote PACSystems PLC. Use of this command does not require a configured produced / consumed exchange in the PLCs.

Write PLC Memory Command Block

Word Offset	Value	Description
Word 1	Length of command data block	Always 22
Word 2	0	Always 0 (no-wait mode request)
Word 3	(See table on page 5-3)	Memory type of COMMREQ Status Word
Word 4	0-based.	Offset of COMMREQ Status Word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	4001 (fa1H)	Write PLC Memory command number.
Word 8	Retry time, in milliseconds	The time between retries of command transfers, in 10-millisecond increments. Default is 1000ms.
Word 9	Local write buffer memory type	Memory type for the data that will be written, in the local PLC.
Word 10	Local write buffer reference table starting address (least significant word)	1-based offset in the local PLC.
Word 11	Local write buffer reference table starting address (most significant word)	
Word 12	Remote write location memory type	Memory type into which data will be written in the remote PLC(s)
Word 13	Remote reference table write location starting address (least significant word)	1-based offset in the remote PLC
Word 14	Remote reference table write location starting address (least significant word)	
Word 15	Write Length	0 to 1400 bytes, 0 to 700 words.
Word 16	Network address type	Must be 1. Indicates an IP address will be used.
Word 17	Network address length	Must be 4 for IP address. Group ID (multicast) is not permitted.
Word 18 – Word 21	IP Address of the remote PLC	Four integers, specified as one integer per word of the dotted-decimal IP address of the remote PLC. May not be a group IP address.
Word 22	Reserved	Always 0

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) EGD Command Number: Word 7 requests that a write PLC memory operation occur. If the command is processed successfully, it will result in PLC reference memory data being sent from the server to the client.

(Word 8) Command Retry Time: Word 8 specifies the time (in milliseconds) the Ethernet Interface will wait between retries when transferring the command. A total of four tries will be made to send the command. If no response is received after the four tries (i.e. after four times the retry time value), an error status will be returned in the COMMREQ status word. If the command retry is specified as zero, the default value of one second is used.

(Word 9) Local PLC - Memory Type: Words 9-11 specify the location in the local PLC where the Ethernet Interface will get the data to be written to the remote PLC. Valid values for Word 9 are listed in the description of Read PLC Memory Command. The amount of data to be transferred is specified by the number of memory units of the data written to the remote PLC (Word 15).

(Words 10 - 11) Local PLC - Memory Starting Address: Words 10 and 11 determine the starting address in the local PLC from which the data is to be written to the remote PLC. The value entered is the 32-bit offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 9. Word 10 contains the least significant 16 bits of the offset; word 11 contains the most significant 16 bits of the offset. This offset will be either in bits, bytes, or words depending on the mode specified. (For example, if Word 9=16 and Words 10,11 = 2, 0 then the starting address will be %I9.) Valid ranges of values depend on the PLC's memory ranges.

(Word 12) Remote PLC - Memory Type: Words 12-14 specify the memory type and starting address in the remote PLC where data is to be written. Valid values for Word 12 are listed above.

(Words 13 - 14) Remote PLC - Memory Starting Address: Words 13,14 determine the starting address in the remote PLC where data is to be written. The value entered is the 32-bit offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 12. Word 13 contains the least significant 16 bits of the offset; word 14 contains the most significant 16 bits of the offset. This offset will be either in bits, bytes, or words depending on the mode specified (for example, if Word 12=16 and Words 13,14 =9, 0, then the starting address will be %I65). Valid ranges of values depend on the remote PLC's memory ranges.

(Word 15) Remote PLC - Number of Memory Units: Word 15 specifies the amount of data to be transferred. The value entered is the number of memory units to be transferred, where the size of the remote PLC memory type (bit, byte, or word) is specified in Word 12. For example, if Word 12=16 and Word 15=4, then 4 bytes (32 bits) of %I memory will be transferred. For Write PLC Memory, the maximum length is 11200 bits, 1400 bytes, or 700 words of data, or the amount of memory available in the PLC for the selected memory type, whichever is less.

(Word 16) Remote PLC - Network Address Type: Word 16 specifies the format of the remote PLC address. Word 16 must contain the value 1. This indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 17) Remote PLC - Network Address Length: Word 17 specifies the length in words of the remote PLC IP address in this COMMREQ Command Block. Word 17 must contain 4.

(Words 18 – 21) Remote PLC - IP Address: Words 18–21 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

Read EGD Exchange (4002)

The Read EGD Exchange command can be used to read some or all of a configured Ethernet Global Data exchange from either the producer or the consumer. This command identifies the data to be read using its configured Producer ID and Exchange ID. It can then read the content of the data for the exchange, directly from the producer or consumer device memory. This command can be sent to PACSystems PLCs and to other EGD Class 2 devices. In a PACSystems PLC, reading an EGD exchange reads the PLC reference memory locations configured to be transferred at the specified offset in the exchange. Thus current process data will be read, not the data that was transferred last in the exchange.

Read EGD Exchange Command Block

Word Offset	Value	Description
Word 1	Length of command data block	Always 25.
Word 2	0	Always 0 (no-wait mode request)
Word 3	(See table on page 5-3)	Memory type of COMMREQ Status Word
Word 4	0-based.	Offset of COMMREQ Status Word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	4002 (fa2H)	Read EGD Exchange command number.
Word 8	Retry time, in milliseconds	The time between retries of command transfers, in 10-millisecond increments. Default is 1000ms.
Word 9	Local read buffer memory type	Memory type for the data, in the local PLC.
Word 10	Local read buffer reference table starting address (least significant word)	1-based offset
Word 11	Local read buffer reference table starting address (most significant word)	
Word 12	Remote signature	EGD Exchange signature. This should be 0 for PLCs.
Word 13	Remote Producer ID (least significant word)	EGD Producer ID
Word 14	Remote Producer ID (most significant word)	
Word 15	Remote Exchange ID (least significant word)	EGD Exchange ID
Word 16	Remote Exchange ID (most significant word)	
Word 17	Remote Exchange Offset	Byte offset (0-based) in the exchange that should be read.
Word 18	Read length	Number of bytes to be read in the range 0 to 1400 bytes.

<i>Word Offset</i>	<i>Value</i>	<i>Description</i>
Word 19	Network address type	Must be 1. Indicates that an IP address will be used.
Word 20	Network address length	Must be 4 for IP address. Group ID (multicast) is not permitted.
Word 21 to Word 24	IP Address of the remote PLC	Four integers, specified as one integer per word of the dotted-decimal IP address of the remote PLC. May not be a group IP address.
Word 25	Reserved	Always 0

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) EGD Command Number: Word 7 requests that a read EGD exchange operation occur. If the command is processed successfully, it will result in data from a specified EGD exchange being read from the client to the server.

(Word 8) Command Retry Time: Word 8 specifies the time (in milliseconds) the Ethernet Interface will wait between retries when transferring the command. A total of four tries will be made to send the command. If no response is received after the four tries (i.e. after four times the retry time value), an error status will be returned in the COMMREQ status word. If the command retry is specified as zero, the default value of one second is used.

(Word 9) Local PLC – Memory Type: Words 9-11 specify the location in the local PLC where the Ethernet Interface will get the data to be read from the remote EGD device. Valid values for Word 9 are listed in the description of Read PLC Memory Command. The amount of data to be transferred is specified by the Exchange Data Length (Word 18).

(Words 10 – 11) Local PLC – Memory Starting Address: Words 10 and 11 determine the starting address in the local PLC where data is to be read from the remote EGD exchange. The value entered is the 32-bit offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 9. Word 10 contains the least significant 16 bits of the offset; word 11 contains the most significant 16 bits of the offset. This offset will be either in bits, bytes, or words depending on the mode specified. (For example, if Word 9=16 and Words 10,11 = 2, 0 then the starting address will be %I9.) Valid ranges of values depend on the PLC’s memory ranges. The user is responsible for assuring that this area is large enough to contain the requested data without overwriting other application data.

(Word 12) Remote EGD exchange – Exchange Signature: Words 12 contains the 16-bit exchange signature value to be compared at the remote EGD device. For remote PLC’s, the exchange signature should ordinarily be set to 0.

(Words 13 – 14) Remote EGD exchange – Producer ID: Words 13 and 14 contains the 32-bit Producer ID of the desired exchange at the remote EGD device. Word 13 contains the least significant 16 bits of the Producer ID; word 14 contains the most significant 16 bits.

(Words 15 – 16) Remote EGD exchange – Exchange ID: Words 15 and 16 contains the 32-bit Exchange ID of the desired exchange at the remote EGD device. Word 15 contains the least significant 16 bits of the Exchange ID; word 16 contains the most significant 16 bits.

(Word 17) Remote EGD exchange – Exchange Data Offset: Word 17 contains the 0-based byte offset of the data to be read from the data portion of the exchange at the remote EGD device.

(Word 18) Remote EGD exchange – Exchange Data Length: Word 18 contains the length (in bytes) of the exchange data to be read from the remote EGD device. The exchange data length may not exceed 1400 bytes or the amount of memory available in the PLC for the selected memory type, whichever is less.

(Word 19) Remote Server – Network Address Type: Word 19 specifies the format of the remote PLC address. Word 19 must contain the value 1. This indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 20) Remote Server – Network Address Length: Word 20 specifies the length in words of the remote PLC IP address in this COMMREQ Command Block. Word 20 must contain 4.

(Words 21 – 24) Remote Server – IP Address: Words 21–24 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

Write EGD Exchange (4003)

The Write EGD Exchange command can be used to write portions of a configured Ethernet Global Data exchange in a remote producer node. EGD protocol prohibits writing to a consumed exchange. . This command identifies the exchange to be written using its configured Producer ID and Exchange ID. It can then write the content of that data directly to the device memory. This command can be sent to PACSystems PLCs and to other EGD Class 2 devices. In a PACSystems PLC, writing an EGD exchange modifies the PLC reference memory locations configured for transfer at the specified offset in the exchange. Thus current process data will be updated, not the data that was transferred last in the exchange.

Write EGD Exchange Command Block

Word Offset	Value	Description
Word 1	Length of command data block	Always 25
Word 2	0	Always 0 (no-wait mode request)
Word 3	(See table on page 5-3)	Memory type of COMMREQ Status Word
Word 4	0-based.	Offset of COMMREQ Status Word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	4003 (fa3H)	Write EGD Exchange command number.
Word 8	Retry time, in milliseconds	The time between retries of command transfers, in 10-millisecond increments. Default is 1000ms.
Word 9	Local write buffer memory type	Memory type for the data, in the local PLC.
Word 10	Local write buffer reference table starting address (least significant word)	1-based offset
Word 11	Local write buffer reference table starting address (most significant word)	
Word 12	Remote signature	EGD Exchange signature. This should be 0 for PLCs.
Word 13	Remote Producer ID (least significant word)	EGD Producer ID
Word 14	Remote Producer ID (most significant word)	
Word 15	Remote Exchange ID (least significant word)	EGD Exchange ID
Word 16	Remote Exchange ID (least significant word)	
Word 17	Remote Exchange Offset	Byte offset (0-based) in the exchange that should be read.
Word 18	Write length	Number of bytes to be written in the range 0 to 1400 bytes.
Word 19	Network address type	Must be 1. Indicates an IP address will be used.

<i>Word Offset</i>	<i>Value</i>	<i>Description</i>
Word 20	Network address length	Must be 4 for IP address. Group ID (multicast) is not permitted.
Word 21 to Word 24	IP Address of the remote PLC	Four integers, specified as one integer per word of the dotted-decimal IP address of the remote PLC. May not be a group IP address.
Word 25	Reserved	Always 0

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) EGD Command Number: Word 7 requests that a write EGD exchange operation occur. If the command is processed successfully, it will result in data for a specified EGD exchange being written from the client to the server.

(Word 8) Command Retry Time: Word 8 specifies the time (in milliseconds) the Ethernet Interface will wait between retries when transferring the command. A total of four tries will be made to send the command. If no response is received after the four tries (i.e. after four times the retry time value), an error status will be returned in the COMMREQ status word. If the command retry is specified as zero, the default value of one second is used.

(Word 9) Local PLC - Memory Type: Words 9-11 specify the location in the local PLC where the Ethernet Interface will get the data to write to the remote EGD device. Valid values for Word 9 are listed in the description of Read PLC Memory Command. The amount of data to be transferred is specified by the Exchange Data Length (Word 18).

(Words 10 - 11) Local PLC - Memory Starting Address: Words 10 and 11 determine the starting address in the local PLC from which data is to be written to the remote EGD exchange. The value entered is the 32-bit offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 9. Word 10 contains the least significant 16 bits of the offset; word 11 contains the most significant 16 bits of the offset. This offset will be either in bits, bytes, or words depending on the mode specified. (For example, if Word 9=16 and Words 10,11 = 2, 0 then the starting address will be %I9.) Valid ranges of values depend on the PLC's memory ranges.

(Word 12) Remote EGD exchange – Exchange Signature: Word 12 contains the 16-bit exchange signature value to be compared at the remote EGD device. For remote PLC's, the exchange signature should ordinarily be set to 0.

(Words 13 - 14) Remote EGD exchange – Producer ID: Words 13 and 14 contains the 32-bit Producer ID of the desired exchange at the remote EGD device. Word 13 contains the least significant 16 bits of the Producer ID; word 14 contains the most significant 16 bits.

(Words 15 - 16) Remote EGD exchange – Exchange ID: Words 15 and 16 contains the 32-bit Exchange ID of the desired exchange at the remote EGD device. Word 15 contains the least significant 16 bits of the Exchange ID; word 16 contains the most significant 16 bits. For the Write EGD Command, the exchange at the remote device must be a Produced exchange.

(Word 17) Remote EGD exchange – Exchange Data Offset: Word 17 contains the 0-based byte offset of the data to be overwritten in the data portion of the exchange at the remote EGD device.

(Word 18) Remote EGD exchange – Exchange Data Length: Word 18 contains the length (in bytes) of the exchange data to be written to the remote EGD device. The exchange data length may not exceed 1400 bytes or the amount of memory available in the PLC for the selected memory type, whichever is less.

(Word 19) Remote Server - Network Address Type: Word 19 specifies the format of the remote PLC address. Word 19 must contain the value 1. This indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 20) Remote Server - Network Address Length: Word 20 specifies the length in words of the remote PLC IP address in this COMMREQ Command Block. Word 20 must contain 4.

(Words 21 – 24) Remote Server - IP Address: Words 21–24 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

Masked Write to EGD Exchange (4004)

The Masked Write to EGD Exchange command can be used to write one or more bits in a single byte of a configured Ethernet Global Data exchange in a remote producer node. EGD protocol prohibits writing to a consumed exchange. This command can be sent to PACSystems PLCs and to other EGD Class 2 devices.

In a PACSystems PLC, writing an EGD exchange modifies the PLC reference memory locations configured to be transferred at the specified offset in the exchange. Thus current process data will be updated, not the data that was transferred last in the exchange.

Masked Write EGD Exchange Command Block

Word Offset	Value	Description
Word 1	Length of command data block	Always 23
Word 2	0	Always 0 (no-wait mode request)
Word 3	(See table on page 5-3)	Memory type of COMMREQ Status Word
Word 4	0-based.	Offset of COMMREQ Status Word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	4004 (fa4H)	Masked Write to EGD Exchange command number.
Word 8	Retry time, in milliseconds	The time between retries of command transfers, in 10-millisecond increments. Default is 1000ms.
Word 9	Bit mask, set bit to be written to 1, rest to 0	The bit mask selects the individual bit to be written. The most significant bytes of Word 9 and Word 10 are ignored.
Word 10	Write 0 or 1 to selected bit.	Value to set the bit selected by the bit mask in Word 9.
Word 11	Remote signature	EGD Exchange signature. This should be 0 for PLCs.
Word 12	Remote Producer ID (least significant word)	EGD Producer ID
Word 13	Remote Producer ID (most significant word)	
Word 14, 15	Remote Exchange ID (least significant word)	EGD Exchange ID
Word 15	Remote Exchange ID (most significant word)	
Word 16	Remote Exchange Offset	Byte offset (0-based) in the exchange that should be read.
Word 17	Network address type	Must be 1. Indicates an IP address will be used.
Word 18	Network address length	Must be 4 for IP address. Group ID (multicast) is not permitted.
Word 19 to Word 22	IP Address of the remote PLC	Four integers, specified as one integer per word of the dotted-decimal IP address of the remote PLC. May not be a group IP address.
Word 23	Reserved	Always 0.

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) EGD Command Number: Word 7 requests that a masked write EGD exchange operation occur. If the command is processed successfully, it will result in a data bit for a specified EGD exchange being written from the client to the server.

(Word 8) Command Retry Time: Word 8 specifies the time (in milliseconds) the Ethernet Interface will wait between retries when transferring the command. A total of four tries will be made to send the command. If no response is received after the four tries (i.e. after four times the retry time value), an error status will be returned in the COMMREQ status word. If the command retry is specified as zero, the default value of one second is used.

(Word 9) Bit Mask: Words 9 – 10 specify the individual data to be written to the remote EGD exchange. The usage of the Bit Mask and Data are described in *Masked Write to EGD Exchange Bit Mask and Data Bits*, below. Word 9 contains a bit mask that identifies a bit or bits within a data byte. The mask bit corresponding to each data bit to be written is set to 1; all other bits are set to 0.

(Word 10) Data: Word 10 contains the data byte that contains the bit or bits to be written to the remote EGD exchange. The individual data bits to be written are in the same position as the 1 bits in the Bit Mask (Word 9).

(Word 11) Remote EGD exchange – Exchange Signature: Words 11 contains the 16-bit exchange signature value to be compared at the remote EGD device. For remote PLC's, the exchange signature should ordinarily be set to 0.

(Words 12 - 13) Remote EGD exchange – Producer ID: Words 12 and 13 contains the 32-bit Producer ID of the desired exchange at the remote EGD device. Word 12 contains the least significant 16 bits of the Producer ID; word 13 contains the most significant 16 bits.

(Words 14 - 15) Remote EGD exchange – Exchange ID: Words 14 and 15 contains the 32-bit Exchange ID of the desired exchange at the remote EGD device. Word 14 contains the least significant 16 bits of the Exchange ID; word 15 contains the most significant 16 bits. For the Masked Write EGD Command, the exchange at the remote device must be a Produced exchange.

(Word 16) Remote EGD exchange – Exchange Data Offset: Word 16 contains the 0-based byte offset of the single data byte data containing the bit or bits to be overwritten in the data portion of the exchange at the remote EGD device.

(Word 17) Remote Server - Network Address Type: Word 17 specifies the format of the remote PLC address. Word 17 must contain the value 1. This indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 18) Remote Server - Network Address Length: Word 18 specifies the length in words of the remote PLC IP address in this COMMREQ Command Block. Word 18 must contain 4.

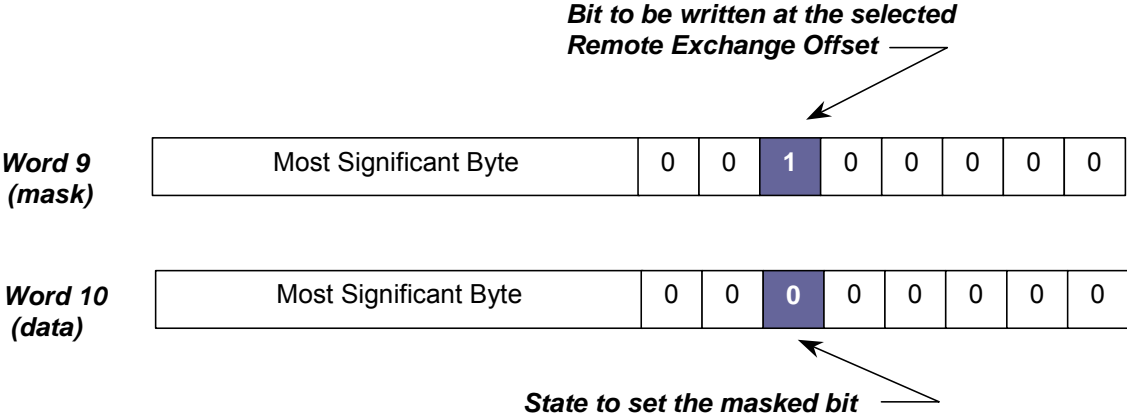
(Words 19 – 22) Remote Server - IP Address: Words 19–22 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

Masked Write to EGD Exchange Bit Mask and Data Bits

Word 9 of the Masked Write command contains the bit mask. The most significant byte of Word 9 is ignored. In the least significant byte, any bits set to 1 will be written to the remote producer.

The equivalent bit of Word 10 of the Masked Write command contains the bit state to be written, 1 or 0. The most significant byte of Word 10 is also ignored.

For example:



Chapter *Programming SRTP Channel Commands*

6

This chapter describes how to implement PLC to PLC communications over the Ethernet network using SRTP Channel commands:

- SRTP Channel Commands
 - Channel Operations
 - Aborting and Re-tasking a Channel
 - SRTP Channel Commands in a Redundant System
 - Executing a Channel Command
- COMMREQ Format for Programming Channel Commands
 - Establish Read Channel
 - Establish Write Channel
 - Send Information Report
 - Abort Channel
 - Retrieve Detailed Channel Status
- Programming for Channel Commands
 - COMMREQ Example
 - Sequencing Communications Requests
 - Managing Channels and TCP Connections
 - Use Channel Re-Tasking to Avoid using up TCP Connections
 - Client Channels TCP Resource Management
 - SRTP Application Timeouts
- Monitoring Channel Status
- Differences between Series 90 and PACSystems SRTP Channels

SRTP Channel Commands

The SRTP Channel commands are a set of client PLC commands that can be used to communicate with a server PLC.

A Channel command can establish a channel to execute multiple *periodic* reads or writes with a single initiation of a COMMREQ function. A Channel command can also be used to execute a single read or write.

There are five Channel commands:

- Establish Read Channel
- Establish Write Channel
- Send Information Report
- Abort Channel
- Retrieve Detailed Channel Status

Up to 32 channels (1–32) can be established by a PACSystems Ethernet Interface. Channels can be individually monitored from the application program.

Channel Operations

Channel commands are based on the concept of periodic data transfers. The client (local) PLC uses a single COMMREQ function to establish a channel (connection) to a server (remote) PLC and to request that specific data be periodically transferred between the PLCs.

The Ethernet Interface automatically manages the establishment of communications and the periodic data transfer. Parameters in the Command Block specify the frequency and direction of the transfer, and the memory locations in the client and server to be used in the transfer.

Aborting and Re-tasking a Channel

There are four ways a channel can be aborted:

1. When the PLC CPU is stopped, all channels in use are aborted automatically.
2. A channel (or all channels) can be aborted by issuing an Abort Channel command.
3. A channel in use can be re-tasked by issuing an establish command for its channel number. This aborts the previous channel operation and then performs the new channel operation.
4. A channel is also automatically aborted if a fatal error occurs.

Monitoring the Channel Status

The Ethernet Interface status bits occupy a single block of memory. The memory location is specified during configuration of the Ethernet Interface. The status bits are updated in the CPU once each PLC scan by the Ethernet Interface. These bits are generally used to prevent initiation of a COMMREQ function when certain errors occur or to signal a problem on an established channel.

The first 16 bits of the block are the LAN Interface Status (LIS) bits. The next 64 bits are the Channel Status bits (2 for each channel). Unless the “LAN Interface OK” bit is set (Status Bit 16), the other status bits are invalid.

Status Bits	Brief Description
1	Port 1A full duplex
2	Port 1A 100Mbps
3	Port 1B full duplex
4	Port 1B 100 Mbps
5	Network Time Lock
6	Redundant IP active
7-8	Reserved
9	Any Channel Error (error on any channel)
10–12	Reserved
13	LAN OK
14	Resource problem
15	Module Overtemperature (RX3i only)
16	LAN Interface OK
17	Data Transfer - Channel 1
18	Channel Error - Channel 1
...	...
79	Data Transfer - Channel 32
80	Channel Error - Channel 32

The LAN Status bits (bits 1 – 16) are described in chapter 10, Diagnostics. They monitor the health of the Ethernet Interface itself.

Bit 16, LAN Interface OK Bit: This bit is set to 1 by the Ethernet Interface each PLC scan. If the Ethernet Interface cannot access the PLC, the CPU sets this bit to 0. *When this bit is 0, all other Ethernet Interface Status bits are invalid.*

Channel Status Bits

The Channel Status bits provide runtime status information for each communication channel. Each channel has two status bits; the meaning of the channel status bits depends upon the type of communication performed on that channel.

SRTP channels operation provides two Channels Status bits for each SRTP channel, a Data Transfer bit and a Channel Error bit.

Bits 17, 19, 21 ... 79, Data Transfer Bit: Typically, a channel is used to perform repetitive reads or writes. The Data Transfer bit pulses (0 → 1 → 0) each time there is a successful read or write. This can be an indicator to the ladder program to move the most recent data to another location.

The Data Transfer bit is not closely synchronized in time with the transfer. The bit indicates only whether a transfer has occurred during the preceding read or write period. A rising edge on the bit indicating that a transfer has completed successfully does not guarantee that the next transfer has not begun or completed.

After an Establish Channel command, the COMMREQ status word is always updated *before* the Data Transfer bit is set to 1. The Data Transfer bit for a channel is not meaningful until the Ethernet Interface updates the COMMREQ status word. Do not use data received from a server until the COMMREQ status word confirming the Read command for that channel is 1 and the Data Transfer bit goes to 1.

Bits 18, 20, 22 ... 80, Channel Error Bit: This bit (normally 0) is the primary indicator for an error on a channel. It indicates any channel error, fatal or non-fatal. It does not necessarily indicate that the channel is idle.

A Channel Error bit is not meaningful until after the Ethernet Interface updates the COMMREQ status word confirming the Read or Write command for that channel. For an Establish Channel command, the COMMREQ status word is updated before the Channel Error bit is set to 1.

A Channel Error bit is set to 1 when an error is detected on the channel. It is set to 0 when the channel is initially established and if the channel resumes normal operation after a transient error condition subsides. The Channel Error bit is also set to 0 when the channel is aborted by an Abort Channel command or when the PLC CPU transitions from RUN to STOP. In the case of an Establish Channel command, the COMMREQ status word is always updated *before* the Channel Error bit is set to 1.

If this bit indicates an error, initiate the Abort command and then reinitiate the Read or Write command. If the error persists, initiate the Retrieve Detailed Channel Status command to find out if the channel is idle, and possibly why it is idle. The status code may change between the time the Channel Error bit indicates an error and the time the Retrieve Detailed Channel Status command retrieves the code.

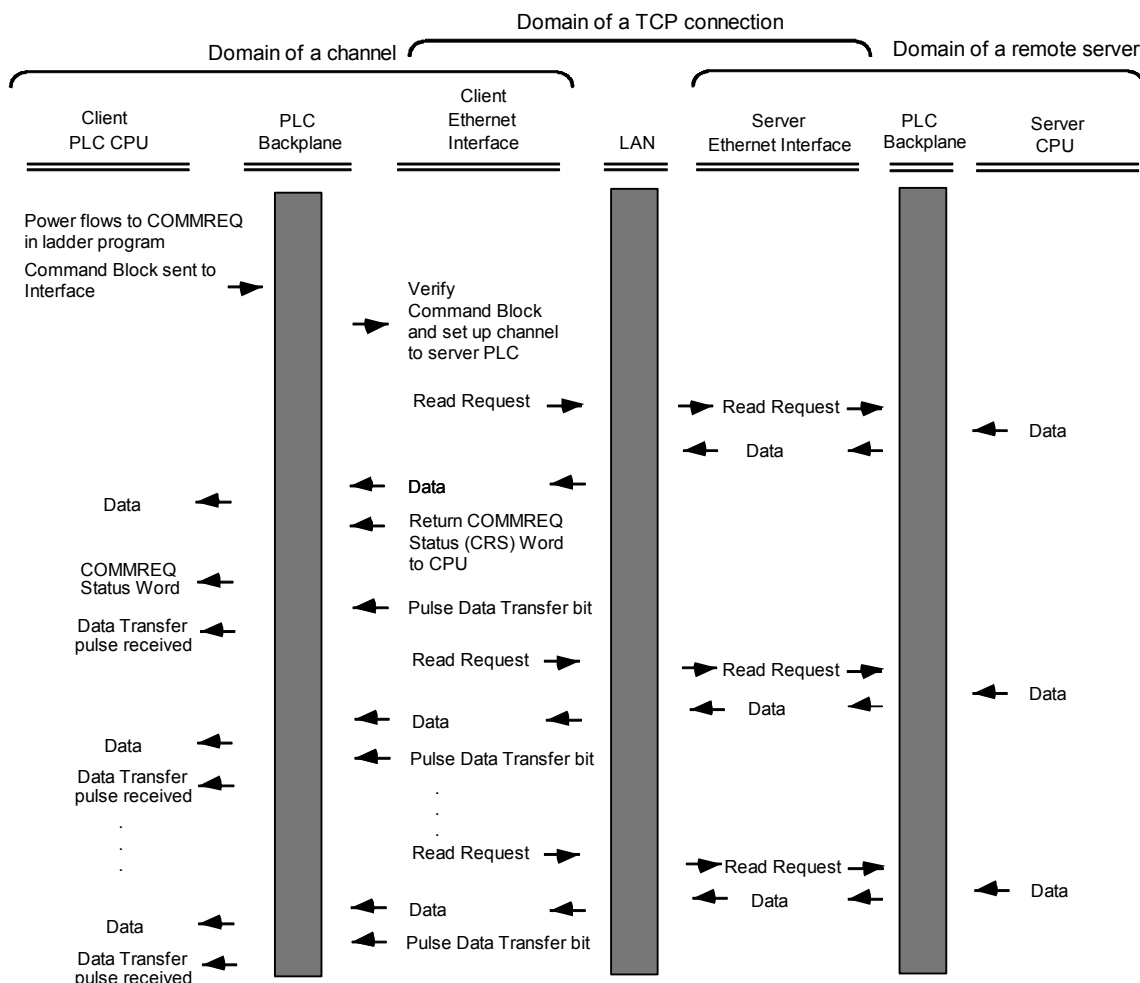
SRTP Channel Commands in a Redundant System

When configured for Redundant IP operation (see chapter 1 for more information), only the active unit establishes and maintains the SRTP Client connections used for the Channel commands. The backup unit does not perform any SRTP Client operations. If SRTP Client operation is attempted, a COMMREQ error status is returned to the local logic program. When the Ethernet interface changes from active to backup state, it takes down all SRTP Client connections and their underlying TCP connections.

Because it can take some time to take down a TCP connection, the Redundant system should reserve a spare SRTP Client connection for each connection using the Redundant IP address. That will prevent temporary resource problems when establishing new SRTP Client connections to the new active unit while the previous connections to the old active unit are being taken down.

Executing a Channel Command

The figure below shows how a Communications Request carries out a Channel command, in this case, Establish Read Channel.

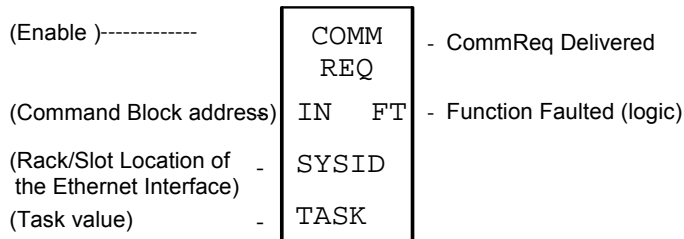


1. The command starts when there is power flow to a COMMREQ function in the client PLC. At this time, the Command Block data is sent from the PLC CPU to the Ethernet Interface.
2. For the Establish Read Channel command, the COMMREQ status word is returned immediately if the Command Block is invalid. If the syntax is correct, the COMMREQ status word is returned after the first significant event: upon failure to establish a channel correctly and in a timely manner or upon the first successful transfer of data.
3. After the channel is successfully set up to the server PLC, the Ethernet Interface performs the periodic reads as specified in the Command Block.

COMMREQ Format for Programming Channel Commands

The Channel commands described in this chapter are sent using the Communications Request (COMMREQ) function.

The Communications Request is triggered when the logic program passes power to the COMMREQ Function Block.



For the Channel Commands, the parameters of the COMMREQ are:

Enable: Control logic for activating the COMMREQ Function Block.

IN: The location of the Command Block. It can be any valid address within a word-oriented area of (%R, %AI, %AQ, %P, %L, or %W).

SYSID: A hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet Interface. For the PACSystems CPU embedded Ethernet interface, enter the rack/slot location of the CPU module.

<i>Rack</i>	<i>Slot</i>	<i>Hex Word Value</i>
0	4	0004H
3	4	0304H
2	9	0209H
4	2	0402H

TASK: For the PACSystems Ethernet module, Task must be set to zero.

For the PACSystems CPU embedded Ethernet interface, Task must be set to the value 65536 (10000H) to address the CPU's Ethernet daughterboard.

Caution

Entering an incorrect TASK value may cause the Ethernet Interface to fail.

FT Output: The FT output is set if the PLC CPU (rather than the Ethernet Interface) detects that the COMMREQ fails. In this case, the other status indicators are not updated for this COMMREQ.

The COMMREQ Command Block: General Description

When the COMMREQ function is initiated, the Command Block is sent from the PLC CPU to the Ethernet Interface. The Command Block contains the details of a Channel command to be performed by the Interface.

The address in CPU memory of the Command Block is specified by the IN input of the COMMREQ Function Block. It can be any valid address within a word-oriented area of memory (%R, %AI, %AQ, %P, %L, or %W). The Command Block is set up using an appropriate programming instruction, such as a BLOCK MOVE or DATA INIT COMM). The Command Block has the following structure:

Word 1	Data Block Length (words)
Word 2	WAIT/NOWAIT Flag
Word 3	COMMREQ status word Memory Type
Word 4	COMMREQ status word Address Offset
Word 5	<i>Reserved</i>
Word 6	<i>Reserved</i>
Words 7 and up	Data Block (Channel Command Details)

(Word 1) Data Block Length: This is the length in words of the Data Block portion of the Command Block. The Data Block portion starts at Word 7 of the Command Block. The length is measured from the beginning of the Data Block at Word 7, not from the beginning of the Command Block. The correct value for each command, and the associated length of each command, is specified in the next section.

(Word 2) WAIT/NOWAIT Flag: Must be set to zero for TCP/IP Ethernet Communications.

COMMREQ Status Word: The Ethernet Interface updates the COMMREQ status word to show success or failure of the command. Command words 3 and 4 specify the PLC memory location of the COMMREQ status word. (COMMREQ Status Word values are described in chapter 9.)

(Word 3) COMMREQ Status Word Memory Type: This word specifies the memory type for the COMMREQ status word. The memory types are listed in the table below:

Type	Value (Decimal)	Value (Hex.)	Description
%R	8	08H	Register memory (word mode)
%AI	10	0AH	Analog input memory (word mode)
%AQ	12	0CH	Analog output memory (word mode)
%I	16	10H	Discrete input memory (byte mode)
	70	46H	Discrete input memory (bit mode)
%Q	18	12H	Discrete output memory (byte mode)
	72	48H	Discrete output memory (bit mode)
%T	20	14H	Discrete temporary memory (byte mode)
	74	4AH	Discrete temporary memory (bit mode)
%M	22	16H	Discrete momentary internal memory (byte mode)
	76	4CH	Discrete momentary internal memory (bit mode)
%G	56	38H	Discrete global data table (byte mode)
	86	56H	Discrete global data table (bit mode)
%W	196	C4H	Word memory (word mode; limited to %W1-%W65536)

(Word 4) COMMREQ Status Word Address Offset: This word contains the offset within the memory type selected. *The status word address offset is a zero-based number.* For example, if you want %R1 as the location of the COMMREQ status word, you must specify a zero for the offset. The offset for %R100 would be 99 decimal. Note, however, that this is the only zero-based field in the Channel commands. (When using %W memory, the maximum offset value that can be entered is 65535, signifying %W65536.)

(Word 5): Reserved. Set to zero.

(Word 6): Reserved. Set to zero.

(Words 7 and up) Data Block: The Data Block defines the Channel command to be performed.

Using COMMREQs for Channel Commands

- Be sure to use unique COMMREQ Status (CRS) memory locations for each COMMREQ.
- Always initialize the COMMREQ Status Word to zero before initiating a Channel command COMMREQ to a given channel. Wait for the COMMREQ Status Word to go to a non-zero value (which signals the COMMREQ is complete) before issuing another Channel command to that channel. The COMMREQ Status Word is updated once per COMMREQ execution: a non-zero value in the status word completes the COMMREQ.
- Always use a one-shot to initiate a Channel command COMMREQ. That prevents the channel COMMREQ from being executed each CPU scan, which would overrun the capability of the Ethernet Interface.

Establish Read Channel (2003)

The Establish Read Channel command requests that a channel be associated with a remote PLC and that data from the remote PLC be transferred (periodically) to the local PLC. The Command Block specifies the period, the number of reads from the server (remote PLC) to perform, and the timeout allowed in waiting for each transfer to complete. The first read is performed immediately, regardless of the period specified.

Example Command Block

Establish a channel (Channel 5) to a remote PLC at IP address 10.0.0.1. Return the COMMREQ Status word to %R10. Read remote PLC registers %R50–%R57 to local PLC registers %R100–%R107. Repeat the read 10 times, once every 7 seconds, with a timeout of 500 ms for each read.

	Dec	(Hex)	
Word 1	00017	(0011)	Length of Channel command Data Block (17–25 words)
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of COMMREQ status word (%R)
Word 4	00009	(0009)	COMMREQ status word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	02003	(07D3)	Establish Read Channel command number
Word 8	00005	(0005)	Channel number (5)
Word 9	00010	(000A)	Number of read repetitions (read 10 times)
Word 10	00003	(0003)	Time unit for read period (3=seconds)
Word 11	00007	(0007)	Number of time units for read period (every 7 seconds)
Word 12	00050	(0032)	Timeout for each read (500 ms)
Word 13	00008	(0008)	Local PLC - Memory type at which to store data (%R)
Word 14	00100	(0064)	Local PLC - Starting address at which to store data (%R100)
Word 15	00008	(0008)	Remote PLC - Memory type from which to read data (%R)
Word 16	00050	(0032)	Remote PLC - Starting address from which to read data (%R50)
Word 17	00008	(0008)	Remote PLC - Number of memory units (8 registers)
Word 18	00001	(0001)	Remote PLC - Network Address type (IP Address)
Word 19	00004	(0004)	Remote PLC - Network Address length in words (4)
Word 20	00010	(000A)	Remote PLC - Register 1 of IP address (10)
Word 21	00000	(0000)	Remote PLC - Register 2 of IP address (0)
Word 22	00000	(0000)	Remote PLC - Register 3 of IP address (0)
Word 23	00001	(0001)	Remote PLC - Register 4 of IP address (1)
Word 24–27			Remote PLC - Program Name (needed for access to remote %P or %L) (zero-terminated and padded)
Word 28–31			Remote PLC - Program Block (needed for access to remote %L) (zero-terminated and padded)

*The term **local PLC** is used here to identify the **client PLC**—the PLC that initiates the communications request.*

*The term **remote PLC** is used here to identify the **server PLC**—the PLC that responds to the communications request.*

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 requests that a read channel be set up. If the command is processed successfully, it will result in attempting the specified number of transfers from the server to the client.

(Word 8) Channel Number: Word 8 specifies the channel to be used for the read. This value must be in the range of 1–32. If the channel number is out of range, a command error indication will be placed in the COMMREQ Status word. If the channel number is the same as a channel already in use, the channel will be retasked to perform this new command.

(Word 9) Number of Read Repetitions: Word 9 specifies the number of reads to be performed before automatically completing the communications request and closing the channel. If this value is set to 1, only a single read will be issued. If this value is set to 0, reads will be issued continuously on the requested period until the channel is aborted.

(Word 10) Time Unit for Read Period: Words 10–11 together define how often the read is to be performed (*read period*). Word 10 specifies the time unit such as seconds or minutes for the read period. Word 11 specifies the number of those units. The choices for the time units are shown below.

<i>Value</i>	<i>Meaning</i>
1	hundredths of seconds (10 ms)
2	tenths of seconds (100 ms)
3	seconds
4	minutes
5	hours

Note: If Time Unit Value is 5 (hours), then the maximum usable value of Number of Time Units is 5965.

(Word 11) Number of Time Units for Read Period: Word 11 specifies the number of time units for the read period. The read period is in effect even when the Channel command is setup to issue a single read.

Example Read Period Calculation: If Word 10 contains a value of 3 specifying seconds as the time unit and Word 11 contains a value of 20, then the read period is 20 seconds.

*A Channel command set up to issue a single read can have only one **pending** read transfer.* A read will normally be issued at the start of each read period. If the *pending* read transfer has not completed during the read period, the Channel Error bit and Detailed Channel Status words will be set to indicate a non-fatal period error. If the period error occurs on the first transfer, the COMMREQ Status will also indicate a non-fatal period error. Note: The COMMREQ Status is issued only once for each COMMREQ; for more information, see “Using COMMREQs for Channel Commands”. The pending transfer can still complete after the period error occurs. You can determine when the pending transfer completes by monitoring the Channel Error and Data Transfer bits. For Channel commands set up to issue multiple reads, the next read transfer will be issued only after the pending read transfer completes.

If the Number of Time Units is zero, a subsequent transfer will be issued as soon as the previous transfer completes. In this case, no period errors can occur.

(Word 12) Timeout for Each Read: Word 12 specifies the time (in hundredths of a second) the Ethernet Interface will wait for a read transfer to complete before setting the Channel Error

bit and Detailed Channel Status words to indicate a non-fatal timeout error. If the timeout error occurs on the first transfer, the COMMREQ Status will also indicate a non-fatal timeout error. Note: The COMMREQ Status is issued only once for each COMMREQ; for more information, see "Using COMMREQs for Channel Commands". The transfer can still complete even after a timeout occurs. You can determine when the pending transfer completes by monitoring the Channel Error and Data Transfer bits. As a result, an application can choose what to do if one occurs. If the timeout value is specified as zero, no timeout errors will be reported.

For most applications a timeout is not needed because the read period acts as a timeout. (Word 12 should be zero for no timeout). However, there are two circumstances in which specifying a timeout is recommended:

- When the number of time units (Word 11) is zero, so that a subsequent transfer will be issued as soon as the previous transfer completes and no period errors are reported. In this case a timeout value can be specified so that the Channel Error bit will report timeout errors.
- When the read period is very long (minutes or hours). In this case a shorter timeout value can be specified so the application doesn't have to wait for the read period to expire before taking action.

(Word 13) Local PLC - Memory Type: Words 13–14 specify the location in the local PLC where the Ethernet Interface will store data received from the remote PLC. Valid values for Word 13 are listed below. The amount of data to be transferred is specified by the number of memory units of the data read from the remote PLC (Word 17).

<i>Type</i>	<i>Value (Decimal)</i>	<i>Description</i>
%L*	0	Program Block Local register memory (word mode)
%P*	4	Program register memory (word mode)
%W ‡	196	Word memory (word mode; max address %W65535)
%R	8	Register memory (word mode)
%AI	10	Analog input memory (word mode)
%AQ	12	Analog output memory (word mode)
%I	16	Discrete input memory (byte mode)
	70	Discrete input memory (bit mode)
%Q	18	Discrete output memory (byte mode)
	72	Discrete output memory (bit mode)
%T	20	Discrete temporary memory (byte mode)
	74	Discrete temporary memory (bit mode)
%M	22	Discrete momentary internal memory (byte mode)
	76	Discrete momentary internal memory (bit mode)
%SA	24	Discrete system memory group A (byte mode)
	78	Discrete system memory group A (bit mode)
%SB	26	Discrete system memory group B (byte mode)
	80	Discrete system memory group B (bit mode)
%SC	28	Discrete system memory group C (byte mode)
	82	Discrete system memory group C (bit mode)
%S †	30	Discrete system memory (byte mode)
	84	Discrete system memory (bit mode)
%G	56	Discrete global data table (byte mode)
	86	Discrete global data table (bit mode)

- † Read-only memory, cannot be written to.
- * Can only be accessed in the Remote PLC
- ‡ %W memory is supported by PACSystems clients and servers only.

(Word 14) Local PLC - Memory Starting Address: Word 14 determines the starting address in the local PLC in which the data from the remote PLC is to be stored. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 13. This offset will be either in bits, bytes, or words depending on the mode specified (for example, if Word 13=16 and Word 14=2, then the starting address will be %I9). Valid ranges of values depend on the PLC’s memory ranges. The user is responsible for assuring that this area is large enough to contain the requested data without overwriting other application data.

(Word 15) Remote PLC - Memory Type: Words 15–16 specify the memory type and starting address in the remote PLC from which the data is to be read. Valid values for Word 15 are listed above. If %P memory is used, you must specify a Program name in Words 24–27. If %L memory is used, you must specify a Program name in Words 24 –27 and a Program Block name in Words 28–31.

(Word 16) Remote PLC - Memory Starting Address: Word 16 determines the starting address in the remote PLC from which the data is to be read. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 15. This offset will be either in bits, bytes, or words depending on the mode specified (for example, if Word 15=16 and Word 16=9, then the starting address will be %I65). Valid ranges of values depend on the remote PLC's memory ranges.

(Word 17) Remote PLC - Number of Memory Units: Word 17 specifies the amount of data to be transferred. The value entered is the number of memory units to be transferred, where the size of a memory unit is a bit, byte, or word as specified in Word 15. For example, if Word 15=16 and Word 17=4, then 4 bytes (32 bits) of %I memory will be transferred. A maximum of 16384 bits, 2048 bytes, or 1024 words of data can be specified.

(Word 18) Remote PLC - Network Address Type: Word 18 specifies the format of the remote PLC address. Word 18 must contain the value 1. This indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 19) Remote PLC - Network Address Length: Word 19 specifies the length in words of the remote PLC IP address. Word 19 must contain 4.

(Words 20 – 23) Remote PLC - IP Address: Words 20–23 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

(Words 24–27) Remote PLC - Program Name: Words 24–27 specify the case-sensitive, zero-terminated and padded program name (also called task name, which can be found through the PROG Station Manager command on the server Ethernet Interface) to be used with access to remote %P or %L memory. These words are required only for access to such memory and will be ignored if the Memory Type field is not %P or %L. See Note below.

(Words 28–31) Remote PLC - Program Block Name: Words 28–31 specify the case-sensitive, zero-terminated and padded program block name (which can be found in the program block declaration in the server ladder program) to be used with access to remote %L memory. These words are required only for access to such memory and will be ignored if the Memory Type field is not %P or %L.

Note: The Program Name (Words 24–27) and Program Block Name (Words 28–31) must have each pair of ASCII characters reversed within the PLC memory. For example, the name "MARY" ("M" = 4DH, "A" = 41H, "R" = 52H, "Y" = 59H) would have 414DH in the first word and 5952H in the second word.

Establish Write Channel (2004)

The Establish Write Channel command requests that a channel be connected to a remote PLC and that data from the local PLC be transferred (periodically) to the remote PLC. The Command Block specifies the period, the number of writes to the server (remote PLC) to perform, and the timeout allowed in waiting for each transfer to complete. The first write is performed immediately, regardless of the period specified.

Example Command Block

Establish a write channel (Channel 6) to a remote PLC at IP address 10.0.0.1. Return the COMMREQ Status word to %R10. Write local PLC registers %R50–%R57 to remote PLC registers %R100–%R107. Repeat the write indefinitely, once every 7 seconds, with a timeout of 500 ms for each write.

	Dec	(Hex)	
	Word 1	00017 (0011)	Length of Channel command Data Block (17–25 words)
	Word 2	00000 (0000)	Always 0 (no-wait mode request)
	Word 3	00008 (0008)	Memory type of COMMREQ status word (%R)
	Word 4	00009 (0009)	COMMREQ status word address minus 1 (%R10) *
	Word 5	00000 (0000)	Reserved
	Word 6	00000 (0000)	Reserved
	Word 7	02004 (07D4)	Establish Write Channel command number
	Word 8	00006 (0006)	Channel number (6)
	Word 9	00000 (0000)	Number of write repetitions (write indefinitely)
	Word 10	00003 (0003)	Time unit for write period (3=seconds)
	Word 11	00007 (0007)	Number of time units for write period (every 7 seconds)
	Word 12	00050 (0032)	Timeout for each write (500 ms)
	Word 13	00008 (0008)	Local PLC - Memory type from which to write data (%R)
	Word 14	00050 (0032)	Local PLC - Starting address from which to write data (%R50)
	Word 15	00008 (0008)	Remote PLC - Memory type at which to store data (%R)
	Word 16	00100 (0064)	Remote PLC - Starting address at which to store data (%R100)
	Word 17	00008 (0008)	Remote PLC - Number of memory units (8 registers)
	Word 18	00001 (0001)	Remote PLC - Network Address type (IP address)
	Word 19	00004 (0004)	Remote PLC - Network Address length in words (4)
	Word 20	00010 (000A)	Remote PLC - Register 1 of IP address (10)
	Word 21	00000 (0000)	Remote PLC - Register 2 of IP address (0)
	Word 22	00000 (0000)	Remote PLC - Register 3 of IP address (0)
	Word 23	00001 (0001)	Remote PLC - Register 4 of IP address (1)
	Word 24–27		Remote PLC - Program Name (needed for access to remote %P or %L) (zero-terminated and padded)
	Word 28–31		Remote PLC - Program Block (needed for access to remote %L) (zero-terminated and padded)

The term local PLC is used here to identify the client PLC—the PLC that initiates the communications request.

The term remote PLC is used here to identify the server PLC—the PLC that responds to the communications request.

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 requests that a write channel be set up. If the command is processed successfully, it will result in attempting the specified number of transfers from the client to the server.

(Word 8) Channel Number: Word 8 specifies the channel to be used for the write. This value must be in the range of 1–32. If the channel number is out of range, a command error indication will be placed in the COMMREQ Status word. If the channel number is the same as a channel already in use, the channel will be re-tasked to perform this new command.

(Word 9) Number of Write Repetitions: Word 9 specifies the number of writes to be performed before automatically completing the communications request and closing the channel. If this value is set to 1, only a single write will be issued. If this value is set to 0, writes will be issued on the requested period until the channel is aborted.

(Word 10) Time Units for Write Period: Words 10–11 together define how often the write is to be performed (*write period*). Word 10 specifies the time unit such as seconds or minutes for the write period. Word 11 specifies the number of those units. The choices for the time units are:

Value	Meaning
1	hundredths of seconds (10 ms)
2	tenths of seconds (100 ms)
3	seconds
4	minutes
5	hours

(Word 11) Number of Time Units for Write Period: Word 11 specifies the number of time units for the write period. The write period is in effect even when the Channel command is setup to issue a single write.

Example Write Period Calculation: If Word 10 contains a value of 3 specifying seconds as the time unit and Word 11 contains a value of 20, then the write period is 20 seconds.

*A Channel command set up to issue a single write can have only one **pending** write transfer.* A write will normally be issued at the start of each write period. If the *pending* write transfer has not completed during the write period, the Channel Error bit and Detailed Channel Status words will be set to indicate a non-fatal period error. If the period error occurs on the first transfer, the COMMREQ Status will also indicate a non-fatal period error. Note: The COMMREQ Status is issued only once for each COMMREQ; for more information, see “Using COMMREQs for Channel Commands”. The pending transfer can still complete after the period error occurs. You can determine when the pending transfer completes by monitoring the Channel Error and Data Transfer bits. For Channel commands set up to issue multiple writes, the next write transfer will be issued only after the pending write transfer completes. If the Number of Time Units is zero, a subsequent transfer will be issued as soon as the previous transfer completes. In this case, no period errors are reported by the Channel Error bit.

(Word 12) Timeout for Each Write: Word 12 specifies the time (in hundredths of a second) the Ethernet Interface will wait for a write transfer to complete before setting the Channel Error bit and Detailed Channel Status bits to indicate a non-fatal timeout error. If the timeout

error occurs on the first transfer, the COMMREQ Status (will also indicate a non-fatal timeout error. Note: The COMMREQ Status is issued only once for each COMMREQ; for more information, see “Using COMMREQs for Channel Commands”. The transfer can still complete even after a timeout occurs. You can determine when the pending transfer completes by monitoring the Channel Error and Data Transfer bits. As a result, an application can choose what to do if one occurs. If the timeout value is specified as zero, no timeout errors will be reported.

For most applications a timeout is not needed because the write period acts as a timeout. (Word 12 should be zero for no timeout.) However, there are two special circumstances in which specifying a timeout is recommended:

- When the number of time units (Word 11) is zero, so that a subsequent transfer will be issued as soon as the previous transfer completes and no period errors are reported. In this case a timeout value can be specified so that the Channel Error bit will report timeout errors.
- When the write period is very long (minutes or hours). In this case a shorter timeout value can be specified so the application doesn't have to wait for the write period to expire before taking action.

(Word 13) Local PLC - Memory Type: Words 13–14 specify the location in the local PLC where the Ethernet Interface will get the data to be written to the remote PLC. Valid values for Word 13 are listed in the description of Establish Read Channel. The amount of data to be transferred is specified by the number of memory units of the data written to the remote PLC (Word 17).

(Word 14) Local PLC - Memory Starting Address: Word 14 determines the starting address in the local PLC from which the data is to be written. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 13. This offset will be in bits, bytes, or words depending on the mode specified (for example, if Word 13=16 and Word 14=2, then the starting address will be %I9). Valid ranges of values depend on the PLC's memory ranges.

(Word 15) Remote PLC - Memory Type: Words 15–16 specify the memory type and starting address in the remote PLC where the data is to be written. Valid values for Word 15 are listed under Establish Read Channel. If %P memory is used, you must specify a Program name in Words 24–27. If %L memory is used, you must specify a Program name in Words 24–27 and a Program Block name in Words 28–31.

(Word 16) Remote PLC - Memory Starting Address: Word 16 determines the starting address in the remote PLC where the data is to be written. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 15. This offset will be either in bits, bytes, or words depending on the mode specified (for example, if Word 15=16 and Word 16=9, then the starting address will be %I65). Valid ranges of values depend on the remote PLC's memory ranges.

(Word 17) Remote PLC - Number of Memory Units: Word 17 specifies the amount of data to be transferred. The value entered is the number of memory units to be transferred, where the size of a memory unit is a bit, byte, or word as specified in Word 15. For example, if Word 15=16 and Word 17=4, then 4 bytes (32 bits) of %I memory will be transferred. The user is responsible for assuring that this area is large enough to contain the requested data without overwriting other application data. A maximum of 16384 bits, 2048 bytes, or 1024 words of data can be specified.

(Word 18) Remote PLC - Network Address Type: Word 18 specifies the format of the remote PLC address. Word 18 must contain the value 1, indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 19) Remote PLC - Network Address Length: Word 19 specifies the length in words of the remote PLC IP address. Word 19 must contain 4.

(Words 20–23) Remote PLC - IP Address: Words 20–23 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote PLC to be accessed.

(Words 24–27) Remote PLC - Program Name: Words 24–27 specify the case-sensitive, zero-terminated and padded program name (also called task name, which can be found through the PROG Station Manager command on the server Ethernet Interface) to be used with access to remote %P or %L memory. These words are required only for access to such memory and will be ignored if the Memory Type field is not %P or %L.

(Words 28–31) Remote PLC - Program Block Name: Words 28–31 specify the case-sensitive, zero-terminated and padded program block name (which can be found in the program block declaration in the server ladder program) to be used with access to remote %L memory. These words are required only for access to such memory and will be ignored if the Memory Type field is not %P or %L.

The Program Name (Words 24–27) and Program Block Name (Words 28–31) must have each pair of ASCII characters reversed within the PLC memory. For example, the name "MARY" ("M" = 4DH, "A" = 41H, "R" = 52H, "Y" = 59H) would have 414DH in the first word and 5952H in the second word.

Send Information Report (2010)

The Send Information Report COMMREQ requests that a particular block of memory within the PLC CPU reference tables be transferred periodically from an Ethernet Interface to a host application SRTP server. The Command Block specifies the repetition period, the number of transfers to the server to perform, and the timeout allowed in waiting for each transfer to complete. The first send is performed immediately, regardless of the period specified.

Example Command Block

Establish a channel (Channel 7) to a remote Host application server at IP address 10.0.0.1. Return the COMMREQ Status word to %R10. Send local PLC registers %R50–%R57 to remote host. Repeat the send 10 times, once every 7 seconds, with a timeout of 500ms for each transfer.

		Dec	(Hex)	
	Word 1	00017	(0011)	Length of Send Information Report Data Block (17 words)
	Word 2	00000	(0000)	Always 0 (no–wait mode request)
	Word 3	00008	(0008)	Memory type of COMMREQ status word (%R)
	Word 4	00009	(0009)	COMMREQ status word address minus 1 (%R10)*
	Word 5	00000	(0000)	Reserved
	Word 6	00000	(0000)	Reserved
	Word 7	02010	(07DA)	Send Information Report Channel command number
	Word 8	00007	(0007)	Channel number (7)
	Word 9	00010	(000A)	Number of repetitions (send 10 times)
<i>The term local PLC is used here to identify the client PLC—the PLC that initiates the communications request.</i>	Word 10	00003	(0003)	Time unit for send period (3=seconds)
	Word 11	00007	(0007)	Minimum interval between host accesses (every 7 seconds)
	Word 12	00050	(0032)	Timeout on each individual transfer response (500 ms)
	Word 13	00008	(0008)	Local PLC - Memory type from which to send data (%R)
<i>The term SRTP Server is used here to identify the Host server.</i>	Word 14	00050	(0032)	Local PLC - Starting address from which to send data (%R50)
	Word 15	00008	(0008)	Local PLC - Number of memory units (8 registers)
	Word 16	00000	(0000)	Reserved
	Word 17	00000	(0000)	Reserved
	Word 18	00001	(0001)	Remote Network Address type (IP Address)
	Word 19	00004	(0004)	Remote Network Address length in words (4)
	Word 20	00010	(000A)	Remote Host - Register 1 of IP address (10)
	Word 21	00000	(0000)	Remote Host - Register 2 of IP address (0)
	Word 22	00000	(0000)	Remote Host - Register 3 of IP address (0)
	Word 23	00001	(0001)	Remote Host - Register 4 of IP address (1)

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block.

Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 requests that a Send Information Report channel be set up. If the command is processed successfully, it will result in attempting the specified number of transfers from the client to the server.

(Word 8) Channel Number: Word 8 specifies the channel to be used for the send. This value must be in the range of 1–32. If the channel number is out of range, a command error indication is placed in the COMMREQ status word. If the channel number is the same as a channel already in use, the channel is re-tasked to perform this new command.

(Word 9) Number of Send Repetitions: Word 9 specifies the number of transfers to be performed before automatically completing the communications request and closing the channel. If this value is set to 1, only a single transfer will be issued. If this value is set to 0, transfers will be issued on the requested period until the channel is aborted.

(Word 10) Time Unit for Send Period: Words 10-11 together define how often the transfer is to be performed (*transfer period*). Word 10 specifies the time unit such as seconds or minutes for the send period. Word 11 specifies the number of those units. The choices for the time units are shown below.

Value	Meaning
1	hundredths of seconds (10 ms)
2	tenths of seconds (100 ms)
3	seconds
4	minutes
5	hours

(Word 11) Number of Time Units for Send Period: Word 11 specifies the number of time units for the send period. The send period is in effect even when the Channel command is set up to issue a single send. *A Channel command set up to issue a single send can have only one **pending** send transfer.*

Example Send Period Calculation: If Word 10 contains a value of 3 specifying seconds as the time unit and Word 11 contains a value of 20, the send period is 20 seconds.

A send is normally issued at the start of each send period. If the *pending* transfer has not completed during the send period, the Channel Error bit and Detailed Channel Status words are set to indicate a non-fatal period error. The pending transfer can still complete after the period error occurs. For Channel commands set up to issue multiple sends, the next transfer is issued only after the pending transfer completes.

If the Number of Time Units is zero, a subsequent transfer is issued as soon as the previous transfer completes. In this case, no period errors are reported by the Channel Error bit.

(Word 12) Timeout for Each Send: Word 12 specifies the time (in hundredths of a second) the Ethernet Interface will wait for a send transfer to complete before setting the Channel Error bit and Detailed Channel Status bits to indicate a non-fatal timeout error. The transfer can still complete even after a timeout occurs. As a result, an application can choose what to do if one occurs. If the timeout value is specified as zero, no timeout errors will be reported.

For most applications a timeout is not needed because the send period acts as a timeout. (Word 12 should be zero for no timeout.) However, there are two circumstances where a timeout is recommended:

- If number of time units (Word 11) is zero, so that a subsequent transfer is issued as soon as the previous transfer completes and no period errors are reported. In this case a timeout value can be specified so that the Channel Error bit will report timeout errors.
- If the send period is very long (minutes or hours). In this case a shorter timeout value can be specified so the application doesn't have to wait for the send period to expire before taking action.

(Word 13) Local PLC - Memory Type: Words 13–14 specify the location in the local PLC where the Ethernet Interface will get the data to be written to the remote SRTP server. Valid values for Word 13 are listed for Establish Read Channel.

(Word 14) Local PLC - Memory Starting Address: Word 14 determines the starting address in the local PLC from which the data is to be sent. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 13. This offset can be in bits, bytes, or words depending on the mode specified (for example, if Word 13=16 and Word 14=2, the starting address will be %I9). Valid ranges of values depend on the PLC's memory ranges.

(Word 15) Local PLC - Number of Memory Units: Word 15 specifies the amount of data to be transferred. The value entered is the number of memory units to be transferred, where the size of a memory unit is a bit, byte, or word as specified in Word 13. For example, if Word 13=16 and Word 15=4, then 4 bytes (32 bits) of %I memory will be transferred. A maximum of 16384 bits, 2048 bytes, or 1024 words of data can be specified.

(Word 16) Reserved: Word 16 is reserved and should contain the value zero.

(Word 17) Reserved: Word 17 is reserved and should contain the value zero.

(Word 18) Remote Host - Network Address Type: Word 18 specifies the format of the remote host's address. Word 18 must contain the value 1, which indicates a dotted-decimal IP address expressed using a separate register for each decimal digit.

(Word 19) Remote Host - Network Address Length: Word 19 specifies the length in words of the remote host's IP address. Word 19 must contain 4.

(Words 20–23) Remote Host - IP Address: Words 20–23 specify the four integers, one integer per word, of the dotted-decimal IP address of the remote host to be accessed.

Abort Channel (2001)

The Abort Channel command immediately disconnects an active channel from its remote PLC, and closes the channel. The Channel Transfer bit, the Channel Error bit, and the Detailed Channel Status words for the channel are set to zero.

Example Command Block

Abort Channel 5. Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00002	(0002)	Length of Channel command Data Block (2 words)
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of COMMREQ status word (%R)
Word 4	00009	(0009)	COMMREQ status word address minus 1 (%R10) (0-based)
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	02001	(07D1)	Abort Channel command number
Word 8	00005	(0005)	Channel number 5

(Word 7) Channel Command Number: This command parameter requests that a channel be aborted. If the command is processed successfully, it terminates processing on the channel by the time success is indicated in the COMMREQ status word.

(Word 8) Channel Number: The channel number specifies the channel to be disconnected (1–32). As a convenient way to abort all channels, if the channel number parameter is –1 (FFFFH), all channels in use are aborted. It is *not* an error to abort all channels if there are none in use. Neither is it an error to abort an idle channel.

Note: For the Abort Channel and Retrieve Detailed Channel Status commands, no actual data is transmitted on the network. Communication occurs between the client PLC CPU and the local Ethernet Interface only. For these commands, the actual function is performed locally within the Ethernet Interface and then the COMMREQ Status word is sent immediately to the CPU.

Retrieve Detailed Channel Status (2002)

The Retrieve Detailed Channel Status command requests that the *current* Detailed Channel Status words are returned for a channel. The Detailed Channel Status words contain an active/inactive channel indicator and the last channel error codes seen. These two words of detailed status supplement the information available in the COMMREQ Status word and the Channel Status bits. The command has no effect on the value of the Channel Status bits.

The Detailed Channel Status words are updated every time the status of the channel changes. If the channel is operating with a fast repetition period, the status words may change faster than the ladder executes the COMMREQ to retrieve them. If that happens, some status values could be missed by the application program.

Example Command Block

Retrieve detailed channel status for Channel 5. Store the Detailed Channel Status words to Registers %R100–%R101. Return the COMMREQ status word to %R10.

	Dec	(Hex)	
Word 1	00004	(0004)	Length of Channel command Data Block (4 words)
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory Type of COMMREQ status word (%R)
Word 4	00009	(0009)	COMMREQ status word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	02002	(07D2)	Retrieve Detailed Channel Status Command number
Word 8	00005	(0005)	Channel number 5
Word 9	00008	(0008)	Local PLC - Memory type to store Detailed Chan. Stat. (%R)
Word 10	00100	(0064)	Local PLC - Starting address (%R100)

The term local PLC is used here to identify the client PLC—the PLC that initiates the communications request.

* Word 4 (COMMREQ status word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: The command parameter in Word 7 requests that Detailed Channel Status words be returned. The Detailed Channel Status words are written to the location specified in Words 9 and 10. The COMMREQ status word indicates successful completion of the command. If the specified channel is not currently in use, the latest status is returned.

(Word 8) Channel Number: The channel number in Word 8 specifies the channel (1 – 32) whose status is to be read.

(Word 9) Local PLC - Memory Type: Words 9 and 10 specify the starting point in the client CPU memory where the Detailed Channel Status words are to be written. The length of the transfer is always 2 words.

(Word 10) Local PLC - Memory Starting Address: Word 10 determines the starting address to store the Detailed Channel Status data. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 9. This offset is in bits, bytes, or words depending on the mode specified (for example, if Word 9=16 and Word 10=2, then the starting address will be %I9). Valid ranges of values depend on the PLC's memory ranges. Make sure this area can contain the 2 words of data without overwriting other application data.

Note: For the Abort Channel and Retrieve Detailed Channel Status commands, no actual data is transmitted on the network. Communication occurs between the client PLC CPU and the local Ethernet Interface only. For these commands, known as “local” commands, the actual function is performed locally within the Ethernet Interface and then the COMMREQ Status word is sent immediately to the CPU.

Monitoring the Detailed Channel Status Words

The Detailed Channel Status words (DCS words) are returned from the Ethernet Interface to the CPU in response to a Retrieve Detailed Channel Status command from the application program. The first two Detailed Channel Status bytes report status and errors in the same format as the COMMREQ Status word. See the list of error codes in chapter 9.

The second word of the DCS words indicates when the channel is active.

If a channel error is indicated (by the Channel Error bit) after the channel is established, the first word of the DCS words contains an error code indicating the cause of the error. The second word of the DCS words indicates whether the channel is active or idle.

The Detailed Channel Status words are updated in the Ethernet Interface every time the status of the channel changes. If the channel is operating with a fast repetition period, the status words may change faster than the ladder executes the COMMREQ to retrieve them. Therefore, some status values may be missed by the program logic.

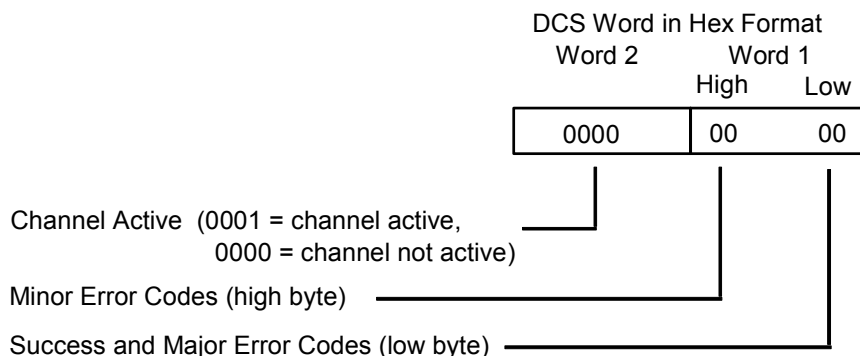
The DCS words location is specified in the Retrieve Detailed Channel Status Command. The contents of these status words are defined below.

The initial value of the Detailed Channel Status words is all zeros. DCS words are reset to zero when:

- The Ethernet Interface is powered up or restarted
- The CPU transitions from STOP to RUN
- A channel abort COMMREQ aborts the channel

Format of the Detailed Channel Status Words (DCS Words)

Display the DCS status words in hexadecimal form to differentiate the high and low bytes.



Programming for Channel Commands

The COMMREQ function for a Channel command must be initiated by a one-shot. That will prevent the COMMREQ from being executed each CPU scan, which would overrun the capability of the Ethernet Interface and possibly require a manual restart. Checking certain status bits before initiating a COMMREQ function is also important. In particular, the LAN Interface OK bit should be used as an interlock to prevent execution of the COMMREQ when the Ethernet Interface is not operational. After initiating a COMMREQ on a channel, no further COMMREQs should be issued to that channel until a non-zero COMMREQ status word has been returned to the program from the Ethernet Interface.

Every ladder program should do the following before initiating a COMMREQ function.

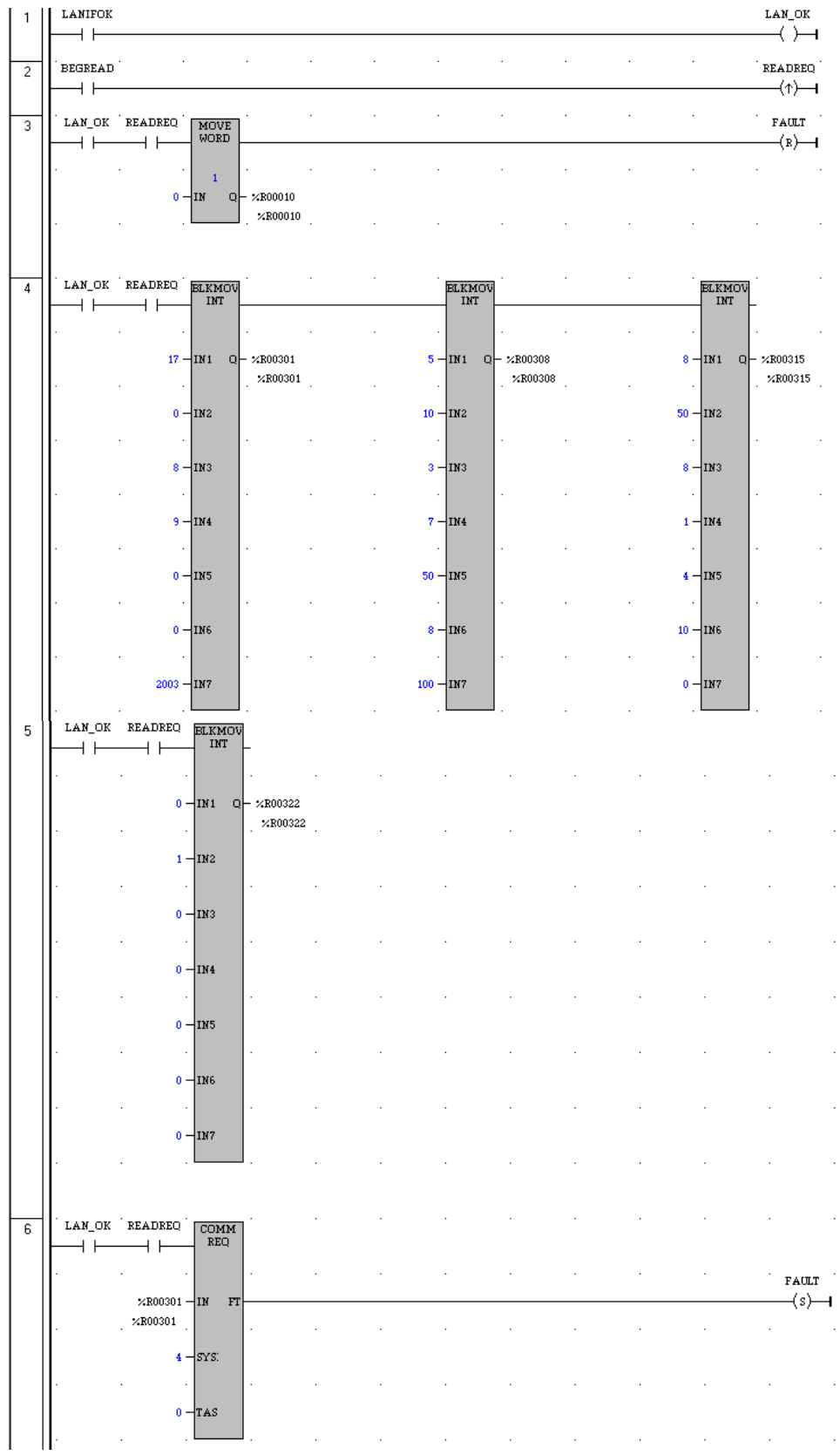
1. Initiate the COMMREQ function with a one-shot. This prevents sending the same COMMREQ Command Block more than once.
2. Include at least the LAN Interface OK bit in the LAN Interface Status Word as an interlock contact for the COMMREQ function.
3. Zero the word location you specify for the COMMREQ status word and FT Outputs of the COMMREQ function block before the COMMREQ function is initiated.
4. Move the command code and parameters for the Channel command into the memory location specified in the IN input of the COMMREQ Function Block before the COMMREQ function is initiated.

An example ladder program segment on the next page illustrates these points.

COMMREQ Example

In the example logic that follows, the input values for the Block Move Functions are taken from the Establish Read Channel (2003) command Example 1 in this chapter.

Nicknames are used in this example to make the ladder program easier to follow. LANIFOK is bit 16 of the LAN Interface Status bits. All other nicknames can be assigned as needed.



Rung # 1: Input LANIFOK (bit 16 of the LAN Interface Status bits) monitors the health of the Ethernet Interface. If it is OK to send a COMMREQ, the LAN_OK coil is ON. LAN_OK is used as an interlock for Rungs 3–6.

Rung # 2: Input BEGREAD triggers READREQ, which enables execution of the MOVE and COMMREQ functions. READREQ is a one-shot (Positive Transition) coil, activating once when BEGREAD transitions from OFF to ON.

Rung # 3: The MOVE WORD function moves a zero to the COMMREQ status word referenced in the Command Block (see rung #4). This clears the COMMREQ status word. This rung also resets the FT output coil of the COMMREQ Function Block in rung #6.

It is vital that the COMMREQ status word be cleared and the COMMREQ fault output coil be cleared each time before initiating a COMMREQ function.

Rungs # 4–5: The BLKMOV INT functions set up the COMMREQ Command Block contents. When these rungs are activated, the constant operands are moved into the memory beginning at the address indicated in the instruction. The constant operands in this example are defined in the Establish Read Channel Example in this chapter.

Rung # 6: The COMMREQ Function Block.

- The IN field points to the starting location of the Command Block parameters (%R00301 in this example).
- The SYSID field of the COMMREQ function block defines the rack and slot of the Ethernet Interface to receive the command data. This is a hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet Interface module. In the example ladder diagram shown, the first three number places (from left to right) are zeros and are not displayed; only the last number, 4, appears. This indicates rack 0, slot 4.
- The TASK field of the COMMREQ function block indicates which mailbox task ID to use for the specified rack and slot. This value should always be 21 decimal (0015H).
- The FT output (energizes the FAULT coil in this example) is turned ON (set to 1) if there were problems preventing the delivery of the Command Block to the Ethernet Interface. In this case, the other status indicators are not updated for this COMMREQ

Sequencing Communications Requests

If the Ethernet Interface receives Command Blocks from the PLC CPU faster than the Interface can process them, the Interface will log an exception event 08, Entry 2=0024H and will log the PLC Fault Table entry:

“Backplane Communications with PLC Fault; Lost Request”

Only one COMMREQ function per channel can be pending at one time. A COMMREQ function is pending from the time it is initiated in the ladder program until its COMMREQ status word has been updated to a non-zero value by the Ethernet Interface.

If the PLC CPU attempts to send COMMREQs to the Ethernet interface faster than the Ethernet interface can receive them, the FT output of the COMMREQ function block will be set and the CPU will generate the following entry in the PLC Fault Table:

“Mailbox queue full – Comm_req aborted”

The PLC logic program should send retry the COMMREQ after a short delay.

Managing Channels and TCP Connections

In Certain Conditions TCP Connections Can Be Totally Consumed

When you issue a COMMREQ to establish a read or write channel, a TCP connection is created, the transfer(s) are made, then upon completion of all the transfers, the TCP connection is terminated. It takes time to create and to terminate these connections. If an application is constructed so that it rapidly and repeatedly establishes a channel with only one repetition (one transfer), the available TCP connections for the Ethernet Interface may be totally consumed. A “snapshot” of the state of the TCP connections would show some of them being created, some being terminated, and some active, but none available.

If the logic for issuing COMMREQs is constructed so it does the following, all available TCP connections can quickly be used up:

- The number of repetitions (Word 9 in an Establish Read or Write Channel COMMREQ) is set to 1, *and*
- A new COMMREQ is issued repeatedly and immediately upon completion of the prior one.

Use “Channel Re-Tasking” To Avoid Using Up TCP Connections

TCP connections can be used up if each successive COMMREQ is directed to the same target device (same IP address). In this case, it is better to establish a channel with the target device once, leave it active, then re-task the channel, even if data transfers take place infrequently. This method will use only one TCP connection.

An additional advantage of re-tasking is that the time and network traffic required to create a channel and its associated TCP connection are not incurred each time a data transfer is required.

The disadvantages to re-tasking are:

- While the TCP connection is open, it is unavailable to the rest of your application, and
- The active TCP connection uses up network bandwidth because the active TCP connection generates a small amount of ongoing periodic network traffic.

How To Re-Task a Channel

1. For Establish Read/Write Channel Commands, set the number of repetitions (COMMREQ Word 9) to 2 and set the read/write period (COMMREQ Words 10 and 11) to be longer than the expected time between transfers. For example, if you expect to transfer data about once per minute, set the read/write period to about two minutes. This will cause a TCP connection to be created and held open for two minutes.
2. Set up the ladder program to:
 - A. Issue the first COMMREQ and wait for the first transfer to complete, which will be indicated when the COMMREQ Status (CRS) word is changed to 1.
 - B. Then before the read/write period expires (at which time the second and final transfer is sent and the TCP connection is dropped), issue the next COMMREQ with the same parameters as specified in step 1. This will “re-task” the channel to use the existing TCP connection instead of opening a new one, and will send another data transfer restarting the timer for the read/write period. Repeat step 2B for each successive data transfer desired.

Client Channels TCP Resource Management

There is a period of time that the OS Network stack hangs on to the TCP resources associated with a connection after it is closed. It applies to the initiator of the close, which is almost always the client side. This time is referred to as the “TCP Linger Period”. Once the TCP Linger Period expires (60 seconds in the current OS implementation), the TCP resources are released. Application developers using client channels need to be aware of this behavior when designing their logic. There are a finite number of TCP resources allocated to client channels, and if channel connections are brought up and down so fast that these resources are depleted, then the application may have to wait until a TCP resource frees up in order to establish another client channel (a COMMREQ Status of 0xA890 is returned if no TCP resources are currently available; application should wait and retry again).

SRTP Client Channels provides features that help the user preserve TCP connections. These include a period time where one can establish an SRTP Channel and specify the channel to run at a given interval, or run as fast as possible. One can also specify a number of iterations, or run forever. Additionally, SRTP Channels allows channel re-tasking of an active channel to the same remote device, where the parameters of an active channel, such as changing the channel command type (Read/Write), number of repetitions, time periods, local memory address, remote memory address, etc. can be changed. SRTP Channels also allows channel re-tasking of an active channel to a different remote device (changing the remote device’s IP address, etc.). However, re-tasking to a different remote device will neither conserve TCP connections, nor save on the time it takes to create a channel.

SRTP Application Timeouts

The application timeouts within SRTP Channels also include the time needed to establish and maintain the underlying network and SRTP connection. Examples are establishing the TCP connection for a new channel, establishing communication with the remote device, and TCP retransmissions during Channel operations. If the time needed for TCP connection establishment or maintenance exceeds the user-specified channel application timeout values, an application timeout will occur. Channel application timeouts are temporary errors; the channel continues to run when the expected response is received.

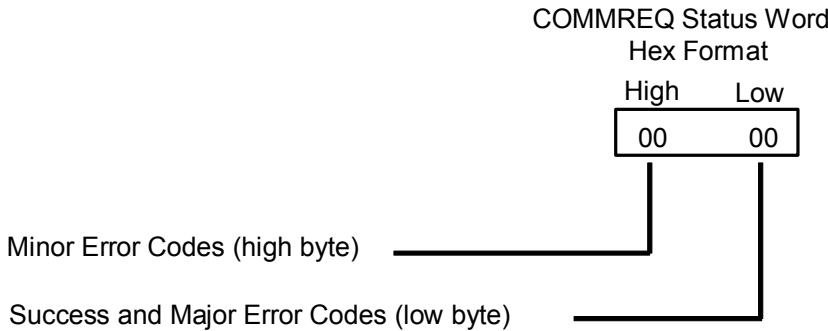
If the application is seeing timeouts during channel startup, there are a few different options:

1. Increase timeout value to account for Channel connection overhead
2. Ignore the timeout error on the first transfer
3. Use a two-step setup approach where the first COMMREQ has a timeout large enough to account for the connection overhead and then Re-Task the channel to the normal operating timeouts.

Monitoring Channel Status

The COMMREQ Status word is returned from the Ethernet Interface to the PLC CPU immediately if the Command Block contains a syntax error or if the command is local. For remote commands with no syntax error, it is returned either after the channel is established successfully and the first transfer has completed or if there is an error establishing the channel. The location of the COMMREQ status word is defined in the Command Block for the COMMREQ function.

Format of the COMMREQ Status Word



It is critical to monitor the COMMREQ status word for each COMMREQ function. Zero the associated COMMREQ status word before executing the COMMREQ function. When the COMMREQ status word becomes non-zero, the Ethernet Interface has updated it.

If after executing a COMMREQ function, the COMMREQ status word is zero (0) and the FT Output is OFF, the Command Block has been sent to the Ethernet Interface, but no status has been returned. If this condition persists, check the PLC Fault Table for information.

If the COMMREQ status word is updated to 1, the Command Block was processed successfully by the Ethernet Interface.

If the COMMREQ status word is updated to a value other than 1, an error has occurred in processing the Command Block. The cause may be:

- Errors in the Command Block (the Channel command code or parameters), or
- For an establish command (Establish Read Channel, Establish Write Channel, or Send Information Report), the command parameters were valid but there was an error in establishing a channel.

Chapter 9 lists the Major and Minor error codes that may be returned in the COMMREQ status words. Do not use data received from a server until the COMMREQ status word for that channel is 1 or the Data Transfer bit goes to 1.

Differences between Series 90 and PACSystems SRTP Channels

This section lists differences between the Series 90 implementation of SRTP Channels and the PACSystems implementation.

1. The TCP Connect Timeout for an SRTP Channel on the Series 90 was 90 seconds. For PACSystems, a new SRTP AUP parameter, "SRTP Channel TCP Connect Timeout", will be added that specifies the amount of time to wait for a TCP connection to be established: `hconn_tout`. The default value will be set to 75 seconds, and its maximum value is 75 seconds, which is the maximum value we can specify to the current OS. Minimum value is 10 milliseconds.
2. PACSystems has a TCP Linger Period, which is the period of time the OS Network stack hangs onto the TCP resources associated with a connection after it is closed. The TCP resources from a channel that was stopped will become available again after the 60 second TCP linger period has expired. The Series 90 had no linger period.
3. The Series 90 SRTP Channel implementation performed a normal stopping of the channel on a Run-to-Stop transition. On PACSystems, a Run-to-Stop transition causes an Abrupt Shutdown, avoiding the TCP Linger period and reducing the chance of exhausting TCP resources when quickly transitioning between Run->Stop and Stop->Run.
4. On the Series 90, if an Abort/Abort All Channel COMMREQ is issued, followed by an Establish Read/Write/Send Info Report Channel COMMREQ before the COMMREQ Status Word for the Abort/Abort All has been updated, the Establish Read/Write/Send Information Report was dropped and the COMMREQ Status Word was not updated (it remained zero). For PACSystems, the Establish Read/Write/Send Information Report COMMREQ is discarded and its COMMREQ Status Word is set to a failure value (A990). That indicates it was discarded because the application logic issued the command while an Abort was in progress.
5. For PACSystems, new COMMREQ Status Codes are defined. See chapter 10 for details.
6. The PACSystems implementation supports Re-tasking to a different remote device (different IP Address).
7. The Series 90-70 limited the total number of TCP connections shared between SRTP Client Channels and SRTP Server to 48. TCP connections will no longer be shared between SRTP Server and Client, and the maximum TCP Connections allowed will be increased as follows:
 - a. Allow a maximum of 48 Server TCP connections
 - b. Allow a maximum of 32 Client Channel TCP connections

Chapter Modbus/TCP Server

7

This section describes the implementation of the Modbus/TCP Server feature for the PACSystems family of products.

- Modbus/TCP Server
- Reference Mapping
- Modbus Function Codes

Modbus/TCP Server

The PACSystems products listed below support Modbus/TCP Server functionality:

- CPU010 and CPU020 with primary firmware version 3.0 or later.
- CRE020 with Ethernet firmware version 3.0 or later.
- RX7i: IC698ETM001 and RX3i IC695ETM001 with firmware version 3.0 or later.

Modbus/TCP Server Connections

The Modbus/TCP Server supports up to 16 simultaneous connections. These connections are not shared with any other applications. Other TCP-based application protocols such as SRTP Server use a different set of TCP connections.

Modbus Conformance Classes

PACSystems Modbus/TCP Server supports Modbus Conformance classes 0, 1, and 2.

The RX3i Ethernet module has been certified by the Modbus/TCP Conformance Test Laboratory to be in conformance with *Conformance Test Policy* Version 2.1.

Server Protocol Services

The Modbus/TCP Server responds to incoming Request Connection, Terminate Connection and Request Service messages. The client with which the server is interacting should wait for the server's response before issuing the next Request Service, otherwise requests could be lost.

There is no inactivity timeout in the server. If a client opens a connection, that connection stays open until the client terminates the connection or until the connection is terminated for some other reason.

Station Manager Support

The Modbus/TCP Server supports the standard Station Manager commands: STAT, TALLY, and TRACE, plus the Modbus/TCP server-specific KILLMS command. The Modbus/TCP Server task letter is "o".

Reference Mapping

The Modbus protocol’s reference table definition is different from the internal structure of the PACSystems reference tables. Modbus refers to Holding Register, Input Register, Input Discrete and Coil tables; PACSystems uses Discrete Input (%I), Discrete Output (%Q), Analog Input (%AI), Register (%R), and Word (%W) reference tables for Modbus data. The following table shows how each Modbus table has been mapped to the PACSystems reference tables.

Modbus Reference Tables

<i>Modbus File Access (6xxxx)</i>	<i>Modbus Holding Register Table (4xxxx)</i>	<i>Modbus Input Register Table (3xxxx)</i>	<i>Modbus Input Discrete Table (1xxxx)</i>	<i>Modbus Coil Table (0xxxx)</i>	<i>PACSystems Reference Tables</i>
---	---	---	1 – 32768 (bits)	---	%I1 – 32768 (bits)
---	---	1 – 32640 (16-bit words)	---	---	%AI1 – 32640 (16-bit words)
---	---	---	---	1 – 32768 (bits)	%Q1 – 32768 (bits)
---	1 – 32640 (16-bit words)	---	---	---	%R1 – 32640 (16-bit words)
F1,R1 – F525,R2880 (16-bit words)	---	---	---	---	%W1 –5,242,880 (16-bit words)

Modbus Holding Register Table

The Modbus Holding Register table is mapped exclusively to the CPU Register (%R) table.

Applicable Functions

- Read Multiple Registers
- Write Multiple Registers
- Write Single Register
- Mask Write Register
- Read/Write Multiple Registers

Modbus Input Register Table

The Modbus Input Register table is mapped exclusively to the CPU Analog Input (%AI) table.

Applicable Functions

- Read Input Registers

Modbus Input Discrete Table

The Modbus Input Discrete table is mapped exclusively to the CPU Discrete Input (%I) table.

Applicable Functions

- Read Input Discretes

Modbus Coil Table

The Modbus Coil table is mapped exclusively to the CPU Discrete Output (%Q) table.

Applicable Functions

- Read Coils
- Write Coils
- Write Single Coil

Modbus File Access Table

The Modbus File Access table is mapped exclusively to PACSystems %W memory.

Applicable Functions

- Read File Record
- Write File Record

Translating %W Reference Addresses

To find the PACSystems %W memory address equivalent of a Modbus File and Record:

$$\%W = 10,000 (F-1) + R$$

To find the Modbus File and Record equivalent of a PACSystems %W memory address:

$$\text{File} = \frac{W-1}{10,000} + 1 \quad \text{(Discard any fractional portion; round the result downward to the next integer value).}$$

$$\text{Record} = W - (10,000 (F - 1))$$

CAUTION

If you use the Modbus function Write File Record, and specify multiple record sections, the first N-1 sections will be written to the server's PLC reference memory, even if an error prevents the writing of the last section.

Address Configuration

Address mapping is done in the Machine Edition Hardware Configuration of the CPU. All Ethernet modules and daughterboards in the PLC use Modbus-to-PLC address mapping based on this one map. The Modbus/TCP Server does not use COMMREQs to configure address mapping.

Each PLC memory area is mapped to an appropriate Modbus address space. On the Settings tab, Modbus Address Space Mapping can be set to Standard Modbus Addressing or Disabled. If Modbus Address Space Mapping is set to Standard, the Modbus/TCP Address Map tab displays the standard references assignments.

<i>Number</i>	<i>Modbus Register</i>	<i>Start Address</i>	<i>End Address</i>	<i>PLC Memory Address</i>	<i>Length</i>
1	0xxxx – Coil Table	1	32768	%Q00001	32768
2	1xxxx Discrete Table	1	32768	%I00001	32768
3	3xxxx Input Registers	1	64	%AI00001	64
4	4xxxx – Register Table	1	1024	%R00001	1024
5	6xxxx – Internal Table	0	0	%W0001	0

When Modbus Address Space Mapping is set to Disabled on the Settings tab, the Modbus/TCP Address Map tab does not appear.

If the CPU module does not receive an address map from Machine Edition, Ethernet interfaces within the PLC will respond to Modbus/TCP clients with Exception Code 4, Slave Device Failure. This same exception code will also be returned when the PLC's hardware configuration is cleared.

Modbus Function Codes

This section summarizes the mapping of PACSystems reference tables to Modbus addresses by the Modbus function codes supported by the Modbus/TCP Server. The mapping shown in this table assumes that the PLC is configured to use its default reference table sizes.

Modbus Function Code	Modbus			PLC	
	Table	Start Address	Length	Start Address	Length
1 Read Coils 5 Write Single Coil 15 Write Multiple Coils	0xxxx	1	32768	%Q00001	32768
2 Read Discrete Inputs	1xxxx	1	32768	%I00001	32768
3 Read Holding Registers 6 Write Single Register 16 Write Multiple Registers 22 Mask Write Register 23 Read/Write Multiple Registers	4xxxx	1	1024	%R00001	1024
4 Read Input Registers	3xxxx	1	64	%AI00001	64
7 Read Exception Status 8 Diagnostics	n/a	N/a	n/a	n/a	n/a
20 Read File Record 21 Write File Record	6yxxxx	1	0	%W00001	0

Chapter *Modbus/TCP Client*

8

This chapter explains how to program communications over the Ethernet network using Modbus/TCP Channel commands. This chapter applies *only* to PLCs being used as client PLCs to *initiate* Modbus/TCP communications.

- The Communications Request
- The COMMREQ Function Block and Command Block
- Modbus/TCP Channel Commands
- Status Data
- Controlling Communications in the Ladder Program
- Differences between Series 90 and PACSystems Modbus/TCP Channels

The Communications Request

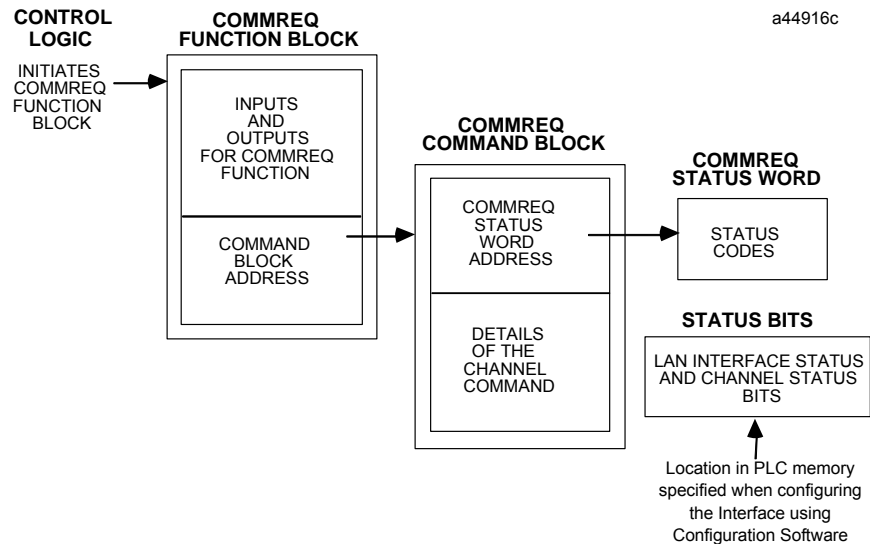
“Communications Request” is a term used to describe all the user elements required for correctly *initiating* Channel commands in the client. No programming of Communications Requests is required for devices acting as servers

Structure of the Communications Request

The Communications Request is made up of the following elements:

- The COMMREQ Function Block (ladder instruction)
- The COMMREQ Command Block
- The Channel Command
- Status Data (COMMREQ Status word, LAN Interface Status and Channel Status bits)
- The logic program controlling execution of the COMMREQ Function Block

The figure below illustrates the relationship of these elements:



COMMREQ Function Block

The COMMREQ Function Block is the ladder instruction that triggers the execution of the Channel command. In the COMMREQ Function Block, you specify the rack and slot location of the Ethernet interface, a task value, and the address of a location in memory that contains the Command Block. There is also a fault output on the COMMREQ Function Block that indicates certain programming errors.

COMMREQ Command Block

The COMMREQ Command Block is a structure that contains information about the Channel command to be executed. The Command Block consists of two parts:

Common Area - includes the address of the COMMREQ Status word (CRS word).

Data Block Area - describes the Channel command to be executed.

When the COMMREQ function is initiated, the Command Block is transferred to the Ethernet interface for action.

Modbus/TCP Channel Commands

The Channel commands are a set of client commands used to communicate with a server. Up to 32 channels (numbered 1–32) can be established. The channel number is specified in the Command Block for the Channel command. The channel can be monitored using the Channel Status bits. The 32 Client connections of an Ethernet interface are shared between all Client protocols. For example, if 16 Client connections are used for SRTP Channels, there are 16 Client connections available for Modbus/TCP Channels. Any given channel can be assigned to only one protocol at a time.

Status Data

There are several types of status available to the client application program.

LAN Interface Status Bits (LIS Bits): The LIS bits comprise bits 1–16 of the 80-bit status area. The location of this 80-bit status area is assigned using the Configuration software. The LIS bits contain information on the status of the Local Area Network (LAN) and the Ethernet interface.

Channel Status Bits: The Channel Status bits comprise bits 17–80 (64 bits) of the 80-bit status area. When used for Modbus/TCP channels, these bits consist of a *connection open* bit and an unused bit, reserved for future use, for each of the 16 channels that can be established. Status bits for unused channels are always set to zero.

COMMREQ Status Word (CRS Word): The 16-bit CRS word will receive the initial status of the communication request. The location of the CRS word is assigned for each COMMREQ function in the COMMREQ Command Block.

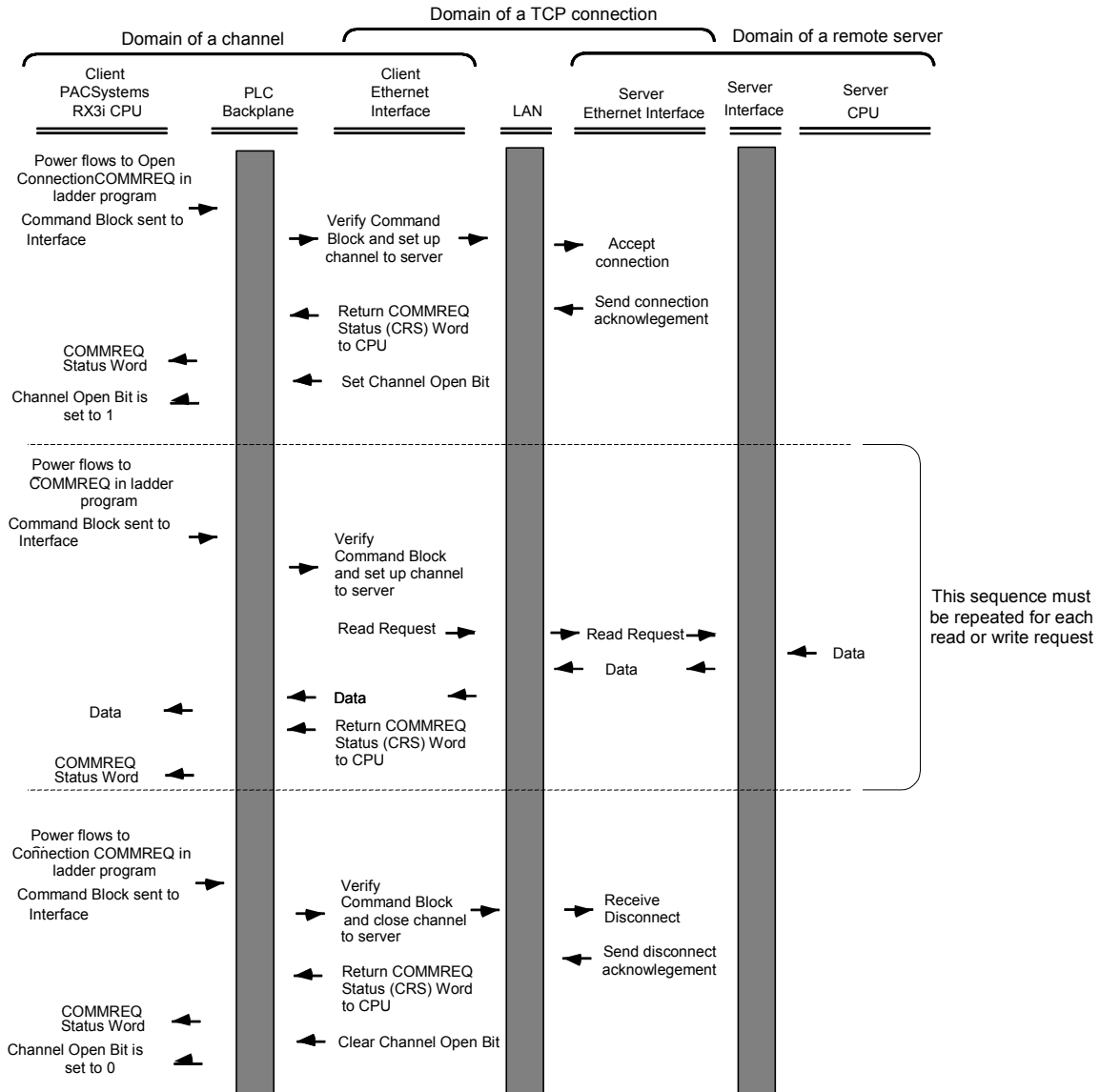
FT Output of the COMMREQ Function Block: This output indicates that the PLC CPU detected errors in the COMMREQ Function Block and/or Command Block and did not pass the Command Block to the Ethernet interface.

The Logic Program Controlling Execution of the COMMREQ Function Block

The COMMREQ must be initiated by a one-shot to prevent the COMMREQ from being executed repeatedly each CPU scan, which would overrun the capability of the Ethernet interface and possibly require a manual restart. Checking certain status bits before initiating a COMMREQ function is also important. In particular, the LAN Interface OK bit should be used as an interlock to prevent execution of the COMMREQ function when the Ethernet interface is not operational. Following initiation of a COMMREQ on a channel, no further COMMREQs should be issued to that channel until a non-zero CRS word has been returned to the program from the Ethernet interface.

Operation of the Communications Request

The diagram below shows how Communications Requests are executed to complete a data read from the remote Modbus/TCP device. The figure specifically illustrates the successful operation of a data read.



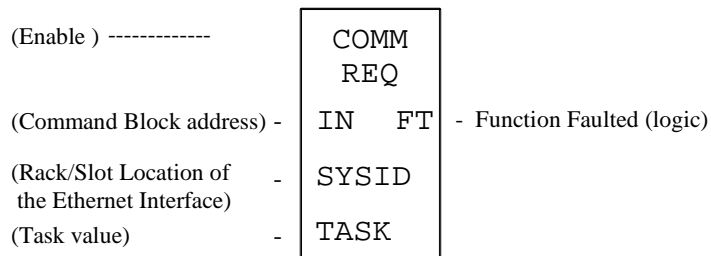
1. A Communications Request begins when there is power flow to a COMMREQ function in the client. The Command Block data is sent from the CPU to the Ethernet interface.
2. The COMMREQ Status word (CRS word) is returned immediately if the Command Block is invalid. If the syntax is correct, then the CRS word is returned after the transfer of data.

COMMREQ Function Block and Command Block

This section describes the programming structures common to all Communications Requests: the COMMREQ Function Block and the Command Block.

The COMMREQ Function Block

The Communications Request is triggered when the logic program passes power to the COMMREQ Function Block.



Each of the inputs and outputs are discussed in detail below. It is important to understand that the Command Block address points to the location in memory you have setup as the Command Block.

Enable: Control logic for activating the COMMREQ Function Block. See Section 5 for tips on developing your program.

IN: The location of the Command Block. It can be any valid address within a word-oriented area of memory (%R, %AI, %AQ, %P, %L or %W for the Ethernet interface).

SYSID: A hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet interface.

Examples:

<i>Rack</i>	<i>Slot</i>	<i>Hex Word Value</i>	<i>Notes</i>
0	1	16#0001	Slot 1 is used for the Ethernet daughterboard on an RX7i CPU.
0	4	16#0004	
3	4	16#0304	
2	10	16#020A	
4	2	16#0402	

TASK: For the RX3i and Rx7i ETM001 Ethernet interfaces TASK must always be set to zero. For PACSystems CPU embedded Ethernet interface, TASK must be set to 65536 (0x10000) to address the CPU's Ethernet daughterboard.

Caution

Entering an incorrect TASK value may cause the Ethernet interface to fail.

FT Output: The FT output is set if the PLC CPU (rather than the Ethernet interface) detects that the COMMREQ fails. In this case, the other status indicators are not updated for this COMMREQ.

The COMMREQ Command Block

When the COMMREQ function is initiated, the Command Block is sent from the PLC CPU to the Ethernet interface. The Command Block contains the details of a command to be performed by the Interface.

The address in CPU memory of the Command Block is specified by the IN input of the COMMREQ Function Block. This address can be any valid address within a word-oriented area of memory. The Command Block is usually set up using either the BLOCK MOVE or the DATA INIT COMM programming instruction. The Command Block has the following structure:

Word 1	Data Block Length (words)
Word 2	WAIT/NOWAIT Flag
Word 3	CRS Word Memory Type
Word 4	CRS Word Address Offset
Word 5	<i>Reserved</i>
Word 6	<i>Reserved</i>
Words 7 and up	Data Block (Channel Command Details)

When entering information for the Command Block, refer to these definitions:

(Word 1) Data Block Length: This is the length in words of the Data Block portion of the Command Block. The Data Block portion starts at Word 7 of the Command Block. The length is measured from the beginning of the Data Block at Word 7, not from the beginning of the Command Block. The correct value for each command, and the associated length of each command, is specified in the next section.

(Word 2) WAIT/NOWAIT Flag: This flag must be set to zero for TCP/IP Ethernet Communications.

COMMREQ Status Word: The Ethernet interface updates the CRS word to show success or failure of the command. Command words 3 and 4 specify the PLC memory location of the CRSW word.

(Word 3) COMMREQ Status Word Memory Type: This word specifies the memory type for the CRS word. The memory types are listed in the table below:

Type	Value (Decimal)	Value (Hex.)	Description
%R	8	08H	Register memory (word mode)
%AI	10	0AH	Analog input memory (word mode)
%AQ	12	0CH	Analog output memory (word mode)
%I	16	10H	Discrete input memory (byte mode)
	70	46H	Discrete input memory (bit mode)
%Q	18	12H	Discrete output memory (byte mode)
	72	48H	Discrete output memory (bit mode)
%T	20	14H	Discrete temporary memory (byte mode)
	74	4AH	Discrete temporary memory (bit mode)
%M	22	16H	Discrete momentary internal memory (byte mode)
	76	4CH	Discrete momentary internal memory (bit mode)
%G	56	38H	Discrete global data table (byte mode)
	86	56H	Discrete global data table (bit mode)
%W	196	C4H	Word memory (word mode limited to %W1 - %W65536)

(Word 4) COMMREQ Status Word Address Offset: This word contains the offset within the memory type selected. **The status word address offset is a zero-based number.** For example, if you want %R1 as the location of the CRS word, you must specify a zero for the offset. The offset for %R100 would be 99 decimal. Note that this is the only zero-based field in the Channel commands.

(Word 5): Reserved. Set to zero.

(Word 6): Reserved. Set to zero.

(Words 7 and up) Data Block: The Data Block defines the Channel command to be performed. For information on how to fill in the Channel command information, see the next section.

Modbus/TCP Channel Commands

This section describes the operation of the Channel commands. A detailed description and example of each Channel command is included. There are four Channel commands:

- Open a Modbus/TCP Connection
- Close a Modbus/TCP Connection
- Read Data from a Modbus Server Device to the PLC
- Write Data from the PLC to a Modbus Server Device
- Mask Write Register Request to a Modbus Server Device
- Read/Write Multiple Registers between PLC memory and a Modbus Server Device

Please note that Modbus/TCP channel COMMREQs (unlike SRTP channel COMMREQs) do not contain a parameter to configure a timeout value. Enforcing a timeout for a Modbus channel command is at the discretion of the user and must be implemented in the user application.

Open a Modbus/TCP Client Connection (3000)

The Modbus/TCP Ethernet interface transfers data to or from another Modbus/TCP device using a *channel*. Up to 32 channels are available for Modbus/TCP client communications. However, these 32 channels are shared with SRTP Channels so that the combination of SRTP Channels and Modbus/TCP Channels cannot exceed 32.

The Open Modbus/TCP COMMREQ requests the communication subsystem to associate a channel with a remote Modbus/TCP device. Using the COMMREQs defined later in this document the PLC may transfer data to and from a remote device.

Once a channel is allocated for Modbus/TCP Client communications, the channel remains allocated (i.e. another protocol such as SRTP Channels cannot use the channel). The channel connection is released only when: the application program closes the channel, the channel is automatically closed when the PLC transitions to STOP, when the Ethernet interface uses a Redundant IP and the CPU transitions from the Active to the Backup unit, the Ethernet interface is reset or the underlying TCP connection is terminated.

The IP address of the remote Modbus/TCP device is specified in the Open Modbus/TCP COMMREQ using the standard dotted-decimal format. No other IP address format is accepted.

The COMMREQ Status Word (CRS) indicates the success or failure of the Open Modbus/TCP Client Connection COMMREQ. If the COMMREQ requests an invalid channel number or an already allocated channel the COMMREQ fails and the CRS is set to a non-zero value to identify the failure. See the section “Status Data” later in this document for detailed CRS failure codes.

Command 3000 Example

Establish a channel (Channel 5) to a remote Modbus/TCP device at IP address 10.0.0.1. Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03000	(0BB8)	Open Modbus/TCP Client Connection
Word 8	00005	(0005)	Channel number (5)
Word 9	00001	(0001)	Remote Device Address Type
Word 10	00004	(0004)	Length of Remote Device Address
Word 11	00010	(0010)	Numeric value of 1 st Octet
Word 12	00000	(0000)	Numeric value of 2 nd Octet
Word 13	00000	(0000)	Numeric value of 3 rd Octet
Word 14	00001	(0001)	Numeric value of 4 th Octet

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 is the command id for an Open Modbus/TCP Client Connection COMMREQ. If successful a TCP connection with the specified device is allocated.

(Word 8) Channel Number: Word 8 specifies the channel number to allocate for the Modbus/TCP Client connection. Channels 1-32 can be used for Client communications.

(Word 9) Address Type: Word 9 specifies the type of IP Address specified for the remote device. A value of one (1) is required in this word.

(Word 10) Length of IP Address: Word 10 specifies the length of the IP Address. A value of four (4) is required in this word.

(Word 11) IP Address 1st Octet: Word 10 specifies the value of the first octet of the IP Address.

(Word 12) IP Address 2nd Octet: Word 11 specifies the value of the second octet of the IP Address.

(Word 13) IP Address 3rd Octet: Word 12 specifies the value of the third octet of the IP Address.

(Word 14) IP Address 4th Octet: Word 13 specifies the value of the fourth octet of the IP Address.

Close a Modbus/TCP Client Connection (3001)

The application program closes a Modbus/TCP Client Connection by issuing the Close Modbus/TCP Client Connection COMMREQ. The Close COMMREQ closes the underlying TCP connection and frees the channel for other communication tasks.

An error response is returned if the channel number in the COMMREQ identifies a non-Modbus/TCP Client connection or an inactive channel.

Command 3001 Example

Terminate the Modbus/TCP Client connection established on Channel 5. Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00002	(0002)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03001	(0BB9)	Close Modbus/TCP Client Connection
Word 8	00005	(0005)	Channel number (5)

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 requests the Close channel service.

(Word 8) Channel Command Number: Word 8 identifies a channel previously opened with a Open Modbus/TCP Client Connection request. If a Close Modbus/TCP Client Connection is sent to a channel that is already closed, a success CRS value of 1 will be returned.

Read Data from a Modbus/TCP Device (3003)

The Read Data from a Modbus/TCP Device COMMREQ requests a data transfer from a Modbus/TCP device to the PLC. The Read Data COMMREQ must reference an active Modbus/TCP channel previously established with the Open Modbus/TCP Client Connection COMMREQ.

Registers, Coils or Exception Status data may be read from the remote Modbus/TCP device. The Modbus Function Code specifies the data type. Valid Function Codes for the Read Data COMMREQ are presented in the following table.

Function Code	Description	Modbus Server Memory Region Accessed*	Data Unit Size	Maximum Data Units
1	Read Coils	Internal Bits or Physical coils	Bit	2000
2	Read Input Discretes	Physical Discrete Inputs	Bit	2000
3	Read Multiple Registers	Internal Registers or Physical Output Registers	Register (16-bit Word)	125
4	Read Input Registers	Physical Input Registers	Register (16-bit Word)	125
7	Read Exception Status	Server Exception Memory	Byte	Not Applicable
24	Read FIFO Queue	Internal Registers or Physical Output Registers	Register (16-bit Word)	32

The table above describes the general Modbus server memory areas. The actual memory accessed is dependent on how the server maps the Modbus memory regions to the server's local memory.

An Address and Length specify the location of the data in the remote device and the number of data units to transfer. The Length is the number of Registers or Coils to transfer. Modbus Function Code 7, Read Exception Status does not require the address as the remote device retrieves the exception status from an internal location.

When transferring data between server bit or coil memory to PLC bit memory, only the number of bits specified is transferred. For example, if the COMMREQ requests to read 9 coils from the Remote Device and requests to put the data at %M00001 in the Local PLC (using a bit type memory type), %M00001 through %M00009 will be updated with the data from the Remote Device and %M00010 through %M00016 will be unaffected. However, if server bit or coil memory is transferred to PLC byte or word memory, the following rules apply:

1. Transferring discrete data from the Remote Device to Local PLC Word (16-bit) memory: If the number of requested coils is not a multiple of 16, the data is padded with 0s to a 16-bit boundary. For example if the COMMREQ requests reading 17 coils from the Remote Device and requests to place this data at %R00010, %R00010 (all 16 bits) and bit 0 of %R00011 will be updated with values from the Remote Device and bits 1 through 15 of %R00011 will be set to 0.

2. Transferring discrete data from the Remote Device to Local PLC byte memory (using byte type memory type): If the number of requested coils is not on an 8-bit boundary, the data is padded with 0s to an 8-bit boundary. For example if the COMMREQ requests 9 coils from the Remote Device and requests to place this data at %M00001, %M00001 through %M00009 will be updated with values from the Remote Device and %M00010 through %M00016 will be set to 0.

Data returned from the remote device is stored in the PLC data area specified in the Read Modbus/TCP Device COMMREQ. Data can be stored in any of the PLC data areas. Refer to page 8-17 for the list of data areas and identification codes for the PLC. Note that the first item referred to in each data area is item 1 not item 0.

The COMMREQ Status Word (CRS) indicates the success or failure of the Read Data COMMREQ. If the COMMREQ requests an invalid channel number or any other field is invalid the COMMREQ fails and the CRS is set to a non-zero value to identify the failure. See the section “Status Data” later in this document for detailed CRS failure codes.

Command 3003 Example 1

Read four Input Registers from Input Registers in the remote Modbus/TCP device. Store the registers at location %R20. Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10) *
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03003	(0BBB)	Read from a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00004	(0004)	Modbus Function Code (Read Input Registers)
Word 10	00008	(0008)	Local PLC Memory Type
Word 11	00020	(0014)	Local PLC Starting Address
Word 12	00200	(00C8)	Address in the Remote Server
Word 13	00004	(0004)	Number of Registers in the Remote Device
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Read Data from Modbus/TCP Device command block.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Modbus Function Code 4, Read Input Registers.

(Word 10) Local PLC Memory Type: Words 10-11 specify the location in the local PLC where the Ethernet interface will store data received from the remote device Valid values for Word 10 are listed below.

Type	Value (Decimal)	Description
%W	196	Word memory (word mode)
%R	8	Register memory (word mode)
%AI	10	Analog input memory (word mode)
%AQ	12	Analog output memory (word mode)
%I	16	Discrete input memory (byte mode)
	70	Discrete input memory (bit mode)
%Q	18	Discrete output memory (byte mode)
	72	Discrete output memory (bit mode)
%T	20	Discrete temporary memory (byte mode)
	74	Discrete temporary memory (bit mode)
%M	22	Discrete momentary internal memory (byte mode)
	76	Discrete momentary internal memory (bit mode)
%SA	24	Discrete system memory group A (byte mode)
	78	Discrete system memory group A (bit mode)
%SB	26	Discrete system memory group B (byte mode)
	80	Discrete system memory group B (bit mode)
%SC	28	Discrete system memory group C (byte mode)
	82	Discrete system memory group C (bit mode)
%S *	30	Discrete system memory (byte mode)
	84	Discrete system memory (bit mode)
%G	56	Discrete global data table (byte mode)
	86	Discrete global data table (bit mode)

* Read-only memory, cannot be written to.

(Word 11) Local PLC Memory Address: Word 11 determines the starting address in the local PLC in which the data from the remote device is to be stored. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC’s memory ranges. Be sure this area is large enough to contain the requested data without overwriting other application data.

(Word 12) Remote Device Address: Word 12 specifies the address in the remote Modbus/TCP device. Note: The function code determines the Modbus server address area, Word 12 is the address within this area.

(Word 13) Number Registers in Remote Device: Words 13 specifies the quantity of registers (16bit words) to read from the remote device.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Command 3003, Example 2

Read nine (9) Input Discretes starting from Discrete input address 5 in the remote Modbus/TCP server. Store the registers at location %T3(bit mode). Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block (8–14 words)
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10) *
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03003	(0BBB)	Read from a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00002	(0002)	Modbus Function Code (Read Input Discretes)
Word 10	00074	(004A)	Local PLC Memory Type
Word 11	00003	(0003)	Local PLC Starting Address
Word 12	00005	(0005)	Address in the Remote Device
Word 13	00009	(0009)	Number of Input Discretes to Read from the Remote Device
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Read Data from Modbus/TCP Device command block.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Modbus Function Code 2, Read Input Discretes.

(Word 10) Local PLC Memory Type: Words 10-11 specify the location in the local PLC where the Ethernet interface will store data received from the remote device . Valid values for Word 10 are listed on page 8-17.

(Word 11) Local PLC Memory Address: Word 11 determines the starting address in the local PLC in which the data from the remote device is to be stored. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC's memory ranges. Be sure this area is large enough to contain the requested data without overwriting other application data.

(Word 12) Remote Device Address: Word 12 specifies the address in the remote Modbus/TCP device.

(Word 13) Number Registers in Remote Device: Words 13 specifies the quantity of input discretes to read from the remote device.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Command 3003, Example 3 – Read Exception Status

Read the Exception Status from the remote Modbus/TCP server. Store the Exception Data at location %Q4(bit mode). Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10) *
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03003	(0BBB)	Read from a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00007	(0007)	Modbus Function Code (Read Exception Status)
Word 10	00072	(0048)	Local PLC Memory Type
Word 11	00004	(0004)	Local PLC Starting Address
Word 12	00000	(0000)	Reserved
Word 13	00001	(0001)	Data Size
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Read Exception Status from the Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Modbus Function Code 7, Read Exception Status.

(Word 10) Local PLC Memory Type: Words 10-11 specify the location in the local PLC where the Ethernet interface will store data received from the remote device . Valid values for Word 10 are listed on page 8-17.

(Word 11) Local PLC Memory Address: Word 11 determines the starting address in the local PLC in which the data from the remote device is to be stored. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC’s memory ranges. Be sure this area is large enough to contain the requested data without overwriting other application data.

(Word 12) Reserved: Word 12 is reserved and must be set to zero.

(Word 13) Data Size: Word 13 is the data size and must be set to 1.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Command 3003, Example 4 – Read FIFO Queue

Read the FIFO Queue from the remote Modbus/TCP server. Store the FIFO Queue Data at location %W1. Return the COMMREQ Status word to %R10.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10) *
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03003	(0BBB)	Read from a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00024	(0018)	Modbus Function Code (Read FIFO Queue)
Word 10	00196	(00C4)	Local PLC Memory Type
Word 11	00001	(0001)	Local PLC Starting Address
Word 12	00048	(0030)	FIFO Pointer Address
Word 13	00001	(0001)	Data Size (Unused)
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Read Exception Status from the Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Modbus Function Code 24, Read FIFO Queue.

(Word 10) Local PLC Memory Type: Words 10-11 specify the location in the local PLC where the Ethernet interface will store data received from the remote device . Valid values for Word 10 are listed on page 8-17.

(Word 11) Local PLC Memory Address: Word 11 determines the starting address in the local PLC in which the data from the remote device is to be stored. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC's memory ranges. Be sure this area is large enough to contain the requested data without overwriting other application data.

(Word 12) FIFO Pointer Address: Word 12 is the FIFO pointer address in the Remote Device.

(Word 13) Data Size: Word 13 is unused because the return data size is dependent on the number of items in the server's FIFO queue when the command is received. Zero (0) through 32 registers can be returned as a result of this function code.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Write Data to a Modbus/TCP Device (3004)

The Write Data to a Modbus/TCP Device COMMREQ requests a data transfer from the PLC to a Modbus/TCP server. The Write Data COMMREQ must reference an active Modbus/TCP channel previously established with the Open Modbus/TCP Client Connection COMMREQ.

Registers or Coils may be written to the remote Modbus/TCP device. The Modbus Function Code specifies the data type. Valid Function Codes for the Write Data COMMREQ are presented in the following table:

Function Code	Description	Modbus Server Memory Region Accessed*	Data Unit Size	Maximum Data Units
5	Write Single Coil	Internal Bits or Physical coils	Bit	1
6	Write Single Register	Internal Registers or Physical Output Registers	Register	1
15	Write Multiple Coils	Internal Bits or Physical coils	Bit	1968
16	Write Multiple Registers	Internal Registers or Physical Output Registers	Register	123

An Address Offset and Length specify the location in the Modbus/TCP device and the number of data units to transfer. The Address Offset is the offset from the Base Address for that memory region in the server. The Length is the number of Registers or Coils to transfer.

A PLC data area is the source for the data written to the Modbus/TCP device. The source of data can be any of the PLC data areas (see page 8-17).

Function Code 5, Write Single Coil, forces a Coil On or Off. To force a coil off, the value zero (0) is used as the COMMREQ data value. If the PLC memory type is a bit type, the remote device coil is set to the same state as the specified PLC memory location. If the PLC memory type is a byte or word type, a value of zero (0) is used to force a coil off and a value of one (1) is used to force a coil on.

Function Code 15, Write Multiple Coils, forces multiple Coils On or Off. If the PLC memory type is a bit type, remote device coils are set to the same state as the corresponding bits in the specified PLC memory location. If the PLC memory type is byte or word type, the remote device coils follow the state of the packed bits contained in the byte or word memory. For example, if 16 coils are written to a PACSystems Modbus server starting at %Q1 from the client PLC memory at %R1 containing a value of 0x1111, the following remote server coils will be set %Q1, %Q5, %Q9 and %Q13 and the following remote server bits will be cleared: %Q2, %Q3, %Q4, %Q6, %Q7, %Q8, %Q10, %Q11, %Q12, %Q14, %Q15, %Q16.

The COMMREQ Status Word (CRS) indicates the success or failure of the Write Data COMMREQ. If the COMMREQ specifies an invalid channel number or any other invalid field the COMMREQ fails and the CRS is set to a non-zero value to identify the failure. See the section “Status Data” later in this document for detailed CRS failure codes.

Command 3004, Example 1 – Set Single Register

Write one register from %AI10 to register address 200 in the remote Modbus/TCP server. Return the COMMREQ Status word to %R10. Use channel 6, a channel previously opened with the Open Modbus/TCP Client Connection COMMREQ.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03004	(0BBC)	Write to a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00006	(0006)	Modbus Function Code – Write Single Register
Word 10	00010	(000A)	Local PLC Memory Type
Word 11	00010	(000A)	Local PLC Starting Address
Word 12	00200	(00C8)	Address in the Remote Device
Word 13	00001	(0001)	Number of Registers in the Remote Device
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Write Data to remote Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Function Code 6, Write Single Register.

(Word 10) Local PLC Memory Type: Words 10–11 specify the location in the local PLC from where the Ethernet interface will get the data to be written to the remote PLC. Valid values for Word 10 are listed on page 8-17.

(Word 11) Local PLC Starting Address: Word 11 determines the starting address in the local PLC from which the data is to be written. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC's memory ranges.

(Word 12) Remote Device Address: specifies the destination register in the remote device.

(Word 13) Number Registers in Remote Device: Word 13 specifies the quantity of registers to write to the remote device. For Function Code 6, Write Single Register this must be set to 1.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Command 3004, Example 2 – Write Single Coil

Set coil 501 ON in the remote Modbus/TCP device using the value at %Q4. Return the COMMREQ Status word to %R10. Use channel 6, a channel previously opened with the Open Modbus/TCP Client Connection COMMREQ.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03004	(0BBC)	Write to a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00005	(0005)	Modbus Function Code – Write Single Coil
Word 10	00072	(0048)	Local PLC Memory Type
Word 11	00004	(0004)	Local PLC Starting Address
Word 12	00501	(01F5)	Address in the Remote Device
Word 13	00001	(0001)	Number of Coils in the Remote Device.
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Write Data to Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Modbus Function Code 5 Write Single Coil.

(Word 10) Local PLC Memory Type: Words 10–11 specify the location in the local PLC from where the Ethernet interface will get the data to be written to the remote PLC. Valid values for Word 10 are listed on page 8-17.

(Word 11) Local PLC Starting Address: Word 11 determines the starting address in the local PLC from which the data is to be written. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC’s memory ranges.

(Word 12) Remote Device Address: Word 12 specifies the destination coil address in the Modbus/TCP device.

(Word 13). Number Coils in Remote Device: Words 13 specifies the quantity of coils to write to the remote device. For Modbus Function Code 5, Write Single Coil, this must be set to 1.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Command 3004, Example 3 – Set Multiple Registers

Write the four registers from Discrete Input Memory (%I40 to) address 200 in the remote Modbus/TCP server. Return the COMMREQ Status word to %R10. Use channel 6, a channel previously opened with the Open Modbus/TCP Client Connection COMMREQ.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03004	(0BBC)	Write to a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00016	(0010)	Modbus Function Code – Write Multiple Registers
Word 10	00016	(0010)	PLC Memory Type
Word 11	00040	(0028)	PLC Starting Address
Word 12	00200	(00C8)	Address in the Remote Device
Word 13	00004	(0004)	Number of Registers in the Remote Device
Word 14	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Write Data to Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Modbus Function Code 16, Write Multiple Registers

(Word 10) Local PLC Memory Type: Words 10–11 specify the location in the local PLC where the Ethernet interface will get the data to be written to the remote PLC. Values for Word 10 are listed on page 8-17. The value 16 specifies Discrete Input Memory %I (byte mode).

(Word 11) Local PLC Starting Address: Word 11 determines the starting address in the local PLC from which the data is to be written. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC's memory ranges.

(Word 12) Remote Device Address: Word 12 specifies the destination register in the remote Modbus/TCP device.

(Word 13) Number Registers in Remote Device: Words 13 specifies the quantity of registers to write to the remote device.

(Word 14) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Mask Write Register Request to a Modbus Server Device (3009)

The Mask Write Register Request to a Modbus Server Device COMMREQ is used to modify the contents of a specified remote device register using a combination of an AND mask, OR mask and the current register's value. This function is used to set or clear individual bits in a register. The register is modified per the following algorithm:

$$\text{Register value} = ((\text{Current register value}) \text{ AND } (\text{And Mask Value})) \text{ OR } ((\text{OR Mask Value}) \text{ AND } (\text{NOT}(\text{And Mask Value})))$$

Command 3009, Example – Mask Write Register

Modify register at address 200 in the remote Modbus/TCP server and clear all bits except bit 0. Return the COMMREQ Status word to %R10. Use channel 6, a channel previously opened with the Open Modbus/TCP Client Connection COMMREQ.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03009	(0BC1)	Mask Write Register to a Modbus/TCP Server Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00022	(0016)	Modbus Function Code – Write Mask Register
Word 10	00200	(00C8)	Address in the Remote Device
Word 11	00001	(0001)	AND Mask
Word 12	00000	(0000)	OR Mask
Word 13	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Mask Write Register operation on remote Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Function Code 22, Mask Write Register.

(Word 10) Remote Device Address: specifies the destination register in the remote device.

(Word 11) AND Mask: Word 11 specifies the AND mask to be used in the Mask Write operation. For this example, all bits are cleared except bit 0.

(Word 12) OR Mask: Word 12 specifies the OR mask to be used in the Mask Write operation. In this example, no bits are to be set.

(Word 13) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Read/Write Multiple Registers to/from a Modbus Server Device (3005)

The Read/Write Multiple Registers to/from a Modbus Server Device COMMREQ is used to read and write data between the remote server and the PLC with one COMMREQ operation. Note, the write operation occurs first and the data exchange does not occur coherently (i.e. data can change in the server between the write and read operations).

Command 3005, Example – Read/Write Multiple Register

Write 10 values starting at %R100 in the Local PLC to register address 200 in the remote Modbus/TCP server and read 20 values starting from register 300 in the remote Modbus/TCP server and write this value to %R300 in the Local PLC. Return the COMMREQ Status word to %R10. Use channel 6, a channel previously opened with the Open Modbus/TCP Client Connection COMMREQ.

	Dec	(Hex)	
Word 1	00008	(0008)	Length of Channel command Data Block
Word 2	00000	(0000)	Always 0 (no-wait mode request)
Word 3	00008	(0008)	Memory type of CRS word (%R)
Word 4	00009	(0009)	CRS word address minus 1 (%R10)*
Word 5	00000	(0000)	Reserved
Word 6	00000	(0000)	Reserved
Word 7	03005	(0BB5)	Read/Write Multiple Registers to/from a Modbus/TCP Device
Word 8	00006	(0006)	Channel number (6)
Word 9	00023	(0017)	Modbus Function Code – Read/Write Multiple Registers
Word 10	00008	(0008)	Local PLC Memory Type of memory to write with data read from Remote Device
Word 11	00300	(012C)	Local PLC Starting Address (LSW) of memory to write with data read from Remote Device
Word 12	00000	(0000)	Local PLC Starting Address (MSW) of memory to write with data read from Remote Device (normally 0 unless %W is used)
Word 13	00300	(012C)	Address to Read From on Remote Server
Word 14	00020	(0014)	Number of Memory Units to Read from Remote Device (1 to 125)
Word 15	00008	(0008)	Local PLC Memory Type of memory to use for writing to the Remote Device
Word 16	00100	(0064)	Local PLC Starting Address (LSW) of memory to use for writing to the Remote Device
Word 17	00000	(0000)	Local PLC Starting Address (MSW) of memory to use for writing to the Remote Device (normally 0 unless %W is used)
Word 18	00200	(00C8)	Address to Write to on the Remote Server
Word 19	00010	(000A)	Number of Memory Units to Write to the Remote Device (1 to 121)
Word 20	00001	(0001)	Unit Identifier

* Word 4 (CRS word address) is the only zero-based address in the Command Block. Only this value requires subtracting 1 from the intended address.

(Word 7) Channel Command Number: Word 7 identifies the COMMREQ as a Read/Write Multiple Register operation on remote Modbus/TCP device.

(Word 8) Channel Number: Word 8 identifies the channel number previously allocated for communication with the remote Modbus/TCP server.

(Word 9) Modbus Function Code: Word 9 specifies Function Code 23, Read/Write Multiple Register.

(Word 10) Local PLC Memory Type (Write With Data Read From Server): Words 10–12 specify the location in the local PLC where the Ethernet interface will write data received from the remote server. Values for Word 10 are listed on page 8-17. The value 8 specifies Register Memory %R.

(Word 11) Local PLC Starting Address LSW (Write With Data Read From Server): Word 11 determines the least significant word (LSW) of the starting address in the local PLC from which the data is to be written. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 10. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC's memory ranges.

(Word 12) Local PLC Starting Address MSW (Write With Data Read From Server): Word 12 determines the most significant word (MSW) of the starting address in the local PLC from which the data is to be written. This value will typically be 0 unless the address is above 65535 for %W memory.

(Word 13) Remote Device Read Address: Word 13 specifies the register(s) to read from the remote Modbus/TCP device.

(Word 14) Number Registers to Read From Remote Device: Words 14 specifies the quantity of registers to read from the remote device.

(Word 15) Local PLC Memory Type (Read Data to Write to Server): Words 15–17 specify the location in the local PLC where the Ethernet interface will read data to use for writing to the remote server. Values for Word 15 are listed on page 8-17. The value 8 specifies Register Memory %R.

(Word 16) Local PLC Starting Address LSW (Read Data to Write to Server): Word 16 determines the least significant word (LSW) of the starting address in the local PLC from which the data is to be read. The value entered is the offset (1-based) from the beginning of PLC memory for the memory type and mode specified in Word 15. This offset will be either in bits, bytes, or words depending on the mode specified. Valid ranges of values depend on the PLC's memory ranges.

(Word 17) Local PLC Starting Address MSW (Read Data to Write to Server): Word 17 determines the most significant word (MSW) of the starting address in the local PLC from which the data is to be read. This value will typically be 0 unless the address is above 65535 for %W memory.

(Word 18) Remote Device Write Address: Word 18 specifies the register(s) to be written on the remote Modbus/TCP device.

(Word 19) Number Registers to Write To Remote Device: Words 19 specifies the quantity of registers to write to the remote device.

(Word 20) Unit Identifier: This field is typically used by Ethernet to Serial bridges to specify the address of a Modbus Slave on a multidrop link. The Modbus/TCP Unit Identifier is a special control code used in a Modbus/TCP message block.

Status Data

This section describes all the status data that is available to the ladder program to determine the state of the Ethernet interface and its Modbus/TCP channels.

Types of Status Data

There are three main types of status data available to the application program:

1. FT Output of the COMMREQ Function Block. This output is set if there is a programming error in the COMMREQ Function Block itself, if the rack and slot specified in the COMMREQ SYSID parameter is not configured to contain an Ethernet interface, or if the data block length specified in the Command Block is out of range. This output also may indicate that no more COMMREQ functions can be initiated in the ladder program until the Ethernet interface has time to process some of the pending COMMREQ functions.

If the FT Output is set, the CPU does not transfer the Command Block to the Ethernet interface. In this case, the other status indicators are not updated for this COMMREQ.

2. Status Bits. The status bits are updated in the CPU once each PLC scan by the Ethernet interface. These bits are generally used to prevent initiation of a COMMREQ function when certain errors occur or to signal a problem on an established channel. The status bits include the LAN Interface Status bits and the Channel Status bits. The starting location of these bits is set up when the module is configured.

The LAN Interface Status bits monitor the health of the Ethernet interface itself, such as the LAN Interface OK bit.. The Channel Status bits monitor the health of a channel.

3. Communications Status Word. The COMMREQ Status word (CRS word) provides detailed information on the status of the COMMREQ request. The communications status word is not updated in the CPU each scan as are the status bits. They are generally used to determine the *cause* of a communication error after the COMMREQ function is initiated. The cause is reported in the form of an error code described later in this section. The COMMREQ Status word (CRS word) is returned from the Ethernet interface to the PLC CPU immediately if the Command Block contains a syntax error or if the command is local. The location of the CRS word is defined in the Command Block for the COMMREQ function.

Description of the Status Data

The errors and status reported in each type of status data are described below.

FT Output of the COMMREQ Function Block

The FT Output passes power upon the following errors:

- Invalid rack/slot specified. The module at this rack/slot is unable to receive a COMMREQ.
- Invalid Task ID.
- Invalid Data Block length (zero or greater than 128).
- Too many simultaneous active COMMREQs (overloading either the PLC CPU or the Ethernet interface).

LAN Interface Status (LIS) Bits

The status bits occupy a single block of memory. The location of this block is specified during configuration of the Ethernet interface. The first 16 bits of the block are the LAN Interface Status (LIS) bits. The next 64 bits are the Channel Status bits (2 for each channel).

Status Bits	Brief Description
1	Port 1A full duplex
2	Port 1A 100Mbps
3	Port 1B full duplex
4	Port 1B 100 Mbps
5	Network Time Locked
6	Redundant IP active (RX7i only)
7-8	Reserved
9	Any Channel Error (error on any channel)
10–12	Reserved
13	LAN OK
14	Resource problem
15	Module Overtemperature (RX3i only)
16	LAN Interface OK
17	Channel Open - Channel 1
18	Reserved – Channel 1
...	...
79	Channel Open - Channel 32
80	Reserved - Channel 32

Note: Unless the “LAN Interface OK” bit is set (Status Bit 16), the other status bits are invalid.

The LAN Status bits (bits 1 – 16) are described in chapter 10, Diagnostics. They monitor the health of the Ethernet Interface itself.

Bit 16, LAN Interface OK Bit: This bit is set to 1 by the Ethernet Interface each PLC scan. If the Ethernet Interface cannot access the PLC, the CPU sets this bit to 0. *When this bit is 0, all other Ethernet Interface Status bits are invalid.*

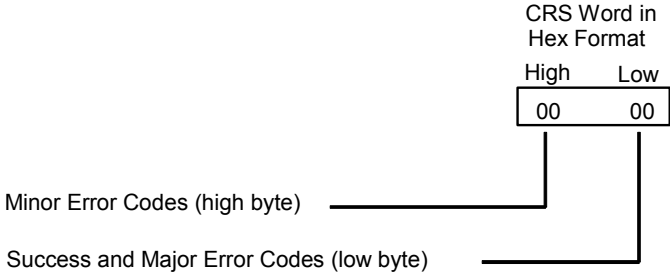
Each Modbus channel has a dedicated status bit:

(Status Bits 17, 19, 21 ... 79) **Connection Open Bit:** This bit is 1 when a TCP connection exists for the associated channel. The bit is 0 when the connection does not exist (either never created or has disconnected). The bit is also set to zero when the PLC goes to STOP, because all connections are automatically closed upon STOP transition.

(Status Bits 18, 20, 22 ... 80) **Reserved:** When a Channel is in use as a Modbus/TCP Channel, these bits are not used.

Communications Status Words

The COMMREQ Status word (CRS word) reports status in the format shown below. The CRS word location is specified in Words 3 and 4 of the Command Block.



The Ethernet Interface reports the status of the COMMREQ back to the status location. See chapter 10, “Diagnostics” for COMMREQ major and minor error codes that may be reported in the CRS words for Modbus/TCP commands.

Controlling Communications in the Ladder Program

This section provides tips on how to control communications in your ladder program. Only segments of actual ladder logic are included. Topics discussed are:

- Essential Elements of the Ladder Program
- Troubleshooting Your Ladder Program
- Monitoring the Communications Channel

Essential Elements of the Ladder Program

Every ladder program, whether in the developmental phase or the operational phase, should do the following before initiating a COMMREQ function.

1. Initiate the COMMREQ function with a one-shot transitional coil. This prevents sending the same COMMREQ Command Block more than once.
2. Include at least the LAN Interface OK bit in the LAN Interface Status Word as an interlock contact for the COMMREQ function. You may choose to add more interlocks.
3. Zero the word location you specify for the COMMREQ Status (CRS) word and the FT Outputs of the COMMREQ Function Block before the COMMREQ function is initiated.
4. Move the command code and parameters for the Channel command into the memory location specified by the IN input of the COMMREQ Function Block before the COMMREQ function is initiated.

Note

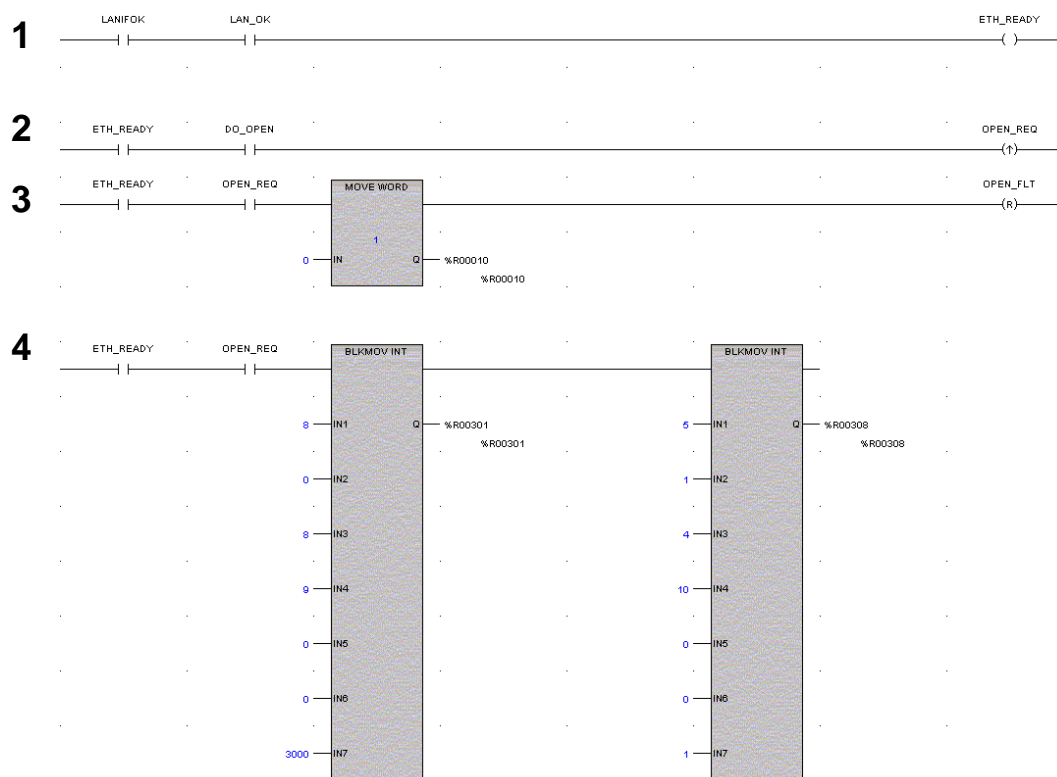
When using a Write Data or Read/Write COMMREQ, data is not read from the local PLC synchronously with execution of the COMMREQ. A number of CPU sweeps may occur before the data is read. It is recommended that the data not be changed until after the COMMREQ Status Word indicates completion of the command.

The example ladder program segment starting on the next page illustrates how to incorporate these important points in your program.

COMMREQ Example

The input values for the Block Move Functions in this example are taken from the Open Modbus/TCP Connection (3000), Modbus/TCP Read (3003), and Close Modbus/TCP Connection (3001) Examples in this chapter.

Named variables are used in this example to make the ladder program easier to follow. LANIFOK is bit 16 of the LAN Interface Status bits. LAN_OK is bit 13 of the LAN Interface Status bits. All other nicknames can be assigned as you choose.



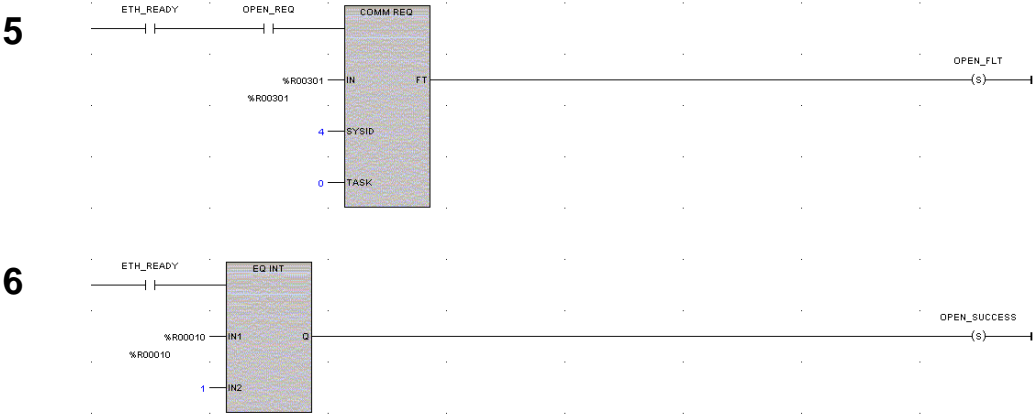
Rung # 1: Input LANIFOK (bit 16 of the LAN Interface Status bits) monitors the health of the Ethernet interface. Input LAN_OK (bit 13 of the LAN Interface Status bits) monitors the online/offline status of the Ethernet interface. If both bits are set it is OK to send a COMMREQ and the ETH_READY coil is ON. ETH_READY is used as an interlock for Rungs 2-16.

Rung # 2: When ETH_READY is set, Input DO_OPEN triggers OPEN_REQ, which enables execution of the MOVE and COMMREQ functions for the Open Modbus/TCP Connection Commreq. OPEN_REQ is a one-shot (Positive Transition) coil, activating once when both ETH_READY and DO_OPEN have transitioned from OFF to ON.

Rung # 3: The MOVE WORD function moves a zero to the CRS word referenced in the Command Block (see rung #4). This clears the CRS word. This rung also resets the OPEN_FLT output coil of the COMMREQ Function Block in rung #5.

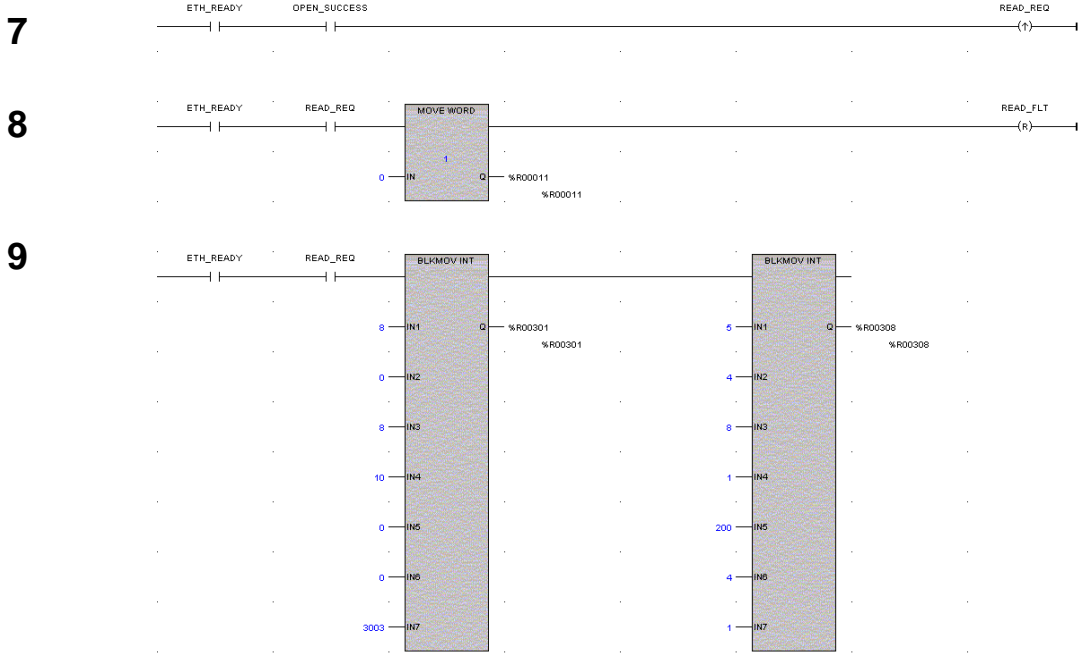
It is vital that the CRS Status Word is cleared and the COMMREQ fault output coil be cleared each time before initiating a COMMREQ function.

Rung # 4: The BLKMV INT functions set up the COMMREQ Command Block contents. When this rung is activated, the constant operands are moved into the memory beginning at the address indicated in the instruction. The constant operands in this example are defined in the Open Modbus/TCP Connection Example in this chapter.



- **Rung # 5:** The COMMREQ Function Block has three input parameters and one output parameter.
- The IN field points to the starting location of the Command Block parameters (%R00301 in this example).
- The SYSID field of the COMMREQ Function Block defines the target rack and slot of the Ethernet interface to receive the command data. This is a hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet interface module. In the example, the first three number places (from left to right) are zeros and are not displayed; only the last number, 4, appears. This indicates rack 0, slot 4.
- The TASK field of the COMMREQ Function Block indicates which mailbox task ID to use for the specified rack and slot. For the RX3i and Rx7i ETM001 Ethernet interfaces TASK must always be set to zero. For PACSystems CPU embedded Ethernet interface, TASK must be set to 65536 (0x10000) to address the CPU’s Ethernet daughterboard.
- The FT output (energizes the OPEN_FLT coil in this example) is turned ON (set to 1) if there were problems preventing the delivery of the Command Block to the Ethernet interface. In this case, the other status indicators are not updated for this COMMREQ.

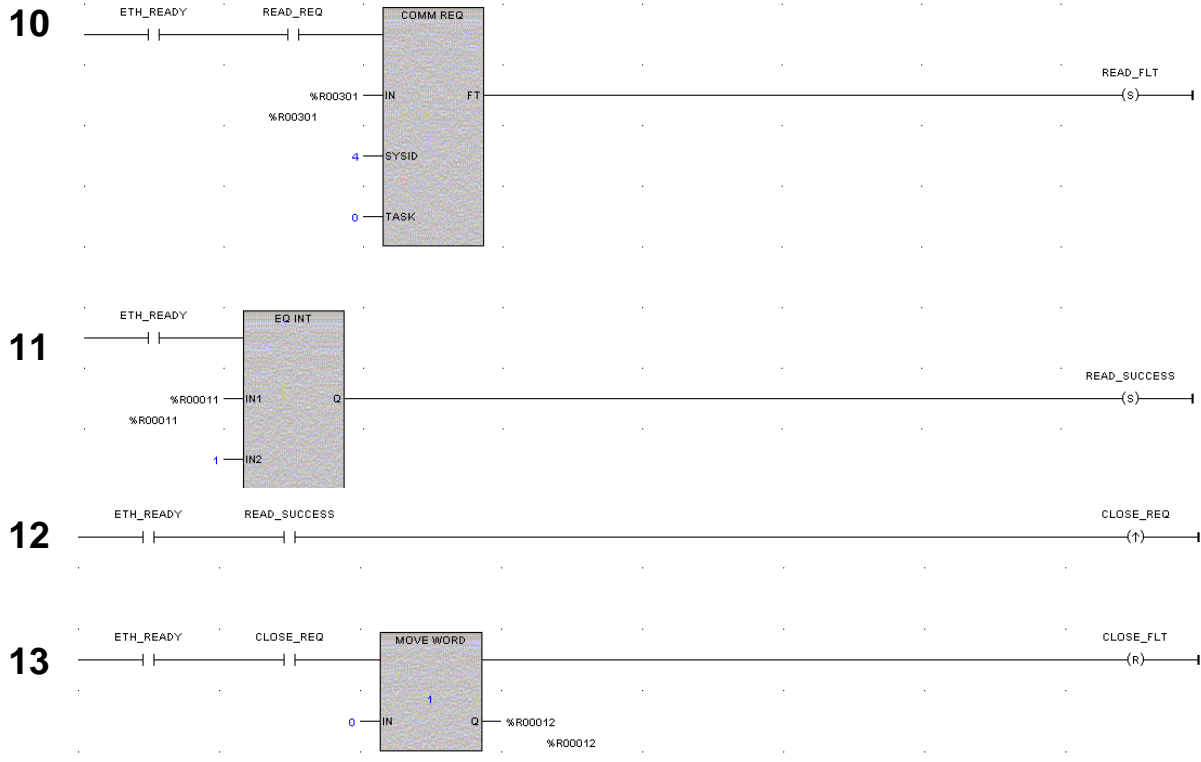
Rung # 6: When ETH_READY is set the CRS word for the Open Modbus/TCP Connection commreq is monitored for a status of 1, indicating that the Open commreq completed successfully. The CRS word change to 1 sets coil OPEN_SUCCESS.



Rung # 7: When OPEN_SUCCESS is set it triggers READ_REQ, which enables execution of the BLKMOV, MOVE and COMMREQ functions for the Modbus/TCP Read Commreq. READ_REQ is a one-shot (Positive Transition) coil, activating once when OPEN_SUCCESS transitions from OFF to ON.

Rung # 8: The MOVE WORD function moves a zero to the CRS word referenced in the Command Block (see rung #9). This clears the CRS word. This rung also resets the READ_FLT output coil of the COMMREQ Function Block in rung #10.

Rung # 9: The BLKMOV INT functions set up the COMMREQ Command Block contents. When this rung is activated, the constant operands are moved into the memory beginning at the address indicated in the instruction. The constant operands in this example are defined in the Modbus/TCP Read Example in this chapter.



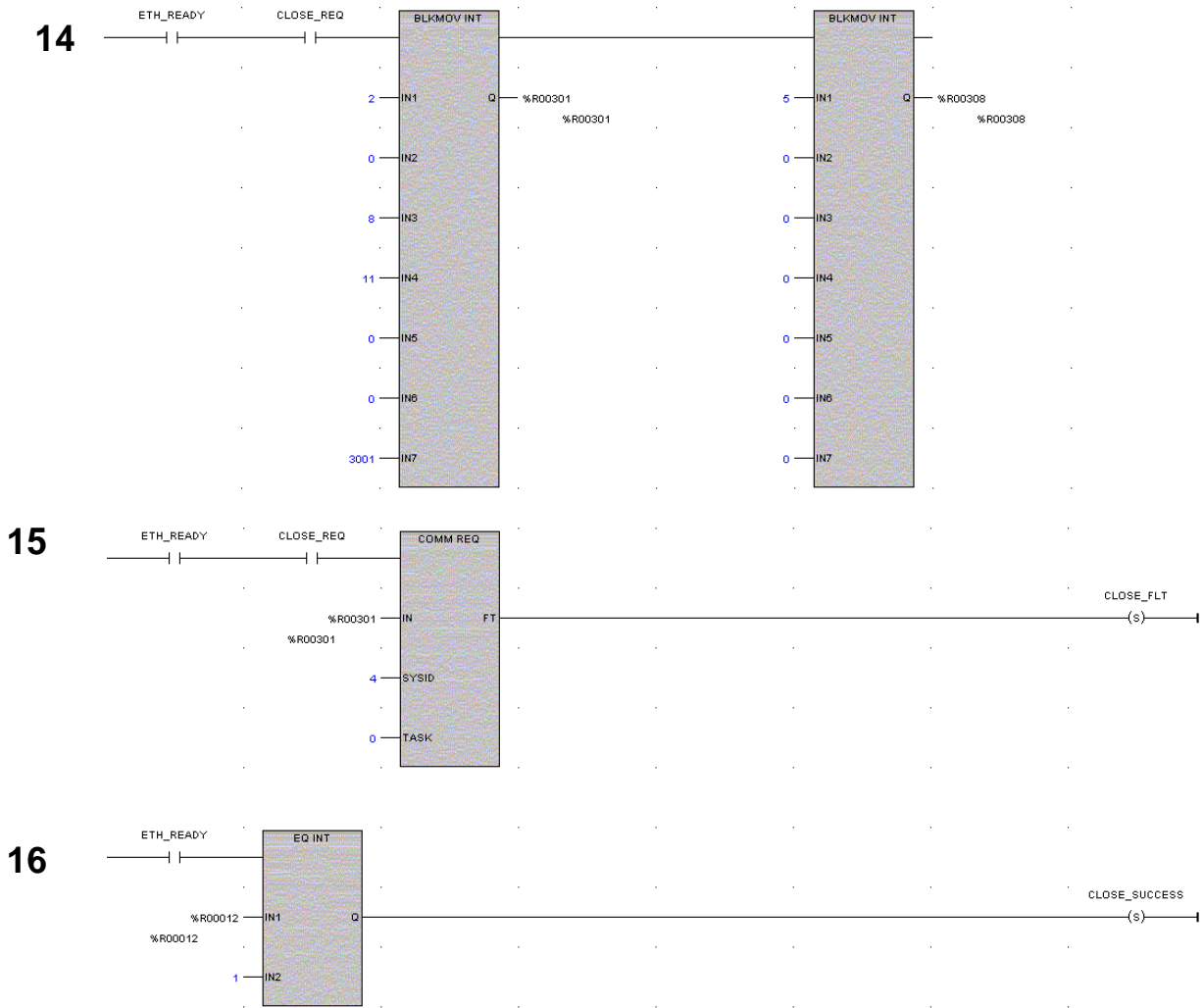
Rung # 10: The COMMREQ Function Block has three input parameters and one output parameter.

- The IN field points to the starting location of the Command Block parameters (%R00301 in this example).
- The SYSID field of the COMMREQ Function Block defines the target rack and slot of the Ethernet interface to receive the command data. This is a hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the Ethernet interface module.
- The TASK field of the COMMREQ Function Block indicates which mailbox task ID to use for the specified rack and slot. For the RX3i and Rx7i ETM001 Ethernet interfaces TASK must always be set to zero. For PACSystems CPU embedded Ethernet interface, TASK must be set to 65536 (0x10000) to address the CPU’s Ethernet daughterboard.
- The FT output (energizes the READ_FLT coil in this example) is turned ON (set to 1) if there were problems preventing the delivery of the Command Block to the Ethernet interface. In this case, the other status indicators are not updated for this COMMREQ.

Rung # 11: When ETH_READY is set the CRS word for the Modbus/TCP Read commreq is monitored for a status of 1, indicating that the Read commreq completed successfully. The CRS word change to 1 sets coil READ_SUCCESS.

Rung # 12: When READ_SUCCESS is set it triggers CLOSE_REQ, which enables execution of the BLKMOV, MOVE and COMMREQ functions for the Close Modbus/TCP Connection Commreq. CLOSE_REQ is a one-shot (Positive Transition) coil, activating once when READ_SUCCESS transitions from OFF to ON.

Rung # 13: The MOVE WORD function moves a zero to the CRS word referenced in the Command Block (see rung #9). This clears the CRS word. This rung also resets the CLOSE_FLT output coil of the COMMREQ Function Block in rung #15.



Rung # 14: The BLKMOV INT functions set up the COMMREQ Command Block contents. When this rung is activated, the constant operands are moved into the memory beginning at the address indicated in the instruction. The constant operands in this example are defined in the Close Modbus/TCP Connection Example in this chapter.

Rung # 15: The COMMREQ Function Block has three input parameters and one output parameter.

- The IN field points to the starting location of the Command Block parameters (%R00301 in this example).
- The SYSID field of the COMMREQ Function Block defines the target rack and slot of the Ethernet interface to receive the command data. This hexadecimal word value gives the rack (high byte) and slot (low byte) location of the Ethernet interface module.
- The TASK field of the COMMREQ Function Block indicates which mailbox task ID to use for the specified rack and slot. For the RX3i and Rx7i ETM001 Ethernet interfaces TASK must always be set to zero. For PACSystems CPU embedded Ethernet interface, TASK must be set to 65536 (0x10000) to address the CPU's Ethernet daughterboard.
- The FT output (energizes the CLOSE_FLT coil in this example) is turned ON (set to 1) if there were problems preventing the delivery of the Command Block to the Ethernet interface. In this case, the other status indicators are not updated for this COMMREQ.

Rung # 16: When ETH_READY is set the CRS word for the Close Modbus/TCP Connection commreq is monitored for a status of 1, indicating that the Close commreq completed successfully. The CRS word change to 1 sets coil CLOSE_SUCCESS.

Troubleshooting a Ladder Program

There are several forms of status data that can be accessed by the application program. The use of the LAN Interface OK bit in the LAN Interface Status Word was described in the example program. Some status data can be used to troubleshoot a program in its developmental stage. The two primary sources of this data are the FT Output on the COMMREQ Function Block and the COMMREQ Status word (CRS word).

FT Output is ON

If after executing a COMMREQ Function, the FT Output is ON, then there is a programming error in one or more of the following areas.

- Invalid rack/slot specified. The module at this rack/slot is unable to receive a COMMREQ Command Block.
- Invalid Task ID. For the RX3i and Rx7i ETM001 Ethernet interfaces TASK must always be set to zero. For PACSystems CPU embedded Ethernet interface, TASK must be set to 65536 (0x10000) to address the CPU's Ethernet daughterboard.
- Invalid Data Block length (0 or greater than 128).

COMMREQ Status Word is Zero (0) and FT Output is OFF

If after executing a COMMREQ function, the CRS word is zero (0) and the FT Output is OFF, then the Command Block has been sent to the Ethernet interface, but no status has been returned yet. If this condition persists, check the PLC Fault Table for information.

COMMREQ Status Word is Not One (1)

If after executing a COMMREQ function, the CRS word is not one (1) indicating success, then there were:

- Errors in the Command Block (the Channel command code or parameters), *or*
- The command parameters were valid but there was an error in completing the request.

If the CRS word does not contain a 1 indicating success, then it contains either a 0 or a code indicating what error occurred.

Monitoring the Communications Channel

The status data can be used to monitor communications and take action after certain events.

Monitoring the COMMREQ Status Word

It is critical to monitor the CRS word for each COMMREQ function. First, zero the associated CRS word before executing the COMMREQ function. When the CRS word becomes non-zero, the Ethernet interface has updated it. If the CRS word is updated to a one (1), the Command Block was processed successfully by the Ethernet interface. If the CRS word is updated to a value other than 1, an error occurred in processing the Command Block.

Do not use data received from a server until the CRS word for that channel is 1. In addition, do not initiate any additional commands to a channel until the CRS word has been updated. The exception to this rule is when you want to terminate a command by using the Close Modbus/TCP Connection command.

Monitoring the Channel Open Bit

This bit is 1 when a Channel has successfully established a connection with a remote server, and is 0 when a Channel has been closed.. The Channel Open Bit is meaningful when the CPU is in Run mode and the particular channel is being used by Modbus/TCP. The Channel Open Bit is set at the same time the successful status is returned to the CRS word for the Open Modbus/TCP Connection COMMREQ.

Sequencing Communications Requests

If the Ethernet interface receives Command Blocks from the CPU faster than it can process them, the Ethernet interface will log an exception event 08, Entry 2=0024H and will log the PLC Fault Table entry:

“Backplane Communications with PLC Fault; Lost Request”

Only one COMMREQ function per channel can be pending at one time. A COMMREQ function is pending from the time it is initiated in the ladder program until its CRS word has been updated to a non-zero value by the Ethernet interface.

Differences between Series 90 and PACSystems Modbus/TCP Channels

This section lists the known differences between the Series 90 implementation of Modbus/TCP Channels and the PACSystems implementation.

1. On the 90-30 CMM321 if a Modbus error response is received for a Modbus/TCP channel, the Ethernet interface closes the TCP connection and updates the CRSW with an appropriate error code. For PACSystems Ethernet, the Modbus error response results in an updated CRSW with an appropriate error code but the TCP connection is NOT closed.
2. A CRSW of 0x8390 (Invalid Server Memory Type) is returned when an invalid Modbus Function code is specified for the CMM321. For PACSystems Ethernet, an improved CRSW of 0xB690 (Invalid/Unsupported Modbus Function Code) is returned.
3. The TCP connect timeout (i.e. the amount of time to wait for the Remote server or Gateway to establish a TCP connection with a Modbus/TCP Channel) is 90 seconds on the Series 90 and 75 seconds on PACSystems. An error is returned in the CRSW for the Open Modbus/TCP Connection COMMREQ when this timeout occurs.
4. The station manager command “stat m” on the Series 90 results in displaying “Closed” for specific Closed channels while PACSystems Modbus/TCP Channels results in displaying nothing for a specific Closed channel.
5. When sending a Close Modbus/TCP Connection COMMREQ, the PACSystems Modbus/TCP Client will return a success CRSW (0x0001) while the CMM321 module returns an error CRSW.

6. The rules for Endian conversion when transferring between Word and Bit types of memory are different in order to make these types of conversions consistent.

CMM321 Modbus Client Endian Conversion Example

For example, depending on the direction of the transfer, the end-to-end values result in bytes being swapped for CMM321 Modbus Client. This can be seen in the example table below.

<i>Memory Location / Type</i>	<i>Memory value example</i>	<i>Transfer Direction</i>	<i>Memory Location / Type</i>	<i>Resulting Value After Transfer</i>	<i>Notes</i>
Client Bit	%M16-%M1 = 0x4321	→	Server Word	%R1 = 0x4321	End-to-end bytes unswapped
Server Bit	%M16-%M1 = 0x4321	→	Client Word	%R1 = 0x2143	End-to-end bytes swapped
Client Word	%R1 = 0x4321	→	Server Bit	%M16-%M1 = 0x4321	End-to-end bytes unswapped
Server Word	%R1 = 0x4321	→	Client Bit	%M16-%M1 = 0x2143	End-to-end bytes swapped

PACSystems Modbus Client Endian Conversion Example

The following example table shows the Endian conversion behavior for the PACSystems Modbus Client:

<i>Memory Location / Type</i>	<i>Memory value example</i>	<i>Transfer Direction</i>	<i>Memory Location / Type</i>	<i>Resulting Value After Transfer</i>	<i>Notes</i>
Client Bit	%M16-%M1 = 0x4321	→	Server Word	%R1 = 0x4321	End-to-end bytes unswapped
Server Bit	%M16-%M1 = 0x4321	→	Client Word	%R1 = 0x4321	End-to-end bytes unswapped
Client Word	%R1 = 0x4321	→	Server Bit	%M16-%M1 = 0x4321	End-to-end bytes unswapped
Server Word	%R1 = 0x4321	→	Client Bit	%M16-%M1 = 0x4321	End-to-end bytes unswapped

Chapter *RX7i PLC Monitoring Via the Web*

9

The PACSystems RX7i embedded CPU Ethernet Interface provides PLC data monitoring using a standard Web browser. Rack-based Ethernet modules do not support web server operation.

You can use the Web server to monitor the following PLC data:

- **PLC reference tables.** This data is a snapshot of the PLC Reference Tables when the data is displayed in the Browser and is not updated until you request another display. All reference tables are supported.
- **PLC and I/O Fault Tables.**

The web server cannot be used to modify PLC data (acknowledge alarms, set/force values in tables).

The maximum number of web server connections that can be configured for the Ethernet Interface is 16. If the system includes FTP server connections, fewer web server connections are available, as explained in chapter 3.

System Requirements

Web monitoring requires version 4.0 or later of Netscape Navigator or Internet Explorer. The browser must be capable of running the Java Virtual Machine (JVM) version 1.3 plug-in. The supported host operating systems are Windows NT 4.0 SP5 or SP6, Windows 95B, Windows 98 (First Edition Service Pack 1, Second Edition), and Windows 2000 Professional SP1, Windows Millennium Edition, Windows XP and Windows CE 3.0. To view the entire Reference Table page, the screen resolution must be 1024 x 768 or higher. Local web firewall blocking issues will be avoided by using HTTP protocol on port 80 to transfer standard HTML files including JavaScript and Java applets from the server to the browser and HTTP Post command to transfer form information from the browser to the server.

Disabling Pop-up Blocking (Required for Newer Web Browsers)

Newer versions of Microsoft® Internet Explorer and Netscape® Browsers include pop-up blocking features that prevent viewing reference tables.

Microsoft Internet Explorer Version 6.0 or Later

For Internet Explorer 6.0 or greater, follow these steps to disable the pop-up blocking functionality:

1. Go to Tools->Pop-up Blocker->Pop-up Blocker Settings.
2. Enter the IP address of the PLC (for example 192.168.177.10) into the text box labeled "Address of Web site to allow".
3. Press the Add button and Close the dialogue.

Netscape Browser 8.0 or Later

For Netscape Browser 8.0 or greater, follow these steps to disable the pop-up blocking function:

1. Enter the PLC IP Address into the Address box and press Enter.
2. Right mouse click on the page and select "Display like Internet Explorer".
3. Go to Tools->Options->Site Controls.
4. Under "My Settings", highlight the IP Address of the PLC.
5. Under "Web Features" check the "Allow unrequested pop-up Windows".
6. Press OK.

WEB Server Operation in a Redundant System

In a redundant system, only the active unit processes Web Server requests at the Redundant IP address and responds to web page requests. The backup unit does not respond to the Redundant IP address. When the active Ethernet interface changes to backup, it takes down all Web Server connections and their underlying TCP connections. The Web Server maintains its underlying TCP connection only long enough to process each web page request; a new TCP connection is opened, used, and closed for each subsequent web page display or update. Unless a web page change or update is requested during a redundancy switch, the operation of the Redundant IP address is transparent to the Web browser. Any web page request in process over the Redundant IP when a role switch occurs is ended.

Although both the active and backup units respond to Web server requests received at the direct IP address, having a remote (host) browser issue Web Server requests to the direct IP address is not recommended. Remote web browsers should use the Redundant IP address when communicating to a Redundant System.

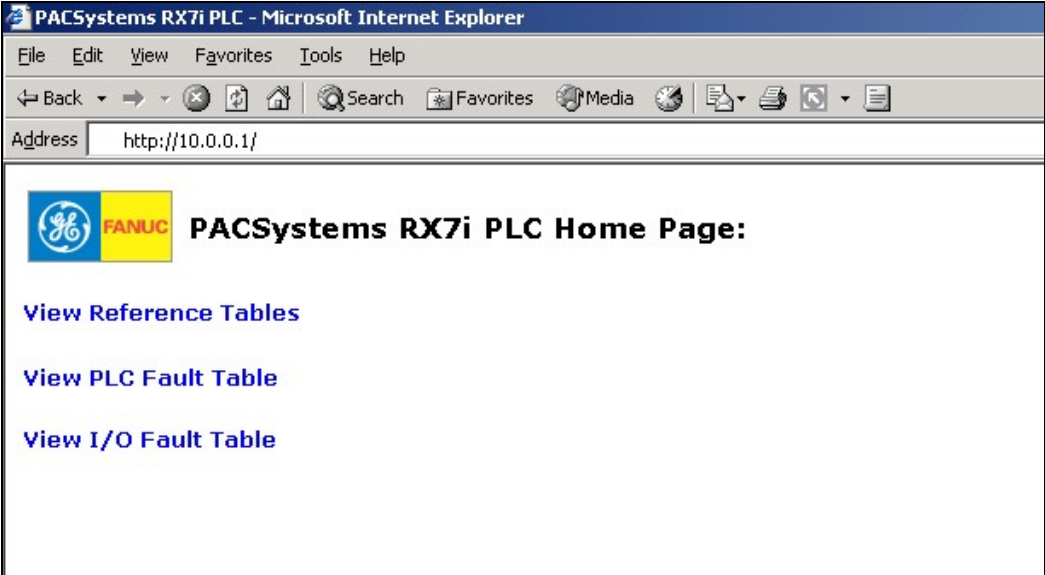
Standard Web Pages

The CPU Ethernet Interface is shipped with a set of standard PLC web pages already installed. These standard web pages include a PLC home page, a Reference Table display page, a PLC Fault Table display page, and an I/O Fault Table display page.

When necessary, new or revised web page files may be transferred into the Ethernet Interface via the standard FTP protocol, as described later.

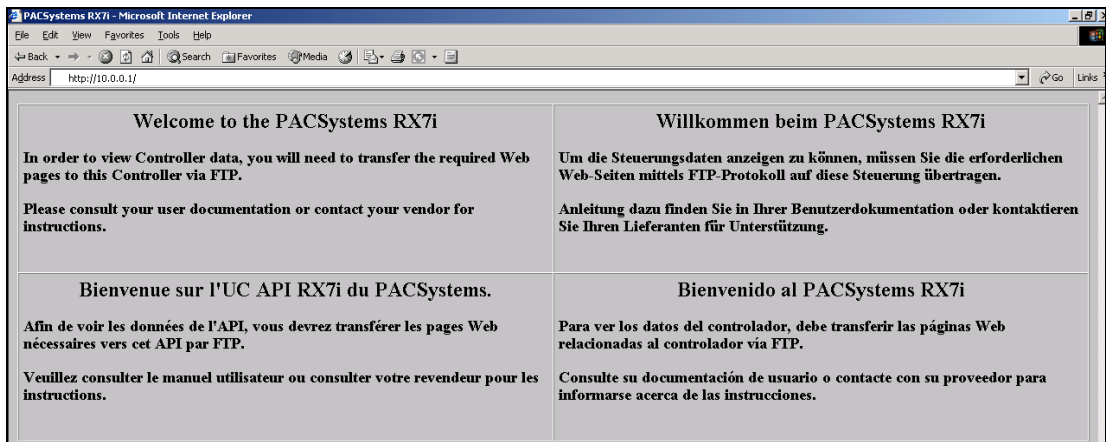
RX7i Home Page

The RX7i home page is displayed after entering the PLC CPU's URL or IP address at your web browser. From the PLC home page, you may navigate to the other PLC web pages.



Factory Default Web Page

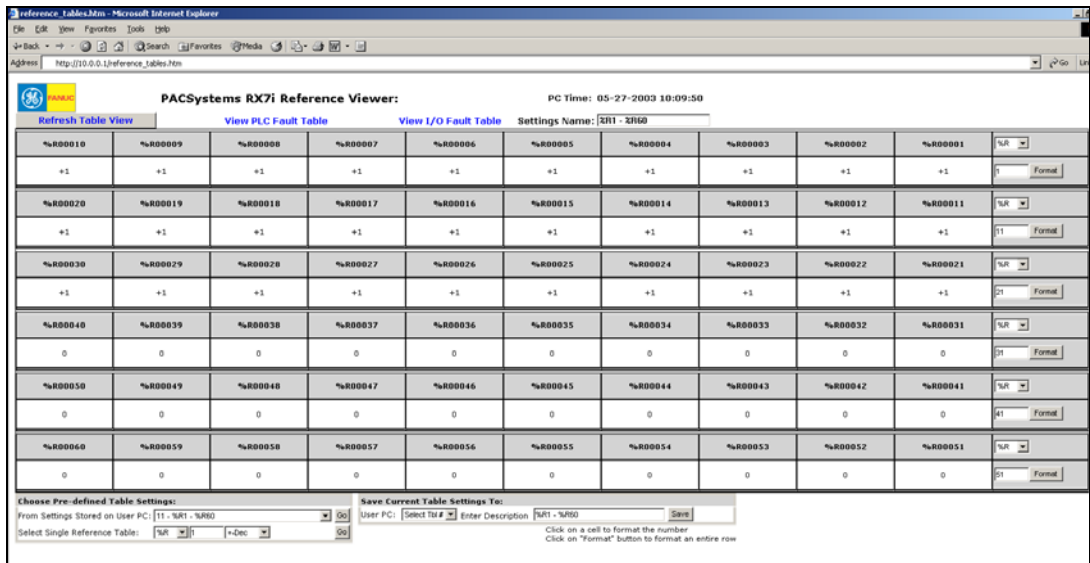
If the PLC home page file (index.htm) is not present in the Ethernet Interface file system, the web server instead displays the factory default web page.



The default web page is displayed in English, French, German and Spanish if the browser is configured to use Western European encoding.

Reference Tables Viewer Page

The Reference Tables Viewer page shows the current states of a range of data references. This data is a snapshot of the PLC Reference Tables when the data was initially requested. It is NOT updated until you refresh the display. All RX7i reference tables are available.

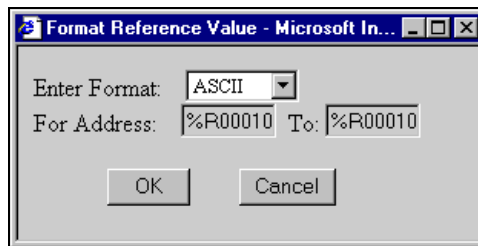


Selecting Reference Table Data

Initially, the previously-viewed reference table is displayed. To change the display, you can:

Select Reference Table Data Row-by-Row: The right column of each row contains the configuration options for that row. For each row, select the reference table, starting address, and data format. You can select the %R, %AI, %AQ, %I, %Q, %M, %T, %G, %S, %SA, %SB, %SC, %P, %L, or %W reference table. For %P and %L memory types, specify the logic program name, and for %L memory, the subroutine block name. The logic program and subroutine block names must be reentered when defining other rows.

To select the data format, click on a reference table address cell above the reference value and select the display format type. For example:



To format a row, click the Format button for the entire row. Use the drop down box to select the data format for the selected reference address or row. With Internet Explorer, pressing the "OK" button changes the format immediately. With Netscape, the format changes after you refresh the screen.

Saving Reference Table Settings

You can save up to 10 previously formatted reference table views on the computer being used to view the data. To save the current reference table settings, go to the section at the bottom of the page labeled 'Save Current Table Settings To:'. From the drop-down box, select a number to assign to these settings. Optionally, enter a description of the table settings by typing into the text box labeled 'Enter Description'. Click on the 'Save' button to save the reference table settings to the computer.

Display Formats

Binary: uses 1s and 0s to represent the bits in a byte or word of data. If a discrete bit is overridden for the %I, %Q, %M or %G tables, the bit is underlined.

+Dec: signed decimal for one word of data. Valid range is –32768 to +32767.

Dec: unsigned decimal for one word of data. Valid range is 0 to 65535.

Hex: a four digit hexadecimal value for one word of data. The value has 16# as a prefix (for example 16#4241). Valid range is 16#0000 to 16#FFFF.

ASCII: ASCII representation of two 8-bit values. For example, a hex value of 16#4142 appears as “A B”. ASCII display requires Internet Explorer 4.0 or Netscape 4.7 or later.

+DbIDecimal: signed decimal for a double word (32 bits). Valid range is -2,147,483,648 to +2,147,483,647. This format is only available for word type memory (%R, %AI, %AQ, %P, %L, and %W).

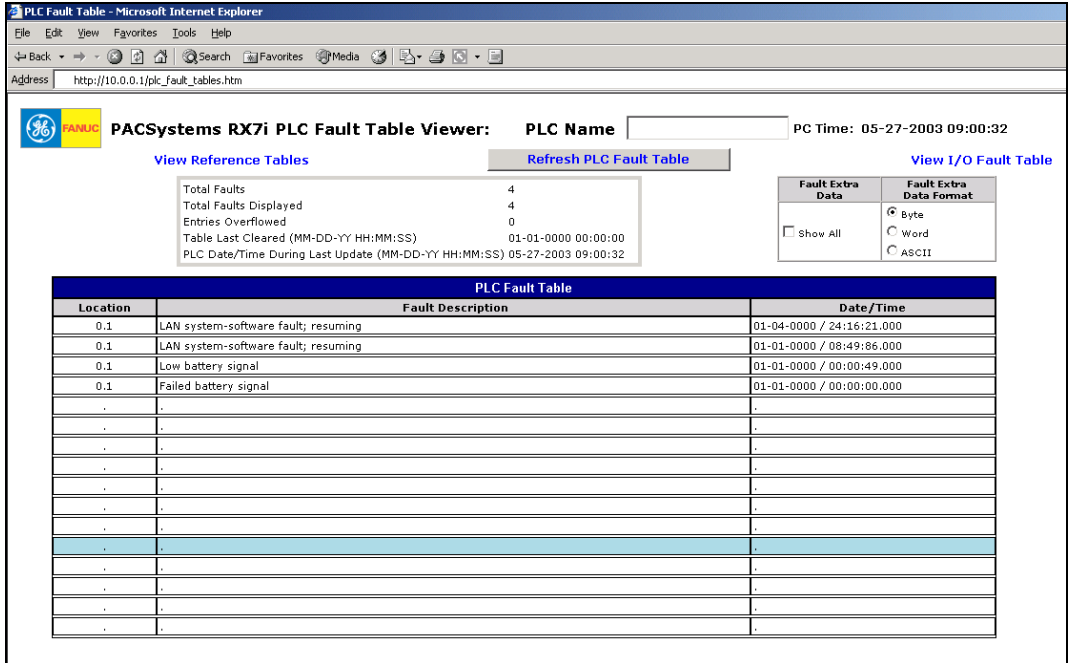
DbIDecimal: unsigned decimal for a double word (32 bits). Valid range is 0 to 4,294,967,295. This format is only available for word type memory (%R, %AI, %AQ, %P, %L, and %W).

Real: 7 decimal digits plus a decimal point and exponent if necessary (for example 123.4567, 1.234567e+038). This format uses 2 words or 32 bits. This format is only available for word type memory (%R, %AI, %AQ, %P, %L, and %W). The range is +-1.401298e-045 to +-3.402823e+038.

Blank: The associated cell or row will have no value or reference address header.

PLC Fault Table Viewer Page

The PLC Fault Table Viewer displays the contents of the PLC fault table.



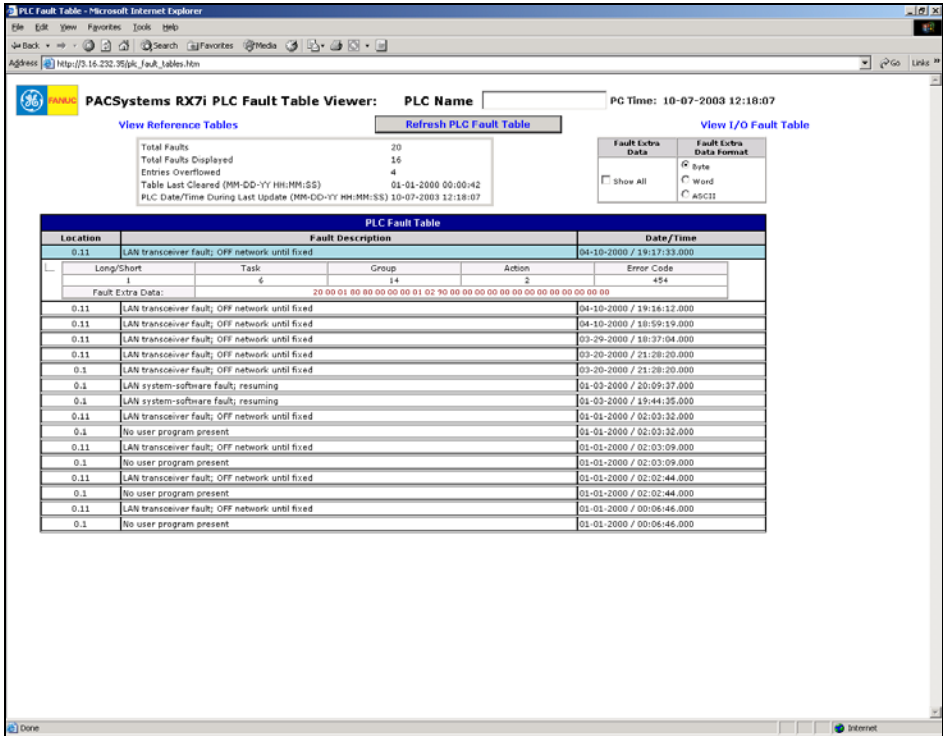
The PLC name is shown at the top of the page, together with the PLC timestamp showing when the page was accessed or refreshed.

The PLC fault table provides up to 16 entries arranged from newest to oldest. If there are fewer than 16 entries, the remaining rows are blank. If there are more than 16 faults, the table displays the most recent faults in the first 8 rows and the oldest faults in the last 8 rows.

To change the format of the fault extra data, select the appropriate checkbox at the top of the page.

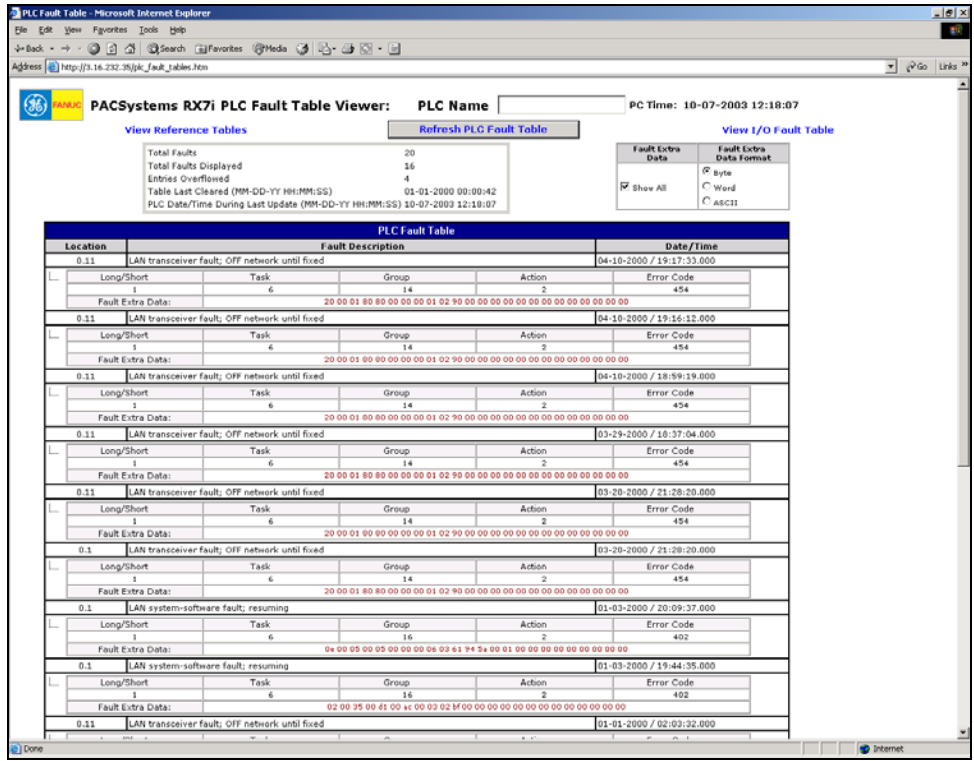
To refresh the fault data, click the 'Refresh PLC Fault Table' button.

When using Internet Explorer, the fault extra data can be viewed by using the mouse to highlight a particular fault and then clicking on the fault. This is shown below:



The fault extra data can be displayed in byte, word or ASCII format depending on which button is selected at the top of the screen. These selections affect the display of all fault extra data. If an error code does not have a string associated with it, the "Fault Description" field is blank.

To view the fault extra data for all faults, select the “Show All” checkbox as shown below:



For Netscape, first check the “Show All” checkbox and press the “Refresh PLC Fault Table” button. This will show the fault extra data for all faults. Netscape cannot show fault extra data for selected faults. To hide the fault extra data, uncheck the “Show All” checkbox and again press the “Refresh PLC Fault Table” button.

I/O Fault Table Viewer Page

The I/O Fault Table web viewer page displays the contents of the I/O Fault Table:

The fault extra data can be shown or hidden by clicking on a fault. The fault extra data for all faults in the table can be displayed by selecting the checkbox at the top of the page labeled 'Fault Extra Data'. To change the format of the fault extra data, select the appropriate checkbox at the top of the page.

To refresh the fault data, click the 'Refresh I/O Fault Table' button.

Downloading PLC Web Pages

To add new or revised web page files or support files, you will need to transfer the appropriate files to the Ethernet Interface via FTP. Once the new web files have been obtained, they are copied into the local computer from which the FTP utility will be run. A general procedure for transferring web files via Windows FTP is described below. (You may also use a commercial FTP program.)

Note: You may not be able to open an FTP connection when the CPU is in Run mode and the level of Ethernet traffic is medium to heavy. If the network traffic is high, it is recommended that you reduce the network traffic before trying to create an FTP connection.

FTP Connect and Login

You can either use a commercial FTP tool or use the “ftp” command on the DOS Prompt or Command line (Note: Not all FTP tools will be guaranteed to work since the server only supports a limited set of FTP commands).

From the Windows DOS box command line interface, enter “ftp” followed by the URL or IP address of the PLC as shown below:

```
ftp <URL or IP address of the Ethernet Interface>
```

You will then be prompted for a login name and password as shown below. The default FTP password is “system”.

```
login: user  
password: system
```

The FTP server in the PLC Ethernet interface does not support multiple levels of login (there are no distinct ‘anon’ or ‘user’ logins). Once successfully logged on, you can execute any of the FTP commands described below; this login is required in order to store web page files to the Ethernet Interface.

Changing the Password

The default FTP password is “system”. You can change the FTP password via a parameter in the AUP file, which is stored to the PLC via the programmer, or by using the Station Manager.

Changing the Password from the Advanced User Parameters File

The following line should be added to the AUP file to change the FTP password (for example, to “my_ftp_pw”):

```
tpassword = my_ftp_pw
```

Changing the Password from the Station Manager

In addition, you can change the FTP password (for example to “my_ftp_pw”) using the following Station Manager command:

```
= CHPARM tpassword my_ftp_pw
```

The FTP password can be up to 10 characters long and uses the same character set listed for the reference viewer password described later in this document. These passwords are not case sensitive.

Arguments for Station Manager CHPARM command must be enclosed in double quotes to preserve the capitalization of the argument. However since these passwords are case insensitive, the double quotes are not required.

Note: The CHPARM command is not available if the PLC has received a valid configuration from the Programmer.

Web Page File Transfer

After logging into the PLC's FTP server, web page files can be copied from the PC to the PLC through the following steps:

1. Set the FTP file transfer type to binary by typing in "binary"
2. For each file, change to the desired directory if appropriate by typing "cd ./subdirectory". Then transfer the file using the "put" command by typing: "put filename.htm"
3. Verify all files are properly transferred by typing in: "dir" or "ls". This returns a list of the files located at the current directory on the PLC Ethernet Interface
4. Quit the FTP session by typing in "quit" or "bye".

If you copy a file that already exists in the module, the new file overwrites the existing file without warning. One of the files stored will be a fault string file that will be specific for each language supported.

The PLC FTP server also supports the following standard FTP commands:

- "get" command - allows the user to transfer files from the PLC web server to their local PC (for example "get filename1.htm").
- "delete" command – allows user to delete web pages from the server (for example "delete filename1.htm").

Viewing the RX7i PLC Web Pages

Each web browser (HTTP) instance (i.e., each browse window) requires at least two TCP connections and each FTP session requires two TCP connections to the PLC. The maximum number of web browser connections and FTP connections at the Ethernet interface at any one time are separately configurable from 0 to 16 (a value of 0 means that the web server or FTP capability is disabled). The total number of configured web browser connections plus FTP connections is limited to 16 connections; once the number of browser/FTP connections reaches the configurable limit, any new browser or FTP connection requests will fail.

The number of Web Server and FTP connections is configurable via the Programmer. The Programmer configuration details are described in the Programmer Help utility.

When the PLC is unconfigured, the user can change the number of web server (HTTP) connections and FTP connections with the following Station Manager commands, respectively:

```
CHSOSW web_max_conn <number from 0-16>
```

```
CHSOSW ftp_max_conn <number from 0-16>
```

As noted in the Ethernet Configuration section, the sum of web server connections plus FTP connections must not exceed 16 connections.

For example:

```
= CHSOSW web_max_conn 6
```

```
= CHSOSW ftp_max_conn 4
```

Note: The CHSOSW commands are not available if the PLC has received a valid configuration from the Programmer.

Chapter *Diagnostics*

10

This chapter describes diagnostic techniques for a PACSystems Ethernet Interface.

- Diagnostic Tools Available for Troubleshooting
- States of the Ethernet Interface
- EOK Blink Codes for Hardware Failures
- PLC Fault Table
- Monitoring the Ethernet Interface Status Bits
- Monitoring the FT Output of the COMMREQ Function Block
- Monitoring the COMMREQ Status Word
- Using the EGD Management Tool
- Troubleshooting Common Ethernet Difficulties

What to do if you Cannot Solve the Problem

If you cannot solve the problem, contact GE Fanuc Automation. Please have the following information ready:

- The Name and Catalog Number marked on the product.
 - PLC CPU version number from CME Status screen
 - Ethernet Interface CPU Embedded or standalone
- Description of symptoms of problem. Depending on the problem, you may also be asked for the following information:
 - The ladder logic application program and the PLC sweep time at the time the problem occurred.
 - A listing of the configuration parameters for the Ethernet Interface that failed.
 - A description of the network configuration. This should include the number of PLCs and host computers accessing the network, the type of network cable used (e.g. twisted pair, fiber optic, etc.), length of network cable, and the number and manufacturer of transceivers, hubs, and network switches used.
 - Description on ALL Ethernet communication activity for the PLC.
 - Versions of all software doing Ethernet communication to the PLC. This includes Proficy Logic Developer, CIMPLICITY PE, IFIX, etc.
 - Be prepared to provide the PLC Fault Table showing Fault Extra Data
 - Be prepared to provide Station Manager Log showing Ethernet Events

Diagnostic Tools Available for Troubleshooting

There are several tools to assist you in diagnosing problems with the Ethernet Interface and the network.

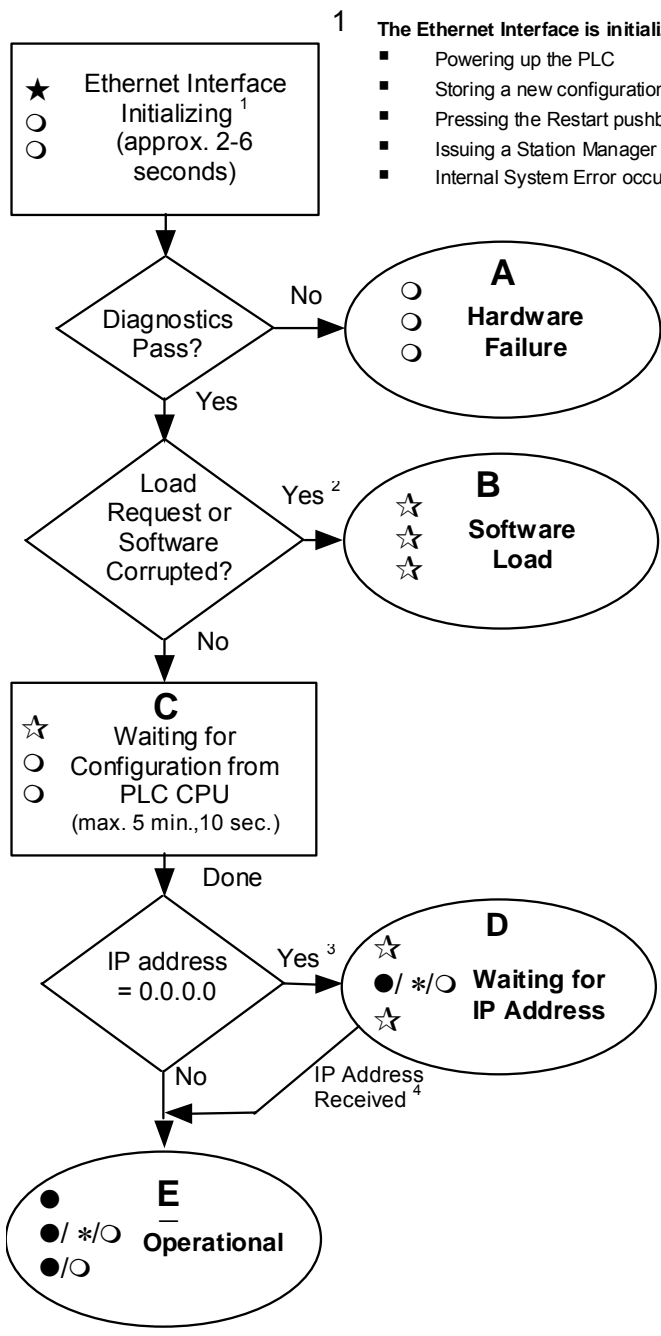
- Use the **Ethernet Interface LEDs** to troubleshoot a problem on power-up of the Ethernet Interface and for an immediate visual summary of the operational state of the Interface.
- Use the PLC Fault Table to troubleshoot a problem once the Interface is running. It provides a record of exceptions logged by the PLC, the Ethernet Interface, and other I/O and communications modules. The PLC Fault Table is accessed through the PLC programming software or a web browser (for a CPU with embedded Ethernet Interface).
- For PLC Fault Table entries generated by the Ethernet Interface, the Detailed Fault Data for that entry contains the same data as the corresponding event in the Ethernet Interface's exception log. Refer to GFK-2225, TCP/IP Ethernet Communications for the PACSystems Station Manager Manual, for information on how to interpret Ethernet exception log events.
- Use the Ethernet Status Data to troubleshoot the Ethernet Interface status
- For Ethernet Global Data operation, the EGD Management Tool can be used to check online operation of the EGD network.
- For Ethernet Global Data operation, Exchange Status words can be used to troubleshoot exchange operations.
- Use the Station Manager to troubleshoot a problem with the Ethernet Interface, the network, PLC backplane communication, or with your application. The LOG, TALLY, EXS, CHANNEL, STAT, and XCHANGE Station Manager commands are especially useful.
- The LOG command provides a complete record of exceptions occurring with the network and Interface.
- The TALLY command provides statistics about operation and performance of the network and Interface.
- The EXS command provides information about COMMREQs.
- The CHANNEL command displays detailed information about a specified SRTP or Modbus/TCP communication channel.
- The STAT command provides the current status of specific components of the Ethernet interface. Of particular use, the STAT V and STAT H commands provide SRTP server and SRTP channel status, respectively. The STAT O and STAT M

commands provide Modbus/TCP server and channel status, respectively. The STAT G command provides the current status on the operation of EGD communications on the Interface.

- The XCHANGE command displays detailed information about a specified Ethernet Global Data exchange.

Refer to GFK-2225, *TCP/IP Ethernet Communications for PACSystems™ Station Manager Manual*, for information on how to access and use the Station Manager software.

States of the Ethernet Interface



- 1 **The Ethernet Interface is initialized by**
- Powering up the PLC
 - Storing a new configuration to the PLC with changes for the Ethernet Interface
 - Pressing the Restart pushbutton
 - Issuing a Station Manager RESTART command
 - Internal System Error occurring when Interface is operational

- 2 **Software Load caused by**
- Pressing the Restart pushbutton
 - Detection of corrupt software

- 3 **Waiting for IP Address caused by**
- Not configuring Interface using configuration software
 - Configuring Interface with IP Address = 0.0.0.0
 - New CPU with no configuration
 - CPU failure to communication with Interface

- 4 **Continue to Operational State caused by**
- IP Address received over network

- Operational**
- Full support for client and server capability
 - Uses user-defined Advanced Parameters

Symbols

The LEDs are labeled from top to bottom as follows:
EOK
LAN
STAT

- The symbols used for the LEDs in the chart are:
OFF
- ON
- ☆ Slow Blink; multiple slow blinking LEDs blink in unison
- ★ Fast Blink
- * Traffic (blinks when there is traffic on the line.)

The process symbols use in this chart are:

- Temporary condition; requires no intervention
- ◇ Decision point during powerup
- Interface State; normally the Interface remains in a state unless there is user intervention.

LED Pattern		Where Stopped	Possible Cause	Corrective Actions
○ ○ ○	EOK (OFF) LAN (OFF) STAT (OFF)	A Hardware Failure	Fatal Hardware Error.	Make sure the PLC has power. Examine PLC Fault Table for clues. Recheck PLC Programmer configuration. Power off baseplate, inspect the Interface for loose components, reseal the module, and Restart. If the problem persists, replace the PLC hardware.
✚ ✚ ✚	EOK (Slow blink) LAN (Slow blink) STAT (Slow blink) All LEDs blink in unison.	B Software Loader	Software corrupt.	Connect a PC Software Loader and load new software.
✚ ○ ○	EOK (Slow blink) LAN (OFF) STAT (OFF)	C Waiting for Configuration from PLC	Did not configure slot using the PLC Programmer. CPU not communicating with Ethernet Interface. (Condition can last a maximum of 5 minutes.)	Use the PLC Programmer configuration software to configure the Interface then store the configuration to the PLC CPU. Power cycle the PLC. Clear faults and Restart Interface.
✚ ○ ○	EOK Blinking error code LAN Off STAT Off		Unrecoverable hardware or runtime failure	See the list of blink codes on the next page.
✚ ● ✚ ○ ✚	EOK (Slow blink) LAN (ON/Traffic/OFF) STAT (Slow blink) EOK and STAT blink in unison.	D Waiting for IP Address	Interface's IP address has not been configured or has been configured as 0.0.0.0.	Use the PLC Programmer to configure the Interface with a non-zero IP address. Assign IP address over network
● ● ✚ ○ ● ○	EOK (ON) LAN (ON/Traffic/OFF) STAT (ON/OFF)	E Operational	If the LAN LED is OFF, the problem may be network cable not connected If the STAT LED is OFF, an exception condition has occurred.	Connect cable. Examine PLC Fault Table to find out why the STAT LED is OFF.

In the RX7i, the Ethernet LEDs are labeled **EOK**, **LAN**, and **STAT**.

In the RX3i, the Ethernet LEDs are labeled **ETHERNET OK**, **LAN OK**, and **LOG EMPTY**, respectively.

EOK LED Blink Codes for Hardware Failures

The EOK LED indicates whether the module is able to perform normal operation. This LED is on for normal operation and flashing for all other operations. If a hardware or unrecoverable runtime failure occurs, the EOK LED blinks a two-digit error code. The EOK LED first blinks to indicate the most significant error digit, then after a brief pause blinks again to indicate the least significant error digit. After a long pause the error code display repeats

Blink Code	Description	Blink Code	Description
0x12	Undefined or Unexpected Interrupt.	0x42	Firmware Loader error
0x13	Timer failure during power up diagnostics.	0x51	Unexpected watchdog timer exception
0x14	DMA failure during power up diagnostics.	0x52	Unexpected debug exception
0x21	RAM failure during power up diagnostics.	0x61	Boot: Critical interrupt exception
0x22	Stack error during power up diagnostics.	0x62	Boot: Machine check exception
0x23	Shared Memory Interface error during power up diagnostics.	0x63	Boot: Data store exception
0x24	Firmware CRC (cyclic redundancy check) error during power up or Factory Test*	0x64	Boot: Instruction store exception
0x25	Run time exception	0x65	Boot: External interrupt exception
0x26	No mail communication available during software load	0x66	Boot: Alignment exception
0x27	Serial EEPROM access exception	0x67	Boot: Program exception
0x28	Serial EEPROM reset exception	0x68	Boot: System call exception
0x31	Machine check exception	0x69	Boot: PIT interrupt exception
0x32	Data store exception.	0x71	Boot: FIT interrupt exception
0x33	Instruction store exception	0x72	Boot: WDT interrupt exception
0x34	Alignment exception	0x73	Boot: Data cache TLB miss exception
0x35	Program exception	0x74	Boot: Instruction cache TLB miss exception
0x36	System call exception	0x75	Boot: Debug exception
0x37	Unexpected IRQ exception	0x76	Boot: Flash memory CRC error
0x38	Data cache TLB miss exception	0x77	Boot: Unexpected ACFAIL interrupt
0x39	Instruction cache TLB miss exception	0x78	Boot: Unexpected Restart pushbutton interrupt
0x41	BSP startup error		

*CRC error or software error during normal operation causes Ethernet restart

PLC Fault Table

Most error conditions involving the Ethernet interface generate faults in the PLC Fault table. The table on the next two pages lists Ethernet interface faults and corrective actions.

To access the details of a PLC Fault Table entry, double-click the Fault Table entry and the details are displayed as “fault extra data”. Refer to Online Help in the PLC programming software for more information.

An example of the fault extra data is shown below:

1600060003000500000000000000000000000000000000000000
| | | |

For Ethernet Interfaces the leftmost 14 digits of fault extra data (underlined in the example above) show the corresponding log Events (2 digits) and Entries 2, 3, and 4 (in that order, 4 digits each). The example above is reporting an Event 16, Entry 2=6, Entry 3=3, and Entry 4=5.

This information can be used to refer directly to detailed fault descriptions included in the Exception Log Event tables in GFK-2225, *TCP/IP Ethernet Communications for PACSystems Station Manager Manual*. (In that document, refer to Appendix B, Exception Log Events.)

PLC Fault Table Descriptions

<i>PLC Fault</i>	<i>User Action</i>
Backplane communications with PLC fault; lost request	Check to make sure that the logic application is not sending COMMREQs faster than the Ethernet Interface can process them. Reduce the rate at which the application is sending COMMREQs to the Ethernet interface. If problem persists, contact GE Fanuc Automation.
Bad local application request; discarded request	Check for valid COMMREQ command code. If problem persists, contact GE Fanuc Automation.
Bad remote application request; discarded request	Try to validate the operation of the remote node. If problem persists, contact GE Fanuc Automation.
Can't locate remote node; discarded request	Error reported when message received where IP/MAC address cannot be resolved. Error may indicate that remote host is not operational on the network. Check that remote host is operational on network and its addresses are correct.
Comm_req - Bad task ID programmed	Message from PLC for unknown Ethernet Interface task. Check COMMREQ function block.
Comm_req - Wait mode not allowed	Check COMMREQ to make sure sent in no-wait mode.
Configured gateway address bad; can't talk off local net	Error in configuration. Verify that IP address, Subnetwork Mask, and default Gateway IP address are correct.
Connection to remote node failed; resuming without it	Underlying communications software detects error transferring data; resuming. If persistent error, check connection to LAN and operation of remote node.
LAN controller fault; restart LAN I/F	HW fault, perform a power cycle. If problem persists, contact GE Fanuc Automation.
LAN controller Tx underflow; attempt recovery	Internal system error. If problem persists, contact GE Fanuc Automation.
LAN controller under run/overrun; resuming	Internal system error. If problem persists, contact GE Fanuc Automation.
LAN data memory exhausted - check parameters; resuming	The Ethernet Interface does not have free memory to process communications. If problem persists, contact GE Fanuc Automation.
LAN duplicate MAC Address; resuming	A frame was received in which the source MAC Address was the same as this station's MAC Address. All stations on a network must have a unique MAC address. Immediately isolate the offending station; it may be necessary to turn it off or disconnect it from the network. This station remains Online unless you intervene to take it Offline.
LAN I/F can't init - check parameters; running soft Sw utl	Internal system error. If problem persists, contact GE Fanuc Automation.
LAN I/F capacity exceeded; discarded request	Verify that connection limits are not being exceeded.
LAN interface hardware failure; switched off network	Replace the Ethernet Interface.

PLC Fault	User Action
LAN network problem exists; performance degraded	Excessive backlog of transmission requests due to excessive traffic on the network. For a sustained period the MAC was unable to send frames as quickly as requested. If problem persists, contact GE Fanuc Automation.
LAN severe network problem; attempting recovery	External condition prevented transmission of frame in specified time. Could be busy network or network problem. Check transceiver to make sure it is securely attached to the network.
LAN system-software fault; aborted connection resuming	Internal system error. If problem persists, contact GE Fanuc Automation.
LAN system-software fault; restarted LAN I/F	Internal system error. If problem persists, contact GE Fanuc Automation.
LAN system-software fault; resuming	Internal system error. If problem persists, contact GE Fanuc Automation.
LAN transceiver fault; OFF network until fixed	Transceiver or transceiver cable failed or became disconnected. Reattach the cable or replace the transceiver cable. Check SQE test switch if present on transceiver.
Local request to send was rejected; discarded request	Internal error. Check that the Ethernet Interface is online. If problem persists, contact GE Fanuc Automation.
Memory backup fault; may lose configuration/log on restart	Internal error accessing non-volatile device. If problem persists, contact GE Fanuc Automation - NA. Replace Ethernet Interface.
Module software corrupted; requesting reload	Catastrophic internal system error. Contact GE Fanuc Automation.
Module state doesn't permit Comm_Req; discarded	COMMREQ received when Ethernet Interface cannot process COMMREQ. Make sure Ethernet Interface is configured and online. Error may occur if the logic application is sending COMMREQs faster than the Ethernet Interface can process them. Reduce the rate at which COMMREQs are sent.
Unsupported feature in configuration	PLC firmware does not support Ethernet communications software or attempt has been made to configure a feature not supported by the Ethernet Interface. Check CPU and Ethernet Interface revisions, order upgrade kit for CPU and/or Ethernet Interface.
Can't locate remote node; discarded request	A specified remote device does not exist on the network. Check that the remote device IP address is correct and that the remote device is functioning properly.
Mailbox Queue full – Comm_req aborted	The CPU is attempting to send COMMREQs faster than the Ethernet Interface can receive them. The PLC logic program should retry the COMMREQ after a short delay. If the condition persists, the logic application should be revised to reduce the rate at which it sends COMMREQs to the Ethernet Interface.
Non-critical CPU software event	The CPU is attempting to send mail messages faster than they can be retrieved by the Ethernet Interface; the messages are discarded. This can result in subsequent "Backplane communications with PLC fault; lost request" faults.

Monitoring the Ethernet Interface Status Bits

The Ethernet Interface status bits occupy a single block of either reference memory, or I/O variables. The access type and location of the Ethernet Interface Status bits is specified during configuration of the Ethernet Interface. The Ethernet Status bits are updated in the CPU once each PLC scan by the Ethernet Interface. These bits are generally used to prevent initiation of a COMMREQ function when certain errors occur.

The first 16 bits of the block are the LAN Interface Status (LIS) bits. The next 64 bits are the Channel Status bits (2 for each channel). Unless the “LAN Interface OK” bit is set (Status Bit 16), the other status bits are invalid.

Status Bits	Brief Description
1	Port 1A full duplex
2	Port 1A 100Mbps
3	Port 1B full duplex
4	Port 1B 100 Mbps
5	Network Time Locked
6	Redundant IP address is active
7-8	Reserved
9	Any Channel Error (error on any channel)
10–12	Reserved
13	LAN OK
14	Resource problem
15	Module Overtemperature (RX3i only)
16	LAN Interface OK
17	Channel 1 Status (SRTP: Data Transfer)
18	Channel 1 Status (SRTP: Channel Error)
...	...
79	Channel 32 Status (SRTP: Data Transfer)
80	Channel 32 Status (SRTP: Channel Error)

LAN Interface Status (LIS) Bits

The LAN Interface Status bits monitor the health of the Ethernet Interface itself.

Bit 1, Port 1a Full Duplex: This bit is set to 1 when Port 1A is set to full duplex. Full-duplex or half-duplex operation is automatically negotiated between the Ethernet Interface and its immediately-connected network device, usually a network hub or switch. If this bit is 0, the port is in half-duplex Ethernet mode. This bit is only valid if bit 13 (LAN OK) is 1.

Bit 2, Port 1A 100Mbps: This bit is set to 1 when Port 1A is operating at 100Mbps.

Bit 3, Port 1B Full Duplex: This bit is set to 1 when Port 1B is set to full duplex. Full-duplex or half-duplex operation is automatically negotiated between the Ethernet Interface and its immediately-connected network device, usually a network hub or switch. If this bit is 0, the port is operating in half-duplex Ethernet mode. This bit is only valid if bit 13 (LAN OK) is 1.

Bit 4, Port 1B 100Mbps: This bit is set to 1 when Port 1B is operating at 100Mbps.

Bit 5, Network Time Locked: The Ethernet clock is locked to a network SNTP timer server. When this bit is 0, the Ethernet module has lost its lock to a network timeserver, or was never locked to a timeserver. This bit is updated whether or not the SNTP Time Transfer feature is configured and whether or not the logic application has enabled CPU Time Update interrupts. For more information, see “Timestamping of Ethernet Global Data Exchanges” in chapter 4.

Bit 6, Redundant IP Address Active: This bit is set to 1 when the configured Redundant IP address is active. Otherwise this status bit is set to 0.

Bit 9, Any Channel In Error: This bit (normally 0) indicates one or more of the channels are in error.

Bit 13, LAN OK: This bit is 1 as long as the Ethernet Interface software is able to communicate on the network. If the network becomes inaccessible due to local or network problems, this bit is set to 0. If LAN communication becomes possible again, it is set to 1.

Bit 14, Resource Problem: This bit is set to 1 if the Ethernet Interface software has a resource problem (i.e., lack of data memory). The bit is reset to 0 on a subsequent PLC sweep. The Ethernet Interface may or may not be able to continue functioning, depending on the severity of the problem. Look in the PLC Fault Table for details. In addition, the Station Manager STAT B and LOG commands can be used. See the *Station Manager Manual*, GFK-2225, for more information.

Bit 15, Module Overtemperature: This bit is set if the Ethernet interface hardware has detected that the internal temperature has exceeded normal limits. The bit is cleared when the internal temperature has not exceeded normal limits, or has recovered from an over-temperature condition. (Overtemperature indication is available in the RX3i only.)

Bit 16, LAN Interface OK Bit: This bit is set to 1 by the Ethernet Interface each PLC scan. If the Ethernet Interface cannot access the PLC, the CPU sets this bit to 0. *When this bit is 0, all other Ethernet Interface Status bits are invalid.*

Channel Status Bits

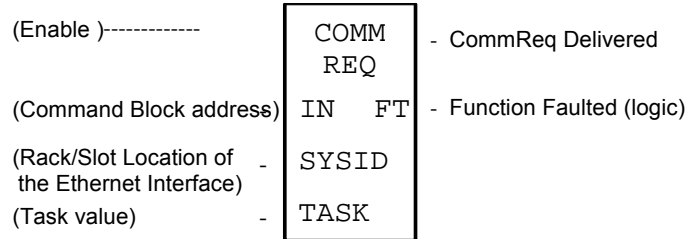
The Channel Status bits provide runtime status information for each communication channel. Each channel has two status bits; the meaning of the channel status bits depends upon the type of communication performed on that channel.

SRTP Client (channels) operation provides two Channel Status bits for each SRTP channel, a Data Transfer bit and a Channel Error bit. These are defined in chapter 6, SRTP Channels.

Bits 17, 19, 21 ... 79, Data Transfer Bit: The Data Transfer bit pulses (0 → 1 → 0) each time there is a successful read or write. **Bits 18, 20, 22 ... 80, Channel Error Bit:** This bit (normally 0) indicates any channel error, fatal or non-fatal. It does not necessarily indicate that the channel is idle.

Monitoring the FT Output of the COMMREQ Function Block.

The COMMREQ function block indicates its status through its FT output:



If after executing a COMMREQ Function, the FT Output is ON, there is a programming error in one or more of the following areas.

- Invalid rack/slot specified. The module at this rack/slot is unable to receive a COMMREQ Command Block.
- Invalid Task ID. This value should always be 65536 decimal (10000H) for the CPU Ethernet daughterboard, or 0 decimal (0000H) for the Ethernet module.
- Invalid Data Block length (0 or greater than 128).

This output also may indicate that no more COMMREQ functions can be initiated in the ladder program until the Ethernet Interface has time to process some of the pending COMMREQ functions.

If the FT Output is set, the CPU did not transfer the Command Block to the Ethernet Interface. In this case, the other status indicators are not updated for this COMMREQ. The Ethernet Interface is unable to return a COMMREQ Status Word to the PLC logic application.

Monitoring the COMMREQ Status Word

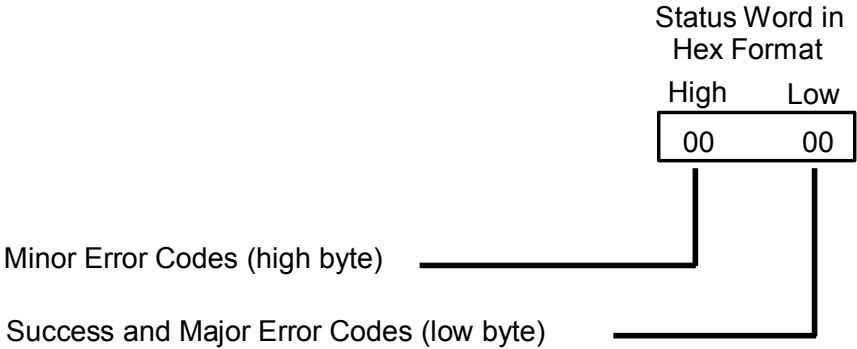
Every COMMREQ Command Block instruction specifies a 1-word memory address to receive status information about the execution of the command.

Before executing a COMMREQ for the Ethernet interface, the application program logic should set the associated status word zero (for example, using a MOVE Word instruction). After executing a COMMREQ, the program should monitor its status word. If the status word is updated to a one (1), the command has been processed successfully. If the status word is updated to a value other than 1, an error has occurred. Any data returned by that command should not be used until the problem is corrected and the status word indicates success. It is critical to monitor the COMMREQ status word for each COMMREQ function. .

If after executing a COMMREQ function, the COMMREQ status word is zero (0), the success Output is ON and the FT Output is OFF, the Command Block has been sent to the Ethernet Interface, but no status has been returned. If this condition persists, check the PLC Fault Table for information.

Format of the COMMREQ Status Word

Displaying the status word in hexadecimal form makes it easier to differentiate the high and low bytes. This can be done using a MOVE WORD function block to display the hexadecimal value within the ladder program.



The following tables list the error codes that are reported in the COMMREQ Status word after the execution of a COMMREQ function.

Note: The COMMREQ Status words for SNTP Time Transfer commands are listed in “Chapter 4, Ethernet Global Data,” following the COMMREQ command descriptions.

Major Error Codes in the COMMREQ Status Word

Success or a Major Error Code appears in the low byte of the COMMREQ Status Word. Hexadecimal values for the low byte are listed below. For many Major Error Codes, additional information appears as a Minor Error Code in the high byte of the COMMREQ Status Word. Hexadecimal values for the high byte are listed on the following pages.

Error Status (Hexadecimal)	Major Error Description
01H	Successful Completion. (This is the expected completion value in the COMMREQ Status word.)
02H	Insufficient Privilege at server PLC. For a PACSystems or Series 90-70 server PLC, the minor error code contains the privilege level required for the service request.
04H	Protocol Sequence Error. The server CPU has received a message that is out of order. <i>Call GE Fanuc Automation for assistance.</i>
05H	Service Request Error at server PLC. The minor error code contains the specific error code. See the following table of Minor Error codes.
06H	Illegal Mailbox Type at server PLC. Service request mailbox type is either undefined or unexpected. <i>Call GE Fanuc Automation for assistance.</i>
07H	The server PLC CPU's Service Request Queue is full, usually due to heavy CPU loading. The client should retry later. It is recommended that the client wait a minimum of 10 milliseconds before sending another service request.
0BH	Illegal Service Request. The requested service is either not defined or not supported at the server PLC. (This value is returned in lieu of the actual service request error (01H), to avoid confusion with the normal successful COMMREQ completion.) <i>Call GE Fanuc Automation for assistance.</i>
11H	SRTP Error Code at server. An error was detected at the SRTP server. See the following table of Minor Error codes.
82H	Insufficient Privilege at client PLC. The minor error code contains the privilege level required for the service request.
84H	Protocol Sequence Error. The CPU has received a message that is out of order. <i>Call GE Fanuc Automation for assistance.</i>
85H	Service Request Error at the client PLC. The minor error code contains the specific error code. See the following table of Minor Error codes.
86H	Illegal Mailbox Type. Service request mailbox type is either undefined or unexpected. <i>Call GE Fanuc Automation for assistance.</i>
87H	The client PLC CPU's Service Request Queue is full. The client should retry later. It is recommended that the client wait a minimum of 10 milliseconds before sending another service request.
8BH	Illegal Service Request. The requested service is either not defined or not supported. (This value is returned in lieu of the actual service request error (01H), to avoid confusion with the normal successful COMMREQ completion.) <i>Call GE Fanuc Automation for assistance.</i>
90H	Client (Channels) error. See the following table of Minor Error codes. (Some EGD command errors also use major code 90 when indicating the same error condition as channels.)
A0H	EGD Command error. See the following table of Minor Error codes.

Minor Error Codes for Major Error Codes 05H (at Remote Server PLC) and 85H (at Client PLC)

Error Status (Hexadecimal)		Error Description
Remote Server	Client	
8F05H	8F85H	Session already exists.
8E05H	8E85H	Memory write is prohibited.
9005H	9085H	Invalid PLC memory reference range.
9305H	9385H	Text buffer length/count does not agree with request parameters.
C105H	C185H	Invalid block state transition.
C305H	C385H	Text length does not match traffic type.
C605H	C685H	Control Program (CP) tasks exist but requestor not logged into main CP.
C705H	C785H	Passwords are set to inactive and cannot be enabled or disabled.
C805H	C885H	Password(s) already enabled and cannot be forced inactive.
C905H	C985H	Login using non-zero buffer size required for block commands.
CA05H	CA85H	Device is write-protected.
CB05H	CB85H	A comm or write verify error occurred during save or restore.
CC05H	CC85H	Data stored on device has been corrupted and is no longer reliable.
CD05H	CD85H	Attempt was made to read a device but no data has been stored on it.
CE05H	CE85H	Specified device has insufficient memory to handle request.
CF05H	CF85H	Specified device is not available in the system (not present).
D105H	D185H	Packet size or total program size does not match input.
D205H	D285H	Invalid write mode parameter.
D505H	D585H	Invalid block name specified.
D605H	D685H	Total datagram connection memory exceeded.
D705H	D785H	Invalid datagram type specified.
D805H	D885H	Point length not allowed.
D905H	D985H	Transfer type invalid for this Memory Type selector.
DA05H	DA85H	Null pointer to data in Memory Type selector.
DB05H	DB85H	Invalid Memory Type selector in datagram.
DC05H	DC85H	Unable to find connection address.
DD05H	DD85H	Unable to locate given datagram connection ID.
DE05H	DE85H	Size of datagram connection invalid.
DF05H	DF85H	Invalid datagram connection address.

continued

Minor Error Codes for Major Error Codes 05H (at Remote Server PLC) and 85H (at Client PLC)

Continued from previous page

Error Status (Hexadecimal)		Error Description
Remote Server	Client	
E005H	E085H	Service in process cannot login.
E405H	E485H	Memory Type for this selector does not exist.
E905H	E985H	Memory Type selector not valid in context.
EA05H	EA85H	Not logged in to process service request.
EE05H	EE85H	Could not return block sizes.
EF05H	EF85H	Programmer is already attached.
F005H	F085H	Request only valid in stop mode.
F105H	F185H	Request only valid from programmer.
F205H	F285H	Invalid program cannot log in.
F405H	F485H	Invalid input parameter in request.
F505H	F585H	Invalid password.
F605H	F685H	Invalid sweep state to set.
F705H	F785H	Required to log in to a task for service.
F805H	F885H	Invalid program name referenced.
F905H	F985H	Task address out of range.
FC05H	FC85H	I/O configuration is invalid.
FE05H	FE85H	No privilege for attempted operation.
FF05H	FF85H	Service request has been aborted.

Minor Error Codes for Major Error Code 11H (at Remote Server PLC)

Error Status (Hexadecimal)	SRTP Error Description
0111H	Generic SRTP error.
0211H	The PLC is inaccessible.
0311H	Reserved.
0411H	Unexpected SRTP version encountered in received message.
0511H	Unrecognized SRTP message received.
0611H	Data present in SRTP message, which should not contain data.
0711H	Generic resource problem detected.
0811H	SRTP message encountered in inappropriate connection state.
0911H	Generic refusal by backplane driver to handle request.
0A11H	Recognized but unsupported SRTP message received.
0B11H	Lost transaction in server.
0C11H	Error sending SRTP PDU to the client PLC.
1411H	Unable to allocate a text buffer from dual port memory.
1711H	Invalid text length detected in a mailbox message.
1811H	Invalid number of destinations detected in a mailbox message.
1911H	Invalid source detected in a mailbox message.
1A11H	Invalid slot number detected in a mailbox message.
1B11H	Invalid rack number detected in a mailbox message.
1D11H	Bad text buffer address in dual port memory.
2111H	Unable to find control data required to send a mailbox message to the PLC.
2211H	Timed out waiting for availability of mail communications with the PLC.
2311H	Invalid task ID detected while attempting to send a mailbox message to the PLC.
2411H	Unable to send mailbox message to PLC because the mail queue is full.
2611H	Unable to communicate with PLC.
2711H	Backplane driver not initialized or unable to acquire a dual port memory semaphore.
2A11H	The backplane driver could not access the PLC.
2B11H	Invalid binding on the message sent to the backplane driver.
2C11H	The message could not be sent to its destination because the mailbox was not open.
2D11H	The maximum number of transfers to the destination is already taking place.
2E11H	The maximum number of transfers of this transfer type is already taking place.
2F11H	Cannot obtain a backplane transfer buffer.

continued

Minor Error Codes for Major Error Code 11H (at Remote Server PLC)

Continued from previous page

Error Status (Hexadecimal)	S RTP Error Description
3011H	Cannot obtain resources other than backplane transfer buffers.
3111H	Connection ID or block transfer ID is not valid.
3211H	Timed out waiting for PLC CPU response.
3311H	The PLC CPU aborted the request.
3411H	An invalid message type was specified.
3511H	The specified task is not registered.
3611H	The mailbox offset specified is invalid.
3711H	The backplane task could not be registered because the message response handler was not specified.
3811H	The backplane task could not be registered because the unsolicited mailbox message handler was not specified.
3911H	The backplane task could not be registered because a required parameter was not specified.
3A11H	More than the allowable byte length in a single transfer.
3B11H	Bad sequence number in the request.
3C11H	Invalid command in request.
3D11H	Response length does not match length specified in the response qualifier.
3E11H	Request failed because the PLC's Service Request Processor is not initialized.
3F11H	Request failed due to an error in the remote device, most likely running out of Dual-Port RAM text buffers.
4011H	Unable to free dual port memory that was allocated for a connection or block transfer area.
4111H	The backplane task could not be registered because the service request handler was not specified.
4211H	No dual port memory was allocated for the connection or block transfer area needed to process the request.
4311H	Failure to register with backplane driver because the requested task is already registered.
4411H	Request failed because an invalid field was identified in the request mailbox qualifier.

continued

Minor Error Codes for Major Error Code 11H (at Remote Server PLC)

Continued from previous page

Error Status (Hexadecimal)	S RTP Error Description
E811H	Unable to send request to the PLC because an internal message queue is full.
E911H	Unable to send request to the PLC because the text buffer type is invalid.
EA11H	Unable to send request to the PLC because the mailbox utility function is invalid.
EB11H	Unable to send request to the PLC because the mailbox message is not specified.
EC11H	Unable to send request to the PLC because the internal message queue is not initialized.
FE11H	Request failed due to mailbox error on remote device. The remote device log will have more information.
2911H	The backplane driver is not initialized.
2A11H	The backplane driver could not access the PLC.
2F11H	Request failed due to an invalid parameter detected in the remote device. The remote device log will have more information.
3011H	The specified task is not registered.
3111H	Failure to register with backplane driver because the requested task is already registered.
3211H	Unable to find resource necessary for backplane driver to process a service request.
3311H	Bad sequence number detected in the service request because it is already in use.
3411H	Invalid data detected that prevents backplane driver from completing a request.
3611H	More than the allowable byte length in a single transfer.
4811H	Memory resource problem detected.
4911H	Network buffer resource problem detected.
4C11H	Error detected while attempting to receive mailbox messages from the PLC.
4D11H	Timed out waiting to obtain a backplane transfer buffer.
4E11H	Timed out waiting to transfer a mailbox message to the PLC.
4F11H	Timed out waiting for PLC CPU response.

Minor Error Codes for Major Error Code 90H (at Client PLC)

Error Status (Hexadecimal)	Error Description
0190H	Timeout expired before transfer completed; still waiting on transfer.
0290H	Period expired before transfer completed; still waiting on transfer.
8190H	COMMREQ data block too short for the command.
8290H	COMMREQ data block too short for server PLC node address.
8390H	Invalid server memory type.
8490H	Invalid Program Name.
8590H	Invalid Program Block Name.
8690H	Zero server unit length is not allowed.
8790H	Server unit length is too large.
8890H	Invalid channel number.
8990H	Invalid time unit for period. (Maximum permitted 3965 hours)
8A90H	Period value is too large.
8B90H	Zero server memory starting address is not allowed.
8C90H	Invalid client memory type.
8D90H	Invalid server host address type.
8E90H	Invalid IP address integer value. (Must be 0–255)
8F90H	Invalid IP address class. (Must be valid Class A, B, or C IP address) May also occur if the destination IP address in the COMMREQ is same as the sender's IP address.
9090H	Insufficient TCP connection resources to do request.
9190H	Zero local starting address is not allowed.
9290H	Address length value invalid. Must be 4 for address type 1.
9390H	COMMREQ data block too short for Program Block name (including 0 pad).
9490H	COMMREQ data block too short for Program name (including 0 pad).
9590H	Internal API error. See PLC Fault Table or exception log for details. This problem may occur due to the Ethernet Interface being asked to perform beyond its capacity. Try transferring less data per message or establishing fewer simultaneous connections.
9690H	Underlying TCP connection aborted (reset) by server end point.
9790H	Underlying TCP connection aborted by client end point.
9890H	The remote server has no Service Request Processor.
9A90H	Response to session request did not arrive in proper order.
9B90H	Session denied by server PLC.
9C90H	Data response did not arrive in proper order.
9D90H	Data response had unexpected size.
9E90H	Unrecognized COMMREQ command code.

continued

Minor Error Codes for Major Error Code 90H (at Client PLC)

Continued from previous page

Error Status (Hexadecimal)	Error Description
A190H	Invalid CRS word memory type.
A290H	Failed an attempt to update the CRS word.
A390H	<i>Reserved.</i>
A490H	<i>Reserved.</i>
A590H	<i>Reserved.</i>
A690H	Invalid bit mask.
A790H	Unable to connect to remote device.
A890H	Channel Resources in Use. Try the command again; a resource will become available.
A990H	“Establish Read/Write/Send Info Report Channel” COMMREQ was received while an Abort was in progress.
AA90H	An attempt to establish a TCP connection with a Remote Server has failed. Check the following: <ul style="list-style-type: none"> ▪ Make sure the Server is turned on. ▪ Make sure cables are connected. ▪ If using a switch, make sure the switch is turned on.
AB90H	A COMMREQ was discarded because the application program issued the COMMREQ before the COMMREQ Status Word for the previous COMMREQ was set.
AC90H	A protocol error occurred while communicating with the local PLC.
AD90H	A TCP Timeout occurred while communicating with the Remote PLC.
AE90H	A protocol error occurred while communicating with the local PLC.
B490H	The channel that the application is trying to open is already open.
B590H	The channel the application is trying to access is owned by a different protocol.
B690H	COMMREQ specified an invalid Modbus function code.
B790H	COMMREQ specified an invalid Modbus unit ID.
B890H	COMMREQ specified an invalid number of subrequests.
B990H	A COMMREQ subrequest specified an invalid record number.
C090H	(Redundancy only) COMMREQs commands are not allowed when Redundant IP address is not active at this Ethernet interface.
FF90H	Abort in Progress on a Channel

Minor Error Codes for Major Error Code A0H (at Client PLC)

Error Status (Hexadecimal)	Error Description
01A0H	Remote exchange is not healthy.
02A0H	Remote exchange is not defined.
03A0H	Remote exchange signature does not match.
04A0H	Request data length is invalid.
05A0H	Response data length is invalid.
06A0H	Invalid memory type selector or address range at remote device.
07A0H	Password protection does not permit access at remote device.
08A0H	Attempt to write to a consumed exchange; this is not permitted.
09A0H	Internal resource error at remote device (memory allocation failed, etc.)
0AA0H	Message delivery error; command was not processed.
0BA0H	Software initialization error; command was not processed.
0CA0H	Invalid RDS session was specified.
0DA0H	Data buffer length is invalid.
0EA0H	Invalid response message from remote device.
0FA0H	Address type is not supported at remote device.
10A0H	A memory access error occurred while processing this command.
11A0H	Remote device did not understand the request.
12A0H	Remote device has no variable defined at the specified address.
13A0H	An attempt was made to write a Read-Only variable at remote device.
14A0H	Data length or contents are invalid for transfer according to the data type of that variable at remote device.
15A0H	Response message would exceed max response size (1400 bytes).
50A0H	The remote server detected an unsupported protocol version in the request.
51A0H	The remote server did not recognize the requested command.
52A0H	The remote server detected a configuration time mismatch in the request.
53A0H	The remote server detected that the request was not a valid RDS message. The RDS_Header bit (required by RDS version 2.01 and higher) was not set.
54A0H	Attempt to establish a second session to a remote server. Only one session at a time is permitted between this device and each remote server.
55A0H	All available RDS sessions are currently in use. (The number of simultaneous RDS sessions is limited to a maximum of 10.)

Using the EGD Management Tool

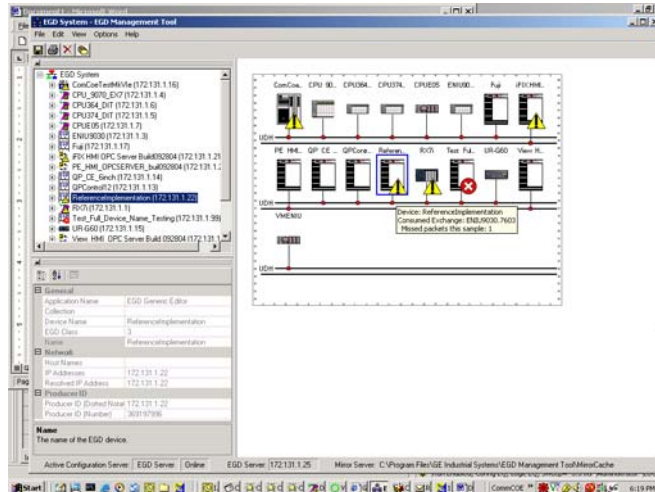
The EGD Management Tool can perform online monitoring of EGD class 2 devices such as the PACSystems Ethernet Interfaces. It can quickly look at the Ethernet Global Data traffic across an entire network of EGD devices to spot problems. To use the EGD Management Tool, you must have configured Ethernet Global Data using the EGD Configuration Server option as described in chapter 3.

Installing the EGD Management Tool

The EGD Management Tool is not automatically installed when you install the Programmer. To install the EGD Management Tool, look in the directory where you installed the programmer and you will find a subdirectory named “EGD Installs”. In that directory, you will find a file named “EgdManagementToolSetup.msi”. Double-click on this file to install the EGD Management Tool.

Launching the EGD Management Tool

To run the EGD Management Tool, select the Ethernet Global Data node in the Navigator and right click. Select “Launch EGD Management Tool”. The EMT will begin execution in a separate frame on your desktop.



The right side of the screen shows a graphical representation of the EGD network based on the configuration data stored in the EGD Configuration Server. EGD collections are displayed as a folder icon. The navigator on the left side allows specific devices, exchanges and variables in the configuration to be examined. Properties for these elements are shown in the property pane at the lower left.

The EGD Management Tool displays devices and networks based on the configuration information in the EGD Configuration Server for the machine it is running on. Using the options menu you can configure the server information much as you do for the programming

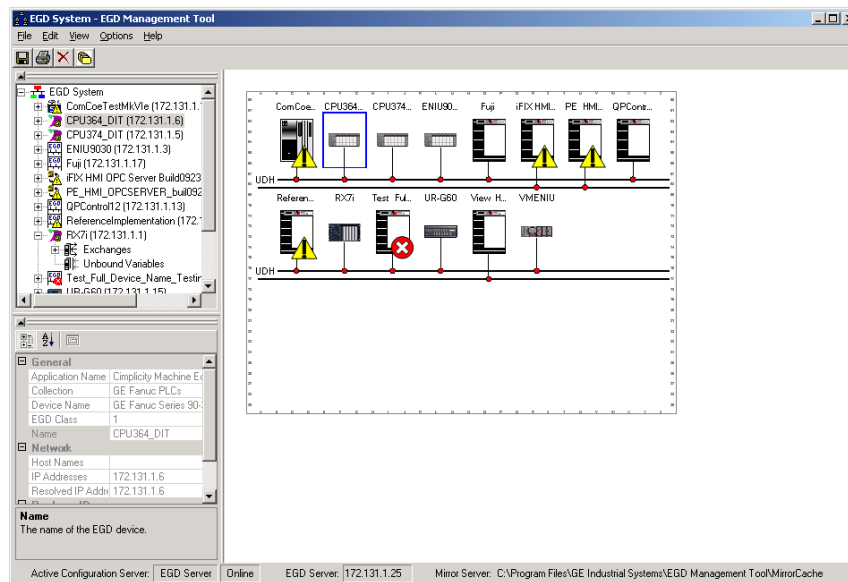
tool, and also set options for the online operation of the tool. Be aware that changing the server configuration will change it for all tools running on that machine, including the programming software.

In addition to the online operations described below, the EGD Management Tool has a number of offline capabilities (such as View/Reports) for doing analysis of the Ethernet Global Data configuration. See the EGD Management Tool help for more information.

Monitoring EGD Devices

The EGD Management Tool monitors the devices on the Ethernet Global Data network provided it has access to that network. To have access to the EGD network, the computer running the EGD Management Tool must have a Network Interface Card that connects to the EGD network. Consult with your local network administrator if you need help connecting the computer to the Ethernet Global Data network.

The screen below shows the EGD Monitoring Tool connected to and monitoring an EGD network.



Devices that have a red 'x' are not responding to communications from the EGD Management Tool. Devices that have a yellow triangle have some kind of error or warning condition that may require attention. Use the browser pane to select the device to get further information about the failures being reported. The EGD Management Tool reports a configuration mismatch for PLCs that have multiple Ethernet Interfaces. Only one of the interfaces in a PLC is queried by the EGD Management Tool, so only a subset of the exchanges in the PLC is visible online through that interface.

Online information is only available for EGD Class 2 devices (devices that support the EGD commands). This includes all PACSystems controllers. It does not include most of the older GE Fanuc Series 90 PLCs.

When the EGD Management Tool is used online, it periodically sends Ethernet Global Data commands to each device. This may have a performance impact on the network and the devices on the network. Before using the EGD Management Tool in a production environment, be sure to assess the performance impact of its use on your application.

Monitoring Status of Ethernet Global Data for a Device

The EGD Management Tool can display detailed information for each exchange in an EGD Class 2 device such as a PACSystems controller. Selecting the Exchanges node for the device in the navigator pane will display the list of exchanges for the device.

Configuration Summary

Selecting the “Configuration Summary” tab displays information about the exchanges defined in the device.

Exchange	Producer ID	Destination	Mode	Type	Configuration Time	Signature	Length	Period
ReferenceImplementation.122	172.131.1.22	172.131.1.1	Unicast	Producer	2004-10-15 19:47:31	1.1	100	500
ReferenceImplementation.222	172.131.1.22	172.131.1.2	Unicast	Producer	2004-10-15 19:49:40	4.0	100	500
ReferenceImplementation.522	172.131.1.22	172.131.1.5	Unicast	Producer	2004-10-15 19:49:40	3.0	100	500
ReferenceImplementation.622	172.131.1.22	172.131.1.6	Unicast	Producer	2004-10-15 19:49:40	3.0	100	500
ReferenceImplementation.2122	172.131.1.22	172.131.1.21	Unicast	Producer	2004-10-15 19:49:40	3.0	100	500
ReferenceImplementation.5122	172.131.1.22	224.0.7.22	Multicast	Producer	2004-09-16 17:14:09	1.0	2	500
ReferenceImplementation.7622	172.131.1.22	172.131.255.255	Broadcast	Producer	2004-09-16 17:14:09	1.0	2	500
ReferenceImplementation.9922	172.131.1.22	172.131.1.1	Unicast	Producer	2004-10-15 15:23:08	2.1	3	500
RX7i.7601	172.131.1.1	172.131.255.255	Broadcast	Consumer	2004-09-09 20:13:37	2.0	2	500
RX7i.7602	172.131.1.1	172.131.255.255	Broadcast	Consumer	2004-09-09 20:13:37	1.1	2	500
RX7i.5101	172.131.1.1	224.0.7.1	Multicast	Consumer	2004-09-09 20:13:37	1.0	2	500
RX7i.5102	172.131.1.1	224.0.7.2	Multicast	Consumer	2004-09-09 20:13:37	1.1	2	500
ENIU9030.7603	172.131.1.3	172.131.255.255	Broadcast	Consumer	2004-08-10 15:00:34	1.0	56	500
CPU374_DIT.7605	172.131.1.5	172.131.255.255	Broadcast	Consumer	2004-09-08 20:42:25	3.1	2	500
CPU374_DIT.5105	172.131.1.5	224.0.7.5	Multicast	Consumer	2004-09-08 20:42:25	3.1	2	500
CPU364_DIT.7606	172.131.1.6	172.131.255.255	Broadcast	Consumer	2004-09-08 20:41:24	3.1	2	500
CPU364_DIT.5106	172.131.1.6	224.0.7.6	Multicast	Consumer	2004-09-08 20:41:24	3.1	2	500
VMENU.1	172.131.1.8	172.131.255.255	Broadcast	Consumer	2004-08-20 19:42:59	0.0	40	500
UR-G60.3	172.131.1.15	172.131.255.255	Broadcast	Consumer	2004-07-06 15:44:38	16.0	22	1000
ComCoeTestMkVle.7616	172.131.1.16	172.131.255.255	Broadcast	Consumer	2004-02-16 11:16:39	1.1	2	480
Fuji.1	172.131.1.17	172.131.255.255	Broadcast	Consumer	2004-02-16 11:16:39	0.0	6	500
Fuji.2	172.131.1.17	172.131.255.255	Broadcast	Consumer	2004-02-16 11:16:39	0.0	56	5000

The configuration summary data for each exchange has the following information:

Exchange –the name of the exchange as it is stored in the EGD configuration server.

Producer ID –the producer ID of the exchange as it is stored in the EGD configuration server.

Destination –the destination IP address for the exchange.

Mode – ‘Unicast’, ‘Multicast’ or ‘Broadcast’ based on the mode of the exchange.

Type – ‘Producer’ or ‘Consumer’ depending on the type of the exchange.

Configuration Time –the configuration timestamp of the exchange as it is stored in the EGD configuration server.

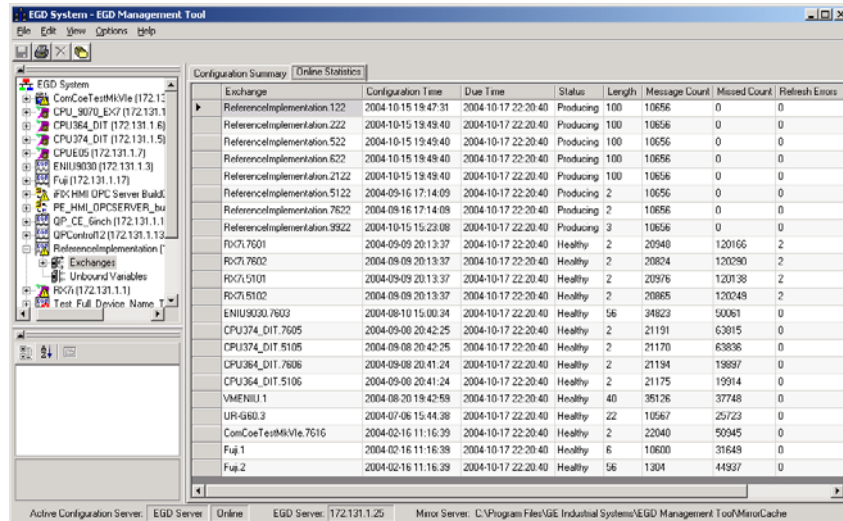
Signature –the signature value of the exchange as it is stored in the EGD configuration server.

Length –the byte size of the exchange as it is stored in the EGD configuration server.

Period –the production period for a produced exchange or the consume timeout for a consumed exchange as it is stored in the EGD configuration server.

Online EGD Statistics

Selecting the “Online Statistics” tab displays a list of the exchanges in the device and statistics information about each exchange. The statistics are updated periodically based on a rate in the Options menu.



The statistics data for each exchange has the following information:

Exchange –the name of the exchange as it is stored in the EGD configuration server.

Configuration Time –the date and time that the configuration for the exchange was created.

Due Time –the date and time that a sample is due. For a produced exchange, this is the time that the next sample will be produced. For a consumed exchange, this is the time at which the exchange will time out if data is not received.

Status –information about the status of the exchange. For a produced exchange, status will be Producing if the exchange is actively being sent to the network and Pending if the exchange is defined but not producing. A Pending status in a PACSystems exchange may indicate that the controller has its I/O disabled thus stopping the production of EGD. For a consumed exchange, status will be Healthy if no timeout has occurred for the exchange and Unhealthy if the exchange is timed out.

Length –the byte size of the data for the exchange.

Message Count –the number of samples transferred on the exchange.

Missed Count –the number of samples that were missed on the exchange. Missed samples may indicate issues with the underlying Ethernet network or overloading of the consuming device.

Refresh Errors –the number of timeouts that have occurred for a consumed exchange.

Produced Variables

Expanding the Exchanges node in the navigator pane displays the list of exchanges for the device as recorded in the EGD Configuration Server. Selecting an exchange brings up a list of variables for that exchange as shown below. This can be used to look at the details of the data for an exchange.

The screenshot shows the EGD System - EGD Management Tool interface. The left pane displays a tree view of exchanges under the 'ReferenceImplementation (172.131.1.22)' node. The right pane displays a table of 'Produced Variables' for the selected exchange.

Name	Type	Array	Access	Value Location	Health	Description
E0122_Var01	UINT	0	ReadOnly	122.0000.0	N/A	
E0122_Var02	BOOL	8	ReadOnly	122.0002.0	N/A	
E0122_Var03	REAL	0	ReadOnly	122.0004.0	N/A	
E0122_Var04	LREAL	0	ReadOnly	122.0008.0	N/A	
E0122_Var06	SINT	0	ReadOnly	122.0020.0	N/A	
E0122_Var07	ULINT	0	ReadOnly	122.0024.0	N/A	
E0122_Var08	INT	0	ReadOnly	122.0032.0	N/A	
E0122_Var09	LINT	0	ReadOnly	122.0040.0	N/A	
E0122_Var10	DINT	0	ReadOnly	122.0048.0	N/A	
E0122_Var11	USINT	0	ReadOnly	122.0052.0	N/A	
E0122_Var12	UINT	0	ReadOnly	122.0054.0	N/A	
E0122_Var13	BYTE	0	ReadOnly	122.0056.0	N/A	
E0122_Var14	UDINT	0	ReadOnly	122.0060.0	N/A	
E0122_Var15	WORD	0	ReadOnly	122.0064.0	N/A	
E0122_Var16	DT	0	ReadOnly	122.0072.0	N/A	
E0122_Var17	DWORD	0	ReadOnly	122.0080.0	N/A	
E0122_Var18	TIME	0	ReadOnly	122.0088.0	N/A	
E0122_Var19	WORD	0	ReadOnly	122.0096.0	N/A	
E0122_Var20	WORD	0	ReadOnly	122.0098.0	N/A	

The bottom status bar shows: Active Configuration Server: EGD Server Online EGD Server: 172.131.1.25 Mirror Server: C:\Program Files\GE Industrial Systems\EGD Management Tool\MirrorCache

Troubleshooting Common Ethernet Difficulties

Some common Ethernet errors are described below. Ethernet errors are generally indicated in the PLC Fault Table and the Ethernet exception log. As previously explained, PLC Faults generated by the Ethernet interface contain Ethernet exception events within the extra fault data. See the *TCP/IP Communications for PACSystems Station Manager Manual*, GFK-2225 for detailed descriptions of Ethernet exception events.

COMMREQ Fault Errors

When the PLC CPU attempts to initiate COMMREQs to the Ethernet Interface more rapidly than the Ethernet Interface can accept them, the COMMREQ delivery will fail. The fault output of the COMMREQ function block will be set and the COMMREQ will not be delivered to the Ethernet Interface. In this case, the PLC logic program should attempt to initiate the COMMREQ on another sweep after a very short delay. This condition may arise when the logic Program attempts to initiate greater than 16 COMMREQs in the same logic sweep.

Sustained heavy COMMREQ delivery from the PLC CPU to the Ethernet Interface can use a considerable portion of the Ethernet Interface's processing capability. Under heavy COMMREQ load, the Ethernet Interface may discard some received COMMREQs until it is once again able to process further COMMREQs. In such cases, the Ethernet Interface increments the "CmrqDscd" tally; this tally is available via the TALLY C Station Manager command.

Under sustained extremely heavy COMMREQ load, the Ethernet Interface may not respond to Station Manager commands and possibly some non-Programmer data communications. If this occurs, first switch the PLC CPU to STOP mode, which ceases COMMREQ delivery in order to resume normal Ethernet operation. Then modify the PLC logic application to reduce the COMMREQ traffic to a manageable level.

PLC Timeout Errors

PLC timeout errors may occur when the SRTP traffic to the Ethernet Interface exceeds the PLC's ability to process the requests, or when the PLC is unable to deliver mail to the Ethernet Interface.. PLC Timeout errors will take down an SRTP Server connection; in this case, the remote SRTP client must reestablish a new SRTP connection to the Ethernet Interface.

This error is indicated in the PLC Fault Table as:

“Backplane communication with PLC fault; lost request”
with exception Event = 8, Entry 2 = 8

These errors may also be accompanied by any of the following:

“Backplane communication with PLC fault; lost request”
with exception Event = 8, Entry 2 = 6; location = Ethernet Interface
“LAN system-software fault; resuming”
with exception Event = 8, Entry 2 = 16; location = Ethernet Interface
“Non-critical CPU software event”
status code (bytes 5-8) = 80 3a 00 12; location = CPU module

The PLC Timeout condition occurs when the CPU cannot process requests within a specified timeout period. The remedy is to reduce the rate of requests, or increase the processing capacity in the PLC.

Cause	Corrective Action
Heavy COMMREQ traffic.	Reduce the rate at which the logic application sends COMMREQs to the Ethernet Interface.
Heavy SRTP traffic.	Reduce the size, number, or frequency of SRTP requests at the remote SRTP client.
Long PLC sweep time.	Modify the PLC application to reduce the PLC sweep time.
PLC Communication Window set to LIMITED mode.	Change to RUN-TO-COMPLETION mode.

Note: The Backplane-mounted Ethernet module uses the Backplane Communications Window. The RX7i CPU-mounted Ethernet daughterboard uses the Controller Communications Window.

Application Timeout Errors

Application timeout errors include:

- SRTP Channel timeout errors (COMMREQ Status 0190H or 0290H at the client)
- EGD Command timeout errors (COMMREQ Status 0190H at the client)
- EGD consumed exchange refresh errors (Exchange Status 6 or 7).

Application timeout errors can happen for several reasons, including:

- Incorrect destination device address, or destination device not on the network. The communication service cannot be performed.
Verify that the destination device address is correct and that the destination device is functioning properly. Ping the destination device to check that it is present on the network.
- The network throughput cannot keep up with the traffic generated by the application. This condition can occur when the intervening network components between the application devices cannot handle the volume of network traffic, causing network packets to be dropped.
For SRTP, this causes TCP retransmissions; repetitive retransmissions can slow the SRTP responses enough that the client detects an application timeout error.
For EGD, this causes samples to be dropped. If the consumer misses enough samples, it detects a consumer timeout error; when that exchange subsequently receives samples, the consumer may detect a Data with Refresh error.
This condition typically arises when intermediate network routers or switches lack the buffering or processing capacity to handle the network load. Reduce the volume of traffic on the network, or identify and upgrade the network component(s) that are unable to handle the traffic volume. Consult you network administrator for assistance.
- The SRTP channel timeout and period include the time required to establish the TCP connection. It is important to consider the connection time when configuring these values. If more than one SRTP channel is being established and the PACSystems server has just been restarted or updated with a new hardware configuration, the channel timeout and period should be more than one second. This allows sufficient time for the high level of TCP traffic required to establish new network connections. When first establishing a channel, a channel timeout lower than one second may result in a 0190H (channel timeout) COMMREQ status and a channel period lower than one second may result in a 0290H (period expired error)

EGD Configuration Mismatch Errors

When using Ethernet Global Data, the produced exchange (defined at the producer) must agree with the consumed exchange (defined at the consumer). The consumer generates an error when the size of an exchange received from the network differs from the configured size for that consumed exchange.

This error is indicated in the PLC Fault Table as:

“LAN system-software fault; resuming”
with exception Event = 28, Entry 2 = 1d

As this error is generated each time the mismatched exchange is received, the Ethernet exception log can quickly fill up with mismatch error events.

<i>Cause</i>	<i>Corrective Action</i>
Producer and Consumer exchange definitions are of different size.	Review the conflicting exchange definitions at the producer and at the consumer. Change the incorrect exchange definition so that produced and consumed definitions are the same size.

If the consumer wishes to ignore certain portions of a consumed exchange, be sure that the length of the ignored portions is correct. The ignored portion is specified as a byte count.

Station Manager Lockout under Heavy Load

Sustained heavy EGD and/or SRTP Server load can utilize all processing resources within the Ethernet interface, effectively locking out the Station Manager function. The Station Manager appears inoperative under either local or remote operation. The Ethernet interface always gives higher priority to data communication functions than to the Station Manager. When the processing load is reduced, the Station Manager becomes operative once again.

This condition is not reported to the PLC Fault Table or Ethernet exception log.

PING Restrictions

To conserve network data buffer resources, the CPU process only one ICMP control message at a time. An ICMP Echo (ping) request that arrives while the CPU is processing another ICMP control message is discarded. When multiple remote hosts attempt to ping the CPU at the same time, some individual ping requests may be ignored depending upon the timing of the ping requests on the network.

The CPU may initiate ping requests to another host on the network via the “ping” Station Manager command. The ping request sequence is restricted to one remote host at a time.

Discarded ping requests are not reported to the PLC Fault Table or Ethernet exception log.

SRTP and Modbus/TCP Connection Timeout

When the Ethernet Interface is abruptly disconnected from a remote SRTP or Modbus/TCP device (for example, by disconnecting the Ethernet cable), the underlying TCP connection attempts to re-establish communication. The underlying TCP connection in the Ethernet Interface may remain open for approximately 3 minutes 30 seconds while TCP attempts to reconnect; during this interval, the SRTP or Modbus/TCP connection is unavailable. If all the SRTP or Modbus/TCP connections in the Ethernet Interface are in use or otherwise unavailable, a new SRTP or Modbus/TCP server connection must wait until the TCP reconnect time expires on an existing connection.

This underlying TCP connection timeout is normal expected behavior, and is consistent with other GE Fanuc PLC products.

Sluggish Programmer Response after Network Disruption

The network programmer attempts to use a special “privileged” SRTP server connection at the Ethernet Interface in order to establish and maintain connection even under heavy load due to EGD and other SRTP connections. The Ethernet Interface supported only one such privileged connection. Once established, no other privileged connections are permitted until the current privileged connection is terminated. This normally occurs when the network programmer disconnects from the target PLC.

As described above under “SRTP Connection Timeout”, when the programmer-PLC network connection is abruptly broken (not the orderly termination performed during disconnection), the SRTP server connection and its underlying TCP connection remain alive until the TCP connection eventually times out (about 3 minutes 30 seconds). If the programmer reconnects during this interval, it actually obtains a new, non-privileged connection. Under heavy load at the Ethernet Interface, the programmer may experience sluggish response over this non-privileged connection. If this occurs, the user can manually disconnect and reconnect the programmer after the previous connection has timed out. Upon reconnection, the programmer should once again obtain the privileged connection.

EGD Command Session Conflicts

EGD Commands support only one pending EGD command from a client device to each server device. Attempts to issue a second EGD command from a client to the same server before completion of the first command will result in an error. Some examples are:

1. The logic application issues a second EGD Command COMMREQ to the same remote server, perhaps from a different location in the logic program.
2. The EGDCMD Station Manager command issues a command to the same remote server device as the logic application.

SRTP Request Incompatibility with Existing Host Communications Toolkit Devices or Other SRTP Clients

The Advanced User Parameter (AUP) named “chct_comp” provides greater compatibility with existing Host Communication Toolkit devices. Some Host Communication Toolkit devices generate incorrectly-encoded SRTP messages. In some cases, PACSystems Ethernet interfaces detect and report SRTP encoding errors that were ignored by previous Series 90 products; these errors cause the PACSystems SRTP server to drop the SRTP connection to the Host Communications Toolkit device. If possible, the Host Communications Toolkit device should be upgraded so that it will generate properly-encoded SRTP messages. If the device cannot be upgraded, the “chct_comp” AUP parameter can be used to tell the PACSystems Ethernet interface to ignore known SRTP errors that were not detected by previous Series 90 products. (See Appendix A for details of the “chct_comp” parameter.)

COMMREQ Flooding Can Interrupt Normal Operation

The PLC logic application program should generally wait for a response from each COMMREQ function block before activating another COMMREQ function block to the same endpoint. Extremely heavy COMMREQ delivery loading, such as activating the same COMMREQ every logic sweep, can prevent normal SRTP, Modbus, EGD, and Station Manager operation. During such loading, the Ethernet LAN LED may be frozen. Under extreme COMMREQ loading, the Ethernet interface may automatically restart.

Accelerated EGD Consumption Can Interfere with EGD Production

Consumed EGD exchanges received from the network normally receive accelerated processing for increased overall EGD performance. This accelerated processing can preempt EGD production activity, possibly delaying transmission of produced exchanges to the network. Such delay varies with network loading and the volume of consumed exchanges. In applications requiring minimal produced exchange timing variability, the consumed exchange acceleration may be disabled via the “gc_accel” AUP parameter. (See appendix A for details of the “gc_accel” parameter.) Under extreme network load, accelerated processing of the incoming EGD samples may consume so much processing time that the watchdog timer for the network interface expires and the network interface is reset.

Channels Operation Depends Upon PLC Input Scanning

Communication channels operation always includes updating the Channel Status Bits (located within the Ethernet Status data) into PLC memory, which occurs when the PLC scans inputs from the Ethernet module. At least one PLC input scan must occur for each data transfer on a channel, so the channel can run no faster than the PLC scans the Ethernet Status data. When the Ethernet interface is configured to use an I/O Scan Set that runs more slowly than the PLC sweep, each channel must wait until the next time that its scan set runs to transfer its Channel Status bits. This can reduce channels performance.

If the Ethernet interface is configured to use an inactive I/O Scan Set, the Channels Status bits will not be transferred and channel operations will not complete.

Chapter Network Administration

11

This chapter discusses how devices are identified on the network and how data is routed among devices. The main topics covered are:

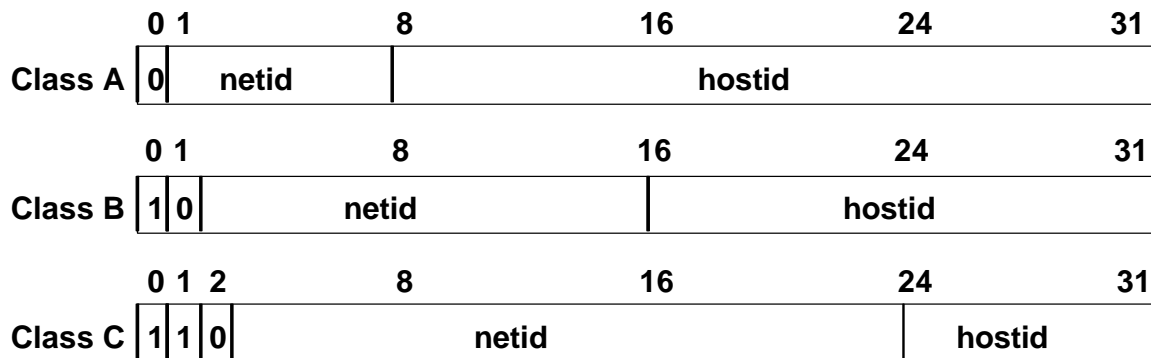
- IP Addressing
- Gateways
- Subnets and Supernets

IP Addressing

Each TCP/IP node on a network must have a unique IP address. The TCP/IP Ethernet Interface is such a node, as is a PC running TCP/IP. There may be other nodes on the network that are not involved with communications to the PLCs, but no matter what their function, each TCP/IP node must have its own IP address. It is the IP address that identifies each node on the IP network (or system of connected networks). The term “host” is often used to identify a node on a network.

IP Address Format for Network Classes A, B, C

The *IP address* is 32 bits long and has a *netid* part and a *hostid* part. Each network is a Class A, Class B or Class C network. The class of a network determines how an IP address is formatted and is based on the number of bits in the netid part of the IP address.



In general, the netid part is assigned by the Internet authorities and the hostid part is assigned by your local network administrator. The class of network determines the number of hosts that can be supported. A Class A network can support $2^{24}-2$ (16,777,214) hosts, Class B, $2^{16}-2$ (65,534) hosts, and Class C, 2^8-2 (254) hosts. The minus 2 refers to host numbers reserved for the network itself and the local broadcast.

Each node on the same physical network must have an IP address of the same class and must have the same netid. Each node on the same physical network must have a different hostid thus giving it a unique IP address.

IP addresses are written in “dotted-decimal” format as four decimal integers (0-255) separated by periods where each integer gives the value of one byte of the IP address. For example, the 32-bit IP address:

00001010 00000000 00000000 00000001

is written as

10.0.0.1

One can determine the class of an IP address by examining the first integer in its dotted-decimal IP address and comparing with the range of values in the following table.

<i>Range of first integer</i>	<i>Class</i>
0 – 126	A
127	Loopback
128 - 191	B
192 - 223	C
224-239	D (Reserved for Multicast Use)
240 - 255	E (Reserved for Experimental Use)

IP Addresses Reserved for Private Networks

RFC 1918 reserves IP addresses in the following ranges to be used for private networks.

- 10.0.0.0 – 10.255.255.255 (Class A)
- 172.16.0.0 – 172.31.255.255 (Class B)
- 192.168.0.0 – 192.168.255.255 (Class C)

Multicast IP Addresses

Multicast IP Addresses are used in multicasting, a technique that allows delivery of a single packet of data to multiple nodes on the network. Any node that joins a Multicast group will respond to the Multicast IP address assigned to that group. Subsequently, any data sent to that Multicast IP address may be received by all nodes that are members of that Multicast group. Multicast (Class D) IP addresses (224.0.0.0 through 239.255.255.255) are reserved by the Internet authorities for multicasting.

Multicasting is a feature of Ethernet Global Data. For more information on the use of multicasting in Ethernet Global Data, see chapter 4.

Loopback IP Addresses

Class A IP Addresses in the 127.xxx.xxx.xxx range are reserved for loopback addressing. A network packet using a loopback destination address is not actually transmitted on the network, but instead is processed by the same device as if it were received from the network.

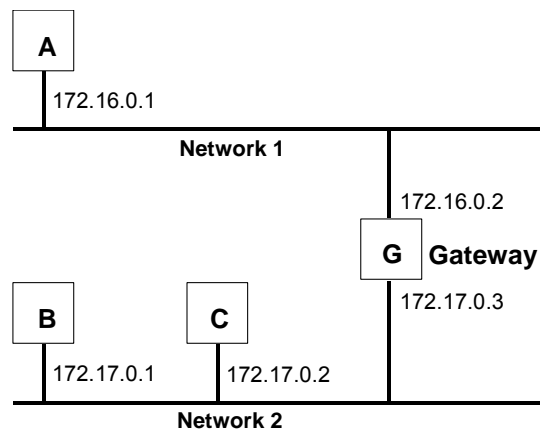
PACSystems Ethernet interfaces recognize only the IP address 127.0.0.1 as a loopback address. All other addresses in the range 127.0.0.2 – 127.255.255.255 are ignored and do not provide loopback operation.

Gateways

Gateways (also known as routers) connect individual physical networks into a system of networks. When a node needs to communicate with a node on another physical network, a gateway transfers the data between the two networks.

Networks Connected by a Gateway

The following example shows Gateway G connecting Network 1 with Network 2.



When host B with IP address 172.17.0.1 communicates with host C, it knows from C's IP address that C is on the same network. In an Ethernet environment, B can then resolve C's IP address to a MAC address (via ARP) and communicate with C directly.

When host B communicates with host A, it knows from A's IP address that A is on another network (the *netids* are different). In order to send data to A, B must have the IP address of the gateway connecting the two networks. In this example, the gateway's IP address on Network 2 is 172.17.0.3. This address would be configured in the Ethernet Interface's module configuration for PLC B as its default gateway address.

Note that the gateway has two IP addresses (172.16.0.2 and 172.17.0.3). The first must be used by hosts on Network 1 and the second must be used by hosts on Network 2. To be usable, a host's gateway must be addressed using an IP address with a *netid* matching its own.

Subnets and Supernets

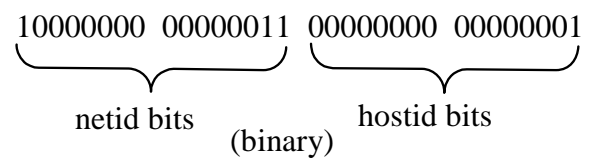
Subnets allow a site's network administrators to divide a large network into several smaller networks while still presenting the overall network as one single entity to the outside world. Each of the site's interior gateways need only maintain the subnet numbers of other interior gateways instead of every single host on the entire network.

PACSystems Ethernet interfaces support "supernetting," a technique of configuring the subnet mask to allow communication to multiple subnets. The resulting supernet is a block of contiguous subnets addressed as a single subnet.

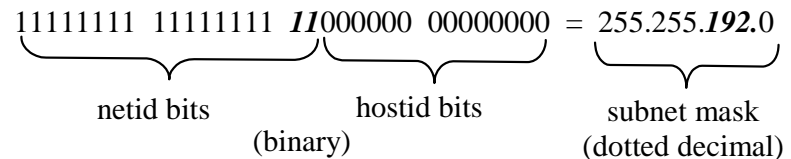
Subnet Addressing and Subnet Masks

Subnet addressing is an extension of the IP address scheme that allows a site to use a single netid for multiple physical networks. Routing outside the site continues as usual by dividing the IP address into a netid and a hostid via the class.

The standard format for the netid bits and hostid bits for an IP address in a Class B network is shown below.



Inside a site the *subnet mask* is used to re-divide the IP address into a custom netid portion and hostid portion. Consider adding another physical network to Network 2 (a Class B network) in the previous example. The result is shown in the figure below. Selecting the subnet mask shown below would add two additional *netid* bits allowing for four physical networks addressed as 0, 64, 128, and 192. The added subnet bits are normally taken from the *hostid bits* adjacent to the *netid* and the subnet mask identifies these bits.

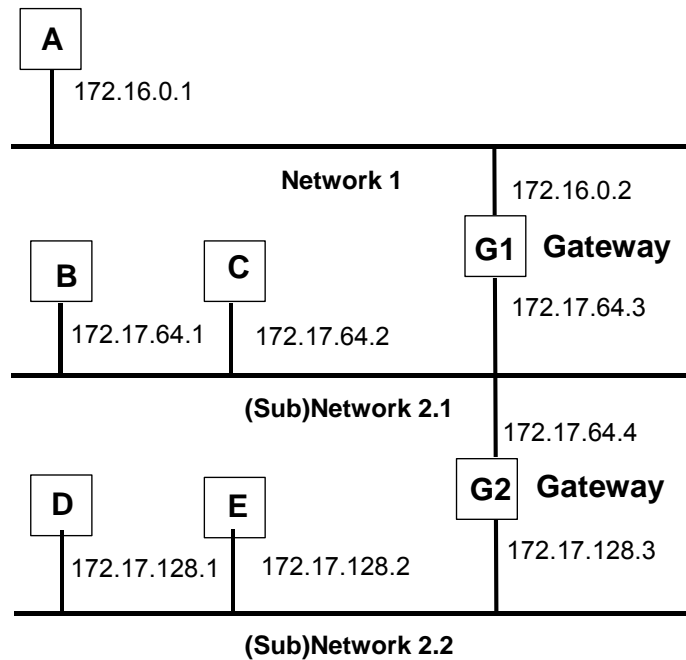


The bits in the subnet mask correspond one to one with the Internet address. The bits in the mask that are 1 treat the corresponding bits in the IP address as part of the *netid* bits. The bits in the mask that are 0 treat the corresponding bits as part of the *hostid* bits.

In effect, two bits of the Class B *hostid* have been used to extend the *netid*, creating an *extended netid*, or *subnetid*. Each unique combination of bits in the part of the *hostid* where subnet mask bits are 1 specifies a different physical network.

Example: Network Divided into Two Subnets

The new network configuration dividing Network 2 into Subnets 2.1 and 2.2 is shown below.



Here, a second network with Hosts D and E has been added. Gateway G2 connects Subnet 2.1 with Subnet 2.2. Hosts D and E will use Gateway G2 to communicate with hosts not on Network 2.2.

Hosts B and C will use Gateways G1 and G2 to communicate with hosts not on Network 2.1. When B is communicating with D, G2 (the configured Gateway for B) will route the data from B to D through Gateway G2.

Host A will use Gateway G1 to communicate with hosts not on Network 1.

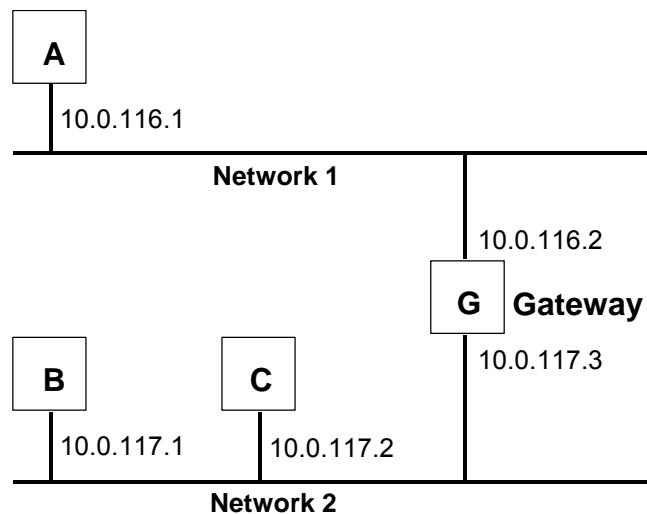
Example: Two Networks Combined into a Supernet

Supernetting is a technique used to combine two smaller networks into a larger network by extending the host portion of the subnet mask and reducing the network portion. Supernetting works only with adjacent networks that share the same network id value, such as networks 1 and 2 in this example.

As with subnets, the *subnet mask* is used to divide the IP address into a custom netid portion and hostid portion.

For example, the two networks 10.0.117.0 and 10.0.116.0 can be combined into a larger 10.0.116.0 network if the subnet mask 255.255.254.0 is applied to both addresses.

$$\begin{array}{ccccccc} 11111111 & 11111111 & 11111110 & 00000000 & = & 255.255.254.0 \\ \underbrace{\hspace{10em}} & & \underbrace{\hspace{4em}} & & & \underbrace{\hspace{4em}} \\ \text{netid bits} & & \text{hostid bits} & & & \text{subnet mask} \\ & & & & & \text{(dotted decimal)} \\ & & \text{(binary)} & & & \end{array}$$



Appendix *Configuring Advanced User Parameters*

A

Advanced User Parameters (AUPs) are internal operating parameters used by the Ethernet interface. For most applications, the default Advanced User Parameters should not be changed.

If it is necessary to modify any of these parameters, it must be done by creating an AUP file, using any ASCII text editor. This file must contain the names and values of only those parameters that are being changed. This user-generated AUP file is then imported into the programmer and assigned to a particular Ethernet Interface. To modify Advanced User Parameters in more than one Ethernet Interface in the same control system, import an AUP file for each Ethernet Interface. (If the changes are identical, you may use the same AUP file for more than one Ethernet Interface.)

When the entire hardware configuration is stored from the programmer to the CPU, the programmer also stores the parameters from all assigned AUP files. The CPU delivers any assigned AUP file data to its Ethernet Interface along with its configuration. AUP file data is transferred along with the rest of the hardware configuration during both download (programmer-to-CPU) and upload (CPU-to-programmer) operations. AUP file data is also included in the configuration Verify operation between programmer and CPU. Note that there may be a separate AUP file for each Ethernet interface (or some may have them while others do not).

If an Ethernet Interface is not configured by the programmer, its Station Manager can be used to locally modify the Advanced User Parameters for that individual module. (Setting the IP address/subnet mask via BOOTP or the "SetIP Tool" does not qualify as a programmer configuration.)

Caution

The IEEE 802.3 standard strongly discourages the manual configuration of duplex mode for a port (as would be possible using AUP.) Before manually configuring duplex mode for a port using AUP, be sure that you know the characteristics of the link partner and are aware of the consequences of your selection. In the words of the IEEE standard: "Connecting incompatible DTE/MAU combinations such as full duplex mode DTE to a half duplex MAU, or a full-duplex station (DTE or MAU) to a repeater or other half duplex network, can lead to severe network performance degradation, increased collisions, late collisions, CRC errors, and undetected data corruption."

Note: If the speed and duplex mode of a port are forced using Advanced User Parameters, the switch will no longer perform automatic cable detection. This means that if you have the switch port connected to a switch or hub port you must use a crossover cable. If you have the switch port connected to the uplink port on a switch or hub or if you have the switch port connected to another Ethernet device you must use a normal cable.

Format of the Advanced User Parameters File

The AUP file must have this format:

AUP_*r_s*

where *r* and *s* indicate the Rack and Slot location of the Ethernet Interface

<parameter name> = <parameter value>

<parameter name> = <parameter value>

<parameter name> = <parameter value>

The AUP file has the following requirements:

- The first line of the file must consist only of the text: AUP_*r_s* where *r* and *s* usually indicate the Rack and Slot location of the Ethernet Interface.

(For example, an Ethernet Module is rack 0, slot 11 would be indicated as AUP_0_11. The CPU-embedded Ethernet Interface always uses Rack 0, Slot 1.)

This was intended as a convenient way to differentiate AUP files for different modules.

Any rack and slot number will do, so that the same AUP file could be imported for use by multiple Ethernet interfaces if desired.

- All parameter names are lowercase. The equal sign (=) is required between the parameter name and parameter value.
- Spaces are allowed, but not required, between the parameter name and the equal symbol (=) and between the equal symbol and the parameter value.
- Character string values are case-sensitive; as with Station Manager commands, uppercase parameter values must be enclosed within a pair of double quotes.
- Numeric parameters are entered in decimal or hexadecimal format; hexadecimal values must be terminated with an 'h' or 'H' character.
- IP addressing parameters must be entered in standard dotted decimal format.
- Comments in the file must start with a semicolon character. All characters in the same line following a semicolon are ignored.
- Blank lines are ignored.
- The maximum line length in the AUP file is 80 characters. Any line, including comments, that exceeds this length will cause errors in processing.

Example:

The following example sets the station manager password to “system” and the IP time-to-live for point-to-point Ethernet Global Data exchanges to 4.

AUP_0_1

stpasswd = “system” ; set the password to “system”

gucast_ttl=4 ; set the EGD unicast IP TTL to 4

Advanced User Parameter Definitions

The following Advanced User Parameters can be configured for the Ethernet interface.

System Memory Parameters (task b)		Default	Range
staudp	Remote command UDP port	18245 (4745H)	1 – 65535 (ffffH)
stpasswd	Station Manager password (only visible from MODIFY prompt)	“system”	0 – 8 characters, case sensitive, no spaces
Backplane Driver Parameters (task c)		Default	Range
crsp_tout	CPU response timeout. Amount of time to wait for the CPU to respond to a request sent through the PLC Driver.	60 seconds	10 – 3600 (E10H)
chct_comp	HCT compatibility option. (Rel 2.57 and later) Allows Ethernet interface to ignore SRTP header errors (typically generated by remote HCT devices) that were not detected in previous Series 90 products. 0 = HCT compatibility disabled (= report all errors) 1 = HCT compatibility enabled (= ignore some errors)	0 (0H)	0, 1
RDS Parameters (task d)		None	None
ARP Parameters (task f)		Default	Range
fflush	Interval in seconds at which to flush the ARP cache	600 (10 minutes)	0 – 604800 (93A80H)
Ethernet Global Data Parameters (task g)		Default	Range
gctl_port	UDP port for EGD control messages	7937 (1f01H)	1 – 65535 (ffffH)
gdata_port	UDP port for point-to-point (unicast) EGD messages	18246 (4746H)	1 – 65535 (ffffH)
gbcast_ttl	IP time-to-live for global broadcast messages (hop count)	1 (1H)	0 – 255 (00ffH)
gucast_ttl	IP time-to-live for point-to-point (unicast) messages (hop count)	16 (10H)	0 – 255 (00ffH)
gp_phase	Startup delay time in ms for successive produced exchanges	0 (0H)	0 – 65535 (ffffH)
gcmd_pri	EGD command processing priority relative to data production. 0 = EGD commands have lower priority. 1 = EGD commands have equal priority. 2 = EGD commands have higher priority.	0 (0H)	0, 1, 2
gc_accel	Enable consumed exchange acceleration. 0= Acceleration disabled; 1= Acceleration enabled.	1 (1H)	0, 1
gnostale	When bit zero in the “Production Status” field of the PDU of a consumed sample is set, sample is stale. 0 = allow status to be sent to the application when exchange status indicates stale data. 1 = prevent the new status from being sent to the application if exchange status indicates stale data.	0 (0H)	0, 1

<i>EGD provides a UDP port parameter and host group IP address parameter for each of 32 possible host groups (0-31). The parameter formats for each host group are shown below. XX specifies host group 0-31.</i>			
gXX_udp	UDP port for host group XX	18246 (4746H)	1 – 65535 (ffffH)
gXX_addr	IP time-to-live for host group XX (must be Class D address)	224.0.7.XX	224.0.0.2 – 239.255.255.255
gXX_ttl	IP time-to-live for host group (multicast) messages (hop count)	1 (1H)	0 – 255 (00ffH)
SRTP Client (Channels) Parameters (task h)		Default	Range
hconn_tout	TCP Connect timeout (in milliseconds)	75000 (124F8H)	10 – 75000 (124F8H)
IP Parameters (task i)		Default	Range
ittl	IP header default time-to-live (hop count)	64 (0040H)	0 – 255 (00ffH)
ifrag_tmr	IP fragment timeout interval in seconds	3 (0003H)	0 – 65535 (ffffH)
ICMP/IGMP Parameters (task j)		None	None
Network Interface Parameters (task l)		Default	Range
Iduplex0	Ethernet duplex for Controller (0=auto-detect, 1 = half, 2= full)	0	0,1,2
Iduplex1a	Ethernet duplex for Port 1A (0=auto-detect, 1=half, 2=full)	0	0,1,2
Iduplex1b	Ethernet duplex for Port 1B (0=auto-detect, 1=half, 2=full)	0	0,1,2
Ispeed0	Ethernet speed for Controller (0=auto-detect, 1=10Mbit, 2=100Mbit)	0	0,1,2
Ispeed1a	Ethernet speed for Port 1A (0=auto-detect, 1=10Mbit, 2=100Mbit)	0	0,1,2
Ispeed1b	Ethernet speed for Port 1B (0=auto-detect, 1=10Mbit, 2=100Mbit)	0	0,1,2
Modbus TCP/IP Server Parameters (task m)		None	None
SNTP Time Transfer to CPU Parameters (task n)		Default	Range
ncpu_sync	Configures this Ethernet interface to support CPU TOD clock synchronization with network timeserver. (0=Not supported; 1=Supported)	0	0, 1
Modbus TCP/IP Client Parameters (task o)		None	None

Ethernet Redundancy Parameters (task q)		Default	Range
rdipckival	Interval between additional checks for Redundant IP in use (in milliseconds)	100 (0064H)	1 – 1000ms
rdiparpivl	Interval between gratuitous ARP requests sent by the backup unit on behalf of the new active unit (in ms).	100 (0064H)	1 – 1000ms
rdipnumarp	Number of gratuitous ARP requests to send out during Redundant IP activation process.	1 (0001H)	1 - 25
rdiparplog	Number of gratuitous ARP requests to send by backup unit before a “Redundant IP not available” exception is logged. (The backup unit continues to send ARP requests as long as it receives network packets addressed to the Redundant IP Address.)	5 (0005H)	1 – 25
FTP Parameters (task t)		Default	Range
tpassword	Password for login for FTP access.	“system”	0 to 8 characters
UDP Parameters (task u)		None	None
SRTP Parameters (task v)		None	None
TCP Parameters (task w)		Default	Range
wndelay	TCP nodelay option (0= inactive; 1 = active)	1 (1H)	0, 1
wkal_idle	TCP keepalive timer value (in seconds)	240 (4.0 min)	0 – 65535 (ffffH)
wkal_cnt	TCP keepalive extra probe count (in addition to single probe always performed)	2	0 – 65535 (ffffH)
wkal_intvl	TCP keepalive probe interval (in seconds)	60 seconds	0 – 65535 (ffffH)
wsnd_buf	TCP send buffer size (in bytes)	65535 (ffffH)	0 – 65535 (ffffH)
wrcv_buf	TCP receive buffer size (in bytes)	4096 (1000H)	0 – 32767 (7fffH)

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GE
Intelligent Platforms
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RX7i & RX3i CPU

Reference Manual

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Chapter 1 Introduction

This manual contains general information about PACSystems CPU operation and program content. It also provides detailed descriptions of specific programming requirements.

Chapter 1 provides a **general introduction** to the PACSystems family of products, including new features, product overviews, and a list of related documentation.

CPU hardware features and specifications are provided in Chapter 2.

Installation procedures are described in the *PACSystems RX7i Installation Manual*, GFK-2223 and the *PACSystems RX3i System Manual*, GFK-2314.

CPU Configuration is described in Chapter 3. Configuration using the programming software determines characteristics of module operation and establishes the program references used by each module in the system. For details on configuration of the embedded RX7i Ethernet interface as well as the rack-based RX7i and RX3i Ethernet Interface modules, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224.

CPU Operation is described in Chapter 4.

Programming Features are described in Chapter 5 through Chapter 9 and in Appendix A.

- Elements of an Application Program: Chapter 5
- Program Data: Chapter 6
- Ladder Diagram (LD) instruction set reference: Chapter 7
- Function Block Diagram (FBD) instruction set reference: Chapter 8
- The Service Request Function: Chapter 9
- The PID Function: Chapter 10
- Structured Text (ST): Chapter 11

Ethernet and Serial Communications are described in Chapter 12.

Serial I/O, SNP, and RTU Protocols are described in Chapter 13.

Diagnostics, including Fault Handling and Diagnostic Logic Blocks are described in Chapter 14.

Instruction Timing is provided in Appendix A.

User Memory Allocation is described in Appendix B.

1.1. Revisions in this Manual

Note: A given feature may not be implemented on all PACSystems CPUs. To determine whether a feature is available on a given CPU model and firmware version, please refer to the *Important Product Information (IPI)* document provided for the CPU version that you are using.

Rev	Date	Description
T	Oct-14	<ul style="list-style-type: none"> ▪ Support for OPC UA using embedded Ethernet port in CPE305/CPE310 with CPU firmware 8.20. ▪ Support for Ethernet Global Data (EGD Class 1) using embedded Ethernet port in CPE305/CPE310 with CPU firmware 8.30. Corresponding impact on sweep times. Direct replacement for S90-30 IC693CPU374. ▪ New communications capabilities provided by: <ul style="list-style-type: none"> ○ IC695PNS001 – PROFINET Scanner Module ○ IC695GCG001 – Genius Communications Gateway via PROFINET ○ IC695EDS001 – Ethernet based DNP3 Outstation
S	July-13	<ul style="list-style-type: none"> ▪ Support for Modbus/TCP Server, SRTP channels and Modbus/TCP client channels on RX3i CPE305/CPE310 embedded Ethernet interface – Chapter 2 & Chapter 12 ▪ Support for Access Control List – Chapter 3 and Chapter 14 ▪ Modbus TCP/IP mapping for CPE305/CPE310 – Chapter 3 ▪ Enhanced Security Passwords and OEM Protection – Chapter 4 ▪ Serial I/O protocol enhancements (Data Set Ready, Ring Indicator, and Data Carrier Detect) – Chapter 13 ▪ Diagnostics for PROFINET alarms and PROFINET network faults, including #PNIO_ALARM, SA0030 – Chapter 6 and Chapter 14 ▪ Instruction executions times measured for RX3i CPU320/CRU320 – Appendix A ▪ Sweep impact times for new modules: IC694MDL758, IC694APU300-CA and later, IC695PNS001, IC694ALG442, IC694ALG220, IC694MDL645 and IC694MDL740 – Appendix A
earlier		<ul style="list-style-type: none"> ▪ Added instructions for replacing the RX3i CPE305/CPE310 real-time clock battery: Chapter 2 ▪ Corrected definitions of <i>reverse acting</i> and <i>direct acting modes</i> for PID functions – Chapter 10 ▪ Expanded data for Boolean execution measurements – Appendix A ▪ Re-instated instruction times for RX7i CPE/CRE030/040 release 6.0 as published in version Q of the manual (unintentionally omitted from version R) – Appendix A ▪ Compatibility information for volatile memory backup batteries has been consolidated in the <i>PACSystems Battery and Energy Pack Manual</i> – throughout

1.2. PACSystems Control System Overview

The PACSystems controller environment combines performance, productivity, openness and flexibility. The PACSystems control system integrates advanced technology with existing systems. The result is seamless migration that protects your investment in I/O and application development.

1.2.1 Programming and Configuration

Proficy* Machine Edition programming software provides a universal engineering development environment for all programming, configuration and diagnostics of PACSystems. A PACSystems CPU is programmed and configured using the programming software to perform process and discrete automation for various applications. The CPU communicates with I/O and smart option modules through a rack-mounted backplane. It communicates with the programmer and/or HMI devices via the Ethernet ports or via the serial ports 1 and 2 using Serial I/O, or Modbus RTU slave protocols.

1.2.2 Process Systems

PACSystems CPUs with firmware version 5.0 and later support Proficy Process Systems (PPS). PPS is a complete, tightly integrated, seamless process control system using PACSystems, Proficy HMI/SCADA, and Proficy Production Management Software to provide control, optimization, and performance management to manage and monitor batch or continuous manufacturing. It delivers the tools required to design, implement, document, and maintain an automated process. For information about purchasing PPS software, refer to the Support website.

1.2.3 PACSystems CPU Models

Family	Catalog Number	Description
RX3i CPUs	IC695CPU310	300MHz Celeron CPU, 10 MB user memory
	IC695CPU315	1 GHz Celeron-M CPU, 20 MB user memory
	IC695CPU320	1 GHz Celeron-M CPU, 64 MB user memory
	IC695NIU001+ versions –AAAA and later	1.1 GHz Atom 510 NIU. For information, see the <i>RX3i Ethernet NIU User's Manual</i> , GFK-2439
	IC695NIU001	300MHz Celeron NIU. For information, see the <i>PACSystems RX3i Ethernet NIU User's Manual</i> , GFK-2439
RX3i CPUs with embedded Ethernet Interface ¹	IC695CPE305	1.1GHz Atom CPU, 5 MB user memory
	IC695CPE310	1.1GHz Atom CPU, 10 MB user memory
RX3i Redundancy CPU	IC695CRU320	1 GHz Celeron-M CPU, 64 MB user memory
RX7i CPUs with embedded Ethernet Interface	IC698CPE010	300MHz, Celeron CPU, 10MB user memory
	IC698CPE020	700MHz, Pentium CPU, 10 MB user memory,
	IC698CPE030	600MHz, Pentium-M CPU, 64MB user memory
	IC698CPE040	1800MHz, Pentium-M CPU, 64MB user memory
RX7i Redundancy CPUs with embedded Ethernet Interface	IC698CRE020	700MHz, Pentium CPU, 10 MB user memory
	IC698CRE030	600MHz, Pentium-M CPU, 64MB user memory
	IC698CRE040	1800MHz, Pentium-M CPU, 64MB user memory

¹ The RX3i CPE305/CPE310 embedded Ethernet interface provides a maximum of two programmer connections. It does not support the full set of Ethernet interface features described in this manual. For a summary of RX3i embedded Ethernet interface features, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224K or later.

1.3. Common CPU Features

PACSystems CPU models have the following features in common:

- Programming in Ladder Diagram, Function Block Diagram, Structured Text and C.
- Floating point (real) data functions.
- Configurable data and program memory.
- CPE305 and CPE310 have battery-less retention of user memory non-volatile flash. All other models have battery-backed RAM for user data (program, configuration, register data, and symbolic variable) storage and clocks.
- CPE305 and CPE310 models have battery backup for real time clock (elapsed time clock).
- Non-volatile built-in flash memory for user data (program, configuration, register data, and symbolic variable) storage. Use of this flash memory is optional.
- Configurable Run/Stop mode switch.
- Embedded RS-232 and RS-485 communications. (CPE305 has only RS-232 communications).
- Up to 512 program blocks. Maximum size for a block is 128KB.
- Auto Located Symbolic Variables, which allows you to create a variable without specifying a reference address.
- Bulk memory area accessed via reference table %W. The upper limit of this memory area can be configured to the maximum available user RAM.
- Larger reference table sizes, compared to Series 90* CPUs: 32Kbits for discrete %I and %Q and up to 32K words each for analog %AI and %AQ.
- Online Editing mode that allows you to easily test modifications to a running program. (For details on using this feature, refer to the programming software online help and *Proficy Logic Developer Getting Started*, GFK-1918.)
- Bit in word referencing that allows you to specify individual bits in a WORD reference in retentive memory as inputs and outputs of Boolean expressions, function blocks, and calls that accept bit parameters.
- In-system upgradeable firmware.

1.3.1 Firmware Storage in Flash Memory

The CPU uses non-volatile flash memory for storing the operating system firmware. This allows firmware to be updated without disassembling the module or replacing EPROMs. The operating system firmware is updated by connecting to the CPU with a PC compatible computer and running the software included with the firmware upgrade kit.

1.3.2 Operation, Protection, and Module Status

Operation of the CPU can be controlled by the three-position Run/Stop switch or remotely by an attached programmer and programming software. Program and configuration data can be locked through software passwords. The status of the CPU is indicated by the CPU LEDs on the front of the module. For details, see "Indicators" for each PACSystems family.

Note: The RESET pushbutton is provided to support future features and has no effect on CPU operation in the current version.

1.3.3 Ethernet Global Data

Note: Effective with RX3i CPE310/CPE305 Firmware Release 8.30, the CPU itself also supports EGD Class 1². Prior to that firmware release, EGD was only available in the RX3i via the RX3i Ethernet Interface Module (ETM001).

Each PACSystems CPU supports up to 255 simultaneous EGD pages across all Ethernet interfaces in the Controller. EGD pages must be configured in the programming software and stored into the CPU. The EGD configuration can also be loaded from the CPU into the programming software. Both produced and consumed pages can be configured. PACSystems CPUs support the use of only part of a consumed EGD page, and EGD page production and consumption to the broadcast IP address of the local subnet.

The PACSystems CPU supports 2ms EGD page production and timeout resolution. EGD pages can be configured for a production period of 0, indicating the page is to be produced every output scan. The minimum period for these “as fast as possible” pages is 2ms.

During EGD configuration, PACSystems Ethernet interfaces are identified by their Rack/Slot location.

1.3.4 OPC UA

Each PACSystems CPE305/CPE310 supports Open Productivity and Connectivity Unified Architecture (OPC UA) Server communications on the embedded Ethernet port only.

For more information on OPC UA support see GFK-2224 version M or higher (Chapter 10).

Note: Effective with CPE310/CPE305 Firmware Release 8.20, the CPE embedded Ethernet port supports OPC UA Server.

² Proficy Machine Edition Release 8.50 SIM 6 is required for EGD Class 1 on CPE305/CPE310.

1.4. RX3i Overview

The RX3i control system hardware consists of an RX3i universal backplane and up to seven Series 90-30 expansion or remote racks. The CPU can be in any slot in the universal backplane except the last slot, which is reserved for the serial bus transmitter, IC695LRE001.

The RX3i supports user defined Function Blocks (LD logic only) and Structured Text programming.

The RX3i universal backplane uses a dual bus that provides both:

- High-speed PCI for fast throughput of new advanced I/O.
- Serial backplane for easy migration of existing Series 90-30 I/O

The RX3i universal backplane and Series 90-30 expansion/remote racks support the Series 90-30 Genius Bus Controller and Motion Control modules, and most Series 90-30/RX3i discrete and analog I/O with catalog prefixes IC693 and IC694. RX3i modules with catalog prefixes IC695, including the Ethernet and other communications modules can only be installed in the universal backplane. See the *PACSystems RX3i System Manual*, GFK-2314 for a list of supported modules.

RX3i supports hot standby (HSB) CPU redundancy, which allows a critical application or process to continue operating if a failure occurs in any single component. A CPU redundancy system consists of an active unit that actively controls the process and a backup unit that is synchronized with the active unit and can take over the process if it becomes necessary. Each unit must have a redundancy CPU, (IC695CRU320). The redundancy communication path is provided by IC695RMX128 Redundancy Memory Xchange (RMX) modules set up as redundancy links. For details on the operation of PACSystems redundancy systems, refer to the *PACSystems Hot Standby CPU Redundancy User's Guide*, GFK-2308.

RX3i communications features include:

- Open communications support includes Ethernet, PROFIBUS, PROFINET, Modbus TCP, Ethernet Global Data (EGD), DNP3 and serial protocols.
- The CPE305 and CPE310 CPUs provide an embedded Ethernet interface which is used to connect up the programmer (Proficy Machine Edition).
- Effective with RX3i CPE310/CPE305 Firmware Release 7.30, the embedded Ethernet port on the CPU provided support for Service Request Transfer Protocol (SRTP) channels and for Modbus TCP.
- Effective with CPE310/CPE305 Firmware Release 8.20, the CPE embedded Ethernet port supports OPC UA Server. See GFK-2224 version M or higher (Chapter 10).
- Effective with RX3i CPE310/CPE305 Firmware Release 8.30, the CPU itself also supports Ethernet Global Data (EGD)². Prior to that firmware release, EGD was only available in the RX3i via the RX3i Ethernet Interface Module (ETM001). With this upgrade, these CPUs are positioned as a direct replacement for S90-30 IC693CPU374.
- The rack-based ETM001 Ethernet Interface has dual RJ-45 ports connected through an auto-sensing switch. This eliminates the need for rack-to-rack switches or hubs. The ETM001 supports upload, download and online monitoring, and provides 32 SRTP channels with a maximum of 48 simultaneous SRTP server connections. It also supports Modbus TCP. For details on Ethernet Interface capabilities, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224.
- PROFIBUS communications via the PROFIBUS Master module. For details, refer to the *PACSystems RX3i PROFIBUS Modules User's Manual*, GFK-2301.
- PROFINET communications via the PROFINET Controller module IC695PNC001 and PROFINET Scanner module IC695PNS001. For details, refer to the *PACSystems RX3i PROFINET Controller Manual*, GFK-2571 and *PACSystems RX3i PROFINET Scanner Manual*, GFK-2737.

- Effective with the release of IC695GCG001, the RX3i may be equipped to control a Genius Bus via a PROFINET Interface. See *Genius Communications Gateway User's Manual* GFK-2892.
- Effective with the release of IC695EDS001, the RX3i may be configured as a DNP3 Outstation. See *DNP3 Outstation User's Manual* GFK-2911.
- IC695CMM002 and IC695CMM004 expand the serial communications capability of the RX3i system. See *RX3i Serial Communications Modules User's Manual*, GFK-2460.
- CPE310, CPU310, CPU315, CPU/CRU320 and NIU001 provide two serial ports, one RS-232 and one RS-485.
- CPE305 provides one RS-232 serial port.

1.5. RX7i Overview

The RX7i control system hardware consists of an RX7i rack and up to seven Series 90-70 expansion racks. The CPU resides in slot 1 of the main rack. RX7i racks use a VME64 backplane that provides up to four times the bandwidth of existing VME based systems, including the current Series 90-70 systems for faster I/O throughput. The VME64 base supports all standard VME modules including Series 90-70 I/O and VMIC modules.

Expansion racks support Series 90-70 discrete and analog I/O, the Genius Bus Controller, and the High Speed Counter. The CPU provides an embedded auto-sensing 10/100 Mbps half/full duplex Ethernet interface.

RX7i supports hot standby (HSB) CPU redundancy, which allows a critical application or process to continue operating if a failure occurs in any single component. A CPU redundancy system consists of an active unit that actively controls the process and a backup unit that is synchronized with the active unit and can take over the process if it becomes necessary. Each unit must have a redundancy CPU, (IC698CRE020, CRE030 or CRE040). The redundancy communication path is provided by IC698RMX016 Redundancy Memory Xchange (RMX) modules set up as redundancy links. For details on the operation of PACSystems redundancy systems, refer to the *PACSystems Hot Standby CPU Redundancy User's Guide*, GFK-2308.

Note: Extended operation with dissimilar CPU types is *not allowed*. During normal operation, the primary and secondary units in an HSB redundancy system must have the same CPU model type.

The primary and secondary units of an HSB redundancy system can have dissimilar model types for a limited time, for the purpose of system upgrade only. Fail wait times for the higher performance CPU in a dissimilar redundant pair may need to be increased to allow synchronization.

RX7i communications features include:

- Open communications support includes Ethernet, Genius, and serial protocols.
- A built-in 10/100mb Ethernet interface that has dual RJ-45 ports connected through an auto-sensing switch for upload, download and online monitoring. This eliminates the need for rack-to-rack switches or hubs. The CPU Ethernet Interface provides basic remote control system monitoring from a web browser and allows a combined total of up to 16 web server and FTP connections. For details on Ethernet Interface capabilities, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224.
- Two serial ports, one RS-232 and one RS-485.
- An RS-232 isolated Ethernet station manager serial port.

1.6. Migrating Series 90 Applications to PACSystems

The PACSystems control system provides cost-effective expansion of existing systems. Support for existing Series 90 modules, expansion racks and remote racks protects your hardware investment. You can upgrade on your timetable without disturbing panel wiring.

- The RX3i supports most Series 90-30 modules, expansion racks, and remote racks. For a list of supported I/O, Communications, Motion, and Intelligent modules, see the *PACSystems RX3i System Manual*, GFK-2314.
- The RX7i supports most existing Series 90-70 modules, expansion racks and Genius networks. For a list of supported I/O, Communications, and Intelligent modules, see the *PACSystems RX7i Installation Manual*, GFK-2223.
- Conversion of Series 90-70 and Series 90-30 programs preserves existing development effort.
- Conversion of VersaPro and Logicmaster applications to Machine Edition allows smooth transition to PACSystems.

1.7. PACSystems Documentation

PACSystems Manuals

PACSystems CPU Reference Manual, GFK-2222
TCP/IP Ethernet Communications for PACSystems, GFK-2224
Station Manager for PACSystems, GFK-2225
PACSystems C Toolkit User's Guide, GFK-2259
PACSystems Memory Xchange Modules User's Manual, GFK-2300
PACSystems Hot Standby CPU Redundancy User's Manual, GFK-2308
PACSystems Battery and Energy Pack Manual, GFK-2741
Proficy Machine Edition Logic Developer Getting Started, GFK-1918
Proficy Process Systems Getting Started Guide, GFK-2487

RX3i Manuals

PACSystems RX3i System Manual, GFK-2314
DSM324i Motion Controller for PACSystems RX3i and Series 90-30, GFK-2347
PACSystems RX3i PROFIBUS Modules User's Manual, GFK-2301
PACSystems RX3i MAXON Software User's Manual, GFK-2409
PACSystems RX3i Ethernet NIU User's Manual, GFK-2439
PACMotion Multi-Axis Motion Controller User's Manual, GFK-2448
PACSystems RX3i PROFINET Controller Manual, GFK-2571
PACSystems RX3i PROFINET Scanner Manual, GFK-2737
PACSystems RX3i Serial Communications Modules User's Manual, GFK-2460
PACSystems RX3i Genius Communications Gateway User's Manual, GFK-2892
PACSystems RX3i DNP3 Outstation User's Manual, GFK-2911

RX7i Manuals

PACSystems RX7i Hardware and Installation Manual, GFK-2223
PACSystems RX7i User's Guide to Integration of VME Modules, GFK-2235
Genius Bus Controller User's Manual, GFK-2017

Series 90 Manuals

Series 90-30 Genius Bus Controller, GFK-1034

Distributed I/O Systems Manuals

Genius I/O System User's Manual, GEK-90486-1
Genius I/O Analog and Discrete Blocks User's Manual, GEK-90486-2

In addition to these manuals, datasheets and product update documents describe individual modules and product revisions. The most recent PACSystems documentation is available on the Support website.

Chapter 2 CPU Features & Specifications

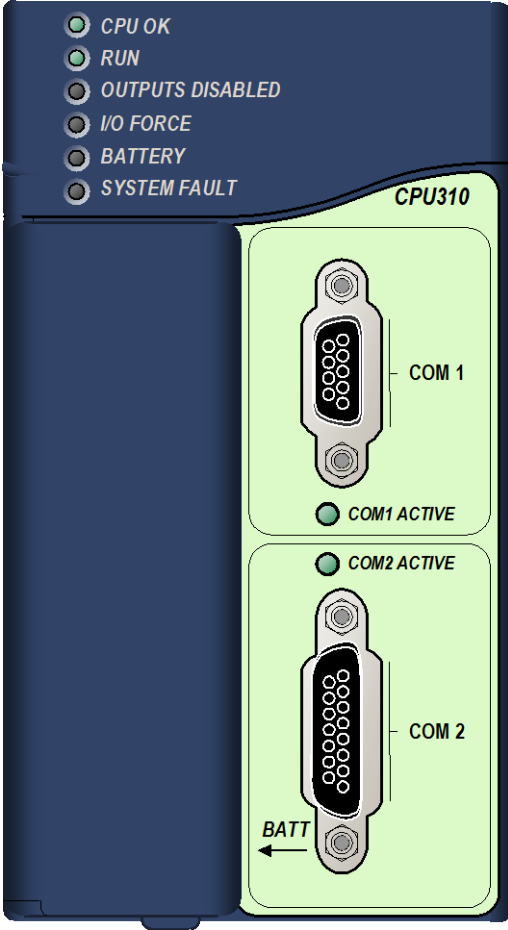
This chapter provides details on the hardware features of the PACSystems CPUs and their specifications.

- RX3i Features and Specifications page 14
- RX7i Features and Specifications page 36

2.1. RX3i Features and Specifications

2.1.1 CPU310

IC695CPU310: 300 MHz CPU microprocessor



Serial Ports

The CPU has two independent, on-board serial ports, accessed by connectors on the front of the module. Ports 1 and 2 provide serial interfaces to external devices. Either port can be used for firmware upgrades. For serial port pin assignments and details on serial communications, refer to Chapter 12.

CPU310 Indicators

The eight CPU LEDs indicate the operating status of various CPU functions.

LED State ● On ✚ Blinking ○ Off			CPU Operating State
●	CPU OK	On	CPU has passed its power-up diagnostics and is functioning properly. ³
○	CPU OK	Off	CPU problem. RUN and OUTPUTS ENABLED LEDs may be blinking in an error code pattern, which can be used by technical support for troubleshooting. This condition and any error codes should be reported to your technical support representative.
✚	CPU OK, OUTPUTS ENABLED, RUN	Blinking in unison	CPU is in boot mode and is waiting for a firmware update through a serial port.
✚	CPU OK	Blinking Other LEDs off.	CPU in Stop/Halt state; possible watchdog timer fault. Refer to the fault tables. If the programmer cannot connect, cycle power with battery attached and refer to fault tables.
●	RUN	On	CPU is in Run mode.
○	RUN	Off	CPU is in Stop mode.
●	OUTPUTS ENABLED	On	Output scan is enabled.
○	OUTPUTS ENABLED	Off	Output scan is disabled.
●	I/O FORCE	On	Override is active on a bit reference.
○	BATTERY	Off	Normal battery ⁴
✚	BATTERY	Blinking	Battery low
●	BATTERY	On	Battery has failed or is not attached
●	SYSTEM FAULT	On	CPU is in Stop/Faulted mode because a fatal fault has occurred.
✚	COM1 COM2	Blinking Blinking	Signal activity on port.

³ After initialization sequence is complete.

⁴ Low battery detection requires a smart battery. For details, refer to *PACSystems Battery and Energy Pack Manual*, GFK-2741.

Specifications – CPU310

For environmental specifications, see Appendix A of the *PACSystems RX3i System Manual*, GFK-2314.

Program storage	Up to 10 Mbytes of battery-backed RAM ⁵ 10Mbyte of non-volatile flash user memory
Power requirements	+3.3 VDC: 1.25 Amps nominal +5 VDC: 1.0 Amps nominal
Operating Temperature	0 to 60°C (32°F to 140°F)
Floating point	Yes
Time of Day Clock accuracy	Maximum drift of ±2 seconds per day. Can be synchronized to an Ethernet time master within ±2ms of the SNTP time-stamp.
Elapsed Time Clock (internal timing) accuracy	±0.01% maximum
Embedded communications	RS-232, RS-485
Serial Protocols supported	Modbus RTU Slave, SNP Slave, Serial I/O
Backplane	Dual backplane bus support: RX3i PCI and 90-30-style serial
PCI compatibility	System designed to be electrically compliant with PCI 2.2 standard
Program blocks	Up to 512 program blocks. Maximum size for a block is 128KB.
Flash memory endurance rating	100,000 write/erase cycles minimum
Memory (For a detailed listing of memory areas, refer to Chapter 6.)	<i>%I and %Q</i> : 32Kbits for discrete <i>%AI and %AQ</i> : configurable up to 32Kwords <i>%W</i> : configurable up to the maximum available user RAM Managed memory (<i>Symbolic and I/O variables combined</i>): configurable up to 10 Mbytes

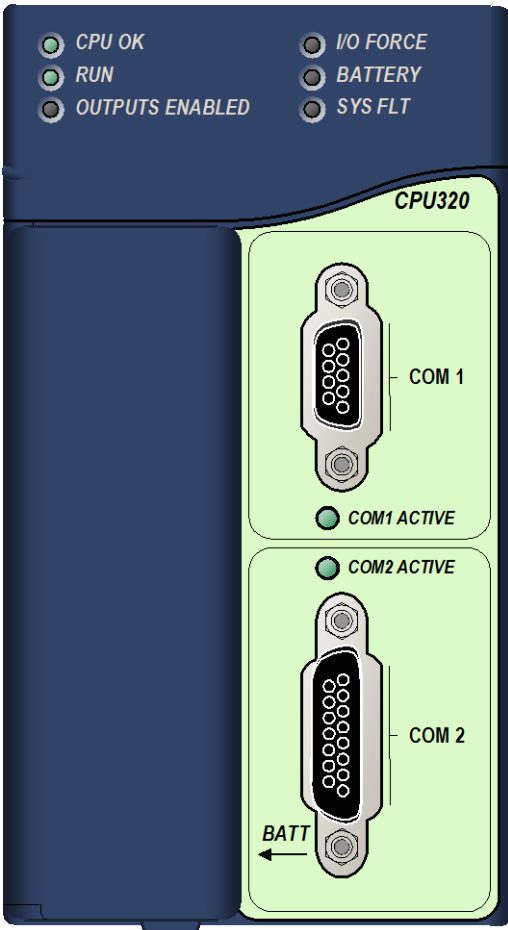
⁵ For estimated battery life under various conditions, refer to the *PACSystems Battery and Energy Pack Manual*, GFK-2741.

2.1.2 CPU315 and CPU320/CRU320

IC695CPU315: 1 GHz CPU microprocessor

IC695CPU320: 1 GHz CPU microprocessor

IC695CRU320: 1 GHz CPU microprocessor with redundancy



Serial Ports

The CPU has two independent, on-board serial ports, accessed by connectors on the front of the module. Ports 1 and 2 provide serial interfaces to external devices. Either port can be used for firmware upgrades. For serial port pin assignments and details on serial communications, refer to Chapter 12.

CPU315, CPU320 and CRU320 Indicators

The eight CPU LEDs indicate the operating status of various CPU functions.

LED State ● On ✚ Blinking ○ Off			CPU Operating State
●	CPU OK	On	CPU has passed its power-up diagnostics and is functioning properly. ⁶
○	CPU OK	Off	CPU problem. RUN and OUTPUTS ENABLED LEDs may be blinking in an error code pattern, which can be used by technical support for troubleshooting. This condition and any error codes should be reported to your technical support representative.
✚	CPU OK, OUTPUTS ENABLED, RUN unison	Blinking in unison	CPU is in boot mode and is waiting for a firmware update through a serial port.
✚	CPU OK	Blinking Other LEDs off.	CPU in Stop/Halt state; possible watchdog timer fault. Refer to the fault tables. If the programmer cannot connect, cycle power with battery attached and refer to fault tables.
●	RUN	On	CPU is in Run mode.
○	RUN	Off	CPU is in Stop mode.
●	OUTPUTS ENABLED	On	Output scan is enabled.
○	OUTPUTS ENABLED	Off	Output scan is disabled.
●	I/O FORCE	On	Override is active on a bit reference.
○	BATTERY	Off	Normal battery ⁷
✚	BATTERY	Blinking	Battery low
●	BATTERY	On	Battery has failed or is not attached ³
●	SYSTEM FAULT	On	CPU is in Stop/Faulted mode because a fatal fault has occurred.
✚	COM1 COM2	Blinking Blinking	Signal activity on port.

⁶ After initialization sequence is complete.

⁷ Low battery detection requires hardware revision -Fx or later and a smart battery. For details, refer to the *PACSystems Battery and Energy Pack Manual*, GFK-2741.

Specifications – CPU315 and CPU320

For environmental specifications, see Appendix A of the *PACSystems RX3i System Manual*, GFK-2314.

Program storage	
CPU315	Up to 20MB of battery-backed RAM 20MB of non-volatile flash user memory
CPU320	Up to 64 MB of battery-backed RAM† 64 MB of non-volatile flash user memory
Power requirements	+3.3 VDC: 1.0 Amps nominal +5 VDC: 1.2 Amps nominal
Operating Temperature	0 to 60°C (32°F to 140°F)
Floating point	Yes
Time of Day Clock accuracy	Maximum drift of ±2 seconds per day. Can be synchronized to an Ethernet time master within ±2ms of the SNTP time-stamp.
Elapsed Time Clock (internal timing) accuracy	±0.01% maximum
Embedded communications	RS-232, RS-485
Serial Protocols supported	Modbus RTU Slave, SNP Slave, Serial I/O
Backplane	Dual backplane bus support: RX3i PCI and 90-30-style serial
PCI compatibility	System designed to be electrically compliant with PCI 2.2 standard
Program blocks	Up to 512 program blocks. Maximum size for a block is 128KB.
Flash memory endurance rating	100,000 write/erase cycles minimum
Memory (For a detailed listing of memory areas, refer to Chapter 6.)	%I and %Q: 32Kbits for discrete %AI and %AQ: configurable up to 32Kwords %W: configurable up to the maximum available user RAM Managed memory (<i>Symbolic and I/O variables combined</i>): configurable up to 64 Mbytes

Specifications – CRU320

Note: For environmental specifications and compliance to standards (for example, FCC or European Union Directives), refer to the *PACSystems RX3i System Manual*, GFK-2314.

Program storage	Up to 64 Mbytes of battery-backed RAM 64 Mbytes of non-volatile flash user memory
Power requirements	+3.3 VDC: 1.0 Amps nominal +5 VDC: 1.2 Amps nominal
Operating Temperature	0 to 60°C (32°F to 140°F)
Floating point	Yes
Time of Day Clock accuracy	Maximum drift of 2 seconds per day
Elapsed Time Clock (internal timing) accuracy	0.01% maximum
Embedded communications	RS-232, RS-485
Serial Protocols supported	Modbus RTU Slave, SNP Slave, Serial I/O
Backplane	Dual backplane bus support: RX3i PCI and 90-30-style serial
PCI compatibility	System designed to be electrically compliant with PCI 2.2 standard
Program blocks	Up to 512 program blocks. Maximum size for a block is 128KB.
Memory	%I and %Q: 32Kbits for discrete %AI and %AQ: configurable up to 32Kwords %W: configurable up to the maximum available user RAM Symbolic: configurable up to 64 Mbytes
Flash memory endurance rating	100,000 write/erase cycles minimum
Memory error checking and correction (ECC)	Single bit correcting and multiple bit checking.
Switchover Time ⁸	Maximum 1 logic scan, minimum 3.133ms.
Typical Base Sweep Time (Reference Data Transfer List Impact) ⁹	3.66ms: 1K Discrete I/O, 125 Analog I/O and 1K Registers 3.87ms: 2K Discrete I/O, 250 Analog I/O and 2K Registers 4.30ms: 4K Discrete I/O, 500 Analog I/O and 4K Registers 5.16ms: 8K Discrete I/O, 1K Analog I/O and 8K Registers
Maximum amount of data in redundancy transfer list	Up to 2 Mbytes
Number of redundant redundancy links supported	Up to two IC695RMX128 synchronization links are supported.

⁸ Switchover time is defined as the time from failure detection until backup CPU is active in a redundancy system.

⁹ Symbolic variable and Reference data can be exchanged between redundancy controllers. Up to 2 Mbytes of data is available for transfer.

Error Checking and Correction, IC695CRU320

RX3i Redundancy CPUs provide error checking and correction (ECC), which results in slightly slower system performance, primarily during power-up, because it uses an extra 8 bits that must be initialized.

For details on ECC, refer to the PACSystems Hot Standby CPU Redundancy User's Guide, GFK-2308.

Note: Multiple Recoverable Memory Error faults may be generated when a single-bit ECC error is detected. When a single-bit ECC error is detected, the value presented to the microprocessor is corrected. However, the value stored in RAM is not corrected until the next time the microprocessor writes to that RAM location.

2.1.3 CPE305 and CPE310

IC695CPE305:
1.1GHz CPU with 5MB of User Memory



IC695CPE310:
1.1GHz CPU with 10MB of User Memory



Specifications

Memory retention	<p>The non-volatile storage (NVS) can retain data indefinitely without loss of data integrity. When CPU power is restored, data stored in NVS is transferred back to user memory and the NVS is cleared.</p> <p>An optional IC695ACC400 Energy Pack powers the CPU long enough to write its user memory contents to non-volatile storage during a system power loss.</p>
Program storage	<p>CPE305: 5 Mbytes of non-volatile flash user memory</p> <p>CPE310: 10 Mbytes of non-volatile flash user memory</p>
Power requirements, nominal	<p>+3.3 VDC: 1.0 A</p> <p>+5 VDC: 1.0 A (up to 1.5 A if USB is fully loaded with 0.5 A)</p> <p>+24 VDC: 0.5A at startup, 0.1 A during run time (Applies only if Energy Pack is connected to the CPE3xx.)</p>
Operating Temperature	0 to 60°C (32°F to 140°F)
Floating point	Yes
Time of Day Clock accuracy	Maximum drift of 2 seconds per day
Elapsed Time Clock (internal timing) accuracy	0.01% maximum
Embedded serial communications	<p>CPE305: RS-232</p> <p>CPE310: RS-232 (COM1) and RS-485 (COM2)</p>
Serial Protocols supported	Modbus RTU Slave, SNP Slave, Serial I/O
Backplane	Dual backplane bus support: RX3i PCI and 90-30-style serial
PCI compatibility	System designed to be electrically compliant with PCI 2.2 standard
Program blocks	Up to 512 program blocks. Maximum size for a block is 128KB.
Memory	<p><i>%I and %Q</i>: 32Kbits for discrete</p> <p><i>%AI and %AQ</i>: configurable up to 32Kwords</p> <p><i>%W</i>: configurable up to the maximum available user memory</p> <p>Symbolic: configurable up to 10 Mbytes</p>

Embedded Ethernet interface specifications	
Max. no. of connections	Up to 32 simultaneous SRTP Server connections, up to 16 simultaneous Modbus/TCP Server connections, and up to 16 simultaneous communications channels of either SRTP Channels or Modbus/TCP Client channels
Ethernet data rate	10Mb/sec and 100Mb/Sec
Physical interface	1 port: 10BaseT RJ-45
Service Request Transfer Protocol (SRTP) channels	Supported via CPE310/CPE305 Firmware Release 7.30
Modbus TCP	Supported via CPE310/CPE305 Firmware Release 7.30
OPC UA ¹⁰	Supports up to 12,500 Variables and up to 5 sessions
Ethernet Global Data (EGD)	EGD Class 1 only [Supported via CPE310/CPE305 Firmware Release 8.30]
Number of EGD configuration-based pages	255
Time synchronization	None.
Selective consumption of EGD	Yes
Load EGD configuration from PLC to programmer	Yes
Remote Station Manager over UDP	Yes. Refer to the <i>Station Manager Manual</i> , GFK-2225L or later for supported commands.
Configurable Advanced User Parameters	Yes. Refer to <i>TCP/IP Ethernet Communications for PACSystems</i> , GFK-2224M or later for supported AUPs.
For environmental specifications and compliance to standards (for example, FCC or European Union Directives), refer to the <i>PACSystems RX3i System Manual</i> , GFK-2314.	

CPE310 Backward Compatibility with CPU310

The CPE310 may be swapped with a CPU310 with no upgrade to the Proficy Machine Edition Logic Developer-PLC programming software. Logic and configuration equality in the programming software will be maintained when storing the same project to either a CPU310 or a CPE310. Proficy Machine Edition versions that recognize the CPE310 (7.0 SIM3 and newer), will allow either a CPU310 configuration or a CPE310 configuration to be stored to the CPE310. For all programming software versions (both current and legacy) a CPU310 device can accept only a CPU310 configuration.

Legacy CPU310 Projects

The CPE310 supports CPU310 projects. Proficy Machine Edition versions earlier than 7.10 SIM 3 interpret the CPE310 as a CPU310. The CPE310 can be configured as a CPU310 using Proficy Machine Edition versions as old as 5.5, Service Pack 1.

¹⁰ See GFK-2224M Chapter 10 for discussion of OPC UA.

RDSB Port

If a CPU310 configuration is stored to a CPE310, the RDSB port is enabled to allow you to transfer CPU310 projects to CPE310 models without using Proficy Machine Edition.

Fault Behavior

Faults related to the embedded CPE310 Ethernet interface may be generated on power-up. For details, see “Replacing a CPU310 with a CPE310” below.

Replacing a CPU310 with a CPE310

- A CPE310 that is configured as a CPU310 logs the following faults in the Controller fault table:
 - A *LAN Transceiver Fault* is generated because the RX3i system detects that the embedded Ethernet module does not have a network connection.
 - An *Extra Option Module* fault is generated because the embedded Ethernet module is detected as an unconfigured module.
 - If the Energy Pack capacitor pack is disconnected or fails, the legacy faults for a missing or failed battery are logged.
- When a CPE310 is configured as a CPU310, Ethernet properties cannot be configured and there should be no cable connected to the Ethernet port.
- When a CPE310 is configured as a CPU310, the Show Status dialog box in Proficy Machine Edition displays “CPU310A.”

CPE310 versus CPU310 Performance Differences

The following differences should be considered when converting legacy applications or developing new applications.

- Some exceptionally lengthy CPE backplane operations, such as MC_CamTableSelect, Data Log and Read Event Queue functions, will take longer to complete compared to other RX3i CPU models, and may delay backplane operations to IC695 modules.

For example, when an MC_CamTableSelect function block is executed on the PMM335 module, the CPU’s acknowledgement of the PMM355 module interrupt may be delayed. In this situation, you may see the following fault in the I/O Fault Table, even when the interrupt has not been dropped: *Error initiating an interrupt to the CPU.*

- Performance specifications for many features, such as power-up time, function block execution times and I/O module sweep times have changed. For details, refer to Appendix A.
- The RS-232 port on the CPE310 does not provide 5V power on pin 5.

CPU305 Performance Differences vs. CPE310 and Legacy RX3i CPUs

The CPE305 exhibits the same performance differences as listed above for the CPE310.

The CPE305 supports legacy CPU310 projects that fit within 5 Mbytes of user memory. ***The project configuration must be changed to support this conversion.***

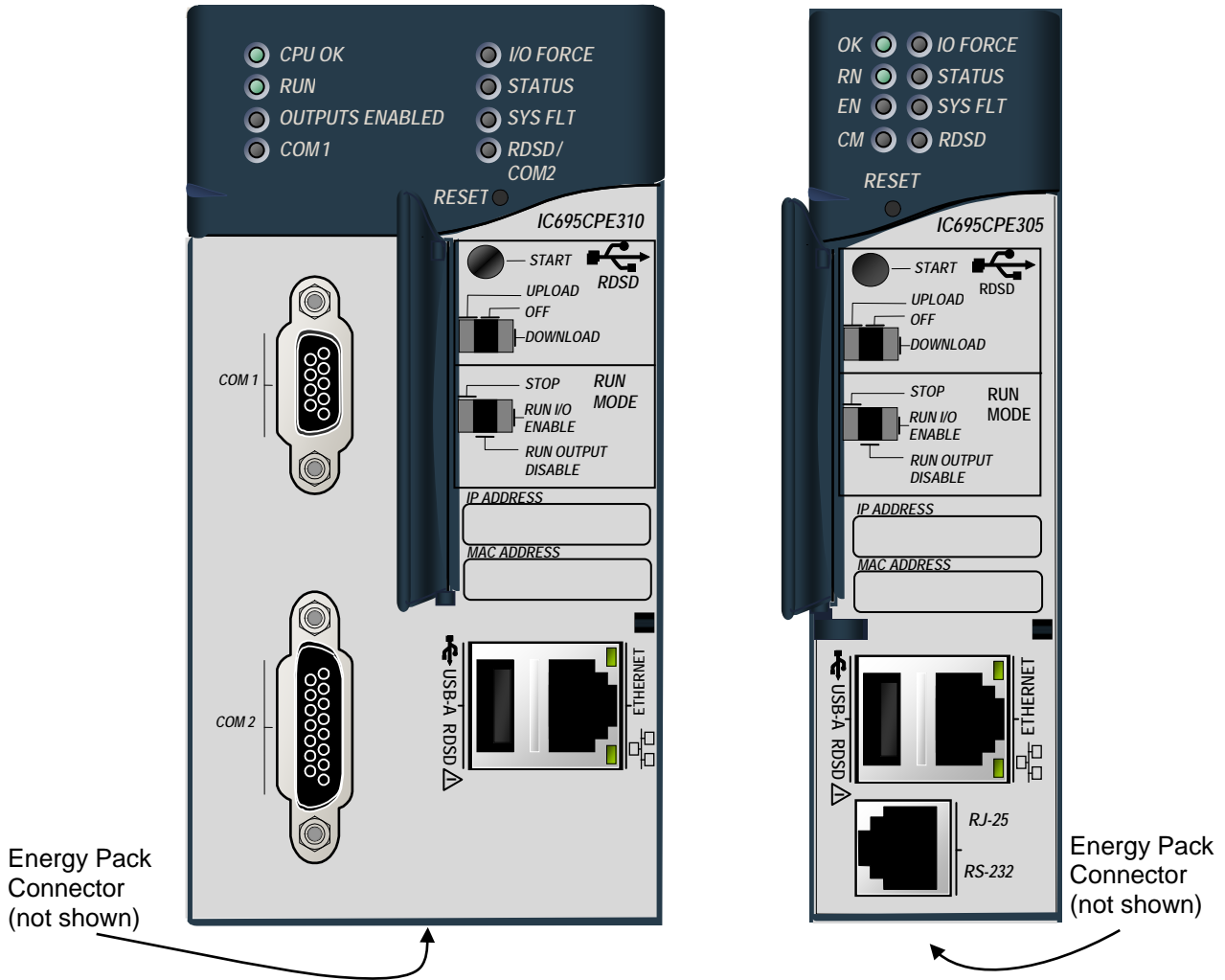
Because the CPE305 has less user memory than the other RX3i CPUs, operations that involve transferring large files could fail.

For example, depending on the number and sizes of Data Log files already stored, the Get_DL (Get Data Log) command could fail with a C10 hex (file transfer failure occurred while sending the data log file to the CPU) error. To correct this error

1. Upload the data logs to Machine Edition and delete the logs from the CPU.
2. Take steps to reduce the size of the log file, such as reducing the number of samples, the sample rate, or the number of parameters logged.

Switches

The RDSD and Run Mode switches are located behind the protective door, as shown below. The Reset switch is not used.



Switch Operation

RDSD Switches	Function
Start pushbutton	Pressing this switch initiates RDSD data transfer. (The three-position switch must be set to Upload or Download.)
Three-position switch	Enables/disables RDSD data transfer and selects the direction of data transfer.
Upload	Loads application from CPU to RDSD.
Off	Disables RDSD data transfer.
Download	Stores application from RDSD to CPU.
Run Mode Switch	The Run Mode switch operates as described in Chapter 4.

Real-Time Clock Battery

The CPE3xx is shipped with a real time clock (RTC) battery (IC690ACC001) installed, with a pull-tab on the battery. The pull-tab should be removed before installing the CPE3xx module.

There are no diagnostics or indicators to monitor RTC battery status.

The RTC battery has an estimated life of 5 years and must be replaced every 5 years on a regular maintenance schedule.

If the RTC battery fails, the CPU date and time is reset to 12:00 AM, 01-10-2000 at startup. The CPU operates normally with a failed or missing RTC battery; only the initial CPU TOD clock information will be incorrect.

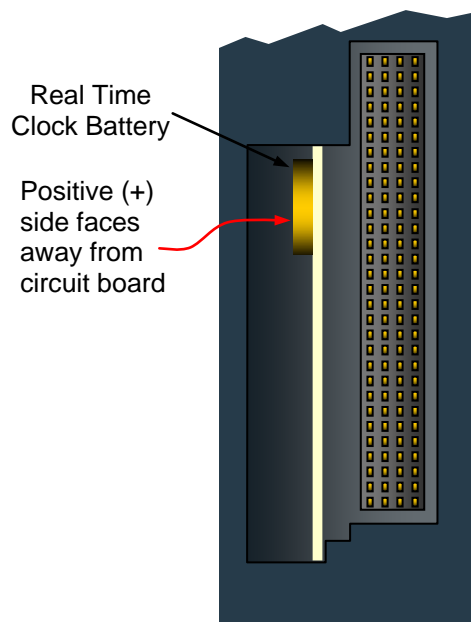


Figure 1: Accessing Real-Time Clock Battery (except CPE330)

Replacing the Real-Time Clock Battery

The replacement battery must be IC690ACC001 from GE Intelligent Platforms or equivalent, such as Panasonic BR2032.



Warning

Use of a different type of battery than that specified here may present a risk of fire or explosion.

Battery may explode if mistreated. Do not recharge, disassemble, heat above 100°C (212°F) or incinerate.

Caution

To avoid damage from electrostatic discharge, use proper precautions when performing these procedures:



- Wear a properly functioning antistatic strap and be sure that you are fully grounded. Never touch the printed circuit board, or components on the board, unless you are wearing an antistatic strap.
- Any surface upon which you place the unprotected circuit board should be static-safe, facilitated by antistatic mats if possible.

Extra caution should be taken in cold, dry weather, when static charges can easily build up.

Battery Removal Method 1

1. Power down the rack and remove the CPU from the backplane.
2. Using a curved probe with a non-conducting surface, for example a non-metallic dental pick, reach in from the back of the module and pull the battery out of its retaining clip. (You can use needle-nose pliers to grasp the battery and pull it the rest of the way out.)

Sample Tool for Battery Removal

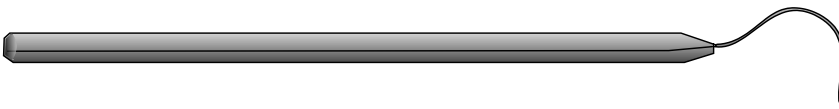


Figure 2: Sample Tool for Coin Battery Extraction

Battery Removal Method 2

1. Power down the rack and remove the CPU from the backplane.
2. Squeeze both sides of the module and remove the front section of the plastic housing.
3. Lift the two clips on the side of the plastic housing to release the circuit board and pull the board out of the housing.
4. Pull the battery out of its retaining clip.

Installing a New RTC Battery

Install the battery with the positive (+) side up. That is, with the + side away from the board and toward the housing plastic.

Indicators

CPU Indicators

LED	LED State ● On ✚ Blinking ○ Off	CPU Operating State
CPE305: OK CPE310: CPU OK	● On, Green	CPU has passed its power-up diagnostics and is functioning properly. <i>(After initialization sequence is complete.)</i>
	○ Off	CPU problem. RUN and OUTPUTS ENABLED LEDs may be blinking in an error code pattern, which can be used by technical support for troubleshooting. This condition and any error codes should be reported to your technical support representative.
	✚ Blinking; Other LEDs off	CPU in Stop-Halt state; possible watchdog timer fault. Refer to the fault tables. If the programmer cannot connect, cycle power with a charged Energy Pack attached and refer to fault tables.
CPE305: OK and EN CPE310: CPU OK and OUTPUTS ENABLED	✚ Blinking in unison	CPU is in boot mode and is waiting for a firmware update through a serial port.
CPE305: RN CPE310: RUN	● On	CPU is in Run mode.
	○ Off	CPU is in Stop mode.
CPE305: EN CPE310: OUTPUTS ENABLED	● On	Output scan is enabled.
	○ Off	Output scan is disabled.
I/O FORCE	● On	Override is active on a bit reference.
STATUS	✚ Blinking green	Energy Pack charging; not yet charged above the minimum operating voltage.
	● On red	Energy Pack circuit fault.
	✚ Blinking red	Energy Pack near its end of life and should be replaced soon.
	● On green	Energy Pack is charged above its minimum operating voltage.
	○ Off	Energy Pack not connected.
SYS FLT (System Fault)	● On red	CPU is in Stop/Faulted mode because a fatal fault has occurred.
CPE305: CM CPE310: COM1	✚ Blinking green	Signal activity on COM1 port.
	○ Off	No activity on COM1 port
CPE310 only RDSD / COM2 (RDSD not attached)	✚ Blinking green	Signal activity on COM2 port.
	○ Off	No activity on COM2 port

RDS D Indicators

LED	LED State ● On ✚ Blinking ○ Off	RDS D Operating State
CPE310 only SYS FLT and RDS D / COM2	● On red	The RDS D has been removed during a store. The CPU must be power cycled to resume RDS D operations.
	○ ✚ Off or blinking green	
CPE305: RDS D CPE310: RDS D / COM2 (RDS D active: RDS D attached to USB-A RDS D port.)	● On green	Valid RDS D connected or data transfer complete.
	✚ Blinking green	Data transfer in progress.
	● On red	RDS D fault. Check for and correct the following conditions: CPU type mismatch with project on RDS D. Data transfer error. Corrupted or invalid USB file system. Insufficient space on RDS D.
	✚ Blinking red	RDS D-Controller project name mismatch.
	○ Off	RDS D not attached or USB port is disabled.

Ethernet Indicators

LED	LED State ● On ✚ Blinking ○ Off	CPU Operating State
100	● On, Green	Network data speed is 100 Mbps.
	○ Off	Network data speed is 10 Mbps.
LINK	● On, Green	The link is physically connected.
	✚ Blinking green	Traffic is detected at the port.

Serial Ports

These ports provide serial interfaces to external devices and can be used for firmware upgrades. All serial ports are isolated. For serial port pin assignments and details on serial communications, refer to Chapter 12.

CPE305 one RS-232 port.

CPE310 one RS-232 port (COM1) and one RS-485 port (COM2).

The RS-232 port does not supply the 5VDC power offered by other RX3i and Series 90-30 CPUs. Cable IC693CBL316 must be used for RS-232 serial connections to the CPE3xx.

Ethernet Port

The embedded Ethernet interface supports communications with the Machine Edition programming software using the proprietary SRTP protocol. The CPE3xx CPUs provide two SRTP-server connections.

This interface does not support Ethernet Global Data protocol.

The embedded Ethernet interface has one RJ-45 Ethernet port that automatically senses the data rate (10Mbps or 100Mbps), duplex (half duplex or full duplex), and cabling arrangement (straight through or crossover) of the attached link.

Removable Data Storage Devices (RDSDs)

The CPE3xx provides the ability to transfer applications to and from an RDSD (USB-compatible device, such as a memory stick, smart phone, digital camera or MP3 device). Once the data is copied to the RDSD, it can be written to other RX3i CPE3xx CPUs of the same type, with no programmer software needed. The RDSD interface requires a user-supplied flash memory device that complies with the USB 2.0 Specification.

The USB port must be enabled in the RX3i configuration in order to transfer data between the CPU and the RDSD. The CPE3xx is shipped with the RDSD (USB) port enabled.

The RDSD load and store operations can include the following data:

- An entire application, including logic and configuration, reference table data, and cam files for Motion applications. (Motion files and local logic for DSM motion applications are supported.) Configuration can include Ethernet Global Data and Advanced User Parameters for the rack-based Ethernet interface. (Although a complete, unmodified application must be placed on the RDSD, you can use an *options.txt* file to download selected components of the application to the target CPU.)
- Passwords and OEM key, if any, are encrypted and written to the RDSD when the project is loaded from the CPU. When the project is stored to a CPU that has no passwords or OEM key, those are copied to the CPU.

Note: With Enhanced Security enabled, the RDSD update will fail if the RDSD source controller has Level 4 password protection and the destination controller is password protected, regardless of whether the passwords match.

With Legacy security, when the project is stored to a CPU that has passwords and/or OEM key, the passwords must match or the store will fail.

- Fault tables are written to the RDSD before and after a load to or store from the RDSD.
- If a hardware configuration that disables the USB port is successfully stored to the CPU, the fault tables will not be written to the RDSD at completion of the store operation.

Note: The USB port is for transfer of application data only. It is not intended for permanent connection.

Note: When using RDSD, all programming software connections must be in the “Offline” state for the RDSD to function properly.

Uploading a Project from the CPU to the RDS

Notes: Only one application project can be stored to the RDS at a time. Before the RX3i writes the project to the RDS, any previous application is removed; if a directory named *PACS_Folder* exists on the RDS at the start of the upload, it is deleted with all of its contents.

Flash devices write in whole memory blocks and memory block sizes vary among devices. The amount of space used by a project may vary between RDSs due to the differences in minimum block sizes and therefore the number of blocks used by a project. The minimum amount of memory required will be the size of the entire project plus an additional block for the *options.txt* file, if used.

1. Place the CPU that contains the project to be transferred in Run or Stop mode.
2. If the programmer is online with the RX3i, either go Offline or select Monitor mode.
3. Insert the RDS into the USB connector on the CPU. (After 1 – 2 sec, the RDS LED turns solid green.)
4. Push the RDS direction switch to the left (UPLOAD).
5. Momentarily depress the START pushbutton. **Do not** remove the RDS from the CPU during the transfer.
 - The RDS LED blinks green during the transfer. This can take from 10 – 150 sec, depending upon the size of the project data.
 - The RDS LED should turn solid green, indicating that the transfer completed successfully.
 - If the RDS LED turns solid red, the transfer has failed. There will be a copy of the fault tables as they existed at the end of the attempted transfer on the RDS. Insert the RDS into a PC which has the PACS Analyzer software and select the *plcfaulter.dat* file on the RDS for fault table analysis by the Analyzer. The PACS Analyzer software can be downloaded from the Support website, <http://support.ge-ip.com>.
 - If the RDS LED turns solid red, indicating an error, another RDS operation cannot be initiated until the device is disconnected then reconnected.

Caution



- If the RDS is removed during data transfer from the CPU, the integrity of the RDS and the files on it cannot be guaranteed. The RDS status LED will indicate a fault, and the CPU will abort the data transfer and remain in its current operating mode.
- The project files, consisting of the entire contents of the *PACS_Folder* directory and all of its subdirectories, loaded on the RDS must *not* be modified. If they are modified, the files transferred to the CPU will be invalid

-
6. When the RDS LED turns solid green, indicating the transfer has been successfully completed, remove the RDS from the CPU. The RDS can now be used to transfer the application to other RX3i controllers of the same model type.

You can copy the entire *applications* directory to another USB device and use that device as the source for downloads to CPE3xx CPUs, provided none of the files in that directory are changed in any way during the transfer.

Downloading a Project from the RDS to the CPU

To download a project to the RX3i, the RDS must contain a valid project, consisting of the hardware configuration, application logic, and reference memory in a compiled format (originating from another RX3i controller). The project files, consisting of the entire contents of the *PACS_Folder* directory and all of its subdirectories, loaded on the RDS must **not** be modified. If they are modified, the files transferred to the CPU will be invalid.

By default, all project components are stored to the CPU and are written to flash. You can change this operation by placing an *options.txt* file on the RDS as described below.

1. Ensure that the RX3i is in STOP mode
 2. If PROFICY Machine Edition is online with the RX3i, either go Offline or select Monitor mode.
 3. Connect the RDS to the USB connector on the CPU that will be receiving the files. The RDS LED turns solid green. Move the RDS direction switch to the right (DOWNLOAD).
 4. Momentarily depress the START pushbutton. **Do not** remove the RDS from the CPU during the transfer.
- If the target name in the RDS is different from the target name in the RX3i, the RDS LED will blink red. If this is expected or acceptable, momentarily depress the START pushbutton again.
 - The RDS LED blinks green during the transfer. This can take from 10 – 150 sec, depending upon the size of the project data.
 - The RDS LED should turn solid green, indicating that the transfer completed successfully. Unless the RUN/STOP switch has been disabled in the hardware configuration just stored, it can be used to place the RX3i into RUN mode after the transfer.
 - If the RDS LED turns solid red, the transfer has failed. There will be a copy of the fault tables as they existed at the end of the attempted transfer on the RDS. Insert the RDS into a PC which has the PACS Analyzer software and select the *plcfaulafter.dat* file on the RDS for fault table analysis by the Analyzer.

If the RDS LED turns solid red, indicating an error, another RDS operation cannot be initiated until the device is disconnected then reconnected.

Caution



If the RDS is removed during data transfer to the CPU, the RX3i controller will generate a fatal fault (sequence store fault). You will need to clear the fault tables through a programmer connection or by power cycling the CPU with the Energy Pack disconnected before attempting to download again.

5. When the RDS LED turns solid green, indicating the transfer has been successfully completed, remove the RDS from the CPU.

The RUN/STOP switch can be used to place the RX3i into RUN mode after the transfer, unless it has been disabled in the hardware configuration just stored. (If the RUN/STOP switch is disabled, you will need to connect with the programmer to place the RX3i in RUN mode.

Using an Options.txt File to Modify Download Operation

An *options.txt* file can be used to modify the operation of the RDSD during a store to the RX3i. This is a plain-text file which can contain some or all of the following statements, in any order. The format of each option line is the option keyword, followed by a space, followed by either a capital Y or a capital N. The option keyword must be spelled exactly as indicated below. If an option statement is omitted from the file, the default value will be used.

If you want to use all of the default operations, *the options.txt* file is not necessary.

Options.txt File Format

Option Keyword	Default value	Description
Download_LogicAndCfg	Y (yes)	Logic and configuration are copied to the CPE305 (including symbolic variables)
Download_Data	Y (yes)	Reference memory is copied to the CPE305 (excluding symbolic variables)
Download_CamFiles	Y (yes)	Cam files are copied to the CPE305
Write_Flash	Y (yes)	The downloaded CPE305 contents (as specified by the above keywords) by default will be written to flash upon completion of the store

Sample options.txt File

If the following *options.txt* file is present on the RDSD, logic, configuration and reference data are copied to the CPU, and files are written to flash. Cam files are not copied.

```
Download_LogicAndCfg Y
Download_Data Y
Download_CamFiles N
Write_Flash Y
```

Security

When the application is written to the RDSD from a controller that has passwords and/or an OEM key defined, the passwords and OEM key are encrypted and stored on the RDSD. When the project is written from the RDSD to a CPE3xx, the passwords and OEM key are copied to it.

If an OEM key is defined on the RDSD, when transfer is complete, the OEM protection will be enabled (locked). When an application is being stored to a CPE305 that already has passwords and/or an OEM key defined, the passwords/key on the RDSD must match the passwords/key in the target CPE3xx, or the transfer will fail.

RDSD Error Reporting

Errors are indicated when the RDSD LED becomes solid red (not blinking). All errors are reported in the Controller fault tables. If the Controller has faults in its fault tables before it receives a store, the fault tables are written to *plcfaultbefore.dat* and *iofaultbefore.dat* on the RDSD. If the Controller has faults in its fault tables after it receives a store, the fault tables are written to *plcfaultafter.dat* and *iofaultafter.dat* on the RDSD. Previous versions of these files are deleted before the transfer. If either fault table is empty, the corresponding file is not written and will not be present.

If a hardware configuration that disables the USB port is stored to the CPU, the fault tables will not be written to the RDSD at completion of the store operation because the USB port will be disabled at the end of the store process.

Operation with Energy Pack

The CPE3xx preserves user memory using an Energy Pack without the need to periodically replace batteries. An IC695ACC400 Energy Pack powers the CPU long enough for the CPU to write its user memory contents to the CPU's non-volatile storage during a system power loss. For details on the Energy Pack, refer to the datasheet GFK-2724.

User memory is preserved only if the Energy Pack is connected (and charged) at power-down and if it is present at power-up. Removing or reconnecting the Energy Pack while the CPE3xx is not powered has no effect on the preservation of user memory.

The %S0014 (PLC_BAT) system status reference indicates the Energy Pack.:

Note: When the Energy Pack is powered up for the first time, or is in a system that has been powered down long enough to completely discharge the Energy Pack, a period of time will be required for it to charge up to its operating level. The STATUS LED of the CPU will blink green during this time.

Note: Because the Time of Day (TOD) clock is powered by the Real Time Clock battery, removal of the Energy Pack does not cause the CPU to lose the TOD value.

Energy Pack Replacement

If an Energy Pack fails, you can replace it with a new unit while the CPU is in operation. When an Energy Pack is replaced, the new Energy Pack must charge. If a loss of power occurs while the Energy Pack is disconnected or before it is fully charged, a memory loss may occur.

2.2. RX7i Features and Specifications

2.2.1 CPE010, CPE020 and CRE020

IC698CPE010: 300MHz CPU microprocessor

IC698CPE020: 700MHz CPU microprocessor

IC698CRE020: 700MHz CPU microprocessor with redundancy

CPU Serial Ports

The CPU has three independent, on-board serial ports, accessed by connectors on the front of the module. Ports 1 and 2 provide serial interfaces to external devices; either can be used for firmware upgrades. The third on-board serial port is a dedicated Ethernet Station Manager port. All serial ports are isolated. For serial port pin assignments and details on serial communications, refer to Chapter 12.

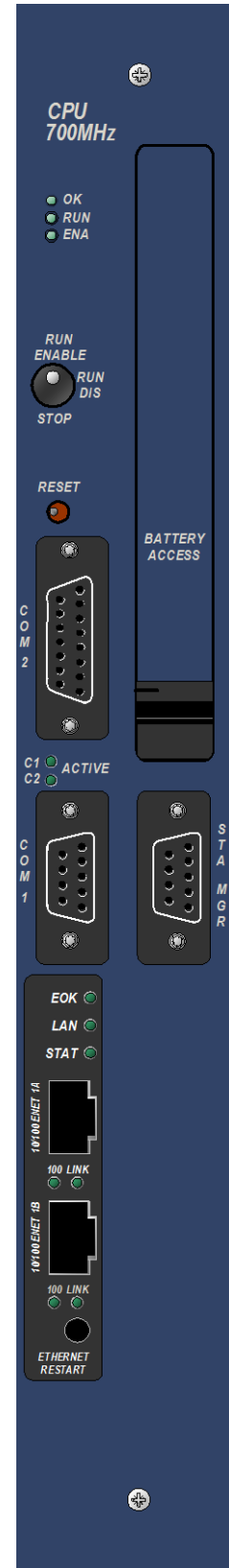
Ethernet Ports

For details on the embedded Ethernet interface, refer to page 41.

CPU Indicators

Five CPU LEDs indicate the operating status of various CPU functions.

LED State			CPU Operating State
● On	✚ Blinking	○ Off	
●	OK	On	CPU has passed its power-up diagnostics and is functioning properly.
○	OK	Off	CPU problem. EN and RUN LEDs may be blinking in an error code pattern, which can be used by technical support for troubleshooting. This condition and any error codes should be reported to your technical support representative.
✚	OK, EN, RUN Blinking in unison		CPU is in boot mode and is waiting for a firmware update through a serial port.
✚	OK Blinking Other LEDs off.		CPU in Stop/Halt state; possible watchdog timer fault. Refer to the fault tables. If the programmer cannot connect, cycle power with battery attached and refer to fault tables.
●	RUN	On	CPU is in Run mode
○	RUN	Off	CPU is in Stop mode.
●	ENA	On	Output scan is enabled.
○	ENA	Off	Output scan is disabled.
✚	C1 (port 1) Blinking C2 (port 2) Blinking		Signals activity on port.



Specifications – CPE010, CPE020 and CRE020 Models

For environmental specifications, see “RX7i General Specifications” in Appendix A of the *RX7i Installation Manual*, GFK-2223.

Program storage	Up to 10 Mbytes of battery-backed RAM 10 Mbytes of non-volatile flash user memory
Power requirements CPE010	+5 VDC: 3.2 Amps nominal +12 VDC: 0.042 Amps nominal -12 VDC: 0.008 Amps nominal
CPE020, CRE020	+5 VDC: 4.5 Amps nominal +12 VDC: 0.042 Amps nominal -12 VDC: 0.008 Amps nominal
Operating Temperature	CPE010: 0 to 50°C (32°F to 122°F) 0 to 60°C (32°F to 140°F) with fan tray CPE020, CRE020: 0 to 60°C (32°F to 140°F), fan tray required
Floating point	Yes
Time of Day Clock accuracy	Maximum drift of ±9 seconds per day. Can be synchronized to an Ethernet time master within ±2ms of the SNTP time-stamp.
Elapsed Time Clock (internal timing) accuracy	±0.01% maximum
Embedded communications	RS-232, RS-485, Ethernet interface
Serial Protocols supported	Modbus RTU Slave, SNP Slave, Serial I/O To determine availability for a given firmware version, please refer to the <i>Important Product Information</i> document provided with the CPU.
Ethernet Ports	Embedded auto-sensing 10/100 Mbps half/full duplex Ethernet interface
VME Compatibility	System designed to support the VME64 standard ANSI/VITA 1
Program blocks	Up to 512 program blocks. Maximum size for a block is 128 KB.
Memory (For a detailed listing of memory areas, refer to Chapter 6.)	%I and %Q: 32Kbits for discrete %AI and %AQ: configurable up to 32k words %W: configurable up to the maximum available user RAM Managed memory (<i>Symbolic and I/O variables combined</i>): configurable up to 10 Mbytes
Error Checking and Correction	CRE020 only.

Ethernet Interface Specifications	
Web-based data monitoring	Up to 16 web server and FTP connections (combined)
Ethernet data rate	10Mb/sec and 100Mb/sec
Physical interface	10BaseT RJ45
WinLoader support	Yes
Number of EGD configuration-based pages	255
Time synchronization	SNTP
Selective consumption of EGD	Yes
Load EGD configuration from PLC to programmer	Yes
Remote Station Manager over UDP	Yes
Local Station Manager (RS-232)	Dedicated RS-232 port
Configurable Advanced User Parameters	Yes

Error Checking and Correction, IC698CRE020

Redundancy CPUs are shipped with error checking and correction (ECC) enabled. Enabling ECC results in slightly slower system performance, primarily during power-up, because it uses an extra 8 bits that must be initialized. If you upgrade the firmware on the non-redundancy CPU model IC698CPE020 to support redundancy, you must set the ECC jumper to the enabled state as described in the installation instructions provided with the upgrade kit.

The CRE020 performance measurements provided in Appendix A were done with ECC enabled.

For details on ECC, refer to the PACSystems Hot Standby CPU Redundancy User's Guide, GFK-2308.

2.2.2 CPE030/CRE030 and CPE040/CRE040

CPE030/CRE030: 600MHz Pentium-M microprocessor

CPE040/CRE040: 1800MHz Pentium-M microprocessor

CPU Serial Ports

The CPU has three independent, isolated, on-board serial ports, accessed by connectors on the front of the module. Ports 1 and 2 provide serial interfaces to external devices and can be used for firmware upgrades. The third serial port is a dedicated Ethernet Station Manager port. For serial communications, see Chapter 13.

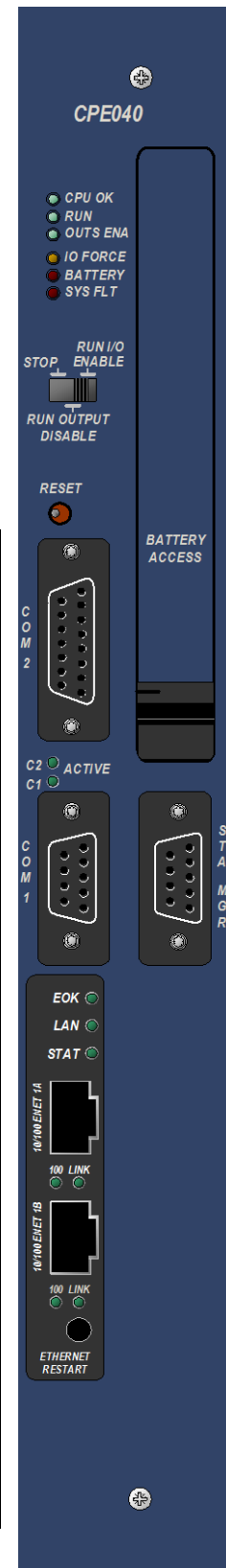
Ethernet Ports

For details on the embedded Ethernet interface, refer to page 41.

CPU Indicators

Seven CPU LEDs indicate CPU operating status.

LED State ● On ✚ Blinking ○ Off			CPU Operating State
●	CPU OK	On	CPU has passed its power-up diagnostics and is functioning properly.
○	CPU OK	Off	CPU problem. RUN and OUTPUTS ENABLED LEDs may be blinking in an error code pattern, which can be used by technical support for diagnostics. This condition and any error codes should be reported to your technical support representative.
✚	CPU OK, OUTS ENA, RUN Blinking in unison		CPU is in boot mode and is waiting for a firmware update through a serial port.
✚	OK	Blinking Other LEDs off	CPU in Stop/Halt state; possible watchdog timer fault. Refer to the fault tables. If the programmer cannot connect, cycle power with battery attached and refer to fault tables.
○	RUN	Off	CPU is in Stop mode.
●	OUTS ENA	On	Output scan is enabled.
○	OUTS ENA	Off	Output scan is disabled.
●	I/O FORCE	On	Override is active on a bit reference (Not used by CRE030 and CRE040.)
●	BATTERY	On	Battery has failed or is not attached.
●	SYS FAULT	On	CPU is in Stop/Faulted mode because a fatal fault has occurred.
✚	C1 (port 1) C2 (port 2)	Blinking Blinking	Signal activity on port.



Specifications – CPE030/CRE030 and CPE040/CRE040 Models

For environmental specifications, see “RX7i General Specifications” in Appendix A of the *RX7i Installation Manual*, GFK-2223.

Program storage	Up to 64 Mbytes of battery-backed RAM 64 Mbytes of non-volatile flash user memory
Power requirements	CPE030/CRE030: +5 VDC: 3.2 Amps nominal +12 VDC: 0.003 Amps nominal -12 VDC: 0.003 Amps nominal CPE040/CRE040: +5 VDC: 6.8 Amps nominal +12 VDC: 0.003 Amps nominal -12 VDC: 0.003 Amps nominal
Operating temperature	CPE030/CRE030: 0 to 50°C (32°F to 122°F) 0 to 60°C (32°F to 140°F) with fan tray CPE040/CRE040: 0 to 60°C (32°F to 140°F), fan tray required
Floating point	Yes
Time of Day Clock accuracy	Maximum drift of ±2 seconds per day. Can be synchronized to an Ethernet time master within ±2ms of the SNTP time-stamp.
Elapsed Time Clock (internal timing) accuracy	±0.01% maximum
Embedded communications	RS-232, RS-485, Ethernet interface
Serial Protocols supported	Modbus RTU Slave, SNP Slave, Serial I/O To determine availability for a given firmware version, please refer to the <i>Important Product Information</i> document provided with the CPU.
Ethernet Ports	Embedded auto-sensing 10/100 Mbps half/full duplex Ethernet interface
[Optional] Station Manager cable for Ethernet Interface	IC200CBL001
VME Compatibility	System designed to support the VME64 standard ANSI/VITA 1
Program blocks	Up to 512 program blocks. Maximum size for a block is 128KB.
Memory (For a detailed listing of memory areas, refer to Chapter 6.)	%I and %Q: 32Kbits for discrete %AI and %AQ: configurable up to 32Kwords %W: configurable up to the maximum available user RAM Managed memory (<i>Symbolic and I/O variables combined</i>): configurable up to 10 Mbytes
Error checking and correction	CRE030 and CRE040 only

Ethernet Interface Specifications	
Web-based data monitoring	Up to 16 web server and FTP connections (combined)
Ethernet data rate	10 Mb/sec and 100 Mb/sec
Physical interface	10BaseT RJ45
WinLoader support	Yes
Number of EGD configuration-based pages	255
Time synchronization	SNTP
Selective consumption of EGD	Yes
Load EGD configuration from PLC to programmer	Yes
Remote Station Manager over UDP	Yes
Local Station Manager (RS-232)	Dedicated RS-232 port
Configurable Advanced User Parameters	Yes

Error Checking and Correction, IC698CRE030 and IC698CRE040

Redundancy CPUs are shipped with error checking and correction (ECC) enabled. Enabling ECC results in slightly slower system performance, primarily during power-up, because it uses an extra 8 bits that must be initialized. If you upgrade the firmware on a non-redundancy CPU model to support redundancy, you must set the ECC jumper to the enabled state as described in the installation instructions provided with the upgrade kit.

For details on ECC, refer to the PACSystems Hot Standby CPU Redundancy User's Guide, GFK-2308.

Note: Multiple Recoverable Memory Error faults may be generated when a single-bit ECC error is detected. When a single-bit ECC error is detected, the value presented to the microprocessor is corrected. However, the value stored in RAM is not corrected until the next time the microprocessor writes to that RAM location.

2.2.3 RX7i Embedded Ethernet Interface

Ethernet Ports

The embedded Ethernet Interface provides two RJ-45 Ethernet ports. Either or both of these ports may be connected to other Ethernet devices. Each port automatically senses the data rate (10Mbps or 100Mbps), duplex (half duplex or full duplex), and cabling arrangement (straight through or crossover) of the attached link.) For Ethernet port pin assignments, refer to Chapter 12. For details on Ethernet communications, refer to the following manuals:

TCP/IP Ethernet Communications for PACSystems User's Guide, GFK-2224
 PACSystems TCP/IP Communications Station Manager Manual, GFK-2225



Caution

The two ports on the Ethernet Interface must not be connected, directly or indirectly to the same device. The hub or switch connections in an Ethernet network must form a tree; otherwise duplication of packets may result.

Ethernet Interface Indicators

The Ethernet Interface indicators consist of seven light emitting diodes (LEDs). All are single-color green LEDs controlled by the Ethernet interface.

- Module OK (EOK)
- LAN online (LAN)
- Status (STAT)
- Two activity LEDs (LINK)
- Two speed LEDs (100)

The **EOK**, **LAN**, and **STAT** LEDs are grouped together and indicate the state and status of the Ethernet interface.

Each Ethernet port has two green LED indicators, **Link** and **100**. The **LINK** LED indicates the network link status and activity. This LED is illuminated when the link is physically connected and blinks when traffic is detected at the port. Note that traffic at the port does not necessarily mean that traffic is present at the Ethernet interface, since the traffic may be going between ports of the switch. The **100** LED indicates the network data speed (10 or 100 Mb/sec). This LED is illuminated if the network connection is 100 Mbps.

LED operation is described in the following tables.

Ethernet LED Operation

LED State ● On ✱ Blinking ○ Off			Ethernet Operating State
✱ ○ ○	EOK LAN STAT	Blink error code Off Off	Hardware Failure
✱ ○ ○	EOK LAN STAT	Fast Blink Off Off	Performing Diagnostics
✱ ○ ○	EOK LAN STAT	Slow Blink Off Off	Waiting for Ethernet configuration from CPU
✱ ● ✱ ○ ✱	EOK LAN STAT	Slow Blink [†] On/Traffic/Off Slow Blink [†] ([†] EOK and STAT blink in unison)	Waiting for IP Address
● ✱ ○	EOK LAN STAT	On On/Traffic/Off On/Off	Operational
✱ ✱ ✱	EOK LAN STAT	Slow Blink [‡] Slow Blink [‡] Slow Blink [‡] ([‡] All LEDs blink in unison)	Software Load

EOK LED Operation

The EOK LED indicates whether the Ethernet interface is able to perform normal operation. This LED is on for normal operation and blinks for all other operations. When a hardware or unrecoverable runtime failure occurs, the EOK LED blinks a two-digit error code identifying the failure. The LED first blinks to indicate the most significant error digit, then after a brief pause blinks again to indicate the least significant error digit. After a long pause the error code display repeats.

EOK LED Blink Codes for Ethernet Hardware Failures

Blink Code	Description
0x12	Undefined or Unexpected Interrupt.
0x13	Timer failure during power up diagnostics.
0x14	DMA failure during power up diagnostics.
0x21	RAM failure during power up diagnostics.
0x22	Stack error during power up diagnostics.
0x23	Shared Memory Interface error during power up diagnostics.
0x24	Firmware CRC (cyclic redundancy check) error during power up or Factory Test.†
0x25	Run time exception
0x31	Undefined instruction or divide by zero
0x32	Software interrupt
0x33	Instruction pre-fetch abort
0x34	Data abort
0x35	Unexpected Runtime IRQ
0x36	Unexpected Runtime FIQ (fast interrupt request)
0x37	Reserved Exception or branch through zero

† CRC error or software error during normal operation causes Ethernet restart.

LAN LED Operation

The LAN LED indicates access to the Ethernet network. During normal operation and while waiting for an IP address, the LAN LED blinks to indicate network activity. This LED remains on when the Ethernet interface is not actively accessing the network but the network is available, and it is off if network access is not available. The definition of the network being available as indicated by this LED is that the Ethernet physical interface is available and one or both of the Ethernet ports is connected to an active network.

STAT LED Operation

The STAT LED indicates the condition of the Ethernet interface in normal operational mode. If the STAT LED is off, an event has been entered into the exception log and is available for viewing via the Station Manager interface. The STAT LED is on during normal operation when no events are logged. In the other states, the STAT LED is either off or blinking and helps define the operational state of the module.

Ethernet Port LEDs Operation (100Mb and Link/Activity)

Each of the two Ethernet ports has two green LED indicators, **100** and **LINK**. The **100** LED indicates the network data speed (10 or 100 Mb/sec). This LED is illuminated if the network connection is 100 Mbps.

The **LINK** LED indicates the network link status and activity. This LED is illuminated when the link is physically connected and blinks when traffic is detected at the port. Note that traffic at the port does not necessarily mean that traffic is present at the Ethernet interface, since the traffic may be going between ports of the switch.

Ethernet Restart Pushbutton

The Ethernet Restart pushbutton is used to manually restart the Ethernet firmware without power cycling the entire control system. It is recessed to prevent accidental operation. The restart does not occur until the pushbutton is released.

The type of restart behavior is selected by the length of time that the pushbutton is depressed. The pushbutton-controlled restart operations are listed in the following table, along with the LED indications for each. In all cases, the EOK, LAN and STAT LEDs briefly turn on in unison as an LED test. The Ethernet port LEDs are not affected by a manual restart of the Ethernet firmware.

Restart Operation	Depress Ethernet Restart pushbutton for	Ethernet LEDs Illuminated
Normal restart	Less than 5 seconds	EOK, LAN, STAT
Restart without Ethernet plug-in applications	5 to 10 seconds	LAN, STAT
Restart into Firmware Update operation	More than 10 seconds	STAT

Normal Restart

When the Ethernet Restart pushbutton is pressed for less than 5 seconds, the Ethernet interface will restart into normal operation.

Restart without Ethernet Plug-in Applications

When the Restart pushbutton is pressed and held for 5 to 10 seconds, the Ethernet interface will restart into normal operation but does not start any optional Ethernet plug-in applications. This is typically done during troubleshooting.

Restart into Firmware Update Operation

When the Ethernet Restart pushbutton is pressed and held for more than 10 seconds, the Ethernet interface will restart into firmware update operation. This is typically done during troubleshooting to bypass possibly invalid firmware and allow valid firmware to be loaded using WinLoader.

Until the firmware update actually begins, you can manually exit the firmware update and restart with the existing firmware by pressing the Ethernet Restart pushbutton again.

Chapter 3 CPU Configuration

The PACSystems CPU and I/O system is configured using Proficy Machine Edition Logic Developer-PLC programming software.

The CPU verifies the physical module and rack configuration at power-up and periodically during operation. The physical configuration must be the same as the programmed configuration. Differences are reported to the CPU alarm processor for configured fault response. Refer to the *Machine Edition Logic Developer-PLC Getting Started Manual*, GFK-1918 and the online help for a description of configuration functions.

Note: A CPE020, CPE030 or CPE040 can be converted to the corresponding redundancy CPU (CRE020, CRE030 or CRE040) by installing different firmware and moving a jumper. Detailed instructions are included in the firmware upgrade kit for the redundancy CPU.

3.1. Configuring the CPU

To configure the CPU using the Logic Developer-PLC programming software, do the following:

1. In the Project tab of the Navigator, expand your PACSystems Target, the hardware configuration, and the main rack (Rack 0).
2. Right click the CPU slot and choose Configure. The Parameter Editor window displays the CPU parameters.

Note: An RX7i CPU must be installed in Rack 0, Slot 1. A double-wide RX3i CPU occupies two slots and can be installed in any pair of slots in Rack 0 except the two highest numbered lots in the rack. The single-wide CPE305 RX3i CPU requires one slot and can be installed in any slot in RX3i Rack 0, **except** the highest numbered slot or slot 0.

3. To edit a parameter value, click the desired tab, then click in the appropriate Values field. Refer to “Configuration Parameters” on page 49 for information on these fields.
4. Store the configuration to the Controller so these settings can take effect. For details, see “Storing (Downloading) a Configuration” on page 65.

Note: If available, the embedded Ethernet Interface is displayed in a sub-slot of the CPU. For details on configuring the embedded Ethernet Interface, refer to page 66.

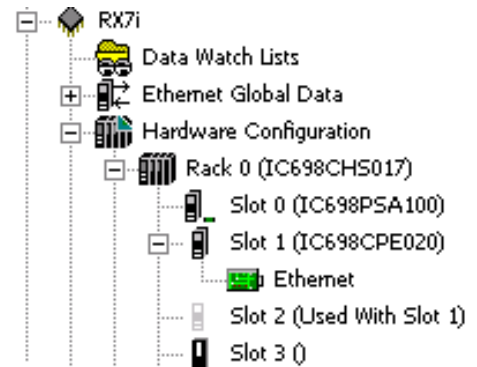


Figure 3: Hardware Configuration Display in Proficy Machine Edition

3.2. Configuration Parameters

3.2.1 Settings Parameters

These parameters specify basic operating characteristics of the CPU. For details on how these parameters affect CPU operation, refer to Chapter 5.

Settings Parameters	
Passwords	<p>Specifies whether passwords are Enabled or Disabled. Default: Enabled.</p> <p>Note: If Enhanced Security¹¹ is enabled in the target properties, the Passwords setting will be Enabled and read-only, and the Access Control tab (page 62) appears.</p> <p>When passwords are disabled, they cannot be re-enabled without clearing PLC memory.</p>
Stop-Mode I/O Scanning	<p>Specifies whether the I/O is scanned while the PLC is in Stop mode. Default: Disabled. (Always Disabled for Redundancy CPU.)</p> <p>Note: This parameter corresponds to the I/O ScanStop parameter on a Series 90-70 PLC.</p>
Watchdog Timer (ms)	<p>(Milliseconds in 10ms increments.) Requires a value that is greater than the program sweep time.</p> <p>The software watchdog timer is designed to detect "failure to complete sweep" conditions. The CPU restarts the watchdog timer at the beginning of each sweep. The watchdog timer accumulates time during the sweep. The software watchdog timer is useful in detecting abnormal operation of the application program, which could prevent the PLC sweep from completing within the watchdog time period.</p> <p>Valid range: 10 through 2550, in increments of 10.</p> <p>Default: 200.</p> <p>For details on setting the watchdog timer in a CPU redundancy system, refer to the <i>PACSystems Hot Standby CPU Redundancy User's Guide</i>, GFK-2308.</p>
Logic/Configuration Power-up Source	<p>Specifies the location/source of the logic and configuration data that is to be used (or loaded/copied into RAM) after each power up.</p> <p>Choices: Always RAM, Always Flash, Conditional Flash.</p> <p>Default: Always RAM.</p>
Data Power-up Source	<p>Specifies the location/source of the reference data that is to be used (or loaded/copied into RAM) after each power up.</p> <p>Choices: Always RAM, Always Flash, Conditional Flash.</p> <p>Default: Always RAM.</p>

¹¹ For availability, refer to the *Important Product Information* document for the CPU firmware version that you are using.

Settings Parameters	
Run/Stop Switch	<p>Enables or disables the Run/Stop Mode Switch.</p> <p>Choices:</p> <p>Enabled: Enables you to use the physical switch on the PLC to switch the PLC into Stop mode or from Stop mode into Run mode and clear non-fatal faults.</p> <p>Disabled: Disables the physical Run/Stop switch on the PLC.</p> <p>Default: Enabled.</p> <p>Note: If both serial ports are configured for any protocol other than RTU Slave or SNP Slave, the Run/Stop switch should not be disabled without first making sure that there is a way to stop the CPU, or take control of the CPU through another device such as an Ethernet interface. If the CPU can be set to Stop mode, it will switch the protocol from Serial I/O to the Stop Mode protocol (default is RTU Slave). For details on Stop mode settings, refer to “Port 1 and Port 2 Parameters” on page 58.</p> <p>This applies to Port 1 on the CPE305, which has only one serial port.</p>
Memory Protection Switch	<p>Enables or disables the Memory Protect feature associated with the Run/Stop Mode Switch.</p> <p>Choices:</p> <p>Enabled: Memory Protect is enabled, which prevents writing to program memory and configuration and forcing or overriding discrete data.</p> <p>Disabled: Memory Protect is disabled.</p> <p>Default: Disabled.</p>
Power-up Mode	<p>Selects the CPU mode to be in effect immediately after power-up.</p> <p>Choices: Last, Stop, Run.</p> <p>Default: Last (the mode it was in when it last powered down).</p> <p>Note: If the battery or Energy Pack is missing or has failed and if Logic/Configuration Power-up Source is set to Always RAM, the CPU powers up in Stop mode regardless of the setting of the Power-up Mode parameter.</p>
Modbus Address Space Mapping Type	<p>Specifies the type of memory mapping to be used for data transfer between Modbus TCP/IP clients and the PACSystems controller.</p> <p>Choices:</p> <p>Disabled: The “Disabled” setting is intended for use in systems containing Ethernet firmware that does not support Modbus TCP.</p> <p>Standard Modbus Addressing: Causes the Ethernet firmware to use the standard map, which is displayed on the Modbus TCP Address Map tab.</p> <p>Default: Disabled</p> <p>For details on the PACSystems implementation of Modbus/TCP server, refer to <i>TCP/IP Communications for PACSystems</i>, GFK-2224.</p>
Universal Serial Bus	<p>RX3i CPE305/CPE310 CPUs only. Enables or disables the USB port for use with RDSD (removable data storage devices). The USB port is enabled by default in the CPE305/CPE310 and in the hardware configuration.</p> <p>If a CPU310 configuration is stored to a CPE310, the USB port will be enabled.</p>

3.2.2 Modbus TCP Address Map

This read-only tab displays the standard mapping assignments between Modbus address space and the CPU address space. Ethernet modules and daughterboards in the PACSystems controller use Modbus-to-PLC address mapping based on this map.

Modbus Register	The Modbus protocol uses five reference table designations: 0xxxx Coil Table. Mapped to the %Q table in the CPU. 1xxxx Input Discrete Table. Mapped to the %I table in the CPU. 3xxxx Input Register Table. Mapped to the %AI register table in the CPU. 4xxxx Holding Register Table. Mapped to the %R table in the CPU. 6xxxx File Access Table. Mapped to the %W table in the CPU.
Start Address	Lists the beginning address of the mapped region.
End Address	Lists the ending address of the mapped region. For word memory types (%AI, %R and %W) the highest address available is configured on the Memory tab.
PLC Memory	Lists the memory type of the mapped region.
Length	Displays the length of the mapped region.

3.2.3 Scan Parameters

These parameters determine the characteristics of CPU sweep execution.

Scan Parameters	
Sweep Mode	<p>The sweep mode determines the priority of tasks the CPU performs during the sweep and defines how much time is allotted to each task. The parameters that can be modified vary depending on the selection for sweep mode.</p> <p>The Controller Communications Window, Backplane Communications Window, and Background Window phases of the PLC sweep can be run in various modes, based on the PLC sweep mode.</p> <p>Choices:</p> <ul style="list-style-type: none"> ▪ Normal mode: The PLC sweep executes as quickly as possible. The overall PLC sweep time depends on the logic program and the requests being processed in the windows and is equal to the time required to execute the logic in the program plus the respective window timer values. The window terminates when it has no more tasks to complete. This is the default value. ▪ Constant Window mode: Each window operates in a Run-to-Completion mode. The PLC alternates among three windows for a time equal to the value set for the window timer parameter. The overall PLC sweep time is equal to the time required to execute the logic program plus the value of the window timer. This time may vary due to sweep-to-sweep differences in the execution of the program logic. ▪ Constant Sweep mode: The overall PLC sweep time is fixed. Some or all of the windows at the end of the sweep might not be executed. The windows terminate when the overall PLC sweep time has reached the value specified for the Sweep Timer parameter.

Scan Parameters	
Logic Checksum Words	The number of user logic words to use as input to the checksum algorithm each sweep. Valid range: 0 through 32760, in increments of 8. Default: 16.
Controller Communication Window Mode	(Available only when Sweep Mode is set to <i>Normal</i> .) Execution settings for the Controller Communications Window. Choices: <ul style="list-style-type: none"> ▪ Complete: The window runs to completion. There is no time limit. ▪ Limited: Time sliced. The maximum execution time for the Controller Communications Window per scan is specified in the Controller Communications Window Timer parameter. Default: Limited. Note: This parameter corresponds to the Programmer Window Mode parameter on a Series 90-70 PLC.
Controller Communications Window Timer (ms)	(Available only when Sweep Mode is set to <i>Normal</i> . Read-only if the Controller Communications Window Mode is set to Complete.) The maximum execution time for the Controller Communications Window per scan. This value cannot be greater than the value for the watchdog timer. The valid range and default value depend on the Controller Communications Window Mode: <ul style="list-style-type: none"> ▪ Complete: There is no time limit. ▪ Limited: Valid range: 0 through 255ms. Default: 10. Note: This parameter corresponds to the Programmer Window Timer parameter on a Series 90-70 PLC.
Backplane Communication Window Mode	(Available only when Sweep Mode is set to <i>Normal</i> .) Execution settings for the Backplane Communications Window. Choices: <p>Complete: The window runs to completion. There is no time limit.</p> <p>Limited: Time sliced. The maximum execution time for the Backplane Communications Window per scan is specified in the Backplane Communications Window Timer parameter.</p> Default: Complete.
Backplane Communications Window Timer (ms)	(Available only when Sweep Mode is set to <i>Normal</i> . Read-only if the Backplane Communications Window Mode is set to <i>Complete</i> .) The maximum execution time for the Backplane Communications Window per scan. This value can be greater than the value for the watchdog timer. The valid range and the default depend on the Backplane Communications Window Mode: <ul style="list-style-type: none"> ▪ Complete: There is no time limit. The Backplane Communications Window Timer parameter is read-only. ▪ Limited: Valid range: 0 through 255ms. Default: 255. (10ms for Redundancy CPUs.)

Scan Parameters	
Background Window Timer (ms)	(Available only when Sweep Mode is set to <i>Normal</i> .) The maximum execution time for the Background Communications Window per scan. This value cannot be greater than the value for the watchdog timer. Valid range: 0 through 255 Default: 0 (5ms for Redundancy CPUs)
Sweep Timer (ms)	(Available only when Sweep Mode is set to <i>Constant Sweep</i> .) The maximum overall PLC scan time. This value cannot be greater than the value for the watchdog timer. Some or all of the windows at the end of the sweep might not be executed. The windows terminate when the overall PLC sweep time has reached the value specified for the Sweep Timer parameter. Valid range: 5 through 2550, in increments of 5. If the value typed is not a multiple of 5ms, it is rounded to the next highest valid value. Default: 100.
Window Timer (ms)	(Available only when Sweep Mode is set to <i>Constant Window</i> .) The maximum combined execution time per scan for the Controller Communications Window, Backplane Communications Window, and Background Communications Window. This value cannot be greater than the value for the watchdog timer. Valid range: 3 through 255, in increments of 1. Default: 10.
Number of Last Scans	(Available only for CPUs with firmware version 1.5 and greater.) The number of scans to execute after the PACSystems CPU receives an indication that a transition from Run to Stop mode should occur. (Used for Stop and Stop Fault, but not Stop Halt.) Choices: 0, 1, 2, 3, 4, 5. Default: 0 when creating a new PACSystems target. 0 when converting a Series 90-70 target to a PACSystems target. 1 when converting a Series 90-30 target to a PACSystems target.

3.2.4 Memory Parameters

The PACSystems user memory contains the application program, hardware configuration (HWC), registers (%R), bulk memory (%W), analog inputs (%AI), analog outputs (%AQ), and managed memory. Managed memory consists of allocations for symbolic variables and I/O variables. The symbolic variables feature allows you to create variables without having to manually locate them in memory. An I/O variable is a symbolic variable that is mapped to the inputs and outputs of a module in the hardware configuration. For details on using symbolic variables and I/O variables, refer to Chapter 7. The amount of memory allocated to the application program and hardware configuration is automatically determined by the actual program (including logic C data, and %L and %P), hardware configuration (including EGD and AUP), and symbolic variables created in the programming software. The rest of the user memory can be configured to suit the application. For example, an application may have a relatively large program that uses only a small amount of register and analog memory. Similarly, there might be a small logic program but a larger amount of memory needed for registers and analog inputs and outputs.

Appendix B provides a summary of items that count against user memory.

Calculation of Memory Required for Managed Memory

The total number of bytes required for symbolic and I/O variables is calculated as follows:

$[(\text{number of symbolic discrete bits}) \times 3] / (8 \text{ bits/byte})]$

+ $[(\text{number of I/O discrete bits}) \times M_d] / (8 \text{ bits/byte})]$

+ $[(\text{number of symbolic words}) \times (2 \text{ bytes/word})]$

+ $[(\text{number of I/O words}) \times (M_w \text{ bytes/word})]$

$M_d = 3$ or 4 . The number of bits is multiplied by 3 to keep track of the force, transition, and value of each bit. If point faults are enabled, the number of I/O discrete bits is multiplied by 4.

$M_w = 2$ or 3 . There are two 8-bit bytes per 16-bit word. If point faults are enabled, the number of bytes is multiplied by 3 because each I/O word requires an extra byte.

Calculation of Total User Memory Configured

The total amount of configurable user memory (in bytes) configured in the CPU is calculated as follows:

total managed memory (bytes)

+ total reference words \times (2 bytes/word)

+ *[if Point Faults are enabled]* (total words of %AI memory + total words of %AQ memory) \times (1 byte / word)

+ *[if Point Faults are enabled]* (total bits of %I memory + total bits of %Q memory) / 8 bits/byte)

Note: The total number of reference points is considered system memory and is not counted against user memory.

Memory Allocation Configuration

Memory Parameters	
Reference Points	
%I Discrete Input, %Q Discrete Output, %M Internal Discrete, %S System, %SA System, %SB System, %SC System, %T Temporary Status, %G Genius Global	The upper range for each of these memory types. Read only.
Total Reference Points	Read only. Calculated by the programming software.
Reference Words	
%AI Analog Input	Valid range: 0 through 32,640 words. Default: 64
%AQ Analog Output	Valid range: 0 through 32,640 words. Default: 64
%R Register Memory	Valid range: 0 through 32,640 words. Default: 1024.
%W Bulk Memory	Valid range: 0 through maximum available user RAM. Increments of 2048 words. Default: 0.
Total Reference Words	Read only. Calculated by the programming software.
Managed Memory	
Symbolic Discrete (Bits)	The configured number of bits reserved for symbolic discrete variables. Valid range: 0 through 83,886,080 in increments of 32768 bits. Default: 32,768.
Symbolic Non-Discrete (Words)	The configured number of 16-bit register memory locations reserved for symbolic non-discrete variables. Valid range: 0 through 5,242,880 in increments of 2048 words. Default: 65,536.
I/O Discrete (Bits)	The configured number of bits reserved for discrete IO variables. Valid range: 0 through 83,886,080 in increments of 32768 bits. Default: 0
I/O Non-Discrete (Words)	The configured number of 16-bit register memory locations reserved for non-discrete IO variables. Valid range: 0 through 5,242,880 in increments of 2048 words. Default: 0
Total Managed Memory Required (Bytes)	Read only. See page 54 for calculation.
Total User Memory Required (Bytes)	Read only. See page 54 for calculation.
Point Fault References	The Point Fault References parameter must be enabled if you want to use fault contacts in your logic. Assigning point fault references causes the CPU to reserve additional memory. When you download both the HWC and the logic to the PLC, the download routine checks if there are fault contacts in the logic and if there are, it checks if the HWC to download has the Point Fault References parameter set to Enabled. If the parameter is Disabled, an error is displayed in the Feedback Zone. When you download only logic to the PLC, the download routine checks if there are fault contacts in the logic and if there are, it checks if the HWC on the PLC has the Point Fault References parameter set to Enabled. If the parameter is Disabled, an error is displayed in the Feedback Zone.

3.2.5 Fault Parameters

You can configure each fault action to be either diagnostic or fatal.

A **diagnostic fault** does not stop the PLC from executing logic. It sets a diagnostic variable and is logged in a fault table.

A **fatal fault** transitions the PLC to the Stop Faulted mode. It also sets a diagnostic variable and is logged in a fault table.

Fault Parameters	
Loss of or Missing Rack	(Fault group 1.) When BRM failure or loss of power loses a rack or when a configured rack is missing, system variable #LOS_RCK (%SA12) turns ON. (To turn it OFF, fix the hardware problem and cycle power on the rack.) Default: Diagnostic.
Loss of or Missing I/O Controller	(Fault group 2.) When a Bus Controller stops communicating with the PLC or when a configured Bus Controller is missing, system variable #LOS_IOC (%SA13) turns ON. (To turn it OFF, replace the module and cycle power on the rack containing the module.) Default: Diagnostic.
Loss of or Missing I/O Module	(Fault group 3.) When an I/O module stops communicating with the PLC CPU or a configured module is missing, system variable #LOS_IOM (%SA14) turns ON. (To turn it OFF, replace the module and cycle power on the rack containing the module.) Default: Diagnostic.
Loss of or Missing Option Module	(Fault group 4.) When an option module stops communicating with the PLC CPU or a configured option module is missing, system variable #LOS_SIO (%SA15) turns ON. (To turn it OFF, replace the module and cycle power on the rack containing the module.) Default: Diagnostic.
System Bus Error	(Fault group 12.) When a bus error occurs on the backplane, system variable #SBUS_ER (%SA32) turns ON. (To turn it OFF, cycle power on the main rack.) Default: Fatal.
I/O Controller or I/O Bus Fault	(Fault group 9.) When a Bus Controller reports a bus fault, a global memory fault, or an IOC hardware fault, system variable #IOC_FLT (%SA22) turns ON. (To turn it OFF, cycle power on the rack containing the module when the configuration matches the hardware after a download.) Default: Diagnostic.
System Configuration Mismatch	(Fault group 11.) When a configuration mismatch is detected during system power-up or during a download of the configuration, system variable #CFG_MM (%SA9) turns ON. (To turn it OFF, power up the PLC when no mismatches are present or download a configuration that matches the hardware.) This parameter determines the fault action when the CPU is not running . If a system configuration mismatch occurs when the CPU is in Run mode, the fault action will be Diagnostic. This prevents the running CPU from going to STOP/FAULT mode. To override this behavior, see "Configuring the CPU to Stop Upon Loss of a Critical Module" on page 57. Default: Fatal.
Fan Kit Failure	(Fault group 0x17.) When a fault is detected in the Smart Fan kit, system variable #FAN_FLT (%SA7) turns ON. (To turn a fan kit fault OFF, clear the PLC fault table or reset the PLC.) Default: Diagnostic.
Recoverable Local Memory Error	Redundancy CPUs only. (Fault group 38) Determines whether a single-bit ECC error causes the CPU to stop or allows it to continue running. Choices: Diagnostic, Fatal. Default: Diagnostic. Note: When a multiple-bit ECC error occurs, a Fatal Local Memory Error fault (error code 169) is logged in the CPU Hardware Fault Group (group number 13).

Fault Parameters	
CPU Over Temperature	(Fault group 24, error code 1.) When the operating temperature of the CPU exceeds the normal operating temperature, system variable #OVR_TMP (%SA8) turns ON. (To turn it OFF, clear the Controller Fault Table or reset the PLC.) Default: Diagnostic.
Controller Fault Table Size	(Read-only.) The maximum number of entries in the Controller Fault Table. Value set to 64.
I/O Fault Table Size	(Read-only.) The maximum number of entries in the I/O Fault Table. Value set to 64.

Configuring the CPU to Stop Upon the Loss of a Critical Module

In some cases, you may want to override the Run mode behavior of the System Configuration Mismatch fault. A given module may be critical to the PLC's ability to properly control a process. In this case, if the module fails then it may be better to have the CPU go to stop mode, especially if the CPU is acting as a backup unit in a redundant system.

One way to cause the CPU to stop is to set the configured action for a Loss-of-Module fault to *Fatal* so that the CPU stops if a module failure causes a loss-of-module fault. The correct loss-of-module fault must be chosen for the critical module of interest: I/O controller, I/O module, and Option module. The Ethernet communications module is an example of an Option module.

This approach has a couple of disadvantages. First, it applies to all modules of that category, which may include modules that are not critical to the process. Second, it relies on the content of the fault table. If the table is cleared via program logic or user action, the CPU will not stop.

In systems that use Ethernet Network Interface Units (ENIUs) for remote I/O, a critical module of interest may be the Ethernet module that provides the network connection to the ENIU. Other techniques can be used to provide a more selective response to an Ethernet module failure than the Loss-of-Option module fault. One technique is to use application logic to monitor the Ethernet Interface Status bits, which are described in "Monitoring the Ethernet Interface Status Bits" in the *TCP/IP Ethernet for PACSystems User's Manual*, GFK-2224. If the logic determined that a critical Ethernet module was malfunctioning, it could execute SVC_REQ #13 to stop the CPU.

Since the ENIU uses Ethernet Global Data to communicate with the PACSystems CPU, another selective technique is to monitor the Exchange Status Words to determine the health of individual EGD exchanges. For details on this status word, refer to "Exchange Status Word Error Codes" in GFK-2224. Because the types of errors indicated by the exchange status word may be temporary in nature, stopping the CPU may not be an appropriate response for these errors. Nevertheless, the status could be used to tailor the response of the application to changing conditions in the EGD network.

In some cases the critical module may reside in an expansion rack. In that case, in addition to the loss-of-module fault, it is recommended to set the Loss-of-Rack fault to *Fatal*. Then if the rack fails or loses power, the CPU will go to stop mode.

3.2.6 Redundancy Parameters (Redundancy CPUs Only)

These parameters apply only to redundancy CPUs. For details on configuring CPU for redundancy, refer to the *PACSystems Hot Standby CPU Redundancy User's Guide*, GFK-2308.

3.2.7 Transfer List

These parameters apply only to redundancy CPUs. For details on configuring CPU for redundancy, refer to the *PACSystems Hot Standby CPU Redundancy User's Guide*, GFK-2308.

3.2.8 Port 1 and Port 2 Parameters

These parameters configure the operating characteristics of the CPU serial ports. Ports 1 and 2 have the same set of configuration parameters. The protocol (Port Mode) determines the parameters that can be set for each port.

Port Parameters	
Port Mode	<p>The protocol to execute on the serial port. Determines the list of parameters displayed on the Port tab. Only the parameters required by the selected protocol are displayed.</p> <p>Choices:</p> <ul style="list-style-type: none"> ▪ RTU Slave mode: Reserved for the use of the Modbus RTU Slave protocol. This mode also permits connection to the port by an SNP master, such as the WinLoader utility or the programming software. ▪ Message mode: The port is open for user logic access. This mode enables C language blocks to perform serial port I/O operations via the C Runtime Library functions. ▪ Available: The port is not to be used by the PLC firmware. (The CPE305 does not support this selection.) ▪ SNP Slave: Reserved for the exclusive use of the SNP slave. This mode permits connection to the port by an SNP master, such as the WinLoader utility or the programming software. ▪ Serial I/O: Enables you to perform general-purpose serial communications by using COMMREQ functions. <p>Default: RTU Slave.</p> <p>Note: If both serial ports are configured for any protocol other than RTU Slave or SNP Slave, the Run/Stop switch should not be disabled without first making sure that there is a way to stop the CPU, or take control of the CPU through another device such as the Ethernet module. The Serial I/O protocol is only active when the CPU is in run mode. If the CPU can be set to Stop mode, it will switch the protocol from Serial I/O to the Stop Mode protocol (default is RTU Slave). If an SNP Master, such as the programming software in Serial mode, begins communicating on a port, the RTU protocol automatically switches to SNP Slave. As long as the CPU can be stopped, the protocol of the port can be auto-switched to one that enables serial programmer connection. For Stop Mode protocols, see page 60.</p> <p>If the Ethernet module is available, you can control the CPU by connecting the Machine Edition programming software to the Ethernet port.</p>
Station Address	<p>(RTU Slave only) ID for the RTU Slave.</p> <p>Valid range: 1 through 247.</p> <p>Default: 1.</p> <p>Note: You should avoid using station address 1 for any other Modbus slave in a PACSystems control system because the default station address for the CPU is 1. The CPU uses the default address in two situations:</p> <ol style="list-style-type: none"> 1. If you power up without a configuration, the default station address of 1 is used. 2. When the Port Mode parameter is set to Message Mode, and Modbus becomes the protocol in stop mode, the station address defaults to 1. <p>In either of these situations, if you have a slave configured with a station address of 1, confusion may result when the CPU responds to requests intended for that slave.</p> <p>Note: The least significant bit of the first byte must be 0. For example, in a station address of 090019010001, 9 is the first byte.</p>
Data Rate	<p>(All Port Modes except "Available".) Data rate (bits per second) for the port.</p> <p>Choices: 1200 Baud, 2400 Baud, 4800 Baud, 9600 Baud, 19.2k Baud, 38.4k Baud, 57.6k Baud, 115.2k Baud.</p> <p>Default: 19.2k Baud.</p>

Port Parameters	
Data Bits	(Available only when Port Mode is set to Message mode or Serial I/O.) The number of bits in a word for serial communication. SNP uses 8-bit words. Choices: 7, 8. Default: 8.
Flow Control	(RTU slave, Message Mode, or Serial I/O.) Type of flow control to be used on the port. Choices: <ul style="list-style-type: none"> ▪ For Serial I/O Port Mode: None, Hardware, Software (XON/XOFF). ▪ For all other Port Modes: None, Hardware. Default: None. Note: The Hardware flow-control is RTS/CTS crossed.
Parity	(All Port Modes except Available.) The parity used in serial communication. Can be changed if required for communication over modems or with a different SNP master device. Choices: None, Odd, Even. Default: Odd.
Stop bits	(Available only when Port Mode is set to Message Mode, SNP Slave or Serial I/O.) The number of stop bits for serial communication. SNP uses 1 stop bit. Choices: 1, 2. Default: 1.
Physical Interface	(All port modes except Available.) The type of physical interface that this protocol is communicating over. Choices: <ul style="list-style-type: none"> ▪ 2-wire: There is only a single path for receive and transmit communications. The receiver is disabled while transmitting. ▪ 4-wire: There is a separate path for receive and transmit communications and the transmit line is driven only while transmitting. ▪ 4-wire Transmitter on: There is a separate path for receive and transmit communications and the transmit line is driven continuously. Note that this choice is not appropriate for SNP multi-drop communications, since only one device on the multi-drop line can be transmitting at a given time. Default: 4-wire Transmitter On.
Turn Around Delay Time (ms)	(Available only when Port Mode is set to SNP Slave.) The Turn Around Delay Time is the minimum time interval required between the reception of a message and the next transmission. In 2-wire mode, this interval is required for switching the direction of data transmission on the communication line. Valid range: 0 through 2550ms, in increments of 10. Default: 0.
Timeout (s)	(Available only when Port Mode is set to SNP Slave.) The maximum time that the slave will wait to receive a message from the master. If a message is not received within this timeout interval, the slave will assume that communications have been disrupted, and then it will wait for a new attach message from the master. Valid range: 0 through 60 seconds. Default: 10.
SNP ID	(Available only when Port Mode is set to SNP Slave.) The port ID to be used for SNP communications. In SNP multi-drop communications, this ID is used to identify the intended receiver of a message. This parameter can be left blank if communication is point to point. To change the SNP ID, click the values field and enter the new ID. The SNP ID is up to seven characters long and can contain the alphanumeric characters (A through Z, 0 through 9) or the underline (_).

Port Parameters													
Specify Stop Mode	<p>(All port modes except Available.) Determines whether you accept the default stop mode or set it yourself. Choices: No: The default stop mode is used. Yes: The stop mode parameters appear and you can select the stop mode. If you set the stop mode to the same protocol as the run mode, then the other stop mode parameters are read-only and are set to the same values as for the run mode. Default: No.</p>												
Stop Mode	<p>(Available only when Specify stop mode is set to Yes.) The stop mode protocol to execute on the serial port. If you set the stop mode to the same protocol as for the run mode, then the other stop mode parameters are read-only and are set to the same values as for the run mode. Choices and defaults are determined by the Port Mode setting.</p> <ul style="list-style-type: none"> ■ SNP Slave: Reserved for the exclusive use of the SNP slave. ■ RTU Slave: Reserved for the exclusive use of the Modbus RTU Slave protocol. <p>If the Stop mode protocol is different from the Port mode protocol, you can set parameters for the Stop mode protocol. If you do not select a Stop mode protocol, the default protocol with default parameter settings is used.</p> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Port (Run) Mode</th> <th>Stop Mode</th> </tr> </thead> <tbody> <tr> <td>RTU Slave</td> <td>Choices: SNP Slave, RTU Slave Default: RTU Slave.</td> </tr> <tr> <td>Message Mode</td> <td>Choices: SNP Slave, RTU Slave Default: RTU Slave.</td> </tr> <tr> <td>Available</td> <td>Available (Not supported on CPE305)</td> </tr> <tr> <td>SNP Slave</td> <td>SNP Slave</td> </tr> <tr> <td>Serial I/O</td> <td>Choices: SNP Slave, RTU Slave Default: RTU Slave.</td> </tr> </tbody> </table> <p>Note: Setting the Port Mode to RTU Slave and the Stop Mode to SNP Slave may cause loss of programmer connection and delayed reconnection when the controller transitions from Stop to Run mode. To avoid this behavior, select SNP Slave for the Port Mode and do not specify a Stop Mode. For additional details, see “RTU Slave/SNP Slave Operation With Programmer Attached” in Chapter 14.</p>	Port (Run) Mode	Stop Mode	RTU Slave	Choices: SNP Slave, RTU Slave Default: RTU Slave.	Message Mode	Choices: SNP Slave, RTU Slave Default: RTU Slave.	Available	Available (Not supported on CPE305)	SNP Slave	SNP Slave	Serial I/O	Choices: SNP Slave, RTU Slave Default: RTU Slave.
Port (Run) Mode	Stop Mode												
RTU Slave	Choices: SNP Slave, RTU Slave Default: RTU Slave.												
Message Mode	Choices: SNP Slave, RTU Slave Default: RTU Slave.												
Available	Available (Not supported on CPE305)												
SNP Slave	SNP Slave												
Serial I/O	Choices: SNP Slave, RTU Slave Default: RTU Slave.												
Turn Around Delay Time (ms)	<p>(Available only when Stop Mode is set to SNP Slave.) The Turn Around Delay Time is the minimum time interval required between the reception of a message and the next transmission. In 2-wire mode, this interval is required for switching the direction of data transmission on the communication line. Valid range: 0 through 2550ms, in increments of 10. Default:</p> <ul style="list-style-type: none"> ■ When the Stop Mode is different from the Port Mode: 0ms. ■ When the Stop Mode is the same as the Port Mode: the value is read-only and is set to the same value as the Turn Around Delay Time for the Port Mode. 												
Timeout (s)	<p>(Available only when Stop Mode is set to SNP Slave.) The maximum time that the slave will wait to receive a message from the master. If a message is not received within this timeout interval, the slave will assume that communications have been disrupted, and then it will wait for a new attach message from the master. Valid range: 0 through 60 seconds. Default:</p> <ul style="list-style-type: none"> ■ When the Stop Mode is different from the Port Mode: 10 seconds. ■ When the Stop Mode is the same as the Port Mode: the value is read-only and is set to the same value as the Timeout for the Port Mode. 												

Port Parameters	
SNP ID	(Available only when Stop Mode is set to SNP Slave.) The port ID to be used for SNP communications. In SNP multi-drop communications, this ID is used to identify the intended receiver of a message. This parameter can be left blank if communication is point to point. To change the SNP ID, click the values field and enter the new ID. The SNP ID is up to seven characters long and can contain the alphanumeric characters (A through Z, 0 through 9) or the underline (_). Default: <ul style="list-style-type: none"> ▪ When the Stop Mode is different from the Port Mode: the default is blank. ▪ When the Stop Mode is the same as the Port Mode: the value is read-only and is set to the same value as the SNP ID for the Port Mode.
Station Address	(Available only when Stop Mode is set to RTU slave.) ID for the RTU Slave. Valid range: 1 through 247. Default: <ul style="list-style-type: none"> ▪ When the Stop Mode is different from the Port Mode: 1. ▪ When the Stop Mode is the same as the Port Mode: the value is read-only and is set to the same value as the Station Address for the Port Mode.

3.2.9 Scan Sets Parameters

You can create multiple sets of asynchronous I/O scans, with a unique scan rate assigned to each scan set. You can assign up to 31 scan sets for a total of 32. Scan set 1 is the standard scan set where I/O is scanned once per sweep. Each module is assigned to a scan set during the configuration of that module. Scan Set 1 is the default scan set.

Scan Set Parameters	
Number	A sequential number from 1 to 32 is automatically assigned to each scan set. Scan set 1 is reserved for the standard scan set.
Scan Type	Determines whether the scan set is enabled (as a fixed scan) or is disabled. Choices: Disabled, Fixed Scan. Default: Disabled.
Number of Sweeps	(Editable only when the Scan Type is set to Fixed Scan.) The scan rate of the scan set. Double-click the field, then select a value. A value of 0 prevents the I/O from being scanned. Valid range: 0 through 64. Default: 1.
Output Delay	(Editable only when the Number of Sweeps is non-zero.) The number of sweeps that the output scan is delayed after the input scan has occurred. Double-click on field, then select a value. Valid range: 0 to (number of Sweeps - 1) Default: 0.
Description	(Editable only when the Scan Type is set to Fixed Scan.) Brief description of the scan set (32 characters maximum).

3.2.10 Power Consumption Parameters

The programming software displays the power consumed by the CPU (in Amps) for each voltage provided by the power supply.

3.2.11 Access Control

The Access Control list allows you to specify the reference address ranges that can be accessed by non-local devices such as HMI's and other controllers. To use this feature, Enhanced Security must be enabled in the properties of the target.

When Enhanced Security mode is enabled, any reference address range not defined **cannot** be accessed by other devices. External reads and writes that do not exist in the table are rejected by the firmware.

If overlapping memory ranges are defined, they must have the same Access level.

For symbolic variables, access control is specified by the *Publish* property of the variable, which includes a Read Only and Read/Write setting.

Note: When requesting data from an external device, some drivers packetize data to optimize communication. If a request attempts to read a value that is not published, the entire packet will fail. A fault has been added to the fault table to help you understand a failed read/write. After addressing the fault, you must clear the fault in order to try again.

Access Control List Settings

Memory Area	The memory area in which the reference address range is defined. Default: Select an Area Choices: %AI Analog Input, %AQ Analog Output, %I Discrete Input, %G Genius Global, %M Internal Discrete, %Q Discrete Output, %R Register Memory, %S System, %SA System, %SB System, %SC System, %T Temporary Status, %W Bulk Memory.
Start	The starting offset of the reference address range. Default: 0 (not valid) Valid range: For %S, %SA, %SB and %SC, must be 1. All other memory types: 1 through the upper limit of the reference address range. Must be less than the End value.
End	The ending offset of the reference address range. Default: 0 (not valid) Valid range: For %S, %SA, %SB and %SC, must be 128. All other memory types: Any value greater than Start, through the upper limit of the reference address range. For word memory types (%AI, %R and %W) the highest address available is configured on the Memory tab.
Access	Selects the type of external access allowed for the defined address range. Choices: Read-Only, Read/Write Default: Read-Only

3.3. Setting a Temporary IP Address

Note: The CPE305/CPE310 does not support setting a temporary IP address. The IP address can be set by connecting through a serial port or over Ethernet using the factory-set default IP address.

To initiate Ethernet communications between the programming software and the Controller, you first need to set an IP address. You can use the Set Temporary IP Address utility to specify an IP address or download a hardware configuration with an IP address through a serial port.

The following restrictions apply when using the Set Temporary IP Address utility:

- To use the Set Temporary IP Address utility, the PLC CPU must not be in RUN mode. IP address assignment over the network will not be processed until the CPU is stopped and is not scanning outputs.
- The Set Temporary IP Address utility does not function if communications with the networked PACSystems target travel through a router. The Set Temporary IP Address utility can be used if communications with the networked PACSystems target travel across network switches and hubs.
- The current user logged on the computer running the Set Temporary IP Address utility must have full administrator privileges.
- The target PACSystems must be located on the same local sub-network as the computer running the Set Temporary IP Address utility. The sub-network is specified by the computer's subnet mask and the IP addresses of the computer and the PACSystems Ethernet Interface.

Note: To set the IP address, you will need the MAC address of the Ethernet Interface.

1. Connect the PACSystems to the Ethernet network.
2. In the Project tab of the Navigator, right click the PACSystems target, choose Offline Commands, and then choose Set Temporary IP Address. The Set Temporary IP Address dialog box appears.
3. In the Set Temporary IP Address dialog box, do the following:
 - Specify the MAC address.
 - In the IP Address to Set box, specify the temporary IP address you want to set on the PACSystems.
 - If necessary, select the Enable Network Interface Selections check box and specify the IP address of the network interface on which the PACSystems is located.
4. When the fields are properly configured, click the Set IP button.
5. The IP Address of the specified PACSystems will be set to the indicated address. This may take up to a minute.

After the programmer is connected, the actual IP address

for the Ethernet interface, which is set in the hardware configuration, should be downloaded to the controller.

The temporary IP address remains in effect until the Ethernet interface is restarted, power-cycled or until the hardware configuration is downloaded or cleared.

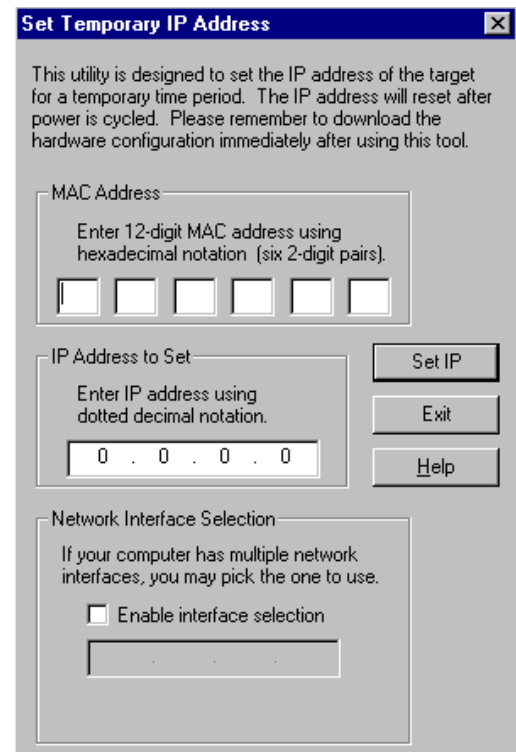


Figure 4: Set Temporary IP Address



Caution

The temporary IP address set by the Set Temporary IP Address utility is not retained through a power cycle. To set a permanent IP Address, you must set the IP Address property of the target and download (store) HWC to the PACSystems.

The Set Temporary IP Address utility can assign a temporary IP address even if the target Ethernet Interface has previously been configured to a non-default IP address. (This includes overriding an IP address previously configured by the programmer.)

Use this IP Address assignment mechanism with care..

3.4. Storing (Downloading) Hardware Configuration

A PACSystems control system is configured by creating a configuration file in the programming software, then transferring (downloading) the file from the programmer to the CPU via serial port1, serial port 2, or an Ethernet Interface. If you use a serial port, it must be configured as RTU Slave (default) or SNP Slave.

The CPU stores the configuration file in its non-volatile RAM memory. After the configuration is stored, I/O scanning is enabled or disabled according to the newly stored configuration parameters.

Before you can use an Ethernet Interface to store the hardware configuration to the PACSystems, you must first set the IP address in the Ethernet Interface either by using the Set Temporary IP Address utility (see page 63) or by downloading a hardware configuration through a serial connection.

1. In the programmer software, go to the Project tab of the Navigator, right click the Target, and choose Go Online.
2. Right click the Target and choose Online Commands, Set Programmer Mode. Make sure the CPU is in Stop mode.
3. Right click the Target node, and choose Download to Controller.
4. In the Download to Controller dialog box, select the items to download and click OK.

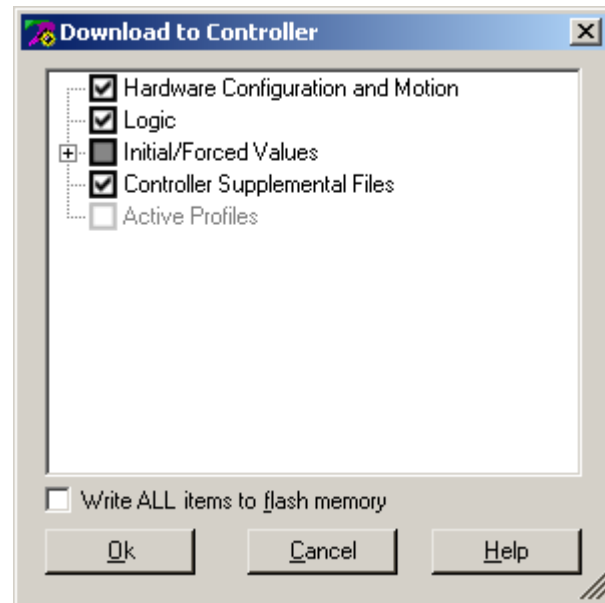


Figure 5: Downloading Hardware Configuration to CPU

Notes: If you download to a PACSystems target that already has a project on it, the existing project is overwritten.

If I/O variables are configured, hardware configuration and logic cannot be stored independently. They must be stored at the same time.

If passwords have been set, when you go online, you will be taken to the highest unprotected level. If no passwords have been set, you will go online with Privilege Level 4.

3.5. Configuring the Embedded Ethernet Interface

Before you can use the embedded Ethernet Interface, you must configure it using the programming software. To configure the embedded Ethernet interface:

1. In the Project tab of the Navigator, expand your PACSystems Target, the hardware configuration, and the main rack (Rack 0).
2. Expand the CPU slot (Slot 1). The Ethernet Interface daughterboard is displayed as *Ethernet*.
3. Right click the daughterboard slot and choose Configure. The Parameter Editor window displays the Ethernet Interface parameters.

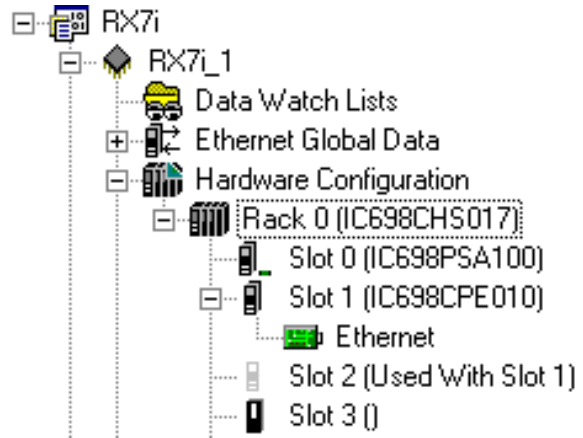


Figure 6: Selecting Embedded Ethernet for Configuration

Ethernet interface configuration includes the following additional procedures. For details on completing these steps, refer to the *TCP/IP Ethernet Communications for PACSystems User's Manual*, GFK-2224.

- Assigning an IP address for initial network operation, such as connecting the programmer to download the hardware configuration, using the Set Temporary IP Address utility (see page 63) or by downloading a hardware configuration through a serial connection.
- Configuring the characteristics of the Ethernet interface.
- Configuring Ethernet Global Data, if used (Not supported by CPE305/CPE310).
- (Optional, not required for most systems). Setting up the RS-232 port for Local Station Manager Operation. This is part of the basic Ethernet Interface configuration.
- (Optional, not required for most systems). Configuring advanced user parameters. This requires creating a separate ASCII parameter file that is stored to the Controller with the hardware configuration. The Ethernet Interface has a set of default Advanced User Parameter values that should be changed only in exceptional circumstances by experienced users.
- (Optional) Setting up the Controller for Modbus/TCP Server operation.

Note: When a CPE310 is configured as a CPU310, Ethernet properties cannot be configured.

The embedded Ethernet interface is *not* supported when CPE310 is configured as a CPU310 and the Ethernet port should *not* be connected to any network because it may have adverse effects on the network and/or operation of the CPU

Chapter 4 CPU Operation

This chapter describes the operating modes of a PACSystems CPU and describes the tasks the CPU carries out during these modes. The following topics are discussed:

- CPU Sweep
- Program Scheduling Modes
- Window Modes
- Run/Stop Operations
- Flash Memory Operation
- Clocks and Timers
- System Security
- I/O System
- Power-Up and Power-Down Sequences

4.1. CPU Sweep

The application program in the CPU executes repeatedly until stopped by a command from the programmer, from another device, from the Run/Stop switch on the CPU module, or a fatal fault occurs. In addition to executing the application program, the CPU obtains data from input devices, sends data to output devices, performs internal housekeeping, performs communications tasks, and performs self-tests. This sequence of operations is called the **sweep**.

The CPU sweep runs in one of three sweep modes:

Normal Sweep	In this mode, each sweep can consume a variable amount of time. The Logic Window is executed in its entirety each sweep. The Communications and Background Windows can be set to execute in Limited or Run-to-Completion mode.
Constant Sweep	In this mode, each sweep begins at a user-specified Constant Sweep time after the previous sweep began. The Logic Window is executed in its entirety each sweep. If there is sufficient time at the end of the sweep, the CPU alternates among the Communications and Background Windows, allowing them to execute until it is time for the next sweep to begin.
Constant Window	In this mode, each sweep can consume a variable amount of time. The Logic Window is executed in its entirety each sweep. The CPU alternates among the Communications and Background Windows, allowing them to execute for a time equal to the user-specified Constant Window timer.

Note: The information presented above summarizes the different sweep modes. For additional information, refer to “CPU Sweep Modes” on page 72.

The CPU also operates in one of four Run/Stop Modes (for details, see “Run/Stop Operations” on page 78):

- Run/Outputs Enabled
- Run/Outputs Disabled
- Stop/IO Scan
- Stop/No IO

4.1.1 Parts of the CPU Sweep

There are seven major phases in a typical CPU sweep as shown in the following figure.

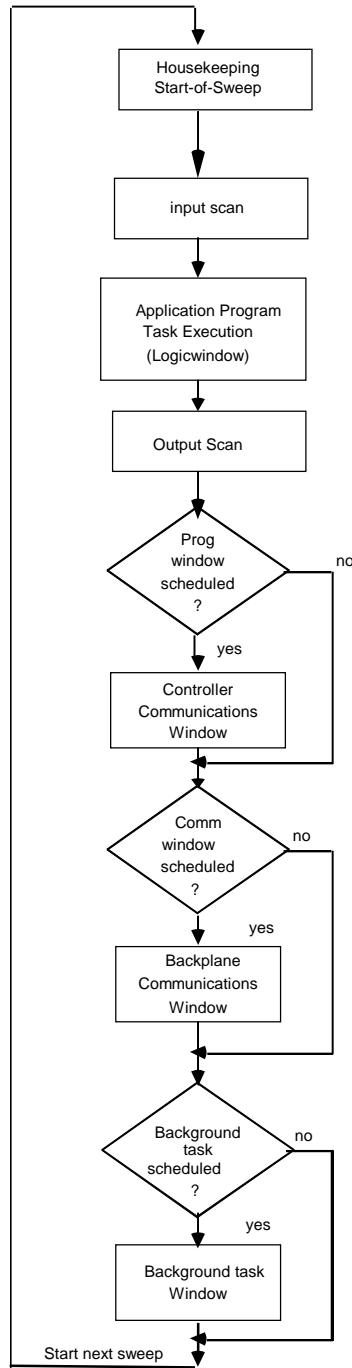


Figure 7: Major Phases of a Typical CPU Sweep

Major Phases in a Typical CPU Sweep

Phase	Activity
Housekeeping	<p>The housekeeping portion of the sweep performs the tasks necessary to prepare for the start of the sweep. This includes updating %S bits, determining timer update values, determining the mode of the sweep (Stop or Run), and polling of expansion racks.</p> <p>Expansion racks are polled to determine if power has just been applied to an expansion rack. Once an expansion rack is recognized, then configuration of that rack and all of its modules are processed in the Controller Communications Window.</p>
Input Scan	<p>During the input scan, the CPU reads input data from the Genius Bus Controllers and input modules. If data has been received on an EGD page, the CPU copies the data for that page from the Ethernet interface to the appropriate reference memory. For details, see <i>TCP/IP Ethernet Communications for PACSystems</i>, GFK-2224</p> <p>Note: The input scan is not performed if a program has an active Suspend I/O function on the previous sweep.</p>
Application Program Task Execution (Logic Window)	<p>The CPU solves the application program logic. It always starts with the first instruction in the program. It ends when the last instruction is executed. Solving the logic creates a new set of output data.</p> <p>For details on controlling the execution of programs, refer to Chapter 5.</p> <p>Interrupt driven logic can execute during any phase of the sweep. For details, refer to Chapter 5.</p> <p>A list of execution times for instructions can be found in Appendix A.</p>
Output Scan	<p>The CPU writes output data to bus controllers and output modules. The user program checksum is computed.</p> <p>During the output scan, the CPU sends output data to the Genius Bus Controllers and output modules. If the producer period of an EGD page has expired, the CPU copies the data for that page from the appropriate reference memory to the Ethernet interface. The output scan is completed when all output data has been sent.</p> <p>If the CPU is in Run mode and it is configured to perform a background checksum calculation, the background checksum is performed at the end of the output scan. The default setting for number of words to checksum each sweep is 16. If the words to checksum each sweep is set to zero, this processing is skipped. The background checksum helps ensure the integrity of the user logic while the CPU is in Run mode.</p> <p>The output scan is not performed if a program has an active Suspend I/O function on the current sweep.</p>

Phase	Activity
Controller Communications Window	<p>Services the onboard Ethernet and serial ports. In addition, reconfiguration of expansion racks and individual modules occurs during this portion of the sweep.</p> <p>The CPU always executes this window. The following items are serviced in this window:</p> <ul style="list-style-type: none"> ▪ Reconfiguration of expansion racks and individual modules. During the Controller Communications Window, highest priority is given to reconfiguration. Modules are reconfigured as needed, up to the total time allocated to this window. Several sweeps are required to complete reconfiguration of a module. ▪ Communications activity involving the embedded Ethernet port and the two serial ports of the CPU. <p>Time and execution of the Controller Communications Window can be configured using the programming software. It can also be dynamically controlled from the user program using Service Request function #3. The window time can be set to a value from 0 to 255 milliseconds (default is 10 milliseconds).</p> <p>Note that if the Controller Communications Window is set to 0, there are two alternate ways to open the window: perform a power-cycle without the battery (or Energy Pack) attached, or go to Stop mode.</p>
Backplane Communications Window	<p>Communications with intelligent devices occur during this window. The rack-based Ethernet Interface module communicates in the Backplane Communications window. During this part of the sweep the CPU communicates with intelligent modules such as the Genius Bus Controller and TCP/IP Ethernet modules.</p> <p>In this window, the CPU completes any previously unfinished request before executing any pending requests in the queue. When the time allocated for the window expires, processing stops.</p> <p>The Backplane Communications Window defaults to Complete (Run to Completion) mode. This means that all currently pending requests on all intelligent option modules are processed every sweep. This window can also run in Limited mode, in which the maximum time allocated for the window per scan is specified.</p> <p>The mode and time limit can be configured and stored to the CPU, or it can be dynamically controlled from the user program using Service Request function #4. The Backplane Communications Window time can be set to a value from 0 to 255ms (default is 255ms). This allows communications functions to be skipped during certain time-critical sweeps.</p>
Background Window	<p>CPU self-tests occur in this window.</p> <p>A CPU self-test is performed in this window. Included in this self-test is a verification of the checksum for the CPU operating system software.</p> <p>The Background Window time defaults to 0 milliseconds. A different value can be configured and stored to the CPU, or it can be changed online using the programming software.</p> <p>Time and execution of the Background Window can also be dynamically controlled from the user program using Service Request function #5. This allows background functions to be skipped during certain time-critical sweeps.</p>

4.1.2 CPU Sweep Modes

Normal Sweep Mode

In Normal Sweep mode, each sweep can consume a variable amount of time. The Logic window is executed in its entirety each sweep. The Communications windows can be set to execute in a Limited or Run-to-Completion mode. Normal Sweep is the most common sweep mode used for control system applications.

The following figure illustrates three successive CPU sweeps in Normal Sweep mode. Note that the total sweep times may vary due to sweep-to-sweep variations in the Logic window, Communications windows, and Background window.

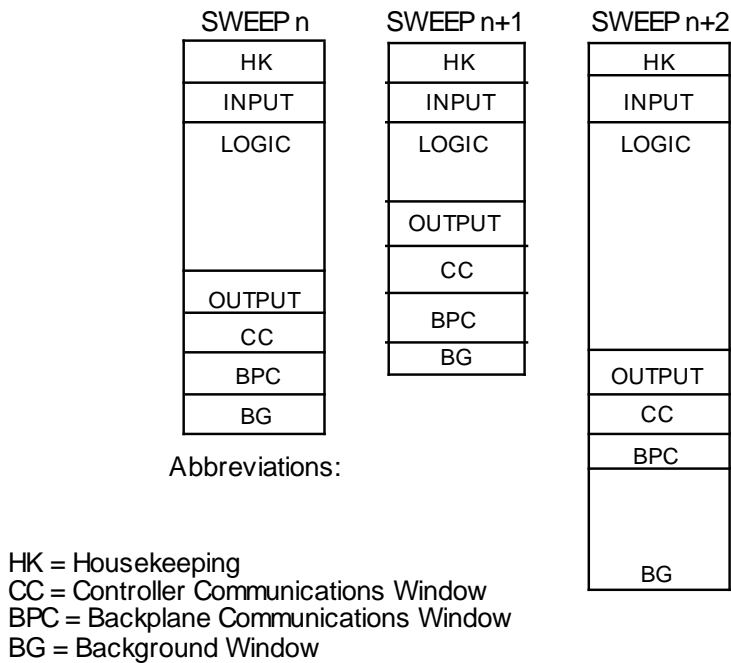


Figure 8: Typical Sweeps in Normal Sweep Mode

Constant Sweep Mode

In Constant Sweep mode, each sweep begins at a specified Constant Sweep time after the previous sweep began. The Logic Window is executed in its entirety each sweep. If there is sufficient time at the end of the sweep, the CPU alternates among the Controller Communications, Backplane Communications, and Background Windows, allowing them to execute until it is time for the next sweep to begin. Some or all of the Communications and Background Windows may not be executed. The Communications and Background Windows terminate when the overall CPU sweep time has reached the value specified as the Constant Sweep time.

One reason for using Constant Sweep mode is to ensure that I/O data are updated at constant intervals.

The value of the Constant Sweep timer can be configured to be any value from 5 to 2550 milliseconds. The Constant Sweep timer value may also be set and Constant Sweep mode may be enabled or disabled by the programming software or by the user program using Service Request function #1. The Constant Sweep timer has no default value; a timer value must be set prior to or at the same time Constant Sweep mode is enabled.

The Ethernet Global data page configured for either consumption or production can add up to 1 millisecond to the sweep time. This sweep impact should be taken into account when configuring the CPU constant sweep mode and setting the CPU watchdog timeout.

If the sweep exceeds the Constant Sweep time in a given sweep, the CPU places an oversweep alarm in the CPU fault table and sets the OV_SWP (%SA0002) status reference at the beginning of the next sweep. Additional sweep time due to an oversweep condition in a given sweep does not affect the time given to the next sweep.

The following figure illustrates four successive sweeps in Constant Sweep mode with a Constant Sweep time of 100 milliseconds. Note that the total sweep time is constant, but an oversweep may occur due to the Logic Window taking longer than normal.

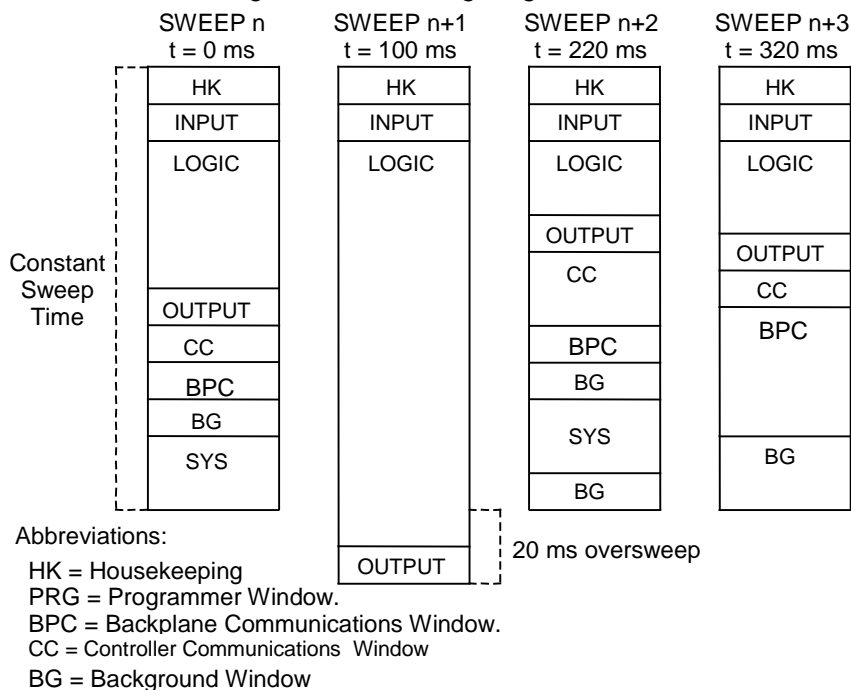


Figure 9: Typical Sweeps in Constant Sweep Mode

Constant Window Mode

In Constant Window mode, each sweep can consume a variable amount of time. The Logic Window is executed in its entirety each sweep. The CPU alternates among the three windows, allowing them to execute for a time equal to the value set for the Constant Window timer. The overall CPU sweep time is equal to the time required to execute the Housekeeping, Input Scan, Logic Window, and Output Scan phases of the sweep plus the value of the Constant Window timer. This time may vary due to sweep-to-sweep variances in the execution time of the Logic Window.

An application that requires a certain amount of time between the Output Scan and the Input Scan, permitting inputs to settle after receiving output data from the program, would be ideal for Constant Window mode.

The value of the Constant Window timer can be configured to be any value from 3 to 255 milliseconds. The Constant Window timer value may also be set by the programming software or by the user program using Service Request functions #3, #4, and #5.

The following figure illustrates three successive sweeps in Constant Window mode. Note that the total sweep times may vary due to sweep-to-sweep variations in the Logic Window, but the time given to the Communications and Background Windows is constant. Some of the Communications or Background Windows may be skipped, suspended, or run multiple times based on the Constant Window time.

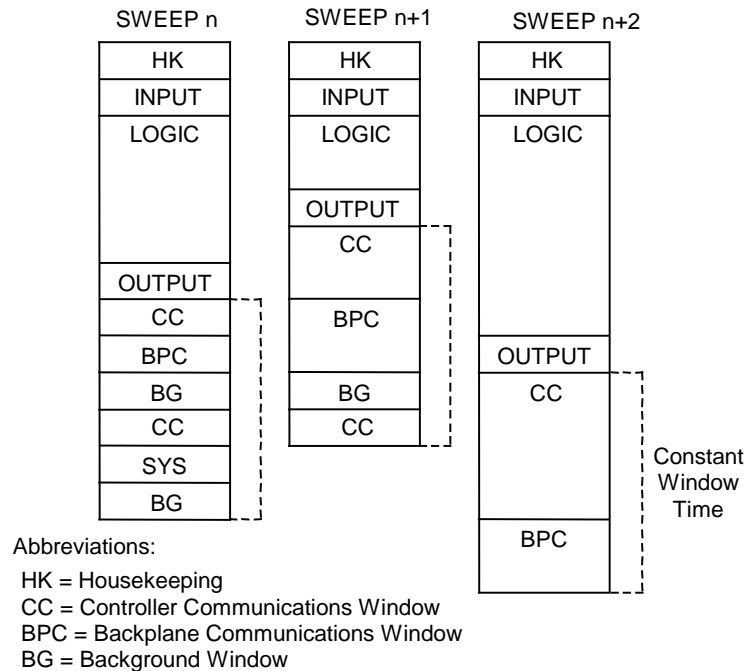


Figure 10: Typical Sweeps in Constant Window Mode

4.2. **Program Scheduling Modes**

The CPU supports one program scheduling mode: the Ordered mode. An ordered program is executed in its entirety once per sweep in the Logic Window.

4.3. Window Modes

The previous section describes the phases of a typical CPU sweep. The Controller Communications, Backplane Communications, and Background windows can be run in various modes, based on the CPU sweep mode. (CPU sweep modes are described in detail on page 72.) The following three window modes are available:

- | | |
|--------------------------|--|
| Run-to-Completion | In Run-to-Completion mode, all requests made when the window has started are serviced. When all pending requests in the given window have completed, the CPU transitions to the next phase of the sweep. (This does not apply to the Background window because it does not process requests.) |
| Constant | In Constant Window mode, the total amount of time that the Controller Communications window, Backplane Communications window, and Background window run is fixed. If the time expires while in the middle of servicing a request, these windows are closed, and communications will be resumed the next sweep. If no requests are pending in this window, the CPU cycles through these windows the specified amount of time polling for further requests. If any window is put in constant window mode, all are in constant window mode. |
| Limited | In Limited mode, the maximum time that the window runs is fixed. If time expires while in the middle of servicing a request, the window is closed, and communications will be resumed the next time that the given window is run. If no requests are pending in this window, the CPU proceeds to the next phase of the sweep. |

4.4. **Data Coherency in Communications Windows**

When running in Constant or Limited Window mode, the Controller and Backplane Communications Windows may be terminated early in all CPU sweep modes. If an external device, such as CIMPLICITY HMI, is transferring a block of data, the coherency of the data block may be disrupted if the communications window is terminated prior to completing the request. The request will complete during the next sweep; however, part of the data will have resulted from one sweep and the remainder will be from the following sweep. When the CPU is in Normal Sweep mode and the Communications Window is in Run-to-Completion mode, the data coherency problem described above does not exist.

Note: External devices that communicate to the CPU while it is stopped will read information as it was left in its last state. This may be misleading to operators viewing an HMI system that does not indicate CPU Run/Stop state. Process graphics will often indicate everything is still operating normally.

Also, note that non-retentive outputs do not clear until the CPU is changed from Stop to Run.

4.5. Run/Stop Operations

The PACSystems CPUs support four run/stop modes of operation. You can change these modes in the following ways: the Run/Stop switch, configuration from the programming software, LD function blocks, and system calls from C applications. Switching to and from various modes can be restricted based on privilege levels, position of the Run/Stop switch, passwords, etc.

Mode	Operation
Run/Outputs Enabled	The CPU runs user programs and continually scans inputs and updates physical outputs, including Genius and Ethernet outputs. The Controller and Backplane Communications Windows are run in Limited, Run-to-Completion, or Constant mode.
Run/Outputs Disabled	The CPU runs user programs and continually scans inputs, but updates to physical outputs, including Genius and Field Control, are not performed. Physical outputs are held in their configured default state in this mode. The Controller and Backplane Communications Windows are run in Limited, Run-to-Completion, or Constant mode.
Stop/I/O Scan Enabled	The CPU does not run user programs, but the inputs and outputs are scanned. The Controller and Backplane Communications Windows are run in Run-to-Completion mode. The Background Window is limited to 10ms.
Stop/I/O Scan Disabled	The CPU does not run user programs, and the inputs and outputs are not scanned. The Controller and Backplane Communications Windows are run in a Run-to-Completion mode. The Background Window is limited to 10ms. Note: Stop mode I/O scanning is always disabled for redundancy CPUs.

Note: You cannot add to the size of %P and %L reference tables in Run Mode unless the %P and %L references are the first of their type in the block being stored or the block being stored is a totally new block.

4.5.1 CPU Stop Modes

The CPU has two modes of operation while it is in Stop mode:

- I/O Scan Enabled - the Input and Output scans are performed each sweep
- I/O Scan Disabled - the Input and Output scans are skipped

When the CPU is in Stop mode, it does not execute the application program. You can configure whether the I/O is scanned during Stop mode. Communications with the programmer and intelligent option modules continue in Stop mode. Also, bus receiver module polling and rack reconfiguration continue in Stop mode.

In both Stop modes, the Controller Communications and Backplane Communications windows run in Run-to-Completion mode and the Background window runs in Limited mode with a 10 millisecond limit.

The number of last scans can be configured in the hardware configuration. Last scans are completed after the CPU has received an indication that a transition from Run to Stop or Stop Faulted mode should occur. The default is 0.

SVCREQ13 can be used in the application program to stop the CPU after a specified number of scans. All I/O will go to their configured default states, and a diagnostic message will be placed in the CPU Fault Table.

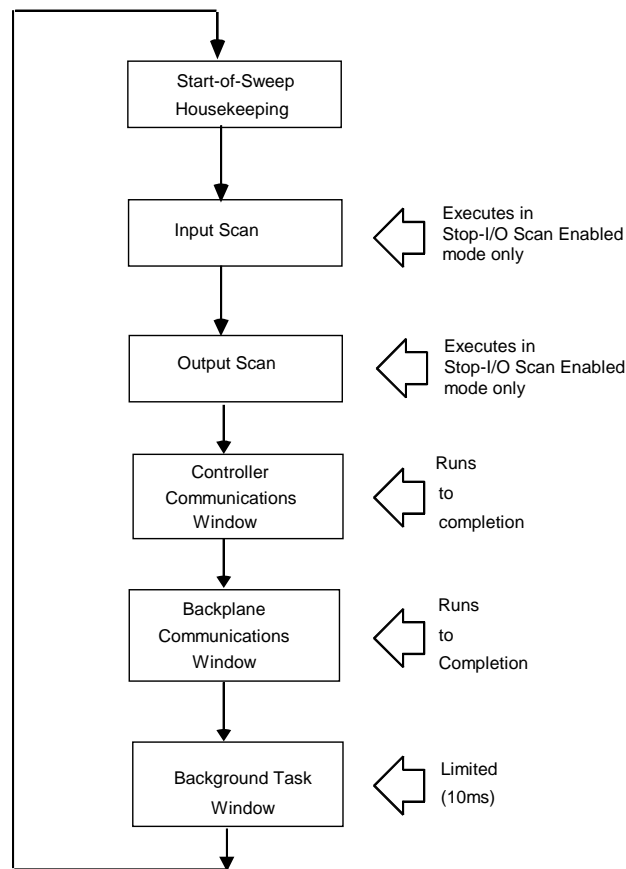


Figure 11: CPU Sweep in Stop-I/O Disabled and Stop-I/O Enabled Modes

4.5.2 Stop-to-Run Mode Transition

The CPU performs the following operations on Stop-to-Run transition:

- Validation of sweep mode and program scheduling mode selections
- Validation of references used by programs with the actual configured sizes
- Re-initialization of data areas for external blocks and standalone C programs
- Clearing of non-retentive memory

4.5.3 Run/Stop Mode Switch Operation

The Run/Stop mode switch has three positions:

Switch Position	CPU and Sweep Mode	Memory Protection
Run I/O Enable	The CPU runs with I/O sweep enabled.	User program memory is read only.
Run Output Disable	The CPU runs with outputs disabled.	User program memory is read only.
Stop	The CPU is not allowed to go into Run mode.	User program memory can be written.

The Run/Mode switch can be disabled in the programming software HWC. The memory protection function of the switch can be disabled separately in HWC. The Run/Mode switch is enabled by default. The memory protection functionality is disabled by default.

The Read Switch Position (Switch_Pos) function allows the logic to read the current position of the Run/Stop switch, as well as the mode for which the switch is configured. For details, refer to Chapter 7.

4.6. Flash Memory Operation

The CPU stores the current configuration and application in user memory (either battery-backed RAM or non-volatile user memory, depending on the CPU model). You can also store the Logic, Hardware Configuration, and Reference Data into non-volatile flash memory. The PACSystems CPU provides enough flash memory to hold all of user space, all reference tables that aren't counted against user space, and any overhead required. For details on which items count against user memory space, refer to Appendix B.

By default, the CPU reads program logic and configuration, and reference table data from user memory at power-up. However, logic/configuration and reference tables can each be configured to always read from flash or conditionally read from flash. To configure these parameters in the programming software, select the CPU's Settings tab in Hardware Configuration.

If logic/configuration and/or reference tables are configured for conditional power-up from flash, these items are restored from flash to user memory when the user memory is corrupted or was not preserved (for example, the memory backup battery or Energy Pack is not installed or not operational). If logic/configuration and/or reference memory are configured for conditional power-up from flash and user memory has been preserved, no flash operation will occur.

If logic/configuration and/or reference tables are configured to always power up from flash, these items are restored from flash to user memory regardless of the state of the user memory.

Note: If *any* component (logic/configuration or reference tables) is read from flash, OEM-mode and passwords are also read from flash.

In addition to configuring where the CPU obtains logic, configuration, and data during power-up, the programming software provides the following flash operations:

- Write a copy of the current configuration, application program, and reference tables (excluding overrides) to flash memory. Note that a write-to-flash operation causes all components to be stored to flash.
- Read a previously stored configuration and application program, and/or reference table values from flash into user memory.
- Verify that flash and user memory contain identical data.
- Clear flash contents.

Flash read and write operations copy the contents of flash memory or user memory as individual files. The programming software displays the progress of the copy operation and allows you to cancel a flash read or write operation during the copy process instead of waiting for the entire transfer process to complete. The entire user memory image must be successfully transferred for the flash copy to be considered successful. If an entire write-to-flash transfer is not completed due to canceling, power cycle, or some other intervention, the CPU will clear flash memory. Similarly, if a read-from-flash transfer is interrupted, user memory will be cleared.

4.7. Logic/Configuration Source and CPU Operating Mode at Power-up

Flash and user memory can contain different values for the Logic/Configuration Power-up Source parameter. The following tables summarize how these settings determine the logic/configuration source after a power cycle. CPU mode is affected by the

Power-up Mode, Run/Stop Switch and Stop-Mode I/O Scanning parameters, Run/Stop mode switch position, and the power down mode as shown in the tables on page 82.

Before Power Cycle		After Power Cycle	
Logic/Configuration Power-up Source in Flash	Logic/Configuration Power-up Source in RAM	Origin of Logic/Configuration	CPU Mode
Always Flash	Memory not preserved (i.e. no battery/Energy Pack, or memory corrupted)	Flash	See “CPU Mode when Memory Not Preserved/Power-up Source is Flash” on page 82.
Always Flash	No configuration in RAM, memory preserved	Flash	See “CPU Mode when Memory Preserved” on page 82.
Always Flash	Always Flash	Flash	
Always Flash	Conditional Flash	Flash	
Always Flash	Always RAM	Flash	
Conditional Flash	Memory not preserved (i.e. no battery/Energy Pack or memory corrupted)	Flash	See “CPU Mode when Memory Not Preserved/Power-up Source is Flash” on page 82.
Conditional Flash	No configuration in RAM, memory preserved	Uses default logic/configuration	Stop Disabled
Conditional Flash	Always Flash	RAM	See “CPU Mode when Memory Preserved” on page 82.
Conditional Flash	Conditional Flash	RAM	
Conditional Flash	Always RAM	RAM	
Always RAM	Memory not preserved (i.e. no battery/Energy Pack, or memory corrupted)	Uses default logic/configuration	Stop Disabled
Always RAM	No configuration in RAM, memory preserved	Uses default logic/configuration	Stop Disabled
Always RAM	Always Flash	Flash	See “CPU Mode when Memory Preserved” on page 82.
Always RAM	Conditional Flash	RAM	
Always RAM	Always RAM	RAM	
No Configuration in Flash	Memory not preserved (i.e. no battery/Energy Pack, or memory corrupted)	Uses default logic/configuration	Stop Disabled
No Configuration in Flash	No configuration in RAM, memory preserved	Uses default logic/configuration	Stop Disabled
No Configuration in Flash	Always Flash	RAM	See “CPU Mode when Memory

Before Power Cycle		After Power Cycle	
Logic/Configuration Power-up Source in Flash	Logic/Configuration Power-up Source in RAM	Origin of Logic/Configuration	CPU Mode
No Configuration in Flash	Conditional Flash	RAM	Preserved” on page 82.
No Configuration in Flash	Always RAM	RAM	

4.7.1 CPU Mode when Memory Not Preserved/Power-up Source is Flash

Configuration Parameters		Run/Stop Switch Position	CPU Mode
Power-up Mode	Run/Stop Switch		
Run	Enabled	Stop	Stop Disabled
Run	Enabled	Run Disabled	Run Disabled
Run	Enabled	Run Enabled	Run Enabled
Run	Disabled	N/A	Run Disabled
Stop	N/A	N/A	Stop Disabled
Last	Enabled	Stop	Stop Disabled
Last	Enabled	Run Disabled	Run Disabled
Last	Enabled	Run Enabled	Run Disabled
Last	Disabled	N/A	Run Disabled

4.7.2 CPU Mode when Memory Preserved

Configuration Parameters			Run/Stop Switch Position	Power Down Mode	CPU Mode
Power-up Mode	Run/Stop Switch	Stop-Mode I/O Scanning			
Run	Enabled	Enabled	Stop	N/A	Stop Enabled
Run	Enabled	Disabled	Stop	N/A	Stop Disabled
Run	Enabled	N/A	Run Disabled	N/A	Run Disabled
Run	Enabled	N/A	Run Enabled	N/A	Run Enabled
Run	Disabled	N/A	N/A	N/A	Run Enabled
Stop	N/A	Enabled	N/A	N/A	Stop Enabled
Stop	N/A	Disabled	N/A	N/A	Stop Disabled
Last	Enabled	Enabled	Stop	Stop Disabled	Stop Disabled
Last	Enabled	Enabled	Stop	Stop Enabled	Stop Enabled
Last	Enabled	Enabled	Stop	Run Disabled	Stop Enabled
Last	Enabled	Enabled	Stop	Run Enabled	Stop Enabled
Last	Enabled	Disabled	Stop	N/A	Stop Disabled
Last	Enabled	N/A	Run Disabled	Stop Disabled	Stop Disabled
Last	Enabled	Enabled	Run Disabled	Stop Enabled	Stop Enabled
Last	Enabled	Disabled	Run Disabled	Stop Enabled	Stop Disabled
Last	Enabled	N/A	Run Disabled	Run Disabled	Run Disabled
Last	Enabled	N/A	Run Disabled	Run Enabled	Run Disabled
Last	Enabled	N/A	Run Enabled	Stop Disabled	Stop Disabled
Last	Enabled	Enabled	Run Enabled	Stop Enabled	Stop Enabled
Last	Enabled	Disabled	Run Enabled	Stop Enabled	Stop Disabled
Last	Enabled	N/A	Run Enabled	Run Disabled	Run Disabled
Last	Enabled	N/A	Run Enabled	Run Enabled	Run Enabled

Last	Disabled	N/A	N/A	Stop Disabled	Stop Disabled
Last	Disabled	Enabled	N/A	Stop Enabled	Stop Enabled
Last	Disabled	Disabled	N/A	Stop Enabled	Stop Disabled
Last	Disabled	N/A	N/A	Run Disabled	Run Disabled
Last	Disabled	N/A	N/A	Run Enabled	Run Enabled

4.8. Clocks and Timers

Clocks and timers provided by the CPU include an elapsed time clock, a time-of-day clock, and software and hardware watchdog timers.

For information on timer functions and timed contacts provided by the CPU instruction set, see “Timers and Counters” in Chapter 8.

4.8.1 Elapsed Time Clock

The elapsed time clock tracks the time elapsed since the CPU powered on. The clock is not retentive across a power failure; it restarts on each power-up. This seconds count rolls over (seconds count returns to zero) approximately 100 years after the clock begins timing.

Because the elapsed time clock provides the base for system software operations and timer function blocks, it may not be reset from the user program or the programmer. However, the application program can read the current value of the elapsed time clock by using Service Request #16 or Service Request #50, which provides higher resolution.

4.8.2 Time-of-Day Clock

A hardware time-of-day clock maintains the time of day (TOD) in the CPU. The time-of-day clock maintains the following time functions:

- Year (two digits)
- Month
- Day of month
- Hour
- Minute
- Second
- Day of week

The TOD clock is battery-backed and maintains its present state across a power failure. The time-of-day clock handles month-to-month and year-to-year transitions and automatically compensates for leap years through year 2036.

You can read and set the hardware TOD time and date through the application program using Service Request function #7. For details, see Chapter 9.

High-Resolution Time of Day Software Clock

A high-resolution software TOD clock is implemented in firmware to provide nanoseconds resolution. When the high-resolution software TOD clock is set, the hardware TOD clock is set with the YYYY: Mon: Day: Hr: Min: Sec fields in the POSIX time, the RTC is read, and the delta between the POSIX time and the value read from the RTC is computed and saved. Thus, if 1-second resolution is desired the hardware TOD clock is read. Otherwise, the high-resolution software TOD clock is read to provide greater resolution. When the latter occurs, the hardware RTC is read and the saved delta added to the value read.

When the SNTP Time Transfer feature is implemented, all SNTP time updates received at the CPU will cause the high-resolution software TOD clock to be updated.

Synchronizing the High-resolution Time of Day Clock to an SNTP Network Time Server

In an SNTP system, a computer on the network (called an SNTP server) sends out a periodic timing message to all SNTP-capable Ethernet Interfaces on the network, which synchronize their internal clocks with this SNTP timing message. If SNTP is used to perform network time synchronization, the time-stamp information typically has ± 10 ms accuracy between controllers on the same network.

Synchronizing the CPU TOD clock to an SNTP server allows you to set a consistent time across multiple systems. Once the CPU TOD clock has been synchronized with the SNTP time, all produced EGD exchanges will use the CPU TOD current value for the time-stamp.

The CPU TOD clock is set with accuracy within ± 2 ms of the SNTP time-stamp.

TOD clock synchronization is enabled on an Ethernet module by the advanced user parameter (AUP), *ncpu_sync*. The CPU must also use a COMMREQ in user logic to select an Ethernet module as the time master. For additional information, refer to “Time-stamping of Ethernet Global Data Exchanges” in Chapter 4 of *TCP/IP Communications for PACSystems*, GFK-2224.

4.8.3 Watchdog Timer

Software Watchdog Timer

A software watchdog timer in the CPU is designed to detect “failure to complete sweep” conditions. The timer value for the software watchdog timer is set by using the programming software. The allowable range for this timer is 10 to 2550 milliseconds; the default value is 200 milliseconds. The software watchdog timer always starts from zero at the beginning of each sweep.

The software watchdog timer is useful in detecting abnormal operation of the application program that prevents the CPU sweep from completing within the user-specified time. Examples of such abnormal application program conditions are as follows:

- Excessive recursive calling of a block
- Excessive looping (large loop count or large amounts of execution time for each iteration)
- Infinite execution loop

When selecting a software watchdog value, always set the value higher than the longest expected sweep time to prevent accidental expiration. For Constant Sweep mode, allowance for oversweep conditions should be considered when selecting the software watchdog timer value.

The watchdog timer continues during interrupt execution. Queuing of interrupts within a single sweep may cause watchdog timer expiration.

If the software watchdog timeout value is exceeded, the OK LED blinks, and the CPU goes to Stop-Halt mode. Certain functions, however, are still possible. A fault is placed in the CPU fault table, and outputs go to their default state. The CPU will only communicate with the programmer; no other communications or operations are possible. To recover, power must be cycled on the rack or backplane containing the CPU.

To extend the current sweep beyond the software watchdog timer value, the application program may restart the software watchdog timer using Service Request function #8. However, the software watchdog timer value may only be changed from the configuration software.

Note that Service Request Function #8 does not reset the output scan timer implemented on the Genius Bus Controller.

CPE3xx CPU models only: The programmer can connect to these CPUs in Stop-Halt mode through the embedded Ethernet port without a reset or power cycle.

Hardware Watchdog Timer

A backup circuit provides additional protection for the CPU. If this backup circuit activates, the CPU is immediately placed in Reset mode. Outputs go to their default state and no communications of any form are possible, and the CPU will halt.

RX3i CPE3xx CPUs Response to a Hardware Watchdog Timeout:

- The CPE3xx automatically restarts and goes into Stop-Halt mode.
- The CPE3xx retains fault tables after a hardware watchdog timeout.
- While the CPE3xx is in Stop-Halt mode, you can connect the programmer software or PACs Analyzer to view the fault tables, including all faults logged before the timeout. (The PACS Analyzer software can be downloaded from the Support website.)
- The CPE3xx does not retain Controller and I/O Fault tables following recovery from the Stop-Halt state. To recover from Stop-Halt mode and return to normal operation, all non-volatile memory must be cleared. This can be done by disconnecting the Energy Pack and power cycling the CPE3xx. If power cycled with the Energy Pack connected, the CPE3xx returns to Stop-Halt mode and retains all non-volatile memory, including fault tables.
- During startup following hardware watchdog reset, the CPE3xx logs an *informational fault* with Error Code 446, which indicates a watchdog auto-reset occurred.

All other RX3i and RX7i CPUs' Response to a Hardware Watchdog Timeout:

The CPU goes to Reset mode. To recover, power must be cycled.

Note: PACSystems does not support Fatal Fault Retries.

4.9. System Security

The PACSystems CPU supports two types of system security:

- Passwords/privilege levels
- OEM protection

CPU versions 7.80 and later support Enhanced Security (including merged password tables). This provides a more secure mechanism for setting and authenticating passwords and OEM keys versus the Legacy Security Mode. Refer to the *Important Product Information* document for the CPU model and firmware version that you are using.

For Enhanced Security operation, see page 89. A summary of operational differences between Enhanced and Legacy Security modes is provided on page 90.

4.9.1 Passwords and Privilege Levels - Legacy Mode

Passwords are a configurable feature of the PACSystems CPU. Their use is optional and is set up using the programming software. Passwords provide different levels of access privilege for the CPU when the programmer is Online. Passwords are not used if the programmer is in Offline mode.

The default state is no password protection. Each privilege level in the CPU may have a unique password; however, the same password can be used for more than one level. Passwords can be changed only through the programming software.

Passwords are one to seven ASCII characters in length.

After passwords have been set up, access to the CPU via any communications path is restricted from the levels at which the passwords are set, unless the proper password has been entered. Once a password has successfully been accepted, access to the highest privilege level requested and below is granted (for example, providing the password for level 3 allows access to functions at levels 1, 2, and 3).

Note: The Run Mode switch on the CPU overrides password protection. Even though the programmer may not be able to switch between Run and Stop mode, the switch on the CPU can do so.

Privilege Levels

Level	Password	Access Description
4	Yes	Write to configuration or logic. Configuration may only be written in Stop mode; logic may be written in Stop or Run mode. Set or delete passwords for any level. Note: This is the default privilege for a connection to the CPU if no passwords are defined.
3	Yes	Write to configuration or logic when the CPU is in Stop mode, including word-for-word changes, addition/deletion of program logic, and the overriding of discrete I/O.
2	Yes	Write to any data memory. This does not include overriding discrete I/O. The CPU can be started or stopped. CPU and I/O Fault Tables can be cleared.
1	Yes	Read any CPU data except for passwords. This includes reading fault tables, performing datagrams, verifying logic/configuration, loading program and configuration, etc. from the CPU. None of this data may be changed. At this level, Run/Stop mode transitions from the programmer are not allowed.

Protection Level Request from Programmer

In Legacy mode, upon connection to the CPU, the programmer requests the CPU to move to the highest non-protected level.

The programmer requests a privilege level change by supplying the new privilege level and the password for that level. If the password sent by the programmer does not agree with the password stored in the CPU's password access table for the requested level, the privilege level change is denied and a fault is logged in the CPU fault table. The current privilege level is maintained, and no change occurs. A request to change to a privilege level that is not password protected is made by supplying the new level and a null password. A privilege change may be to a lower level as well as to a higher level.

Maintaining Passwords through a Power Cycle

Initial passwords are blank for a new controller or a controller that has its passwords cleared. For passwords to be maintained through power cycles, the controller must either:

Store to RAM and use an Energy Pack or battery to maintain memory.

Store to User Flash with configuration set up to load from Flash at power up.

Disabling Passwords

The use of password protection is optional. Passwords can be disabled using the programming software.

Note: To enable passwords after they have been disabled, the CPU must be power cycled with the battery or Energy Pack removed.

4.9.2 OEM Protection – Legacy Mode

Original Equipment Manufacturer (OEM) protection provides a higher level of security than password levels 1 through 4. This feature allows a third-party OEM to create control programs for the CPU and then set the OEM-locked mode, which prevents the end user from reading or modifying the program.

The OEM protection feature is enabled/disabled using a 1 to 7 character password, known as the *OEM key*. When OEM protection is enabled, all read and write access to the CPU program and configuration is prohibited: any store, load, verify, or clear user program operation will fail.

OEM Protection in Systems that Load from Flash Memory

For OEM protection, it is recommended to store the program to User Flash and set configuration to always load from Flash. When setting up OEM protection it is important to download the user program to RAM and User Flash before enabling the OEM protection. For example, the following steps can be used to set up OEM protection.

1. Set OEM Key password (Must be at Access Level 4 to set OEM Key)
2. Download program to both RAM and User Flash.
3. Set OEM Protection to the Locked state (see firmware note below).

If you are storing a non-blank OEM key to flash memory, you should be careful to record the OEM key for future reference. If disabling OEM protection, be sure to clear the OEM key that is stored in flash memory.

Note: In CPU firmware versions 7.80 or later which support Enhanced Security (with merged password tables), OEM Protection Lock must be explicitly set.

In earlier versions, the OEM Protection could be enabled in User Flash without explicitly setting the OEM Protection to Locked. With the earlier firmware, a non-blank OEM Key that is loaded from User Flash at power-up would result in an automatic OEM Lock. In CPU firmware versions 7.80 or later (i.e. with merged passwords), this is no longer supported.

In firmware versions earlier than 6.01, the OEM protection was not preserved unless a battery was attached.

4.9.3 Enhanced Security for Passwords and OEM Protection

Enhanced Security passwords are supported by CPU firmware versions 7.80 or later. This feature provides a cryptographically secure password protocol between an SRTP client (for example Proficy Machine Edition) and a PACSystems controller. Enhanced Security passwords operate in a very similar fashion to the Legacy security password operation that is supported by previous firmware releases.

Enhanced Security passwords are enabled in Proficy Machine Edition¹². PME requires a password in order to enable/disable the Enhanced Security mode of a target. This PME password restricts changes to the security mode used by a specific PME target and is independent of any passwords later configured on the controller.

Enabling Enhanced Security on a target does not force the controller to use only Enhanced Security. The controller supports both Legacy and Enhanced Security requests concurrently. For example, one PME target could be used to set initial passwords with Legacy security and a different PME target with Enhanced Security could connect and authenticate with the same controller.

Passwords set with one password mechanism (Legacy or Enhanced Security) can be authenticated and changed using the other mechanism, as long as the password is 7 characters or less. Setting passwords with Enhanced Security that are greater than 7 characters prevents access using the Legacy mechanism. For example, you could use Enhanced Security to set a 10 character password for Level 4 and Level 3, but set a 7 character password for Level 2. In this case, a Legacy target could be used to obtain Level 2 access, but the Legacy target could never access Level 4 or Level 3 because of 7-character limit of the Legacy scheme.

Password and OEM Protection in Systems that Load from Flash Memory



Caution

Be careful when setting passwords and loading passwords from User Flash on every power-up. In this situation, it is not possible to clear passwords back to a default state if the Level 4 password and OEM key are forgotten.

For a recommended procedure, see “OEM Protection in Systems that Load from Flash Memory” on page 88.

¹² To determine the required Proficy Machine Edition version, refer to the *Important Product Information (IPI)* document provided with the CPU firmware version you are using.

4.9.4 Legacy/Enhanced Security Comparison

Feature	Legacy (less secure)	Enhanced (more secure)
Level 2, 3 and 4 protection	Levels 2, 3 and 4 must be set or modified simultaneously. (If you only want to change one, you must enter all three.)	Passwords can be set individually or in a group. When changing passwords, the old password for that level is required in order to change it.
Maximum password length	7 characters	31 characters
Clearing passwords	Passwords can be cleared back to initial blank password values.	Once a password is set, the Enhanced Security mode in PME will not allow it to be cleared back to a blank password. To revert to a blank password, the CPU memory must be cleared and power cycled.
Passwords ≤ 7 characters, set with either mode	Password verification and password changes allowed.	Password verification and password changes allowed.
Passwords > 7 characters, set with Enhanced Security mode	Password verification and password changes <i>not</i> allowed.	Password verification and password changes allowed.
Maximum OEM key length	7 characters.	31 characters.
OEM keys ≤ 7 characters, set with Enhanced Security	Can change OEM Protection Lock state <i>Cannot</i> change the OEM key.	Can change OEM Protection Lock state and the OEM key.
OEM keys > 7 characters, set with Enhanced Security	<i>Cannot</i> change OEM Protection Lock state or the OEM key.	Can change OEM Protection Lock state and the OEM key.

4.10. PACSystems I/O System

The PACSystems I/O system provides the interface between the CPU and other devices. The PACSystems I/O system supports:

- I/O and Intelligent option modules.
- Ethernet Interface
- Motion modules (RX3i)
- The Genius I/O system (RX7i). A Genius I/O Bus Controller (GBC) module provides the interface between the RX7i CPU and a Genius I/O bus.

4.10.1 I/O Configuration

Module Identification

In addition to the catalog number, the programming software stores a Module ID for each configured module in the hardware configuration that it delivers to the CPU. The CPU uses the Module ID to determine how to communicate with a given module.

When the hardware configuration is downloaded to the CPU (and during subsequent power-ups), the CPU compares the Module IDs stored by the programmer with the IDs of the modules physically present in the system. If the Module IDs do not match, a System Configuration Mismatch fault will be generated.

Because I/O modules of similar type may share the same Module ID, it is possible to download a configuration containing a module catalog number that does not match the module that is physically present in the slot without generating a System Configuration Mismatch.

Certain discrete modules with both reference memory inputs and reference memory outputs will experience invalid I/O transfer if incorrect configuration is stored from a similar mixed I/O module. No fault or error condition will be detected during configuration store and the module will be operational, although not in the manner described by configuration.

For example, a configuration swap between the IC693MDL754 output module and IC693MDL660 input module will not be detected as a configuration mismatch, but I/O data transfer between the module and the CPU reference memory will be invalid. If the input module (MDL660) is sent the configuration of the output module (MDL754) with the following parameters:

```
Reference Address: %Q601
Module Status Reference: %I33
Hold Last State Enable
```

It will receive inputs at the module status reference %I33 and the status of the module will be received at %Q601.

If the output module is sent the configuration of the input module with the following parameters:

```
Reference Address: %I601
Input Filter: Enable
Digital Filter Settings Reference: %I65
```

It will output values at the digital filter settings reference %I65 and the status of the module will be received at %I601.

Default Conditions for I/O Modules

Interrupts

Some input modules can be configured to send an interrupt to the application program. By default, this interrupt is disabled and the input filter is set to slow. If changed by the programming software, the new settings are applied when the configuration is stored and during subsequent power-cycles.

Outputs

Some output modules have a configurable output default mode that can be specified as either Off or Hold Last State. If a module does not have a configurable output default mode, its output default mode is Off. The selected action applies when the CPU transitions from Run/Enabled to Run/Disabled or Stop mode, or experiences a fatal fault.

At power-up, Series 90-30 discrete output modules default to all outputs off. They will retain this default condition until the first output scan from the PACSystems controller. Analog output modules can be configured with a jumper located on the removable terminal block of the module. The jumper may be set to cause outputs to either “default to zero” or “retain last state”.

Inputs

Input modules that have a configurable input default mode can be configured to Hold Last State or to set inputs to 0. If a module does not have a configurable input default mode, its input default mode is Off. The selected action applies when the CPU transitions from Run/Enabled to Run/Disabled or Stop mode, or experiences a fatal fault.

For details on the power-up and stop mode behavior of other modules, refer to the documentation for that module.

Multiple I/O Scan Sets

Up to 32 I/O scan sets can be defined for a PACSystems CPU. A scan set is a group of I/O modules that can be assigned a unique scan rate. A given I/O module can belong to one scan set. By default, all I/O modules are assigned to scan set 1, which is scanned every sweep.

For some applications, the CPU logic does not need to have the I/O information every sweep. The I/O scan set feature allows the scanning of I/O points to be more closely scheduled with their use in user logic programs. If you have a large number of I/O modules, you may be able to significantly reduce scan time by staggering the scanning of those modules.

A disadvantage of placing all modules into different scan sets appears when the CPU is transitioning from Stop to Run. In that case, scan sets with a programmed delay are not scanned on the first sweep. These modules' outputs are not enabled until the new data has been scanned to them, perhaps many scans later. Therefore there is a period of time during which the user logic is executing and some modules' outputs are disabled. During that time, outputs of those modules are in the module's stop-mode state. Stop-mode behavior is module-dependent. Some modules zero their outputs, some hold their last scanned state (if any), and some force their outputs to a configured default value. When the module's outputs are enabled, the module uses the last scanned value, which will either be zero or the contents of the register the module uses to hold the corresponding output values from the reference tables.

4.10.2 Genius I/O

The Genius Bus Controller (GBC) controls a single Genius I/O bus. Any type of Genius I/O device may be attached to the bus.

In the I/O Fault Table, the rack, slot, bus, module, and I/O point number are given for a fault. Bus number one refers to the bus on the single-channel GBC.

Genius I/O Configuration

The programming software can configure a subset of the parameters associated with Genius I/O blocks.

Genius I/O blocks have a number of parameters that can be set using the Genius I/O Hand-Held Monitor. These parameter values are stored in EEPROM in the block itself. The serial bus address (SBA) and baud rate must be set using the Genius I/O Hand-Held Monitor. For specific information on Genius I/O block types, configuration, and setup, refer to the *Genius I/O System User's Manuals*, GEK-90486-1 and -2.

Through the COMMREQ function block, the application program can request the GBC to change any default condition on a specific block. However, the block only accepts this change if it is not in Config Protect mode. If Config Protect mode is set, only the Hand-Held Monitor can be used to change the defaults. The format of the COMMREQ function block for Genius I/O is described in the *Series 90-70 Genius Bus Controller User's Manual*, GFK-2017 and the *Series 90-30 Genius Bus Controller User's Manual*, GFK-1034.

Genius I/O Data Mapping

Genius I/O discrete inputs and outputs are stored as bits in the CPU Bit Cache memory. Genius I/O analog data is stored in the application RAM allocated for that purpose (%AI and %AQ). Analog data is always stored one channel per one word (16 bit).

An analog grouped module consumes (in the input and output data memories) only the amount of data space required for the actual inputs and outputs. For example, the Genius I/O 115 VAC Grouped Analog Block, IC660CBA100, has four inputs and two outputs. It consumes four words of Analog Input memory (%AI) and two words of Analog Output memory.

A discrete grouped module, each point of which is configurable with the Hand-Held Monitor (HHM) to be input, output, or output with feedback, consumes an amount in both discrete input memory (%I) and discrete output memory (%Q) equal to its physical size. Therefore, the eight-point Discrete Grouped Block (IC660CBD100) requires eight bits in the %I memory and eight bits in the %Q memory, regardless of how each point on the block is configured.

Analog Grouped Block

The six-channel Analog Grouped block contains four analog input channels and two analog output channels. When this block gets its turn on the Genius I/O Bus, it broadcasts the data for all four input channels in one broadcast control message. Then, when the GBC gets its turn, it sends the data for both output channels to the block in a directed control message.

Low-Level Analog Blocks

Unlike the Analog Grouped block, the low-level analog blocks, such as the Thermocouple and RTD blocks, are input-only blocks. All have six channels.

Genius Global Data Communications

The PACSystems RX7i supports the sharing of data among multiple control systems that share a common Genius I/O bus. This mechanism provides a means for the automatic and repeated transfer of %G, %I, %Q, %AI, %AQ, %R, and %W data. No special application programming is required to use global data since it is integrated into the I/O scan. Controllers that have Genius I/O capability can send global data to an RX7i and can receive data from an RX7i. The programming software is used to configure the receiving and transmitting of global data on a Genius I/O bus.

Note: Genius global data communications do not continue to operate when the RX7i CPU is in Stop-I/O Scan Disabled mode. However, if the CPU is in Stop-I/O Scan Enabled mode, Genius global data communications continue to operate.

4.10.3 I/O System Diagnostic Data Collection

Diagnostic data in a PACSystems I/O system is obtained in either of the following two ways:

- If an I/O module has an associated bus controller, the bus controller provides the diagnostic data from that module to the CPU. For details on GBC faults, see “PACSystems Handling of GBC Faults” on page 95.
- For I/O modules not interfaced through a bus controller, the CPU’s I/O Scanner subsystem generates the diagnostic bits based on data provided by the module.

The diagnostic bits are derived from the diagnostic data sent from the I/O modules to their I/O controllers (CPU or bus controller). Diagnostic bits indicate the current fault status of the associated module. Bits are set when faults occur and are cleared when faults are cleared.

Diagnostic data is not maintained for modules from other manufacturers. The application program must use the BUS Read function blocks to access diagnostic information provided by those boards.

Note: At least two sweeps must occur to clear the diagnostic bits: one scan to send the %Q data to the module and one scan to return the %I data to the CPU. Because module processing is asynchronous to the controller sweep, more than two sweeps may be needed to clear the bits, depending on the sweep rate and the point at which the data is made available to the module.

Discrete I/O Diagnostic Information

The CPU maintains diagnostic information for each discrete I/O point. Two memory blocks are allocated in application RAM for discrete diagnostic data, one for %I memory and one for %Q memory. One bit of diagnostic memory is associated with each I/O point. This bit indicates the validity of the associated I/O data. Each discrete point has a fault reference that can be interrogated using two special contacts: a fault contact (-[F]-) and a no-fault contact (-[NF]-). The CPU collects this fault data if enabled to do so by the programming software. The following table shows the state of the fault and no-fault contacts.

Condition	[FAULT]	[NOFLT]
Fault Present	ON	OFF
Fault Absent	OFF	ON

Analog I/O Diagnostic Data

Diagnostic information is made available by the CPU for each analog channel associated with analog modules and Genius analog blocks. One byte of diagnostic memory is allocated to each analog I/O channel. Since each analog I/O channel uses two bytes of %AI and %AQ memory, the diagnostic memory is half the size of the data memory.

The analog diagnostic data contains both diagnostics and process data with the process data being the High Alarm and Low Alarm bits. The diagnostic data is referenced with the -[F]- and -[NF]- contacts. The process bits are referenced with the high alarm (-[HA]-) and low alarm (-[LA]-) contacts. The memory allocation for analog diagnostic data is one byte per word of analog input and analog output allocated by programming software. When an analog fault contact is referenced in the application program, the CPU does an Inclusive OR on all bits in the diagnostic byte, except the process bits. The alarm contact is closed if any diagnostic bit is ON and OFF only if all bits are OFF.

PACSystems Handling of GBC Faults

Defaulting of input data associated with failed/lost GBCs

When a GBC is missing, mismatched, or otherwise failed, the CPU applies the Input Default setting for each device on that Genius bus when defaulting the input data. If the device is configured for HOLD LAST STATE, the data is left alone. If the device is configured for OFF, the input data is set to 0. If a redundant GBC is operational, the input data is not affected.

Application of default input and diagnostic data for lost redundant blocks

When a GBC reports that a redundant block is lost, the CPU updates the input data tables and input diagnostic tables with the default data during the very next input scan. The output diagnostic data tables are updated during the very next output scan.

4.11. Power-Up and Power-Down Sequences

4.11.1 Power-Up Sequence

System power-up consists of the following parts:

- Power-up self-test
- CPU memory validation
- System configuration
- Intelligent option module self-test completion
- Intelligent option module dual port interface tests
- I/O system initialization

Power-Up Self-Test

On system power-up, many modules in the system perform a power-up diagnostic self-test. The CPU module executes hardware checks and software validity checks. Intelligent option modules perform setup and verification of on-board microprocessors, software checksum verification, local hardware verification, and notification to the CPU of self-check completion. Any failed tests are queued for reporting to the CPU during the system configuration portion of the cycle.

If a low or failed battery (or Energy Pack fault) indication is present, a fault is logged in the CPU fault table.

CPU Memory Validation

The next phase of system power-up is the validation of the CPU memory. First, if the system verifies that user memory areas are still valid. A known area of user memory is checked to determine if data was preserved. Next, if a ladder diagram program exists, a checksum is calculated across the `_MAIN` ladder block. If no ladder diagram program exists, a checksum is calculated across the smallest standalone C program.

When the system is sure that the user memory is preserved, a known area of the bit cache area is checked to determine if the bit cache data was preserved. If this test passes, the Bit Cache memory is left containing its power-up values. (Non-retentive outputs are cleared on a transition from Stop to Run mode.) If the checksum is not valid or the retentive test on the user memory fails, the bit cache memory is assumed to be in error and all areas are cleared. The CPU is now in a cleared state, the same as if a new CPU module were installed. All logic and configuration files must be stored from the programmer to the CPU.

System Configuration

After completing its self-test, the CPU performs the system configuration. It first clears all system diagnostic bits in the bit cache memory. This prevents faults that were present before power-down but are no longer present from accidentally remaining as faulted. Then it polls each module in the system for completion of the corresponding self-test.

The CPU reads information from each module, comparing it with the stored (downloaded) rack/slot configuration information. Any differences between actual configuration and the stored configuration are logged in the fault tables.

Intelligent Option Module Self-Test Completion

Intelligent option modules may take a longer time to complete their self-tests than the CPU due to the time required to test communications media or other interface devices. As an intelligent option module completes its initial self-tests, it tells the CPU the time required to complete the remainder of these self-tests. During this time, the CPU provides whatever additional information the module

needs to complete its self-configuration, and the module continues self-tests and configuration. If the module does not report back in the time it specified, the CPU marks the module as faulted and makes an entry in one of the fault tables. When all self-tests are complete, the CPU obtains reports from the module as generated during that particular module's power-up self-test and places fault information (if any) in the fault tables.

Intelligent Option Module Dual Port Interface Tests

After completion of the intelligent option module self-test and results reporting, integrity tests are jointly performed on the dual-port interface used by the CPU and intelligent option module for communications. These tests validate that the two modules are able to pass information back and forth, as well as verify the interrupt and semaphore capabilities needed by the communications protocol. After dual port interface tests are complete, the communications messaging system is initialized.

I/O System Initialization

If the module is an input module, no further configuration is required. If the module is an output module, the module is commanded to go to its default state. The output modules default to all outputs off at power-up and in failure mode, unless configured otherwise.

A bus transmitter module is interrogated about what expansion racks are present in the system. Based on the bus transmitter module's response, the CPU adds those racks and their associated slots into the list of slots to be configured.

Finally, the I/O Scanner performs its initialization. The I/O Scanner initializes all the I/O controllers in the system by establishing the I/O connections to each I/O bus on the I/O controller and obtaining all I/O configuration data from that I/O controller. This configuration data is compared with the stored I/O configuration and any differences reported in the I/O Fault Table. The I/O Scanner then sends each I/O controller a list of the I/O modules to be configured on the I/O bus. After the I/O controllers have been initialized, the I/O Scanner replaces the factory default settings in all I/O modules with any application-specified settings.

4.11.2 Power-Down Sequence

System power-down occurs when the power supply detects that incoming power has dropped for more than 15ms.

4.11.3 Retention of Data Memory Across Power Failure

The following types of data are preserved across a power cycle with an operational battery (or for CPE3xx, an Energy Pack):

- Application program
- Fault tables and other diagnostic data
- Checksums on programs and blocks
- Override data
- Data in register (%R), local register (%L), and program register (%P) memory
- Data in analog memory (%AI and %AQ)
- State of discrete inputs (%I)
- State of retentive discrete outputs (%Q)
- State of retentive discrete internals (%M)

The following types of data are not preserved across a power cycle:

- State of discrete temporary memory (%T)
- %M and %Q memories used on non-retentive -()- coils
- State of discrete system internals (system bits, fault bits, reserved bits)

Chapter 5 Program Organization

This chapter provides information about the operation of application programs in a PACSystems CPU.

- Structure of the Application Program
- Controlling Program Execution
- Interrupt-Driven Blocks

5.1. Structure of a PACSystems Application Program

A PACSystems application consists of one block-structured application program. The application program contains all the logic needed to control the operations of the CPU and the modules in the system. Application programs are created using the programming software and transferred to the CPU. Programs are stored in the CPU’s non-volatile memory.

During the CPU Sweep (described in Chapter 4), the CPU reads input data from the modules in the system and stores the data in its configured input memory locations. The CPU then executes the entire application program once, using this fresh input data. Executing the application program creates new output data that is placed in the configured output memory locations.

After the application program completes its execution, the CPU writes the output data to modules in the system.

A block-structured program always includes a `_MAIN` block. Program execution begins with the `_MAIN` block. Counting the `_MAIN` block, the program can contain up to 512 blocks.

5.1.1 Blocks

A block is a named section of executable logic that can be downloaded to and run on the target controller. The logic in a block can include functions, function blocks and calls to other blocks.

5.1.2 Functions and Function Blocks

A function is a type of instruction that has no internal storage (instance data). Therefore, it produces the same result for the same set of input values every time it executes.

A function block defines data as a set of inputs and output parameters that can be used as software connections to other blocks and internal variables. It has an algorithm that runs every time the function block is executed. Because a function block has instance data, that is it can store values, it has a defined state.

The following table describes the types of instructions that make up the PACSystems instruction set.

Instruction Type	Instance Data	Examples
Functions	None	BIT_SEQ, ADD, RANGE
Built-in function blocks	WORD array.	TMR, PID_IND, PID_ISA
Standard function blocks	Structure variable. (See “Instance Data Structures” on page 106.)	TP, TOF, TON

Note: A user defined function block (UDFB) is a block of logic that can be called in your program logic to create multiple instances of the block, allowing you to create a block of logic once and reuse it as if it was a standard function block instruction. For additional information, see pages 101 and 105.

5.1.3 How Blocks Are Called

A block executes when called from the program logic in the `_MAIN` block or another block. In this example, `LD_BLK1` is always called. Conditional logic can be used to control calling a block. For `LD_BLK2` to be called, input `%I00500` and output `%Q00100` must be ON. For details on using the Call function, refer to Chapter 7 (LD programming), Chapter 8 (FBD programming) or Chapter 11 (ST programming).

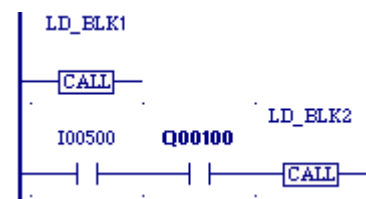


Figure 12: Example of Block Call

5.1.4 Nested Calls

The CPU allows nested block calls as long as there is enough execution stack space to support the call. If there is not enough stack space to support a given block call, an “Application Stack Overflow” fault is logged. In these circumstances, the CPU cannot execute the block. Instead, it sets all of the block’s Boolean outputs to FALSE, and resumes execution at the point after the block call instruction.

Note: To halt the CPU when there is not enough stack space to execute a block, there are two choices. The best method is to add logic to detect the occurrence of any User Application Fault by testing the diagnostic bit %SA38, and then call SVC_REQ 13 to halt the CPU. An alternative method is to add logic that tests for a negative OK value coming out of the block and then call SVC_REQ 13 to halt the CPU.

A call depth of eight levels or more can be expected, except in rare cases where several of the called blocks have very large numbers of parameters. The actual call depth achieved depends on several factors, including the amount of data (non-Boolean) flow used in the blocks, the particular functions called by the blocks, and the number and types of parameters defined for the blocks. If blocks use less than the maximum amount of stack resources, more than eight nested calls may be possible. The call level nesting counts the _MAIN block as level 1.

5.1.5 Types of Blocks

PACSystems supports four types of blocks.

Block Type	Local Data	Programming Languages	Size Limit	Parameters
Block	Has its own local data	LD FBD ST	128 KB	0 inputs 1 output
Parameterized Block	Inherits local data from caller	LD FBD ST	128 KB	63 inputs 64 outputs
User Defined Function Block (UDFB)	Has its own local data	LD FBD ST	128 KB	63 inputs 64 outputs Unlimited internal member variables
External Block	Inherits local data from caller	C	user memory size limit (10 MB)	63 inputs 64 outputs

All PACSystems block types automatically provide an OK output parameter. The name used to reference the OK parameter within a block is Y0. Logic within the block can read and write the Y0 parameter. When a block is called, its Y0 parameter is automatically initialized to TRUE. This will result in a positive power flow out of the block call instruction when the block completes execution, unless Y0 is set to FALSE within the logic of the block.

For all block types, the maximum number of input parameters is one less than the maximum number of output parameters. This is because the EN input to the block call is not considered to be an input parameter to the block. It is used in LD language to determine whether or not to call the block, but is not passed into the block if the block is called.

Program Blocks

Any block can be a program block. The `_MAIN` block is automatically declared when you create a block-structured program. When you declare any other block, you must assign it a unique block name. A block is automatically configured with no input parameters and one output parameter (OK). When a block-structured program is executed, the `_MAIN` block is automatically executed. Other blocks execute when called from the program logic in the `_MAIN` block, another block, or itself. In the following example, if `%M00001` is ON, the block named `ProcessEGD` will be executed:

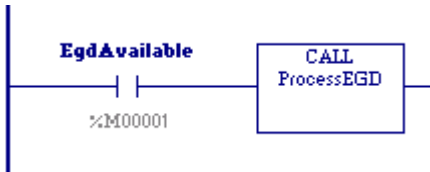


Figure 13: Conditional Block Call

Program Blocks and Local Data

Program blocks support the use of `%P` global data. In addition, each block, except `_MAIN`, has its own `%L` local data. Blocks do not inherit `%L` local data from their callers.

Using Parameters with a Program Block

Every block is automatically defined to have one formal 'power flow' (or OK) output parameter, named `Y0`. `Y0` is a `BOOL` parameter of `LENGTH 1`, passed by initial-value result. It indicates successful execution of the block. It can be read and written to by the logic within the block.

Parameterized Blocks

Any block except `_MAIN` can be a parameterized block. When you declare a parameterized block, you must assign it a unique block name. A parameterized block can be configured with up to 63 input and 64 output parameters.

A parameterized block executes when called from the program logic in the `_MAIN` block, another block, or itself. In the following example, if `%I00001` is set, the parameterized block named `LOAD_41` will be executed.

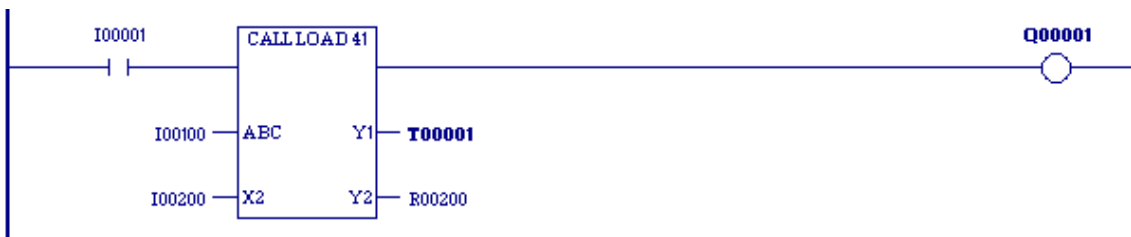


Figure 14: Block Call with Parameters

Parameterized Blocks and Local Data

Parameterized blocks support the use of %P global data. Parameterized blocks do not have their own %L data, but instead inherit the %L data of their calling blocks. Parameterized blocks also inherit the FST_EXE system reference and “time-stamp” data that is used to update timer functions from their calling blocks. If %L references are used within a parameterized block and the block is called by _MAIN, %L references will be inherited from the %P references wherever encountered in the parameterized block (for example, %L0005 = %P0005).

Note: It is possible, by using Online Editing in the programming software to cause a parameterized block to use %L higher than allowed because of the way it inherits data. Using a word-for-word change to restore this reference to a valid address does not correct the block because the variable still exists in the variable list. Deleting the variable from the variable list does not cause an update to the CPU, so the parameterized block still sees the reference out of range fault. To correct this condition, you must remove the unused variables from the variable list after deleting them from the logic.

Using Parameters with a Parameterized Block

A parameterized block may be defined to have between 0 and 63 formal input parameters, and between 1 and 64 formal output parameters. A ‘power-flow out’ (or OK) parameter, named Y0, is automatically defined for every parameterized block. It is a BOOL parameter of LENGTH 1, and indicates the successful execution of the parameterized block. It can be read and written to by the parameterized block’s logic.

The following table lists the TYPES, LENGTHs, and parameter-passing mechanisms allowed for parameterized block parameters. (For definitions of the parameter passing types, see “Parameter Passing Mechanisms” on page 113.)

Type	Length	Default Parameter Passing Mechanism
BOOL	1 to 256	INPUTS: by reference
		OUTPUTS: by value result; except Y0, which is by initial-value result
BYTE	1 to 1024	INPUTS: by reference
		OUTPUTS: by reference
INT, UINT, and WORD	1 to 512	INPUTS: by reference
		OUTPUTS: by reference
DINT, REAL, and DWORD	1 to 256	INPUTS: by reference
		OUTPUTS: by reference
LREAL	1 to 128	INPUTS: by reference
		OUTPUTS: by reference
function block ¹³	1	INPUTS: by reference
		OUTPUTS: not allowed
UDFB	1	INPUTS: by reference
		OUTPUTS: not allowed
User Defined Type (UDT)	1 to 1024	INPUTS: by reference
		OUTPUTS: not allowed

¹³ A maximum of 16 input parameters can be of type function block or UDFB.

The PACSystems default parameter passing mechanisms correspond to the way that parameterized subroutine block (PSB) parameters are passed on 90-70 controllers. The parameter passing mechanisms of formal parameters cannot be changed from their default values.

Arguments, or “actual parameters” are passed into a parameterized block when a parameterized block call is executed. In general, arguments to formal parameters may come from any memory type, may be data flow, and may be constants (when the formal parameter’s LENGTH is 1). The following list contains the restrictions on arguments relative to this general rule:

- %S memory addresses cannot be used as arguments to any output parameter. This is because user logic is not allowed to write to %S memory.
- Indirect references used as arguments are resolved immediately before the parameterized block is called, and the corresponding direct reference is passed into the block. For example, where %R1 contains the value 10 and @R1 is used as an argument to a call, immediately before calling the block, @R1 is resolved to be %R10, and %R10 is passed in as the argument to the block. During execution of the block, the argument remains as %R10, regardless of whether the value in %R1 changes.

In general, formal parameters within a parameterized block may be used with any instruction or with any block call, as long as their TYPE and LENGTH are compatible with what the instruction, function, or block call requires. The following list contains the restrictions on formal parameters relative to this general rule:

- Formal parameters cannot be used on legacy transitional contacts or coils, or on FAULT, NOFLT, HIALM, or LOALM contacts. However, formal parameters can be used on IEC transitional contacts and coils.
- Formal BOOL input parameters cannot be used on coils or as output arguments to a function or to a block call.
- Formal parameters cannot be used with the DO I/O function.
- Formal parameters cannot be used with indirect referencing.

User-Defined Function Blocks (UDFBs)

Users can define their own blocks, which have parameters and instance data, instead of being limited to the standard and built-in function blocks provided in the PACSystems instruction set. In many cases, the use of this feature results in a reduction in total program size.

Once defined, multiple instances of a UDFB can be created by calling it within the program logic. Each instance has its own unique copy of the function block's *instance data*, which consists of the function block's internal member variables and all of its input and output parameters except those that are passed by reference. When a UDFB is called on a given instance, the UDFB's logic operates on that instance's copy of the instance data. The values of the instance data persist from one execution of the UDFB to the next.

A *member variable* is not passed into or out of a UDFB as a parameter. A

A UDFB cannot be triggered by an interrupt.

UDFB logic is created using FBD, LD or ST. UDFB logic can make calls to all the other types of PACSystems blocks (blocks, parameterized blocks, external blocks and other UDFBs). Blocks, parameterized blocks, and other UDFBs can make calls to UDFBs.

Unless otherwise stated, the PACSystems implementation of UDFBs meets the IEC 61131-3 requirements for user defined function blocks.

Defining a UDFB

To create a UDFB in the programming software, create an LD, FBD or ST block in the Program Blocks folder. In the Properties for the block, select Function Block.

To define instance data for a UDFB, select Parameters in the block's properties. Input and output parameters are defined in the same way as for parameterized blocks. In the following example, three internal member variables are defined: ***temp***, ***speed***, and ***modelno***.

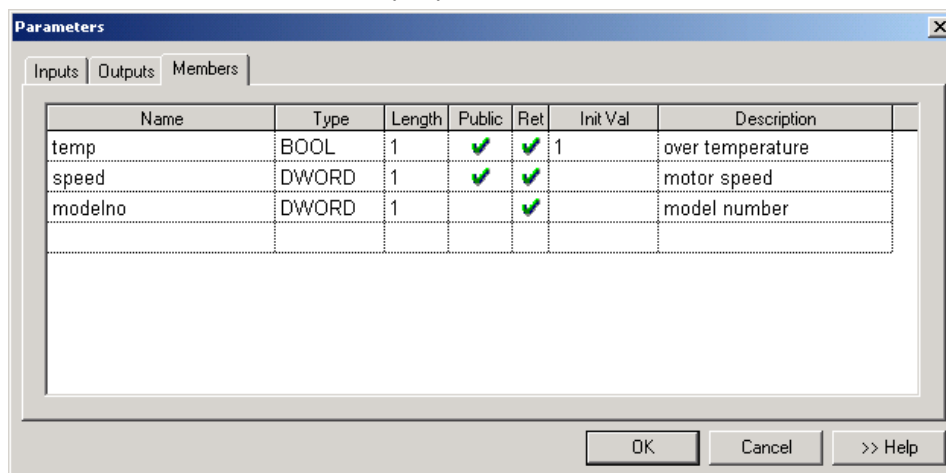


Figure 15: Defining Member Variables for a User-Defined Function Block

Creating UDFB Instances

You create an instance of a UDFB by calling it in your logic and assigning an instance name in the function properties.

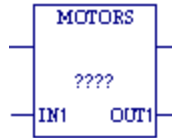


Figure 16: Creating a User-Defined Function Block

In the following LD example, the first rung creates two instances of the UDFB, Motors. The instance variables associated with the instances are motors.motor1 and motors.motor2. The second rung uses the two instances of the internal variable **temp** in logic.

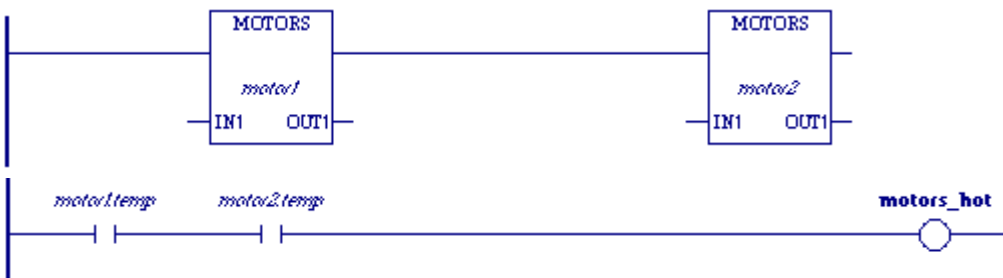


Figure 17: Use of User-Defined Function Block in Ladder Logic

Instance Data Structures

A variable with the format **function_block_name.instance_name** is automatically created for each instance of a UDFB. The instance data makes up a single composite variable that is of a structure type. The example to the right shows the variable structures associated with two instances of the UDFB named Motors. Each instance variable has elements corresponding to parameters **In1**, **Out1**, and **Y0**, and internal variables **modelno**, **speed**, and **temp**.

Instances are created as symbolic variables, never as mapped variables. This ensures that instance data is only referenced by the instance name and not by a memory address, which means that no aliases can be created for the UDFB data elements. The indirect reference operator cannot be used on an instance variable because indirect references are not permitted on symbolic variables.

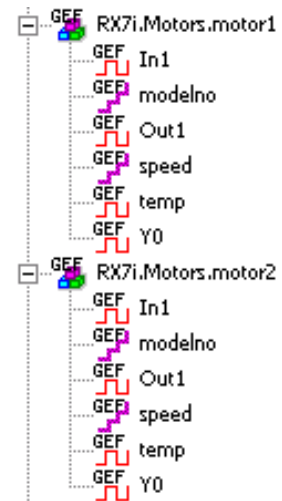


Figure 18: Display of Instance Data Structures

UDFBs and Scope

Unlike a parameterized subroutine, a UDFB has its own %L memory.

By default, internal variables of a UDFB have local scope, making them visible only to the logic inside the UDFB. They cannot be read or written by any external logic or by the hardware configuration. An internal variable can be made visible outside the UDFB by changing its scope to global. Logic outside the UDFB can read but cannot write to internal variables whose scope is global.

Note: If you give internal variables global scope, your application will not conform to IEC requirements.

Using Parameters with UDFBs

UDFBs support up to 63 inputs and up to 64 outputs.

Each UDFB has a predefined Boolean output parameter, Y0, which the CPU sets to true upon each invocation of the block. Y0 can be controlled by logic within the block and provides the output status of the block.

The following table lists the TYPEs, LENGTHs, and parameter-passing mechanisms allowed for UDFB parameters. For additional information on parameter passing, see “Parameter Passing Mechanisms” on page 113.

Type	Length	Parameter Passing Mechanism	Retentiveness of Instance Data for Parameters
BOOL	1 to 256	INPUTS: by reference, constant reference, value, or value result. (Default: value)	Not Applicable if passed by reference, since not stored in instance data. Can be retentive (default) or non-retentive for value or value result.
		OUTPUTS: by result; except Y0, which is by initial-value result	Retentive (default) or Non-retentive
BYTE	1 to 1024	INPUTS: by reference, constant reference, value, or value result. (Default: value)	Retentive for value or value result. Not applicable for reference
		OUTPUTS: by result	
INT, UINT, and WORD	1 to 512	INPUTS: by reference, constant reference, value, or value result. (Default: value)	Retentive for value or value result. Not applicable for reference
		OUTPUTS: by result	
DINT, REAL, and DWORD	1 to 256	INPUTS: by reference, constant reference, value, or value result. (Default: value)	Retentive for value or value result. Not applicable for reference
		OUTPUTS: by result	
LREAL	1 to 128	INPUTS: by reference, constant reference, value, or value result. (Default: value)	Retentive for value or value result. Not applicable for reference
		OUTPUTS: by result	
Function block (standard or PACMotion)	1	INPUTS: by reference, constant reference, (Default: reference)	Not applicable since passed by reference
		OUTPUTS: by result	
UDFB¹⁴	1	INPUTS: by reference, constant reference, friend	Not applicable since passed by reference
		OUTPUTS: not allowed	

¹⁴ A maximum of 16 input parameters can be of type UDFB.

Type	Length	Parameter Passing Mechanism	Retentiveness of Instance Data for Parameters
UDT	1 to 1024	INPUTS: by reference, constant reference	Not applicable since passed by reference
		OUTPUTS: not allowed	

If an input parameter is passed by reference or by value result, it requires an argument. All other parameters of a UDFB are optional. That is, they do not have to be given arguments on each instance of the UDFB. If no argument is given for an optional parameter, the variable element associated with the parameter retains the value it previously had.

UDFB outputs cannot be passed as arguments to input parameters that are passed by reference or passed by value result. This restriction prevents modification of a UDFB output.

Using Internal Member Variables with UDFBs

A UDFB can have any number of internal member variables. Internal variables' values are not passed through the input and output parameters. An internal variable cannot have the same name as a parameter of the UDFB it is defined in.

An internal variable can be:

- Any basic type supported by PACSystems (BOOL, INT, UINT, DINT, REAL, LREAL, BYTE, WORD, and DWORD).
- A UDFB type. Such member variables are known as nested instances. For example, the function block "Motor" can have an internal variable of type "Valve," where Valve is a UDFB type. Note that defining a member variable as a UDFB type does not create an instance.

A nested instance cannot be of the same type as the UDFB being defined because this would set up an infinitely recursive definition. Nor can any level of a nested instance be of the same type as the parent UDFB being defined. For example, the UDFB "Motor" cannot have an internal variable of type "Valve," if the Valve UDFB contains an internal variable of type "Motor."

- A UDT. A structured, user-defined data type consisting of elements of other selected data types.
- A one-dimensional array.

Internal variables of TYPE BOOL can be retentive (default) or non-retentive. All other TYPEs must be retentive.

Member variables corresponding to a UDFB's input parameters cannot be read or written outside of the UDFB. (This is more restrictive than the IEC 61131-3 requirements for user defined function blocks.) Member variables corresponding to the UDFB's output parameters can be read but not written outside the UDFB.

Internal member variables that have basic types may be given initial values. The same initial values apply to all instances of a UDFB. If an initial value isn't given, the internal member variable is set to zero when the application transitions to RUN mode for the first time.

An internal member variable that is a nested instance has initial values as specified by its UDFB type definition.

Initial values are not stored during a RUN mode store. They will not take effect until a Stop mode store is performed.

UDFB Logic

An instance of a BOOL parameter or internal variable can be forced ON or OFF, or used with transition-detecting instructions. The exception to this is that BOOL input parameters passed by reference cannot be forced or used with the Series 90-70 legacy transition-detecting instructions (POSCOIL, NEGCOIL, POSCON and NEGCON) because their values are not stored in instance data.

All input parameters to a UDFB, and their corresponding instance data elements, can be read by the logic of that particular UDFB.

Input parameters that are passed by reference or passed by value result to a UDFB can be written to by their UDFB's logic. Input parameters passed by value **cannot** be written to by their UDFB logic. Note that the restriction on writing to input parameters passed by value does not apply to other types of blocks.

All UDFB output parameters can be both read and written to by their logic.

UDFB Operation with Other Blocks

A UDFB instance that is of global scope can be invoked by another UDFB's logic or any other block's logic.

A UDFB instance that is passed (by reference) as an argument to a UDFB can be invoked by the UDFB's logic.

A UDFB instance that is passed (by reference) as an argument to a parameterized block can be invoked by the parameterized block's logic.

The output parameters, and their corresponding instance data elements, of a UDFB instance that is passed as an argument can be read but not modified by the receiving block's logic. The input parameters of a UDFB instance that is passed as an argument cannot be read or modified by the receiving block's logic. The internal variables of a UDFB instance that is passed as an argument cannot be modified by the receiving block's logic. They can be read if their scope is global, but not if their scope is local.

External Blocks

External blocks are developed using external development tools as well as the C Programmer's Toolkit for PACSystems. Refer to the *C Programmer's Toolkit for PACSystems User's Manual*, GFK-2259 for detailed information regarding external blocks.

Any block except `_MAIN` can be an external block. When you declare an external block, you must assign it a unique block name. It can be configured with up to 63 input parameters and 64 output parameters.

An external block executes when called from the program logic in the `_MAIN` block or from the logic in another block, parameterized block, or UDFB. External blocks themselves cannot call any other block. In the following example, if `%I00001` is set, the external block named `EXT_11` is executed.



Figure 19: Calling an External Block in Ladder Logic

Note: Unlike other block types, external blocks cannot call other blocks.

External Blocks and Local Data

External blocks support the use of %P global data. External blocks do not have their own %L data, but instead inherit the %L data of their calling blocks. They also inherit the FST_EXE system reference and the “time-stamp” data that is used to update timer function blocks from their calling blocks. If %L references are used within an external block and the block is called by _MAIN, %L references will be inherited from the %P references wherever encountered in the external block (for example, %L0005 = %P0005).

Initialization of C Variables

When an external block is stored to the CPU, a copy of the initial values for its global and static variables is saved. However, if static variables are declared without an initial value, the initial value is undefined and must be initialized by the C application. (Refer to “Global Variable Initialization” and “Static Variable” in the *C Programmer’s Toolkit for PACSystems*, GFK-2259). The saved initial values are used to re-initialize the block’s global and static variables whenever the CPU transitions from Stop to Run.

Using Parameters with an External Block

An external block may be defined to have between zero and 63 formal input parameters and between one and 64 formal output parameters. A ‘power-flow out’ (or OK) parameter, named Y0, is automatically defined for every external block. Y0 is a BOOL parameter of LENGTH 1, and indicates the successful execution of the block. It can be read and written to by the external block’s logic.

The following table gives the TYPEs, LENGTHs, and parameter-passing mechanisms allowed for external block parameters.

Type	Length	Default Parameter Passing Mechanism
BOOL	1 to 256	INPUTS: by reference
		OUTPUTS: by reference; except Y0, which is by initial-value result
BYTE	1 to 1024	INPUTS: by reference
		OUTPUTS: by reference
INT, UINT, and WORD	1 to 512	INPUTS: by reference
		OUTPUTS: by reference
DINT, REAL, and DWORD	1 to 256	INPUTS: by reference
		OUTPUTS: by reference
LREAL	1 to 128	INPUTS: by reference
		OUTPUTS: by reference
UDT ¹⁵	1 to 128	INPUTS: by reference
		OUTPUTS: not allowed

¹⁵ To use a UDT, you must include the UDT definition as a C structure in the external block. For details, see “Using a UDT as a C block input parameter data type” in the online help.

The PACSystems default parameter passing mechanisms correspond to the way that external block parameters are passed on 90-70 controllers. The parameter passing mechanisms of formal parameters cannot be changed from their default values.

You must define a name for each formal input and output parameter.

Arguments, or “actual parameters”, are passed into an external block when an external block call is executed.

Arguments may be any valid reference address including an indirect reference, may be flow, or may be a constant if the corresponding parameter’s LENGTH is 1.

5.1.6 Local Data

Each block or UDFB in a block-structured program has an associated local data block. `_MAIN`'s data block memory is referenced by `%P`; all other data block memories are referenced by `%L`.

The size of the data block is dependent on the highest reference in its block for `%L` and in all blocks for `%P`.

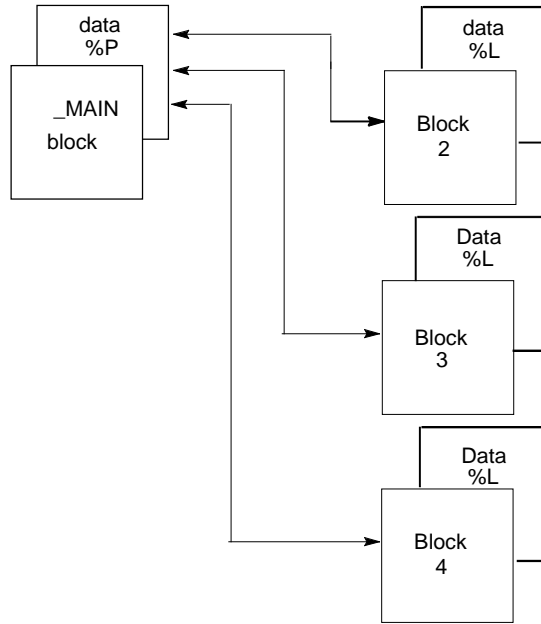


Figure 20: Relationship of `%L` & `%P` to Program Blocks

All blocks within the program can use data associated with the `_MAIN` block (`%P`). Blocks and UDFBs can use their own `%L` data as well as the `%P` data that is available to all blocks. The `_MAIN` block cannot use `%L`.

External blocks and parameterized blocks can use the Local Data (`%L`) of their calling block as well as the `%P` data of the `_MAIN` block. If a parameterized block or external block is called by `MAIN`, all `%L` references in the parameterized block or external block will actually be references to corresponding `%P` references (for example, `%L0005 = %P0005`). In addition to inheriting the Local Data of their calling blocks, parameterized blocks and external blocks inherit the `FST_EXE` status of their calling blocks.

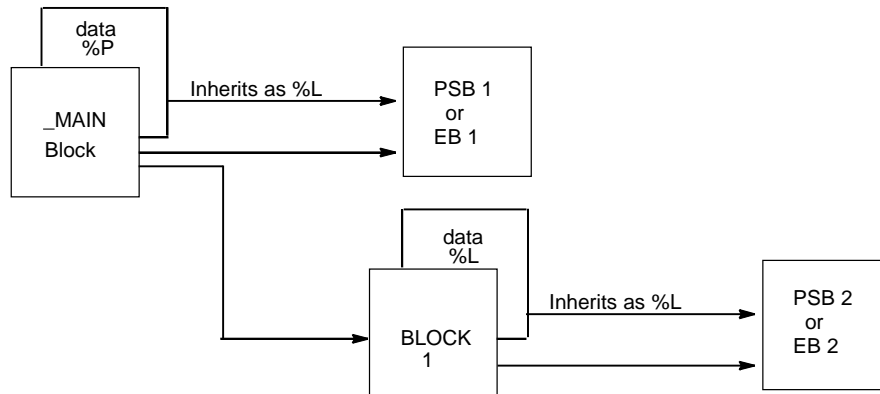


Figure 21: Local Data (`%L`) Usage by Program Blocks

5.1.7 Parameter Passing Mechanisms

All blocks (except `_MAIN`) have at least one parameter and thus are affected by parameter passing mechanisms. A “parameter passing mechanism” describes the way that data is passed from an argument in a calling block to a parameter in the called block, and from the parameter in the called block back to the argument in the calling block.

PACSystems supports the following parameter-passing mechanisms: pass by reference, pass by constant reference, pass by value, pass by value result, pass by result and pass by initial-value result. An additional type, pass by friend, is available when the input Data Type is a UDFB. A parameter is defined by its TYPE, LENGTH, and parameter passing mechanism.

- When a parameter is passed by **reference**, the address of its argument is passed into the function block instance or parameterized block. All logic within the called block that reads or writes to the parameter directly reads or writes to the actual argument.
- When a parameter is passed by **constant reference**, the CPU passes a reference address pointer, symbolic variable pointer, or I/O variable pointer into the function block instance or parameterized block. The instance or block can only read the reference address or variable.
- When a parameter is passed by **friend** (UDFB inputs only), the CPU passes a UDFB instance variable pointer into the function block instance or parameterized block. The instance or block can write to any output or member, whether public or private, of the UDFB instance variable passed as a friend.

Tip: In the logic of a UDFB, when you want to pass the UDFB as a friend, assign the pseudo-variable “#This” to the input that expects an instance variable of that UDFB type. In the following example, the In2 input of the LDPSB parameterized block expects a UDFB instance variable friend of the ABC data type. Inside the logic of ABC, assign “#This” to In2 in the call to LDPSB.



LDPSB Parameters							
Inputs							
	Name	Data Type	Length	Pass By	Retentive	Initial Value	Description
▶	In1	BOOL	1	Value			
	In2	ABC	1	Friend			
*					<input type="checkbox"/>		

Figure 22: Parameter Passing Example

- When a parameter is passed by **value (UDFB inputs only)**, the value of its argument is copied into a local stack memory associated with the called block. All logic within the called block that reads or writes to the parameter is reading or writing to this stack memory. Thus no changes are ever made to the actual argument.

- When a parameter is passed by **value result (UDFB inputs only)**, the value of its argument is copied into a local stack memory associated with the called block, and the address of its argument is saved. All logic within the called block that reads or writes to the parameter is reading or writing to this stack memory. When the called block completes its execution, the value in the stack memory is copied back to the actual argument's address. Thus no changes are made to the actual argument while the called block is executing, but when it completes execution, the actual argument is updated.

5.1.8 Languages

Ladder Diagram (LD)

Logic written in Ladder Diagram language consists of a sequence of rungs that execute from top to bottom. The logic execution is thought of as “power flow”, which proceeds down along the left “rail” of the ladder, and from left to right along each rung in sequence.

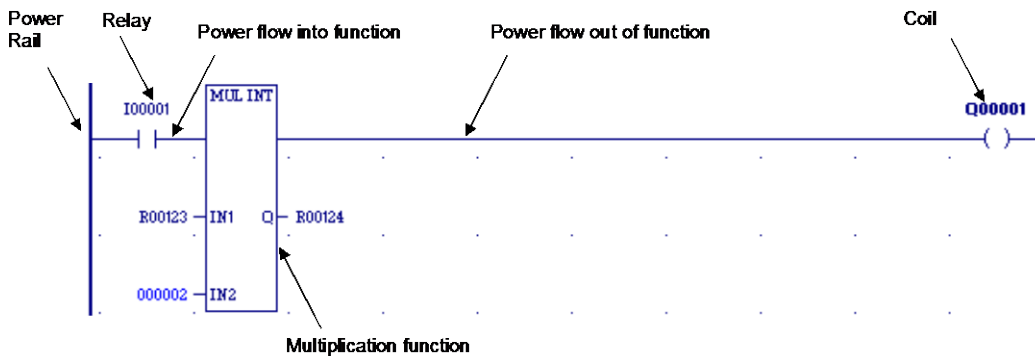


Figure 23: Explanation of Ladder Diagram Rung

The flow of logical power through each rung is controlled by a set of simple program instructions that work like mechanical relays and output coils. Whether or not a relay passes logical power flow along the rung depends on the content of a memory location with which the relay has been associated in the program. For instance, a relay might pass positive power flow if its associated memory location contains the value 1. The same relay passes negative power flow if the memory location contains the value 0.

Usually an instruction that receives negative power flow does not execute and propagates the negative power flow on to the next instruction in the rung. However, some instructions such as timers and counters execute even when they receive negative power flow, and may even pass positive power flow out. Once a rung completes execution, with either positive or negative power flow, power flows down along the left rail to the next rung.

Within a rung, there are many complex functions that are part of the standard function library and can be used for operations like moving data stored in memory, performing math operations, and controlling communications between the CPU and other devices in the system. Some program functions, such as the Jump function and Master Control Relay, can be used to control the execution of the program itself. Together, this large group of Ladder Diagram instructions and standard library functions makes up the *instruction set* of the CPU.

Function Block Diagram

Function Block Diagram (FBD) is an IEC 61131-3 graphical programming language that represents the behavior of functions, function blocks and programs as a set of interconnected graphical blocks. FBD depicts a system in terms of the flow of signals between processing elements, in a manner very similar to signal flows depicted in electronic circuit diagrams. Instructions are shown with inputs entering from the left and outputs exiting on the right. A function block type name is always shown within the element and the name of the function block instance is shown above the element.

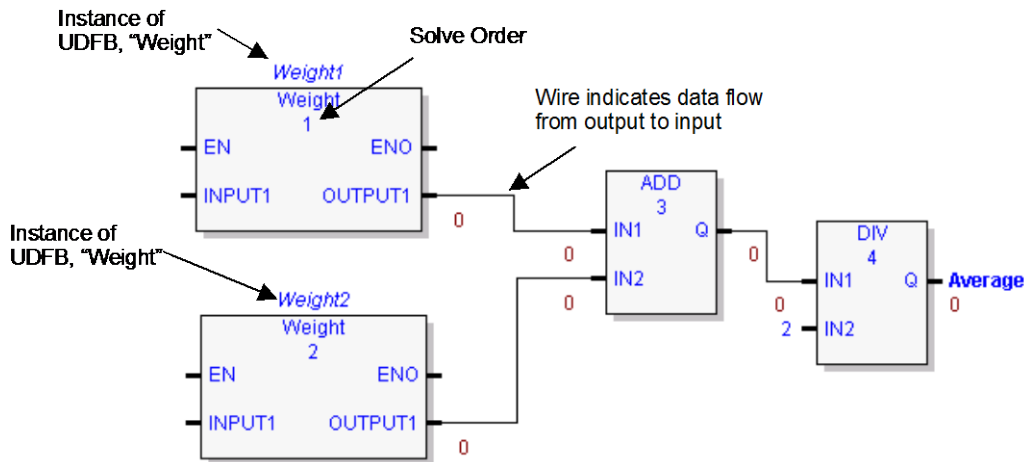


Figure 24: Illustration of Function Block Diagram

The order of execution of instructions in an FBD is determined by the following:

- a) The display position of the instruction in the FBD editor
- b) Whether the inputs to the FBD instruction are resolved.

To determine the order of execution of FBD instructions in the FBD editor, the FBD compiler performs the following steps:

1. The FBD compiler scans the instructions in the FBD editor, beginning from left to right, and top to bottom. When an instruction is encountered, the compiler attempts to resolve the instruction, that is, the inputs are known. If the inputs are known, the instruction is solved, and scanning continues for the next instruction.
2. If the current instruction cannot be resolved, that is, the inputs are not known, then the compiler scans for the previous instruction, using the wire connecting the output of the previous instruction to the input of the current instruction.
3. If the previous instruction can be resolved, the compiler calculates the output. The output of the previous instruction then becomes the input to the current instruction, the current instruction is resolved, and scanning continues for the next instruction.
4. If the previous instruction cannot be resolved, that is, the inputs are not known, then step 2 is repeated until an instruction is encountered, which can be resolved.

Structured Text

The Structured Text (ST) programming language is an IEC 1131-3 textual programming language. A structured text program consists of a series of statements, which are constructed from expressions and language keywords. A statement directs the PLC to perform a specified action. Statements provide variable assignments, conditional evaluations, iteration, and the ability to call other blocks. For details on ST statements, parameters, keywords, and operators supported by PACSystems, refer to Chapter 11, "Structured Text."

Blocks, parameterized blocks, and UDFBs can be programmed in ST. The `_MAIN` program block can also be programmed in ST.

A block programmed in ST can call blocks, parameterized blocks, and UDFBs.

5.2. Controlling Program Execution

There are many ways in which program execution can be controlled to meet the system's timing requirements. The PACSystems CPU instruction set contains several powerful control functions that can be included in an application program to limit or change the way the CPU executes the program and scans I/O. For details on using these functions, refer to Chapter 7.

The following is a partial list of the commonly used methods:

- The Jump (JUMPN) function can be used to cause program execution to move either forward or backward in the logic. When a JUMPN function is active, the coils in the part of the program that is skipped are left in their previous states (not executed with negative power flow, as they are with a Master Control Relay). Jumps cannot span blocks.
- The nested Master Control Relay (MCRN) function can be used to execute a portion of the program logic with negative power flow. Logic is executed in a forward direction and coils in that part of the program are executed with negative power flow. Master Control Relay functions can be nested to 255 levels deep.
- The Suspend I/O function can be used to stop both the input scan and output scan for one sweep. I/O can be updated, as necessary, during the logic execution through the use of DO I/O instructions.
- The Service Request function can be used to suspend or change the time allotted to the window portions of the sweep.
- Program logic can be structured so that blocks are called more or less frequently, depending on their importance and on timing constraints. The CALL function can be used to cause program execution to go to a specific block. Conditional logic placed before the Call function controls the circumstances under which the CPU executes the block logic. After the block execution is finished, program execution resumes at the point in the logic directly after the CALL instruction.

5.3. Interrupt-Driven Blocks

Three types of interrupts can be used to start a block's execution:

- **Timed Interrupts** are generated by the CPU based on a user-specified time interval with an initial delay (if specified) applied on Stop-to-Run transition of the CPU.
- **I/O Interrupts** are generated by I/O modules to indicate discrete input state changes (rising/falling edge), analog range limits (low/high alarms), and high speed signal counting events.
- **Module Interrupts** are generated by VME modules. A single interrupt is supported per module.



Caution

Interrupt-driven block execution can interrupt the execution of non-interrupt-driven logic. Unexpected results may occur if the interrupting logic and interrupted logic access the same data. If necessary, Service Request #17 or Service Request # 32 can be used to temporarily mask I/O and Timed Interrupt-driven logic from executing when shared data is being accessed.

5.3.1 Interrupt Handling

An I/O, Module, or Timed interrupt can be associated with any block except `_MAIN`, as long as the block has no parameters other than an OK output. After an interrupt has been associated with a block, that block executes each time the interrupt trigger occurs. A given block can have multiple timed, I/O, and module interrupt triggers associated with it. It is executed each time any one of its associated interrupts triggers. For details on how interrupt blocks are prioritized, refer to "Interrupt Block Scheduling" on page 121.

If a parameterized block or external block is triggered by an interrupt, it inherits `%P` data as its `%L` local data. For example, a `%L00005` reference in the parameterized block or C block actually references `%P00005`.

Note: Timer function blocks do not accumulate time if used in a block that is executed as a result of an interrupt.

Blocks that are triggered by interrupts can make calls to other blocks. The application stack used during interrupt-driven execution is different from the stack used during normal block-structured program execution. In particular, the nested call limit is different from the limit described for calls from the `_MAIN` block. If a call results in insufficient stack space to complete the call, the CPU logs an "Application Stack Overflow" fault.

Note: We strongly recommend that interrupt-driven blocks not be called from the `_MAIN` block or other non-interrupt driven blocks because the interrupt and non-interrupt driven blocks could be reading and writing the same global memories at indeterminate times relative to each other. In the following example (Figure 25) `INT1`, `INT2`, `BLOCK5`, and `PB1` should not be called from `_MAIN`, `BLOCK2`, `BLOCK3`, or `BLOCK4`.

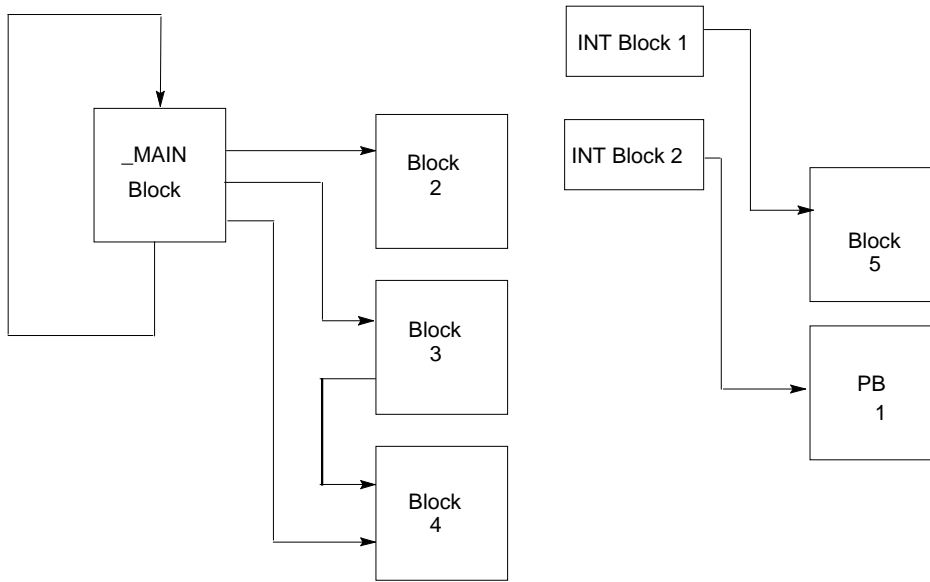


Figure 25: Conflict Avoidance when using Interrupt-Driven Blocks

5.3.2 Timed Interrupts

A block can be configured to execute on a specified time interval with an initial delay (if specified) applied on a Stop-to-Run transition of the CPU.

To configure a timed interrupt block, specify the following parameters in the scheduling properties for the block:

Time Base	The smallest unit of time that you can specify for Interval and Delay. The time base can be 1.0 second, 0.10 second, or 0.01 second, or 0.001 second.
Interval	Specifies how frequently the block executes in multiples of the time base.
Delay	(Optional) Specifies an additional delay for the first execution of the block in multiples of the time base.

The first execution of a Timed Interrupt block will occur at $((\text{delay} * \text{time base}) + (\text{interval} * \text{time base}))$ after the CPU is placed in Run mode.

5.3.3 I/O Interrupts

A block can be triggered by an interrupt input from certain hardware modules. For example, on the 32-Circuit 24 VDC Input Module (IC697MDL650), the first input can be configured to generate an interrupt on either the rising or falling edge of the input signal. If the interrupt is enabled in the module configuration, that input can serve as a trigger to cause the execution of a block.

To configure an I/O interrupt, specify a trigger in the scheduling properties for the block. The trigger must be a global variable in %I, %AI or %AQ memory, or an I/O variable. (An I/O variable is a form of symbolic variable that is mapped to a module I/O point in hardware configuration.)

PACSystems modules that can trigger user interrupt logic always send the interrupt to the CPU when configured to do so. If the CPU is in Stop mode when it receives the interrupt, it does not run the user interrupt block. The CPU does not run the user interrupt block when it transitions from Stop to Run mode.

5.3.4 Module Interrupts

A block can be triggered by an interrupt from a module that supports I/O interrupts if the Interrupt parameter is enabled in the module's hardware configuration.

To configure a module interrupt, specify the module by rack/slot/interrupt ID as the Trigger in the scheduling properties for the block.

5.3.5 Interrupt Block Scheduling

You can select one of two types of interrupt block scheduling at the target level:

- **Normal block scheduling** allows you to associate a maximum of 64 I/O and Module Interrupts and 16 Timed Interrupts. With normal block scheduling, all interrupt-triggered blocks have equal priority. This is the default scheduling mode.
- **Preemptive block scheduling** allows you to associate a maximum of 32 interrupt triggers. With preemptive block scheduling, each trigger can be assigned a relative priority.

Normal Block Scheduling

Interrupt-driven logic has the highest priority of any user logic in the system. The execution of a block triggered from an interrupt preempts the execution of the normal CPU sweep activities. Execution of the normal CPU sweep activities is resumed after the interrupt-driven block execution completes.

If the CPU receives one or more interrupts while executing an interrupt block, it places the incoming interrupts into the queue while it finishes executing the current interrupt block. Timed interrupt driven blocks are queued ahead of I/O or Module driven blocks. I/O or Module interrupt driven blocks are queued in the order in which the interrupts are received. If an interrupt driven block is already in the queue, additional interrupts that occur for this block are ignored.

Preemptive Block Scheduling

Preemptive scheduling allows you to assign a priority to each interrupt trigger. The priority values range from 1 to 16, with 1 being the highest. A single block can have multiple interrupts with different priorities or the same priorities.

An incoming interrupt is handled according to its priority compared to that of the currently executing block as follows:

- If an incoming interrupt has a higher priority than the interrupt associated with the block that is currently executing, the currently executing block is stopped and put in the interrupt queue. The block associated with the incoming interrupt begins executing.
- If an incoming interrupt has the same priority as the interrupt trigger associated with the block that is currently executing, that block continues to execute and the incoming interrupt is placed in the queue.
- If an incoming interrupt has a lower priority than the interrupt associated with the block that is currently executing, the incoming interrupt is placed in the queue.

When the CPU completes the execution of an interrupt block, the block associated with the interrupt trigger that has the highest priority in the queue begins execution — or resumes execution if the block's execution was preempted by another interrupt block and was placed in the queue.

If multiple blocks in the queue have the same interrupt priority, their execution order is not deterministic.

Note: Certain functions, such as DOIO, BUS_RD, BUS_WRT, COMMREQ, SCAN_SET_IO, and some SVC_REQs may cause a block to yield to another queued block that has the same priority.

Chapter 6 Program Data

This chapter describes the types of data that can be used in an application program, and explains how that data is stored in the PACSystems CPU's memory.

- Variables
- Reference Memory
- User Reference Size and Default
- Genius Global Data
- Transitions and Overrides
- Retentiveness of Logic and Data
- Data Scope
- System Status References
- How Program Functions Handle Numerical Data
- User Defined Types (UDTs)
- Word-for-Word Changes
- Operands for Instructions

6.1. Variables

A variable is a named storage space for data values. It represents a memory location in the target PACSystems CPU.

A variable can be mapped to a reference address (for example, %R00001). If you do not map a variable to a specific reference address, it is considered a *symbolic variable*. The programming software handles the mapping for symbolic variables in a special portion of PACSystems user space memory.

The kinds of values a variable can store depends on its data type. For example, variables with a UINT data type store unsigned whole numbers with no fractional part. Data types are described in “How Program Functions Handle Numerical Data” on page 143.

In the programming software, all variables in a project are displayed in the Variables tab of the Navigator. You create, edit, and delete variables in the Variables tab. Some variables are also created automatically by certain components (such as TIMER variables when you add a Timer instruction to ladder logic). The data type and other properties of a variable, such as reference address are configured in the Inspector.

For more information about *system variables*, which are created when you create a target in the programming software, refer to page 138.

6.1.1 Mapped Variables

Mapped (manually located) variables are assigned a specific reference address. For details on the types of Reference Memory and their uses, refer to page 130.

6.1.2 Symbolic Variables

Symbolic variables are variables for which you do not specify a reference address (similar to a variable in a typical high-level language). Except as noted in this section, you can use these in the same ways that you use mapped variables.

In the programming software, a symbolic variable is displayed with a blank address. You can change a mapped variable to a symbolic variable by removing the reference address from the variable’s properties. Similarly, you can change a symbolic variable into a mapped variable by specifying a reference address for the variable in its properties.

The memory required to support symbolic variables counts against user space. The amount of space reserved for these variables is configured on the Memory tab in the CPU hardware configuration.

Restrictions on the Use of Symbolic Variables

- Symbolic variables cannot be used with indirect references (for example, @Name). For a description of Indirect References, see page 130
- Only global scope Symbolic variables can be used in EGD pages.
- A variable must be globally scoped and published (internal or external) to be used in a C block.
- Symbolic variables cannot be used in the COMMREQ status word.
- Use of symbolic variables is not supported on web pages.
- Symbolic Boolean variables are not allowed on non-BOOL parameters.
- Symbolic non-discrete variables cannot be used on Series 90-70 style Transition contacts and coils. (Symbolic discrete variables are supported.)
- Overrides and Forces cannot be used on symbolic non-discrete variables. (Symbolic discrete variables are supported.)
- Arrays of the following data types are not supported:

- Arrays of user defined function block (UDFB) instance variables.
- Arrays of PACMotion function block instance variables.
- Arrays of TON, TOF, or TP instance variables.
- Arrays of reference ID variables (RIVs) that contain one or more linked RIV elements.

Note: An RIV array is supported when none of its elements is linked.

6.1.3 I/O Variables

An I/O variable is a symbolic variable that is mapped to a terminal in the hardware configuration. A terminal can be one of the following: Physical discrete or analog I/O point on a PACSystems module or on a Genius device, a discrete or analog status returned from a PACSystems module, or Global Data. The use of I/O variables allows you to configure hardware modules without having to specify the reference addresses to use when scanning their inputs and outputs. Instead, you can directly associate variable names with a module's inputs and outputs.

As with symbolic variables, memory required to support I/O variables counts against user space. You can configure the space available for I/O variables in the Memory tab of the PACSystems CPU.

For a given module or Genius bus, you must use either I/O variables or manually located mapped variables: you cannot use both in combination. It is not necessary to map all points on a module. Points that are disconnected or unused can be skipped. When points are skipped, space is reserved in user memory for that point (that is, a 32-point discrete module will always use 32 bits of memory).

The hardware configuration (HWC) and logic become coupled in a PACSystems target on your computer as soon as you do one of the following: Enable I/O variables for a module or Genius bus (even if you don't create any I/O variables), use one or more symbolic variables in the Ethernet Global Data (EGD) component, or upload a coupled HWC and logic from a PACSystems PLC. The HWC and logic become coupled in a PACSystems controller when coupled HWC and logic are downloaded to it.

Effects of coupled HWC and logic:

- Whether the HWC and logic are coupled in the PACSystems target on your computer or in the PACSystems controller, you cannot download or upload the HWC and logic independently.
- When the HWC and logic are coupled in the PACSystems controller, you cannot clear the HWC and the logic independently.
- As for any download, you cannot run mode store (RMS) the HWC and logic independently.
- The HWC must be completely equal for you to make word-for-word changes, launch the Online Test mode of Test Edit, or accept the edits of Test Edit.

I/O variables can be used any place that other symbolic variables are supported, such as in logic as parameters to built-in function blocks, user defined function blocks, parameterized function blocks, C blocks, bit-in-word references, and transition contacts and coils.

Restrictions on the Use of I/O Variables

- Since I/O variables are a form of symbolic variable, the same restrictions that apply to other symbolic variables of the same data type and array bounds apply to I/O variables.
- Only a global variable can become an I/O variable. A local variable cannot become an I/O variable.
- You can map only a discrete variable to a discrete terminal.
- You can map only a non-discrete variable to an analog terminal.
- Arrays and UDT variables must fit on the number of terminals in the reference address node counting from and including the terminal where you enter the array head or UDT variable. For example, if you have 32 analog terminals and you have a WORD array of 12 elements, you can map it to terminal 21 or any terminal before it (1 through 20).

- You can map a discrete array only to a terminal $8n+1$, where $n = 0, 1, 2$, and so on. The "+1" is there because the terminals are numbered beginning with 1. If you map it to a terminal other than $8n+1$, an error occurs upon validation.
- An I/O variable cannot be mapped to more than one location in hardware configuration.
- For the DO_IO function block, if an I/O variable is assigned to the ST parameter, then the same I/O variable must also be assigned to the END parameter, and the entire module is scanned.
- Some I/O modules do not support the use of I/O variables. For a list of modules that support I/O variables, please refer to the *Important Product Information* for Logic Developer – PLC programming software.

I/O Variable Format

To map an I/O variable, use the format **%vdr.s.[z.]g.t:**

v = I (input) or Q (output)

d = data type: X (discrete) or W (analog).

r = rack number

s = slot number

[z] = sub-slot number. This element and the period that follows it appear only if there is a sub-slot, for example, the SBA number of a Genius device. For an Ethernet daughterboard, set this value to 0.

g = segment number or number of the reference address node. Set to 0 for the first reference address node on the Terminals tab, 1 for the second reference node, and so on.

t = terminal number. One-based, that is, the numbering begins at 1.



Supported I/O Variable Types

Data Type Mnemonic	Supported Data Types	Number of Consecutive Terminals Required
X	BOOL variable	1
	BOOL array	Number of elements in array.
	BYTE variable	8
	BYTE array	$8n$, where n is the number of array elements.
W	DINT variable	2
	DINT array	Number of elements in array times 2
	DWORD variable	2
	DWORD array	Number of elements in array times 2
	INT variable	1
	INT array	Number of elements in array
	LREAL variable	4
	LREAL array	Number of elements in array times 4
	REAL variable	2
	REAL array	Number of elements in array times 2
	UINT variable	1
	UINT array	Number of elements in array
	WORD variable	1
	WORD array	Number of elements in array

I/O Variable Examples

  QW1 Sample_IO_Variable %QW0.8.0.1

The I/O variable, Sample_IO_Variable is mapped to a non-discrete (W) output point (Q) on the module located in rack 0, slot 8. The variable is mapped to the first point in the first group of non-discrete output reference addresses.

  I2 IO_VAR_EXAMPLE %IX0.5.2.2

The I/O variable, IO_VAR_EXAMPLE, is mapped to a discrete (X) input point (I) on the module located in rack 0, slot 5. The point is located in the module's third group of discrete input points and is point 2 in that group.

6.1.4 Arrays

An array is a complex data type composed of a series of variable elements with identical data types. Any variable can become an array, except for another array, a variable element, or a UDFB. In Machine Edition, you can create single-dimensional arrays and two-dimensional arrays.

In the controller CPU, each element of an array is treated as a separate variable with a separate, read-only reference address. The "root" node of the array variable also has a reference address that is editable. When you set or change the reference address of the "root" node of an array variable, the reference addresses of its elements are filled in with a range of addresses starting at that reference address and incremented for each element so as to create contiguous non-overlapping memory.

6.1.5 Variable Indexes and Arrays

PACSystems CPUs with firmware version 6.00 or later support variable indexes for arrays. With a variable index, when logic is executed, the value of the variable is evaluated and the corresponding array element is accessed.

Note: The numbering of array elements is zero-based.

For example, to access an element of the array named ABC, you could write ABC[DEF] in logic. When logic is executed, if the value of DEF is 5, then ABC[DEF] is equivalent to ABC[5], and the sixth element of array ABC is accessed.

If the value of the variable index exceeds the array boundary, a non-fatal fault is logged to the CPU fault table. In LD, the instruction for which this occurred does not pass power to the right.

Requirements and Support

An index variable must be of the INT, UINT, or DINT data type.

The valid range of values for an index variable is 0 through Y, where Y = [the number of array elements in the array] - 1. See *Ensuring that a Variable Index does not Exceed the Upper Boundary of an Array* (page 129).

An index variable can be one of the following:

- Symbolic variable
- I/O variable
- Variable mapped to % memory areas such as %R
- Structure element
- Array element with a constant index
- Array element with a variable index
- Alias variable
- In the logic of a UDFB or parameterized block: formal parameter

The following support a variable index:

- Array elements of any data type except STRING
- Parameter array elements of any data type
- Alias variables

Dimensional support:

- One-dimensional (1D) formal parameter arrays in the logic of a UDFB or parameterized block
- 2D support for the top level of an array of structures and 1D support for a structure element that is an array. For example:

PQR[a, b].STRU[y].Zed,

where Zed is an element of the array of structures STRU, which itself is an element of the 2D array of structures PQR.

- 1D and 2D arrays for other variables

Other features:

- An array with a variable index supports a bit reference, for example
MyArray[nIndex].X[4],
where .X[4] is the fifth bit of the value stored in MyArray[nIndex]. The bit reference itself, [4] in the example, must be a constant.
- In LD, the following word-for-word changes are supported for array elements with variable indexes:

Replacing an index variable with another index variable

Replacing an index variable with a constant

Replacing a constant with an index variable

In LD, Diagnostic Logic Blocks support the use of array elements with variable indexes.

Where Array Elements with Variable Indexes are Not Supported:

The following do not support array elements with variable indexes:

- Indirect references
- EGD variables
- Reference ID variables (RIVs) and I/O variables when accessed in the Hardware Configuration

Note: In logic, RIVs and I/O variables support variable indexes.

- STRING variables

A variable index cannot be one of the following:

- A math expression. For example, ABC[GH+1] is not supported.
- An indirect reference. For example, W[@XYZ] is not supported.
- A bit reference. For example, ABC[DEF.X[3]] is not supported.

Note: You can use a bit reference on an array element designated by a variable index. For example, ABC[DEF].X[3] is supported.

- An array head. For example, if MNP and QRS are arrays, MNP[QRS] is not supported, but MNP[QRS[3]] and MNP[QRS[TUV]] are, where TUV is an index variable.
- A negative index. This generates a run-time non-fatal CPU fault.
- A value greater than Y, where Y = [number of array elements] - 1. This generates a run-time non-fatal CPU fault.

Ensuring that a Variable Index does not Exceed the Upper Boundary of an Array

One-Dimensional Array

1. Once per scan, execute ARRAY_SIZE_DIM1 to count the number of elements in the array.

Note: The array size of a variable can be changed in a run mode store but it will not be changed while logic is executing.

ARRAY_SIZE_DIM1 places the count value in the variable associated with its output Q.

2. Before executing an instruction that uses a variable index, compare the value of the index variable with the number of elements in the array.

Tip: In LD, use a RANGE instruction.

Notes Checking before executing each instruction that uses an indexed variable is recommended in case logic has modified the index value beyond the array size or in case the array size has been reduced before the scan to less than the value of an index variable that has not been reduced accordingly since.

Valid range of an index variable: 0 through (n-1), where n is the number of array elements.
Array indexes are zero-based.

Two-Dimensional Array

- Execute both ARRAY_SIZE_DIM1 and ARRAY_SIZE_DIM2 to count the number of elements in respectively the first and second dimensions of the array.

6.2. Reference Memory

The CPU stores program data in bit memory and word memory. Both types of memory are divided into different types with specific characteristics. By convention, each type is normally used for a specific type of data, as explained below. However, there is great flexibility in actual memory assignment.

Memory locations are indexed using alphanumeric identifiers called references. The reference's letter prefix identifies the memory area. The numerical value is the offset within that memory area, for example %AQ0056.

6.2.1 Word (Register) References

Type	Description
%AI	The prefix %AI represents an analog input register. An analog input register holds the value of one analog input or other non-discrete value.
%AQ	The prefix %AQ represents an analog output register. An analog output register holds the value of one analog output or other non-discrete value.
%R	Use the prefix %R to assign system register references that will store program data such as the results of calculations.
%W	Retentive Bulk Memory Area, which is referenced as %W (WORD memory).
%P	Use the prefix %P to assign program register references that will store program data with the _MAIN block. This data can be accessed from all program blocks. The size of the %P data block is based on the highest %P reference in all blocks. %P addresses are available only to the LD program they are used in, including C blocks called from LD blocks; they are not system-wide.

Note: All register references are retained across a power cycle to the CPU.

Indirect References

An indirect reference allows you to treat the contents of a variable assigned to an LD instruction operand as a pointer to other data, rather than as actual data. Indirect references are used only with word memory areas (%R, %W, %AI, %AQ, %P, and %L). An indirect reference in %W requires two %W locations as a DWORD indirect index value. For example, @%W0001 would use the %W2:W1 as a DWORD index into the %W memory range. The DWORD index is required because the %W size is greater than 65K.

Indirect references cannot be used with symbolic variables.

To assign an indirect reference, type the @ character followed by a valid reference address or variable name. For example, if %R00101 contains the value 1000, @R00101 instructs the CPU to use the data location of %R01000.

Indirect references can be useful when you want to perform the same operation to many word registers. Use of indirect references can also be used to avoid repetitious logic within the application program. They can be used in loop situations where each register is incremented by a constant or by a value specified until a maximum is reached.

Bit in Word References

Bit in word referencing allows you to specify individual bits in a word reference type as inputs and outputs of Boolean expressions, functions, and calls that accept bit parameters (such as parameterized blocks). This feature is restricted to word references in retentive memory. The bit number in the bit within word construct must be a constant.

You can use the programmer or an HMI to set an individual bit on or off within a word, or monitor a bit within a word. Also, C blocks can read, modify, and write a bit within a word.

Bit in Word references can be used in the following situations:

- In retentive 16-bit memory (AI, AQ, R, W, P, and L) and symbolics.
- On all contacts and coils **except** legacy transition contacts (POSCON/NEGCON) and transition coils (POSCOIL/NEGCOIL).
- On all functions and call parameters that accept single or unaligned bit parameters.

Functions that accept unaligned discrete references	Parameters
ARRAY MOVE (BIT)	SR and DS
ARRAY RANGE (BIT)	Q
MOVE (BIT)	IN and Q
SHFR (BIT)	IN, ST and Q

Restrictions

The use of Bit in Word references has the following restrictions:

- Bit in Word references cannot be used on legacy transition contacts (POSCON/NEGCON) and transition coils (POSCON/NEGCON).
- The bit number (index) must be a constant; it cannot be a variable.
- Bit addressing is not supported for a constant.
- Indirect references cannot be used to address bits in 16-bit memory.
- You cannot force a bit within 16-bit memory.

Examples:

%R2.X [0] addresses the first (least significant) bit of %R2

%R2.X [1] addresses the second bit of %R2. In the examples

In the examples [0] and [1] are the bit indexes. Valid bit indexes for the different variable types are:

BYTE variable	[0] through [7]
WORD, INT, or UINT variable	[0] through [15]
DWORD or DINT variable	[0] through [31]

6.2.2 Bit (Discrete) References

Type	Description
%I	Represents input references. %I references are located in the input status table, which stores the state of all inputs received from input modules during the last input scan. A reference address is assigned to discrete input modules using your programming software. Until a reference address is assigned, no data will be received from the module. %I memory is always retentive.
%Q	Represents physical output references. The coil check function checks for multiple uses of %Q references with relay coils or outputs on functions. You can select the level of coil checking desired (Single, Warn Multiple, or Multiple). %Q references are located in the output status table, which stores the state of the output references as last set by the application program. This output status table's values are sent to output modules at the end of the program scan. A reference address is assigned to discrete output modules using your programming software. Until a reference address is assigned, no data is sent to the module. A particular %Q reference may be either retentive or non-retentive.
%M	Represents internal references. The coil check function of your programming software checks for multiple uses of %M references with relay coils or outputs on functions. A particular %M reference may be either retentive or non-retentive.
%T	Represents temporary references. These references are never checked for multiple coil use and can, therefore, be used many times in the same program even when coil use checking is enabled—this is not a recommended practice because it makes subsequent trouble-shooting more difficult. %T may be used to prevent coil use conflicts while using the cut/paste and file write/include functions. Because this memory is intended for temporary use, it is cleared on Stop-to-Run transitions and cannot be used with retentive coils.
%S %SA %SB %SC	Represent system status references. These references are used to access special CPU data such as timers, scan information, and fault information. For example, the %SC0012 bit can be used to check the status of the CPU fault table. Once the bit is set on by an error, it will not be reset until after the sweep. %S, %SA, %SB, and %SC can be used on any contacts. <ul style="list-style-type: none"> ▪ %SA, %SB, and %SC can be used on retentive coils -(M)-. <p>Note: Although the programming software forces the logic to use retentive coils with %SA, %SB, and %SC references, most of these references are not preserved across power cycles regardless of the state of the battery or Energy Pack.</p> <p>%S can be used as word or bit-string input arguments to functions or function blocks. %SA, %SB, and %SC can be used as word or bit-string input or output arguments to functions and function blocks. For a description of the behavior of each bit, see <i>System Status References</i> on page 138.</p>
%G	Represents global data references. These references are used to access data shared among several control systems.

Note: For details on retentiveness, refer to “Retentiveness of Logic and Data” on page 136.

6.3. User Reference Size and Default

Maximum user references and default reference sizes are listed in the table below.

Item	Range	Default
Reference Points		
%I reference	32768 bits	32768 bits
%Q reference	32768 bits	32768 bits
%M reference	32768 bits	32768 bits
%S total (S, SA, SB, SC)	512 bits (128 each)	512 bits (128 each)
%T reference	1024 bits	1024 bits
%G	7680 points	7680 points
Total Reference Points	107520	107520
Reference Words		
%AI reference	0—32640 words	64 words
%AQ reference	0—32640 words	64 words
%R, 1K word increments	0—32640 words	1024 words
%W	0—maximum available user RAM	0 words
Total Reference Words	0—maximum available user RAM	1152 words
%L (per block)	8192 words	8192 words
%P (per program)	8192 words	8192 words
Managed Memory		
Symbolic Discrete	0—83,886,080 (bits)	32768
Symbolic Non-Discrete	0—5,242,880 (words)	65536
I/O Discrete	0 through 83,886,080	0
I/O Non-Discrete	0 through 5,242,880.	0
Total Symbolic	0—42,088,704 bytes (This is the total memory available for the combined total of symbolic memory. This also includes other user memory use, program etc.)	143360

6.3.1 %G User References and CPU Memory Locations

The CPU contains one data space for all of the global data references (%G). The internal CPU memory for this data is 7680 bits long. For Series 90-70 systems, the programming software subdivides this range using %G, %GA, %GB, %GC, %GD, and %GE prefixes—allowing each of these prefixes to be used with bit offsets in the range 1–1280. For PACSystems, these ranges are converted to %G.

6.4. **Genius Global Data**

PACSystems supports the sharing of data among multiple control systems that share a common Genius I/O bus. This mechanism provides a means for the automatic and repeated transfer of %G, %I, %Q, %AI, %AQ, and %R data. No special application programming is required to use global data since it is integrated into the I/O scan. All devices that have Genius I/O capability can send and receive global data from a PACSystems CPU.

Using I/O Variables (page 125), you can directly associate variable names to a module's Genius global data that is scanned as part of an input/output scan.

6.5. Transitions and Overrides

The %I, %Q, %M, and %G user references, and symbolic variables of type BOOL, have associated transition and override bits. %T, %S, %SA, %SB, and %SC references have transition bits but not override bits. The CPU uses transition bits for counters, transition contacts, and transitional coils. Note that counters do not use the same kind of transition bits as contacts and coils. Transition bits for counters are stored within the locating reference.

The transition bit for a reference tells whether the most recent value (ON, OFF) written to the reference is the same as the previous value of the reference. Therefore when a reference is written and its new value is the same as its previous value, its transition bit is turned OFF. When its new value is different from its previous value, its transition bit is turned ON. The transition bit for a reference is affected every time the reference is written to. The source of the write is immaterial; it can result from a coil execution, an executed function's output, the updating of reference memory after an input scan, etc.

When override bits are set, the associated references cannot be changed from the program or the input device; they can only be changed on command from the programmer. Overrides do not protect transition bits. If an attempted write occurs to an overridden memory location, the corresponding transition bit is cleared.

6.6. Retentiveness of Logic and Data

Data is defined as retentive if it is saved by the CPU when the CPU transitions from STOP mode to RUN mode.

The following items are retentive:

- program logic
- fault tables and diagnostics
- checksums for program logic
- overrides and output forces
- word data (%R, %W, %L, %P, %AI, %AQ)
- bit data (%I, %G, fault locating references, and reserved bits)
- %Q and %M variables that are configured as retentive (%T data is non-retentive and therefore not saved on STOP to RUN transitions.)
- symbolic variables that have a data type other than BOOL
- symbolic variables of BOOL type that are configured as retentive
- Retentive data is also preserved during power-cycles of the CPU with battery backup or Energy Pack backup. Exceptions to this rule include the fault locating references and most of the %S, %SA, %SB, and %SC references. These references are initialized to zero at power-up regardless of the state of the battery or Energy Pack. (See page 138 for a description of the behavior of each system status reference.)

When %Q or %M variables are configured as retentive, the contents are retained through power loss and Run-to-Stop-to-Run transitions.

6.7. Data Scope

Each of the user references has “scope”; that is, it may be available throughout the system, available to all programs, restricted to a single program, or restricted to local use within a block.

User Reference Type	Range	Scope
%I, %Q, %M, %T, %S, %SA, %SB, %SC, %G, %R, %W, %AI, %AQ, convenience references, fault locating references	Global	From any program, block, or host computer. Variables defined in these registers have system (global) scope by default. However, variables with local scope can also be assigned in these registers.
Symbolic variable	Global	From any program, block, or host computer. Symbolic variables have system (global) scope by default. However, symbolic variables with local scope can be created using the naming conventions for local variables.
I/O variable	Global	From any program, block, or host computer.
%P	Program	From any block, but not from other programs (also available to a host computer).
%L	Local	From within a block only (also available to a host computer).

In an LD block:

- %P should be used for program references that are shared with other blocks.
- %L are local references that can be used to restrict the use of register data to that block. These local references are not available to other parts of the program.
- %I, %Q, %M, %T, %S, %SA, %SB, %SC, %G, %R, %W, %AI, and %AQ references are available throughout the system.

6.8. System Status References

System status references in the CPU are assigned to %S, %SA, %SB, and %SC memory. The four timed contacts (time tick references) include #T_10MS, #T_100MS, #T_SEC, and #T_MIN. Examples of other system status references include #FST_SCN, #ALW_ON, and #ALW_OFF

Note: %S bits are read-only bits; do not write to these bits. However, you can write to %SA, %SB, and %SC bits.

Listed below are available system status references that can be used in an application program. When entering logic, either the reference or the nickname can be used. Refer to Chapter 14 for detailed fault descriptions and information on correcting faults.

6.8.1 %S References

Reference	System Variable	Definition
%S0001	#FST_SCN	Current sweep is the first sweep in which the LD executed. Set the first time the user program is executed after a Stop/Run transition and cleared upon completion of its execution.
%S0002	#LST_SCN	Set when the CPU transitions to run mode; cleared when the CPU is performing its final sweep. The CPU clears this bit and then performs one more complete sweep before transitioning to Stop or Stop Faulted mode. If the number of last scans set to 0, %S0002 will be cleared after the CPU is stopped and user logic will not see this bit cleared.
%S0003	#T_10MS	0.01 second timed contact.
%S0004	#T_100MS	0.1 second timed contact.
%S0005	#T_SEC	1.0 second timed contact.
%S0006	#T_MIN	1.0 minute timed contact.
%S0007	#ALW_ON	Always ON.
%S0008	#ALW_OFF	Always OFF.
%S0009	#SY_FULL	Set when the CPU fault table fills up (size configurable with a default of 16 entries). Cleared when an entry is removed from the CPU fault table and when the CPU fault table is cleared.
%S0010	#IO_FULL	Set when the I/O Fault Table fills up (size configurable with a default of 32 entries). Cleared when an entry is removed from the I/O Fault Table and when the I/O Fault Table is cleared.
%S0011	#OVR_PRE	Set when an override exists in %I, %Q, %M, or %G, or symbolic BOOL memory.
%S0012	#FRC_PRE	Set when force exists on a Genius point.
%S0013	#PRG_CHK	Set when background program check is active.
%S0014	#PLC_BAT	CPUs with batteries, including CPU310, CPU315, CPU/CRU320 and NIU001 <ul style="list-style-type: none"> ▪ If the battery is disconnected, this contact is set to 1. ▪ Whenever a Smart Battery fails during operation, this contact is set to 1. If used in conjunction with a legacy (non-smart) battery, this indication is not reliable. Battery-less CPUs, including CPE305 and CPE310: <ul style="list-style-type: none"> ▪ Energy Pack is connected and functioning = 0 ▪ Energy Pack is not connected or has failed = 1

Note: The #FST_EXE name is not associated with a %S address, it must be referenced by the name "#FST_EXE" only. This bit is set when transitioning from Stop to Run and indicates that the current sweep is the first time this block has been called.

6.8.2 %SA, %SB, and %SC References

Note: %SA, %SB, and %SC contacts are not set or reset until the input scan phase of the sweep following the occurrence of the fault or a clearing of the fault table(s). %SA, %SB, and %SC contacts can also be set or reset by user logic and CPU monitoring devices.

Reference	System Variable	Definition
%SA0001	#PB_SUM	Set when a checksum calculated on the application program does not match the reference checksum. If the fault was due to a temporary failure, the condition can be cleared by again storing the program to the CPU. If the fault was due to a hard RAM failure, then the CPU must be replaced. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0002	#OV_SWP	Set when the CPU detects that the previous sweep took longer than the time specified by the user. To clear this bit, clear the CPU fault table or power cycle the CPU. Only occurs if the CPU is in Constant Sweep mode.
%SA0003	#APL_FLT	Set when an application fault occurs. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0009	#CFG_MM	Set when a configuration mismatch fault is logged in the fault tables. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0008	#OVR_TMP	Set when the operating temperature of the CPU exceeds the normal operating temperature, 58°C. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0010	#HRD_CPU	Set when the diagnostics detects a problem with the CPU hardware. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0011	#LOW_BAT	The low battery indication is not supported for all CPU modules. For details, refer to "Battery Status (Group 18)" in Chapter 14. The CPU may set this contact when an I/O module or special-purpose module has reported a low battery. In this case, a fault will be reported in the I/O Fault Table. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0012	#LOS_RCK	Set when an expansion rack stops communicating with the CPU. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0013	#LOS_IOC	Set when a Bus Controller stops communicating with the CPU. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0014	#LOS_IOM	Set when an I/O module stops communicating with the CPU. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0015	#LOS_SIO	Set when an option module stops communicating with the CPU. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0017	#ADD_RCK	Set when an expansion rack is added to the system. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SA0018	#ADD_IOC	Set when a Bus Controller is added to a rack. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0019	#ADD_IOM	Set when an I/O module is added to a rack. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0020	#ADD_SIO	Set when an intelligent option module is added to a rack. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0022	#IOC_FLT	Set when a Bus Controller reports a bus fault, a global memory fault, or an IOC hardware fault. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0023	#IOM_FLT	Set when an I/O module reports a circuit or module fault. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0027	#HRD_SIO	Set when a hardware failure is detected in an option module. To clear this bit, clear the I/O Fault Table or power cycle the CPU.

Reference	System Variable	Definition
%SA0029	#SFT_IOC	Set when there is a software failure in the I/O Controller. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0030	#PNIO_ALARM	A PROFINET alarm has been received and an I/O fault has been logged in group 28. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0031	#SFT_SIO	Set when an option module detects an internal software error. To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0032	#SBUS_ER	Set when a bus error occurs on the VME bus backplane To clear this bit, clear the I/O Fault Table or power cycle the CPU.
%SA0081 – %SA0112		Set when a user-defined fault is logged in the CPU fault table. To clear these bits, clear the CPU fault table or power cycle the CPU. For more information, see discussion of SVC_REQ 21: User-Defined Fault Logging in Chapter 10.
%SB0001	#WIND_ER	Set when there is not enough time to start the Programmer Window in Constant Sweep mode. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SB0009	#NO_PROG	Set when the CPU powers up with memory preserved, but no user program is present. Cleared when the CPU powers up with a program present or by clearing the CPU fault table.
%SB0010	#BAD_RAM	Set when the CPU detects corrupted RAM memory at power-up. Cleared when the CPU detects that RAM memory is valid at power-up or by clearing the CPU fault table.
%SB0011	#BAD_PWD	Set when a password access violation occurs. Cleared when the CPU fault table is cleared or when the CPU is power cycled.
%SB0012	#NUL_CFG	Set when an attempt is made to put the CPU in Run mode when there is no configuration data present. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SB0013	#SFT_CPU	Set when the CPU detects an error in the CPU operating system software. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SB0014	#STOR_ER	Set when an error occurs during a programmer store operation. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SB0016	#MAX_IOC	Set when more than 32 IOCs are configured for the system. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SB0017	#SBUS_FL	Set when the CPU fails to gain access to the bus. To clear this bit, clear the CPU fault table or power cycle the CPU.
%SC0009	#ANY_FLT	Set when any fault occurs that causes an entry to be placed in the CPU or I/O Fault Table. Cleared when both fault tables are cleared or when the CPU is power cycled.
%SC0010	#SY_FLT	Set when any fault occurs that causes an entry to be placed in the CPU fault table. Cleared when the CPU fault table is cleared or when the CPU is power cycled.
%SC0011	#IO_FLT	Set when any fault occurs that causes an entry to be placed in the I/O Fault Table. Cleared when the I/O Fault Table is cleared or when the CPU is power cycled.
%SC0012	#SY_PRES	Set as long as there is at least one entry in the CPU fault table. Cleared when the CPU fault table is cleared.
%SC0013	#IO_PRES	Set as long as there is at least one entry in the I/O Fault Table. Cleared when the I/O Fault Table is cleared.
%SC0014	#HRD_FLT	Set when a hardware fault occurs. Cleared when both fault tables are cleared or when the CPU is power cycled.
%SC0015	#SFT_FLT	Set when a software fault occurs. Cleared when both fault tables are cleared or when the CPU is power cycled.

6.8.3 Fault References

The fault references are discussed in Chapter 14 of this manual but are also listed here for your convenience.

System Fault References

System Fault Ref	Description
#ANY_FLT	Any new fault in either table since the last power-up or clearing of the fault tables
#SY_FLT	Any new system fault in the CPU fault table since the last power-up or clearing of the fault tables
#IO_FLT	Any new fault in the I/O Fault Table since the last power-up or clearing of fault tables
#SY_PRES	Indicates that there is at least one entry in the CPU fault table
#IO_PRES	Indicates that there is at least one entry in the I/O Fault Table
#HRD_FLT	Any hardware fault
#SFT_FLT	Any software fault

Configurable Fault References

Configurable Faults (Default Action)	Description
#SBUS_ER (diagnostic)	System bus error. (The BSERR signal was generated on the VME system bus.)
#SFT_IOC (diagnostic)	Non-recoverable software error in a Genius Bus Controller.
#LOS_RCK (diagnostic)	Loss of rack (BRM failure, loss of power) or missing a configured rack.
#LOS_IOC (diagnostic)	Loss of Bus Controller missing a configured Bus Controller.
#LOS_IOM (diagnostic)	Loss of I/O module (does not respond) or missing a configured I/O module.
#LOS_SIO (diagnostic)	Loss of intelligent option module (does not respond) or missing a configured module.
#IOC_FLT (diagnostic)	Non-fatal bus or Bus Controller error—more than 10 bus errors in 10 seconds (error rate is configurable).
#CFG_MM (fatal)	Wrong module type detected during power-up, store of configuration, or Run mode. The CPU does not check the configuration parameters set up for individual modules such as Genius I/O blocks.

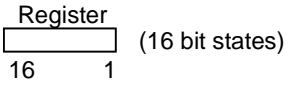
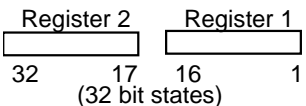
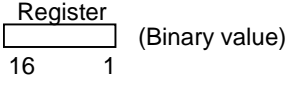
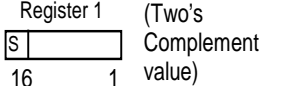
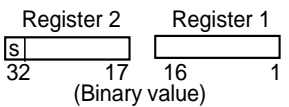
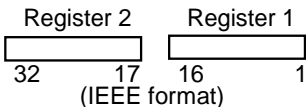
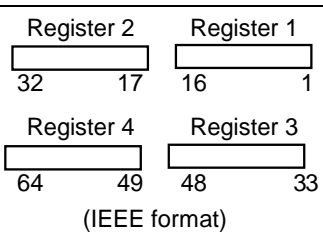
Non-Configurable Faults

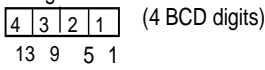
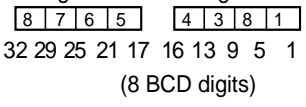
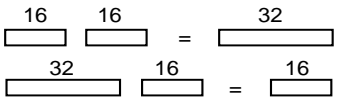
Non-Configurable Faults (Action)	Description
#SBUS_FL (fatal)	System bus failure. The CPU was not able to access the VME bus. BUSGRT-NMI error.
#HRD_CPU (fatal)	CPU hardware fault, such as failed memory device or failed serial port.
#HRD_SIO (diagnostic)	Non-fatal hardware fault on any module in the system.
#SFT_SIO (diagnostic)	Non-recoverable software error in a LAN interface module.
#PB_SUM (fatal)	Program or block checksum failure during power-up or in Run mode.
#LOW_BAT (diagnostic)	The low battery indication is not supported for all CPU modules. For details, refer to "Battery Status (Group 18)" in Chapter 14. The CPU may set this contact when an I/O module or special-purpose module has reported a low battery. In this case, a fault will be reported in the I/O Fault Table. To clear this bit, clear the CPU fault table or power cycle the CPU.
#OV_SWP (diagnostic)	Constant sweep time exceeded.
#SY_FULL, IO_FULL (diagnostic)	CPU fault table full I/O Fault Table full
#IOM_FLT (diagnostic)	Point or channel on an I/O module—a partial failure of the module.
#APL_FLT (diagnostic)	Application fault.
#ADD_RCK (diagnostic)	New rack added, extra, or previously faulted rack has returned.
#ADD_IOC (diagnostic)	Extra I/O Bus Controller or reset of I/O Bus Controller.
#ADD_IOM (diagnostic)	Previously faulted I/O module is no longer faulted or extra I/O module.
#ADD_SIO (diagnostic)	New intelligent option module is added, extra, or reset.
#NO_PROG (information)	No application program is present at power-up. Should only occur the first time the CPU is powered up or if the user memory is not retained.
#BAD_RAM (fatal)	Corrupted program memory at power-up. Program could not be read and/or did not pass checksum tests.
#WIND_ER (information)	Window completion error. Servicing of Programmer or Logic Window was skipped. Occurs in Constant Sweep mode.
#BAD_PWD (information)	Change of privilege level request to a protection level was denied; bad password.
#NUL_CFG (fatal)	No configuration present upon transition to Run mode. Running without a configuration is similar to suspending the I/O scans.
#SFT_CPU (fatal)	CPU software fault. A non-recoverable error has been detected in the CPU. May be caused by Watchdog Timer expiring.
#MAX_IOC (fatal)	The maximum number of bus controllers has been exceeded. The CPU supports 32 bus controllers.
#STOR_ER (fatal)	Download of data to CPU from the programmer failed; some data in CPU may be corrupted.

6.9. How Program Functions Handle Numerical Data

Regardless of where data is stored in memory – in one of the bit memories or one of the word memories – the application program can handle it as different data types.

6.9.1 Data Types

Type	Name	Description	Data Format
BOOL	Boolean	The smallest unit of memory. It has two states: 1 or 0. A BOOL array may have length N.	
BYTE	Byte	Has an 8-bit value. Has 256 values (0–255). A BYTE array may have length N.	
WORD	Word	Uses 16 consecutive bits of data memory. The valid range of word values is 0000 hex to FFFF hex.	 Register (16 bit states)
DWORD	Double Word	Has the same characteristics as a single word data type, except that it uses 32 consecutive bits in data memory instead of only 16 bits.	 Register 2 Register 1 (32 bit states)
UINT	Unsigned Integer	Uses 16-bit memory data locations. They have a valid range of 0 to +65535 (FFFF hex).	 Register (Binary value)
INT	Signed Integer	Uses 16-bit memory data locations, and are represented in 2's complement notation. The valid range of an INT data type is –32768 to +32767.	 Register 1 (Two's Complement value) s=sign bit (0=positive, 1=negative)
DINT	Double Precision Integer	Stored in 32-bit data memory locations (two consecutive 16-bit memory locations). Always signed values (bit 32 is the sign bit). The valid range of a DINT data type is –2147483648 to +2147483647	 Register 2 Register 1 (Binary value) s=sign bit (0=positive, 1=negative)
REAL	Floating Point	Uses 32 consecutive bits (two consecutive 16-bit memory locations). The range of numbers that can be stored in this format is from ±1.401298E-45 to ±3.402823E+38. For the IEEE format, refer to "Floating Point Numbers" on page 145.	 Register 2 Register 1 (IEEE format)
LREAL	Double Precision Floating Point	Uses 64 consecutive bits (four consecutive 16-bit memory locations). The range of numbers that can be stored in this format is from ±2.2250738585072020E-308 to ±1.7976931348623157E+308. For the IEEE format, refer to "Floating Point Numbers" on page 145.	 Register 2 Register 1 Register 4 Register 3 (IEEE format)

Type	Name	Description	Data Format
BCD-4	Four-Digit BCD	Uses 16-bit data memory locations. Each binary coded decimal (BCD) digit uses four bits and can represent numbers between 0 and 9. This BCD coding of the 16 bits has a legal value range of 0 to 9999.	Register 1  (4 BCD digits)
BCD-8	Eight-Digit BCD	Uses two consecutive 16-bit data memory locations (32 consecutive bits). Each BCD digit uses 4 bits per digit to represent numbers from 0 to 9. The complete valid range of the 8-digit BCD data type is 0 to 99999999.	Register 2 Register 1  (8 BCD digits)
MIXED	Mixed	Available only with the MUL and DIV functions. The MUL function takes two integer inputs and produces a double integer result. The DIV function takes a double integer dividend and an integer divisor to product an integer result.	
ASCII	ASCII	Eight-bit encoded characters. A single word reference is required to make two (packed) ASCII characters. The first character of the pair corresponds to the low byte of the reference word. The remaining 7 bits in each section are converted.	

Note: Using functions that are not explicitly bit-typed will affect transitions for all bits in the written byte/word/dword. For information about using floating point numbers, refer to *Floating Point Numbers* on page 145.

6.9.2 Floating Point Numbers

Floating point numbers are stored in one of two IEEE 754 standard formats that uses adjacent 16-bit words: 32-bit single precision or 64-bit double precision.

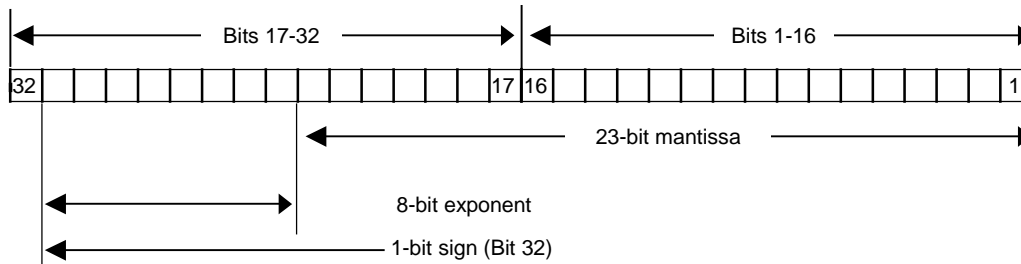
The REAL data type represents single precision floating point numbers. The LREAL data type represents double precision floating point numbers. REAL and LREAL variables are typically used to store data from analog I/O devices, calculated values, and constants.

Types of Floating Point Variables

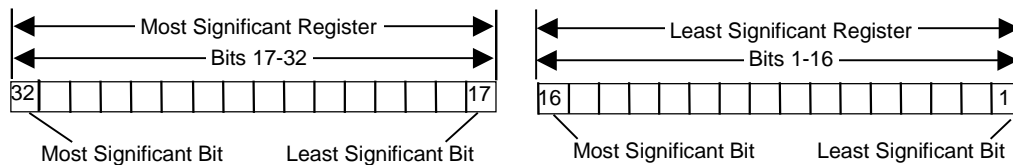
Data Type	Precision and Range
REAL	Limited to 6 or 7 significant digits, with a range of approximately $\pm 1.401298 \times 10^{-45}$ through $\pm 3.402823 \times 10^{38}$.
LREAL	Limited to 17 significant digits, with a range of approximately $\pm 2.2250738585072020 \times 10^{-308}$ to $\pm 1.7976931348623157 \times 10^{308}$.

Note: The programming software allows 32-bit and 64-bit arguments (DWORD, DINT, REAL, and LREAL) to be placed in discrete memories such as %I, %M, and %R in the PACSystems target. This is not allowed on Series 90-70 targets. (Note that any bit reference address that is passed to a non-bit parameter must be byte-aligned. This is the same as the Series 90-70 CPU.)

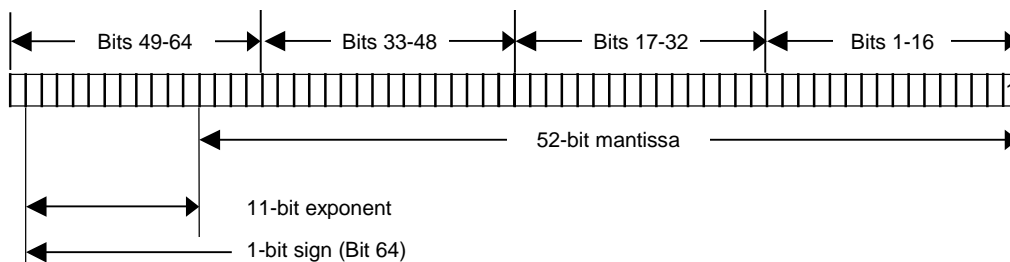
Internal Format of REAL Numbers



Register use by a single floating point number is diagrammed below. For example, if the floating point number occupies registers R5 and R6, R5 is the least significant register and R6 is the most significant register.



Internal Format of LREAL Numbers



Errors in Floating Point Numbers and Operations

Overflow occurs when a REAL or LREAL function generates a number outside the allowed range. When this occurs, the Enable Out output of the function is set Off, and the result is set to positive infinity (for a number greater than the upper limit) or negative infinity (for a number less than the lower limit). You can determine where this occurs by testing the sense of the Enable Out output. Binary representations of Infinity and NaN values have exponents that contain all 1s.

IEEE 754 Infinity Representations

	REAL	LREAL
POS_INF (positive infinity)	= 7F800000h	= 7FF0000000000000h
NEG_INF (negative infinity)	= FF800000h	= 7FF0000000000001h

If the infinities produced by overflow are used as operands to other REAL or LREAL functions, they may cause an undefined result. This undefined result is referred to as a NaN (Not a Number). For example, the result of adding positive infinity to negative infinity is undefined. When the ADD_REAL function is invoked with positive infinity and negative infinity as its operands, it produces a NaN. If any operand of a function is a NaN, the result will be some NaN.

Note: For NaN, the Enable Out output is Off (not energized).

IEEE 754 Representations of NaN values:

REAL	LREAL
7F800001 through 7FFFFFFF	7FF8000000000001 through 7FFFFFFFFFFFFFFF
FF800001 through FFFFFFFF	FFF0000000000001 through FFFFFFFFFFFFFFFF

Note: For releases 5.0 and greater, the CPU may return slightly different values for NaN compared to previous releases. In some cases, the result is a special type of NaN displayed as #IND in Machine Edition. In these cases, for example, EXP(-infinity), power flow out of the function is identical to that in previous releases.

6.10. User Defined Types (UDTs)

A UDT is a structured data type consisting of elements of other selected data types. Each top-level UDT element can be one of the following:

Top-level UDT Element	Example
Simple data type, except STRING	INT
Another UDT, except any in which the current UDT is nested at any level. Note: A UDT cannot be nested within itself.	A UDT named UDT_ABC has a top-level element whose data type is another UDT, named UDT_2.
Array of a simple data type	LREAL array of length 8.
Array of UDTs Note: A UDT cannot be nested within itself.	A UDT named UDT_ABC has a top-level element that is an array whose data type is another UDT, named UDT_row.

6.10.1 Working with UDTs

1. In Machine Edition, add a UDT as a node under a target in the Project tab of the Navigator. A UDT will be saved with the target in which it is used.
2. Edit the UDT properties and define the elements in the UDT's structure.
3. Create a variable whose data type is the UDT. By default, the variable resides in symbolic memory. You can convert the symbolic variable to an I/O variable by assigning it to an I/O terminal.
4. Use the variable in logic.

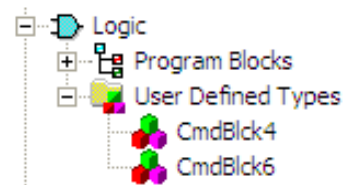


Figure 26: Adding a UDT to Project in PME Navigator

6.10.2 UDT Properties

Name: The UDT's name. Maximum length: 32 characters.

Description: The user-defined description of the UDT.

Memory Type: The type of symbolic or I/O variable memory in which a variable of this UDT resides.

Non-Discrete: (Default) Word-oriented memory organized in groups of 16 contiguous bits.

Discrete: Bit-oriented memory.

Notes: You cannot nest a UDT of one memory type in a UDT of a different memory type. Changing the memory type propagates to existing variables of this UDT only after target validation.

Is Fixed Size: If set to True, you can increase the Size (Bytes) value to a maximum of 65,535 bytes to create a buffer at the end of the UDT. The buffer is included in the memory allocated to every downloaded variable of that UDT data type. Use of a buffer may allow run mode store of a UDT when the size of the UDT definition has changed. For details, see page 148.

If set to False (default), the Size (Bytes) value is read-only and does not include a buffer at the end of the UDT.

Size (bytes): (Read-only when Is Fixed Size is set to False.) The total number of bytes required to store a structure variable of the user-defined data type (UDT).

Bytes Remaining: (Read-only; displayed if Is Fixed Size is set to True.) The UDT's buffer size; the number of bytes available before the actual size of the UDT reaches the value of the Size (bytes) property.

6.10.3 UDT Limits

- Maximum number of UDTs per target: 2048
- Maximum UDT size: 65,535 bytes

Note: Bit spares created to line up the end of a section of BOOL variables or arrays with the end of a byte will count toward the maximum size.

- Maximum number of top-level UDT elements: 1024
- Maximum array size of a top-level UDT element: 1024 array elements
- UDTs **do not** support the following:
 - Two-dimensional arrays
 - Function block data types
 - Enumerated data types
- You cannot nest a UDT of one memory type in a UDT of a different memory type.
- You cannot alias a variable to a UDT variable or UDT variable element.
- A FAULT contact supports a BOOL element of a UDT I/O variable, but not a BOOL element of a UDT parameter in a UDFB or parameterized block.
- POSCON and NEGCON do not support BOOL elements of UDT parameters in parameterized blocks or UDFBs.

6.10.4 Run Mode Store of UDTs

An RMS can be performed on a target that contains a variable of a UDT, unless:

- An operation in the UDT editor modifies the offset or bit mask of an element that has the same name before and after the operation.
- The size of the UDT definition increases.
- Array length increases.
- The memory type of the UDT definition changes.
- There is a data type change in the UDT definition, except for the following interchangeable data types:
 - WORD, INT, UINT
 - DWORD, DINT
- The UDT definition is renamed.

6.10.5 UDT Operational Notes

- By default, a UDT variable resides in symbolic memory. You can convert the symbolic variable to an I/O variable.
- All UDT elements are public and, therefore, readable and writable.
- Properties of elements of UDT variables:

The Input Transfer List and Output Transfer List properties are read-only and set to False.

The Retentive property is editable only for BOOLS and only if the UDT Memory Type is discrete. For UDTs whose Memory Type is non-discrete, a BOOL variable has its Retentive property set to True during validation.

- UDT variables are supported in LD, FBD, and ST blocks, as well as in Diagnostic Logic Blocks.

For additional operational notes, refer to the programmer Help.

Example

You want to set up six COMMREQ commands to send values to a series of six identical intelligent modules that require individualized data of the same data types in the same format, specified by the manual for the intelligent module. This data contains header information and several words of data. You could proceed as follows:

1. Add a UDT named COMMREQ6 and edit it to contain the data in the required data types and sequence.
2. Create an array of length 6, named ABC, of the COMMREQ6 data type.
3. The array resides in symbolic memory. You can convert the symbolic variable to an I/O variable.
4. Populate the variable. If the value of an element needs to be the same for all six COMMREQ6 elements, you can set up an ST for loop that uses a variable index to populate each element with the same data, for example:


```
for i = 1 to 6 do
  ABC[i].WaitFlag := 0;
end_for;
```
5. Just before issuing one or more COMMREQs, use the Move to Flat instruction to "flatten" the COMMREQ6 array or one or more of its top-level elements from a structure to a "flat" series of contiguous registers in an area of % memory supported by COMMREQ.
6. Issue the COMMREQs based on the % memory registers that you just populated with the Move to Flat instruction.

Although you can populate the memory registers directly without a UDT and Move to Flat, there are advantages when working with UDT variables:

- UDT variables reside in symbolic or I/O variable memory, which protects them from memory overlaps and offers more protection against overwriting, whereas reference memory areas offer no such protection. It is best to use reference memory just before issuing a COMMREQ.
- You can work with meaningful structure variable names and structure element names.
- You can set up loops with variable indexes to populate some of the values.

6.11. Operands for Instructions

The operands for PACSystems instructions can be in the following forms:

- Constants
- Variables that are located in any of the PACSystems memory areas (%I, %Q, %M, %T, %G, %S, %SA, %SB, %SC, %R, %W, %L, %P, %AI, %AQ)
- Symbolic variables, including I/O variables
- Parameters of a Parameterized block or C block
- Power flow
- Data flow
- Computed references such as indirect references or bit-in-word references
- BOOL arrays

An operand's type and length must be compatible with that of the parameter it is being passed into. PACSystems instructions and functions have the following operand restrictions:

- Constants cannot be used as operands to output parameters because output values cannot be written to constants.
- Variables located in %S memory cannot be used as operands to output parameters because %S memory is read-only.
- Variables located in %S, %SA, %SB, and %SC memories cannot be used as operands to numerical parameters such as INTs, DINTs, REALs, LREALs, etc.
- Data flow is prohibited on some input parameters of some functions. This occurs when the function, during the course of its execution, actually writes a value to the input parameter. Data flow is prohibited in these cases because data flow is stored in a temporary memory and any updated value assigned to it would be inaccessible to the user application.
- The arguments to EN, OK, and many other BOOLEAN input and output parameters are restricted to be power flow.
- Restrictions on using Parameterized block or External block parameters as operands to instructions or functions are documented in Chapter 5.
- References in discrete memory (I, Q, M, and T) must be byte-aligned.

Note the following:

- Indirect references, which are available for all WORD-oriented memories (%R, %W, %P, %L, %AI, %AQ), can be used as arguments to instructions wherever located variables in the corresponding WORD-oriented memory are allowed. Note that indirect references are converted into their corresponding direct references immediately before they are passed into an instruction or function.
- Bit-in-word references are generally allowed on contact and coil instructions other than legacy transition contacts and coils (POSCON, NEGCON, POSCOIL and NEGCOIL). They are also allowed as arguments to function parameters that accept single or unaligned bits.

BOOL arrays can be used as parameters to an instruction instead of variables of other data types. The array must be of sufficient length to replace the given data type. For example, instead of using a 16-bit INT variable, you could use a BOOL array of length 16 or more.

The following conditions must be met:

- The BOOL array must be byte-aligned, that is, the reference address of the first element of the BOOL array must be $8n + 1$, where $n = 0, 1, 2, 3$, and so on. For example, %M00033 is byte-aligned, because $33 = (8 \times 4) + 1$.
- The parameter in question must support discrete memory reference addresses.
- The instruction in question must not have a Length parameter. (The Length parameter is displayed as ?? in the LD editor until a value has been assigned.)
- The data type to be replaced with a BOOL array must be one of the following:

Data Type	Minimum Length
BYTE	8
INT, UINT, WORD	16
DINT, DWORD, REAL	32
REAL	64

- Excess bits are ignored. For example, if you use a BOOL array of length 12 instead of an 8-bit BYTE, the last four bits of the BOOL array are ignored.

6.12. Word-for-Word Changes

Many changes to the program that do not modify the size of the program are considered word-for-word changes. Examples include changing the type of contact or coil, or changing a reference address used for an existing function block.

The following are word-for-word changes:

- Switching between two symbolic variables
- Switching between an symbolic variable and a mapped variable
- Switching between a constant and a symbolic variable

6.12.1 Exception: Symbolic Variables

Creating, deleting, or modifying a symbolic variable definition is not a word-for-word change.

Chapter 7 Ladder Diagram (LD) Programming

This chapter describes the programming instructions that can be used to create ladder logic programs for the PACSystems control system.

For an overview of the types of operands that can be used with instructions, refer to “Operands for Instructions” in Chapter 6.

The ladder logic implementation of the PACSystems instruction set includes the following categories:

- Advanced Math *see page* 154
- Bit Operations 159
- Coils 176
- Communication
Consists of the PNIO_DEV_COMM function. For details, refer to the *PACSystems RX3i PROFINET Controller Manual*, GFK-2571.
- Contacts 184
- Control Functions 193
- Conversion Functions 212
- Counters 226
- Data Move Functions 231
- Data Table Functions 264
- Math Functions 281
- Program Flow Functions 292
- Relational Functions 301
- Timers 306
- Motion Functions and Function Blocks
RX3i CPUs support PLCopen compliant motion functions and function blocks. Details of these function blocks can be found in the *PACMotion Multi-Axis Motion Controller User's Manual*, GFK-2448.

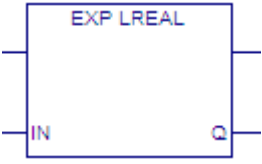
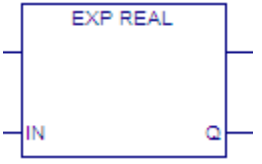
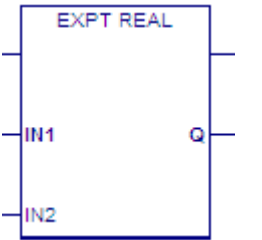
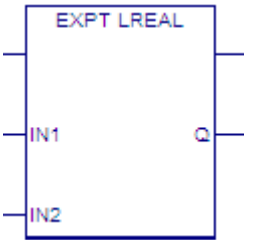


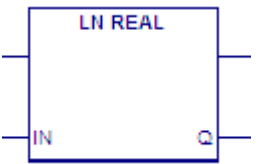

7.1. Advanced Math Functions

The Advanced Math functions perform logarithmic, exponential, square root, trigonometric, and inverse trigonometric operations.

Function	Mnemonic	Description
Exponential	EXP_REAL EXP_LREAL	Raises e to the value specified in IN (e^{IN}). Calculates the inverse natural logarithm of the IN operand.
	EXPT_REAL EXPT_LREAL	Calculates IN1 to the IN2 power ($IN1^{IN2}$).
Inverse Trig	ACOS_REAL ACOS_LREAL	Calculates the inverse cosine of the IN operand and expresses the result in radians.
	ASIN_REAL ASIN_LREAL	Calculates the inverse sine of the IN operand and expresses the result in radians.
	ATAN_REAL ATAN_LREAL	Calculates the inverse tangent of the IN operand and expresses the result in radians.
Logarithmic	LN_REAL LN_LREAL	Calculates the natural logarithm of the operand IN.
	LOG_REAL LOG_LREAL	Calculates the base 10 logarithm of the operand IN.
Square Root	SQRT_DINT	Calculates the square root of the operand IN, a double-precision integer, and stores in Q the double-precision integer portion of the square root of the input IN.
	SQRT_INT	Calculates the square root of the operand IN, a single-precision integer, and stores in Q the single-precision integer portion of the square root of the input IN.
	SQRT_REAL SQRT_LREAL	Calculates the square root of the operand IN, a real number, and stores the real-number result in Q
Trig	COS_REAL COS_LREAL	Calculates the cosine of the operand IN, where IN is expressed in radians.
	SIN_REAL SIN_LREAL	Calculates the sine of the operand IN, where IN is expressed in radians.
	TAN_REAL TAN_LREAL	Calculates the tangent of the operand IN, where IN is expressed in radians.

7.1.1 Exponential/Logarithmic Functions

When an exponential or logarithmic function receives power flow, it performs the appropriate operation on the REAL or LREAL input value(s) and places the result in output Q.

The inverse natural log (EXP) function raises e to the power specified by IN.		
The Power of X (EXPT) function raises the value of input IN1 to the power specified by the value IN2.		
The Base 10 Logarithm (LOG) function calculates the base 10 logarithm of IN.		
The Natural Logarithm (LN) function calculates the logarithm of IN.		

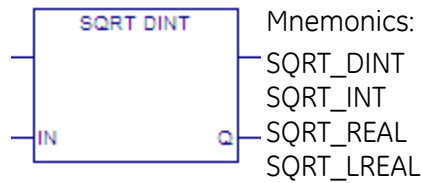
The power flow output is energized when the function is performed, unless overflow or one of the following invalid conditions occurs:

- $IN < 0$, for LOG or LN
- $IN1 < 0$, for EXPT
- IN is negative infinity, for EXP
- IN, IN1, or IN2 is a NaN (Not a Number)

Operands of the Exponential/Logarithmic Functions

Parameter	Description	Allowed Operands	Optional
IN or IN1	For EXP, LOG, and LN, IN contains the REAL or LREAL value to be operated on. The EXPT function has two inputs, IN1 and IN2. For EXPT, IN1 is the base value and IN2 is the exponent.	All except variables located in %S—%SC	No
IN2 (EXPT)	The REAL or LREAL exponent for EXPT.	All except variables located in %S—%SC	No
Q	Contains the REAL or LREAL logarithmic/exponential value of IN or of IN1 and IN2.	All except constants and variables located in %S—%SC	No

7.1.2 Square Root



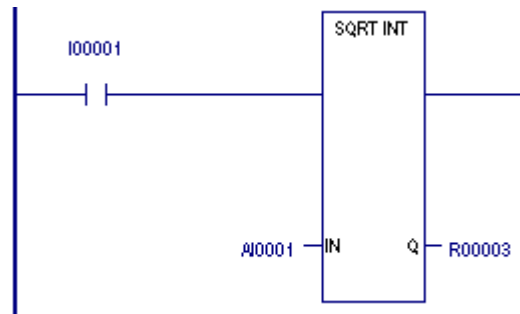
When the Square Root function receives power flow, it finds the square root of IN and stores the result in Q. The output Q must be the same data type as IN.

The power flow output is energized when the function is performed without overflow, unless one of these invalid REAL operations occurs:

- If $IN < 0$, Q is set to 0 and ENO is set FALSE.
- If IN is a NaN (Not a Number), Q will also be a NaN value and ENO will be set false.

Example

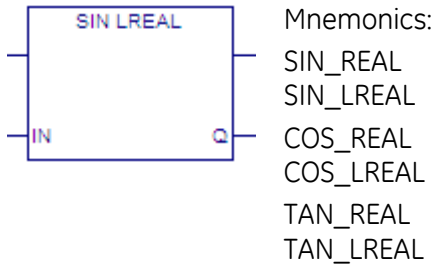
The square root of the integer number located at %AI0001 is placed into %R00003 when %I00001 is ON.



Operands for the Square Root Function

Parameter	Description	Allowed Operands	Optional
IN	The value to calculate the square root of. If $IN < 0$, the function does not pass power flow.	All except variables located in %S - %SC	No
Q	The calculated square root.	All except constants and variables located in %S - %SC	No

7.1.3 Trig Functions



The SIN, COS, and TAN functions are used to find the trigonometric sine, cosine, and tangent, respectively, of an input whose units are radians. When one of these functions receives power flow, it computes the sine (or cosine or tangent) of IN and stores the result in output Q.

The SIN, COS, and TAN functions accept a broad range of input values, where $-2^{63} < IN < 2^{63}$, (2^{63} is approximately 9.22×10^{18}). Input values outside this range will produce incorrect results.

The power flow output is energized unless the following invalid condition occurs:

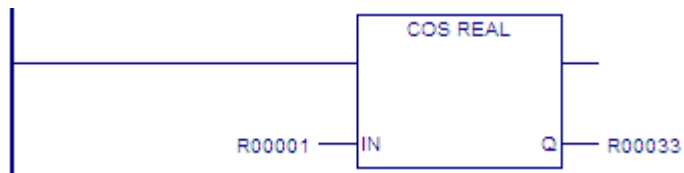
- IN or Q is a NaN (Not a Number)

Operands of Trig Functions

Parameter	Description	Allowed Operands	Optional
IN	Number of radians. $-2^{63} < IN < 2^{63}$	All except variables located in %S—%SC	No
Q	Trigonometric value of IN (REAL or LREAL)	All except constants and variables located in %S—%SC	No

Example

The COS of the value in V_R00001 is placed in V_R00033.



7.1.4 Inverse Trig – ASIN, ACOS, and ATAN



Mnemonics:
 ASIN_REAL
 ASIN_LREAL
 ACOS_REAL
 ACOS_LREAL
 ATAN_REAL
 ATAN_LREAL

When an Inverse Sine (ASIN), Inverse Cosine (ACOS), or Inverse Tangent (ATAN) function receives power flow, it respectively computes the inverse sine, inverse cosine or inverse tangent of IN and stores the result in radians in output Q.

The ASIN and ACOS functions accept a narrow range of input values, where $-1 \leq IN \leq 1$. Given a valid value for the IN parameter, the ASIN function produces a result Q such that:

$$ASIN(IN) = -\frac{\pi}{2} \leq Q \leq \frac{\pi}{2}$$

The ACOS function produces a result Q such that:

$$ACOS(IN) = -0 \leq Q \leq \pi$$

The ATAN function accepts the broadest range of input values, where $-\infty \leq IN \leq +\infty$. Given a valid value for the IN parameter, the ATAN function produces a result Q such that:

$$ATAN(IN) = -\frac{\pi}{2} \leq Q \leq \frac{\pi}{2}$$

The power flow output is energized unless one of the following invalid conditions occurs:

- IN is outside the valid range for ASIN, ACOS, or ATAN
- IN is a NaN (Not a Number)

Operands of Inverse Trig Functions

Parameter	Description	Allowed Operands	Optional
IN	The REAL or LREAL value to process. ASIN and ACOS: $-1 \leq IN \leq 1$ ATAN: $-\infty \leq IN \leq +\infty$	All except variables located in %S - %SC	No
Q	Trigonometric value of IN. REAL or LREAL value expressed in radians. ASIN: $(-\pi/2) \leq Q \leq (\pi/2)$ ACOS: $0 \leq Q \leq \pi$ ATAN: $(-\pi/2) \leq Q \leq (\pi/2)$	All except constants and variables located in %S - %SC	No

7.2. Bit Operation Functions

The Bit Operation functions perform comparison, logical, and move operations on bit strings.

Function	Mnemonics	Description
Bit Position	BIT_POS_DWORD BIT_POS_WORD	Bit Position. Locates a bit set to 1 in a bit string.
Bit Sequencer	BIT_SEQ	Bit Sequencer. Sequences a string of bit values, starting at ST. Performs a bit sequence shift through an array of bits. The maximum length allowed is 256 words.
Bit Set, Clear	BIT_SET_DWORD BIT_SET_WORD	Bit Set. Sets a bit in a bit string to 1.
	BIT_CLR_DWORD BIT_CLR_WORD	Bit Clear. Clear a bit within a string by setting that bit to 0.
Bit Test	BIT_TEST_DWORD BIT_TEST_WORD	Bit Test. Tests a bit within a bit string to determine whether that bit is currently 1 or 0.
Logical AND	AND_DWORD AND_WORD	Compares the bit strings IN1 and IN2 bit by bit. When a pair of corresponding bits are both 1, places a 1 in the corresponding location in output string Q; otherwise, places a 0 in the corresponding location in Q.
Logical NOT	NOT_DWORD NOT_WORD	Logical invert. Sets the state of each bit in output bit string Q to the opposite state of the corresponding bit in bit string IN1.
Logical OR	OR_DWORD OR_WORD	Compares the bit strings IN1 and IN2 bit by bit. When a pair of corresponding bits are both 0, places a 0 in the corresponding location in output string Q; otherwise, places a 1 in the corresponding location in Q.
Logical XOR	XOR_DWORD XOR_WORD	Compares the bit strings IN1 and IN2 bit by bit. When a pair of corresponding bits are different, places a 1 in the corresponding location in the output bit string Q; when a pair of corresponding bits are the same, places a 0 in Q.
Masked Compare	MASK_COMP_DWORD MASK_COMP_WORD	Masked Compare. Compares the contents of two separate bit strings with the ability to mask selected bits.
Rotate Bits	ROL_DWORD ROL_WORD	Rotate Left. Rotates all the bits in a string a specified number of places to the left.
	ROR_DWORD ROR_WORD	Rotate Right. Rotates all the bits in a string a specified number of places to the right.
Shift Bits	SHIFTL_DWORD SHIFTL_WORD	Shift Left. Shifts all the bits in a word or string of words to the left by a specified number of places.
	SHIFTR_DWORD SHIFTR_WORD	Shift Right. Shifts all the bits in a word or string of words to the right by a specified number of places.

7.2.1 Data Lengths for the Bit Operation Functions

The Bit Operation functions operate on a single WORD or DWORD of data or up to 256 WORDs or DWORDs that occupy adjacent memory locations.

Bit Operation functions treat the WORD or DWORD data as a continuous string of bits, with bit 1 of the first WORD or DWORD being the Least Significant Bit (LSB). The last bit of the last WORD or DWORD is the Most Significant Bit (MSB). For example, if you specify three WORDs of data beginning at reference %R0100, they are treated as 48 contiguous bits.

%R0100	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	← bit 1 (LSB)
%R0101	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	
%R0102	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	
	↑																
	(MSB)																

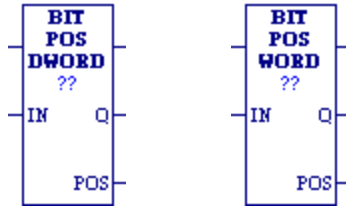


Warning

Overlapping input and output reference address ranges in multiword functions is not recommended, as it can produce unexpected results

Note that for all functions (Bit Test, Bit Set, Bit Clear, and Bit Position) that return a bit position indicator as an output parameter (POS), bit position numbering starts at 1, not 0, as shown in the diagram above.

7.2.2 Bit Position



The Bit Position function locates a bit set to 1 in a bit string.

Each scan that power is received, the function scans the bit string starting at IN. When the function stops scanning, either a bit equal to 1 has been found or the entire length of the string has been scanned.

POS is set to the position within the bit string of the first non-zero bit; POS is set to zero if no non-zero bit is found.

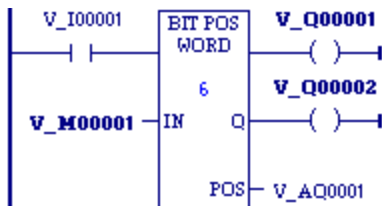
A string length of 1 to 256 WORDs or DWORDs can be selected. The function passes power flow to the right whenever it receives power.

Operands of Bit Position

Parameter	Description	Allowed Operands	Optional
Length (displayed as ??)	The number of WORDs or DWORDs in the bit string. $1 \leq \text{Length} \leq 256$.	Constants	No
IN	The data to operate on	All. Constants may only be used when Length is 1.	No
Q	Energized if a bit set to 1 is found	Flow	Yes
POS	An unsigned integer giving the position of the first nonzero bit found, or zero if no non-zero bit is found	All except constants and variables located in %S - %SC	No

Examples

When V_I00001 is set, the bit string starting at V_M00001 is searched until a bit equal to 1 is found, or 6 words have been searched. Coil V_Q00001 is turned on. If a bit equal to 1 is found, its location within the bit string is written to V_AQ0001 and V_Q00002 is turned on. For example, if V_I00001 is set, bit V_M00001 is 0, and bit V_M0002 is 1, the value written to V_AQ0001 is 2.



7.2.3 Bit Sequencer

The Bit Sequencer (BIT_SEQ) function performs a bit sequence shift through a series of contiguous bits.

The operation of BIT_SEQ depends on the value of the reset input (R), and both the current value and previous value of the enabling power flow input (EN):



R Current Execution	EN Previous Execution	EN Current Execution	Bit Sequencer Execution
ON	ON/OFF	ON/OFF	Bit sequencer resets
OFF	OFF	ON	Bit sequencer increments/decrements by 1
		OFF	Bit sequencer does not execute
		ON	Bit sequencer does not execute

The reset input (R) overrides the enabling power flow (EN) and always resets the sequencer. When R is active, the current step number is set to the value of the optional N operand. If you did not specify N, the step number is set to 1. All bits in the bit sequencer, ST, are set to 0, except for the bit pointed to by the current step, which is set to 1.

When EN is active and R is not active, and the previous EN was OFF, the bit pointed to by the current step number is cleared. The current step number is incremented or decremented, based on the direction (DIR) operand. Then the bit pointed to by the new step number is set to 1.

- When the step number is being incremented and it goes outside the range of $(1 \leq \text{step number} \leq \text{Length})$, it is set back to 1.
- When the step number is being decremented and it goes outside the range of $(1 \leq \text{step number} \leq \text{Length})$, it is set to Length.

The parameter ST is optional. If it is not used, BIT_SEQ operates as described above, except that no bits are set or cleared. The function just cycles the current step number through its allowed range.

BIT_SEQ passes power to the right whenever it receives power.

Note: Before using the BIT_SEQUENCER function block, the current step number (Word 1 in the control block) must be set to an integer value between 1 and the length, as defined in the function block properties. Failure to properly initialize the step number in the BIT_SEQUENCER function block may result in the CPU going to STOP-HALT mode.

Asserting the Reset parameter (R), before using the BIT SEQUENCER function block assures that the current step number is set to a valid value.

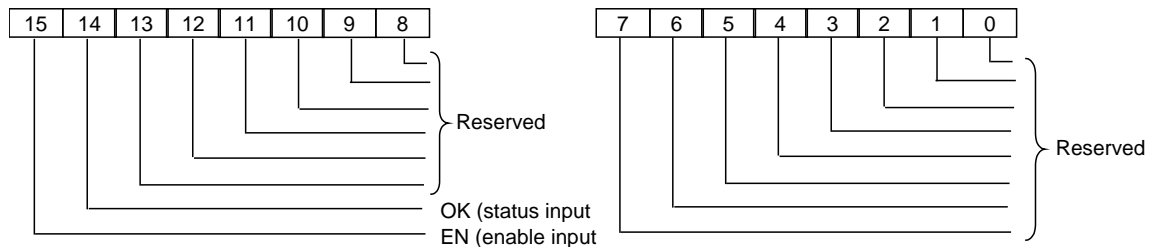
Memory Required for Bit Sequencer

Each bit sequencer uses a three word array of control block information. The control block can be a symbolic variable or it can be located in %R, %W, %L, or %P memory:

Word 1	current step number
Word 2	length of sequence (in bits)
Word 3	control word

Note: Do not write to the control block memory registers from other functions.

Word 3 (the control word) stores the state of the Boolean inputs and outputs of its associated function in the following format:



Notes:

Bits 0 through 13 are not used.

In the N operand, bits are entered as 1 through 16, not 0 through 15.

Operands for Bit Sequencer



Warning

Do not write to the Control Block memory with other instructions. Overlapping references may cause erratic operation of BIT_SEQ.

Parameter	Description	Allowed Operands	Optional
Address (????)	Beginning address of the Control Block, which is a three-word array: Word 1: current step number Word 2: length of sequence in bits Word 3: control word, which tracks the status of the last enabling power flow and the status of the power flow to the right.	Symbolic variables, variables located in %R, %W, %P, or %L	No
Length (??)	The number of bits in the bit sequencer, ST, that BIT_SEQ will step through. $1 \leq \text{Length} \leq 256$.	Constants	No
R	When R is energized, the step number of BIT_SEQ is set to the value in N (default = 1), and the bit sequencer, ST, is filled with zeroes, except for the current step number bit.	Flow	No

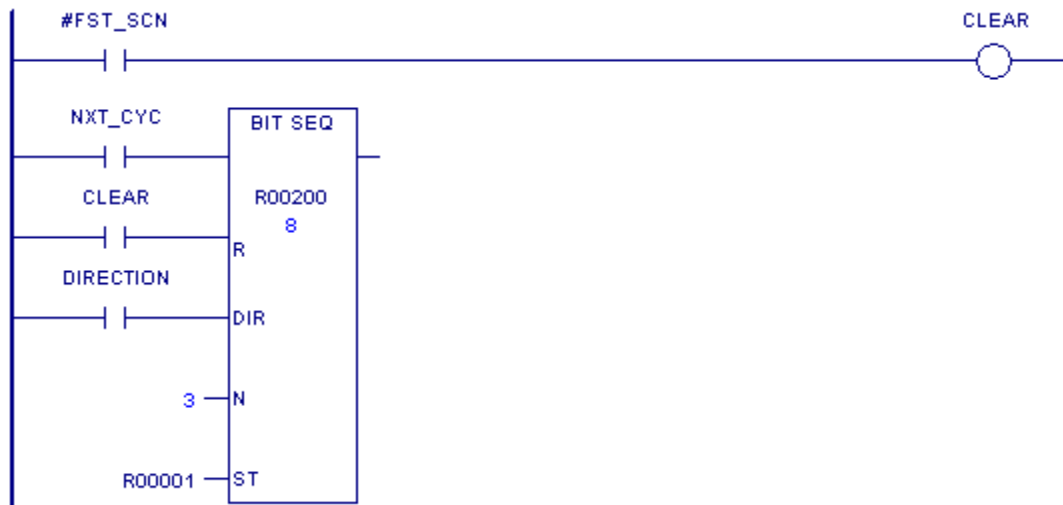
Parameter	Description	Allowed Operands	Optional
DIR	(Direction) When DIR is energized, the step number of BIT_SEQ is incremented prior to the shift. Otherwise, it is decremented.	Flow	No
N	The value that the step number is set to when R is energized. Default value is 1. $1 \leq N \leq \text{Length}$. If $N < 1$, the step number will be reset to 1 when R is energized. If $N > \text{Length}$, the step number will be reset to Length. Must be an integer variable or constant.	All except variables located in %S - %SC	Yes
ST	Contains the first word of the bit sequencer. If ST is not used, the Bit Sequencer function operates as described above, except that no bits are set or cleared. The function just cycles the current step number (in word 1 of the control block) through its allowed range. If ST is in %M memory and the Length is 3, the bit sequencer occupies 3 bits; the other 5 bits of the byte are not used. If ST is in %R memory, and the Length is 17, the bit sequencer uses 4 bytes, all of %R1 and %R2.	All except constants, flow, and variables located in %S	Yes

Example

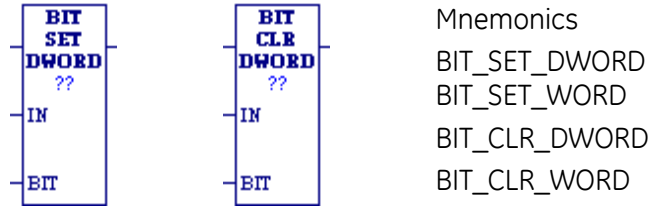
In the following example, a #FST_SCN system variable is used to set CLEAR to ON for one scan. This sets the step number in Word 1 of the Bit Sequencer’s control block to an initial value of 3.

The Bit Sequencer operates on register memory %R00001. Its control block is stored in registers %R0010, %R0011, and %R0012. When CLEAR is active, the sequencer is reset and the current step is set to step number 3, as specified in N. The third bit of %R00001 is set to one and the other seven bits are set to zero.

When NXT_CYC is active and CLEAR is not active, the bit for step number 3 is cleared and the bit for step number 2 or 4 (depending on whether DIRECTION is energized) is set.



7.2.4 Bit Set, Bit Clear



Mnemonics
 BIT_SET_DWORD
 BIT_SET_WORD
 BIT_CLR_DWORD
 BIT_CLR_WORD

The Bit Set (BIT_SET_DWORD and BIT_SET_WORD) function sets a bit in a bit string to 1. The Bit Clear (BIT_CLR_DWORD and BIT_CLR_WORD) function clears a bit in a string by setting the bit to 0.

Each scan that power is received; the function sets or clears the specified bit. If a variable rather than a constant is used to specify the bit number, the same function can set or clear different bits on successive scans. Only one bit is set or cleared, and the transition information for that bit is updated. The transition status of all the other bits in the bit string is not affected.

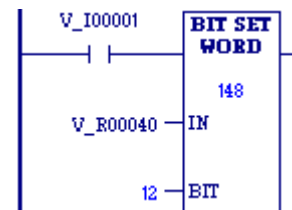
The function passes power flow to the right, unless the value for BIT is outside the specified range.

Operands for Bit Set, Bit Clear

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of WORDs or DWORDs in the bit string. $1 \leq \text{Length} \leq 256$.	Constants	No
IN	The first WORD or DWORD of the data to process	All except constants, flow, and variables located in %S	No
BIT	The number of the bit to set or clear in IN. $1 \leq \text{BIT} \leq (16 \times \text{Length})$ for WORD. $1 \leq \text{BIT} \leq (32 \times \text{length})$ for DWORD	All except variables located in %S - %SC	No

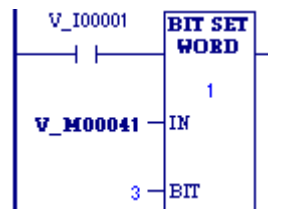
Example 1

Whenever input V_I0001 is set, bit 12 of the string beginning at reference %R00040 (as specified by variable V_R0040) is set to 1.



Example 2

Whenever V_I00001 is set, %M00043, the third bit of the string beginning at %M00041, is set to 1. Note that neither the status nor the transition value of any of the other bits in the same byte as %M00043 (e.g., %M00041, %M00042, %M00044, etc.) is affected by the BIT_SET function



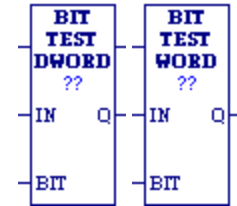
7.2.5 Bit Test

When the Bit Test function receives power flow, it tests a bit within a bit string to determine whether that bit is currently 1 or 0. The result of the test is placed in output Q.

Each scan that power is received, the Bit Test function sets its output Q to the same state as the specified bit. If a register rather than a constant is used to specify the bit number, the same function can test different bits on successive sweeps. If the value of BIT is outside the range ($1 \leq \text{BIT} \leq (16 \times \text{length})$) for a WORD and $1 \leq \text{BIT} \leq (32 \times \text{length})$ for a DWORD), then Q is set OFF.

You can specify a string length of 1 to 256 WORDs or DWORDs.

Note: When using the Bit Test function, the bits are numbered 1 through 16 for a WORD, *not* 0 through 15. They are numbered 1 through 32 for a DWORD.



Operands for Bit Test

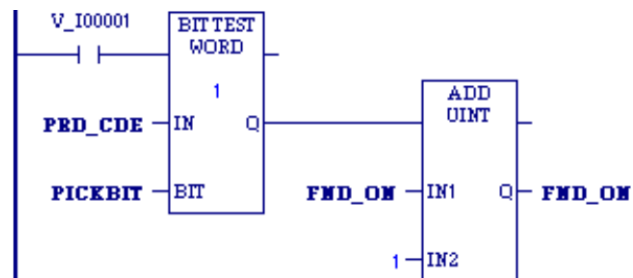
Parameter	Description	Allowed Operands	Optional
Length (??)	The number of WORDs or DWORDs in the data string to test. $1 \leq \text{Length} \leq 256$.	Constant	No
IN	The first WORD or DWORD in the data to test	All	No
BIT	The number of the bit to test in IN. $1 \leq \text{BIT} \leq (16 \times \text{Length})$.	All except variables located in %S - %SC	No
Q	The state of the specific bit tested; Q is energized if the bit tested is a 1.	Flow	No

Example 1

When input V_I0001 is set, the bit at the location contained in reference PICKBIT is tested.

The bit is part of string PRD_CDE.

If it is 1, output Q passes power flow to the ADD function, causing 1 to be added to the current value of the ADD function input IN1.

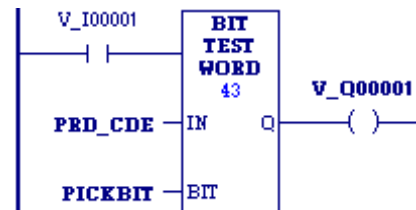


Example 2

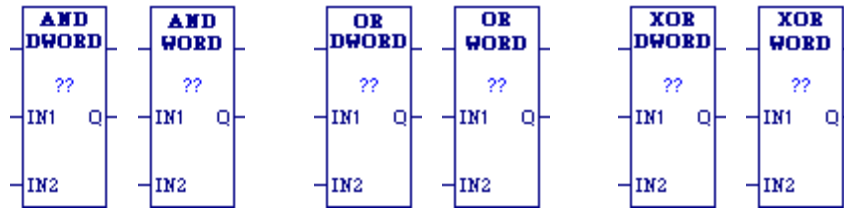
When input V_I0001 is set, the bit at the location contained in reference PICKBIT is tested.

The bit is part of string PRD_CDE.

If it is 1, output Q passes power flow and the coil V_Q0001 is turned on



7.2.6 Logical AND, Logical OR, and Logical XOR



Each scan that power is received, the Logical function examines each bit in bit string IN1 and the corresponding bit in bit string IN2, beginning with the least significant bit in each. You can specify a string length of 1 to 256 WORDs or DWORDs. The IN1 and IN2 bit strings specified may overlap.

Logical AND

If both bits examined by the Logical AND function are 1, AND places a 1 in the corresponding location in output string Q. If either bit is 0 or both bits are 0, AND places a 0 in string Q in that location.

AND passes power flow to the right whenever it receives power.

Tip: You can use the Logical AND function to build masks or screens, where only certain bits are passed (the bits opposite a 1 in the mask), and all other bits are set to 0.

Logical OR

If either bit examined by the Logical OR function is 1, OR places a 1 in the corresponding location in output string Q. If both bits are 0, Logical OR places a 0 in string Q in that location. The function passes power flow to the right whenever it receives power.

Tips:

- You can use the Logical OR function to combine strings or to control many outputs with one simple logical structure. The Logical OR function is the equivalent of two relay contacts in parallel multiplied by the number of bits in the string.
- You can use the Logical OR function to drive indicator lamps directly from input states or to superimpose blinking conditions on status lights.

Logical XOR

When the Exclusive OR (XOR) function receives power flow, it compares each bit in bit string IN1 with the corresponding bit in string IN2. If the bits are different, a 1 is placed in the corresponding position in the output bit string.

For each pair of bits examined, if only one bit is 1, then XOR places a 1 in the corresponding location in bit string Q. XOR passes power flow to the right whenever it receives power.

Tips for Logical XOR

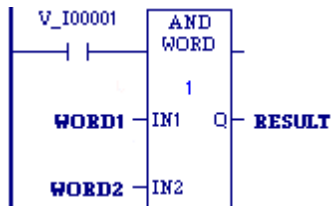
- If string IN2 and output string Q begin at the same reference, a 1 placed in string IN1 will cause the corresponding bit in string IN2 to alternate between 0 and 1, changing state with each scan as long as power is received.
- You can program longer cycles by pulsing the power flow to the function at twice the desired rate of flashing. The power flow pulse should be one scan long (one-shot type coil or self resetting timer).
- You can use XOR to quickly compare two bit strings, or to blink a group of bits at the rate of one ON state per two scans.
- XOR is useful for transparency masks.

Operands for Logical AND, OR, and XOR

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of words in the bit string on which to perform the logical operation. $1 \leq \text{Length} \leq 256$.	Constant	No
IN1	The first WORD or DWORD of the first string operate on.	All	No
IN2 (Must be the same data type as IN1.)	The first WORD or DWORD of the second string to operate on.	All	No
Q (Must be the same data type as IN1.)	The first WORD or DWORD of the operation's result.	All except constants and variables located in %S memory	No

Example: Logical AND

When input v_I0001 is set, the 16-bit strings represented by variables WORD1 and WORD2 are examined. The logical AND places the results in output string RESULT.

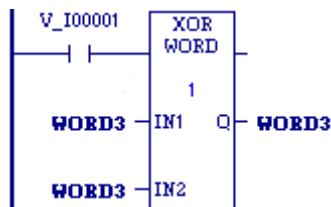


WORD1	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	0
WORD2	1	1	0	1	1	1	0	0	0	0	0	0	1	1	1	1

RESULT	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0
---------------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Example: Logical XOR

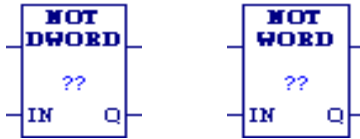
Whenever V_I0001 is set, the bit string represented by the variable WORD3 is cleared (set to all zeroes).



I1 (WORD3)	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	0
I2 (WORD3)	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	0

Q (WORD3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
------------------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

7.2.7 Logical NOT



When the Logical Not or Logical Invert (NOT) function receives power flow, it sets the state of each bit in the output bit string Q to the opposite of the state of the corresponding bit in bit string IN1.

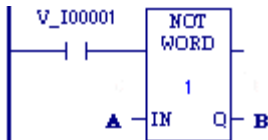
All bits are altered on each scan that power is received, making output string Q the logical complement of input string IN1. Logical NOT passes power flow to the right whenever it receives power. You can specify a string length of 1 to 256 WORDs or DWORDs

Operands for Logical NOT

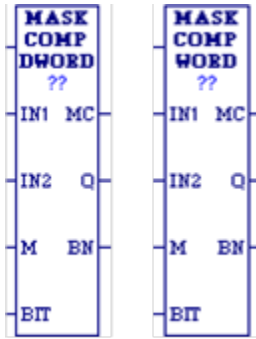
Parameter	Description	Allowed Operands	Optional
Length (??)	The number of WORDs or DWORDs in the bit string to NOT. $1 \leq \text{Length} \leq 256$.	Constant	No
IN1	The first WORD or DWORD of the input string to NOT.	All	No
Q (Must be the same data type as IN1)	The first WORD or DWORD of the NOT's result.	All except constants and variables located in %S memory	No

Example

When input V_I0001 is set, the bit string represented by the variable A is negated. Logical NOT stores the resulting inverse bit string in variable B. Variable A retains its original bit string value.



7.2.8 Masked Compare



The Masked Compare (MASK_COMP_DWORD and MASK_COMP_WORD) function compares the contents of two bit strings. It provides the ability to mask selected bits

Tip: Input string 1 might contain the states of outputs such as solenoids or motor starters. Input string 2 might contain their input state feedback, such as limit switches or contacts.

When the function receives power flow, it begins comparing the bits in the first string with the corresponding bits in the second string. Comparison continues until a mismatch is found or until the end of the string is reached.

The BIT input stores the bit number where the next comparison should start. Ordinarily, this is the same as the number where the last mismatch occurred. Because the bit number of the last mismatch is stored in output BN, the same reference can be used for both BIT and BN. The comparison actually begins 1 bit following BIT; therefore, the initial value of BIT should be 1 less than the first bit to be compared (for example, zero (0) to begin comparison at %I00001). Using the same reference for BIT and BN causes the compare to start at the next bit position after a mismatch; or, if all bits compared successfully upon the next invocation of the function, the compare starts at the beginning.

Tip: If you want to start the next comparison at some other location in the string, you can enter different references for BIT and BN. If the value of BIT is a location that is beyond the end of the string, BIT is reset to 0 before starting the next comparison.

The function passes power flow whenever it receives power. The other outputs of the function depend on the state of the corresponding mask bit.

If all corresponding bits in strings IN1 and IN2 match, the function sets the mismatch output MC to 0 and BN to the highest bit number in the input strings. The comparison then stops. On the next invocation of a Masked Compare, it is reset to 0.

If a Mismatch is found, that is, if the two bits being compared are not the same, the function checks the correspondingly numbered bit in string M (the mask).

If the mask bit is a 1, the comparison continues until it reaches another mismatch or the end of the input strings.

If a mismatch is detected and the corresponding mask bit is a 0, the function does the following:

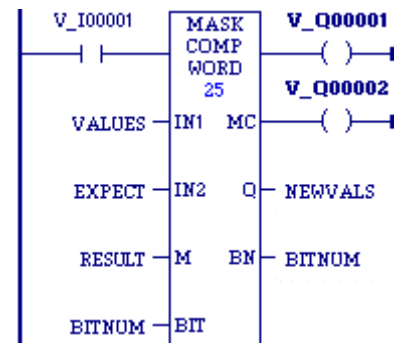
1. Sets the corresponding mask bit in M to 1.
2. Sets the mismatch (MC) output to 1.
3. Updates the output bit string Q to match the new content of mask string M.
4. Sets the bit number output (BN) to the number of the mismatched bit.
5. Stops the comparison.

Operands for Masked Compare Function

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of DWORDs or WORDs in the two compared strings. DWORD: $1 \leq \text{Length} \leq 2,048$ WORD: $1 \leq \text{Length} \leq 4,096$	Constant	No
IN1	The first bit string to be compared	All. Constants are legal only when Length is 1	No
IN2	The second bit string to be compared	All. Constants are legal only when Length is 1	No
M	The bit string mask containing the ongoing status of the compare	All except flow or variables in %S memory. Constants are legal only when Length is 1	No
BIT	BIT+1=the bit number where the next comparison starts	All except variables in %S - %SC memories	No
Q	The output copy of the compare mask bit string	All except constants	No
BN	The number of the bit where the latest mismatch occurred, or the highest bit number in the inputs if no mismatch occurred	All except constants and variables in %S memory	No
MC	Can be used to determine if a mismatch has occurred.	flow	Yes

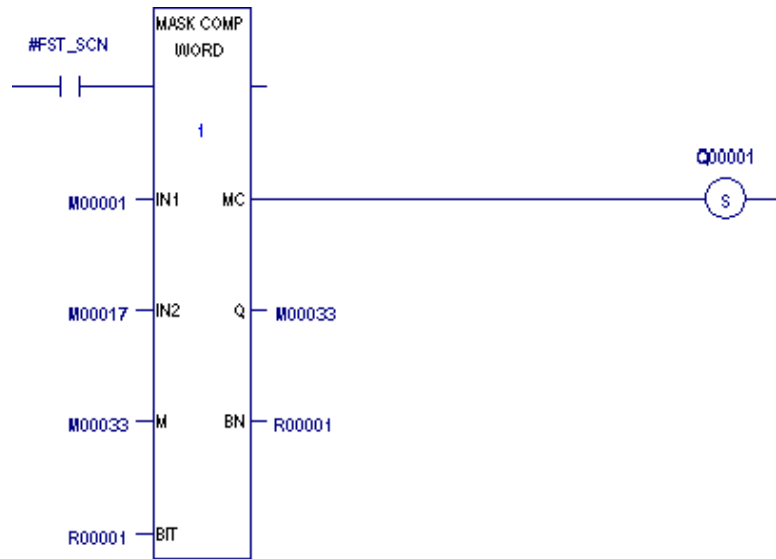
Masked Compare Example 1

When %I00001 is set, MASK_COMP_WORD compares the bits represented by the reference VALUES against the bits represented by the reference EXPECT. Comparison begins at BITNUM+1. If an unmasked mismatch is detected, the comparison stops. The corresponding bit is set in the mask RESULT. BITNUM is updated to contain the bit number of the mismatched bit. In addition, the output string NEWVALS is updated with the new value of RESULT, and coil %Q00002 is turned on. Coil %Q00001 is turned on whenever MASK_COMP_WORD receives power flow.



Masked Compare Example 2

On the first scan, the Masked Compare Word function executes. %M0001 through %M0016 is compared with %M0017 through %M0032. %M0033 through %M0048 contains the mask value. The value in %R0001 determines the bit position in the two input strings where the comparison starts.



Before the function is executed, the contents of the above references are:

(I1) - %M0001 = 6C6Ch =

0	1	1	0	1	1	0	0	0	1	1	0	1	1	0	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(I2) - %M0017 = 606Fh =

0	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(M/Q) - %M0033 = 000Fh =

0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(BIT/BN) - %R0001 = 0

(MC) - %Q0001 = OFF

The contents of these references after the function block is executed are as follows:

(I1) - %M0001 =

0	1	1	0	1	1	0	0	0	1	1	0	1	1	0	0
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(I2) - %M0017 =

0	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(M/Q) - %M0033 =

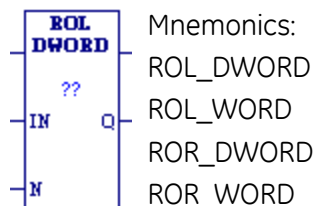
0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

(BIT/BN) - %R0001 = 8

(MC) - %Q0001 = ON

The #FST_SCN contact forces one and only one execution; otherwise, the function would repeat with possibly unexpected results.

7.2.9 Rotate Bits



- Mnemonics:
 ROL_DWORD
 ROL_WORD
 ROR_DWORD
 ROR_WORD

When receiving power flow, the Rotate Bits Right (ROR_DWORD and ROR_WORD) and Rotate Bits Left (ROL_DWORD and ROL_WORD) functions rotate all the bits in a string of WORDs or DWORDs N positions respectively to the right or to the left. When rotation occurs, the specified number of bits is rotated out of the input string respectively to the right or to the left and back into the string on the other side.

The Rotate Bits function passes power flow to the right, unless the number of bits to rotate is less than 0, or is greater than the total length of the string. The result is placed in output string Q. If you want the input string to be rotated, the output parameter Q must use the same memory location as the input parameter IN. The entire rotated string is written on each scan that power is received.

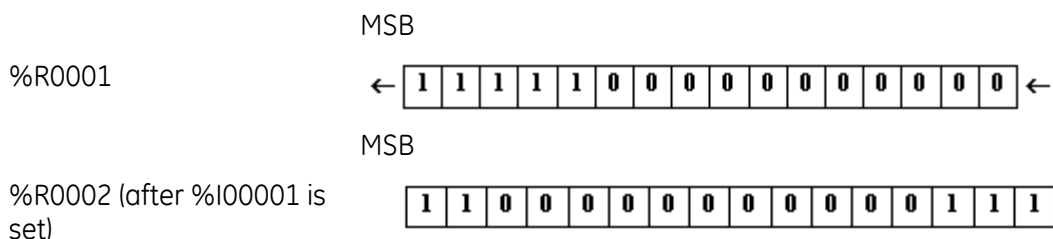
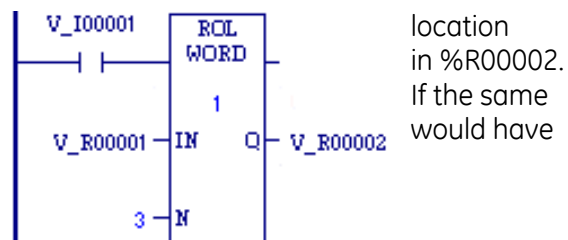
A string length of 1 to 256 words or double words can be specified.

Operands for Rotate Bits

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of WORDs or DWORDs in the string to be rotated. $1 \leq \text{Length} \leq 256$.	Constant	No
IN	The string to rotate	All. Constants are legal when Length is 1	No
N	The number of positions to rotate. $0 \leq N \leq \text{Length}$.	All except variables in %S - %SC memories	No
Q	The resulting rotated string	All except constants and variables in %S memory	No

Example

Whenever input V_I0001 is set, the input bit string in %R0001 is rotated left 3 bits and the result is placed in %R0002. The actual input bit string %R0001 is left unchanged. If the same reference had been used for IN and Q, a rotation would have occurred in place.



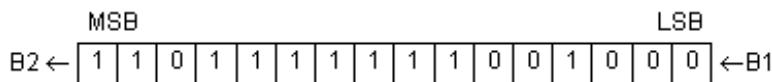
7.2.10 Shift Bits



Mnemonics:
 SHIFTL_DWORD
 SHIFTL_WORD
 SHIFTR_DWORD
 SHIFTR_WORD

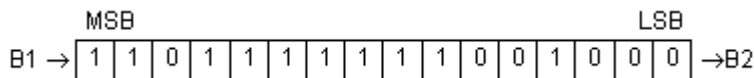
Shift Left

When the Shift Left (SHIFTL_WORD) function receives power flow, it shifts all the bits in a word or group of words to the left by a specified number of places, N. When the shift occurs, the specified number of bits is shifted out of the output string to the left. As bits are shifted out of the high end of the string (Most Significant Bit (MSB)), the same number of bits is shifted in at the low end (Least Significant Bit (LSB)). The SHIFTL_DWORD function operates in a similar manner on DWORDs instead of WORDs.



Shift Right

When the Shift Right (SHIFTR_WORD) function receives power flow, it shifts all the bits in a word or group of words a specified number of places to the right (N). When the shift occurs, the specified number of bits is shifted out of the output string to the right. As bits are shifted out of the low end of the string (LSB), the same number of bits is shifted in at the high end (MSB).



Shift Left and Shift Right

A string length (Length) of 1 to 256 words can be specified.

The bits being shifted into the beginning of the string are specified via input parameter B1. If the value of N is greater than 1, each bit is filled with the same value (0 or 1). This can be:

- The Boolean output of another program function.
- All 1s. To do this, use the #AWL_ON (always on) system bit (in memory location %S7), as a permissive to input B1.
- All 0s. To do this, use the #ALW_OFF (always off) system bit (in memory location %S8), as a permissive to input B1.

The Shift Bits function passes power flow to the right, unless the number of bits specified to shift is zero or is greater than the array size.

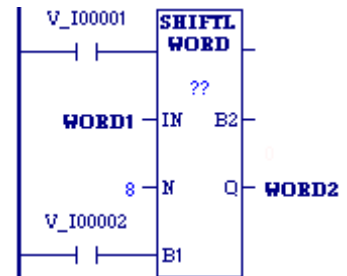
Output Q is the shifted copy of the input string. If you want the input string to be shifted, the output parameter Q must use the same memory location as the input parameter IN. The entire shifted string is written on each scan that power is received. Output B2 is the last bit shifted out. For example, if four bits were shifted, B2 would be the fourth bit shifted out.

Operands for Shift Left, Shift Right, Shift Left and Shift Right

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of WORDs or DWORDs in the string. $1 \leq \text{Length} \leq 256$.	Constants.	No
IN	The string of WORDs or DWORDs to shift	All. Constants are legal only when Length = 1.	No
N	The number of places (bits) to shift the array. $0 \leq N \leq \text{Length}$ If N is 0, no shift occurs, but power flow is generated. If N is greater than the number of bits in the string (Length), all bits in Q are set to the value B1, OK is set FALSE, and B2 is set to B1.	All except variables in %S— %SC memories	No
B1	The bit value to shift into the array	flow	No
B2	The bit value of the last bit shifted out of the array.	flow	Yes
Q (Must be the same data type as IN)	The first WORD or DWORD of the shifted array	All except constants and variables in %S memory.	No

Example

Whenever input V_I0001 is set, the bits in the input string that begins at WORD1 are copied to the output bit string that starts at WORD2. WORD2 is left-shifted by 8 bits, as specified by the input N. The resulting open bits at the beginning of the output string are set to the value of V_I0002.



7.3. Coils

Coils are used to control the discrete (BOOL) references assigned to them. Conditional logic must be used to control the flow of power to a coil. Coils cause action directly. They do not pass power flow to the right. If additional logic in the program should be executed as a result of the coil condition, you can use an internal reference for the coil or a continuation coil/contact combination.

A continuation coil does not use an internal reference. It must be followed by a continuation contact at the beginning of any rung following the continuation coil.

Coils are always located at the rightmost position of a line of logic.

7.3.1 Coil Checking

The level of coil checking is set to “Show as error” by default. If you want a coil conflict to result in a warning instead of this error, or if you want no warning at all, edit the Controller option: **Multiple Coil Use Warning** in the programming software.

The “Show as warning” option enables you to use any coil reference with multiple Coils, Set Coils, and Reset Coils, but you will be warned at validation time every time you do so. With both the “Show as warning” and the “no warning” options, a reference can be set ON by either a Set Coil or a normal Coil and can be set OFF by a Reset Coil or by a normal Coil.

7.3.2 Graphical Representation of Coils

The programming software displays the COIL, NCCOIL, SETCOIL, and RESETCOIL instructions differently depending on the retentive state of the BOOL variables assigned to them. Examples are provided in the discussion of each type of coil. For a discussion of retentiveness, refer to “Retentiveness of Logic and Data” in Chapter 6.

Coil (Normally Open)



A retentive variable is assigned to the coil



A non-retentive variable is assigned to the coil

When a COIL receives power flow, it sets its associated BOOL variable ON (1). When it receives no power flow, it sets the associated BOOL variable OFF (0). COIL can be assigned a retentive variable or a non-retentive variable.

Valid memory areas: %I, %Q, %M, %T, %SA - %SC, and %G. Symbolic discrete variables are permitted. Bit-in-word references on any word-oriented memory except %AI, including symbolic non-discrete memory, are also permitted.

Continuation Coil



A continuation coil instructs the PLC to continue the present rung's LD logic power flow value (TRUE or FALSE) at the continuation contact on a following rung.

The flow state of the continuation coil is passed to the continuation contact.

Notes:

- If the flow of logic does not execute a continuation coil before it executes a continuation contact, the state of the continuation contact is no flow (FALSE).
- The continuation coil and the continuation contact do not use parameters and do not have associated variables.
- You can have multiple rungs with continuation contacts after a single continuation coil.
- You can have multiple rungs with continuation coils before one rung with a continuation contact.

Negated Coil



A retentive variable is assigned to the negated coil



A non-retentive variable is assigned to the negated coil

When it does *not* receive power flow, a negated coil (NCCOIL) sets a discrete reference ON. When it does receive power flow, NCCOIL sets a discrete reference OFF. NCCOIL can be assigned a retentive variable or a non-retentive variable.

Valid memory areas: %I, %Q, %M, %T, %SA - %SC, and %G. Symbolic discrete variables are permitted. Bit-in-word references on any word-oriented memory except %AI, including symbolic non-discrete memory, are also permitted.

7.3.3 Set Coil, Reset Coil



Set Coil and Reset Coil with a retentive variable assigned



Set Coil and Reset Coil with a non-retentive variable assigned

The SET and RESET coils can be used to keep ("latch") the state of a reference either ON or OFF.



Warning

SET / RESET coils write an undefined result to the transition bit for the given reference. This result differs from that written by Series 90-70 CPUs and could change for future PACSystems CPU models.

Because they write an undefined result to transition bits, do not use SET or RESET coils with references used on POSCON or NEGCON transition contacts.

When a SET coil receives power flow, it sets its discrete reference ON. When a SET coil does not receive power flow, it does not change the value of its discrete reference. Therefore, whether or not the coil itself continues to receive power flow, the reference stays ON until the reference is reset by other logic, such as a RESET coil.

When a RESET coil receives power flow, it resets a discrete reference to OFF. When a RESET coil does not receive power flow, it does not change the value of its discrete reference. Therefore, its reference remains OFF until it is set ON by other logic, such as a SET coil.

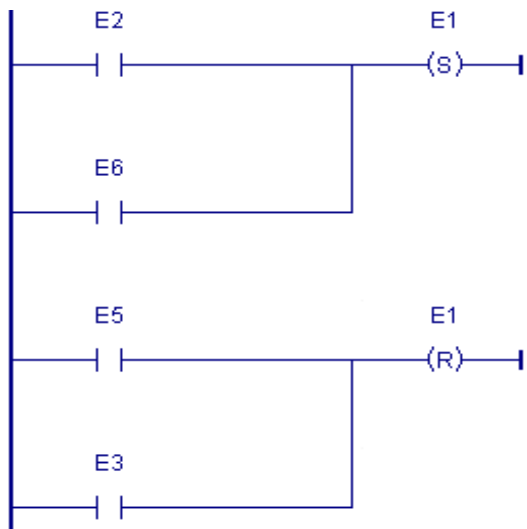
The last solved SET coil or RESET coil of a pair takes precedence.

The SET and RESET coils can be assigned a retentive variable or a non-retentive variable.

Valid memory areas: %I, %Q, %M, %T, %SA - %SC, and %G. Symbolic discrete variables are permitted. Bit-in-word references on any word-oriented memory except %AI, including symbolic non-discrete memory, are also permitted.

Example of Set Coil, Reset Coil

The coil represented by E1 is turned ON when reference E2 or E6 is ON and is turned OFF when reference E5 or E3 is ON.



7.3.4 Transition Coils

PACSystems controllers provide four transition coils: PTCOIL, NTCOIL, POSCOIL, and NEGCOIL.

POSCOIL and NEGCOIL are updated every time they are called.

PTCOIL and NTCOIL are updated once per CPU scan.



For examples showing the differences in the operation of the two types of transition coils, see page 183.

POSCOIL and NEGCOIL

Warning



- These transition coil instructions should not be used in a parameterized block or user-defined function block (UDFB) with a parameter or member. In these cases, an R_TRIG or F_TRIG should be used instead.
- Do not override a transition coil by putting a force on its reference bit. If a transition coil is overridden, the coil has no effect on the bit, and if the override is then removed, the coil might be set ON for one sweep. . This can cause unexpected behavior in the Controller logic and in field devices attached to the Controller.
- Do not write to the reference bit of a transition coil using any other instruction or from an external device. Doing so will destroy the coil's one-shot nature and the coil may not behave as described.
- Do not use a transition contact with the same reference address used on a transition coil because the value of the transition bit, which stores the power flow value into the coil, will be affected.

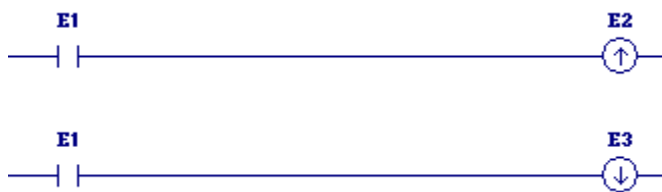
Positive Transition Coil (POSCOIL) 	Negative Transition Coil (NEGCOIL) 
<p>If:</p> <ul style="list-style-type: none"> ■ the <i>transition</i> bit is OFF, and ■ the input power flow is ON, <p>the POSCOIL sets the <i>reference</i> bit of its associated variable ON until the coil is executed again. When the coil is executed again, it sets its reference bit OFF.</p> <p>Note: When the Positive Transition Coil sets its <i>reference</i> bit ON, it also sets its <i>transition</i> bit to ON. The next time the Positive Transition coil executes, it finds its transition bit set to ON and sets its reference bit to OFF.</p>	<p>If:</p> <ul style="list-style-type: none"> ■ the <i>transition</i> bit is OFF, and ■ the input power flow input is OFF, <p>the NEGCOIL sets the <i>reference</i> bit of its associated variable ON until the coil is executed again. When the coil is executed again, it sets its reference bit OFF.</p> <p>Note: When the Negative Transition Coil sets its <i>reference</i> bit ON, it also sets its <i>transition</i> bit to ON. The next time the Negative Transition Coil executes, it finds the transition bit set to ON and sets its reference bit to OFF.</p>

Operands for POSCOIL and NEGCOIL

Parameter	Description	Allowed Operands	Optional
BOOL_V	The variable associated with POSCOIL or NEGCOIL	BOOL variable: I, Q, M, T, G, SA, SB, SC, symbolic discrete variables, and I/O variable. Bit reference in BOOL variable: I, Q, M, T, G, SA, SB, SC	No

Example for POSCOIL and NEGCOIL

When reference E1 goes from OFF to ON, coils E2 and E3 receive power flow, turning E2 ON. When E1 goes from ON to OFF, power flow is removed from E2 and E3, turning coil E3 ON.





PTCOIL and NTCOIL

Because the behavior of PTCOILs and NTCOILs is determined only by the current power flow into the coil and the previous power flow into the coil (i.e., the transition bit), it is not affected by writes to its associated BOOL variable by other coils or instructions in the logic. Therefore, many of the cautions that apply to POSCOILs and NEGCOILs do not apply to PTCOILs and NTCOILs.

Warning



- PTCOIL and NTCOIL instructions should not be used in a parameterized block or user-defined function block (UDFB) with a parameter or member. In these cases, an R_TRIG or F_TRIG should be used instead.
- The transition bit of a given PTCOIL or NTCOIL is changed only once per CPU scan. Therefore, using a PTCOIL or NTCOIL in a block that can be called multiple times per scan can have adverse effects on all calls after the first one because the PTCOIL or NTCOIL cannot detect the transition on the second and subsequent calls.
- Do not override a transition coil by putting a force on its reference bit. If a transition coil is overridden, the coil has no effect on the bit, and if the override is then removed, the coil might be set ON for one sweep. . This can cause unexpected consequences in the Controller logic and in field devices attached to the Controller.
- Do not use a transition contact with the same reference address used on a transition coil because the value of the transition bit, which stores the power flow value into the coil, will be affected.

 Positive Transition Coil (PTCOIL)	 Negative Transition Coil (NTCOIL)
If: <ul style="list-style-type: none"> ■ the <i>transition</i> bit is OFF, and ■ the input power flow is ON the PTCOIL sets the <i>reference</i> bit and transition bit of its associated variable ON.	If: <ul style="list-style-type: none"> ■ the <i>transition</i> bit is OFF, and ■ the input power flow is OFF the NTCOIL sets the <i>reference</i> bit and transition bit of its associated variable ON.
The <i>transition bit</i> depends on the value of the input power flow the last time the PTCOIL or NTCOIL was executed.	

Notes:

- As soon as a PTCOIL or NTCOIL is set to ON or OFF, it updates its transition bit.
- Multiple instances of PTCOIL and/or NTCOIL can be associated with the same BOOL variable, but the transition status of each instance of the PTCOIL or NTCOIL associated with the BOOL variable is unique, that is, it is tracked independently.
- The transition bit is non-retentive, that is, it is cleared to OFF when the CPU transitions from stop to run. As a result, the first time a PTCOIL executes with its input power flow set to ON its associated BOOL variable will be set to ON.

Operands for PTCOIL and NTCOIL

Parameter	Description	Allowed Operands	Optional
BOOL_V	The variable associated with PTCOIL or NTCOIL	Variables in I, Q, M, T, SA, SB, SC, or G memories as well as symbolic discrete variables. In addition, bit-in-word references on any non-discrete memory (e.g., %R) or on symbolic non-discrete variables are allowed.	No

Examples Comparing PTCOIL and POSCOIL

PTCOIL

In the example below, the power flow into the PTCOIL alternates between OFF and ON. On the first sweep the power flow in is OFF, on the second sweep it is ON, and so forth. Each time the power flow into the PTCOIL changes from OFF to ON, the value of Xsition is turned ON. Therefore, on the first sweep, the PTCOIL turns Xsition OFF, on the second sweep it turns it ON, on the third sweep it turns it OFF, and so forth. Notice that the behavior of the PTCOIL is **not** affected by the presence of the fourth rung, which also writes to Xsition. PTCOIL behaves the same way when the fourth rung is removed.

POSCOIL

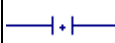





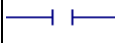
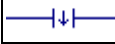
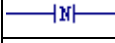
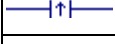
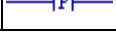
If a POSCOIL is used in place of the PTCOIL in the example below (keeping the rest of the logic identical and same alternation of power flow into the POSCOIL), the behavior of the logic will be different. The behavior of the POSCOIL **is** affected by the execution of the fourth rung, which writes to Xsition and changes both its value and its transition bit. In this example, the POSCOIL never turns Xsition ON. If the fourth rung is removed, POSCOIL will behave exactly as the PTCOIL behaves, turning Xsition OFF on the first sweep, ON on the second sweep, and so forth.



7.4. Contacts

A contact is used to monitor the state of a reference address. Whether the contact passes power flow depends on positive power flow into the contact, the state or status of the reference address being monitored, and the contact type.

A reference address is ON if its state is 1; it is OFF if its state is 0.

Contact	Display	Mnemonic	Contact Passes Power to Right...
Continuation Contact		CONTCON	if the preceding continuation coil is set ON
Fault Contact	BOOLV 	FAULT	if its associated BOOL or WORD variable has a point fault
High Alarm Contact	WORDV 	HIALR	if the high alarm bit associated with the analog (WORD) reference is ON
Low Alarm Contact	WORDV 	LOALR	if the low alarm bit associated with the analog (WORD) reference is ON
No Fault Contact	BOOLV 	NOFLT	if its associated BOOL or WORD variable does not have a point fault
Normally Closed Contact	BOOLV 	NCCON	if associated BOOL variable is OFF
Normally Open Contact	BOOLV 	NOCON	if associated BOOL variable is ON
Transition Contacts	BOOLV 	NEGCON	(negative transition contact) if BOOL reference transitions from ON to OFF. Updated every time it is called.
	BOOL_V 	NTCON	(negative transition contact) if BOOL reference transitions from ON to OFF. Updated once per scan.
	BOOLV 	POSCON	(positive transition contact) if BOOL reference transitions from OFF to ON. Updated every time it is called.
	BOOL_V 	PTCON	(positive transition contact) if BOOL reference transitions from OFF to ON. Updated once per scan.

7.4.1 Continuation Contact



A continuation contact continues the LD logic from the last previously-executed rung in the block that contained a continuation coil.

The flow state of the continuation contact is the same as the preceding executed continuation coil. A continuation contact has no associated variable.

Notes:

- If the flow of logic does not execute a continuation coil before it executes a continuation contact, the state of the continuation contact is no flow.
- The state of the continuation contact is cleared (set to no flow) each time a block begins execution.
- The continuation coil and the continuation contact do not use parameters and do not have associated variables.
- You can have multiple rungs with continuation contacts after a single continuation coil.
- You can have multiple rungs with continuation coils before one rung with a continuation contact.

7.4.2 Fault Contact

BWVAR



A Fault contact (FAULT) detects faults in discrete or analog reference addresses, or locates faults (rack, slot, bus, module).

- To guarantee correct indication of module status, use the reference address (%I, %Q, %AI, %AQ) with the FAULT/NOFLT contacts.
- To locate a fault, use the rack, slot, bus, module fault locating system variable with a FAULT/NOFLT contact.

Note: The fault indication of a given module is cleared when the associated fault is cleared from the fault table.

- For I/O point fault reporting, you must enable point fault references in Hardware Configuration.

FAULT passes power flow if its associated variable or location has a point fault.

Operands

Parameter	Description	Allowed Operands	Optional
BWVAR	The variable associated with the FAULT contact	variables in %I, %Q, %AI, and %AQ memories, and predefined fault-locating references	No

7.4.3 High and Low Alarm Contacts



The **high alarm contact** (HIALR) is used to detect a high alarm associated with an analog reference. Use of this contact and the low alarm contact must be enabled during CPU configuration.

A high alarm contact passes power flow if the high alarm bit associated with the analog reference is ON.

The **low alarm contact** (LOALR) detects a low alarm associated with an analog reference. Use of this contact must be enabled during CPU configuration.

A low alarm contact passes power flow if the low alarm bit associated with the analog reference is ON.

Operands

Parameter	Description	Allowed Operands	Optional
WORDV	The variable associated with the HIALR or LOALR contact	variables in AI and AQ memories	No

7.4.4 No Fault Contact



A No Fault (NOFLT) contact detects faults in discrete or analog reference addresses, or locates faults (rack, slot, bus, module). NOFLT passes power flow if its associated variable or location does not have a point fault.

- To guarantee correct indication of module status, use the reference address (%I, %Q, %AI, %AQ) with the FAULT/NOFLT contacts.
- To locate a fault, use the rack, slot, bus, module fault locating system variables with a FAULT/NOFLT contact.
- For I/O point fault reporting, you must configure your Hardware Configuration (HWC) to enable the PLC point faults.

Note: The fault indication of a given module is cleared when the associated fault is cleared from the fault table.

Operands

Parameter	Description	Allowed Operands	Optional
BWVAR	The variable associated with the NOFLT contact	variables in %I, %Q, %AI, and %AQ memories, and predefined fault-locating references	No

7.4.5 Normally Closed and Normally Open Contacts



A **normally closed contact** (NCCON) acts as a switch that passes power flow if the BOOLV operand is OFF (false, 0).

A **normally open contact** (NOCON) acts as a switch that passes power flow if the BOOLV operand is ON (true, 1).

Operands

Parameter	Description	Allowed Operands	Optional
BOOLV	<p>BOOLV may be a predefined system variable or a user-defined variable.</p> <p>NCCON: If BOOLV is ON, the normally closed contact does not pass power flow. If BOOLV is OFF, the contact passes power flow.</p> <p>NOCON: If BOOLV is ON, the normally open contact passes power flow. If BOOLV is OFF, the contact does not pass power flow.</p>	discrete variables in I, Q, M, T, S, SA, SB, SC, and G memories; symbolic discrete variables; bit-in-word references on variables in any non-discrete memory (e.g., %L) or on symbolic non-discrete variables.	No

7.4.6 Transition Contacts

PACSystems controllers provide four transition contacts: POSCON, NEGCON, PTCON and NTCON.

- The power flow out of the POSCON and NEGCON transition contacts is determined by the last write to the BOOL variable associated with the contact. The associated transition bit is updated every time the function is called.
- The power flow out of the PTCON and NTCON transition contacts is determined by the value that the associated BOOL variable had the last time the contact was executed. The associated transition bit is updated once per scan.

For an example showing the differences in the operation of the two types of transition contacts, see page 192.

POSCON and NEGCON

Warning



- These transition contact instructions should not be used in a parameterized block or user-defined function block (UDFB) with a parameter or member. In these cases, an R_TRIG or F_TRIG should be used instead.
- Do not use POSCON or NEGCON transition contacts for references used with transition coils (also called one-shot coils) or with SET and RESET coils.
- If a SETCOIL or RESETCOIL receives positive power flow and its associated variable is *not* overridden, the SETCOIL or RESETCOIL writes the expected result to the transition bit for the associated variable (that is, the transition bit is set if the variable's value is set from ON to OFF or is set from OFF to ON, and is cleared when its value remains the same). However, if the SETCOIL or RESETCOIL receives positive power flow and its associated variable is overridden, the SETCOIL or RESETCOIL causes the transition bit to be cleared.
- Do not use a transition contact with the same reference address used on a transition coil because the value of the transition bit, which stores the power flow value into the coil, will be affected.

<p>BOOLV</p> <p>Positive Transition Contact POSCON</p>	<p>BOOLV</p> <p>Negative Transition Contact NEGCON</p>
---	---

<p>POSCON starts passing power flow and continues passing power flow to the right only when all of the following conditions are met:</p> <ul style="list-style-type: none"> ■ the input power flow to POSCON is ON, ■ the value of the associated variable is ON, and ■ the <i>transition</i> bit for the associated variable is ON <p>The POSCON's transition bit is set to ON when the variable associated with the POSCON transitions from OFF to ON.</p>	<p>NEGCON starts passing power flow and continues passing power flow to the right only when all of the following conditions are met:</p> <ul style="list-style-type: none"> ■ the input power flow to NEGCON is ON ■ the value of the associated variable is OFF, and ■ the <i>transition</i> bit for the associated variable is ON <p>The NEGCON's transition bit is set to ON when the variable associated with the NEGCON transitions from ON to OFF.</p>
<p>The transition bit is set to OFF when the associated variable is written to while the POSCON or NEGCON contact is passing power flow, regardless of whether the value written is ON or OFF. Power flow stops when the transition bit is set to OFF.</p>	

Depending on the logic flow, writes to the POSCON's or NEGCON's associated variable can occur at different intervals within the Controller scan:

- multiple times during a Controller scan, resulting in the transition bit being ON for only a portion of the scan.
- several Controller scans apart, resulting in the transition bit being ON for more than one scan.
- once per scan, for example if the POSCON or NEGCON's associated variable is a %I input bit.

The source of the write is immaterial; it can be an output coil, a function block output, the input scan, an input interrupt, a data change from the program, or external communications. When the variable is written, the transition bit is immediately affected. The scan does not affect the transition bit. The only way to clear the transition bit is to write to the associated variable.

Overrides

Overrides do not protect transition bits. If a write is attempted to an overridden point, the point's transition bit is cleared. As a result, any associated POSCON or NEGCON contacts will stop passing power flow.

Transition to Run Mode

- Variables that are non-retentive and not overridden will have values and transitions cleared to 0.
- Variables that are non-retentive and overridden will retain their values and transition bits.
- Variables that are retentive will retain their values and transition bits.

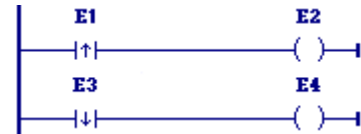
Operands for POSCON and NEGCON

Parameter	Description	Allowed Operands	Optional
BOOLV	The variable associated with the transition contact	<p>BOOL variable: I, Q, M, T, S, SA, SB, SC, and G, symbolic discrete variables, I/O variables</p> <p>Bit reference in BOOL variable: I, Q, M, T, S, SA, SB, SC.</p>	No

POSCON and NEGCON Example 1

Coil E2 is turned ON when the value of the variable E1 transitions from OFF to ON. It stays ON until E1 is written to again, causing the POSCON to stop passing power flow.

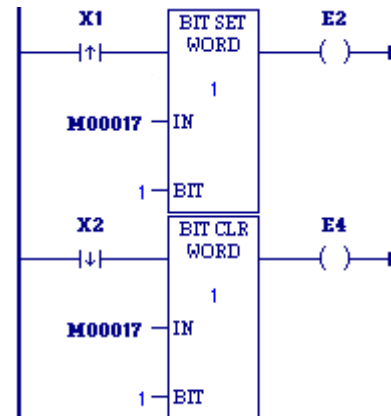
Coil E4 is turned ON when the value of the variable E3 transitions from ON to OFF. It stays ON until E3 is written to again, causing the NEGCON to stop passing power flow.



POSCON and NEGCON Example 2

Bit %M00017 is set by a BIT_SET function and then cleared by a BIT_CLR function. The positive transition contact X1 activates the BIT_SET, and the negative transition X2 activates the BIT_CLR.

The positive transition associated with bit %M00017 will be on until %M00017 is reset by the BIT_CLR function. This occurs because the bit is only written when contact X1 goes from OFF to ON. Similarly, the negative transition associated with bit %M00017 will be ON until %M00017 is set by the BIT_SET function.



PTCON and NTCN

**Warning**

PTCON or NTCN instructions should not be used in a parameterized block or user-defined function block with a parameter or member. In these cases, an R_TRIG or F_TRIG should be used instead.

The transition bit of a given PTCON or NTCN is updated only once per CPU scan. Therefore, using a PTCON or NTCN in a block that can be called multiple times per scan may have adverse effects on all calls after the first one because the PTCON or NTCN cannot detect the transition on the second and subsequent calls.

BOOL_V — P — Positive Transition Contact PTCON	BOOL_V — N — Negative Transition Contact NTCN
PTCON passes power flow to the right only when all of the following conditions are met: <ul style="list-style-type: none"> ■ The input power flow to PTCON is ON. ■ The value of the BOOL variable associated with PTCON is ON. ■ The transition bit associated with the PTCON is OFF 	NTCON passes power flow to the right only when all of the following conditions are met: <ul style="list-style-type: none"> ■ The input power flow to NTCN is ON. ■ The value of the BOOL variable associated with NTCN is OFF. ■ The transition bit associated with the NTCN is ON
The transition bit depends on the value of the BOOL variable associated with this PTCON or NTCN when it was last executed.	

Notes:

- As soon as a PTCON or NTCN is set to ON or OFF, it updates its transition bit.
- Multiple instances of PTCON and/or NTCN can be associated with the same BOOL variable, but the instance data of each instance of the PTCON or NTCN associated with the BOOL variable is unique, that is, it is tracked independently.
- Transition data is non-retentive, that is, it is cleared to OFF when the CPU transitions from stop to run. As a result, the first time a PTCON executes with its input power flow set to ON and its associated BOOL variable also set to ON, it passes power flow to the right.

Operands for PTCON and NTCN

Parameter	Description	Allowed Operands	Optional
BOOL_V	The variable associated with PTCON or NTCN contact	BOOL variable: I, Q, M, T, S, SA, SB, SC, and G memories, symbolic discrete variables, I/O variables. Bit reference in non-BOOL variable: R, AI, AQ, L, P, W, and on symbolic non-discrete variables.	No

Examples Comparing PTCON and POSCON

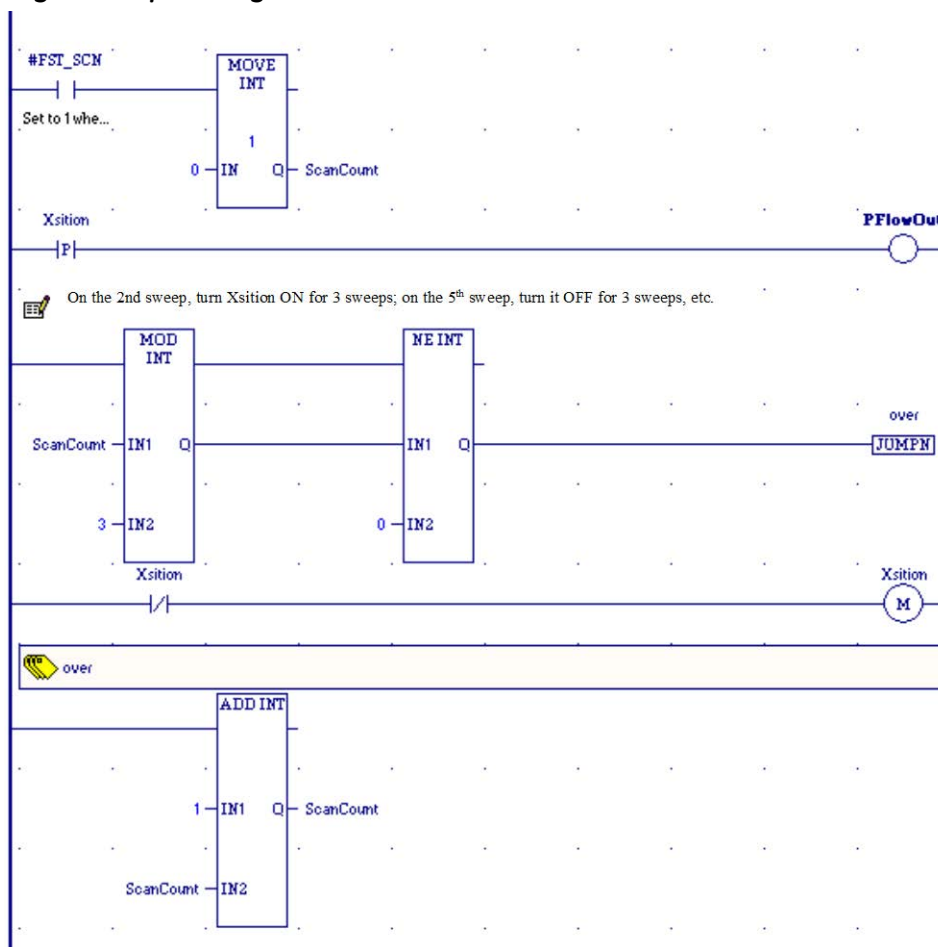
PTCON

The logic in the following example starts execution with all variables set to 0. Before the second sweep begins, the Xsition variable used on the PTCON instruction is set to 1. It retains that value for sweeps 2, 3, and 4. Then it is reset back to 0 before sweep 5 begins and retains its 0 value for sweeps 5, 6, and 7. This pattern repeats. The PTCON instruction in rung two passes power flow on the 2nd sweep, the 8th sweep, the 14th sweep, and so on. These are sweeps where the Xsition variable's value becomes a 1, after having been a 0 on the previous sweep. On all other sweeps, the PTCON instruction does not pass power flow.

POSCON

If a POSCON is used in place of the PTCON in the following example (keeping the rest of the logic identical), the same alternation of the Xsition variable's value occurs. The POSCON instruction passes power flow on sweeps 2, 3, and 4; then again on sweeps 8, 9, and 10; and so forth. The POSCON's behavior is dependent on Xsition's transition bit. Since Xsition's value is written once and then simply retained for three sweeps, its transition bit retains its same value for three sweeps. Thus the POSCON will pass or not pass power flow for three sweeps in a row. Note that if Xsition's value is actually written on each sweep, the POSCON and the PTCON behave identically.

Logic Example Using PTCON

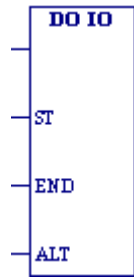


7.5. Control Functions

The control functions limit program execution and change the way the CPU executes the application program.

Function	Mnemonic	Description
Do I/O	DO_IO	For one scan, immediately services a specified range of inputs or outputs. (All inputs or outputs on a module are serviced if any reference locations on that module are included in the DO I/O function. Partial I/O module updates are not performed.) Optionally, a copy of the scanned I/O can be placed in internal memory, rather than at the real input points.
Drum	DRUM	Provides predefined On/Off patterns to a set of 16 discrete outputs in the manner of a mechanical drum sequencer.
Edge Detectors	F_TRIG R_TRIG	Detect the changing state of a Boolean signal.
For Loop	FOR_LOOP EXIT_FOR END_FOR	For loop. Repeats the logic between the FOR_LOOP instruction and END_FOR instruction a specified number of times or until EXIT_FOR is encountered.
Mask I/O Interrupt	MASK_IO_INTR	Mask or unmask an interrupt from an I/O module when using I/O variables. If not using I/O variables, use SVC_REQ 17, described in Chapter 9.
Proportional Integral Derivative Control	PID_ISA PID_IND	Provides two PID (Proportional/Integral/Derivative) closed-loop control algorithms: Standard ISA PID algorithm (PID_ISA) Independent term algorithm (PID_IND) Note: For details, refer to Chapter 10.
Read Switch Position	SWITCH_POS	Reads position of the Run/Stop switch and the mode for which the switch is configured.
Scan Set IO	SCAN_SET_IO	Scans the IO of a specified scan set.
Service Request	SVC_REQ	Requests a special PLC service. Note: For details, refer to Chapter 9.
Suspend IO	SUS_IO	Suspends for one sweep all normal I/O updates, except those specified by DO I/O instructions.
Suspend or Resume I/O Interrupt	SUSP_IO_INTR	Suspend or resume an I/O interrupt when using I/O variables. If not using I/O variables, use SVC_REQ 32, described in Chapter 9.

7.5.1 Do I/O



When the DO I/O (DO_IO) function receives power flow, it updates inputs or outputs for one scan while the program is running. You can also use DO_IO to update selected I/O during the program in addition to the normal I/O scan.

You can use DO_IO in conjunction with a Suspend IO (SUS_IO) function, which stops the normal I/O scan. For details, see page 209.

If input references are specified, DO_IO allows the most recent values of inputs to be obtained for program logic. If output references are specified, DO I/O updates outputs based on the most current values stored in I/O memory. I/O is serviced in increments of entire I/O modules; the PLC adjusts the references, if necessary, while DO_IO executes. DO_IO does not scan I/O modules that are not configured.

DO_IO continues to execute until all inputs in the selected range have reported or all outputs have been serviced on the I/O modules. Program execution then returns to the function that follows the DO_IO.

If the range of references includes an option module (HSC, APM, etc.), all the input data (%I and %AI) or all the output data (%Q and %AQ) for that module are scanned. The ALT parameter is ignored while scanning option modules.

DO_IO passes power to the right whenever it receives power unless:

- Not all references of the type specified are present within the selected range.
- The CPU is not able to properly handle the temporary list of I/O created by the function.
- The range specified includes I/O modules that are associated with a “Loss of I/O” fault.



Warning

If DO_IO is used with timed or I/O interrupts, transition contacts associated with scanned inputs may not operate as expected.

Note: The Do I/O function skips modules that do not support DO_IO scanning:

IC693BEM331	90-30 Genius Bus Controller
IC694BEM331	RX3i Genius Bus Controller
IC693BEM341	90-30 2.5 GHz FIP Bus Controller
IC693DNM200	90-30 DeviceNet Master
IC695PBM300	RX3i PROFIBUS Master
IC695PBS301	RX3i PROFIBUS Slave
IC687BEM731	90-70 Genius Bus Controller
IC697BEM731	90-70 Standard Width Genius Bus Controller

Do I/O for Inputs

When DO_IO receives power flow and input references are specified, the PLC scans input points from the starting reference (ST) to the ending reference (END). If a reference is specified for ALT, a copy of the new input values is placed in memory beginning at that reference, and the real input values are not updated. ALT must be the same size as the reference type scanned. If a discrete reference is used for ST and END, ALT must also be discrete.

If no reference is specified for ALT, the real input values are updated. This allows inputs to be scanned one or more times during the program execution portion of the CPU scan.

Do I/O for Outputs

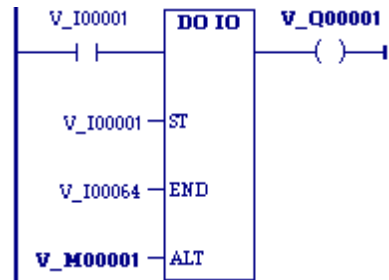
When DO_IO receives power flow and output references are specified, the PLC writes to the output points. If no value is specified in ALT, the range of outputs written to the output modules is specified by the starting reference (ST) and the ending reference (END). If outputs should be written to the output points from internal memory other than %Q or %AQ, the beginning reference is specified for ALT and the end reference is automatically calculated from the length of the END—ST range.

Operands

Parameter	Description	Allowed Operands	Optional
ST	The starting address of the set of input or output points or words to be serviced. ST and END must be in the same memory area. <ul style="list-style-type: none"> ■ If ST and END are placed in BOOL memory, ST must be byte-aligned. That is, its reference address must start at (8n+1), for example, %I01, %Q09, %Q49. ■ If ST and END are mapped to analog memory, they can have the same reference address. ■ If ST is mapped to an I/O variable, the same I/O variable must also be assigned to the END parameter, and the entire module is scanned. 	I, Q, AI, AQ, I/O Variable	No
END	The address of the end bit of input or output points or words to be serviced. Must be in the same memory area as ST. <ul style="list-style-type: none"> ■ If ST and END are placed in BOOL memory, END's reference address must be 8n, for example, %I08, %Q16. ■ If ST and END are mapped to analog memory, they can have the same reference address. ■ If ST is mapped to an I/O variable, the same I/O variable must also be assigned to the END parameter, and the entire module is scanned. 	I, Q, AI, AQ, I/O Variable	No
ALT	For an input scan, ALT specifies the address to store scanned input point/word values. For an output scan, ALT specifies the address to get output point/word values from, to send to the I/O modules. <p>Note: ALT can be a WORD only if ST and END are in analog memory.</p>	I, Q, M, T, G, R, AI, AQ	Yes

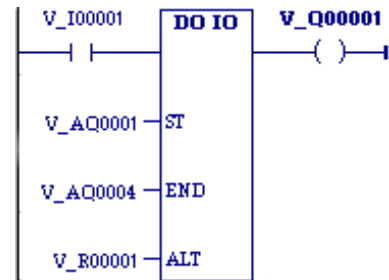
Example - Do I/O for Inputs

When DO_IO receives power flow, the PLC scans references %I0001—64 and %Q0001 is turned on. A copy of the scanned inputs is placed in internal memory from %M0001-64. Because a reference is specified for ALT, the real inputs are not updated. This allows the current values of inputs to be compared with their values at the beginning of the scan. This form of DO_IO allows input points to be scanned one or more times during the program execution portion of the CPU scan.

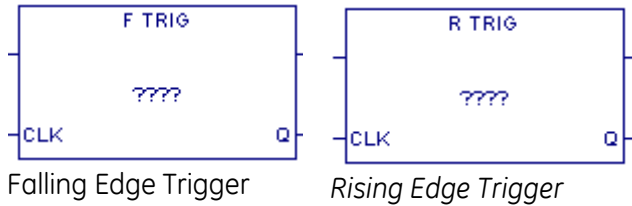


Example - Do I/O for Outputs

Because a reference is entered for ALT, the values at %AQ001—004 are *not* written to output modules. When DO_IO receives power flow, the PLC writes the values from references %R0001-0004 to the analog output modules and %Q0001 is turned on.



7.5.2 Edge Detectors



These function blocks detect the changing state of a Boolean signal and produce a single pulse when an edge is detected.

When transitional instructions, such as Transition Coils (page 180) or Transition Contacts (page 188), are used inside a function block, there is a problem when the same function block is called more than once per scan. The first call executes the transition correctly but subsequent calls do not because they see the state as adjusted from the first call. The rising and falling edge trigger instructions solve this problem. These instructions have their own instance data that can be a member or an input of the function block so that the transition state follows that of the function block instance and not the function block.

If an edge detector function block is used within a UDFB, its instance data must be a member variable of the UDFB.

Operands

Parameter	Description	Allowed Operands	Optional
????	Instance data for function block. This is a structure variable, described below.	F_TRIG, R_TRIG	No
CLK	Input to be monitored for a change in state.	All	Yes
Q	Edge detection output.	Must be flow in LD. In other languages all types allowed except S, SA, SB, SC and constants.	Yes

Instance Data Structure

These elements cannot be published or written to.

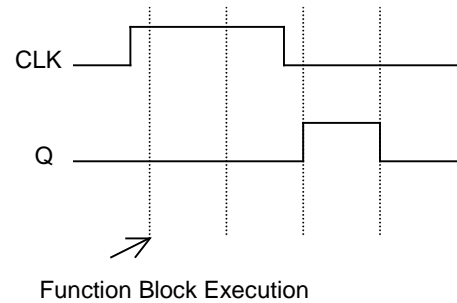
Element Name	Type	Description
CLK	BOOL	Edge detection input. Not accessible in user logic.
Q	BOOL	Edge detection output. Accessible in user logic. Read only.
STATE	BOOL	Internal value. Not accessible in user logic.
ENO	BOOL	Enable Output. User logic can access as read-only.

F_TRIG Operation

When the CLK input goes from true to false, the output Q is true for one function block instance execution. The output Q then remains false until a new falling edge is detected.

When the Controller transitions from stop to run mode and the CLK input is false and the instance memory is non-retentive, the output Q is true after the function block's first execution. After the next execution, the output is false.

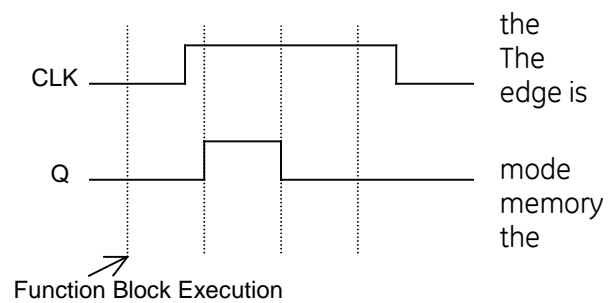
The F_TRIG output Q will be true for one function block instance execution at a stop-to-run transition after the first download, whether or not instance memory is retentive.



R_TRIG Operation

When the CLK input transitions from false to true, output Q is true for one function block execution. output Q then remains false until a new rising edge is detected.

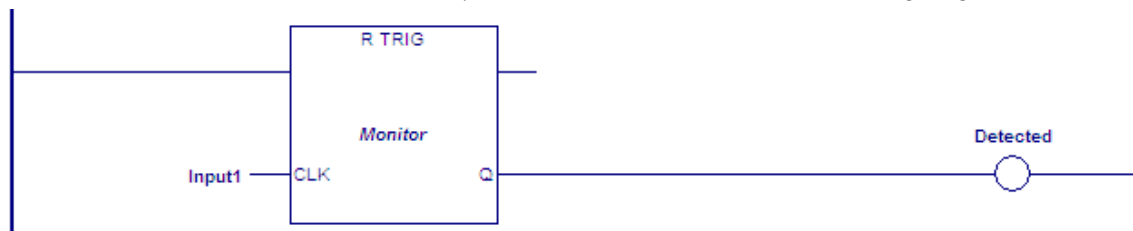
When the Controller transitions from stop to run and the CLK input is true and the instance is non-retentive, the output Q is set to true after function block's first execution. After the second execution, the output is false.



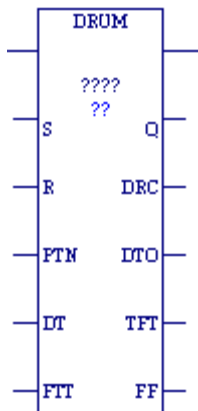
If the CLK input is initialized on, the R_TRIG output Q will be true for one function block instance execution at a stop-to-run transition after the first download, whether or not instance memory is retentive.

Example

In the following example, when Input1 transitions from false to true, the coil, Detected, is set ON for one function block execution. The output Q remains false until a new rising edge is detected.



7.5.3 Drum



The Drum function operates like a mechanical drum sequencer, which steps through a set of potential output bit patterns and selects one based on inputs to the function. The selected value is copied to a group of 16 discrete output references.

When the Drum function receives power flow, it copies the contents of a selected reference to the Q reference.

Power flow to the R (Reset) input or to the S (Step) input selects the reference to be copied.

The function passes power to the right only if it receives power from the left and no error condition is detected.

The DTO (Dwell Timeout Output) bit is cleared the first time the drum is in a new step. This is true:

- Whether the drum is introduced to a new step by changing the Active Step or by using the S (Step) Input.
- Regardless of the DT (Dwell Time array) value associated with the step (even if it is 0).
- During the first sweep the Active Step is initialized.

Using Drum in Parameterized Blocks

The Drum dwell and fault timer features use an internal timer that is implemented in the same manner as for the OFDT, ONDTR, and TMR timers. Therefore, special care must be taken when programming Drum in parameterized blocks. Drum functions in parameterized blocks can be programmed to track true real-time as long as the guidelines and rules below are followed. If the guidelines and rules described here are not followed, the operation of the Drum function in parameterized blocks is undefined.

Note: These rules are not enforced by the programming software. It is your responsibility to ensure these rules are followed.

The best use of a Drum function is to invoke it with a particular reference address exactly one time each scan. With parameterized blocks, it is important to use the appropriate reference memory with the Drum function and to call the parameterized block an appropriate number of times.

Finding the Source Block

The source block is either the `_MAIN` block or the lowest logic block of type Block that appears above the parameterized block in the call tree. To determine the source block for a given parameterized block, determine which block invoked that parameterized block. If the calling block is `_MAIN` or of type Block, it is the source block. If the calling block is any other type (parameterized block or function block), apply the same test to the block that invoked this block. Continue back up the call tree until the `_MAIN` block or a block of type Block is found. This is the source block for the parameterized block.

Programming Drum in Parameterized Blocks

Different guidelines and rules apply depending on whether you want to use the parameterized block in more than one place in your program logic.

Parameterized block called from one block

If your parameterized block that contains a Drum function will be called from only one logic block, follow these rules:

1. Call the parameterized block exactly one time per execution of its source block.
2. Choose a reference address for the Drum control block that will not be manipulated anywhere else. The reference address may be %R, %P, %L, %W, or symbolic.

Note: %L memory is the same %L memory available to the source block of type Block. %L memory corresponds to %P memory when the source block is `_MAIN`.

Parameterized block called from multiple blocks

When calling the parameterized block from multiple blocks, it is imperative to separate the Drum reference memory used by each call to the parameterized block. Follow these rules and guidelines:

1. Call the parameterized block exactly one time per execution of each source block that it appears in.
2. Choose a %L reference or parameterized block formal parameter for the Drum control block. Do not use a %R, %P, %W, or symbolic memory reference.

Notes:

- The strongly recommended choice is a %L location, which is inherited from the parameterized block's source block. Each source block has its own %L memory space except the `_MAIN` block, which has a %P memory area instead. When the `_MAIN` block calls another block, the %P mappings from the `_MAIN` block are accessed by the called block as %L mappings.
- If you use a parameterized block formal parameter (word array passed-by-reference), the actual parameter that corresponds to this formal parameter must be a %L, %R, %P, %W, or symbolic reference. If the actual parameter is a %R, %P, %W, or symbolic reference, a unique reference address must be used by each source block.

Recursion

If you use recursion (that is, if you have a block call itself either directly or indirectly) and your parameterized block contains a Drum function, you must follow two additional rules:

- Program the source block so that it invokes the parameterized block before making any recursive calls to itself.
- Do not program the parameterized block to call itself directly.

Using Drum in UDFBs

UDFBs are user-defined logic blocks that have parameters and instance data. For details on these and other types of blocks, refer to Chapter 5.

When a Drum function is present inside a UDFB, and a member variable is used for the control block of a Drum function, the behavior of the Drum function may not match your expectations. If multiple instances of the UDFB are called during a logic sweep, only the first-executed instance will update the timer in the Drum function. If a different instance is then executed, the timer value will remain unchanged.

In the case of multiple calls to a UDFB during a logic scan, only the first call will add elapsed time to its timer functions. This behavior matches the behavior of the Drum function timer in a normal program block.

Example

A UDFB is defined that uses a member variable for a Drum function block. Two instances of the function block are created: Drum_A and Drum_B. During each logic scan, both Drum_A and Drum_B are executed. However, only the member variable in Drum_A is updated and the member variable in Drum_B always remains at 0.

Operands for Drum

Parameter	Description	Allowed Operands	Optional
????	(Control Block) The beginning address of a five-word array that contains the Drum Sequencer's control block. The contents of the control block are described below.	R, P, L, W, Symbolic	No
??	(Length) Value between 1 and 128 that specifies the number of steps.	Constant	No
S	Step input. Used to go one step forward in the sequence. When the function receives power flow and S makes an OFF to ON transition, the Drum Sequencer moves one step. When R (Reset) is active, the function ignores S.	flow	No
R	Reset input. Used to select a specific step in the sequence. When the DRUM function and Reset both receive power flow, DRUM copies the Preset Step value in the Control Block to the Active Step reference in the Control Block. Then the function copies the value in the Preset Step reference to the Q reference bits. When R is active, the function ignores S.	flow	No
PTN	(Pattern) The starting address of an array of words. The number of words is specified by the Length (??) operand. Each word represents one step of the Drum Sequencer. The value of each word represents the desired combination of outputs for a particular value of the Active Step word in the control block. The first element corresponds to an Active Step value of 1; the last element corresponds to an Active Step value of Length. The programming software does not create an array for you. You must ensure you have enough memory for PTN.	All except constant and S, SA–SC numerical data.	No
DT	(Dwell Time) If you use the DT operand, you must also use the DTO operand and vice-versa. The DT operand is the starting address of Length words of memory, where Length is the number of steps. Each DT word corresponds to one word of PTN. The value of each word represents the dwell time for the corresponding step of the Drum Sequencer in 0.1 second units. When the dwell time expires for a given step the DTO bit is set. If a Dwell Time is specified, the drum cannot sequence into its next step until the Dwell Time has expired. The programming software does not create an array for you. You must ensure you allocate enough memory for DT.	All except S, SA, SB, SC and constant	Yes

Parameter	Description	Allowed Operands	Optional
FTT	(Fault Timeout) If you use the FTT operand, you must also use the TFT operand, and vice-versa. The FTT operand is the starting address of Length words of memory, where Length is the number of steps. Each FTT word corresponds to one word of PTN. The value of each word represents the fault timeout for the corresponding step of the Drum Sequencer in 0.1 second units. When the fault timeout has expired the Fault Timeout bit is set. The programming software does not create an array for you. You must ensure you allocate enough memory for FTT.	All except S, SA, SB, SC and constant	Yes
Q	A word of memory containing the element of the PTN that corresponds to the current Active Step.	All except S and constant	No
DRC	(Drum Coil) Bit reference that is set whenever the function is enabled and Active Step is not equal to Preset Step.	All except S	Yes
DTO	(Dwell Timeout) If you use the DTO operand, you must also use DT and vice-versa. This bit reference is set if the dwell time for the current step has expired.	All except S and constant	Yes
TFT	(Timeout Fault) If you use the TFT operand, you must also use the FTT operand and vice-versa. Bit reference that is set if the drum has been in a particular step longer than the step's specified Fault Timeout.	All except S and constant	Yes
FF	(First Follower) The starting address of (Length/8+1) bytes of memory, where Length is the number of steps. If MOD (Length/8+1)>0, FF has (Length/8+1) bytes. Each bit in the bytes of FF corresponds to one word of PTN. No more than one bit in the FF bytes is ON at any time, and that bit corresponds to the value of the Active Step. The first bit corresponds to an Active Step value of one. The last used bit corresponds to an Active Step value of Length.	All except S and constant	Yes

Control Block for the Drum Sequencer Function

The control block for the Drum Sequencer function contains information needed to operate the Drum Sequencer.

address	Active Step
address + 1	Preset Step
address + 2	Step Control
address + 3	Timer Control

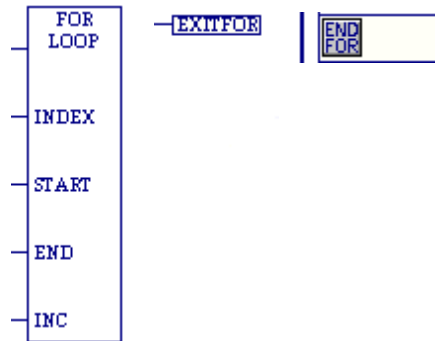
Active Step The active step value specifies the element in the Pattern array to copy to the Out output memory location. This is used as the array index into the Pattern, Dwell Time, Fault Timeout, and First Follower arrays.

Preset Step A word input that is copied to the Active Step output when the Reset is On.

Step Control A word that is used to detect Off to On transitions on both the Step input and the Enable input. The Step Control word is reserved for use by the function, and **must not be written to**.

Timer Control Two words of data that hold values needed to run the timer. These values are reserved for use by the function and **must not be written to**.

For Loop



A FOR loop repeats rung logic a specified number of times while varying the value of the INDEX variable in the loop.

A FOR loop begins with a FOR_LOOP instruction and ends with an END_FOR instruction.

The logic to be repeated must be placed between the FOR and END_FOR instructions.

The optional EXIT_FOR instruction enables you to exit the loop if a condition is met before the FOR loop ends normally.

When FOR_LOOP receives power flow, it saves the START, END, and INC (Increment) operands and uses them to evaluate the number of times the rungs between the FOR_LOOP and its END_FOR instructions are executed. Changing the START and END operands while the FOR loop is executing does not affect its operation.

When an END_FOR receives power flow, the FOR loop is terminated and power flow jumps directly to the statement following the END_FOR instruction.

There can be nothing after the FOR_LOOP instruction in the rung and the FOR_LOOP instruction must be the last instruction to be executed in the rung. An EXIT_FOR statement can be placed only between a FOR instruction and an END_FOR instruction. The END_FOR statement must be the only instruction in its rung.

A FOR_LOOP can assign decreasing values to its index variable by setting the increment to a negative number. For example, if the START value is 21, the END value is 1, and the increment value is -5, the statements of the FOR loop are executed five times, and the index variable is decremented by 5 in each pass. The values of the index variable will be 21, 16, 11, 6, and 1.

When the START and END values are set equal, the statements of the FOR loop are executed only once.

When START cannot be incremented or decremented to reach the END, the statements within the FOR loop are not executed. For example, if the value of START is 10, the value of END is 5, and the INCREMENT is 1, power flow jumps directly from the FOR statement to the statement after the END_FOR statement.

Note: If the FOR_LOOP instruction has power flow when it is first tested, the rungs between the FOR and its corresponding END_FOR statement are executed the number of times initially specified by START, END, and INCREMENT. This repeated execution occurs on a single sweep of the PLC and may cause the watchdog timer to expire if the loop is long.

Nesting of FOR loops is allowed, but it is restricted to five FOR/END_FOR pairs. Each FOR instruction must have a matching END_FOR statement following it.

Nesting with JUMPs and MCRs is allowed, provided that they are properly nested. MCRs and ENDMCRs must be completely within or completely outside the scope of a FOR_LOOP/END_FOR pair. JUMPs and LABEL instructions must also be completely within or completely outside the scope of a FOR_LOOP/END_FOR pair. Jumping into or out of the scope of a FOR/END_FOR is not allowed.

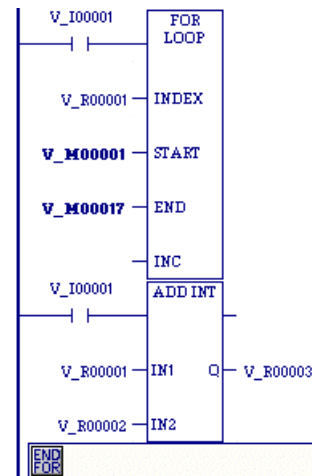
Operands

Only the FOR_LOOP function requires operands.

Parameter	Description	Allowed Operands	Optional
INDEX	The index variable. When the loop has completed, this value is undefined. Note: Changing the value of the index variable within the scope of the FOR loop is not recommended.	All except constants, flow, and variables in %S - %SC	No
START	The index start value.	All except variables in %S - %SC	No
END	The index end value.	All except variables in %S - %SC	No
INC	The increment value. (Default: 1.)	Constants	Yes

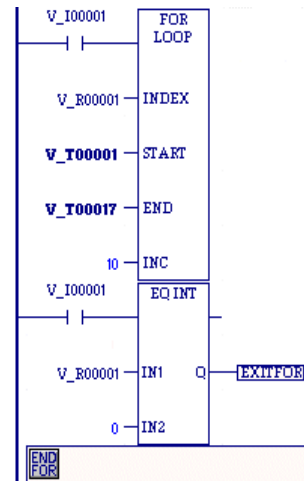
For Loop Example 1

The value for %M00001 (START) is 1 and the value for %M00017 (END) is 10. The INDEX (%R00001) increments by the value of the INC operand (which is assumed to be 1 when omitted) starting at 1 until it reaches the ending value 10. The ADD function of the loop is executed 10 times, adding the current value of I1 (%R00001), which will vary from 1 to 10, to the value of I2 (%R00002).

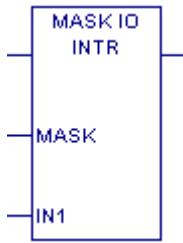


For Loop Example 2

The value for %T00001 (START) is -100 and the value for %T00017 (END) is 100. The INDEX (%R00001) increments by tens, starting at -100 until it reaches its end value of +100. The EQ function of the loop tries to execute 21 times, with the INDEX (%R00001) being equal to -100, -90, -80, -70, -60, -50, -40, -30, -20, -10, 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100. However, when the INDEX (%R00001) is 0, the EXIT statement is enabled and power flow jumps directly to the statement after the END_FOR statement.



7.5.4 Mask I/O Interrupt



Mask or unmask an interrupt from an I/O board when using I/O variables. If not using I/O variables, use SVC_REQ 17.

When the interrupt is masked, the CPU processes the interrupt but does not schedule the associated logic for execution. When the interrupt is unmasked, the CPU processes the interrupt and schedules the associated logic for execution.

When the CPU transitions from Stop to Run, the interrupt is unmasked

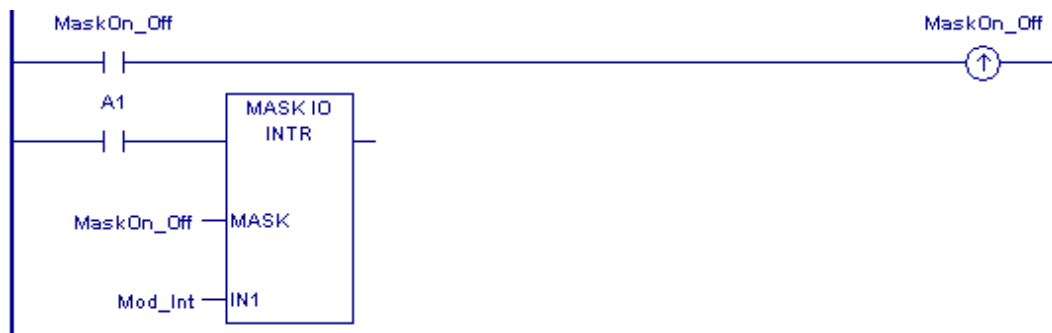
The function passes power to the right when it executes successfully.

Operands

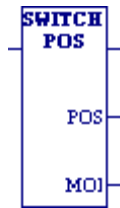
Parameter	Description	Allowed Types	Allowed Operands	Optional
MASK	Selects unmask or mask operation. Unmask=0; Mask=1	BOOL variable or Bit reference in non-discrete memory	data flow, I, Q, M, T, G, S, SA, SB, SC, R, P, L, AI, AQ, W, symbolic, I/O variable	No
IN1	The interrupt trigger to be masked or unmasked. <ul style="list-style-type: none"> ■ The I/O board must be a supported input module. ■ The reference address specified must correspond to a valid interrupt trigger reference. ■ The interrupt for the specified channel must be enabled in the configuration. 	BOOL or WORD variable	I, Q, M, T, G, R, P, L, AI, AQ, W, I/O variable	No

Example

In the following example, the variable Mod_Int is mapped to an I/O point on a hardware module and is configured as an I/O interrupt to a program block. When the BOOL variable MaskOn_Off transitions from OFF to ON and A1 is set to ON, the interrupt Mod_Int is masked (not executed) for one scan.



7.5.5 Read Switch Position

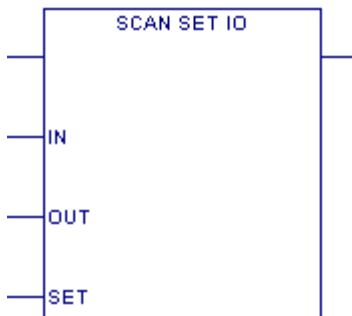


Read Switch Position (SWITCH_POS) allows the logic to read the current position of the RUN/STOP switch, as well as the mode for which the switch is configured.

Operands

Parameter	Description	Allowed Operands	Optional
POS	Memory location at which to write current switch position value. 1 - Run I/O Enabled 2 - Run Outputs Disabled 3 - Stop Mode	All except S, SA, SB, SC	No
MODE	Memory location to which switch configuration value is written. 0 - Switch configuration not supported 1 - Switch controls run/stop mode 2 - Switch not used, or is used by the user application 3 - Switch controls both memory protection and run/stop mode 4 - Switch controls memory protection	All except S, SA, SB, SC	No

7.5.6 Scan Set IO



The Scan_Set_IO function scans the I/O of a specified scan set number. (Modules can be assigned to scan sets in hardware configuration.) You can specify whether the Inputs and/or Outputs of the associated scan set will be scanned.

Execution of this function block does not affect the normal scanning process of the corresponding scan set. If the corresponding scan set is configured for non-default Number of Sweeps or Output Delay settings, they remain in effect regardless of how many executions of the Scan Set IO function occur in any given sweep.

The Scan Set IO function skips those modules that do not support DO_IO scanning (page 194).

Operands for SCAN_SET_IO

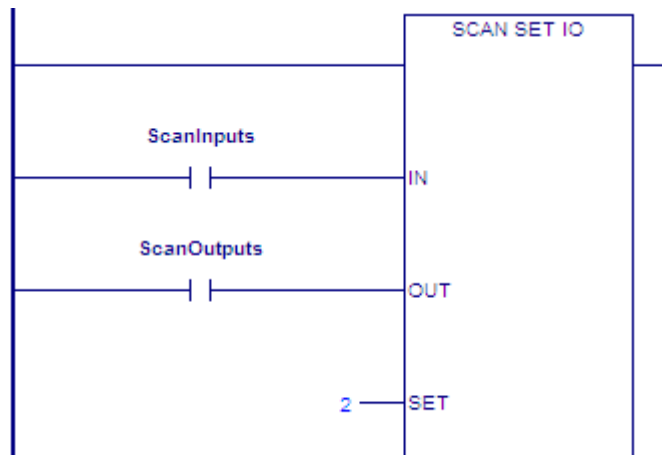
Parameter	Description	Allowed Types	Allowed Operands	Optional
IN	If true the inputs will be scanned.	BOOL variable or bit reference in a non-BOOL variable	Power flow	No
OUT	If true the outputs will be scanned.	BOOL variable or bit reference in a non-BOOL variable	Power flow	No
SET	Number of the scan set to be scanned. Scan sets are specified in the CPU hardware configuration and assigned to modules in the module hardware configuration.	UINT	All except %S memory types.	No
ENO	Energized when all arguments to the function are valid and there are no errors in scanning.	BOOL variable or bit reference in a non-BOOL variable	Power flow.	Yes

Example


By using the Scan Set IO function block in an interrupt block, you can create a custom I/O scan. For example, two Scan Set IO function blocks can be used in an interrupt block to scan the inputs of a scan set at the beginning of the block and the outputs of the same scan set at the end of the block.

In the example at right:

- When ScanInputs is ON, input data for all I/O modules assigned to Scan Set 2 is updated.
- When ScanOutputs is ON, output data for all I/O modules assigned to Scan Set 2 is updated



7.5.7 Suspend I/O

 The Suspend I/O (SUS_IO) function stops normal I/O scans from occurring for one CPU sweep. During the next output scan, all outputs are held at their current states. During the next input scan, the input references are not updated with data from inputs. However, during the input scan portion of the sweep, the CPU verifies that Genius bus controllers have completed their previous output updates.

Note: The PACSystems SUS_IO function suspends analog and discrete I/O, whether integrated I/O or Genius I/O. It does not suspend Ethernet Global Data. For details, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224.

When SUS_IO receives power flow, all I/O servicing stops except that provided by DO_IO functions.



Warning

If SUS_IO were placed at the left rail of the ladder, without enabling logic to regulate its execution, no regular I/O scan would ever be performed.

SUS_IO passes power flow to the right whenever it receives power.

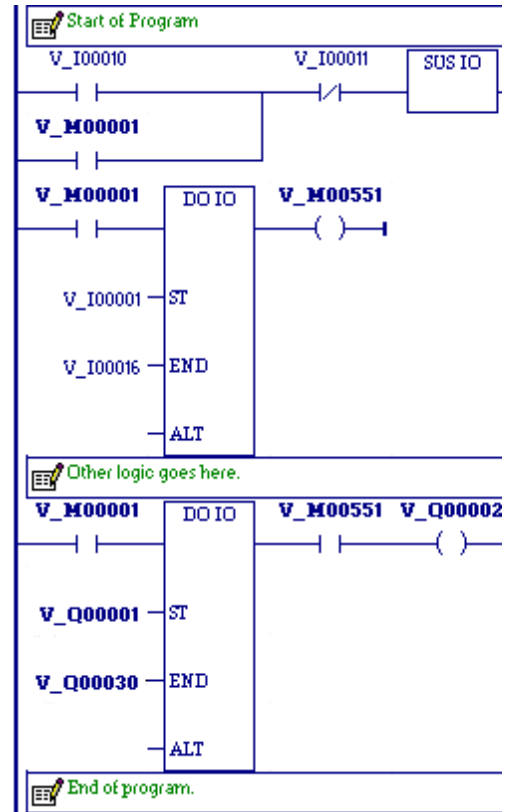
Example

The example at right shows a SUS_IO function and a DO_IO function used to stop I/O scans, then cause certain I/O to be scanned from the program.

Inputs %I00010 and %I00011 form a latch circuit with the contact from %M00001. This keeps the SUS_IO function active on each sweep until %I00011 goes on. If this input were not scanned by DO_IO after SUS_IO went active, SUS_IO could only be disabled by powering down the PLC.

Output %Q00002 is set when both DO_IO functions execute successfully. The rung is constructed so that both DO_IO functions execute even if one does not set its OK output. With normal I/O suspended, output %Q00002 is not updated until a DO_IO function with %Q00002 in its range executes. This does not occur until the sweep after the setting of %Q00002. Outputs that are set after a DO_IO function executes are not updated until another DO_IO function executes, typically in the next sweep. Because of this delay, most programs that use SUS_IO and DO_IO place the SUS_IO function in the first rung of the program, the DO_IO function that processes inputs in the next rung, and the DO_IO function that processes outputs in the last rung.

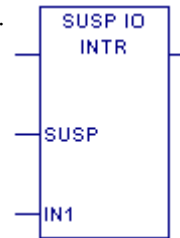
The range of the DO_IO function doing outputs is %Q00001 through %Q00030. If the module in this range were a 32-point module, the DO_IO function would actually perform a scan of the entire module. A DO_IO function will not break the scan in the middle of an I/O module.



7.5.8 Suspend or Resume I/O Interrupt

Suspend or resume an I/O interrupt when using I/O variables.

If not using I/O variables, use SVC_REQ 32.



The function executes successfully and passes power to the right unless:

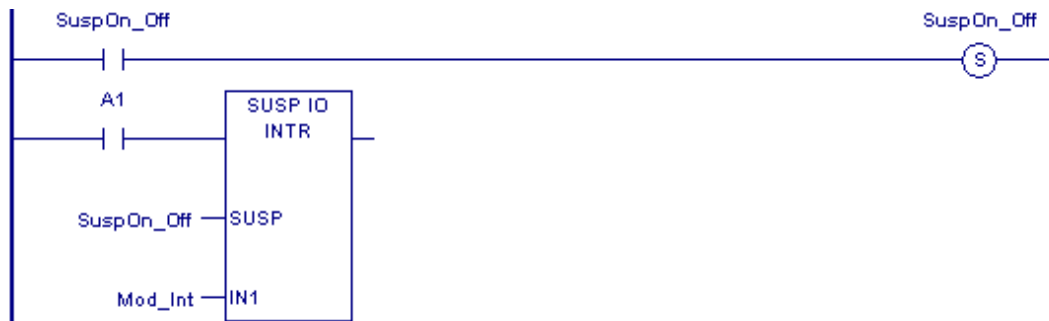
- The I/O module associated with the interrupt trigger specified in IN1 is not supported.
- The reference address specified does not correspond to a valid interrupt trigger reference.
- The specified channel does not have its interrupt enabled in the configuration.

Operands

Parameter	Description	Allowed Types	Allowed Operands	Optional
SUSP	Selects a suspend or resume operation. 1 (ON)=suspend 0 (OFF)=resume	BOOL variable or bit reference in a non-BOOL variable	data flow, I, Q, M, T, G, S, SA, SB, SC, R, P, L, discrete symbolic, I/O variable	No
IN1	The interrupt trigger to be suspended or resumed.	BOOL or WORD variable	I, Q, M, T, G, R, P, L, AI, AQ, W, I/O variable	No

Example

In the following example, the variable Mod_Int is mapped to an I/O point on a hardware module and is configured as an I/O interrupt to a program block. When the BOOL variable SuspOn_Off is set to ON and A1 is set to ON, interrupts from Mod_Int are suspended until SuspOn_Off is reset.

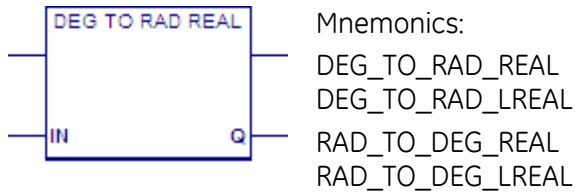


7.6. Conversion Functions

The Conversion functions change a data item from one number format (data type) to another. Many programming instructions, such as math functions, must be used with data of one type. As a result, data conversion is often required before using those instructions.

Function	Description
Convert Angles	
DEG_TO_RAD	Converts degrees to radians
RAD_TO_DEG	Converts radians to degrees
Convert to BCD4 (4-digit Binary-Coded-Decimal)	
UINT_TO_BCD4	Converts UINT (16-bit unsigned integer) to BCD4
INT_TO_BCD4	Converts INT (16-bit signed integer) to BCD4
Convert to BCD8 (8-digit Binary-Coded-Decimal)	
DINT_TO_BCD8	Converts DINT (32-bit signed integer) to BCD8
Convert to INT (16-bit signed integer)	
BCD4_TO_INT	Converts BCD4 to INT
UINT_TO_INT	Converts UINT to INT
DINT_TO_INT	Converts DINT to INT
REAL_TO_INT	Converts REAL to INT
Convert to UINT (16-bit unsigned integer)	
BCD4_TO_UINT	Converts BCD4 to UINT
INT_TO_UINT	Converts INT to UINT
DINT_TO_UINT	Converts DINT to UINT
REAL_TO_UINT	Converts REAL to UINT
Convert to DINT (32-bit signed integer)	
BCD8_TO_DINT	Converts 8-digit Binary-Coded-Decimal (BCD8) to DINT
UINT_TO_DINT	Converts UINT to DINT
INT_TO_DINT	Converts INT to DINT
REAL_TO_DINT	Converts REAL (32-bit signed real or floating-point values) to DINT
LREAL_TO_DINT	Converts REAL (64-bit signed real or floating-point values) to DINT
Convert to REAL (32-bit signed real or floating-point values)	
BCD4_TO_REAL	Converts BCD4 to REAL
BCD8_TO_REAL	Converts BCD8 to REAL
UINT_TO_REAL	Converts UINT to REAL
INT_TO_REAL	Converts INT to REAL
DINT_TO_REAL	Converts DINT to REAL
LREAL_TO_REAL	Converts LREAL to REAL
Convert to LREAL(64-bit signed real or floating-point values)	
DINT_TO_LREAL	Converts DINT to LREAL
REAL_TO_LREAL	Converts REAL to LREAL
Truncate	
TRUNC_DINT	Rounds a REAL number down to a DINT (32-bit signed integer) number
TRUNC_INT	Rounds a REAL number down to an INT (16-bit signed integer) number

7.6.1 Convert Angles



When the Degrees to Radians (DEG_TO_RAD) or the Radians to Degrees (RAD_TO_DEG) function receives power flow, it performs the appropriate angle conversion on the REAL or LREAL value in input IN and places the result in output Q.

DEG_TO_RAD and RAD_TO_DEG pass power flow to the right when they execute, unless IN is NaN (Not a Number).

Operands

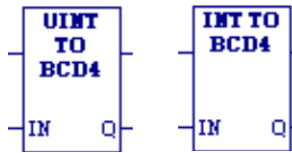
Parameter	Description	Allowed Operands	Optional
IN	The value to convert.	All except S, SA, SB, and SC	No
Q	The converted value.	All except S, SA, SB, and SC	No

Example

A value of +1500 radians is converted to degrees. The result is placed in %R00001 and %R00002.



7.6.2 Convert UINT or INT to BCD4



When this function receives power flow, it converts the input unsigned (UINT) or signed single-precision integer (INT) data into the equivalent 4-digit Binary-Coded-Decimal (BCD) values, which it outputs to Q.

This function does not change the original input data. The output data can be used directly as input for another program function.

The function passes power flow when power is received, unless the conversion would result in a value that is outside the range 0 to 9,999.

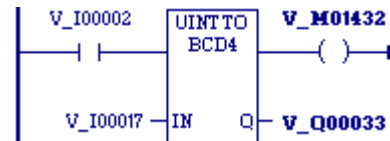
Tip: Data can be converted to BCD format to drive BCD-encoded LED displays or presets to external devices such as high-speed counters.

Operands

Parameter	Description	Allowed Operands	Optional
IN	The UINT or INT value to convert to BCD4.	All except S, SA, SB, and SC	No
Q	The BCD4 equivalent value of the original UINT or INT value in IN.	All except S, SA, SB, and SC	No

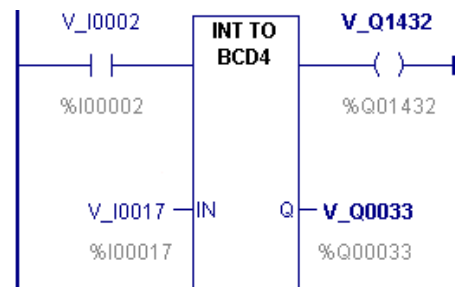
Example - UINT to BCD4

Whenever input %I0002 is set and no errors exist, the UINT at input location %I00017 through %I00032 is converted to four BCD digits and the result is stored in memory locations %Q00033 through %Q00048. Coil %M01432 is used to check for successful conversion.



Example - INT to BCD4

Whenever input %I0002 is set and no errors exist, the INT values at input locations %I0017 through %I0032 are converted to four BCD digits, and the result is stored in memory locations %Q0033 through %Q0048. Coil %Q1432 is used to check for successful conversion.



7.6.3 Convert DINT to BCD8



When DINT_TO_BCD8 receives power flow, it converts the input signed double-precision integer (DINT) data into the equivalent 8-digit Binary-Coded-Decimal (BCD) values, which it outputs to Q. DINT_TO_BCD8 does not change the original DINT data.

Note: The output data can be used directly as input for another program function.

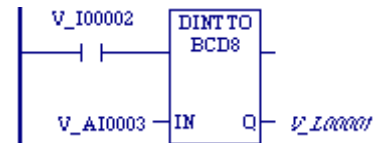
The function passes power flow when power is received, unless the conversion would result in a value that is outside the range 0 to 99,999,999.

Operands

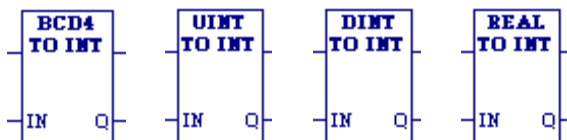
Parameter	Description	Allowed Operands	Optional
IN	The DINT value to convert to BCD8	All except S, SA, SB, and SC	No
Q	The BCD8 equivalent value of the original DINT value in IN	All except S, SA, SB, and SC	No

Example

Whenever input %I00002 is set and no errors exist, the double-precision signed integer (DINT) at input location %AI0003 is converted to eight BCD digits and the result is stored in memory locations %L00001 through %L00002.



7.6.4 Convert BCD4, UINT, DINT, or REAL to INT



BCD4, UINT, and DINT

When this function receives power flow, it converts the input data into the equivalent single-precision signed integer (INT) value, which it outputs to Q. This function does not change the original input data. The output data can be used directly as input for another program function, as in the examples. The function passes power flow when power is received, unless the data is out of range.

REAL

When REAL_TO_INT receives power flow, it rounds the input REAL data up or down to the nearest single-precision signed integer (INT) value, which it outputs to Q. REAL_TO_INT does not change the original REAL data.

Note: The output data can be used directly as input for another program function.

The function passes power flow when power is received, unless the data is out of range or NaN (Not a Number).



Warning

Converting from REAL to INT may result in overflow. For example, REAL 7.4E15, which equals 7.4×10^{15} , converts to INT OVERFLOW.

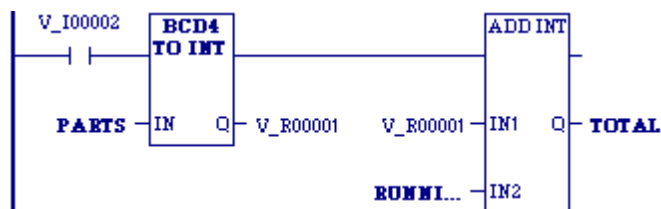
Tip: To truncate a REAL value and express the result as an INT, i.e., to remove the fractional part of the REAL number and express the remaining integer value as an INT, use TRUNC_INT.

Operands

Parameter	Description	Allowed Operands	Optional
IN	The value to convert to INT.	All except S, SA, SB, and SC	No
Q	The INT equivalent value of the original value in IN.	All except S, SA, SB, and SC	No

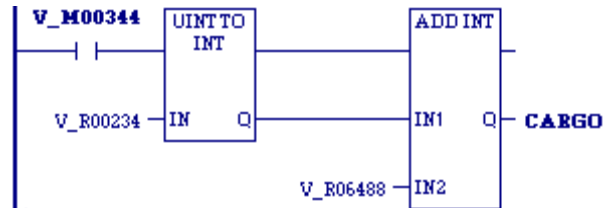
Example: BCD4 to INT

Whenever input %I0002 is set, the BCD-4 value in PARTS is converted to a signed integer (INT) and passed to the ADD_INT function, where it is added to the INT value represented by the reference RUNNING. The sum is output by ADD_INT to the reference TOTAL.



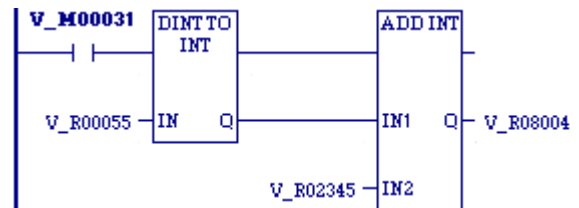
Example: UINT to INT

Whenever input %M00344 is set, the UINT value in %R00234 is converted to a signed integer (INT) and passed to the ADD function, where it is added to the INT value in %R06488. The sum is output by the ADD function to the reference CARGO.

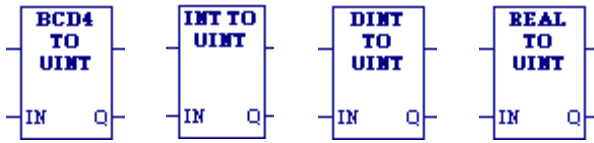


Example: DINT to INT

Whenever input %M00031 is set, the DINT value in %R00055 is converted to a signed integer (INT) and passed to the ADD function, where it is added to the INT at %R02345. The sum is output by the ADD function to %R08004.



7.6.5 Convert BCD4, INT, DINT, or REAL to UINT



When this function receives power flow, it converts the input data into the equivalent single-precision unsigned integer (UINT) value, which it outputs to Q.

The conversion to UINT does not change the original data. The output data can be used directly as input for another program function, as in the example.

The function passes power flow when power is received, unless the resulting data is outside the range 0 to +65,535.



Warning

Converting from REAL to UINT may result in overflow. For example, REAL 7.2E17, which equals 7.2×10^{17} , converts to UINT OVERFLOW.

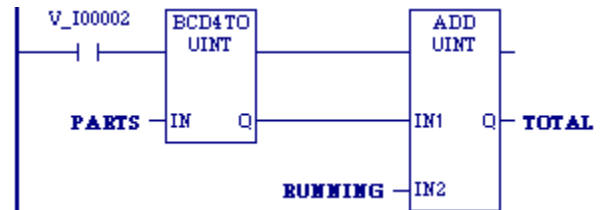
Operands

Parameter	Description	Allowed Operands	Optional
IN	The value to convert to UINT.	All except S, SA, SB, and SC	No
Q	The UINT equivalent value of the original input value in IN.	All except S, SA, SB, and SC	No

Example: BCD4 to UINT

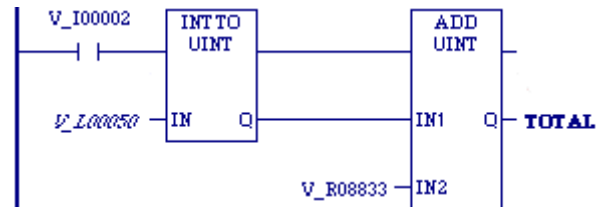
Tip: One use of BCD4_TO_UINT is to convert BCD data from the I/O structure into integer data and store it in memory. This can provide an interface to BCD thumbwheels or external BCD electronics, such as high-speed counters and position encoders.

In the example at right, whenever input %I0002 is set, the BCD4 value in PARTS is converted to an unsigned single-precision integer (UINT) and passed to the ADD_UINT function, where it is added to the UINT value represented by the reference RUNNING. The sum is output by ADD_UINT to the reference TOTAL.



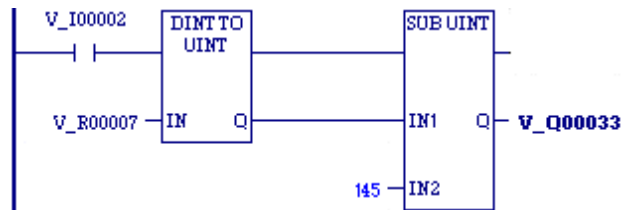
Example: INT to UINT

Whenever input %I0002 is set, the INT value in %L00050 is converted to an unsigned single-precision integer (UINT) and passed to the ADD_UINT function, where it is added to the UINT value in %R08833. The sum is output by ADD_UINT to the reference TOTAL.

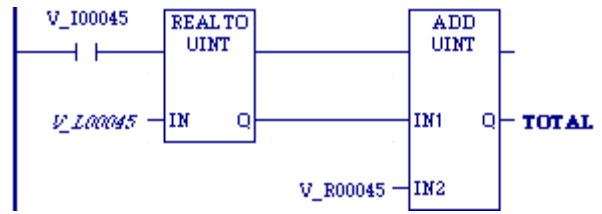


Example: DINT to UINT

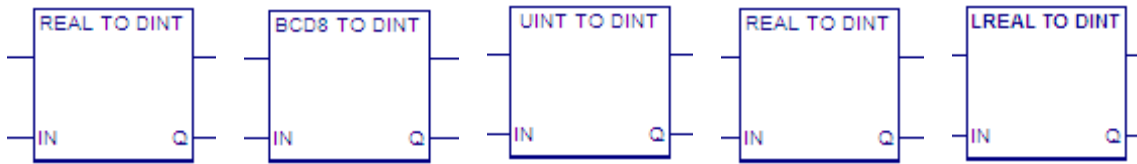
Whenever input %I00002 is set and no errors exist, the double precision signed integer (DINT) at input location %R00007 is converted to an unsigned integer (UINT) and passed to the SUB function, where the constant value 145 is subtracted from it. The result of the subtraction is stored in the output reference location %Q00033.

**Example: REAL to UINT**

Whenever input %I00045 is set, the REAL value in %L00045 is converted to an unsigned single-precision integer (UINT) and passed to the ADD_UINT function, where it is added to the UINT value in %R00045. The sum is output by ADD_UINT to the reference TOTAL.



7.6.6 Convert BCD8, UINT, INT, REAL or LREAL to DINT



BCD8, UINT, and INT

When this function receives power flow, it converts the data into the equivalent signed double-precision integer (DINT) value, which it outputs to Q. The conversion to DINT does not change the original data.

The output data can be used directly as input for another program function. The function passes power flow when power is received, unless the data is out of range.

REAL and LREAL

When REAL_TO_DINT or LREAL_TO_DINT receives power flow, it rounds the input data to the nearest double-precision signed integer (DINT) value, which it outputs to Q. These functions do not change the original REAL or LREAL data.

The output data can be used directly as input for another program function. The function passes power flow when power is received, unless the conversion would result in an out-of-range DINT value.



Warning

Converting from LREAL or REAL to DINT may result in overflow. For example, REAL 5.7E20, which equals 5.7×10^{20} , converts to DINT OVERFLOW.

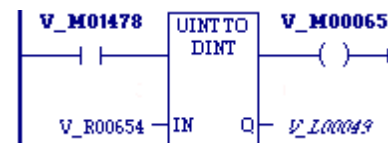
Tip: To truncate a REAL value and express the result as a DINT, i.e., to remove the fractional part of the REAL number and express the remaining integer value as a DINT, use TRUNC_DINT.

Operands

Parameter	Description	Allowed Operands	Optional
IN	The value to convert to DINT.	All except S, SA, SB, and SC	No
Q	The DINT equivalent value of the original input value in IN.	All except S, SA, SB, and SC	No

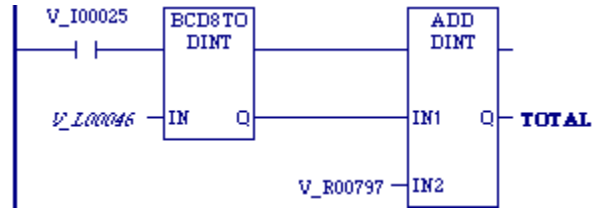
Example: UINT to DINT

Whenever input %M01478 is set, the unsigned single-precision integer (UINT) value at input location %R00654 is converted to a double-precision signed integer (DINT) and the result is placed in location %L00049. The output %M00065 is set whenever the function executes successfully.



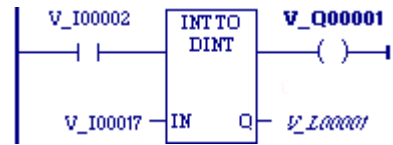
Example: BCD8 to DINT

Whenever input %I00025 is set, the BCD-8 value in %L00046 is converted to a signed double-precision integer (DINT) and passed to the ADD_DINT function, where it is added to the DINT value in %R00797. The sum is output by ADD_DINT to the reference TOTAL.



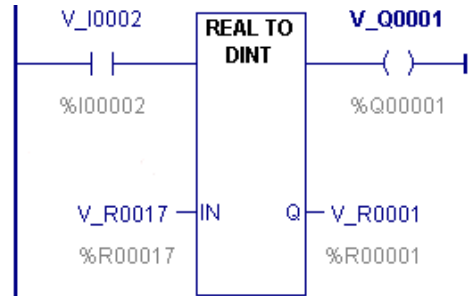
Example: INT to DINT

Whenever input %I00002 is set, the signed single-precision integer (INT) value at input location %I00017 is converted to a double-precision signed integer (DINT) and the result is placed in location %L00001. The output %Q01001 is set whenever the function executes successfully.

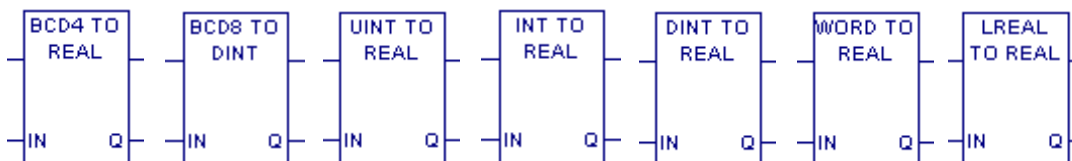


Example: REAL to DINT

Whenever input %I0002 is set, the REAL value at input location %R0017 is converted to a double precision signed integer (DINT) and the result is placed in location %R0001. The output %Q1001 is set whenever the function executes successfully.



7.6.7 Convert BCD4, BCD8, UINT, INT, DINT, and LREAL to REAL



When this function receives power flow, it converts the input data into the equivalent 32-bit floating-point (REAL) value, which it outputs to Q. The conversion to REAL does not change the original input data.

The output data can be used directly as input for another program function.

The function passes power flow when power is received, unless the conversion would result in a value that is out of range.



Warning

Converting from BCD8 to REAL may result in the loss of significant digits.

This is because a BCD8 value is stored in a DWORD, which uses 32 bits to store a value, whereas a REAL (32-bit IEEE floating point number) uses 8 bits to store the exponent and the sign and only 24 bits to store the mantissa.



Warning

Converting from DINT to REAL may result in the loss of significant digits for numbers with more than 7 significant base-10 digits.

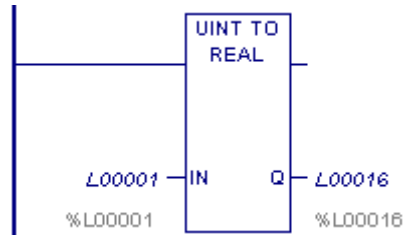
This is because a DINT value uses 32 bits to store a value, which is the equivalent of up to 10 significant base-10 digits, whereas a REAL (32-bit IEEE floating point number) uses 8 bits to store the exponent and the sign and only 24 bits to store the mantissa, which is the equivalent of 7 or 8 significant base-10 digits. When the REAL result is displayed as a base-10 number, it may have up to 10 digits, but these are converted from the rounded 24-bit mantissa, so that the last 2 or 3 digits may be inaccurate.

Operands

Parameter	Description	Allowed Operands	Optional
IN	The value to convert to REAL.	All except S, SA, SB, and SC	No
Q	The REAL equivalent value of the original input value in IN.	All except S, SA, SB, and SC	No

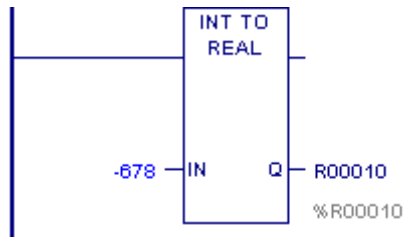
Example: UINT to REAL

The unsigned integer value in %L00001 is 825. The value placed in %L00016 is 825.000.



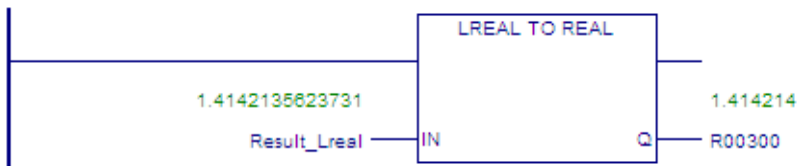
Example: INT to REAL

The integer value of input IN is -678. The value placed in %R00010 is -678.000.

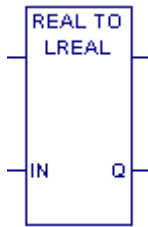


Example: LREAL to REAL

The double-precision floating point value of the square root of 2 is rounded to the nearest single-precision floating point value and placed in R00300.



7.6.8 Convert REAL to LREAL



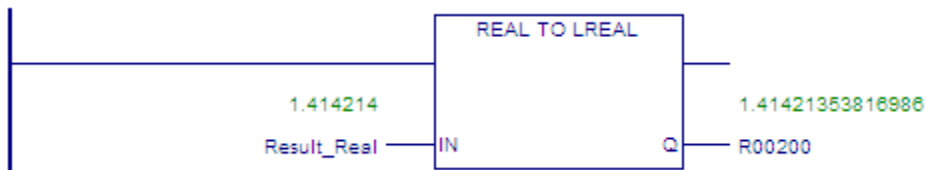
When REAL_TO_LREAL receives power flow, it converts the 32-bit single precision floating point REAL data to the equivalent 64-bit double-precision floating point data. REAL_TO_LREAL does not change the original REAL data.

Operands

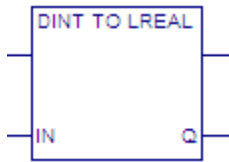
Parameter	Description	Allowed Operands	Optional
IN	The REAL value to convert to LREAL.	All except S, SA, SB, and SC	No
Q	The LREAL equivalent value of the original REAL value.	All except S, SA, SB, and SC	No

Example

The REAL value of the square root of 2 is converted to the LREAL data type and placed in R00200. Because the actual precision of the data in Result_Real is seven decimal places, the additional decimal places in the data in R00200 are not valid.

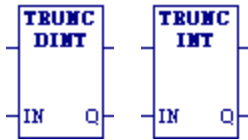


7.6.9 Convert DINT to LREAL



When DINT_TO_LREAL receives power flow, it converts the double-precision input data to 64-bit double-precision floating point data.

7.6.10 Truncate



When power is received, the Truncate functions TRUNC_DINT and TRUNC_INT round a floating-point (REAL) value down respectively to the nearest signed double-precision signed integer (DINT) or signed single-precision integer (INT) value. TRUNC_DINT and TRUNC_INT output the converted value to Q. The original data is not changed.

Note: The output data can be used directly as input for another program function.

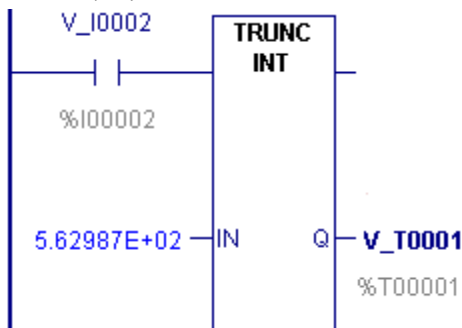
TRUNC_DINT and TRUNC_INT pass power flow when power is received, unless the specified conversion would result in a value that is out of range or unless IN is NaN (Not a Number).

Operands

Parameter	Description	Allowed Operands	Optional
IN	The REAL value whose copy is to be converted and truncated. The original is left intact.	All except S, SA, SB, and SC	No
Q	The truncated value of the original REAL value in IN.	All except S, SA, SB, and SC	No

Example

The displayed constant is truncated and the integer result 562 is placed in %T0001.



7.7. Counters

Function	Mnemonic	Description
Down Counter	DNCTR	Counts down from a preset value. The output is ON whenever the Current Value is ≤ 0 .
Up Counter	UPCTR	Counts up to a designated value. The output is ON whenever the Current Value is \geq the Preset Value.

7.7.1 Data Required for Counter Function Blocks



Warning

Do not use two consecutive words (registers) as the starting addresses of two counters. Logic Developer - PLC does not check or warn you if register blocks overlap. Timers will not work if you place the current value of a second timer on top of the preset value for the previous timer.

Each counter uses a one-dimensional, three-word array of %R, %W, %P, %L, or symbolic memory to store the following information:

Current value (CV) Word 1



Warning

The first word (CV) can be read but should not be written to, or the function may not work properly.

Preset value (PV) Word 2 When the Preset Value (PV) operand is a variable, it is normally set to a different location than word 2 in the timer's or counter's three-word array.

- If you use a different address and you change word 2 directly, your change will have no effect, as PV will overwrite word 2.
- If you use the same address for the PV operand and word 2, you can change the Preset Value in word 2 while the timer or counter is running and the change will be effective.

Control word Word 3

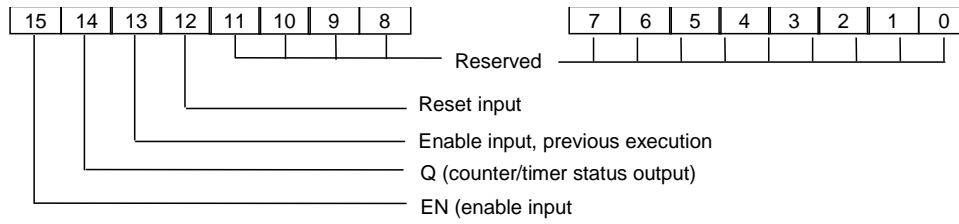
The control word stores the state of the Boolean inputs and outputs of its associated timer or counter, as shown in the following diagram:



Warning

The third word (Control) can be read but should not be written to; otherwise, the function will not work.

Word 3: Control Word Structure



Note: Bits 0 through 13 are not used for counters.

7.7.2 Down Counter



The Down Counter (DNCTR) function counts down from a preset value. The minimum Preset Value (PV) is zero; the maximum PV is +32,767 counts. When the Current Value (CV) reaches the minimum value, -32,768, it stays there until reset. When DNCTR is reset, CV is set to PV. When the power flow input transitions from OFF to ON, CV is decremented by one. The output is ON whenever $CV \leq 0$.

The output state of DNCTR is retentive on power failure; no automatic initialization occurs at power-up.



Warning

Do not use the Address of the down counter with other instructions. Overlapping references cause erratic counter operation.

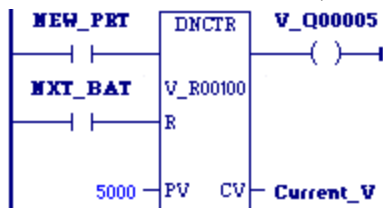
Note: For DNCTR to function properly, you must provide an initial reset to set the CV to the value in PV. If DNCTR is not initially reset, CV will decrement from 0 and the output of DNCTR will be set to ON immediately.

Operands

Parameter	Description	Allowed Operands	Optional
Address (????)	The beginning address of a three-word WORD array: Word 1: Current Value (CV) Word 2: Preset Value (PV)% Word 3: Control word	R, W, P, L, symbolic	No
R	When R receives power flow, it resets the counter's CV to PV.	Power flow	No
PV	Preset Value to copy into word 2 of the counter's address when the counter is enabled or reset. $0 \leq PV \leq 32,767$. If PV is out of range, word 2 cannot be reset.	All except S, SA, SB, SC	No
CV	The current value of the counter	All except S, SA, SB, SC and constant	No

Example – Down Counter

DNCTR counts 5000 new parts before energizing output %Q00005.



7.7.3 Up Counter

UPCTR The Up Counter (UPCTR) function counts up to the Preset Value (PV). The range is 0 to +32,767 counts. When the Current Value (CV) of the counter reaches 32,767, it remains there until reset. When the UPCTR reset is ON, CV resets to 0. Each time the power flow input transitions from OFF to ON, CV increments by 1. CV can be incremented past the Preset Value (PV). The output is ON whenever $CV \geq PV$. The output (Q) stays ON until the R input receives power flow to reset CV to zero.

The state of UPCTR is retentive on power failure; no automatic initialization occurs at power-up.



Warning

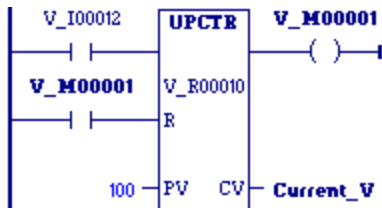
Do not use the Address of the up counter with other instructions. Overlapping references cause erratic counter operation.

Operands

Parameter	Description	Allowed Operands	Optional
Address (????)	The beginning address of a three-word WORD array: Word 1: Current Value (CV) Word 2: Preset Value (PV) Word 3: Control word	R, W, P, L, symbolic	No
R	When R is ON, it resets the counter's CV to 0.	Power flow	No
PV	Preset Value to copy into word 2 of the counter's address when the counter is enabled or reset. $0 \leq PV \leq 32,767$. If PV is out of range, it does not affect word 2.	All except S, SA, SB, and SC	No
CV	The current value of the counter	All except S, SA, SB, SC and constant	No

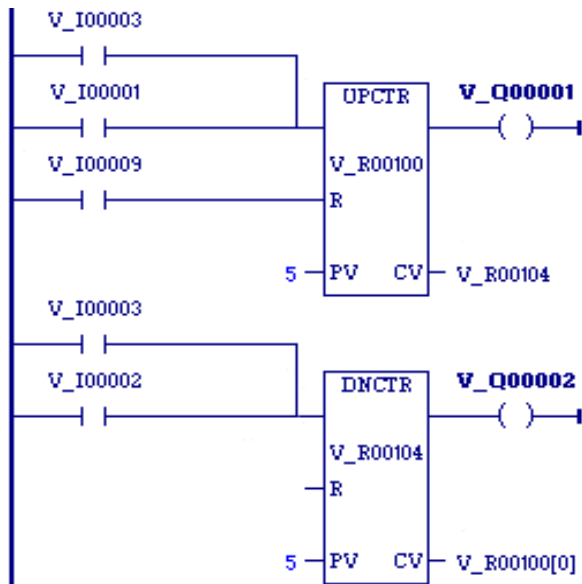
Example – Up Counter

Every time input %I0012 transitions from OFF to ON, the Up Counter counts up by 1; internal coil %M0001 is energized whenever 100 parts have been counted. Whenever %M0001 is ON, the accumulated count is reset to zero.



Example – Up Counter and Down Counter

This example uses an up/down counter pair with a shared register for the accumulated or current value. When the parts enter the storage area, the up counter increments by 1, increasing the current value of the parts in storage by a value of 1. When a part leaves the storage area, the down counter decrements by 1, decreasing the inventory storage value by 1. To avoid conflict with the shared register, both counters use different register addresses but each has a current value (CV) address that is the same as the accumulated value for the other register.



7.8. Data Move Functions

The Data Move functions provide basic data move capabilities.

Function	Mnemonics	Description
Array Size	ARRAY_SIZE	Counts the number of elements in an array.
Array Size Dimension 1	ARRAY_SIZE_DIM1	Returns the value of the Array Dimension 1 property of a one- or two-dimensional array.
Array Size Dimension 2	ARRAY_SIZE_DIM2	Returns the value of the Array Dimension 2 property of a two-dimensional array.
Block Clear	BLK_CLR_WORD	Replaces all the contents of a block of data with zeroes. Can be used to clear an area of WORD or analog memory.
Block Move	BLKMOV_DINT BLKMOV_DWORD BLKMOV_INT BLKMOV_REAL BLKMOV_UINT BLKMOV_WORD	Copies a block of seven constants to a specified memory location. The constants are input as part of the function.
Bus Read	BUS_RD_BYTE BUS_RD_DWORD BUS_RD_WORD	Reads data from a module on the bus.
Bus Read Modify Write	BUS_RMW_BYTE BUS_RMW_DWORD BUS_RMW_WORD	Uses a read/modify/write cycle to update a data element in a module on the bus.
Bus Test and Set	BUS_TS_BYTE BUS_TS_WORD	Handles semaphores on the bus.
Bus Write	BUS_WRT_BYTE BUS_WRT_DWORD BUS_WRT_WORD	Writes data to a module on the bus.
Communication Request	COMMREQ	Allows the program to communicate with an intelligent module, such as a Genius Bus Controller or a High Speed Counter.
Data Initialization	DATA_INIT_DINT DATA_INIT_DWORD DATA_INIT_INT DATA_INIT_REAL DATA_INIT_LREAL DATA_INIT_UINT DATA_INIT_WORD	Copies a block of constant data to a reference range. The mnemonic specifies the data type.
Data Initialize ASCII	DATA_INIT_ASCII	Copies a block of constant ASCII text to a reference range.
Data Initialize DLAN	DATA_INIT_DLAN	Used with a DLAN Interface module.
Data Initialize Communications Request	DATA_INIT_COMM	Initializes a COMMREQ function with a block of constant data. The length should equal the size of the COMMREQ function's entire command block.

Function	Mnemonics	Description
Move	MOVE_BOOL MOVE_DATA MOVE_DINT MOVE_DWORD MOVE_INT MOVE_REAL MOVE_LREAL MOVE_UINT MOVE_WORD	Copies data as individual bits, so the new location does not have to be the same data type. Data can be moved into a different data type without prior conversion.
Move Data Explicit	MOVE_DATA_EX	Provides an input that allows for data coherency by locking symbolic memory being written to during the copy operation.
Move from Flat	MOVE_FROM_FLAT	Copies reference memory data to a UDT variable or UDT array. Provides the option of locking the symbolic or I/O variable memory area being written to during the copy operation.
Move to Flat	MOVE_TO_FLAT	Copies data from symbolic or I/O variable memory to reference memory. Copies across mismatching data types.
Shift Register	SHFR_BIT SHFR_DWORD SHFR_WORD	Shifts one or more data bits, data WORDs or data DWORDs from a reference location into a specified area of memory. Data already in the area is shifted out.
Size Of	SIZE_OF	Counts the number of bits used by a variable.
Swap	SWAP_DWORD SWAP_WORD	Swaps two BYTES of data within a WORD or two WORDs within a DWORD.

7.8.1 Array Size



Counts the number of elements in the array assigned to input IN and writes the number to output Q.

In an array of structure variables, the number of structure variables is written to Q; the elements in the structure variables are not counted.

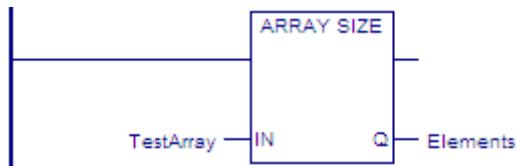
Tip: If the array assigned to input IN of ARRAY_SIZE is passed to a parameterized C block for processing, also pass the value of output Q to the block. In the C block logic, use the value of output Q to ensure all array elements are processed without exceeding the end of the array. For a two-dimensional array, this method works only if all elements are treated identically; for example, all are initialized to the same value.

Operands

Parameter	Description	Allowed Operands	Optional
IN	Array of any data type whose elements are counted. If a non-array variable is assigned to IN, the value of Q is 1.	Data flow, I, Q, M, T, S, SA, SB, SC, G, discrete symbolic, I/O variable	No
Q	Number of elements in the array assigned to input IN.	DINT or DWORD variable. Data flow, I, Q, M, T, G, R, P, L, AI, AQ, W, symbolic, I/O variable	No

Example

The two-dimensional array TestArray has its Array Dimension 1 property set to 4 and its Array Dimension 2 property set to 3. ARRAY_SIZE calculates 4×3 and writes the value 12 to the variable Elements.



7.8.2 Array Size Dimension Function Blocks

Array Size Dimension 1



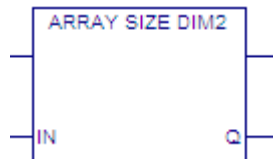
Returns the value of the Array Dimension 1 property of an array and writes the value to output Q. If a non-array variable is assigned to IN, the value of Q is 0.

In an LD or ST block that is not a parameterized block or a User Defined Function Block (UDFB), you can use the output Q value to ensure that a loop using a variable index to access array elements does not exceed the array's first dimension.

Operands

Parameter	Description	Allowed Operands	Optional
IN	Array of any data type.	Data flow, I, Q, M, T, S, SA, SB, SC, G, discrete symbolic, I/O variable	No
Q	The value of the Array Dimension 1 property of the array assigned to input IN. The value is set to 0 if a non-array is assigned to IN. Note: Because the index of the first element of an array is zero, the index of the last element is one less than the value assigned to Q.	DINT or DWORD variable. Data flow, I, Q, M, T, G, R, P, L, AI, AQ, W, symbolic, I/O variable	No

Array Size Dimension 2



Returns the value of the Array Dimension 2 property of an array and writes the value to output Q. If a non-array variable is assigned to IN, the value of Q is 0.

In an LD or ST block that is not a parameterized block or a User Defined Function Block (UDFB), you can use the output Q value to ensure that a loop using a variable index to access array elements does not exceed the array's second dimension.

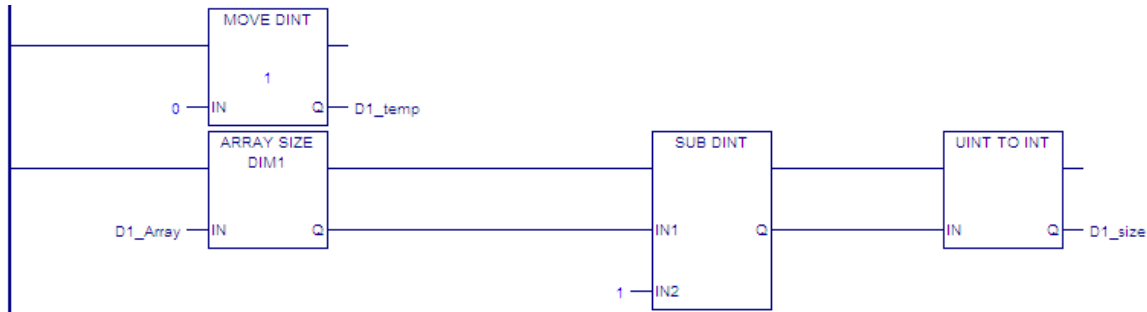
Operands

Parameter	Description	Allowed Operands	Optional
IN	Array of any data type.	Data flow, I, Q, M, T, S, SA, SB, SC, G, discrete symbolic, I/O variable	No
Q	The value of the Array Dimension 2 property of the array assigned to input IN. The value is set to 0 if a non-array is assigned to IN. Note: Because the index of the first element of an array is zero, the index of the last element is one less than the value assigned to Q.	DINT or DWORD variable. Data flow, I, Q, M, T, G, R, P, L, AI, AQ, W, symbolic, I/O variable	No

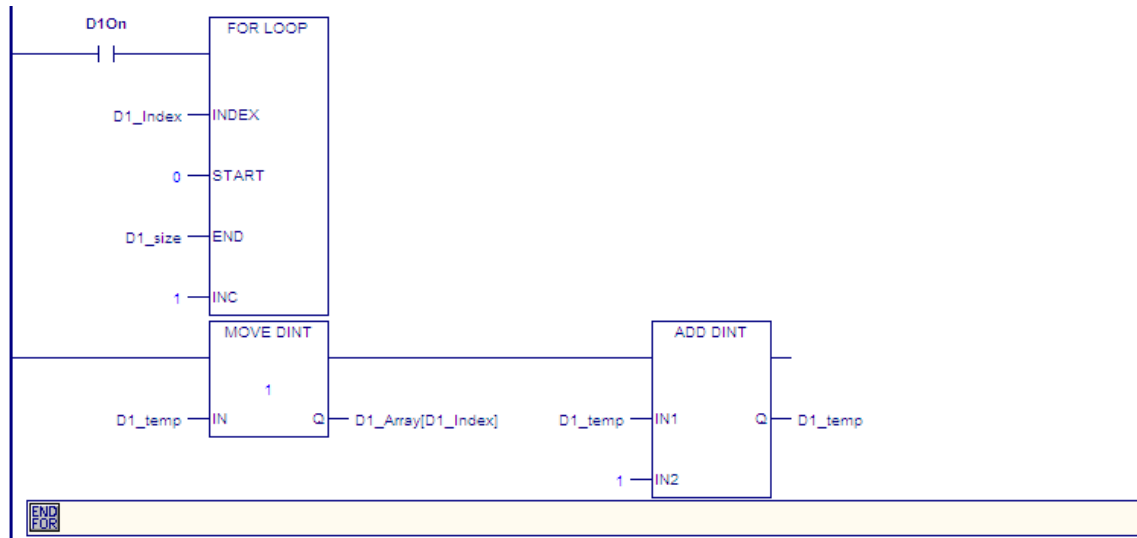
Example - FOR_LOOP that Iterates Through Dimension 1 of an Array

To use a FOR_LOOP to access array elements by means of a variable index, you must ensure that the FOR_LOOP does not iterate beyond the last element of the array.

In the following logic, MOVE_DINT initializes the variable D1_temp to 0. ARRAY_SIZE_DIM1 counts the number of elements of a one-dimensional array named D1_Array and outputs the result to output Q. Because the index of the first element of an array is zero, the loop must iterate (Q - 1) times. SUB_DINT performs the subtraction and the result is converted to an INT value and assigned to variable D1_size.



In the following rungs, the FOR_LOOP executes when D1On is set to On. The variable index D1_Index increments by 1 from 0 through D1_size, the value calculated by ARRAY_SIZE_DIM1 and SUB_DINT. In each loop, the value of D1_temp is assigned to the element D1_Array[D1_Index] and D1_temp is increased by 1.



You can use a FOR_LOOP to iterate through an array's second dimension in a method similar to this example. You can also use nested FOR_LOOPS to ensure that operations on elements using two variable indexes each do not exceed their array dimension. For additional examples, refer to the online help.

7.8.3 Block Clear



When the Block Clear (BLKCLR_WORD) function receives power flow, it fills the specified block of data with zeroes, beginning at the reference specified by IN. When the data to be cleared is from BOOL (discrete) memory (%I, %Q, %M, %G, or %T), the transition information associated with the references is updated. BLKCLR_WORD passes power to the right whenever it receives power.

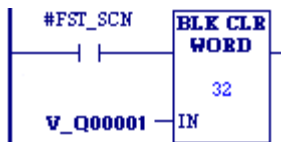
Note: The input parameter IN is not included in coil checking.

Operands

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of words to clear, starting at the IN location. $1 \leq \text{Length} \leq 256$ words.	Constant	No
IN	The first WORD of the memory block to clear to 0.	All except %S and data flow.	No

Example

At power-up, 32 words of %Q memory (512 points) beginning at %Q0001 are filled with zeroes. The transition information associated with these references will also be updated.



7.8.4 Block Move



When the Block Move (BLKMOV) function receives power flow, it copies a block of seven constants into consecutive locations beginning at the destination specified in output Q. BLKMOV passes power to the right whenever it receives power.

Mnemonics:
 BLKMOV_DINT
 BLKMOV_DWORD
 BLKMOV_INT
 BLKMOV_REAL
 BLKMOV_UINT
 BLKMOV_WORD

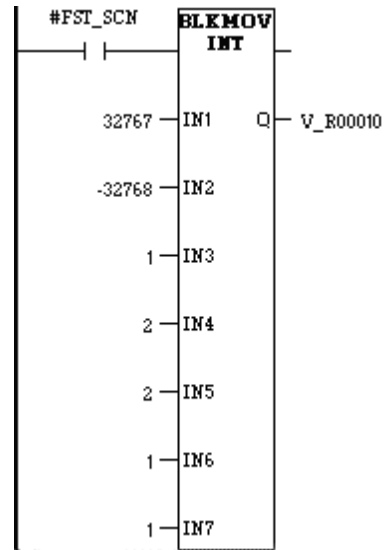
Operands

Note: For each mnemonic, use the corresponding data type for the Q operand. For example, BLKMOV_DINT requires Q to be a DINT variable.

Parameter	Description	Allowed Operands	Optional
IN1 to IN7	The seven constant values to move.	Constants. Constant type must match function type.	No
Q	The first memory location of the destination for the moved values. IN1 is moved to Q.	All except %S. %SA, SB, SC are also prohibited on BLKMOV_REAL, BLK_MOV_INT, and BLK_MOV_UINT.	No

Example

When the enabling input represented by the name #FST_SCN is ON, BLKMOV_INT copies the seven input constants into memory locations %R0010 through %R0016.



7.8.5 BUS_Functions

Four program functions allow the PACSystems CPU to communicate with modules in the system.

- Bus Read (BUS_RD)
- Bus Write (BUS_WRT)
- Bus Read/Modify/Write (BUS_RMW)
- Bus Test and Set (BUS_TS)

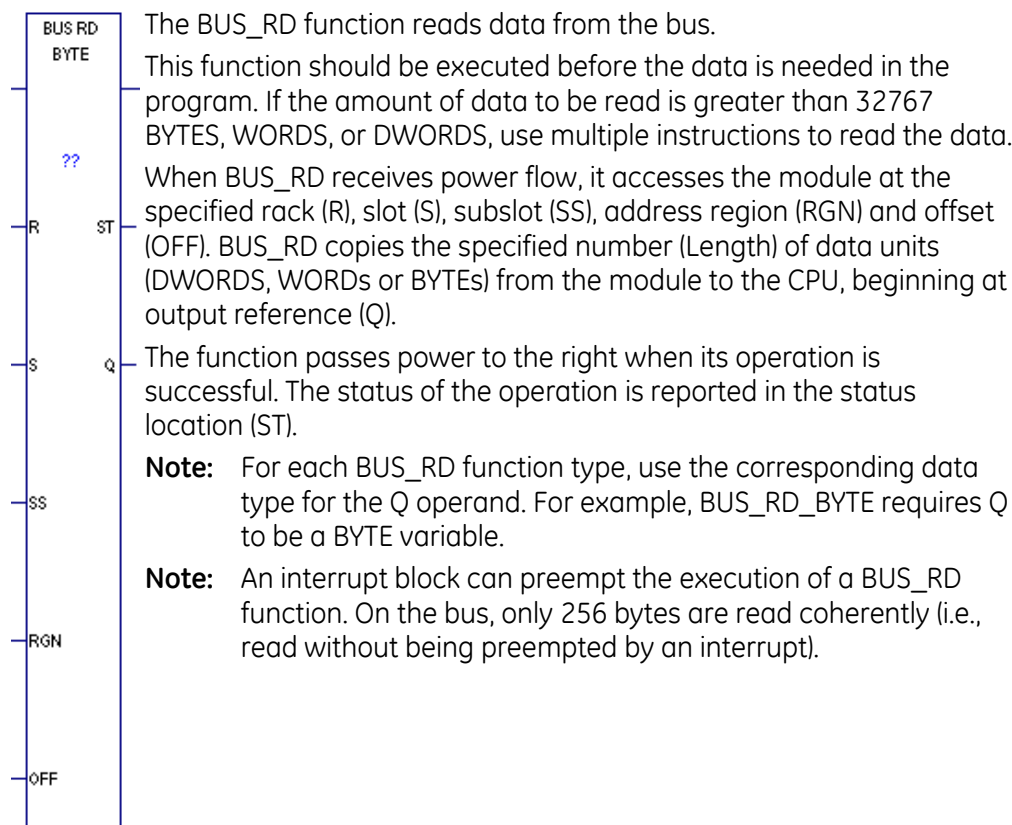
These functions use the same parameters to specify which module on the bus will exchange data with the CPU.

Note: Additional information related to addressing modules is required to use the BUS_ functions. For open VME modules in an RX7i system, refer to the *PACSystems RX7i User's Guide to Integration of VME Modules*, GFK-2235. For other modules, refer to the product documentation provided by the manufacturer.

Rack, Slot, Subslot, Region, and Offset Parameters

The rack and slot parameters refer to a module in the hardware configuration. The region parameter refers to a memory region configured for that module. The sub-slot is ordinarily set to 0. The offset is a 0-based number that the function adds to the module's base address (which is part of the memory region configuration) to compute the address to be read or written.

BUS Read



Mnemonics:
 BUS_RD_DINT
 BUS_RD_DWORD
 BUS_RD_WORD

Operands for BUS READ

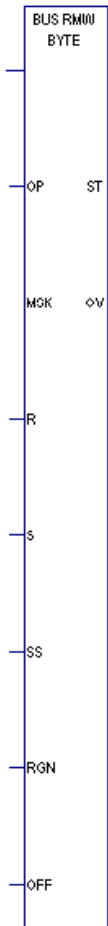
Parameter	Description	Allowed Operands	Optional
Length (??)	The number of BYTES, DWORDs, or WORDs. 1 to 32,767.	Constant	No
R	Rack number. UINT constant or variable.	All except %S—%SC	No
S	Slot number. UINT constant or variable.	All except %S—%SC	No
SS	Subslot number (defaults to 0). UINT constant or variable.	All except %S—%SC	Yes
RGN	Region (defaults to 1). WORD constant or variable.	All except %S—%SC	Yes
OFF	The offset in bytes. DWORD constant or variable.	All except %S—%SC	No
ST	The status of the operation. WORD variable.	All except variables located in %S—%SC, and constants	Yes
Q	Reference for data read from the module. DWORD variable.	All except variables located in %S—%SC, and constants	No

BUS_RD Status in the ST Output

The BUS_RD function returns one of the following values to the ST output:

0	Operation successful.
1	Bus error
2	Module does not exist at rack/slot location.
3	Module at rack/slot location is an invalid type.
4	Start address outside the configured range.
5	End address outside the configured address range.
6	Absolute address even but interface configured as odd byte only
8	Region not enabled
10	Function parameter invalid.

BUS Read Modify Write



The BUS_RMW function updates one byte, word, or double word of data on the bus. This function locks the bus while performing the read-modify-write operation.

Other mnemonic:
BUS_RMW_WORD

When the BUS_RMW function receives power flow through its enable input, the function reads a dword, word or byte of data from the module at the specified rack (R), slot (S), subslot (SS) and optional address region (RGN) and offset (OFF). The original value is stored in parameter (OV).

The function combines the data with the data mask (MSK). The operation performed (AND / OR) is selected with the OP parameter. The mask value is dword data. When operating on a word of data, only the lower 16 bits are used. When operating on a byte of data, only the lower 8 bits of the mask data are used. The result is then written back to the same address from which it was read.

The BUS_RMW function passes power to the right when its operation is successful, and returns a status value to the ST output.

Operands for BUS_RMW

For BUS_RMW_WORD, the absolute bus address must be a multiple of 2. For BUS_RMW_DWORD, it must be a multiple of 4.

The absolute bus address is equal to the base address plus the offset value.

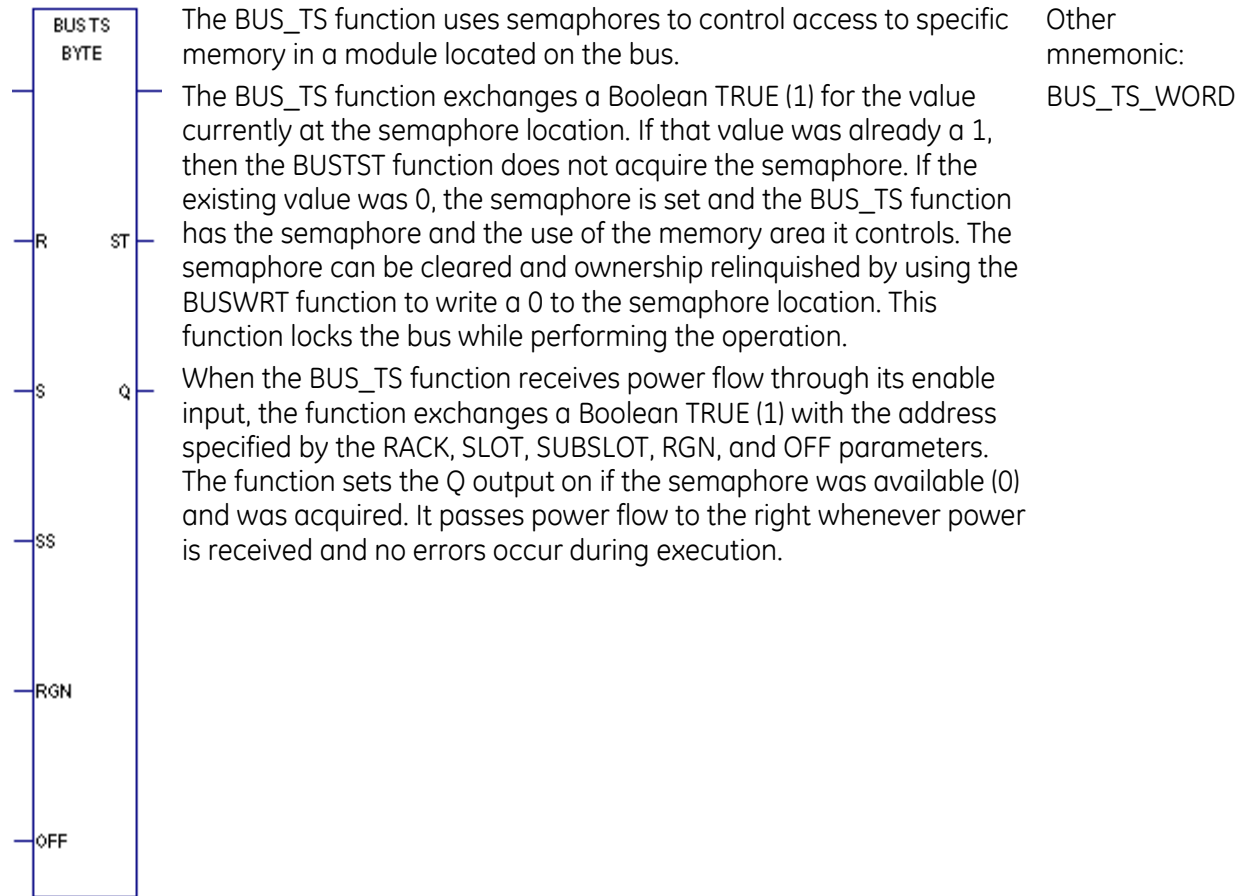
Parameter	Description	Allowed Operands	Optional
OP	Type of operation: 0 = AND 1 = OR	Constant	No
MSK	The data mask. DWORD constant or variable.	All except %S—%SC	No
R	Rack number. UINT constant or variable.	All except %S—%SC	No
S	Slot number. UINT constant or variable.	All except %S—%SC	No
SS	Subslot number (optional, defaults to 0). UINT constant or variable.	All except %S—%SC	Yes
RGN	Region (defaults to 1). WORD constant or variable.	All except %S—%SC	Yes
OFF	The offset in bytes. DWORD constant or variable.	All except %S—%SC	No
ST	The status of the operation. WORD variable.	All except variables located in %S—%SC, and constants	Yes
OV	Original value. DWORD variable.	All except variables located in %S—%SC, and constants	Yes

BUS_RMW Status in the ST Output

The BUS_RMW function returns one of the following values to the ST output:

0	Operation successful.
1	Bus error
2	Module does not exist at rack/slot location.
3	Module at rack/slot location is an invalid type.
4	Start address outside the configured range.
5	End address outside the configured address range.
6	Absolute address even but interface configured as odd byte only
7	For WORD type, absolute bus address is not a multiple of 2. For DWORD type, absolute bus address is not a multiple of 4.
8	Region not enabled
9	Function type too large for configured access type.
10	Function parameter invalid.

BUS Test and Set

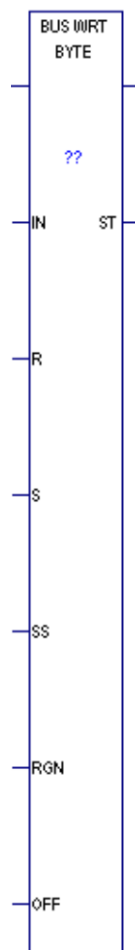


Operands for BUS Test and Set

BUS_TS can be programmed as BUS_TS_BYTE or BUS_TS_WORD. For BUS_TS_WORD, the absolute address of the module must be a multiple of 2. The absolute address is equal to the base address plus the offset value.

Parameter	Description	Allowed Operands	Optional
R	Rack number. UINT constant or variable.	All except %S—%SC	No
S	Slot number. UINT constant or variable.	All except %S—%SC	No
SS	Subslot number (defaults to 0). UINT constant or variable.	All except %S—%SC	Yes
RGN	Region (defaults to 1). WORD constant or variable.	All except %S—%SC	Yes
OFF	The offset in bytes. DWORD constant or variable.	All except %S—%SC	No
ST	The status of the bus test and set operation. WORD variable.	All except variables located in %S—%SC, and constant	Yes
Q	Output set on if the semaphore was available (0). Otherwise, Q is set off.	Power flow	Yes

BUS Write



When the BUS_WRT function receives power flow through its enable input, it writes the data located at reference (IN) to the module at the specified rack (R), slot (S), subslot (SS) and optional address region (RGN) and offset (OFF). BUSWRT writes the specified length (LEN) of data units (DWORDS, WORDs or BYTES).

The BUS_WRT function passes power to the right when its operation is successful. The status of the operation is reported in the status location (ST).

Note: For each BUS_WRT function type, use the corresponding data type for the IN operand. For example, BUS_WRT_BYTE requires IN to be a BYTE variable.

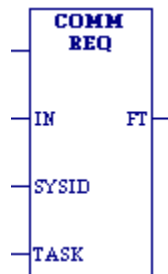
Note: An interrupt block can preempt the execution of a BUS_WRT function. On the bus, only 256 bytes are written coherently (i.e., written without being preempted by an interrupt).

Mnemonics:
 BUS_WRT_DINT
 BUS_WRT_DWORD
 BUS_WRT_WORD

Operands for Bus Write

Parameter	Description	Allowed	Optional
Length (??)	Length. The number of BYTES, DWORDs, or WORDs. 1 to 32,767.	Constant	No
IN	Reference for data to be written to the module. DWORD variable.	All except variables located in %S–%SC, and constant	No
R	Rack number. UINT constant or variable.	All except %S–%SC	No
S	Slot number. UINT constant or variable.	All except %S–%SC	No
SS	Subslot number (defaults to 0) UINT constant or variable.	All except %S–%SC	Yes
RGN	Region. (defaults to 1) WORD constant or variable.	All except %S–%SC	Yes
OFF	The offset in bytes. DWORD constant or variable.	All except %S–%SC	No
ST	The status of the operation. WORD variable.	All except variables located in %S–%SC, and constant	Yes

7.8.6 Communication Request (COMMREQ)



The Communication Request (COMMREQ) function communicates with an intelligent module, such as a Genius Communications Module or High Speed Counter.

Notes:

- The information presented in this section shows only the basic format of the COMMREQ function. Many types of COMMREQs have been defined. You will need additional information to program the COMMREQ for each type of device. Programming requirements for each module that uses the COMMREQ function are described in the specialty module's user documentation.
- If you are using serial communications, refer to Chapter 13, "Serial I/O, SNP & RTU Protocols".
- A COMMREQ instruction inside an interrupt block being executed may cause the block to be preempted when a new, incoming interrupt has the same priority.

When COMMREQ receives power flow, it sends the command block of data specified by the IN operand to the communications TASK in the intelligent or specialty module, at the rack/slot location specified by the SYSID operand. The command block contents are sent to the receiving device and the program execution resumes immediately. (Because PACSystems does not support WAIT mode COMMREQs, the timeout value is ignored.)

The COMMREQ passes power flow unless the following fault conditions exist. The Function Faulted (FT) output may be set ON if:

- Control block is invalid
- Destination is invalid (target module is not present or is faulted)
- Target module cannot receive mail because its queue is full

The Function Faulted output may have these states:

Enable	Error?	Function Faulted Output
active	no	OFF
active	yes	ON
not active	no execution	OFF

Command Block

The command block provides information to the intelligent module on the command to be performed. The command block starts at the reference specified by the operand IN. This address may be in any word-oriented area of memory (%R, %P, %L, %W, %AI, %AQ, or symbolic non-discrete variables). The length of the command block depends on the amount of data sent to the device.

The Command Block contains the data to be communicated to the other device, plus information related to the execution of the COMMREQ. Information required for the command block can be placed in the designated memory area using a programming function such as MOVE, BLKMOV, or DATA_INIT_COMM.

Command Block Structure

Address	Data Block Length (in words)	The number of data words starting with the data at address+6 to the end of the command block, inclusive. The data block length ranges from 1 to 128 words. Each COMMREQ command has its own data block length. When entering the data block length, you must ensure that the command block fits within the register limits
Address + 1	Wait/No Wait Flag	Must be set to 0 (No Wait)
Address + 2	Status Pointer Memory Type	Specifies the memory type for the location where the COMMREQ status word (CSR) returned by the device will be written when the COMMREQ completes.
Address + 3	Status Pointer Offset	The word at address + 3 contains the offset for the status word within the selected memory type. Note: The status pointer offset is a zero-based value. For example, %R00001 is at offset zero in the register table.
Address + 4	Idle Timeout Value	This parameter is ignored in No Wait mode.
Address + 5	Maximum Communication Time	This parameter is ignored in No Wait mode.
Address + 6 to Address + 133	Data Block	The data block contains the command's parameters. The data block begins with a command number in address + 6, which identifies the type of communications function to be performed. Refer to the specific device manual for COMMREQ command formats.

Status Pointer Memory Type

Status pointer memory type contains a numeric code that specifies the user reference memory type for the status word. The table below shows the code for each reference type:

For this memory type		Enter this decimal value
%I	Discrete input table (BIT mode)	70
%Q	Discrete output table (BIT mode)	72
%I	Discrete input table (BYTE mode)	16
%Q	Discrete output table (BYTE mode)	18
%R	Register memory	8
%W	Word memory	196
%AI	Analog input table	10
%AQ	Analog output table	12

Notes:

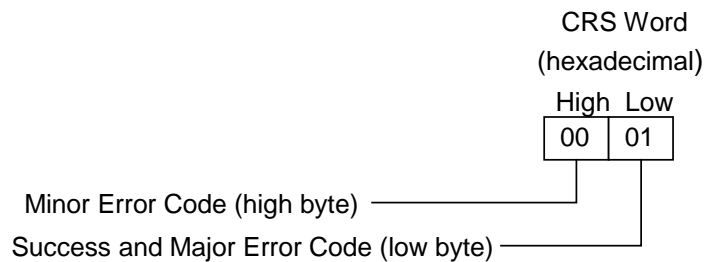
- The value entered determines the mode. For example, if you enter the %I bit mode is 70, then the offset will be viewed as that bit. On the other hand, if the %I value is 16, then the offset will be viewed as that byte.
- The high byte at address + 2 should contain zero.

Operands for COMMREQ

Parameter	Description	Allowed Operands	Optional
IN	The reference of the first WORD of the command block.	Variables in %R, %P, %L, %AI, %AQ, %W, and symbolic non-discrete variables	No
SYSID	The rack number (most significant byte) and slot number (least significant byte) of the target device (intelligent module). Note: For systems that do not have expansion racks, SYSID must be zero for the main rack.	All except flow and variables in %S - %SC	No
TASK	The task ID of the process on the target device	Constants; variables in %R, %P, %L, %AI, %AQ, %W, and symbolic non-discrete variables	No
FT	Function Faulted output. FT is energized if an error is detected processing the COMMREQ: <ul style="list-style-type: none"> This is a WAIT mode COMMREQ and the CPU does not support it The specified target address (SYSID operand) is not present. The specified task (TASK operand) is not valid for the device. The data length is 0. The device's status pointer address (part of the command block) does not exist. This may be due to an incorrect memory type selection, or an address within that memory type that is out of range. 	Power flow	Yes

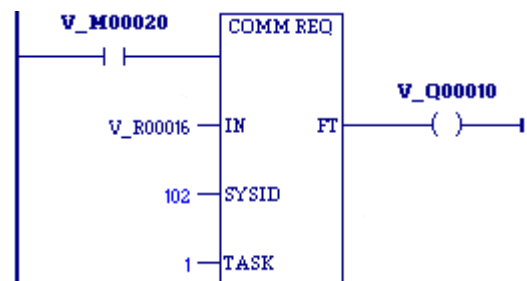
COMMREQ Status Word

The CRS word consists of two byte values, a major code and a minor code. Refer to the specific device manual for CRS major and minor codes used by COMMREQ commands at that device.



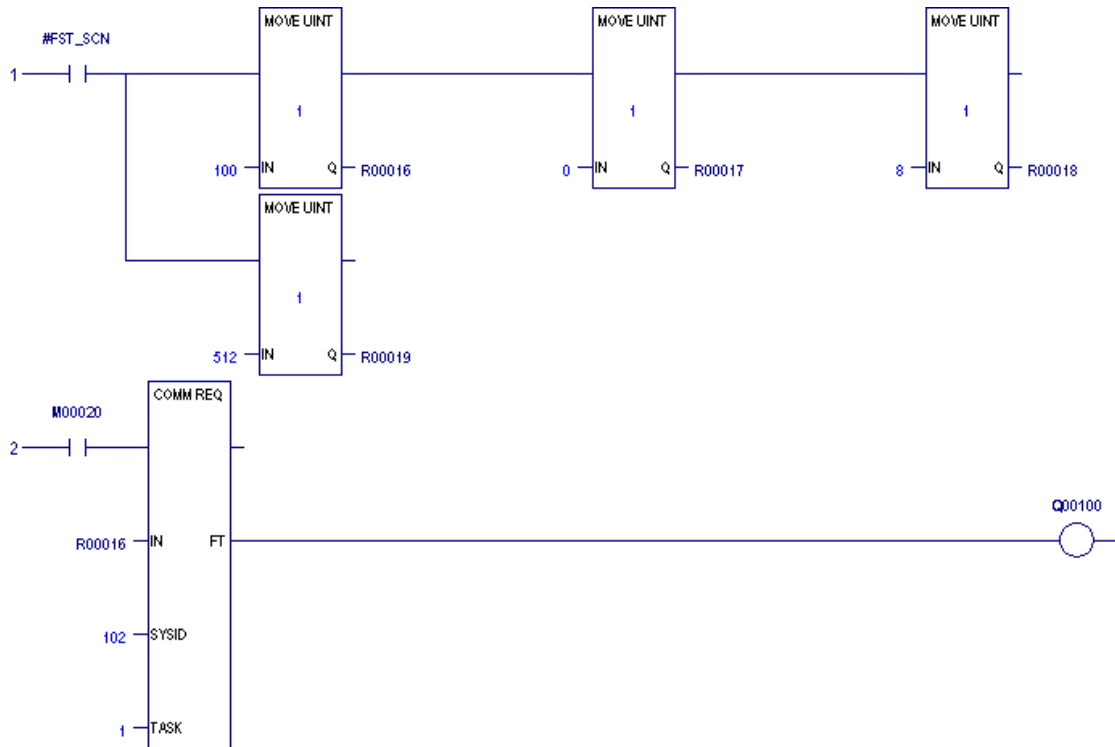
COMMREQ Example 1

When enabling input %M0020 is ON, a command block starting at %R0016 is sent to communications task 1 in the device located at rack 1, slot 2 of the PLC. If an error occurs processing the COMMREQ, %Q0100 is set.



COMMREQ Example 2

The MOVE function can be used to enter the command block contents for the COMMREQ described in example 1.



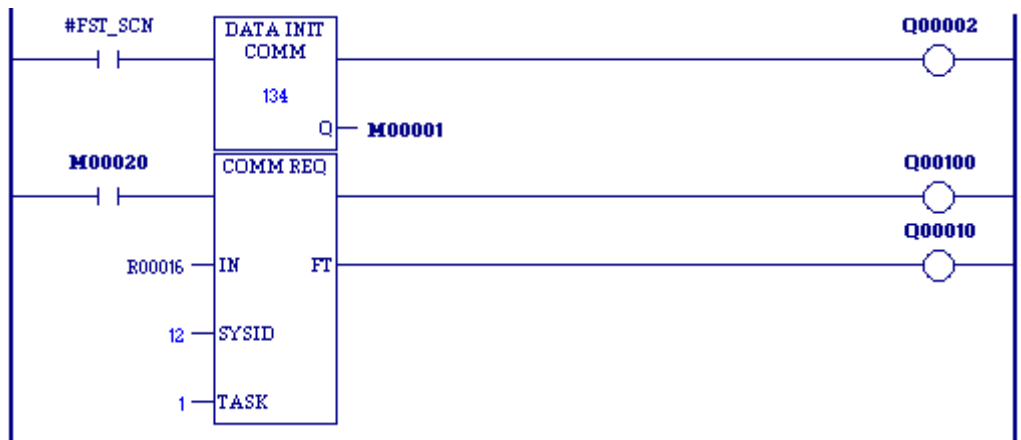
Input IN of the COMMREQ specifies %R00016 as the beginning reference for the command block. Successive references contain the following:

%R00016	Data Block Length
%R00017	Wait/No Wait Flag
%R00018	Status Pointer Memory Type
%R00019	Status Pointer Offset
%R00020	Idle Timeout Value (Because this parameter is ignored in NO WAIT mode, no value is input).
%R00021	Maximum Communication Time Value (Because this parameter is ignored in NO WAIT mode, no value is input).
%R00022 to end of data	Data Block

MOVE functions supply the following command block data for the COMMREQ.

- The first MOVE function places the length of the data being communicated in %R00016.
- The second MOVE function places the constant 0 in %R00017. This specifies NO WAIT mode.
- The third MOVE function places the constant 8 in %R00018. This specifies the register table as the location for the status pointer.
- The fourth MOVE function places the constant 512 in reference %R00019. Therefore, the status pointer is located at %R00513.

The programming logic displayed in example 2 can be simplified by replacing the six MOVE functions with one DATA_INIT_COMM function.



7.8.7 Data Initialization



The Data Initialization (DATA_INIT) function copies a block of constant data to a reference range.

When the DATA_INIT instruction is first programmed, the constants are initialized to zeroes. To specify the constant data to copy, double-click the DATA_INIT instruction in the LD editor.

Note: The mnemonics DATA_INIT_ASCII (page 250) and DATA_INIT_COMM (page 251) operate differently from the other six functions.

- Mnemonics:
- DATA_INIT_DWORD
 - DATA_INIT_DWORD
 - DATA_INIT_INT
 - DATA_INIT_UINT
 - DATA_INIT_REAL
 - DATA_INIT_LREAL
 - DATA_INIT_WORD

When DATA_INIT receives power flow, it copies the constant data to output Q. DATA_INIT's constant data length (LEN) specifies how much constant data of the function type is copied to consecutive reference addresses starting at output Q. DATA_INIT passes power to the right whenever it receives power.

Notes:

- The output parameter is not included in coil checking.
- If you replace one DATA_INIT instruction (except DATA_INIT_ASCII or DATA_INIT_COMM) with another (except DATA_INIT_ASCII or DATA_INIT_COMM), Logic Developer - PLC attempts to keep the same data. For example, configuring a DATA_INIT_INT with eight rows and then replacing the instruction with a DATA_INIT_DINT would keep the data for the eight rows. Some precision may be lost when replacing a DATA_INIT_ instruction, and a warning message will be displayed when this case is detected.

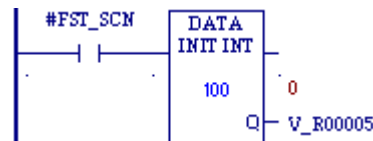
Operands

Note: For each mnemonic, use the corresponding data type for the Q operand. For example, DATA_INIT_DINT requires Q to be a DINT variable.

Parameter	Description	Allowed Operands	Optional
Length	The quantity (default 1) of constant data copied to consecutive reference addresses starting at output Q.	Constants	No
Q	The beginning address of the area to which the data is copied.	All, except %S. SA, SB, and SC are not allowed for REAL, LREAL, INT, and UINT versions.	No

Example

On the first scan (as restricted by the #FST_SCN system variable), 100 words of initial data are copied to %R00005 through %R00104.



7.8.8 Data Initialize ASCII



The Data Initialize ASCII (DATA_INIT_ASCII) function copies a block of constant ASCII text to a reference range.

When DATA_INIT_ASCII is first programmed, the constants are initialized to zeroes. To specify the constant data to copy, double-click the DATA_INIT_ASCII instruction in the LD editor.

When DATA_INIT_ASCII receives power flow, it copies the constant data to output Q.

DATA_INIT_ASCII's constant data length (LEN) specifies how many bytes of constant text are copied to consecutive reference addresses starting at output Q. LEN must be an even number.

DATA_INIT_ASCII passes power to the right whenever it receives power.

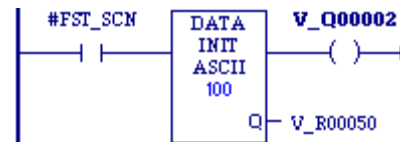
Note: The output parameter is not included in coil checking.

Operands

Parameter	Description	Allowed Operands	Optional
Length	The number (default 1) of bytes of constant text copied to consecutive reference addresses starting at output Q. LEN must be an even number.	Constants	No
Q	The beginning address of the area where the data is copied.	All except %S.	No

Example

On the first scan (as restricted by the #FST_SCN system variable) the decimal equivalent of 100 bytes of ASCII text is copied to %R00050 through %R00149. %Q00002 receives power.



7.8.9 Data Initialize Communications Request



The Data Initialize Communications Request (DATA_INIT_COMM) function initializes a COMMREQ function with a block of constant data. The IN parameter of the COMMREQ must correspond with output Q of this DATA_INIT_COMM function.

When DATA_INIT_COMM is first programmed, the constants are initialized to zeroes. To specify the constant data to copy, double-click the DATA_INIT_COMM instruction in the LD editor.

When DATA_INIT_COMM receives power flow, it copies the constant data to output Q.

DATA_INIT_COMM's constant data length operand specifies how many words of constant data to copy to consecutive reference addresses starting at output Q. The length should be equal to the size of the COMMREQ function's entire command block. DATA_INIT_COMM passes power to the right whenever it receives power.

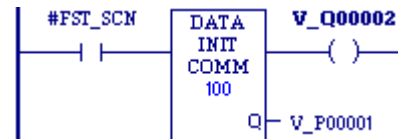
Note: The output parameter is not included in coil checking.

Operands

Parameter	Description	Allowed Operands	Optional
Length	The number of WORDs (default 7) of constant data copied to consecutive reference addresses starting at output Q. Must equal the size of the COMMREQ function's entire command block, including the header (words 0-5).	Constant	No
Q	The beginning address of the area where the data is copied.	R, W, P, L, AI, AQ, and symbolic non-discrete variables	No

Example

On the first scan (as restricted by the #FST_SCN system variable), a command block consisting of 100 words of data, including the 6 header words, is copied to %P00001 through %P00100. %Q00002 receives power.



7.8.10 Data Initialize DLAN

The Data Initialize DLAN (DATA_INIT_DLAN) function is used with a DLAN Interface module, which is a limited availability, specialty system. If you have a DLAN system, refer to the *DLAN/DLAN+ Interface Module User's Manual*, GFK-0729, for details.

Operands

Parameter	Description	Allowed Operands	Optional
Q	The beginning address of the area where the data is copied.	flow, R, W, P, L, AI, AQ, and symbolic non-discrete variables	No

7.8.11 Move



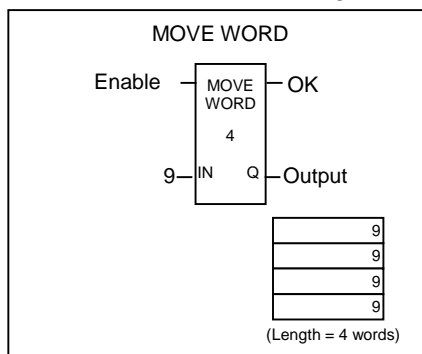
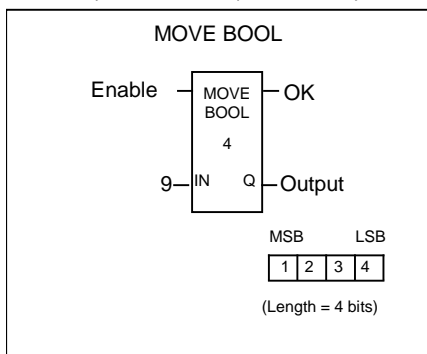
When the MOVE function receives power flow, it copies data as individual bits from one location in PLC memory to another. Because the data is copied in bit format, the new location does not need to be the same data type as the original.

- Mnemonics:
 MOVE_BOOL
 MOVE_DINT
 MOVE_DWORD
 MOVE_INT
 MOVE_REAL
 MOVE_UINT
 MOVE_WORD

The MOVE function copies data from input operand IN to output operand Q as bits. If data is moved from one location in BOOL (discrete) memory to another, for example, from %I memory to %T memory, the transition information associated with the BOOL memory elements is updated to indicate whether or not the MOVE operation caused any BOOL memory elements to change state. Data at the input operand does not change unless there is an overlap in the source and destination.

Note: If an array of BOOL-type data specified in the Q operand does not include all the bits in a byte, the transition bits associated with that byte (which are not in the array) are cleared when the Move function receives power flow. The input IN can be either a variable providing a reference for the data to be moved or a constant. If a constant is specified, then the constant value is placed in the location specified by the output reference. For example, if a constant value of 4 is specified for IN, then 4 is placed in the memory location specified by Q. If the length is greater than 1 and a constant is specified, then the constant is placed in the memory location specified by Q and the locations following, up to the length specified. Do not allow overlapping of IN and Q operands.

The result of the MOVE depends on the data type selected for the function, as shown below. For example, if the constant value 9 is specified for IN and the length is 4, then 9 is placed in the bit memory location specified by Q and the three locations following:



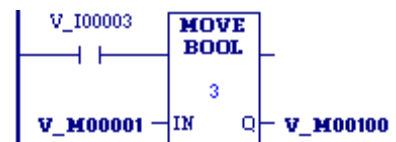
The MOVE function passes power to the right whenever it receives power.

MOVE Operands

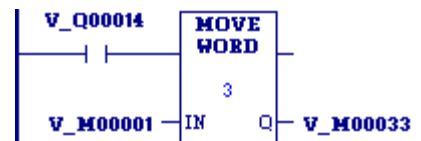
Parameter	Description	Allowed Operands	Optional
Length (??)	The length of IN; the number of bits, words, or double words to copy. If IN is a constant and Q is BOOL, then $1 \leq \text{Length} \leq 16$; otherwise, $1 \leq \text{Length} \leq 256$. $1 \leq \text{Length} \leq 32,767$	Constant	No
IN	The location of the first data item to copy. For MOVE_BOOL, any discrete reference may be used. It does not need to be byte-aligned. However 16 bits beginning with the reference address specified are displayed online. If IN is a constant, it is treated as an array of bits. The value of the least significant bit is copied into the memory location specified by Q. If Length is greater than one, the bits are copied in order from the least significant to the most significant into successive memory locations, up to the length specified.	All. %S, %SA, %SB, %SC allowed only for WORD, DWORD, BOOL types.	No
Q	The location of the first destination data item. For MOVE_BOOL, any discrete reference may be used. It does not need to be byte-aligned. However 16 bits beginning with the reference address specified are displayed online.	All except %S. Also no %SA, SB, SC except for WORD, DWORD, BOOL types.	No

MOVE_BOOL Example

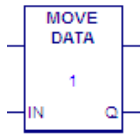
When %I00003 is set, the three bits %M00001, %M00002, and %M00003 are moved to %M00100, %M00101, and %M00102, respectively. Coil %Q00001 is turned on.

**MOVE_WORD Example**

V_M00001 and V_M00033 are both WORD arrays of length 3, for a total of 48 bits in each array. Since PLCs do not recognize arrays, Length has to be set at 3, for the total number of WORDs to be moved. When enabling input V_Q0014 is ON, MOVE_WORD moves 48 bits from the memory location %M00001 to memory location %M00033. Even though the destination overlaps the source for 16 bits, the move is done correctly.



7.8.12 Move Data

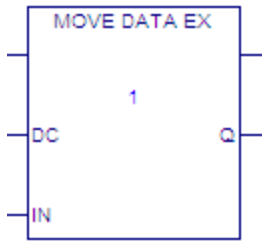


The MOVE_DATA function copies the variable assigned to the input, IN to the variable assigned to the output, Q. If the constant 0 is assigned to IN, the variable assigned to Q is initialized to its default value. Mnemonic: MOVE_DATA

MOVE_DATA Operands

Parameter	Description	Allowed Operands	Optional
Length (??)	The length of IN; the number of elements to copy. $1 \leq \text{Length} \leq 32,767$	Constant	No
IN	The location of the data item to copy. If IN is 0, Q is set to its default value.	Enumerated variable, structure variable, or array of these types; the constant 0. For details, refer to "Data Types and Structures" in the <i>PACMotion Multi-Axis Motion Controller User's Manual</i> , GFK-2448.	No
Q	The location of the data copied from IN. Q must be the same data type as IN, unless IN is the constant 0.	Enumerated variable, structure variable, or array of these types.	No

7.8.13 Move Data Explicit



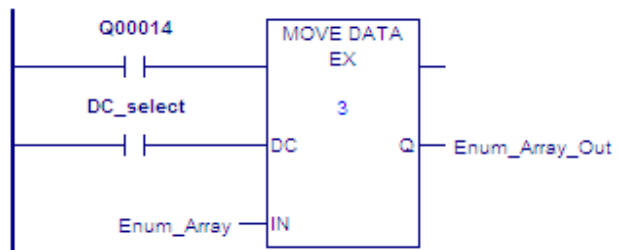
MOVE_DATA_EX provides optional data coherency by locking the symbolic memory being written to during the copy operation. This allows data to be copied coherently when accessed by multiple logic threads (i.e. interrupt blocks). Note that copying large amounts of data with coherency enabled can increase interrupt latency.

MOVE_DATA_EX Operands

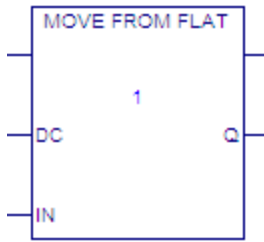
Parameter	Description	Allowed Operands	Optional
Length (??)	The length of IN; the number of elements to copy. $1 \leq \text{Length} \leq 32,767$	Constant	No
DC	Data coherency. If True memory being written to is locked, enabling coherent copying of data from one Controller memory area to another. If False (default), data is copied normally from one Controller memory area to another <i>without</i> data coherency. <ul style="list-style-type: none"> The input DC should be used only when using interrupt blocks and is required only when the same memory is used in more than one interrupt block, or in the main program and an interrupt block. If DC is True, an interrupt block cannot preempt the copy operation. If DC is False or not present, then interrupts can preempt the copy. Using DC can impact interrupt latency if the amount of data copied is large. 	Data flow.	Yes
IN	The location of the data item to copy. If IN is 0 (LD only), length is assigned the constant 1 and the variable or structure assigned to Q is set to its default value.	Enumerated variable or structure variable, or array of these types; the constant 0.	No
Q	Variable or array to which IN is copied. Q must be the same data type as IN, unless IN is the constant 0.	Enumerated variable or structure variable, or array of these types.	No

Example

Enum_Array and Enum_Array_Out are arrays of enumerated variables, with three elements each. To copy all elements in Enum_Array, input Length should be 3. When the enabling input Q00014 is on, MOVE_DATA_EX copies three elements from memory location Enum_Array to memory location Enum_Array_Out.



7.8.14 Move From Flat



MOVE_FROM_FLAT copies reference memory data to a User-defined Data Type (UDT) variable or UDT array.

MOVE_FROM_FLAT provides optional data coherency by locking the data being written to during the copy operation. This allows data to be copied coherently when accessed by multiple logic threads (i.e. interrupt blocks). Note that copying large amounts of data with coherency enabled can increase interrupt latency.

Operation

Copying arrays and array elements

The constant value assigned to input LEN (Length) determines the number of UDT array elements to be filled by copying data from reference memory to output Q.

Example:

If constant value 6 is assigned to input LEN (Length), there should be a UDT array of at least six elements assigned to output Q. During logic execution, n bytes of data are copied from reference memory to the first six UDT array elements, where n is the length of the UDT array element (in bytes) times six.

Copying to specified array elements

For output Q, a single element of a UDT array can be specified, for example, myUDT_array[4] (5th element of myUDT_array). In this case, the input LEN (Length) operand applies to the array elements starting from and including myUDT_array[4].

Example:

myUDT_array is a UDT array of ten elements, of which each element is a UDT variable, and myUDT_array[4] is assigned to output Q. This restricts the value of input LEN (Length) to six or less because there are six remaining UDT array elements that can be filled in myUDT_array.

Notes:

- Length determines how many UDT variable elements to overwrite in Q.
- If an array head is assigned to input IN, the Length determines how many UDT array elements assigned to Q are filled by copying data from reference memory.

MOVE_FROM_FLAT Operands

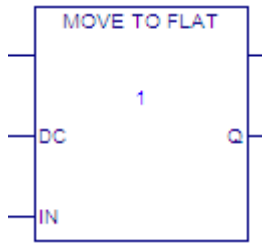
Parameter	Description	Allowed Operands	Optional
Length (??)	Determines the number of UDT array elements to be filled by copying data from reference memory to output Q. $1 \leq \text{Length} \leq 32,767$	Constant	No
DC	Data coherency. If True, memory being written to is locked, enabling coherent copying of data from one Controller memory area to another. If False (default), data is copied normally from one Controller memory area to another; that is <i>without</i> data coherency. <ul style="list-style-type: none"> ▪ The input DC should be used only when using interrupt blocks and is required only when the same memory is used in more than one interrupt block, or in the main program and an interrupt block. ▪ If DC is True, an interrupt block cannot preempt the copy operation. ▪ If DC is False or not present, then interrupts can preempt the copy. ▪ Using DC can impact interrupt latency if the amount of data copied is large. 	Data flow.	Yes
IN	Reference memory data being copied to UDT variable elements in output Q as determined by the Length.	All except %S, symbolic, or I/O variable.	No
Q	UDT variable or UDT array to which IN is copied.	Discrete or non-discrete symbolic, discrete or non-discrete I/O variable.	No

Example

A WORD variable mapped to %R1 is assigned to input IN and a value of 1 is assigned to Length. A UDT variable or UDT array is assigned to output Q.

When MOVE_FROM_FLAT executes, n bytes of data are copied, starting at %R1 to a UDT variable or UDT array, where n is the UDT array element length (in bytes). If a UDT array is assigned to output Q, n bytes of data are copied to the first UDT array element.

7.8.15 Move to Flat



MOVE_TO_FLAT instruction copies data from symbolic or I/O variable memory to reference memory. MOVE_TO_FLAT copies across mismatched data types for an operation such as a Modbus transfer.

MOVE_TO_FLAT provides optional data coherency by locking the reference memory being written to during the copy operation. This allows data to be copied coherently when accessed by multiple logic threads (i.e. interrupt blocks). Note that copying large amounts of data with coherency enabled can increase interrupt latency.

Notes:

- The Data Coherency (DC) input should be used only when using interrupt blocks and is required only when the same memory is used in more than one interrupt block, or in the main program and an interrupt block.
- If DC is True, an interrupt block cannot preempt the copy operation.
- If DC is False or not present, then interrupts can preempt the copy.
- Using DC can impact interrupt latency if the amount of data copied is large.

Copying Arrays and Array Elements

The Length determines the number of UDT array elements to be copied to the reference memory of the variable assigned to output Q.

Example: If the value 6 is assigned to Length, there should be a UDT array of at least six elements assigned to input IN. When logic executes, n bytes of data are copied from the UDT array elements to the reference memory of the variable assigned to output Q, where n is the length of the UDT array element (in bytes) times six.

MOVE_TO_FLAT Operands

Parameter	Description	Allowed Operands	Optional
Length (??)	The length of IN; the number of elements to copy. $1 \leq \text{Length} \leq 32,767$	Constant	No
DC	Data coherency. If True, the memory being written to is locked. This enables a coherent copy of a UDT to reference memory. If False (default), data is copied normally from one Controller memory area to another; that is <i>without</i> data coherency. <ul style="list-style-type: none"> DC should be used only when using interrupt blocks and is required only when the same memory is used in more than one interrupt block, or in the main program and an interrupt block. If DC is True, an interrupt block cannot preempt the copy operation. If DC is False or not present, interrupts can preempt the copy. Using DC can impact interrupt latency if the amount of data copied is large. 	Data flow.	Yes
IN	UDT variable or UDT array. The data copied to the reference memory mapped to the variable assigned to Q. If IN is 0, length is assigned the constant 1 and the variable or structure assigned to Q is set to its default value.	Discrete or non-discrete symbolic, discrete or non-discrete I/O variable.	No
Q	Variable or array to which IN is copied. The amount of data copied is determined by the constant value assigned to input LEN (Length).	All memory areas except %S, discrete symbolic, discrete I/O variable. <ul style="list-style-type: none"> Indirect referencing is available for all register references (%R, %P, %L, %W, %AI, and %AQ). BYTE arrays must be packed; that is, they must be in discrete memory. 	No

Example

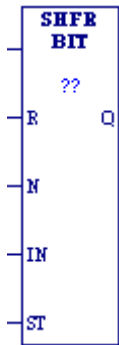
A UDT variable or UDT array is assigned to input IN.

The constant value 8 is assigned to input LEN (Length).

A DWORD variable mapped to %R1 is assigned to output Q.

If the constant value 8 is assigned to LEN (length), there should be a UDT array of at least eight elements assigned to IN. When MOVE_TO_FLAT executes, n bytes of data are copied from the UDT variable or array to %R memory, starting at %R1 in the example, where n is the length of a UDT array element (in bytes) times eight.

7.8.16 Shift Register



When the Shift Register (SHFR_BIT, SHFR_DWORD, or SHFR_WORD) function receives power and the R operand does not, SHFR shifts one or more data BITS, data DWORDs, or data WORDs from a reference location into a specified area of memory. A contiguous section of memory serves as a shift register. For example, one word might be shifted into an area of memory with a specified length of five words. As a result of this shift, another word of data would be shifted out of the end of the memory area.

Mnemonics:
SHFR_BIT
SHFR_DWORD
SHFR_WORD



Warning

The use of overlapping input and output reference address ranges in multiword functions is not recommended, as it may produce unexpected results.

The reset input (R) takes precedence over the function enable input. When the reset is active, all references beginning at the shift register (ST) up to the length specified, are filled with zeroes. If the function receives power flow and R is not active, each BIT, DWORD, or WORD of the shift register is moved to the next highest reference. The elements shifted out of ST are shifted into Q. The highest reference of IN is shifted into the vacated element starting at ST.

Note: The contents of the shift register are accessible throughout the program because they are overlaid on absolute locations in logic addressable memory.

The function passes power to the right whenever it receives power flow and the R operand does not.

Operands for Shift Register

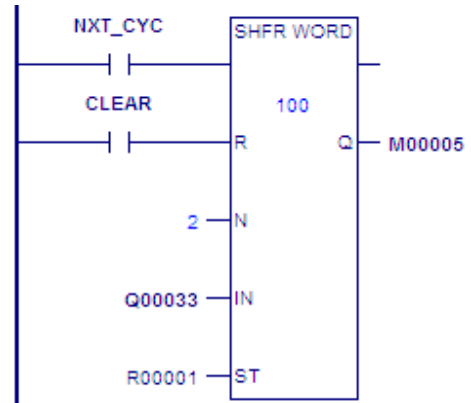
Parameter	Description	Allowed Operands	Optional
Length (??)	The number of data items in the shift register, ST. $1 \leq \text{Length} \leq 256$		No
R	Reset. When R is ON, the shift register located at ST is filled with zeroes.	Power flow	No
N	The number of data items to shift into ST.	Constants	No
IN	The value to shift into the first data item of ST. SHFR_BIT: For %I, %Q, %M and %T memory, any BOOL reference may be used; it does not need to be byte-aligned. However, 1 bit, beginning with the reference address specified, is displayed online.	All	No
ST	The first data item of the shift register. Note: For %I, %Q, %M and %T memory, any BOOL reference may be used; it does not need to be byte-aligned. However, 16 bits, beginning with the reference address specified, are displayed online.	All except data flow, constants, S	No

Parameter	Description	Allowed Operands	Optional
Q	The data shifted out of ST. The same number of data items will be shifted into Q as were shifted out of ST. SHFR_BIT: For %I, %Q, %M and %T memory, any BOOL reference may be used; it does not need to be byte-aligned. However, 1 bit, beginning with the reference address specified, is displayed online.	All except S	No

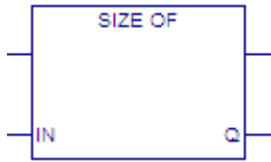
Example

SHFR_WORD operates on register memory locations %R0001 through %R0100. When the reset reference CLEAR is active, the Shift Register words are set to zero.

When the NXT_CYC reference is active and CLEAR is not, the two words at the starting address V_Q00033 are shifted into the Shift Register at %R0001. The words shifted out of the Shift Register from %R0100 are stored in output %M0005. Note that, for this example, the length specified and the amount of data to be shifted (N) are not the same.



7.8.17 Size Of



Counts the number of bits used by the variable assigned to input IN and writes the number of bits to output Q.

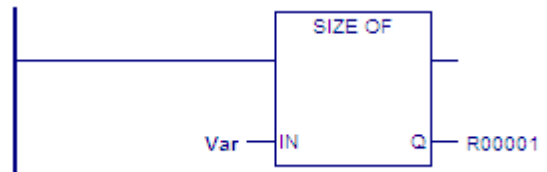
Mnemonics:
SIZE_OF

Operands

Parameter	Description	Allowed Operands	Optional
IN	The variable whose size in bits is calculated.	Variable of any data type except BYTE arrays in non-discrete memory and double-segment structures.	No
Q	The number of bits used by the variable assigned to input IN.	DINT or DWORD variable. ST also supports INT and WORD variables.	No

Example

The single-segment structure named Var assigned to input IN contains eight BOOL elements ($8 \times 1 = 8$ bits) and twelve WORD elements ($12 \times 16 = 192$ bits). SIZE_OF outputs the value $8 + 192 = 200$ to the variable R00001 assigned to output Q.



7.8.18 Swap

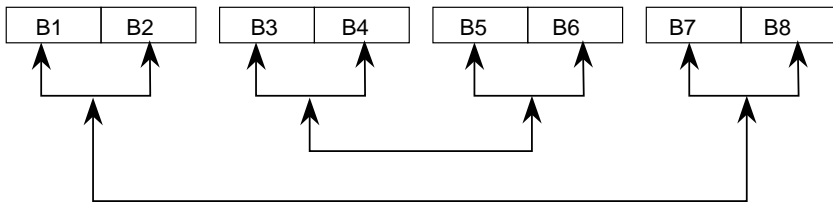


The SWAP function is used to swap two bytes within a word (SWAP WORD) or two words within a double word (SWAP DWORD). The SWAP can be performed over a wide range of memory by specifying a length greater than 1. If that is done, the data in each word or double word within the specified length is swapped. Other mnemonic: SWAP_WORD

When the SWAP function receives power flow, it swaps the data in reference IN and places the swapped data into output reference Q. The function passes power to the right whenever it receives power.

PACSystems CPUs use the Intel convention for storing word data in bytes. They store the least significant byte of a word in address n and the most significant byte in address n+1. Many VME modules follow the Motorola convention of storing the most significant byte in address n and the least significant byte in address n+1.

The PACSystems CPU assigns byte address 1 to the same storage location regardless of the byte convention used by the other device. However, because of the difference in byte significance, word and multiword data, for example, 16 bit integers (INT, UINT), 32 bit integers (DINT) or floating point (REAL) numbers, must be adjusted when being transferred to or from Motorola-convention modules. In these cases, the two bytes in each word must be swapped, either before or after the transfer. In addition, for multiword data items, the words must be swapped end-for-end on a word basis. For example, a 64-bit real number transferred to the PACSystems CPU from a Motorola-convention module must be byte-swapped and word-reversed, either before or after reading, as shown below:



Character (ASCII) strings or BCD data require no adjustment since the Intel and Motorola conventions for storage of character strings are identical.

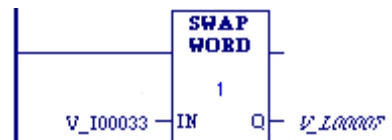
Operands for Swap

The two parameters, IN and Q, must both be the same type, WORD or DWORD.

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of WORDs or DWORDs to operate on. $1 \leq \text{Length} \leq 256$	Constant	No
IN	Reference for data to be swapped. (must be the same type as Q)	All	No
Q	Reference for swapped data. (must be the same type as IN)	All except S	No

Example for Swap

Two bytes located in bits %I00033 through %I00048 are swapped. The result is stored in %L00007.



7.8.19 Data Table Functions

Function	Mnemonic	Description
Array Move	ARRAY_MOVE_BOOL ARRAY_MOVE_BYTE ARRAY_MOVE_DINT ARRAY_MOVE_INT ARRAY_MOVE_WORD	Copies a specified number of data elements from a source memory block to a destination memory block. Note: The memory blocks do not need to be defined as arrays. You must supply a starting address and the number of contiguous registers to use for the move.
Array Range	ARRAY_RANGE_DINT ARRAY_RANGE_DWORD ARRAY_RANGE_INT ARRAY_RANGE_UINT ARRAY_RANGE_WORD	Determines if a value is between the range specified in two tables
FIFO Read	FIFO_RD_DINT FIFO_RD_DWORD FIFO_RD_INT FIFO_RD_UINT FIFO_RD_WORD	Removes the entry at the bottom of the First In First Out (FIFO) table, and decrements the pointer by one
FIFO Write	FIFO_WRT_DINT FIFO_WRT_DWORD FIFO_WRT_INT FIFO_WRT_UINT FIFO_WRT_WORD	Increments the table pointer and writes data to the bottom of the FIFO table
LIFO Read	LIFO_RD_DINT LIFO_RD_DWORD LIFO_RD_INT LIFO_RD_UINT LIFO_RD_WORD	Removes the entry at the pointer location in the LIFO (Last In First Out) table, and decrements the pointer by one
LIFO Write	LIFO_WRT_DINT LIFO_WRT_DWORD LIFO_WRT_INT LIFO_WRT_UINT LIFO_WRT_WORD	Increments the LIFO table's pointer and writes data to the table
Search	SEARCH_EQ_BYTE SEARCH_EQ_DINT SEARCH_EQ_DWORD SEARCH_EQ_INT SEARCH_EQ_UINT SEARCH_EQ_WORD	Searches for all array values equal to a specified value
	SEARCH_GE_BYTE SEARCH_GE_DINT SEARCH_GE_DWORD SEARCH_GE_INT SEARCH_GE_UINT SEARCH_GE_WORD	Searches for all array values greater than or equal to a specified value

Function	Mnemonic	Description
	SEARCH_GT_BYTE SEARCH_GT_DINT SEARCH_GT_DWORD SEARCH_GT_INT SEARCH_GT_UINT SEARCH_GT_WORD	Searches for all array values greater than a specified value
	SEARCH_LE_BYTE SEARCH_LE_DINT SEARCH_LE_DWORD SEARCH_LE_INT SEARCH_LE_UINT SEARCH_LE_WORD	Searches for all array values less than or equal to a specified value
	SEARCH_LT_BYTE SEARCH_LT_DINT SEARCH_LT_DWORD SEARCH_LT_INT SEARCH_LT_UINT SEARCH_LT_WORD	Searches for all array values less than a specified value
	SEARCH_NE_BYTE SEARCH_NE_DINT SEARCH_NE_DWORD SEARCH_NE_INT SEARCH_NE_UINT SEARCH_NE_WORD	Searches for all array values not equal to a specified value
Sort	SORT_INT SORT_UINT SORT_WORD	Sorts a memory block in ascending order
Table Read	TBL_RD_DINT TBL_RD_DWORD TBL_RD_INT TBL_RD_UINT TBL_RD_WORD	Copies a value from a specified table location to an output reference
Table Write	TBL_WRT_DINT TBL_WRT_DWORD TBL_WRT_INT TBL_WRT_UINT TBL_WRT_WORD	Copies a value from an input reference to a specified table location

7.8.20 Array Move



When the Array Move function receives power flow, it copies a specified number of elements from a source memory block to a destination memory block. Starting at the indexed location (SR+SNX-1) of the input memory block, it copies N elements to the output memory block, starting at the indexed location (DS+DNX-1) of the output memory block.

Mnemonics:
 ARRAY_MOVE_BOOL
 ARRAY_MOVE_BYTE
 ARRAY_MOVE_DINT
 ARRAY_MOVE_DWORD
 ARRAY_MOVE_INT
 ARRAY_MOVE_UINT
 ARRAY_MOVE_WORD

Note: For ARRAY_MOVE_BOOL, when 16-bit registers are selected for the operands of the source memory block and/or destination memory block starting address, the least significant bit of the specified 16-bit register is the first bit of the memory block. The value displayed contains 16 bits, regardless of the length of the memory block.

The indices in an Array Move instruction are 1-based. In using an Array Move, no element outside either the source or destination memory blocks (as specified by their starting address and length) may be referenced.

The function passes power flow unless one of the following conditions occurs:

- It receives no power flow.
- (N + SNX - 1) is greater than Length.
- (N + DNX - 1) is greater than Length.

Note: For each mnemonic, use the corresponding data type for the SR and DS operands. For example, ARRAY_MOVE_BYTE requires SR and DS to be BYTE variables.

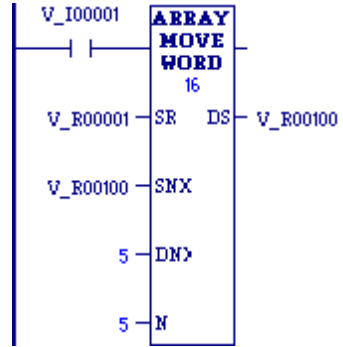
Operands for Array Move

Parameter	Description	Allowed Operands	Optional
Length (??)	The length of each memory block (source and destination); the number of elements in each memory block. $1 \leq \text{Length} \leq 32,767$.	Constant	No
SR (must be the same data type as DS)	The starting address of the source memory block. Note: For an Array Move with the data type BOOL, any reference may be used; it does not need to be byte-aligned. Sixteen bits, beginning with the reference address specified, are displayed online.	All except constants. %S - %SC allowed only for BYTE, WORD, DWORD types.	No
SNX	The index of the source memory block	All except variables in %S - %SC.	No
DNX	The index of the destination memory block	All except variables in %S - %SC.	No
N	Count indicator	All except variables in %S - %SC	No
DS (must be the same data type as SR)	The starting address of the destination memory block. Note: For an Array Move with the data type BOOL, any reference may be used; it does not need to be byte-aligned. Sixteen bits, beginning with the reference address specified, are displayed online.	All, except S and constants. %SA - %SC allowed only for BYTE, WORD, DWORD types	No

Array Move Example 1

To define the input memory block %R0001 - %R0016 and the output memory block %R0100 - %R0115, SR is set as %R0001, DS is set as %R0100, and Length is set to 16.

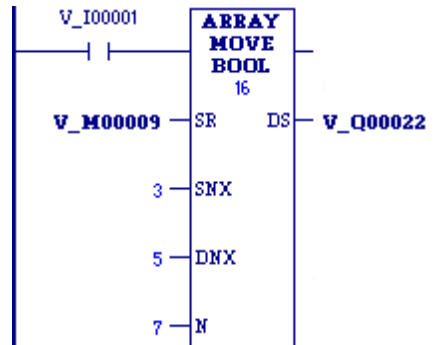
To copy the five registers %R0003 - %R0007 to the registers %R0104 - %R0108, N is set to 5, SNX=%R0100 is set to 3 (to designate the third register, %R0003, of the block starting at %R0001), and DNX is set to 5 (to designate the fifth register, %R0104, of the block starting at %R0100).



Array Move Example 2

Using bit memory blocks, the input block starts at SR=%M0009, the output block starts at %Q0022, and the length of both blocks is 16 one-bit registers (Length=16).

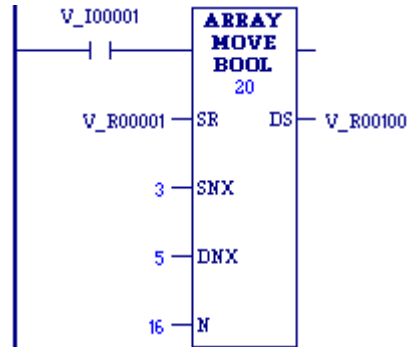
To copy the seven registers %M0011 - %M0017 to %Q0026 - %Q0032, N is set to 7, SNX is set to 3 (to designate the third register, %M0011, of the block starting at %M0009), and DNX is set to 5 (to designate the fifth register, %Q0026, of the block starting at %Q0022).



Array Move Example 3

Sixteen (=N) bits that are not byte-aligned are moved from the two 16-bit registers that start at %R00001 (SR) to the two 16-bit registers that begin at %R00100 (DS). For the purposes of this Boolean move, Length is set to 20, because the other 12 bits in either memory block are not considered.

By setting SNX to 3, N to 16, and DNX to 5, the third (SNX) least significant bit of %R0001 through the second least significant bit of %R0002 (for a total of 16 bits=N) are written into the fifth (DNX) least significant bit of %R0100 through the fourth least significant bit of %R0101 (for the same total of 16 bits).



7.8.21 Array Range



The ARRAY_RANGE function compares a single input value against two arrays of delimiters that specify an upper and lower bound to determine if the input value falls within the range specified by the delimiters. The output is an array of bits that is set ON (1) when the input value is greater than or equal to the lower limit and less than or equal to the upper limit. The output is set OFF (0) when the input is outside this range or when the range is invalid, as when the lower limit exceeds the upper limit.

Mnemonics:
 ARRAY_RANGE_DINT
 ARRAY_RANGE_DWORD
 ARRAY_RANGE_INT
 ARRAY_RANGE_UINT
 ARRAY_RANGE_WORD

The ARRAY_RANGE function compares a single input value against two arrays of delimiters that specify an upper and lower bound to determine if the input value falls within the range specified by the delimiters. The output is an array of bits that is set ON (1) when the input value is greater than or equal to the lower limit and less than or equal to the upper limit. The output is set OFF (0) when the input is outside this range or when the range is invalid, as when the lower limit exceeds the upper limit.

When ARRAY_RANGE receives power, it compares the value in input parameter IN against each range specified by the array element values of LL and UL. Output Q sets a bit ON (1) for each corresponding array element where the value of IN is greater than or equal to the value of LL and is less than or equal to the value of UL. Output Q sets a bit OFF (0) for each corresponding array element where the value of IN is not within this range or when the range is invalid, as when the value of LL exceeds the value of UL. If the operation is successful, ARRAY_RANGE passes power flow to the right.

Operands for Array Range

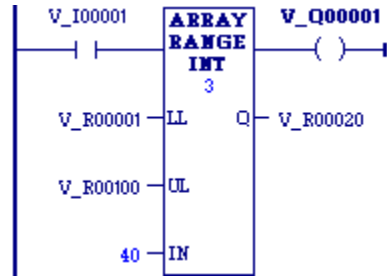
Notes:

- For each mnemonic, use the corresponding data type for the LL, UL, and Q operands. For example, ARRAY_RANGE_DINT requires LL, UL, and Q to be DINT variables.
- Q is not aligned. It is displayed in bit format. It displays either a 1 (ON) or a 0 (OFF) for the first array element. For BOOL references, it represents the reference displayed. For other references, it represents the low order bit of the reference displayed.

Parameter	Description	Allowed Operands	Optional
Length (??)	The number of elements in each array.	Constant	No
LL	The lower limit of the range	All except constants and %S - %SC for INT, DINT.	No
UL	The upper limit of the range	All except constants and %S - %SC for INT, DINT.	No
IN	The value to compare against each range specified by LL and UL	All except constants and %S - %SC for INT, DINT.	No
Q	Energized when the value in IN is within the range specified by LL and UL, inclusive.	All except S	No

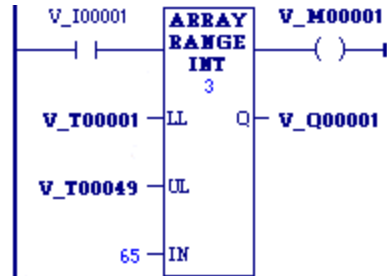
Array Range Example 1

The lower limit (LL) values of %R00001 through %R00008 are 1, 20, 30, 100, 25, 50, 10, and 200. The upper limit (UL) values of %R00100 through %R00108 are 40, 50, 150, 2, 45, 90, 250, and 47. The resulting Q values will be placed in the first 8 bits of %R00200. The bit values low order to high are: 1, 1, 1, 0, 1, 0, 1, and 0. The bit value displayed will be set ON (1) for the low order bit of %R00200. The ok output will be set ON (1).

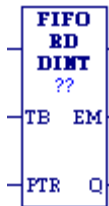


Array Range Example 2

The lower limit (LL) array contains %T00001 through %T00016, %T00017 through %T00032, and %T00033 through %T00048. The lower limit values are 100, 65, and 1. The upper limit (UL) values are 29, 165, and 2. The resulting Q values of 0, 1, and 0 will be placed in %Q00001 through %Q00003. The bit value displayed will be 0 (OFF), representing the value of %Q00001. The power output will be set ON (1).



7.8.22 FIFO Read



The First-In-First-Out (FIFO) Read (FIFO_RD) function moves data out of tables. Values are always moved out of the bottom of the table. If the pointer reaches the last location and the table becomes full, FIFO_RD must be used to remove the entry at the pointer location and decrement the pointer by one. FIFO_RD is used in conjunction with the FIFO_WRT function, which increments the pointer and writes entries into the table.

Mnemonics:
 FIFO_RD_DINT
 FIFO_RD_DWORD
 FIFO_RD_INT
 FIFO_RD_UINT
 FIFO_RD_WORD

1. FIFO_RD copies the top location (entry 0) of the table to output parameter Q. Additional program logic must then be used to place the data in the input reference.
2. The remaining items in the table are copied to a lower numbered position in the table.
3. FIFO_RD decrements the pointer by one.
4. Steps 1, 2, and 3 are repeated each time FIFO_RD is executed, until the table is empty (PTR = 0).

The pointer does not wrap around when the table is full.

When FIFO_RD receives power flow, the data at the first location of the table is copied to output Q. Next, each item in the table is moved down to the next lower location. This begins with item 2 in the table, which is moved into position 1. Finally, the pointer is decremented. If this causes the pointer location to become 0, the output EM is set ON, i.e., EM indicates whether or not the table is empty.

FIFO_RD passes power to the right if the pointer is greater than zero and less than the value specified for LEN.

Note: A FIFO table is a queue. A LIFO table is a stack.

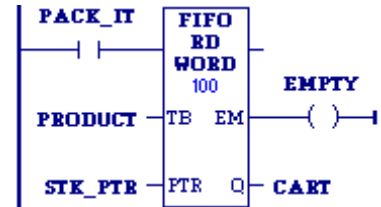
Operands for FIFO Read

Note: For each mnemonic, use the corresponding data type for the TB and Q operands. For example, FIFO_RD_DINT requires TB and Q to be DINT variables.

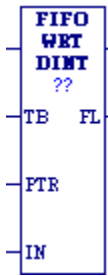
Parameter	Description	Allowed Operands	Optional
Length (??)	$1 \leq \text{Length} \leq 32,767$.	Constants	No
TB (must be the same type as Q)	The elements in the FIFO table	All except constants	No
PTR	Pointer. Index of the last element of the FIFO table.	All except constants, data flow, and variables in %S -%SC	No
EM	Energized when the last element of the table is read	Flow	No
Q (must be the same type as TB)	The element read from the FIFO table	All except constants, S; SA, SB, SC allowed only for WORD, DWORD	No

Example for FIFO Read

PRODUCT is a FIFO table with 100 word-sized elements. When the enabling input PACK_IT is ON, the PRODUCT data item in the table location pointed to by STK_PTR is copied to the reference location specified in CART. This table location pointed to would be the bottom, or oldest data item in the table. The number in STK_PTR is then decremented. A copy of the oldest data item in the PRODUCT table is left behind in each table location as the current data is copied out during successive PACK_IT triggers. Output node EM passes power when the PTR = 0, firing the coil EMPTY. No further data from the PRODUCT table can be read without first copying data in using the FIFO_WRT function.



7.8.23 FIFO Write



The First-In-First-Out (FIFO) Write (FIFO_WRT) function moves data into tables. The function increments the table pointer by one and adds an entry at the new pointer location in a FIFO table. Values are always moved in at the bottom of the table. If the pointer reaches the last location and the table becomes full, FIFO_WRT can add no further values. The FIFO_RD function must then be used to remove the entry at the pointer location and decrement the pointer by one.

Mnemonics:
 FIFO_WRT_DINT
 FIFO_WRT_DWORD
 FIFO_WRT_INT
 FIFO_WRT_UINT
 FIFO_WRT_WORD

1. FIFO_WRT increments the pointer by one.
2. FIFO_WRT copies data from input parameter IN to the position in the table indicated by the pointer. (It writes over any value currently at that location.) Additional program logic must then be used to place the data in the input reference.
3. Steps 1 and 2 are repeated each time FIFO_WRT is executed, until the table is full (PTR=0).

The pointer does not wrap around when the table is full.

When FIFO_WRT receives power flow, the pointer is incremented by 1. Then, input data is written into the table at the pointer location. If the pointer was already at the last location in the table, no data is written and FIFO_WRT does not pass power to the right. The pointer always indicates the last item entered into the table. If the table becomes full, it is not possible to add more entries to it.

FIFO_WRT passes power to the right after a successful execution (PTR < LEN).

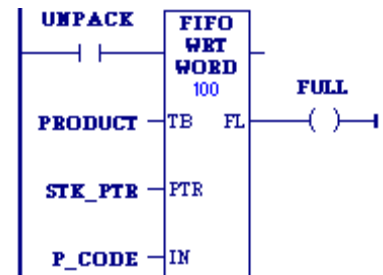
Operands for FIFO Write

Note: For each mnemonic, use the corresponding data type for the TB and IN operands. For example, FIFO_WRT_DINT requires TB and IN to be DINT variables.

Parameter	Description	Allowed Operands	Optional
Length (??)	$1 \leq \text{Length} \leq 32,767$.	Constants	No
TB (must be the same data type as IN)	The elements in the FIFO table	All except constants, data flow, and S. SA - SC allowed only for WORD, DWORD types	No
PTR	Pointer. Index of the last element of the FIFO table.	All except constants, data flow, S - SC.	No
IN (must be the same data type as TB)	The element to write to the FIFO table	All. S - SC allowed only for WORD, DWORD types.	No
FL	Energized when IN is written to the last element of the table	Power flow	No

Example for FIFO Write

PRODUCT is a FIFO table with 100 word-sized elements. When the enabling input UNPACK is ON, a data item from P_CODE is copied to the table location pointed to by the value in STK_PTR. Output node FL passes power when $\text{PTR} = \text{LEN}$, firing the FULL coil. No further data from P_CODE can be added to the table without first copying data out, using the FIFO_RD function.



7.8.24 LIFO Read



The Last-In-First-Out (LIFO) Read (LIFO_RD) function moves data out of tables. Values are always moved out of the top of the table. If the pointer reaches the last location and the table becomes full, LIFO_RD must be used to remove the entry at the pointer location and decrement the pointer by one. LIFO_RD is used in conjunction with the LIFO_WRT function, which increments the pointer and writes entries into the table.

Mnemonics:
 LIFO_RD_DINT
 LIFO_RD_DWORD
 LIFO_RD_INT
 LIFO_RD_UINT
 LIFO_RD_WORD

1. LIFO_RD copies data indicated by the pointer to output parameter Q. Additional program logic must then be used to place the data in the input reference.
2. LIFO_RD decrements the pointer by one.
3. Steps 1 and 2 are repeated each time the instruction is executed, until the table is empty (PTR = LEN).

The pointer does not wrap around when the table is full.

When LIFO_RD receives power flow, the data at the pointer location is copied to output Q, then the pointer is decremented. If this causes the pointer location to become 0, the output EM is set ON, i.e., EM indicates whether or not the table is empty. If the table is empty when LIFO_RD receives power flow, no read occurs. The pointer always indicates the last item entered into the table.

LIFO_RD passes power to the right if the pointer was in range for an element to be read.

Note: A LIFO table is a stack. A FIFO table is a queue.

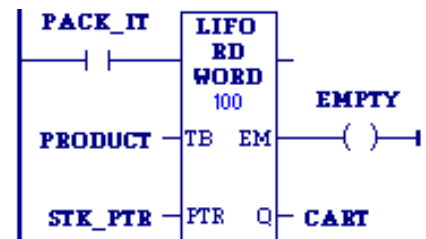
Operands for LIFO Read

Note: For each mnemonic, use the corresponding data type for the TB and Q operands. For example, LIFO_RD_DINT requires TB and Q to be DINT variables.

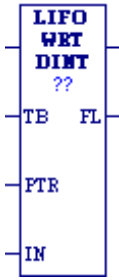
Parameter	Description	Allowed Operands	Optional
Length (??)	$1 \leq \text{Length} \leq 32,767$.	Constant	No
TB (must be the same type as Q)	The elements in the table	All except constants	No
PTR	Pointer. Index of the next element to read.	All except constants, S - SC, and data flow	No
EM	Energized when the last element of the table is read	Power flow	No
Q (must be the same type as TB)	The element read from the table	All except constants and S. SA, SB, SC allowed only for WORD, DWORD.	No

Example for LIFO Read

PRODUCT is a LIFO table with 100 word-sized elements. When the enabling input PACK_IT is ON, the data item at the top of the table is copied into the reference indicated by the nickname CART. The reference identified by STK_PTR contains the table pointer. Output coil EMPTY indicates when the table is empty.



7.8.25 LIFO Write



The Last-In-First-Out (LIFO) Write (LIFO_WRT) function increments the table pointer by one and then adds an entry at the new pointer location in a table. Values are always moved in at the top of the table. If the pointer reaches the last location and the table becomes full, LIFO_WRT cannot add further values. LIFO_RD must then be used to remove the entry at the pointer location and decrement the pointer by one.

Mnemonics:
 LIFO_WRT_DINT
 LIFO_WRT_DWORD
 LIFO_WRT_INT
 LIFO_WRT_UINT
 LIFO_WRT_WORD

1. LIFO_WRT increments the table pointer by one.
2. LIFO_WRT copies data from input parameter IN to the position in the table indicated by the pointer. (It writes over any value currently at that location.) Additional program logic must then be used to place the data in the input reference.
3. Steps 1 and 2 are repeated each time LIFO_WRT is executed, until the table is full (PTR=LEN).

The pointer does not wrap around when the table is full.

When LIFO_WRT receives power flow, the pointer increments by 1; then the new data is written at the pointer location. If the pointer was already at the last location in the table, no data is written and LIFO_WRT does not pass power to the right. The pointer always indicates the last item entered into the table. If the table is full, it is not possible to add more entries to it.

LIFO_WRT passes power to the right after a successful execution (PTR < LEN).

Note: A LIFO table is a stack. A FIFO table is a queue.

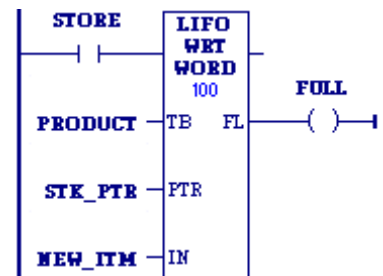
Operands for LIFO Write

Note: For each mnemonic, use the corresponding data type for the TB and IN operands. For example, LIFO_WRT_DINT requires TB and Q to be DINT variables.

Parameter	Description	Allowed Operands	Optional
Length (??)	$1 \leq \text{Length} \leq 32,767$.	Constants	No
TB (must be the same type as IN)	The elements in the table	All except constants, S, data flow. SA - SC allowed only for WORD, DWORD.	No
PTR	Pointer. Index of the next element to write.	All except constants, S - SC, and data flow	No
IN (must be the same type as TB)	The element to write to the table	All. S - SC allowed only for WORD, DWORD	No
FL	Energized when IN is written to the last element of the table	All	No

Example for LIFO Write

PRODUCT is a LIFO table with 100 word-sized elements. When the enabling input STORE is ON, a data item from NEW_ITEM is copied to the table location pointed to by the value in STK_PTR. Output FL passes power when PTR = LEN, firing the FULL coil. No further data from NEW_ITEM can be added to the table without first copying data out, using the LIFO_RD function.



7.8.26 Search



When the Search function receives power, it searches the specified memory block for a value that satisfies the search criteria. For example, SEARCH_GE_DWORD searches for a DWORD that is greater than or equal to the specified value (the IN operand).

Search can evaluate six different relationships for six data types, for a total of thirty-six mnemonics.

Search Relationships:

- SEARCH_EQ_ searches for a value of the specified data type **equal** to the IN operand.
- SEARCH_GE_ searches for a value of the specified data type **greater than or equal** to IN.
- SEARCH_GT_ searches for a value of the specified data type **greater than** IN.
- SEARCH_LE_ searches for a value of the specified data type **less than or equal** to IN.
- SEARCH_LT_ searches for a value of the specified data type **less than** IN.
- SEARCH_NE_ searches for a value of the specified data type that is **not equal** to IN.

Data types:

BYTE, DINT, DWORD, INT, UINT, WORD

Searching begins at AR+INX, where AR is the starting address and INX is the index value into the memory block. The search continues either until a register that satisfies the search criteria is found or until the end of the memory block is reached.

- If a register is found, the Found Indication (FD) is set ON and the Output Index (ONX) is set to the relative position of this register within the block.
- If no register is found before the end of the block is reached, the Found Indication (FD) is set OFF and the Output Index (ONX) is set to zero.

The input index (INX) is zero-based, that is, 0 means first reference, whereas the output index (ONX) is one-based, that is, 1 means the first reference.

The valid values for INX are 0 to (Length - 1). The valid values for ONX are 1 to Length.

INX should be set to zero to begin searching at the memory block's first register. This value increments by one at the time of execution. If the value of input INX is out-of-range, (< 0 or > Length-1), INX is set to the default value of zero.

SEARCH passes power flow to the right when it performs without error. If INX is out of range, SEARCH does not pass power flow to the right.

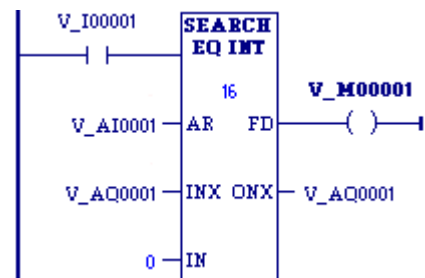
Operands for the Search Function

Note: For each mnemonic, use the corresponding data type for the AR and IN operands. For example, SEARCH_EQ_BYTE requires AR and IN to be BYTE variables.


Parameter	Description	Allowed Operands	Optional
Length (??)	The number of registers starting at AR that make up the memory block to search. $1 \leq \text{Length} \leq 32,767$ 8-bit or 16-bit registers.	Constants	No
AR (must be the same type as IN)	The starting address of the memory block to search; the address of the first register in the memory block.	All except constants	No
INX	The zero-based index into the memory block at which to begin the search. Zero points to the first reference. Valid range: $0 \leq \text{INX} \leq (\text{Length}-1)$. If INX is out of range, it is set to the default value of 0.	All except constants	No
IN (must be the same type as AR)	The value that the search is based on. For example: SEARCH_GT_DINT searches for a DINT value that is greater than IN. SEARCH_NE_UINT searches for a UINT value that is not equal to IN. SEARCH_GE_WORD searches for a WORD value that is greater than or equal to IN.	All	No
ONX	The one-based position within the memory block of the search target. A value of 1 points to the first reference. Valid range: $1 \leq \text{ONX} \leq \text{Length}$	data flow, I, Q, M, T, G, R, P, L, AI, AQ	No
FD	Found indicator. This power flow indicator is energized when a register that satisfies the search criteria is found and the function was successful.	Power flow	No

Example for the Search Function

To search the memory block %AI00001 - %AI00016, AR is set as %AI00001 and Length is set as 16. The values of the 16 registers are 100, 20, 0, 5, 90, 200, 0, 79, 102, 80, 24, 34, 987, 8, 0, and 500. Initially, the search index into AR, %AQ0001, is 5. When power flow input is ON, each scan searches the memory block looking for a match to the IN value of 0. The first scan starts searching at %AI00006 and finds a match at %AI00007, so FD turns ON and %AQ00001 becomes 7. The second scan starts searching at %AI00008 and finds a match at %AI00015, so FD remains ON and %AQ00001 becomes 15. The next scan starts at %AI00016. Since the end of the memory block is reached without a match, FD is set OFF and %AQ00001 is set to zero. The next scan starts searching at the beginning of the memory block.



7.8.27 Sort


 When it receives power flow, the SORT function sorts the elements of the memory block 'IN' in ascending order. The output memory block Q contains integers that give the index that the sorted elements had in the original memory block or list. Q is exactly the same size as IN. It also has a specification (LEN) of the number of elements to be sorted.

Mnemonics:
 SORT_INT
 SORT_UINT
 SORT_WORD

SORT operates on memory blocks of no more than 64 elements. When EN is ON, all of the elements of IN are sorted into ascending order, based on their data type. The array Q is also created, giving the original position that each sorted element held in the unsorted array. OK is always set ON.

Notes: The SORT function is executed each scan it is enabled.

Do not use the SORT function in a timed or triggered input program block.

Operands

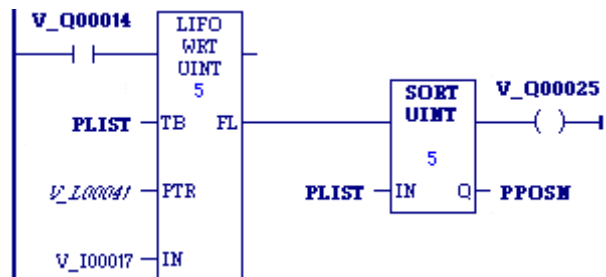
Note: For each mnemonic, use the corresponding data type for the IN and Q operands. For example, SORT_INT requires IN and Q to be INT variables.

Parameter	Description	Allowed Operands	Optional
Length (??)	The number (1–64) of elements that make up the memory block to sort.	Constants	No
IN	The memory block that contains the elements to sort. After the sort, IN contains the elements in the sorted order.	All except data flow, S, constants. SA – SC valid only for WORD type	No
Q (must be the same type as IN)	An array of indexes that gives the position of the sorted elements in the original memory block	All except S - SC and constants	No

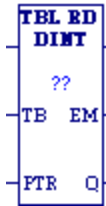
Example

New part numbers (%I00017 - %I00032) are pushed onto a parts array PLIST every time %Q00014 is ON. When the array is filled, it is sorted and the output %Q00025 is turned on. The array PPOSN then contains the original position that the now-sorted elements held before the sort was done on PLIST.

If PLIST were an array of five elements and contained the values 25, 67, 12, 35, 14 before the sort, then after the sort it would contain the values 12, 14, 25, 35, 67. PPOSN would contain the values 3, 5, 1, 4, 2.



7.8.28 Table Read



The Table Read (TBL_RD) function sequentially reads values in a table. When the pointer reaches the end of the table, it wraps around to the beginning of the table. (TBL_RD is like FIFO_RD with a wrap-around.)

Mnemonics:
 TBL_RD_DINT
 TBL_RD_DWORD
 TBL_RD_INT
 TBL_RD_UINT
 TBL_RD_WORD

When TBL_RD receives power flow:

1. TBL_RD increments the pointer by one.
2. TBL_RD copies data indicated by the pointer to output parameter Q. Additional program logic must then be used to capture the data from the output reference.
3. Steps 1 and 2 are repeated each time the instruction is executed, until the end of the table is reached (PTR=the length specified in Length). When the end of the table is reached, the pointer wraps around to the beginning of the table.

When TBL_RD receives power flow, the pointer (PTR) increments by one. If this new pointer location is the last item in the table, the output EM is set ON. The next time TBL_RD executes, PTR is automatically set back to 1. After PTR is incremented, the content at the new pointer location is copied to output Q.

TBL_RD always passes power to the right when it receives power.

Note: The TBL_RD and TBL_WRT functions can operate on the same or different tables. By specifying a different reference for the pointer, these functions can access the same data table at different locations or at different rates.

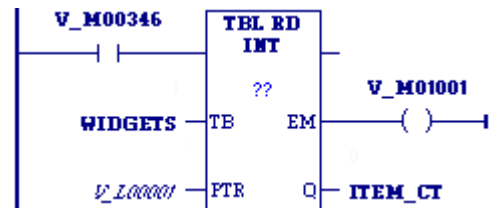
Operands

Note: For each mnemonic, use the corresponding data type for the TB and Q operands. For example, TBL_RD_DINT requires TB and Q to be DINT variables.

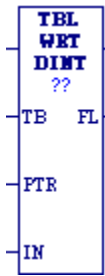
Parameter	Description	Allowed Operands	Optional
Length	$1 \leq \text{Length} \leq 32,767$	Constants	No
TB (must be the same type as Q)	The elements in the table	All except constants	No
PTR	Pointer. Index of the next element.	All except data flow, S - SC, constants	No
EM	Energized when the last element of the table is read	Power flow	No
Q (must be the same type as TB)	The element read from the table	All except constants, S, SA, SB, SC allowed only for WORD, DWORD	No

Table Read Example

WIDGETS is a table with 20 integer elements. When the enabling input %M00346 is ON, the pointer increments and the contents of the next element of the table are copied into ITEM_CT. %L00001 functions as the pointer into the data table. %M01001 is used to signal when all items of the data table have been accessed.



7.8.29 Table Write



The Table Write (TBL_WRT) function sequentially updates values in a table that never becomes full. When the pointer (PTR) reaches the end of the table, it automatically returns to the beginning of the table.

Mnemonics:
 TBL_WRT_DINT
 TBL_WRT_DWORD
 TBL_WRT_INT
 TBL_WRT_UINT
 TBL_WRT_WORD

1. TBL_WRT increments the pointer by one.
2. TBL_WRT copies data from input parameter IN to the position in the table indicated by the pointer. (It writes over any value currently at that location.) Additional program logic must then be used to place the data in the input reference.
3. Steps 1 and 2 are repeated each time the instruction is executed, until the table is full (PTR=LEN). When the table is full, the pointer wraps around to the beginning of the table.

Note: The TBL_WRT and TBL_RD functions can operate on the same or different tables. By specifying a different reference for the pointer, these functions can access the same data table at different locations or at different rates.

When TBL_WRT receives power flow, the pointer (PTR) increments by 1. If this new pointer location is the last item in the table, the output FL is set to ON. The next time TBL_WRT executes, PTR is automatically set back to 1. After incrementing PTR, TBL_WRT writes the content of the input reference to the current pointer location, overwriting data already stored there.

TBL_WRT always passes power to the right when it receives power.

Note: TBL_WRT is like FIFO_WRT with a wrap-around.

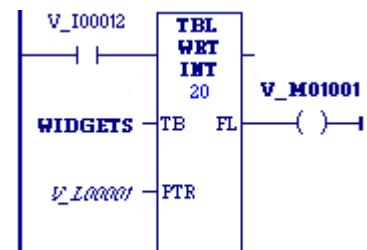
Operands

Note: For each mnemonic, use the corresponding data type for the TB and IN operands. For example, TBL_WRT_DINT requires TB and IN to be DINT variables.

Parameter	Description	Allowed Operands	Optional
Length	$1 \leq \text{Length} \leq 32,767$.	Constants	No
TB (must be the same data type as IN)	The elements in the table	All except S, constants, data flow. SA - SC allowed only for WORD, DWORD	No
PTR	Pointer. Index of the next element.	All except constants, data flow, %S - %SC	No
IN (must be the same data type as TB)	The element to write to the table	All. %S - %SC allowed only for WORD, DWORD	No
FL	Energized when IN is written to the last element of the table	Power flow	No

Table Write Example

WIDGETS is a table with 20 integer elements. When the enabling input %I00012 is ON, the pointer increments and the contents of %P00077 are written into the table at the pointer location. %L00001 functions as the pointer into the data table.



7.9. Math Functions

Your program may need to include logic to convert data to a different type before using a Math or Numerical function. The description of each function includes information about appropriate data types. The “Conversion Functions” section on page 212 explains how to convert data to a different type.

Function	Mnemonics	Description
Absolute Value	ABS_DINT, ABS_INT, ABS_REAL, ABS_LREAL	Finds the absolute value of a double-precision integer (DINT), signed single-precision integer (INT), or floating-point (REAL or LREAL) value. The mnemonic specifies the value's data type.
Add	ADD_DINT, ADD_INT, ADD_REAL, ADD_LREAL, ADD_UINT	Addition. Adds two numbers.
Divide†	DIV_DINT, DIV_INT, DIV_MIXED, DIV_REAL, DIV_LREAL, DIV_UINT	Division. Divides one number by another and outputs the quotient. Note: Take care to avoid overflow conditions when performing divisions.
Modulus	MOD_DINT, MOD_INT, MOD_UINT	Modulo Division. Divides one number by another and outputs the remainder.
Multiply†	MUL_DINT, MUL_INT, MUL_MIXED, MUL_REAL, MUL_LREAL, MUL_UINT	Multiplication. Multiplies two numbers. Note: Take care to avoid overflow conditions when performing multiplications.
Scale	SCALE	Scales an input parameter and places the result in an output location.
Subtract	SUB_DINT, SUB_INT, SUB_REAL, SUB_LREAL, SUB_UINT	Subtraction. Subtracts one number from another.

† To avoid overflows when multiplying or dividing 16-bit numbers, use the Conversion Functions described on page 212 to convert the numbers to a 32-bit format.

Overflow

When an operation results in overflow, there is no power flow.

If an operation on signed operands (INT, DINT, REAL) results in overflow, the output reference is set to its largest possible value for the data type. For signed numbers, the sign is set to show the direction of the overflow. If signed or double precision integers are used, the sign of the result for DIV and MUL functions depends on the signs of I1 and I2.

Maximum Values	MAXINT16	Maximum signed 16-bit	7FFF hex	32,767
	MAXUINT16	Maximum unsigned 16-bit	FFFF hex	65,535
	MAXINT32	Maximum signed 32-bit	7FFFFFFF hex	2,147,483,647
Minimum Values	MININT16	Minimum signed 16-bit	8000 hex	-32,768
	MININT32	Minimum signed 32-bit	80000000 hex	-2,147,483,648

If an operation on unsigned operands (UINT) results in overflow or underflow, the output value wraps around. For example the ADD_UINT operation, 65535+16, yields a result of 15.

7.9.1 Absolute Value



When the function receives power flow, it places the absolute value of input IN into output Q.

Mnemonics:
 ABS_DINT
 ABS_INT
 ABS_REAL
 ABS_LREAL

The function outputs power flow, unless one of the following conditions occurs:

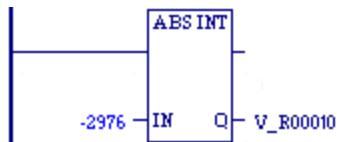
- For INT type, IN is $-32,768$.
- For DINT type, IN is $-2,147,483,648$.
- For REAL or LREAL type, IN is NaN (Not a Number).

Operands

Parameter	Description	Allowed Operands	Optional
IN (must be same type as Q)	The value to process.	All except S, SA, SB, SC	No
Q (must be same type as IN)	The absolute value of IN.	All except S, SA, SB, SC and constant	No

Example

The absolute value of $-2,976$, which is $2,976$, is placed in %R00010:



7.9.2 Add



When the ADD function receives power flow, it adds the two operands IN1 and IN2 of the same data type and stores the sum in the output variable assigned to Q, also of the same data type.

- Mnemonics:
 ADD_DINT
 ADD_INT
 ADD_REAL
 ADD_LREAL
 ADD_UINT

The power flow output is energized when ADD is performed, unless an invalid operation or overflow occurs. (For more information, see "Overflow" on page 281.)

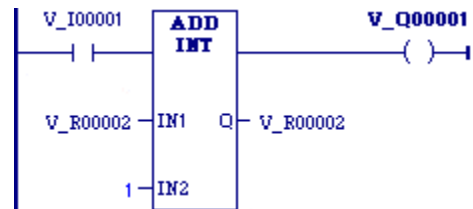
Mnemonic	Operation	Displays as
ADD_INT	Q(16 bit) = IN1(16 bit) + IN2(16 bit)	base 10 number with sign, up to 5 digits long
ADD_DINT	Q(32 bit) = IN1(32 bit) + IN2(32 bit)	base 10 number with sign, up to 10 digits long
ADD_REAL	Q(32 bit) = IN1(32 bit) + IN2(32 bit)	base 10 number, sign and decimals, up to 8 digits long (excluding the decimals)
ADD_LREAL	Q(64 bit) = IN1(64 bit) + IN2(64 bit)	base 10 number, sign and decimals, up to 17 digits long (excluding the decimals)
ADD_UINT	Q(16 bit) = IN1(16 bit) + IN2(16 bit)	base 10 number, unsigned, up to 5 digits long

Operands of the ADD Function

Operand	Description	Allowed Operands	Optional
IN1	The value to the left of the plus sign (+) in the equation $IN1+IN2=Q$.	All except S, SA, SB, SC	No
IN2	The value to the right of the plus sign (+) in the equation $IN1+IN2=Q$.	All except S, SA, SB, SC	No
Q	The result of $IN1+IN2$. If an ADD of signed operands results in overflow, Q is set to the largest possible value and there is no power flow. If an ADD_UINT operation results in overflow, Q wraps around.	All except S, SA, SB, SC and constant.	No

Example1 for ADD

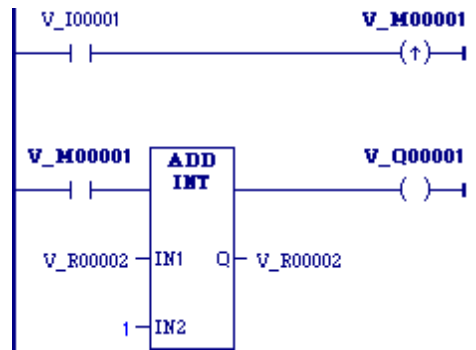
The first example is a failed attempt to create a counter circuit that would count the number of times switch %I00001 closes. The running total is stored in register %R00002. The intent of this design is that when %I0001 closes, the ADD instruction should add one to the value in %R00002 and place the new value right back into %R00002. The problem with this design is that the ADD instruction executes once every PLC scan while %I0001 is closed. For example, if %I0001 stays closed for five scans, the output increments five times, even though %I00001 only closed once during that period.



Example2 for ADD

To correct the above problem, the enable input to the ADD instruction should come from a transition ("one-shot") coil, as shown below. In the improved circuit, the %I0001 input switch controls a transition coil, %M0001, whose contact turns on the enable input of the ADD function for only one scan each time contact %I00001 closes. In order for the %M00001 contact to close again, contact %I00001 has to open and close again.

Note: If IN1 and/or IN2 is NaN (Not a Number), ADD_REAL passes no power flow.



7.9.3 Divide



When the DIV function receives power flow, it divides the operand IN1 by the operand IN2 of the same data type as IN1 and stores the quotient in the output variable assigned to Q, also of the same data type as IN1 and IN2.

The power flow output is energized when DIV is performed, unless an invalid operation or overflow occurs. (For more information, see “Overflow” on page 281.)

Mnemonics:

DIV_DINT
 DIV_INT
 DIV_MIXED
 DIV_REAL
 DIV_LREAL
 DIV_UINT

Notes:

- DIV rounds down; it does not round to the closest integer. For example, 24 DIV 5 = 4.
- DIV_MIXED uses mixed data types.
- Be careful to avoid overflows.

The following REAL and LREAL operations are invalid for DIV:

- Any number divided by 0. This operation yields a result of 65535.
- ∞ divided by ∞
- I1 and/or I2 is NaN (Not a Number)

Mnemonic	Operation	Displays as
DIV_UINT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) / IN2(16 \text{ bit})$	base 10 number, unsigned, up to 5 digits long
DIV_INT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) / IN2(16 \text{ bit})$	base 10 number with sign, up to 5 digits long
DIV_DINT	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) / IN2(32 \text{ bit})$	base 10 number with sign, up to 10 digits long
DIV_MIXED	$Q(16 \text{ bit}) = IN1(32 \text{ bit}) / IN2(16 \text{ bit})$	base 10 number with sign, up to 5 digits long
DIV_REAL	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) / IN2(32 \text{ bit})$	base 10 number, sign and decimals, up to 8 digits long (excluding the decimals)
DIV_LREAL	$Q(64 \text{ bit}) = IN1(64 \text{ bit}) / IN2(64 \text{ bit})$	base 10 number, sign and decimals, up to 17 digits long (excluding the decimals)

Operands for the DIV Function

Parameter	Description	Allowed Operands	Optional
IN1	The value to be divided; the value to the left of “DIV” in the equation $IN1 \text{ DIV } IN2=Q$.	All except S, SA, SB, SC	No
IN2	The value to divide IN1 with; the value to the right of “DIV” in the equation $IN1 \text{ DIV } IN2=Q$.	All except S, SA, SB, SC	No
Q	The quotient of IN1/IN2. If a DIV operation on signed operands results in overflow, Q is set to the largest possible value and there is no power flow. If a DIV_UINT operation results in overflow, Q wraps around.	All except S, SA, SB, SC and constant	No

DIV_MIXED Operands

Parameter	Description	Allowed Operands	Optional
IN1	The value to be divided; the value to the left of "DIV" in the equation $IN1 \text{ DIV } IN2=Q$.	All except S, SA, SB, SC	No
IN2	The value to divide IN1 with; the value to the right of "DIV" in the equation $IN1 \text{ DIV } IN2=Q$.	All except S, SA, SB, SC	No
Q	The quotient of $IN1/IN2$. If an overflow occurs, the result is the largest value with the proper sign and no power flow.	All except S, SA, SB, SC and constant	No

DIV_MIXED Example

DIV_DINT can be used in conjunction with a MUL_DINT function to scale a ± 10 volt input to $\pm 25,000$ engineering units. See "Example – Scaling Analog Input Values" on page 289.

7.9.4 Modulus



When the Modulo Division (MOD) function receives power flow, it divides input IN1 by input IN2 and outputs the remainder of the division to Q.

Mnemonics:
 MOD_DINT
 MOD_INT
 MOD_UINT

All three operands must be of the same data type. The sign of the result is always the same as the sign of input parameter IN1. Output Q is calculated using the formula:

$$Q = IN1 - ((IN1 \text{ DIV } IN2) \times IN2)$$

where DIV produces an integer number.

The power flow output is always ON when the function receives power flow, unless there is an attempt to divide by zero. In that case, the power flow output is set to OFF.

Operands for Modulus Function

Parameter	Description	Allowed Operands	Optional
IN1	The value to be divided to obtain the remainder; the value to the left of "MOD" in the equation $IN1 \text{ MOD } IN2=Q$.	All except S, SA, SB, SC	No
IN2	The value to divide IN1 with; the value to the right of "MOD" in the equation $IN1 \text{ MOD } IN2=Q$.	All except S, SA, SB, SC	No
Q	The remainder of $IN1/IN2$.	All except S, SA, SB, SC and constant	No

7.9.5 Multiply



When the MUL function receives power flow, it multiplies the two operands IN1 and IN2 of the same data type and stores the result in the output variable assigned to Q, also of the same data type.

The power flow output is energized when the function is performed, unless an invalid operation or overflow occurs. (For more information, see “Overflow” on page 281.)

Mnemonics:
 MUL_DINT
 MUL_INT
 MUL_MIXED
 MUL_REAL
 MUL_LREAL
 MUL_UINT

Note: MUL_MIXED uses mixed data types. Be careful to avoid overflows.

The following REAL and LREAL operations are invalid for MUL:

- $0 \times \infty$
- I1 and/or I2 is NaN (Not a Number).

Mnemonic	Operation	Displays as
MUL_INT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) \times IN2(16 \text{ bit})$	base 10 number with sign, up to 5 digits long
MUL_DINT	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) \times IN2(32 \text{ bit})$	base 10 number with sign, up to 10 digits long
MUL_REAL	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) \times IN2(32 \text{ bit})$	base 10 number, sign and decimals, up to 8 digits long (excluding the decimals)
MUL_LREAL	$Q(64 \text{ bit}) = IN1(64 \text{ bit}) \times IN2(64 \text{ bit})$	base 10 number, sign and decimals, up to 17 digits long (excluding the decimals)
MUL_UINT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) \times IN2(16 \text{ bit})$	base 10 number, unsigned, up to 5 digits long
MUL_MIXED	$Q(32 \text{ bit}) = IN1(16 \text{ bit}) \times IN2(16 \text{ bit})$	base 10 number with sign, up to 10 digits long

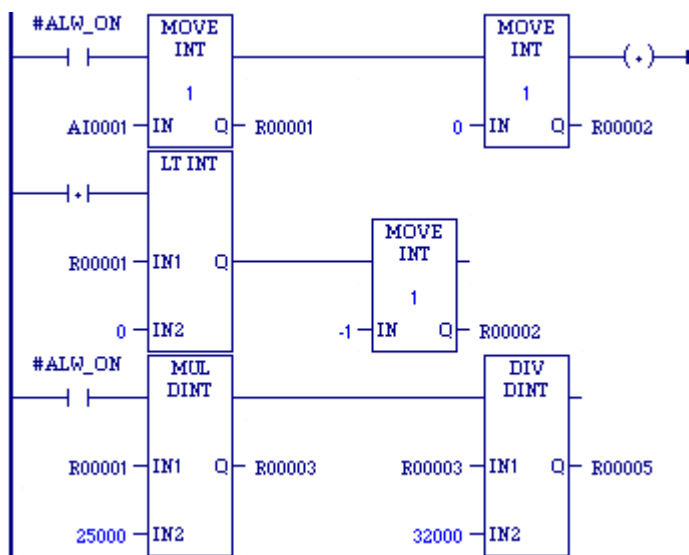
Operands for Multiply

Parameter	Description	Allowed Operands	Optional
IN1	The first value to multiply; the value to the left of the multiply sign (x) in the equation $IN1 \times IN2=Q$.	All except S, SA, SB, SC	No
IN2	The second value to multiply; the value to the right of the multiply sign (x) in the equation $IN1 \times IN2=Q$.	All except S, SA, SB, SC	No
Q	The result of $IN1 \times IN2$. If a MUL operation on signed operands results in overflow, Q is set to the largest possible value and there is no power flow. If a MUL_UINT operation results in overflow, Q wraps around.	All except S, SA, SB, SC and constant	No

Example – Scaling Analog Input Values

A common application is to scale analog input values with a MUL operation followed by a DIV and possibly an ADD operation. A 0 to ± 10 volt analog input will place values of 0 to $\pm 32,000$ in its corresponding %AI input register. Multiplying this input register using an MUL_INT function will result in an overflow since an INT type instruction has an input and output range of 32,767 to -32,768. Using the %AI value as in input to a MUL_DINT also does not work as the 32-bit IN1 will combine 2 analog inputs at the same time. To solve this problem, you can move the analog input to the low word of a double register, then test the sign and set the second register to 0 if the sign tests positive or -1 if negative. Then use the double register just created with a MUL_DINT which gives a 32-bit result, and which can be used with a following DIV_DINT function.

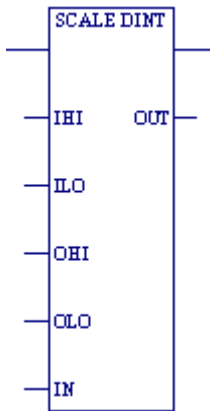
For example, the following logic could be used to scale a ± 10 volt input %AI1 to ± 25000 engineering units in %R5.



An alternate, but less accurate, way of programming this circuit using INT values involves placing the DIV_DINT instruction first, followed by the MUL_DINT instruction. The value of IN2 for the DIV instruction would be 32, and the value of IN2 for the MUL would be 25. This maintains the scaling proportion of the above circuit and keeps the values within the working range of the INT type instructions. However, the DIV instruction inherently discards any remainder value, so when the DIV output is multiplied by the MUL instruction, the error introduced by a discarded remainder is multiplied. The percent of error is non-linear over the full range of input values and is greater at lower input values.

By contrast, in the example above, the results are more accurate because the DIV operation is performed last, so the discarded remainder is not multiplied. If even greater precision is required, substitute REAL type math instructions in this example so that the remainder is not discarded.

7.9.6 Scale



When the SCALE function receives power flow, it scales the input operand IN and places the result in the output variable assigned to output operand OUT. The power flow output is energized when SCALE is performed without overflow.

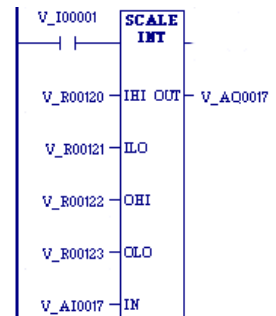
Mnemonics:
SCALE_DINT
SCALE_INT
SCALE_DINT
SCALE_UINT

Operands

Parameter	Description	Allowed Operands	Optional
IHI	(Inputs High) Maximum input value (module-related). The upper limit of the unscaled data. IHI is used with ILO, OHI and OLO to calculate the scaling factor applied to the input value IN.	All except S, SA, SB, SC	No
ILO	(Inputs Low) Minimum input value (module-related). The lower limit of the unscaled data. Must be the same data type as IHI.	All except S, SA, SB, SC	No
OHI	(Outputs High) Maximum output value. The upper limit of the scaled data. Must be the same data type as IHI. When the IN input is at the IHI value, the OUT value is the same as the OHI value.	All except S, SA, SB, SC	No
OLO	(Outputs Low) Minimum output value. The lower limit of the scaled data. Must be the same data type as IHI. When the IN input is at the ILO value, the OUT value is the same as the OLO value.	All except S, SA, SB, SC	No
IN	(INput value) The value to be scaled. Must be the same data type as IHI	All except S, SA, SB, SC	No
OUT	(OUTput value) The scaled equivalent of the input value. Must be the same data type as IHI.	All except S, SA, SB, SC	No

Example

In the example at right, the registers %R0120 through %R0123 are used to store the high and low scaling values. The input value to be scaled is analog input %AI0017. The scaled output data is used to control analog output %AQ0017. The scaling is performed whenever %I0001 is ON.



7.9.7 Subtract



When the SUB function receives power flow, it subtracts the operand IN2 from the operand IN1 of the same data type as IN2 and stores the result in the output variable assigned to Q, also of the same data type.

Mnemonics:
 SUB_DINT
 SUB_INT
 SUB_REAL
 SUB_LREAL
 SUB_UINT

The power flow output is energized when SUB is performed, unless an invalid operation or overflow occurs. (For more information, see “Overflow” on page 281.)

If a SUB_UINT operation results in a negative number, Q wraps around, yielding a result that is the highest possible value (65535) minus the absolute value of the difference -1.

The following REAL and LREAL operations are invalid for SUB:

- $(\pm \infty) - (\pm \infty)$
- I1 and/or I2 is NaN (Not a Number)

Mnemonic	Operation	Displays as
SUB_INT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) - IN2(16 \text{ bit})$	base 10 number with sign, up to 5 digits long
SUB_DINT	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) - IN2(32 \text{ bit})$	base 10 number with sign, up to 10 digits long
SUB_REAL	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) - IN2(32 \text{ bit})$	base 10 number, sign and decimals, up to 8 digits long (excluding the decimals)
SUB_LREAL	$Q(64 \text{ bit}) = IN1(64 \text{ bit}) - IN2(64 \text{ bit})$	base 10 number, sign and decimals, up to 17 digits long (excluding the decimals)
SUB_UINT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) - IN2(16 \text{ bit})$	base 10 number, unsigned, up to 5 digits long

Operands for Subtract

Parameter	Description	Allowed Operands	Optional
IN1	The value to subtract from; the value to the left of the minus sign (-) in the equation $IN1-IN2=Q$.	All except S, SA, SB, SC	No
IN2	The value to subtract from IN1; the value to the right of the minus sign (-) in the equation $IN1-IN2=Q$.	All except S, SA, SB, SC	No
Q	The result of $IN1-IN2$. If a SUB operation on signed operands results in underflow, Q is set to the smallest possible value and there is no power flow. If a SUB_UINT operation results in overflow, Q wraps around. For example, The SUB_UINT operation $600 - 601 = -1$ sets Q to 65535 The SUB_UINT operation $600 - 602 = -2$ sets Q to 65534	All except S, SA, SB, SC and constant	No

7.10. Program Flow Functions

The program flow functions limit program execution or change the way the CPU executes the application program.

Function	Mnemonic	Description
Argument Present	ARG_PRES	Determines whether an input or output parameter value was present when the function block instance of the parameter was invoked. For example, a parameter can be optional (pass by value).
Call	CALL	Causes program execution to go to a specified block.
Comment	COMMENT	Places a text explanation in the program.
End Master Control Relay	ENDMCRN	Nested End Master Control Relay. Indicates that the subsequent logic is to be executed with normal power flow.
End of Logic	END	Provides an unconditional end of logic. The program executes from the first rung to the last rung or the END instruction, whichever is encountered first.
Jump	JUMPN	Nested jump. Causes program execution to jump to a specified location indicated by a LABELN. JUMPN/LABELN pairs can be nested within one another. Multiple JUMPNs can share the same LABELN.
Label	LABELN	Nested label. Specifies the target location of a JUMPN instruction.
Master Control Relay	MCRN	Nested Master Control Relay. Causes all rungs between the MCR and its subsequent ENDMCRN to be executed without power flow. Up to MCRN/ENDMCRN pairs can be nested within one another. All the MCRNs share the same ENDMCRN.
Wires	H_WIRE	Horizontally connects elements of a line of LD logic, to complete the power flow.
	V_WIRE	Vertically connects elements of a line of LD logic, to complete the power flow.

7.10.1 Argument Present



The ARG_PRES function determines whether an input parameter value was present when the function block instance of the parameter was invoked. This may be necessary if the parameter is optional.

This function must be called from a function block instance or a parameterized block.

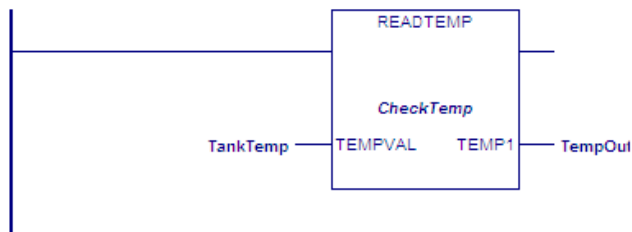
The standard output parameter ENO is false only when EN is false.

Operands for ARG_PRES

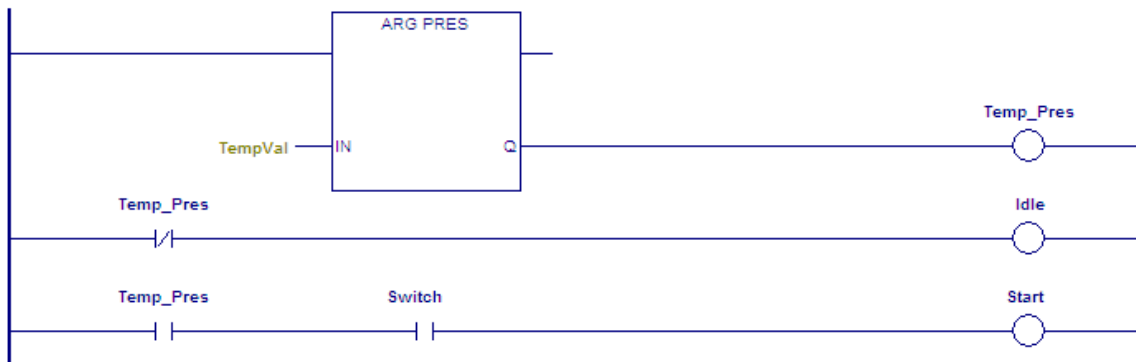
Parameter	Description	Allowed Operands	Optional
IN	Parameter name. Must be a parameter of the function block that contains the ARG_PRES instruction. Cannot be an array element or structure element. An alias to a parameter should resolve only to the parameter name.	All except flow and constants.	No
Q	True if the parameter is present, otherwise false.	Must be flow in LD. In other languages all types allowed except S, SA, SB, SC and constants.	No

Example for ARG_PRES

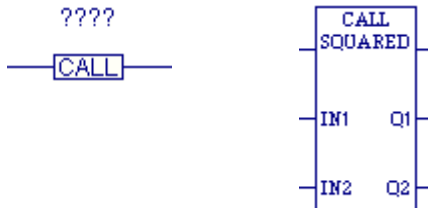
The following sample rung calls the user defined function block, ReadTemp, which has two parameters, TempVal and Temp1.



The function block ReadTemp contains the following logic, which uses an ARG_PRES function to determine whether a value for TempVal is present. If TempVal does not have a value, Temp_Pres is OFF and Idle is ON. If a value exists for TempVal, the ARG_PRES function sets Temp_Pres ON. When Temp_Pres and Switch are both ON, Start is set ON.



7.10.2 Call



Non-parameterized **Parameterized.** May call a parameterized external block or a parameterized block. May have up to 7 input and 8 output parameters.

When the CALL function receives power flow, it causes the logic execution to go immediately to the designated program block, external C block (parameterized or not), or parameterized block and execute it. After the block's execution is complete, control returns to the point in the logic immediately following the CALL instruction.

Notes:

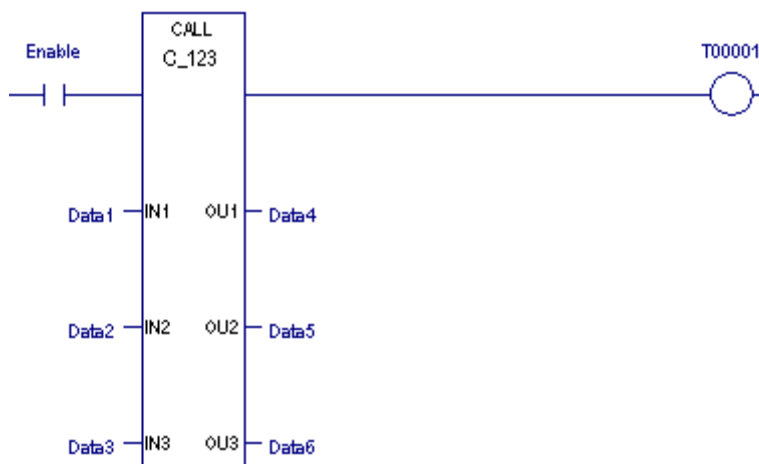
- A CALL function can be used in any program block, including the `_MAIN` block, or a parameterized block. It cannot be used in an external block.
- You cannot call a `_MAIN` block.
- The called block must exist in the target before making the call.
- There is no limit to the number of calls that can be made from or to a given block.
- You can set up recursive subroutines by having a block call itself. When stack size is configured to be the default (64K), the PLC guarantees a minimum of eight nested calls before an "Application Stack Overflow" fault is logged.
- Each block has a predefined parameter, `Y0`, which the CPU sets to 1 upon each invocation of the block. `Y0` can be controlled by logic within the block and provides the output status of the block. When the `Y0` parameter of a Program Block, parameterized block, or external C block returns ON, the CALL passes power to the right; when it returns OFF, the CALL does not pass power to the right.

Operands for Call

Parameter	Description
Block Name (????)	Block name; the name of the block to transfer to. You cannot CALL the _MAIN block. A program block or a parameterized block can call itself.
(Parameterized calls only) Input parameters (0 – 7) Output parameters (1 – 8)	<p>Notes for External (C) blocks:</p> <ul style="list-style-type: none"> You must define the TYPE, LENGTH, and NAME for each external C block parameter. The valid data type, value range, and memory area for each parameter are stated in the external block's written documentation. Data flow is permitted for any parameter. For additional information, see the section on External Blocks in Chapter 5. <p>Notes for Parameterized Blocks:</p> <ul style="list-style-type: none"> You must define the TYPE, LENGTH, and NAME for each parameter. Valid operands on the CALL instruction include variables, flow, and indirect references. Input operands can also be constants. If a formal parameter is an array of BOOL type and has a length evenly divisible by 16, then a variable or array residing in word-oriented memory can be passed on to the parameterized block as an operand. For example, if a parameterized block has a formal parameter Y1 of data type BIT and length 48, you can pass a WORD array of length 3 to Y1. The BOOL parameter Y0 is automatically defined for all parameterized blocks and can be used in the parameterized block's logic. When the parameterized block stops executing and Y0 is ON, the CALL passes power flow to the right. If Y0 is OFF, the CALL passes no power flow. A parameterized block is not required to have the same number of inputs and outputs. For additional information, see "Using Parameters with a Parameterized Block" in Chapter 5.

Example 1 for Call

In the example at right, if Enable is set, the C block named C_123 is executed. C_123 operates on the input data located at reference addresses Data1, Data2, and Data 3, and produces values located at reference addresses Data4, Data5, and Data6. Logic within C_123 controls the power flow output.



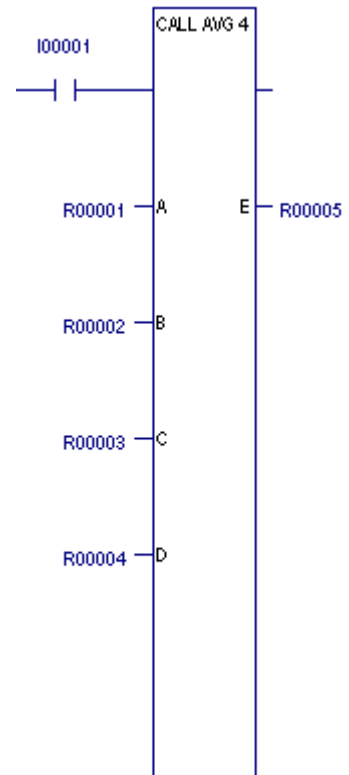
Example 2 for Call

Parameterized blocks are useful for building libraries of user-defined functions. For example, if you have an equation such as:

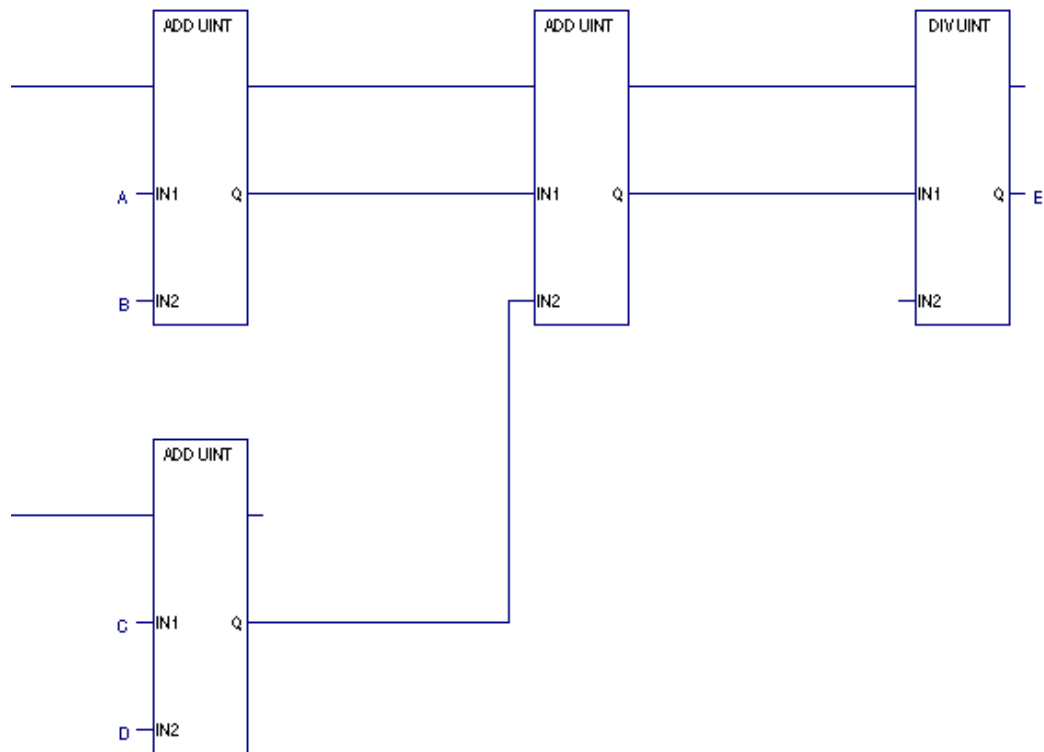
$E=(A+B+C+D)/4$, a parameterized block named AVG_4 could be called as shown in the example to the right.

In this example, the average of the values in R00001, R00002, R00003, and R00004 would be placed in R00005.

The logic within the parameterized block would be defined as shown below.



Logic for AVG_4 Parameterized Block



7.10.3 Comment



The Comment function is used to enter a text explanation in the program. When you insert a Comment instruction into the LD logic, it displays ???. After you key in a comment, the first few words are displayed.



You can set the Comment mode option to Brief or Full.

Notes:

- Editing a comment makes the Programmer lose equality.
- Comment text is downloaded to the controller and retrieved upon Logic Upload.

7.10.4 JumpN



Description

Always associated with...

Mnemonic



Nested form of Jump instruction.

a LABELN instruction

JUMPN

A JUMPN instruction causes a portion of the program logic to be bypassed. Program execution continues at the LABELN specified in the same block. Power flow jumps directly from the JUMPN to the rung with the named LABELN.

When the Jump is active, any functions between the jump and the label are not executed. All coils between JUMPN and its associated LABELN are left at their previous states. This includes coils associated with timers, counters, latches, and relays.

Any JUMPN can be either a forward or a backward jump, i.e., its LABELN can be either in a further or previous rung. The LABELN must be in the same block.

Note: To avoid creating an endless loop with forward and backward JUMPN instructions, a backward JUMPN should contain a way to make it conditional.

A JUMPN and its associated LABELN can be placed anywhere in a program, as long as the JUMPN / LABELN range:

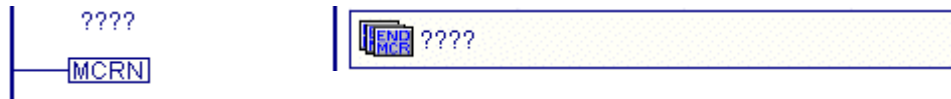
- does not overlap the range of a MCRN / ENDMCRN pair.
- does not overlap the range of a FOR_LOOP / END_FOR pair.

Nothing can be connected to the right side of a JUMPN instruction.

Operands

Parameter	Description	Optional
Label (????)	Label name; the name assigned to the destination LABEL(N).	No

7.10.5 Master Control Relay/End Master Control Relay



Description	Always associated with...	Mnemonics
Nested form of the Master Control Relay	an ENDMCRN instruction	MCRN
Nested End Master Control Relay	an MCRN instruction	ENDMCRN

MCRN

An MCRN instruction marks the beginning of a section of logic that will be executed with no power flow. The end of an MCRN section must be marked with an ENDMCRN having the same name as the MCRN. ENDMCRNs must follow their corresponding MCRNs in the logic.

All rungs between an active MCRN and its corresponding ENDMCRN are executed with negative power flow from the power rail. The ENDMCRN function associated with the MCRN causes normal program execution to resume, with positive power flow coming from the power rail.

With a Master Control Relay, functions within the scope of the Master Control Relay are executed *without power flow, and coils are turned off.*

Block calls within the scope of an active Master Control Relay will not execute. However, any timers in the block will continue to accumulate time.

A rung may not contain anything after an MCRN.

Unlike JUMP instructions, MCRNs can only move forward. An ENDMCRN instruction must appear after its corresponding MCRN instruction in a program.

The following controls are imposed by an MCRN:

- Timers do not increment or decrement. TMR types are reset. For an ONDTR function, the accumulator holds its value.
- Normal outputs are off; negated outputs are on.

Note: When an MCRN is energized, the logic it controls is scanned and contact status is displayed, but no outputs are energized. If you are not aware that an MCRN is controlling the logic being observed, this might appear to be a faulty condition.

An MCRN and its associated ENDMCRN can be placed anywhere in a program, as long as the MCRN / ENDMCRN range:

- Is completely nested within another MCRN / ENDMCRN range, up to a maximum 255 levels of nesting, or is completely outside of the range of another MCRN / ENDMCRN range.
- Is completely nested within a FOR_LOOP / END_FOR range or is completely outside of the range of a FOR_LOOP / END_FOR.

EndMCRN

The End Master Control Relay instruction marks the end of a section of logic begun with a Master Control Relay instruction. When the MCRN associated with the ENDMCRN is active, the ENDMCRN causes program execution to resume with normal power flow. When the MCRN associated with the ENDMCRN is not active, the ENDMCRN has no effect.

ENDMCRN must be tied to the power rail; there can be no logic before it in the rung; execution cannot be conditional.

ENDMCRN has a name that identifies it and associates it with the corresponding MCRN(s). The ENDMCRN function has no outputs; there can be nothing after an ENDMCR instruction in a rung.

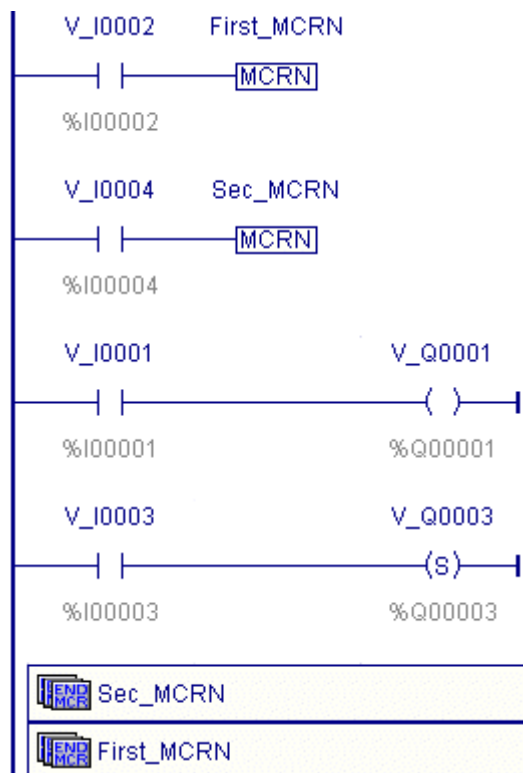
Operands for MCRN/ENDMCRN

The Master Control Relay function has a single operand, a name that identifies the MCRN. This name is used again with an ENDMCRN instruction. The MCRN has no output.

Parameter	Description	Optional
Name (????)	The name associated with the MCRN that starts the section of logic.	No

Example of MCRN/ENDMCRN

The example at right an MCRN named "Sec_MCRN" nested inside the MCRN named "First_MCRN." Whenever the V_I0002 contact allows power flow into the MCRN function, program execution will continue without power flow to the coils until the associated ENDMCRN is reached. If the V_I0001 and V_I0003 contacts are ON, the V_Q0001 coil is turned OFF and the SET coil V_Q0003 maintains its current state.



7.10.6 Wires

Horizontal and vertical wires (H_WIRE and V_WIRE) are used to connect elements of a line of LD logic between functions. Their purpose is to complete the flow of logic (“power”) from left to right in a line of logic.



A horizontal wire transmits the BOOLEAN ON/OFF state of the element on its immediate left to the element on its immediate right.

A vertical wire may intersect with one or more horizontal wires on each side. The state of the vertical wire is the inclusive OR of the ON states of the horizontal wires on its left side. The state of the vertical wire is copied to all of the attached horizontal wires on its right side.

Note: Wires can be used for data flow, but you cannot route data flow leftwards. Nor can two separate data flow lines come into the left side of the same vertical wire.

7.11. Relational Functions

Relational functions compare two values of the same data type or determine whether a number lies within a specified range. The original values are unaffected.

Function	Mnemonic	Description
Compare	CMP_DINT CMP_INT CMP_REAL CMP_LREAL CMP_UINT	Compares two numbers, IN1 and IN2, of the data type specified by the mnemonic. <ul style="list-style-type: none"> ■ If $IN1 < IN2$, the LT output is turned ON. ■ If $IN1 = IN2$, the EQ output is turned ON. ■ If $IN1 > IN2$, the GT output is turned ON.
Equal	EQ_DATA EQ_DINT EQ_INT EQ_REAL EQ_LREAL EQ_UINT	Tests two numbers for equality
Greater or Equal	GE_DINT GE_INT GE_REAL GE_LREAL GE_UINT	Tests whether one number is greater than or equal to another
Greater Than	GT_DINT GT_INT GT_REAL GT_LREAL GT_UINT	Tests whether one number is greater than another
Less or Equal	LE_DINT LE_INT LE_REAL LE_LREAL LE_UINT	Tests whether one number is less than or equal to another
Less Than	LT_DINT LT_INT LT_REAL LT_LREAL LT_UINT	Tests whether one number is less than another
Not Equal	NE_DINT NE_INT NE_REAL NE_LREAL NE_UINT	Tests two numbers for non-equality
Range	RANGE_DINT RANGE_DWORD RANGE_INT RANGE_UINT RANGE_WORD	Tests whether one number is within the range defined by two other supplied numbers

7.11.1 Compare



When the Compare (CMP) function receives power flow, it compares the value IN1 to the value IN2.

- If IN1 < IN2, CMP energizes the LT (Less Than) output.
- If IN1 = IN2, CMP energizes the EQ (Equal) output.
- If IN1 > IN2, CMP energizes the GT (Greater Than) output.

Mnemonics:
 CMP_DINT
 CMP_INT
 CMP_REAL
 CMP_LREAL
 CMP_UINT

IN1 and IN2 must be the same data type.

CMP compares data of the following types: DINT, INT, REAL, LREAL, and UINT.

Tip: To compare values of different data types, first use conversion functions to make the types the same.

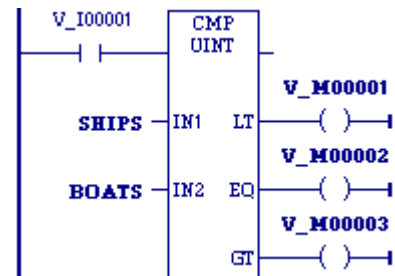
When it receives power flow, CMP always passes power flow to the right, unless IN1 and/or IN2 is NaN (Not a Number).

Operands

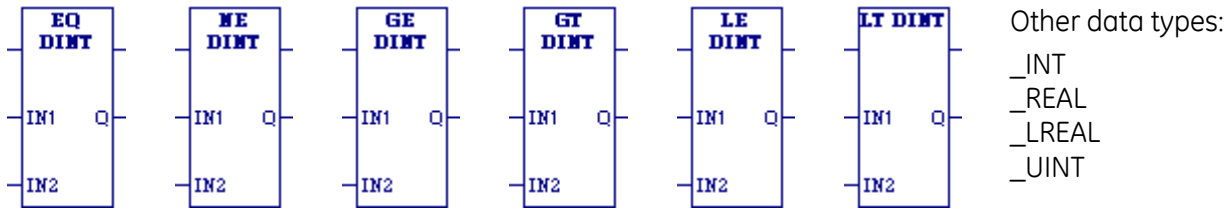
Parameter	Description	Allowed Operands	Optional
IN1	The first value to compare.	All except S, SA, SB, SC	No
IN2	The second value to compare.	All except S, SA, SB, SC	No
LT	Output LT is energized when I1 < I2.	Power flow	No
EQ	Output EQ is energized when I1 = I2.	Power flow	No
GT	Output GT is energized when I1 > I2.	Power flow	No

Example

When %I00001 is ON, the integer variable SHIPS is compared with the variable BOATS. Internal coils %M0001, %M0002, and %M0003 are set to the results of the compare.



7.11.2 Equal, Not Equal, Greater or Equal, Greater Than, Less or Equal, Less Than



When the relational function receives power flow, it compares input IN1 to input IN2. These operands must be the same data type. If inputs IN1 and IN2 are equal, the function passes power to the right, unless IN1 and/or IN2 is NaN (Not a Number). The following relational functions can be used to compare two numbers:

Function	Definition	Relational Statement
EQ	Equal	$IN1=IN2$
NE	Not Equal	$IN1\neq IN2$
GE	Greater Than or Equal	$IN1\geq IN2$
GT	Greater Than	$IN1>IN2$
LE	Less Than or Equal	$IN1\leq IN2$
LT	Less Than	$IN1<IN2$

Note: If an overflow occurs with a _UINT operation, the result wraps around – see “Overflow” on page 281.

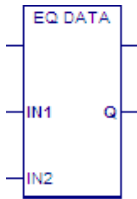
If the _DINT or _INT operations are fed the largest possible value with any sign, they cannot determine if it is an overflow value. The power flow output of the previous operation would need to be checked. If an overflow occurred on a previous DINT, or INT operation, the result was the largest possible value with the proper sign and no power flow.

Tip: To compare values of different data types, first use conversion functions to make the types the same. The relational functions require data to be one of the following types: DINT, INT, REAL, LREAL, or UINT.

Operands

Parameter	Description	Allowed Operands	Optional
IN1	The first value to be compared; the value on the left side of the relational statement.	All except S, SA, SB, SC	No
IN2	The second value to be compared; the value on the right side of the relational statement. IN2 must be the same data type as IN1.	All except S, SA, SB, SC	No
Q	The power flow. If the relational statement is true, Q is energized, unless IN1 or IN2 is NaN.	Power flow	No

7.11.3 EQ_DATA

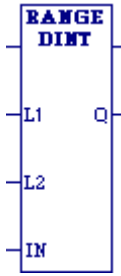


The EQ_DATA function compares two input variables, IN1 and IN2 of the same data type. If IN1 and IN2 are equal, output Q is energized. If they are not equal, Q is cleared. Mnemonic: EQ_DATA

Operands

Parameter	Description	Allowed Operands	Optional
IN1	The first value to be compared; the value on the left side of the relational statement.	PACMotion ENUM variable or structure variable. For details, refer to "Data Types and Structures" in the <i>PACMotion Multi-Axis Motion Controller User's Manual</i> , GFK-2448.	No
IN2	The second value to be compared; the value on the right side of the relational statement. IN2 must be the same data type as IN1.	PACMotion ENUM variable or structure variable.	No
Q	If IN1 or IN2 is true, Q is energized.	Power flow	No

7.11.4 Range



When the Range function is enabled, it compares the value of input IN against the range delimited by operands L1 and L2. Either L1 or L2 can be the high or low limit. When $L1 \leq IN \leq L2$ or $L2 \leq IN \leq L1$, output parameter Q is set ON (1). Otherwise, Q is set OFF (0).
If the operation is successful, it passes power flow to the right.

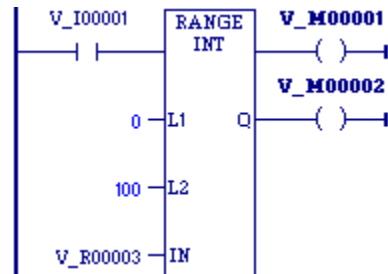
Mnemonics:
 RANGE_DINT
 RANGE_DWORD
 RANGE_INT
 RANGE_UINT
 RANGE_WORD

Operands

Parameter	Description	Allowed Operands	Optional
IN	The value to compare against the range delimited by L1 and L2. Must be the same data type as L1 and L2.	All except S, SA, SB, SC	No
L1	The start point of the range. May be the upper limit or the lower limit. Must be the same data type as IN and L2.	All except S, SA, SB, SC	No
L2	The end point of the range. May be the lower or upper limit. Must be the same data type as IN and L1.	All except S, SA, SB, SC	No
Q	If $L1 \leq IN \leq L2$ or $L2 \leq IN \leq L1$, Q is energized; otherwise, Q is off.	Power flow	No

Example

When RANGE_INT receives power flow from the normally open contact %I0001, it determines whether the value in %R00003 is within the range 0 to 100 inclusively. Output coil %M00001 is ON only if $0 \leq \%AI0050 \leq 100$.



7.12. Timers

This section describes the PACSystems timed contacts and timer function blocks that are implemented in the LD language.

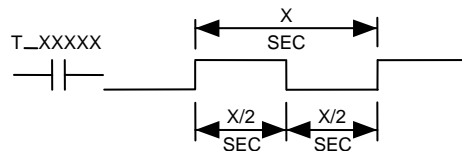
7.12.1 Timed Contacts

The PACSystems has four timed contacts that can be used to provide regular pulses of power flow to other program functions. Timed contacts cycle on and off, in square-wave form, every 0.01 second, 0.1 second, 1.0 second, and 1 minute. Timed contacts can be read by an external communications device to monitor the state of the CPU and the communications link. Timed contacts are also often used to blink pilot lights and LEDs.

The timed contacts are referenced as T_10MS (0.01 second), T_100MS (0.1 second), T_SEC (1.0 second), and T_MIN (1 minute). These contacts represent specific locations in %S memory:

```
#T_10MS  0.01 second timed contact  %S0003
#T_100MS 0.1 second timed contact   %S0004
#T_SEC    1.0 second timed contact   %S0005
#T_MIN    1.0 minute timed contact   %S0006
```

These contacts provide a pulse having an equal on and off time duration. The following timing diagram illustrates the on/off time duration of these contacts.



Caution

Do not use timed contacts for applications requiring accurate measurement of elapsed time. Timers, time-based subroutines, and PID blocks are preferred for these types of applications.

The CPU updates the timed contact references based on a free-running timer that has no relationship to the start of the CPU sweep. If the sweep time remains in phase with the timed contact clock, the contact will always appear to be in the same state. For example, if the CPU is in constant sweep mode with a sweep time setting of 100ms, the T_10MS and T_100MS bits will never toggle.



7.12.2 Timer Function Blocks

Function	Function Block Type	Mnemonic	Description
Off Delay Timer	Built-in (instance data is WORD array) See page 307.	OFDT_HUNDS OFDT_SEC OFDT_TENTHS OFDT_THOUS	The Current Value (CV) of the timer resets to zero when power flow input is on. CV increments while power flow is off. When CV=PV (Preset Value), power flow is no longer passed to the right until power flow input is on again.
On Delay Stopwatch Timer		ONDTR_HUNDS ONDTR_SEC ONDTR_TENTHS ONDTR_THOUS	Retentive on delay timer. Increments while it receives power flow and holds its value when power flow stops.
On Delay Timer		TMR_HUNDS TMR_SEC TMR_TENTHS TMR_THOUS	Simple on delay timer. Increments while it receives power flow and resets to zero when power flow stops.
Timer Off Delay	Standard (instance data is a structure variable) See page 321.	TOF	When the input IN transitions from ON to OFF, the timer starts timing until a specified period of time has elapsed, then sets the output Q to OFF.
Timer On Delay		TON	When the input IN transitions from OFF to ON, the timer starts timing until a specified period of time has elapsed, then sets the output Q to ON.
Timer Pulse		TP	When the input IN transitions from OFF to ON, the timer sets the output Q to ON for a specified time interval.

Built-In Timer Function Blocks

Note: Special care must be taken when programming timers in program blocks that are not called every sweep, and in parameterized blocks and UDFBs. For details, see:

“Using OFDT, ONDTR and TMR in Program Blocks not Called Every Sweep”, page 310.

“Timers that are Skipped by the Jump Instruction”, page 310.

“Using OFDT, ONDTR and TMR in Parameterized Blocks” page 310, and

“Using OFDT, ONDTR and TMR in UDFBs”, page 312.

Data Required for Built-in Timer Function Blocks

The data associated with these functions is retentive through power cycles. Each timer uses a three-word array of %R, %W, %P, %L or symbolic memory to store the following information:

Current value (CV) Word 1
 Preset value (PV) Word 2
 Control word Word 3



Warning

Do not use two consecutive words (registers) as the starting addresses of two timers. Logic Developer - PLC does not check or warn you if register blocks overlap. Timers will not work if you place the current value of a second timer on top of the preset value for the previous timer.

Word 1: Current value (CV)



Warning

The first word (CV) can be read but should not be written to, or the function may not work properly.

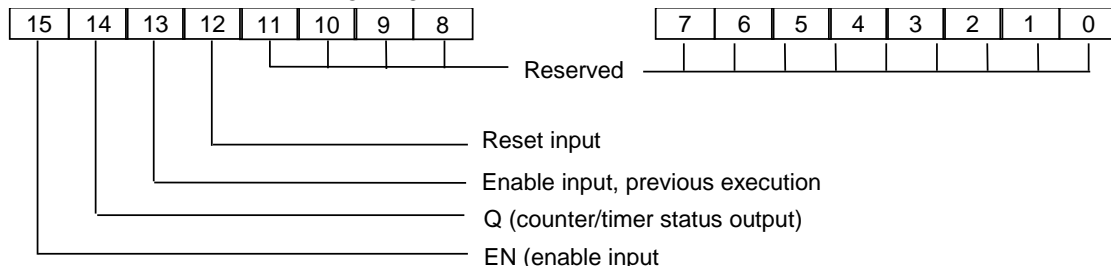
Word 2: Preset value (PV)

When the Preset Value (PV) operand is a variable, it is normally set to a different location than word 2 in the timer's or counter's three-word array.

- If you use a different address and you change word 2 directly, your change will have no effect, as PV will overwrite word 2.
- If you use the same address for the PV operand and word 2, you can change the Preset Value in word 2 while the timer or counter is running and the change will be effective.

Word 3: Control word

The control word stores the state of the Boolean inputs and outputs of its associated timer or counter, as shown in the following diagram:





Warning

The third word (Control) can be read but should not be written to; otherwise, the function will not work.

Note: Bits 0 through 13 are used for timer accuracy.

Using OFDT, ONDTR and TMR in Program Blocks not Called Every Sweep

Care should be taken when timers (ONDTR, TMR, and OFDTR) are used in program blocks that are **not** called every sweep. The timers accumulate time across calls to the sub-block unless they are reset. This means that they function like timers operating in a program with a much slower sweep than the timers in the main program block. For program blocks that are inactive for large periods of time, the timers should be programmed in such a manner as to account for this catch up feature.

Timers that are Skipped by the Jump Instruction

You should not program a Jump around an instance of OFDT, ONDTR or TMR. Timers that are skipped will **not** catch up and will therefore not accumulate time in the same manner as if they were executed every sweep.

Note: Timer function blocks do not accumulate time if used in a block that is executed as a result of an interrupt.

Using OFDT, ONDTR and TMR in Parameterized Blocks

Special care must be taken when programming timers in PACSystems parameterized blocks. Timers in parameterized blocks can be programmed to track true real-time as long as the guidelines and rules below are followed. If the guidelines and rules described here are not followed, the operation of the timer functions in parameterized blocks is undefined.

Note: These rules are not enforced by the programming software. It is your responsibility to ensure these rules are followed.

The best use of a timer function is to invoke it with a particular reference address exactly one time each scan. With parameterized blocks, it is important to use the appropriate reference memory with the timer function and to call the parameterized block an appropriate number of times.

Finding the Source Block

The source block is either the `_MAIN` block or the lowest logic block of type Block that appears above the parameterized block in the call tree. To determine the source block for a given parameterized block, determine which block invoked that parameterized block. If the calling block is `_MAIN` or of type Block, it is the source block. If the calling block is any other type (parameterized block or function block), apply the same test to the block that invoked this block. Continue back up the call tree until the `_MAIN` block or a block of type Block is found. This is the source block for the parameterized block.

Programming OFDT, ONDTR and TMR in Parameterized Blocks

Different guidelines and rules apply depending on whether you want to use the parameterized block in more than one place in your program logic.

Parameterized block called from one block

If your parameterized block that contains a timer will be called from only one logic block, follow these rules:

1. Call the parameterized block exactly one time per execution of its source block.
2. Choose a reference address for the timer that will not be manipulated anywhere else. The reference address may be %R, %P, %L, %W, or symbolic.

Note: %L memory is the same %L memory available to the source block of type Block. %L memory corresponds to %P memory when the source block is `_MAIN`.

Parameterized block called from multiple blocks

When calling the parameterized block from multiple blocks, it is imperative to separate the timer reference memory used by each call to the parameterized block. Follow these rules and guidelines:

1. Call the parameterized block exactly one time per execution of each source block in which it appears.
2. Choose a %L reference or parameterized block formal parameter for the timer reference memory. Do not use a %R, %P, %W, or symbolic memory reference.

Notes:

- The strongly recommended choice is a %L location, which is inherited from the parameterized block's source block. Each source block has its own %L memory space except the `_MAIN` block, which has a %P memory area instead. When the `_MAIN` block calls another block, the %P mappings from the `_MAIN` block are accessed by the called block as %L mappings.
- If you use a parameterized block formal parameter (word array passed-by-reference), the actual parameter that corresponds to this formal parameter must be a %L, %R, %P, %W, or symbolic reference. If the actual parameter is a %R, %P, %W, or symbolic reference, a unique reference address must be used by each source block.

Recursion

If you use recursion (that is, if you have a block call itself either directly or indirectly) and your parameterized block contains an OFDT, ONDTR, or TMR, you must follow two additional rules:

- Program the source block so that it invokes the parameterized block before making any recursive calls to itself.
- Do not program the parameterized block to call itself directly.

Using OFDT, ONDTR and TMR in UDFBs

UDFBs are user-defined logic blocks that have parameters and instance data. For details on these and other types of blocks, refer to Chapter 5.

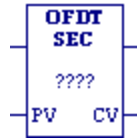
When a timer function is present inside a UDFB, and a member variable is used for the control block of a timer, the behavior of the timer may not match your expectations. If multiple instances of the UDFB are called during a logic sweep, only the first-executed instance will update its timer. If a different instance is then executed, its timer value will remain unchanged.

In the case of multiple calls to a UDFB during a logic scan, only the first call will add elapsed time to its timer functions. This behavior matches the behavior of timers in a normal program block.

Example

A UDFB is defined that uses a member variable for a timer function block. Two instances of the function block are created: timer_A and timer_B. During each logic scan, both timer_A and timer_B are executed. However, only the member variable in timer_A is updated and the member variable in timer_B always remains at 0.

Off Delay Timer



The Off-Delay Timer (OFDT) increments while power flow is off, and the timer's Current Value (CV) resets to zero when power flow is on. OFDT passes power until the specified interval PV (Preset Value) has elapsed.

Mnemonics:
 OFDT_SEC
 OFDT_TENTHS
 OFDT_HUNDS
 OFDT_THOUS

Time may be counted in the following increments:

- Seconds
- Tenths (0.1) of a second
- Hundredths (0.01) of a second
- Thousandths (0.001) of a second

The range for PV is 0 to +32,767 time units. If PV is out of range, it has no effect on the timer's word 2. The state of this timer is retentive on power failure; no automatic initialization occurs at power-up.

When OFDT receives power flow, CV is set to zero and the timer passes power to the right. The output remains on as long as OFDT receives power flow.

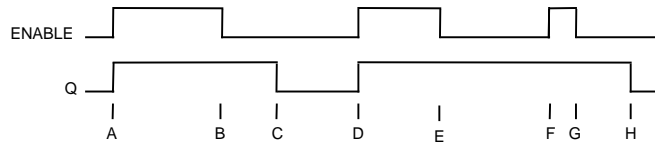
Each time the OFDT is invoked with its power flow input turned OFF, CV is updated to reflect the elapsed time since the timer was reset. OFDT continues passing power to the right until CV equals or exceeds PV. When this happens, OFDT stops passing power flow to the right and stops accumulating time. If PV is 0 or negative, the timer stops passing power flow to the right the first time that it is invoked with its power flow input OFF.

When the function receives power flow again, CV resets to zero.

Notes:

- The best way to use an OFDT function is to invoke it with a particular reference address exactly one time each scan. Do not invoke an OFDT with the same reference address more than once per scan (inappropriate accumulation of time would result). When an OFDT appears in a program block, it accumulates time once per scan. Subsequent calls to that program block within the same scan will have no effect on its OFDTs.
- Do not program an OFDT function with the same reference address in two different blocks. You should not program a JUMP around a timer function. Also, if you use recursion (where a block calls itself either directly or indirectly), program the program block so that it invokes the timer before it makes any recursive calls to itself.
- For information on using timers inside parameterized blocks, see page 310.
- An OFDT expires (turns OFF power flow to the right) the first scan that it does not receive power flow if the previous scan time was greater than PV.
- When OFDT is used in a program block that is not called every scan, the timer accumulates time between calls to the program block unless it is reset. This means that OFDT functions like a timer operating in a program with a much slower scan than the timer in the main program block. For program blocks that are inactive for a long time, OFDT should be programmed to allow for this catch-up feature. For example, if a timer in a program block is reset and the program block is not called (is inactive) for four minutes, when the program block is called, four minutes of time will already have accumulated. If the enable input is OFF, these four minutes are applied to the timer (that is, CV is set to 4 minutes).

Timing diagram



- A. ENABLE and Q both go high; timer is reset (CV = 0).
- B. ENABLE goes low; timer starts accumulating time.
- C. CV reaches PV; Q goes low and timer stops accumulating time.
- D. ENABLE goes high; timer is reset (CV = 0).
- E. ENABLE goes low; timer starts accumulating time.
- F. ENABLE goes high; timer is reset (CV = 0) before CV had a chance to reach PV. (The diagram is not to scale.)
- G. ENABLE goes low; timer begins accumulating time.
- H. CV reaches PV; Q goes low and timer stops accumulating time.

Operands for OFDT



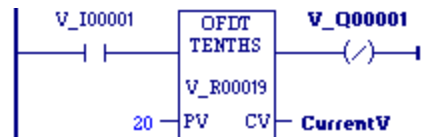
Warning

Do not use the Address, Address+1, or Address+2 addresses with other instructions. Overlapping references cause erratic timer operation.

Parameter	Description	Allowed Operands	Optional
Address (????)	The beginning address of a three-word WORD array: Word 1: Current value (CV) Word 2: Preset value (PV) Word 3: Control word	R, W, P, L, symbolic	No
PV	The Preset Value, used when the timer is enabled or reset. $0 \leq PV \leq +32,767$. If PV is out of range, it has no effect on Word 2.	All except S, SA, SB, SC	Optional
CV	The current value of the timer.	All except S, SA, SB, SC, constant	Optional

Example for OFDT

The output action is reversed by the use of a negated output coil. In this circuit, the OFDT timer turns off negated output coil %Q0001 whenever contact %I0001 is closed. After %I0001 opens, %Q0001 stays off for 2 seconds then turns on.



On Delay Stopwatch Timer



The retentive On-Delay Stopwatch Timer (ONDTR) increments while it receives power flow and holds its value when power flow stops.

Time may be counted in the following increments:

- Seconds
- Tenths (0.1) of a second
- Hundredths (0.01) of a second
- Thousandths (0.001) of a second

Mnemonics:

ONDTR_SEC
ONDTR_TENTHS
ONDTR_HUNDS
ONDTR_THOUS

The range is 0 to +32,767 time units. The state of this timer is retentive on power failure; no automatic initialization occurs at power-up.

When ONDTR first receives power flow, it starts accumulating time (Current Value (CV)). When the CV equals or exceeds Preset Value (PV), output Q is energized, regardless of the state of the power flow input.

As long as the timer continues to receive power flow, it continues accumulating until CV equals the maximum value (+32,767 time units). Once the maximum value is reached, it is retained and Q remains energized regardless of the state of the enable input.

When power flow to the timer stops, CV stops incrementing and is retained. Output Q, if energized, will remain energized. When ONDTR receives power flow again, CV again increments, beginning at the retained value.

When reset (R) receives power flow and PV is not equal to zero, CV is set back to zero and output Q is de-energized.

Note: If PV equals zero, the time is disabled and the reset is activated, and the output of the time becomes high. Subsequent removal of the reset or activation of input will have no effect on the timer output; the output of the time remains high.

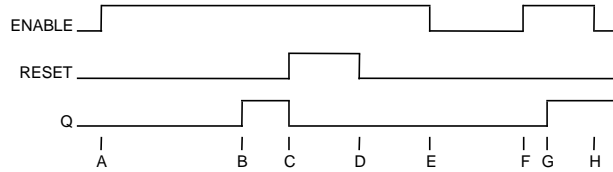
ONDTR passes power flow to the right when CV is greater than or equal to PV. Since no automatic initialization to the outgoing power flow state occurs at power-up, the power flow state is retentive across power failure.

Notes:

- The best way to use an ONDTR function is to invoke it with a particular reference address exactly one time each scan. Do not invoke an ONDTR with the same reference address more than once per scan (inappropriate accumulation of time would result). When an ONDTR appears in a program block, it will only accumulate time once per scan. Subsequent calls to that same program block within the same scan will have no effect on its ONDTRs. Do not program an ONDTR function with the same reference address in two different blocks. You should not program a JUMPN around a timer function. Also, if you use recursion (that is, having a block call itself either directly or indirectly), program the program block so that it invokes the timer before it makes any recursive calls to itself.
- For information on using timers inside parameterized blocks, see page 310.
- An ONDTR expires (passes power flow to the right) the first scan that is enabled and not reset if the previous scan time was greater than PV.
- When ONDTR is used in a program block that is not called every scan, it accumulates time between calls to the program block unless it is reset. This means that ONDTR functions like a timer operating in a program with a much slower scan than the timer in the main program block. For program blocks that are inactive for a long time, ONDTR should be programmed to allow for this catch-up feature. For example, if a timer in a program block is reset and the program block is

not called (is inactive) for four minutes, when the program block is called, four minutes of time will already have accumulated. If the enable input is ON and the reset input is OFF, these four minutes are applied to the timer (that is, CV is set to 4 minutes).

Timing diagram



- A. ENABLE goes high; timer starts accumulating.
- B. Current value (CV) reaches preset value (PV); Q goes high. Timer continues to accumulate time until ENABLE goes low, RESET goes high or current value becomes equal to the maximum time.
- C. RESET goes high; Q goes low, accumulated time is reset (CV=0).
- D. RESET goes low; timer then starts accumulating again, as ENABLE is high.
- E. ENABLE goes low; timer stops accumulating. Accumulated time stays the same.
- F. ENABLE goes high again; timer continues accumulating time.
- G. CV becomes equal to PV; Q goes high. Timer continues to accumulate time until ENABLE goes low, RESET goes high or CV becomes equal to the maximum time.
- H. ENABLE goes low; timer stops accumulating time.

Operands for On Delay Stopwatch Timer



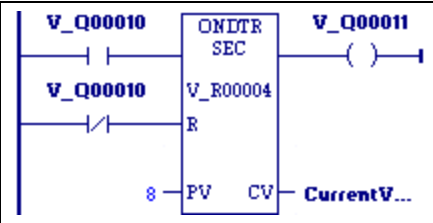
Warning

Do not use the Address, Address+1, or Address+2 addresses with other instructions. Overlapping references cause erratic timer operation.

Parameter	Description	Allowed Operands	Optional
Address (????)	Beginning address of a three-word WORD array: Word 1: Current value (CV) Word 2: Preset value (PV) Word 3: Control word	R, W, P, L, symbolic	No
R	When R is ON, it resets the Current Value (Word 1) to zero.	Power flow	Optional
PV	The Preset Value, used when the timer is enabled or reset. $0 \leq PV \leq +32,767$. If PV is out of range, it has no effect on Word 2.	All except S, SA, SB, SC	Optional
CV	Current Value of the timer	All except S, SA, SB, SC and constant	Optional

Example for On Delay Stopwatch Timer

A retentive on-delay timer is used to create a signal (%Q0011) that turns on 8.0 seconds after %Q0010 turns on, and turns off when %Q0010 turns off.



On Delay Timer



The On-Delay Timer (TMR) increments while it receives power flow and resets to zero when power flow stops. The timer passes power after the specified interval PV (Preset Value) has elapsed, as long as power is received.

Mnemonics:
 TMR_SEC
 TMR_TENTHS
 TMR_HUNDS
 TMR_THOUS

The range for PV is 0 to +32,767 time units. If PV is out of range, it has no effect on the timer's word 2. The state of this timer is retentive on power failure; no automatic initialization occurs at power-up.

Time may be counted in the following increments:

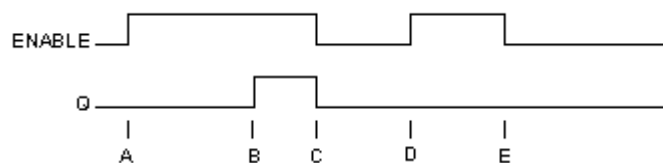
- Seconds
- Tenths (0.1) of a second
- Hundredths (0.01) of a second
- Thousandths (0.001) of a second

When TMR is invoked with its power flow input turned OFF, its Current Value (CV) is reset to zero, and the timer does not pass power flow to the right. Each time the TMR is invoked with its power flow input turned ON, CV is updated to reflect the elapsed time since the timer was reset. When CV reaches PV, the timer function passes power flow to the right.

Notes:

- The best way to use a TMR function is to invoke it with a particular reference address exactly one time each scan. Do not invoke a TMR with the same reference address more than once per scan (inappropriate accumulation of time would result). When a TMR appears in a program block, it will only accumulate time once per scan. Subsequent calls to that same program block within the same scan will have no effect on its TMRs. Do not program a TMR function with the same reference address in two different blocks. You should not program a JUMP around a timer function. Also, if you use recursion (that is, having a block call itself either directly or indirectly), program the program block so that it invokes the timer before it makes any recursive calls to itself.
- For information on using timers inside parameterized blocks, see page 310.
- A TMR timer expires (passes power flow to the right) the first scan that it is enabled if the previous scan time was greater than PV.
- When TMR is used in a program block that is not called every scan, TMR accumulates time between calls to the program block unless it is reset. This means that it functions like a timer operating in a program with a much slower sweep than the timer in the main program block. For program blocks that are inactive for a long time, TMR should be programmed to allow for this catch-up feature. For example, if a timer in a program block is reset and the program block is not called (is inactive) for 4 minutes, when the program block is called, four minutes of time will already have accumulated. If the enable input is ON, these four minutes are applied to the timer (i.e. CV is set to 4 minutes).

Timing Diagram



ENABLE goes high; timer begins accumulating time.

CV reaches PV; Q goes high and timer continues accumulating time.

ENABLE goes low; Q goes low; timer stops accumulating time and CV is cleared.

ENABLE goes high; timer starts accumulating time.

ENABLE goes low before current value reaches PV; Q remains low; timer stops accumulating time and is cleared to zero (CV=0).

Operands for On Delay Timer



Warning

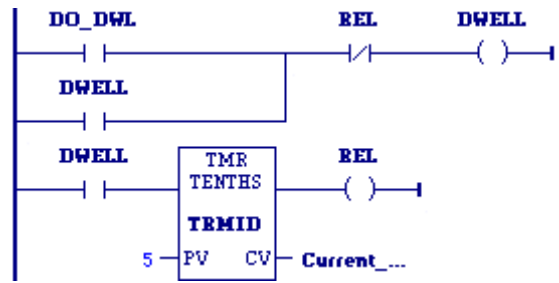
Do not use the Address, Address+1, or Address+2 addresses with other instructions. Overlapping references cause erratic timer operation.

Parameter	Description	Allowed Operands	Optional
????	The beginning address of a three-word WORD array: Word 1: Current value (CV) Word 2: Preset value (PV) Word 3: Control word	R, W, P, L, symbolic	No
PV	The Preset Value, used when the timer is enabled or reset. $0 \leq PV \leq +32,767$. If PV is out of range, it has no effect on Word 2.	All except S, SA, SB, SC	Yes
CV	The current value of the timer.	All except S, SA, SB, SC and constant	Yes

Example for On Delay Timer

An on-delay timer with address TMRID is used to control the length of time that a coil is on. This coil has been assigned the variable DWELL. When the normally open (momentary) contact DO_DWL is ON, coil DWELL is energized.

The contact of coil DWELL keeps coil DWELL energized (when contact DO_DWL is released) and also starts the timer TMRID. When TMRID reaches its preset value of five tenths of a second, coil REL energizes, interrupting the latched-on condition of coil DWELL. The contact DWELL interrupts power flow to TMRID, resetting its current value and de-energizing coil REL. The circuit is then ready for another momentary activation of contact DO_DWL.



7.12.3 Standard Timer Function Blocks

The standard timers are a pulse timer (TP), an on-delay timer (TON), and an off-delay timer (TOF). The pulse timer block can be used to generate output pulses of a given duration. The on-delay timer can be used to delay setting an output ON for a fixed period after an input is set ON. The off-delay timer can be used to delay setting an output OFF for a fixed period after an input goes OFF so that the output is held on for a given period longer than the input.

Notes:

- Any block type can contain calls to the standard timers. (See Chapter 5 for a discussion of the various block types.)
- Interrupt blocks can contain standard timers.
- An instance of a timer can be passed by reference to a parameterized block or UDFB.
- When the timer stops timing as a result of reaching its Preset Time (PT), the Elapsed Time (ET) contains the actual timer duration. For example, if the Preset Time was specified as 333ms, but the timer actually timed to 350ms, the 350ms value is saved in ET.

Data Required for Standard Timer Function Blocks

Each invocation of a timer has associated instance data that persists from one execution of the timer to the next. Instance variables are automatically located in symbolic memory. (You cannot specify an address.) You can specify a stored value for each element. The user logic cannot modify the values.

Each timer instance variable has the following structure. Elements of a timer structure cannot be published.

The instance data type for each timer must be the same as the timer type:

The TOF timer requires an instance variable of type TOF.

The TON timer requires an instance variable of type TON.

The TP timer requires an instance variable of type TP.

Element	Type	Description	Details
IN	BOOL	Timer input	Cannot be accessed in user logic.
PT	DINT	Preset time	Cannot be accessed in user logic.
ET	DINT	Elapsed time	Read only. Accessible in user logic.
Q	BOOL	Set ON when timer finishes timing	Read only. Accessible in user logic.
ENO	BOOL	Enable output	Read only. Accessible in user logic.
TI	BOOL	Set ON when the timer instance is timing (that is, ET is incrementing).	Read only. Accessible in user logic.

Resetting the Timer

The preset time (PT) may be changed while the timer is timing to affect the duration.

When the timer reaches PT, the timer stops timing and the elapsed time parameter (ET) contains the actual timer duration.

To reset the timer function block, set the PT input to 0. When the function block resets:

- ET is set to 0
- Q is set to off (0)
- The TI element is set to 0
- The IN parameter is ignored

Operands

TOF, TON and TP have the same input and output parameters, except for the instance variable, which must be the same type as the instruction.

Note: Writing or forcing values to the instance data elements IN, PT, Q, ET, ENO or TI may cause erratic operation of the timer function block.

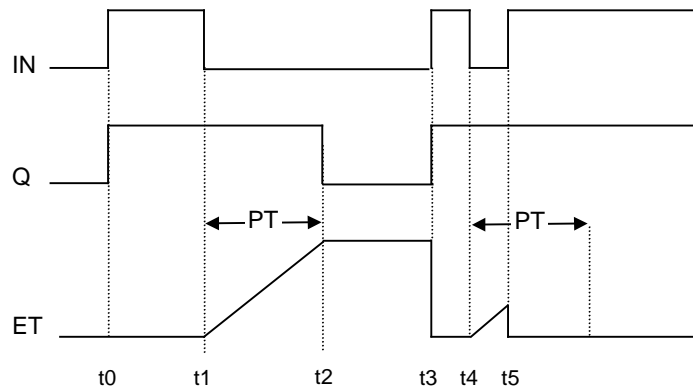
Parameter	Description	Allowed Types	Allowed Operands	Optional
???	Structure variable containing the internal data for the timer instance. (See "Data Required for Standard Timer Function Blocks" on page 321.)	TOF, TON, or TP. Must be same type as the instruction.	NA	No
IN	Timer input. Controls when the timer will accumulate time. TON and TP will begin to time when IN transitions from OFF to ON. TOF will begin to time when IN transitions from ON to OFF.	Flow	NA	Yes
PT	Preset time (in milliseconds). Indicates the amount of time the timer will time until turning Q either ON or OFF, depending on the timer type. Setting PT to 0 resets the timer.	DINT	All except S, SA, SB, SC	Yes
Q	Timer output. Action depends on the timer type. When TP is timing, Q is ON. When TON is done timing, Q turns ON. When TOF is done timing, Q turns OFF.	Flow	NA	Yes
ET	Elapsed time. Indicates the length of time, in milliseconds, that the timer has been measuring time.	DINT	All except S, SA, SB, SC and constants	Yes

Timer Off Delay



When the input IN transitions from ON to OFF, the timer starts timing until a specified period of time (PT) has elapsed, then sets the output Q to OFF.

Timing Diagram



- t0 When input IN is set to ON, the output Q follows and remains ON. The elapsed time, ET, does not increment.
- t1 When IN goes OFF, the timer starts to measure time and ET increments. ET continues to increment until its value equals the preset time, PT.
- t2 When ET equals PT, Q is set to OFF and ET remains at the preset time, PT.
- t3 When input IN is set to ON, the output Q follows and remains ON. ET is set to 0.
- t4 When IN is set to OFF, ET, begins incrementing. When IN is OFF for a period shorter than that specified by PT, Q remains ON.
- t5 When IN is set to ON, ET is set to 0.

Example

In the following sample rung, a TOF function block is used to keep Light ON for 30,000ms (30 seconds) after Door_Open is set to OFF. As long as Door_Open is ON, Light remains ON.

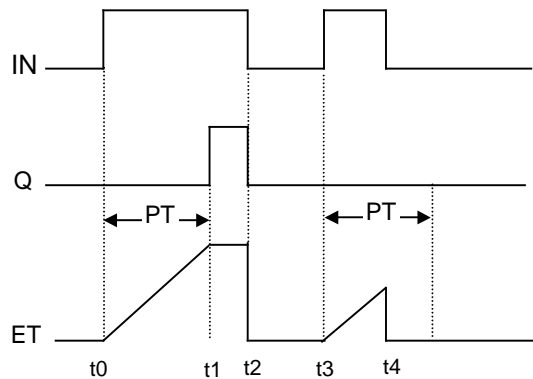


Timer On Delay



When the input IN transitions from OFF to ON, the timer starts timing until a specified period of time (PT) has elapsed, then sets the output Q to ON.

Timing Diagram



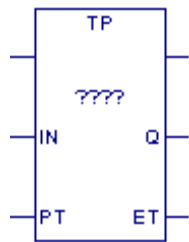
- t0 When input IN is set to ON, the timer starts to measure time and the elapsed time output ET starts to increment. The output Q remains OFF and ET continues to increment until its value equals the preset time, PT.
- t1 When ET equals PT, the output Q is goes ON, and ET remains at the preset time, PT. Q remains ON until IN goes OFF.
- t2 When IN is set to OFF, Q goes OFF and ET is set to 0.
- t3 When IN is set to ON, ET starts to increment.
- t4 If IN is ON for a shorter time than the delay specified in PT, the output Q remains OFF. ET is set to 0 when IN is set to OFF.

Example

In the following sample rung, a TON function block is used to delay setting Start to ON for 1 minute (60,000ms) after Preheat is set to ON.

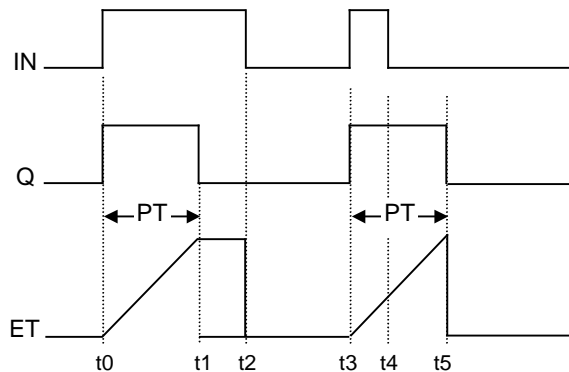


Timer Pulse



When the input IN transitions from OFF to ON, the timer sets the output Q to ON for the specified time interval, PT

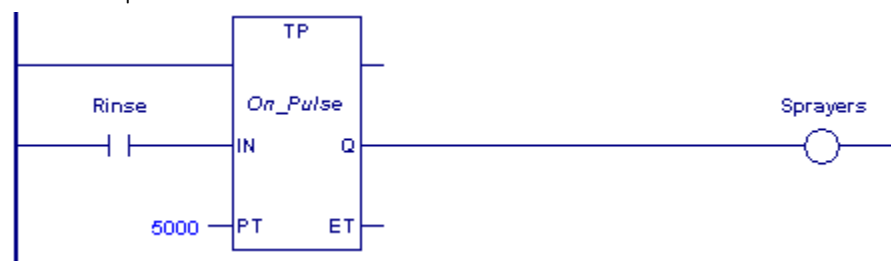
Timing Diagram



- t0 When input IN is set to ON, the timer starts to measure time and the elapsed time output, ET, increments until its value equals that of the specified preset time, PT. Q is set to 0 on until ET equals PT.
- t1 When ET equals PT, Q is set to OFF. The value of ET is held until IN is set to OFF.
- t2 When IN is set to OFF, ET is set to 0.
- t3 When IN is set to ON, the timer starts to measure time and ET begins incrementing. Q is set to ON.
- t4 If the input is OFF for a period shorter than the input PT, the output Q remains on and ET continues incrementing.
- t5 When ET equals PT, Q is set to OFF and ET is set to 0.

Example

In the following sample rung, a TP function block is used to set Sprayers to ON for a 5-second (5000ms) pulse.



Chapter 8 Function Block Diagram (FBD)

Function Block Diagram (FBD) is an IEC 61131-3 graphical programming language that represents the behavior of functions, function blocks and programs as a set of interconnected graphical blocks.

The block types Block, Parameterized Block, and Function Block can be programmed in FBD. The `_MAIN` program block can also be programmed in FBD. For details on blocks, refer to Chapter 6, “Program Data”. For information on using the FBD editor in the programming software, refer to the online help.

For an overview of the types of operands that can be used with instructions, refer to “Operands for Instructions” in Chapter 6.

Most functions and function blocks implemented in FBD are the same as their LD counterparts. Instructions that are implemented differently are discussed in detail in this chapter. FBD has the following general differences compared to LD:

- In FBD, except for timers and counters, functions and function blocks do not have EN or ENO parameters.
- In FBD, all functions and function blocks display a solve order, which is calculated by the FBD editor.

Note on Reentrancy

When a function block is created using the FBD language, the wires are created as global variables, not as members. This has two consequences. First, if there are multiple instances of that block in the program, the wires will show the values from the last instance executed during the sweep, not the values for the instance being viewed. This will give the appearance of incorrect operation while actually working properly.

The second consequence is that function blocks written in FBD are not reentrant. If you have multiple instances of a block, and one of them can be called by an interrupt, then it is possible for the interrupt to trigger while one instance of the block is in process, change the values of the wires, and then return control to the original block. This will result in improper operation.

There is a work-around for both of these symptoms, which is to create the wires as member variables rather than global variables. This must be done manually by creating member variables of the appropriate types. You can then right-click on each wire in the FBD diagram and use the *Replace Variable* command to change the wire from a global variable to a member variable.

Caution



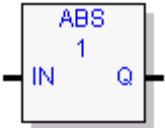
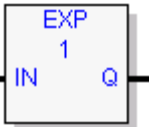

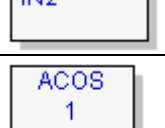


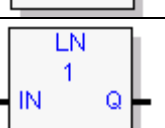
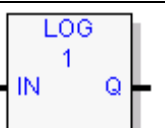
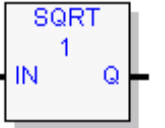
Blocks written in the FBD language are not reentrant. Because of this, if the block is called directly, or indirectly, from an interrupt, the block must not be called anywhere else in the program, except when steps are taken to explicitly make it reentrant (see above). Doing so can lead to unexpected operation. This applies to basic blocks, parameterized blocks, and user-defined function blocks written in FBD.

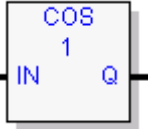
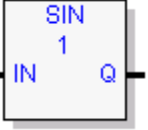
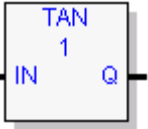
The FBD implementation of the PACSystems instruction set includes the following categories:

- Advanced Math *page* 351
- Bit Operations 332
- Comment Block 337
- Communication
Consists of the PNIO_DEV_COMM function. For details, refer to the *PACSystems RX3i PROFINET Controller Manual*, GFK-2571.
- Comparison Functions 338
- Control Functions 341
- Counters 343
- Data Move Functions 344
- Math Functions 351
- Program Flow Functions 359
- Timers 360
- Type Conversion Functions 362

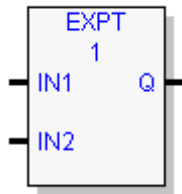
8.1. Advanced Math Functions

The Advanced Math functions perform logarithmic, exponential, square root, trigonometric, and inverse trigonometric operations.

Function	Description
	<p>Absolute value. Finds the absolute value of a double-precision integer (DINT), signed single-precision integer (INT), REAL or LREAL (floating-point) value. The mnemonic specifies the value's data type.</p> <p>For details, see "Absolute Value" in Chapter 7.</p>
	<p>Exponential. Raises e to the value specified in IN (e^{IN}). Calculates the inverse natural logarithm of the IN operand.</p> <p>For details, see "Exponential/Logarithmic Functions" in Chapter 7.</p>
	<p>Exponential. Calculates IN1 to the IN2 power ($IN1^{IN2}$).</p> <p>For details, see page 331.</p>
	<p>Inverse trig. Calculates the inverse cosine of the IN operand and expresses the result in radians.</p> <p>For details, see "Inverse Trig – ASIN, ACOS, and ATAN" in Chapter 7.</p>
	<p>Inverse trig. Calculates the inverse sine of the IN operand and expresses the result in radians.</p> <p>For details, see "Inverse Trig – ASIN, ACOS, and ATAN" in Chapter 7.</p>
	<p>Inverse trig. Calculates the inverse tangent of the IN operand and expresses the result in radians.</p> <p>For details, see "Inverse Trig – ASIN, ACOS, and ATAN" in Chapter 7.</p>
	<p>Logarithmic. Calculates the natural logarithm of the operand IN.</p> <p>For details, see "Exponential/Logarithmic Functions" in Chapter 7.</p>
	<p>Logarithmic. Calculates the base 10 logarithm of the operand IN.</p> <p>For details, see "Exponential/Logarithmic Functions" in Chapter 7.</p>
	<p>Square root. Calculates the square root of the operand IN and stores the result in Q.</p> <p>For details, see "Square Root" in Chapter 7.</p>

Function	Description
 <p>The diagram shows a rectangular function block with 'COS' at the top and '1' below it. On the left side, there is an input terminal labeled 'IN'. On the right side, there is an output terminal labeled 'Q'.</p>	<p>Trig. Calculates the cosine of the operand IN, where IN is expressed in radians. For details, see “Trig Functions” in Chapter 7.</p>
 <p>The diagram shows a rectangular function block with 'SIN' at the top and '1' below it. On the left side, there is an input terminal labeled 'IN'. On the right side, there is an output terminal labeled 'Q'.</p>	<p>Calculates the sine of the operand IN, where IN is expressed in radians. For details, see “Trig Functions” in Chapter 7.</p>
 <p>The diagram shows a rectangular function block with 'TAN' at the top and '1' below it. On the left side, there is an input terminal labeled 'IN'. On the right side, there is an output terminal labeled 'Q'.</p>	<p>Calculates the tangent of the operand IN, where IN is expressed in radians. For details, see “Trig Functions” in Chapter 7.</p>

8.1.1 EXPT Function



The Power of X (EXPT) function raises the value of input IN1 to the power specified by the value IN2 and places the result in Q. The EXPT function operates on REAL or LREAL input value(s) and place the result in output Q. The instruction is not carried out if one of the following invalid conditions occurs:

- IN1 < 0, for EXPT
- IN1 or IN2 is a NaN (Not a Number)

Invalid operations (error cases) may yield results that are different from those in the LD implementation of this function.

Operands of the EXPT Function

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN or IN1	For EXP, LOG, and LN, IN contains the REAL value to be operated on. The EXPT function has two inputs, IN1 and IN2. For EXPT, IN1 is the base value and IN2 is the exponent.	REAL, LREAL	All except variables located in %S—%SC	No
IN2 (EXPT)	The REAL exponent for EXPT.	REAL, LREAL	All except variables located in %S—%SC	No
Q	Contains the REAL logarithmic/exponential value of IN or of IN1 and IN2.	REAL, LREAL	All except constants and variables located in %S—%SC	No

8.2. Bit Operation Functions

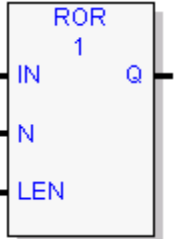
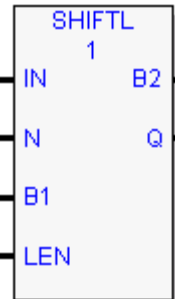
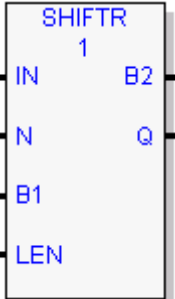
The Bit Operation functions perform comparison, logical, and move operations on bit strings. Bit Operation functions treat each WORD or DWORD data as a continuous string of bits, with bit 1 of the WORD or DWORD being the Least Significant Bit (LSB). The last bit of the WORD or DWORD is the Most Significant Bit (MSB).



Warning

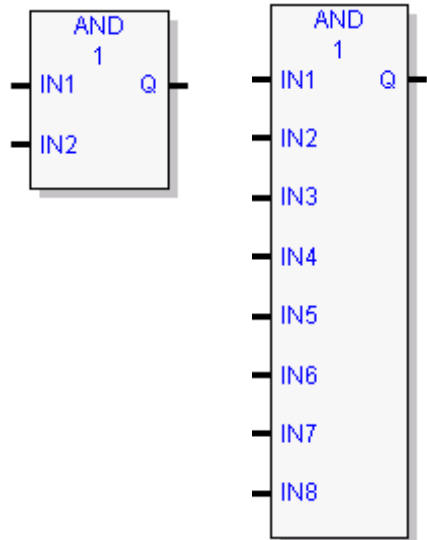
Overlapping input and output reference address ranges in multiword functions is not recommended, as it can produce unexpected results.

Function	Description
	<p>Logical AND. Compares the bit strings IN1 and IN2 bit by bit. When the corresponding bits are both 1, places a 1 in the corresponding location in output string Q; otherwise, places a 0 in the corresponding location in Q.</p> <p>If additional inputs (IN3 through IN8) are used, each additional bit string is compared to the string in Q and the result is placed in Q.</p> <p>For details, see page 334.</p>
	<p>Logical OR. Compares the bit strings IN1 and IN2 bit by bit. When a pair of corresponding bits are both 0, places a 0 in the corresponding location in output string Q; otherwise, places a 1 in the corresponding location in Q.</p> <p>If additional inputs (IN3 through IN8) are used, each additional bit string is compared to the string in Q and the result is placed in Q.</p> <p>For details, see page 334.</p>
	<p>Logical XOR. Compares the bit strings IN1 and IN2 bit by bit. When a pair of corresponding bits are different, places a 1 in the corresponding location in the output bit string Q; when a pair of corresponding bits are the same, places a 0 in Q.</p> <p>If additional inputs (IN3 through IN8) are used, each additional bit string is compared to the string in Q and the result is placed in Q.</p> <p>For details, see page 334.</p>
	<p>Logical NOT. Sets the state of each bit in output bit string Q to the opposite state of the corresponding bit in bit string IN1.</p> <p>For details, see page 336.</p>
	<p>Rotate Bits Left. Rotates all the bits in a string a specified number of places to the left.</p> <p>For details, see "Bit Operation Functions" in Chapter 7.</p>

Function	Description
	<p>Rotate Bits Right. Rotates all the bits in a string a specified number of places to the right. For details, see "Bit Operation Functions" in Chapter 7.</p>
	<p>Shift Bits Left. Shifts all the bits in a word or string of words to the left by a specified number of places. For details, see "Bit Operation Functions" in Chapter 7.</p>
	<p>Shift Bits Right. Shifts all the bits in a word or string of words to the right by a specified number of places. For details, see "Bit Operation Functions" in Chapter 7.</p>

8.2.1 Logical AND, Logical OR, and Logical XOR

The Logical functions examine each bit in bit string IN1 and the corresponding bit in bit string IN2, beginning with the least significant bit in each string, and places the result in Q. If additional inputs (IN3 up to IN8) are used, the function compares each bit in the input with the corresponding bit in Q and places the result in Q. The comparison is repeated for each input that is used. The input bit strings specified in IN1 ... IN8 may overlap.

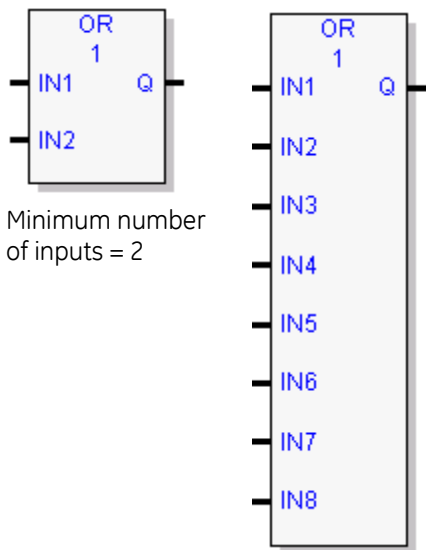


Logical AND

If both bits examined by the Logical AND function are 1, AND places a 1 in the corresponding location in output string Q. If either bit is 0 or both bits are 0, AND places a 0 in string Q in that location.

Tip: You can use the Logical AND function to build masks or screens, where only certain bits are passed (the bits opposite a 1 in the mask), and all other bits are set to 0.

Minimum number of inputs = 2
Maximum number of inputs = 8



Minimum number of inputs = 2

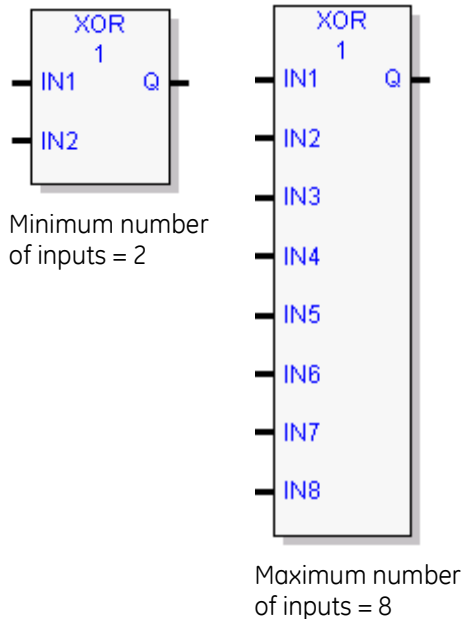
Logical OR

If either bit examined by the Logical OR function is 1, OR places a 1 in the corresponding location in output string Q. If both bits are 0, Logical OR places a 0 in string Q in that location.

Tips:

- You can use the Logical OR function to combine strings or to control many outputs with one simple logical structure. The Logical OR function is the equivalent of two relay contacts in parallel multiplied by the number of bits in the string.
- You can use the Logical OR function to drive indicator lamps directly from input states or to superimpose blinking conditions on status lights.

Maximum number of inputs = 8



Logical XOR

If the bits in the strings examined by XOR are different, a 1 is placed in the corresponding position in the output bit string. For each pair of bits examined, if only one bit is 1, XOR places a 1 in the corresponding location in string Q.

If both bits are 0, XOR places a 0 in the corresponding location in string Q.

Tips:

- If string IN2 and output string Q begin at the same reference, a 1 placed in string IN1 will cause the corresponding bit in string IN2 to alternate between 0 and 1, changing state with each scan as long as input is received.
- You can program longer cycles by pulsing the input to the function at twice the desired rate of flashing. The input pulse should be one scan long (one-shot type coil or self resetting timer).
- You can use XOR to quickly compare two bit strings, or to blink a group of bits at the rate of one ON state per two scans.
- XOR is useful for transparency masks.

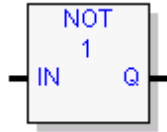
Operands for AND, OR, and XOR

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1	The value to operate on.	BOOL, WORD DWORD	All	No
IN2 (Must be the same data type as IN1.)	The value to operate on.	BOOL, WORD DWORD	All	No
IN3 ... IN8 (Must be the same data type as IN1.)	Values to operate on.	BOOL, WORD DWORD	All	Yes
Q (Must be the same data type as IN1 and IN2.)	The operation's result.	BOOL, WORD DWORD	All except constants and variables located in %S memory	No

Properties for AND, OR, and XOR

Property	Valid Range
Number of Inputs	2 to 8

8.2.2 Logical NOT



The Logical Not or Logical Invert (NOT) function sets the state of each bit in the output bit string Q to the opposite of the state of the corresponding bit in bit string IN1.

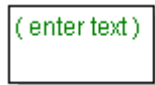
All bits are altered on each scan that input is received, making output string Q the logical complement of input string IN1.

Operands

<i>Parameter</i>	<i>Description</i>	<i>Allowed Types</i>	<i>Allowed Operands</i>	<i>Optional</i>
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1	The input string to NOT.	WORD DWORD	All	No
Q (Must be the same data type as IN1)	The NOT's result.	WORD DWORD	All except constants and variables located in %S memory	No

8.3. Comments

8.3.1 Text Block



The Text block is used to place an explanation in the program. When you type in a comment, the first few words are displayed.



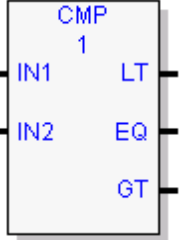
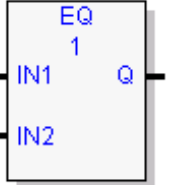
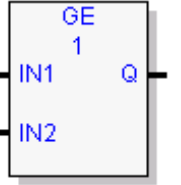
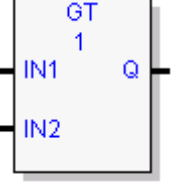
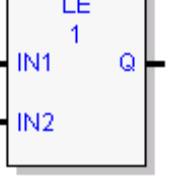
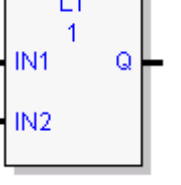
To increase the size of the text box and display more text, select the box and drag one of the handles.

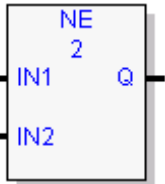
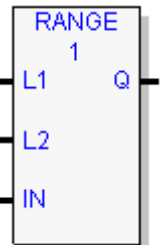
There are no operands for the Text block.

- Editing a comment makes the Programmer lose equality.
- Comment text is downloaded to the controller and retrieved upon Logic Upload.

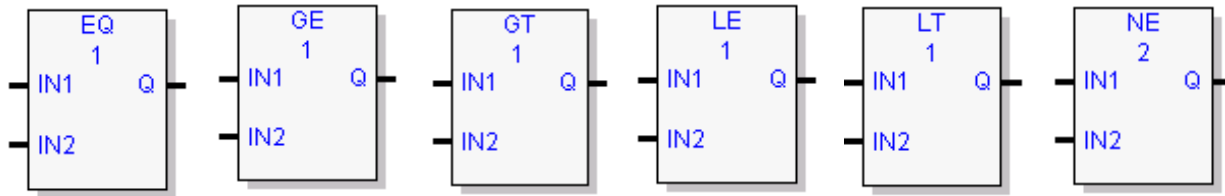
8.4. Comparison Functions

Comparison functions compare two values of the same data type or determine whether a number lies within a specified range. The original values are unaffected.

Function	Description
 <p>The diagram shows a rectangular function block labeled 'CMP 1'. It has two input terminals on the left labeled 'IN1' and 'IN2'. On the right side, there are three output terminals labeled 'LT', 'EQ', and 'GT'.</p>	<p>Compare. Compares two numbers, IN1 and IN2. For details, see "Relational Functions" in Chapter 7.</p>
 <p>The diagram shows a rectangular function block labeled 'EQ 1'. It has two input terminals on the left labeled 'IN1' and 'IN2'. On the right side, there is one output terminal labeled 'Q'.</p>	<p>Equal. Tests two numbers for equality. For details, see page 340.</p>
 <p>The diagram shows a rectangular function block labeled 'GE 1'. It has two input terminals on the left labeled 'IN1' and 'IN2'. On the right side, there is one output terminal labeled 'Q'.</p>	<p>Greater Than or Equal. Tests whether one number is greater than or equal to another. For details, see page 340.</p>
 <p>The diagram shows a rectangular function block labeled 'GT 1'. It has two input terminals on the left labeled 'IN1' and 'IN2'. On the right side, there is one output terminal labeled 'Q'.</p>	<p>Greater Than. Tests whether one number is greater than another. For details, see page 340.</p>
 <p>The diagram shows a rectangular function block labeled 'LE 1'. It has two input terminals on the left labeled 'IN1' and 'IN2'. On the right side, there is one output terminal labeled 'Q'.</p>	<p>Less Than or Equal. Tests whether one number is less than or equal to another. For details, see page 340.</p>
 <p>The diagram shows a rectangular function block labeled 'LT 1'. It has two input terminals on the left labeled 'IN1' and 'IN2'. On the right side, there is one output terminal labeled 'Q'.</p>	<p>Less Than. Tests whether one number is less than another. For details, see page 340.</p>

Function	Description
	Not Equal. Tests whether two numbers are not equal. For details, see page 340.
	Range. Tests whether one number is within the range defined by two other supplied numbers. For details, see "Relational Functions" in Chapter 7.

8.4.1 Equal, Not Equal, Greater or Equal, Greater Than, Less or Equal, Less Than



The relational functions compare input IN1 to input IN2. These operands must be the same data type. If inputs IN1 and IN2 are equal, the function outputs the result to Q, unless IN1 and/or IN2 is NaN (Not a Number). The following relational functions can be used to compare two numbers:

Function	Definition	Relational Statement
EQ	Equal	$IN1=IN2$
NE	Not Equal	$IN1\neq IN2$
GE	Greater Than or Equal	$IN1\geq IN2$
GT	Greater Than	$IN1>IN2$
LE	Less Than or Equal	$IN1\leq IN2$
LT	Less Than	$IN1<IN2$

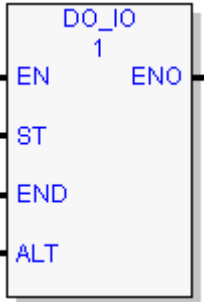

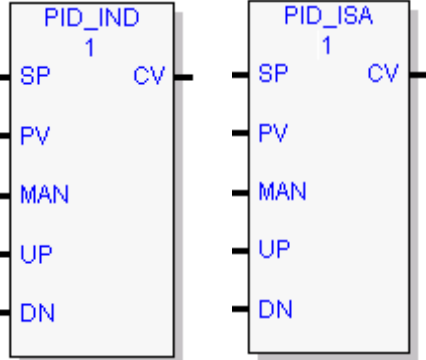
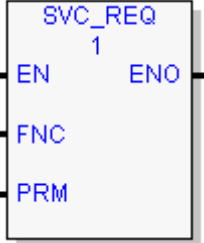
Tip: To compare values of different data types, first use conversion functions to make the types the same.

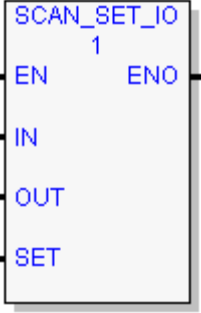
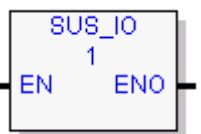
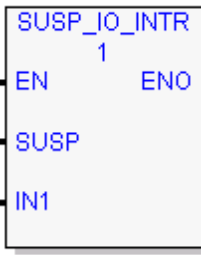
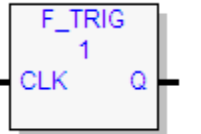
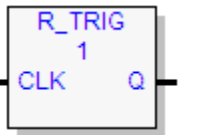
Operands

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1	The first value to be compared; the value on the left side of the relational statement.	BOOL (for EQ and NE functions only), BYTE, DINT, DWORD, INT, REAL, LREAL, UINT, WORD	All except S, SA, SB, SC	No
IN2	The second value to be compared; the value on the right side of the relational statement. IN2 must be the same data type as IN1.			No
Q	If the relational statement is true, Q=1.	BOOL Bit reference in a non-BOOL variable.	I, Q, G, M, T, SA, SB, SC All except constants.	No

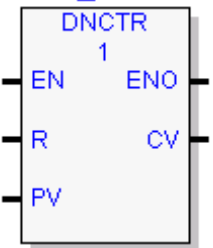
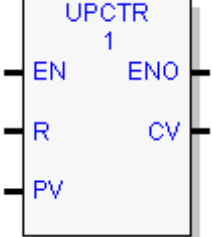
8.5. Control Functions

The control functions limit program execution and change the way the CPU executes the application program.

Function	Description
 <p>DO_IO 1</p> <p>EN ENO</p> <p>ST</p> <p>END</p> <p>ALT</p>	<p>Do I/O Interrupt. For one scan, immediately services a specified range of inputs or outputs. (All inputs or outputs on a module are serviced if any reference locations on that module are included in the DO I/O function. Partial I/O module updates are not performed.) Optionally, a copy of the scanned I/O can be placed in internal memory, rather than at the real input points.</p> <p>For details, see “Control Functions” in Chapter 7.</p>
 <p>MASK_IO_INTR 1</p> <p>EN ENO</p> <p>MASK</p> <p>IN1</p>	<p>Mask I/O Interrupt. Mask or unmask an interrupt from an I/O board when using I/O variables. If not using I/O variables, use SVC_REQ 17: Mask/Unmask I/O Interrupt, described in Chapter 9.</p> <p>For details, see “Control Functions” in Chapter 7.</p>
 <p>PID_IND 1 CV</p> <p>SP PV</p> <p>MAN</p> <p>UP</p> <p>DN</p> <p>PID_ISA 1 CV</p> <p>SP PV</p> <p>MAN</p> <p>UP</p> <p>DN</p>	<p>Proportional Integral Derivative (PID) Control. Provides two PID closed-loop control algorithms:</p> <ul style="list-style-type: none"> Standard ISA PID algorithm (PID_ISA) Independent term algorithm (PID_IND) <p>Note: For details, refer to Chapter 10.</p>
 <p>SVC_REQ 1</p> <p>EN ENO</p> <p>FNC</p> <p>PRM</p>	<p>Service Request. Requests a special control system service.</p> <p>Note: For details, refer to Chapter 9.</p>

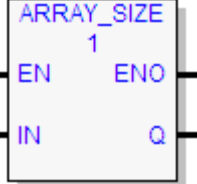
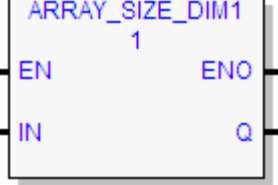
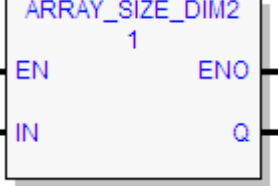
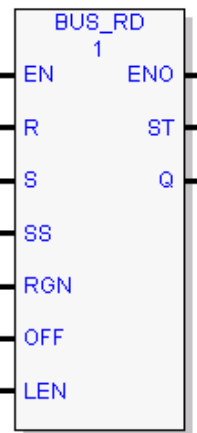
Function	Description
	<p>Scan Set I/O. Scans the IO of a specified scan set. For details, see “Control Functions” in Chapter 7.</p>
	<p>Suspend I/O. Suspends for one sweep all normal I/O updates, except those specified by DO I/O instructions. For details, see “Control Functions” in Chapter 7.</p>
	<p>Suspend I/O Interrupt. Suspend or resume an I/O interrupt when using I/O variables. If not using I/O variables, use SVC_REQ 32: Suspend/Resume I/O Interrupt, described in Chapter 9. For details, see “Control Functions” in Chapter 7.</p>
	<p>Falling Edge Trigger. Detects a high-to-low transition of a Boolean input. Produces a single output pulse when a falling edge is detected. For details, see “Control Functions” in Chapter 7.</p>
	<p>Rising Edge Trigger. Detects a low-to-high transition of a Boolean input. Produces a single output pulse when a rising edge is detected. For details, see “Control Functions” in Chapter 7.</p>

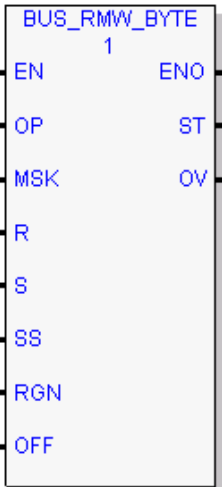
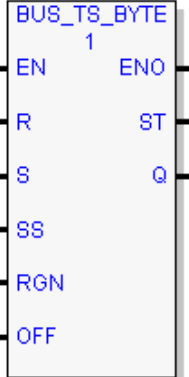
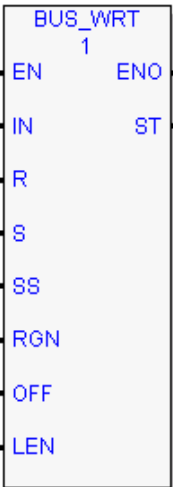
8.6. Counters

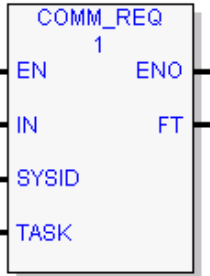
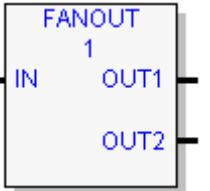
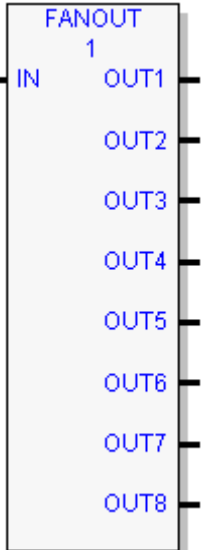
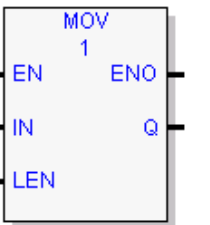
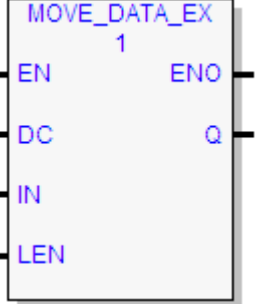
Function	Description
<p>control_parameter</p> 	<p>Down Counter. Counts down from a preset value. The output is ON whenever the Current Value is ≤ 0.</p> <p>The parameter that appears above the function block is a one-dimensional, three-word array in %R, %W, %P, %L, or symbolic memory that the counter uses to store its current value, preset value and control word.</p> <p>For details, see "Counters" in Chapter 7.</p>
<p>control_parameter</p> 	<p>Up Counter. Counts up to a designated value. The output is ON whenever the Current Value is \geq the Preset Value.</p> <p>The parameter that appears above the function block is a one-dimensional, three-word array in %R, %W, %P, %L, or symbolic memory that the counter uses to store its current value, preset value and control word.</p> <p>For details, see "Counters" in Chapter 7.</p>

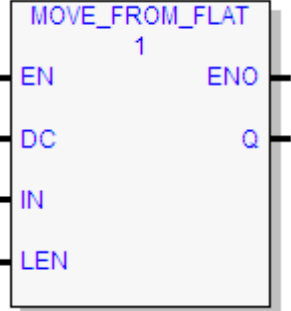
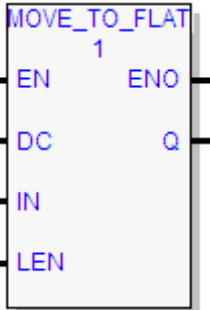
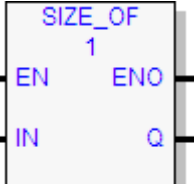
8.7. Data Move Functions

The Data Move functions provide basic data move capabilities.

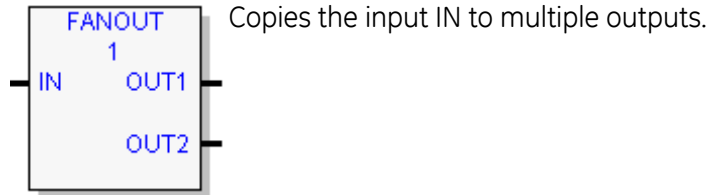
Function	Description
	<p>Array Size. Counts the number of elements in an array. For details, see “Data Move Functions” in Chapter 7.</p>
	<p>Array Size Dim1. Returns the value of the Array Dimension 1 property of an array. For details, see “Data Move Functions” in Chapter 7.</p>
	<p>Array Size Dim2. Returns the value of the Array Dimension 2 property of an array. For details, see “Data Move Functions” in Chapter 7.</p>
	<p>Bus Read. Reads data from the bus. For details, see “Data Move Functions” in Chapter 7.</p>

Function	Description
 <p>The diagram shows a vertical rectangular function block labeled 'BUS_RMW_BYTE' at the top. Below the label is a small '1' in a square. On the left side, there are eight input terminals labeled EN, OP, MSK, R, S, SS, RGN, and OFF. On the right side, there are three output terminals labeled ENO, ST, and OV.</p>	<p>Bus Read Modify Write. Uses a read/modify/write cycle to update a data element in a module on the bus.</p> <p>Other BUS_RMW functions: BUS_RMW_DWORD BUS_RMW_WORD</p> <p>For details, see “Data Move Functions” in Chapter 7.</p>
 <p>The diagram shows a vertical rectangular function block labeled 'BUS_TS_BYTE' at the top. Below the label is a small '1' in a square. On the left side, there are six input terminals labeled EN, R, S, SS, RGN, and OFF. On the right side, there are three output terminals labeled ENO, ST, and Q.</p>	<p>Bus Test and Set. Handles semaphores on the bus.</p> <p>Other BUS_TS function: BUS_TS_WORD</p> <p>For details, see “Data Move Functions” in Chapter 7.</p>
 <p>The diagram shows a vertical rectangular function block labeled 'BUS_WRT' at the top. Below the label is a small '1' in a square. On the left side, there are eight input terminals labeled EN, IN, R, S, SS, RGN, OFF, and LEN. On the right side, there are two output terminals labeled ENO and ST.</p>	<p>Bus Write. Writes data to a module on the bus.</p> <p>For details, see “Data Move Functions” in Chapter 7.</p>

Function	Description	
 <p>COMM_REQ 1 EN ENO IN FT SYSID TASK</p>	<p>Communication Request. Allows the program to communicate with an intelligent module, such as a Genius Bus Controller or a High Speed Counter.</p> <p>For details, see “Communication Request” in Chapter 7.</p>	
 <p>FANOUT 1 IN OUT1 OUT2</p> <p>Minimum Outputs = 2</p>	 <p>FANOUT 1 IN OUT1 OUT2 OUT3 OUT4 OUT5 OUT6 OUT7 OUT8</p> <p>Maximum Outputs = 8</p>	<p>Fan Out. Copies the input value to multiple outputs of the same data type as the input.</p> <p>For details, see page 348.</p>
 <p>MOV 1 EN ENO IN Q LEN</p>	<p>Move Data. Copies data as individual bits, so the new location does not have to be the same data type. Data can be moved into a different data type without prior conversion.</p> <p>For details, see page 349.</p>	
 <p>MOVE_DATA_EX 1 EN ENO DC Q IN LEN</p>	<p>Move Data Explicit. Provides data coherency by locking symbolic memory being written to during the copy operation.</p> <p>For details, see “Data Move Functions” in Chapter 7.</p> <p>Note: FBD and ST do not support the constant 0 as a value for the input IN.</p>	

Function	Description
 <p>The diagram shows a rectangular function block titled 'MOVE_FROM_FLAT' with a '1' in the top right corner. On the left side, there are four input terminals labeled 'EN', 'DC', 'IN', and 'LEN'. On the right side, there are two output terminals labeled 'ENO' and 'Q'.</p>	<p>Move From Flat. Copies reference memory data to a UDT variable or UDT array. Provides the option of locking the symbolic or I/O variable memory area being written to during the copy operation. For details, see “Data Move Functions” in Chapter 7.</p>
 <p>The diagram shows a rectangular function block titled 'MOVE_TO_FLAT' with a '1' in the top right corner. On the left side, there are four input terminals labeled 'EN', 'DC', 'IN', and 'LEN'. On the right side, there are two output terminals labeled 'ENO' and 'Q'.</p>	<p>Move to Flat. Copies data from symbolic or I/O variable memory to reference memory. Copies across mismatching data types. For details, see “Data Move Functions” in Chapter 7.</p>
 <p>The diagram shows a rectangular function block titled 'SIZE_OF' with a '1' in the top right corner. On the left side, there are two input terminals labeled 'EN' and 'IN'. On the right side, there are two output terminals labeled 'ENO' and 'Q'.</p>	<p>Size Of. Counts the number of bits used by a variable. For details, see “Data Move Functions” in Chapter 7.</p>

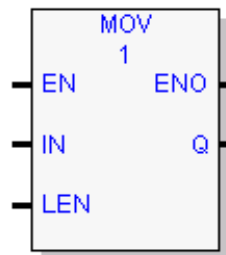
8.10.1 Fan Out



Operands

<i>Parameter</i>	<i>Description</i>	<i>Allowed Types</i>	<i>Allowed Operands</i>	<i>Optional</i>
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The input to copy to the outputs.	BOOL, DINT, DWORD, INT, REAL, UINT, or WORD variable or constant	All except SA, SB, SC.	No
OUT1 ...OUT8	Variables of the same data type as the IN operand. The outputs. Minimum: two outputs. Maximum: eight outputs.	Must be same type as IN.	All except S, SA, SB, SC and constant.	No

8.10.2 Move Data



When the input operand, EN, is set to ON, the MOVE instruction copies data as bits from one location in PACSystems controller memory to another. Because the data is copied as bits, the new location does not need to use the same type of memory area as the source. For example, you can copy data from an analog memory area into a discrete memory area, or vice versa.

MOV sets its output, ENO, whenever it receives data unless one of the following occurs:

- When the input, EN, is set to OFF, then the output, ENO, is set to OFF.
- When the input, EN is set to ON, and the input, IN, contains an indirect reference, and the memory of IN is out of range, then the output, ENO, is set to OFF.

The value to store at the destination Q is acquired from the IN parameter. If IN is a variable, the value to store in Q is the value stored at the IN address. If IN is a constant, the value to store in Q is that constant

The result of the MOVE depends on whether the data type for the Q operand is a bit reference or a non-bit reference:

- If Q is a non-bit reference, LEN (the length) indicates the number of memory locations in which the IN value should be repeated, starting at the location specified by Q.
- If Q is a bit reference, IN is treated as an array of bits. LEN therefore indicates the number of bits to acquire from the IN parameter to make up the stored value. If IN is a constant, bits are counted from the least-significant bit. If IN is a variable, LEN indicates the number of bits to acquire starting at the IN location. Regardless, only LEN bits are stored starting at address Q.

For example, if IN was the constant value 29 and LEN is 4, the results of a MOV operation are as follows:

- Q is a WORD reference: The value 29 is repeatedly stored in locations Q, Q+1, Q+2, and Q+3.
- Q is a BOOL reference: The binary representation of 29 is 11101. Since LEN is 4, only the four least-significant bits are used (1101). This value is stored at location Q in the same order, so 1 is stored in Q, 1 is stored in Q+1, 0 is stored in Q+2, and 1 is stored in Q+3.

If data is moved from one location in discrete memory to another, such as from %I memory to %T memory, the transition information associated with the discrete memory elements is updated to indicate whether or not the MOVE operation caused any discrete memory elements to change state.

Note: If an array of BOOL-type data specified in the Q operand does not include all the bits in a byte, the transition bits associated with that byte (which are not in the array) are cleared when the Move instruction receives data.

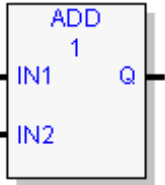
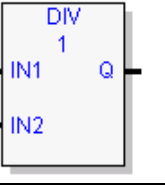
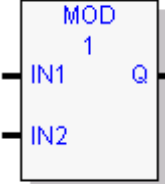
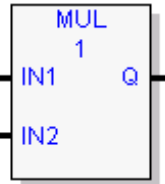

Data at the IN operand does not change unless there is an overlap in the source and destination—a situation that is to be avoided.

MOV Operands

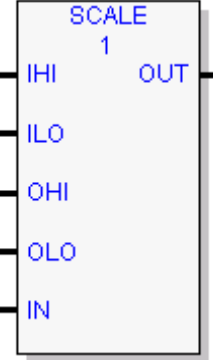
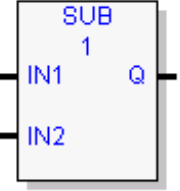
Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
EN	Enable	BOOL variable	data flow, I, Q, M, T, G, S, SA, SB, SC, discrete symbolic, I/O variable	No
		Bit reference in a non-BOOL variable	R, P, L, AI, AQ, W, non-discrete symbolic, I/O variable	
IN	The source of the data to copy into the output Q. This can be either a constant or a variable whose reference address is the location of the first source data item to move. IN must have the same data type as the variable in the Q parameter. If IN is a BOOL variable or a bit reference, an %I, %Q, %M, or %T reference address need not be byte-aligned, but 16 bits beginning with the reference address specified are displayed online.	DINT, DWORD, INT, REAL, LREAL, UINT, WORD, or bit reference in a non-BOOL variable	All. S, SA, SB, SC allowed only for WORD, DWORD, BOOL types.	No
LEN	The length of IN; the number of bits to move. If IN is a constant and Q is BOOL: $1 \leq \text{LEN} \leq 16$; If IN is a constant and Q is <i>not</i> BOOL: $1 \leq \text{LEN} \leq 256$. All other cases: $1 \leq \text{LEN} \leq 32,767$ LEN is also interpreted differently depending on the data type of the Q location. For details, see discussion on page 349.	Constant	Constant	No
ENO	Indicates whether the operation was successfully completed. If ENO = ON (1), the operation was initiated. Results of the operation are indicated in the FT output. If ENO = OFF (0), the operation was not performed. If EN was ON, the FT output indicates an error condition. If EN was OFF, FT is not changed.	BOOL variable	data flow, I, Q, M, T, G, discrete symbolic, I/O variable	Yes
		Bit reference in a non-BOOL variable	I, Q, M, T, G, R, P, L, AI, AQ, W, non-discrete symbolic, I/O variable	
Q	The location of the first destination data item. Q must have the same data type as the variable in the IN parameter. If Q is a BOOL variable or a bit reference, an %I, %Q, %M, or %T reference address does not need to be byte-aligned, but 16 bits beginning with the specified reference address are displayed online.	DINT, DWORD, INT, REAL, LREAL, UINT, WORD, or bit reference in a non-BOOL variable	data flow, I, Q, M, T, S, SA, SB, SC, G, R, P, L, AI, AQ, W, symbolic, I/O variable	No

8.8. Math Functions

Your program may need to include logic to convert data to a different type before using a Math or Numerical function. The description of each function includes information about appropriate data types. The **Type Conversion Functions** section on page 362 explains how to convert data to a different type.

Function	Description
	<p>Addition. Adds two or up to eight numbers. For details, see page 353.</p>
	<p>Division.¹⁶ Divides one number by another and outputs the quotient. Note: Take care to avoid overflow conditions when performing divisions. For details, see page 354.</p>
	<p>Modulo Division. Divides one number by another and outputs the remainder. For details, see page 355.</p>
	<p>Multiplication. Multiplies two or up to eight numbers. Note: Take care to avoid overflow conditions when performing multiplications. For details, see page 356.</p>
	<p>Negate. Multiplies a number by -1 and places the result in an output location. For details, see page 357.</p>

¹⁶ To avoid overflows when multiplying or dividing 16-bit numbers, use the **Type Conversion Functions** described on page 336 to convert the numbers to a 32-bit format.

Function	Description
	<p>Scales an input parameter and places the result in an output location. For details, see “Math Functions” in Chapter 7.</p>
	<p>Subtraction. Subtracts one or up to seven numbers from the input IN1 and places the result in an output location. For details, see page 358.</p>

The output is calculated when the instruction is performed without overflow, unless an invalid operation occurs.

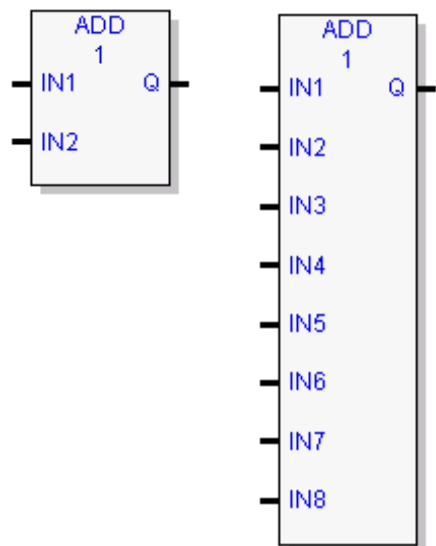
Overflow

If an operation on integer operands results in overflow, the output value wraps around.

Examples:

- If the ADD operation, $32767 + 1$, is performed on signed integer operands, the result is -32768
- If the SUB operation, $-32767 - 1$, is performed on signed integer operands, the result is 32767
- If an ADD_UINT operation is performed on $65535 + 16$, the result is 15 .

8.11.1 Add



Minimum number of inputs = 2 Maximum number of inputs = 8.

Adds the operands IN1 and IN2 ... IN8 and stores the sum in Q. IN1 ... IN8 and Q must be of the same data type.

The result is output to Q when ADD is performed without overflow, unless one of the following invalid conditions occurs:

- (+ ∞)
- IN1 and/or IN2 ... IN8 is NaN (Not a Number).

If an ADD operation results in overflow, the result wraps around. For example:

- If an ADD_DINT, ADD_INT or ADD_REAL operation is performed on 32767 + 1, Q will be set to -32768.
- If an ADD_UINT operation is performed on 65535 + 16, Q will be set to 15.

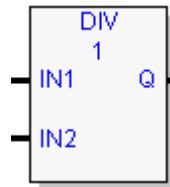
Operands of the ADD Function

Operand	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1 ... IN8	The values to be added.	INT, DINT, REAL, LREAL, UINT Must be same data type as Q.	All except S, SA, SB, SC and data flow	No
Q	The sum of IN1 ... IN8. If an overflow occurs, Q wraps around.	INT, DINT, REAL, LREAL, UINT variable Must be same data type as IN1 IN8.	All except S, SA, SB, SC, constant and data flow	No

Properties for ADD

Property	Valid Range
Number of Inputs	2 to 8

8.11.2 Divide



Divides the operand IN1 by the operand IN2 of the same data type as IN1 and stores the quotient in the output variable assigned to Q, also of the same data type as IN1 and IN2.

The result is output to Q when DIV is performed without overflow, unless one of the following invalid conditions occurs:

- 0 divided by 0 (Results in an application fault.)
- IN1 and/or IN2 is NaN (Not a Number).

If an overflow occurs, the result wraps around.

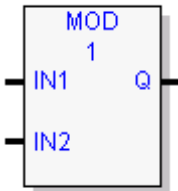
Notes:

- DIV rounds down; it does not round to the closest integer. For example, 24 DIV 5 = 4.
- Be careful to avoid overflows.

Operands for DIV_UINT, DIV_INT, DIV_DINT, and DIV_REAL

<i>Parameter</i>	<i>Description</i>	<i>Allowed Types</i>	<i>Allowed Operands</i>	<i>Optional</i>
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1	The value to be divided; the value to the left of "DIV" in the equation IN1 DIV IN2=Q.	INT, DINT, UINT, REAL, LREAL	All except S, SA, SB, SC	No
IN2	The value to divide IN1 with; the value to the right of "DIV" in the equation IN1 DIV IN2=Q.	INT, DINT, UINT, REAL, LREAL	All except S, SA, SB, SC	No
Q	The quotient of IN1/IN2. If an overflow occurs, the result is the largest value with the proper sign.	INT, DINT, UINT, REAL or LREAL variable	All except S, SA, SB, SC and constant	No

8.11.3 Modulus



Divides input IN1 by input IN2 and outputs the remainder of the division to Q.

All three operands must be of the same data type. The sign of the result is always the same as the sign of input parameter IN1. Output Q is calculated using the formula:

$$Q = IN1 - ((IN1 \text{ DIV } IN2) * IN2)$$

where DIV produces an integer number.

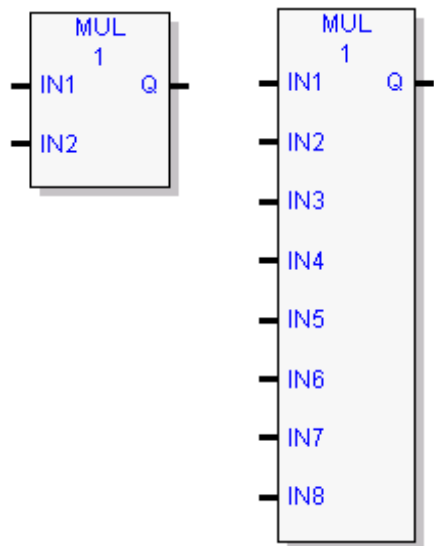
The result is output to Q unless one of the following invalid conditions occurs:

- 0 divided by 0 (Results in an application fault.)
- IN1 and/or IN2 is NaN (Not a Number)

Operands for Modulus Function

<i>Parameter</i>	<i>Description</i>	<i>Allowed Types</i>	<i>Allowed Operands</i>	<i>Optional</i>
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1	The value to be divided to obtain the remainder; the value to the left of "MOD" in the equation IN1 MOD IN2=Q.	INT, DINT, UINT	All except S, SA, SB, SC	No
IN2	The value to divide IN1 with; the value to the right of "MOD" in the equation IN1 MOD IN2=Q.	INT, DINT, UINT	All except S, SA, SB, SC	No
Q	The remainder of IN1/IN2.	INT, DINT, UINT variable	All except S, SA, SB, SC and constant	No

8.11.4 Multiply



Multiplies two through eight operands (IN1 ... IN8) of the same data type and stores the result in the output variable assigned to Q, also of the same data type.

The output is calculated when the function is performed without overflow, unless an invalid operation occurs.

If an overflow occurs, the result wraps around.

Minimum number of inputs = 2 Maximum number of inputs = 8.

Mnemonic	Operation	Displays as
INT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) * IN2(16 \text{ bit})$	base 10 number with sign, up to 5 digits long
DINT	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) * IN2(32 \text{ bit})$	base 10 number with sign, up to 10 digits long
REAL	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) * IN2(32 \text{ bit})$	base 10 number, sign and decimals, up to 8 digits long (excluding the decimals)
UINT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) * IN2(16 \text{ bit})$	base 10 number, unsigned, up to 5 digits long

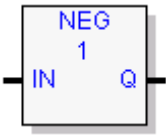
Operands for Multiply

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1 ... IN8	The values to multiply. Must be the same data type as Q.	INT, DINT, UINT, REAL	All except S, SA, SB, SC	No
Q	The result of the multiplication.	INT, DINT, UINT, REAL variable	All except S, SA, SB, SC and constant	No

Properties for Multiply

Property	Valid Range
Number of Inputs	2 to 8

8.11.5 Negate

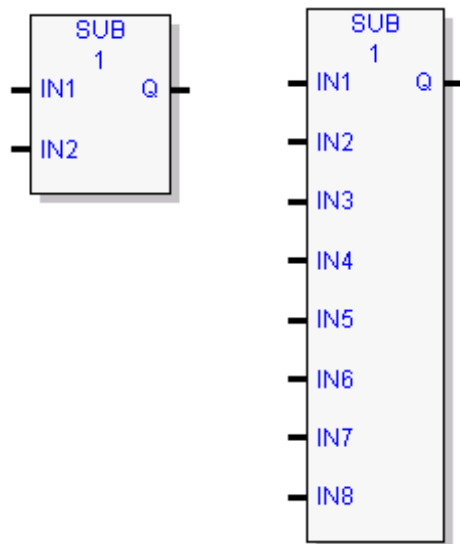


Multiplies a number by -1 and places the result in the output location, Q.

Operands

<i>Parameter</i>	<i>Description</i>	<i>Allowed Types</i>	<i>Allowed Operands</i>	<i>Optional</i>
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The value to be negated.	INT, DINT, REAL	All except S, SA, SB, SC	No
Q	The result, -1(IN)	INT, DINT, REAL variable	All except S, SA, SB, SC and constant	No

8.11.6 Subtract



Subtracts the operands IN2 ...IN8 from the operand IN1 and stores the result in the output variable assigned to Q.

The calculation is carried out when SUB is performed without overflow, unless an invalid operation occurs. If a SUB operation results in overflow, the result wraps around. For example:

- If a SUB_DINT, SUB_INT or SUB_REAL operation is performed on 32768 - 1, Q will be set to -32767.

If a SUB_UINT operation results in a negative number, Q wraps around. (For example, a result of -1 sets Q to 65535.)

Minimum number of inputs = 2 Maximum number of inputs = 8.

Mnemonic	Operation	Displays as
SUB_INT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) - IN2(16 \text{ bit})$	base 10 number with sign, up to 5 digits long
SUB_DINT	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) - IN2(32 \text{ bit})$	base 10 number with sign, up to 10 digits long
SUB_REAL	$Q(32 \text{ bit}) = IN1(32 \text{ bit}) - IN2(32 \text{ bit})$	base 10 number, sign and decimals, up to 8 digits long (excluding the decimals)
SUB_UINT	$Q(16 \text{ bit}) = IN1(16 \text{ bit}) - IN2(16 \text{ bit})$	base 10 number, unsigned, up to 5 digits long

Operands for Subtract

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN1	The value to subtract from.	DINT, INT, REAL, UINT	All except S, SA, SB, SC	No
IN2 ... IN8	The value(s) to subtract from IN1. Must be the same data type as IN1.		All except S, SA, SB, SC	No
Q	The result of the subtraction. Must be the same data type as IN1.	DINT, INT, REAL, UINT variable	All except S, SA, SB, SC and constant	No

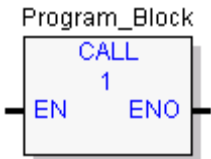
Properties for Subtract

Property	Valid Range
Number of Inputs	2 to 8

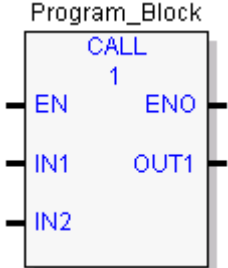
8.9. Program Flow Functions

The program flow functions limit program execution or change the way the CPU executes the application program.

Function



Non-parameterized CALL

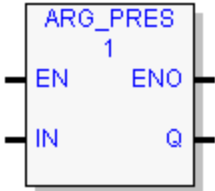


Parameterized CALL. May call a parameterized external block or a parameterized block.

Description

The CALL function causes the logic execution to go immediately to the designated program block, external C block (parameterized or not), or parameterized block and execute it. After the block's execution is complete, control returns to the point in the logic immediately following the CALL instruction.

For details, see "Program Flow Functions" in Chapter 7.



The ARG_PRES (Argument Present) function determines whether a parameter value was present when the function block instance of the parameter was invoked.

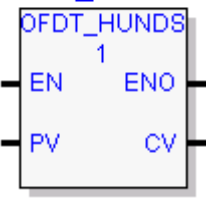
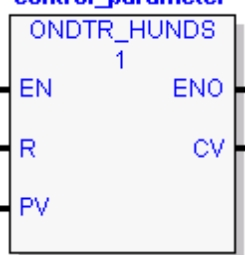
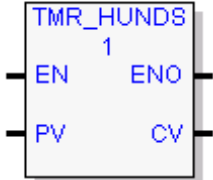
For details, see "Program Flow Functions" in Chapter 7.

8.10. Timers

This section describes the PACSystems timing functions that are implemented in the FBD language.

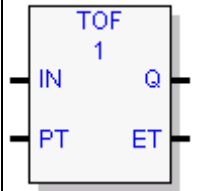
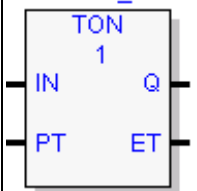
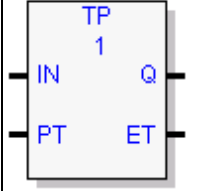
8.13.1 Built-in Timer Function Blocks

These function blocks use WORD Array instance data. The parameter that appears above the function block is a one-dimensional, three-word array in %R, %W, %P, %L, or symbolic memory that the timer uses to store its current value, preset value and control word.

Function	Description
<p>control_parameter</p> 	<p>Off Delay Timer. The timer's Current Value (CV) resets to zero when its enable parameter (EN) is set to ON.. CV increments while EN is OFF. When CV=PV (Preset Value), ENO is set to OFF until EN is set to ON again.</p> <p>Other OFDT functions: OFDT_SEC OFDT_TENTHS OFDT_THOUS</p> <p>For details, see "Timers" in Chapter 7.</p>
<p>control_parameter</p> 	<p>On Delay Stopwatch Timer. Retentive on delay timer. Increments while EN is ON and holds its value when EN is OFF.</p> <p>ONDTR_SEC ONDTR_TENTHS ONDTR_THOUS</p> <p>For details, see "Timers" in Chapter 7.</p>
<p>control_parameter</p> 	<p>On Delay Timer. Simple on delay timer. Increments while EN is ON and resets to zero when EN is OFF.</p> <p>TMR_SEC TMR_TENTHS TMR_THOUS</p> <p>For details, see "Timers" in Chapter 7.</p>


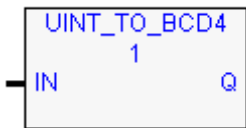
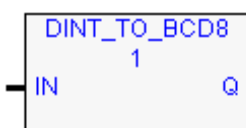
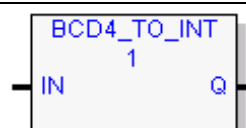
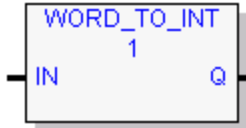
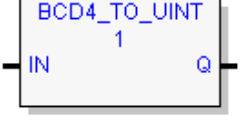
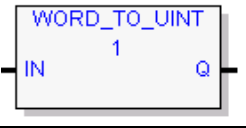
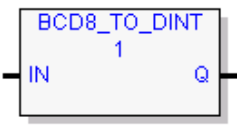
8.13.2 Standard Timer Function Blocks

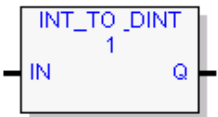
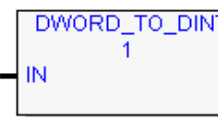
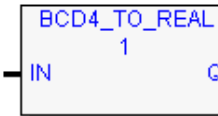
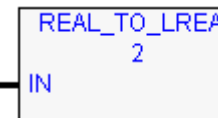
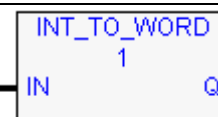
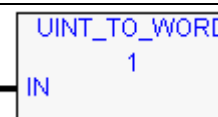
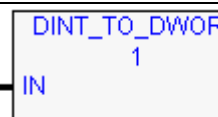
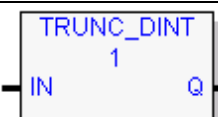

These functions blocks use Structure Variable instance data. Each invocation of a timer has associated instance data that persists from one execution of the timer to the next. Instance variables are automatically located in symbolic memory. (You cannot specify an address.) You can specify a stored value for each element. The user logic cannot modify the values.

Function	Description
<p><i>Instance_Var</i></p>  <p>The diagram shows a rectangular function block labeled 'TOF 1'. It has two input terminals on the left: 'IN' at the top and 'PT' at the bottom. It has two output terminals on the right: 'Q' at the top and 'ET' at the bottom. The text 'Instance_Var' is written above the block.</p>	<p>Timer Off Delay. When the input IN transitions from ON to OFF, the timer starts timing until a specified period of time has elapsed, then sets the output Q to OFF.</p> <p>For details, see “Timers” in Chapter 7.</p>
<p><i>Instance_Var</i></p>  <p>The diagram shows a rectangular function block labeled 'TON 1'. It has two input terminals on the left: 'IN' at the top and 'PT' at the bottom. It has two output terminals on the right: 'Q' at the top and 'ET' at the bottom. The text 'Instance_Var' is written above the block.</p>	<p>Timer On Delay. When the input IN transitions from OFF to ON, the timer starts timing until a specified period of time has elapsed, then sets the output Q to ON.</p> <p>For details, see “Timers” in Chapter 7.</p>
<p><i>Instance_Var</i></p>  <p>The diagram shows a rectangular function block labeled 'TP 1'. It has two input terminals on the left: 'IN' at the top and 'PT' at the bottom. It has two output terminals on the right: 'Q' at the top and 'ET' at the bottom. The text 'Instance_Var' is written above the block.</p>	<p>Timer Pulse. When the input IN transitions from OFF to ON, the timer sets the output Q to ON for a specified time interval.</p> <p>For details, see “Timers” in Chapter 7.</p>

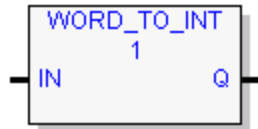
8.11. Type Conversion Functions

The Conversion functions change a data item from one number format (data type) to another. Many programming instructions, such as math functions, must be used with data of one type. As a result, data conversion is often required before using those instructions.

Function	Description
Convert Angles	
	DEG_TO_RAD: Converts degrees to radians. RAD_TO_DEG: Converts radians to degrees. For details, see "Conversion Functions" in Chapter 7.
Convert to BCD4 (4-digit Binary-Coded-Decimal)	
	UINT_TO_BCD4: Converts UINT (16-bit unsigned integer) to BCD4. INT_TO_BCD4: Converts INT (16-bit signed integer) to BCD4. For details, see "Conversion Functions" in Chapter 7.
Convert to BCD8 (8-digit Binary-Coded-Decimal)	
	DINT_TO_BCD8: Converts DINT (32-bit signed integer) to BCD8. For details, see "Conversion Functions" in Chapter 7.
Convert to INT (16-bit signed integer)	
	BCD4_TO_INT: Converts BCD to INT. UINT_TO_INT: Converts UINT to INT. DINT_TO_INT: Converts DINT to INT. REAL_TO_INT: Converts REAL to INT. For details, see "Conversion Functions" in Chapter 7.
	Converts a 16-bit string (WORD) value to INT. For details, see page 364.
Convert to UINT (16-bit unsigned integer)	
	BCD4_TO_UINT: Converts BCD4 to UINT. INT_TO_UINT: Converts INT to UINT. DINT_TO_UINT: Converts DINT to UINT. REAL_TO_UINT: Converts REAL to UINT. For details, see "Conversion Functions" in Chapter 7.
	WORD_TO_UINT: Converts a 16-bit string (WORD) value to UINT. For details, see page 364.
Convert to DINT (32-bit signed integer)	
	BCD8_TO_DINT: Converts BCD8 to DINT. UINT_TO_DINT: Converts UINT to DINT. For details, see "Conversion Functions" in Chapter 7.

Function	Description
	<p>INT_TO_DINT: Converts INT to DINT. REAL_TO_DINT: Converts REAL (32-bit signed real or floating-point values) to DINT. For details, see "Conversion Functions" in Chapter 7.</p>
	<p>DWORD_TO_DINT: Converts a 32-bit bit string (DWORD) value to DINT. For details, see page 365.</p>
Convert to REAL (32-bit signed real or floating-point values)	
	<p>BCD4_TO_REAL: Converts BCD4 to REAL. BCD8_TO_REAL: Converts BCD8 to REAL. UINT_TO_REAL: Converts UINT to REAL. INT_TO_REAL: Converts INT to REAL. DINT_TO_REAL: Converts DINT to REAL. LREAL_TO_REAL: Converts LREAL to REAL. For details, see "Conversion Functions" in Chapter 7.</p>
Convert to LREAL(64-bit signed real or floating-point values)	
	<p>Converts a REAL value to LREAL. For details, see "Conversion Functions" in Chapter 7.</p>
Convert to WORD (16-bit string)	
	<p>Converts an INT (16-bit signed integer) value to a WORD value. For details, see page 365.</p>
	<p>Converts an unsigned single-precision integer (UINT) to WORD. For details, see page 365.</p>
Convert to DWORD (32-bit bit string)	
	<p>Converts a double-precision signed integer (DINT) value to DWORD. For details, see page 366</p>
Truncate	
	<p>Rounds a REAL (32-bit signed real or floating-point) number down to a DINT number For details, see "Conversion Functions" in Chapter 7.</p>
	<p>Rounds a REAL (32-bit signed real or floating-point) number down to an INT number For details, see "Conversion Functions" in Chapter 7.</p>

8.14.1 Convert WORD to INT



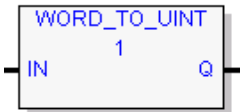
Converts the input data into the equivalent single-precision signed integer (INT) value, which it outputs to Q. This function does not change the original input data. The output data can be used directly as input for another program function, as in the examples.

The function passes data to Q, unless the data is out of range (0 through +65,535).

Operands

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The value to convert to INT.	WORD	All except S, SA, SB, and SC	No
Q	The INT equivalent value of the original value in IN.	INT	All except S, SA, SB, SC and constant	No

8.14.2 Convert WORD to UINT



These functions convert the input data into the equivalent single-precision unsigned integer (UINT) value, which it outputs to Q.

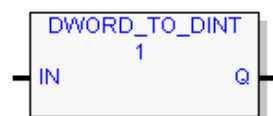
The conversion to UINT does not change the original data. The output data can be used directly as input for another program function, as in the example.

The function passes the converted data to Q, unless the resulting data is outside the range 0 to +65,535.

Operands

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The value to convert to UINT.	WORD	All except S, SA, SB, and SC	No
Q	The UINT equivalent value of the original input value in IN.	UINT	All except S, SA, SB, SC and constant	No

8.14.3 Convert DWORD to DINT



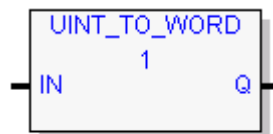
Converts DWORD data into the equivalent signed double-precision integer (DINT) value and stores the result in Q. The conversion to DINT does not change the original data.

The output data can be used directly as input for another program function. The function passes data to Q unless the data is out of range.

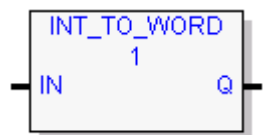
Operands

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The value to convert to DINT.	DWORD	All except S, SA, SB, and SC	No
Q	The DINT equivalent value of the original input value in IN.	UINT	All except S, SA, SB, SC and constant	No

8.14.4 Convert INT or UINT to WORD



Converts an unsigned single-precision integer (UINT) operand IN to a 16-bit bit string (WORD) value and stores the result in the variable assigned to Q.



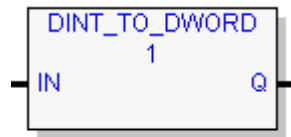
Converts a 16-bit signed integer (INT) operand IN to a 16-bit bit string (WORD) value and stores the result in the variable assigned to Q.

The output data can be used directly as input for another program function. The function passes data to Q unless the data is out of range.

Operands

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The value to convert to WORD.	INT or UINT, depending on function	All except S, SA, SB, and SC	No
Q	The WORD equivalent value of the original value in IN. $0 \leq Q \leq 65,535$.	WORD	All except S, SA, SB, SC and constant	No

8.14.5 Convert DINT to DWORD



When DINT_TO_DWORD receives data, it converts the input double-precision signed integer (DINT) data into the equivalent DWORD (32-bit bit string) value, which it outputs to Q. DINT_TO_DWORD does not change the original DINT data.

The output data can be used directly as input for another program function. The function passes data to Q unless the data is out of range.

Operands

<i>Parameter</i>	<i>Description</i>	<i>Allowed Types</i>	<i>Allowed Operands</i>	<i>Optional</i>
Solve Order	Calculated by the FBD editor.	NA	NA	No
IN	The value to convert to DWORD.	DINT	All except S, SA, SB, and SC	No
Q	The DWORD equivalent value of the original value in IN. $0 \leq Q \leq 4,294,967,295$.	DWORD	All except S, SA, SB, SC and constant	No

Chapter 9 Service Request Function

Use a Service Request function to request one of the following control system services:

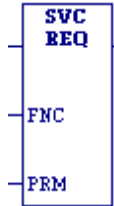
Service Request	Description	Page
SVC_REQ 1	Change/read constant sweep timer	370
SVC_REQ 2	Read window modes and time values	372
SVC_REQ 3	Change controller communications window mode and timer value	373
SVC_REQ 4	Change backplane communications window mode and timer value	374
SVC_REQ 5	Change background task window mode and timer value	375
SVC_REQ 6	Change/read number of words to checksum	376
SVC_REQ 7	Read or change the time-of-day clock	378
SVC_REQ 8	Reset watchdog timer	385
SVC_REQ 9	Read sweep time from beginning of sweep - milliseconds	386
SVC_REQ 10	Read target name	387
SVC_REQ 11	Read controller ID	388
SVC_REQ 12	Read controller run state	389
SVC_REQ 13	Shut down (stop) controller	390
SVC_REQ 14	Clear controller or I/O Fault Tables	391
SVC_REQ 15	Read last-logged fault table entry	392
SVC_REQ 16	Read elapsed time clock - microseconds	395
SVC_REQ 17	Mask/unmask I/O interrupt	397
SVC_REQ 18	Read I/O Force status	399
SVC_REQ 19	Set run enable/disable	400
SVC_REQ 20	Read fault tables	401
SVC_REQ 21	User-defined fault logging	406
SVC_REQ 22	Mask/unmask timed interrupts	408
SVC_REQ 23	Read master checksum	409
SVC_REQ 24	Reset module	410
SVC_REQ 25	Disable/enable EXE Block and standalone C program checksums	411
SVC_REQ 26	Role switch (redundancy)	17
SVC_REQ 27	Write to reverse transfer area (Hot Standby Redundancy)	17
SVC_REQ 28	Read from reverse transfer area (Hot Standby Redundancy)	
SVC_REQ 29	Read elapsed power down time	412
SVC_REQ 32	Suspend/resume I/O interrupt	413
SVC_REQ 43	Disable data transfer copy in backup unit (Hot Standby Redundancy)	
SVC_REQ 45	Skip next I/O scan	414
SVC_REQ 50	Read elapsed time clock - nanoseconds	415
SVC_REQ 51	Read sweep time from beginning of sweep - nanoseconds	417
SVC_REQ 55	Set application redundancy mode (non-Hot Standby Redundancy)	
SVC_REQ 56	Read from nonvolatile storage	418
SVC_REQ 57	Write to nonvolatile storage	422

¹⁷ For information on Service Requests used in CPU HSB redundancy applications, refer to the *PACSystems Hot Standby CPU Redundancy User's Guide*, GFK-2308. For non-HSB applications, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224.

9.1. Operation of SVC_REQ Function

PACSystems supports the Service Request function in LD and FBD.

9.1.1 Ladder Diagram



When SVC_REQ receives power flow, it requests the CPU to perform the special service identified by the FNC operand.

Parameters for SVC_REQ are located in the parameter block, which begins at the reference identified by the PRM operand. The number of 16-bit references required depends on the type of special controller service being requested. The parameter block is used to store both the function's inputs and outputs.

SVC_REQ passes power flow unless an incorrect function number, incorrect parameters, or out-of-range references are specified. Specific SVC_REQ functions may have additional causes for failure.

Because the service request continues to be invoked each time power flow is enabled to the function, additional enable/disable logic preceding the request may be necessary, depending upon the application. (For example, repeated calling of SVC_REQ 24 would continually reset a module, probably not the intended behavior.) In many cases a transition contact or coil will be sufficient. Alternatively, you could use more complex logic, such as having the function contained within a block that is only called a single time.

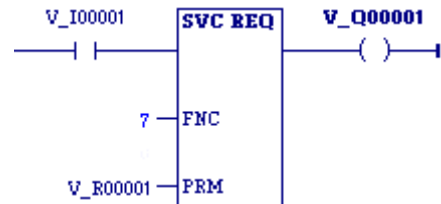
Operands

Note: Indirect referencing is available for all register references (%R, %P, %L, %W, %AI, and %AQ).

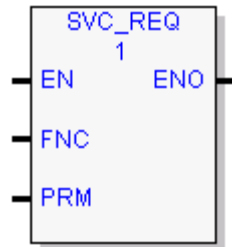
Operand	Data Type	Memory Area	Description
FNC	INT variable or constant	All except %S - %SC	Function number; Service Request number. The constant or reference that identifies the requested service.
PRM	WORD variable	All except flow, %S - %SC and constant	The first WORD in the parameter block for the requested service. Successive 16-bit locations store additional parameters.

Example

When the enabling input %I0001 is ON, SVC_REQ function number 7 is called, with the parameter block starting at %R0001. If the operation succeeds, output coil %Q0001 is set ON.



9.1.2 Function Block Diagram



The SVC_REQ function requests the CPU to perform the special service identified by the FNC operand.

Parameters for SVC_REQ are located in the parameter block, which begins at the reference identified by the PRM operand. The number of 16-bit references required depends on the type of special controller service being requested. The parameter block is used to store both the function's inputs and outputs.

Operands

Note: Indirect referencing is available for all register references (%R, %P, %L, %W, %AI, and %AQ).

Parameter	Description	Allowed Types	Allowed Operands	Optional
Solve Order	Calculated by the FBD editor.	NA	NA	No
EN	Enable input. When set to ON, the SVC_REQ executes	BOOL Bit reference in a non-BOOL variable	data flow, I, Q, M, T, G, S, SA, SB, SC, discrete symbolic, I/O variable I, Q, M, T, G, R, P, L, AI, AQ, W, non-discrete symbolic, I/O variable	No
FNC	Function number; Service Request number. The constant or variable that identifies the requested service.	INT, DINT, UINT, WORD, DWORD	All except %S - %SC You can use data flow only if the parameter block requires only one WORD If you use a symbolic variable or an I/O variable, ensure that its Array Dimension 1 property is set to a value large enough to contain the entire parameter block.	No
PRM	The first word in the parameter block for the requested service. Successive 16-bit locations store additional parameters.	INT, DINT, UINT, WORD, DWORD	All except flow, %S - %SC and constant	No
ENO	Set to ON unless an incorrect function number, incorrect parameters, or out-of-range references are specified. Specific SVC_REQ functions may have additional causes for failure.	BOOL Bit reference in a non-BOOL variable.	data flow, I, Q, M, T, G, non-discrete symbolic, I/O variable I, Q, M, T, G, R, P, L, AI, AQ, W, non-discrete symbolic, I/O variable	Yes

9.2. SVC_REQ 1: Change/Read Constant Sweep Timer

Use SVC_REQ function 1 to:

- Disable Constant Sweep mode
- Enable Constant Sweep mode and use the old Constant Sweep timer value
- Enable Constant Sweep mode and use a new Constant Sweep timer value
- Set a new Constant Sweep timer value only
- Read Constant Sweep mode state and timer value.

The parameter block has a length of two words used for both input and output.

SVC_REQ executes successfully unless:

- A number other than 0, 1, 2, or 3 is entered as the requested operation:
- The scan time value is greater than 2550ms (2.55 seconds)
- Constant sweep time is enabled with no timer value programmed or with an old value of 0 for the timer.

To disable Constant Sweep mode:

Enter SVC_REQ 1 with this parameter block:

Address	0
Address + 1	Ignored

To enable Constant Sweep mode and use the old timer value:

Enter SVC_REQ 1 with this parameter block:

Address	1
Address + 1	0

If the timer value does not already exist, entering 0 causes the function to set the OK output to OFF.

To enable Constant Sweep mode and use a new timer value:

Enter SVC_REQ 1 with this parameter block:

Address	1
Address + 1	New timer value Note: If the timer value does not already exist, entering 0 causes the function to set the OK output to OFF.

To change the timer value without changing the selection for sweep mode state:

Enter SVC_REQ 1 with this parameter block:

Address	2
Address + 1	New timer value

To read the current timer state and value without changing either:

Enter SVC_REQ 1 with this parameter block:

Address	3
Address + 1	ignored

Output

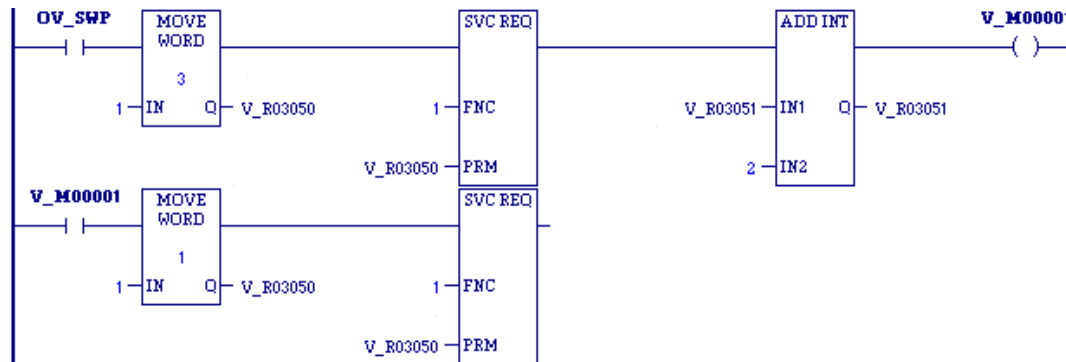
SVC_REQ 1 returns the timer state and value in the same parameter block references:

Address	0 = Normal Sweep 1 = Constant Sweep
Address + 1	Current timer value

If the word address + 1 contains the hexadecimal value FFFF, no timer value has been programmed.

Example

If contact OV_SWP is set, the Constant Sweep Timer is read, the timer is increased by two milliseconds, and the new timer value is sent back to the CPU. The parameter block is at location %R3050. The example logic uses discrete internal coil %M0001 as a temporary location to hold the successful result of the first rung line. On any sweep in which OV_SWP is not set, %M0001 is turned off.



9.3. SVC_REQ 2: Read Window Modes and Time Values

Use SVC_REQ 2 to obtain the current window mode and time values for the controller communications window and the backplane communications and the background task window. The parameter block has a length of three words. All parameters are output parameters. It is not necessary to enter values in the parameter block to program this function.

Output

Address	Window	High Byte	Low Byte
Address	Controller Communications Window	Mode	Value in ms
Address + 1	Backplane Communications Window	Mode	Value in ms
Address + 2	Background Window	Mode	Value in ms

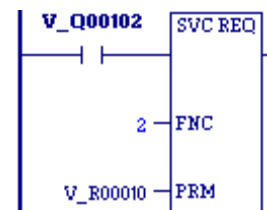
Note: A window is disabled when the time value is zero.

Mode Values

Mode Name	Value	Description
Limited Mode	0	The execution time of the window is limited to its respective default value or to a value defined using SVC_REQ 3 for the controller communications window or SVC_REQ 4 for the systems communications window. The window will terminate when it has no more tasks to complete.
Constant Mode	1	Each window will operate in a Run to Completion mode, and the CPU will alternate among the three windows for a time equal to the sum of each window's respective time value. If one window is placed in Constant mode, the remaining two windows are automatically placed in Constant mode. If the CPU is operating in Constant Window mode and a particular window's execution time is not defined using the associated SVC_REQ function, the default time for that window is used in the constant window time calculation.
Run to Completion Mode	2	Regardless of the window time associated with a particular window, whether default or defined using a service request function, the window will run until all tasks within that window are completed.

Example

When %Q00102 is set, the CPU places the current time values of the windows in the parameter block starting at location %R0010.



9.4. SVC_REQ 3: Change Controller Communications Window Mode

Use SVC_REQ 3 to change the controller communications window mode and timer value. The change takes place during the next CPU sweep after the function is called.

The parameter block has a length of one word.

SVC_REQ 3 executes unless a mode other than 0 (Limited) or 2 (Run to Completion) is selected.

To disable the controller communications window:

Enter SVC_REQ 3 with this parameter block:

Address	High Byte	Low Byte
Address	0	0

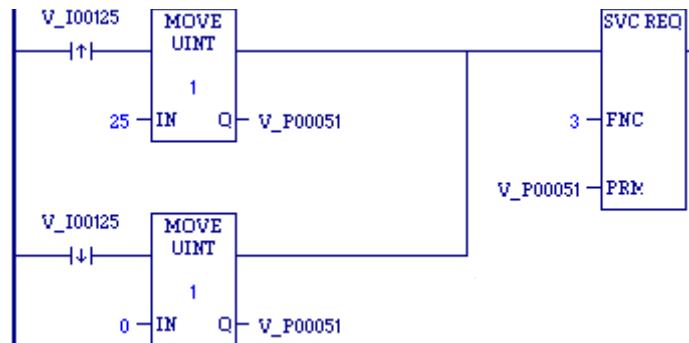
To re-enable or change the controller communications window mode:

Enter SVC_REQ 3 with this parameter block:

Address	High Byte	Low Byte
Address	Mode: 0 = Limited 2 = Run to Completion	1ms ≤ value ≤ 255ms in 1ms increments

Example

When enabling input %I00125 transitions on, the controller communications window is enabled and assigned a value of 25ms. When the contact transitions off, the window is disabled. The parameter block is in global memory location %P00051.



9.5. SVC_REQ 4: Change Backplane Communications Window Mode and Timer Value

Use SVC_REQ 4 to change the Backplane Communications window mode and timer value. The change takes place during the next CPU sweep after the function is called.

SVC_REQ 4 executes unless a mode other than 0 (Limited) or 2 (Run to Completion) is selected. The parameter block has a length of one word.

To disable the Backplane Communications window:

Enter SVC_REQ 4 with this parameter block:

Address	High Byte	Low Byte
Address	0	0

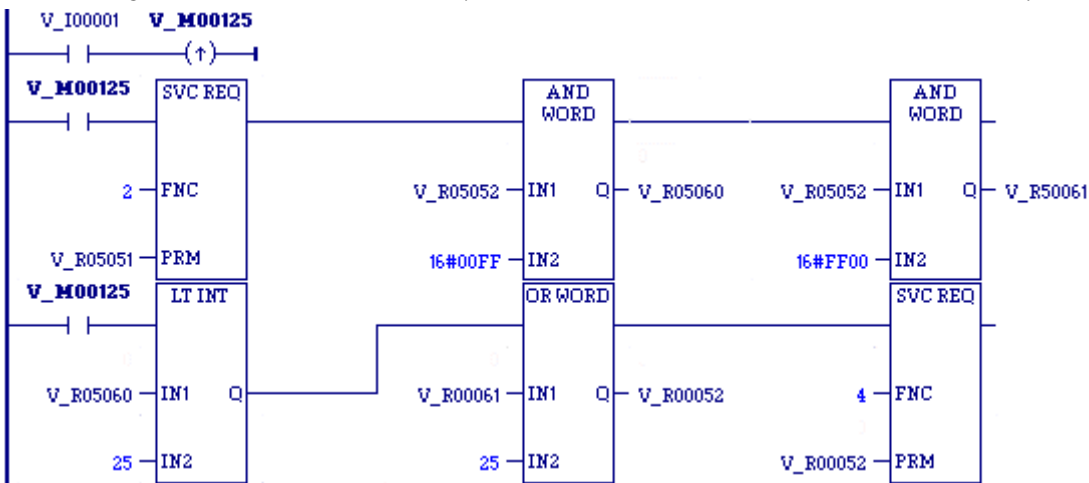
To enable the Backplane Communications window mode:

Enter SVC_REQ 4 with this parameter block:

Address	High Byte	Low Byte
Address	Mode 0 = Limited 2 = Run to Completion	1ms ≤ value ≤ 255ms

Example

When enabling output %M0125 transitions on, the mode and timer value of the Backplane Communications window is read. If the timer value is greater than or equal to 25ms, the value is not changed. If it is less than 25ms, the value is changed to 25ms. In either case, when the rung completes execution the window is enabled. The parameter block for all three windows is at location %R5051. Since the mode and timer for the Backplane Communications window is the second value in the parameter block returned from the Read Window Values function (SVC_REQ 2), the location of the existing window time for the Backplane Communications window is in the low byte of %R5052.



9.6. SVC_REQ 5: Change Background Task Window Mode and Timer Value

Use SVC_REQ 5 to change the Background Task window mode and timer value. The change takes place during the next CPU sweep after the function is called.

SVC_REQ 5 executes unless a mode other than 0 (Limited) or 2 (Run-to-Completion) is selected.

The parameter block has a length of one word.

To disable the Background Task window:

Enter SVC_REQ 5 with this parameter block:

Address	High Byte	Low Byte
Address	0	0

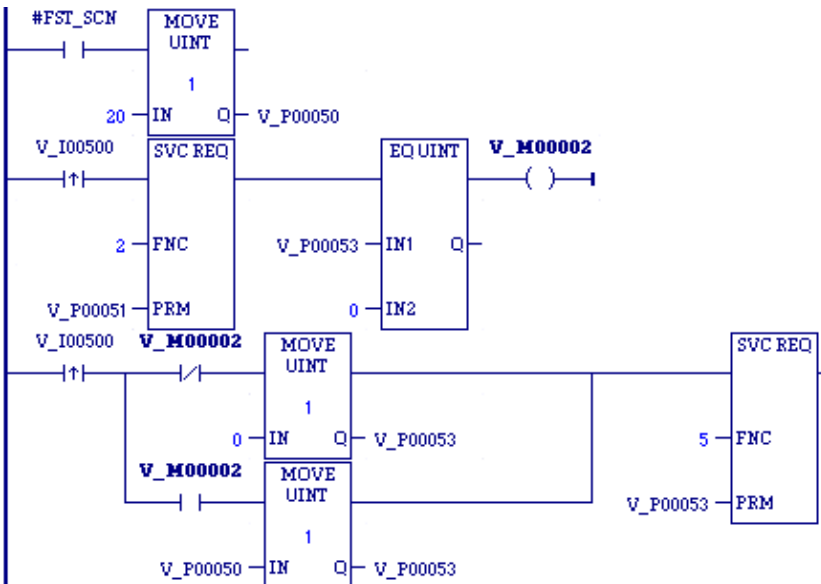
To enable the Background Task window mode:

Enter SVC_REQ 5 with this parameter block:

Address	High Byte	Low Byte
Address	Mode 0 = Limited 2 = Run to Completion	1ms ≤ value ≤ 255ms

Example

When enabling contact #FST_SCN is set in the first scan, the MOVE function establishes a value of 20ms for the Background task window, using a parameter block beginning at %P00050. Later in the program, when input %I00500 transitions on, the state of the Background task window toggles on and off. The parameter block for all three windows is at location %P00051. The time for the Background task window is the third value in the parameter block returned from the Read Window Values function (function #2); therefore, the location of the existing window time for the Background window is %P00053.



9.7. SVC_REQ 6: Change/Read Number of Words to Checksum

Use SVC_REQ 6 to read the current word count in the program to be check-summed or set a new word count. By default, 16 words are checked. The function is successful unless some number other than 0 or 1 is entered as the requested operation.

The parameter block has a length of 2 words.

To read the word count:

Enter a zero in the first word of the parameter block.

Address	0
Address + 1	Ignored

The function returns the current checksum (word count) in the second word of the parameter block. No range is specified for the read function; the value returned is the number of words currently being check-summed.

Address	0
Address + 1	Current word count

To set a new word count:

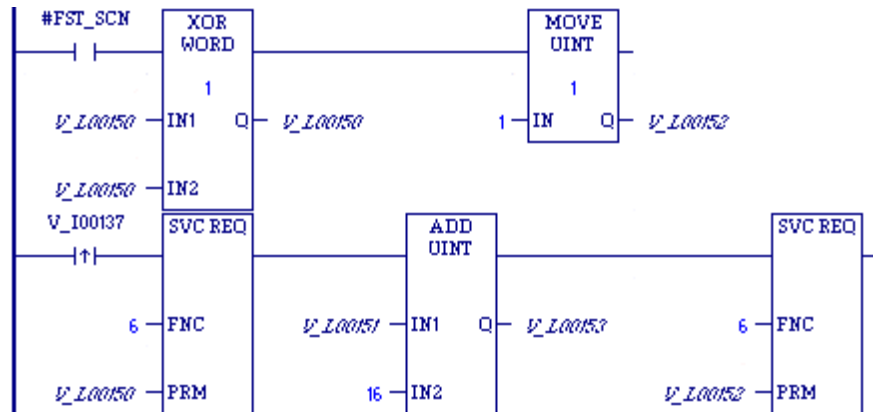
Enter a one in the first word of the parameter block and the new word count in the second word.

Address	1
Address + 1	New word count

The CPU changes the number of words to be check-summed to the value given in the second word of the parameter block, rounded up to the next multiple of 8. To disable check-summing, set the new word count to 0.

Example

When enabling contact #FST_SCN is set, the parameter blocks for the checksum task function are built. Later in the program, when input %I00137 transitions on, the number of words being check-summed is read from the CPU operating system. This number is increased by 16, with the results of the ADD_UINT function being placed in the “hold new count for set” parameter. The second service request block requests the CPU to set the new word count.



The example parameter blocks are located at address %L00150. They have the following contents:

%L00150	0 = read current count
%L00151	hold current count
%L00152	1 = set current count
%L00153	hold new count for set

9.8. SVC_REQ 7: Read or Change the Time-of-Day Clock

Use SVC_REQ 7 to read or change the time of day clock in the CPU. The function is successful unless:

- An invalid number is entered for the requested operation.
- An invalid data format is specified.
- Data is provided in an unexpected format.

9.8.1 Parameter Block Formats

In the first two words of the parameter block, you specify whether to read or set the time and date, and which format to use.

Address	2-Digit Year Format	4-Digit Year Format
Address (word 1)	0 = read time and date	0 = read time and date
	1 = set time and date	1 = set time and date
Address+1 (word 2)	0 = numeric data format	80h = numeric data format
	1 = BCD format	81h = BCD format
	2 = unpacked BCD format	82h = unpacked BCD format
	3 = packed ASCII format (with embedded spaces and colons)	83h = packed ASCII format
	4 = POSIX format	n/a
Address+2 (word 3) to the end	Data	Data

Words 3 to the end of the parameter block contain output data returned by a read function, or new data being supplied by a change function. In both cases, format of these data words is the same. When reading the date and time, words (address + 2) to the end of the parameter block are ignored on input.

The format and length of the parameter block depends on the data format and number of digits required for the year:

Data Format and N-digit Year	Length of parameter block (number of words)
BCD, 2-digit year	6
BCD, 4-digit year	6
POSIX format	6
Unpacked BCD 2	9
Unpacked BCD 4	10
Numeric (2 and 4 digit years)	9
Packed ASCII, 2-digit year	12
Packed ASCII, 4-digit year	13

In any format:

- Hours are stored in 24-hour format.
- Day of the week is a numeric value ranging from 1 (Sunday) to 7 (Saturday).

Value	Day of the Week
1	Sunday
2	Monday
3	Tuesday
4	Wednesday
5	Thursday
6	Friday
7	Saturday

BCD, 2-Digit Year

In BCD format, each time and date item occupies one byte, so the parameter block has six words. The last byte of the sixth word is not used. When setting the date and time, this byte is ignored; when reading date and time, the function returns a null character (00).

Parameter Block Format	Address	Example <i>(Sun., July 3, 2005, at 2:45:30 p.m. = 14:45:30 in 24-hour format)</i>
1 = change or 0 = read	Address	0 (read)
1 (BCD format)	Address+1	1 (BCD format)

High Byte	Low Byte	Address	High Byte	Low Byte
month	year	Address+2	07 (July)	05 (year)
hours	day of month	Address+3	14 (hours)	03 (day)
seconds	minutes	Address+4	30 (seconds)	45 (minutes)
(null)	day of week	Address+5	00	01 (Sunday)

BCD, 4-Digit Year

In this format, all bytes are used.

Parameter Block Format	Address	Example <i>(Sun., July 3, 2005, at 2:45:30 p.m. = 14:45:30 in 24-hour format)</i>
1 = change or 0 = read	Address	00 (read)
81h (BCD format, 4-digit)	Address+1	81h (BCD format, 4-digit)

High Byte	Low Byte	Address	High Byte	Low Byte
year	year	Address+2	20 (year)	05 (year)
day of month	month	Address+3	03 (day)	07 (July)
minutes	hours	Address+4	45 (minutes)	14 (hours)
day of week	seconds	Address+5	01 (Sunday)	30 (seconds)

POSIX

The POSIX format of the Time-of-Day clock uses two signed 32-bit integers (two DINTs) to represent the number of seconds and nanoseconds since midnight January 1, 1970. Reading the clock in POSIX format might make it easier for your application to calculate time differences. This format can also be useful if your application communicates to other devices using the POSIX time format. To read and/or change the date and time using POSIX format, enter SVC_REQ 7 with this parameter block:

Parameter Block Format	Address	Example: December 1, 2000 at 12 noon
1 = change or 0 = read	Address	0
4 (POSIX format)	Address+1	4
Seconds (LSW)	Address+2	975,672,000
(MSW)	Address+3	
Nanoseconds (LSW)	Address+4	0
(MSW)	Address+5	

The PACSystems CPU's maximum POSIX clock value is F48656FE (hexadecimal) seconds and 999,999,999 (decimal) nanoseconds, which corresponds to December 31st, 2099 at 11:59 pm. This is the maximum POSIX value that SVC_REQ 7 will accept for changing the clock. This is also the maximum POSIX value SVC_REQ 7 will return once the Time-Of-Day clock passes this date.

If SVC_REQ 7 receives an invalid POSIX time to write to the clock, it does not change the Time-Of-Day clock and disables its power-flow output.

Note: When reading the PACSystems CPU clock in POSIX format, the data returned is not easily interpreted by a human viewer. If desired, it is up to the application logic to convert the POSIX time into year, month, day of month, hour, and seconds.

Unpacked BCD (2-Digit Year)

In Unpacked BCD format, each digit of the time and date items occupies the low-order four bits of a byte. The upper four bits of each byte are always zero. This format requires nine words. Values are hexadecimal.

Parameter Block Format	Address	Example (Thurs., Dec. 8, 2002, at 9:34:57 a.m.)
1 = change or 0 = read	Address	0h
2 (Unpacked BCD format)	Address+1	2h

High Byte	Low Byte		High Byte	Low Byte
	year	Address+2	00h	02h
	month	Address+3	01h	02h
	day of month	Address+4	02h	08h
	hours	Address+5	00h	09h
	minutes	Address+6	03h	04h
	seconds	Address+7	05h	07h
	day of week	Address+8	00h	05h

Unpacked BCD (4-Digit Year)

In Unpacked BCD format, each digit of the time and date items occupies the low-order four bits of a byte. The upper four bits of each byte are always zero. This format requires nine words. Values are hexadecimal.

Parameter Block Format	Address	Example <i>(Thurs., Dec. 8, 2002, at 9:34:57 a.m.)</i>
1 = change or 0 = read	Address	0h
82h (Unpacked 4-digit BCD format)	Address+1	82h

High Byte	Low Byte		High Byte	Low Byte
	year	Address+2	00h	02h
	month	Address+3	01h	02h
	day of month	Address+4	00h	08h
	hours	Address+5	00h	09h
	minutes	Address+6	03h	04h
	seconds	Address+7	05h	07h
	day of week	Address+8	00h	05h

Numeric, 2-Digit Year

In numeric format, the year, month, day of month, hours, minutes, seconds and day of week each occupy one unsigned integer. To read and/or change the date and time using the numeric format, enter SVC_REQ function #7 with this parameter block:

Parameter Block Format	Address	Example <i>Wed., June 15, 2005, at 12:15:30 a.m.</i>
1 = change or 0 = read	Address	0
0 (Numeric format, 2-digit year)	Address+1	0

High Byte	Low Byte		Value
	year	Address+2	05
	month	Address+3	06
	day of month	Address+4	15
	hours	Address+5	12
	minutes	Address+6	15
	seconds	Address+7	30
	day of week	Address+8	04

Numeric, 4-Digit Year

In numeric format, the year, month, day of month, hours, minutes, seconds and day of week each occupy one unsigned integer. To read and/or change the date and time using the numeric format, enter SVC_REQ function #7 with this parameter block:

Parameter Block Format	Address	Example: Wed., June 15, 2005, at 12:15:30 a.m.
1 = change or 0 = read	Address	0
80h (Numeric format, 4 digit year)	Address+1	80h

High Byte	Low Byte		Value
	year	Address+2	2005
	month	Address+3	06
	day of month	Address+4	15
	hours	Address+5	12
	minutes	Address+6	15
	seconds	Address+7	30
	day of week	Address+8	04

Packed ASCII, 2-Digit Year

In Packed ASCII format, each digit of the time and date items is an ASCII formatted byte. Spaces and colons are embedded into the data to format it for printing or display. ASCII format for a 2-digit year requires 12 words in the parameter block. Values are hexadecimal.

Parameter Block Format	Address	Example (Mon., Oct. 5, 2005, at 11:13:25 p.m. = 23:13:25 in 24-hour format)
1 = change or 0 = read	Address	0h (read)
3 (ASCII format)	Address+1	3h (ASCII format)

High Byte	Low Byte		High Byte	Low Byte
year	year	Address+2	35h (5)	30h (0)
month	(space)	Address+3	31h (1)	20h (space)
(space)	month	Address+4	20h (space)	30h (0)
day of month	day of month	Address+5	35h (5)	30h (leading 0)
hours	(space)	Address+6	32h (2)	20h (space)
: (colon)	hours	Address+7	3Ah (:)	33h (3)
minutes	minutes	Address+8	33h (3)	31h (1)
seconds	: (colon)	Address+9	32h (2)	3Ah (:)
(space)	seconds	Address+10	20h (space)	35h (5)
day of week	day of week	Address+11	32h (2 = Mon.)	30h (leading 0)

Packed ASCII, 4-Digit Year

ASCII format for a 4-digit year requires 13 words in the parameter block. Values are hexadecimal.

<i>Parameter Block Format</i>	<i>Address</i>	<i>Example (Mon., Oct. 5, 2005, at 11:13:25 p.m. = 23:13:25 in 24-hour format)</i>
1 = change or 0 = read	Address	0h (read)
83 (ASCII format)	Address+1	83h (ASCII format, 4-digit)

<i>High Byte</i>	<i>Low Byte</i>		<i>High Byte</i>	<i>Low Byte</i>
year (hundreds)	year (thousands)	Address+2	30h (0)	32h (2)
year (ones)	year (tens)	Address+3	35h (5)	30h (0)
month (tens)	(space)	Address+4	31h (1)	20h (space)
(space)	month (ones)	Address+5	20h (space)	30h (0)
day of month (ones)	day of month (tens)	Address+6	35h (5)	30h (leading 0)
hours (tens)	(space)	Address+7	32h (2)	20h (space)
: (colon)	hours (ones)	Address+8	3Ah (:)	33h (3)
minutes (ones)	minutes (tens)	Address+9	33h (3)	31h (1)
seconds (tens)	: (colon)	Address+10	32h (2)	3Ah (A)
(space)	seconds (ones)	Address+11	20 (space)	35 (5)
day of week (ones)	day of week (tens)	Address+12	32h (2 = Mon.)	30h (leading 0)

Example: SVC_REQ 7

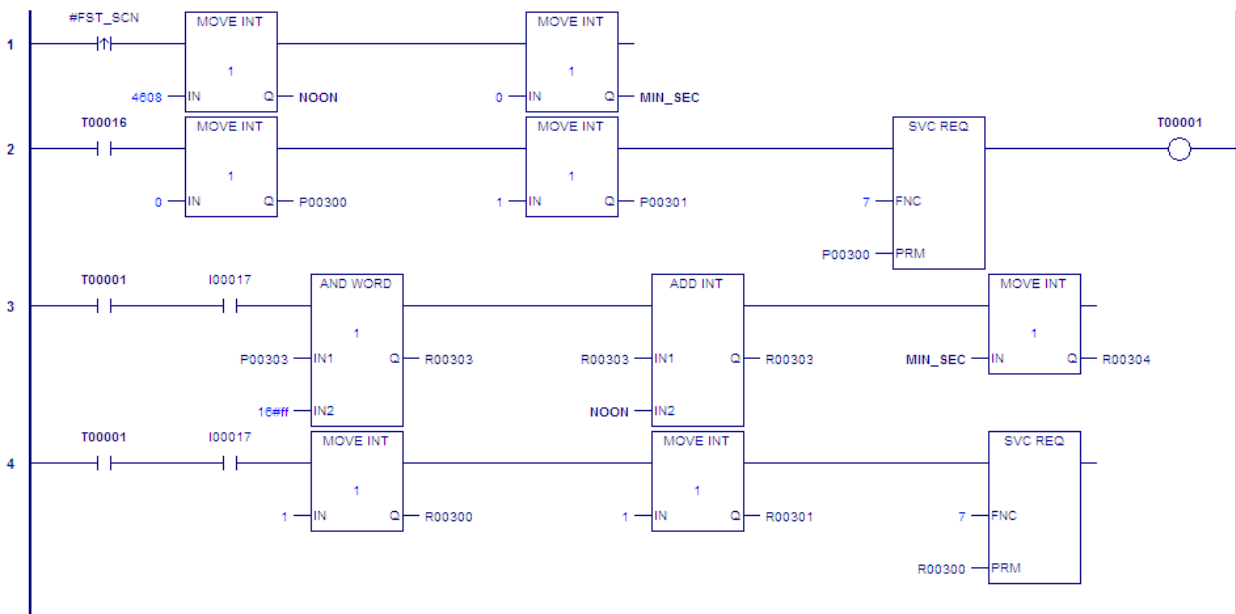
In this example, the time of day is set to 12:00 pm without changing the current year, BCD format requires six contiguous memory locations for the parameter block.

Rung 1 sets up the new time of day in two-digit year BCD format. It writes the value 4608 (equivalent to 12 00 BCD) to NOON and the value 0 to MIN_SEC.

Rung 2 requests the current date and time using the parameter block located at %P00300.

Rung 3 moves the new time value into the parameter block starting at R00300. It uses AND and ADD operations to retrieve the current clock value from %P00303 and replace the hours, minutes and seconds portion of the value with the values in NOON and MIN_SEC.

Rung 4 uses the parameter block beginning at %R00300 to set the new time.



9.9. SVC_REQ 8: Reset Watchdog Timer

Use SVC_REQ 8 to reset the watchdog timer during the scan.

Ordinarily, when the watchdog timer expires, the CPU goes to Stop-Halt mode without warning. SVC_REQ 8 allows the timer to keep going during a time-consuming task (for example, while waiting for a response from a communications line).



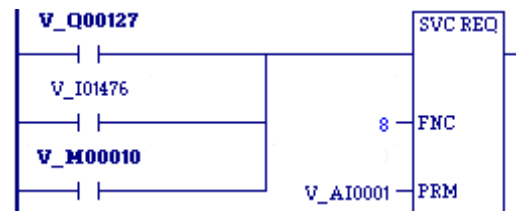
Warning

Be sure that resetting the watchdog timer does not adversely affect the controlled process.

SVC_REQ 8 has no associated parameter block; however, you must specify a dummy parameter, which SVC_REQ 8 will not use.

Example

In the LD example at right, power flow through enabling output %Q0127 or input %I1476 or internal coil %M00010 causes the watchdog timer to be reset.



9.10. SVC_REQ 9: Read Sweep Time from Beginning of Sweep

Use SVC_REQ 9 to read the time in milliseconds since the start of the sweep. The data format is unsigned 16-bit integer.

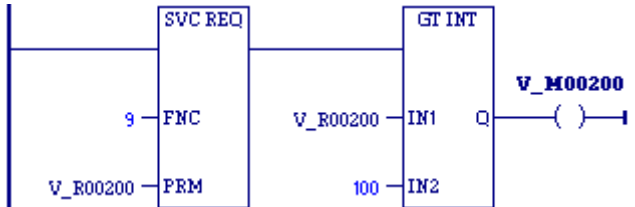
Output

The parameter block is an output parameter block only; it has a length of one word.

Address	time since start of scan
----------------	--------------------------

Example

The elapsed time from the start of the scan is read into location %R00200. If it is greater than 100ms, internal coil %M0200 is turned on.



Note: Higher resolution (in nanoseconds) can be obtained by using SVC_REQ 51: Read Sweep Time from Beginning of Sweep, described on page 417.

9.11. SVC_REQ 10: Read Target Name

Use SVC_REQ 10 to read the name of the currently executing target.

Output

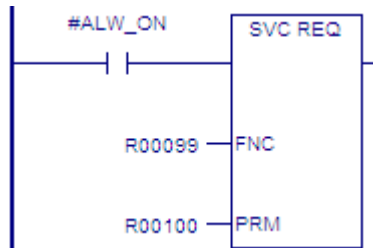
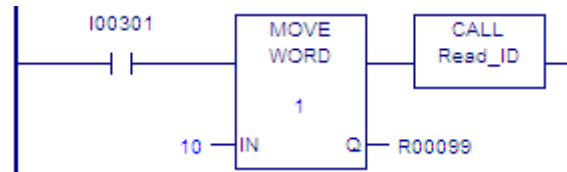
The output parameter block has a length of four words. It returns eight ASCII characters: the target name (from one to seven characters) followed by null characters (00h). The last character is always a null character. If the target name has fewer than seven characters, null characters are appended to the end.

Address	Low Byte	High Byte
Address	character 1	character 2
Address+1	character 3	character 4
Address+2	character 5	character 6
Address+3	character 7	00

Example

When enabling input %I0301 goes ON, register location %R0099 is loaded with the value 10, which is the function code for the Read Target Name function. The program block READ_ID is then called to retrieve the target name. The parameter block is located at address %R0100.

Program block READ_ID:



9.12. SVC_REQ 11: Read Controller ID

Use SVC_REQ 11 to read the name of the controller executing the program.

Output

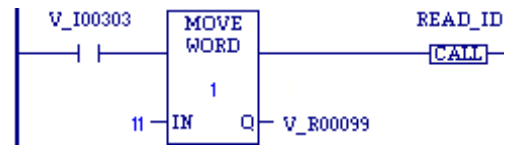
The output parameter block has a length of four words. It returns eight ASCII characters: the Controller ID (from one to seven characters) followed by null characters (00h). The last character is always a null character

If the Controller ID has fewer than seven characters, null characters are appended to the end.

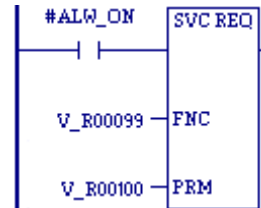
Address	Low Byte	High Byte
Address	character 1	character 2
Address+1	character 3	character 4
Address+2	character 5	character 6
Address+3	character 7	00

Example

When enabling input %I0303 is ON, register location %R0099 is loaded with the value 11, which is the function code for the Read Controller ID function. The program block READ_ID is then called to retrieve the ID. The parameter block is located at address %R0100.



Program Block READ_ID:



9.13. SVC_REQ 12: Read Controller Run State

Use SVC_REQ 12 to read the current RUN state of the CPU.

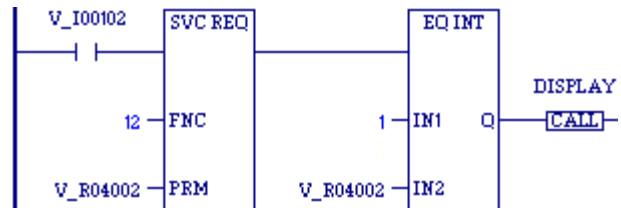
Output

The output parameter block has a length of one word.

Address	1 = run/disabled
	2 = run/enabled

Example

When contact V_I00102 is ON, the CPU run state is read into location %R4002. If the state is Run/Disabled, the CALL function calls program block DISPLAY.



9.14. SVC_REQ 13: Shut Down (Stop) CPU

Use SVC_REQ 13 to stop the CPU after the specified number of scans has been performed. All outputs go to their designated default states at the start of the next CPU scan. An informational “Shut Down Controller” fault is placed in the Controller Fault Table. The I/O scan continues as configured.

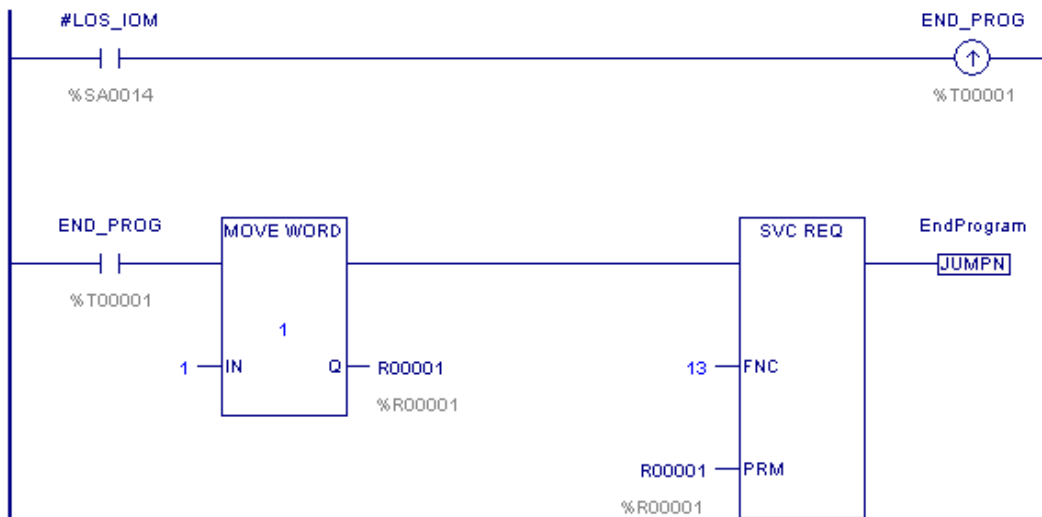
SVC_REQ 13 has an input parameter block with a length of one word.

Address	Number of scans. Valid values: -1: The CPU uses the Number of Last Scans value configured in the Hardware Configuration Scan tab to determine when to transition to Stop mode. For details on Hardware Configuration parameters, refer to Chapter 3. 1 through 5: The CPU finishes executing this scan, then executes this number of scans -1, and transitions to Stop mode.
----------------	--

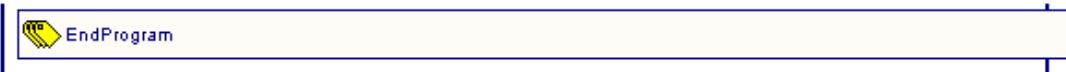
Note: For CPUs with firmware version earlier than 2.00, the value must be set to 0; otherwise the CPU does not stop.

Example

When a “Loss of I/O Module” fault occurs, the #LOS_IOM contact turns ON and SVC_REQ 13 executes. In this example, if the Shut Down CPU function executes, the JUMPN to the end of the program prevents the logic that follows the JUMPN from executing in the current sweep.



The block's last instruction is a LABELN:



9.15. SVC_REQ 14: Clear Controller or I/O Fault Table

Use SVC_REQ 14 to clear either the Controller Fault Table or the I/O Fault Table. The SVC_REQ output is set ON unless some number other than 0 or 1 is entered as the requested operation.

The parameter block has a length of 1 word. It is an input parameter block only. There is no output parameter block.

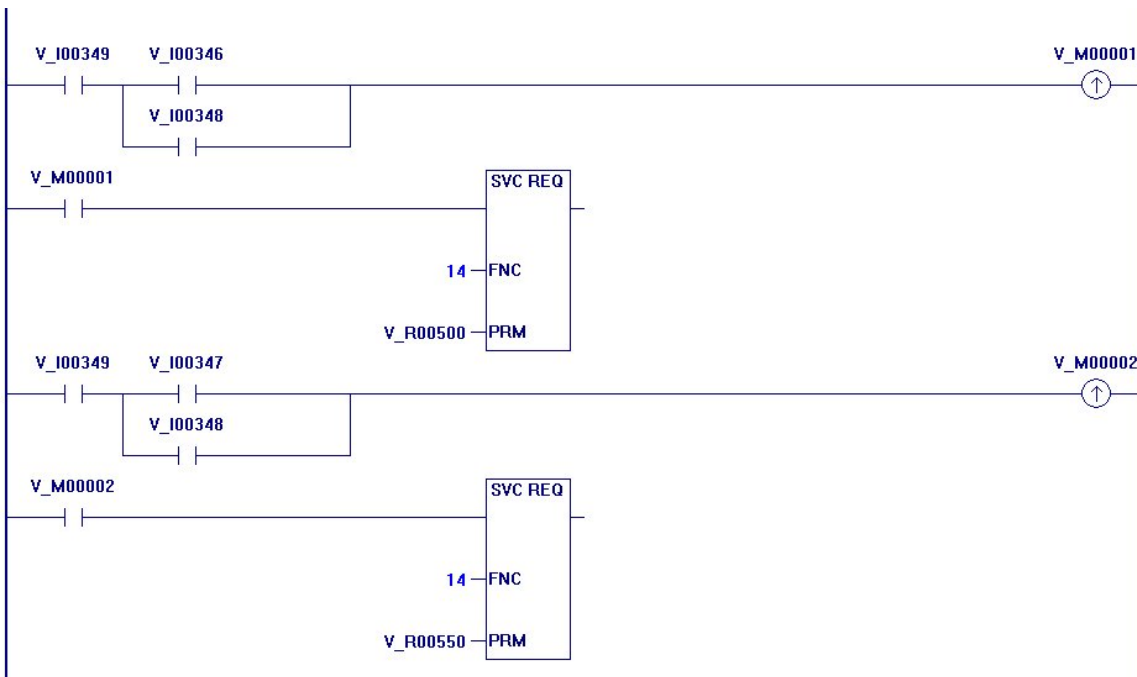
Address	0 = clear Controller Fault Table
	1 = clear I/O Fault Table

Example

When inputs %I0346 and %I0349 are on, the Controller Fault Table is cleared. When inputs %I0347 and %I0349 are on, the I/O Fault Table is cleared. When input %I0348 is on and input %I0349 is on, both are cleared. Positive transition coils V_M00001 and V_M00002 are used to trigger these service requests to prevent the fault tables from being cleared multiple times.

The parameter block for the Controller Fault Table is located at %R0500; for the I/O Fault Table the parameter block is located at %R0550.

Note: Both parameter blocks are set up elsewhere in the program.



9.16. SVC_REQ 15: Read Last-Logged Fault Table Entry

Use SVC_REQ 15 to read the last entry logged in the Controller Fault Table or the I/O Fault Table. The SVC_REQ output is set ON unless some invalid number is entered as the requested operation or the fault table is empty.

The non-extended parameter block has a length of 22 words and the extended parameter block has a length of 24 words.

Input Parameter Block

Address	Format
Address+0	0 = Read Controller Fault Table
	1 = Read I/O Fault Table
	80h = Read extended Controller Fault Table
	81h = Read extended I/O Fault Table

Output Parameter Block

The format of the output parameter block depends on whether SVC_REQ 15 reads the Controller Fault Table, the extended Controller Fault Table, the I/O Fault Table or the extended I/O Fault Table.

Controller Fault Table Output Format		Address	I/O Fault Table Output Format	
High Byte	Low Byte		High Byte	Low Byte
	0	Address+0		1
unused	long/short (always 01)	Address+1	reference address memory type	long/short (always 03)
unused	unused	Address+2	reference address offset	
slot	rack	Address+3	slot	rack
	task	Address+4	block	bus
fault action	fault group	Address+5		point
error code		Address+6	fault action	fault category
fault extra data		Address+7	fault type	fault category
		Address+8 to Address+18	fault extra data	fault description
minutes	seconds	Address+19	minutes	seconds
day of month	hour	Address+20	day of month	hour
year	month	Address+21	year	month
milliseconds (extended format only)		Address+22	milliseconds (extended format only)	
not used (extended format only)		Address+23	not used (extended format only)	

Long/Short Value

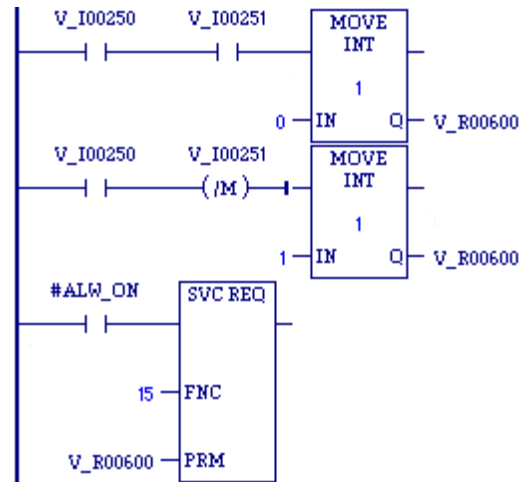
The first byte (low byte) of word *address +1* contains a number that indicates the length of the fault-specific data in the fault entry. Possible values are as follows:

Controller extended and non-extended fault tables	00 = 8 bytes (short)	01 = 24 bytes (long)
I/O extended and non-extended fault tables	02 = 5 bytes (short)	03 = 21 bytes (long)

Note: PACSystems CPUs always return the Long values for both extended and non-extended formats.

SVC_REQ 15 Example 1

When inputs %I0250 and %I0251 are both on, the first Move function places a zero (read Controller Fault Table) into the parameter block for SVC_REQ 15. When input %I0250 is on and input %I0251 is off, the Move instruction instead places a one (read I/O Fault Table) in the SVC_REQ parameter block. The parameter block is located at location %R0600.



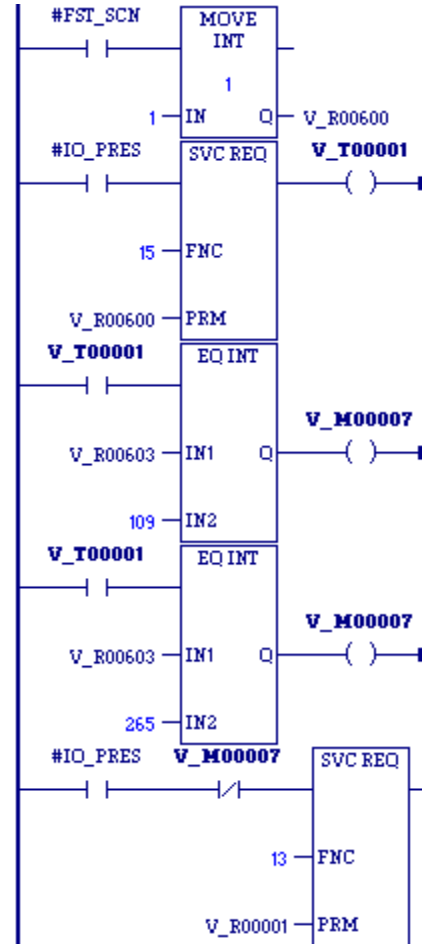
SVC_REQ 15 Example 2

The CPU is shut down when any fault occurs on an I/O module except when the fault occurs on modules in rack 0, slot 9 and in rack 1, slot 9. If faults occur on these two modules, the system remains running. The parameter for "table type" is set up on the first scan. The contact IO_PRES, when set, indicates that the I/O Fault Table contains an entry. The CPU sets the normally open contact in the scan after the fault logic places a fault in the table. If faults are placed in the table in two consecutive scans, the normally open contact is set for two consecutive scans.

The example uses a parameter block located at %R0600. After the SVC_REQ function executes, the second, third, and fourth words of the parameter block identify the I/O module that faulted:

	High Byte	Low Byte
%R0600		1
%R0601	reference address memory type	long/short
%R0602	reference address offset	
%R0603	slot number	rack number
%R0604	block (bus address)	I/O bus no.
%R0605		point address
%R0606	fault data	

In the program, the EQ_INT blocks compare the rack/slot address in the table to hexadecimal constants. The internal coil %M0007 is turned on when the rack/slot where the fault occurred meets the criteria specified above. If %M0007 is on, its normally closed contact is off, preventing the shutdown. Conversely, if %M0007 is off because the fault occurred on a different module, the normally closed contact is on and the shutdown occurs.



9.17. SVC_REQ 16: Read Elapsed Time Clock

Use SVC_REQ 16 to read the system's elapsed time clock. The elapsed time clock measures the time in seconds since the CPU was powered on. The parameter block has a length of three words used for output only.

Output

Address	Seconds from power on (low order)
Address+1	Seconds from power on (high order)
Address+2	100 microsecond ticks

The first two words are the elapsed time in seconds. The last word is the number of 100 microsecond ticks in the current second.

The resolution of the CPU's elapsed time clock is 100 microseconds. The overall accuracy of the elapsed time clock is $\pm 0.01\%$. The accuracy of an individual sample of the elapsed time clock is approximately 105 microseconds.



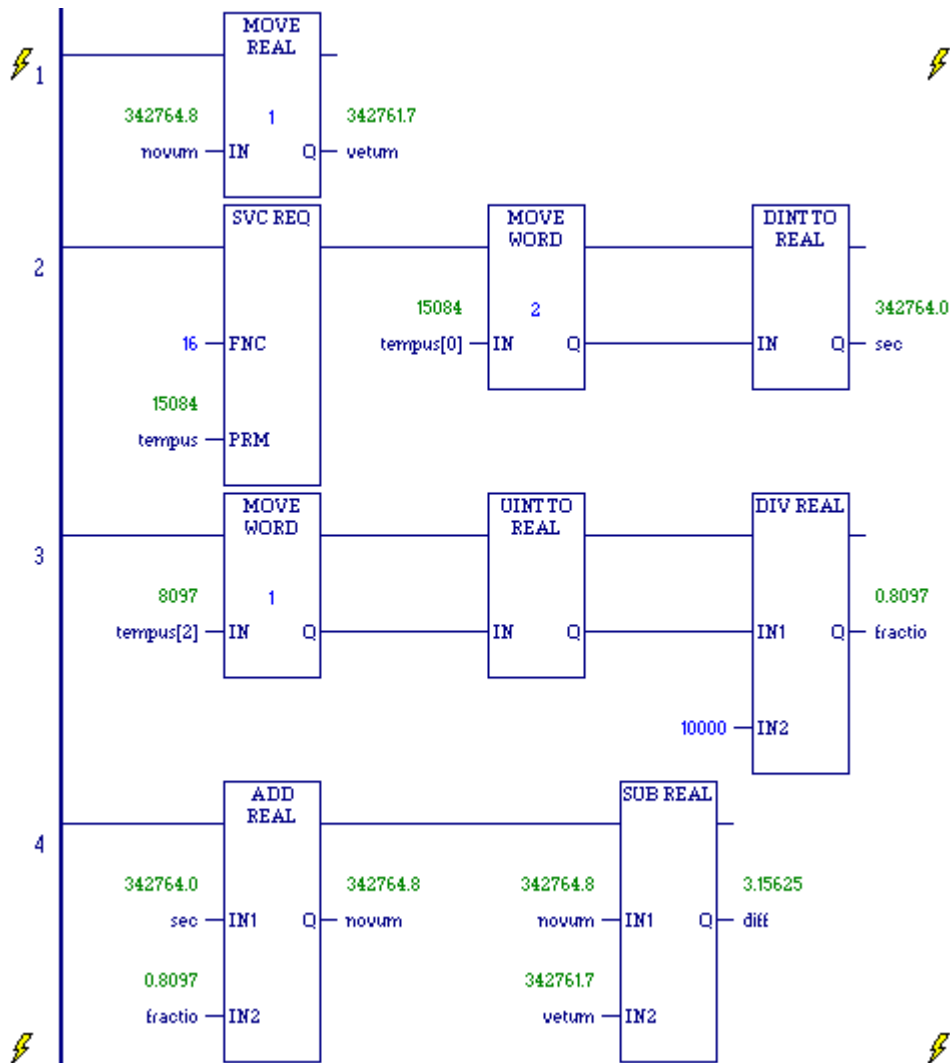
Warning

The SVC_REQ instruction is not protected against operating system and user interrupts. The timing and length of these interrupts are unpredictable. The clock sample returned by SVC_REQ 16 can sometimes be much more than 105 microseconds old by the time execution is returned to the LD logic.

Example

The following logic is used in a block that is called infrequently. The screen shot was taken between calls to the block. The logic displayed calculates the number of seconds that have elapsed since the last time the block was called. It performs the final operation on rung 4 by subtracting the time obtained by SVC_REQ 16 the last time the block was called (vetum) from the time currently obtained by SVC_REQ 16 (novum) and storing the calculated value in the variable named diff.

On rung 2, SVC_REQ 16 returns three WORDs, stored in the 3-WORD array tempus. The first two WORDs (16-bit values) are moved to a DINT (a 32-bit value). This move amounts to a rough data type conversion that ignores the fact that the DINT type is actually a signed value. Despite that, the subsequent calculations are correct until the time since power-on reaches approximately 50 years. The DINT is converted to REAL to yield the number of whole seconds elapsed since power-on, stored in variable sec. On rung 3, the third word returned by SVC_REQ 16, tempus[2], is converted to REAL. This is the number of 100 microsecond ticks. To obtain a fraction of a second, stored in the variable fractio, the value is divided by 10,000. On rung 4, sec and fractio are added to express the exact number of seconds elapsed since power-on, and this value is stored in the variable novum. On rung 1, the previous value of novum was saved as vetum, the exact number of seconds elapsed since power-on the last time the block was called. The last instruction on the fourth rung subtracts vetum from novum to yield the number of seconds that have elapsed since the last time the block was called.



Note: Higher resolution (in nanoseconds) can be obtained by using SVC_REQ 50: Read Elapsed Time Clock, described on page 415.

9.18. SVC_REQ 17: Mask/Unmask I/O Interrupt

Use SVC_REQ 17 to mask or unmask an interrupt from an input/output board. When an interrupt is masked, the CPU does not execute the corresponding interrupt block when the input transitions and causes an interrupt.

The parameter block is an input parameter block only; it has a length of three words.

Address	0 = unmask input 1 = mask input
Address+1	memory type
Address+2	reference (offset)

“Memory type” is a decimal number that resides in the low byte of word *address + 1*. It corresponds to the memory type of the input:

70	%I memory in bit mode
10	%AI memory
12	%AQ memory

Successful execution occurs unless:

- Some number other than 0 or 1 is entered as the requested operation.
- The memory type of the input/output to be masked or unmasked is not %I, %AI or %AQ memory.
- The I/O board is not a supported input/output module.
- The reference address specified does not correspond to a valid interrupt trigger reference.
- The specified channel does not have its interrupt enabled in the configuration.

9.18.1 Masking/Unmasking Module Interrupts

During module configuration, interrupts from a module can be enabled or disabled. If a module's interrupt is disabled, it cannot be used to trigger logic execution in the application program and it cannot be unmasked. However, if an interrupt is enabled in the configuration, it can be dynamically masked or unmasked by the application program during system operation.

The application program can mask and unmask interrupts that are enabled using Service Request Function Block #17. To mask or unmask an interrupt from an open VME module, the application logic should pass VME_INT_ID (17 decimal, 11H) as the memory type and the VME interrupt id as the offset to SVC_REQ 17.

When the interrupt is not masked, the CPU processes the interrupt and schedules the associated program logic for execution. When the interrupt is masked, the CPU processes the interrupt but does not schedule the associated program logic for execution.

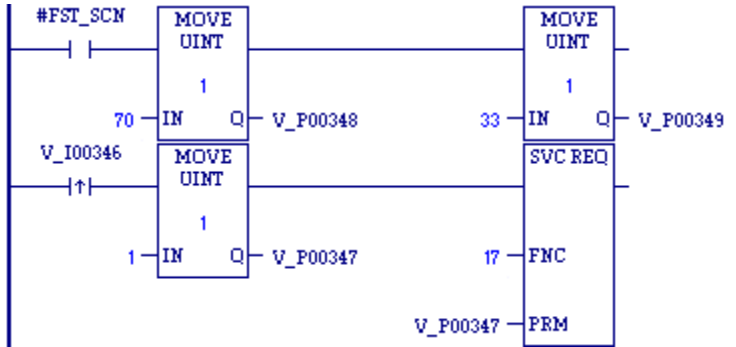
When the CPU transitions from Stop to Run, the interrupt is unmasked.

For additional information on configuring and using VME module interrupts in a PACSystems RX7i control system, refer to *PACSystems RX7i User's Guide to Integration of VME Modules*, GFK-2235.

SVC_REQ 17 Example 1

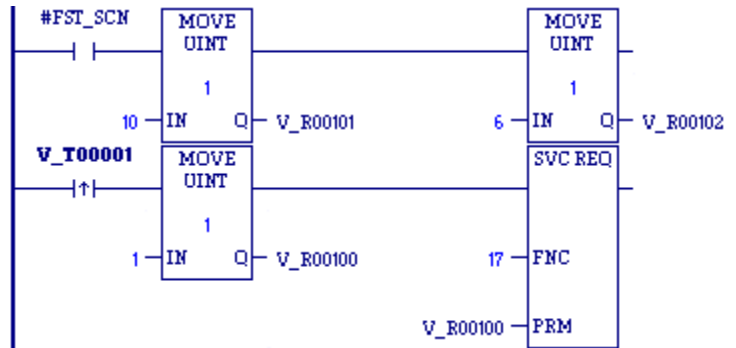
In this example, interrupts from input %I00033 are masked. The following values are moved into the parameter block, which starts at %P00347, on the first scan:

Address	%P00347	1	Interrupts from input are masked.
Address + 1	%P00348	70	Input type is %I.
Address + 2	%P00349	33	Offset is 33.



SVC_REQ 17 Example 2

When %T00001 transitions on, alarm interrupts from input %AI0006 are masked. The parameter block at %R00100 is set up on the first scan.



9.19. SVC_REQ 18: Read I/O Forced Status

Use SVC_REQ 18 to read the current status of forced values in the CPU's %I and %Q memory areas.

Note: SVC_REQ 18 does not detect overrides in %G or %M memory types. Use %S0011 (#OVR_PRE) to detect overrides in %I, %Q, %G, %M, and symbolic memory types.

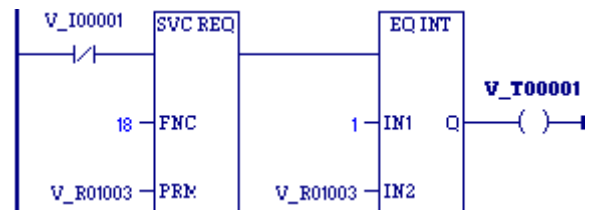
The parameter block has a length of one word used for output only.

Output

Address	0 = No forced values are set
	1 = Forced values are set

Example

SVC_REQ reads the status of I/O forced values into location %R1003. If the returned value in %R1003 is 1, there is a forced value, and EQ INT turns the %T0001 coil ON.



9.20. SVC_REQ 19: Set Run Enable/Disable

Use SVC_REQ 19 to permit the LD program to control the RUN mode of the CPU.

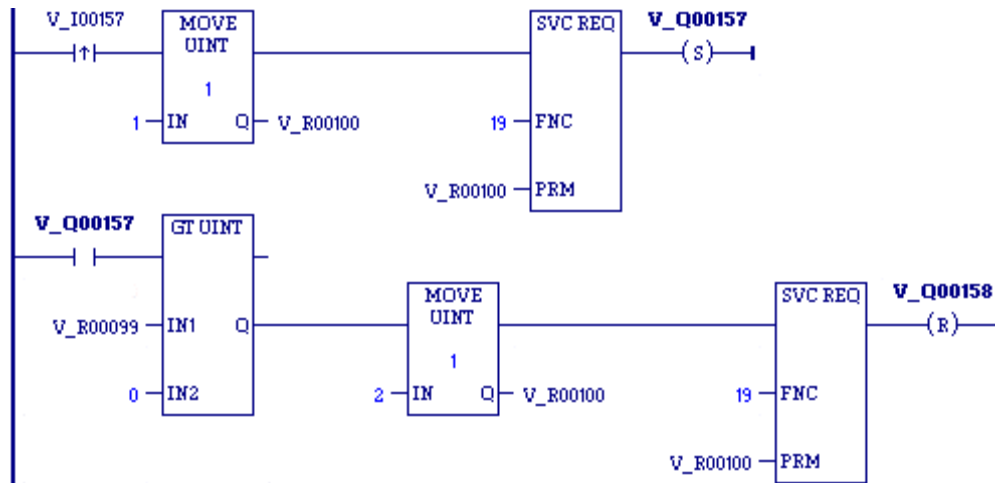
The parameter passed indicates which function to perform. The OK output is turned ON if the function executes successfully. It is set OFF if the requested operation is not SET RUN DISABLE mode (1) or SET RUN ENABLE mode (2).

The parameter block is an input parameter block only with this format:

Address	1 = SET RUN DISABLE mode
	2 = SET RUN ENABLE mode

Example

When input %I00157 transitions to on, the RUN DISABLE mode is set. When the SVC_REQ function successfully executes, coil %Q00157 is turned on. When %Q00157 is on and register %R00099 is greater than zero, the mode is changed to RUN ENABLE mode. When the SVC_REQ successfully executes, coil %Q00158 is turned off.



9.21. SVC_REQ 20: Read Fault Tables

Use SVC_REQ 20 to retrieve the entire Controller or I/O Fault Table and return it to the LD program in designated registers.

The first input parameter designates which table is to be read. A second input parameter (always zero for the standard Read Fault Tables) is used by the extended format to read a designated fault entry or to read a range of fault entries. The fault table data is placed in the parameter block following the input parameters.

The OK output is turned on if the function executes successfully. It is off if the requested operation is not Read Controller Fault Table (00h), Read I/O Fault Table (01h), Read Extended Controller Fault Table (80h), or Read Extended I/O Fault Table (81h), or if there is not enough of the specified memory reference to hold the fault data. If the specified fault table is empty, the function sets the OK output on, but returns only the fault table header information.

The parameter block is an input and output parameter block. The parameter block comes in two formats:

- Non-Extended: Read Controller Fault Table (00h), Read I/O Fault Table (01h)
- Extended: Read Extended Controller Fault Table (80h), Read Extended I/O Fault Table (81h)

9.21.1 Non-Extended Formats

For non-extended formats, SVC_REQ 20 requires 693 registers available.

Input Parameter Block Format

Address + 0	00h = Read Controller fault table 01h = Read I/O Fault Table
Address + 1	Always 0

Non-Extended Output Parameter Block Format

<i>Controller Fault Table Output Format</i>		<i>Address</i>	<i>I/O Fault Table Output Format</i>	
<i>High Byte</i>	<i>Low Byte</i>		<i>High Byte</i>	<i>Low Byte</i>
Unused	0 = Controller Fault Table	Address+0	Unused	1 = I/O Fault Table
Unused	Always zero (0)	Address+1	Unused	Always zero (0)
Unused	Unused	Address+2	Unused	Unused
Unused	Unused	Address+3— Address+14	Unused	Unused
Minutes	Seconds	Address+15— Address+17 (Time Since Last Clear, in BCD Format)	Minutes	Seconds
Day Of Month	Hour		Day of month	Hour
Year	Month		Year	Month
Number of faults since last clear		Address+18	Number of faults since last clear	
Number of faults in queue		Address+19	Number of faults in queue	
Number of faults read		Address+20	Number of faults read	
Start of fault data		Address+21	Start of fault data	

For the non-extended formats, the returned data for each fault consists of 21 words (42 bytes). This request returns 16 Controller Fault Table entries or 32 I/O Fault Table entries, or the actual number of faults if it is fewer. If the fault table read is empty, no data is returned.

The following table shows the return format of a Controller Fault Table entry and an I/O Fault Table entry.

Format of Returned Data for Fault Table Entries

Controller Fault Table Output Format		Address	I/O Fault Table Output Format	
High Byte	Low Byte		High Byte	Low Byte
Unused	Long/short	Address+21	Memory type	Long/Short ¹⁸
Unused	Unused	Address+22	Offset	
Slot	Rack	Address+23	Slot	Rack
Task		Address+24	Bus address	I/O Bus Number (block)
Fault action	Fault group	Address+25	Point	
Error code		Address+26	Fault action	Fault group
Fault extra data		Address+27	Fault type	Fault category
		Address+28	Fault extra data	Fault description
		Address+29— Address+38	Fault extra data	
Minutes	Seconds	Address+39— Address+41 (Time-stamp, in BCD Format)	Minutes	Seconds
Day of month	Hour		Day of month	Hour
Year	Month		Year	Month
Start of next fault output parameter block		Address+42	Start of next fault output parameter block	

¹⁸ The Long/Short indicator in the low byte of *Address + 21* specifies the amount of fault data present in the fault entry:

Fault Table	Long/Short Value	Fault Data Returned
Controller	00	8 bytes of fault extra data present in the fault entry
	01	24 bytes of fault extra data
I/O	02	5 bytes of fault extra data
	03	21 bytes of fault extra data

9.21.2 Extended Formats

Each extended format request can read a maximum of 64 faults, or the size of the fault table if it contains less than 64 faults.

For extended formats (Read Extended Controller Fault Table (80h), or Read Extended I/O Fault Table (81h)), the controller calculates the number of entries being read. You must ensure that enough registers are available to receive the amount of fault entries requested. If the amount of data requested exceeds the registers available, the CPU returns a fault indicating that reference memory is out of range.

The total size of the fault table for the extended fault format is
Header Size + ((# fault entries) × (size of fault entry))

Input Parameter Block Format

Address+0	80h = Read extended Controller Fault Table 81h = Read extended I/O Fault Table
Address+1	Starting index of faults to be read
Address+2	Number of faults to be read

Extended Format Output Parameter Block Format

<i>Controller Fault Table Output Format</i>		<i>Address</i>	<i>I/O Fault Table Output Format</i>	
<i>High Byte</i>	<i>Low Byte</i>		<i>High Byte</i>	<i>Low Byte</i>
Unused	80h = Extended Controller Fault Table	Address	Unused	81h = Extended I/O Fault Table
Starting index of faults to be read		Address+1	Starting index of faults to be read	
Number of faults to be read		Address+2	Number of faults to be read	
Unused	Unused	Address+3—Address+14	Unused	Unused
Minutes	Seconds	Address+15—Address+17 (Time Since Last Clear, in BCD Format)	Minutes	Seconds
Day of Month	Hour		Day of month	Hour
Year	Month		Year	Month
Number of faults since last clear		Address+18	Number of faults since last clear	
Number of faults in queue		Address+19	Number of faults in queue	
Number of faults read		Address+20	Number of faults read	
Unused		Address+21—Address+36	Unused	
Start of fault data		Address+37	Start of fault data	

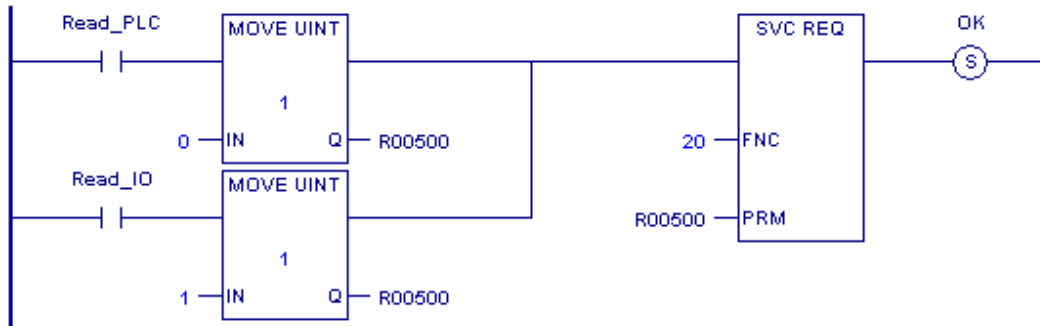
For Read Extended Controller Fault Table (80h) and Read Extended I/O Fault Table (81h), the returned data for each fault entry consists of 23 words (46 bytes).

Format of Returned Data for Fault Table Entries

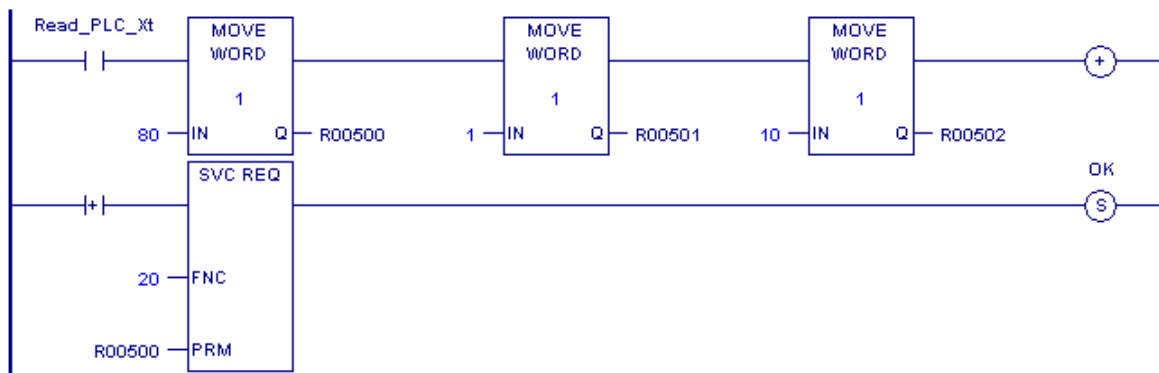
Controller Fault Table Output Format		Address	I/O Fault Table Output Format	
High Byte	Low Byte		High Byte	Low Byte
Unused	Long/Short	Address+37	Reference address memory type	Long/Short (See page 393.)
Unused	Unused	Address+38	Reference address offset	
Slot	Rack	Address+39	Slot	Rack
Task		Address+40	Bus address	I/O bus number (block)
Fault action	Fault group	Address+41	point	
Error code		Address+42	Fault action	Fault group
Fault extra data		Address+43	Fault type	Fault category
		Address+44	Fault extra data	Fault description
		Address+45— Address+54	Fault extra data	
Minutes	Seconds	Address+55— Address+58 (Time-stamp in BCD Format)	Minutes	Seconds
Day of month	Hour		Day of month	Hour
Year	Month		Year	Month
Milliseconds			Milliseconds	
Not used			Not used	
Start of next fault output parameter block		Address+60	Start of next fault output parameter block	

SVC_REQ 20 Example 1: Non-Extended Format

When Read_PLC transitions on, a value of 0 is moved to the parameter block, which is located at %R00500, and the Controller Fault Table is read. When Read_IO transitions on, a value of 1 is moved to the parameter block and the I/O Fault Table is read. When the SVC_REQ function successfully executes, coil OK is turned on.

**SVC_REQ 20 Example 2: Extended Format**

When Read_PLC_Xt transitions on, the Extended Controller Fault Table is read. The parameter block begins at %R00500. %R00500 contains the fault table type (Controller Extended); %R00501 contains the starting fault to read, and %R00502 contains the number of faults to read starting with the fault number in %R00501. When the SVC_REQ function successfully executes, coil OK is turned on.



9.22. SVC_REQ 21: User-Defined Fault Logging

Use SVC_REQ 21 to define a fault that can be displayed in the Controller Fault Table. The fault contains binary information or an ASCII message. The user-defined fault codes start at 0 hex. The error code information for the fault must be within the range 0 to 2047 for an "Application Msg:" to be displayed. If the error code is in the range 81 to 112 decimal, the CPU sets a fault bit of the same number in %SA system memory. This allows up to 32 bits to be individually set.

Error Code	Status Bit
Errors 0—80	No bit set
Errors 81—112	Sets %SA
Errors 113—2047	No bit set
Errors 2048—32,767	Reserved

When EN is active, the fault data array referenced by IN is logged as a fault to the Controller Fault Table. If EN is not enabled, the ok bit is cleared. If the error code is out of range, the ok bit is cleared and the fault will not be logged as requested.

The parameter block is an input parameter block only with this format:

Parameter address	Error code	
	MSB	LSB
Address+1	Text2	Text1
Address+2	Text4	Text3
Address+3	Text6	Text5
Address+4	Text8	Text7
Address+5	Text10	Text9
Address+6	Text12	Text11
Address+7	Text14	Text13
Address+8	Text16	Text15
Address+9	Text18	Text17
Address+10	Text20	Text19
Address+11	Text22	Text21
Address+12	Text24	Text23

The input parameter data allows you to select an error code in the range 0 to 2047 and text information that will be placed in the fault extra data portion of a long controller fault. The controller fault address, fault group, and fault action are filled in by the function block.

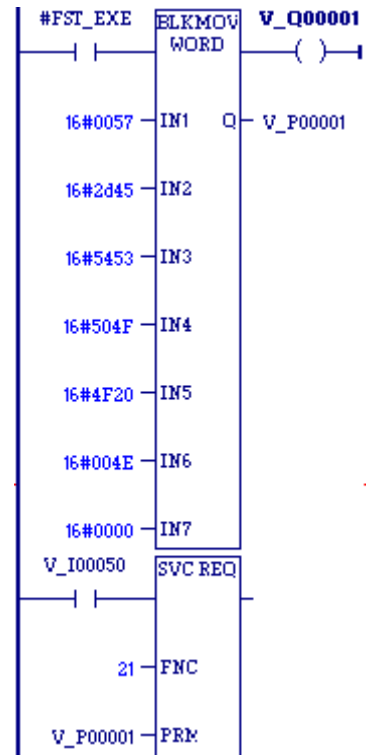
The fault text bytes 1 – 24 can be used to pass binary or ASCII data with the fault. If the first byte of the fault text data is non-zero, the data will be an ASCII message string. This message will then be displayed in the fault description area of the fault table. If the message is less than 24 characters, the ASCII string must be NULL byte-terminated. The programmer will display “Application Msg:” and the ASCII data will be displayed as a message immediately following “Application Msg:”. If the error code is between 1 and 2047, the error code number will be displayed immediately after “Msg” in the “Application Msg:” string. (If the error code is greater than 2047, the function is ignored and its output is set to OFF.)

If the first byte of text is zero, then only “Application Msg:” will display in the fault description. The next 1-23 bytes will be considered binary data for user data logging. This data is displayed in the Controller Fault Table.

Note: When a user-defined fault is displayed in the Controller Fault Table, a value of -32768 (8000 hex) is added to the error code. For example, the error code 5 will be displayed as -32763.

Example

The value passed to IN1 is the fault error code. The value passed in, 16x0057, represents an error code of 87 decimal and will appear as part of the fault message. The values of the next inputs give the ASCII codes for the text of the error message. For IN2, the input is 2D45. The low byte, 45, decodes to the letter **E** and the high byte, 2D, decodes to **-**. Continuing in this manner, the string continues with **S T O P O** and **N**. The final character, **00**, is the null character that terminates the string. In summary, the decoding yields the string message **E_STOP ON**.



9.23. SVC_REQ 22: Mask/Unmask Timed Interrupts

Use SVC_REQ 22 to mask or unmask timed interrupts and to read the current mask. When the interrupts are masked, the CPU does not execute any timed interrupt block timed program that is associated with a timed interrupt. Timed interrupts are masked/unmasked as a group. They cannot be individually masked or unmasked.

Successful execution occurs unless some number other than 0 or 1 is entered as the requested operation or mask value.

The parameter block is an input and output parameter block.

To determine the current mask, use this format:

Address	0 = Read interrupt mask
----------------	-------------------------

The CPU returns this format:

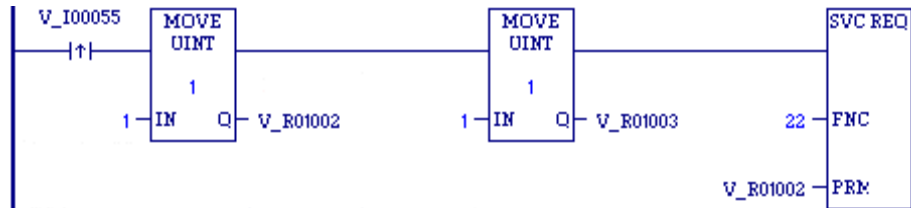
Address	0 = Read interrupt mask
Address+1	0 = Timed interrupts are unmasked 1 = Timed interrupts are masked

To change the current mask, use this format:

Address	1 = Mask/unmask interrupts
Address+1	0 = Unmask timed interrupts 1 = Mask timed interrupts

Example

When input %I00055 transitions on, timed interrupts are masked.



9.24. SVC_REQ 23: Read Master Checksum

Use SVC_REQ 23 to read master checksums for the set of user program(s) and the configuration, and to read the checksum for the block from which the service request is made.

There is no input parameter block for this service request. The output parameter block requires 15 words of memory.

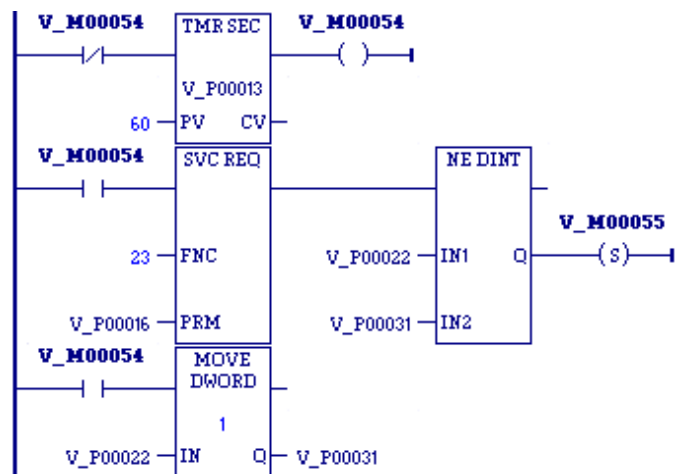
Output

When a RUN MODE STORE is active, the program checksums may not be valid until the store is complete. To determine when checksums are valid, three flags (one each for Program Block Checksum, Master Program Checksum, and Master Configuration Checksum) are provided at the beginning of the output parameter block.

Address	Description
Address	Program Checksum Valid (0 = not valid, 1 = valid)
Address + 1	Master Program Checksum Valid (0 = not valid, 1 = valid)
Address + 2	Master Configuration Checksum Valid (0 = not valid, 1 = valid)
Address + 3	Number of LD/SFC Blocks (including _MAIN)
Address + 4	Size of User Program in Bytes (DWORD data type)
Address + 6	Program Set Additive Checksum
Address + 7	Program CRC Checksum (DWORD data type)
Address + 9	Size of Configuration Data in Kbytes
Address + 10	Configuration Additive Checksum
Address + 11	Configuration CRC Checksum (DWORD data type)
Address + 13	high byte: always zero low byte: Currently Executing Block's Additive Checksum
Address + 14	Currently Executing Block's CRC Checksum

SVC_REQ 23 Example

When the timer using registers %P00013 through %P00015 expires, the checksum read is performed. The checksum data returns in registers %P00016 through %P00030. The master program checksum in registers %P00022 and %P00023 (the program checksum is a DWORD data type and occupies two adjacent registers) is compared with the last saved master program checksum. If these are different, coil %M00055 is latched on. The current master program checksum is then saved in registers %P00031 and %P00032.



9.25. SVC_REQ 24: Reset Module

Use SVC_REQ 24 to reset a daughterboard or some modules. Modules that support SVC_REQ 24 include:

RX3i IC693BEM331, IC694BEM331, IC693APU300, IC694APU300, IC695ETM001, IC693ALG2222, IC694ALG2222, IC695PNC001

RX7i: Embedded Ethernet Interface module, IC697BEM731, IC698BEM731, IC697HSC700, IC697ALG230, IC698ETM001

The SVC_REQ output is set ON unless one of the following conditions exists:

- An invalid number for rack and/or slot is entered.
- There is no module at the specified location.
- The module at the specified location does not support a runtime reset.
- The CPU was unable to reset the module at the specified location.

For this function, the parameter block has a length of 1 word. It is an input parameter block only.

Address	Module slot (low byte) Module rack (high byte) <i>Rack 0, Slot 1 indicates that a reset is to be sent to the daughterboard.</i>
----------------	---

Note: It is important to invoke SVC_REQ #24 for a given module for only one sweep at a time. Each time this function executes, the target module will be reset regardless of whether it has finished starting up from a previous reset.

After sending a SVC_REQ #24 to a module, you must wait a minimum of 5 seconds before sending another SVC_REQ #24 to the same module. This ensures that the module has time to recover and complete its startup.

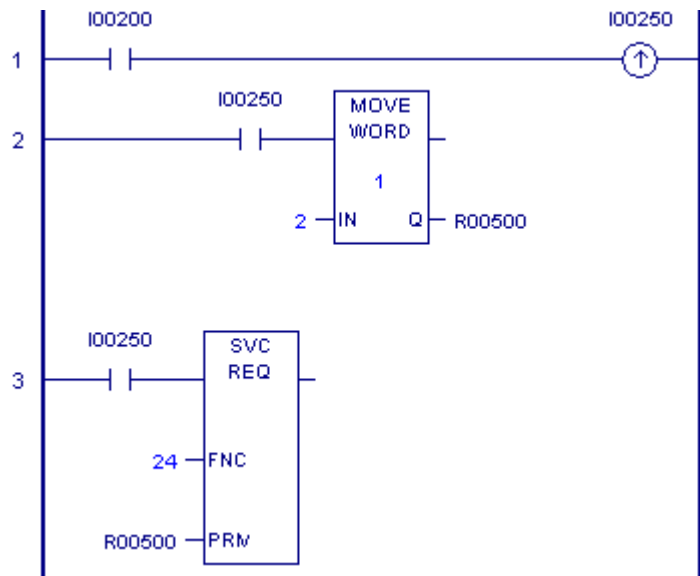
Example

This example resets the module in rack0/slot 2.

In rung 1, when contact %I00200 is closed, the positive transition coil sets %I00250 to ON for one sweep.

The MOVE_WORD instruction in rung 2 receives power flow and moves the value 2 into %R00500.

The SVC_REQ function in rung 3 then receives power flow and resets the module indicated by the rack/slot value in %R00500.



9.26. SVC_REQ 25: Disable/Enable EXE Block and Standalone C Program Checksums

Use SVC_REQ 25 to enable or disable the inclusion of EXE in the background checksum calculation. The default is to include the checksums.

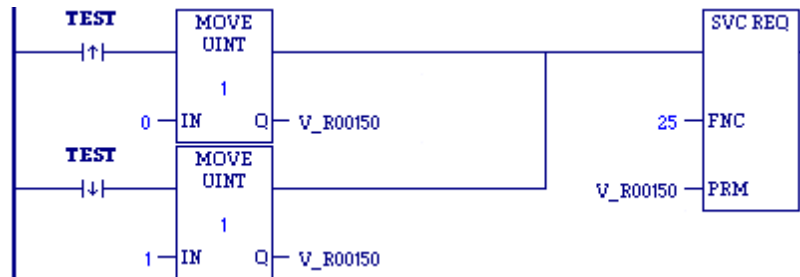
This service request uses only an input parameter block.

Address	0 = Disable C applications inclusion in checksum calculation
	1 = Enable C application inclusion in checksum calculation

The parameter block is unchanged after execution of the service request.

Example

When the coil TEST transitions from OFF to ON, SVC_REQ 25 executes to disable the inclusion of EXE blocks in the background checksum calculation. When coil TEST transitions from ON to OFF, the SVC_REQ executes to again include EXE blocks in the background checksum calculation.



9.27. SVC_REQ 29: Read Elapsed Power Down Time

Use SVC_REQ 29 to read the amount of time elapsed between the last power-down and the most recent power-up. If the watchdog timer expired before power-down, the CPU is not able to calculate the power down elapsed time, so the time is set to 0.

This service request cannot be accessed from a C block.

This function has an output parameter block only. The parameter block has a length of three words.

Address	Power-down elapsed seconds (low order)
Address + 1	Power-down elapsed seconds (high order)
Address + 2	100µS ticks

The first two words are the power-down elapsed time in seconds. The last word is the number of 100 microsecond ticks in the current second.

Note: Although this request responds with a resolution of 100µS, the actual accuracy is 1 second. The battery-backed clock, which is used when the controller is powered down, is accurate to within 1 second.

SVC_REQ 29 Example

When input %I0251 is ON, the elapsed power-down time is placed into the parameter block that starts at %R0050. The output coil (%Q0001) is turned on.



9.28. SVC_REQ 32: Suspend/Resume I/O Interrupt

Use SVC_REQ 32 to suspend a set of I/O interrupts and cause occurrences of these interrupts to be queued until these interrupts are resumed. The number of I/O interrupts that can be queued depends on the I/O module's capabilities. The CPU informs the I/O module that its interrupts are to be suspended or resumed. The I/O module's default is resumed. The Suspend applies to all I/O interrupts associated with the I/O module. Interrupts are suspended and resumed within a single scan.

SVC_REQ 32 uses only an input parameter block. Its length is three words.

Address	0 = resume interrupt 1 = suspend interrupt
Address + 1	memory type
Address + 2	reference (offset)

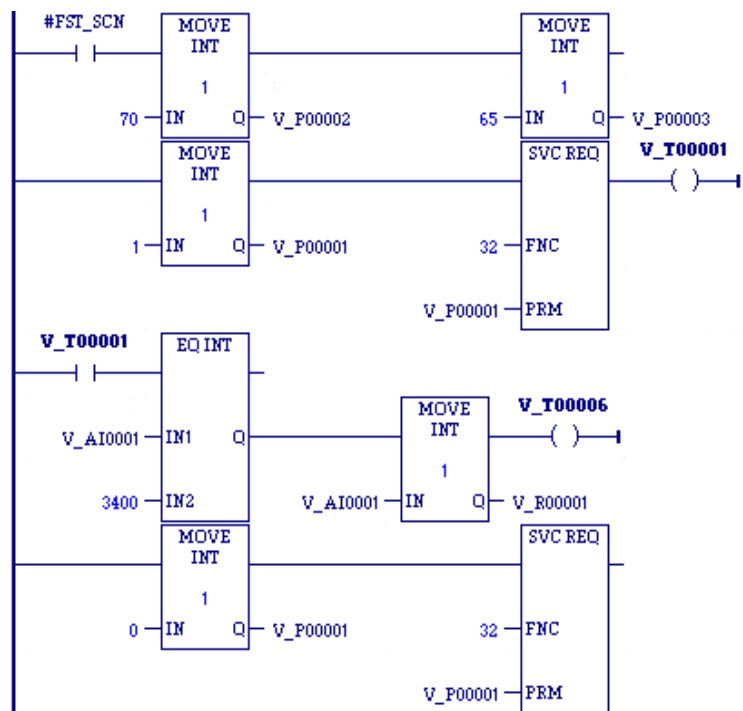
Successful execution occurs unless:

- Some number other than 0 or 1 is passed in as the first parameter.
- The memory type parameter is not 70 (%I memory).
- The I/O module associated with the specified address is not an appropriate module for this operation.
- The reference address specified is not the first %I reference for the High Speed Counter.
- Communication between the CPU and this I/O module has failed. (The board is not present, or it has experienced a fatal fault.)

Note: I/O interrupts, unless suspended or masked, can interrupt the execution of a function block. The most often used application of this Service Request is to prevent the effects of the interrupts for diagnostic or other purposes.

SVC_REQ 32 Example

Interrupts from the high speed counter module whose starting point reference address is %I00065 will be suspended while the CPU solves the logic of the second rung. Without the Suspend, an interrupt from the HSC could occur during execution of the third rung and %T00006 could be set while %R00001 has a value other than 3,400. (%AI00001 is the first non-discrete input reference for the High Speed Counter.)



9.29. SVC_REQ 45: Skip Next I/O Scan

Use the SVC_REQ function #45 to skip the next output and input scans. Any changes to the output reference tables during the sweep in which the SVC_REQ #45 was executed will not be reflected on the physical outputs of the corresponding modules. Any changes to the physical input data on the modules will not be reflected in the corresponding input references during the sweep after the one in which the SVC_REQ #45 was executed.

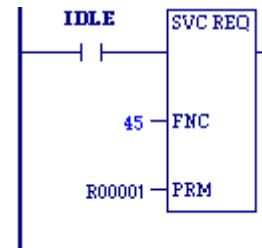
This function has no parameter block.

Note: This service request is provided for conversion of Series 90-30 applications. The Suspend I/O (SUS_IO) function block, which is supported by all PACSystems firmware versions, should be used in new applications.

Note: The DOIO Function Block is not affected by the use of SVC_REQ #45. It will still update the I/O when used in the same logic program as the SVC_REQ #45.

Example

In the following LD example, when the “Idle” contact passes power flow, the next Output and Input Scan are skipped.



9.30. SVC_REQ 50: Read Elapsed Time Clock

Use SVC_REQ 50 to read the system's elapsed time clock. The elapsed time clock measures the time in seconds since the CPU was powered on. The parameter block has a length of four words used for output only.

Output

Address	Seconds from power on (low order)
Address+1	Seconds from power on (high order)
Address+2	nanosecond ticks (low order)
Address+3	nanosecond ticks (high order)

The first two words are the elapsed time in seconds. The second two words are the number of nanoseconds elapsed in the current second.

The resolution of the CPU's elapsed time clock is 100 microseconds. The overall accuracy of the elapsed time clock is $\pm 0.01\%$. The accuracy of an individual sample of the elapsed time clock is approximately 105 microseconds.

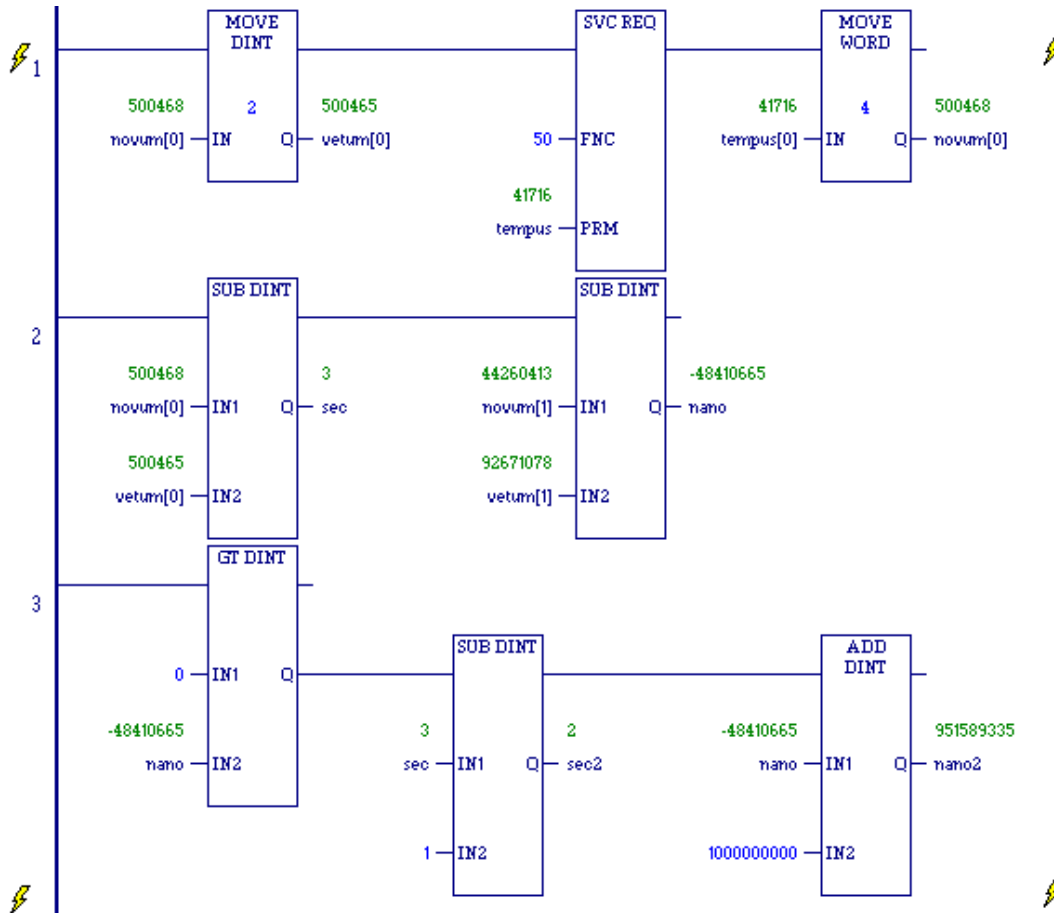


Warning

The SVC_REQ instruction is not protected against operating system and user interrupts. The timing and length of these interrupts are unpredictable. The clock sample returned by SVC_REQ 50 can sometimes be much more than 105 microseconds old by the time execution is returned to the LD logic.

SVC_REQ 50 Example

The following logic is used in a block that is called once in a while. The screen shot was taken between calls to the block. The second rung of logic calculates the number of seconds that have elapsed since the last time the block was called. The third rung calculates the number of nanoseconds to be added to, or subtracted from, the number of seconds. The first rung saves the previous value of novum[0] and novum[1] into vetum[0] and vetum[1] before the second rung of logic places the current time values in novum[0] and novum[1].



9.31. SVC_REQ 51: Read Sweep Time from Beginning of Sweep

Use SVC_REQ 51 to read the time in nanoseconds since the start of the sweep. The data is unsigned 32-bit integer.

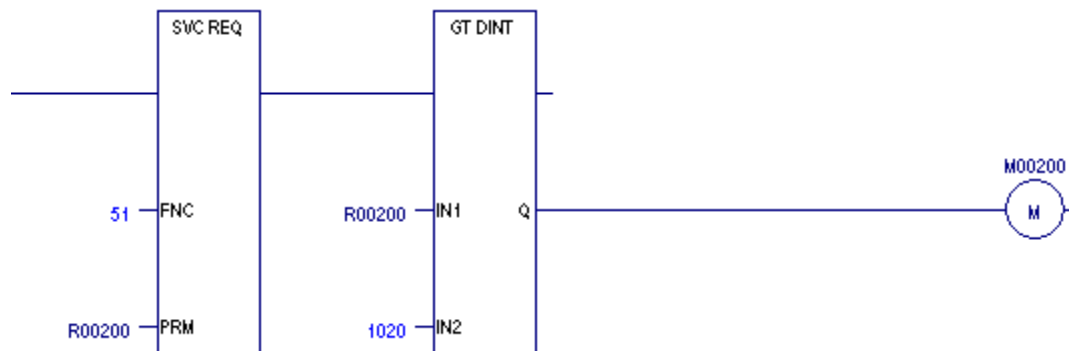
Output

The parameter block is an output parameter block only; it has a length of two words.

Address	time (nanoseconds) since start of scan – low order
Address+1	time (nanoseconds) since start of scan – high order

Example

The elapsed time from the start of the scan is read into locations %R00200 and %R00201 if it is greater than 10,020ns, internal coil %M0200 is turned on.



9.32. SVC_REQ 56: Logic Driven Read of Nonvolatile Storage

PACSystems controllers support a 64KB nonvolatile flash memory area, which can be accessed by the logic-driven read/write service requests. Values are stored in the nonvolatile storage area using SVC_REQ 57: Logic Driven Write to Nonvolatile Storage (see page 422). These values are applied to the controller user memory on power-up.

If you want only to write to nonvolatile storage and have the values restored on a power cycle, you may not need to use SVC_REQ 56. However, a logic driven read from nonvolatile storage can be commanded as needed. For example, you can use #FST_SCN with SVC_REQ 56 calls to force a reload on each Stop to Run transition.

SVC_REQ 56 specifies a read operation from nonvolatile storage when the PACSystems is running. You can specify which reference address range to read and optionally a different destination memory location in CPU memory in which to place the read data. Using different memory locations enables you to set up a comparison between existing values in CPU memory with values in nonvolatile storage.

SVC_REQ 56 execution time will vary depending on the number of values stored in nonvolatile storage, as it will find the most recent value for the requested reference address range.

You can read up to 32 words (64 bytes) inclusively per invocation of SVC_REQ 56.

Discrete Memory

Discrete memory can be read as individual bits or as bytes. For more information, see “Memory Type Codes” on page 420.

If a discrete memory destination is forced, the forced value remains intact in CPU memory even though the count in word 10 (address + 10) indicates that all the data was read and transferred.

If a memory location has an associated transition bit and SVC_REQ 56 causes a transition on that value, the transition bit is set.

Storage Disabled Conditions

By default, the following write operations disable SVC_REQ 56 until logic is written to nonvolatile storage:

- Run Mode Store (RMS), even if a second RMS reverts everything to the original state.
- Test-Edit session, even when you cancel your edits.
- Word-for-word change.
- Downloading to RAM only of a stopped PACSystems CPU, even if the downloaded contents are equal to the contents already on the nonvolatile storage. Setting bit 0 of input word 8 (address + 7) to a value of 1 enables SVC_REQ 56 despite the above conditions.

Maximum of One Active Instruction

When SVC_REQ 56 is active, it does not support an interrupt that attempts to activate SVC_REQ 57 or a second instance of SVC_REQ 56. If an attempt fails, an error indicating that another instance is active will be returned.

ENO and Power Flow To The Right

If the status is Success or Partial Read (see address+9), on the SVC_REQ instruction, ENO is set to True in FBD and ST, and power flow passes to the right in LD.

Parameter Block

Address+0	Memory type. See “Memory Type Codes” on page 420.								
Address+1	The zero-based offset N to read from nonvolatile storage. Contains the complete offset for any memory area except %W, which also requires the use of address + 2 for offsets greater than 65,535. <ul style="list-style-type: none"> For %I, %Q, %M, %T, and %G memory in byte mode, $N = (Ra - 1) / 8$, where Ra = one-based reference address. For example, to read from the one-based bit reference address %T33, enter the byte offset 4: $(33 - 1) / 8 = 4$. For %W, %R, %AI, and %AQ memory, and for %I, %Q, %M, %T, and %G memory in bit mode, $N = Ra - 1$. For example, to read from the one-based reference address %R200, enter the zero-based reference offset 199; to read from %I73 in bit mode, enter offset 72. For memory in bit mode, the offset must be set on a byte boundary, that is, a number exactly divisible by 8: 0, 8, 16, 24, and so on. 								
Address+2									
Address+3	Length. The number of items to read from nonvolatile storage beginning at the reference address calculated from the offset defined at [address + 1 and address + 2]. The length can be one of the following: <table border="1"> <thead> <tr> <th>Description</th> <th>Valid range</th> </tr> </thead> <tbody> <tr> <td>The number of words (16-bit registers) to read from %W, %R, %AI, or %AQ nonvolatile storage</td> <td>1 through 32 words</td> </tr> <tr> <td>The number of bytes to read from %I, %Q, %M, %T, or %G in byte mode nonvolatile storage</td> <td>1 through 64 bytes</td> </tr> <tr> <td>The number of bits to read from %I, %Q, %M, %T, or %G in bit mode nonvolatile storage</td> <td>1 through 512 bits in increments of 8 bits</td> </tr> </tbody> </table> <p>The value must reside in the low byte of address + 3. The high byte must be set to zero.</p>	Description	Valid range	The number of words (16-bit registers) to read from %W, %R, %AI, or %AQ nonvolatile storage	1 through 32 words	The number of bytes to read from %I, %Q, %M, %T, or %G in byte mode nonvolatile storage	1 through 64 bytes	The number of bits to read from %I, %Q, %M, %T, or %G in bit mode nonvolatile storage	1 through 512 bits in increments of 8 bits
Description	Valid range								
The number of words (16-bit registers) to read from %W, %R, %AI, or %AQ nonvolatile storage	1 through 32 words								
The number of bytes to read from %I, %Q, %M, %T, or %G in byte mode nonvolatile storage	1 through 64 bytes								
The number of bits to read from %I, %Q, %M, %T, or %G in bit mode nonvolatile storage	1 through 512 bits in increments of 8 bits								
Address + 4	Destination memory. The CPU memory area to write the read data to. This does not need to be the same memory area as specified at [address]. Writing to a different memory area enables you to compare the values that were already in the CPU with the values read from nonvolatile storage.								
Address+5	The zero-based offset N in CPU memory to start writing the read data to. Address + 5, the least significant word, contains the complete offset for any memory area except %W, which also requires the use of address + 6 for offsets greater than 65,535. <ul style="list-style-type: none"> For %I, %Q, %M, %T, and %G memory in byte mode, $N = (Ra - 1) / 8$, where Ra = one-based reference address. For example, to write to the one-based bit reference address %T33, enter the byte offset 4: $(33 - 1) / 8 = 4$. For %W, %R, %AI, and %AQ memory, and for %I, %Q, %M, %T, and %G memory in bit mode, $N = Ra - 1$. For example, to write to the one-based reference address %R200, enter the zero-based reference offset 199; to write to %I73 in bit mode, enter offset 72. 								
Address+6									
Address+7	<ul style="list-style-type: none"> When bit 0 is set to 1, storage disabled conditions are ignored. A read is allowed even if the logic in RAM has changed since nonvolatile storage was read or written. Bits 1 through 15 must be set to zero; otherwise, the read fails. 								
Address+8	Reserved. Must be set to zero; otherwise, the read fails.								
Address+9	Response status. The status read from nonvolatile storage. The low byte contains the major error code; the high byte contains the minor error code. For definitions, see “Response Status Codes for SVC_REQ 56” on page 420.								
Address+10	Response Count. The number of words, bytes, or bits copied.								

Memory Type Codes

Type	Decimal Value	Type	Decimal Value
%R	8	%G (byte mode)	56
%AI	10	%I (bit mode)	70
%AQ	12	%Q (bit mode)	72
%I (byte mode)	16	%T (bit mode)	74
%Q (byte mode)	18	%M (bit mode)	76
%T (byte mode)	20	%G (bit mode)	86
%M (byte mode)	22	%W	196

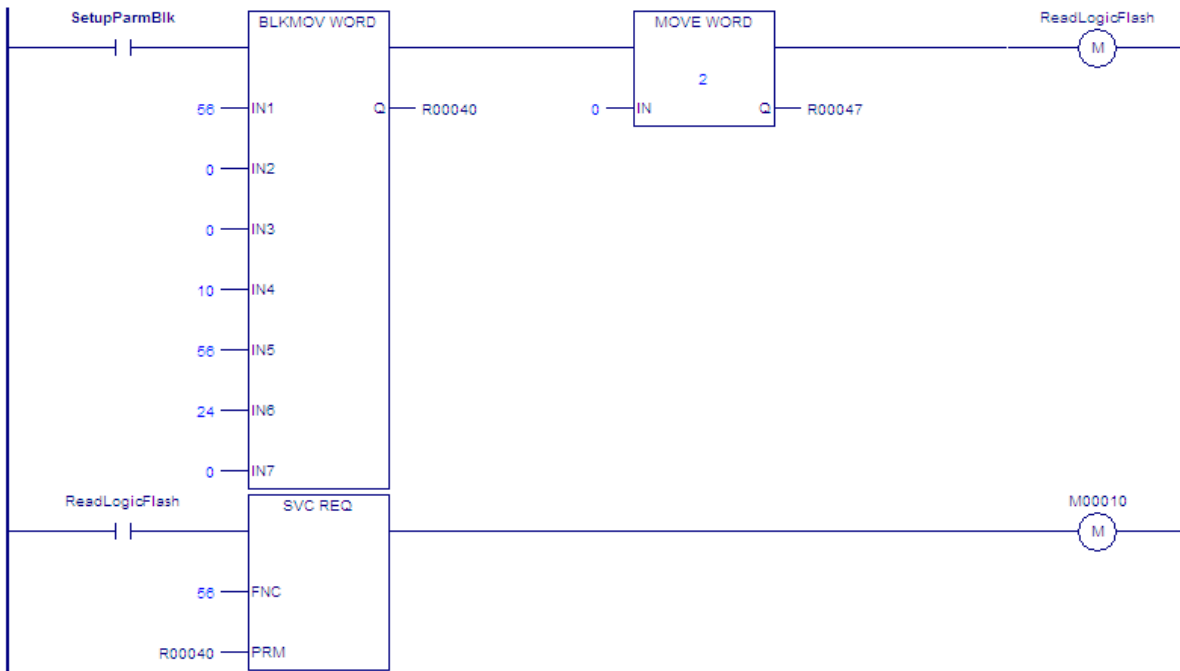
Response Status Codes for SVC_REQ 56

Minor	Major	Description
00	01	Success. All values requested were found and copied.
01	01	Partial Read. All values found were copied, but some or all values were not in storage.
01	02	Insufficient Destination Memory. The Destination memory location is not large enough to store the requested values.
02	02	Invalid Length. The length requested is larger than 64 bytes or less than 1 byte or the number of bits is not an exact multiple of 8.
03	02	Invalid storage or destination reference address. A specified memory area is not %I, %Q, %T, %M, %G, %R, %AI, %AQ, or %W, or the offset is out of range, or the offset is not byte-aligned for discrete memory in bit mode.
04	02	Invalid request. Spare bits or spare words in parameter block are not set to zero.
01	03	Storage Busy. A SVC_REQ 57 or another SVC_REQ 56 instruction is active. For example, an interrupt block is attempting to execute SVC_REQ 56 when the block it interrupted was executing SVC_REQ 56.
01	04	Storage Disabled. The logic in RAM differs from the logic in nonvolatile storage. See Storage disabled conditions.
02	04	Storage Closed. Either the storage has not been created or a previous corruption error or unexpected read/write failure closed the storage.
01	05	Unexpected Read Failure. A command to the storage hardware failed unexpectedly.
02	05	Corrupted storage. A corrupted checksum or storage header caused a read to fail.

SVC_REQ 56 Example

The following LD logic reads ten continuous bytes written to nonvolatile storage from %G1—%G80 into %G193—%G273. The value applied to IN1, 56, selects byte mode.

The parameter block starts at %R00040. The response words are returned to %R00049 and %R00050.

**Parameter Block for SVC_REQ 56 Example**

Address + Offset	Address	Input Value	Definition
Address+0	%R00040	56	Data type = %G (byte mode)
Address+1	%R00041	0	Address written from, low word
Address+2	%R00042	0	Address written from, high word
Address+3	%R00043	10	Length = 10 bytes
Address+4	%R00044	56	Data type to write to = %G (byte mode)
Address+5	%R00045	24	Address to write to, low word
Address+6	%R00046	0	Address to write to, high word
Address+7	%R00047	0	Storage disabled conditions are enforced
Address+8	%R00048	0	Reserved, must be set to 0
Address+9	%R00049	NA	Response status.
Address+10	%R00050	NA	Response count.

9.33. SVC_REQ 57: Logic Driven Write to Nonvolatile Storage

PACSystems controllers support a 65,500 byte nonvolatile flash memory area that can be accessed by the logic-driven read/write service requests. Values are stored in the nonvolatile storage area using SVC_REQ 57. These values are applied to the controller user memory on power up.

SVC_REQ 57 specifies a range of reference addresses to read from a running PACSystems CPU and write to nonvolatile storage. This feature is intended to retain a limited set of values, such as set points or tuning parameters that need to change when the PACSystems is running.

This feature uses 65,536 bytes of nonvolatile storage. But not all of this memory is available for the actual data being written by the service request. Some of the memory is used internally by the controller to maintain information about the data being stored.

Note: Nonvolatile storage is intended for storing values that do not change frequently. Once the nonvolatile storage area fills up, a power cycle or stop mode store is required to store more values. The logic-driven write is not a replacement for battery backed RAM for values that change frequently or during every sweep. (See “When nonvolatile storage is full” on page 424.)

Length of Data Written

SVC_REQ 57 scans the nonvolatile storage to find the most recent values stored for the specified range. If it finds no values for the range or the most recent stored values are different, the new values are written to nonvolatile storage.

SVC_REQ 57 reports the length of data written in word 8 (*starting address + 7*) of the parameter block. The number of words written is calculated from the first word that changed to the end of the array. For example, if you specify 8 words to be written, but only the values of words 3 and 4 are changed, the SVC_REQ identifies the first mismatch at word 3 and writes the values of words 3 through 8 (a length of 6 words).

You can write up to 32 words (64 bytes) inclusively per invocation of SVC_REQ 57. Each invocation requires 4 words of command data (8 bytes). A 1-byte write requires 9 bytes whereas a 64-byte write requires 72 bytes. You can generally make the most efficient use of nonvolatile storage by transferring data in 56-byte increments, since this will actually write 64 bytes to the device. Given the bookkeeping overhead required by the Controller and possible fragmentation, at least 54,912 bytes and no more than 64,000 bytes will be available for the reference data and the 8 bytes of command data for each invocation. For additional information on “Fragmentation”, see page 423.

Write Frequency

Multiple calls to SVC_REQ 57 in a single sweep may cause CPU watchdog timeouts. The number of calls to SVC_REQ 57 that can be made requires consideration of many variables: the software watchdog timeout value, how much data is being written, how long the sweep is, age of nonvolatile storage (flash), etc. If the application attempts to write to flash too frequently, the CPU could experience a watchdog timeout while waiting for a preceding write operation to complete.

The Logic Driven Read/Write to Flash service requests are not intended for high frequency use. We recommend limiting the number of calls to SVC_REQ 57 to one call per sweep to avoid the potential of for causing a watchdog timeout and the resulting transition to Stop-Halt mode.

Erase Cycles

The flash component on the PACSystems CPU is rated for 100K erase cycles. Erase cycles occur under the following conditions:

- Write to flash is commanded from the programmer.
- Clear flash operation.
- Flash compaction after a power cycle when flash memory allotted for SVC_REQ 57 has become full.

Discrete Memory

Discrete memory can be written to as individual bits or as bytes. For more information, see Address. Force and transition information is not written to nonvolatile storage.

Retentiveness

Writing values to nonvolatile storage for non-retentive memory such as %T does not make the memory retentive. For example, all values stored to %T memory are set to zero on power-up or a stop to run transition. You can, however, read such values from storage after power-up or stop to run transition by using SVC_REQ 56.

Maximum of One Active Instruction

When SVC_REQ 57 is active, it does not support an interrupt that attempts to activate SVC_REQ 56 or a second instance of SVC_REQ 57.

Storage Disabled Conditions

By default, the following write operations disable SVC_REQ 57 until logic is written to nonvolatile storage:

- Run Mode Store (RMS), even if a second RMS reverts everything to the original state
- Test-Edit session, even when you cancel your edits
- Word-for-word change
- Downloading to RAM only of a stopped PACSystems CPU, even if the downloaded contents are equal to the contents already on the nonvolatile storage

Setting bit 0 of input word 4 (address + 4) to a value of 1 enables SVC_REQ 57 despite the above conditions.

Error Checking

When writing to nonvolatile storage, error checking is provided to ensure that logic and the Hardware Configuration (HWC) in nonvolatile memory match the logic and HWC in PACSystems RAM.

Fragmentation

Due to the nature of the media in PACSystems CPUs, writes may produce fragmentation of the memory. That is, small portions of the memory may become unavailable, depending upon the sequence of the writes and the size of each one. Data is stored on the device in 128 512-byte sections. Each section uses 12 bytes of bookkeeping information, leaving a maximum of 64,000 bytes devoted to the reference data and command data for each invocation. However, the data for a single invocation cannot be split across sections. So, if there is insufficient space in the currently used section to contain the new data, the unused portion of that section becomes lost.

Example: Suppose that the current operation is writing 64 bytes of reference data and 8 bytes of command data (72 bytes total). If there are only 71 bytes remaining in the current section, the new data will be written to a new section and the unused 71 bytes in the old section become unavailable.

When nonvolatile storage is full

When logic driven user nonvolatile storage is full, a fault is logged. Before you can use SVC_REQ 57 to write again, use one of the following solutions:

To retain the most up-to-date data and continue writing with SVC_REQ 57 to nonvolatile storage:

1. Stop the PACSystems.

2. Power cycle the PACSystems.

A power cycle when nonvolatile storage is full triggers a compaction of existing data. During compaction, multiple writes of the same reference memory address are removed, which leaves only the most recent data, and contiguous reference memory addresses are combined into the fewest number of records necessary.

If compaction cannot take place, a second fault is logged and you need to use one of the following two solutions.

To retain specific data from nonvolatile storage, clear nonvolatile storage, and then return the data to nonvolatile storage:

1. While the controller is still running, use SVC_REQ 56 to read the desired values into PACSystems memory.

2. Upload the current values from controller memory as initial values to your project.

3. Stop the controller.

4. Do one of the following:

Clear the flash memory, or

Write to flash. The flash is erased prior to writing, which frees up some space.

5. Download the initial values to the controller.

6. Start the controller.

7. Use SVC_REQ 57 to write the desired values from controller memory to nonvolatile storage.

To write to flash to erase everything:

1. Stop the Controller.

2. Write to flash. The flash is erased prior to writing, which frees up some space.

Equality

Because data in nonvolatile storage is not considered part of the project, writing to nonvolatile storage does not impact equality between the CPU and Logic Developer.

Redundancy

Redundancy systems can benefit from the use of logic driven user nonvolatile storage as long as all of the references saved to nonvolatile storage are included in the transfer lists. Each redundancy CPU maintains its own separate logic driven user nonvolatile storage by means of SVC_REQ 57 during its logic scan. If the values of reference addresses to be stored to user nonvolatile storage are synchronized, the logic driven user nonvolatile storage data in each CPU is identical. If the values to be stored are not synchronized, then each CPU's user nonvolatile storage may be different.

ENO and power flow to the right

If the status is Success or Partial Read, then on the SVC_REQ instruction, ENO is set to True in FBD and ST, and power flow passes to the right in LD.

9.33.1 Parameter Block for SVC_REQ 57

Address+0	Memory type. See "Memory Type Codes" on page 420								
Address+1	The zero-based offset N to write to nonvolatile storage. Contains the complete offset for any memory area except %W, which also requires the use of address + 2 for offsets greater than 65,535.								
Address+2	<ul style="list-style-type: none"> ▪ For %I, %Q, %M, %T, and %G memory in byte mode, $N = (Ra - 1) / 8$, where Ra = one-based reference address. For example, to read from the one-based bit reference address %T33, enter the byte offset 4: $(33 - 1) / 8 = 4$. ▪ For %W, %R, %AI, and %AQ memory, and for %I, %Q, %M, %T, and %G memory in bit mode, $N = Ra - 1$. For example, to read from the one-based reference address %R200, enter the zero-based reference offset 199; to read from %I73 in bit mode, enter offset 72. For memory-in-bit mode, the offset must be set on a byte boundary, that is, a number exactly divisible by 8: 0, 8, 16, 24, and so on. 								
Address+3	<p>Length. The number of items to write to nonvolatile storage beginning at the reference address calculated from the offset defined at [address + 1 and address + 2]. The length can be one of the following:</p> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Description</th> <th>Valid range</th> </tr> </thead> <tbody> <tr> <td>The number of words (16-bit registers) to read from %W, %R, %AI, or %AQ nonvolatile storage</td> <td>1 through 32 words</td> </tr> <tr> <td>The number of bytes to read from %I, %Q, %M, %T, or %G in byte mode nonvolatile storage</td> <td>1 through 64 bytes</td> </tr> <tr> <td>The number of bits to read from %I, %Q, %M, %T, or %G in bit mode nonvolatile storage</td> <td>1 through 512 bits in increments of 8 bits</td> </tr> </tbody> </table> <p>The value must reside in the low byte of address + 3. The high byte must be set to zero.</p>	Description	Valid range	The number of words (16-bit registers) to read from %W, %R, %AI, or %AQ nonvolatile storage	1 through 32 words	The number of bytes to read from %I, %Q, %M, %T, or %G in byte mode nonvolatile storage	1 through 64 bytes	The number of bits to read from %I, %Q, %M, %T, or %G in bit mode nonvolatile storage	1 through 512 bits in increments of 8 bits
Description	Valid range								
The number of words (16-bit registers) to read from %W, %R, %AI, or %AQ nonvolatile storage	1 through 32 words								
The number of bytes to read from %I, %Q, %M, %T, or %G in byte mode nonvolatile storage	1 through 64 bytes								
The number of bits to read from %I, %Q, %M, %T, or %G in bit mode nonvolatile storage	1 through 512 bits in increments of 8 bits								
Address + 4	When bit 0 is set to 1, storage disabled conditions, described on page 423, are ignored. A write is allowed even if the logic in RAM has changed since nonvolatile storage was read or written. Bits 1 through 15 must be set to zero; otherwise, the write fails.								
Address+5	Reserved. Value must be set to zero.								
Address+6	Response status. The low byte contains the major error code; the high byte contains the minor error code.								
Address+7	Count of items written: Words, bytes or bits. Calculated from the first word that changed to the end of the array.								
Address+8	The number of bytes available in nonvolatile storage.								
Address+9									
Address+10	Reserved.								
Address+11									

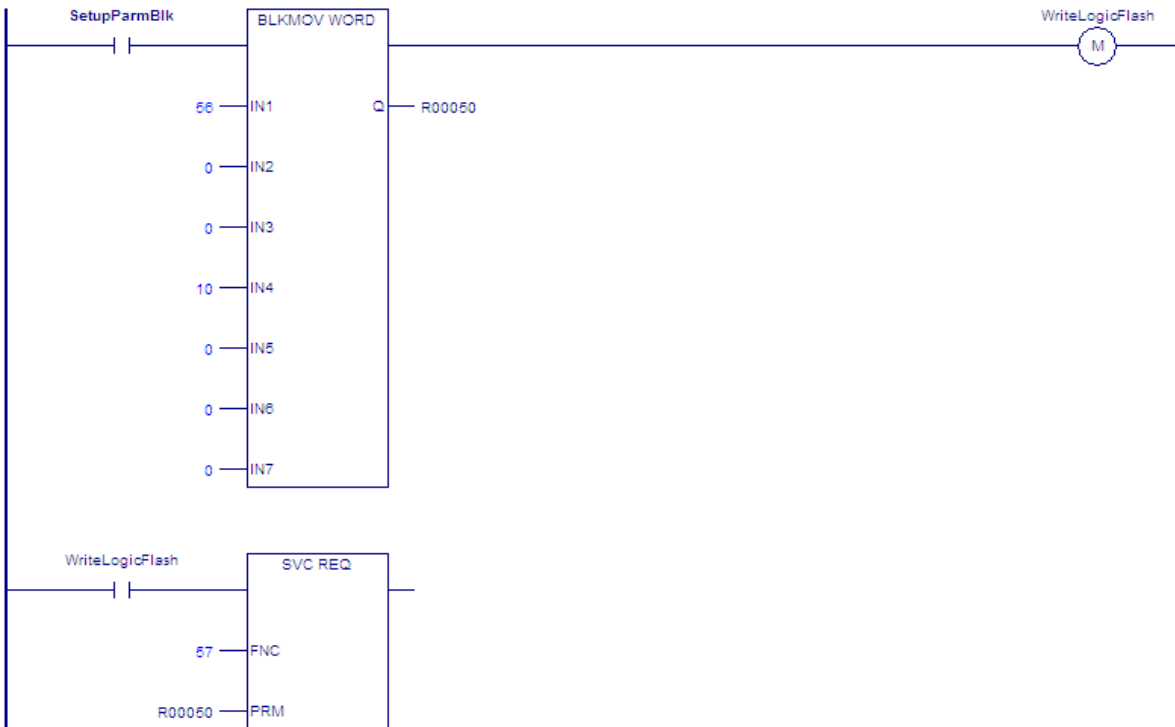
Response Status Codes for SVC_REQ 57

<i>Minor</i>	<i>Major</i>	<i>Description</i>
00	01	Success. All values requested were written.
01	01	Existing values found. All values requested are in storage, but one or more values were already stored.
01	02	Insufficient source memory. Counting from the offset, not enough reference addresses are left in the specified memory area.
02	02	Invalid length. The length requested was larger than 64 bytes or less than 1 byte or the number of bits is not divisible by 8.
03	02	Invalid source reference address. The memory area specified is not supported, the starting or ending offset is out of range, or the offset is not byte-aligned for discrete memory areas.
04	02	Invalid request. Spare bits or spare words in the parameter block are not set to zero.
01	03	Storage busy. A SVC_REQ 56 or another SVC_REQ 57 instruction is active. For example, an interrupt block is attempting to execute SVC_REQ 57 when the block it interrupted was executing SVC_REQ 57.
01	04	Storage disabled. The logic in RAM differs from the logic stored in nonvolatile storage. See "Storage Disabled Conditions" on page 423,
02	04	Storage closed. Either the storage has not been created or a previous corruption error or unexpected read/write failure closed the storage.
01	05	Unexpected write failure. The command to the storage hardware failed unexpectedly.
02	05	Corrupted storage. The write failed due to a bad checksum or corrupted storage header information.
01	06	Write failed. Storage is full.

SVC_REQ 57 Example

The following LD logic writes ten continuous bytes to nonvolatile storage, ranging from %G1 through %G80. The value applied to IN1, 56, determines byte mode.

The parameter block starts at %R00050. The response words are returned to %R00056—%R00059.

**Parameter Block for SVC_REQ 57 Example**

Address + Offset	Address	Input Value	Definition
Address+0	%R00050	56	Data type = %G (byte mode)
Address+1	%R00051	0	Address written from, low word
Address+2	%R00052	0	Address written from, high word
Address+3	%R00053	10	Length = 10 bytes
Address+4	%R00054	0	Storage disabled conditions are enforced
Address+5	%R00055	0	Reserved, must be set to 0
Address+6	%R00056	NA	Response status. The low byte contains the major error code; the high byte contains the minor error code.
Address+7	%R00057	NA	Count of items written: Words, bytes or bits.
Address+8	%R00058	NA	The number of bytes available in nonvolatile storage.
Address+9	%R00059	NA	
Address+10	%R00060	NA	Reserved
Address+11	%R00061	NA	Reserved

Chapter 10 PID Built-In Function Block

This chapter describes the PID (Proportional plus Integral plus Derivative) built-in function block, which is used for closed-loop process control. The PID function compares feedback from a process variable (PV) with a desired process set point (SP) and updates a control variable (CV) based on the error.

The PID function uses PID loop gains and other parameters stored in a 40-word reference array of 16-bit integer words to solve the PID algorithm at the desired time interval.

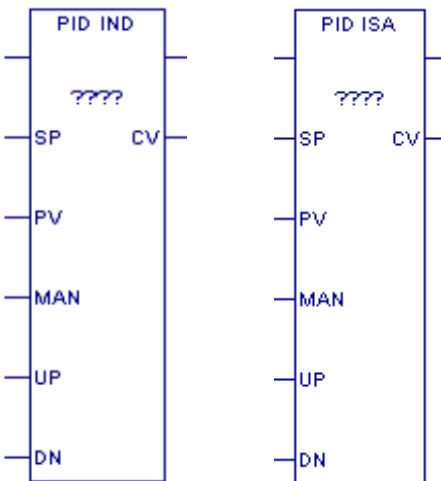


Figure 27:PID in Ladder Diagram

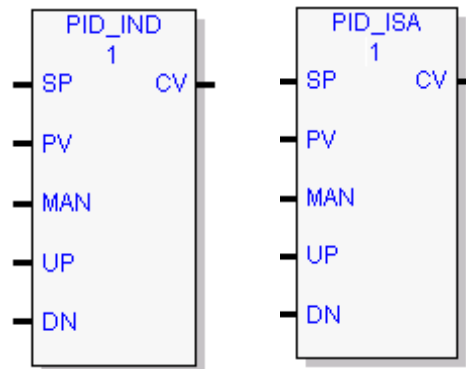
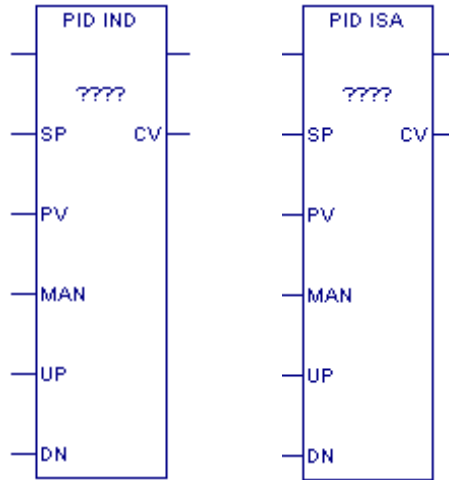


Figure 28: PID in Function Block Diagram

This chapter presents the following topics:

- Operands of the PID Function
- Reference Array for the PID Function
- PID Algorithm Selection and Gain Calculations
- Determining the Process Characteristics
- Setting and Tuning Loop Gains
- Example

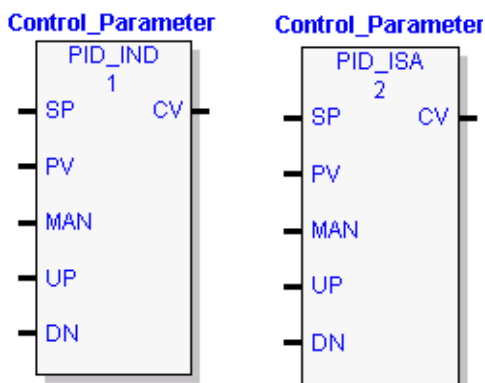
10.1. Operands of the PID Function



10.1.1 Operands for LD Version of PID Function Block

Parameter	Description	Allowed Types	Allowed Operands	Optional
(????)	Instance Variable name of the PID Parameter Block array, which contains user-configurable and internal parameters, described on page 432. Uses 40 words that cannot be shared.	WORD	R, L, P, W and symbolic	No
SP	The control loop or process set point. Set using process variable counts, the PID function adjusts the output control variable so that the process variable matches the set point (zero error).	INT, BOOL array of length 16 or more, Constant	All except S, SA, SB, and SC	No
PV	Process Variable input from the process being controlled. Often a %AI input.	INT, BOOL array of length 16 or more	All except S, SA, SB, and SC, and constant	No
MAN	While Power Flow is received, the PID function block is held in manual mode. If no Power Flow is received the PID function block is in Auto mode.	Power Flow	NA	No
UP	While Power Flow is received, the Manual Command is increased by 1 each user configured Sample Period.	Power Flow	NA	No
DN	While Power Flow is received, the Manual Command is decreased by 1 each user configured Sample Period.	Power Flow	NA	No
CV	The control variable output to the process. Often a %AQ output.	INT, BOOL array of length 16 or more	All except %S and constant	No

10.1.2 Operands for FBD Version of PID Function Block



Parameter	Description	Allowed Types	Allowed Operands	Optional
Control Structure Variable	Instance Variable name of the PID Parameter Block array, which contains user-configurable and internal parameters, described on page 432. Uses 40 words that cannot be shared.	WORD	R, L, P, W and symbolic	No
Function block solve order – FBD version	Calculated by the FBD editor. Can be changed by the user.	NA	NA	No
SP	The control loop or process set point. Set using process variable counts, the PID function adjusts the output control variable so that the process variable matches the set point (zero error).	INT, BOOL array of length 16 or more, Constant	All except S, SA, SB, and SC	No
PV	Process Variable input from the process being controlled. Often a %AI input.	INT, BOOL array of length 16 or more	All except S, SA, SB, SC and constant	No
MAN	When energized to 1 (through a contact), the PID function block is in <i>manual</i> mode. If this input is 0, the PID block is in <i>automatic</i> mode.	BOOL, Power Flow	All	No
UP	If energized along with MAN, increases the control variable by 1 CV count per solution of the PID function block.	BOOL, Power Flow	All	No
DN	If energized along with MAN, decreases the control variable by 1 CV count per solution of the PID function block.	BOOL, Power Flow	All	No
CV	The control variable output to the process. Often a %AQ output.	INT, BOOL array of length 16 or more	All except %S and constant	No

10.2. Reference Array for the PID Function

This parameter block for the PID function occupies 40 words of memory, located at the starting Instance Variable specified in the PID function block operands. Some of the words are configurable. Other words are used by the CPU for internal PID storage and are normally not changed.

Every PID function call must use a different 40-word memory area, even if all the configurable parameters are the same.

The configurable words of the reference array must be specified before executing the PID function. Zeros can be used for most default values. Once suitable PID values have been chosen, they can be defined as constants in BLKMOV functions so the program can set and change them as needed.

The LD version of the PID function does not pass power flow if there is an error in the configurable parameters. The function can be monitored using a temporary coil while modifying data.

10.2.1 Scaling Input and Outputs

All parameters of the PID function are 16 bit integer words for compatibility with 16 bit analog process variables. Some parameters must be defined in either PV counts or units or in CV counts or units.

The SP input must be scaled over the same range as the PV, because the PID function calculates error by subtracting these two inputs.

The process PV and control CV counts do not have to use the same scaling. Either may be -32000 or 0 to 32000 to match analog scaling, or from 0 to 10000 to display variables as 0.00% to 100.00%. If the process PV and control CV do not use the same scaling, scale factors are included in the PID gains.

10.2.2 Reference Array Parameters


Note: Machine Edition software allows you to modify the configurable parameters for a PID instruction in real time in online programmer mode. To customize PID parameters, right click the PID function and select Tuning.

Words	Parameter/Description	Low Bit Units	Range
1 (Address+0)	Loop Number Optional number of the PID block. It provides a common identification in the CPU with the loop number defined by an operator interface device.	Integer	0 to 255 (for user display only)
2 (Address+1)	Algorithm 1 = ISA algorithm 2 = Independent algorithm	-	Set by the CPU
3 (Address+2)	Sample Period The shortest time, in 10ms. increments, between solutions of the PID algorithm. For example, use a 10 for a 100ms. sample period. Minimum time of 10ms is enforced by the block if the sweep<10ms)	10ms.	0 (every sweep) to 65535 (10.9 Min) At least 10ms.

Words	Parameter/Description	Low Bit Units	Range
4,5 (Address+3, Address+4)	<p>Dead Band + Dead Band -</p> <p>Integral values defining the upper (+) and lower (-) Dead Band limits. If no Dead Band is required, these values must be 0. If the PID Error (SP - PV) or (PV - SP) is above the (-) value and below the (+) value, the PID calculations are solved with an Error of 0. If non-zero, the (+) value must greater than 0 and the (-) value less than 0 or the PID block will not function.</p> <p>Leave these at 0 until the PID loop gains are set up or tuned. A Dead Band might be added to avoid small CV output changes due to variations in error.</p>	PV Counts	<p>Dead Band +: 0 to 32767 (never negative)</p> <p>Dead Band -: -32768 to 0 (never positive)</p>
6 (Address+5)	<p>PID_IND: Proportional Gain (Kp) PID_ISA: Controller gain (Kc = Kp)</p> <p>PID_IND: Change in the control variable in CV Counts for a 100 PV Count change in the Error term. Entered as an integer representing a fixed-point decimal ratio with two decimal places. Displayed as a ratio of percentages with two decimal places.</p> <p>For example, a Kp entered as 450 is displayed as 4.50 and results in a $Kp * Error / 100$ or $450 * Error / 100$ contribution to the PID Output.</p> <p>PID_ISA: Same as PID_IND.</p> <p>Kp is generally the first gain set when adjusting a PID loop.</p>	0.01 CV%/PV% %CV/%PV	0 to 327.67%
7 (Address+6)	<p>PID_IND: Derivative Gain (Kd) PID_ISA: Derivative Time (Td = Kd)</p> <p>PID_IND: Change in the control variable in CV Counts if the Error or PV changes 1 PV Count every 10ms. Entered as an integer representing a fixed-point decimal time in seconds with two decimal places. The least significant digit represents 0.01 second (10ms.) units. Displayed as seconds with two decimal places.</p> <p>For example, Kd entered as 120 is displayed as 1.20 Sec and results in a $Kd * \Delta Error / \text{delta time}$ or $120 * 4 / 3$ contribution to the PID Output if Error changes by 4 PV Counts every 30ms. Kd can be used to speed up a slow loop response, but is very sensitive to PV input noise. This noise sensitivity can be reduced by using the derivative filter, which is enabled by setting bit 5 of the Config Word (see page 435.)</p> <p>PID_ISA: The ISA derivative time in seconds, Td, is entered and displayed in the same way as Kd. Total derivative contribution to PID Output is $Kc * Td * \Delta Error / dt$.</p>	0.01 sec	0 to 327.67 sec

Words	Parameter/Description	Low Bit Units	Range
8 (Address+7)	<p>PID_IND: Integral Rate (Ki) PID_ISA: Integral Rate (1/Ti = Ki)</p> <p>PID_IND: Rate of change in the control variable in CV Counts per second when the Error is a constant 1 PV Count. Entered as an integer representing a fixed-point decimal rate with three decimal places. The least significant digit represents 0.001 counts per second, or 1 count per 0.001 second. Displayed as Repeats/Sec with three decimal places.</p> <p>For example, Ki entered as 1400 is displayed as 1.400 Repeats/Sec and results in a $K_i * Error * dt$ or $1400 * 20 * 50/1000 = 1,400$ contribution to PID Output for an Error of 20 PV Counts and a 50ms. CPU sweep time (Sample Period of 0).</p> <p>PID_ISA: The ISA Integral Time in <u>seconds</u>, Ti, must be inverted and entered, as integral rate, as described for PID_IND. Total integral contribution to PID Output is $K_c * K_i * Error * dt$.</p> <p>Ki is usually the second gain set after Kp.</p>	Repeats/ 0.001 Sec	0 to 32.767 repeats/sec
9 (Address+8)	<p>CV Bias/Output Offset</p> <p>Number of CV Counts added to the PID Output before the rate and amplitude clamps. It can be used to set non-zero CV values when only Kp Proportional gains are used, or for feed-forward control of this PID loop output from another control loop.</p>	CV Counts	-32768 to 32767 (add to PID output)
10, 11 (Address+9. Address+10)	<p>CV Upper Clamp CV Lower Clamp</p> <p>Number of CV Counts that define the highest and lowest value that CV is allowed to take. These values are required. The Upper Clamp must have a more positive value than the Lower Clamp, or the PID block will not work. These are usually used to define limits based on physical limits for a CV output. They are also used to scale the Bar Graph display for CV. The PID block has anti-reset-windup, controlled by bit 4 of the Config Word, to modify the integral term value when a CV clamp is reached.</p>	CV Counts	-32768 to 32767 (Word 10 must be greater than word 11.)
12 (Address+11)	<p>Minimum Slew Time</p> <p>Minimum number of seconds for the CV output to move from 0 to full travel of 100% or 32000 CV Counts. It is an inverse rate limit on how fast the CV output can change.</p> <p>If positive, CV cannot change more than 32000 CV Counts times the solution time interval (seconds) divided by Minimum Slew Time.</p> <p>For example, if the Sample Period is 2.5 seconds and the Minimum Slew Time is 500 seconds, CV cannot change more than $32000 * 2.5 / 500$ or 160 CV Counts per PID solution.</p> <p>The integral term value is adjusted if the CV rate limit is exceeded.</p> <p>When Minimum Slew Time is 0, there is no CV rate limit. Set Minimum Slew Time to 0 while tuning or adjusting PID loop gains.</p>	Seconds / Full Travel	0 (none) to 32000 sec to move full CV travel

Words	Parameter/Description	Low Bit Units	Range
<p>13 (Address+12)</p>	<p>Config Word The low 6 bits of this word are used to modify default PID settings. The other bits should be set to 0.</p> <p>Bit 0: Error Term Mode. When this bit has the default value of 0, the error term is SP - PV. If the Error=SP-PV is positive, the CV output will decrease. If the Error=SP-PV is negative, the CV output will increase. This is type of operation is known as <i>reverse acting</i>. A good example is your home heating system. When this bit is 1, the error term is PV - SP. If the Error=PV-SP is positive, the CV output will increase. If the Error= PV-SP is negative, the CV output will decrease. This type of operation is known as <i>direct acting</i>. A good example is your home cooling system.</p> <p>Bit 1: Output Polarity. When this bit is 0, the CV output is the output of the PID calculation. When it is set to 1, the CV output is the negated output of the PID calculation. Setting this bit to 1 inverts the Output Polarity so that CV is the negative of the PID output rather than the normal positive value.</p> <p>Bit 2: Derivative Action on PV. When this bit is 0, the derivative action is applied to the error term. When it is set to 1, the derivative action is applied to PV only.</p> <p>Bit 3: Deadband action. When the Deadband action bit is 0, the actual error value is used for the PID calculation. When the Deadband action bit is 1, deadband action is chosen. If the error value is within the deadband limits, the error used for the PID calculation is forced to be zero. If, however, the error value is outside the deadband limits, the magnitude of the error used for the PID calculation is reduced by the deadband limit ($\text{error} = \text{error} - \text{deadband limit}$).</p> <p>Bit 4: Anti-reset windup action. When this bit is 0, the anti-reset-windup action uses a reset (integral term) back-calculation. When the output is clamped, the accumulated integral term is replaced with whatever value is necessary to produce the clamped output exactly. When the bit is 1, the accumulated integral term is replaced with the value of the integral term at the start of the calculation. In this way, the pre-clamp integral value is retained as long as the output is clamped. This option is not recommended for new applications. See "CV Amplitude and Rate Limits" on page 443.</p> <p>Bit 5: Enable derivative filtering. When this bit is set to 0, no filtering is applied to the derivative term. When set to 1, a first order filter is applied. This will limit the effects of higher frequency process disturbances, such as measurement noise, on the derivative term.</p>	Low 6 bits used	Boolean

Words	Parameter/Description	Low Bit Units	Range																								
14 (Address+13)	<p>Manual Command Set to the current CV output while the PID block is in Automatic mode. When the block is switched to Manual mode, this value is used to set the CV output and the internal value of the integral term within the Upper and Lower Clamp and Slew Time limits.</p>	CV Counts	Tracks CV in Auto or sets CV in Manual																								
15 (Address+14)	<p>Control Word If the Override bit (bit 0) is set to 1, the Control Word and the internal SP, PV and CV parameters must be used for remote operation of the PID block (see below). This allows a remote operator interface device, such as a computer, to take control away from the application program.</p> <hr/> <p style="text-align: center;">Caution</p> <div style="display: flex; align-items: center;">  <p>If you do not want to allow remote operation of the PID block, make sure the Control Word is set to 0. If the low bit is 0, the next 4 bits can be read to track the status of the PID input contacts as long as the PID Enable contact has power.</p> </div> <hr/> <p>Control Word is a discrete data structure with the first five bit positions defined in the following format:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Bit</th> <th>Word Value</th> <th>Function</th> <th>Status or External Action if Override bit is set to 1:</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>1</td> <td>Override</td> <td>If 0, monitor block contacts below. If 1, set them externally.</td> </tr> <tr> <td>1</td> <td>2</td> <td>Manual /Auto</td> <td>If 1, block is in Manual mode. If other numbers, it is in Automatic mode.</td> </tr> <tr> <td>2</td> <td>4</td> <td>Enable</td> <td>Should normally be 1. Otherwise block is never called.</td> </tr> <tr> <td>3</td> <td>8</td> <td>UP /Raise</td> <td>If 1 and Manual (Bit 1) is 1, CV is incremented every solution.</td> </tr> <tr> <td>4</td> <td>16</td> <td>DN /Lower</td> <td>If 1 and Manual (Bit 1) is 1, CV is decremented every solution.</td> </tr> </tbody> </table>	Bit	Word Value	Function	Status or External Action if Override bit is set to 1:	0	1	Override	If 0, monitor block contacts below. If 1, set them externally.	1	2	Manual /Auto	If 1, block is in Manual mode. If other numbers, it is in Automatic mode.	2	4	Enable	Should normally be 1. Otherwise block is never called.	3	8	UP /Raise	If 1 and Manual (Bit 1) is 1, CV is incremented every solution.	4	16	DN /Lower	If 1 and Manual (Bit 1) is 1, CV is decremented every solution.	Maintained by the CPU, unless bit 0 (Override) is set to 1.	Boolean
Bit	Word Value	Function	Status or External Action if Override bit is set to 1:																								
0	1	Override	If 0, monitor block contacts below. If 1, set them externally.																								
1	2	Manual /Auto	If 1, block is in Manual mode. If other numbers, it is in Automatic mode.																								
2	4	Enable	Should normally be 1. Otherwise block is never called.																								
3	8	UP /Raise	If 1 and Manual (Bit 1) is 1, CV is incremented every solution.																								
4	16	DN /Lower	If 1 and Manual (Bit 1) is 1, CV is decremented every solution.																								
16 (Address+15)	<p>Internal SP Tracks the SP input. If Override = 1, must be set externally to solve the PID algorithm using an alternate SP value. The original SP value is maintained until overwritten.</p>	Set and maintained by the CPU, unless bit 0 (Override) of Control Word is set to 1.	Non-configurable, unless bit 0 (Override) of Control Word is set to 1.																								

Words	Parameter/Description	Low Bit Units	Range
17 (Address+16)	Internal CV Tracks CV output.	Set and maintained by the CPU.	Non-configurable.
18 (Address+17)	Internal PV Tracks PV input. Must be set externally if Override bit is set to 1.	Set and maintained by the CPU, unless bit 0 (Override) of Control Word is set to 1.	Non-configurable, unless bit 0 (Override) of Control Word is set to 1.
19 (Address+18)	Output A Signed word value representing the output of the function block before the optional inversion. If the output polarity bit in the Config Word is set to 0, this value equals the CV output. If the output polarity bit is set to 1, this value equals the negative of the CV output.	Set and maintained by the CPU.	Non-configurable.
20 (Address+19)	Derivative Term Storage Used internally for storage of intermediate values. Do not write to this location.		
21, 22 (Address+20. Address+21)	Integral Term Storage Used internally for storage of intermediate values. Do not write to these locations.		
23 (Address +22)	Slew Term Storage Used internally for storage of intermediate values. Do not write to this location.		
24 – 26 (Address+23 – Address+25)	Previous Solution Time Internal storage of time of last PID solution. Normally do not write to these locations. Some special circumstances may justify writing to these locations. Note: If you call the PID block in Automatic mode after a long delay, you might want to use SVC_REQ #16 or SVC_REQ #51 to load the current CPU elapsed time clock into Word 24 to update the last PID solution time to avoid a step change of the integral term.	Set and maintained by the CPU.	Non-configurable.
27 (Address+26)	Integral Remainder Storage Holds remainder from integral term scaling.	Set and maintained by the CPU.	Non-configurable.
28, 29 (Address+27, Address+28)	SP, PV Lower Range SP, PV Upper Range Optional integer values in PV Counts that define high and low display values for SP and PV. (Word 29 must be greater than word 28.)	PV Counts	-32768 to 32767
30 (Address+29)	Reserved Word 30 is reserved. Do not use this location.	N/A	Non-configurable.

<i>Words</i>	<i>Parameter/Description</i>	<i>Low Bit Units</i>	<i>Range</i>
31, 32 (Address+30, Address+31)	Previous Derivative Term Storage Used in calculations for derivative filter. Do not write to these locations.	Set and maintained by the CPU.	Non-configurable.
33 – 40 (Address+32 - Address+39)	Reserved Words 32-39 are reserved. Do not use these references.	N/A	Non-configurable

10.3. Operation of the PID Function

10.3.1 Automatic Operation

When the PID function block is called, it compares the current CPU time with the last PID solution time stored in the reference array. If the interval between the two times is equal to or greater than the Sample Period (word 3 of the reference array) and also equal to or greater than 10 milliseconds, the PID algorithm is solved using this time interval. Both the last solution time and CV output are updated. In Automatic mode, the output CV is copied to the Manual Command parameter (word 14 of the reference array).

Note: If you call the PID block in Auto mode after a long delay, you may want to use SVC_REQ 16 or SVC_REQ 51 to load the current CPU time into the stored previous solution time (word 24 of the reference array, described on page 437). This will update the last PID solution time and avoid a large step change of the integral term. Another method to prevent the step change is to copy the PV value to the SP before placing the loop into Auto.

10.3.2 Manual Operation

The PID function block is placed in Manual mode by providing power flow to both the Enable and Manual input contacts. The output CV is set from the Manual Command parameter. If either the UP or DN inputs have power flow, the Manual Command word is incremented (UP) or decremented (DN) by one CV count every PID Sample Period. For faster manual changes of the output CV, it is also possible to add or subtract any CV count value directly to/from the Manual Command word (word 14 of the reference array).

The PID function block uses the CV Upper Clamp and CV Lower Clamp parameters to limit the CV output. If a positive Minimum Slew Time (word 12 of the reference array) is defined, it is used to limit the rate of change of the CV output. If either CV Clamp or the rate of change limit is exceeded, the value of the integral (reset) term is adjusted so that CV is at the limit. The anti-reset-windup feature assures that when the error term tries to drive CV above (or below) the clamps for a long period of time, the CV output will move off the clamp immediately when the error term changes sufficiently.

This operation, with the Manual Command tracking CV in Automatic mode and setting CV in Manual mode, provides a bump-less transfer from Automatic to Manual mode. The CV Upper and Lower Clamps and the Minimum Slew Time always apply to the CV output in Manual mode and the integral term is always updated. This assures that when a user rapidly changes the Manual Command value in Manual mode, the CV output cannot change any faster than the slew rate limit set by the Minimum Slew Time, and the CV cannot go above the CV Upper Clamp limit or below the CV Lower Clamp limit.

In order to assure a bump-less transfer from Manual back to Automatic mode, the user program should copy the PV to the SP before switching back to Automatic mode. This allows the algorithm to update the last sample period time and prepare to re-calculate CV based upon the new Auto Mode SP commanded.

10.3.3 Time Interval for the PID Function

The start time of each CPU sweep is used as the current time when calculating the time interval between solutions of the PID function. The times and time intervals have a resolution of 100 microseconds. When an application uses multiple PID functions, all of them use the same time value. The PID algorithm is solved when the current time is equal to or greater than the time of the last PID solution plus the Sample Period or 10 milliseconds; whichever is larger. If the Sample Period is set for execution on every sweep (value = 0), the PID function is restricted to a minimum of 10 milliseconds between solutions. ***If the sweep time is less than 10 milliseconds, the PID function waits until enough sweeps have occurred to accumulate an elapsed time of at least 10 milliseconds.*** For example, if the sweep time is 9 milliseconds, the PID function executes every other sweep, and the time interval between solutions is 18 milliseconds. If a specific PID function is executed more than once per sweep (by referencing the same reference array location in multiple PID function blocks), the algorithm is solved only on the first call.

The longest possible interval between executions is 65,535 times 10 milliseconds, or 10 minutes, 55.35 seconds.

10.4. PID Algorithm Selection (PIDISA or PIDIND) and Gain Calculations

The PID function supports both the Independent Term (PID_IND) and ISA standard (PID_ISA) forms of the PID algorithm. The Independent Term form takes its name from the fact that the coefficients for the proportional, integral and derivative terms act independently. The ISA algorithm is named for the Instrument Society of America (now the International Society for Measurement and Control), which standardized and promoted it.

The two algorithms differ in how words 6 through 8 of the reference array are used and in how the PID output (CV) is calculated.

The Independent term PID (PID_IND) algorithm calculates the output as:

$$\text{PID Output} = K_p * \text{Error} + K_i * \text{Error} * dt + K_d * \text{Derivative} + \text{CV Bias}$$

where K_p is the proportional gain, K_i is the integral rate, K_d is the derivative time, and dt is the time interval since the last solution.

The ISA (PID_ISA) algorithm has different coefficients for the terms:

$$\text{PID Output} = K_c * (\text{Error} + \text{Error} * dt/T_i + T_d * \text{Derivative}) + \text{CV Bias}$$

where K_c is the controller gain, T_i is the Integral time and T_d is the Derivative time. The advantage of PID_ISA is that adjusting K_c changes the contribution for the integral and derivative terms as well as the proportional term, which can simplify loop tuning.

If you have the PID_ISA K_c , T_i and T_d values, use the following equations to convert them to use as PID_IND parameters:

$$K_p = K_c, K_i = K_c/T_i, \text{ and } K_d = K_c * T_d$$

The following diagram shows how the PID_IND algorithm works:

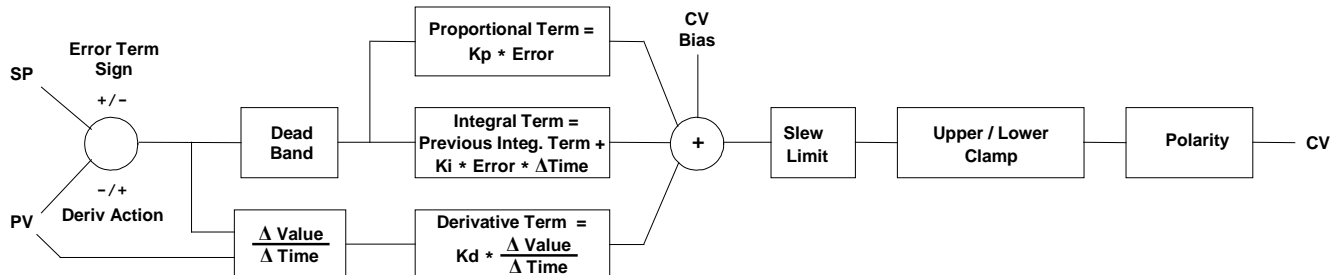


Figure 29: PID_IND Diagram

The ISA Algorithm (PID_ISA) is similar except that its K_c gain coefficient is applied after the three terms are summed, so that the integral gain is K_c / T_i and the derivative gain is $K_c * T_d$.

Bits 0, 1 and 2 in the Config Word set the Error sign, Output Polarity and Derivative Action, respectively.

10.4.1 Derivative Term

The Derivative Term is K_d (word 7 of the reference array) multiplied by the time rate of change of the Error term in the interval since the last PID solution.

$$\text{Derivative} = K_d * \Delta\text{Error} / dt = K_d * (\text{Error} - \text{previous Error}) / dt$$

where

$$dt = \text{Current controller time} - \text{controller time at previous PID solution.}$$

Two bits in the Config Word (word 13 of the reference array) affect the calculation of ΔError : Error Term Mode and Derivative Action. For additional information about the operation of these bits, see "Config Word" on page 435.

10.4.2 Error Term Mode

The sign of the Error term is determined by the value of a mode bit in the reference array for the PID function.

In *reverse acting* mode, the change in the error term is:

$$\Delta\text{Error} = (\text{Error} - \text{previous Error}) = \Delta\text{SP} - \Delta\text{PV}$$

where

$$\Delta\text{PV} = (\text{PV} - \text{previous PV}), \text{ and } \Delta\text{SP} = (\text{SP} - \text{previous SP}).$$

However, in *direct acting* mode, the error term is $(\text{PV} - \text{SP})$, the sign of the change in the error term is reversed:

$$\Delta\text{Error} = (\text{Error} - \text{previous Error}) = \Delta\text{PV} - \Delta\text{SP}.$$

10.4.3 Derivative Action on PV Bit

By default, the change in the error term depends on changes in both SP and PV. If SP is constant, $\Delta\text{SP} = 0$, and SP has no effect on the derivative term. When SP changes, however, it can cause large transient swings in the derivative term and hence the output. Loop stability can be improved by eliminating the effect of SP changes on the derivative term.

To calculate the Derivative based only on the change in PV, set bit 2 of the Config Word to 1. This modifies the equations above by assuming SP is constant ($\Delta\text{SP} = 0$).

10.4.4 Combined Operation of Error Term and Derivative Action Modes

Bit 0 of Config Word		Bit 2 of Config Word		Error Term Value
Value	Error Term Mode	Value	Derivative Action	
0	Reverse Acting (default)	0	ΔSP included	$\Delta\text{SP} - \Delta\text{PV}$
1	Direct Acting	0	ΔSP included	$\Delta\text{PV} - \Delta\text{SP}$
0	Reverse Acting (default)	1	ΔSP ignored	$-\Delta\text{PV}$
1	Direct Acting	1	ΔSP ignored	ΔPV

10.4.5 CV Bias Term

The CV Bias term (word 9 in the reference array) is an additive term separate from the PID inputs. It may be useful if you are using only Proportional gain (Kp) and you want the CV to be a non-zero value when the PV equals the SP and the Error is 0. In this case, set the CV Bias to the desired CV when the PV is at the SP. CV Bias can also be used for feed forward control where another PID loop or control algorithm is used to adjust the CV output of this PID loop.

If a non-zero Integral rate is used, the CV Bias will normally be 0 as the integral term acts as an automatic bias or “reset.” Just start up in Manual mode and use the Manual Command word (word 14 of the reference array) to set the desired CV, and then switch to Automatic mode. This will immediately calculate the required value for the integral term.

10.4.6 CV Amplitude and Rate Limits

The PID block does not send the calculated Output directly to CV. Both PID algorithms can impose amplitude and rate of change limits on the output Control Variable. If the Minimum Slew Time (word 12 of the reference array) is non-zero, the rate of change (slew rate) limit is determined by dividing the maximum CV value (32,000) by the Minimum Slew Time. For example, if the Minimum Slew Time is 100 seconds, the rate limit will be 320 CV counts per second. If the solution interval was 50 milliseconds, the new CV output cannot change more than $320 \times 50 / 1000$ or 16 CV counts from the previous CV output.

The CV output is then compared to the CV Upper Clamp and CV Lower Clamp values (words 10 and 11 of the reference array). If CV is outside either limit, the CV output is clamped to the appropriate limit value. When the CV output is modified to impose either slew rate or amplitude limits (or both) the stored integral term would normally accumulate a large value over time. This phenomenon is known as “reset windup.” Reset windup introduces errors in CV after the PID output no longer needs to be limited. For example, windup would prevent the CV output from moving off a clamp value immediately.

There are two optional methods for preventing reset windup. If the Anti-reset-windup Action bit (bit 4) of Config Word (word 13 of the reference array) is zero (the default), the integral term is adjusted at each PID solution to match the error input and limited CV output exactly. When PV changes while CV is clamped, or when CV is both rate and amplitude limited in a particular PID solution, this option assures that a smooth transition will always occur after CV is no longer limited.

If the Anti-reset-windup Action bit of Config Word is set, then the integral term stored on the previous PID solution is simply retained as long as CV is limited. This option was added to assure compatibility with existing PID applications when the default action described above was introduced. This option is not recommended for new applications.

Finally, the PID block checks the Output Polarity (bit 2 of the Config Word) and changes the sign of the output if the bit is 1.

$CV = - (\text{Clamped PID Output})$ if Output Polarity bit set, or

$CV = (\text{Clamped PID Output})$ if Output Polarity bit cleared.

If the block is in Automatic mode, the final CV is placed in the Manual Command (word 14 of the reference array). If the block is in Manual mode, the PID equation is skipped because CV is set by the Manual Command, but the slew rate and amplitude limits are still checked. This assures that the Manual Command cannot change the output above the CV Upper Clamp or below the CV Lower Clamp, and the output cannot change faster than allowed by the Minimum Slew Time.

10.4.7 Sample Period and PID Function Block Scheduling

The PID function block is a digital implementation of an analog control function, so the dt sample time in the PID Output equation is not the infinitesimally small sample time available with analog controls. The majority of processes being controlled can be approximated as a gain with a first or second order lag and (possibly) a pure time delay. The PID function block sets a CV output to the process and uses the process feedback PV to determine an Error to adjust the next CV output. A key process parameter is the total time constant, which is how fast the process can change PV when the CV is changed. As discussed in “Determining the Process Characteristics” on page 445, the total time constant, T_p+T_c , for a first order system is the time required for PV to reach 63% of its final value when CV is stepped. The PID function block will not be able to control a process unless its Sample Period is well under half the total time constant. Larger Sample Periods will make it unstable.

The Sample Period should be no bigger than the total time constant divided by 10 (or down to 5 worst case). For example, if PV seems to reach about 2/3 of its final value in 2 seconds, the Sample Period should be less than 0.2 seconds, or 0.4 seconds worst case. On the other hand, the Sample Period should not be too small, such as less than the total time constant divided by 1000, or the $K_i * dt$ term for the PID integral term will round down to 0. For example, a very slow process that takes 10 hours or 36,000 seconds to reach the 63% level should have a Sample Period of 40 seconds or longer.

Variations of the time interval between PID function solutions can have short-term effects on the CV output. For example, if a step change to PV caused by measurement noise occurs between solutions, the value of the derivative term will be inversely proportional to the time interval. The performance of PID loops that are tuned for quick response may be improved when the solution interval is held constant by configuring the CPU for constant sweep mode. Depending on the CPU model and the application, constant sweep times of 10 milliseconds, integer multiples of 10 milliseconds, or exact divisors of 10 milliseconds (1, 2 or 5 milliseconds) will be possible. The Sample Period can then be set for a suitable multiple of 10 milliseconds.

If many PID loops are used, allowing the application to solve all the loops on the same sweep may lead to wide variations in CPU sweep time. If the loops have a common Sample Period that is at least equal to the number of PID loops times the sweep time, a simple solution is to sequence one or more 1's through an array of zero's and use these bits to enable power flow to individual PID function blocks. The logic should assure that each PID function block is enabled no more often than its Sample Period.

10.5. Determining the Process Characteristics

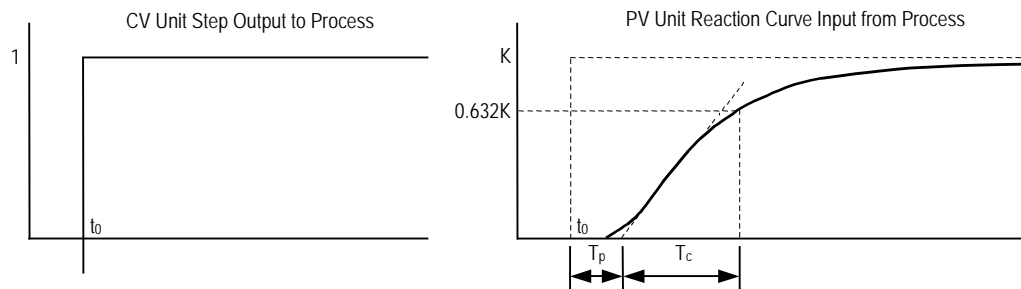
The PID loop gains, K_p , K_i and K_d , are determined by the characteristics of the process being controlled. Two key questions when setting up a PID loop are:

1. How big is the change in PV when CV is changed by a fixed amount, or what is the open loop gain of the process?
2. How fast does the system respond, or how quickly does PV change after the CV output is stepped?

Many processes can be approximated by a process gain, first or second order lag and a pure time delay. In the frequency domain, the transfer function for a first order lag system with a pure time delay is:

$$\frac{PV(s)}{CV(s)} = G(s) = Ke^{-T_p/(1+T_c s)}$$

Plotting the response to a step input at time t_0 in the time domain provides an open-loop unit reaction curve:



The following process model parameters can be determined from the PV unit reaction curve:

K	Process open loop gain = final change in PV/change in CV at time t_0 (Note no subscript on K)
T_p	Process or pipeline time delay or dead time after t_0 before the process output PV starts moving
T_c	First order Process time constant, time required after T_p for PV to reach 63.2% of the final PV

Usually the quickest way to measure these parameters is by putting the PID function block in Manual mode, making a small step change in the CV output by changing the Manual Command (word 14 of the reference array), and then plotting the PV response over time. For slow processes this can be done manually, but for faster processes a chart recorder or computer graphic data-logging package will help. The CV step size should be large enough to cause an observable change in PV, but not so large that it disrupts the process being measured. A good step size may be from 2 to 10% of the difference between the CV Upper and CV Lower Clamp values.

10.6. Setting Tuning Loop Gains

10.6.1 Basic Iterative Tuning Approach

Because PID parameters are dependent on the process being controlled, there are no predetermined values that will work. However, a simple iterative process can be used to find acceptable values for Kp, Ki, and Kd gains.

1. Set all the reference array parameters to 0, then set the CV Upper and CV Lower Clamps to the highest and lowest CV expected. Set the Sample Period to a value within the range $T_c/10$ to $T_c/100$, where T_c is the estimated process time constant defined on page 445.
2. Put the PID function block in Manual mode and set the Manual Command (word 14 in the reference array) to different values to check if CV can be moved to Upper and Lower Clamp. Record the PV value at some CV point and load it into SP.
3. Set a small gain, such as $100 * \text{Maximum CV}/\text{Maximum PV}$, into Kp and turn off Manual mode. Step SP by 2% to 10% of the Maximum PV range and observe PV response. Increase Kp if PV step response is too slow or reduce Kp if PV overshoots and oscillates without reaching a steady value.
4. Once a Kp is found, start increasing Ki to get overshooting that dampens out to a steady value in two to three cycles. This may require reducing Kp. Also try different SP step sizes and CV operating points.
5. After suitable Kp and Ki gains are found, try adding Kd to get quicker responses to input changes, providing it doesn't cause oscillations. Kd is often not needed and will not work with noisy PV.
6. Check gains over different SP operating points and add Dead Band and Minimum Slew Time if needed. Some Reverse Acting processes may need setting of Config Word Error Term or Output Polarity bits.

10.6.2 Setting Loop Gains Using the Ziegler and Nichols Tuning Approach

This approach provides good response to system disturbances with gains producing an amplitude ratio of 1/4. The amplitude ratio is the ratio of the second peak over the first peak in the closed loop response.

1. Determine the three process model parameters, K, T_p and T_c for use in estimating initial PID loop gains.

2. Calculate the Reaction rate:

$$R = K/T_c$$

3. For Proportional control only, calculate Kp as:

$$K_p = 1/(R * T_p) = T_c/(K * T_p)$$

For Proportional and Integral control, use:

$$K_p = 0.9/(R * T_p) = 0.9 * T_c/(K * T_p) \quad K_i = 0.3 * K_p/T_p$$

For Proportional, Integral and Derivative control, use:

$$K_p = G/(R * T_p) \quad \text{where } G \text{ is from } 1.2 \text{ to } 2.0$$

$$K_i = 0.5 * K_p/T_p$$

$$K_d = 0.5 * K_p * T_p$$

4. Check that the Sample Period is in the range $(T_p + T_c)/10$ to $(T_p + T_c)/1000$

10.6.3 Ideal Tuning Method

The "Ideal Tuning" procedure provides the best response to SP changes that are delayed only by the T_p process delay or dead time.

1. Determine the three process model parameters, K , T_p and T_c for use in estimating initial PID loop gains.
2. Calculate K_p , K_i , and K_d as follows:

$$K_p = 2 * T_c / (3 * K * T_p)$$

$$K_i = T_c$$

$$K_d = K_i / 4$$

if Derivative term is used

3. Once initial gains are determined, convert them to integers.
4. Calculate the Process gain, K , as a change in input PV Counts divided by the resulting output step change in CV Counts. (Not in process PV or CV engineering units.) Specify all times in seconds.
5. Once K_p , K_i and K_d are determined, K_p and K_d are multiplied by 100 while K_i is multiplied by 1000. The resulting values are entered into the corresponding reference array word locations.

10.7. Example

The following PID example has a sample period of 100ms, a Kp gain of 4.00 and a Ki gain of 1.500. The set point is stored in %R0001, the control variable is output in %AQ0002, and the process variable is returned in %AI0003. CV Upper and CV Lower Clamps must be set, in this case to 20000 and 4000, and an optional small Dead Band of +5 and -5 is included. The 40-word reference array starts in %R0100. Normally, user parameters are set in the reference array, but %M0006 can be set to re-initialize the 14 words starting at %R0102 (word 3) from constants stored in logic (a useful technique).

The block can be switched to Manual mode with %M1 so that the Manual Command, %R113, can be adjusted. Bits %M4 or %M5 can be used to increase or decrease %R113 and the PID CV by 1 every 100ms solution. For faster manual operation, bits %M2 and %M3 can be used to add or subtract the value in %R2 to/from %R113 every CPU sweep. The %T1 output is on when the PID is OK.

Reference Array Initialization using %M0006

For details on the contents of the reference array, refer to page 432.

Word	Function	Address	Value
3	Sample Period	%R102	10
4	+ Dead Band	%R103	5
5	- Dead Band	%R104	5
6	Kp	%R105	400
7	Kd	%R106	0
8	Ki	%R107	1500
9	CV Bias	%R108	0
10	CV Upper Clamp	%R109	2000
11	CV Lower Clamp	%R110	400
12	Minimum Slew Time	%R111	0
13	Config Word	%R112	0
14	Manual Command	%R113	0
15	Control Word	%R114	0
16	Internal SP	%R115	0

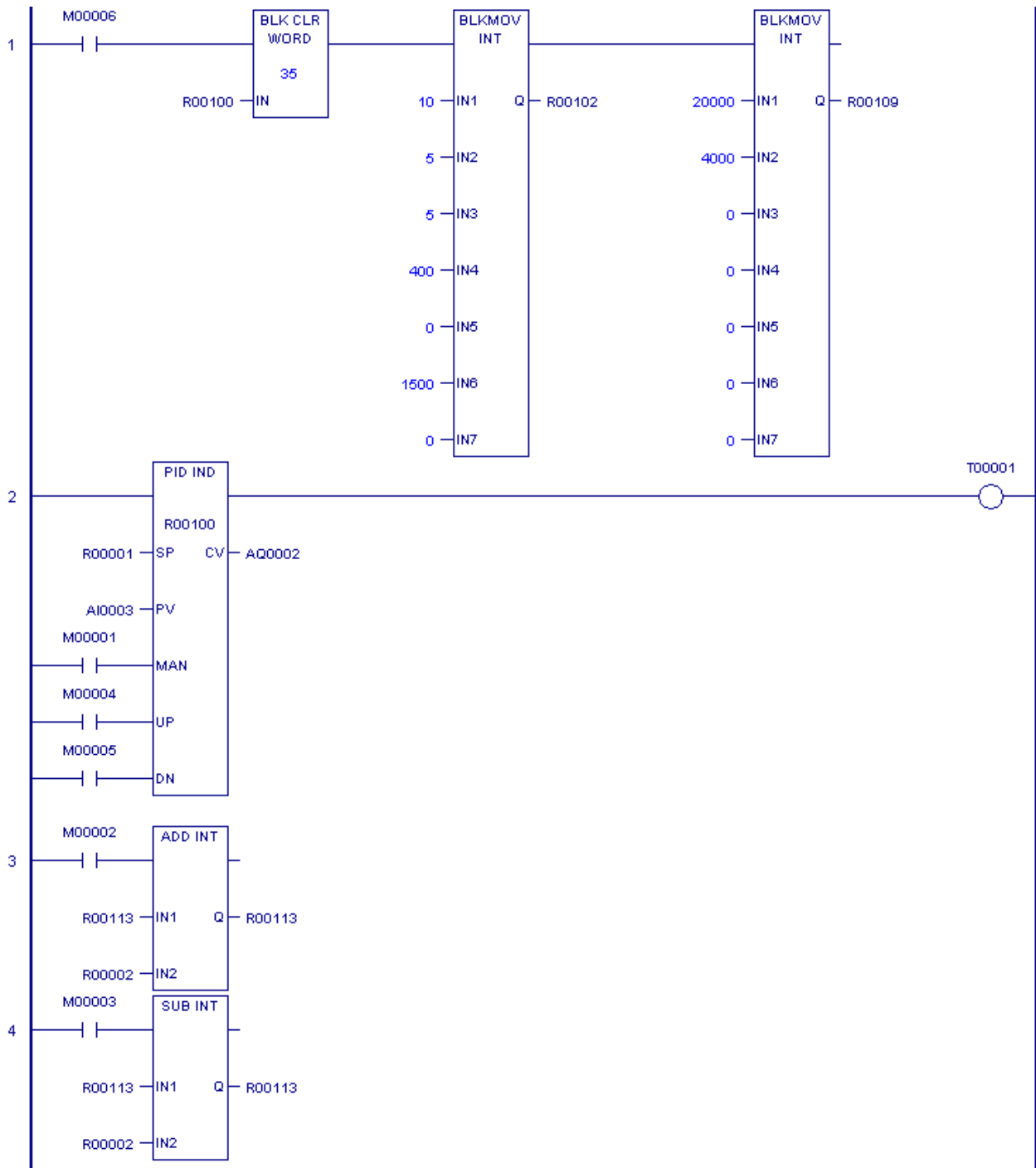


Figure 30: PID Example Logic

Chapter 11 Structured Text (ST) Programming

The Structured Text (ST) programming language is an IEC 61131-3 textual programming language. This chapter describes how structured text is implemented in PACSystems. For information on using the structured text editor in the programming software, refer to the online help.

The block types Block, Parameterized Block, and Function Block (UDFB) can be programmed in ST. The `_MAIN` program block can also be programmed in ST. For details on blocks, refer to Chapter 5, "Program Organization".

11.1. Language Overview

11.1.1 Statements

A structured text program consists of a series of statements, which are constructed from expressions and language keywords. A statement directs the PACSystems controller to perform a specified action. Statements provide variable assignments, conditional evaluations, iteration, and the ability to call built-in functions. PACSystems supports the statements described in “Statement Types” on page 455.

11.1.2 Expressions

Expressions use operators to calculate values from variables and constants. An example of a simple expression is $(x + 5)$.

Composite expressions can be created by nesting simpler expressions, for example,

$(a + b) * (c + d) - 3.0 ** 4$.

11.1.3 Operators

The table below lists the operators that you can use within an expression. They are listed according to their evaluation precedence, which determines the sequence in which they are executed within the expression. The operator with the highest precedence is applied first, followed by the operator with the next highest precedence. Operators of equal precedence are evaluated left to right. Operators in the same group, for example + and -, have the same precedence.

Any address operators used in LD can be used on ST operands. Address operators have precedence over the ST language operators. Address operators include indirect addressing (for example, @Var1), array indexing (for example, Var1[3]), bit within word addressing (for example, Var1.X[3]), and structure fields (for example, Var1.field1).

Precedence	Operator	Operand Types	Description
Group 1 (Highest)	(...)		Parenthesized expression
Group 2	- NOT	INT, DINT, REAL, LREAL BOOL, BYTE, WORD, DWORD	Negation Boolean complement
Group 3	** , ^	INT, DINT, UINT, REAL, LREAL ¹⁹	Exponentiation ^{20, 21}
Group 4	* / MOD	INT, DINT, UINT, REAL, LREAL INT, DINT, UINT, REAL, LREAL INT, DINT, UINT	Multiplication Division ^{20, 22} Modulus operation
Group 5	+ -	INT, DINT, UINT, REAL, LREAL INT, DINT, UINT, REAL, LREAL	Addition Subtraction
Group 6	<, >, <=, >=	INT, DINT, UINT, REAL, LREAL, BYTE, WORD, DWORD	Comparison
Group 7	= <>, !=	ANY ²³ ANY	Equality Inequality
Group 8	AND, &	BOOL, BYTE, WORD, DWORD	Boolean AND
Group 9	XOR	BOOL, BYTE, WORD, DWORD	Boolean exclusive OR
Group 10 (Lowest)	OR	BOOL, BYTE, WORD, DWORD	Boolean OR

Some comparison and math operators have corresponding built-in functions. For instance the '+' operator is similar to the ADD_INT function. You can use either the language operator or the built-in function. The built-in function has the advantage of returning an ENO status. For information on "Built-in Functions Supported for ST Calls", see page 457.

Operand Types

Type casting is not supported. To convert a type, use one of the built-in conversion functions. Use of built-in functions is described in "Function Call" on page 456.

For untyped operators (+, *, ...), the types of the operands must match.

¹⁹ The base must be type REAL or LREAL. If the base is REAL, the power can be type INT, DINT, UINT, or REAL and the result is type REAL. If the base is type LREAL, the power must be LREAL and the result will be LREAL

²⁰ Use of math operators can cause overflow or underflow. Overflow results are truncated.

²¹ If either operand is positive or negative infinity, the result is undefined.

²² The CPU flags a "divide-by-0" error as an application fault.

²³ Operators that can take operands of type ANY can be used with any of the supported elementary data types. The supported data types are: BOOL, INT, DINT, UINT, BYTE, WORD, DWORD, LREAL and REAL. STRING and TIME data types are not supported

11.1.4 Structured Text Syntax

The syntax of the ST implementation for PACSystems follows the IEC 61131-3 standard.

- Structured Text statements must end in a semi-colon (;).
- Structured Text variables must be declared in the variable list for the target.

These symbols have the following functions.

:= assigns an expression to a variable

; required to designate the end of a statement

[] used for array indexing where the array index is an integer. For example, this sets the third element of an array to the value $j+10$: **intarray[3] = j + 10;**

(* *) designates a comment. These comments can span multiple lines. For example, **(*This comment spans multiple lines.*)**

// or ' designates a single line comment. For example,

c := a+b; //This is a single line comment.

c := a+b; 'This is a single line comment.

11.2. Statement Types

The Structured Text statements, which specify the actual program execution, consist of the following types, which are described in more detail on the following pages.

Statement Type	Description	Example
Assignment	Sets an object to a specified value.	A := 1; B := A; C := A + B;
CASE	Provides for the conditional execution of a set of statements.	CASE A OF 1,2 : C := 3; 3: C := 4; 4..5: C := 5; ELSE C := 0; END_CASE;
COMMENT	Places a text explanation in the program. Ignored by the ST compiler.	(* This is a block comment *) ' This is a line comment // This is a line comment //
Function call	Calls a function for execution.	FbInst(IN1 := 1, OUT1 => A);
RETURN	Causes the program to return from a subroutine. The return statement provides an early exit from a block.	RETURN;
EXIT	Terminates iterations before the terminal condition becomes TRUE (1).	EXIT;
IF	Specifies that one or more statements be executed conditionally.	IF (A < B) THEN C := 4; ELSIF (A = B) THEN C := 5; ELSE C := 6 END_IF;
FOR ... DO	Executes a statement sequence repeatedly based on the value of a control symbol.	FOR I := 1 TO 100 BY 2 DO IF (Var1 - I) = 40 THEN Key := I; EXIT; END_IF; END_FOR;
WHILE	Indicates that a statement sequence be executed repeatedly until a Boolean expression evaluates to FALSE (0).	WHILE J <= 100 DO J := J + 2; END_WHILE;
REPEAT	Indicates that a statement sequence be executed repeatedly until a Boolean expression evaluates to TRUE (1).	REPEAT J := J + 2; UNTIL J >= 100 END_REPEAT;
ARG_PRESENT	Determines whether a parameter value was present when the function block instance of the parameter was invoked. For example, a parameter can be optional (pass by value).	ARG_PRES (IN :=In1, Q:>Out1, ENO:>Out2);
Empty Statement		;

11.2.1 Assignment Statement

The assignment statement replaces the value of a variable with the result of evaluating an expression (of the same data type).

Notes:

- Assignment statements can affect transition bits.
- Assignment statements take override bits into account.

Format

Variable := Expression;

Where:

Variable is a simple variable, array element, etc.

Expression is a single value, expression, or complex expression.

Examples

Boolean assignment statements:

```
VarBool1 := 1;
```

```
VarBool2 := (val <= 75);
```

Array element assignment:

```
Array_1[13] := (RealA / RealB) * PI;
```

11.2.2 Function Call

The structured text function call executes a predefined algorithm that performs a mathematical, bit string or other operation. The function call consists of the name of the function or block followed by required input or output parameters.

The structured text logic can call blocks or the PACSystems built-in functions listed in the table below. The call must be made in a single statement and cannot be part of a nested expression.

Calls to some functions, such as communications request (COMMREQ), require a command block or parameter block. For these functions, an array is declared, initialized in logic, and then passed as a parameter to the function.

Built-in Functions Supported for ST Calls

Note: Only the functions listed in the following table are supported in the current PACSystems version. Other built-in functions are not supported.

Example: `cos(IN := inReal, Q => outReal, ENO => outBool);`

Category	Functions	More information
Advanced Math	ASIN, ATAN, ACOS, COS, SIN, TAN LOG, LN, EXP, EXPT, SQRT_INT, SQRT_DINT, SQRT_REAL	Chapter 7
Math	ABS_INT, ABS_DINT, ABS_REAL SCALE_DINT, SCALE_INT, SCALE_UINT	Chapter 7
Communication	PNIO_DEV_COMM	<i>PACSystems RX3i PROFINET Controller Manual, GFK-2571</i>
Control	DO_IO, MASK_IO_INTR, SCAN_SET_IO, SUS_IO, SUS_IO_INTR, SVC_REQ, SWITCH_POS, F_TRIG, R_TRIG	Chapter 7
Data Conversion	BCD4_TO_INT, BCD4_TO_UINT, BCD4_TO_REAL BCD8_TO_DINT, BCD8_TO_REAL DINT_TO_BCD8, DINT_TO_DWORD, DINT_TO_INT, DINT_TO_UINT, DINT_TO_REAL, DINT_TO_LREAL DWORD_TO_DINT INT_TO_BCD4, INT_TO_DINT, INT_TO_UINT, INT_TO_REAL, INT_TO_WORD UINT_TO_BCD4, UINT_TO_BCD8, UINT_TO_INT, UINT_TO_DINT, UINT_TO_REAL, UINT_TO_WORD REAL_TO_INT, REAL_TO_UINT, REAL_TO_DINT, REAL_TO_LREAL LREAL_TO_DINT, LREAL_TO_REAL TRUNC_INT, TRUNC_DINT DEG_TO_RAD, RAD_TO_DEG WORD_TO_INT, WORD_TO_UINT	Chapter 7
Data Move	ARRAY_SIZE, ARRAY_SIZE_DIM1, ARRAY_SIZE_DIM2, COMMREQ, MOVE_DATA_EX, SIZE_OF	Chapter 7
PACMotion	The RX3i CPUs support 56 PLCopen compliant motion functions and function blocks.	<i>PACMotion Multi-Axis Motion Controller User's Manual, GFK-2448</i>

Calls to Standard Function Blocks

Standard function blocks are instructions that have instance data in the form of a structure variable. (For more information on function blocks and their instance data, refer to “Functions and Function Blocks” in Chapter 5.) Standard function blocks are called in the same way that a UDFB is called.

PACSystems controllers support three standard function blocks:

Pulse timer (TP)	Generates output pulses of a given duration	See page 325
On-delay timer (TON)	Delays setting an output ON for a fixed period after an input is set ON.	See page 324
Off-delay timer (TOF)	Delays setting an output OFF for a fixed period after an input goes OFF so that the output is held on for a given period longer than the input.	See page 323

Format of Calls to Standard Timer Function Blocks

Notes: TOF, TON and TP have the same input and output parameters, except for the instance variable, which must be the same type as the instruction.

Writing or forcing values to the instance data elements IN, PT, Q, ET, ENO or TI may cause erratic operation of the timer function block.

Instance data can be a variable or a parameter of the current UDFB or parameterized block.

Formal Convention

```
myTOF_Instance_Data(IN := inBool, PT := inDINT, ET => outDINT, Q => outBool, ENO => outBoolSuccess);
```

```
myTON_Instance_Data(IN := inBool, PT := inDINT, ET => outDINT, Q => outBool, ENO => outBoolSuccess);
```

```
myTP_Instance_Data(IN := inBool, PT := inDINT, ET => outDINT, Q => outBool, ENO => outBoolSuccess);
```

Note: ENO is an optional BOOL output parameter. If ENO is used in a statement that uses the formal convention, the state of *outBoolSuccess* is set to 1 (call was successful) or 0 (call failed).

Informal Convention

```
myTOF_Instance_Data(inBool, inDINT, outDINT, outBool);
```

```
myTON_Instance_Data(inBool, inDINT, outDINT, outBool);
```

```
myTP_Instance_Data(inBool, inDINT, outDINT, outBool);
```

Note: When using the informal convention, the operands must be assigned in the order shown above (that is, IN, PT, ET, Q and ENO).

Block Types Supported for ST Calls

An ST block can call blocks of type Block, Parameterized Block, or user defined Function Block (UDFB) or External Block (C block). For more information on block types, refer to Chapter 5.

Formal Calls vs. Informal Calls

PACSystems supports formal and informal calls in ST.

Formal Calls	Informal Calls
Input parameter assignments use the ':= ' notation while output assignments use the '=>' notation.	Input and output parameters are listed in parentheses.
Optional parameters can be omitted.	Parameters cannot be omitted.
Parameters can be in any order.	Parameters must be in the correct order as follows: Inputs Instance location (if required) Length parameter (if required) Outputs, starting with the last output parameter.
The ENO parameter is specified in a formal function or block call. All built-in functions and user-defined blocks have an optional ENO output parameter indicating the success of the function or block. Either ENO or Y0 can be used as this output parameter name.	The ENO parameter is not specified in an informal function or block call.

Format of Formal Function Call

FunctionName(IN1 := inparam1, IN2 := inparam2, OUT1 => outparam1, ENO => enoparam);

Format of Informal Function Call

FunctionName(inparam1, inparam2, outparam1);

Example

This code fragment shows the TAN function call.

```
TAN( AnyReal, Result );
```


11.2.3 RETURN Statement

The return statement provides an early exit from a block. For example, in the following lines of code the third line will never execute. The variable **a** will have the value 4.

```
a := 4;  
RETURN;  
a := 5;
```

11.2.4 IF Statement

The IF construct offers conditional execution of a statement list. The condition is determined by result of a Boolean expression. The IF construct includes two optional parts, ELSE and ELSIF, that provide conditional execution of alternate statement list(s). One ELSE and any number of ELSIF sections are allowed per IF construct.

Format

```

IF BooleanExpression1 THEN
    StatementList1;
[ELSIF BooleanExpression2 THEN    (*Optional*)
    StatementList2;]
[ELSE                               (*Optional*)
    StatementList3;]
END_IF;

```

Where:

BooleanExpression Any expression that resolves to a Boolean value.

StatementList Any set of structured text statements.

Note: Either ELSIF or ELSEIF can be used for the else if clause in an IF statement.

Operation

The following sequence of evaluation occurs if both optional parts are present:

- If BooleanExpression1 is TRUE (1), StatementList1 is executed. Program execution continues with the statement following the END_IF keyword.
- If BooleanExpression1 is FALSE (0) and BooleanExpression2 is TRUE (1), StatementList2 is executed. Program execution continues with the statement following the END_IF keyword.
- If both Boolean expressions are FALSE (0), StatementList3 is executed. Program execution continues with the statement following the END_IF keyword.

If an optional part is not present, program execution continues with the statement following the END_IF keyword.

Example

The following code fragment puts text into the variable Status, depending on the value of I/O point input value.

```

IF Input01 < 10.0 THEN
    Status := Low_Limit_Warning;
ELSIF Input02 > 90.0 THEN
    Status := Upper_Limit_Warning;
ELSE
    Status := Limits_OK;
END_IF;

```

11.2.5 CASE Statement

The CASE ... OF construct offers conditional execution of statement lists. It uses the value of an ST integer expression to determine whether to execute a statement list. The statement list to be executed can be selected from multiple statement lists, depending on the value of the associated integer expression.

Conditions can be expressed as a single value, a list of values, or a range of values. The single-value, list of values, or range forms can be used by themselves or in combination. The optional ELSE keyword can be used to execute a statement list when the associated value does not meet any of the specified conditions.

You can have a maximum of 1024 cases in a single CASE ... OF construct. Additional cases can be handled by adding the ELSE keyword to the construct and specifying a nested CASE ... OF construct or an IF ... THEN construct after the ELSE.

The number of nested CASE ... OF constructs and the number of levels are limited by the memory in your computer.

The number of constants and constant ranges in a single conditional statement is limited by the memory in your computer.

Format

```

CASE Integer_Expression OF
  Int1:                (*Single Value*)
  StatementList_1;
  Int2,Int3,Int4:     (*List of Values*)
  StatementList_2;
  Int5..Int6:         (*Range of Values*)
  StatementList_3;
[ELSE                 (*Optional*)
  StatementList_Else;]
END_CASE;
```

Where:

<i>Integer_Expression</i>	An ST expression that resolves to an integer (INT, DINT or UINT) value.
<i>Int</i>	A constant integer value.
<i>StatementList_1 ... StatementList_n</i>	Structured Text statements.

Operation

The Int values are compared to Integer_Expression. The statement list following the first Int value that matches Integer_Expression is executed. If the optional ELSE keyword is used and no Int value matches Integer_Expression, the statement list following ELSE is executed. Otherwise, no statement list is executed.

Requirements for Conditional Statements

- All constants must be of type INT, DINT or UINT.
- In range declarations, the beginning value must be less than the ending value (reading from left to right). For example, 10..3 and 5..5 are invalid.
- Overlapping values in different case conditions are not allowed. For example, 5..10 and 7 cannot be specified as conditions in the same CASE ... OF construct.

Examples

The following code fragment assigns a value to the variable ColorVariable.

```
CASE ColorSelection OF
  0:    ColorVariable:= Red;
  1:    ColorVariable:= Yellow;
  2,3,4: ColorVariable:= Green;
  5..9: ColorVariable:= Blue;
ELSE   ColorVariable:= Violet;
END_CASE;
```

The following code fragment uses a nested CASE...OF...END_CASE construct.

```
CASE ColorSelection OF
  0:    ColorVariable:= Red;
  1:    ColorVariable:= Yellow;
  2,3,4: ColorVariable:= Green;
  5..9: ColorVariable:= Blue;
ELSE
  CASE ColorSelection OF
    10: ColorVariable:= Violet;
  ELSE ColorVariable:= Black;
  END_CASE;
  ColorError: 1;
END_CASE;
```

11.2.6 FOR ... DO Statements

The FOR loop repeatedly executes a statement list contained within the FOR ... DO ... END_FOR construct. It is useful when the number of iterations can be predicted in advance, for example to initialize an array. The number of iterations is determined by the value of a control variable which is incremented (or decremented) from an initial value to a final value by the FOR statement.

By default, each iteration of the FOR statement changes the value of the control variable by 1. The optional BY keyword can be used to specify an increment or decrement of the control variable by specifying a (non-zero) positive or negative integer or an expression that resolves to an integer.

FOR loops can be nested to a maximum of ten levels.

Format

```
FOR Control_Variable := Start_Value TO End_Value [BY Step_Value] DO
Statement list;
END_FOR;
```

Where:

<i>Control_Variable</i>	The control variable. Can be an INT, DINT or UINT variable or parameter.
<i>Start_Value</i>	The starting value of the control variable. Must be an expression, variable, or constant of the same data type as Int_Variable.
<i>End_Value</i>	The ending value of the control variable. Must be an expression, variable, or constant of the same data type as Int_Variable.
<i>Step_Value</i>	(Optional) The increment or decrement value for each iteration of the loop. Must be an expression, variable, or constant of the same data type as Int_Variable. If Step_Value is not specified, the control variable is incremented by 1.
<i>Statement list</i>	Any list of Structured Text statements.

Operation

The values of Start_Value, End_Value and Step_Value are calculated at the beginning of the FOR loop. On the first iteration, Control_Variable is set to Start_Value.

At the beginning of each iteration, the termination condition is tested. If it is satisfied, execution of the loop is complete and the statements after the loop will proceed. If the termination condition is not satisfied, the statements within the FOR...END_FOR construct are executed. At the end of each iteration, the value of Control_Variable is incremented by Step_Value (or 1 if Step_Value is not specified).

The termination condition of a FOR loop depends on the sign of the step value.

Step Value Termination Condition

- > 0 Control_Variable > End_Value
- < 0 Control Variable < End Value
- 0 None. A termination condition is never reached and the loop will repeat infinitely.

As with the other iterative statements (WHILE and REPEAT), loop execution can be prematurely halted by an EXIT statement.

To avoid infinitely repeating or unpredictable loops, the following precautions are recommended:

- Do not allow the statement list logic within the FOR loop to modify the control variable.
- Do not use the control variable in logic outside the FOR loop.

Examples

The following code fragment initializes an array of 100 elements starting at %R1000 (given that R1000 is at %R1000) by assigning a value of 10 to all array elements.

```
FOR R1000 := 1 TO 100 DO  
    @R1000 := 10;  
END_FOR;
```

The following code fragment assigns the values of an I/O point to array elements over ten I/O scans. The last entry is put in the array element with the smallest index.

```
FOR R1000 := 10 TO 1 BY -1 DO  
    @R1000 := Input01;  
END_FOR;
```

11.2.7 WHILE Statement

The WHILE loop repeatedly executes (iterates) a statement list contained within the WHILE...END_WHILE construct as long as a specified condition is TRUE (1). It checks the condition first, then conditionally executes the statement list. This looping construct is useful when the statement list does not necessarily need to be executed.

Format

```
WHILE <BooleanExpression> DO
    <StatementList>;
END_WHILE;
```

Where:

BooleanExpression Any expression that resolves to a Boolean value.

StatementList Any set of Structured Text statements.

Operation

If BooleanExpression is FALSE (0), the loop is immediately exited; otherwise, if the BooleanExpression is TRUE (1), the StatementList is executed and the loop repeated. The statement list may never execute, since the Boolean expression is evaluated at the beginning of the loop.

Note: It is possible to create an infinite loop that will cause the watchdog timer to expire. Avoid infinite loops.

Example

The following code fragment increments J by a value of 2 as long as J is less than or equal to 100.

```
WHILE J <= 100 DO
    J := J + 2;
END_WHILE;
```

11.2.8 REPEAT Statement

The REPEAT loop repeatedly executes (iterates) a statement list contained within the REPEAT...END_REPEAT construct until an exit condition is satisfied. It executes the statement list first, then checks for the exit condition. This looping construct is useful when the statement list needs to be executed at least once.

Format

```
REPEAT
    StatementList;
UNTIL BooleanExpression END_REPEAT;
```

Where:

BooleanExpression Any expression that resolves to a Boolean value.

StatementList Any set of Structured Text statements.

Operation

The StatementList is executed. If the BooleanExpression is FALSE (0), then the loop is repeated; otherwise, if the BooleanExpression is TRUE (1), the loop is exited. The statement list executes at least once, since the BooleanExpression is evaluated at the end of the loop.

Note: It is possible to create an infinite loop that will cause the watchdog timer to expire. Avoid infinite loops.

Example

The following code fragment reads values from an array until a value greater than 5 is found (or the upper bound of the array is reached). Since at least one array value must be read, the REPEAT loop is used. All variables in this example are of type DINT, UINT, or INT.

```
Index :=1;
REPEAT
    Value:= @Index;
    Index:=Index+1;
UNTIL Value > 5 OR Index >= UpperBound END_REPEAT;
```


11.2.9 ARG_PRES Statement

The ARG_PRES function determines whether an input parameter value was present when the function block instance of the parameter was invoked. This may be necessary if the parameter is optional (pass by value).

This function must be called from a function block instance or a parameterized block.

Format

ARG_PRES (IN :=In1, Q:>Out1, ENO:>Out2);

Where:

In1 Must be an input parameter of the function block that contains the ARG_PRES instruction. Cannot be an array element or structure element. An alias to a parameter should resolve only to the parameter name.

Can be a BOOL, DINT, DWORD, INT, REAL, UINT, WORD variable, variable array head name or variable array head name element [000]. Input or output parameter value of a function block instance or a parameterized block

Out2 A BOOL variable. True if the parameter is present, otherwise false.

Note: ENO is an optional BOOL output parameter. If ENO is used in a statement that uses the formal convention, the state of *Out2* is set to 1 (call was successful) or 0 (call failed).

Example

The parameter TempVal is an input to the function block CheckTemp. In the following code fragment, ARG_PRES is used to determine whether a value existed for the parameter TempVal when an instance of CheckTemp was invoked. If TempVal had a value, the BOOL output Temp_Pres is set to 1.

ARG_PRES (TempVal, Temp_Pres);

11.2.10 Exit Statement

The EXIT statement is used to terminate and exit from a loop (FOR, WHILE, REPEAT) before it would otherwise terminate. Program execution resumes with the statement following the loop terminator (END_FOR, END_WHILE, END_REPEAT). An EXIT statement is typically used within an IF statement.

Format

```
EXIT;
```

Where:

ConditionForExiting An expression that determines whether to terminate early.

Example

The following code fragment shows the operation of the EXIT statement. When the variable number equals 10, the WHILE loop is exited and execution continues with the statement immediately following END_WHILE.

```
while (1) do
  a := a + 1;
  IF (a = 10) THEN
    EXIT;
  END_IF;
END_WHILE;
```


Chapter 12 Communications

This chapter describes the Ethernet and Serial communications features of the PACSystems CPU. The following information is included:

Ethernet Communications	<i>page</i> 472
Ethernet Port Pin Assignments	473
Serial Communications	474
Serial Port Communications Capabilities	474
Serial Port Pin Assignments	475
Serial Port Baud Rates	478
Series 90-70 Communications and Intelligent Option Modules (RX7i only)	480
Communications Coprocessor Module (CMM)	480
Programmable Coprocessor Module (PCM)	481
DLAN/DLAN+ (Drives Local Area Network) Interface	482

12.1. Ethernet Communications

For details on Ethernet communications for PACSystems, please refer to the following manuals:

TCP/IP Ethernet Communications for PACSystems User's Guide, GFK-2224

PACSystems TCP/IP Communications Station Manager Manual, GFK-2225

12.1.1 Embedded Ethernet Interface

RX3i

RX3i CPE305 and CPE310 CPUs have an embedded Ethernet interface that provides TCP/IP communications with programming software and other control systems. These communications use the proprietary SRTP protocol and the standard Modbus/TCP protocol. The embedded Ethernet interface has one RJ-45 Ethernet port that automatically senses the data rate (10Mbps or 100Mbps), duplex (half duplex or full duplex), and cabling arrangement (straight through or crossover) of the attached link. On the CPE3xx models, the same shared processor performs Ethernet port processing and Controller logic processing.

RX7i

RX7i CPUs have an embedded Ethernet interface that provides TCP/IP communications with programming software and other control systems. These communications use the proprietary SRTP protocol and the standard Modbus/TCP protocol over a four-layer TCP/IP (Internet) stack. The Ethernet interface also supports Ethernet Global Data protocol using UDP (user datagram protocol). The embedded Ethernet interface has two RJ-45 Ethernet ports. Either or both of these ports may be attached to other Ethernet devices. Each port automatically senses the data rate (10Mbps or 100Mbps), duplex (half duplex or full duplex), and cabling arrangement (straight through or crossover) of the attached link.



Caution

The two ports on the Ethernet Interface must *not* be connected, directly or indirectly to the same device. The hub or switch connections in an Ethernet network must form a tree, otherwise duplication of packets may result.

10Base-T/100Base-Tx Port Pin Assignments

Pin assignments are the same for the RX3i and RX7i embedded Ethernet ports.

<i>Pin Number</i>	<i>Signal</i>	<i>Description</i>
1	TD+	Transmit Data +
2	TD-	Transmit Data -
3	RD+	Receive Data +
4	NC	No connection
5	NC	No connection
6	RD-	Receive Data -
7	NC	No connection
8	NC	No connection

12.1.2 Ethernet Interface Modules

The RX7i and RX3i support rack-based Ethernet Interface modules. (These modules are not interchangeable.) For details about the capabilities, installation, and operation of these modules, refer to *TCP/IP Ethernet Communications for PACSystems*, GFK-2224 and *Station Manager for PACSystems*, GFK-2225.

<i>Type</i>	<i>Catalog Number</i>	<i>Description</i>
RX7i	IC698ETM001	Ethernet peripheral VME module
RX3i	IC695ETM001	Ethernet peripheral PCI module

12.2. Serial Communications

The independent on-board serial ports of the CPU are accessed via connectors on the front of the module. Ports 1 and 2 provide serial interfaces to external devices. Port 1 is also used for firmware upgrades. The RX7i CPUs provide a third serial port that is used as the Ethernet station manager port. All serial ports are isolated.

12.2.1 Serial Port Communications Capabilities

Ports 1 and 2 can each be configured for one of the following modes. For details on CPU configuration, refer to Chapter 3.

- RTU Slave – The port can be used for the Modbus RTU slave protocol. This mode also permits connection to the port by an SNP master, such as the WinLoader utility or the programming software. For details, refer to Chapter 13, “Serial I/O, SNP & RTU Protocols”.
- Message Mode – The port is available for access by user logic. This enables C language blocks to perform serial port I/O operations via C Runtime Library functions.
- Available – The port is not to be used by the CPU firmware.
- SNP Slave – The port can only be used for the SNP slave protocol. For details, refer to Chapter 13, “Serial I/O, SNP & RTU Protocols”.
- Serial I/O – The port can be used for general-purpose serial communication through use of COMMREQ functions. For details, refer to Chapter 13, “Serial I/O, SNP & RTU Protocols”.

Features Supported

Feature	Port 1 (COM 1)	Port 2 (COM 2)	Port 3 (Station Mgr) RX7i only
RTU Slave protocol	Yes	Yes	No
SNP Slave	Yes	Yes	No
Serial I/O – used with COMMREQs	Yes	Yes	No
Firmware Upgrade (WinLoader utility)	CPU in STOP/No IO mode	No	No
Message Mode –used only with C blocks (C Runtime Library Functions: serial read, serial write, sscanf, sprintf)	Yes	Yes	No
Station Manager (RX7i only)	No ²⁴	No	Yes
RS-232	Yes	No	Yes
RS-485	No	Yes	No

²⁴ RX3i CPE-type CPUs, ETM001 & EDS001 support Station Manager using UDP over Ethernet, but not via serial communications.

12.2.2 Configurable Stop Mode Protocols

You can configure the protocol to be used in Stop mode, based upon the configured Port (Run mode) protocol. The Run/Stop protocol switching is independently configured for each serial port.

The Run mode protocol setting determines which choices are available for Stop mode. If a Stop mode protocol is not selected, the default Stop mode protocol is used. For details, refer to “Port 1 and Port 2 Parameters” in Chapter 3.

12.2.3 Serial Port Pin Assignments

Port 1 (RS-232, 9-pin Subminiature D Connector)

This port has a 9-pin, female, D-sub connector with a standard pin out. This is a DCE (data communications equipment) port that allows a simple straight-through cable to connect with a standard AT-style RS-232 port.

The CPE310 provides the DCD and RI signals to support point-to-point protocol (PPP).

Port 1 RS-232 Signals

<i>RX3i CPU, RX3i CRU, and RX7i CPE Models Optocoupler Isolated</i>			<i>RX3i CPE310 Model Non-Isolated</i>		
<i>Pin No.</i> ²⁵	<i>Signal Name</i>	<i>Description</i>	<i>Pin No.</i>	<i>Signal Name</i>	<i>Description</i>
1	NC	No Connection	1	DCD	Data Carrier Detect
2	TXD	Transmit Data	2	TXD	Transmit Data
3	RXD	Receive Data	3	RXD	Receive Data
4	DSR	Data Set Ready	4	DSR	Data Set Ready
5	0V	Signal Ground	5	COM	Signal Ground
6	DTR	Data Terminal Ready	6	DTR	Data Terminal Ready
7	CTS	Clear to Send	7	CTS	Clear to Send
8	RTS	Request to Send	8	RTS	Request to Send
9	NC	No Connection	9	RI	Ring Indicator

Port 1 (RS-232, RJ-25 Connector)

The CPE305 provides RS-232 communications via an RJ-25 connector and requires shielded cable (IC693CBL316). This port is non-isolated.

CPE305 Port 1 RS-232 Signals

<i>Pin No.</i>	<i>Signal Name</i>	<i>Description</i>
1	CTS	Clear to Send
2	TXD	Transmit Data
3	0V	Signal Ground
4	0V	Signal Ground
5	RXD	Received Data
6	RTS	Request to Send

²⁵ Pin 1 is at the bottom right of the connector as viewed from the front of the module.

Port 2 (RS-485, 15-pin, Female D-sub Connector) –RX7i CPU/CRU Models

On RX7i CPUs, this port is optocoupler isolated.

This port does not supply +5V volts, therefore RS-485 to RS-232 conversion requires a converter that is self-powered. It does not support the RS-485 to RS-232 adapter IC690ACC901.

This is a DCE port that allows a simple straight-through cable to connect with a standard AT-style RS-232 port.

Port 2 RS-485 Signals

<i>Pin No.</i>	<i>Signal Name</i>	<i>Description</i>
1	Shield	Cable Shield Located at the bottom right of the connector as viewed from the front of the module.
2	NC	No Connection
3	NC	No Connection
4	NC	No Connection
5	NC	No Connection
6	RTS(A)	Differential Request to Send A
7	0V	Signal Ground
8	CTS(B')	Differential Clear To Send
9	RT ²⁶	Resistor Termination
10	RD(A') ^{26,27}	Differential Receive Data A
11	RD(B')	Differential Receive Data B
12	SD(A)	Differential Send Data A
13	SD(B)	Differential Send Data B
14	RTS(B')	Differential Request To Send B
15	CTS(A')	Differential Clear To Send A

²⁶ To provide termination using the built-in 120Ω resistor, install a jumper between pins 9 and 10.

²⁷ To provide termination using an external resistor, connect a user-supplied resistor across pins 10 and 11.

Port 2 (RS-485, 15-pin, Female D-sub Connector) – All RX3i CPU and CRU Models and RX3i CPE310

This port is **not** isolated.

This is a DCE port that allows a simple straight-through cable to connect with a standard AT-style RS-232 port.

Port 2 RS-485 Signals

Pin No.	Signal Name	Description
1	Shield	Cable Shield Located at the bottom right of the connector as viewed from the front of the module.
2	NC	No Connection
3	NC	No Connection
4	NC	No Connection
5	+5VDC	Logic Power: Provides isolated +5VDC power (300mA maximum) for powering external options.
6	RTS(A)	Differential Request to Send A
7	0V	Signal Ground
8	CTS(B')	Differential Clear To Send B
9	RT	Resistor Termination
10	RD(A) ^{26, 27}	Differential Receive Data A
11	RD(B') ²⁷	Differential Receive Data B
12	SD(A)	Differential Send Data A
13	SD(B)	Differential Send Data B
14	RTS(B')	Differential Request To Send B
15	CTS(A')	Differential Clear To Send A

Port 3 (RX7i only)

Port 3, the Station Manager serial port used by the embedded Ethernet Interface, is RS-232 compatible and isolated. Port 3 has a 9-pin, female, D-connector. This is a DCE port that allows a simple straight-through cable to connect with a standard AT-style RS-232 port. This port contains full use of the standard RS-232 signals for future use with point-to-point protocol (PPP).

Station Manager RS-232 Signals

<i>Pin No.</i> ²⁵	<i>Signal Name</i>	<i>Description</i>
1	DCD	Data Carrier Detect
2	TXD	Transmit Data
3	RXD	Receive Data
4	DSR	Data Set Ready
5	0V	Signal Ground
6	DTR	Data Terminal Ready
7	CTS	Clear To Send
8	RTS	Request to Send
9	RI	Ring Indicator

Serial Cable Lengths and Shielding

The connection from a CPU serial port to the serial port on a computer or other serial device requires a serial cable. Maximum cable lengths (the total distance from the CPU to the last device attached to the serial cable) are:

<i>Port</i>	<i>Maximum Cable Length</i>	<i>Cable Type</i>
COM 1/Port 1 (RS-232)	15 meters (50 ft.)	Shielded cable required for RX3i; Shielded cable optional for RX7i
COM 2/Port 2 (RS-485)	1200 meters (4000 ft.)	Shielded cable required for all models that support this port
STA MGR/Port 3 (RS-232)	15 meters (50 ft.)	Shielded cable optional (RX7i only)

Note: For details on conformance to radiated emissions standards, refer to Appendix A in the following manuals:

PACSystems RX7i Installation Manual, GFK-2223

PACSystems RX3i System Manual, GFK-2314

12.2.4 Serial Port Baud Rates

Protocol	Port 1 (RS-232)	Port 2 (RS-485)	Station Mgr (Port 3) (RS-232)
RTU Slave	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	not supported
Firmware Upgrade via WinLoader	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	Not supported	not supported
Message Mode	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	not supported
SNP Slave	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	not supported
Serial I/O	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	not supported

12.3. Series 90-70 Communications and Intelligent Option Modules

PACSystems RX7i supports the following Series 90-70 communications and intelligent option modules:

- Communications Coprocessor Module (CMM), IC697CMM711
- Programmable Coprocessor Module (PCM), IC697PCM711
- DLAN Interface Module, IC697BEM763

12.3.1 Communications Coprocessor Module (CMM)

PACSystems RX7i CPUs with versions 1.50 and higher support IC697CMM711 modules with firmware versions 4.20 and higher. You must ensure that you are using a valid version of the CMM firmware because the CPU cannot check the CMM's firmware version. (The module's firmware version can be found on a label attached to the EEPROM.)

PACSystems **does not** support the following with an IC697CMM711:

- Access to Symbolic variables
- WAIT mode COMMREQs.
- Connecting the programming software to the CPU through the CMM's serial ports.
- Permanent datagrams.

The following restrictions apply when using the IC697CMM711 with PACSystems:

- Access to %W references is partially supported. Only offsets 0–65535 of %W can be accessed via the CMM.
- The Program Name is currently always LDPROG1 for PACSystems.
- Reads and writes beyond currently configured reference table limits will report a minor code error of 90 (REF_OUT_OF_RANGE) instead of F4 (INVALID_PARAMETER) as reported on the Series 90-70.
- In case of ERROR NACK, the Control Program number, privilege level and other piggyback status data will be set to 0.
- PACSystems CPUs return the major/minor type of the 90-70 CPX935 (major type 12, minor type 35) to the CMM scratch pad memory when communicating with a CMM.
- Control Program Number will be returned as 01 in PACSystems instead of FF as reported on the Series 90-70.
- If your RX7i application program needs to access the dual port memory of a CMM, use the BUS READ and WRITE functions. When accessing the CMM, set the Region parameter on the function block to 1. (For the CMM, region 1 is predefined to be the module's entire dual port memory.)

Note: For details on operation of the IC697CMM711, refer to the *Serial Communications User's Manual*, GFK-0582.

12.3.2 Programmable Coprocessor Module (PCM)

PACSystems RX7i CPUs with versions 1.50 and higher support IC697PCM711 modules with firmware versions 4.05 and higher. You must ensure that you are using a valid version of the PCM firmware because the CPU cannot check the PCM's firmware version. (The module's firmware version can be found on a label attached to the EEPROM.)

PACSystems **does not** support the following with an IC697PCM711:

- Connecting the programming software to the CPU through the PCM's serial ports.
- Access to Symbolic variables.
- WAIT mode COMMREQs.
- The following C functions are not supported:
 - chk_genius_bus
 - chk_genius_device
 - get_cpu_type_rev
 - get_memtype_sizes
 - get_one_rackfault
 - get_rack_slot_faults
- The C function write_dev will not write to "read only" references (%S references, transition bits, and override bits). If this is attempted, the call will fail at run time and return an error code.
- The following restrictions apply when using the IC697PCM711 with PACSystems:
- Access to %W references is partially supported. Only offsets 0–65535 of %W can be accessed via the PCM.
- The Program Name is currently always LDPROG1 for PACSystems.
- In case of ERROR NACK, the Control Program number, privilege level and other piggyback status data will be set to 0.
- If an application program running on the PCM accesses the VME bus, the VME addresses being used by that program must be in agreement with the PACSystems RX7i VME address assignments. The PACSystems RX7i VME address assignments are described in the *PACSystems RX7i User's Guide to Integration of VME Modules*, GFK-2235.
- PACSystems CPUs return the major/minor type of the Series 90-70 CPX935 (major type 12, minor type 35) to the PCM scratch pad memory when communicating with a PCM.
- If your RX7i application program needs to access the PCM's dual port memory, use the BUS READ and WRITE functions. When accessing the PCM, set the Region parameter on the function block to 1. (For the PCM, region 1 is predefined to be the module's entire dual port memory.)

Note: For details on operation of the IC697PCM711, refer to *Programmable Coprocessor Module and Support Software*, GFK-0255.

12.3.3 DLAN/DLAN+ (Drives Local Area Network) Interface

PACSystems RX7i CPUs with versions 1.50 and higher support IC697BEM763 modules with firmware versions 3.00 and higher. You must ensure that you are using a valid version of the PCM firmware because the CPU cannot check the DLAN's firmware version. (The module's firmware version can be found on a label attached to the EEPROM.)

If your RX7i application program needs to access the DLAN's dual port memory, use the BUS READ and WRITE functions. When accessing a DLAN module, set the Region parameter on the function block to 1. (For the DLAN module, region 1 is predefined to be the module's entire dual port memory.)

Note: The DLAN Interface module is a specialty module with limited availability. If you have a DLAN system, refer to the *DLAN/DLAN+ Interface Module User's Manual*, GFK-0729 for details.

Chapter 13 Serial I/O, SNP & RTU Protocols

This chapter discusses the following topics related to communications on CPU serial ports 1 and 2:

- Configuring Serial Ports Using COMMREQ Function 65520
- Serial I/O Protocol
- RTU Slave Protocol
- SNP Slave Protocol

Details of the RTU and SNP protocol are described in the *Serial Communications User's Manual* (GFK-0582).

13.1. Configuring Serial Ports Using COMMREQ Function 65520

The Serial Port Setup COMMREQ function 65520 (FFF0 hex) may be used to activate a serial communication protocol for a serial port, overriding the protocol that was specified in the port settings of the CPU configuration. The COMMREQ installed protocol remains active as long as the CPU is in run mode. When the CPU is stopped, the COMMREQ installed protocol is removed, and the protocol settings from the CPU configuration are reactivated.

The COMMREQ requires that all its command data be placed in the correct order (in a *command block*) in the CPU memory before it is executed. The COMMREQ should be executed by a contact of a one-shot coil to prevent sending the data multiple times. For details on the operands and command block format used by the COMMREQ function, refer to Chapter 7, “Ladder Diagram (LD) Programming”.

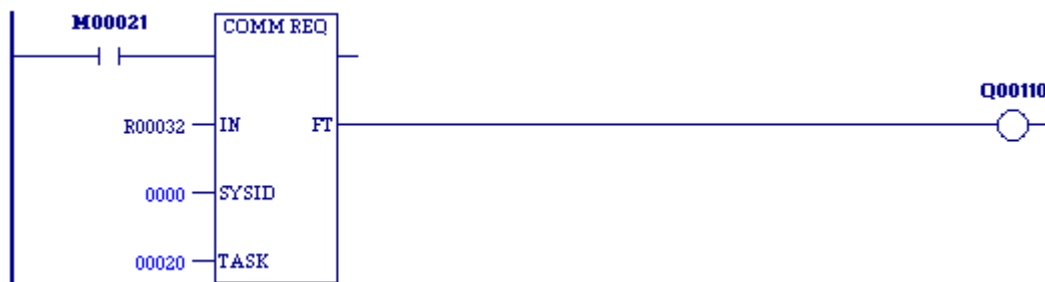
The COMMREQ uses the following TASKs to specify the port for which the operation is intended:

- task 19 for port 1
- task 20 for port 2

Note: Because address offsets are stored in a 16-bit word field, the full range of %W memory type cannot be used with COMMREQs.

13.1.1 COMMREQ Function Example

In the example, when %M0021 is ON, a Command Block located starting at %R0032 is sent to port 2 (communications task 20) of the CPU (rack 0, slot 0). If an error occurs processing the COMMREQ, %Q00110 is set.



13.1.2 Timing

If a port configuration COMMREQ is sent to a serial port that currently has an SNP master (for example, the programmer) connected to it, the COMMREQ function returns an error code to the COMMREQ status word.

13.1.3 Sending Another COMMREQ to the Same Port

After sending a COMMREQ to configure a serial port, the application program should monitor the COMMREQ status word to determine when it can begin sending protocol specific COMMREQs to that port. It is recommended that the application clear the COMMREQ status word prior to issuing the configuration change. The status word will be set to a nonzero value when the request has been processed.

13.1.4 Invalid Port Configuration Combinations

The Machine Edition programming software safeguards against the download of some hardware configurations that would prevent the programmer from communicating serially with the CPU. In a system that does not have an embedded Ethernet module, if a rack-based Ethernet is not present, a serial connection is required for programmer communications.

For CPE305/CPE310 CPUs, which have an embedded Ethernet port that, when configured, is available for programmer communications, the safeguards on serial port configurations are still enforced.

13.1.5 COMMREQ Command Block Parameter Values

The following table lists common parameter values that are used within the COMMREQ command blocks for configuring a serial port. All values are in decimal.

Parameter	Values
Protocol Selector	1 = SNP 3 = RTU 5 = Serial I/O 7 = Message Mode
Data Rate	0 = 300 1 = 600 2 = 1200 3 = 2400 4 = 4800 5 = 9600 6 = 19200 7 = 38400 8 = 57600 9 = 115200
Parity	0 = None 1 = Odd 2 = Even
Flow Control	0 = Hardware [RTS / CTS] 1 = None 2 = Software [XON / XOFF] (Serial I/O only)
Bits Per Character	0 = 7 bits 1 = 8 bits
Stop Bits	0 = 1 stop bit 1 = 2 stop bits
Duplex Mode	0 = 2-wire 1 = 4-wire 2 = 4-wire transmitter always on
Turnaround Delay (SNP only)	0 = none 1 = 10ms 2 = 100ms 3 = 500ms
Timeout (SNP only)	0 = Long (8 sec) 1 = Medium (2 sec) 2 = Short (500ms) 3 = "None" (200ms)

13.1.6 Sample COMMREQ Command Blocks for Serial Port Setup function

The following COMMREQ command blocks provide examples for configuring the various protocols. All values are in decimal unless followed by an H indicating hexadecimal.

Note that an example is not provided for Message Mode, but it can be setup with a command block similar to the one for Serial I/O, with a value of 7 for the protocol selector.

Example COMMREQ Command Block for Configuring SNP Protocol

	Values	Meaning
Address	16	Data Block Length
Address + 1	0 = No Wait (WAIT mode not supported)	WAIT/NOWAIT Flag
Address + 2	0008 = %R, register memory	Status Word Pointer Memory Type
Address + 3	Zero-based number that gives the address of the COMMREQ status word (for example, a value of 99 gives an address of 100 for the status word)	Status Word Pointer Offset
Address + 4	not used	Idle Timeout Value
Address + 5	not used	Maximum Communication Time
Address + 6	FFF0H	Command Word (serial port setup)
Address + 7	1 = SNP	Protocol
Address + 8	0 = Slave	Port Mode
Address + 9	See "COMMREQ Command Block Parameter Values" on page 485.	Data Rate
Address + 10	0 = None, 1 = Odd, 2 = Even	Parity
Address + 11	not used (SNP always chooses NONE by default)	Flow Control
Address + 12	0 = None, 1 = 10ms, 2 = 100ms, 3 = 500ms	Turnaround Delay
Address + 13	0 = Long, 1 = Medium, 2 = Short, 3 = None	Timeout
Address + 14	not used (SNP always chooses 8 bits by default)	Bits Per Character
Address + 15	0 = 1 Stop Bit, 1 = 2 Stop bits	Stop Bits
Address + 16	not used	Interface
Address + 17	not used (SNP always chooses 4-wire mode by default)	Duplex Mode
Address + 18	user-provided ²⁸	Device identifier bytes 1 and 2
Address + 19	user-provided	Device identifier bytes 3 and 4
Address + 20	user-provided	Device identifier bytes 5 and 6
Address + 21	user-provided	Device identifier bytes 7 and 8

²⁸ The device identifier for SNP Slave ports is packed into words with the least significant character in the least significant byte of the word. For example, if the first two characters are "A" and "B," the Address + 18 will contain the hex value 4241.

Example COMMREQ Data Block for Configuring RTU Protocol

	Values	Meaning
Address	13, or 17	Data Block Length
Address + 1	0 = No Wait (WAIT mode not supported)	WAIT/NOWAIT Flag
Address + 2	0008 = %R, register memory	Status Word Pointer Memory Type
Address + 3	Zero-based number that gives the address of the COMMREQ status word (for example, a value of 99 gives an address of 100 for the status word)	Status Word Pointer Offset
Address + 4	not used	Idle Timeout Value
Address + 5	not used	Maximum Communication Time
Address + 6	FFF0H	Command Word (serial port setup)
Address + 7	3 = RTU	Protocol
Address + 8	0 = Slave	Port Mode
Address + 9	See "COMMREQ Command Block Parameter Values" on page 485.	Data Rate
Address + 10	0 = None, 1 = Odd, 2 = Even	Parity
Address + 11	0 = Hardware, 1 = None	Flow Control
Address + 12	not used	Turnaround delay
Address + 13	not used	Timeout
Address + 14	not used (RTU always chooses 8 bits by default)	Bits per Character
Address + 15	not used (RTU always chooses 1 stop bit by default)	Stop Bits
Address + 16	not used	Interface
Address + 17	0 = 2-wire, 1 = 4-wire, 2 = 4-wire transmitter always on	Duplex Mode
Address + 18	Station Address (1-247)	Device Identifier
Address + 19	Count of 100 microseconds units (0 = 3.5 character times)	End-of-frame timeout ²⁹
Address + 20	not used	
Address + 21	not used	
Address + 22	Count of 10 millisecond units (range 0-255)	Receive-to-transmit delay

²⁹ The End-of-frame timeout and Receive-to-transmit delay values were added in Release 6.70 for the RX3i. They are discussed in the RTU Slave Protocol section.

Example COMMREQ Data Block for Configuring Serial I/O Protocol

	Values	Meaning
Address	12	Data Block Length
Address + 1	0 = No Wait (WAIT mode not supported)	WAIT/NOWAIT Flag
Address + 2	0008 = %R, register memory	Status Word Pointer Memory Type
Address + 3	Zero-based number that gives the address of the COMMREQ status word (for example, a value of 99 gives an address of 100 for the status word)	Status Word Pointer Offset
Address + 4	not used	Idle Timeout Value
Address + 5	not used	Maximum Communication Time
Address + 6	FFF0H	Command Word (serial port setup)
Address + 7	5 = Serial I/O	Protocol
Address + 8	not used	Port Mode
Address + 9	See "COMMREQ Command Block Parameter Values" on page 485.	Data Rate
Address + 10	0 = None, 1 = Odd, 2 = Even	Parity
Address + 11	0 = Hardware, 1 = None, 2 = Software	Flow Control
Address + 12	not used	Turnaround Delay
Address + 13	not used	Timeout
Address + 14	0=7 bits, 1=8 bits	Bits per Character
Address + 15	0 = 1 stop bit, 1 = 2 stop bits	Stop Bits
Address + 16	not used	Interface
Address + 17	0 = 2-wire, 1 = 4-wire, 2 = 4-wire transmitter always on	Duplex Mode

13.2. Serial I/O Protocol

Serial I/O protocol is a communication protocol that is driven entirely by the application program. Serial I/O protocol is active only when the CPU is in run mode, since it is driven completely by COMMREQ functions in the application program. Those COMMREQ functions are described in detail within this section.

When the CPU is stopped, a port configured for Serial I/O protocol will revert to a stop mode protocol as specified in the port settings of the CPU configuration. If a stop mode protocol was not specified, RTU slave protocol is used by default.

13.2.1 Calling Serial I/O COMMREQs from the CPU Sweep

Implementing a serial protocol using Serial I/O COMMREQs may be restricted by the sweep time. For example, if the protocol requires that a reply to a certain message from the remote device be initiated within 5ms of receiving the message, this method may not be successful if the sweep time is 5ms or longer, since timely response is not guaranteed.

13.2.2 Compatibility

The COMMREQ function blocks supported by Serial I/O are not supported by other currently existing protocols (such as SNP slave and RTU slave). Errors are returned if they are attempted for a port configured for one of those protocols.

13.2.3 Status Word for Serial I/O COMMREQs

A value of 1 is returned in the COMMREQ status word upon successful completion of the COMMREQ. Any other value returned is an error code where the low byte is a major error code and the high byte is a minor error code.

Major Error Code	Description	
1 (01h)	Successful Completion (this is the expected completion value in the COMMREQ status word).	
12 (0Ch)	Local error –Error processing a local command. The minor error code identifies the specific error.	
	2 (02h)	COMMREQ command is not supported.
	6 (06h)	Invalid CPU memory type specified.
	7 (07h)	Invalid CPU memory offset specified.
	8 (08h)	Unable to access CPU memory.
	12 (0Ch)	COMMREQ data block length too small.
	14 (0Eh)	COMMREQ data is invalid.
	15 (0Fh)	Could not allocate system resources to complete COMMREQ.
13 (0Dh)	Remote error – Error processing a remote command. The minor error code identifies the error.	
	2 (02h)	Number of bytes requested to read is greater than input buffer size OR number bytes requested to write is zero or greater than 250 bytes.
	3 (03h)	COMMREQ data block length is too small. String data is missing or incomplete.

Major Error Code	Description	
	4 (04h)	Receive timeout awaiting serial reception of data
	6 (06h)	Invalid CPUmemory type specified.
	7 (07h)	Invalid CPUmemory offset specified.
	8 (08h)	Unable to access CPU memory.
	12 (0Ch)	COMMREQ data block length too small.
	16 (10h)	Operating system service error. The operating system service used to perform the request has returned an error.
	17 (11h)	Port device error. The port device used to perform the service has detected an error. Either a break was received or a UART Error (parity, framing, overrun) occurred.
	18 (12h)	Request cancelled. The request was terminated before it could complete.
	48 (30h)	Serial output timeout. The serial port was unable to transmit the string. (Could be due to missing CTS signal when the serial port is configured to use hardware flow control.)
14 (0Eh)	Autodial Error — An error occurred while attempting to send a command string to an attached external modem. The minor error code identifies the specific error.	
	2 (02h)	The modem command string length exceeds end of reference memory type.
	3 (03h)	COMMREQ Data Block Length too small. Output command string data missing or incomplete.
	4 (04h)	Serial output timeout. The serial port was unable to transmit the modem autodial output.
	5 (05h)	Response was not received from modem. Check modem and cable.
	6 (06h)	Modem responded with BUSY. Modem is unable to complete the requested connection. The remote modem is already in use; retry the connection request later.
	7 (07h)	Modem responded with NO CARRIER. Modem is unable to complete the requested connection. Check the local and remote modems and the telephone line.
	8 (08h)	Modem responded with NO DIALTONE. Modem is unable to complete the requested connection. Check the modem connections and the telephone line.
	9 (09h)	Modem responded with ERROR. Modem is unable to complete the requested command. Check the modem command string and modem.
	10 (0Ah)	Modem responded with RING, indicating that the modem is being called by another modem. Modem is unable to complete the requested command. Retry the modem command later.
	11 (0Bh)	Unknown response received from the modem. Modem unable to complete the request. Check the modem command string and modem. Response should be CONNECT or OK.

13.2.4 Serial I/O COMMREQ Commands

The following COMMREQs are used to implement Serial I/O:

- Local COMMREQs - do not receive or transmit data through the serial port.
 - Initialize Port (4300)
 - Set Up Input Buffer (4301)
 - Flush Input buffer (4302)
 - Read port status (4303)
 - Write port control (4304)
 - Cancel Operation (4399)
- Remote COMMREQs - receive and/or transmit data through the serial port.
 - Autodial (4400)
 - Write bytes (4401)
 - Read bytes (4402)
 - Read String (4403)

13.2.5 Overlapping COMMREQs

Some Serial I/O COMMREQs must complete execution before another COMMREQ can be processed. Others can be left pending while others are executed.

COMMREQs that Must Complete Execution

- Autodial (4400)
- Initialize Port (4300)
- Set Up Input Buffer (4301)
- Flush Input buffer (4302)
- Read port status (4303)
- Write port control (4304)
- Cancel Operation (4399)
- Serial Port Setup (FFF0)

COMMREQs that can be Pending While Others Execute

The table below shows whether Write Bytes, Read Bytes and Read String COMMREQs can be pending when other COMMREQs are executed.

Currently-Pending COMMREQs	NEW COMMREQ										
	Autodial (4400)	Write Bytes (4401)	Initialize Port (4300)	Set Up Input Buffer (4301)	Flush Input Buffer (4302)	Read Port Status (4303)	Write Port Control (4304)	Read Bytes (4402)	Read String (4403)	Cancel Operation (4399)	Serial Port Setup (FFF0)
Write Bytes (4401)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Read Bytes (4402)	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No
Read String (4403)	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No

13.2.6 Initialize Port Function (4300)

This function causes a reset command to be sent to the specified port. It also cancels any COMMREQ currently in progress and flushes the internal input buffer. RTS and DTR are set to inactive.

Example Command Block for the Initialize Port Function

	<i>Value (decimal)</i>	<i>Value (hexadecimal)</i>	<i>Meaning</i>
Address	0001	0001	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4300	10CC	Initialize port command

Operating Notes

Remote COMMREQs that are cancelled due to this command executing will return a COMMREQ status word indicating request cancellation (minor code 12H).

Caution



If this COMMREQ is sent when a Write Bytes (4401) COMMREQ is transmitting a string from a serial port, transmission is halted. The position within the string where the transmission is halted is indeterminate. In addition, the final character received by the device to which the CPU is sending is also indeterminate.

13.2.7 Set Up Input Buffer Function (4301)

This function is provided for compatibility with legacy Serial I/O applications. In PACSystems releases 5.70 and later, the internal input buffer is always set to 2097 bytes. In earlier PACSystems implementations, the internal input buffer is set to 2K bytes.

The Set Up Input Buffer function returns a success status to the COMMREQ status word, regardless of the buffer length specified in the command block.

As data is received from the serial port it is placed in the input buffer. If the buffer becomes full, any additional data received from the serial port is discarded and the Overflow Error bit in the Port Status word (See Read Port Status Function) is set.

Retrieving Data from the Buffer

Data can be retrieved from the buffer using the Read String or Read Bytes function. It is not directly accessible from the application program.

If data is not retrieved from the buffer in a timely fashion, some characters may be lost.

Example Command Block for the Set Up Input Buffer Function

	VALUE (decimal)	VALUE (hexadecimal)	MEANING
Address	0002	0002	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4301	10CD	Setup input buffer command
Address +7	0064	0040	Buffer length (in words)

13.2.8 Flush Input buffer Function (4302)

This operation empties the input buffer of any characters received through the serial port but not yet retrieved using a read command. All such characters are lost.

Example Command Block for the Flush Input Buffer Function

	VALUE (decimal)	VALUE (hexadecimal)	MEANING
Address	0001	0001	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4302	10CE	Flush input buffer command

13.2.9 Read port status Function (4303)

This function returns the current status of the port. The following events can be detected:

1. A read request was initiated previously and the required number of characters has now been received or the specified time-out has elapsed.
2. A write request was initiated previously and transmission of the specified number of characters is complete or a time-out has elapsed.

The status returned by the function indicates the event or events that have completed. More than one condition can occur simultaneously, if both a read and a write were initiated previously.

Example Command Block for the Read Port Status Function

	VALUE (decimal)	VALUE (hexadecimal)	MEANING
Address	0003	0003	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4303	10CF	Read port status command
Address +7	0076	004C	Port status memory type (%M)
Address +8	0101	0065	Port status memory offset (%M101)

Port Status

The port status consists of a status word and the number of characters in the input buffer that have not been retrieved by the application (characters which have been received and are available).

word 1	Port status word (see below)
word 2	Characters available in the input buffer

Port Status Word Meanings

Bit	Name	Definition	Status	Meaning
15	RP	Read In progress	Set	Read Bytes or Read String invoked
			Cleared	Previous Read bytes or String has timed out, been canceled, or finished
14	RS	Read Success	Set	Read Bytes or Read String has successfully completed
			Cleared	New Read Bytes or Read String invoked
13	RT	Read Time-out	Set	Receive timeout occurred during Read Bytes or Read String
			Cleared	New Read Bytes or Read String invoked
12	WP	Write In progress	Set	New Write Bytes invoked
			Cleared	Previously-invoked Write Bytes has timed out, been canceled, or finished
11	WS	Write Success	Set	Previously-invoked Write Bytes has successfully completed
			Cleared	New Write Bytes invoked
10	WT	Write Time-out	Set	Transmit timeout occurred during Write Bytes
			Cleared	New Write Bytes invoked
9	CA	Character Available	Set	Unread characters are in the buffer
			Cleared	No unread characters in the buffer
8	OF	Overflow error	Set	Overflow error occurred on the serial port or internal buffer
			Cleared	Read Port Status invoked
7	FE	Framing Error	Set	Framing error occurred on the serial port
			Cleared	Read Port Status invoked
6	PE	Parity Error	Set	Parity error occurred on the serial port
			Cleared	Read Port Status invoked
5	CTS	Clear to Send	Set	Clear to Send signal is active
			Cleared	Clear to Send signal is not active
4	DSR	Data Set Ready	Set	Data Set Ready signal is active
			Cleared	Data Set Ready signal is not active
3	RI	Ring Indicator	Set	Ring Indicator signal is active
			Cleared	Ring Indicator signal is not active
2	DCD	Data Carrier Detect	Set	Data Carrier Detect signal is active
			Cleared	Data Carrier Detect signal is not active
1-0	n/a	Not used	These bits are always set to 0	

Operating Notes

For reference, see the tables under “Serial Port Pin Assignments” in Chapter 12.

Support for the DSR status bit is provided for Port 1 only, on all RX7i and RX3i models (except CPE305), in Rel. 7.16 and later releases.

Support for the RP and DCD status bits is provided only for Port 1 on the CPE310, in Rel. 7.16 and later releases.

Write Port Control Function (4304)

This function controls output signals on the specified port:

Example Command Block for the Write Port Control Function

	VALUE (decimal)	VALUE (hexadecimal)	MEANING
Address	0002	0002	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4304	10D0	Write port control command
Address +7	xxxx	xxxx	Port control word

Port Control Word

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RTS	DTR	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Port Control Word Meanings:

15	RTS	Commanded state of Request to Send signal 1 = Activates RTS 0 = Deactivates RTS
14	DTR	Commanded state of Data Terminal Ready signal 1 = Activates DTR 0 = Deactivates DTR
13-0	n/a	Unused (should be zero)

Operating Notes

For reference, see the tables under “Serial Port Pin Assignments” in Chapter 12.

Support for the DTR output signal is provided for Port 1 only, on all RX7i and RX3i models (except CPE305), in Rel 7.16 and later releases.

For CPU port 2 (RS-485), the RTS signal is also controlled by the transmit driver. Therefore, control of RTS is dependent on the current state of the transmit driver. If the transmit driver is not enabled, asserting RTS with the Write Port Control COMMREQ will not cause RTS to be asserted on the serial line. The state of the transmit driver is controlled by the protocol and is dependent on the current Duplex Mode of the port. For 2-wire and 4-wire Duplex Mode, the transmit driver is only enabled during transmitting. Therefore, RTS on the serial line will only be seen active on port 2 (configured for 2-wire or 4-wire Duplex Mode) when data is being transmitted. For point-to-point Duplex Mode, the transmit driver is always enabled. Therefore, in point-to-point Duplex Mode, RTS on the serial line will always reflect what is chosen with the Write Port Control COMMREQ.

13.2.10 Cancel COMMREQ Function (4399)

This function cancels the current operations in progress. It can be used to cancel both read operations and write operations.

If a read operation is in progress and there are unprocessed characters in the input buffer, those characters are left in the input buffer and available for future reads. The serial port is not reset.

Example Command Block for the Cancel Operation Function

	Value (decimal)	Value (hexadecimal)	Meaning
Address	0002	0002	Data block length (2)
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4399	112F	Cancel operation command
Address +7	0001	0001	Transaction type to cancel 1 All operations 2 Read operations 3 Write operations

Operating Notes

Remote COMMREQs that are cancelled due to this command executing will return a COMMREQ status word indicating request cancellation (minor code 12H).

Caution



If this COMMREQ is sent in either Cancel All or Cancel Write mode when a Write Bytes (4401) COMMREQ is transmitting a string from a serial port, transmission is halted. The position within the string where the transmission is halted is indeterminate. In addition, the final character received by the device to which the CPU is sending is also indeterminate.

13.2.11 Autodial Function (4400)

This feature allows the CPU to automatically dial a modem and send a specified byte string.

To implement this feature, the port must be configured for Serial I/O. After the autodial function is executed and the modem has established a connection, other serial I/O functions (Write bytes, Set Up Input Buffer, Flush Input buffer, Read port status, Write port control, Read bytes, Read String, and Cancel Operation) can be used.

Example

Pager enunciation can be implemented by three commands, requiring three COMMREQ command blocks:

Autodial: Dials the modem.
04400 (1130h)

Write Bytes: Specifies an ASCII string, from 1 to 250 bytes in length, to send from the serial port.
04401 (1131h)

Autodial: It is the responsibility of the application program to hang up the phone connection.
04400 (1130h) This is accomplished by reissuing the autodial command and sending the hang up command string.

Autodial Command Block

The Autodial command automatically transmits an Escape sequence that follows the Hayes convention. If you are using a modem that does not support the Hayes convention, you may be able to use the Write Bytes command to dial the modem.

Examples of commonly used command strings for Hayes-compatible modems are listed below:

Command String	Length	Function
ATDP15035559999<CR>	16 (10h)	Pulse dial the number 1-503-555-9999
ATDT15035559999<CR>	16 (10h)	Tone dial the number 1-503-555-9999
ATDT9,15035559999<CR>	18 (12h)	Tone dial using outside line with pause
ATH0<CR>	5 (05h)	Hang up the phone
ATZ <CR>	4 (04h)	Restore modem configuration to internally saved values

Sample Autodial Command Block

This COMMREQ command block dials the number 234-5678 using a Hayes-compatible modem.

Word	Definition	Values
1	0009h	CUSTOM data block length (includes command string)
2	0000h	NOWAIT mode
3	0008h	Status word memory type (%R)
4	0000h	Status word address minus 1 (Register 1)
5	0000h	not used
6	0000h	not used
7	04400 (1130h)	Autodial command number
8	00030 (001Eh)	Modem response timeout (30 seconds)
9	0012 (000Ch)	Number of bytes in command string
10	5441h	A (41h), T (54h)
11	5444h	D (44h), T (54h)
12	3332h	Phone number: 2 (32h), 3 (33h)
13	3534h	4 (34h), 5 (35h)
14	3736h	6 (36h), 7 (37h)
15	0D38h	8 (38h) <CR> (0Dh)

13.2.12 Write bytes Function (4401)

This operation can be used to transmit one or more characters to the remote device through the specified serial port. The character(s) to be transmitted must be in a word reference memory. They should not be changed until the operation is complete.

Up to 250 characters can be transmitted with a single invocation of this operation. The status of the operation is not complete until all of the characters have been transmitted or until a timeout occurs (for example, if hardware flow control is being used and the remote device never enables the transmission).

Example Command Block for the Write Bytes Function

	Value (decimal)	Value (hexadecimal)	Meaning
Address	0006	0006	Data block length (includes characters to send)
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4401	1131	Write bytes command
Address +7	0030	001E	Transmit time-out (30 seconds). See note below.
Address +8	0005	0005	Number of bytes to write
Address +9	25960	6568	'h' (68h), 'e' (65h)
Address +10	27756	6C6C	'l' (6Ch), 'l' (6Ch)
Address +11	0111	006F	'o' (6Fh)

Although printable ASCII characters are used in this example, there is no restriction on the values of the characters that can be transmitted.

Operating Notes

Specifying zero as the Transmit time-out sets the time-out value to the amount of time actually needed to transmit the data, plus 4 seconds.

Caution



If an Initialize Port (4300) COMMEQ is sent or a Cancel Operation (4399) COMMREQ is sent in either Cancel All or Cancel Write mode while this COMMREQ is transmitting a string from a serial port, transmission is halted. The position within the string where the transmission is halted is indeterminate. In addition, the final character received by the device the CPU is sending to is also indeterminate.

13.2.13 Read bytes Function (4402)

This function causes one or more characters to be read from the specified port. The characters are read from the internal input buffer and placed in the specified input data area. The function returns both the number of characters retrieved and the number of unprocessed characters still in the input buffer. If zero characters of input are requested, only the number of unprocessed characters in the input buffer is returned.

If insufficient characters are available to satisfy the request and a non-zero value is specified for the number of characters to read, the status of the operation is not complete until either sufficient characters have been received or the time-out interval expires. In either of those conditions, the port status indicates the reason for completion of the read operation. The status word is not updated until the read operation is complete (either due to timeout or when all the data has been received).

If the time-out interval is set to zero, the COMMREQ remains pending until it has received the requested amount of data, or until it is cancelled.

If this COMMREQ fails for any reason, no data is returned to the input data area. Any data that has not been read from the internal input buffer remains and it can be retrieved with a subsequent read request.

Example Command Block for the Read Bytes Function

	<i>Value (decimal)</i>	<i>Value (hexadecimal)</i>	<i>Meaning</i>
Address	0005	0005	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4402	1132	Read bytes command
Address +7	0030	001E	Read time-out (30 seconds)
Address +8	0005	0005	Number of bytes to read
Address +9	0008	0008	Input data memory type (%R).
Address +10	0100	0064	Input data memory address (%R0100)

Return Data Format for the Read Bytes Function

The return data consists of the number of characters actually read, the number of characters still available in the input buffer after the read is complete (if any), and the actual input characters.

Address	Number of characters actually read
Address + 1	Number of characters still available in the input buffer, if any
Address + 2	first two characters (first character is in the low byte)
Address + 3	third and fourth characters (third character is in the low byte)
Address + n	subsequent characters

Operating Notes for Read Bytes

If the input data memory type parameter is specified to be a word memory type, and if an odd number of bytes is actually received, then the high byte of the last word to be written with the received data is left unchanged.

As data is received from the serial port it is placed in the internal input buffer. If the buffer becomes full, then any additional data received from the serial port is discarded and the Overflow Error bit in the Port Status word (See Read Port Status Function) is set.

13.2.14 Read String Function (4403)

This function causes characters to be read from the specified port until a specified terminating character is received. The characters are read from the internal input buffer and placed in the specified input data area.

The function returns both the number of characters retrieved and the number of unprocessed characters still in the input buffer. If zero characters of input are requested, only the number of unprocessed characters in the input buffer is returned.

If the terminating character is not in the input buffer, the status of the operation is not complete until either the terminating character has been received or the time-out interval expires. In either of those conditions, the port status indicates the reason for completion of the read operation.

If the time-out interval is set to zero, the COMMREQ remains pending until it has received the requested string, terminated by the specified end character.

If this COMMREQ fails for any reason, no data is returned to the input data area. Any data that has not been read from the internal input buffer remains, and it can be retrieved with a subsequent read request.

Example Command Block for the Read String Function

	Value (decimal)	Value (hexadecimal)	Meaning
Address	0005	0005	Data block length
Address +1	0000	0000	NOWAIT mode
Address +2	0008	0008	Status word memory type (%R)
Address +3	0000	0000	Status word address minus 1 (%R0001)
Address +4	0000	0000	Not used
Address +5	0000	0000	Not used
Address +6	4403	1133	Read string command
Address +7	0030	001E	Read time-out (30 seconds)
Address +8	0013	000D	Terminating character (carriage return): must be between 0 and 255 (0xFF), inclusive
Address +9	0008	0008	Input data memory type (%R)
Address +10	0100	0064	Input data memory address (%R0100)

Return Data Format for the Read String Function

The return data consists of the number of characters actually read, the number of characters still available in the input buffer after the read is complete (if any), and the actual input characters:

Address	Number of characters actually read
Address + 1	Number of characters still available in the input buffer, if any
Address + 2	first two characters (first character is in the low byte)
Address + 3	third and fourth characters (third character is in the low byte)
Address + n	subsequent characters

Operating Notes for Read String

If the input data memory type parameter is specified to be a word memory type, and if an odd number of bytes is actually received, then the high byte of the last word to be written with the received data is left unchanged.

As data is received from the serial port it is placed in the internal input buffer. If the buffer becomes full, then any additional data received from the serial port is discarded and the Overflow Error bit in the Port Status word (See Read Port Status Function) is set.

13.3. RTU Slave Protocol

RTU protocol is a query-response protocol used for communication between the RTU device and a host computer, which is capable of communicating using RTU protocol. The host computer is the master device and it transmits a query to a RTU slave, which responds to the master. The RTU slave device cannot query; it can only respond to the master. A PACSystems CPU can only function as an RTU slave.

The RTU data transferred consists of 8-bit binary characters with an optional parity bit. No control characters are added to the data block; however, an error check (Cyclic Redundancy Check) is included as the final field of each query and response to ensure accurate transmission of data.

Note: You should avoid using station address 1 for any other Modbus slave in a PACSystems control system because the default station address for the PACSystems CPU is 1. The CPU uses the default address in two situations:

1. If you power up without a configuration, the default station address of 1 is used.
2. When the Port Mode parameter is set to Message Mode, and Modbus becomes the protocol in stop mode, the station address defaults to 1, unless you specify a stop mode for the port in the CPU configuration, and then change the station address to be used for stop mode.

In either of these situations, if you have a slave configured with a station address of 1, confusion may result when the PACSystems CPU responds to requests intended for that slave.

13.3.1 Message Format

The general formats for RTU message transfers are shown below:

RTU Message Transfers

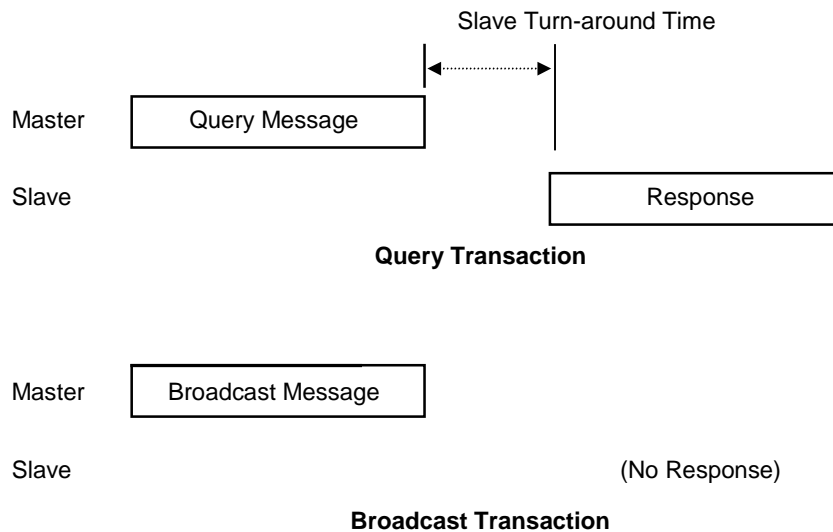


Figure 31: RTU Message Transactions

The master device begins a data transfer by sending a query or broadcast request message. A slave completes that data transfer by sending a response message if the master sent a query message addressed to it. No response message is sent when the master sends a broadcast request.

RTU Slave Turnaround Time

The time between the end of a query and the beginning of the response to that query is called the slave turnaround time. The turnaround time of a PACSystems slave depends on the Controller Communications Window time and the sweep time of the PACSystems. RTU requests are processed only in the Controller Communications Window. In Normal sweep mode, the Controller Communications Window occurs once per sweep. Because the sweep time on PACSystems can be up to 2.5 seconds, the time to process an RTU request could be up to 2.5 seconds. Another factor is the Controller Communications Window time allowed in Hardware Configuration. If you configure a very small Controller Communications Window, the RTU request may not be completed in one sweep, causing RTU processing to require multiple sweeps. For details on CPU window modes, refer to “Window Modes” in Chapter 4.

Receive-to-Transmit Delay

Part of the RTU Slave Turnaround time is the receive-to-transmit delay. The RTU driver inserts this delay after a request from the master has been received, and before the response to the master is sent. Starting with Release 6.70 for the RX3i, the receive-to-transmit delay can be configured with the Serial Port Setup COMMREQ function 65520. The timeout is specified in units of 10 milliseconds, with a range of 0–255 units (maximum delay is 2.55 seconds). If the specified time is less than 3.5 character times, then the delay is set to 3.5 character times.

Message Types

The RTU protocol has four message types: query, normal response, error response, and broadcast.

Query

The master sends a message addressed to a single slave.

Normal Response

After the slave performs the function requested by the query, it sends back a normal response for that function. This indicates that the request was successful.

Error Response

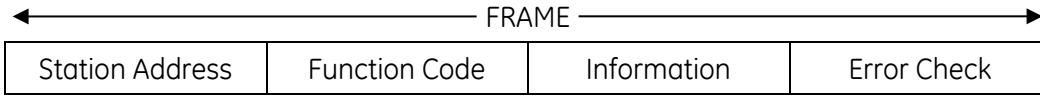
The slave receives the query, but cannot perform the requested function. The slave sends back an error response that indicates the reason the request could not be processed. (No error message will be sent for certain types of errors. For more information see “Communication Errors.”)

Broadcast

The master sends a message addressed to all of the slaves by using address 0. All slaves that receive the broadcast message perform the requested function. This transaction is ended by a time-out within the master.

Message Fields

The message fields for a typical message are shown in the figure below, and are explained in the following sections.



Station Address

The Station Address is the address of the slave station selected for this data transfer. It is one byte in length and has a value from 0 to 247 inclusive. An address of 0 selects all slave stations, and indicates that this is a broadcast message. An address from 1 to 247 selects a slave station with that station address.

Function Code

The Function Code identifies the command being issued to the station. It is one byte in length and is defined for the values 0 to 255 as follows:

Function Code	Description
0	Illegal Function
1	Read Output Table
2	Read Input Table
3	Read Registers
4	Read Analog Input
5	Force Single Output
6	Preset Single Register
7	Read Exception Status
8	Loopback Maintenance
9-14	Unsupported Function
15	Force Multiple Outputs
16	Preset Multiple Registers
17	Report Device Type
18-21	Unsupported Function
22	Mask Write 4x Register
23	Read/Write 4x Registers
24-66	Unsupported Function
67	Read Scratch Pad Memory
68-127	Unsupported Function
128-255	Reserved for Exception Responses

Information Fields

All message fields, other than the Station Address field, Function Code field, and Error Check field are called, generically, “information” fields. Information fields contain additional information required to specify or respond to a requested function. Different types of messages have different types or numbers of information fields. (Details on information fields for each message type and function code are found in “Message Descriptions,” page 515) Some messages (Message 07 Query and Message 17 Query) do not have information fields.

Examples

As shown in the following figure, the information fields for message *READ OUTPUT TABLE (01) Query* consist of the Starting Point No. field and Number of Points field. The information fields for message *READ OUTPUT TABLE (01) Response* consist of the Byte Count field and Data field.

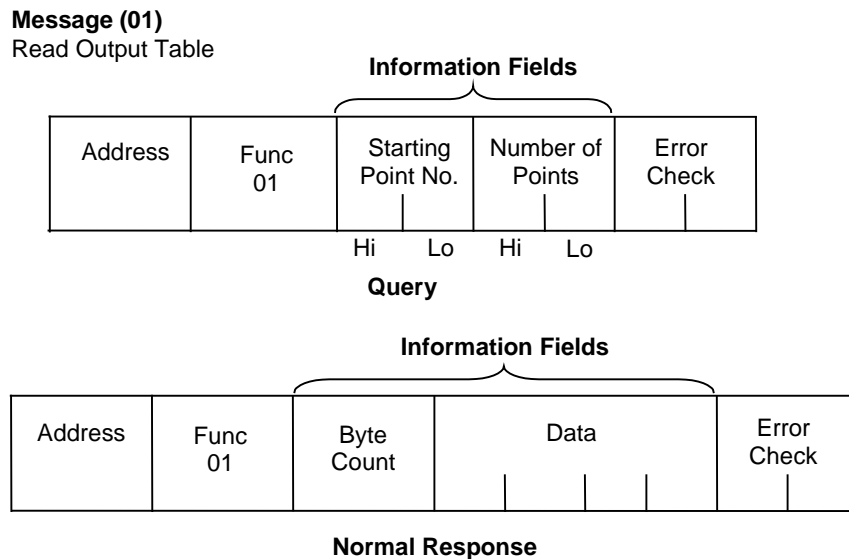


Figure 32: RTU Read Output Table Example

Some information fields include entries for the range of data to be accessed in the RTU slave.

Note: Data addresses are 0-based. This means you will need to subtract 1 from the actual address when specifying it in the RTU message. For message (01) *READ OUTPUT TABLE Query*, used in the example above, you would specify a starting data address in the Starting Point No. field. To specify %Q0001 as the starting address, you would place the address %Q0000 in this field. Also, the value placed in the Number of Points field determines how many %Q bits are read, starting with address %Q0001. For example:

- Starting Point No. field = %Q0007, so the starting address is %Q0008.
- Number of Points field = 16 (0010h), so addresses %Q0008 through %Q0023 will be read.

Error Check Field

The Error Check field is two bytes in length and contains a cyclic redundancy check (CRC-16) code. Its value is a function of the contents of the station Address, Function code, and Information field. The details of generating the CRC-16 code are described in “Cyclic Redundancy Check (CRC)” on page 511. Note that the Information field is variable in length. To properly generate the CRC-16 code, the length of frame must be determined. To calculate the length of a frame for each of the defined function codes, see “Calculating the Length of Frame” on page 514.

Message Length

Message length varies with the type of message and amount of data to be sent. Information for determining message length for individual messages is found in “Message Descriptions.”

Character Format

A message is sent as a series of characters. Each byte in a message is transmitted as a character. The illustration below shows the character format. A character consists of a start bit (0), eight data bits, an optional parity bit, and one stop bit (1). Between characters the line is held in the 1 state.

		Data Bits								
		MSB							LSB	
10	9	8	7	6	5	4	3	2	1	0
Stop	Parity (optional)									Start

Message Termination

Each station monitors the time between characters. When a period of three character times elapses without the reception of a character, the end of a message is assumed. The reception of the next character is assumed to be the beginning of a new message. The end of a frame occurs when the first of the following two events occurs:

- The number of characters received for the frame is equal to the calculated length of the frame.
- A length of 4 character times elapses without the reception of a character.

Timeout Usage

Timeouts are used on the serial link for error detection, error recovery, and to prevent the missing of the end of messages and message sequences. Note that although the module allows up to three character transmission times between each character in a message that it receives, there is no more than half a character time between each character in a message that the module transmits. After sending a query message, the master should wait an appropriate amount of time for slave turnaround before assuming that the slave did not respond to the request. Slave turnaround time is affected by the Controller Communications Window time and the CPU sweep time, as described in “RTU Slave Turnaround Time” on page 507.

End-of-frame Timeout

The End-of-frame timeout is a feature that compensates for message gaps that can occur due to the use of radio modems. The timeout is added to the amount of time allowed for receiving a message from the master. The timeout should be sized according to the maximum gap time that could be introduced by the master’s transmitting equipment. Starting with Release 6.70 for the RX3i, the end-of-frame timeout can be configured with the Serial Port Setup COMMREQ function 65520. The timeout is specified in units of 100 microseconds. If the specified time is less than 3.5 character times, then the RTU driver sets the timeout to 3.5 character times.

13.3.2 Cyclic Redundancy Check (CRC)

The CRC is one of the most effective systems for checking errors. The CRC consists of two check characters generated at the transmitter and added at the end of the transmitted data characters. Using the same method, the receiver generates its own CRC for the incoming data and compares it to the CRC sent by the transmitter to ensure proper transmission. A complete mathematic derivation for the CRC is not given in this section. This information can be found in a number of texts on data communications. The essential steps that should be understood in calculating the CRC are as follows:

- The number of bits in the CRC multiplies the data bits that make up the message.
- The resulting product is then divided by the generating polynomial (using modulo 2 with no carries). The CRC is the remainder of this division.
- Disregard the quotient and add the remainder (CRC) to the data bits and transmit the message with CRC.
- The receiver then divides the message plus CRC by the generating polynomial and if the remainder is 0, the transmission was transmitted without error.

A generating polynomial is expressed algebraically as a string of terms in powers of X such as $X^3 + X^2 + X^0$ (or 1) which can in turn be expressed as the binary number 1101. A generating polynomial could be any length and contain any pattern of 1s and 0s as long as both the transmitter and receiver use the same value. For optimum error detection, however, certain standard generating polynomials have been developed. RTU protocol uses the polynomial $X^{16} + X^{15} + X^2 + 1$ which in binary is 1 1000 0000 0000 0101. The CRC this polynomial generates is known as CRC-16.

The discussion above can be implemented in hardware or software. One hardware implementation involves constructing a multi-section shift register based on the generating polynomial.

13.3.3 Cyclic Redundancy Check Register

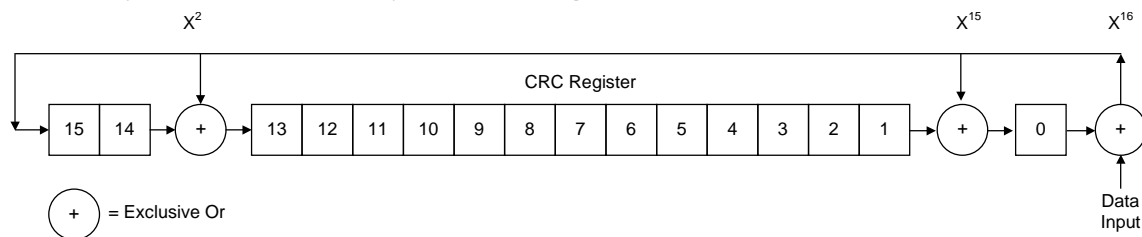


Figure 33: CRC Register Operation

To generate the CRC, the message data bits are fed to the shift register one at a time. The CRC register contains a preset value. As each data bit is presented to the shift register, the bits are shifted to the right. The LSB is XORed with the data bit and the result is XORed with the old contents of bit 1 (the result placed in bit 0), XORed with the old contents of bit 14 (and the result placed in bit 13), and finally, it is shifted into bit 15. This process is repeated until all data bits in a message have been processed. Software implementation of the CRC-16 is explained in the next section.

13.3.4 Calculating the CRC-16

The pseudo code for calculation of the CRC-16 is given below.

Preset byte count for data to be sent.

Initialize the 16-bit remainder (CRC) register to all ones.

XOR the first 8-bit data byte with the high order byte of the 16-bit CRC register. The result is the current CRC.

INIT SHIFT: Initialize the shift counter to 0.

SHIFT: Shift the current CRC register 1 bit to the right.

Increment shift count.

Is the bit shifted out to the right (flag) a 1 or a 0?

If it is a 1, XOR the generating polynomial with the current CRC.

If it is a 0, continue.

Is shift counter equal to 8?

If NO, return to SHIFT.

If YES, increment byte count.

Is byte count greater than the data length?

If NO, XOR the next 8-bit data byte with the current CRC and go to INIT SHIFT.

If YES, add current CRC to end of data message for transmission and exit.

When the message is transmitted, the receiver performs the same CRC operation on all the data bits and the transmitted CRC. If the information is received correctly the resulting remainder (receiver CRC) is 0.

Sample CRC-16 Calculation

The RTU device transmits the rightmost byte (of registers or discrete data) first. The first bit of the CRC-16 transmitted is the MSB. Therefore, in the example the MSB of the CRC polynomial is to the extreme right. The X^{16} term is dropped because it affects only the quotient (which is discarded) and not the remainder (the CRC characters). The generating polynomial is therefore 1010 0000 0000 0001. The remainder is initialized to all 1s.

In this example, the CRC-16 is calculated for RTU message, Read Exception Status 07. The message format is as follows:

Address	Function	CRC-16
01	07	

In this example, device number 1 (address 01) is queried. You need to know the amount of data to be transmitted and this information can be found for every message type in "Calculating the Length of Frame." For this message the data length is 2 bytes.

Transmitter CRC-16 Algorithm					Receiver¹ CRC-16 Algorithm						
	MSB²		LSB²	Flag		MSB²		LSB²	Flag		
Initial Remainder	1111	1111	1111	1111		Rcvr CRC after data	1110	0010	0100	0001	
XOR 1st data byte	0000	0000	0000	0001		XOR 1st byte Trns CRC	0000	0000	0100	0001	
Current CRC	1111	1111	1111	1111		Current CRC	1110	0010	0000	0000	
Shift 1	0111	1111	1111	1111	0	Shift 1	0111	0001	0000	0000	0
Shift 2	0011	1111	1111	1111	1	Shift 2	0011	1000	1000	0000	0
XOR Gen. Polynomial	1010	0000	0000	0001		Shift 3	0001	1100	0100	0000	0
Current CRC	1001	1111	1111	1110		Shift 4	0000	1110	0010	0000	0
Shift 3	0100	1111	1111	1111	0	Shift 5	0000	0111	0001	0000	0
Shift 4	0010	0111	1111	1111	1	Shift 6	0000	0011	1000	1000	0
XOR Gen. Polynomial	1010	0000	0000	0001		Shift 7	0000	0001	1100	0100	0
Current CRC	1000	0111	1111	1110		Shift 8	0000	0000	1110	0010	0
Shift 5	0100	0011	1111	1111	0	XOR 2nd byte trns CRC	0000	0000	1110	0010	
Shift 6	0010	0001	1111	1111	1	Current CRC	0000	0000	0000	0000	
XOR Gen. Polynomial	1010	0000	0000	0001		Shift 1-8 yields	0000	0000	0000	0000	
Current CRC	1000	0001	1111	1110		All errors for receiver final CRC-16 indicates transmission correct.					
Shift 7	0100	0000	1111	1111	0						
Shift 8	0010	0000	0111	1111	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Current CRC	1000	0000	0111	1110							
XOR 2nd data byte	0000	0000	0000	0111							
Current CRC	1000	0000	0111	1001							
Shift 1	0100	0000	0011	1100	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Current CRC	1110	0000	0011	1101							
Shift 2	0111	0000	0001	1110	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Current CRC	1101	0000	0001	1111							
Shift 3	0110	1000	0000	1111	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Current CRC	1100	1000	0000	1110							
Shift 4	0110	0100	0000	0111	0						
Shift 5	0011	0010	0000	0011	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Current CRC	1001	0010	0000	0010							
Shift 6	0100	1001	0000	0001	0						
Shift 7	0010	0100	1000	0000	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Current CRC	1000	0100	1000	0001							
Shift 8	0100	0010	0100	0000	1						
XOR Gen. Polynomial	1010	0000	0000	0001							
Transmitted CRC	1110	0010	0100	0001							
	E	2	4	1							

- The receiver processes incoming data through the same CRC algorithm as the transmitter. The example for the receiver starts at the point after all the data bits but not the transmitted CRC have been received correctly. Therefore, the receiver CRC should be equal to the transmitted CRC at this point. When this occurs, the output of the CRC algorithm will be zero indicating that the transmission is correct.

The transmitted message with CRC would then be:

Address	Function	CRC-16	
01	07	41	E2

- The MSB and LSB references are to the data bytes only, not the CRC bytes. The CRC MSB and LSB order are the reverse of the data byte order.

13.3.5 Calculating the Length of Frame

To generate the CRC-16 for any message, the message length must be known. The length for all types of messages can be determined from the table below.

RTU Message Length

Function Code	Name	Query or Broadcast Message Length Less CRC Code	Response Message Length Less CRC Code
0		Not Defined	Not Defined
1	Read Output Table	6	3 + 3rd byte ³⁰
2	Read Input Table	6	3 + 3rd byte
3	Read Registers	6	3 + 3rd byte
4	Read Analog Input	6	3 + 3rd byte
5	Force Single Output	6	6
6	Preset Single Register	6	6
7	Read Exception Status	2	3
8	Loopback/Maintenance	6	6
9-14		Not Defined	Not Defined
15	Force Multiple Outputs	7 + 7th byte	6
16	Preset Multiple Registers	7 + 7th byte	6
17	Report Device Type	2	8
18-21		Not Defined	Not Defined
22	Mask Write 4x Registers	8	8
23	Read/Write 4x Registers	13+byte 11	5+byte 3
24-66		Not Defined	Not Defined
67	Read Scratch Pad	6	3 + 3rd byte
68-127		Not Defined	Not Defined
128-255		Not Defined	3

³⁰ The value of this byte is the number of bytes contained in the data being transmitted.

13.3.6 RTU Message Descriptions

This section presents the format and fields for each RTU message.

Message (01): Read Output Table

Format:

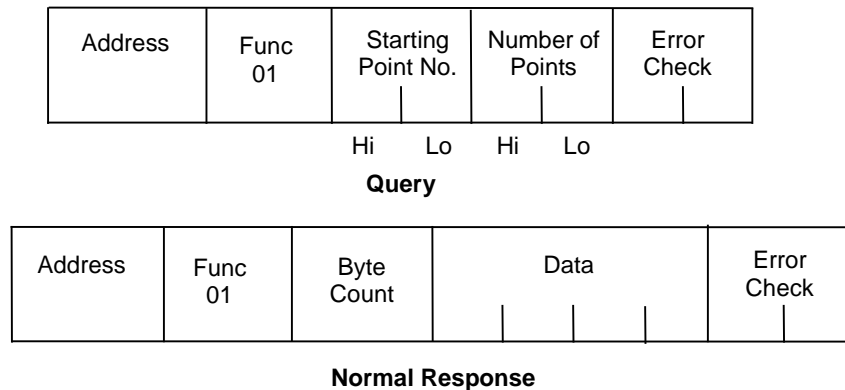


Figure 34: RTU Read Output Table Message Format

Query:

- An address of 0 is not allowed because this cannot be a broadcast request.
- The function code is 01.
- The starting point number is two bytes in length and may be any value less than the highest output point number available in the attached CPU. The starting point number is equal to one less than the number of the first output point returned in the normal response to this request.
- The *number of points* value is two bytes in length. It specifies the number of output points returned in the normal response. The sum of the starting point value and the number of points value must be less than or equal to the highest output point number available in the attached CPU. The high order byte of the Starting Point Number and Number of Points fields is sent as the first byte. The low order byte is the second byte in each of these fields.

Response:

- The byte count is a binary number from 1 to 256 (0 = 256). It is the number of bytes in the normal response following the byte count and preceding the error check.
- The Data field of the normal response is packed output status data. Each byte contains eight output point values. The least significant bit (LSB) of the first byte contains the value of the output point whose number is equal to the starting point number plus one. The values of the output points are ordered by number starting with the LSB of the first byte of the Data field and ending with the most significant bit (MSB) of the last byte of the Data field. If the number of points is not a multiple of 8, the last data byte contains zeroes in one to seven of its highest order bits.

Message (02): Read Input Table

Format:

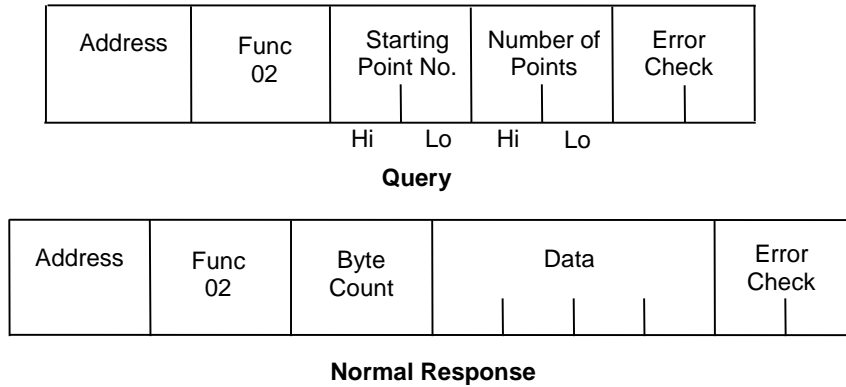


Figure 35: RTU Read Input Table Message Format

Query:

- An address of 0 is not allowed as this cannot be a broadcast request.
- The function code is 02.
- The starting point number is two bytes in length and may be any value less than the highest input point number available in the attached CPU. The starting point number is equal to one less than the number of the first input point returned in the normal response to this request.
- The number of points value is two bytes in length. It specifies the number of input points returned in the normal response. The sum of the starting point value and the number of points value must be less than or equal to the highest input point number available in the attached CPU. The high order byte of the Starting Point Number and Number Of Bytes fields is sent as the first byte. The low order byte is the second byte in each of these fields.

Response:

- The byte count is a binary number from 1 to 256 (0 = 256). It is the number of bytes in the normal response following the byte count and preceding the error check.
- The Data field of the normal response is packed input status data. Each byte contains eight input point values. The least significant bit (LSB) of the first byte contains the value of the input point whose number is equal to the starting point number plus one. The values of the input points are ordered by number starting with the LSB of the first byte of the Data field and ending with the most significant bit (MSB) of the last byte of the Data field. If the number of points is not a multiple of 8, then the last data byte contains zeroes in one to seven of its highest order bits.

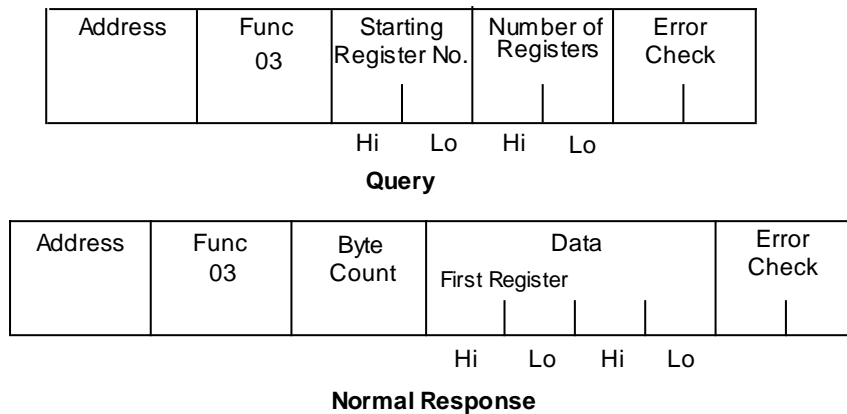
Message (03): Read Registers**Format:**

Figure 36: RTU Read Registers Message Format

Query:

- An address of 0 is not allowed as this request cannot be a broadcast request.
- The function code is equal to 3.
- The starting register number is two bytes in length. The starting register number may be any value less than the highest register number available in the attached CPU. It is equal to one less than the number of the first register returned in the normal response to this request.
- The number of registers value is two bytes in length. It must contain a value from 1 to 125 inclusive. The sum of the starting register value and the number of registers value must be less than or equal to the highest register number available in the attached CPU. The high order byte of the Starting Register Number and Number of Registers fields is sent as the first byte in each of these fields. The low order byte is the second byte in each of these fields.

Response:

- The byte count is a binary number from 2 to 250 inclusive. It is the number of bytes in the normal response following the byte count and preceding the error check. Note that the byte count is equal to two times the number of registers returned in the response. A maximum of 250 bytes (125) registers is set so that the entire response can fit into one 256 byte data block.
- The registers are returned in the Data field in order of number with the lowest number register in the first two bytes and the highest number register in the last two bytes of the Data field. The number of the first register in the Data field is equal to the Starting Register Number plus one. The high order byte is sent before the low order byte of each register.

Message (04): Read Analog Inputs

Format:

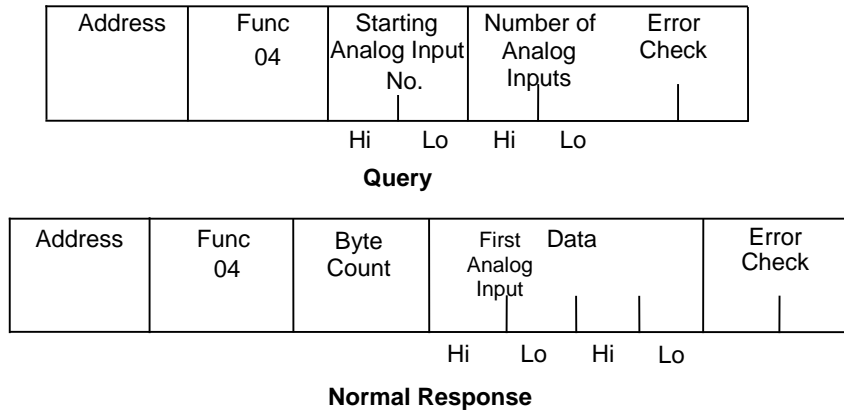


Figure 37: RTU Read Analog Inputs Message Format

Query:

- An Address of 0 is not allowed as this request cannot be a broadcast request.
- The function code is equal to 4.
- The Starting Analog Input Number is two bytes in length. The Starting Analog Input Number may be any value less than the highest analog input number available in the attached CPU. It is equal to one less than the number of the first analog input returned in the normal response to this request.
- The Number Of Analog Inputs value is two bytes in length. It must contain a value from 1 to 125 inclusive. The sum of the Starting Analog Input value and the Number Of Analog Inputs value must be less than or equal to the highest analog input number available in the at-attached CPU. The high order byte of the Starting Analog Input Number and Number of Analog Inputs fields is sent as the first byte in each of these fields. The low order byte is the second byte in each of these fields.

Response:

- The Byte Count is a binary number from 2 to 250 inclusive. It is the number of bytes in the normal response following the byte count and preceding the error check. Note that the Byte Count is equal to two times the number of analog inputs returned in the response. A maximum of 250 bytes (125) analog inputs is set so that the entire response can fit into one 256 byte data block.
- The analog inputs are returned in the Data field in order of number with the lowest number analog input in the first two bytes and the highest number analog input in the last two bytes of the Data field. The number of the First Analog Input in the Data field is equal to the Starting analog input number plus one. The high order byte is sent before the low order byte of each analog input.

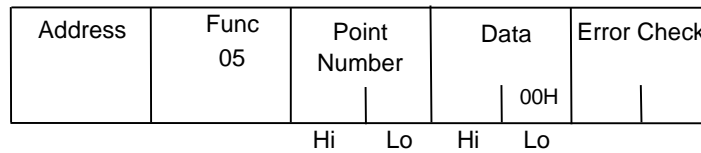
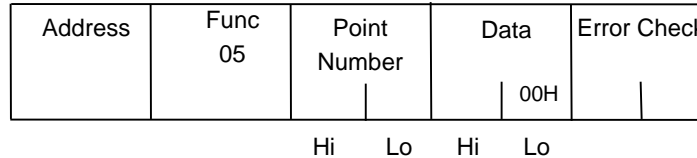
Message (05): Force Single Output**Format:****Query****Normal Response**

Figure 38: RTU Force Single Output Message Format

Query:

- An Address of 0 indicates a broadcast request. All slave stations process a broadcast request and no response is sent.
- The function code is equal to 05.
- The Point Number field is two bytes in length. It may be any value less than the highest output point number available in the attached CPU. It is equal to one less than the number of the output point to be forced on or off.
- The first byte of the Data field is equal to either 0 or 255 (FFH). The output point specified in the Point Number field is to be forced off if the first Data field byte is equal to 0. It is to be forced on if the first Data field byte is equal to 255 (FFH). The second byte of the Data field is always equal to zero.

Response:

- The normal response to a force single output query is identical to the query.

Note: The force single output request is not an output override command. The output specified in this request is ensured to be forced to the value specified only at the beginning of one sweep of the user logic.

Message (06): Preset Single Register

Format:

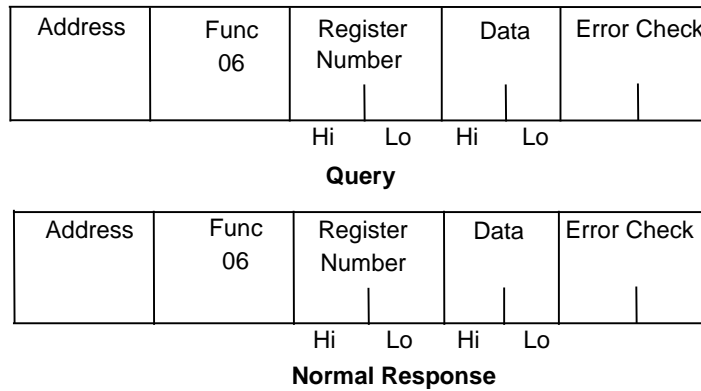


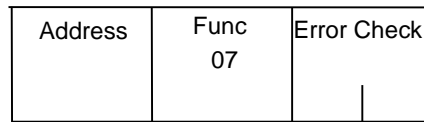
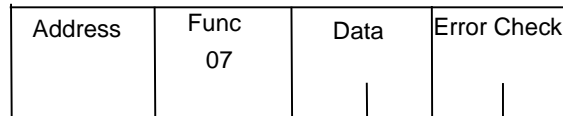
Figure 39: RTU Preset Single Register Message Format

Query:

- An Address 0 indicates a broadcast request. All slave stations process a broadcast request and no response is sent.
- The function code is equal to 06.
- The Register Number field is two bytes in length. It may be any value less than the highest register available in the attached CPU. It is equal to one less than the number of the register to be preset.
- The Data field is two bytes in length and contains the value that the register specified by the Register Number Field is to be preset to. The first byte in the Data field contains the high order byte of the preset value. The second byte in the Data field contains the low order byte.

Response:

- The normal response to a preset single register query is identical to the query.

Message (07): Read Exception Status**Format:****Query****Normal Response****Figure 40: RTU Read Exception Status Message Format****Query:**

This query is a short form of request for the purpose of reading the first eight output points.

- An Address of zero is not allowed as this cannot be a broadcast request.
- The function code is equal to 07.

Response:

- The Data field of the normal response is one byte in length and contains the states of output points one through eight. The output states are packed in order of number with output point one's state in the least significant bit and output point eight's state in the most significant bit.

Message (08): Loopback/Maintenance (General)

Format:

Address	Func 08	Diagnostic Code 0, 1, or 4	Data DATA 1 DATA 1	Error Check
---------	------------	----------------------------------	-------------------------	-------------

Query

Address	Func 08	Diagnostic Code 0, 1, or 4	Data DATA 1 DATA 1	Error Check
---------	------------	----------------------------------	-------------------------	-------------

Normal Response

Figure 41: RTU Loopback/Maintenance Message Format

Query:

- The Function code is equal to 8.
- The Diagnostic Code is two bytes in length. The high order byte of the Diagnostic Code is the first byte sent in the Diagnostic Code field. The low order byte is the second byte sent. The loopback/maintenance command is defined only for Diagnostic Codes equal to 0, 1, or 4. All other Diagnostic Codes are reserved.
- The Data field is two bytes in length. The contents of the two Data bytes are defined by the value of the Diagnostic Code.

Response:

- See descriptions for individual Diagnostic Codes.

Diagnostic Return Query Data Request (Loopback/Maintenance Code 00):

- An address of 0 is not allowed for the return query data request.
- The values of the two Data field bytes in the query are arbitrary.
- The normal response is identical to the query.
- The values of the Data bytes in the response are equal to the values sent in the query.

Diagnostic Initiate Communication Restart Request (Loopback/Maintenance Code 01):

- An Address of 0 indicates a broadcast request. All slave stations process a broadcast request and no response is sent.
- This request disables the listen-only mode (enables responses to be sent when queries are received so that communications can be restarted).
- The value of the first byte of the Data field (DATA1) must be 0 or FF. Any other value will cause an error response to be sent. The value of the second byte of the Data field (DATA2) is always equal to 0.
- The normal response to an Initiate Communication Restart query is identical to the query.

Diagnostic Force Listen-Only Mode Request (Loopback/Maintenance code 04):

- An Address of 0 indicates a broadcast request. All slave stations process a broadcast request.
- After receiving a Force Listen-Only mode request, the RTU device will go into the listen-only mode, will not perform a requested function, and will not send either normal or error responses to any queries. The listen-only mode is disabled when the RTU device receives an Initiate Communication Restart request or when the RTU device is powered up.
- Both bytes in the Data field of a Force Listen-Only Mode request are equal to 0. The RTU device never sends a response to a Force Listen-Only Mode request.

Note: Upon power up, the RTU device disables the listen-only mode and is enabled to continue sending responses to queries.

Message (15): Force Multiple Outputs

Format:

Address	Func 15	Starting Point No.	Number of Points	Byte Count	Data	Error Check
---------	------------	-----------------------	---------------------	---------------	------	-------------

Query

Address	Func 15	Starting Point No.	Number of Points	Error Check
---------	------------	-----------------------	---------------------	-------------

Normal Response

Figure 42: RTU Force Multiple Outputs Message Format

Query:

- An Address of 0 indicates a broadcast request. All slave stations process a broadcast request and no response is sent.
- The value of the Function code is 15.
- The Starting Point Number is two bytes in length and may be any value less than the highest output point number available in the attached CPU. The Starting Point Number is equal to one less than the number of the first output point forced by this request.
- The Number of Points value is two bytes in length. The sum of the Starting Point Number and the Number of Points value must be less than or equal to the highest output point number available in the attached CPU. The high order byte of the Starting Point Number and Number of Bytes fields is sent as the first byte in each of these fields. The low order byte is the second byte in each of these fields.
- The Byte Count is a binary number from 1 to 256 (0 = 256). It is the number of bytes in the Data field of the force multiple outputs request.
- The Data field is packed data containing the values that the outputs specified by the Starting Point Number and the Number of Points fields are to be forced to. Each byte in the Data field contains the values that eight output points are to be forced to. The least significant bit (LSB) of the first byte contains the value that the output point whose number is equal to the starting point number plus one is to be forced to. The values for the output points are ordered by number starting with the LSB of the first byte of the Data field and ending with the most significant bit (MSB) of the last byte of the Data field. If the number of points is not a multiple of 8, then the last data byte contains zeroes in one to seven of its highest order bits.

Response:

- The descriptions of the fields in the response are covered in the query description.

Note: The force multiple outputs request is not an output override command. The outputs specified in this request are ensured to be forced to the values specified only at the beginning of one sweep of the user logic.

Message (16): Preset Multiple Registers**Format:**

Address	Func 16	Starting Point	Number of Registers	Byte Count	Data	Error Check
---------	------------	-------------------	------------------------	---------------	------	-------------

Query

Address	Func 16	Starting Register No	Number of Registers	Error Check
---------	------------	-------------------------	------------------------	-------------

Normal Response

Figure 43: RTU Preset Multiple Registers Message Format

Query:

- An Address of 0 indicates a broadcast request. All slave stations process a broadcast request and no response is sent.
- The value of the Function code is 16.
- The Starting Register Number is two bytes in length. The Starting Register Number may be any value less than the highest register number available in the attached CPU. It is equal to one less than the number of the first register preset by this request.
- The Number of Registers value is two bytes in length. It must contain a value from 1 to 125 inclusive. The sum of the Starting Register Number and the Number of Registers value must be less than or equal to the highest register number available in the attached CPU. The high order byte of the Starting Register Number and Number of Registers fields is sent as the first byte in each of these fields. The low order byte is the second byte in each of these fields.
- The Byte Count field is one byte in length. It is a binary number from 2 to 250 inclusive. It is equal to the number of bytes in the data field of the preset multiple registers request. Note that the Byte Count is equal to twice the value of the Number of Registers.
- The registers are returned in the Data field in order of number with the lowest number register in the first two bytes and the highest number register in the last two bytes of the Data field. The number of the first register in the Data field is equal to the starting register number plus one. The high order byte is sent before the low order byte of each register.

Response:

- The descriptions of the fields in the response are covered in the query description.

Message (17): Report Device Type

Format:

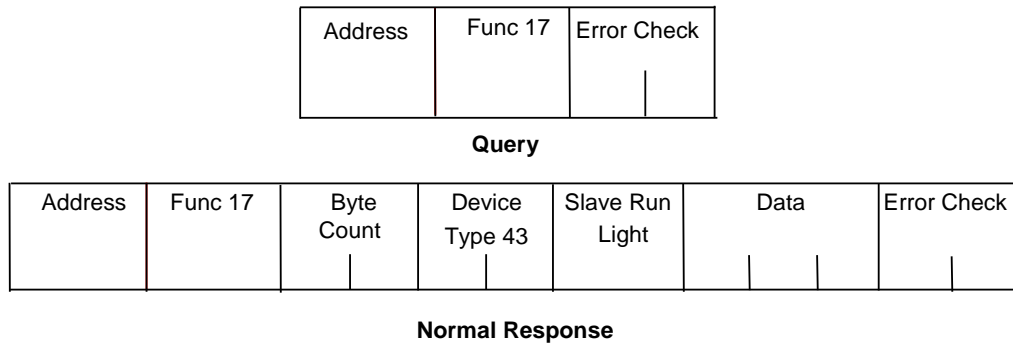


Figure 44: RTU Report Device Type Message Format

Query:

The Report Device Type query is sent by the master to a slave in order to learn what type of programmable control or other computer it is.

- An Address of zero is not allowed as this cannot be a broadcast request.
- The Function code is 17.

Response:

- The Byte Count field is one byte in length and is equal to 5.
- The Device Type field is one byte in length and is equal to 43 (hexadecimal) for PACSystems
- The Slave Run Light field is one byte in length. The Slave Run Light byte is equal to OFFH if the CPU is in RUN mode. It is equal to 0 if the CPU is not in RUN mode.
- The Data field contains three bytes. For PACSystems CPUs, the first byte is the Minor Type, and the remaining bytes are zeroes. The following table lists minor types.

<i>Response Data (Minor Type)</i>	<i>CPU Model</i>
02 hex	IC698CPE010
04 hex	IC698CPE020
05 hex	IC698CRE020
06 hex	IC698CPE030
08 hex	IC698CPE040
0A hex	IC695CPE305 IC695CPU310
0C hex	IC695NIU001
10 hex	IC695CPU320
11 hex	IC695CRU320
12 hex	IC695CPE305
18 hex	IC695CPU315

Message (22): Mask Write 4x Memory

Modifies the contents of a specified 4x register using a combination of an AND mask, an OR mask, and the register's current contents. The function can be used to set or clear individual bits in the register. Broadcast is not supported.

Query

The query specifies the 4x reference to be written, the data to be used as the AND mask, and the data to be used as the OR mask.

The function's algorithm is:

$$\text{Result} = (\text{Current Contents AND And_Mask}) \text{ OR } (\text{Or_Mask AND And_Mask})$$

For example:

	<i>Hex</i>	<i>Binary</i>	
Current Contents	12	0001	0010
And_Mask	F2	1111	0010
Or_Mask	25	0010	0101
And_Mask	0D	0000	1101
Result	17	0001	0111

Note: If the Or_Mask value is zero, the result is simply the logical ANDing of the current contents and And_Mask. If the And_Mask value is zero, the result is equal to the Or_Mask value.

Note: The contents of the register can be read with the Read Holding Registers function (function code 03). They could, however, be changed subsequently as the controller scans its user logic program.

Example of a Mask Write to register 5 in slave device 17, using the above mask values:

<i>Field Name</i>	<i>Example (Hex)</i>
Slave Address	11
Function	16
Reference Address Hi	00
Reference Address Lo	04
And_Mask Hi	00
And_Mask Lo	F2
Or_Mask Hi	00
Or_Mask Lo	25
Error Check (LRC or CRC)	--

Response

The normal response is an echo of the query. The response is returned after the register has been written.

Message (23): Read Write 4x Memory

Performs a combination of one read and one write operation in a single Modbus transaction. The function can write new contents to a group of 4x registers, and then return the contents of another group of 4x registers. Broadcast is not supported.

Query

The query specifies the starting address and quantity of registers of the group to be read. It also specifies the starting address, quantity of registers, and data for the group to be written. The Byte Count field specifies the quantity of bytes to follow in the Write Data field.

Here is an example of a query to read six registers starting at register 5, and to write three registers starting at register 16, in slave device 17:

<i>Field Name</i>	<i>Example (Hex)</i>
Slave address	11
Function	17
Read Reference Address Hi	00
Read Reference Address Lo	04
Quantity to Read Hi	00
Quantity to Read Lo	06
Write Reference Address Hi	00
Write Reference Address Lo	0F
Quantity to Write Hi	00
Quantity to Write Lo	03
Byte Count	06
Write Data 1 Hi	00
Write Data 1 Lo	FF
Write Data 2 Hi	00
Write Data 2 Lo	FF
Write Data 3 Hi	00
Write Data 3 Lo	FF
Error Check (LRC or CRC)	--

Response

The normal response contains the data from the group of registers that were read. The Byte Count field specifies the quantity of bytes to follow in the Read Data field.

Here is an example of a response to the query:

Field Name	Example (Hex)
Slave Address	11
Function	17
Byte Count	0C
Read Data 1 Hi	00
Read Data 1 Lo	FE
Read Data 2 Hi	0A
Read Data 2 Lo	CD
Read Data 3 Hi	00
Read Data 3 Lo	01
Read Data 4 Hi	00
Read Data 4 Lo	03
Read Data 5 Hi	00
Read Data 5 Lo	0D
Read Data 6 Hi	00
Read Data 6 Lo	FF
Error Check (LRC or CRC)	--

Message (67): Read Scratch Pad Memory

Format:

Address	Func 67	Starting Byte No.	Number of Bytes	Error Check

Query

Address	Func 67	Byte Count	Data	Error Check

Normal Response

Figure 45: RTU Read Scratch Pad Memory Message Format

Query:

- An Address of 0 is not allowed as this cannot be a broadcast request.
- The Function Code is equal to 67.
- The Starting Byte Number is two bytes in length and may be any value less than or equal to the highest scratch pad memory address available in the attached CPU as indicated in the table below. The Starting Byte Number is equal to the address of the first scratch pad memory byte returned in the normal response to this request.
- The Number of Bytes value is two bytes in length. It specifies the number of scratch pad memory locations (bytes) returned in the normal response. The sum of the Starting Byte Number and the Number of Bytes values must be less than two plus the highest scratch pad memory address available in the attached CPU. The high order byte of the Starting Byte Number and Number of Bytes fields is sent as the first byte in each of these fields. The low order byte is the second byte in each of the fields.

Response:

- The Byte Count is a binary number from 1 to 256 (0 = 256). It is the number of bytes in the Data field of the normal response.
- The Data field contains the contents of the scratch pad memory requested by the query. The scratch pad memory bytes are sent in order of address. The contents of the scratch pad memory byte whose address is equal to the Starting Byte Number is sent in the first byte of the Data field. The contents of the scratch pad memory byte whose address is equal to one less than the sum of the starting byte number and number of bytes values is sent in the last byte of the Data field.

13.3.7 RTU Scratch Pad

The entire scratch pad is updated every time an external READ request is received by the PACSystems RTU slave. All scratch pad locations are *read only*. The scratch pad is a byte-oriented memory type.

RTU Scratch Pad Memory Allocation

SP Address	Field Identifier	Bits							
		7	6	5	4	3	2	1	0
00	CPU Run Status	0	0	0	0	See note. ³¹			
01	CPU Command Status	Bit pattern same as SP(00)							
02	CPU Type	Major ³² (in hexadecimal)							
03		Minor ³³ (in hexadecimal)							
04 – 0B	CPU SNP ID	7 ASCII characters + termination character (00h)							
0C	CPU Firmware Revision No.	Major (in BCD)							
0D		Minor (in BCD)							
0E	Communications Management Module (CMM) Firmware Revision No.	Major							
0F		Minor							
10–11	Reserved	00h							
12	Node Type Identifier	PACSystems 43 (hexadecimal)							
13–15	Reserved	00h							
16	RTU Station Address	1–247 (decimal)							
17	Reserved	00h							
18–33 ³⁴	Sizes of Memory Types								
18–1B	Register Memory	%R size (words)							
1C–1F	Analog Input Table	%AI size (words)							
20–23	Analog Output Table	%AO size (words)							
24–27	Input Table	%I size (bits)							
28–2B	Output Table	%O size (bits)							
2C–2F	Internal Discrete Memory	%M size (bits)							
30–33	User Program Code	The amount of program memory occupied by the logic program.							
34–FF	Reserved	00h							

³¹ 0000 = Run_Enabled 0100 = Halted 0001 = Run_Disabled
 0101 = Suspended 0010 = Stopped 0110 = Stopped_IO_Enabled

³² CPU Major Type Codes: PACSystems 0x43

³³ PACSystems Minor Types for CPU: see Message (17) Report Device Type

³⁴ Four bytes hold the hexadecimal length of each memory type with the most significant word reserved for future expansion. For example, the default register memory size of 1024 words (0400h) would be returned in the following format:

Word	Least	Significant	Most	Significant
SP Byte	18	19	1A	1B
Contains	00	04	00	00

13.3.8 Communication Errors

Serial link communication errors are divided into three groups:

- Invalid Query Message
- Serial Link Time Outs
- Invalid Transaction

Invalid Query Message

When the communications module receives a query addressed to itself, but cannot process the query, it sends one of the following error responses:

	Subcode
Invalid Function Code	1
Invalid Address Field	2
Invalid Data Field	3
Query Processing Failure	4

The format for an error response to a query is as follows:

Address	Exception Func	Error Subcode	Error Check
---------	-------------------	------------------	----------------

Figure 46: RTU Error Response Format

The address reflects the address provided on the original request. The exception function code is equal to the sum of the function code of the query plus 128. The error subcode is equal to 1, 2, 3, or 4. The value of the subcode indicates the reason the query could not be processed.

Invalid Function Code Error Response (1)

An error response with a subcode of 1 is called an invalid function code error response. This response is sent by a slave if it receives a query whose function code is not equal to 1- 8, 15, 16, 17, or 67.

Note: Starting with Release 6.70 for the RX3i, the invalid function code error response is not used. Instead, undefined and unsupported function codes are ignored, and no response is generated.

Invalid Address Error Response (2)

An error response with a subcode of 2 is called an invalid address error response. This error response is sent in the following cases:

1. The Starting Point Number and Number of Points fields specify output points or input points that are not available in the attached CPU (returned for function codes 1, 2, 15).
2. The Starting Register Number and Number of Registers fields specify registers that are not available in the attached CPU (returned for function codes 4, 16).
3. The Starting Analog Input Number and Analog Input Number fields specify analog inputs that are not available in the attached CPU (returned for function code 3).
4. The Point Number field specifies an output point not available in the attached CPU (returned for function code 5).
5. The Register Number field specifies a register not available in the attached CPU (returned for function code 6).
6. The Analog Input Number field specifies an analog input number not available in the at-attached CPU (returned for function code 3).
7. The Diagnostic Code is not equal to 0, 1, or 4 (returned for function code 8).
8. The starting Byte Number and Number of Bytes fields specify a scratch pad memory address that is not available in the attached CPU (returned for function code 67).

Invalid Data Value Error Response (3)

An error response with a subcode of 3 is called an invalid data value error response. This response is sent in the following cases:

The first byte of the Data field is not equal to 0 or 255 (FFh) or the second byte of the Data field is not equal to 0 for the Force Single Output Request (Function Code 5) or the initiate communication restart request (function code 8, diagnostic code 1). The two bytes of the Data field are not both equal to 0 for the Force Listen-Only request (Function Code 8, Diagnostic Code 4). This response is also sent when the data length specified by the Memory Address field is longer than the data received.

Query Processing Failure Error Response (4)

An error response with a subcode of 4 is called a query processing failure response. This error response is sent by a RTU device if it properly receives a query but communication between the associated CPU and the CMM fails.

Serial Link Timeout

The only cause for a RTU device to timeout is if an interruption to a data stream of 4 character times occurs while a message is being received. If this occurs the message is considered to have terminated and no response will be sent to the master. There are certain timing considerations due to the characteristics of the slave that should be taken into account by the master. After sending a query message, the master should wait an appropriate amount of time for slave turnaround before assuming that the slave did not respond to the request. Slave turnaround time is affected by the Controller Communications Window time and the CPU sweep time, as described in “RTU Slave Turnaround Time” on page 507.

Invalid Transactions

If an error occurs during transmission that does not fall into the category of an invalid query message or a serial link time-out, it is known as an invalid transaction. Types of errors causing an invalid transaction include:

- Bad CRC.
- The data length specified by the Memory Address field is longer than the data received.
- Framing or overrun errors.
- Parity errors.

If an error in this category occurs when a message is received by the slave serial port, the slave does not return an error message; rather the slave ignores the incoming message, treating the message as though it was not intended for it.

13.3.9 RTU Slave/SNP Slave Operation with Programmer Attached

A port that has been configured for RTU Slave protocol can switch to SNP protocol if an SNP master such as a programmer begins communicating to the port. The programmer must use the same serial communications parameters (baud rate, parity, stop bits, etc.) as the currently active RTU Slave protocol for it to be recognized. When the CPU recognizes the SNP master, the CPU removes the RTU Slave protocol from the port and installs SNP Slave as the active protocol.

The SNP protocol that is installed in this case has the following fixed characteristics:

- The SNP ID is set to blank. Therefore the SNP master must use a blank ID in the SNP attach message. This also means that this capability is only useful for point-to-point connections.
- The turnaround time is set to 0ms.
- The idle timeout is set to 10 seconds.

After the programmer is removed, there is a slight delay (equal to the idle timeout) before the CPU recognizes its absence. During this time, no messages are processed on the port. The CPU detects removal of the programmer as an SNP Slave protocol timeout. Therefore, it is important to be careful when disabling timeouts used by the SNP Slave protocol.

When the CPU recognizes the programmer disconnect, it reinstalls RTU Slave protocol unless a new protocol has been configured in the meantime. In that case, the CPU installs the new protocol instead.

Example

1. Port 1 is running RTU Slave protocol at 9600 baud.
2. A programmer is attached to port 1. The programmer is using 9600 baud.
3. The CPU installs SNP Slave on port 1 and the programmer communicates normally.
4. The programmer stores a new configuration to port 1. The new configuration sets the port for SNP Slave at 4800 baud (it will not take effect until the port loses communications with the programmer).
5. When the CPU loses communications with the programmer, the new configuration takes effect.

13.4. SNP Slave Protocol

PACSystems CPUs can communicate with Machine Edition software through either Port 1 or Port 2 using SNP slave protocol.

CPU port 1 is wired as an RS-232 Data Communications Equipment (DCE) port, and can be connected directly using straight-through cable to one of the serial ports of a PC running Machine Edition or other SNP master software.

CPU port 2 is wired for RS-485. If the SNP master does not have an RS-485 port, an RS-485/RS-232 converter is required. The RX3i can use converter IC690ACC901, which uses +5VDC from the serial port. The RX7i CPU port 2 does not support IC690ACC901 and requires an externally powered converter.

PACSystems provides the *break free* version of SNP, so that the SNP master does not need to issue a break signal as part of the SNP attach sequence. However, the CPU responds appropriately if a break signal is detected, by resetting the protocol to wait for another attach sequence from the master.

PACSystems supports both point-to-point connections (single master/single slave) and multi-drop connections (single master/multiple slaves).

For details on SNP protocol, refer to the *Serial Communications User's Manual*, GFK-0582.

13.4.1 Permanent Datagrams

Permanent datagrams survive after the SNP session that created them has been terminated. This allows an SNP master device to periodically retrieve datagram data from a number of different controllers on a multi-drop link, without the master having to establish and write the datagram each time it reconnects to the controller.

The maximum number of permanent datagrams that can be established is 32. When this limit is reached, additional requests to establish datagrams are denied. One or more of the permanent datagrams will need to be cancelled before others can be established. Since the permanent datagrams are not automatically deleted when the SNP session is terminated, this limit prevents an inordinate amount of these datagrams from being established.

Permanent datagrams do not survive a power-cycle.

13.4.2 Communication Requests (COMMREQs) for SNP

The PACSystems serial ports 1 and 2 currently do not provide SNP Master service, nor do they support COMMREQ functions for SNP commands. However, those COMMREQ functions can be used with PCM/CMM modules that are configured to provide SNP service. For more information, refer to the *Serial Communications User's Manual*, GFK-0582.

Chapter 14 Diagnostics

This chapter explains the PACSystems fault handling system, provides definitions of fault extra data, and suggests corrective actions for faults.

Faults occur in the control system when certain failures or conditions happen that affect the operation and performance of the system. Some conditions, such as the loss of an I/O module or rack, may impair the ability of the PACSystems controller to control a machine or process. Other conditions, such as when a new module comes online and becomes available for use, may be displayed to inform or alert the user.

Any detected fault is recorded in the Controller Fault Table or the I/O Fault Table, as applicable.

Information in this chapter is organized as follows:

- | | | |
|--|-------------|-----|
| ▪ Fault Handling Overview | <i>page</i> | 538 |
| ▪ Using the Fault Tables | | 540 |
| ▪ System Handling of Faults | | 544 |
| ▪ Controller Fault Descriptions and Corrective Actions | | 551 |
| ▪ I/O Fault Descriptions and Corrective Actions | | 585 |
| ▪ Diagnostic Logic Blocks | | 611 |

14.1. Fault Handling Overview

The PACSystems CPU detects three classes of faults:

Fault Class	Examples
Internal Failures (Hardware)	Non-responding modules Failed battery Failed Energy Pack (CPE305/CPE310 models) Memory checksum errors
External I/O Failures (Hardware)	Loss of rack or module Addition of rack or module Loss of Genius I/O block
Operational Failures	Communication failures Configuration failures Password access failures

14.1.1 System Response to Faults

Hardware failures require that either the system be shut down or the failure be tolerated. I/O failures may be tolerated by the control system, but they may be intolerable by the application or the process being controlled. Operational failures are normally tolerated.

Faults have three attributes:

Fault Table Affected	I/O Fault Table Controller Fault Table
Fault Action	Fatal Diagnostic Informational
Configurability	Configurable Non-configurable

14.1.2 Fault Tables

The PACSystems CPU maintains two fault tables, the Controller Fault Table for internal CPU faults and the I/O Fault Table for faults generated by I/O devices (including I/O controllers). For more information, see "Using the Fault Tables" on page 540.

14.1.3 Fault Actions and Fault Action Configuration

Fatal faults cause the fault to be recorded in the appropriate table, diagnostic variables to be set, and the system to be stopped. Only fatal faults cause the system to stop.

Diagnostic faults are recorded in the appropriate table, and any diagnostic variables are set. Informational faults are only recorded in the appropriate table.

Fault Action	Response by CPU
Fatal	Log fault in fault table. Set fault references. Go to Stop/Fault mode.
Diagnostic	Log fault in fault table. Set fault references.
Informational	Log fault in fault table.

The hardware configuration can be used to specify the fault action of some fault groups. For these groups, the fault action can be configured as either fatal or diagnostic. When a fatal or diagnostic fault within a configurable group occurs, the CPU executes the configured fault action instead of the action specified within the fault.

Note: The fault action displayed in the expanded fault details indicates the fault action specified by the fault that was logged, but not necessarily the executed fault action. To determine what action was executed for a particular fault in a configurable fault group, you must refer to the hardware configuration settings.

Faults that are part of configurable fault groups:

Fault Action Displayed in Fault Table	Informational	Diagnostic	Fatal
Fault Action Executed	Informational	Diagnostic or Fatal. Determined by action selected in Hardware Configuration.	Diagnostic or Fatal. Determined by action selected in Hardware Configuration.

Faults that are part of non-configurable fault groups:

Fault Action Displayed in Fault Table	Informational	Diagnostic	Fatal
Fault Action Executed	Informational	Diagnostic	Fatal

14.2. Using the Fault Tables

To display the fault tables in Logic Developer software,

1. Go online with the PACSystems.
2. Select the Project tab in the Navigator, right click the Target node and choose Diagnostics. The Fault Table Viewer appears.

The Controller Fault Table and the I/O Fault Table display the following information:

Controller Time/Date	The current date and time of the CPU.
Last Cleared	The date and time faults were last cleared from the fault table. This information is maintained by the PACSystems controller.
Status	Displays “Updating” while the programmer is reading the fault table. Status is “Online” when update is complete.
Total Faults	The total number of faults since the table was last cleared.
Entries Overflowed	The number of entries lost because the fault table has overflowed since it was cleared. Each fault table can contain up to 64 faults.

14.2.1 Controller Fault Table

The Controller Fault Table displays CPU faults such as password violations, configuration mismatches, parity errors, and communications errors.

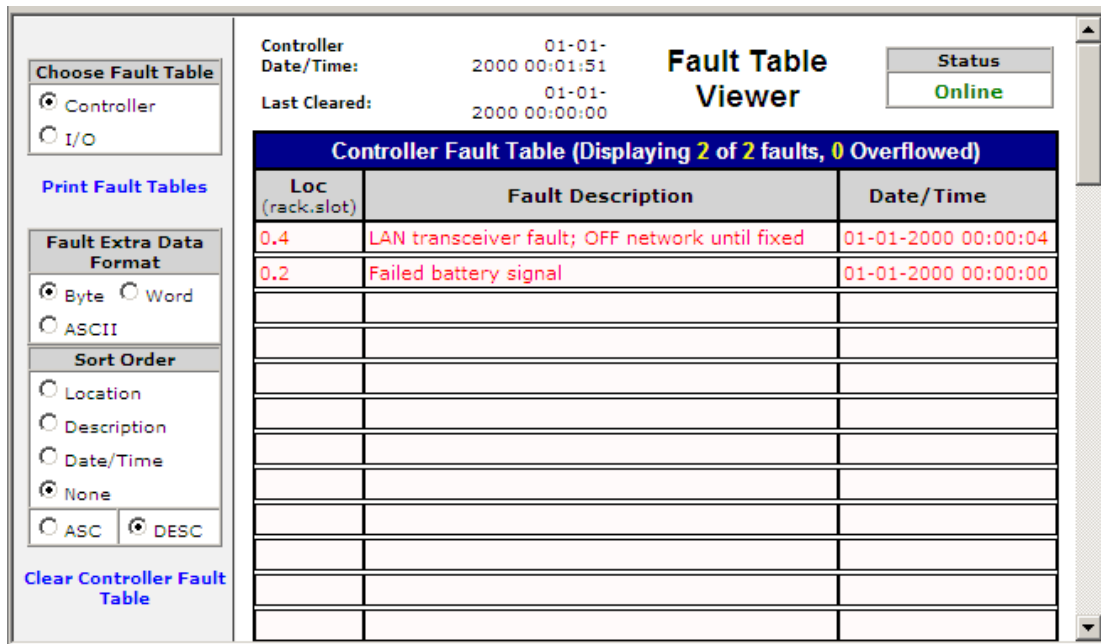


Figure 47: Controller Fault Table Display

The Controller Fault Table provides the following information for each fault:

- Location** Identifies the location of the fault by rack.slot.
- Description** Corresponds to a fault *group*, which is identified in the fault Details.
- Date/Time** The date and time the fault occurred based on the CPU clock.
- Details** To view detailed information, click the fault entry. See “Viewing Controller Fault Details” for more information.

Viewing Controller Fault Details

Note: The fault action displayed in the expanded fault details indicates the fault action specified by the fault that was logged, but not necessarily the executed fault action. To determine what action was executed for a particular fault in a configurable fault group, you must refer to the hardware configuration settings.

To see controller fault details, click the fault entry. The detailed information box for the fault appears. (To close this box, click the fault.)

0.1	Failed battery signal			01-02-2000 19:06:59
...	Error Code	Group	Action	Task Num
	0	18	2:Diagnostic	0
	Fault Extra Data: 02 00			

Figure 48: Detail Information for Controller Fault Entry

The detailed information for controller faults includes the following:

- Error Code** Further identifies the fault. Each fault group has its own set of error codes.
- Group** Group is the highest classification of a fault and identifies the general category of the fault. The fault description text displayed by your programming software is based on the fault group and the error codes.
- Action** Fatal, Diagnostic, or Informational. For definitions of these actions, see p.539.
- Task Number** Not used for most faults. When used, provides additional information for Technical Support representatives.
- Fault Extra Data** Provides additional information for diagnostics by Technical Support engineers. Explanations of this information are provided as appropriate for specific faults in "Controller Fault Descriptions and Corrective Actions" on page 551.

User-Defined Faults

User-defined faults can be logged in the Controller Fault Table. When a user-defined fault occurs, it is displayed in the appropriate fault table as "Application Msg (error_code):" and may be followed by a descriptive message up to 24 characters. The user can define all characters in the descriptive message. Although the message must end with the null character, e.g., zero (0), the null character does not count as one of the 24 characters. If the message contains more than 24 characters, only the first 24 characters are displayed.

Certain user-defined faults can be used to set a system status reference (%SA0081-%SA0112).

User-defined faults are created using SVC_REQ 21: User-Defined Fault Logging, which is described in Chapter 9.

Note: When a user-defined fault is displayed in the Controller Fault table, a value of -32768 (8000 hex) is added to the error code. For example, the error code 5 will be displayed as -32763.

14.2.2 I/O Fault Table

The I/O Fault Table displays I/O faults such as circuit faults, address conflicts, forced circuits, I/O module addition/loss faults and I/O bus faults.

The fault table displays a maximum of 64 faults. When the fault table is full, it displays the earliest 32 faults (33–64) and the last 32 faults (1–32). When another fault is received, fault 32 is shoved out of the table. In this way, the first 32 faults are preserved for the user to view.

Fault Table Viewer						Status
Choose Fault Table <input type="radio"/> PLC <input checked="" type="radio"/> I/O		PLC Date/Time: 09-22-2005 12:41:56 Last Cleared: 09-13-2005 12:06:57				Online
Print Fault Tables						
Fault Extra Data Format <input checked="" type="radio"/> Byte <input type="radio"/> Word <input type="radio"/> ASCII						
Sort Order <input type="radio"/> Location <input type="radio"/> Description <input type="radio"/> Date/Time <input checked="" type="radio"/> None <input type="radio"/> ASC <input checked="" type="radio"/> DESC						
I/O Fault Table (Displaying 27 of 27 faults, 0 Overflowed)						
Loc	CIRC No.	Variable Name	Ref. Address	Fault Category	Fault Type	Date/Time
0.3	n/a			Loss of I/O Module		09-22-2005 03:27:38
0.5	n/a	ai1		Loss of I/O Module		09-22-2005 03:27:38
0.6	n/a	in1		Loss of I/O Module		09-22-2005 03:27:38
0.3	n/a			Loss of I/O Module		09-22-2005 03:24:51
0.5	n/a	ai1		Loss of I/O Module		09-22-2005 03:24:51
0.6	n/a	in1		Loss of I/O Module		09-22-2005 03:24:51

Figure 49: I/O Fault Table Display

The I/O Fault Table provides the following information for each fault:

- Location** Identifies the location of the fault by rack.slot location, and sometimes bus and buss address.
- CIRC No.** When applicable, identifies the specific I/O point on the module.
- Variable Name** If the fault is on a point that is mapped to an I/O variable, and the variable is set to publish (either internal or external), the I/O Fault Table displays the variable name. Unpublished I/O variables will not be displayed in this field.
- Ref. Address** If the fault is on a point that is mapped to a reference address, this field identifies the I/O memory type and location (offset) that corresponds to the point experiencing the fault. When a Genius device fault or local analog module fault occurs, the reference address refers to the first point on the block where the fault occurred.
- Note:** The Reference Address field displays 16-bits and %W memory has a 32-bit range. Addresses in %W are displayed correctly for offsets in the 16-bit range ($\leq 65,535$). For %W offsets greater than 16-bits, the I/O Fault Table displays a blank reference address.
- Fault Category** Specifies a general classification of the fault.
- Fault Type** Consists of subcategories under certain fault categories. Set to zero when not applicable to the category.
- Date/Time** The date and time the fault occurred based on the CPU clock.
- Details** To view detailed information, click the fault entry. See “Viewing I/O Fault Details” for more information.

Viewing I/O Fault Details

To see I/O fault details, click the fault entry. The detailed information box for the fault appears. (To close this box, click the fault.)

0.3	1	%AQ 00001	Circuit Fault	Analog Fault	01-01-2000 00:02:27		
	I/O Bus	Bus Address	Point Address	Group	Action	Category	Fault Type
	n/a	n/a	1	10	2:Diagnostic	1	2
	Fault Extra Data	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00					
	Fault Description	Input Open Wire					

Figure 50: I/O Fault Table Fault Entry Detail Display

The detailed information for I/O faults includes:

I/O Bus	When the module in the slot is a Genius Bus Controller (GBC), this number is always one.
Bus Address	The serial bus address of the Genius device that reported or has the fault.
Point Address	Identifies the point on the I/O device that has the fault when the fault is a point-type fault.
Group	Fault group is the highest classification of a fault. It identifies the general category of the fault.
Action	Fatal, Diagnostic, or Informational. For definitions of these actions, refer to page 539.
Category	Identifies the category of the fault.
Fault Type	Identifies the fault type by number. Set to zero when not applicable to the category.
Fault Extra Data	Provides additional information for diagnostics by Technical Support engineers. Explanations of this information are provided as appropriate for specific faults in "I/O Fault Descriptions and Corrective Actions" on page 582.
Fault Description	Provides a specific fault code when the I/O fault category is a circuit fault (discrete circuit fault, analog circuit fault, low-level analog fault) or module fault. It is set to zero for other fault categories.

14.3. System Handling of Faults

The system fault references listed below can be used to identify the specific type of fault that has occurred. (A complete list of “System Status References” is provided in Chapter 6.)

System Fault Reference	Address	Description
#ANY_FLT	%SC0009	Any new fault in either table since the last power-up or clearing of the fault tables
#SY_FLT	%SC0010	Any new system fault in the Controller Fault Table since the last power-up or clearing of the fault tables
#IO_FLT	%SC0011	Any new fault in the I/O Fault Table since the last power-up or clearing of the fault tables
#SY_PRES	%SC0012	Indicates that there is at least one entry in the Controller Fault Table
#IO_PRES	%SC0013	Indicates that there is at least one entry in the I/O Fault Table
#HRD_FLT	%SC0014	Any hardware fault
#SFT_FLT	%SC0015	Any software fault

On power-up, the system fault references are cleared. If a fault occurs, the positive contact transition of any affected reference is turned on the sweep after the fault occurs. The system fault references remain on until both fault tables are cleared or All Memory in the CPU is cleared.

14.3.1 System Fault References

When a system fault reference is set, additional fault references are also set. These other types of faults are listed in “Fault References for Configurable Faults” below and “Fault References for Non-Configurable Faults” on page 546.

Fault References for Configurable Faults

Fault <i>(Default Action)</i>	Address	Description	May Also Be Set
#SBUS_ER (diagnostic)	%SA0032	System bus error. All system bus error faults are logged as informational.	#HRD_FLT, #SY_PREP, #SY_FLT
#SFT_IOC ³⁵ (diagnostic)	%SA0029	Non-recoverable software error in an I/O Controller (IOC).	#IO_FLT, #IO_PREP, #SFT_FLT
#LOS_RCK ³⁶ (diagnostic)	%SA0012	Loss of rack (BRM failure, loss of power) or missing a configured rack.	#SY_FLT, #SY_PREP, #IO_FLT, #IO_PREP
#LOS_IOC ³⁷ (diagnostic)	%SA0013	Loss of I/O Controller or missing a configured Bus Controller.	#IO_FLT, #IO_PREP
#LOS_IOM (diagnostic)	%SA0014	Loss of I/O module (does not respond), or missing a configured I/O module.	#IO_FLT, #IO_PREP
#LOS_SIO (diagnostic)	%SA0015	Loss of intelligent module (does not respond), or missing a configured module.	#SY_FLT, #SY_PREP
#IOC_FLT (diagnostic)	%SA0022	Non-fatal bus or I/O Controller error, more than 10 bus errors in 10 seconds. (Error rate is configurable.)	#IO_FLT, #IO_PREP
#CFG_MM (fatal)	%SA0009	Configuration mismatch. Wrong module type detected. The CPU does not check the configuration parameter settings for individual modules such as Genius I/O blocks.	#SY_FLT, #SY_PREP
#OVR_TMP (diagnostic)	%SA0008	CPU temperature has exceeded its normal operating temperature.	#SY_FLT, #SY_PREP

Note: If the fault action for a fault logged to the fault table is informational, the configured action is not used. For example, if the logged fault action for an SBUS_ERR is informational, but you configure it as fatal, the action is still informational.

³⁵ The #SFT_IOC software fault will have the same action as what you set for #LOS_IOC.

³⁶ When a Loss of Rack or Addition of Rack fault is logged, individual loss or add faults for each module in that rack are usually not generated.

³⁷ Even if the #LOS_IOC fault is configured as Fatal, the CPU will not go to STOP/FAULT unless both GBCs of an internal redundant pair fail.

Fault References for Non-Configurable Faults

Fault	Address	Description	Result
#PS_FLT	%SA0005	Power supply fault	Sets #SY_FLT, #SY_PRE
#HRD_CPU (fatal)	%SA0010	CPU hardware fault (such as failed memory device or failed serial port).	Sets #SY_FLT, #SY_PRE, #HRD_FLT
#HRD_SIO (diagnostic)	%SA0027	Non-fatal hardware fault on any module in the system, such as failure of a serial port on a LAN interface module.	Sets #SY_FLT, #SY_PRE, #HRD_FLT
#PNIO_ ALARM	%SA0030	A diagnostic PROFINET alarm has been received and an I/O fault has been logged in group 28.	Sets #ANY_FLT, #IO_FLT, #IO_PRE
#SFT_SIO (diagnostic)	%SA0031	Non-recoverable software error in a LAN interface module.	Sets #SY_FLT, #SY_PRE, #SFT_FLT
#PB_SUM (fatal)	%SA0001	Program or block checksum failure during power-up or in Run mode.	Sets #SY_FLT, #SY_PRE
#LOW_BAT (diagnostic)	%SA0011	The low battery indication is not supported for all CPU versions. For details, see "Battery Status (Group 18)" on page 567.	Sets #SY_FLT, #SY_PRE
#OV_SWP (diagnostic)	%SA0002	Constant sweep time exceeded.	Sets #SY_FLT, #SY_PRE
#SY_FULL #IO_FULL (diagnostic)	%SA0022	Controller fault table full (64 entries). I/O Fault Table full (64 entries).	Sets #SY_FLT, #SY_PRE, #IO_FLT, #IO_PRE
#APL_FLT (diagnostic)	%SA0003	Application fault.	Sets #SY_FLT, #SY_PRE
#ADD_RCK (diagnostic)	%SA0017	New rack added, extra rack, or previously faulted rack has returned.	Sets #SY_FLT, #SY_PRE
#ADD_IOC (diagnostic)	%SA0018	Extra IOC, previously faulted I/O Controller is no longer faulted.	Sets #IO_FLT, #IO_PRE
#ADD_IOM (diagnostic)	%SA0019	Extra IO module, or previously faulted I/O module is no longer faulted.	Sets #IO_FLT, #IO_PRE
#ADD_SIO (diagnostic)	%SA0020	New intelligent module is added, or previously faulted module no longer faulted.	Sets #SY_FLT, #SY_PRE
#IOM_FLT (diagnostic)	%SA0023	Point or channel on an I/O module; a partial failure of the module.	Sets #IO_FLT, #IO_PRE
#NO_PROG (information)	%SB0009	No application program is present at power-up. Should only occur the first time the PACSystems controller is powered up or if the user memory containing the program fails.	CPU will not go to Run mode; it continues executing Stop mode sweep until a valid program is loaded. This can be a "null" program that does nothing. Sets #SY_FLT and #SY_PRE.

Fault	Address	Description	Result
#BAD_RAM (fatal)	%SB0010	Corrupted program memory at power-up. Program could not be read and/or did not pass checksum tests.	Sets #SY_FLT and #SY_PRES.
#WIND_ER (information)	%SB0001	Window completion error. Servicing of Controller Communications or Logic Window was skipped. Occurs in Constant Sweep mode.	Sets #SY_FLT and #SY_PRES.
#BAD_PWD (information)	%SB0011	Change of privilege level request to a protection level was denied; bad password.	Sets #SY_FLT and #SY_PRES.
#NUL_CFG (fatal)	%SB0012	No configuration present upon transition to Run mode. Running without a configuration is equivalent to suspending the I/O scans.	Sets #SY_FLT and #SY_PRES.
#SFT_CPU (fatal)	%SB0013	CPU software fault. A non-recoverable error has been detected in the CPU. May be caused by Watchdog Timer expiring.	CPU immediately transitions to Stop/Halt mode. The only activity permitted is communication with the programmer. To be cleared, controller power must be cycled. Sets SY_FLT, SY_PRES, and SFT_FLT.
#STOR_ER (fatal)	%SB0014	Download of data to CPU from the programmer failed; some data in CPU may be corrupted.	CPU will not transition to Run mode. This fault is not cleared at power-up, intervention is required to correct it. Sets SY_FLT and SY_PRES.

14.3.2 Using Fault Contacts

Fault (-[F]-) and no-fault (-[NF]-) contacts can be used to detect the presence of I/O faults in the system. These contacts cannot be overridden. The following table shows the state of fault and no-fault contacts.

Condition	[F]	[NF]
Fault Present	ON	OFF
Fault Absent	OFF	ON

An NF contact will be ON (F contact will be OFF) when the referenced I/O point is not faulted, **or** the referenced I/O point does not exist in the hardware configuration.

Fault Locating References (Rack, Slot, Bus, Module)

The PACSystems CPU supports reserved fault names for each rack, slot, bus, and module. By programming these names on the FAULT and NOFLT contact instructions, logic can be executed in response to faults associated with configured racks and modules.

Fault Locating Reference Name Format

These fault names can only be programmed on the FAULT and NOFLT contacts. The reserved fault names are always available. It is not necessary to enable a special option, such as point faults.

Fault Reference Type	Reserved Name	Comment
Rack	#RACK_000r	Where r is rack number 0 to 7.
Slot	#SLOT_0rss	Where r is rack number 0 to 7 and ss is slot number 0 to 31.
Bus	#BUS_0rssb (Genius only)	Where r is rack number 0 to 7, ss is slot number 0 to 31, and b is the bus number (0 or 1).
Module	#M_rssbmmm (Genius only)	Where r is rack number 0 to 7, ss is slot number 0 to 31, b is the bus number, and mmm is the Bus Address number 000 to 255.

These fault names do not correspond to %SA, %SB, %SC, or to any other reference type. They are mapped to a memory area that is not user-accessible. Only the name is displayed.

Fault Reference Name Examples:



#RACK_0001 represents rack 1.

#SLOT_0105 represents rack 1, slot 5.

#BUS_02041 represents rack 2, slot 4, bus 1.

#M_2061028 represents rack 2, slot 6, bus 1, Genius module 28.

Note: When a slot level failure fault is reported to the fault tables, all bus and module fault locating references associated with that slot are set (the FAULT contact passes power flow, and the NOFLT contact does not pass power flow), regardless of what type of module it is. Conversely, when a slot level reset fault is reported to the fault tables, all bus and module fault locating references are cleared (the FAULT contact does not pass power flow, and the NOFLT contact passes power flow).

Behavior of Fault Locating References

At power-up, all fault locating references are cleared in the CPU. When a fault is logged, the CPU transitions the state of the affected reference(s). The state of the fault reference remains in the fault state until one of the following actions occurs:

- Both the Controller and the I/O Fault Tables are cleared through your programming software either by clearing each table individually or clearing the entire CPU memory.
- The associated device (rack, I/O module, or Genius device) is added back into the system. Whenever an “Addition of. . .” fault is logged, the CPU initializes all fault references associated with the device to the NoFlt state. These references remain in the NoFlt state until another fault associated with the device is reported. (This could take several seconds for distributed I/O faults, especially if the bus controller has been reset.)

Note: These fault references are set for informational purposes only. They should not be used to qualify I/O data. The Alarm Contacts (described on page 549) may be used to qualify I/O data. The CPU does not halt execution as a result of setting a fault locating reference to the Fault state.

The fault references have a cascading effect. If there is a problem in the module located at rack 5, slot 6, bus 1, module 29, the following fault references are set: RACK_05, SLOT_0506, BUS_05061, and M_5061029. There will only be one entry in the fault table to describe the problem with the module. The fault table does not show separate entries pertaining to the rack, slot, and bus in this case.

If an analog base module (IC697ALG230) is lost, the fault locating reference for that module is set. The fault locating references for its expander modules (IC697ALG440 and ALG441) are not set as a result of the loss. Therefore, any fault locating references to an expander module should also reference the base module to verify that the module or its base have not been lost.

14.3.3 Using Point Faults

Point faults pertain to external I/O faults, although they are also set due to the failure of associated higher-level internal hardware (for example, IOC failure or loss of a rack). To use point faults, they must be enabled in Hardware Configuration on the Memory parameters tab of the CPU.

When enabled, a bit for each discrete I/O point and a byte for each analog I/O channel are allocated in CPU memory. The CPU memory used for point faults is included in the total reference table memory size. The FAULT and NOFLT contacts described in “Using Fault Contacts” on page 548 provide access to the point faults.

The full support of point fault contacts depends on the capability of the I/O module. Some Series 90-30 modules do not support point fault contacts. The point fault contacts for these modules remain all off, unless a Loss of I/O Module occurs, in which case the RX3i CPU turns on all point fault contacts associated with the lost module.

14.3.4 Using Alarm Contacts

High (-[HA]-) and low (-[LA]-) alarm contacts are used to represent the state of the analog input module comparator function. To use alarm contacts, point faults must first be enabled in Hardware Configuration on the Memory parameters tab of the CPU.

The following example logic uses both high and low alarm contacts.



Note: HA and LA contacts do not create an entry in a fault table.

14.4. Controller Fault Descriptions and Corrective Actions

Each fault explanation contains a fault description and instructions to correct the fault. Many fault descriptions have multiple causes. In these cases, the error code and additional fault information are used to distinguish among fault conditions sharing the same fault description.

14.4.1 Controller Fault Groups

Group	Name	Default Fault Action ³⁸	Configurable
1	Loss of or Missing Rack	Diagnostic	Yes
4	Loss of or Missing Option Module	Diagnostic	Yes
5	Addition of, or Extra Rack	N/A	No
8	Reset of, Addition of, or Extra Option Module	N/A	No
11	System Configuration Mismatch	Fatal ³⁹	Yes
12	System Bus Error	Fatal	Yes
13	CPU Hardware Failure	N/A	No
14	Module Hardware Failure	N/A	No
16	Option Module Software Failure	N/A	No
17	Program or Block Checksum Failure Group	N/A	No
18	Battery Status Group	N/A	No
19	Constant Sweep Time Exceeded	N/A	No
20	System Fault Table Full	N/A	No
21	I/O Fault Table Full	N/A	No
22	User Application Fault	N/A	No
24	CPU Over Temperature	Diagnostic	Yes
128	System Bus Failure	N/A	No
129	No User Program on Power-up	N/A	No
130	Corrupted User Program on Power-up	N/A	No
131	Window Completion Failure	N/A	No
132	Password Access Failure	N/A	No
134	Null System Configuration for Run Mode	N/A	No
135	CPU System Software Failure	N/A	No
137	Communications Failure During Store	N/A	No
140	Non-critical CPU Software Event	N/A	No

³⁸ The fault action indicated is not applicable if the fault is displayed as informational. Faults displayed as informational, always behave as informational.

³⁹ If a system configuration mismatch occurs when the CPU is in Run mode, the fault action will be Diagnostic regardless of the fault configuration. For additional information, see "Fault Parameters" in Chapter 3.

14.4.2 Loss of or Missing Rack (Group 1)

The fault group Loss of or Missing Rack occurs when the system cannot communicate with an expansion rack because the BTM (Bus Transmitter Module) in the main rack failed, the BRM (Bus Receiver Module) in the expansion rack failed, power failed in the expansion rack, or the expansion rack was configured in the configuration file but did not respond during power-up.

Default action: Diagnostic. Configurable.

1, Rack Lost

The CPU generates this error when the main rack can no longer communicate with an expansion rack. The error is generated for each expansion rack that exists in the system.

Correction

- 1) Power off the system. Verify that both the BTM and the BRM are seated properly in their respective racks and that all cables are properly connected and seated.
- 2) Replace the cables.
- 3) Replace the BRM.
- 4) Replace the BTM.

2, Rack Not Responding

The CPU generates this error when the configuration file stored from the programmer indicates that a particular expansion rack should be in the system but none responds for that rack number.

Correction

- 1) Check rack number jumper behind power supply—first on missing rack and then on all other racks—for duplicated rack numbers.
- 2) Update the configuration file if a rack should not be present.
- 3) Add the rack to the hardware configuration if a rack should be present and one is not.
- 4) Power off the system. Verify that both the BTM and the BRM are seated properly in their respective racks and that all cables are properly connected and seated.
- 5) Replace the cables.
- 6) Replace the BRM.
- 7) Replace the BTM.
- 8) Check for Termination Plug on last BRM.

14.4.3 Loss of or Missing Option Module (Group 4)

The fault group Loss of or Missing Option Module occurs when a LAN interface module, BTM, or BRM fails to respond. The failure may occur at power-up or store of configuration if the module is missing or during operation if the module fails to respond. This may also occur due to hot removal of an option module.

Default action: Diagnostic. Configurable

3C hex/60 decimal, Module in Firmware Update Mode

The CPU generates this error when it finds a module in Firmware Update mode. Modules in this mode will not communicate with the CPU.

Correction

- 1) Run the firmware update utility for the module.
- 2) Reset the module with the push-button.
- 3) Power-cycle the entire system.
- 4) Power-cycle the rack containing the module.

63 hex/99 decimal, Module Hot Removed

The CPU logs this fault when it detects hot removal of an option module such as the LAN interface module. No correction necessary

All Others, Module Failure During Configuration

The CPU generates this error when a module fails during power-up or configuration store.

Correction

- 1) Power off the system. Replace the module located in that rack and slot.
- 2) If the board is located in an expansion rack, verify BTM/BRM cable connections are tight and the modules are seated properly; verify the addressing of the expansion rack.
- 3) Replace the BTM.
- 4) Replace the BRM.
- 5) Replace the rack.

14.4.4 Addition of, or Extra Rack (Group 5)

This fault group occurs when a configured expansion rack with which the CPU could not communicate comes online or is powered on, or an unconfigured rack is found.

Action: Non-configurable.

1, Extra Rack

Correction

- 1) Check rack jumper behind power supply for correct setting.
- 2) Update the configuration file to include the expansion rack.

Note: No correction necessary if rack was just powered on.

14.4.5 Reset of, Addition of, or Extra Option Module (Group 8)

The fault group Reset of, Addition of, or Extra Option Module occurs when an option module (LAN interface module, BTM, etc.) comes online, is reset, is hot inserted or a module is found in the rack but is not configured.

Action: Non-configurable.

3, LAN Interface Restart Complete, Running Utility

The LAN Interface module has restarted and is running a utility program.

Correction

Refer to the LAN Interface manual, GFK-0868 or GFK-0869 (previously GFK-0533).

7, Extra Option Module

Note: This fault is logged for an RX3i CPE310 that is configured as a CPU310 because the RX3i system detects the embedded Ethernet module as an unconfigured module.

Correction

- 1) Update the configuration file to include the module.
- 2) Remove the module from the system.

E Hex/14 Decimal, Option Module Hot inserted

The CPU logs this fault when it detects hot insertion of an option module such as the LAN interface module. No correction necessary

Note: When configuration is cleared or stored, a reset fault is generated for every intelligent option module physically present in the system.

14.4.6 System Configuration Mismatch (Group 11)

The fault group Configuration Mismatch occurs when the module occupying a slot is different from that specified in the configuration file. When the GBC generates the mismatch because of a Genius block, the second byte in the Fault Extra Data field contains the bus address of the mismatched block.

Default action: Fatal. Configurable.

Note: If a system configuration mismatch occurs when the CPU is in Run mode, the fault action will be Diagnostic regardless of the fault configuration. For additional information, see “Fault Parameters” in Chapter 3.

2, Genius I/O Block Model Number Mismatch

The CPU generates this fault when the configured and physical Genius I/O blocks have different model numbers.

Correction

- 1) Replace the Genius I/O block with one corresponding to the configured module.
- 2) Update the configuration file.

Fault Extra Data for Genius I/O Block Model Number Mismatch

Byte	Value
[0]	FF (flag byte)
[1]	Serial Bus address
[2]	Installed module type (See “Installed/Configured Module Types” on page 556.)
[3]	Configured module type (See “Installed/Configured Module Types” on page 556.)

Installed/Configured Module Types (Bytes 2 and 3 of Fault Extra Data)

Number		Description
Decimal	Hexadecimal	
4	4	Genius Network Interface (GENI)
5	5	Phase B Hand Held Monitor
6	6	Phase B Series Six GBC with Diagnostics
7	7	Phase B Series Six GBC without Diagnostics
8	8	PLCM/Series Six
9	9	PLCM/Series 90-70
10	A	Series 90-70 Single Channel Bus Controller
11	B	Series 90-70 Dual Channel Bus Controller
12	C	Series 90-10 Genius Communications Module
13	D	Series 90-30 Genius Communications Module
32	20	High Speed Counter
69	45	Phase B 115Vac 8-point (2 amp) Grouped Block
70	46	Phase B 115Vac/125Vdc 8-point Isolated Block
70	46	Phase B 115Vac/125Vdc 8-point Isolated Block without Failed Switch
71	47	Phase B 220Vac 8-point Grouped Block
72	48	Phase B 24-48Vdc 16-point Proximity Sink Block

Number		Description
Decimal	Hexadecimal	
72	48	Phase B 24Vdc 16-point Proximity Sink Block
73	49	Phase B 24-48Vdc 16-point Source Block
73	49	Phase B 24Vdc 16-point Proximity Source Block
74	4A	Phase B 12-24Vdc 32-point Sink Block
75	4B	Phase B 12-24Vdc 32-point Source Block
76	4C	Phase B 12-24Vdc 32-point 5V Logic Block
77	4D	Phase B 115Vac 16-point Quad State Input Block
78	4E	Phase B 12-24Vdc 16-point Quad State Input Block
79	4F	Phase B 115/230Vac 16-point Normally Open Relay Block
80	50	Phase B 115/230Vac 16-point Normally Closed Relay Block
81	51	Phase B 115Vac 16-point AC Input Block
82	52	Phase B 115Vac 8-point Low-Leakage Grouped Block
127	7F	Genius Network Adapter (GENA). See "GENA Application ID Numbers" below.
131	83	Phase B 115Vac 4-input, 2-output Analog Block
132	84	Phase B 24Vdc 4-input, 2-output Analog Block
133	85	Phase B 220Vac 4-input, 2-output Analog Block
134	86	Phase B 115Vac Thermocouple Input Block
135	87	Phase B 24Vdc Thermocouple Input Block
136	88	Phase B 115Vac RTD Input Block
137	89	Phase B 24/48Vdc RTD Input Block
138	8A	Phase B 115Vac Strain Gauge/mV Analog Input Block
139	8B	Phase B 24Vdc Strain Gauge/mV Analog Input Block
140	8C	Phase B 115Vac 4-input, 2-output Current Source Analog Block
141	8D	Phase B 24Vdc 4-input, 2-output Current Source Analog Block

GENA Application ID Numbers

If the model number is 7F hex (Genius Network Adapter), the block may be one of the following. (The GENA Application ID is shown for reference.)

Number		Description
Decimal	Hexadecimal	
131	83	115Vac/230Vac/125Vdc Power Monitor Module
132	84	24/48Vdc Power Monitor Module
160	A0	Genius Remote 90-70 Rack Controller

4, I/O Type Mismatch

The CPU generates this fault when the physical and configured I/O types of Genius grouped blocks are different.

Correction

- 1) Remove the indicated Genius module and install the module indicated in the configuration file.
- 2) Update the Genius module descriptions in the configuration file to agree with what is physically installed.

Fault Extra Data for I/O Type Mismatch

Byte	Value
[0]	FF
[1]	Bus address
[2]	Installed module's I/O type
[3]	Configured module's I/O type

Genius Installed Module I/O Types (Byte 2 of Fault Extra Data)

Value	Description
01	Input only
02	Output only
03	Combination

Genius Configured Module I/O Types (Byte 3 of Fault Extra Data)

Value		Description
Decimal	Hexadecimal	
0	0	Discrete input
1	1	Discrete output
2	2	Analog input
3	3	Analog output
4	4	Discrete grouped
5	5	Analog grouped
20	14	Analog in, discrete in
21	15	Analog in, discrete out
24	18	Analog in, discrete grouped
30	1E	Analog out, discrete in
31	1F	Analog out, discrete out
34	22	Analog out, discrete grouped
50	32	Analog grouped, discrete in
51	33	Analog grouped, discrete out
54	36	Analog grouped, discrete grouped

8, Analog Expander Mismatch

The CPU generates this error when the configured and physical Analog Expander modules have different model numbers.

Correction

- 1) Replace the Analog Expander module with one corresponding to configured module.
- 2) Update the configuration file.

9, Genius I/O Block Size Mismatch

The CPU generates this error when block configuration size does not match the configured size.

Correction

Reconfigure the block.

Fault Extra Data for Genius I/O Block Size Mismatch

Byte	Value
[0]	FF
[1]	Bus address
[2]	Module's broadcast data length
[3]	Configured module's broadcast data length

A hex/10 decimal, Unsupported Feature

Configured feature not supported by this revision of the module.

Correction

- 1) Update the module to a revision that supports the feature.
- 2) Change the module configuration.

Fault Extra Data for Unsupported Feature

Byte	Value
[8]	Contains a reason code indicating what feature is not supported. 0x5 – GBC revision too old 0x6 – Only supported in main rack

E hex/14 decimal, LAN Duplicate MAC Address

This LAN Interface module has the same MAC address as another device on the LAN. The module is off the network.

Correction

- 1) Change the module's MAC address.
- 2) Change the other device's MAC address.

F hex/15 decimal, LAN Duplicate MAC Address Resolved

Previous duplicate MAC address has been resolved. The module is back on the network. This is an informational message. No correction required.

10 hex/16 decimal, LAN MAC Address Mismatch

MAC address programmed by softswitch utility does not match configuration stored from software.

Correction

Change MAC address on softswitch utility or in software.

11 hex/17 decimal, LAN Softswitch/Modem mismatch

Configuration of LAN module does not match modem type or configuration programmed by softswitch utility.

Correction

- 1) Correct configuration of modem type.
- 2) Consult LAN Interface manual for configuration setup.

13 hex/19 decimal, DCD Length Mismatch

Directed control data lengths do not match.

Correction

See Fault Extra Data.

Fault Extra Data for DCD Length Mismatch

Byte	Value
[0]	FF
[1]	Bus address
[2]	Module's directed data length
[3]	Configured module's directed data length

25 hex/37 decimal, Controller Reference Out-of-Range

A reference on either the trigger, disable, or I/O specification is out of the configured limits.

Correction

Modify the incorrect reference to be within range, or increase the configured size of the reference data.

26 hex/38 decimal, Bad Program Specification

The I/O specification of a program is corrupted.

Correction

Contact Technical Support.

27 hex/39 decimal, Unresolved or Disabled Interrupt Reference

The CPU generates this error when an interrupt trigger reference is either out of range or disabled in the I/O module's configuration.

Correction

- 1) Remove or correct the interrupt trigger reference.
- 2) Update the configuration file to enable this particular interrupt.

43 hex/67 decimal, Module Configuration Failure

Module configuration was not successfully accepted by the module.

Correction

Check fault table for other module-specific faults for possible reasons why the module did not accept the configuration. Check that the configuration for the module is correct and valid.

4B hex/75 decimal, ECC jumper is disabled, but should be enabled

If the CPU redundancy feature is supported and required, the ECC jumper must be in the enabled position.

Correction

Set the ECC jumper to the enabled position. (See the instructions provided with the Redundancy CPU firmware upgrade kit).

4C hex/76 decimal, ECC jumper is enabled, but should be disabled

If the CPU firmware does not support redundancy, the ECC jumper must be in the disabled position.

Correction

Set the ECC jumper to the disabled position (jumper on one pin or removed entirely).

All Others, Module and Configuration do not Match

The CPU generates this fault when the module occupying a slot is not of the same type that the configuration file indicates.

Correction

- 1) Replace the module in the slot with the type indicated in the configuration file.
- 2) Update the configuration file.

14.4.7 System Bus Error (Group 12)

The fault group System Bus Error occurs when the CPU encounters a bus error.

Default action: Diagnostic. Configurable.

4, Unrecognized VME Interrupt Source

The CPU generates this error when a module generates an interrupt not expected by the CPU (unconfigured or unrecognized).

Correction

Ensure that all modules configured for interrupts have corresponding interrupt declarations in the program logic.

14.4.8 CPU Hardware Failure (Group 13)

The fault group CPU Hardware occurs when the CPU detects a hardware failure, such as a RAM failure or a communications port failure.

When a CPU Hardware failure occurs, the OK LED will flash on and off to indicate that the failure was not serious enough to prevent Controller Communications to retrieve the fault information.

Action: Non-configurable.

6E hex/110 decimal, Time-of-Day Clock not Battery-Backed

The battery-backed value of the time-of-day clock has been lost.

Correction

- 1) Replace the battery. Do not remove power from the main rack until replacement is complete. Reset the time-of-day clock using your programming software.
- 2) Replace the module.

0A8 hex/168 decimal, Critical Over-Temperature Failure

CPU's critical operating temperature exceeded.

All Others

Correction

Replace the module.

Fault Extra Data for CPU Hardware Failure

For a RAM failure in the CPU (one of the faults reported as a CPU hardware failure), the address of the failure is stored in the first four bytes of the field.

14.4.9 Module Hardware Failure (Group 14)

The fault group Module Hardware Failure occurs when the CPU detects a non-fatal hardware failure on any module in the system, for example, a serial port failure on a LAN interface module. The fault action for this group is Diagnostic.

Action: Non-configurable.

1A0 hex/416 decimal, Missing 12 Volt Power Supply

A power supply that supplies 12 volts is required to operate the LAN Interface module.

Correction

- 1) Install/replace a 100 watt power supply.
- 2) Connect an external VME power supply that supplies 12 volts.

1C2 - 1C6 hex (450 - 454 decimal), LAN Interface Hardware Failure

Refer to the LAN Interface manual, GFK-0868 or GFK-0869 (previously GFK-0533), for a description of these errors.

All Others, Module Hardware Failure

A module hardware failure has been detected.

Correction

Replace the affected module.

14.4.10 Option Module Software Failure (Group 16)

The fault group Option Module Software Failure occurs when:

- A non-recoverable software failure occurs on an intelligent option module.
- The module type is not a supported type.
- The Ethernet Interface logs an event in its Ethernet exception log.

Action: Non-configurable.

1, Unsupported Board Type

The board is not one of the supported types.

Correction

- 1) Upload the configuration file and verify that the software recognizes the board type in the file. If there is an error, correct it, download the corrected configuration file, and retry.
- 2) Display the Controller Fault Table on the programmer. Contact Technical Support, giving them all the information contained in the fault entry.

2, 3, COMMREQ Frequency Too High

COMMREQs are being sent to a module faster than it can process them.

Correction

Change the application program to send COMMREQs to the module at a slower rate or check the completion status of each COMMREQ before sending the next.

4, More Than One BTM in a Rack

There is more than one BTM present in the rack.

Correction

Remove one of the BTMs from the rack; there can only be one in a CPU rack.

>4, Option Module Software Failure

Software failure detected on an option module.

Correction

- 1) Reload software into the indicated module.
- 2) Replace the module.

>400, LAN System Software Fault

The Ethernet interface software has detected an unusual condition and recorded an event in its exception log. The Fault Extra Data contains the corresponding event in the Ethernet exception log, which can be viewed by the Ethernet Interface's Station Manager function. The first two digits of Fault Extra Data contain the Event type; the remaining data correspond to the four-digit values for Entry 2 through Entry 6. Some exceptions may also contain optional multi-byte SCode and other data.

Correction

For information on interpreting the fault extra data, refer to the *PACSystems TCP/IP Communications Station Manager Manual*, GFK-2225, Appendix B.

14.4.11 Program or Block Checksum Failure (Group 17)

The fault group Program or Block Checksum Failure occurs when the CPU detects error conditions in program or blocks. It also occurs during Run mode background checking. In all cases, the Fault Extra Data field of the Controller Fault Table record contains the name of the program or block in which the error occurred.

Action: Non-configurable.

All Error Codes, Program or Block Checksum Failure

The CPU generates this error when a program or block is corrupted.

Correction

- 1) Clear CPU memory and retry the store.
- 2) Examine C application for errors.
- 3) Display the Controller Fault Table on the programmer. Contact Technical Support, giving them all the information contained in the fault entry.

Fault Extra Data for Program or Block Checksum Failure

The name of the offending program block is contained in the first eight bytes of the Fault Extra Data field.

14.4.12 Battery Status (Group 18)

Faults in this group occur when the CPU detects a failed battery (or Energy Pack).

Action: Non-configurable.

0, Failed Battery

CPUs with battery-backed RAM, including RX7i CPUs, and RX3i CPU310, CPU315, CPU/CRU320 and NIU001

The battery in the CPU module has failed or is disconnected.

If the battery is disconnected, this fault is logged for all CPU types and all supported battery types.

Should a Smart Battery fail during operation, this fault is logged for all CPU types. When used with a legacy (non-smart) battery, this indication is not reliable.

CPE305 and CPE310

The Energy Pack has failed or is disconnected.

Correction

Replace the battery or Energy Pack. For instructions on replacing the battery, refer to the *PACSystems Battery and Energy Pack Manual*, GFK-2741.

1, Low Battery – CPUs with Battery-Backed RAM

This fault is supported only by the CPU versions listed in the *PACSystems Battery and Energy Pack Manual*, GFK-2741.

The CPU detects the low battery condition only while the CPU is powered up.

If a low battery condition occurs while the CPU is powered down, the CPU logs a Low Battery fault upon power-up as soon as it detects the signal from the smart battery.

While the CPU is powered up, it is unlikely that a Low Battery fault will be detected because the current drain on the battery is negligible. The exception is when a good battery is replaced with a low battery while the CPU has power. In this case, a Low Battery fault would indicate that a good battery has been accidentally replaced with a depleted battery.

The Controller fault table indicates the battery status. For details of LED operation of specific CPUs, refer to Chapter 2.

When a Failed Battery fault is logged, this fault is also logged.

Correction

Replace the battery. For instructions on replacing the battery, refer to the *PACSystems Battery and Energy Pack Manual*, GFK-2741.

1, Low Battery – CPE3xx CPUs with Energy Pack

The Status LED and the Controller fault table indicate the Energy Pack status.

PLC_BAT (%S0014)	LOW_BAT (%SA0011)	Energy Pack Status
0	0	Energy Pack connected and operational (may be charging)
1	1	Energy Pack not connected or has failed
0	1	Energy Pack is nearing its end-of-life and should be replaced.

14.4.13 Constant Sweep Time Exceeded (Group 19)

The fault group Constant Sweep Exceeded occurs when the CPU operates in Constant Sweep mode and detects that the sweep has exceeded the constant sweep timer. In the fault extra data, the DWORD at byte offset 8 contains the amount of time that the sweep went beyond the constant sweep time (in microsecond units). Stored in Big Endian format.

Action: Non-configurable.

0, Constant Sweep

Correction

If Constant Sweep (0):

- 1) Increase constant sweep time.
- 2) Remove logic from application program.

Note: Error code 1 is not used.

14.4.14 System Fault Table Full (Group 20)

The fault group System Fault Table Full occurs when the Controller Fault Table reaches its limit (see page 540).

Action: Non-configurable.

0, System Fault Table Full

Correction

Clear the Controller Fault Table.

14.4.15 I/O Fault Table Full (Group 21)

The fault group I/O Fault Table Full occurs when the I/O Fault Table reaches its maximum configured limit (see page 542). To avoid loss of additional faults, clear the earliest entry from the table.

Action: Non-configurable.

0, I/O Fault Table Full

Correction

Clear the I/O Fault Table.

14.4.16 User Application Fault⁴⁰ (Group 22)

The fault group Application Fault occurs when the CPU detects a fault in the user program.

Action: Non-configurable.

2, Software Watchdog Timer Expired

The CPU generates this error when the watchdog timer expires. The CPU stops executing the user program and enters Stop/Halt mode. To recover, cycle power to the CPU with battery disconnected. Causes of timer expiration include: Looping, via jump, very long program, etc.

Correction

- 1) Determine what caused the expiration (logic execution, external event, etc.) and correct.
- 2) Use the system service function block to restart the watchdog timer.

7, Application Stack Overflow

Block call depth has exceeded the CPU capability.

Correction

Increase the program's stack size or adjust application program to reduce nesting.

11 hex/17 decimal, Program Run Time Error

A run-time error occurred during execution of a program.

Correction

Correct the specific problem in the application.

22 hex/34 decimal, Unsupported Protocol

Hardware does not support configured protocol.

33 hex/51 decimal, Flash Read Failed

Possible causes:

- 1) Files not in flash. (May be caused by power cycle during flash write.)
- 2) Could not read from flash because OEM protection is enabled.

34 hex/52 decimal, Memory Reference Out of Range

A user logic memory reference, computed during logic execution, is out of range. Includes indirect references, array element references, and potentially other types of references.

Correction

Correct logic or adjust memory size in hardware configuration.

35 hex/53 decimal, Divide by zero attempted in user logic.

User logic contained a divide by zero operation. (Applies to ST and FBD logic.)

Correction

Correct logic.

⁴⁰ Error Codes 1, 4, 5, 6, 8-15, 28, 29 and 49 are not used by PACs.

36 hex/54 decimal, Operand is not byte aligned.

A variable in user logic is not properly byte-aligned for the requested operation.

Correction

Correct logic or adjust memory size in hardware configuration.

39 hex/57 decimal, DLB heartbeat not received, All DLBs stopped and deleted

The controller has not received a heartbeat signal from the programmer within the time specified by the DLB Heartbeat setting in the Target properties.

Correction

Increase the DLB Heartbeat setting. For additional information, see “Executing DLBs” on page 614.

3B hex /59 decimal, PSB called by a block whose %L or %P memory is not large enough to accommodate this reference.

Parameterized blocks do not have their own %L data, but instead inherit the %L data of their calling blocks. If %L references are used within a parameterized block and the block is called by `_MAIN`, %L references are inherited from the %P references wherever encountered in the parameterized block (for example, `%L0005 = %P0005`). For a discussion of the use of local data with parameterized blocks, refer to “Parameterized Blocks and Local Data” in Chapter 5.

Correction

Determine which block called the parameterized subroutine block and increase the size of %L or %P memory allocated to the calling block. (To do this, change the Extra Local Words setting in the block’s Properties.)

The maximum size of %L or %P is 8192 words per block. If your application needs more space, consider changing some %P or %L references to %R, %W, %AI, or %AQ. These changes require a recompilation of the program block and a Stop Mode store to the CPU.

It is possible, by using Online Editing in the programming software to cause a parameterized block to use %L higher than allowed because of the way it inherits data. To correct this condition, delete the %L variables from the logic and then remove the unused variables from the variable list. These changes require a recompilation of the program block and a Stop Mode store to the CPU.

14.4.17 CPU Over-Temperature (Group 24)

Default action: Diagnostic. Configurable.

1, Over-Temperature failure.

CPU's normal operating temperature exceeded.

Correction

Turn off CPU to allow heat to disperse and install a fan kit to regulate temperature.

14.4.18 Power Supply Fault (Group 25)

Action: Non-configurable.

1, Power supply failure.

Unknown power supply failure.

Correction

Replace power supply module.

2, Power supply overloaded

The load on the power supply has reached its rated maximum

Correction

Replace power supply with a higher capacity model or reconfigure system to reduce load on power supply.

3, Power supply switched off

The switch on the power supply was moved to the OFF position.

4, Power-supply has exceeded normal operating temperature

The temperature of the power supply is a just a few degrees from causing it to turn off.

Correction

Turn off system to allow heat to disperse. Install a fan kit to regulate temperature.

14.4.19 No User Program on Power-Up (Group 129)

The fault group No User Program on Power-Up occurs when the CPU powers up with its memory preserved but no user program exists in the CPU. The CPU detects the absence of a user program on power-up; the controller stays in Stop mode.

Action: Non-configurable.

Correction

Download an application program before attempting to go to Run mode.

14.4.20 Corrupted User Program on Power-Up (Group 130)

The fault group Corrupted User Program on Power-Up occurs when the CPU detects corrupted user RAM. The CPU will remain in Stop mode.

Action: Non-configurable.

1, Corrupted user RAM on power-up

The CPU generates this error when it detects corrupted user RAM on power-up.

Recommended Corrections, Listed in Order

- 1) Cycle power without battery or Energy Pack.
- 2) Examine any C applications for errors.
- 3) Replace the volatile memory backup battery on the CPU.
- 4) Replace the CPU.

7, User memory not preserved over power cycle

The CPU generates this error when it detects a battery failure that occurred while the controller was powered down.

If this fault occurs on a power cycle when the battery was not detached or replaced, the battery has failed and should be replaced.

Correction

Replace the battery on the CPU. For instructions on replacing the battery, refer to the *PACSystems Battery and Energy Pack Manual*, GFK-2741.

14.4.21 Window Completion Failure (Group 131)

The fault group Window Completion Failure is generated by the pre-logic and end-of-sweep processing software in the CPU. The fault extra data contains the name of the task that was executing when the error occurred.

Action: Non-configurable.

0, Window Completion Failure

The CPU generates this error when it is operating in Constant Sweep mode and the constant sweep time was exceeded before the programmer window had a chance to begin executing.

Correction

Increase the constant sweep timer value.

1, Logic Window Skipped

The logic window was skipped due to lack of time to execute.

Correction

- 1) Increase base cycle time.
- 2) Reduce Communications Window time.

14.4.22 Password Access Failure (Group 132)

The fault group Password Access Failure occurs when the CPU receives a request to change to a new privilege level and the password included with the request is not valid for that level.

Action: Non-configurable.

0, Password Access Failure

Correction

Retry the request with the correct password.

14.4.23 Null System Configuration for Run Mode (Group 134)

The fault group Null System Configuration for Run Mode occurs when the CPU transitions from Stop to one of the Run modes and a configuration file is not present. The transition to Run is permitted, but no I/O scans occur.

Action: Informational. Non-configurable.

0, Null System Configuration for Run Mode

Correction

Download a configuration file.

14.4.24 CPU System Software Failure (Group 135)

Faults in this group are generated by the operating software of the CPU. They occur at many different points of system operation. When a fatal fault occurs, the CPU immediately transitions to Stop/Halt. The only activity permitted when the CPU is in this mode is communications with the programmer. The only method of clearing this condition is to cycle power on the controller with the battery disconnected.

Action: Non-configurable.

5A hex/90 decimal, User Shut Down Requested

The CPU generates this informational alarm when SVC_REQ #13 (User Shut Down) executes in the application program.

Correction

None required. Information-only alarm.

94 hex/148 decimal, Units Contain Mismatched Firmware, Update Recommended

This fault is logged each time the redundancy state changes and the redundant CPUs contain incompatible firmware.

Correction

Ensure that redundant CPUs have compatible firmware.

D8 hex/216 decimal, Processor Exception Trap

The processor has detected an error condition while executing an instruction. The CPU was placed into Stop/Halt mode.

Correction

Disconnect the battery from the CPU and cycle power to clear the Stop/Halt condition.

DA hex/218 decimal, Critical Over-Temperature Failure

CPU's critical operating temperature exceeded.

Correction

Turn off CPU to allow heat to disperse and install a fan kit to regulate temperature.

All Others, CPU Internal System Error

An internal system error has occurred that should **not** occur in a production system.

Correction

Display the Controller Fault Table on the programmer. Contact Technical Support and give them all the information contained in the fault entry.

Error	Fault Extra Data Value (First Byte)	Description
DEVICE_NOT_AVAILABLE	CF	Specific device is not available in the system.
BAD_DEVICE_DATA	CC	Data stored on device has been corrupted and is no longer reliable. Or, Flash Memory has not been initialized.
DEVICE_RW_ERROR	CB	Error occurred during a read/write of the Flash Memory device.
FLASH_INCOMPAT_ERROR	8E	Data in Flash Memory is incompatible with the CPU firmware release due to the CPU firmware revision numbers, the instruction groups supported, or the CPU model number.
ITEM_NOT_FOUND_ERROR	8D	One or more specified items were not found in Flash Memory.

14.4.25 Communications Failure During Store (Group 137)

This fault group occurs during the store of programs or blocks and other data to the CPU. The stream of commands and data for storing programs or blocks and data starts with a special start-of-sequence command and terminates with an end-of-sequence command. This fault is logged if communications with the programming device performing the store is interrupted or any other failure that terminates the store occurs. As long as this fault is present in the system, the controller will not transition to Run mode. This fault is *not* automatically cleared on power-up; you must specifically clear the condition.

Action: Non-configurable.

0, Communications Failure During Store

Correction

Clear the fault and retry the download of the program or configuration file.

1, Communications Lost During Run Mode Store

Communications or power was lost during a Run Mode Store. The new program or block was not activated and was deleted.

Correction

Perform the Run Mode Store again. This fault is diagnostic.

2, Communications Lost During Cleanup for Run Mode Store

Communications was lost, or power was lost during the cleanup of old programs or blocks during a Run Mode Store. The new program or block is installed, and the remaining programs and blocks were cleaned up.

Correction

None required. This fault is informational.

3, Power Lost During a Run Mode Store

Power was lost in the middle of a Run Mode Store.

Correction

Delete and restore the program. This error is fatal.

14.4.26 Non-Critical CPU Software Event (Group 140)

This group is used for recording conditions in the system that may provide valuable information to Technical Support.

Default action: Non-configurable.

Error Code	Description	Correction
1-30	Events during power-up	No corrective action is required unless this fault occurs with other specific faults. The fault may contain useful information for Technical Support if other problems are encountered.
31-50	Events on the serial port or in a serial protocol	
51, 52	Miscellaneous internal system events	
53	Access control fault	See details below.
54 and greater	Miscellaneous internal system events	No corrective action is required unless this fault occurs with other specific faults. The fault may contain useful information for Technical Support if other problems are encountered.

Error code 53, Access Control Fault

If data access is prevented because of the Enhanced Security settings, the Controller logs a fault into the fault table. This fault can be used to help diagnose access problems. To prevent overflowing the fault table, only one fault is logged until the fault table is cleared.

Fault example

Location: 0.8 Date/Time: 07-07-2013 17:06:55.087

Group: 140 INFO_CPU_SOFTWR - CPU software event

Error Code: 53 Action:1 Task Num:3

Extra Data: 00 fa 02 a5 00 00 00 00 01 1e 06 00 00 00 00 00 00 00 01 00 00 00 00 00

Meaning of this example fault

A 1-bit READ request beginning at %S7 was rejected due to an access violation.

Interpreting the Fault Extra Data

- Bytes 1 - 8: Ignored when decoding a security-related fault.
- Byte 9: The operation during which the fault occurred.
 - 01 (as in the example): Read
 - 02: Write
- Byte 10: The hexadecimal value (HV) that specifies a CPU memory area.

Hexadecimal Value (HV)	Memory area
08	%R (Register memory)
0A	%AI (Analog input memory)
0C	%AQ (Analog output memory)
10	%I (Discrete input memory)
12	%Q (Discrete output memory)
14	%T (Discrete temporary status memory)
16	%M (Discrete momentary internal memory)
18	%SA (Discrete system memory A)
1A	%SB (Discrete system memory B)
1C	%SC (Discrete system memory C)
1E	%S (Discrete system memory)
38	%G (Genius global memory)
C4	%W (Bulk Memory)

- Bytes 11–18: 0-based bit offset of the memory area being accessed. The 8-byte value is encoded in little endian format, meaning that the byte values are reversed. In the example, the value is 0x0000000000000006, which is equal to 1-based bit offset 7.
- Bytes 19–22: The length in bits of data requested. In the example, 1 bit was requested.
- Bytes 23–24: Ignored when decoding a security-related fault.

14.5. I/O Fault Descriptions and Corrective Actions

The I/O fault table reports the following data about faults:

- Fault Group
- Fault Action
- Fault category
- Fault type
- Fault description

All faults have a fault category, but a fault type and fault group may not be listed for every fault. To view the detailed information pertaining to a fault, click the fault entry in the I/O Fault Table.

Note: The model number mismatch and I/O type mismatch faults are reported in the controller fault table under the System Configuration Mismatch group. They are not reported in the I/O fault table.

14.5.1 Fault Extra Data

An I/O fault table entry contains up to 21 bytes of I/O fault extra data that contains additional information related to the fault. Not all entries contain I/O fault extra data.

14.5.2 I/O Fault Groups

Group Number	Group Name	Default Fault Action	Configurable
2	Loss of or Missing IOC	Diagnostic	Yes
3	Loss of or Missing I/O module or network Device	Diagnostic	Yes
6	Addition or Reset of, or Extra IOC	N/A	No
7	Addition of or Extra I/O module or network Device	N/A	No
9	IOC or I/O Bus Fault	Diagnostic	Yes
10	I/O Module Fault	N/A	No
15	IOC Software Failure	Same As Group 2 ⁴¹	Yes
16	Module Software Failure	N/A	No
28	PROFINET Alarms	Diagnostic	No
133	Genius Block Address Mismatch	N/A	No

⁴¹ The fault action for the IOC Software Failure group 15 always matches the action used by the Loss of or Missing IOC group 2. If the Loss of or Missing IOC group is configured, the IOC Software Failure group is also configured to take the same fault action.

14.5.3 I/O Fault Categories

Category	Fault Type	Fault Description	Fault Extra Data
Circuit Fault (1)	Discrete Fault (1)	Loss of User Side Power (01 hex)	Circuit Configuration
		Short Circuit in User Wiring (02 hex)	Circuit Configuration
		Sustained Overcurrent (04 hex)	Circuit Configuration
		Low or No Current Flow (08 hex)	Circuit Configuration
		Switch Temperature Too High (10 hex)	Circuit Configuration
		Switch Failure (20 hex)	Circuit Configuration
		Point Fault (83 hex)	Circuit Configuration
		Output Fuse Blown (84 hex)	Circuit Configuration
	Analog Fault (2)	Input Channel Low Alarm (01 hex)	Circuit Configuration
		Input Channel High Alarm (02 hex)	Circuit Configuration
		Input Channel Under Range (04 hex)	Circuit Configuration
		Input Channel Over Range (08 hex)	Circuit Configuration
		Input Channel Open Wire (10 hex)	Circuit Configuration
		Over Range or Open Wire (18 hex)	Circuit Configuration
		Output Channel Under Range (20 hex)	Circuit Configuration
		Output Channel Over Range (40 hex)	Circuit Configuration
		Expansion Channel Not Responding (80 hex)	Circuit Configuration
		Invalid Data (81 hex)	Circuit Configuration
	Low-Level Analog Fault (4)	Input Channel Low Alarm (01 hex)	Circuit Configuration
		Input Channel High Alarm (02 hex)	Circuit Configuration
		Input Channel Under Range (04 hex)	Circuit Configuration
		Input Channel Over Range (08 hex)	Circuit Configuration
		Input Channel Open Wire (10 hex)	Circuit Configuration
		Wiring Error (20 hex)	Circuit Configuration
		Internal Fault (40 hex)	Circuit Configuration
		Input Channel Shorted (80 hex)	Circuit Configuration
		Invalid Data (81 hex)	Circuit Configuration
	GENA (Genius Network Adapter) Fault (3)	GENA Circuit Fault (80 hex)	Byte 2:GENA Fault

Category	Fault Type	Fault Description	Fault Extra Data
Loss of Block (2)	Not Specified (0) A/D Communications Lost (1)	NA	Block Configuration Number of Input Circuits Number of Output Circuits
Addition of Block (3)	NA	NA	Block Configuration Number of Input Circuits Number of Output Circuits
I/O Bus Fault (6)	Bus Fault (1) Bus Outputs Disabled (2) SBA Conflict (3)	NA	NA
Genius Module Fault (8)	Headend Fault (0) A to D Comm. Fault (1) User Scaling Error (5) Store Fail (6)	Configuration Memory Failure (08 hex) Calibration Memory Failure (20 hex) Shared RAM Failure (40 hex) Internal Circuit Fault (80 hex) Watchdog Timeout (81 hex) Output Fuse Blown (84 hex)	NA
Addition of IOC (9)	NA	Extra Module (01 hex) Reset Request (02 hex)	NA
Loss of IOC (10)	NA	NA	Timeout Unexpected State Unexpected Mail Status VME Bus Error
IOC Software Fault (11)	NA	NA	NA
Forced Circuit (12)	NA	NA	Block Configuration Discrete/Analog Indication*
Unforced Circuit (13)	NA	NA	Block Configuration Discrete/Analog Indication*
Loss of I/O Module (14)	NA	NA	NA
Addition of I/O Module (15)	NA	VME Module Reset Requested (30 hex)	NA
Extra I/O Module (16)	NA	NA	NA
Extra Block (17)	NA	NA	NA
IOC Hardware Failure (18)	NA	NA	NA

Category	Fault Type	Fault Description	Fault Extra Data
GBC stopped reporting faults because too many faults have occurred (19)	GBC detected high error count on Genius Bus and dropped off the bus for at least 1.5 seconds. (1)	NA	NA
GBC Software Exception (21)	Datagram queue full (1) R/W request queue full (2) Low priority mail rejected (3) Background message received before CPU completed initialization (4) Genius software version too old (5) Excessive use of internal GBC memory (6)	NA	
Block Switch (22) – redundant Genius block switched bus	NA	NA	Block Configuration Number of Input Circuits Number of Output Circuits Rack/Slot address of GBC from which block was removed.
Block not active on redundant bus (23)	NA	NA	NA
Reset of IOC (27)	NA	NA	NA
PROFINET network faults (33 and higher)	NA	Refer to PROFINET controller documentation.	NA

14.5.4 Circuit Faults (Category 1)

Circuit faults apply to Genius I/O modules and the IC697VRD008 RTD/Strain Bridge modules. Fault extra data is available for all faults in this category. More than one condition may be present in a particular reporting of the fault.

Action: Diagnostic.

Fault Extra Data for Circuit Faults

Genius Bus Controller

Circuit fault entries use one or two bytes of the fault extra data area. If the GBC reports the fault, the first byte is generated by the GBC and the second byte contains the circuit configuration and is encoded as shown in the following table.

Value (Byte 2)	Description
1	Circuit is an input.
2	Circuit is an input.
3	Circuit is an output.

If the fault type is a GENA fault, the second byte contains the data that was reported from the GENA module in fault byte 2 of its "Report Fault" message.

VRD001 RTD/Strain Bridge

Circuit fault entries 13 bytes of the fault extra data area. The fault extra data is encoded as shown in the following table.

Bytes	Description
1-10	Used by technical support.
11	Line number
12	Module number
13	Used by technical support.

Fault Descriptions for Discrete Faults

1, Loss of User Side Power

The GBC generates this error when there is a power loss on the field wiring side of a Genius I/O block.

Correction

- 1) (Only valid for Isolated I/O blocks.) Initiate "Pulse Test" COMREQ #1. Pulse test may be enabled or disabled at I/O block.
- 2) Correct the power failure.

2, Short Circuit in User Wiring

The GBC generates this error when it detects a short circuit in the user wiring of a Genius block. A short circuit is defined as a current level greater than 20 amps.

Correction

Fix the cause of the short circuit.

4, Sustained Overcurrent

The GBC generates this error when it detects a sustained current level greater than 2 amps in the user wiring.

Correction

Fix the cause of the over current.

8, Low or No Current Flow

The GBC generates this error when there is very low or no current flow in the user circuit.

Correction

Fix the cause of the condition.

10 hex, Switch Temperature Too High

The GBC generates this error when the Genius block reports a high temperature in the Genius Smart Switch.

Correction

- 1) Ensure that the block is installed to provide adequate circulation.
- 2) Decrease the ambient temperature surrounding the block.
- 3) Install RC Snubbers on inductive loads.

20 hex, Switch Failure

The GBC generates this error when the Genius block reports a failure in the Genius Smart Switch.

Correction

- 1) Check for shunts across Genius output (pushbuttons).
- 2) Replace the Genius I/O block.

83 hex, Point Fault

The CPU generates this error when it detects a failure of a single I/O point on a Genius I/O module.

Correction

Replace the Genius I/O block.

84 hex, Output Fuse Blown

The CPU generates this error when it detects a blown fuse on a Genius I/O output block.

Correction

- 1) Determine and repair the cause of the fuse blowing; replace the fuse.
- 2) Replace the block.

Fault Descriptions for Analog Faults**1, Input Channel Low Alarm**

The GBC generates this error when the Genius Analog module reports a low alarm on an input channel.

Correction

Correct the condition causing the low alarm.

2, Input Channel High Alarm

The GBC generates this error when the Genius Analog module reports a high alarm on an input channel.

Correction

Correct the condition causing the high alarm.

4, Input Channel Under Range

The GBC generates this error when the Genius Analog module reports an under-range condition on an input channel.

Correction

Correct the problem causing the condition.

8, Input Channel Over Range

The GBC generates this error when the Genius Analog module reports an over-range condition on an input channel.

Correction

Correct the problem causing the condition.

10 hex/16 decimal, Input Channel Open Wire

The GBC generates this error when a Genius Analog module detects an open wire condition on an input channel.

Correction

Correct the problem causing the condition.

18 hex/24 decimal, Over Range or Open Wire

Inputs open or inputs off-scale.

Correction

Correct the problem causing the condition.

20 hex/32 decimal, Output Channel Under Range

The GBC generates this error when the Genius Analog module reports an under-range condition on an output channel.

Correction

Correct the problem causing the condition.

40 hex/64 decimal, Output Channel Over Range

The GBC generates this error when the Genius Analog module reports an over-range condition on an output channel.

Correction

Correct the problem causing the condition.

80 hex/128 decimal, Expansion Channel Not Responding

The CPU generates this error when data from an expansion channel on a multiplexed analog input board is not responding.

Correction

- 1) Check wiring to the module.
- 2) Replace the module.

81 hex/129 decimal, Invalid Data

The GBC generates this error when it detects invalid data from a Genius Analog input block.

Correction

Correct the problem causing the condition.

Low-Level Analog Faults

1, Input Channel Low Alarm

The GBC generates this error when the Genius Analog module reports a low alarm on an input channel.

Correction

Correct the condition causing the low alarm.

2, Input Channel High Alarm

The GBC generates this error when the Genius Analog module reports a high alarm on an input channel.

Correction

Correct the condition causing the high alarm.

4, Input Channel Under Range

The GBC generates this error when the Genius Analog module reports an under-range condition on an input channel.

Correction

Correct the problem causing the condition.

8, Input Channel Over Range

The GBC generates this error when the Genius Analog module reports an over-range condition on an input channel.

Correction

Correct the problem causing the condition.

10 hex, Input Channel Open Wire

The GBC generates this error when the Genius Analog module detects an open wire condition on an input channel.

Correction

Correct the problem causing the condition.

20 hex/32 decimal, Wiring Error

The GBC generates this error when the Genius Analog module detects an improper RTD connection or thermocouple reverse junction fault.

Correction

Correct the problem causing the condition.

40 hex/64 decimal, Internal Fault

The GBC generates this error when the Genius Analog module reports a cold junction sensor fault on a thermocouple block or an internal error in an RTD block.

Correction

Correct the problem causing the condition.

80 hex/128 decimal, Input Channel Shorted

The GBC generates this error when it detects an input channel shorted on a Genius RTD or Strain Gauge Block.

Correction

Correct the problem causing the condition.

81 hex/129 decimal, Invalid Data

The GBC generates this error when it detects invalid data from a Genius Analog input block.

Correction

Correct the problem causing the condition.

GENA Fault

The GENA Fault has no fault descriptions associated with it. GENA Fault Byte 2 is the first byte of the fault extra data.

80 hex/128 decimal

The Genius I/O operating software generates this error when it detects a failure in a GENA block attached to the Genius I/O bus.

Correction

Replace the GENA block.

14.5.5 Loss of Block (Category 2)

The fault category Loss of Block applies to Genius devices.

Action: Diagnostic.

Loss of Block

The GBC generates this error when it is unable to communicate to the Genius device.

Correction

- 1) Verify power and wiring to the block.
- 2) Replace the block.

Loss of Block - A/D Communications Fault

The GBC generates this error when it detects a failure of A/D communications on a Genius device.

Correction

- 1) Verify power and serial bus wiring to the block.
- 2) Replace the block.

Fault Extra Data for Loss of Block

The Loss of Block fault provides four bytes of fault extra data. The second byte contains the block configuration and is encoded as shown in the following table. The third byte specifies the number of input circuits possibly used, and the fourth byte specifies the number of output circuits possibly used.

Block Configuration (Byte 2)

Value	Description
1	Block is configured for inputs only.
2	Block is configured for outputs only.
3	Block is configured for inputs and outputs (grouped block).

14.5.6 Addition of Block (Category 3)

The fault category Addition of Block applies only to Genius devices. There are no fault types or fault descriptions associated with this category.

The Genius operating software generates this error when it detects that a Genius block that stopped communicating with the controller starts communicating again.

Action: Diagnostic.

Correction

Informational only. None required.

Fault Extra Data for Addition of Block

The Addition of Block fault provides four bytes of fault extra data. The second byte contains the block configuration and is encoded as shown in the following table. The third byte specifies the number of input circuits possibly used, and the fourth byte specifies the number of output circuits possibly used.

Block Configuration (Byte 2)

Value	Description
1	Block is configured for inputs only.
2	Block is configured for outputs only.
3	Block is configured for inputs and outputs (grouped block).

14.5.7 I/O Bus Fault (Category 6)

The fault category I/O Bus Faults has three fault types associated with it.

Default action: Diagnostic. Configurable.

Bus Fault

The GBC operating software generates this error when it detects a failure with a Genius I/O bus. (Generated when Error Rate in the GBC configuration is exceeded—the default Error Rate is 10 errors in a 10 second period).

Correction

- 1) Determine the reason for the bus failure and correct it.
- 2) Replace the GBC.

The Error Rate can be set higher than the default value if needed, but the bus should be examined electrically—use an oscilloscope for waveform check.

Bus Outputs Disabled

The GBC operating software generates this error when it times out waiting for the CPU to perform an output scan.

Correction

- 1) Reduce time between GBC output scans by assigning them to scan set 1.
- 2) Increase CPU software watchdog timer setting
- 3) Replace the CPU.
- 4) Display the controller fault table on the programmer. Contact Technical Support, giving them all the information contained in the fault entry.

SBA Conflict

The GBC detected a conflict between its serial bus address and that of another device on the bus.

Correction

Adjust one of the conflicting serial bus addresses.

14.5.8 Module Fault (Category 8)

The fault category Module Fault has one fault type, headend fault, and eight fault descriptions. This fault category does not provide fault extra data. The default fault action for this category is Diagnostic.

08 hex, Configuration Memory Failure

The GBC generates this error when it detects a failure in a Genius block's EEPROM or NVRAM.

Correction

Replace the Genius block's electronics module.

20 hex/32 decimal, Calibration Memory Failure

The GBC generates this error when it detects a failure in a Genius block's calibration memory.

Correction

Replace the Genius block's electronics module.

40 hex/64 decimal, Shared RAM Fault

The GBC generates this error when it detects an error in a Genius block's shared RAM.

Correction

Replace the Genius block's electronics module.

80 hex/128 decimal, Module Fault

An internal failure has been detected in a module.

Correction

Replace the affected module.

81 hex/129 decimal, Watchdog Timeout

The CPU generates this error when it detects that an input module watchdog timer has expired.

Correction

Replace the input module.

84 hex/132 decimal, Output Fuse Blown

The CPU generates this error when it detects a blown fuse on an output module.

Correction

- 1) Determine and repair the cause of the fuse blowing, and replace the fuse.
- 2) Replace the module.

14.5.9 Addition of IOC (Category 9)

The fault category Addition of I/O Controller has no fault types or fault descriptions associated with it. The default fault action for this category is Diagnostic.

Addition of IOC

The CPU generates this error when an IOC that has been faulted returns to operation or when an IOC is found in the system and the configuration file indicates that no IOC is to be in that slot or when an IOC is hot inserted.

Correction

- 1) No action is necessary if the faulted module is in a remote rack and is returning due to a remote rack power cycle.
- 2) Update the configuration file or remove the module.

01 hex, Extra Module

Module present, but not configured.

Correction

Update the configuration file or remove the module.

02 hex, Reset Request

Module added back after reset request. No corrective action is necessary.

14.5.10 Loss of or Missing IO Controller (Category 10)

The fault category Loss of IOC has no fault types or fault descriptions associated with it.

Default action: Diagnostic. Configurable.

Note: This fault is always displayed as Fatal in the I/O Fault Table, regardless of its configured action.

The CPU generates this error when it cannot communicate with an I/O Controller and an entry for the IOC exists in the configuration file.

This fault is also logged when an IOC is hot removed (No corrective action necessary in this case).

Correction

- 1) Verify that the module in the slot/bus address is the correct module.
- 2) Review the configuration file and verify that it is correct.
- 3) Replace the module.
- 4) If fault is not resolved, display the controller fault table on the programmer. Contact Technical Support, giving them all the information contained in the fault entry.

Fault Extra Data for Loss of or Missing IOC

Fault extra data for Loss of or Missing IOC provides additional information for diagnostics by Technical Support.

14.5.11 IOC (I/O Controller) Software Fault (Category 11)

The fault category IOC Software Fault applies to any type of I/O Controller.

Action: Fatal.

Datagram Queue Full, Read/Write Queue Full

Too many datagrams or read/write requests have been sent to the GBC.

Correction

Adjust the system to reduce the request rate to the GBC.

Response Lost

The GBC is unable to respond to a received datagram or read/write request.

Correction

Adjust the system to reduce the request rate to the GBC.

14.5.12 Forced and Unforced Circuit (Categories 12 and 13)

The fault categories Forced Circuit and Unforced Circuit report point conditions and therefore are not technically faults. They have no fault types or fault descriptions. These reports occur when a Genius I/O point was forced or unforced with the Hand-Held Monitor.

Action: Informational.

Fault Extra Data for Forced/Unforced Circuit

Three bytes of fault extra data are present when a circuit force is added or removed

Byte Number	Description	Value	Description
1	Circuit Configuration	1	Circuit is an input.
		2	Circuit is an input.
		3	Circuit is an output.
2	Analog/Discrete Information	1	Block is a discrete block.
		2	Block is an analog block.
		3	Block has both discrete and analog.

14.5.13 Loss of or Missing I/O Module (Category 14)

The fault category Loss of I/O Module applies to discrete and analog I/O modules. There are no fault types or fault descriptions associated with this category.

Default action: Diagnostic. Configurable.

The CPU generates this error when it detects that an I/O module is no longer responding to commands from the CPU, or when the configuration file indicates an I/O module is to occupy a slot and no module exists in the slot. This fault is also logged when an I/O module is hot removed (No corrective action necessary in this case).

Correction

- 1) Replace the module.
- 2) Correct the configuration file.
- 3) Display the I/O fault table on the programmer. Contact Technical Support, giving them all the information contained in the fault entry.

14.5.14 Addition of I/O Module (Category 15)

The fault category Addition of I/O Module applies to discrete and analog I/O modules. There are no fault types or fault descriptions associated with this category.

Action: Diagnostic.

Addition of I/O Module

The CPU generates this error when an I/O module that had been faulted returns to operation or is hot inserted.

Correction

- 1) No action necessary if module was removed or replaced or if the remote rack was power cycled.
- 2) Update the configuration file or remove the module.

30 hex/48 decimal, VME Reset on Request

Reset of VME module was requested. No corrective action necessary.

14.5.15 Extra I/O Module (Category 16)

The fault category Extra I/O Module applies to discrete and analog I/O modules. There are no fault types or fault descriptions associated with this category.

Action: Diagnostic.

The CPU generates this error when it detects an I/O module in a slot that the configuration file indicates should be empty.

Correction

- 1) Remove the module. (It may be in the wrong slot.)
- 2) Update and restore the configuration file to include the extra module.

14.5.16 Extra Block (Category 17)

The fault category Extra Block applies only to Genius I/O devices. There are no fault types or fault descriptions associated with this category.

Action: Diagnostic.

The GBC generates this error when it detects a Genius device on the bus at a serial bus address where the configuration file does not have a block.

Correction

- 1) Remove or reconfigure the block. (It may be at the wrong serial bus address.)
- 2) Update and restore the configuration file to include the extra block.

14.5.17 IOC Hardware Failure (Category 18)

The fault category IOC Hardware Failure has no fault types or fault descriptions.

Action: Diagnostic.

The Genius operating software generates this error when it detects a hardware failure in the bus communication hardware or a baud rate mismatch.

Correction

- 1) Verify that the baud rate set in the configuration file for the GBC agrees with the baud rate programmed in every block on the bus.
- 2) Change the configuration file and restore it, if necessary.
- 3) Replace the GBC.
- 4) Selectively remove each block from the bus until the offending block is isolated then replace it.

14.5.18 GBC Stopped Reporting Faults (Category 19)

GBC detected a high error count on the Genius I/O bus and dropped off the bus for at least 1.5 seconds.

Correction

Check for incorrect wiring, interference from other equipment, a loose connection, or a failed device on the Genius bus.

14.5.19 GBC Software Exception (Category 21)

1, Incoming datagram queue full

Too many datagrams or read/write requests have been sent to the GBC.

Correction

Adjust the system to reduce the request rate to the GBC.

2, Read/write request queue full

The queue for Read/Write requests in the GBC is full. The requests may be from the Genius Bus or from COMMREQs.

Correction

Adjust the system to reduce the request rate to the GBC.

3, Low priority mail queue from GBC to CPU full

The response to the CPU was lost.

4, Genius background message requiring CPU action received before CPU completed **initialization**

Message was ignored.

5, GBC software version too old

Correction

Update GBC firmware.

6, Excessive use of internal GBC memory

Correction

Verify COMMREQ usage.

14.5.20 Block Switch (Category 22)

The Block Switch fault category has no fault types or fault descriptions.

Action: Diagnostic.

The GBC generates this error when a Genius block on redundant Genius buses switches from one bus to another.

Correction

- 1) No action is required to keep the block operating.
- 2) The bus that the block switched from may need to be repaired.
 - a) Verify the bus wiring.
 - b) Replace the I/O controller.
 - c) Replace the Bus Switching Module (BSM).

Fault Extra Data for Block Switch

<i>Byte Number</i>	<i>Description</i>	<i>Value</i>	<i>Description</i>
1	Circuit configuration	1	Circuit is an input.
		2	Circuit is an input.
		3	Circuit is an output.
2	Block configuration	1	Block is configured for inputs only.
		2	Block is configured for outputs only.
		3	Block is configured for inputs and outputs (grouped block).
3	Number of input circuits used		
4	Number of output circuits used		

14.5.21 Reset of IOC (Category 27)

The fault category Reset of I/O Controller has no fault types or fault descriptions associated with it. The default fault action for this category is Diagnostic.

The CPU generates this message when an I/O Controller is reset. No corrective action necessary.

14.6. Diagnostic Logic Blocks (DLBs)

A Diagnostic Logic Block (DLB) is a block of Ladder Diagram logic that can be downloaded to the controller for independent execution. These blocks are useful tools for interacting with an application that is running in the PACSystems controller. DLBs may be used to:

- Collect information from a running application to analyze and diagnose problems
- Test modifications and corrections to a running application before actually incorporating them into the application.
- Test the devices that will be controlled by the application.

DLBs are intended to accomplish a specific task that is temporary in nature, such as diagnosing the source of a problem or testing tuning parameters. When you have finished using a DLB, it should be removed from the host controller. At this point the application logic and its variable allocation return to what it was before the DLB was downloaded.

You can also remove the DLBs from the Logic Developer target, at which point the target's logic and variable allocation will be identical to what they were before the DLBs were introduced.

Note that, although the DLB is removed from the controller, any changes the DLB made to the system are **not** removed. For example, if the DLB logic changes a hardware parameter, the parameter does not return to its previous value when the DLB is removed.

DLB logic can be executed with the controller in Stop IO Enabled mode, which allows debugging the application without the main application program running.



Caution

Do not use a DLB as a permanent part of a production application, because a DLB is stopped and deleted from memory when Logic Developer loses its Programmer-mode connection with the host controller. This could happen if the programmer's communications cable is disconnected or if a second programmer connects serially to the same RX3i and establishes a Programmer-mode session.

Note: Redundancy CPUs do not support DLBs.

14.6.1 DLB Operation

DLBs are created as components of a specific Target and are separate from the application logic block components associated with a target.

They are written in LD programming language and support many of the same features, such as View Lock, Edit Lock, etc. as other block types.

A target can have a maximum of 128 DLBs in a given PME target. Each DLB can have associated published variable table (PVT) and cam profile (used with Motion applications) files. Each DLB can use up to 128K bytes of memory.

A DLB can be copied and pasted like other blocks. Regardless of where a DLB is pasted, normal conflict handling is applied.

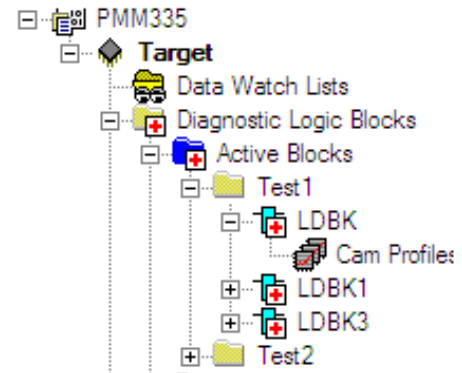


Figure 51: Diagnostic Logic Blocks (DLBs) assigned to Target in MPE

An active DLB can be dragged to the Toolchest, to folders under the **Active Blocks** node, or to folders under the **Program Blocks** node. Note that only active blocks can be dragged. Downloading, executing, or modifying a DLB does not affect the equality of the main logic program.

Suspend I/O Function and DLBs

The Suspend I/O (SUS_IO) function operates the same in a DLB as it does in application logic. Both application logic and DLB logic execute in the CPU Sweep Logic window. Therefore, when a SUSPEND_IO is executed by either the application or the DLB, outputs are held current during the output scan that occurs immediately after the Logic window finishes its execution, and input references will not be updated from inputs during the input scan that occurs immediately before the Logic window is executed in the next CPU sweep.

Note that a SUSPEND_IO only affects normal I/O scans. It does not affect I/O scanning that is done as the result of DO_IO or SCAN_SET_IO functions that execute in application or DLB logic. SUS_IO has the same effect whether it is executed once in a sweep or multiple times in a sweep.

Restrictions on DLB Operation

Because DLBs are intended only for temporary use, there are more restrictions on their operation compared to application logic blocks. All built-in functions and function blocks other than those listed below can be used in DLB logic.

- DLB logic may not call any logic block or be called by any logic block.
- You cannot define parameters or scheduling for a DLB.
- A DLB has no parameters other than the standard ENO output parameter. Since DLBs cannot be called from other blocks, you can access its ENO parameter only by reading or writing it in the DLB's logic.
- You cannot use variables that have %L or %P addresses. As a consequence, the following features that require %L or %P memory cannot be used in a DLB:
 - a. #FST_EXE system variable
 - b. The built-in timer function blocks, ONDTR, OFDT, and TMR
 - c. %L or %P variables.
- Locally scoped variables must be symbolic. For additional information, see "DLB Variables."
- DLBs or their associated files cannot be loaded from the RX3i.
- DLBs and their associated files cannot be downloaded to flash memory.

- You cannot give an LD DLB the name `_MAIN`.
- You cannot modify an active LD DLB while it is executing on the Controller.
- You cannot perform a Test Edit (Online Edit Mode and Online Test Mode).
- You cannot perform word-for-word changes on an active DLB.

DLB Variables

A DLB can have its own variables, which are local to the DLB and not accessible by any other block. All DLB local variables are symbolic, retentive, and published.

Local variables should be used within DLBs whenever possible. If the system is already running and you create new global variables in the DLB, the programming software will not download the DLB because the programmer's memory map will no longer match the RX3i controller's memory map.

DLB logic can read and write the global variables of the application that resides in the same target as it does. These variables may be mapped or symbolic.

To use functions that require the use of located variables, a DLB must use the global located variables of the application that resides in the same target as the DLB. These functions include:

- a. `COMMREQ` (location of the Status variable)
- b. `DO_IO`
- c. Some `SVC_REQ` functions

A DLB can create aliases to global located application variables or arrays of variables that were specifically created and documented to serve as "scratchpad" memory for DLBs that need to use located variables.

14.6.2 Executing DLBs

DLB Properties

The properties for an active DLB include *Execution Mode*, which has the following possible values:

- **Sweep** (Default) - The DLB executes at a fixed point in the normal Controller sweep, until explicitly stopped.
- **Update Rate** - Uses the *Update Rate* defined for the Target. The actual rate varies from a minimum value equal to the *Update Rate* to a maximum value of *Update Rate + 1 sweep*. If the sweep takes more time than the update rate, the DLB is executed as soon as the user logic program execution completes in the current sweep.
- **Scan Once** - The DLB executes exactly one time when the user requests for DLB execution to start. It then stops executing until it is manually instructed to run again.

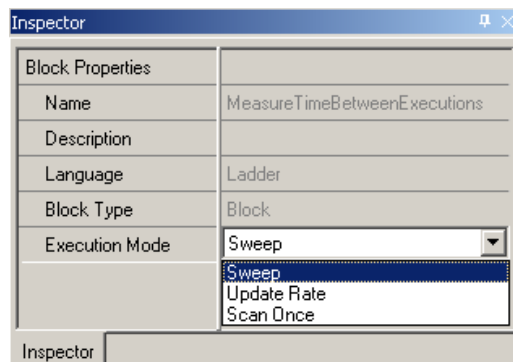


Figure 52: Properties of Diagnostic Logic Block (DLB)

Target Properties

The Target properties include *DLB Heartbeat*, which specifies, in milliseconds, the maximum time the controller waits for a heartbeat signal from the programmer. If a heartbeat timeout occurs, the DLB will be stopped and removed from the controller. This insures that DLB execution is stopped in the event of a communications failure between the programmer and the controller.

With larger applications or a slower PC, some operations such as opening the Controller File Explorer may cause the DLB Heartbeat to time out. If this happens, you may need to increase the DLB Heartbeat interval.

The DLB Heartbeat must always be greater than the *Update Rate* setting for the Target.

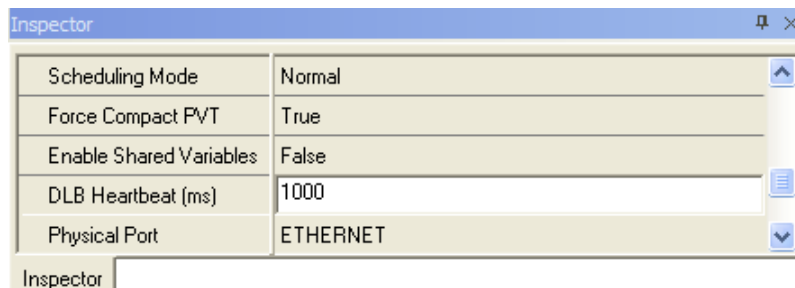


Figure 53: DLB Heartbeat Setting

Right-click Online Operations for an Active DLB

Menu	Enable Rules	Description
Download	Disabled if block is already running on controller, target not in programmer mode, Config+Logic is not equal, or Access Level prevents write.	Downloads block to controller, removing any other DLB that was already there.
Start	Disabled if block is already running, target not in programmer mode, another block is executing on controller, HWC+Logic is not equal, or Access Level prevents write	Downloads block to controller, removing any other DLB that was already there, and then starts executing block.
Stop	Disabled if block is not executing	Stops execution of block.
Remove	Disabled if block is not on controller, block is executing, or not in programmer mode	Stops block, then removes it from controller.

DLB Online Operations

Only a single DLB can be downloaded and executed on the controller at a time. To download an Active DLB to the controller, you must have:

- Program logic and HWC equal to the controller (Logic EQ)
- Target in programmer mode
- Sufficient privilege to write to the controller

Operation	Minimum PACSystems RX3i Privilege Level Required
Storing DLBs in Stop mode	3
Storing DLBs in Run mode	4

When a DLB is downloaded, you are given the option of storing initial values or clearing memory for local variables. If another DLB is already downloaded on the controller it will be removed before the selected DLB is downloaded.

When a DLB is downloaded to the controller, all variables locally scoped to the DLB are published from the controller so that HMIs or other devices can view the data.

While a DLB is running, the active target is read-only; no changes are allowed to DLB or the application logic. If the DLB has been downloaded to the controller but is not executing, changes are allowed but the first change will remove the DLB from the controller. You will be prompted to confirm the change before the DLB is removed. Uploading of the DLB is not supported.

Once a DLB is downloaded to the controller, it can be started if the main program is running on the controller in Stop with I/O Enabled or Run with I/O Enabled mode.

Removing a DLB from the Controller

The following actions will cause the DLB to be removed from the controller. If the DLB is executing, it will be stopped before being removed.

- Removing the DLB from the controller through the Online Operations menu.
- Programmer connection to controller is lost by going offline or a communication failure that causes a DLB Heartbeat timeout
- Switching from programmer mode to monitor mode
- Downloading to controller (Config, Logic, Stored Values, etc.)
- Clearing the controller, other than fault tables and controller supplemental files
- Performing any Flash operation, other than Verify
- Uploading from controller (Config, Logic, Stored Values, etc.)
- Changing the DLB that is on the controller

If there is an executing DLB, and you transition from run mode to stop mode, the executing DLB will be stopped as well. The DLB will not be removed from the controller in this case.

If you initiate an upload, and there is a DLB on the controller, you will be prompted for confirmation and notified that the DLB will be removed and that all active DLBs will be made inactive. If there are no DLBs on the controller but there is at least one active DLB, you will be prompted for confirmation and notified that all active DLBs will be made inactive. If you choose to abort the upload, no changes are made. If you proceed, all DLBs are deactivated. If DLBs are de-activated, you will have to reactivate them manually.



When a DLB is removed from the controller, any PMM data logger (DLOG) and event queue (ELOG) files that were created by the DLB are also removed.

Basic Steps for Using a DLB in the Controller

- 1) Create an LD Block under the Active Blocks DLB Node in the Navigator.
You can accomplish this in several ways, such as by creating a new block under the Active Blocks node, dragging a block from the Toolchest, or copying and pasting a block from another project.
- 2) Select DLB block properties, for example, Execution Mode, as desired.
- 3) If necessary, change the Target property, DLB Heartbeat. For larger projects, you may need to increase DLB Heartbeat from its default value of 1000ms to avoid timing out while performing some operations, such as opening the Controller File Explorer.
- 4) Go online to the Controller and go into Programmer Mode, Logic Equal.
- 5) Right click the DLB and select the Online Operations menu to download the DLB to the controller and start its execution. (To download and start the DLB in one operation, select Online Operations > Start.)
- 6) Monitor DLB execution.

Monitoring DLB Execution

There are several tools to monitor the execution of the DLB in the controller:

- DLB Local Symbolic variables monitored in Data Watch, LD Editor, or Data Monitor.
- DLB Icon shows the DLB state in the Navigator: Downloaded  to controller or Executing .
- A Proficiency View application can monitor the execution of the DLB by using its Local Symbolic Variables in Panels and Scripts.

The DLB block icon in the Navigator indicates its current state, as shown below:

- Inactive DLB** -  (block displayed in gray)
- Active DLB Downloaded to Controller** -  (block displayed in blue)
- Executing DLB** -  (block displayed in green)

14.6.3 Diagnostic Logic Block (DLB) Example

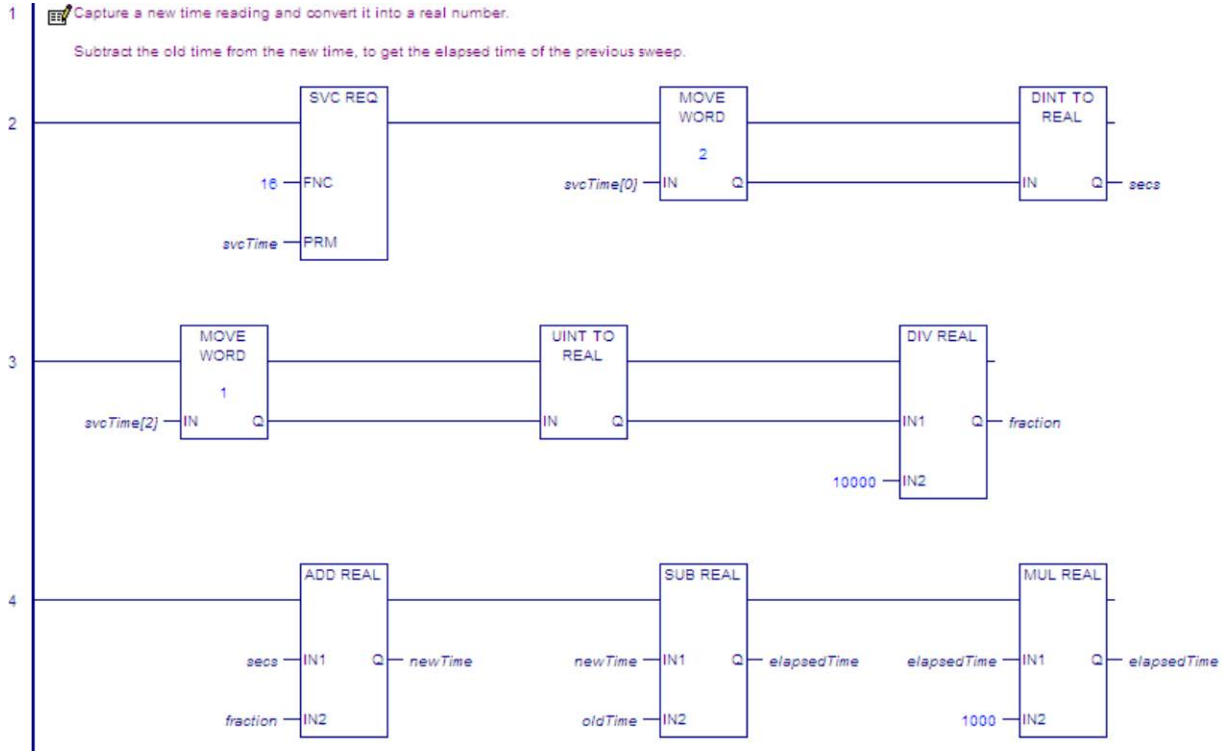
In this example, a block of LD logic is downloaded to the controller and executed.

The basic steps for using a sample DLB in the controller are as follows:

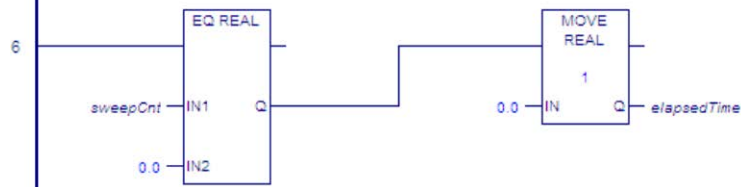
- 1) Create an LD block named *MonitorScan* and place it in the Toolchest. For information on working with the Toolchest, refer to the online help.

The logic in the DLB block measures Controller scan time. It calculates the Minimum (*minTime*), Maximum (*maxTime*), and Average (*avgTime*) time between DLB block executions. When the DLB is set to Sweep Mode, these values should be close to the Controller Sweep time.

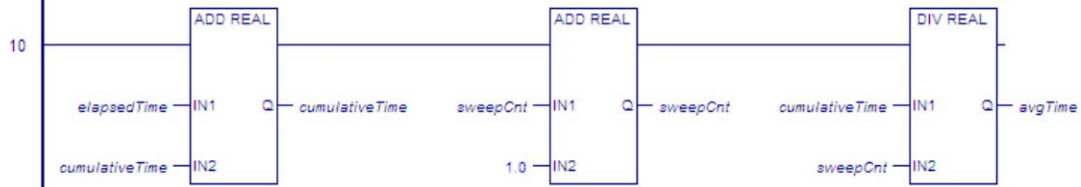
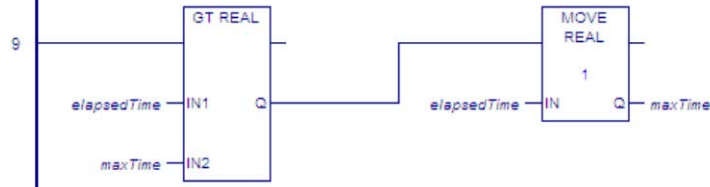
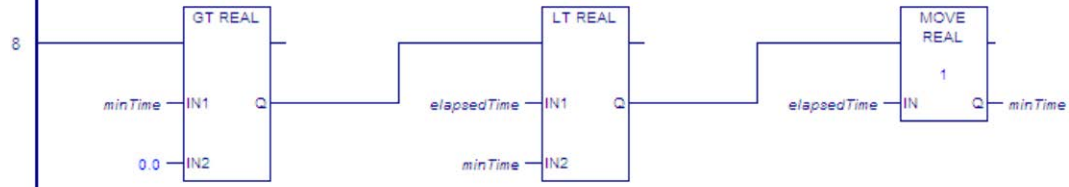
Logic for the MonitorScan Block



5 On the "first" sweep, force elapsed sweep time to 0.



7 Update the min, max, and average sweep times



11 Initialize old time to previous new time



- 2) Drag and drop the DLB Block from the Toolchest to the Active Blocks node in the Navigator.

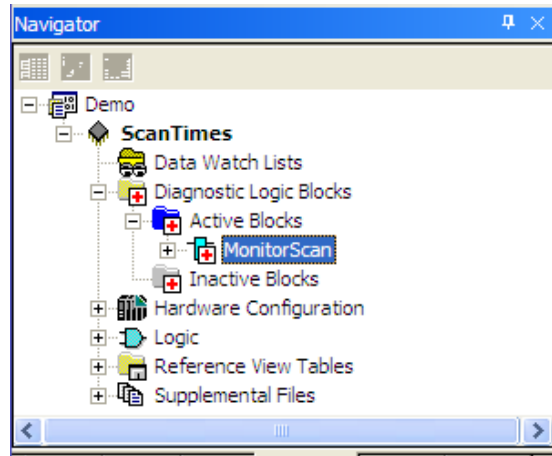


Figure 54: Drag DLB from Toolchest and Drop in Active Blocks Node

- 3) In the DLB block properties, set the Execution Mode to Sweep.

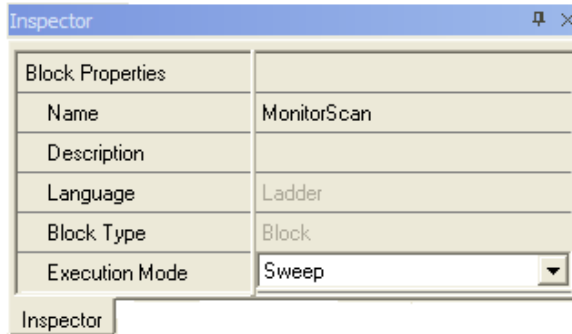


Figure 55: Set DLB Execution Mode to Sweep (Properties Tab)

- 4) Go online to the Controller, and select Programmer Mode. Put the Controller in Run mode or Stop Enabled mode.
- 5) Select the DLB Online Operations > Start menu to download the DLB to the controller and start its execution.

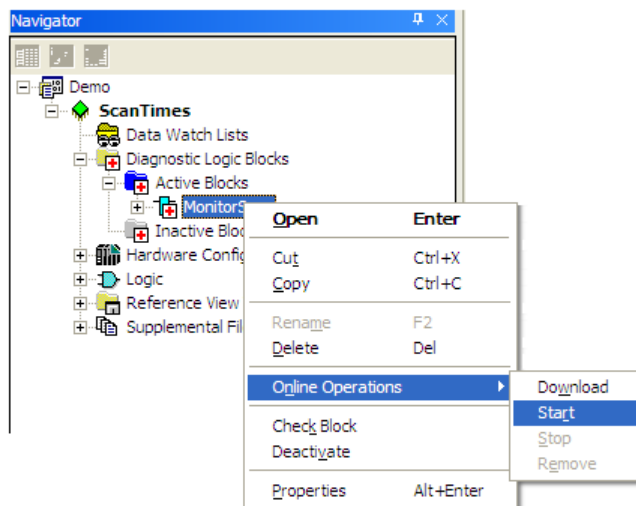


Figure 56: Start DLB Execution

- 6) In the Initialize Symbolic Variables dialog box, select how new local symbolic variables will be initialized and click OK.

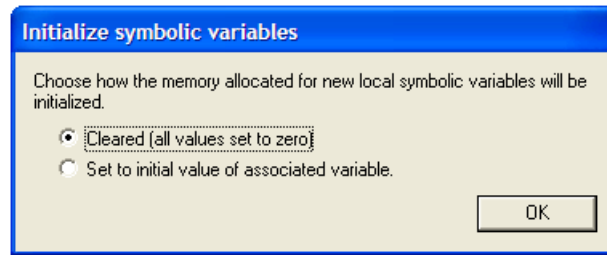


Figure 57: Initialize Local Symbolic Variables

- 7) Notice the change in the DLB Icon and the DLB status in the Status bar.

DLB Block Icon/Status Bar Once Started.

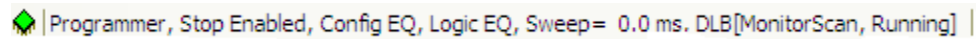
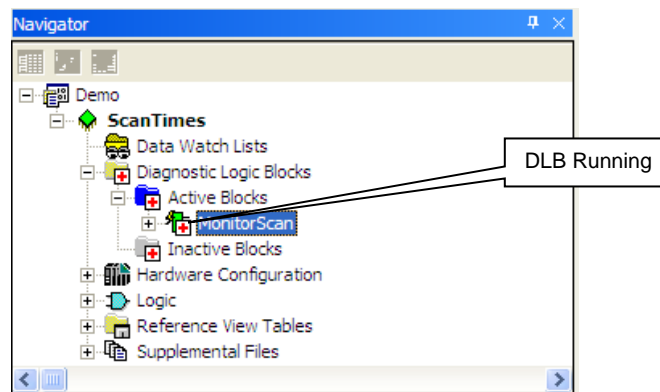


Figure 58: DLB Icon and Status Bar after Execution has Commenced

- 8) Open the DLB block and place the DLB variables in the Data Watch window to observe their operation.

Variable Name	Address	Value
GEF MonitorScan.avgTime		11.06866
GEF MonitorScan.minTime		0.0
GEF MonitorScan.maxTime		27109.38
GEF MonitorScan.elapsedTime		7.8125

Figure 59: Data Watch for DLB Variables

Appendix A Performance Data

This appendix contains instruction and overhead timing collected for each PACSystems CPU module. This timing information can be used to predict CPU sweep times. The information in this appendix is organized as follows:

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Instruction Timing		625
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CPU Version Information		626
RX3i		627
RX7i		640
Overhead Sweep Impact Times		650

A-1 Boolean Execution Times

Boolean execution times for contacts and coils depend on several factors, including the CPU model, the type of reference address associated with the contact/coil, and whether the address is used directly or passed as a parameter. To help compare Boolean performance across PACSystems CPUs, average time measurements are presented below for each CPU model.

The measurements are for these three categories:

- **Simple address:** Boolean with a simple reference address that is known at compile/validation time. For example, a symbolic variable, or a mapped variable, such as %I00001, or a Boolean from an array that is indexed by a constant, such as BoolArray[3].
- **Complex address:** Boolean with a complex address that requires run-time computation to resolve. For example, a Boolean from an array that is indexed by a variable, such as BoolArray[j].
- **Passed as parameter:** Boolean within a parameterized block or UDFB, where the reference address of the Boolean is passed as a parameter to the block. The measurement covers the Boolean execution time within the block, but does not include the time to compute the reference address before passing it to the block.

A-1.1 Boolean Execution Measurements (milliseconds per 1000 Boolean executions)⁴²

CPU Model	Boolean Category		
	Simple Address	Complex Address	Passed as Parameter
CPU310	0.253	1.371	0.467
CPE310	0.103	0.512	0.203
CPE305	0.102	0.513	0.203
CPU320 / CPU315	0.053	0.272	0.113
CRU320	0.055	0.272	0.111
CPE010	0.244	1.329	0.469
CPE020	0.095	0.543	0.198
CRE020	0.096	0.556	0.194
CPE030	0.087	0.450	0.183
CRE030	0.090	0.451	0.184
CPE040	0.029	0.150	0.061
CRE040	0.029	0.149	0.061

⁴² Measured with CPU firmware version 7.18.

A-2 Instruction Timing

A-2.1 Overview

The tables in this section list the execution and incremental times in microseconds for each function supported by the PACSystems CPUs. Two execution times are shown for each instruction.

Execution Time	Description
Enabled	Time in microseconds required to execute the function or function block when power flows into the function with valid inputs.
Disabled	Time in microseconds required to execute the function when it is not enabled.

Notes:

- All times represent typical execution time. Times may vary with input and error conditions.
- Enabled time is for single length units of word-oriented memory.
- COMMREQ time was measured between CPU and Ethernet module with NOWAIT option.
- DOIO time was measured using a discrete output module.
- Timers are updated each time they are encountered in the logic by the amount of time consumed by the last sweep.
- Performance times for the BUS_ functions were measured on the RX7i using a Series 90-70 Genius Bus Controller, and on the RX3i using an RMX128 Redundancy Memory Xchange Module.
- Performance times for all redundancy (CRE and CRU) CPUs were measured with ECC enabled.
- Due to a change in caching, measured times for some instructions changed for release 6.0 as compared to releases 5.0/5.1. It was found that increases in some instructions were offset by decreases in other instructions, so that no effective net change was observed.

A-2.2 CPU Version Information

The instruction execution and incremental times were obtained by testing the following CPU versions:

	Model	Firmware Version
All instructions except as listed below	IC695CPE305/CPE310	7.10
	IC695CPU310/CPU315	6.0
	IC695CPU320/IC695CRU320 ⁴³	7.18
	IC698CPE010/CPE020	6.0
	IC698CRE020	6.0 (with ECC enabled)
	IC698CPE030/CPE040	6.0
	IC698CRE030/CRE040	6.0 (with ECC enabled)
MOVE_UINT	CPE010/020	3.5
	CRE020	2.04 (with ECC enabled)
SVC_REQs for Redundancy	IC695CRU320	6.0 (with ECC enabled)
TON, TOF, TP Instructions	CPU310/CPU315//320, CRU320	5.7
	CPE010/030/040	3.6
	CRE030/040	3.6 (with ECC enabled)
Instructions for PACMotion	CPU315/CPU320	5.6
	CPU310	6.0

⁴³ Due to Error Checking and Correction (ECC), Redundant CPU times are approximately 5% slower, on average, than the equivalent Non-Redundant CPU.

A-2.3 RX3i Instruction Times

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
Bit Operation								
AND_WORD	1.47	0.51	3.40	1.45	0.84	0.46	0.911	0.382
AND_DWORD	1.433	0.44	3.50	1.46	0.84	0.46	0.968	0.378
OR_WORD	1.332	0.44	3.40	1.50	0.84	0.47	0.891	0.437
OR_DWORD	1.387	0.45	3.63	1.51	0.89	0.47	0.919	0.375
XOR_WORD	1.347	0.46	3.37	1.44	0.86	0.46	0.908	0.375
XOR_DWORD	1.391	0.47	3.46	1.45	0.83	0.46	0.866	0.388
NOT_WORD	1.089	0.40	2.97	1.29	0.64	0.42	0.659	0.274
NOT_DWORD	1.03	0.37	2.93	1.32	0.67	0.40	0.662	0.282
MCMP_WORD	2.477	0.80	5.58	2.29	1.51	0.61	1.668	0.605
MCMP_DWORD	2.385	0.74	5.61	2.20	1.50	0.63	1.682	0.636
SHL_WORD	1.921	0.84	4.52	2.39	1.15	0.56	1.275	0.633
SHL_DWORD	1.903	0.77	4.54	2.44	1.12	0.56	1.321	0.665
SHR_WORD	1.875	0.76	5.15	2.43	1.18	0.57	1.26	0.614
SHR_DWORD	1.864	0.78	4.69	2.45	1.14	0.57	1.24	0.616
ROL_WORD	1.176	0.48	2.99	1.50	0.68	0.46	0.735	0.431
ROL_DWORD	1.125	0.42	3.22	1.53	0.64	0.46	0.773	0.402
ROR_WORD	1.105	0.41	2.91	1.43	0.66	0.46	0.704	0.431
ROR_DWORD	1.116	0.43	2.87	1.44	0.71	0.46	0.711	0.384
BTST_WORD	1.333	0.45	3.22	1.27	0.71	0.35	0.693	0.314
BTST_DWORD	1.265	0.39	3.09	1.26	0.71	0.34	0.73	0.321
BSET_WORD	0.897	0.35	2.38	1.17	0.59	0.30	0.635	0.293
BSET_DWORD	0.88	0.37	2.36	1.14	0.58	0.30	0.635	0.293
BCLR_WORD	0.849	0.35	2.39	1.14	0.59	0.30	0.659	0.316
BCLR_DWORD	0.86	0.33	2.45	1.19	0.59	0.30	0.623	0.291
BPOS_WORD	1.719	0.47	4.03	1.33	0.80	0.23	1.024	0.309
BPOS_DWORD	1.941	0.40	4.83	1.31	0.96	0.22	1.302	0.324
Relational								
CMP_INT	1.623	0.41	3.52	1.16	0.89	0.33	1.11	0.363
CMP_DINT	1.552	0.38	3.54	1.19	0.91	0.34	1.143	0.393
CMP_REAL	1.619	0.39	3.63	1.20	0.94	0.35	1.146	0.362
CMP_LREAL	1.835	0.44	3.92	1.13	1.08	0.34	1.227	0.361
CMP_UINT	1.485	0.39	3.50	1.17	0.93	0.33	1.097	0.361
EQ_DATA	-	-	10.63	7.98	2.37	1.29		
EQ_DATA_INPUTREF	2.247	0.12	--	--	--	--	1.55	0.448
EQ_DATA_AXISREF	2.377	0.32	--	--	--	--	1.616	0.491
EQ_DINT	1.074	0.29	2.32	0.96	0.65	0.24	0.737	0.277
EQ_INT	1.123	0.36	2.45	0.96	0.66	0.24	0.69	0.276
EQ_LREAL	1.174	0.37	2.88	1.07	0.78	0.26	0.832	0.282
EQ_REAL	1.05	0.30	2.38	0.96	0.66	0.26	0.677	0.328

Appendix A. Performance Data

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
EQ_UINT	1.01	0.31	2.37	0.96	0.65	0.25	0.659	0.269
NE_INT	1.03	0.32	2.29	0.98	0.64	0.24	0.715	0.292
NE_DINT	1.074	0.33	2.37	1.00	0.66	0.24	0.718	0.269
NE_UINT	1.14	0.34	2.39	0.96	0.66	0.24	1.029	0.583
NE_REAL	1.076	0.32	2.35	0.95	0.67	0.25	0.863	0.408
NE_LREAL	1.142	0.35	2.87	1.04	0.79	0.26	0.926	0.279
GT_INT	1.035	0.31	2.49	0.98	0.66	0.25	0.703	0.269
GT_DINT	1.018	0.31	2.34	1.01	0.65	0.24	0.714	0.268
GT_REAL	1.057	0.31	2.36	0.94	0.65	0.24	0.714	0.269
GT_LREAL	1.146	0.36	2.82	1.02	0.77	0.27	0.893	0.324
GT_UINT	1.048	0.31	2.37	0.95	0.66	0.24	0.714	0.27
GE_INT	1.017	0.31	2.44	0.93	0.68	0.24	0.682	0.269
GE_DINT	1.082	0.32	2.43	1.01	0.66	0.24	0.675	0.284
GE_REAL	1.075	0.32	2.35	0.94	0.66	0.26	0.678	0.266
GE_LREAL	1.154	0.34	2.85	1.04	0.77	0.26	0.817	0.282
GE_UINT	1.03	0.32	2.44	1.03	0.67	0.24	0.677	0.272
LT_INT	1.049	0.32	2.53	1.02	0.64	0.24	0.712	0.281
LT_DINT	1.08	0.33	2.37	1.05	0.65	0.25	0.72	0.269
LT_REAL	1.044	0.32	2.37	0.97	0.64	0.25	0.873	0.409
LT_LREAL	1.139	0.35	2.81	1.01	0.77	0.26	0.882	0.299
LT_UINT	1.087	0.31	2.41	0.95	0.65	0.24	0.71	0.271
LE_INT	1.123	0.32	2.46	0.99	0.69	0.25	0.678	0.269
LE_DINT	1.014	0.31	2.33	1.03	0.65	0.25	0.665	0.27
LE_UINT	1.045	0.32	2.44	1.02	0.64	0.24	0.683	0.283
LE_REAL	1.03	0.31	2.34	1.00	0.65	0.25	0.676	0.27
LE_LREAL	1.136	0.35	2.78	0.98	0.77	0.26	0.818	0.291
Conversion								
BCD-4 to INT	0.933	0.30	2.17	1.00	0.55	0.23	0.544	0.25
DINT to INT	0.694	0.30	1.90	0.98	0.55	0.21	0.507	0.247
UINT to INT	0.736	0.30	2.04	0.94	0.49	0.20	0.583	0.234
BCD-8 to DINT	0.889	0.28	2.58	0.97	0.62	0.21	0.612	0.235
INT to DINT	0.672	0.29	1.88	0.2	0.51	0.21	0.567	0.232
UINT to DINT	0.771	0.32	1.90	0.96	0.63	0.21	0.591	0.227
INT to UINT	0.724	0.30	1.93	0.93	0.62	0.21	0.551	0.251
DINT to UINT	0.674	0.30	1.92	1.06	0.50	0.21	0.517	0.248
BCD-4 to UINT	0.792	0.35	2.18	1.04	0.55	0.22	0.603	0.247
INT to BCD-4	0.922	0.30	2.19	0.93	0.61	0.22	0.596	0.239
UINT to BCD-4	0.853	0.30	2.17	0.94	0.67	0.22	0.644	0.229
DINT to BCD-8	0.849	0.30	2.35	1.03	0.62	0.21	0.63	0.235
REAL_TO_INT	0.922	0.31	2.43	1.00	0.66	0.21	0.665	0.23
REAL_TO_UINT	0.882	0.30	2.37	0.99	0.63	0.21	0.637	0.239
REAL_TO_LREAL	0.697	0.31	2.10	0.95	0.52	0.21	0.555	0.224

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
REAL_TO_DINT	0.877	0.30	2.42	0.99	0.64	0.21	0.638	0.24
INT_TO_REAL	0.707	0.31	2.00	0.98	0.49	0.22	0.521	0.255
UINT_TO_REAL	0.724	0.31	1.87	0.95	0.55	0.23	0.595	0.239
DINT_TO_REAL	0.773	0.30	1.95	1.02	0.56	0.21	0.516	0.231
DINT_TO_LREAL	0.741	0.36	2.06	1.02	0.50	0.20	0.584	0.248
REAL_TRUN_INT	0.757	0.34	1.77	0.73	0.45	0.19	0.515	0.16
REAL_TRUN_DINT	0.776	0.35	1.84	0.83	0.52	0.19	0.516	0.167
DEG_TO_RAD_REAL	0.749	0.28	1.90	1.01	0.55	0.21	0.515	0.24
DEG_TO_RAD_LREAL	0.901	0.34	2.33	0.94	0.64	0.23	0.63	0.249
RAD_TO_DEG_REAL	0.703	0.28	1.91	0.97	0.59	0.21	0.515	0.25
RAD_TO_DEG_LREAL	0.789	0.32	2.33	0.94	0.64	0.23	0.636	0.256
BCD-4 to REAL	0.852	0.30	2.30	1.03	0.56	0.20	0.692	0.301
BCD-8 to REAL	0.996	0.30	2.62	0.94	0.66	0.20	0.661	0.25
LREAL_TO_DINT	0.869	0.33	2.67	1.03	0.63	0.20	0.673	0.23
LREAL_TO_REAL	0.666	0.30	2.25	1.01	0.54	0.21	0.549	0.224
Data Move								
BLKCLR	0.796	0.29	1.96	0.96	0.45	0.19	0.528	0.223
BITSEQ	0.175	0.15	1.14	4.14	0.90	0.89		
MOVE_BIT	1.162	0.41	3.00	1.37	0.67	0.25	0.861	0.245
MOVE_DINT	0.864	0.37	2.21	1.32	0.47	0.43	0.533	0.292
MOVE_INT	0.857	0.38	2.21	1.33	0.48	0.44		
MOVE_UINT	-	-	-	-	-	-	0.523	0.305
MOVE_WORD	0.919	0.44	2.15	1.25	0.48	0.41	0.551	0.298
MOVE_DWORD	0.884	0.36	2.15	1.24	0.48	0.42	0.548	0.293
MOVE_REAL	0.844	0.35	2.15	1.24	0.47	0.41	0.594	0.354
MOVE_LREAL	1.136	0.41	2.63	1.27	0.57	0.41	0.604	0.297
MOVE_DATA	-	-	8.36	2.36	2.16	1.20	-	-
MOVE_DATA_INPUTREF	2.094	0.34	10.63	2.60	-	-	2.077	0.384
MOVE_DATA_AXISREF	2.437	0.39	10.63	2.60	-	-	2.172	0.376
MOVE_DATA_EX	2.094	0.34	9.28	1.98	2.60	1.66	2.23	0.544
MOVE_DATA_EX_INPUTREF	2.437	0.39	9.28	1.98	-	-	2.509	0.587
MOVE_TO_FLAT	2.094	0.34	9.28	1.98	2.60	1.66	2.23	0.544
MOVE_FROM_FLAT	2.094	0.34	9.28	1.98	2.60	1.66	2.23	0.544
BLKMOV_WORD	1.009	0.72	2.89	2.17	0.68	0.60	0.788	0.511
BLKMOV_DWORD	1.019	0.65	3.03	2.17	0.71	0.54	0.862	0.517
BLKMOV_DINT	1.133	0.68	3.04	2.22	0.71	0.55	0.842	0.541
BLKMOV_INT	0.938	0.69	2.78	2.13	0.69	0.60	0.8	0.511
BLKMOV_REAL	1.004	0.66	2.98	2.14	0.70	0.53	0.853	0.528
BLKMOV_UINT	0.91	0.65	2.79	2.09	0.67	0.60	0.785	0.531
DATA_INIT_ASCII	0.432	0.45	0.89	1.25	0.20	0.35	0.176	0.236
DATA_INIT_COMM	0.37	0.36	1.03	1.20	0.22	0.34	0.196	0.221
DATA_INIT_DLAN	0.433	0.39	1.33	1.32	0.33	0.35	0.254	0.238

Appendix A. Performance Data

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
DATA_INIT_DINT	0.313	0.37	0.89	1.21	0.21	0.33	0.169	0.24
DATA_INIT_DWORD	0.313	0.36	0.97	1.26	0.21	0.34	0.172	0.221
DATA_INIT_INT	0.343	0.38	0.94	1.27	0.20	0.33	0.178	0.231
DATA_INIT_REAL	0.344	0.38	0.91	1.22	0.21	0.35	0.172	0.248
DATA_INIT_LREAL	0.468	0.41	0.96	1.18	0.18	0.34	0.183	0.248
DATA_INIT_WORD	0.342	0.36	0.97	1.27	0.20	0.34	0.179	0.219
DATA_INIT_UINT	0.419	0.37	0.93	0.9	0.21	0.35	0.16	0.254
SWAP_WORD	0.976	0.36	2.67	1.24	0.58	0.41	0.616	0.291
SWAP_DWORD	1.008	0.38	2.75	1.29	0.59	0.41	0.62	0.308
SHFR_BIT	2.461	1.11	6.52	2.88	1.45	0.64	1.621	0.705
SHFR_WORD	2.441	1.49	7.13	4.94	1.94	1.40	2.072	1.51
SHFR_DWORD	2.403	1.48	7.16	4.91	2.00	1.42	2.127	1.493
Data Table								
SORT_INT	15.58	0.40	36.56	1.25	9.89	0.42	9.743	0.295
SORT_UINT	15.436	0.35	36.49	1.24	9.86	0.42	9.628	0.296
SORT_WORD	15.516	0.36	36.46	1.26	9.87	0.42	9.613	0.332
TBLRD_INT	1.299	0.47	3.49	1.23	0.88	0.33	0.968	0.402
TBLRD_DINT	1.21	0.44	3.58	1.27	0.90	0.33	0.887	0.345
TBLWRT_INT	1.71	0.53	4.02	1.53	1.03	0.41	1.06	0.388
TBLWRT_DINT	1.599	0.48	3.94	1.52	1.03	0.42	1.113	0.391
FIFORD_INT	1.67	0.54	4.04	1.68	0.92	0.41	0.931	0.405
FIFORD_DINT	1.627	0.55	4.00	1.69	0.92	0.41	0.927	0.408
FIFOWRT_INT	1.189	0.32	3.06	1.21	0.83	0.30	0.838	0.358
FIFOWRT_DINT	1.197	0.31	3.05	1.19	0.84	0.30	0.836	0.278
LIFORD_INT	1.563	0.54	3.83	1.69	0.87	0.41	0.887	0.403
LIFORD_DINT	1.508	0.54	3.81	1.64	0.87	0.41	0.886	0.403
LIFOWRT_INT	1.211	0.33	3.06	1.18	0.83	0.30	0.836	0.278
LIFOWRT_DINT	1.194	0.35	3.05	1.19	0.83	0.32	0.837	0.284
LIFOWRT_DWORD	1.2	0.34	3.06	1.18	0.83	0.30	0.838	0.293
Array								
ARRAY_MOVE_BIT	1.787	0.69	4.62	2.03	0.91	0.51	0.984	0.504
ARRAY_MOVE_BYTE	1.385	0.57	3.62	1.84	0.78	0.57	0.927	0.49
ARRAY_MOVE_WORD	1.335	0.59	3.67	1.92	0.80	0.57	0.858	0.556
ARRAY_MOVE_DWORD	1.346	0.59	3.61	1.85	0.80	0.58	0.86	0.49
ARRAY_MOVE_DINT	1.368	0.59	3.62	1.94	0.80	0.57	0.856	0.491
ARRAY_MOVE_INT	1.357	0.61	3.72	1.99	0.80	0.57	0.868	0.496
ARRAY_MOVE_UINT	1.408	0.61	3.61	1.87	0.79	0.58	0.88	0.491
SRCH_BYTE	1.8	0.63	4.35	1.86	1.04	0.46	1.254	0.487
SRCH_WORD	1.666	0.57	4.05	1.81	1.02	0.46	1.306	0.508
SRCH_DWORD	1.721	0.57	4.17	1.82	1.12	0.46	1.245	0.531
ARRAY_RANGE_WORD	1.715	0.59	4.16	1.77	1.00	0.42	1.159	0.419
ARRAY_RANGE_DWORD	1.714	0.53	4.43	1.78	1.21	0.42	1.209	0.417

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
ARRAY_RANGE_DINT	1.724	0.54	4.47	1.83	1.16	0.43	1.171	0.419
ARRAY_RANGE_INT	1.647	0.53	4.69	1.85	1.16	0.41	1.185	0.404
ARRAY_RANGE_UINT	1.706	0.55	4.17	1.84	1.11	0.41	1.162	0.406
Math								
ADD_INT	0.932	0.41	2.08	1.19	0.70	0.30	0.796	0.28
ADD_DINT	0.841	0.35	2.22	1.17	0.63	0.31	0.825	0.272
ADD_REAL	0.819	0.34	2.12	1.13	0.61	0.32	0.751	0.327
ADD_LREAL	0.962	0.38	3.09	1.20	0.75	0.31	0.94	0.299
ADD_UINT	0.801	0.34	2.08	1.14	0.64	0.30	0.717	0.259
SUB_INT	0.805	0.34	2.08	1.15	0.66	0.30	0.729	0.258
SUB_DINT	0.846	0.33	2.17	1.13	0.64	0.30	0.75	0.258
SUB_REAL	0.826	0.34	2.17	1.18	0.62	0.31	0.743	0.26
SUB_LREAL	0.998	0.40	2.81	1.27	0.81	0.31	0.958	0.3
MUL_INT	0.822	0.34	2.21	1.13	0.64	0.30	0.727	0.258
MUL_DINT	0.883	0.35	2.20	1.20	0.63	0.31	0.765	0.255
MUL_REAL	0.86	0.35	2.13	1.14	0.57	0.31	0.752	0.265
MUL_LREAL	0.97	0.39	3.03	1.44	0.75	0.33	0.94	0.29
MUL_MIXED	0.913	0.37	2.06	1.19	0.64	0.31	0.823	0.275
MUL_UINT	0.8	0.34	2.42	1.18	0.65	0.30	0.728	0.259
DIV_INT	0.913	0.35	2.35	1.19	0.64	0.30	0.74	0.268
DIV_DINT	0.904	0.36	2.45	1.21	0.64	0.31	0.77	0.281
DIV_REAL	0.894	0.34	2.39	1.13	0.69	0.30	0.761	0.258
DIV_LREAL	1.012	0.39	2.93	1.20	0.79	0.31	0.962	0.279
DIV_MIXED	1.00	0.34	2.45	1.15	0.67	0.30	0.788	0.259
MOD_INT	0.903	0.35	2.36	1.23	0.69	0.31	0.762	0.278
MOD_DINT	0.904	0.35	2.30	1.18	0.64	0.31	0.742	0.277
MOD_UINT	0.82	0.35	2.23	1.19	0.71	0.31	0.83	0.261
ABS_INT	0.728	0.29	1.96	0.91	0.51	0.23	0.555	0.241
ABS_DINT	0.717	0.29	1.99	0.91	0.56	0.23	0.528	0.241
ABS_REAL	0.751	0.28	2.12	0.96	0.56	0.21	0.521	0.239
ABS_LREAL	0.875	0.38	2.54	1.01	0.62	0.22	0.678	0.24
SCALE_INT	1.12	0.58	3.07	1.54	0.85	0.44	0.931	0.437
SCALE_DINT	1.263	0.56	2.65	1.51	0.71	0.51	0.991	0.429
SCALE_UINT	1.067	0.55	2.70	1.50	0.71	0.49	0.9	0.404
SQRT_INT	0.905	0.26	2.36	0.93	0.63	0.21	0.618	0.24
SQRT_DINT	0.906	0.33	2.86	0.93	0.69	0.21	0.742	0.24
SQRT_REAL	0.812	0.28	2.15	0.92	0.55	0.23	0.592	0.293
SQRT_LREAL	0.897	0.30	2.60	1.02	0.65	0.22	0.644	0.244
Trigonometric								
SIN_REAL	1.031	0.28	2.48	0.92	0.61	0.22	0.628	0.239
SIN_LREAL	1.063	0.35	2.97	1.02	0.74	0.22	0.74	0.294
COS_REAL	0.988	0.28	2.41	0.93	0.67	0.21	0.616	0.239

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
COS_REAL	1.04	0.28	2.93	1.02	0.75	0.21	0.736	0.235
TAN_REAL	1.156	0.28	2.53	0.92	0.63	0.21	0.635	0.24
TAN_LREAL	1.086	0.32	3.03	1.02	0.83	0.22	0.776	0.236
ASIN_REAL	1.096	0.28	2.80	0.98	0.73	0.21	0.743	0.24
ASIN_LREAL	1.127	0.49	3.23	1.00	0.88	0.21	0.835	0.223
ACOS_REAL	1.096	0.28	2.80	0.98	0.73	0.21	0.743	0.24
ACOS_LREAL	1.221	0.33	3.27	0.99	0.88	0.21	0.845	0.239
ATAN_REAL	1.013	0.29	2.56	1.03	0.67	0.23	0.63	0.256
ATAN_LREAL	0.992	0.31	2.88	1.00	0.76	0.21	0.719	0.24
Logarithmic								
LOG_REAL	0.977	0.29	2.46	0.99	0.65	0.21	0.641	0.241
LOG_LREAL	1.052	0.30	3.25	0.95	0.73	0.21	0.733	0.223
LN_REAL	1	0.30	2.46	0.97	0.65	0.22	0.66	0.287
LN_LREAL	1.05	0.33	3.14	1.01	0.75	0.22	0.744	0.239
EXPT_REAL	1.568	0.36	3.75	1.29	0.88	0.31	0.988	0.246
EXPT_LREAL	1.114	0.39	3.35	1.31	0.72	0.30	0.727	0.277
EXP_REAL	0.91	0.29	2.26	0.97	0.61	0.23	0.612	0.254
EXP_LREAL	0.966	0.34	2.85	1.1	0.76	0.23	0.698	0.232
PID								
PIDISA	2.862	2.54	6.80	6.14	1.52	1.43	1.74	1.468
PIDIND	2.701	2.46	6.83	6.16	1.51	1.39	1.784	1.495
Range								
RANGE_INT	1.424	0.62	3.57	2.09	0.85	0.47	1.055	0.615
RANGE_DINT	1.341	0.57	3.28	1.85	0.85	0.47	0.952	0.463
RANGE_DWORD	1.363	0.59	3.39	1.84	0.85	0.47	0.911	0.482
Timers								
ONDTR	1.918	1.52	4.91	3.81	1.11	0.83	1.104	0.807
OFDT	1.756	1.56	4.70	4.22	1.03	0.87	1.027	0.838
TMR	1.797	1.58	4.69	4.21	1.04	0.88	1.031	0.838
TOF	2.986	1.951	7.8	4.7	1.8	1.2	1.803	1.107
TON	2.262	1.912	7.4	4.5	1.8	1.1	1.357	1.108
TP	2.312	1.909	7.5	4.5	1.8	1.2	1.422	1.11
Counters								
UPCTR	1.851	1.69	4.24	4.28	0.96	0.92	0.899	0.907
DNCTR	1.668	1.68	4.20	4.23	0.94	0.93	0.903	0.896
Control								
JUMPN	0.021	0.06	0.29	0.13	0.02	0.01	0.134	0.01
FOR/NEXT	0.482	0.22	1.40	0.70	0.23	0.18	0.256	0.167
MCRN/ENDMCRN Combined	0.212	0.21	0.64	0.65	0.06	0.07	0.1	0.146
SWITCH_POS	0.787	0.28	1.96	0.91	0.57	0.21	0.549	0.185
DOIO	78.972	0.41	58.32	1.32	38.72	0.30	16.97	0.29

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
DOIO with ALT	79.187	0.41	58.17	1.28	38.67	0.33	16.947	0.305
DRUM_SEQ	2.68	2.20	6.74	5.42	1.63	1.30	1.71	1.266
SCAN_SET_IO	138.471	0.797	155.02	1.87	111.81	0.50	39.488	0.394
SUSIO	0.797	0.14	1.93	0.38	0.49	0.11	0.514	0.094
COMM_REQ	221.447	0.39	219.48	1.51	133.87	0.36	136.466	0.362
CALL/RETURN (C Block)	2.907	0.17	7.23	0.44	1.83	0.09	1.853	0.088
CALL/RETURN (LD)	2.859	0.13	7.50	0.42	1.73	0.10	1.853	0.106
CALL/RETURN (Parameterized Block)	1.85	0.12	4.92	0.41	1.22	0.11	1.288	0.087
Bus⁴⁴								
BUS_RD_BYTE	16.228	0.75	20.16	2.35	7.41	0.68	1.02	0.589
BUS_RD_WORD	16.189	0.73	20.67	2.46	7.48	0.71	1.07	0.64
BUS_RD_DWORD	16.383	0.72	20.80	2.43	7.55	0.70	1.032	0.613
BUS_WRT_BYTE	12.34	0.70	20.94	2.59	6.19	0.70	1.944	0.589
BUS_WRT_WORD	12.478	0.71	20.76	2.49	6.17	0.69	1.956	0.593
BUS_WRT_DWORD	12.489	0.73	21.09	2.49	6.24	0.69	1.957	0.601
BUS_RMW_BYTE	17.5	0.83	21.72	2.67	7.96	0.78	1.385	0.682
BUS_RMW_WORD	17.647	0.83	21.01	2.69	7.95	0.79	1.358	0.659
BUS_RMW_DWORD	17.484	0.79	21.20	2.71	7.96	0.78	1.429	0.665
BUS_TS_BYTE	17.284	0.61	19.07	2.05	7.80	0.50	1.309	0.511
BUS_TS_WORD	17.378	0.59	20.16	2.09	7.66	0.51	1.254	0.512

⁴⁴ Results will vary with how quickly the module responds to bus cycles. Because of this, incremental times do not appear in the "Incremental Times" tables.

Appendix A. Performance Data

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
SVC_REQ								
#1	2.179	0.26	6.57	1.02	1.34	0.18	1.54	0.217
#2	2.523	0.27	6.35	1.01	1.57	0.21	1.809	0.176
#3	1.746	0.25	4.80	0.92	0.98	0.18	1.15	0.142
#4	1.735	0.24	4.83	0.98	0.99	0.19	1.14	0.158
#5	1.697	0.24	4.90	0.92	0.97	0.17	1.158	0.153
#6	1.688	0.25	4.58	0.97	0.99	0.19	1.099	0.18
#7	3.661	0.32	8.64	1.12	1.95	0.20	2.022	0.182
#8	10.343	0.28	6.82	1.01	3.14	0.20	3.306	0.192
#9	1.76	0.28	4.53	1.03	1.06	0.20	1.192	0.195
#10	2.487	0.28	7.09	1.04	1.72	0.20	1.586	0.205
#11	1.751	0.28	4.25	1.03	1.07	0.20	1.166	0.195
#12	0.931	0.28	2.37	1.03	0.60	0.20	0.708	0.187
#13	1.438	0.25	4.56	1.09	0.89	0.18	0.903	0.177
#14	178.204	0.23	436.25	1.11	124.34	0.19	117.072	0.161
#15	1.13	0.36	2.72	1.10	0.60	0.34	0.712	0.308
#16	1.739	0.33	4.39	1.01	1.04	0.21	1.058	0.202
#17	1.235	0.32	2.95	0.90	0.85	0.19	0.732	0.196
#18	31.168	0.33	112.51	1.05	41.61	0.21	25.369	0.181
#19	1.618	0.32	4.30	1.05	0.88	0.20	0.929	0.173
#20	4.997	0.33	17.78	1.05	4.59	0.21	4.614	0.173
#21	16.058	0.34	35.02	1.00	9.48	0.21	9.344	0.173
#22	1.07	0.29	2.82	1.00	0.65	0.20	0.735	0.175
#23	36.224	0.29	118.94	1.03	32.49	0.21	24.019	0.188
#24	2.003	0.30	4.66	0.98	1.05	0.20	0.665	0.173
#25	1.181	0.29	3.00	0.98	0.74	0.20	0.746	0.167
#26	NA	NA	NA	NA	NA	NA	NA 1.73	NA 1.28
#27	NA	NA	NA	NA	NA	NA	NA 1.75	NA 1.29
#28	NA	NA	NA	NA	NA	NA	NA 1.96	NA 1.30
#32	9.788	0.30	12.88	1.31	5.03	0.20	4.824	0.178
#43	NA	NA	NA	NA	NA	NA	NA 1.77	NA 1.27
#50	1.655	0.29	4.48	1.05	1.00	0.21	1.116	0.157
#51	1.67	0.29	4.54	0.99	1.05	0.20	1.154	0.157
#56	563.143 ⁴⁵ 17.413 ⁴⁶	0.39	84.16 84.16	0.97	22.73	0.21	1396.47	0.159
#57	9167.403 8.79	0.39	17558.33 17558.33	0.97	13970.00	0.21	6131.71	0.159

⁴⁵ Initial execution.

⁴⁶ Subsequent executions.

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
PACMotion								
MC_AbortTrigger	167.406	5.322	150.954	12.762	50.35	3.01	50.35	3.01
MC_CamFileRead	22.997	14.603	63.861	44.001	13.84	7.05	13.84	7.05
MC_CamFileWrite	25.499	15.152	52.938	27.52	12.02	4.7	12.02	4.7
MC_CamIn	185.117	10.867	169.563	30.988	102.8	4.86	102.8	4.86
MC_CamOut	134.517	4.580	99.325	10.812	47.49	2.8	47.49	2.8
MC_CamTableDeselect	104.051	8.023	116.468	18.343	60.09	3.56	60.09	3.56
MC_CamTableSelect	126.359	7.399	138.508	21.01	75.97	3.77	75.97	3.77
MC_DelayedStart	122.332	7.167	141.552	20.164	76.77	3.22	76.77	3.22
MC_DigitalCamSwitch	229.067	39.904	227.174	70.804	152.59	4.32	152.59	4.32
MC_DL_Activate	102.622	19.693	101.982	26.656	50.63	3.39	50.63	3.39
MC_DL_Configure	182.666	8.776	200.857	23.556	130	3.72	130	3.72
MC_DL_Delete	92.780	10.230	116.745	21.212	49.57	3.14	49.57	3.14
MC_DL_Get	102.580	9.065	109.414	35.919	61.29	3.16	61.29	3.16
MC_GearIn	170.551	7.611	165.344	23.176	91.03	4.34	91.03	4.34
MC_GearInPos	115.852	7.790	134.393	21.776	70.31	4.43	70.31	4.43
MC_GearOut	89.184	4.646	100.441	10.64	46.91	3.2	46.91	3.2
MC_Halt	152.450	7.622	155.891	19.243	82.5	4.11	82.5	4.11
MC_Home	117.432	7.715	134.787	19.626	71.45	3.77	71.45	3.77
MC_JogAxis	114.385	11.529	128.661	32.746	65.18	3.38	65.18	3.38
MC_LibraryStatus	91.545	8.275	105.757	16.573	48.78	3.33	48.78	3.33
MC_ModuleReset	95.198	6.322	103.803	17.462	83.73	3.15	83.73	3.15
MC_MoveAbsolute	175.661	7.095	174.49	18.321	99.53	3.95	99.53	3.95
MC_MoveAdditive	159.697	7.495	168.611	19.947	89.47	4.14	89.47	4.14
MC_MoveRelative	159.920	7.440	158.805	19.89	90.54	3.83	90.54	3.83
MC_MoveVelocity	162.556	7.650	159.625	22.839	65.66	3.98	65.66	3.98
MC_Phasing	170.154	7.646	167.904	21.544	95.11	4.6	95.11	4.6
MC_Power	37.423	37.284	130.954	130.871	24.49	20.06	24.49	20.06
MC_ReadActualPosition	39.528	1.656	36.643	4.216	18.61	0.73	18.61	0.73
MC_ReadActualVelocity	39.183	1.644	36.072	4.262	18.36	0.74	18.36	0.74
MC_ReadAnalogInput	45.623	1.988	51.211	4.74	22.38	1.17	22.38	1.17
MC_ReadAnalogOutput	59.744	3.318	47.314	7.89	22.16	1.67	22.16	1.67
MC_ReadAxisError	36.524	2.813	38.94	6.712	17.17	1.32	17.17	1.32
MC_ReadBoolParameter	32.953	2.761	37.485	6.408	14.85	1.57	14.85	1.57
MC_ReadBoolParameters	31.974	3.435	37.936	7.479	15	1.64	15	1.64
MC_ReadDigitalInput	38.895	3.226	36.186	7.043	14.63	1.67	14.63	1.67
MC_ReadDigitalOutput	44.757	2.485	47.597	6.216	17.07	1.58	17.07	1.58
MC_ReadDwordParameters	31.176	3.467	36.61	7.079	14.54	1.58	14.54	1.58
MC_ReadEventQueue	108.594	9.296	123.594	22.352	60.86	4.33	60.86	4.33
MC_ReadParameter	45.460	3.075	58.045	9.839	22.87	1.58	22.87	1.58
MC_ReadParameters	43.504	4.021	47.405	8.012	20.72	1.61	20.72	1.61
MC_ReadStatus	32.917	3.436	41.05	7.167	16.01	4.12	16.01	4.12

Appendix A. Performance Data

Instruction	CPE305 /CPE310		CPU310		CPU315/		CPU320/ CRU320	
	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)	Enabled (µs)	Disabled (µs)
MC_ReadTorqueCommand	39.639	1.720	36.657	4.36	18.51	0.73	18.51	0.73
MC_Reset	93.936	5.851	103.623	16.885	48.37	2.99	48.37	2.99
MC_SetOverride	107.928	11.412	116.23	36.465	62.21	3.81	62.21	3.81
MC_SetPosition	98.519	7.638	116.732	23.002	54	3.97	54	3.97
MC_Stop	99.332	6.130	112.185	16.24	56.38	3.6	56.38	3.6
MC_Superimposed	105.975	5.892	122.646	16.499	63.24	3.75	63.24	3.75
MC_SyncStart	103.035	6.320	122.121	17.198	60.23	3.1	60.23	3.1
MC_TouchProbe	173.373	7.268	160.243	18.934	56.11	3.32	56.11	3.32
MC_WriteAnalogOutput	134.439	8.041	112.994	21.111	53.53	3.36	53.53	3.36
MC_WriteBoolParameter	104.890	7.287	95.696	20.303	48.29	3.21	48.29	3.21
MC_WriteBoolParameters	131.228	8.106	106.974	22.215	57.41	3.23	57.41	3.23
MC_WriteDigitalOutput	96.338	8.259	116.644	23.822	52.99	4.27	52.99	4.27
MC_WriteDwordParameters	160.433	7.661	125.168	19.661	73.23	3.25	73.23	3.25
MC_WriteParameter	98.558	8.231	122.482	27.394	55.3	4.03	55.3	4.03
MC_WriteParameters	192.054	6.859	161.002	18.911	94.77	4.84	94.77	4.84

RX3i Incremental Times

An Increment time is shown for functions that can have variable length inputs.

Incremental time is added to the base function time for each addition to the length of an input parameter. This time applies only to functions that can have varying input lengths (Search, Array Moves, etc.)

Units:

- For table functions, increment is in units of length specified.
- For bit operation functions, increment is microseconds per bit.
- For data move functions, increment is in microseconds per unit.

<i>Instruction</i>	<i>CPE305 CPE310</i>	<i>CPU310</i>	<i>CPU315</i>	<i>CPU320/ CRU320</i>
Bit Operation				
AND_WORD	0.04	0.12	0.02826	0.02463
AND_DWORD	0.06	0.16	0.3088	0.03789
OR_WORD	0.04	0.12	0.03	0.02472
OR_DWORD	0.06	0.16	0.03444	0.03798
XOR_WORD	0.04	0.12	0.02818	0.02478
XOR_DWORD	0.06	0.16	0.03424	0.03762
NOT_WORD	0.02	0.08	0.02011	0.01888
NOT_DWORD	0.04	0.12	0.02839	0.02799
MCMP_WORD	0.08	0.26	0.05934	0.055
MCMP_DWORD	0.09	0.29	0.06407	0.05919
SHL_WORD	0.07	0.17	0.0468	0.05032
SHL_DWORD	0.07	0.18	0.04381	0.04681
SHR_WORD	0.07	0.18	0.04883	0.03557
SHR_DWORD	0.09	0.19	0.0455	0.04718
BTST_WORD	0.00	0	0.00011	0.04332
BTST_DWORD	0.00	0	0.00046	0.03983
ROL_WORD	0.06	0.19	0.05071	0.03634
ROL_DWORD	0.07	0.17	0.03929	0.04152
ROR_WORD	0.06	0.16	0.0428	0.00012
ROR_DWORD	0.07	0.17	0.03992	0.00033
BPOS_WORD	0.32	0.76	0.17369	0.19574
BPOS_DWORD	0.72	1.69	0.38279	0.43922
Relational				
EQ_DATA		0.0001	0.00019	0
Conversion				
REAL_TO_UINT		0	0.00421	0
REAL_TO_DINT		0	0.00936	0
LReal_To_Real	-	-	-	0

Appendix A. Performance Data

Instruction	CPE305 CPE310	CPU310	CPU315	CPU320/ CRU320
Data Move				
MOVE_BIT	0.01	0.02	0.00412	0.00488
MOVE_DINT	0.02	0.04	0	0.0089
MOVE_INT	0.01	0.02	0	0
MOVE_UINT	-	-	-	0.00439
MOVE_WORD	0.01	0.02	0.00968	0.0041
MOVE_DWORD	0.02	0.04	0.04613	0.00913
MOVE_REAL	0.02	0.04	0.0372	0.00951
MOVE_LREAL	0.03	0.09	0.01952	0.01928
MOVE_DATA		0.0002	0.00022	0
MOVE_DATA_EX		0.0002	0.00028	0
DATA_INIT_ASCII	0.00	0.01	0.00217	0.00304
DATA_INIT_COMM	0.01	0.02	0.00408	0.00398
DATA_INIT_DLAN	-	0	0	0
DATA_INIT_DINT	0.01	0.04	0.00811	0.00812
DATA_INIT_DWORD	0.01	0.04	0.00817	0.00807
DATA_INIT_INT	0.01	0.02	0.00447	0.00432
DATA_INIT_REAL	0.01	0.04	0.00796	0.00822
DATA_INIT_LREAL	0.03	0.08	0.01584	0.01639
DATA_INIT_WORD	0.01	0.02	0.00439	0.00469
DATA_INIT_UINT	0.01	0.02	0.00391	0.00422
SWAP_WORD	0.04	0.19	0.00498	0.02921
SWAP_DWORD	0.06	0.16	0.00942	0.03614
BLKCLR_WORD	0.01	0.02	0.00568	0.00627
SHFR_BIT	0.02	0.04	0.01174	0.01241
SHFR_WORD	0.06	0.18	0.04529	0.03804
SHFR_DWORD	0.07	0.20	0.04751	0.04277
Data Table				
SORT_INT	0.33	0.74	0.22253	0.2179
SORT_UINT	0.33	0.74	0.22237	0.21686
SORT_WORD	0.32	0.74	0.22243	0.21704
TBLRD_INT	0.00	0	-1E-05	0.00016
TBLRD_DINT	0.00	0	0.00012	0.00014
TBLWRT_INT	0.00	0	-0.0002	0.00003
TBLWRT_DINT	0.00	0	-0.0002	0.0002
FIFORD_INT	0.01	0.02	0.00432	0.00417
FIFORD_DINT	0.02	0.04	0.00927	0.0093
FIFOWRT_INT	0.00	-0.1333333	0.00011	0.00009
FIFOWRT_DINT	0.00	-1.1777778	-0.001	0.00001
LIFORD_INT	0.00	0.01111111	0.00021	0.00001
LIFORD_DINT	0.00	0.64444444	0.00021	0.00011
LIFOWRT_INT	0.00	-0.8666667	0.0001	0.00004
LIFOWRT_DINT	0.00	-0.8777778	4.4E-05	0.00001
LIFOWRT_DWORD	0.00	0.11111111	-0.0002	0.00001

<i>Instruction</i>	<i>CPE305 CPE310</i>	<i>CPU310</i>	<i>CPU315</i>	<i>CPU320/ CRU320</i>
Array				
ARRAY_MOVE_BIT	0.01	0.02	0.00558	0.00538
ARRAY_MOVE_BYTE	0.00	0.01	0.0024	0.00207
ARRAY_MOVE_INT	0.01	0.02	0.00424	0.00407
ARRAY_MOVE_DINT	0.02	0.05	0.00961	0.00986
ARRAY_MOVE_WORD	0.01	0.02	0.0041	0.00442
ARRAY_MOVE_DWORD	0.02	0.04	0.00974	0.009
ARRAY_MOVE_UINT	0.01	0.02	0.00413	0.0038
SRCH_BYTE	0.02	0.07	0.01796	0.0173
SRCH_WORD	0.03	0.07	0.01828	0.01946
SRCH_DWORD	0.02	0.07	0.01507	0.01407
ARRAY_RANGE_DINT	0.19	0.54	0.13903	0.13582
ARRAY_RANGE_INT	0.18	0.52	0.13471	0.13199
ARRAY_RANGE_UINT	0.18	0.52	0.13647	0.13241
ARRAY_RANGE_WORD	0.18	0.52	0.13578	0.13282
ARRAY_RANGE_DWORD	0.19	0.56	0.14221	0.13928
PACMotion				
MC_ReadBoolParameters	16.000	14.000	7.62	-
MC_ReadDwordParameters	30.000	28.000	12.34	-
MC_ReadParameters	40.000	38.000	19.42	-
MC_WriteBoolParameters	22.000	10.000	0.48	-
MC_WriteDwordParameters	40.000	34.000	1.4	-
MC_WriteParameters	45.000	42.000	1.34	-

A-2.4 RX7i Instruction Times

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)

Bit Operation

AND_WORD	3.42	1.58	1.49	0.69	1.71	0.81	1.29	0.58	0.43	0.20
AND_DWORD	3.64	1.58	1.58	0.70	1.67	0.81	1.31	0.58	0.44	0.20
OR_WORD	3.58	1.71	1.56	0.76	1.72	0.90	1.28	0.59	0.43	0.20
OR_DWORD	3.55	1.66	1.54	0.73	1.71	0.83	1.44	0.60	0.48	0.20
XOR_WORD	3.42	1.57	1.48	0.69	1.73	0.80	1.29	0.61	0.48	0.25
XOR_DWORD	3.55	1.58	1.54	0.70	1.66	0.81	1.32	0.58	0.44	0.25
NOT_WORD	2.73	1.38	1.17	0.59	1.39	0.72	1.02	0.40	0.34	0.13
NOT_DWORD	2.81	1.44	1.21	0.62	1.44	0.75	1.07	0.41	0.35	0.14
MCMP_WORD	5.69	2.43	2.44	1.04	2.64	1.14	2.51	1.08	0.85	0.36
MCMP_DWORD	5.69	2.32	2.50	1.00	2.63	1.11	2.48	1.03	0.82	0.34
SHL_WORD	4.46	2.62	1.89	1.11	2.31	1.25	1.92	1.00	0.64	0.34
SHL_DWORD	4.53	2.73	1.92	1.56	2.31	1.28	1.90	0.98	0.63	0.32
SHR_WORD	4.64	2.59	1.96	1.09	2.45	1.24	1.98	0.98	0.66	0.32
SHR_DWORD	4.51	2.65	1.91	1.12	2.11	1.29	1.90	1.01	0.63	0.34
ROL_WORD	2.95	1.61	1.27	0.69	1.43	0.82	1.17	0.61	0.39	0.20
ROL_DWORD	3.27	1.61	1.39	0.70	1.46	0.84	1.07	0.59	0.36	0.20
ROR_WORD	2.93	1.52	1.25	0.66	1.45	0.82	1.11	0.57	0.39	0.19
ROR_DWORD	2.92	1.58	0.68	0.68	1.41	0.81	1.20	0.57	0.40	0.19
BTST_WORD	3.23	1.45	0.58	0.5	1.49	0.75	1.16	0.63	0.39	0.21
BTST_DWORD	3.29	1.37	1.41	0.5	1.48	0.72	1.19	0.63	0.40	0.19
BSET_WORD	2.62	1.43	1.12	0.61	1.17	0.72	0.97	0.48	0.31	0.16
BSET_DWORD	2.59	1.40	1.13	0.60	1.16	0.71	0.97	0.48	0.32	0.16
BCLR_WORD	2.51	1.36	1.08	0.59	1.20	0.72	0.97	0.48	0.31	0.16
BCLR_DWORD	2.49	1.33	1.07	0.57	1.16	0.70	0.97	0.47	0.32	0.16
BPOS_WORD	3.63	1.24	1.66	0.64	1.84	0.76	1.51	0.56	0.50	0.19
BPOS_DWORD	3.29	1.18	1.97	0.62	2.18	0.75	1.78	0.48	0.59	0.18

Relational

CMP_INT	3.51	1.25	1.50	0.54	1.45	0.60	1.58	0.52	0.53	0.17
CMP_DINT	3.86	1.32	1.66	0.57	1.51	0.66	1.61	0.52	0.53	0.17
CMP_REAL	3.65	1.30	1.57	0.56	1.52	0.62	0.53	0.53	0.54	0.1
CMP_LREAL	4.08	1.25	1.75	0.53	1.64	0.59	1.84	0.52	0.61	0.18
CMP_UINT	4.15	1.35	1.78	0.58	1.48	0.63	1.62	0.53	0.54	0.17
EQ_DATA	10.13	2.02	2.91	1.05	2.81	0.94	2.82	1.08	1.27	0.66
EQ_DINT	2.45	1.15	1.06	0.50	1.08	0.60	1.05	0.41	0.35	0.13
EQ_INT	2.49	1.14	1.07	0.50	1.04	0.58	1.04	0.47	0.35	0.16
EQ_LREAL	3.00	1.27	1.28	0.54	1.25	0.64	1.27	0.47	0.43	0.17
EQ_REAL	2.61	1.12	1.12	0.49	1.03	0.60	1.15	0.43	0.37	0.14
EQ_UINT	2.33	1.11	1.00	0.48	1.01	0.59	1.04	0.40	0.35	0.13

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
NE_INT	2.34	1.13	1.01	0.49	0.97	0.60	1.03	0.42	0.34	0.14
NE_DINT	2.56	1.34	1.10	0.55	1.10	0.66	1.08	0.43	0.36	0.14
NE_UINT	2.43	1.18	1.04	0.51	1.00	0.62	1.08	0.43	0.36	0.14
NE_REAL	2.65	1.18	1.14	0.51	1.05	0.61	1.13	0.40	0.38	0.13
NE_LREAL	2.93	1.17	1.26	0.51	1.24	0.60	1.29	0.42	0.44	0.15
GT_INT	2.50	1.14	1.08	0.49	1.05	0.60	1.05	0.40	0.35	0.13
GT_DINT	2.42	1.15	1.04	0.50	1.04	0.59	1.05	0.40	0.35	0.13
GT_REAL	2.60	1.11	1.11	0.48	1.02	0.58	1.13	0.40	0.38	0.13
GT_LREAL	2.90	1.15	1.27	0.50	1.21	0.60	1.28	0.43	0.43	0.15
GT_UINT	2.39	1.10	1.02	0.48	0.99	0.59	1.06	0.40	0.35	0.13
GE_INT	2.48	1.13	1.07	0.50	1.04	0.59	1.08	0.40	0.36	0.13
GE_DINT	2.57	1.19	1.08	0.51	1.08	0.62	1.07	0.41	0.36	0.14
GE_REAL	2.59	1.10	1.11	0.48	1.02	0.58	1.13	0.43	0.38	0.14
GE_LREAL	2.92	1.17	0.51	0.6	1.25	0.62	1.24	0.41	0.43	0.14
GE_UINT	2.42	1.19	1.04	0.51	1.01	0.63	1.06	0.41	0.35	0.13
LT_INT	2.54	1.22	1.09	0.50	1.06	0.61	1.05	0.42	0.35	0.14
LT_DINT	2.58	1.27	1.11	0.54	1.09	0.66	1.08	0.43	0.36	0.14
LT_REAL	2.66	1.18	1.14	0.51	1.04	0.72	1.13	0.39	0.38	0.13
LT_LREAL	2.90	1.15	1.24	0.50	1.22	0.59	1.29	0.43	0.43	0.14
LT_UINT	2.48	1.15	1.03	0.49	1.02	0.60	1.04	0.0	0.35	0.13
LE_INT	2.48	1.14	1.07	0.49	1.03	0.60	1.08	0.40	0.36	0.13
LE_DINT	2.46	1.15	1.05	0.50	1.04	0.59	1.05	0.40	0.35	0.13
LE_UINT	2.41	1.17	1.03	0.50	1.04	0.61	1.02	0.41	0.34	0.13
LE_REAL	2.68	1.14	1.16	0.49	1.02	0.60	1.10	0.40	0.37	0.13
LE_LREAL	2.89	1.15	1.24	0.49	12.1	0.58	1.26	0.39	0.43	0.14

Conversion

BCD-4 to INT	2.11	1.11	0.90	0.48	0.95	0.62	0.83	0.34	0.27	0.14
DINT to INT	2.18	1.15	0.94	0.48	0.81	0.56	0.85	0.33	0.28	0.14
UINT to INT	1.95	1.14	0.84	0.49	0.81	0.55	0.77	0.31	0.25	0.14
BCD-8 to DINT	3.00	1.10	1.29	0.47	1.02	0.58	0.94	0.32	0.30	0.14
INT to DINT	2.19	1.13	0.94	0.49	0.78	0.55	0.75	0.33	0.23	0.15
UINT to DINT	2.17	1.18	0.94	0.51	0.92	0.57	0.79	0.32	0.27	0.13
INT to UINT	1.88	1.12	0.81	0.48	0.76	0.56	0.80	0.35	0.27	0.14
DINT to UINT	2.15	1.11	0.93	0.48	0.83	0.58	0.72	0.33	0.24	0.14
BCD-4 to UINT	2.13	1.08	0.93	0.48	0.94	0.65	0.81	0.35	0.27	0.14
INT to BCD-4	2.24	1.12	0.94	0.48	0.92	0.56	0.95	0.35	0.27	0.15
UINT to BCD-4	2.26	1.17	0.97	0.50	0.93	0.56	1.07	0.36	0.33	0.15
DINT to BCD-8	3.15	1.08	1.35	0.47	1.00	0.60	0.91	0.34	0.31	0.14
REAL_TO_INT	2.75	1.20	1.18	0.52	1.02	0.58	0.99	0.34	0.33	0.14
REAL_TO_UINT	2.67	1.18	1.15	0.51	1.01	0.57	0.95	0.34	0.31	0.14
REAL_TO_LREAL	2.26	1.01	0.97	0.43	0.88	0.55	0.88	0.37	0.29	0.12

Appendix A. Performance Data

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
REAL_TO_DINT	3.06	1.14	1.32	0.49	1.05	0.57	0.98	0.34	0.31	0.14
INT_TO_REAL	2.17	1.12	0.93	0.48	0.77	0.56	0.73	0.36	0.24	0.15
UINT_TO_REAL	2.19	1.17	0.94	0.50	0.77	0.57	0.83	0.37	0.28	0.15
DINT_TO_REAL	2.43	1.14	1.04	0.49	0.84	0.60	0.75	0.34	0.27	0.14
DINT_TO_LREAL	2.24	1.01	0.96	0.44	0.85	0.73	0.85	0.42	0.28	0.13
REAL_TRUN_INT	2.22	1.37	0.87	0.49	0.83	0.59	0.56	0.13	0.26	0.11
REAL_TRUN_DINT	2.42	1.13	1.09	0.55	0.89	0.64	0.70	0.13	0.30	0.11
DEG_TO_RAD_REAL	2.39	1.11	1.03	0.48	0.83	0.57	0.87	0.35	0.29	0.12
DEG_TO_RAD_LREAL	2.34	1.05	1.01	0.44	0.92	0.52	0.98	0.34	0.33	0.11
RAD_TO_DEG_REAL	2.34	1.16	1.03	0.48	0.94	0.57	0.86	0.35	0.29	0.12
RAD_TO_DEG_LREAL	2.33	1.06	1.00	0.44	0.93	0.52	0.98	0.34	0.33	0.11
BCD-4 to REAL	2.42	1.09	1.04	0.48	0.99	0.64	0.89	0.34	0.28	0.14
BCD-8 to REAL	3.07	1.14	1.32	0.49	1.11	0.55	0.98	0.31	0.31	0.14
LREAL_TO_DINT	2.85	1.00	1.21	0.43	1.07	0.73	1.10	0.42	0.36	0.13
LREAL_TO_REAL	2.35	1.09	1.01	0.47	0.87	0.58	0.83	0.35	0.2	0.12

Data Move

BLKCLR	2.13	1.16	0.91	0.50	1.09	0.62	0.73	0.34	0.24	0.11
BITSEQ	3.90	3.93	1.63	1.64	1.76	1.74	1.50	1.59	0.50	0.53
MOVE_BIT	2.93	1.53	1.22	0.63	1.47	0.81	1.06	0.41	0.35	0.14
MOVE_DINT	2.23	1.44	0.92	0.58	1.07	0.75	0.78	0.26	0.3	0.13
MOVE_INT	2.27	1.47	0.94	0.60	1.06	0.75	0.79	0.42	0.26	0.14
MOVE_DWORD	2.31	1.51	0.96	0.62	1.10	0.77	0.81	0.41	0.26	0.14
MOVE_LREAL	2.74	1.43	1.15	0.61	1.56	0.77	0.95	0.42	0.31	0.14
MOVE_REAL	2.18	1.39	0.91	0.57	1.07	0.74	0.78	0.40	0.26	0.14
MOVE_UINT	2.3	1.2	1.0	0.5	-	-	-	-	-	-
MOVE_WORD	2.25	1.45	0.93	0.59	1.04	0.76	0.80	0.43	0.27	0.14
MOVE_DATA	9.81	3.22	2.72	1.02	2.73	0.95	2.54	1.12	1.11	0.69
MOVE_DATA_EX	12.25	4.22	3.53	1.15	3.35	1.27	2.85	1.44	1.27	0.80
MOVE_TO_FLAT	12.25	4.22	3.53	1.15	3.35	1.27	2.85	1.44	1.27	0.80
MOVE_FROM_FLAT	12.25	4.22	3.53	1.15	3.35	1.27	2.85	1.44	1.27	0.80
BLKMOV_WORD	2.73	2.26	1.17	0.97	1.23	1.14	1.13	0.91	0.38	0.30
BLKMOV_DINT	3.02	2.36	1.30	1.01	1.35	1.10	1.19	0.90	0.40	0.30
BLKMOV_INT	2.71	2.26	1.16	0.97	1.21	1.13	1.11	0.88	0.37	0.30
BLKMOV_DWORD	2.97	2.31	1.28	0.99	1.33	1.08	1.19	0.87	0.40	0.29
BLKMOV_REAL	3.01	2.34	1.29	1.00	1.35	1.10	1.18	0.89	0.39	0.29
BLKMOV_UINT	2.71	2.21	1.17	0.96	1.23	1.15	1.12	0.87	0.37	0.29
DATA_INIT_ASCII	0.91	1.39	0.40	0.60	0.76	0.77	0.30	0.44	0.10	0.15
DATA_INIT_COMM	1.05	1.36	0.46	0.60	0.84	0.78	0.37	0.43	0.11	0.15
DATA_INIT_DLAN	1.33	1.49	0.58	0.64	0.94	0.83	0.39	0.45	0.14	0.15
DATA_INIT_DINT	0.92	1.37	0.40	0.59	0.78	0.79	0.30	0.45	0.10	0.15
DATA_INIT_DWORD	0.98	1.39	0.41	0.60	0.79	0.81	0.32	0.45	0.11	0.15

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
DATA_INIT_INT	0.95	1.41	0.42	0.61	0.81	0.81	0.31	0.46	0.10	0.15
DATA_INIT_REAL	0.90	1.36	0.40	0.59	0.77	0.78	0.30	0.44	0.18	0.22
DATA_INIT_LREAL	0.98	1.33	0.42	0.57	0.79	0.78	0.36	0.48	0.11	0.16
DATA_INIT_WORD	0.90	1.41	0.40	0.61	0.78	0.79	0.30	0.44	0.10	0.15
DATA_INIT_UINT	0.90	1.37	0.39	0.59	0.78	0.79	0.31	0.46	0.10	0.15
SWAP_WORD	2.83	1.41	1.18	0.57	1.34	0.74	0.96	0.42	0.32	0.13
SWAP_DWORD	2.59	1.43	1.08	0.58	1.29	0.73	0.93	0.42	0.31	0.14
SHFR_BIT	6.35	2.94	2.74	1.27	2.92	1.22	2.37	1.08	0.79	0.36
SHFR_WORD	7.08	4.90	3.04	2.11	3.25	2.16	3.27	2.46	1.09	0.82
SHFR_DWORD	7.62	5.03	3.27	2.1	3.39	2.24	3.29	2.43	1.10	0.81
Data Table										
SORT_INT	36.57	1.40	15.66	0.60	15.94	0.75	16.50	0.44	5.50	0.15
SORT_UINT	36.48	1.40	15.66	0.60	15.90	0.75	16.50	0.44	5.49	0.15
SORT_WORD	36.51	1.39	15.61	0.60	15.90	0.76	16.46	0.44	5.49	0.15
TBLRD_INT	4.14	1.75	1.79	0.77	2.03	0.97	1.52	0.73	0.49	0.25
TBLRD_DINT	4.19	1.77	1.79	0.76	2.02	0.97	1.47	0.69	0.48	0.22
TBLWRT_INT	4.06	1.74	1.73	0.74	1.72	0.84	1.59	0.74	0.53	0.25
TBLWRT_DINT	4.00	1.70	1.72	0.72	1.70	0.84	1.60	0.72	0.53	0.23
FIFORD_INT	3.92	1.69	1.68	0.71	1.67	0.72	1.58	0.66	0.53	0.22
FIFORD_DINT	3.89	1.71	1.65	0.73	1.65	0.68	1.56	0.66	0.52	0.22
FIFOWRT_INT	3.17	1.46	1.35	0.64	1.41	0.75	1.23	0.49	0.42	0.18
FIFOWRT_DINT	3.10	1.43	1.33	0.62	1.39	0.72	1.25	0.51	0.42	0.17
LIFORD_INT	3.77	1.73	1.60	0.72	1.62	0.72	1.49	0.66	0.50	0.22
LIFORD_DINT	3.77	1.74	1.60	0.72	1.63	0.72	1.48	0.66	0.49	0.22
LIFOWRT_INT	3.18	1.49	1.35	0.63	1.43	0.72	1.25	0.51	0.42	0.17
LIFOWRT_DINT	3.08	1.42	1.33	0.61	1.41	0.72	1.33	0.68	0.42	0.18
LIFOWRT_DWORD	3.15	1.47	1.35	0.63	1.43	0.72	1.25	0.53	0.41	0.18

Array

ARRAY_MOVE_BIT	4.10	2.16	1.76	0.92	1.94	1.06	1.57	0.75	0.52	0.25
ARRAY_MOVE_BYTE	3.12	1.97	1.34	0.84	1.45	0.95	1.25	0.82	0.42	0.27
ARRAY_MOVE_WORD	3.19	2.10	1.37	0.91	1.45	1.05	1.26	0.81	0.42	0.27
ARRAY_MOVE_DINT	3.10	2.04	1.33	0.85	1.41	0.97	1.24	0.81	0.41	0.2
ARRAY_MOVE_DWORD	3.07	1.97	1.32	0.84	1.42	0.95	1.24	0.81	0.42	0.27
ARRAY_MOVE_INT	3.23	2.12	1.39	0.92	1.47	1.03	1.26	0.79	0.42	0.26
ARRAY_MOVE_UINT	3.10	1.96	1.33	0.84	1.53	1.07	1.37	1.14	0.42	0.28
SRCH_BYTE	4.07	1.86	1.74	0.79	2.11	0.91	1.74	0.87	0.58	0.29
SRCH_WORD	3.90	1.86	1.70	0.82	1.83	0.91	1.90	0.83	0.63	0.27
SRCH_DWORD	4.57	1.91	1.96	0.82	1.92	0.96	1.78	0.78	0.59	0.25
ARRAY_RANGE_WORD	4.14	1.89	1.80	0.81	1.90	0.96	1.70	0.69	0.57	0.23
ARRAY_RANGE_DWORD	4.61	1.88	1.99	0.80	2.06	0.97	1.70	0.65	0.57	0.22
ARRAY_RANGE_DINT	4.39	1.89	1.88	0.81	1.97	0.99	1.81	0.69	0.61	0.23

Appendix A. Performance Data

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
ARRAY_RANGE_INT	4.22	1.84	1.81	0.79	1.92	0.96	1.84	0.68	0.61	0.23
ARRAY_RANGE_UINT	4.44	1.82	1.76	0.78	1.91	0.96	1.68	0.66	0.56	0.22

Math

ADD_INT	2.11	1.31	0.91	0.58	0.87	0.66	1.00	0.49	0.33	0.16
ADD_DINT	2.56	1.34	1.12	0.58	0.97	0.67	0.90	0.46	0.30	0.15
ADD_REAL	2.75	1.32	1.19	0.56	0.96	0.66	0.92	0.50	0.30	0.17
ADD_LREAL	2.82	1.30	1.21	0.54	1.09	0.62	1.28	0.53	0.43	0.18
ADD_UINT	2.23	1.42	0.93	0.57	0.96	0.68	0.90	0.51	0.29	0.16
SUB_INT	2.13	1.35	0.91	0.55	0.87	0.65	0.87	0.49	0.29	0.16
SUB_DINT	2.50	1.35	1.09	0.56	0.94	0.65	0.90	0.49	0.30	0.16
SUB_REAL	2.46	1.29	1.13	0.63	1.08	0.85	1.08	0.69	0.30	0.17
SUB_LREAL	1.26	1.26	1.26	0.54	1.10	0.63	1.37	0.53	0.47	0.17
MUL_INT	2.25	1.42	0.93	0.57	0.90	0.65	0.89	0.49	0.30	0.16
MUL_DINT	2.53	1.34	1.10	0.59	0.95	0.69	1.05	0.49	0.35	0.17
MUL_MIXED	2.36	1.31	1.00	0.58	0.89	0.66	0.90	0.51	0.30	0.16
MUL_REAL	2.57	1.39	1.08	0.56	0.93	0.65	0.88	0.48	0.29	0.17
MUL_LREAL	2.87	1.21	1.24	0.52	1.19	0.61	1.28	0.54	0.44	0.18
MUL_UINT	2.14	1.35	0.92	0.55	0.90	0.65	0.87	0.49	0.29	0.16
DIV_INT	2.25	1.29	0.99	0.58	0.98	0.68	0.90	0.48	0.30	0.16
DIV_DINT	2.71	1.35	1.16	0.60	0.99	0.73	0.93	0.48	0.30	0.16
DIV_REAL	2.70	1.43	1.11	0.56	0.96	0.68	1.07	0.49	0.36	0.16
DIV_LREAL	2.86	1.20	1.23	0.52	1.14	0.61	1.33	0.53	0.45	0.18
DIV_MIXED	2.70	1.35	1.15	0.56	1.11	0.65	0.97	0.49	0.33	0.16
MOD_INT	2.23	1.38	0.95	0.57	0.93	0.66	0.91	0.48	0.30	0.16
MOD_DINT	2.65	1.35	1.12	0.56	1.09	0.79	1.09	0.69	0.30	0.17
MOD_UINT	2.19	1.29	1.01	0.63	0.99	0.74	0.99	0.50	0.33	0.17
ABS_INT	2.01	1.21	0.99	0.63	0.93	0.60	0.84	0.38	0.29	0.13
ABS_DINT	2.44	1.17	1.05	0.50	0.96	0.60	0.84	0.37	0.28	0.12
ABS_REAL	2.45	1.14	1.05	0.49	0.87	0.59	0.90	0.35	0.30	0.12
ABS_LREAL	2.58	1.07	1.11	0.46	0.97	0.53	0.98	0.35	0.33	0.11
SCALE_INT	3.54	1.84	1.57	0.83	1.82	0.91	1.23	0.54	0.48	0.24
SCALE_DINT	2.98	1.79	1.37	0.89	1.61	1.03	1.00	0.51	0.41	0.24
SCALE_UINT	2.89	1.78	1.27	0.81	1.39	0.98	0.98	0.5	0.40	0.25
SQRT_INT	2.39	1.13	1.05	0.50	1.08	0.57	0.99	0.35	0.32	0.12
SQRT_DINT	3.37	1.18	1.44	0.51	1.28	0.58	1.08	0.35	0.36	0.12
SQRT_REAL	2.54	1.23	1.09	0.54	0.91	0.61	0.85	0.37	0.29	0.13
SQRT_LREAL	2.36	1.09	1.00	0.46	0.92	0.53	0.99	0.32	0.34	0.12

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
Trigonometric										
SIN_REAL	3.02	1.11	1.26	0.48	0.97	0.57	0.95	0.35	0.32	0.12
SIN_LREAL	3.05	1.10	1.31	0.48	1.13	0.55	1.16	0.35	0.39	0.11
COS_REAL	2.96	1.11	1.22	0.48	0.97	0.57	1.06	0.35	0.36	0.12
COS_LREAL	2.88	1.09	1.18	0.47	1.10	0.56	1.17	0.35	0.39	0.11
TAN_REAL	3.02	1.11	1.26	0.48	1.02	0.57	0.96	0.35	0.32	0.12
TAN_LREAL	2.89	1.09	1.23	0.476	1.14	0.56	1.32	0.36	0.44	0.11
ASIN_REAL	3.29	1.20	1.41	0.52	1.26	0.63	1.13	0.35	0.38	0.12
ASIN_LREAL	3.14	10.5	1.32	0.45	1.33	0.54	1.37	0.35	0.46	0.12
ACOS_REAL	3.29	1.20	1.41	0.52	1.26	0.63	1.13	0.35	0.38	0.12
ACOS_LREAL	3.10	1.04	1.32	0.45	1.28	0.53	1.36	0.54	0.47	0.12
ATAN_REAL	3.26	1.25	1.37	0.54	1.02	0.65	1.05	0.37	0.35	0.12
ATAN_LREAL	2.87	1.04	1.20	0.46	1.08	0.53	1.18	0.35	0.40	0.12
Logarithmic										
LOG_REAL	2.90	1.16	1.25	0.50	1.03	0.59	1.04	0.35	0.35	0.12
LOG_LREAL	2.88	1.03	1.21	0.43	1.11	0.52	1.19	0.38	0.39	0.12
LN_REAL	2.84	1.13	1.22	0.50	1.01	0.58	1.06	0.37	0.35	0.12
LN_LREAL	2.83	1.07	1.22	0.46	1.16	0.53	1.19	0.34	0.40	0.11
EXPT_REAL	4.13	1.41	1.77	0.63	1.52	0.72	1.39	0.40	0.46	0.13
EXPT_LREAL	3.03	1.33	1.30	0.57	1.35	0.71	1.24	0.42	0.42	0.14
EXP_REAL	2.70	1.16	1.16	0.50	0.97	0.59	1.00	0.37	0.33	0.12
EXP_LREAL	2.71	1.04	1.16	0.45	1.08	0.54	1.25	0.34	0.42	0.12
PID										
PIDISA	6.92	6.18	2.98	2.66	3.17	2.79	2.66	2.44	0.89	0.81
PIDIND	6.86	6.13	2.97	2.66	3.17	2.79	2.65	2.43	0.88	0.81
Range										
RANGE_INT	3.27	1.89	1.40	0.81	1.35	0.91	1.40	0.87	0.53	0.35
RANGE_DINT	3.26	1.94	1.40	0.83	1.36	0.92	1.41	0.81	0.47	0.27
RANGE_DWORD	3.40	2.02	0.87	0.87	1.46	1.01	1.42	0.82	0.47	0.27
Timers										
ONDTR	4.79	3.70	2.01	1.54	2.11	1.57	1.82	1.38	0.61	0.46
OFDT	4.57	4.08	1.92	1.71	1.97	1.76	1.71	1.45	0.57	0.49
TMR	4.52	4.04	1.92	1.71	2.05	1.79	1.71	1.45	0.58	0.49
TOF	9.6	4.9	4.1	2.1	NA	NA	3.9	2.0	1.3	0.6
TON	9.5	4.8	4.0	2.0	NA	NA	3.9	2.0	1.3	0.6
TP	9.8	4.8	4.2	2.1	NA	NA	3.9	2.0	1.3	0.6
Counters										
UPCTR	4.13	4.17	1.74	1.76	1.85	1.86	1.59	1.53	0.53	0.51
DNCTR	4.16	4.18	1.73	1.75	1.84	1.86	1.54	1.53	0.52	0.51

Appendix A. Performance Data

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
Control										
JUMPN	0.21	0.26	0.06	0.06	0.12	0.09	0.12	0.08	0.04	0.03
FOR/NEXT	1.51	0.72	0.64	0.31	0.90	0.47	0.56	0.26	0.19	0.09
MCRN/ENDMCRN Combined	0.68	0.68	0.28	0.29	0.28	0.28	0.10	0.10	0.03	0.03
SWITCH_POS	1.91	1.02	0.82	0.44	0.87	0.59	0.60	0.13	0.26	0.12
DOIO	32.78	1.45	17.60	0.63	6.50	0.76	14.94	0.23	9.374	0.15
DOIO with ALT	32.56	1.48	17.47	0.63	6.47	0.75	14.91	0.32	9.36	0.18
DRUM_SEQ	6.98	5.70	2.99	2.45	3.21	2.67	2.63	2.21	0.88	0.74
SCAN_SET_IO	55.21	1.92	32.65	0.83	33.69	0.86	30.40	0.76	22.84	0.25
SUSIO	2.14	0.45	0.92	0.20	1.12	0.35	0.68	0.06	0.30	0.05
COMMREQ	117.27	1.60	73.25	0.73	73.30	0.90	73.42	0.59	65.23	0.22
CALL/RETURN (LD)	7.27	0.51	3.11	0.23	3.58	0.42	2.79	0.06	0.99	0.05
CALL/RETURN (Parameterized Block)	7.84	0.56	2.07	0.23	2.33	0.42	1.94	0.05	0.72	0.06
CALL/RETURN (C Block)	7.24	0.55	3.05	0.25	3.29	0.45	2.91	0.06	1.04	0.04
Bus										
BUS_RD_BYTE	21.30	2.42	10.87	1.04	1.94	1.18	8.56	1.00	5.24	0.33
BUS_RD_DWORD	21.96	2.51	11.16	1.09	2.13	1.25	8.14	1.00	5.17	0.33
BUS_RD_WORD	21.44	2.54	10.98	1.10	2.11	1.29	8.14	1.01	5.17	0.33
BUS_WRT_BYTE	23.76	2.72	11.62	1.17	3.10	1.26	9.46	0.96	5.76	0.32
BUS_WRT_DWORD	23.52	2.56	11.53	1.10	3.11	1.30	9.48	0.95	5.77	0.32
BUS_WRT_WORD	23.51	2.55	11.54	1.10	3.09	1.28	9.46	0.95	5.76	0.32
BUS_RMW_BYTE	24.44	2.78	12.97	1.19	2.41	1.37	10.28	1.12	6.58	0.37
BUS_RMW_DWORD	24.73	2.82	12.80	1.21	2.23	1.35	10.06	1.13	6.48	0.38
BUS_RMW_WORD	24.00	2.77	12.54	1.19	2.41	1.38	10.25	1.12	6.54	0.38
BUS_TS_BYTE	23.23	2.36	12.23	1.01	2.19	1.28	9.93	0.87	6.45	0.29
BUS_TS_WORD	22.98	2.31	12.14	0.99	2.06	1.15	9.96	0.91	6.5	0.28

Instruction	CPE010		CPE020		CRE020		CPE030 CRE030 ⁴³		CPE040 CRE040	
	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)	Enabled (μ s)	Disabled (μ s)
SVC_REQ										
#1	6.40	1.20	2.75	0.52	2.78	0.79	2.10	0.1	0.77	0.10
#2	6.45	1.04	2.76	0.45	2.74	0.67	2.67	0.35	0.89	0.12
#3	4.94	1.15	2.10	0.49	2.45	0.74	1.39	0.09	0.53	0.10
#4	4.93	1.12	2.09	0.47	2.49	0.74	1.42	0.08	0.54	0.10
#5	4.99	1.19	2.12	0.50	2.49	0.77	1.44	0.10	0.55	0.10
#6	4.62	1.12	1.96	0.47	1.97	0.74	1.46	0.13	0.55	0.11
#7	8.81	1.17	3.67	0.51	3.72	0.78	3.30	0.34	1.05	0.10
#8	7.08	1.07	3.82	0.46	4.00	0.66	3.92	0.34	2.53	0.12
#9	4.12	1.06	1.76	0.46	1.95	0.66	1.83	0.32	0.60	0.11
#10	6.81	1.10	3.02	0.45	3.04	0.67	2.71	0.35	0.91	0.12
#11	4.26	1.12	1.84	0.48	1.90	0.68	1.82	0.34	0.61	0.11
#12	2.25	1.01	0.97	0.44	1.12	0.66	1.02	0.33	0.34	0.11
#13	4.55	1.24	1.96	0.51	2.78	0.75	1.32	0.08	0.51	0.09
#14	424.95	1.16	188.07	0.48	203.10	0.76	197.46	0.09	71.70	0.10
#15	3.18	1.14	1.38	0.49	1.25	0.51	0.94	0.49	0.31	0.16
#16	4.57	1.20	1.94	0.52	2.06	0.70	1.71	0.35	0.57	0.12
#17	2.94	1.13	1.24	0.49	NA	NA	1.27	0.32	0.35	0.04
#18	112.36	1.18	48.09	0.51	48.20	0.69	69.36	0.33	23.12	0.11
#19	4.61	1.19	1.97	0.51	2.71	0.66	1.51	0.33	0.50	0.11
#20	18.92	1.19	8.09	0.51	7.58	0.65	7.69	0.33	2.56	0.11
#21	36.19	1.23	18.15	0.52	17.77	0.66	13.29	0.32	7.15	0.18
#22	2.86	1.23	1.23	0.53	1.28	0.63	1.19	0.36	0.39	0.12
#23	119.63	1.19	51.22	0.52	54.68	0.65	54.33	0.33	18.01	0.11
#24	150.79	1.17	77.38	0.51	1.26	0.65	58.55	0.32	34.67	0.11
#25	3.03	1.21	1.30	0.52	1.25	0.66	1.30	0.35	0.43	0.121
#26	NA	NA	NA	NA	3.20	2.85	NA 2.65	NA 2.13	NA 0.88	NA 0.71
#27	NA	NA	NA	NA	3.42	2.85	NA 2.90	NA 2.16	NA 0.97	NA 0.72
#28	NA	NA	NA	NA	3.19	2.86	NA 3.30	NA 2.17	NA 1.18	NA 0.73
#32	54.47	1.21	48.97	0.50	NA	NA	47.36 NA	0.30 NA	45.12 NA	0.12 NA
#43	NA	NA	NA	NA	3.53	2.91	NA 2.93	NA 2.11	NA 0.98	NA 0.70
#50	4.48	1.18	1.90	0.51	1.92	0.63	1.76	0.33	0.59	0.11
#51	4.60	1.13	1.98	0.49	1.9	0.64	2.27	0.80	0.59	0.10
#56	82.65	1.23	42.66	0.52	44.03	0.78	29.75	0.32	10.26	0.11
#57	19331.60	1.21	19017.30	0.52	18848.20	0.78	13585	0.32	13540	0.11

RX7i Incremental Times

An Increment time is shown for functions that can have variable length inputs.

Incremental time is added to the base function time for each addition to the length of an input parameter. This time applies only to functions that can have varying input lengths (Search, Array Moves, etc.)

Units:

- For table functions, increment is in units of length specified.
- For bit operation functions, increment is microseconds per bit.
- For data move functions, microseconds per unit.

<i>Instruction</i>	<i>CPE010</i>	<i>CPE020</i>	<i>CRE020</i>	<i>CPE030/ CRE030</i>	<i>CPE040/ CRE040</i>
Bit Operation					
AND_WORD	0.11572	0.04957	0.05006	0.04553	0.01517
AND_DWORD	0.15567	0.5996	0.6002	0.5095	0.1766
OR_WORD	0.11857	0.05078	0.05039	0.04842	0.01543
OR_DWORD	0.15729	0.06743	0.067	0.05626	0.01859
XOR_WORD	0.1156	0.04983	0.05022	0.04613	0.01532
XOR_DWORD	0.15568	0.06691	0.06669	0.05623	0.0187
NOT_WORD	0.07498	0.03249	0.03248	0.03343	0.01117
NOT_DWORD	0.11946	0.0513	0.05011	0.04666	0.01556
MCMP_WORD	0.26347	0.11279	0.11288	0.0969	0.03228
MCMP_DWORD	0.28671	0.12257	0.1226	0.10587	0.03523
SHL_WORD	0.17382	0.07444	0.0745	0.07786	0.02594
SHL_DWORD	0.18306	0.07839	0.07842	0.07287	0.02428
SHR_WORD	0.18397	0.07872	0.0785	0.08088	0.02686
SHR_DWORD	0.18868	0.08229	0.08062	0.07612	0.02537
BTST_WORD	0.00014	-6E-05	-3E-05	0.00026	0.0001
BTST_DWORD	0.00098	3.3E-05	0.00042	0.00071	0.00024
ROL_WORD	0.1944	0.08303	0.08316	0.08447	0.02821
ROL_DWORD	0.16617	0.07114	0.0714	0.06493	0.02161
ROR_WORD	0.15893	0.06819	0.06809	0.0715	0.02382
ROR_DWORD	0.16617	0.0737	0.07399	0.06634	0.0221
BPOS_WORD	0.76048	0.32549	0.32584	0.28894	0.09634
BPOS_DWORD	1.68499	0.72159	0.7231	0.6378	0.21258
Relational					
EQ_DATA	0.00029	0.00004	0.00021	0.00051	2.6E-05
Conversion					
REAL_TO_UINT	0	0	0	0	0
REAL_TO_DINT	0	0	0	0	0

<i>Instruction</i>	<i>CPE010</i>	<i>CPE020</i>	<i>CRE020</i>	<i>CPE030/ CRE030</i>	<i>CPE040/ CRE040</i>
Data Move					
MOVE_BIT	0.01958	0.00821	0.00813	0.00919	0.00307
MOVE_DINT	0.04398	0.01884	0.01943	0.0157	0.00533
MOVE_INT	0.02002	0.00833	0.00863	0.00694	0.00231
MOVE_DWORD	0.04447	0.01904	0.0193	0.01584	0.00528
MOVE_LREAL	0.08989	0.03854	0.03878	0.03242	0.01083
MOVE_UINT	0.02	0.01	0.02	0.03	0.01
MOVE_WORD	0.02046	0.00876	0.00839	0.00704	0.00234
MOVE_REAL	0.04464	0.01914	0.01946	0.01572	0.00523
MOVE_DATA	0.00021	0.00015	0.00015	-0.0002	7.2E-05
MOVE_DATA_EX	0.0011	6.9E-05	6.9E-05	3.2E-05	2.1E-05
DATA_INIT_ASCII	0.01057	0.00459	0.00844	0.00686	0.00101
DATA_INIT_COMM	0.01982	0.00851	0.01724	0.01381	0.00229
DATA_INIT_DLAN	0	0	0	0	0
DATA_INIT_DINT	0.04034	0.01713	0.00878	0.00754	0.00464
DATA_INIT_DWORD	0.04032	0.01728	0.0084	0.00649	0.00461
DATA_INIT_INT	0.01952	0.00837	0.01714	0.01392	0.00253
DATA_INIT_REAL	0.03997	0.01711	0	0	0.00453
DATA_INIT_LREAL	0.08051	0.03457	0.03434	0.02621	0.00902
DATA_INIT_WORD	0.02071	0.00888	0.01718	0.01343	0.0025
DATA_INIT_UINT	0.01971	0.00844	0.00849	0.00732	0.00226
SWAP_WORD	0.18858	0.08076	0.08082	0.07672	0.02551
SWAP_DWORD	0.15904	0.06834	0.06833	0.0613	0.0204
BLKCLR	0.02528	0.01094	0.01097	0.0101	0.00334
SHFR_BIT	0.04324	0.01827	0.01867	0.02013	0.00666
SHFR_WORD	0.16054	0.06598	0.06848	0.07023	0.0251
SHFR_DWORD	0.19577	0.08384	0.08263	0.08009	0.02663
Data Table					
SORT_INT	0.74431	0.31843	0.31607	0.37118	0.12369
SORT_UINT	0.74589	0.31942	0.317	0.3717	0.12383
SORT_WORD	0.74476	0.31838	0.31632	0.37082	0.12369
TBLRD_INT	0.00096	-0.0001	-9E-05	-0.0005	-0.0002
TBLRD_DINT	-0.0002	-0.0001	0.00016	-0.0001	-9E-05
TBLWRT_INT	0.00048	0.00018	0.00023	1.1E-05	-4E-05
TBLWRT_DINT	-0.0009	-0.0004	-0.0003	-0.0002	-6E-05
FIFORD_INT	0.1939	0.00816	0.00866	0.00698	0.00234
FIFORD_DINT	0.04449	0.01866	0.0188	0.01529	0.00511
FIFOWRT_INT	0.00058	0.00047	0.00046	-3E-05	-1E-05
FIFOWRT_DINT	-0.0007	-0.0003	-0.0004	0	-1E-05
LIFORD_INT	0.00022	0.00031	0.00042	-7E-05	1.1E-05
LIFORD_DINT	0.00087	0.00037	0.00044	0.00027	8.9E-05
LIFOWRT_INT	0.00037	0.00041	0.00042	0.00011	6.7E-05
LIFOWRT_DINT	-0.0006	-0.0003	-0.0003	0.00019	0
LIFOWRT_DWORD	0.00101	0.00029	0.00028	-0.0002	-7E-05

<i>Instruction</i>	<i>CPE010</i>	<i>CPE020</i>	<i>CRE020</i>	<i>CPE030/ CRE030</i>	<i>CPE040/ CRE040</i>
Array					
ARRAY_MOVE_BIT	0.01967	0.00841	0.00863	0.00914	0.00304
ARRAY_MOVE_BYTE	0.00957	0.00387	0.00379	0.00358	0.00119
ARRAY_MOVE_INT	0.02002	0.00857	0.00857	0.0067	0.00223
ARRAY_MOVE_DINT	0.04762	0.02019	0.02021	0.0164	0.00547
ARRAY_MOVE_WORD	0.02063	0.00883	0.00878	0.00643	0.00211
ARRAY_MOVE_DWORD	0.04489	0.01922	0.01913	0.01529	0.00511
ARRAY_MOVE_UINT	0.02014	0.00863	0.00922	0.00687	0.00231
SRCH_BYTE	0.07277	0.03143	0.03112	0.03001	0.0101
SRCH_WORD	0.07492	0.03186	0.03177	0.02826	0.0094
SRCH_DWORD	0.06664	0.02854	0.02841	0.02641	0.00882
ARRAY_RANGE_DINT	0.5422	0.232	0.23221	0.23434	0.07808
ARRAY_RANGE_INT	0.51968	0.22242	0.22204	0.22419	0.07467
ARRAY_RANGE_UINT	0.51902	0.22204	0.22200	0.22429	0.07492
ARRAY_RANGE_WORD	0.52001	0.22294	0.22249	0.2255	0.07511
ARRAY_RANGE_DWORD	0.55802	0.23898	0.23903	0.23764	0.07917

A-3 Overhead Sweep Impact Times

This section contains overhead timing information for the PACSystems CPUs. This information can be used in conjunction with the estimated logic execution time to predict sweep times for the CPUs. The information in this section is made up of a base sweep time plus sweep impact times for each of the CPU models. The predicted sweep time is computed by adding the sweep impact time(s), the base sweep, and the estimated logic execution time.

A sample calculation for estimating sweep times is provided on page 670.

The following components make up the total sweep time:

- Programmer communications sweep impact
- I/O Scan and fault sweep impact
- Ethernet Global Data sweep impact
- Intelligent Option Module (LAN modules) sweep impact
- I/O interrupt performance and sweep impact
- Timed interrupt performance and sweep impact

A-3.1 Base Sweep Times

Base sweep time is the time for an empty _MAIN program block to execute, with no configuration stored and none of the windows active. The following table gives the base sweep times in microseconds for each CPU model.

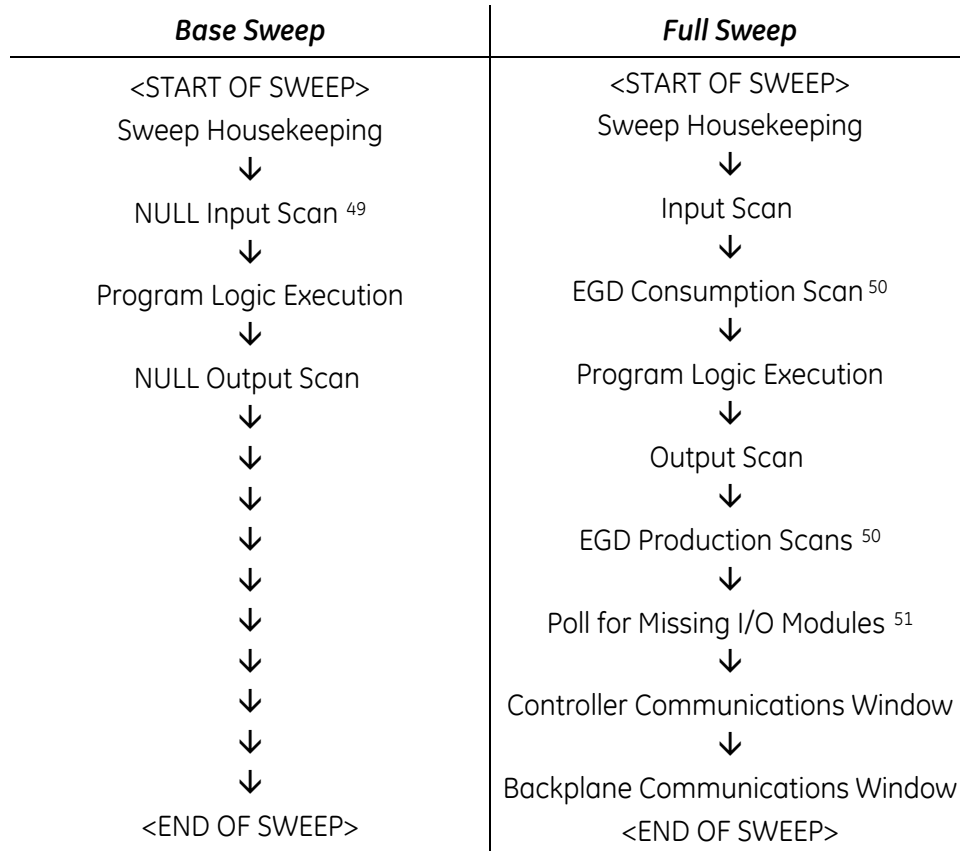
Family	Model	Run I/O enabled (μ s)	Run outputs disabled (μ s)
RX3i	CPU310 ⁴⁷	1086	1076
	CPU315 CPU320	180	176
	CRU320	198	194
	CPE305 CPE310	426	424
RX7i ⁴⁸	CPE010	457	449
	CPE020 CRE020	182	180
	CPE030 CRE030	169	165
	CPE040 CRE040	77.4	74.8

⁴⁷ Base sweep time calculated with RUN/STOP switch, single ETM.

⁴⁸ Base sweep time with I/O enabled includes time to scan the status bits for the Ethernet daughterboard.

The following diagram shows the differences between the full sweep phases and the base sweep phases.

Base Sweep vs. Full Sweep Phases



For the base sweep, if there is no configuration, the input and output scan phases of the sweep are NULL (i.e., check for configuration and then end). The presence of a configuration with no I/O modules or intelligent I/O modules (GBC) has the same effect. The logic execution time is not zero in the base sweep. The time to execute the empty _MAIN program is included so that you only need to add the estimated execution times of the functions actually programmed. The base sweep also assumes no missing I/O modules. The lack of programmer attachment means that the Controller Communications Window is never opened. The lack of intelligent option modules means that the Backplane Communications Window is never opened.

⁴⁹ If I/O is suspended, the input and output scans are skipped.

⁵⁰ If no Ethernet Global Data (EGD) exchanges are configured, the consumption and production scans are skipped.

⁵¹ Polling for missing I/O modules only occurs if a "Loss of ..." fault has been logged for an I/O module.

A-3.2 What the Sweep Impact Tables Contain

In some tables, functions are shown as asynchronously impacting the sweep. This means that there is not a set phase of the sweep in which the function takes place. For instance, the scanning of all I/O modules takes place during either the input or output scan phase of the CPU's sweep. However, I/O interrupts are totally asynchronous to the sweep and will interrupt any function currently in progress. The communication functions (with the exception of the high priority programmer requests) are all processed within one of the two windows in the sweep (the Controller Communications Window and the Backplane Communications Window). Sweep impact times for the various service requests are all minimum sweep impact times for the defined functions, where the window times have been adjusted so that no time slicing (limiting) of the window occurs in a given sweep. This means that, as much as possible, each function is completed in one occurrence of the window (between consecutive logic scans). The sweep impact of these functions can be spread out over multiple sweeps (limited) by adjusting the window times to a value lower than the documented sweep impact time. For the programmer, the default time is 10 milliseconds; therefore, some of the functions listed in that section will naturally time slice over successive sweeps.

A-3.3 Programmer Sweep Impact Times

The following table shows nominal programmer sweep impact times in microseconds.

Sweep Impact Item	Description	RX3i		RX7i			
		CPU310 (μs)	CPU315 CPU320 CRU320 (μs)	CPE010 (μs)	CPE020 CRE020 (μs)	CPE030 CRE030 (μs)	CPE040 CRE0400 (μs)
Programmer window	The time required to open the Programmer Window but not process any requests. The programmer is attached through an Ethernet connection; no reference values are being monitored.	2.9	0.2	1.95	0.21	0.2	0.2
Reference table monitor	The sweep impact to refresh the reference table screen. (The %R table was used as the example.) Mixed table display impacts are slightly larger. The sweep impact may not be continuous, depending on the sweep time of the CPU and the speed of the host of the programming software.	4.9	0.29	1.2	0.33	0.26	0.29
Editor monitor	The sweep impact to refresh the editor screen when monitoring ladder logic. The times given in the table are for a logic screen containing one contact, two coils, and eleven registers. As with the reference table sweep impact, the impact may not be continuous.	4.1	0.31	1.41	0.35	0.31	0.31

A-3.4 I/O Scan and I/O Fault Sweep Impact

The I/O scan sweep impact has two parts, Local I/O and Genius I/O. The equation for computing I/O scan sweep impact is:

$$\boxed{\text{I/O Scan Sweep Impact}} = \boxed{\text{Local Scan Impact}} + \boxed{\text{Genius I/O Scan}}$$

Sweep Impact of Local I/O Modules

The I/O scan of I/O modules is impacted as much by location and reference address of a module as it is by the number of modules. The I/O scan has several basic parts.

<i>I/O Scan</i>	<i>Description</i>
Rack Setup Time	Each expansion rack is selected separately because of the addressing of expansion racks on the VME bus. This results in a fixed overhead per expansion rack, regardless of the number of modules in that rack.
Per Module Setup Time	Each Local I/O module has a fixed setup scan time.
Byte Transfer Time	The actual transfer of bytes is much faster for modules located in the main rack than for those in expansion racks. The byte transfer time differences will be accounted for by using different times for I/O modules in the main rack versus expansion racks.

In addition, analog input expander modules (the same as Genius blocks) have the ability to be grouped into a single transfer as long as consecutive reference addresses are used for modules that have consecutive slot addresses. Each sequence of consecutively addressed modules is called a scan segment. There is a time penalty for each additional scan segment.

RX7i I/O Module Types

<i>Type</i>	<i>Part Numbers</i>
Discrete Input Type I (16 point, 14 point)	IC697MDL240, IC697MDL241, IC697MDL251, IC697MDL640, IC697MDL671
Discrete Input Type II (32 point)	IC697MDL250, IC697MDL252, IC697MDL253, IC697MDL254, IC697MDL651, IC697MDL652, IC697MDL653, IC697MDL650, IC697MDL654
Discrete Output Type I (16 point, 12 point)	IC697MDL340, IC697MDL341, IC697MDL740, IC697MDL940
Discrete Output Type II (32 point)	IC697MDL350, IC697MDL750, IC697MDL752, IC697MDL753
Analog Input Type I (8 Channel)	IC697ALG230
Analog Input Type II (16 Channel with 8 channel AI module)	IC697ALG440, IC697ALG441
Analog Output (4 channel)	IC697ALG320

RX7i Module Sweep Impact Times (microseconds)

The following table provides sweep impact times for modules in the Main rack and in an expansion (Exp) rack. The base case provides the overhead a single module in the rack. The increment (Inc) refers to the overhead for each similar module that is added to the same rack.

Model	CPE010				CPE020/CRE020				CPE030/CRE030				CPE040/CRE040			
	Main		Exp		Main		Exp		Main		Exp		Main		Exp	
Impact	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc
Discrete In. Type - I	35.8	9.3	29.6	30.2	9.5	6.3	10.2	13.8	10.2	10.6	14.4	16.5	5.1	4.1	6.0	9.8
Discrete In. Type - II	35.1	13.4	34.3	31.9	12.1	6.6	14.5	10.9	10.5	6.4	14.4	16.5	5.7	4.6	9.9	13.7
Discrete Out. Type - I	38.9	14.8	33.1	33.0	12.9	6.2	11.7	14.4	11.5	6.4	10.8	12.9	6.0	4.5	6.3	10.0
Discrete Out. Type - II	40.2	15.8	36.9	37.2	13.6	7.3	16.2	18.1	11.7	6.9	14.5	17.2	7.0	5.7	10.4	13.9
Per fault message	106.254	—	111.01	—	44.608	—	45.716	—	—	—	—	—	—	—	—	—
Analog In. Type 1	49.5	26.3	71.6	54.7	19.2	11.7	40.3	35.3	16.3	11.9	38	34	9.9	8.7	31.3	30.6
Analog Exp - Type 2	80.1	15.2	133.9	58.6	33.5	12.6	96.8	56.4	30.1	13.7	94.9	57	22.4	12.6	87.0	55.4
Analog Out.	49.9	25.1	63.2	39.6	16.6	11.2	29.3	24.7	15.2	10.2	27	22.3	8.4	7.1	20.1	19.2
Per fault message	86.207	—	86.7	—	40.135	—	60.762	—	—	—	—	—	—	—	—	—
Analog In. VAL132	74.0	54.3	N/A	N/A	44.9	38.2	N/A	N/A	42.8	38.1	N/A	N/A	35.8	32.2	N/A	N/A
Analog In. VME-3125A	64.7	47.9	N/A	N/A	34.1	32.6	N/A	N/A	35.1	32.4	N/A	N/A	28.8	28.7	N/A	N/A
Analog In. VAL264	91.4	74.8	N/A	N/A	61.7	59.6	N/A	N/A	60.9	57.8	N/A	N/A	53.6	48.2	N/A	N/A
Analog In. VME-3122A	88.1	72.1	N/A	N/A	62.7	59.1	N/A	N/A	62.4	59.5	N/A	N/A	55.0	54.1	N/A	N/A
Analog In. VRD008	86.5	38.0	N/A	N/A	33.4	33.4	N/A	N/A	38.8	28.4	N/A	N/A	41.2	37.0	N/A	N/A
Analog Out. VAL301	96.5	67.0	N/A	N/A	52.3	47.5	N/A	N/A	45.1	42.3	N/A	N/A	43.0	38.7	N/A	N/A
Discrete In. VDD100	54.1	33.1	N/A	N/A	24.4	18.3	N/A	N/A	31.3	28.4	N/A	N/A	26.1	23.4	N/A	N/A
Discrete In. VME-1182A	50.5	29.2	NA	NA	24.5	18.1	N/A	N/A	22.5	18.7	N/A	N/A	14.7	14.7	N/A	N/A
Discrete Out. VDQ120	71.6	45.6	N/A	N/A	32.1	25.2	N/A	N/A	30.2	27.9	N/A	N/A	20.6	18.5	N/A	N/A
Discrete Out. VDR151	87.2	70.6	N/A	N/A	36.1	34.0	N/A	N/A	32.2	29.2	N/A	N/A	28.7	23.5	N/A	N/A

RX3i I/O Module Types

Type	Part Numbers
Discrete Input, 16 point	IC694MDL240, IC694MDL241, IC694MDL645, IC694MDL646
Discrete Input - Smart Digital Input, 16 point	IC695MDL664
Discrete Input, 32 point	IC694MDL654, IC694MDL655, IC694MDL654
Discrete Output, 8 point	IC694MDL330, IC694MDL732, IC694MDL930, IC694MDL940
Discrete Output, 16 point and 12 point	IC694MDL340, IC694MDL341, IC694MDL740, IC694MDL741
Discrete Output – Smart Digital Output. 16 point	IC695MDL765
Discrete Output, 32 point	IC694MDL350, IC694MDL340, IC694MDL742, IC694MDL752, IC694MDL753, IC694MDL940
Discrete Output, 32 point	IC694MDL758
Discrete In/Out, 8 point	IC693MDR390, IC693MAR590
Analog Input, 4 Channel	IC695ALG220, IC694ALG221
Analog Input, 6 Channel	IC695ALG106
Analog Input, 12 channel	IC695ALG112
Analog Input, 16 Channel	IC694ALG222, IC694ALG223
Analog Output, 2 channel	IC694ALG390, IC694ALG391
Analog Mixed Input/Output	IC694LG442
Analog Input with Diagnostics	IC694ALG232, IC694ALG233
Analog Mixed Input/Output with Diagnostics	IC694ALG542

RX3i I/O Module Sweep Impact Times (microseconds)

The following table provides sweep impact times for modules in the Main rack and in an expansion (Exp) rack. The base case provides the overhead for a single module in the rack. The increment (Inc) refers to the overhead for each similar module that is added to the same rack. To estimate sweep impact for modules in a remote rack, multiply the time in the main rack by 6:

main rack base time × 6 = approximate sweep impact in remote rack

	CPU310				CPU315/CPU320				CPE305/CPE310			
	Main Rack		Exp		Main Rack		Exp		Main Rack		Exp	
	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc
Discrete Input 16 point	57.1	41.4	87.6	74.4	37.4	34.6	68.2	66.3	-	-	-	-
Discrete Input 16 point (Smart Digital Input – IC695MDL664)	24.6	21.6	NA	NA	-	-	NA	NA	-	-	-	-
Discrete Input 32 point	78.4	59.7	105.9	96.1	56.2	55.3	86.1	85.7	-	-	-	-
Discrete Output 8 point	61.0	40.3	84.3	74.9	35.6	34.7	64.5	65.5	-	-	-	-
Discrete Output 16 point	61.5	38.9	87	74.4	35.4	34.5	65.2	64.9	-	-	-	-
Discrete Output 16 point (Smart Digital Output – IC695MDL765)	24.8	21.4	NA	NA	-	-	NA	NA	-	-	-	-
Discrete Output 32 point	79.7	57	101.8	90.6	54.4	50.1	81.8	81.9	-	-	-	-
Discrete Output 32 point (IC694MDL758)	-	-	-	-	128.57	123.69	220.88	216.02	193.06	-	288.53	-
Discrete Mixed 8 point in/ 8 point out	104.5	85.7	167	151.7	72.2	68.9	132.3	131.2	-	-	-	-
Analog In/Out 4 channel	114.9	99	142.7	132	93.7	92.5	124.8	123.3	-	-	-	-
Analog Input 16 channel	427.7	407.1	538.8	538	385.3	378.8	499.9	499.3	-	-	-	-
Analog Output 2 channel	98.3	80.8	154.4	143.4	69.7	66.8	129.1	128.3	-	-	-	-
Analog Input 6 channel, IC695ALG106	92.9	73.4	N/A	N/A	51.6	51.0	N/A	N/A	-	-	-	-
Analog Input 12 channel, IC695ALG112	111.7	94.8	N/A	N/A	66.8	58.7	N/A	N/A	-	-	-	-
Universal Analog IC695ALG600	90.3	77.2	N/A	N/A	50.9	45.7	N/A	N/A	-	-	-	-
Analog Input 8 channel IC695ALG608	84.4	68.3	N/A	N/A	43.3	39.8	N/A	N/A	-	-	-	-
Analog Input 16 channel IC695ALG616	99.5	82.6	N/A	N/A	56.3	55.6	N/A	N/A	-	-	-	-
Analog Output 4 channel IC695ALG704	122	101.8	N/A	N/A	54.6	48.3	N/A	N/A	-	-	-	-
Analog Output 8 channel IC695ALG708	121.6	103.3	N/A	N/A	54.7	49.6	N/A	N/A	-	-	-	-

Worksheet A: I/O Module Sweep Time

The following form can be used for computing I/O module sweep impact. The calculation contains times for analog input expanders that are either grouped into the same scan segment as the preceding module or are grouped in a separate new scan segment. The sweep impact times of I/O Modules can be found on pages 656 and 658.

Number of expansion racks	_____		
Sweep impact per expansion rack	x _____	=	_____
Number of discrete I/O modules—main rack	_____		
Sweep impact per discrete I/O module—main rack	x _____	=	_____
Number of discrete I/O modules—expansion rack	_____		
Sweep impact per discrete I/O module—expansion rack	x _____	=	_____
Number of analog input base and output modules—main rack	_____		
Sweep impact per analog input base and output module—main rack	x _____	=	_____
Number of analog input expander modules (same segment)—main rack	_____		
Sweep impact per analog input expander module (same segment)—main rack	x _____	=	_____
Number of analog input expander modules (new segment)—main rack	_____		
Sweep impact per analog input expander module (new segment)—main rack	x _____	=	_____
Number of analog input base and output modules—expansion rack	_____		
Sweep impact per analog input base and output module—expansion rack	x _____	=	_____
Number of analog input base and output modules (same segment)—exp. rack	_____		
Sweep impact per analog input base and output module (same seg.)—exp. rack	x _____	=	_____
Number of analog input base and output modules (new segment)—exp. rack	_____		
Sweep impact per analog input base and output module (new seg.)—exp. rack	x _____	=	_____
Predicted I/O Module Sweep Impact			_____

Note: If point faults are enabled, substitute the corresponding times for point faults enabled, as shown in the following table.

Sweep Impact of Genius I/O and GBCs

For the sweep impact of Genius I/O and Genius Bus Controllers (GBC), there is a sweep impact for each GBC, a sweep impact for each scan segment, and a transfer time (per word) sweep impact for all I/O data.

The GBC sweep impact has three parts:

1. Sweep impact to open the System Communications Window. This is added only once when the first intelligent option module (of which the GBC is one) is placed in the system.
2. Sweep impact to poll each GBC for background messages (datagrams). This part is an impact for every GBC in the system.

Note: Both the first and second parts of the GBC's sweep impact may be eliminated by closing the Backplane Communications Window (setting its time to 0). This should only be done to reduce scan time during critical phases of a process to ensure minimal scan time. Incoming messages will timeout and COMM_REQs will stop working while the window is closed.

3. Sweep impact to scan the GBC. This results from the CPU notifying the GBC that its new output data has been transferred, commanding the GBC to ready its input data, and informing the GBC that the CPU has finished another sweep and is still in RUN mode.

A scan segment for a Genius I/O block consists of consecutive memory locations starting from a particular reference address. A new scan segment is created for each starting input or output reference address. The time to process a single scan segment is higher for an input scan segment than it is for an output scan segment. The scan segment processing is the same for analog, discrete, and global data scan segments. Discrete data is transferred a byte at a time and takes longer to complete the transfer than analog data, which is transferred a word at a time. Global data should be counted as either discrete or analog, based on the memory references used in the source or destination.

Sweep Impact Time of Genius I/O and GBCs

Note: Functions in **bold type** impact the sweep continuously. All other functions impact the sweep only when invoked. Not all the timing information listed in the following table was available at print time for this manual (the blank spaces).

	CPU310 (μ s)	CPE010 (μ s)	CPE020 (μ s)	CPE030 (μ s)	CPE040 (μ s)
Genius Bus Controller					
open backplane communications window	30	24	4	4	1
per Genius Bus Controller polling for background messages	403	19	11	9	6
per Genius Bus Controller I/O Scan					
Genius Bus Controller in the main rack	469	1	1	1	1
Genius Bus Controller in the expansion rack	683	11	7	6.9	1
Genius I/O Blocks					
per I/O block scan segment	3	217	217	193.7	208
per I/O block scan segment w/point faults enabled	3	217	217	194.8	213
per byte discrete I/O data in the main rack	13	3	3	2.1	3
per byte discrete I/O data in expansion racks	16	8	5	4.2	4
per word analog I/O data in the main rack	24	5	4	4	5
per word analog I/O data in expansion racks	34	11	8	8	11

Worksheet B: Genius I/O Sweep Time

Use the following worksheet for predicting the sweep impact due to Genius I/O. The sweep impact times can be found in "Sweep Impact Time of Genius I/O and GBCs" above (page 660).

Open backplane communications window	_____	=	_____
GBC poll for background messages	x _____	=	_____
Number of GBCs			
GBC I/O scan for the main rack	_____		
Number of GBCs in the main rack	X _____	=	_____
GBC I/O scan for the expansion rack	_____		
Number of GBCs in the expansion rack	X _____	=	_____
Input block scan segments—number of I/O block scan segments—sweep impact	x _____	=	_____
Output block scan segments—number of I/O block scan segments—sweep impact	x _____	=	_____
Bytes of discrete I/O data on GBCs—main rack	_____		
Sweep impact/bytes of discrete I/O data—main rack	x _____	=	_____
Bytes of discrete I/O data on GBCs—expansion racks	_____		
Sweep impact/bytes of discrete I/O data—expansion racks	x _____	=	_____
Words of analog I/O data on GBCs—main rack	_____		
Sweep impact/word analog I/O data—main rack	x _____	=	_____
Words of analog I/O data on GBCs—expansion racks	_____		
Sweep impact/word analog I/O data—expansion racks	x _____	=	_____
Predicted Genius I/O Scan Impact			_____

A-3.5 Ethernet Global Data Sweep Impact

Depending on the relationship between the CPU sweep time and an Ethernet Global Data (EGD) exchange's period, the exchange's data may be transferred every sweep or periodically after some number of sweeps. Therefore, the sweep impact varies based on the number of exchanges that are scheduled to be transferred during the sweep. All of the exchanges must be taken into account when computing the worst-case sweep impact.

The Ethernet Global Data (EGD) sweep impact has two parts, Consumption Scan and Production Scan:

$$\boxed{\text{EGD Sweep Impact}} = \boxed{\text{Consumption Scan}} + \boxed{\text{Production Scan}}$$

This sweep impact should be taken into account when configuring the CPU constant sweep mode and setting the CPU watchdog timeout.

Where the Consumption and Production Scans consist of two parts, exchange overhead and byte transfer time:

$$\boxed{\text{Scan Time}} = \boxed{\text{Exchange Overhead}} + \boxed{\text{Byte Transfer Time}}$$

Exchange Overhead

Exchange overhead includes the setup time for each exchange that will be transferred during the sweep. When computing the sweep impact, include overhead time for each exchange.

Note: The exchange overhead times in the table below were measured for a test-case scenario of 1400 bytes over 100 variables.

<i>EGD Exchange Overhead Time</i>			
		<i>Embedded Ethernet Interface (μs)</i>	<i>Rack-based Ethernet Module (μs)</i>
CPE305/CPE310	Consume / READ	TBD ⁵²	—
	Produce / WRITE	TBD	—
CPU310/NIU001	Consume / READ	NA	233.6
	Produce / WRITE	NA	480.6
CPU315/CPU320	Consume / READ	NA	100.0
	Produce / WRITE	NA	195.1
CPE010	Consume / READ	184.3	238.2
	Produce / WRITE	342.0	452.0
CPE020	Consume / READ	87.7	117.8
	Produce / WRITE	187.9	257.5
CPE030	Consume / READ	85.1	114.1
	Produce / WRITE	191.8	253.5
CPE040	Consume / READ	35.08	47.12
	Produce / WRITE	75.16	103.0

⁵² EGD Class 1 for this CPU type requires RX3i CPE310/CPE305 Firmware Release 8.30 or later. Prior to that, EGD was only possible in RX3i via the ETM001 Module.

Data Transfer Time

Note: This is the time required to transfer the data between the CPU module and the rack-based Ethernet module. EGD data transfer times do not increase linearly in relation to data size. Please use the data values in the table below to estimate data transfer times.

Note: CPE modules do not need to use this table with respect their embedded Ethernet port, as there is no transfer of data across the backplane corresponding to EGD traffic.

CPU	Data Size (Bytes)	Direction	Embedded Ethernet Interface (μ S)	Rack-based Ethernet Module (μ S)
CPU310 NIU001 ⁵³	1	Consume / READ	NA	9.3
	100	Consume / READ	NA	51.8
	200	Consume / READ	NA	97.9
	256	Consume / READ	NA	123.8
	1	Produce / WRITE	NA	6.5
	100	Produce / WRITE	NA	14.1
	200	Produce / WRITE	NA	17.7
	256	Produce / WRITE	NA	19.3
CPU315, CPU320	1	Consume / READ	NA	6.2
	100	Consume / READ	NA	49.5
	200	Consume / READ	NA	96.4
	256	Consume / READ	NA	122.8
	1	Produce / WRITE	NA	3.4
	100	Produce / WRITE	NA	9.9
	200	Produce / WRITE	NA	14.9
	256	Produce / WRITE	NA	16.5
CPE010	1	Consume / READ	4.1	8.8
	100	Consume / READ	25.7	23.5
	200	Consume / READ	49.0	38.6
	256	Consume / READ	61.4	46.8
	1	Produce / WRITE	1.9	8.8
	100	Produce / WRITE	4.0	16.5
	200	Produce / WRITE	6.0	22.2
	256	Produce / WRITE	7.1	25.1
CPE020	1	Consume / READ	2.7	5.5
	100	Consume / READ	23.6	19.5
	200	Consume / READ	46.3	34.9
	256	Consume / READ	58.9	42.7
	1	Produce / WRITE	0.8	5.5
	100	Produce / WRITE	2.7	13.9
	200	Produce / WRITE	4.7	19.2
	256	Produce / WRITE	5.9	22.1

⁵³ EGD performance is different on the IC695NIU001+ (versions-AAAA and later) compared to the IC695NIU001. In general consumed data exchanges with a size greater than 31 bytes will result in contributing less of a sweep time impact and data exchanges with a size less than that will contribute slightly greater sweep impact. All produced exchanges on the IC695NIU001+ will appear to have a slightly greater sweep impact when compared to the IC695NIU001.

CPU	Data Size (Bytes)	Direction	Embedded Ethernet Interface (µS)	Rack-based Ethernet Module (µS)
CPE030	1	Consume / READ	2.8	5.3
	100	Consume / READ	25.8	18.7
	200	Consume / READ	50.7	33.4
	256	Consume / READ	60.1	40.4
	1	Produce / WRITE	0.8	5.5
	100	Produce / WRITE	2.5	13.1
	200	Produce / WRITE	4.2	18.2
	256	Produce / WRITE	5.2	21.5
CPE040	1	Consume / READ	1.9	3.85
	100	Consume / READ	21.1	10.1
	200	Consume / READ	43.5	31.4
	256	Consume / READ	56.5	39.2
	1	Produce / WRITE	0.3	3.8
	100	Produce / WRITE	1.8	11.8
	200	Produce / WRITE	3.6	16.8
	256	Produce / WRITE	4.8	19.8

Worksheet C: Ethernet Global Data Sweep Time

Number of consumed exchanges		_____			
Sweep impact per exchange	×	_____	=	_____	
Number of data bytes in all of the consumed exchanges		_____			
Sweep impact per consumed data byte	×	_____	=	_____	
Number of produced exchanges		_____			
Sweep impact per exchange	×	_____	=	_____	
Number of data bytes in all of the produced exchanges		_____			
Sweep impact per produced data byte	×	_____	=	_____	
Predicted EGD Sweep Impact					_____

A-3.6 Sweep Impact of Intelligent Option Modules

The tables in this section list the sweep impact times in microseconds for intelligent option modules. The fixed sweep impact is the sum of the polling sweep impact and the I/O scan impact. The opening of the Backplane Communications Window and the polling of each module have relatively small impacts compared to the sweep impact of CPU memory read or write requests.

Intelligent option modules include GBCs being used for Genius LAN capabilities. The sweep impact for these intelligent option modules is highly variable.

Fixed Sweep Impact Times of Intelligent Option Modules, RX7i

Sweep Impact Item	CPE010	CPE020	CPE030	CPE040
IC698ETM001	104 μ s	51 μ s	48 μ s	36 μ s
IC698HSC700	267 μ s	157 μ s	148 μ s	116 μ s
IC697BEM731 (GBC)	See "Sweep Impact Time of Genius I/O and GBCs", page 660.			

Fixed Sweep Impact Times of RX3i Intelligent Option Modules (μ s)

Sweep Impact Item	CPU310				CPU315/CPU320				NIU001+			
	Main		Exp		Main		Exp		Main		Exp	
	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc	Base	Inc
IC694APU300B and earlier	1085	—	—	—	1109	—	—	—	—	—	—	—
IC694APU300-CA and later												
Classic	2759 ⁵⁴	—	—	—	2043 ⁵⁵	—	—	—	—	—	—	—
Enhanced	4074	—	—	—	3276	—	—	—	—	—	—	—
IC694BEM331	See page 660				—	—	—	—	—	—	—	—
IC694DSM314	See page 666				—	—	—	—	See page 666			
IC695ETM001	199	—	NA	NA	188	51	NA	NA	—	—	NA	NA
IC695HSC304	208.7	173.9	NA	NA	136.4	131.0	NA	NA	—	—	NA	NA
IC695HSC308	282.4	256.5	NA	NA	202.6	200.3	NA	NA	—	—	NA	NA
IC695PBM300		—	NA	NA		—	NA	NA	—	—	NA	NA
No I/O	132				60							
100 bytes Input,	196				105							
100 bytes Output												
100 bytes Input,	206				140							
200 bytes Output												
200 bytes Input,	248				106							
100 bytes Output												
IC695PNC001	NA	NA	NA	NA	See page 666	NA	NA	NA	NA	NA	NA	NA

⁵⁴ CPU firmware version 7.13

⁵⁵ CPU firmware version 7.14

PROFINET Controller (PNC001) and PROFINET I/O Sweep Impact

The PLC CPU sweep impact for a PROFINET IO network is a function of the number of PNCs, the number of PROFINET devices, and the number of each PROFINET device's IO modules. The table below shows the measured sweep impact of the RX3i PROFINET Controller, supported VersaMax PROFINET devices, and I/O modules.

	CPU315/CPU320
RX3i PROFINET Controller (PNC)	50
RX3i Devices	
PROFINET Scanner (PNS) IC695PNS001	46
ALG442 Mixed Analog	54
ALG220 Analog Input	27
ALG390 Analog Output	24
MDL645 Discrete Input	23
MDL740 Discrete Output	22
VersaMax Devices	
PROFINET Scanner (PNS), IC200PNS001	40
Discrete Input Module (8/16/32 pt.)	23
Discrete Output Module (8/16/32 pt.)	18
Analog Input Module (15 channel)	59
Analog Output Module (12 channel)	21
CMM020 (64AI/64AQ)	204

To calculate the total expected PLC sweep impact for a PROFINET I/O network, add the individual sweep impact times for each PROFINET Controller, PROFINET Device, and PROFINET Device I/O module, using the times provided above.

For example, for a PROFINET I/O network that consists of one PNC and one VersaMax PROFINET Scanner, which has both an 8 point. input and an 8 point output module:

$$\begin{aligned} \text{Expected PLC Sweep Impact} &= 50 \text{ (PNC)} + 40 \text{ (PNS)} + 23 \text{ (8pt. Input)} + 18 \text{ (8pt. Output)} \\ &= 131 \mu\text{s.} \end{aligned}$$

DSM314 Sweep Impact (μs)

No. of Axes Configured	Rx3i CPU310 Rack		Rx3i NIU001+ Rack	
	Main	Exp	Main	Exp
1	1535	2160	1830	2360
2	2018	2906	2304	3160
3	2500	6371	2840	3920
4	2990	4430	3350	4680

A-3.7 I/O Interrupt Performance and Sweep Impact

There are several important performance numbers for I/O interrupt blocks. The sweep impact of an I/O interrupt invoking an empty block measures the overall time of fielding the interrupt, starting up the block, exiting the block, and restarting the interrupted task. The time to execute the logic contained in the interrupt block affects the limit by causing the CPU to spend more time servicing I/O interrupts and thus reduce the maximum I/O interrupt rate.

The minimum, typical, and maximum interrupt response times reflect the time from when a single I/O module sees the input pulse until the first line of ladder logic is executed in the I/O interrupt block. Minimum response time reflects a 300 microsecond input card filter time + time from interrupt occurrence to first line of ladder logic in I/O interrupt block. The minimum response time can only be achieved when no intelligent option modules are present in the system and the programmer is not attached. Typical response time is the minimum response time plus a maximum interrupt latency of 2.0 milliseconds. This interrupt latency time is valid, except when one of the following operations occurs:

- The programmer is attached.
- A store of logic, RUN mode store, or word-for-word change occurs.
- A fault condition (logging of a fault) occurs.
- Another I/O interrupt occurs.
- The CPU is transferring a large amount of input (or output) data from an I/O controller (such as a GBC). Heavily loaded I/O controllers should be placed in the main rack whenever possible.
- An event that has higher priority and requires a response occurs. An example of this type of event is clearing the I/O fault table.

Any one of these events extends the interrupt latency (the time from when the interrupt card signals the interrupt to the CPU to when the CPU services the interrupt) beyond the typical value. However, the latency of an interrupt occurring during the processing of a preceding I/O interrupt is unbounded. I/O interrupts are processed sequentially so that the interrupt latency of a single I/O interrupt is affected by the duration of the execution time of all preceding interrupt blocks. (The worst case is that every I/O interrupt in the system occurs at the same time so that one of them has to wait for all others to complete before it starts.)

The maximum response times shown below do not include the two unbounded events.

I/O Interrupt Block Performance and Sweep Impact Times

<i>Sweep Impact Item</i>	<i>CPE305 CPE310</i>	<i>CPU310 (μs)</i>	<i>CPU315/ CPU320 (μs)</i>	<i>CPE010 (μs)</i>	<i>CPE020 (μs)</i>	<i>CPE030 (μs)</i>	<i>CPE040 (μs)</i>
I/O interrupt sweep impact	— ⁵⁶	127.8	-	309.7	335	125.6	24
Minimum response time	—	151.7	326.1	392.4	334	330.6	315.2
Typical response time		175.0	327.3	396.1	336	331.5	315.5
Maximum response time		302.7	346.2	434.9	359	375.1	325.7

Note that the min, typical, and max response times include a 300 μ s Input card filter time.

⁵⁶ Not available for this release.

Dropped Interrupts

When multiple interrupts are triggered during the interrupt latency period, it is possible that interrupt blocks will only be executed one time even though the interrupt trigger has occurred more than once. The likelihood of this occurring will increase if the system interrupt latency has increased due to the specific configuration and use of the system.

This will not cause the CPU to miss a given interrupt; just consolidate the number of times an interrupt block is executed even though the interrupt stimulus had occurred more than one time.

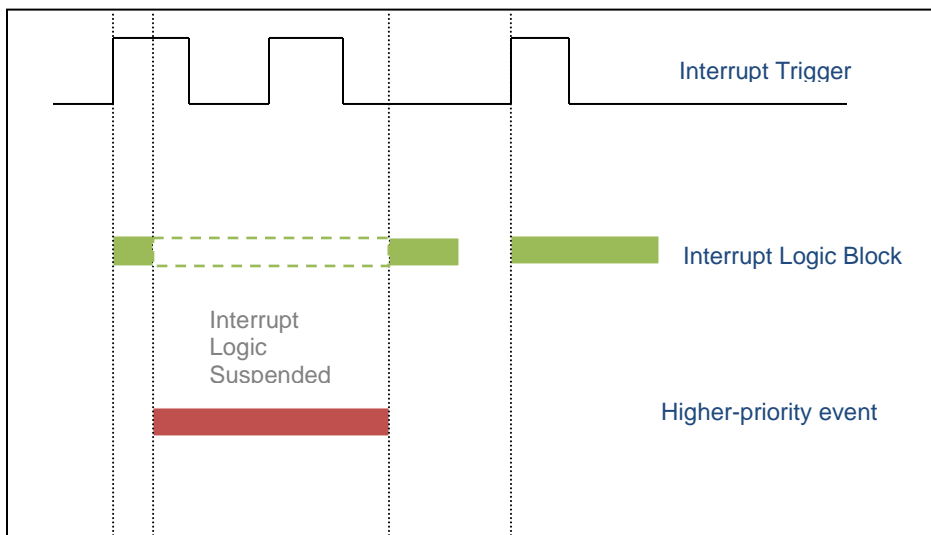


Figure 60: Interrupt Execution Considerations

Worksheet D: Programmer, IOM, I/O Interrupt Sweep Time

The following worksheet can be used to calculate the sweep impact times of programmer sweep impact, intelligent option modules, and I/O Interrupts. For time data, refer to the following tables:

Programmer Sweep Impact Times, page 654

RX7i I/O Module Types, page 656 or

RX3i I/O Module Types, page 658

Sweep Impact Time of Genius I/O and GBCs, page 660

Programmer sweep impact		=	_____
IOM—first module (open comm. window)			_____
IOM—per module (polling)	+		_____
LAN module I/O scan	+		_____
Total IOM Sweep Impact		=	_____
CPU memory access from IOMs		=	_____
I/O interrupt sweep impact			_____
I/O interrupt response time	+		_____
		=	_____
Predicted Sweep Time (Other)			_____

A-3.8 Timed Interrupt Performance

The sweep impact of a timed interrupt invoking an empty program block or timed program measures the overall time of fielding the interrupt, starting up the program or block, exiting the program or block, and restarting the interrupted task. The minimum, average, and maximum interrupt period reflect the time period from when the first line of ladder logic is executed in the timed interrupt block.

Timed Interrupt Performance and Sweep Impact Times for a 0.001s Timed Interrupt Block

<i>Sweep Impact Item</i>	<i>CPU310 (μs)</i>	<i>CPU315 CPU320 (μs)</i>	<i>CPE010 (μs)</i>	<i>CPE020 (μs)</i>	<i>CPE030 (μs)</i>	<i>CPE040 (μs)</i>
Timed interrupt sweep impact	87.3	26.2	88.6	28	31.2	23.3
Minimum interrupt period	908.3	969.8	951.4	946	922.8	973
Average interrupt period	1000	1000.0	1005.5	999.7	1000.0	999.9
Maximum interrupt period	1081.2	1030.8	1056.6	1054	1077.0	1026.9

A-3.9 Example of Predicted Sweep Time Calculation

The sweep time estimate in this example does not include a time for logic execution. The calculated sweep is for normal sweep time with point faults disabled, and the programmer is not attached. The times used in the calculation are extracted from the following tables:

Base Sweep Times, page 651

RX7i I/O Module Types, page 656 or

RX3i I/O Module Types, page 658

Sweep Impact Time of Genius I/O and GBCs, page 660

A sample calculation of predicted sweep times is provided after the example.

Sample RX7i System Configuration

PS	CPE010	BTM	32PT Input	32PT Input	32PT Output	32PT Output	8CHN Analog Input	4CHN Analog Output	ETM
0	1	2	3	4	5	6	7	8	9

MAIN RACK

Sweep Calculations (in μ S)

$$\boxed{\text{Predicted Sweep}} = \boxed{\text{Base Sweep}} + \boxed{\text{I/O Scan Impact}}$$

Base Sweep Time		= 465
I/O Scan Impact ...		
Number of discrete input type 2 modules—main rack	2	
Sweep impact time per discrete I/O module	x 37.9	= 75.8
Number of discrete output type 2 modules—main rack	2	
Sweep impact time per discrete I/O module	x 80.4	= 80.4
Number of analog input modules—main rack	1	
Sweep impact time per analog base and output module	x 49.3	= 49.3
Number of analog output modules—main rack	1	
Sweep impact time per analog base and output module	x 49.7	= 49.7
Ethernet Module	1 x 55	= 55.0
Predicted Sweep Time		= 775.2

Appendix B User Memory Allocation

User Memory Size is the number of bytes of memory available to the user for PLC applications.

Model	User Memory Size
IC695CPE305	5MB
IC695CPU310, IC695CPE310, IC698CPE010, IC698CPE020, IC698CRE020	10MB
IC695CPU315	20MB
IC695CPU320, IC695CRU320	64MB
IC698CPE030, IC698CRE030 IC698CPE040, IC698CRE040	64MB

For a list of items that count against user memory, see below.

B-1 Items that Count Against User Memory

The following items count against the CPU memory and can be used to estimate the minimum amount of memory required for an application. Additional space may be required for items such as Advanced User Parameters, zipped source files, user heap, and published symbols.

Register Memory Size (%R)	Bytes = %R references configured × 2
Word Memory Size (%W)	Bytes = %W references configured × 2
Analog Inputs (%AI)	If point faults enabled: Bytes = %AI references configured × 3 If point faults disabled: Bytes = %AI references configured × 2
Analog Outputs (%AQ)	If point faults enabled: Bytes = %AQ references configured × 3 If point faults disabled: Bytes = %AQ references configured × 2
Discrete Point Faults	If point faults enabled: Bytes = 3072
Managed Memory (Symbolic Variable and I/O Variable Storage)	The total number of bytes required for symbolic and I/O variables. Calculated as follows: [(number of symbolic discrete bits) × 3 / (8 bits/byte)] + [(number of I/O discrete bits) × Md / (8 bits/byte)] + [(number of symbolic words) × (2 bytes/word)] + [(number of I/O words) × (Mw bytes/word)] Md = 3 or 4. The number of bits is multiplied by 3 to keep track of the force, transition, and value of each bit. If point faults are enabled, the number of I/O discrete bits is multiplied by 4. Mw = 2 or 3. There are two 8-bit bytes per 16-bit word. If point faults are enabled, the number of bytes is multiplied by 3 because each I/O word requires an extra byte.
EGD (included in HWC)	Bytes = 0 if no Ethernet Global Data pages are configured
I/O Scan Set File (included in HWC)	Based on number of scan sets used. Note: 32 bytes of user memory are consumed if the application scans all I/O every sweep (the default).
User Programs	See “User Program Memory Usage” page 671 for details on user programs.

B-2 User Program Memory Usage

Space required for user logic includes the following items.

B-2.1 %L and %P Program Memory

%L and %P are charged against your user space and sized depending on their use in your applications. The maximum size of %L or %P is 8192 words per block.

The %L and %P tables are sized to allow extra space for Run Mode Stores according to the following rules.

- If %L memory is not used in the block, the %L memory size is 0 bytes. If %L memory is used in the block, a buffer is added beyond the highest %L address actually used in logic or in the variable table. The default buffer size is 256 bytes, but can be changed by editing the Extra Local Words parameter in the block Properties.
- The same rules apply for the size of %P memory, but %P memory can be used in any block in the program.
- The buffer cannot make the %P or %L table exceed the maximum size of 8,192 words. In such a case, a smaller buffer is used.
- You can add, change, or delete %L and/or %P variables in your application and Run Mode Store the application if these variables fit in the size of the last-stored %L/%P tables (where the "size" includes the previous buffer space), or if going from a zero to non-zero size.
- The size of the %L/%P tables is always recalculated for Stop Mode Stores.

B-2.2 Program Logic and Overhead

The data area for C (.gefelf) blocks is considered part of the user program and counts against the user program size. Additional space is required for information internal to the CPU that is used for execution of the C block.

The program block is based on overhead for the block itself plus the logic and register data being used (that is, %L).

Note: The program stack of the LD is not counted against the CPU's memory size.

Note: If your application needs more space for LD logic, consider changing some %P or %L references to %R, %W, %AI, or %AQ. Such changes require a recompilation of the program block and a Stop Mode store to the CPU.

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Programmable Control Products

PACSystems* RX3i System Manual

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Chapter 1 Introduction

The PACSystems RX3i controller is a member of the PACSystems family of programmable automation controllers (PACs). Like the rest of the PACSystems family, the RX3i features a single control engine and universal programming environment to provide application portability across multiple hardware platforms.

This chapter is an overview of PACSystems RX3i products and features. The rest of the manual describes RX3i products in detail, and explains installation procedures.

1.1 Revisions of this Manual

Rev	Date	Description
M	Jul-16	Updated Chapter 11 for the Remote Hart Get Device Information COMMREQ. Additionally, there were updates to clarify the upper word (command status) of the two-word COMMREQ status word.
L	Feb-16	Added new sections to <i>Analog Output Module 8-Channel Current/Voltage Isolated: IC695ALG808</i> for <i>Configuration: IC695ALG808</i> and <i>Module Data: IC695ALG808</i> .
K	Dec-15	Updated <i>RX3i CEP Carrier</i> list of <i>Supported I/O Modules</i>
J	Nov-15	New hardware replaces the existing hardware revision in production after full consumption of previous revision FAB boards (C0 rev). This is applicable for both Rx3i and 90-30 systems. Updated Output points and voltage range
H	Sept-15	Updated module load requirements
G	Jun-15	Added new modules IC695EDS001 and IC695EIS001. Added HART Pass Through functionality. Updated list of modules supported by IC695CEP001 (up to firmware rev 2.40) & IC694CEE001. Revised sense of <i>Module I/O Data Ready</i> bit in <i>Module Status</i> for MDL250, MDL260, MDL350 & MDL660. The sense of this bit was inverted in prior documentation and is corrected in this update.
F	Dec-14	Updates for IC695CEP001 & IC694CEE001
E	Jul-14	Added new modules IC694MDL648, IC694MDL730, IC694MDL758, IC694MDR390, IC694ALG542, IC695RMX228, IC695PMM335, IC695ECM850, IC695PNS001, IC695GCG001, IC695CEP001 & IC694CEE001. Revised Hot Insertion and Removal table in Chapter 2. Updated content for IC694APU300 (added <i>Enhanced</i> mode) in Chapter 8. Moved IC694APU305 to Chapter 8. Updated power consumption specifications for ALG106 and ALG112. Corrected Field Wiring diagrams for ALG222 & ALG232 Updated Chapter 17. For IC693ACC3xx terminal blocks, added new diagrams and connection info between terminals and D-connectors. Added overview of how this quick-connect system works. Also absorbed former Appendix B (32-point module terminal blocks and cables) into Chapter 17.

1.2 Overview

1.2.1 Features

- High-speed processor and patented technology for faster throughput
- Universal backplane that supports two different backplane busses per module slot:
 - High-speed, PCI-based for fast throughput of new advanced I/O
 - Serial backplane for RX3i serial modules and easy migration of Series 90-30 I/O
- Selection of CPUs to meet a wide range of programming and performance needs. Refer to the *PACSystems RX7i and RX3i CPU Reference Manual*, GFK-2222. The RX3i product line of CPUs includes:

CPE330	1 GHz dual core CPU with 64 MB of user memory and embedded Ethernet
CPE305	1.1 GHz CPU with 5 MB of user memory and embedded Ethernet
CPE310	1.1 GHz CPU with 10 MB of user memory and embedded Ethernet
CPU310	300 MHz CPU with 10 MB of user memory
CPU315	1 GHz CPU with 20 MB of user memory
CPU320	1 GHz CPU with 64 MB of user memory
CRU320	1 GHz Redundancy CPU with 64 MB of user memory
NIU001	300 MHz Ethernet Network Interface Unit
NIU001+	1.1 GHz Ethernet Network Interface Unit
- Memory for ladder logic documentation and machine documentation in the controller to reduce downtime and improve troubleshooting
- Open communications support
- Variety of discrete, analog, and special-purpose modules
- Hot insertion in both the PCI Backplane and Serial Backplane for new and migrated I/O modules. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.
- Isolated 24 Vdc terminal for I/O modules and a grounding bar that reduces user wiring

1.2.2 Programming and Configuration

PACSystems equipment is configured and programmed using Proficy Machine Edition (PME) software, PME features a common user interface across product families and drag-and-drop editing. Machine Edition also includes a built-in Web server for real-time data delivery during system operation.

- For more information about programming, instruction sets, syntax and diagnostics, refer to the *PACSystems CPU Programmer's Reference Manual*, GFK-2950.
- For more information about configuration and CPU features, refer to the *PACSystems RX7i and RX3i CPU Reference Manual*, GFK-2222.

1.2.3 Migration from Series 90-30 to PACSystems RX3i

PACSystems RX3i is designed to facilitate migration of Series 90-30 PLC systems and equipment. System migration is discussed in detail in *Converting Series 90 Applications to PACSystems*, GFK-2722.

1.2.4 PACSystems Documentation

PACSystems Manuals

<i>PACSystems RX7i and RX3i CPU Reference Manual</i>	GFK-2222
<i>PACSystems RX7i and RX3i CPU Programmer's Reference Manual</i>	GFK-2950
<i>PACSystems RX7i & RX3i TCP/IP Ethernet Communications User Manual</i>	GFK-2224
<i>PACSystems TCP/IP Ethernet Communications Station Manager User Manual</i>	GFK-2225
<i>C Programmer's Toolkit for PACSystems</i>	GFK-2259
<i>PACSystems Memory Xchange Modules User's Manual</i>	GFK-2300
<i>PACSystems Hot Standby CPU Redundancy User Manual</i>	GFK-2308
<i>PACSystems Battery and Energy Pack Manual</i>	GFK-2741
<i>Proficy Machine Edition Logic Developer Getting Started</i>	GFK-1918
<i>Proficy Process Systems Getting Started Guide</i>	GFK-2487
<i>High Speed Counter Modules for PACSystems* RX3i and Series 90*-30 User's Manual</i>	GFK-0293
<i>PACSystems RXi, RX3i, and RX7i Controller Secure Deployment Guide</i>	GFK-2830
<i>PACSystems HART Pass Through User Manual</i>	GFK-2929

RX3i Manuals

<i>PACSystems RX3i System Manual</i>	GFK-2314
<i>DSM324i Motion Controller for PACSystems RX3i and Series 90-30 User's Manual</i>	GFK-2347
<i>PACSystems RX3i PROFIBUS Modules User's Manual</i>	GFK-2301
<i>PACSystems RX3i Max-On Hot Standby Redundancy User's Manual</i>	GFK-2409
<i>PACSystems RX3i Ethernet Network Interface Unit User's Manual</i>	GFK-2439
<i>PACMotion Multi-Axis Motion Controller User's Manual</i>	GFK-2448
<i>PACSystems RX3i PROFINET I/O Controller Manual</i>	GFK-2571
<i>PACSystems RX3i PROFINET Scanner Manual</i>	GFK-2737
<i>PACSystems RX3i CEP PROFINET Scanner User Manual</i>	GFK-2883
<i>PACSystems RX3i IEC 61850 Ethernet Communication Module User Manual</i>	GFK-2849
<i>PACSystems RX3i Serial Communications Modules User's Manual</i>	GFK-2460
<i>PACSystems RX3i Genius Communications Gateway User Manual</i>	GFK-2892
<i>PACSystems RX3i DNP3 Outstation Module IC695EDS001 User's Manual</i>	GFK-2911
<i>PACSystems RX3i IEC 104 Server Module IC695EIS001 User's Manual</i>	GFK-2949

In addition to these manuals, datasheets and product update documents describe individual modules and product revisions. The most recent PACSystems documentation is available on the GE support website <http://support.ge-ip.com>.

1.3 Modules for RX3i Systems

The tables in this section list the types of modules that can be included in an RX3i system:

- RX3i Modules (IC695 and IC694)
 - **IC695 modules** must be installed in a Universal (IC695CHSxxx) Backplane.
 - **IC694 modules** are compatible with the RX3i serial bus in Universal Backplanes and RX3i Serial Expansion (IC694CHSxxx) Backplanes.
- **Series 90-30 Modules (IC693)** modules are compatible with the RX3i serial bus in Universal Backplanes and RX3i Serial Expansion Backplanes.

1.3.1 RX3i Modules (IC695 and IC694)

Description	Catalog Number	Minimum RX3i CPU Version
RX3i Power Supplies		
Power Supply 120/240 V ac 125Vdc 40W	IC695PSA040	All
Power Supply 24Vdc 40W	IC695PSD040	All
Power Supply 24Vdc 40W Multi-purpose	IC695PSD140	All
Power Supply 120/240 V ac 125Vdc 40W Multi-Purpose	IC695PSA140	All
Power Supply 120/240 V ac 125Vdc 30W Serial Expansion	IC694PWR321	All
Power Supply 120/240 V ac 125Vdc 30W High Capacity Serial Expansion	IC694PWR330	All
Power Supply 24Vdc 30W High Capacity Serial Expansion	IC694PWR331	All
Discrete Input Modules		
Input Simulator Module	IC694ACC300	All
Input 120 V ac 8-Pt Isolated	IC694MDL230	All
Input 240 V ac 8-Pt Isolated	IC694MDL231	All
Input 120 V ac 16-Pt	IC694MDL240	All
Input 24Vac 16-Pt	IC694MDL241	All
Input 120 V ac 16-Pt Isolated	IC694MDL250	3.50
Input 120 V ac 32-Pt Grouped	IC694MDL260	3.50
Input 125Vdc 8-Pt Pos/Neg Logic	IC694MDL632	All
Input 24Vdc 8-Pt Pos/Neg Logic	IC694MDL634	All
Input 125Vdc 16-Pt Pos/Neg Logic	IC694MDL635	All
Input 24Vdc 16-Pt Pos/Neg Logic	IC694MDL645	All
Input 24Vdc 16-Pt Pos/Neg Fast	IC694MDL646	All
Input 48Vdc 16-Pt Pos/Neg Logic, 1ms filter	IC694MDL648	All
Input 5/12Vdc (TTL) 32-Pt Pos/Neg	IC694MDL654	All
Input 24Vdc 32-Pt Pos/Neg	IC694MDL655	All
Input 48Vdc 32-Pt Pos/Neg Logic	IC694MDL658	All
Input 24Vdc 32-Pt High-Density	IC694MDL660	2.90
Input 24Vdc, 16-Pt, Pos Logic	IC695MDL664	6.70
Discrete Output Modules		
Output 120 V ac 0.5A 12-Pt	IC694MDL310	All
Output 120/240 V ac 2A 8-Pt	IC694MDL330	All
Output 120 V ac 0.5A 16-Pt	IC694MDL340	All
Output 120/240 V ac Isolated 16-Pt	IC694MDL350	3.50
Output 120/240 V ac 2A 5-Pt Isolated	IC694MDL390	All
Output 12/24Vdc 2A 8-Pt Positive Logic	IC694MDL730	All
Output 12/24Vdc 0.5A 8-Pt Positive Logic	IC694MDL732	All
Output 125Vdc 1A 6-Pt Isolated Pos/Neg	IC694MDL734	All
Output 12/24Vdc 0.5A 16-Pt Positive Logic	IC694MDL740	All
Output 12/24Vdc 0.5A 16-Pt Negative Logic	IC694MDL741	All

Description	Catalog Number	Minimum RX3i CPU Version
Output 12/24Vdc 1A 16-Pt Positive Logic ESCP	IC694MDL742	All
Output 5/24Vdc (TTL) 0.5A 32-Pt Negative Logic	IC694MDL752	All
Output 12/24Vdc 0.5A 32-Pt Positive Logic	IC694MDL753	All
Output 24Vdc 32-Pt High-Density	IC694MDL754	2.90
Output 12/24Vdc 0.5A 32-Pt Positive Logic with ESCP per group	IC694MDL758	7.70
Output 2 Amp 16-Pt Positive Logic	IC695MDL765	6.70
Output 4 Amp 16-Pt Relay	IC694MDL916	3.81
Output Relay N.O. 4 A 8-Pt Isolated	IC694MDL930	All
Output Relay N.C. and Form C 3 A 8-Pt Isolated	IC694MDL931	All
Output Relay N.O. 2 A 16-Pt	IC694MDL940	All
Discrete Mixed Modules		
High-Speed Counter Module (Classic Mode)	IC694APU300	All
High-Speed Counter Module (Enhanced Mode)		7.13
Special I/O Processor	IC694APU305	2.90
High-Speed Counter Module, 1.5MHz, 8 Inputs, 7 Outputs	IC695HSC304	3.81
High-Speed Counter Module, 1.5MHz, 16 Inputs, 14 Outputs	IC695HSC308	3.81
Mixed I/O 24Vdc Input (8-Pt) N.O. Relay Output (8-Pt)	IC694MDR390	All
Analog Input Modules		
Analog Input Module, 6 Channel Isolated Voltage/Current	IC695ALG106	5.00
Analog Input Module, 12 Channel Isolated Voltage/Current	IC695ALG112	5.00
Input Analog 4pt Voltage	IC694ALG220	All
Input Analog 4pt Current	IC694ALG221	All
Input Analog 16 Single-Ended/8 Differential Voltage	IC694ALG222	All
Input Analog 16 Single-Ended Current	IC694ALG223	All
Input Analog 16 Channel Current	IC694ALG232	6.70
Input Analog 16 Channel Voltage	IC694ALG233	6.70
Isolated Thermocouple Input Module, 6 Channels	IC695ALG306	5.50
Isolated Thermocouple Input Module, 12 Channels	IC695ALG312	5.50
Isolated Thermocouple Input Module, 12 Channels	IC695ALG412	6.50
Isolated RTD Input Module, 8 Channels	IC695ALG508	5.50
Universal Analog Input Module, Voltage, Current, Resistance, RTD, TC	IC695ALG600	2.80
Analog Input Module, 8 Channel Non-Isolated / 4 Channel Differential	IC695ALG608	3.00
Analog Input Module, 16 Channel Non-Isolated / 8 Channel Differential	IC695ALG616	3.00
Analog Input Module, 16 Channel Non-Isolated / 8 Channel Differential with HART Communications	IC695ALG626	3.50
Analog Input Module, 8 Channel Non-Isolated / 4 Channel Differential with HART Communications	IC695ALG628	3.50
Analog Output Modules		
Output Analog Voltage 2 Channels	IC694ALG390	All
Output Analog Current 2 Channels	IC694ALG391	All

Description	Catalog Number	Minimum RX3i CPU Version
Output Analog Current/Voltage 8 Channels	IC694ALG392	All
Output Analog Current/Voltage 4 Channels	IC695ALG704	3.00
Output Analog Current/Voltage 8 Channels	IC695ALG708	3.00
Output Analog Current/Voltage 8 Channels with HART Communications	IC695ALG728	3.50
Analog Output Current/Voltage 8 Channels, Isolated	IC695ALG808	5.00
Analog Mixed I/O Modules		
Analog Module, 4-Inputs, 2-Outputs, Current/Voltage	IC694ALG442	All
Analog Module, 4-Inputs, 2-Outputs, Current/Voltage with Advanced Diagnostics	IC694ALG542	6.70
Special Purpose Modules		
I/O Link Interface Module	IC694BEM320	All
I/O Link Master Module	IC694BEM321	All
Genius Bus Controller Module	IC694BEM331	All
Serial Communications Module, 2 Ports	IC695CMM002	3.83
Serial Communications Module, 4 Ports	IC695CMM004	3.83
Memory Exchange Module	IC695CMX128	5.50
DeviceNet Master Module	IC694DNM200	3.50
DSM314 Motion Controller	IC694DSM314	All
DSM324 Motion Controller	IC694DSM324	2.80
IEC 61850 Ethernet Communication Module	IC695ECM850	8.05
RX3i DNP3 Outstation Module	IC695EDS001	8.05
RX3i Ethernet 104 Server Module	IC695EIS001	8.05
Ethernet Transmitter Module	IC695ETM001	All
Genius Communications Gateway	IC695GCG001	8.15
Serial Bus Transmitter Module	IC695LRE001	All
Ethernet Network Interface Unit Module	IC695NIU001	NA
PROFIBUS Master Module	IC695PBM300	2.90
PROFIBUS Slave Module	IC695PBS301	3.00
PACMotion Multi-Axis Motion Controller	IC695PMM335	5.60
PROFINET Controller Module	IC695PNC001	CPU315/CPU320 7.00 CPE330 8.50
PROFINET Scanner Module	IC695PNS001	CPU315/CPU320 CPE305/CPE310 7.10 CRU320 8.00 CPE330 8.50
Pressure Transducer Module	IC695PRS015	6.50
Redundancy Memory Xchange Module, Multi-Mode Fiber	IC695RMX128	5.70
Redundancy Memory Xchange Module, Single-Mode Fiber	IC695RMX228	5.70

1.3.2 Series 90-30 (IC693) Modules for RX3i Systems

The following table lists the 90-30 modules that are compatible with the RX3i serial bus in Universal Backplanes, RX3i Serial Expansion Backplanes and 90-30 Expansion Backplanes.

Description	Catalog Number	Minimum Revision Supported	CE Mark Approved
Discrete Input Modules			
Series 90-30 Input Simulator Module	IC693ACC300	A	D
Series 90-30 Input 120 V ac 8-Pt Isolated	IC693MDL230	A	C
Series 90-30 Input 240 V ac 8-Pt Isolated	IC693MDL231	A	E
Series 90-30 Input 120 V ac 16-Pt	IC693MDL240	A	E
Series 90-30 Input 120 V ac 16-Pt Isolated	IC693MDL250	A	
Series 90-30 Input 120 V ac 32-Pt Grouped	IC693MDL260	A	
Series 90-30 Input 24Vac 16-Pt	IC693MDL241	A	D
Series 90-30 Input 125Vdc 8-Pt Pos/Neg Logic	IC693MDL632	A	D
Series 90-30 Input 24Vdc 8-Pt Pos/Neg Logic	IC693MDL634	A	C
Series 90-30 Input 24Vdc 16-Pt Pos/Neg Logic	IC693MDL645	A	D
Series 90-30 Input 24Vdc 16-Pt Pos/Neg Fast	IC693MDL646	A	C
Series 90-30 Input 48Vdc 16-Pt Pos/Neg Fast	IC693MDL648	A	B
Series 90-30 Input 5/12Vdc (TTL) 32-Pt Pos/Neg	IC693MDL654	A	E
Series 90-30 Input 24Vdc 32-Pt Pos/Neg	IC693MDL655	A	E
Series 90-30 Input High-Density 24Vdc 32-Pt	IC693MDL660	A	
Series 90-30 Output 120 V ac 0.5A 12-Pt	IC693MDL310	A	D
Series 90-30 Output 120/240 V ac 2A 8-Pt	IC693MDL330	A	F
Series 90-30 Output 120 V ac 0.5A 16-Pt	IC693MDL340	A	D
Series 90-30 Output 120/240 V ac Isolated 16-Pt	IC693MDL350	A	
Series 90-30 Output 120/240 V ac 2A 5-Pt Isolated	IC693MDL390	A	E
Series 90-30 Output 12/24Vdc 2A 8-Pt Positive Logic	IC693MDL730	A	E
Series 90-30 Output 12/24Vdc 2A 8-Pt Negative Logic	IC693MDL731	A	E
Series 90-30 Output 12/24Vdc 0.5A 8-Pt Positive Logic	IC693MDL732	A	C
Series 90-30 Output 12/24Vdc 0.5A 8-Pt Negative Logic	IC693MDL733	A	C
Discrete Output Modules			
Series 90-30 Output 125Vdc 1A 6-Pt Isolated Pos/Neg	IC693MDL734	A	D
Series 90-30 Output 12/24Vdc 0.5A 16-Pt Positive Logic	IC693MDL740	A	E
Series 90-30 Output 12/24Vdc 0.5A 16-Pt Negative Logic	IC693MDL741	A	E
Series 90-30 Output 12/24Vdc 1A 16-Pt Positive Logic ESCP	IC693MDL742	A	D
Series 90-30 Output 48Vdc 0.5A 8-Pt Positive Logic	IC693MDL748	A	B
Series 90-30 Output 5/24Vdc (TTL) 0.5A 32-Pt Negative Logic	IC693MDL752	A	D
Series 90-30 Output 12/24Vdc 0.5A 32-Pt Positive Logic	IC693MDL753	A	D
Series 90-30 Output High-Density 24Vdc 32-Pt	IC693MDL754	A	

Description	Catalog Number	Minimum Revision Supported	CE Mark Approved
Series 90-30 Solenoid Out 11 Pt/24Vdc Out 5-Pt Positive Logic	IC693MDL760	A	B
Series 90-30 Output Relay N.O. 4 A 8-Pt Isolated	IC693MDL930	A	D
Series 90-30 Output Relay N.C. and Form C 3 A 8-Pt Isolated	IC693MDL931	A	D
Series 90-30 Output Relay N.O. 2 A 16-Pt	IC693MDL940	A	D
Discrete Mixed Modules			
Series 90-30 High-Speed Counter Module	IC693APU300	D	H
Series 90-30 Special I/O Processor	IC693APU305	C	
Series 90-30 Mixed I/O 8-Pt 120 V ac In / 8-Pt Relay Out	IC693MAR590	A	C
Series 90-30 Mixed I/O 8-Pt 24Vdc In / 8-Pt Relay Out	IC693MDR390	A	C
Analog Input Modules			
Series 90-30 Input Analog 4-Channel Voltage	IC693ALG220	A	G and H
Series 90-30 Input Analog 4-Channel Current	IC693ALG221	A	G and H
Series 90-30 Input Analog 16 Single-Ended/ 8 Differential Voltage	IC693ALG222	A	C and D
Series 90-30 Input Analog 16 Single-Ended/ 8 Differential Current	IC693ALG223	A	C
Analog Output Modules			
Series 90-30 Output Analog 2-Channel Voltage	IC693ALG390	A	F
Series 90-30 Output Analog 2-Channel Current	IC693ALG391	A	E
Series 90-30 Output Analog Current/Voltage 8-Channel	IC693ALG392	A	B
Analog Mixed I/O Modules			
Series 90-30 Analog Current/Voltage 4-Input/2-Output	IC693ALG442	B	B
Communication Modules			
Series 90-30 I/O Link Module (Master)	IC693BEM321	C	F
Series 90-30 Genius Bus Controller	IC693BEM331	K	
Series 90-30 FIP Bus Controller	IC693BEM341		
Special Purpose Modules			
Series 90-30 I/O Link Interface Module	IC693BEM320		
Series 90-30 I/O Link Master Module	IC693BEM321		
Series 90-30 DeviceNet Master Module	IC693DNM200	AA	
Series 90-30 DeviceNet Slave Module	IC693DNS301	AA	
Series 90-30 DSM314 Motion Controller	IC693DSM314	AC	AA
Series 90-30 DSM324i Motion Controller	IC603DSM324		
Series 90-30 Temperature Controller Module	IC693TCM302	*	
Series 90-30 Temperature Controller Module Extended Range	IC693TCM303	*	
Series 90-30 Power Transducer Module	IC693PTM100	A	
Series 90-30 Power Transducer Module	IC693PTM101	A	

1.3.3 Series 90-30 Modules that Cannot Be Used in an RX3i System

The Series 90-30 modules listed in the following table cannot be included in a Universal Backplane or in any Expansion or Remote Backplane in an RX3i system. For information about whether another company's Series 90-30-compatible module may be suitable for PACSystems RX3i applications, please contact the manufacturer of the module. That includes Series 90-30 modules that have catalog numbers beginning with HE693.

Description	Catalog Number
CIMPLICITY 90-ADS 9030 Module	IC693ADC311
CIMPLICITY 90-ADS 9030 System	IC693ADS301
Axis Position Module (1-Axis)	IC693APU301
Axis Position Module (2-Axis)	IC693APU302
Series 90-30 SDS Bus Interface	IC693BEM310
Remote FIP Interface Module	IC693BEM330
FIP Remote I/O 2.5MHz	IC693BEM332
Remote FIP Interface	IC693BEM333
Genius Bus Controller	IC693BEM334
FIP Remote I/O 2.5MHz	IC693BEM335
Ethernet Network Interface Unit	IC693BEM350
Cscan Interface Module	IC693CDC200
Genius Communications Module	IC693CMM301
Enhanced Genius Communications Module	IC693CMM302
Alspa N80 Communications Module	IC693CMM304
Alspa Enhanced N80 Communications Module	IC693CMM305
Communication Control Module	IC693CMM311
Ethernet Interface Module 3.10	IC693CMM321
Digital Servo Module (2-Axis)	IC693DSM302
Digital Valve Driver Module	IC693DVM300
Power Mate "J" Interface Module	IC693MCM001
Power Mate "J" Interface 2 Axis	IC693MCM002
PM-J 1-Axis International Only	IC693MCS001
PM-J 2-Axis International Only	IC693MCS001
Input 120/240 V ac 8-Pt Isolated	IC693MDL232
Input 24Vdc 8-Pt Pos Logic	IC693MDL630
Input 24Vdc 8-Pt Neg Logic	IC693MDL631
Input 24Vdc 8-Pt Neg Logic	IC693MDL633
Input 24Vdc 16-Pt Pos Logic	IC693MDL640
Input 24Vdc 16-Pt Neg Logic	IC693MDL641
Input 24Vdc 16-Pt Pos Logic Fast (1ms)	IC693MDL643
Input 24Vdc 16-Pt Neg Logic Fast (1ms)	IC693MDL644
Input 24Vdc 32-Pt Pos/Neg	IC693MDL652
Input 24Vdc 32-Pt Pos/Neg Fast	IC693MDL653

Description	Catalog Number
Output 12/24Vdc 0.3A 32-Pt Neg	IC693MDL750
Output 12/24Vdc 0.3A 32-Pt Pos	IC693MDL751
PROFIBUS-DP Master	IC693PBM200
PROFIBUS-DP Slave	IC693PBS201
Programmable Coprocessor W/Epr	IC693PCM30
Programmable Coprocessor Module	IC693PCM300
Programmable Coprocessor Module (64k)	IC693PCM301
Programmable Coprocessor Module (640k)	IC693PCM311
Clamp Position Module	IC693PMC801
Injection Position Module	IC693PMI800

1.4 Backplanes and Power Supplies

1.4.1 RX3i Universal Backplane

The RX3i system must include at least one Universal Backplane: it accommodates the RX3i CPU. Three sizes of Universal Backplane are available: 7-slot IC695CHS007, 12-slot IC695CHS012 (Figure 1), and 16-slot (IC695CHS016).

With its dual-purpose backplane, the RX3i Universal Backplane supports both PCI-based backplane (IC695) and serial backplane (IC693 and IC694) I/O and option modules. It also supports Series 90-30 I/O and option modules.

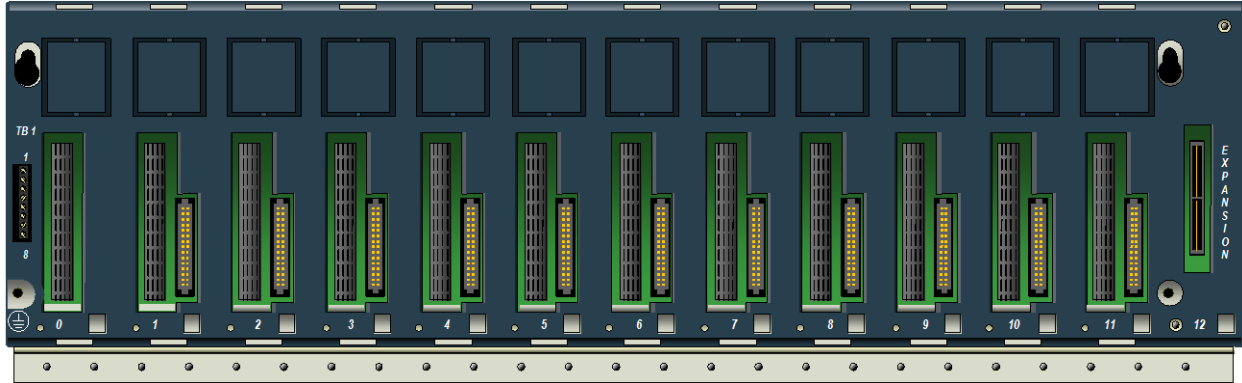


Figure 1: 12-Slot Universal Backplane IC695CHS012

1.4.2 Expansion (12-slot and 16-slot Universal Backplanes Only)

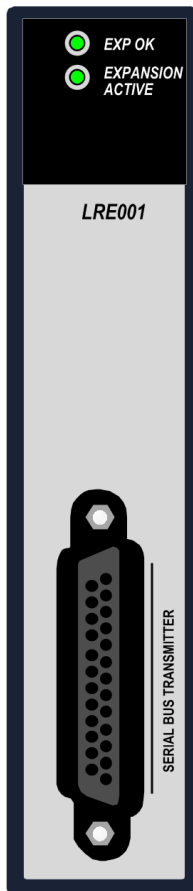


Figure 2: LRE001

Whenever an application requires more modules than the selected Universal Backplane can accommodate, or whenever some modules must be installed in another location, an RX3i Serial Bus Transmitter Module (IC695LRE001) (Figure 2) must be installed in the last slot of the Universal Backplane. Note that only 12-slot and 16-slot Universal Backplanes accommodate the LRE001.

The Bus Transmitter module (LRE001) is connected to the first Expansion or Remote backplane via a cable. Subsequent racks are daisy-chained together using cables (see Figure 5 through Figure 7).

The D-connector (right side, Figure 3) is used to connect the Rx3i Serial Expansion backplane to the LRE001.

Remote Backplanes may also be connected to the RX3i system in this manner.

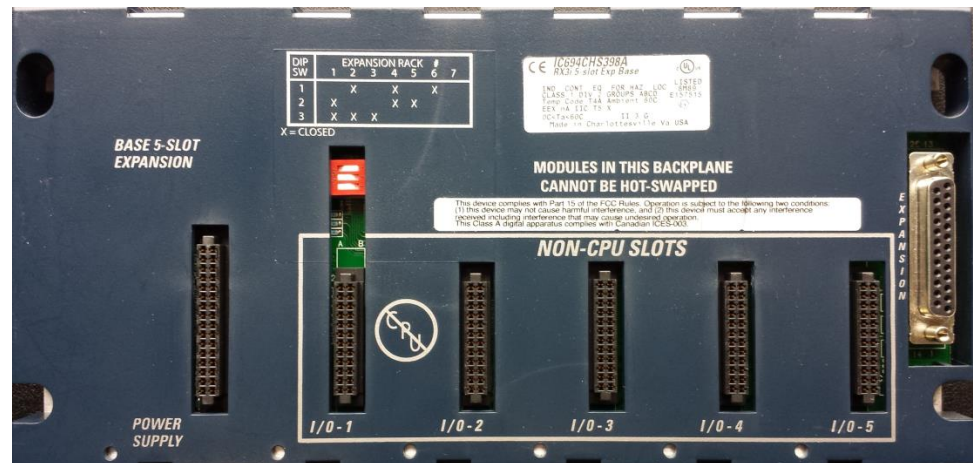


Figure 3: 5-Slot RX3i Serial Expansion Backplane IC694CHS398

Use of Expansion and Remote Backplanes is summarized on the following pages. For more information about the Serial Bus Transmitter module and cables, refer to Chapter 5.

1.4.3 Backplanes Available for the RX3i System

Universal and Expansion Backplanes that are compatible with RX3i systems are listed below. Refer to Chapter 3 of this manual for descriptions and specifications of the RX3i Backplanes. For information about Series 90-30 Expansion Backplanes, refer to the *Series 90-30 I/O Modules Specifications Manual*, GFK-0898.

Backplanes	
RX3i 16-Slot Universal Backplane	IC695CHS016
RX3i 12-Slot Universal Backplane	IC695CHS012
RX3i 7-Slot Universal Backplane	IC695CHS007
RX3i 10-Slot Serial Expansion Backplane	IC694CHS392
RX3i 5-Slot Serial Expansion Backplane	IC694CHS398
Series 90-30 10-Slot Expansion Backplane	IC693CHS392
Series 90-30 5-Slot Expansion Backplane	IC693CHS398
Series 90-30 10-Slot Remote Expansion Backplane	IC693CHS393
Series 90-30 5-Slot Remote Expansion Backplane	IC693CHS399

1.4.4 Power Supplies for RX3i Systems

Power Supplies for Universal and Serial Expansion Backplanes are listed below. Refer to Chapter 4 for descriptions and specifications of the RX3i Power Supplies. For information about Series 90-30 Power Supplies, refer to the GFK-0898, *Series 90-30 I/O Modules Specifications Manual*.

Description	Catalog Number	Installed in Universal Backplane	Installed in Serial Expansion Backplane
Power Supplies			
RX3i Power Supply, 120/240 V ac, 125Vdc, 40 W	IC695PSA040 IC695PSA140	√	
RX3i Power Supplies, 24Vdc, 40 W	IC695PSD040 IC695PSD140	√	
RX3i Serial Expansion Power Supply, 120/240 V ac, 125Vdc	IC694PWR321		√
RX3i Serial Expansion Power Supply, 120/240 V ac, 125Vdc, High Capacity	IC694PWR330		√
RX3i Serial Expansion Power Supply, 24Vdc, High Capacity	IC694PWR331		√
Series 90-30 Power Supply for Expansion Backplane, 120/240 V ac, 125Vdc	IC693PWR321		√
Series 90-30 Power Supply for Expansion Backplane, 120/240 V ac, 125Vdc, High Capacity	IC693PWR330		√
Series 90-30 Power Supply for Expansion Backplane, 24Vdc, High Capacity	IC693PWR331		√



Figure 4: Typical Single-Wide RX3i Power Supply Module

1.5 Expansion Systems

The PACSystems RX3i can include a combination of up to seven Serial Expansion and/or Remote Backplanes. The Expansion Backplanes can be any of the RX3i or Series 90-30 models listed earlier. The Remote Backplanes can be any of the Series 90-30 Remote Backplanes listed in the GEK-0898, *Series 90-30 I/O Module Specifications Manual*.

- If the system includes only Expansion Backplanes, the total distance from the CPU to the last backplane cannot be more than 15 meters (50 feet)
- If the system includes any Remote Backplanes, the total distance from the CPU to the last backplane cannot be more than 213 meters (700 feet).

Remote Backplanes provide the same functionality as Expansion Backplanes over a much greater distance. Remote Backplanes have extra isolation circuitry that lessens the effect of unbalanced ground conditions that can occur when backplanes are located long distances from each other and do not share the same ground system. Communications between the CPU and a Remote Backplane may take slightly longer than communications between the CPU and an Expansion Backplane. This delay is usually small compared to the total CPU scan time.

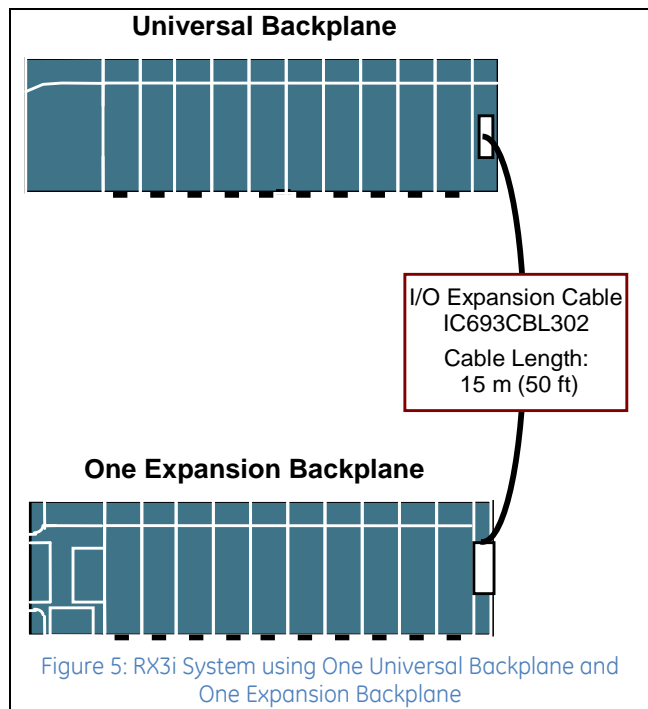
1.5.1 Expansion System with One Expansion or Remote Backplane

An Expansion system can consist of a Universal Backplane with just one Expansion or Remote Backplane.

This example includes one Universal Backplane IC695CHS012 and one Expansion Backplane, IC694CHS392. Each Backplane in this example has a DC Power Supply. Together, they accommodate 19 discrete, analog, and special-function modules.

These backplanes are located 15m (50 ft) apart. They are connected via an Expansion Cable IC693CBL302, which has a built-in terminating resistor.

If it were necessary to locate the second backplane more than 15m (50 ft) from the Universal Backplane, a Series 90-30 Remote Backplane could be used with a custom-length cable and external terminating resistor.



1.5.2 Using Multiple Expansion and Remote Backplanes

The next two example systems are similar to each other except for the distance between the backplanes. The example on the left includes two RX3i Expansion Backplanes and a Series 90-30 Expansion Backplane. The Expansion Backplanes can be any combination of RX3i (IC694) and Series 90-30 (IC693) Expansion Backplanes. I/O modules in the system can be any combination of RX3i and Series 90-30 modules.

In the example on the right, two of the backplanes must be installed beyond the 15 m (50-ft) limit of an Expansion system. Two Series 90-30 Remote Backplanes are used in those locations. All other features of the two example systems are the same, including their I/O modules.

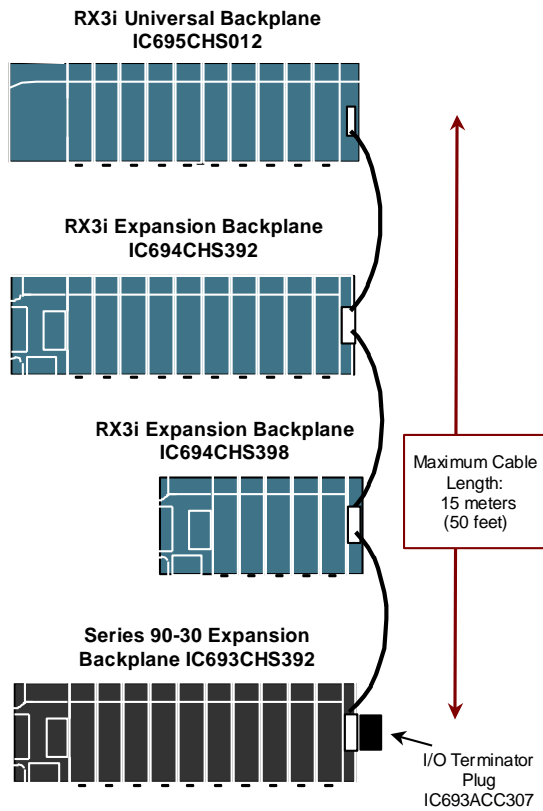


Figure 6: RX3i System using Multiple Expansion Backplanes

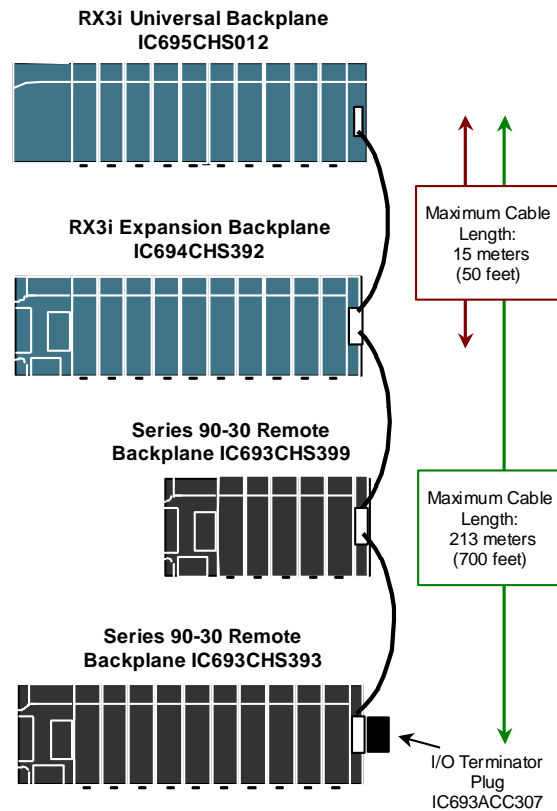


Figure 7: Rx3i System using Expansion and Remote Backplanes

Chapter 2 Installation

This chapter provides general instructions for installing PACSystems RX3i equipment.

- Pre-Installation Check
- System Layout Guidelines
- Enclosures
- System Wiring
- System Grounding
- System Installation

For additional information about system installation, refer to the following:

- Chapter 3, Backplanes, for backplane dimension diagrams
- Chapter 4, Power Supplies, for power supply specifications and wiring diagrams
- Chapters 5 through 16 for module wiring diagrams and specifications
- Chapter 17 for information about terminal blocks for some higher-density modules, the Terminal Block Quick Connect System (TBQC) and interconnect cables.
- Appendix A for general standards information
- Appendix B for information about calculating heat dissipation
- Appendix C for information about the Cable Clamping Assembly

2.1 Pre-Installation Check

Upon receiving your RX3i equipment, carefully inspect all shipping containers for damage. If any part of the system is damaged, notify the carrier immediately. The damaged shipping container should be saved as evidence for inspection by the carrier.

As the consignee, it is your responsibility to register a claim with the carrier for damage incurred during shipment. However, we will fully cooperate with you, should such action be necessary.

After unpacking the RX3i equipment, **record all serial numbers**. Serial numbers are required if you should need to contact Customer Care during the warranty period. All shipping containers and all packing material should be saved should it be necessary to transport or ship any part of the system.

Verify that all components of the system have been received and that they agree with your order. If the system received does not agree with your order, contact Customer Care.

If you need technical help, contact Technical Support. For phone numbers and email addresses, refer to *Contact Information*.

2.2 System Layout Guidelines

A good layout helps minimize the chance of electrical shock to personnel working on the system. It lets maintenance technicians easily access the unit to make measurements, load software, check indicator lights, remove and replace modules, etc. It also makes it easier to trace wiring and locate components while troubleshooting. In addition, proper system layout promotes good heat dissipation and helps eliminate electrical noise from the system. Excess heat and noise are two major causes of electronic component failure.

- Locate RX3i equipment away from other components that generate a lot of heat, such as transformers, power supplies, or power resistors.
- Locate RX3i equipment away from components that generate electrical noise such as relays and contacts.
- Locate RX3i equipment away from high-voltage components and wiring, such as circuit breakers and fusible disconnects, transformers, and motor wiring.
- Locate equipment at a convenient level that allows technicians reasonable access for maintaining the system.
- Route sensitive input wires away from electrically-noisy wires such as discrete output and AC wiring. This can be facilitated by grouping I/O modules to keep output modules separated from sensitive input modules.
- Clearance space of 10 cm (4 in) on all four sides of each RX3i backplane for ventilation/cooling is required.
- RX3i backplanes are designed to be mounted horizontally due to thermal considerations. Other mounting orientations may affect system performance, reliability, and agency approvals, and are therefore not recommended.
- Use shielded cable connections with the shield grounded at one end (at source) for all analog modules, including RTD and Thermocouple modules.

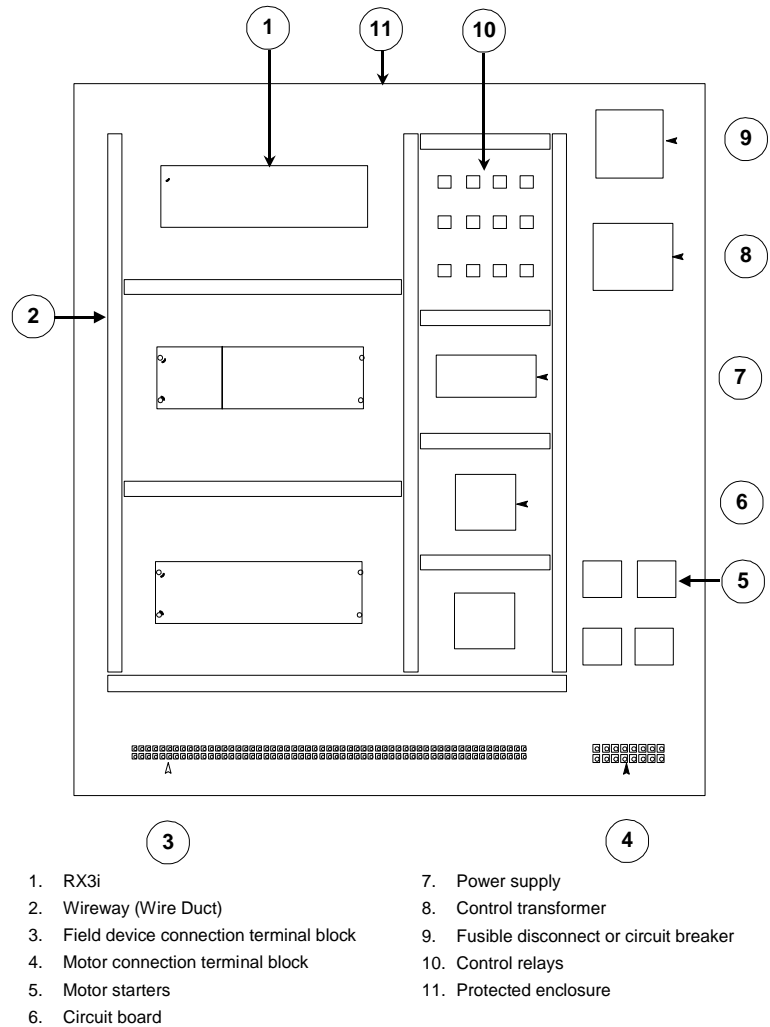


Figure 8: System Layout Guidelines

2.3 Enclosures

The RX3i system and its components are considered open equipment [having live electrical parts that may be accessible to users] and must be installed in a protective enclosure or incorporated into other assemblies manufactured to provide safety. At a minimum, the enclosure or assemblies shall provide a degree of protection against solid objects up to 12mm (e.g. fingers). This equates to a NEMA/UL Type 1 enclosure or an IP20 rating (IEC60529) providing at least a pollution degree 2 environment.

When an RX3i system is installed into an area designated as a Hazardous Area, then the enclosure must be one that is only accessible by use of a tool. Refer to Appendix A for reference to specific product certifications, types of Hazardous Area approvals, Hazardous Area warnings, and additional enclosure requirements with respect to ATEX. The enclosure must be able to adequately dissipate the heat generated by all of the components mounted inside so that no components overheat. Heat dissipation is also a factor in determining the need for enclosure cooling options such as fans and air conditioning. A minimum space of at least 102 mm (4 in) is required on all sides of the RX3i backplane for cooling. Additional space may be required, depending on the amount of heat generated by the equipment during operation, or on other requirements such as minimum bend radius for system cabling. *Appendix B* explains how to calculate heat dissipation for RX3i modules and field devices in an enclosure.

2.3.1 RX3i Universal Backplane Dimensions and Spacing

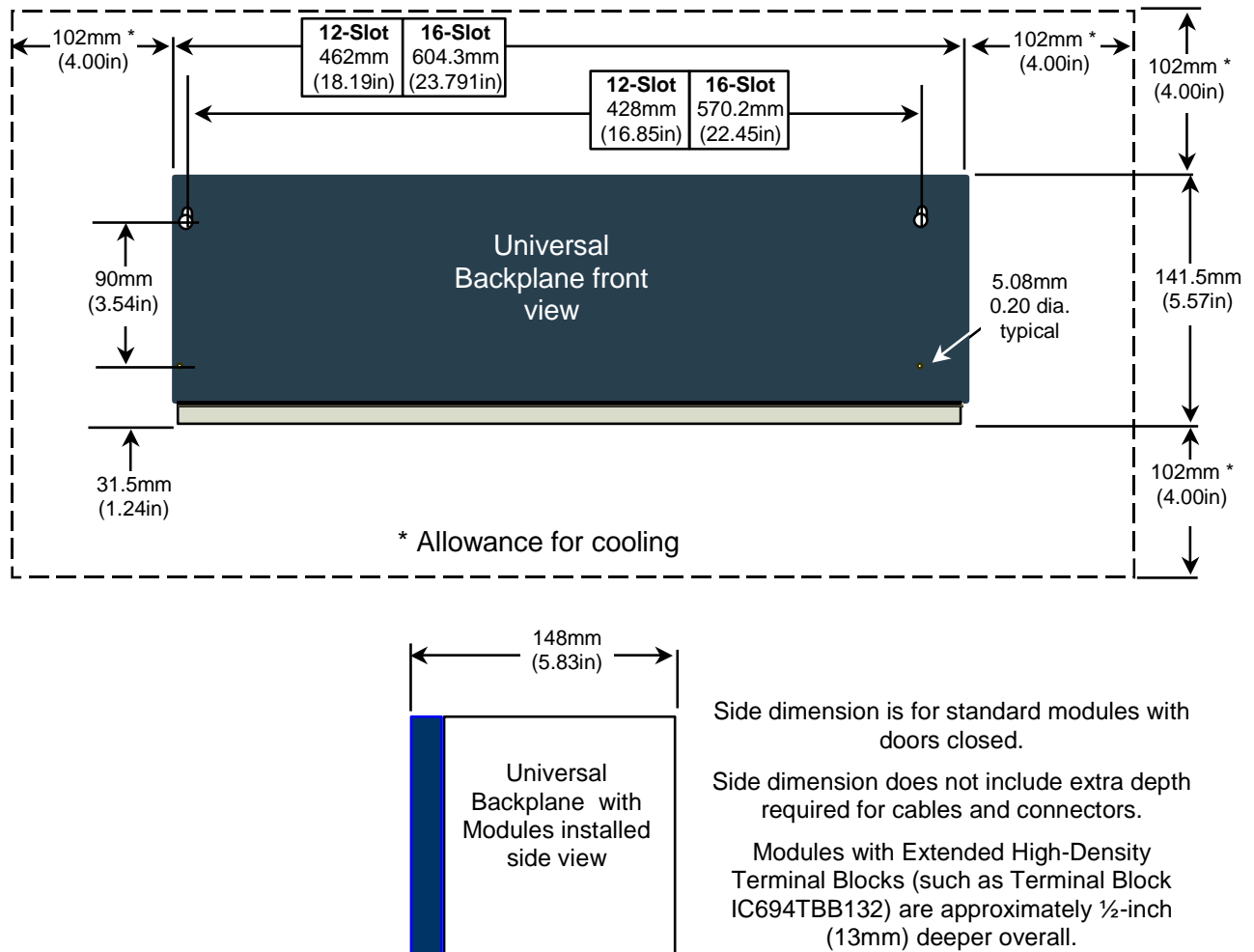


Figure 9: RX3i Universal Backplane Dimensions and Spacing

The mounting holes for the 12-slot RX3i Universal Backplane match the 10-slot Series 90-30 Backplane exactly, for easy upgrades.

Backplanes must be mounted horizontally, as represented above, to meet product performance and reliability specifications by providing adequate airflow around the modules. Other mounting orientations may affect system performance, reliability and agency approvals, and are therefore not recommended.

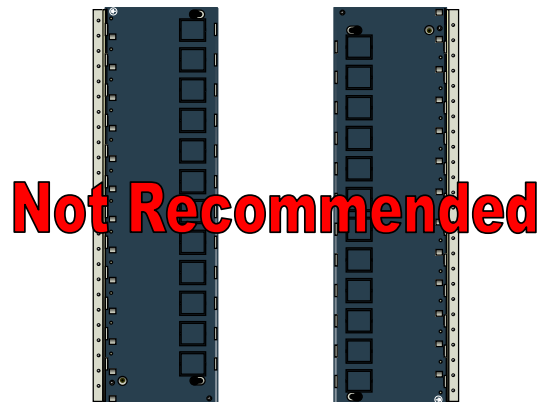
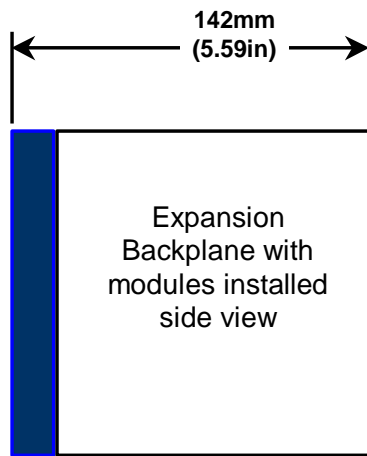
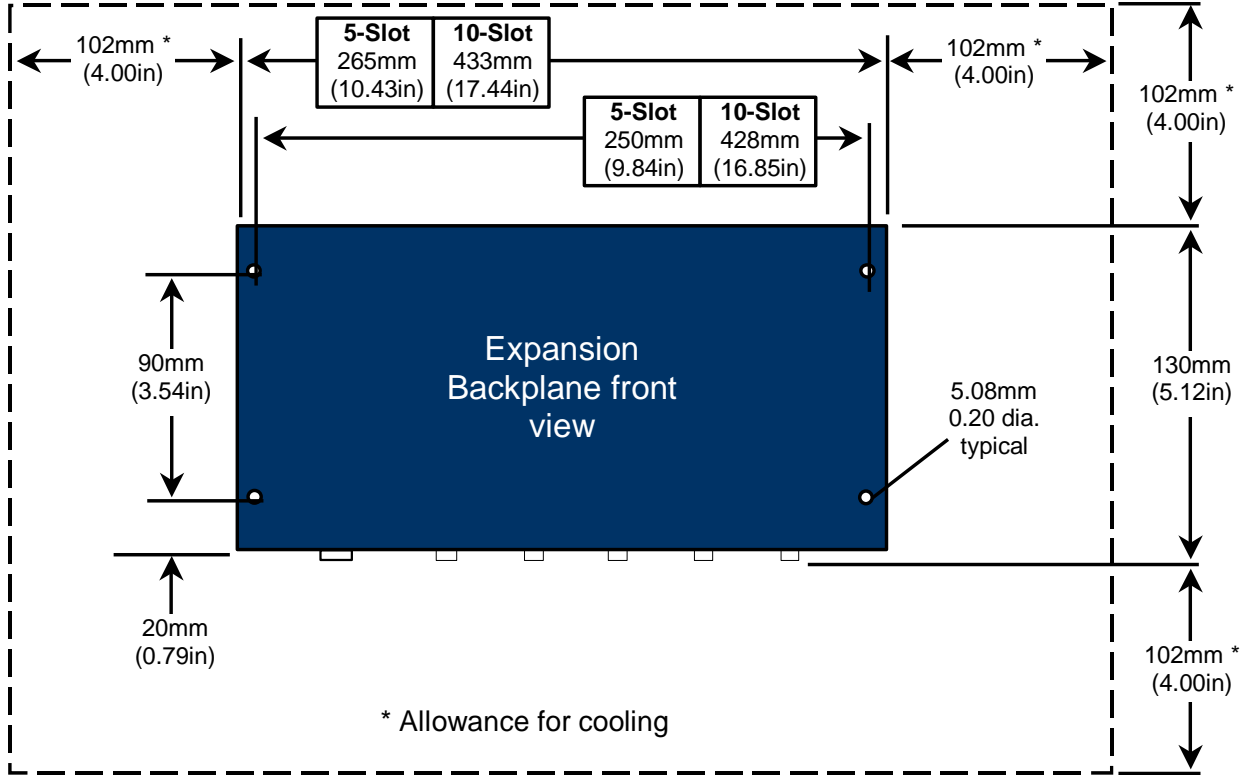


Figure 10: Vertical Mounting Not Recommended

2.3.2 RX3i Serial Expansion Backplane Dimensions and Spacing

Each backplane has standard attachment flanges for mounting on an electrical panel.



Side dimension is for modules with doors closed.

Side dimension does not include extra depth required for cables and connectors.

Modules with Extended High-Density Terminal Blocks (such as Terminal Block IC694TBB132) are approximately ½-inch (13mm) deeper overall.

Figure 11: RX3i Serial Expansion Backplane Dimensions and Spacing

2.4 System Wiring

Adhere to the following information to avoid possible misrouting of wiring to I/O modules:

- Label all wires to and from I/O devices. Record circuit identification numbers or other pertinent data on the inserts that go into the faceplate door of the module.
- Wires should be dressed so that each field I/O connector is fixed relative to its respective module.



Warning

In addition to information provided here, always follow all wiring and safety codes that apply to your area or your type of equipment. For example, in the United States, most areas have adopted the National Electrical Code standard and specify that all wiring conform to its requirements. In other countries, different codes will apply. For maximum safety to personnel and property you must follow these codes. Failure to do so can lead to personal injury or death, property damage or destruction, or both.

2.4.1 Color Coding Wires

These color codes are commonly used in industrial equipment manufactured in the United States. Where they differ from codes that apply to your area or your type of equipment, follow your applicable codes instead. Besides satisfying code requirements, wire color coding makes testing and troubleshooting safer, faster, and easier.

- Green or green with stripe- Ground
- Black - Primary AC
- Red - Secondary AC
- Blue - DC
- White - Common or neutral
- Yellow - Secondary power source not controlled by the main disconnect. Alerts maintenance personnel that there may be power present (from an external source) even if the equipment is disconnected from its main power source.

2.4.2 Wire Routing

To reduce noise-coupling among PLC wires, electrically-noisy wiring such as AC power wiring and discrete output module wiring should be separated from low-level signal wiring such as DC and analog input module wiring or communications cables. Where practical, group separately the following types of wiring:

- **AC power wiring** includes the AC input to the PLC power supply, as well as other AC devices in the control cabinet.
- **Analog Input or Output Module wiring** should be shielded to further reduce noise coupling.
- **Discrete Output Module wiring** often includes switch-inductive loads that produce noise spikes when switched off.
- **DC Input Module wiring**, although suppressed internally, are low-level inputs that should be further protected against noise coupling by observing these wiring practices.
- **Communications Cables** are noise-producing wiring cables from which wiring such as Genius bus or serial cables should be kept away.

Where AC or Output wiring bundles must pass near noise-sensitive signal wiring bundles, avoid running them beside each other. If they have to cross, route them a right angle to minimize coupling between them.

2.4.2.1 *Grouping of Similar Modules to Keep Wires Segregated*

If practical, grouping similar modules together on the backplanes can help keep wiring segregated. For example, one backplane could contain AC modules only, while another could contain DC modules only, with further grouping by input and output types.

2.5 System Grounding

All components of a control system and the devices it is controlling must be properly grounded. This is particularly important for the following reasons:

- A low-resistance path from all parts of a system to earth minimizes exposure to shock in the event of short circuits or equipment malfunction.
- The RX3i system requires proper grounding for correct operation.
- All backplanes grouped together in the PLC system must have a common ground connection. This is especially important for backplanes that are not mounted in the same control cabinet.



Warning

In addition to observing the grounding procedures described here, it is important to follow local grounding codes. In the United States, most areas have adopted the National Electrical Code standard and specify that all wiring conform to its requirements. In other countries, different codes apply. For maximum safety to personnel and property, follow these codes. Failure to do so can mean injury or death to personnel, damage to property, or both.

In addition to observing the system grounding procedures, periodic inspections of the ground connections should be performed to ensure that the system remains properly grounded.

- The PLC equipment, other control equipment, and the machine should be interconnected to maintain a common earth ground reference, also called the machine chassis ground.

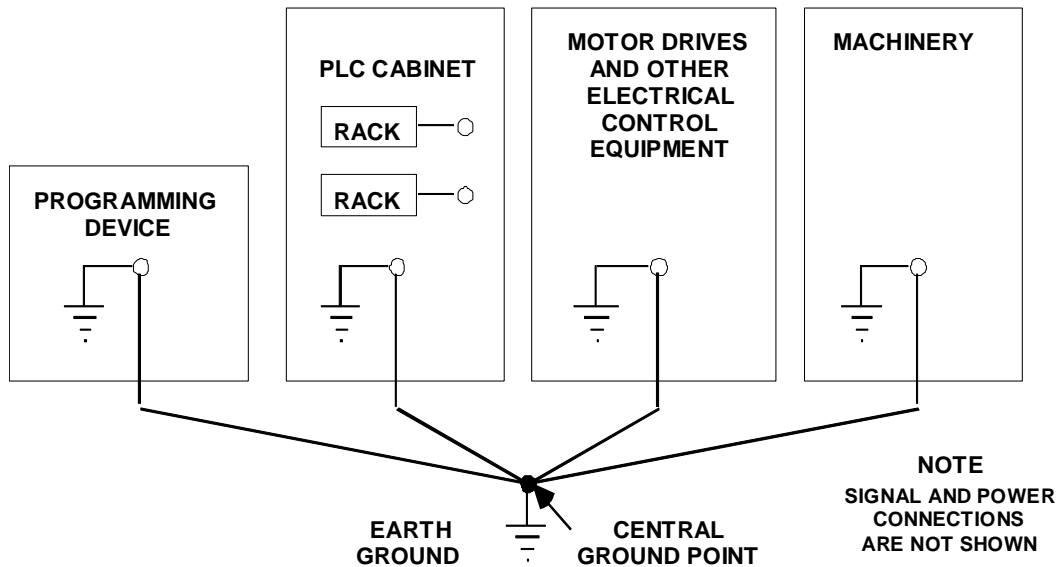


Figure 12: System Grounding

2.5.1 Ground Conductors

Ground conductors should be connected in a tree fashion with branches routed to a central earth ground point, as shown on the previous page. This ensures that no ground conductor carries current from any other branch.

A low inductance path from all parts of a system to earth minimizes emissions and increases immunity to electrical interferences. Ground conductors should be as short and as large in size as possible. Braided straps (maximum 10:1 length to width ratio recommended) or ground cables (typically green insulation with a yellow tracer - AWG #12 (3.3 mm²) or larger) can be used to minimize resistance. Conductors must always be large enough to carry the maximum short circuit current of the path being considered.

2.5.2 Backplane Safety and EMC Reference Grounding

The metal back of the backplane must be grounded using a separate conductor; the backplane mounting screws alone do not provide an adequate ground connection. At a minimum, use AWG #12 (3.3 mm²) wire with a ring terminal and star lock-washer. Connect the other end of this ground wire to a tapped hole in the mounting panel using a machine screw, star lock washer, and flat washer. Alternately, if the panel has a ground stud, use a nut and star lock washer for each wire on the ground stud to ensure adequate grounding. Where connections are made to a painted panel, the paint should be removed so clean, bare metal is exposed at the connection point. Terminals and hardware used should be rated to work with the aluminum backplane material.



Warning

All backplanes must be grounded to minimize electrical shock hazard. Failure to do so can result in severe personal injury.

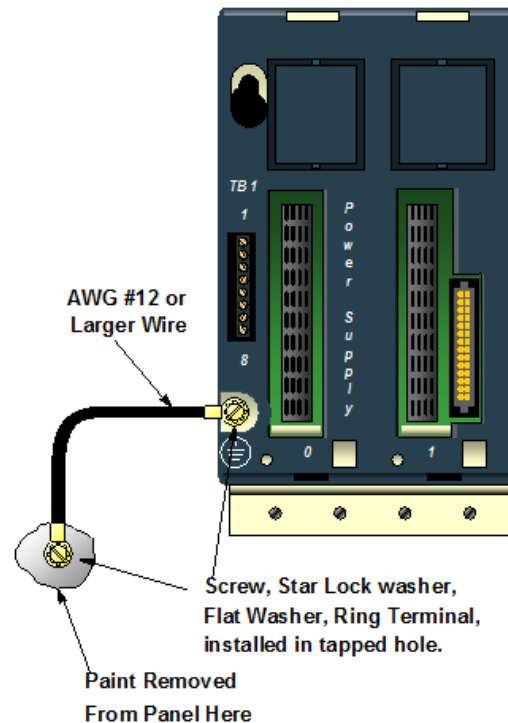


Figure 13: Ground Strap Installation

All backplanes grouped together in the PLC system must have a common ground connection. This is especially important for backplanes that are not mounted in the same control cabinet.

2.5.3 Power Supply Grounding

Refer to the section, Power Supply Field Wiring.

2.5.4 Programmer Grounding

For proper operation, the computer (programmer) running the PLC software must have a ground connection in common with the CPU. Normally, this common ground connection is provided by connecting the power cord of the programming device to the same power source (with the same ground reference point) as the backplane. If the programmer ground is at a different potential than the PLC ground, a shock hazard could exist. Also, damage to the ports could occur when the programmer serial cable is connected between the two.

2.5.5 Shield Grounding

In general, the aluminum PLC backplane is used for module shield grounding. On some modules, shield connections to the user terminal connector on the module are routed to the backplane through the backplane connector of the module. Other modules, such as the DSM314 require a separate shield ground, as displayed in the module descriptions in this manual.

For modules installed in a Universal Backplane, shield grounds can be connected to the Grounding Bar at the bottom of the Backplane using size M3 screws. The recommended torque is 0.45 Nm (4 in-lb) maximum.

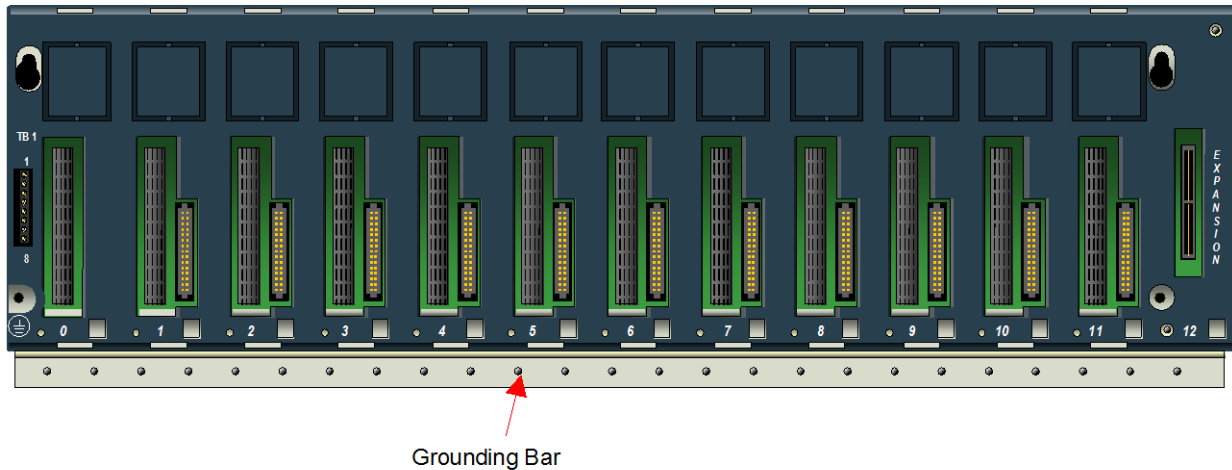


Figure 14: Grounding Bar on RX3i Universal Backplane

2.6 System Installation

2.6.1 Universal Backplanes

Mount a Universal Backplane using four good quality 8-32 x 1/2 (4 x 12mm) machine screws, lock washers and flat washers. Install the screws in the four tapped holes displayed in the following figure.

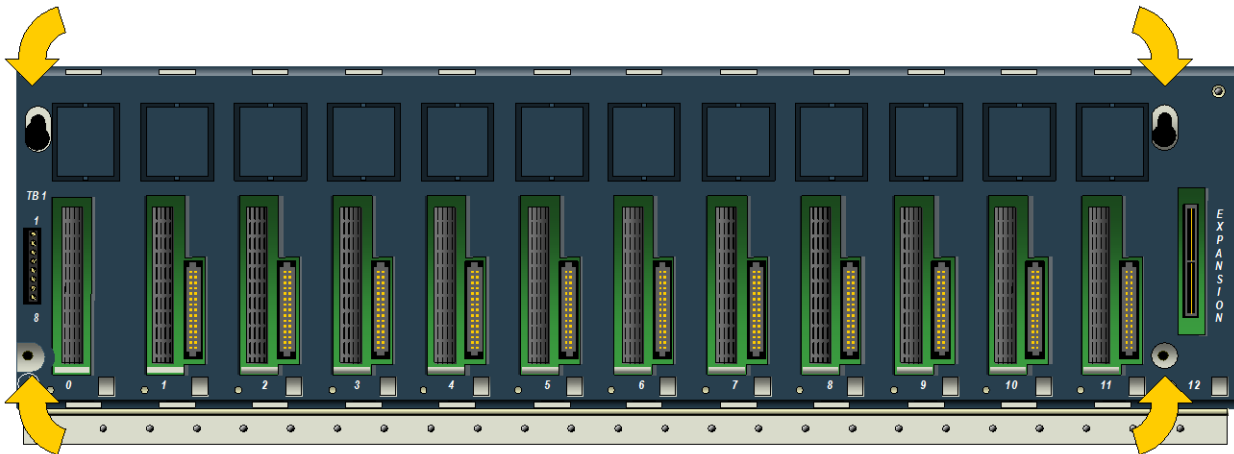


Figure 15: Location of Mounting Screws for Universal Backplane

Backplanes must be mounted horizontally, as represented above, to meet product performance and reliability specifications by providing adequate airflow around the modules. Other mounting orientations may affect system performance, reliability and agency approvals, and are therefore not recommended.

Universal Backplane Terminal TB1

The RX3i IC695 Power Supplies do not provide Isolated +24Vdc output power over the backplane.

TB1 Terminals 7 and 8 can be used to connect an optional external source of Isolated +24Vdc (see Section 3.1.1.1 for details). Isolated +24Vdc is required for some IC693 and IC694 modules as listed in the table of *Module Load Requirements*, Section 4.2.

These terminals accept individual wires from 14 to 22 AWG.

If modules that require Isolated +24Vdc are installed in an Expansion Backplane rather than in a Universal Backplane, an external Isolated +24Vdc power supply will not be required.

Terminals 1 through 6 are not used.

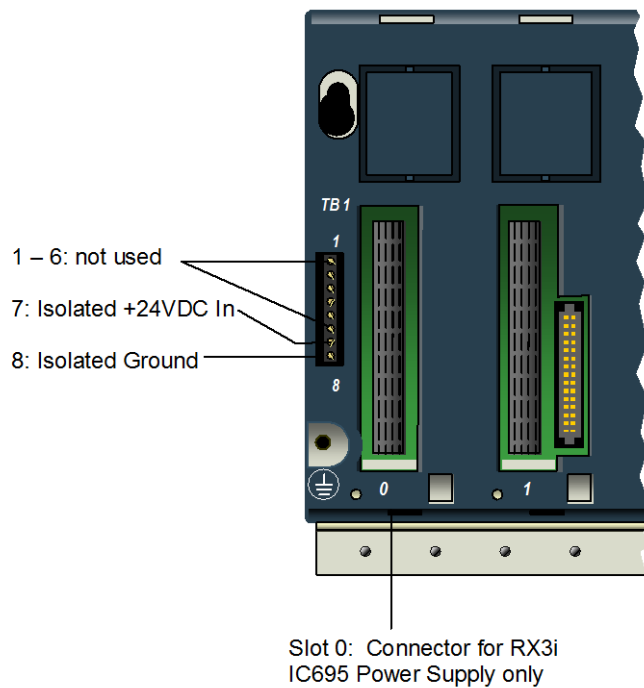


Figure 16: Universal Backplane Terminal TB1

2.6.1.1 Power Supply Models and Slot Occupancy

Power Supply Catalog Number	#Slots Occupied ¹	Max in Universal Backplane	Redundant Mode	Remote or Expansion Backplane
IC695PSD040	1	1	Not supported	Not supported
IC695PSD140	1	4 ²	Supported	Not supported
IC695PSA040	2	1	Not supported	Not supported
IC695PSA140	2	4 ²	Supported	Not supported
IC693 Power Supplies	Not permitted	Not permitted	N/A	Max 1
IC694 Power Supplies	Not permitted	Not permitted	N/A	Max 1

2.6.1.2 Universal Backplane Slot Occupancy Rules

- An RX3i CPU module can be installed anywhere in the Universal Backplane except the rightmost (expansion) slot. With the exception of CPE305, CPU modules occupy 2 slots. CPE305 occupies one slot.
- CPE305, I/O, and option modules can be installed in any available slot except the rightmost (expansion) slot and slot 0, which can only accept IC695 Power Supplies. Each I/O slot has two connectors, so can accept either an RX3i PCI-based module or a module with a serial backplane interface.
- The rightmost slot is the expansion slot. It can only be used for optional Serial Bus Transmitter module IC695LRE001.

¹ IC695 Power Supply modules may be installed in any Universal Backplane slot.

² Any combination of IC695PSD140 & IC695PSA140, up to max of four.

2.6.2 Expansion Backplanes

To mount an Expansion Backplane on a panel, use four good-quality 8-32 x 1/2 (4 x 12 mm) machine screws, lock washers and flat washers. Install the screws in the four tapped holes.

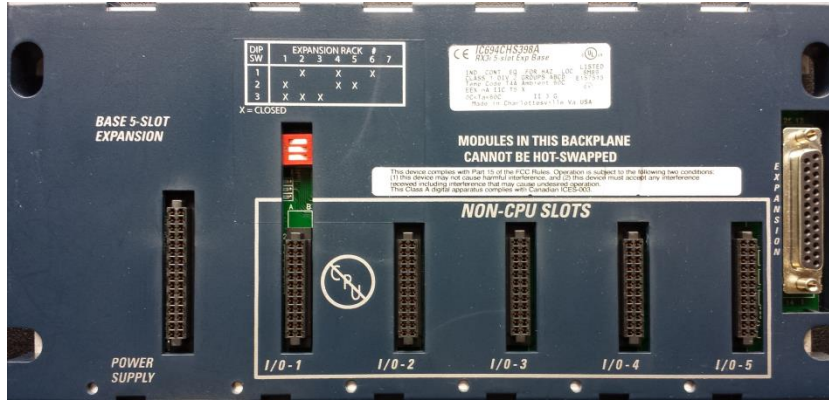


Figure 17: Expansion Backplane

An Expansion Backplane can also be mounted in a 19-inch rack using a mounting bracket as described in this section.

2.6.2.1 Setting the Rack Number DIP Switch

Each backplane is identified with a unique number called a Rack Number. Rack number 0 is always automatically assigned to the backplane with the CPU. Rack numbers must not be duplicated in a system. Backplanes do not need to be sequentially numbered, although for consistency, rack numbers should not be skipped.

Rack Numbers for Expansion and Remote backplanes are set using a DIP switch on the backplane. The following table provides the DIP switch positions for rack number selection.

DIP Switch	Rack Number						
	1	2	3	4	5	6	7
1	open	closed	open	closed	open	closed	open
2	closed	open	open	closed	closed	open	open
3	closed	closed	closed	open	open	open	open

For example, these switch settings select rack number 2:

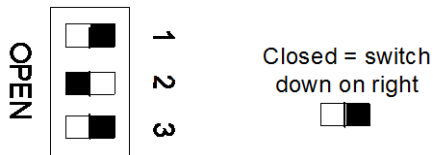


Figure 18: Example of Backplane DIP Switch Setting for Rack Number



Caution

Do not use a pencil to set the DIP switches. Graphite from the pencil can damage the switch.

2.6.2.2 Recommended Mounting Orientation for Expansion Backplanes

For Expansion and Remote Backplanes, power supply load rating depends on the mounting position of the backplane and the surrounding temperature.

The load rating with the Expansion Backplane mounted upright on a panel is 100% at 60°C (140°F).

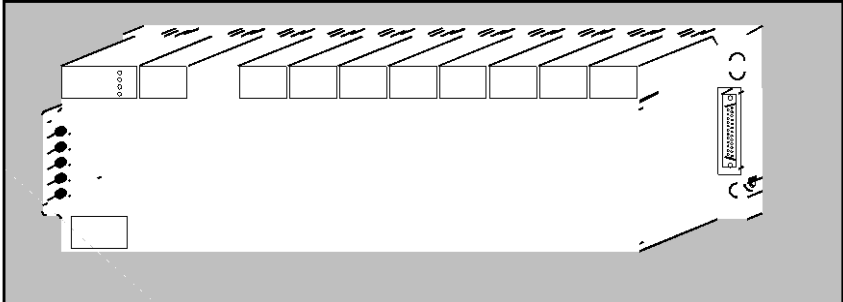


Figure 19: Effect on Load Rating, Vertical Mounting

Power supply load ratings with the backplane mounted horizontally are:

- Temperature at 25°C (77°F) – full load
- Temperature at 60°C (140°F) – 50% of full load

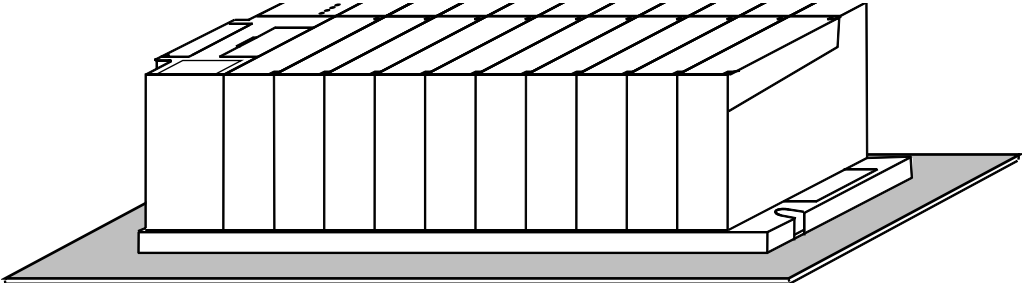


Figure 20: Effect on Load Rating, Horizontal Mounting

2.6.3 Mounting a Backplane in a 19-Inch Rack

The **IC693ACC308 Front Mount Adapter Bracket** (Figure 21) can be used to mount a 10-Slot Expansion Backplane (IC694CHS392) to the front face of a 19 inch rack. Install the adapter bracket by inserting the tabs at the top and bottom of the adapter bracket into the corresponding slots at the top and bottom of the plastic backplane cover. It is not necessary to remove the cover to install the bracket. With the bracket in place, insert and tighten the two screws (included with the bracket) through the back of the backplane holes into the threaded holes in the bracket.

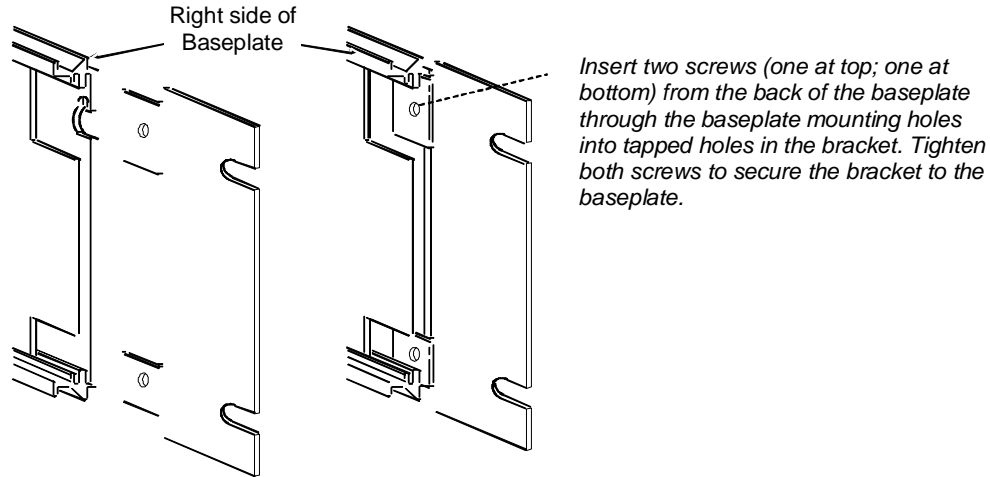


Figure 21: IC693ACC308 Front Mount Adapter Bracket

Dimensions for rack mounting a backplane with the IC693ACC308 Front Mount Adapter Bracket are displayed in Figure 22.

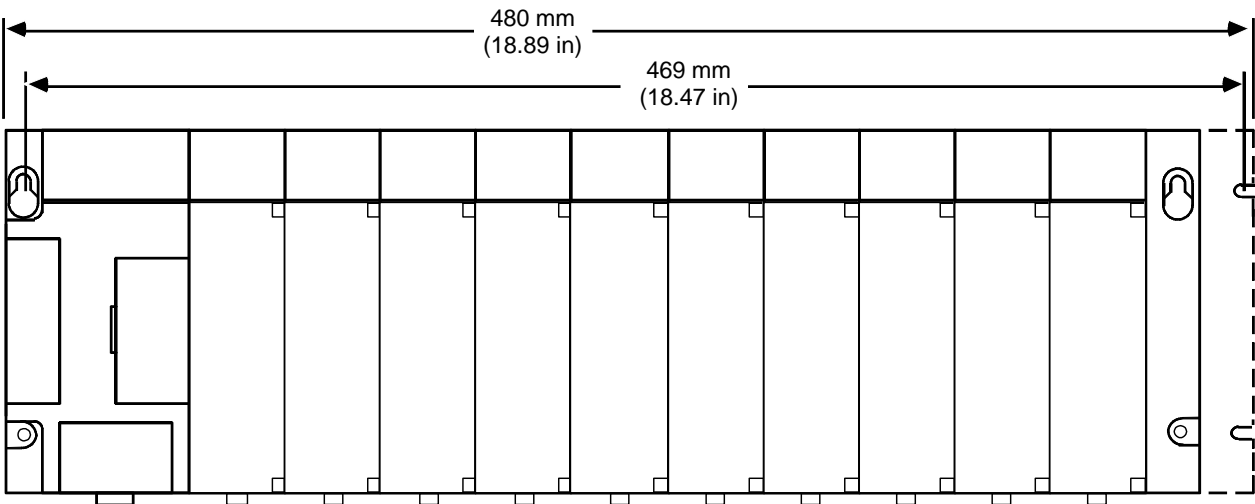


Figure 22: Dimensions for Backplane with IC693ACC308 Front Mount Adapter Bracket

The **IC693ACC313 Recessed Mount Adapter Bracket** can be used to recess-mount a 10-Slot Expansion Backplane (IC694CHS392) inside a 19" rack. This bracket cannot be used with a Universal Backplane.

An Expansion Backplane mounts on the rear panel of this adapter bracket using four 8-32 (4mm) screws, nuts, lock washers, and flat washers. The Adapter Bracket bolts through its four slotted holes to the face of the 19" rack using applicable hardware (lock washers recommended).

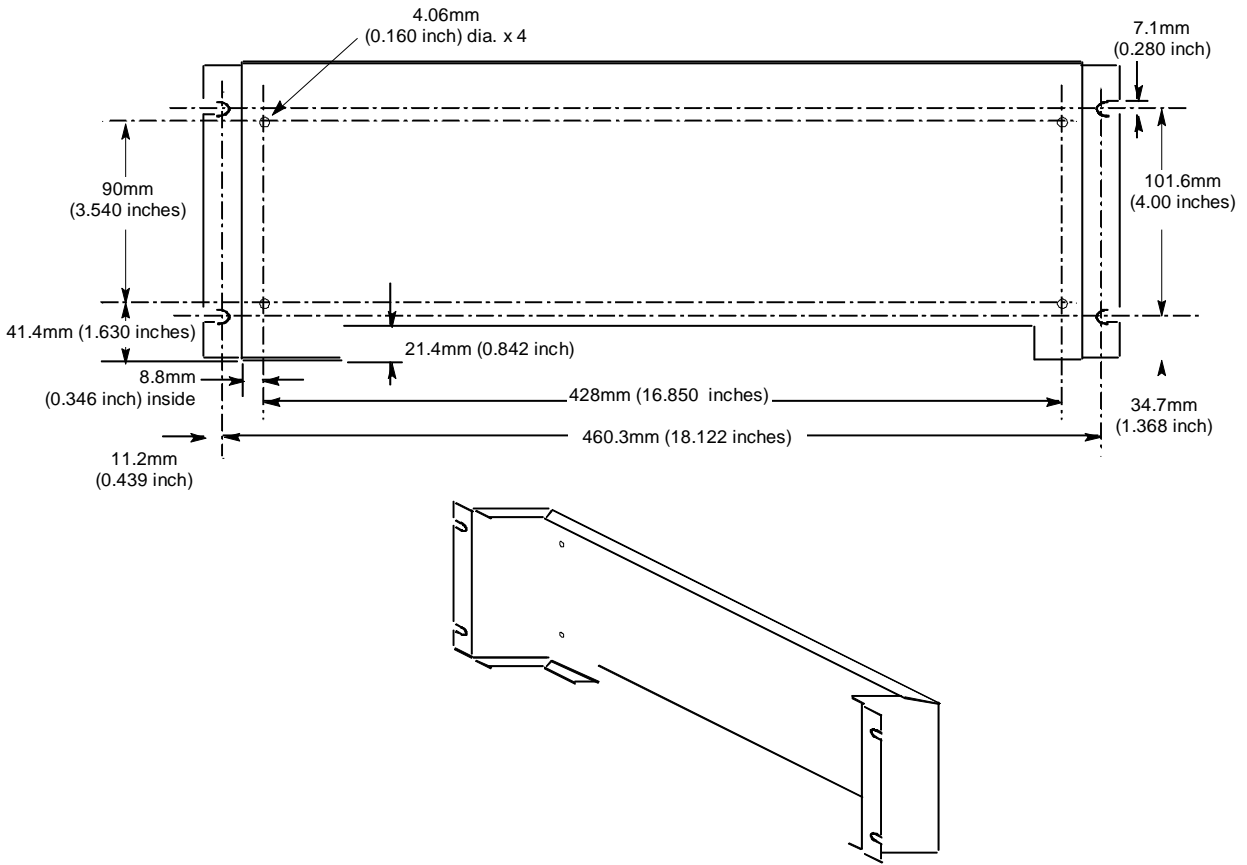


Figure 23: IC693ACC313 Recessed Mount Adapter Bracket

2.6.3.1 Grounding Rack-Mounted Expansion Backplanes

If an Expansion Backplane is mounted in a 19-inch rack using an Adapter bracket, the rack must be properly grounded as described in the section, *System Grounding Procedures*. In addition, the backplane should be grounded according to the guidelines in the section, *Backplane Safety Grounding*, using a separate ground wire from the PLC backplane.

- For a Recessed Mount Adapter Bracket (IC693ACC313), the ground wire can be installed with the ground attached to the Recessed Mount Adapter Bracket. An additional ground wire should be installed that connects the Adapter Bracket to a solid chassis ground.
- For a Surface Mount Adapter Bracket (IC693ACC308), the ground wire should be run from the backplane to a solid chassis ground on the rack.

2.6.4 Modules

2.6.4.1 Hot Insertion and Removal

In general, modules in a Universal Backplane (IC695CHS007, CHS012 or CHS016) can be installed or removed while power is applied to the system. This includes backplane power and field power supplied to the module. However, no CPU modules fall into this category. The following table lists the I/O modules that do not support this feature or have not yet been verified to support this feature.

Note: For products that support hot insertion, the module must be properly seated on the carrier with the latch engaged and all pins connected within 2 seconds. For removal, the module must be completely disengaged from the carrier within 2 seconds. It is important that the module not remain partially inserted during the insertion or removal process. There must be at a minimum of two seconds between the removal and insertion of modules.

Note: A CPU module cannot be installed or removed from a Universal Backplane while power is applied to system. System power must be removed before installing or removing the CPU.

The following modules support hot insertion and removal, with restrictions as noted:

Catalog Number	Hot-Swap Compatible	Notes / Restrictions on Hot Swap Capability
IC693ACC300	Yes	
IC694ACC300	Yes	
IC695ALG106	Yes	
IC695ALG112	Yes	
IC693ALG222	Yes - Revision FA & later	Revision E & earlier do not support hot swap.
IC694ALG222	Yes - Revision BA & later	Revision A does not support hot swap.
IC693ALG223	Yes - Revision EA & later	Revision D & earlier do not support hot swap.
IC694ALG223	Yes - Revision BA & later	Revision A does not support hot swap.
IC694ALG232	Yes	
IC694ALG233	Yes	
IC695ALG306	Yes	
IC695ALG312	Yes	
IC693ALG391	Yes	
IC693ALG392	Yes	
IC694ALG392	Yes	
IC695ALG412	Yes	
IC693ALG442	Yes - Revision DA & later	Revision C & earlier do not support hot swap.
IC694ALG442	Yes - Revision BA & later	Revision A does not support hot swap.
IC695ALG508	Yes	
IC694ALG542	Yes	
IC695ALG600	Yes	
IC695ALG608	Yes	
IC695ALG616	Yes	
IC695ALG626	Yes	
IC695ALG628	Yes	
IC695ALG704	Yes	
IC695ALG708	Yes	

Catalog Number	Hot-Swap Compatible	Notes / Restrictions on Hot Swap Capability
IC695ALG728	Yes	
IC695ALG808	Yes	
IC693APU300	Yes – Revision MA & later	Revision L and earlier do not support hot swap.
IC694APU300	Yes – Revision CA & later	Revision -BA and earlier do not support hot swap.
IC693APU305	Yes	
IC694APU305	Yes	
IC693BEM331	Yes	Genius Bus Controller modules that are included in a Max-ON redundancy system should not be installed or removed from the PLC that is operating as a Master. If a module is removed from the Master and then re-installed, the outputs for that module will not be enabled until the next Backup-to-Master transition.
IC694BEM331	Yes	Any time a Genius Bus Controller is removed from an active system, there is a possibility that the bus may be disrupted with a subsequent impact on the corresponding I/O devices. For systems that require online maintainability, it is recommended that dual (redundant) Genius busses be used. Otherwise, the BEM331 can be hot-swapped.
IC695CMM002	Yes	
IC695CMM004	Yes	
IC695CMX128	Yes	
IC693DSM324	Yes	
IC694DSM324	Yes	
IC695ECM850	Yes	
IC695EDS001	Yes	
IC695EIS001	Yes	
IC695ETM001	Yes	
IC695GCG001	Yes	The Genius Communications Gateway requires an external 24Vdc power supply and does not draw power from the RX3i backplane. Swapping out the GCG001 will therefore not impact the PLC. However, this cannot be performed without disconnecting its power supply. If configured to support Genius Hot Standby, the loss of a single GCG001 will be tolerated; otherwise not.
IC695HSC304	Yes	
IC695HSC308	Yes	
IC693MDL230	Yes	
IC694MDL230	Yes	
IC693MDL231	Yes	
IC694MDL231	Yes	
IC693MDL240	Yes	
IC694MDL240	Yes	
IC693MDL241	Yes	
IC694MDL241	Yes	

Catalog Number	Hot-Swap Compatible	Notes / Restrictions on Hot Swap Capability
IC693MDL250	Yes	
IC694MDL250	Yes	
IC693MDL260	Yes	
IC694MDL260	Yes	
IC693MDL310	Yes	
IC694MDL310	Yes	
IC693MDL330	Yes	
IC694MDL330	Yes	
IC693MDL340	Yes	
IC694MDL340	Yes	
IC693MDL350	Yes	
IC694MDL350	Yes	
IC693MDL390	Yes	
IC694MDL390	Yes	
IC693MDL632	Yes	
IC694MDL632	Yes	
IC693MDL634	Yes	Hot swap can only be performed with field side terminal block removed from the module. The terminal block is to be removed before hot extraction from the RX3i Universal Backplane and re-installed after hot insertion.
IC694MDL634	Yes	
IC693MDL635	Yes	
IC694MDL635	Yes	
IC693MDL645	Yes	Hot swap can only be performed with field side terminal block removed from the module. The terminal block is to be removed before hot extraction from the RX3i Universal Backplane and re-installed after hot insertion.
IC694MDL645	Yes	
IC693MDL646	Yes	Hot swap can only be performed with field side terminal block removed from the module. The terminal block is to be removed before hot extraction from the RX3i Universal Backplane and re-installed after hot insertion.
IC694MDL646	Yes	
IC693MDL648	Yes	Hot swap can only be performed with field side terminal block removed from the module. The terminal block is to be removed before hot extraction from the RX3i Universal Backplane and re-installed after hot insertion.
IC694MDL648	Yes	
IC693MDL654	Yes	
IC694MDL654	Yes	
IC693MDL655	Yes	
IC694MDL655	Yes	
IC694MDL658	Yes	
IC693MDL660	Yes	
IC694MDL660	Yes	

Catalog Number	Hot-Swap Compatible	Notes / Restrictions on Hot Swap Capability
IC695MDL664	Yes	
IC693MDL730	Yes	
IC694MDL730	Yes	
IC693MDL731	Yes	
IC693MDL732	Yes	
IC694MDL732	Yes	
IC693MDL733	Yes	
IC693MDL734	Yes	
IC694MDL734	Yes	
IC693MDL740	Yes	
IC694MDL740	Yes	
IC693MDL741	Yes	
IC694MDL741	Yes	
IC693MDL742	Yes	
IC694MDL742	Yes	
IC693MDL748	Yes	
IC693MDL752	Yes	
IC694MDL752	Yes	
IC693MDL753	Yes	
IC694MDL753	Yes	
IC693MDL754	Yes	
IC694MDL754	Yes	
IC694MDL758	Yes	
IC695MDL765	Yes	
IC693MDL916	Yes	
IC694MDL916	Yes	
IC695PBM300	Yes	
IC695PBS301	Yes	
IC695PMM335	Yes	Hot-Swap can only be performed while PLC is in STOP mode
IC695PNC001	Yes	
IC695PRS015	Yes	
IC695PSA140	Yes	Hot-swappable only when redundant power supplies are present and each is powered up.
IC695PSD140	Yes	Hot-swappable only when redundant power supplies are present and each is powered up.
IC694PSM001	Yes	
IC695RMX128	Yes	
IC695RMX228	Yes	



Warning

Inserting or removing a module with power applied to the system may cause an electrical arc. This can result in unexpected and potentially dangerous action by field devices. Arcing is an explosion risk in hazardous locations. Be sure that the area is non-hazardous or remove system power before removing or inserting a module.



Warning

Do not insert or remove modules in RX3i Serial Expansion Backplanes or Series 90-30 Expansion Backplanes with power applied to the backplane. This could cause the PLC to stop or malfunction. Injury to personnel and damage to the module or backplane may result. If the PLC is in RUN mode, I/O data to/from this backplane will not be updated while power is removed..

2.6.4.2 Hot Insertion and Removal Not Supported

The following modules **do not support** hot Insertion and removal. Do not attempt to insert or remove them while power is applied to the rack.

Catalog Number	Notes
IC693ALG220	
IC694ALG220	
IC693ALG221	
IC694ALG221	
IC693ALG222	Revision E & earlier do not support hot swap.
IC694ALG222	Revision A does not support hot swap.
IC693ALG223	Revision D & earlier do not support hot swap.
IC694ALG223	Revision A does not support hot swap.
IC693ALG390	
IC694ALG390	
IC694ALG391	
IC693ALG442	Revision C & earlier do not support hot swap.
IC694ALG442	Revision A does not support hot swap.
IC693APU300	Revision L and earlier do not support hot swap.
IC694APU300	Revision -BA and earlier do not support hot swap.
IC693BEM320	
IC694BEM320	
IC693BEM321	
IC694BEM321	
IC693BEM341	
IC695CMU310	Head-end unit - shuts down everything if removed.
IC695CPE305	Head-end unit - shuts down everything if removed.
IC695CPE310	Head-end unit - shuts down everything if removed.
IC695CPU310	Head-end unit - shuts down everything if removed.
IC695CPU311	Head-end unit - shuts down everything if removed.
IC695CPU315	Head-end unit - shuts down everything if removed.

Catalog Number	Notes
IC695CPU320	Head-end unit - shuts down everything if removed.
IC695CRU320	Head-end unit - shuts down everything if removed.
IC693DNM200	
IC694DNM200	
IC693DSM314	
IC694DSM314	
IC695LRE001	Can cause communications issues with remote racks if hot-swapped.
IC693MAR590	
IC693MDL760	
IC693MDL930	
IC694MDL930	
IC693MDL931	
IC694MDL931	
IC693MDL940	
IC694MDL940	
IC693MDR390	
IC694MDR390	
IC695NIU001	Head-end unit - shuts down everything if removed.
IC695PNS001	Head-end unit - shuts down everything if removed.
IC695PSA040	Only power source in rack - shuts everything off and can cause corrupt user memory if hot removed.
IC695PSD040	Only power source in rack - shuts everything off and can cause corrupt user memory if hot removed.

2.6.4.3 Installing Modules



Warning

Potentially dangerous voltages may be present on the screw terminals of the module, even though power to the backplane is turned off. Always be careful when handling the removable terminal board of the module and any wires connected to it.

- Be sure the module catalog number matches the intended slot configuration.
- Holding the module firmly, align the module with the correct slot and connector.
- Engage the rear pivot hook(s) of the module (Figure 24) in the notch(es) on the top of the backplane (1).
- Swing the module down (2) until the connector of the module engages the backplane connector, and the release lever(s) on the bottom of the module snaps into place in the bottom module retainer (3).
- Visually inspect the module to be sure it is properly seated.

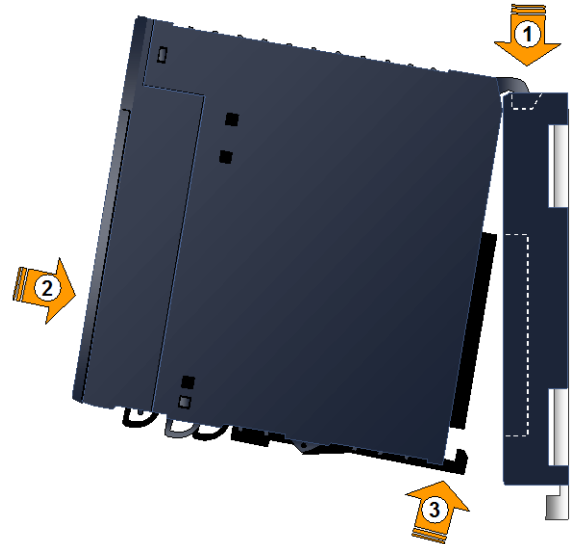


Figure 24: Installing Module in Backplane

2.6.4.4 Removing Modules

- If the module has a removable terminal board, remove it as described later in this section.
- Locate the release lever(s) at the bottom of the module (Figure 25) and firmly press upward (1), toward the module. Wider modules have two release levers that must both be pressed up at the same time.
- While holding the module firmly and fully depressing the release lever(s), pivot the module upward until its connector is out of the backplane (2).
- Lift the module up and away from the backplane to disengage the pivot hook.

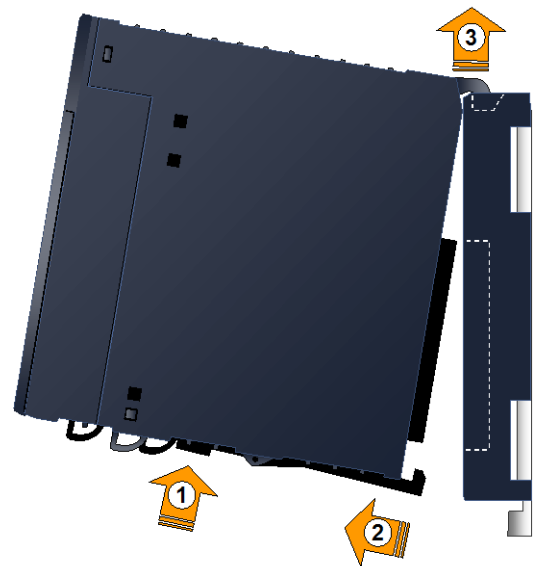


Figure 25: Removing Module from Backplane

2.6.4.5 I/O Module Terminal Block Assemblies

Most PACSystems RX3i I/O modules have removable front terminal block assemblies. Each module of this type has a door label that can be removed, marked up as required for the application, then re-inserted into the retaining grooves. (Figure 28). The front of the label (Figure 26) displays the catalog number of the module and a color band to indicate the module type. It also provides space to record identifying application information about the inputs or outputs wired to the module. The wiring diagram is printed on the reverse side and is visible to the technician (Figure 27) once the door is swung open.

The terminal blocks have fully-hinged doors that can be opened to either the left or right to access wiring.

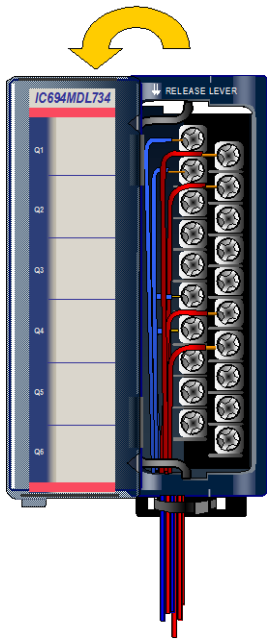


Figure 26 Module Door Label Front View

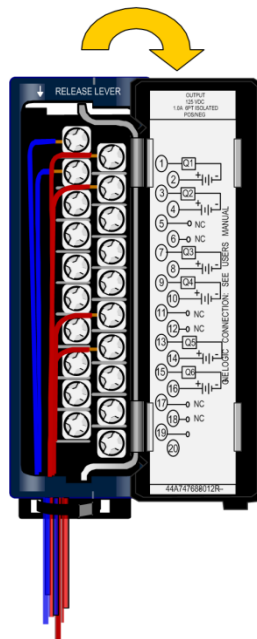


Figure 27: Wiring Diagram on Reverse Side of Door

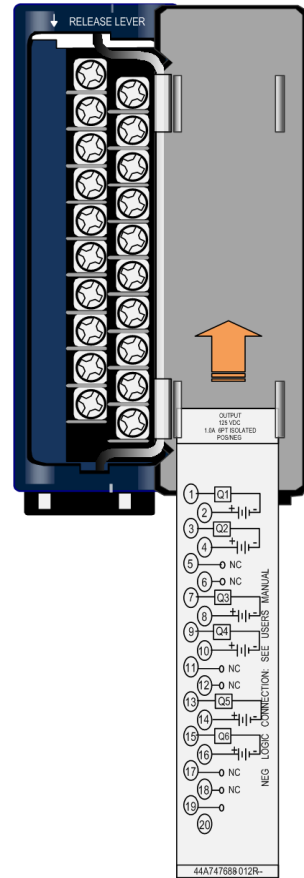


Figure 28: Insertion of Door Label following Mark-up for Application

2.6.4.6 I/O Module Connections

For most RX3i I/O modules, connections are made to the removable terminal board of the module. Specific wiring information for each module is printed on the door insert and also shown in the module description in this manual.

This section describes the 20-Connector removable terminal block (Figure 29), which is used by most RX3i I/O modules. Higher-density modules use other connection methods.

Refer to Chapter 17 for details concerning the following:

- 36-pin removable terminal blocks used for most higher-density modules.
- Connections to I/O modules that have two 20-Connector connectors on the front of the module.
- Terminal Board Quick Connect (TBQC) system that allows users to land the field wiring on interposing terminal strips and complete the connection to the I/O module using pre-fabricated interconnect cables.

Screw terminals on a 20-Connector terminal block accept from two AWG #22 (0.36 mm²) to two AWG #16 (1.3 mm²), or one AWG #14 (2.1 mm²) copper 90°C (194°F) wire(s). Each terminal can accept solid or stranded wires, but the wires into any given terminal should be the same type (both solid or both stranded) to ensure a good connection. Wires are routed to and from the terminals out of the bottom of the terminal board cavity. The suggested torque for the I/O terminal board connection screws is from 1.1 to 1.3 Nm (9.6 to 11.5 in-lb).

After the wiring is completed, wires should be bundled and fastened at the bottom of the terminal block, as shown in Figure 29.

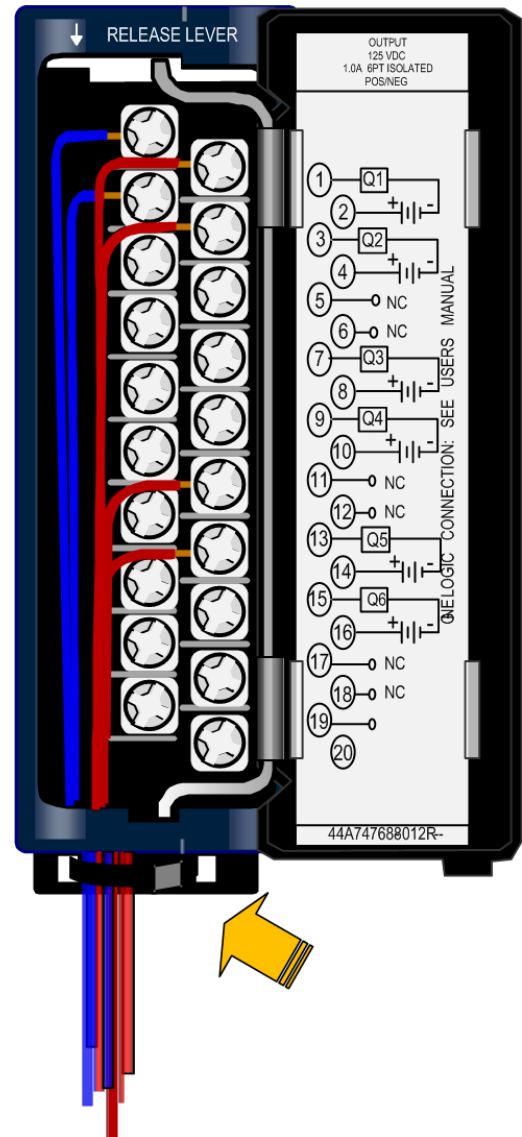


Figure 29: 20-Connector removable terminal block with Tie Wrap Landing Location noted

2.6.4.7 Installing or Removing a 20-Connector Terminal Block Assembly

(Refer to Chapter 17 for instructions for installing or removing a 36-pin terminal assembly). Compare the module catalog number on the label on the terminal assembly door and the label on the side of the to be sure they match. If a wired terminal block is installed on the wrong module type, the module may be damaged when the system is powered up.



Warning

Field power must be turned off when installing or removing a Terminal Block assembly.

Installing a Terminal Block

- To install a terminal block (Figure 30):
 1. Insert the pivot hook on the bottom of the terminal block assembly into the slot on the bottom of the module.
 2. Pivot the terminal block assembly upward to engage the connector.
 3. Press the terminal block assembly toward the module until the release lever latch snaps into place. Check to be sure the terminal block is firmly seated.

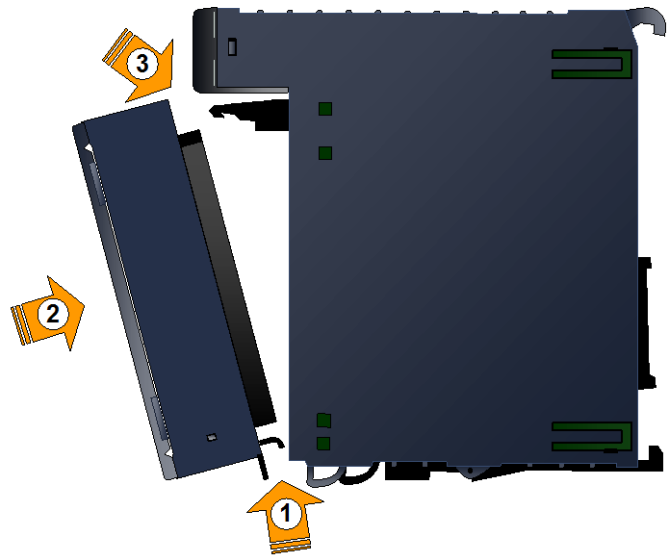


Figure 30: Installing Terminal Block into I/O Module

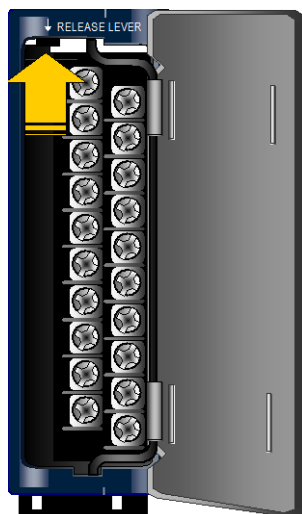


Figure 31: Release Lever Usage prior to Removal from I/O Module

Removing a Terminal Block

- To remove a terminal block:
 1. Open the terminal block door.
 2. Push up the release lever (Figure 31) to unlock the terminal block.
 3. Pull the terminal block away from the module until the contacts have separated and the bottom pivot hook has disengaged.

2.6.4.8 *Installing or Removing a Terminal Block Cover*

The terminal block assembly cover can be removed for easier access to the terminals.



Warning

Potentially dangerous voltages from user devices may be present on the screw terminals of the module, even though power to the backplane is turned off. Always be careful when handling the removable terminal block assembly of the module and any wires connected to it.



Figure 32: Extraction or Insertion of Terminal Block into its Cover

Removing a Terminal Block from its Cover

- To remove a Terminal Block from its cover:
 1. Grasp the sides of the Terminal Block cover.
 2. Pull down on the bottom of the Terminal Block as shown in Figure 32.

Inserting a Terminal Block in its Cover

- To re-insert a Terminal Block in its cover:
 1. Align the top of the Terminal Block with the bottom of the cover, making sure that the notches in the Terminal Block match up with the grooves in the cover.
 2. Slide the Terminal Block upward (Figure 32) until it clicks into place.

2.6.4.9 Positive and Negative Logic Connections to Discrete Modules

The IEC definitions for positive logic and negative logic for PACSystems RX3i modules are described in the following sections.

Positive Logic

Positive logic input modules (Figure 33) sink current from the input device to the user common or negative power bus. The input device is connected between the positive power bus and the input terminal.

Positive logic output modules (Figure 34) source current to the loads from the user common or positive power bus. The load is connected between the negative power bus and the module output.

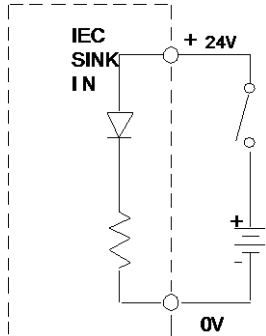


Figure 33: Positive Logic Input Circuit

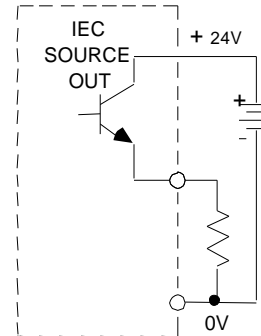


Figure 34: Positive Logic Output Circuit

Negative Logic

Negative logic input modules (Figure 35) source current through the input device to the user common or positive power bus. The input device is connected between the negative power bus and the input terminal.

Negative logic output modules (Figure 36) sink current from the loads to the user common or negative power bus. The load is connected between the positive power bus and the output terminal.

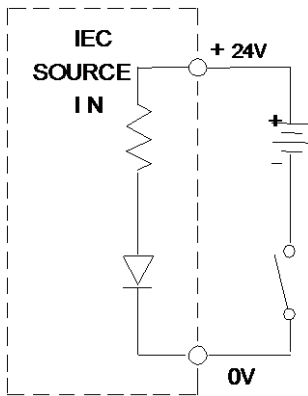


Figure 35: Negative Logic Input Circuit

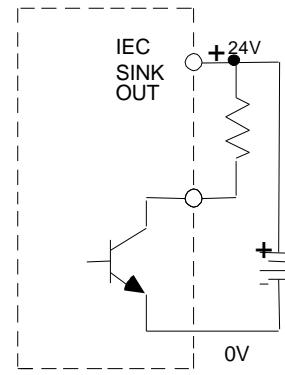


Figure 36: Negative Logic Output Circuit

2.6.4.10 *Wiring for Analog Modules*

Twisted, shielded instrumentation cable is strongly recommended for analog module input or output signal connections. Proper grounding of the shield is also important. For maximum electrical noise suppression, the cable shield should only be grounded at one end of the cable.

It is generally best to ground the cable shield as close to the source of the noise as possible. For Analog Input modules, ground the end that is in the noisiest environment (usually the field device end). Cut the shield off at the module end of cable and insulate with shrink tubing. For Analog Output modules, ground at the module end. Cut the shield off at device end of cable and insulate with shrink tubing.

It is best to keep the length of stripped cable leads as short as possible to minimize the length of unshielded conductors exposed to the noisy environment.

Connections can be made directly to the module terminals, or via an intermediate terminal block. The diagrams in this section show wiring for various types of analog input and analog output installations.

Shielding for Analog Input Modules

Generally, the shield for analog input cables should be grounded at the analog source. However, ground connections for each channel, labeled COM and GND, can be used to connect shields at the analog input module if appropriate. The COM terminals of the analog input module connect to the analog circuit common in the module. The GND terminals connect to the backplane (frame ground). Shields may be connected to either COM or GND. This section shows four shield grounding examples for analog input modules.

Analog Input Shield Grounding with a Terminal Strip

For an unbalanced source, the ground shield should be connected to the source common or ground at the source end. If all source inputs to the module come from the same location and are referenced to the same common, all shield grounds should be connected to the same ground point. If there is an additional terminal strip between the analog input module and the field devices (analog sources), use the method displayed in the following figure to continue each cable shield using a terminal on the terminal strip. Each cable is only grounded at one end - the end closer to the field devices (analog sources). Shield connections are shown in red (bold) in Figure 37.

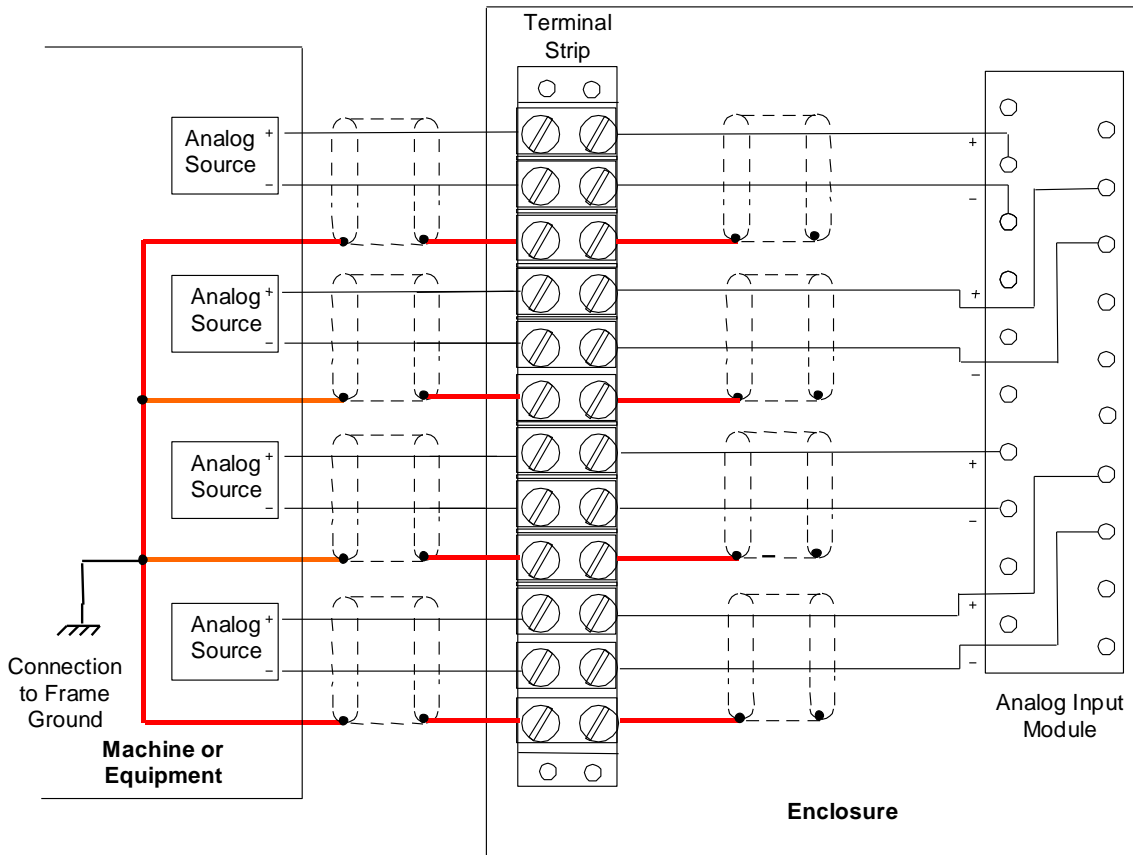


Figure 37: Analog Input Shield Grounding with a Terminal Strip

Analog Input Shield Grounding to Common Connections

In some applications, noise rejection can be improved by connecting the source common points together at the source end, then connecting a common line to the module at only one module COM terminal. That will eliminate multiple grounding or ground loops that could cause false input data. The common connections here are shown in red (bold) in Figure 38.

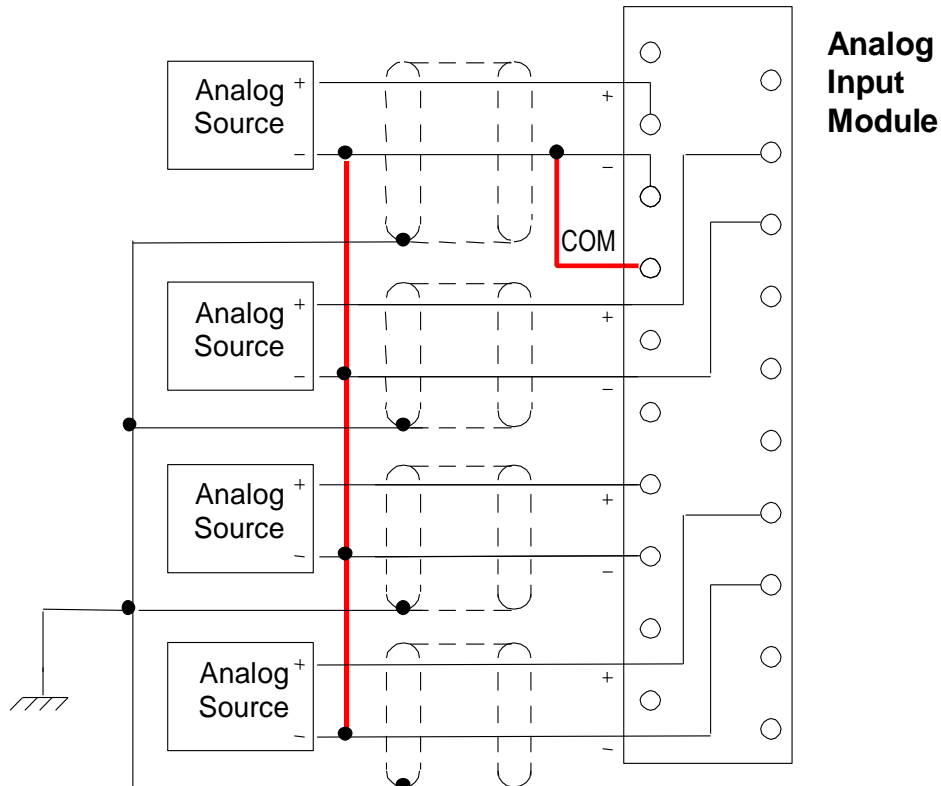


Figure 38: Analog Input Shield Grounding to Common Connections

Analog Input Shields Connected to Module Terminal Board

It is usually preferable to ground cable shields at the source end. If that is difficult, or if electrical noise is not a concern, it may be acceptable to ground cable shields at the analog input module end. They can be connected to one of the GND terminals of the module (which are connected to frame ground through an internal path) as shown left below. If necessary to improve noise immunity, a conductor can be used to connect a GND terminal on the module to earth ground as displayed in Figure 39. This will bypass noise around the module.

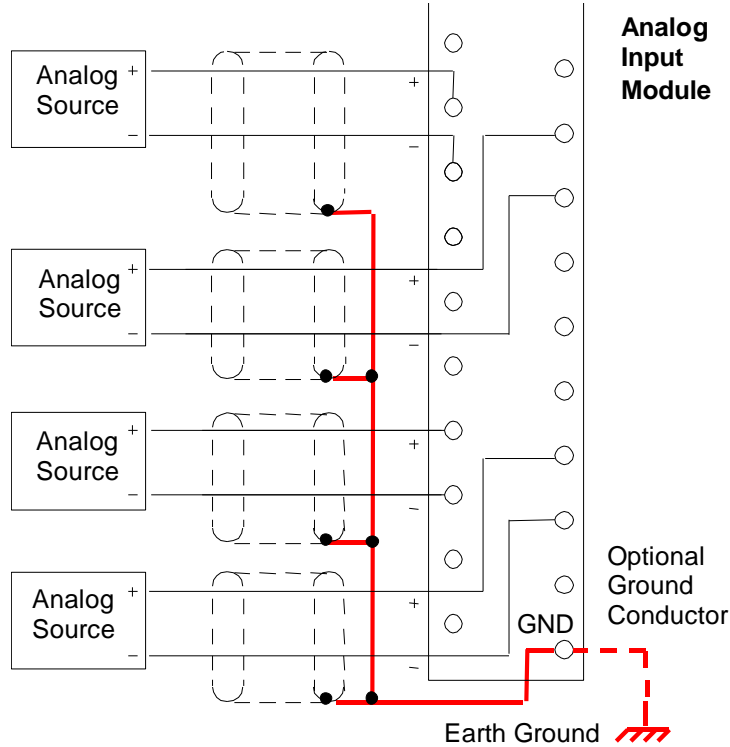


Figure 39: Analog Input Shields Connected to Module Terminal Board

Wiring for Current Transducers

For all of the examples displayed in Figure 40 through Figure 43, connect the (-) conductor to the Analog Input module COM terminal, if the source is floating, to limit common-mode voltages. Common mode voltage is limited to 11 volts.

If noise causes inaccurate readings, the (-) conductor can also be connected to the Analog Input module GND terminal.

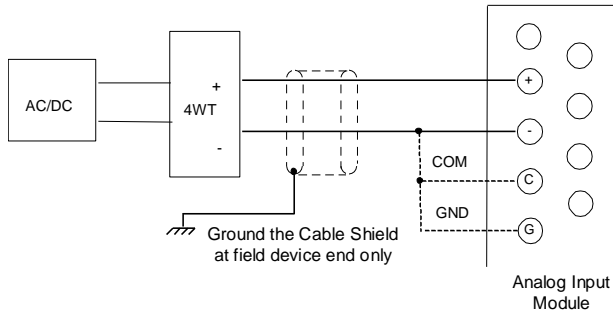


Figure 40: 4-Wire Transducer, Externally Powered by AC or DC Supply

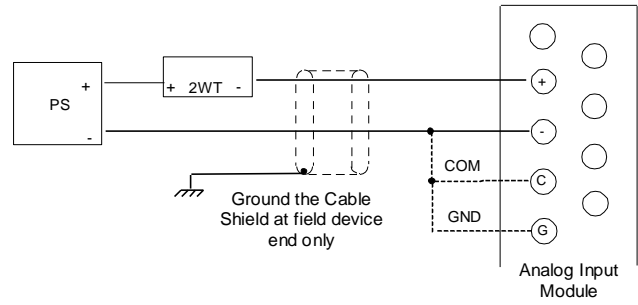


Figure 41: 2-Wire Transducer, Externally Powered by DC Supply

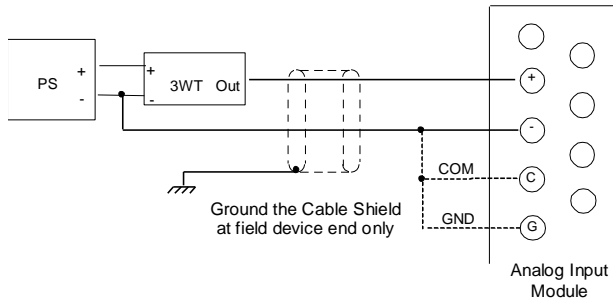


Figure 42: 3-Wire Transducer, Externally Powered by DC Supply

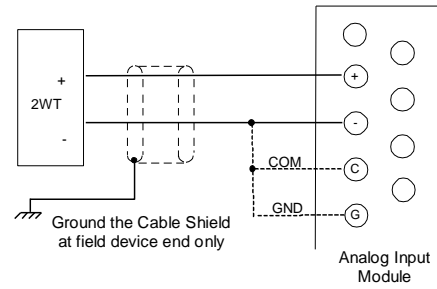


Figure 43: 2-Wire Transducer, Self-Powered

2-Wire Transducer Connected to Two Measuring Devices

As shown in Figure 44, connect the (-) conductor to the Analog Input module COM terminal, if the source is floating, to limit common-mode voltages. Common mode voltage is limited to 11 volts.

If noise causes inaccurate readings, the (-) conductor can also be connected to the Analog Input module GND terminal.

The analog module must be the last device on the circuit. When grounding the (-) return side of the Analog Input Module, the other current-sensing device must be floating and able to withstand a common mode voltage of at least 20 V, including the noise level.

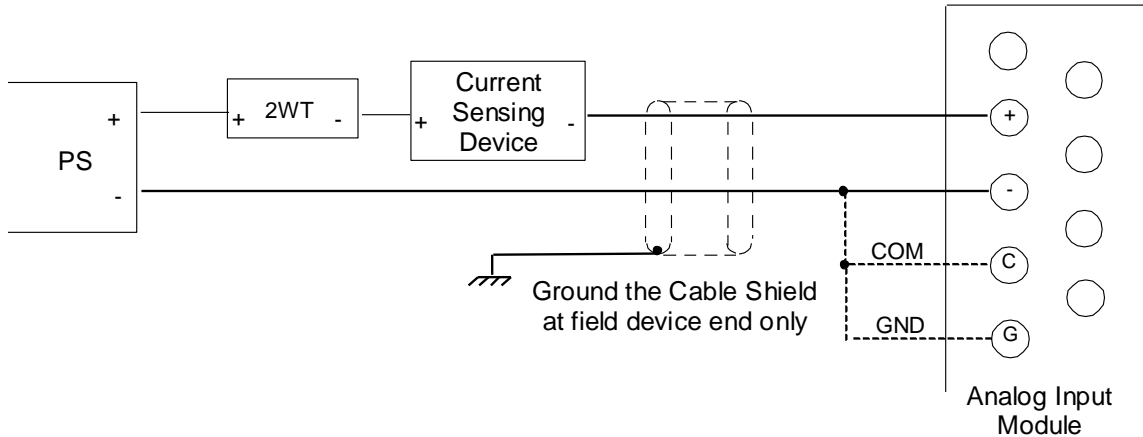


Figure 44: 2-Wire Transducer Connected to Two Measuring Devices

Verifying Analog Input Current

RX3i Analog Current Input Modules have an internal 250Ω resistor across the input terminals. You can measure the voltage across the input terminals using a voltmeter, then use Ohm’s Law to determine the input current:

$$\text{Input Current (in Amps)} = V / 250$$

For example, if you measured 3 V across the input terminals:

$$\text{Input Current (in Amps)} = 3/250$$

$$\text{Input Current (in Amps)} = 0.012 \text{ (or 12 mA)}$$

Shield Connections for Analog Output Modules

For analog output modules, the shield is normally grounded only at the source end (i.e. at the module - Figure 45). The GND connection provides access to the backplane (frame ground) resulting in superior rejection of noise caused by any shield drain currents. In extreme-noise environments, you can connect an optional ground braid from the GND terminal to an external earth ground to bypass noise around the module.

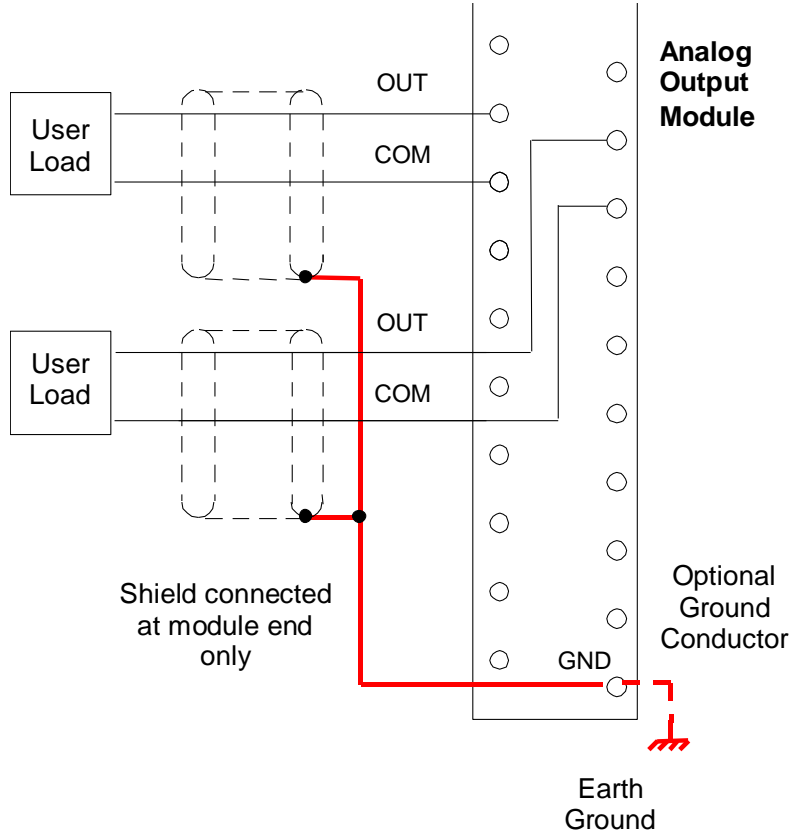


Figure 45: Shield Connections for Analog Output Module

Analog Output Shield Grounding with a Terminal Strip

If there is a terminal strip between the analog output module and the field devices (user loads), use the method in Figure 46 for grounding the cable shields. Each cable is only grounded at one end, the end closer to the Analog Output Module. An optional external ground connection to the GND terminal of the module is illustrated for installations that require extra noise suppression.

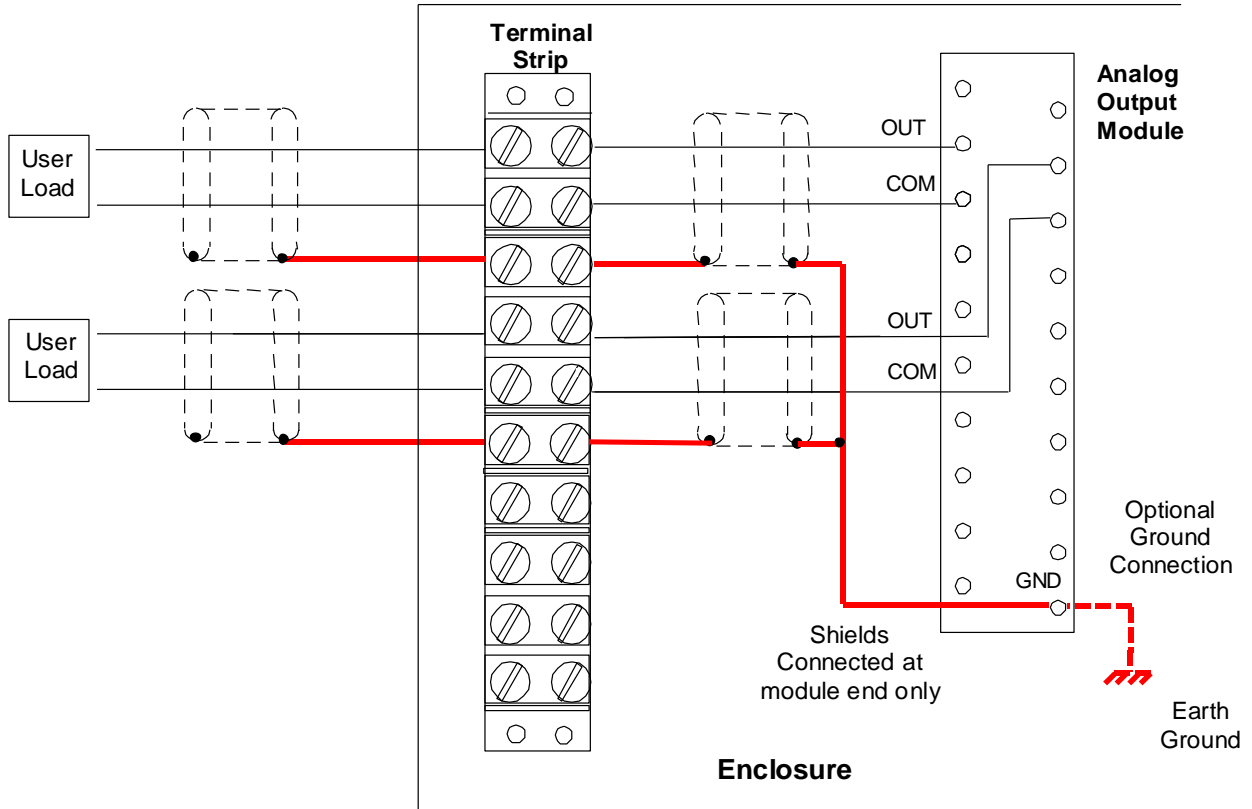


Figure 46: Analog Output Shield Grounding with a Terminal Strip

2.6.4.11 Module Fuse List

**Warning**

Replace fuse only with the correct size and type. Using an incorrect fuse can result in harm to personnel, damage to equipment, or both.

Module Catalog Number <small>(note)</small>	Module Type	Current Rating	Quantity on Module	GE Fuse Part Number	Other Sources and Part Numbers
IC694MDL310 ³	120 V ac, 0.5A	3A	2	44A724627-111	Bussman - GMC-3 Littlefuse - 239003
IC694MDL330 ³	120/240 V ac, 1A	5A	2	42G6101-0013	Bussman - S506-5-R Schurter - 034.3124
IC694MDL340 ³	120 V ac, 0.5A	3A	2	44A724627-111	Bussman - GMC-3 Littlefuse - 239003
IC694MDL390 ³	120/240 V ac, 2A	3A	5	44A724627-111	Bussman - GMC-3 Littlefuse - 239003
IC694PWR321 ⁴ IC694PWR330 ⁴	120/240 V ac or 125Vdc Input, 30 W Power Supply	2A	1	44A724627-109	Bussman - 215-002 (GDC-2 or GMC-2) Littlefuse - 239-002
IC694PWR331 ⁴	24Vdc Input, 30 W Power Supply	5A	1	44A724627-114	Bussman - GMC-5-R

³ Fuse is mounted in clip accessible by removing circuit board from module housing.

⁴ Power input fuse mounted in clip and accessible by removing front of module.

2.6.5 CPU Installation

- To install the CPU:
 1. Make sure that rack power is off.
 2. Install the CPU module in the appropriate slot (refer to *Universal Backplane Slot Occupancy Rules*, Section 2.6.1.2). With the exception of CPE305, the CPU occupies two slots and can use any slots except the highest numbered (rightmost) slot. CPE305 occupies one slot.
 3. Turn on power. When the CPU has successfully completed initialization, the OK LED stays on and the RUN and EN LEDs are off. The CPU is now ready to be programmed.
 4. For CPUs with battery back-up, connect the battery to either of the battery connectors on the module. (You can connect the battery at any step in the installation process but it will begin to drain immediately unless power is applied. To maximize battery life, install it after power has been turned on).
 5. For CPUs backed up by an Energy Pack, follow the installation instructions for the specific Energy Pack.
 6. Where appropriate, communications cables can be secured to the tie-downs on the bottom of the module.

After the program has been verified, the mode switch can be moved to the appropriate operation mode position: RUN I/O ENABLED, RUN OUTPUT DISABLE, or STOP. The LEDs indicate the position of the mode switch and status of serial port activity.



Figure 47: CPE330 (example of 2-Slot CPU)



Caution

CPUs may NOT be hot-inserted in the backplane; power must be removed before installing or removing the CPU.

2.6.6 Power Supplies

- To install the power supplies
 1. Install the Power Supply module(s) in the appropriate slot(s).
 - a) Universal Power Supplies (IC695) can be installed in any slot except the highest numbered (rightmost) slot in a Universal Backplane.
 - b) Expansion Power Supplies (IC694) must be installed in the Power Supply (leftmost) slot in an Expansion Backplane.
 - c) Where multiple power supplies are to be used, refer to *Power Supply Models and Slot Occupancy*, Section 2.6.1.1)
 2. Connect wiring to the Power Supply per the installation instructions for that specific power supply.
 3. Use the three wiring tie-downs on the bottom of the module to secure the power and ground wires after installation.

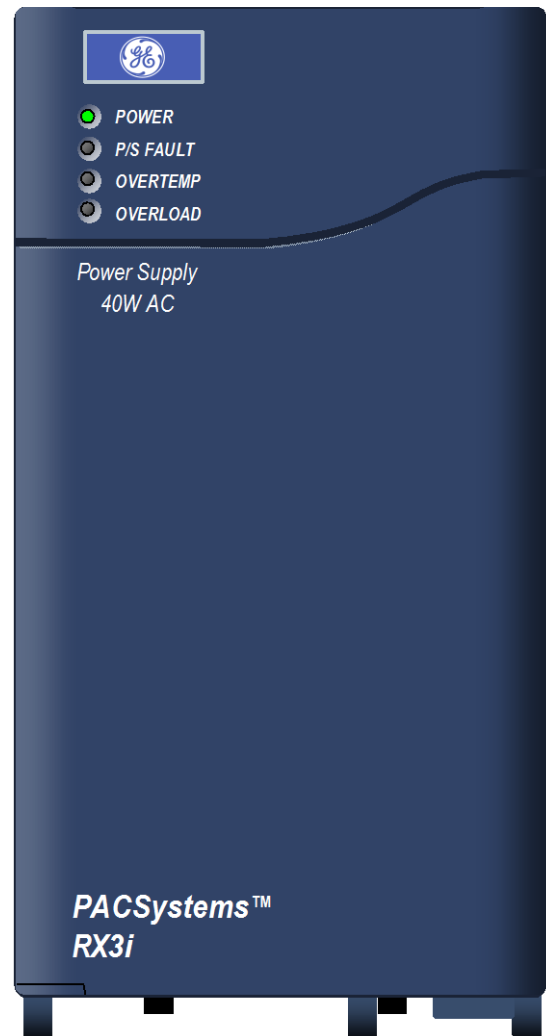


Figure 48: Typical RX3i Power Supply Module



Warning

For all Power Supplies, if the same input power source is used to provide power to two or more power supplies in the system, connection polarity must be identical at each power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

2.6.6.1 Power Supply Field Wiring

- For IC695 Power Supplies, each terminal accepts one AWG #14 to AWG #22 wire. Figure 49 (below) is a cross-section of one of the terminals on an IC695 Power Supply. The end of each wire should be stripped at least 3/8-inch (9mm). The terminal can accept a wire that is stripped up to 11 mm (.433 in) while providing full seating of the insulator. The wire must be fully-inserted into the terminal block as illustrated in Figure 49 at left, so that the insulation meets the insulation stop position inside the terminal. Tightening the terminal screw pivots the clamp firmly against the stripped end of the wire, holding it in place. If the wire is not fully inserted, as shown on the right, tightening the clamp may push the wire upward, so that it is not connected.

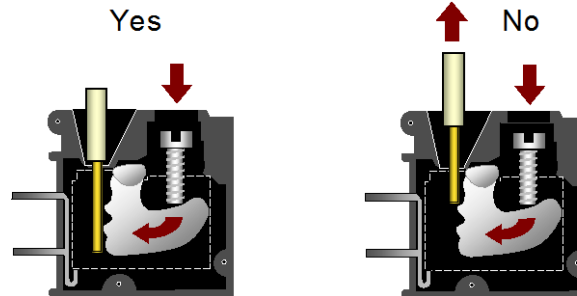


Figure 49: Correct Wiring Practice for Power Supply Input Terminals

- For IC694 Power Supplies, each terminal accepts one AWG #14 (2.1mm²) or two AWG #16 (1.3mm²) copper 75°C (167°F) wires. The suggested torque for the Power Supply terminals is 1.36 Nm (12 in-lb). Each terminal can accept solid or stranded wires. Multiple wires in the same terminal should be of the same type (solid or stranded) and size.

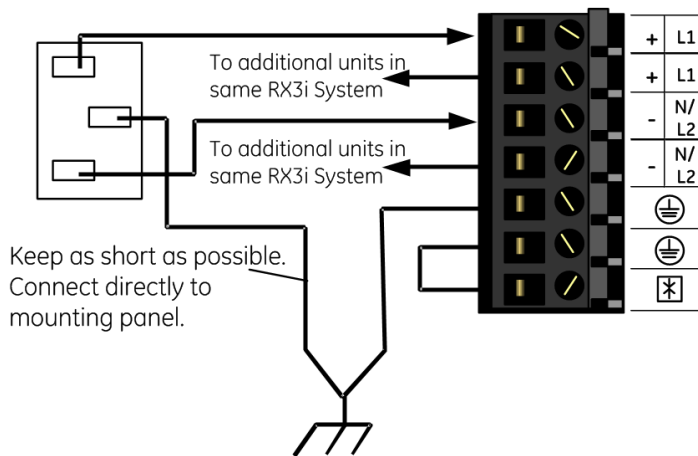


Figure 50: IC695 Power Supply Terminals

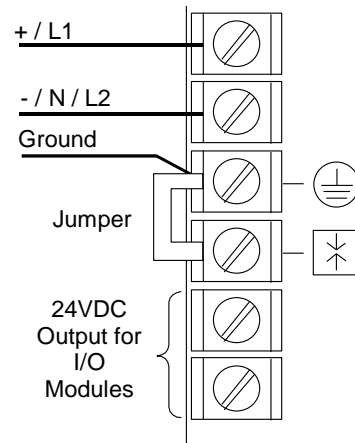


Figure 51: IC694 Power Supply Terminals

- For Expansion (IC694) Power Supplies only, the bottom terminals provide access to the Isolated +24Vdc output of the Expansion Backplane, which can be used to power input circuits for certain IC694 modules. Refer to the table *Module Load Requirements*, Section 4.2 for information.



Caution

If the Isolated 24Vdc supply is overloaded or shorted, the PLC will stop operation.

2.6.6.2 AC Power Source Connections

Connect the hot and neutral wires or lines L1 and L2 to the appropriate Power Supply terminals.

2.6.6.3 DC Power Source Connections

All RX3i Power Supplies have DC input capabilities. Connect the + and - wires from the DC source to the appropriate terminals. These connections are polarity-sensitive DC-only supplies.

Ground Connection

Connect the safety ground wire to the terminal marked with a ground symbol.

2.6.6.4 External Overvoltage Protection

The Ground and MOV terminals on a Power Supply module are normally connected to frame ground with a user-installed jumper as shown at right. If over-voltage protection is not required or is supplied upstream, no jumper is needed.

In systems with a floating neutral input (the neutral line is not referenced to Protective Earth Ground), this jumper must NOT be installed. In addition, in a floating neutral system, voltage surge protection devices such as MOVs **must** be installed from L1 to earth ground, and from L2 (Neutral) to earth ground.

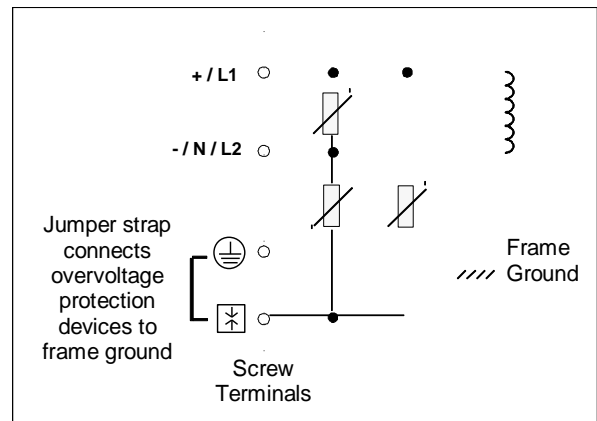


Figure 52: External Overvoltage Protection

2.6.6.5 AC Power Supply Connections for Floating Neutral (IT) Systems

If an AC input power supply is installed in a system where the Neutral line is not referenced to Protective Earth Ground, special installation instructions must be followed to prevent damage to the power supply.

A *Floating Neutral System* is a system of power distribution wiring where Neutral and Protective Earth Ground are not tied together by negligible impedance. In Europe this is referred to as an IT system (refer to IEC950). In a *Floating Neutral System*, voltages measured from input terminals to protective earth ground may exceed the 264Vac maximum input voltage power supply specification.

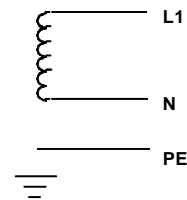


Figure 53: Floating Neutral

2.6.6.6 AC Power Supply Connections for Non-Floating Neutral System

Systems where one leg of the power distribution wiring is tied to Protective Earth or a tap between two legs of the power distribution wiring is tied to Protective Earth are not *Floating Neutral Systems*. Non-floating neutral systems **do not** require special installation procedures.

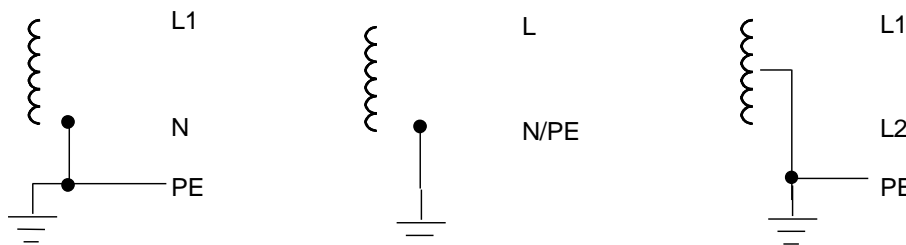


Figure 54: Neutral Not Floating (Tied to Ground)

2.6.6.7 Instructions for Floating Neutral Systems

1. The input power terminals should be wired as shown in Figure 49 through Figure 51 above.
2. No jumper may be installed jumper between terminals 3 and 4 of the Power Supply module.
3. Voltage surge protection devices such as MOVs must be installed:
 - From L1 to earth ground
 - From L2 (Neutral) to earth ground

The voltage surge devices must be rated such that the system is protected from power line transients that exceed $Line\ voltage + 100\ V\ ac + (N-PE)_{MAX}$. The expression $N-PE$ refers to the voltage potential between neutral and Protective Earth (PE) ground.

For example, in a 240 Volt AC system with neutral floating 50 V ac above earth ground, the transient protection should be rated at: $240\ V\ ac + 100\ V\ ac + 50\ V\ ac = 390\ V\ ac$

2.6.7 Serial Bus Transmitter Module

The RX3i Serial Bus Transmitter Module, IC695LRE001, provides communications between a PACSystems RX3i Universal Backplane (IC695-model number), and serial expansion and remote backplanes (IC694- or IC693-model numbers). It must reside in the expansion connector on the right end of a Universal Backplane.

2.6.7.1 Module Installation

This module may NOT be hot-inserted in the backplane; power must be removed before installing or removing the Bus Transmitter Module.

Insert the Serial Bus Transmitter Module straight into its slot as displayed in Figure 56 below. This module does not have the same pivoting and latching mechanisms as other RX3i modules.

Tighten the two captive screws in the corners of the module. Recommended torque is 0.5 Nm (4.4 in-lb) maximum.

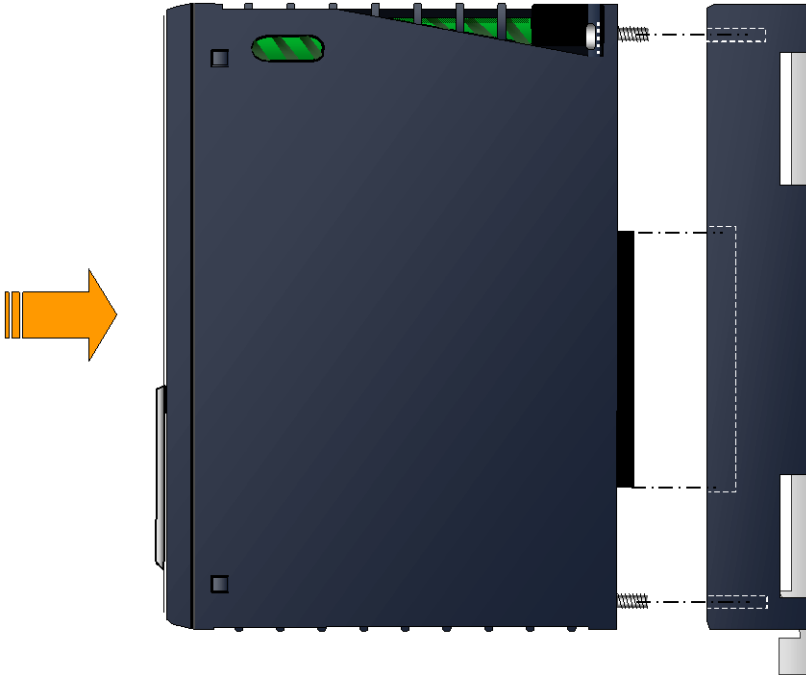


Figure 56: LRE001 Attachment Using Captive Screws

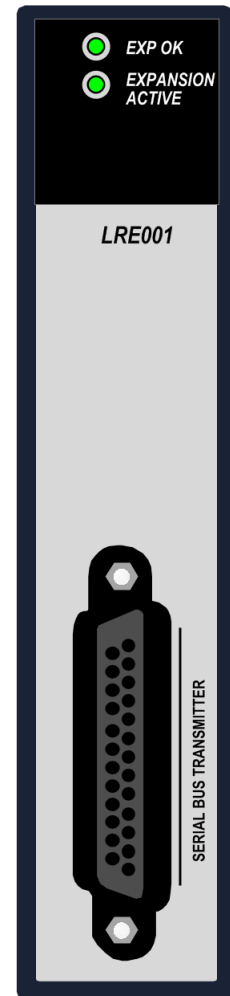


Figure 55: LRE001 Front View

2.6.7.2 Expansion Cable Installation

Subsequent backplanes in the system are linked by expansion cables as described in Chapter 5. The expansion cable may not be attached or removed while the expansion rack has power applied.

Chapter 3 Backplanes

This section describes the types of backplane that can be included in an RX3i system:

Backplane Type	Catalog Number	Section
7-Slot RX3i Universal Backplane	IC695CHS007	3.1
12-Slot RX3i Universal Backplane	IC695CHS012	3.1
16-Slot RX3i Universal Backplane	IC695CHS016	3.1
5-Slot RX3i Serial Expansion Backplane	IC694CHS398	3.2
10-Slot RX3i Serial Expansion Backplane	IC694CHS392	3.2
5-Slot Series 90-30 Expansion Backplane	IC693CHS398 ⁵	
10-Slot Series 90-30 Expansion Backplane	IC693CHS392 ⁵	
5-Slot Series 90-30 Remote Backplane	IC693CHS399 ⁵	
10-Slot Series 90-30 Remote Backplane	IC693CHS393 ⁵	

⁵ For information about the IC693 Series 90-30 Expansion and Remote Backplanes, refer to the *Series 90-30 PLC Installation Manual*, GFK-0356.

3.1 RX3i Universal Backplanes: IC695CHS007, IC695CHS012, IC695CHS016

Three Universal Backplanes are available for RX3i PACSystems:

- the 7-slot IC695CHS007,
- the 12-slot IC695CHS012, displayed in Figure 57 below, and
- the 16-slot IC695CHS016.

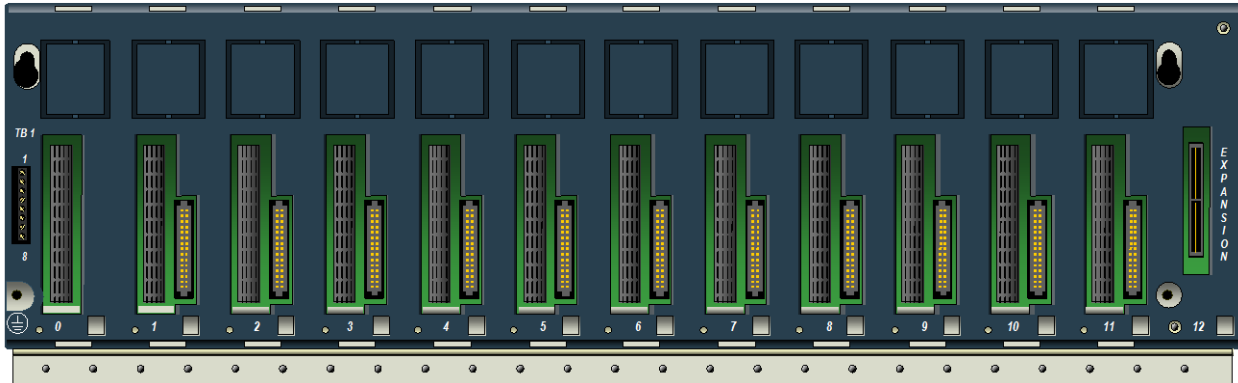


Figure 57: 12-Slot RX3i Universal Backplane IC695CHS012

The RX3i Universal Backplane supports both PCI (IC695) and serial (IC694) I/O and option modules with its dual-bus backplane. The RX3i Universal Backplane also supports 90-30 IO and option modules. Refer to Section 1.3 for supported modules and to Section 1.3.3 for *Series 90-30 Modules that Cannot Be Used in an RX3i System*.

RX3i modules (IC695 catalog numbers) communicate over the backplane PCI bus.

RX3i modules (IC694 catalog numbers) and Series 90-30 modules (IC693) communicate over the backplane serial bus.

3.1.1 RX3i Universal Backplane Features

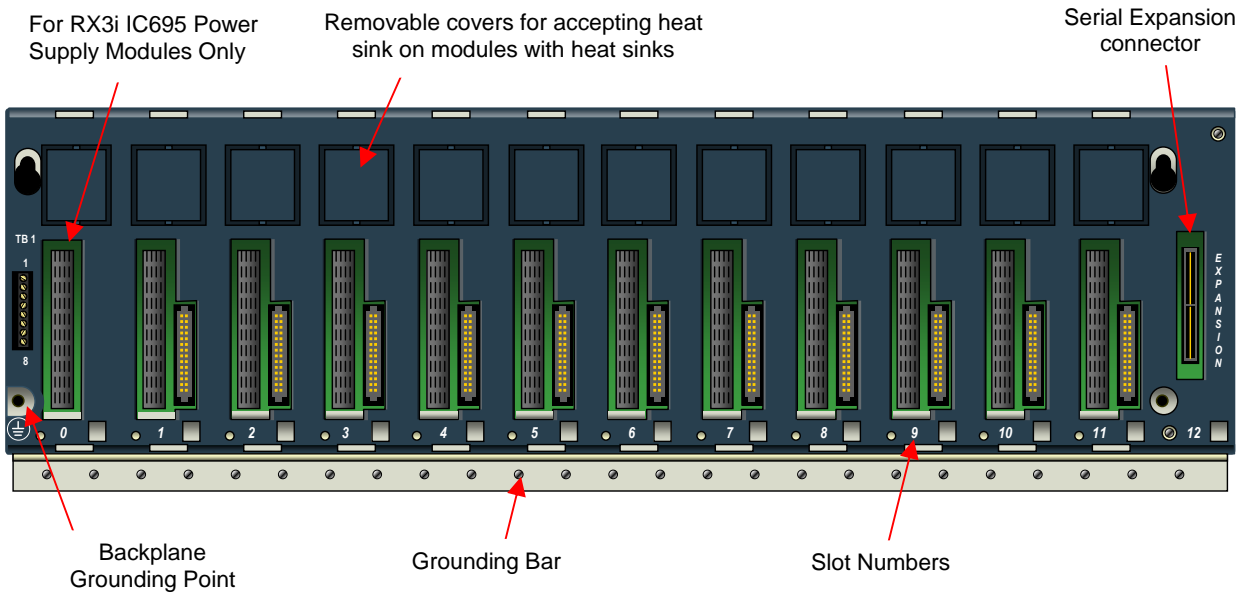


Figure 58: Features of RX3i Universal Backplanes

RX3i Universal Backplane features include:

- Terminal Strip on the left (Figure 58) for Isolated +24Vdc input.
- Backplane grounding point as described in Section 2.5.2.
- An integral grounding bar for connecting module/shield grounds as described in Section 2.5.5.
- Removable covers that, when knocked out, allow heat sinks on modules equipped with heat sinks to be inserted..
- Serial Expansion connector for connection (Figure 58, far right) to Serial Expansion and Remote Backplanes (12- and 16-slot models only).
- Slot numbers are printed on the backplane (Figure 58) and are used for reference for configuration in Proficy Machine Edition (PME). Slots and connectors are described on the following pages. Most modules occupy one slot. Some modules, such as CPUs and AC Power Supplies occupy two slots.

3.1.1.1 Universal Backplane TB1 Input Terminals

The RX3i IC695 Power Supplies do not provide Isolated +24Vdc output power over the backplane. Terminals 7 and 8 can be used to connect an optional external source of Isolated +24Vdc, which is required for some IC693 and IC694 modules as listed in the table, *Module Load Requirements*, Section 4.2.

These terminals accept individual wires from 14 to 22 AWG.

If modules that require Isolated +24Vdc are installed in an Expansion Backplane instead, an external Isolated +24Vdc power supply is not required.

Terminals 1 through 6 are not used.

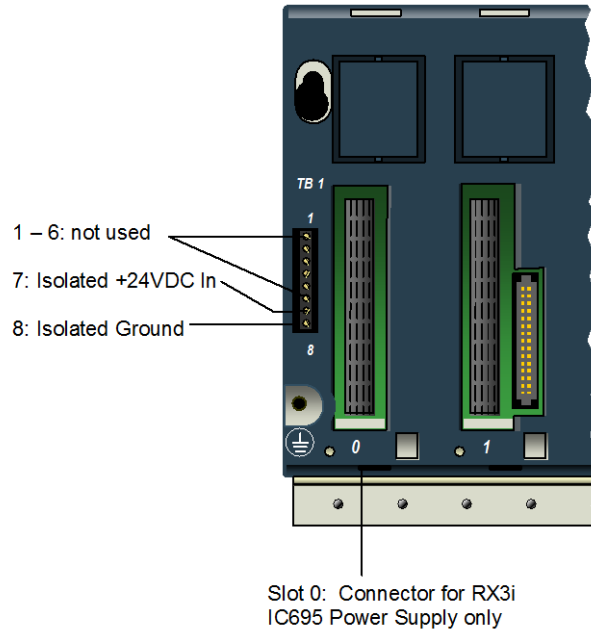


Figure 59: TB1 Terminal Detail

3.1.1.2 Slot 0

The leftmost slot in a Universal Backplane is slot 0. Only the backplane connector of IC695 Power Supplies can be installed in slot 0 (note: IC695 Power Supplies can be installed any slot). However 2-slot wide modules that have right-justified connectors, such as the CPU310, can be plugged into slot 1 and also cover slot 0.

The CPU is referenced for configuration and application logic by the leftmost slot occupied by the entire module, not by the slot the physical connector is located in. For example, if the CPU has its physical connector inserted in slot 3, the module occupies slots 2 and 3 and the CPU is referenced as being located in slot 2. A double-wide CPU may therefore be located in slot 0 with its backplane connector inserted in slot 1.

3.1.1.3 Dual-Connector Slots

Dual-connector slots are identified as follows:

CHS016: 0 through 15

CHS012: 0 through 11

CHS007: 0 through 5

They have two connectors, a connector for the RX3i PCI bus, and connector for the RX3i serial bus. Each of these slots can accept any type of compatible module: IC695 Power Supply, IC695 CPU, or IC695, IC694 and IC693 I/O or option modules.

Provided the *Hot Insertion and Removal* procedure described in Section 2.6.4.1 is carefully followed, I/O and option modules in a Universal Backplane may be removed and replaced without powering-down.

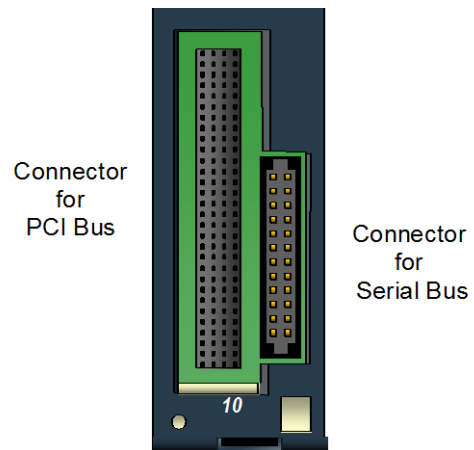


Figure 60: RX3i Universal Backplane Dual Connector Slot for PCI Bus & Serial Bus

3.1.1.4 Expansion Slot (Slot 12 or Slot 16)

The rightmost slot in a Universal Backplane has a different connector than the other slots. It can only be used for an RX3i Serial Expansion Module (IC695LRE001).

An RX3i 2-slot module may not occupy this expansion slot. The 7-slot CHS007 rack does not provide an expansion slot, or support the LRE001 Serial Expansion Module.

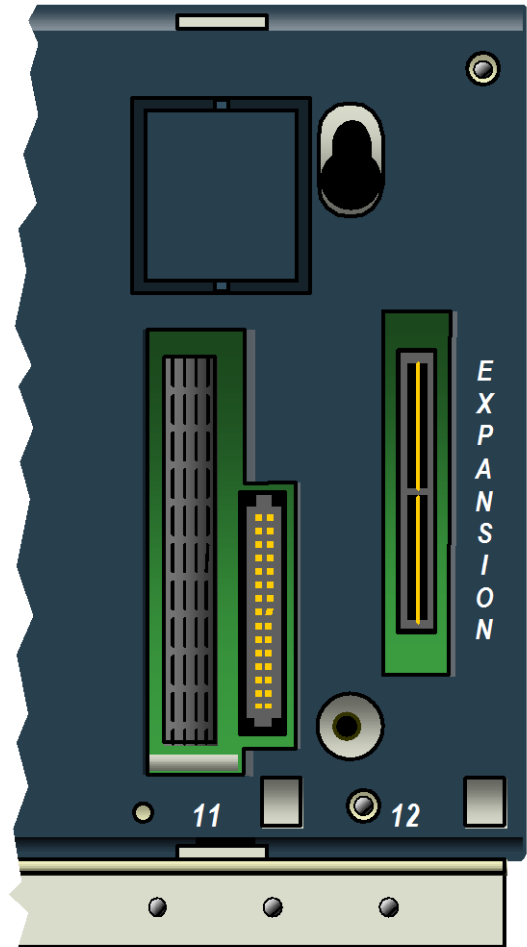


Figure 61: Expansion Slot Connector shown at Slot 12

3.1.1.5 Slot 6 of 7-Slot Rack

In the CHS007 seven-slot rack, slot 6 has one RX3i PCI connector and can accept only IC695 single-width I/O or option modules.

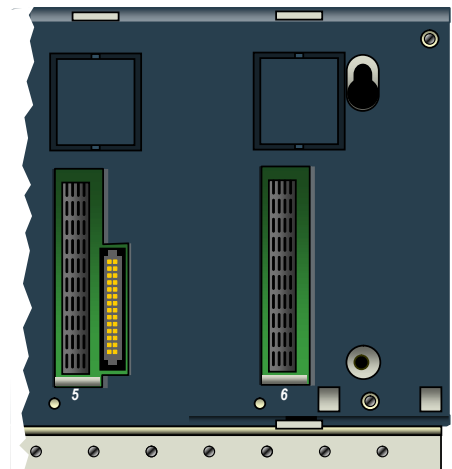


Figure 62: Slot 6 of IC695CHS007

3.1.2 Module Locations in a 12- or 16-Slot Universal Backplane

- IC695 Power Supply modules may be installed in any slot. DC Power Supplies IC695PSDx40 occupy one slot and AC Power Supplies IC695PSAx40 occupy two slots. RX3i (IC694) and Series 90-30 (IC693) Power Supplies cannot be installed in Universal Backplanes.
- An RX3i CPU module can be installed anywhere in the backplane except the Expansion slot. CPU modules occupy two slots.
- I/O and option modules can be installed in any available slot except slot 0, which can only accept IC695 Power Supplies, and the Expansion slot. Each I/O slot has two connectors, so either an RX3i PCI-based module or a serial module can be installed in any I/O slot.
- The rightmost slot is the expansion slot. It can only be used for optional serial expansion module IC695LRE001. Refer to Chapter 5 for information about the LRE001 Serial Expansion Module and expansion cables.

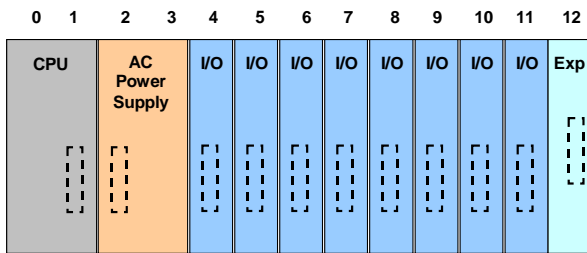


Figure 63: Configured as CPU in slot 0, Power Supply in Slot 2

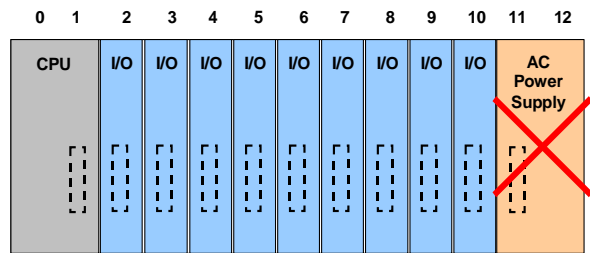


Figure 64: Invalid: AC Power Supply cannot be in Slot 11

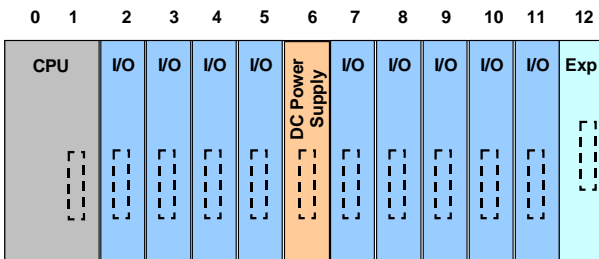


Figure 65: Configured as CPU in slot 0, Power Supply in Slot 6

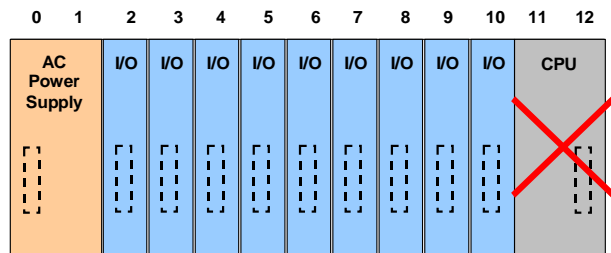


Figure 66: Invalid: CPU cannot be configured in Slot 11

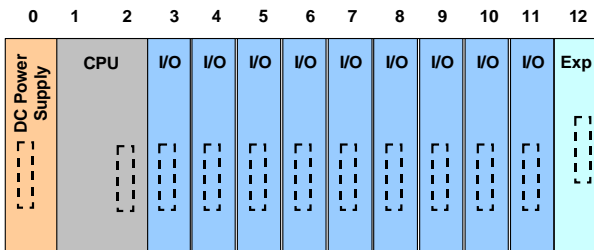


Figure 67: Configured as Power Supply in slot 0, CPU in Slot 1

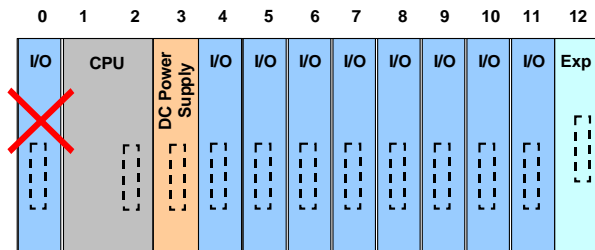


Figure 68: Invalid: Only a Power Supply can be installed in Slot 0

3.1.2.1 Locating the CPU in Slot 1

Whenever the CPU is installed in slot 1, only a single-wide power supply may be used in slot 0. Either DC power supply can be used (IC695PSD040 or IC695PSD140). If, for a given application, the CPU must be located in slot 1, and also uses an AC power-supply, the RX3i AC power-supply must then be located in the slot to the right of that CPU.

3.1.2.2 Locating the CPU in a Slot Other than 1

Before deciding to place the CPU in a slot other than slot 1, it is important to consider possible issues that could arise as follows.

Communications: For Service Request #15 (Read Last-Logged Fault Table Entry) and Service Request #20 (Read Fault Tables), the location of CPU faults is not the standard 0.1 location, but the slot the CPU is located in. Logic that decodes fault table entries retrieved by these service requests may need updating.

COMMREQs directed to the CPU (e.g. those directed to the serial ports of the CPU) will need to be updated with the correct CPU slot reference.

Hardware Configuration: The slot location of the CPU must be updated in the hardware configuration to reflect the true location of the CPU.

Fault Tables: Faults logged for the CPU in the fault table will reflect the actual slot of the CPU.

Remote Series 90 PLCs that use SRTP Channels COMMREQs expect the CPU to be in slot 1 or slot 2. To support communications with Series 90 SRTP clients such as Series 90 PLCs using SRTP Channels, the RX3i internally redirects incoming SRTP requests destined for {backplane 0, slot 1} to {backplane 0, slot 2}, provided that the CPU is located in backplane 0 slot 2 (and the remote client has not issued an SRTP Destination service on the connection to discover the backplane and slot of the CPU). This special redirection permits Series 90-30 applications that expect the power supply to be located leftmost and the CPU to be located to the right of the power supply to function. Attempts to establish channels with CPUs in slots other than 1 or 2 will fail if initiated from Series 90 PLCs.

All external communication devices that interact with the CPU should be checked for compatibility with CPU slot locations other than slot 1. Problems may arise with, but are not limited to, initial connection sequences and fault reporting. Machine Edition View users should select *GE SRTP* as their communications driver as it can communicate with a CPU in any slot.

3.1.3 Module Locations in a 7-Slot Universal Backplane

- DC Power Supplies IC695PSDx40 occupy one slot and can be installed in any slot. AC Power Supplies IC695PSAx40 occupy two slots and cannot be installed in slot 6. *IC694 and IC693 Power Supplies cannot be installed in Universal Backplanes.*
- Any I/O or option module can be installed in slots 1 through 5, which have two connectors and can accommodate either an RX3i PCI-based module or a serial module. Slot 6 can accommodate only RX3i PCI-based single-wide modules. I/O and option modules cannot be installed in slot 0, which can only accept IC695 Power Supplies.
- An RX3i CPU can be installed anywhere in the backplane except slot 6. CPU modules occupy two slots. Installing the CPU in slot 1 means only a singlewide power supply can be used in slot 0. If the application must maintain a slot 1 CPU and use an AC power supply, the AC power supply must be located in a slot to the right of the RX3i CPU in slot 1. Before deciding to place the CPU in a slot other than slot 1, it is important to consider the factors listed in the section, *Locating the CPU in a Slot Other than 1.*

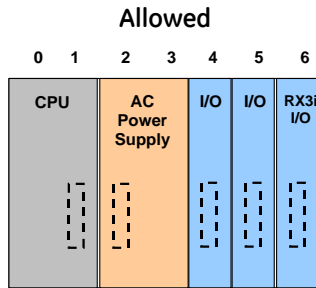


Figure 69: Configured as CPU in slot 0, Power Supply in Slot 2

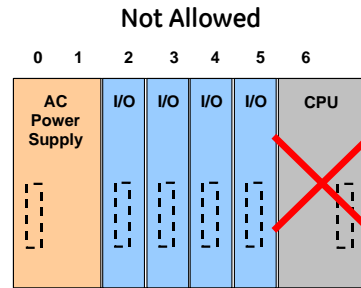


Figure 70: CPU cannot be configured in Slot 6

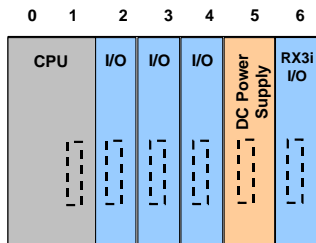


Figure 71: Configured as CPU in slot 0, Power Supply in Slot 5

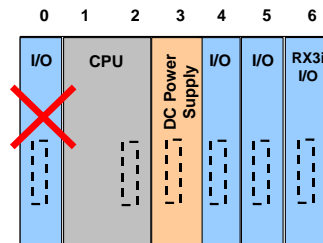


Figure 72: I/O or Option Module cannot be installed in Slot 0

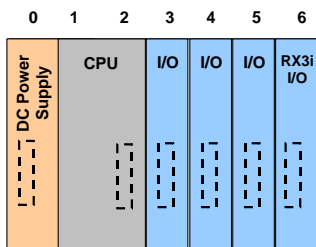


Figure 73: Configured as Power Supply in slot 0, CPU in Slot 1

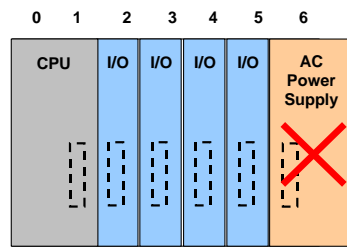


Figure 74: AC Power Supply cannot be configured in Slot 6

3.2 Serial Expansion Backplanes: IC694CHS392, IC694CHS398

The RX3i system can include any combination of up to seven RX3i Serial Expansion backplane and/or Series 90-30 Expansion/Remote Backplanes. RX3i Serial Expansion Backplanes are available with either five I/O slots (IC694CHS398, displayed in the following figure) or ten I/O slots (IC694CHS392).

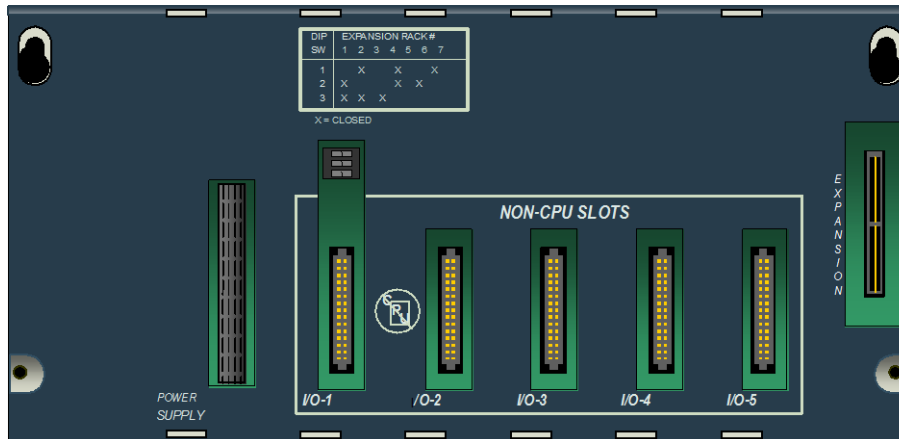


Figure 75: Serial Expansion Backplane

- The leftmost module in an RX3i Serial Expansion Backplane must be a Serial Expansion Power Supply:
 - IC694PWR321: Serial Expansion Power Supply, 120/240 V ac, 125Vdc
 - IC694PWR330: Serial Expansion Power Supply, 120/240 V ac, 125Vdc, High Capacity
 - IC694PWR331: Serial Expansion Power Supply, 24Vdc, High Capacity
- Module Hot Insertion and Removal are NOT permitted on Expansion Backplanes.
- Each Expansion Backplane has a Rack Number Selection DIP switch (Figure 18) that must be set before module installation.
- Each Expansion Backplane has a Bus Expansion connector at its right end for attaching an optional expansion cable. There can be no more than 50 feet (15 meters) of cable connecting Expansion backplanes with the Universal Backplane. If the system includes Series 90-30 Remote Backplanes, the additional requirements summarized in Section 1.3 through Section 1.5 must also be observed.

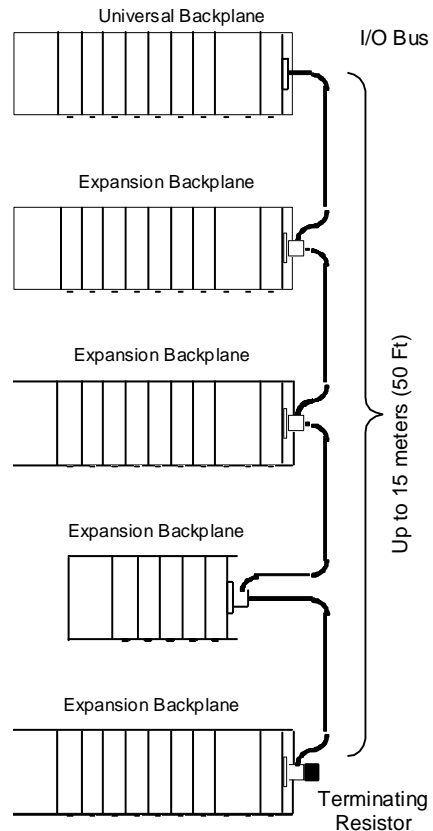


Figure 76: Example RX3i System with Expansion Backplane Racks

Chapter 4 Power Supplies

This chapter describes power supplies for RX3i PACSystems:

Power Supply Description	Catalog Number	Section
120/240 V ac 125Vdc 40 W Power Supply	IC695PSA040	4.4
120/240 V ac 125Vdc 40 W Multi-Purpose Power Supply	IC695PSA140	4.5
24Vdc 40 W Power Supply	IC695PSD040	4.6
24Vdc 40 W Multi-purpose Power Supply	IC695PSD140	4.7
120/240 V ac 125Vdc 30 W Serial Expansion Power Supply	IC694PWR321	4.8
120/240 V ac 125Vdc 30 W High Capacity Serial Expansion Power Supply	IC694PWR330	4.9
24Vdc 30 W High Capacity Serial Expansion Power Supply	IC694PWR331	4.10

4.1 Power Supply Overview

This section provides a general description of the IC695 Power Supplies, which must be used in RX3i (IC695) Universal Backplanes, and IC694 Power Supplies, which must be used in RX3i Serial Expansion (IC694) Backplanes. Individual power supply specifications are listed in the following sections.

The IC695 Power Supplies provide up to 40 W each. The IC694 (Expansion) Power Supplies provide up to 30 W each. However, IC694PWR321 is limited to 15 Watts on the +5Vdc output.

The total of all outputs combined cannot exceed the stated load capacity in Watts. PME Logic Developer will automatically calculate the power consumption of modules as they are added to the system configuration. Power requirements of system modules are shown in this section, for reference when planning the system.

The maximum load for each type of power supply is displayed in the following table.

Catalog Number	Can be Located In	Nominal Input	Load Capacity ⁶	Load Sharing, Redundancy	Max +3.3Vdc	Max +5Vdc	Max +24Vdc Isolated	Max +24Vdc Relay
IC695PSA040	Universal Backplane	120/240 V ac or 125Vdc	40 W	No	30 W	30 W	-	40 W
IC695PSA140	Universal Backplane	120/240 V ac or 125Vdc	40 W	Yes	30 W	30 W	-	40 W
IC695PSD040	Universal Backplane	24Vdc	40 W	No	30 W	30 W	-	40 W
IC695PSD140	Universal Backplane	24Vdc	40 W	Yes	30 W	30 W	-	40 W
IC694PWR321	Serial Expansion Backplane	100/240 V ac or 125Vdc	30 W	No	-	15 W	20 W	15 W
IC694PWR330	Serial Expansion Backplane	100/240 V ac or 125Vdc	30 W	No	-	30 W	20 W	15 W
IC694PWR331	Serial Expansion Backplane	24Vdc	30 W	No	-	30 W	20 W	15 W

4.1.1 Power Supply Field Wiring

Refer to *Power Supply Field Wiring*, Section 2.6.6.1. See also AC Power Source Connections (Section 2.6.6.2) or DC Power Source Connections (Section 2.6.6.3) as appropriate for how each power supply is being applied.

4.1.2 24Vdc Isolated Power

The IC695 Power Supplies do not have Isolated +24Vdc output terminals. The RX3i Universal Backplane provides external input terminals (TB1) for connecting an optional Isolated +24Vdc external supply. Modules

⁶ A power supply must be able to provide the total of the internal and external loads that may be placed upon it by all the hardware components in the backplane as well as by all the loads that may be connected to the Isolated +24Vdc supply on an expansion backplane.

that draw +24Vdc from the backplane are listed in the table *Module Load Requirements*, Section 4.2. Refer to *Universal Backplane TB1 Input Terminals* for details on how to wire to terminal TB1.

4.1.3 RX3i IC695 Power Supply Outputs

The IC695 power supplies have +5.1Vdc, +24Vdc Relay, and 3.3Vdc outputs that are connected internally on the backplane. The voltage and power required by modules installed on the backplane is supplied through the backplane connectors.

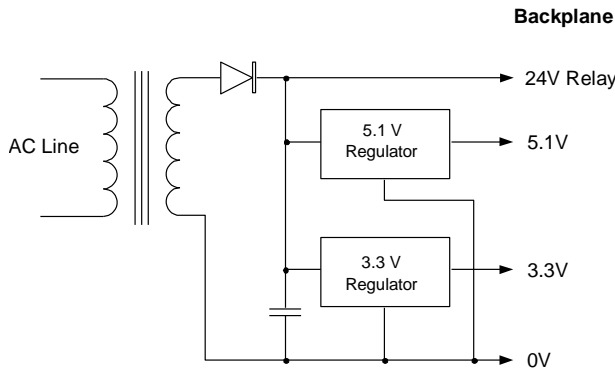


Figure 77: Outputs of Power Supply IC695PSA040

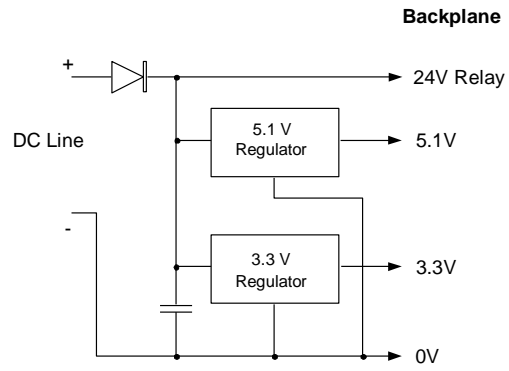


Figure 78: Outputs of Power Supply IC695PSD040 & IC695PSD140

4.1.4 RX3i IC694 Power Supply Outputs

The IC694 power supplies have +5Vdc, Relay +24Vdc and Isolated +24Vdc outputs that are connected internally on the backplane. The voltage and power required by modules installed on the backplane is supplied through the backplane connectors.

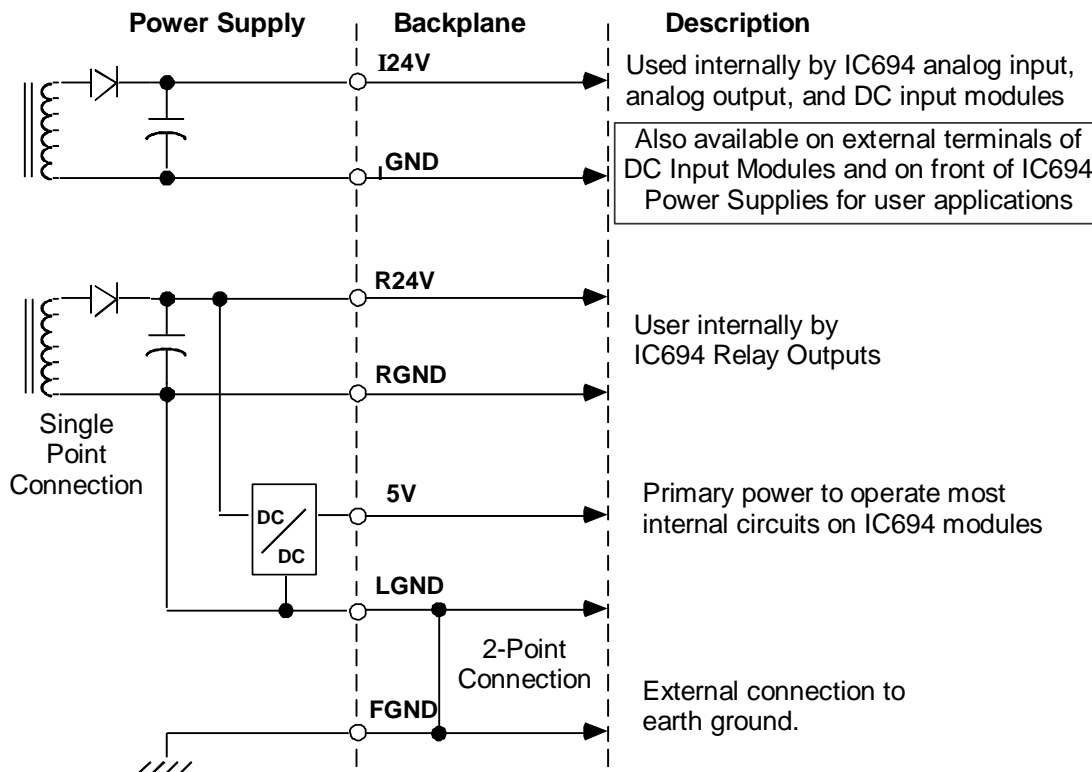


Figure 79: Outputs of Power Supplies IC694PWR321, IC694PWR330, and IC694PWR331

4.2 Module Load Requirements

The following table summarizes the maximum load requirements in milliamps and Watts for RX3i modules. Modules are listed alphabetically by the last six characters of the catalog number. For I/O modules, the actual load may depend on the number of points on at the same time.

Catalog Number	Module	+3.3Vdc		+5Vdc		+24Vdc Relay		+24Vdc Isolated	
		mA	W	mA	W	mA	W	mA	W
IC694ACC300	Input Simulator	-	-	120	0.60	-	-	-	-
IC694ACC307	Expansion Bus Termination Plug	-	-	72	0.36	-	-	-	-
IC695ALG106	Analog Input Module, 6-Channel Isolated Current/Voltage	390	1.287	225	1.125	-	-	-	-
IC695ALG112	Analog Input Module, 12-Channel Isolated Current/Voltage	370	1.221	425	2.125	-	-	-	-
IC694ALG220	Analog Input, Voltage, 4-Channel	-	-	27	0.135	-	-	98	2.352
IC694ALG221	Analog Input, Current, 4-Channel	-	-	25	0.125	-	-	100	2.4
IC694ALG222	Analog Input, 8-/16-Channel Voltage Version -AA Versions -BA and later	-	-	112	0.56	-	-	0 41	0.984
		-	-	112	0.56	-	-	110	2.64
IC694ALG223	Analog Input, 8-/16-Channel Current	-	-	120	0.60	-	-	65	1.56
IC694ALG232	Advanced Diagnostics, 16-Channel Input Analog Voltage Module	-	-	112	0.56	-	-	110	2.64
IC694ALG233	Advanced Diagnostics, 16-Channel Input Analog Current Module	-	-	120	0.60	-	-	65	1.56
IC695ALG306	Thermocouple Input Module, 6-Channel Isolated	400	1.320	225	1.125	-	-	-	-
IC695ALG312	Thermocouple Input Module, 12-Channel Isolated	400	1.320	425	2.125	-	-	-	-
IC694ALG390	Analog Output 2-Channel Voltage	-	-	32	0.16	-	-	120	2.88
IC694ALG391	Analog Output 2-Channel Current	-	-	30	0.15	-	-	215	5.16
IC694ALG392	Analog Output 8-Channel Current/Voltage	-	-	110	0.55	-	-	315	7.56
IC694ALG542	Analog Module 4-Input 2-Output Current /Voltage with Advanced Diagnostics	-	-	95	0.475	-	-	150	3.6
IC695ALG412	Isolated Thermocouple Input Module 12-Channel	400	1.320	425	2.125	-	-	-	-
IC694ALG442	Analog Module 4-Input 2-Output Current/Voltage	-	-	95	0.475	-	-	129	3.096
IC695ALG508	RTD Input Module, 8-Channel Isolated	400	1.320	200	1.00	-	-	-	-
IC695ALG600	Universal Analog Input Module	350	1.155	400	2.00	-	-	-	-

Catalog Number	Module	+3.3Vdc		+5Vdc		+24Vdc Relay		+24Vdc Isolated	
		mA	W	mA	W	mA	W	mA	W
IC695ALG608	Analog Input 8-/4-Channel Current/Voltage	330	1.089	600	3.00	-	-	-	-
IC695ALG616	Analog Input 16-/8-Channel Current/Voltage	450	1.485	600	3.00	-	-	-	-
IC695ALG626	Analog Input 16-/8-Channel Current/Voltage with HART Communications	625	2.063	600	3.00	-	-	-	-
IC695ALG628	Analog Input 8-/4-Channel Current/Voltage with HART Communications	625	2.063	450	2.25	-	-	-	-
IC695ALG704	Analog Output, 4-Channel Current/Voltage	375	1.238	-	-	-	-	150	3.6
IC695ALG708	Analog Output, 8-Channel Current/Voltage	375	1.238	-	-	-	-	250	6
IC695ALG728	Analog Output, 8-Channel Current/Voltage with HART Communications enabled	380	1.255	-	-	-	-	-	-
IC695ALG808	Analog Output 8-Channel Current/Voltage Isolated	450	1.485	25	-	0.138	-	600	14.4
IC694APU300	High-Speed Counter	-	-	250	1.25	-	-	-	-
IC694APU305	Special I/O Processor (360mA module +10mA per output on)	-	-	440	2.2	-	-	80	1.92
IC694BEM320	I/O Link Interface Module with Optical Adapter	-	-	205 405	1.025 2.025	-	-	-	-
IC694BEM321	IO Link Master Module with Optical Adapter	-	-	415 615	2.075 3.075	-	-	-	-
IC694BEM331	Genius Bus Controller Module	-	-	1300	6.50	-	-	-	-
IC695CHS007	Universal Backplane 7-Slot	600	1.98	240	1.20	-	-	-	-
IC695CHS012	Universal Backplane 12-Slot	600	1.98	240	1.20	-	-	-	-
IC695CHS016	Universal Backplane 16-Slot	600	1.98	240	1.20	-	-	-	-
IC694CHS392	Expansion/Remote Backplane 10-Slot	-	-	150	0.75	-	-	-	-
IC694CHS398	Expansion/Remote Backplane 5-Slot	-	-	170	0.85	-	-	-	-
IC695CMM002	Serial Communications Module, 2 Ports	700	2.310	115	0.508	-	-	-	-
IC695CMM004	Serial Communications Module, 4 Ports	700	2.310	150	0.75	-	-	-	-
IC695CMX128	Control Memory Xchange Module	660	2.178	253	1.27	-	-	-	-
IC695CPU310	300MHz CPU, 10 Meg memory	1250	4.125	1000	5.00	-	-	-	-
IC695CPU315	1 GHz CPU, 20 MB of user memory	1000	3.300	1200	6.00	-	-	-	-
IC695CPU320	1 GHz CPU, 64 MB of user memory	1000	3.300	1200	6.00	-	-	-	-

Catalog Number	Module	+3.3Vdc		+5Vdc		+24Vdc Relay		+24Vdc Isolated	
		mA	W	mA	W	mA	W	mA	W
IC695CRU320	1 GHz Redundancy CPU, 64 MB of user memory	1000	3.300	1200	6.00	-	-	-	-
IC694DNM200	DeviceNet Master Module	-	-	450	2.25	-	-	-	-
IC694DSM314	Motion Controller (+ external encoder, if used)	-	-	800 +500	4.00 +2.50	-	-	-	-
IC694DSM324	Motion Controller (+ external encoder, if used)	-	-	860 +500	4.30 +2.50	-	-	-	-
IC695ETM001	Ethernet Module	840	2.772	614	3.07	-	-	-	-
IC695ECM850	IEC 61850 Ethernet Communication Module	1900	6.270	1100	5.500	-	-	-	-
IC695GCG001	Genius Communications Gateway	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IC695HSC304	High Speed Counter Module, 1.5MHz, 8 inputs, 7 outputs	457	1.51	64	0.32	-	-	-	-
IC695HSC308	High Speed Counter Module, 1.5MHz, 16 inputs, 14 outputs	561	1.85	94	0.47	-	-	-	-
IC695LRE001	Expansion Module	-	-	132	1.60	-	-	-	-
IC694MDL230	Input 120 V ac Isolated 8-Pt	-	-	60	0.30	-	-	-	-
IC694MDL231	Input 240 V ac Isolated 8-Pt	-	-	60	0.30	-	-	-	-
IC694MDL240	Input 120 V ac 16-Pt	-	-	90	0.45	-	-	-	-
IC694MDL241	Input 24Vac/Vdc Pos/Neg Logic 16-Pt	-	-	80	0.40	-	-	125	3.00
IC694MDL250	Input 120 V ac 16-Pt Isolated (all inputs on)	-	-	220	1.10	-	-	-	-
IC694MDL260	Input 120 V ac 32-Pt Isolated (all inputs on)	-	-	220	1.10	-	-	-	-
IC694MDL310	Output 120 V ac 0.5A 12-Pt (all outputs on)	-	-	210	1.05	-	-	-	-
IC694MDL330	Output 120/240 V ac 0.5A 16-Pt (all outputs on)	-	-	160	0.80	-	-	-	-
IC694MDL340	Output 120 V ac 0.5A 16-Pt (all outputs on)	-	-	315	1.575	-	-	-	-
IC694MDL350	Output 120/240 V ac Isolated 16-Pt (all outputs on)	-	-	315	1.575	-	-	-	-
IC694MDL390	Output 120/240 V ac Isolated 2A 5-Pt (all outputs on)	-	-	110	0.55	-	-	-	-
IC694MDL632	Input 125Vdc Pos/Neg Logic 8-Pt	-	-	40	0.20	-	-	-	-
IC694MDL634	Input 24Vdc Pos/Neg Logic 8-Pt	-	-	45	0.225	-	-	62	1.488
IC694MDL635	Input 125Vdc Pos/Neg, 16-Pt (all inputs on)	-	-	80	0.40	-	-	-	-
IC694MDL645	Input 24Vdc Pos/Neg Logic 16-Pt	-	-	80	0.40	-	-	125	3.00
IC694MDL646	Input 24Vdc Pos/Neg Logic FAST 16-Pt	-	-	80	0.40	-	-	125	3.00

Catalog Number	Module	+3.3Vdc		+5Vdc		+24Vdc Relay		+24Vdc Isolated	
		mA	W	mA	W	mA	W	mA	W
IC694MDL648	Input 48Vdc 16-Pt Pos/Neg Logic, 1ms filter	-	-	80	0.40	-	-	-	-
IC694MDL654	Input 5/12Vdc (TTL) Pos/Neg 32-Pt 195 = (29mA + 0.5mA/point ON + 4.7mA/LED ON) 440mA (maximum) from +5V bus on backplane (if module isolated +5V supply used to power inputs & all 32 inputs ON)	-	-	195 / 440	0.975 / 2.20	-	-	-	-
IC694MDL655	Input 24Vdc Pos/Neg 32-Pt (29mA +0.5mA/point ON +4.7mA/LED ON)	-	-	195	0.975	-	-	224 (typ)	5.376
IC694MDL658	Input 48Vdc 32-Pt Pos/Neg Logic	-	-	195	0.975	-	-	-	-
IC694MDL660	Input 24Vdc 32-Pt Pos/Neg	-	-	300	1.50	-	-	-	-
IC695MDL664	Input 24Vdc 16-Pt, Pos Logic	95	0.314	225	1.125	-	-	-	-
IC694MDL730	Output 12/24Vdc 2A 8-Pt Pos Logic	-	-	55	0.275	-	-	-	-
IC694MDL732	Output 12/24Vdc 0.5A 8-Pt Pos Logic	-	-	50	0.25	-	-	-	-
IC694MDL734	Output 125Vdc Pos/Neg Logic 6 Pt (all outputs on)	-	-	90	0.45	-	-	-	-
IC694MDL740	Output 12/24Vdc 0.5A 16-Pt Pos Logic (all outputs on)	-	-	110	0.55	-	-	-	-
IC694MDL741	Output 12/24Vdc 0.5A 16-Pt Neg Logic (all outputs on)	-	-	110	0.55	-	-	-	-
IC694MDL742	Output 12/24Vdc 1A 16-Pt Pos Logic ESCP (all outputs on)	-	-	130	0.65	-	-	-	-
IC694MDL752	Output 5/24Vdc (TTL) 0.5A 32-Pt Neg Logic (13mA + 3 mA/point ON + 4.7 mA/LED)	-	-	260	1.30	-	-	-	-
IC694MDL753	Output 12/24Vdc 0.5A 32-Pt Pos Logic (13mA + 3mA/point ON + 4.7mA/LED)	-	-	260	1.3	-	-	-	-
IC694MDL754	Output 24Vdc High-Density 32-Pt (with all outputs on)	-	-	300	1.50	-	-	264	6.336
IC694MDL758	Output 12/24Vdc 0.5A 32-Pt Positive Logic with ESCP per group	-	-	250	1.25	-	-	66	1.584
IC695MDL765	Output Module, 24/125Vdc 16-Pt Pos Logic	152	0.502	540	2.7				
IC694MDL916	Output 4 Amp 16-Pt Relay	-	-	300	1.50	-	-	-	-
IC694MDL930	Relay NO 4A Isolated 8-Pt Output (all outputs on)	-	-	6	0.03	70	1.68	-	-
IC694MDL931	Relay NC and Form C 8 A Isolated 8-Pt Output (all outputs on)	-	-	6	0.03	110	2.64	-	-

Catalog Number	Module	+3.3Vdc		+5Vdc		+24Vdc Relay		+24Vdc Isolated	
		mA	W	mA	W	mA	W	mA	W
IC694MDL940	Relay NO 2A 16-Pt Output (all outputs on)	-	-	7	0.035	135	3.24	-	-
IC694MDR390	Mixed I/O 24Vdc Input (8-Pt) N.O. Relay Output (8-Pt)	-	-	80	0.40	70	1.68	-	-
IC695NIU001	Ethernet Network Interface Unit	1250	4.125	1000	5.00	-	-	-	-
IC695NIU001	Ethernet Network Interface Unit Plus (version AAAA and later)	520	1.716	950	4.750	-	-	-	-
IC695PBM300	PROFIBUS Master Module	440	1.452	-	-	-	-	-	-
IC695PBS301	PROFIBUS Slave Module	440	1.452	-	-	-	-	-	-
IC695PMM335	PACMotion Multi-Axis Motion Controller	1010	3.333	440	2.2	-	-	-	-
IC695PNC001	PROFINET Controller Module (maximum with 2 SFP devices installed, 0.35 A per SFP device)	1200	3.960	1500	7.5	-	-	-	-
IC695PNS001	PROFINET Scanner Module (maximum with 2 SFP devices installed, 0.35 A per SFP device)	1900	6.270	1100	5.5	-	-	-	-
IC695PRS015	Pressure Transducer Module	700	2.310	115	0.575	-	-	-	-
IC695RMX128	Redundancy Memory Xchange Module, Multi-Mode Fiber	580	.264	220	1.1	-	-	-	-
IC695RMX228	Redundancy Memory Xchange Module, Single-Mode Fiber	580	.264	220	1.1	-	-	-	-

4.2.1 Power Supply Loading Example

To determine the total load placed on a power supply, add the current requirements of each module and the backplane. The following table provides an example of power supply loading.

Catalog Number	Module	+3.3Vdc	+5.1Vdc	+24Vdc Relay	+24Vdc Isolated ⁷
IC695CPU310	300MHz CPU 10 Meg memory	1250	1000	-	-
IC695CHS012	Universal Backplane, 12-Slot	600	240	-	-
IC695ETM001	Ethernet Module	840	614	-	-
IC695LRE001	Expansion Module	-	132	-	-
IC694ALG220	Analog Input, Voltage, 4-Ch	-	27	-	98 ⁷
IC694ALG390	Analog Output 2-Ch Voltage	-	32	-	120 ⁷
IC694ALG442	Analog Current/Voltage 4-Ch In / 2-Ch Out	-	95	-	-
IC694APU300	High-Speed Counter	-	250	-	4000 ⁷
IC694MDL340	120 V ac 0.5A 16-Pt Output	-	315	-	-
IC694MDL230	120 V ac Isolated, 8-Pt Input	-	60	-	-
IC694MDL240	120 V ac 16-Pt Input	-	90	-	-
IC694MDL930	Relay NO 4A Isolated 8-Pt Output (all outputs on)	-	6	70	-
IC694MDL931	Relay NC and Form C 8 A Isolated 8-Pt Output (all outputs on)	-	6	110	-
	Total Amps	2.690	2.867	0.180	-
	Converted to Watts	(x3.3V)	(x5.1V)	(x24V)	-
	Power Consumption from Power Supply	=8.877W	=14.622W	=4.32W	-
Total Power Consumption from Power Supply		8.877 + 14.622 + 4.32 = 27.817 W			

At ambient temperatures up to 32°C, power supply IC695PSA040 provides the following power outputs:

- 40 W maximum total
- 5.1Vdc = 30 W maximum
- 3.3Vdc = 30 W maximum

In this example, all of the module power requirements are met by Power Supply PSA040.

⁷ Because the IC695 power supply does not provide +24Vdc Isolated power, an external +24Vdc supply, wired via terminal TB1 on the Universal Backplane, is required for modules ALG220, ALG221, ALG222 and APU300.

4.2.2 Load Sharing / Redundancy

To meet the power needs of the application, as many as four multi-purpose power supplies can be installed in a Universal Backplane. These power supplies can be combined to provide:

- Load Sharing
- Power Supply Module Redundancy
- Power Source Redundancy

No other types of RX3i power supply can be included in these applications.

4.2.2.1 Load Sharing

Multi-purpose power supplies can be combined into load sharing applications. The following rules must be observed:

If multiple power supplies are required to meet the system load requirements, Multi-purpose power supplies must be wired to the same power source in such a way that they all can be powered up or powered down simultaneously. The On/Off switch on the front-panel of each of the power supplies must be left in the On position.

Caution



In a load-sharing application, it is important to ensure that the load-sharing power supply modules' On/Off switches cannot be inadvertently used. The minimum number of power supplies needed to meet the system power requirements **MUST** have their switches always kept in the On position. Also, the load-sharing power supplies must be connected to the system power source through the same external switch. The system must be powered up and powered down only from the external switch. If individual power supplies are powered up or powered down using their On/Off switches *or separate external switches*, resulting in insufficient power capacity, equipment damage may result. It may be necessary to re-load the PLC operating system to resume operation.

4.2.2.2 Connections for Load Sharing

In load-sharing installations, additional multi-purpose power supplies above the minimum required for the system load may be wired to the same power source, or to a different source.

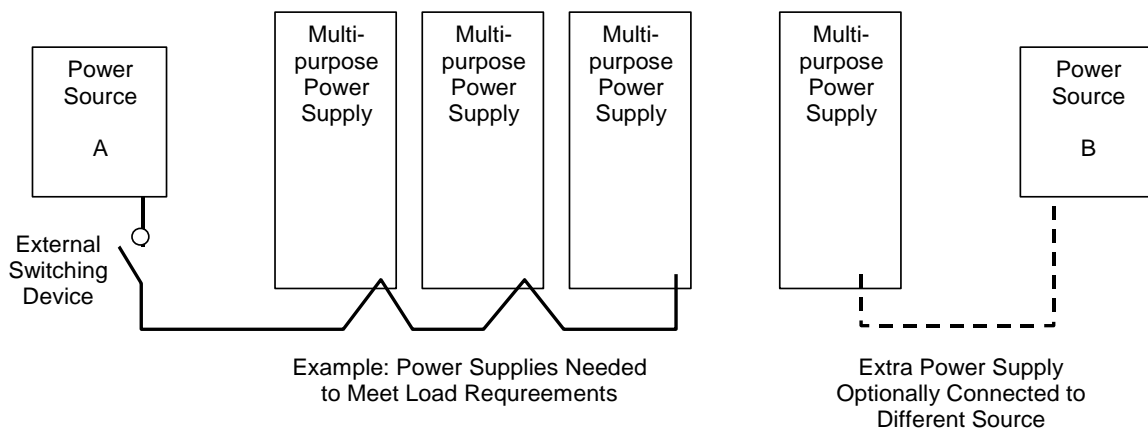


Figure 80: Power Supply Connections for Load Sharing

4.2.2.3 Connections for Power Supply Module Redundancy

Power supply module redundancy can be provided by using one additional multi-purpose power supply above the minimum required for the system power load (Figure 81). In this type of installation, all Multi-purpose power supplies contribute a share of the backplane power and run at a correspondingly reduced load. This results in longer life for the individual power supplies. In addition, should one power supply module fail, system operation is not interrupted. The front panel switch can be used to remove a redundant unit. Note that this type of system does not provide protection against loss of the input power source. If more than one power supply is switched off, the remaining power supplies may become overloaded and shut down. An External switching device must be used to remove power from more than one power supply at a time in the Power Supply Redundancy mode.

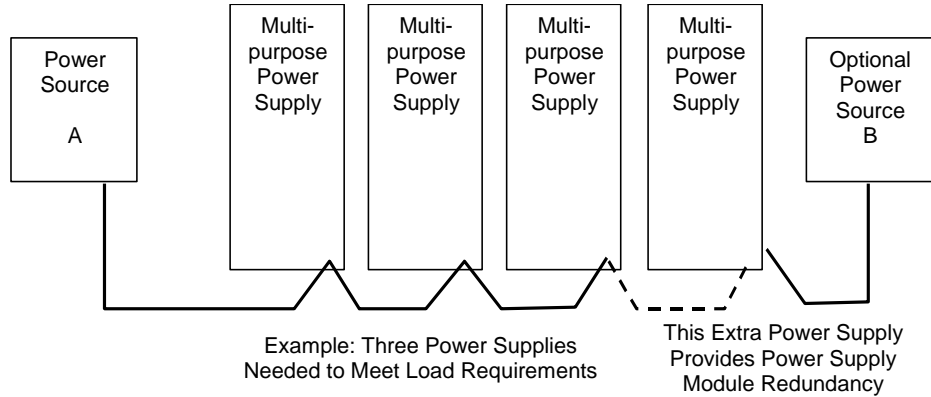


Figure 81: Redundant Power Supply Connections

4.2.2.4 Power Source Redundancy

If the overall power needs of the system can be met using either one or two Multi-purpose power supplies, then power source redundancy can be provided. This requires using twice the minimum number of Multi-purpose power supplies required to meet the system load requirements. In this type of system, half of the Multi-purpose power supplies must be connected to one power source and the other half must be connected to a separate source. This arrangement provides all the advantage of a Basic Redundancy system, as described above, plus power source redundancy. The front panel switch may be used to remove an individual power supply as long as the minimum number of units remains powered up.

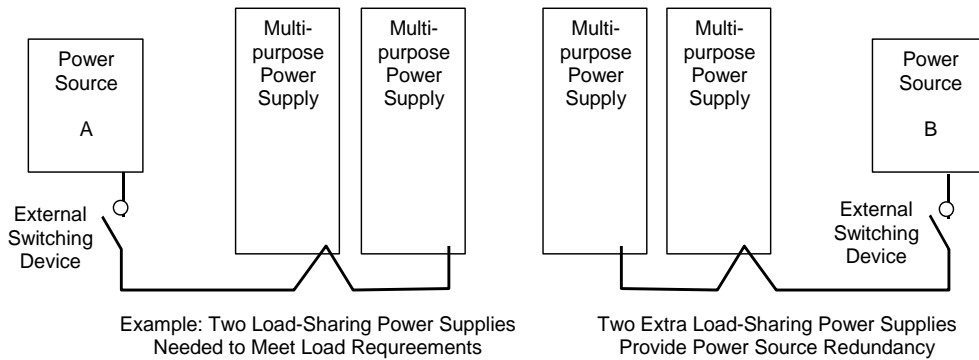


Figure 82: Connections for Power Source Redundancy

4.3 AC Power Supply Connections for Floating Neutral (IT) Systems

If an AC input power supply is installed in a system where the Neutral line is not referenced to Protective Earth Ground, special installation instructions must be followed to prevent damage to the power supply.

A *Floating Neutral System* is a system of power distribution wiring where Neutral and Protective Earth Ground are not tied together by negligible impedance. In Europe, this is referred to as an IT system (refer to IEC950). In a *Floating Neutral System*, voltages measured from input terminals to protective earth ground may exceed the 264Vac maximum input voltage power supply specification.

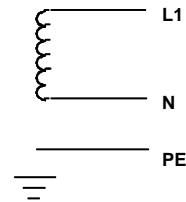


Figure 83: Floating Neutral

4.3.1 Special Instructions for Floating Neutral Systems

The input power terminals should be wired according to the instructions in *Power Supply Field Wiring*, Section 2.6.6.1 with the following exceptions.

- 1) For IC695 power supplies, no jumper may be installed between terminal 5 or 6 and terminal 7.
- 2) For IC694 and IC693 power supplies, no jumper may be installed between terminals 3 and 4 of the power supply module.
- 3) Voltage surge protection devices such as MOVs must be installed:
 - From L1 to earth ground
 - From L2 (Neutral) to earth ground

The voltage surge devices must be rated such that the system is protected from power line transients that exceed $\text{Line voltage} + 100\text{V} + (N-PE)_{\text{MAX}}$. The expression $N-PE$ refers to the voltage potential between neutral and Protective Earth (PE) ground. For example, in a 240 Volt AC system with neutral floating 50 V ac above earth ground, the transient protection should be rated at:

$$240 \text{ V ac} + 100 \text{ V ac} + 50 \text{ V ac} = 390 \text{ V ac}$$

4.3.2 Non-Floating Neutral System

Systems where one leg of the power distribution wiring is tied to Protective Earth or a tap between two legs of the power distribution wiring is tied to Protective Earth are not *Floating Neutral Systems*. Non-floating neutral systems **do not** require special installation procedures.

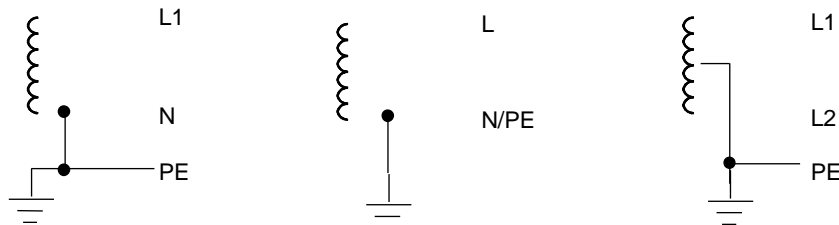


Figure 84: Non-Floating Neutral Wiring

4.4 Power Supply, 120/240 V ac or 125Vdc, 40 W: IC695PSA040

Power Supply IC695PSA040 is a 40-Watt supply that operates from an input voltage source in the range of 85 to 264Vac or 100 V dc to 300 V dc.

This power supply provides three outputs:

- +5.1Vdc output,
- +24Vdc relay output that can be used to power circuits on Output Relay modules.
- +3.3Vdc. This output is used internally by RX3i modules with IC695 catalog numbers.

Caution



Only one IC695PSA040 can be used in a PACSystems RX3i (IC695 catalog number) Universal Backplane.

This power supply cannot be used with other RX3i power supplies in redundant or increased capacity modes.

Power supply version IC695PSA040C or earlier may cause equipment damage if inadvertently installed in the same backplane as another RX3i power supply.

If the number of modules required exceeds the capacity of the power supply, the additional modules must be installed in Expansion or Remote backplanes.

The power supply indicates when an internal fault occurs so the CPU can detect loss of power or log the appropriate fault code.

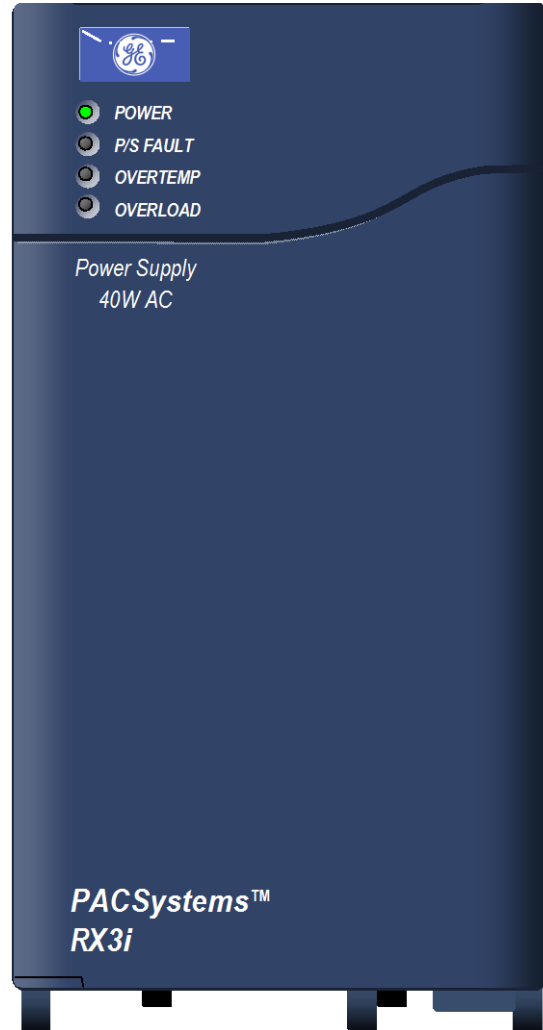


Figure 85: IC695PSA040

4.4.1.1 LEDs

Four LEDs on the power supply indicate:

- Power (Green/Amber). When this LED is green, it indicates power is being supplied to the backplane. When this LED is amber, power is applied to the power supply but the Power Supply switch is off.
- P/S Fault (Red). When this LED is lit, it indicates the power supply has failed and is no longer supplying sufficient voltage to the backplane.
- Over Temperature (Amber). When this LED is lit, it indicates the power supply is approaching or exceeding its maximum operating temperature.
- Overload (Amber). When this LED is lit, it indicates the power supply is approaching or exceeding its maximum output capability on at least one of its outputs.

The CPU Fault Table shows a fault if any Over-temperature, Overload, or Power Supply fault occurs.

4.4.1.2 On/Off Switch

The ON/OFF switch is located behind the door on the front of the module. The switch controls the operation of the outputs of the supply. It does NOT interrupt line power. Projecting tabs next to the switch help prevent accidentally turning it on or off.

4.4.1.3 Wiring Terminals

Terminals for power, ground, and MOV disconnect accept individual 14 to 22 AWG wires.

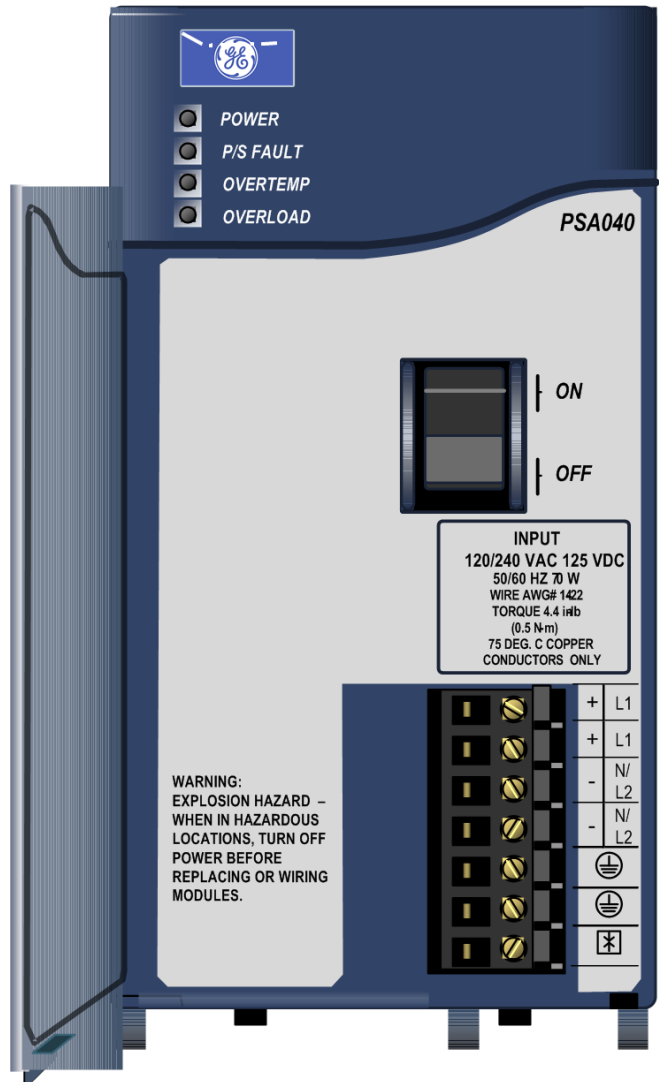


Figure 86: PSA040 Showing Terminals & On/Off Switch

4.4.2 Specifications: PSA040

Nominal Rated Voltage	120/240 Vac or 125 Vdc
Input Voltage Range	
AC	85 to 264 Vac
DC	100 to 300 Vdc
Input Power (Maximum with Full Load)	70 W maximum
Inrush Current ⁸	4 A, 250 ms maximum
Output Power	40 W maximum total 5.1 Vdc = 30 W maximum 3.3 Vdc = 30 W maximum The maximum total output power available depends on the ambient temperature, as shown.
Output Voltage	24 Vdc: 19.2 to 28.8 Vdc 5.1 Vdc: 5.0 to 5.2Vdc (5.1 Vdc nominal) 3.3 Vdc: 3.1 to 3.5Vdc (3.3 Vdc nominal)
Output Current	24 Vdc: 0 to 1.6 A 5.1 Vdc: 0 to 6 A 3.3 Vdc: 0 to 9 A
Isolation (input to backplane):	250 Vac continuous; 1500 Vac for 1 minute
Ripple (all outputs)	150 mV
Noise (all outputs)	150 mV
Ride-through time	20 ms is the length of time the power supply maintains valid outputs if the power source is interrupted
Wiring Terminals	Each terminal accepts one 14 AWG to 22 AWG wire
Current per Terminal	6 A
Number of Daisy-Chaind PSA040 Supplies	Up to 4

For product standards and general specifications, refer to *Appendix A*.



Warning

The door of the power supply module must be closed. During normal operation with an AC power source either 120 V ac or 240 V ac is present on the AC power supply. The door protects against accidental shock hazard that could cause severe or fatal injury to personnel.

⁸ The Inrush Current specification is given as a guide for sizing the external power source for the IC695PSA040. Peak inrush current may be higher for shorter durations.

4.4.2.1 Thermal Derating: PSA040

The maximum output power for power supply PSA040 depends on the ambient temperature, as displayed in the following figure. Full output power is available up to at least 32°C (89.6°F).

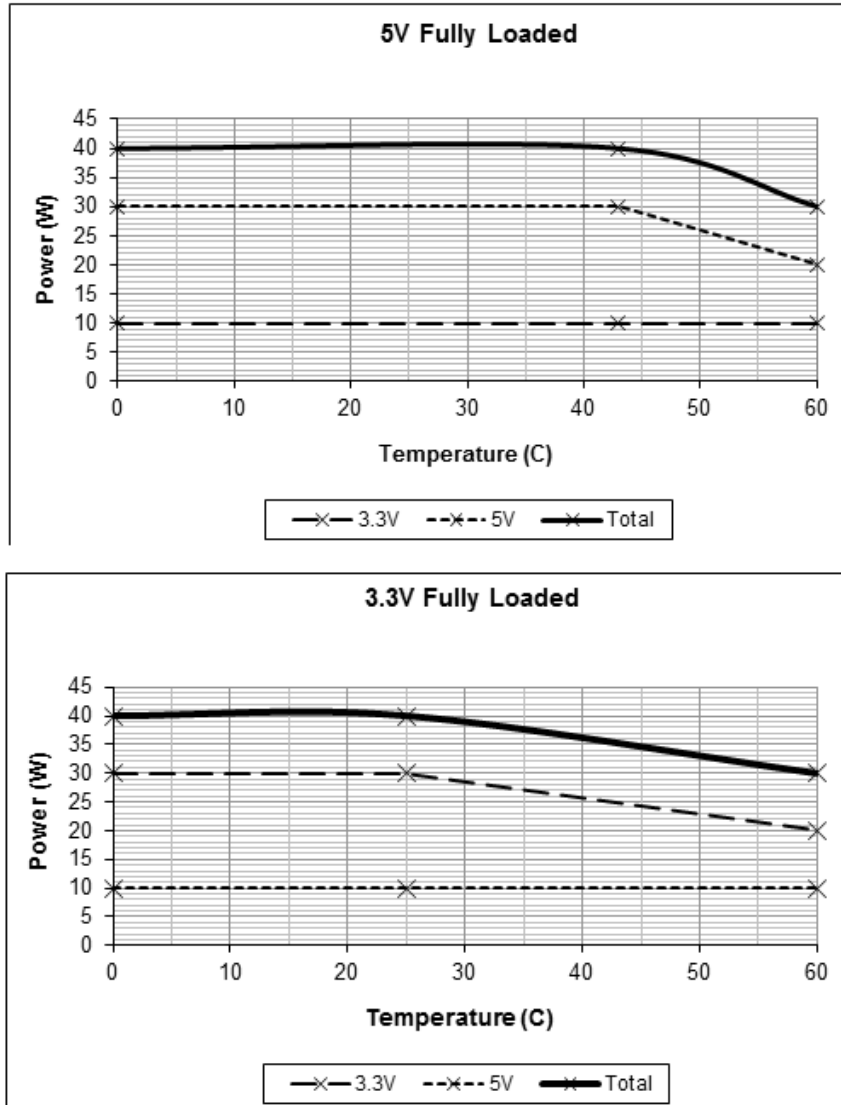


Figure 87: Thermal Derating Curves for PSA040

4.4.2.2 Over-Current Protection: PSA040

The 5.1 Vdc output is electronically limited to 7 A. The 3.3Vdc output is limited to 10 A. If an overload (including short circuit) occurs, it is sensed internally and the power supply shuts down. The power supply continually tries to restart until the overload condition is removed. An internal, non-repairable, fusible link in the input line is provided as a backup. The power supply usually shuts down before the fusible link blows. The fusible link also protects against internal supply faults. The CPU Fault Table displays a fault if any Over-temperature, Overload, or Power Supply fault occurs. There is no additional indication if the power supply fusible link blows.

4.4.3 Field Wiring: PSA040

4.4.3.1 Power Source and Ground Connections

The wires from the power source and ground connect to the terminals on the power supply as shown in Figure 88. Each terminal accepts one AWG 14 to AWG 22 wire.

When tightening the screw terminals, do not exceed the maximum torque limit of 0.5 Nm (4.4 in-lb).

Warning



If the same external AC power source is used to provide power to two or more RX3i power supplies in the system, connection polarity must be identical at each power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

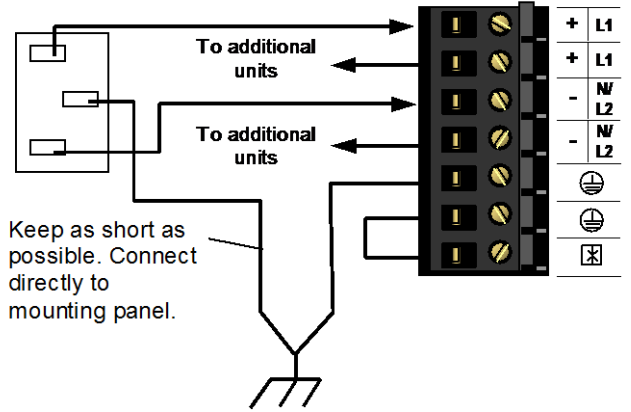


Figure 88: Field Wiring PSA040

4.4.3.2 Input Over-Voltage Protection

The bottom terminal is normally connected to frame ground with a user-installed jumper as shown in Figure 89. If over-voltage protection is not required or is supplied upstream, no jumper is needed.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the jumper. Re-enable over-voltage protection after testing by reinstalling the jumper.

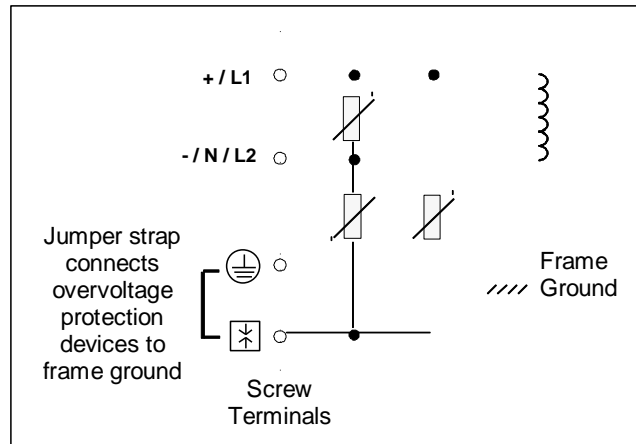


Figure 89: Over-Voltage Protection for PSA040

In systems with a floating neutral input (Figure 83 - the neutral line is not referenced to Protective Earth Ground), this jumper must NOT be installed. In addition, in a floating neutral system, voltage surge protection devices such as MOVs **must** be installed from L1 to earth ground, and from L2 (Neutral) to earth ground, as discussed in *Special Instructions for Floating Neutral Systems*, Section 4.3.1.

4.5 Multi-purpose Power Supply, 120/240 V ac or 125Vdc, 40 W: IC695PSA140

Power Supply IC695PSA140 is a multi-purpose 40 W supply that operates from an input voltage source in the range of 85 to 264Vac or 100 V dc to 300 V dc.

This power supply provides three outputs:

- +5.1Vdc output
- +24Vdc relay output that can be used to power circuits on Output Relay modules.
- +3.3Vdc. This output is used internally by RX3i modules with IC695 catalog numbers.

This power supply is suitable for use in load-sharing and redundancy applications. Up to four multi-purpose power supplies (PSA140 and/or PSD140) can be used in a PACSystems RX3i (IC695 catalog number) Universal Backplane. Use these Power Supplies if the number of modules required exceeds the capacity of one power supply. This power supply occupies two backplane slots.

The power supply indicates when an internal fault occurs so the CPU can detect loss of power or log the appropriate fault code.

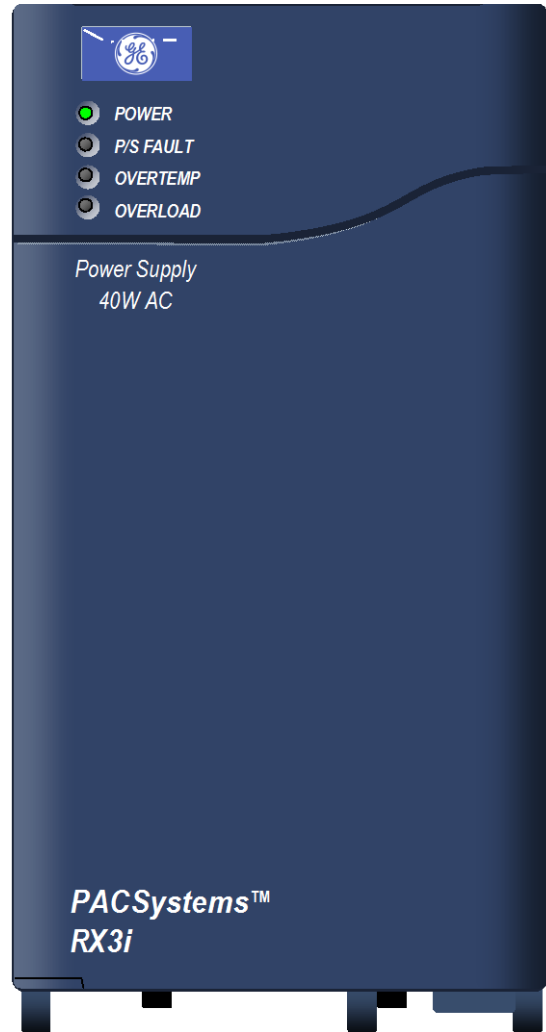


Figure 90: IC695PSA140



Caution

This power supply cannot be used with RX3i IC695PSD040 or IC695PSA040 Power Supplies in redundant or increased capacity modes. Damage to equipment may result.

4.5.1.1 LEDs

Four LEDs on the power supply indicate:

- Power (Green/Amber). When this LED is green, it indicates that power is being supplied to the backplane. When this LED is amber, power is applied to the power supply but the Power Supply switch is off.
- P/S Fault (Red). When this LED is lit, it indicates the power supply has failed and is no longer supplying sufficient voltage to the backplane.
- Over Temperature (Amber). When this LED is lit, it indicates the power supply is approaching or exceeding its maximum operating temperature.
- Overload (Amber). When this LED is lit, it indicates the Power Supply is approaching or exceeding its maximum output capability on at least one of its outputs.

The CPU Fault Table shows a fault if any Over-temperature, Overload, or Power Supply fault occurs.

4.5.1.2 On/Off Switch

The ON/OFF switch is located behind the door on the front of the module. The switch controls the operation of the outputs of the supply. It does NOT interrupt line power. Projecting tabs next to the switch help prevent accidentally turning it on or off.

4.5.1.3 Wiring Terminals

Terminals for power, ground, and MOV disconnect accept individual 14 to 22 AWG wires.

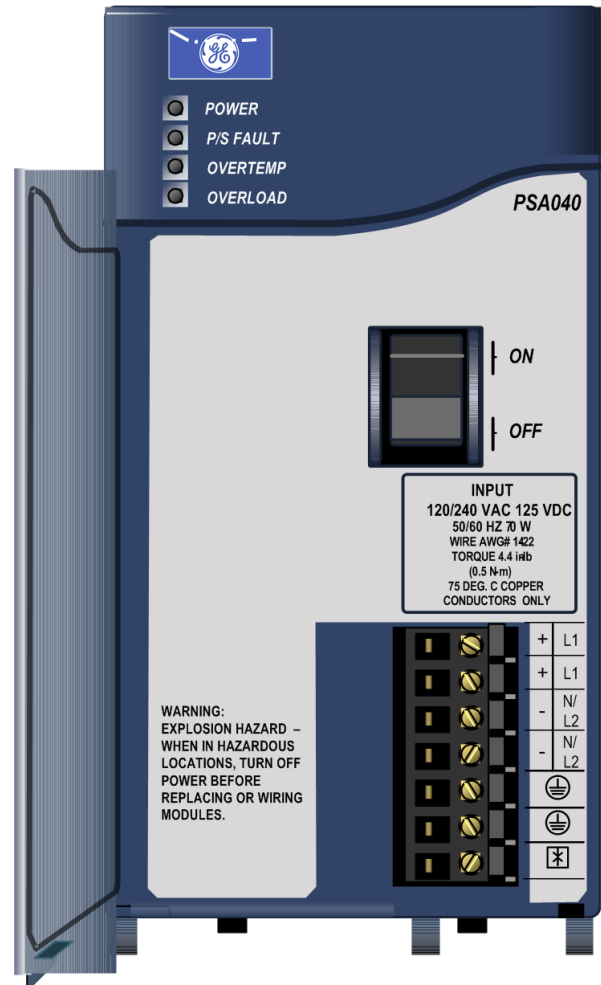


Figure 91: PSA140 Showing Terminals & On/Off Switch

4.5.2 Specifications: PSA140

Nominal Rated Voltage	120/240 Vac or 125 Vdc
Input Voltage Range	
AC	85 to 264 Vac
DC	100 to 300 Vdc
Input Power (Maximum with Full Load)	70 W maximum
Inrush Current ⁹	4 A, 250 ms maximum
Output Power	40 W maximum total 5.1 Vdc = 30 W maximum 3.3 Vdc = 30 W maximum The maximum total output power available depends on the ambient temperature.
Output Voltage	24 Vdc: 19.2 to 28.8 Vdc 5.1 Vdc: 5.0 to 5.2 Vdc (5.1 Vdc nominal) 3.3 Vdc: 3.1 to 3.5 Vdc (3.3 Vdc nominal)
Output Current	24 Vdc: 0 to 1.6 A 5.1 Vdc: 0 to 6 A 3.3 Vdc: 0 to 9 A
Isolation (input to backplane):	250 Vac continuous; 1500 Vac for 1 minute
Ripple (all outputs)	150 mV
Noise (all outputs)	150 mV
Ride-through time	20 ms. This is the length of time the power supply maintains valid outputs if the power source is interrupted
Wiring Terminals	Each terminal accepts one 14 AWG to 22 AWG wire.
Current per Terminal	6 A
Number of Daisy-Chaind PSA140 Supplies	Up to 4
Number of PSA140 Power Supplies in Universal Backplane	Up to 4

For product standards and general specifications, refer to *Appendix A*.



Warning

The door of the power supply module must be closed. During normal operation with an AC power source either 120 V ac or 240 V ac is present on the AC power supply. The door protects against accidental shock hazard that could cause severe or fatal injury to personnel.

⁹ The Inrush Current specification is given as a guide for sizing the external power source for the IC695PSA140. Peak inrush current may be higher for shorter durations.

4.5.2.1 Thermal Derating: PSA140

The maximum output power for power supply PSA140 depends on the ambient temperature.

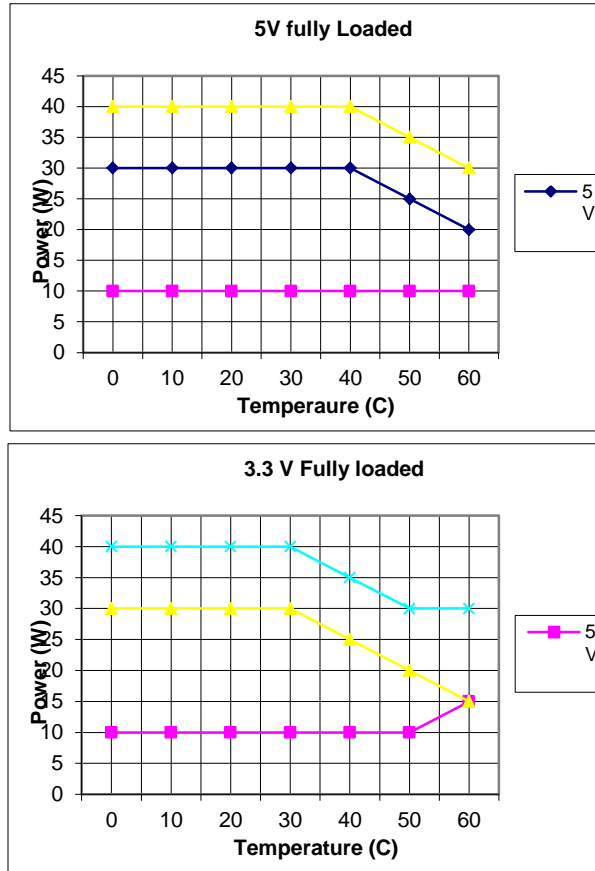


Figure 92: Thermal Derating Curves for PSA140

4.5.2.2 Over-Current Protection: PSA140

The 5.1Vdc output is electronically limited to 7 Amps. The 3.3Vdc output is limited to 10 A. If an overload (including short circuits) occurs, it is sensed internally and the power supply shuts down. Because it is designed for redundancy applications, this power supply latches off in fault conditions. It does not automatically try to restart until the overload condition is removed. Input power must be cycled to clear a latched fault. However, if the power supply is used in a non-redundant application where automatic restarting is required, a jumper plug can be installed.

An internal non-repairable fusible link in the input line is provided as a backup. The power supply usually shuts down before the fusible link blows. The fusible link also protects against internal supply faults. The CPU Fault Table shows a fault if any Over-temperature, Overload, or P/S Fault occurs. There is no additional indication if the power supply fusible link blows.

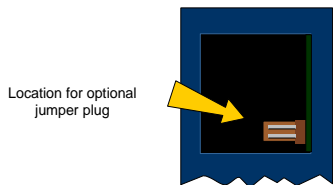


Figure 93: Jumper Location PSA140

In a non-redundancy application, where automatic restarting may be appropriate, a jumper plug (or shunt) can be installed at the rear of the module as shown in Figure 93. The jumper plug must have 0.100 inch spacing on center and accommodate 0.25 inch pins. Example parts are Radio Shack DIP Programming Shunt #276-1512 and DIGI-Key #59000-ND. The module must be removed from the backplane to install the jumper plug.

4.5.3 Field Wiring: PSA140

4.5.3.1 Power Source and Ground Connections

The wires from the power source and ground connect to the terminals on the power supply as shown in Figure 94. Each terminal accepts one AWG 14 to AWG 22 wire.

When tightening the screw terminals, do not exceed the maximum torque limit of 0.5 Nm (4.4 in-lb).



Warning

If the same external AC power source is used to provide power to two or more RX3i power supplies in the system, connection polarity must be identical at each power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

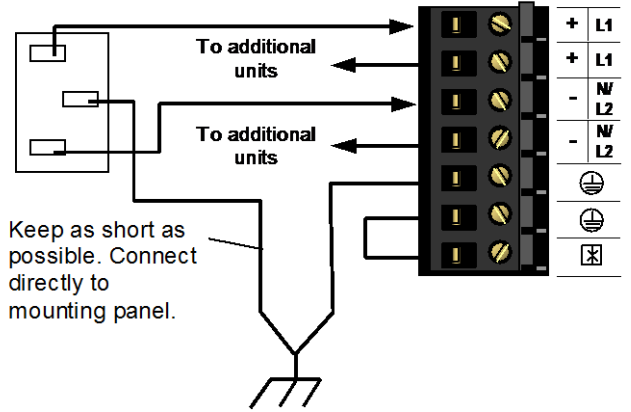


Figure 94: Field Wiring for PSA140

4.5.3.2 Input Over-Voltage Protection

The bottom terminal is normally connected to frame ground with a user-installed jumper as shown in Figure 95. If over-voltage protection is not required or is supplied upstream, no jumper is needed.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the jumper. Re-enable over-voltage protection after testing by reinstalling the jumper.

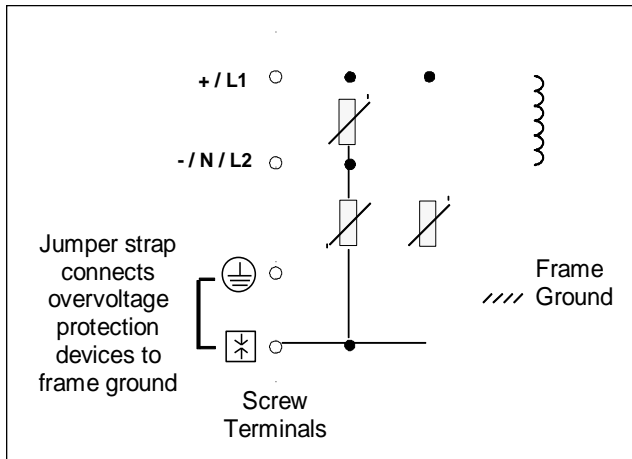


Figure 95: Over-Voltage Protection for PSA140

In systems with a floating neutral input (Figure 83 - the neutral line is not referenced to Protective Earth Ground), this jumper must NOT be installed. In addition, in a floating neutral system, voltage surge protection devices such as MOVs **must** be installed from L1 to earth ground, and from L2 (Neutral) to earth ground, as discussed in *Special Instructions for Floating Neutral Systems*, Section 4.3.1.

4.6 Power Supply, 24Vdc, 40 W: IC695PSD040

Power Supply IC695PSD040 is a 40 W supply that operates from an input voltage source in the range of 18Vdc to 30 V dc.

- +5.1Vdc output
- +24Vdc relay output that can be used to power circuits on Output Relay modules
- +3.3Vdc. This output is used internally by RX3i modules with IC695 catalog numbers

Caution



Only one IC695PSD040 can be installed in a PACSystems RX3i (IC695 catalog number) Universal Backplane.

This Power supply cannot be used with other RX3i power supplies in redundant or increased capacity modes.

Power supply version IC695PSD040C or earlier may cause equipment damage if inadvertently installed in the same backplane as another RX3i power supply.

This power supply occupies one slot. If the number of modules required exceeds the capacity of the power supply, the additional modules must be installed in expansion or remote backplanes.

The power supply indicates when an internal fault occurs so the CPU can detect loss of power or log the appropriate fault code.



Figure 96: IC695PSD040

4.6.1.1 LEDs

Four LEDs on the power supply indicate:

- Power (Green/Amber). When this LED is green, it indicates power is being supplied to the backplane. When this LED is amber, power is applied to the power supply but the power supply switch is off.
- P/S Fault (Red). When this LED is lit, it indicates the Power Supply has failed and is no longer supplying sufficient voltage to the backplane.
- Over Temperature (Amber). When this LED is lit, it indicates the power supply is approaching or exceeding its maximum operating temperature.
- Overload (Amber). When this LED is lit, it indicates the Power Supply is approaching or exceeding its maximum output capability on at least one of its outputs.

If the red P/S FAULT LED is lit, the power supply has failed and is no longer supplying sufficient voltage to the backplane.

The amber OVERTEMP and OVERLOAD LEDs light to warn of high temperature or high load conditions.

The CPU Fault Table shows a fault if any Over-temperature, Overload, or Power Supply fault occurs.

4.6.1.2 On/Off Switch

The ON/OFF switch is located behind the door on the front of the module. The switch controls the operation of the outputs of the supply. It does NOT interrupt line power. A projecting tab next to the switch helps prevent accidentally turning it on or off.

4.6.1.3 Wiring Terminals

Terminals for +24V and -24V power, ground, and MOV disconnect accept individual 14 to 22AWG wires.

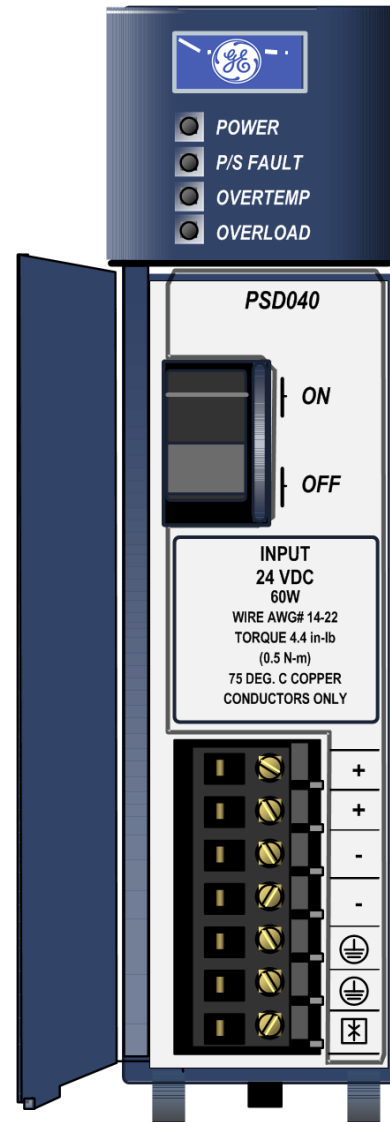


Figure 97: PSD040 Terminals and Switch Locations

4.6.2 Specifications: PSD040

Nominal Rated Voltage	24 Vdc
Input Voltage Range	18 to 30 Vdc
Input Power	60 W maximum at full load
Inrush Current ¹⁰	4 A, 100 ms maximum
Output Power	40 W maximum total of both outputs 5.1 Vdc = 30 W maximum 3.3 Vdc = 30 W maximum Maximum output power depends on ambient temperature
Output Voltage	5.1 Vdc: 5.0 to 5.2 Vdc (5.1 Vdc nominal) 3.3 Vdc: 3.1 to 3.5 Vdc (3.3 Vdc nominal)
Output Current	5.1Vdc: 0 to 6 A 3.3 Vdc: 0 to 9 A
Isolation	None
Ripple (all outputs)	50 mV
Noise (all outputs)	50 mV
Ride-through time	10 ms is the length of time the Power Supply maintains valid outputs if the power source is interrupted. If this Power Supply is used with IC694 and IC693 modules that have relay outputs, note that dropouts longer than 10ms will cause dropouts on the modules.
Wiring Terminals	Each terminal accepts one 14 AWG to 22 AWG wire.
Terminal Current	6 A
Number of Daisy-chained PSD040 Supplies	Up to 2

¹⁰ The Inrush Current specification is given as a guide for sizing the external power source for the IC695PSD040. Peak inrush current may be higher for shorter durations.

4.6.2.1 Thermal Derating: PSD040

The maximum output power for power supply PSD040 depends on the ambient temperature. Full output power is available up to at least 40°C (89.6°F).

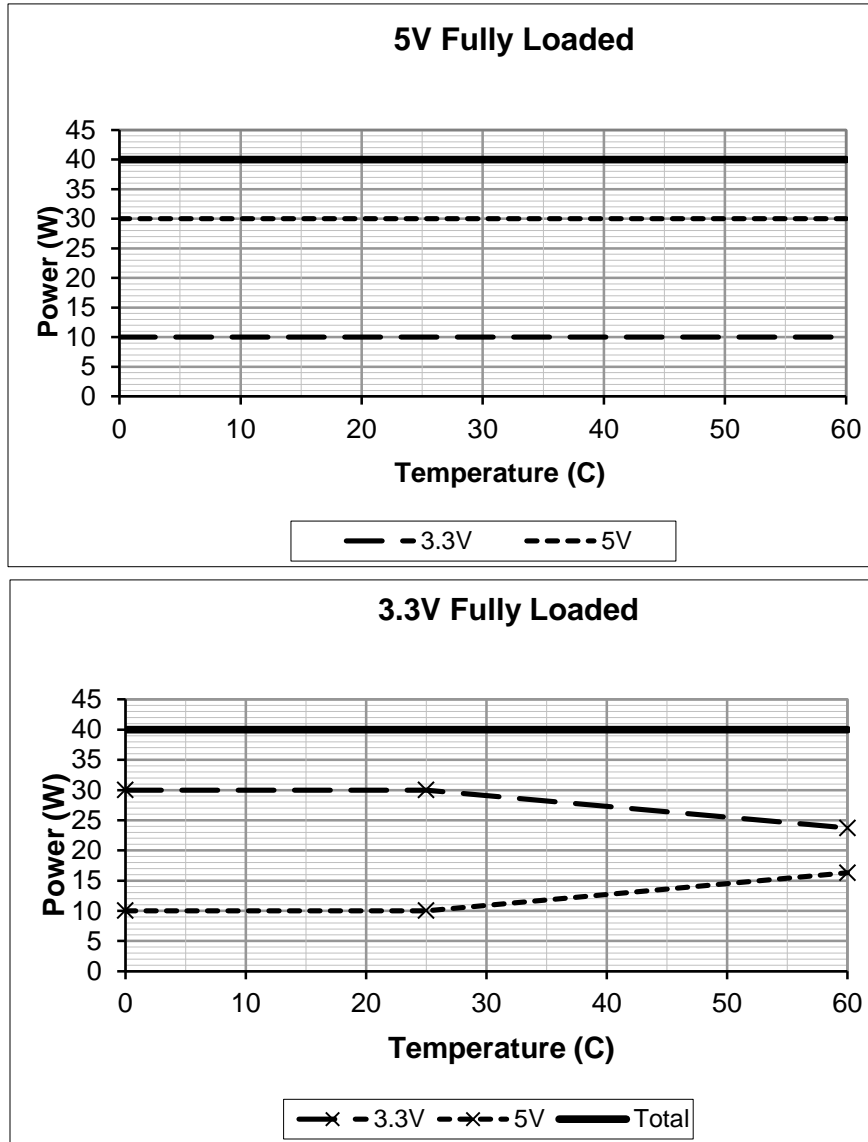


Figure 98: Thermal Derating Curves for PSD040

4.6.2.2 Over-Current Protection: PSD040

The 5.1Vdc output is electronically limited to 7 A. The 3.3Vdc output is limited to 10 A. If an overload (including short circuits) occurs, it is sensed internally and the power supply shuts down. The power supply continually tries to restart until the overload condition is removed. An internal non-repairable fusible link in the input line is provided as a backup. The power supply usually shuts down before the fusible link blows. The fusible link also protects against internal supply faults. The CPU Fault Table shows a fault if any Over-temperature, Overload, or Power Supply fault occurs. There is no additional indication if the power supply fusible link blows.

4.6.3 Field Wiring: PSD040

4.6.3.1 Power Source and Ground Connections

The wires from the power source and ground connect to the terminals on the power supply as shown in Figure 99. Each terminal accepts one AWG 14 to AWG 22 wire.

When tightening the screw terminals, do not exceed the maximum torque limit of 0.5 Nm (4.4 in-lb).

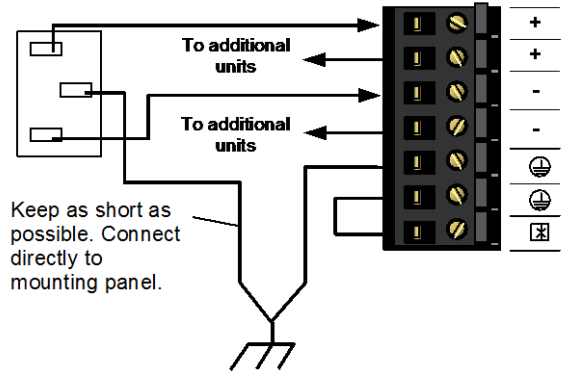


Figure 99: Field Wiring for PSD040

Warning



If the same external DC power source is used to provide power to two or more power supplies in the system, connection polarity must be identical at each RX3i power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

4.6.3.2 Input Over-Voltage Protection

The bottom terminal is normally connected to frame ground with a user-installed jumper as shown in Figure 100. If over-voltage protection is not required or is supplied upstream, no jumper is required.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the jumper. Re-enable over-voltage protection after testing by reinstalling the jumper.

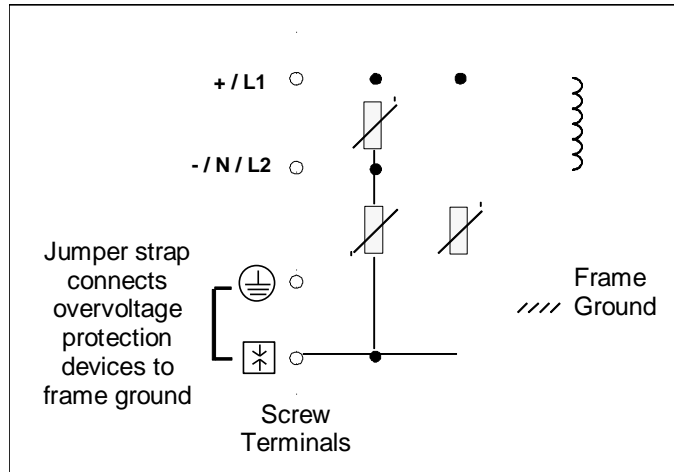


Figure 100: Over-Voltage Protection for PSD040



Warning

This power supply is not isolated and is therefore not compatible with floating or positive grounded systems.

4.7 Multi-Purpose Power Supply, 24Vdc, 40 W: IC695PSD140

Power supply IC695PSD140 is a multi-purpose 40-Watt supply that operates from an input voltage source in the range of 18Vdc to 30 V dc.

This power supply provides three outputs:

- +5.1Vdc output
- +24Vdc relay output that can be used to power circuits on Output Relay modules
- +3.3Vdc. This output is used internally by RX3i modules with IC695 catalog numbers

Multi-purpose power supply IC695PSD140 is suitable for use in load-sharing and redundancy application. It must be installed in a PACSystems RX3i (IC695 catalog number) Universal Backplane. It can be used as the only power supply in the backplane, or combined with up to three additional multi-purpose power supplies.

The power supply indicates when an internal fault occurs so the CPU can detect loss of power or log the appropriate fault code.



Figure 101: IC695PSD140



Caution

This power supply cannot be used with RX3i IC695PSD040 or IC695PSA040 power supplies in redundant or increased capacity modes. Damage to equipment may result.

4.7.1.1 LEDs

Four LEDs on the power supply indicate:

- Power (Green/Amber). When this LED is green, it indicates power is being supplied to the backplane. When this LED is amber, power is applied to the power supply but the power supply switch is off.
- P/S Fault (Red). When this LED is lit, it indicates the Power Supply has failed and is no longer supplying sufficient voltage to the backplane.
- Over Temperature (Amber). When this LED is lit, it indicates that the power supply is approaching or exceeding its maximum operating temperature.
- Overload (Amber). When this LED is lit, it indicates the power supply is approaching or exceeding its maximum output capability on at least one of its outputs.

If the red P/S FAULT LED is lit, the power supply has failed and is no longer supplying sufficient voltage to the backplane.

The amber OVERTEMP and OVERLOAD LEDs light to warn of high temperature or high load conditions.

The CPU Fault Table shows a fault if any Over-temperature, Overload, or Power Supply fault occurs.

4.7.1.2 Wiring Terminals

Terminals for +24V and -24V power, ground, and MOV disconnect accept individual 14 to 22 AWG wires.

4.7.1.3 On/Off Switch

The ON/OFF switch is located behind the door on the front of the module. The switch controls the operation of the outputs of the supply. It does NOT interrupt line power. A projecting tab next to the switch helps prevent accidentally turning it on or off.

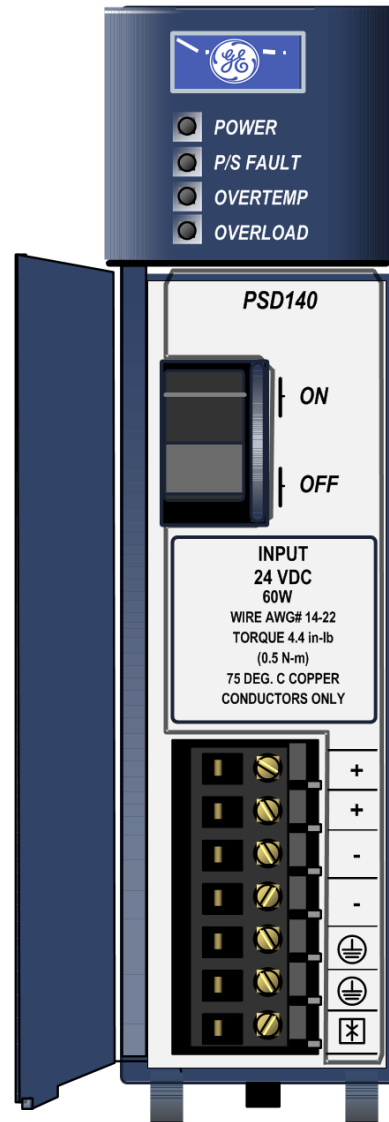


Figure 102 PSD140 Terminals and On/Off Switch

4.7.2 Specifications: PSD140

Nominal Rated Voltage	24 Vdc
Input Voltage Range	18 to 30 V dc
Input Power	60 W maximum at full load
Inrush Current ¹¹	4 A, 100 ms maximum
Output Power	40 W maximum total of both outputs 5.1 Vdc = 30 W maximum 3.3 Vdc = 30 W maximum Maximum output power depends on ambient temperature
Output Voltage	5.1 Vdc: 5.0V to 5.2 Vdc (5.1Vdc nominal) 3.3 Vdc: 3.1V to 3.5 Vdc (3.3Vdc nominal)
Output Current	5.1 Vdc: 0 to 6 A 3.3 Vdc: 0 to 9 A
Isolation	None
Ripple (all outputs)	50 mV
Noise (all outputs)	50 mV
Ride-through time	10 ms is the length of time the power supply maintains valid outputs if the power source is interrupted. If this power supply is used with IC694 and IC693 modules that have relay outputs, special precautions should be taken because dropouts in the source voltage will be seen by the module and may cause relay dropouts.
Wiring Terminals	Each terminal accepts one 14 AWG to 22 AWG wire
Terminal Current	6 A
Number of Daisy-Chain PSD140 Supplies	Up to 4
Number of PSD140 Supplies in Universal Backplane	Up to 4

¹¹ The Inrush Current specification is given as a guide for sizing the external power source for the IC695PSD140. Peak inrush current may be higher for shorter durations.

4.7.2.1 Thermal Derating: PSD140

The maximum output power for power supply PSD140 depends on the ambient temperature. Full output power is available up to at least 40°C (89.6°F).

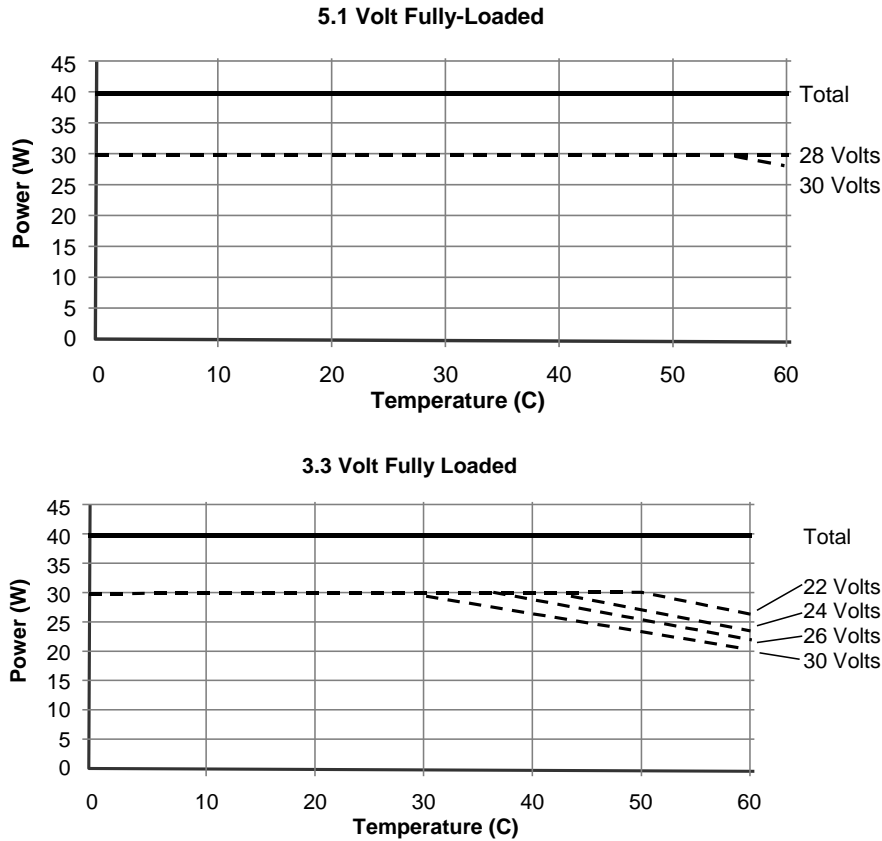


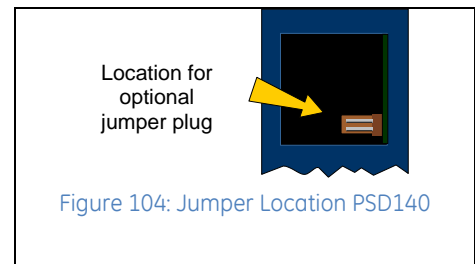
Figure 103: Thermal Derating Curves for PSD140

4.7.2.2 Over-Current Protection: PSD140

The 5.1Vdc output is electronically limited to 7 A. The 3.3Vdc output is limited to 10 A. If an overload (including short circuits) occurs, it is sensed internally and the power supply shuts down. Because it is designed for redundancy applications, this power supply latches OFF in fault conditions and will not automatically try to restart. Input power must be cycled to clear a latched fault.

An internal non-repairable fusible link in the input line is provided as a backup. The power supply usually shuts down before the fusible link blows. The fusible link also protects against internal supply faults. The CPU Fault Table shows a fault if any Over-temperature, Overload, or P/S Fault occurs. There is no additional indication if the power supply fusible link blows.

In a non-redundancy application, where automatic restarting may be appropriate, a jumper plug (or shunt) can be installed at the rear of the module as shown in Figure 104. The jumper plug must have 0.100 inch spacing on center and accommodate 0.25 inch pins. Example parts are Radio Shack DIP Programming Shunt #276-1512 and DIGI-Key #59000-ND. The module must be removed from the backplane to install the jumper plug.



4.7.3 Field Wiring: PSD140

4.7.3.1 Power Source and Ground Connections

The wires from the power source and ground connect to the terminals on the power supply as shown in Figure 105. Each terminal accepts one AWG 14 to AWG 24 wire.



Warning

If the same external DC power source is used to provide power to two or more power supplies in the system, connection polarity must be identical at each RX3i power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

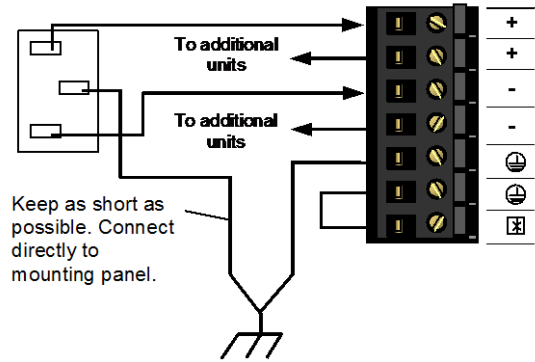


Figure 105: Field Wiring for PSD140

4.7.3.2 Input Over-Voltage Protection

The bottom terminal is normally connected to frame ground with a user-installed jumper as shown in Figure 106. If over-voltage protection is not required or is supplied upstream, no jumper is required.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the jumper. Re-enable over-voltage protection after testing by reinstalling the jumper.

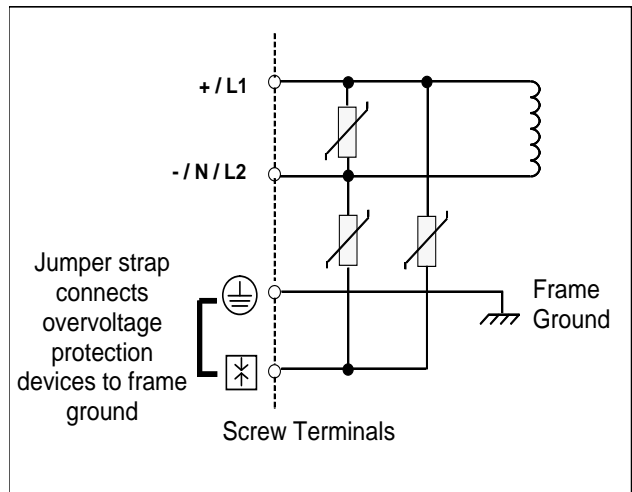


Figure 106: Over-Voltage Protection for PSD140



Warning

This power supply is not isolated and is therefore not compatible with floating or positive grounded systems.

4.8 Power Supply, 120/240 V ac or 125Vdc: IC694PWR321

Power Supply IC694PWR321 is a 30-Watt supply that operates from an input voltage source in the range of 85Vac to 264Vac or 100 V dc to 300 V dc.

This power supply provides three outputs:

- +5Vdc output
- Relay +24Vdc output that can be used to power circuits on Output Relay modules
- Isolated +24Vdc. This power is used internally by some modules. It can also be used to power field devices connected to 24Vdc Input modules

Power Supply IC694PWR321 can be used in an Expansion backplane in an RX3i system. The battery backup and serial port functions are not available in Expansion Backplanes.

4.8.1.1 LEDs

The green PWR LED shows the operating state of the Power Supply. PWR is ON when the power supply has a correct source of power and is operating properly. It is OFF when a power supply fault occurs or power is not applied.

The green OK LED is steady ON if the PLC is operating properly. It is OFF if a problem is detected by the PLC.

The green RUN LED is ON when the PLC is in Run mode.

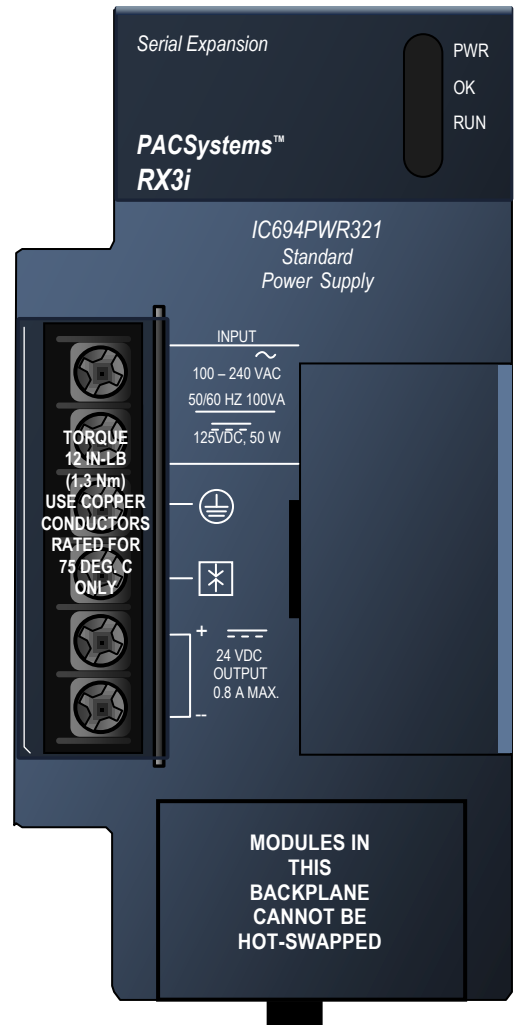


Figure 107: IC694PWR321

4.8.2 Specifications: PWR321

Nominal Rated Voltage	120/240 Vac or 125 Vdc
Input Voltage Range	
AC	85 Vdc to 264 Vac
DC	100 Vdc to 300 Vdc
Input Power (Maximum with Full Load)	90 VA with Vac Input 50 W with Vdc Input
Inrush Current ¹²	4 A peak, 250 ms maximum
Output Power	5Vdc and 24 Vdc Relay: 15 W maximum 24 Vdc Relay: 15 W maximum 24 Vdc Isolated: 20 W maximum <i>NOTE: 30 W maximum total (all three outputs)</i>
Output Voltage	5Vdc: 5.0 Vdc to 5.2 Vdc (5.1Vdc nominal) Relay 24 Vdc: 24 to 28 Vdc Isolated 24 Vdc: 21.5 to 28 Vdc
Isolation (input to backplane):	1500 Vac (for 1 minute)
Protective Limits	
Over-voltage:	5 Vdc output: 6.4 Vdc to 7Vdc
Over-current:	5 Vdc output: 4 A maximum
Ride-through Time:	20 ms minimum This is the length of time the power supply maintains valid outputs if the power source is interrupted.
Fuse	2 A, part number 44A724627-109. Refer to <i>Module Fuse List</i> , Section 2.6.4.11.

4.8.2.1 Over-Current Protection: PWR321

The 5 Vdc output is electronically limited to 3.5 A. If an overload (including short circuits) occurs, it is sensed internally and the power supply shuts down. The power supply continually tries to restart until the overload condition is removed. An internal replaceable fuse in the input line is provided as a backup. The power supply usually shuts down before the fuse blows. The fuse also protects against internal supply faults.



Warning

The door of the power supply module must be closed. During normal operation with an AC power source either 120 V ac or 240 V ac is present on the AC Power Supply. The door protects against accidental shock hazard that could cause severe or fatal injury to personnel.

¹² The Inrush Current specification is given as a guide for sizing the external power source for the IC695PWR321. Peak inrush current may be higher for shorter durations.

4.8.3 Field Wiring: PWR321

4.8.3.1 AC Power Source Connections

The Hot, Neutral, and Ground wires from the 120 V ac power source or L1, L2, and Ground wires from the 240 V ac power source connect to the top three terminals on the Power Supply.

4.8.3.2 DC Power Source Connections

Connect the + and - wires from the 125Vdc power source to the top two terminals. These connections are not polarity-sensitive on power supply PWR321.

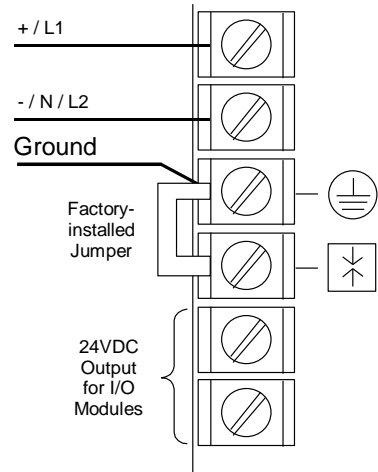


Figure 108: Field Wiring for PWR321

Warning



If the same external DC power source is used to provide power to two or more power supplies in the system, connection polarity must be identical at each RX3i power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

The bottom two terminals of the power supply terminal strip provide output connections to the Isolated +24Vdc. This output can be used to provide power for external circuits (within limitations of the power supply).



Caution

If the Isolated 24Vdc supply is overloaded or shorted, the PLC will stop operation.

4.8.3.3 Input Over-Voltage Protection: PWR321

Terminal 4 is normally connected to frame ground (terminal 3) with a factory-installed jumper strap, as shown in Figure 109. If over-voltage protection is not required or is supplied upstream, this feature can be disabled by removing the jumper.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the terminal strip jumper. Re-enable over-voltage protection after testing by reinstalling the strap.

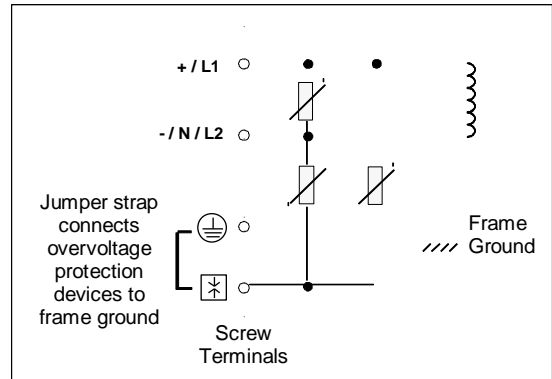


Figure 109: Over-Voltage Protection for PWR321

In systems with a floating neutral input (Figure 83 - the neutral line is not referenced to Protective Earth Ground), this jumper must NOT be installed. In a floating neutral system, voltage surge protection devices such as MOVs **must** be installed from L1 to earth ground, and from L2 (Neutral) to earth ground, as discussed in *Special Instructions for Floating Neutral Systems*, Section 4.3.1.

4.9 Power Supply, 120/240 V ac or 125Vdc High Capacity: IC694PWR330

High Capacity Power Supply IC694PWR330 is rated for 30 W. It allows all 30 W to be consumed from the +5Vdc output. This power supply operates from an input voltage source in the range of 85 to 264Vac or 100 to 300 V dc.

PWR330 Power supplies provide the following outputs:

- +5Vdc output
- Relay +24Vdc which provides power to circuits on Output Relay modules
- Isolated +24Vdc, which is used internally by some modules, can also be used to provide external power for 24Vdc Input modules

Power Supply IC694PWR330 must be installed in an Expansion backplane in an RX3i system. The battery backup and serial port functions are not available in Expansion Backplanes.

4.9.1.1 LEDs

The green PWR LED shows the operating state of the Power Supply. PWR is ON when the power supply has a correct source of power and is operating properly. It is OFF when a Power Supply fault occurs or power is not applied.

The green OK LED is steady ON if the PLC is operating properly. It is OFF if a problem is detected by the PLC.

The green RUN LED is ON when the PLC is in Run mode.

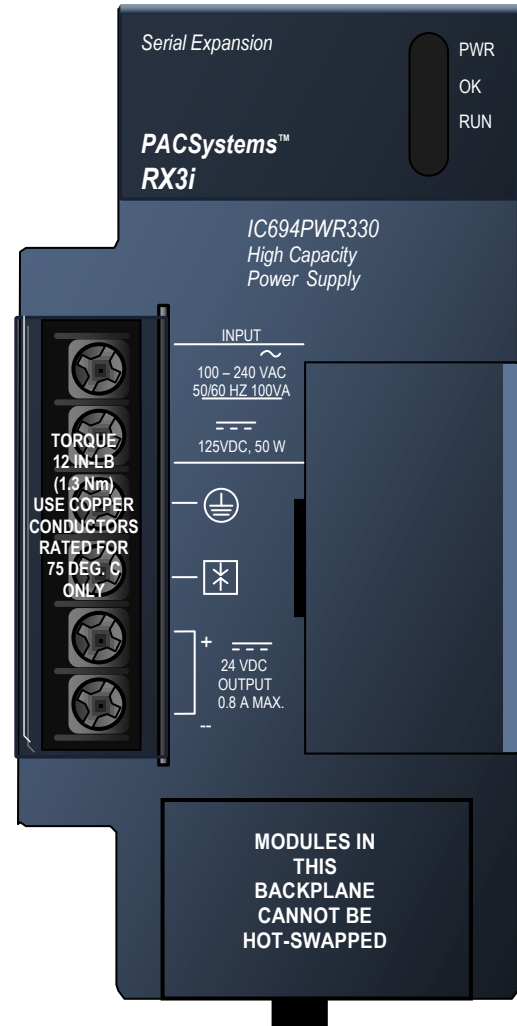


Figure 110: IC694PWR330

4.9.2 Specifications: PWR330

Nominal Rated Voltage Input Voltage Range AC DC	120/240 Vac or 125 Vdc 85 Vac to 264 Vac 100 Vdc to 300 Vdc
Input Power (Maximum with Full Load) Inrush Current ¹³	100 VA with Vac Input 50 W with Vdc Input 4 A peak, 250ms maximum
Output Power	5 Vdc: 30 W maximum 24 Vdc Relay: 15 W maximum 24 Vdc Isolated: 20 W maximum <i>NOTE: 30 W maximum total (all three outputs)</i>
Output Voltage	5 Vdc: 5.0 to 5.2 Vdc (5.1 Vdc nominal) 24 Vdc Relay: 24 to 28 Vdc 24 Vdc Isolated: 21.5 to 28 Vdc
Isolation (input to backplane)	1500 Vac (for 1 minute)
Protective Limits Over-voltage: Over-current:	5 Vdc output: 6.4 to 7 Vdc 5 Vdc output: 7 A maximum
Ride-through Time	20 ms minimum is the length of time the power supply maintains valid outputs if the power source is interrupted.
Fuse	2 A, GE part number 44A724627-109. Refer to <i>Module Fuse List</i> , Section 2.6.4.11.

4.9.2.1 Over-Current Protection

The 5 Vdc output is electronically limited to 7 Amps. If an overload (including short circuits) occurs, it is sensed internally and the power supply shuts down. The power supply continually tries to restart until the overload condition is removed. An internal replaceable fuse in the input line is provided as a backup. The power supply usually shuts down before the fuse blows. The fuse also protects against internal supply faults.



Warning

The door of the power supply module must be closed. During normal operation with an AC power source either 120 V ac or 240 V ac is present on the AC Power Supply. The door protects against accidental shock hazard that could cause severe or fatal injury to personnel.

¹³ The Inrush Current specification is given as a guide for sizing the external power source for the IC695PWR330. Peak inrush current may be higher for shorter durations.

4.9.3 Field Wiring: PWR330

4.9.3.1 AC Power Source Connections

The Hot, Neutral, and Ground wires from the 120 V ac power source or L1, L2, and Ground wires from the 240 V ac power source connect to the top three terminals on the Power Supply.

4.9.3.2 DC Power Source Connections

Connect the + and - wires from the 125Vdc power source to the top two terminals. These connections are not polarity-sensitive on Power Supply PWR330.

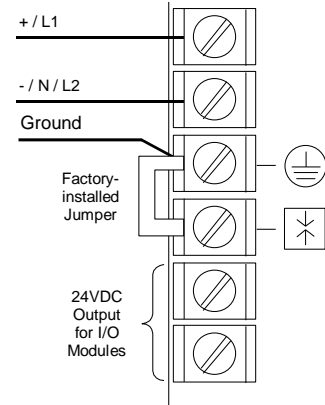


Figure 111: Field Wiring for PWR330

Warning



If the same external DC power source is used to provide power to two or more power supplies in the system, connection polarity must be identical at each RX3i power supply. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

The bottom two terminals of the power supply terminal strip provide output connections to the Isolated +24Vdc. This output can be used to provide power for external circuits (within power limitations of the supply).



Caution

If the Isolated 24Vdc supply is overloaded or shorted, the PLC will stop operation.

4.9.3.3 Input Over-Voltage Protection

Terminal 4 is normally connected to frame ground (terminal 3) with a factory-installed jumper strap. If over-voltage protection is not required or is supplied upstream, this feature can be disabled by removing the jumper.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the terminal strip jumper. Re-enable over-voltage protection after testing by reinstalling the strap.

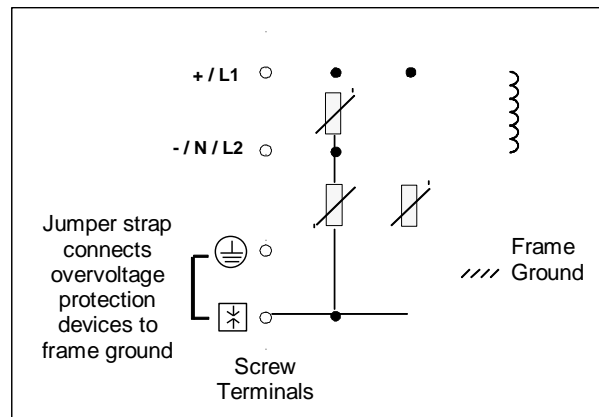


Figure 112: Over-Voltage Protection for PWR330

In systems with a floating neutral input (Figure 83 - the neutral line is not referenced to Protective Earth Ground), this jumper must NOT be installed. In a floating neutral system, voltage surge protection devices such as MOVs **must** be installed from L1 to earth ground, and from L2 (Neutral) to earth ground, as discussed in *Special Instructions for Floating Neutral Systems*, Section 4.3.1.

4.10 Power Supply, 24Vdc High-Capacity: IC694PWR331

High Capacity Power Supply IC694 PWR331 is rated for 30 W output. For applications requiring greater +5Vdc current capacity than is available with a standard supply (PWR321), a High-Capacity Power Supply allows all 30 W to be consumed from the +5Vdc supply. This supply can operate from an input voltage source in the range of 12Vdc to 30 V dc. Although it is capable of maintaining all outputs within specifications with input voltages as low as 12Vdc, it requires an initial input voltage of 18Vdc to start up.

PWR331 Power supplies provide the following outputs:

- +5Vdc output
- Relay +24Vdc, which provides power to circuits on Output Relay modules
- Isolated +24Vdc, which is used internally by some modules, can also be used to provide external power for 24Vdc Input modules

Power Supply IC694PWR331 must be installed in an Expansion backplane in an RX3i system. The battery backup and serial port functions are not available in Expansion Backplanes.

4.10.1.1 LEDs

The green PWR LED shows the operating state of the Power Supply. PWR is ON when the power supply has a correct source of power and is operating properly. It is OFF when a power supply fault occurs or power is not applied.

The green OK LED is steady ON if the PLC is operating properly. It is OFF if a problem is detected by the PLC.

The green RUN LED is ON when the PLC is in Run mode.

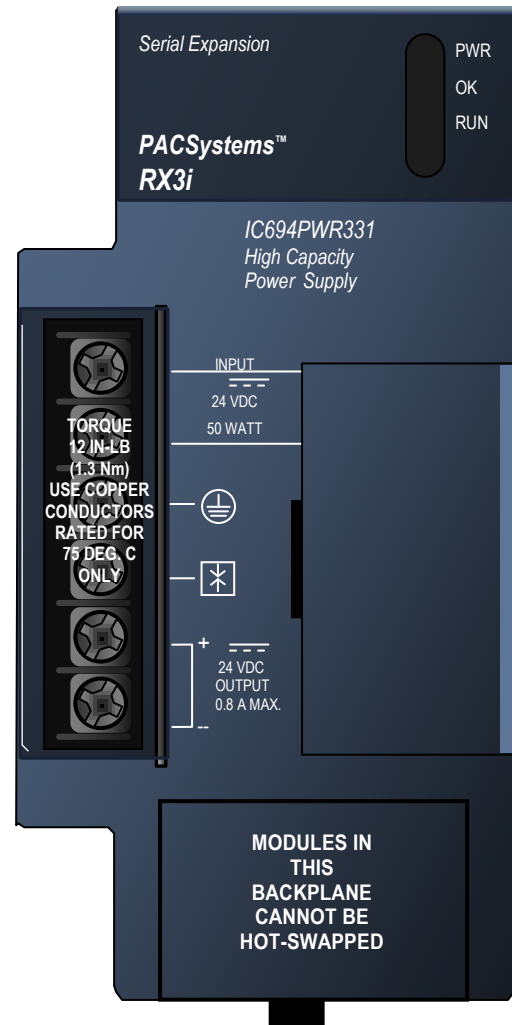


Figure 113: IC694PWR331

4.10.2 Specifications: PWR331

Nominal Rated Voltage	24 Vdc
Input Voltage Range	18 to 30 Vdc
Start	18 to 30 Vdc
Run	12 to 30 Vdc
Input Power	50 W maximum at full load
Inrush Current ¹⁴	4 A peak, 100 ms, maximum
Output Power	5 Vdc: 30 W maximum (Derate per Figure 114) 24 Vdc Relay: 15 W maximum 24 Vdc Isolated: 20 W maximum <i>NOTE: 30 W maximum total (all three outputs)</i>
Output Voltage	5 Vdc: 5.0 to 5.2 Vdc (5.1 Vdc nominal) 24 Vdc Relay: 19.2 to 28.8 Vdc 24 Vdc Isolated: 19.2 to 28.8 Vdc
Isolation (input to backplane)	1500 Vac (for 1 minute)
Protective Limits	
Over-voltage;	5 Vdc output: 6.4 to 7 Vdc
Over-current;	5 Vdc output: 7 A maximum
Ride-through Time:	10 ms minimum. This is the length of time the power supply maintains valid outputs if the power source is interrupted
Fuse	5 A, GE part number 44A724627-114. Refer to <i>Module Fuse List</i> , Section 2.6.4.11.

4.10.2.1 Thermal Derating: PWR331

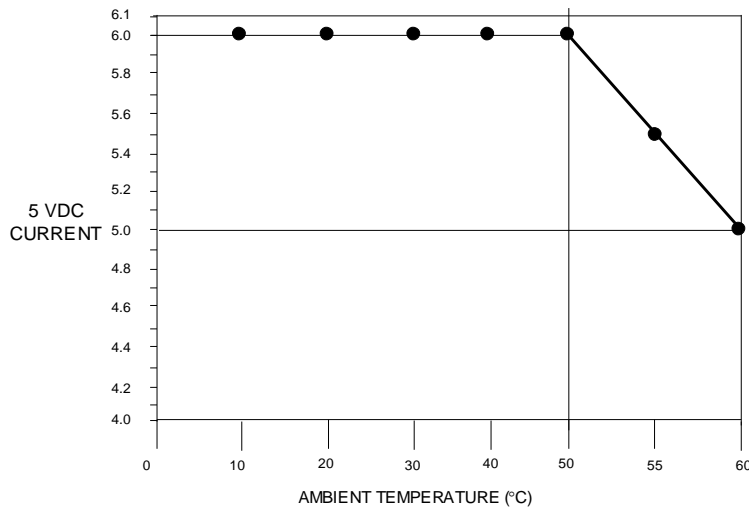


Figure 114: Thermal Derating Curve for 5Vdc Output PWR331

¹⁴ The Inrush Current specification is given as a guide for sizing the external power source for the IC695PWR331. Peak inrush current may be higher for shorter durations.

4.10.2.2 *Over-Current Protection: PWR331*

The 5 Vdc output is electronically limited to 7 A. If an overload (including short circuits) occurs, it is sensed internally and the power supply shuts down. The power supply continually tries to restart until the overload condition is removed. An internal replaceable fuse in the input line is provided as a backup. The power supply usually shuts down before the fuse blows. The fuse also protects against internal supply faults.

4.10.2.3 *Calculating Input Power Requirements: PWR331*

Use the following procedure to determine input power requirements for the 24Vdc High Capacity Power Supply:

- Determine total output power load from typical specifications listed for individual modules in this chapter
- Multiply the output power by 1.5 to determine the input power value
- Divide the input power value by the operating source voltage to determine the input current requirements
- Use the lowest input voltage to determine the maximum input current
- Allow for start-up surge current requirements
- Allow margins (10% to 20%) for variations

4.10.3 Field Wiring: PWR331

The + wire connects to the top terminal screw, and the - wire connects to the second. These connections are polarity-sensitive for PWR331. Ground connects to the third screw.



Warning

If the same external DC power source is used to provide power to two or more power supplies in the system, connection polarity must be identical at each power supply. Do not cross the Positive (+) and Negative (-) lines. A resulting difference in potential can injure personnel or cause damage to equipment. Also, each backplane must be connected to a common system ground.

The bottom two terminals of the power supply terminal strip provide connections to the Isolated +24Vdc output. This output can be used to provide power for external circuits (within power limitations of the supply).



Caution

If the Isolated 24Vdc supply is overloaded or shorted, the PLC will stop operation.

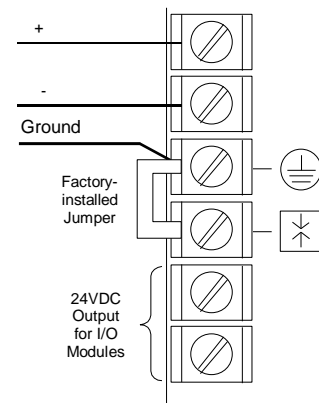


Figure 115: Field Wiring for PWR331

4.10.3.1 Input Over-Voltage Protection

Terminal 4 is normally connected to frame ground (terminal 3) with a factory-installed jumper strap, as shown in Figure 116. If over-voltage protection is not required or is supplied upstream, this feature can be disabled by removing the jumper.

To Hi-pot test this supply, over-voltage protection must be disabled during the test by removing the terminal strip jumper. Re-enable over-voltage protection after testing by reinstalling the jumper.

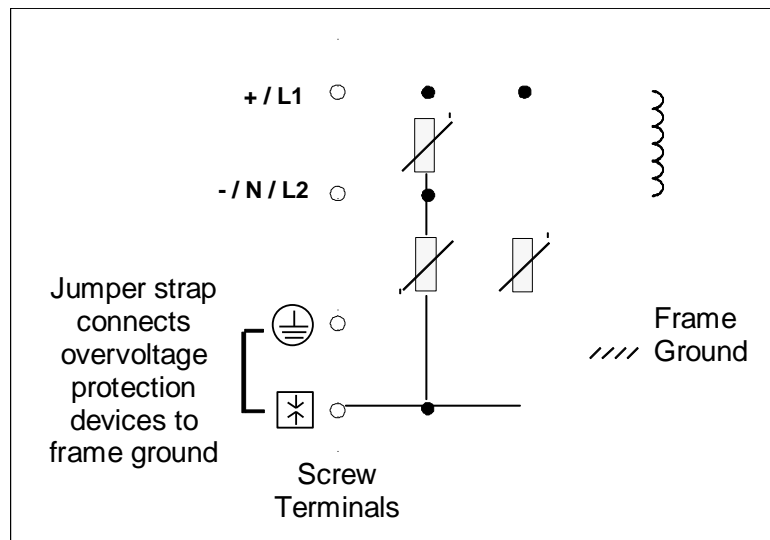


Figure 116: Over-Voltage Protection for PWR331

Chapter 5 Serial Bus Transmitter & Expansion Cables

This chapter describes the serial expansion module and expansion cables for PACSystems RX3i controllers. It also gives specifications for building custom expansion cables.

Description	Catalog Number	Section
Serial Bus Transmitter Module	IC695LRE001	5.1
Expansion Cable, Wye, 1m (3 ft) Length	IC693CBL300	5.2.2
Expansion Cable, Wye, 2m (6 ft)	IC693CBL301	5.2.2
Expansion Cable, 2 Connectors, Built-in Terminating Resistor, 15m (50 ft)	IC693CBL302	5.2.1
Expansion Cable, Wye, 0.15m (0.5 ft)	IC693CBL312	5.2.2
Expansion Cable, Wye, 8m (25 ft)	IC693CBL313	5.2.2
Termination Resistor Pack	IC693ACC307	5.3.3

5.1 Serial Bus Transmitter Module: IC695LRE001

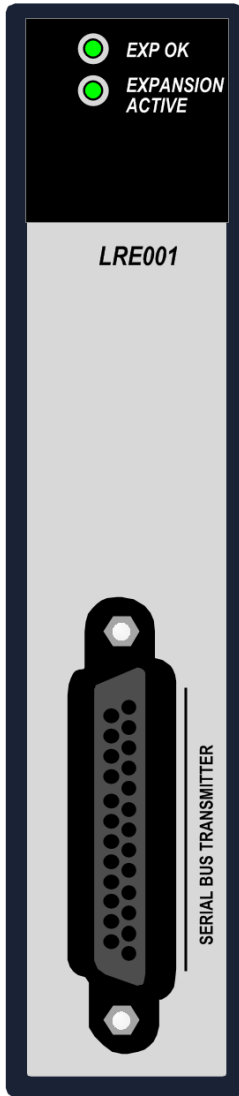


Figure 117: IC695LRE001

The RX3i Serial Bus Transmitter Module, IC695LRE001, provides communications between a PACSystems RX3i Universal Backplane (IC695-model number), and serial expansion and remote backplanes (IC694- or IC693-model numbers). It converts the signal levels present in the Universal Backplane to the signal levels required by a Serial Expansion Backplane.

The Serial Bus Transmitter Module must reside in the special expansion connector on the right end of the Universal Backplane.

Two green LEDs indicate the operating status of the module and the status of the expansion link.

- The EXP OK LED is lit when backplane 5Vdc power is applied to the module.
- The Expansion Active LED indicates the status of the expansion bus. This LED is ON when the Expansion module is communicating with expansion backplanes. It is OFF when they are not communicating.

The connector on the front of the module is used to attach the expansion cable.

5.1.1 Specifications: LRE001

Current Required from Backplane	5.0 Vdc: 132mA 3.3 Vdc: 0 mA
Maximum Total Expansion Cable Length	15 m (50 ft) – Expansion Backplanes 213 m (700 ft) – Remote Backplanes
Effective Data Rate	500 k Bytes per second if the expansion bus includes Remote backplanes
Electrical Isolation	Non-isolated differential communications

For product standards and general specifications, refer to *Appendix A*.

5.1.2 Expansion Module Installation

The Serial Bus Transmitter Module (LRE001) resides in the special expansion connector located on the right-hand end of the 12- or 16-slot RX3i Universal Backplane. It does not latch into the backplane. Secure LRE001 with the captive screws supplied (Figure 118).

This module may NOT be hot-inserted in the backplane; power must be removed before installing or removing the Expansion Module. In addition, the expansion cable may not be attached or removed while the expansion rack has power applied.

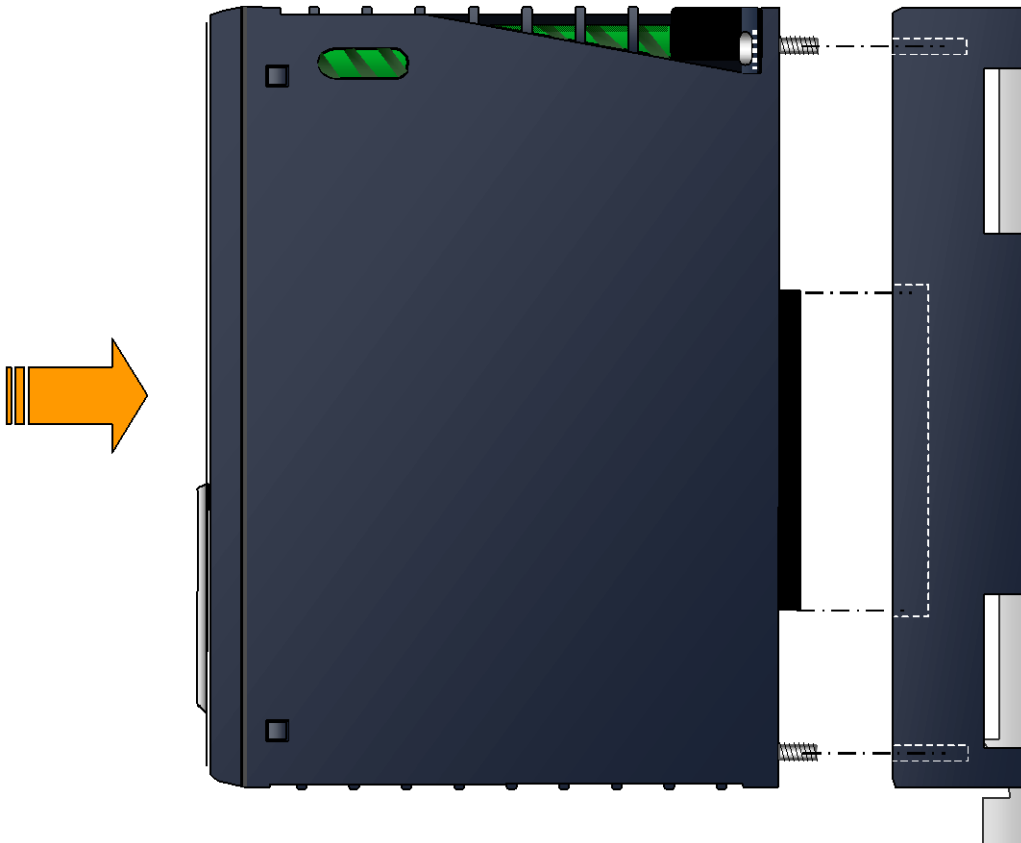


Figure 118: Install LRE001 in Rightmost Connector & Secure with Captive Screws

5.1.3 Powering Down Individual Expansion or Remote Backplanes

Expansion and Remote Backplanes can be powered down individually without affecting the operation of other backplanes; however, powering off a backplane generates a loss of module (LOSS_OF_MODULE) fault in the PLC Fault Table for each module in the backplane. When this fault condition occurs, and until the backplane is powered back on and all modules recovered, the lost I/O modules are not scanned.

5.2 I/O Bus Expansion Cables: IC693CBL300, 301, 302 ,312, 313

I/O Bus Expansion Cables are used to connect a Serial Bus Transmitter Module (IC695LRE001) in a Universal Backplane (IC695CHS012 or IC695CHS016) to a Serial Expansion Backplane (IC694CHS392, IC694CHS398, IC693CHS392 or IC693CHS398).

These cables are also used to interconnect additional expansion and remote backplanes (as listed above) in the RX3i system.

Several lengths and configurations of prefabricated cables are available (part numbers IC693CBL300, IC693CBL301, IC693CBL302, IC693CBL312, and IC693CBL313), as described in this section.

The prefabricated cables described in this section are made with a *continuous*, 100% shield. The braided cable shield is connected to the metal shell of the connector around the entire perimeter of the connector. That provides a low-impedance path to frame ground for any noise energy that is coupled onto the cable shield.

5.2.1 Cable with Two Connectors: IC693CBL302

Cable IC693CBL302 (shown in Figure 119) is 15 meters (50 feet) long and has one male connector on each end. This cable has I/O bus terminating resistors built into the end connector on the cable.

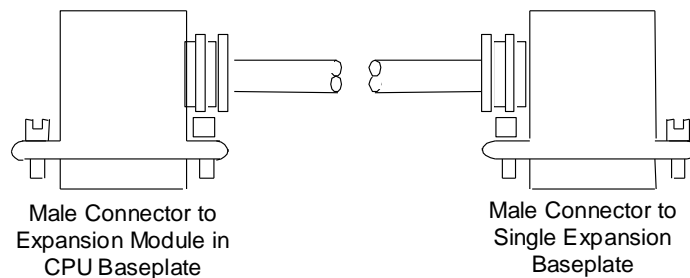


Figure 119: Cable IC693CBL302

This cable does not require a separate termination block. It can only be used in a system with just one expansion backplane (Figure 120).

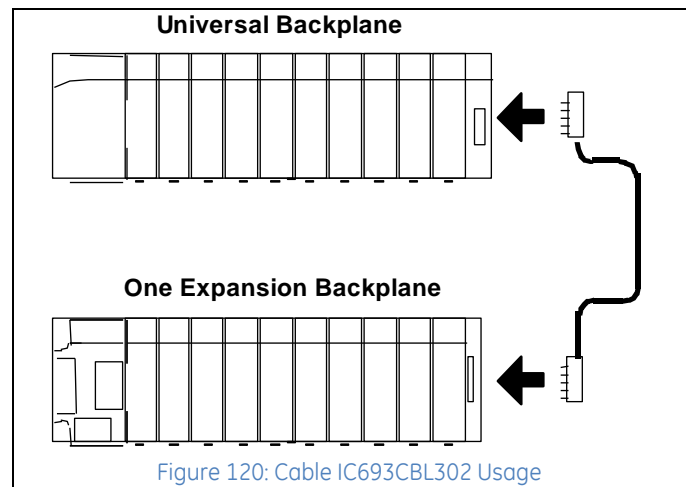


Figure 120: Cable IC693CBL302 Usage

5.2.2 Cables with Three Connectors: IC693CBL300, 301, 312, 313

Cables IC693CBL300, IC693CBL301, IC693CBL312, and IC693CBL313 (shown in Figure 121) have a male and female connector on one end and a male connector on the other end (“wye” cables).

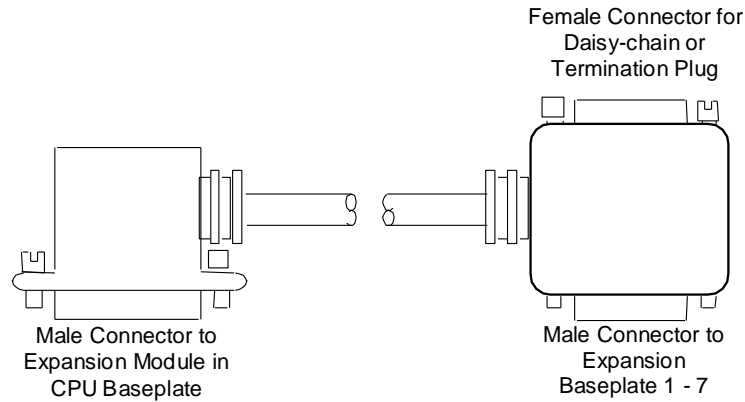


Figure 121: Cables IC693CBL300, IC693CBL301, IC693CBL312, or IC693CBL313

These cables are the same except for their lengths:

- IC693CBL312: 0.15 m (0.5 ft)
- IC693CBL300: 1 m (3 ft)
- IC693CBL301: 2 m (6 ft)
- IC693CBL313: 8 m (25 ft)

Combinations of these cables can be used to daisy-chain up to seven expansion backplanes to the main backplane (Figure 122). Custom cables can also be made. Wiring information is given in this section.

These cables can also be used to provide connection points for custom point-to-point cables (IC693CBL300 is often used for this).

These cables do not have built-in termination. The last cable in the expansion system must be terminated as displayed in bottom right of Figure 122. Terminator Plug IC693ACC307 can be used for this purpose.

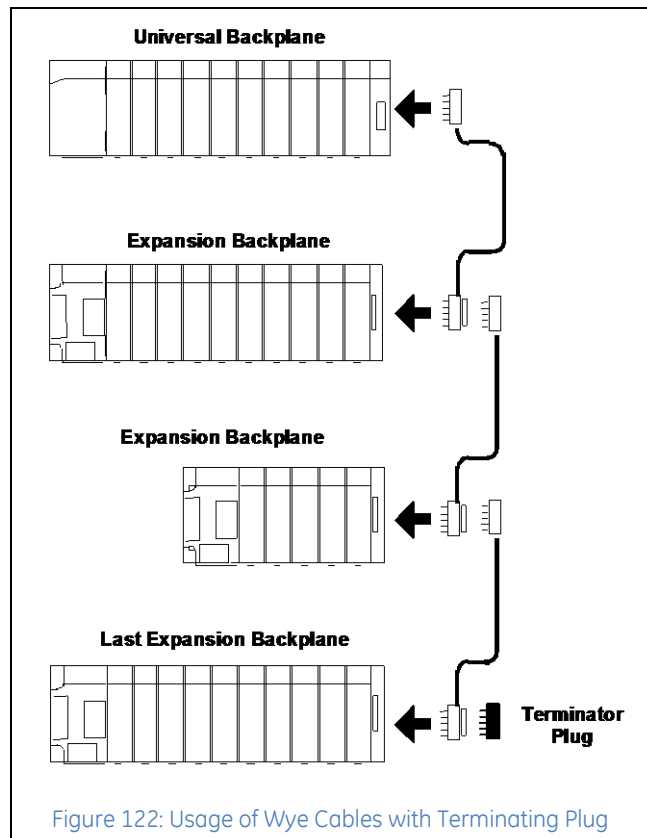


Figure 122: Usage of Wye Cables with Terminating Plug

The maximum number of cables that can be included in an I/O expansion system is seven, and the total maximum cable length between the Universal Backplane and the last expansion backplane is 15 m (50 ft). Failure to observe these limits could result in erratic system operation.

5.3 Specifications: IC693CBL300, 301, 302, 312, 313

Cable	Belden 8107 only (no substitutes): Computer cable, overall braid over foil shield, twisted-pair 30 volt/80°C (176°F) 24 AWG (.22mm ²) tinned copper, 7 x 32 stranding Velocity of propagation = 70% Nominal impedance = 100Ω
25-Pin Male Connector	Crimp Plug = Amp 207464-7; Pin = Amp 66506-9 Solder Plug = Amp 5-747912-2
25-Pin Female Connector	Crimp Receptacle = Amp 207463-1; Pin = Amp 66504-9 Solder Receptacle = Amp 5-747913-2
Connector Shell	Kit - Amp 5745833-5: Metal-plated plastic (plastic with nickel over copper) Crimp ring - Amp 745508-1, split ring ferrule

Connector part numbers are provided for reference only. Any part meeting the same specifications could be used for making custom cables.

5.3.1 Expansion Port Pin Assignments

All connections between cables are point-to-point, that is, pin 2 of one end to pin 2 of the opposite end, pin 3 to pin 3, and such.

Pin Number	Signal Name	Function	Termination Pairings
16	DIODT	I/O Serial Data Positive	}
17	DIODT/	I/O Serial Data Negative	
24	DIOCLK	I/O Serial Clock Positive	}
25	DIOCLK/	I/O Serial Clock Negative	
20	DRSEL	Remote Select Positive	}
21	DRSEL/	Remote Select Negative	
12	DRPERR	Parity Error Positive	}
13	DRPERR/	Parity Error Negative	
8	DRMRUN	Remote Run Positive	}
9	DRMRUN/	Remote Run Negative	
2	DFRAME	Cycle Frame Positive	}
3	DFRAME/	Cycle Frame Negative	
1	FGND	Frame Ground for Cable Shield	
7	0V	Logic Ground	

The I/O expansion bus *must be terminated* at the last backplane in an expansion system. Each signal pair must be terminated with 120Ω, ¼-watt resistors wired between the appropriate pins, as indicated by the brackets above:

16 - 17; 24 - 25; 20 - 21; 12 - 13; 8 - 9; 2 - 3.

5.3.2 Building Custom Cables

For custom length cables, the best noise immunity is achieved when using a metalized connector cover that makes contact with the braided wires and foil shield in the cable and with the connector shell on the terminating end. *It is not sufficient* to only solder the drain wire to the connector shell. The shield must be continuous across the entire length of the cable, including at the terminations.

When using 100% shielded cables all CPU and expansion backplanes in the system must be solidly referenced to the same ground point or a potential difference between backplanes could disturb signal transmission.

Use the following steps to build a 100% shielded cable:

1. Strip approximately 5/8 inch of insulation from the cable to expose the shield.
2. Put a split-ring ferrule over the cable insulation.
3. Fold the shield back over the top of the cable insulation and ferrule.

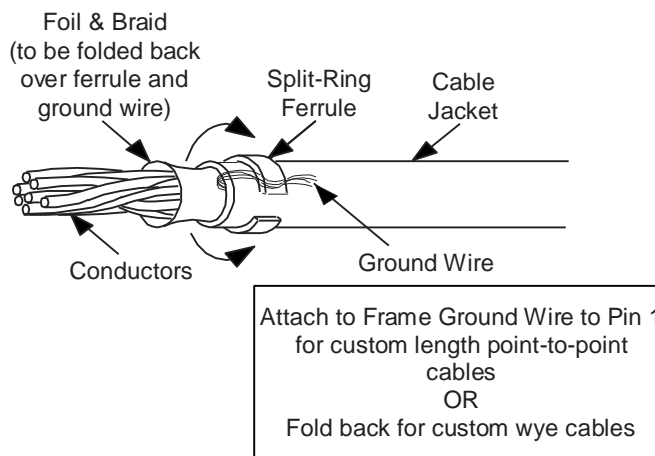
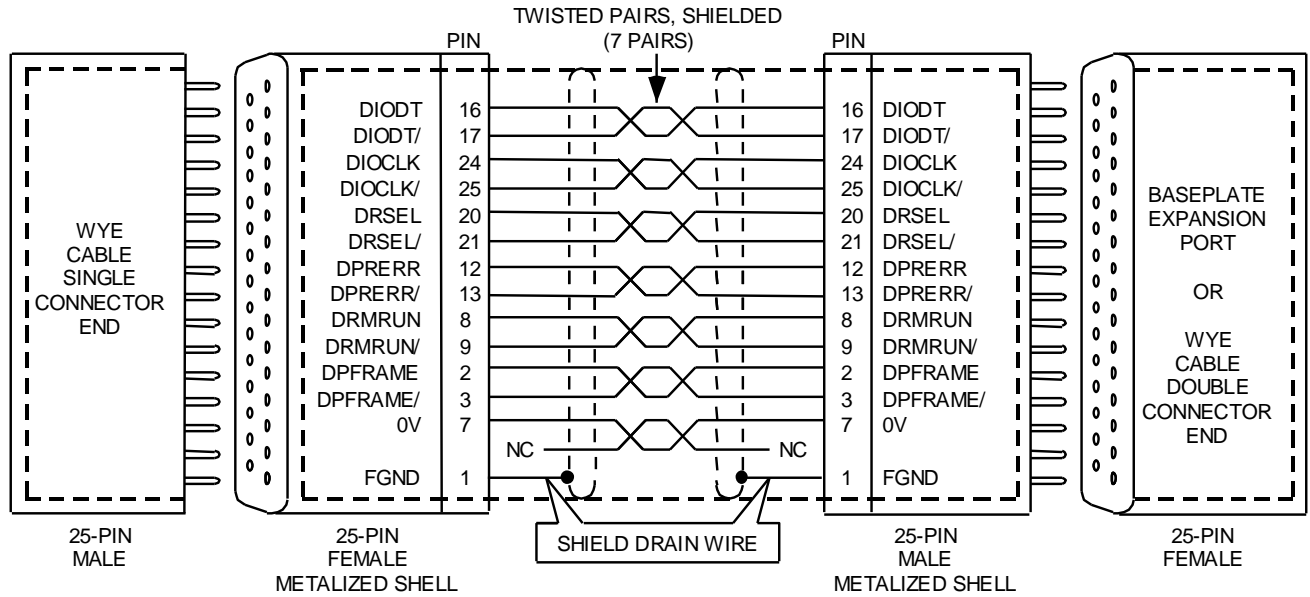


Figure 123: Construction of a Custom Shielded Cable

4. Place the collar of the metal hood over the top of the folded shield, and securely clamp the hood.
5. Test the cable for continuity between both connector shells. Connect an ohmmeter between the shells and flex the cable at both ends. If the metallic connector hood is not making proper contact with the cable shield at either end, the connection will show intermittent continuity on the ohmmeter.
6. Plug the metal hooded cable into an expansion port and securely tighten the two screws. Installing and tightening the screws electrically connects the shield to the backplane frame ground, which should be connected to earth ground.

5.3.2.1 Cable with Continuous Shielding



NOTE: Bold dashed line shows continuous (100%) shielding when metallized shell connectors are plugged together.

Figure 124: Wiring Diagram - Cable with Continuous Shielding

5.3.2.2 Cable for Applications Requiring Less Noise Immunity

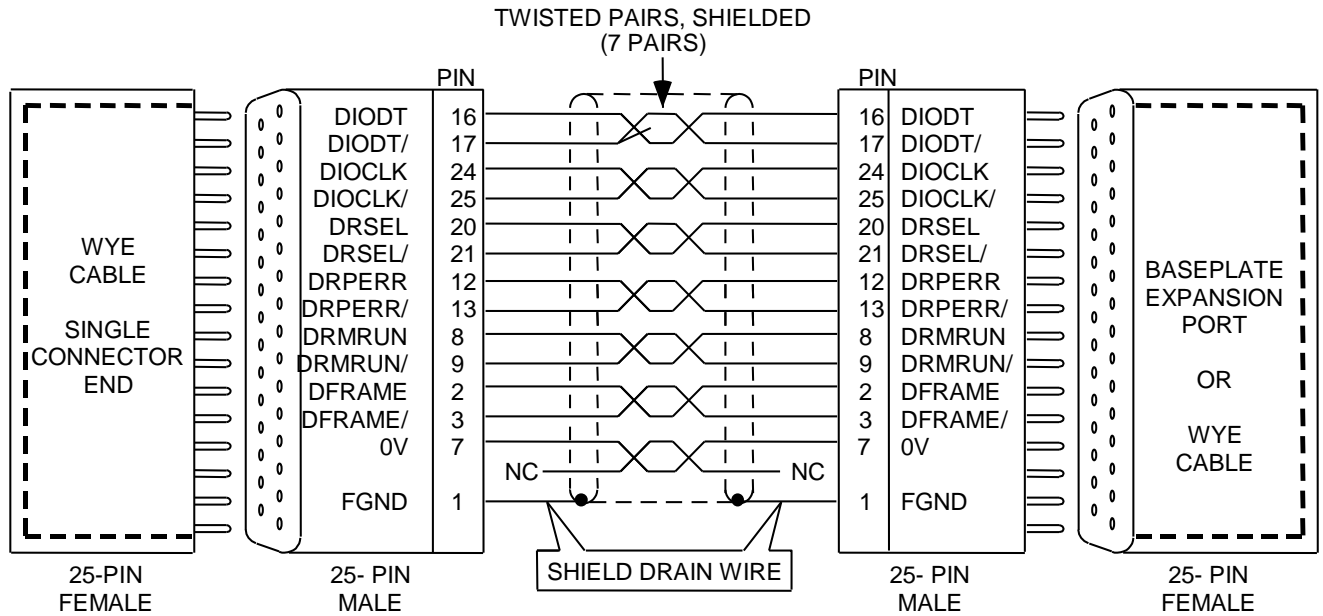


Figure 125: Wiring Diagram - Cable without Continuous Shielding

5.3.3 Termination Requirement for Expansion or Remote System

When two or more backplanes are connected via the I/O Bus Expansion System, the I/O Expansion Bus must be properly terminated. The most common method of terminating the I/O Expansion Bus is by installing a termination resistor pack (IC693ACC307) on the open connector on the last (i.e. most distant from the CPU) expansion or remote backplane in the system.

The resistor pack is physically mounted inside of a connector. Although a termination resistor pack is shipped with each backplane, only the last backplane in the chain needs to have this termination connector installed. Unused termination packs may be discarded. The prewired 50 foot (15 meter) cable (IC693CBL302) has termination resistors wired inside the connector on one end of the cable. This cable can be used if only one expansion rack is needed in a system and a 50-foot cable link is required (the IC693ACC307 resistor pack is not needed in this case). Also, a custom-built cable with built-in resistors would eliminate the need for the IC693ACC307 resistor pack.

Chapter 6 Discrete Input Modules

This chapter describes discrete input modules for PACSystems RX3i systems.

Discrete Input Module Description	Catalog Number	Section
Input 120 V ac 8-Pt Isolated	IC694MDL230	6.1
Input 240 V ac 8-Pt Isolated	IC694MDL231	6.2
Input 120 V ac 16-Pt	IC694MDL240	6.3
Input 24Vac/Vdc 16-Pt Pos/Neg Logic	IC694MDL241	6.4
Input 120 V ac 16-Pt Isolated	IC694MDL250	6.5
Input 120 V ac 32-Pt Grouped	IC694MDL260	6.6
Input 125Vdc 8-Pt Pos/Neg Logic	IC694MDL632	6.7
Input 24Vdc 8-Pt Pos/Neg Logic	IC694MDL634	6.8
Input 125Vdc 16-Pt Pos/Neg Logic	IC694MDL635	6.9
Input 24Vdc 16-Pt Pos/Neg Logic	IC694MDL645	6.10
Input 24Vdc 16-Pt Pos/Neg Logic Fast	IC694MDL646	6.11
Input 48Vdc, 16-Pt Isolated Pos/Neg Logic	IC694MDL648	6.12
Input 5/12Vdc (TTL) 32-Pt Pos/Neg Logic	IC694MDL654	6.13
Input 24Vdc 32-Pt Pos/Neg Logic	IC694MDL655	6.13
Input 48Vdc 32-Pt Pos/Neg Logic	IC694MDL658	6.13
Input 24Vdc 32-Pt Pos/Neg Logic	IC694MDL660	6.14
Input 24Vdc 16-Pt Pos Logic with Diagnostics	IC695MDL664	6.15
Input Simulator Module	IC694ACC300	6.16

6.1 Input Module, 120 V ac, 8-Point Isolated: IC694MDL230

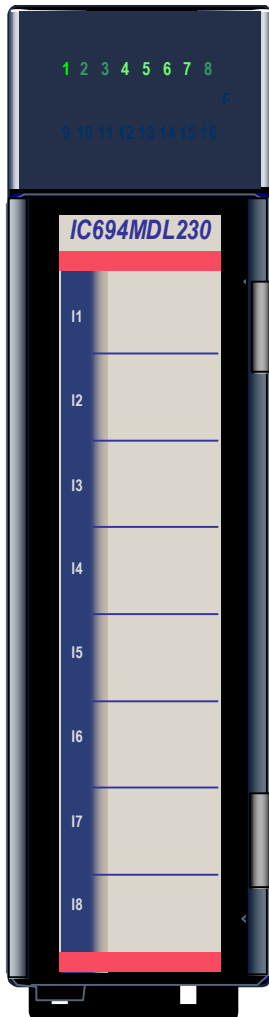


Figure 126: IC694MDL230

The **120 V ac Isolated Input** module, IC694MDL230, provides eight isolated input points, each with a common power input terminal. Because the inputs are isolated, each input can be powered by a separate AC power source.

The input circuits are reactive (resistor/capacitor) inputs. Current into an input point results in a logic 1 in the input status table (%I). Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Power to operate the field devices must be supplied by the user. This module requires an AC power source; *it cannot be used with a DC power source.*

Eight green LEDs indicate the ON/OFF status of points 1 through 8. The red bands on the label show that MDL230 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.1.1 Specifications: MDL230

Rated Voltage	120 Vac, 50/60 Hz
Input Voltage Range	0 to 132 Vac, 50/60 Hz
Inputs per Module	8 (each input point has a separate common)
Isolation:	
Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Point to Point	250 Vac continuous; 1500 Vac for one minute
Input Current	14.5 mA (typical) at rated voltage
Input Characteristics:	
On-state Voltage	74 to 132 Vac
Off-state Voltage	0 to 20 Vac
On-state Current	6 mA minimum
Off-state Current	2.2 mA maximum
On response Time	30 ms maximum
Off response Time	45 ms maximum
Power Consumption	60 mA (all inputs on) sourced from 5 Vdc bus on backplane

For product standards and general specifications, refer to Appendix A.

6.1.2 Field Wiring: MDL230

Terminals	Connections
1	No connection
2	Input 1
3	Input 1 Return
4	Input 2
5	Input 2 Return
6	Input 3
7	Input 3 Return
8	Input 4
9	Input 4 Return
10	No connection
11	No connection
12	Input 5
13	Input 5 Return
14	Input 6
15	Input 6 Return
16	Input 7
17	Input 7 Return
18	Input 8
19	Input 8 Return
20	No connection

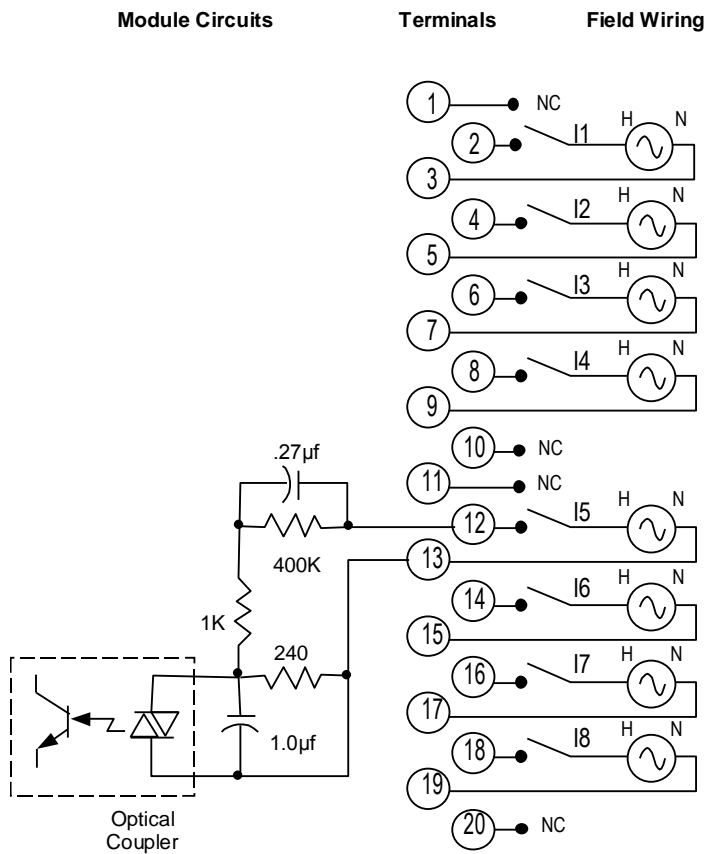


Figure 127: Field Wiring MDL230

6.2 Input Module, 240 V ac, 8-Point Isolated: IC694MDL231

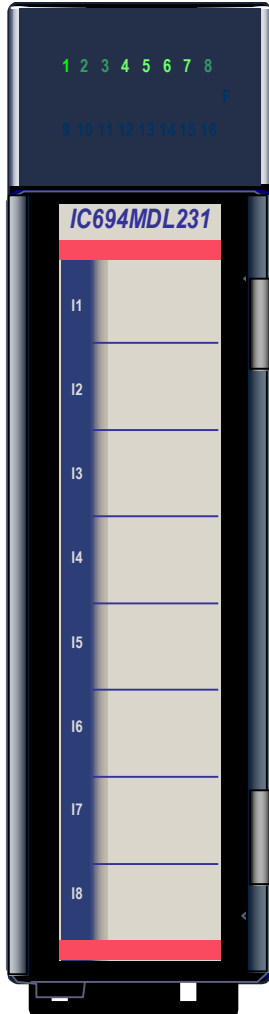


Figure 128: IC694MDL231

The **240 V ac Isolated Input** module, IC694MDL231, provides eight isolated input points, each with a common power input terminal. The input circuits are reactive (resistor/capacitor) inputs. Current into an input point results in a logic 1 in the input status table (%I). Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches.

Because the inputs are isolated, each input can be powered by a separate AC power source. Power to operate the field devices must be supplied by the user. This module requires an AC power source; *it cannot be used with a DC power source.*

Eight green LEDs indicate the ON/OFF status of points 1 through 8. The red bands on the label show that MDL231 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.2.1 Specifications: MDL231

Rated Voltage	240 Vac, 50/60 Hz
Input Voltage Range	0 to 264 Vac, 50/60 Hz
Inputs per Module	8 (each input point has a separate common)
Isolation:	
Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Point to Point	250 Vac continuous; 1500 Vac for one minute
Input Current	15 mA (typical) at rated voltage
Input Characteristics:	
On-state Voltage	148 to 264 Vac
Off-state Voltage	0 to 40 Vac
On-state Current	6 mA minimum
Off-state Current	2.2 mA maximum
On response Time	30 ms maximum
Off response Time	45 ms maximum
Power Consumption	60mA (all inputs on) from 5 Vdc bus on backplane

For product standards and general specifications, refer to *Appendix A*.

6.2.2 Field Wiring: MDL231

Terminals	Connections
1	No connection
2	Input 1
3	Input 1 Return
4	Input 2
5	Input 2 Return
6	Input 3
7	Input 3 Return
8	Input 4
9	Input 4 Return
10	No connection
11	No connection
12	Input 5
13	Input 5 Return
14	Input 6
15	Input 6 Return
16	Input 7
17	Input 7 Return
18	Input 8
19	Input 8 Return
20	No connection

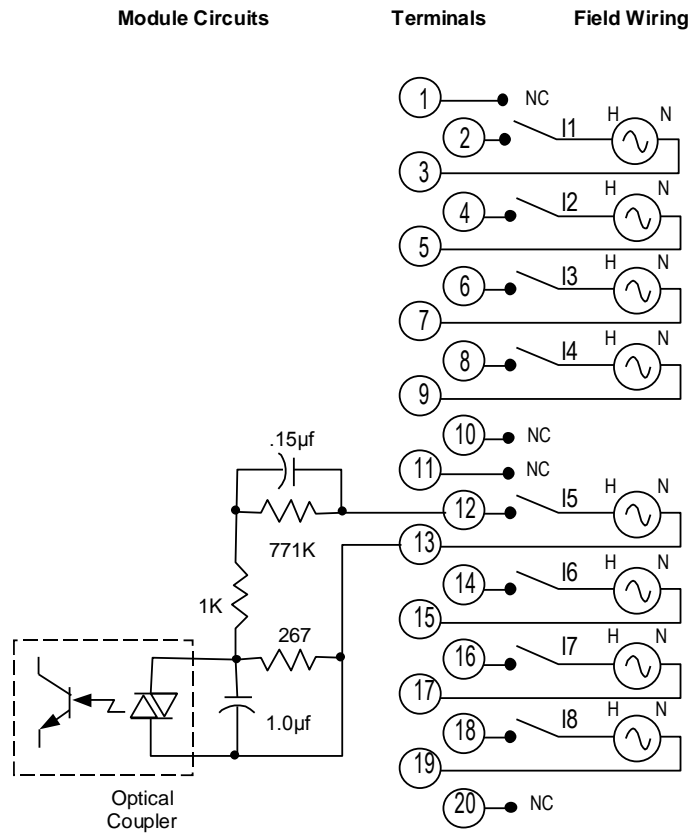


Figure 129: Field Wiring MDL231

6.3 Input Module, 120 V ac, 16-Point: IC694MDL240

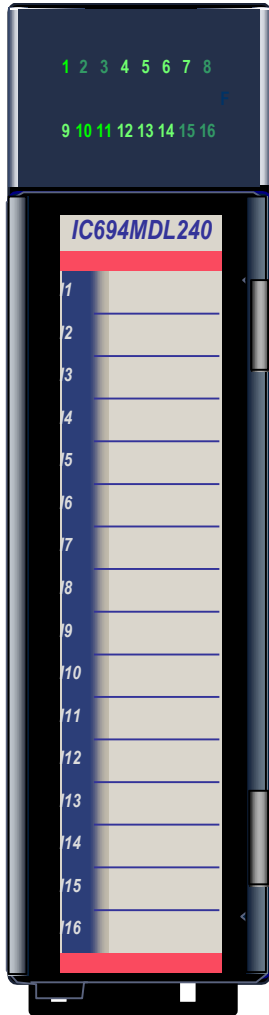


Figure 130: IC694MDL240

The **120 V ac Input** module, IC694MDL240, provides sixteen input points with one common power input terminal. The input circuits are reactive (resistor/capacitor) inputs. Current into an input point results in a logic 1 in the input status table (%I). Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches.

Power to operate the field devices must be supplied by the user. This module requires an AC power source; *it cannot be used with a DC power source.*

Sixteen green LEDs indicate the ON/OFF status of points 1 through 16. The red bands on the label show that MDL240 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.3.1 Specifications: MDL240

Rated Voltage	120 Vac
Input Voltage Range	0 to 132 Vac, 50/60 Hz
Inputs per Module	16 (one group with a single common) The maximum number of inputs on at the same time depends on the ambient temperature (Figure 131).
Isolation: Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Input Current	12 mA (typical) at rated voltage
Input Characteristics:	
On-state Voltage	74 to 132 Vac
Off-state Voltage	0 to 20 Vac
On-state Current	6 mA minimum
Off-state Current	2.2mA maximum
On response Time	30 ms maximum
Off response Time	45 ms maximum
Power Consumption	90 mA (all inputs on) from 5 Vdc bus on backplane

For product standards and general specifications, refer to *Appendix A*.

6.3.2 Thermal Derating: MDL240

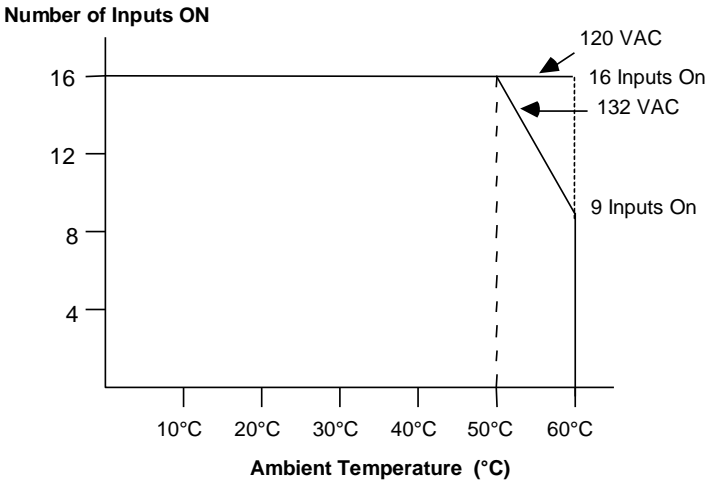


Figure 131: Thermal Derating MDL240

6.3.3 Field Wiring: MDL240

Terminals	Connections
1	Input 1
2	Input 2
3	Input 3
4	Input 4
5	Input 5
6	Input 6
7	Input 7
8	Input 8
9	Input 9
10	Input 10
11	Input 11
12	Input 12
13	Input 13
14	Input 14
15	Input 15
16	Input 16
17	No connection
18	No connection
19	Inputs 1-16 Common (Return)
20	No connection

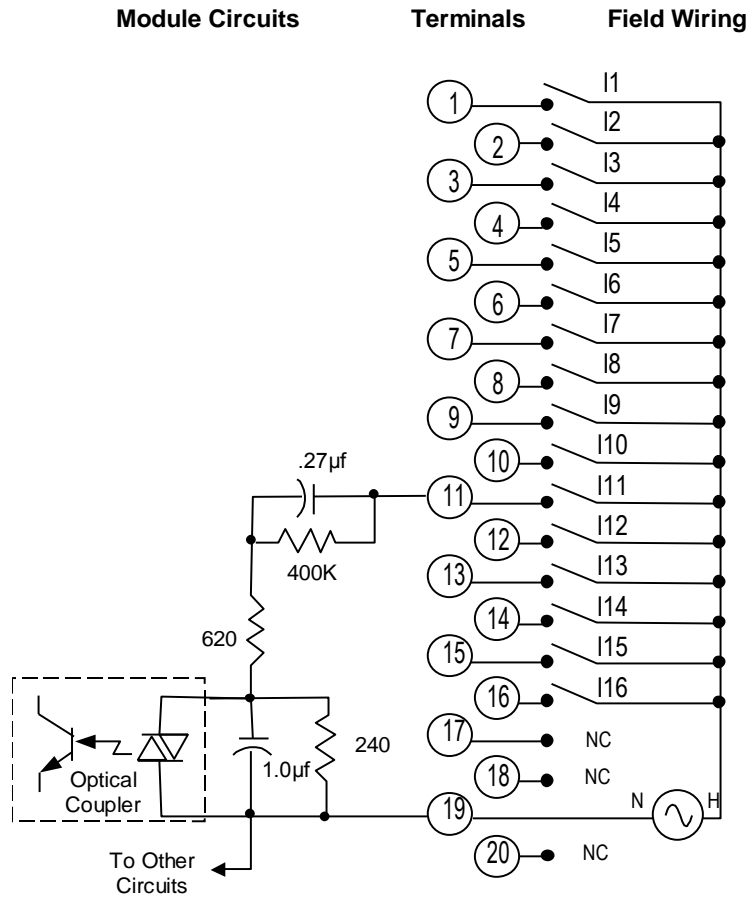


Figure 132: Field Wiring MDL240

6.4 Input Module, 24Vac/Vdc 16-Point Pos/Neg Logic IC694MDL241

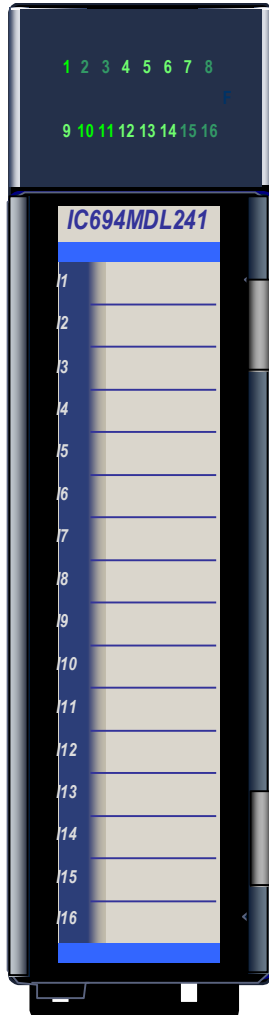


Figure 133: IC694MDL241

The 24Vac/Vdc 16-Point C Positive/Negative Logic Input module, IC694MDL241, provides sixteen input points in one group with a common power input terminal. This module can be used with AC or DC field inputs. In DC mode, it can be wired for either positive or negative logic. Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (%I).

Power to operate AC and DC input devices must be supplied by the user.

Sixteen green LEDs indicate the ON/OFF status of points 1 through 16. The blue bands on the label show that MDL241 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.4.1 Specifications: MDL241

Rated Voltage	24 Vac or 24 Vdc
Input Voltage Range	0 to +30 Vdc or 0 to +30 Vac, 50/60Hz
Inputs per Module	16 (one group with a single common)
Isolation: Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Input Current	7 mA (typical) at rated voltage
Input Characteristics	
On-state Voltage	11.5 to 30 Vac or DC
Off-state Voltage	0 to +4 Vac or DC
On-state Current	3.2mA minimum
Off-state Current	1 mA maximum
On response Time	12 ms typical
Off response Time	28 ms typical
Power Consumption: 5 Vdc	80 mA (all inputs on) from 5 Vdc bus on backplane
Power Consumption ¹⁵ : 24 Vdc	125 mA from the Isolated 24 Vdc backplane bus or from user supplied power

For product standards and general specifications, refer to *Appendix A*.

¹⁵ If terminals 18 & 19 are employed, the following applies:

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required. The external source must be connected via the TB1 connector located on the left side of the backplane.

If this module is located in an RX3i Expansion Backplane or Series 90-30 backplane, the backplane power supply provides the Isolated +24Vdc for the module.

6.4.2 Field Wiring: MDL241

Terminals	Connections
1	Inputs 1-16 Common (Return)
2	Input 1
3	Input 2
4	Input 3
5	Input 4
6	Input 5
7	Input 6
8	Input 7
9	Input 8
10	Input 9
11	Input 10
12	Input 11
13	Input 12
14	Input 13
15	Input 14
16	Input 15
17	Input 16
18	24Vdc for input devices
19	0V for input devices
20	No connection

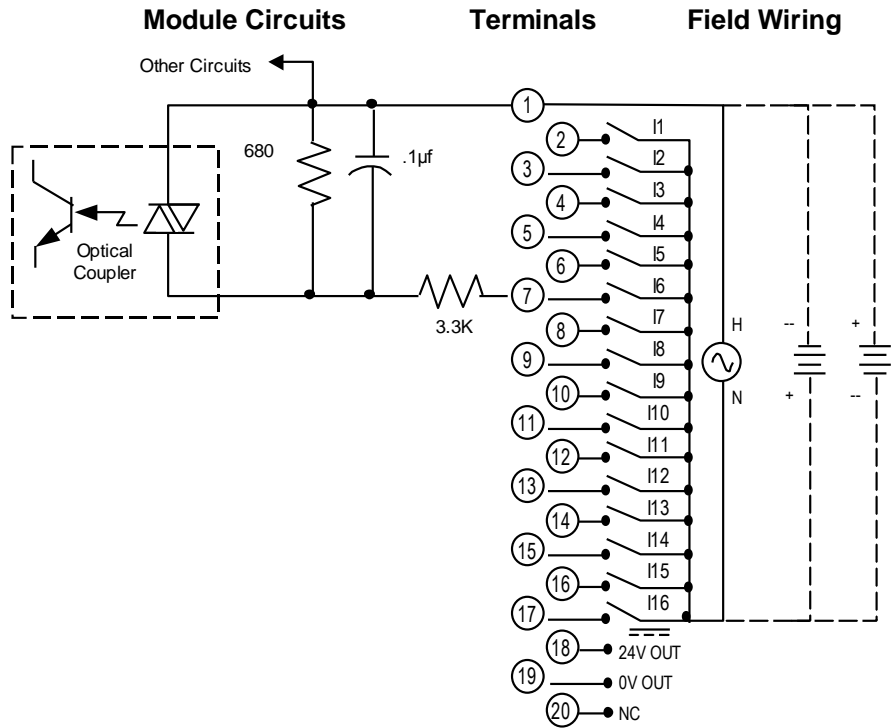


Figure 134: Field Wiring MDL241

Note: If the 24V OUT pin is used to connect to input devices in the field, the isolation specification for this module changes to:

Field to Backplane (optical) and to frame ground: 50 V ac continuous; 500 V ac for 1 minute

6.5 Input Module, 120 V ac 16-Point Isolated: IC694MDL250

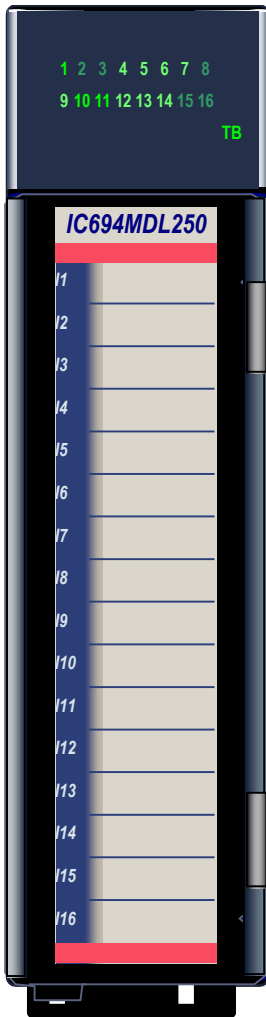


Figure 135: IC694MDL250

The **120 V ac 16-Point Isolated Input** module, IC694MDL250, provides sixteen isolated input points. Input points can be used on different phases of the AC supply or powered from the same supply. An RC snubber protects each input against transient electrical noise on the power line.

The input filtering time of the module can be changed during system operation by the application program. No DIP switch settings are required.

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth typically needed for field wiring to AC devices. Refer to Chapter 17 for more information about Terminal Blocks. Terminal Blocks are ordered separately.

Individually numbered LEDs show the ON/OFF status of each Input point. The TB LED is green when the removable terminal block of the module is locked in place. It is red when the terminal block is not locked. The module also sends an *Addition of Terminal Block* or *Loss of Terminal Block* message to the RX3i CPU to report the terminal block status.

The red bands on the door card indicate the MDL250 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

Module cannot be used with a Series 90-30 PLC CPU.

6.5.1 Specifications: MDL250

Rated Voltage	120 Vac
Input Voltage Range	0 – 132 Vac (47 to 63 Hz), 120 Vac nom.
Inputs per Module	16 isolated
Isolation:	
Field to Backplane	250 Vac continuous; 1500 Vac for 1 minute
Group to Group	250 Vac continuous; 1500 Vac for 1 minute
Input Current	7.0 mA per point (typical) at rated voltage
Input Filter Times	20 msec – 2540 msec in 20 msec increments. Sent from CPU.
ON response Time	0.5ms, 1.0ms, 2.0ms, 5.0ms, 10.0ms, 50.0ms & 100.0ms (as per filter setting)
Power Consumption	220 mA (all inputs on) from 5 V bus on backplane
Diagnostics	Field side terminal block reported to RX3i CPU.
Input Characteristics:	
On-state Voltage	70-132 Vac
Off-state Voltage	0 to 20 Vac
On-state Current	5 mA minimum
Off-state Current	2.5 mA maximum
On/Off Response Time	±0-1 AC cycles for filter times up to 840 ms ±1-2 AC cycles for filter times of 840 to 1600 ms ±2-3 AC cycles for filter times of 1600 to 1920 ms ±3-4 AC cycles for filter times of 1920 ms or more

For product standards and general specifications, refer to *Appendix A*.

6.5.2 Input Filter Setup: MDL250

If an input filter time should be applied to all the module inputs, input filtering should be enabled in the software configuration of the module. The Digital Filter Settings Length must be set to 16, and a memory location to be used for the filter value must be specified. Configuring a Digital Filter Settings Length of 0 disables the input filter.

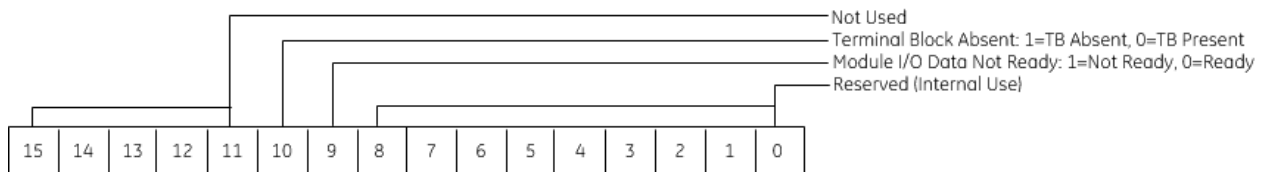
During system operation, the input filter time can be changed from the programmer by entering a filter setting value from 1 to 127 decimal (1_{hex} to 7F_{hex}) into the assigned memory location. This filter setting value is equal to the new filter time divided by 20 decimal. For example, to change the filter time to 200ms, enter the value 10_{dec} (0A_{hex}) into the memory location. Some example filter times and their hexadecimal setting values are listed below.

Setting (hexadecimal)	Filter Time in ms	Setting (hexadecimal)	Filter Time in ms	Setting (hexadecimal)	Filter Time in ms
0A	200	21	660	5A	1800
0F	300	22	680	5F	1900
11	340	2A	840	71	2260
12	360	2F	940	72	2280
1A	520	51	1620	7A	2240
1F	620	52	1660	7F	2540

6.5.3 Module Status Data: MDL250

Discrete input module IC694MDL250 optionally provides sixteen bits of status data to the CPU in the assigned Module Status Reference location. By default, the configured length of this status area is 0. To access this data, the length must be changed from 0 to 16.

The module uses the lower eleven input bits to report its internal status information to the RX3i CPU, as follows:



Note that the sense of bit 9 is inverted compared to most other modules. Here "1" indicates *not ready*.

6.5.4 Field Wiring: MDL250

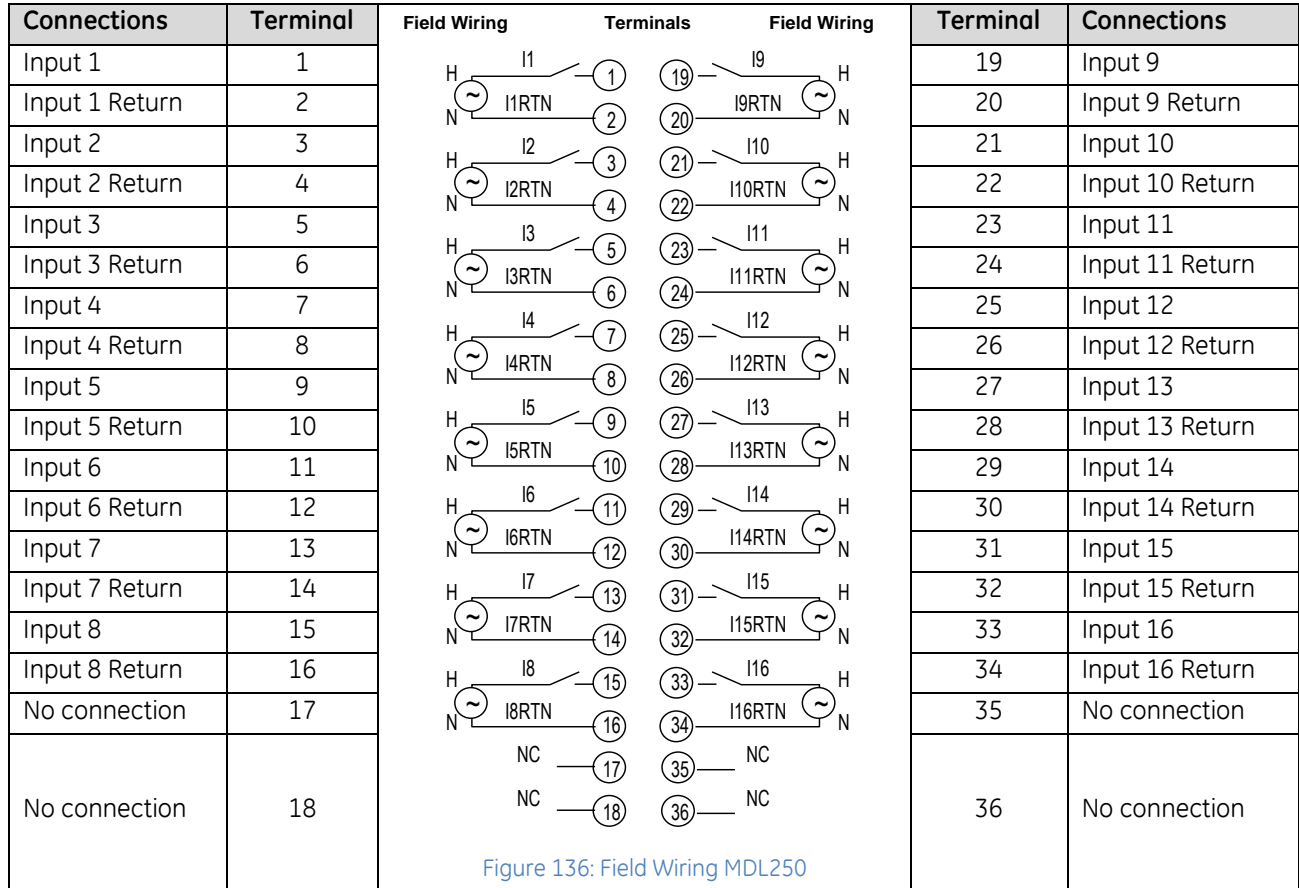


Figure 136: Field Wiring MDL250

6.6 Input Module, 120 V ac, 32-Point: IC694MDL260

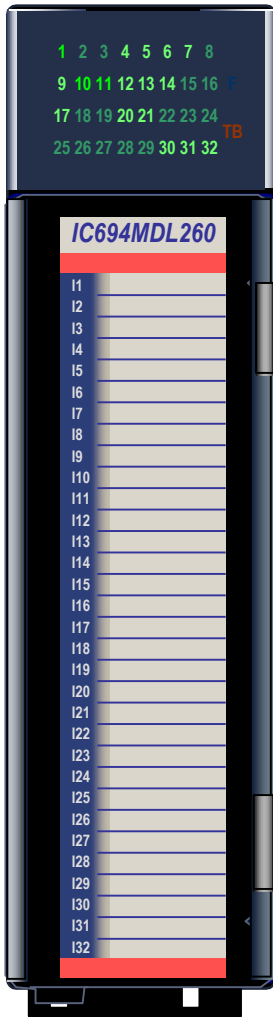


Figure 137: IC694MDL260

The **120 V ac Grouped Input** module, IC694MDL260, provides thirty-two discrete input points. The inputs are arranged in four isolated groups of eight. Isolation is provided between the four groups of inputs, however all inputs within a group are referenced to the same user common connection.

Module MDL260 can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth typically needed for field wiring to AC devices. Refer to Chapter 17 for more information about Terminal Blocks. The Terminal Block is ordered separately.

Input filter times can be set from the programmer using the assigned output data references of the module.

Individually-numbered LEDs indicate the ON/OFF status of points 1 through 32. The red/green TB LED is green when the removable terminal block of the module is locked in place. It is red when the terminal block is not locked. The module also sends an *Addition of Terminal Block* or *Loss of Terminal Block* message to the RX3i CPU to report the terminal block status.

The red bands on the label show that MDL260 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

Module cannot be used with a Series 90-30 PLC CPU.

6.6.1 Specifications: MDL260

Rated Voltage	120 Vac
Input Voltage Range	0 to 132 Vac (47 to 63Hz)
Inputs per Module	32 (four isolated groups of 8 inputs)
Input Filter Times	20 to 2540ms in 20 ms increments. Sent from CPU.
Input Current	7.0 mA per point (typical) at rated voltage
Isolation:	
Field to Backplane (optical)	264 Vac continuous; 1500 V ac for one minute
Group to Group	264 Vac continuous; 1500 V ac for one minute
Thermal Derating	Refer to Figure 138.
Power Consumption	220 mA at 5 Vdc with all inputs on
Diagnostics	Terminal block presence reported to RX3i CPU
Input Characteristics	
On-state Voltage	70 to 132 Vac
Off-state Voltage	0 to 20 Vac
On-state Current	5 mA minimum
Off-state Current	2.5 mA maximum
On/Off response Time	±0-1 AC cycles for filter times up to 840 ms ±1-2 AC cycles for filter times of 840 to 1600 ms ±2-3 AC cycles for filter times of 1600 to 1920 ms ±3-4 AC cycles for filter times of 1920 ms or more

6.6.2 Thermal Derating: MDL260

The number of inputs that can be on at the same time depends on the ambient temperature:

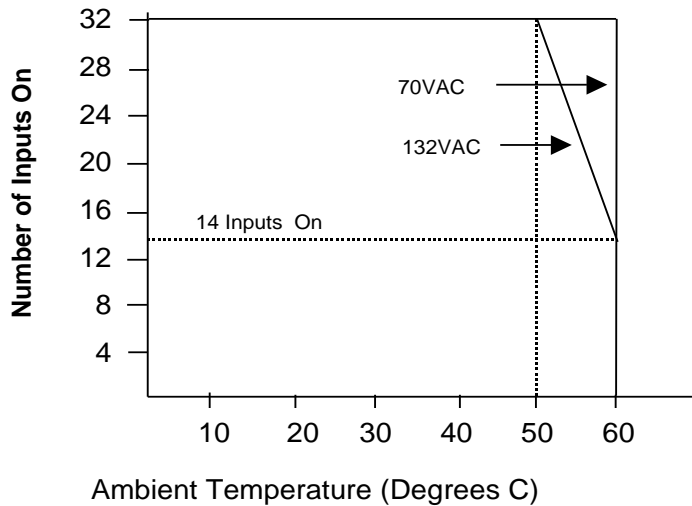


Figure 138: Thermal Derating Curve MDL260

6.6.3 Input Filter Setup: MDL260

If an input filter time should be applied to all the module inputs, input filtering should be enabled in the software configuration of the module. For an MDL260 module installed in an RX3i main backplane, this is done by setting the Digital Filter Settings Length to 16 and specifying a memory location for the data. Configuring a Digital Filter Settings Length of 0 disables the input filter.

During system operation, the input filter time can easily be changed from the programmer by entering a filter setting value from 1 to 127 decimal (1_{hex} to 7F_{hex}) into the assigned memory location. This filter setting value is equal to the new filter time divided by 20. For example, to change the filter time to 200ms, enter the value 10_{dec} (200 / 20 = 10) into the memory location. The input filter time is automatically sent to the module each scan.

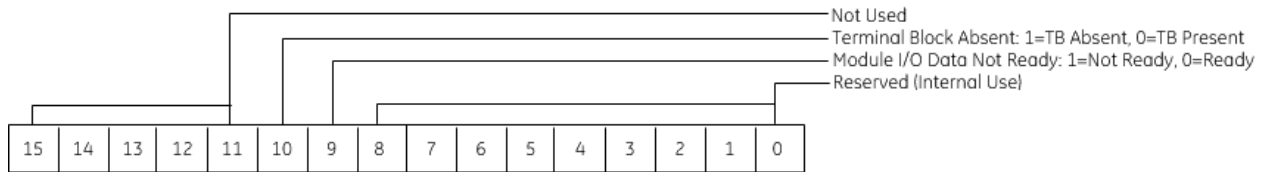
Some example filter times and their hexadecimal setting values are listed below.

Setting (hexadecimal)	Filter Time in ms	Setting (hexadecimal)	Filter Time in ms	Setting (hexadecimal)	Filter Time in ms
0A	200	21	660	5A	1800
0F	300	22	680	5F	1900
11	340	2A	840	71	2260
12	360	2F	940	72	2280
1A	520	51	1620	7A	2240
1F	620	52	1660	7F	2540

6.6.4 Module Status Data: MDL260

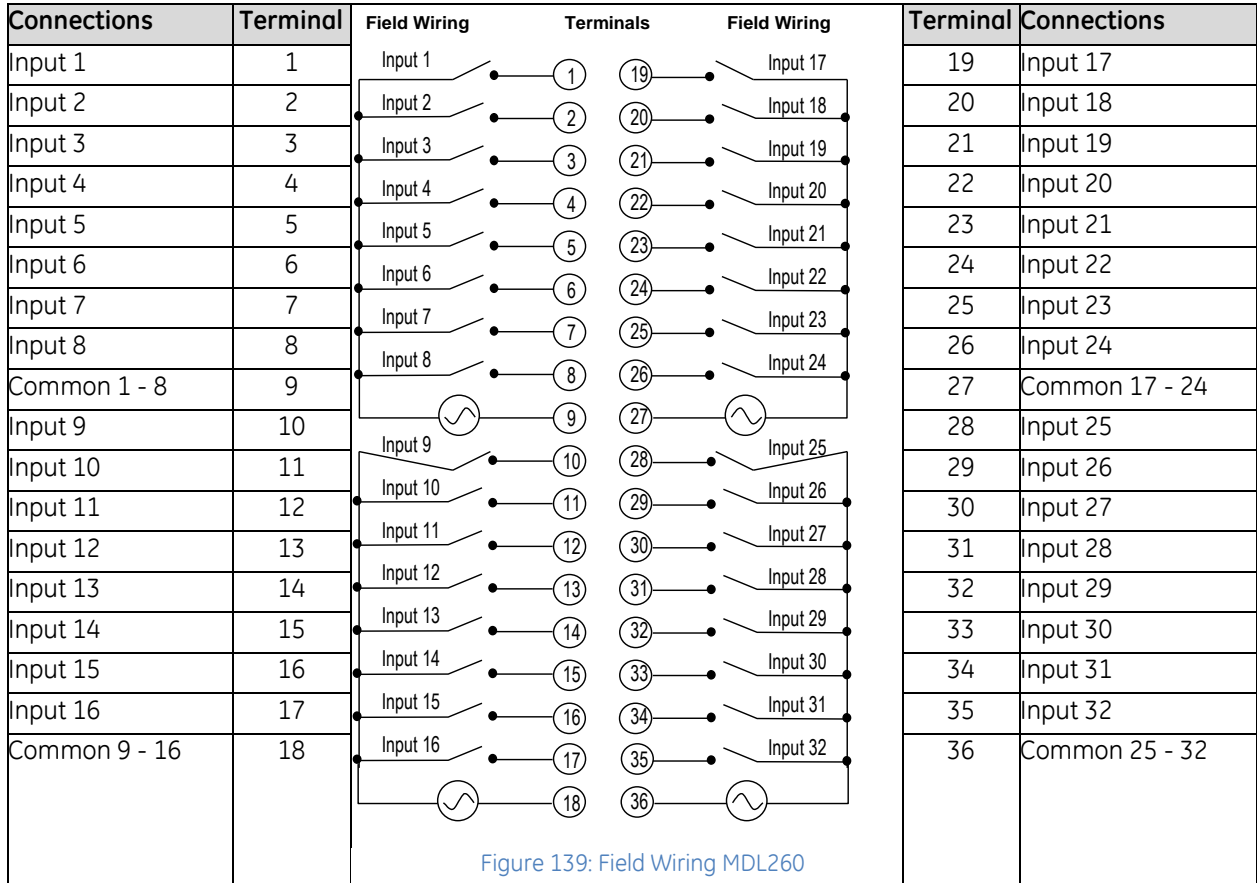
Discrete input module IC694MDL260 optionally provides sixteen bits of status data to the CPU in its assigned Module Status Reference location. By default, the configured length of this status area is 0. To access this data, the length must be changed from 0 to 16.

The module uses the lower eleven input bits to report its internal status information to the RX3i CPU, as follows:



Note that the sense of bit 9 is inverted compared to most other modules. Here "1" indicates *not ready*.

6.6.5 Field Wiring: MDL260



6.7 Input Module, 125Vdc Pos/Neg, 8-Point IC694MDL632

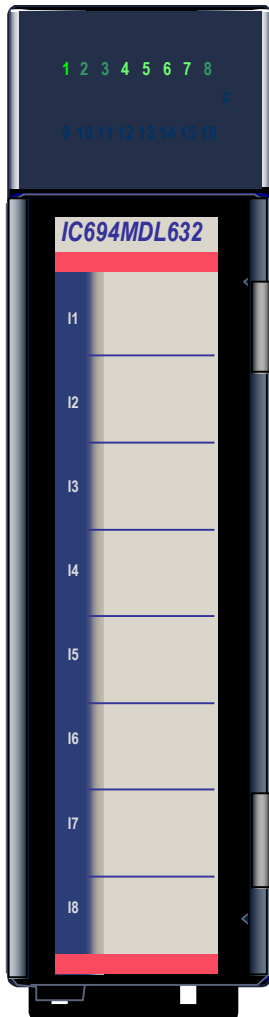


Figure 140: IC694MDL632

The *125Vdc Positive/Negative Logic Input* module, IC694MDL632, provides eight input points in two isolated groups with four points in each group. Each group has a separate common (the two commons are not tied together inside the module). Each group can be wired for either positive or negative logic. Current into an input point results in a logic 1 in the input status table (%I). Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches.

Power to operate field devices must be supplied by the user.

Eight green LEDs indicate the ON/OFF status of points 1 through 8. The red bands on the label show that MDL632 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.7.1 Specifications: MDL632

Rated Voltage	125 Vdc (Positive or Negative Logic)
Input Voltage Range	0 to +150 Vdc
Inputs per Module	8 (two groups of four inputs) Maximum number of inputs on at the same time depends on ambient temperature (Figure 141).
Isolation:	
Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Group to Group	250 Vac continuous; 1500 Vac for one minute
Input Current	4.5 mA typical
Input Characteristics	
On-state Voltage	90 to 150 Vdc
Off-state Voltage	0 to 30 Vdc
On-state Current	3.1 mA
Off-state Current	1.1 mA maximum
On response Time	7 ms typical
Off response Time	7 ms typical
Power Consumption	40 mA from the 5 V bus on the backplane 36 mA (typical) from user input supply (all inputs ON)

For product standards and general specifications, refer to *Appendix A*.

6.7.2 Thermal Derating: MDL632

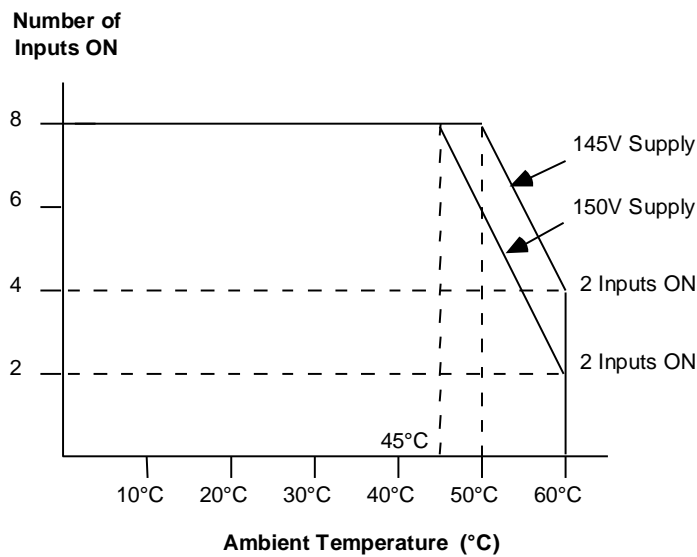
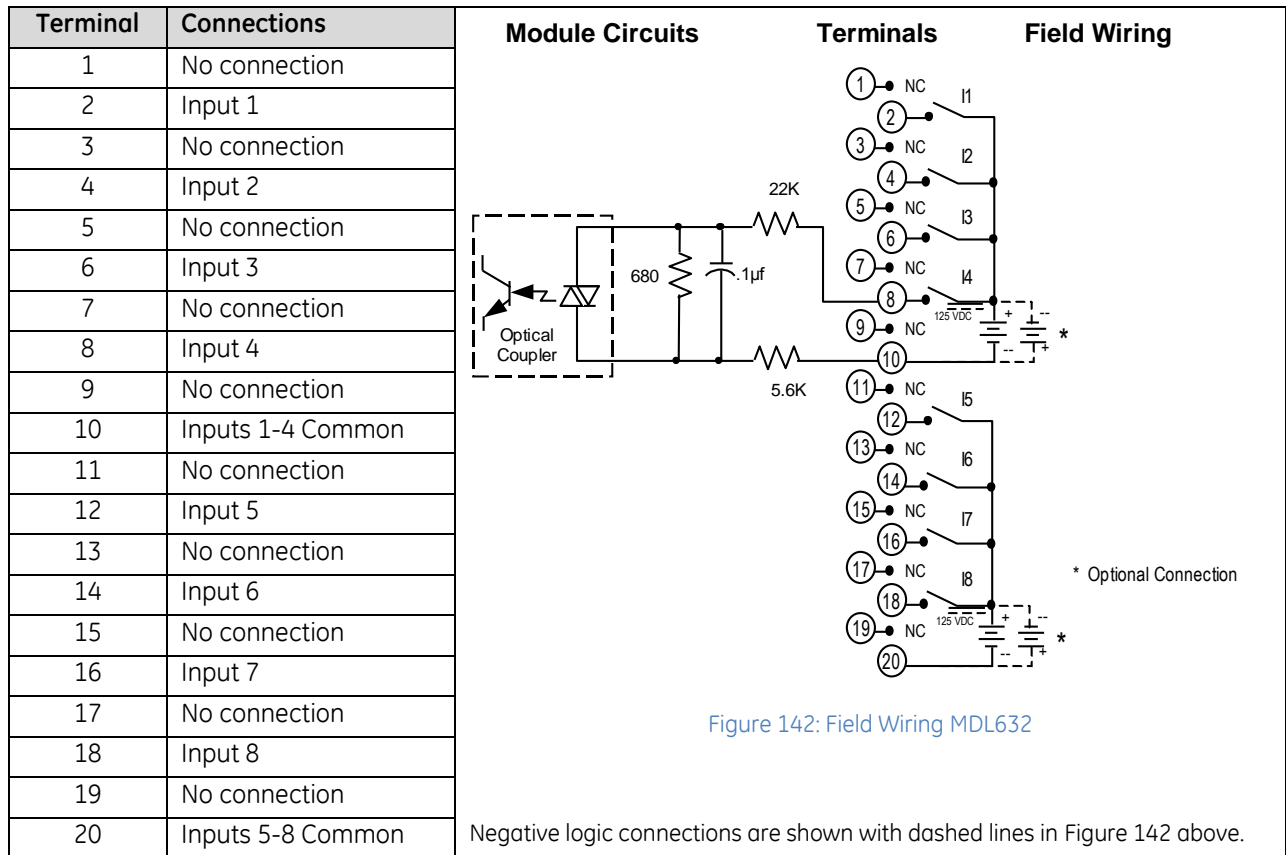


Figure 141: Thermal Derating Curve MDL632

6.7.3 Field Wiring: MDL632



6.8 Input Module, 24Vdc Pos/Neg, 8-Point IC694MDL634

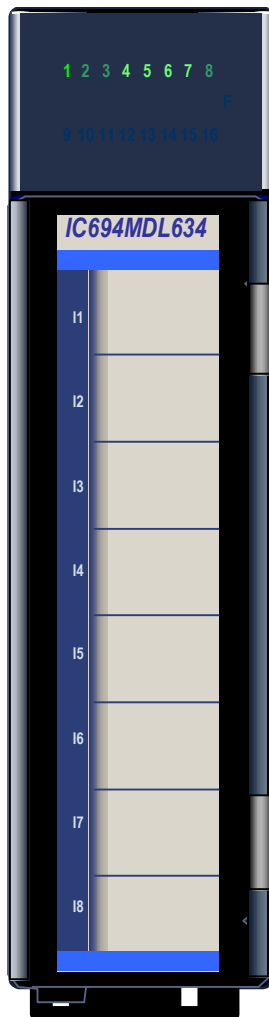


Figure 143: IC694MDL634

The 24Vdc *Positive/Negative Logic Input* module, IC694MDL634, provides eight input points in one group with a common power input terminal. This input module can be wired for either positive logic or negative logic. Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (%I). Field devices can be powered from an external supply. Depending on their requirements, some input devices can be powered from the +24V OUT and 0V OUT terminals of the module.

Eight green LEDs indicate the ON/OFF status of points 1 through 8. The blue bands on the label show that MDL634 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1. Note that field side terminal block must be removed from the module during such a procedure.

6.8.1 Specifications: MDL634

Rated Voltage	24 Vdc
Input Voltage Range	0 to +30 Vdc
Inputs per Module	8 (one group with a single common)
Isolation: Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Input Current	7 mA (typical) at rated voltage
Input Characteristics	
On-state Voltage	11.5 to 30 Vdc
Off-state Voltage	0 to +5 Vdc
On-state Current	3.2 mA minimum
Off-state Current	1.1 mA maximum
On response Time	7 ms typical
Off response Time	7 ms typical
Power Consumption: 5Vdc	45 mA (all inputs on) from 5Vdc bus on backplane
Power Consumption: 24Vdc ¹⁶	62 mA from the Isolated 24Vdc backplane bus or from user supplied power

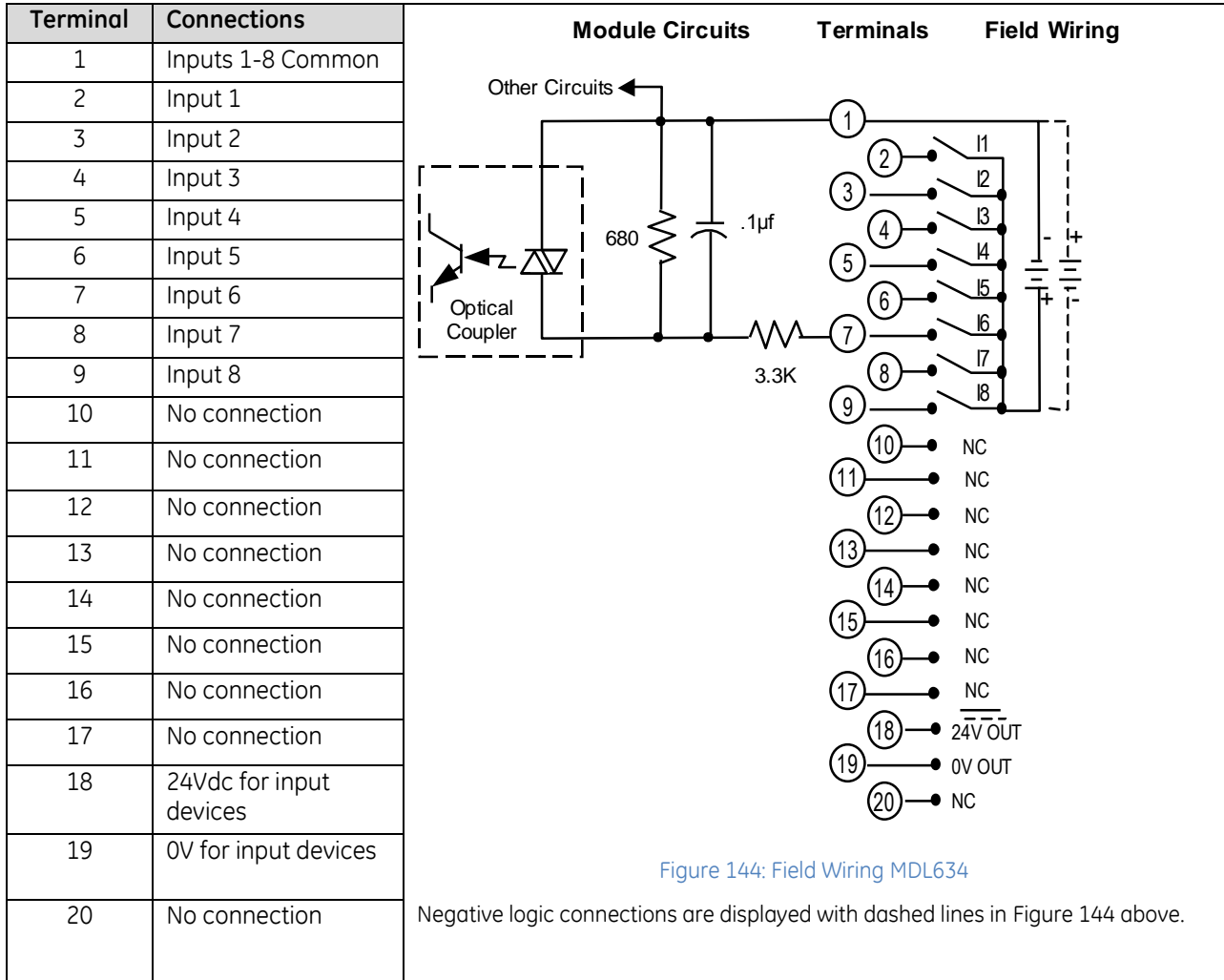
For product standards and general specifications, refer to *Appendix A*.

¹⁶ If terminals 18 & 19 are employed, the following applies:

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24 Vdc is required. The external source must be connected through the TB1 connector located on the left side of the backplane.

If this module is located in an RX3i Expansion Backplane or Series 90-30 backplane, the backplane power supply provides the isolated +24 Vdc for the module.

6.8.2 Field Wiring: MDL634



Note: If the 24V OUT pin is used to connect to input devices in the field, the isolation specification for this module changes to:

Field to Backplane (optical) and to frame ground: 50 Vac continuous; 500 Vac for 1 minute

6.9 Input Module, 125Vdc Pos/Neg, 16-Point IC694MDL635

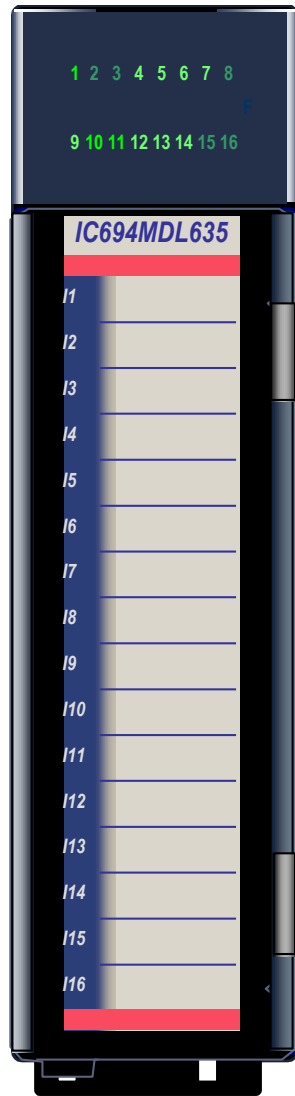


Figure 145: IC694MDL635

The *125Vdc Positive/Negative Logic Input* module, IC694MDL635, provides sixteen input points in one group with a common power input terminal. This input module can be wired for either positive logic or negative logic. Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (%I).

Power to operate field devices must be supplied by the user.

Sixteen green LEDs indicate the ON/OFF status of points 1 through 16. The red bands on the label show that MDL635 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.9.1 Specifications: MDL635

Rated Voltage	125 Vdc
Input Voltage Range	0 to +150 Vdc
Inputs per Module	16 (one group with a single common). See Thermal Derating Figure 146.
Isolation: Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Input Current	1.97 mA (typical) at rated voltage
Input Characteristics	
On-state Voltage	90 to 150 Vdc
Off-state Voltage	0 to +30 Vdc
On-state Current	1.41 mA minimum
Off-state Current	0.46 mA maximum
On response Time	8 ms typical
Off response Time	8 ms typical
Power Consumption: 5Vdc	80 mA (all inputs on) from 5 Vdc bus on backplane
Power Consumption: 125Vdc	31.5 mA from user supplied power (all inputs ON at 125 Vdc)

6.9.1.1 Thermal Derating: MDL635

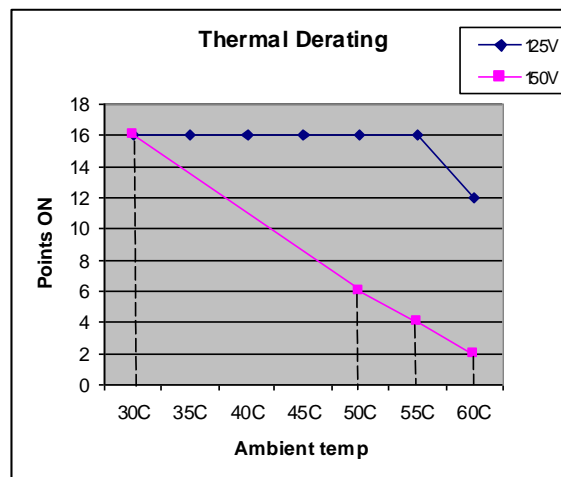


Figure 146: Thermal Derating MDL635

6.9.2 Field Wiring: MDL635

6.9.2.1 Terminal Block Wiring

Torque: 1.08 to 1.30 Nm (9.6 to 11.5 in-lb)

Wiring: Copper conductors stranded or solid 90°C rated: One 14-22 AWG or two 16-22 AWG

Wiring Notes: No combination of solid or stranded wires are to be used in the same terminal.
 No combination of different wire sizes are to be used in one terminal.

Terminal	Connection
1	Inputs 1-16 Common
2	Input 1
3	Input 2
4	Input 3
5	Input 4
6	Input 5
7	Input 6
8	Input 7
9	Input 8
10	Input 9
11	Input 10
12	Input 11
13	Input 12
14	Input 13
15	Input 14
16	Input 15
17	Input 16
18	Not used
19	Not used
20	Not used

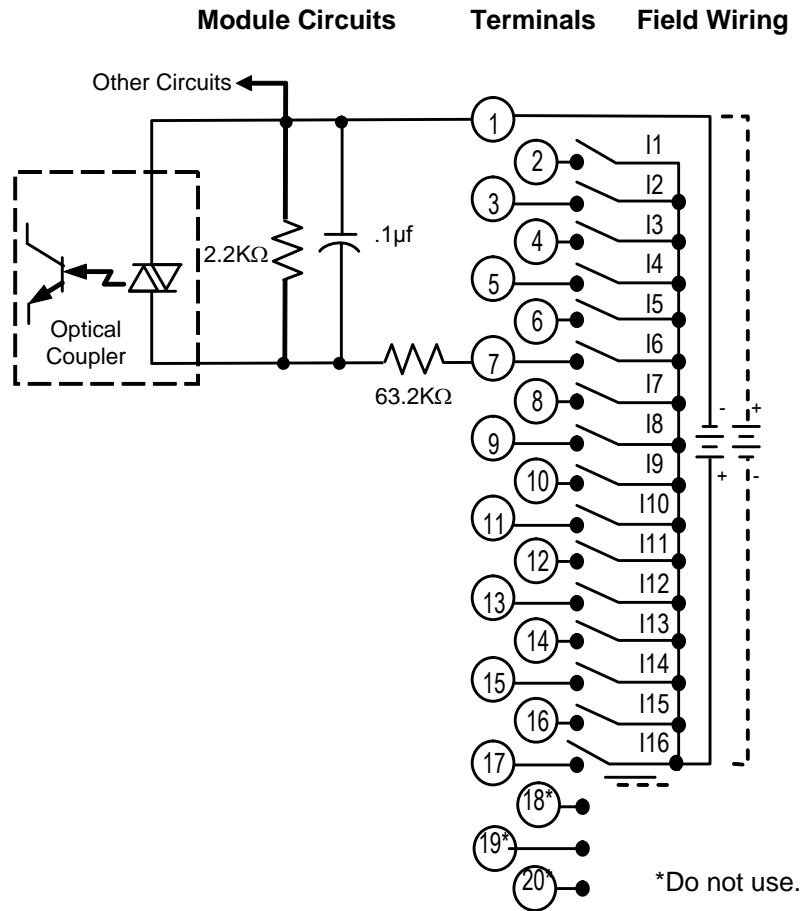


Figure 147: Field Wiring MDL635

6.10 Input Module, 24Vdc Pos/Neg, 16-Point IC694MDL645

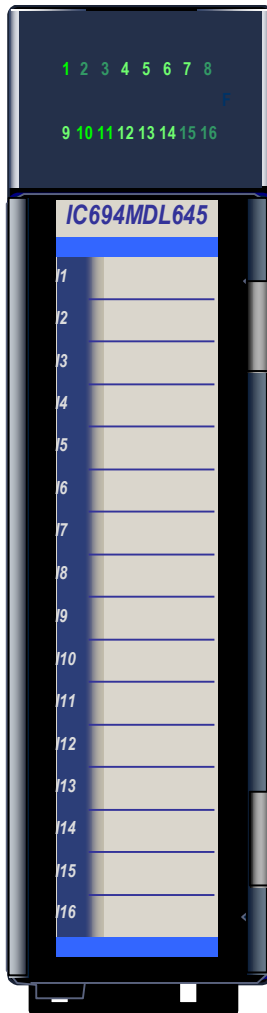


Figure 148: IC694MDL645

The *24Vdc Positive/Negative Logic Input* module, IC694MDL645, provides sixteen input points in one group with a common power input terminal. This input module can be wired for either positive logic or negative logic. Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (%I).

Field devices can be powered from an external supply. Depending on their requirements, some input devices can be powered from the +24 V OUT and 0 V OUT terminals of the module.

Sixteen green LEDs indicate the ON/OFF status of points 1 through 16. The blue bands on the label show that MDL645 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1. Note that field side terminal block must be removed from the module during such a procedure.

6.10.1 Specifications: MDL645

Rated Voltage	24 Vdc
Input Voltage Range	0 to +30 Vdc
Inputs per Module	16 (one group with a single common)
Isolation: Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Input Current	7 mA (typical) at rated voltage
Input Characteristics	
On-state Voltage	11.5 to 30 Vdc
Off-state Voltage	0 to +5 Vdc
On-state Current	3.2 mA minimum
Off-state Current	1.1 mA maximum
On response Time	7 ms typical
Off response Time	7 ms typical
Power Consumption: 5Vdc	80 mA (all inputs on) from 5Vdc bus on backplane
Power Consumption: 24Vdc ¹⁷	125 mA from the Isolated 24Vdc backplane bus or from user supplied power

For product standards and general specifications, refer to *Appendix A*.

¹⁷ If terminals 18 & 19 are employed, the following applies:

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24 Vdc is required. The external source must be connected via the TB1 connector located on the left side of the backplane.

If this module is located in an RX3i Expansion Backplane or Series 90-30 backplane, the backplane power supply provides the isolated +24 Vdc for the module.

6.10.2 Field Wiring: MDL645

Terminal	Connection
1	Inputs 1-16 Common
2	Input 1
3	Input 2
4	Input 3
5	Input 4
6	Input 5
7	Input 6
8	Input 7
9	Input 8
10	Input 9
11	Input 10
12	Input 11
13	Input 12
14	Input 13
15	Input 14
16	Input 15
17	Input 16
18	24Vdc for input devices
19	0V for input devices
20	No connection

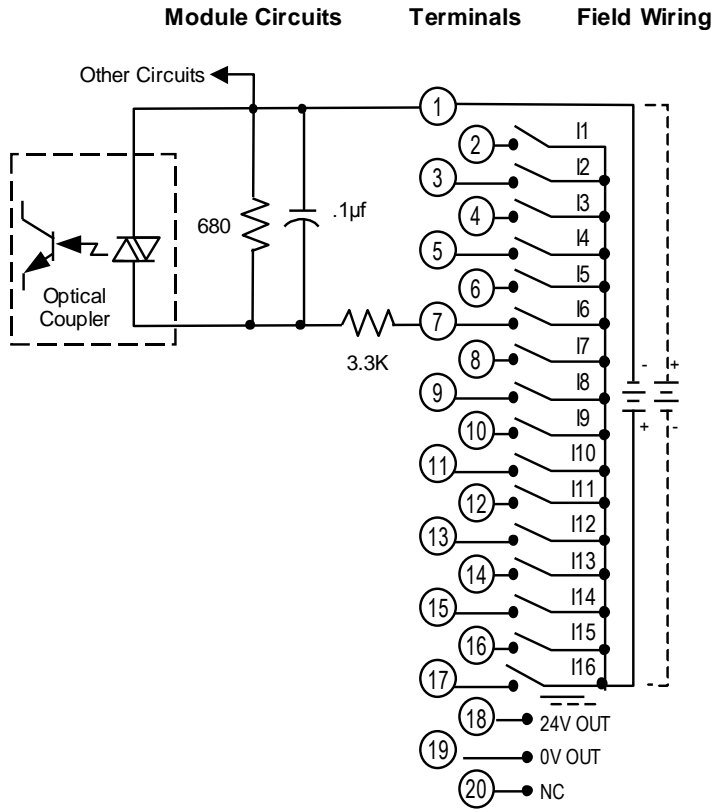


Figure 149: Field Wiring MDL645

Note: If the 24V OUT pin is used to connect to input devices in the field, the isolation specification for this module changes to:

Field to Backplane (optical) and to frame ground: 50 Vac continuous; 500 Vac for 1 minute

6.11 Input Module: 24Vdc 16-Point Pos/Neg Logic IC694MDL646

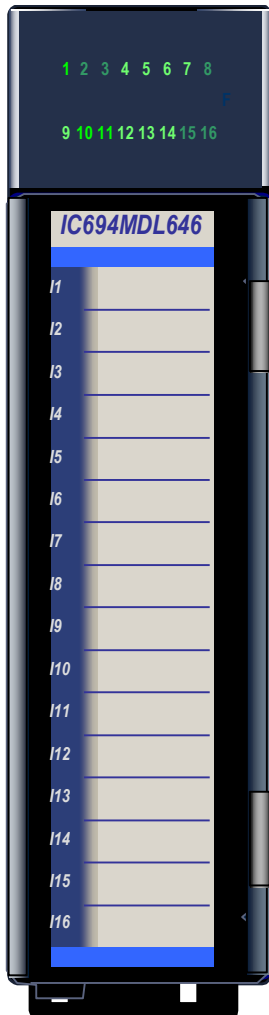


Figure 150: IC694MDL646

The 24Vdc Positive/Negative Logic 16-Point Input module, IC694MDL646, provides sixteen input points in one group with a common power input terminal. The on and off response times for this module are typically 1 ms. This input module can be wired for either positive logic or negative logic. Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (%I).

Field devices can be powered from an external supply. Depending on their requirements, some input devices can be powered from the +24 V OUT and 0V OUT terminals of the module.

Sixteen green LEDs indicate the ON/OFF status of points 1 through 16. The blue bands on the label show that MDL646 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1. Note that field side terminal block must be removed from the module during such a procedure.

6.11.1 Specifications: MDL646

Rated Voltage	24 Vdc
Input Voltage Range	0 to +30 Vdc
Inputs per Module	16 (one group with a single common)
Isolation: Field to Backplane (optical) and to frame ground	250 Vac continuous; 1500 Vac for one minute
Input Current	7 mA (typical) at rated voltage
Input Characteristics	
On-state Voltage	11.5 to 30 Vdc
Off-state Voltage	0 to +5 Vdc
On-state Current	3.2 mA minimum
Off-state Current	1.1 mA maximum
On response Time	1 ms typical
Off response Time	1 ms typical
Power Consumption: 5Vdc	80 mA (all inputs on) from 5Vdc bus on backplane
Power Consumption: 24Vdc ¹⁸	125 mA from the Isolated 24Vdc backplane bus or from user supplied power

For product standards and general specifications, refer to *Appendix A*.

¹⁸ If terminals 18 & 19 are employed, the following applies:

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24 Vdc is required. The external source must be connected via the TB1 connector located on the left side of the backplane.

If this module is located in an RX3i Expansion Backplane or Series 90-30 backplane, the backplane power supply provides the isolated +24 Vdc for the module.

6.11.2 Field Wiring: MDL646

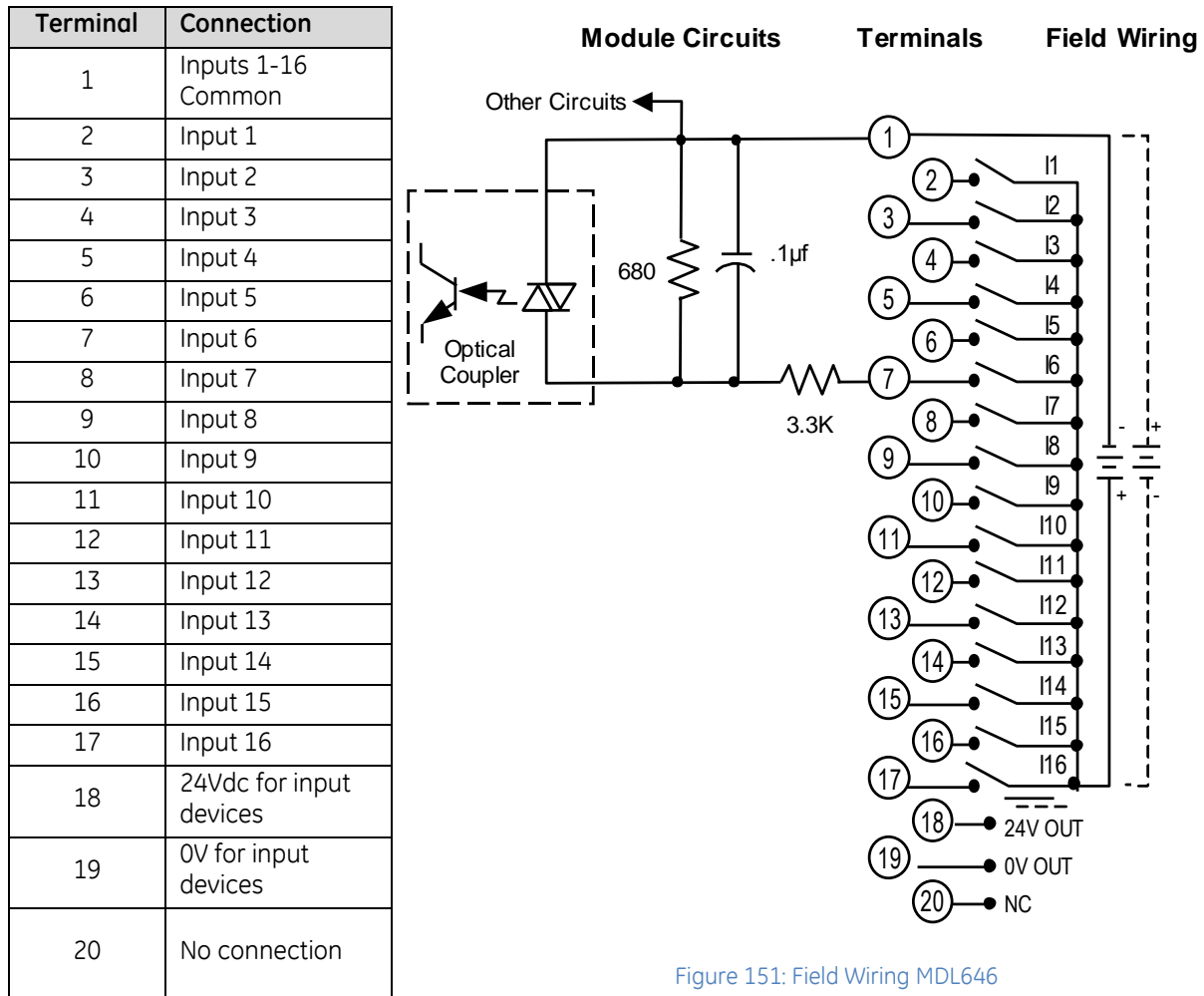


Figure 151: Field Wiring MDL646

Note: If the 24V OUT pin is used to connect to input devices in the field, the isolation specification for this module changes to:

Field to Backplane (optical) and to frame ground: 50 Vac continuous; 500 Vac for 1 minute

6.12 Input Module: 48 Vdc 16-Point Isolated Pos/Neg Logic IC694MDL648

The 48Vdc Positive/Negative Logic 16-Point Input module, IC694MDL648, provides sixteen isolated input points in one group with a common power input terminal. The ON and OFF response times for this module are 1ms maximum. This input module is designed to be used in either positive logic or negative logic applications. Input characteristics are compatible with a wide range of user-supplied input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current flow into an input point results in a logic 1 in the Controller's input status table (%I).

The blue bands on the label indicate that this is a low-voltage module.

This module can be installed in any I/O slot in an RX3i PLC System.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1. Note that field side terminal block must be removed from the module during such a procedure.

Power to operate input devices is derived from an external 48Vdc power source supplied by the user

6.12.1.1 LED Indicators

LED indicators provide the ON/OFF status of each point. They may be viewed via the lens at the top of the module. This LED block has two horizontal rows with eight green LEDs in each row: the top row is labeled A1 through 8 (corresponding to points 1 through 8); the bottom row is labeled B1 through 8 (points 9 through 16).

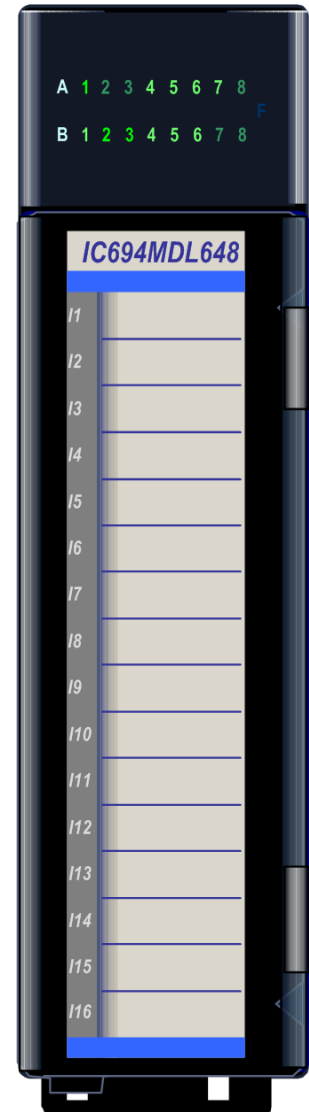


Figure 152: IC694MDL648

6.12.2 Specifications: MDL648

Rated Voltage	48 Vdc
Input Voltage Range	0 to 60 Vdc
Inputs per Module	16 (one group with a single common). Note Thermal Derating (Figure 153)
Isolation	1500 V between field side and logic side
Input Current	4.2 mA (typical) at rated voltage
Input Characteristics	
On-state Voltage	34 to 60 Vdc
Off-state Voltage	0 to 10 Vdc
On-state Current	3 mA minimum
Off-state Current	1.1 mA maximum
On response Time	1 ms maximum
Off response Time	1 ms maximum
Power Consumption: 5Vdc	80 mA (all inputs on) from 5Vdc bus on PLC backplane
Power Consumption: 48Vdc	74 mA from the user-supplied 48Vdc power supply

For product standards and general specifications, refer to Appendix A.

6.12.3 Thermal Derating: MDL648

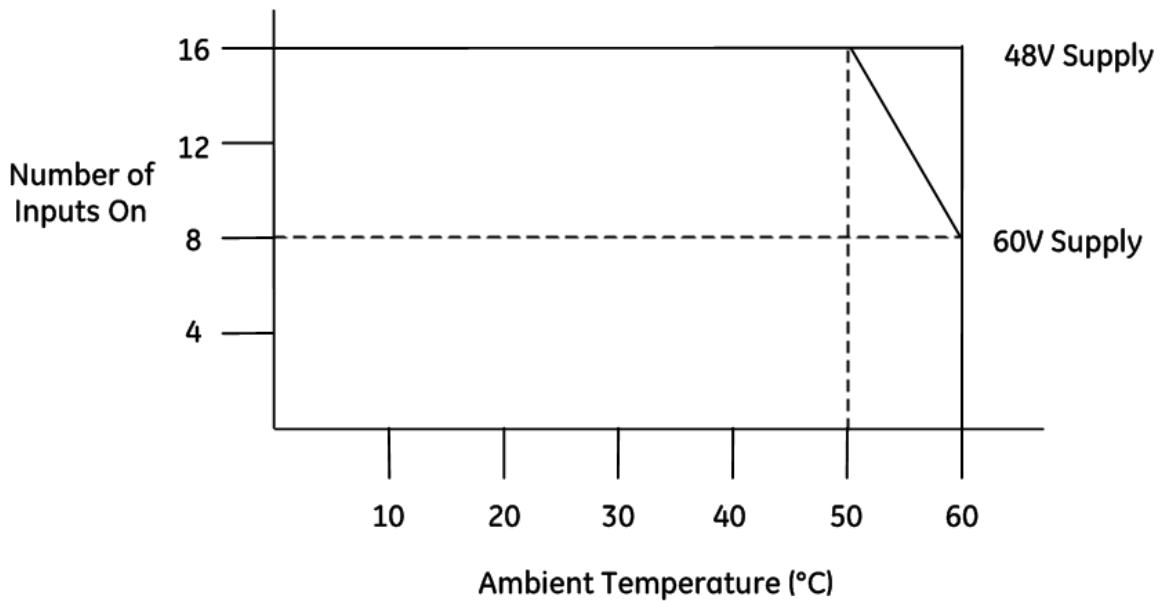
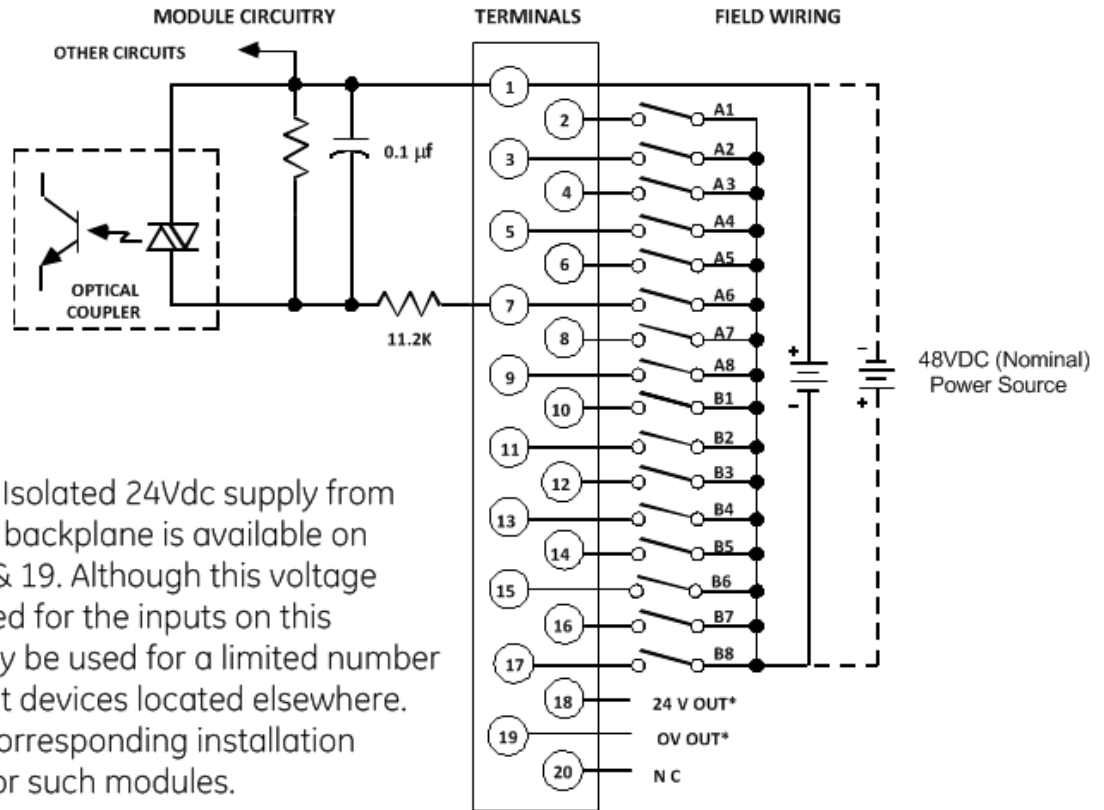


Figure 153: Thermal Derating MDL648

6.12.4 Field Wiring: MDL648

The Figure 154 provides wiring information for connecting user-supplied input devices and power source to the 48Vdc positive/negative logic input module.



Note that the Isolated 24Vdc supply from the controller backplane is available on terminals 18 & 19. Although this voltage cannot be used for the inputs on this module, it may be used for a limited number of 24Vdc input devices located elsewhere. Refer to the corresponding installation instructions for such modules.

Figure 154: Field Wiring MDL648

6.13 Input Modules, 5/12Vdc (TTL) 32-Point Pos/Neg Logic IC694MDL654, IC694MDL655, IC694MDL658

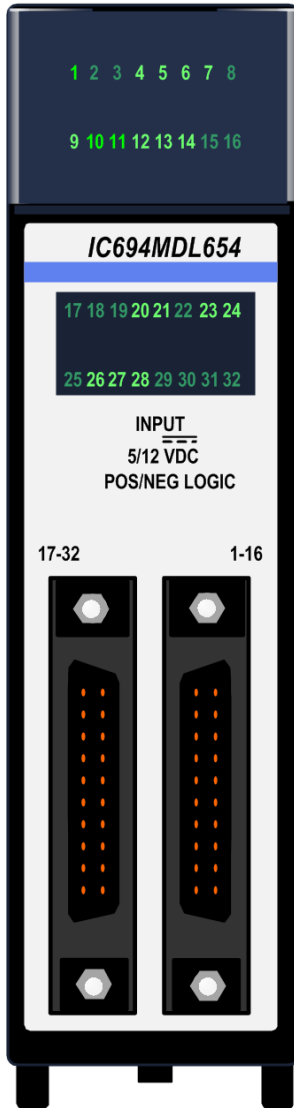


Figure 155: IC694MDL654

PACSystems RX3i 32-Point Positive/Negative Logic input modules each provides thirty-two positive or negative logic input points in four isolated groups of eight. Each group is referenced to its own common connection.

5/12Vdc (TTL) 32-Point Positive/Negative Logic Input module, IC694MDL654 provides thirty-two discrete TTL voltage threshold input points that operate at levels up to 15V. A single, regulated +5V supply (current limited to approximately 150mA) is available through the I/O connectors on the front of the module. This supply is generated on the module and is isolated from the backplane. Its power input comes from the +5V logic supply on the PLC backplane. By installing jumpers on the I/O connector, you can choose to power the inputs from this internal supply instead of powering them with an external user provided supply.

24Vdc 32-Point Positive/Negative Logic Input module, IC694MDL655, provides thirty-two discrete input points that operate at levels up to 30V. Power to operate field devices can come from an external supply or from the isolated +24Vdc output of the module.

48Vdc 32-Point Positive/Negative Logic Input module, IC694MDL658, provides thirty-two discrete input points that operate at levels up to 60V. Power to operate field devices must be provided using an external supply.

The blue band on the front label indicates a low-voltage module.

These modules do not report special fault or alarm diagnostics. Green LEDs indicate the ON/OFF status of each input point.

These modules can be installed in any I/O slot in the RX3i system.

These modules support insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

6.13.1 Specifications: MDL654, MDL655, MDL658

	IC694MDL654	IC694MDL655	IC694MDL658
Rated Voltage, Positive or Negative Logic	5 to 12 Vdc	24 Vdc	48 Vdc
Input Voltage Range	0 to 15 Vdc	0 to 30 Vdc	0 to 60 Vdc
Input Current (typical ON current at rated voltage)	3.0 mA at 5 Vdc 8.5 mA at 12 Vdc	7.0 mA at 24Vdc	1.7mA at 48 Vdc
Input Characteristics			
On-state Voltage	4.2 to 15 Vdc	11.5 to 30 Vdc	34 to 60 Vdc
Off-state Voltage	0 to 2.6 Vdc	0 to 5Vdc	0 to 10 Vdc
On-state Current	≥2.5 mA (min) guaranteed on	≥3.2mA (min) guaranteed on	≥1.0 mA (min) guaranteed on
Off-state Current	≤1.2 mA (max) guaranteed off	≤1.1 mA (max) guaranteed off	≤0.4 mA (max) guaranteed off
On or Off Response Time ¹⁹	1 ms maximum	2 ms maximum	2 ms maximum
Inputs per Module	32 (four groups of eight inputs each) 30 m (98.4 ft), maximum cable length for module IC694MDL654. For modules MDL654 and MDL655, the maximum number of inputs per group that can be on at the same time depends on the ambient temperature as displayed in Figure 156. There is no thermal derating for module MDL658.		
Isolation:			
Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for one minute For modules IC694MDL654 and IC694MDL655, if the 5V OUT / 24V OUT pin is used to connect to input devices in the field, the isolation is 50 V ac continuous; 500 V ac for one minute.		
Group to Group	50 V ac continuous; 500 V ac for one minute		
Internal Power Consumption	440 mA (max) from +5 Vdc bus on backplane (if module isolated +5 Vdc supply used to power inputs and all 32 inputs ON) 96 mA (typical) from user input supply at 5 Vdc and 32 inputs ON); 272 mA (typical) from user input supply at 12 Vdc and 32 inputs ON)	195 mA (max) from +5 Vdc bus on backplane; (29 mA + 0.5mA/point ON + 4.7 mA/LED ON) 224 mA (typical) from isolated +24 Vdc supply ²⁰	195 mA (max) from +5 Vdc bus on backplane; (29 mA + 0.5 mA/point ON + 4.7 mA/LED ON)
Isolated +5 Vdc Supply	For MDL654: +5Vdc ±5%		
Current limit	For MDL654: 150mA (typical)		

For product standards and general specifications, refer to Appendix A.

¹⁹ Within the module; does not include communications with CPU

²⁰ If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required. The external source must be connected via the TB1 connector located on the left side of the backplane.

If this module is located in an RX3i Expansion Backplane or Series 90-30 backplane, the backplane power supply provides the isolated +24Vdc for the module.

6.13.2 Thermal Derating: MDL654 & MDL655

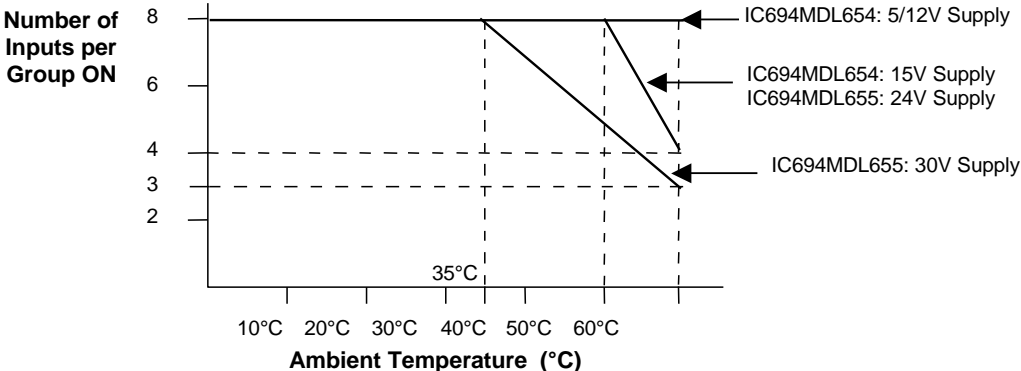


Figure 156: Thermal Derating MDL654 & MDL655

6.13.3 Field Wiring: MDL654, MDL655, MDL658

Connections are made to two male 24-pin connectors (Fujitsu FCN-365P024-AU) on the front of the module. Inputs are arranged in four groups of eight. Each group has its own common connection. Within each group, four points attach to the A half of the connector and four points attach to the B half of the connector.

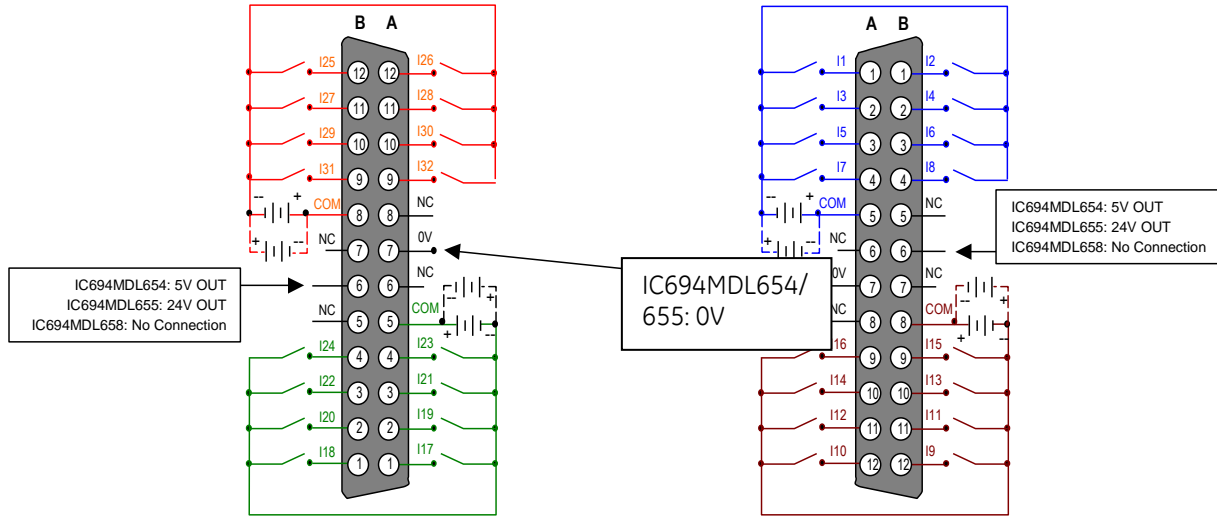


Figure 157: Left-side and Right-side Connectors MDL654, MDL655, MDL658

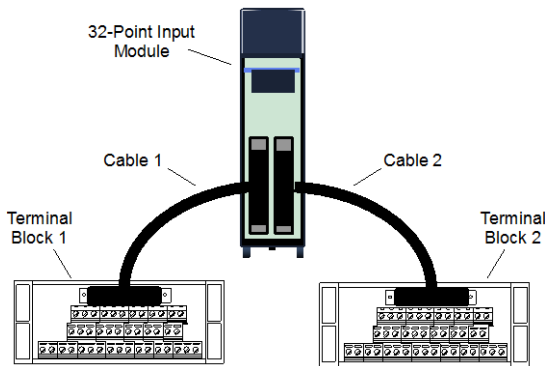


Figure 158: Attachment to Terminal Blocks for Field Wiring

Wiring from each module connector to field devices is made through a cable. Prewired cables are available, or custom cables can be used. Input devices can be wired directly to the cables, or to intermediate Terminal Blocks, IC693ACC337. Refer to Chapter 17 for information about prewired cables, custom cables, and Terminal Block IC693ACC337.

6.13.3.1 TTL Wiring: MDL654

Conventional TTL wiring practices should be followed when installing module IC694MDL654.

For noise immunity, I/O control lines connected to the module must be less than 30 meters in length (signal attenuation limits wiring length to less than this maximum).

To be compatible with TTL outputs, the negative logic configuration should be used as shown in Figure 159.

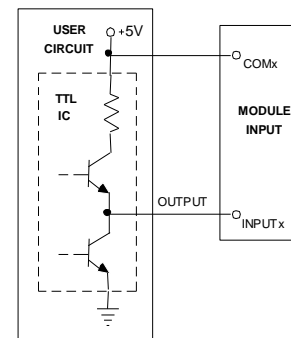


Figure 159: Wiring for Negative Logic MDL654

6.14 Input Module, 24Vdc 32-Point Grouped IC694MDL660

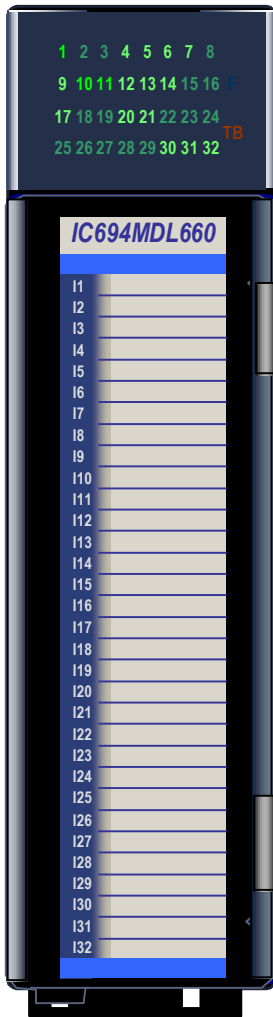


Figure 160: IC694MDL660

The 24Vdc *Positive/Negative Logic Input* module, IC694MDL660, provides thirty-two discrete input points. The inputs are positive or negative logic inputs and will operate at levels up to 30V.

The inputs are arranged in four isolated groups of eight; each group has its own common. Isolation is provided between the four groups of inputs; however each group of eight inputs is referenced to the same user common connection.

Module MDL660 provides seven selectable input filter times. Filter times can be set from the programmer using the assigned output data references of the module.

32 green LEDs indicate the ON/OFF status of points 1 through 32. The red/green TB LED is green when the removable terminal block of the module is locked in place. It is red when the terminal block is not locked. The module also sends an *Addition of Terminal Block* or *Loss of Terminal Block* message to the RX3i CPU to report the terminal block status.

The blue bands on the label show that MDL660 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Springstyle (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth typically needed for field wiring to AC devices. Refer to Chapter 17 for more information about Terminal Blocks. The Terminal Block is ordered separately.

This module cannot be used with a Series 90-30 PLC CPU.

6.14.1 Specifications: MDL660

Rated Voltage	24 Vdc
Input Voltage Range	0 to 30 Vdc
Inputs per Module	32 (four isolated groups of 8 inputs)
Isolation:	
Field to Backplane (optical)	250 Vac continuous; 1500 Vac for one minute
Group to Group	250 Vac continuous; 1500 Vac for one minute
Input Current	7.0 mA per point (typical) at rated voltage
Thermal De-Rating	Refer to Figure 161.
Input Characteristics:	
On-state Voltage	11.5 to 30 Vdc
Off-state Voltage	0 to 5 Vdc
On-state Current	3.2 mA minimum
Off-state Current	1.1 mA maximum
Input Filter Times	0.5 ms, 1.0 ms, 2.0 ms, 5 ms, 10 ms, 50 ms and 100 ms, selectable per module
On response time	0.5 ms, 1.0 ms, 2.0 ms, 5.0 ms, 10.0 ms, 50.0 ms & 100.0 ms (as per filter setting)
Off response time	0.5 ms, 1.0 ms, 2.0ms, 5.0 ms, 10.0 ms, 50.0 ms & 100.0 ms (as per filter setting)
Power Consumption	300 mA (all inputs on) from 5 Vdc bus on backplane
Diagnostics	Terminal block presence/absence reported to RX3i CPU

For product standards and general specifications, refer to Appendix A.

6.14.2 Thermal Derating: MDL660

The number of points that can be on at the same time depends on the ambient temperature and the voltage.

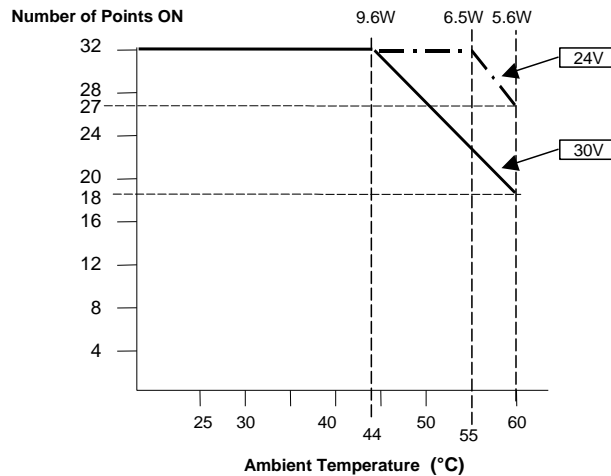
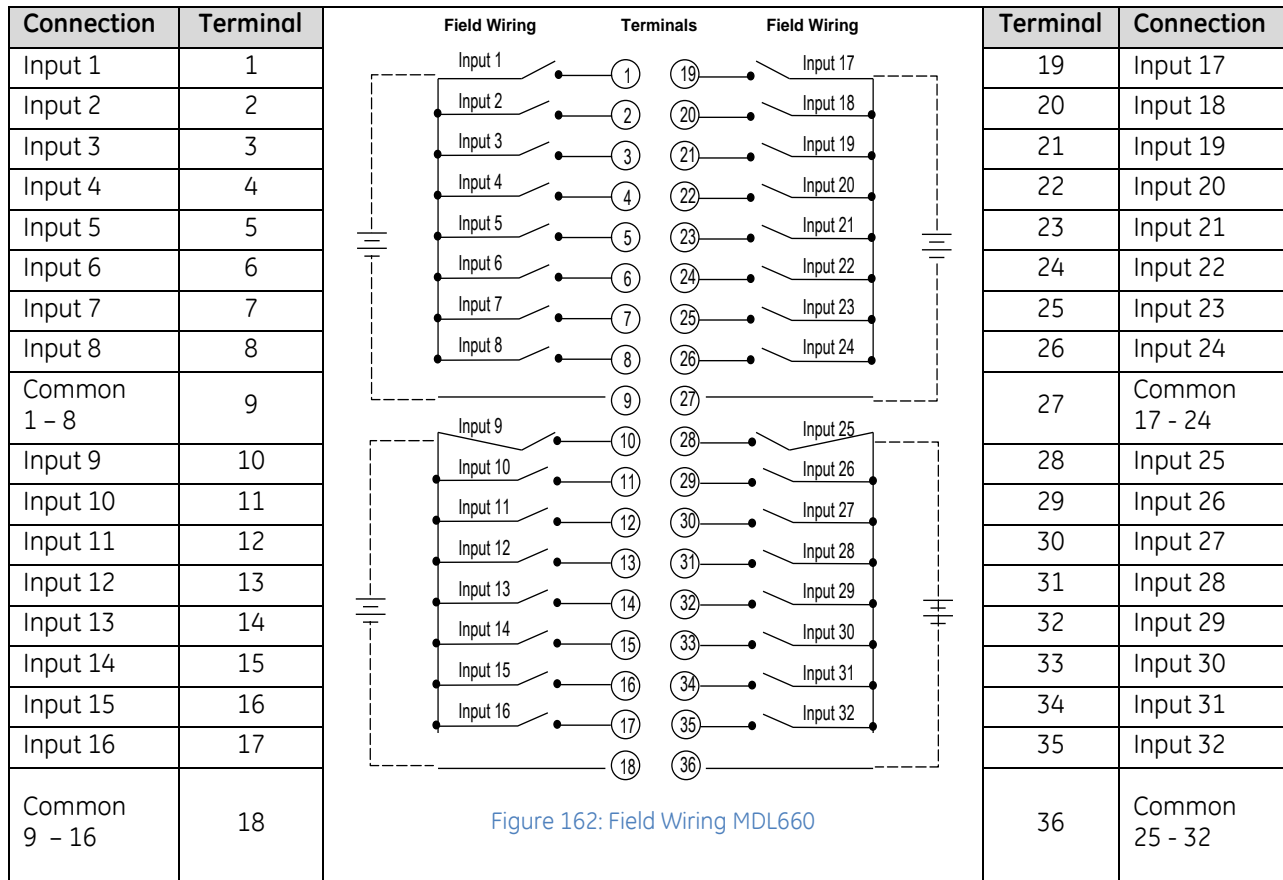


Figure 161: Thermal Derating Curve MDL660

6.14.3 Field Wiring: MDL660



6.14.4 Module Status Data: MDL660

Discrete Input Module IC694MDL660 can optionally be configured to provide 16 bits of status data. By default, the length assigned to the module status data is 0. To use the status data, the length must be changed to 16. If a length of 16 has been assigned to the module status data, the module uses the lower eleven input bits to report its internal status information to the RX3i CPU, as follows:



Note that the sense of bit 9 is inverted compared to most other modules. Here “1” indicates *not ready*.

6.14.5 Input Filter Setup: MDL660

If an input filter time should be applied to all the module inputs, input filtering should be enabled in the software configuration of the module. The Digital Filter Settings Length must be set to 16, and a memory location to be used for the filter value must be specified. Configuring a Digital Filter Settings Length of 0 disables the input filter.

During system operation, the input filter time can be changed from the application by modifying the memory location used for the filter value. Bits 0- 7 contain the filter time configuration data as displayed in the following table. Bits 8 - 15 are not used.

Binary Value in the Output Reference Bits	Filter Time
0000 0000	0.5ms
0000 0001	1ms
0000 0011	2ms
0000 1001	5ms
0001 0011	10ms
0110 0011	50ms
1100 0111	100ms

6.15 Input Module, 24 Vdc 16-Point Grouped IC695MDL664

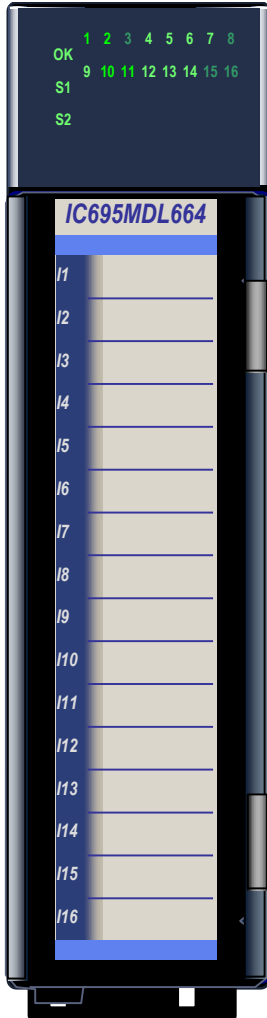


Figure 163: IC695MDL664

The *Smart Digital Input* module, IC695MDL664 provides sixteen positive logic input channels in two groups of eight. The module uses 24Vdc field input power. Each group of eight inputs is referenced to an isolated common connection. Input characteristics are compatible with a wide range of input devices, such as pushbuttons, limit switches, and electronic proximity switches. Current into an input point results in a logic 1 in the input status table (%I).

Power to operate field devices must be supplied by the user.

Sixteen dual LEDs indicate the ON/OFF/FAULT status of points 1 through 16. Two LEDs, S1 and S2 indicate whether field power is applied to each of the two input channel groups, and the status of the terminal block. The module also logs an *Addition of Terminal Block* or *Loss of Terminal Block* message to the I/O fault table to report the terminal block status.

The blue bands on the label show that MDL664 is a low-voltage module.

Features of the Smart Digital input module include:

- Selectable Input Filter Time from 0.5 ms to 100 ms.
- Open wire / Short to DC- (with external sense resistor)
- Short to DC + (with external sense resistor and external pull-up resistor)
- Input Pulse Test

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1..

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Springstyle (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth typically needed for field wiring to AC devices. Refer to Chapter 17 for more information about Terminal Blocks. The Terminal Block is ordered separately.

6.15.1 LED Operation: MDL664

The Smart Input Module has 19 bi-color LEDs on the faceplate. The states of the input points are indicated by 16 green and amber channel status LEDs. The Module OK LED indicates module status. The field status LEDs (S1 and S2) indicate whether the external +24Vdc power supply is present and is above the minimum level, whether faults are present, and whether the terminal block is locked into place.

LED Name	Function	LED Indications
OK	Module status	Off: Module is not receiving power from the RX3i backplane or the module has failed self-test.
		Solid green: Module OK and configured.
		Blinking green: The module has not received configuration from the CPU. If configuration is not successful, the module will continue to blink in this mode.
		Amber: Module hardware watchdog timeout
		Blinking amber: Module internal error. Record the blink pattern and contact technical support.
1-16	Channel status	Off: Input is off
		Green: Input is on
		Amber: Input fault
S1, S2	Terminal block and field power status	Off: Terminal present and field power not present
		Green: Terminal and field power present
		Red: Terminal not present or field power over-voltage

Note: The OK, S1 and S2 LEDs blink green in unison when the module is in firmware update mode.

6.15.2 Specifications: MDL664

Inputs per Module	16 (two isolated groups of 8 inputs each)
Power Requirements	
Input Voltage (24V nominal), V_{IN}	18Vdc–32Vdc
Ripple Voltage, maximum	10% Vpp
Backplane Power Consumption +3.3Vdc +5.1Vdc	95 mA 225 mA (worst-case, i.e. with all channels on.)
Thermal De-Rating	None required with input voltages in the 18Vdc–24Vdc range. For the 25Vdc–32Vdc range, refer to Figure 164 below.
Input Characteristics	
DC Characteristics	
Input Resistance	1966 Ω
Input Capacitance	0.05 μ f
Input Current (at 24Vdc)	12.2 mA
Input Voltage ON (Logic 1)	$0.5 \times V_{IN}$ Vdc
Input Voltage OFF (Logic 0)	$0.3 \times V_{IN}$ Vdc
AC Characteristics	
Turn On Delay, typical	20.6 ms
Turn Off Delay, typical	20.6 ms
Digital Input Filter Time	0.5–100 ms, 20 ms default
Isolation	
Field to Backplane Continuous For 1 minute	250 V ac 1500 V ac
Group to Group Continuous For 1 minute	250 V ac 1500 V ac

For product standards and general specifications, refer to Appendix A.

6.15.3 Thermal Derating: MDL664

With input voltage in the 18Vdc to 24Vdc range, no temperature de-rating is required, and all input channels can operate within the entire Surrounding Air temperature range. With input voltage greater than 24Vdc, the number of active channels must be reduced as temperature increases, according to the following de-rating curve.

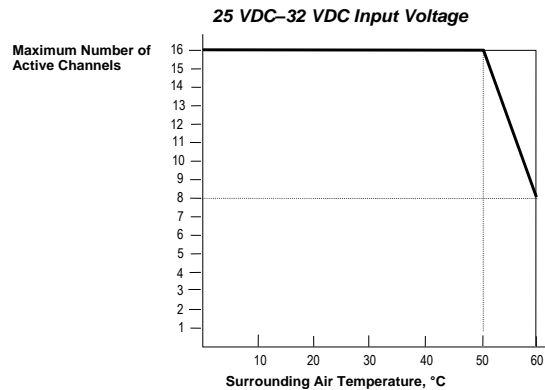


Figure 164: Thermal Derating Curve MDL664

6.15.4 Field Wiring: MDL664

Connection	Terminal
Input 1	1
NC	2
Input 2	3
NC	4
Input 3	5
NC	6
Input 4	7
NC	8
Input 5	9
NC	10
Input 6	11
NC	12
Input 7	13
NC	14
Input 8	15
NC	16
DC +	17
DC -	18

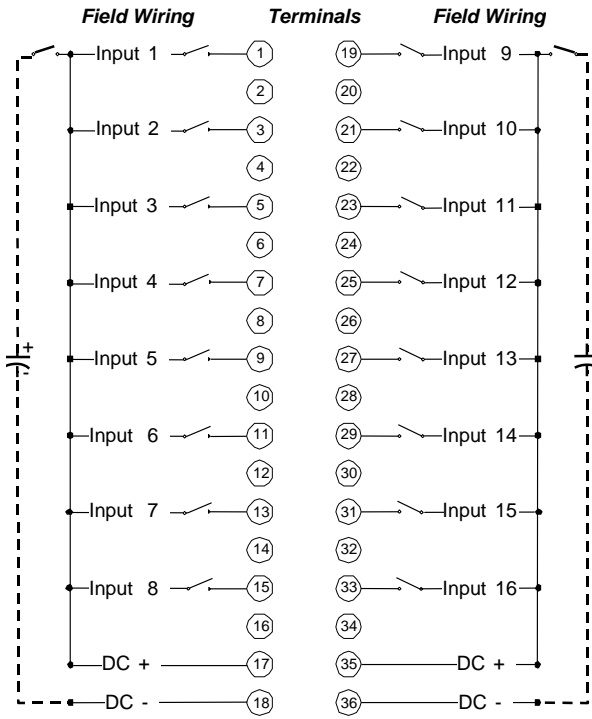


Figure 165: Field Wiring MDL664

Terminal	Connection
19	Input 9
20	NC
21	Input 10
22	NC
23	Input 11
24	NC
25	Input 12
26	NC
27	Input 13
28	NC
29	Input 14
30	NC
31	Input 15
32	NC
33	Input 16
34	NC
35	DC+
36	DC-

6.15.5 Circuit Operation: MDL664

6.15.5.1 Normal Operation

The input circuit references the input to the common (DC -) on the field side of the module. An ON condition for the input device is read as a logic 1, and an OFF condition for the input device is read as a logic 0.

Normal Thresholds

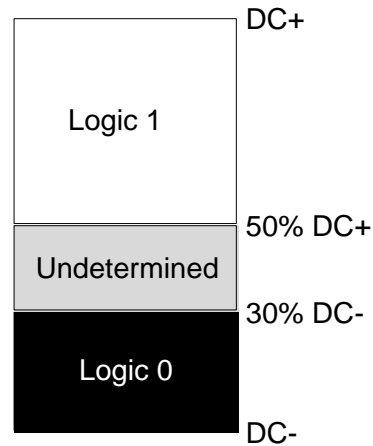


Figure 166: Normal Thresholds MDL664

6.15.5.2 Tri-State Operation (Open Wire / Short to DC- Detection)

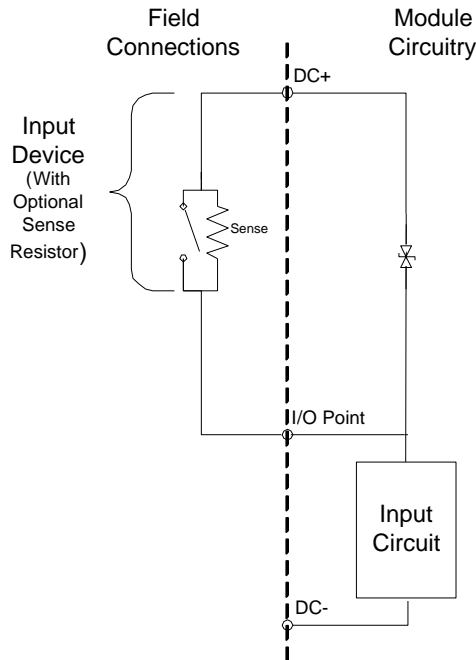


Figure 167: Tri-State Input Circuit Diagram

Tri-state Thresholds

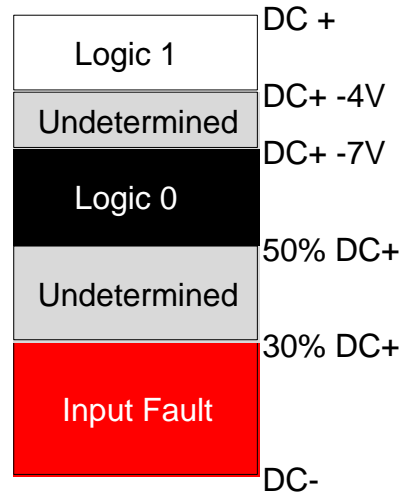


Figure 168: Tri-State Thresholds MDL664

The Open Wire / Short to Ground diagnostic can be enabled on any circuit configured as a tri-state input. In addition to being configured as a tri-state input, the circuit must have a non-inductive sense resistor placed as close as practical to the actual dry contacts (such as across the field device terminals).

6.15.5.3 Quad-State Operation (Open Wire / Short to DC- and Short to DC+ Detection)

Quadstate Input Diagram

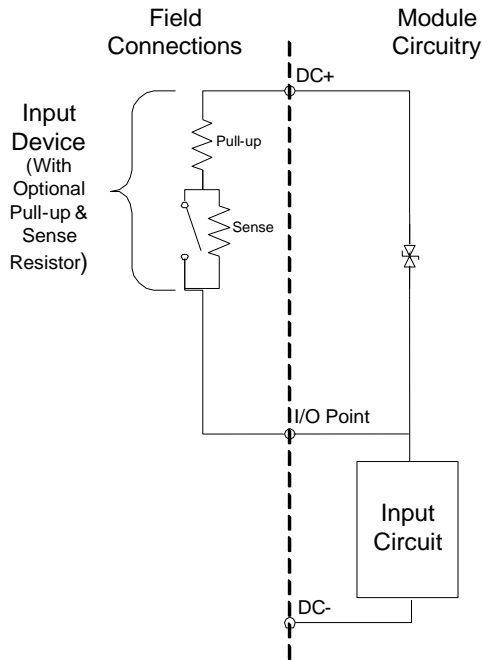


Figure 169: Quad-State Input Circuit Diagram

Quad-state Thresholds

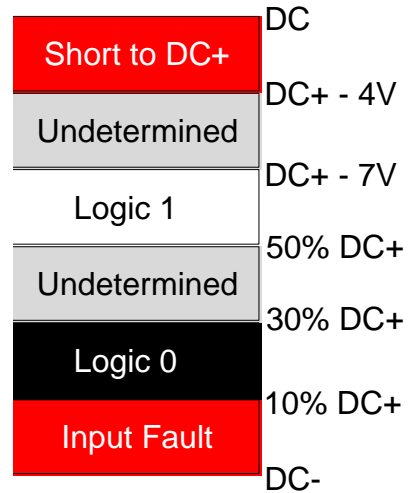


Figure 170: Quad-State Thresholds MDL664

The Open Wire / Short to DC- diagnostic and the Short to DC+ diagnostic can be enabled on any circuit configured as a quad-state input. In addition to being configured as a quad-state input, the circuit must have a non-inductive sense resistor placed as close as practical to the actual dry contacts (such as across the field device terminals) and a pull-up resistor between the high side of the Input Device and DC+.

6.15.5.4 External Resistor Selection

For Tri-State and Quad-State, the external resistor values must be calculated to allow the logic levels to fall within the ranges for the selected Input mode when driven by the expected voltage of the device connected to the input point.

Example

Consider an ideal situation with an input configured for Quad-state, a DC+ reference of 24V, and the input point connected to normally open contact that is driven by a voltage between 22V and 24V. A sense resistor is placed across the contact and a pull-up resistor connects the contact to the voltage source.

Select the pull-up resistor first, using the logic 1 voltage levels. For Quad-state logic 1, the voltage at the input point must be between 12Vdc (50% of DC+) and 17Vdc (DC+ -7V.) The closed contact shorts the sense resistor, so the voltage at the input point is determined by a divider between the internal resistance and the external pull-up resistor. To achieve the best margin across the range of input voltages, two resistances are determined to complete the divider from the maximum and minimum device voltage to the midpoint of the logic 1 range (14.5Vdc.) From these two results, a standard resistor value that lies between the limits is chosen, such as 1100Ω.

$$14.5 = 22 * \left(\frac{1966}{1966 + R_p} \right) \quad R_p = 1017$$

$$14.5 = 24 * \left(\frac{1966}{1966 + R_p} \right) \quad R_p = 1288$$

The sense resistor across the contact is solved next, using the logic 0 voltage levels. For Quad-state logic 0, the voltage at the input point must be between 2.4Vdc (10% of DC+) and 7.2Vdc (30% of DC+.) The voltage at the input point is determined by a voltage divider between the internal resistance and the two external resistors. To achieve the best margin across the range of input voltages, two resistances are determined to complete the divider from the maximum and minimum device voltage to the midpoint of the logic 0 range (4.8Vdc.) From these two results, a standard resistor value that lies between the limits is chosen, such as 6200Ω.

$$4.8 = 22 * \left(\frac{1966}{1966 + 1100 + R_s} \right) \quad R_s = 5945$$

$$4.8 = 24 * \left(\frac{1966}{1966 + 1100 + R_s} \right) \quad R_s = 6764$$

6.15.6 Input and Output Data Formats: MDL664

6.15.6.1 Channel Value Data

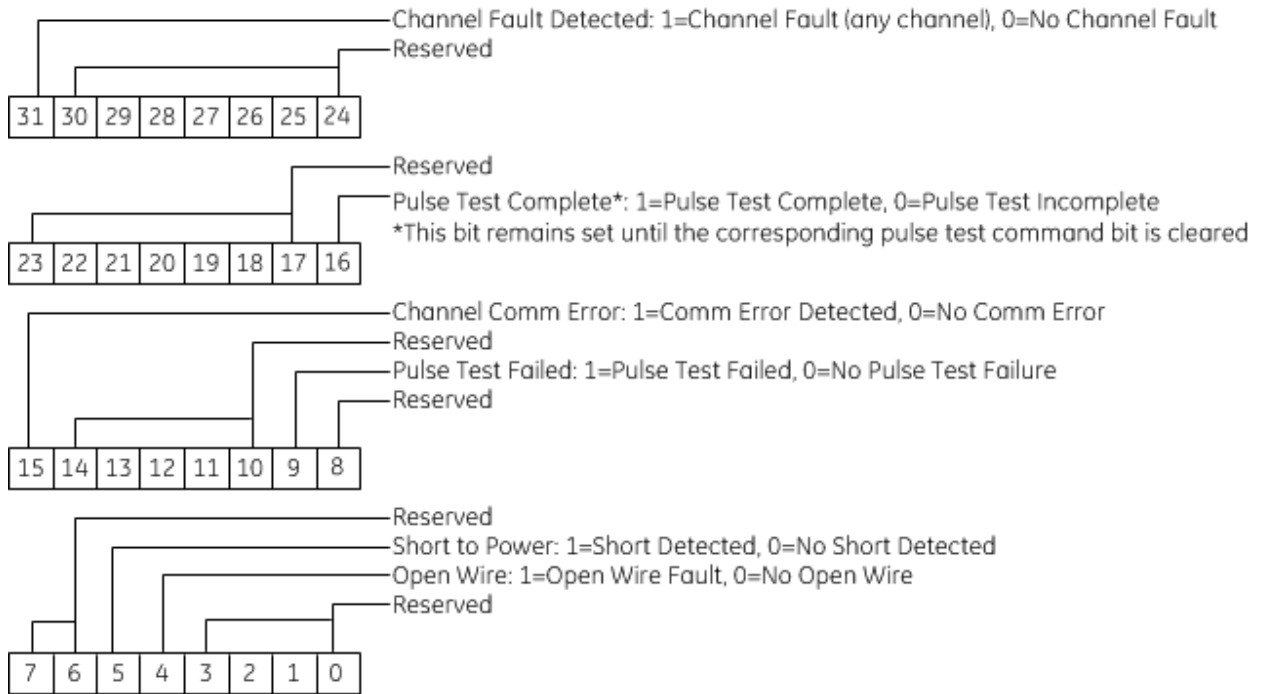
The module reports its input channel data in one bit per input, beginning at the configured *Channel Value Reference Address*.

6.15.6.2 Channel Diagnostic and Status Data

The module can be configured to report channel diagnostic and status data to the CPU. The CPU stores this data at the configured *Diagnostic Reference Address* of the module. Use of this feature is optional.

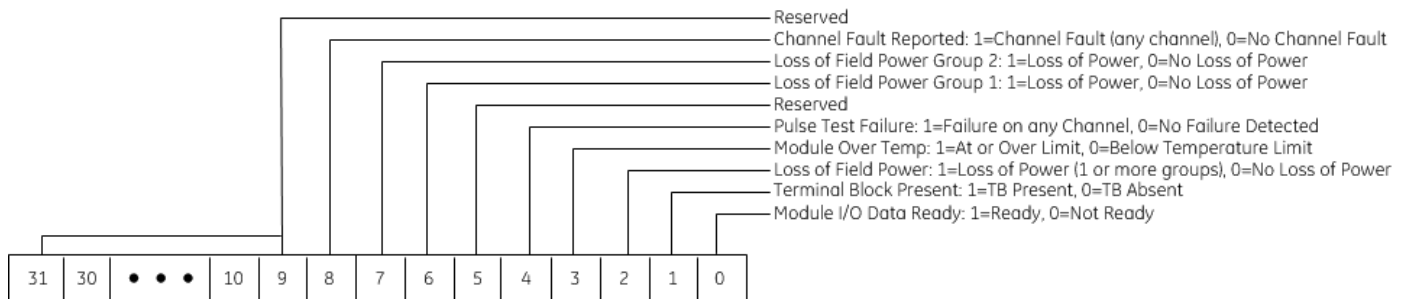
The data for each channel occupies two words whether or not the channel is used.

Note: At least two sweeps must occur to clear the diagnostic bits: one scan to send the %Q data to the module and one scan to return the %I data to the CPU. Because module processing is asynchronous to the controller sweep, more than two sweeps may be needed to clear the bits, depending on the sweep rate and the point at which the data is made available to the module.



6.15.6.3 Module Status Data: MDL664

The module can be configured to return two words of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data* reference area configured for the module.



6.15.6.4 Pulse Test Command Output Data

The module uses these bits (one bit per input), beginning at the configured *Pulse Command Output Reference Address* to command an on-demand pulse test. To command an on-demand pulse test, the Pulse Test Enable parameter for the channel must be set to *Enabled - Manual*.

6.15.7 Diagnostics: MDL664

The module always performs a set of standard diagnostic checks. Individual circuits can be configured not to log a fault to the CPU if a fault occurs. The module returns current diagnostics for all circuits to %I bits.

6.15.7.1 Input Pulse Test

The Input Pulse Test is an optional diagnostic feature that exercises the input points to confirm they can detect and respond to changes in the actual input state. Pulse testing verifies the ability of the input circuits to detect a change in state. Pulse Testing should be enabled if the module has loads that hold state for long periods of time. The application must be capable of withstanding the loss of the input feedback for up to 16 ms.

When the pulse test occurs, the input point power is removed, and then the input is connected internally to DC+. This verifies the ability of the input to detect a change in state. Each of the input points is tested individually to ensure there are no shorts between inputs. If a change in state is not detected, a fault is logged with the CPU. Valid field power must be present for the pulse test to run successfully.

On Demand Pulse Test

To use this feature, the Pulse Test Enable parameter for the channel must be set to *Enabled-Manual*. To command a pulse test, set the Pulse Test Command bit for the channel(s) to be pulse tested.

The module will perform one or more pulse tests for each channel selected. Since this will take many sweeps, you should keep the Pulse Test Command bit set until the Pulse Test Complete bit is set for that channel in the Channel Diagnostic and Status Data.

The module will keep the Pulse Test Complete bit set as long as the Pulse Test Command bit is set. One output scan with the Pulse Test Command bit cleared clears the Pulse Test Complete status bit and the Pulse Test Failure diagnostic bit.

Automatic Pulse Test

To use this feature, the Pulse Test Enable parameter for the channel must be set to *Enabled-Auto*.

The Input Pulse Test occurs at a frequency selected in the Hardware Configuration, with no intervention from the CPU. The pulse test execution is based on the Time of Day clock set in the CPU, and the frequency is relative to 12:00am. For example, a frequency of 12 hours will result in a pulse test run at 12:00am and 12:00pm.

If the pulse test fails, the Pulse Test Failed bit is set.

6.15.8 Configuration: MDL664

6.15.8.1 Module Settings: MDL664

Parameter	Function
Channel Value Reference Address Channel Value Reference Length	Specifies the memory location where the module reports 16 bits of channel values.
Diagnostic Reference Address	Specifies the starting address for reporting channel diagnostics data.
Diagnostic Reference Length	Provides thirty-two bits of diagnostic data per channel. Setting this value to 0 disables channel diagnostics reporting.
Module Status Reference Address	Specifies the starting address for reporting module status data.
Module Status Reference Length	Provides thirty-two bits of module status data. Setting this value to 0 disables channel diagnostics reporting.
Pulse Test Command Output Reference Address/ Pulse Test Command Output Reference Length	Specifies the memory location for manual pulse test command data.
Channel Faults w/o Terminal Block	Enables or disables generation of channel faults and alarms after a Terminal Block has been removed.
Inputs Default w/o Terminal Block	Enables or disables defaulting inputs when the terminal block is removed.
Loss of Terminal Block Detection	Enables or disables logging of a fault to indicate a Terminal Block has been removed.
Loss of Field Power Group 1 Detection/ Loss of Field Power Group 2 Detection	Enables or disables loss of field power detection for the specified group.
Inputs Default	Specifies whether inputs will go to Force Off or Hold Last State if module loses communication with the CPU.
I/O Scan Set	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data.

6.15.8.2 Channel Settings: MDL664

Parameter	Function	Input Type
Input Type	Selects the input operation, along with enabling the corresponding fault logging. Choices are: Dual state, Tri-state or Quad-state.	
Digital Filter	Enables or disables the digital filter for the input.	All
Digital Filter Frequency	Selects the digital filter frequency in 0.5ms increments. For details, refer to <i>Input Filter Time: MDL664</i> .	All
Pulse Test Enable	Enables or disables pulse testing of input. Allows you to select Manual or Automatic pulse testing. For details about this feature, refer to <i>Diagnostics: MDL664</i> .	All
Pulse Test Frequency	If Pulse Test Enable is set to Auto, allows you to select the frequency of pulse testing.	All
Diagnostic Reporting Enable	Enables or disables channel diagnostics. If enabled, channel diagnostic data is written to the Channel Diagnostic and Status Data.	All
Open Wire Reporting Enable	If enabled, an open wire condition is reported in the Channel Diagnostic and Status Data.	Tri-State Quad-State
Short to Power Reporting Enable	If enabled, a short to power is reported in the Channel Diagnostic and Status Data.	Quad-State
Pulse Test Failed Enable	If enabled, the results of manual or automatic pulse testing are reported in the Channel Diagnostic and Status Data.	All
Fault Reporting Enable	If enabled, channel faults are reported to the I/O fault table.	All
Open Wire Reporting Enable	If enabled and the corresponding diagnostic reporting is enabled, an open wire condition is reported in the I/O fault table.	Tri-State Quad-State
Short to Power Reporting Enable	If enabled and the corresponding diagnostic reporting is enabled, a short to power is reported in the I/O fault table.	Quad-State
Pulse Test Failed Enable	If enabled and the corresponding diagnostic reporting is enabled, a failed pulse test is reported in the I/O fault table.	All

6.15.8.3 Input Filter Time: MDL664

An input filter time of 0.5 ms to 100 ms can be selected for the module, in 0.5ms increments. The default filter time is 20 ms. The input filter can be disabled.

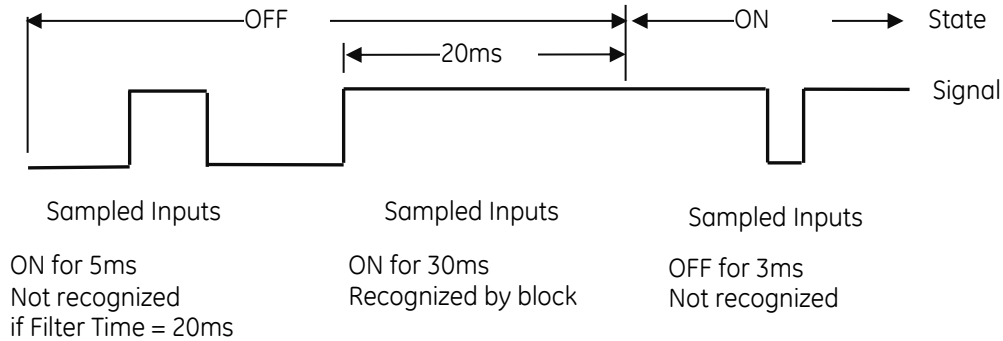


Figure 171: Effect of Input Filter Time

The filter is a digital low-pass filter. The module continuously samples an input for the length of the filter time period. The input must remain at a constant state for the length of the Filter Time for the module to recognize the state.

An input filter helps reject spurious noise spikes and multiple inputs generated by the bounce of mechanical devices. In controlled, noise-free environments, signals generated by clean, solid state electronics may be unnecessarily slowed by a filter, delaying system response. In such an environment, no additional filter time is needed. In noisy environments, use a longer filter time to prevent noise from possibly causing erratic or unsafe system operations.

6.16 Input Simulator, 8-/16-Point IC694ACC300

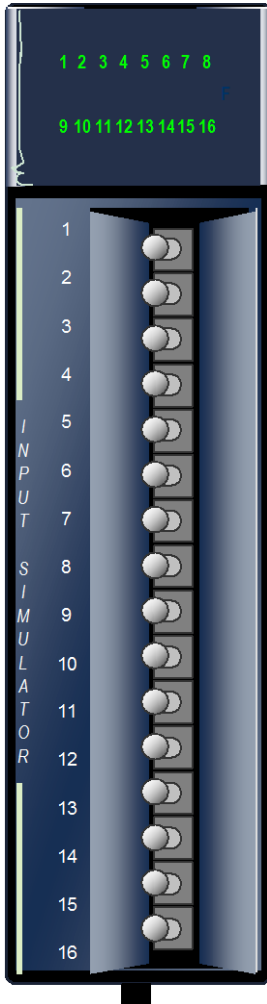


Figure 172: IC694ACC300

The **Input Simulator** module, IC694ACC300, can be used to simulate the operation of 8-point or 16-point discrete input modules. The Input Simulator has no field connections.

The Input Simulator can be substituted for actual inputs until the program or system is debugged. It can also remain permanently installed to provide either 8 or 16 conditional input contacts for manual control of output devices.

Before the Input Simulator module is installed, a switch in the back of the module (Figure 173) can be used to set it up for either 8-point or 16-point-operation. When this switch is set for 8 points, only the first 8 toggle switches on the front of the Input Simulator can be used.

Toggle switches on the front of the Input Simulator simulate the operation of discrete input devices. A switch in the ON position results in a logic 1 in the input table (%I).

Individual green LEDs indicate the ON or OFF position of each toggle switch.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

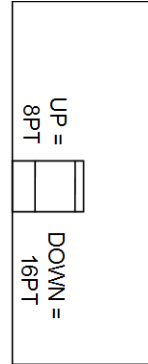


Figure 173: Mode Switch

6.16.1 Specifications: ACC300

Inputs per Module	8 or 16 (switch selectable)
Off Response Time	20 ms maximum
On Response Time	30 ms maximum
Internal Power Consumption	120 mA (all inputs on) from 5 Vdc bus on backplane

For product standards and general specifications, refer to Appendix A.

Chapter 7 Discrete Output Modules

This chapter describes discrete output modules for PACSystems RX3i controllers.

Discrete Output Module Description	Catalog Number	Section
Output 120 V ac 0.5A 12-Pt	IC694MDL310	7.1
Output 120/240 V ac 2A 8-Pt	IC694MDL330	7.2
Output 120 V ac 0.5A 16-Pt	IC694MDL340	7.3
Output 120/240 V ac 16-Pt Isolated	IC694MDL350	7.4
Output 120/240 V ac 2A 5-Pt Isolated	IC694MDL390	7.5
Output 12/24Vdc 2A 8-Pt Positive Logic	IC694MDL730	7.6
Output 12/24Vdc 0.5A 8-Pt Positive Logic	IC694MDL732	7.7
Output 125Vdc 1A 6-Point Isolated Positive/Negative Logic	IC694MDL734	7.8
Output 12/24Vdc 0.5A 16-Pt Positive Logic	IC694MDL740	7.9
Output 12/24Vdc 0.5A 16-Pt Negative Logic	IC694MDL741	7.10
Output 12/24Vdc 1A 16-Pt Positive Logic with ESCP per Group	IC694MDL742	7.11
Output 5/24Vdc (TTL) 0.5A 32-Pt Negative Logic	IC694MDL752	7.12
Output 12/24Vdc 0.5A 32-Pt Positive Logic	IC694MDL753	7.13
Output 12/24Vdc 0.75A 32-Pt Positive Logic with ESCP per Group	IC694MDL754	7.14
Output 12/24Vdc 0.5A 32-Pt Positive Logic with ESCP per Group	IC694MDL758	7.15
Output 24/125Vdc 2A 16-Pt Grouped Positive Logic with ESCP & Diagnostics	IC695MDL765	7.16
Output Relay 4 Amp 16-Pt	IC694MDL916	7.17
Output Isolated Relay N.O. 4 A 8-Pt	IC694MDL930	7.18
Output Isolated Relay N.C. and Form C 3 A 8-Pt	IC694MDL931	7.19
Output Relay N.O. 2A 16-Pt	IC694MDL940	7.20

7.1 Output Module, 120 V ac, 0.5 Amp, 12-Point: IC694MDL310

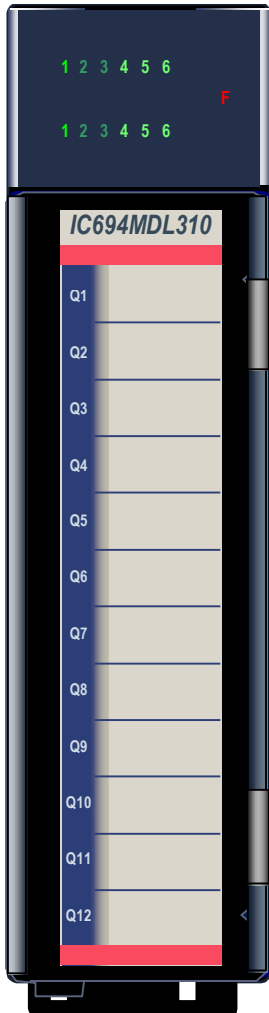


Figure 174: IC694MDL310

The **120 V ac 0.5 Amp Output** module, IC694MDL310, provides 12 output points in two isolated groups of six points. Each group has a separate common. The two commons are not tied together inside the module. The groups can be used on different phases of the AC supply or powered from the same supply. Each group is protected with a 3 Amp fuse. An RC snubber for each output protects against transient electrical noise on the power line. This module provides a high degree of inrush current (10x the rated current) so the outputs can control a wide range of inductive and incandescent loads.

AC power to operate loads connected to outputs must be user supplied. This module requires an AC power source; *it cannot be used with a DC power source.*

Individual numbered LEDs show the ON/OFF status of each output point. The red LED (F) turns ON if an output fuse blows. The red bands on the label show that MDL310 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.1.1 Specifications: MDL310

Rated Voltage	120 V ac
Output Voltage Range	85Vac to 132Vac, 50/60 Hz
Outputs per Module	12 (two groups of six outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	0.5 Amp maximum per point 1 Amp maximum per group at 60°C (140°F) 2 Amps maximum per group at 50°C (122°F) Maximum load current depends on ambient temperature as displayed in Figure 175.
Output Characteristics	
Inrush Current	5 Amps maximum for one cycle
Minimum Load Current	50mA
Output Voltage Drop	1.5 volts maximum
Output Leakage Current	3mA maximum at 120 V ac
On Response Time	1ms maximum
Off Response Time	1/2 cycle maximum
Power Consumption	210mA (all outputs on) from 5Vdc bus on backplane
Fuses (quantity 2)	3 Amps, part number 44A724627-111. Refer to <i>Module Fuse List</i> , Section 2.6.4.11 for more information.

For product standards and general specifications, refer to Appendix A.

7.1.2 Thermal Derating: MDL310

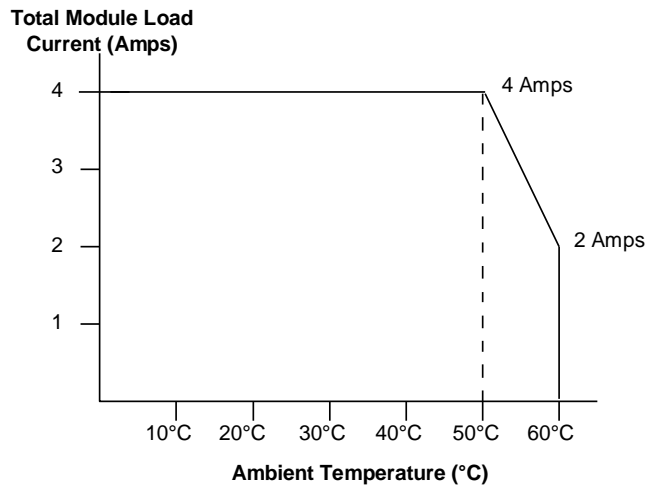


Figure 175: Thermal Derating Curve MDL310

7.1.3 Field Wiring: MDL310

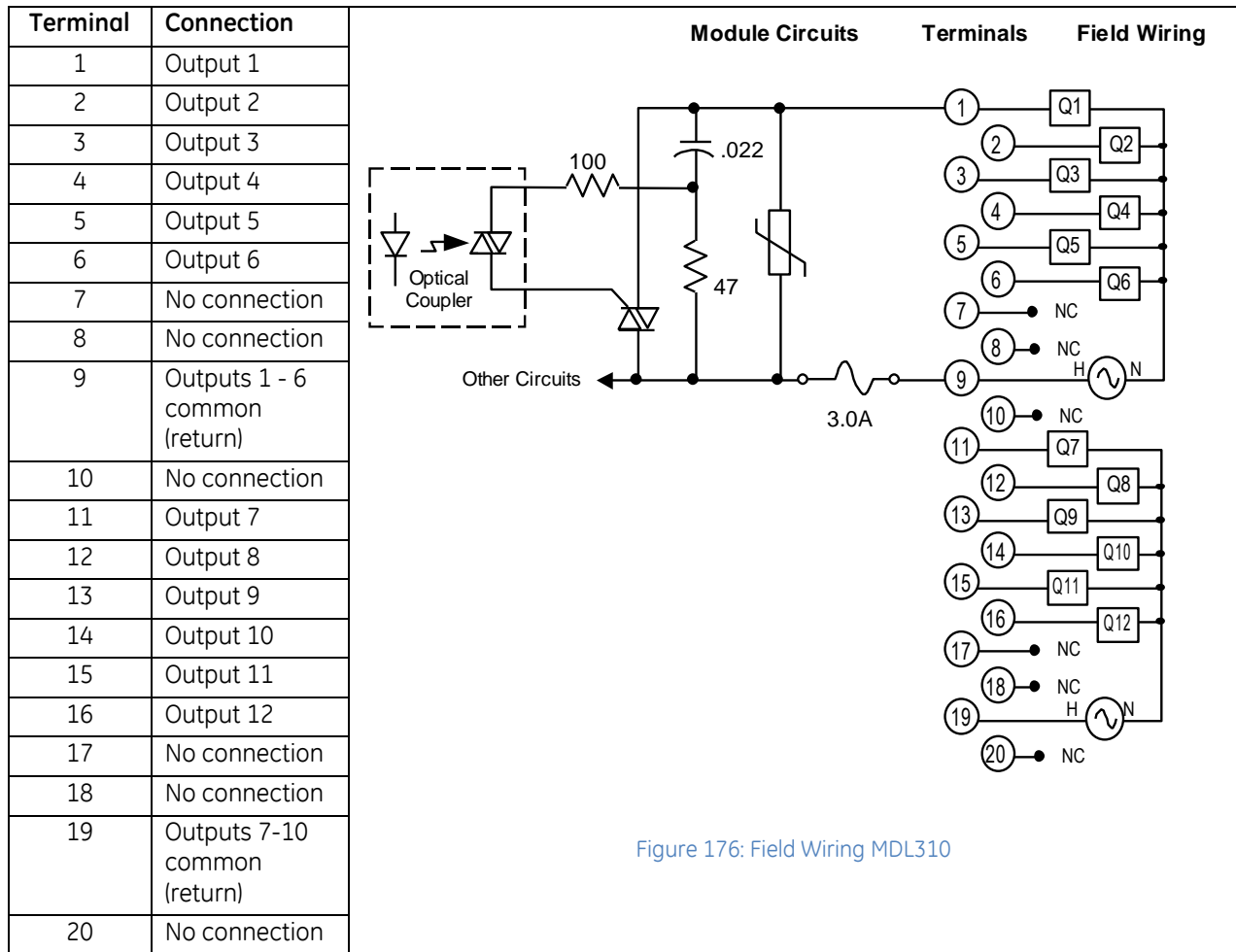


Figure 176: Field Wiring MDL310

7.2 Output Module, 120/240 V ac, 2 Amp, 8-Point: IC694MDL330

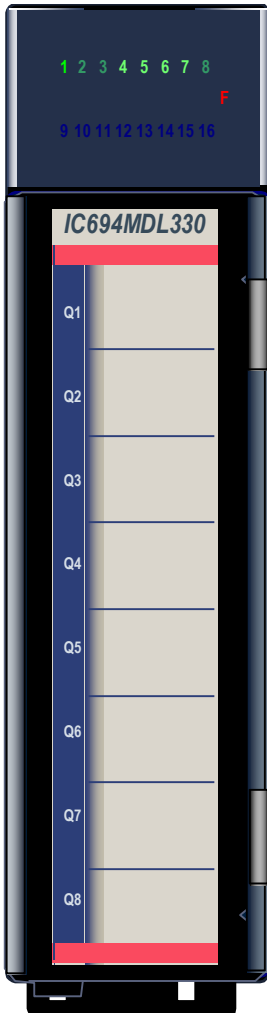


Figure 177: IC694MDL330

The **120/240 V ac 2 Amp Output** module, IC694MDL330, provides eight output points in two isolated groups of four points. Each group has a separate common. The two commons are not tied together inside the module.

The groups can be used on different phases of the AC supply or powered from the same supply. AC power to operate loads connected to outputs must be user supplied. This module requires an AC power source; *it cannot be used with a DC power source.*

Each group is protected with a 5 Amp fuse for each common. An RC snubber for each output protects against transient electrical noise on the power line. This module provides a high degree of inrush current (10 times the rated current) so the outputs can control a wide range of inductive and incandescent loads.

Individual numbered LEDs show the ON/OFF status of each output point. The red LED (F) turns ON if an output fuse blows. The red bands on the label show that MDL330 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.2.1 Specifications: MDL330

Rated Voltage	120/240 V ac
Output Voltage Range	85 to 264Vac, 50/60 Hz
Outputs per Module	8 (two groups of four outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	2 Amp maximum per point 4 Amps maximum per group at 40°C (104°F) Maximum load current depends on ambient temperature as displayed in Figure 178.
Output Characteristics	
Inrush Current	20 Amps maximum for one cycle
Minimum Load Current	100mA
Output Voltage Drop	1.5 volts maximum
Output Leakage Current	3mA maximum at 120 V ac 6mA maximum at 240 V ac
On Response Time	1ms maximum
Off Response Time	1/2 cycle maximum
Power Consumption	160mA (all outputs on) from 5 Vdc bus on backplane
Fuses (quantity 2)	5 Amp, part number 44A724627-114. Refer to <i>Module Fuse List</i> , Section 2.6.4.11 for more information.

For product standards and general specifications, refer to Appendix A.

7.2.2 Thermal Derating: MDL330

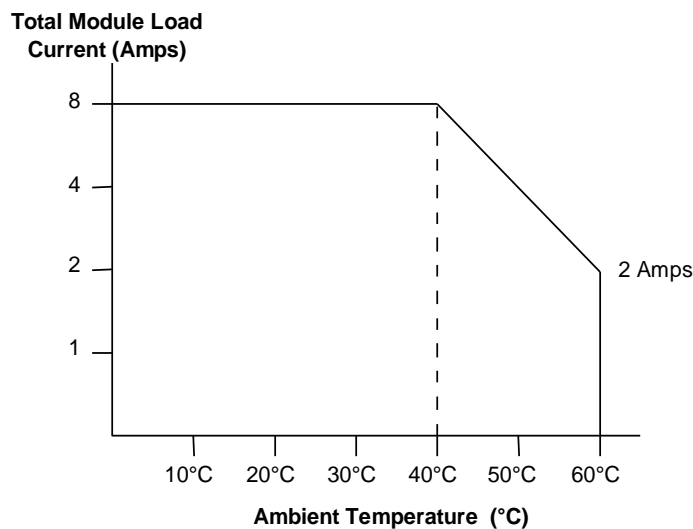


Figure 178: Thermal Derating Curve MDL330

7.2.3 Field Wiring: MDL330

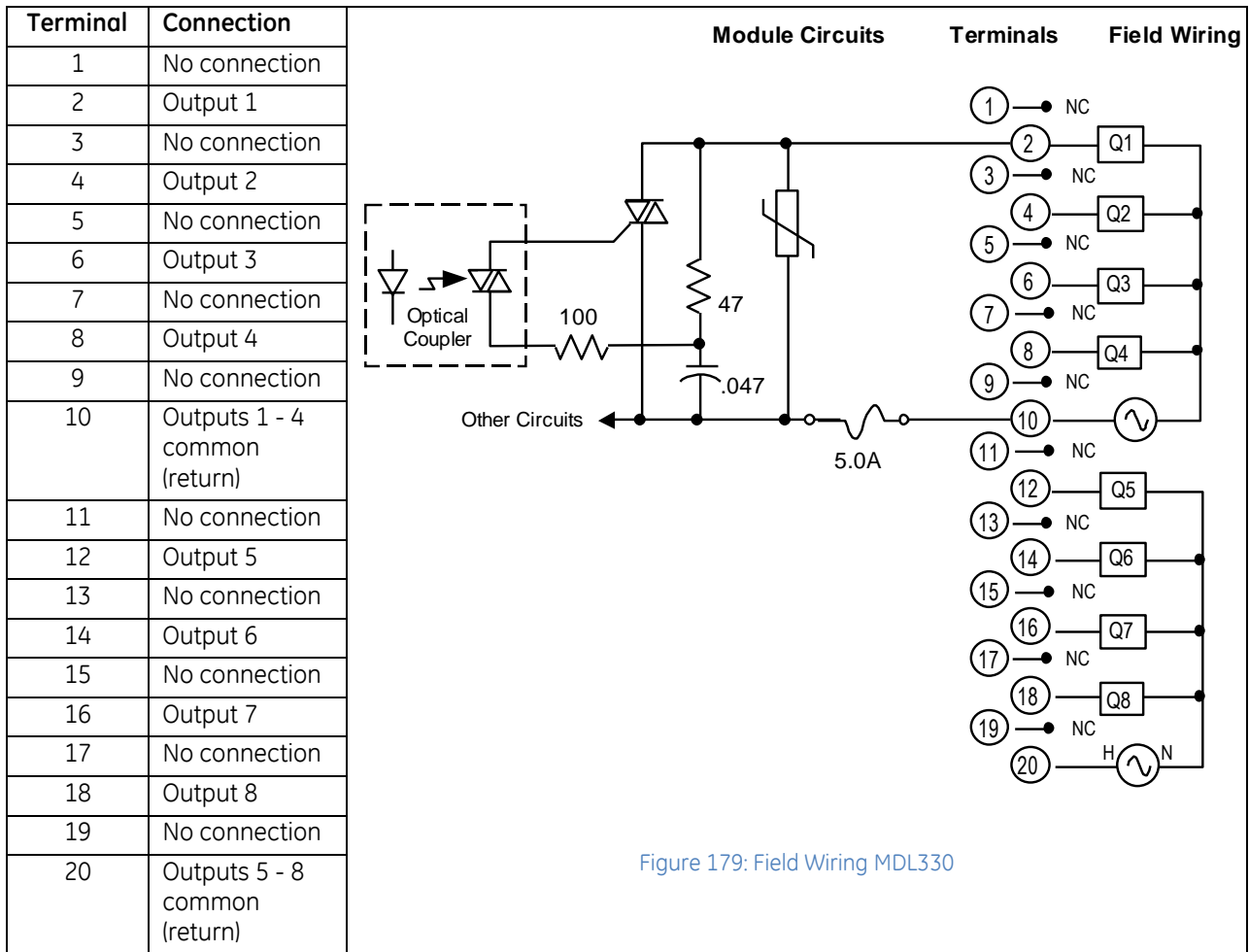


Figure 179: Field Wiring MDL330

7.3 Output Module, 120 V ac, 0.5 Amp, 16-Point: IC694MDL340

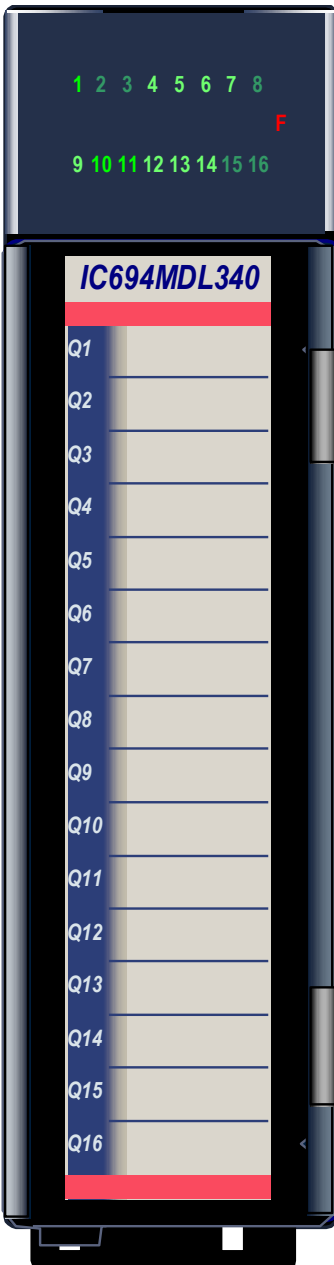


Figure 180: IC694MDL340

The **120 V ac 0.5 Amp Output** module, IC694MDL340, provides sixteen output points in two isolated groups of eight points. Each group has a separate common. The two commons are not tied together inside the module. The groups can be used on different phases of the AC supply or powered from the same supply. Each group is protected with a 3 Amp fuse. An RC snubber protects each output against transient electrical noise on the power line. This module provides a high degree of inrush current; so the outputs can control a wide range of inductive and incandescent loads.

AC Power to operate loads connected to outputs must be supplied by the user. This module requires an AC power source.

Individual numbered LEDs show the ON/OFF status of each output point. The red LED (F) turns ON if either of the fuses blows. A load must be connected to the blown fuse for the indicator to light. The red bands on the label show that MDL340 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.3.1 Specifications: MDL340

Rated Voltage	120 V ac
Output Voltage Range	85 to 132Vac, 50/60 Hz
Outputs per Module	16 (two groups of eight outputs each)
Isolation:	
Field to Backplane (optical) to Frame Ground	and 250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	0.5 amp maximum per point 3 amps maximum per group
Output Characteristics	
Inrush Current	20 amps maximum for one cycle
Minimum Load Current	50 mA
Output Voltage Drop	1.5 volts maximum
Output Leakage Current	2 mA maximum at 120 V ac
On Response Time	1 ms maximum
Off Response Time	1/2 cycle maximum
Power Consumption	315 mA (all outputs ON) from 5 volt bus on backplane
Fuses (quantity 2)	3 Amps, part number 44A724627-111. Refer to <i>Module Fuse List</i> , Section 2.6.4.11 for more information.

For product standards and general specifications, refer to Appendix A.

7.3.2 Field Wiring: MDL340

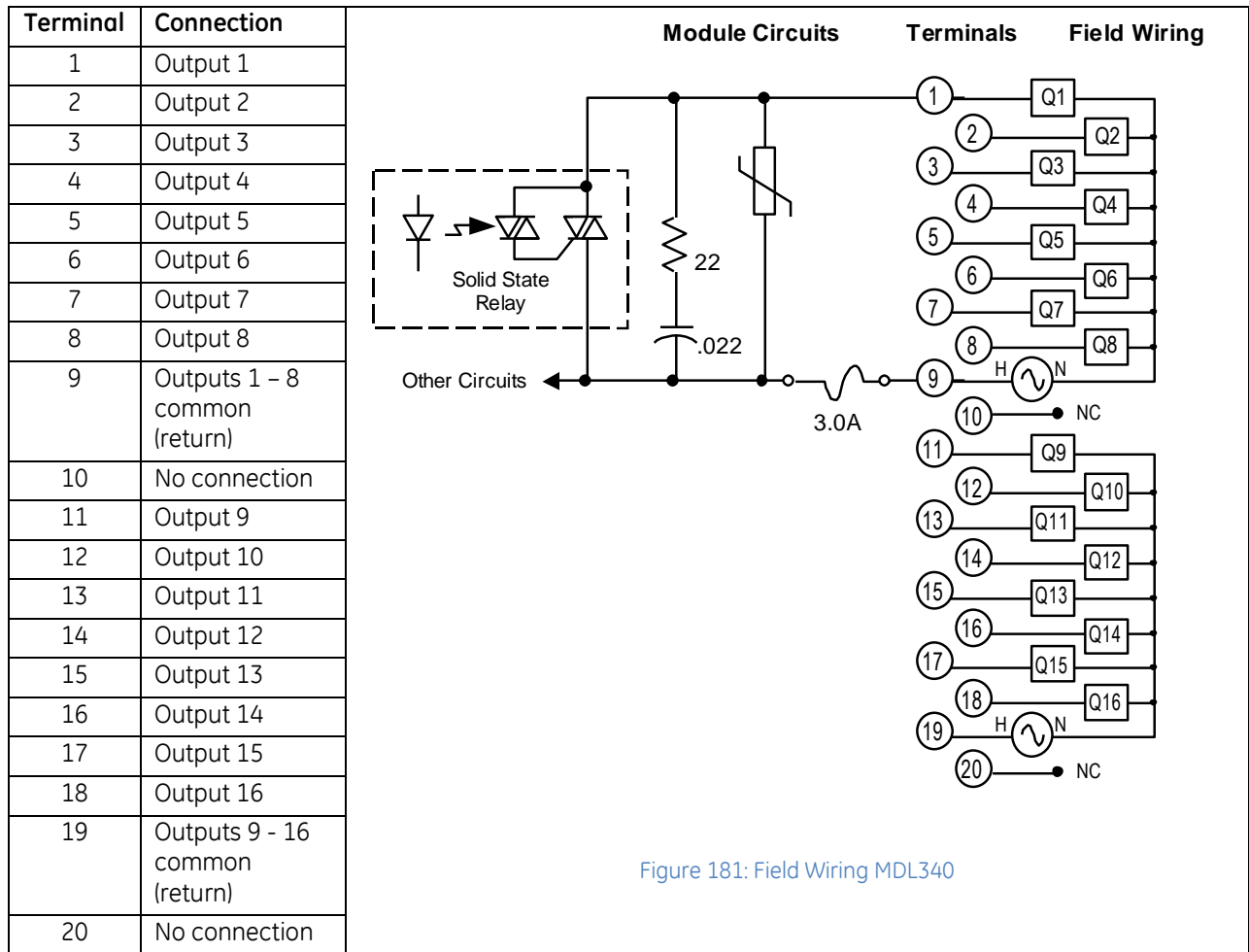


Figure 181: Field Wiring MDL340

7.4 Output Module, 120/240 V ac 16-Point Isolated: IC694MDL350

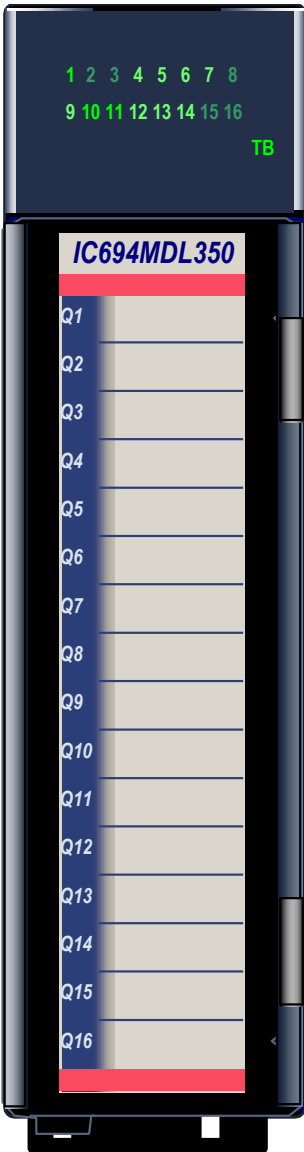


Figure 182: IC694MDL350

The **120/240 V ac 16-Point Isolated Output** module, IC694MDL350, provides sixteen individually-isolated output points. A high level of noise immunity minimizes the need for external snubbers to protect the outputs against transient electrical noise on the power line. The outputs can control a wide range of inductive and incandescent loads.

Power to operate the output loads must be provided with an external AC power supply.

A DIP switch at the rear of the module is used to select the outputs' default mode: Force Off or Hold Last State. The module must be removed from the backplane to set this switch.

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth typically needed for field wiring to AC devices. Refer to Chapter 17 for more information on Terminal Blocks. Terminal Blocks are ordered separately.

Individually-numbered LEDs show the ON/OFF status of each output point. The TB LED indicates presence of the removable Terminal Block. The TB LED is green when the Terminal Block is present or red when the Terminal Block is not present. The red bands on the door card indicate the MDL350 is a high-voltage module.

The IC694MDL350 module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

Module cannot be used with a Series 90-30 PLC CPU.

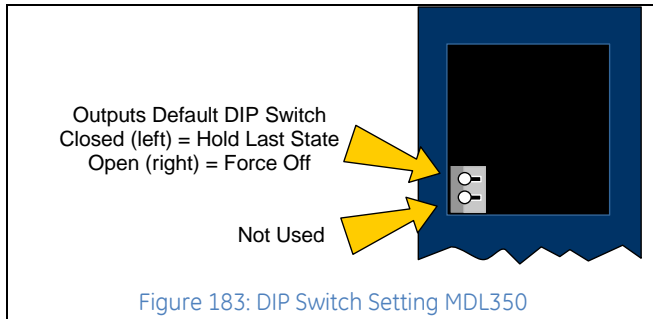
7.4.1 Specifications: MDL350

Rated Voltage	120/240 V ac
Output Voltage Range	74 – 265Vac (47 to 63 Hz), 120/240 V ac nominal
Outputs per Module	16 isolated
Isolation:	
Field to Logic Side	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Power Consumption	315 mA (with all outputs ON) from 5 volt bus on backplane
Diagnostics	Field side terminal block status reported to RX3i CPU
Output Current (Linear de-rating)	Per Point 2A max. at 30°C, 1A max. at 60°C Per Module 5A max. at 30°C, 4A max. at 60°C
Output Characteristics	
Inrush Current	20 Amps maximum for one cycle
Minimum Load Current	10 mA per point
Output Voltage Drop	1.5 volts maximum
Output Leakage Current	2 mA maximum
On, Off Response Times	1/2 cycle maximum
Fuses	No internal fusing. Use of appropriate external fuses is recommended for short circuit protection.

For product standards and general specifications, refer to Appendix A.

7.4.1.1 Setting the Output Defaults

The DIP switch at the rear of the module selects the default operation for the output circuits of this module. The module must be removed from the backplane to set this switch. Note that there are two DIP switches on the module. Only the upper switch is used for this module.



With the Outputs Default Mode switch in the right (open) position, the outputs will turn off whenever communication with the CPU is lost. When the switch is in the left position, the outputs will hold their last programmed value whenever communication with the CPU is lost.

Backplane power and power to the outputs must be present to Hold Last State. Otherwise, the module will default outputs regardless of the DIP switch setting.

The Outputs Default Mode selection made with the DIP switch must match the selection made for this feature in the software configuration of this module. If the two do not match, a warning message is displayed in the fault table.

7.4.2 Field Wiring: MDL350

Connection	Terminal	Field Wiring	Terminals	Field Wiring	Terminal	Connection
Output 1	1		<p>19</p> <p>20</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p> <p>26</p> <p>27</p> <p>28</p> <p>29</p> <p>30</p> <p>31</p> <p>32</p> <p>33</p> <p>34</p> <p>35</p> <p>36</p>	<p>Q9</p> <p>Q10</p> <p>Q11</p> <p>Q12</p> <p>Q13</p> <p>Q14</p> <p>Q15</p> <p>Q16</p> <p>NC</p> <p>NC</p>	19	Output 9
Output 1 Supply	2				20	Output 9 Supply
Output 2	3				21	Output 10
Output 2 Supply	4				22	Output 10 Supply
Output 3	5				23	Output 11
Output 3 Supply	6				24	Output 11 Supply
Output 4	7				25	Output 12
Output 4 Supply	8				26	Output 12 Supply
Output 5	9				27	Output 13
Output 5 Supply	10				28	Output 13 Supply
Output 6	11				29	Output 14
Output 6 Supply	12				30	Output 14 Supply
Output 7	13				31	Output 15
Output 7 Supply	14				32	Output 15 Supply
Output 8	15				33	Output 16
Output 8 Supply	16				34	Output 16 Supply
No connection	17	35	No connection			
No connection	18	36	No connection			

Figure 184: Field Wiring MDL350

7.4.3 Module Status Data: MDL350

Discrete output module IC694MDL350 provides sixteen bits of status data to the CPU in the assigned Module Status Reference location. By default, the configured length of this status area is 0. To access this data, the length must be changed from 0 to 16.

The module uses the lower 11 input bits to report its status information to the RX3i CPU. It has the following content:



Note that the sense of bit 9 is inverted compared to most other modules. Here "1" indicates *not ready*.

7.5 Output Module, 120/240 V ac Isolated, 2 Amp, 5-Point: IC694MDL390

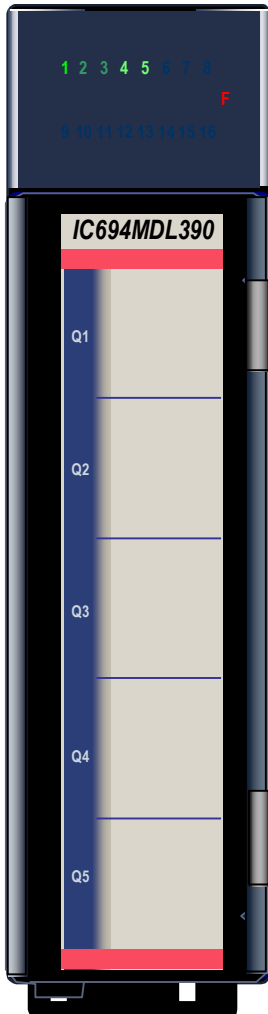


Figure 185: IC694MDL390

The **120/240 V ac 2 Amp Isolated Output** module, IC694MDL390, provides five isolated output points, each with a separate common. Each output circuit is isolated from the others relative to the AC power source. The commons are not tied together inside the module. The output circuits can be used on different phases of the AC supply or powered from the same supply.

AC Power to operate the loads connected to the outputs must be supplied by the user. *This module requires an AC power source, it cannot be used with a DC power source.*

Outputs are individually fused with a 3 Amp fuse. An RC snubber protects each output against transient electrical noise on the power line. This module provides a high degree of inrush current (greater than 10 times the rated current) so the outputs can control a wide range of inductive and incandescent loads.

Individual numbered LEDs show the ON/OFF status of each output point. The red LED (F) turns ON if an output fuse blows. The red bands on the label show that MDL390 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system. It should be configured as an 8-point output module with programs referencing the five least significant bits.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.5.1 Specifications: MDL390

Rated Voltage	120/240 V ac
Output Voltage Range	85 to 264Vac, 50/60 Hz
Outputs per Module	5 (each output isolated from the others)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Point to Point	250 V ac continuous; 1500 V ac for 1 minute
Output Current	2 Amps maximum per point 5 Amps maximum per module at 45°C (113°F) 2 Amps maximum per module at 60°C (140°F) Maximum load current depends on ambient temperature as displayed in Figure 186.
Output Characteristics	
Inrush Current	25 Amps maximum for one cycle
Minimum Load Current	100mA
Output Voltage Drop	1.5 volts maximum
Output Leakage Current	3mA maximum at 120 V ac 6mA maximum at 240 V ac
On Response Time	1ms maximum
Off Response Time	1/2 cycle maximum
Power Consumption	110mA (all outputs on) from 5Vdc bus on backplane
Fuses (quantity 5)	3 Amps, part number 44A724627-111. Refer to <i>Module Fuse List</i> , Section 2.6.4.11 for more information.

For product standards and general specifications, refer to Appendix A.

7.5.2 Thermal Derating MDL390

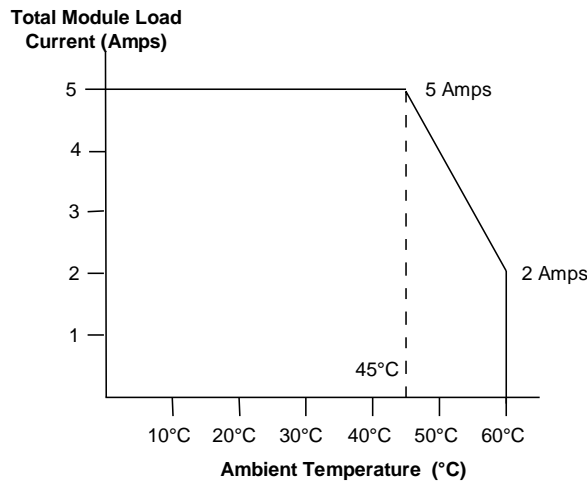


Figure 186: Thermal Derating Curve MDL390

7.5.3 Field Wiring: MDL390

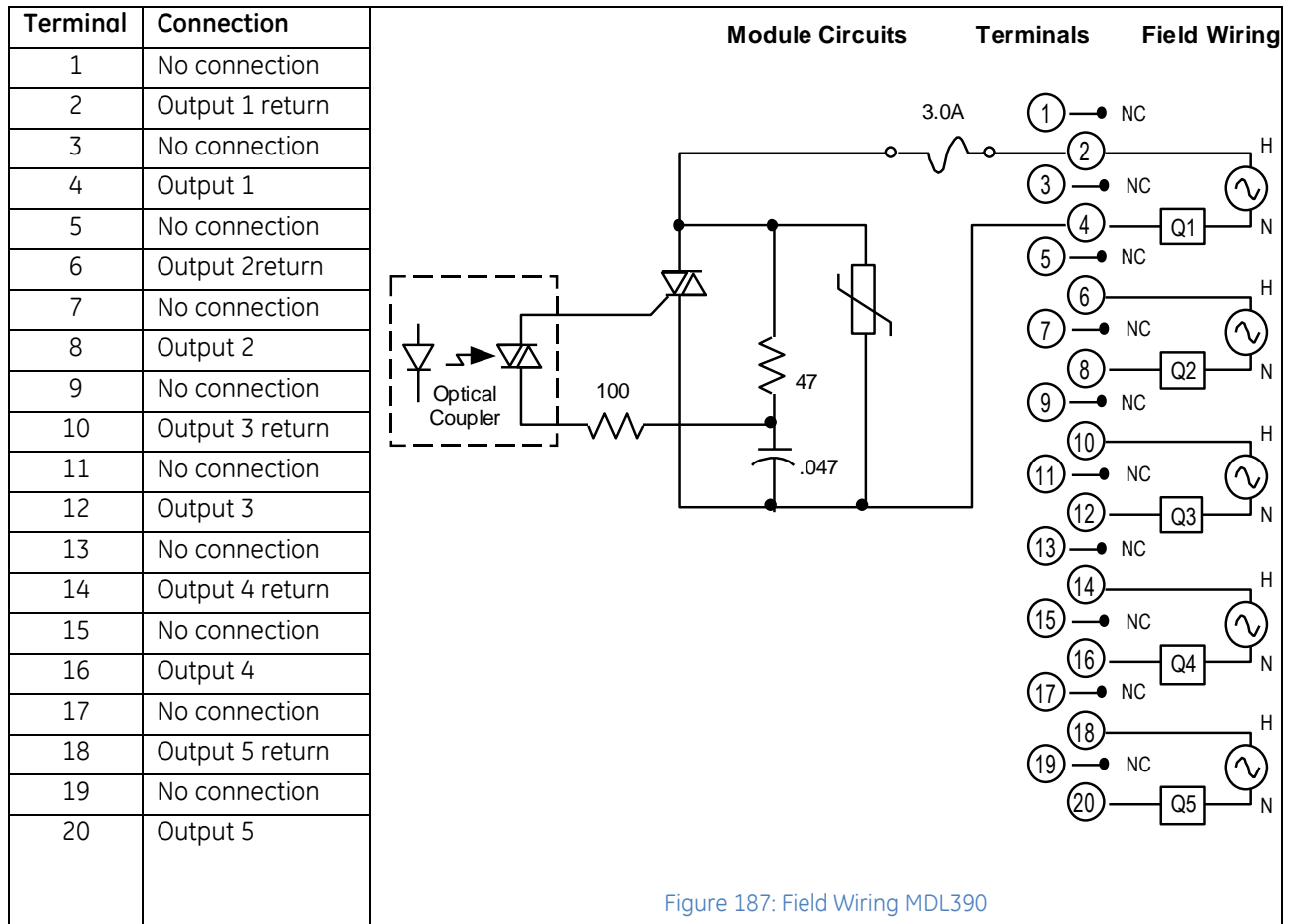


Figure 187: Field Wiring MDL390

7.6 Output Module, 12/24Vdc 2A Positive Logic 8-Point: IC694MDL730

The **12/24Vdc 2 Amp Positive Logic Output** module, IC694MDL730, provides one group of eight outputs with a common power output terminal. This module has positive logic characteristics; it sources current to the loads from the user common or positive power bus. The output device is connected between the negative power bus and the module output. The output characteristics are compatible with a wide range of load devices, such as: motor starters, solenoids, and indicators.

Individual numbered LEDs show the ON/OFF status of each output point.

The red LED (F) turns ON if either of the fuses blows. A load must be connected to the blown fuse for the indicator to light up. The module has two 5-Amp fuses with each fuse protecting four outputs: the first fuse protects A1 – A4; the second fuse protects A5 – A8. The fuses are electrically connected to the same common.

The blue bands on the label indicate that MDL730 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i or Series 90 30 system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

DC power to operate the field devices is supplied by the user.

7.6.1 LEDs

Output Status (1-8)	Green	Output is ON
	OFF	Output is OFF
Fuse (F)	OFF	Fuses are OK
	Red	One or more of the fuses is blown

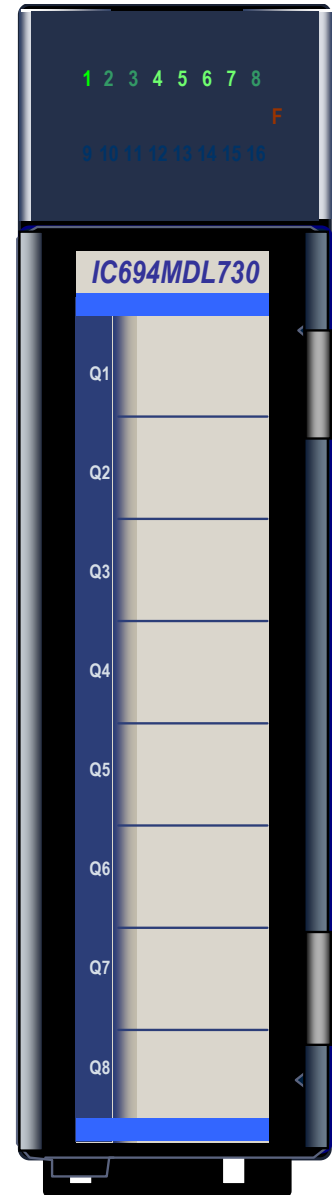


Figure 188: IC694MDL730

7.6.2 Specifications: MDL730

Rated Voltage	12/24 Vdc
Output Voltage Range	12 to 24 Vdc (+20%, -15%)
Outputs per Module	8 (one group of eight outputs)
Isolation	1500 volts between field side and logic side
Output Current ²¹	2 Amps maximum per point 2 Amps maximum per fuse at 60°C (140°F) 4 Amps maximum per fuse at 50°C (122°F)
Output Characteristics	
Inrush Current	9.4 Amps for 10 ms
Output Voltage Drop	1.2 volt maximum
Off-state Leakage	1mA maximum
On Response Time	2ms maximum
Off Response Time	2ms maximum
Power Consumption	55mA (all outputs on) from 5Vdc bus on backplane

7.6.3 Thermal Derating MDL730

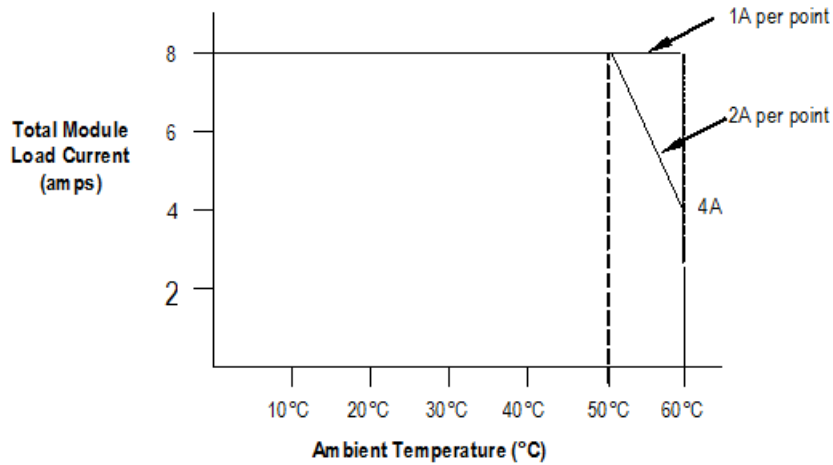


Figure 189: Thermal Derating Curve MDL730

²¹ Maximum load current depends upon surrounding air temperature.

7.6.4 Field Wiring: MDL730

Field wiring connections to the module are made via the removable terminal assembly described below.

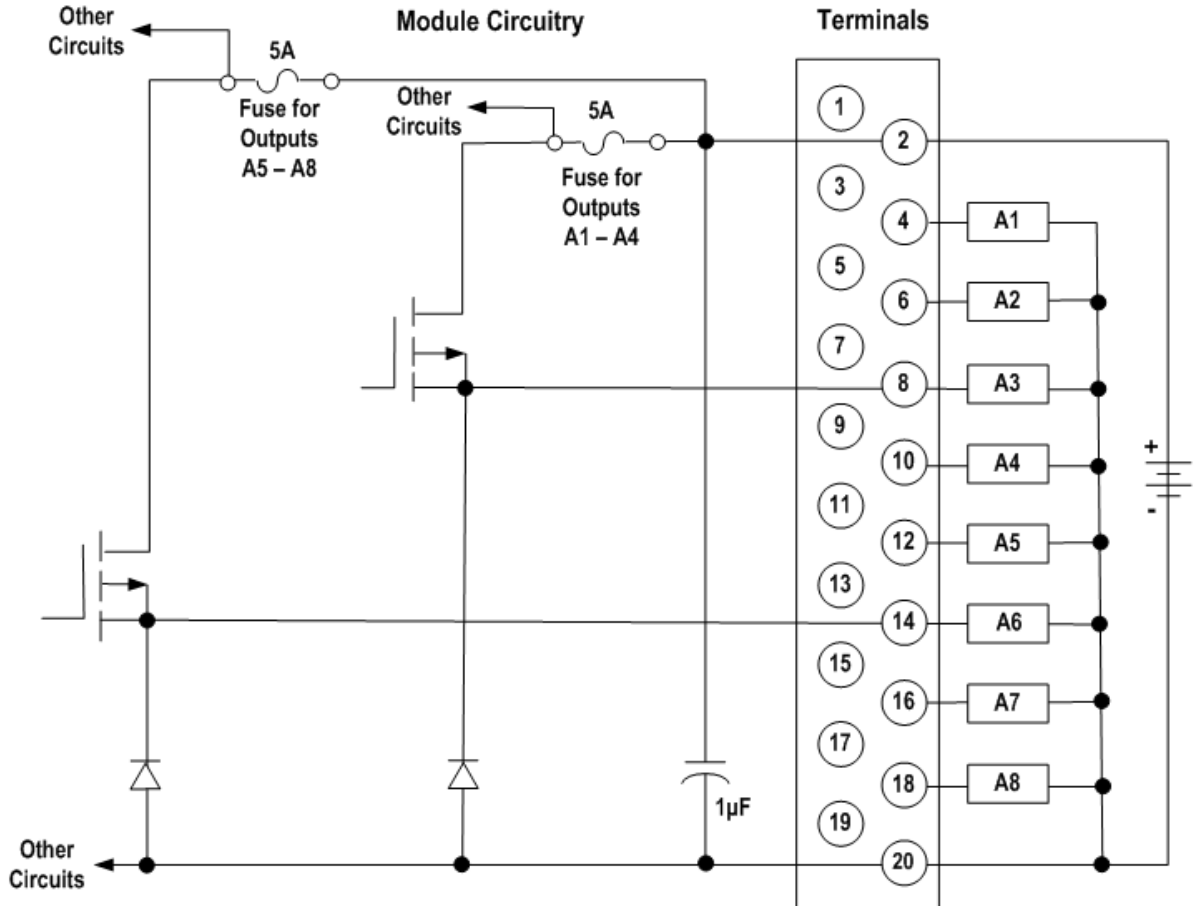


Figure 190: Field Wiring MDL730

7.6.4.1 Terminal Assemblies

The MDL730 module has a special terminal assembly that is equipped with holding screws. These screws prevent the terminal assembly to module connections from deteriorating in applications where the controller is subject to severe vibration. To install these terminal assemblies, follow the standard installation instructions in Chapter 17, then tighten the two holding screws to 8 to 10 in-lbs (1 Nm).

Screw terminals accept two copper wires in the range AWG #22 (0.36 mm²) to AWG #16 (1.3 mm²), or one AWG #14 (2.1 mm²) copper 90°C (194°F) wire. Each terminal can accept solid or stranded wires, but the wires into any given terminal must be the same type (both solid or both stranded) and the same size. Screw torque is from 9.6 in-lbs to 11.5 in-lbs (1.1 Nm to 1.3 Nm).

7.7 Output Module, 12/24Vdc 0.5A Positive Logic 8-Point: IC694MDL732

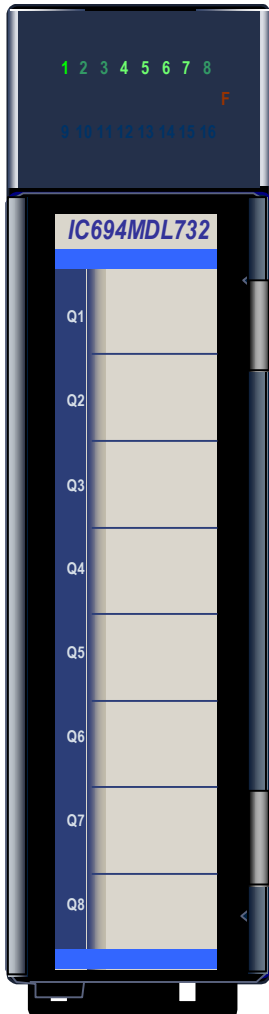


Figure 191: IC694MDL732

The **12/24Vdc 0.5 Amp Positive Logic Output** module, IC694MDL732, provides one group of eight outputs with a common power output terminal. This module has positive logic characteristics; it sources current to the loads from the user common or positive power bus. The output device is connected between the negative power bus and the module output. The output characteristics are compatible with a wide range of load devices, such as: motor starters, solenoids, and indicators.

Power to operate the field devices must be supplied by the user.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The blue bands on the label show that MDL732 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.7.1 Specifications: MDL732

Rated Voltage	12/24 Vdc
Output Voltage Range	12 to 24 Vdc (+20%, -15%)
Outputs per Module	8 (one group of eight outputs)
Isolation: Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Output Current	0.5 Amps maximum per point 2 Amps maximum per common
Output Characteristics	
Inrush Current	4.78 Amps for 10 ms
Output Voltage Drop	1 volt maximum
Off-state Leakage	1mA maximum
On Response Time	2ms maximum
Off Response Time	2ms maximum
Power Consumption	50mA (all outputs on) from 5 volt bus on backplane

For product standards and general specifications, refer to Appendix A.

7.7.2 Field Wiring: MDL732

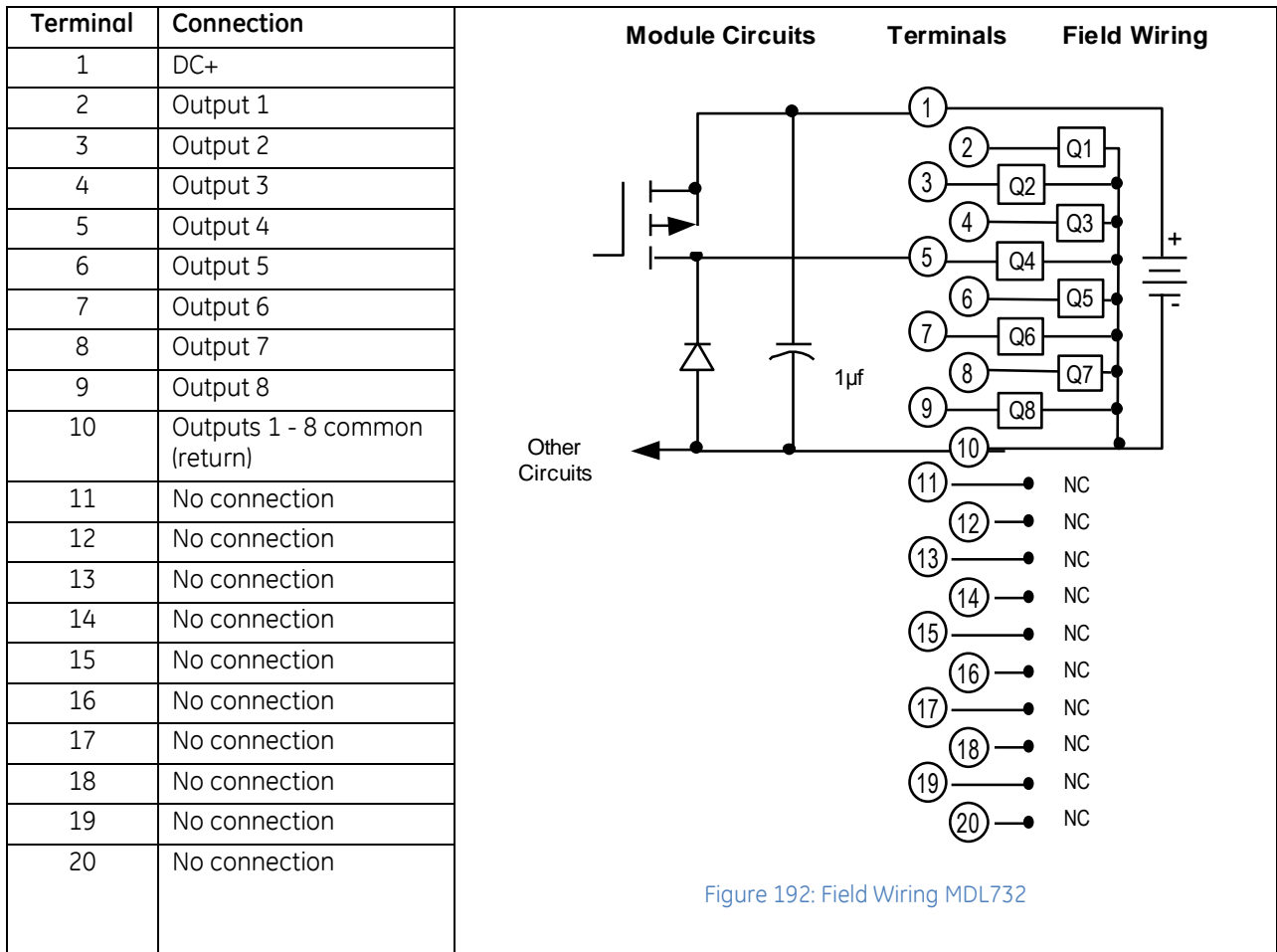


Figure 192: Field Wiring MDL732

7.8 Output Module 125Vdc, 1 Amp, 6-Point Isolated Positive/Negative: IC694MDL734

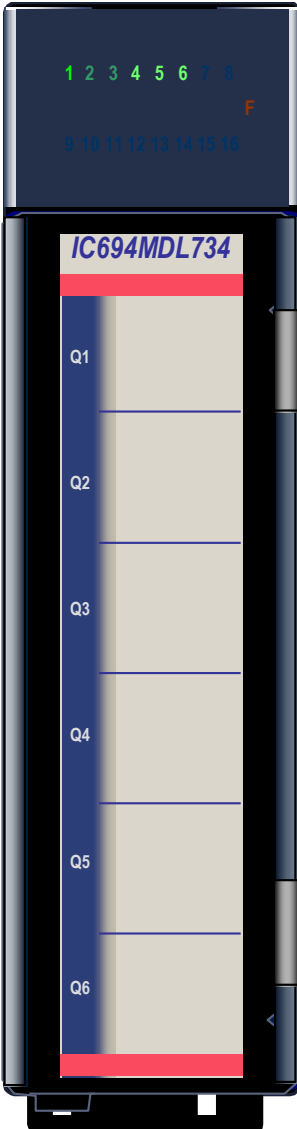


Figure 193: IC694MDL734

The **125Vdc 1 Amp Positive/Negative Logic Output** module, IC694MDL734, provides six isolated output points. Each output point has a separate common terminal. This output module can be wired to have either *positive logic* characteristics so that it sources current to the loads from the user common or positive power bus; or *negative logic* characteristics so that it sinks current from the loads to the user common or negative power bus. The output characteristics are compatible with a wide range of load devices, such as: motor starters, solenoids, and indicators.

Power to operate the field devices must be supplied by the user. External fusing is recommended. Two Amp loads can be driven by wiring and driving two outputs in parallel.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The red bands on the label show that MDL734 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.8.1 Specifications: MDL734

Rated Voltage	125 Vdc
Output Voltage Range	+10.8 to +150 Vdc
Outputs per Module	6 (isolated)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Point to Point	250 V ac continuous; 1500 V ac for 1 minute
Output Current	1 Amp maximum per point
Output Characteristics	
Inrush Current	7 Amps for 100 ms at 2% duty cycle, using 2 outputs wired in parallel
Output Voltage Drop	1 volt maximum
Off-state Leakage	1mA maximum
On Response Time	7ms maximum
Off Response Time	5ms maximum
Power Consumption	90 mA (all outputs on) from 5 volt bus on backplane

For product standards and general specifications, refer to Appendix A.

7.8.2 Field Wiring: MDL734

Terminal	Positive Logic Connection	Negative Logic Connection
1	Output 1	Output 1 return (DC+)
2	Output 1 return (DC+)	Output 1
3	Output 2	Output 2 return (DC+)
4	Output 2 return (DC+)	Output 2
5	No connection	No connection
6	No connection	No connection
7	Output 3	Output 3 return (DC+)
8	Output 3 return (DC+)	Output 3
9	Output 4	Output 4 return (DC+)
10	Output 4 return (DC+)	Output 4
11	No connection	No connection
12	No connection	No connection
13	Output 5	Output 5 return (DC+)
14	Output 5 return (DC+)	Output 5
15	Output 6	Output 6 return (DC+)
16	Output 6 return (DC+)	Output 6
17	No connection	No connection
18	No connection	No connection
19	No connection	No connection
20	No connection	No connection

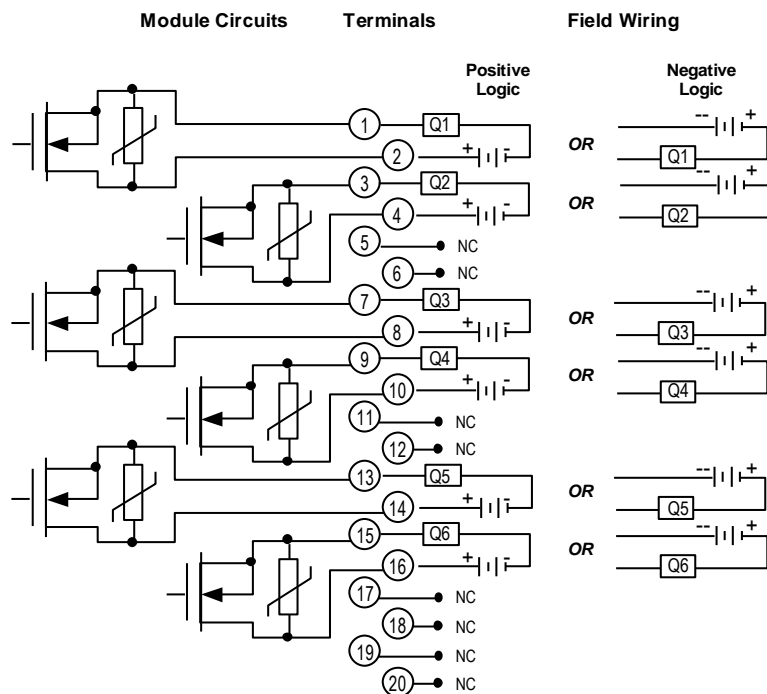


Figure 194: Field Wiring MDL734

7.9 Output Module, 12/24Vdc, 0.5 Amp, Positive Logic, 16-Point: IC694MDL740

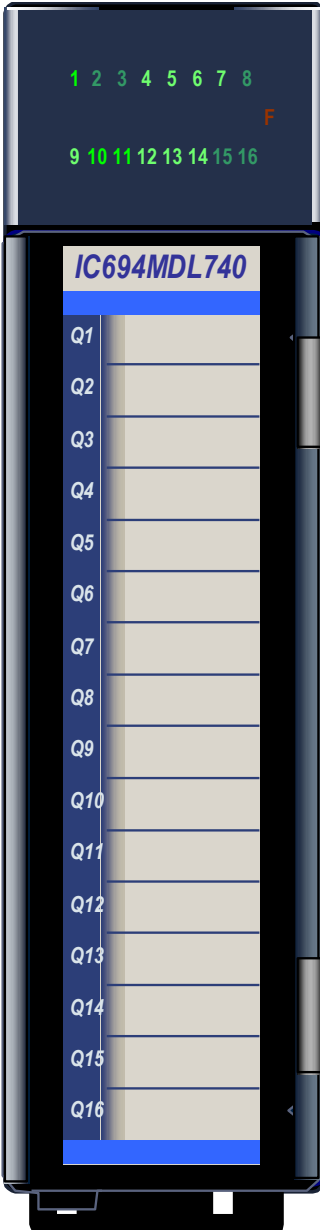


Figure 195: IC694MDL740

The **12/24Vdc 0.5 Amp Positive Logic Output** module, IC694MDL740, provides sixteen output points in two groups of eight. Each group has a common power output terminal. The module has positive logic characteristics; it sources current to the loads from the user common or positive power bus. Output devices are connected between the negative power bus and the module terminals. The output characteristics of this module are compatible with a wide range of load devices, such as: motor starters, solenoids, and indicators. Power to operate the field devices must be supplied by the user.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The blue bands on the label show that MDL740 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.9.1 Specifications: MDL740

Rated Voltage	12/24 Vdc
Output Voltage Range	12 to 24 Vdc (+20%, -15%)
Outputs per Module	16 (two groups of eight outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	0.5 Amps maximum per point 2 Amps maximum per common
Power Consumption	110mA (all outputs on) from 5 volt bus on backplane
Output Characteristics	
Inrush Current	4.78 Amps for 10 ms
Output Voltage Drop	1 volt maximum
Off-state Leakage	1mA maximum
On Response Time	2ms maximum
Off Response Time	2ms maximum

For product standards and general specifications, refer to Appendix A.

7.9.2 Field Wiring: MDL740

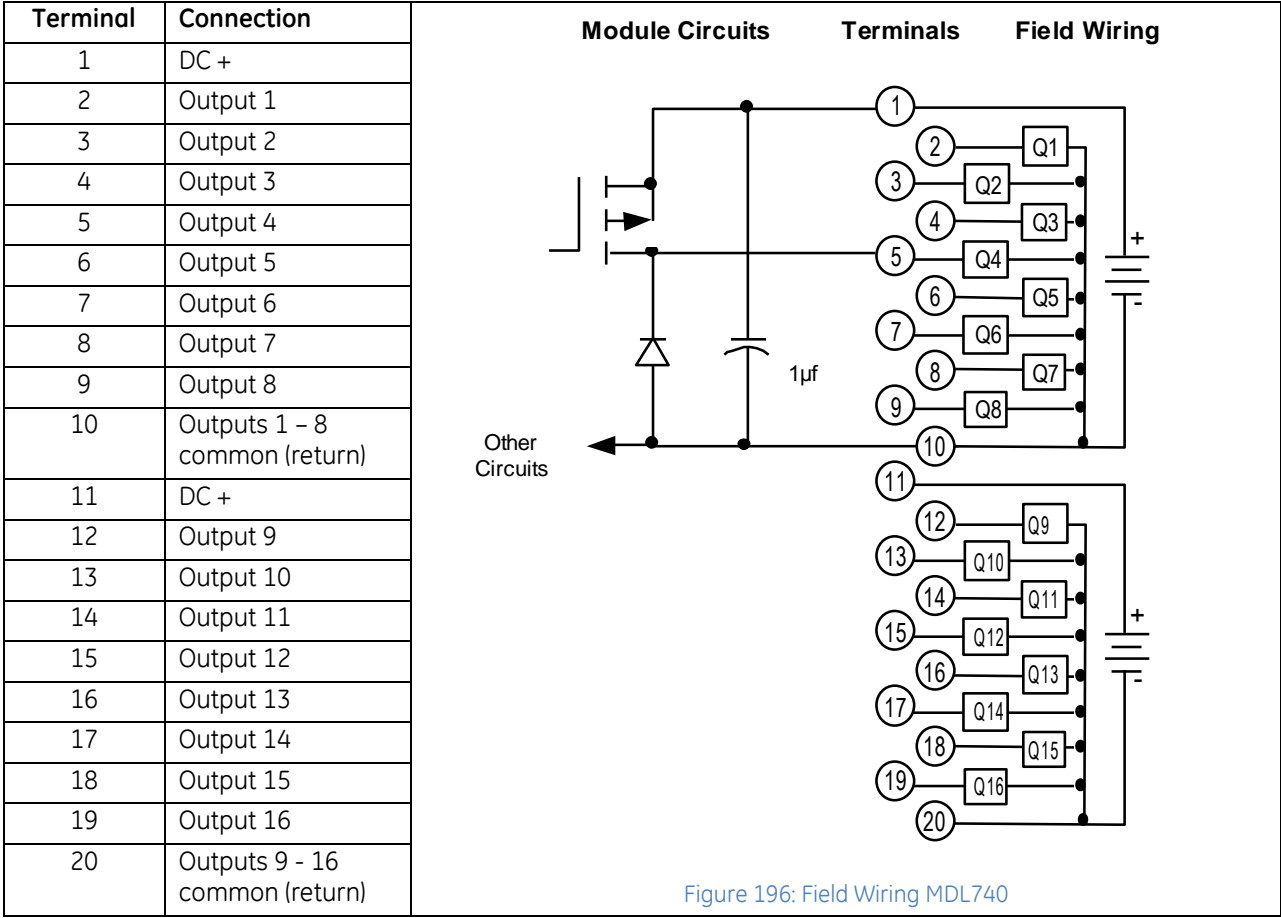


Figure 196: Field Wiring MDL740

7.10 Output Module, 12/24Vdc, 0.5 Amp, Negative Logic 16-Point: IC694MDL741

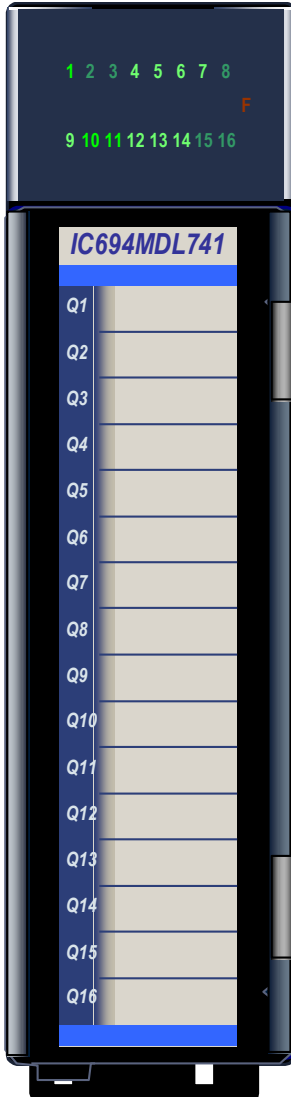


Figure 197: IC694MDL741

The **12/24Vdc 0.5 Amp Negative Logic Output** module, IC694MDL741, provides sixteen output points in two groups. Each group has a common power output terminal. This output module has negative logic characteristics; it sinks current from the loads to the user common or negative power bus. Output devices are connected between the positive power bus and the output terminals. The output characteristics of this module are compatible with a wide range of load devices, such as: motor starters, solenoids, and indicators. Power to operate the field devices must be supplied by the user.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module.

The blue bands on the label show that MDL741 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.10.1 Specifications: MDL741

Rated Voltage	12/24 Vdc
Output Voltage Range	12 to 24 Vdc (+20%, -15%)
Outputs per Module	16 (two groups of eight outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	0.5 Amps maximum per point 2 Amps maximum per common
Power Consumption	110mA (all outputs on) from 5 volt bus on backplane
Output Characteristics	
Output Voltage Drop	0.5 volts maximum
Off-state Leakage	1mA maximum
On Response Time	2ms maximum
Off Response Time	2ms maximum

For product standards and general specifications, refer to Appendix A.

7.10.2 Field Wiring: MDL741

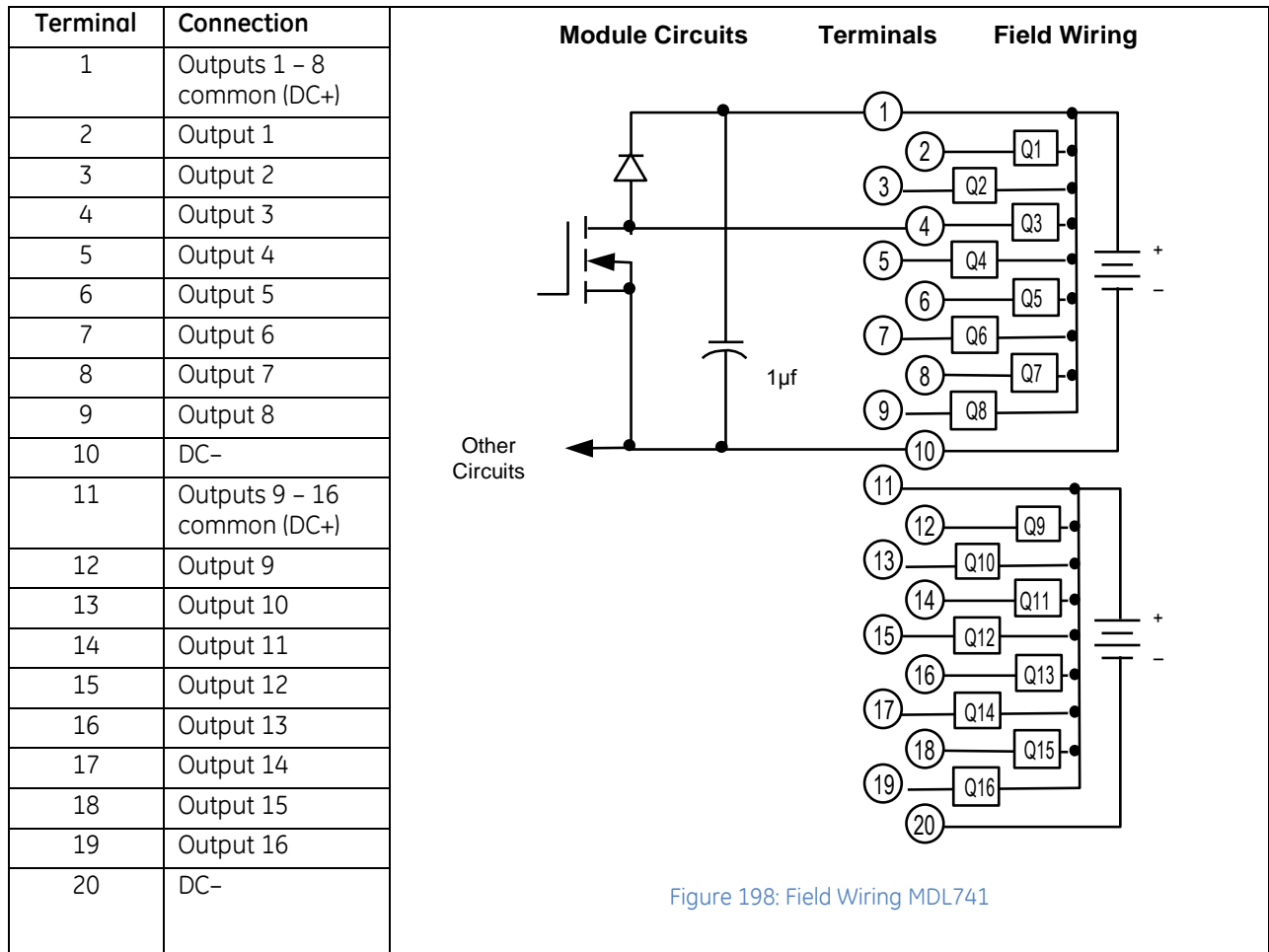


Figure 198: Field Wiring MDL741

7.11 Output Module, 12/24Vdc 1A Positive Logic, 16-Point with ESCP per Group: IC694MDL742

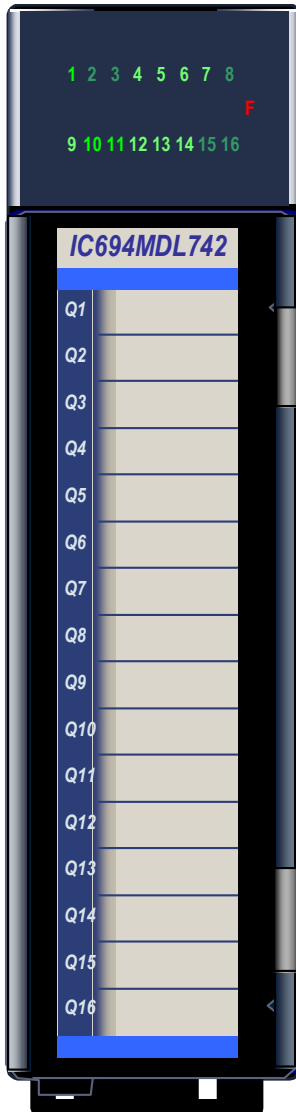


Figure 199: IC694MDL742

The **12/24Vdc 1 Amp Positive Logic Electronic Short Circuit Protection (ESCP) Output** module, IC694MDL742, provides sixteen output points in two groups of eight. Each group has a common power output terminal. This output module has positive logic characteristics: it sources current to the loads from the user common or positive power bus. Output devices are connected between the negative power bus and the output terminals. The output characteristics of this module are compatible with a wide range of load devices, such as: motor starters, solenoids, and indicators.

Power to operate the field devices must be supplied by the user.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The red LED (F) in the module header indicates electronic short circuit protection trips. The blue bands on the label show that MDL742 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.11.1 Electronic Short-Circuit Protection (ESCP)

Module MDL742 has two Electronic Short Circuit Protection circuits. The first circuit protects points 1 to 8 and the second protect points 9 to 16. The module electronically monitors the common signal for each group. If a short circuit occurs, the module turns off the output points in that group, and turns on the red LED (F). The point LEDs do not turn off. Electronic Short Circuit Protection does not prevent individual outputs from exceeding their ratings, but it protects the module in case of a short-circuited load. Electronic Short Circuit Protection is reset by cycling the 12/24Vdc user power to the module.

7.11.2 Specifications: MDL742

Rated Voltage	12/24 Vdc
Output Voltage Range	12 to 24 Vdc (+20%, -15%)
Outputs per Module	16 (two groups of eight outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	1 Amp maximum per point 4 Amps maximum per group at at 50°C 3 Amps maximum per group at 60°C Maximum total load current depends on the ambient temperature as displayed in Figure 200.
Power Consumption	130mA (all outputs on) from 5 volt bus on backplane
Output Characteristics	
Inrush Current	5.2 Amps for 10 ms
Output Voltage Drop	1.2 volts maximum
Off-state Leakage	1mA maximum
On Response Time	2ms maximum
Off Response Time	2ms maximum

For product standards and general specifications, refer to Appendix A.

7.11.3 Thermal Derating: MDL742

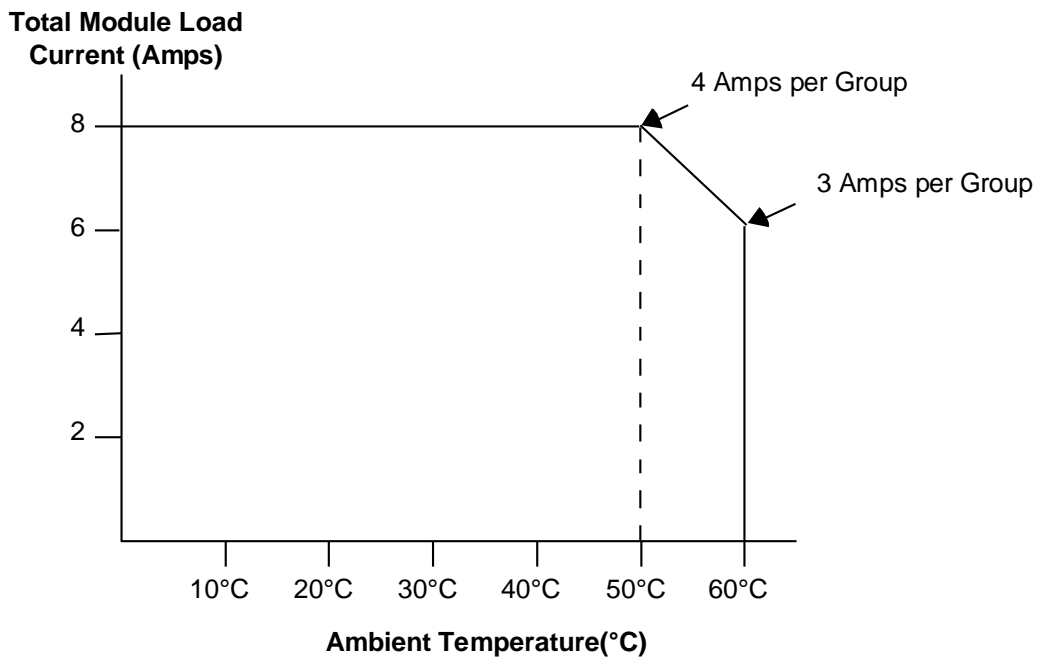
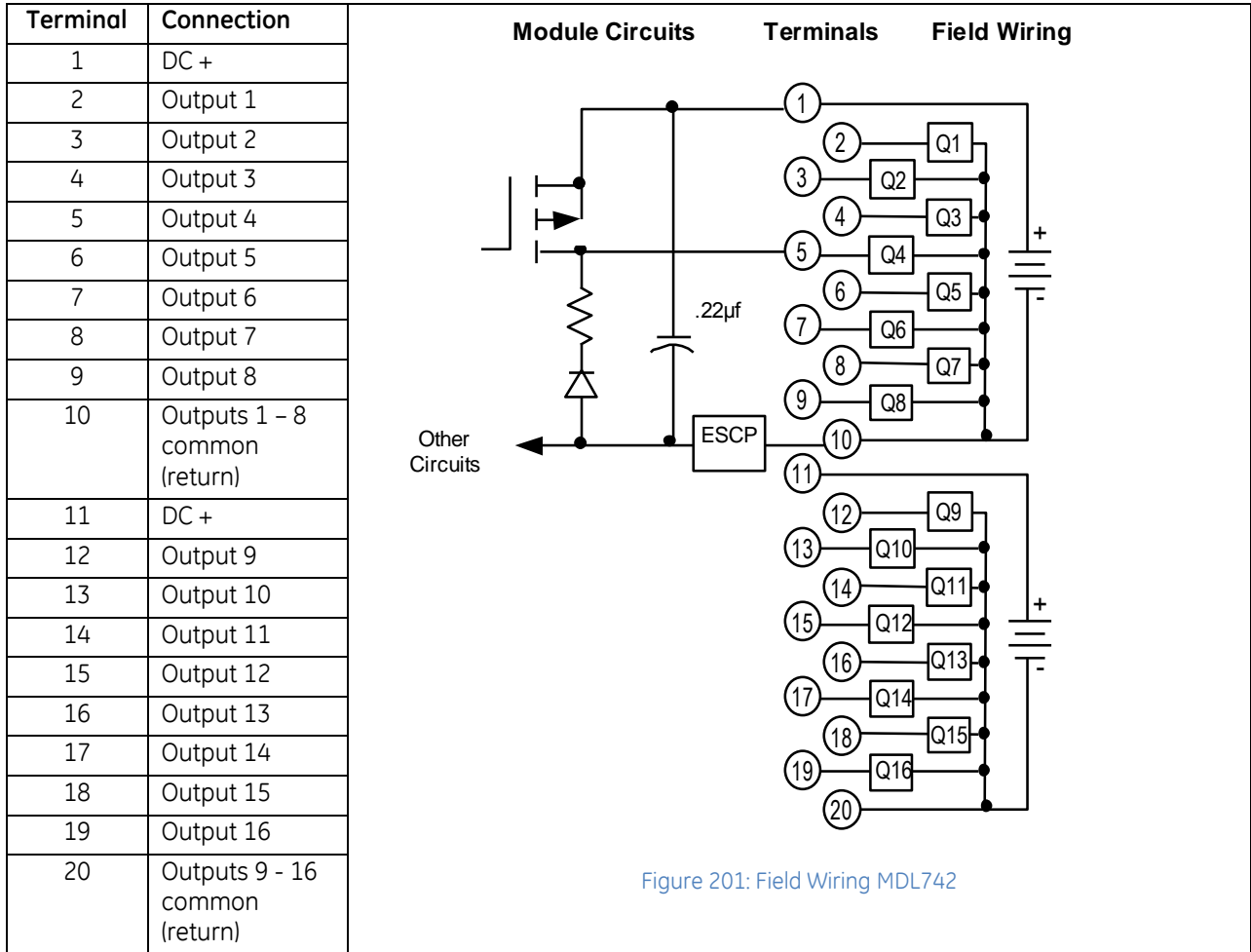


Figure 200: Thermal Derating Curve MDL742

7.11.4 Field Wiring: MDL742



7.12 Output Module, 5/24Vdc (TTL) Negative Logic, 32-Point: IC694MDL752

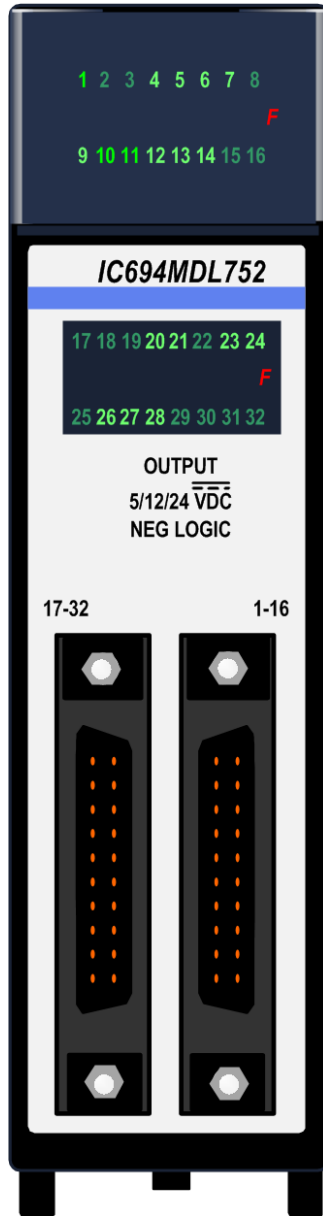


Figure 202: IC694MDL752

The **5/24Vdc (TTL) Negative Logic Output** module, IC694MDL752, provides thirty-two discrete outputs arranged in four isolated groups of eight. Each group has its own common. The outputs are negative logic or sinking-type outputs (the ON state for a point results in an active low output).

The module has two modes of operation. In TTL mode, the outputs can switch loads across +5Vdc ($\pm 5\%$) and are capable of sinking a maximum current of 25mA per point. In 12/24V mode, the outputs can switch loads over the range of +12 to -24Vdc (+20%, -15%) and are capable of sinking a maximum current of 0.5A per point.

There are two pins on the I/O connectors for each group common. Each pin has a current-handling capacity of 3 Amps. It is recommended that connections be made to both pins when connecting the common; however, it is required for high-current applications (between 3 and 4 Amps).

Each group can be used to drive different loads. For example, the module can drive TTL loads, 12Vdc loads, and 24Vdc loads on different groups. It is important to consider the effects of electrical noise when mixing TTL and inductive-type loads.

Each point has an internal pull-up resistor. The resistor passively pulls up the output to the user positive side power input (typically +5V for TTL mode) when the output point FET is OFF, providing a high logic level for TTL applications. All 32 outputs are forced OFF when the CPU is stopped.

Power to provide current to the loads must be provided by the user. The module also draws a minimum amount of power from the user supply to provide gate drive to the output devices

Backplane isolation between the field side and logic side is provided by opto-couplers on the module. No special fault or alarm diagnostics are reported. Individual numbered LEDs show the ON/OFF status of each output.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.12.1 Specifications: MDL752

Rated Voltage	5, and 12 through 24 Vdc, negative logic (active low)
Output Voltage Range	4.75 to 5.25 Vdc (TTL mode) 10.2 to 28.8 Vdc (12/24V mode)
Outputs per Module	32 (four groups of eight outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	50 V ac continuous; 500 V ac for 1 minute
Output Current	25mA per point (maximum in TTL mode) 0.5 Amps per point (maximum in 12/24V mode); with 4 Amps maximum per group and 3 Amps maximum per group common pin
Power Consumption	260mA (maximum) from 5 volt bus on backplane; (13mA + 3 mA/point ON + 4.7 mA/LED) 12 mA (maximum) per group from user supply at 5Vdc and all eight outputs in group ON 25 mA (maximum) per group from user supply at 12Vdc and all eight outputs in group ON 44 mA (maximum) per group from user supply at 24Vdc and all eight outputs in group ON
Output Characteristics	
Inrush Current	4.6 Amps for 10ms
On-state (active low)	0.4 Vdc (maximum in TTL mode)
Voltage Drop	0.24 Vdc (maximum in 12/24V mode)
Off-state Leakage Current	0.1mA maximum
On Response Time	0.5ms maximum
Off Response Time	0.5ms maximum

For product standards and general specifications, refer to Appendix A.

7.12.2 Field Wiring: MDL752

Connections to the output circuits are made from the load devices to two male 24-pin D-connectors (Fujitsu FCN-365P024-AU) on the front of the module.

The connectors on this module can be connected directly to field devices using a cable having a mating female connector on one end and stripped and tinned wires on the other end. You can purchase a pair of pre-wired cables, catalog numbers IC693CBL327 and IC693CBL328 or build cables. Refer Chapter 17 of this manual for more information.

Connections can also be made a pair of cables with connectors on each end. These cables connect the module with DIN-rail mounted terminal blocks as described in Chapter 17.

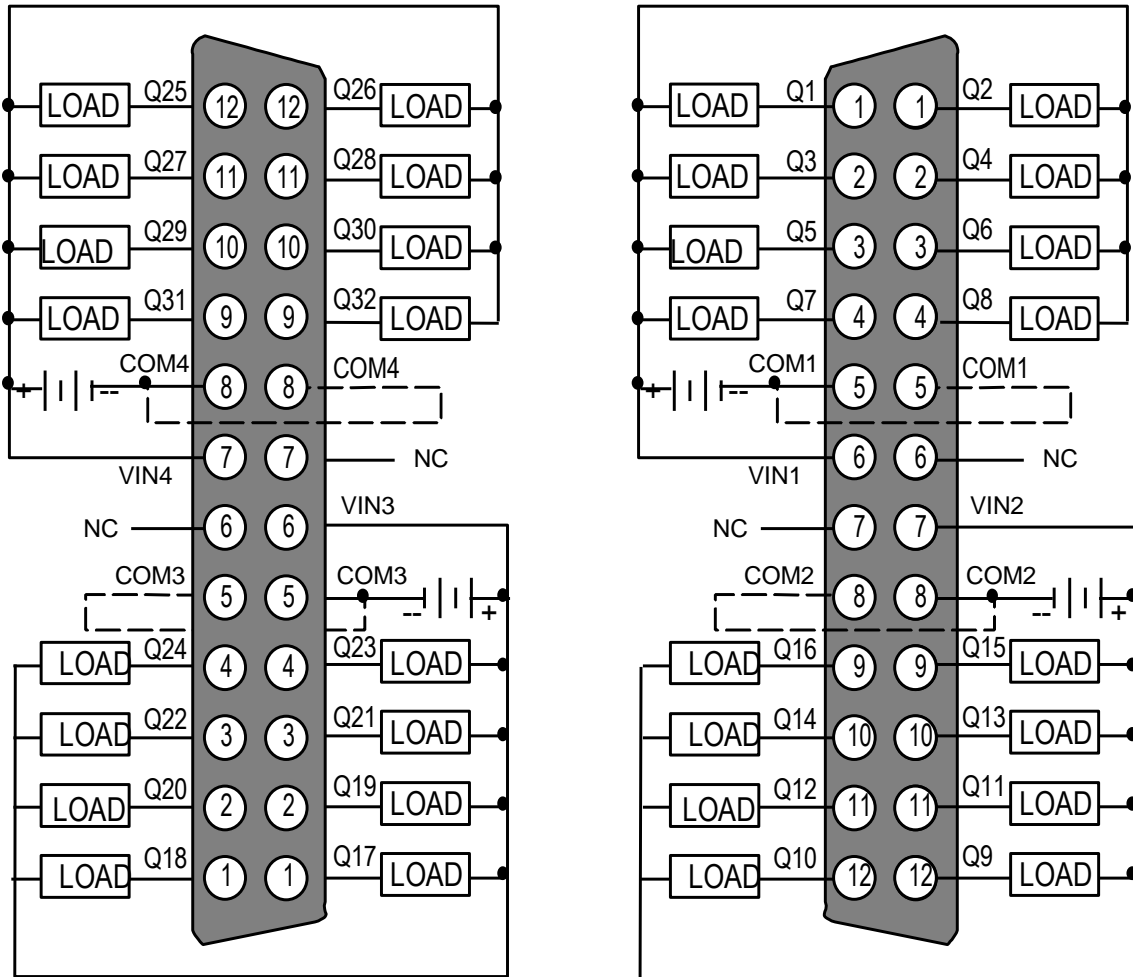


Figure 203: Field Wiring Pinouts MDL752

7.12.3 Typical Connections: MDL752

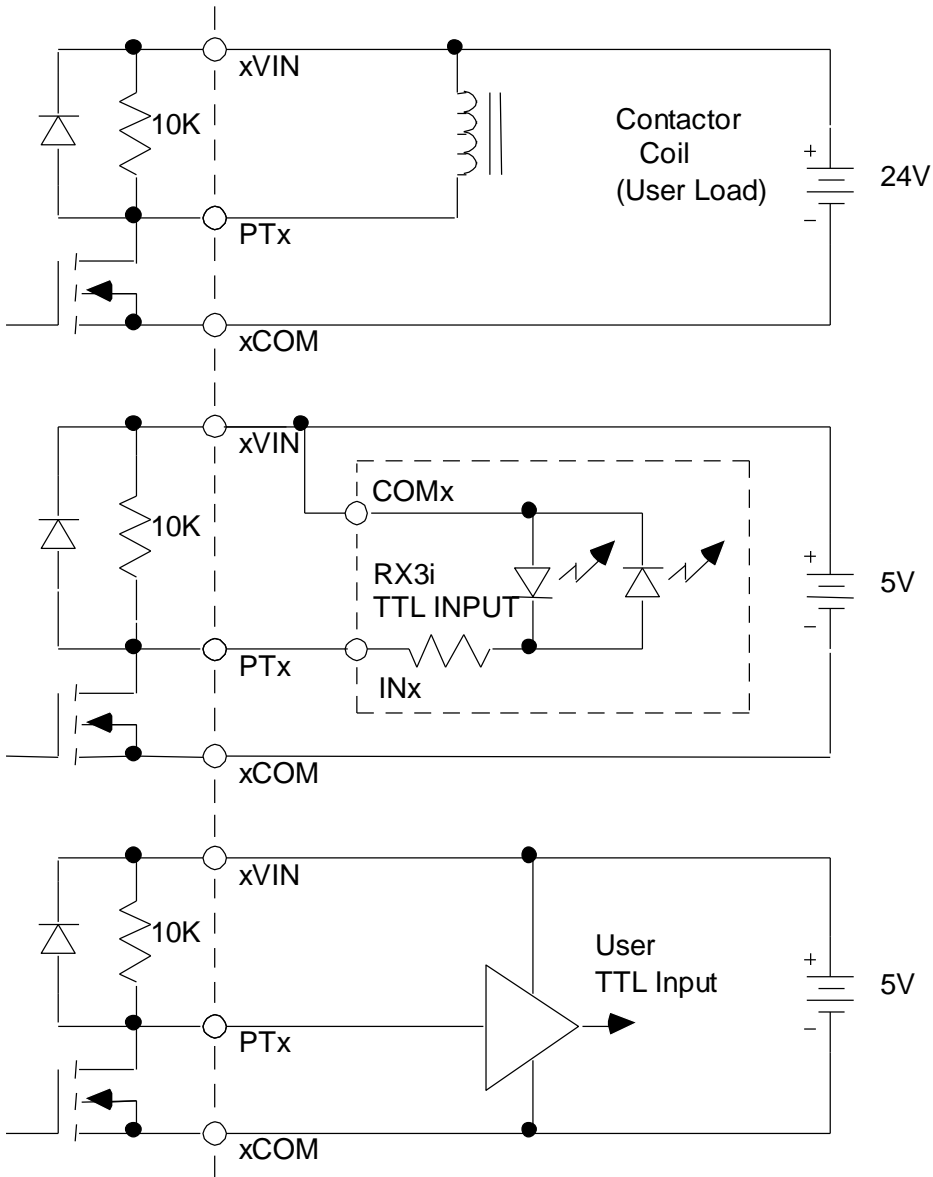


Figure 204: Typical Connections Diagram MDL752

7.13 Output Module, 12/24Vdc, 0.5A Positive Logic, 32-Point: IC694MDL753

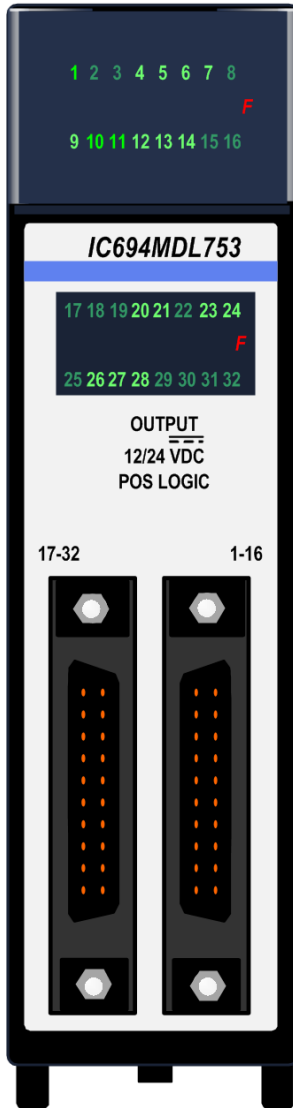


Figure 205: IC694MDL753

The **12/24Vdc 0.5A Positive Logic Output** module, IC694MDL753, provides thirty-two discrete outputs in four isolated groups of eight. Each group has its own common. The outputs are positive logic or sourcing type outputs; they switch the loads on the positive side of the power supply, and supply current to the load. The outputs can switch user loads over the range of +12 to +24Vdc (+20%, -15%) and can source a maximum current of 0.5 Amps per point. There are two pins on the I/O connectors for each group common. Each pin has a current handling capacity of 3 Amps. It is recommended that connections be made to both pins when connecting the common; however, it is required for high-current applications (between 3 and 4 Amps).

Each group can be used to drive different loads. For example, three groups might drive 24Vdc loads, while the fourth was reserved for driving 12Vdc loads.

Power to provide current to the loads must be provided by the user. The module also draws a minimum amount of power from the user supply to provide gate drive to the output devices.

Backplane isolation between the field side and logic side is provided by opto-couplers on the module.

All 32 outputs are forced OFF when the CPU is stopped. No special fault or alarm diagnostics are reported. Individual numbered LEDs show the ON/OFF status of each output.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.13.1 Specifications: MDL753

Rated Voltage	12 through 24 Vdc, positive logic
Output Voltage Range	10.2 to 28.8 Vdc
Outputs per Module	32 (four groups of eight outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	50 V ac continuous; 500 V ac for 1 minute
Output Current	0.5 Amps per point with 4 Amps maximum per group and 3 Amps maximum per group common pin
Power Consumption	260 mA (maximum) from 5 volt bus on backplane; (13mA + 3mA/point ON + 4.7mA/LED) 16.5mA (maximum) per group from user supply at 24Vdc and all eight outputs in group ON 9.6mA (maximum) per group from user supply at 12Vdc and all eight outputs in group ON
Output Characteristics	
Inrush Current	5.4 Amps for 10 ms
On-state Voltage Drop	0.3Vdc
Off-state Leakage Current	0.1mA maximum
On Response Time	0.5ms maximum
Off Response Time	0.5ms maximum

For product standards and general specifications, refer to Appendix A.

7.13.2 Field Wiring: MDL753

Connections to the output circuits are made from the load devices to two male 24-pin D-connectors (Fujitsu FCN-365P024-AU) on the front of the module. The connectors on this module can be wired directly to field devices using a cable having a mating female connector on one end and stripped and tinned wires on the other end. You can purchase a pair of pre-wired cables, catalog numbers IC693CBL327 and IC693CBL328 or build cables. Refer to Chapter 17 of this manual for more information.

Connections can also be made a pair of cables with connectors on each end. These cables connect the module with DIN-rail mounted terminal blocks as described in Chapter 17.

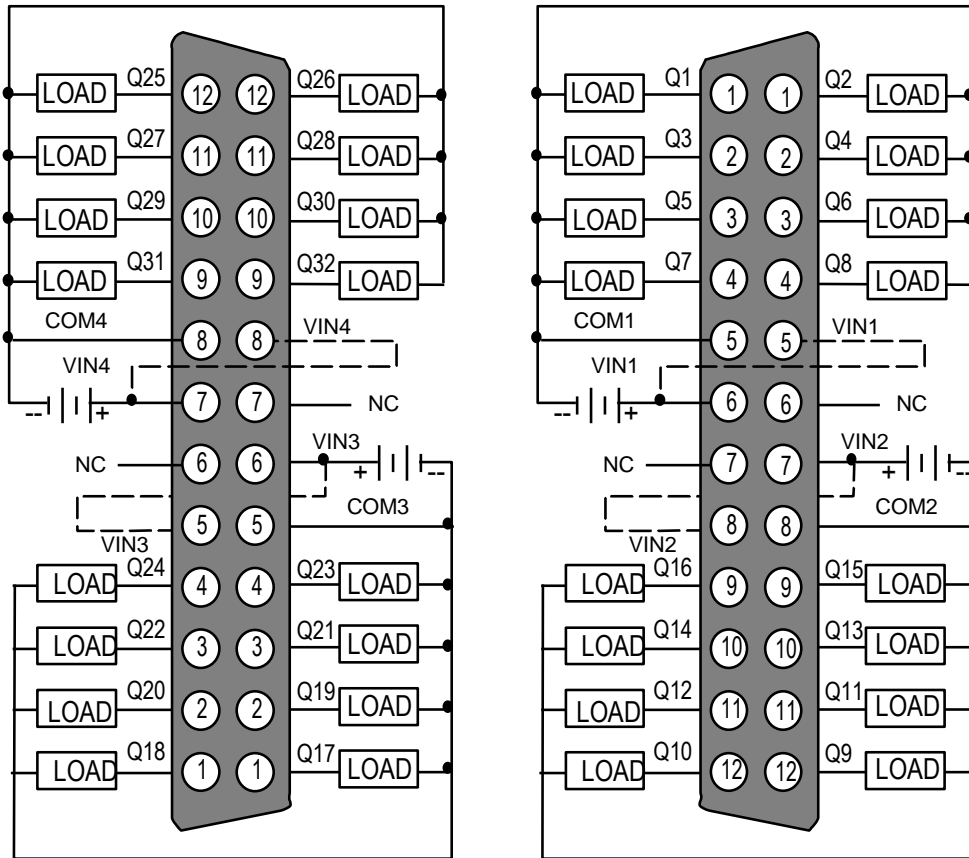


Figure 206: Field Wiring Pinouts MDL753

If the total current is greater than 3 Amps for a group, use both V_{IN} pins for the group by adding a second wire (shown by dashed lines above).

7.14 Output Module, 12/24Vdc, 0.75A Positive Logic, 32-Point with ESCP per Group: IC694MDL754

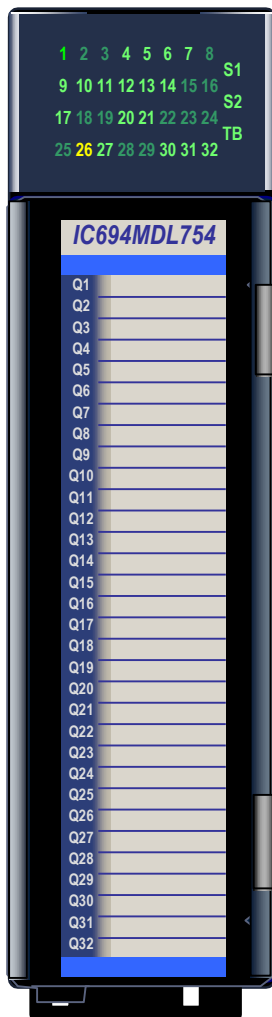


Figure 207: IC694MDL754

The **12/24Vdc, 0.75A Positive Logic ESCP Output** module, IC694MDL754, provides thirty-two discrete outputs in two isolated groups of 16. Each group has its own common. The outputs are positive logic or sourcing type outputs; they switch the loads on the positive side of the power supply, and supply current to the load. The outputs can switch user loads over the range of +12Vdc to +24Vdc (+20%, -15%) and can source a maximum current of 0.75 Amps per point.

Each point has electronic overcurrent/short circuit protection and generates an individual fault if either condition exists. In addition to output driver faults being sent back to the RX3i controller, the module provides a loss of field side power fault, ESCP point failure within a group, field terminal block ON/OFF status and a DIP switch configuration mismatch fault.

Each group can be used to drive different loads. For example, one group might drive 24Vdc loads, and the other could drive 12Vdc loads. Power for the loads must be provided by the user.

A DIP switch at the rear of the module is used to select the outputs default mode: Force Off or Hold Last State. The module must be removed from the backplane to set this switch.

This module can be used with either a Box-style (IC694TBB032) or Spring-style (IC694TBS032) front Terminal Block (Refer to Chapter 17). The Terminal Block is ordered separately.

The blue bands on the label show that MDL754 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

Module cannot be used with a Series 90-30 PLC CPU.

7.14.1 Electronic Short-Circuit Protection (ESCP)

Each output point provides “self-recovering” protection against overcurrent, short circuit and over-temperature. The fault is present until the condition that caused the fault is removed or the faulted point is turned off. After the fault condition is removed the output driver automatically sets the output to the state it was in before the fault occurred.

Each output point provides transient voltage protection to clamp high voltages at or below 40 V dc. Reverse voltage protection is provided for field power inputs.

7.14.2 LEDs: MDL754



Outputs 1 – 16 Power Present
 Outputs 17 – 32 Power Present
 Terminal Block Present

Thirty-two green/yellow LEDs on the module indicate the ON/OFF status of points 1 through 32. These LEDs are green when the corresponding outputs are on, and yellow if the outputs are faulted. They are off when the corresponding outputs are off.

Figure 208: LED Layout MDL754

Two green/yellow LEDs indicate the presence of field power to each of the isolated output groups. They are green if field power is within limits. They are yellow if a point fault exists within their group. And they are off when field power is absent or outside operating limits.

The red/green Terminal Block LED is green when the removable terminal block of this module is locked in place. It is red when the terminal block is not locked. The Terminal Block LED blinks if there is a non-recoverable module fault. The module also sends an *Addition of Terminal Block* or *Loss of Terminal Block* message to the RX3i CPU to report the Terminal Block status.

7.14.3 Specifications: MDL754

Rated Voltage	12/24 Vdc, nominal
Output Voltage Range	10.2Vdc to 30 V dc
Outputs per Module	32 (two isolated groups of 16 outputs each)
Isolation:	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	250 V ac continuous; 1500 V ac for 1 minute
Output Current	0.75 Amps per point
Power Consumption	300 mA (maximum) from 5 volt bus on backplane;
Thermal Derating	No derating at 24Vdc. At 30 V dc, outputs are de-rated above 42 degrees C as displayed in Figure 209.
External Power Supply	
Rated Voltage	+12Vdc to +30 V dc, 12/24Vdc nominal Module does not provide isolation between external power and I/O points. Isolation can be achieved through the use of an isolated external power supply.
External Power Supply Current Required (not including load current)	Module version –CC and later: 72 mA/group with all outputs commanded Off, 132 mA/group with all outputs commanded ON. Module version –BC and earlier: 72 mA/group with all outputs commanded OFF, 100 mA/group with all outputs commanded ON.
Output Characteristics	
Inrush Current	3 A supplied for 10ms without ESCP trip
Output Voltage Drop	0.3 Vdc maximum
Steady-state overcurrent trip	5 A typical per point
Output Leakage Current	0.1 mA maximum
On Response Time	0.5 ms maximum
Off Response Time	0.5 ms maximum
Protection	Short-circuit protection, over-current protection, over-temperature protection, all with auto recovery.

For product standards and general specifications, refer to Appendix A.

7.14.4 Thermal Derating: MDL754

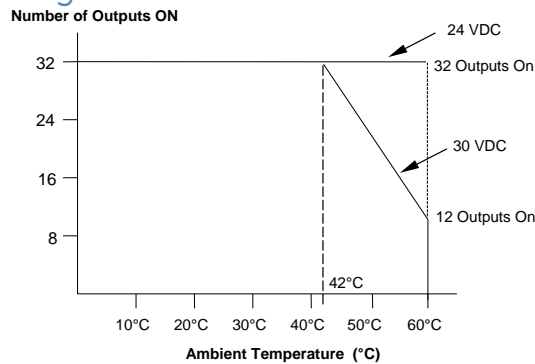


Figure 209: Thermal Derating Curve MDL754

7.14.5 Output Defaults: MDL754

The DIP switch at the rear of the module selects the default operation for the output circuits of this module. The module must be removed from the backplane to set this switch. Note that there are two DIP switches on the module. Only the upper switch is used for module IC694MDL754.

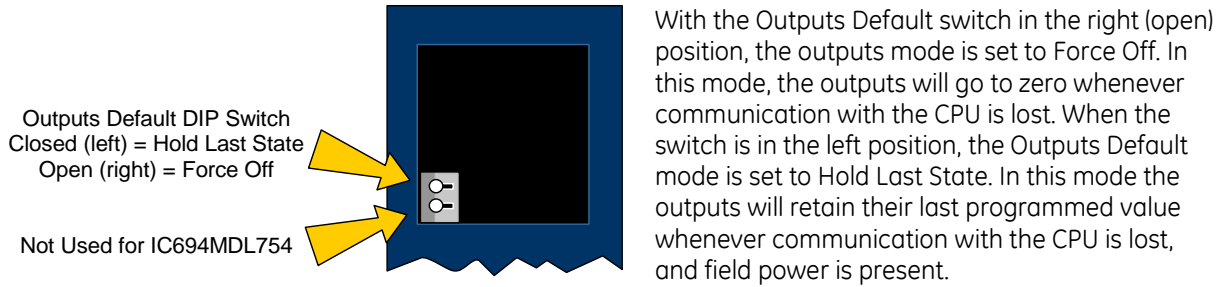


Figure 210: DIP Switch Settings MDL754

The Outputs Default selection made with the DIP switch must match the selection made for this feature in the software configuration of this module. If the two do not match, a *Module Outputs Default Mode Configuration Mismatch* fault occurs.

The following table summarizes the operation of Outputs Default mode with and without backplane power and field (external) power.

Backplane Power	Field Power	Outputs Default	Operation
On	On	Force Off or Hold Last State	Normal Operation. If module fault detected, outputs are set to zero.
On	Off	Force Off or Hold Last State	Module detects loss of field power, communicates fault to CPU while setting outputs to Off state. After field power is restored, the outputs are held in Off state until the module receives new output data from the CPU. Point LEDs indicate desired output without field power.
Off	On	Force Off	Module detects loss of communications and turns off the outputs within 400ms. LEDs are off.
		Hold Last State	Module detects loss of communications and holds outputs on their last states until the CPU sends new output data. LEDs are off

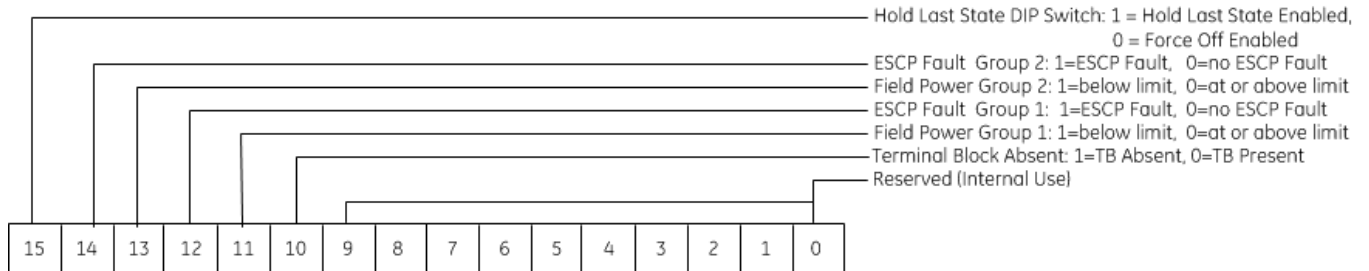
7.14.6 Field Wiring: MDL754

Connection	Terminal	Field Wiring	Terminals	Field Wiring	Terminal	Connection
Output 1	1		<p>19</p> <p>20</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p> <p>26</p> <p>27</p> <p>28</p> <p>29</p> <p>30</p> <p>31</p> <p>32</p> <p>33</p> <p>34</p> <p>35</p> <p>36</p>	<p>Q17</p> <p>Q18</p> <p>Q19</p> <p>Q20</p> <p>Q21</p> <p>Q22</p> <p>Q23</p> <p>Q24</p> <p>Q25</p> <p>Q26</p> <p>Q27</p> <p>Q28</p> <p>Q29</p> <p>Q30</p> <p>Q31</p> <p>Q32</p>	19	Output 17
Output 2	2				20	Output 18
Output 3	3				21	Output 19
Output 4	4				22	Output 20
Output 5	5				23	Output 21
Output 6	6				24	Output 22
Output 7	7				25	Output 23
Output 8	8				26	Output 24
Output 9	9				27	Output 25
Output 10	10				28	Output 26
Output 11	11				29	Output 27
Output 12	12				30	Output 28
Output 13	13				31	Output 29
Output 14	14				32	Output 30
Output 15	15				33	Output 31
Output 16	16				34	Output 32
DC+ for 1 - 16	17	+	35	DC+ for 17 - 32		
DC- for 1 - 16	18	-	36	DC- for 17 - 32		

Figure 211: Field Wiring MDL754

7.14.7 Module Status Data: MDL754

The module can optionally report sixteen bits of status data to the CPU. To access this data, the length must be changed from 0 to 16. It has the following content:



Status bit 15 indicates the state of the Output Default DIP switch of this module. The module configuration should be set to match the DIP switch, as discussed earlier in this section.

7.14.8 ESCP Status Data: MDL754

The module can optionally report the ESCP fault status of the outputs in input bits 0 - 31. By default, the length of this data area is 0. To access this data, the length must be changed from 0 to 32. The ESCP fault can be identified using the ESCP status bits:

Output ESCP Status Bits	
Output Group 1	Output Group 2
0 - 15	16 - 31

7.15 Output Module, 12/24Vdc, 0.5A Positive Logic, 32-Point with ESCP per Group: IC694MDL758

The 12/24Vdc, 0.5A Positive Logic Output module with ESCP per group, IC694MDL758, provides thirty-two discrete outputs in two isolated groups of 16. Each group has its own common. The outputs are positive logic or sourcing-type outputs; they switch the loads on the positive side of the power supply, and supply current to the load. The outputs can switch user loads over the range of +12 to +24Vdc (+20%, -15%) and can source a maximum current of 0.5 Amps per point.

Each group has electronic short circuit protection and generates a fault if any output in the group is in a short circuit condition. The module provides an ESCP failure status within a group back to the RX3i controller. In addition to this, the module provides a fault on loss of field side power within a group.

Each group can be used to drive different loads. For example, one group might drive 24Vdc loads, and the other could drive 12Vdc loads. Power for the loads must be provided by the user from an isolated source.

This module can be used with either a Box-style (IC694TBB032) or Spring-style (IC694TBS032) front Terminal Block (Refer to Chapter 17). The Terminal Block is ordered separately.

The blue bands on the label show that MDL758 is a low-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

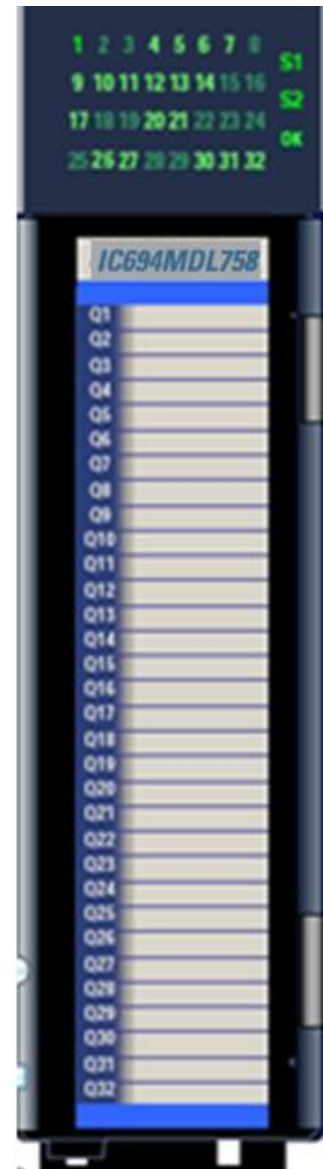


Figure 212: IC694MDL758

7.15.1 Electronic Short-Circuit Protection (ESCP)

Each output group provides “self-recovering” protection against short circuit. The fault is present until the condition that caused the fault is removed or the faulted group is turned off. After the fault condition is removed the output driver automatically sets the output to the state it was in before the fault occurred.

Each output point provides transient voltage protection to clamp high voltages at or below 40 V dc.

7.15.2 LEDs: MDL758

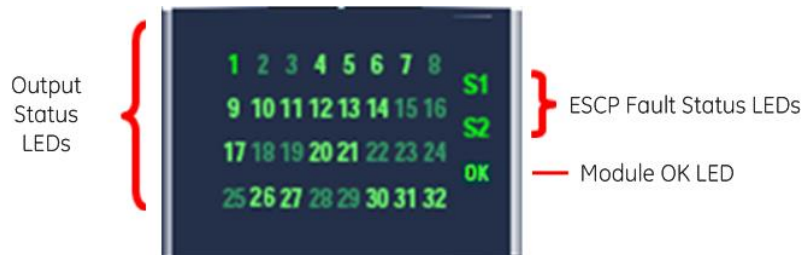


Figure 213: LED Layout MDL758

Thirty-two green LEDs to show the status of the corresponding output channels

Output Status (1-32)	GREEN	Output is ON
	OFF	Output is OFF

Two bi-color LEDs show the fault status of the two output channel groups:

- S1 corresponds to fault condition on channels 1-16;
- S2 corresponds to fault condition on channels 17-32.

ESCP Status (S1-S2)	GREEN	Groupx Outputs are Normal
	RED	Groupx Outputs have ESCP fault

A single green LED shows the status of module power from backplane.

Module Status (OK)	GREEN	Module power OK
	OFF	Module power not available

7.15.3 Specifications: MDL758

Rated Voltage	12Vdc through 24Vdc, positive logic
Output Voltage Range	10.2Vdc to 28.8Vdc
Outputs per Module	32 (two groups of sixteen outputs each)
Isolation	
Field to Backplane (optical) and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Group to Group	50 V ac continuous; 500 V ac for 1 minute
Output Current	0.5 Amps per point with 8 Amps maximum per group without ESCP trip
UL Approved Load Ratings	0.5 Amps per point pilot duty 0.5 Amps per point resistive
Power Consumption	250 mA (maximum) from 5 volt bus on backplane
	33mA (maximum) per group from user supplied isolated 24Vdc with all sixteen outputs in group ON
	20mA (maximum) per group from user supplied isolated 12Vdc with all sixteen outputs in group ON

Output Characteristics

Inrush Current	5.4 Amps for 10 ms without ESCP trip
On-state Voltage Drop	0.3Vdc
Off-state Leakage Current	0.1mA maximum
On Response Time	0.5ms maximum
Off Response Time	0.5ms maximum
Installation Environment	Surrounding Air 60°C maximum; For use in Pollution Degree 2 environments only

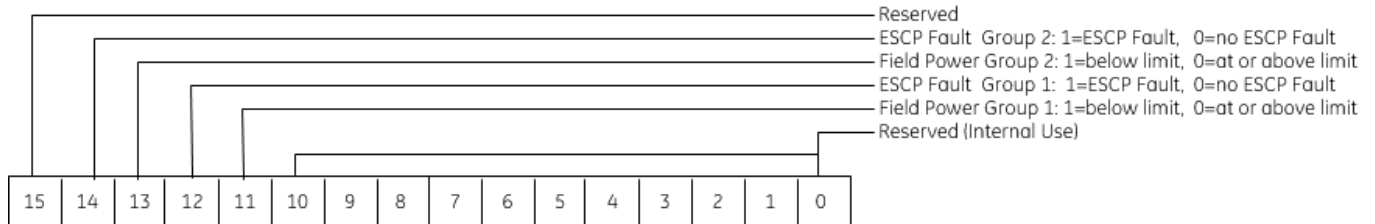
For product standards and general specifications, refer to Appendix A.

7.15.4 Module Data: MDL758

Module MDL758 uses sixteen input bits and thirty-two output bits to exchange status and filter information with the RX3i CPU. The memory types and offsets for this data are selected in the hardware configuration for the module.

7.15.4.1 Input Data: MDL758

The module uses sixteen input bits to report its status information to the RX3i CPU. It has the following content:



7.15.4.2 Output Data: MDL758

The module receives thirty-two bits of output data from the RX3i CPU, one bit per output point. Bit 0 determines the state of Output 1; bit 31 determines the state of Output 32.

7.15.5 Field Wiring: MDL758

Field wiring connections to the module are made via the interposing quick-connect (TBQC) terminal assembly (Refer to Chapter 17):

Connection	Terminal	Field Wiring	Terminals	Field Wiring	Terminal	Connection
Output 1	1				19	Output 17
Output 2	2				20	Output 18
Output 3	3				21	Output 19
Output 4	4				22	Output 20
Output 5	5				23	Output 21
Output 6	6				24	Output 22
Output 7	7				25	Output 23
Output 8	8				26	Output 24
Output 9	9				27	Output 25
Output 10	10				28	Output 26
Output 11	11				29	Output 27
Output 12	12				30	Output 28
Output 13	13				31	Output 29
Output 14	14				32	Output 30
Output 15	15				33	Output 31
Output 16	16				34	Output 32
DC+ for 1 - 16	17	35	DC+ for 17 - 32			
DC- for 1 - 16	18	36	DC- for 17 - 32			

Figure 214: Field Wiring MDL758

7.16 Output Module, 24/125Vdc, 2A Positive Logic, 16-Point with ESCP & Diagnostics: IC695MDL765

The 24/125Vdc 2A Smart Digital Output module, IC695MDL765, provides sixteen discrete outputs in two isolated groups of 8 outputs. Each group of 8 outputs is referenced to an isolated common, providing group-to-group isolation. The module uses 24Vdc or 125Vdc.

The outputs are positive logic or sourcing-type outputs; they switch the loads on the positive side of the power supply, and supply current to the load. The outputs can switch user loads over the ranges of +18Vdc to +30 V dc or 105Vdc to 132Vdc and can source a maximum current of 2 Amps per point.

Power for the loads must be provided by the user.

The field status LEDs (S1 and S2) indicate whether the external +24Vdc or +125Vdc power supply is present and above the minimum level, whether faults are present, and whether the terminal block is locked into place. The module also logs an *Addition of Terminal Block* or *Loss of Terminal Block* message to the I/O fault table to report the terminal block status.

Each point has electronic short circuit protection (ESCP) that shuts down an output and generates an individual fault if capacitive or incandescent surge current exceeds 10 amps, or if it exceeds 2 amps for more than 10 ms. In addition to output driver faults being sent back to the RX3i controller, the module provides a loss of field side power fault, ESCP point failure within a group and field terminal block ON/OFF status.

Features of the Smart Digital Output module include:

- Output Pulse Test Capability
- Output Hold Last State or Default

Additional Diagnostics include:

- Over temperature
- Failed Switch Detection
- Overload Detection and Shutdown
- No-load Detection

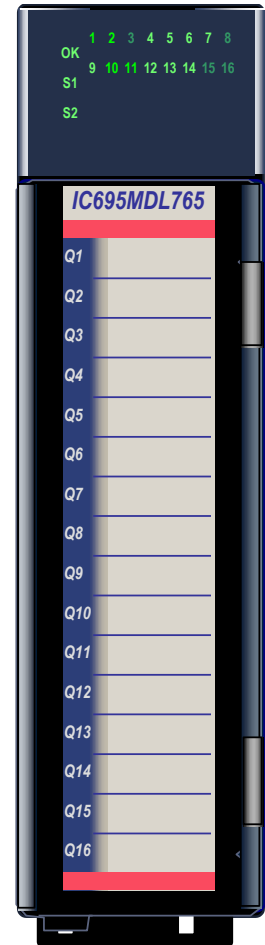


Figure 215:
IC695MDL765

This module can be used with either a Box-style (IC694TBB032) or Spring-style (IC694TBS032) front Terminal Block (Refer to Chapter 17). The Terminal Block is ordered separately.

The red bands on the label show that the MDL765 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

7.16.1 Electronic Short-Circuit Protection (ESCP)

Each output point provides protection against overcurrent, short circuit and over-temperature. The fault is present until the condition that caused the fault is removed and the faulted point is turned off.

Each output point provides transient voltage protection to clamp high voltages at or below 136Vdc.

7.16.2 LED Operation: MDL765



Figure 216: LED Layout MDL765

The 16 green/amber channel status LEDs on the module indicate the ON/OFF status of points 1 through 16.

The Module OK LED indicates module status. The field status LEDs (S1 and S2) indicate whether the external +24Vdc or +125Vdc power supply is present and is above the minimum level, whether faults are present, and whether the terminal block is locked into place. The module also logs an *Addition of Terminal Block* or *Loss of Terminal Block* message to the I/O fault table to report the Terminal Block status.

LED Name	Function	LED Indications
OK	Module status	Off: Module is not receiving power from the RX3i backplane or the module has failed self-test.
		Solid green: Module OK and configured.
		Blinking green: The module has not received configuration from the CPU. If configuration is not successful, the module will continue to blink in this mode.
		Amber: Module hardware watchdog timeout.
1-16	Channel status	Off: Output is off
		Green: Output is on
		Amber: Output fault
S1, S2	Terminal block and field power status	Off: Terminal block present and field power not present
		Green: Terminal block and field power present
		Red: Terminal block not present or field power error. Field power errors include detecting 125Vdc when configured for 24Vdc or detecting only 24Vdc when configured for 125Vdc.

Note: The OK, S1 and S2 LEDs blink green in unison when the module is in firmware update mode.

7.16.3 Specifications: MDL765

Field Power Voltage (24V nominal I/O), V_{In}	18 to 30 V dc
Field Power Voltage (125V nominal I/O), V_{In}	105 to 132Vdc
Ripple Voltage, Field Power	10%Vpp
Outputs per Module	16 (two isolated groups of 8 outputs each)
Isolation	
Field to Backplane Continuous For 1 minute	250 V ac 1500 V ac
Group to Group Continuous For 1 minute	250 V ac 1500 V ac
Backplane Power Consumption +3.3Vdc +5.1Vdc	152mA 540mA
Thermal De-rating	None required with output currents of 1 amp per channel. For 2 amps per channel, refer to Figure 217.
Continuous Output Current per Point	Refer to <i>Output Load Ratings: MDL765</i> .
Output Characteristics	
Peak Inrush Current	10A supplied for 10ms without ESCP trip
Output Leakage Current	1mA maximum
Group Output Current at 35°C ambient	8A maximum
Module Output Current at 35°C ambient	16A maximum
Sourcing Circuit Output On Voltage ($I_{OUT} = 2A$)	($V_{In}-2$) to V_{In}
Minimum Load Current with no-load detection enabled	50 mA
On Response Time	1ms maximum
Off Response Time	1ms maximum
Maximum Switching Frequency	Refer to <i>Output Load Ratings: MDL765</i> below.
Protection	Short-circuit protection, overcurrent protection, and over-temperature protection. Over-temperature, short-circuit, and overcurrent faults must be recovered by turning the point off and back on.

For product standards and general specifications, refer to Appendix A.

7.16.3.1 Output Load Ratings: MDL765

Resistive	2A at 132Vdc 2A at 30 V dc No external suppression components required.
Inductive (Pilot Duty)	0.6A at 132Vdc For inductive loads greater than 2.2H, maximum switching frequency is 0.125Hz. Overall maximum switching frequency: 1 Hz No external suppression components required.
	1.2A at 30 V dc For inductive loads greater than 0.8H, maximum switching frequency is 0.5Hz. Overall maximum switching frequency: 1 Hz No external suppression components required.
Incandescent (Lamp)	0.75A at 132Vdc 0.75A at 30 V dc No external suppression components required.

7.16.3.2 Thermal Derating: MDL765

With output currents of 1 amp per channel, no temperature de-rating is required, and all channels can operate within the entire Surrounding Air temperature range. With output currents of 2 amps per channel, the number of active channels must be reduced as temperature increases, according to the following de-rating curve.

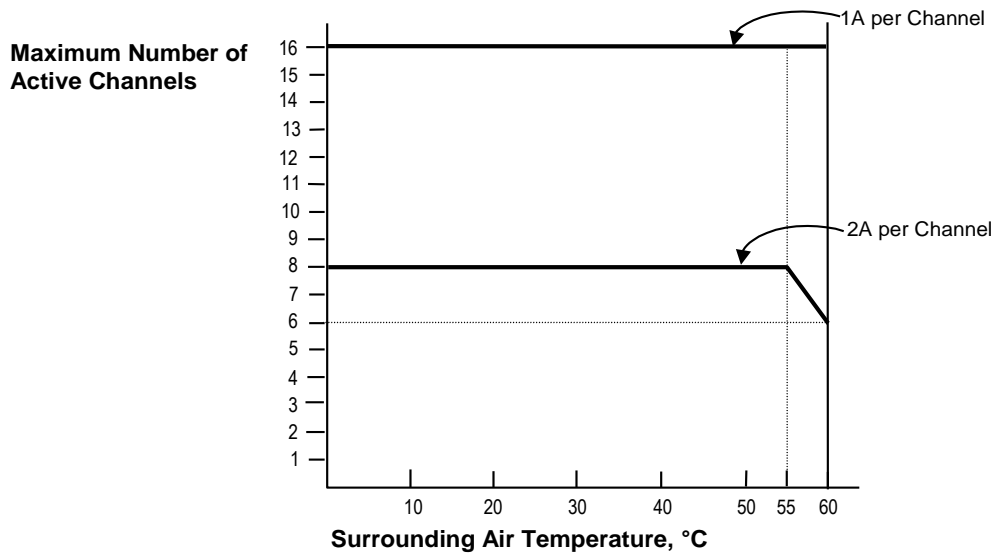


Figure 217: Thermal Derating Curve MDL765

7.16.4 Field Wiring: MDL765

Field wiring connections to the module are made to the interposing quick-connect (TBQC) terminal assembly, as described in Chapter 17.

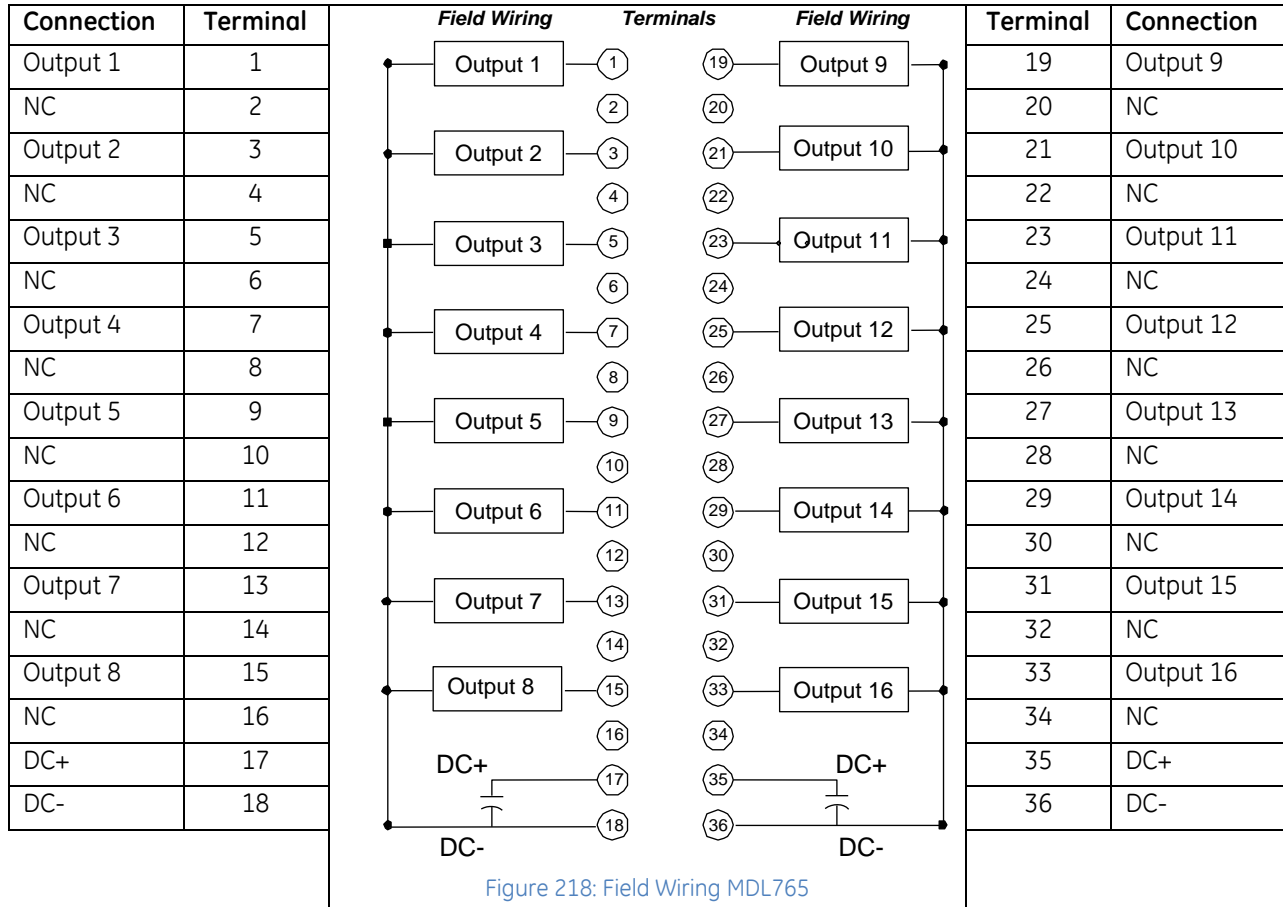


Figure 218: Field Wiring MDL765

7.16.5 Circuit Operation: MDL765

The two eight-circuit DC sourcing circuit groups have all output devices connected to the negative side of the power supply (DC-). The sourcing circuit outputs provide power to the output devices. For sourcing circuit outputs, an ON condition is logic 1 and an OFF condition is logic 0.

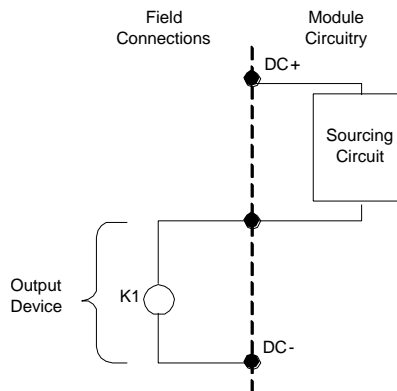


Figure 219: Circuit Detail MDL765

7.16.6 Input and Output Data Formats: MDL765

7.16.6.1 Output Value Data: MDL765

The application uses these bits (one bit per output), beginning at the configured *Outputs Reference Address* to write the commanded output values to the module.

7.16.6.2 Output Command Value Feedback Data: MDL765

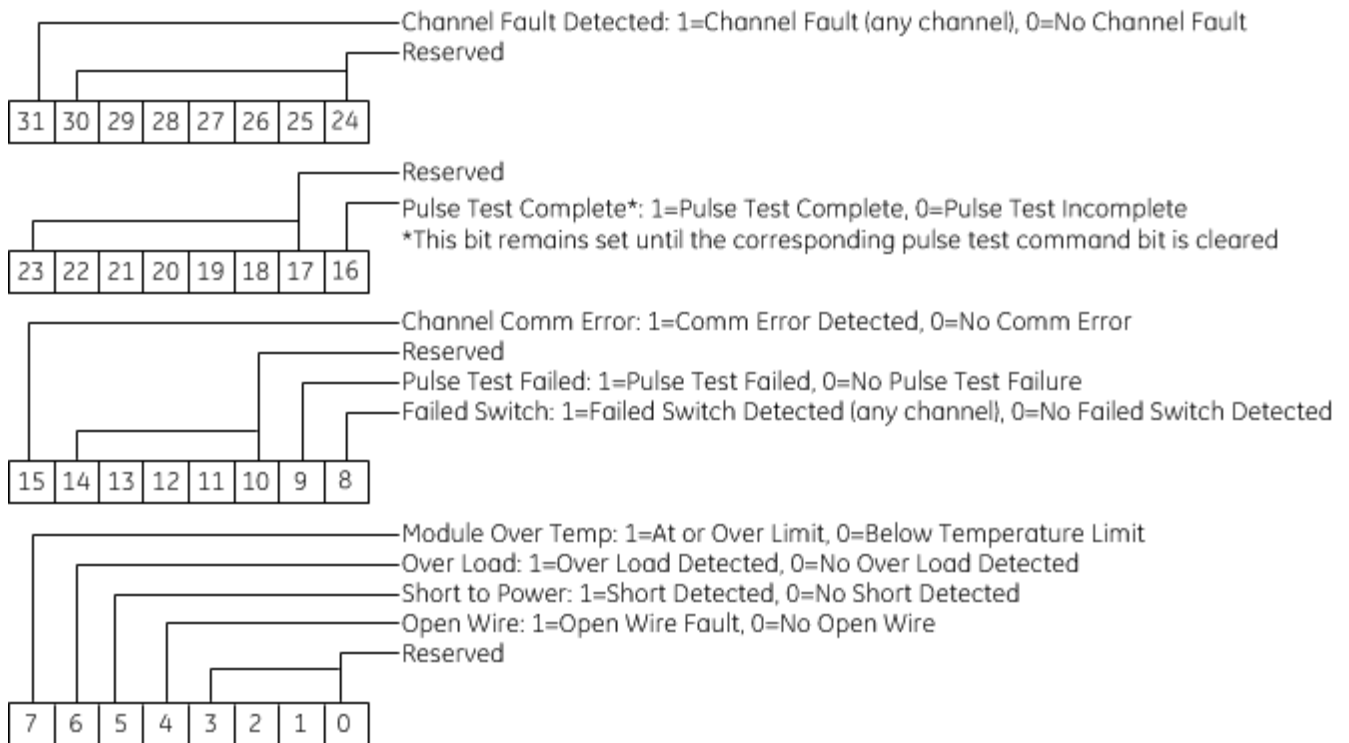
The module uses these bits (one bit per output), beginning at the configured *Output Command Reference Address* to report the output feedback data values.

7.16.6.3 Channel Diagnostic and Status Data: MDL765

The module can be configured to report channel diagnostic and status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for this module. Use of this feature is optional.

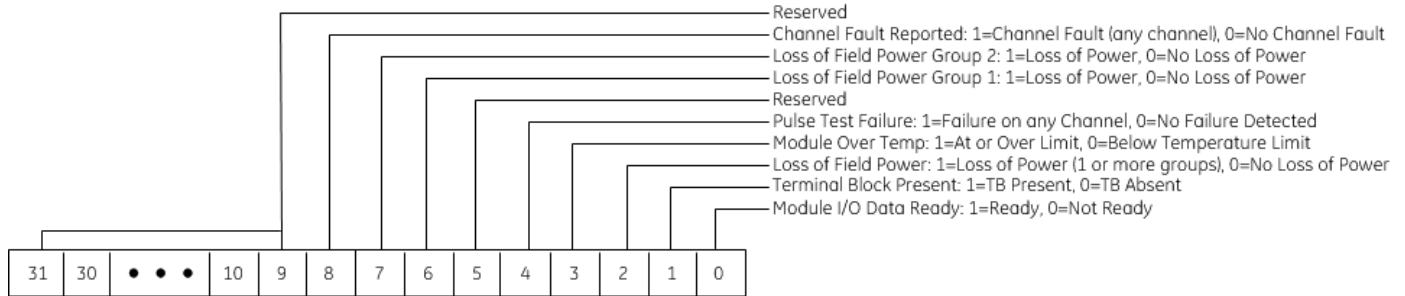
The data for each channel occupies two words whether the channel is used or not.

Note: At least two sweeps must occur to clear the diagnostic bits: one scan to send the %Q data to the module and one scan to return the %I data to the CPU. Because module processing is asynchronous to the controller sweep, more than two sweeps may be needed to clear the bits, depending on the sweep rate and the point at which the data is made available to the module.



7.16.6.4 **Module Status Data: MDL765**

The module can be configured to return two words of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status* reference area configured for this module.



7.16.6.5 **Pulse Test Command Output Data: MDL765**

The module uses these bits (one bit per output), beginning at the configured *Pulse Command Output Reference Address* to command an on-demand pulse test. To command an on-demand pulse test, the Pulse Test Enable parameter for the channel must be set to *Enabled - Manual*.

7.16.7 Diagnostics: MDL765

The module always performs its standard diagnostic checks, plus one optional output diagnostic. The module returns current circuit diagnostics to %I bits for all circuits.

For Over-temperature, Short Circuit, Failed Switch and Overload, the user must de-assert the output %Q bit to clear the error. The corresponding %I bit will be turned off within at least two CPU sweeps.

7.16.7.1 Over Temperature Diagnostics: MDL765

Each circuit has a built-in thermal sensor. If the internal temperature exceeds the allowable limit the module logs an OVER-TEMPERATURE fault in the I/O fault table and turns off the circuit to protect its internal electronics. The temperature must decrease below the allowable limit before the output can turn on again. This diagnostic is always performed for all the outputs.

7.16.7.2 Short Circuit Diagnostics: MDL765

Output circuits are protected by a short circuit threshold sensor at the switching device. If the instantaneous current on an output exceeds 10 amps, the module turns the output off within microseconds. The module will try to restart the load; if two additional attempts are unsuccessful, the output circuit is forced off, and the module logs a SHORT CIRCUIT fault in the I/O fault table. To restore normal operation to output the cause of the current surge must be removed, then the diagnostic must be cleared from the CPU.

This diagnostic detects shorts across the load only. Also, systems with floating power supplies do not detect shorts of I/O points to ground because there is no return current path. Systems with power supplies grounded on the negative side detect grounded output points as Short Circuit.

Partial (high resistance) shorts may not draw enough current to be detected by the Pulse Test.

7.16.7.3 Failed Switch Diagnostics: MDL765

The module automatically monitors all circuits for several types of faults, which may be reported as Failed Switch diagnostics.

Failed Switch is reported if the switch state is not the same as the commanded state of the circuit. The module logs a FAILED SWITCH fault in the I/O fault table identifying the failed circuit. The logic state of the circuit is set to OFF.

When an output fault occurs, the actual condition of the output switch is not known. If the output switch has failed shorted (or closed), current flow is not interrupted when the module forces the output state OFF. Action external to the module must be taken to remedy the problem. The FAILED SWITCH fault can alert personnel or cause program logic to be activated, possibly shutting off power to the module, I/O section, or process.

7.16.7.4 No Load Diagnostics: MDL765

Reporting for this diagnostic can be enabled or disabled for individual outputs.

By default, outputs are configured to report No-Load conditions. In this configuration, energizing the output activates a no-load current level. If the load does not continuously draw 50mA from the output circuit, the module logs a NO LOAD fault in the I/O fault table. This diagnostic should not be used for circuits on which very small loads (small relays or indicating lamps) will draw less than 50 mA. To clear the No-Load error, a load of at least 85mA must be applied to the output.

7.16.7.5 Overload Diagnostic: MDL765

In addition to the protection provided by the built-in Short Circuit detection, Overload Shutdown provides further protection for output loads, field wiring, and switching devices connected to this module. If a load exceeds 2 amps DC continuously for 10ms, the module turns the output off and logs an OVERLOAD fault in the I/O fault table.

7.16.7.6 Under-Voltage Detection: MDL765

The field power supply on each group includes support for detecting supply voltages below the minimum voltage for the selected voltage standard. The fault can be disabled by group. Detecting the fault has no impact on the state of the output control.

7.16.7.7 Output Pulse Test: MDL765

The Output Pulse Test is an optional diagnostic feature that exercises the output points to confirm they can be switched to a known state.

The pulse test attempts to switch the output from its Normal State to its Default State. For a load with a Normal State of ON, the source output is pulsed OFF. For a load with a Normal State of OFF, the source output is pulsed on. A fault is logged in the I/O fault table if a failure is detected in the output point.

Pulse Testing should remain enabled if the module has loads that hold one state for long periods of time, *unless any load(s) are sensitive to pulses or interruptions of up to 16ms*. It should be disabled if the loads experienced by this module will normally change state as the program executes. These will report faults during normal operation, and do not need to be pulsed.

Pulse Test Selections: Pulse test frequency
 Output Default State / Output Normal State

On Demand Pulse Test: MDL765

To use this feature, the Pulse Test Enable parameter for the channel must be set to *Enabled-Manual*. To command a pulse test, set the Pulse Test Command bit for the channel(s) to be pulse tested.

The module performs one or more pulse tests for each channel selected. Since this will take many sweeps, you should keep the Pulse Test Command bit set until the Pulse Test Complete bit is set for that channel in the Channel Diagnostic and Status Data.

The module keeps the Pulse Test Complete bit set as long as the Pulse Test Command bit is set. If the pulse test fails, the Pulse Test Failed bit is set at the same time as the Pulse Test Complete bit. One output scan with the Pulse Test Command bit cleared clears the Pulse Test Complete status bit and Pulse Test Failure diagnostic bit.

Automatic Pulse Test: MDL765

To use this feature, set the Pulse Test Enable parameter for the channel to *Enabled-Auto*. The Output Pulse Test occurs at a frequency selected in the Hardware Configuration, with no intervention from the CPU. The pulse test execution is based on the Time of Day clock set in the CPU, and the frequency is relative to 12:00am. For example, a frequency of 12 hours will result in a pulse test run at 12:00am and 12:00pm.

If the pulse test fails, the Pulse Test Failed bit is set.

7.16.8 Configuration: MDL765

7.16.8.1 Module Settings: MDL765

Parameter	Function
Outputs Reference Address Outputs Value Reference Length	Specifies the memory location used by the module for 16 bits of output data.
Output Command Feedback Reference Address	Specifies the starting address where the module returns 16 bits of feedback output data.
Output Command Feedback Reference Length	Provides 1 bit per channel of feedback output data. Setting this value to 0 disables feedback data reporting.
Diagnostic Reference Address	Specifies the starting address for reporting channel diagnostics data.
Diagnostic Reference Length	Provides thirty-two bits of diagnostic data per channel. Setting this value to 0 disables channel diagnostics reporting.
Module Status Reference Address	Specifies the starting address for reporting module status data.
Module Status Reference Length	Provides thirty-two bits of module status data. Setting this value to 0 disables channel diagnostics reporting.
Pulse Test Command Output Reference Address/ Pulse Test Command Output Reference Length	Specifies the memory location for 16 bits of manual pulse test command data.
Channel Faults w/o Terminal Block	Enables or disables generation of channel faults and alarms after a Terminal Block has been removed.
Loss of Terminal Block Detection	Enables or disables logging of a fault to indicate a Terminal Block has been removed.
Loss of Field Power Group 1 Detection/ Loss of Field Power Group 2 Detection	Enables or disables loss of field power detection for the specified group.
Voltage Selection	Specifies field power voltage level for under-voltage detection. Can be enabled or disabled by the Loss of Field Power Group 1/Group 2 Detection parameter.
Inputs Default	Specifies whether inputs will go to Force Off or Hold Last State if the module loses communication with the CPU. An output goes to its power up default state when the module is first powered up.
I/O Scan Set	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data.

7.16.8.2 Channel Settings: MDL765

Parameter	Function
Outputs Default Mode	Force Off, Force On, or Hold Last State Outputs are forced into this state when the CPU is placed into Outputs Disabled. This includes immediately after download of Hardware Configuration. Outputs remain in the Outputs Default state indefinitely or until one of the following occurs: CPU is placed into Outputs Enabled. Communications with the CPU are restored. Power is removed from the module.
Pulse Test Enable	Enables or disables pulse testing of the output. Allows you to select Manual or Automatic pulse testing. For details about this feature, refer to <i>Output Pulse Test: MDL765</i> above.
Pulse Test Frequency	If Pulse Test Enable is set to Auto, allows you to select the frequency of pulse testing.
Pulse Test Normal State	Available when Pulse Test is enabled. Specifies the state in which this output point will spend the majority of its time. The module performs a pulse test only from the normal state to the default state.
Pulse Test Default State	Available when Pulse Test Enable is enabled. Specifies the state the point will go to if a channel failure occurs. When the output is placed into the default state the module will not perform a pulse test into the normal state.
Diagnostic Reporting Enable	Enables or disables channel diagnostics. If enabled, channel diagnostic data is written to the Channel Diagnostic and Status Data.
Open Load Reporting Enable	If enabled, an open load (no-load) condition is reported in the Channel Diagnostic and Status Data.
Pulse Test Failed Enable	If enabled, the results of manual or automatic pulse testing are reported in the Channel Diagnostic and Status Data.
Over Load Reporting Enable	Always enabled: An output over load condition is reported in the Channel Diagnostic and Status Data.
Fault Reporting Enable	If enabled, channel faults are reported to the I/O fault table.
Open Load Reporting Enable	If enabled and the corresponding diagnostic reporting is enabled, an open load (no-load) condition is reported in the I/O fault table.
Pulse Test Failed Enable	If enabled and the corresponding diagnostic reporting is enabled, a failed pulse test is reported in the I/O fault table.
Over Load Reporting Enable	Always enabled: An output over load condition is reported in the I/O fault table.

7.17 Output Module, Isolated Relay, N.O., 4 Amp, 16-Point: IC694MDL916

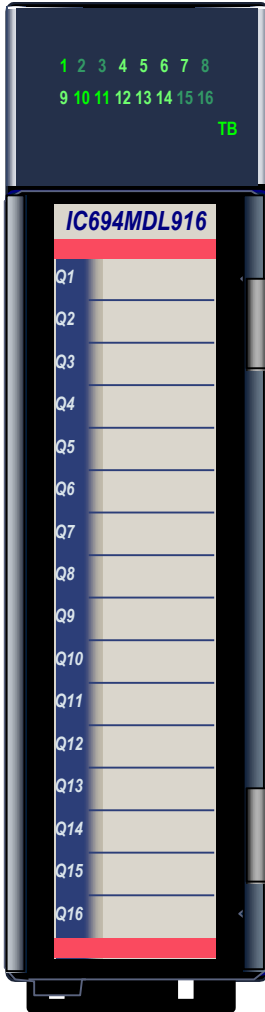


Figure 220: IC694MDL916

The **4 Amp 16-Point Relay Output** module IC694MDL916 provides sixteen Form A relays for controlling output loads. The maximum output switching capacity of each circuit is 4 Amps. Each output point is isolated from the other points, and each point has a separate common power output terminal. Outputs provide a high degree of noise immunity, minimizing the need to add external snubbers. The relay outputs can control a wide range of output devices, such as: motor starters, solenoids, and indicators.

The user must supply the AC or DC power to operate the field devices.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

The red bands on the door card show that MDL916 is a high-voltage module.

A DIP switch at the rear of the module is used to select the default mode for the outputs: Force Off or Hold Last State. The module must be removed from the backplane to set this switch.

Module cannot be used with a Series 90-30 PLC CPU.

Individually-numbered LEDs indicate the ON/OFF state of each output. The red/green TB LED is green when the removable terminal block of this module is locked in place. It is red when the terminal block is not locked.

Module MDL916 can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block (Refer to Chapter 17). Extended terminal blocks provide the extra shroud depth typically needed for shielded wires. Terminal Blocks are ordered separately.

The module reports *Addition of Terminal Block*, *Loss of Terminal Block*, and *Hold Last State Configuration Mismatch* messages to the RX3i CPU.

7.17.1 Specifications: MDL916

Outputs per Module	16 isolated Form A relay outputs
External Power Supply	0 – 125Vdc (5/24/125Vdc nominal) 0 – 250 V ac (47 to 63 Hz), 120-240 V ac nominal
Isolation	
Field to Backplane and to Frame Ground, Group to Group	250 V ac continuous; 1500 V ac for 1 minute.
Power Consumption	300mA at 5Vdc from backplane maximum (all outputs ON) 150mA at 24Vdc from backplane relay power (all outputs ON)
Thermal Derating	Refer to below.

Output Characteristics	
Output Voltage ²²	5 – 125Vdc (5/24/125Vdc nominal) 5 – 250 V ac (47 to 63 Hz), 120-240 V ac nominal
Output Current	10mA per point minimum 4A for 5-250 V ac maximum (resistive or general purpose) 4A for 5-30 V dc maximum (resistive) 2A pilot duty per output (5Vdc to 30 V dc, 5Vac to 240 V ac)
Output Voltage Drop	0.3Vdc maximum
Output Leakage Current	Not Applicable (open contact)
Response Times (On/Off)	10ms maximum (At nominal voltage excluding contact bounce)
Switching Frequency	20 cycles per minute maximum
Protection	None. External snubbers may be applied if necessary
Relay Contact Life	Refer to <i>Load Current Limitations: MDL916</i> below
Diagnostic Information	Field side terminal block presence detection reported to CPU (RX3i only)

For product standards and general specifications, refer to Appendix A.

7.17.1.1 Thermal Derating: MDL916

The following table shows the number of outputs that can be on at the same time under the maximum load of 4 Amps per point.

²² When this module is used with DC power supply IC695PSD040 or PSD140, special precautions should be taken because dropouts in the source voltage will be seen by this module and may cause relay dropouts.

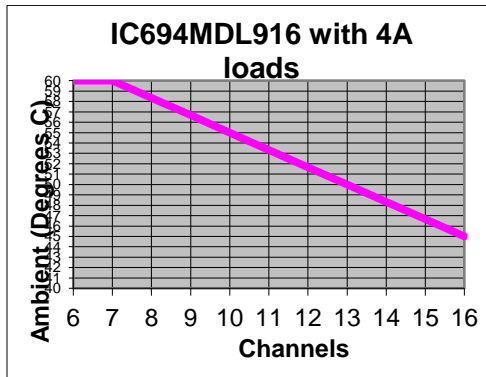


Figure 221: Thermal Derating Curve MDL916

7.17.1.2 Load Current Limitations: MDL916

Operating Voltage	Maximum Current for Load Type		Typical Contact Life (Number of Operations)
	Resistive	Lamp or Solenoid ²³	
5 to 240 V ac	4 Amps	2 Amps	200,000
5 to 240 V ac	0.1 Amp	0.05 Amp	1,000,000
5 to 240 V ac	1 Amp	0.5 Amp	700,000
5 to 24Vdc	-	3 Amps	100,000
5 to 24Vdc	4 Amps	2 Amps	200,000
5 to 24Vdc	1 Amp	0.5 Amp	700,000
5 to 24Vdc	0.1 Amp	0.05 Amp	1,000,000

7.17.1.3 Suppression Circuits: MDL916

Relay contact life, when switching inductive loads, will approach resistive load contact life if suppression circuits are used. Examples of typical suppression circuits for AC and DC loads are displayed in the following figure. The 1A, 200V diode shown in the DC load typical suppression example is an industry standard 1N4935. The resistor and capacitor shown for AC load suppression are standard components, available from most electronics distributors.

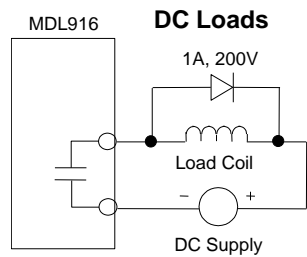


Figure 222: Suppression of DC Loads MDL916

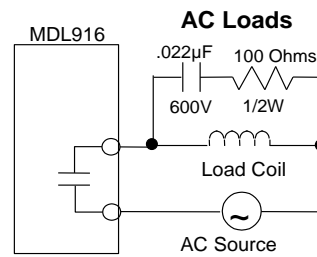


Figure 223: Suppression of AC Loads MDL916

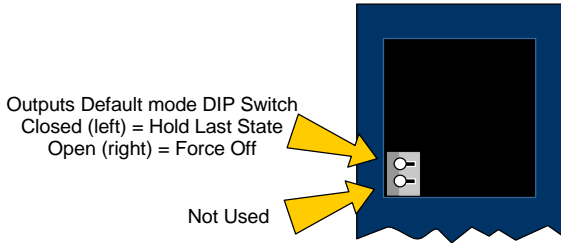
²³ Assumes a 7ms L/R time constant (DC inductive load) or Cos $\phi \geq 0.4$ (AC inductive load).

7.17.1.4 Setting the Output Defaults: MDL916

The DIP switch at the rear of the module determines how the outputs will operate if the CPU is set to Stop Mode or loses communications with the module. The Outputs Default Mode selection made with the DIP switch must match the selection made for this feature in the software configuration of this module. If the two do not match, a warning message is displayed in the fault table.

The module must be removed from the backplane to set this switch. Note that there are two DIP switches on the module. Only the upper switch is used.

With the Outputs Default Mode switch in the right (open) position, the outputs will turn off whenever communication with the CPU is lost.

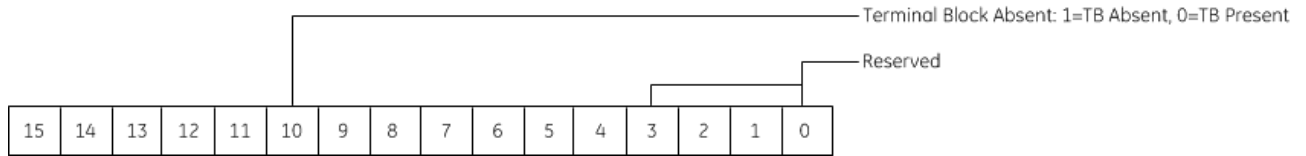


When the switch is in the left position, the outputs will hold their last programmed value whenever communication with the CPU is lost. Backplane power must be present to Hold Last State. Otherwise, the module will default outputs regardless of the DIP switch setting.

Figure 224: DIP Switch Settings MDL916

7.17.1.5 Module Status Data: MDL916

The module can optionally use 16 input bits to report its status information to the RX3i CPU. To access this data, the length must be changed from 0 to 16. The module status data has the following content:



7.17.2 Field Wiring: MDL916

Connection	Terminal	Terminal	Connection
Output 1, Normally-Open	1	19	Output 9, Normally-Open
Output 1 Return	2	20	Output 9 Return
Output 2, Normally-Open	3	21	Output 10, Normally-Open
Output 2 Return	4	22	Output 10 Return
Output 3, Normally-Open	5	23	Output 11, Normally-Open
Output 3 Return	6	24	Output 11 Return
Output 4, Normally-Open	7	25	Output 12, Normally-Open
Output 4 Return	8	26	Output 12 Return
Output 5, Normally-Open	9	27	Output 13, Normally-Open
Output 5 Return	10	28	Output 13 Return
Output 6, Normally-Open	11	29	Output 14, Normally-Open
Output 6 Return	12	30	Output 14 Return
No Connection	13	31	No Connection
Output 7, Normally-Open	14	32	Output 15, Normally-Open
Output 7 Return	15	33	Output 15 Return
No Connection	16	34	No Connection
Output 8, Normally-Open	17	35	Output 16, Normally-Open
Output 8 Return	18	36	Output 16 Return

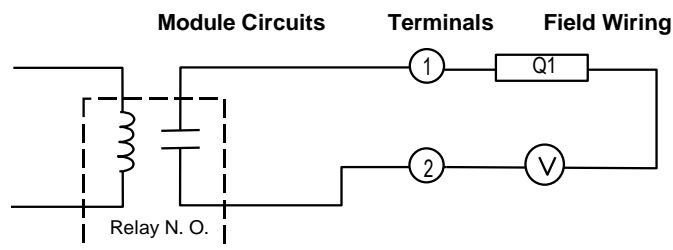


Figure 225: Typical Relay Output Circuit MDL916

7.18 Output Module, Isolated Relay, N.O., 4 Amp, 8-Point: IC694MDL930

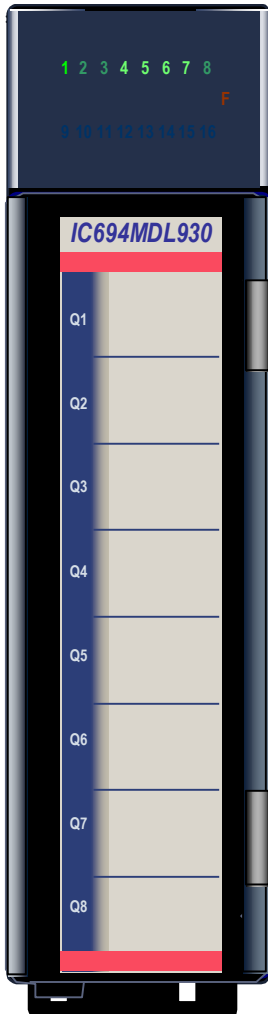


Figure 226: IC694MDL930

The **4 Amp Isolated Relay Output** module, IC694MDL930, provides eight normally–open relay circuits for controlling output loads. The output switching capacity of each circuit is 4 Amps. Each output point is isolated from the other points, and each point has a separate common power output terminal. The relay outputs can control a wide range of output devices, such as: motor starters, solenoids, and indicators.

The user must supply the AC or DC power to operate the field devices connected to this module.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The red bands on the label show that MDL930 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

7.18.1 Specifications: MDL930

Rated Voltage	24 Vdc, 120/240 V ac (nominal - refer to the following table for exceptions)
Operating Voltage	5 to 30 Vdc 5 to 250 V ac, 50/60 Hz
Outputs per Module	8 isolated outputs
Isolation:	
Field to Backplane and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Point to Point	250 V ac continuous; 1500 V ac for 1 minute
Maximum Load	4 Amps resistive maximum per output 2 Amps pilot duty per output 20 Amps maximum per module for UL installations Maximum Load depends on the ambient temperature as displayed in Figure 227
Minimum Load	10mA
Maximum Inrush	5 Amps
On Response Time²⁴	15ms maximum
Off Response Time²⁴	15ms maximum
Power Consumption	6mA (all outputs on) from 5 Vdc bus on backplane 70mA (all outputs on) from relay 24Vdc bus on backplane

For product standards and general specifications, refer to Appendix A.

7.18.1.1 Thermal Derating: MDL930

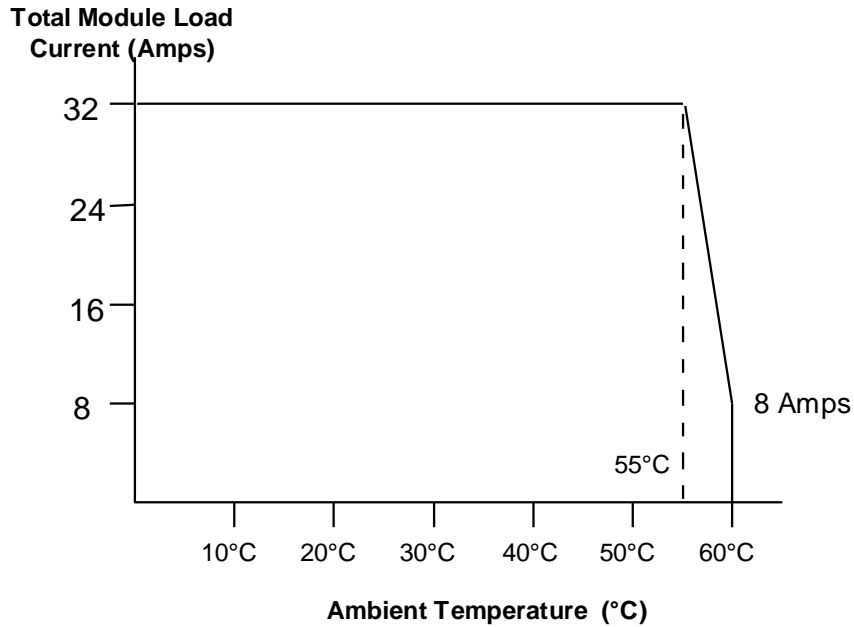


Figure 227: Thermal Derating Curve MDL930

²⁴ When this module is used with DC power supply IC695PSD040 or PSD140, special precautions should be taken because dropouts in the source voltage will be seen by this module and may cause relay dropouts.

7.18.1.2 Load Current Limitations: MDL930

Operating Voltage	Maximum Current for Load Type		Typical Contact Life (Number of Operations)
	Resistive	Lamp or Solenoid ²⁵	
24 to 120 V ac	4 Amps	2 Amps	150,000
24 to 120 V ac	1 Amp	0.5 Amp	500,000
24 to 120 V ac	0.1 Amp	0.05 Amp	1,000,000
240 V ac	4 Amps	2 Amps	50,000
240 V ac	0.1 Amp	0.05 Amp	500,000
240 V ac	1 Amp	0.5 Amp	200,000
24Vdc	-	3 Amps	50,000
24Vdc	4 Amps	2 Amps	100,000
24Vdc	1 Amp	0.5 Amp	500,000
24Vdc	0.1 Amp	0.05 Amp	1,000,000
125Vdc	0.2 Amp	0.1 Amp	300,000

Relay contact life, when switching inductive loads, will approach resistive load contact life if suppression circuits are used. Examples of typical suppression circuits for AC and DC loads are displayed in the following figure. The 1A, 200V diode shown in the DC load typical suppression example is an industry standard 1N4935. The resistor and capacitor shown for AC load suppression are standard components, available from most electronics distributors.

Load Suppression Examples for Output Module MDL930

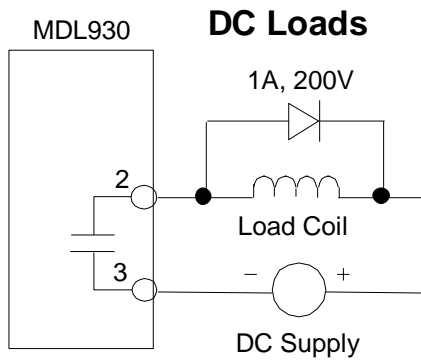


Figure 228: Suppression of DC Loads MDL930

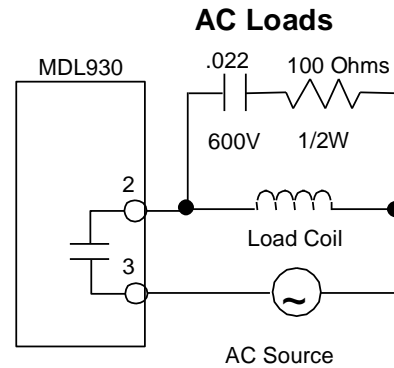
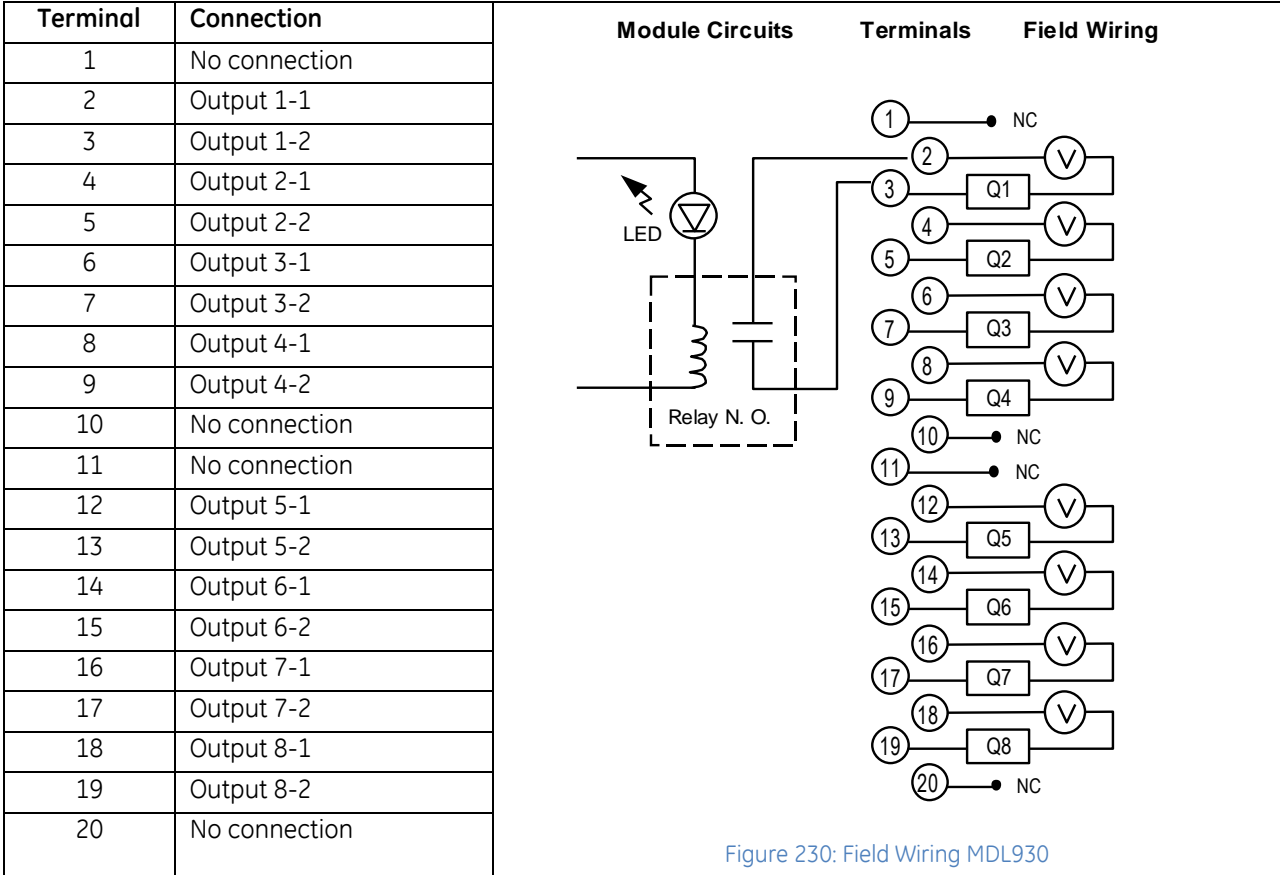


Figure 229: Suppression of AC Loads MDL930

²⁵ Assumes a 7ms time constant

7.18.2 Field Wiring: MDL930



7.19 Output Module, Isolated Relay, N.C. and Form C, 8A , 8-Point: IC694MDL931

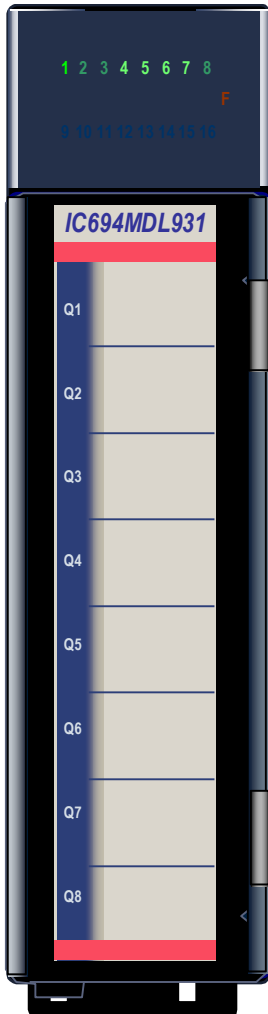


Figure 231: IC694MDL931

The **8 Amp Isolated Relay Output** module, IC694MDL931, provides four normally-closed and four Form C relay circuits for controlling output loads provided by the user. The output switching capacity of each circuit is 8 Amps. Each output relay is isolated from the other relays, and each relay has a separate common power output terminal. The relay outputs can control a wide range of load devices, such as: motor starters, solenoids, and indicators.

The user must supply the AC or DC power to operate the field devices.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The red bands on the label show that MDL931 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

7.19.1 Specifications: MDL931

Rated Voltage	24 Vdc, 120/240 V ac, 50/60 Hz (nominal - refer to the following table for exceptions)
Output Voltage Range	5 to 30 Vdc 5 to 250 V ac, 50/60 Hz
Outputs per Module	8 isolated outputs
Isolation:	
Field to Backplane and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Point to Point	250 V ac continuous; 1500 V ac for 1 minute
Maximum Load	8 Amps resistive maximum per output 20 Amps maximum per module for UL installations Maximum load depends on ambient temperature as shown.
Minimum Load	10mA
Inrush Current	8 Amps maximum for one cycle
On Response Time ²⁶	15ms maximum
Off Response Time ²⁶	15ms maximum
Output Leakage Current	1mA maximum at 250 V ac, (25°C (77°F))
Power Consumption	6mA (all outputs on) from 5 volt bus on backplane 110mA (all outputs on) from relay 24V bus on backplane

For product standards and general specifications, refer to Appendix A.

²⁶ When this module is used with DC power supply IC695PSD040 or PSD140, special precautions should be taken because dropouts in the source voltage will be seen by this module and may cause relay dropouts.

7.19.1.1 Thermal Derating: MDL931

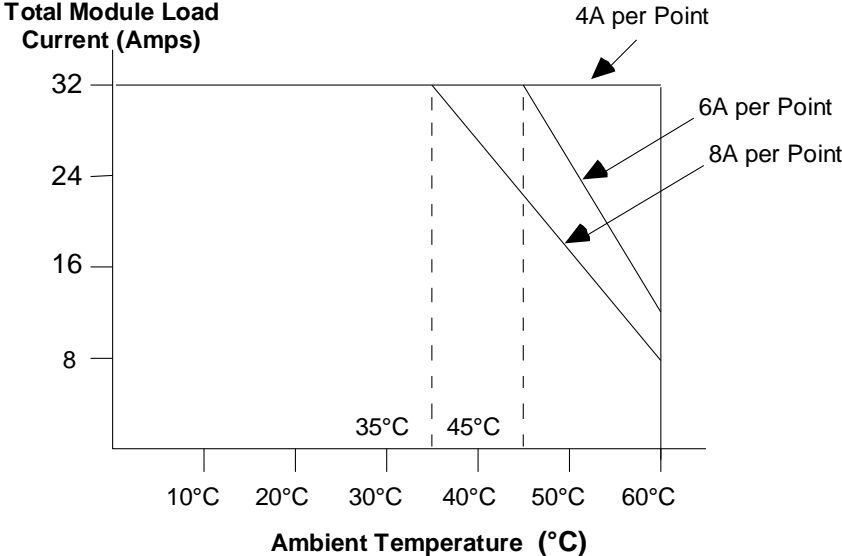


Figure 232: Thermal Derating Curve MDL931

7.19.1.2 Load Current Limitations: MDL931

Operating Voltage	Maximum Current for Load Type		Typical Contact Life (Number of operations)
	Resistive	Lamp or Solenoid ²⁷	
5 to 120 V ac	8 Amps	3 Amps	200,000
	6 Amps	2.5 Amps	300,000
	4 Amps	1.5 Amps	400,000
	1 Amp	0.5 Amp	1,100,000
240 V ac	8 Amps	3 Amps	100,000
	6 Amps	2.5 Amps	150,000
	4 Amps	1.5 Amps	200,000
	1 Amp	0.5 Amp	800,000
24Vdc	8 Amps	3 Amps	100,000
	6 Amps	2.5 Amps	150,000
	4 Amps	1.5 Amps	200,000
	1 Amp	0.5 Amp	800,000
48Vdc	1.5 Amps	-	100,000
100 V dc	0.5 Amp	-	100,000
125Vdc	0.38 Amp	0.12 Amp	100,000
150 V dc	0.30 Amp	0.10 Amp	100,000

Relay contact life, when switching inductive loads, will approach resistive load contact life if suppression circuits are used. The examples below show typical suppression circuits for AC and DC loads. The 1A, 200V diode shown in the DC load typical suppression circuit is an industry standard 1N4935. The resistor and capacitor shown for AC load suppression are standard components.

Load Suppression Examples for Output Module IC694MDL931

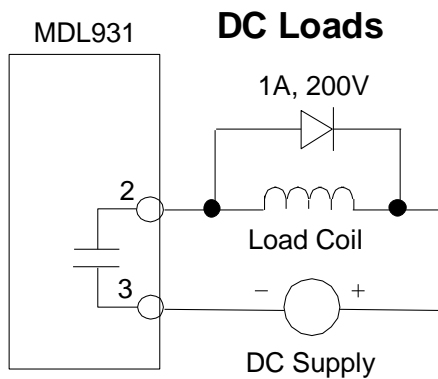


Figure 233: Suppression of DC Loads MDL931

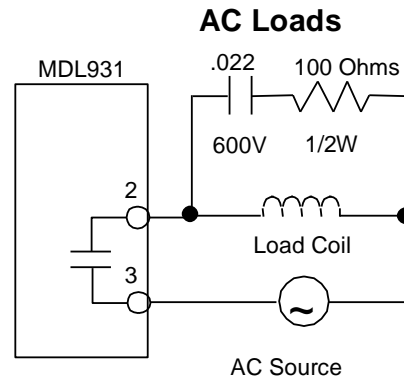


Figure 234: Suppression of AC Loads MDL931

²⁷ For inductive loads

7.19.2 Field Wiring: MDL931

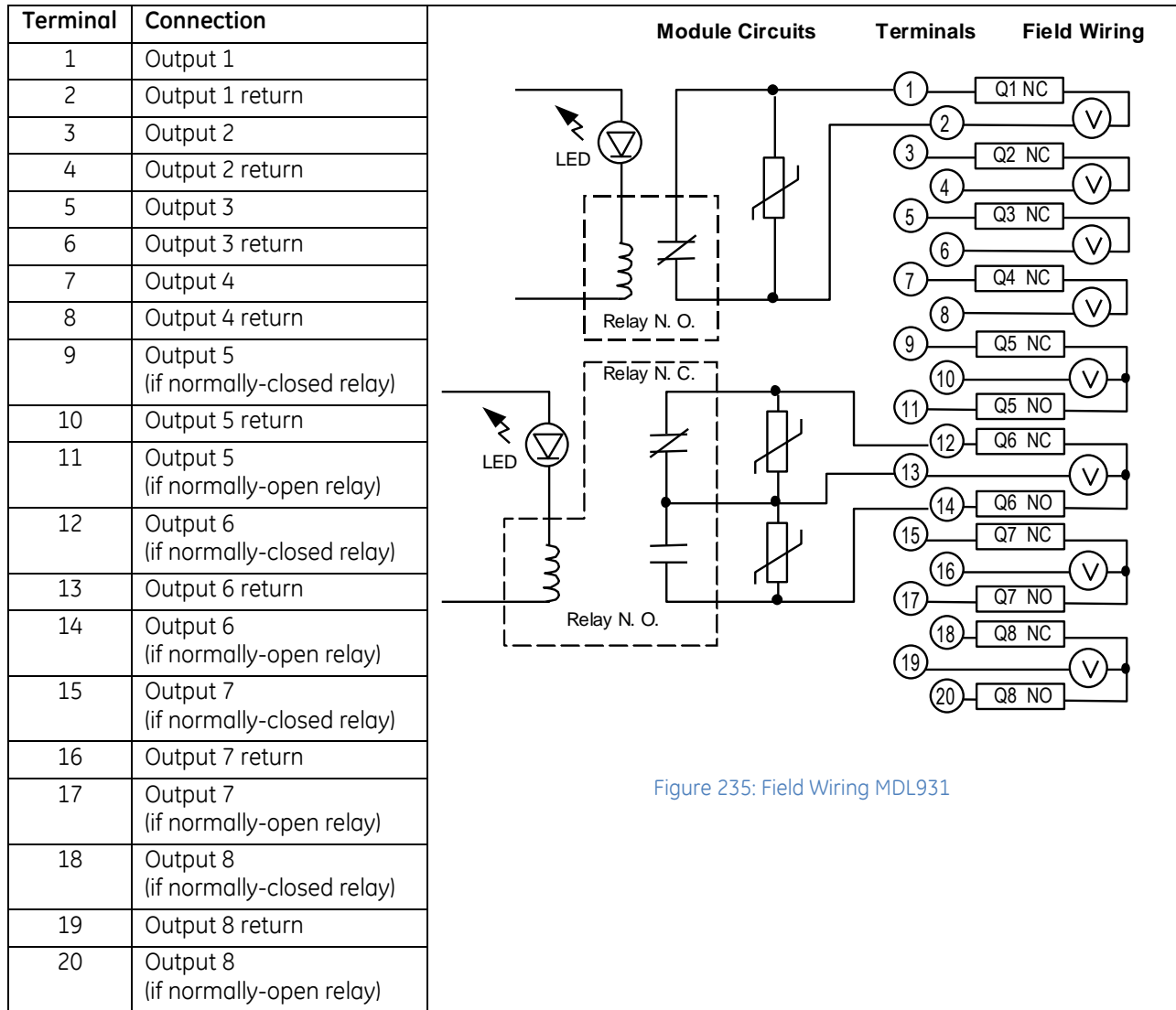


Figure 235: Field Wiring MDL931

7.20 Output Module, Relay Output, N.O., 2 Amp, 16-Point: IC694MDL940

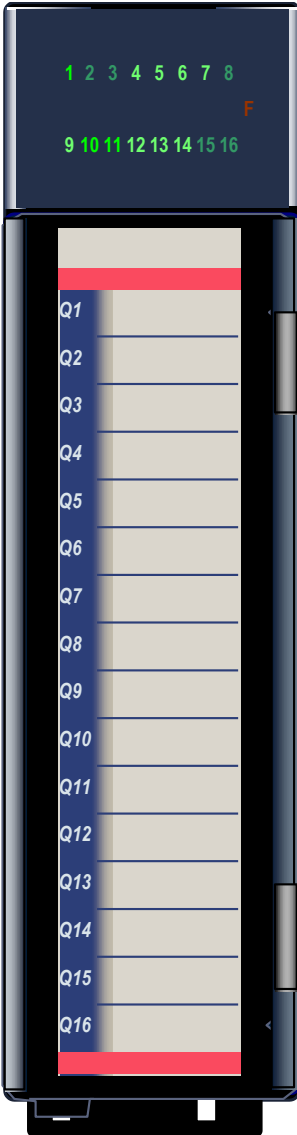


Figure 236: IC694MDL940

The **2 Amp Relay Output** module, IC694MDL940, provides sixteen normally-open relay circuits for controlling output loads. The output switching capacity of each output is 2 Amps. The output points are in four groups of four points each. Each group has a common power output terminal. The relay outputs can control a wide range of load devices, such as: motor starters, solenoids, and indicators. Power for the internal relay circuits is provided by the +24Vdc bus on the backplane.

The user must supply the AC or DC power to operate field devices.

Individual numbered LEDs show the ON/OFF status of each output point. There are no fuses on this module. The red bands on the label show that MDL940 is a high-voltage module.

This module can be installed in any I/O slot in an RX3i system.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

7.20.1 Specifications: MDL940

Rated Voltage	24 Vdc, 120/240 V ac (nominal - refer to the following table for exceptions)
Operating Voltage	5 to 30 Vdc 5 to 250 V ac, 50/60 Hz
Outputs per Module	16 (four groups of four outputs each)
Isolation:	
Field to Backplane and to Frame Ground	250 V ac continuous; 1500 V ac for 1 minute
Point to Point	250 V ac continuous; 1500 V ac for 1 minute
Maximum Load	2 Amps pilot duty maximum per output 4 Amps maximum per common
Minimum Load	10mA
Maximum Inrush	5 Amps
On Response Time ²⁸	15ms maximum
Off Response Time ²⁸	15ms maximum
Power Consumption, all outputs on	7mA from 5 volt bus on backplane 135mA from relay 24V bus on backplane

For product standards and general specifications, refer to Appendix A.

²⁸ When this module is used with DC power supply IC695PSD040 or PSD140, special precautions should be taken because dropouts in the source voltage will be seen by this module and may cause relay dropouts.

7.20.1.1 Load Current Limitations: MDL940

Operating Voltage	Maximum Current for Load Type		Typical Contact Life (Number of Operations)
	Resistive	Lamp or Solenoid ²⁹	
24 to 120 V ac	2 Amps	1 Amp	300,000
24 to 120 V ac	1 Amp	0.5 Amp	500,000
24 to 120 V ac	0.1 Amp	0.05 Amp	1,000,000
240 V ac	2 Amps	1 Amp	150,000
240 V ac	1 Amp	0.5 Amp	200,000
240 V ac	0.1 Amp	0.05 Amp	500,000
24Vdc	-	2 Amps	100,000
24Vdc	2 Amps	1 Amp	300,000
24Vdc	1 Amp	0.5 Amp	500,000
24Vdc	0.1 Amp	0.05 Amp	1,000,000
125Vdc	0.2 Amp	0.1 Amp	300,000

Relay contact life, when switching inductive loads, will approach resistive load contact life if suppression circuits are used. The following figures are examples of typical suppression circuits for AC and DC loads. The 1A, 200V diode shown in the DC load suppression circuit is an industry standard 1N4935. The resistor and capacitor shown for AC load suppression are standard components.

Load Suppression Examples for Output Module MDL940

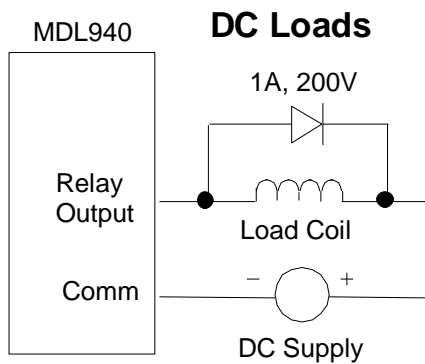


Figure 237: Suppression of DC Loads MDL940

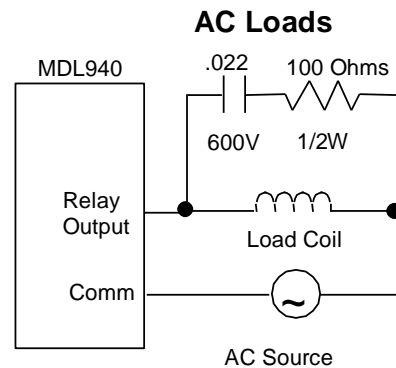


Figure 238: Suppression of AC Loads MDL940

²⁹ Assumes a 7 ms time constant

7.20.2 Field Wiring: MDL940

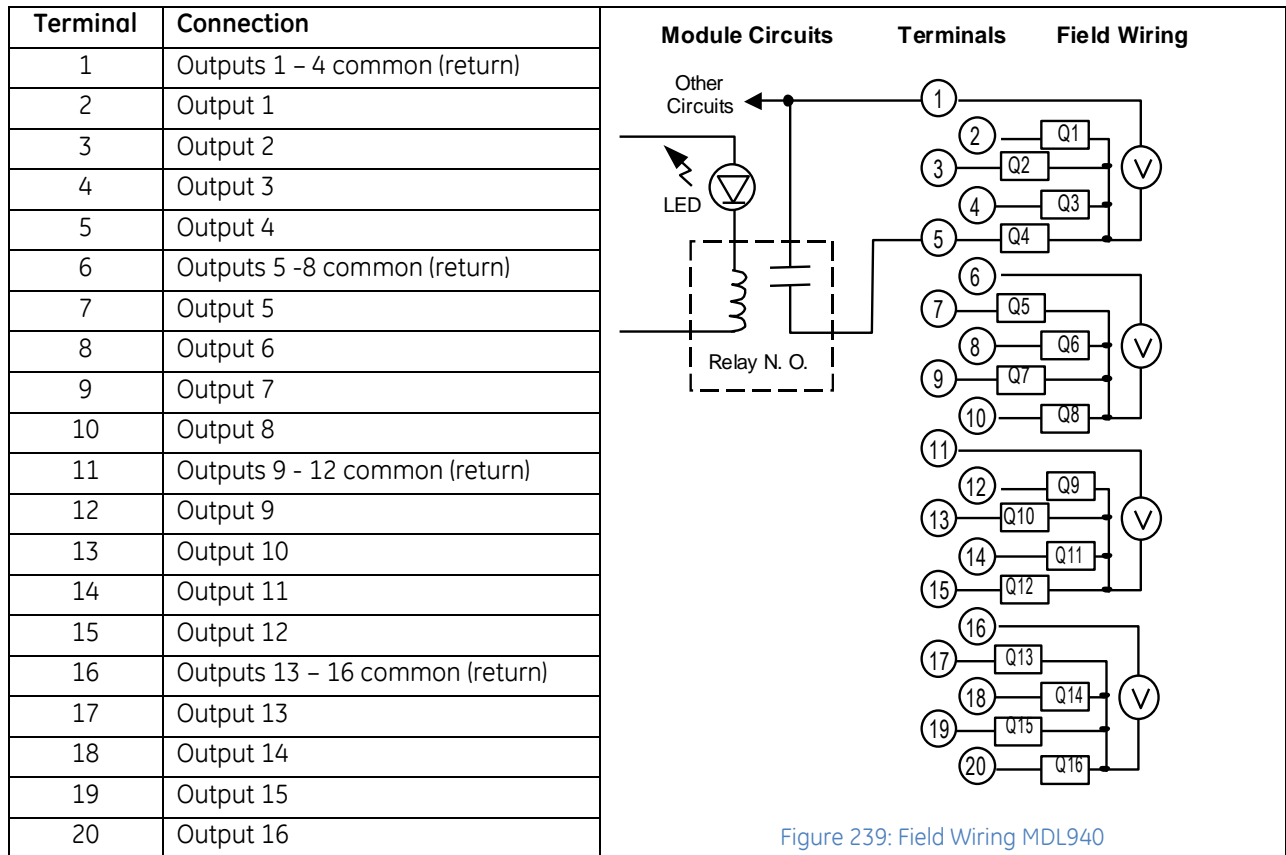


Figure 239: Field Wiring MDL940

Chapter 8 Discrete Mixed I/O Modules

This chapter describes the following discrete mixed input/output module for RX3i PACSystems:

Discrete Mixed I/O Module Description	Catalog Number	Section
High-Speed Counter Module 80kHz 12-Input 4-Output	IC694APU300	8.1
Serial I/O Processor Module	IC694APU305	8.2
High-Speed Counter Module 1.5MHz 8-Input 7-Output	IC695HSC304	8.3
High-Speed Counter Module 1.5MHz 16-Input 14-Output	IC695HSC308	8.3
Mixed I/O 24Vdc Input (8 points) N.O. Relay Output (8 points)	IC694MDR390	8.4

8.1 High-Speed Counter Module: IC694APU300

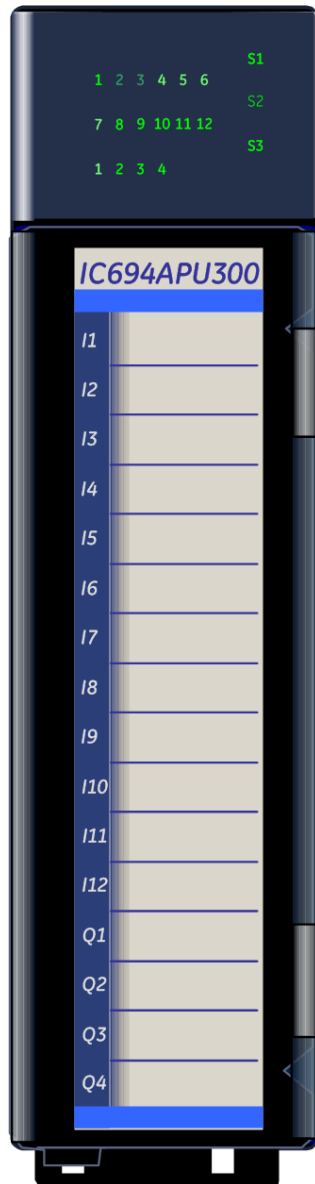


Figure 240: IC694APU300

Two versions of the APU300 exist: Enhanced version IC694APU300-CA and later (shown at left) and Classic version IC694APU300-BA and earlier. All classic features are supported by the enhanced version. Refer to *High Speed Counter Modules for PACSystems* RX3i and Series 90*-30 User's Manual*, GFK-0293D or later, for complete specifications and to Chapter 6 of that manual for enhanced features.

The High-Speed Counter module, IC694APU300, provides direct processing of rapid pulse signals up to 1MHz (Enhanced), 80kHz (Classic). The module senses inputs, processes the input count information, and instantaneously controls the outputs per each counter's configuration without needing to communicate with a CPU.

The High-Speed Counter uses 16 bits of discrete input memory (%I), 15 words of analog input memory (%AI), and 16 bits of discrete output memory (%Q) in the CPU.

The High-Speed Counter can be configured to have:

- 4 identical, independent simple counters
- 2 identical, independent more complex counters
- 1 complex counter
- 2 simple counters with Clock Z input (Enhanced version only)

Additional module features include:

- 12 positive logic (source) inputs with input voltage range selection of either 5 Vdc or 10 to 30 Vdc
- 4 positive logic (source) outputs
- Enhanced version supports both Differential and Single-Ended Encoders. Classic version supports Single-Ended only.
- Counts per timebase register for each counter
- Internal module diagnostics
- A removable terminal board for field wiring
- LEDs to indicate the state of each input, each output and three status LEDs (enhanced version only). Classic version has two LEDs.

Inputs can be used as count signals, direction, disable, edge-sensitive strobe, and preload inputs depending on the counter type selected by the user. Outputs can be used to drive indicating lights, solenoids, relays, and other devices.

The blue bands on the label indicate that the APU300 is a low-voltage module. This module can be installed in any I/O slot in an RX3i system.

Power for the module is drawn from the backplane 5Vdc bus. Power sources for input and output devices must be supplied by the user or by the +24 Vdc Isolated output of the power supply. The module also provides a selectable threshold voltage to allow the inputs to respond to either 5Vdc signal levels or 10 to 30 V dc signal levels.

IC694APU300 Revision CA & later supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1. Revision -BA and earlier do not.

8.1.1 Counter Types: APU300

A counter type must be selected when the module is configured. In Enhanced mode, whenever differential encoders are used, the number of available counters will be reduced (refer to *High Speed Counter Modules for PACSystems* RX3i and Series 90*-30 User's Manual*, GFK-0293, Sections 7-8). The number of counters listed below applies to single-ended applications. The choices are:

- Type A – selects four identical, independent simple counters.
- Type B – selects two identical, independent more complex counters.
- Type C – selects one complex counter.
- Type Z – selects two simple counters with Clock Z input (enhanced mode only).

8.1.1.1 Type A Configuration: APU300

When used in this basic configuration, the module has four identical programmable up or down counters. Enhanced supports 32-bit or 16-bit counters; Classic supports 16-bit counters only. Each counter:

- Can be programmed to count either up or down.
- Has three inputs: a Preload input, a Count Pulse input, and a Strobe input.
- Has one output, with programmable on and off Output Presets.

8.1.1.2 Type B Configuration: APU300

In this configuration, the module has two identical bidirectional 32-bit counters.

- The count inputs can be configured to accept Up/Down, Pulse/Direction, or A Quad B signals.
- Each counter has two completely independent sets of Strobe inputs and Strobe registers.
- Each counter has two outputs; each output has programmable on/off Presets.
- Each counter has one Disable input that can be used to suspend counting.

8.1.1.3 Type C Configuration: APU300

The Type C configuration is suitable for applications requiring motion control, differential counting, or homing capability.

In this configuration, the module has one 32-bit counter with four outputs.

- Each output has programmable on/off output presets, three strobe registers with strobe inputs, and two Preload values with Preload inputs.
- Two sets of bidirectional counter inputs can be connected to operate in a differential fashion. Each set of inputs can be configured for A Quad B, Up/Down, or Pulse/Direction operation.
- The module has a Home Position register for preloading the Accumulator to the Home Position value.

8.1.1.4 Type Z Configuration (Enhanced Mode): APU300

Type Z is a simple counter that uses a pair of clock inputs to perform Up/Down, Pulse/Direction, or A Quad B Counting. A special Clock Z input combines the functions of a Strobe input (copies the current count value to a Strobe register), Disable input (optionally suspends counting), and Clear input (optionally resets the Accumulator to zero). Each Type Z counter has four set-point values that can be used to control its outputs. The Type Z counter has multiple modes of operation which may be selected by the user. Refer to *High Speed Counter Modules for PACSystems* RX3i and Series 90*-30 User's Manual*, GFK-0293, Sections 6 & 7 for a full description of the Type Z counter and enhanced mode configuration.

8.1.2 Status LEDs: APU300

8.1.2.1 Enhanced Version: APU300

Module Status LEDs

S1 (MODULE OK)	Green	The High Speed Counter is powered up and has completed its internal diagnostics.
	Red	The watchdog timer circuit has detected a module failure.
	Off	Module is not powered up correctly or internal diagnostics failed.
S2 (CONFIG)	On	A user configuration has been downloaded to the module.
	Off	A configuration has not been downloaded; the default configuration is in effect.
S3 (FIELD POWER)	On	Output field power present
	Off	Output field power not present

Input Status LEDs

A status LED is provided for each of the twelve input points.

1 -12	On	Input is on
	Off	Input is off

Output Status LEDs

A status LED is provided for each of the four output points.

1-4	Green	Output is on
	Amber	Output has overcurrent fault
	Off	Output is off

8.1.2.2 Classic Version: APU300

MODULE OK	Green	The High Speed Counter is powered up and has completed its internal diagnostics.
	Off	Module is not powered up correctly or internal diagnostics failed.
CONFIG	On	A user configuration has been downloaded to the module.
	Off	A configuration has not been downloaded; the default configuration is in effect.

8.1.3 Specifications: APU300

	IC694APU300 Classic		IC694APU300 Enhanced	
General				
Power Consumption	250 mA (1.25 W) from backplane 5Vdc bus		250 mA (1.25 W) from backplane 5Vdc bus	
Output Points	Powered by user supplied 5Vdc, or 10 V dc - 30 V dc		Powered by user supplied 4.7Vdc to 40 V dc	
Maximum Count Rate	80 kHz		1 MHz (duty cycle 25% to 87%)	
LEDs	BOARD OK and CONFIG OK		BOARD OK (S1), CONFIG OK (S2), Field Power OK (S3), Input Status, Output Status	
Isolation				
Field to Backplane (optical) and to frame ground	250 V ac continuous, 1500 V ac for one minute		250 V ac continuous, 1500 V ac for one minute	
Group to Group	250 V ac continuous, 1500 V ac for one minute		250 V ac continuous, 1500 V ac for one minute	
Inputs				
Voltage Range	5 V dc (TSEL jumpered to INCOM)		5 V dc (TSEL jumpered to INCOM)	
	10 to 30 V dc (TSEL open)		10 to 30 V dc (TSEL open)	
Number of Positive Logic Inputs	12 (Single Ended)		12 (Single Ended) or 6 (Differential)	
Input Thresholds (I1 to I12)	5 V dc Range	10–30 V dc Range	5 V dc Range	10–30 V dc Range
	Von	3.55 V min.	8.35 V min.	3.55 V min.
	Ion	3.2 mA min.	3.2 mA min.	3.2 mA min.
	Voff	1.5 V max.	2.4 V max.	1.5 V max.
	Ioff	0.8 mA max.	0.8 mA max.	0.8 mA max.
Survivable Peak Voltage	± 500 V for 1μSec		± 500 V for 1μSec	
Transient Common Mode Noise Rejection	1000 V/μSec minimum		1000 V/μSec minimum	
Input Impedance	Refer to Figure 241 for V-I characteristics			
Outputs				
Voltage Range	10 to 30 V dc at 500 mA maximum 4.75 to 6 V dc at 20 mA maximum		4.7 to 40 V dc at 1.5A maximum	
Off State Leakage Current	10μA maximum per point		10μA maximum per point	
Output Voltage Drop	0.5 V maximum at 500 mA		0.5 V maximum at 500 mA 1.5 V maximum at 1.5 A	
Inrush current	–		1.6 A without ESCP tripping	
CMOS Load Drive Capability	Yes		Yes	
Positive Logic Outputs	Four		Four	
Output Protection	Outputs are short circuit protected by a 3A pico fuse common to all four outputs		Outputs are protected for overcurrent (ESCP) with self-healing capability.	
Reverse Polarity Protection	None		Outputs protected from reverse wiring between OUTPWR and OUTCOM terminals	

For product standards and general specifications, refer to Appendix A.

8.1.3.1 Input Impedance: APU300

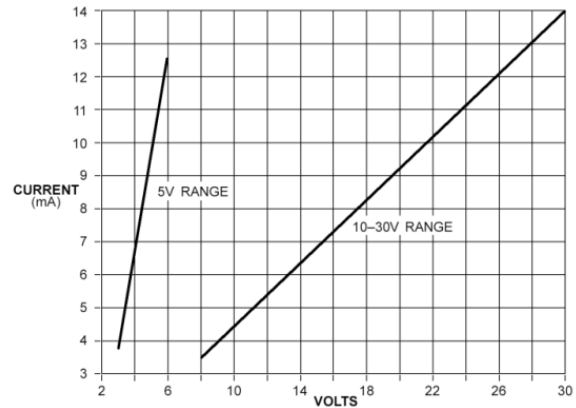


Figure 241: Input Impedance APU300

8.1.4 Field Wiring: APU300

Refer to *High Speed Counter Modules for PACSystems* RX3i and Series 90*-30 User's Manual*, GFK-0293D (or later) Chapter 2 for detailed wiring information.

Shielded cable must be used for connecting to the High-Speed Counter module. The shield for the cable must have a high frequency ground within 6 inches (15.24 cm) of the module to meet the IEC 1000-4-4 levels specified in *Appendix A*. The cable length is limited to 30 meters.



Caution

Do not connect voltage in the 10 V dc to 30 V dc range to the module inputs when the 5Vdc input range (pins 13 to 15 jumpered) is selected. Doing so will damage the module.

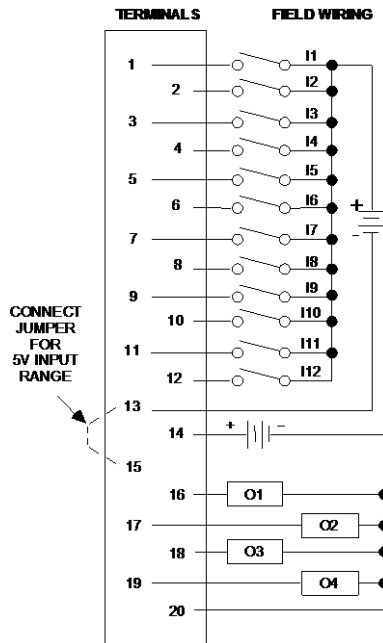


Figure 242: Field Wiring APU300

8.1.4.1 **Input Characteristics: APU300**

The High Speed Counter uses single-ended positive logic (source) type inputs.

- Transducers with CMOS buffer outputs (74HC04 equivalent) can directly drive the High Speed Counter inputs using the 5Vdc input range.
- Transducers using open collector outputs must include a 470Ω pull-up resistor to 5Vdc to guarantee compatibility with the High Speed Counter inputs.
- Transducers using high voltage open collector (sink) type outputs must have a 1kΩ pull-up resistor to +12Vdc for compatibility with the High Speed Counter 10 to 30 Vdc input range.

Note: Classic versions of the APU300 required that transducers using TTL totem pole outputs include a 470Ω pull-up resistor (to 5Vdc) to guarantee compatibility with the High-Speed Counter inputs. The enhanced APU300 versions do not require a 470Ω pull-up resistor for such transducers.

8.1.4.2 **Input Voltage Ranges: APU300**

The default voltage range is 10 V dc to 30 V dc. To use this voltage range, leave the threshold selection terminals (pins 13 and 15) unconnected.

To select the 5Vdc threshold, connect a jumper between two terminals on the detachable terminal board connector.

8.1.4.3 Terminal Assignments for Each Counter Type (Classic Mode): APU300

The following table shows which terminals to use for the Classic Mode counter type selected during module configuration.

Terminal	Signal Name	Pin Definition	Use in Counter Type ³⁰		
			Type A	Type B ³¹	Type C ³²
1	I1	Positive Logic Input	A1	A1	A1
2	I2	Positive Logic Input	A2	B1	B1
3	I3	Positive Logic Input	A3	A2	A2
4	I4	Positive Logic Input	A4	B2	B2
5	I5	Positive Logic Input	PRELD1	PRELD1	PRELD1.1
6	I6	Positive Logic Input	PRELD2	PRELD2	PRELD1.2
7	I7	Positive Logic Input	PRELD3	DISAB1	DISAB1
8	I8	Positive Logic Input	PRELD4	DISAB2	HOME
9	I9	Positive Logic Input	STRB1	STRB1.1	STRB1.1
10	I10	Positive Logic Input	STRB2	STRB1.2	STRB1.2
11	I11	Positive Logic Input	STRB3	STRB2.1	STRB1.3
12	I12	Positive Logic Input	STRB4	STRB2.2	MARKER
13	INCOM	Common for positive logic inputs	INCOM	INCOM	INCOM
14	OUTPWR ³³ DC+	Power for positive logic outputs	OUTPWR	OUTPWR	OUTPWR
15	TSEL	Threshold select, 5V or 10 to 30V	TSEL	TSEL	TSEL
16	O1	Positive Logic Output	OUT1	OUT1.1	OUT1.1
17	O2	Positive Logic Output	OUT2	OUT1.2	OUT1.2
18	O3	Positive Logic Output	OUT3	OUT2.1	OUT1.3
19	O4	Positive Logic Output	OUT4	OUT2.2	OUT1.4
20	OUTCOM DC-	Common for positive logic outputs	OUTCOM	OUTCOM	OUTCOM

³⁰ Notation: Inputs and outputs identified by two numbers separated by a decimal point (x.y) indicate the counter number (x) to the left of the decimal point and the counter element (y) number on the right. For example, STRB1.2 indicates Counter 1, Strobe 2 input.

³¹ Type B, Type Z Counters:

A1, B1 are the A and B inputs for counter 1.

A2, B2 are the A and B inputs for counter 2 (classic notation).

A3, B3 are the A and B inputs for counter 3 (enhanced notation).

³² Type C Counter:

A1, B1 are the A and B count inputs for (+) loop

A2, B2 are the A and B count inputs for (-) loop

³³ OUTPWR **does not** source power for user loads. Output power **must be supplied** from an external supply.

8.1.4.4 Terminal Assignments for Each Counter Type (Enhanced Mode): APU300

The following table lists terminal block pin assignments based on the counter type combinations and input mode settings. Footnotes appear on the previous page.

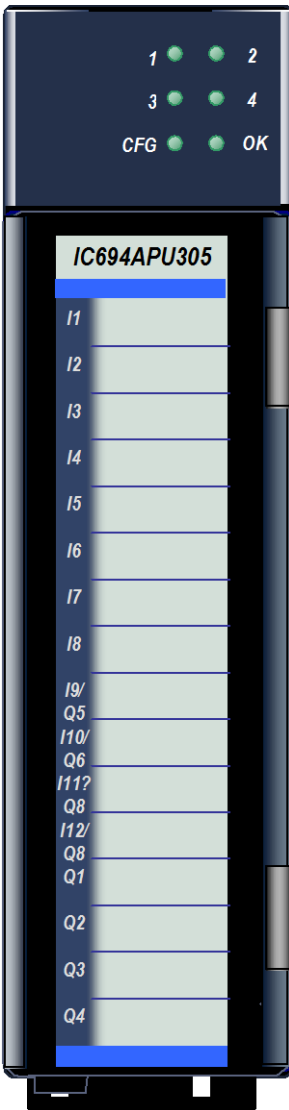
Input	C1	C2	C3	C4	I1	I2	I3	I4	I5 ³⁰	I6 ³⁰	I7 ³⁰	I8 ³⁰	I9 ³⁰	I10 ³⁰	I11 ³⁰	I12 ³⁰
Single Ended	A	A	A	A	A1	A2	A3	A4	PRELD1	PRELD2	PRELD3	PRELD4	STRB1	STRB2	STRB3	STRB4
Single Ended	B ³¹	-	B ³¹	-	A1	B1	A3	B3	PRELD1.1	DISAB1.1	PRELD3.1	DISAB3.1	STRB1.1	STRB1.2	STRB3.1	STRB3.2
Single Ended	C ³²	-	-	-	A1	B1	A2	B2	PRELD1.1	PRELD1.2	DISAB1	HOME	STRB1.1	STRB1.2	STRB1.3	MARKER
Single Ended	A	A	B ³¹	-	A1	A2	A3	B3	PRELD1.1	PRELD2.1	PRELD3.1	DISAB3.1	STRB1.1	STRB2.1	STRB3.1	STRB3.2
Single Ended	A	A	Z ³¹	-	A1	A2	A3	B3	PRELD1.1	PRELD2.1	‡	‡	STRB1.1	STRB2.1	Z3.1	‡
Single Ended	B ³¹	-	A	A	A1	B1	A3	A4	PRELD1.1	DISAB1.1	PRELD3.1	PRELD4.1	STRB1.1	STRB1.2	STRB3.1	STRB4.1
Single Ended	B ³¹	-	Z ³¹	-	A1	B1	A3	B3	PRELD1.1	DISAB1.1	‡	‡	STRB1.1	STRB1.2	Z3.1	‡
Single Ended	Z ³¹	-	A	A	A1	B1	A3	A4	‡	‡	PRELD3.1	PRELD4.1	Z1.1	‡	STRB3.1	STRB4.1
Single Ended	Z ³¹	-	B ³¹	-	A1	B1	A3	B3	‡	‡	PRELD3.1	DISAB3.1	Z1.1	‡	STRB3.1	STRB3.2
Single Ended	Z ³¹	-	Z ³¹	-	A1	B1	A3	B3	‡	‡	‡	‡	Z1.1	‡	Z3.1	‡
Differential	A	-	A	-	A1+	A1-	A3+	A3-	PRELD1.1+	PRELD1.1-	PRELD3.1+	PRELD3.1-	STRB1.1+	STRB1.1-	STRB3.1+	STRB3.1-
Differential	B ³¹	-	-	-	A1+	A1-	B1+	B1-	PRELD1+	PRELD1-	DISAB1+	DISAB1-	STRB1.1+	STRB1.1-	STRB1.2+	STRB1.2-
Differential	Z ³¹	-	-	-	A1+	A1-	B1+	B1-	‡	‡	‡	‡	Z1+	Z1-	‡	‡

8.1.5 ESCP Outputs with 1.5 Amps per Point Minimum

The Enhanced APU300 modules support ESCP (Electronic Short Circuit Protection) for all four outputs. The ESCP fault will be detected if the output channel is shorted to OUTCOM. The module will report ESCP fault condition in the I/O status data – Bit 24 to Bit 27 corresponding to Output1 to Output4 respectively. Also, the output LEDs O1 to O4 will be amber during the short circuit condition.

‡ No connection.

8.2 Serial I/O Processor Module: IC694APU305



The PACSystems RX3i I/O Processor module (IC694APU305) provides direct processing of rapid pulse signals for industrial control applications such as:

- Fast response process control
- Velocity measurement
- Material handling, marking, and packaging

The module is able to sense inputs, process the input information, and control the outputs without needing to communicate with a CPU.

Features

- Up to 12 positive logic (source) inputs with input voltage range selection of either 5Vdc (TTL) or 10 to 30 V dc (non-TTL).
- Up to eight positive logic (source) outputs: four outputs with 1 amp rating and four configurable outputs with 0.5 amp rating
- Outputs protected by replaceable fuse (one fuse for all outputs)
- Counts per Timebase register for input rate measurement
- Total Counts register accumulates total counts received by module
- Four Strobe data registers for input position capture
- Two Timer data registers for indicating input pulse length or input spacing in milliseconds
- Thirty-two range comparators (outputs returned in %I and %AI data)
- Internal module diagnostics

Figure 243: IC694APU305

Inputs can be used as count signals or edge-sensitive strobe signals. Outputs can be used to drive indicating lights, solenoids, relays, and other devices.

Power to operate the logic circuitry of the module is obtained from the 5Vdc bus on the backplane. +24Vdc power sources for the input and output devices must be supplied (80mA max).

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

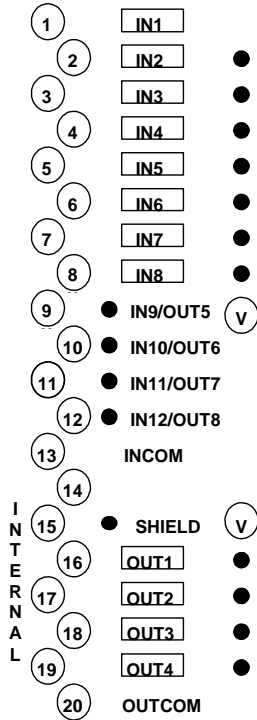
The I/O Processor module provides a configurable threshold voltage to allow the inputs to respond to either a 5Vdc signal level or a 10 to 30 V dc signal level.

Six green LEDs indicate the operating status of the module, the status of configuration parameters, and the state of hardware outputs 1 through 4.

8.2.1 Specifications: APU305

Power Supply Voltage	5Vdc from backplane
Power Supply Current	360mA + (10mA x number of ON faceplate outputs)
Field I/O to logic isolation	Peak (1 second): 1500 V Steady State: 30 V ac/Vdc
Maximum Number of modules per RX3i system	No limit
Input Specifications	
Input type	Positive Logic, optically isolated. Note: Input Common is internally connected to Output Common
Input Circuit Power	Supplied by module using DC/DC converter
Encoder Power	Supplied by user (5V or 10–30 V dc). (Inputs will operate with Output Circuit power disconnected)
Input Impedance	4300Ω typical
Input Threshold	8.0v (non-TTL), 1.5V (TTL)
Input Hysteresis	250 mV typical
Maximum Input Voltage	+30 V dc
Input duty cycle limit	If Input 1–12 voltages exceed 24.0 V dc, derate total input duty cycle from 100% at 40° C to 50% at 60° C
Input filter delays	Absolute Encoder: 20 μs AQUADB Encoder & Preload: 20 μs / 2 μs selectable AQUADB Home Switch: 10 ms AQUADB IN 6–8: 10 ms
Minimum Strobe Input Pulse Width	2ms (Minimum time between consecutive strobe inputs)
Strobe Register Resolution	1ms (Maximum time from when strobe input is asserted until the strobe register value is updated)
Maximum Count Rate	30 kHz (Absolute Encoder) 200 kHz (A Quad B Encoder)
Input Cable	Shielded cable recommended, Maximum length: 30m
Output Specifications	
Output type	Positive Logic, optically isolated
Maximum Supply Voltage	30.0 V dc
Continuous Output Current (10–30 V dc supply)	1.0 A (each output 1–4) 0.5 A (each output 5–8)
Total Continuous Output Current at 40° C	4.0 A (total of outputs 1–8)
Output 1–4 derating above 40° C	Derate total Output 1–4 current to 2.0A at 60° C
Output 5–8 derating above 40° C	Derate total Output 5–8 current to 0.5A at 60° C
Output current using 5Vdc supply	20 mA typical with 5.0 V dc supply 2 mA minimum with 4.9Vdc supply
Inductive Load Clamp Voltage	–8.0 V typical (outputs 1–4) –1.0 V typical (outputs 5–8)
OFF state leakage current	10 mA (each output)
Output Fuse	5 A (5x20mm replaceable) common to all outputs
Output Response Time	500 μs typical

8.2.2 Field Wiring: APU305



The I/O Processor Module has a removable terminal strip for connection to field devices.



Caution

Do not apply loads greater than 0.5 Amp to the OUT5 through OUT8 outputs (terminals 9 through 12), or 1.0 Amp to OUT1 through OUT4 (terminals 16 through 19). Doing so may damage the module.

Notes

- Pin 13 (Input Common) and pin 20 (Output Common) are internally connected together in the IOP module.
- All 12 I/O Processor inputs are positive logic (source) type.
- Transducers using TTL open collector outputs must include a 2000Ω (maximum) pull-up resistor (to 5V) to guarantee compatibility with the inputs.
- Transducers using high voltage open collector (sink) type outputs must have a 1kΩ (maximum) pull-up resistor to +12V for compatibility with the 10 to 30 volt input range.

Figure 244: Field Wiring APU305

8.2.2.1 Typical Connections: APU305

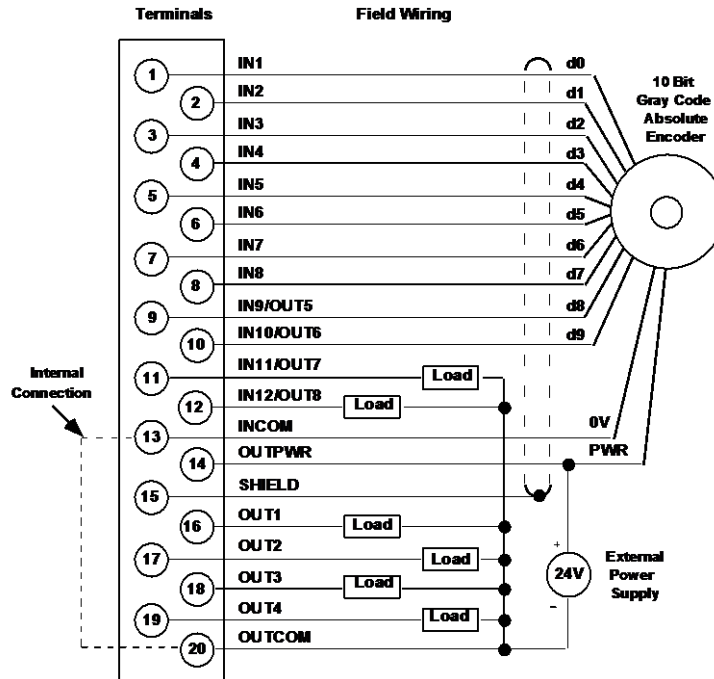


Figure 245: Typical Connections APU305

8.2.3 Configuration: APU305

8.2.3.1 Settings Tab: APU305

Settings	Description
Reference Addresses and Lengths	32 discrete inputs (%I), 15 words of analog inputs (%AI), 32 discrete outputs (%Q), and 6 words of analog outputs (%AQ).
Input Threshold	Selects the Input voltage level to be used. If 5Vdc inputs are used, select TTL, otherwise select Non-TTL (for 10–30 V dc inputs). <i>Default: Non-TTL</i>
In Timer #1 Mode	Selects the inputs that control the starting and stopping of Timer 1. The resulting time recorded for Timer 1 is reported in the eleventh %AI word. IN10 causes Timer 1 to report the elapsed time (in ms) from the configured edge of input 10 to the other edge of input 10. IN09-10 causes Timer 1 to report the elapsed time (in ms) from the configured edge of input 10 to the configured edge of input 9. <i>Default: IN10</i>
In Timer #2 Mode	Selects the inputs that control the starting and stopping of Timer 2. The resulting time recorded for Timer 2 is reported in the twelfth %AI word. IN12 causes Timer 2 to report the elapsed time (in ms) from the configured edge of input 12 to the other edge of input 12. IN11-12 causes Timer 2 to report the elapsed time (in ms) from the configured edge of input 12 to the configured edge of input 11. <i>Default: IN12</i>
Timebase (ms)	The timebase for the Counts per Timebase return data (second %AI word). The default is 1000ms (1 second) resulting in Counts per Timebase return data that indicates input counts per second.
Strobe1 Edge	The strobe 1 (Input 9) trigger edge: positive (rising) or negative (falling).
Strobe2 Edge	The strobe 2 (Input 10) trigger edge: positive (rising) or negative (falling).
Strobe3 Edge	The strobe 3 (Input 11) trigger edge: positive (rising) or negative (falling).
Strobe4 Edge	The strobe 4 (Input 12) trigger edge: positive (rising) or negative (falling).
Strobe1 Enable	Selects whether strobe 1 (Input 9) is Always enabled (default selection) or is only enabled when preset output 5 is On (Rcomp-05 selection).
Strobe2 Enable	Selects whether strobe 2 (Input 10) is Always enabled (default selection) or is only enabled when preset output 6 is On (Rcomp-06 selection).
Strobe3 Enable	Selects whether strobe 3 (Input 11) is Always enabled (default selection) or is only enabled when preset output 7 is On (Rcomp-07 selection).
Strobe4 Enable	Selects whether strobe 4 (Input 12) is Always enabled (default selection) or is only enabled when preset output 8 is On (Rcomp-08 selection).
Output 5	Selects whether point 9 is output or an input. Disabled (default) defines the point as Input #9. Enabled defines it as output #5.
Output 6	Selects whether point 10 is an output or an input. Disabled (default) defines the point as Input #10. Enabled defines it as output #6.
Output 7	Selects whether point 11 is an output or an input. Disabled (default) defines the point as Input 11. Enabled defines it as output #7.
Output 8	Selects whether point 12 is to be used for an output or an input. Disabled (default) defines the point as Input #12. Enabled defines it as output #8.
Outputs Default	The state outputs will assume if the output mode configured for the CPU is set to Outputs Disabled or the CPU is no longer available. Continue (default) indicates that outputs continue to operate under control of the input counts to the I/O Processor. Force Off causes the outputs to be forced to off Hold Last State causes the I/O Processor to retain the last state of the outputs.

Settings	Description
Function	<p>ABS-256 (default): Encoder 8-bit parallel gray code input (for 0–255 counts)</p> <p>ABS-360: Encoder 9-bit parallel (excess 76 gray code for 0–359 count rollover)</p> <p>ABS-512: Encoder 9-bit parallel gray code (for 0–511 counts)</p> <p>If ABS-360 or 512 is selected, Input 9 is not available for a strobe Input and Output 5 is unavailable.</p> <p>ABS-1024: Encoder 10-bit parallel gray code (for 0–1023 counts)</p> <p>If ABS-1024 is selected, Inputs 9 and 10 are not available for strobe Inputs and Outputs 5 and 6 are unavailable.</p> <p>AQUADB: Encoder AQUADB input selection</p>
Encoder Direction	Changes the count direction (up or down) without reversing the Absolute Encoder direction of rotation. If Normal (default) is selected, increasing the count input causes the IOP to register up counts and decreasing the count input causes the IOP to register down counts. The Reverse selection produces the opposite effect.
Position Offset	Adjusts the count input with an offset value to compensate for a rotational offset error in the Encoder coupling. Enter any required count value within the count range. <i>Default: 0</i>

8.2.3.2 A Quad B Encoder Parameters: APU305

Input Filter	The Input filter range for the AQUADB Count inputs, the Marker input, and the Preload input. If the maximum count input rate is < 25 kHz, use the 20 μ s default selection, otherwise use the 2 μ s selection. <i>Default: 20μs.</i>
Max Counts	The count range for the internal counter registering the AQUADB input counts. It counts from 0 to this maximum value and then rolls over to 0. The range for this parameter is 10 to 64,999 counts. <i>Default: 255</i>
Preload Position	The initializing count value to be set into the input counter when the Preload command is received by the I/O Processor. The Preload command can be from either the Preload input or the %Q bit command. <i>Range: 0 to maximum counts</i>
Home Position	The initializing count value to be set into the input counter when the Marker input is received by the I/O Processor when executing the Home cycle. <i>Range: 0 to maximum counts</i>

8.2.3.3 ABS or AQUADB Encoder Parameters: APU305

These parameters are repeated for each output.

Mode	The type of pulse generated by the range comparator output. Preset (the default) causes the output to be On (or Off) continuously from one preset point to the other. Timer causes timed pulses to be produced at the preset points defined by Timer 1 and Timer 2.
ON Preset	The count input value that causes the output to turn On. Can be any value in the count range. <i>Default: Maximum encoder value for Absolute Encoders, 255 for AQUADB mode</i>
OFF Preset	The count input value that causes the output to turn Off. Can be any value in the count range. <i>Default: 0</i>
Timer# 1 (ms)	Effective only when the output mode is Timer. The length of the pulse (in ms) produced by the output when the input count reaches the On preset value. 0 specifies no output pulse at the On preset point. <i>Default: 0</i>
Timer #2 (ms)	Effective only when the output mode is Timer. The length of the pulse (in ms) produced by the output when the input count reaches the Off preset value. 0 specifies no output pulse at the Off preset point. <i>Default: 0</i>

8.2.4 Module Data: APU305

Each CPU sweep, the I/O Processor Module automatically exchanges the following status and command data, with the CPU:

- Status Bits: 32 bits of %I data
- Status Words: 15 words of %AI data
- Discrete Commands: 32 bits of %Q data
- Immediate Command Data: 6 words of %AQ data

8.2.4.1 %I Status Bits: APU305

The Starting Address of the Status Bits is selected during configuration. The following table lists bit offsets from the Starting Address.

Offset	Description	Offset	Description
00	Range Comparator 1 status	16	Input 9 status
01	Range Comparator 2 status	17	Input 10 status
02	Range Comparator 3 status	18	Input 11 status
03	Range Comparator 4 status	19	Input 12 status
04	Range Comparator 5 status	20	Strobe 1 status (Input 9 latch)
05	Range Comparator 6 status	21	Strobe 2 status (Input 10 latch)
06	Range Comparator 7 status	22	Strobe 3 status (Input 11 latch)
07	Range Comparator 8 status	23	Strobe 4 status (Input 12 latch)
08	Range Comparator 9 status	24	Home Found ³⁴
09	Range Comparator 10 status	25	Preload Latch status ³⁴
10	Range Comparator 11 status	26	Home Switch Input (IN5) status ³⁴
11	Range Comparator 12 status	27	IN6 status ³⁴
12	Range Comparator 13 status	28	IN7 status ³⁴
13	Range Comparator 14 status	29	IN8 status ³⁴
14	Range Comparator 15 status	30	Module Ready
15	Range Comparator 16 status	31	Error

³⁴ Applies to AQUADB function only.

%I Status Bit Descriptions: APU305

Range Comparator 1-8 Status	The ON/OFF state for range comparator outputs 1-8. If the Output Mode = Preset, the state of the status bit is defined by the ON/OFF presets. If the Output Mode = Timer, the status bit will be on after each preset point is passed for the length of time designated by Timer 1 or Timer 2. These bits always indicate the output state for range comparators 1-8, even if the corresponding hardware output is disabled (and Terminal Points 9-12 are used as Inputs).
Range Comparator 9-16 Status	The ON/OFF state for range comparator outputs 9-16 based solely on the ON & OFF presets defined for each output.
Input 9-12 Status	The present on/off input status for Inputs 9-12. State changes in these inputs produce strobe inputs 1-4 according to the configured strobe edge (input 9 = strobe 1, input 10 = strobe 2, etc.).
Strobe 1-4 status (Input 9-12 latch)	Indicates that strobe data has been captured by Inputs 9-12, respectively. Once acknowledged, the corresponding %Q command (Reset Strobe) should be sent to clear the strobe status for future strobe captures. <i>Following strobes will be locked out until this flag is cleared.</i>
Home Found (AQUADB only)	Indicates that the Home marker, after a Home command sequence, has been recognized and the AQUADB Input Counter has been set to the Home preload value.
Preload Latch Status (AQUADB only)	Indicates that the AQUADB input counter has been preloaded by a Preload Input. When acknowledged, this status indication should be cleared (by the Reset Preload Latch %Q bit). <i>This latch locks out the effect of the Preload Input, it will not be effective again until this bit is cleared. This latch does <u>not</u> apply to the %Q preload command bit.</i>
Home Switch Input (AQUADB only)	The status of the Home switch input. When this switch is closed during the Home cycle, the next encoder marker encountered will preload the counter with the configured Home value and set the Home Found %I indication. If a Home Switch is not used, this %I bit can be used as a general-purpose input reporting the status of faceplate Input 5.
IN6, IN7, IN8 (AQUADB only)	The on/off status of Inputs 6, 7, & 8.
Module Ready	Power-up tests have all completed successfully and the module is ready for operation.
Error	An error condition has been detected by the module. The error code is reported in the first %AI word. If the error was caused by a bad data command, the data has been ignored. Once acknowledged by the program, the %Q command (Clear error) must be toggled to clear the error status.

8.2.4.2 %AI Data Words: APU305

The following %AI Data words are transferred automatically to the CPU each sweep. The Starting Address of the Status Words is selected during configuration. The following table lists word offsets from the Starting Address.

Offset	Description
000	Module Status Code
001	Counts per timebase
002	Gray Code Encoder Data ³⁵
003	Binary Data
004-005	Total Counts
006	Strobe Data 1 (Input 9)
007	Strobe Data 2 (Input 10)
008	Strobe Data 3 (Input 11)
009	Strobe Data 4 (Input 12)
010	Start/Stop Timer 1 Data
011	Start/Stop Timer 1 Data
012	Range Comparator 17-32 status (16 bits)
013, 014	reserved

³⁵ Not applicable for the AQUADB function selection.

%AI Data Word Descriptions: APU305

Module Status Code	Indicates the Error identification code when an error has been detected. The error identified is the first error encountered. The error condition must be cleared before other errors will be reported.	
	Error Code	Description
	0010	Encoder Position Offset out of range (ABS Encoder Function only)
	xx11	ON Preset xx is out of range
	xx12	OFF Preset xx is out of range
	0015	Home Position out of range (AQUADB Function only)
	0016	Preload Position out of range (AQUADB Function only)
	001E	AQUADB Input Quadrature error (AQUADB Function only)
	001C	Internal Home Command Sequence State Machine Error (AQUADB function only)
	001D	Absolute Encoder Input Error (ABS Encoder Function Only)
Counts per Timebase	Indicates the number of input counts received in the last time interval defined by the Timebase configuration parameter. With the default Timebase (1000 ms), this indicates counts per second.	
Gray Code Encoder Data	Indicates the Gray code value presently being received by the module inputs from the Encoder parallel outputs (ABS Encoder only)	
Binary Data	The binary equivalent of the Gray code value being received by the module inputs from the Encoder parallel outputs, or the input counter Binary count value for the AQUADB selection.	
Total Counts	The total input counts received by the module. This total counts register can be initialized (preloaded) by a %AQ data command from the CPU. It is initialized to 0 at power-up. For AQUADB operation, it is also initialized to 0 at the Home position marker. In AQUADB mode, the Preload Input does not affect Total Counts.	
Strobe Data 1-4	The captured input binary data value recorded when the strobe input occurred. Inputs 9-12 correspond to Strobe inputs 1-4, respectively. Either input edge may be configured to trigger the strobe data capture.	
Start/Stop Timer 1 Data (ms)	The time (in ms) between the input edges of Input 10 (default) or the input edges of Inputs 9-10 depending upon the configuration. To start the capture of this timing data, the strobe latch for Input 10 must be cleared, and if the strobe 2 enable configuration is RCOMP-6, the output range comparator 6 must be on when the Input 10 strobe occurs. If Input 9 is used to stop the time measurement and the strobe 1 enable configuration is RCOMP-5, output range comparator 5 must be on (when strobe input occurs) before the timing will stop.	
Start/Stop Timer 2 Data (ms)	The time (in ms) between the input edges of Input 12 (default) or the input edges of Inputs 11-12 depending upon the configuration. To start the capture of this timing data the strobe latch for Input 12 must be cleared, and if the strobe 4 enable configuration is RCOMP-8, output range comparator 8 must be on when the Input 12 strobe occurs. If Input 11 is used to stop the time measurement and the strobe 3 enable configuration is RCOMP-7, output range comparator 7 must be on (when strobe input occurs) before the timing will stop.	
Range Comparator 17-32 status (16 bits)	Indicates the ON/OFF state for range comparator outputs 17-32 based solely on the ON and OFF presets defined for each output.	

8.2.4.3 %Q Control Bits: APU305

The following %Q Control Bits are transferred automatically to the CPU each sweep. The Starting Address of the Control Bits is selected during configuration. The following table lists bit offsets from the Starting Address.

Offset	Description	Offset	Description
00	Enable Output 1	16 - 19	reserved
01	Enable Output 2		
02	Enable Output 3		
03	Enable Output 4		
04	Enable Output 5 (only if cfg = enabled)	20	Reset Strobe 1 (Input 9 latch)
05	Enable Output 6 (only if cfg = enabled)	21	Reset Strobe 2 (Input 10 latch)
06	Enable Output 7 (only if cfg = enabled)	22	Reset Strobe 3 (Input 11 latch)
07	Enable Output 8 (only if cfg = enabled)	23	Reset Strobe 4 (Input 12 latch)
08 - 15	reserved	24	Home Command ³⁶
		25	Reset Preload Latch ³⁶
		26	Preload Command ³⁶
		27 - 30	reserved
		31	Clear Error

%Q Control Bit Descriptions: APU305

Enable Output 1-8	Enables each hardware Output (ON = Enable). If the configuration for Outputs 5-8 is DISABLED, these corresponding output bit commands have no effect.
Reset Strobe 1-4 (Input 9-12 Latch)	Clears the respective strobe latch condition so the next strobe can be captured and reported via the corresponding %I bits. If this %Q bit is held ON, the %I status bit will stay OFF and every strobe input pulse will cause new strobe data to be captured in the associated %AI strobe register.
Home Command (AQUADB only)	Initiates the Home command sequence. When the Home Marker Input is recognized, the input counter will be preloaded with the configured home value, and the Home Found %I indication will be set.
Reset Preload Latch (AQUADB only)	Clears the Preload Latch status after it has been set by the Preload switch Input. If this command is left on, it will allow all Preload switch inputs to be effective.
Preload Command (AQUADB only)	Preloads the input counter with the configured preload value. The Preload Latch status %I indication will not be set by this command since it only applies to the Preload faceplate input.
Clear Error	Toggling this command ON clears the module status error condition reported by the %I Error bit and the %AI module status word and thus allows another error condition to be reported.

³⁶ Applies to AQUADB function only.

8.2.4.4 %AQ Immediate Commands: APU305

Six %AQ words are sent automatically from the CPU to the I/O Processor Module during each sweep. These words can be used to transfer immediate command data to the module for temporarily altering configuration parameters or to initialize counter data. Configuration parameter changes made in this manner do not affect the module configuration data (stored in the CPU) which will again become effective if the module is power cycled.

Each immediate command requires three sequential %AQ words. Two immediate commands are always sent during each PLC sweep. The first word of each command set contains the identifying command number and the other two words contain the data. The actual address of each command word depends on the starting address configured for the %AQ references.

Even though the commands are sent each sweep, the module will act on a command *only* if the command has changed since the last sweep. Whenever any of the three-word data changes, the module accepts the data as a new command and responds accordingly.

When these commands are sent, all three %AQ words should be loaded on the same PLC sweep. If they cannot be loaded on the same sweep (for example, when entering data from the programmer), the steps below must be followed to ensure that no wrong or incomplete data is momentarily sent.

Step 1) Set Word 1 to Null Command (0000).

Step 2) Set correct data in Words 2 and 3.

Step 3) Set command in Word 1.

The following immediate commands may be sent by %AQ data to the I/O Processor:

Command	Data		Command # (hex) Word 1
	Word 3	Word 2	
Null	(not used)	(not used)	0000
Load Home Position (AQUADB) ³⁷	(not used)	Home Position	0101
Load Preload Position (AQUADB) ³⁷	(not used)	Preload Position	0102
Load Timebase	(not used)	Timebase (ms)	0106
Load Encoder Position Offset ³⁸	(not used)	Offset	0107
Load Total Counts	(not used)	Counts	0109
Load ON/OFF Preset Pairs 1-32	OFF preset	ON preset	0140 - 015F
Load Output Timer 1.1-8.1	(not used)	Time (ms)	01C0 - 01C7
Load Output Timer 1.2-8.2	(not used)	Time (ms)	01D0 - 01D7

³⁷ AQUADB function only.

³⁸ ABS Encoder function only.

%AQ Immediate Command Descriptions: APU305

Null	The default %AQ Immediate command. Since the %AQ words are transferred each PLC sweep, you should always enter the Null command to avoid inadvertent execution of another immediate command.
Load Home Position (AQUADB)	The Home reference position value that will be preloaded into the Input counter at the marker location after a Home command.
Load Preload Position (AQUADB)	The position value that will be preloaded into the Input Counter when a Preload Switch Input is recognized or the %Q Preload command is set.
Load Timebase	The timebase to be used for determining the Counts per Timebase value returned in the second %AI word assigned to the module.
Load Encoder Position Offset (ABS Encoder Function only)	The Encoder offset value. The Input Count Value is shifted relative to the Encoder Input by this amount as follows: $\text{Input Count Value} = \text{Encoder Input} - \text{Offset}$
Load Total Counts	The Total Count value reported in the fifth and sixth %AI words assigned to the module
Load ON/Off Preset Pairs 1-32	The ON and OFF preset value for the specified range comparator output.
Load Output Timer 1.1-8.1	The Output Timer 1 value for the specified range comparator output 1-8.
Load Output Timer 1.2-8.2	The Output Timer 2 value for the specified range comparator output 1-8.

8.3 High-Speed Counter Modules: IC695HSC304, IC695HSC308

For detailed information about both RX3i High-Speed Counter modules, please refer to the *RX3i High-Speed Counters Manual*, GFK-2441.

PACSystems RX3i High-Speed Counter modules provide direct processing of rapid pulse signals up to 1.5 MHz for industrial control applications such as:

- Turbine flowmeter
- Meter proving
- Velocity measurement
- Material handling
- Motion control
- Process control

These modules can sense inputs, process input count information, and control outputs without CPU intervention.

High-Speed Counter module IC695HSC304 provides: 8 high-speed inputs, 7 high-speed outputs, and 1 to 4 counters.

High-Speed Counter module IC695HSC308 provides: 16 high-speed inputs, 14 high-speed outputs, and 1 to 8 counters.

Standard counter types A, B, C, D, E, Z, and a user-defined type can be combined on a module.

Module features include:

- Terminal Block insertion or removal detection
- Meets CE, UL/CUL 508 and 1604, and ATEX requirements
- Flash memory for future upgrades
- Module fault reporting
- Configurable I/O Interrupts
- Select module parameters easily changed without re-configuration.

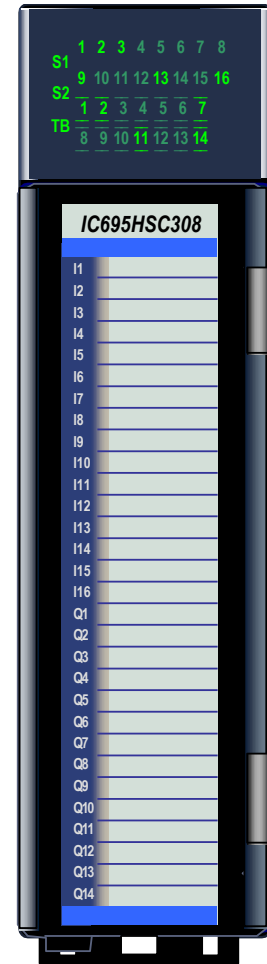


Figure 246: IC695HSC308

These modules must be located in an RX3i Universal Backplane.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1. When the module is removed from the backplane or is power-cycled, it stops counting and accumulated counts are lost.

High-Speed Counter modules can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block (Refer to Chapter 17). Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Terminal Blocks are ordered separately.

8.3.1 LEDs: HSC304 & HSC308

Individual green LEDs indicate the ON/OFF status of the external input and output points of this module. These LEDs are green when the corresponding points are on. They are off when the corresponding points are off. LED positions are illustrated below.

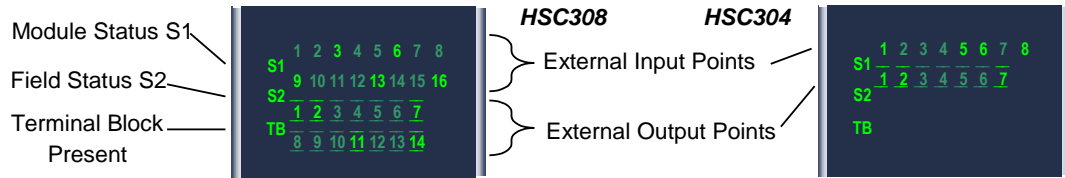


Figure 247: LED Layout HSC304 & HSC308

The Module Status (S1) LED indicates the status of the module. Solid green indicates that the module has been configured. Blinking green indicates no configuration. Blinking amber/yellow indicates a fatal module failure.

The Field Status (S2) LED is off if field power is not present. For module IC695HSC308, this LED is off unless power is present on BOTH V_A and V_B . Solid green indicates that field power is present and that no output circuit faults have been detected on circuits for which fault detection has been enabled in the configuration. If S2 is amber/yellow, field power is present but circuit faults exist for one or more outputs.

The red/green Terminal Block LED is green when the removable terminal block of this module is locked in place. It is red when the terminal block is not locked. The module also sends an *Addition of Terminal Block* or *Loss of Terminal Block* message to the RX3i CPU to report the Terminal Block status.

During a firmware update, the S1, S2, and TB LEDs blink in a green/off pattern.

8.3.2 Specifications: HSC304 & HSC308

Number of Counter Channels	IC695HSC304: 4 counters (8 inputs and 7 outputs) IC695HSC308: 8 counters (16 inputs and 14 outputs)	
High-Speed Counter Types	Configurable as Types A, B, C, D, E, Z, and User-Defined.	
Maximum Count Rates	1.5MHz with configurable input filtering, all counter types except 750kHz for Type C or User-Defined when using four counter outputs. (40 MHz internal oversampling). For A-Quad B count mode, 1.5MHz is the maximum overall count rate.	
Counting Range	-2147483648 to 2147483647	
Oscillator Accuracy Over Operating Temperature Range	±100ppm	
Oscillator Drift Over Time	±5ppm maximum per year	
Backplane Power Requirements	IC695HSC304:	64 mA maximum at 5Vdc 457 mA maximum at 3.3Vdc
	IC695HSC308:	94 mA maximum at 5Vdc 561 mA maximum at 3.3Vdc
LEDs	Module Status (S1), Field Status (S2), Terminal Block (TB), plus LEDs to indicate state of each input and output point.	
Input Voltages	5Vdc nominal: 4.7Vdc to 5.5Vdc 12 to 24Vdc nominal: 10 V dc to 26.4Vdc	
Peak input voltage	35Vdc	
Input Impedance	>5kΩ	
Output Voltage Range	4.7 to 40 V dc, V _A /V _B input range	
Output Current Rating	1.5A maximum per channel, 10.5A maximum per module	
Thermal De-rating	Number of output points on at the same time depends on ambient temperature and current per point. For module IC695HSC308, thermal de-rating also depends on distribution of output points on the module. Refer to the charts that follow	
Output Control	Module outputs can be mapped to any number of counter setpoint outputs. Each counter controls up to 4 setpoints with “turn on” and “turn off” values. If multiple setpoint outputs are assigned to the same external module output, the signals are logically ORed. External outputs can optionally be configured for control through output scan bits from PLC memory.	
Surge Current per Point	4.5A < 450μS (Self-protected for overcurrent faults)	
Minimum Load Current	0mA (up to 150mA to satisfy open load detection)	
Maximum On State Voltage Drop/Output	0.35Vdc at 1.5A	
Maximum Off-State Leakage Current/Output	200μA	
Output Delay time	Off to On: 125μS at 1.5A On to Off: 85μS at 1.5A	
Current Limit	4.5A < 450μS, 1.5A continuous	
Reverse Polarity Protection	Outputs protected from reverse wiring	
Isolation:	Field to Backplane: 250 Vac continuous; 1500 Vac for 1 minute Field to Frame Ground, Inputs to Outputs, Output Group A to Output Group B: 50 Vac continuous; 500 Vac for 1 minute	

8.3.2.1 Thermal Derating: HSC304 & HSC308 Outputs

The charts below show thermal deratings for modules IC695HSC304 and IC695HSC308 with maximum loads of 0.75A on each output.

For example, if five outputs are used on module IC695HSC304, at 60°C the total current of all outputs would be 3.75 Amps. If smaller loads are used on the outputs, then more output channels can be used at a given temperature.

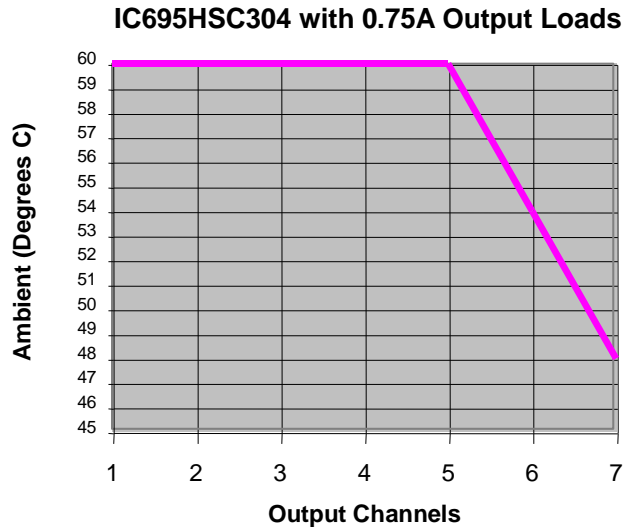


Figure 248: Thermal Derating HSC304 Outputs

For module IC695HSC308, more output channels can be used at the same time at a given ambient temperature when outputs are evenly distributed into two groups. If outputs are either set up as one output group or unevenly distributed between two output groups, fewer output channels can be used for a given ambient temperature.

For example, if eight outputs are used on module IC695HSC308, and they are equally distributed between two output groups, the total current of all outputs at 60°C can be up to 6 Amps. At a given ambient temperature, if smaller loads are used on the outputs, more output channels can be used.

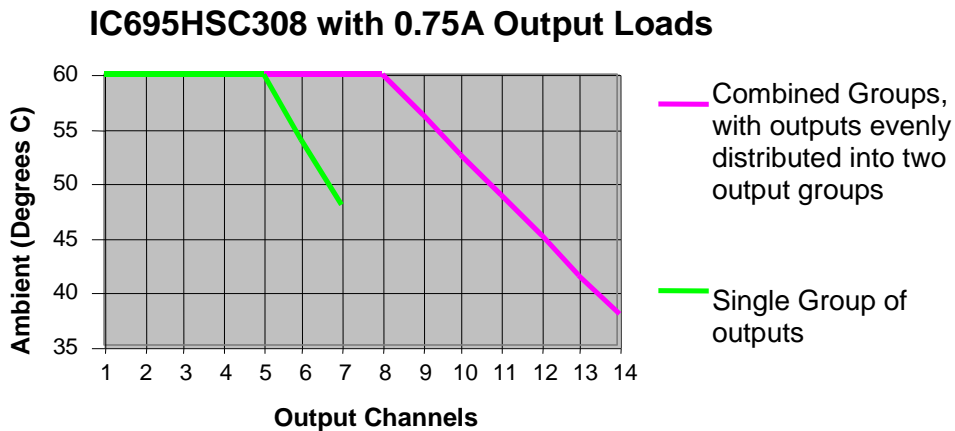


Figure 249: Thermal Derating HSC308 Outputs

8.3.3 Field Wiring: HSC304 & HSC308

Field wiring connections are made to the removable terminal assembly. For installations that must meet radiated emissions requirements as in EN 55022, high-speed connections must be made with double-shielded cable. The outside braided shield should be terminated at the entrance to the enclosure and not continue within the enclosure. Both ends of the shielded cable should be grounded. If low-frequency (power line) ground loops are an issue with the application, directly ground one end of the shielded cable and capacitively tie the other end of the shielded cable to ground with approximately 0.01µf capacitance.

8.3.3.1 Field Wiring: HSC304

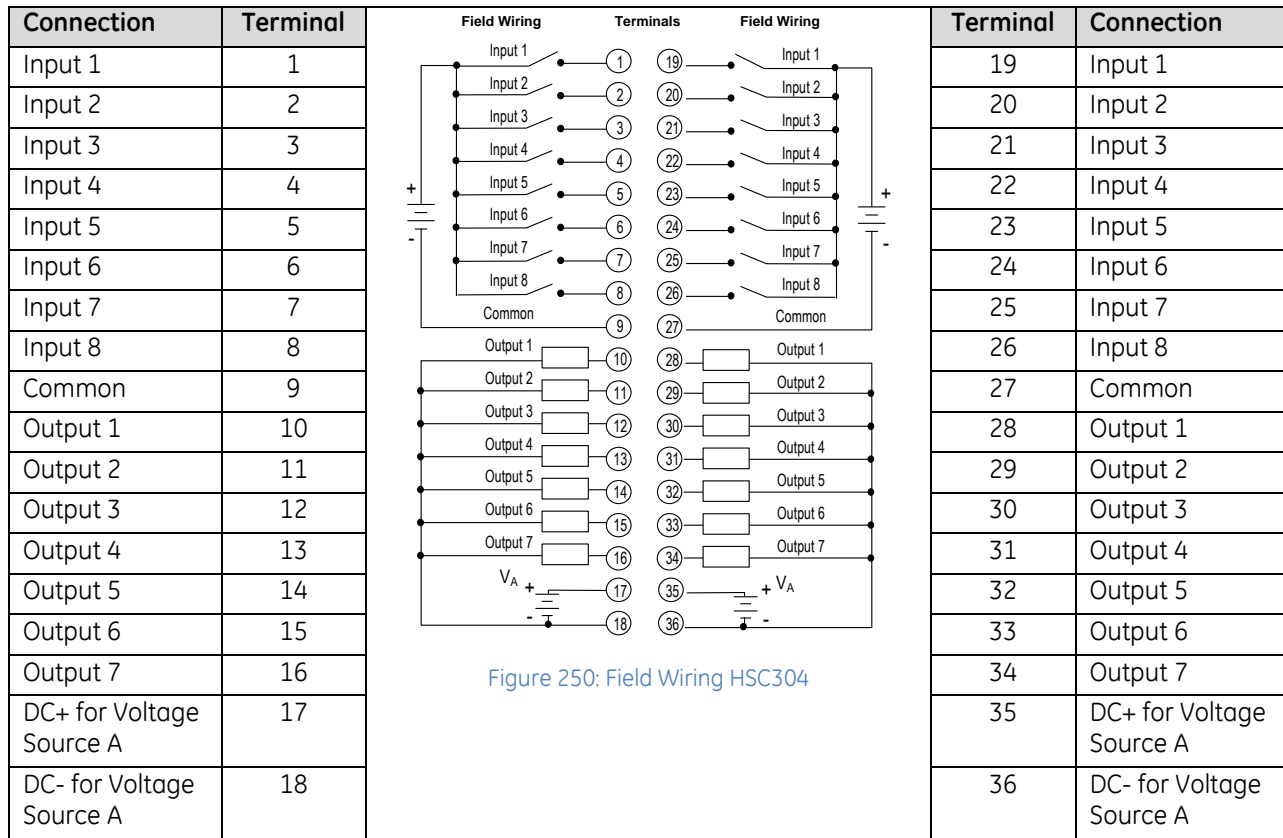


Figure 250: Field Wiring HSC304

All outputs on module IC695HSC304 form a single output group. Each row of terminals (i.e.: 1-18, 19-36) is internally connected. The dual connection points are for wiring convenience; the module cannot be wired for differential inputs. For load distributions, Refer to *Thermal Derating: HSC304 & HSC308 Outputs* above.

8.3.3.2 Field Wiring: HSC308

All sixteen High-Speed Counter inputs on this module are positive logic (source) type.

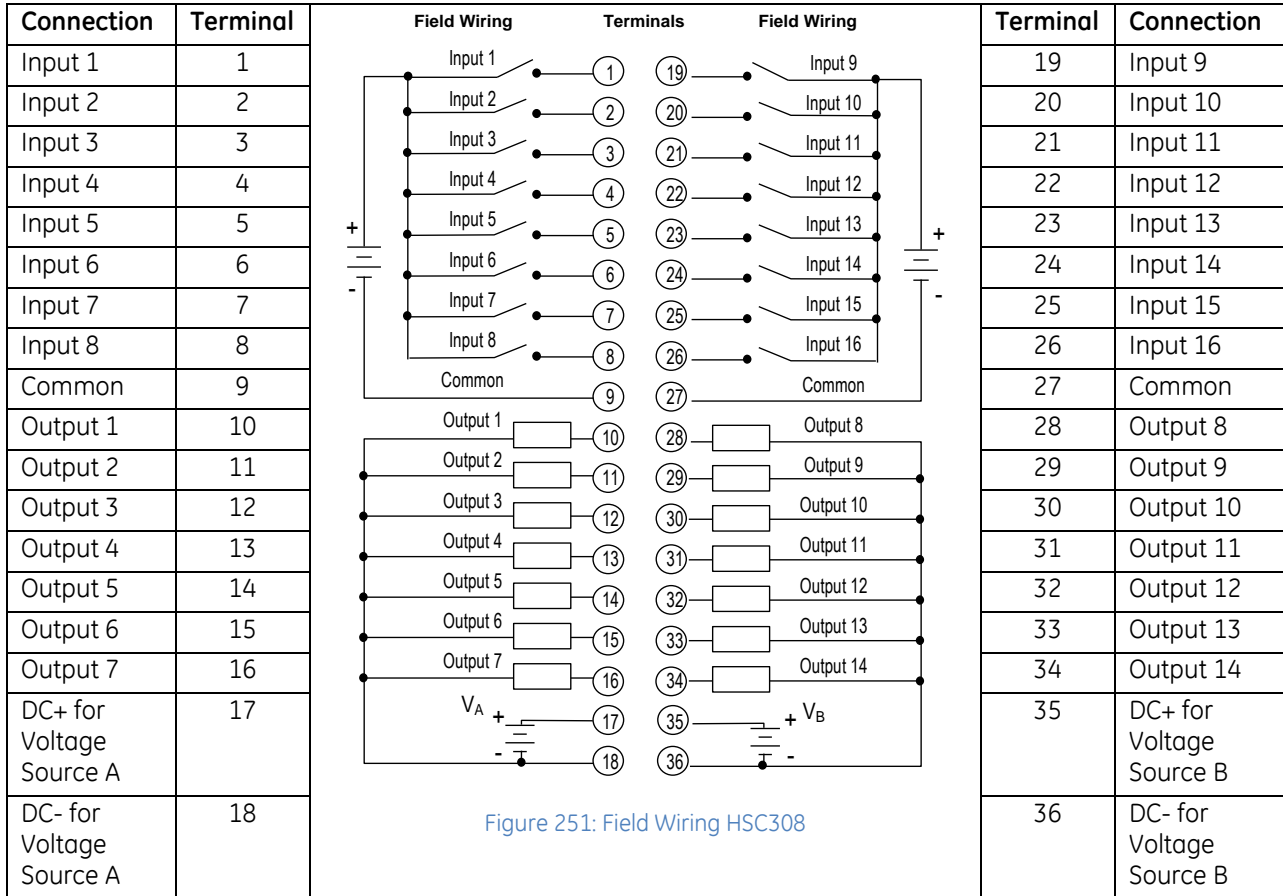


Figure 251: Field Wiring HSC308

Inputs 1 to 16 form one isolated input group. Outputs 1 to 7 and 8 to 14 form two isolated output groups, each with its own voltage connections.

Outputs should be evenly distributed between the two output groups, as discussed under *Thermal Derating: HSC304 & HSC308 Outputs* above.

8.4 Mixed I/O Module: IC694MDR390

The 24Vdc 8-Input/8-N.O. Relay Output module provides eight isolated input points with one common power input terminal, and eight isolated normally open relay circuits in the same module.

The input circuits can have either positive or negative characteristics in that they sink or source current to/from the input devices to/from the user common. Input characteristics are compatible with a wide range of user-supplied devices, such as pushbuttons, limit switches, and electronic proximity switches. Current through an input results in a logic 1 in the input status table (%I).

The relay output circuits are arranged in two groups of four circuits each. Each group has a common power output terminal. The normally-open relay circuits are used for controlling output loads provided by the user. The output switching capacity of each output is 2 Amps. The relay outputs can control a wide range of user-supplied load devices, such as motor starters, solenoids, and indicators.

The top half of the outside left edge of the insert is color-coded blue to indicate low-voltage circuits and the bottom half of the outside left edge is color-coded red to indicate high-voltage circuits.

This module can be installed in any I/O slot in an RX3i PLC System.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

Power for the internal relay circuits is provided by the +24Vdc bus on the backplane. The user must supply the AC or DC power to operate field devices. There are no fuses on this module.

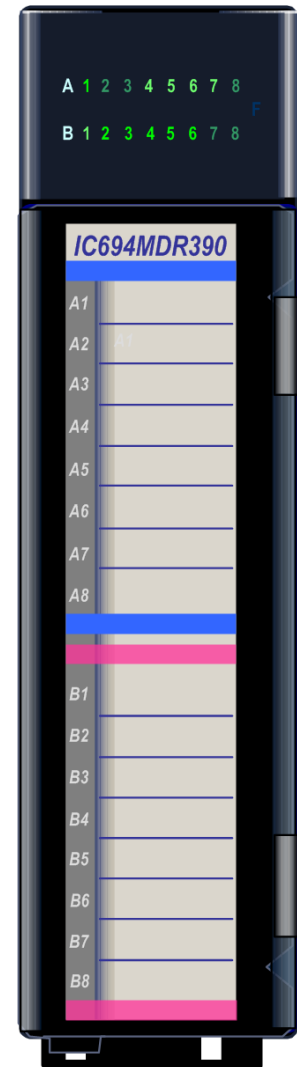


Figure 252: IC694MDR390

8.4.1 LEDs: MDR390

LED indicators that provide the ON/OFF status of each point are visible through the lens at the top of the module. The LEDs are arranged in two horizontal rows with eight green LEDs in each row. The top row (labeled A1 through A8) indicates the states of the input points (1 through 8). The bottom row (labeled B1 through B8) indicates the states of the relay output points (1 through 8).

8.4.2 Specifications: MDR390

Inputs	
Rated Voltage	24 Vdc
Input Voltage range	-30 to +32 Vdc
Inputs per Module	8 (one group of eight inputs)
Isolation	1500 Vrms between field and logic side 500 Vrms between inputs
Input Current	7.5 mA (typical) at rated voltage
Input Characteristics	
On-State Voltage	15 to 32 Vdc
Off-State Voltage	0 to +5 Vdc
On-State Current	4 mA (minimum)
Off-State Current	1.5 mA (maximum)
On Response Time	7 ms typical
Off Response Time	7 ms typical
Outputs	
Rated Voltage	24Vdc, 120/240 V ac
Operating Voltage	5 to 30 Vdc 5 to 250 Vac, 50/60 Hz
Outputs per Module	8 (two groups of four outputs each)
Isolation	1500 Vrms between field and logic side 500 Vrms between groups
Maximum Load	2 Amps maximum per output 4 Amps maximum per common
Minimum Load	10 mA
Maximum Inrush	5 Amps
On Response Time	15 ms maximum
Off Response Time	15 ms maximum
Internal Power Consumption	80 mA (all I/O on) from +5Vdc backplane bus 70 mA (all outputs on) from relay +24Vdc backplane bus

Maximum load current is dependent on operating voltage as displayed in the following table.

8.4.2.1 Load Current Limitations: MDR390

Operating Voltage	Maximum Current for Load Type		Typical Operations (number of operations)
	Resistive	Lamp or Solenoid ³⁹	
240 Vac, 120 Vac, 24 Vdc	2A	0.6A	200,000
240 Vac, 120 Vac, 24 Vdc	1A	0.3A	400,000
240 Vac, 120 Vac, 24 Vdc	0.5A	0.1A	800,000

Relay contact life, when switching inductive loads, will approach resistive load contact life if suppression circuits are used. The following figures are examples of typical suppression circuits for AC and DC loads. The 1A, 100V diode shown in the DC load typical suppression circuit is an industry standard 1N4934. The resistor and capacitor shown for AC load suppression are standard components, available from most electronics distributors.

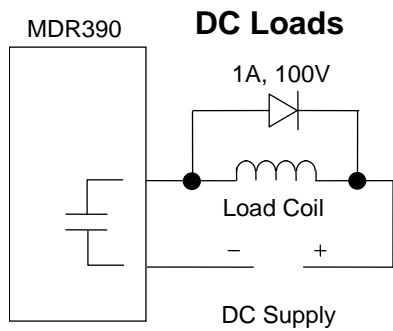


Figure 253: Suppression of DC Loads MDR390

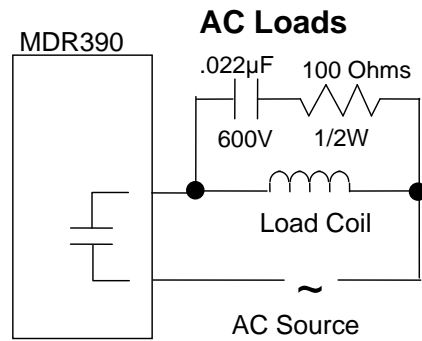


Figure 254: Suppression of AC Loads MDR390

³⁹ For inductive loads.

8.4.3 Field Wiring: MDR390

The following figure provides wiring information for connecting user supplied input and load devices, and power source(s) to the 24 Volt Input/Relay Output module:

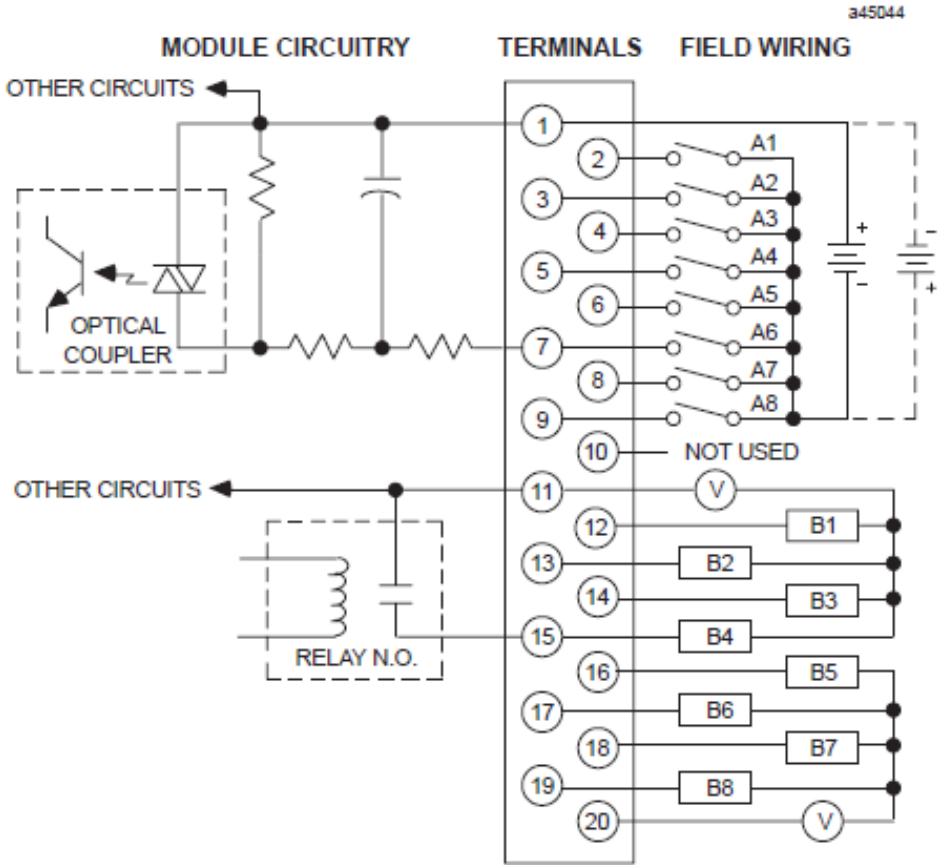


Figure 255: Field Wiring Diagram MDR390

Chapter 9 Analog Input Modules

This chapter describes Analog Input modules for PACSystems RX3i controllers.

Analog Input Module Description	Catalog Number	Section
Analog Input Module 6-Channel Isolated Current/Voltage	IC695ALG106	9.1
Analog Input Module 12-Channel Isolated Current/Voltage	IC695ALG112	9.1
Analog Input Module 4-Channel Voltage	IC694ALG220	9.2
Analog Input Module 4-Channel Current	IC694ALG221	9.3
Analog Input Module 16-/8-Channel Voltage	IC694ALG222	9.4
Analog Input Module 16-Channel Current	IC694ALG223	9.5
Advanced Diagnostics Analog Input Module: 16-Channel Voltage	IC694ALG232	9.6
Advanced Diagnostics Analog Input Module: 16-Channel Current	IC694ALG233	9.7
Analog Input Module 8-Channel Non-Isolated / 4-Channel Differential	IC695ALG608	9.8
Analog Input Module 16-Channel Non-Isolated / 8-Channel Differential	IC695ALG616	9.8

9.1 Analog Input Modules Isolated Current/Voltage: IC695ALG106 and IC695ALG112

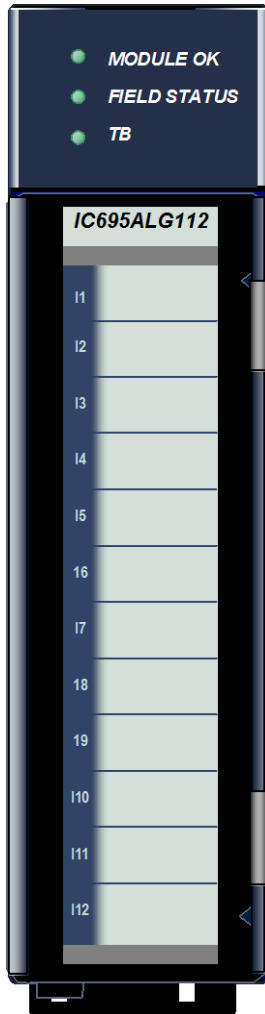


Figure 256: IC695ALG112

Isolated Analog Current/Voltage Input module IC695ALG106 provides 6 isolated input channels.

Isolated Analog Current/Voltage Input module IC695ALG112, shown at left, provides 12 input channels.

Analog input channels can be configured for these ranges:

- Current: 0 to 20mA, 4 to 20mA, ± 20 mA
- Voltage: ± 10 V dc, 0 to 10 V dc, ± 5 Vdc, 0 to 5Vdc, 1 Vdc to 5Vdc

These modules must be installed in an RX3i Universal Backplane. The modules require the use of one front-mounted terminal block (ordered separately).

Terminal blocks are available in the following different styles:

- Box-style (IC694TBB032),
- Extended Box-style (IC694TBB132),
- Spring-style (IC694TBS032), and
- Extended Spring-style (IC694TBS132).

Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Refer to *Terminal Block Detection* below for more information about terminal blocks.

Note: Terminal blocks for this module must be ordered separately.

9.1.1 Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If this module is located in an Expansion or Remote backplane, the backplane power supply provides the Isolated +24Vdc output for the module.

9.1.2 Features

- Completely software-configurable, no module jumpers to set
- On-board error-checking
- Open-circuit detection for all voltage and 4–20mA inputs
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program
- Flash memory for future upgrades
- Positive and negative Rate of Change Alarms
- Configurable interrupts for channel alarms and faults
- Terminal Block insertion or removal detection
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

9.1.3 Specifications: ALG106 & ALG112






Input Ranges	Current: 0 to 20mA, 4 to 20mA, ± 20 mA Voltage: ± 10 V dc, 0 to 10 V dc, ± 5 V, 0 to 5V, 1 to 5V		
Power Requirements (from the backplane)	ALG106:	230 mA maximum at 5.0V +5% / -2.5%, 320 mA maximum at 3.3V +5% / -3%	
	ALG112:	490 mA maximum at 5.0V +5% / - 2.5%, 310 mA maximum at 3.3V +5% / - 3%	
Power Dissipation within Module	IC695ALG106:	2.97 watts maximum with 20mA inputs on all 6 channels	
	IC695ALG112:	4.89 watts maximum with 20mA inputs on all 12 channels	
Thermal Derating	No derating		
Resolution	16 bit ADC converted to Floating Point or Integer		
Input Data Format	Configurable as floating point IEEE 32 bit or 16-bit integer in a 32-bit field		
Filter Options	8Hz, 12Hz, 16Hz, 40Hz, 250Hz, 1000Hz		
Input Impedance	>500 k Ω voltage inputs		
Current Input Resistance	250 Ω $\pm 1\%$		
Open Circuit Detection time	1 second maximum		
Over-voltage	± 35 Vdc continuous, maximum		
Overcurrent	± 35 mA continuous, maximum		
Normal Mode Noise Rejection in dB		At 50Hz	At 60Hz
	8 Hz filter	90	75
	12 Hz filter	75	80
	16 Hz filter	35	75
Common Mode Noise Rejection	100dB minimum at 50/60 Hz with 8 Hz filter 100dB minimum at 50/60 Hz with 12 Hz filter		
Channel-Channel DC Crosstalk	-70 dB minimum		
Isolation Voltage terminal block to backplane/chassis and channel to channel	I-coupler, transformer isolated 250 V ac continuous/1500 V ac for 1 minute		
Analog Step Change Response	The analog input will settle to 0.1% of its final value within 1.7ms for a step change on the input pins of the module. (Any digital filtering is additional to this time.)		
Digital Filtering Settling Time (ms)	The settling time depends on the configured filter time. 8 Hz Filter: 127 ms 12 Hz Filter: 67 ms 16 Hz Filter: 56 ms 40 Hz Filter: 21 ms 250 Hz Filter: 3.1 ms 1000 Hz Filter: 0 ms (No digital filtering, only the analog front-end filter)		
Analog Module Scan Time (ms)	The module provides a new sample every 1ms, regardless of the digital filtering selected. Refer to the <i>Digital Filtering Settling Time</i> for the amount of time required to have settled data.		
Calibrated Accuracy ⁴⁰	0.1% of range at 25°C 0.2% of range over entire temperature span		

⁴⁰ In the presence of severe RF interference (IC 801-3, 10V/m), accuracy may be degraded by 2.0% of range,




Calibration Interval	12 months typical to meet accuracy specifications over time. Offset can be applied as a periodic calibration adjustment.
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9.1.3.1 Indicator Light Emitting Diodes (LEDs): ALG106 & ALG112




MODULE OK – indicates the module’s ability to perform normal operations.

	Green, ON	Module OK and configured
 or 	Green or Amber, slow flashing	Module OK but not configured.
	Green, quick flashing	Error
	OFF	Not OK: no backplane power present or module is defective

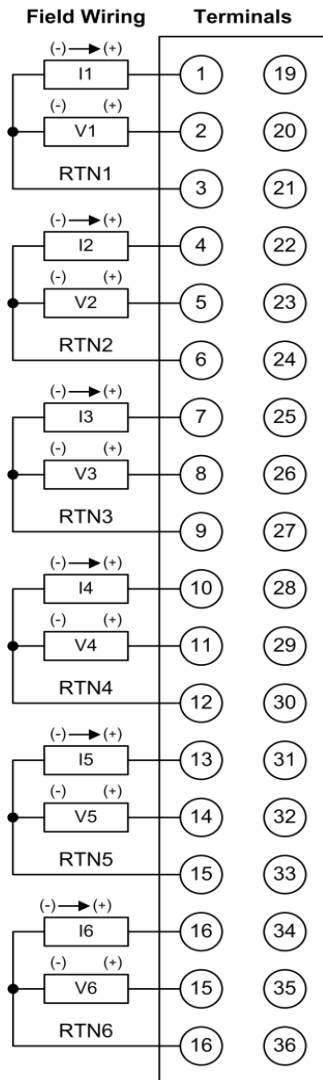
FIELD STATUS – indicates the status of the module’s field connections.

	Green, ON	No faults on any enabled channel, and Terminal Block is present
	Amber, ON	Fault on at least one channel
	OFF	Terminal block not present or not fully seated

TB – indicates the status of the module’s connection to its terminal block.

	Green, ON	Terminal block present
	Red, ON	Terminal block not present or not fully seated
	OFF	No backplane power to module

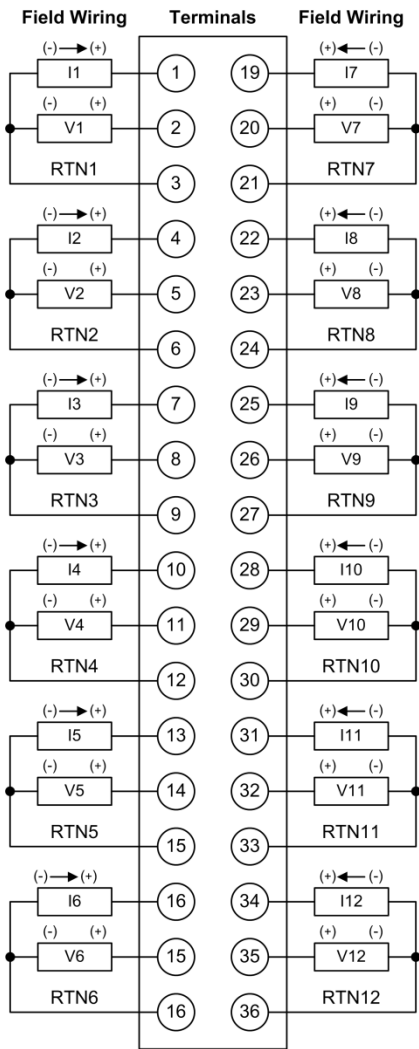
9.1.4 Field Wiring: ALG106



Terminal	Connection	Connection	Terminal
1	CH 1 Current In	No Connection	19
2	CH 1 Voltage In	No Connection	20
3	CH 1 RTN	No Connection	21
4	CH 2 Current In	No Connection	22
5	CH 2 Voltage In	No Connection	23
6	CH 2 RTN	No Connection	24
7	CH 3 Current In	No Connection	25
8	CH 3 Voltage In	No Connection	26
9	CH 3 RTN	No Connection	27
10	CH 4 Current In	No Connection	28
11	CH 4 Voltage In	No Connection	29
12	CH 4 RTN	No Connection	30
13	CH 5 Current In	No Connection	31
14	CH 5 Voltage In	No Connection	32
15	CH 5 RTN	No Connection	33
16	CH 6 Current In	No Connection	34
17	CH 6 Voltage In	No Connection	35
18	CH 6 RTN	No Connection	36

Figure 257: Field Wiring ALG106

9.1.5 Field Wiring: ALG112



Terminal	Connection	Connection	Terminal
1	CH 1 Current In	CH 7 Current In	19
2	CH 1 Voltage In	CH 7 Voltage In	20
3	CH 1 RTN	CH 7 RTN	21
4	CH 2 Current In	CH 8 Current In	22
5	CH 2 Voltage In	CH 8 Voltage In	23
6	CH 2 RTN	CH 8 RTN	24
7	CH 3 Current In	CH 9 Current In	25
8	CH 3 Voltage In	CH 9 Voltage In	26
9	CH 3 RTN	CH 9 RTN	27
10	CH 4 Current In	CH 10 Current In	28
11	CH 4 Voltage In	CH 10 Voltage In	29
12	CH 4 RTN	CH 10 RTN	30
13	CH 5 Current In	CH 11 Current In	31
14	CH 5 Voltage In	CH 11 Voltage In	32
15	CH 5 RTN	CH 11 RTN	33
16	CH 6 Current In	CH 12 Current In	34
17	CH 6 Voltage In	CH 12 Voltage In	35
18	CH 6 RTN	CH 12 RTN	36

Figure 258: Field Wiring: ALG112

There are no shield terminals on these modules. For shielding, tie cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided in the ground bar for this purpose.

Operating Note

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the same controller logic scan. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

9.1.6 Configuration: ALG106 & ALG112

9.1.6.1 Module Parameters: ALG106 & ALG112

Parameter	Default	Description
Channel Value Reference Address	%Alxxxxx	Starting address for the input data of the module. This defaults to the next available %AI block.
Channel Value Reference Length	ALG106: 12	The number of words used for the input data of the module.
	ALG112: 24	
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	ALG106: 0 or 192	The number of bit reference bits (0 or 192) for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to 192 / 384 to enable Channel Diagnostics mapping.
	ALG112: 0 or 384	
Module Status Reference Address	%Ixxxxx	Starting address for the status data of the module. This defaults to the next available %I block.
Module Status Reference Length	0	The number of bits (0 or 32) for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to 32 to enable Module Status data mapping.
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Inputs Default	Force Off	In the event of module failure or removal, this parameter specifies the state of the Channel Value References. Force Off = Channel Values clear to 0. Hold Last State = Channel Values hold their last state.
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
AD Filter Frequency	40Hz	Can be set to 8, 12, 16, 40, 250, or 1000Hz.

9.1.6.2 Channel Parameters: ALG106 & ALG112

Parameter	Default	Description
Range Type	Disabled	Current/Voltage, Disabled
Range	±10 V dc	±10 V dc, 0 to +10 V dc, 0 to +5Vdc, ±5Vdc, 1Vdc to +5Vdc, ±20mA, 4 to 20 mA, 0 to 20 mA
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type have a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default is High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

9.1.6.3 Input Scaling: ALG106 & ALG112

By default, the module converts a voltage or current input over the entire span of its configured Range into a floating point value for the CPU. For example, if the Range of a channel is 4 to 20mA, the module reports channel input values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the PLC that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example 1

For a voltage input, 6.0 volts equals a speed of 20 feet per second, and 1.0 volt equals 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000

Low Scale Value (Eng Units) = 0.000

High Scale Value (A/D Units) = 6.000

Low Scale Value (A/D Units) = 1.000

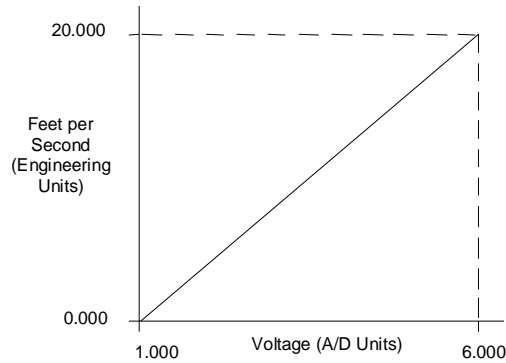


Figure 259: Scaling Example ALG106 or ALG112

For this example, 1.0 V dc to 6.0 V dc is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 10.0 V dc were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or take other precautions for scaled inputs that are outside the acceptable range or invalid.

Example 2

An existing application uses traditional analog to digital (A/D) count integer values. With scaling and the 16-bit integer input option, a channel can be configured to report integer count values. In this example, the application should interpret +10 V dc as 32000 counts and -10 V dc as -32000 counts. The following channel configuration will scale a ± 10 V dc input channel to ± 32000 counts.

Channel Value Format = 16 Bit Integer

High Scale Value (Eng Units) = 32000.0

Low Scale Value (Eng Units) = -32000.0

High Scale Value (A/D Units) = 10.000

Low Scale Value (A/D Units) = -10.000

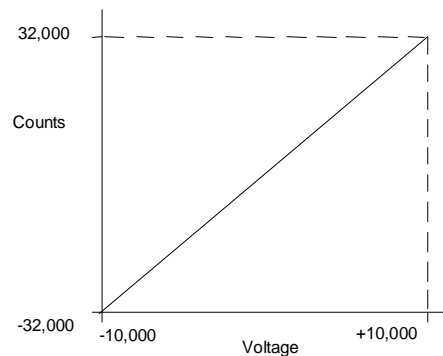


Figure 260: Scaling Example ALG106 or ALG112

Channel Parameters (Continued)

Parameter	Default	Description
Positive Rate of Change Limit (Eng Units)	0.000	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units)	0.000	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate	0.000	Time from 0 to 300 seconds to wait between comparisons. Default of 0.0 is to check after every input sample.

9.1.6.4 Rate of Change Alarms: ALG106 & ALG112

When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous rate of change sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Unit change between samples is positive, the module compares the results in comparing the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the "Diagnostic Reporting Enable", "Fault Reporting Enable", and "Interrupts Enabled" parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. If the Rate of Change Sampling Rate is 0 or any time period less than the channel update rate, the module compares the Rate of Change for every input sample of the channel.

Channel Parameters (Continued)

Parameter	Default	Description
High-High Alarm (Eng Units)	The defaults for the High-High, High, Low, and Low-Low parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of default values.	Alarms and Deadbands All of the alarm parameters are specified in Engineering Units. To use alarming, the A/D Alarm Mode must also be configured as enabled.
High Alarm (Eng Units)		High-High Alarm and Low-Low Alarm: When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.
Low Alarm (Eng Units)		High Alarm and Low Alarm: When the configured value is reached or below (above), a Low (High) Alarm is triggered.
Low-Low Alarm (Eng Units)		High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.
High-High Alarm Deadband (Eng Units)		Alarm Deadbands should not cause the alarm clear to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		

Using Alarming: ALG106 & ALG112

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address corresponding to that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Channel Parameters (Continued)

Parameter	Default	Description
User Offset	0.000	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filter Integration Time (ms)	0.000	If Software Filtering is enabled, the Integration Time parameter specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms. Default is disabled
Diagnostic Reporting Enable <i>If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.</i>	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area. Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table.
Fault Reporting Enable <i>If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.</i>	Disabled	Interrupts Enable options enable I/O Interrupt trigger when alarm conditions occur. These parameters enable or disable the individual diagnostics features of a channel.
Interrupts Enable <i>If Interrupts are enabled, the additional parameters listed below can be used to enable specific types of Interrupts.</i>	Disabled	When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature. For example, if Over Range is enabled in the <i>Diagnostic Reporting Enable</i> menu, the module will set the Over Range bit in the Diagnostic Reference for the channel.
Low Alarm Enable	Disabled	If any of these parameters is disabled, the module does not react to the associated alarm conditions.
High Alarm Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable	Disabled	
Low-Low Alarm Enable	Disabled	
High-High Alarm Enable	Disabled	
Negative Rate of Change Detection Enable	Disabled	For example, if Low Alarm Enable is set to Disabled in the <i>Fault Reporting Enable</i> menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.
Positive Rate of Change Detection Enable	Disabled	

Using Interrupts: ALG106 & ALG112

To configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of the module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address corresponding to that channel.

Example:

In this example, the Channel Values Reference Address block is mapped to %AI0001-%AI0020. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AI00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AI0003" as the Trigger.

Note on Using Interrupts

This module has separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

9.1.7 Module Data: ALG106 & ALG112

The module reports its input channel data in its configured input words, beginning at its assigned Channel Value Reference Address. Each channel occupies two words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6

For Module IC695ALG112 Only:

+12, 13	Channel 7
+14, 15	Channel 8
+16, 17	Channel 9
+18, 19	Channel 10
+20, 21	Channel 11
+22, 23	Channel 12

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

9.1.7.1 Channel Diagnostic Data: ALG106 & ALG112

In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured of the module. Use of this feature is optional.

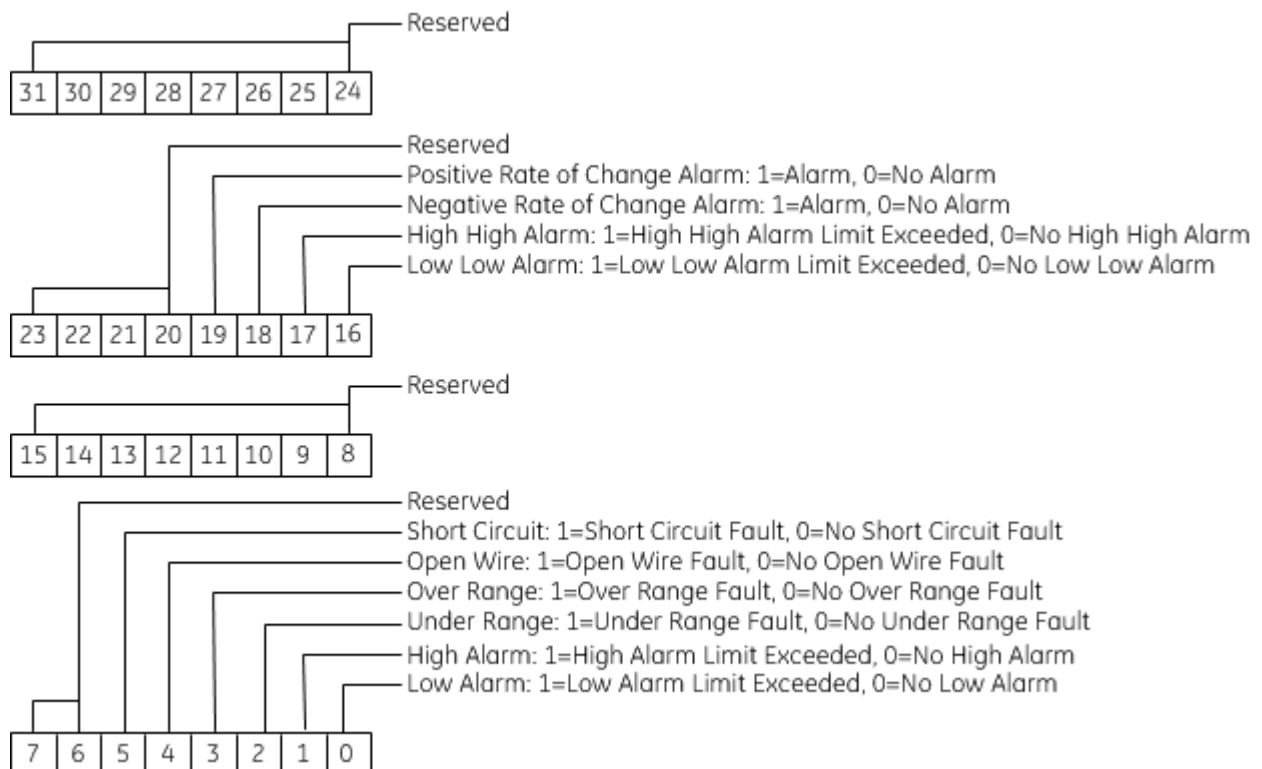
The diagnostics data for each channel occupies 2 words (whether the channel is used or not):

Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6

For Module IC695ALG112 Only:

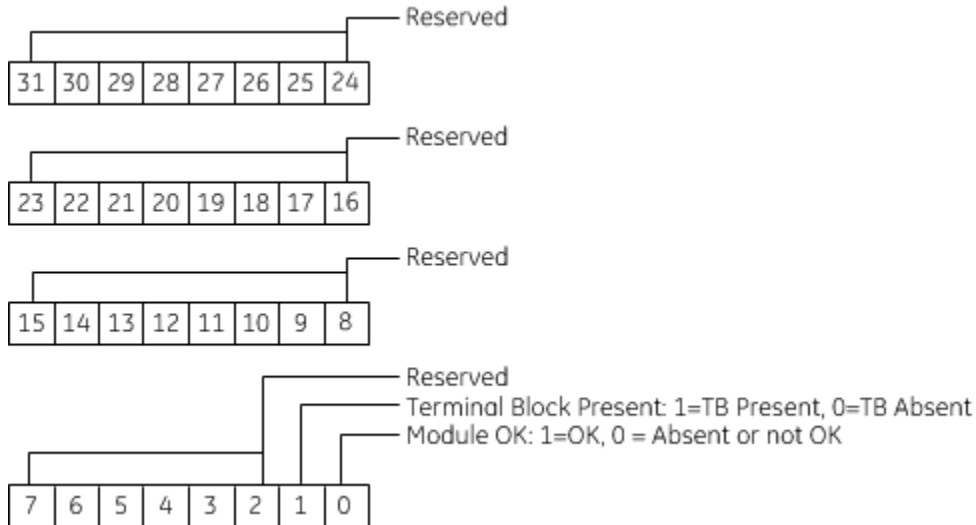
+12, 13	Channel 7
+14, 15	Channel 8
+16, 17	Channel 9
+18, 19	Channel 10
+20, 21	Channel 11
+22, 23	Channel 12

When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel. For each channel, the format of this data is:



9.1.7.2 Module Status Data: ALG106 & ALG112

The module can also optionally be configured to return 32 bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data* reference area configured for the module.



Terminal Block Detection

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of the module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 1 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

9.2 Analog Input Module 4-Channel Differential Voltage: IC694ALG220

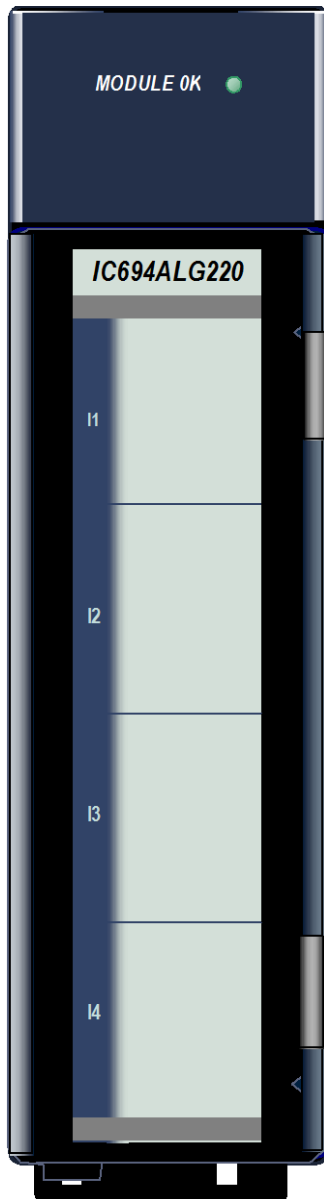


Figure 261: IC694ALG220

The **4-Channel Analog Voltage Input** module, IC694ALG220, provides four analog input channels. This module accepts inputs in the range of -10 to +10 volts. Individual channels can be used with 4 to 20 mA inputs by jumpering the input terminals.

Conversion speed for each of the four channels is one millisecond. This provides an update rate of four milliseconds for any channel.

This module can be installed in any I/O slot of an RX3i PLC system.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

9.2.1 Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If this module is located in an Expansion or Remote backplane, the backplane power supply provides the Isolated +24Vdc output for the module.

9.2.2 LEDs: ALG220

The **Module OK** LED is ON when the module power supply is operating.

9.2.3 Specifications: ALG220

Voltage Range ⁴¹	-10 to +10 Vdc
Calibration	Factory calibrated
Update Rate	4 ms (all four channels)
Resolution	5 mV/20 μ A, (1 LSB = 5 mV)
Absolute Accuracy ⁴²	\pm 10 mV/40 μ A (typical) over operating temperature \pm 30 mV/160 μ A (maximum) over operating temperature
Linearity	<1 Least Significant Bit
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Cross-Channel Rejection	> 80dB
Input Impedance	> 9 M Ω (voltage mode) 250 Ω (current mode)
Input Filter Response	17 Hz
Internal Power Consumption	27 mA from +5Vdc bus on the backplane 98 mA from the isolated +24Vdc backplane bus

For product standards and general specifications, refer to *Appendix A*.

⁴¹ Both inputs must be within \pm 11 volts of COM, including any noise present on the inputs.

⁴² In the presence of severe RF interference (IEC 801-3, 10V/m), accuracy may be degraded to \pm 100 mV/400 μ A.

9.2.4 Data Format: ALG220

Module data is stored in the PLC CPU in 16-bit 2's complement format as displayed in the following figure.

MSB											LSB				
+/-	10	9	8	7	6	5	4	3	2	1	0	X	X	X	X

9.2.4.1 Scaling and Resolution: ALG220

The module scales input data so that -10 Vdc corresponds to -32000 and +10 Vdc corresponds to +32000. Resolution per bit is 5 mV or 20 mA per bit.

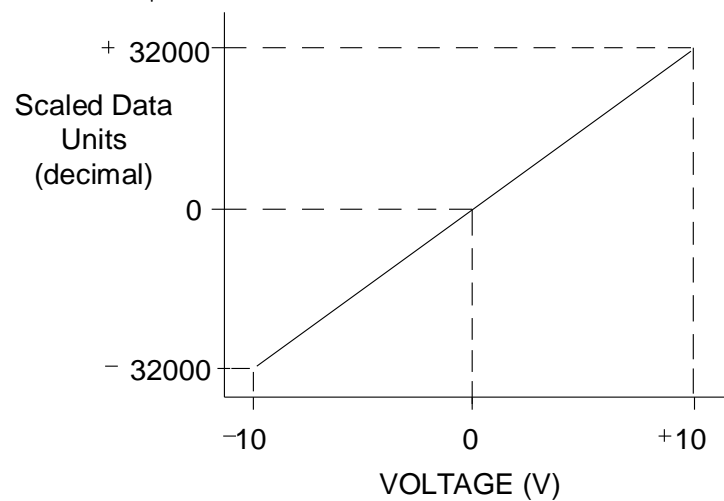


Figure 262: Input Voltage Scaling: ALG220

A 4 to 20 mA input corresponds to a 1 to 5 Volt input to the module; therefore, the resolution of the 4 to 20 mA input signal is approximately 10 bits binary (1 part in 1024). The resolution can be increased to approximately 11 bits (1 part in 2048) by using a precision 250 Ω resistor instead of the jumper. The resistor causes the voltage input module to see a 4 to 20 mA input as 2 to 10 volts.

9.2.5 Field Wiring: ALG220

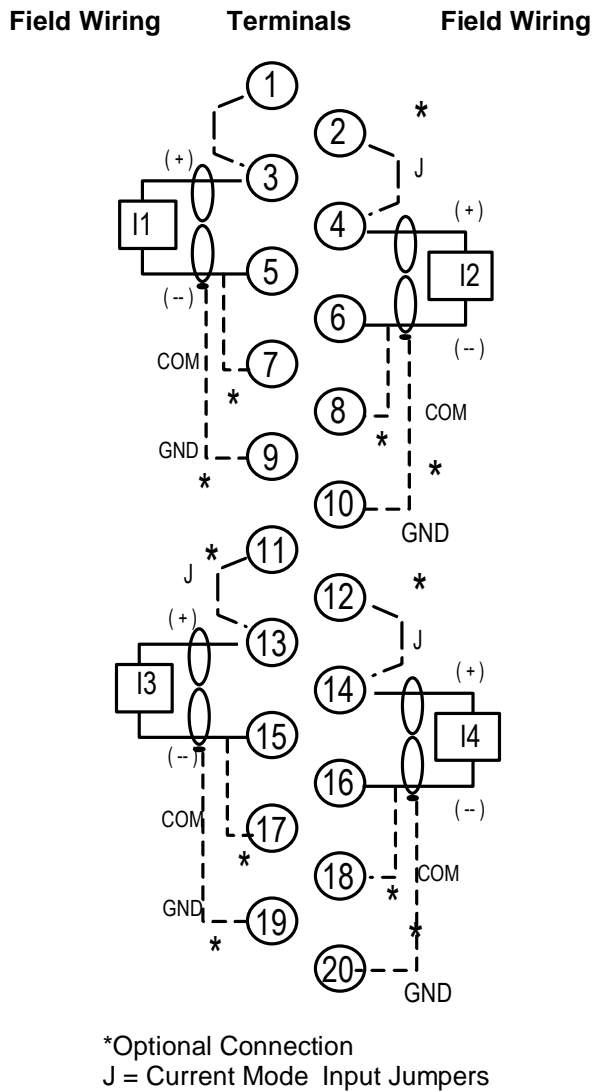


Figure 263: Field Wiring ALG220

Terminal	Connection
1-3	Current mode input jumper for Channel 1
2-4	Current mode input jumper for Channel 2
3	Channel 1 +
4	Channel 2+
5	Channel 1-
6	Channel 2 -
7	Common
8	Common
9	Shield Termination Point for Channel 1
10	Shield Termination Point for Channel 2
11 - 13	Current mode input jumper for Channel 3
12 - 14	Current mode input jumper for Channel 4
13	Channel 3 +
14	Channel 4+
15	Channel 3-
16	Channel 4 -
17	Common
18	Common
19	Shield Termination Point for Channel 3
20	Shield Termination Point for Channel 4

To minimize the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to either COM or GND. The COM connection provides access to the common of the analog circuitry in the module. The GND connection provides access to the backplane (frame ground). The (-) side of the voltage source can also be tied to the COM terminal if the source is floating to limit common-mode voltages.

The optional jumpers shown can be used to configure a channel for use with 4 to 20 mA inputs. The resolution of 4 to 20 mA inputs can be increased from 10 bits to approximately 11 bits by installing a 250Ω resistor instead of the jumper

Connect the + and - terminals together for all unused inputs to minimize any fluctuations in the analog input table for the unused points.

9.3 Analog Input Module 4-Channel Differential Current: IC694ALG221

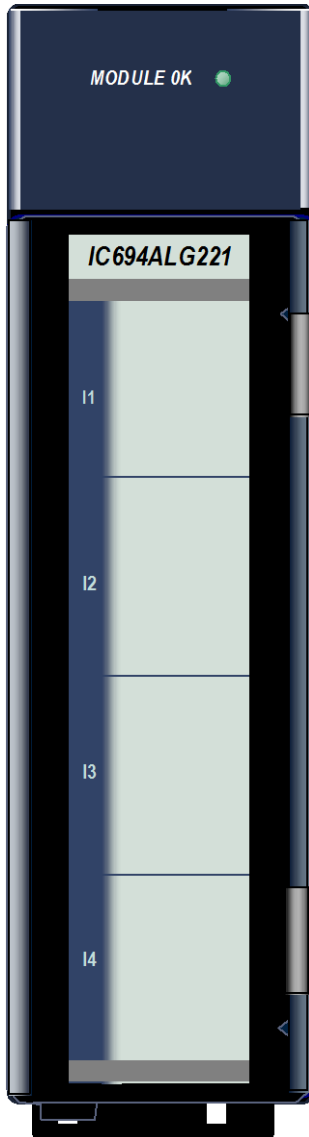


Figure 264: IC694ALG221

The **4-Channel Analog Current Input** module, IC694ALG221, provides four analog input channels. This module has two possible input ranges:

- 4 to 20 mA
- 0 to 20 mA

Two range jumpers are provided with the module; one for channels one and two, and the other for channels three and four.

Conversion speed for each of the four channels is one-half millisecond. This provides an update rate of two milliseconds for any channel. Resolution of the converted signal is 12 bits binary (1 part in 4096) over either range.

Input protection for the module is sufficient for operation with reduced performance with up to 200 V common-mode. The module provides electrical isolation of externally generated noise between field wiring and the backplane through the use of optical isolation.

This module can be installed in any I/O slot of an RX3i system.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

9.3.1 Isolated +24Vdc Power

If this module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If the module is located in an Expansion or Remote backplane, the backplane power supply provides the Isolated +24Vdc output for the module.

9.3.2 LEDs: ALG221

The **Module OK** LED is ON when the module power supply is operating.

9.3.3 Specifications: ALG221

Input Current Ranges	4 to 20 mA and 0 to 20 mA
Calibration	Factory calibrated to 4 μ A per count
Update Rate	2 milliseconds (all four channels)
Resolution at 4–20 mA	4 μ A (1 LSB = 4 μ A)
Resolution at 0–20 mA	5 μ A (1 LSB = 5 μ A)
Absolute Accuracy ⁴³	0.1% full scale + 0.1% reading
Common Mode Voltage	200 volts
Linearity	< 1 Least Significant Bit
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Common Mode Rejection	> 70dB at DC; >70dB at 60Hz
Cross-Channel Rejection	> 80dB from DC to 1kHz
Input Impedance	250 Ω
Input Filter Response	325 Hz
Internal Power Consumption	100 mA from the isolated +24Vdc supply 25 mA from +5Vdc bus on the backplane

For product standards and general specifications, refer to *Appendix A*.

⁴³ In the presence of severe RF interference (IEC 801–3, 10V/m), accuracy may be degraded to $\pm 0.5\%$ FS.

9.3.4 Data Format: ALG221

Module data is stored in the PLC CPU in 16-bit 2's complement format as displayed in the following figure.

MSB											LSB				
X	11	10	9	8	7	6	5	4	3	2	1	0	X	X	X

9.3.4.1 Current Inputs, A/D Data and Scaled Units: ALG221

The default range for each input is 4 to 20 mA, scaled so that 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000 with each 1000 counts representing 0.5 mA.

When a jumper is added to the I/O terminal board, the input range for a PAIR of inputs is changed to 0 to 20mA. In 0 to 20 mA range, 0 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000 with each 800 counts representing 0.5 mA.

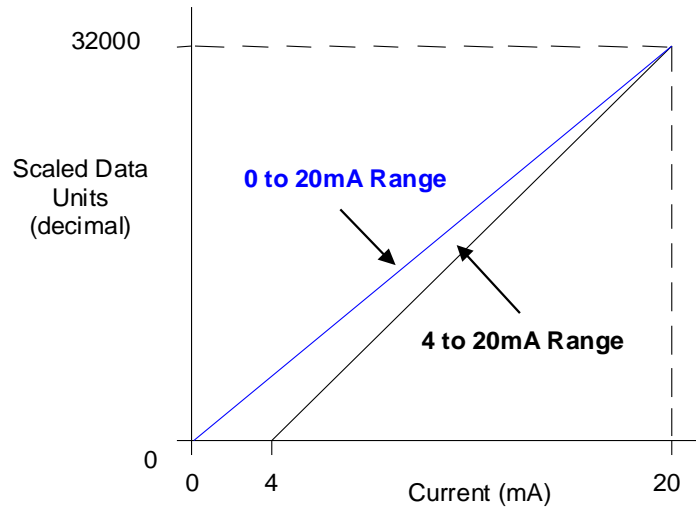
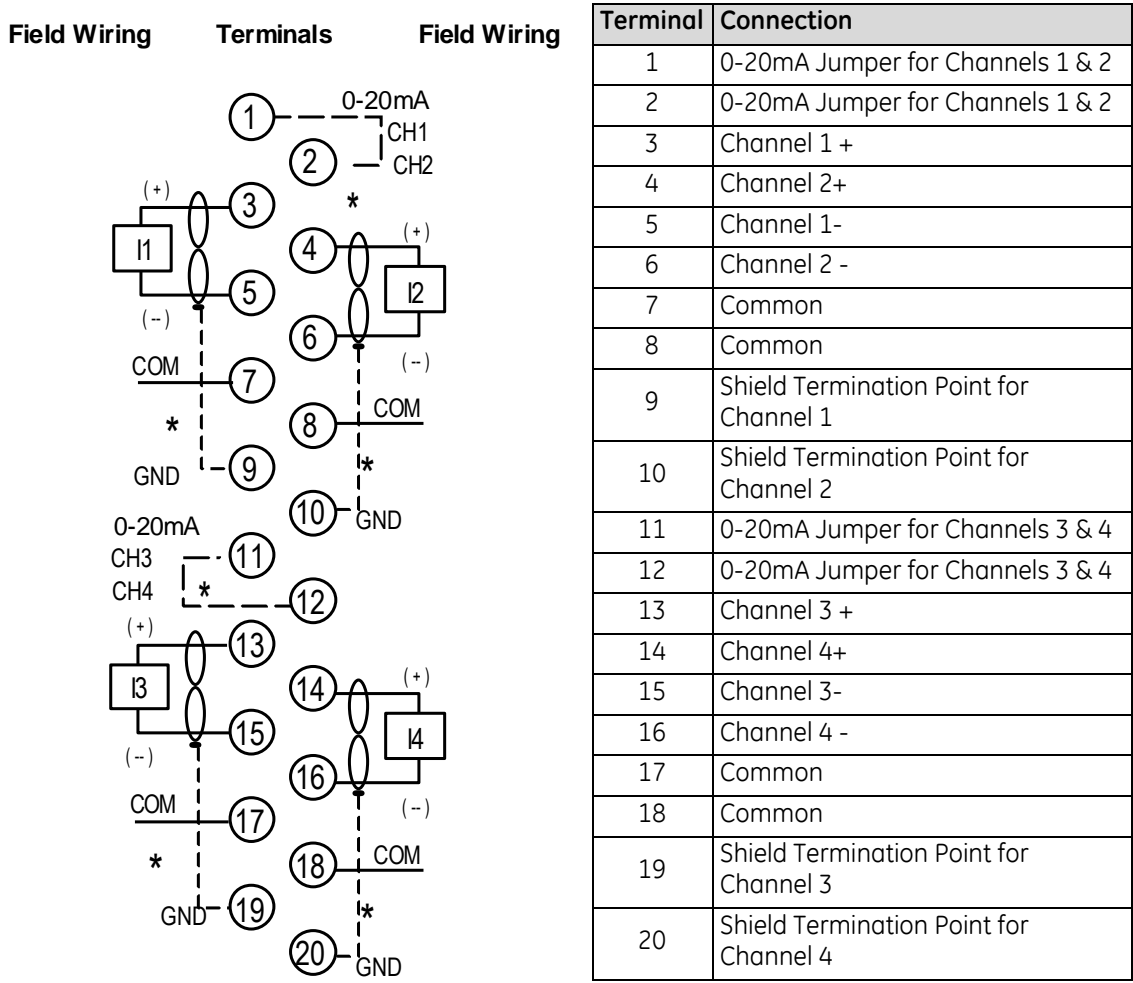


Figure 265: Input Current Scaling ALG221

If the current source is reversed into the input or is less than the low end of the current range, the module provides an input data word corresponding to the low end of the current range (0000H in PLC memory). If an input is greater than 20 mA, the module provides an input data value at full scale (7FF8H in PLC memory).

9.3.5 Field Wiring: ALG221



*Optional Connections

Figure 266: Field Wiring ALG221

To minimize the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields can be connected to either COM or GND. The COM connection provides access to the common of the analog circuitry in the module. The GND connection provides access to the Backplane (frame ground).

To limit common-mode voltages, each current source common line may also be tied to its associated COM terminal if the source is floating. These optional connections are shown above.

9.4 Analog Input Module 16-/8-Channel Voltage: IC694ALG222

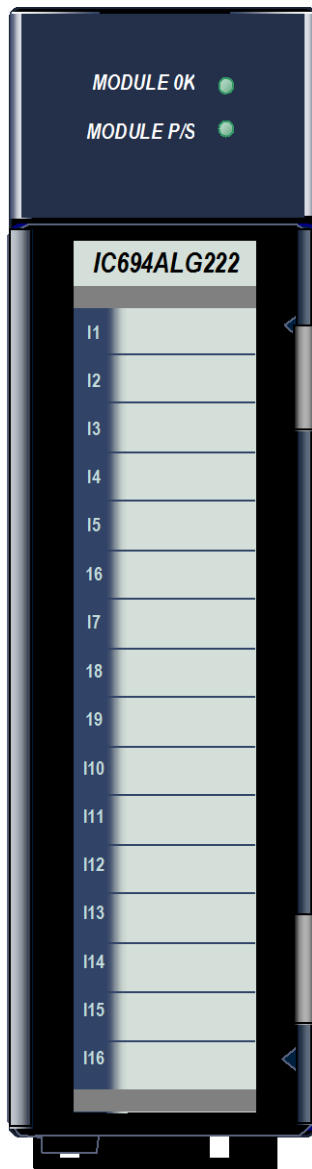


Figure 267: IC694ALG222

The **16-Channel Analog Voltage Input** module, IC694ALG222, provides sixteen single-ended or eight differential input channels.

Each channel can be configured using the configuration software for either of two input ranges:

- 0 to 10 V (unipolar), default
- -10 to +10 V (bipolar)

High and Low alarm limits can be configured for both ranges.

This module can be installed in any I/O slot of an RX3i system.

Revision -BA and later supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1 .

9.4.1 Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If this module is located in an Expansion or Remote backplane, the backplane power supply provides the Isolated +24Vdc for the module.

9.4.2 LEDs: ALG222

The **MODULE OK** LED provides module status information on power-up:

- *ON*: status is OK, module configured
- *OFF*: no backplane power or software not running (watchdog timer timed out)
- *Continuous rapid flashing*: configuration data not received from CPU
- *Slow flashes, then OFF*: failed power-up diagnostics or encountered code execution error

The **Module P/S** LED indicates that the internally-generated +5Vdc supply is above a minimum designated level for the module.

9.4.3 Specifications: ALG222

Number of Channels	1 to 16 selectable, single-ended 1 to 8 selectable, differential
Input Voltage Ranges	0 Vdc to +10 Vdc (unipolar) or -10 Vdc to +10 Vdc (bipolar); selectable each channel
Calibration	Factory calibrated to: 2.5 mV per count on 0 V to +10 V (unipolar) range 5 mV per count on -10 to +10 V (bipolar) range
Update Rate	Single Ended Input Update Rate: 5 ms Differential Input Update Rate: 2 ms
Resolution at 0V to +10 V dc	2.5 mV (1 LSB = 2.5 mV)
Resolution at -10 V dc to +10 V dc	5 mV (1 LSB = 5 mV)
Absolute Accuracy ^{44,45}	±0.25% of full scale at 25°C (77°F) ±0.5% of full scale over specified operating temperature range
Linearity	< 1 LSB
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Common Mode Voltage (Differential) ⁴⁶	±11 V (bipolar range)
Cross-Channel Rejection	> 70dB from DC to 1 kHz
Input Impedance	>500kΩ (single-ended mode) >1 MΩ (differential mode)
Input Filter Response	23 Hz (single-ended mode) 57 Hz (differential mode)
Internal Power Consumption	112 mA (maximum) from the backplane +5Vdc bus IC694ALG222-BA and later: 110 mA (maximum) from the isolated +24Vdc supply IC694ALG222-AA: 41 mA (maximum) from the isolated +24Vdc supply

For product standards and general specifications, refer to *Appendix A*.

⁴⁴ In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to ±5% of full scale.

⁴⁵ In the presence of severe Conducted RF interference (IEC 61000-4-6, 10Vrms), accuracy may be degraded to ±1% of full scale.

⁴⁶ The sum of the differential input, common-mode voltage, and noise must not exceed ±11 volts when referenced to COM.

9.4.4 Configuration: ALG222

Configurable parameters for module IC694ALG222 are described below.

9.4.4.1 Module Settings: ALG222

Parameter	Choices	Description
Active Channels	1 to 16 for Single-ended mode, or 1 to 8 for Differential mode	The number of channels to be scanned. Channels are scanned in sequential, contiguous order.
Mode	Single-ended (default), or Differential	In Single-ended mode, there are 16 inputs referenced to a single common. In Differential mode, each of the 8 inputs has its own signal and common.
Channel Value Reference Address	Valid memory type: %AI	The starting address for input data from the module.
Channel Value Reference Length	Read-only.	Each channel provides 16 bits (1 word) of analog input data to the Controller CPU.
Module Status Reference Address	Valid memory type: %I	The starting address for status information from the module.
Module Status Reference Length	0, 8, 16, 24, 32, 40	The number of status bits (0 to 40) reported to the Controller. When set to 0, status reporting is disabled. To enable status reporting, set this parameter to a value other than 0. Data formats are shown in Section Error! Reference source not found.
I/O Scan Set	1 through 32	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data

9.4.4.2 Input Channel Parameters: ALG222

Parameter	Choices	Description
Voltage	0 to 10 Vdc (default) or -10 V dc to 10 V dc	In the 0 to 10 Vdc default range, input voltage values from 0 to 10 Vdc the module reports 0 to 32,000 integer values to the CPU. In the -10 to 10 Vdc range, input voltage values from -10 to 10 Vdc, the module reports -32,000 to 32,000 integer values to the CPU.
Alarm Low (Engineering Units)	0 to 10 Vdc Range = 0 to 32760 -10 V dc to 10 V dc Range = -32767 to 32752	Each channel can be assigned a low alarm limit alarm. Values entered without a sign are assumed to be positive. Be sure the alarm low values are appropriate for the selected range.
Alarm High (Engineering Units)	0 to 10 Vdc Range = 0 to 32760 -10 V dc to 10 V dc Range = -32767 to 32752	Each channel can be assigned a high alarm limit. Values entered without a sign are assumed to be positive. Be sure the alarm high values are appropriate for the selected range.

9.4.4.3 Input Scaling: ALG222

The default input mode and range is single-ended, unipolar. In 0 to 10 V dc mode, input data is scaled so that 0 volts corresponds to a count of 0 and 10 volts corresponds to a count of +32000.

The bipolar range and mode can be selected by changing the configuration parameters of the module. In bipolar mode, -10 V corresponds to a count of -32000, 0 V corresponds to a count of 0, and +10 V corresponds to a count of +32000.

Factory calibration adjusts the analog value per bit (resolution) to a multiple of full scale (2.5 mV per bit for unipolar; 5 mV per bit for bipolar). The data is then scaled with the 4000 counts over the analog range. The data is scaled as displayed in the following figure.

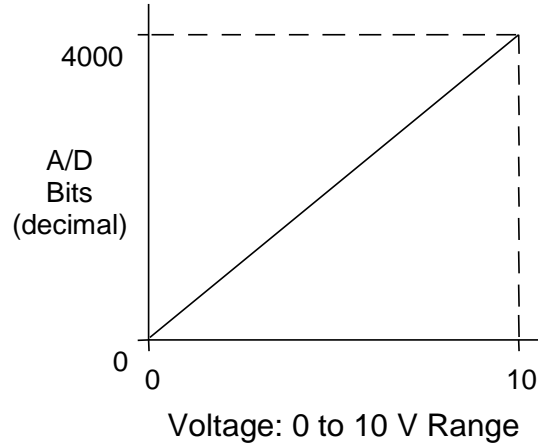
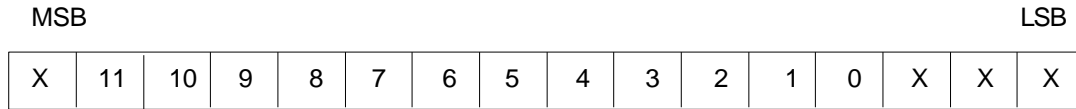


Figure 268: Input Scaling ALG222

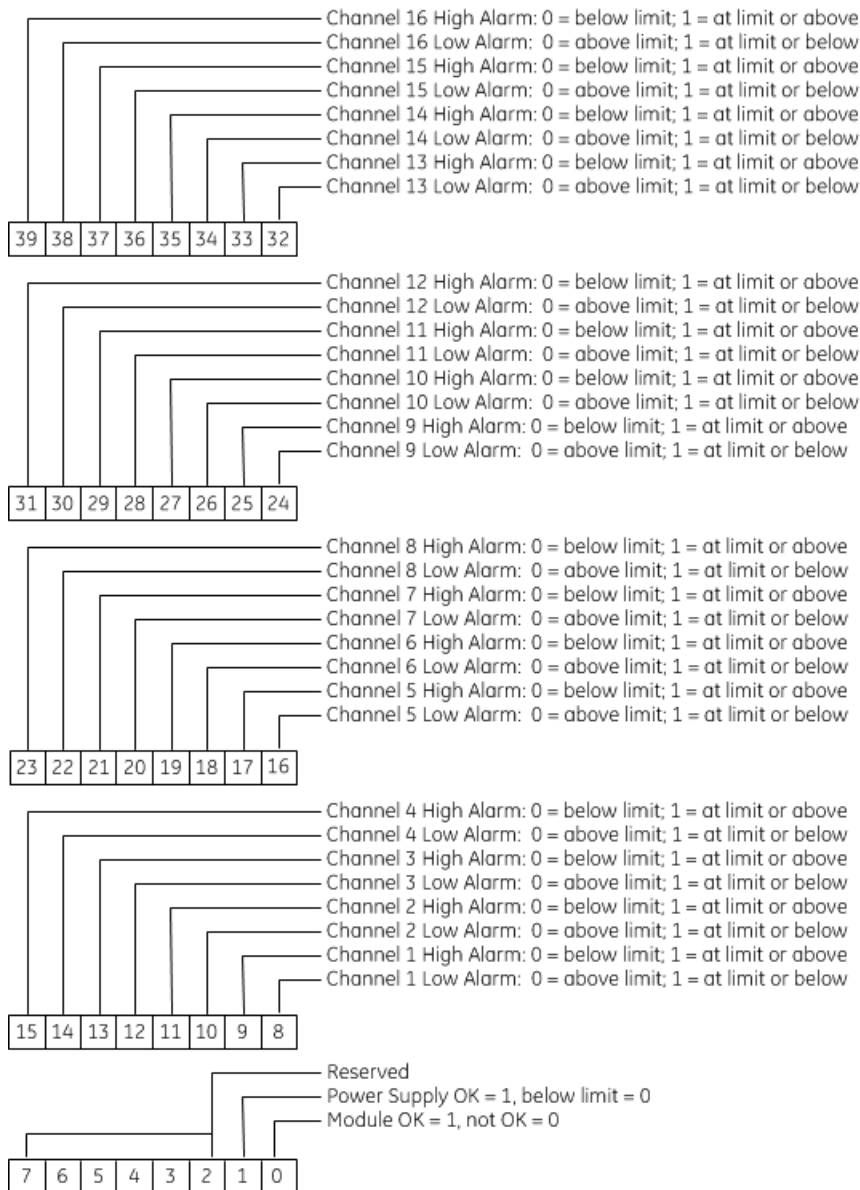
9.4.5 Data Format: ALG222

The 12-bit resolution module analog input data is stored in the PLC CPU in 16-bit 2's complement format in the unipolar range as displayed in the following figure.



9.4.5.1 Status Data: ALG222

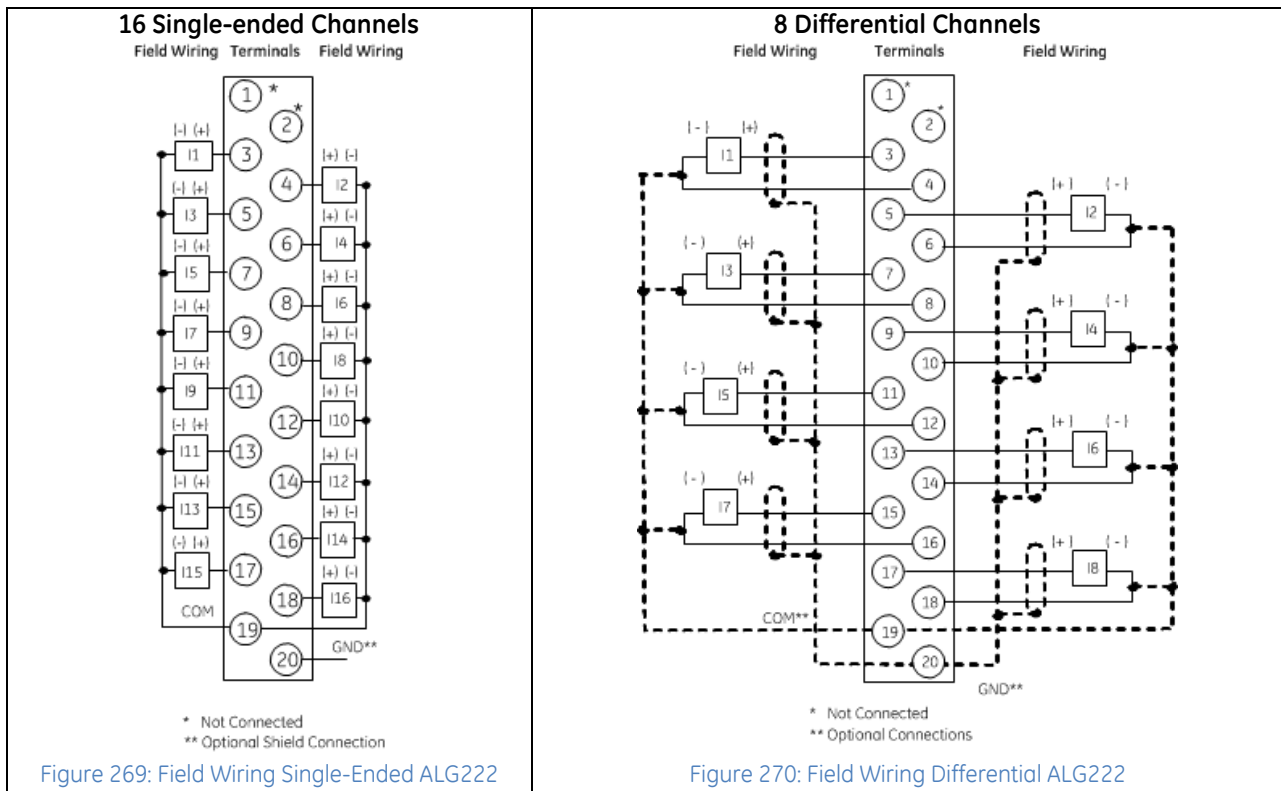
Analog Module IC694ALG222 can be configured to return 8, 16, 24, 32, or 40 status bits to the PLC CPU. This status data provides the following information about module operation:



9.4.6 Field Wiring: ALG222

Terminal	Single-ended Mode	Differential Mode
1, 2	not used	
3	Channel 1	Channel 1 +
4	Channel 2	Channel 1 -
5	Channel 3	Channel 2 +
6	Channel 4	Channel 2 -
7	Channel 5	Channel 3 +
8	Channel 6	Channel 3 -
9	Channel 7	Channel 4 +
10	Channel 8	Channel 4 -
11	Channel 9	Channel 5 +
12	Channel 10	Channel 5 -
13	Channel 11	Channel 6 +
14	Channel 12	Channel 6 -
15	Channel 13	Channel 7 +
16	Channel 14	Channel 7 -
17	Channel 15	Channel 8 +
18	Channel 16	Channel 8 -
19	Common	Common
20	Ground	Ground

Connections for 16-channel single-ended mode are displayed in Figure 269 and for the 8-channel differential mode in Figure 270. Single-ended mode is the default operating mode for the module. Differential mode must be set up by configuration.



9.5 Analog Input Module 16-Channel Current: IC694ALG223

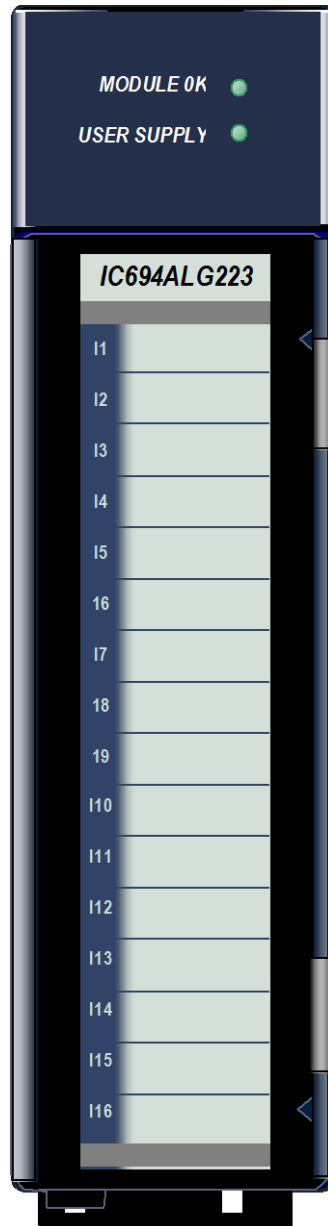


Figure 271: IC694ALG223

The **16-Channel Analog Current Input** module, IC694ALG223, provides sixteen single-ended inputs. Each input can be configured using the configuration software for any of three input ranges:

- 4 to 20 mA
- 0 to 20 mA
- 4 to 20 mA Enhanced

High and Low alarm limits are available on all ranges. In the 4 to 20 mA Enhanced range, a low alarm limit can be set up to detect input current from 4 mA to 0 mA, providing open-wire fault detection in 4 to 20 mA applications.

The module also reports module status and external power supply status to the CPU using its assigned program reference addresses.

This module can be installed in any I/O slot in an RX3i system.

Revision -BA and later supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1..

9.5.1 Module Power

This module consumes 120 mA from the 5Vdc bus on the PLC backplane. It also requires 65 mA plus current loop current(s) from a user-supplied +24Vdc supply.

9.5.2 Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If this module is located in an Expansion or Remote backplane, the power supply in the backplane provides the Isolated +24Vdc for the module.

9.5.3 LEDs: ALG223

The **MODULE OK** LED provides module status information on power-up as follows:

- *ON*: status is OK, module configured;
- *OFF*: no backplane power or software not running (watchdog timer timed out);
- *Continuous rapid flashing*: configuration data not received from CPU;
- *Slow flashes, then OFF*: failed power-up diagnostics or encountered code execution error.

The **User Supply** LED indicates that the external 24Vdc supply is within specifications.

9.5.4 Specifications: ALG223

Number of Channels	1 to 16 selectable; single-ended
Input Current Ranges	0 to 20 mA, 4 to 20 mA and 4 to 20 mA Enhanced (selectable per channel)
Calibration	Factory calibrated to: 4 μ A per count on 4 to 20 mA range 5 μ A per count on 0 to 20 mA and 4 to 20 mA Enhanced range
Update Rate	Update Rate: 6 ms
Resolution at 4–20 mA	4 μ A (4 μ A/bit)
Resolution at 0–20 mA	5 μ A (5 μ A/bit)
Resolution at 4–20 mA Enhanced	5 μ A (5 μ A/bit)
Absolute Accuracy ⁴⁷	$\pm 0.25\%$ of full scale at 25°C (77°F); $\pm 0.5\%$ of full scale over specified operating temperature range
Linearity	< 1 LSB from 4 to 20 mA (4 to 20 mA range) < 1 LSB from 100 μ A to 20 mA (0 to 20 mA and 4 to 20 mA Enhanced ranges)
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Common Mode Voltage ⁴⁸	0 volts (single-ended channels)
Cross-Channel Rejection	> 70dB from DC to 1kHz
Input Impedance	250 Ω
Input Low Pass Filter Response	19 Hz
External Supply Voltage Range	20 to 30 V dc
External Supply Voltage Ripple	10%
Internal Power Consumption	120 mA from the +5Vdc bus on the backplane 65 mA from 24Vdc external user power supply (in addition to current loop currents)

For product standards and general specifications, refer to *Appendix A*.

⁴⁷ In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to $\pm 5\%$ of full scale.

⁴⁸ In the presence of severe Conducted RF interference (IEC 61000-4-6, 10Vrms), accuracy may be degraded to $\pm 0.5\%$ of full scale.

9.5.5 Configuration: ALG223

9.5.5.1 Module Settings: ALG223

Parameter	Choices	Description
Active Channels	1 to 16	The number of channels to be scanned. Channels are scanned in sequential, contiguous order.
Channel Value Reference Address	Valid memory type: %AI	The starting address for input data from the module.
Channel Value Reference Length	Read-only.	Each channel provides 16 bits (1 word) of analog input data to the Controller CPU.
Module Status Reference Address	Valid memory type: %I	The starting address for status information from the module.
Module Status Reference Length	0, 8, 16, 24, 32, 40	The number of status bits (0 to 40) reported to the Controller CPU. When set to 0, status reporting is disabled. To enable status reporting, set this parameter to a value other than 0. Data formats are shown on the following page.
I/O Scan Set	1 through 32	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data

9.5.5.2 Input Channel Parameters: ALG223

Parameter	Choices	Description
Range	4-20 mA (default), 0-20 mA, or 4-20 mA enhanced	In the 4-20 mA range, input currents from 4 to 20 mA are reported to the CPU as values from 0 to 32000 units. In the 0 to 20 mA range, input currents from 0 to 20 mA are reported to the CPU as values from 0 to 32000 units. In the 4 to 20 mA enhanced range, currents from 4 to 20 mA are reported to the CPU as values from 0 to 32000 units. Currents below 4 mA are reported as negative values with 0 represented as -8000 units.
Alarm Low (Engineering Units)	4-20 mA = 0 to 32759	Each channel can be assigned a low alarm limit alarm. Values entered without a sign are assumed to be positive. Be sure the alarm low values are appropriate for the selected range.
	0-20 mA = 0 to 32759	
	4-20 mA enhanced = -8000 to +32759	
Alarm High (Engineering Units)	4-20 mA = 1 to 32760	Each channel can also be assigned a high alarm limit. Values entered without a sign are assumed to be positive. Be sure the alarm high values are appropriate for the selected range.
	0-20 mA = 1 to 32760	
	4-20 mA enhanced = -7999 to +32760	

9.5.6 Data Format: ALG223

The 12-bit resolution module analog input data is stored in the PLC CPU in 16-bit 2's complement format as displayed in the following figure.

MSB												LSB			
X	11	10	9	8	7	6	5	4	3	2	1	0	X	X	X

9.5.6.1 Input Scaling: ALG223

In the 4 to 20 mA range, input data is scaled so that 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000.

In the 0 to 20 mA range, 0 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000. Full 12-bit resolution is available over the 4 to 20 mA and 0 to 20 mA ranges.

4 to 20 mA Enhanced range can also be configured. In that range, 0 mA corresponds to a count of -8000, 4 mA corresponds to a count of 0 (zero) and 20 mA corresponds to a count of +32000. A low alarm limit can be set up to detect input current from 4 mA to 0 mA, providing open-wire fault detection in 4 to 20 mA applications.

Analog values are scaled over the range of the converter. Factory calibration adjusts the analog value per bit (resolution) to a multiple of full scale (4 μ A/bit). This calibration leaves a normal 12-bit converter with 4000 counts (normally $2^{12} = 4096$ counts). The data is then scaled with the 4000 counts over the analog range. The data is scaled as displayed in the following figure.

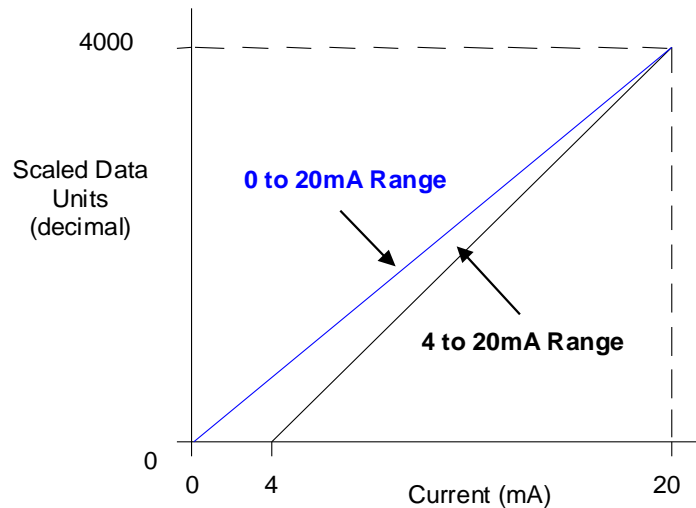
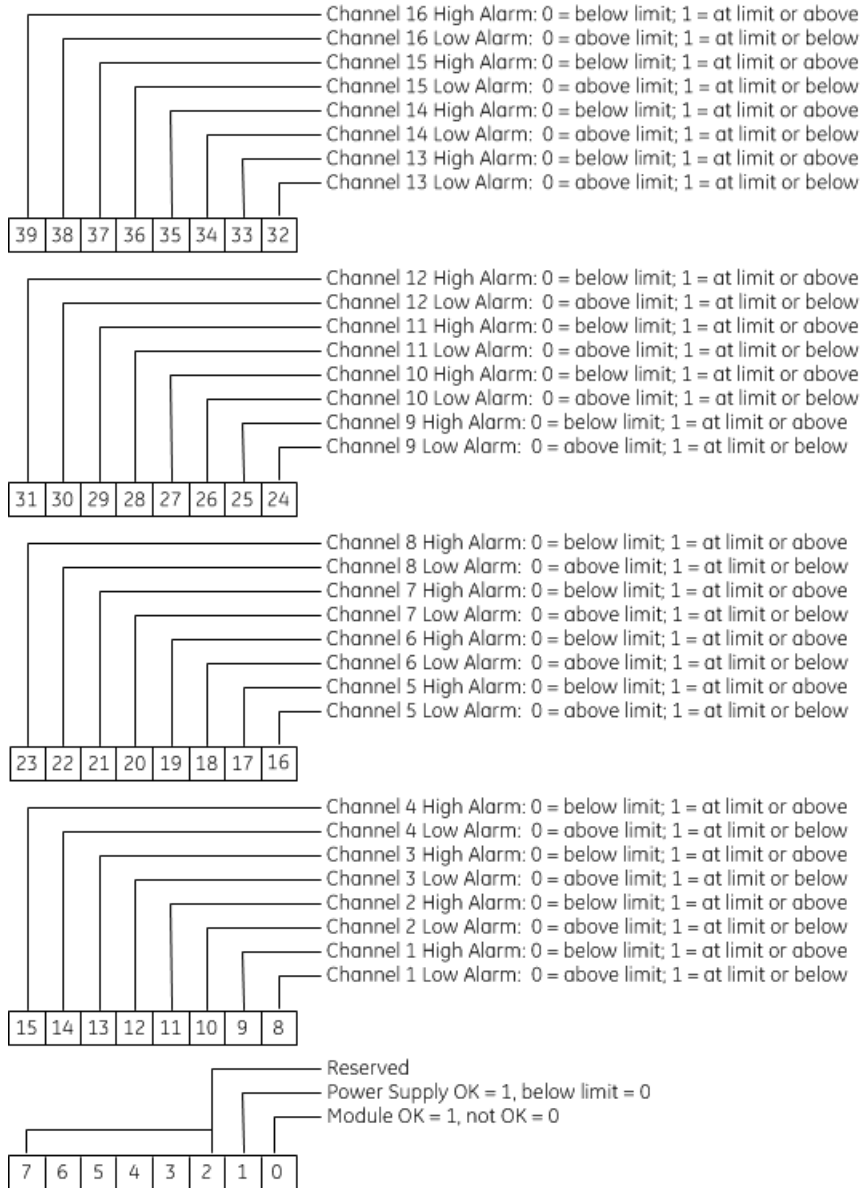


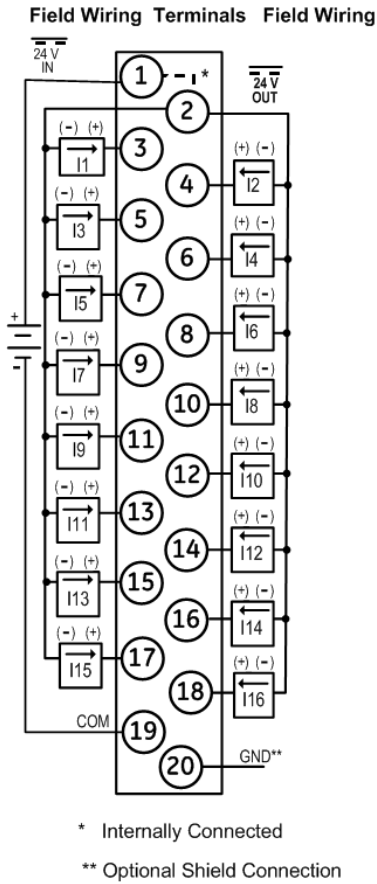
Figure 272: Input Scaling ALG223

9.5.6.2 Status Data: ALG223

Analog Module IC694ALG223 can be configured to return 8, 16, 24, 32, or 40 status bits to the PLC CPU. This status data provides the following information about module operation:



9.5.7 Field Wiring: ALG223



Terminal	Connection
1	User supplied 24V Input; provides loop power via 24VOUT terminal (pin 2)
2	+24V loop power tie point
3	Current Input, Channel 1
4	Current Input, Channel 2
5	Current Input, Channel 3
6	Current Input, Channel 4
7	Current Input, Channel 5
8	Current Input, Channel 6
9	Current Input, Channel 7
10	Current Input, Channel 8
11	Current Input, Channel 9
12	Current Input, Channel 10
13	Current Input, Channel 11
14	Current Input, Channel 12
15	Current Input, Channel 13
16	Current Input, Channel 14
17	Current Input, Channel 15
18	Current Input, Channel 16
19	Common connection to input current sense resistors; user supplied 24V input return or 24VIN return
20	Frame ground connections for cable shields

Figure 273: Field Wiring ALG223

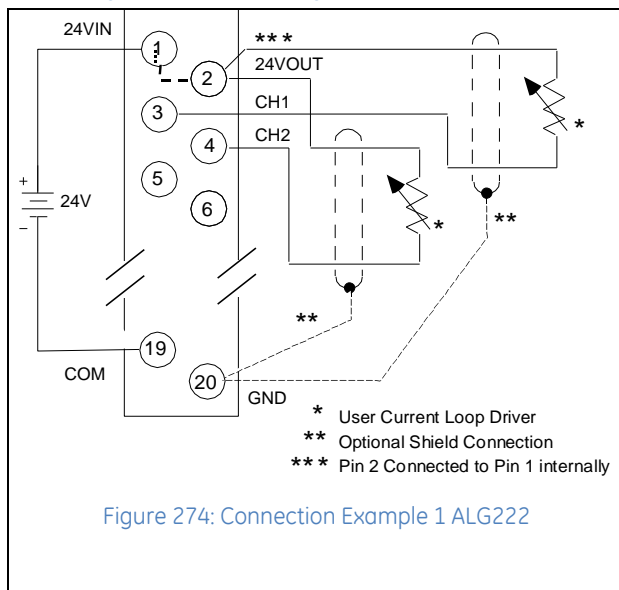


Figure 274: Connection Example 1 ALG222

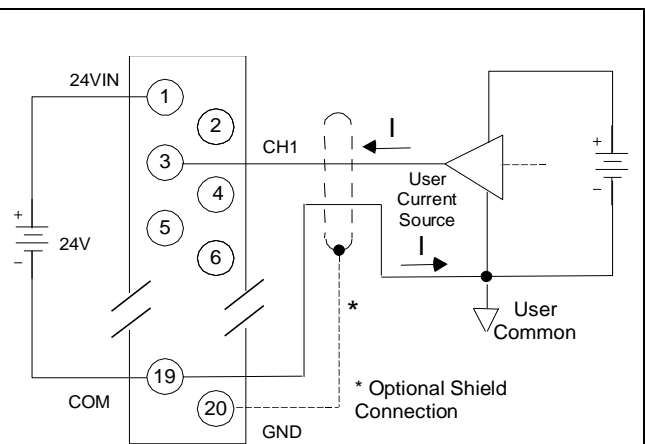


Figure 275: Connection Example 2 ALG222

To limit common-mode voltages, the current source can be tied to the COM terminal provided the source is floating.

9.6 Analog Input Module Advanced Diagnostics 16-Channel Voltage: IC694ALG232

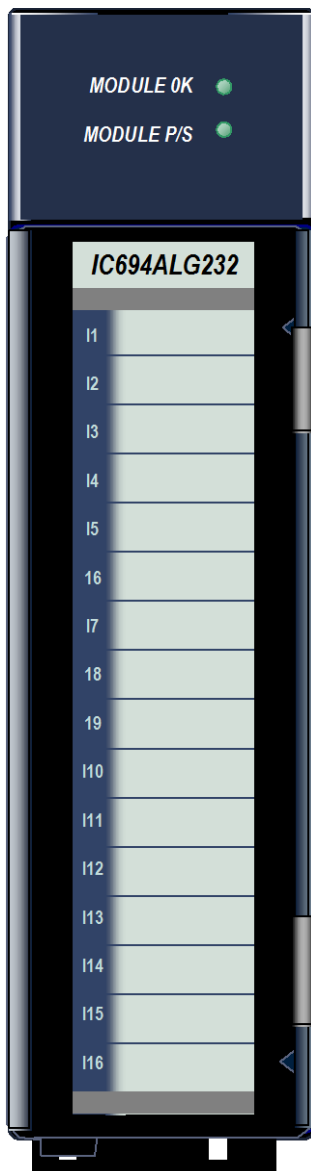


Figure 276: IC694ALG232

The PACSystems RX3i 16-Channel Analog Voltage Input module IC694ALG232 provides sixteen single-ended or eight differential input channels. Each channel can be configured for either of two input ranges:

- 0 to 10 V (unipolar), default
- -10 to +10 V (bipolar)

High and Low alarm limits can be configured for both ranges.

This module can be installed in any I/O slot that has a serial connector in an RX3i system.

9.6.1 Features

- Completely software-configurable, no module jumpers to set
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program
- Supports firmware upgrades.
- Positive and negative Rate of Change Alarms
- Display of module serial number, revision and date code in programming software.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.
- Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If this module is located in an Expansion or Remote backplane, the backplane power supply provides the Isolated +24Vdc for the module.

9.6.2 LEDs: ALG232

The **MODULE OK** LED provides module status information as follows:

- ON: status is OK, module configured
- OFF: no backplane power or software not running (watchdog timer timed out)
- Continuous rapid blinking: configuration data not received from CPU
- Slow blinking, then OFF: failed power-up diagnostics or encountered code execution error

The **Module P/S LED** indicates that the internally-generated +5Vdc supply is above a minimum designated level for the module.

9.6.3 Specifications: ALG232

Number of Channels	1 to 16 selectable, single-ended input mode 1 to 8 selectable, differential input mode
Input Ranges	0 Vdc to +10 Vdc (unipolar) or -10 Vdc to +10 Vdc (bipolar); selectable each channel
Calibration	Factory calibrated to: 0.3125 mV per count on 0 Vdc to +10 Vdc (unipolar) range 0.3125 mV per count on -10 to +10 Vdc (bipolar) range
Update Rate for All Channels	Single Ended Input 5 ms Differential Input 3 ms
Resolution at 0 V dc to +10 V dc	1 LSB = 0.3125 mV
Resolution at -10 V dc to +10 V dc	1 LSB = 0.3125 mV
Absolute Accuracy ^{49,50}	±0.25% of full scale at 25°C (77°F) ±0.5% of full scale over specified operating temperature range
Linearity	< 4 LSB
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Common Mode Voltage (Differential) ⁵¹	±11 Vdc (bipolar range)
Cross-Channel Rejection	> 70dB from DC to 1 kHz
Input Impedance	>500kΩ (single-ended mode) >1 MΩ (differential mode)
Input Filter Response	23 Hz (single-ended mode) 38 Hz (differential mode)
Internal Power Consumption	112 mA (maximum) from the backplane +5Vdc bus 110 mA (maximum) from the backplane isolated +24Vdc supply

For product standards and general specifications, refer to *Appendix A*.

⁴⁹ In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to ±5% of full scale.

⁵⁰ In the presence of severe Conducted RF interference (IEC 61000-4-6, 10Vrms), accuracy may be degraded to ±1% of full scale.

⁵¹ The sum of the differential input, common mode voltage, and noise must not exceed ±11 volts when referenced to COM.

9.6.4 Configuration: ALG232

9.6.4.1 Module Parameters: ALG232

Parameter	Choices	Description
Active Channels	1 to 16 for Single-ended Input Mode, or 1 to 8 for Differential Input Mode	The number of channels to be scanned. Channels are scanned in sequential, contiguous order.
Channel Value Reference Address	Valid memory types: %AI (default), %AQ, %R, %W, %G, %M, %T, Symbolic Memory*	The starting address in memory for input data from the module. * Note: To support this feature "Variable Mode" property should be enabled in Machine Edition.
Channel Value Reference Length	Read-only	Depends on the number of active channels. Each channel provides two words of analog input data to the Controller CPU.
Diagnostic Reference Address	Valid memory types: %I (default), %Q, %AI, %AQ, %R, %W, %G, %M, %T, Symbolic Memory*	Starting address for the channel diagnostics data. Used only when Module Level Diagnostic Reporting is enabled. * Note: To support this feature "Variable Mode" property should be enabled in Machine Edition.
Diagnostic Reference Length	Read-only	The amount of memory required for the channel diagnostics data. When Module Level Diagnostic Reporting is enabled, 32 bits (2 words) of diagnostic data are allocated for each active channel.
Module Status Reference Address	Valid memory types: %I (default), %Q, %AI, %AQ, %R, %W, %G, %M, %T, Symbolic Memory*	The starting address in memory for status information from the module. * Note: To support this feature "Variable Mode" property should be enabled in Machine Edition.
Module Status Reference Length	0, 32	The number of module status bits reported to the CPU. Data format is displayed in the following figure. When set to 0, status reporting is disabled. To enable status reporting, set this parameter to a value other than 0.
I/O Scan Set	1 through 32	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Inputs Default	Force Off (default) or Hold Last State	In the event of module failure or removal, this parameter specifies the state of all Channel Value References for the module. Force Off = Channel Values clear to 0. Hold Last State = Channels hold their last state.
Analog Input Mode	Single-Ended Input Mode (default), or Differential Input Mode	In Single-Ended Input Mode, 16 inputs are referenced to a single common. In Differential Input Mode, each of the 8 inputs has its own signal and common. Selection must match the input wiring to the module.
Module Level Diagnostic Reporting	Disabled (default) or Enabled	If enabled, 32 bits of data are allocated for each active channel. Diagnostic Reporting and Fault Reporting can be enabled separately for each channel.

9.6.4.2 Channel Configuration Parameters: ALG232

Parameter	Choices	Description
Range	0 to 10 V (default) or -10 to 10 V	In the 0 to 10 V default range, input voltage values from 0 to 10 V report 0 to 32,000 integer values to the CPU. In the -10 to 10 V range, input voltage values from -10 to 10 V report -32000 to 32,000 integer values to the CPU.
Channel Value Format	32 Bit Floating Point (default) or 16 Bit Integer	32 Bit Floating Point: A real value, range 3.40282e+38 through 3.40282e+38 16 Bit Integer: The low word of the 32-bit channel data contains the 16-bit integer channel value. The high word contains the sign of the 16-bit integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data is set to 0xFFFF. If the 16-bit integer result is positive, the upper word is set to 0x0000. When the Channel Value Format parameter is set to 16 Bit Integer, 1000 Eng Units are equal to 1.0 A/D Unit.
High Scale Value (Eng Units)	The defaults and ranges for the four scaling parameters depend on the configured Range Type and Channel Value Format.	Scaling is disabled if : High Scale Eng. Units = High Scale A/D Units and Low Scale Eng. Units = Low Scale A/D Units. Default is High A/D Limit of selected range type. When <i>Channel Value Format</i> is set to 32 Bit Floating Point, range is -3.40282e+38 through 3.40282e+38. When set to 16 Bit Integer, range -32,768 through +32,767.
Low Scale Value (Eng Units)		
High Scale Value (A/D Units)		
Low Scale Value (A/D Units)		
Positive Rate of Change Limit (Eng Units/Second)	Range: 0.0 (default) through 3.40282e+38	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. If set to 0, limit is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units/Second)	Range: 0.0 (default) through 3.40282e+38	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. If set to 0, limit is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate (ms)	0 (default) through 300	Time from 0 through 300 seconds to wait between comparisons. If set to the default value of 0.0, the module checks after every input sample.

Channel Parameters (Continued)

Parameter	Choices	Description
High-High Alarm (Eng Units)	The defaults and ranges for these parameters depend on the configured Range and Channel Value Format.	Alarms and Deadbands All of the alarm parameters are specified in Engineering Units. To use alarming, Diagnostic Reporting or Fault Reporting must be enabled.
High Alarm (Eng Units)		High-High Alarm and Low-Low Alarm: When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.
Low Alarm (Eng Units)		High Alarm and Low Alarm: When the configured value is reached or below (above), a Low (High) Alarm is triggered.
Low-Low Alarm (Eng Units)		High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.
High-High Alarm Deadband (Eng Units)		Alarm Deadbands should not cause the alarm clear condition to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
Low-Low Alarm Deadband (Eng Units)		
User Offset	16-Bit Integer range: -32768 through 32768 32-Bit Floating Point, range: -3.40282e+38 through 3.40282e+38. 0.0 (default) 0.0 (default)	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filtering	Disabled (default) or Enabled	Controls whether software filtering will be performed on the inputs.
Integration Time (ms)	0 (default) through 4,294,967,295 ms	Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms.
Diagnostic Reporting Enable	Disabled (default) or Enabled <i>(Available only if Module Level Diagnostic Reporting is enabled on the Settings tab.)</i>	If Diagnostic Reporting is enabled, the module reports channel alarms in the Diagnostic Reference memory. Channel alarms can be individually enabled.
Fault Reporting Enable		If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm. Fault reporting for channel alarms can be individually enabled.

9.6.4.3 Input Scaling: ALG232

By default, the module converts a voltage input over the entire span of its configured Range into a floating point value for the CPU. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the Controller that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example:

For a voltage input, 6.0 volts equals a speed of 20 feet per second, and 1.0 volt equals 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000
 Low Scale Value (Eng Units) = 0.000
 High Scale Value (A/D Units) = 6.000
 Low Scale Value (A/D Units) = 1.000

For this example, 1.0V to 6.0V is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 10.0V were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or other precautions for scaled inputs that are outside the acceptable range or otherwise invalid.

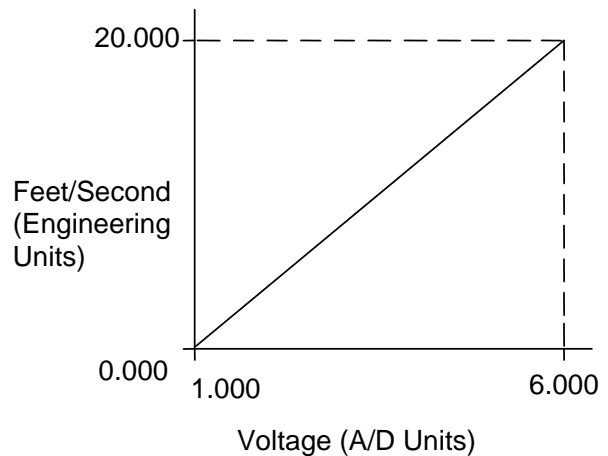


Figure 277: Input Scaling ALG232

9.6.4.4 Rate of Change Alarms: ALG232

ALG232 can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Unit change between samples is positive, the module compares the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the Diagnostic Reporting Enable and Fault Reporting Enable parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. The minimum value which can be used with this parameter is 60 ms, i.e., the module can compare the rate of change after every 60 ms.

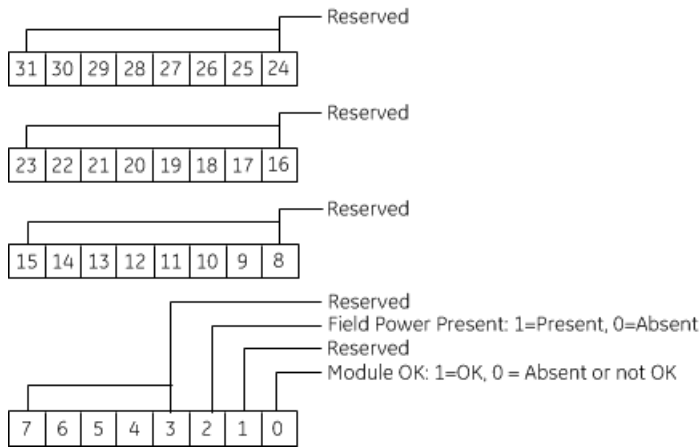
When the CPU transitions to RUN mode or the module field power is cycled, the ALG232 waits 100ms before starting Rate of Change detection. This is to ignore any glitches in the input signal.

Using Alarming

The Diagnostic Reporting Enable and Fault Reporting Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarms can be enabled for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.

9.6.4.5 Module Status Data: ALG232



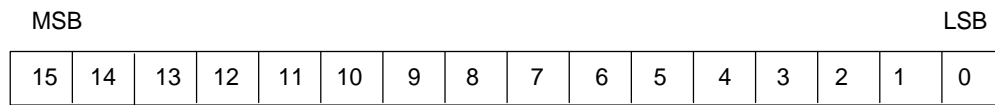
9.6.4.6 Channel Input Data: ALG232

The module reports its channel input data in its configured input words, beginning at its assigned Channel Value Reference Address. Each channel occupies 2 words (whether the channel is used or not):

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

The 16-bit resolution module analog input data is stored in the CPU in 16-bit 2's complement format as displayed in the following figure.



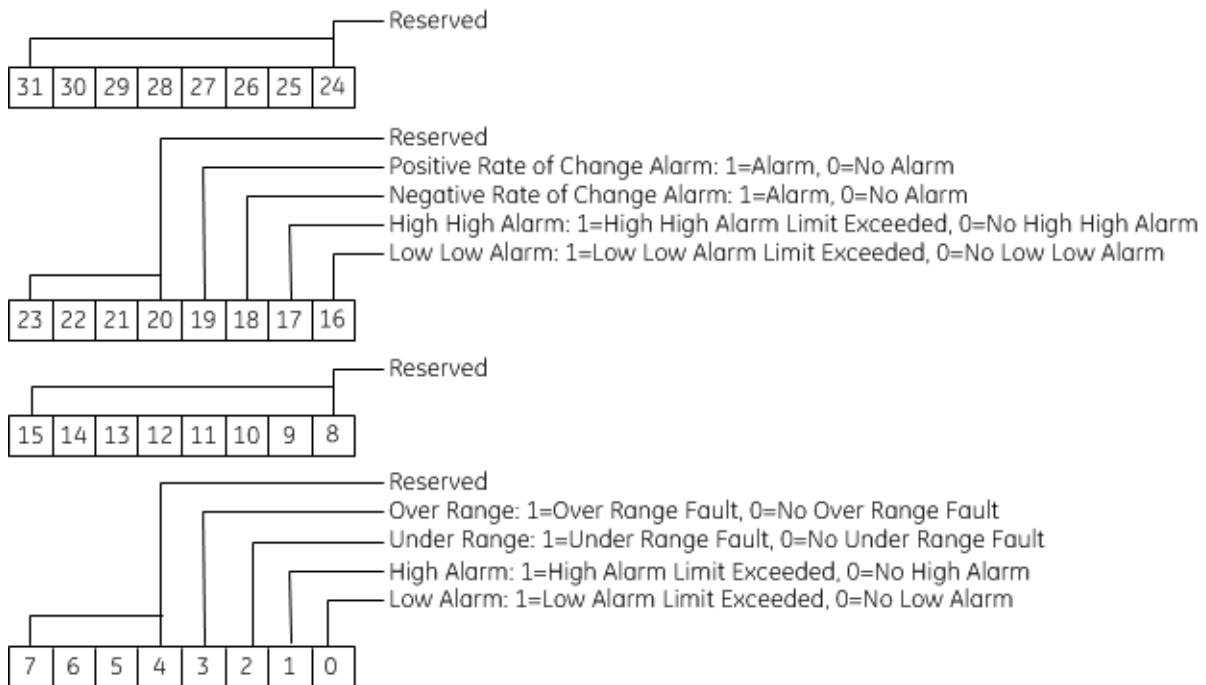
9.6.4.7 Channel Diagnostic Data: ALG232

In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for the module. Use of this feature is optional.

The diagnostics data for each channel occupies two words (whether the channel is used or not):

When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

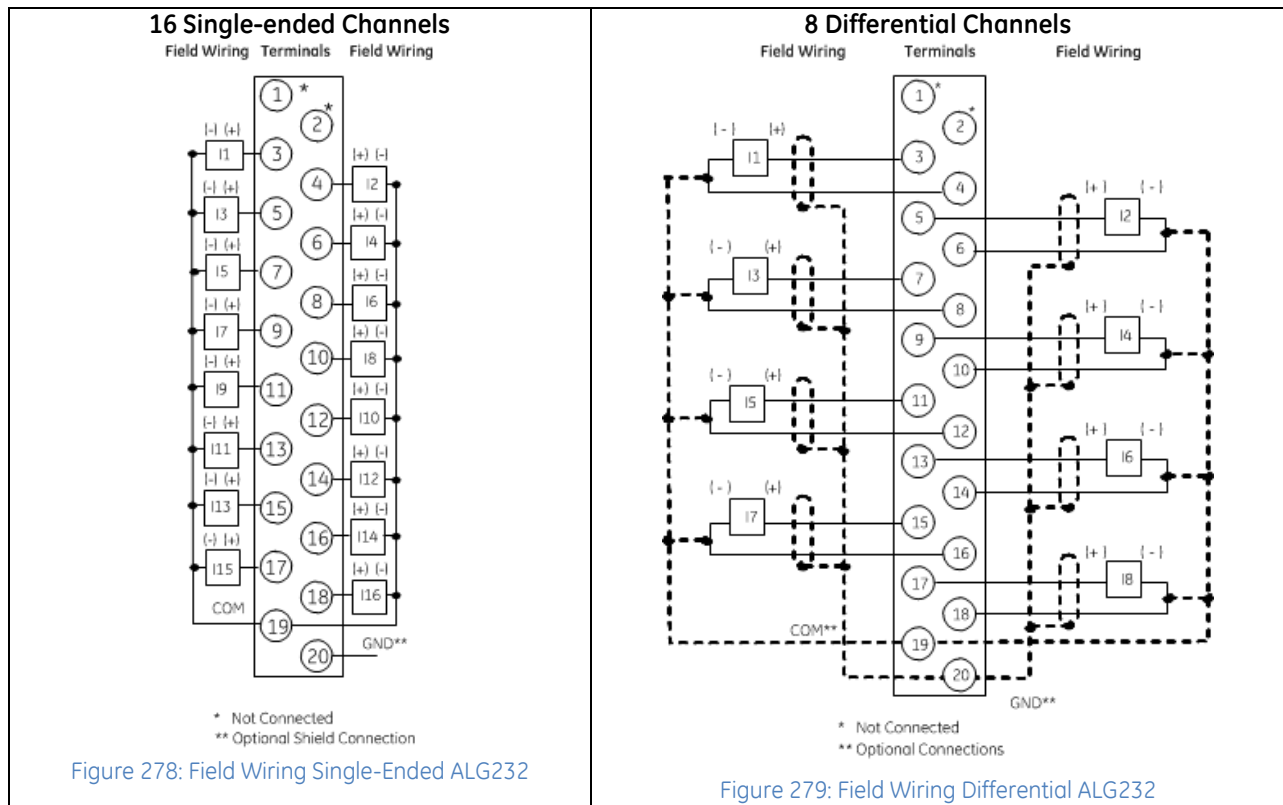
For each channel, the format of this data is:



9.6.5 Field Wiring: ALG232

Terminal	Single-ended Mode	Differential Mode
1, 2	not used	
3	Channel 1	Channel 1 +
4	Channel 2	Channel 1 -
5	Channel 3	Channel 2 +
6	Channel 4	Channel 2 -
7	Channel 5	Channel 3 +
8	Channel 6	Channel 3 -
9	Channel 7	Channel 4 +
10	Channel 8	Channel 4 -
11	Channel 9	Channel 5 +
12	Channel 10	Channel 5 -
13	Channel 11	Channel 6 +
14	Channel 12	Channel 6 -
15	Channel 13	Channel 7 +
16	Channel 14	Channel 7 -
17	Channel 15	Channel 8 +
18	Channel 16	Channel 8 -
19	Common	Common
20	Ground	Ground

Connections for 16-channel single-ended mode are displayed in Figure 278 and for 8-channel differential mode in Figure 279. Single-ended mode is the default operating mode for the module. Differential mode must be selected by configuration.



9.7 Analog Input Module Advanced Diagnostics 16-Channel Current: IC694ALG233

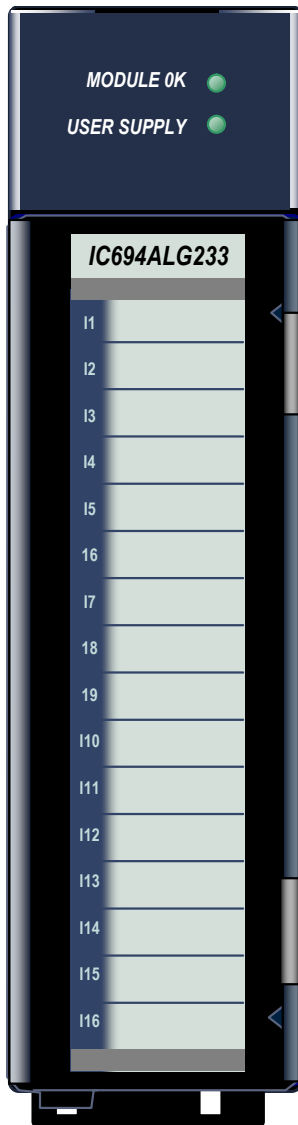


Figure 280: IC694ALG233

The PACSystems RX3i 16-Channel Analog Current Input module IC694ALG233 provides sixteen single-ended input channels. Each input can be configured using the configuration software for any of three input ranges:

- 4 to 20 mA
- 0 to 20 mA
- 4 to 20 mA Enhanced

High and Low alarm limits are available on all ranges. In the 4 to 20 mA Enhanced range, a low alarm limit can be set up to detect input current from 4 mA to 0 mA, providing open-wire fault detection in 4 to 20 mA Enhanced applications.

The module also reports module status and external power supply status to the CPU using its assigned program reference addresses.

This module can be installed in any I/O slot that has a serial connector in an RX3i system.

9.7.1 Module Power

This module consumes 120 mA from the 5Vdc bus on the RX3i backplane. It also requires 65 mA plus current loop current(s) from a user-supplied +24Vdc supply.

9.7.2 Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source must be connected via the TB1 connector on the left side of the backplane.

If this module is located in an Expansion or Remote backplane, the power supply in the backplane provides the Isolated +24Vdc for the module.

9.7.3 Features

- Completely software-configurable, no module jumpers to set
- Open-circuit detection for all inputs in 4 to 20 mA Enhanced Range
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program
- Supports firmware upgrades.
- Positive and negative Rate of Change Alarms
- Display of module serial number, revision and date code in programming software.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

9.7.4 LEDs: ALG233

The **MODULE OK** LED provides module status information as follows:

ON: status is OK, module configured;

OFF: no backplane power or software not running (watchdog timer timed out);

Continuous rapid blinking: configuration data not received from CPU;

Slow blinking, then OFF: failed power-up diagnostics or encountered code execution error.

The **USER SUPPLY** LED indicates that the external 24Vdc supply is within specifications.

9.7.5 Specifications: ALG233

Number of Channels	1 to 16 selectable; single-ended
Input Current Ranges	0 to 20 mA, 4 to 20 mA and 4 to 20 mA Enhanced (selectable per channel)
Calibration	Factory calibrated to: 0.5 μ A per count on 4 to 20 mA range 0.625 μ A per count on 0 to 20 mA and 4 to 20 mA Enhanced range
Update Rate for All Channels	5 ms
Resolution at 0–20 mA	0.625 μ A/bit
Resolution at 4–20 mA	0.5 μ A/bit
Resolution at 4–20 mA Enhanced	0.5 μ A/bit
Absolute Accuracy ^{52,53}	\pm 0.25% of full scale at 25°C (77°F) \pm 0.5% of full scale over specified operating temperature range
Linearity	< 4 LSB from 4 to 20 mA (4 to 20 mA range) < 4 LSB from 100 μ A to 20 mA (0 to 20 mA and 4 to 20 mA Enhanced ranges)
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Common Mode Voltage	0 volts (single-ended channels)
Cross-Channel Rejection	> 70dB from DC to 1kHz
Input Impedance	250 Ω
Input Low Pass Filter Response	23 Hz
External Supply Voltage Range	20 to 30 V dc
External Supply Voltage Ripple	10%
Power Consumption	120 mA from the +5Vdc bus on the backplane 65 mA from 24Vdc external user power supply (in addition to current loop currents)

For product standards and general specifications, refer to *Appendix A*.

⁵² In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 5% of full scale.

⁵³ In the presence of severe Conducted RF interference (IEC 61000-4-6, 10Vrms), accuracy may be degraded to \pm 0.5% of full scale.

9.7.6 Configuration: ALG233

9.7.6.1 Module Settings: ALG233

Parameter	Choices	Description
Active Channels	1 to 16	The number of channels to be scanned. Channels are scanned in sequential, contiguous order.
Channel Value Reference Address	Valid memory types: %AI (default), %AQ, %R, %W, %G, %M, %T, Symbolic Memory ⁵⁴	The starting address in memory for input data from the module.
Channel Value Reference Length	Read-only	Depends on the number of active channels. Each channel provides two words of analog input data to the Controller CPU.
Diagnostic Reference Address	Valid memory types: %I (default), %Q, %AI, %AQ, %R, %W, %G, %M, %T, Symbolic Memory ⁵⁴	Starting address for the channel diagnostics data. Used only when Module Level Diagnostic Reporting is enabled.
Diagnostic Reference Length	Read-only	The amount of memory required for the channel diagnostics data. When Module Level Diagnostic Reporting is enabled, 32 bits of diagnostic data are allocated for each active channel.
Module Status Reference Address	Valid memory types: %I (default), %Q, %AI, %AQ, %R, %W, %G, %M, %T, Symbolic Memory ⁵⁴	The starting address in memory for status information from the module.
Module Status Reference Length	0, 32	The number of module status bits reported to the CPU. Data format is displayed in the following figure. When set to 0, status reporting is disabled. To enable status reporting, set this parameter to a value other than 0.
I/O Scan Set	1 through 32	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Inputs Default	Force Off (default) or Hold Last State	In the event of module failure or removal, this parameter specifies the state of all Channel Value References for the module. Force Off = Channel Values clear to 0. Hold Last State = Channels hold their last state.
Module Level Diagnostic Reporting	Disabled (default) or Enabled	If enabled, 32 bits of data are allocated for each active channel. Diagnostic Reporting and Fault Reporting can be enabled separately for each channel.

⁵⁴ Note: To support this feature, *Variable Mode* property should be enabled in Machine Edition.

9.7.6.2 Channel Configuration Parameters: ALG233

Parameter	Choices	Description
Range	4-20 mA (default), 0-20 mA, or 4-20 mA + (enhanced)	In the 4-20 mA range, input currents from 4 to 20 mA are reported to the CPU as values from 0 to 32000 units. In the 0 to 20 mA range, input currents from 0 to 20 mA are reported to the CPU as values from 0 to 3200 units. In the 4 to 20 mA enhanced range, currents from 4 to 20 mA are reported to the CPU as values from 0 to 32000 units. Currents below 4 mA are reported as negative values with 0 represented as -8000 units.
Channel Value Format	32 Bit Floating Point (default) or 16 Bit Integer	32 Bit Floating Point: A real value, range $3.40282e+38$ through $3.40282e+38$ 16 Bit Integer: The low word of the 32-bit channel data contains the 16-bit integer channel value. The high word contains the sign of the 16-bit integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data is set to 0xFFFF. If the 16-bit integer result is positive, the upper word is set to 0x0000. When the Channel Value Format parameter is set to 16 Bit Integer, 1000 Eng Units are equal to 1.0 A/D Unit.
High Scale Value (Eng Units)	The defaults and ranges for the four scaling parameters depend on the configured Range Type and Channel Value Format.	Scaling is disabled if : High Scale Eng. Units = High Scale A/D Units and Low Scale Eng. Units = Low Scale A/D Units. Default is High A/D Limit of selected range type. When <i>Channel Value Format</i> is set to 32 Bit Floating Point, range is $-3.40282e+38$ through $3.40282e+38$. For 16 Bit Integer, range is -32,768 through +32,767.
Low Scale Value (Eng Units)		
High Scale Value (A/D Units)		
Low Scale Value (A/D Units)		
Positive Rate of Change Limit (Eng Units/Second)	Range: 0.0 (default) through $3.40282e+38$	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. If set to 0, limit is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units/Second)	Range: 0.0 (default) through $3.40282e+38$	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. If set to 0, limit is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate (Seconds)	0.0 (default) through 300.0	Time from 0 through 300 seconds to wait between comparisons. If set to the default value of 0.0, the module checks after every input sample.

Channel Parameters (Continued)

Parameter	Choices	Description
High-High Alarm (Eng Units)	The defaults and ranges for these parameters depend on the configured Range and Channel Value Format.	<p>Alarms and Deadbands</p> <p>All of the alarm parameters are specified in Engineering Units. To use alarming, Diagnostic Reporting or Fault Reporting must be enabled.</p> <p>High-High Alarm and Low-Low Alarm: When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.</p> <p>High Alarm and Low Alarm: When the configured value is reached or below (above), a Low (High) Alarm is triggered.</p> <p>High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.</p> <p>Alarm Deadbands should not cause the alarm clear condition to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.</p>
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
Low-Low Alarm Deadband (Eng Units)		
User Offset	16 Bit Integer range: -32768 through 32768 32 Bit Floating Point, range: -3.40282e+38 through 3.40282e+38. 0.0 (default)	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filtering	Disabled (default) or Enabled	Controls whether software filtering will be performed on the inputs.
Integration Time (ms)	0 (default) through 4,294,967,295 ms	Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms.
Diagnostic Reporting Enable	Disabled (default) or Enabled <i>(Available only if Module Level Diagnostic Reporting is enabled on the Settings tab.)</i>	If Diagnostic Reporting is enabled, the module reports channel alarms in the Diagnostic Reference memory. Channel alarms can be individually enabled.
Fault Reporting Enable		If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm. Fault reporting for channel alarms can be individually enabled.

9.7.6.3 Input Scaling: ALG233

In the 4 to 20 mA range, input data is scaled so that 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000.

In the 0 to 20 mA range, 0 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000. Full 12-bit resolution is available over the 4 to 20 mA and 0 to 20 mA ranges.

4 to 20 mA Enhanced range can also be configured. In that range, 0 mA corresponds to a count of -8000, 4 mA corresponds to a count of 0 (zero) and 20 mA corresponds to a count of +32000. A low alarm limit can be set up to detect input current from 4 mA to 0 mA, providing open-wire fault detection in 4 to 20 mA applications.

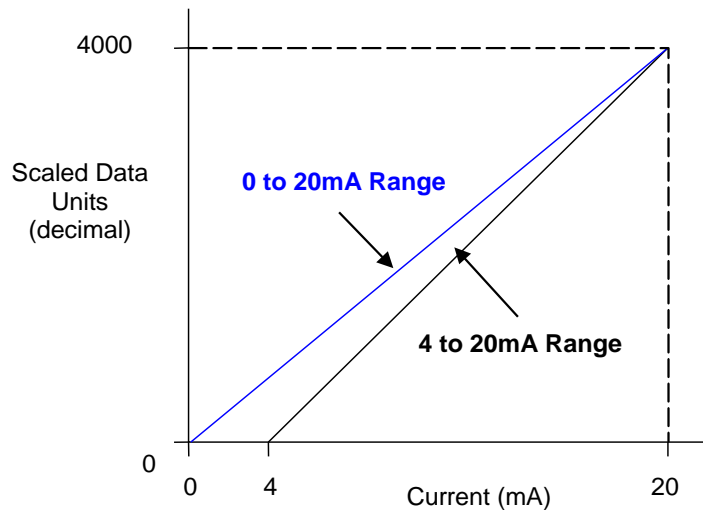


Figure 281: Input Scaling ALG233

Analog values are scaled over the range of the converter. Factory calibration adjusts the analog value per bit (resolution) to a multiple of full scale (4 μ A/bit). This calibration leaves a normal 12-bit converter with 4000 counts (normally $2^{12} = 4096$ counts). The data is scaled with the 4000 counts over the analog range. The data is scaled as shown above.

9.7.6.4 Rate of Change Alarms

The ALG233 can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

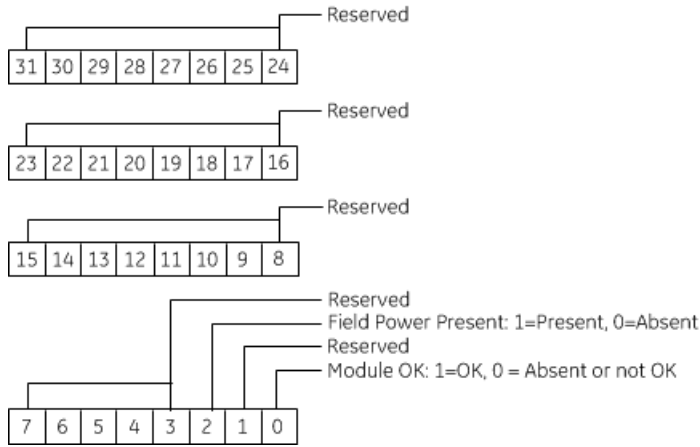
If the Engineering Unit change between samples is positive, the module compares the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the Diagnostic Reporting Enable and Fault Reporting Enable parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. The minimum value which can be used with this parameter is 60 ms i.e., the module can compare the rate of change after every 60 ms.

When the CPU transitions to RUN mode or the module field power is cycled, the ALG233 waits 100ms before starting Rate of Change detection. This is to ignore any glitches in the input signal.

9.7.6.5 **Module Status Data: ALG233**

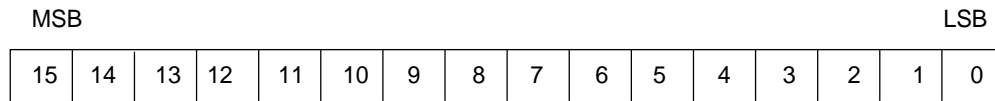


9.7.6.6 **Channel Input Data: ALG233**

The module reports its channel input data in its configured input words, beginning at its assigned Channel Value Reference Address. Each channel occupies 2 words, whether or not the channel is used: Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

The 16-bit resolution module analog input data is stored in the CPU in 16-bit 2's complement format as displayed in the following figure.



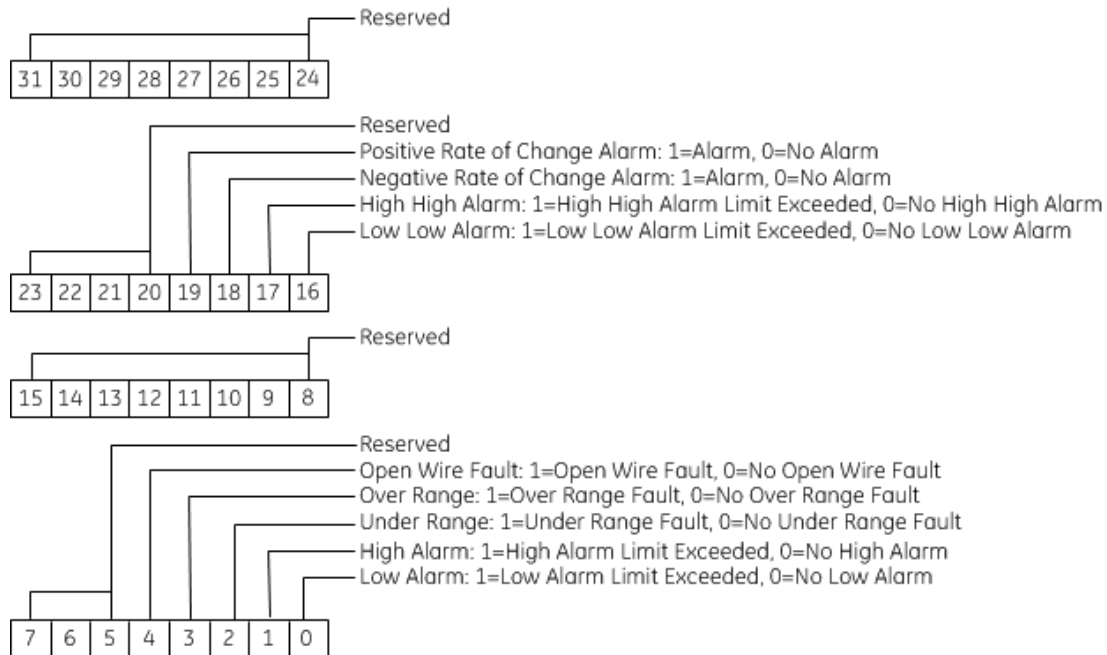
9.7.6.7 Channel Diagnostic Data: ALG233

In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for the module. Use of this feature is optional.

The diagnostics data for each channel occupies two words (whether the channel is used or not):

When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



9.7.7 Field Wiring: ALG233

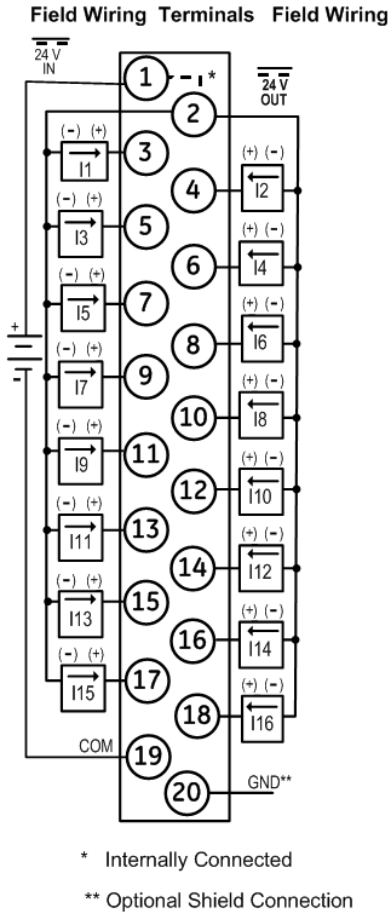


Figure 282: Field Wiring ALG233

Terminal	Connection
1	User supplied 24V Input; provides loop power via 24VOUT terminal (pin 2)
2	+24V loop power tie point
3	Current Input, Channel 1
4	Current Input, Channel 2
5	Current Input, Channel 3
6	Current Input, Channel 4
7	Current Input, Channel 5
8	Current Input, Channel 6
9	Current Input, Channel 7
10	Current Input, Channel 8
11	Current Input, Channel 9
12	Current Input, Channel 10
13	Current Input, Channel 11
14	Current Input, Channel 12
15	Current Input, Channel 13
16	Current Input, Channel 14
17	Current Input, Channel 15
18	Current Input, Channel 16
19	Common connection to input current sense resistors; user supplied 24V input return or 24VIN return
20	Frame ground connections for cable shields

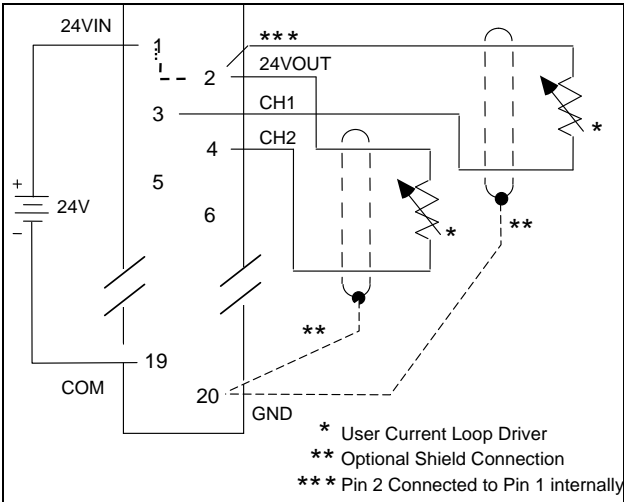


Figure 283: Connection Example 1 ALG233

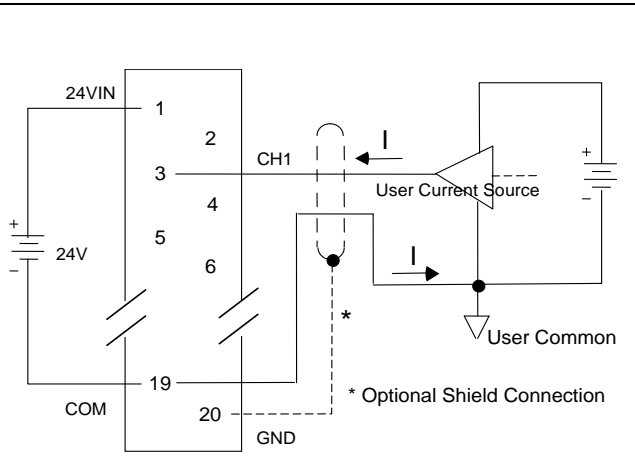


Figure 284: Connection Example 2 ALG233

To limit common-mode voltages, the current source can be tied to the COM terminal if the source is floating

9.8 Analog Input Module 8-/4-Channel Current/Voltage: IC695ALG608

Analog Input Module 16-/8-Channel Current/Voltage: IC695ALG616

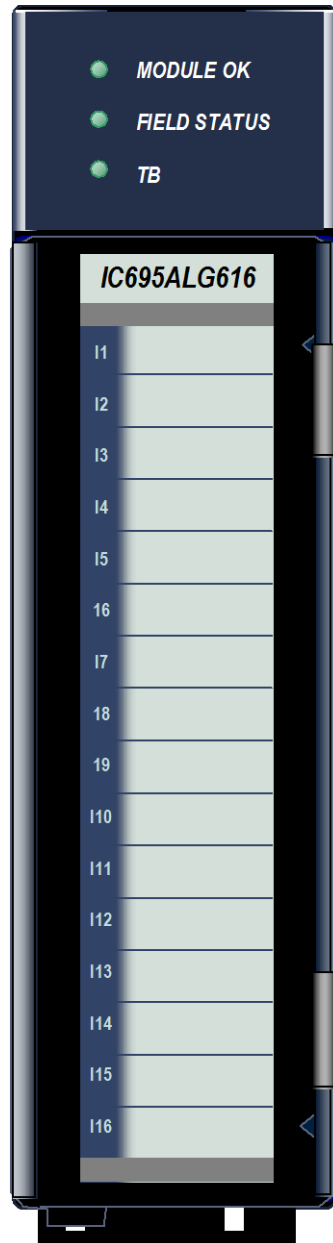


Figure 285: IC695ALG616

Non-Isolated Differential Analog Input Current/Voltage module IC695ALG608 provides eight single-ended or four differential input channels. **Non-Isolated Differential Analog Input Current/Voltage** module IC695ALG616, (Figure 285) provides 16 single-ended or 8 differential input channels. Analog input channels can be configured for these ranges:

- Current: 0 to 20mA, 4 to 20mA, ± 20 mA
- Voltage: ± 10 V dc, 0 to 10 V dc, ± 5 Vdc, 0 to 5Vdc, 1Vdc to 5Vdc.

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Refer to Chapter 17 for more information about Terminal Blocks. Terminal Blocks are ordered separately.

These modules must be located in an RX3i Universal Backplane.

9.8.1 Features

- Completely software-configurable, no module jumpers to set
- Full auto-calibration
- On-board error-checking
- Open-circuit detection for all voltage and 4-20mA inputs
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program
- Flash memory for future upgrades
- Positive and negative Rate of Change Alarms
- Auto-calibration at startup
- Configurable interrupts for channel alarms and faults
- Terminal Block insertion or removal detection
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

9.8.2 LEDs: ALG608 & ALG616

The **Module OK** LED indicates module status. The **Field Status** LED indicates the presence of a fault on at least one channel or a terminal block error. The **TB** (Terminal Block) LED indicates the presence or absence of the terminal block. LEDs are powered by the backplane power bus.

LED	Indicates
Module OK	ON Green: Module OK and configured. Slow Flashing Green or Amber: Module OK but not configured. Quick Flashing Green: Error. OFF: Module is defective or no backplane power present
Field Status	ON Green: No faults on any enabled channel, and Terminal Block is present. ON Yellow: Fault on at least one channel. OFF: Terminal block not present or not fully seated.
TB	ON Red: Terminal block not present or not fully seated. ON Green: Terminal block is present. OFF: No backplane power to module.

9.8.3 Specifications: ALG608 & ALG616

Input Ranges	Current: 0 to 20mA, 4 to 20mA, ± 20 mA Voltage: ± 10 V dc, 0 to 10 V dc, ± 5 Vdc, 0 to 5Vdc, 1Vdc to 5Vdc				
Backplane Power Requirements	Module	Rev	5.0V +5% / -2.5%	3.3V +5% / -3%	
	ALG608	-EA & earlier	330mA max	600mA max	
		-FB & later	200mA max	200mA max	
	ALG616	-EA & earlier	450mA max	600mA max	
-FB & later		350mA max	200mA max		
CPU Version	PACSystems RX3i CPU firmware version 3.0 and later				
Programmer Version	Machine Edition version 5.0 SP3 and later				
Power Dissipation within Module	Module	Rev	Power Dissipation		
	ALG608	-EA & earlier	4.83W max		
		-FB & later	2.58W max		
	ALG616	-EA & earlier	6.48W max		
-FB & later		4.25W max			
Thermal De-rating	None				
Resolution	Refer to the table <i>Resolution and Range Types</i> in this section.				
Input Data Format	Configurable as floating point IEEE 32 bit or 16-bit integer in a 32-bit field				
Filter Options	8Hz, 12Hz, 16Hz, 40Hz, 200Hz, 500Hz				
Module Scan Time (in ms)	The module scan can consist of up to four acquisition cycles. Each cycle includes a specific set of channels, as described in the section "Channel Scanning". Total Scan Time depends on the number of acquisition cycles in the scan, and the configured filter option.				
<p style="text-align: center;"><i>Configured Filter</i></p>	<i>Number of Acquisition Cycles in the Scan</i>				
		1	2	3	4
	8 Hz filter	121	241	362	482
	12 Hz filter	81	161	242	322
	16 Hz filter	61	121	182	242
	40 Hz filter	21	41	62	82
	200 Hz filter	5	9	14	18
	500 Hz filter, filtering and rate detection disabled	3	5	7	9
	500 Hz filter, all options enabled	3	6	9	12
Input Impedance	>100 k Ω voltage inputs				
Current Input Resistance	249 Ω $\pm 1\%$				
Open Circuit Detection time	1 second maximum				
Over-voltage	± 60 V dc continuous, maximum				
Overcurrent	± 28 mA continuous, maximum				

Normal Mode Noise Rejection in dB		At 50Hz	At 60Hz
	8 Hz filter	103	97
	12 Hz filter	94	89
	16 Hz filter	39	65
	40 Hz filter	4	7
	200 Hz filter	0.1	0.2
	500 Hz	0.0	0.0
Common Mode Noise Rejection	120dB minimum at 50/60 Hz with 8 Hz filter 110dB minimum at 50/60 Hz with 12 Hz filter		
Channel-Channel DC Crosstalk	-80 dB minimum (single ended mode) -80 dB minimum (differential mode, grounded common) -60 dB minimum (differential mode, floating common)		
Calibrated Accuracy ⁵⁵ at 13°C – 33°C with 8 Hz, 12 Hz and 16 Hz filter	±5Vdc, ±10 V dc, ±20 mA: 0.05% of range. 0 to 10 V dc, 0 to 5Vdc, 1Vdc to 5Vdc, 0 to 20 mA: 0.1% of range. 4 to 20 mA: 0.125% of range		
Calibrated Accuracy ⁵⁵ at 0°C – 60°C with 8 Hz, 12 Hz and 16 Hz filter	0 to 10 V dc, 0 to 5Vdc, 1Vdc to 5Vdc: 0.2% of range. 0 to 20 mA: 0.25% of range. 4 to 20 mA: 0.3125% of range. ±5Vdc, ±10 V dc: 0.1% ±20 mA: 0.125% of range.		
Calibration Interval	12 months typical to meet accuracy specifications over time. Offset can be applied as a periodic calibration adjustment.		
Isolation Voltage terminal block to backplane/chassis	Opto-isolated, transformer isolated 250 V ac continuous/1500 V ac for 1 minute		

For product standards and general specifications, refer to *Appendix A*.

⁵⁵ In the presence of severe RF interference (IC 801-3, 10V/m), accuracy may be degraded by ±1.5% of range.

9.8.4 Configuration: ALG608 & ALG616

9.8.4.1 Module Parameters: ALG608 & ALG616

Parameter	Default	Description
Channel Value Reference Address	%Alxxxxx	Starting address for the input data of the module. This defaults to the next available %AI block.
Channel Value Reference Length	ALG608: 16 ALG616: 32	The number of words used for the input data of the module. This parameter cannot be changed.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data.
Diagnostic Reference Length	0	The number of bit reference bits required for the Channel Diagnostics data. When set to 0, Channel Diagnostics is disabled. To enable Channel Diagnostics mapping, change this to a non-zero value.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of the module.
Module Status Reference Length	0	The number of bits (0 to 32) required for the Module Status data. When set to 0, mapping of Module Status data is disabled. To enable Module Status data mapping, change this to a non-zero value.
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Inputs Default	Force Off	In the event of module failure or removal, this parameter specifies the state of all Channel Value References for the module. Force Off = Channel Values clear to 0. Hold Last State = Channels hold their last state.
Inputs Default w/o Terminal Block	Enabled	Enabled / Disabled: Controls whether inputs will be set to their defaults if the Terminal Block is removed.
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses are generated after Terminal Block removal. If Disabled, channel faults and alarms are suppressed when the Terminal Block is removed. This setting does not affect module faults including the Terminal Block loss/add fault generation.
Analog Input Mode	Single-ended Input Mode	Single-ended / Differential: This selection must match the input wiring to the module.
A/D Filter Frequency	40Hz	Low pass A/D hardware filter setting for all inputs: 8, 12, 16, 40, 200, or 500Hz. Frequencies below the filter setting are not filtered by hardware.
Range Type	Disabled	Current/Voltage, Disabled
Range (Not for Range Type Disabled)	-10 V dc to +10 V dc	Current/Voltage: -10 V dc to +10 V dc, 0 to +10 V dc, 0 to +5Vdc, 1Vdc to +5Vdc, -5Vdc to +5Vdc, -20mA to +20mA, 4 to 20 mA, 0 to 20 mA

9.8.4.2 Channel Parameters: ALG608 & ALG616

Parameter	Default	Description
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default is High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

9.8.4.3 Input Scaling: ALG608 & ALG616

By default, the module converts a voltage or current input over the entire span of its configured Range into a floating point value for the CPU. For example, if the Range of a channel is 4 to 20mA, the module reports channel input values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the PLC that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example 1

For a voltage input, 6.0 volts represents a speed of 20 feet per second, and 1.0 volt represents 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000

Low Scale Value (Eng Units) = 0.000

High Scale Value (A/D Units) = 6.000

Low Scale Value (A/D Units) = 1.000

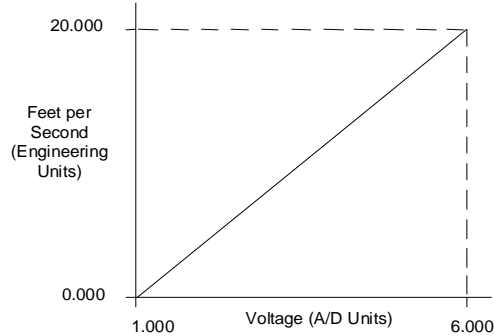


Figure 286: Scaling Example ALG608 or ALG616

For this example, 1.0 V dc to 6.0 V dc is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 10.0 V dc were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or take other precautions for scaled inputs that are outside the acceptable range or invalid.

Example 2

An existing application uses traditional analog to digital (A/D) count integer values. With scaling and the optional 16-bit integer input option, a channel can be configured to report integer count values. In this example, the application should interpret +10 V dc as 32000 counts and -10 V dc as -32000 counts. The following channel configuration will scale a ± 10 V dc input channel to ± 32000 counts.

Channel Value Format = 16 Bit Integer

High Scale Value (Eng Units) = 32000.0

Low Scale Value (Eng Units) = -32000.0

High Scale Value (A/D Units) = 10.000

Low Scale Value (A/D Units) = -10.000

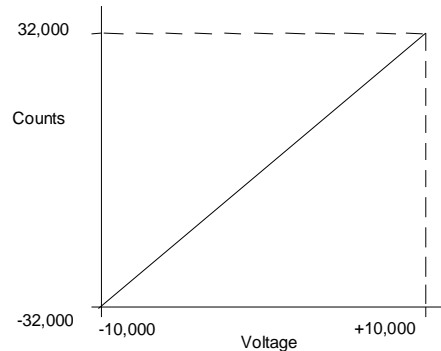


Figure 287: Scaling Example ALG608 or ALG616

Channel Parameters (Continued)

Parameter	Default	Description
Positive Rate of Change Limit (Eng Units)	0.0	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. Default is disabled. Used with <i>Rate of Change Sampling Rate</i> parameter.
Negative Rate of Change Limit (Eng Units)	0.0	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. Default is disabled. Used with <i>Rate of Change Sampling Rate</i> parameter.
Rate of Change Sampling Rate	0.0	Time from 0 to 300 seconds to wait between comparisons. Default of 0.0 is to check after every input sample.

9.8.4.4 Rate of Change Alarms: ALG608 & ALG616

Modules IC695ALG608 and IC695ALG616 can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous rate of change sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Unit change between samples is positive, the module compares the results in comparing the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the "Diagnostic Reporting Enable", "Fault Reporting Enable", and "Interrupts Enabled" parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. If the Rate of Change Sampling Rate is 0 or any time period less than the channel update rate, the module compares the Rate of Change for every input sample of the channel.

Channel Parameters (Continued)

Parameter	Default	Description
High-High Alarm (Eng Units)	The defaults for the High-High, High, Low, and Low-Low parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of default values.	<p>Alarms and Deadbands</p> <p>All of the alarm parameters are specified in Engineering Units. To use alarming, the A/D Alarm Mode must also be configured as enabled.</p> <p><i>High-High Alarm and Low-Low Alarm:</i> When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.</p> <p><i>High Alarm and Low Alarm:</i> When the configured value is reached or below (above), a Low (High) Alarm is triggered.</p> <p>High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.</p> <p>Alarm Deadbands should not cause the alarm clear condition to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.</p>
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
Low-Low Alarm Deadband (Eng Units)		
User Offset	0.0	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filtering	Disabled	Disabled / Enabled. Controls whether software filtering will be performed on the inputs.
Integration Time (ms)	0	<p>Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value.</p> <p>A value of 0 indicates software filter is disabled.</p> <p>A value of 100 indicates data will achieve 63.2% of its value in 100ms.</p> <p>Default is 0.</p>

9.8.4.5 Using Alarming: ALG608 & ALG616

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

9.8.4.6 Using Interrupts: ALG608 & ALG616

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of the module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address of the corresponding channel.

Example:

In this example, the Channel Values Reference Address block is mapped to %AI0001-%AI0020. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AI00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AI0003" as the Trigger.

Fault Reporting and Interrupts: ALG608 & ALG616

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

9.8.5 Module Data: ALG608 & ALG616

The module reports its input channel data in its configured input words, beginning at its assigned Channel Value Reference Address. Each channel occupies two words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

For Module IC695ALG616 Only:

+16, 17	Channel 9
+18, 19	Channel 10
+20, 21	Channel 11
+22, 23	Channel 12
+24, 25	Channel 13
+26, 27	Channel 14
+28, 29	Channel 15
+30, 31	Channel 16

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

9.8.5.1 Resolution and Range Types: ALG608 & ALG616

The actual resolution for each input depends on the Range Type and A/D Filter Frequency configured for that channel. At higher Filter Frequencies, input resolution decreases. The approximate resolution in bits for each Filter Frequency and Range Type are displayed in the following table.

Resolution (in bits)			
Filter Frequency	Range Type		
	±10 V dc	0 to 10 V dc, ±5Vdc, ±20 V dc	0 to 5Vdc, 1 to 5Vdc, 0 to 20mA, 4 to 20mA
8 Hz	18	17	16
12 Hz	17	16	15
16 Hz	17	16	15
40 Hz	16	15	14
200 Hz	15	14	13
500 Hz	14	13	12

9.8.5.2 Channel Scanning: ALG608 & ALG616

These modules use 4 A/D converters to achieve the fastest possible channel scan times. The module has up to four acquisition cycles for each module scan. The acquisition cycles and channels acquired during each cycle are:

Acquisition Cycle	Channels Acquired	
	IC695ALG608	IC695ALG616
1	1, 5	1, 5, 9, 13
2	2, 6	2, 6, 10, 14
3	3, 7	3, 7, 11, 15
4	4, 8	4, 8, 12, 16

To bypass an acquisition cycle, all channels that would be acquired during that cycle must be disabled.

For fastest scan times, always wire by acquisition cycle. For example, if only eight channels were used on the 16-channel module, IC695ALG616, channels 1, 2, 5, 6, 9, 10, 13, and 14 should be used for optimum performance.

9.8.5.3 Channel Diagnostic Data: ALG608 and ALG616

In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for the module. Use of this feature is optional.

The diagnostics data for each channel occupies two words (whether the channel is used or not):

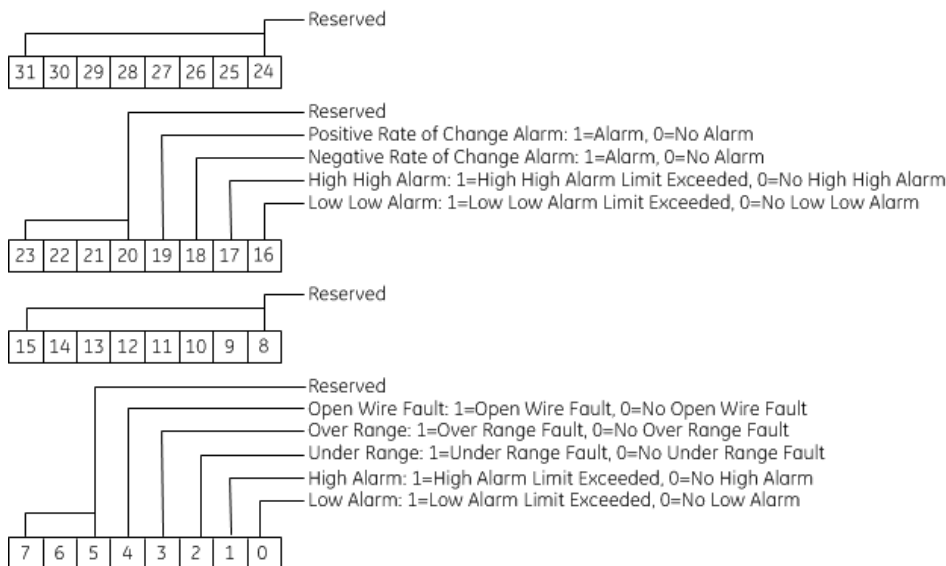
Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

For Module IC695ALG616 Only:

+16, 17	Channel 9
+18, 19	Channel 10
+20, 21	Channel 11
+22, 23	Channel 12
+24, 25	Channel 13
+26, 27	Channel 14
+28, 29	Channel 15
+30, 31	Channel 16

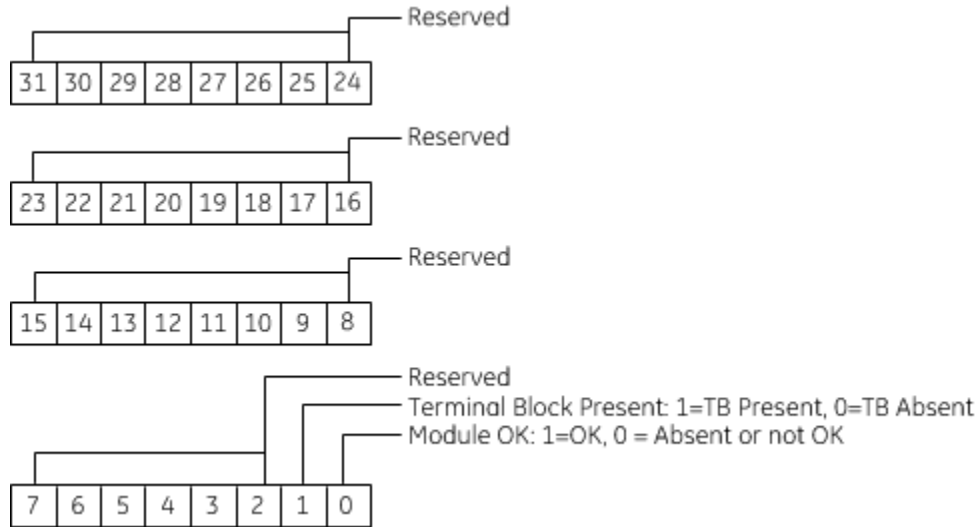
When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



9.8.5.4 Module Status Data: ALG608 & ALG616

The module can also optionally be configured to return two bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data* reference area configured for the module.



Terminal Block Detection

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of the module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 1 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

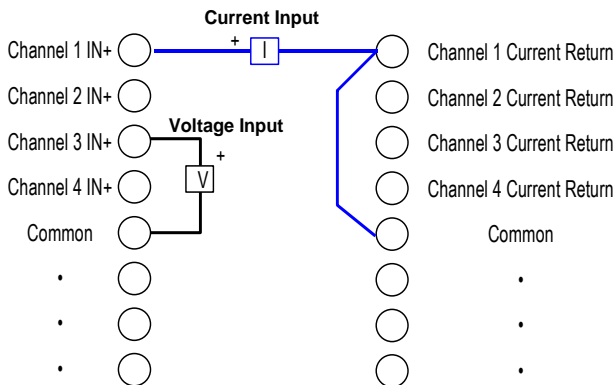
9.8.6 Field Wiring: ALG608 & ALG616, Single-Ended Mode

The following table lists wiring connections for Non-Isolated Analog Input Modules in Single-ended mode. Single-ended mode is the configured default operating mode.

Terminal	IC695ALG608	IC695ALG616	IC695ALG608	IC695ALG616	Terminal
1	Channel 1 IN+		Channel 1 Current Return (IRTN1)		19
2	Channel 2 IN+		Channel 2 Current Return (IRTN2)		20
3	Channel 3 IN+		Channel 3 Current Return (IRTN3)		21
4	Channel 4 IN+		Channel 4 Current Return (IRTN4)		22
5	Common		Common		23
6	Channel 5 IN+		Channel 5 Current Return (IRTN5)		24
7	Channel 6 IN+		Channel 6 Current Return (IRTN6)		25
8	Channel 7 IN+		Channel 7 Current Return (IRTN7)		26
9	Channel 8 IN+		Channel 8 Current Return (IRTN8)		27
10	No Connection	Channel 9 IN+	No Connection	Channel 9 Current Return (IRTN9)	28
11	No Connection	Channel 10 IN+	No Connection	Channel 10 Current Return (IRTN10)	29
12	No Connection	Channel 11 IN+	No Connection	Channel 11 Current Return (IRTN11)	30
13	No Connection	Channel 12 IN+	No Connection	Channel 12 Current Return (IRTN12)	31
14	Common		Common		32
15	No Connection	Channel 13 IN+	No Connection	Channel 13 Current Return (IRTN13)	33
16	No Connection	Channel 14 IN+	No Connection	Channel 14 Current Return (IRTN14)	34
17	No Connection	Channel 15 IN+	No Connection	Channel 15 Current Return (IRTN15)	35
18	No Connection	Channel 16 IN+	No Connection	Channel 16 Current Return (IRTN16)	36

There are no shield terminals on these modules. For shielding, tie the cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided for this purpose.

All the common terminals are connected together internally, so any common terminal can be used for the negative lead of the external power supply.



For single-ended mode, a voltage input should be connected between its Channel IN+ terminal and a Common (CM) return terminal.

A current input should be connected between its Channel IN+ terminal and its Channel Current Return Terminal. In addition, a jumper wire should be connected between the Channel Current Return terminal and a Common (COM) return.

Figure 288: Field Wiring, Single-Ended ALG608 or ALG616

9.8.7 Field Wiring: ALG608 & ALG616, Differential Mode

The following table lists wiring connections for Non-Isolated Analog Input Modules configured for Differential mode.

Terminal	IC695ALG608	IC695ALG616	IC695ALG608	IC695ALG616	Terminal
1	Channel 1 IN+		Channel 1 Current Return (IRTN1)		19
2	Channel 1 IN -		No Connection		20
3	Channel 2 IN+		Channel 2 Current Return (IRTN3)		21
4	Channel 2 IN -		No Connection		22
5	Common		Common		23
6	Channel 3 IN+		Channel 3 Current Return (IRTN5)		24
7	Channel 3 IN-		No Connection		25
8	Channel 4 IN+		Channel 4 Current Return (IRTN7)		26
9	Channel 4 IN-		No Connection		27
10	No Connection	Channel 5 IN+	No Connection	Channel 5 Current Return (IRTN9)	28
11	No Connection	Channel 5 IN-	No Connection		29
12	No Connection	Channel 6 IN+	No Connection	Channel 6 Current Return (IRTN11)	30
13	No Connection	Channel 6 IN-	No Connection		31
14	Common		Common		32
15	No Connection	Channel 7 IN+	No Connection	Channel 7 Current Return (IRTN13)	33
16	No Connection	Channel 7 IN-	No Connection		34
17	No Connection	Channel 8 IN+	No Connection	Channel 8 Current Return (IRTN15)	35
18	No Connection	Channel 8 IN-	No Connection		36

There are no shield terminals on these modules. For shielding, tie the cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided for this purpose.

All the common terminals are connected together internally, so any common terminal can be used for the negative lead of the external power supply.

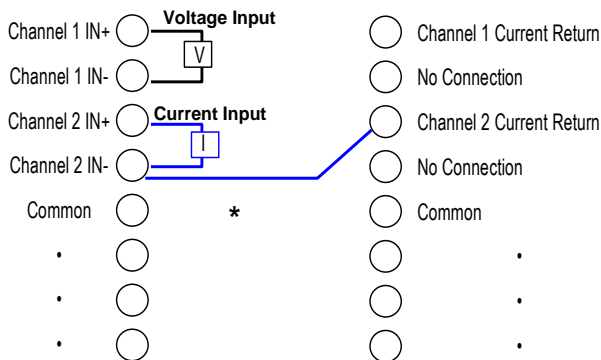


Figure 289: Field Wiring, Differential Mode ALG608 or ALG616

* Keep this jumper as short as possible to minimize error due to the added resistance of the wire. This resistance should be 25mΩ or less.

For differential inputs, two adjacent terminals are connected as one channel. The lower-numbered terminal acts as the high side.

A voltage input is connected between the two adjacent Channel IN terminals as shown at left.

A current input is connected between the Channel IN+ and Current Return terminals for that channel. In addition, a jumper wire must be connected between the Channel IN - terminal and the corresponding Channel Current Return terminal.

Tie common to signal ground for improved channel-to-channel Crosstalk immunity.

Two door cards are provided with the module: one shows connections for single-ended mode and the other shows connections for differential mode. Insert the card that matches the wiring that will be used.

Chapter 10 Analog Output Modules

This chapter describes Analog Output modules for PACSystems RX3i controllers.

Analog Output Module Description	Catalog Number	Section
Analog Output 2-Channel Voltage	IC694ALG390	10.1
Analog Output 2-Channel Current	IC694ALG391	10.2
Analog Output 8-Channel Current/Voltage	IC694ALG392	10.3
Analog Output 4-Channel Current/Voltage	IC695ALG704	10.4
Analog Output 8-Channel Current/Voltage	IC695ALG708	10.4
Analog Output 8-Channel Current/Voltage Isolated	IC695ALG808	10.5

10.1 Analog Output Module Voltage 2-Channel: IC694ALG390

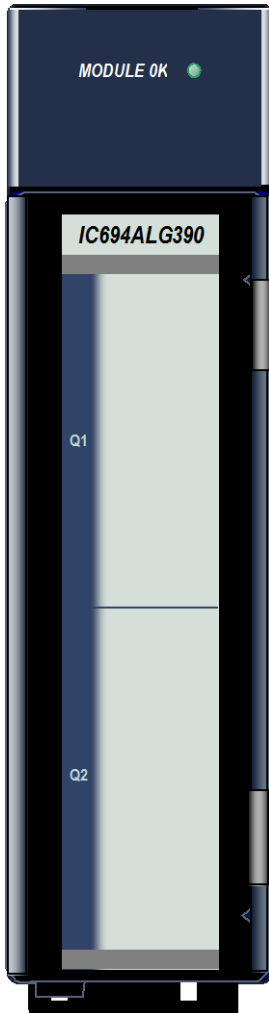


Figure 290: IC694ALG390

The **2-Channel Analog Voltage Output** module, IC694ALG390, has two output channels, each capable of converting 13 bits of binary (digital) data to an analog output signal for field devices. The Analog Voltage Output module provides outputs in the range of -10 volts to +10 volts. Both channels are updated on every scan.

The outputs on this module can be set up to either *Default to 0 volts* or *Hold-Last-State* if the CPU goes to the Stop mode or Reset. Selection of the output default state is made by a jumper on the module. If the jumper is not installed, the outputs Hold Last State.

This module can be installed in any I/O slot in an RX3i system.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

10.1.1 Isolated +24Vdc Power

The module must receive its 24Vdc power from an external source. The external source must be connected directly to the terminal block of this module. It cannot be connected via the TB1 connector on the RX3i Universal Backplane.

10.1.2 LED

The **Module OK** LED is ON when the module power supply is operating.

10.1.3 Specifications: ALG390

Voltage Range	-10 to +10 volts
Calibration	Factory calibrated to 2.5 mV per count
Supply Voltage (nominal)	+24Vdc, from isolated +24Vdc on backplane or user-supplied voltage source, and +5Vdc from backplane
External Supply Voltage Range	18Vdc to 30 V dc
External Supply Voltage Ripple	10%
Update Rate	Approximately 5ms (both channels) Update rate is application dependent.
Resolution	2.5 mV (1 LSB = 2.5 mV)
Absolute Accuracy ⁵⁶	±5 mV at 25°C (77°F)
Offset	1 mV maximum, 0°C to 60°C (32°F to 140°F)
Output Loading (maximum)	5 mA (2kΩ minimum resistance)
Output Load Capacitance	2000 pF, maximum
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V dc for 1 minute
Internal Power Consumption	32 mA from +5Vdc supply 120 mA from +24Vdc supply (isolated backplane or user supply)

For product standards and general specifications, refer to *Appendix A*.

⁵⁶ In the presence of severe RF interference (IEC 801-3, 10V/m), accuracy may be degraded to ±50 mV.

10.1.4 Module Data: ALG390

Module data is stored by the PLC CPU in 16-bit 2's complement format:

MSB											LSB				
+/-	10	9	8	7	6	5	4	3	2	1	0	X	X	X	X

Resolution of the converted signal is 12 bits binary plus sign, which is effectively 13 bits (1 part in 8192). The module scales the digital data to create an output voltage for the output:

10.1.4.1 D/A Bits versus Output Voltage

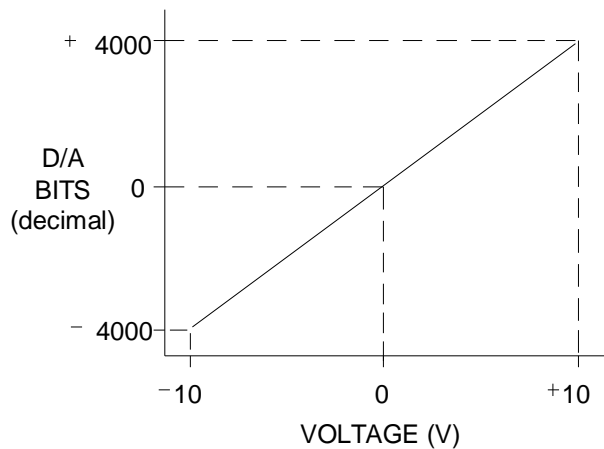


Figure 291: D/A Bits versus Output Voltage

10.1.4.2 Scaling: ALG390

Scaling of the output is displayed in the following figure.

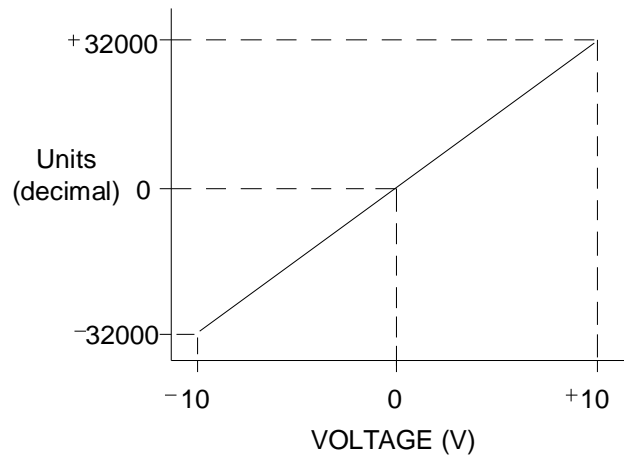
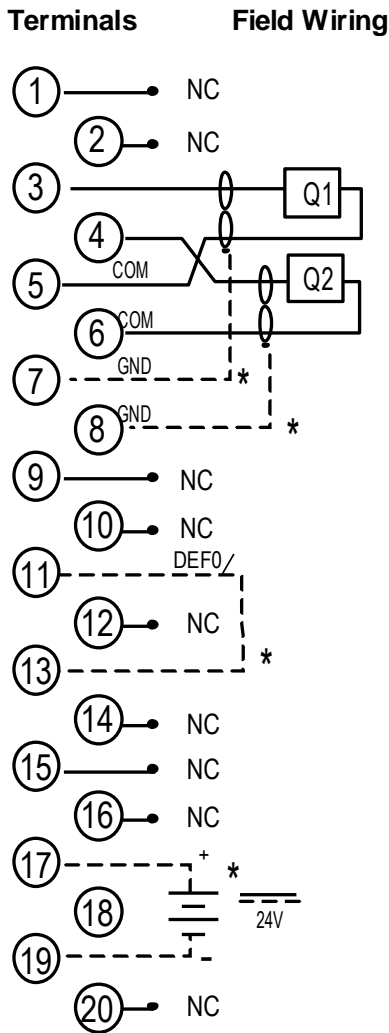


Figure 292: Scaling Units versus Output Voltage

10.1.5 Field Wiring: ALG390



*Optional Connections

Terminal	Connection
1	No connection
2	No connection
3	Output 1
4	Output 2
5	Output 1 Common
6	Output 2 Common
7	Shield termination point for output 1
8	Shield termination point for output 2
9	No connection
10	No connection
11 - 13	Output default selection jumper
12	No connection
13	Output default selection jumper
14	No connection
15	No connection
16	No connection
17	External +24Vdc Power Supply +
18	No connection
19	External +24Vdc Power Supply -
20	No connection

To minimize capacitive loading and noise, all field connections should be wired using a good grade of twisted, shielded instrumentation cable. The shields should be connected to GND on the user terminal connector block. The GND connection provides access to the backplane (frame ground) resulting in superior rejection of noise caused by any shield drain currents.

DEF0 is the optional Output Default Jumper. It determines the operation of both outputs when the CPU is in Stop or Reset mode. The jumper should be installed if outputs should default to 0. The jumper should not be installed if outputs should hold their last state (the last valid commanded value received from the CPU).

An optional external +24Vdc supply can be installed as shown.

10.2 Analog Output Module Current 2-Channel: IC694ALG391

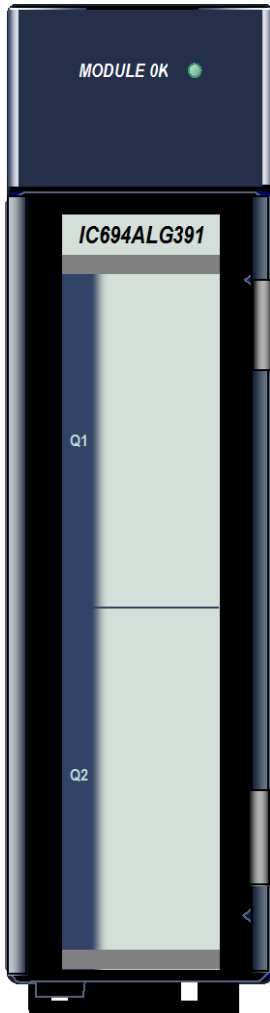


Figure 293: IC694ALG391

The **2-Channel Analog Current Output** module, IC694ALG391, has two output channels, each capable of converting 12 bits of binary (digital) data to an analog output signal for field devices. Each output can be set using a jumper on the module to produce output signals in one of two ranges:

- 0 to 20 mA
- 4 to 20 mA.

Each output may also be set up as a less accurate voltage source. The selection of current or voltage output is made with a jumper or resistor on the module terminals. Both channels are updated on every scan.

The outputs on this module can be set up to either *Default to 0/4 mA* or *Hold-Last-State* if the CPU goes to the Stop mode or Reset. Selection of the output default state is made by a jumper on the terminal board of this module. Refer to Output Defaults in this section for more information.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

10.2.1 LED

The **Module OK** LED is ON when the module power supply is operating.

10.2.2 Isolated +24Vdc Power

If the module is located in an RX3i Universal Backplane, an external source of Isolated +24Vdc is required to provide power for the module. The external source can be connected via the TB1 connector on the left side of the backplane or directly on the terminal block of this module.

If this module is located in an Expansion or Remote backplane, its primary power source can be either the Isolated +24Vdc from the backplane power supply or an external Isolated +24Vdc power supply connected to the terminal block of this module. If the external source is set between 27.5-30 V dc, it takes over the load from the Isolated 24Vdc system supply. Note that an external source should be used if it is desired to maintain hold last state operation during a loss of backplane power.

10.2.3 Specifications: ALG391

Output Current Range	4 to 20 mA and 0 to 20 mA
Output Voltage Range	1 to 5 volts and 0 to 5 volts
Calibration	Factory calibrated to 4 μ A per count
External Supply Voltage Range	20 V dc to 30 V dc. Depends on the current load and the ambient temperature as displayed in Figure 294.
External Supply Voltage Ripple	10%
Update Rate	5 ms (approximate, both channels) Application dependent.
Resolution:	
4 to 20mA	4 μ A (1 LSB = 4 μ A)
0 to 20mA	5 μ A (1 LSB = 5 μ A)
1 to 5V	1 mV (1 LSB = 1 mV)
0 to 5V	1.25 mV (1 LSB = 1.25 mV)
Absolute Accuracy: ⁵⁷	
4 to 20mA	$\pm 8 \mu$ A at 25°C (77°F)
0 to 20mA	$\pm 10 \mu$ A at 25°C (77°F)
1 to 5V	± 50 mV at 25°C (77°F)
0 to 5V	± 50 mV at 25°C (77°F)
Maximum Compliance Voltage	25Vdc
User Load (current mode)	0 to 850 Ω
Output Load Capacitance (current mode)	2000 pF
Output Load Inductance (current mode)	1 H
Maximum Output Loading (voltage mode)	5 mA (2k Ω minimum resistance) (2000 pF maximum capacitance)
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V dc for 1 minute
Internal Power Consumption	30 mA from +5Vdc supply 215 mA from Isolated +24Vdc supply

For product standards and general specifications, refer to *Appendix A*.

10.2.3.1 Load Current Derating

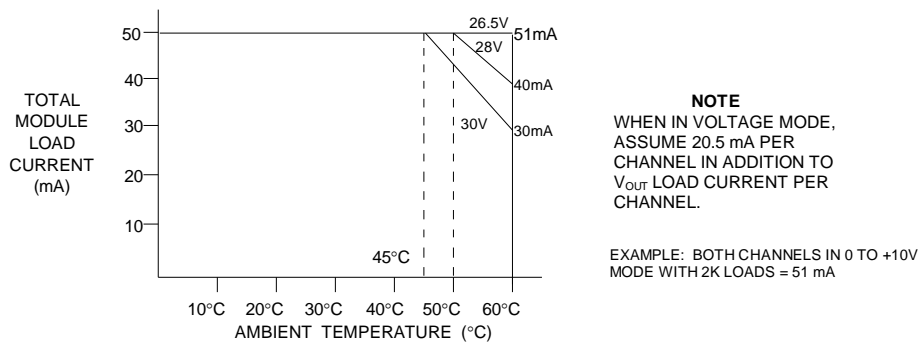


Figure 294: Derating Curve ALG391

⁵⁷ In the presence of severe RF interference (IEC 801-3, 10 V/m), accuracy may be degraded to $\pm 80 \mu$ A (4 to 20 mA range), $\pm 100 \mu$ A (0 to 20 mA range).

10.2.4 Module Data: ALG391

Module data is stored by the PLC CPU in 16-bit 2's complement format as displayed in the following figure.

MSB													LSB		
X	11	10	9	8	7	6	5	4	3	2	1	0	X	X	X

The 13 most significant bits from the %AQ register are converted to sign magnitude by the PLC and sent to the module.

10.2.4.1 D/A Bits versus Output Current

The module scales the output data received from the CPU according to the range selected for the channel.

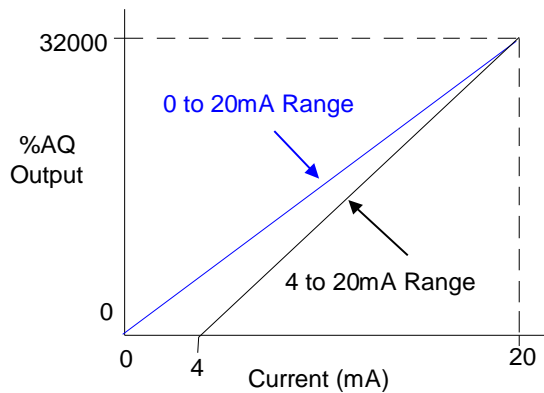


Figure 295: Relationship between Output Value (%AQ) and Output Current: ALG391

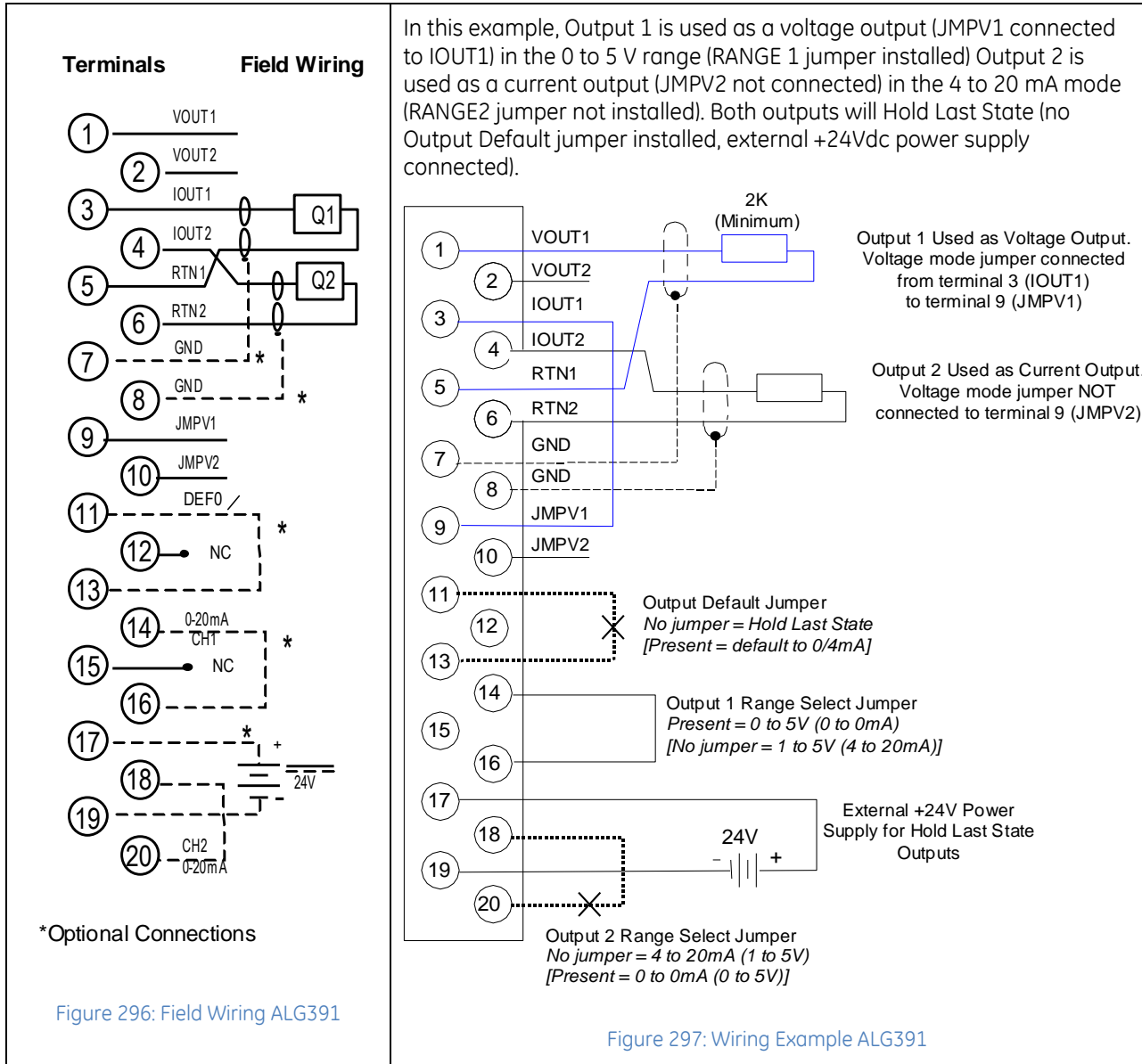
In the 4 to 20 mA range, the module scales output data with each 1000 counts representing 0.5 mA. In this range a count of 0 corresponds to 4 mA and a count of 32000 corresponds to 20 mA.

In the 0 to 20 mA range, the module scales output data so that each 800 counts represents 0.5 mA. In this range, a count of 0 corresponds to 0 mA and a count of 32000 corresponds to 20 mA with each 800 counts representing 0.5 mA.

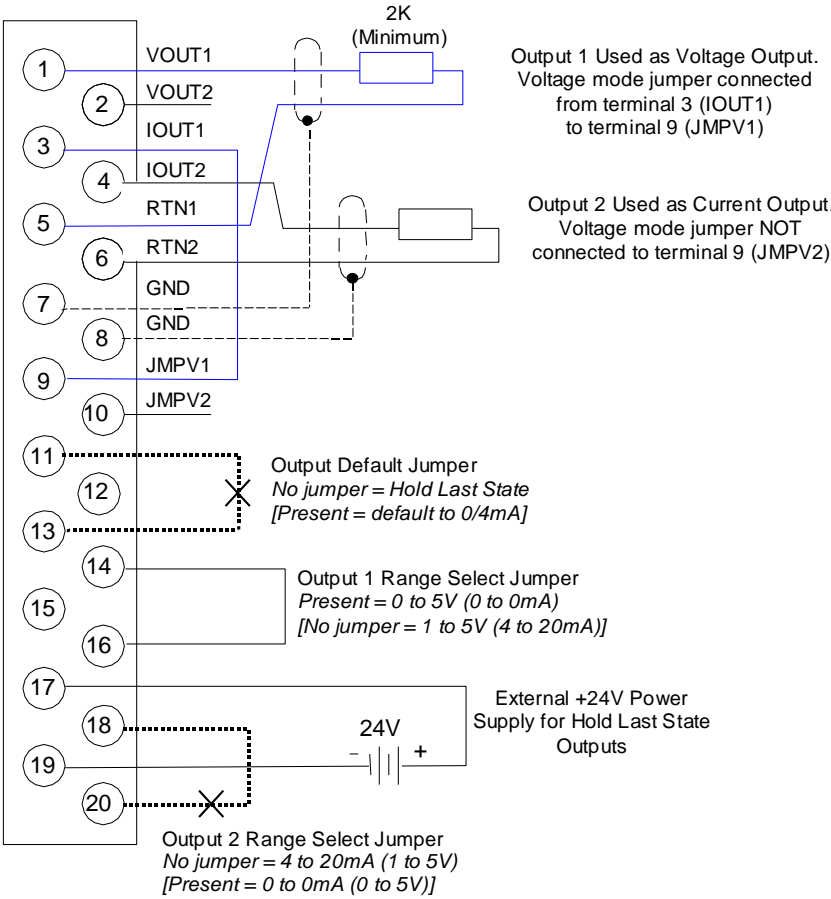
If the module receives negative data from the CPU, it outputs the low end of the range (either 0 mA or 4 mA). If a value greater than 32767 is received, it is not accepted.

10.2.5 Field Wiring: ALG391

To minimize the capacitive loading and noise, all field connections to the module should be wired using a good grade of twisted, shielded instrumentation cable. The shields should be connected to GND on the user terminal connector block. The GND connection provides access to the backplane (frame ground) resulting in superior rejection of noise caused by any shield drain currents. If no jumper is installed, the module performs as a current source. If the jumper is present, the module performs as a voltage source.



In this example, Output 1 is used as a voltage output (JMPV1 connected to IOUT1) in the 0 to 5 V range (RANGE 1 jumper installed) Output 2 is used as a current output (JMPV2 not connected) in the 4 to 20 mA mode (RANGE2 jumper not installed). Both outputs will Hold Last State (no Output Default jumper installed, external +24Vdc power supply connected).



10.2.5.1 Current or Voltage Outputs

The range of each channel and its operation in current or voltage mode are set with jumpers on the module terminals. For voltage operation, a 250 Ω resistor can be used instead of a voltage jumper to increase the voltage range. The following table lists the output ranges that can be set up for each output, and the jumper or resistor settings for each range.

Range of the Output	Range Jumper Installed	Voltage Jumper or Resistor Installed
4 mA to 20 mA	No	No
0 mA to 20 mA	Yes	No
0 Vdc to 5 Vdc	Yes	jumper
0 Vdc to 10 Vdc	Yes	250 Ω resistor
1 Vdc to 5 Vdc	No	jumper
2 Vdc to 10 Vdc	No	250 Ω resistor

10.2.5.2 Output Defaults

Both module outputs can be set to either Default to 0 or 4 mA or Hold Last State if the CPU goes to STOP mode or is Reset. The Output Default operation of this module is set using another jumper on the terminal block.

If the Output Default (DEF0/4) jumper is installed on module terminals 11 and 13, both outputs default to the low end of their ranges.

If the Output Default jumper is not installed, both outputs hold the last valid output value received from the PLC CPU. This option requires an external +24Vdc power supply to maintain output power when the system power goes down.

10.3 Analog Output Module Current/Voltage 8-Channel: IC694ALG392

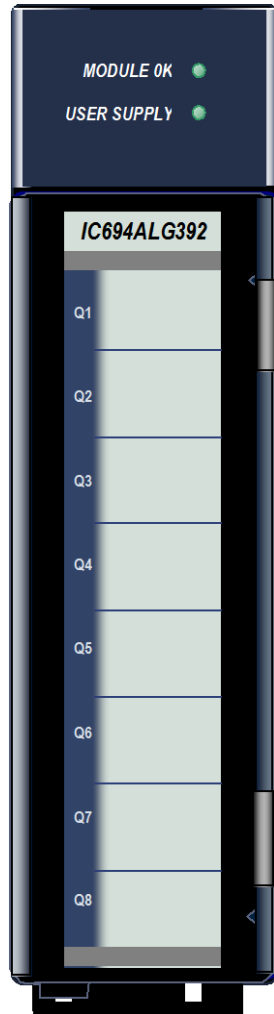


Figure 298: IC694ALG392

The **8-Channel Analog Current/Voltage Output** module; IC694ALG392, provides up to eight single-ended output channels with current loop outputs and/or voltage outputs. Each output channel can be set up using the configuration software for any of these ranges:

- 0 to +10 volts (unipolar)
- 10 to +10 volts (bipolar)
- 0 to 20 milliamps
- 4 to 20 milliamps

Each channel is capable of converting 15 to 16 bits (depending on the range selected) of binary data to an analog output. All eight channels are updated every 12 ms.

In current modes, the module reports an Open Wire fault to the CPU for each channel. The module can go to a known last state when system power is interrupted. As long as external power is applied to the module, each output will maintain its last value or reset to zero, as configured.

This module can be installed in any I/O slot of an RX3i system.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

10.3.1 Isolated +24Vdc Power

The module must receive its 24Vdc power from an external source.

If the module is located in an RX3i Universal Backplane, the external source can be connected via the TB1 connector on the left side of the backplane or directly to the module terminal block.

If this module is located in an Expansion or Remote backplane, the external source must be connected to the terminal block of this module.

10.3.2 LEDs: ALG392

The **Module OK** LED indicates module status. The **User Supply** LED indicates whether the external +24Vdc power supply is present and is above the minimum level. Both LEDs are powered from the +5Vdc backplane power bus.

LED	Indicates
Module OK	ON: Module OK and configured Flashing: Module OK but not configured OFF: Module is defective or no +5V backplane power present
User Supply	ON: External power supply present OFF: No user power

10.3.3 Specifications: ALG392

Number of Output Channels	1 to 8 selectable, single-ended
Output Current Range	4 to 20 mA and 0 to 20 mA
Output Voltage Range	0 to 10 V and -10 V to +10 V
Calibration	Factory calibrated to .625 μ A for 0 to 20 mA; 0.5 μ A for 4 to 20 mA; and .3125 mV for voltage (per count)
User Supply Voltage (nominal)	+24Vdc, from user supplied voltage source
External Supply Voltage Range	20 V dc to 30 V dc
Power Supply Rejection Ratio (PSRR)	
Current	5 μ A/V (typical), 10 μ A/V (maximum)
Voltage	25 mV/V (typical), 50 mV/V (maximum)
External Power Supply Voltage Ripple	10% (maximum)
Internal Supply Voltage	+5Vdc from PLC backplane
Update Rate	8 ms (approximate, all eight channels) Determined by I/O scan time, application dependent.
Resolution:	4 to 20mA: 0.5 μ A (1 LSB = 0.5 μ A) 0 to 20mA: 0.625 μ A (1 LSB = 0.625 μ A) 0 to 10 V dc: 0.3125 mV (1 LSB = 0.3125 mV) -10 to +10 V dc: 0.3125 mV (1 LSB = 0.3125 mV)
Absolute Accuracy: ⁵⁸	
Current Mode	\pm 0.1% of full scale at 25°C (77°F), typical \pm 0.25% of full scale at 25°C (77°F), maximum
Voltage Mode	\pm 0.5% of full scale over operating temperature range (maximum) \pm 0.25% of full scale at 25°C (77°F), typical \pm 0.5% of full scale at 25°C (77°F), maximum \pm 1.0% of full scale over operating temperature range (maximum)
Maximum Compliance Voltage	$V_{USER} - 3$ V (minimum) to V_{USER} (maximum)
User Load (current mode)	0 to 850 Ω (minimum at $V_{USER} = 20$ V, maximum 1350 Ω at $V_{USER} = 30$ V) (Load less than 800 Ω is temperature dependent.)
Output Load Capacitance (current mode)	2000 pF (maximum)
Output Load Inductance (current mode)	1 H
Output Loading (voltage mode)	5 mA (2k Ω minimum resistance)
Output load Capacitance	(1 μ F maximum capacitance)
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V dc for 1 minute
Power Consumption	110 mA from +5Vdc PLC backplane supply 315 mA from +24Vdc user supply

For product standards and general specifications, refer to *Appendix A*.

In order to meet the IEC 1000-4-3 levels for RF Susceptibility specified in *Appendix A*, when this module is present, the system must be mounted in a metal enclosure.

⁵⁸ In the presence of severe RF interference (IEC 801-3, 10V/m), accuracy may be degraded to \pm 1% full scale (FS) for current outputs and \pm 3% FS for voltage outputs.

10.3.3.1 Derating Graphs: ALG392

For maximum performance and module life, the module should be operated at maximum load resistance to offload heat. Module thermal derating depends on the voltage level and the use of current and voltage outputs. The first two charts (in Figure 299 below) show the maximum ambient temperature for current-only modules at 30 V dc and at 26.5Vdc, respectively.

Current Outputs Only

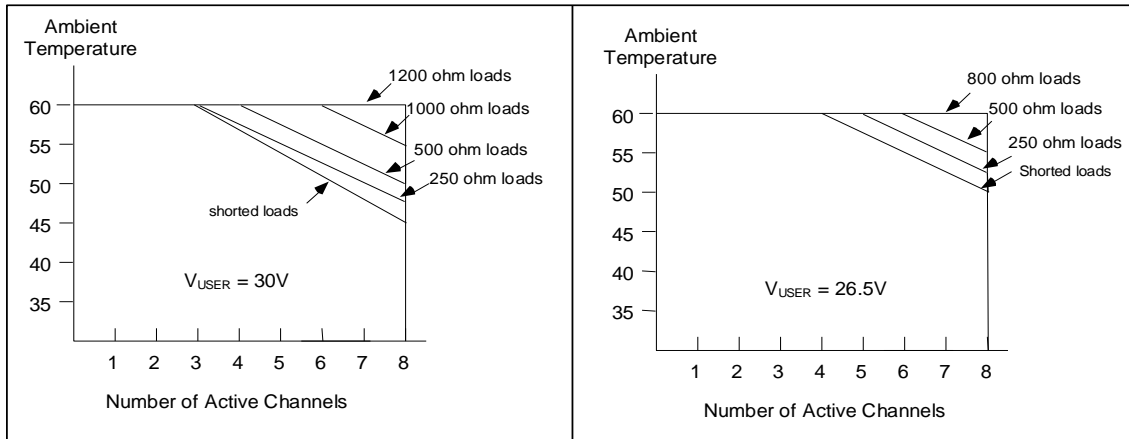


Figure 299: Derating for Current Outputs: ALG392

Mixed Current and Voltage Outputs

In the derating graphs displayed in Figure 300, voltage channels have 2kΩ loads and current channels have shorted loads. To determine the maximum operating temperature for mixed current and voltage outputs, select the line in the chart below that corresponds to the number of voltage channels being used. For example, a module uses two voltage channels and three current channels. The total channels in use is five, so, from Figure 300, the maximum operating temperature is approximately 52.5°C:

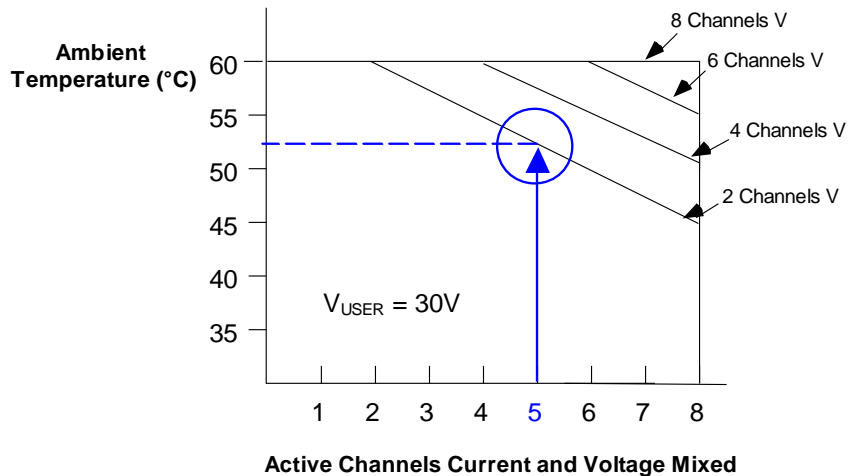


Figure 300: Derating for Mixed Current & Voltage Outputs: ALG392

10.3.4 Current and Voltage Ranges and Resolution: ALG392

In the 4 to 20 mA range the module scans output data from the PLC so that 4 mA corresponds to a count of 0, and 20 mA corresponds to a count of 32000. In the 0 to 20 mA range, user data is scaled so that 0 mA corresponds to a count of 0 and 20 mA corresponds to 32000. In 0 to 20 mA mode, a value up to 32767 provides a maximum output of approximately 20.5 mA. In current mode, the module also reports an open loop fault to the PLC.

For voltage operation in the default unipolar mode (0 to +10 volts), data is scaled so that 0 volts corresponds to a count of 0 and +10 volts corresponds to a count of 32000. In this mode, a value up to 32767 creates an over-range output of approximately 10.24 volts.

In the -10 to +10 volt range, data is scaled so that -10 volts corresponds to a count of -32000 and +10 volts corresponds to a count of +32000. In this range, output values from -32767 to +32767 result in an over-range of approximately -10.24 volts to +10.24 volts.

Scaling for both current and voltage ranges is displayed in the following figure.

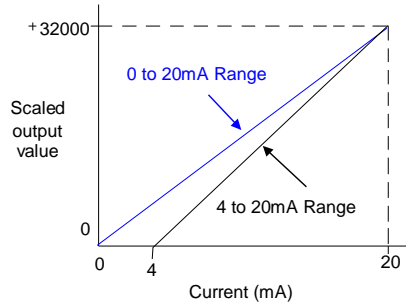


Figure 301: Scaling for Current Modes: ALG392

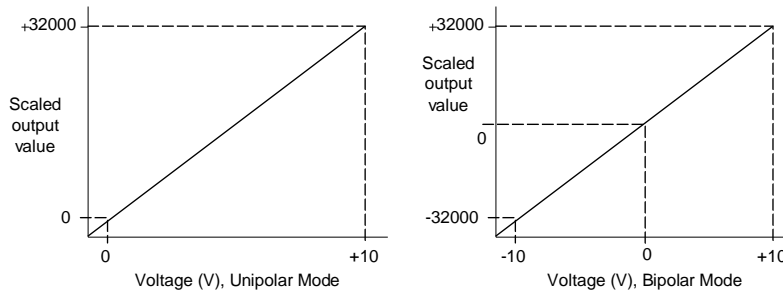


Figure 302: Scaling for Voltage Modes: ALG392

The resolution per bit depends on the configured range of that channel:

4 to 20 mA:	0.5 μ A
0 to 20 mA:	0.625 μ A
0 to 10 Vdc:	0.3125 mV
-10 V dc to +10 V dc:	0.3125 mV

10.3.5 Module Data: ALG392

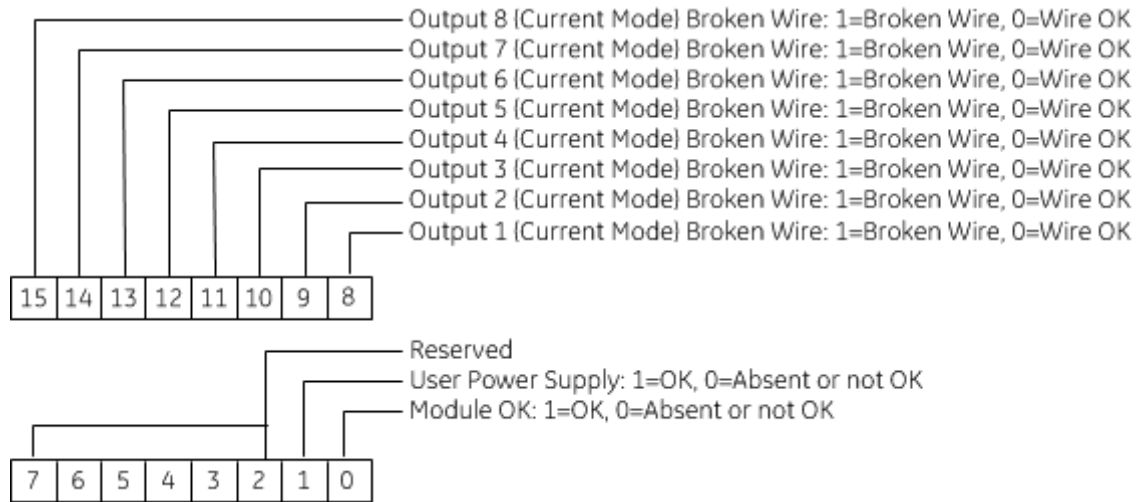
Module ALG392 uses up to eight output reference words. Each channel provides 16 bits of analog output data as an integer value. Output resolution is 15 bits except for the bipolar voltage mode, which has 16-bit resolution. The 16th bit is the sign bit.

Range	Resolution	Range Limits
0 to 20 mA	15 bits	0 to 32767
4 to 20 mA	15 bits	0 to 32767 ⁵⁹
0 to 10 Vdc	15 bits	0 to 32767
-10 V dc to 10 V dc	16 bits	- 32768 to 32767

10.3.5.1 Status Data: ALG392

This module uses either 8 or 16 discrete input bits, as configured. The lower 8 bits are used for module status information as displayed in the following figure.

In current mode, individual channels can also report Broken Wire diagnostics. Those diagnostics are reported in the upper eight bits, as shown:



⁵⁹ In 4-20 mA mode, if the PLC CPU sends a channel a value that is greater than 32000, the module uses the value 32000 instead.

10.3.6 Field Wiring: ALG392

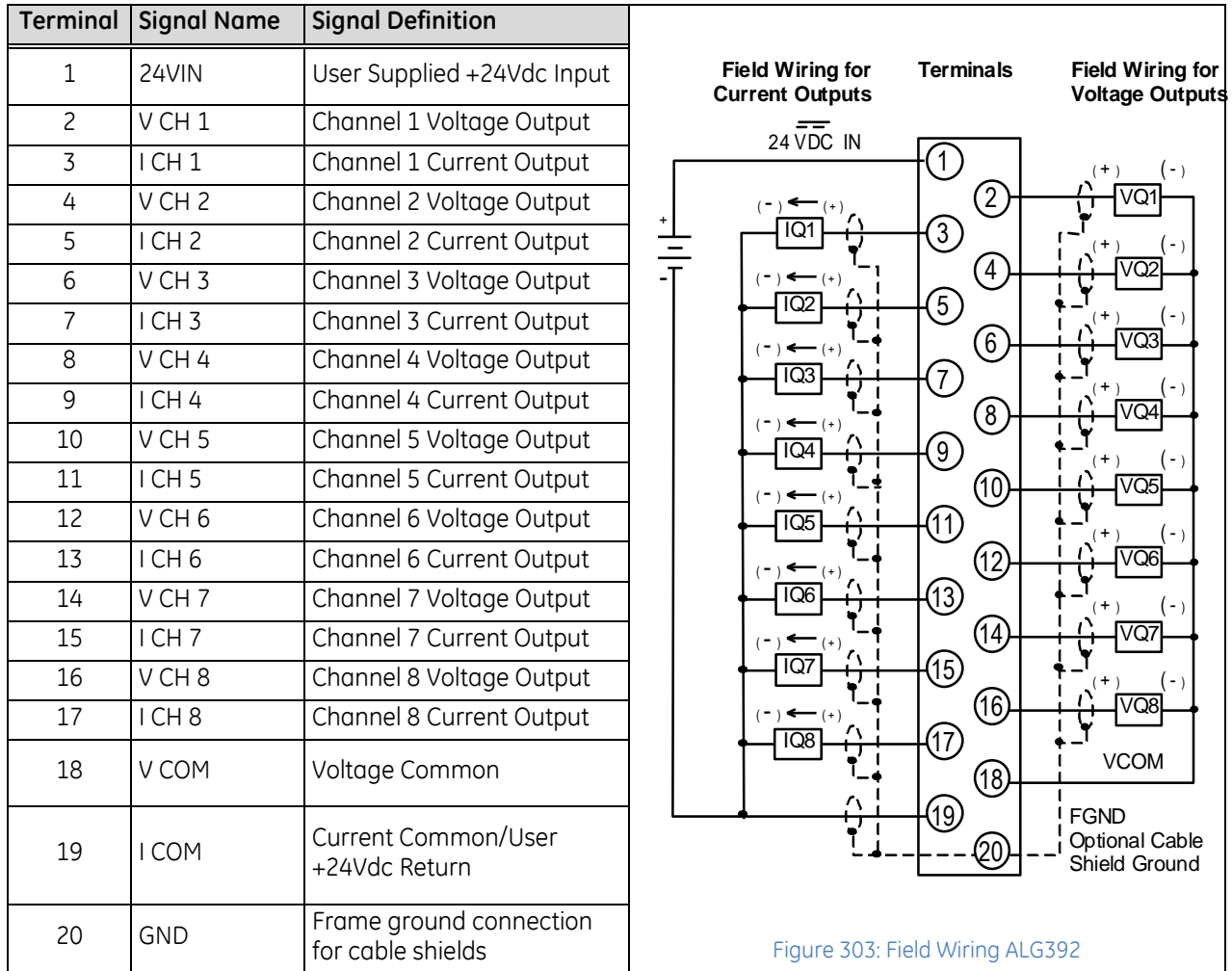


Figure 303 shows connections for current and voltage outputs. Each channel can be configured to operate as a voltage output or a current output - not both simultaneously.

10.3.7 Configuration: ALG392

Parameter	Description	Values	Default Values
Active Channels	Number of channels scanned	1 through 8	1
Reference Address for Module Output Data	Starting address for %AQ reference type	standard range	%AQ0001, or next highest available address
Reference Address for Channel Status Data	Starting address for %I reference type	standard range	%I00001, or next highest available address
Length	Number of %I status locations	8 or 16	8
STOP Mode	Output state when module toggled from RUN to STOP mode	Hold Last State or Default to Zero	Hold Last State
Output Channel Range	Type of Output Range	0, +10 V dc ±10 V dc 4, 20 mA 0, 20 mA	0, 10 V dc

Active Channels indicates the number of channels that will be scanned by the PLC CPU.

The choice made for STOP Mode determines whether the outputs on this module will hold their last states or default to zero when the goes from RUN to STOP mode.

The %AQ Reference Address parameter selects the start of the area in the %AQ memory where the output data to the module will begin.

The %I Reference Address selects the start of the area in %I memory for the status data of this module. If the length is set to 8, then only module status will be reported. If the length is set to 16, channel status will also be reported for channels that are operating as current outputs.

Each channel can be set up to operate on one of four output ranges:

- 0 to 10 Vdc (default)
- -10 V dc to +10 V dc range
- 4 to 20 mA, and 0 to 20 mA
- 0 to 20 mA

10.4 Analog Output Module 4-Channel Current/Voltage: IC695ALG704

Analog Output Module 8-Channel Current/Voltage: IC695ALG708

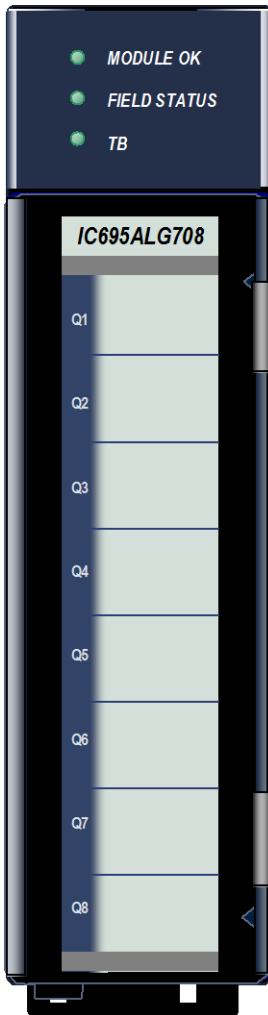


Figure 304: IC695ALG708

The **Analog Current/Voltage Output** module IC695ALG704 provides four non-isolated configurable voltage or current output channels. The **Analog Current/Voltage Output** module IC695ALG708 (Figure 304) provides eight non-isolated configurable voltage or current output channels.

Analog channels can be configured for these output ranges:

- Current: 0 to 20mA, 4 to 20mA
- Voltage: ± 10 V dc, 0 to 10 V dc

These modules can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Refer to Chapter 17 for more information about Terminal Blocks. Terminal Blocks are ordered separately.

These modules must be located in an RX3i Universal Backplane. They require an RX3i CPU with firmware version 3.0 or later. Machine Edition Version 5.0 SP3 Logic Developer-PLC or later must be used for configuration.

10.4.1 Isolated +24Vdc Power

The module must receive its 24Vdc power from an external source. The external source must be connected directly to the terminal block of this module. It cannot be connected via the TB1 connector on the RX3i Universal Backplane.

10.4.2 Features: ALG704 & ALG708

- Completely software-configurable, no module jumpers to set
- Individually enable or disable channels
- Clamping and Alarm Limits
- Latching of Alarms
- Configurable output bias
- Rapid channel acquisition times based on filter frequency
- Full auto-calibration
- On-board error-checking
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Configurable Hold Last State or Output Defaults
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

10.4.3 LEDs: ALG704 and ALG708

The **Module OK** LED indicates module status. The **Field Status** LED indicates whether the external +24Vdc power supply is present and is above the minimum level and whether or not faults are present. All LEDs are powered from the backplane power bus.

LED	Indicates
Module OK	ON Green: Module OK and configured. Quick Flashing Green: Module performing power-up sequence. Slow Flashing Green or Amber: Module OK but not configured. OFF: Module is defective or no backplane power present
Field Status	ON Green No faults on any enabled channel, Terminal Block is present, and field power is present. ON Amber and TB Green: Terminal Block is installed, fault on at least one channel, or field power is not present. ON Amber and TB Red: Terminal Block not fully removed, field power still detected. OFF and TB Red: Terminal block not present and no field power is detected.
TB	ON Red: Terminal block not present or not fully seated. Refer to above. ON Green: Terminal block is present. Refer to above. OFF: No backplane power to module.

10.4.4 Specifications: ALG704 and ALG708

Output Ranges	Current: 0 to 20mA, 4 to 20mA Voltage: ± 10 V dc, 0 to 10 V dc
Backplane Power Requirements	375 mA maximum at 3.3V
Power Dissipation within Module ($V_{user}=24V$)	IC695ALG704: 4.8 Watts maximum IC695ALG708: 7.25Watts maximum
Thermal De-rating	IC695ALG704: None IC695ALG708: Voltage mode: none Current mode: Refer to Figure 305.
External Power Supply V_{user}	Voltage Range: +19.2V to +30 V dc Current required for ALG704: 150mA maximum Current required for ALG708: 250mA maximum
Resolution	± 10 V dc: 15.9 bits, 0 to 10 V dc: 14.9 bits, 0 to 20mA: 15.9 bits, 4 to 20mA : 15.6 bits
Output Data Format	Configurable as floating point IEEE 32 bit or 16-bit integer in a 32-bit field
Update Rate	8 ms (approximate, all eight channels) (Determined by I/O scan time, application dependent.)
Output Over-voltage Protection	Current outputs only: -30V for 60 seconds, +30V for one hour
Calibrated Accuracy ⁶⁰	Accurate to within 0.15% of full scale at 25°C Accurate to within 0.30% of full scale at 60°C
Output Load Reactance	Current: 10 μ H maximum, Voltage: 1 μ F maximum
Maximum Output Load	Current: 850 Ω maximum at $V_{user} = 20V$ Voltage: 2k Ω minimum
Output Gain Drift	Voltage output: 20ppm per degree C typical Current output: 35ppm per degree C typical
Output Settling Time	Voltage or current output: 2ms, 0 to 95%.
Isolation, Field to Backplane	2550 V dc for one second
Maximum Compliance Voltage	$V_{user} - 3V$ (minimum) to V_{user} (maximum)

For product standards and general specifications, refer to *Appendix A*.

⁶⁰ In the presence of severe RF interference (IC 801-3, 10V/m), accuracy may be degraded to $\pm 1\%$ FS.

10.4.4.1 Thermal Derating, Current Mode: ALG708

Module IC695ALG704 has no thermal derating.

Module IC695ALG708 has no thermal derating in voltage mode.

Thermal derating for module IC695ALG708 in current mode is displayed in Figure 305.

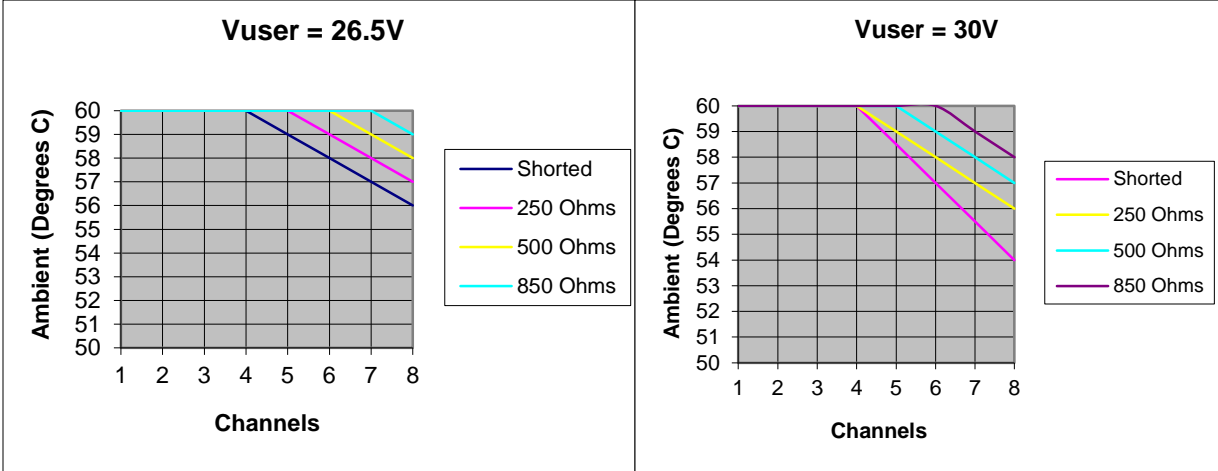


Figure 305: Thermal Derating Curves for ALG708 at selected Voltage Levels (Current Mode only)

10.4.5 Configuration: ALG704 and ALG708

10.4.5.1 Module Parameters

Parameter	Default	Description
Outputs Reference Address	%AQxxxxx	Starting address for the output data of this module. This defaults to the next available %AQ block.
Outputs Reference Length	ALG704: 8	The number of words used for the output data of this module. This parameter cannot be changed.
	ALG708: 16	
Output Command Feedback Reference Address	%AIxxxxx	Starting address for the command feedback data of this module. This defaults to the next available %AI address after a non-zero length is configured.
Output Command Feedback Length	0	The number of words used for the command feedback data of this module. Length defaults to 0. It can be set to 8 or 16, depending on the module type being configured.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	0	Read Only. The number of bit reference bits required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping. Maximum length is 128 bits for module IC695ALG704 or 256 bits for module IC695ALG708.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of this module. This defaults to the next available %I block.
Module Status Reference Length	0	Read Only. The number of bits (0 or 32) required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping.

Analog Output Commanded Feedback

The module returns a copy of the analog output data received from CPU in its corresponding channel analog input shared memory. Output Feedback can be monitored to check the values being sent to the channels. The data is in the same scaled format as the output data for each channel. During normal operation this feedback data should match the actual output data after one or more PLC scans of module inputs. During faults, ramping, over-range, and clamping conditions, the analog output data may differ from the commanded output.

Over-Temperature

If Over-Temperature is enabled, the module generates an Over-Temperature alarm if the internal temperature of this module is too great for the number of outputs that are on at the same time. In addition to the configurable options for Over-Temperature fault reporting and interrupts, an over temperature condition is also indicated by the Over-Temperature bit in the Status Reference data of this module. Detection of the Over-Temperature status bit is always enabled.

Module Parameters (Continued)

Parameter	Default	Description
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
Module Fault Reporting Enabled	Enabled	Enabled / Disabled. Controls whether the module will report faults resulting from either loss of field power or over-temperature conditions.
Field Power Removed Enabled	Enabled	Enabled / Disabled. With Module Fault Reporting enabled, this parameter controls reporting of Field Power Removed module faults.
Over Temp Enabled	Enabled	Enabled / Disabled. With Module Fault Reporting enabled, this parameter controls reporting of Over-temperature module faults.
Module Interrupt Reporting Enabled	Disabled	Enabled / Disabled.
Field Power Removed Enabled	Disabled	Enabled / Disabled. With Module Interrupt Reporting enabled, this parameter controls interrupts for Field Power Removed module faults.
Over Temp Enabled	Disabled	Enabled / Disabled. With Module Interrupt Reporting enabled, this parameter controls interrupts for Over-temperature module faults.
Range Type	Disabled Current	Sets up the type of output to be used for each channel. Choices are: Disabled Voltage, Disabled Current, Current/Voltage.
Range (Only for Range Type Current/Voltage)	-10 V dc to +10 V dc	For Current/Voltage: -10 V dc to +10 V dc, 0 V dc to +10 V dc, 4mA to 20 mA, 0mA to 20 mA.
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
Outputs Default	Force to Default Value	Controls the state the output will be set to in Outputs Disabled mode (stop), if a fault occurs, if power is lost, or if the configuration is cleared. Choices are Hold Last State, or default to a specific configured default value.

Range Type

Each channel on the module that will be used should be configured for Current/Voltage. Its voltage or current range and other parameters can then be configured as needed. If the channel output will not be used and is not wired, select either "Disabled" option. If a channel is disabled, it is not necessary to configure any of its other parameters.

If the channel is wired to a current output, but is not being used, select "Disabled Current". This will set the output current of that channel to 0mA (the output voltage of that channel will be non-zero).

If the channel is wired to a voltage output, but is not being used, select "Disabled Voltage". This will set the output voltage of that channel to 0V (the output current of that channel will be non-zero).

Output Defaults

If Hold Last State is enabled, an output will hold its last commanded value when the CPU indicates Outputs Not Enabled, or if one of the fault conditions listed below occurs. If Hold Last State is disabled, the output is commanded to go to the Default Value. The Default Value must be set within the selected output range. If both Default Value and Ramp Rate are enabled, the channel will ramp to the default value. Fault conditions are:

- CPU outputs are not enabled
- Backplane power is not ok. In that case, there is no ramping, even if ramping has been enabled.
- Loss of communications from CPU.
- Loss of I/O communications.
- Loss of field power.

Outputs Default Notes

- Hot Removal of the module in an I/O Enabled mode will cause all outputs to Hold Last State (even channels configured for Force to Default Value). If that operation is not desirable, the outputs can be forced to default by first turning off field power and removing the Terminal Block of this module before hot-removing the module.
- Resetting the module using SVC_REQ 24 causes all channels to Hold Last State even if Default Value is configured. The application program must handle output defaulting before execution of the Service Request.
- Default Ramp Rate configuration is ignored if backplane power from the power supply is lost. Channels configured for Default Value go to the default value immediately.
- The first time a configuration is stored following a return of backplane power, the Default Ramp rate is not used. Any channel configured for Default Value goes to its default value immediately. If analog power was not lost and the same configuration is restored on the next power-up, the channel state is unchanged from the time the power was lost. The Default Ramp Rate is used for any subsequent reconfiguration.

Output Default Conditions and Actions

Condition	Hold Last State or Default Value	Default Ramp Rate Enabled	Outputs Enabled and Ramp Rate Enabled	Channel Output Setting (Except where indicated, field power is assumed to be present).
Outputs Enabled and No Faults	N/A	N/A	No	Output goes to its commanded value from reference memory; defaults don't apply.
	N/A	N/A	Yes	Output is ramped to the commanded output from reference memory at the Outputs Enabled ramp rate. Defaults don't apply.
Outputs Disabled, Fault Mode, or Reconfiguration	Default Value	No	N/A	Output is set to the Default Value
	Default Value	Yes	N/A	Output is ramped to the Default Value at the Default ramp rate, starting at the last commanded value before entering mode.
	Hold Last State	N/A	N/A	Output is held at the last commanded value
Loss of Backplane Power or First Configuration Store after Power-up	Default Value	N/A	N/A	Output is set to the Default Value.
	Hold Last State	N/A	N/A	Output is held at last commanded value.
Hot Removal, Reset with SVCREQ 24 or Cleared Configuration	N/A	N/A	N/A	Output is held at last commanded value.
Loss of Field Power	N/A	N/A	N/A	All outputs go to 0V and 0mA.

10.4.5.2 Channel Parameters

Parameter	Default	Description
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type have a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default = High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

Output Scaling: ALG704 and ALG708

By default, the module converts a floating point value from the CPU into a voltage or current output over the entire span of its configured Range. For example, if the Range of a channel is 4 to 20mA, the module accepts channel output values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D units value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the output.

Example

In this example, the application should interpret 32000 counts as +10 V dc and -32000 counts as -10 V dc. The following channel configuration will scale a ±10 V dc output channel to ±32000 counts.

- Channel Value Format = 16 Bit Integer
- High Scale Value (Eng Units) = 32000.0
- Low Scale Value (Eng Units) = -32000.0
- High Scale Value (A/D Units) = 10.000
- Low Scale Value (A/D Units) = -10.000

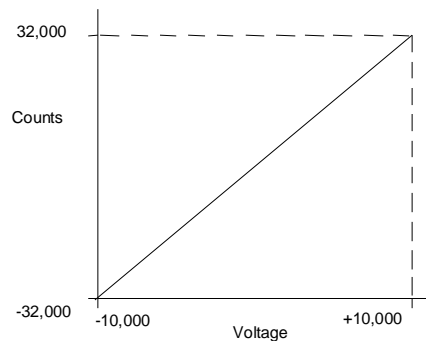


Figure 306: Channel Scaling Example

Channel Parameters (Continued)

Parameter	Default	Description
High Alarm (Eng Units)	The defaults depend on the configured Range.	All of the alarm parameters are specified in Engineering Units. When the configured value is reached or below (above), a Low (High) Alarm is triggered.
Low Alarm (Eng Units)		
Outputs Enabled Ramp Rate (Eng Units)	0.0	The rate in Engineering Units at which the output will change during normal operation.
Default Ramp Rate (Eng Units)	0.0	The rate in Engineering Units at which the output will change if a fault condition occurs or if outputs are not enabled.
Output Clamping Enabled	Disabled	Enabled / Disabled. Refer to description below.
Upper Clamp Limit (Eng Units)	The defaults depend on the configured Range.	The Upper Clamp Limit must be greater than the Lower Clamp Limit. This parameter can be used to restrict the output to a range that is narrower than its configured Range Type. For example, a channel configured for -10 V dc to +10 V dc could be restricted to -8V to +7.5V.
Lower Clamp Limit (Eng Units)		
Default Value (Eng Units)	0.0	If Hold Last State is disabled, the output is commanded to go to the Default Value when the CPU is not in Outputs Enabled mode or under certain fault conditions.
User Offset (Eng Units)	0.0	A configurable value that can be used to change the base of the channel. This value is added to the scaled value of the channel before alarm-checking.

10.4.5.3 Lower, Upper Clamp and Alarms: ALG704 and ALG708

Alarms can be used to indicate when the module has been commanded to meet or exceed the configured high or low limits for each channel. These are set at six configurable alarm trigger points:

- High Alarm and Low Alarm
- Upper Clamp and Lower Clamp
- Over-range and Under-range Alarm

Each alarm is individually configurable per channel to generate diagnostics bit status, fault alarms, or interrupt alarms.

If a channel is commanded higher than the Upper Clamp value, the output is set to the Upper Clamp value and an Upper Clamp condition is indicated. If a channel is commanded lower than the Lower Clamp value, the output is set to the Lower Clamp value and a Lower Clamp condition is indicated.

The High and Low Alarm checks are performed on the engineering units output value after possibly being adjusted by ramping, clamping, and fault conditions.

Channel Parameters (Continued)

Parameter	Default	Description
Diagnostic Reporting Enable If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area. Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table. These parameters enable or disable the individual diagnostics features of a channel. When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature. For example, if Over Range is enabled in the <i>Diagnostic Reporting Enable</i> menu, the module will set the Over Range bit in the Diagnostic Reference for the channel. If any of these parameters is disabled, the module does not react to the associated alarm conditions. For example, if Low Alarm Enable is set to Disabled in the <i>Fault Reporting Enable</i> menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.
Fault Reporting Enable If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	
Interrupts Enable	Disabled	
Low Alarm Enable	Disabled	
High Alarm Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Lower Clamp Alarm Enable	Disabled	
Upper Clamp Alarm Enable	Disabled	

Alarming and Fault Reporting

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Using Interrupts

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of this module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address corresponding to that channel.

Example:

In this example, the Output Reference Address block is mapped to %AQ0001-%AQ0008. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address of Channel 2 corresponds to %AQ00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AQ0003" as the Trigger.

Fault Reporting and Interrupts

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

10.4.6 Module Data: ALG704 and ALG708

The module receives its channel data from its configured output words, beginning at its assigned Channel Value Reference Address. Each channel occupies two words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4

For Module IC695ALG708 Only:

+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

Depending on its configured Channel Value Format, each enabled channel output reference location is read as a 32-bit floating point or 16-bit integer value.

In the 16-bit integer mode, low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bits is ignored. The full range of the 16-bit integer is a signed decimal value from +32767 to -32768.

Because the channel reference location is 32 bits, it is possible for the application program to write 32-bit signed decimal values to the output reference. However, the program logic must restrict the magnitude of the value to the range +32767 to -32768. Exceeding this range will result in misinterpretation of the sign bit, and incorrect output channel operation.

10.4.6.1 Channel Diagnostic Data: ALG704 and ALG708

In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for this module. Use of this feature is optional.

The diagnostics data each channel occupies 2 words (whether the channel is used or not):

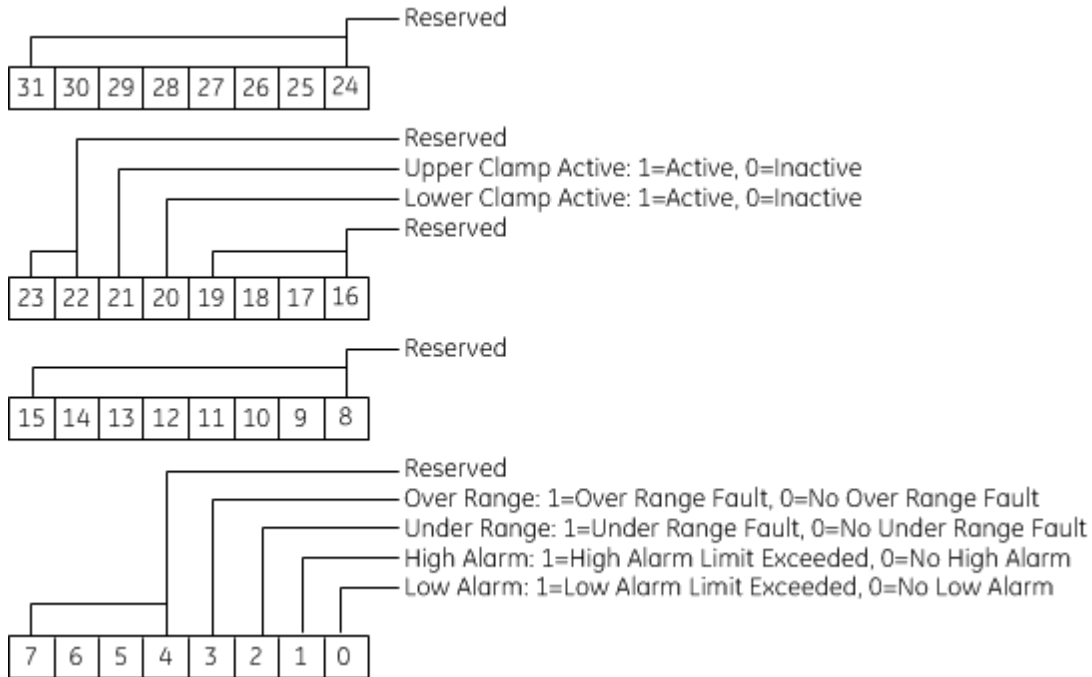
Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4

For Module IC695ALG708 Only:

+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

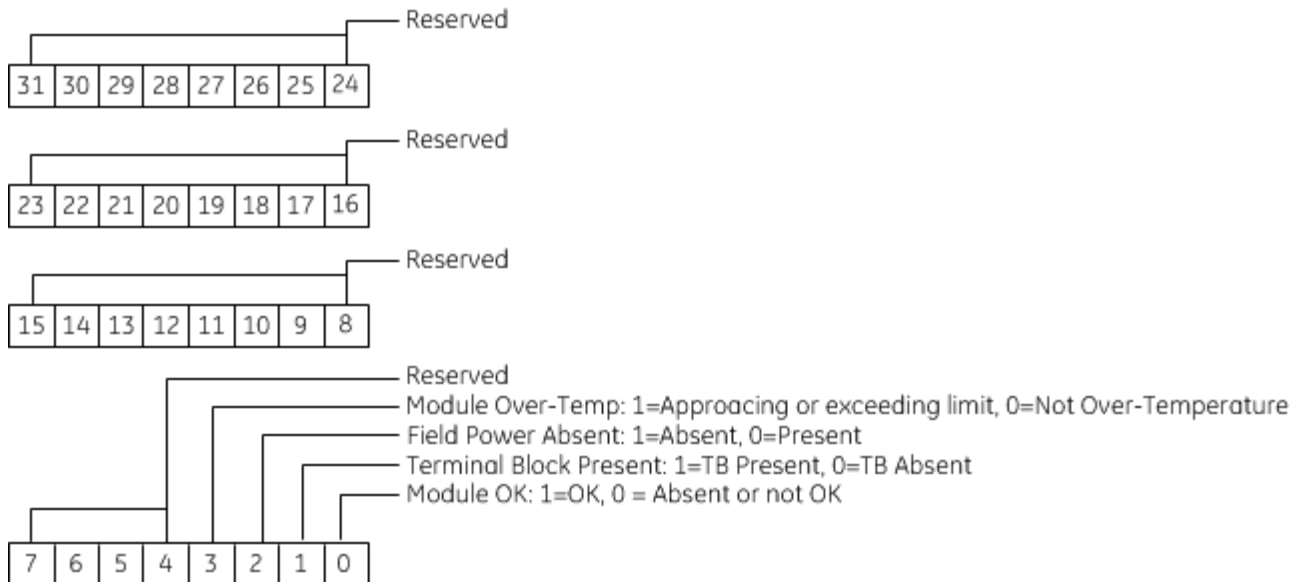
When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



10.4.6.2 Module Status Data: ALG704 and ALG708

The module can also optionally be configured to return 4 bits of module status data to the CPU. The CPU stores this data in the 32-bit Module Status Data reference area configured for this module.



Terminal Block Detection

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of this module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 2 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

10.4.7 Field Wiring: ALG704 and ALG708

The following table lists wiring connections for the Non-Isolated Analog Output Modules. There are no shield terminals. For shielding, tie cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provide in the ground bar for this purpose.

Terminal	IC695ALG704	IC695ALG708	IC695ALG704	IC695ALG708	Terminal
1	Channel 2 Voltage Out		Channel 1 Voltage Out		19
2	Channel 2 Current Out		Channel 1 Current Out		20
3	Common (COM)		Common (COM)		21
4	Channel 4 Voltage Out		Channel 3 Voltage Out		22
5	Channel 4 Current Out		Channel 3 Current Out		23
6	Common (COM)		Common (COM)		24
7	No Connection	Channel 6 Voltage Out	No Connection	Channel 5 Voltage Out	25
8	No Connection	Channel 6 Current Out	No Connection	Channel 5 Current Out	26
9	Common (COM)		Common (COM)		27
10	No Connection	Channel 8 Voltage Out	No Connection	Channel 7 Voltage Out	28
11	No Connection	Channel 8 Current Out	No Connection	Channel 7 Current Out	29
12	Common (COM)		Common (COM)		30
13	Common (COM)		Common (COM)		31
14	Common (COM)		Common (COM)		32
15	Common (COM)		Common (COM)		33
16	Common (COM)		Common (COM)		34
17	Common (COM)		Common (COM)		35
18	Common (COM)		External + Power Supply (+24V In)		36

Each channel can be individually-configured to operate as a voltage output or a current output, not both simultaneously. All the common terminals are connected together internally, so any common terminal can be used for the negative lead of the external power supply.

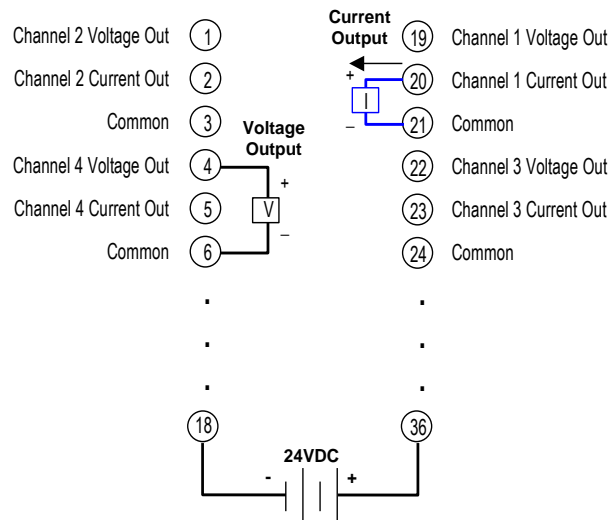


Figure 307: Field Wiring ALG704 & ALG708

10.5 Analog Output Module 8-Channel Current/Voltage Isolated: IC695ALG808

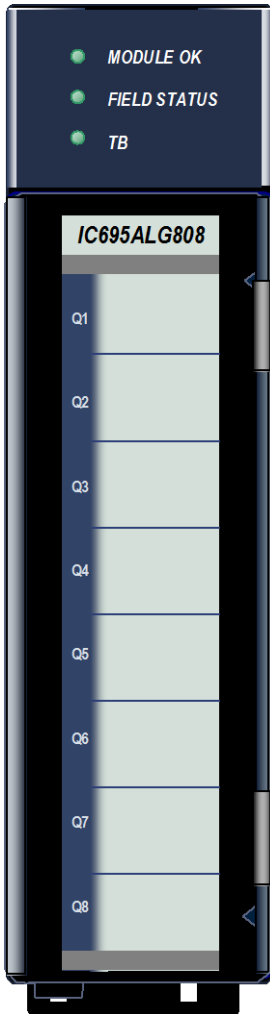


Figure 308: IC695ALG808

The **Analog Current/Voltage Output Isolated** module IC695ALG808 provides eight configurable voltage or current output channels. Analog channels can be configured for the following output ranges:

- Current: 0 to 20mA, 4 to 20mA
- Voltage: ± 10 V dc, 0 to 10 V dc

The module must be located in an RX3i Universal Backplane. These modules can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Terminal Blocks are ordered separately.

10.5.1 Isolated +24Vdc Power

The module must receive 24Vdc field power from an external source. The external source must be connected directly to the terminal block of this module. It cannot be connected via the TB1 connector on the RX3i Universal Backplane.

10.5.2 Features

- Completely software-configurable, no module jumpers to set
- Individually enable or disable channels
- Clamping and Alarm Limits
- Latching of Alarms
- Configurable output bias
- Rapid channel acquisition times based on filter frequency
- On-board error-checking
- Open-circuit detection for current outputs
- Short-circuit detection for voltage outputs
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Configurable Hold Last State or Output Defaults
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

10.5.3 LEDs: IC695ALG808

The **Module OK** LED indicates module status. The **Field Status** LED indicates whether the external +24Vdc power supply is present and is above the minimum level and whether or not faults are present. All LEDs are powered from the backplane power bus.

LED	Indicates
Module OK	ON Green: Module OK and configured. Quick Flashing Green: Module performing power-up sequence. Slow Flashing Green or Amber: Module OK but not configured. OFF: Module is defective or no backplane power present
Field Status	ON Green No faults on any enabled channel, Terminal Block is present, and field power is present. ON Amber and TB Green: Terminal Block is installed, fault on at least one channel, or field power is not present. ON Amber and TB Red: Terminal Block not fully removed, field power detected. OFF and TB Red: Terminal block not present and no field power is detected.
TB	ON Red: Terminal block not present or not fully seated. Refer to above. ON Green: Terminal block is present. Refer to above. OFF: No backplane power to module.

10.5.4 Specifications: IC695ALG808

Output Ranges	Current: 0 to 20mA, 4 to 20mA Voltage: ± 10 V dc, 0 to 10 V dc
Backplane Power Requirements	450mA maximum at 3.3V 25mA maximum at 5.0V
Power Dissipation within Module	7.25 Watts maximum (Vuser=24V)
Thermal De-rating	None required
External +Power Supply	Voltage Range: 19.2V to 30V (24V nominal) Current: 600mA maximum
Resolution	± 10 V dc: 15 bits, 0 to 10 V dc: 14 bits, 0 to 20mA: 15 bits, 4 to 20mA: 15 bits
Output Data Format	Configurable as floating point IEEE 32 bit or 16-bit integer in a 32-bit field
Analog Update Rate (Determined by I/O scan time, application dependent)	8 ms (approximate, all eight channels)
Output Over-voltage Protection	Current outputs only: -30V for 60 seconds, +30V for one hour
Calibrated Accuracy ⁶⁰	Accurate to within 0.15% of full scale at 25°C Accurate to within 0.25% of full scale at 60°C
Output Load Reactance	Current: 10 μ H maximum, Voltage: 1 μ F maximum
Maximum Output Load	Current: 1350 Ω maximum Voltage: 2k Ω minimum
Output Gain Drift	Voltage output: 20ppm per degree C typical Current output: 35ppm per degree C typical
Output Settling Time	Voltage or current output: 2ms, 0 to 95%
Isolation, Field to Backplane	2550 V dc for one second
Isolation, Channel to Channel	250 V ac continuous 1500 V ac for one minute per channel

10.5.5 Configuration: IC695ALG808

10.5.5.1 Module Parameters

Parameter	Default	Description
Outputs Reference Address	%AQxxxxx	Starting address for the output data of this module. This defaults to the next available %AQ block.
Outputs Reference Length	16	The number of words used for the output data of this module. This parameter cannot be changed.
Output Command Feedback Reference Address	%AIxxxxx	Starting address for the command feedback data of this module. This defaults to the next available %AI address after a non-zero length is configured.
Output Command Feedback Length	0	The number of words used for the command feedback data of this module. Length defaults to 0. It can be set to 16.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	0	Read Only. The number of bit reference bits required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping. Maximum length is 256 bits for module IC695ALG808.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of this module. This defaults to the next available %I block.
Module Status Reference Length	0	Read Only. The number of bits (0 or 32) required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping.

Analog Output Commanded Feedback

The module returns a copy of the analog output data received from the CPU in its corresponding channel analog input shared memory. Output Feedback can be monitored to check the values being sent to the channels. The data is in the same scaled format as the output data for each channel. During normal operation this feedback data should match the actual output data after one or more PLC scans of module inputs. During faults, ramping, over-range, and clamping conditions, the analog output data may differ from the commanded output.

Over-Temperature

If Over-Temperature is enabled, the module generates an Over-Temperature alarm if the internal temperature of this module is too great for the number of outputs that are on at the same time. In addition to the configurable options for Over-Temperature fault reporting and interrupts, an over temperature condition is also indicated by the Over-Temperature bit in the Status Reference data of this module. Detection of the Over-Temperature status bit is always enabled.

Module Parameters (Continued)

Parameter	Default	Description
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
Module Fault Reporting Enabled	Enabled	Enabled / Disabled. Controls whether the module will report faults resulting from either loss of field power or over-temperature conditions.
Field Power Removed Enabled	Enabled	Enabled / Disabled. With Module Fault Reporting enabled, this parameter controls reporting of Field Power Removed module faults.
Over Temp Enabled	Enabled	Enabled / Disabled. With Module Fault Reporting enabled, this parameter controls reporting of Over-temperature module faults.
Module Interrupt Reporting Enabled	Disabled	Enabled / Disabled.
Field Power Removed Enabled	Disabled	Enabled / Disabled. With Module Interrupt Reporting enabled, this parameter controls interrupts for Field Power Removed module faults.
Over Temp Enabled	Disabled	Enabled / Disabled. With Module Interrupt Reporting enabled, this parameter controls interrupts for Over-temperature module faults.
Range Type	Disabled Current	Sets up the type of output to be used for each channel. Choices are: Disabled Voltage, Disabled Current, Current/Voltage.
Range (Only for Range Type Current/Voltage)	-10 V dc to +10 V dc	For Current/Voltage: -10 V dc to +10 V dc, 0 V dc to +10 V dc, 4mA to 20 mA, 0mA to 20 mA.
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
Outputs Default	Force to Default Value	Controls the state the output will be set to in Outputs Disabled mode (stop), if a fault occurs, if power is lost, or if the configuration is cleared. Choices are Hold Last State, or default to a specific configured default value.

Range Type

Each channel on the module that will be used should be configured for Current/Voltage. Its voltage or current range and other parameters can then be configured as needed. If the channel output will not be used and is not wired, select either "Disabled" option. If a channel is disabled, it is not necessary to configure any of its other parameters.

If the channel is wired to a current output, but is not being used, select "Disabled Current". This will set the output current of that channel to 0mA (the output voltage of that channel will be non-zero).

If the channel is wired to a voltage output, but is not being used, select "Disabled Voltage". This will set the output voltage of that channel to 0V (the output current of that channel will be non-zero).

Output Defaults

If Hold Last State is enabled, an output will hold its last commanded value when the CPU indicates Outputs Not Enabled, or if one of the fault conditions listed below occurs. If Hold Last State is disabled, the output is commanded to go to the Default Value. The Default Value must be set within the selected output range. If both Default Value and Ramp Rate are enabled, the channel will ramp to the default value. Fault conditions are:

- CPU outputs are not enabled.
- Backplane power is not ok. In that case, there is no ramping, even if ramping has been enabled.
- Loss of communications from CPU.
- Loss of I/O communications.
- Loss of field power.

Outputs Default Notes

- Hot Removal of the module in an I/O Enabled mode will cause all outputs to Hold Last State (even channels configured for Force to Default Value). If that operation is not desirable, the outputs can be forced to default by first turning off field power and removing the Terminal Block of this module before hot-removing the module.
- Resetting the module using SVC_REQ 24 causes all channels to Hold Last State even if Default Value is configured. The application program must handle output defaulting before execution of the Service Request.
- Default Ramp Rate configuration is ignored if backplane power from the power supply is lost. Channels configured for Default Value go to the default value immediately.

The first time a configuration is stored following a return of backplane power, the Default Ramp rate is not used. Any channel configured for Default Value goes to its default value immediately. If analog power was not lost and the same configuration is restored on the next power-up, the channel state is unchanged from the time the power was lost. The Default Ramp Rate is used for any subsequent reconfiguration.

Output Default Conditions and Actions

Condition	Hold Last State or Default Value	Default Ramp Rate Enabled	Outputs Enabled and Ramp Rate Enabled	Channel Output Setting (Except where indicated, field power is assumed to be present).
Outputs Enabled and No Faults	N/A	N/A	No	Output goes to its commanded value from reference memory; defaults don't apply.
	N/A	N/A	Yes	Output is ramped to the commanded output from reference memory at the Outputs Enabled ramp rate. Defaults don't apply.
Outputs Disabled, Fault Mode, or Reconfiguration	Default Value	No	N/A	Output is set to the Default Value
	Default Value	Yes	N/A	Output is ramped to the Default Value at the Default ramp rate, starting at the last commanded value before entering mode.
	Hold Last State	N/A	N/A	Output is held at the last commanded value
Loss of Backplane Power or First Configuration Store after Power-up	Default Value	N/A	N/A	Output is set to the Default Value.
	Hold Last State	N/A	N/A	Output is held at last commanded value.
Hot Removal, Reset with SVCREQ 24 or Cleared Configuration	N/A	N/A	N/A	Output is held at last commanded value.
Loss of Field Power	N/A	N/A	N/A	All outputs go to 0V and 0mA.

10.5.5.2 Channel Parameters

Parameter	Default	Description
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type have a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default = High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

Output Scaling

By default, the module converts a floating point value from the CPU into a voltage or current output over the entire span of its configured Range. For example, if the Range of a channel is 4 to 20mA, the module accepts channel output values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D units value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the output.

Example

In this example, the application should interpret 32000 counts as +10 V dc and -32000 counts as -10 V dc. The following channel configuration will scale a ±10 V dc output channel to ±32000 counts.

- Channel Value Format = 16 Bit Integer
- High Scale Value (Eng Units) = 32000.0
- Low Scale Value (Eng Units) = -32000.0
- High Scale Value (A/D Units) = 10.000
- Low Scale Value (A/D Units) = -10.000

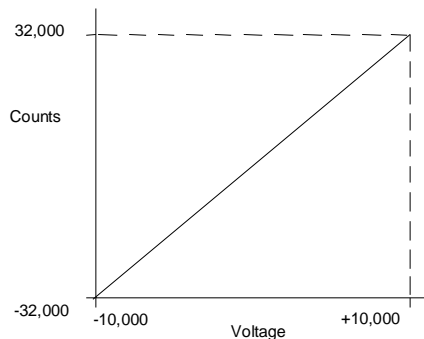


Figure 309: Channel Scaling Example

Channel Parameters (Continued)

Parameter	Default	Description
High Alarm (Eng Units)	The defaults depend on the configured Range.	All of the alarm parameters are specified in Engineering Units. When the configured value is reached or below (above), a Low (High) Alarm is triggered.
Low Alarm (Eng Units)		
Outputs Enabled Ramp Rate (Eng Units)	0.0	The rate in Engineering Units at which the output will change during normal operation.
Default Ramp Rate (Eng Units)	0.0	The rate in Engineering Units at which the output will change if a fault condition occurs or if outputs are not enabled.
Output Clamping Enabled	Disabled	Enabled / Disabled. Refer to description below.
Upper Clamp Limit (Eng Units)	The defaults depend on the configured Range.	The Upper Clamp Limit must be greater than the Lower Clamp Limit. This parameter can be used to restrict the output to a range that is narrower than its configured Range Type. For example, a channel configured for -10 V dc to +10 V dc could be restricted to -8V to +7.5V.
Lower Clamp Limit (Eng Units)		
Default Value (Eng Units)	0.0	If Hold Last State is disabled, the output is commanded to go to the Default Value when the CPU is not in Outputs Enabled mode or under certain fault conditions.
User Offset (Eng Units)	0.0	A configurable value that can be used to change the base of the channel. This value is added to the scaled value of the channel before alarm-checking.

10.5.5.3 Lower, Upper Clamp and Alarms

Alarms can be used to indicate when the module has been commanded to meet or exceed the configured high or low limits for each channel. These are set at six configurable alarm trigger points:

- High Alarm and Low Alarm
- Upper Clamp and Lower Clamp
- Over-range and Under-range Alarm

Each alarm is individually configurable per channel to generate diagnostics bit status, fault alarms, or interrupt alarms.

If a channel is commanded higher than the Upper Clamp value, the output is set to the Upper Clamp value and an Upper Clamp condition is indicated. If a channel is commanded lower than the Lower Clamp value, the output is set to the Lower Clamp value and a Lower Clamp condition is indicated.

The High and Low Alarm checks are performed on the engineering units output value after possibly being adjusted by ramping, clamping, and fault conditions.

Channel Parameters (Continued)

Parameter	Default	Description
Diagnostic Reporting Enable If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area. Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table.
Fault Reporting Enable If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	These parameters enable or disable the individual diagnostics features of a channel. When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature.
Interrupts Enable	Disabled	
Low Alarm Enable	Disabled	
High Alarm Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable (current mode only)	Disabled	
Lower Clamp Alarm Enable	Disabled	
Upper Clamp Alarm Enable	Disabled	
Short Circuit Enable (voltage mode only)	Disabled	

Alarming and Fault Reporting

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Using Interrupts

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of this module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address corresponding to that channel.

Example:

In this example, the Output Reference Address block is mapped to %AQ0001-%AQ0008. An I/O Interrupt block should be triggered if a High Alarm condition occurs on Channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address of Channel 2 corresponds to %AQ00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AQ0003" as the Trigger.

Fault Reporting and Interrupts

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

10.5.6 Module Data: IC695ALG808

The module receives its channel data from its configured output words, beginning at its assigned Channel Value Reference Address. Each channel occupies two words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

Depending on its configured Channel Value Format, each enabled channel output reference location is read as a 32-bit floating point or 16-bit integer value.

In the 16-bit integer mode, low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bits is ignored. The full range of the 16-bit integer is a signed decimal value from +32767 to -32768.

Because the channel reference location is 32 bits, it is possible for the application program to write 32-bit signed decimal values to the output reference. However, the program logic must restrict the magnitude of the value to the range +32767 to -32768. Exceeding this range will result in misinterpretation of the sign bit, and incorrect output channel operation.

10.5.6.1 Channel Diagnostic Data

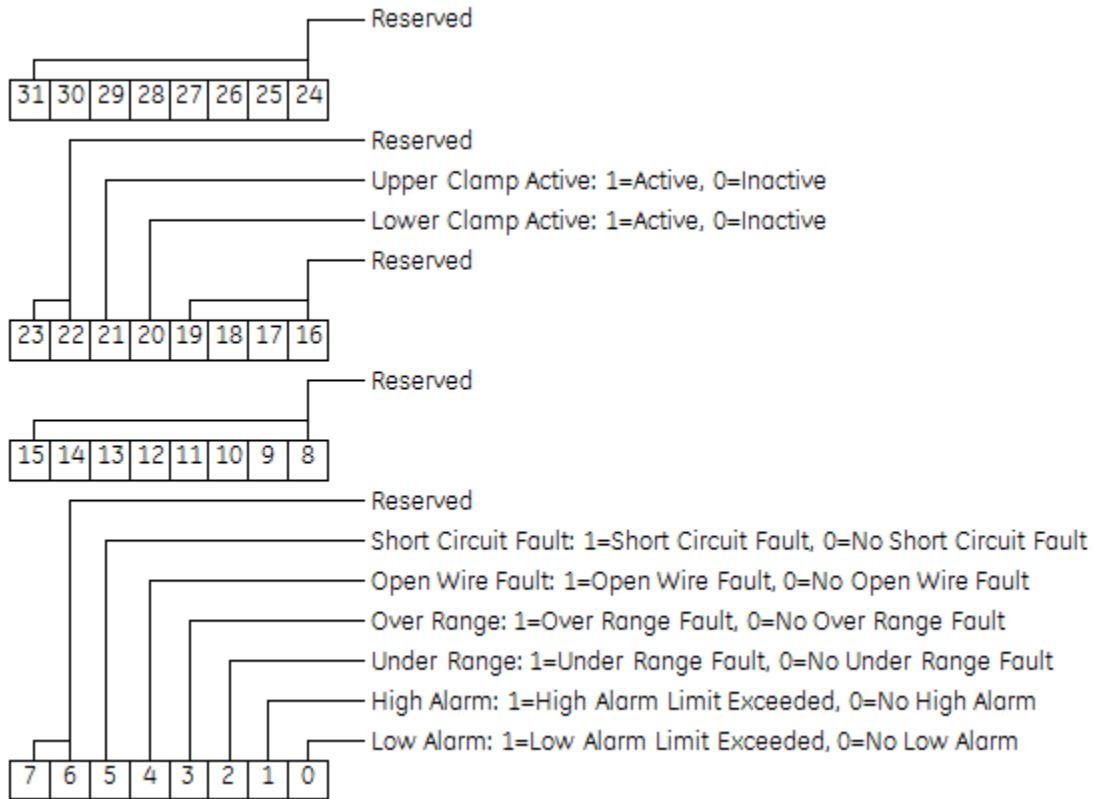
In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for this module. Use of this feature is optional.

The diagnostics data for each channel occupies 2 words (whether the channel is used or not):

Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

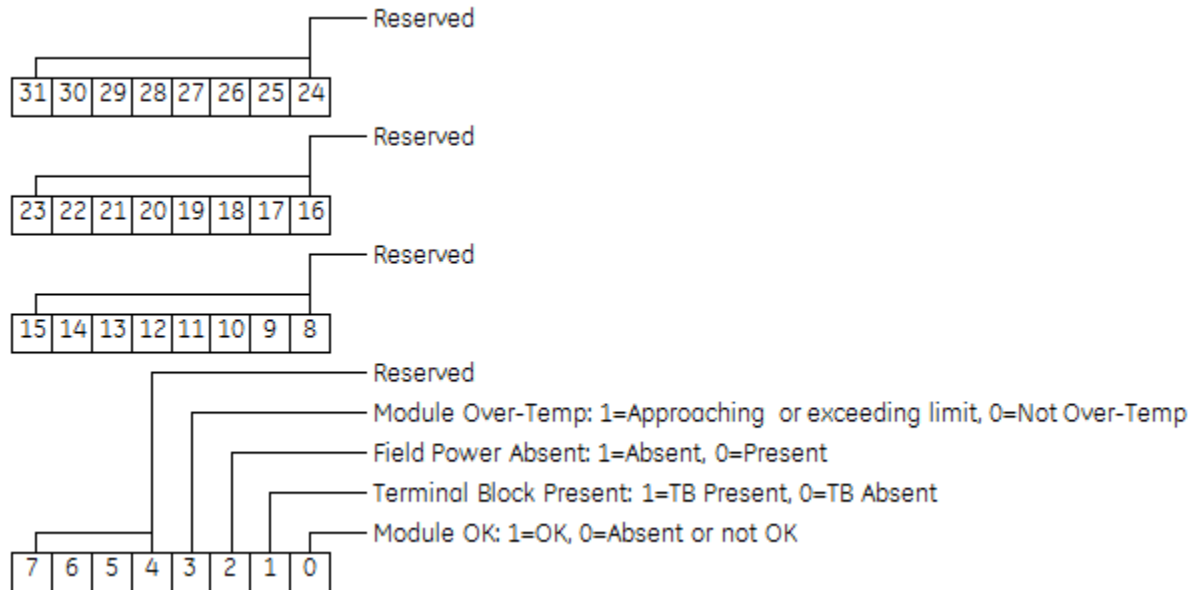
When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



10.5.6.2 Module Status Data: ALG808

The module can also optionally be configured to return 4 bits of module status data to the CPU. The CPU stores this data in the 32-bit Module Status Data reference area configured for this module.



Terminal Block Detection

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of this module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 2 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

10.5.7 Field Wiring: IC695ALG808

The following table lists wiring connections for the Isolated Analog Output Modules. There are no shield terminals.

Terminal	Assignment	Assignment	Terminal
1	No Connect	No Connect	19
2	Channel 1 Current/Voltage Output	Channel 5 Current/Voltage Output	20
3	Channel 1 Ground/Return	Channel 5 Ground/Return	21
4	No Connect	No Connect	22
5	No Connect	No Connect	23
6	Channel 2 Current/Voltage Output	Channel 6 Current/Voltage Output	24
7	Channel 2 Ground/Return	Channel 6 Ground/Return	25
8	No Connect	No Connect	26
9	No Connect	No Connect	27
10	Channel 3 Current/Voltage Output	Channel 7 Current/Voltage Output	28
11	Channel 3 Ground/Return	Channel 7 Ground/Return	29
12	No Connect	No Connect	30
13	No Connect	No Connect	31
14	Channel 4 Current/Voltage Output	Channel 8 Current/Voltage Output	32
15	Channel 4 Ground/Return	Channel 8 Ground/Return	33
16	No Connect	No Connect	34
17	External + Power Supply (+24V In)	No Connect	35
18	External - Power Supply (+24V Rtn)	No Connect	36

Each channel can be individually configured to operate as a voltage output or a current output - not both simultaneously.

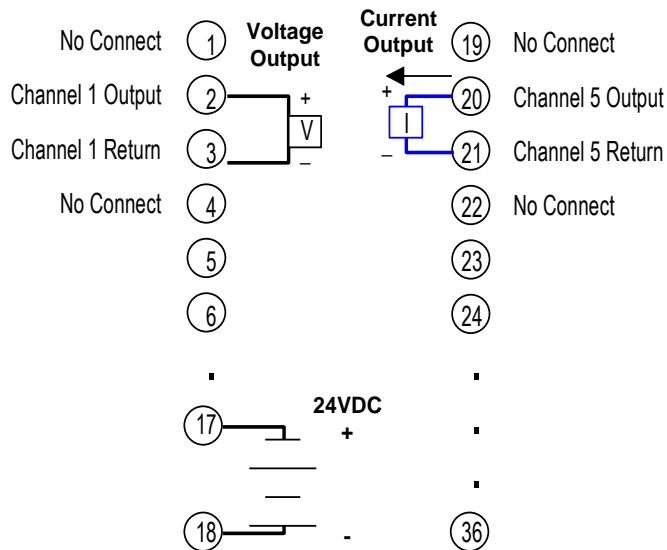


Figure 310: Field Wiring: ALG808

Chapter 11 Analog Modules with HART Communications

This chapter describes Non-Isolated Analog modules that provide HART® communications and are compatible with PACSystems RX3i controllers.

- Overview of HART Communications for PACSystems RX3i (Section 11.1)
- Module Descriptions, specifications, configuration parameters, and wiring information for:
 - Analog Input Module 16-/8-Channel Current/Voltage with HART: IC695ALG626 (Section 11.1.4)
 - Analog Input Module 8-/4-Channel Current/Voltage with HART: IC695ALG628 (Section 11.1.4)
 - Analog Output Module 8-Channel Current/Voltage with HART: IC695ALG728 (Section 11.3)
- HART Reference Data (Section 11.4)
- COMMREQs for HART Modules (Section 11.5)
- HART Function Blocks for the Application Program (Section 11.6)
- Converting HART Data to / from RX3i Format (Section 11.7)

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11.1 Overview of HART Communications for PACSystems RX3i

HART (Highway Addressable Remote Transducer) protocol is an open standard owned by the members of the HART Communication Foundation. HART combines simultaneous 4-20mA current loop operation with digital communications using the same signal. It imposes a frequency-shifted AC signal on the normal 4 to 20mA current loop signal. Both analog and digital communications signals utilize the same set of wires without signal disruptions. For more information about HART, refer to the HART Application Guide, published by the HART Communication Foundation (www.hartcomm.org).

For PACSystems RX3i, point-to-point HART communications are provided by the three analog modules described in this chapter. Each channel on modules IC695ALG626, ALG628, and ALG728 can utilize HART 5.0 protocol to communicate with HART field devices. The HART devices must be revision 5.0 or later; earlier HART versions use a different messaging format that is not supported by the RX3i analog HART modules.

To utilize HART communications, a channel must be configured for HART operation as described in this chapter, and for 4-20mA current range. During module operation, the 4-20mA channel signal communicates one process variable. Additional process variables, configuration data, and device data are transferred digitally using the HART protocol. The 4-20mA signal is not affected by the HART signal.

Effective with Release 8.50 of the RX3i CPU firmware, the product line also supports HART Pass Through functionality, which is described in the *PACSystems HART Pass Through User Manual*, GFK-2929.

11.1.1 RX3i HART Module Operation

HART is a master-slave communications protocol. An RX3i analog module with HART communications acts as the Primary Master for a single HART field device. It tolerates the presence of a Secondary Master, usually an optional handheld device. The RX3i Analog HART module does not support multi-drop communications (i.e. multiple field devices on a channel), nor does it support Burst Mode transmissions.

The RX3i HART module automatically issues HART commands to any HART device that is present and enabled in configuration. The response data from these commands is maintained within the internal memory of the RX3i HART module and is made available to the RX3i Controller via input scanning of HART Data, or via the Get Device Information COMMREQ (command 1).

An RX3i HART module can be configured to make HART device data available to the RX3i controller via input scanning by using the *HART Data Scan Control*. With this option, the automatic HART command response data from each device is formatted and written to RX3i reference memory at the HART Data Reference Address. This occurs during the normal RX3i input scan. This option may be disabled.

Two modes of automatic data presentation are configurable: “*All Data*” and “*Dynamic Data*”.

- *Dynamic Only* periodically executes HART command #3 and provides the resulting PV, SV, TV, and FV variables to the RX3i input reference memory. If *HART Slot Variables* are enabled, HART command #33 slot variable values are also updated automatically. *Dynamic Only* data also includes the most current Communication and Device Status.
- *All Data* option provides the same information as the *Dynamic Only* option, plus additional data from HART commands 0, 12, 13, 15, 16, 48, and 50.

During start-up, or after a device configuration changes (as indicated by the “configuration changed” bit on the HART device being set), the RX3i HART module executes HART commands 0, 3, 12, 13, 15, 16, 33, 48, and 50 (*All Data* mode). In addition, if HART Slot Variables are enabled (*Dynamic Data* mode), the module periodically re-issues commands #3 and #33. The repetition period at which the *Dynamic Data* commands are issued depends on the configuration for HART Pass-Through Service Options and on the number of HART devices enabled in a modem group. HART command #59 is issued each time a HART device initializes: it sets the number of preambles to 5.

In many applications, the *Dynamic Only* option should provide all of the needed HART variables. The variable data updates automatically in the input scan data of the HART module (no COMMREQ trigger is needed). If the *Dynamic Only* data is not sufficient, additional HART data may be accessed automatically using the *All Data* option. Enabling either the *Dynamic Only* or *All Data* option affects the PLC I/O sweep time because of increased input scan data from the module.

If neither scan option provides all the necessary inputs, or if additional control of HART devices is needed, COMMREQs are available that provide additional functionality or replace the automatic input scanning. Three COMMREQs are available.

- The Get Device Information COMMREQ (Command 1) returns the same data for a HART device as the *All Data* scan option; however, this COMMREQ must be reissued in logic to get updates of the variable data.
- The HART Pass-Through COMMREQ is capable of executing any HART command including manufacturer-specific commands; however, care must be used to correctly format HART command request and response data, which must be byte-packed and “big-endian” formatted. Instructions are given in this chapter.
- The Remote Get Device Information COMMREQ returns the same data for a HART device as the *All Data* scan option; however, this COMMREQ must be reissued in logic to get updates of the variable data.

11.1.2 Using DO I/O with HART Modules

The HART modules fully support the DOIO function block provided only analog channel values and analog diagnostics are to be scanned. However, DOIO will not function under certain conditions when HART devices are enabled and the HART Data Scan Control is set to either *All Data* or *Dynamic Only*.

Due to RX3i CPU limitations, only modules with input scan sizes of 256 bytes or less can use the DOIO function block. HART modules will function normally with DOIO except when the input scan size exceeds 256 bytes (this input size limitation may be increased or eliminated in future releases). When this input scan size is exceeded, any attempt to use DOIO for HART module inputs or outputs will fail, and the DOIO function will not pass power flow. The exact number of devices that can be enabled while DOIO continues to operate normally depends on the RX3i HART module employed.

- For ALG628 and ALG728, the number of HART devices that can be enabled with *All Data* selected is one, and the number of devices with *Dynamic Only* selected is five or fewer.
- For ALG626, the number devices enabled with *Dynamic Only* selected is three. Furthermore, DOIO will not function at all for ALG626 whenever any HART devices are enabled with *All Data* selected.

11.1.3 Using a Hand-held Calibrator with RX3i Analog HART Modules

It is often necessary to perform maintenance on field devices using a hand-held HART calibrator. The RX3i HART module behaves as a HART master and the field device is considered the slave.

When using a hand-held communicator in conjunction with the HART I/O, the calibrator is considered a secondary master.

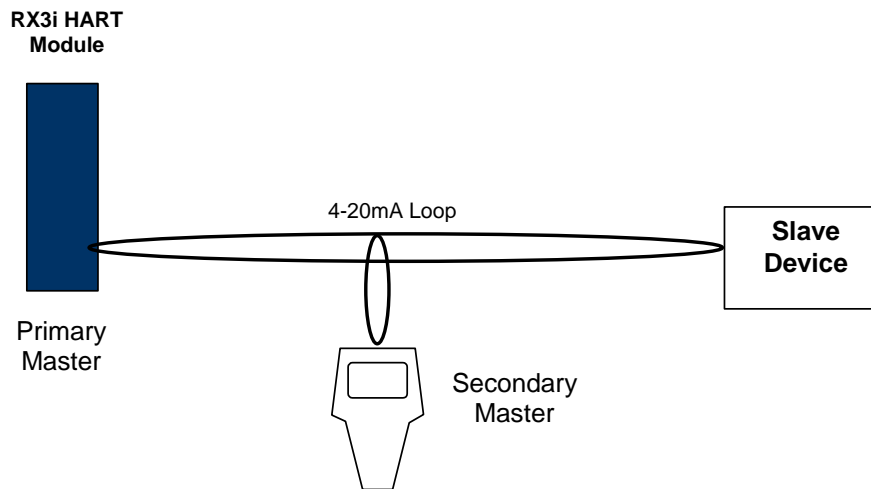


Figure 311: Use of Hand-Held HART Calibrator

The master must initiate the communication with the field device. The device simply replies with an appropriate response.

Any given channel may have a master, a secondary master (hand-held calibrator), and a slave connected simultaneously.

11.1.4 HART Pass-Through Functionality

HART Pass Through is the term given to the bidirectional tunneling of HART commands and responses through a PLC system. The HART communications in question are between those HART devices connected to HART-capable analog I/O modules and a monitoring station. Both the I/O and the monitoring station must be connected to the same PLC. For further information, refer to the *PACSystems HART Pass Through User Manual*, GFK-2929.

Compatible PACSystems* PLC CPUs support two independent and distinct HART Pass Through technologies:

- *PACSystems Field Device Tool (FDT) HART Device Type Managers (DTMs)* and
- the *PACSystems HART Multiplexer*.

Both technologies support HART devices connected to analog IO modules with HART support. The analog I/O modules may be located in one of the following:

- 1) an RX3i CPU rack,
- 2) an RX3i PROFINET Scanner rack (i.e. an I/O rack under the control of a PNS001 module), or
- 3) an RX3i PROFINET CEP remote drop, which is always controlled by a CEP001 module.

Support for the PROFINET racks requires that the supervising RX3i PROFINET IO Controller (PNC001) be located in the RX3i CPU rack. Operation with Hot Standby CPU Redundancy and PROFINET I/O is supported using a redundant IP connection.

The following RX3i analog modules support HART:

IC695ALG626
IC695ALG628⁶¹
IC695ALG728

If used for HART Pass Through, the supporting RX3i PROFINET Controller (PNC001) and PROFINET Scanner (PNS001 or CEP001) must also contain HART-compatible firmware:

IC695PNC001 Firmware Release 2.20
IC695PNS001 Firmware Release 2.30
IC695CEP001 Firmware Release 2.30.

The primary difference between the PACSystems FDT HART DTMs and the PACSystems HART Multiplexer is that they are designed to work with different types of HART asset management applications.

- The PACSystems FDT HART DTMs are installed whenever the HART devices will be configured and monitored using an FDT Frame Application such as GE Device Manager Essentials™ or another FDT-compatible asset management application.
- The PACSystems HART Multiplexer is installed whenever the HART devices will be configured and monitored using AMST™ from Emerson Process Management™.

Both technologies require Ethernet communications between the host PC and the PLC. Note that the architecture of the PLC system is the same in either solution.

⁶¹ If used, IC695ALG628 must be installed in the RX3i CPU Rack. At time of publication, it is not supported by PROFINET scanners IC695PNS001 or IC695CEP001. Refer to IPIs for IC695PNS001 or IC695CEP001 for future updates.

11.2 Analog Input Module 16-/8-Channel Current/Voltage HART: IC695ALG626

Analog Input Module 8-/4-Channel Current/Voltage with HART: IC695ALG628

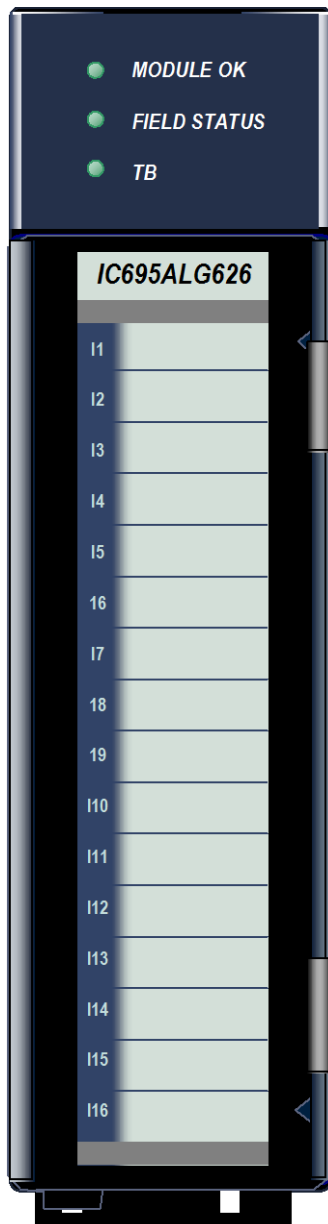


Figure 312: IC695ALG626

Non-Isolated Differential Analog Current/Voltage Input module IC695ALG628 provides 8 single-ended or 4 differential input channels. Non-Isolated Differential Analog Current/Voltage Input module IC695ALG626 provides 16 single-ended or 8 differential input channels.

Both modules feature HART version 5.0 communications capability on each channel. Module IC695ALG626 has four internal HART modems. Module IC695ALG628 has two internal HART modems. In single-ended mode, four single-ended channels are multiplexed into each HART modem. In differential mode, two differential channels are multiplexed into each HART modem.

Analog input channels can be configured for these ranges:

- Current: 0 to 20mA, 4 to 20mA, ± 20 mA
- Voltage: ± 10 V dc, 0 to 10 V dc, ± 5 Vdc, 0 to 5Vdc, 1 Vdc to 5Vdc.

Channels that will use HART communications must be configured for the 4-20mA range.

11.2.1 Features

- Completely software-configurable, no module jumpers to set
- Full auto-calibration
- On-board error-checking
- Open-circuit detection for all voltage and 4-20mA inputs
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program
- Flash memory for future upgrades
- Positive and negative Rate of Change Alarms
- Auto-calibration at startup
- Configurable interrupts for channel alarms and faults
- Terminal Block insertion or removal detection
- Version 5.0 HART communications
- These modules must be located in an RX3i Universal Backplane.
- Modules support insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

The modules can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Terminal Blocks are ordered separately.

11.2.2 Specifications: ALG626 and ALG628

Input Ranges	Current: 0 to 20mA, 4 to 20mA, ±20mA Voltage: ±10 V dc, 0 to 10 V dc, ±5Vdc, 0 to 5Vdc, 1Vdc to 5Vdc								
Backplane Power Requirements	Module	FB & later	EA & earlier	Specification					
	ALG626	400 200	600 625	mA maximum at 5.0V +5% / - 2.5% mA maximum at 3.3V +5% / - 3%					
	ALG628	260 200	450 625	mA maximum at 5.0V +5% / - 2.5% mA maximum at 3.3V +5% / - 3%					
Power Dissipation within Module	Module	FB & later	EA & earlier	Specification					
	ALG626	4.50	7.35	Watts maximum					
	ALG628	2.83	5.55	Watts maximum					
Thermal De-rating	Module IC695ALG628 has no thermal derating. Module IC695ALG626 has no thermal derating in voltage mode. Thermal derating for IC695ALG626 in current mode is shown in Figure 313.								
Resolution	Refer to <i>Resolution and Range Type</i> table below.								
Input Data Format	Configurable as floating point IEEE 32 bit or 16-bit integer in a 32-bit field.								
Filter Options	8Hz, 12Hz, 16Hz, 40Hz, 200Hz, 500Hz								
Analog Module Scan Time (ms)	The module scan can consist of up to four acquisition cycles. Each cycle includes a specific set of channels, as described in the <i>Channel Scanning</i> section below. Total Scan Time depends on the number of acquisition cycles in the scan, the configured filter option, and whether the channels are analog or HART.								
Configured Filter	<i>Number of Acquisition Cycles in the Scan</i>								
	1		2		3		4		
	Analog	HART	Analog	HART	Analog	HART	Analog	HART	
	8 Hz filter	121	128	241	254	362	380	482	506
	12 Hz filter	81	88	161	174	242	260	322	346
	16 Hz filter	61	68	121	134	182	200	242	266
	40 Hz filter	21	28	41	54	62	80	82	106
	200 Hz filter	5	12	9	22	14	32	18	42
	500 Hz filter	3	N/A	5	N/A	7	N/A	9	N/A
	500 Hz filter with rate detection enabled	N/A	N/A	6	N/A	9	N/A	12	N/A
HART Data Scan Time (in seconds)	The HART data scan can consist of up to four acquisition cycles (similar but asynchronous to the analog scan time). Each cycle includes a specific set of channels: for ALG626 single ended: channels 1-4, 5-8, 9-12, 13-16 are separate channel groups. for ALG626 differential: channels 1-2, 3-4, 5-6, 7-8 are separate channel groups. for ALG628 single ended: channels 1-4, 5-8 are separate channel groups. for ALG628 differential: channels 1-2, 3-4 are separate channel groups. Note: If you have only four Hart Devices on an ALG626 module, to minimize update times it is best to connect them to channels 1, 5, 9, and 13 so you only have one Hart-enabled channel per channel group. Total HART scan time depends on the number of acquisition cycles in the scan, number of retries, enabling/disabling of slot variables, and use of Pass-Through commands. If slot variables are enabled, update times are doubled.								
	# Channels in Group Enabled for HART:				Each HART Data Channel updates every:				
	1				0.7 second (typical)				
	2				1.9 seconds (typical)				
	3				3.0 seconds (typical)				
4				4.0 seconds (typical)					

Input Impedance	>100k Ω voltage inputs		
Current Input Resistance	249 Ω \pm 1%		
Open Circuit Detection time	1 second maximum		
Over-voltage	\pm 60 V dc continuous, maximum		
Overcurrent	\pm 28mA continuous, maximum		
Normal Mode Noise Rejection in dB		At 50Hz	At 60Hz
	8 Hz filter	85	85
	12 Hz filter	85	85
	16 Hz filter	35	62
	40 Hz filter	3	6
	200 Hz filter	0	0
	500 Hz	0	0
Common Mode Noise Rejection	120dB minimum at 50/60 Hz with 8 Hz filter 110dB minimum at 50/60 Hz with 12 Hz filter		
Channel-Channel DC Crosstalk	-80 dB minimum (single ended mode) -80 dB minimum (differential mode, grounded common) -60 dB minimum (differential mode, floating common)		
Calibrated Accuracy ⁶² at 13°C - 33°C with 8 Hz, 12 Hz and 16 Hz filter	\pm 5Vdc, \pm 10 V dc, \pm 20mA	0.05% of range	
	0 to 10 V dc, 0 to 5Vdc, 1Vdc to 5Vdc, 0 to 20mA	0.1% of range	
	4 to 20mA	0.125% of range	
Calibrated Accuracy ⁶² at 0°C - 60°C with 8 Hz, 12 Hz and 16 Hz filter	0 to 10 V dc, 0 to 5Vdc, 1Vdc to 5Vdc	0.2% of range	
	0 to 20mA	0.25% of range.	
	4 to 20mA	0.3125% of range	
	\pm 5Vdc, \pm 10 V dc	0.1% of range	
	\pm 20 mA	0.125% of range	
Calibration Interval	12 months typical to meet accuracy specifications over time. Offset can be applied as a periodic calibration adjustment.		
Isolation Voltage terminal block to backplane/chassis	Opto-isolated, transformer isolated 250 V ac continuous/1500 V dc for 1 minute		

For product standards and general specifications, refer to *Appendix A*.

11.2.2.1 Thermal Derating: ALG626 Current Mode

For module IC695ALG626 in current mode, the number of inputs that can be on at the same time depends on the ambient temperature as displayed in Figure 313.

⁶² In the presence of severe RF interference (IC 801-3, 10V/m), accuracy may be degraded to \pm 1% FS.

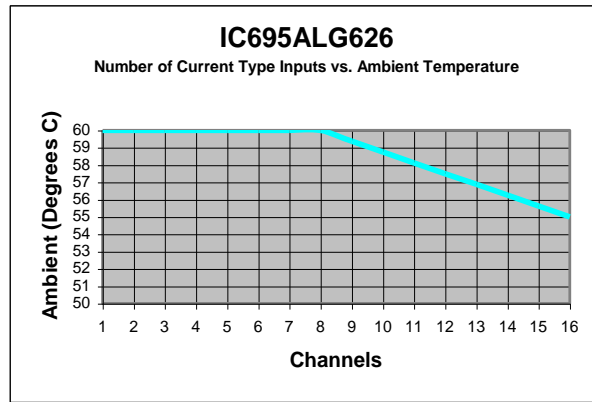


Figure 313: Thermal Derating ALG626 Current Mode

11.2.2.2 LEDs

The **Module OK** LED indicates module status. The **Field Status** LED indicates the presence of a fault on at least one channel or a terminal block error. The TB (Terminal Block) LED indicates the presence or absence of the terminal block. LEDs are powered from the backplane power bus.

LED	State	Indicates
Module OK	ON Green	Module OK and configured
	Green or Amber, blinking slowly	Error
	Green, blinking rapidly	Module OK but not configured
	OFF	Module is defective or no backplane power present
Field Status	ON Green	No faults on any enabled channel, and Terminal Block is present
	ON Yellow	Fault on at least one channel
	OFF	Terminal block not present or not fully seated
TB	ON Red	Terminal block not present or not fully seated
	ON Green	Terminal block is present
	OFF	No backplane power to module

11.2.3 Configuration: ALG626 and ALG628

11.2.3.1 Module Parameters

Parameter	Default	Description	
Channel Value Reference Address	%AIxxxxx	Starting address for the input data of this module. This defaults to the next available %AI block. The format of this data is shown in Section 11.2.4.1.	
Channel Value Reference Length	ALG628: 16 ALG626: 32	The number of words used for the input data of this module. This parameter cannot be changed.	
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. The format of this data is shown in Section 11.2.4.2.	
Diagnostic Reference Length	0	The number of bit reference bits required for the Channel Diagnostics data. When set to 0, Channel Diagnostics is disabled. To enable Channel Diagnostics mapping, change this to a non-zero value.	
Module Status Reference Address	%Ixxxxx	Starting address for the status data of this module. The format of this data is shown in Section 11.2.4.3.	
Module Status Reference Length	0	The number of bits (0 to 32) required for the Module Status data. When set to 0, mapping of Module Status data is disabled. To enable Module Status data mapping, change this to a non-zero value.	
HART Data Scan Control	No data	Selects whether the CPU will automatically scan from the HART module: no data, changed data only, or all data for each HART-enabled channel. Refer to the below for details of memory usage. Dynamic Data Only: the first 18 words or 288 bits of HART data per input device. All Data: all of the HART data (88 words or 1408 bits for each HART input device).	
HART Pass-Through Service Options	Once per two channel scans	Selects whether the module will automatically service a HART pass-through command in each 1, 2, or 4 channel scans or only upon change of the HART device configuration or if data hasn't been read for 10 seconds (Pass-Through Only). If Pass-Through Only is selected, scan data is not automatically available to the application program. However, it can be read using COMMREQ 1.	
HART Status Reference Address		Starting address for the HART Status data. The format of this data is shown on in Section 11.4.1.	
HART Status Reference Length		Length of the HART Status data; 4 words or 64 bits.	
HART Data Reference Address		Starting address for the HART data for the module in %I, %Q, %AI, %AQ, %R, %W, %G, %M, or %T memory. The format of this data is shown in Section 11.4.2.	
HART Data Reference Length	0	Length of the HART data. If Data Scan Control is set to no data, the length is 0. The length is automatically set according to the selection made for HART Data Scan Control	
		HART Data Scan Control	HART Data Reference Length
		No Data	0
		Dynamic Data Only	Highest HART-enabled Channel Number X (18 words or 288 bits)
		All Data	Highest HART-enabled Channel Number X (88 words or 1408 bits)
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data	

Parameter	Default	Description
Inputs Default	Force Off	In the event of module failure or removal, this parameter specifies the state of all Channel Value References for the module. Force Off = Channel Values clear to 0. Hold Last State = Channel Values hold their last state.
Inputs Default w/o Terminal Block	Enabled	Enabled / Disabled: Controls whether inputs will be set to their defaults if the Terminal Block is removed.
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
Analog Input Mode	Single-ended Input Mode	Single-ended / Differential: This selection must match the input wiring to the module.
A/D Filter Frequency	40Hz	Low pass A/D hardware filter setting for all inputs on the module: 8, 12, 16, 40, 200, or 500Hz. Default is 40Hz. Frequencies below the filter setting are not filtered by hardware.

11.2.3.2 Channel Parameters

Parameter	Default	Description
Range Type	Disabled	Current/Voltage, Disabled
Range (Not for Range Type Disabled)	-10 V dc to +10 V dc	For Current/Voltage: -10 V dc to +10 V dc, 0 to +10 V dc, 0 to +5Vdc, 1Vdc to +5Vdc, -5Vdc to +5Vdc, -20mA to +20mA, 4 to 20 mA, 0 to 20 mA
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type have a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default is High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

Input Scaling: ALG626 and ALG628

By default, the module converts a voltage or current input over the entire span of its configured Range into a floating point value for the CPU. For example, if the Range of a channel is 4 to 20mA, the module reports channel input values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the PLC that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example 1

For a voltage input, 6.0 volts represents a speed of 20 feet per second, and 1.0 volt represents 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000

Low Scale Value (Eng Units) = 0.000

High Scale Value (A/D Units) = 6.000

Low Scale Value (A/D Units) = 1.000

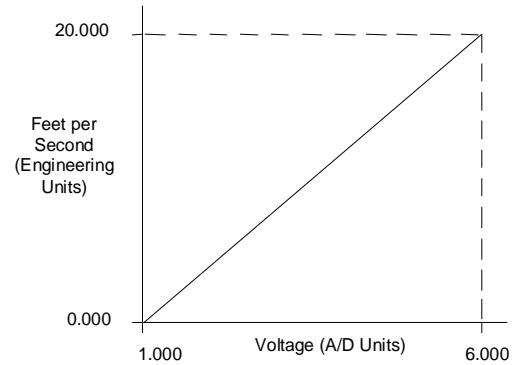


Figure 314: Scaling Example ALG626/ALG628

For this example, 1.0 V dc to 6.0 V dc is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 10.0V were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or take other precautions for scaled inputs that are outside the acceptable range or invalid.

Example 2

An existing application uses traditional analog to digital (A/D) count integer values. With scaling and the optional 16-bit integer input option, a channel can be configured to report integer count values. In this example, the application should interpret +10 V dc as 32000 counts and -10 V dc as -32000 counts. The following channel configuration will scale a ± 10 V dc input channel to ± 32000 counts.

Channel Value Format = 16 Bit Integer

High Scale Value (Eng Units) = 32000.0

Low Scale Value (Eng Units) = -32000.0

High Scale Value (A/D Units) = 10.000

Low Scale Value (A/D Units) = -10.000

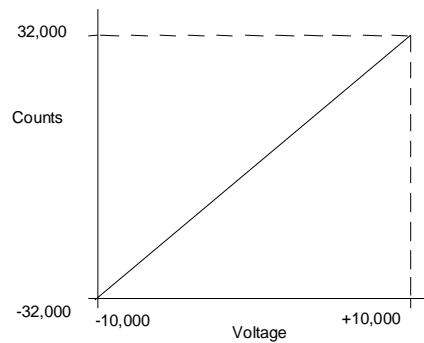


Figure 315: Scaling Example ALG626/ALG628

Channel Parameters (Continued)

Parameter	Default	Description
Positive Rate of Change Limit (Eng Units)	0.0	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units)	0.0	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate	0.0	Time to wait between comparisons (from 0 to 300 seconds). Default of 0.0 is to check after every input sample.

Rate of Change Alarms: ALG626 and ALG628

These modules can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either Rate of Change parameter is configured to be non-zero, the module takes the difference in Engineering Units between the previous rate of change sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Units change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Units change between samples is positive, the module compares the results in comparing the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the "Diagnostic Reporting Enable", "Fault Reporting Enable", and "Interrupts Enabled" parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. If the Rate of Change Sampling Rate is 0 or any time period less than the channel update rate, the module compares the Rate of Change for every input sample of the channel.

Channel Parameters (Continued)

Parameter	Default	Description
High-High Alarm (Eng Units)	The defaults for the High-High, High, Low, and Low-Low parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of default values.	<p>Alarms and Deadbands</p> <p>All of the alarm parameters are specified in Engineering Units. To use alarming, the A/D Alarm Mode must also be configured as enabled.</p> <p><i>High-High Alarm and Low-Low Alarm:</i> When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.</p> <p><i>High Alarm and Low Alarm:</i> When the configured value is reached or below (above), a Low (High) Alarm is triggered.</p> <p>High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.</p> <p>Alarm Deadbands should not cause the alarm clear condition to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.</p>
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
Low-Low Alarm Deadband (Eng Units)		
User Offset	0.0	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filtering	Disabled	Disabled / Enabled. Controls whether software filtering will be performed on the inputs.
Integration Time (ms)	0	<p>Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value.</p> <p>A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms. Default is 0.</p>

Using Alarming: ALG626 and ALG628

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Using Interrupts

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of this module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address corresponding to that channel.

Example:

In this example, the Channel Values Reference Address block is mapped to %AI0001-%AI0020. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AI00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AI0003" as the Trigger.

Fault Reporting and Interrupts

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

Channel Parameters (Continued)

Parameter	Default	Description
HART Communications	Disabled	Enabled/disabled. Set this to <i>enabled</i> if the channel will use HART communications. Enabling HART communications on a channel forces the channel to 4-20mA operation.
HART Slot Variables	Disabled	Enabled/disabled. If HART Slot Variables is enabled, the module will periodically send HART command #33 to request data. Channel variables will be read and placed in the HART scan block channel data. For each slot, the variable assignment code can be set between 0 and 255.
Slot Code 0, 1, 2, 3	1	The slot transmitter variable assignment code that will be used to retrieve data from the connected HART device. This is used with HART Pass-Through command 33, byte 0. These values are used in the request data for HART command #33.

11.2.4 Input Module Data Formats: ALG626 and ALG628

This section explains how the module uses separate reference areas that can be assigned during module configuration:

- *Channel Value Reference Data*, required memory for the analog input channel values.
- *Input Channel Diagnostic Reference Data*, optional memory for channel faults and alarms.
- *Module Status Reference Data*, optional memory for general module status data.

In addition, during configuration, optional *HART Reference Data*, memory can be assigned. Refer to the section “HART Reference Data” later in this chapter for details.

11.2.4.1 Channel Value Reference Data: ALG626 and ALG628

The module reports its input channel data in its configured *Channel Value Reference* input words, beginning at its assigned Channel Value Reference Address. Each channel value occupies 2 words, whether the channel is used or not:

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

For Module IC695ALG626 Only:

+16, 17	Channel 9
+18, 19	Channel 10
+20, 21	Channel 11
+22, 23	Channel 12
+24, 25	Channel 13
+26, 27	Channel 14
+28, 29	Channel 15
+30, 31	Channel 16

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

Resolution and Range Type

The actual resolution for each input depends on the Range Type and A/D Filter Frequency configured for that channel. At higher Filter Frequencies, input resolution decreases. The approximate resolution in bits for each Filter Frequency and Range Type are displayed in the following table.

Filter Frequency	Range Type		
	±10 V dc	0 to 10 V dc, ±5Vdc, ±20 V dc	0 to 5Vdc, 1Vdc to 5Vdc, 0 to 20mA, 4 to 20mA
8 Hz	18	17	16
12 Hz	17	16	15
16 Hz	17	16	15
40 Hz	16	15	14
200 Hz	15	14	13
500 Hz	14	13	12

Channel Scanning

These modules use 4 A/D converters to achieve the fastest possible channel scan times. The module has up to four acquisition cycles for each module scan. The acquisition cycles and channels acquired during each cycle are:

Acquisition Cycle	Channels Acquired	
	IC695ALG628	IC695ALG626
1	1, 5	1, 5, 9, 13
2	2, 6	2, 6, 10, 14
3	3, 7	3, 7, 11, 15
4	4, 8	4, 8, 12, 16

To bypass an acquisition cycle, all channels that would be acquired during that cycle must be disabled.

For fastest scan times, always wire by acquisition cycle. For example, if only eight channels were used on the 16-channel module, IC695ALG626, channels 1, 2, 5, 6, 9, 10, 13, and 14 should be used for optimum performance.

11.2.4.2 Input Channel Diagnostic Reference Data: ALG626 and ALG628

If the module is configured to use a *Diagnostic Reference Address*, it reports channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for this module. Use of this feature is optional.

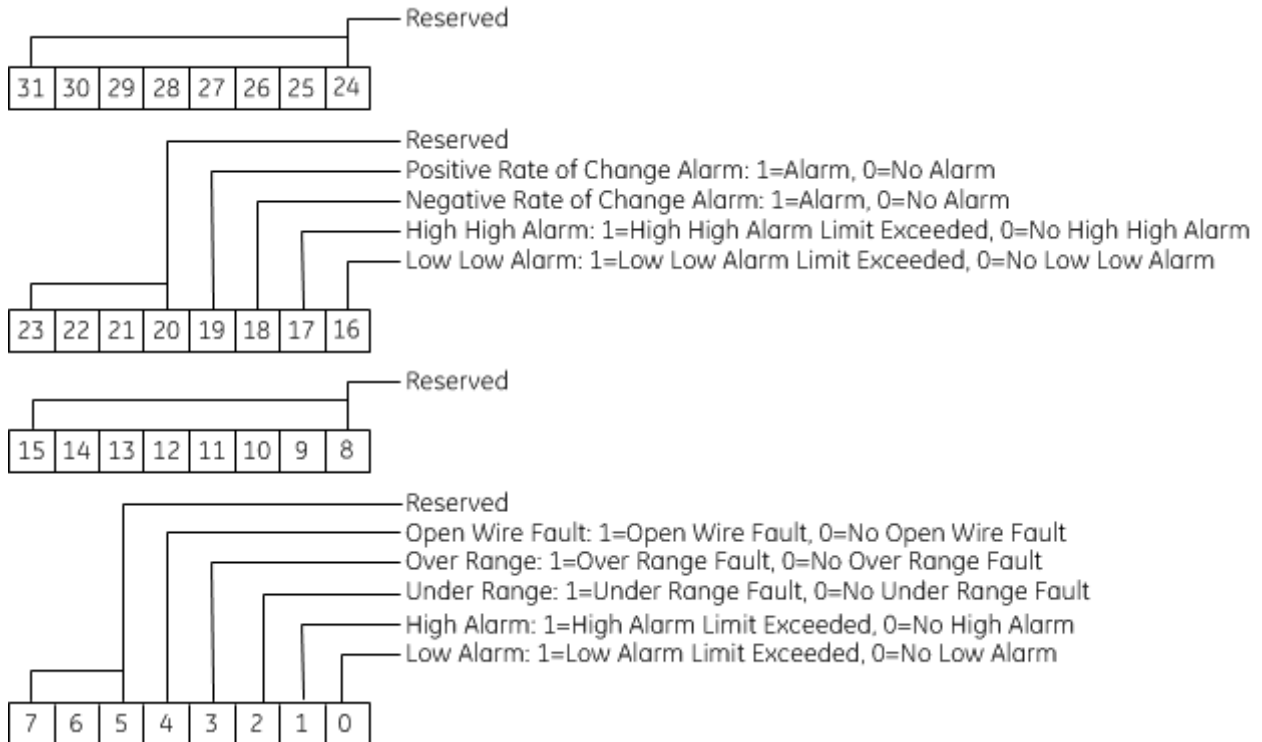
The diagnostics data for each channel occupies 2 words (whether the channel is used or not):

Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

For Module IC695ALG626 Only:

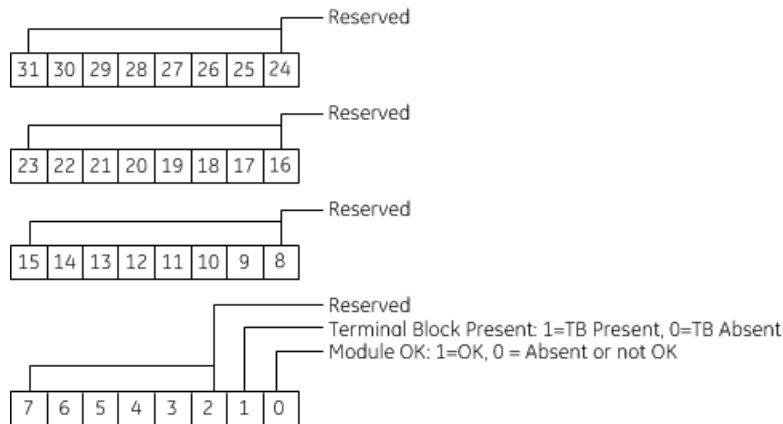
+16, 17	Channel 9
+18, 19	Channel 10
+20, 21	Channel 11
+22, 23	Channel 12
+24, 25	Channel 13
+26, 27	Channel 14
+28, 29	Channel 15
+30, 31	Channel 16

When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel. For each channel, the format of this data is:



11.2.4.3 Module Status Reference Data: ALG626 and ALG628

The module can optionally be configured to return two bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Reference* area configured for this module.



During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

Terminal Block Detection

The module automatically checks for the presence of a Terminal Block. The TB LED indicates the state of the terminal block of this module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block." If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 2 of the Module Status Reference indicates the status of the terminal block.

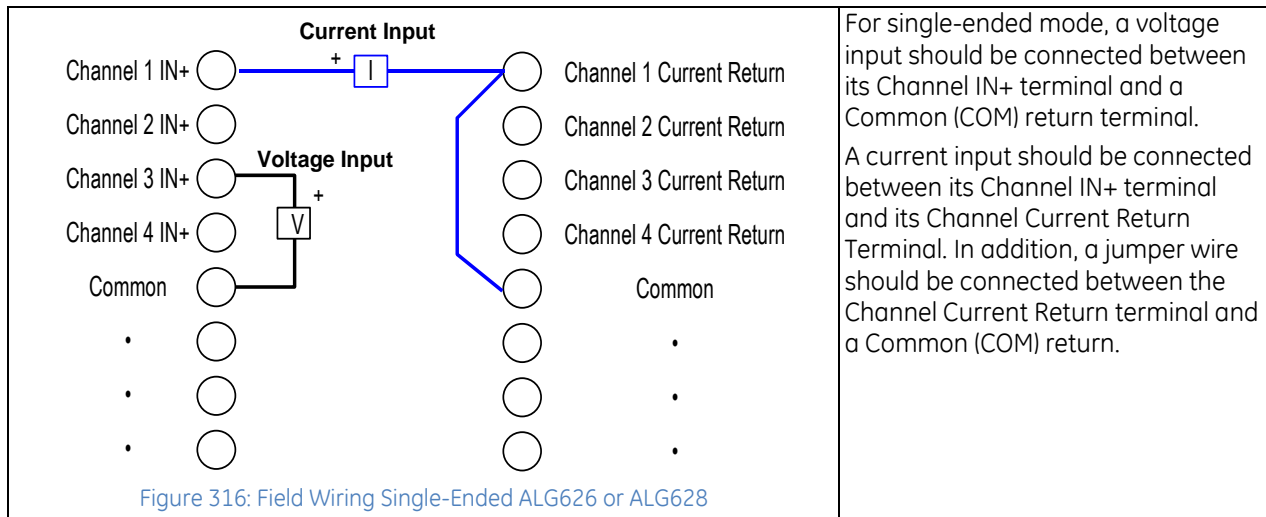
11.2.5 Field Wiring: IC695ALG626 and ALG628, Single-Ended Mode

The following table lists wiring connections for Single-ended mode.

Terminal	ALG628	ALG626	ALG628	ALG626	Terminal
1	Channel 1 IN+		Channel 1 Current Return (IRTN1)		19
2	Channel 2 IN+		Channel 2 Current Return (IRTN2)		20
3	Channel 3 IN+		Channel 3 Current Return (IRTN3)		21
4	Channel 4 IN+		Channel 4 Current Return (IRTN4)		22
5	Common		Common		23
6	Channel 5 IN+		Channel 5 Current Return (IRTN5)		24
7	Channel 6 IN+		Channel 6 Current Return (IRTN6)		25
8	Channel 7 IN+		Channel 7 Current Return (IRTN7)		26
9	Channel 8 IN+		Channel 8 Current Return (IRTN8)		27
10	No Connection	Channel 9 IN+	No Connection	Channel 9 Current Return (IRTN9)	28
11	No Connection	Channel 10 IN+	No Connection	Channel 10 Current Return (IRTN10)	29
12	No Connection	Channel 11 IN+	No Connection	Channel 11 Current Return (IRTN11)	30
13	No Connection	Channel 12 IN+	No Connection	Channel 12 Current Return (IRTN12)	31
14	Common		Common		32
15	No Connection	Channel 13 IN+	No Connection	Channel 13 Current Return (IRTN13)	33
16	No Connection	Channel 14 IN+	No Connection	Channel 14 Current Return (IRTN14)	34
17	No Connection	Channel 15 IN+	No Connection	Channel 15 Current Return (IRTN15)	35
18	No Connection	Channel 16 IN+	No Connection	Channel 16 Current Return (IRTN16)	36

There are no shield terminals on these modules. For shielding, tie the cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided for this purpose.

All the common terminals are connected together internally, so any common terminal can be used for the negative lead of the external power supply.



11.2.6 Field Wiring: IC695ALG626 and ALG628, Differential Mode

The following table lists wiring connections for modules configured for Differential mode.

Terminal	ALG628	ALG626	ALG628	ALG626	Terminal
1	Channel 1 IN+		Channel 1 Current Return (IRTN1)		19
2	Channel 1 IN -		No Connection		20
3	Channel 2 IN+		Channel 2 Current Return (IRTN3)		21
4	Channel 2 IN -		No Connection		22
5	Common		Common		23
6	Channel 3 IN+		Channel 3 Current Return (IRTN5)		24
7	Channel 3 IN-		No Connection		25
8	Channel 4 IN+		Channel 4 Current Return (IRTN7)		26
9	Channel 4 IN-		No Connection		27
10	No Connection	Channel 5 IN+	No Connection	Channel 5 Current Return (IRTN9)	28
11	No Connection	Channel 5 IN-	No Connection		29
12	No Connection	Channel 6 IN+	No Connection	Channel 6 Current Return (IRTN11)	30
13	No Connection	Channel 6 IN-	No Connection		31
14	Common		Common		32
15	No Connection	Channel 7 IN+	No Connection	Channel 7 Current Return (IRTN13)	33
16	No Connection	Channel 7 IN-	No Connection		34
17	No Connection	Channel 8 IN+	No Connection	Channel 8 Current Return (IRTN15)	35
18	No Connection	Channel 8 IN-	No Connection		36

There are no shield terminals on these modules. For shielding, tie the cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided for this purpose.

All the common terminals are connected together internally, so any common terminal can be used for the negative lead of the external power supply.

Figure 317: Field Wiring Differential Mode ALG626 or ALG628

* Keep this jumper as short as possible to minimize error due to the added resistance of the wire. This resistance should be 25mΩ or less.

For differential inputs, two adjacent terminals are connected as one channel. The lower-numbered terminal acts as the high side.

A voltage input is connected between the two adjacent Channel IN terminals as shown at left.

A current input is connected between the Channel IN+ and Current Return terminals for that channel. In addition, a jumper wire must be connected between the Channel IN - terminal and the corresponding Channel Current Return terminal.

Tie common to signal ground for improved channel-to-channel Crosstalk immunity.

Two door cards are provided with the module: one shows connections for single-ended mode and the other shows connections for differential. Insert the card that matches the wiring that will be used.

11.2.7 HART Device Connections

Example connections for 2-wire transmitters are displayed in the following figure.

11.2.7.1 Connecting Two-Wire Current Loop

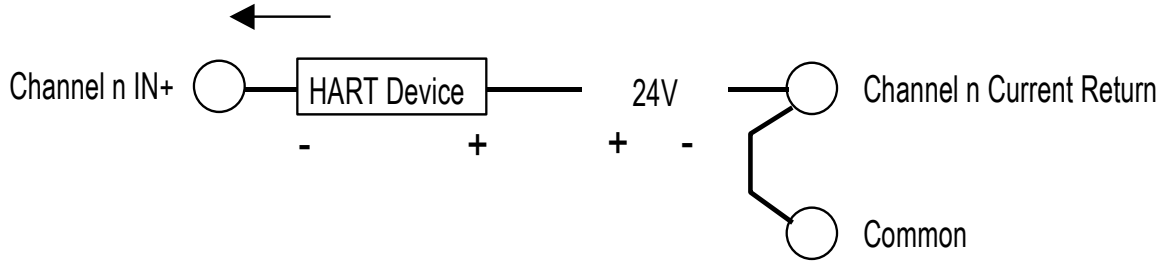


Figure 318: HART 2-Wire Current Loop Connection

11.2.7.2 Connecting an Active-Source Device

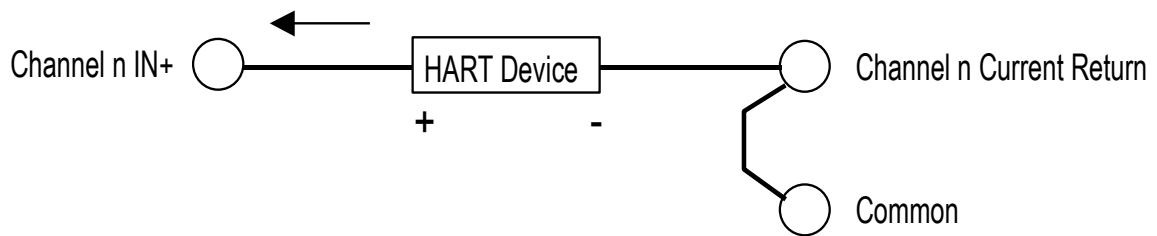


Figure 319: HART Active Source Device Connection

11.3 Analog Output Module 8-Channel Current/Voltage with HART: IC695ALG728

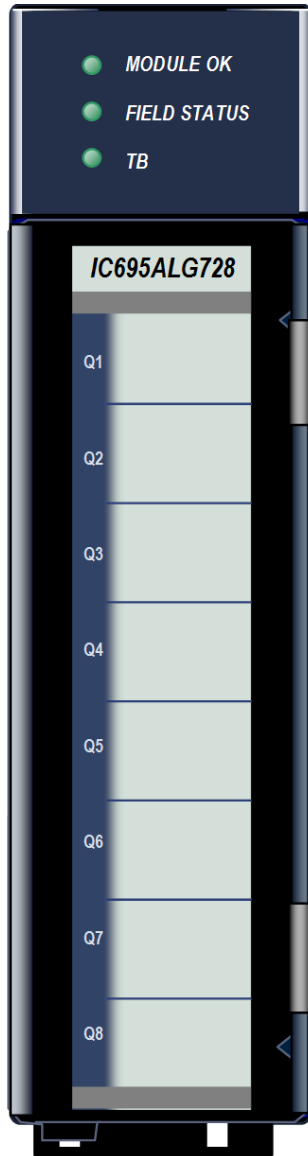


Figure 320: IC695ALG728

Non-Isolated Analog Current/Voltage Output module IC695ALG728 provides eight configurable voltage or current output channels with HART version 5.0 communications capability on each channel. The module has two internal HART modems. Four single-ended channels are multiplexed with each HART modem. Analog channels can be configured for these output ranges:

- Current: 0 to 20mA, 4 to 20mA
- Voltage: ± 10 V dc, 0 to 10 V dc

Channels that will use HART communications must be configured for the 4-20mA range.

11.3.1 Features

- Completely software-configurable, no module jumpers to set
- Individually enable or disable channels
- Clamping and Alarm Limits
- Latching of Alarms
- Configurable output bias
- Rapid channel acquisition times based on filter frequency
- Full auto-calibration
- On-board error-checking
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Configurable Hold Last State or Output Defaults
- Version 5.0 HART communications
- The module must be located in an RX3i Universal Backplane.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Terminal Blocks are ordered separately.

11.3.2 Isolated +24Vdc Power

The module must receive its 24Vdc power from an external source. The external source must be connected directly to the terminal block of this module. It cannot be connected via the TB1 connector on the RX3i Universal Backplane.

11.3.3 LEDs: ALG728

The **Module OK** LED indicates module status. The **Field Status** LED indicates whether the external +24Vdc power supply is present and is above the minimum level and whether or not faults are present. All LEDs are powered from the backplane power bus.

LED	State	Indicates
Module OK	ON Green	Module OK and configured
	Green or Amber, blinking slowly	Module OK but not configured
	Green, blinking rapidly	Module performing power-up sequence
	OFF	Module is defective or no backplane power present
Field Status	ON Green	No faults on any enabled channel, and Terminal Block is present
	ON Amber and TB Green	Terminal Block is installed, fault on at least one channel, or field power is not present
	ON Amber and TB Red	Terminal Block not fully removed, field power still detected.
	OFF and TB Red	Terminal block not present and no field power is detected.
TB	ON Red	Terminal block not present or not fully seated
	ON Green	Terminal block is present
	OFF	No backplane power to module

11.3.4 Specifications: ALG728

Output Ranges	Current: 0 to 20mA, 4 to 20mA Voltage: ± 10 V dc, 0 to 10 V dc
Backplane Power Requirements	380 mA maximum at 3.3Vdc
Power Dissipation within Module ($V_{user}=24$ Vdc)	7.25 Watts maximum
Thermal Derating	Refer to <i>Thermal Derating Charts ALG728</i> below. Applies to Current Mode only.
External Power Supply V_{user}	Voltage Range: +19.2Vdc to +30 V dc Current required: 250mA maximum
Resolution	± 10 V dc: 15.9 bits, 0 to 10 V dc: 14.9 bits, 0 to 20mA: 15.9 bits, 4 to 20mA : 15.6 bits
HART Communications	Version 5.0 HART protocol
Output Data Format	Configurable as floating point IEEE 32 bit or 16-bit integer in a 32-bit field
Analog Update Rate (Determined by I/O scan time, application dependent.)	16ms with HART (approximate, all eight channels) 8ms without HART (approximate, all eight channels)
HART Data Scan Time (in seconds) The HART data scan can consist of up to two acquisition cycles (similar but asynchronous to the analog scan time). Each cycle includes a specific set of channels. For ALG728: 1-4, 5-8 are separate channel groups. Total HART scan time depends on the number of acquisition cycles in the scan, number of retries, enabling/disabling of slot variables, and use of pass-through commands. If slot variables are enabled, update times are doubled.	
1 HART device in group	Each HART Data channel updates every 0.7 second (typical)
2 HART devices in group	Each HART Data channel updates every 1.9 seconds (typical)
Output Over-voltage Protection	Current outputs only: -30V for 60 seconds, +30V for one hour
Calibrated Accuracy ⁶³	Accurate to within 0.15% of full scale at 25°C Accurate to within 0.30% of full scale at 60°C
Output Load Reactance	Current: 10 μ H maximum, Voltage: 1 μ F maximum
Maximum Output Load	Current: 850 Ω maximum at $V_{user} = 20$ V Voltage: 2 k Ω minimum
Output Gain Drift	Voltage output: 20ppm per degree C typical Current output: 35ppm per degree C typical
Output Settling Time	Voltage Output: 2ms, 0 to 95% Current output with HART: 70ms, 0 to 95% Current output without HART: 23ms, 0 to 95%
Isolation, Field to Backplane	2550 V dc for one second
Maximum Compliance Voltage	$V_{user} - 3$ V (minimum) to V_{user} (maximum)

For product standards and general specifications, refer to *Appendix A*.

⁶³ In the presence of severe RF interference (IC 801-3, 10V/m), accuracy may be degraded to $\pm 1\%$ FS.

11.3.4.1 Thermal Derating, ALG728 Current Mode

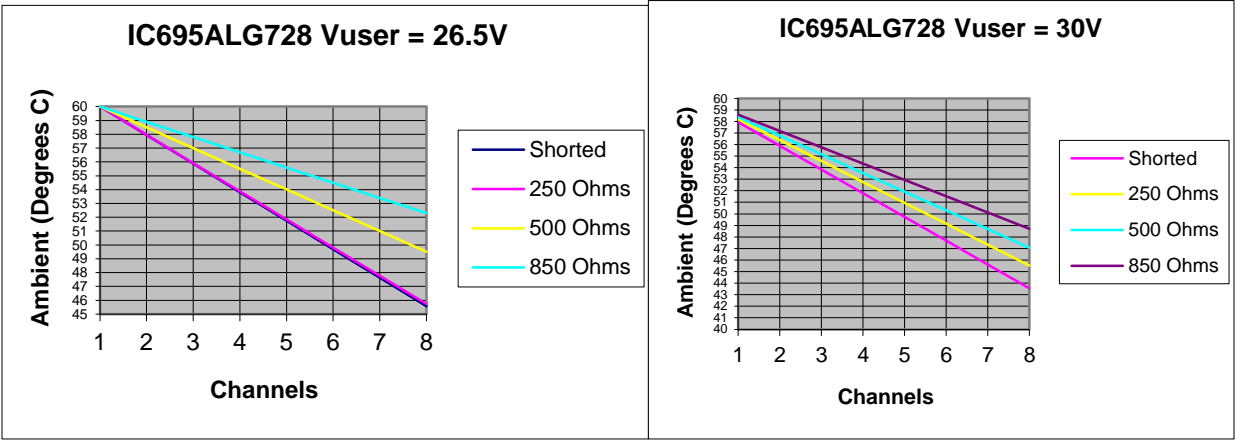


Figure 321: Thermal Derating Charts ALG728 Current Mode

11.3.5 Configuration: ALG728

11.3.5.1 Module Parameters

Parameter	Default	Description
Outputs Reference Address	%AQxxxxx	Starting address for the output data of this module. This defaults to the next available %AQ block. The format of this data is shown on in Section 11.3.6.
Outputs Reference Length	ALG728: 16	The number of words used for the output data of this module. This parameter cannot be changed.
Output Command Feedback Reference Address	%AIxxxxx	Starting address for the command feedback data of this module. This defaults to the next available %AI address after a non-zero length is configured.
Output Command Feedback Length	0	The number of words used for the command feedback data of this module. Length defaults to 0. It can be set to 8 or 16, depending on the module type being configured.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block. The format of this data is shown in Section 11.3.6.2.
Diagnostic Reference Length	0	Read Only. The number of bit reference bits required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping. Maximum length is 256 bits.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of this module. This defaults to the next available %I block. The format of this data is shown in Section 11.3.6.3.
Module Status Reference Length	0	Read Only. The number of bits (0 or 32) required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping.

Analog Output Commanded Feedback

The module returns a copy of the analog output data received from CPU in its corresponding channel analog input shared memory. Output Feedback can be monitored to check the values being sent to the channels. The data is in the same scaled format as the output data for each channel. During normal operation this feedback data should match the actual output data after one or more PLC scans of module inputs. During faults, ramping, over-range, and clamping conditions, the analog output data may differ from the commanded output.

Over-Temperature

If Over-Temperature is enabled, the module generates an Over-Temperature alarm if the internal temperature of this module is too great for the number of outputs that are on at the same time. In addition to the configurable options for Over-Temperature fault reporting and interrupts, an over temperature condition is also indicated by the Over-Temperature bit in the Status Reference data of this module. Detection of the Over-temperature status bit is always enabled.

Module Parameters (Continued)

Parameter	Default	Description	
HART Data Scan Control	No data	Selects whether the CPU will automatically scan from the HART module: no data, changed data only, or all data for each HART-enabled channel. Refer to the below for details of memory usage. Dynamic Data Only: the first 18 words or 288 bits of HART data per input device. All Data: all of the HART data (88 words or 1408 bits for each HART input device).	
HART Pass-Through Service Options	Once per two channel scans	Selects whether the module will automatically service a HART pass-through command each 1, 2, or 4-channel scans or only upon change of HART device configuration, or if data hasn't been read for 10 seconds (Pass-Through Only). If Pass-Through Only is selected, scan data is not available to the application program.	
HART Status Reference Address		Starting address of the HART Status data. Format of this data is shown in Section 11.4.1.	
HART Status Reference Length		Length of the HART Status data; 4 words or 64 bits.	
HART Data Reference Address		Starting address for the HART data of this module in %I, %Q, %AI, %AQ, %R, %W, %G, %M, or %T memory. Format of this data is shown in Section 11.4.2.	
HART Data Reference Length	0	Length of the HART data. If Data Scan Control is set to no data, the length is 0. The length is automatically set according to the selection made for HART Data Scan Control:	
		HART Data Scan Control	HART Data Reference Length
		No Data	0
		Dynamic Data Only	Highest HART-enabled Channel Number X (18 words or 288 bits)
		All Data	Highest HART-enabled Channel Number X (88 words or 1408 bits)
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data	
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.	
Module Fault Reporting Enabled	Enabled	Enabled / Disabled. Controls whether the module will report faults resulting from either loss of field power or over-temperature conditions.	
Field Power Removed Enabled	Enabled	Enabled / Disabled. With Module Fault Reporting enabled, this parameter controls reporting of Field Power Removed module faults.	
Over Temp Enabled	Enabled	Enabled / Disabled. With Module Fault Reporting enabled, this parameter controls reporting of Over-temperature module faults.	
Module Interrupt Reporting Enabled	Disabled	Enabled / Disabled.	
Field Power Removed Enabled	Disabled	Enabled / Disabled. With Module Interrupt Reporting enabled, this parameter controls interrupts for Field Power Removed module faults.	
Over Temp Enabled	Disabled	Enabled / Disabled. With Module Interrupt Reporting enabled, this parameter controls interrupts for Over-temperature module faults.	

11.3.5.2 Channel Parameters

Parameter	Default	Description
Range Type	Disabled Current	Sets up the type of output to be used for each channel. Choices are: Disabled Voltage, Disabled Current, Current/Voltage. Channels used for HART communications must have Range Type set to Current/Voltage.
Range (Only for Range Type Current/Voltage)	-10 V dc to +10 V dc	For Current/Voltage: -10 V dc to +10 V dc, 0V to +10 V dc, 4mA to 20 mA, 0mA to 20 mA. Channels used for HART communications must have Range set to 4mA to 20A.
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
Outputs Default	Force to Default Value	Controls the state the output will be set to in Outputs Disabled mode (stop), if a fault occurs, if power is lost, or if the configuration is cleared. Choices are Hold Last State, or default to a specific configured default value.

Range Type

Each channel on the module that will be used should be configured for Current/Voltage. Its voltage or current range and other parameters can then be configured as needed. If the channel output will not be used and is not wired, select either "Disabled" option. If a channel is disabled, it is not necessary to configure any of its other parameters.

If the channel is wired to a current output, but is not being used, select "Disabled Current". This will set the output current for that channel to 0mA (the output voltage for that channel will be non-zero).

If the channel is wired to a voltage output, but is not being used, select "Disabled Voltage". This will set the output voltage for that channel to 0V (the output current for that channel will be non-zero).

Output Defaults

If Hold Last State is enabled, an output will hold its last commanded value when the CPU indicates Outputs Not Enabled, or if one of the fault conditions listed below occurs. If Hold Last State is disabled, the output is commanded to go to the Default Value. The Default Value must be set within the selected output range. If both Default Value and Ramp Rate are enabled, the channel will ramp to the default value. Fault conditions are:

- CPU outputs are not enabled
- Backplane power is not ok. In that case, there is no ramping, even if ramping is enabled.
- Loss of communications from CPU.
- Loss of I/O communications.
- Loss of field power.

Outputs Default Notes

- Hot Removal of the module in an I/O Enabled mode will cause all outputs to Hold Last State (even channels configured for Force to Default Value). If that operation is not desirable, the outputs can be forced to default by first turning off field power and removing the Terminal Block of this module before hot-removing the module.
- Resetting the module using SVC_REQ 24 causes all channels to Hold Last State even if Default Value is configured. The application program must handle output defaulting before execution of the Service Request.
- Default Ramp Rate configuration is ignored if backplane power from the power supply is lost. Channels configured for Default Value go to the default value immediately.
- The first time a configuration is stored following a return of backplane power, the Default Ramp rate is not used. Any channel configured for Default Value goes to its default value immediately. If analog power was not lost and the same configuration is restored on the next power-up, the channel state is unchanged from the time the power was lost. The Default Ramp Rate is used for any subsequent reconfiguration.

Output Default Conditions and Actions

Condition	Hold Last State or Default Value	Default Ramp Rate Enabled	Outputs Enabled and Ramp Rate Enabled	Channel Output Setting (Except where indicated, field power is assumed to be present).
Outputs Enabled and No Faults	N/A	N/A	No	Output goes to its commanded value from reference memory; defaults don't apply.
	N/A	N/A	Yes	Output is ramped to the commanded output from reference memory at the Outputs Enabled ramp rate. Defaults don't apply.
Outputs Disabled, Fault Mode, or Reconfiguration	Default Value	No	N/A	Output is set to the Default Value
	Default Value	Yes	N/A	Output is ramped to the Default Value at the Default ramp rate, starting at the last commanded value before entering mode.
	Hold Last State	N/A	N/A	Output is held at the last commanded value
Loss of Backplane Power or First Configuration Store after Power-up	Default Value	N/A	N/A	Output is set to the Default Value.
	Hold Last State	N/A	N/A	Output is held at last commanded value.
Hot Removal, Reset with SVCREQ 24 or Cleared Configuration	N/A	N/A	N/A	Output is held at last commanded value.
Loss of Field Power	N/A	N/A	N/A	All outputs go to 0V and 0mA.

Channel Parameters (Continued)

Parameter	Default	Description
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type have a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default = High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

Output Scaling: ALG728

By default, the module converts a floating point value from the CPU into a voltage or current output over the entire span of its configured Range. For example, if the Range of a channel is 4 to 20mA, the module accepts channel output values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D units value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the output.

Example

In this example, the application should interpret 32000 counts as +10 V dc and -32000 counts as -10 V dc. The following channel configuration will scale a ±10 V dc output channel to ±32000 counts.

- Channel Value Format = 16 Bit Integer
- High Scale Value (Eng Units) = 32000.0
- Low Scale Value (Eng Units) = -32000.0
- High Scale Value (A/D Units) = 10.000
- Low Scale Value (A/D Units) = -10.000

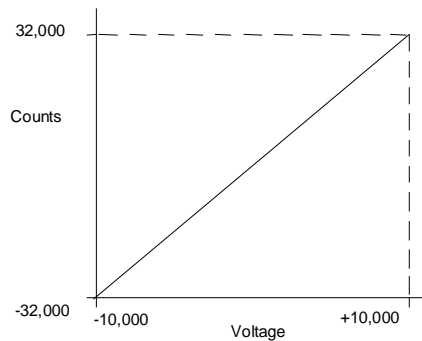


Figure 322: Scaling Example ALG728

Channel Parameters (Continued)

Parameter	Default	Description
High Alarm (Eng Units)	The defaults depend on the configured Range.	All of the alarm parameters are specified in Engineering Units. When the configured value is reached or below (above), a Low (High) Alarm is triggered.
Low Alarm (Eng Units)		
Outputs Enabled Ramp Rate (Eng Units)	0.0	The rate in Engineering Units at which the output will change during normal operation.
Default Ramp Rate (Eng Units)	0.0	The rate in Engineering Units at which the output will change if a fault condition occurs or if outputs are not enabled.
Output Clamping Enabled	Disabled	Enabled / Disabled. Refer to description below.
Upper Clamp Limit (Eng Units)	The defaults depend on the configured Range.	The Upper Clamp Limit must be greater than the Lower Clamp Limit. This parameter can be used to restrict the output to a range that is narrower than its configured Range Type. For example, a channel configured for -10 V dc to +10 V dc could be restricted to -8Vdc to +7.5Vdc.
Lower Clamp Limit (Eng Units)		
Default Value (Eng Units)	0.0	If Hold Last State is disabled, the output is commanded to go to the Default Value when the CPU is not in Outputs Enabled mode or under certain fault conditions.
User Offset (Eng Units)	0.0	A configurable value that can be used to change the base of the channel. This value is added to the scaled value of the channel before alarm-checking.

Lower, Upper Clamp and Alarms: ALG728

Alarms can be used to indicate when the module has been commanded to meet or exceed the configured high or low limits for each channel. These are set at six configurable alarm trigger points:

- High Alarm and Low Alarm
- Upper Clamp and Lower Clamp
- Over-range and Under-range Alarm

Each alarm is individually configurable per channel to generate diagnostics bit status, fault alarms, or interrupt alarms.

If a channel is commanded higher than the Upper Clamp value, the output is set to the Upper Clamp value and an Upper Clamp condition is indicated. If a channel is commanded lower than the Lower Clamp value, the output is set to the Lower Clamp value and a Lower Clamp condition is indicated.

The High and Low Alarm checks are performed on the engineering units output value after possibly being adjusted by ramping, clamping, and fault conditions.

Channel Parameters (Continued)

Parameter	Default	Description
Diagnostic Reporting Enable <i>If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.</i>	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area. Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table.
Fault Reporting Enable <i>If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.</i>	Disabled	These parameters enable or disable the individual diagnostics features of a channel. When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature.
Interrupts Enable	Disabled	
Low Alarm Enable	Disabled	
High Alarm Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Lower Clamp Alarm Enable	Disabled	
Upper Clamp Alarm Enable	Disabled	
		For example, if Over Range is enabled in the “Diagnostic Reporting Enable” menu, the module will set the Over Range bit in the Diagnostic Reference for the channel. If any of these parameters is disabled, the module does not react to the associated alarm conditions. For example, if Low Alarm Enable is set to Disabled in the “Fault Reporting Enable” menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.

Alarming and Fault Reporting: ALG728

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Using Interrupts

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of this module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address corresponding to that channel.

Example:

In this example, the Outputs Reference Address block is mapped to %AQ0001-%AQ0008. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AQ0003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the *I/O Interrupt* Type and %AQ0003 as the Trigger.

Fault Reporting and Interrupts

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

Channel Parameters (Continued)

Parameter	Default	Description
HART Communications	Disabled	Enabled/disabled. Set HART Communications to <i>enabled</i> if the channel will use HART communications. Enabling HART communications forces the channel to 4-20mA operation.
HART Slot Variables	Disabled	Enabled/disabled. If HART Slot Variables is enabled, the module will periodically send HART command #33 to request data. Channel variables will be read and placed in the HART scan block channel data. For each slot, the variable assignment code can be set between 0 and 255.
Slot Code 0, 1, 2, 3	1	The slot transmitter variable assignment code that will be used to retrieve data from the connected HART device. These values are used in the request data for HART command #33.

11.3.6 Output Module Data Formats: ALG728

This section explains how the module uses separate reference areas that can be assigned during module configuration:

- *Output Value Reference Data*, required memory for the analog output channel values.
- *Output Channel Diagnostic Reference Data*, optional memory for channel faults and alarms.
- *Module Status Reference Data*, optional memory for general module status data.

In addition, during configuration, optional *HART Reference Data*, memory can be assigned. Refer to the section “HART Reference Data” later in this chapter for details.

11.3.6.1 Output Value Reference Data: ALG728

The module receives its channel data from its configured output words, beginning at its assigned *Outputs Reference Address*. Each channel occupies 2 words, whether the channel is used or not:

Outputs Reference Address	Contains Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

Depending on its configured Channel Value Format, each enabled channel output reference location is read as a 32-bit floating point or 16-bit integer value.

In the 16-bit integer mode, low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bits is ignored. The full range of the 16-bit integer is a signed decimal value from +32767 to -32768.

Because the channel reference location is 32 bits, it is possible for the application program to write 32-bit signed decimal values to the output reference. However, the program logic must restrict the magnitude of the value to the range +32767 to -32768. Exceeding this range will result in misinterpretation of the sign bit, and incorrect output channel operation.

11.3.6.2 Output Channel Diagnostic Reference Data: ALG728

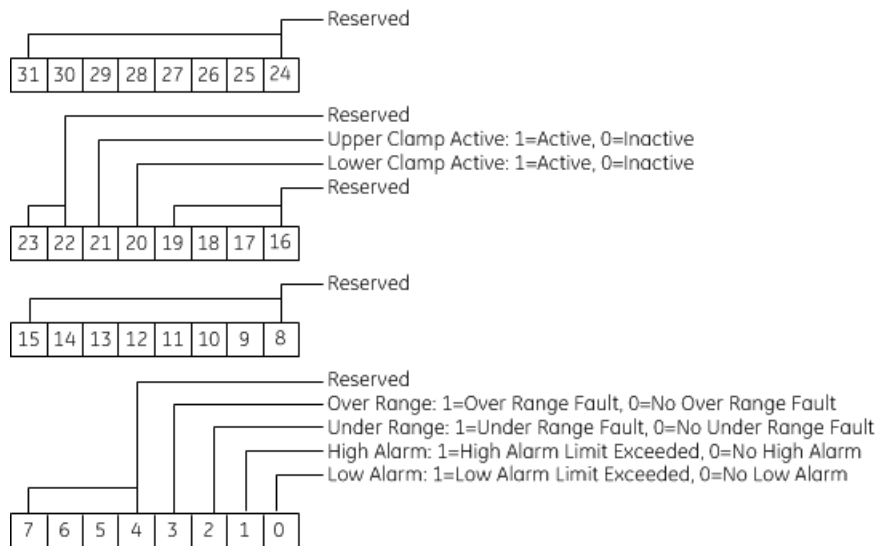
The module can optionally be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for this module. Use of this feature is optional.

The diagnostics data each channel occupies 2 words (whether the channel is used or not):

Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

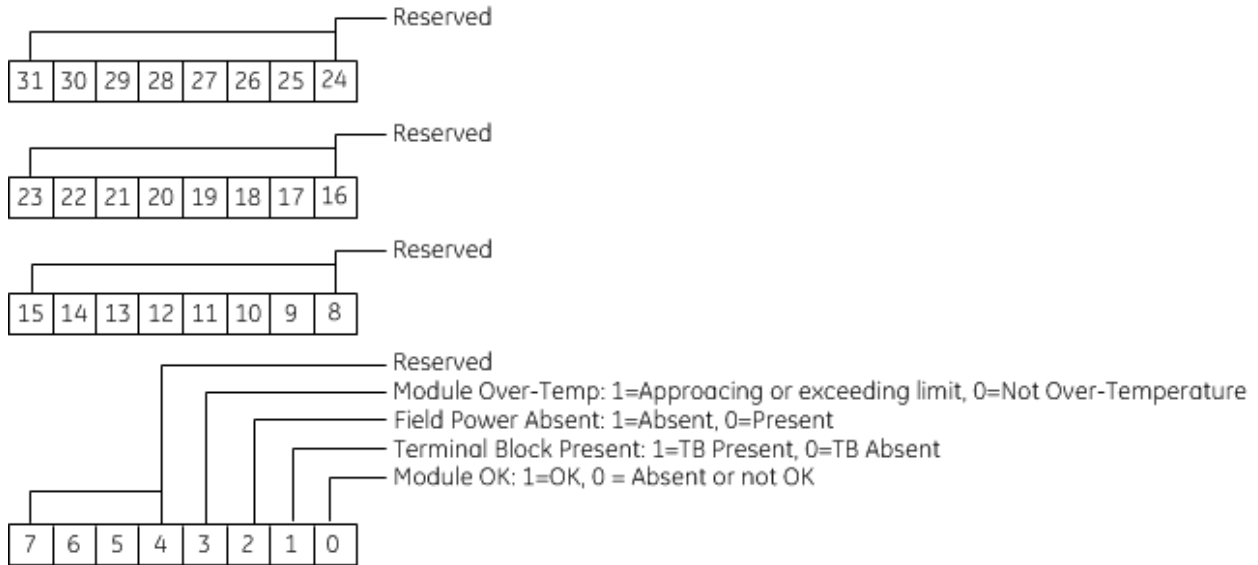
When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



11.3.6.3 **Module Status Data: ALG728**

The module can also optionally be configured to return 4 bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data reference* area configured for this module.



Terminal Block Detection

The module automatically checks for the presence of a Terminal Block. The TB LED indicates the state of the terminal block of this module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 2 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

11.3.7 Field Wiring: ALG728

The following table lists wiring connections for the module. There are no shield terminals. For shielding, tie cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provide in the ground bar for this purpose.

Terminal	Assignment	Assignment	Terminal
1	Channel 2 Voltage Out	Channel 1 Voltage Out	19
2	Channel 2 Current Out	Channel 1 Current Out	20
3	Common (COM)	Common (COM)	21
4	Channel 4 Voltage Out	Channel 3 Voltage Out	22
5	Channel 4 Current Out	Channel 3 Current Out	23
6	Common (COM)	Common (COM)	24
7	Channel 6 Voltage Out	Channel 5 Voltage Out	25
8	Channel 6 Current Out	Channel 5 Current Out	26
9	Common (COM)	Common (COM)	27
10	Channel 8 Voltage Out	Channel 7 Voltage Out	28
11	Channel 8 Current Out	Channel 7 Current Out	29
12	Common (COM)	Common (COM)	30
13	Common (COM)	Common (COM)	31
14	Common (COM)	Common (COM)	32
15	Common (COM)	Common (COM)	33
16	Common (COM)	Common (COM)	34
17	Common (COM)	Common (COM)	35
18	Common (COM)	+24V In	36

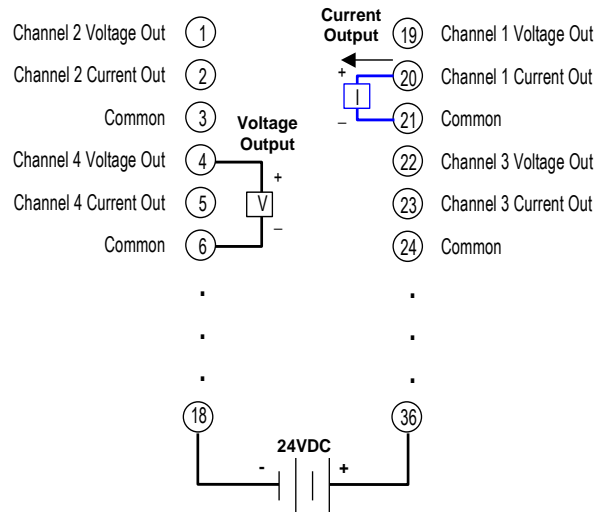


Figure 323: Field Wiring ALG728

Each channel can be individually-configured to operate as a voltage output or a current output, not both simultaneously. All the common terminals are connected together internally. Therefore, any common terminal can be used for the negative lead of the external power supply.

11.3.8 HART Device Connections

Example connections for 2-wire transmitters are displayed in the following figure.

Connecting a HART Output Device

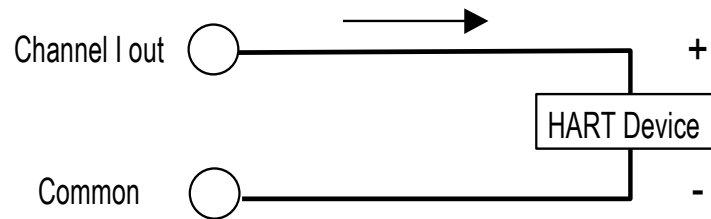


Figure 324: Attaching HART 2-Wire Output Device

Connecting a HART Input Transmitter to an Output Channel

In this type of application, the HART output module, IC695ALG728, cannot read the analog current level from the HART device. However, the module can communicate with the HART signal. There is no analog input to the module.

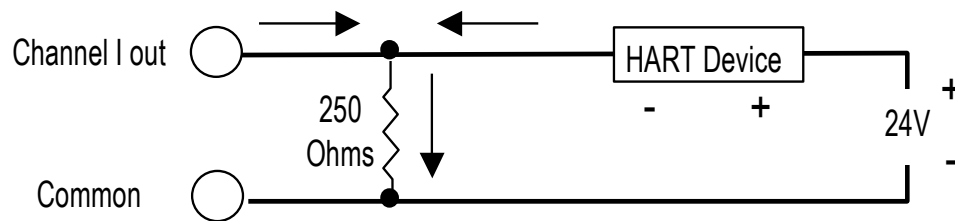


Figure 325: HART Input Transmitter attached to Analog Output Channel

11.4 HART Reference Data

If *HART Data Scan Control* is configured as “Dynamic Data Only” or “All Data”, the CPU automatically scans the HART data listed on the next page into the *HART Data Reference Address* configured for this module. The data length depends on whether All Data or Dynamic Data is selected.

This data includes response data associated with several HART Pass-Through Commands. The module stores this data, and then passes it to the CPU either in the automatic HART data scan described above, or in response to function blocks in the application program.

Note that invalid or uninitialized REAL (floating point) data will be set to NaN (Not-A-Number).

11.4.1 HART Status Data

In addition to the HART Reference Data, the module reports the status of HART communications in its configured HART Status Reference Address. The length of this data is 4 words / 64 bits:

Word 1	Device Present, one bit per channel. Channel 1 in lowest bit. For 8-channel module, bits 9-16 are not used.
Word 2	Device Initializing, one bit per channel. Channel 1 in lowest bit. For 8-channel module, bits 9-16 are not used.
Words 3 and 4	Not used

11.4.2 HART Data Format

		Byte Offset	Field Description	Type	
		Begin	End		
All HART Data	Dynamic HART Data Only	0x0000	0x0003	HART Primary Variable, CMD#3, Bytes 5-8	REAL
		0x0004	0x0007	HART Secondary Variable CMD#3, Bytes 10-13	REAL
		0x0008	0x000b	HART Tertiary Variable CMD#3, Bytes 15-18	REAL
		0x000c	0x000f	HART Fourth Variable CMD#3, Bytes 20-23	REAL
		0x0010	0x0013	Slot 0 value. CMD#33, Bytes 2-5	REAL
		0x0014	0x0017	Slot 1 value CMD#33, Bytes 8-11	REAL
		0x0018	0x001b	Slot 2 value CMD#33, Bytes 14-17	REAL
		0x001c	0x001f	Slot 3 value CMD#33, Bytes 20-23	REAL
		0x0020		HART communication status byte from the last HART command response.	BYTE
		0x0021		HART device status byte from the last HART command response.	BYTE
		0x0022		Spare for alignment.	BYTE*2
		0x0024		HART device Manufacturer ID. CMD#0, Byte 1	BYTE
		0x0025		HART device type code. CMD#0, Byte 2	BYTE
		0x0026		Minimum number of preambles device requires. CMD#0, Byte 3	BYTE
		0x0027		HART Universal command code. CMD#0, Byte 4	BYTE
0x0028		HART Transmitter specific revision. CMD#0, Byte 5	BYTE		
0x0029		HART device software revision number. CMD#0, Byte 6	BYTE		

	Byte Offset		Field Description	Type
	Begin	End		
	0x002A		HART device hardware revision number. CMD#0, Byte 7	BYTE
	0x002B		HART flags. CMD#0, Byte 8	BYTE
	0x002C	0x002F	HART device ID number. CMD#0, Byte 9-11	BYTE*4
	0x0030	0x0037	8 character device tag. CMD#13, Bytes 0-5 in unpacked ASCII.	BYTE*8
	0x0038	0x0047	Device Descriptor. CMD#13, Bytes 6-17 in unpacked ASCII	BYTE*16
	0x0048		HART Primary Variable Units. CMD#3, Byte 4	BYTE
	0x0049		HART Secondary Variable Units. CMD#3, Byte 9, 0 if not present.	BYTE
	0x004a		HART Tertiary Variable Units. CMD#3, Byte 14, 0 if not present.	BYTE
	0x004b		HART Fourth Variable Units. CMD#3, Byte 19, 0 if not present.	BYTE
	0x004c		HART Primary Variable Code. CMD#50, Byte 0	BYTE
	0x004d		HART Secondary Variable Code. CMD#50, Byte 1	BYTE
	0x004e		HART Tertiary Variable Code. CMD#50, Byte 2	BYTE
	0x004f		HART Fourth Variable Code. CMD#50, Byte 3	BYTE
	0x0050		Units code for range parameter. CMD#15, Byte 2	BYTE
	0x0051	0x0053	Spare for alignment	BYTE*3
	0x0054	0x0057	Low transmitter range for analog signal in eng. units. CMD#15, Bytes 3-6	REAL
	0x0058	0x005b	High transmitter range for analog signal in eng. units. CMD#15, Bytes 7-10	REAL
	0x005c		Slot 0 units code. CMD#33, Byte 1	BYTE
	0x005d		Slot 1 units code. CMD#33, Byte 7	BYTE
	0x005e		Slot 2 units code. CMD#33, Byte 13	BYTE
	0x005f		Slot 3 units code. CMD#33, Byte 19	BYTE
	0x0060		Slot 0 variable code. CMD#33, Byte 0	BYTE
	0x0061		Slot 1 variable code. CMD#33, Byte 6	BYTE
	0x0062		Slot 2 variable code. CMD#33, Byte 12	BYTE
	0x0063		Slot 3 variable code. CMD#33, Byte 18	BYTE
	0x0064	0x0083	32 character message. CMD#12, Bytes 0-23 unpacked ASCII.	BYTE*32
	0x0084	0x0087	Stored date in the field device. CMD#13, Bytes 18-20.	BYTE*4
	0x0088	0x008b	The final assembly number is used for identifying the material and electronics that comprise the field device. CMD#16, Bytes 0-2	BYTE*4
	0x008c	0x00a4	The extended status returned by HART command 48.	BYTE*25
	0x00a5	0x00af	Spare	BYTE*11

11.5 COMMREQs for HART Modules

Three Communication Request (COMMREQ) functions can be used in the application program to communicate with RX3i HART modules.

COMMREQ 1, Get HART Device Information, reads (local rack)

- The TaskID must be set to 1.

Remote Get HART Device Information, reads (remote rack)

- The TaskID must be set to:
 - Rack mounted PNC, Hex 85 or decimal 133
 - Embedded PNC, Hex 20085 or decimal 131205

Note that a UDFB that automates the COMMREQ control logic is available for download from the GE support website. (Article ID: 000017816) https://ge-ip.force.com/communities/en_US/Download/Remote-Get-HART-Device-Information-COMMREQ-UDFB

COMMREQ 2, Send HART Pass-Through Command

- The TaskID must be set to 1.

11.5.1 Get HART Device Information, COMMREQ 1 Command Block

Word Offset	Value Dec (Hex)	Definition		
Word 1	8 (0008)	Length of command Data Block in words beginning at Word 7.		
Word 2	0 (0000)	Always 0 (no-wait mode request)		
Word 3		Memory type of COMMREQ status word. (Words 3 and 4 specify the starting address where the status word will be written.) It can be:		
		Memory Type	Memory Type	Decimal code
		%I	Discrete input table (Bit mode)	70
		%Q	Discrete output table (Bit mode)	72
		%I	Discrete input table (Byte mode)	16
		%Q	Discrete output table (Byte mode)	18
		%R	Register memory	8
		%W	Word memory	196
%AI	Analog input table	10		
%AQ	Analog output table	12		
Word 4	0-based offset	COMMREQ status word address minus 1. Example: if Words 3 and 4 contain values of 8 and 9 respectively, the status word will be written to %R10.		
Word 5, 6	0 (0000)	Reserved		
Word 7	1 (0001)	Command code for the COMMREQ to be executed. Get HART Device Information = 1.		
Word 8	1 (0001)	Number of Response Reference areas that follow (does not include COMMREQ status word). Always 1.		
Word 9		Memory type for the reply data. (Words 9–12 specify the starting address where the response will be written.)		
		Memory Type	Memory Type	Decimal code
		%I	Discrete input table (Byte mode)	16
		%Q	Discrete output table (Byte mode)	18
		%W	Word memory	196
		%R	Register memory	8
		%AI	Analog input table	10
		%AQ	Analog output table	12
%T	Discrete temporary memory (Byte)	20		
%M	Discrete internal memory (Byte)	22		
Word 10	0 (0000)	Bit Offset (must be 0 for all requests).		
Word 11	0-based offset (low word).	Starting address to which the response will be written. The value entered is the 0-based offset from the beginning of PLC memory for the memory type specified in Word 9. This offset is in bytes or words depending on the memory type specified. Valid ranges of values depend on the memory ranges of the host PLC. Example: If Words 9 and 11 contain values of 8 and 250 respectively, the response will be written to %R251.		
Word 12	0-based offset (high word)	High word of offset. Value = 0 for most memory types. High word is non-zero only on if %W memory is used.		
Word 13	Words: 90 (005A) Bytes: 180 (00B4)	Maximum size of response area. Must be 90 if word memory type is used; 180 if discrete memory type is used.		
Word 14	Range 1-16.	Channel Number 1-16 (valid range depends on module channel count and single-ended versus differential mode)		

11.5.2 Remote Get HART Device Information, Command Block

Word Offset	Value Dec (Hex)	Definition		
Word 1	11 (000B)	Length of command Data Block in words beginning at Word 7.		
Word 2	0 (0000)	Always 0 (no-wait mode request)		
Word 3		Memory type of COMMREQ status words ⁶⁴ . (Words 3 and 4 specify the starting address where the status words will be written.) It can be:		
		Memory Type	Memory Type	Decimal code
		%I	Discrete input table (Bit mode)	70
		%Q	Discrete output table (Bit mode)	72
		%I	Discrete input table (Byte mode)	16
		%Q	Discrete output table (Byte mode)	18
		%R	Register memory	8
		%W	Word memory	196
		%AI	Analog input table	10
%AQ	Analog output table	12		
Word 4	0-based offset	COMMREQ status words address minus 1. Example: if Words 3 and 4 contain values of 8 and 9 respectively, the status words will be written to %R10 and %R11.		
Word 5, 6	0 (0000)	Reserved		
Word 7	1 (0001)	Command code for the COMMREQ to be executed. Get HART Device Information = 1.		
Word 8	1 (0001)	Number of Response Reference areas that follow (does not include COMMREQ status word). Always 1.		
Word 9		Memory type for the reply data. (Words 9–12 specify the starting address where the response will be written.)		
		Memory Type	Memory Type	Decimal code
		%I	Discrete input table (Byte mode)	16
		%Q	Discrete output table (Byte mode)	18
		%W	Word memory	196
		%R	Register memory	8
		%AI	Analog input table	10
		%AQ	Analog output table	12
		%T	Discrete temporary memory (Byte)	20
%M	Discrete internal memory (Byte)	22		
Word 10	0 (0000)	Bit Offset (must be 0 for all requests).		
Word 11	0-based offset (low word).	Starting address to which the response will be written. The value entered is the 0-based offset from the beginning of PLC memory for the memory type specified in Word 9. This offset is in bytes or words depending on the memory type specified. Valid ranges of values depend on the memory ranges of the host PLC. Example: If Words 9 and 11 contain values of 8 and 250 respectively, the response will be written to %R251.		
Word 12	0-based offset (high word)	High word of offset. Value = 0 for most memory types. High word is non-zero only on if %W memory is used.		

⁶⁴ The COMMREQ status words consist of two words of memory. The lower 16-bit word provides the COMMREQ Status and the upper 16-bit word provides the Command Status.

Word Offset	Value Dec (Hex)	Definition
Word 13	Words: 90 (005A) Bytes: 180 (00B4)	Maximum size of response area. Must be 90 if word memory type is used; 180 if discrete memory type is used.
Word 14	Range 1-16.	Channel Number 1-16 (valid range depends on module channel count and single-ended versus differential mode)
Word 15	Device ID	ID of Remote PROFINET Scanner.
Word 16	Slot	Remote Rack Slot number of HART capable Analog module.
Word 17	SubSlot	Remote Rack SubSlot number of HART capable Analog module

11.5.2.1 Command Status Word

The Command status word for the Remote Get HART Device Information command is displayed in the following figure.

Value		Description
Dec	(Hex)	
0	(0000)	No command-specific status available.
1	(0001)	Invalid PROFINET device number.
2	(0002)	Undeclared PROFINET device (invalid name or nonexistent).
3	(0003)	Invalid slot or subslot number.
4	(0004)	Non-specific PROFINET error.
5	(0005)	Invalid channel number.
6	(0006)	Non-specific command error.

11.5.2.2 Minimum Firmware & GSDML Requirements

The Remote Get HART Device Information COMMREQ requires the following firmware revisions and GSDMLs:

- RX3i CPUs with version 8.95 or later
- IC695PNC001 RX3i PROFINET Controller version 2.26 or later
- IC695PNS001 RX3i PROFINET Scanner version 2.41 or later
- IC695PNS001 RX3i PROFINET Scanner GSDML-V2.3-GEIP-RX3iPNS-20160602.xml

Note that the updated IC695PNS001 RX3i PROFINET Scanner GSDML-V2.3-GEIP-RX3iPNS-20160602.xml is required to enable the HART Pass Through Service Options settings for HART capable analog modules in PME. The settings are:

- Once per Channel Scan
- Once per Two Channel Scans (default)
- Once per Four Channel Scans
- Pass-Thru Only

The first three option settings set the rate at which an analog module that supports HART communications queries a HART device for its Remote Get HART Device Information data. Whereas, the Pass-Thru Only setting configures channel scanning that occurs only when the HART device configuration changes or has not been read for 10 seconds. Note that the Remote Get HART Device Information feature does not work when the "Pass-Thru Only" setting is selected.

11.5.3 COMMREQ Status Word

The COMMREQ status word for the Remote and Local Get HART Device Information command is displayed in the following figure.

Value		Description
Dec	(Hex)	
0	(0000)	Device has not yet processed the COMMREQ.
1	(0001)	Command Complete Note: This status does not necessarily mean success. Some commands have reply data that must also be checked.
2	(0002)	Command Terminated – module busy
3	(0003)	Command Terminated – invalid command
4	(0004)	Command Terminated – invalid command data
5	(0005)	Command Terminated – not enough data
6	(0006)	Not used
7	(0007)	Command Terminated – not enough memory in reply area The command did not specify sufficient PLC memory for the reply. Command will be ignored.
8	(0008)	Command Terminated – command-specific error. Local Commreq; Refer to Additional Code in the Status Block for more information. Remote Commreq; Refer to the additional codes in section 11.5.2.1 Command Status Word for more information. Example: If the first word (lower) contains a value of 8 and the second word (upper) contains a value of 3 then the error is an “Invalid slot or subslot number.”
265	(0109)	Error, Hart device not connected
521	(0209)	Error, Channel not HART-enabled
777	(0309)	Error, Analog Output Module, No field power
1033	(0409)	Error. HART command not allowed
1289	(0509)	Error. Invalid HART command
1545	(0609)	Error. Device did not respond
1801	(0709)	Error, HART data count too large

11.5.4 Remote and Local Get HART Device Information, Reply Data Format

The response to a *Remote and Local Get HART Device Information* COMMREQ is written to the PLC memory location specified in words 9-12 of the COMMREQ.

Byte	Name	Description
1, 2	Command Code	Echo of Command code. (0x0001)
3, 4	Channel Number	Echo of Channel Number
5-8	HART Primary Variable	CMD#3, Bytes 5-8. Type: REAL
9-12	HART Secondary Variable	CMD#3, Bytes 10-13 Type: REAL
13-16	HART Tertiary Variable	CMD#3, Bytes 15-18. Type: REAL
17-20	HART Fourth Variable	CMD#3, Bytes 20-23. Type: REAL
21-24	Slot 0 value	CMD#33, Bytes 2-5. Type: BYTE
25-28	Slot 1 value	CMD#33, Bytes 8-11. Type: BYTE
29-32	Slot 2 value	CMD#33, Bytes 14-17. Type: BYTE
33-36	Slot 3 value	CMD#33, Bytes 20-23. Type: BYTE
37	HART communication status byte from the last HART command response, refer to next page	
38	HART device status byte from the last HART command response, refer to next page.	
39-40	Spare for alignment.	Type: BYTE
41	HART device Manufacturer ID. CMD#0, Byte 1	Type: BYTE
42	HART device type code. CMD#0, Byte 2	Type: BYTE
43	Minimum number of preambles device requires	CMD#0, Byte 3. Type: BYTE
44	HART Universal command code	CMD#0, Byte 4. Type: BYTE
45	HART Transmitter specific revision	CMD#0, Byte 5 Type: BYTE
46	HART device software revision number	CMD#0, Byte 6 Type: BYTE
7	HART device hardware revision number	CMD#0, Byte 7 Type: BYTE
48	HART flags	CMD#0, Byte 8 Type: BYTE
49-52	HART device ID number	CMD#0, Byte 9-11 Type: 4 BYTES
53-60	8 character device tag.	CMD#13, Type: 8 BYTES. Bytes 0-5 are unpacked ASCII
61-76	Device Descriptor	CMD#13, TYPE: 16 BYTES. Bytes 6-17 are unpacked ASCII
77	HART Primary Variable Units	CMD#3, Byte 4. Type: BYTE
78	HART Secondary Variable Units	CMD#3, Byte 9, 0 if not present. Type: BYTE
79	HART Tertiary Variable Units	CMD#3, Byte 14, 0 if not present. Type: BYTE
80	HART Fourth Variable Units	CMD#3, Byte 19, 0 if not present. Type: BYTE
81	HART Primary Variable Code	CMD#50, Byte 0 Type: BYTE
82	HART Secondary Variable Code	CMD#50, Byte 1 Type: BYTE
83	HART Tertiary Variable Code	CMD#50, Byte 2 Type: BYTE
84	HART Fourth Variable Code	CMD#50, Byte 3 Type: BYTE
85	Units code for range parameter	CMD#15, Byte 2 Type: BYTE
86-88	Spare for alignment	3 BYTES
89-92	Low transmitter range for analog signal in engineering units	CMD#15, Bytes 3-6 Type: REAL
93-96	High transmitter range for analog signal in engineering units	CMD#15, Bytes 7-10 Type: REAL
97	Slot 0 units code	CMD#33, Byte 1 Type: REAL
98	Slot 1 units code	CMD#33, Byte 7 Type: REAL

Byte	Name	Description
99	Slot 2 units code	CMD#33, Byte 13 Type: REAL
100	Slot 3 units code	CMD#33, Byte 19 Type: REAL
101	Slot 0 variable code	CMD#33, Byte 0 Type: REAL
102	Slot 1 variable code	CMD#33, Byte 6 Type: REAL
103	Slot 2 variable code	CMD#33, Byte 12 Type: REAL
104	Slot 3 variable code	CMD#33, Byte 18 Type: REAL
105-136	32 character message	CMD#12, Bytes 0-23 unpacked ASCII. Type: 32 BYTES
137-140	Stored date in the field device	CMD#13, Bytes 18-20. Type 4 BYTES
141-144	Number identifying the field device's material and electronics	CMD#16, Bytes 0-2. Type 4 BYTES
145-169	The extended status returned by HART command 48.	Type: 25 BYTES
170-180	Spare for alignment	Type: 11 BYTES

11.5.5 Sending a HART Pass-Through Command to a HART Device

The HART module automatically uses several HART Pass-Through commands as described earlier in this chapter. In addition, the application program can use the Send HART Pass-Through Command (COMMREQ 2) to send HART Pass-Through commands to an RX3i HART module. The HART module stores the data returned by the command in its on-board memory. This data can then be scanned automatically by the CPU or read as needed from the application program.

A list of Pass-Through commands is included in this section. The RX3i HART module then passes the command to the intended HART input or output device. Responses to HART Pass-Through commands are available to the application program in the COMMREQ replies.

The Send HART Pass-Through Command COMMREQ automatically fills in the Start Character, Address, Byte Count, Status, and the checksum. The RX3i HART module waits until the data from the HART device is available before it replies to this command, so the application program does not have to query the module for the response. The application program must check the COMMREQ Status word to determine when the reply data is available. The reply is returned between 750mS and 8 seconds later. The reply time depends on the number of channels enabled, the Pass Through rate selected, and whether other Pass-Through operations are occurring at the same time.

Only one application program Pass-Through command per channel is allowed at a time. If another request is made on a channel that has a Pass-Through in-progress, the module returns a COMMREQ Status Word = 0x0002 (module busy).

11.5.5.1 HART Pass-Through Command Block, COMMREQ 2

Word Offset	Value Dec (Hex)		Definition		
Word 1	10+x	000A + x	Length of command Data Block in words beginning at Word 7		
Word 2	0	0000	Always 0 (no-wait mode request)		
Word 3			Memory type of COMMREQ status word. It can be:		
			Memory Type	Memory Type	Decimal code
			%I	Discrete input table (Bit mode)	70
			%Q	Discrete output table (Bit mode)	72
			%I	Discrete input table (Byte mode)	16
			%Q	Discrete output table (Byte mode)	18
			%R	Register memory	8
			%W	Word memory	196
			%AI	Analog input table	10
%AQ	Analog output table	12			
Word 4	0-based offset		COMMREQ status word address minus 1 Example: if Words 3 and 4 contain values of 8 and 9 respectively, the status word will be written to %R10.		
Word 5	0	0000	Reserved		
Word 6	0	0000	Reserved		
Word 7	2	0002	Command code for the COMMREQ to be executed. HART Pass-Through Command = 2		
Word 8	1	0001	Number of Response Reference areas that follow (does not include COMMREQ status word). Always 1		
Word 9			Memory type for the reply data. (Words 9–12 specify the starting address where the response will be written).		
			Memory Type	Memory Type	Decimal code
			%I	Discrete input table (Byte mode)	16
			%Q	Discrete output table (Byte mode)	18
			%W	Word memory	196
			%R	Register memory	8
			%AI	Analog input table	10
			%AQ	Analog output table	12
			%T	Discrete temporary memory (Byte)	20
%M	Discrete internal memory (Byte)	22			
Word 10	0	0000	Bit Offset (must be 0 for all requests)		
Word 11	0-based offset (low word)		Starting address to which the response will be written. The value entered is the 0-based offset from the beginning of PLC memory for the memory type specified in Word 9. This offset will be in bytes or words depending on the memory type specified. Valid ranges of values depend on the memory ranges of the host PLC. Example: If Words 9 and 11 contain values of 8 and 250 respectively, the response will be written to %R251.		
Word 12	0-based offset (high word)		High word of offset. Value = 0 for most memory types. Would only have a non-zero value if %W memory is used		
Word 13	Response data size		Maximum size of response area. Size in bytes if discrete memory type used for response. Size in words if word type used		
Word 14	Channel Number (1-16).		Channel Number 1-16 (valid range depends on module channel count and single-ended versus differential mode)		
Word 15	HART command (0x0 – 0xff)		HART Pass-Through Command type. HART Pass-Through Commands that can be sent to an RX3i HART module are listed in this section.		

Word Offset	Value Dec (Hex)	Definition
Word 16	Command Data byte count	Size (in bytes) of command data that follows
...
Word 16+x	...	HART Command Data. Request data must be byte-packed and in big-endian format, PLC CPU format is little-endian, so some commands may require swapping of fields from little-endian to big-endian format as described in this chapter. This is usually needed for floating point data.

11.5.5.2 HART Pass-Through Reply Data Format

The RX3i HART module returns the response data below to the CPU memory location specified by words 9-12 of the COMMREQ. Data beginning at Word 7 of the reply is byte-packed and in big-endian format. PLC CPU format is little-endian, so some commands may require swapping of fields from big-endian to little-endian format as described in this chapter. This is usually needed for floating point data.

Word	Name	Description
1	Command Code	Echo of Command code (0x0002)
2	Channel Number	Echo of Channel Number (same as request)
3	HART command	Echo of HART Pass-Through Command type. Refer to the tables in this section.
4	HART Status	Low byte is HART Comm Status and high byte is HART Dev Status from HART device response.
5	Spare	Spare for future use. User logic should not check this value because future module revisions may make this non-zero.
6	Response Byte Count (x)	Size in bytes of the response data that follows.
7L	Data Low	First response data byte from device.
7H	Data High	Second response data byte from device.
...
7+(x-1)/2 L	Data Low
7+(x-1)/2 H	Data High	Last response data byte from device.

11.5.5.3 COMMREQ Status Word

The following table defines the values that can be returned in the COMMREQ status word.

Value		Description
Dec	(Hex)	
0	(0000)	Device has not yet processed the COMMREQ.
1	(0001)	Command Complete. This status does not necessarily mean success. Some commands have reply data that must also be checked.
2	(0002)	Command Terminated - module busy
3	(0003)	Command Terminated - invalid command
4	(0004)	Command Terminated - invalid command data
5	(0005)	Command Terminated - not enough data
6	(0006)	Not used
7	(0007)	Command Terminated - not enough memory in reply area. The command did not specify sufficient PLC memory for the reply. Command will be ignored.
8	(0008)	Command Terminated - command-specific error. Refer to the additional codes in in the Status Block for more information.
265	(0109)	Error, Hart device not connected
521	(0209)	Error, Channel not HART-enabled
777	(0309)	Error, Analog Output Module, No field power
1033	(0409)	Error. HART command not allowed
1289	(0509)	Error. Invalid HART command

This status information relates to the execution of the COMMREQ function, not to the status of the HART communications. HART communications status is provided in the response data, as shown previously in this section.

11.5.6 HART Pass-Through Commands and Command Codes for RX3i Modules

Within a HART command, data can be represented as integers, floating point numbers, ASCII text strings, or enumerated item lists. Unmarked data types are 8-, 16-, or 24-bit integers (including code values)

Universal Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
0	Read unique identifier	None			0	"254" (expansion)	
					1	Manufacturer identification code	
					2	Manufacturer device type code	
					3	Number of preambles required	
					4	Universal command revision	
					5	Device-specific command revision	
					6	Software revision	
					7	Hardware revision	Integer
					8	Device function flags: bit 0 = multisensor device, bit 1 = protocol bridge device	Bit
					9-11	Device ID number	
1	Read primary variable	None			0	PV units code	
					1-4	Primary variable (PV)	Floating pt
2	Read current and percent of range	None			0-3	Current (mA)	Floating pt
3	Read current and four predefined dynamic variables	None			0-3	Current (mA)	Floating pt
					4	PV units code	
					5-8	Primary variable (PV)	Floating pt
					9	SV units code	
					10-13	Secondary variable (SV)	Floating pt
					14	TV units code	
					15-18	Third variable (VT)	Floating pt
					19	FV units code	
20-23	Fourth variable (FV)	Floating pt					
6	Write polling address	0	Polling address		same as command		
11	Read unique identifier associated with tag	0-5	Tag	ASCII	0-11	Same as command #0, refer to above	
12	Read message	None			0-23	Message (32 characters)	ASCII
13	Read tag, descriptor, date	None			0-5	Tag (8 characters)	ASCII
					6-17	Descriptor (16 characters)	ASCII
					18-20	Date	Date
14	Read Primary Variable sensor information	None			0-2	Sensor serial number	
					3	Units code for sensor limits and min. span	
					4-7	Upper sensor limit	Floating pt
					8-11	Lower sensor limit	Floating pt
					12-15	Minimum span	Floating pt

Universal Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
15	Read output information	None			0	Alarm select code	
					1	Transfer function code	
					2	PV/range units code	
					3-6	Upper range value	Floating pt
					7-10	Lower range value	Floating pt
					11-14	Damping value (seconds)	Floating pt
					15	Write-protect code	
				16	Private-label distributor code		
16	Read final assembly number	None			0-2	Final assembly number	
17	Write message	0-23	Message (32 characters)	ASCII	Same as command		
18	Write tag, descriptor, date	0-5	Tag (8 characters)	ASCII	Same as command		
		6-17	Descriptor (16 characters)	ASCII			
		18-20	Date	Date			
19	Write final assembly number	0-2	Final assembly number		Same as command		

Among the common-practice commands listed below, commands #60 and #62 through #70 are used to configure and control the multiple outputs generated by some multivariable transmitters. Such multiple outputs are numbered 1 to 4, corresponding to the HART dynamic variables: PV (primary variable), SV (secondary variable), TV (third variable) and FV (fourth variable).

Common-Practice Commands		Data in Command			Data in Reply			
#	Function	Byte	Data	Type	Byte	Data	Type	
33	Read transmitter variables	0	Transmitted variable code for slot 0		0	Transmitted variable code for slot 0		
		1	Transmitted variable code for slot 1		1	Units code for slot 0		
		2	Transmitted variable code for slot 2		2-5	Variable for slot 0	Floating pt	
		3	Transmitted variable code for slot 3		6	Transmitted variable code for slot 1		
		Truncated after last requested code				7	Units code for slot 1	
						8-11	Variable for slot 1	Floating pt
						12	Transmitted variable code for slot 2	
						13	Units code for slot 2	
						14-17	Variable for slot 2	Floating pt
						18	Transmitted variable code for slot 3	
						19	Units code for slot 3	
						20-23	Variable for slot 3	Floating pt
		Truncated after last requested variable						

Common-Practice Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
34	Write damping value	0-3	Damping value (seconds)	Floating pt	Same as command		
35	Write range values	0	Range units code		Same as command		
		1-4	Upper range value	Floating pt			
		5-8	Lower range value	Floating pt			
36	Set upper range value (= push SPAN button)	None			none		
37	Set lower range value (= push ZERO button)	None			none		
38	Reset Configuration Changed flag	None			none		
39	EEPROM control	0	EEPROM control code: (0 = write to EEPROM 1 = read EEPROM to RAM)		Same as command		
40	Enter/exit fixed current mode	0-3	Current (mA) (0 = fixed current mode)	Floating pt	Same as command		
41	Perform device self-test	None			none		
42	Perform master reset	None			none		
43	Set (trim) PV zero	None			none		
44	Write PV units	0	PV units code		Same as command		
45	Trim DAC zero	0-3	Measured current (mA)	Floating pt	Same as command		
46	Trim DAC gain	0-3	Measured current (mA)	Floating pt	Same as command		
47	Write transfer function	0	Transfer function code		Same as command		
48	Read additional device status	None			0-5	Device-specific status	Bit
					6-7	Operational modes (1-5)	
					8-10	Analog outputs saturated ⁶⁵	Bit
					11-13	Analog outputs fixed ⁶⁵	Bit
					14-24	Device-specific status	Bit

⁶⁵ 24 bytes each: LSB...MSB refers to analog outputs 1 to 24. Response is truncated after last byte implemented.

Common-Practice Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
49	Write PV sensor serial number	0-2	Sensor serial number		Same as command		
50	Read dynamic variable assignments	None			0	PV transmitter variable code	
					1	SV transmitter variable code	
					2	TV transmitter variable code	
					3	FV transmitter variable code	
51	Read dynamic variable assignments	0	PV transmitter variable code		Same as command		
		1	SV transmitter variable code				
		2	TV transmitter variable code				
		3	FV transmitter variable code				
52	Set transmitter variable zero	0	Transmitter variable code		Same as command		
53	Write transmitter variable units	0	transmitter variable code		Same as command		
		1	transmitter variable units code				
54	Read transmitter variable information	0	Transmitter variable code		0	Transmitter variable code	
					1-3	Transmitter variable sensor serial number	
					4	Transmitter variable limits units code	
					5-8	Transmitter variable upper limit	Floating pt
					9-12	Transmitter variable lower limit	Floating pt
					13-16	Transmitter variable damping value (sec.)	Floating pt
					17-20	Transmitter variable minimum span	Floating pt
55	Write transmitter variable damping value	0	transmitter variable code		Same as command		
		1-4	transmitter variable damping value (seconds)	Floating pt			

Common-Practice Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
56	Write transmitter variable sensor serial number	0	transmitter variable code		Same as command		
		1-3	transmitter variable sensor serial number	Floating pt			
57	Read unit tag, descriptor, date	None			0-5	Unit tag (8 characters)	ASCII
					6-17	Unit descriptor (16 characters)	ASCII
					18-20	Unit date (3 bytes: day, month, year)	Date
58	Write unit tag, descriptor, date	0-5	Unit tag (8 characters)	ASCII	Same as command		
		6-17	Unit descriptor (16 characters)	ASCII			
		18-20	Unit date (3 bytes: day, month, year)	Date			
59	Write number of response preambles	0	Number of response preambles		Same as command		
60	Read analog output and percent of range	0	analog output number code		0	Analog output number code	
					1	Analog output units code	
					2-5	Analog output level	Floating pt
					6-9	Analog output percent of range	Floating pt
61	Read dynamic variables and Primary Variable analog output	None			0	PV analog output units code	
					1-4	PV analog output level	Floating pt
					5	PV units code	
					6-9	Primary variable (PV)	Floating pt
					10	SV analog output units code	
					11-14	Secondary variable	Floating pt
					15	TV analog output units code	
					16-19	Third variable	Floating pt
					20	FV analog output units code	
					21-24	Fourth variable	Floating pt
			Truncated after last supported variable				

Common-Practice Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
62	Read analog outputs (5.1)	0	Analog output number code for slot 0		0	Slot 0 analog output number code	
		1	Analog output number code for slot 1		1	Slot 0 units code	
		2	Analog output number code for slot 2		2-5	Slot 0 level	Floating pt
		3	Analog output number code for slot 3		6	Slot 1 analog output number code	
		Truncated after last requested level			7	Slot 1 units code	
					8-11	Slot 1 level	Floating pt
					12	Slot 2 analog output number code	
					13	Slot 2 units code	
					14-17	Slot 2 level	Floating pt
					18	Slot 3 analog output number code	
					19	Slot 3 units code	
Truncated after last requested level			20-23	Slot 3 level	Floating pt		
			Truncated after last requested level				
63	Read analog output information	0	Analog output number code		0	Analog output number code	
					1	Analog output alarm select code	
					2	Analog output transfer function code	
					3	Analog output range units code	
					4-7	Analog output upper range value	Floating pt
					8-11	Analog output lower range value	Floating pt
					12-15	Analog output additional damping value (seconds)	Floating pt
64	Write analog output additional damping value	0	Analog output number code		Same as command		
		1-4	Analog output additional damping value	Floating pt			

Common-Practice Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
65	Write analog output range values	0	Analog output number code		Same as command		
		1	Analog output units code				
		2-5	Analog output upper range value	Floating pt			
		6-9	Analog output lower range value	Floating pt			
66	Enter/exit fixed analog output mode	0	Analog output number code		Same as command		
		1	Analog output units code				
		2-5	Analog output level ⁶⁶	Floating pt			
67	Trim analog output zero	0	Analog output number code		Same as command		
		1	Analog output units code				
		2-5	Externally-measured analog output level ⁶⁶	Floating pt			
68	Trim analog output gain	0	Analog output number code		Same as command		
		1	Analog output units code				
		2-5	Externally-measured analog output level ⁶⁶	Floating pt			
69	Write analog output transfer function	0	Analog output number code		Same as command		
		1	Analog output transfer function code				
70	Read analog output endpoint values	0	Analog output number code		0	Analog output number code	
					1	Analog output endpoint units code	
					2-5	Analog output upper endpoint value	Floating pt
					6-9	Analog output lower endpoint value	Floating pt

⁶⁶ "not a number" exits fixed output mode

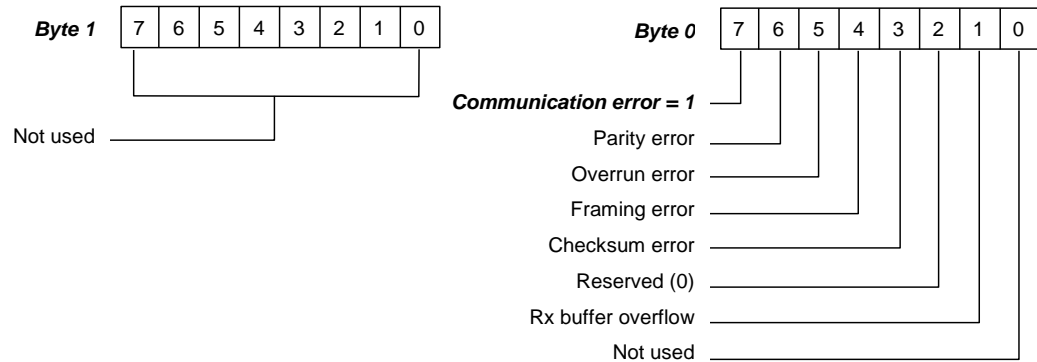
Common-Practice Commands		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
107	Write burst mode transmitter variable (for command 33)	0	Transmitter variable code for slot 0		Same as command		
		1	Transmitter variable code for slot 1				
		2	Transmitter variable code for slot 2				
		3	Transmitter variable code for slot 3				
108	Write burst mode command number	0	Burst mode command number		Same as command		
109	Burst mode control	0	Burst mode control code (0 = exit, 1 = enter)		Same as command		
110	Read all dynamic variables	none			0	Primary Variable units code	
					1-4	Primary Variable value	Floating pt
					5	Second Variable units code	
					6-9	Second Variable value	Floating pt
					10	Third Variable units code	
					11-14	Third Variable value	Floating pt
					15	Fourth Variable units code	
		16-19	Fourth Variable value	Floating pt			

11.5.7 HART Communications Status

Each message from a field slave device includes two bytes of status information, which is also referred to as the “response code”. The format of the HART communications status data is shown in this section.

11.5.7.1 Response Data with Command Response = 1

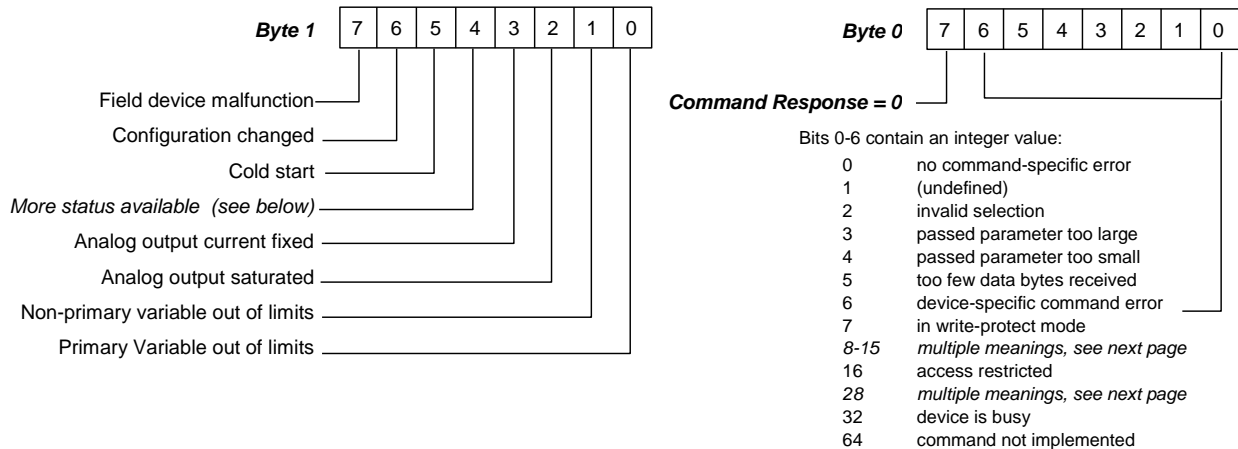
If the Most Significant Bit of the first byte is 1 (Communications Error), an error has occurred in the outgoing HART communication. The rest of the bits individually indicate one or more error conditions:



Error conditions include parity and overrun errors. In addition, a field device will report an overflow of its receive buffer. It will also report any discrepancy between the message content and the received checksum.

11.5.7.2 Response Data with Command Response = 0

If the Most Significant Bit of the first byte is 0 (Command Response), the outgoing HART communications completed normally. The first byte then contains an integer value (the Command Response code) with the command status. The second byte contains the field device status, indicating the operational state of the slave device:



11.5.7.3 Field Device Status Codes

The Field Device Status codes in the second byte are explained below.

Field Device Status Code	Meaning
Field device malfunction	Measurements may not be correct.
Configuration changed	The configuration has been changed, so the master should check the configuration, and clear the bit by sending Command #38.
Cold start	Set for the first transaction when a field device is powered up.
More status available	The master should issue Command #48 to read more status information.
Analog output fixed	The output has been set to a fixed value for testing. This bit applies only to analog output #1. In a multi-drop output device, command #48 may return similar status information for the other outputs.
Analog output saturated	Analog output #1 is out of range.
Primary variable out of limits	The primary measurement is outside the sensor operating limits. The analog signal and the digital signal read by HART commands may be incorrect.
Non-primary variable out of limits	A non-primary measurement is outside the sensor operating limits. The analog signal and the digital signal read by HART commands may be incorrect. Command #48 may provide more information.

11.5.7.4 Command Codes with Multiple Meanings

The interpretation of Command Codes 8-15 and 28 in the first Command Response byte depends on the command that was issued.

Code in First Byte	For these Commands	Meaning of the Code
8 (warning)	1, 2, 3, 33, 60, 62, 110	Update failure
	34, 55, 64	Set to nearest possible value
	48	Update in progress
9 (error)	35, 65	Lower range value too high
	36, 37, 43, 52	Applied process too high
	45, 46, 67, 68	Not in proper current mode (fixed at 4 or 20mA)
10 (error)	6	Multi-drop not supported
	35, 65	Lower range value too low
	36, 37, 43, 52	Applied process too low
11 (error)	35, 65	Upper range value too high
	40, 45, 46, 66, 67, 68	In multi-drop mode
	53	Invalid transmitter variable code
12 (error)	35, 65	Upper range value too high
	53, 66, 67, 68	Invalid units code
13 (error)	35, 65	Both range values out of limits
	69	Invalid transfer function code
14 (warning)	35, 36, 65	Span too small
	37	Pushed upper range value over limit
15 (error)	65, 66, 67, 68, 69	Invalid analog output number code
28 (error)	65	Invalid range units code

11.6 Function Blocks to Read HART Data

Proficy Machine Edition release 5.5 includes two custom HART function blocks for use in ladder logic application programs. These function blocks can be used to assign variable names to HART data inputs or on HART Get Device Information response data, beginning at word 3.

- DYN_HART_STRUCT interprets the first 36 bytes of the HART data map for a channel. This function block reads on demand the same data that would be automatically scanned if the module were configured for *HART Data Scan Control* set to "Dynamic Data".
- ALL_HART_STRUCT interprets the entire HART data for a channel, including the data interpreted by the DYN_HART_STRUCT function block. This function block reads on demand the same data that would be automatically scanned if the module were configured for *HART Data Scan Control* set to "All Data".

Instead of being read into an assigned CPU reference address, the data read by these Function Blocks is placed into a reference address that is defined by the Function Block.

The HART function blocks are located in the Toolchest under the folder "HART Utilities". To create an instance of one of these function blocks, drag and drop the desired function from the Toolchest folder into LD logic.

11.6.1 DYN_HART_STRUCT

The DYN_HART_STRUCT function block interprets the first 36 bytes on the data (offsets 0x0000 to 0x0023) of the HART data map for a channel. Refer to the example in this section. Use of this function block is not required. It only provides a mechanism to assign variable names to the HART data,

When the DYN_HART_STRUCT function executes (receives power flow), each of the HART variables in reference memory is assigned to DYN_HART_STRUCT instance variables. The instance variable names closely match the names listed in the table. They can be used as input to other functions, or for debugging purposes. The entire instance can be added to a Data Watch window so that HART data is easily viewed.

The instance data variables are only updated when the function block receives power flow. An instance of the function block is needed for each HART channel on which automatic assignment is desired.

Parameter types:

IN - Type = WORD, Length = 18, Pass-by = Reference

11.6.1.1 Data Obtained with the DYN_HART_STRUCT Function Block

Byte Offset		Field Description	Data Type
Begin	End		
0x0000	0x0003	HART Primary Variable, CMD#3, Bytes 5-8	REAL
0x0004	0x0007	HART Secondary Variable CMD#3, Bytes 10-13	REAL
0x0008	0x000b	HART Tertiary Variable CMD#3, Bytes 15-18	REAL
0x000c	0x000f	HART Fourth Variable CMD#3, Bytes 20-23	REAL
0x0010	0x0013	Slot 0 value. CMD#33, Bytes 2-5	REAL
0x0014	0x0017	Slot 1 value CMD#33, Bytes 8-11	REAL
0x0018	0x001b	Slot 2 value CMD#33, Bytes 14-17	REAL
0x001c	0x001f	Slot 3 value CMD#33, Bytes 20-23	REAL
0x0020		HART communication status byte from the last HART command response. Refer to Section 11.5.7.	BYTE
0x0021		HART device status byte from the last HART command response. (Dynamic Data)	BYTE
0x0022		Spare for alignment. (Dynamic Data)	BYTE*2

11.6.2 ALL_HART_STRUCT

The ALL_HART_STRUCT function block interprets the entire HART data map for a channel. This is the same data obtained by the DYN_HART_STRUCT block, plus the additional data displayed in the following figure.

Parameter types: IN - Type = WORD, Length = 88, Pass-by = Reference

11.6.2.1 Additional Data Obtained with the ALL_HART_STRUCT Function Block

Byte Offset		Field Description	Data Type
Begin	End		
0x0024		HART device Manufacturer ID. CMD#0, Byte 1	BYTE
0x0025		HART device type code. CMD#0, Byte 2	BYTE
0x0026		Minimum number of preambles device requires. CMD#0, Byte 3	BYTE
0x0027		HART Universal command code. CMD#0, Byte 4	BYTE
0x0028		HART Transmitter specific revision. CMD#0, Byte 5	BYTE
0x0029		HART device software revision number. CMD#0, Byte 6	BYTE
0x002A		HART device hardware revision number. CMD#0, Byte 7	BYTE
0x002B		HART flags. CMD#0, Byte 8	BYTE
0x002C	0x002F	HART device ID number. CMD#0, Byte 9-11	BYTE*4
0x0030	0x0037	8 character device tag. CMD#13, Bytes 0-5 in unpacked ASCII.	BYTE*8
0x0038	0x0047	Device Descriptor. CMD#13, Bytes 6-17 in unpacked ASCII	BYTE*16
0x0048		HART Primary Variable Units. CMD#3, Byte 4	BYTE
0x0049		HART Secondary Variable Units. CMD#3, Byte 9, 0 if not present.	BYTE
0x004a		HART Tertiary Variable Units. CMD#3, Byte 14, 0 if not present.	BYTE
0x004b		HART Fourth Variable Units. CMD#3, Byte 19, 0 if not present.	BYTE
0x004c		HART Primary Variable Code. CMD#50, Byte 0	BYTE
0x004d		HART Secondary Variable Code. CMD#50, Byte 1	BYTE
0x004e		HART Tertiary Variable Code. CMD#50, Byte 2	BYTE
0x004f		HART Fourth Variable Code. CMD#50, Byte 3	BYTE
0x0050		Units code for range parameter. CMD#15, Byte 2	BYTE
0x0051	0x0053	Spare for alignment	BYTE*3
0x0054	0x0057	Low transmitter range for analog signal in engineering units. CMD#15, Bytes 3-6	REAL
0x0058	0x005b	High transmitter range for analog signal in engineering units. CMD#15, Bytes 7-10	REAL
0x005c		Slot 0 units code. CMD#33, Byte 1	BYTE
0x005d		Slot 1 units code. CMD#33, Byte 7	BYTE
0x005e		Slot 2 units code. CMD#33, Byte 13	BYTE
0x005f		Slot 3 units code. CMD#33, Byte 19	BYTE
0x0060		Slot 0 variable code. CMD#33, Byte 0	BYTE
0x0061		Slot 1 variable code. CMD#33, Byte 6	BYTE
0x0062		Slot 2 variable code. CMD#33, Byte 12	BYTE
0x0063		Slot 3 variable code. CMD#33, Byte 18	BYTE
0x0064	0x0083	32 character message. CMD#12, Bytes 0-23 unpacked ASCII.	BYTE*32
0x0084	0x0087	Stored date in the field device. CMD#13, Bytes 18-20.	BYTE*4
0x0088	0x008b	The final assembly number is used for identifying the material and electronics that comprise the field device. CMD#16, Bytes 0-2	BYTE*4
0x008c	0x00a4	The extended status returned by HART Command 48.	BYTE*25
0x00a5	0x00af	Spare	BYTE*11

Example: ALL_HART_STRUCT and DYN_HART_STRUCT

This example uses the following HART module hardware configuration parameters:

- HART Data Scan Control is set to: All Data
- HART Data Reference Address is configured as: %AI1001

The example shows ALL_HART_STRUCT for channels 1 and 2 on a HART module, and DYN_HART_STRUCT for channels 3 and 4 on the same module. The math function blocks in the example show how the structure instance variables can be used on the HART data.

When using either ALL_HART_STRUCT or DYN_HART_STRUCT, the instance data should be made global. This is done by adding "g" to the end of the instance name when it is created (for example, "ch1,g" creates a global instance named "ch1"). If the instance data is not global, the instance can only be used in the program block where the ALL_HART_STRUCT or DYN_HART_STRUCT function block is executed.

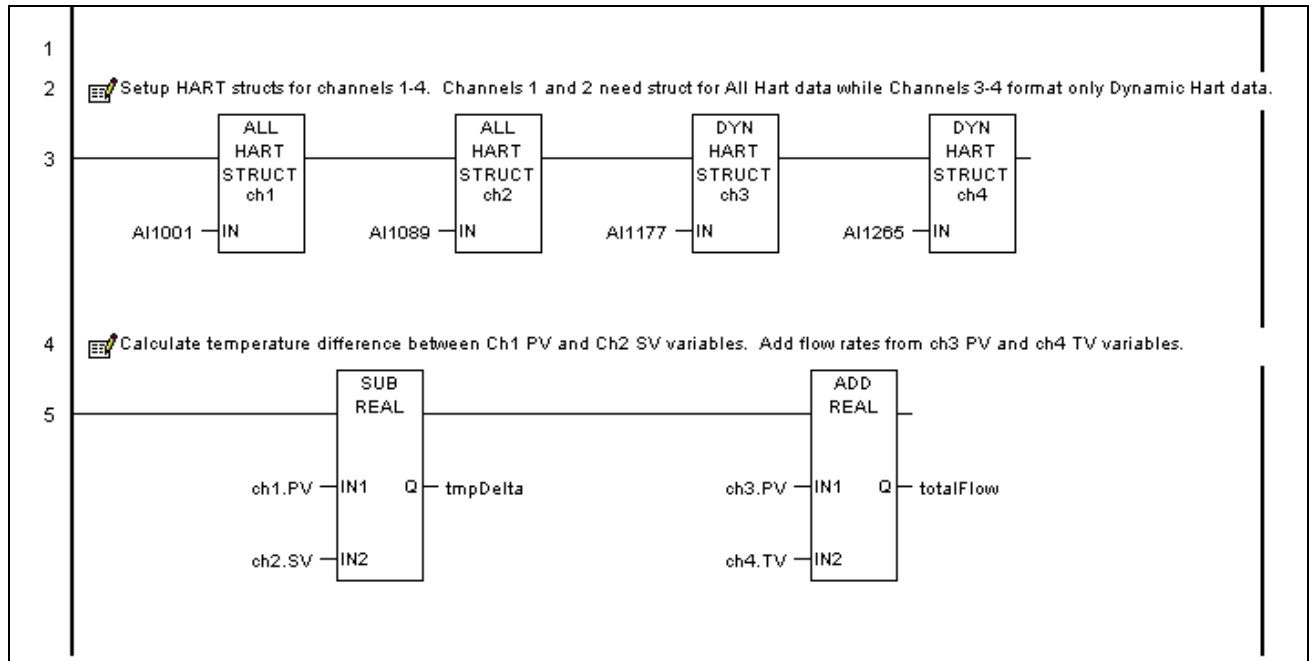


Figure 326: Ladder Logic using ALL_HART_STRUCT & DYN_HART_STRUCT

11.7 Converting HART Data to / from RX3i Format

When using HART Pass-Through COMMREQ (command 2) only, HART data must be both byte-packed and in big-endian format as defined by the HART Specification. Because PACSystems CPUs use little-endian format, floating point values and ASCII data must be reformatted by the program logic.

Note that this conversion is not required when using COMMREQ 1 or for HART data that is automatically scanned.

Two function blocks in the Proficy Machine Edition release 5.5 toolchest can be used to pack/unpack HART ASCII data:

- ASCII_PACK prepares ASCII data before sending it to a HART module.
- ASCII_UNPACK can be used to unpack ASCII characters returned by a HART device.

These are described in the next section.

11.7.1 Converting Floating Point Data (Endian Flip)

Floating point values that begin at word 17 of a Pass-Through Request must be converted **to** big-endian format. Floating point values that begin at word 7 of the reply must be converted **from** big-endian format.

The basic procedure is to pass any HART float values through the SWAP_DWORD (size = 1) and SWAP_WORD (size = 2) functions, as displayed in the following figure. This swaps the words within the float dword, and swaps the bytes within the two float words. In this example shows how to format floating point data prior to sending HART command 34, *Write Damping Value*.

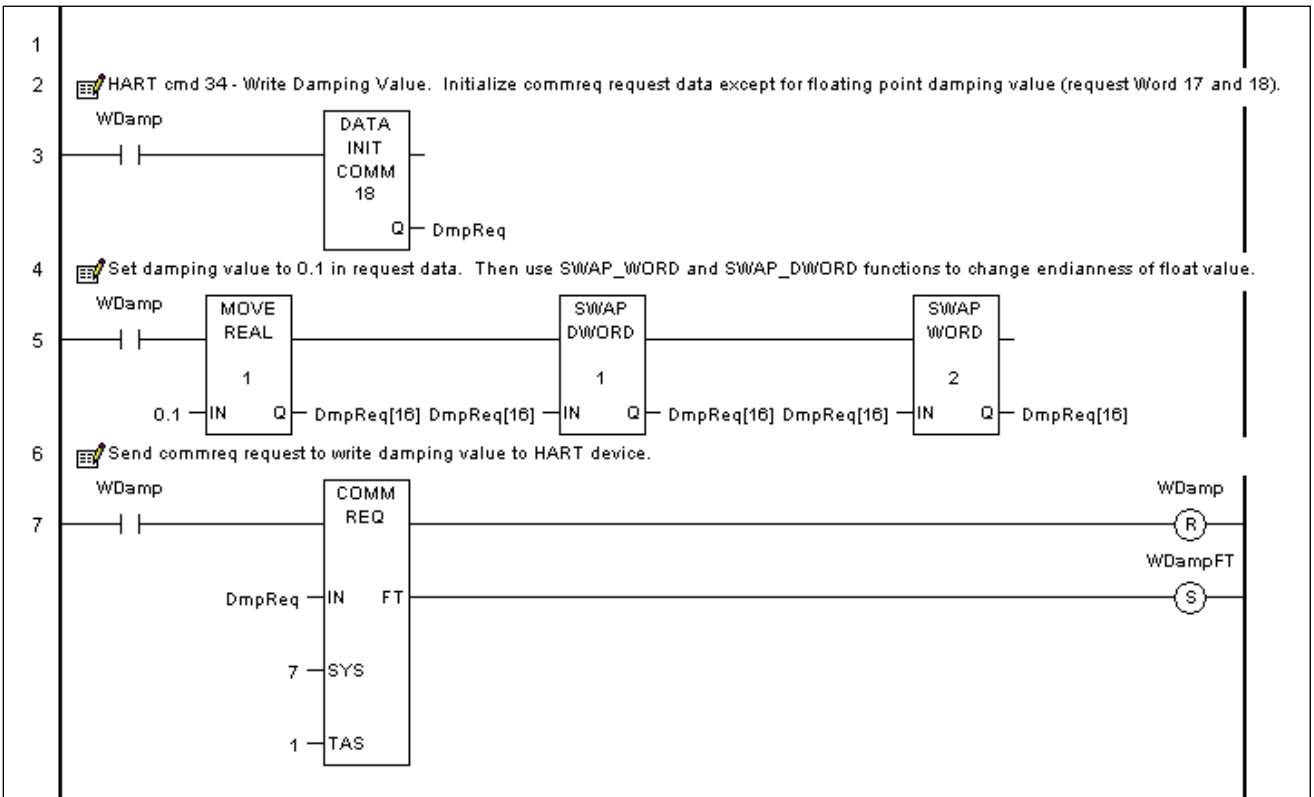


Figure 327: Ladder Logic Using Swap DWord & Swap Word

11.7.2 ASCII_PACK

ASCII_PACK prepares ASCII data before sending it to a HART module using COMMREQ2 (HART Pass-Through Request). All of the function block parameters are either Type = WORD, Pass-By = Value or word arrays of Type = WORD and Pass-by = Reference. All word-based reference memory types and symbolics can be used.

It is possible to use data of a different type for the array data (for example, using a byte array of data as input to the ASCII_PACKED and ASCII_UNPACKED blocks), although Machine Edition will issue a warning during verification. In the example mentioned, the size of the input byte array would need to be at least as large as the data size of the function block parameter word array.

Parameter types:

- IN - Type = WORD, Length = 16, Pass-by = Reference
- NUM - Type = WORD, Length = 1, Pass-by = Value
- Q - Type = WORD, Length = 12, Pass-by = Reference

Example Function Block: ASCII_PACK

This example shows how ASCII_PACK can be used to prepare ASCII data before using a COMMREQ to send it to a HART module. First, the logic sets up the data that will be used by the COMMREQ. The ASCII_PACK function block packs the 32 ASCII characters of the message and also places that into the COMMREQ data area. After clearing the COMMREQ status to 0, the logic uses a COMMREQ to send HART command 17 "Write Message" to the device.

HART ASCII format packs data into 6 bits per character, 4 characters per 3 bytes. This chart shows the format with the most significant hex digits in the rightmost column and the lowest row.

Less significant

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	at	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	P	Q	R	S	T	U	V	W	X	Y	Z	[\]	^	_
2	SP	!	"	#	\$	%	&	'	()	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?

More significant

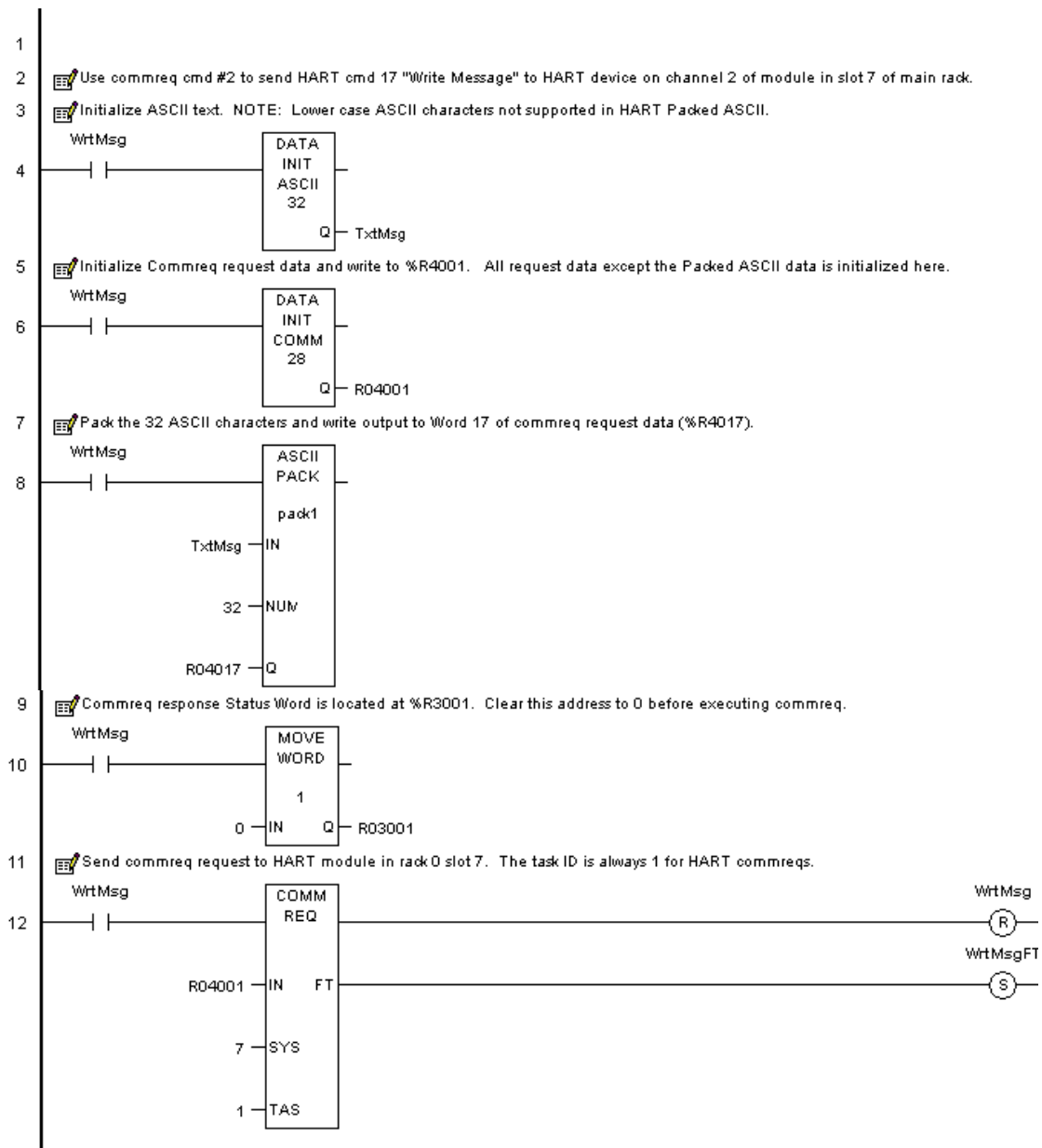


Figure 328: Ladder Logic for ACSII Pack

11.7.3 ASCII_UNPACK

ASCII_UNPACK can be used to unpack ASCII characters returned by a HART device in Pass-Through Reply data send in response to COMMREQ 2.

All of the function block parameters are either Type = WORD, Pass-By = Value or word arrays of Type = WORD and Pass-by = Reference. All word-based reference memory types and symbolics can be used.

Parameter types:

- IN - Type = WORD, Length = 12, Pass-by = Reference
- NUM - Type = WORD, Length = 1, Pass-by = Value
- Q - Type = WORD, Length = 16, Pass-by = Reference

Example Function Block 3: ASCII_UNPACK:

In this example, after initializing the COMMREQ completion status, the ladder logic sends COMMREQ command #12, "Read Message" to the HART module in Rack 0, Slot 7. When the status = complete and the Response Byte Count =24, showing that all the data is present, the ASCII_UNPACK function block unpacks the HART ASCII data.

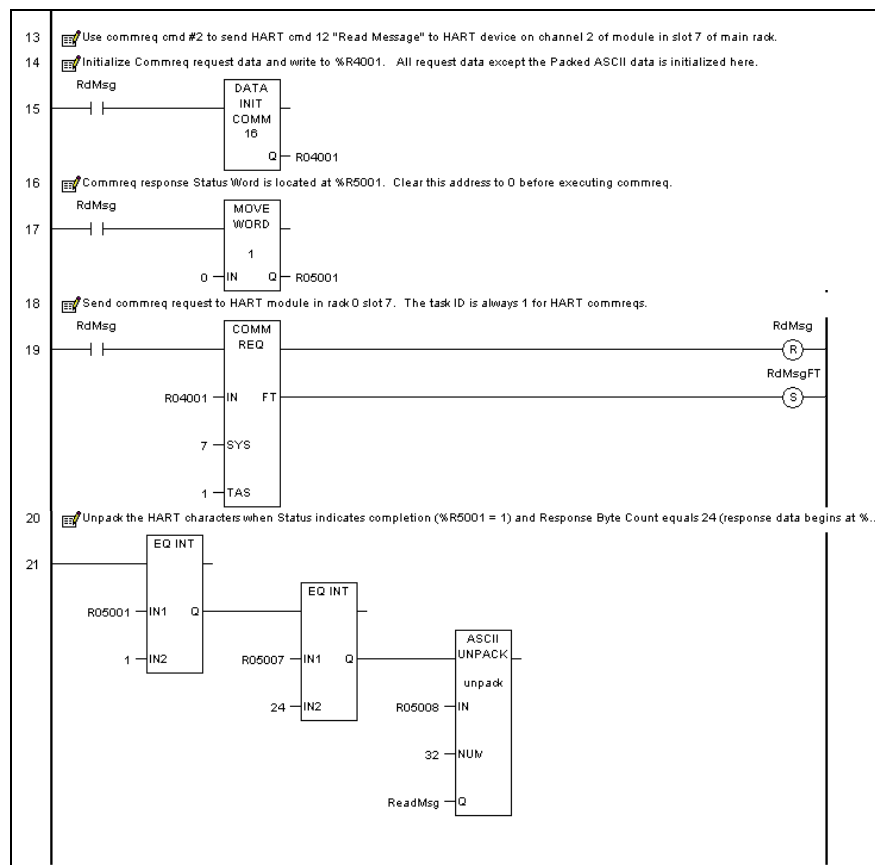


Figure 329: Ladder Logic for ACSII Unpack

Chapter 12 Analog Mixed I/O Modules

This chapter describes the following Analog Mixed I/O modules for PACSystems RX3i controllers.

Analog Mixed I/O Module Description	Catalog Number	Section
Analog Module 4-Input 2-Output Current/Voltage	IC694ALG442	12.1
Analog Module 4-Input 2-Output Current/Voltage with Advanced Diagnostics	IC694ALG542	12.2

12.1 Analog Module 4-Input/2-Output Current/Voltage: IC694ALG442

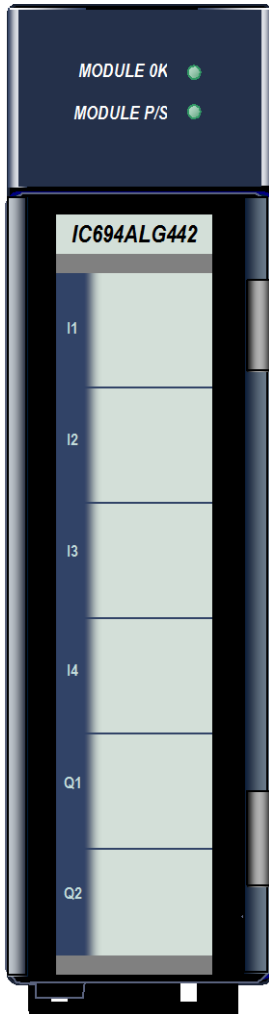


Figure 330: IC694ALG442

Analog Current/Voltage Input/Output module, IC694ALG442, provides four differential input channels and two single-ended output channels. Each channel can be configured with the Machine Edition software for one of the following ranges:

- 0 to +10 volts (unipolar), default.
- -10 to +10 volts (bipolar)
- 0 to 20 mA
- 4 to 20 mA

Input channels can also be configured for 4 - 20 mA Enhanced mode.

This module may be installed in any I/O slot in the RX3i system.

12.1.1 Features

Outputs can be configured to either Hold Last State if system power is interrupted or to reset to the low end of their range. Outputs can also be configured to operate in ramp mode on command from the application program. In ramp mode, the output channel ramps to a new value over a period of time, rather than taking the new value immediately.

High and low alarm limits can be set for all input channels and an open-wire fault (current output modes) can be reported to the CPU for each output channel.

Revision BA & later supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1..

12.1.2 Isolated +24Vdc Power

This module must receive 24Vdc power from an external source. If the module is located in an RX3i Universal Backplane, the external source can be connected via the TB1 connector on the left side of the backplane or directly on the module terminal block. If the module is located in an Expansion Backplane, the external source must be connected to the terminal block of this module.

12.1.3 LEDs: ALG442

The **MODULE OK** LED provides module status information as follows:

ON: status is OK, module configured;

OFF: no backplane power or software not running (watchdog timer timed out);

Continuous rapid blinking: configuration data not received from CPU;

Slow blinking, then OFF: failed power-up diagnostics or encountered code execution error.

The **USER SUPPLY** LED indicates that the external 24Vdc supply is within specifications.

12.1.4 Specifications: ALG442

Power Requirements	
External Supply Voltage Range	20 to 30 V dc (24Vdc typical)
Power Supply Rejection Ratio	Current: 5 μ A/V (typical), 10 μ A/V (maximum) Voltage: 25 mV/V (typical), 50 mV/V (maximum) (Measured by varying V_{USER} from 24Vdc to 30 V dc)
Voltage Ripple	10%
Power Consumption	95 mA from internal +5Vdc Supply, 129 mA from external supply
Update Rate	Update Rate: 3 ms
Isolation, Field to Backplane (optical) and to frame ground	250 V ac continuous; 1500 V ac for 1 minute
Analog Outputs	
Two, Single-Ended	
Analog Current Output	
Output Ranges	0 to 20 mA, 4 to 20 mA
Resolution	0 to 20 mA: 0.6 μ A (1 LSB = 0.6 μ A) 4 to 20 mA: 0.5 μ A (1 LSB = 0.5 μ A)
Absolute Accuracy ^{67,68}	\pm 0.1% of full scale at 25°C (77°F), typical \pm 0.25% of full scale at 25°C (77°F), maximum \pm 0.5% of full scale over operating temperature range (maximum)
Maximum Compliance Voltage	$V_{USER} - 3$ V (minimum) to V_{USER} (maximum)
User Load	0 to 850 Ω (minimum at $V_{USER} = 20$ V, maximum 1350 Ω at $V_{USER} = 30$ V)
Output Load Capacitance	2000 pF (maximum)
Output Load Inductance	1 H (maximum)
Analog Voltage Output	
Output Ranges	-10 to +10 V (bipolar), 0 to +10 V (unipolar)
Resolution	-10 V to +10 V: 0.3125 mV (1 LSB = 0.3125 mV) 0 to +10 V: 0.3125 mV (1 LSB = 0.3125 mV)
Absolute Accuracy ^{69,68}	\pm 0.25% of full scale at 25°C (77°F), typical \pm 0.5% of full scale at 25°C (77°F), maximum \pm 1.0% of full scale over operating temperature range (maximum)
Output Loading	5 mA (2k Ω minimum resistance)
Output Load Capacitance	1 μ F (maximum capacitance)

⁶⁷ Analog Current output: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 1% of full scale.

⁶⁸ Applicable for all inputs and outputs: In the presence of severe Conducted RF interference (IEC 61000-4-6, 10Vrms), accuracy may be degraded to \pm 2% of full scale.

⁶⁹ Analog Voltage output: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 4% of full scale.

<p>Analog Inputs</p> <p>Analog Current Input</p> <p>Input Ranges</p> <p>Resolution</p> <p>Absolute Accuracy⁷⁰</p> <p>Linearity</p> <p>Common Mode Voltage</p> <p>Common Mode Rejection</p> <p>Cross Channel Rejection</p> <p>Input Impedance</p> <p>Input Filter Response</p>	<p>Four, differential</p> <p>0 to 20 mA, 4 to 20 mA, 4 to 20 mA Enhanced</p> <p>Versions -Dx and later: 0.625µA (1 LSB = 0.625µA)</p> <p>Earlier versions: 5 µA (1 LSB = 5µA)</p> <p>±0.25% of full scale at 25°C (77°F)</p> <p>±0.5% of full scale over specified operating temperature range</p> <p><1 LSB</p> <p>200 V dc (maximum)</p> <p>>70 dB at DC; >70 dB at 60 Hz</p> <p>>80 dB from DC to 1 kHz</p> <p>250 Ω</p> <p>29 Hz</p>
<p>Analog Voltage Input</p> <p>Input Ranges</p> <p>Resolution</p> <p>Absolute Accuracy^{71,68}</p> <p>Linearity</p> <p>Common Mode Voltage</p> <p>Common Mode Rejection</p> <p>Cross Channel Rejection</p> <p>Input Impedance</p> <p>Input Filter Response</p>	<p>0 to +10 V (unipolar), -10 to +10 V (bipolar)</p> <p>Versions -Dx and later, both ranges: 0.3125 mV (1 LSB = 0.3125 mV)</p> <p>Earlier versions: 0 to +10 V: 2.5 mV (1 LSB = 2.5 mV)</p> <p>-10 to +10 V: 5 mV (1 LSB = 5 mV)</p> <p>±0.25% of full scale at 25°C (77°F);</p> <p>±0.5% of full scale over specified operating temperature range</p> <p><1 LSB</p> <p>200 V dc (maximum)</p> <p>>70 dB at DC; >70 dB at 60 Hz</p> <p>>80 dB from DC to 1 kHz</p> <p>800kΩ (typical)</p> <p>38 Hz</p>

For product standards and general specifications, refer to *Appendix A*.

In order to meet the IEC 1000-4-3 levels for RF Susceptibility specified in *Appendix A*, when this module is present, the system must be mounted in a metal enclosure.

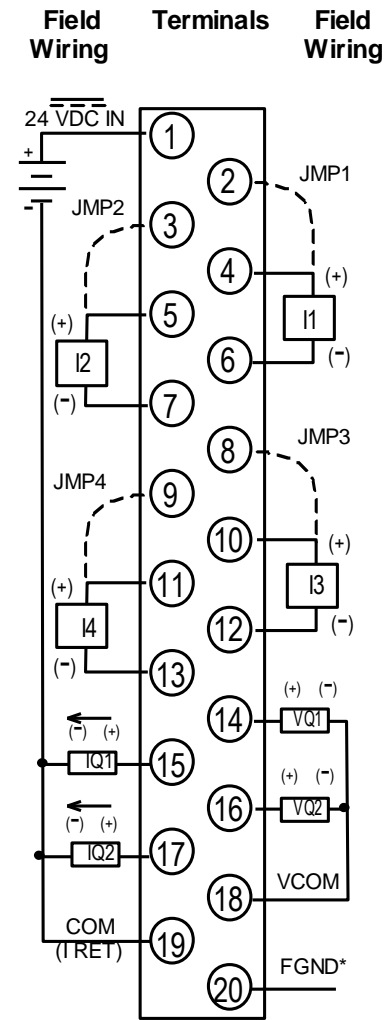
⁷⁰ Analog Current Input: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to ±2% of full scale.

⁷¹ Analog Voltage Input: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to ±1% of full scale

12.1.5 Field Wiring: ALG442

The diagram below shows voltage and current connections for the module. Each channel can be configured independently as a voltage or a current channel, not both simultaneously.

Terminal	Signal	Definition
1	24VIN	User Supplied +24Vdc Input
2	JMP1	Jumper terminal for connecting 250Ω sense resistor for CH1
3	JMP2	Jumper terminal for connecting 250Ω sense resistor for CH2
4	+CH1	Positive connection for differential analog input channel 1
5	+CH2	Positive connection for differential analog input channel 2
6	-CH1	Negative connection for differential analog input channel 1
7	-CH2	Negative connection for differential analog input channel 2
8	JMP3	Jumper terminal for connecting 250Ω sense resistor for CH3
9	JMP4	Jumper terminal for connecting 250Ω sense resistor for CH4
10	+CH3	Positive connection for differential analog input channel 3
11	+CH4	Positive connection for differential analog input channel 4
12	-CH3	Negative connection for differential analog input channel 3
13	-CH4	Negative connection for differential analog input channel 4
14	V _{out} CH1	Voltage output for channel 1
15	I _{out} CH1	Current output for channel 1
16	V _{out} CH2	Voltage output for channel 2
17	I _{out} CH2	Current output for channel 2
18	V COM	Common return for voltage outputs
19	I RET	Common return for User Supplied +24 V and current outputs
20	GND	Frame ground connections for cable shields



* Optional Shield Connection

Figure 331: Field Wiring ALG442

12.1.6 Input Scaling: ALG442

Resolution per bit depends on the configured input or output range as shown in the table of module specifications. The module scales each current and voltage input to a value in counts for the CPU.

Configured Range	Scaled Counts Values
0 to 10 V (default)	0 to 32767
-10 to 10 V	-32768 to 32767
4 to 20 mA	0 to 32767
0 to 20 mA	0 to 32767
0 to 20 mA Enhanced	-8000 to 32,000

In the 0 to +10 V default range, 0 volts corresponds to a count of 0 and +10 volts corresponds to a count of 32000. In the -10 to +10 volt range, -10 volts corresponds to a count of -32000 and +10 volts corresponds to a count of +32000. Full 12-bit resolution is available over either range.

In the 4 to 20 mA range, 4 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000. In the 0 to 20 mA range, 0 mA corresponds to a count of 0 and 20 mA corresponds to a count of 32000. Full 12-bit resolution is available over the 0 to 20 mA range. If the value exceeds 32,000 it is truncated to 32,000.

In the 4 to 20 mA Enhanced range, 0 mA corresponds to a count of -8000, 4 mA corresponds to a count of 0 (zero) and 20 mA corresponds to a count of +32000. The Enhanced range automatically provides 4 to 20 mA range scaling. Negative digital values are provided for input current levels between 4 mA and 0 mA. This creates a low alarm limit that detects when the input current falls from 4 mA to 0 mA, providing open-wire fault detection in 4 to 20 mA applications. If the value exceeds 32,000 it is truncated to 32,000.

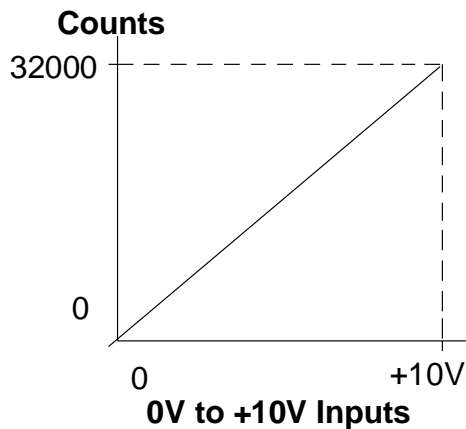


Figure 332: Input Voltage Scaling ALG442

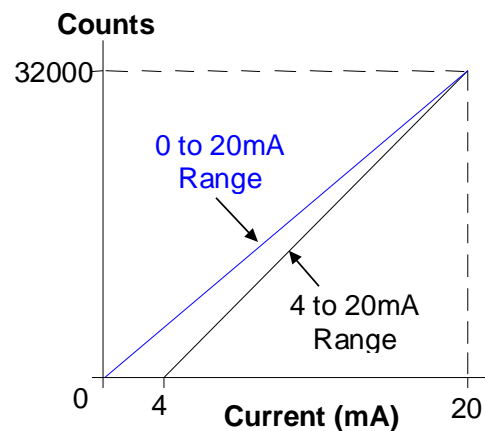


Figure 333: Input Current Scaling ALG442

If the current source is reversed into the input, or is less than the low end of the current range, the module inputs a data word corresponding to the low end of the current range (0000H in %AI). If an input is out of range (greater than 20 mA), the A/D converter adjusts it to full scale (corresponding to 7FFFH in %AI).

12.1.7 Output Scaling: ALG442

The module scales counts data received from the CPU to a current or voltage value for each output.

Configured Range	Values Sent By CPU	Values Accepted by Module
0 to 10 V (default)	0 to 32767	0 to 32767
-10 to 10 V	-32768 to 32767	- 32768 to 32767
4 to 20 mA	0 to 32767	0 to 32000
0 to 20 mA	0 to 32767	0 to 32767

For a 0 to 10 V output, the module scales count outputs from 0 to 32000 to output voltages from 0 to +10 volts. The module scales count values from 32001 to 32767 to over range voltages up to a maximum of approximately 10.24 volts.

For a -10 to +10 V output, the module scales count outputs in the range ± 32000 to output voltages from -10 V to +10 V. The module scales count values from -32001 to -32768 and from +32001 to +32767 to over range voltages up to a maximum of approximately ± 10.24 V.

For a 4 to 20 mA output, the module scales count outputs from 0 to 32000 counts to output currents from 4 to 20 mA. If the CPU sends a value above 32000 counts, the module uses the value 32000 in the D/A converter. No error is returned.

For a 0 to 20 mA output, the module scales count outputs from 0 to 32000 to output currents from 0 to 20 mA. The module scales count values from 32001 to 32767 up to a maximum output current of approximately 20.5 mA.

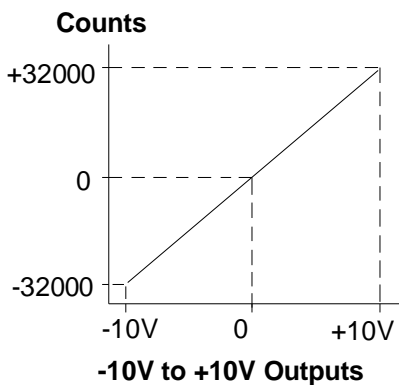


Figure 334: Output Voltage Scaling ALG442

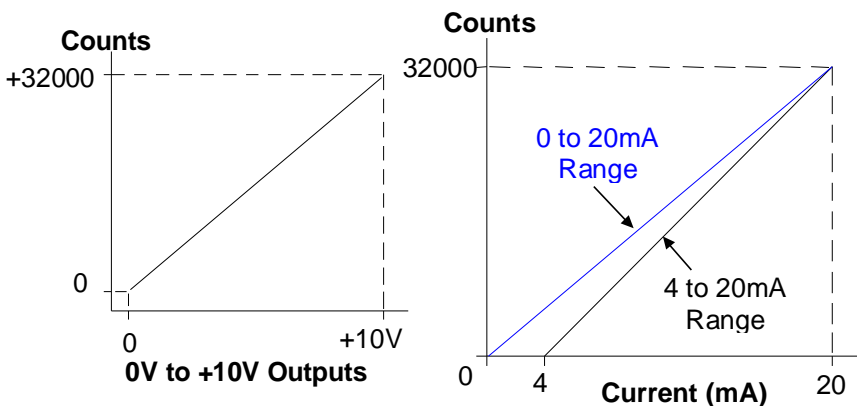


Figure 335: Output Current Scaling ALG442

12.1.8 I/O Data: ALG442

This module uses two %AQ references and four %AI references, depending on configuration. Data in the %AI and %AQ registers is in 16-bit 2's complement format.

MSB												LSB			
X	11	10	9	8	7	6	5	4	3	2	1	0	X	X	X

The module also uses 8, 16 or 24 %I references for status data, depending on the alarm status configuration. Status data format is shown on the next page.

12.1.8.1 Input Data

Resolution of the converted signal is 12 bits binary (1 part in 4096). The placement of the 12 bits from the A/D converter in the %AI data word is shown above.

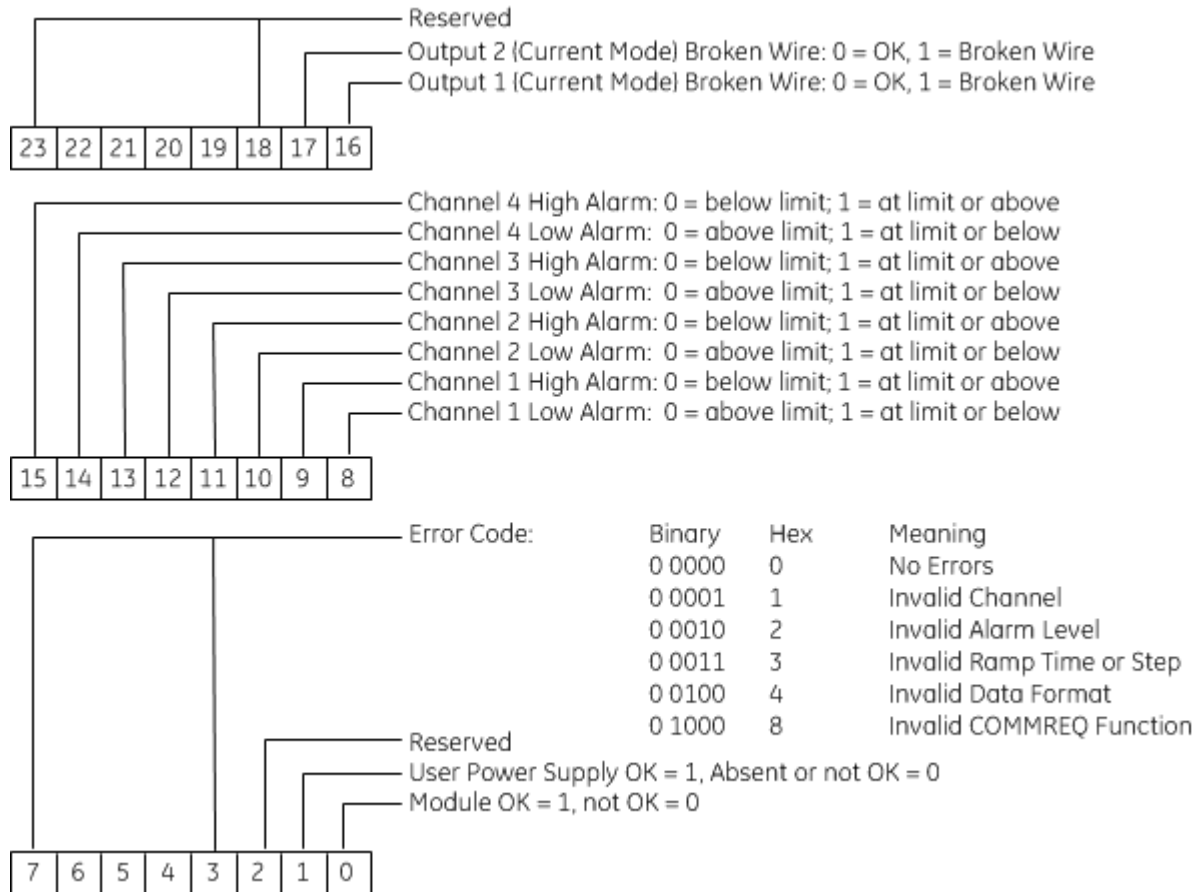
The bits in the %AI data table that were not used are forced to 0 (zero) by the analog input channel.

12.1.8.2 Output Data

Each output channel is capable of converting 15 to 16 bits (depending on the range selected) of binary data to an analog output.

12.1.9 Status Data: ALG442

The Analog Module can be configured to return 8, 16, or 24 status bits to the PLC CPU. Content of the status data is displayed in the following figure.



12.1.9.1 Error Code

Byte 1 of the status data contains a status/error code for COMMREQs sent to the module. Only the most recent error is reported; an existing error code will be overwritten if another error occurs. The priority of errors is:

1. Invalid COMMREQ function (highest priority)
2. Invalid channel.
3. Invalid data (ramp or alarm parameter) (lowest priority).

If multiple errors occur, the one with the highest priority is reported in the error code. The module will not stop standard operation if an error is detected; these error bits are informational only, and can be ignored.

12.1.10 Configuration: ALG442

The following module parameters can be configured using the Machine Edition software:

12.1.10.1 Module Settings

Parameter	Choices	Description
Stop Mode	Hold (default) or DeFlow	Output state when module goes from Run to Stop mode. If the configured Stop Mode is <i>Hold</i> , the module holds outputs at the last state received from the CPU. If the Stop Mode is <i>Default Low</i> , the outputs will go to their low values as follows: Current mode (4-20 mA): outputs go to 4 mA Current mode (0-20 mA): outputs go to 0 mA Voltage mode (unipolar (0 to +10 V dc) and bipolar (+10 V dc to -10 V dc): outputs go to 0V
Input Channel Value Reference Address	Valid memory type: %AI	Starting %AI address for the analog input data of this module.
Input Channel Value Reference Length	Read-only	Each input channel provides 16 bits (1 word) of analog input data to the Controller CPU.
Output Channel Value Reference Address	Valid memory type: %AQ	Starting %AQ address for the analog output data of this module.
Output Channel Value Reference Length	Read-only	Each input channel receives 16 bits (1 word) of analog input data to the Controller CPU.
Module Status Reference Address	Valid memory type: %I	Starting %I address for the status data of this module.
Module Status Reference Length	0 (Module status reporting Disabled) 8 (module and power status only) 16 (above plus input status) 24 (all above plus output status)	Number of status bits (0 to 24) that will be used for module and channel status data. When set to 0, status reporting is disabled. To enable status reporting, set this parameter to a value other than 0. For resulting data format, refer to Section 12.1.9 above.
I/O Scan Set	1 through 32	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data

The choice for Stop Mode (Hold or DeFlow) determines how outputs operate when the module goes from Run to Stop mode. If the configured Stop Mode is Hold (the default), the module holds outputs at the last state received from the CPU. If the Stop Mode is DeFlow, the outputs will go to their low values. In current mode (4-20 mA), outputs go to 4 mA if configured for DeFlow. In current mode (0-20 mA), outputs go to 0 mA if configured for DeFlow. In voltage mode (unipolar (0 to +10 V dc) and bipolar (+10 V dc to -10 V dc), outputs go to 0V if configured for DeFlow.

12.1.10.2 Output Channel Configuration Parameters ALG442

Parameter	Choices	Description
Output Range	0 to +10 V, -10 to +10 V, 4 to 20 mA, 0 to 20 mA	Type of output range.

12.1.10.3 Input Channel Configuration Parameters ALG442

Parameter	Choices	Description
Input Range	0 to +10 V, -10 to +10 V, 4 to 20 mA, 0 to 20 mA, 4 to 20 mA Enhanced	Type of input range
Alarm Low Limit	-32768 to 32759	Low limit alarm value for each input. Must be less than the high alarm for the same channel.
Alarm High Limit	-32767 to 32760	High limit alarm value for each input. The Alarm Low and Alarm High parameters can be used to set up limits that cause alarms to be passed to the Controller for each channel. Values entered without a sign are assumed to be positive. These configured alarm limits are stored until changed by a new configuration. The configured high and low alarm limits can be changed temporarily by a COMMREQ command.

The Alarm Low and Alarm High parameters can be used to set up limits that cause alarm indications to be passed to the PLC for each channel. Values entered without a sign are assumed to be positive. These configured alarm limits are stored until changed by a new configuration. The configured high and low alarm limits can be changed temporarily by a COMMREQ from the application program as described later in this chapter.

12.1.11 Ramp Mode Operation: ALG442

Outputs on module ALG442 can be set up by a COMMREQ command to operate in Ramp mode. In normal operating mode, a new value entered in the %AQ reference for an output channel causes the output to change directly to the new value. In Ramp mode, the output goes to the new value over a period of time. The output channel starts a new ramp (either up or down) each time the value in its %AQ reference changes. The module performs range checking on new output values and automatically adjusts out-of-range values before making the ramp computations.

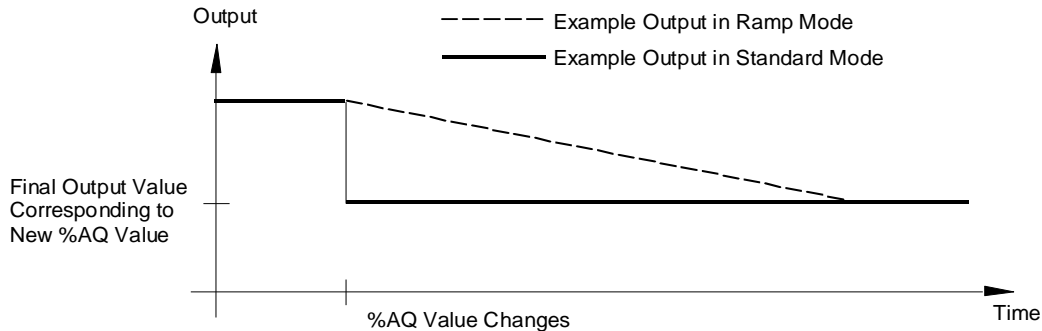


Figure 336: Ramp Mode Example ALG442

Use of Ramp mode is set up for either channel or both output channels using a COMMREQ command as explained in this chapter. The ramp slope can be set up in the COMMREQ as:

- a total ramp time from 1 millisecond to 32 seconds, or:
- a sequence of 1 to 32000 1-millisecond steps.

A channel stays in Ramp mode until the module receives a new COMMREQ either changing or canceling the ramp operation, or until power is cycled. The channel will not change modes after a hardware configuration download. Because COMMREQ settings are temporary, it will be lost after a power cycle.

If the module receives a new COMMREQ that changes ramp operation while an output is in the process of ramping, the new ramp settings take effect as follows:

- If Ramp mode is turned off during a ramp, the channel goes directly to the value in its %AQ reference.
- If a channel is set up to ramp over a period of time, but a new COMMREQ is received commanding the channel to instead ramp in a sequence of measured steps, ramp operation changes as soon as the COMMREQ is processed (assuming that the step is valid).
- If a channel is set up to ramp as a sequence of measured steps, but a new COMMREQ is received commanding the channel to instead ramp over a period of time, it immediately starts a new ramp using the present output as the starting output and the present time as the start time.

If the module receives a Ramp command for an invalid channel, step height or ramp time, the module ignores the command and returns an error code in the first byte of its %I status references. The error code can be cleared by a Clear Errors COMMREQ as described in this chapter, or by reconfiguring the module.

12.1.12 Changing Module Operation on Command: ALG442

Module ALG442 can respond directly to a specific COMMREQ command from the application program to:

- clear the %I error code for this module
- modify the Input alarm limits, and
- put one or both outputs in Ramp mode and set up the ramp characteristics

These changes to module are not retained during loss of power. If the module is power-cycled, new commands must be sent to the module to again modify the configured alarm limits, or to set up Ramp operation for the outputs.

12.1.12.1 COMMREQ Format

The Communications Request is triggered when the logic program passes power to the COMMREQ Function Block.

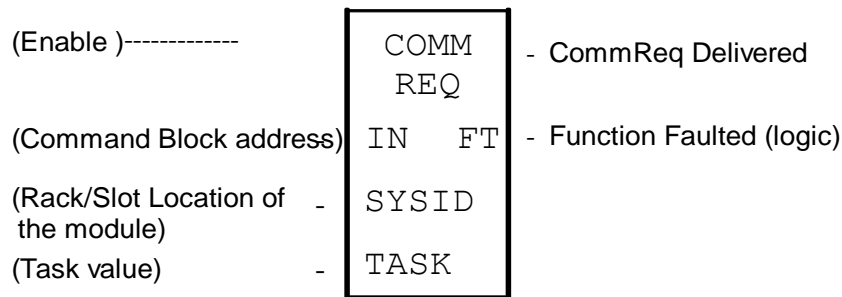


Figure 337: COMMREQ usage ALG442

When sent to module ALG442, the parameters of the COMMREQ are:

- Enable** Control logic for activating the COMMREQ Function Block.
- IN** The location of the Command Block. The Command Block contains the parameters of the COMMREQ request. It can be located at any valid address within a word-oriented memory area (%R, %AI, %AQ, %P, %L, or %W) in the PACSystems PLC.
- SYSID** A hexadecimal word value that gives the rack (high byte) and slot (low byte) location of the analog module.
- TASK** Task must be set to zero.
- FT Output** The FT output is set if the PLC CPU is unable to deliver the COMMREQ to the module. When the FT output is set, the module is unable to return a COMMREQ status word to the PLC logic application.

12.1.12.2 COMMREQ Command Block

The format of the COMMREQ for module ALG442 is displayed in the following figure. For more information about using COMMREQs, refer to the online help and the *PACSystems RX7i and RX3i CPU Reference Manual*, GFK-2222.

Word Offset	Value	Description
Word 1	Must be 0004	Length of the command block
Word 2	0000	Not used
Word 3	(Refer to below)	Memory type of COMMREQ Status Word
Word 4	0-based.	Offset of COMMREQ Status Word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	E201H (-7679 decimal)	COMMREQ command number
Word 8	0006	Byte length of Command Data (refer to below)
Word 9	(Refer to <i>Memory Types and Offsets</i> below)	Memory type in the CPU for the Command Data
Word 10	0-based	Memory offset for the Command data

12.1.12.3 Memory Types and Offsets

The COMMREQ Command Block specifies a memory type and location to receive status information about the execution of the command (word 3), and for the command data (word 9). The memory types are listed in the following table. **For word 4 and word 10, the address offset is a zero-based number.** For example, the offset for %R100 is 99 decimal.

Type	Value (Decimal)	Value (Hex.)	Description
%R	8	08H	Register memory (word mode)
%AI	10	0AH	Analog input memory (word mode)
%AQ	12	0CH	Analog output memory (word mode)
%I	16 70	10H 46H	Discrete input memory (byte mode) Discrete input memory (bit mode)
%Q	18 72	12H 48H	Discrete output memory (byte mode) Discrete output memory (bit mode)
%T	20 74	14H 4AH	Discrete temporary memory (byte mode) Discrete temporary memory (bit mode)
%M	22 76	16H 4CH	Discrete momentary internal memory (byte mode) Discrete momentary internal memory (bit mode)
%G	56 86	38H 56H	Discrete global data table (byte mode) Discrete global data table (bit mode)
%W	196	C4H	Word memory (word mode; limited to %W1-%W65536)

12.1.12.4 COMMREQ Command Data Format

In the COMMREQ Command Block (above) words 9 and 10 assign a CPU memory location for six bytes of command data. The program logic can use these bytes to set the parameters of the COMMREQ. This module does not use the last command data word.

word 1	command word
word 2	alarm or ramp data
word 3	Unused for module ALG442

Command to be Performed	Word 1 Contains	Word 2 Contains
Change the low alarm limit of the specified input channel to the value in word 2.	0000 (Input 1) 0001 (Input 2) 0002 (Input 3) 0003 (Input 4)	New low alarm limit for the input
Change the high alarm limit of the specified input channel to the value in word 2.	0010 (Input 1) 0011 (Input 2) 0012 (Input 3) 0013 (Input 4)	New high alarm limit for the input
Change the low alarm limit of the specified input channel by the increment in word 2.	0020 (Input 1) 0021 (Input 2) 0022 (Input 3) 0023 (Input 4)	Increment used to change the configured low alarm limit. Increment can be + or -.
Change the high alarm limit of the specified input channel by the increment in word 2.	0030 (Input 1) 0031 (Input 2) 0032 (Input 3) 0033 (Input 4)	Increment used to change the configured high alarm limit. Increment can be + or -.
Turn off Ramp operation for the specified output channel and put it in normal mode.	0040 (Output 1) 0041 (Output 2)	
Put the specified output channel in Ramp step mode. Step increment in word 2.	0050 (Output 1) 0051 (Output 2)	Step (1 to 32000 counts) to be taken each millisecond.
Put the specified output channel in Ramp time mode. Ramp total time in word 2.	0060 (Output 1) 0061 (Output 2)	Time in milliseconds: 1 to 32000 (1 ms to 32 seconds)
Clear the %I error code for this module.	00C0	

If the requested command is not valid (for example, if the changed alarm limit would be out of range) the module ignores the COMMREQ command and returns an error code in the %I status data for this module. The module does NOT stop operating; these error bits are informational only and can be ignored. The error code remains in the %I status bits until cleared by another COMMREQ (command 00C0, refer to directly above), or until the module is reconfigured.

COMMREQ Example

This example shows setting up COMMREQ data and issuing the COMMREQ to an Analog Mixed module.

The application program should verify the completion of the COMMREQ in progress before initiating another, so the module does not receive COMMREQs faster than it can process them. One way to do that is to zero the contents of the COMMREQ status (%R0001 in this example) as the COMMREQ is enabled. Since the status returned for a completed COMMREQ is never zero, a non-zero status word indicates that the COMMREQ has completed.

In this example, the COMMREQ command block starts at %R0002 and is initialized on the first scan. The 6 bytes of COMMREQ data sent to the module must have been moved into %R0101-%R0103 before the COMMREQ is enabled.

The module is located in rack 0, slot 2 so the SYSID input to the COMMREQ is 0002.

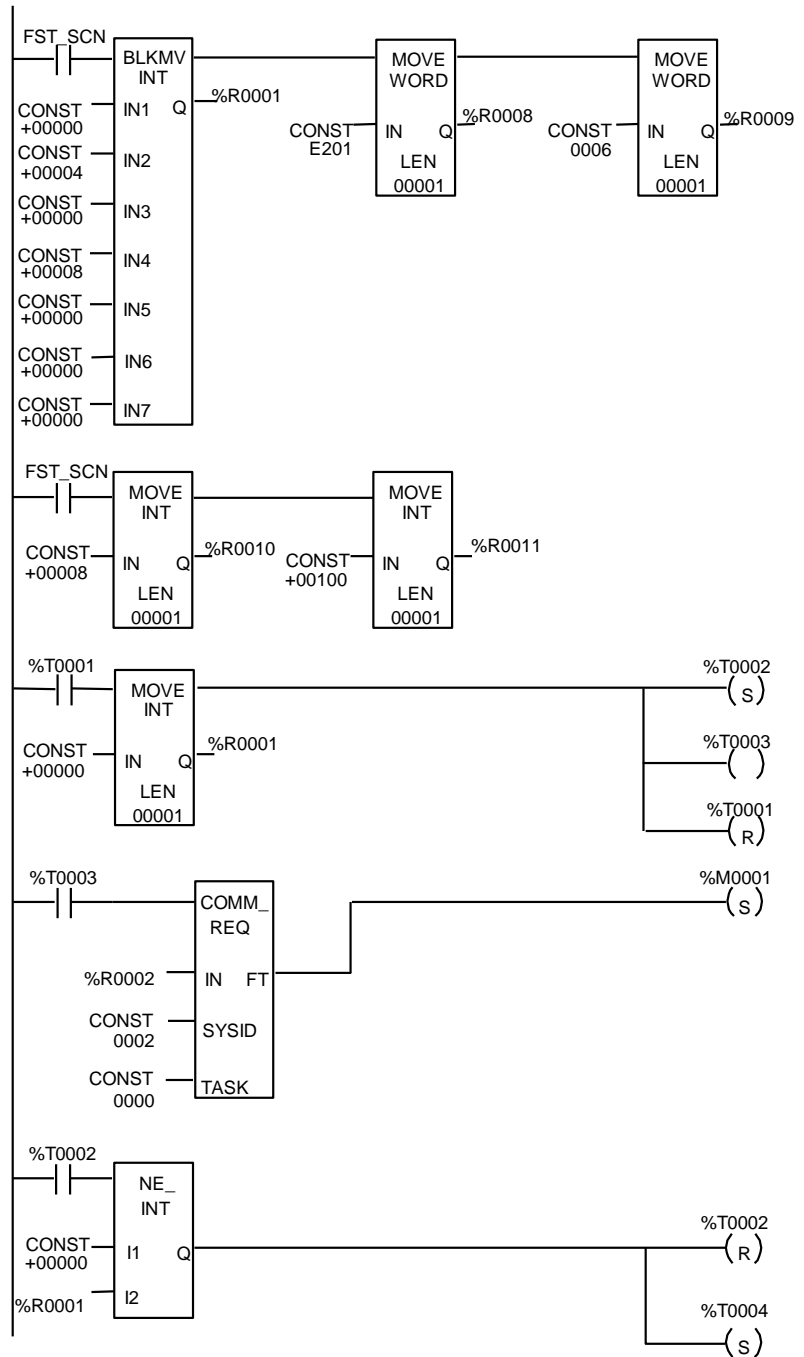


Figure 338: COMMREQ Example ALG442

Setting %T0001 moves zero into the COMMREQ status word, enables %T0003 for one sweep to initiate the COMMREQ, and sets %T0002 to begin checking the status word. When a non-zero status word is detected, %T0002 is reset to discontinue checking and %T0004 is set to indicate that the module is ready for the next COMMREQ. Reference %M0001 is set if a COMMREQ fault occurs.

12.2 Analog Module 4-Input/2-Output Current/Voltage with Advanced Diagnostics: IC694ALG542

Advanced Diagnostics mixed I/O Analog Current/Voltage module, IC694ALG542, provides four differential input channels and two single-ended output channels. Each channel can be configured with the Machine Edition software for one of the following ranges:

- 0 to +10 volts (unipolar), default.
- -10 to +10 volts (bipolar)
- 0 to 20 mA
- 4 to 20 mA

Input channels can also be configured for 4–20 mA Enhanced mode.

Individual outputs can be configured to either Hold Last State if system power is interrupted or to reset to the low end of their range. Outputs can also be configured to operate in ramp mode on command from the application program. In ramp mode, the output channel ramps to a new value over a period of time, rather than taking the new value immediately.

High and low alarm limits can be set for all input channels and an open wire fault (current output modes) can be reported to the CPU for each output channel.

12.2.1 Features

- Open-circuit detection for all inputs in 4 to 20 mA Enhanced Range
- Configurable scaling and offsets per channel
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting selectable per channel
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program
- Supports firmware upgrades
- Positive and negative Rate of Change Alarms
- Display of module serial number, revision and manufacturing date code in programming software.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

12.2.2 Isolated +24Vdc Power

This module requires 150mA plus loop current(s) from a user-supplied 24Vdc external source.

12.2.3 LEDs: ALG542

The **MODULE OK** LED provides module status information as follows:

ON: status is OK, module configured;

OFF: no backplane power or software not running (watchdog timer timed out);

Continuous rapid blinking: configuration data not received from CPU;

Slow blinking, then OFF: failed power-up diagnostics or encountered code execution error.

The **USER SUPPLY** LED indicates that the external 24Vdc supply is within specifications.

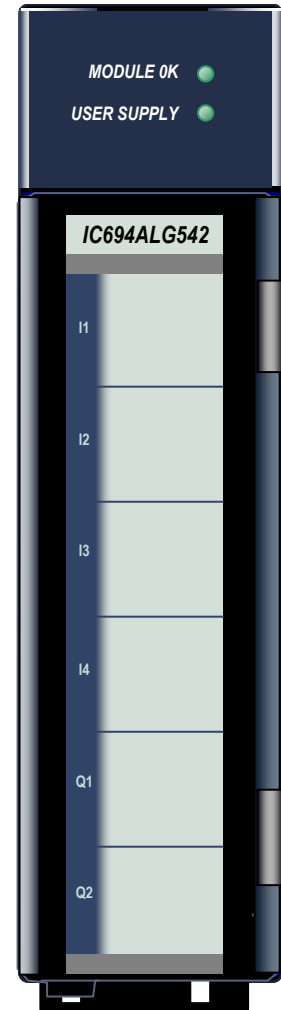


Figure 339: IC694ALG542

12.2.4 Specifications: ALG542

Power Requirements	
External Supply Voltage Range	20 to 30 Vdc (24 Vdc typical)
Power Supply Rejection Ratio	Current: 5 μ A/V (typical), 10 μ A/V (maximum) Voltage: 25 mV/V (typical), 50 mV/V (maximum) (Measured by varying V_{USER} from 24 Vdc to 30 Vdc)
Voltage Ripple	10%
Power Consumption	
	95 mA from backplane +5 Vdc supply 150 mA from external +24 Vdc supply
Update Rate	
	Update Rate: 2ms
Isolation Field to Backplane (optical) and to frame ground	
	250 Vac continuous; 1500 Vac for 1 minute
Analog Outputs	
	Two, Single-Ended
Analog Current Output	
Output Current Ranges	0 to 20 mA, 4 to 20 mA
Resolution	0 to 20 mA: 0.625 μ A (1 LSB = 0.625 μ A) 4 to 20 mA: 0.5 μ A (1 LSB = 0.5 μ A)
Absolute Accuracy ^{72,73}	\pm 0.1% of full scale at 25°C (77°F), typical \pm 0.25% of full scale at 25°C (77°F), maximum \pm 0.5% of full scale over operating temperature range (maximum)
Maximum Compliance Voltage	$V_{USER} - 3$ V (minimum) to V_{USER} (maximum)
User Load	0 to 850 Ω (minimum at $V_{USER} = 20$ V, maximum 1350 Ω at $V_{USER} = 30$ V)
Output Load Capacitance	2000 pF (maximum)
Output Load Inductance	1 H (maximum)
Analog Voltage Output	
Output Ranges	-10 to +10 V (bipolar), 0 to +10 V (unipolar)
Resolution	-10 V to +10 V: 0.3125 mV (1 LSB = 0.3125 mV) 0 to +10 V: 0.3125 mV (1 LSB = 0.3125 mV)
Absolute Accuracy ^{74,73}	\pm 0.25% of full scale at 25°C (77°F), typical \pm 0.5% of full scale at 25°C (77°F), maximum \pm 1.0% of full scale over operating temperature range (maximum)
Output Loading	5 mA (2 k Ω minimum resistance)
Output Load Capacitance	1 μ F (maximum capacitance)

⁷² Analog Current Output: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 1% of full scale.

⁷³ Applicable for all outputs and inputs: In the presence of severe Conducted RF interference (IEC 61000-4-6, 10Vrms), accuracy may be degraded to \pm 2% of full scale.

⁷⁴ Analog Voltage Output: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 4% of full scale

Analog Inputs	Four, differential
Analog Current Input	
Input Ranges	0 to 20 mA, 4 to 20 mA, 4 to 20 mA Enhanced
Resolution	0–20 mA : 0.625 μ A (1 LSB = 0.625 μ A) 4–20 mA : 0.5 μ A/bit(1 LSB = 0.5 μ A) 4–20 mA Enhanced : 0.5 μ A/bit(1 LSB = 0.5 μ A)
Absolute Accuracy at 0–20 mA ^{75,73}	\pm 0.25% of full scale at 25°C (77°F); \pm 0.5% of full scale over specified operating temperature range
Absolute Accuracy at 4–20 mA ^{75,73}	\pm 0.25% of full scale at 25°C (77°F); \pm 0.5% of full scale over specified operating temperature range
Absolute Accuracy at 4–20 mA Enhanced ^{75, 73}	\pm 0.25% of full scale at 25°C (77°F); \pm 0.5% of full scale over specified operating temperature range
Linearity	<4 LSB
Common Mode Voltage	200 V dc (maximum)
Common Mode Rejection	>70 dB at DC; >70 dB at 60 Hz
Cross Channel Rejection	>80 dB from DC to 1 kHz
Input Impedance	250 Ω
Input Filter Response	55 Hz
Analog Voltage Input	
Input Ranges	0 to +10 V (unipolar), -10 to +10 V (bipolar)
Calibration	Factory calibrated to: 2.5 mV per count on 0 V to +10 V (unipolar) range 5 mV per count on -10 to +10 V (bipolar) range
Resolution at 0V to +10 V dc	0 to +10 V: 0.3125 mV (1 LSB = 0.3125 mV) -10 to +10 V: 0.3125 mV (1 LSB = 0.3125 mV)
Resolution at -10 V dc to +10 V dc	1 LSB = 0.3125 mV
Absolute Accuracy ^{76,73} over specified operating temperature range	\pm 0.25% of full scale at 25°C (77°F); \pm 0.5% of full scale over specified operating temperature range
Linearity	<4 LSB
Common Mode Voltage	200 V dc (maximum)
Common Mode Rejection	>70 dB at DC; >70 dB at 60 Hz
Cross Channel Rejection	>80 dB from DC to 1 kHz
Input Impedance	800k Ω (typical)
Input Filter Response	55 Hz

For product standards and general specifications, refer to *Appendix A*.

In order to meet the IEC 1000-4-3 levels for RF Susceptibility specified in *Appendix A*, when this module is present, the system must be mounted in a metal enclosure.

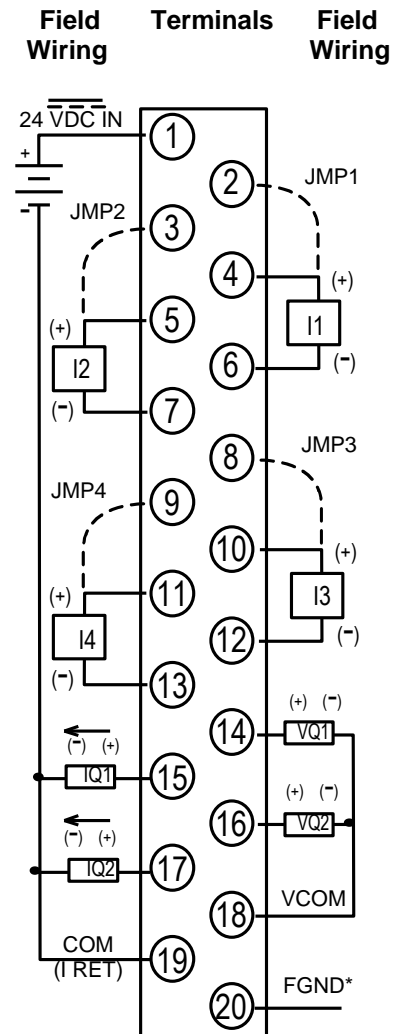
⁷⁵ Analog Current Input: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 2% of full scale.

⁷⁶ Analog Voltage Input: In the presence of severe Radiated RF interference (IEC 61000-4-3, 10V/m), accuracy may be degraded to \pm 1% of full scale.

12.2.5 Field Wiring: ALG542

The diagram below shows voltage and current connections for the module. Each channel can be configured independently as a voltage or a current channel, not both simultaneously.

Terminal	Signal	Definition
1	24VIN	User Supplied +24Vdc Input
2	JMP1	Jumper terminal for connecting 250Ω sense resistor for CH1 current mode
3	JMP2	Jumper terminal for connecting 250Ω sense resistor for CH2 current mode
4	+CH1	Positive connection for differential analog input channel 1
5	+CH2	Positive connection for differential analog input channel 2
6	-CH1	Negative connection for differential analog input channel 1
7	-CH2	Negative connection for differential analog input channel 2
8	JMP3	Jumper terminal for connecting 250Ω sense resistor for CH3 current mode
9	JMP4	Jumper terminal for connecting 250Ω sense resistor for CH4 current mode
10	+CH3	Positive connection for differential analog input channel 3
11	+CH4	Positive connection for differential analog input channel 4
12	-CH3	Negative connection for differential analog input channel 3
13	-CH4	Negative connection for differential analog input channel 4
14	V _{out} CH1	Voltage output for channel 1
15	I _{out} CH1	Current output for channel 1
16	V _{out} CH2	Voltage output for channel 2
17	I _{out} CH2	Current output for channel 2
18	V COM	Common return for voltage outputs
19	I RET	Common return for User supplied +24 Vdc and current outputs
20	GND	Frame ground connections for cable shields



* Optional Shield Connection

Figure 340: Field Wiring ALG542

12.2.6 Input Scaling: ALG542

By default, the module converts a voltage or current input over the entire span of its configured Range. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters), the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the Controller that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible.

All alarm values apply to the scaled Engineering Units value, not to the A/D input value. The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example:

For a voltage input, 6.0 volts equals a speed of 20 feet per second, and 1.0 volt equals 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000

Low Scale Value (Eng Units) = 0.000

High Scale Value (A/D Units) = 6.000

Low Scale Value (A/D Units) = 1.000

For this example, 1.0V to 6.0V is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 10.0V were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or other precautions for scaled inputs that are outside the acceptable range or otherwise invalid.

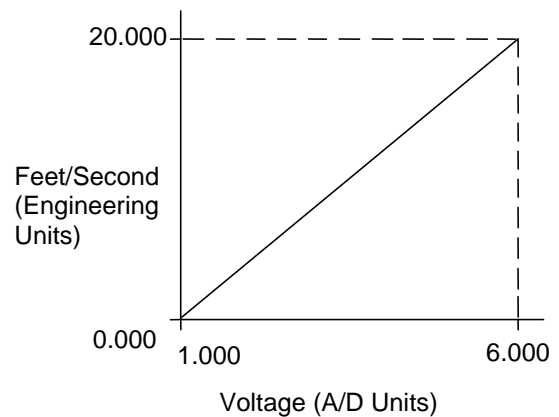


Figure 341: Input Scaling Example ALG542

12.2.7 Output Scaling: ALG542

By default, the module converts a floating point value from the CPU into a voltage or current output over the entire span of its configured Range. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters), the scaled Engineering Unit range can be changed for a specific application. Scaling is always linear and inverse scaling is possible.

All alarm values apply to the scaled Engineering Units value, not to the A/D units value. The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the output.

Example:

In this example, the application should interpret 32000 counts as +10 V dc and -32000 counts as -10 V dc. The following channel configuration will scale a ± 10 V dc output channel to ± 32000 counts.

Channel Value Format = 16-Bit Integer
High Scale Value (Eng Units) = 32000.0
Low Scale Value (Eng Units) = -32000.0
High Scale Value (A/D Units) = 10.000
Low Scale Value (A/D Units) = -10.000

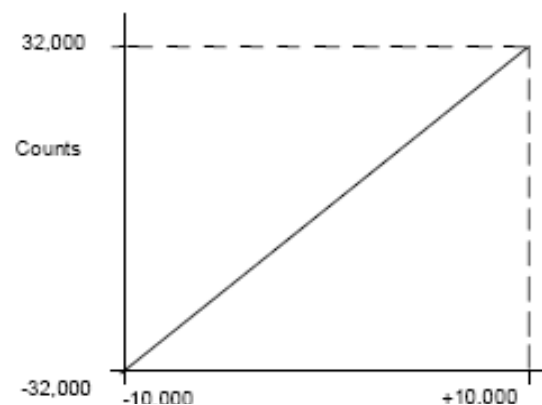
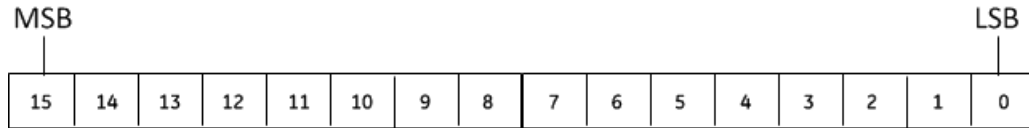


Figure 342: Output Scaling Example ALG542

12.2.8 I/O Data: ALG542

This module uses two %AQ references and four %AI references, depending on configuration. Data in the %AI and %AQ registers is in 16-bit 2's complement format.



12.2.8.1 Input Data

The module reports its channel input data in its configured input words, beginning at its assigned Channel Value Reference Address. Each channel occupies 2 words, whether or not the channel is used: Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

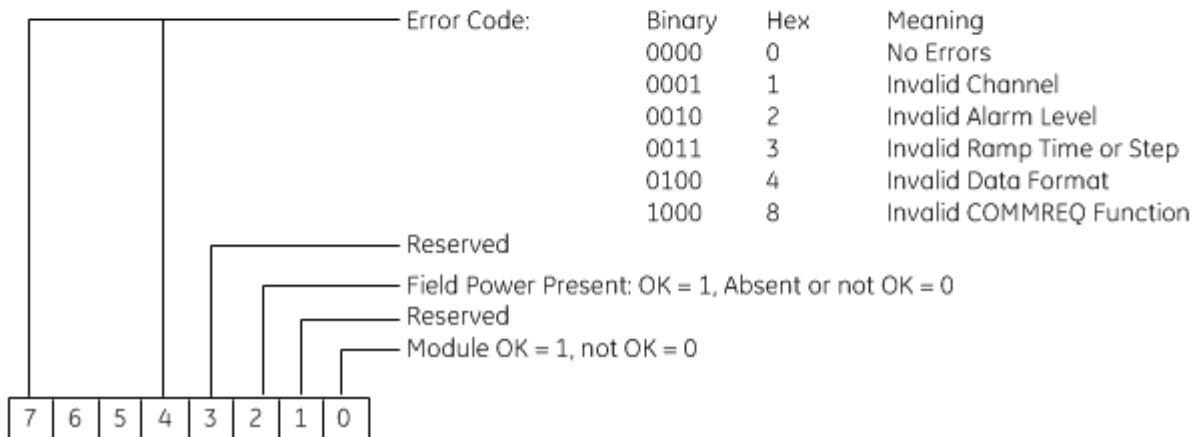
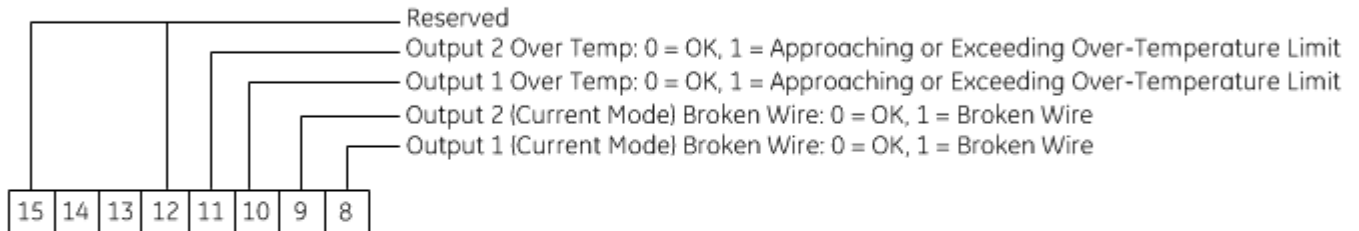
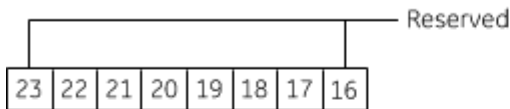
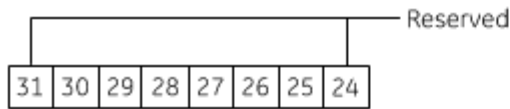
In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

12.2.8.2 Output Data

The module drives its channel output data in its configured output words, beginning at its assigned Channel Value Reference Address. Each channel occupies 2 words, whether or not the channel is used: Depending on its configured Channel Value Format, each enabled channel drives analog voltage/current corresponding to a 32-bit floating point or 16-bit integer value driven by CPU.

In the 16-bit integer mode, the low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value is set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be driven as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

12.2.9 Status Data: ALG542



12.2.10 Configuration: ALG542

The following parameters can be configured using the Machine Edition software.

12.2.10.1 Module Settings

Parameter	Choices	Description
Input Reference Address	Valid memory types: %AI (default), %AQ, %R, %W, %G, %M, %T, Symbolic Memory. ⁷⁷	The starting address in memory for input data from the module.
Input Reference Length	Read-only	Each input channel provides two words of analog data to the Controller CPU.
Output Reference Address	Valid memory types: %AI (default), %AQ, %R, %W, %G, %M, %T, Symbolic Memory. ⁷⁷	The starting address in memory for output data to the module.
Output Reference Length	Read-only	Each channel accepts two words of analog output data to the Controller CPU.
Diagnostic Reference Address	Valid memory types: %I (default), %Q, %AI, %AQ, %R, %W, %G, %M, %T Symbolic Memory. ⁷⁷	Starting address for the channel diagnostics data. Used only when Module Level Diagnostic Reporting is enabled.
Diagnostic reference Length	Read-only	The amount of memory required for the channel diagnostics data. When Module Level Diagnostic Reporting is enabled, two words (32 bits) of diagnostic data are allocated for each channel, whether or not the channel is used.
Module Status Reference Address	Valid memory types: %I (default), %Q, %AI, %AQ, %R, %W, %G, %M, %T, Symbolic Memory. ⁷⁷	The starting address in memory for status information from the module.
Module Status Reference Length	0, 32	The number of module status bits reported to the Controller. Data format is displayed in the following figure. When set to 0, status reporting is disabled. To enable status reporting, set this parameter to a value other than 0.
I/O Scan Set	1 through 32	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data
Inputs Default	Force Off (default) or Hold Last State	In the event of module failure or removal, this parameter specifies the state of all Channel Value References for the module. Force Off = Channel Values clear to 0. Hold Last State = Channels hold their last state.

⁷⁷ To use this feature “Variable Mode” property must be enabled in Proficy* Machine Edition.

Parameter	Choices	Description
Module Level Diagnostic Reporting	Disabled (default) or Enabled	If enabled, 32 bits of data are allocated for each active channel. Diagnostic Reporting and Fault Reporting can be enabled separately for each channel.

12.2.10.2 Output Channel Configuration Parameters ALG542

Parameter	Choices	Description
Range Type	Disabled (default), Voltage/Current	Enables/disables the output channel.
Range	0 to +10 V (default), -10 to +10 V, 4 to 20 mA, 0 to 20 mA	Selects the analog output type.
Channel Value Format	32-Bit Floating Point (default) 16-Bit Integer	32-Bit Floating Point: A real value, range 3.40282e+38 through 3.40282e+38 16-Bit Integer: The low word of the 32-bit channel data contains the 16-bit integer channel value. The high word is ignored. It is possible for the application program to write 32-bit signed decimal values to the output reference. However, the program logic must restrict the magnitude of the value to the range +32767 to -32768. Exceeding this range results in misinterpretation of the sign bit and incorrect output channel operation.
Outputs Default	Force to Default Value (default) Hold Last State	Determines how the output channel operates when one of the following events occurs: <ul style="list-style-type: none"> • The CPU transitions to Stop Disabled mode. • The CPU transitions to Run Disabled mode. • There is a loss of backplane power fault. • There is a non-recoverable module fault for this module. • There is a critical CPU fault. • The configuration is cleared. Force To Default Value: When an event listed above occurs, the module sets the channel output to the Default Value set for the channel. The channel output remains set to the default value until the CPU completes a successful reconfiguration of the outputs. If the Default Ramp Rate is set to a value other than 0, the channel ramps to the default value. Hold Last State: When one of the listed events occurs, the module retains the last successful configured state on its outputs until the CPU completes a successful reconfiguration of the outputs.
High Scale Value (Eng Units)	The defaults and ranges for the four scaling parameters depend on the configured Range and Channel Value Format.	Scaling is disabled if : High Scale Eng. Units = High Scale A/D Units and Low Scale Eng. Units = Low Scale A/D Units. Default is High A/D Limit of selected range type. When Channel Value Format is set to 32-Bit Floating Point, range is -3.40282e+38 through 3.40282e+38. When set to 16-Bit Integer, range -32,768 through +32,767.
Low Scale Value (Eng Units)		
High Scale Value (A/D Units)		
Low Scale Value (A/D Units)		

Parameter	Choices	Description
High Alarm (Eng Units) Low Alarm (Eng Units)	The defaults and ranges for these parameters depend on the configured Range and Channel Value Format.	The alarm parameters are specified in Engineering Units. To use alarming, Diagnostic Reporting or Fault Reporting must be enabled. High Alarm: When the channel value reaches or exceeds this value, a High Alarm is triggered. Low Alarm: When the channel value reaches or goes below this value, a Low Alarm is triggered.
Outputs Enabled Ramp Rate (Eng Units/ms)	Valid range: 0.0, or Lower Limit: (High Scale Eng Units -Low Scale Eng Units) / 60,000 through High Scale Eng Units	The maximum rate at which the output will change during normal operation (outputs are enabled and no fault conditions exist). A value of 0 disables ramping.
Default Ramp Range (Eng Units/ms)	Valid range: 0.0, or Lower Limit: (High Scale Eng Units -Low Scale Eng Units) / 60,000 through High Scale Eng Units	The maximum rate at which the output will change if the Outputs Default parameter is set to Force to Default and one or more of the events defined for Force to Default occurs . A value of 0 disables ramping.
Output Clamping Enable	Disabled (default), Enabled	Disabled: The Upper Clamp Limit is set to the same value as the High Scale Value. The Lower Clamp Limit is set to the same value as the Low Scale Value. Enabled: You can select the values for Upper Clamp Limit and Lower Clamp Limit.
Upper Clamp Limit (Eng Units)	Valid range: 0.0, or Lc+ through Heu+, where Lc+ is a value greater than the Lower Clamp Limit, and Heu+ is a calculated value slightly greater than the High Scale Value (Eng Units). Default: Heu+.	Enabled when Output Clamping is Enabled. The highest value to which the output can be set. If the commanded value exceeds the upper clamp limit, the output is set to the upper clamp limit and an Upper Clamp condition occurs: an alarm is issued if the Upper Clamp Alarm Enable parameter is set to Enabled under Diagnostic Reporting Enable and/or Fault Reporting Enable. If Output Clamping Enable is set to Disabled, the Upper Clamp Limit is set to the same value as the High Scale Value (Eng Units). Note: If you change the High Scale Value (Eng Units), the Upper Clamp Limit is not automatically updated. To update it automatically to Heu+, set the Output Clamping Enable parameter to Disabled and then set it to Enabled. This also sets the value of the Lower Clamp Limit to its default.

Parameter	Choices	Description
Lower Clamp Limit (Eng Units)	Valid range: 0.0, or Leu- through Hc-, where Leu is a calculated value slightly lower than the Low Scale Value (Eng Units), and Hc- is a value lower than the Upper Clamp Limit (Eng Units). Default: Leu-.	Enabled when Output Clamping is Enabled. The lowest value to which the output can be set. If the commanded value exceeds the lower clamp limit, the output is set to the lower clamp limit and a Lower Clamp condition occurs: an alarm is issued if the Lower Clamp Alarm Enable parameter is set to Enabled under Diagnostic Reporting Enable and/or Fault Reporting Enable. If Output Clamping Enable is set to Disabled, the Lower Clamp Limit is set to the same value as the Low Scale Value (Eng Units). Note: If you change the Low Scale Value (Eng Units), the Lower Clamp Limit is not automatically updated. To update it automatically to Leu-, set the Output Clamping Enable parameter to Disabled and then set it to Enabled. This also sets the value of the Upper Clamp Limit to its default.
Default Value (Eng Units)	Valid range: 0.000 - 10.500 Default: -10 to +10 V: 0.0 Other ranges: Lowest value of configured Range.	If the Outputs Default parameter is set to Force to Default Value the channel will be set to this value if one or more of the events defined for Force to Default Value occurs.
User Offset	16-Bit Integer range: -32768 to 32768 32-Bit Floating Point, range: -3.40282e+38 through 3.40282e+38. 0.0 (default)	Engineering Units offset to change the base of the channel. This value is added to the scaled value on the channel prior to alarm checking.
Diagnostic Reporting Enable	Disabled (default) or Enabled (Available only if Module Level Diagnostic Reporting is enabled on the Settings tab.)	If Diagnostic Reporting is enabled, the module reports channel alarms in the Diagnostic Reference memory. Channel alarms can be individually enabled.
Fault Reporting Enable		If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm. Fault reporting for channel alarms can be individually enabled.

12.2.10.3 Input Channel Configuration Parameters ALG542

Parameter	Choices	Description
Range Type	Disabled (default), Voltage/Current	Enables/disables the output channel.
Input Range	Disabled (default) 0 to +10 V, -10 to +10 V, 4 to 20 mA, 0 to 20 mA, 4 to 20 mA Enhanced	Selects the analog input type.
Channel Value Format	32-Bit Floating Point (default) 16-Bit Integer	32-Bit Floating Point: A real value, range 3.40282e+38 through 3.40282e+38 16-Bit Integer: The low word of the 32-bit channel data contains the 16-bit integer channel value. The high word is ignored. It is possible for the application program to write 32-bit signed decimal values to the output reference. However, the program logic must restrict the magnitude of the value to the range +32767 to -32768. Exceeding this range results in misinterpretation of the sign bit and incorrect output channel operation.
High Scale Value (Eng Units)	The defaults and ranges for the four scaling parameters depend on the configured Range and Channel Value Format.	Scaling is disabled if : High Scale Eng. Units = High Scale A/D Units and Low Scale Eng. Units = Low Scale A/D Units. Default is High A/D Limit of selected range type. When <i>Channel Value Format</i> is set to 32-Bit Floating Point, range is -3.40282e+38 through 3.40282e+38. When set to 16-Bit Integer, range -32,768 through +32,767.
Low Scale Value (Eng Units)		
High Scale Value (A/D Units)		
Low Scale Value (A/D Units)		
Positive Rate of Change Limit (Eng Units/Sec)	Range: 0.0 (default) through 3.40282e+38	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. If set to 0, limit is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units/Sec)	Range: 0.0 (default) through 3.40282e+38	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. If set to 0, limit is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate (Seconds)	0.06 (default) through 300.0	Time from 0.06 through 300 seconds to wait between comparisons. If set to 0.0, the module checks after every 0.06 second input sample. Note: Module will start the Rate of Change detection 100ms after switching CPU to RUN mode or module field power is cycled. This is to ignore any glitches in the input signal.

Parameter	Choices	Description
High-High Alarm (Eng Units)	The defaults and ranges for these parameters depend on the configured Range and Channel Value Format.	<p>Alarms and Deadbands</p> <p>All of the alarm parameters are specified in Engineering Units. To use alarming, Diagnostic Reporting or Fault Reporting must be enabled.</p> <p>High-High Alarm and Low-Low Alarm: When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.</p> <p>High Alarm and Low Alarm: When the configured value is reached or below (above), a Low (High) Alarm is triggered.</p> <p>High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.</p> <p>Alarm Deadbands should not cause the alarm clear condition to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.</p>
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
Low-Low Alarm Deadband (Eng Units)		
User Offset	16-Bit Integer range: -32768 through 32768 32-Bit Floating Point range: -3.40282e+38 through 3.40282e+38. 0.0 (default)	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filtering	Disabled (default) or Enabled	Controls whether software filtering will be performed on the inputs.
Integration Time (ms)	0 (default) through 4294967295 ms	Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms.
Diagnostic Reporting Enable	Disabled (default) or Enabled (Available only if Module Level Diagnostic Reporting is enabled on the Settings tab.)	If Diagnostic Reporting is enabled, the module reports channel alarms in the Diagnostic Reference memory. Channel alarms can be individually enabled.
Fault Reporting Enable		If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm. Fault reporting for channel alarms can be individually enabled.

Outputs Default Notes

- Hot Removal of the module in an I/O Enabled mode will cause all outputs to Hold Last State (even channels configured for Force to Default Value). If that operation is not desirable, the outputs can be forced to default by first turning off field power and removing the Terminal Block of this module before hot-removing the module.
- Resetting the module using SVC_REQ 24 causes all channels to Hold Last State even if Default Value is configured. The application program must handle output defaulting before execution of the Service Request.
- Default Ramp Rate configuration is ignored if backplane power from the power supply is lost. Channels configured for Default Value go to the default value immediately.
- The first time a configuration is stored following a return of backplane power, the Default Ramp rate is not used. Any channel configured for Default Value goes to its default value immediately. If analog power was not lost and the same configuration is restored on the next power-up, the channel state is unchanged from the time the power was lost. The Default Ramp Rate is used for any subsequent reconfiguration.

Output Default Conditions and Actions

Condition	Hold Last State or Default Value	Default Ramp Rate Enabled	Outputs Enabled and Ramp Rate Enabled	Channel Output Setting (Except where indicated, field power is assumed to be present).
Outputs Enabled and No Faults	N/A	N/A	No	Output goes to its commanded value from reference memory; defaults don't apply.
	N/A	N/A	Yes	Output is ramped to the commanded output from reference memory at the Outputs Enabled ramp rate. Defaults don't apply.
Outputs Disabled, Fault Mode, or Reconfiguration	Default Value	No	N/A	Output is set to the Default Value
	Default Value	Yes	N/A	Output is ramped to the Default Value at the Default ramp rate, starting at the last commanded value before entering mode.
	Hold Last State	N/A	N/A	Output is held at the last commanded value
Loss of Backplane Power or First Configuration Store after Power-up	Default Value	N/A	N/A	Output is set to the Default Value.
	Hold Last State	N/A	N/A	Output is held at last commanded value.
Hot Removal, Reset with SVCREQ 24 or Cleared Configuration	N/A	N/A	N/A	Output is held at last commanded value.
Loss of Field Power	N/A	N/A	N/A	All outputs go to 0V and 0mA.

12.2.11 Rate of Change Alarms: ALG542

The ALG542 can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the *Negative Rate of Change* parameter.

If the Engineering Unit change between samples is positive, the module compares the rate change with the *Positive Rate of Change* parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the *Diagnostic Reporting Enable* and *Fault Reporting Enable* parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. The minimum value which can be used with this parameter is 60 ms i.e., the module can compare the rate of change after every 60 ms.

When the CPU transitions to RUN mode or the module field power is cycled, the ALG542 waits 100ms before starting Rate of Change detection. This is to ignore any glitches in the input signal.

12.2.12 Ramp Mode Operation: ALG542

In ALG542, the output channels can be set up to operate in Ramp mode. In this mode the output goes to the new value over a period of time, instead of changing directly to the new value (Standard Mode). The output channel starts a new ramp (either up or down) each time the value in its %AQ reference changes.

In normal operating mode, the ramp operation of any given output channel is defined by the channel configuration parameter *Outputs Enabled Ramp Rate (Eng Units / ms)*. A value of zero indicates that the ramp operation is disabled and the respective output channel operates in Standard mode.

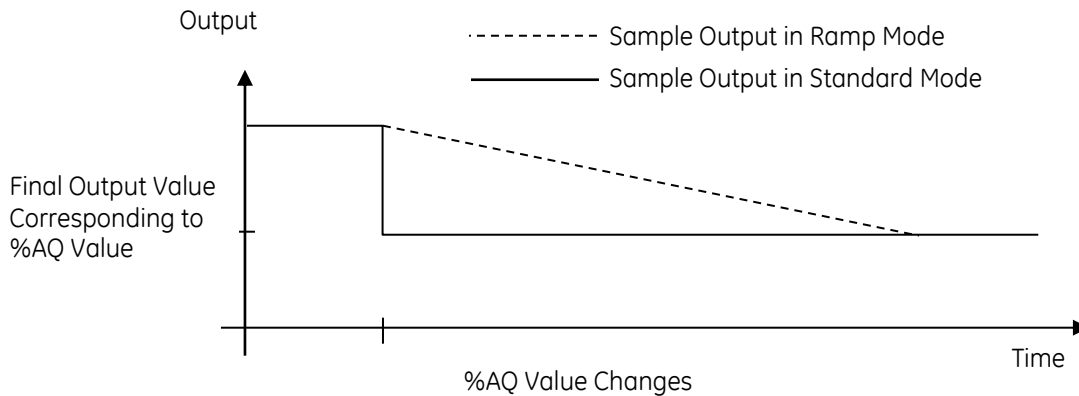


Figure 343: Ramp Mode Example ALG542

An output channel can also be set up to operate in Ramp mode using COMMREQ command.. The ramp slope can be set up in the COMMREQ as:

1. Ramp Time Mode: A total ramp time from 1 millisecond to 32 seconds.
2. Ramp Step Mode: A step size of 1 to 32000 counts in every millisecond.

A channel stays in any one of the above modes until the module receives a new COMMREQ either changing or canceling the ramp operation, or until power is cycled. In this case the value of channel configuration parameter *Outputs Enabled Ramp Rate (Eng Units / ms)* is overridden by the data sent along with the command. The output channel will not change modes even after re-loading the hardware configuration.

After canceling the ramp operation using a new COMMREQ the value of channel configuration parameter *Outputs Enabled Ramp Rate (Eng Units / ms)* is restored and the ramp operation is enabled / disabled accordingly.

If the module receives a new COMMREQ that changes ramp operation while an output is in the process of ramping, the new ramp settings take effect as follows:

1. If Ramp mode is turned off during a ramp, the channel goes directly to the value in its %AQ reference.
2. If a channel is set up to ramp over a period of time, but a new COMMREQ is received commanding the channel to instead ramp in a sequence of measured steps, ramp operation changes as soon as the COMMREQ is processed (assuming that the step is valid).
3. If a channel is set up to ramp as a sequence of measured steps, but a new COMMREQ is received commanding the channel to instead ramp over a period of time, it immediately starts a new ramp using the present output as the starting output and the present time as the start time.

If the module receives a command for an invalid channel, step height or ramp time, the module ignores the command and returns an error code in its %I status references. The error code can be cleared by a Clear Errors COMMREQ or by reconfiguring the module.

12.2.13 Clamp Mode Operation: ALG542

12.2.13.1 Output Channel Clamping Enable Upper Clamp Limit (Eng Units)

Available when Output Clamping Enable is set to Enabled. This permits the user to define the uppermost value to which the output can be set. If the commanded value exceeds the upper clamp limit, the output is set to the upper clamp limit and an Upper Clamp condition occurs: an alarm is issued if the Upper Clamp Alarm Enable parameter is set to Enabled under Diagnostic Reporting Enable and/or Fault Reporting Enable and/or Interrupts Enable.

User can use the upper clamp to restrict the maximum output to a value lower than its configured Range Type. For example, a -10 V dc to +10 V dc channel can be restricted to -10 V dc to +8.5Vdc.

The Upper Clamp Limit also provides an output over range capability.

If Output Clamping Enable is set to Disabled, the Upper Clamp Limit is set to the same value as the High Scale Value (Eng Units).

Valid range: $Lc+$ through $Heu+$, where $Lc+$ is a value greater than the Lower Clamp Limit, and $Heu+$ is a calculated value slightly greater than the High Scale Value (Eng Units).

Default: $Heu+$. If you change the High Scale Value (Eng Units), the Upper Clamp Limit is not automatically updated. To update it automatically to $Heu+$, set the Output Clamping Enable parameter to Disabled and then set it to Enabled. This also sets the value of the Lower Clamp Limit to its default.

12.2.13.2 Output Channel Clamping Enable Lower Clamp Limit (Eng Units)

Available when Output Clamping Enable is enabled. This permits the user to define the lowest value to which the output can be driven. If the commanded value exceeds the lower clamp limit, the output is set to the lower clamp limit and a Lower Clamp condition occurs: an alarm is issued if the Lower Clamp Alarm Enable parameter is set to Enabled under Diagnostic Reporting Enable and/or Fault Reporting Enable and/or Interrupts Enable.

User can use the lower clamp to restrict the minimum output to a value higher than its configured Range Type. For example, a -10 V dc to +10 V dc channel can be restricted to -7.5Vdc to +10 V dc.

The Lower Clamp Limit also provides an output under range capability.

If Output Clamping Enable is set to Disabled, the Lower Clamp Limit is set to the same value as the Low Scale Value (Eng Units).

Valid range: $Leu-$ through $Uc-$, where $Leu-$ is a calculated value slightly lower than the Low Scale Value (Eng Units), and $Uc-$ is a value lower than the Upper Clamp Limit (Eng Units).

Default: $Leu-$. If you change the Low Scale Value (Eng Units), the Lower Clamp Limit is not automatically updated. To update it automatically to $Leu-$, set the Output Clamping Enable parameter to Disabled and then set it to Enabled. This also sets the value of the Upper Clamp Limit to its default.

12.2.14 Changing Module Operation on Command: ALG542

Module ALG542 can respond directly to a specific COMMREQ (Communication Request) command from the application program to:

1. Clear %I error code for the module.
2. Modify the Input alarm limits, and.
3. Put one or both outputs in Ramp mode and set up the ramp characteristics.

These changes to module are not retained during loss of power. If the module is power-cycled, new commands must be sent to the module to again modify the configured alarm limits, or to set up Ramp operation for the outputs.

12.2.14.1 COMMREQ Command Block

The format of the COMMREQ for module ALG542 is displayed in the following figure. The COMMREQ Command Block specifies a memory type and location to receive status information about the execution of the command (word 3), and for the command data (word 9). For more information about using COMMREQs, refer to the online help and the *PACSystems RX7i and RX3i CPU Reference Manual*, GFK-2222.

Word Offset	Value	Description
Word 1	Must be 0004	Length of the command block
Word 2	0000	Not used.
Word 3	Refer to GFK-2222.	Memory type of COMMREQ status word
Word 4	0-based	Offset of COMMREQ status word
Word 5	0	Reserved
Word 6	0	Reserved
Word 7	E201 hex (-7679 decimal)	COMMREQ command number
Word 8	0008	Byte length of command data
Word 9	Refer to GFK-2222	Memory type in the CPU for the Command Data
Word 10	0-based	Memory offset for the command data.

12.2.14.2 COMMREQ Command Data Format

In the COMMREQ Command Block (above) words 9 and 10 assign a CPU memory location for eight bytes of command data. The program logic can use these bytes to set the parameters of the COMMREQ.

1. Word 1 - Command Word
2. Word 2 - Channel Value Format (0000 - 16-Bit Integer / 0001 - 32-Bit Float).
3. Word 3 & 4 - Alarm or Ramp data.

Command to be Performed	Word 1 (hex)	Word 2	Contents of Word 3 & 4
Change the low alarm limit of the specified input / output channel to the value in words 3 & 4.	0000 (Input 1) 0001 (Input 2) 0002 (Input 3) 0003 (Input 4) 0004 (Output 1) 0005 (Output 2)	32-Bit Float / 16-Bit Integer	New low alarm limit for the input / output.
Change the high alarm limit of the specified input / output channel to the value in words 3 & 4.	0010 (Input 1) 0011 (Input 2) 0012 (Input 3) 0013 (Input 4) 0014 (Output 1) 0015 (Output 2)	32-Bit Float / 16-Bit Integer	New high alarm limit for the input / output.
Change the low-low alarm limit of the specified input channel to the value in words 3 & 4.	0100 (Input 1) 0101 (Input 2) 0102 (Input 3) 0103 (Input 4)	32-Bit Float / 16-Bit Integer	New low-low alarm limit for the input.
Change the high-high alarm limit of the specified input channel to the value in words 3 & 4.	0110 (Input 1) 0111 (Input 2) 0112 (Input 3) 0113 (Input 4)	32-Bit Float / 16-Bit Integer	New high-high alarm limit for the input.
Change the low alarm dead band limit of the specified input channel to the value in words 3 & 4.	0200 (Input 1) 0201 (Input 2) 0202 (Input 3) 0203 (Input 4)	32-Bit Float / 16-Bit Integer	New low alarm dead band limit for the input.
Change the high alarm dead band limit of the specified input channel to the value in words 3 & 4.	0210 (Input 1) 0211 (Input 2) 0212 (Input 3) 0213 (Input 4)	32-Bit Float / 16-Bit Integer	New high alarm dead band limit for the input.
Change the low-low alarm dead band limit of the specified input channel to the value in words 3 & 4.	0300 (Input 1) 0301 (Input 2) 0302 (Input 3) 0303 (Input 4)	32-Bit Float / 16-Bit Integer	New low-low alarm dead band limit for the input.
Change the high-high alarm dead band limit of the specified input channel to the value in words 3 & 4.	0310 (Input 1) 0311 (Input 2) 0312 (Input 3) 0313 (Input 4)	32-Bit Float / 16-Bit Integer	New high-high alarm dead band limit for the input.
Change the low alarm limit of the specified input / output channel by the increment in words 3 & 4.	0020 (Input 1) 0021 (Input 2) 0022 (Input 3) 0023 (Input 4) 0024 (Output 1) 0025 (Output 2)	32-Bit Float / 16-Bit Integer	Increment used to change the input / output configured low alarm limit. Increment can be + or -.

Command to be Performed	Word 1 (hex)	Word 2	Contents of Word 3 & 4
Change the high alarm limit of the specified input / output channel by the increment in words 3 & 4.	0030 (Input 1) 0031 (Input 2) 0032 (Input 3) 0033 (Input 4) 0034 (Output 1) 0035 (Output 2)	32-Bit Float / 16-Bit Integer	Increment used to change the input / output configured high alarm limit. Increment can be + or -.
Turn off Ramp operation for the specified output channel and put it in normal mode. ⁷⁸	0040 (Output 1) 0041 (Output 2)	--	
Put the specified output channel in Ramp step mode. Step increment in word 3 & 4. ⁷⁸	0050 (Output 1) 0051 (Output 2)	32-Bit Float	Step to be taken (in Eng Units / ms).
Put the specified output channel in Ramp time mode. Ramp total time in word 3 & 4. ⁷⁸	0060 (Output 1) 0061 (Output 2)	16-Bit Integer	Time in milliseconds: 1 to 32000 (1 ms to 32 seconds)
Clear the module %I error code	00C0	--	

If the requested command is not valid (for example, if the changed alarm limit would be out of range or the specified data format in word 2 does not match with the data format used by the channel configuration) the module ignores the COMMREQ command and returns an error code in the %I status data for the module. The module does **not** stop operating; these error bits are informational only and can be ignored. The error code remains in the %I status bits until cleared by another COMMREQ (command 00C0, refer to directly above), or until the module is reconfigured.

12.2.14.3 COMMREQ Error Code

The first byte of the ALG542 module status data contains a status/error code for COMMREQs sent to the module. Only the most recent error is reported; an existing error code will be overwritten if another error occurs. Following is the list of supported error codes:

Error Code	Description
0	No Error.
1	Invalid channel.
2	Invalid alarm level.
3	Invalid ramp time or step.
4	Invalid data format.
8	Invalid COMMREQ function.

The priority of errors is:

1. Invalid COMMREQ function (highest priority).
2. Invalid channel.
3. Invalid data format.
4. Invalid data (ramp or alarm parameter) (lowest priority).

If multiple errors occur, the one with the highest priority is reported in the error code. The module will not stop standard operation if an error is detected; these error bits are informational only, and can be ignored.

⁷⁸ These commands do not modify the configuration parameter *Outputs Enabled Ramp Rate* of the specified output channel of ALG542.

Chapter 13 Universal Analog Input Module

This chapter describes the following Analog module for PACSystems RX3i controllers.

Universal Analog Input Module Description	Catalog Number	Section
Universal Analog Input: Voltage, Current, Resistance, RTD, Thermocouple; 8-Channel	IC695ALG600	13.1

13.1 Universal Analog Input: Voltage, Current, Resistance, RTD, Thermocouple, 8-Channel + 2 CJC: IC695ALG600

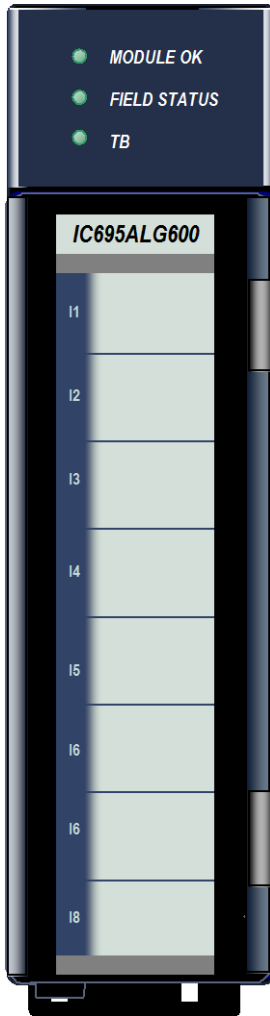


Figure 344: IC695ALG600

Universal Analog Input module IC695ALG600 provides eight general purpose input channels and two Cold Junction Compensation (CJC) channels. Inputs are divided into two equal groups of four. Channels can be individually-configured using the Machine Edition software for:

- Any combination of up to 8 channels of voltage, current, thermocouple, RTD, and resistance inputs.
- Thermocouple Inputs: B, C, E, J, K, N, R, S, T
- RTD Inputs: PT 385 / 3916, N 618 / 672, NiFe 518, CU 426
- Resistance Inputs: 0 to 250 / 500 / 1000 / 2000 / 3000 / 4000Ω
- Current: 0–20 mA, 4–20 mA, ± 20 mA
- Voltage: ± 50 mV, ± 150 mV, 0–5 V, 1–5 V, 0–10 Vdc, ± 10 V dc

13.1.1 Features

- Completely software-configurable, no module jumpers to set
- Six hardware analog-to-digital filter frequencies, individually-selectable by channel
- Rapid channel acquisition times based on filter frequency
- Full auto-calibration
- On-board error-checking
- Open-circuit detection for most input types
- Short-circuit detection for RTDs.
- User-defined scaling
- High alarm, low alarm, high-high alarm, low-low alarm detection and reporting
- Module fault reporting
- Supports diagnostic point fault contacts in the logic program.
- Flash memory for future upgrades
- Module Status, Field Status, and TB LEDs
- CJC compensation on terminal block
- Temperature in Celsius or Fahrenheit
- Positive and negative Rate of Change Alarms
- Configurable software filters for each input channel
- Configurable interrupts for channel alarms and faults
- Terminal Block insertion or removal detection
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

This module must be located in an RX3i Universal Backplane. It cannot be located in an expansion or remote backplane.

13.1.2 LEDs: ALG600

The **Module OK** LED indicates module status. The **Field Status** LED indicates the presence of a fault on at least one channel or a terminal block error. The **TB** (Terminal Block) LED indicates the presence or absence of the terminal block. LEDs are powered from the backplane power bus.

LED	Indication	Meaning
Module OK	ON Green	Module OK and configured.
	Slow Blinking Green	Module OK but not configured.
	Quick Blinking Green	Module starting up, waiting for CPU-to-module communication to be established.
	Blinking Amber	Internal Module Failure. (Count the number of blinks for a two-digit blink code.)
	OFF	Module is defective or no backplane power present
Field Status	ON Green	No faults on any enabled channel, and Terminal Block is present.
	ON Yellow	Fault on at least one channel.
	OFF	Terminal block not present or not fully seated.
TB	ON Red	Terminal block not present or not fully seated.
	ON Green	Terminal block is present.
	OFF	No backplane power to module.

13.1.3 Specifications: ALG600

Specification	Description	
Backplane Power Requirements	400 mA maximum at 5Vdc 350 mA maximum at 3.3Vdc	
CPU Memory Usage	40 bytes (20 words) of input references for channel input data. 40 bytes for enhanced diagnostics 4 bytes for module status reporting.	
Power Dissipation within Module	5.4 watts maximum	
LEDs	One bi-color green/amber LED to indicate the module status One bi-color green/yellow LED to indicate the field status One bi-color red/green LED to indicate the terminal block status	
Channel Acquisition Time	10 msec at 1000 Hz, 13 msec at 200 Hz, 27 msec at 40 Hz, 67 msec at 16 Hz, 87 msec at 12 Hz, 127 msec at 8 Hz	
Channel Update Time	The sum of the channel acquisition times for a bank of 4 channels plus one of the following, if applicable: a) RTD Lead resistance measurement time (= channel acquisition time) b) CJC acquisition time 7 msec.	
Input resolution	11 to 16 bits, depending on configured range and A/D filter frequency.	
<i>Inputs in Ω</i>	Resistance	0-250, 0-500, 0-1000, 0-2000, 0-3000, 0-4000
	Platinum 385	100, 200, 500,1000
	Platinum 3916	100, 200, 500,1000
	Nickel 672	120
	Nickel 618	100,200, 500,1000
	Nickel-Iron 518	604
	Copper 426	10
<i>RTD Inputs</i>	Copper 426	-100 to 260 °C
	Nickel 618	-100 to 260 °C
	Nickel 672	-80 to 260 °C
	Nickel-Iron 518	-100 to 200 °C
	Platinum 385	-200 to 850 °C
	Platinum 3916	-200 to 630 °C
<i>Thermocouple Inputs</i>	Type B	300 to 1820 °C
	Type C	0 to 2315 °C
	Type E	-270 to 1000 °C
	Type J	-210 to 1200 °C
	Type K	-270 to 1372 °C
	Type N	-210 to 1300 °C
	Type R	0 to 1768 °C
	Type S	0 to 1768 °C
	Type T	-270 to 400 °C

Specification	Description
Voltage / Current Inputs	-10 V dc to +10 V dc, 0 to +10 V dc, 0 to +5Vdc, 1Vdc to +5Vdc, -50mV to +50mV, -150mV to +150mV, -20mA to +20mA, 4 to 20 mA, 0 to 20 mA
Configurable Input Filter	8Hz, 12Hz, 16Hz, 40Hz, 200Hz, 1000Hz
Scaling	Floating point user scaling.
Max RTD Cable Impedance	25 Ω
RTD Wire Length	1000 ft max w/settling time of 1mSec
Input Impedance	>1M Ω for Tc/V/RTD
Current Input Resistance	249 Ω \pm 1%
Open circuit detection time	5 seconds max. Open circuit detection is available for all configurations except \pm 20mA current, 0-20mA current, and \pm 10 V dc voltage.
Max Over-voltage	\pm 14.5Vdc continuous
Max Overcurrent	28mA continuous
Normal Mode Noise Rejection	95 dB minimum at 50/60 Hz with 8 Hz filter 85 dB minimum at 50/60 Hz with 12 Hz filter
Common Mode Noise Rejection	120dB minimum at 50/60 Hz with 8 Hz filter 110dB minimum at 50/60 Hz with 12 Hz filter
Settling time to 5% of Full Scale (notch filter dependent)	<80mS
Calibrated Accuracy at 25°C	Better than 0.1% of range (except 10 Ω Cu RTD) Accuracy depends on A/D filter, data format, input noise, and ambient temperature.
Calibration interval	12 months typical to meet accuracy specifications over time. Module will allow for user offset to be applied as a periodic calibration adjustment.
Input Offset Drift with Temperature	3.0 m Ω /°C maximum 2.0 μ V/°C maximum
Gain Drift with Temperature	50 ppm/°C typical (90 ppm/°C maximum)
Module error over Full Temp range	0.5% of range typical (depends on range) 1.0% of range maximum
Module Scan Time (notch filter dependent)	(Assumes 2 ADCs running in parallel, no CJC or lead resistance) 10ms per Channel * 4 Channels = 40ms (1KHz filter) 127ms per Channel * 4 Channels = 508ms (8Hz filter) Channels that are disabled are not scanned, shortening scan time.
Module conversion method	Sigma-delta
Isolation Voltage channel to channel group to group terminal block to backplane/chassis	Opto-isolated, transformer isolated \pm 12.5Vdc channel to channel Tc/V/I/RTD 250 V ac continuous/1500 V ac for 60 seconds 250 V ac continuous/1500 V ac for 60 seconds

13.1.3.1 Accuracy Specifications

Maximum Error at:		+25°C			0°C to +60°C		
Configured Input Filter		8, 12, 16Hz	200Hz	1000Hz	8, 12, 16Hz	200Hz	1000Hz
Voltage Inputs ⁷⁹	± 10.5 V, 0.0 to +10.5 V	± 5 mV	± 5.5 mV	± 7 mV	± 10 mV	± 11 mV	± 14 mV
	0 to +5.25 V, +1.0 to +5.25 V	± 3 mV	± 3.3 mV	± 4.2 mV	± 5 mV	± 5.5 mV	± 7 mV
	± 155 mV	± 30 µV	± 33 µV	± 42 µV	± 110 µV	± 121 µV	± 154 µV
	± 55 mV	± 15 µV	± 17 µV	± 21 µV	± 70 µV	± 77 µV	± 98 µV
Current Inputs ⁷⁹	± 22.5 mA, 0.0 to +22.5 mA, +3.0 to +22.5 mA	± 20 µA	± 22 µA	± 28 µA	± 40 µA	± 44 µA	± 56 µA
Thermocouple Inputs ⁷⁹	Type J (-180°C to +1200°C)	± 0.6°C	± 0.7°C	± 0.9°C	± 2.3°C	± 2.6°C	± 3.3°C
	Type J (-210°C to -180°C)	± 0.8°C	± 0.9°C	± 1.2°C	± 3.3°C	± 3.7°C	± 4.7°C
	Type N (-160°C to +1300°C)	± 1.0°C	± 1.1°C	± 1.4°C	± 4.5°C	± 5.0°C	± 6.3°C
	Type N (-210°C to -160°C)	± 1.8°C	± 2.0°C	± 2.6°C	± 8.0°C	± 8.8°C	± 11.2°C
	Type T (-190°C to +400°C)	± 0.9°C	± 1.0°C	± 1.3°C	± 4.0°C	± 4.4°C	± 5.6°C
	Type T (-270°C to -190°C)	± 6.7°C	± 7.4°C	± 9.4°C	± 18.0°C	± 19.8°C	± 25.2°C
	Type K (-200°C to +1372°C)	± 1.0°C	± 1.1°C	± 1.4°C	± 4.0°C	± 4.4°C	± 5.6°C
	Type K (-270°C to -200°C)	± 9.5°C	± 10.5°C	± 13.3°C	± 21.0°C	± 23.1°C	± 29.4°C
	Type E (-200°C to +1000°C)	± 0.6°C	± 0.7°C	± 0.9°C	± 2.5°C	± 2.8°C	± 3.5°C
	Type E (-270°C to -200°C)	± 5.3°C	± 5.8°C	± 7.5°C	± 14.0°C	± 15.4°C	± 19.6°C
	Type S and R	± 2.8°C	± 3.1°C	± 4.0°C	± 11.5°C	± 12.7°C	± 16.1°C
	Type C	± 1.7°C	± 1.9°C	± 2.4°C	± 7.0°C	± 7.7°C	± 9.8°C
Type B	± 3.3°C	± 3.7°C	± 4.5°C	± 20.0°C	± 22.0°C	± 28.0°C	
RTD Inputs ⁷⁹	100 Ω Platinum 385	± 0.7°C	± 0.8°C	± 1.0°C	± 1.2°C	± 1.4°C	± 1.7°C
	200 Ω Platinum 385	± 0.6°C	± 0.7°C	± 0.9°C	± 1.0°C	± 1.1°C	± 1.4°C
	500 Ω Platinum 385	± 0.5°C	± 0.6°C	± 0.7°C	± 0.9°C	± 1.0°C	± 1.3°C
	1000 Ω Platinum 385	± 0.5°C	± 0.6°C	± 0.7°C	± 0.9°C	± 1.0°C	± 1.3°C
	100 Ω Platinum 3916	± 0.6°C	± 0.7°C	± 0.9°C	± 1.1°C	± 1.2°C	± 1.6°C
	200 Ω Platinum 3916	± 0.5°C	± 0.6°C	± 0.7°C	± 0.9°C	± 1.0°C	± 1.3°C
	500 Ω Platinum 3916	± 0.4°C	± 0.5°C	± 0.6°C	± 0.8°C	± 0.9°C	± 1.2°C
	1000 Ω Platinum 3916	± 0.4°C	± 0.5°C	± 0.6°C	± 0.8°C	± 0.9°C	± 1.2°C
	Nickel 672	± 0.3°C	± 0.4°C	± 0.5°C	± 0.5°C	± 0.6°C	± 0.7°C
	Nickel 618	± 0.3°C	± 0.6°C	± 0.5°C	± 0.5°C	± 0.6°C	± 0.7°C
	Nickel-Iron 518	± 0.4°C	± 0.5°C	± 0.6°C	± 0.7°C	± 0.8°C	± 1.0°C
	Copper 426	± 1.0°C	± 1.1°C	± 1.4C	± 2.4 °C	± 2.7 °C	± 3.4 °C
Resistance Inputs ⁷⁹	250 Ω	± 0.25 Ω	± 0.28 Ω	± 0.35 Ω	± 0.35 Ω	± 0.39 Ω	± 0.49 Ω
	500 Ω	± 0.3 Ω	± 0.33 Ω	± 0.42 Ω	± 0.45 Ω	± 0.5 Ω	± 0.63 Ω
	1000 Ω	± 0.5 Ω	± 0.55 Ω	± 0.7 Ω	± 0.8 Ω	± 0.88 Ω	± 1.2 Ω
	2000 Ω	± 0.9 Ω	± 1.0 Ω	± 1.26 Ω	± 1.5 Ω	± 1.65 Ω	± 2.1 Ω
	3000 Ω	± 1.3 Ω	± 1.43 Ω	± 1.82 Ω	± 2.2 Ω	± 2.42 Ω	± 3.08 Ω
	4000 Ω	± 1.7 Ω	± 1.87 Ω	± 2.38Ω	± 2.9 Ω	± 3.19 Ω	± 4.06 Ω
Cold Junction Temperature	± 1.5°C maximum						

⁷⁹ Accuracy is dependent on the ADC output rate selection, data format, and input noise. In severe RF environments, accuracy may be degraded by up to ±2% of full scale.

CJC Sensor	$\pm 0.3^{\circ}\text{C}$ maximum 0°C to $+80^{\circ}\text{C}$
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13.1.4 Field Wiring: ALG600

The following table lists wiring connections for the module. Except for RTD and resistance type inputs, channels are wired as differential inputs. There are no shield terminals. For shielding, tie cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided in the ground bar for this purpose.

Terminal	RTD or Resistance	TC / Voltage / Current	RTD or Resistance	TC / Voltage / Current	Terminal
1		CJC1 IN+	Channel 1 EXC+		19
2		CJC1 IN-	Channel 1 IN+	Channel 1 IN+	20
3	Channel 2 EXC+			Channel 1 iRTN	21
4	Channel 2 IN+	Channel 2 IN+	Channel 1 IN-	Channel 1 IN -	22
5		Channel 2 iRTN	Channel 3 EXC+		23
6	Channel 2 IN-	Channel 2 IN -	Channel 3 IN+	Channel 3 IN+	24
7	Channel 4 EXC+			Channel 3 iRTN	25
8	Channel 4 IN+	Channel 4 IN+	Channel 3 IN-	Channel 3 IN-	26
9		Channel 4 iRTN	Channel 5 EXC+		27
10	Channel 4 IN-	Channel 4 IN -	Channel 5 IN+	Channel 5 IN+	28
11	Channel 6 EXC+			Channel 5 iRTN	29
12	Channel 6 IN+	Channel 6 IN+	Channel 5 IN-	Channel 5 IN-	30
13		Channel 6 iRTN	Channel 7 EXC+		31
14	Channel 6 IN-	Channel 6 IN-	Channel 7 IN+	Channel 7 IN+	32
15	Channel 8 EXC+			Channel 7 iRTN	33
16	Channel 8 IN+	Channel 8 IN+	Channel 7 IN-	Channel 7 IN-	34
17		Channel 8 iRTN		CJC2 IN+	35
18	Channel 8 IN-	Channel 8 IN-		CJC2 IN-	36

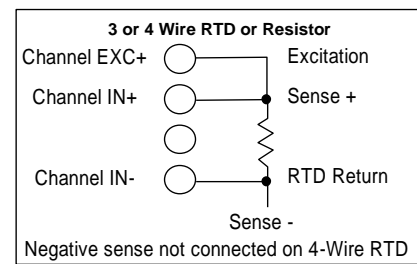
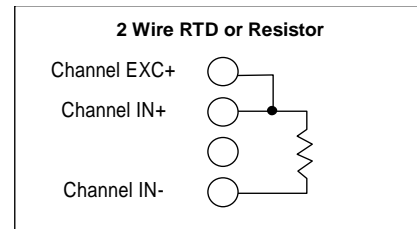
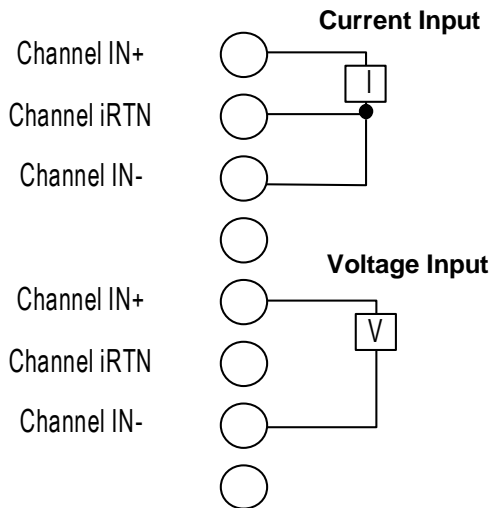


Figure 345: Thermocouple / Voltage / Current Field Wiring ALG600

Figure 346: RTD / Resistance Field Wiring ALG600

- For current inputs, tie the Return to the associated IN- pin.
- For 2 wire RTDs, tie EXC+ and IN+ together at the terminal block.
- For 4 wire RTDs, leave one of the negative sense leads unconnected.
- For 3 wire RTDs, IN+ = Sense+, IN- = RTD Return, and EXC+ = Excitation current.
- Unconnected RTD channels must have a jumper installed to assure proper operation. Failure to do so could affect the accuracy of adjacent channels.

13.1.4.1 Installing CJC Sensors

When using thermocouple inputs on this module, the use of CJC sensors is recommended. Installing one CJC sensor will greatly improve the accuracy of thermocouple readings. Installing two CJC sensors will provide the highest thermocouple input accuracy. Refer to “CJC Scan Enable” later in this chapter for information about configuring and using CJC sensors.

A CJC sensor compensates for offset voltages introduced into the input signal where the thermocouple wires are connected to the module. A set of two CJC sensors is available as part number IC695ACC600.

The thermistor end of the CJC sensor must be installed in the CJC1 IN+ or CJC2 IN+ terminal for accurate thermocouple temperature measurements. The gold pin end of the sensor must be installed in the CJC1 IN- or the CJC2 IN- terminal.

Open the Terminal Block contacts fully before installing the CJC sensor. Insert the sensor into the Terminal Block contact, maintaining metal-to-metal contact between the thermistor and the Terminal Block contact.

For a Box-style Terminal Block, maintain pressure while screwing down the contact.

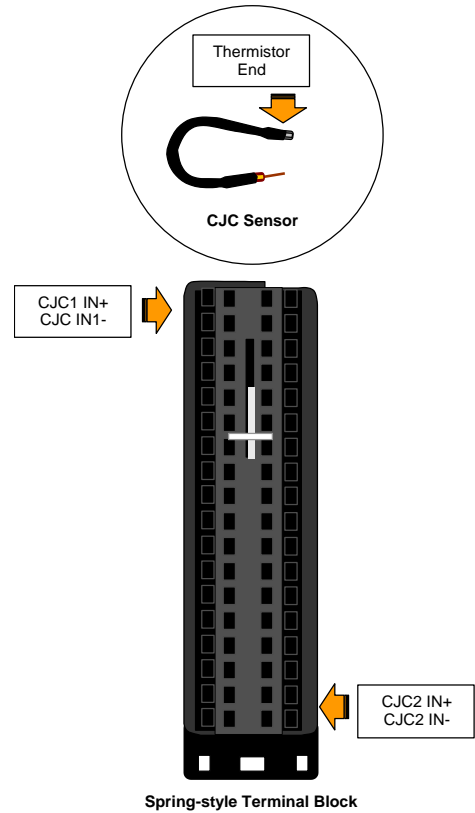


Figure 347: Installing Cold Junction Sensor

13.1.4.2 Connecting Channels to the Same Thermocouple Point

When connecting one or more channels from channels 1–4 and one or more channels from channels 5–8 to the same thermocouple point electrically, the point should be grounded. It can be grounded at either the sensor or the module, by adding a jumper wire from frame ground to the low side of one thermocouple input.

13.1.5 Configuration: ALG600

13.1.5.1 Module Parameters

Parameter	Default	Description
Channel Value Reference Address	%AIxxxxx	Starting address for the input data of the module. This defaults to the next available %AI block.
Inputs Default	Force Off	In the event of module failure or removal, this parameter specifies the state of the Channel Value References. Force Off = Channel Values clear to 0. Hold Last State = Channel Values hold their last state.
Channel Value Reference Length	20	The number of words used for the input data of the module.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	0	The number of bit reference bits (0 – 320) required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of the module. This defaults to the next available %I block.
Module Status Reference Length	0	The number of bits (0 – 32) required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping.
CJC Scan Enable	Disabled	Cold Junction Compensation can be: No Scan, Scan CJC1, Scan CJC2, Scan Both CJs. Use of these parameters is described later in this section.
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data

13.1.5.2 Channel 1 – 8 Parameters

Parameter	Default	Description
Range Type	Disabled	Voltage/Current, Thermocouple, RTD, Resistance, Disabled
Range (Not for Range Type Disabled)	-10 V dc to +10 V dc	For voltage/current: -10 V dc to +10 V dc, 0 to +10 V dc, 0 to +5Vdc, 1Vdc to +5Vdc, -50mV to +50mV, -150mV to +150mV, -20mA to +20mA, 4 to 20 mA, 0 to 20 mA For Thermocouple: B, C, E, J, K, N, R, S, T For RTD: Platinum 385: 100 Ω / 200 Ω/ 500 Ω/ 1000 Ω Platinum 3916: 100 Ω / 200 Ω / 500 Ω / 1000 Ω Nickel 672: 120 Ω Nickel 618: 100 Ω / 200 Ω / 500 Ω / 1000 Ω Nickel-Iron 518: 604 Ω Copper 426: 10 Ω For Resistance: 0-250 Ω, 0 – 500 Ω, 0 – 1000 Ω, 0 - 2000 Ω, 0 – 3000 Ω, 0 – 4000 Ω
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
Temperature Units (for Thermocouple or RTD Range Type only)	Celsius	Celsius, Fahrenheit
RTD	RTD 2 Wire	(for RTD Range Type only) RTD 2 or 3 Wire
RTD Lead Resistance Compensation	Enabled	(for RTD Range Type only)Enabled, Disabled
High Scale Value (Eng Units)	The defaults for the four Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of defaults.	<i>Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units.</i> Default is High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

13.1.5.3 Input Scaling: ALG600

By default, the module converts a voltage, current, resistance, or temperature input over the entire span of its configured Range into a floating point value for the CPU. For example, if the Range of a channel is 4 to 20mA, the module reports channel input values from 4.000 to 20.000. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the PLC that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example 1

For a voltage input, 6.0 Vdc represents a speed of 20 feet per second, and 1.0 Vdc represents 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000

Low Scale Value (Eng Units) = 0.000

High Scale Value (A/D Units) = 6.000

Low Scale Value (A/D Units) = 1.000

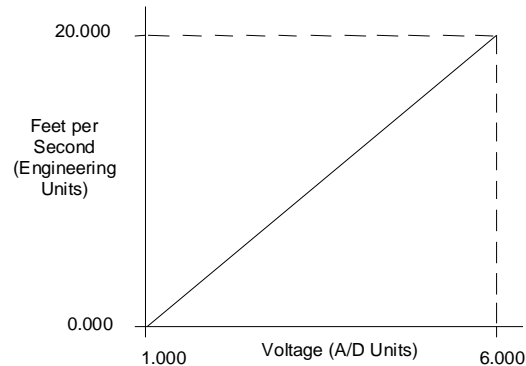


Figure 348: Input Scaling Example 1: ALG600

For this example, 1.0V to 6.0V is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 10.0V were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or take other precautions for scaled inputs that are outside the acceptable range or invalid.

Example 2

An existing application uses traditional analog to digital (A/D) count integer values. With scaling and the optional 16-bit integer input option, a channel can be configured to report integer count values. In this example, the application should interpret +10 V dc as 32000 counts and -10 V dc as -32000 counts. The following channel configuration will scale a ± 10 V dc input channel to ± 32000 counts.

Channel Value Format = 16 Bit Integer

High Scale Value (Eng Units) = 32000.0

Low Scale Value (Eng Units) = -32000.0

High Scale Value (A/D Units) = 10.000

Low Scale Value (A/D Units) = -10.000

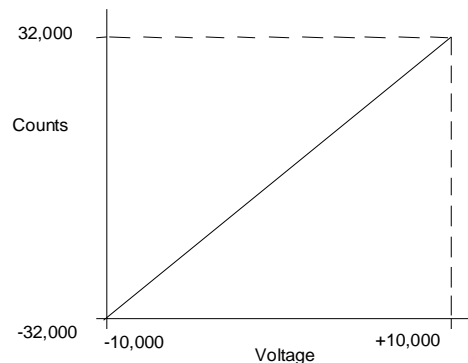


Figure 349: Input Scaling Example 2: ALG600

Channel 1 – 8 Parameters continued

Parameter	Default	Description
Positive Rate of Change Limit (Eng Units)	0.000	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units)	0.000	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate	0.000	Time from 0 to 300 seconds to wait between comparisons. Default of 0.0 is to check after every input sample.

13.1.5.4 Rate of Change Alarms: ALG600

The Universal Analog module can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous rate of change sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Unit change between samples is positive, the module compares the results in comparing the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the "Diagnostic Reporting Enable," "Fault Reporting Enable," and "Interrupts Enabled" parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. If the Rate of Change Sampling Rate is 0 or any time period less than the channel update rate, the module compares the Rate of Change for every input sample of the channel.

Channel 1 – 8 Parameters continued

Parameter	Default	Description
High-High Alarm (Eng Units)	The defaults for the High-High, High, Low, and Low-Low parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of default values.	<p>Alarms and Deadbands</p> <p>All of the alarm parameters are specified in Engineering Units. To use alarming, the A/D Alarm Mode must also be configured as enabled.</p> <p><i>High-High Alarm and Low-Low Alarm:</i> When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits.</p> <p><i>High Alarm and Low Alarm:</i> When the configured value is reached or below (above), a Low (High) Alarm is triggered.</p> <p><i>High and Low Alarm Deadbands:</i> A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range.</p> <p>Alarm Deadbands should not cause the alarm clear to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.</p>
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		

Channel 1 – 8 Parameters continued

Parameter	Default	Description
User Offset	0.000	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filter Integration Time (ms)	0.000	Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms. Default is disabled
A/D Filter Frequency	40 Hz	Low pass A/D hardware filter setting: 8, 12, 16, 40, 200, or 1000Hz. Default is 40Hz. Frequencies below this are not filtered by hardware.
Diagnostic Reporting Enable If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area. Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table.
Fault Reporting Enable If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	Interrupts Enable options enable I/O Interrupt trigger when alarm conditions occur. These parameters enable or disable the individual diagnostics features of a channel.
Interrupts Enable If Interrupts are enabled, the additional parameters listed below can be used to enable specific types of Interrupts.	Disabled	When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature.
Low Alarm Enable	Disabled	For example, if Over Range is enabled in the "Diagnostic Reporting Enable" menu, the module will set the Over Range bit in the Diagnostic Reference for the channel.
High Alarm Enable	Disabled	
Under Range Enable	Disabled	If any of these parameters is disabled, the module does not react to the associated alarm conditions.
Over Range Enable	Disabled	
Open Wire Enable	Disabled	
Calibration Fault Enable	Disabled	
Low-Low Alarm Enable	Disabled	For example, if Low Alarm Enable is set to Disabled in the "Fault Reporting Enable" menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.
High-High Alarm Enable	Disabled	
Negative Rate of Change Detection Enable	Disabled	
Positive Rate of Change Detection Enable	Disabled	

13.1.5.5 Using Alarming: ALG600

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

13.1.5.6 Using Interrupts

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of the module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address corresponding to that channel.

Example:

In this example, the Channel Values Reference Address block is mapped to %AI0001-%AI0020. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AI00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AI0003" as the Trigger.

Note on Using Interrupts

This module has separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

13.1.5.7 CJC Parameters

Parameter	Default	Description
Channel Value Format	16-bit Integer	16-bit integer or 32-bit floating point
Temperature Units	Celsius	Celsius, Fahrenheit
User Offset (Temperature Units)	0.000	Temperature offset added to CJC values. Range -25°C to +25°C with C temp units and -45°F to +45°F with F temp units.
Diagnostic Reporting Enable	Disabled	These parameters enable or disable the individual diagnostics features of a CJC input.
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable	Disabled	
Fault Reporting Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable	Disabled	
Interrupts Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable	Disabled	

13.1.5.8 CJC Scan Enable

Cold Junction Compensation for the module can be configured as: Disabled, CJC1 only, CJC2 only, or Both CJC's.

Compensation Options	Description	CJC1 Scanning	CJC2 Scanning
No Scan	Module assumes 25°C for any thermocouple compensation.	Disabled	Disabled
Scan Both	Highest thermocouple compensation accuracy. Uses both values in thermocouple compensation as explained below.	Enabled	Enabled
Scan CJC1 only	Lowers the thermocouple compensation accuracy, but can improve scan time for channels 5-8.	Enabled	Disabled
Scan CJC2 only	Lowers the thermocouple compensation accuracy, but can improve scan time for channels 1-4.	Disabled	Enabled

When scanning both CJC inputs, the module subtracts the temperature of CJC2 from the temperature of CJC1. It then multiplies the difference by a specific multiplier for each channel to compensate for the position of the channel on the terminal block.

Channel	Channel Multiplier	Channel	Channel Multiplier
1	0.10	5	0.45
2	0.05	6	0.60
3	0.25	7	0.75
4	0.25	8	0.90

For example: if CJC1 is 30°C and CJC2 is 25°C, the compensated channel 1 terminal block temperature is $30 - [(30-25) * 0.10] = 29.5°C$. The module then adjusts this temperature for the particular thermocouple type to determine the thermoelectric effect (mV) caused by the connection at the terminal block.

13.1.6 Module Data: ALG600

The module reports its input channel data in 20 input words, beginning at its assigned Channel Value Reference Address. Each channel occupies two words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8
+16, 17	CJC1
+18, 19	CJC2

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value are set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

13.1.6.1 Resolution and Update Time

The actual resolution and update time for each input depend on the Range Type and A/D Filter Frequency configured for that channel. At higher Filter Frequencies, channel update time increases while input resolution decreases. The approximate number of bits for each Filter Frequency and Range Type are displayed in the following table.

Filter Frequency	Range Type: Voltage / Current Approximate Number of Bits	Range Type: TC / mV Approximate Number of Bits	Channel Update Time
8 Hz	16	16	127 ms
12 Hz	16	16	87 ms
16 Hz	16	16	67 ms
40 Hz	16	14	27 ms
200 Hz	14	13	13 ms
1000 Hz	11	11	10 ms

13.1.6.2 Isolated Input Groups

This module provides two isolated groups of four input channels each. This allows fast inputs and slower or highly-filtered inputs to be connected to the same module without adversely affecting the update rate of the fast inputs. To take advantage of this feature, up to four inputs requiring fast response should be placed together in one isolated group while slower inputs should be connected to the other isolated group. For example, voltage and current inputs with higher frequency input filter settings should be grouped together on one of the isolated groups while thermocouple, RTD, resistance, or voltage/current inputs with low-frequency input filter settings should be grouped together on the other isolated group.

Each isolated group provides a CJC input. The CJC input is considered a slow-response input and will reduce the update rate for the associated channel group when enabled.

13.1.6.3 Channel Diagnostic Data: ALG600

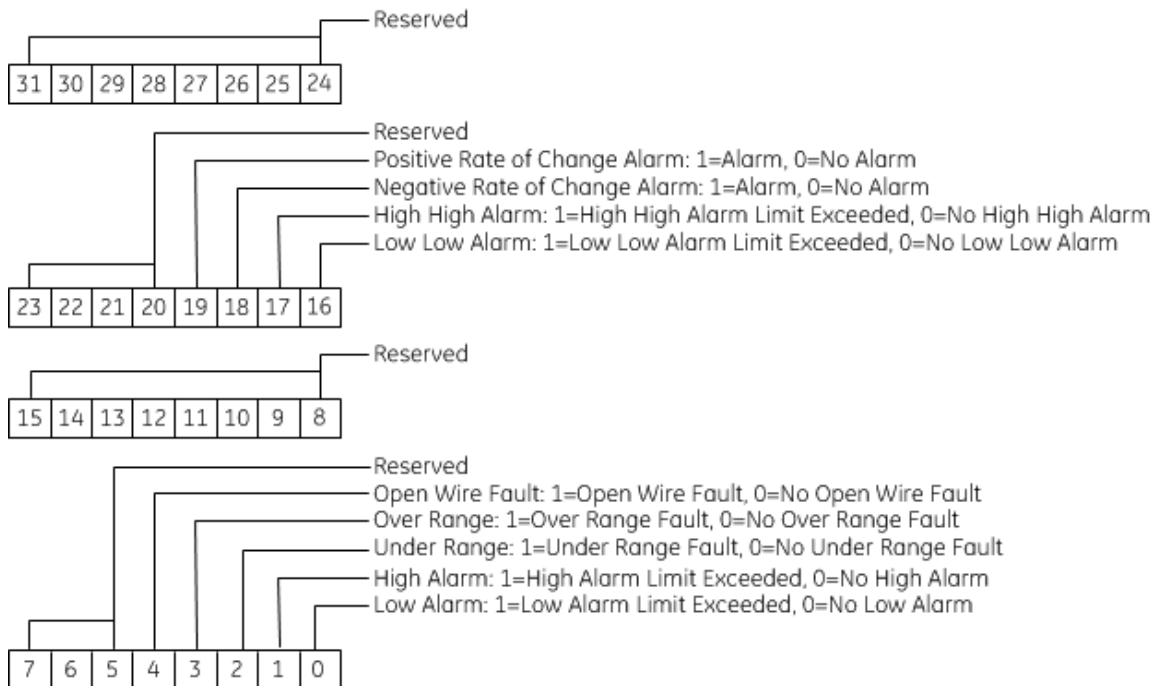
In addition to the 20 words of input data from field devices, the module can be configured to report 320 bits (20 words) of channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for the module. Use of this feature is optional.

The diagnostics data for each channel occupies two words (whether the channel is used or not):

Diagnostic Reference Address	Contains Diagnostics Data for:
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8
+16, 17	CJC1
+18, 19	CJC2

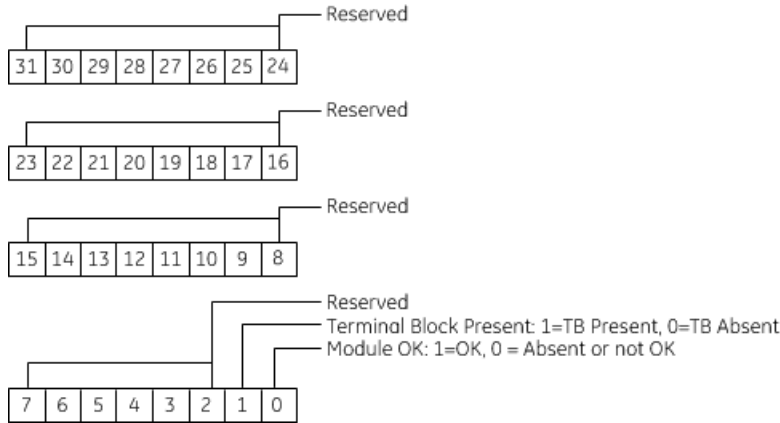
When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



13.1.6.4 Module Status Data: ALG600

The module can also optionally be configured to return two bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data* reference area configured for the module.



13.1.6.5 Terminal Block Detection

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of the module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 1 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

Chapter 14 Thermocouple Input Modules

This chapter describes the following Thermocouple input modules for PACSystems RX3i controllers.

Thermocouple Module Description	Catalog Number	Section
Thermocouple Input Module 6-Channel Isolated	IC695ALG306	14.1
Thermocouple Input Module 12-Channel Isolated	IC695ALG312	14.1
Thermocouple Input Module 12-Channel Isolated (Improved Noise Rejection)	IC695ALG412	14.2

For operating information common to these modules, refer to Section 14.3.

14.1 Thermocouple Input 6-/12-Channel Isolated Modules IC695ALG306 & IC695ALG312

Thermocouple Input module IC695ALG306 provides six isolated differential thermocouple input channels. Thermocouple Input module IC695ALG312 provides twelve isolated differential thermocouple input channels. Each channel can be individually configured for inputs from:

- Thermocouple types: J, K, T, E, R, S, B, N, or C
- Voltage: $\pm 150\text{mV}$ or $\pm 50\text{mV}$

14.1.1 Features

- Completely software-configurable, no module jumpers to set
- Thermocouple Linearization based on ITS-90
- 32-bit IEEE floating point or 16 bit integer (in 32 bit field) input data format selectable per channel
- Temperature units selectable in $^{\circ}\text{C}$ and $^{\circ}\text{F}$
- User Scaling
- Programmable notch filter from 2.3Hz to 28Hz per channel
- Under Range/Over Range alarm detection and reporting by channel
- Alarm dead band for high alarm, low alarm, high-high alarm, and low-low alarm by channel
- Wire-off (open circuit) condition support for all inputs.
- Module fault status reporting (Watchdog, Ram Fail, Flash Fail)
- Module identity and status reporting including LED status indicators
- User offset for all channels including CJC's.
- Supports Cold Junction Compensation on Terminal Block (Cold Junction Sensors sold separately).
- Support field upgrade of firmware application code.
- Optional "CJC Disable" selection
- Reports CJC temperatures as separate channels in Input Data.
- CJC update rate is fixed at 20Hz.
- CJC filter setting fixed with first notch at 10Hz, and 3dB input attenuation at 4.7Hz.
- Terminal Block detection switch
- The module must be located in an RX3i Universal Backplane.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

The module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Terminal Blocks are ordered separately.

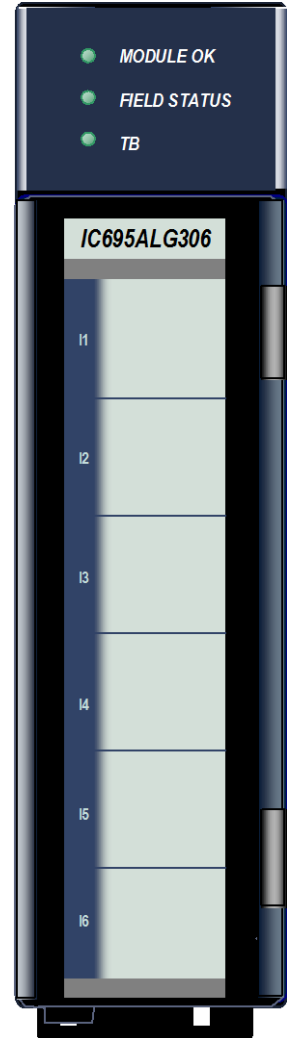


Figure 350: IC695ALG306

14.1.2 Specifications: ALG306 & ALG312

Specification	Description		
Number of Channels	6 / 12 Individually isolated channels		
Resolution	11.5–16 bits (refer to filter table)		
Measuring method selectable per channel	Voltage: $\pm 50\text{mV}$ and $\pm 150\text{mV}$ Thermocouple types: J, K, T, E, R, S, B, N and C		
Integration time for 12 channels	Configurable from 15 msec to 120 msec.		
Voltage Accuracy over temperature span	$\pm 0.1\%$ of voltage span at 25 °C. $\pm 0.25\%$ of span over temperature range.		
Thermocouple Input Types and Ranges	Thermocouple Type	Temperature Range(°C)	
	Type B	+300 to +1820	
	Type C	0 to +2315	
	Type E	-270 to +1000	
	Type J	-210 to +1200	
	Type K	-270 to +1372	
	Type N	-210 to +1300	
	Type R	0 to +1768	
	Type S	0 to +1768	
Type T	-270 to +400		
Voltage Input Ranges	Input Type	Voltage Range	
	-50mV to +50mV	-55.0 mV to +55.0 mV	
	-150mV to +150mV	-155.0 mV to +155.0 mV	
Module temperature accuracy for thermocouple inputs over temperature span (2.3, 4, and 4.7 Hz filters). Does not include cold junction compensation or thermocouple tolerances.	Thermocouple Type & Range	+25°C	0°C to +60°C
	Type J (-180°C to +1200°C)	$\pm 0.6^\circ\text{C}$	$\pm 2.3^\circ\text{C}$
	Type J (-210°C to -180°C)	$\pm 0.8^\circ\text{C}$	$\pm 3.3^\circ\text{C}$
	Type N (-160°C to +1300°C)	$\pm 1.0^\circ\text{C}$	$\pm 4.5^\circ\text{C}$
	Type N (-210°C to -160°C)	$\pm 1.8^\circ\text{C}$	$\pm 8.0^\circ\text{C}$
	Type T (-190°C to +400°C)	$\pm 0.9^\circ\text{C}$	$\pm 4.0^\circ\text{C}$
	Type T (-270°C to -190°C)	$\pm 6.7^\circ\text{C}$	$\pm 18.0^\circ\text{C}$
	Type K (-200°C to +1372°C)	$\pm 1.0^\circ\text{C}$	$\pm 4.0^\circ\text{C}$
	Type K (-270°C to -200°C)	$\pm 9.5^\circ\text{C}$	$\pm 21.0^\circ\text{C}$
	Type E (-200°C to +1000°C)	$\pm 0.6^\circ\text{C}$	$\pm 2.5^\circ\text{C}$
	Type E (-270°C to -200°C)	$\pm 5.3^\circ\text{C}$	$\pm 14.0^\circ\text{C}$
	Type S and R	$\pm 2.8^\circ\text{C}$	$\pm 11.5^\circ\text{C}$
	Type C	$\pm 1.7^\circ\text{C}$	$\pm 7.0^\circ\text{C}$
Type B	$\pm 3.3^\circ\text{C}$	$\pm 20.0^\circ\text{C}$	
Measurement Units	Degrees C or F, or Voltage		
Repeatability	0.05% of voltage span at a constant temperature over a 30-second period		

Specification		Description	
Diagnostics reported to the controller		User configurable for Over Range, Under Range, High and Low Alarm, High-high and Low-low alarm, Open Circuit Detection, Positive and Negative Rate of Change alarm	
Channel-to-channel crosstalk		70 dB minimum	
Common Mode Rejection		2.3 Hz filter, 50/60Hz: 100 dB 4 Hz filter, 50Hz: 100 dB 4.7 Hz filter, 60Hz: 100 dB	
Default or Hold Last State		Configurable per channel for Default to 0 or Hold Last State	
Fault Reporting		Configurable per channel to enable or disable fault reporting for under or over range alarm, open circuit, rate of change alarm.	
Rate of change		Configurable per channel to enable/disable and specify positive and negative rate of change alarms.	
Channel Value Format		Configurable as 16-bit integer (in a 32-bit field) or 32-bit real number.	
Backplane Power Requirements		3.3V IC695ALG306 = 400mA IC695ALG312 = 400mA 5.0V IC695ALG306 = 225mA IC695ALG312 = 425mA	
Input Impedance		Voltage: $\geq 500k\Omega$	
Power Dissipation within the module		IC695ALG306 = 2.5W max IC695ALG312 = 3.5W max	
Isolation Voltage (Field to Backplane and Channel to Channel) (CJC inputs are not isolated from the backplane)		250 V ac Continuous 1500 V ac 1 minute 2550 V dc 1 second	
Normal Mode Noise Rejection		2.3 Hz filter, 50Hz/60Hz: 67dB 4 Hz filter, 50Hz/60Hz: 80dB 24 Hz filter, 50Hz/60Hz: 25dB	
CJC measurement resolution		0.01° (C or F) for temperatures 0-60°C	
CJC Temperature Accuracy		$\pm 1.5^\circ\text{C}$ max (0-60°C) when using IC695ACC600 with an accuracy of $\pm 0.3^\circ\text{C}$	
Module Filter settings, update times, rejection and resolution	Filter Frequency (-3dB frequency)	Update Time (ms)	Normal Mode Rejection at 50/60 Hz
	2.3 Hz	120 (130 max)	67dB at 50/60 Hz
	4 Hz	70 (80 max)	80dB at 50 Hz
	4.7 Hz	60 (70 max)	80dB at 60 Hz
	24 Hz	20 (30 max)	25dB at 50 Hz
	28 Hz	15 (25 max)	25dB at 60 Hz

14.1.2.1 Update Time: ALG306 & ALG312

The channel update times include channel scan time and filter delay time. The update rate of any individual channel is independent of that of any other channel.

Module update time is the time required for the module to sample and convert the input signals, and provide the resulting data values to the processor.

14.1.2.2 Module Resolution: ALG306 & ALG312

The module resolution depends on the input type and the filter chosen. The following table summarizes the effective number of bits of resolution, by filter and input type. It is based on the full-scale range of the input type. If integer format is used, the resolution is limited to 16 bits.

Input Type	Op Range	Filter Setting / Resolution									
		2.3Hz		4.0Hz		4.7Hz		24Hz		28Hz	
		Bits	°C	Bits	°C	Bits	°C	Bits	°C	Bits	°C
J	>-180°C <-180°C	15.0	0.09 0.12	14.8	0.10 0.14	14.7	0.11 0.15	11.6	0.93 1.25	11.0	1.40 1.89
K	>-200°C <-200°C	14.6	0.15 2.37	14.4	0.17 2.72	14.3	0.18 2.92	11.2	1.56 25.0	10.6	2.37 37.9
T	>-190°C <-190°C	13.4	0.13 1.18	13.2	0.15 1.36	13.1	0.16 1.46	10.0	1.39 12.50	9.4	2.11 18.95
E	>-200°C >-200°C	15.0	0.09 1.18	14.8	0.11 1.36	14.7	0.12 1.46	11.6	1.00 12.50	11.0	1.52 18.95
R		13.1	0.47	12.9	0.54	12.8	0.58	9.7	5.00	9.1	7.58
S		13.0	0.47	12.8	0.54	12.7	0.58	9.6	5.00	9.0	7.58
B		12.5	0.79	12.3	0.91	12.2	0.97	9.1	8.33	8.5	12.63
N	>-160°C <-160°C	14.4	0.16 0.30	14.2	0.18 0.34	14.1	0.19 0.36	11.0	1.67 3.13	10.4	2.53 4.74
C		14.9	0.26	14.7	0.30	14.6	0.32	11.5	2.78	10.9	4.21
Voltage			(μV)		(μV)		(μV)		(μV)		(μV)
	±50mV	15.5	2.4	15.3	2.8	15.2	3.0	12.1	25.0	11.5	37.9
	±150mV	17.0	2.4	16.8	2.8	16.7	3.0	13.6	25.0	13.0	37.9

14.2 Thermocouple Input 12-Channel Isolated Module IC695ALG412

The Thermocouple Input module IC695ALG412 provides twelve isolated differential thermocouple input channels. The ALG412 offers a 10dB improvement in noise rejection compared to the ALG312 thermocouple input module.

Each channel can be individually configured for inputs from:

- Thermocouple types: J, K, T, E, R, S, B, N, or C
- Voltage: $\pm 50\text{mV}$

14.2.1 Features

- Completely software-configurable, no module jumpers to set
- Thermocouple Linearization based on ITS-90
- 32-bit IEEE floating point or 16 bit integer (in 32 bit field) input data format selectable per channel
- Temperature units selectable in $^{\circ}\text{C}$ and $^{\circ}\text{F}$
- User Scaling
- Programmable notch filter from 2.3 Hz to 28 Hz per channel
- Under Range/Over Range alarm detection and reporting by channel
- Alarm dead band for high alarm, low alarm, high-high alarm, and low-low alarm by channel
- Wire-off (open circuit) condition support for all inputs.
- Module fault status reporting (Watchdog, Ram Fail, Flash Fail)
- Module identity and status reporting including LED status indicators
- User offset for all channels including CJs.
- Supports Cold Junction Compensation on Terminal Block (Cold Junction Sensors sold separately).
- Support field upgrade of firmware application code.
- Optional CJC enable selections
- Reports CJC temperatures as separate channels in Input Data
- CJC update rate is fixed at 20Hz.
- CJC filter setting fixed with first notch at 60Hz, and 3dB input attenuation at 26.5Hz.
- Terminal Block detection switch.
- Module must be located in an RX3i Universal Backplane.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

These modules can be used with a Box-style (IC694TBB032), Extended Box style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block.

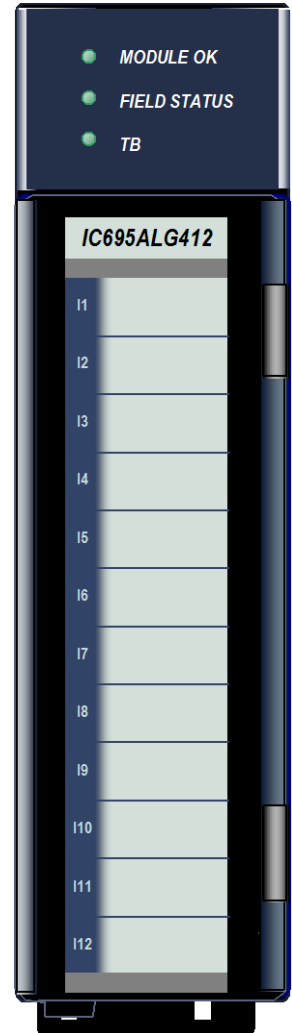


Figure 351: IC695ALG412

14.2.2 Specifications: ALG412

Specification	Description			
Number of Channels	12 Individually isolated channels			
Resolution	11.5–16 bits (refer to filter table)			
Measuring method selectable per channel	Voltage: ±50mV Thermocouple types: J, K, T, E, R, S, B, N and C			
Integration time for 12 channels	Configurable from 15 msec to 120 msec.			
Voltage Accuracy over temperature span	± 0.1% of voltage span at 25 °C. ± 0.25% of span over temperature range.			
Thermocouple Input Types and Ranges	Thermocouple Type	Temperature Range(°C)		
	Type B	+300 to +1820		
	Type C	0 to +2315		
	Type E	-270 to +1000		
	Type J	-210 to +1200		
	Type K	-270 to +1372		
	Type N	-210 to +1300		
	Type R	0 to +1768		
	Type S	0 to +1768		
Type T	-270 to +400			
Voltage Input Ranges	Input Type	Voltage Range		
	-50mV to +50mV	-55.0 mV to +55.0 mV		
Module temperature accuracy for thermocouple inputs over temperature span (2.3, 4, 4.7 and 8Hz filters). Does not include cold junction compensation or thermocouple tolerances.	Thermocouple Type & Range	+25°C	0°C–60°C	40°C–75°C
	Type J (-180°C to +1200°C)	± 0.6°C	± 2.3°C	-
	Type J (-210°C to -180°C)	± 0.8°C	± 3.3°C	-
	Type J (5°C to 45°C)	-	-	± 1.25°C
	Type N (-160°C to +1300°C)	± 1.0°C	± 4.5°C	-
	Type N (-210°C to -160°C)	± 1.8°C	± 8.0°C	-
	Type T (-190°C to +400°C)	± 0.9°C	± 4.0°C	-
	Type T (-270°C to -190°C)	± 6.7°C	± 18.0°C	-
	Type K (-200°C to +1372°C)	± 1.0°C	± 4.0°C	-
	Type K (-270°C to -200°C)	± 9.5°C	± 21.0°C	-
	Type K (5°C to 45°C)	-	-	± 2.5°C
	Type E (-200°C to +1000°C)	± 0.6°C	± 2.5°C	-
	Type E (-270°C to -200°C)	± 5.3°C	± 14.0°C	-
	Type S and R	± 2.8°C	± 11.5°C	-
	Type C	± 1.7°C	± 7.0°C	-
Type B	± 3.3°C	± 20.0°C	-	
Measurement Units	Degrees C or F, or Voltage			
Repeatability	0.05% of voltage span at a constant temperature over a 30-second period			

Specification		Description	
Diagnostics reported to the controller		User configurable for Over Range, Under Range, High and Low Alarm, High-high and Low-low alarm, Open Circuit Detection, Positive and Negative Rate of Change alarm	
Channel-to-channel crosstalk		70 dB minimum	
Common Mode Rejection		All filters, 50/60 Hz: 110 dB	
Default or Hold Last State		Configurable per channel for Default to 0 or Hold Last State	
Fault Reporting		Configurable per channel to enable or disable fault reporting for under or over range alarm, open circuit, rate of change alarm.	
Rate of change		Configurable per channel to enable/disable and specify positive and negative rate of change alarms.	
Channel Value Format		Configurable as 16-bit integer (in a 32-bit field) or 32-bit real number.	
Backplane Power Requirements		3.3V IC695ALG412 = 400mA 5.0V IC695ALG412 = 425mA	
Input Impedance		Voltage: $\geq 500k\Omega$	
Power Dissipation within the module		IC695ALG412 = 3.5W max	
Isolation Voltage (Field to Backplane and Channel to Channel) (CJC inputs are not isolated from the backplane)		250 V ac Continuous 1500 V ac 1 minute 2550 V dc 1 second	
CJC measurement resolution		0.01° (C or F) for temperatures 0-60°C	
CJC Temperature Accuracy		$\pm 1.5^\circ\text{C}$ max (0-60°C) when using IC695ACC600 with an accuracy of $\pm 0.3^\circ\text{C}$	
Module Filter settings, update times, rejection and resolution	Filter Frequency (-3dB frequency)	Update Time (milliseconds)	Normal Mode Noise Rejection at 50/60 Hz
	2.3 Hz	120 (130 max)	80dB at 50/60 Hz
	4.0 Hz	70 (80 max)	80dB at 50 Hz, 65dB at 60 Hz
	4.7 Hz	60 (70 max)	80dB at 50/60 Hz
	8.0 Hz	30 (40ms max)	48dB at 50 Hz; 28dB at 60 Hz
	24.0 Hz	20 (30 max)	38dB at 50 Hz
	28.0 Hz	15 (25 max)	38dB at 60 Hz

14.2.2.1 Update Time: ALG412

The channel update times include channel scan time and filter delay time. The update rate of any individual channel is independent of that of any other channel.

Module update time is the time required for the module to sample and convert the input signals, and provide the resulting data values to the processor.

14.2.2.2 Module Resolution: ALG412

The module resolution depends on the input type and the filter chosen. The following table summarizes the effective number of bits of resolution, by filter and input type. It is based on the full scale range of the input type. If integer format is used, the resolution is limited to 16 bits.

Input Type		Filter Setting / Resolution											
		2.3Hz		4.0Hz		4.7Hz		8Hz		24Hz		28Hz	
	Op Range	Bits	°C	Bits	°C	Bits	°C	Bits	°C	Bits	°C	Bits	°C
J	<-180°C	14.8	0.04	15.0	0.03	14.6	0.05	14.9	0.04	13.9	0.08	13.6	0.09
	>-180°C	14.9	0.04	14.9	0.04	15.2	0.03	15.2	0.03	14.4	0.05	14.0	0.07
K	<-200°C	13.8	0.06	13.5	0.08	13.1	0.10	13.0	0.11	11.7	0.27	10.9	0.48
	>-200°C	14.3	0.04	14.3	0.04	14.5	0.04	14.5	0.04	13.4	0.08	12.7	0.14
T	<-190°C	13.4	0.05	13.4	0.05	13.4	0.05	13.1	0.06	11.7	0.16	11.1	0.25
	>-190°C	15.2	0.01	15.0	0.02	15.0	0.02	15.1	0.02	14.0	0.03	13.5	0.05
E	<-200°C	14.5	0.04	14.4	0.05	14.0	0.06	14.3	0.05	13.4	0.09	12.7	0.15
	>-200°C	15.1	0.03	15.0	0.03	15.0	0.03	15.2	0.03	13.6	0.08	13.0	0.13
R		14.4	0.07	14.6	0.06	14.7	0.06	14.4	0.07	13.1	0.16	12.2	0.31
S		14.3	0.07	14.1	0.08	14.3	0.07	14.3	0.07	13.1	0.16	13.6	0.12
B		13.2	0.14	13.0	0.15	12.8	0.17	12.3	0.24	11.2	0.52	10.9	0.65
N	<-160°C	14.3	0.06	14.3	0.06	14.3	0.06	14.2	0.07	12.9	0.16	12.7	0.18
	>-160°C	14.9	0.04	14.9	0.04	15.0	0.04	14.9	0.04	13.9	0.08	13.3	0.13
C		14.1	0.11	13.9	0.13	14.1	0.11	14.3	0.10	13.2	0.2	12.8	0.26
Voltage ±50mV		17	(µV) 0.63	16.9	(µV) 0.7	16.1	(µV) 1.2	16.1	(µV) 1.2	14.2	(µV) 4.2	14.1	(µV) 4.6

14.3 Thermocouple Module Operation: ALG306, ALG312 & ALG412

The information in this section applies to all three Thermocouple Input Modules: ALG306, ALG312 and ALG412.

14.3.1 LEDs: ALG306, ALG312 & ALG412

The **Module OK** LED indicates module status. The **Field Status** LED indicates whether the external +24Vdc power supply is present and is above the minimum level and whether or not faults are present. All LEDs are powered from the backplane power bus.

LED	Indication	Meaning
Module OK	Off	Module is not receiving power from the RX3i backplane, or the module has failed self-test.
	Solid Green	Module OK and configured.
	Blinking Green, rapidly	Module performing power up sequence.
	Blinking Green, slowly	The module has not received configuration from the CPU. If configuration is not successful, the module will continue to blink in this mode.
Field Status	ON Green	No faults on any enabled channel, Terminal Block is present, and field power is present.
	ON Amber and TB Green	Terminal Block is installed, fault on at least one channel, or field power is not present.
	ON Amber and TB Red	Terminal Block not fully removed, field power still detected.
	OFF and TB Red	Terminal block not present and no field power is detected.
TB	ON Red	Terminal block not present or not fully seated. Refer to above.
	ON Green	Terminal block is present. Refer to above.
	OFF	No backplane power to module.

14.3.2 Field Wiring: ALG306, ALG312, & ALG412

The following table lists wiring connections for the Isolated Thermocouple Input Modules. There are no shield terminals. For the 6-Channel module, IC695ALG306, the channel 7 to 12 connections are not used.

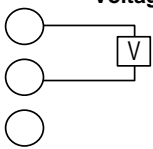
Terminal	Assignment (All Modules)	Channel IN+ Channel IN- 	Assignment (ALG312 / ALG412 only)	Terminal
1	No Connect		No Connect	19
2	CJC1-IN+		No Connect	20
3	CJC1-IN-		No Connect	21
4	CH1+		CH7+	22
5	CH1-		CH7-	23
6	CH2+		CH8+	24
7	CH2-		CH8-	25
8	CH3+		CH9+	26
9	CH3-		CH9-	27
10	CH4+		CH10+	28
11	CH4-		CH10-	29
12	CH5+		CH11+	30
13	CH5-		CH11-	31
14	CH6+		CH12+	32
15	CH6-		CH12-	33
16	CJC2 IN+		No Connect	34
17	CJC2 IN-		No Connect	35
18	No Connect		No Connect	36

Figure 352: Field Wiring ALG306, ALG312, ALG412 (Thermocouple/Voltage)

Depending on the Terminal block type chosen, the wire gauge supported ranges from 0.081...1.5mm² (28...14AWG) solid or stranded wire.

14.3.2.1 Grounding

There are no shield terminals on these modules. For shielding, tie cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided in the ground bar for this purpose. **For optimal performance, thermocouple inputs should be ungrounded, and use shielded cable with the shield(s) grounded at the module end.** If a grounded thermocouple is required, a 0.1uF capacitor from the shield to the ground bar may be necessary on the module end to eliminate ground noise created from grounding both ends of the shield.

14.3.2.2 Installing CJC Sensors

When using thermocouple inputs, the use of CJC sensors is recommended. Installing one CJC sensor will greatly improve the accuracy of thermocouple readings. Installing two CJC sensors will provide the highest thermocouple input accuracy for the module. A CJC sensor compensates for offset voltages introduced into the input signal where the thermocouple wires are connected to the module. A set of two CJC sensors is available as part number IC695ACC600.

Under normal circumstances, adding one or both CJC sensors does not affect the channel or module scan times.

The thermistor end of the CJC sensor must be installed in the CJC1 IN+ or CJC2 IN+ terminal for accurate temperature measurements. The gold pin end of the CJC sensor must be installed in the CJC1 IN- or the CJC2 IN- terminal.

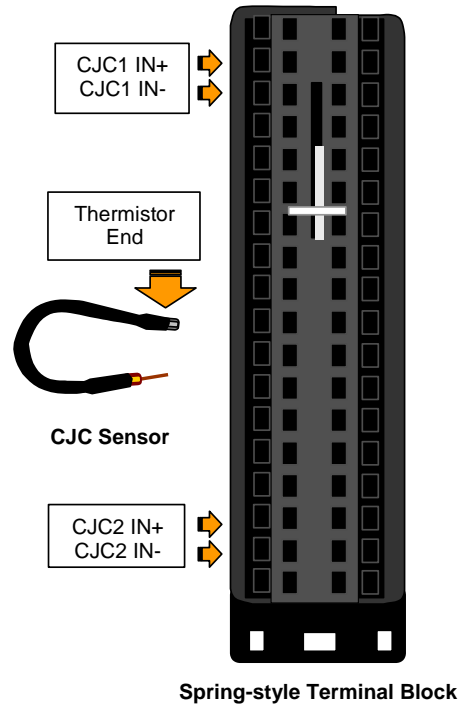


Figure 353: Installing Cold Junction Sensor

Open the Terminal Block contacts fully before installing the CJC sensor. Insert the sensor into the Terminal Block contact, maintaining metal-to-metal contact between the thermistor and the Terminal Block contact. For a Box-style Terminal Block, maintain pressure while screwing down the contact.

Note: To use cold junction compensation, CJC scanning must be enabled in the hardware configuration profile of the module.

For each CJC sensor used, the Open Wire diagnostic should be enabled in the CJC Channel configuration. This diagnostic will allow you to detect improper installation or a failed CJC sensor.

14.3.3 Configuration: ALG306, ALG312 & ALG412

14.3.3.1 Module Parameters: ALG306, ALG312 & ALG412

Parameter	Default	Description
Channel Value Reference Address	%Alxxxxx	Starting address for the input data of the module. This defaults to the next available %AI block.
Channel Value Reference Length	28	The number of words used for the input data of the module. Each channel is mapped to 2 words whether or not the channel is used.
Inputs Default	Force Off	The state of the Channel Value References when the module is not available. Force Off = Channel Values clear to 0. Hold Last State = Channel Values hold their last state.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	0	The number of bit reference bits required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of the module. This defaults to the next available %I block.
Module Status Reference Length	0	The number of bits required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping.
CJC Scan Enable	Disabled	Cold Junction Compensation can be: No Scan, Scan CJC1, Scan CJC2, Scan Both CJCs. Use of these parameters is described below.
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data

CJC Scan Enable

Cold Junction Compensation for the module can be configured as: No Scan, Scan CJC1, Scan CJC2, or Scan Both. The module uses the CJC inputs to compensate for the thermal gradient on the terminal block and adjusts the terminal temperature appropriately.

Compensation Options	Description	CJC1 Scanning	CJC2 Scanning
No Scan	Module assumes 25°C for any thermocouple compensation.	Disabled	Disabled
Scan Both	Highest thermocouple compensation accuracy. Uses both values in thermocouple compensation as explained below.	Enabled	Enabled
Scan CJC1	Module assumes ambient temperature measured by CJC1 for any thermocouple compensation.	Enabled	Disabled
Scan CJC2	Module assumes ambient temperature measured by CJC2 for any thermocouple compensation.	Disabled	Enabled

14.3.3.2 Channel Parameters: ALG306, ALG312 & ALG412

Parameter	Default	Description
Range Type	Disabled	Voltage, Thermocouple, Disabled
Range	Depends on the configured Range Type	For voltage: -50mV to +50mV, -150mV to +150mV
		For Thermocouple: B, C, E, J, K, N, R, S, T
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
Temperature Units (for Thermocouple Range Type only)	Celsius	Celsius, Fahrenheit
High Scale Value (Eng Units)	The defaults for the Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of defaults.	The upper end value, in engineering units, used for scaling. Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default is High A/D Limit of selected range type.
Low Scale Value (Eng Units)		The lower end value, in engineering units, used for scaling. Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		The upper end value, in A/D units, used for scaling. Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		The lower end value, in A/D units, used for scaling. Default is Low A/D Limit of selected range type.

14.3.3.3 Input Scaling: ALG306, ALG312 & ALG412

By default, the module converts a voltage or temperature input over the entire span of its configured Range into a floating point value for the CPU. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the PLC that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example 1

For a voltage input, 60 millivolts equals a speed of 20 feet per second, and 10 millivolts equals 0 feet per second. The relationship in this range is linear. For this example, the input values should represent speed rather than volts. The following channel configuration sets up this scaling:

- High Scale Value (Eng Units) = 20.000
- Low Scale Value (Eng Units) = 0.000
- High Scale Value (A/D Units) = 60.000
- Low Scale Value (A/D Units) = 10.000

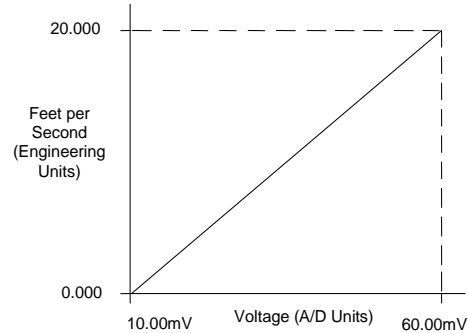


Figure 354: Input Scaling Example 1

For this example, 10.0mV to 60.0mV is the normal voltage range, but the module will attempt to scale the inputs for a voltage that lies outside the range. If a voltage of 100.0mV were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or take other precautions for scaled inputs that are outside the acceptable range or invalid.

Example 2

An existing application uses traditional analog to digital (A/D) count integer values. With scaling and the optional 16-bit integer input option, a channel can be configured to report integer count values. In this example, the application should interpret +150mV as 32000 counts and -150mV as -32000 counts. The following channel configuration will scale a ±150mV input channel to ±32000 counts.

- Channel Value Format = 16 Bit Integer
- High Scale Value (Eng Units) = 32000
- Low Scale Value (Eng Units) = -32000
- High Scale Value (A/D Units) = 150.00
- Low Scale Value (A/D Units) = -150.00

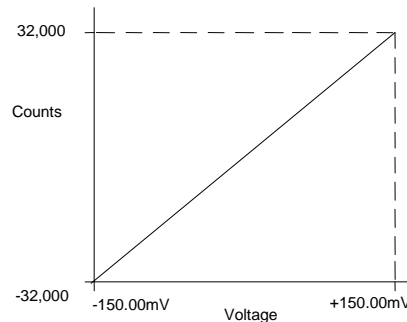


Figure 355: Input Scaling Example 2

Channel Parameters (Continued)

Parameter	Default	Description
Positive Rate of Change Limit (Eng Units/Second)	0.0	Positive rate of change in Engineering Units per Second, above which will trigger a Positive Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units)/Second	0.0	Negative rate of change in Engineering Units per Second, below which will trigger a Negative Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate (Seconds)	0.0	Time from 0 to 300 seconds to wait between comparisons. Default of 0.0 is to check after every input sample.

14.3.3.4 Rate of Change Alarms: ALG306, ALG312 & ALG412

A Thermocouple Input module can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous rate of change sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Unit change between samples is positive, the module compares the results in comparing the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the "Diagnostic Reporting Enable", "Fault Reporting Enable", and "Interrupts Enabled" parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. If the Rate of Change Sampling Rate is 0 or any time period less than the channel update rate, the module compares the Rate of Change for every input sample of the channel.

Channel Parameters (Continued)

Parameter	Default	Description
High-High Alarm (Eng Units)	The defaults for the High-High, High, Low, and Low-Low parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of default values.	Alarms and Deadbands All of the alarm parameters are specified in Engineering Units. To use alarming, the A/D Alarm Mode must also be configured as enabled. High-High Alarm and Low-Low Alarm: When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits. High Alarm and Low Alarm: When the configured value is reached or below (above), a Low (High) Alarm is triggered. High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range. Alarm Deadbands cannot cause the alarm clear to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to 1100.0. A deadband greater than 1100.0 would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
User Offset (Eng Units)	0.000	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filtering	Disabled	Enable or disable Software Integration Time Filter.
Software Filter Integration Time (ms)	0.000	Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms. Default is disabled
A/D Filter Frequency	4.7Hz	All modules: 2, 3, 4, 4.7, 24, 28Hz ALG412 only: 8 Hz

14.3.3.5 Using Alarming: ALG306, ALG312 & ALG412

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Channel Parameters (Continued)

Parameter	Default	Description
<i>Diagnostic Reporting Enable</i> If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area.
<i>Fault Reporting Enable</i> If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table.
<i>Interrupts Enable</i> If Interrupts are enabled, the additional parameters listed below can be used to enable specific types of Interrupts.	Disabled	Interrupts Enable options enable I/O Interrupt trigger when alarm conditions occur.
Low Alarm Enable	Disabled	These parameters enable or disable the individual diagnostics features of a channel. When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature. For example, if Over Range is enabled in the "Diagnostic Reporting Enable" menu, the module will set the Over Range bit in the Diagnostic Reference for the channel. If any of these parameters is disabled, the module does not react to the associated alarm conditions. For example, if Low Alarm Enable is set to Disabled in the "Fault Reporting Enable" menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.
High Alarm Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable	Disabled	
Low-Low Alarm Enable	Disabled	
High-High Alarm Enable	Disabled	
Negative Rate of Change Detection Enable	Disabled	
Positive Rate of Change Detection Enable	Disabled	

14.3.3.6 Using Interrupts: ALG306, ALG312 & ALG412

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of the module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address configured for that channel.

Example:

In this example, the Channel Values Reference Address block is mapped to %AI0001-%AI0020. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AI00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AI0003" as the Trigger.

Note on Using Interrupts

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

14.3.3.7 CJC Parameters

Parameter	Default	Description
Channel Value Format	32-bit floating point	16-bit integer in 32-bit field, or 32-bit floating point
Temperature Units	Celsius	Celsius, Fahrenheit
User Offset (Temperature Units)	0.0	Temperature offset added to CJC values. For Celsius: -25°C to +25°C For Fahrenheit: -45°F to +45°F
Diagnostic Reporting Enable If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	<i>Diagnostic Reporting Enable</i> options are used to enable reference memory reporting of alarms into the Diagnostic Reference area. <i>Fault Reporting Enable</i> options enable fault logging of alarms into the I/O Fault Table.
Fault Reporting Enable If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	<i>Interrupts Enable</i> options enable I/O Interrupt trigger when alarm conditions occur. These parameters enable or disable the individual diagnostics features of a channel. When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature.
Interrupts Enable If Interrupts are enabled, the additional parameters listed below can be used to enable specific types of Interrupts.	Disabled	For example, if Over Range is enabled in the “Diagnostic Reporting Enable” menu, the module will set the Over Range bit in the Diagnostic Reference for the channel.
Under Range Enable	Disabled	If any of these parameters is disabled, the module does not react to the associated alarm conditions. For example, if Low Alarm Enable is set to Disabled in the “Fault Reporting Enable” menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.
Over Range Enable	Disabled	
Open Wire Enable	Disabled	

14.3.4 Module Data: ALG306, ALG312 & ALG412

The module reports its input channel data in its assigned input words, beginning at the configured Channel Value Reference Address. Each channel occupies 2 words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input	Channel Value Reference Address (ALG312 / ALG412 Only)	Contains this Input
+0, 1	Channel 1	+16, 17	Channel 9
+2, 3	Channel 2	+18, 19	Channel 10
+4, 5	Channel 3	+20, 21	Channel 11
+6, 7	Channel 4	+22, 23	Channel 12
+8, 9	Channel 5	+24, 25	CJC1
+10, 11	Channel 6	+26, 27	CJC2
+12, 13	CJC1 (IC695ALG306) Channel 7 (IC695ALG312)		
+14, 15	CJC2 (IC695ALG306) Channel 8 (IC695ALG312)		

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

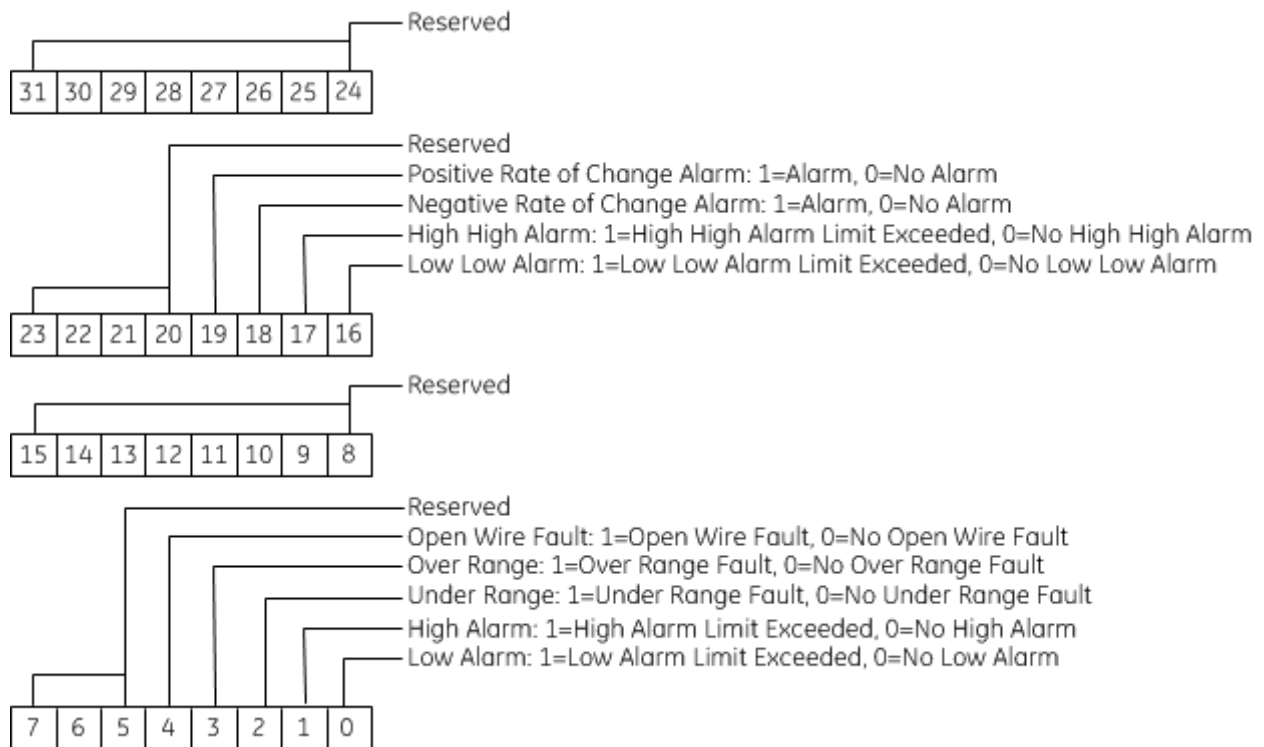
In the 16-bit integer mode, low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16-bits) of the 32-bit value are set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

14.3.4.1 Channel Diagnostic Data: ALG306, ALG312 & ALG412

In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for the module. Use of this feature is optional. The diagnostics data for each channel occupies 2 words (whether the channel is used or not):

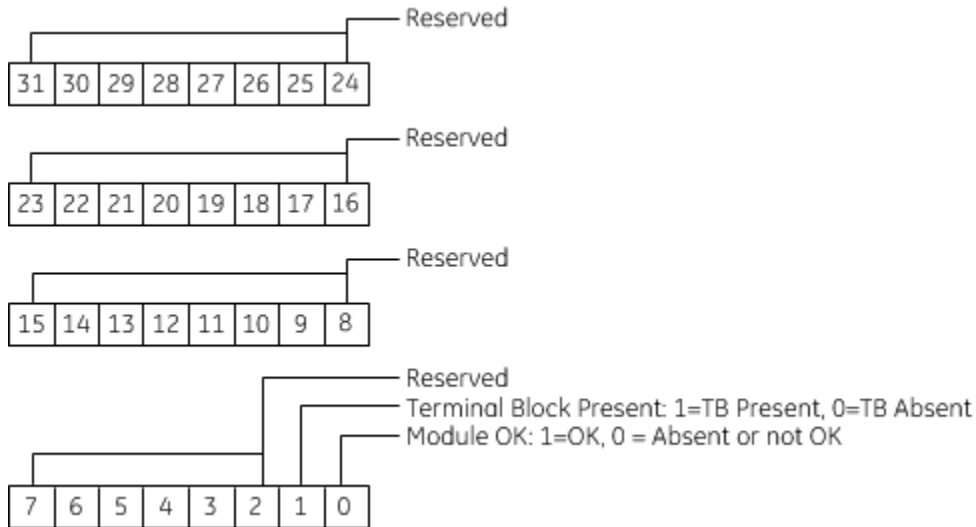
Diagnostic Reference Address	Contains Diagnostic Data for:	Diagnostic Reference Address (ALG312 / ALG412 Only)	Contains Diagnostics Data for:
+0, 1	Channel 1	+16, 17	Channel 9
+2, 3	Channel 2	+18, 19	Channel 10
+4, 5	Channel 3	+20, 21	Channel 11
+6, 7	Channel 4	+22, 23	Channel 12
+8, 9	Channel 5	+24, 25	CJC1
+10, 11	Channel 6	+26, 27	CJC2
+12, 13	CJC1 (ALG306) Channel 7 (ALG312 / ALG412)		
+14, 15	CJC2 (ALG306) Channel 8 (ALG312 / ALG412)		

When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel. For each channel, the format of this data is:



14.3.4.2 Module Status Data: ALG306, ALG312 & ALG412

The module can also optionally be configured to return two bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data* reference area configured for the module.



14.3.4.3 Terminal Block Detection

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of the module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block." If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 1 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

Chapter 15 RTD Input Module

This chapter describes the following RTD input module for PACSystems RX3i controllers.

RTD Module Description	Catalog Number	Section
RTD Input 8-Channel Isolated Module	IC695ALG508	15.1

15.1 RTD Input 8-Channel Isolated Module IC695ALG508

The *RTD Input module* IC695ALG508 provides eight isolated differential RTD input channels. Each channel can be individually configured for:

RTD Inputs:	50, 100, 200, 500, and 1000 Ω Pt 385
	50, 100, 200, 500, and 1000 Ω Pt 391.6
	100, 200, 500, and 1000 Ω Ni 618
	120 Ω Ni 672
	604 Ω NiFe 518
	10, 50 and 100 Ω Cu 426
Resistance Inputs:	250, 500, 1000, 2000, 3000, and 4000 Ω

15.1.1 Features

- Completely software-configurable, no module jumpers to set
 - RTD Linearization based on ITS-90
 - 32-bit IEEE floating point or 16-bit integer (in 32-bit field) input data format selectable per channel
 - Temperature units selectable in $^{\circ}\text{C}$ and $^{\circ}\text{F}$
 - User Scaling
 - Programmable notch filter from 2.3Hz to 28Hz per channel
 - Under range/Over range alarm detection and reporting by channel
 - Alarm dead band for high alarm, low alarm, high-high alarm, and low-low alarm by channel
 - Wire-off (open circuit) condition support for all inputs.
 - Module fault status reporting (Watchdog, Ram Fail, Flash Fail)
 - Module identity and status reporting including LED status indicators
 - Support for 2-, 3-, or 4-wire RTD types for each channel.
 - For Resistance inputs, fixed 2-wire measurement mode.
- Periodic Lead Resistance compensation measurement update enable/disable control for 3-wire RTDs. When enabled, the module will switch to measure the lead resistance once every 100 samples, and will use this value for the next 100 samples.
 - RTD user offset support for all channels
 - Terminal Block detection switch.
 - The module must be located in an RX3i Universal Backplane.
 - Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

This module can be used with a Box-style (IC694TBB032), Extended Box-style (IC694TBB132), Spring-style (IC694TBS032), or Extended Spring-style (IC694TBS132) Terminal Block. Extended terminal blocks provide the extra shroud depth needed for shielded wiring. Terminal Blocks are ordered separately.

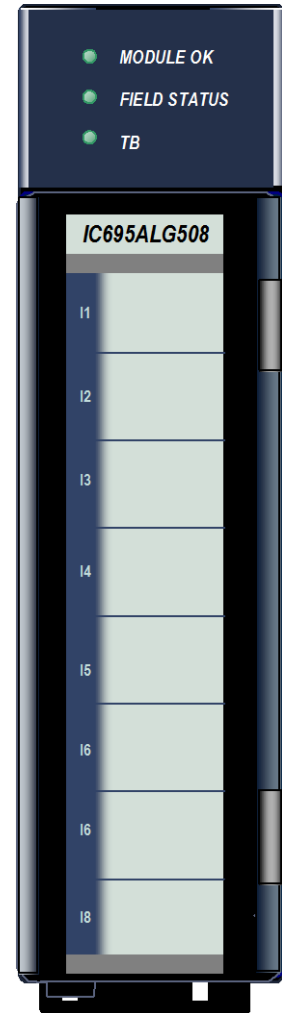


Figure 356: IC695ALG508

15.1.2 LEDs: ALG508

The **Module OK** LED indicates module status. The **Field Status** LED indicates whether the external +24Vdc power supply is present and is above the minimum level and whether or not faults are present. All LEDs are powered from the backplane power bus.

LED	Indication	Meaning
Module OK	Off	Module is defective or no backplane power present
	Solid Green	Module OK and configured
	Blinking Green, rapidly	Module performing power-up sequence
	Blinking Green or Amber, slowly	Module OK but not configured.
Field Status	ON Green	No faults on any enabled channel, Terminal Block is present, and field power is present.
	ON Amber and TB Green	Terminal Block is installed, fault on at least one channel, or field power is not present.
	ON Amber and TB Red	Terminal Block not fully removed, field power still detected.
	OFF and TB Red	Terminal block not present and no field power is detected.
TB	ON Red	Terminal block not present or not fully seated. Refer to above.
	ON Green	Terminal block is present. Refer to above.
	OFF	No backplane power to module.

15.1.3 Specifications: ALG508

Specification	Description		
Number of Channels	8		
Measuring method selectable per channel	RTD/resistance: up to 4k Ω		
RTD input types	<ul style="list-style-type: none"> ▪ 50, 100, 200, 500, and 1000Ω Platinum 385 (IEC751 1983, Amend 2 1995; JISC 1604 1997) ▪ 50, 100, 200, 500, and 1000Ω Platinum 391.6 (JISC 1604: 1981) ▪ 100Ω, 200Ω, 500Ω, and 1000Ω Nickel 618 (DIN 43760 Sept. 1987) ▪ 120Ω Nickel 672 (MINCO Application Aid #18, 5/90 Type Ni) ▪ 10, 50, and 100Ω Copper 426 (SAMA RC21-4-1966) ▪ 604Ω Nickel-Iron 518 		
Resistance Input Types	0-260, 0-525, 0-1050, 0-2100, 0-3150, 0-4200 Ω		
Maximum RTD Lead Resistance	25 Ω each side, for a total of 50 Ω .		
RTD and Resistance Input Types	Input Type	Resistance Range Supported (Ω)	Excitation Current
	Resistance	0-260, 0-525	0.717 mA
		0-1050, 0-2100, 0-3150, 0-4200	0.238 mA
	Platinum 385	50	1.175 mA
		100	0.717 mA
		200, 500, 1000	0.238 mA
	Platinum 391.6	50	1.175 mA
		100, 200	0.717 mA
		500, 1000	0.238mA
	Nickel 672	120	0.717 mA
	Nickel 618	100,200	0.717 mA
		500,1000	0.238 mA
	Nickel-Iron 518	604	0.238 mA
Copper 426	10	1.654 mA	
	50, 100	1.175 mA	
RTD Ranges	RTD Type	Low temp ($^{\circ}$ C)	High temp ($^{\circ}$ C)
	Copper 426	-100.0	+260.0
	Nickel 618	-100.0	+260.0
	Nickel 672	-80.0	+260.0
	Nickel-Iron 518	-100.0	+200.0
	Platinum 385	-200.0	+850.0
	Platinum 391.6	-200.0	+630.0

Specification	Description		
<p>Temperature accuracy for inputs from 4-wire RTDs over temperature span (2.3, 4, and 4.7Hz filters). This data does not include the RTD sensor accuracy, which must be included when determining the overall system performance.</p> <p>Three-wire RTDs have similar accuracies, but depend on the lead resistances being balanced.</p> <p>For 2-wire RTDs, the lead resistance of the RTD contributes to the temperature error.</p> <p>All tolerances double when 24Hz or 28Hz filters are used.</p>	RTD Type	+25°C	0°C to +60°C
	50 Ω Platinum 385	±1.0°C	±1.7°C
	100 Ω Platinum 385	±0.7°C	±1.2°C
	200 Ω Platinum 385	±0.6°C	±1.0°C
	500 Ω Platinum 385	±0.5°C	±0.9°C
	1000 Ω Platinum 385	±0.5°C	±0.9°C
	100 Ω Platinum 391.6	±0.6°C	±1.1°C
	200 Ω Platinum 391.6	±0.5°C	±0.9°C
	500 Ω Platinum 391.6	±0.4°C	±0.8°C
	1000 Ω Platinum 391.6	±0.4°C	±0.8°C
	Nickel 672	±0.3°C	±0.5°C
	Nickel 618	±0.3°C	±0.5°C
	Nickel-Iron 518	±0.4°C	±0.7°C
	10 Ω Copper 426	±1.0°C	±2.4°C
	50 Ω Copper 426	±0.8°C	±1.9°C
100 Ω Copper 426	±0.8°C	±1.9°C	
<p>Temperature accuracy for Resistance inputs</p>	Resistance	+25°C	0°C to +60°C
	250Ω	±0.25 Ω	±0.35 Ω
	500Ω	±0.3 Ω	±0.45 Ω
	1000Ω	±0.5 Ω	±0.8 Ω
	2000Ω	±0.9 Ω	±1.5 Ω
	3000Ω	±1.3 Ω	±2.2 Ω
	4000Ω	±1.7 Ω	±2.9 Ω
Measurement Units	Degrees C or F, or Ω		
Repeatability	0.05% of span at a constant temperature over a 30-second period (0.1% for 10Ω copper, 28Hz filter)		
Diagnostics reported to the controller	User configurable for Over Range, Under Range, High and Low Alarm, High-high and Low-low alarm, Open Circuit Detection, Positive and Negative Rate of change alarm		
Service Requests	Report module firmware revision		
Hot-Swap	Supports removal and replacement under power		
Calibration	Module should be field calibrated via the configuration software.		
Channel-to-channel crosstalk	70 dB minimum at 120mS update rate for all channels		
Common Mode Rejection	2.3Hz filter, 50/60Hz: 100 dB for 4-wire, 90 dB for 2- and 3-wire 4Hz filter, 50/60Hz: 100 dB 4.7Hz filter, 50/60Hz: 100 dB 24Hz, 28Hz filter 50/60Hz: 80 dB		
Default or Hold Last State	For each of fault and disabled modes, the configuration will specify either to default a channel input to 0 or hold the last state of the input		

Specification		Description	
Fault Reporting		The configuration can enable or disable fault reporting for either of under or over range alarm, open circuit, and rate of change alarm.	
Rate of change		For each channel, the configuration can enable/disable and specify positive and negative rate of change alarms.	
Channel Value Format		16-bit integer (in a 32-bit field) or 32-bit real number data for each channel.	
Power Consumption		3.3Vdc: 400mA; 5.0 V dc: 200mA	
Excitation Current		0.238mA-1.654 mA, depending on the input range.	
Power Dissipation		2.5W max	
Isolation Voltage (Field to Backplane and Channel to Channel)		250 V ac Continuous 1500 V ac 1 minute 2550 V dc 1 second	
Normal Mode Noise Rejection		2.3 Hz filter, 50Hz:	67dB
		2.3 Hz filter, 60Hz:	67dB
		4.0 Hz filter, 50Hz:	80dB
		4.7 Hz filter, 60Hz:	80dB
		24 Hz filter, 50Hz:	25dB
		28 Hz filter, 60Hz:	25dB
Filter Settings, Update Times, Rejection, and Resolution	Filter Frequency (-3dB frequency)	Update Time (ms)	Normal Mode Rejection at 50/60 Hz
	2.3 Hz	120 (130 max)	67dB at 50/60 Hz
	4.0 Hz	70 (80 max)	80dB at 50 Hz
	4.7 Hz	60 (70 max)	80dB at 60 Hz
	24.0 Hz	20 (30 max)	25dB at 50 Hz
	28.0 Hz	15 (25 max)	25dB at 60 Hz

15.1.3.1 Update Time: ALG508

The module update time (refer to above) assumes all channels are configured with the same parameters. If channels are configured differently, the module update time corresponds to the slowest channel update time chosen. Update Time is the time required for the module to sample and convert the input signals provide the resulting data values to the processor. The channel times include channel scan time and filter delay time.

15.1.3.2 Module Resolution: ALG508

The module resolution depends on the input type and the filter chosen. The following table summarizes the effective resolution for the module by filter chosen, and input type selected for 2- or 4-wire modes. If 3-wire mode is used, the resolution values shown are reduced by 1.2 bits. If integer format is used, the resolution is limited to 16 bits.

RTD Type	Filter Setting / Resolution							
	2.3Hz		4.0 Hz and 4.7 Hz		24 Hz		28 Hz	
	Bits ⁸⁰	m°C	Bits ⁸⁰	m°C	Bits ⁸⁰	m°C	Bits ⁸⁰	m°C
Platinum 385	16.5	13.2	16.3	15.2	13.4	113	12.8	172
Platinum 391.6	16.5	10.6	16.3	12.2	13.4	91.0	12.8	138
Nickel 672	16.5	5.2	16.3	6.0	13.4	44.7	12.8	67.8
Nickel 618	16.2	7.3	16.0	8.3	13.1	56.2	12.5	94.3
Nickel-Iron 518	16.5	5.7	16.3	6.5	13.4	48.6	12.8	73.7
Copper 426								
10 Ω	13.6	29.0	13.4	33.3	10.5	249	9.9	377
50 Ω	15.6	7.8	15.4	8.9	12.5	66.5	11.9	101
100 Ω	16.2	5.2	16.0	5.9	13.1	44.3	12.5	67.2
Resistance	Bits	mΩ	Bits	mΩ	Bits	mΩ	Bits	mΩ
250	16.6	2.6	16.4	3.0	13.5	22.4	12.9	34.0
500	16.6	5.3	16.4	6.1	13.5	45.3	12.9	68.7
1000	16.6	10.6	16.4	12.1	13.5	90.6	12.9	137
2000	17.0	16.0	16.8	18.4	13.9	137	13.3	208
3000	16.6	31.7	16.4	36.4	13.5	272	12.9	412
4000	17.0	32.0	16.8	36.8	13.9	275	13.3	416

⁸⁰ The effective number of bits is based on the full-scale range of the input type.

15.1.4 Field Wiring: ALG508

Terminal	Assignment	Assignment	Terminal
1	No Connect	No Connect	19
2	RTD 1 Exc	RTD 5 Exc	20
3	RTD 1 In +	RTD 5 In +	21
4	RTD 1 In -	RTD 5 In -	22
5	RTD 1 Rtn	RTD 5 Rtn	23
6	RTD 2 Exc	RTD 6 Exc	24
7	RTD 2 In +	RTD 6 In +	25
8	RTD 2 In -	RTD 6 In -	26
9	RTD 2 Rtn	RTD 6 Rtn	27
10	RTD 3 Exc	RTD 7 Exc	28
11	RTD 3 In +	RTD 7 In +	29
12	RTD 3 In -	RTD 7 In -	30
13	RTD 3 Rtn	RTD 7 Rtn	31
14	RTD 4 Exc	RTD 8 Exc	32
15	RTD 4 In +	RTD 8 In +	33
16	RTD 4 In -	RTD 8 In -	34
17	RTD 4 Rtn	RTD 8 Rtn	35
18	No Connect	No Connect	36

The pinout is set up for two, three or four-wire RTD sensors. No additional jumper or shorting wires are needed for wiring in any of the three modes. Connect the RTD sensor as shown:

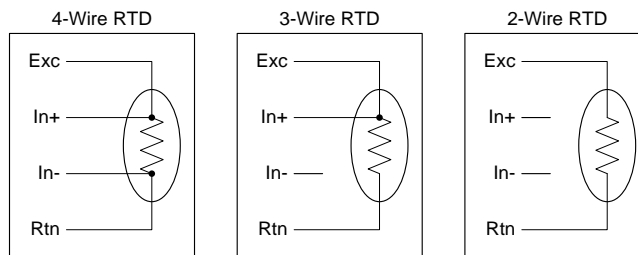


Figure 357: Field Wiring for RTDs ALG508

Depending on the Terminal block type chosen, the wire gauge supported ranges from .081...1.5mm² (28...14AWG) solid or stranded wire.

15.1.4.1 Grounding

There are no shield terminals on these modules. For shielding, tie cable shields to the ground bar along the bottom of the backplane. M3 tapped holes are provided in the ground bar for this purpose. **For optimal performance, RTD inputs should be ungrounded, and use shielded cable with the shield(s) grounded at the module end.** If a grounded thermocouple is required, a 0.1uF capacitor from the shield to the ground bar may be necessary on the module end to eliminate ground noise created from grounding both ends of the shield.

15.1.5 Configuration: ALG508

15.1.5.1 Module Parameters

Parameter	Default	Description
Channel Value Reference Address	%Alxxxxx	Starting address for the input data of this module. This defaults to the next available %AI block.
Inputs Default	Force Off	In the event of module failure or removal, this parameter specifies the state of the Channel Value References. Force Off = Channel Values clear to 0. Hold Last State = Channel Values hold their last state.
Channel Value Reference Length		The number of words used for the input data of this module.
Diagnostic Reference Address	%lxxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	0	The number of bit reference bits required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping.
Module Status Reference Address	%lxxxxx	Starting address for the status data of this module. This defaults to the next available %I block.
Module Status Reference Length	0	The number of bits required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping.
Channel Faults w/o Terminal Block	Disabled	Enabled / Disabled: Controls whether channel faults and configured alarm responses will be generated after a Terminal Block removal. The default setting of Disabled means channel faults and alarms are suppressed when the Terminal Block is removed. This parameter does not affect module faults including the Terminal Block loss/add fault generation.
I/O Scan Set	1	Assigns the module I/O status data to a scan set defined in the CPU configuration. Determines how often the RX3i polls the data

15.1.5.2 Channel Parameters

Parameter	Default	Description
Range Type	Disabled	RTD, Resistance, Disabled
Range		For resistance: 0-250, 0-500, 0-1000, 0-2000, 0-3000, 0-4000 Ω For RTD: 50, 100, 200, 500, and 1000 Ω Pt 385 50, 100, 200, 500, and 1000 Ω Pt 391.6 100, 200, 500, and 1000 Ω Ni 618 120 Ω Ni 672 604 Ω NiFe 518 10, 50 and 100 Ω Cu 426
Channel Value Format	32-bit Floating Point	16-bit integer or 32-bit floating point
RTD	RTD 2 Wire	(for RTD Range Type only) RTD 2, 3 or 4 Wire
RTD Lead Resistance Compensation	Enabled	(for RTD Range Type only) Enabled, Disabled
Temperature Units	Celsius	Celsius, Fahrenheit
High Scale Value (Eng Units)	The defaults for the Scaling parameters depend on the configured Range Type and Range. Each Range and Range Type have a different set of defaults.	Note: Scaling is disabled if both High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units. Default is High A/D Limit of selected range type.
Low Scale Value (Eng Units)		Default is Low A/D Limit of selected range type. Must be lower than the high scaling value.
High Scale Value (A/D Units)		Default is High A/D Limit of selected range type. Must be greater than the low scaling value.
Low Scale Value (A/D Units)		Default is Low A/D Limit of selected range type.

Input Scaling: ALG508

By default, the module converts a voltage or temperature input over the entire span of its configured Range into a floating-point value for the CPU. By modifying one or more of the four channel scaling parameters (Low/High Scale Value parameters) from their defaults, the scaled Engineering Unit range can be changed for a specific application. Scaling can provide inputs to the PLC that are already converted to their physical meaning, or convert input values into a range that is easier for the application to interpret. Scaling is always linear and inverse scaling is possible. All alarm values apply to the scaled Engineering Units value, not to the A/D input value.

The scaling parameters only set up the linear relationship between two sets of corresponding values. They do not have to be the limits of the input.

Example

For a resistance input, 600Ω corresponds to a weight of 20 kg, and 100Ω corresponds to a weight of 0 kg. The relationship in this range is linear. For this example, the input values should represent weight rather than resistance measured in ohms. The following channel configuration sets up this scaling:

High Scale Value (Eng Units) = 20.000

Low Scale Value (Eng Units) = 0.000

High Scale Value (A/D Units) = 600.0

Low Scale Value (A/D Units) = 100.0

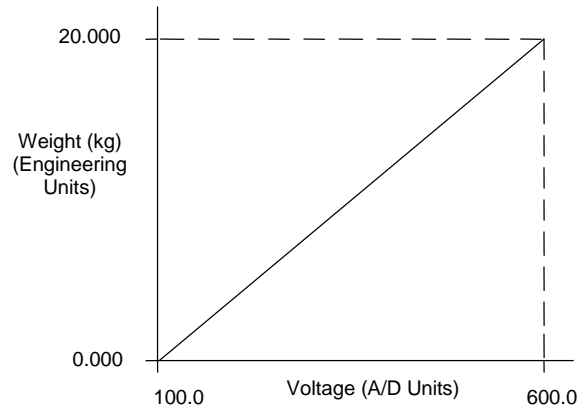


Figure 358: Input Scaling Example ALG508

For this example, 100Ω to 600Ω is the normal resistance range, but the module will attempt to scale the inputs for a resistance that lies outside the range. If a resistance of 1000Ω were input to the channel, the module would return a scaled channel value of 36.000. The application should use alarms or take other precautions for scaled inputs that are outside the acceptable range or invalid.

Channel Parameters (Continued)

Parameter	Default	Description
Positive Rate of Change Limit (Eng Units)	0.000	Rate of change in Engineering Units per Second that will trigger a Positive Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Negative Rate of Change Limit (Eng Units)	0.000	Rate of change in Engineering Units per Second that will trigger a Negative Rate of Change alarm. Default is disabled. Used with "Rate of Change Sampling Rate" parameter.
Rate of Change Sampling Rate	0.000	Time from 0 to 300 seconds to wait between comparisons. Default of 0.0 is to check after every input sample.

Rate of Change Alarms: ALG508

An RTD Input module can detect both Negative Rate of Change and Positive Rate of Change in Engineering Units per Second. When either of the Rate of Change parameters is configured to be non-zero, the module takes the difference in Engineering Units between the previous rate of change sample and the current sample, then divides by the elapsed time between samples.

If the Engineering Unit change from the previous sample to current sample is negative, the module compares the rate change with the Negative Rate of Change parameter.

If the Engineering Unit change between samples is positive, the module compares the results in comparing the rate change with the Positive Rate of Change parameter value.

In either case, if the rate of change is greater than the configured rate, a rate of change alarm occurs. The actions taken by the module following the alarm depend on the enabled rate of change actions that have been set up in the "Diagnostic Reporting Enable", "Fault Reporting Enable", and "Interrupts Enabled" parameters.

The Rate of Change Sampling Rate parameter determines how frequently the module compares the Rate of Change. If the Rate of Change Sampling Rate is 0 or any time period less than the channel update rate, the module compares the Rate of Change for every input sample of the channel.

Channel Parameters (Continued)

Parameter	Default	Description
High-High Alarm (Eng Units)	The defaults for the High-High, High, Low, and Low-Low parameters depend on the configured Range Type and Range. Each Range and Range Type has a different set of default values.	Alarms and Deadbands All of the alarm parameters are specified in Engineering Units. To use alarming, the A/D Alarm Mode must also be configured as enabled. High-High Alarm and Low-Low Alarm: When the configured value is reached or passed, a Low-Low Alarm or High-High Alarm is triggered. The configured values must be lower than/higher than the corresponding low/high alarm limits. High Alarm and Low Alarm: When the configured value is reached or below (above), a Low (High) Alarm is triggered. High and Low Alarm Deadbands: A range in Engineering Units above the alarm condition (low deadband) or below the alarm condition (high deadband) where the alarm status bit can remain set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range. Alarm Deadbands should not cause the alarm clear to be outside the Engineering Unit User Limits range. For example, if the engineering unit range for a channel is -1000.0 to +1000.0 and a High Alarm is set at +100.0, the High Alarm Deadband value range is 0.0 to less than 1100.0. A deadband of 1100.0 or more would put the High Alarm clear condition below -1000.0 units making the alarm impossible to clear within the limits.
High Alarm (Eng Units)		
Low Alarm (Eng Units)		
Low-Low Alarm (Eng Units)		
High-High Alarm Deadband (Eng Units)		
High Alarm Deadband (Eng Units)		
Low Alarm Deadband (Eng Units)		
User Offset	0.000	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking.
Software Filter Integration Time in milliseconds.	0.000	Specifies the amount of time in milliseconds for the software filter to reach 63.2% of the input value. A value of 0 indicates software filter is disabled. A value of 100 indicates data will achieve 63.2% of its value in 100ms. Default is disabled
A/D Filter Frequency		2, 3, 4, 4.7, 24, 28Hz

Channel Parameters (Continued)

Parameter	Default	Description
Diagnostic Reporting Enable If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	Diagnostic Reporting Enable options are used to enable reference memory reporting of alarms into the Diagnostic Reference area.
Fault Reporting Enable If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	Fault Reporting Enable options enable fault logging of alarms into the I/O Fault Table.
Interrupts Enable If Interrupts are enabled, the additional parameters listed below can be used to enable specific types of Interrupts.	Disabled	Interrupts Enable options enable I/O Interrupt trigger when alarm conditions occur.
Low Alarm Enable	Disabled	These parameters enable or disable the individual diagnostics features of a channel. When any of these parameters is enabled, the module uses associated parameters to perform the enabled feature. For example, if Over Range is enabled in the "Diagnostic Reporting Enable" menu, the module will set the Over Range bit in the Diagnostic Reference for the channel. If any of these parameters is disabled, the module does not react to the associated alarm conditions. For example, if Low Alarm Enable is set to Disabled in the "Fault Reporting Enable" menu, the Low Alarm fault is not logged in the I/O Fault Table when Low Alarm is detected on the channel.
High Alarm Enable	Disabled	
Under Range Enable	Disabled	
Over Range Enable	Disabled	
Open Wire Enable	Disabled	
Calibration Fault Enable	Disabled	
Low-Low Alarm Enable	Disabled	
High-High Alarm Enable	Disabled	
Negative Rate of Change Detection Enable	Disabled	
Positive Rate of Change Detection Enable	Disabled	

Using Alarming: ALG508

The Diagnostic Reporting Enable, Fault Reporting Enable, and Interrupt Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel.

- If Diagnostic Reporting is enabled, the module reports channel alarms in reference memory at the Diagnostic Reference address configured for that channel.
- If Fault Reporting is enabled, the module logs a fault log in the I/O Fault table for each occurrence of a channel alarm.
- If Interrupts are enabled, an alarm can trigger execution of an Interrupt Block in the application program, as explained below.

Using Interrupts: ALG508

To properly configure an I/O Interrupt, the Interrupt enable bit or bits must be set in the configuration profile of this module. In addition, the program block that should be executed in response to the channel interrupt must be mapped to the reference address configured for that channel.

Example:

In this example, the Channel Values Reference Address block is mapped to %AI0001-%AI0020. An I/O Interrupt block should be triggered if a High Alarm condition occurs on channel 2.

- Configure the High-Alarm condition.
- Set the High-Alarm Interrupt Enable flag for Channel 2 in the module configuration.

The reference address for Channel 2 corresponds to %AI00003 (2 Words per channel), so the interrupt program block Scheduling properties should be set for the "I/O Interrupt" Type and "%AI0003" as the Trigger.

Note on Using Interrupts

These modules have separate enable/disable options for Diagnostic Reporting and Interrupts. Normally, disabling a diagnostic (such as Low/High Alarm or Over/Under range) in the configuration means that its diagnostic bit is never set. However, if interrupts are enabled for a condition and that interrupt occurs, the diagnostic bit for that condition is also set during the I/O Interrupt block logic execution. The next PLC input scan always clears this interrupt status bit back to 0, because Diagnostic Reporting has it disabled.

15.1.6 Module Input Data: ALG508

The module reports its input channel data in its assigned input words, beginning at the configured Channel Value Reference Address. Each channel occupies two words (whether the channel is used or not):

Channel Value Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

Depending on its configured Channel Value Format, each enabled channel reports a 32-bit floating point or 16-bit integer value to the CPU.

In the 16-bit integer mode, low word of the 32-bit channel data area contains the 16-bit integer channel value. The high word (upper 16 bits) of the 32-bit value are set with the sign extension of the 16-bit integer. This sign-extended upper word allows the 16-bit integer to be read as a 32-bit integer type in logic without losing the sign of the integer. If the 16-bit integer result is negative, the upper word in the 32-bit channel data has the value 0xFFFF. If the 16-bit integer result is positive, the upper word is 0x0000.

15.1.6.1 Channel Diagnostic Data: ALG508

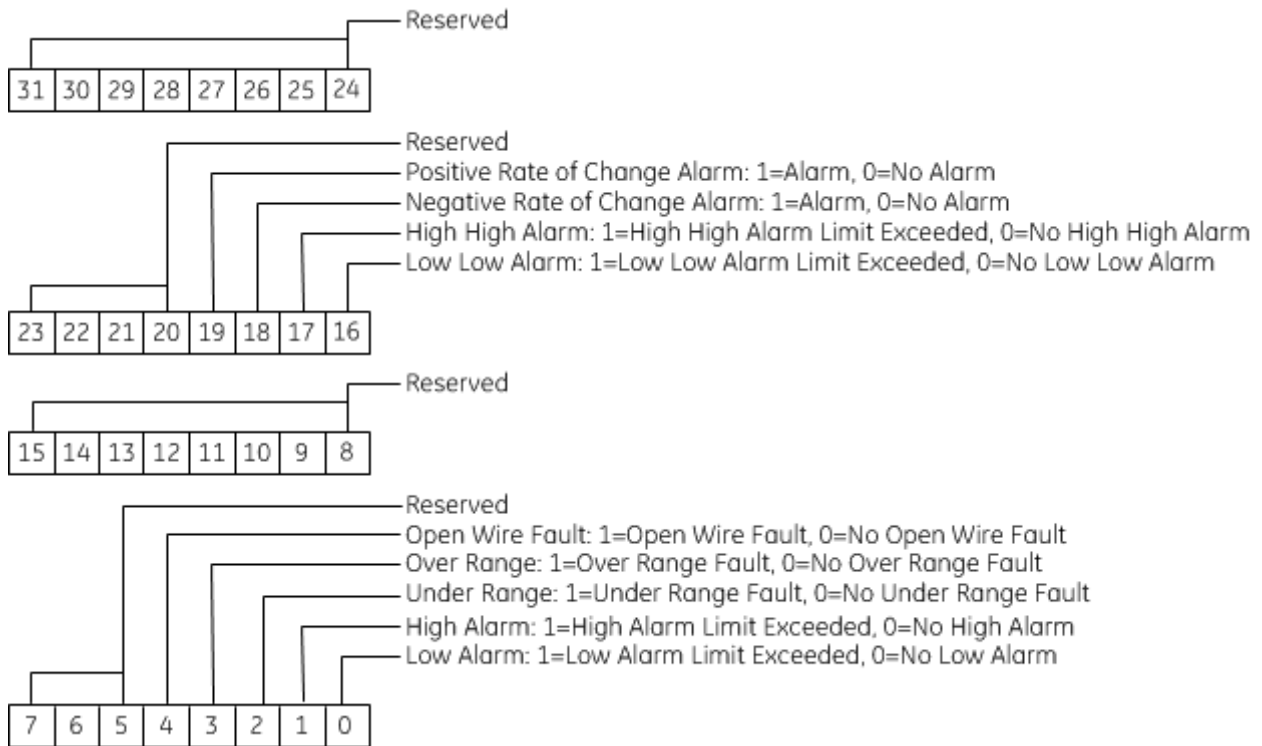
In addition to the input data from field devices, the module can be configured to report channel diagnostics status data to the CPU. The CPU stores this data at the *Diagnostic Reference Address* configured for this module. Use of this feature is optional.

The diagnostics data for each channel occupies two words (whether the channel is used or not):

Diagnostic Reference Address	Contains this Input
+0, 1	Channel 1
+2, 3	Channel 2
+4, 5	Channel 3
+6, 7	Channel 4
+8, 9	Channel 5
+10, 11	Channel 6
+12, 13	Channel 7
+14, 15	Channel 8

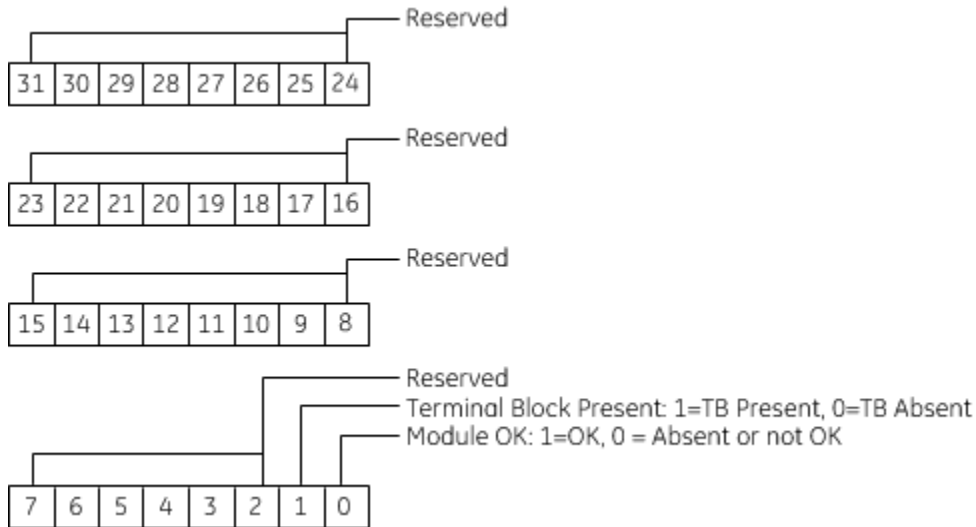
When a diagnostic bit equals 1, the alarm or fault condition is present on the channel. When a bit equals 0 the alarm or fault condition is either not present or detection is not enabled in the configuration for that channel.

For each channel, the format of this data is:



15.1.6.2 Module Status Data: ALG508

The module can also optionally be configured to return two bits of module status data to the CPU. The CPU stores this data in the 32-bit *Module Status Data* reference area configured for this module.



15.1.6.3 Terminal Block Detection ALG508

The module automatically checks for the presence of a Terminal Block.

The TB LED indicates the state of the terminal block of this module. It is green when the Terminal Block is present or red if it is not.

Faults are automatically logged in the CPU I/O Fault table when the terminal block is inserted or removed from a configured module in the system. The fault type is Field Fault and the fault description indicates whether the fault is a "Loss of terminal block" or an "Addition of terminal block". If a Terminal Block is not present while a configuration is being stored, a "Loss of terminal block" fault is logged.

Bit 1 of the Module Status Reference indicates the status of the terminal block. To enable Module Status reporting, the Module Status Reference must be configured. During operation, the PLC must be in an I/O Enabled mode for the current Module Status to be scanned and updated in reference memory.

Chapter 16 Special Purpose Modules

This chapter describes special-purpose modules for PACSystems RX3i controllers:

Module Description	Catalog Number	Section
RX3i I/O Link Interface Module	IC694BEM320	16.1
RX3i I/O Link Master Module	IC694BEM321	16.2
RX3i Genius Bus Controller Module	IC694BEM331	16.3
RX3i Serial Communications Module, 2 Ports	IC695CMM002	16.4
RX3i Serial Communications Module, 4 Ports	IC695CMM004	16.4
RX3i Control Memory Xchange Module	IC695CMX128	16.5
RX3i Redundancy Memory Xchange Module, Multi-mode fiber	IC695RMX128	16.6
RX3i Redundancy Memory Xchange Module, Single-mode fiber	IC695RMX228	16.6
RX3i DeviceNet Master Module	IC694DNM200	16.7
RX3i Motion Mate Module	IC694DSM314	16.8
RX3i Motion Controller Module	IC694DSM324	16.9
RX3i PACMotion Multi-Axis Motion Controller	IC695PMM335	16.10
RX3i IEC 61850 Ethernet Communication Module	IC695ECM850	16.11
RX3i Ethernet Transmitter Module	IC695ETM001	16.12
RX3i DNP3 Outstation Module	IC695EDS001	16.13
RX3i Ethernet 104 Server Module	IC695EIS001	16.14
RX3i Ethernet Network Interface Unit	IC695NIU001	16.15
RX3i Ethernet Network Interface Unit	IC695NIU001 <i>PLUS</i>	16.16
RX3i Profibus Master Module	IC695PBM300	16.17
RX3i Profibus Slave Module	IC695PBS301	16.18
RX3i PROFINET Controller Module	IC695PNC001	16.19
RX3i PROFINET Scanner Module	IC695PNS001	16.20
RX3i CEP Carrier	IC695CEP001	16.21
RX3i CEP Expansion Carrier	IC694CEE001	16.21
RX3i Genius Communications Gateway	IC695GCG001	16.22
RX3i Pressure Transducer Module	IC695PRS015	16.23

16.1 RX3i I/O Link Interface Module: IC694BEM320

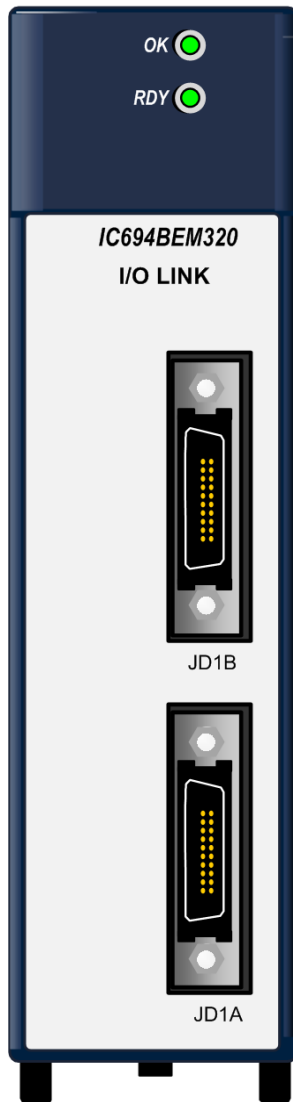


Figure 359: IC694BEM320

The RX3i I/O Link Interface Module, IC694BEM320, operates as a slave on an I/O Link network. It can exchange either 32 or 64 inputs and outputs with the master. Typical masters on the I/O Link include all modern CNCs and Power Mates, PACSystems controllers and Series 90 PLCs equipped with an I/O Link Master Module.

An I/O Link Interface Module occupies one module slot in an RX3i backplane. It can be installed in any available backplane slot.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

The maximum number of I/O Link Interface Modules that can be installed in the backplane depends on the power that is available from the power supply. To determine the exact number of modules allowed in your system, refer to the information on power supplies in Chapter 3.

Usually, when there are multiple I/O Link Interface Modules in the same RX3i system, they are on separate I/O Links. However, it is possible to have more than one I/O Link Interface Module in the system connected to the same link, if that suits the needs of the application.

16.1.1 Specifications

Module type	RX3i I/O Link Interface Module, providing I/O Link communications with I/O Link Master.	
LEDs	OK, RDY	
I/O Points	32 or 64, jumper selectable	
+5V current	without Optical Adapter connected:	205mA
	with Optical Adapter:	405 mA
User Manual	RX3i I/O Link Interface Modules User's Manual, GFK-2358	

16.1.2 I/O Size Selection: BEM320

The front cover of the module is removable (Figure 360).

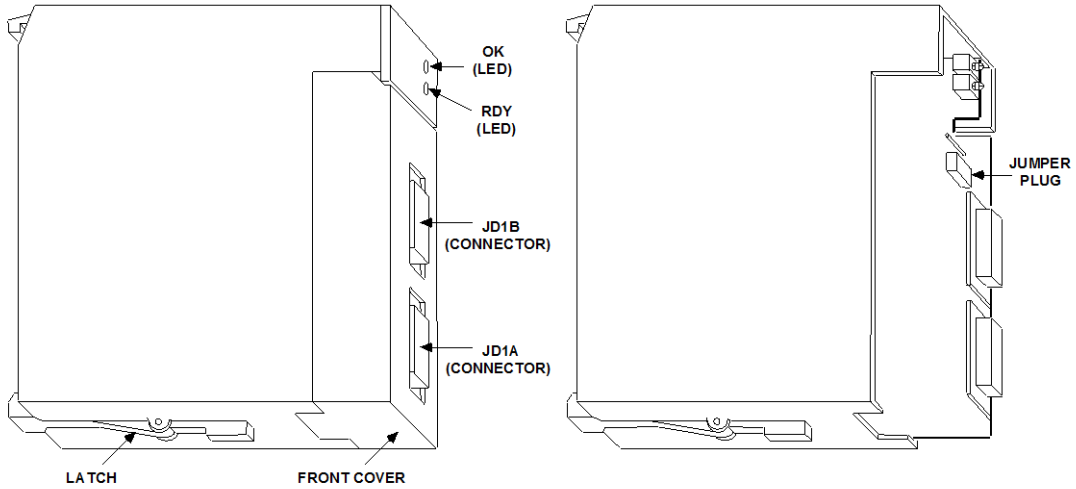
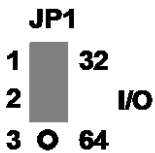


Figure 360: Removable Cover BEM320



A jumper plug (Figure 361) inside the front cover is used to set the module up as a 32-point or 64-point I/O module. The factory-shipped default is 32.

- To select 32 inputs and 32 outputs, apply the jumper to pins 1 & 2.
- To select 64 inputs and 64 outputs, apply the jumper to pins 2 & 3.

Figure 361: Module Size Selection (JP1) BEM320

16.1.3 LEDs: BEM320

The module has two LEDs that show its operating, and communications status.

- OK: Indicates the operating status of the module.
- RDY: Indicates the communications status of the module.

After power-up, the OK LED should remain ON. The RDY LED turns ON after the I/O Link master has established communications with the module.

16.1.4 Serial Ports: BEM320

The front of the module has two 20-pin connectors that are used to attach the I/O Link cable. One connector is for the cable to the previous device on the link--either the master or another slave. The other connector is for the cable to the next slave on the link, if there is one. Refer to the *RX3i I/O Link Modules User's Manual*, GFK-2358 for more information. Signal levels are RS422/485 compatible.

16.2 RX3i I/O Link Master Module: IC694BEM321

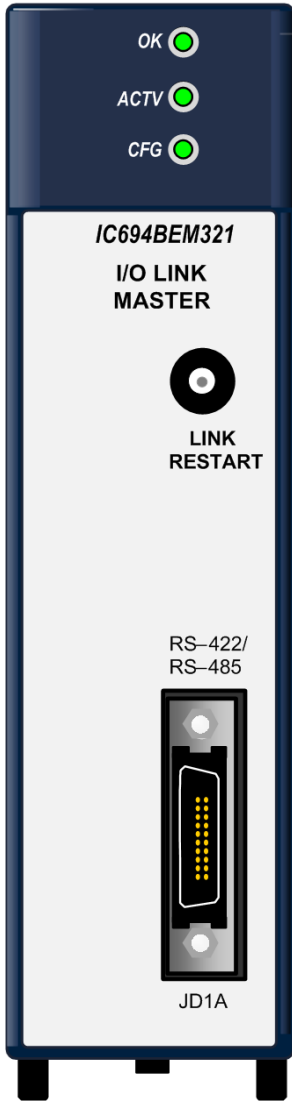


Figure 362: IC694BEM321

The RX3i I/O Link Master module (IC694BEM321) allows a PACSystems RX3i controller to act as a master on a proprietary I/O Link. The master can receive 1024 discrete inputs from slaves, and send up to 1024 discrete outputs. Typical items running under the control of an I/O Link Master can include clusters of I/O (such as I/O Model A and Connector Panel I/O), PACSystems and Series 90 PLCs with I/O Link Interface (slave) modules, and Operator Panels that are I/O Link-compatible.

An I/O Link Master Module can be installed in any available slot in any RX3i backplane. For best performance, it should be installed in the Main Backplane or in an Expansion Backplane. The maximum number of I/O Link Master Modules that can be installed in the backplane depends on the power that is available from the power supply. To determine the exact number of modules allowed in your system, refer to the information on power supplies in Chapter 3.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

If there are multiple I/O Link Master Modules in the same RX3i system, they must be on separate I/O Links.

16.2.1 Specifications: BEM321

Module type	PACSystems RX3i controller module, providing I/O Link communications with up to 16 I/O Link slaves.	
I/O Points	Up to 1024 inputs and 1024 outputs	
+5Vdc current required	without Optical Adapter connected:	415mA
	with Optical Adapter:	615mA
Host CPUs	<ul style="list-style-type: none"> ▪ PACSystems RX3i CPUs ▪ Series 90-30 CPUs (models 311, 313, 321, 323, 331, and 341): release 4.4 or later, and all versions of the CPU models 350, 351, 352, 360, 363, and 364 ▪ Series 90-30 Hand-held Programmer (HHP) 	
User Manual	RX3i I/O Link Interface Modules User's Manual, GFK-2358	

16.2.2 LEDs: BEM321

The module has three LEDs that show its operating and communications status.

OK	CFG	ACTV	Meaning
off	off	off	No power to module, or power-up in progress
on	off	off	Module powered up but not configured
on	on	off	Module powered up and configured with minimum configuration (input status reference assigned and output status reference assigned), but link is not yet active, or has been activated but has gone down
on	on	on	Normal operation with active link

After power-up, the OK LED should stay ON. The CFG LED goes on after the CPU supplies the module configuration. The ACTV LED goes on when link communications have been established.

16.2.3 Restart Pushbutton: BEM321

The LINK RESTART pushbutton can be used to restart the operation of the link if a failure occurs.

Note

Pushing the LINK RESTART button while the link is operating has no effect. If the link stops operating, all slaves must be power-cycled before using the LINK RESTART pushbutton to restart operation of the link.

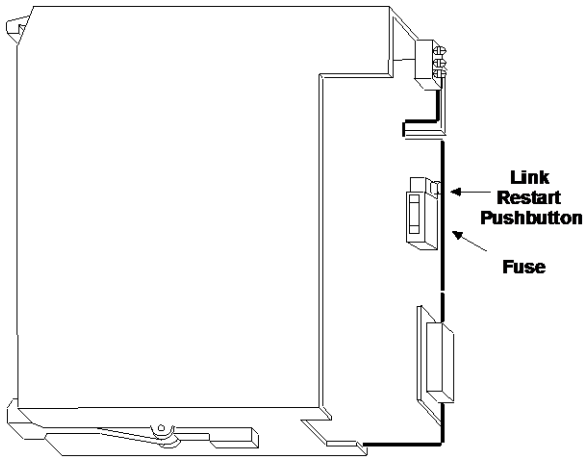


Figure 363: Fuse location BEM321

16.2.3.1 Fuse

The front cover of the module is removable. A fuse located directly below the Restart pushbutton protects the +5Vdc signal pins used by Optical Adapter cable. It is a replaceable 0.5A fast-blow fuse (5mm diameter x 20mm length).

16.2.4 Serial Port: BEM321

The front of the module has one 20-pin, Honda-type connector, used for connection to the first slave on the I/O Link. Signal levels are RS422/485 compatible.

16.3 RX3i Genius Bus Controller: IC694BEM331

The RX3i Genius Bus Controller, IC694BEM331, interfaces a PACSystems RX3i and a Genius I/O serial bus. In addition to the Bus Controller, the bus can serve: Genius blocks, other PLCs with Genius Bus Controllers, Remote Drops, VersaMax and Field Control I/O Stations, Genius Hand-Held Monitor (HHM), Multiple hosts.

16.3.1 Features

- The Bus Controller can exchange up to 128 bytes with each device on the Genius I/O bus.
- Genius blocks and other devices on the bus automatically report faults, alarms and certain other predefined conditions to the Bus Controller. The Bus Controller stores any diagnostic messages it receives. They are read automatically by the CPU. Faults can then be displayed in the fault table using the programming software.
- The Bus Controller supports all Genius datagrams. Refer to Chapter 3 of the Genius I/O System and Communications User's Manual, GEK-90486-1, for details on using datagrams.
- The Bus Controller can send up to 128 bytes of Global Data each bus scan. Global Data is data that is automatically and repeatedly broadcast by a Genius Bus Controller.
- The Bus Controller can receive up to 128 bytes of Global Data each bus scan from every other Bus Controller on its bus.
- Up to eight Genius Bus Controllers can be included in an RX3i system.

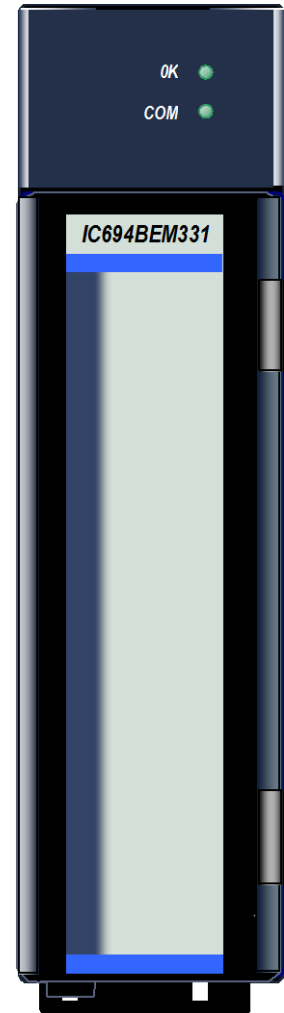


Figure 364: IC694BEM331

16.3.2 LEDs: BEM331

The LEDs on the front of the Genius Bus Controller indicate its operating status. Both LEDs should be On during normal operation.

- OK** Shows the status of the Bus Controller. This LED turns on after power up diagnostics are completed.
- COM** Shows the status of the Genius communications bus. This LED is on steadily when the bus is operating properly. It blinks for intermittent bus errors and is off for a failed bus. It is also off when no configuration has been received from the CPU.

16.3.3 Specifications: BEM331

Current Consumption	300mA at 5Vdc, maximum
Diagnostics	Advanced diagnostics capabilities
Communications	Global Data and Datagrams
Data Length	128 bytes per message
Data Rates	Configurable: 153.5kbaud standard/extended, 76.8kbaud, or 38.4kbaud

Genius Bus Specifications

Bus Type	Daisy-chained bus cable; single twisted-pair plus shield or Twinax. Fiber optical cable and modems can also be used.
Bus Termination	75Ω, 100Ω, 120Ω, or 150Ω resistor at both ends of electrical bus cable.
Maximum Bus Length	7800 feet at 38.4kbaud, 4500 feet at 76.8kbaud, 3500 feet at 153.6kbaud extended, 2000 feet at 153.6Kbaud standard. Maximum length at each baud rate also depends on cable type, as listed in the <i>Genius System and Communications Manual GEK-90486-1</i>
Maximum Number of Devices	32 devices at all baud rates except 38.4kbaud. 16 devices at 38.4kbaud.
Isolation	2000 volts Hi-Pot, 1500 volts transient common mode rejection.

For product standards and general specifications, refer to *Appendix A*.

16.3.3.1 Compatibility

Specific equipment or software versions required for compatibility with the Bus Controller are listed below.

Series 90-30 PLC	If the RX3i Genius Bus Controller is installed in a Series 90-30 PLC, the CPU model can be: IC693CPU311K, 321K, 331L or later, or any version of the IC693CPU313, 323, 340, 341, 350, 351, 352, 360, 363, and 364. The CPU firmware must be release 5.0 or later.
Series Six PLC	To exchange global data with an RX3i Genius Bus Controller, a Series Six Bus Controller must be catalog number IC660CBB902F/903F (firmware version 1.5), or later.
Genius Hand-Held Monitor	There is no Hand-Held Monitor connector on the module, but a Hand-Held Monitor can communicate with the Bus Controller while connected to any other device on the bus. HHM version IC660HHM501H (revision 4.5) or later is required.
Genius Bus	The Genius bus is a shielded twisted-pair wire, daisy-chained between devices, and terminated at both ends. Proper cable selection is critical to successful operation of the system. Suitable cable types are listed in GEK-90486-1, the <i>Genius I/O System and Communications User's Manual GEK-90486-1</i> .

16.3.3.2 Genius System Documentation

Refer to the following manuals for detailed information on the Genius I/O system:

- GEK-90486-1, Genius I/O System and Communications User's Manual
- GEK-90486-2, Genius I/O Discrete and Analog Blocks User's Manual

16.3.4 Field Wiring: BEM331

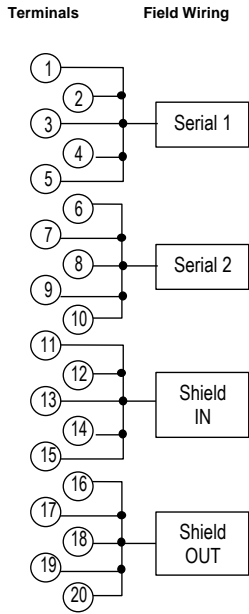


Figure 365: Terminal Assignments BEM331

1. Connect the Serial 1 terminals of adjacent devices and the Serial 2 terminals of adjacent devices.
2. Connect Shield In to the Shield Out terminal of the previous device. (For the first device on the bus, Shield In is not connected.)
3. Connect Shield Out to the Shield In terminal of the next device. (For the last device on the bus, Shield Out is not connected.)

The Serial 1 and Serial 2 terminals are interconnected *on the circuit board*, not on the terminal strip. Incoming and outgoing signal wire pairs can be connected to either one or two Serial 1 or Serial 2 terminals:

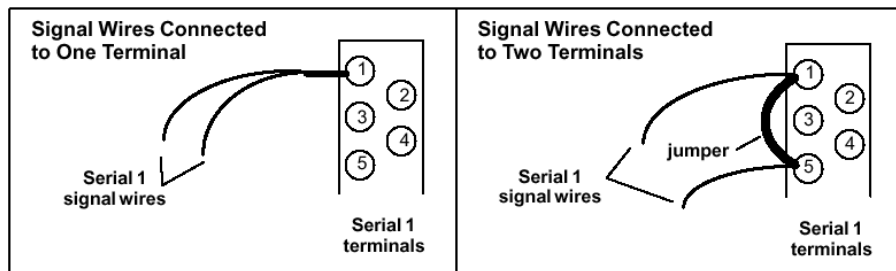


Figure 367: Wiring Genius Bus Signals for Continuous Signal Path

When connecting two signal wires to the same terminal, use spade or lug-type connectors, or twist the exposed ends of the wires together before inserting them. This will allow future removal of the Terminal Assembly without disrupting other devices on the bus.

When connecting two signal wires to separate terminals, install a jumper between the two terminals as shown on the right in Figure 367 above. Failure to install the jumper will cause the entire bus to be disrupted whenever the faceplate is removed.

Using the cable type selected for the application, connect the devices as displayed in Figure 366. Each terminal accepts up to one AWG #14 (2.10mm² wire or two AWG #16 (1.32mm² wires using ring or lug-type connectors).

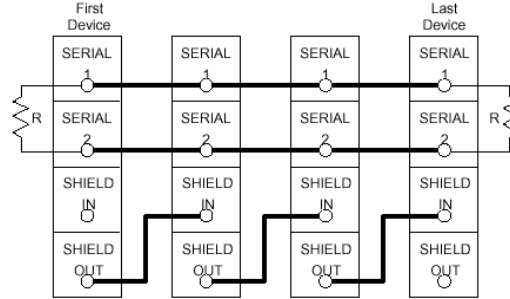


Figure 366: Interconnection of Devices on Genius Bus

The bus shield wires are not insulated; do not permit them to touch other wires or terminals. Spaghetti tubing should be used to cover these wires.

16.3.4.1 Terminating the Bus

The bus must be terminated at both ends by its characteristic impedance. The list of suitable cable types in the *Genius I/O System and Communications User's Manual GEK-90486-1* includes the termination requirements for each cable type. If the Bus Controller is at the end of the bus, install a resistor of the appropriate impedance across its Serial 1 and Serial 2 terminals as displayed in the Figure 368.

If you need to install the terminating resistor across terminals different than those used for the signal wires, attach jumper wires between the signal wire terminals and the resistor terminals to prevent the bus from becoming unterminated if the Terminal Assembly is removed. Failure to do so will cause the entire bus to be disrupted whenever the faceplate is removed.

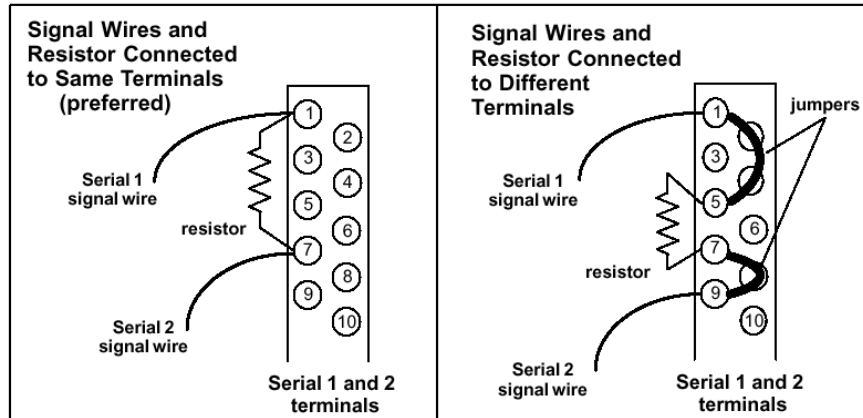


Figure 368: Installing Genius Bus Terminating Resistor

16.3.4.2 Hot-Swapping IC693BEM331/IC694BEM331 Modules

Genius Bus Controller modules IC693BEM331/IC694BEM331 that are included in a Max-ON redundancy system should not be installed or removed from the PLC that is operating as a Master. If a module is removed from the Master and then re-installed, the outputs for that module will not be enabled until the next Backup-to-Master transition.

Any time a Genius Bus Controller is removed from an active system, there is a possibility that the bus may be disrupted with a subsequent impact on the corresponding I/O devices. For systems that require online maintainability, it is recommended that dual (redundant) Genius busses be used.

16.4 RX3i Serial Communications Modules: IC695CMM002, IC695CMM004

PACSystems RX3i Serial Communications modules expand the serial communications capabilities of the RX3i system.

Serial Communications module IC695CMM002 provides two independent, isolated serial ports. Serial Communications module IC695CMM004 (Figure 369), provides four independent, isolated serial ports. Up to six Serial Communications modules can be located in the main PACSystems RX3i backplane.

Each port can be configured for MODBUS Master, MODBUS Slave, or Serial I/O protocol. If any port is configured for DNP3 Master or Slave, the other ports on the module can only be configured for DNP3 Master or Slave.

For modules with firmware version 1.32 or later, half-duplex flow control can be configured using Machine Edition *Release 5.90, SP1, SIM 6* or later. Otherwise, flow control defaults to full-duplex.

16.4.1 Features:

- Port-to-port isolation and port-to-backplane isolation
- RS-232, RS-485/422 communication, software-selected
- Hardware handshake: RTS/CTS for RS-232
- Selectable Baud Rates: 1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k
- Module fault status reporting (Watchdog, Ram Fail, Flash Fail)
- Module identity and status reporting, including LED status indicators
- Meets CE, UL/CUL 508 and 1604, and ATEX requirements
- Flash memory for future upgrades

These modules must be located in an RX3i Universal Backplane.

These modules support insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

Note: If retentive memory is used for Port Control Data, when a power cycle with battery or hot swap of the CMM module occurs, all exchanges whose control bit is in the ON state will be re-executed on the next PLC output scan or output DO I/O. To prevent this, all exchange control bits must be cleared by the application logic on the initial PLC logic scan or upon detection of CMM module removal.

Operating information for these modules is provided in the *RX3i Serial Communications Modules Manual*, GFK-2460.

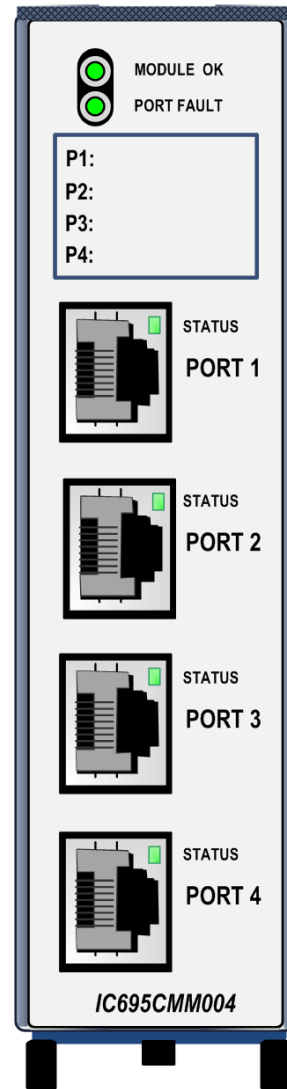


Figure 369: IC695CMM004

16.4.2 LEDs: CMM002 & CMM004

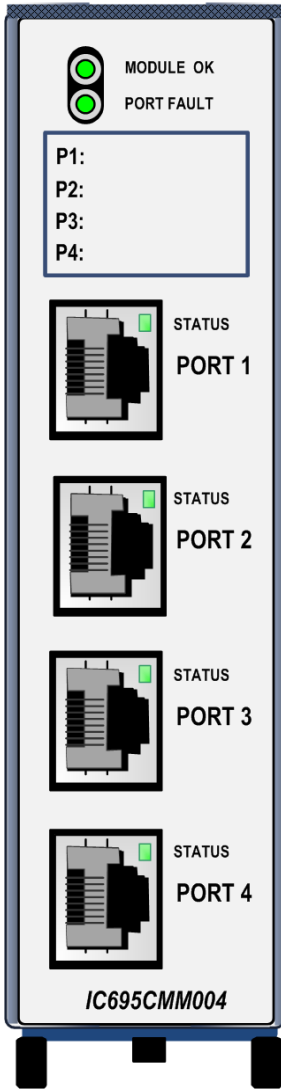


Figure 370: Module LEDs & Ethernet Port LEDs: CMM004

The Module OK LED indicates the status of the module. Solid green indicates that the module has been configured. The Module OK LED is off, if the module is not receiving power from the R3i backplane, or if a serious module fault exists.

At power-up, the Module OK LED flashes green/off while the module is executing power-up diagnostics. It then flashes more slowly as the module receives its configuration from the CPU.

If a problem occurs, the Module OK LED flashes amber, The blink code (below) indicates the cause of the error.

- 1 = watchdog expired
- 2 = RAM error
- 6 = Invalid CPU Master Interface version
- 7 = CPU heartbeat failure
- 8 = Failed to get semaphore

The Port Fault LED indicates the status of all ports. The Port Fault LED is green when there are no faults present on any enabled port. If this LED turns amber, there is a fault on at least one port.

The Port Status LED flashes green when there is activity on the corresponding port.

The area below the module LEDs can be used to record identifying information about each port.

16.4.3 Specifications: CMM002 and CMM004

Number of Serial Ports	IC695CMM002: two independent serial ports IC695CMM004: four independent serial ports	
Connectors	RJ-45	
Number of Serial Communications Modules per CPU	Six in the main CPU backplane	
Backplane power requirements	IC695CMM002	0.7 Amps maximum at 3.3Vdc 0.115 Amps maximum at 5.0 V dc
	IC695CMM004	0.7 Amps maximum at 3.3Vdc 0.150 Amps maximum at 5.0 V dc
LEDs	Module OK, Port Fault, Port Status (2 or 4)	
Port Type	RS-232 or RS-485/22. 4-wire (full duplex) or 2-wire (half-duplex) operation for RS-485/422	
Flow Control for R-232	Selectable: Hardware (CTS/RTS) or none	
Baud rates	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Parity	Even, odd, none	
Data bits	7, 8	
Stop bits	1, 2	
Operating Temperature	0°C to + 60°C	
Input Impedance	Zin > 96 kΩ for RS-485/422 3 kΩ < Zin < 7 kΩ for RS-232	
Max Over-voltage	±25V	
Channel-Channel Crosstalk	-55dB minimum	
Isolation	Port to Backplane and to frame ground: 250 V ac continuous; 1500 V ac for 1 minute, 2550 V dc for one second. Port to port: 500 V dc continuous, 710 V dc for one minute.	

To meet emission and immunity requirements for the EMC directive (CE mark), shielded cable must be used with this module.

16.4.4 Serial Ports: CMM002 & CMM004

Each port is a standard RJ-45 female connector with the following pin assignments. For MODBUS applications, note that these pin assignments are different than the standard MODBUS pin assignments. If the port is configured for MODBUS master or slave operation, custom cables are needed.

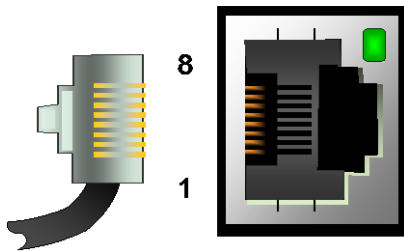


Figure 371: RJ-45 Jack & Pinouts

RJ-45 Pin	RS-232	RS-485/422 Half Duplex	RS-485/422 Full Duplex
8	COM	GND	GND
7			Termination 2
6	CTS		R- (RxD0)
5	COM	GND	GND
4		Termination 1	
3	RxD		R+ (RxD1)
2	TxD	T- / R- (D0)	T- (TxD0)
1	RTS	T+ / R+ (D1)	T+ (TxD1)

Note: There is no shield or frame ground pin on the port connector.

If the Serial Communications module is communicating with a Series 90-30 CPU363 or external PACSystems RX3i CPU serial port, the connections are:

RX3i Serial Module		CPU363/RX3i CPU with Serial Port
T+	To	RD('B')
T-	To	RD('A')
R+	To	SD('B')
R-	To	SD('A')

16.4.4.1 Termination

By default, each port is set for no termination. Termination is needed if the module is the first or last device on an RS-485 network, even if there is only one other device on the network. Termination can be provided using either an external resistor as displayed in the following figure or the 120Ω termination resistor built into the port. If line termination other than 120 Ω is required, an appropriate external resistor must be supplied.

User-Supplied Termination for RS-485

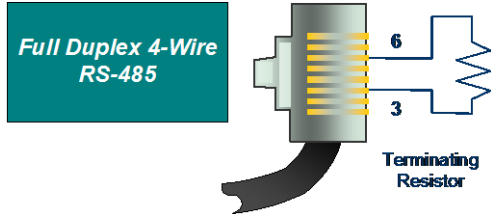


Figure 372: Termination RS-485 4-Wire Full Duplex

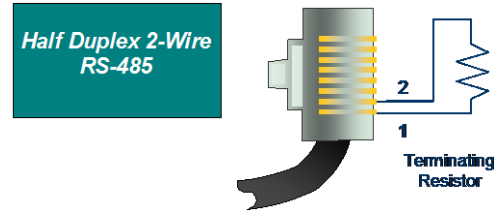


Figure 373: Termination RS-485 2-Wire Half Duplex

Built-in 120Ω Termination for RS-485

By default, each port is set for no termination. There are two ways to use the built-in 120Ω termination:

- A. Using the internal jumpers. To use this method, remove the faceplate of the module by pressing in on the side tabs and pulling the faceplate away from the module. With the module oriented as shown, move either the upper or lower jumper:

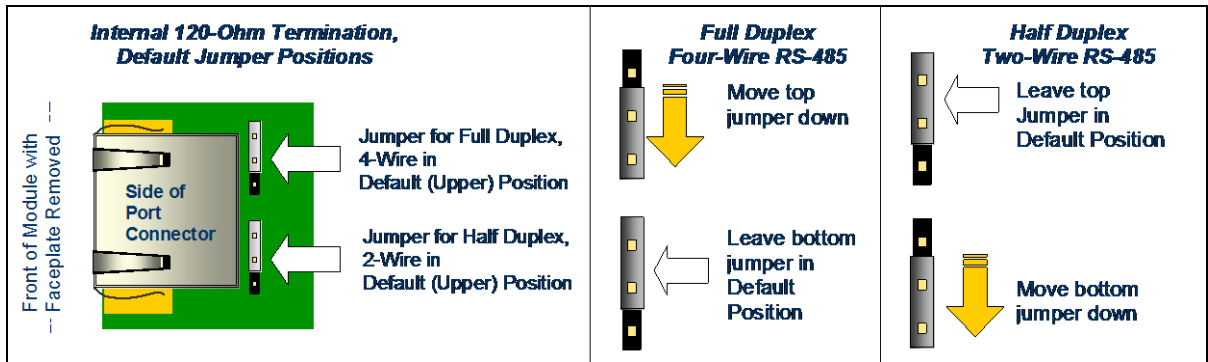


Figure 374: Using the Module Internal Jumpers & Built-in 120Ω Resistor for Termination

- B. Using an external jumper wire. To use this method, do NOT change the positions of the internal jumpers as shown in Figure 374 above. Instead, connect an external jumper wire across connector pins 3 and 7 for RS-485 4-wire, or across connector pins 1 and 4 for RS-485 2-wire.

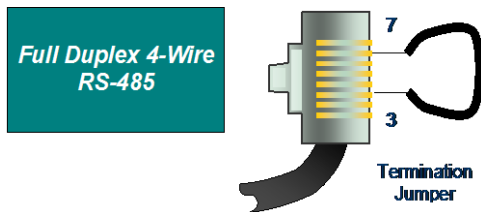


Figure 375: Using External Jumper & Built-in 120Ω Resistor for RS-485 4-Wire Full Duplex

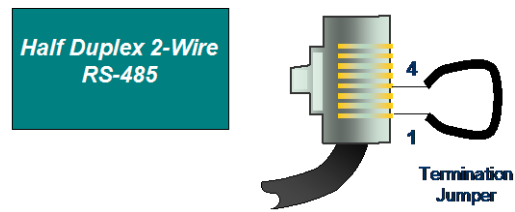


Figure 376: Using External Jumper & Built-in 120Ω Resistor for RS-485 2-Wire Half Duplex

16.5 RX3i Control Memory Xchange Module: IC695CMX128

The RX3i Control Memory Xchange (IC695CMX128) module provides deterministic sharing of data among PLCs and other computing devices on a high-speed fiber optic network, using reflective memory technology. A reflective memory network can contain up to 256 nodes. Each node in the network can be any reflective memory device that is compatible with the 5565 family. When data is written to one node, all nodes on the network are automatically updated with the new data.

Each node in the reflective memory network is connected in a daisy-chained loop using fiber optic cables. The transmitter of the first node is tied to the receiver of the second. The transmitter of the second node is tied to the receiver of the third node, and so on, until the loop is completed back at the receiver of the first node.

A PACSystems RX3i main rack supports a maximum of six CMX modules.

16.5.1 Features

- 128 Mbytes reflective memory with parity.
- No RX3i CPU processing required to operate the network.
- Network error detection.
- Connection with multimode fiber up to 300m/984.25ft
- Software configuration of all node parameters (no jumper or switch settings required).
- Dynamic packet sizes of 4 to 64 bytes, controlled by the CMX module
- Network transfer rate of 43 Mbyte/s (4 byte packets) to 174 Mbyte/s (64 byte packets)
- Network link speed of 2.1 Gigabits/sec.
- Programmable module interrupt output.
- Four general-purpose network interrupts with 32 bits of data each.
- Redundant transfer mode operation.
- Configurable network memory offset.

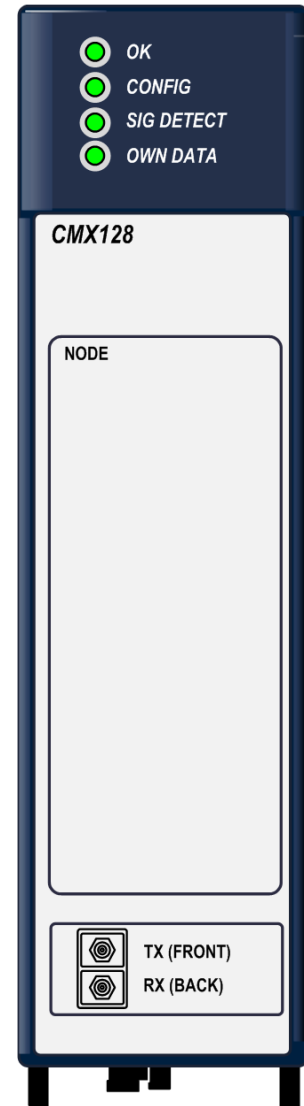


Figure 377: IC695CMX128

The CMX128 module must be located in an RX3i Universal Backplane.

Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

CMX128 modules require a metal enclosure to meet radiated emissions requirements. For details, refer to the module datasheet, GFK-2506.

16.5.2 LEDs: CMX128

All front panel LED indicators are green.

OK	ON indicates the CMX module and the CPU are functioning properly.
CONFIG ⁸¹	ON indicates the module is configured.
SIG DETECT	ON indicates the receiver is detecting a fiber optic signal.
OWN DATA	ON indicates the module has received its own data packet from the network at least once.

16.5.3 Specifications: CMX128

Packet size	Dynamic packet sizes of 4 to 64 bytes, automatically controlled by the CMX128 module
Transfer rate	Network link speed of 2.1 Gbits/sec
User memory	128MB SDRAM
Input power (from RX3i power supply)	660 mA at +3.3Vdc 253 mA at +5Vdc
Connectors	<ul style="list-style-type: none"> ▪ Fiber optic LC type, conforms to IEC 61754-20 ▪ Zirconium ceramic ferrule ▪ Insertion loss: 0.35 dB (maximum) ▪ Return loss: -30dB

For product standards and general specifications, refer to *Appendix A*.

16.5.4 Optical Transceiver: CMX128

The optical transceiver, located on the bottom of the module, has two LC-type fiber optic ports. The port labeled "TX" is the transmitter and the port labeled "RX" is the receiver.

CMX modules are networked together using either simplex (single fiber) or duplex (dual fiber) multimode fiber optic cables. For details on cables, refer to the *PACSystems Memory Xchange Modules User's Manual*, GFK-2300.

⁸¹ A reflective memory hub can be used to bypass a node that is not configured.

16.6 RX3i Redundancy Memory Xchange Modules: IC695RMX128, IC695RMX228

Both Redundancy Memory Xchange (RMX) modules operate as a node on a reflective memory network or as a dedicated link between CPUs in an RX3i Hot Standby CPU Redundancy system. When the RMX is not being used as a link in a redundancy system, it is functionally identical to the IC695CMX128 module. Each node in the network can be any reflective memory device that is compatible with the 5565 family. Whenever data is written to one node, all nodes on the network are automatically updated with the new data.

Note: A hub is required to connect a single mode fiber device into a ring with multi-mode fiber devices. Hubs are not permitted when connecting redundant pairs.

When used as a node on a reflective memory network, the RMX module provides deterministic sharing of data among PLCs and other computing devices on a high-speed fiber optic network. A reflective memory network can contain up to 256 nodes.

Each node in the reflective memory network is connected in a daisy-chained loop using fiber optic cables. The transmitter of the first node is tied to the receiver of the second. The transmitter of the second node is tied to the receiver of the third node, and so on, until the loop is completed at the receiver of the first node.

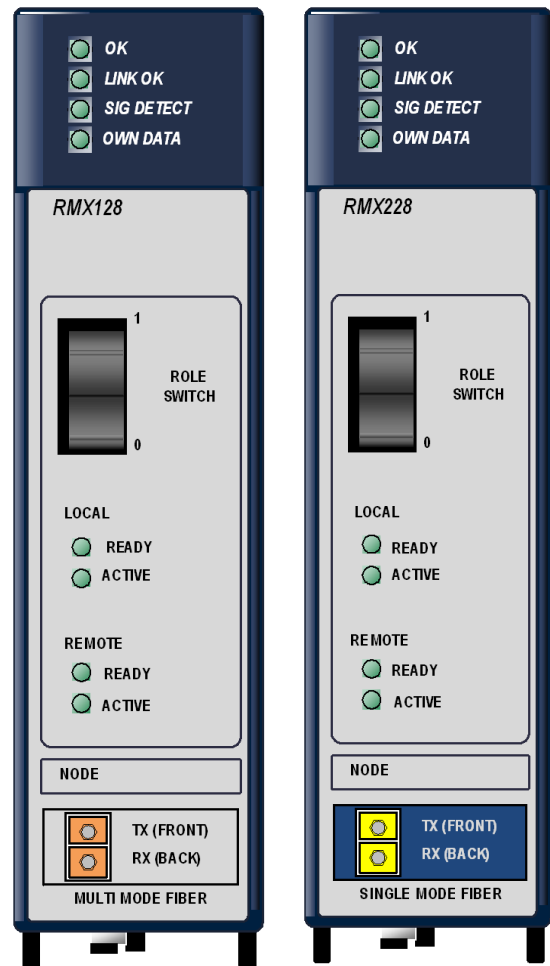


Figure 378: IC695RMX128 Figure 379: IC695RMX228

When used in a CPU redundancy system, the RMX modules provide a path for transferring data between the two redundancy CPUs in the redundant system. A complete communications path consists of one RMX in the primary unit, one RMX in the secondary unit, and two high-speed fiber optic cables connecting them to each other. This must be a two-node ring: no other reflective memory nodes are allowed to be part of this fiber optic network.

GE **strongly recommends** two redundancy links (a total of four RMX modules) be configured and installed. Optionally, systems can be configured for a single redundancy link (a total of two RMX modules).

When the RMX is being used as link in a redundancy system, it cannot be used as a general-purpose Memory Xchange module. For details on the operation of a PACSystems CPU redundancy system, refer to the *PACSystems Hot Standby CPU Redundancy User's Manual*, GFK-2308.

A PACSystems RX3i main rack supports a maximum of six Memory Xchange modules in any combination of RMX128, RMX228 and CMX128 modules. A maximum of two RMX modules can be configured as redundancy communication links.

16.6.1 Features: RMX128 & RMX228

- PACSystems RX3i single slot form factor.
- 128 Mbytes reflective memory.⁸²
- Software configuration of all node parameters (no jumper or switch settings required).⁸²
- High-speed easy-to-use 2.12 GBaud fiber-optic network.
- No RX3i CPU processing required to operate the network.
- Network-compatible with VMIC 5565 family of reflective memory devices, including the RX7i CMX/RMX module.

Note: A hub is required to connect a single-mode fiber device into a ring with multi-mode fiber devices. Hubs are not permitted when connecting redundant pairs.

- IC695RMX128: Connection with multi-mode fiber up to 300m (984.25ft).
- IC695RMX228: Connection with single-mode fiber up to 10 km (32,808 ft 4 in).
- Dynamic packet sizes of 4 to 64 bytes, controlled by the RMX module.
- Programmable module interrupt output.
- Four general-purpose network interrupts with 32 bits of data each.⁸²
- Network error detection.
- Up to 256 nodes per network.⁸²
- Redundant transfer mode operation. This optional mode reduces the chance of a data packet being dropped from the network.⁸²
- Configurable network memory offset allows you to assign nodes on a network to groups according to the 16MB segment in the network address space that they use.⁸²

The RMX128/RMX228 module must be located in an RX3i Universal Backplane. These modules support insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

RMX128/RMX228 modules require a metal enclosure to meet radiated emissions requirements. For details, refer to the module datasheet, GFK-2511.

16.6.2 Specifications: RMX128 & RMX228

Packet size	Dynamic, automatically controlled by RMX128/RMX228 module
User memory	128MB SDRAM
Input power (from RX3i power supply)	580 mA at +3.3Vdc 220 mA at +5Vdc
Connectors	<ul style="list-style-type: none"> ■ Fiber optic LC type, conforms to IEC 61754-20 ■ Zirconium ceramic ferrule ■ Insertion loss: 0.35 dB (maximum) ■ Return loss: Refer to cable/connector specifications.

For product standards and general specifications, refer to *Appendix A*.

⁸² Not available when operating as a redundancy link in a CPU redundancy system.

16.7 RX3i DeviceNet Master Module: IC694DNM200

The DeviceNet Master Module (DNM200) allows the CPU to send and receive data over a DeviceNet network. It can act as master for up to 63 slaves on the DeviceNet network. It can also be configured to simultaneously function as a slave to another master on the bus.

DeviceNet is a communications network that transmits data between control systems (for example: PLCs, PCs, VMEbus computers, and robot controllers) and distributed industrial devices such as switches, sensors, valve manifolds, motor starters, bar code readers, drives, displays, and operator interfaces.

This module can be installed in any available RX3i universal backplane I/O slot; it cannot be located in remote or expansion racks. Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

16.7.1 Features

- Bus communications at all standard DeviceNet data rates (125k, 250k, 500k baud)
- Up to 255 bytes input data transfer and 255 bytes output data transfer per slave.
- Up to 3972 bytes of input data transfer and 3972 bytes of output data transfer per master.
- UCMM-capable Group 2 Server
- One or two I/O connections per Slave - Typically one connection is used for Polled and the other is used for Strobe, Cyclic, or COS
- Supports Unconnected Message Manager (UCMM) with one proxy connection per slave device
- Configurable global scan rate
- Supports Poll, Strobe, Cyclic and COS I/O connections, Fragmented I/O and Explicit Messaging
- Configurable update rates for Poll and COS/Cyclic on a connection basis.
- Configurable response to loss of communication
- Firmware update via service port on module

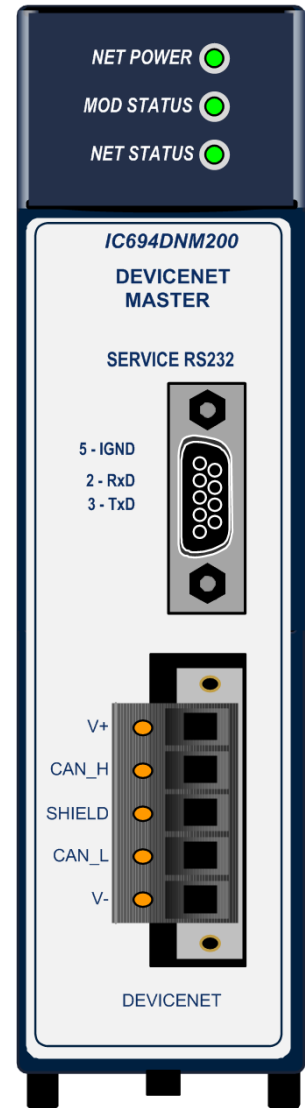


Figure 380: IC694DNM200

16.7.2 LEDs and Connectors: DNM200

The three DeviceNet-compliant LEDs of the module show its operating and communications status. The RS-232 serial port is used for a computer connection during firmware upgrades. The DeviceNet connector is a removable spring-clamp terminal. It provides bus continuity and can be removed from the module without disrupting bus operation.

16.7.3 Specifications: DNM200

Backplane Current Consumption	450mA at 5Vdc (typical)
Thick Cable General Specifications	Two shielded pairs - Common axis with drain wire in center
	Overall braid shield - 65% coverage; 36 AWG or 0.12mm tinned Cu braid minimum (individually tinned)
	Drain wire - #18 Copper min.; 19 strands minimum (individually tinned)
	Outside diameter - 0.410 inches (min) to 0.490 inches (max.) roundness - radius delta to be within 15% of 0.5 O.D.
Thin Cable General Specifications	Two shielded pairs - Common axis with drain wire in center
	Overall braid shield - 65% coverage; 36 AWG or 0.12mm tinned Cu braid minimum (individually tinned)
	Drain wire - #22 Copper; 19 strands minimum (individually tinned)
	Outside diameter - 0.240 inches (min.) to 0.280 inches (max.) roundness - radius delta to be within 20% of 0.5 O.D.
Network Topology	Bus with limited branching (trunkline/dropline)
Redundancy	Not Supported
Network Power for Node devices	Nominal 24Vdc \pm 4%
Allowed Nodes (Bridging excluded)	64 nodes
Data Packet Size	0-8 bytes with allowance for message fragmentation
Duplicate Address Detection	Addresses verified at power-up
Error Detection / Correction	CRC - retransmission of message if validity not acknowledged by recipient

For product standards and general specifications, refer to *Appendix A*.

16.7.4 The DeviceNet Bus

Devices can be connected directly to the trunk cable, or to drop lines that are joined to the trunk cable with taps. Taps can be mounted in junction boxes or panels. Drop lines and daisy-chains are often used inside control panels where multiple devices are grouped together. When using drops with daisy-chains and branches, the maximum length from a tap to its farthest drop is 20 feet.

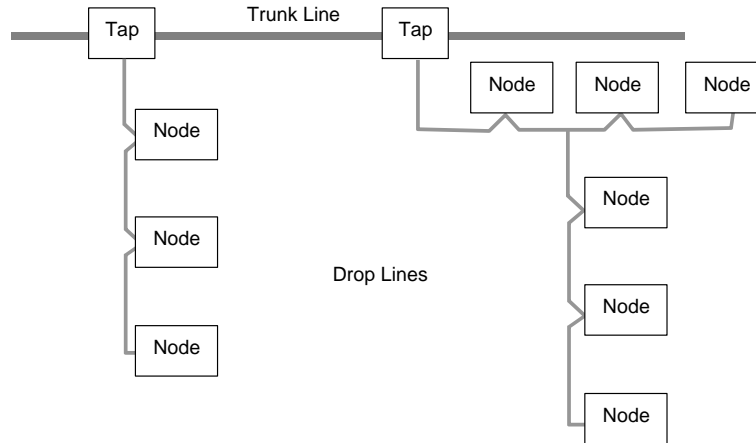


Figure 381: DeviceNet Bus Topology

16.7.4.1 Bus Length

The maximum length of the trunk cable and drops both depend on the cable type and data rate. Individual drops may not exceed 6 meters and are limited to one network node per drop. However, the node may have multiple ports.

Data Rates	125kbps	250kbps	500kbps
thick cable, trunk length	500m (1640ft)	250m (820ft)	100m (328ft)
thin cable, trunk length	100m (328ft)	100m (328ft)	100m (328ft)
maximum drop length	6m (20ft)	6m (20ft)	6m (20ft)
total length of all drops	156m (512ft)	78m (256ft)	39m (128ft)

For each baud rate, the total drop length is the sum of all the drop lines of both cable types in the network.

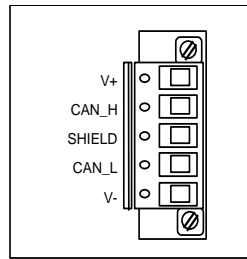
In addition, if the distance from a tap to the most distant device on its drop is longer than the distance from the tap to the nearest terminating resistor, the drop line length also counts as part of the trunk cable length (as well as the overall drop length).

16.7.4.2 DeviceNet Cable

Either DeviceNet thick cable or thin cable can be used. Thick cable permits greater cable lengths and higher current levels. Generally, thick cable is used for the trunk cable. Thin cable is normally used for shorter distances and is suitable for drop cables and for installations where more cable flexibility is needed. Both thick cable and thin cable are 5-wire, multi-conductor copper cable. Two wires form a transmission line for network communications. A second pair transmits network power. The fifth conductor forms an electromagnetic shield. Most cables have color coded leads which correspond to the color coding on the terminals on the DeviceNet Master Module.

16.7.4.3 Bus Connector Pin Assignments

The DeviceNet connector on the RX3i DeviceNet Master module has five color-coded screw-clamp terminals.



Signal	Pin	Wire Color
V+	5	Red
CAN_H	4	White
Shield	3	Bare
CAN_L	2	Blue
V-	1	Black

Figure 382: DeviceNet Connector Pinout

Wiring to the DeviceNet Master module depends on its location on the network:

121Ω 1% ¼ watt terminating resistors MUST be installed at both ends of the DeviceNet network. The terminating resistor is placed across the data communication signals at pin 2 (CAN_L) and pin 4 (CAN_H).
 If the DeviceNet module is located at either end of the bus trunk, it is wired with one cable connection and a terminating resistor:

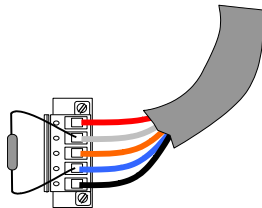


Figure 383: DeviceNet Terminating Resistor Installation

If the module is installed at the end of a drop or drop segment, it is wired with one cable connection only.

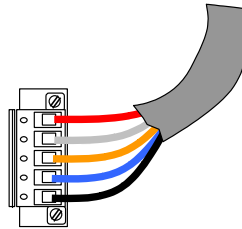


Figure 384: DeviceNet Wiring for End of Segment

If the module is installed directly on the trunk cable or as part of a daisy-chained drop cable, it has both an incoming and outgoing cable connected:

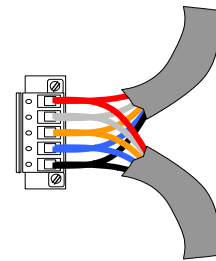


Figure 385: DeviceNet Wiring for Daisy Chain

16.7.4.4 Grounding

All DeviceNet cable shields must be tied to ground at each device connection. This is done by tying the bare wire of the cable to pin 3 (Shield) of the connector.

16.7.4.5 Power Requirements

The DeviceNet Master module consumes 450mA at 5Vdc (typical) from the PLC backplane. This power is used for module operation, The DeviceNet Master powers its network transceiver from the 24Vdc DeviceNet network power source. Linear power supplies are recommended for the DeviceNet power source. The DeviceNet power source should *not* also be used for device power. Transients caused by I/O devices can cause communications errors and even create bus-off conditions.

The DeviceNet specification recommends using a power tap to connect a power supply to the network. The power tap should be appropriately fused for the current capacity of the bus cables. The maximum current on the network depends on the cable type.

The DeviceNet network power supply must be grounded, but only at one point. The V- signal must be connected to protective earth ground at the power supply only. If multiple power supplies are used, only one power supply must have V- connected to earth ground.

Current Limit for Thick Cable

For thick cable, the maximum current on the network is 16 Amps. However, only 8 Amps is permitted on a single network segment. 16 Amps can be drawn from a single power supply by locating the power supply at the center point of two network segments, supplying 8 Amps to each segment.

Current Limit for Thin Cable

For thin cable, the maximum current permitted is 3 Amps.

16.8 Motion Mate Module: IC694DSM314

The Motion Mate Module (DSM314) is a multi-axis motion control module. It supports two control loop configurations:

- Standard Mode (Follower Control Loop Disabled)
- Follower Mode (Follower Control Loop Enabled)

The DSM314 Module can be used with GE α Series and β Series digital servo amplifiers and motors. It can also be used with analog GE SL Series analog servos and third-party analog velocity command interface and analog torque command interface servos. Module features include:

- Velocity Feed forward and Position Error Integrator
- High resolution of programming units
- Simple and powerful motion program instruction set
- Simple 1 to 4-axis motion programs
- Non-volatile storage for 10 programs and 40 subroutines
- Single-point-of-connect for programming and configuration.
- Firmware is stored in flash memory and is updated via COMM port.
- Recipe programming using command parameters.
- Electronic CAM capability
- Home and over-travel switch inputs for each Servo Axis
- Two Position Capture Strobe Inputs for each axis
- 5v , 24v and analog I/O for use by PLC
- Incremental Quadrature Encoder input on each axis for Encoder/Analog mode
- 13 bit Analog Output can be controlled by PLC or used as Digital Servo Tuning monitor
- High speed digital output (four each 24V and four each 5V) via on-board Local Logic control

This module can be installed in any available I/O slot in any RX3i or Series 90-30 backplane. Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

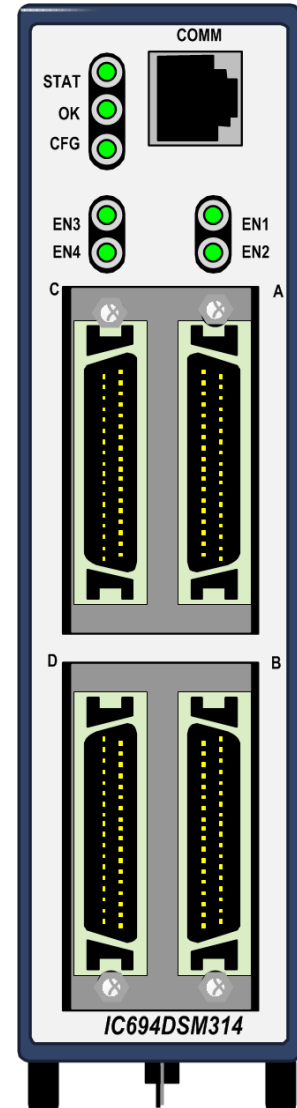


Figure 386: IC694DSM314

16.8.1 Overview: DSM314

The DSM314 integrates high-performance motion control with the logic-solving functions of the RX3i Controller.

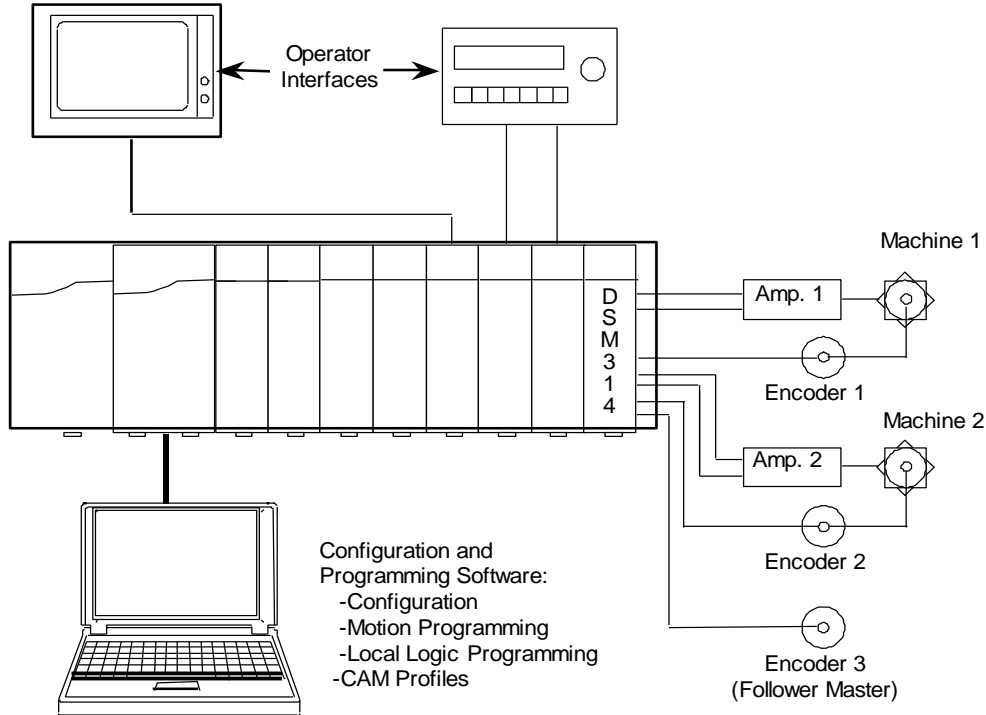


Figure 387: System Overview: DSM314

For more information about configuring and installing the DSM314 module, refer to the *Motion Mate User's Manual*, GFK-1742. For details about interfacing the DSM314 to the GE SL Servo products, refer to the manual, *SL Series Servo User's Manual*, GFK-1581.

16.8.2 Specifications: DSM314

Power Supply Voltage	5Vdc from backplane
Power Supply Current Draw by DSM	800 mA plus encoder supply current (refer to next item).
Available +5Vdc Current/Module to supply external encoder, if used	500 mA (if used, must be added to module +5Vdc current draw)
Number of DSM314 Modules in PACSystems RX3i Main Backplane	Up to 5 DSM314 modules in RX3i Main Backplane with Power Supply PWR040
Number of DSM314 Modules in PACSystems RX3i Expansion/Remote Backplane	<ul style="list-style-type: none"> ▪ 3 DSM314 modules in expansion/remote backplane with PWR321 ▪ 6 DSM314modules in remote backplane with PWR330/331 ▪ 7 DSM314modules in expansion backplane with PWR330/331

16.8.3 Features: DSM314

16.8.3.1 LEDs

There are seven LED status indicators on the DSM314 module:

The **STAT** LED is normally On. When the LED is OFF, the DSM314 is not functioning. Slow blinking indicates status errors. Rapid blinking indicates errors that cause the servo to stop.

The **OK** LED indicates the current status of the DSM314 module. When the LED is steady On, the module is functioning properly. When the LED is Off, the module is not functioning.

The **CFG** LED is On when a module configuration has been received.

The **EN1** through **EN4** LEDs are On if the Axis 1 through Axis 4 Drive Enable relays are on.

16.8.3.2 COMM Connector

The COMM port is an RJ-11 connector, used to download firmware updates to the module.

16.8.3.3 I/O Connectors

The DSM314 is a two-axis digital servo/one axis analog velocity interface or four-axis analog servo (Torque Mode and/or Velocity Mode) controller with four 36-pin I/O connectors labeled A, B, C, and D. All four connectors provide similar analog and digital I/O circuits.

16.8.3.4 Shield Ground Connection

The DSM314 must be connected to frame ground via the ground terminal on the bottom of the module

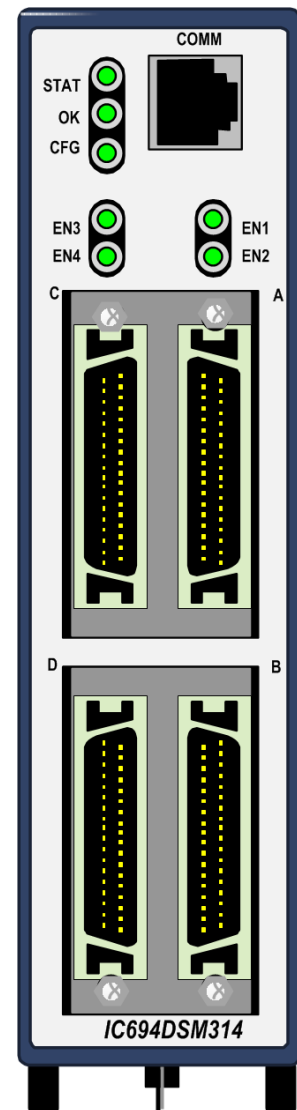


Figure 388: DSM314 Features

16.9 Motion Controller Module: IC694DSM324

The Motion Controller Module, IC694DSM324, is a multi-axis motion control module. It supports two control loop configurations:

- Standard Mode (Follower Control Loop Disabled)
- Follower Mode (Follower Control Loop Enabled)

The DSM324 Module can be used with GE β i Series digital servo amplifiers and motors. Module features include:

- Block Processing time under 5ms
- Velocity Feed forward and Position Error Integrator
- High resolution of programming units
- Simple and powerful motion program instruction set
- Simple 1 to 4-axis motion programs
- Non-volatile storage for 10 programs and 40 subroutines
- Single-point-of-connect for programming and configuration.
- Firmware is stored in flash memory and is updated via COMM port.
- Recipe programming using command parameters.
- Electronic CAM capability
- Home and over-travel switch inputs for each Servo Axis
- Two Position Capture Strobe Inputs for each axis
- 5v , 24v and analog I/O for use by PLC
- Incremental Quadrature Encoder input on each axis for Encoder/Analog mode
- 13-bit Analog Output can be controlled by PLC or used as Digital Servo Tuning monitor
- High speed digital output (four each 24Vdc and four each 5Vdc) via on-board Local Logic control

This module can be installed in any available I/O slot in any RX3i or Series 90-30 backplane. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

Refer to the *DSM324i Motion Controller for PACSystems RX3i and Series 90-30*, GFK-2347, for more information about the DSM324 module.



Figure 389: IC694DSM324

16.9.1 Overview: DSM324

The DSM324 integrates high-performance motion control with the logic-solving functions of the RX3i controller.

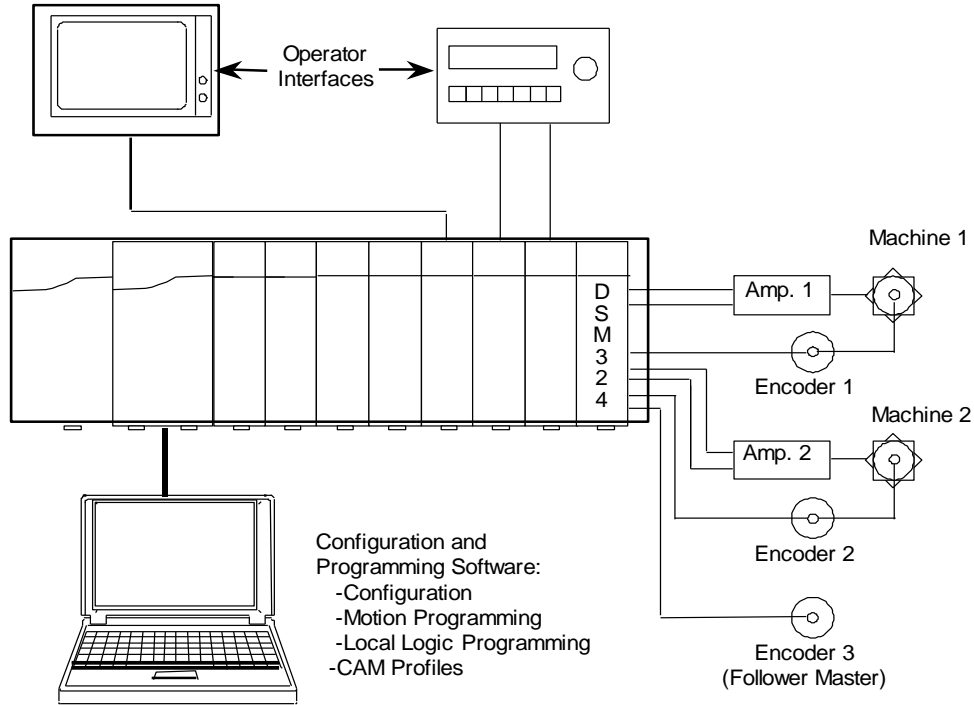


Figure 390: System Overview: DSM324

For more information about configuring and installing the DSM324 module, refer to the *DSM324i Motion Controller for PACSystems RX3i and Series 90-30*, GFK-2347. For details about interfacing the DSM324 to the GE SL Servo products, refer to the manual, *AC Servo Motor βis Descriptions Manual*, GFZ-65302EN.

16.9.2 Specifications: DSM324

Power Supply Voltage	5Vdc from backplane
Power Supply Current Draw by DSM	860 mA plus encoder supply current (refer to next item).
Available +5V Current/Module to supply external encoder, if used	500 mA (if used, must be added to module +5v current draw)
Number of DSM324i Modules in PACSystems RX3i Main Backplane	Up to 5 DSM324i modules in RX3i Main Backplane with Power Supply PWR040
Number of DSM324i Modules in PACSystems RX3i Expansion/Remote Backplane	<ul style="list-style-type: none"> ▪ 2 DSM324i modules in expansion/remote backplane with PWR321 ▪ 6 DSM324i modules in remote backplane with PWR330/331 ▪ 6 DSM324i modules in expansion backplane with PWR330/331

16.9.3 Features: DSM324

16.9.3.1 LEDs

There are eight LED status indicators on the DSM324 module:

The **STATUS** LED is normally On. When the LED is OFF, the DSM324 is not functioning as the result of a status error. Flashing signals an error condition.

The **OK** LED indicates the current status of the DSM314 module. When the LED is steady On, the module is functioning properly. When the LED is Off, the module is not functioning.

The **CONFIG** LED is On when a module configuration has been received.

The **FSSB** LED is On when FSSB communications are active. It blinks during FSSB setup. This LED is Off if FSSB communications are inactive or if FSSB setup has failed.

The Axis Enable LEDs, 1 through 4, are On if the Axis 1 through Axis 4 Drives are enabled.

16.9.3.2 FSSB Connector

The FSSB connector provides optical fiber connection to Servo Amplifiers for the exchange of command, feedback, and diagnostics data. This connector has a removable protective cap.

16.9.3.3 COMM Connector

The COMM port is an RJ-11 connector, used to download firmware updates to the module.

16.9.3.4 I/O Connectors

The DSM324 provides two connectors for 5Vdc and 24Vdc I/O. Pre-manufactured cables are available in 1-meter and 3-meter lengths for both I/O connectors.

16.9.3.5 Shield Ground Connection

The DSM324 must be connected to frame ground via the ground terminal on the bottom of the module. The grounding resistance of the system ground should be 100Ω or less (class 3 grounding).



Figure 391: DSM324 Features

16.10 PACMotion Multi-Axis Motion Controller: IC695PMM335

The PACMotion Multi-Axis Motion Controller (IC695PMM335) is designed with the performance to deliver improved machine productivity required for today's high-speed machines and lean manufacturing environments.

Each module can control up to four servo axes. Up to 40 axes can be controlled from a single RX3i backplane.

The PMM335 supports discrete and synchronous motion control yielding a flexible motion controller that scales to fit your requirements.

16.10.1 Servo Types Supported

- Digital: Supports FANUC β i, β HVi and α HVi Series digital servo amplifiers and motors. For a list of supported FANUC motors, refer to *Motor Type Codes* in *PACMotion Multi-Axis Motion Controller User's Manual*, GFK-2448.
- Analog: Provides analog velocity and analog torque command interfaces to third-party analog servos.

16.10.2 Features: PMM335

- Fast motion path (1ms) planning and position update rates (500 μ s) deliver improved accuracy and faster response to changing control requirements.
- Consistent motion update rate regardless of the number of axes.
- High reliability FANUC servos improve machine uptime.
- High speed synchronization of up to 40 axes over the PACSystems RX3i backplane.
- Advanced CAM and gearing features for electronic line shaft applications.
- Single software development environment for complete automation control solution simplifies programming.
- Distributed architecture for greater machine flexibility – up to 100 meters between axes using noise immune fiber cables
- Optional Fiber Terminal Block allows distributed motion-centric I/O to reduce wiring complexity and cost.
- Two high-speed position capture inputs per axis for registration and sequence control.

This module is compatible with all RX3i CPUs except CRU320. It can be installed in any available RX3i I/O slot. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

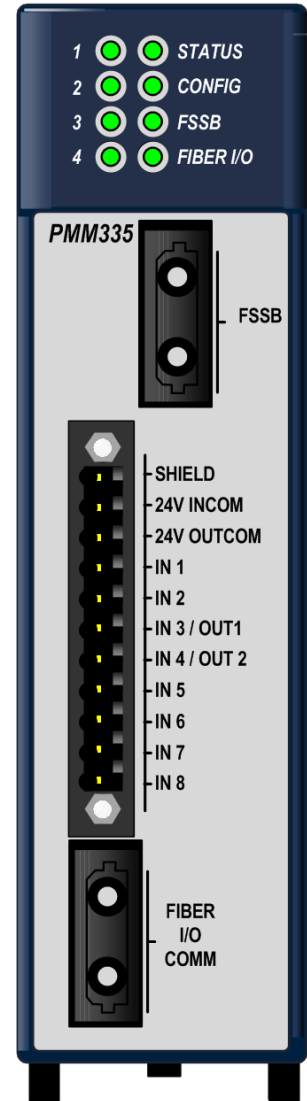


Figure 392: IC695PMM335

16.10.3 Fiber I/O Terminal Block

The DIN-rail mounted FTB, IC695FTB001, allows the user to connect 5-volt, 24-volt, and analog I/O to motion specific devices, such as limit switches and encoders, over a full-duplex fiber optic link up to 100m from the PMM335. FTB I/O can be configured as over-travel switch, home switch, quadrature encoder and high speed touch probe position capture inputs, digital cam switch outputs or general purpose I/O. The FTB's analog outputs can be used as general-purpose analog outputs, or configured for closed position loop (velocity interface) or velocity loop (torque interface) control of up to two analog servos

A robust serial protocol encodes and decodes the data as it sent between the PMM and the FTB. In the event of a system malfunction, such as loss of communication with the PMM, the FTB sets its I/O to the user-configured state.

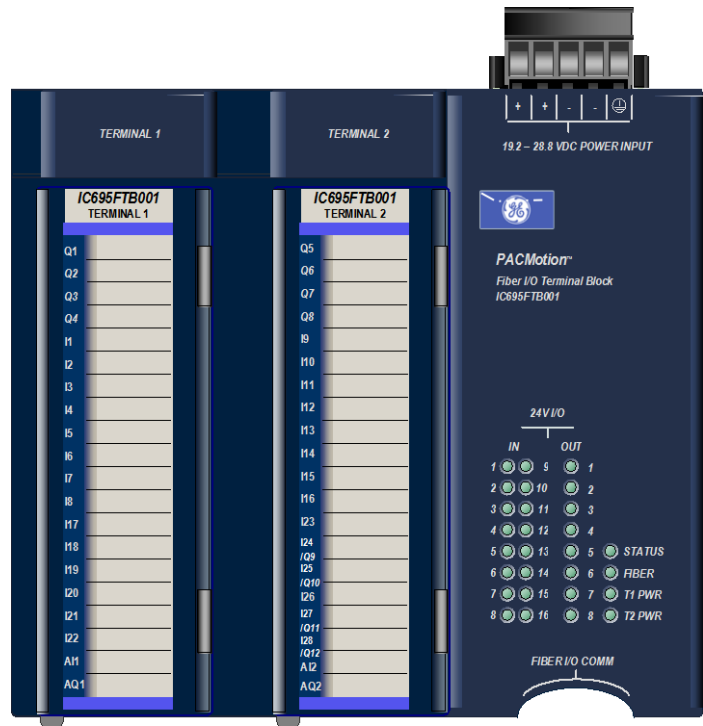


Figure 393: PMM335 with DIN-Rail Mounted FTB001 Terminal Blocks

16.10.4 Features

- Fiber optic connection allows choice of cable lengths from 1m to 100m
- Fiber optic connection provides optical isolation between the main rack and the FTB.
- Current capability to 0.5A on all 24V outputs.
- Loss of encoder and open wire fault detection on 5V differential inputs (quadrature encoder lines).
- Visual diagnostics provided via individual LEDs that indicate I/O point state.
- DIN-rail mounting allows convenient location of I/O.
- Fiber optic interface reduces remote I/O wiring cost and improves noise immunity.
- Removable RX3i terminal block headers provide ease of use
- A 5Vdc power source for external quadrature encoders

16.11 IEC 61850 Ethernet Communication Module: IC695ECM850

The PACSystems RX3i IEC 61850 Ethernet Communication Module, IC695ECM850, (ECM850), connects an RX3i controller to an IEC 61850 network, enabling the controller to act as an IEC 61850 Client and communicate with Intelligent Electronic Devices (IEDs, IEC 61850 servers) on the network using the IEC 61850 protocol. (IEC 61850 is a standard for the design of electrical substation automation.) The ECM850 provides the functions and services required for an IEC 61850 Client, as described in the PICS and MICS in the appendices.

The ECM850 supports 10/100/1000 Mbps copper, 100/1000 Mbps multi-mode fiber, and 100/1000 Mbps single-mode fiber Ethernet connections. The network can include media interfaces of more than one type.

Features of the ECM850 include:

- Supports the following IEC 61850 client features
 - Multiple connections to IEDs
 - Read and write of data values
 - Control model – all models
 - Report by exception – reporting buffered and un-buffered
 - Browse data model – logical devices, nodes, data objects & attributes
 - Self-description – reads data model from IED over IEC 61850 network
- Full programming and configuration services for the IEC 61850 Client, including reading of device Substation Configuration Language (SCL) files and reading configuration data online directly from IEDs using the Machine Edition programming and configuration application.
- Supports operation in hot standby redundant systems.
- Firmware upgrades using the WinLoader software utility.
- Built-in command-line interface function that supports direct monitoring and partial configuration by means of the module's Micro USB port or Telnet over Ethernet.
- Support for both star (switched) and linear (daisy-chained) network topologies.
- Four switched Ethernet ports (located on the underside) —
 - Two 8-conductor RJ-45 shielded twisted pair 10/100/1000 Mbps copper interfaces;
 - Two Small Form-factor Pluggable (SFP) cages for user-supplied SFP devices.
- Internal clock synchronized with the RX3i CPU for time-stamped diagnostics.
- Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1

Note: The USB port is intended for system setup and diagnostics only. It must not remain permanently connected.



Figure 394: IC695ECM850

16.11.1 Specifications: ECM850

Protocol Support	IEC 61850 Client as per PICs and MICs specifications
Power Requirements	3.3Vdc: 1.2 A with no SFP devices installed 1.9 A maximum (2 SFP devices installed, 0.35 A per SFP device)
	5Vdc: 1.1 A maximum
Operating Temperature Range	0 to 60°C De-rated to 57°C: <ul style="list-style-type: none"> • if 100 MB Fiber SFPs installed, or • if Copper SFPs operating at 1 GB.
Number of Port Connectors	Two RJ-45 and Two SFP Cages (SFP devices not included, available separately.)
Micro USB Connector	One, for communication with a computer using Command Line Interface.
Local Area Network (LAN)	IEEE 802.2 Logical Link Control Class I IEEE 802.3 CSMA/CD Medium Access Control 10/100/1000 Mbps
CPU Status Bits	32
Polling Rate ⁸³	Configurable for every IED connection from 0 to 31267 ms (default is 1000 ms).
Number of IP Addresses	One
Number of MAC Addresses	Five. One per external port and one internal.
Network Topologies Supported	Star (switched), linear (daisy-chain)
Time Synchronization	SNTP Client – Multicast and Broadcast
System Maximum Limits	
ECM850s per RX3i CPU	Four (4). All must be located in main rack. (Use in remote or expansion racks not supported).
No of IED connections supported per ECM850	32
No of IED connections supported per RX3i CPU	128
Maximum I/O Memory per ECM850	32 Kbytes of combined Input/Output memory
Maximum I/O Memory per RX3i CPU	128 Kbytes of combined Input/Output memory
No of PLC Protocol Variables ⁸⁴ (PPVs) per ECM850	5000

⁸³ The polling rate for each IED connection can be configured by the IEC 61850 Configurator. ECM850 also supports unsolicited communication using report control blocks (RCB). The RCB can be used for faster updates irrespective of polling rate, based on RCB trigger options. Refer to *PACSystems RX3i IEC 61850 Ethernet Communication Module User Manual*, GFK-2849 for more details.

⁸⁴ *PLC Protocol Variables* is defined as the set of RX3i controller variables which represents the IEC 61850 protocol data attributes in a structured format in a variable list. This typically includes the additional variables which are required to perform *WRITE* operations to an IED. Refer to *PACSystems RX3i IEC 61850 Ethernet Communication Module User Manual*, GFK-2849 for more details.

No of PPVs per RX3i CPU	20000
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16.11.1.1 Indicator LEDs

The following table summarizes the light-emitting diode (LED) indicator functions. More detailed information about error indications and blink patterns is given in *PACSystems RX3i IEC 61850 Ethernet Communication Module User Manual*, GFK-2849.

OK	Indicates whether the module is able to perform normal operation.
LAN	Indicates access to and activity on the Ethernet local area network (LAN). The LAN LED indicates network packets are being processed by the network interface (not just passing through the embedded switch)
STATUS	Indicates the condition of the ECM850 during normal operation. It indicates whether an entry other than the startup event is present in the module's local log. STATUS can also indicate whether any of the MAC addresses are invalid.
CONN	Indicates whether the module has received its configuration from the RX3i CPU.
ACTIVE	Indicates the status of IED connections.
USB	Indicates activity on the USB port.
1, 2, 3, 4	Indicates link speed, link connection and link activity corresponding to each of the four external Ethernet ports.

16.11.1.2 Connectors

Secure Digital (SD) Card Slot

The SD card slot is designed to support non-volatile memory cards in both standard capacity (SD) and high-capacity (SDHC) formats. It is provided for future use.

Switched Ethernet Ports

The ECM850 connects to an IEC 61850 network by means of one or more of its four switched external Ethernet ports. These are located on the underside of the module. Two 8-conductor RJ-45 shielded twisted pair 10/100/1000 Mbps copper interfaces and two Small Form-factor Pluggable (SFP) cages provide flexibility in media selection.

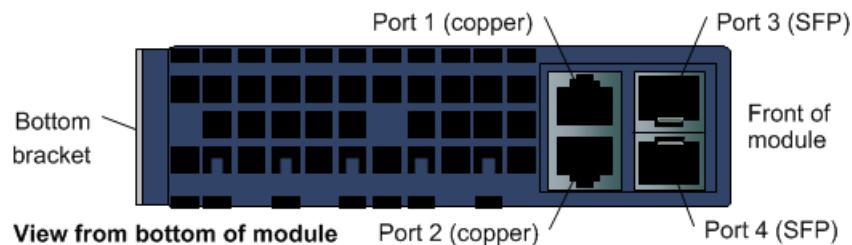


Figure 395: ECM850 Ethernet Connections (Located Underneath Module)

The module is assigned five Ethernet MAC addresses: one for each of the four external Ethernet ports and one for the internal switch.

Micro USB Port

The ECM850 has a USB Micro-B socket for connection to a computer running Windows Vista or Windows 7. The USB port can be used to access the Command Line Interface (CLI) function for the ECM850, using a terminal emulation application such as HyperTerminal. The Command Line Interface function can be used to monitor an ECM850 and check its operation. If a problem occurs, the Command Line Interface can be used to help determine the cause. A driver installation application is provided to configure a Windows computer to

communicate with the ECM850 through its USB port. Refer to *PACSystems RX3i IEC 61850 Ethernet Communication Module User Manual*, GFK-2849 for more details.

16.11.1.3 Restart Pushbutton

The Restart pushbutton on an ECM850 can be used to manually restart the module without cycling power. The restart operation begins when the pushbutton is released.

16.12 Ethernet Transmitter Module: IC695ETM001

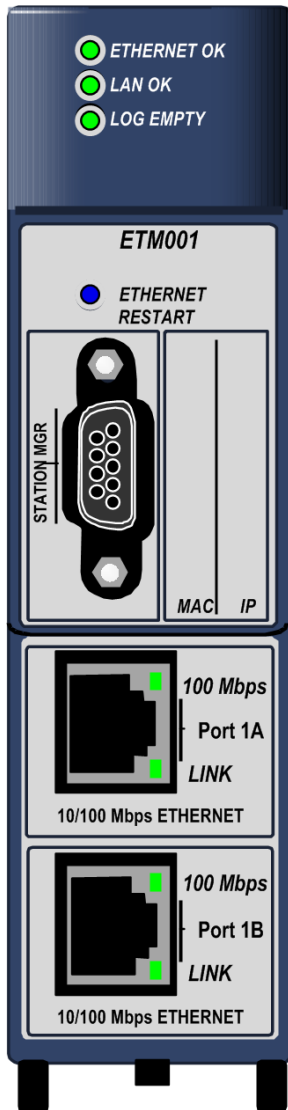


Figure 396: IC695ETM001

The Ethernet Transmitter Module, IC695ETM001, is used to connect a PACSystems RX3i controller to an Ethernet network. It enables the RX3i controller to communicate with other PACSystems equipment and with Series 90 and VersaMax controllers. The Ethernet interface provides TCP/IP communications with other PLCs, host computers running the Host Communications Toolkit or programmer software, and computers running the TCP/IP version of the programming software. These communications use the GE SRTP and Ethernet Global Data (EGD) protocols over a four-layer TCP/IP (Internet) stack.

Features of the RX3i Ethernet Transmitter Module include:

- Full PLC programming and configuration services
- Periodic data exchange using Ethernet Global Data (EGD)
- EGD Commands to read and write PLC and EGD exchange memory over the network.
- TCP/IP communication services using SRTP
- Comprehensive station management and diagnostic tools
- Extended PLC connectivity via IEEE 802.3 CSMA/CD 10Mbps and 100Mbps Ethernet LAN port connectors.
- Network switch that has Auto-negotiate, Sense, Speed, and crossover detection.
- Direct connection to BaseT (twisted pair) network switch, hub, or repeater without an external transceiver.

This module can be installed in any available RX3i I/O slot. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

For more information about this module, please refer to the following publications:

- *PACSystems RX7i & RX3i TCP/IP Ethernet Communications User Manual*, GFK-2224
- *PACSystems TCP/IP Ethernet Communications Station Manager User Manual*, GFK-2225

16.12.1 Specifications: ETM001

Ethernet processor speed	200 MHz
Connectors	Station Manager (RS-232) Port: 9-pin female D-connector Two 10BaseT / 100BaseTX Ports: 8-pin female shielded RJ-45
LAN	IEEE 802.2 Logical Link Control Class I IEEE 802.3 CSMA/CD Medium Access Control 10/100 Mbps
Number of IP addresses	One
Number of Ethernet Port Connectors	Two, both are 10BaseT / 100BaseTX with auto-sensing RJ-45 connection.
Embedded Ethernet Switch	Yes – Allows daisy chaining of Ethernet nodes.
Serial Port	Station Manager Port: RS-232 DCE, 1200 - 115200 bps.

For product standards and general specifications, refer to *Appendix A*.

16.12.2 Ethernet Interface Ports

The Ethernet Transmitter Module has two auto-sensing 10Base T / 100Base TX RJ-45 shielded twisted pair Ethernet ports for connection to either a 10BaseT or 100BaseTX IEEE 802.3 network. The port automatically senses the speed (10Mbps or 100Mbps), duplex mode (half duplex or full duplex) and cable (straight-through or crossover) attached to it with no intervention required. There is only one interface to the network (only one Ethernet MAC address and only one IP address).

16.12.2.1 Ethernet Media

The Ethernet Interface can operate directly on 10BaseT/100BaseTX media via its network ports.

10BaseT: 10BaseT uses a twisted pair cable of up to 100 meters in length between each node and a switch, hub, or repeater. Typical switches, hubs, or repeaters support 6 to 12 nodes connected in a star wiring topology.

100BaseTX: 100BaseTX uses a cable of up to 100 meters in length between each node and a switch, hub, or repeater. The cable should be data grade Category 5 unshielded twisted pair (UTP) or shielded twisted pair (STP) cable. Two pairs of wire are used, one for transmission, and the other for collision detection and receive. Typical switches, hubs, or repeaters support 6 to 12 nodes connected in a star wiring topology.

16.12.3 Station Manager

The built-in Station Manager function of the Ethernet Transmitter Module provides on-line supervisory access to the Ethernet Interface, through the Station Manager port or over the Ethernet cable. Station Manager services include:

- An interactive set of commands for interrogating and controlling the station.
- Unrestricted access to observe internal statistics, an exception log, and configuration parameters.
- Password security for commands that change station parameters or operation.

Refer to the *PACSystems TCP/IP Ethernet Communications Station Manager User Manual*, GFK-2225, for complete information on the Station Manager.

16.12.4 Firmware Upgrades

The Ethernet Transmitter Module receives its firmware upgrades indirectly from the PLC CPU using the WinLoader software utility. WinLoader is supplied with any updates to the Ethernet Interface software.

16.12.5 Ethernet Global Data (EGD)

Each PACSystems CPU supports up to 255 simultaneous Ethernet Global Data (EGD) exchanges. EGD exchanges are configured using the programmer and stored into the PLC. Both Produced and Consumed exchanges can be configured. PACSystems Ethernet Interfaces support both selective consumption of EGD exchanges and EGD exchange production and consumption to the broadcast IP address of the local subnet. The Ethernet Interface can be configured to use SNTP to synchronize the timestamps of produced EGD exchanges.

The Ethernet Transmitter Module implements the capabilities of a Class 1 and Class 2 device. COMMREQ-driven EGD Commands can be used in the application program to read and write data into the CPU or other EGD Class 2 devices.

16.12.6 Ethernet Interface Controls and Indicators

16.12.6.1 LEDs

- The **Ethernet OK** LED indicates whether the module is able to perform normal operation. This LED is On for normal operation and flashing for all other operations. If a hardware or runtime failure occurs, the EOK LED blinks a two-digit error.
- The **LAN OK** LED indicates access to the Ethernet network. The LAN LED blinks when data is being sent or received over the network directed to or from the Ethernet interface. It remains On when the Ethernet interface is not actively accessing the network but the Ethernet physical interface is available and one or both of the Ethernet ports is operational. It is Off otherwise unless software load is occurring.
- The **Log Empty** LED is On during normal operation. It is Off if an event has been logged.
- Two Ethernet network LEDs (**LINK**) indicate the network link status.
- Two Ethernet network speed LEDs (**100Mbps**) indicate the network data speed (10 (off) or 100 Mb/sec (on)).

16.12.6.2 Ethernet Restart Pushbutton

This pushbutton is used to manually restart the Ethernet firmware without power cycling the entire system. It is recessed to prevent accidental operation.

16.12.6.3 Connectors

The module has two 10BaseT/100BaseTX Ethernet Network Port Connectors. There is only one interface to the network (only one Ethernet MAC address and only one IP address).

The Station Manager (RS-232) Serial Port is serviced via the D-connector on the front panel.

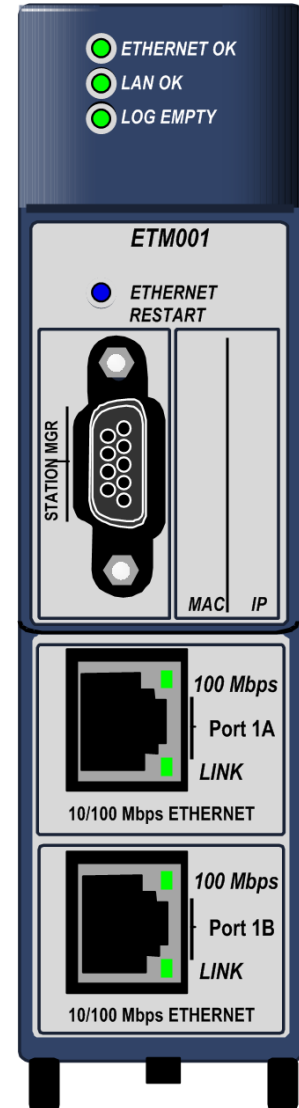


Figure 397: Ethernet Features
ETM001

16.13 RX3i DNP3 Outstation Module: IC695EDS001

The PACSystems RX3i DNP3 Outstation Module IC695EDS001 is an Ethernet-connected module which fits in the RX3i backplane and permits the RX3i to behave as an Outstation on the DNP3 network, where it may interact with up to eight DNP3 masters.

16.13.1 Module features:

- Two auto-sensing RJ-45 Ethernet ports with LED indicators
 - Connects via Ethernet at 10BaseT or 100BaseTX
 - Internal network switch with Auto-negotiate, Sense, Speed, and crossover detection
 - Supports Linear (daisy-chained) and Star network configurations
 - TCP/IP and LLA protocols supported
 - One Ethernet MAC Address and one IP Address per module
 - Time synchronization to SNTP Time Server
 - Recessed Ethernet Restarts pushbutton to manually restart the Ethernet firmware without power-cycling the module.
- Dedicated RS-232 Station Manager Port for network supervision
- LED behavior same as ETM001
- DNP3 configuration via a single COMMREQ command
 - Data exchanges up to 12,072 points and 20,000 events supported
 - Eight DNP3 Objects supported: DI, DI w/time, DO, DO w/time, CROB, analog output values, time setting, and class polls
 - Multiple RX3i memory types may be utilized for DNP3 data exchange
 - Binary DI/DO
 - Analog (32-bit signed, 16-bit signed, or single-precision floating point)
 - Supports unsolicited data communications with DNP3 Master
- Compatible with any RX3i CPU, including redundant controllers
 - Up to 4 EDS001 per RX3i, as allowed by available power and slots
 - Module can be installed in any available RX3i main rack I/O slot
 - Module supports insertion into and removal from an RX3i backplane which is under power.
 - Firmware upgrade via RX3i CPU using WinLoader software utility

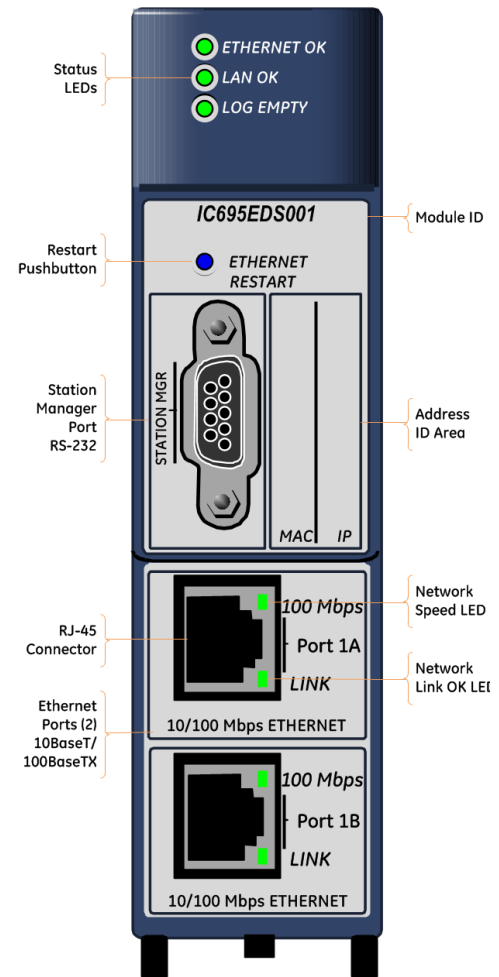


Figure 398: EDS001 Features at a Glance

For more information about this module, please refer to *PACSystems RX3i DNP3 Outstation Module IC695EDS001 User's Manual*, GFK-2911.

16.14 RX3i IEC 104 Server Module: IC695EIS001

The PACSystems RX3i Ethernet IEC 104 Server Module, catalog number IC695EIS001, implements the IEC 60870-5-104 communications protocol. It permits a PACSystems RX3i controller to be connected to an Ethernet network using a standard TCP/IP connection scheme, allowing an IEC 104 Client to poll data from the Server, as well generate unsolicited communications from the Server back to the Client.

Two auto-sensing 10BaseT/100BaseTX RJ-45 shielded twisted-pair Ethernet ports permit direct connection to either a 10BaseT or 100BaseTX IEEE 802.3 network without an external transceiver. Line, Star and Daisy Chain topologies are supported.

The RX3i Ethernet IEC 104 Server Module hosts the IEC104 Server side protocol on a common RX3i ETM001 module hardware platform. Thus, many of the specifications and behaviors are shared with the ETM001 module including protocol support. IC695EIS001 is an Ethernet-connected module that fits in the RX3i backplane and permits the RX3i to behave as a Server on the IEC104 network. The data exchanges between the EIS001 module and IEC104 Client(s) are configurable, using a single COMMREQ instruction in the ladder logic or Structured Text program.

16.14.1 Module Features

- Supports one connection to the RX3i Controller data set specified in the configuration.
- Supports Interrogation and RBE for Single Point and Double Point data.
- Supports Interrogation and RBE for Regulated Step.
- Supports Interrogation and Measured data sets for Scaled, normalized, and single precision Float.
- Supports 56-bit IEC 60870-5-104 time format, with the default being 56-bit time format.
- Supports *Time Set*, and query of the RX3i Controller CPU Clock in UTC time.
- *Cause of Transmission* size is two octets.

RX3i Interface specifications:

- Up to four EIS001 per RX3i, as allowed by available power and slots.
- Module can be installed in any available RX3i main rack I/O slot.
- Module supports insertion into and removal from an RX3i backplane which is under power.
- Firmware upgrade through RX3i CPU using WinLoader software utility.

For more information about this module, please refer to *PACSystems RX3i IEC 104 Server Module IC695EIS001 User's Manual*, GFK-2949.

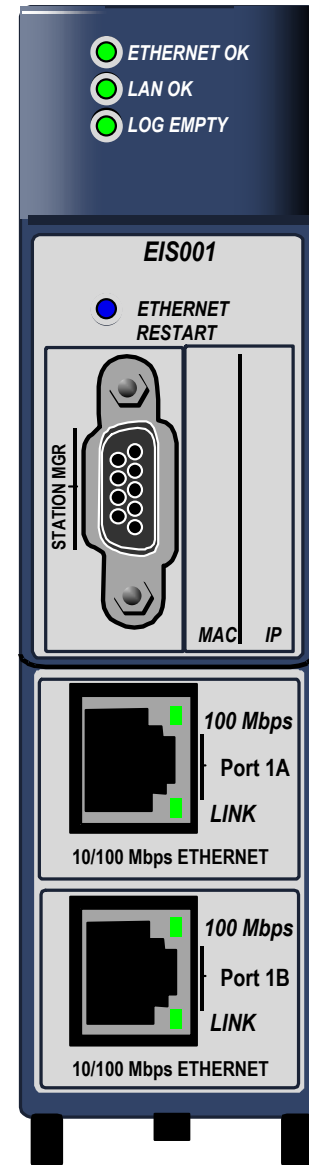


Figure 399: EIS001 Front View

16.15 Ethernet Network Interface Unit: IC695NIU001

The PACSystems RX3i Ethernet NIU, IC695NIU001, makes it possible to use PACSystems RX3i and Series 90-30 I/O remotely on an Ethernet network. System control can be provided by any GE master device that is capable of exchanging Ethernet Global Data.

The Ethernet NIU resides in an I/O station that consists of:

- an RX3i Universal Backplane (IC695CHS0xx)
- an RX3i power supply (IC695PSxxxx)
- the RX3i Ethernet NIU (IC695NIU001)
- one or more RX3i Ethernet modules (IC695ETM001), as required for Ethernet communications
- proprietary application software
- Optional Series 90-30 expansion backplanes.
- PACSystems RX3i and/or Series 90-30 modules, as appropriate for the application.

16.15.1 Ethernet NIU Features

- 20Kbytes of optional local logic. Supports all languages except C programming.
- 10 Mbytes of built-in flash memory for local user data storage.
- Battery-backed calendar clock.
- In-system upgradeable firmware.
- Two serial ports: an RS-485 serial port and an RS-232 serial port.
- Supports Ethernet communications via the backplane-based Ethernet Transmitter Module (IC695ETM001)
- Data exchange using Ethernet Global Data (EGD)
- TCP/IP communication services using SRTIP
- Comprehensive station management and diagnostic tools
- Supports operation with redundant controllers

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

This section gives a brief overview of the Ethernet NIU module. For details of installing, configuring, and operating an Ethernet NIU, please refer to the *PACSystems RX3i Ethernet Network Interface Unit User's Manual*, GFK-2439.

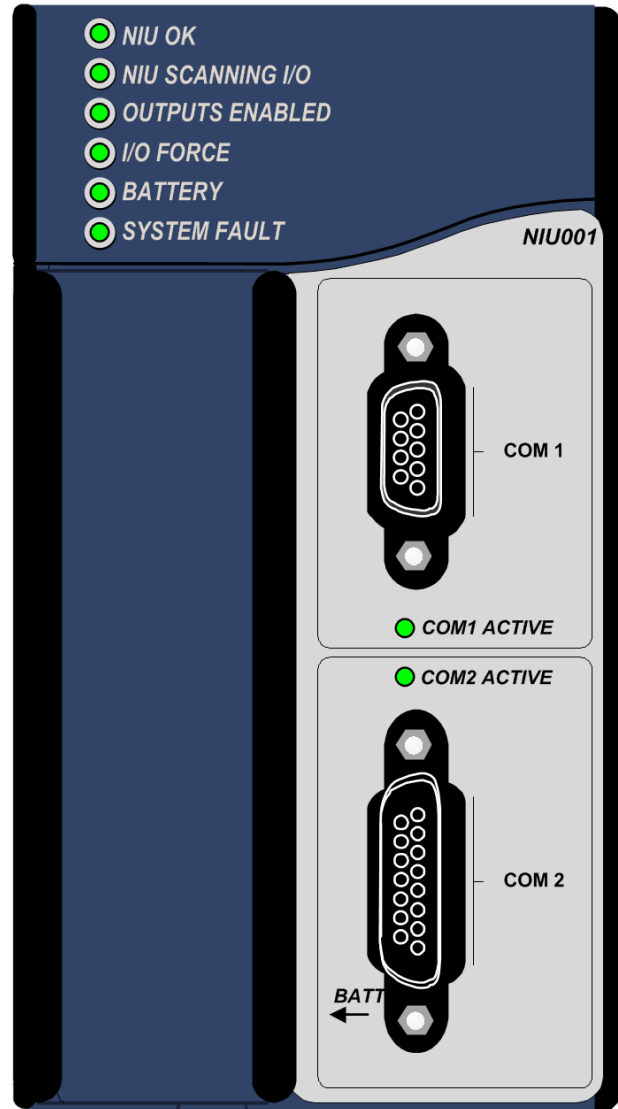


Figure 400: IC695NIU001

16.15.2 Specifications: NIU001

Battery	For estimated battery life under various conditions, refer to the <i>PACSystems Battery and Energy Pack Manual</i> , GFK-2741.
Power requirements	+3.3Vdc: 1.25 Amps nominal, +5Vdc: 1.0 Amps nominal
Operating Temperature	0°C to 60°C (32°F to 140°F)
Floating point	Yes
Embedded communications	RS-232, RS-485
Serial Protocols supported	Modbus RTU Slave, SNP, Serial I/O, Modbus RTU Master by application "C" block
Backplane	Dual backplane bus support: RX3i PCI and 90-30-style serial
PCI compatibility	System designed to be electrically compliant with PCI 2.2 standard

For product standards and general specifications, refer to *Appendix A*.

16.15.3 Ethernet Global Data Features

The Ethernet NIU communicates with its controller via Ethernet Global Data exchanges. One exchange is used to send outputs to the Ethernet NIU and another exchange is used to send inputs back to the controller.

The Ethernet NIU can also use Ethernet Global Data exchanges to receive the following COMMREQ commands from a PACSystems Rx7i or RX3i controller:

- Modbus Master – function codes 1, 2, 3, 4, 5, 6, 7, 15, 16, 17
- Genius – enable/disable outputs, switch BSM, clear fault, clear all faults, assign monitor, read diagnostic
- Profibus Master – COMMREQs 1, 2, 4, 5, 6
- Motion (DSM314/DSM324) – load parameters
- High Speed Counter – Data command
- DeviceNet Master – COMMREQs 1, 4, 5, 6, 7, 9
- Analog Module – HART Protocol COMMREQs

The Ethernet NIU executes the COMMREQ and sends the results back to the RX7i or RX3i using another Ethernet Global Data exchange.

16.15.4 Ports

The NIU has two independent, on-board serial ports, accessed by connectors on the front of the module. These ports provide serial interfaces to external devices.

Port 1 (COM1) is a DCE port that allows a simple straight-through cable to connect with a standard AT-style RS-232 port. It has a 9-pin, female, D-sub connector with a standard pin out.

Port 2 (COM2) is a DCE port that is RS-485 compatible. Port 2 has a 15-pin, female D-sub connector.

The Ethernet NIU does not have an Ethernet port. Ethernet communications are provided by one or more Ethernet Transmitter Modules (described previously in this chapter) located in the I/O Station.

16.15.4.1 Protocols Supported

Protocol	Port 1	Port 2
RTU (slave)	Yes	Yes
SNP Slave	Yes	Yes
Serial I/O ⁸⁵	Yes	Yes
Firmware Upgrade	ENIU in STOP/No I/O mode	
Message Mode (C Runtime Library Functions: serial read, serial write, sscanf, sprintf)	Yes	Yes

16.15.4.2 Serial Port Baud Rates

Protocol	Port 1 (RS-232)	Port 2 (RS-485)
Modbus RTU Slave protocol	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Message	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Firmware Upgrade via WinLoader	2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
SNP Slave	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Serial I/O	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	

⁸⁵ Modbus Master is supported in application code in Serial I/O mode.

16.16 Ethernet Network Interface Unit: IC695NIU001 PLUS

The PACSystems RX3i Ethernet NIU PLUS, IC695NIU001, makes it possible to use PACSystems RX3i and Series 90-30 I/O remotely on an Ethernet network. Once set up by configuration, data exchange is completely automatic. System control can be provided by any master device capable of exchanging Ethernet Global Data (EGD). The Ethernet NIU automatically provides the controller with status information in each exchange. The application program logic in the controller can monitor this status data, and issue appropriate commands to the Ethernet NIU.

An RX3i Ethernet NIU station consists of:

- an RX3i Universal Backplane (IC695CHS0xx)
- an RX3i power supply (IC695PSxxxx)
- the RX3i Ethernet NIU (IC695NIU001)
- one or more RX3i Ethernet modules (IC695ETM001)
- proprietary application software
- optional Series 90-30 expansion backplanes.
- PACSystems RX3i and/or Series 90-30 modules, as appropriate for the application.

The Ethernet NIU is compatible with the same types of modules, backplanes, and other equipment as a PACSystems RX3i CPU. For a list of compatible products, refer to the *PACSystems RX3i Hardware and Installation Manual*, GFK-2314.

Module does not support insertion into or removal from an RX3i Universal Backplane which is under power (see *Hot Insertion and Removal Not Supported*, Section 2.6.4.2).

This module requires Machine Edition Logic Developer software, version 5.51 or later.



Figure 401: IC695NIU001 PLUS

16.16.1 Compatibility

The Ethernet NIU PLUS is compatible with the same types of modules, backplanes, and other equipment as a PACSystems RX3i CPU.

This module requires Logic Developer software, version 6.50 or later. Additional product enhancements require the use of later programmer software versions, as detailed in the *Ethernet NIU PLUS datasheet*, GFK-2598.

The NIU001 Classic and NIU001 Plus are interchangeable. An application created for an NIU001 PLUS can be used with an NIU001 Classic and vice versa.

16.16.2 Features: Ethernet NIU001 PLUS

- 20 Kbytes of optional local logic. Supports all languages except C programming.
- 10 Mbytes of built-in flash memory for local user data storage.
- Battery-backed Real Time Clock.
- In-system upgradeable firmware.
- Two serial ports: an RS-485 serial port and an RS-232 serial port.
- Supports Ethernet communications via the backplane-based Ethernet Interface module (IC695ETM001)
- Data exchange using EGD
- TCP/IP communication services using SRTIP
- Comprehensive station management/diagnostic tools
- Supports operation with redundant controllers
- PACSystems RX7i and RX3i controllers can send selected COMMREQs to the RX3i ENIU via EGD. The ENIU executes the COMMREQs and returns the results to the controller.
- During EGD configuration, RX3i Ethernet interfaces are identified by their Backplane/Slot locations.
- Supports display of module hardware revision, serial number and date code in Machine Edition Logic Developer software.
- Units manufactured with date codes greater than 1129 are compliant with EU RoHS Directive 2002/95/EC using the following exemptions identified in the Annex: 7a, 7c-I, & 7c-III.

16.16.3 Ethernet Global Data Features

The Ethernet NIU communicates with its controller via EGD exchanges. One exchange is used to send outputs to the ENIU and another exchange is used to send inputs back to the controller. The ENIU supports receiving outputs from redundant controllers. By sending the EGD exchange to a group address both controllers can receive the inputs. Up to 1300 bytes of outputs can be sent to a set of ENIUs from a controller. Each ENIU can send up to 1300 bytes of inputs to the controller.

A typical system might consist of a controller with five ENIUs. The controller sends 1300 bytes of outputs and each ENIU sends 100 bytes of inputs to the controller. This typical system would have its I/O updates occur in less than 25ms. Whenever the controller scan time is greater than 25ms, the update occurs at the scan rate of the controller. This performance timing is a guideline, not a guarantee, and assumes that there is no other traffic on the Ethernet link to the I/O. Performance data for other system configurations can be found in the *PACSystems RX3i Ethernet Network Interface Unit User's Manual*, GFK-2439.

16.16.4 Ethernet NIU COMMREQ Support

The Ethernet NIU supports COMMREQs that are sent to it by a C block application in a PACSystems RX7i or RX3i controller. This feature is not available with other types of controllers. Ladder code in the RX7i or RX3i CPU interfaces to the C block. The C block sends COMMREQ commands to the Ethernet NIU in an Ethernet Global Data Exchange. The Ethernet NIU executes the COMMREQ and sends the results back to the RX7i or RX3i using another EGD exchange. The following COMMREQs can be sent in this way:

- Modbus Master – function codes 1, 2, 3, 4, 5, 6, 7, 15, 16, 17
- Genius – enable/disable outputs, switch BSM, clear fault, clear all faults, assign monitor, read diagnostic
- PROFIBUS Master – COMMREQs 1, 2, 4, 5, 6
- Motion (DSM314/DSM324) – load parameters
- High Speed Counter – Data command
- DeviceNet Master – COMMREQs 1, 4, 5, 6, 7, 9
- Analog Module – HART Protocol COMMREQs.

In addition, any COMMREQ supported by a module in the Ethernet NIU can be sent as a Generic COMMREQ, with the exception of DeviceNet Master Send Extended Explicit Message. For more information, refer to the *PACSystems RX3i Ethernet Network Interface Unit User's Manual*, GFK-2439.

16.16.5 Specifications: NIU001 PLUS

Real Time Clock battery life	Estimated 5 years. Battery must be replaced every 5 years on a regular maintenance schedule. Note: The module is shipped with a pull-tab on the battery. The pull-tab should be removed before installing the module.
Power requirements	+3.3Vdc: 0.52 Amps nominal +5.0 V dc: 0.95 Amps nominal
Operating Temperature	0°C to 60°C (32°F to 140°F)
Floating point	Yes
Boolean execution speed, typical	0.072 ms per 1000 Boolean instructions
Embedded communications	RS-232, RS-485
Serial Protocols supported	Modbus RTU Slave, SNP, Serial I/O, Modbus RTU Master by application "C" block
Backplane	Dual backplane bus support: RX3i PCI and 90-30-style serial
PCI compatibility	System designed to be electrically compliant with PCI 2.2 standard
Ports	RS-232 Serial Port RS-485 Serial Port External isolation recommended. (For details, refer to <i>RS-485 Port Isolator, IC690ACC903</i> , GFK-1663.)

For environmental specifications and compliance to standards (for example, FCC or European Union Directives), refer to the *PACSystems RX3i Hardware and Installation Manual*, GFK-2314.

16.16.6 NIU001 PLUS vs. NIU001 Classic Comparison

Feature	NIU001 Classic	NIU001 PLUS
Processor	Celeron 300 MHz	Atom 510, 1.1 GHz
Real Time Clock Battery	Not supported	IC690ACC001
Memory Backup and Real Time Clock Battery	IC698ACC701	Not supported
Embedded communications	RS-232, RS-485	RS-232, RS-485
Power requirements	+3.3Vdc: 1.25 Amps nominal +5.0 V dc: 1.0 Amps nominal	+3.3Vdc: 0.52 Amps nominal +5.0 V dc: 0.95 Amps nominal
Performance	Same as CPU310. For performance data, refer to the <i>PACSystems RX7i and RX3i CPU Reference Manual</i> , GFK-2222.	Note: The processor has been upgraded from a 300MHz Celeron to a 1.1 GHz Atom processor. There have been many associated changes to the performance compared to the NIU001 Classic. For performance data, refer to the <i>PACSystems RX7i and RX3i CPU Reference Manual</i> , GFK-2222R or later.
Boolean execution speed, typical	0.181 ms per 1000 Boolean instructions	0.072 ms per 1000 Boolean instructions
Battery and switch locations	For details, refer to the <i>PACSystems RX3i Ethernet Network Interface Unit User's Manual</i> , GFK-2439.	For details, refer to the <i>PACSystems RX3i Ethernet Network Interface Unit User's Manual</i> , GFK-2439

16.16.7 Ports

The NIU PLUS has two independent, on-board serial ports, accessed by connectors on the front of the module. These ports provide serial interfaces to external devices.

Port 1 (COM1) is a DCE port that allows a simple straight-through cable to connect with a standard AT-style RS-232 port. It has a 9-pin, female, D-sub connector with a standard pin out.

Port 2 (COM2) is a DCE port that is RS-485 compatible. Port 2 has a 15-pin, female D-sub connector.

The Ethernet NIU does not have an Ethernet port. Ethernet communications are provided by one or more Ethernet Transmitter Modules (described previously in this chapter) located in the I/O Station.

16.16.7.1 Protocols Supported

Protocol	Port 1	Port 2
RTU (slave)	Yes	Yes
SNP Slave	Yes	Yes
Serial I/O ⁸⁶	Yes	Yes
Firmware Upgrade	ENIU in STOP/No I/O mode	
Message Mode (C Runtime Library Functions: serial read, serial write, sscanf, sprintf)	Yes	Yes

16.16.7.2 Serial Port Baud Rates

Protocol	Port 1 (RS-232)	Port 2 (RS-485)
Modbus RTU Slave protocol	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Message	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Firmware Upgrade via WinLoader	2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
SNP Slave	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	
Serial I/O	1200, 2400, 4800, 9600, 19.2k, 38.4k, 57.6k, 115.2k	

⁸⁶ Modbus Master is supported in application code in Serial I/O mode.

16.17 Profibus Master Module: IC695PBM300

The RX3i PROFIBUS Master Module, IC695PBM300, allows the RX3i CPU to send and receive data on a PROFIBUS-DP network.



Figure 402: IC695PBM300

16.17.1 Features

The IC695PBM300 module provides the following features:

- supports up to 125 PROFIBUS-DP slaves
- supports up to 244 bytes of input data and 244 bytes of output data per slave
- Supports up to 3,584 bytes of input data and 3,584 bytes of output data total
- Supports all standard data rates
- Supports Sync and Freeze modes
- Supports DP-V1 Read, Write and Alarm messages
- PROFIBUS-compliant Module and Network Status LEDs

This module must be located in an RX3i Universal Backplane. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

For more information about this module, please refer to the *PACSystems RX3i Profibus Module User's Manual*, GFK-2301.

16.17.2 Profibus Master Module Controls and Indicators

16.17.2.1 Network Connector

The Profibus Master module has a 9-pin sub-D connector for attaching the bus cable. For pin assignments, segment length, cable type and termination requirements, refer to the *RX3i PACSystems PROFIBUS Modules User's Manual*, GFK-2301.

16.17.2.2 LEDs

The PROFIBUS Master module provides three PROFIBUS-compliant LEDs that indicate module and network status.

- The green OK LED indicates the presence of power, and completion of backplane reset.
- The bicolor Network LED is steadily yellow when the module is holding the PROFIBUS token and able to transmit PROFIBUS telegrams. It flashes yellow if the module is sharing the network with another PROFIBUS master. The Network LED is red if a communications problem such as a connection timeout exists with at least one slave on the network.
- The bi-color Mod Status LED indicates module status. When this LED is steadily green, the module is configured and has established a connection with a least one device on the network. If it is flashing green, the module may be waiting for a configuration or may have a firmware problem. If it is flashing yellow, the module is in boot loader mode, downloading firmware, or has a non-recoverable error. The rate of LED flashing provides additional status information as described in the *RX3i Profibus Modules User's Manual*.

16.17.3 Specifications: PBM300

Backplane Current Consumption	440 mA at 3.3Vdc
Data rates	Supports all standard data rates (9.6 kBit/s, 19.2 kBit/s, 93.75 kBit/s, 187.5 kBit/s, 500 kBit/s, 1.5 MBit/s, 3 MBit/s, 6 MBit/s and 12 MBit/s)
Status Information Available	Slave Status Bit Array Table Network Diagnostic Counters DP Master Diagnostic Counters Firmware Module Revision Slave Diagnostic Address

16.18 Profibus Slave Module: IC695PBS301

The IC695PBS301 provides slave communications on a PROFIBUS DP network. The slave module automatically exchanges data with a master device. The slave module has no bus access rights. It can only acknowledge received messages or transmit messages to a master upon request.

The PROFIBUS Slave module provides the following PROFIBUS communications features:

- Ability to read up to 244 bytes of input data from the network, and send up to 244 bytes of output data
- Support for all standard PROFIBUS data rates
- Support for DP-V1 Read, Write and Alarm messages
- PROFIBUS-compliant module and network status LEDs

This module must be located in an RX3i Universal Backplane. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

The PROFIBUS module receives its firmware upgrades indirectly from the host controller CPU using the WinLoader software utility. WinLoader is supplied with any updates to the PROFIBUS module software.



Figure 403: IC695PBS301

16.18.1 Profibus Slave Module Controls and Indicators

16.18.1.1 Network Connector

The PROFIBUS Slave module has a 9-pin sub-D connector for attaching the bus cable. For pin assignments, segment length, cable type and termination requirements, refer to the *RX3i PACSystems PROFIBUS Modules User's Manual*, GFK-2301.

16.18.1.2 LEDs

The PROFIBUS Slave module provides three PROFIBUS-compliant LEDs that indicate module and network status.

- The green Profibus OK LED indicates the presence of power, and completion of backplane reset.
- The bicolor Network LED is yellow when the module is able to transmit PROFIBUS telegrams. It is red if a critical communications problem has occurred.
- The bi-color Mod Status LED indicates module status. When this LED is steadily green, the module is configured and has established a connection with the network master. If it is flashing green, the module may be waiting for a configuration or may have a firmware problem. If it is flashing yellow, the module is in boot loader mode, downloading firmware, or has a non-recoverable error. The rate of LED flashing provides additional status information as described in the *RX3i Profibus Modules User's Manual*.

16.18.2 Specifications: PBS301

Backplane current consumption	440mA at 3.3Vdc
Data rates	Supports all standard data rates (9.6 kBit/s, 19.2 kBit/s, 93.75 kBit/s, 187.5 kBit/s, 500 kBit/s, 1.5 MBit/s, 3 MBit/s, 6 MBit/s and 12 MBit/s)
Status information available	Slave Status Word

For product standards and general specifications, refer to *Appendix A*.

16.19 PROFINET Controller Module: IC695PNC001

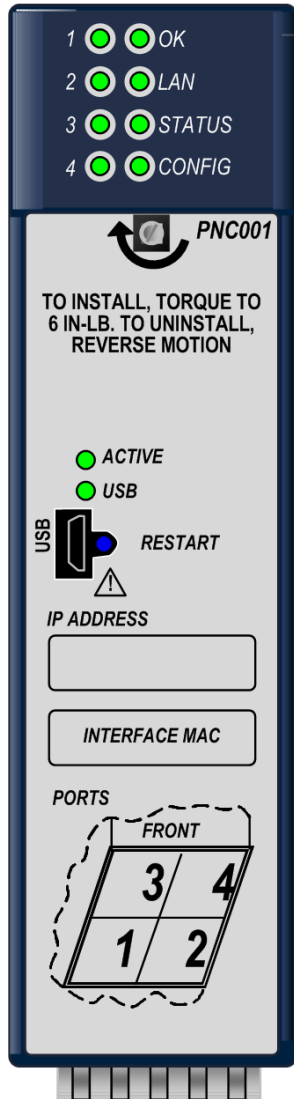


Figure 404: IC695PNC001

The PACSystems RX3i PROFINET Controller (PNC) module, IC695PNC001, connects a PACSystems RX3i controller to a high-speed PROFINET local area network. It enables the RX3i controller to communicate with IO-Devices on the LAN. The PNC module provides all the functions, services, and protocols required for certification as a PROFINET IO Version 2.2 IO Controller, running at both 100 Mbps and 1 Gbps. The PNC supports 10/100/1000 Mbps Copper, 100/1000 Mbps Multi-mode Fiber, and 100/1000 Mbps Single-mode Fiber. The LAN can include media interfaces of more than one type. PROFINET communications on the LAN require 100 and 1000 Mbps link speed. 10 Mbps cannot be used for PROFINET communications. However, 10 Mbps can be used for other types of Ethernet traffic such as ping and telnet.

16.19.1 Features:

- Full programming and configuration services for the PROFINET Controller, VersaMax PROFINET Scanner and third-party IO-Devices using Proficy Machine Edition.
- Firmware upgrades using the WinLoader software utility.
- Built-in Command Line Interface function that provides direct monitoring and partial configuration via the micro USB port or using telnet.

Note: The USB port is for system setup and diagnostics only. It is not intended for permanent connection.

- Support for star, ring, and daisy-chain/line network topologies.
- Four switched Ethernet ports - two 8-conductor RJ-45 shielded twisted pair 10/100/1000 Mbps copper interfaces and two Small Form-factor Pluggable (SFP) cages for user-supplied SFP devices.
- Internal clock synchronized with the RX3i CPU for time-stamped diagnostics entries.
- Restart pushbutton to manually restart the module without power cycling the system.
- LEDs: OK, LAN, STATUS, CONFIG, ACTIVE, USB, and four Port LEDs.
- Compliant with EU RoHS Directive 2002/95/EC using the following exemptions identified in the Annex: 7c-I and & 7c-III.

For installation instructions and operating details, refer to the following manuals:

PACSystems RX3i PROFINET Controller Manual, GFK-2571

PACSystems RX3i PROFINET Controller Command Line Interface Manual, GFK-2572

PACSystems HSB Hot Standby CPU Redundancy User's Manual, GFK-2308.

16.19.2 Specifications: PNC001

PROFINET Support	PROFINET Version 2.2 General Class A IO-Controller
CPU Compatibility	CPU330 firmware version 8.45 or later CPU315 or CPU320, with firmware version 7.0 or higher.
Power Requirements	3.3 V: 0.5 A with no SFP devices installed 1.2 A maximum (two SFP devices installed, 0.35 A per SFP device)
	5 V: 1.5 A maximum
Operating Temperature Range	0 to 60°C maximum surrounding air temperature without a fan. A lower maximum temperature may be required depending on PNC location and SFP population. Refer to <i>Operating Range for Surrounding Air Temperature</i> below.
Number of Port Connectors	Two RJ-45 and Two SFP Cages (SFP devices not included, available separately)
Micro USB Connector	One, for communication with a computer using Command Line Interface.
LAN	IEEE 802.2 Logical Link Control Class I IEEE 802.3 CSMA/CD Medium Access Control 10/100/1000 Mbps
Maximum I/O Memory	128 Kbytes of combined input/output memory per PROFINET Controller
CPU Status Bits	32
PROFINET IO Device Data Update Rates on the PROFINET LAN	Configurable: 1 ms, 2 ms, 4 ms, 8 ms, 16 ms, 32 ms, 64 ms, 128 ms, 256 ms and 512 ms
Number of IP addresses	One
Number of MAC Addresses	Five. One per external port and one internal.
Hot-swappable	Yes. Before hot swapping, refer to the <i>PACSystems RX3i PROFINET Controller Manual</i> , GFK-2571.

System Maximum Limits

PROFINET Controllers per RX3i CPU	4. Must be located in main rack. Cannot be located in a remote node.
IO-Devices per IO-Controller	64 per PROFINET Controller
IO-Devices per Network	255 per network, spread across up to 8 IO-Controllers
IO-Devices per RX3i CPU	255 per RX3i CPU, spread across up to 4 PROFINET Controllers
IO-Controllers per network	8
Number of PROFINET Slots per device	256
Number of PROFINET Subslots per slot	256
Number of PROFINET Submodules per RX3i CPU	2048

Programmer Limits

Number of IO-Controllers	128 (32 RX3i CPU targets × 4 IO-Controllers per RX3i CPU)
Number of IO-Devices	2048 (128 per network × 16 PROFINET networks)
Total number of devices	2176 (not including backplanes, power supplies, or I/O modules)

For product standards and general specifications, refer to *Appendix A*.

16.19.2.1 Operating Range for Surrounding Air Temperature

Baseline Installation	0 to 60°C surrounding air temperature under the following installation: <ul style="list-style-type: none"> ▪ 12-slot panel mounted backplane ▪ Two PNC modules in adjacent slots per backplane ▪ 1 GB Fiber SFPs ▪ All four ports active
-----------------------	--

The following installation exceptions are cumulative:

Installation Exceptions	Reduces maximum operating temperature: <ul style="list-style-type: none"> ▪ If 7 slot backplane, then reduce by 2°C ▪ If air mounted (rack mount), then reduce by 2°C ▪ If three or four PNCs per backplane, then reduce by 1°C ▪ Either/or: <ul style="list-style-type: none"> - If 100 MB Fiber SFPs installed, then reduce by 5°C - If Copper SFPs operating at 1 GB, then reduce by 6°C
	Increases maximum operating temperature to an upper limit of 60°C: <ul style="list-style-type: none"> ▪ If only one PNC per backplane, then increase by 2°C ▪ If PNC in non-adjacent slots, then increase by 1°C ▪ If Copper SFP operating at 100MB, then increase by 4°C ▪ If RJ45 ports unused, then increase by 0°C ▪ If 16 slot backplane, then increase by 0°C

Example - Calculating Maximum Operating Temperature with Installation Exceptions

Baseline Installation	60°C
7 slot Backplane	-2°C
Two PNC modules in non-adjacent slots	+1°C
Copper SFPs operating at 1 GB	-6°C
Maximum operating temperature after installation exceptions	53°C

16.20 PROFINET Scanner Module: IC695PNS001

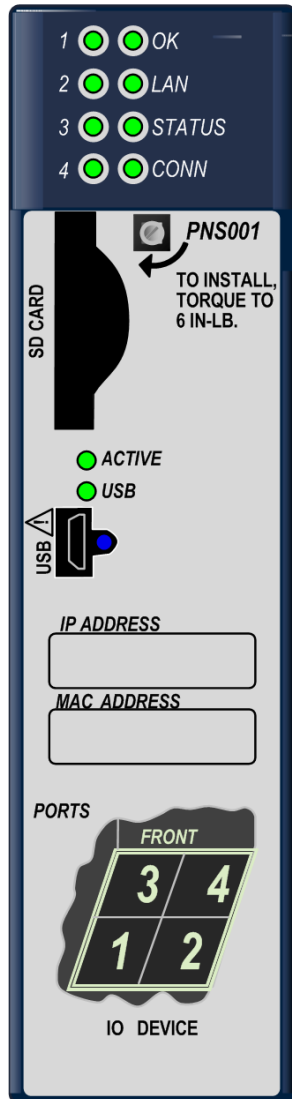


Figure 405: IC695PNS001

For additional information, please refer to *PACSystems RX3i PROFINET Scanner Manual*, GFK-2737.

The PACSystems* RX3i PROFINET Scanner (PNS) module, IC695PNS001, connects a remote universal RX3i I/O rack of Series 90-30 or RX3i modules to a PROFINET I/O Controller. The PROFINET Scanner scans the modules in its rack, retrieving input data and providing output data, and exchanges that data on the PROFINET I/O LAN at the configured production rate.

The PNS manages PROFINET communication and module configuration between an I/O Controller and modules in the remote rack. If network communications are lost, the PNS manages I/O states according to the individual module configurations.

The PNS supports 10/100/1000 Mbps Copper, 100/1000 Mbps Multi-mode Fiber, and 100/1000 Mbps Single-mode Fiber. PROFINET communications on the network require 100 or 1000 Mbps link speed. Although 10 Mbps cannot be used for PROFINET communications, 10 Mbps can be used for other types of Ethernet traffic such as PING.

16.20.1 Features



- Programming and configuration services for all supported Series 90-30 and RX3i I/O Modules using Proficy Machine Edition. Refer to table below for compatibility details.
- Support for daisy-chain/line, star, or ring (PROFINET Media Redundancy Protocol (MRP)) topologies.
- Four switched Ethernet ports - two 8-conductor RJ-45 shielded twisted pair 10/100/1000 Mbps copper interfaces and two Small Form-factor Pluggable (SFP) cages for user-supplied SFP devices.
- The network can include media interfaces of more than one type.
- Support for transfer of I/O Device Name to another PNS module using an SD card. This eliminates the need to connect a configuration tool, such as Proficy Machine Edition when replacing a module.
- A USB port for field updates of firmware using WinLoader.

Note: The USB port is for firmware upgrades only. It is not intended for permanent connection.

16.20.2 LED Indications: PNS001



16.20.2.1 OK LED

The OK LED indicates whether the module is able to perform normal operation.

	Green, on	OK
	Off	Not OK



16.20.2.2 LAN LED

The LAN LED indicates access to and activity on the Ethernet network. The LAN LED indicates network packets are being processed by the network interface (not just passing through the embedded switch).

	Blinking on	The network interface in the module is active
	Off	No activity




16.20.2.3 STATUS LED

The STATUS stays Green during normal operation.

	Green, on	Normal Operation
	Red, blinking	A MAC address read from nonvolatile memory is invalid. Ports with invalid MAC addresses remain disconnected from the Ethernet network.









16.20.2.4 CONN LED

The CONN LED indicates the status of PROFINET connections.

	Green, on	At least one PROFINET connection (AR) exists with an I/O Controller.
	Amber, blinking	No device name configured.
	Off	No PROFINET connection (AR) exists.



16.20.2.5 Port LEDs

The PROFINET Controller has four Port LEDs, PORT1, PORT2, PORT3, and PORT4 that indicate link speed, link connection and link activity corresponding to the four possible external Ethernet ports.

	Blue, on	Link connected, 1000 Mbps
	Blue, blinking	Port active, 1000 Mbps
	Green, on	Link connected, 100 Mbps
	Green, blinking	Port active, 100 Mbps
	Purple, on	Link connected, 10 Mbps
	Purple, blinking	Port active, 10 Mbps
	Off	The associated Ethernet port is not connected to an active link
	Red, on	Port 3 and port 4 only. Incompatible SFP plugged into port.




16.20.2.6 ACTIVE LED

The active LED indicates the Scanner is connected to a PROFINET I/O Controller that is controlling the I/O data for the PNS's I/O modules.

	Green, on	PNS is connected to a PROFINET I/O Controller that is controlling I/O Module IO data.
	Off	PNS is not connected to a PROFINET I/O Controller.

16.20.2.7 USB LED

The USB LED indicates activity on the USB port.

	Green, on	A USB cable is connected.
	Green, blinking	USB port activity
	Off	No USB port activity

Refer to the *PACSystems RX3i PROFINET Scanner Module Data Sheet*, GFK-2738 for LED indications at power-up.

16.20.3 Specifications: PNS001

PROFINET Support	PROFINET Class A I/O Device Redundantly controlled operation implements PROFINET Type S-2 System Redundancy	
Power Requirements	3.3 V: 1.2 A with no SFP devices installed 1.9 A maximum (two SFP devices installed, 0.35A per SFP)	
	5V: 1.1 A maximum	
Operating Temperature Range	0 to 60°C De-rated to 57°C: <ul style="list-style-type: none"> If 100MB Fiber SFPs installed, or If Copper SFPs operating at 1GB 	
Number of Port Connectors	Two RJ-45 and Two SFP Cages (SFP devices not included, available separately.)	
USB Connector (for firmware upgrades)	One Micro-B connector. USB 2.0 compliant running at Full-speed (12 MHz)	
SD Card	Supports SD and SDHC cards.	
PNS Status and Control Bits	32 input status bits and 32 output control bits	
PROFINET I/O production rate (I/O Update Rate)	Configurable selections: 1ms, 2ms, 4ms, 8ms, 16ms, 32ms, 64ms, 128ms, 256ms or 512ms	
Number of IP addresses	One. Supports Classless Inter-Domain Routing (CIDR)	
Number of MAC Addresses	Five. One per external port and one internal.	
I/O Station Maximum Limits	Number of I/O Modules per station	Number of backplane slots minus one for PNS and at least one for a power supply
	I/O data per station	2880 bytes total 1440 bytes of input data 1440 bytes of output data
Configuration	V2.3 GSDML file is available on the Support website for download and import into Proficy Machine Edition. The GSDML supporting a firmware release is part of the firmware upgrade kit available on the Support website.	
Hot Swappable	No	

For product standards and general specifications, refer to *Appendix A*.

At the time of publication, the following CPU firmware, programming software and backplane hardware versions are required. Refer to the *PACSystems RX3i PROFINET Scanner Module Data Sheet*, GFK-2738 for updated information.

16.20.4 Compatibility: PNS001

Controller CPU firmware	CPU330 firmware version 8.45 or later CPU315/CPU320 firmware version 7.10 or later CPE305/CPE310 firmware version 7.10 or later RXi Controller firmware version 7.80 or later CRU320 Primary Firmware version 8.00	
Programmer software	Proficy Machine Edition version 8.50 SIM 2 or later	
RX3i PROFINET Controller	IC695PNC001 with firmware version 1.20 or later (Simplex I/O) IC695PNC001 with firmware version 2.00 or later (Redundant I/O)	
RX3i backplane hardware	<p>The following minimum backplane hardware revision must be used:</p> <p>IC695CHS012-BAMP IC695CHS016-BAMP IC695CHS012CA-BAMP IC695CHS016CA-BAMP</p> <p>or</p> <p>IC695CHS012-CA (or later) IC695CHS016-CA (or later) IC695CHS012CA-CA (or later) IC695CHS016CA-CA (or later)</p> <p>or</p> <p>IC695CHS007-AA (or later)</p> <p>When installing, operating, or maintaining the IC695PNS001, personnel must insure any electrostatic charge is discharged through the use of a grounded ESD strap or other means. This requirement does not apply if the IC695PNS001 is used with the following backplane revisions:</p> <p>IC695CHS012-EA (or later) IC695CHS016-EA (or later) IC695CHS012EA-CA (or later) IC695CHS016EA-CA (or later)</p> <p>or</p> <p>IC695CHS007-BA (or later)</p>	
Small form-factor pluggable modules	IC695SPC100A or later	RX3i 10/100/1000Base-T copper SFP
	IC695SPF002A or later	RX3i 100Base-FX (fiber 2 km) SFP (Multi-mode fiber - MMF)
	IC695SPF550A or later	RX3i 1000Base-SX (fiber 550 m) SFP (MMF)
	IC695SPF010A or later	RX3i 1000Base-LX (fiber 10 km) SFP (Single-mode fiber - SMF)
RX3i modules	For a complete list, refer to <i>PACSystems RX3i PROFINET Scanner Module Data Sheet</i> , GFK-2738.	

16.21 RX3i CEP Carrier: IC695CEP001

RX3i CEP Expansion Carrier: IC694CEE001

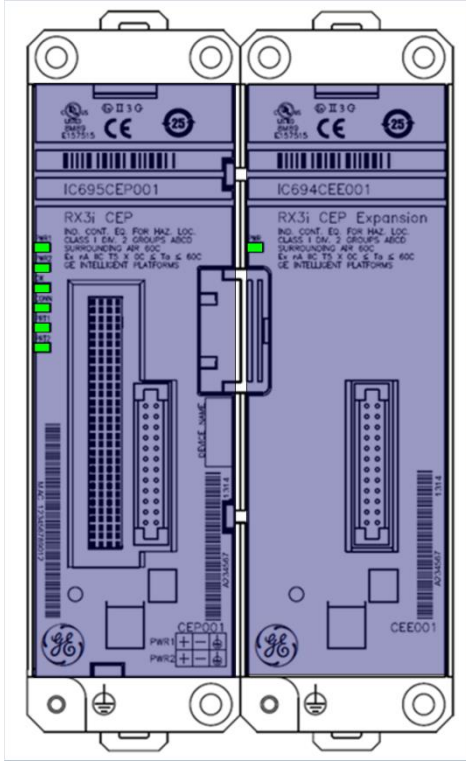


Figure 406: IC695CEP001 with IC694CEE001 Attached

The PACSystems RX3i Carrier IC695CEP001 interfaces a remote node, consisting of one RX3i I/O module, to a PROFINET I/O Local Area Network (LAN).

The optional RX3i Expansion Carrier IC694CEE001 attaches to the RX3i CEP001 Carrier and provides the ability to add one additional RX3i IC694 I/O module to the remote node.

The RX3i CEP001 Carrier functions as a PROFINET IO-Device. The RX3i CEP001 Carrier's main Remote I/O functions include:

- Scanning all the modules within the remote node (input and output scan)
- Publishing data on the PROFINET network to a PROFINET IO-Controller at a user-specified production period
- Receiving data from a PROFINET IO-Controller on the PROFINET network at a customer-specified production period
- Managing PROFINET communication and module configuration between a PROFINET IO-Controller and modules within the remote node
- Managing the state of the I/O when communications is lost
- Publishing fault information (alarms, diagnostics, and such) to the PROFINET IO-Controller
- Provides power to the CEE001 Expansion Carrier

The insertion and removal of I/O modules is the same as in an RX3i Universal Backplane. Refer to Section 2.6.4.

The RX3i CEP001 Carrier provides two RJ-45 Ethernet receptacles. It supports 10/100BASE-TX Ethernet standard interface.

16.21.1 Features

- Full programming and configuration services for all supported RX3i I/O Modules using Proficy Machine Edition. Refer to the section, [Supported I/O Modules](#).
- Support daisy-chain/line, star, or ring (redundant media) network topologies.
- Two switched Ethernet ports: two eight-conductor RJ-45 shielded-twisted pair 10/100 Mbps copper interfaces.
- USB port for field updates of firmware using WinLoader.
- Supports Hot-standby CPU Redundancy using PROFINET I/O: requires RX3i CEP001 2.01 GSDML version 2.3 or later.
- Supports HART® Pass Through using PROFINET.

Note: The USB port is for firmware upgrades only. It is not intended for permanent connection.



® HART® is a registered trademark of the HART Communication Foundation of Austin, Texas USA. Any use of the term HART hereafter in this document, or any document referenced by this document, implies the registered trademark.

Note: The CEP001 Carrier requires a user-supplied +24 Vdc power source.

16.21.2 Normal Operation of Individual LEDs: CEP001 & CEE001






16.21.2.1 Power LEDs

The RX3i CEP001 Carrier has two Power LEDs, PWR1 and PWR2 that indicate whether the power is applied and is within range corresponding to the two power sources.

	Green, ON	Power is applied at the minimum specified level
	OFF	The power supply does not have power or has failed.





16.21.2.2 OK LED

The OK LED indicates whether the CEP001 Carrier is able to perform normal operation.

	Green, ON	RX3i CEP001 is OK
	Amber, ON	Either the RX3i CEP001 Carrier or IO module has a fault
	Amber, blink pattern	Fatal error. Flashes once between error codes.
	Fast blinking	CEP001 has no valid MAC addresses
	OFF	CEP001 has an unrecoverable fault







16.21.2.3 Connect LED

The CONN LED indicates the status of PROFINET connections.

	Green, ON	At least one PROFINET connection (AR) exists with an IO-Controller
	Amber, blink pattern	Fatal error. Flashes once between error codes blinked on the OK LED
	Amber, blink in 1Hz	No device name configured
	OFF	No PROFINET connection (AR) exists

16.21.2.4 Port LEDs




The RX3i CEP001 has two Port LEDs, PRT1 and PRT2 that indicate link speed, link connection and link activity corresponding to the two external Ethernet ports.

	Green, ON	Link connected, 100 Mbps
	Green, blinking	Port active, 100 Mbps
	Amber, ON	Link connected, 10 Mbps
	Amber, blinking	Port active, 10 Mbps
	Amber, blink pattern	Fatal error. Flashes once between error codes blinked on the OK LED
	OFF	The associated Ethernet port is not connected to an active link (can be disabled by configuration)

Note: Multiple LEDs can blink in patterns that indicate special conditions, such as a request for module identification. Refer to *PACSystems RX3i PROFINET Scanner IC695CEP001 User Manual*, GFK-2883.

16.21.2.5 Power LED (IC694CEE001)

The RX3i Expansion Carrier CEE001 has one PWR LED to indicate whether the power provided by the RX3i CEP001 Carrier is within range.

	Green, ON	OK
	Amber, ON	Power 24Vdc and/or 5Vdc is not in specified range
	OFF	No power

16.21.3 Ordering Information

IC695CEP001	RX3i CEP001 Carrier with RJ-45 Copper Ethernet Interface
IC694CEE001	RX3i CEE001 Expansion Carrier

16.21.4 Specifications

PROFINET support	PROFINET Version 2.3 Class A IO-Device	
RX3i Controller version required	IC695CPU315/CPU320/CPE305/CPE310/CPE330/CRU320, firmware v8.50 or later IC69PNC001 PROFINET IO-controller with firmware version 2.20 or later	
RXi Controller version required	RXi Controller, ICRXICTL000, with firmware version 7.80 or later is compatible with CEP001 up to version 2.01, but is not compatible with CEP001 version 2.30.	
Proficy Machine Edition version required	Version 8.6 with SIM 3 or later	
Power requirements ⁸⁷	IC695CEP001: 5.25W (0.22 A) at 24 Vdc with or without Expansion Carrier (IC694CEE001) DC power supply input range: 19.2 to 30 Vdc	
Module dimensions	177.2 x 51 x 35 mm (6.98" x 2.01" x 1.38"). Same for CEP001 and CEE001.	
Operating temperature	0°C to 60°C (32°F to 140°F) maximum surrounding air temperature	
Number of Ethernet port connectors	IC695CEP001: Two RJ-45 10/100Base-TX receptacles IC694CEE001: None	
USB connector (for firmware upgrades)	IC695CEP001: One Micro-B connector. USB 2.0 compliant running at full-speed (12 MHz) in device mode IC694CEE001: None	
PNS status and control bits	32 input status bits and 32 output control bits	
I/O data update on the PROFINET LAN	Configurable: 1ms, 2ms, 4ms, 8ms, 16ms, 32ms, 64ms, 128ms, 256ms and 512ms	
Number of IP addresses	One; supports Classless Inter-Domain Routing (CIDR)	
Number of MAC addresses	Three; one per external port and one internal. External MAC addresses are only used for specialized Ethernet protocols such as MRP or LLDP.	
I/O station maximum limits	Number of I/O modules per station	IC695CEP001: One IC695CEP001 with IC694CEE001: Two
	I/O data per station	1024 bytes total 512 bytes of input data 512 bytes of output data
Configuration	Configured using Proficy Machine Edition when used with a PACSystems RX3i PROFINET Controller module as part of an RX3i High-speed I/O LAN system. V2.3 GSDML file available for import into 3rd-Party tools.	

For product standards and general specifications, refer to *Appendix A*.

⁸⁷ Value does not include the power consumption of the installed I/O modules. When calculating the total power requirements, add the power consumption of the I/O modules according to the I/O module datasheet.

16.21.5 Quick Start: CEP001 & CEE001

16.21.5.1 Carrier Installation Requirements

The CEP001 Carrier and optional Expansion Carrier CEE001 can be mounted on a DIN-rail or on a panel.

Adequate installation space is required for:

1. Clearance for communications port cables.
2. Power wiring.
3. Operating the DIN latch.

The RX3i CEP001 Carrier with an I/O module attached requires an enclosure with minimum depth of 165 mm.

Rated thermal specifications are based on a clearance of 5.1 cm (2") above and below the equipment and 2.54 cm (1") to the left of the RX3i CEP001 Carrier.

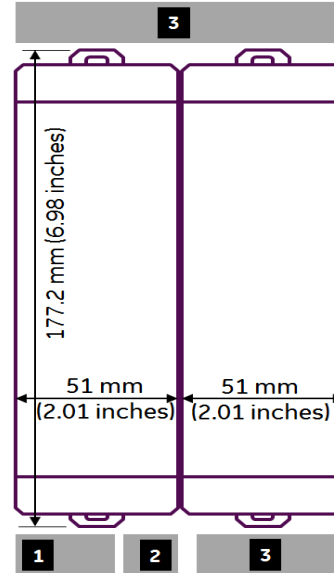


Figure 407: Mounting Diagram CEP001 & CEE001

16.21.5.2 Connecting the CEE001 Expansion Carrier to the CEP001 Carrier

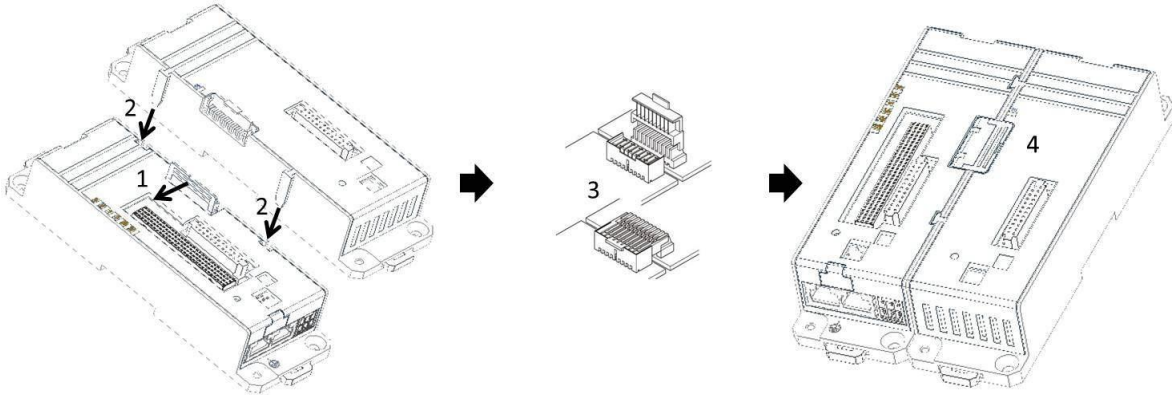
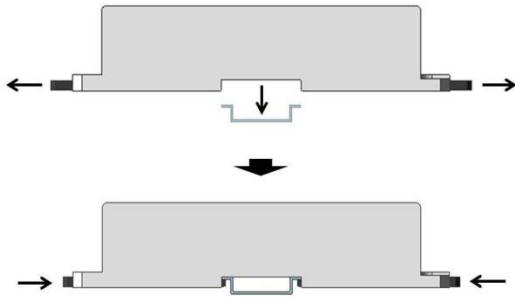


Figure 408: Attaching CEE001 to CEP001

1. Open the connector cap on the RX3i CEP001 Carrier.
2. Slide and install the RX3i CEE001 Expansion Carrier along the guide slots on the RX3i CEP001 Carrier.
3. When the Expansion Carrier is aligned with the CEP001 Carrier, engage the expansion connectors.
4. Close the connector cap.
5. Secure the Expansion Carrier to the DIN rail or panel. Refer to *Installing an RX3i CEP001 Carrier on a DIN-rail or Panel Mounting*.
6. Connect the grounding hole on the CEE001 to the panel or enclosure as described in *Grounding* below.

16.21.5.3 Installing an RX3i CEP001 Carrier on a DIN-rail



The carrier mounts on a standard EN 50022, 35 x 7.5 mm DIN-rail. Conductive (unpainted) finish is required for proper grounding.

For best resistance to vibration, the DIN-rail should be installed horizontally on a panel using screws spaced approximately 15 cm (6") apart.

Figure 409: DIN Rail Mounting Sequence

1. With a small flathead screwdriver, pull out the two DIN-rail latches and stand the carrier on the DIN-rail.
2. Push in the two DIN-rail latches so that the latches hold the DIN-rail.

16.21.5.4 Panel Mounting

For applications requiring maximum or long term resistance to mechanical vibration and shock, the panel-mounting method is strongly recommended. A minimum panel thickness of 2.4 mm (.093") is required. The mounting diagram (Figure 410 below) applies to both the CEP001 Carrier and CEE001 Expansion Carrier.

Note 1: Tolerances on all dimensions are ±0.2 mm (0.078") non-cumulative.

Note 2: Apply 1.1 to 1.4 Nm (10 to 12 in/lbs) of torque to M3.5 (#6-32) steel screws threaded into tapped holes in the panel.

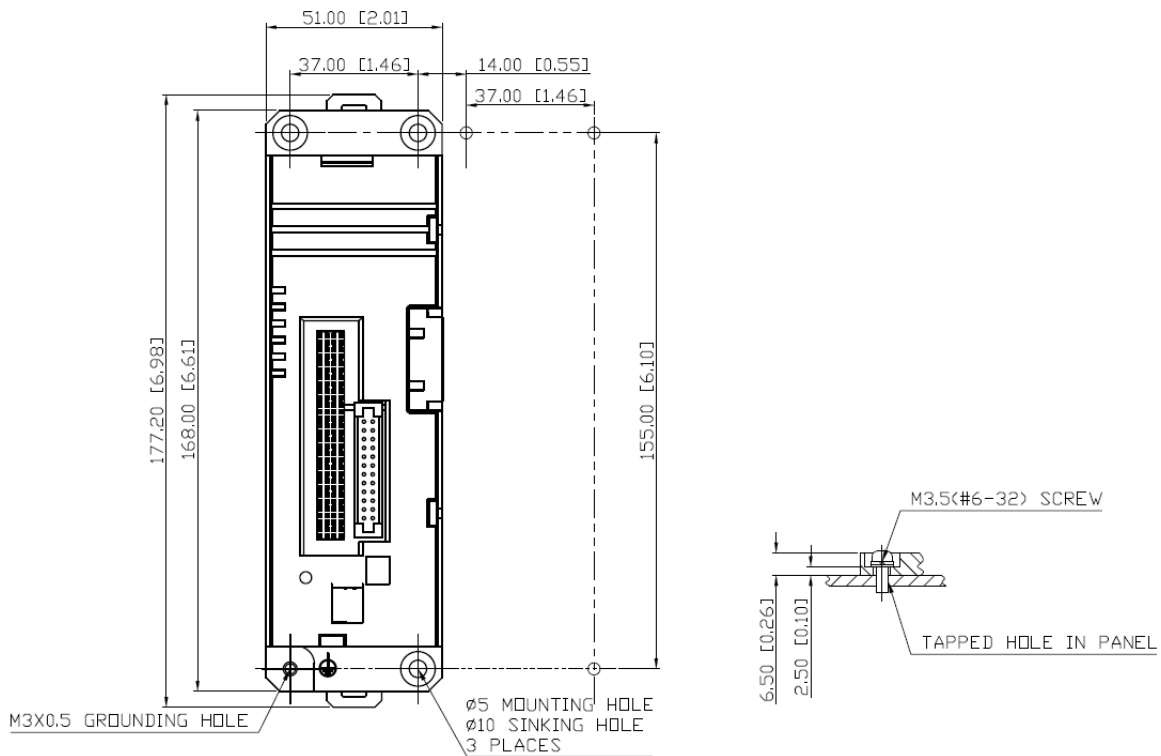


Figure 410: Panel Mounting Diagram: CEP001 or CEE001

16.21.5.5 Grounding

**Warning**

All CEP001 Carriers in a system must be grounded to minimize electrical shock hazard. Failure to do so can result in severe personal injury.

The RX3i CEP001 Carrier and CEE001 Expansion Carrier each provide two grounding connection contacts:

- Grounding clips at the back of the carrier, which require DIN-rail installation
- Grounding screw hole at bottom-left of the carrier

Note: When the Carrier is mounted on a DIN-rail, the grounding clips on the back of the Carrier do not provide an adequate ground connection. The Carrier's metal back must also be grounded using a separate conductor.

Ground each Carrier to the panel or enclosure using a minimum AWG #12 (3.3 mm²) wire with ring terminals. Use an M3 screw, star lock washer and a flat washer to connect the wire at the Carrier's grounding hole. Connect the other end of the ground wire to a tapped hole in the grounded mounting panel or enclosure, using a machine screw, star lock washer and flat washer. Alternately, if the panel has a ground stud, use a nut and star lock washer for each wire on the ground stud to ensure adequate grounding. Where connections are made to a painted panel, the paint should be removed so clean, bare metal is exposed at the connection point. Terminals and hardware used should be rated to work with the aluminum carrier material.

Note: The star lock washer method is suitable for a shield ground, but not suitable for a safety ground.

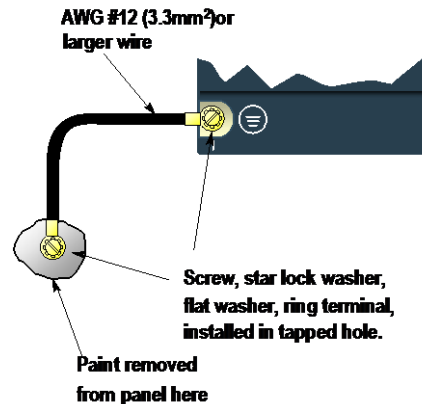


Figure 411: Ground Connection Diagram

16.21.5.6 Installing Modules on the Carrier

The insertion and removal of I/O modules is the same as in an RX3i Universal Backplane. Refer to Section 2.6.4.



Caution

Do not install a Power Supply module on the CEP001 or CEE001 Carrier. Attempting to do so could damage the module and/or the Carrier.

16.21.5.7 Unsupported Modules



Caution

If an unsupported module is inserted in the CEP001 or CEE001 Carrier, the module will not be recognized correctly and could cause damage to the Carrier or the module.

When an unsupported I/O module is inserted into either the RX3i CEP001 Carrier or RX3i CEE001 Expansion Carrier, no alarm is reported to indicate this.

For the latest updated list of supported I/O modules, refer to the section, [Supported I/O Modules](#).

Some unsupported I/O modules have the same Distinguishing Class (for example, IC694MDL740 has the same Distinguishing Class as IC694MDL742).

16.21.5.8 Connecting Power Supplies

You will need:

Note: Two power supplies are required if using redundant power supplies.

- One 24 Vdc power supply which provides a low voltage/limited current (LVLC) power source. (For example, the combination of an isolated DC supply and a fuse, listed 30 Vdc minimum and 3 A maximum, connected in series with the input.)
- Power cord with 28 to 16 AWG / 0.08 to 1.32 mm² wires
- Ferrules for 28 to 16 AWG wires (optional)
- Frame ground wire, 28 to 16 AWG
- Input power terminal block; provided (WAGO Part Number 713-1103)
- Small flathead screwdriver (jeweler's size 14)

Note: For CE Mark purposes, input power lines to the CEP001 Carrier should be limited 30 m (98 ft) or less.

Note: Before inserting the wires into the power connector terminal block, use a small flathead screwdriver to release the spring clamp on the terminal block.

1. Using the power cord, attach the power supply to the power terminal block as displayed in Figure 412.
Recommended wire stripping length is 6 to 7 mm (0.25").
2. If using redundant power supplies, connect the second power supply to the input power terminal block.
3. Insert the input power terminal block into the Input Power connector.

Note: There are no user-serviceable fuses in the CEP001 Carrier.

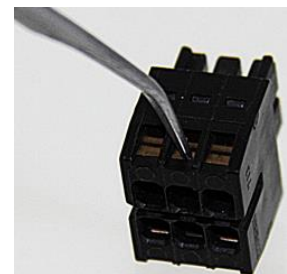


Figure 412: Power Terminal Block CEP001

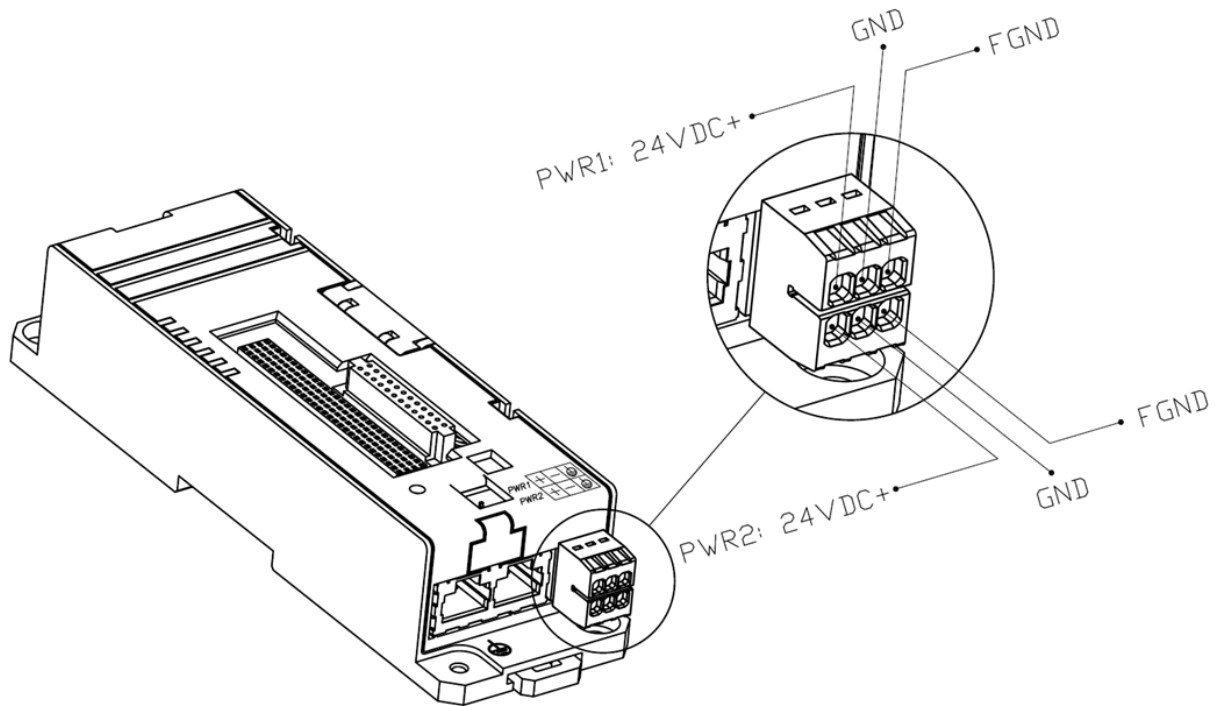


Figure 413: CEP001 Power Terminal Wiring

16.21.5.9 Adding a Redundant Power Supply

➤ To add a redundant power supply to a system that is already in operation

1. Remove power from the primary power supply to the RX3i CEP001 carrier
2. Remove the power terminal block from the carrier.
3. Without disturbing the primary power supply input lines, connect the redundant power supply input lines to the power terminal block.
4. Insert the power terminal block into the Input Power connector.
5. Apply power to the redundant power supply. The PWR2 LED on the RX3i CEP001 carrier should turn on.
6. Apply power to the primary power supply. The PWR1 LED on the CEP001 Carrier should turn on.

Note: For the procedure to swap a redundant power supply, refer to *PACSystems RX3i PROFINET Scanner IC695CEP001 User Manual*, GFK-2883.

16.21.5.10 Connecting the CEP001 to the PROFINET Network

The two external RJ-45 Ethernet ports, which provide 10/100 Mbps copper interfaces, are on the bottom of the CEP001 Carrier.

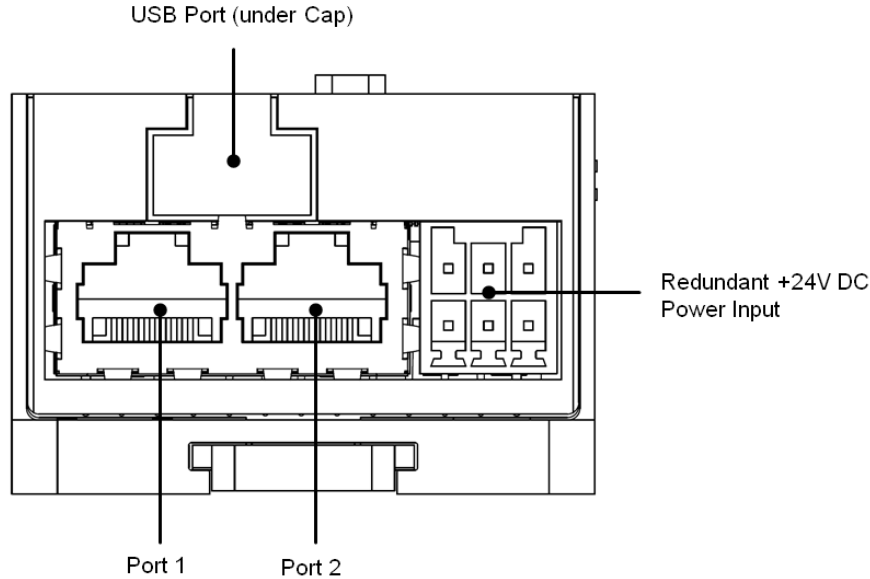


Figure 414: Locations of Ethernet Ports CEP001

Devices connected to the RX3i CEP001 ports should have Ethernet Auto-negotiation enabled. The RX3i CEP001 Carriers and other participating devices can be connected in a daisy-chain/line, or star topology.

Caution



Do not connect both ports on the Ethernet interface, directly or indirectly, to the same device so as to form a circular network unless Media Redundancy is enabled with one node actively set up as the Media Redundancy Manager.

Supported Network Media Types and Distances

PROFINET I/O over-wired infrastructure must be 100Mbps full-duplex or faster. The hardware is capable of operating at 10Mbps but should not be used for PROFINET.

Media Type	Connector Type	Wavelength (nm)	Media Type	Core Size (µm)	Modal Bandwidth (MHz – km)	Maximum Distance
10/100BASE-TX	RJ-45	-	CAT5/CAT5e/CAT6	-	-	100 m (328 ft)

16.21.5.11 Assigning an I/O Device Name to the CEP001

Before attempting to connect to or configure the CEP001, the I/O Device Name must be set with a Discovery and Configuration Protocol (DCP) tool.

16.21.5.12 Configuring the CEP001/CEE001 Node and Resident I/O Modules on a PROFINET Network

Proficy Machine Edition is the primary tool used to configure an RX3i PROFINET network. The GSDML file for the RX3i CEP001 is included with Proficy Machine Edition, or may be downloaded from the support website at <http://support.ge-ip.com>. To obtain the GSDML for import into a 3rd-Party tool, contact GE.

16.21.6 Supported I/O Modules

The following table indicates the minimum CEP001 firmware version required for compatibility with the listed I/O modules and whether the module can be installed in the RX3i Expansion Carrier CEE001.

Catalog Number	Module Description	Distinguishing Classes⁸⁸	Earliest CEP001 Compatible Version	CEE001⁸⁹ Compatible
Discrete Input Modules				
IC693MDL230	8 Circuit Input 120 Vac Isolated	8 in	2.30	Y
IC693MDL231	8 Circuit Input 240 Vac Isolated	8 in	2.50	Y
IC693MDL240	16 Circuit Input 120 Vac	16 in	2.30	Y
IC693MDL241	16 Circuit Input 24 Vac / Vdc	16 in	2.50	Y
IC693MDL260	32 Circuit Input 120 Vac, Input Filtering Off	32 in	2.50	Y
IC693MDL260	32 Circuit Input 120 Vac, Input Filtering On	32 in/32 out	2.50	Y
IC693MDL632	8 Circuit Input 125 Vdc Positive / Negative Logic	8 in	2.30	Y
IC693MDL634	8 Circuit Input 24 Vdc Positive / Negative Logic	8 in	2.50	Y
IC693MDL635	16 Circuit Input 125 Vdc Positive / Negative Logic	16 in	2.30	Y
IC693MDL645	16 Circuit Input 24 Vdc Positive / Negative Logic	16 in	2.40	Y
IC693MDL648	16 Circuit Input 48 Vdc Positive / Negative Logic Fast	16 in	2.30	Y
IC693MDL654	32 Circuit Input 5/12 Vdc Positive / Negative Logic	32 in	2.50	Y
IC693MDL655	32 Circuit Input 24 Vdc Positive / Negative Logic Fast	32 in	2.59	Y
IC693MDL660	32 Circuit Input 24 Vdc Positive / Negative Logic, Input Filtering Off	32 in	2.30	Y
IC693MDL660	32 Circuit Input 24 Vdc Positive / Negative Logic, Input Filtering On	32 in	2.30	Y
IC694MDL230	8 Circuit Input 120 Vac Isolated	8 in	2.30	Y
IC694MDL231	8 Circuit Input 240 Vac Isolated	8 in	2.50	Y
IC694MDL240	16 Circuit Input 120 Vac	16 in	2.30	Y
IC694MDL241	16 Circuit Input 24 Vac / Vdc	16 in	2.50	Y
IC694MDL250	16 Circuit Input 120 Vac Isolated	None	1.00	Y
IC694MDL260	32 Circuit Input 120 Vac	None	2.50	Y
IC694MDL632	8 Circuit Input 125 Vdc Positive / Negative Logic	8 in	2.30	Y
IC694MDL634	8 Circuit Input 24 Vdc Positive / Negative Logic	8 in	2.50	Y
IC694MDL635	16 Circuit Input 125 Vdc Positive / Negative Logic	16 in	2.30	Y
IC694MDL645	16 Circuit Input 24 Vdc Positive / Negative Logic	16 in	2.40	Y
IC694MDL646	16 Circuit Input 24 Vdc Positive / Negative Logic Fast	16 in	1.00	Y
IC694MDL648	48 Vdc Input Pos/Neg Fast (16 Points)	16 in	2.30	Y
IC694MDL654	32 Circuit Input 5/12 Vdc Positive / Negative Logic	32 in	2.50	Y
IC694MDL655	32 Circuit Input 24 Vdc Positive / Negative Logic Fast	32 in	2.50	Y
IC694MDL658	32 Circuit Input 48 Vdc Positive / Negative Logic Fast	32 in	2.50	Y
IC694MDL660	32 Circuit Input 24 Vdc Positive / Negative Logic	32 in	2.30	Y
IC695MDL664	16 Circuit Input with diagnostic	None	1.00	N
Discrete Output Modules				
IC693MDL310	12 Circuit Output 120 Vac 0.5A	16 out	2.50	Y
IC693MDL330	8 Circuit Output 120/240 Vac 2A	8 out	2.40	Y
IC693MDL340	16 Circuit Output 120 Vac 0.5A	16 out	2.50	Y

⁸⁸ The RX3i CEP Carrier and the RX3i CEP Expansion Carrier currently does not support fault reporting or "Interrupts" from this module.

⁸⁹ The RX3i CEP Carrier and the RX3i CEP Expansion Carrier cannot distinguish between modules within the same Distinguishing Class type. This means that any module physically present that is within the same class as the one configured will not alert the user with a System Configuration Mismatch fault on the Controller Fault Table. Refer to GFK-2222 Chapter 3 for CPU operation during System Configuration Mismatch faults.

Catalog Number	Module Description	Distin- guishing Classes⁸⁸	Earliest CEP001 Compatible Version	CEE001⁸⁹ Comp- atible
IC693MDL350	16 Circuit Output 120/240 Vac Isolated	16 out	2.50	Y
IC693MDL390	5 Circuit Output 120/240 Vac 2A Isolated	None	2.30	Y
IC693MDL732	8 Circuit Output 12/24 Vdc 0.5A Positive	8 out	2.50	Y
IC693MDL734	6 Circuit Output 125 Vdc 1A Positive/Negative	8 out	2.50	Y
IC693MDL740	16 Circuit Output 12/24 Vdc 0.5A Positive	16 out	2.50	Y
IC693MDL741	16 Circuit Output 12/24 Vdc 0.5A Negative	16 out	2.50	Y
IC693MDL752	32 Circuit Output 5/24 Vdc 0.5A Negative	32 out	2.50	Y
IC693MDL753	32 Circuit Output 12/24 Vdc 0.5A Positive	32 out	2.50	Y
IC693MDL754	32 Circuit Output 24 Vdc 0.75A Positive, Diagnostics Off	32 out	2.30	Y
IC693MDL754	32 Circuit Output 24 Vdc 0.75A Positive, Diagnostics On	32 in/32 out	2.30	Y
IC693MDL930	8 Circuit Output 4A Relay Isolated	8 out	2.30	Y
IC693MDL931	8 Circuit Output Relay Form BC Isolated	8 out	2.50	Y
IC693MDL940	16 Circuit Output 2A Relay	16 out	2.30	Y
IC694MDL310	12 Circuit Output 120 Vac 0.5A	16 out	2.50	Y
IC694MDL330	120/240 V ac Output 2A (8 Points)	8 out	2.40	Y
IC694MDL340	16 Circuit Output 120 Vac 0.5A	16 out	2.50	Y
IC694MDL350	16 Circuit Output 120/240 Vac Isolated	None	2.50	Y
IC694MDL390	5 Circuit Output 120/240 Vac 2A Isolated	None	2.30	Y
IC693MDL732	8 Circuit Output 12/24 Vdc 2A Positive	8 out	2.50	Y
IC693MDL734	6 Circuit Output 125 Vdc 1A Positive/Negative	8 out	2.50	Y
IC694MDL740	16 Circuit Output 12/24 Vdc 0.5A Positive	16 out	2.50	Y
IC694MDL741	16 Circuit Output 12/24 Vdc 1A Negative	16 out	2.50	Y
IC694MDL742	16 Circuit Output 12/24 Vdc 1A Positive	16 out	1.00	Y
IC694MDL752	32 Circuit Output 5/24 Vdc 0.5A Negative	32 out	2.50	Y
IC694MDL753	32 Circuit Output 12/24 Vdc 0.5A Positive	32 out	2.50	Y
IC694MDL754	32 Circuit Output with ESCP	None	2.30	Y
IC694MDL916	16 Circuit Output 4A Relay	None	1.00	Y
IC694MDL930	8 Circuit Output 4A Relay Isolated	8 out	2.30	Y
IC694MDL931	8 Circuit Output Relay Form BC Isolated	8 out	2.50	Y
IC694MDL940	16 Circuit Output 2A Relay	16 out	2.30	Y
IC695MDL765	16 Circuit Smart Output 24/125 Vdc 2A Positive Logic	None	1.00	N
Mixed Discrete Input/Output Modules				
IC693MDR390	8 Circuit Mixed 24 Vdc Input / Relay Output	8 in/8 out	2.40	Y
IC693MAR590	8 Circuit Mixed 120 Vac Input / Relay Output	8 in/8 out	2.30	Y
IC694MDR390	8 Circuit Mixed 24Vdc Input/Relay Output	8 in/8 out	2.40	Y
Analog Input Modules				
IC693ALG222	16 Point Analog Voltage Input	ALG IN 16	2.50	Y
IC693ALG223	16 Point Analog Current Input	ALG IN 16	2.50	Y
IC694ALG222	16 Point Analog Voltage Input	ALG IN 16	2.50	Y
IC694ALG223	16 Point Analog Current Input	ALG IN 16	2.50	Y
IC695ALG112	12 Point Isolated Analog Current/Voltage Input ⁸⁸	None	2.01	N
IC695ALG600	8 point Universal Analog Input Module	None	2.01	N
IC695ALG616	16 Point Analog Current / Voltage Input ⁸⁸	None	1.00	N
IC695ALG626	16 Point Analog Current / Voltage Input (HART Support) ⁸⁸	None	1.00 ⁸⁸	N

Catalog Number	Module Description	Distin- guishing Classes⁸⁸	Earliest CEP001 Compatible Version	CEE001⁸⁹ Comp- atible
Analog Output Modules				
IC693ALG392	8 Point Analog Current / Voltage Output	ALG OUT 8	2.50	Y
IC694ALG392	8 Point Analog Current / Voltage Output	ALG OUT 8	2.50	Y
IC695ALG704	4 Point Analog Current / Voltage Output ⁸⁸	None	2.50	N
IC695ALG708	8 Point Analog Current / Voltage Output ⁸⁸	None	2.50	N
IC695ALG728	8 Point Analog Current / Voltage Output (HART Support) ^{88, 90}	None	1.00	N
IC695ALG808	8 Point Isolated Analog Current / Voltage Output ⁸⁸	None	1.00	N
Analog Mixed Modules				
IC693ALG442	4 Input / 2 Output, Current / Voltage	ALG IN 4, ALG OUT 2	2.30	Y
IC694ALG442	4 Input / 2 Output, Current / Voltage	ALG IN 4, ALG OUT 2	2.30	Y
Thermocouple Input Modules				
IC695ALG312	12 Point Isolated Thermocouple Input ⁸⁸	None	2.50	Y
High-speed Counter Modules				
IC695HSC308	High-Speed Counter Module, 1.5MHz, 16 Inputs, 14 Outputs	None	2.40	Y
Specialty Modules				
IC694PSM001	Power Sync and Measurement System	None	2.01	Y

⁹⁰ The RX3i CEP Carrier and the RX3i CEP Expansion Carrier currently does not support all HART features in this module

16.22 Genius Communications Gateway Module IC695GCG001

The RX3i Genius Communications Gateway, IC695GCG001 (GCG001), interfaces Genius I/O devices on a Simplex Genius Serial Bus to a GE PROFINET IO Controller (IC695PNC001).

The GCG001 operates as a Genius Bus Controller on a Genius network. It scans the Genius I/O devices configured to it, retrieving input data and providing output data. It then exchanges that data with its configured PROFINET IO Controller over its Ethernet interfaces at the configured production rate. The GCG001 can manage communications for up to 31 Genius I/O devices on a single Genius Serial Bus.

The GCG001 also operates as an I/O Device, controlled by the RX3i PROFINET IO Controller (PNC001) to which is attached. Thus, when correctly configured, the entire Genius Bus, including the GCG001 itself, becomes visible to the controlling PLC (in this case an RX3i). Note that the GCG001 operates only with GE PLC PROFINET IO Controllers.

PROFINET operates on an Ethernet network. If the Ethernet network or Genius serial bus communications are lost, the GCG001 manages IO states according to the individual module configurations.

Both PROFINET and Genius may be set up in Redundant configurations.

Genius Communications Gateway features include:

- Attachment of two RJ-45 Ethernet connections (Ports 1 & 2)
- Support for both star (switched) and linear (daisy-chained) network topologies
- Supports Ethernet Media Redundancy Protocol (MRP)
- LEDs to indicate Ethernet status (ACT & LINK)
- Attachment Genius bus connections (marked Genius A).
- Supports Genius Redundancy consisting of a single Genius bus with two GCG001 Gateways, one at SBA #30 and the other at SBA #31. No other form of Genius redundancy is supported.
- LED to indicate Genius Communications Status (COM)
- LEDs to indicate module status (refer to module header)
- Panel-mount (typical). Optional mounting in RX3i expansion slot.
- Cable tie-down loop on underside of module (at front)
- 24Vdc power connector on underside of module
- Secure Digital (SD) Card Slot, accessible at rear of module
- Firmware load pushbutton, accessible at rear of module





Figure 415: IC695GCG001

Refer to *PACSystems RX3i Genius Communications Gateway User Manual*, GFK-2892.





16.22.1 LED Indications: GCG001

The four LEDs in the module header provide a visual indication of the GCG001 module status.




POWER – indicates the presence of power to the module.

	Green, ON steady	Power supply is good.
	OFF	Power supply is off or not good.




OK – indicates GCG001 readiness to perform normal module operations.

	Green, ON steady	Module able to perform normal operations.
	Green/Amber, blinking	Module loading main operating system
	Amber, ON steady	Module loading boot-loader operating system
	OFF	Module has an unrecoverable fault or power is not applied.

FAULT – indicates the detection of faults by the module.



	OFF	No faults present.
	Red, blinking 2Hz	DCP Device Identification Signal received.
	Red, ON	A fault or other Ethernet-type diagnostic data exists on the Gateway

CONNECT – indicates status of the connection to a PROFINET controller.



	OFF	One or more connections with GE PROFINET Controllers have been established to this device.
	Red, blinking	Device trying to connect to a controller. Continuous if device has not been assigned a valid station name.
	Red, ON	No PROFINET Controller connection

The two LEDs associated with each Ethernet port (used here as PROFINET ports) are labelled ACT and LINK. These LEDs provide information about activity on that particular port.




PORT 1, PORT 2 LINK – indicates connection status on Ethernet ports.

	Green, ON steady	Ethernet connection established
	OFF	No Ethernet connection

PORT 1, PORT 2 ACT – indicates activity on Ethernet ports.

	Amber, blinking	Communications occurring on port
	OFF	No communication

COM – indicates the status of Genius Bus communications.

	Green, ON steady	The Genius Bus is configured and operating properly.
	Green, blinking	A Genius Bus error has been detected.
	OFF	The Genius Bus has failed or no Genius Bus configuration has been received.

BUS B – indicates activity on the Genius B port: This LED is inactive and always OFF.

16.22.2 Specifications: GCG001

Communications Support	Operates only under the control of a GE PROFINET Controller
Power Requirements	External 24Vdc: ($\pm 10\%$) 0.2 A
Operating Temperature Range	0 to 60°C (32 to 140 °F)
Number of Port Connectors	Two RJ-45
Local Area Network (LAN)	IEEE 802.2 Logical Link Control Class I IEEE 802.3 CSMA/CD Medium Access Control 10/100 Mbps
SD Card	The SD card slot is designed to support a Secure Digital (SD) non-volatile memory card in standard capacity format. Size: 2Gbyte max. This optional card has two distinct uses: (1) Backup storage of some key Ethernet configuration data (2) Loading new GCG001 module firmware.
Status Data	64 (two banks of 32 bits)
Genius Bus Support	Supports One Genius Bus. Genius A terminal is active; Genius B is inactive. Serial 1, Serial 2, Shield In and Shield Out, as marked. Up to 31 additional devices supported per Genius Bus. Selectable Baud Rate, per Genius specifications. Genius Hot Standby and Duplex Redundancy supported.
HHM Compatibility	IC66*HHM501
Other Genius Compatibility	Refer to <i>PACSystems RX3i Genius Communications Gateway User Manual</i> , GFK-2892, Genius Communications Gateway User Manual
Configuration	GSDML file is available on the Support website for download and import into Proficy Machine Edition. The GSDML supporting a firmware release is part of the firmware upgrade kit available on the Support website.
Hot Swappable	Yes (does not draw power from RX3i Backplane). However, cannot be done without disconnecting external 24Vdc power. If configured to support Genius Hot Standby, the loss of a single GCG001 will be tolerated; otherwise not.

For product standards and general specifications, refer to *Appendix A*.

16.23 IC695PRS015 Pressure Transducer Module

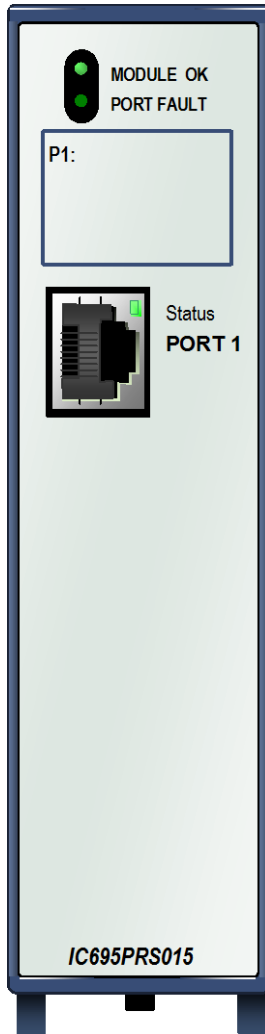


Figure 416: IC695PRS015

The PACSystems RX3i Pressure Transducer module expands the serial communications capabilities of the RX3i system to communicate with up to 15 Honeywell LG1237 Smart Pressure Transducer sensors.

The IC695PRS015 module provides an independent, isolated serial port. Up to four Pressure Transducer modules can be located in the main PACSystems RX3i backplane.

Additional module features include:

- Port-to-backplane isolation
- RS-485 communication
- Module fault status reporting (Watchdog, Ram Fail, Flash Fail)
- Module identity and status reporting, including LED status indicators
- Flash memory for future upgrades

These modules must be located in an RX3i Universal Backplane. Module supports insertion into and removal from an RX3i Universal Backplane which is under power. Refer to *Hot Insertion and Removal*, Section 2.6.4.1.

16.23.1 LEDs: PRS015

- Module OK** The Module OK LED indicates the status of the module.
- Off: The module is not receiving power from the RX3i backplane or the module has failed self-test.
 - Solid green: The module has been configured.
 - Blinking green, rapidly: The module is executing power-up diagnostics.
 - Blinking green, slowly: The module has not received configuration from the CPU. If configuration is not successful, the module will continue to blink in this mode.
 - Blinking amber: If a problem occurs, the Module OK LED blinks amber. The blink code (refer to below) indicates the cause of the error.
 - 1 = watchdog expired
 - 2 = RAM error
 - 6 = Invalid CPU Master Interface version
 - 7 = CPU heartbeat failure
 - 8 = Failed to get semaphore
- PORT FAULT** The Port Fault LED indicates the status of the port.
- Green: There are no faults present on any enabled port.
 - Amber: There is a fault on the port.
- Note: The area below the module LED can be used to record identifying information about the port.
- Port STATUS** The Port Status LED blinks green when there is activity on the corresponding port.

16.23.2 Specifications: PRS015

Number of Serial Ports	One
Connectors	RJ-45
Number of modules per CPU	Four in the main CPU backplane
Backplane power requirements	0.7 A maximum at 3.3 Vdc 0.115 A maximum at 5.0 Vdc
LEDs	Module OK, Port Fault, Port Status
Port Type	RS-485 four-wire (full duplex)
Baud rate	375 kBaud
Input Impedance	Zin > 96 kΩ for RS-485/422
Max Over-voltage	± 25V
Channel-Channel Crosstalk	-55dB minimum
Isolation	Port to Backplane and to frame ground: 250 Vac continuous; 1500 Vac for 1 minute, 2550 V dc for one second

For product standards and general specifications, refer to *Appendix A*.
 To meet emission and immunity requirements for the EMC directive (CE mark), shielded cable must be used with this module.

16.23.3 PRS015 Configuration

16.23.3.1 Module Parameters

Parameter	Default	Description
Channel Value Reference Address	%AIxxxxx	Starting address for the input data of the module. This defaults to the next available %AI block.
Channel Value Reference Length	30 (word oriented memory) 480 (bit oriented memory)	The number of words or bits used for the input data of the module. Each channel is mapped to 2 words or 32 bits, whether the channel is used or not.
Inputs Default	Hold Last State	In the event of module failure or removal, this parameter specifies the state of the Channel Value References. Force Off: Sets input channel values to 0 and clears all alarm flags. Hold Last State: Channel Values hold their last state.
Diagnostic Reference Address	%Ixxxxx	Starting address for the channel diagnostics status data. This defaults to the next available %I block.
Diagnostic Reference Length	0	The number of bits or words required for the Channel Diagnostics data. Default is 0, which means mapping of Channel Diagnostics is disabled. Change this to a non-zero value to enable Channel Diagnostics mapping. 0 or 30 (Word oriented memory) 0 or 480 (bit oriented memory)
Command Input Data Reference Address	%AIxxxxx	Starting address for the command input data of the module. This defaults to the next available %AI block.
Command Input Data Reference Length	6 (word oriented memory) 96 (bit oriented memory)	The number of bits or words required for the command input data of the module.
Command Output Data Reference Address	%AQxxxxx	Starting address for the command output data of the module. This defaults to the next available %AQ block.
Command Output Data Reference Length	6 (word oriented memory) 96 (bit oriented memory)	The number of bits or words required for the command output data of the module.
Module Status Reference Address	%Ixxxxx	Starting address for the status data of the module. This defaults to the next available block in the selected memory area.
Module Status Reference Length	0	The number of bits required for the Module Status data. Default is 0, which means mapping of Module Status data is disabled. Change this to a non-zero value to enable Module Status data mapping. 2 (word oriented memory) 32 (bit oriented memory)
I/O Scan Set	1	The scan set, as defined in the CPU Scan Sets tab, to be assigned to this module. The scan set determines how often the CPU polls the data. Valid range: 1 through 32.

16.23.3.2 Channel Parameters (Channels 1 through 15)

Parameter	Default	Description
Channel Enable	Disabled	Disabled, Enabled, Simulation Mode When Enabled, the Channel Value will be updated with the value of the associated LG1237. When Simulation Mode is selected the associated LG1237 will simulate a specified pressure reading.
Simulated Value	10.0	Pressure value to be reported, in A/D units when Channel Enable is set to Simulation Mode. Valid range: -3.40282E+38 through 3.40282E+38.
Channel Value Format	32-bit Floating Point	Read only: 32-bit floating point
High Scale Value (Eng Units)	1024.0	The upper value, in engineering units, used for scaling. Valid range: -3.40282E+38 through 3.40282E+38 engineering units. Note: Scaling is disabled if High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units.
Low Scale Value (Eng Units)	0.0	The lower value, in engineering units, used for scaling. Valid range: -3.40282E+38 through 3.40282E+38 engineering units. The Low Scale Value (Eng Units) parameter cannot be equal to the High Scale Value (Eng Units) parameter. It can be higher than the High Scale Value (Eng Units) parameter for reversed or inverse scaling. Default is Low A/D Limit of selected range type. Must be lower than the High Scale Value.
High Scale Value (A/D Units)	1024.0	The upper value, in A/D Units, used for scaling. Valid range: 0 through 65535. Note: Scaling is disabled if High Scale Eng. Units equals High Scale A/D Units and Low Scale Eng. Units equals Low Scale A/D Units.
Low Scale Value (A/D Units)	0.0	The upper value, in A/D Units, used for scaling. Valid range: 0 through 65535.
High Alarm (Eng Units)	1024.0	When the channel input value reaches or exceeds this value, a High Alarm is triggered. Valid range: Within High Scale Value–Low Scale Value (Eng Units) range. Must be greater than Low Alarm. Note: A channel uses this value only when High Alarm Enable is set to Enabled under Diagnostic Reporting Enable and/or Fault Reporting Enable.
Low Alarm (Eng Units)	1.0	When the channel input value reaches or goes lower than this value, a Low Alarm is triggered. Valid range: Within High Scale Value to Low Scale Value (Eng Units) range. Must be less than High Alarm. Note: A channel uses this value only when Low Alarm Enable is set to Enabled under Diagnostic Reporting Enable and/or Fault Reporting Enable.

Parameter	Default	Description
High Alarm Deadband (Eng Units)	1.0	A range in Engineering Units below the alarm condition where the alarm status bit remains set even after the alarm condition no longer exists. For the alarm status to clear, the channel input must fall outside the deadband range. Valid range: 0 through the difference between High Scale Value and Low Scale Value (Eng Units).
Low Alarm Deadband (Eng Units)	1.0	A range in Engineering Units above the alarm condition where the alarm status bit remains set even after the alarm condition goes away. For the alarm status to clear, the channel input must fall outside the deadband range. Valid range: 0 through the difference between High Scale Value and Low Scale Value (Eng Units).

User Offset (Eng Units)	0.0	Engineering Units offset to change the base of the input channel. This value is added to the scaled value on the channel prior to alarm checking. Valid range: -3.40282E+38 through 3.40282E+38 (Eng Units).
Diagnostic Reporting Enable If Diagnostic Reporting is enabled, the additional parameters listed below can be used to enable specific types of alarms.	Disabled	The Diagnostic Reporting Enable, and Fault Reporting Enable configuration parameters can be used to enable different types of responses for individual channel alarms. By default, all responses are disabled on every channel. Any combination of alarm enables can be configured for each channel. Alarm values are applied to the scaled Engineering Units value.
Fault Reporting Enable If Fault Reporting is enabled, the additional parameters listed below can be used to enable specific types of Faults.	Disabled	If <i>Diagnostic Reporting</i> is enabled, the module reports channel faults and enabled alarms in reference memory at the Diagnostic Reference Address configured for that channel. (Diagnostic Reference Length must be greater than 0.) If <i>Fault Reporting</i> is enabled, the module logs a fault in the I/O Fault table for each occurrence of a channel fault or an enabled channel alarm.
Low Alarm Enable	Disabled	These additional parameters enable or disable individual diagnostics features of a channel. When any of these parameters is enabled, the module uses the associated parameters to perform the enabled feature. For example, if the module detects a loss of circuit communication fault, and Open Wire is enabled for Diagnostic Reporting, the module will set the corresponding bit in the Diagnostic Reference memory for the channel. If any of these parameters is disabled, the module does not react to the associated alarm conditions. For details, refer to the section, <i>Channel Diagnostic Bit Definitions</i> .
High Alarm Enable	Disabled	
Open Wire Enable	Disabled	
New Data Alarm Enable	Disabled	
Error Response Fault	Disabled	
Latched BIT Failure Fault	Disabled	
Latched IIC Failure Fault	Disabled	
Latched ICS Failure Fault	Disabled	

Sensor Scan Group	1	Associates the input channel with other channels that have been assigned the same value. Determines groups of channels to be scanned each internal sweep. To scan all sensors every sweep, they must be in the same scan group. Valid range: 1 through 15.
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16.23.4 Module Status Data: PRS015

Bit offsets are from the Module Status Reference Address.

Bit Offset	Bit Flag Name	Description
0	Module OK	Set to 1 when the module is powered up and there are no errors on module Cleared when module has failed or is not present
1–14	Reserved	Reserved
15	Watchdog failure	Set to 1 when watchdog timeout error has occurred
16	RAM failure	Set to 1 when RAM failure has occurred
17	Interface failure	Set to 1 when interface failure has occurred
18–31	Reserved	Reserved

16.23.5 Input Channel Scaling: PRS015

Scaling parameters specify the relationship between the LG1237 reported value (input signal) and the engineering units value.

AL = Low Scale A/D Units

AH = High Scale A/D Units

EL = Low Scale Engineering Units

EH = High Scale Engineering Units

IS = Input Signal (in signal units)

$$\text{User Scaled value} = IS \times \frac{EH - EL}{AH - AL} + EL - AL \times \frac{EH - EL}{AH - AL}$$

16.23.6 Channel Diagnostic Reporting: PRS015

The module reports channel diagnostics in the Diagnostic Reference memory area, which is configured on the module Settings tab. Two words (32 bits) are allocated to each channel.

16.23.6.1 Channel Segments

Channel	Starting Reference Address
0	Diagnostic Reference Address +0
1	Diagnostic Reference Address +2
2	Diagnostic Reference Address +4
3	Diagnostic Reference Address +6
4	Diagnostic Reference Address +8
5	Diagnostic Reference Address +10
6	Diagnostic Reference Address +12
7	Diagnostic Reference Address +14

Channel	Starting Reference Address
8	Diagnostic Reference Address +16
9	Diagnostic Reference Address +18
10	Diagnostic Reference Address +20
11	Diagnostic Reference Address +22
12	Diagnostic Reference Address +24
13	Diagnostic Reference Address +26
14	Diagnostic Reference Address +28

16.23.6.2 Channel Diagnostic Bit Definitions

Bit offsets are from the start of each channel segment in Diagnostic Reference memory.

Bit Offset	Bit Flag Name	Description
0	Low Alarm fault	Set to 1 when Low Alarm is detected. Cleared when Low Alarm off or detection is disabled.
1	High Alarm fault	Set to 1 when High Alarm is detected. Cleared when High Alarm off or detection is disabled.
2–3	Reserved	Used by other analog modules
4	Loss of circuit communication (Open Wire)	Set to 1 if the LG1237 fails to respond to the most recent attempt to read pressure. If any of the transducer fault bit (28, 29 or 30) is set for this channel, this bit will also be set. Cleared when the CPU completes an I/O scan.
5–22	Reserved	Reserved
23	New Data	Set on every successful reading of pressure from the LG1237. Cleared when the CPU completes an I/O scan. This flag allows the application program to detect when new values are available to process.
24	Error response fault	Set when the most recent Response Status flags (bits 25–27) sent from the LG1237 indicate an error.
25–27	Response Status bit 0	Reserved
28	Latched Bit Failure fault	Set when LG1237 BIT failure is detected. The PRS015 reads this bit from the enabled channel on configured download and after a reset command is issued. Cleared when the CPU completes an I/O scan.
29	Latched IIC Failure fault	Set when LG1237 IIC (invalid input conditions) failure is detected. The PRS015 reads this bit from the enabled channel on configured download and after a reset command is issued. Cleared when the CPU completes an I/O scan.
30	Latched ICS Failure fault	Set when LG1237 ICS failure is detected. The PRS015 reads this bit from the enabled channel on configured download and after a reset command is issued. Cleared when the CPU completes an I/O scan.
31	Reserved	Reserved for future fault

16.23.7 Command Data: PRS015

The application logic uses the Command Data memory areas defined in the PRS015 configuration profile of the module to send commands to LG1237 transducers and receive the responses from the transducers through the serial port.

The application logic issues a command to the LG1237 by setting the value of the Command field in the Command Output data.

When the module is processing a command, the Command Response field contains the *Processing Command* value.

To issue another command, the application must set the Command field to *No Command* and wait for the *No Command Processing* response.

16.23.7.1 Command Output Data

The Command Output data consists of six words, starting at the Command Output Data Reference Address.

Byte Offsets	Field Name	Command Values
0–3	Command	0x0000 0x0000 No Command 0x0000 0x0001 RESET All other values are reserved.
4–7	Address	Specifies the LG1237 channel to be accessed by the RESET command. Can be changed by the application logic in RUN mode Bits 0–3 Address (0–15 valid; no error checking)
8–23	Reserved	Reserved

16.23.7.2 Reset Command

The Reset command addresses the LG1237 channel defined in the Address field. No errors are generated for this command.

To reset all LG1237 transducers, issue the Reset command to the global address, 15.

16.23.7.3 Command Input Data

When the LG1237 receives a command from the Pressure Transducer module, it returns a command response, which is written to the Command Input Data Reference memory, starting at the Command Input Data Reference Address.

Byte Offsets	Field Name	Response Values
0–3	Command Response	0x0000 0x0000 (0 dec) No Command Processing† 0x0000 0x0001 Processing Command† 0x0000 0x0002 Command Complete† 0x1111 0x1111 (-1 dec) Response not received prior to time out 0x1111 0x1110 Response error: Parity, Address or Response code 0x1111 0x1101 Detected BIT (Built In Test) Failure 0x1111 0x1100 Detected IIC (Invalid Input Conditions) 0x1111 0x0111 Command Order Error†
4–23	Reserved	Reserved

16.23.8 Wiring: PRS015

16.23.8.1 Serial Ports

This port is a standard RJ-45 female connector with the following pin assignments.

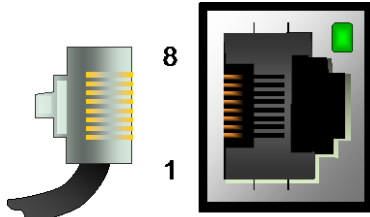


Figure 417: RJ-45 Pinout PRS015

RJ-45 Pin	RS-485/422 Four-Wire Pinouts
8	GND
7	Termination 2
6	Rx- (Input)
5	GND
4	
3	Rx+ (Input)
2	Tx- (Output)
1	Tx+ (Output)

Note: There is no shield or frame ground pin on the port connector. To reduce susceptibility to noise, the RX+ and RX- signals should be wired to the same twisted pair. Likewise, the TX+ and TX- signals should be wired to a single twisted pair.

16.23.8.2 Termination

By default, each port is set for no termination. Termination is needed if the module is the first or last device on an RS-485 network, even if there is only one other device on the network. Termination can be provided using either an external resistor as displayed in the following figure or the 120Ω termination resistor built into the port. If line termination other than 120Ω is required, an appropriate external resistor must be supplied.

User-Supplied Termination for RS-485

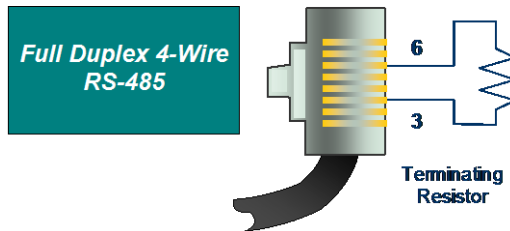


Figure 418: Externally-Mounted Terminating Resistor

Built-in Termination for RS-485

Termination using the built-in 120Ω resistor can be provided by setting the appropriate RS-485 termination jumper OR by installing shorting jumpers on the RS-485 cable connector that attaches to the serial port.

- To set 120 Ω termination internally
 - 1) Remove the faceplate of the module by pressing in on the side tabs and pulling the faceplate away from the module.
 - 2) With the module oriented as shown, move *either* the upper or lower jumper

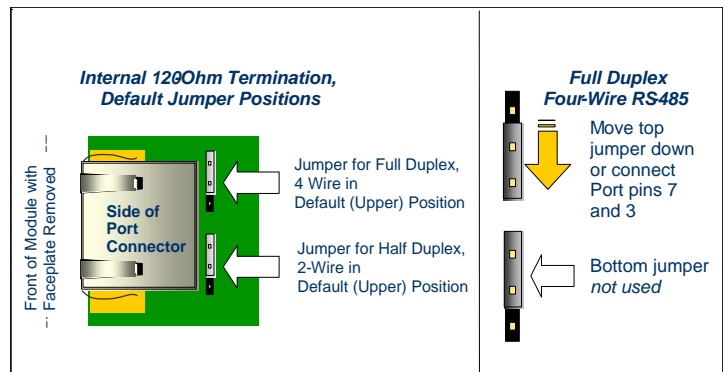


Figure 419: Using the Internal Terminating Resistor PRS015

Chapter 17 Terminal Blocks and Interconnect Cables

This chapter describes the following:

- High-Density Module-Mounted Terminal Blocks (Section 17.1)
- Terminal Block Quick Connect (TBQC) system (Section 17.2)
 - for RX3i and Series 90-30 20-terminal discrete modules
 - for RX3i and Series 90-30 32-point discrete modules with dual D-Connectors
 - for RX3i and Series 90-30 Modules with 36 terminals
- Pre-fabricated interconnect cable suitable for connecting the I/O Modules to the Remote TBQC terminal blocks
- How to build a custom interconnect cable.
- Terminal Block Selection Options

Unless otherwise stated, RX3i I/O modules are provided with a suitable terminal block. Refer to the section in this manual which discusses the specific I/O module of interest.

In the case of high-density discrete I/O modules, the user has some terminal block selection options, so terminal blocks are purchased separately. The user may select:

- A module-mounted terminal block, in which case all field wiring will be directly attached to the I/O module
- An interposing terminal strip with an interconnect cable, allowing all field wiring to be landed on the interposing terminal strip, which is then attached to the I/O module via a pre-fabricated or custom cable. This allows for quick connection of the I/O module to previously wired terminal strips. It also provides a solution where wiring directly to the I/O module is not possible due to space limitations or due to the rigidity or thickness of the wire bundle.

17.1 High-Density Module-Mounted Terminal Blocks

Terminal Block Type	Catalog Number
Box-style Terminal Block, 36 Terminals	IC694TBB032
Spring-style Terminal Block, 36 Terminals	IC694TBS032
Extended Box-style Terminal Block, 36 Terminals	IC694TBB132
Extended Spring-style Terminal Block, 36 Terminals	IC694TBS132

17.1.1 Terminal Blocks for High-Density RX3i Modules

17.1.1.1 Extended High-Density vs. High-Density Terminal Blocks

Extended High-Density Terminal Blocks IC694TBB132 and IC694TBS132 are functionally identical to High-Density Terminal Blocks IC694TBB032 and IC694TBS032. Both attach directly to the I/O module. The Extended High-Density Terminal Blocks have an outer cover that is approximately 13 mm (½ in) deeper. This is to accommodate wires with thicker insulation, such as wires typically used with AC I/O modules.

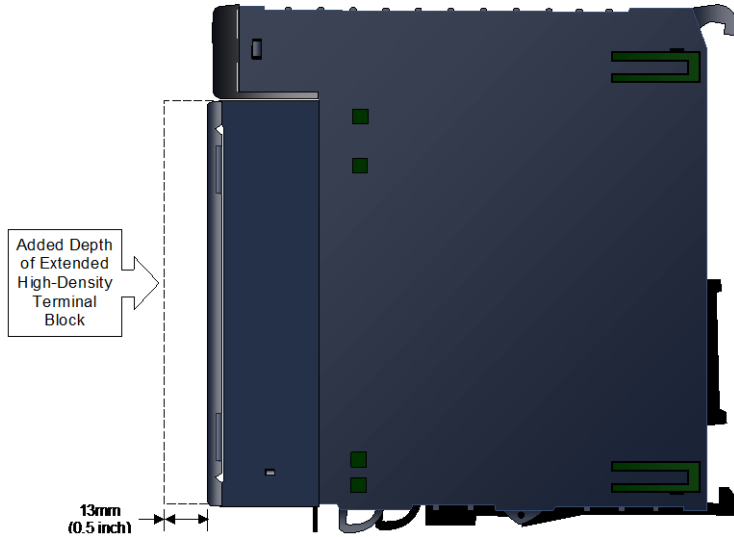


Figure 420: Additional Depth due to Extended High-Density Terminal Blocks

Figure 421 compares the space for wiring on a High-Density Terminal Block (left) and an Extended High-Density Terminal Block (right), seen from the bottom of the module.

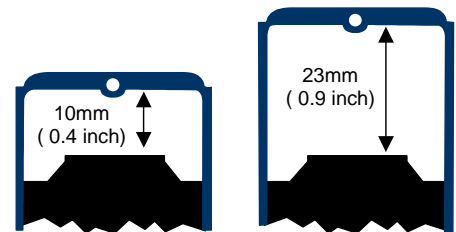


Figure 421: Depth Comparison: High-Density vs Extended High-Density Terminal Block

17.1.1.2 IC694TBB032 and TBB132 Box-Style Terminal Blocks, 36 Terminals



Box-Style Terminal Blocks, IC694TBB032 and IC694TBB132, are used with high-density PACSystems RX3i modules and equivalent Series 90-30 PLC modules. These terminal blocks provide 36 screw terminals for field wiring to the module.

Terminal Blocks IC694TBB032 and TBB132 are functionally identical. Terminal Block IC694TBB032 comes with a standard-depth outer cover. When installed, it is the same depth as most other PACSystems and Series 90-30 PLC modules.

Extended Terminal Block IC694TBB132 comes with an outer cover that is approximately 13 mm (½ in) deeper than Terminal Block IC694TBB032, to accommodate wires with thicker insulation, such as that typically used with AC I/O modules.

Specifications: TBB032 and TBB132

Torque	0.79 Nm (7 in-lb)
Wire strip length	7.87 mm (0.310 in)
Wire gauges supported	#14-26 AWG (solid or stranded)

Figure 422: 36-Terminal Box-Style Terminal Block

Connecting Field Wiring to a Box-Style High-Density Terminal Block

The bottom of the terminal block can be used as a gauge for the wire strip length, as displayed in Figure 423. The stripped wire must be fully inserted into the terminal block so that the insulation meets the stop position inside the terminal, and the end of the wire is bent. Tightening the terminal screw raises the wire and clamps it in place.

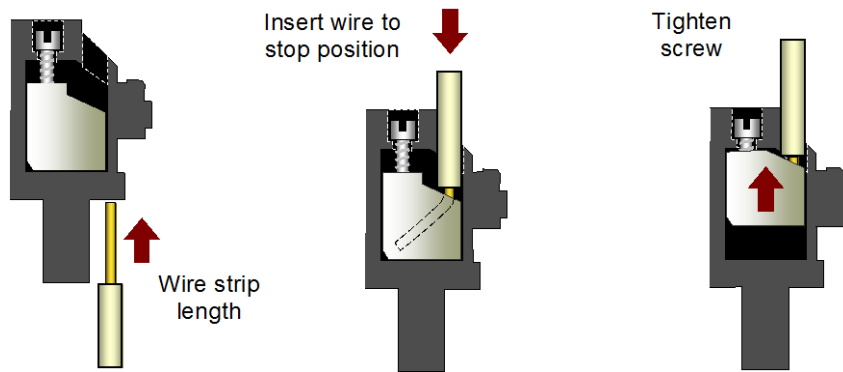
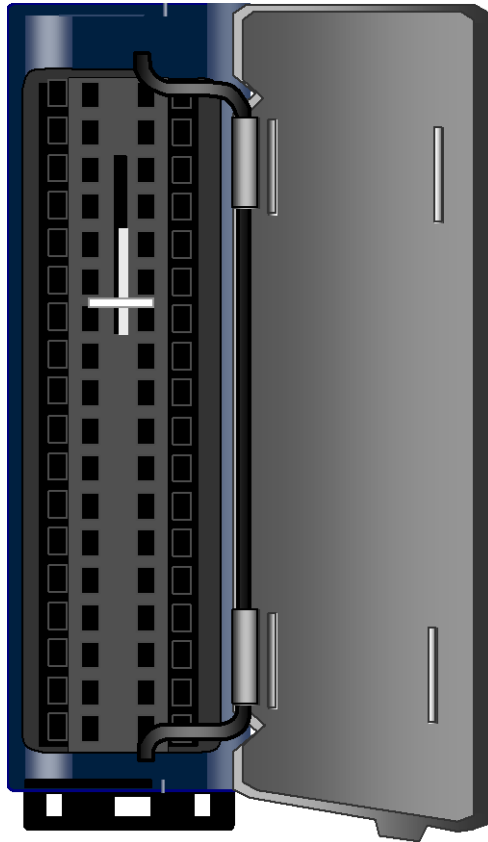


Figure 423: Wire Preparation and Insertion into Box-Style Terminal Block

17.1.1.3 IC694TBS032 and TBS132 Spring-Style Terminal Blocks, 36 Terminals



Spring-Style Terminal Blocks, IC694TBS032 and IC694TBS132, are used with High-Density PACSystems RX3i modules and equivalent Series 90-30 PLC modules. These terminal blocks provide 36 spring style terminals for field wiring to the module.

Terminal Blocks IC694TBS032 and TBS132 are functionally identical. Terminal Block IC694TBS032 comes with a standard-depth outer cover. When installed, it is the same depth as most other PACSystems and Series 90-30 PLC modules.

Extended Terminal Block IC694TBS132 comes with an outer cover that is approximately ½ inch (13mm) deeper than Terminal Block IC694TBS032, to accommodate wires with thicker insulation, such as that typically used with AC I/O modules.

Specifications: TBS032 and TBS132

Wire strip length	7.87 mm (0.310 in)
Wire gauges supported	#14-28 AWG (solid or stranded)

Figure 424: 36-Terminal Spring-Style Terminal Block

17.1.2 Installing and Removing High-Density Terminal Blocks

This section has special installation instructions for High-Density Terminal Blocks. Refer to Chapter 2 for general installation information.



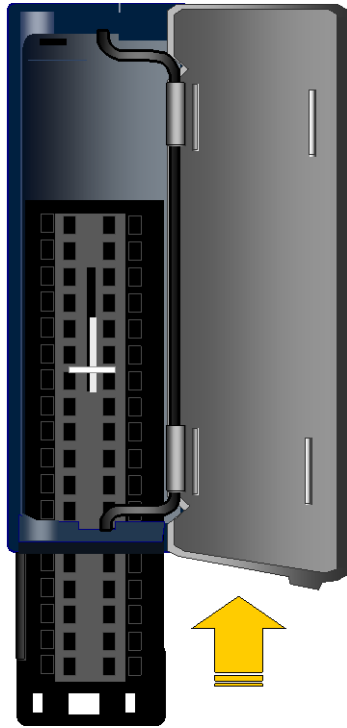
Warning

Field power must be turned off when installing or removing a Terminal Block assembly.

17.1.2.1 *Installing or Removing the Terminal Block Assembly of a Module*

- To install or remove the terminal block module assembly
- 1. Install the small catalog number label (for example: "MDL240") supplied with the module in the slot on the top of the Terminal Block.
- 2. Complete the module wiring and secure the wire bundles to the tie downs on the bottom of the Terminal Block.

17.1.2.2 Inserting a Terminal Block in its Cover



- To insert a terminal block in the cover
- 1) Align the top of the Terminal Block with the bottom of the cover, making sure that the notches in the Terminal Block match up with the grooves in the cover.
- 2) Slide the Terminal Block upward until it clicks into place.

Figure 425: Inserting Terminal Block into its Cover

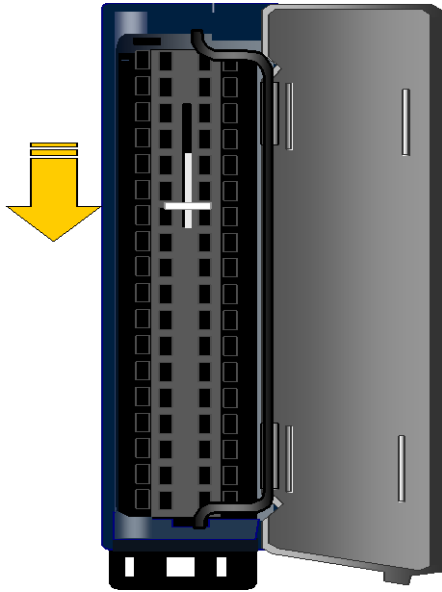
17.1.2.3 Installing a High-Density Terminal Block Assembly

- To install a high-density terminal block assembly
- 1) Press the terminal block assembly straight toward the module until it is partially seated.
- 2) Open the door on the front of the terminal block and push the latch (refer to below) up very firmly until it reaches the top of the slot and clicks into place.
- 3) Check to be sure the terminal block is fully seated.



Figure 426: Installing a High-Density Terminal Block

17.1.2.4 Removing a High-Density Terminal Block from the Module



- To install a high-density terminal block assembly
 - 1) Open the terminal block door.
 - 2) Push the white plastic latch down as shown at left very firmly until the terminal block is released.
 - 3) Pull the terminal block straight out and away from the module until the contacts have separated.

Figure 427: Removing a High-Density Terminal Block

17.1.2.5 Removing a Terminal Block from its Cover

- To remove a Terminal Block from its cover
 - 1) Grasp the sides of the Terminal Block cover.
 - 2) Pull down on the bottom of the Terminal Block.

17.2 Terminal Block Quick Connect (TBQC) System

The optional Terminal Block Quick Connect (TBQC) system allows the listed discrete and analog I/O modules to be quickly connected to external TBQC terminal blocks via an interconnecting cable. The TBQC system significantly reduces wiring costs by reducing wiring time and eliminating wiring errors. The TBQC terminal blocks also have integrated test points to simplify wiring troubleshooting.

There are three distinct TBQC product offerings (not interchangeable):

- 1) The Low-Density TBQC products (IC693ACC329 -333) provide 20-terminal remote connector blocks. They are compatible primarily with Low-Density Discrete I/O Modules that come equipped with a 20-terminal connector header. They connect to the I/O module via an unshielded cable. The original 20-terminal connector may be retained on the I/O module, or may be replaced with a faceplate containing a compatible D-connector (catalog number IC693ACC334). Using the D-connector faceplate greatly simplifies the wiring effort.
- 2) IC693ACC337 is a variant of (1) above. It provides a 24-terminal remote connector and a pair of interconnecting cables that are compatible with those 32-point discrete I/O modules that come equipped with a pair of D-connectors. They connect to the I/O module via a pair of unshielded cables.
- 3) The high-density remote terminal block (IC694RTB032) is compatible with IC694TBC032, which is a 36-terminal module-mounted terminal block. They are interconnected via a shielded cable. This allows it to support analog modules as well as discrete.

17.2.1 Low-Density TBQC System Overview

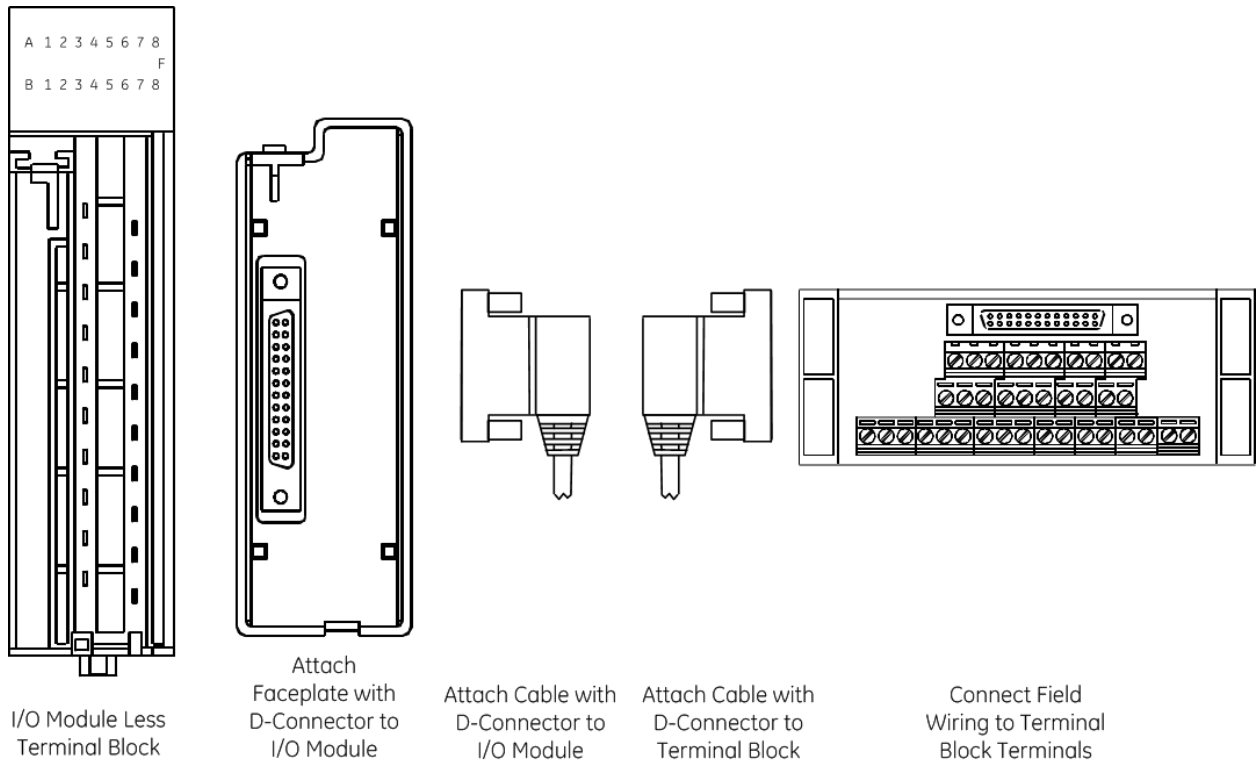


Figure 428: Low-Density Terminal Block Quick Connect System

The TBQC terminal block is snapped onto a standard DIN-rail. Then a pre-fabricated cable is connected between the D-connector of the terminal block and the connector of the I/O module. An I/O module normally equipped with terminals needs to be converted to a D-connector type using an adapter faceplate (IC693ACC334) shown above. Alternatively, the interconnecting cable may have wires at the I/O module end and a D-connector at the TBQC end.

Using the pre-fabricated cables (refer to Section, 17.2.1.1 for *Low-Density, Unshielded 20-/24-point TBQC*), the 24-conductor cables are wired straight through from the I/O Faceplate to the TBQC terminal block, ensuring that Terminal 1 of the I/O Module maps to Terminal 1 of the TBQC Terminal Block, and Terminal 20 maps to Terminal 20, etc.

The IC693ACC series of terminal blocks have three rows of terminals, arranged in three levels, as displayed in the following figures. These terminal blocks feature an easy to use captive-screw, rising cage type connection system.

The IC693ACC TBQC system is not recommended for use with Analog modules because it does not meet the shielding recommendations for Analog module connections.

17.2.1.1 Components for Low-Density, Unshielded 20-/24-point TBQC

Part Number	Description	Compatibility
IC693ACC334	Low-Density, 20-point terminal block with 24-pin D-connector.	IC693MDLxxx / IC694MDLxxx compatible with 20-point terminal block.
IC693ACC329 ⁹¹	Low-Density, 20-point terminal block with 24-pin D-connector.	IC69xMDL645, IC69xMDL646, IC69xMDL240, IC69xMDL740, IC69xMDL741, IC69xMDL742
IC693ACC332	Low-Density, 20-point terminal block with 24-pin D-connector.	IC69xMDL940 only
IC693ACC333	Low-Density, 20-point terminal block with 24-pin D-connector.	IC69xMDL340 only
IC693ACC337	Medium density, 24-point terminal block with 24-pin D-connector.	IC69xMDL654, IC69xMDL655, IC69xMDL752, IC69xMDL753
IC693CBL329	Unshielded 1.0 meter cable with 24-pin D-connector termination on both ends.	IC693ACC337 (left side)
IC693CBL330	Unshielded 1.0 meter cable with 24-pin D-connector termination on both ends.	IC693ACC334 and IC693ACC329 & IC693ACC337 (right side)
IC693CBL331	Unshielded 2.0 meter cable with 24-pin D-connector termination on both ends.	IC693ACC337 (left side)
IC693CBL332	Unshielded 2.0 meter cable with 24-pin D-connector termination on both ends.	IC693ACC334 and IC693ACC329 & IC693ACC337 (right side)
IC693CBL333	Unshielded 0.5 meter cable with 24-pin D-connector termination on both ends.	IC693ACC337 (left side)
IC693CBL334	Unshielded 0.5 meter cable with 24-pin D-connector termination on both ends.	IC693ACC334 and IC693ACC329 & IC693ACC337 (right side)
IC693CBL327	Unshielded 3.0 meter cable with 24-pin D-connector termination on one end.	IC694MDL752, IC694MDL753
IC693CBL328	Unshielded 3.0 meter cable with 24-pin D-connector termination on one end.	IC694MDL752, IC694MDL753 IC693ACC334

⁹¹ This Terminal Block may be used with most I/O modules that have up to 16 I/O points. It cannot be used with 32-point modules. Jumpers may have to be added at the terminal block; for details of required wiring connections, refer to individual module specifications.

17.2.1.2 Typical IC693ACC Terminal Block

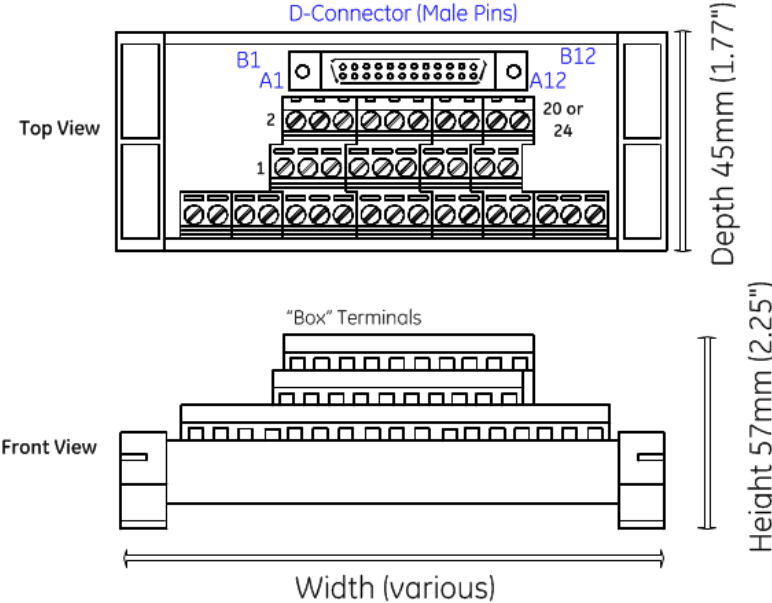


Figure 429: IC693ACC Terminal Block

17.2.1.3 IC693ACC329 TBQC Terminal Block

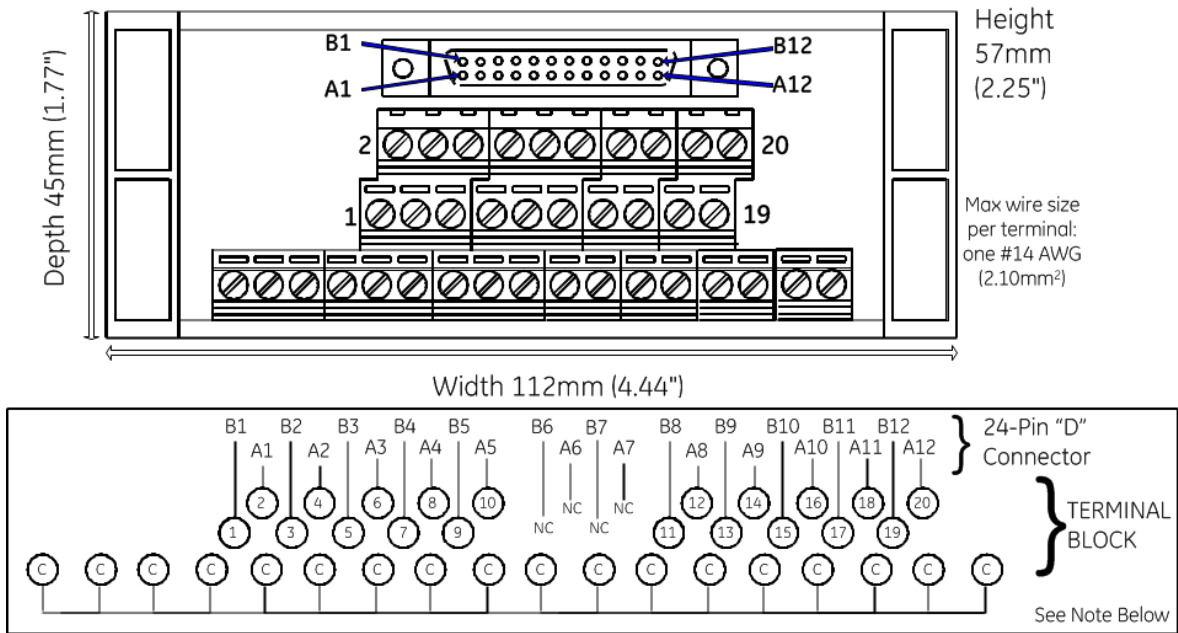


Figure 430: IC693ACC329 TBQC Terminal Block

Note: The common row terminals (labeled with the letter C) are provided for wiring convenience. Their use is optional. They are electrically isolated from the numbered terminals. You may use them as is, or jumper them to a numbered terminal.

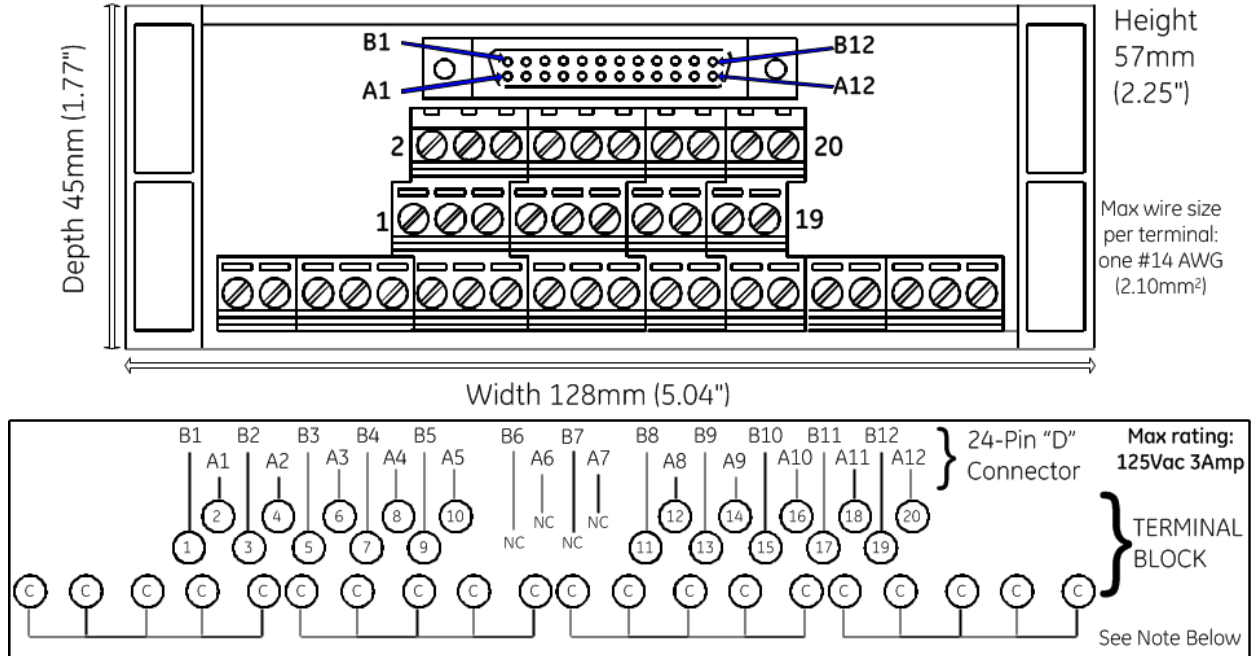
Connecting

Refer to cable selection in Section, 17.2.1.1 for Low-Density, Unshielded 20-/24-point TBQC.

Mounting

These terminal blocks are mounted on a standard, user-supplied 35 mm DIN-rail.

17.2.1.4 IC693ACC332 TBQC Terminal Block



Note: The common row terminals (labeled with the letter C) are provided for wiring convenience. Their use is optional. They are electrically isolated from the numbered terminals. You may use them as is, or jumper them to a numbered terminal.

Connecting

Refer to cable selection in Section, 17.2.1.1 for Low-Density, Unshielded 20-/24-point TBQC.

Mounting

These terminal blocks are mounted on a standard, user-supplied 35 mm DIN-rail.

17.2.1.5 IC693ACC333 TBQC Terminal Block

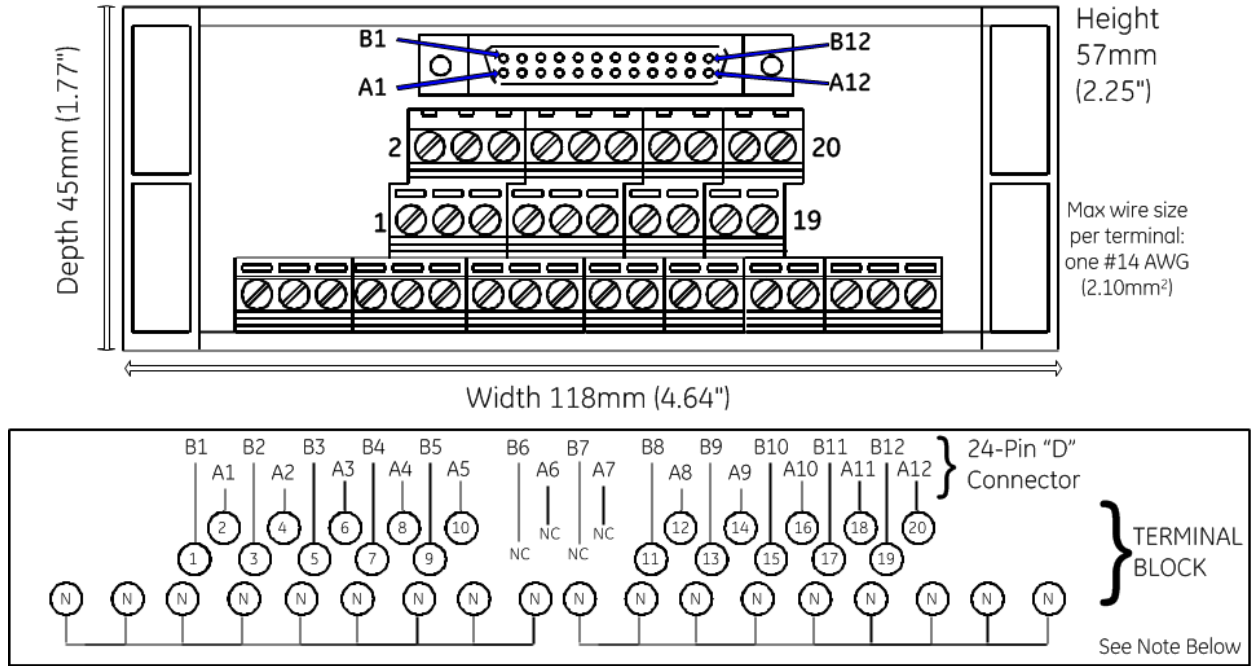


Figure 432: IC693ACC333 TBQC Terminal Block

Note: The neutral row terminals (labeled with the letter N) are provided for wiring convenience. Their use is optional. They are electrically isolated from the numbered terminals. You may use them as is, or jumper them to a numbered terminal.

Connecting

Refer to cable selection in Section, 17.2.1.1 for Low-Density, Unshielded 20-/24-point TBQC.

Mounting

These terminal blocks are mounted on a standard, user-supplied 35 mm DIN-rail.

17.2.1.6 I/O Faceplate with D-Connector for 20-Terminal I/O Modules

The I/O Faceplate (catalog number IC693ACC334) may be inserted into the I/O Module header in place of the 20-screw type terminal block. IC693ACC334 provides a 24-pin D-connector, which may be connected to the remote TBQC terminal block via a pre-fabricated cable. This Faceplate replaces the standard 20-screw type terminal board on the listed modules.

Faceplate Connector Pin Orientation and Connection to Module Terminal

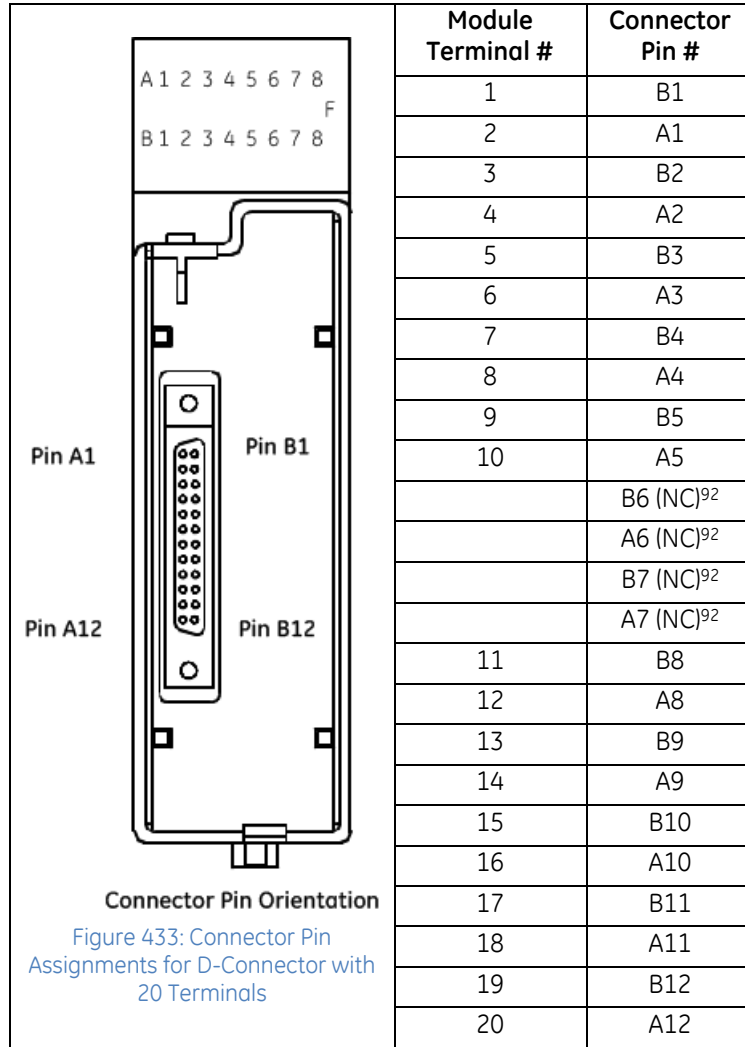
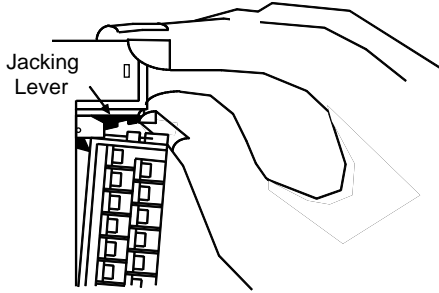


Figure 433: Connector Pin Assignments for D-Connector with 20 Terminals

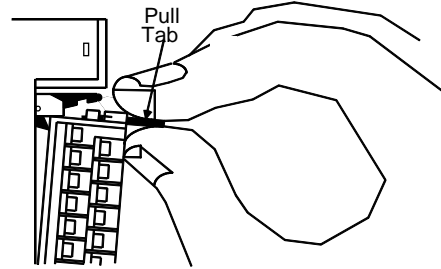
⁹² Note that there are four “No Connect” pins in the D-Connector.

Installation of I/O Faceplate IC693ACC334

- To install the IC693ACC334 I/O faceplate
- 1) Remove 20-pin terminal assembly from module



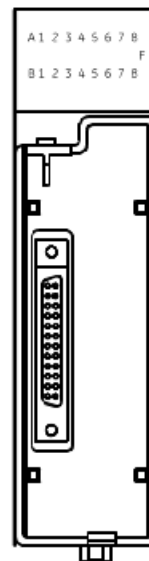
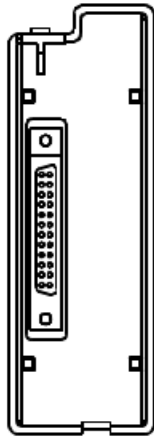
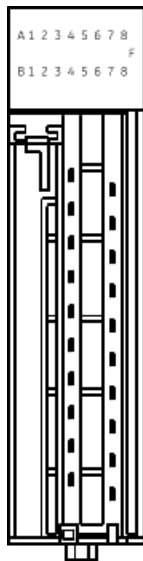
1. Open the plastic terminal board cover. Push up on the jacking lever to release the terminal block.



2. Grasp pull-tab towards you until contacts have separated from module housing and hook has disengaged for full removal.

Figure 434: IC693ACC334 I/O Faceplate Installation

- 2) Snap the I/O faceplate assembly on module.



Installing the I/O Faceplate

Module with I/O Faceplate Installed

Figure 435: IC693ACC334 I/O Faceplate Snaps into Place

Install the TBQC terminal block of your choice and run the interconnecting cable between the I/O Faceplate and the D-connector on the TBQC terminal block.

17.2.1.7 Cable Current Rating for Available Interconnect Cables

Each conductor in the IC693CBL* 24-conductor cables has a current rating of 1.2 A.

If using cables with a 16-point output module with a higher output current rating, your loads must not draw more than 1.2 A. If you have field devices that require more than 1.2 A, do not use a TBQC assembly; use the standard Terminal Board that comes with the module instead.

A current rating of 1.2 A is more than adequate to handle the current requirement of any of the 32-point I/O modules listed earlier.

17.2.1.8 Interconnect Cable Connector & Construction Information

Cables IC693CBL327 and IC693CBL328 each have a right-angle 24-pin connector (Fujitsu FCN-365S024-AU) on one end and a set of stripped wire ends on the other.

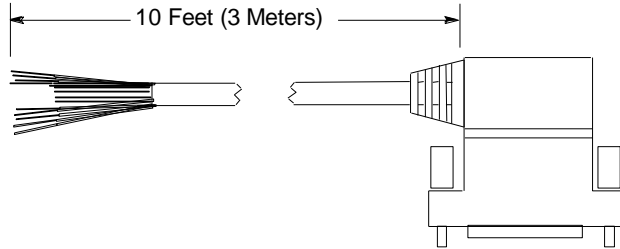


Figure 436: IC693CBL327 and IC693CBL328 Cable Construction

All of the other IC693CBL* cables types have connectors (Fujitsu FCN-365S024-AU) on both ends. These cables are wired pin-to-pin (pin A1 to pin A1, pin A2 to pin A2, and so forth).

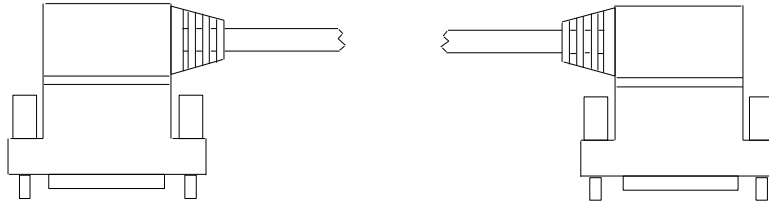


Figure 437: Cable Construction for all other IC693CBL* Cables

Each pin on these connectors has a current rating of 1.2 A.

17.2.1.9 Connector Depth

The prefabricated IC693CBL* cables extend 51 mm (2in) out from the face of the modules to which they are connected. The depth of the cabinet that the PLC is mounted in should allow for the 51 mm (2in) depth added by the connector.

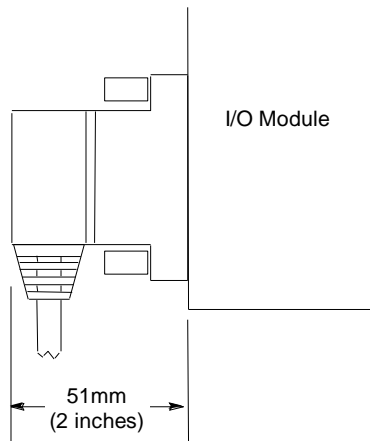


Figure 438: Connector Depth for IC693CBL* Cables

17.2.1.10 Building Custom Length 24-Conductor D-Connector Cables

Cables similar to IC693ACC* connecting the I/O module to TBQC terminals can be built to length.

Purchase the mating female (socket type) 24-pin connectors. The 24-pin connector kit can be ordered as an accessory kit from GE. Catalog numbers for these connectors and their associated parts are listed in the following table.

The list includes catalog numbers for three types of connectors: solder pin, crimp pin, and ribbon cable. Each accessory kit contains enough components (such as D-connectors, backshells, and contact pins) to assemble ten single-ended cables of the type specified for each kit.

GE Catalog Number	Vendor Catalog Number	Description
IC693ACC316 (Solder Eyelet Type)	FCN-361J024-AU	Solder eyelet receptacle
	FCN-360C024-B	Backshell (for above)
IC693ACC317 (Crimp Type)	FCN-363J024	Crimp wire receptacle
	FCN-363J-AU	Crimp pin (for above, 24 needed)
	FCN-360C024-B	Backshell (for above)
IC693ACC318 (Ribbon or IDC Type)	FCN-367J024-AUF	IDC (ribbon) receptacle, closed cover
	FCN-367J024-AUH	IDC (ribbon) receptacle, open cover

Additional tools from Fujitsu are required to properly assemble the crimped contact and ribbon cable type connectors. *The solder eyelet connectors (as provided in IC693ACC316) do not require any special tooling.*

Crimped Contact Connectors (as provided in IC693ACC317) require:

Hand Crimping Tool FCN-363T-T005/H
Contact Extraction Tool FCN-360T-T001/H

Ribbon Cable Connectors (as provided in IC693ACC318) require:

Cable Cutter FCN-707T-T001/H
Hand Press FCN-707T-T101/H
Locator Plate FCN-367T-T012/H

These tools must be ordered from an authorized Fujitsu distributor.

Pin connections with color codes are displayed in the following figure. Cables are made of 12 twisted pairs; wire size is #24 AWG (0.22mm²). Each pair has a solid color wire and the same color wire with a black tracer.

Pin Number	Pair #	Wire Color Code	Pin Number	Pair #	Wire Color Code
A1	1	BROWN	B1	7	VIOLET
A2	1	BROWN/BLACK	B2	7	VIOLET/BLACK
A3	2	RED	B3	8	WHITE
A4	2	RED/BLACK	B4	8	WHITE/BLACK
A5	3	ORANGE	B5	9	GRAY
A6	3	ORANGE/BLACK	B6	9	GRAY/BLACK
A7	4	YELLOW	B7	10	PINK
A8	4	YELLOW/BLACK	B8	10	PINK/BLACK
A9	5	DARK GREEN	B9	11	LIGHT BLUE
A10	5	DARK GREEN/BLACK	B10	11	LIGHT BLUE/BLACK
A11	6	DARK BLUE	B11	12	LIGHT GREEN
A12	6	DARK BLUE/BLACK	B12	12	LIGHT GREEN/BLACK

Figure 439: D-Connector Pinout

17.2.1.11 Connector Depth for Custom Built Cables

If custom-built cables use a straight connector, as indicated above, they will require more space in front of the PLC than the prefabricated cables (refer to Section, 17.2.1.1 for Low-Density, Unshielded 20-/24-point TBQC), which use right-angle connectors. The depth of the cabinet that the PLC is mounted in should allow for the depth added by the selected connector.

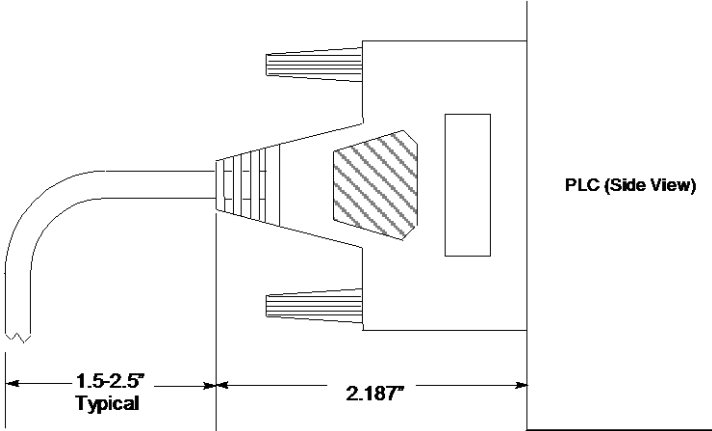


Figure 440: Allowance for Extra Depth using Straight-On Connectors

17.2.2 Low-Density TBQC System Variant for 32-Point I/O Modules with Dual D-Connectors

IC693ACC337 provides 24 terminals (versus 20). It is designed for use with those 32-point discrete modules that come equipped with dual D-connectors. This TBQC configuration uses a mated pair of cables (one right-egress and one left-egress) in order to connect the dual D-connectors on the I/O Module to a pair of IC693ACC337 terminal blocks.

The compatible cables connect Pin 1 of the TBQC D-connector to Pin 1 of the corresponding D-connector on the I/O module, and Pin 24 to Pin 24, and such.



Figure 441: IC693ACC337 Terminal Block Top and Front Views

17.2.2.1 IC693ACC337 TBQC Terminal Block

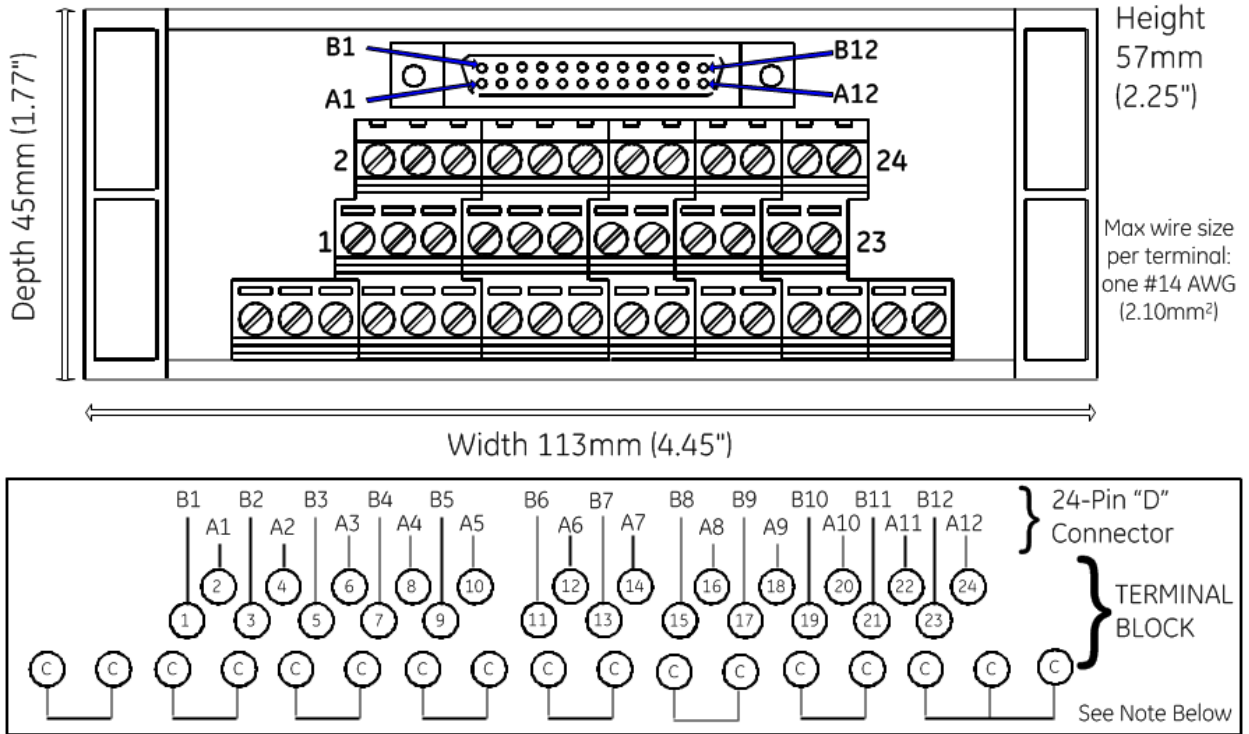


Figure 442: IC693ACC337 TBQC Terminal Block

Note: The common row terminals (labeled with the letter C) are provided for wiring convenience. Their use is optional. They are electrically isolated from the numbered terminals. You may use them as is, or jumper them to a numbered terminal.

Connecting

Refer to Section, 17.2.1.1 for Low-Density, Unshielded 20-/24-point TBQC for cable selection. Remember that for interfacing with a 32-point module with dual D-connectors, it will be necessary to pick a left-side cable and a right-side cable.

Mounting

These terminal blocks are mounted on a standard, user-supplied 35 mm DIN-rail.

17.2.2.2 Connecting TBQC Components to 32-Point Modules

Those 32-point modules equipped with a pair of 24-pin D-connectors on their faceplate may be used with TBQC terminal block IC693ACC337. They do not require a substitute faceplate as was described for the 20-terminal modules.

Since each 32-point I/O module provides two 24-pin D-connectors, they will each require two cables and two IC693ACC337 TBQC terminal blocks. Additionally, since the two connectors on the I/O module are oriented differently (refer to figure below), the egress for each of the cables is different. GE supplies “right side” and “left side” cables to simplify installation. Refer to Section, 17.2.1.1 for Low-Density, Unshielded 20-/24-point TBQC for cable selection.

After installation, cables can be secured to the two tie-downs on the bottom of the module.

Note: These terminal blocks do not work with 32-point I/O modules that have 50-pin connectors.

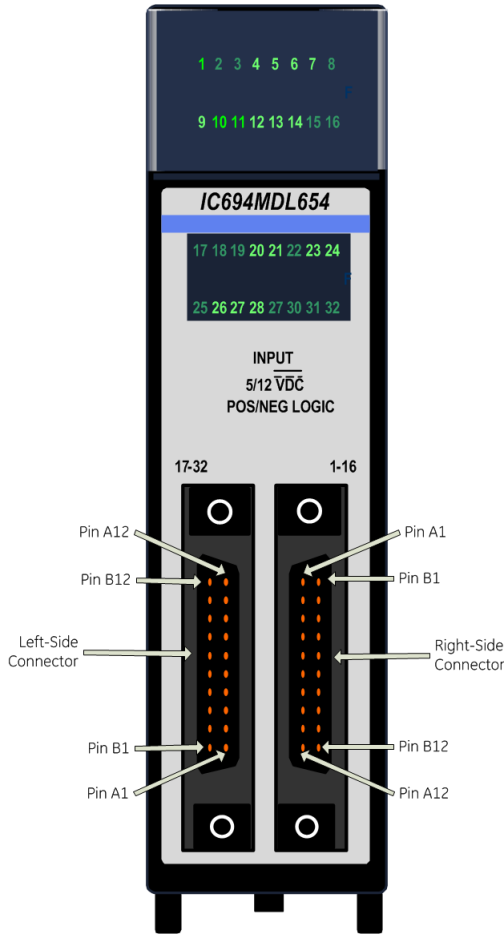


Figure 443: Pinout Assignments on Dual D-Connector Modules

17.2.3 High-Density TBQC System Overview

The High-Density Compact Remote Terminal Base IC694RTB032 connects to the I/O module faceplate IC694TBC032 via a shielded cable IC694CBL* (refer to the section, *Components for High-Density, Shielded 36-TBQC*) and supports both analog and discrete I/O modules, as displayed in the following table.

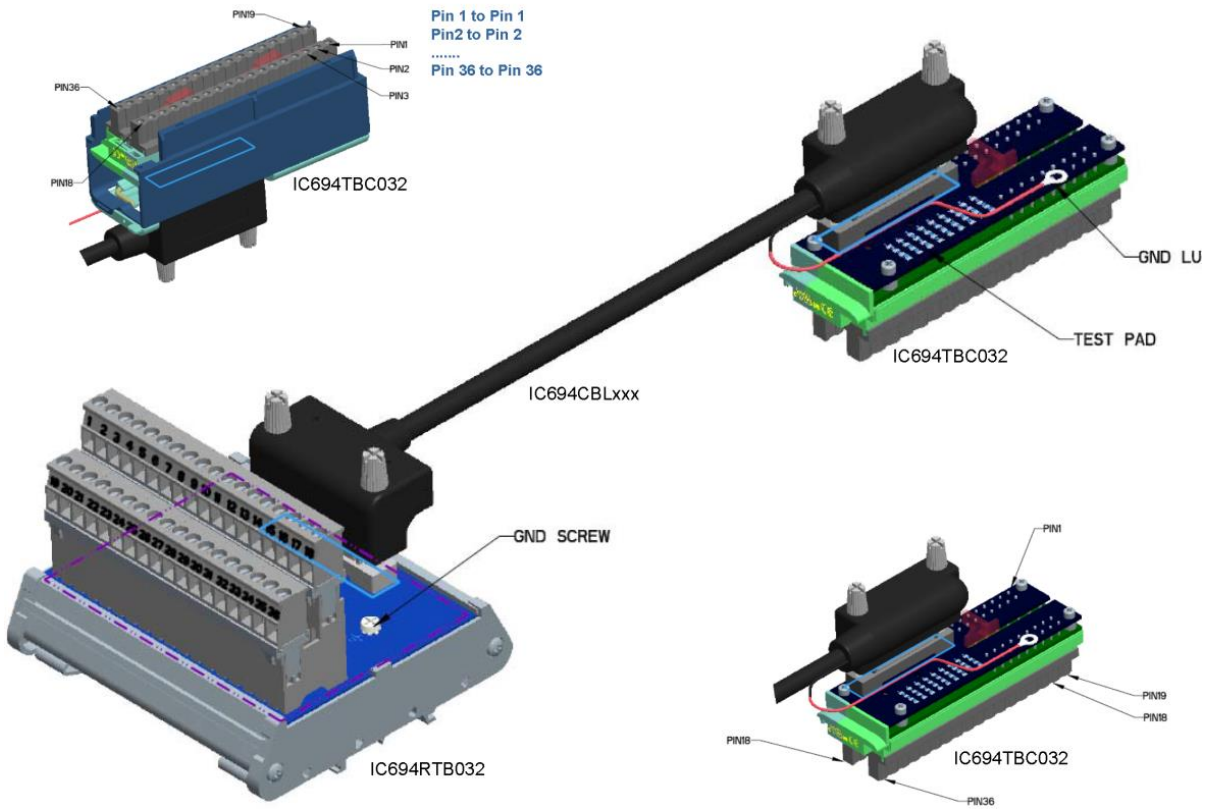


Figure 444: High-Density TBQC System Overview

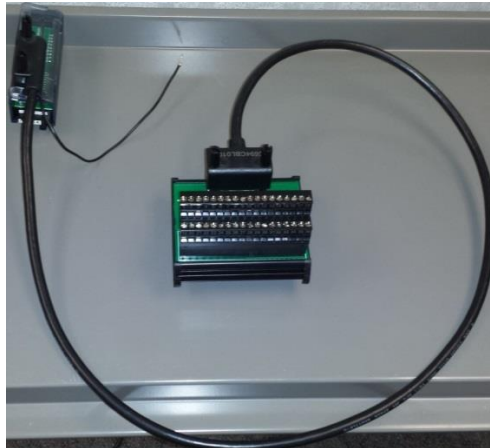


Figure 445: High-Density Compact Remote Terminal Base IC694RTB032 Usage

17.2.3.1 Components for High-Density, Shielded 36-TBQC

Part Number	Description	Compatibility
IC694TBB032	Box-Style 36-point Terminal Block (refer to Section 17.1.1.2).	As listed throughout the manual.
IC694TBC032	High-Density terminal block with single 36-pin D-connector.	IC695ALGxxx, IC69xMDL660 and IC694MDL664 modules only. Discrete output modules and Thermocouple modules are not supported.
IC694RTB032	High-Density remote base, with 36-pin D-connector, shield ground lug and with a 36-point removable terminal block.	IC695ALGxxx, IC69xMDL660 and IC694MDL664 modules only. Discrete output modules and Thermocouple modules are <u>not</u> supported.
IC694CBL005	Shielded 0.5 meter cable with 36-pin D-connector termination on both ends.	IC694TBC032 and IC694TBB032 only
IC694CBL010	Shielded 1.0 meter cable with 36-pin D-connector termination on both ends.	IC694TBC032 and IC694TBB032 only
IC694CBL030	Shielded 3.0 meter cable with 36-pin D-connector termination on both ends.	IC694TBC032 and IC694TBB032 only
IC694CBL130	Shielded 3.0 meter cable with 36-pin D-connector termination on the end that connects to the IC694TBC032 terminal block. The other end is unterminated.	IC694TBC032 only

IC694RTB032 High-Density Remote Base, 36-Terminal

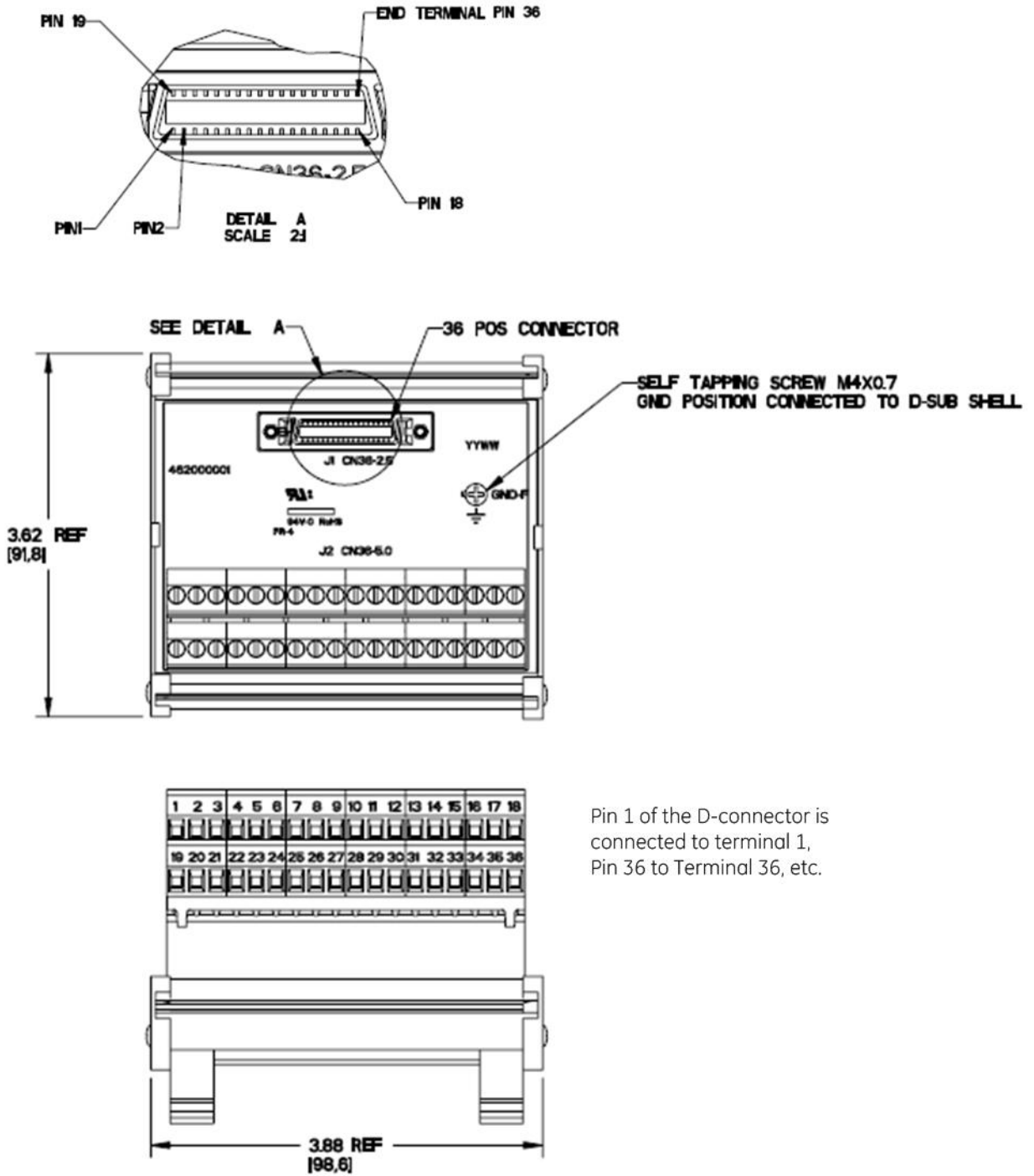


Figure 446: IC694RTB032 High-Density Remote Base, 36-Terminal

IC694TBC032 High-Density Terminal Block with Single 36-Pin D-Connector

To connect the remote terminal block IC694RTB032 to an I/O module, the I/O module must be fitted with an IC694TBC032 terminal block.

Since both the I/O module and the remote terminal block are fitted with 36-point D-connectors, only one cable is required to interconnect the two. Additionally, both ends are equipped to handle shielded cables. These features provide a significant advantage over the IC693ACC377 TBQC.

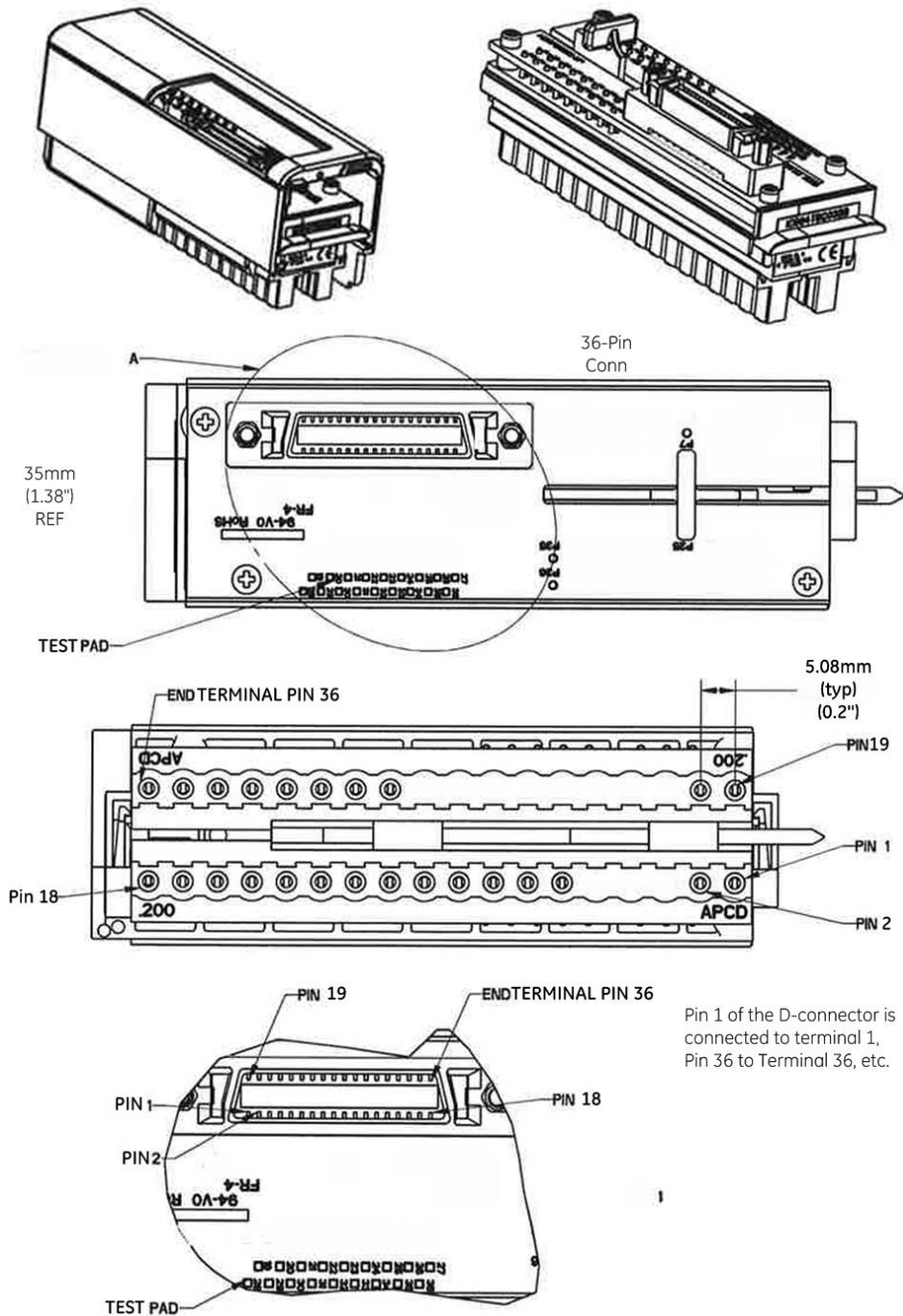
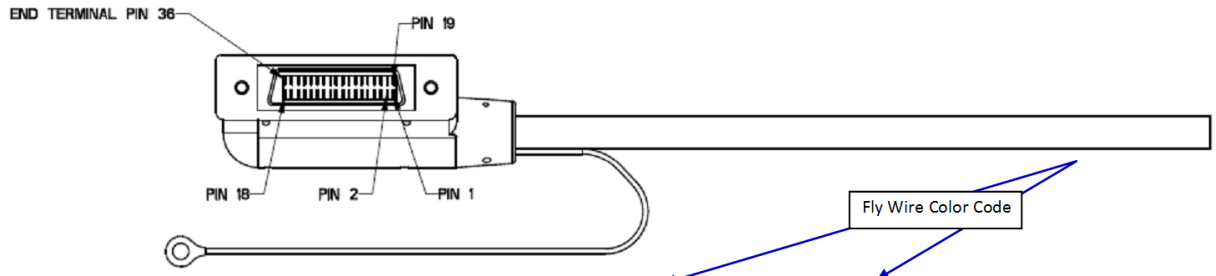


Figure 447: IC694TBC032 High-Density Terminal Block with Single 36-Pin D Connector

IC694CBL* Cable Wiring Details








TERMINAL BLOCK / CABLE CONNECTOR PIN	MAIN WIRE COLOR	ACCENT WIRE COLOR
SHELL	BRAID LUG	--
1	BROWN	RED
2	LIGHT GRAY	BROWN
3	BLUE	BROWN
4	ORANGE	BROWN
5	RED	BROWN
6	VIOLET	WHITE
7	GREEN	WHITE
8	ORANGE	WHITE
9	BROWN	WHITE
10	PINK	--
11	WHITE	--
12	VIOLET	--
13	BLUE	--
14	GREEN	--
15	YELLOW	--
16	ORANGE	--
17	RED	--
18	BROWN	--
19	LIGHT GRAY	RED
20	PINK	BROWN
21	VIOLET	BROWN
22	GREEN	BROWN
23	YELLOW	BROWN
24	LIGHT GRAY	WHITE
25	BLUE	WHITE
26	YELLOW	WHITE
27	RED	WHITE
28	PINK	BLACK
29	WHITE	BLACK
30	VIOLET	BLACK
31	BLUE	BLACK
32	GREEN	BLACK
33	YELLOW	BLACK
34	ORANGE	BLACK
35	RED	BLACK
36	BROWN	BLACK

Figure 448: IC694CBL* Cable Wiring Details

Appendix A Product Certifications and Installation Guidelines for Conformance

This appendix describes the compliance markings that appear on PACSystems RX3i products and the corresponding standards to which the products have been certified. This appendix also provides installation requirements for conformance to standards and additional safety guidelines for installing in the European Union.

A-1 RX3i Agency Approvals

Description	Agency Standard or Marking	Comments
N.A. Safety for Industrial Control Equipment		Certification by Underwriter's Laboratories to UL508 standard and equivalent CSA C22.2 No 142 - M1987 standard
N.A. Safety for Hazardous Areas Class I, Div. 2, Groups A, B, C, D		Certification by Underwriter's Laboratories to ISA 12.12.01 standard and equivalent CSA C22.2 No 213-M1987 standard
Low Voltage Directive European Safety for Industrial Control Equipment		Self-Declaration in accordance with European Directives; Refer to Declaration of Conformity found at http://www.ge-ip.com/ for a complete list of approved products
Electromagnetic Compatibility Directive European EMC for Industrial Control Equipment		Certification by Competent Body in accordance with European Directives; Refer to Declaration of Conformity found at http://www.ge-ip.com/ for a complete list of approved products
Explosive Atmospheres Directive European Safety for Hazardous Areas Equipment Group II, Category 3, Gas Groups A, B, C		Certification in accordance with European Directives and Independent 3 rd Party Assessment Certificate; Refer to Declaration of Conformity found at http://www.ge-ip.com/ for complete list of approved products

Note: The agency approvals listed above and on the Declaration of Conformities are believed to be accurate; however, agency approvals for a product should be verified by the marking on the unit itself.

A-2 UL Class 1 Division 2 Hazardous Areas Requirements

The following statements are required to display for Class I Division 2 Hazardous Locations:

1. EQUIPMENT LABELED WITH REFERENCE TO CLASS I, GROUPS A, B, C, and D, DIV. 2 HAZARDOUS LOCATIONS IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, D OR NON-HAZARDOUS LOCATIONS ONLY.
2. WARNING – EXPLOSION HAZARD – SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.
3. WARNING – EXPLOSION HAZARD – DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.
4. EQUIPMENT SHALL BE INSTALLED INTO AN ENCLOSURE THAT IS ONLY ACCESSIBLE WITH THE USE OF A TOOL

A-3 ATEX Zone 2 Hazardous Areas Requirements

To maintain compliance with the ATEX Directive, an RX3i system located in a Zone 2 area (Category 3) must be installed within a protective enclosure meeting the following criteria:

- IP54 or greater
- Mechanical strength to withstand an impact energy of 3.5 Joules
- Only accessible with the use of a tool

A-4 Standards

A-4.1 PACSystems RX3i Environmental Specifications

Vibration	IEC60068-2-6, JISC0911	10 - 57 Hz, 0.0524 mm (0.006 in) displacement peak-peak 57 - 500 Hz, 1.0 g acceleration
Shock	IEC60068-2-27, JISC0912	15G, 11ms
Operating Temperature		0 to 60°C: [inlet] (32 to 140 °F)
Storage Temperature		-40 to +85°C (-40 to 185 °F)
Humidity		5 to 95%, non-condensing

A-4.2 Additional RX3i Specifications

Standards for EMC Emissions, and Immunity, for RX3i products are provided on the following pages. Refer to the listing of module catalog numbers below to determine which set of standards applies to a specific module: Specifications Group 1 or Group 2.

Group 1 Table

IC694ACC300	IC694DNM200	IC694MDL390	IC694MDL740
IC694ALG220	IC694DNS201	IC694MDL632	IC694MDL741
IC694ALG221	IC694DSM314	IC694MDL634	IC694MDL742
IC694ALG390	IC694DSM324	IC694MDL635	IC694MDL752
IC694ALG391	IC694MDL230	IC694MDL645	IC694MDL753
IC694ALG392	IC694MDL231	IC694MDL646	IC694MDL758
IC694APU300	IC694MDL240	IC694MDL648	IC694MDL930
IC694APU305	IC694MDL241	IC694MDL654	IC694MDL931
IC694BEM320	IC694MDL250	IC694MDL655	IC694MDL940
IC694BEM321	IC694MDL310	IC694MDL658	IC694MDR390
IC694BEM340	IC694MDL330	IC694MDL730	IC694PWR321
IC694BEM341	IC694MDL340	IC694MDL732	IC694PWR330
IC694CHS392	IC694MDL350	IC694MDL734	IC694PWR331
IC694CHS398			

Group 2 Table

IC694ALG222	IC695ALG106	IC695CMM002	IC695HSC308
IC694ALG223	IC695ALG112	IC695CMM004	IC695LRE001
IC694ALG232	IC695ALG306	IC695CMU310	IC695MDL664
IC694ALG233	IC695ALG312	IC695CMX128	IC695MDL765
IC694ALG442	IC695ALG412	IC695CNM001	IC695NIU001
IC694ALG542	IC695ALG508	IC695CPE305	IC695NIU001 PLUS
IC694BEM331	IC695ALG600	IC695CPE310	IC695PBM300
IC694CEE001	IC695ALG608	IC695CPU310	IC695PBS301
IC694MDL260	IC695ALG616	IC695CPU315	IC695PMM335
IC694MDL660	IC695ALG626	IC695CPU320	IC695PNC001
IC694MDL754	IC695ALG628	IC695CRE311	IC695PNS001
IC694MDL916	IC695ALG704	IC695CRH---	IC695PRS015
IC695ACC302	IC695ALG708	IC695CRU320	IC695PSA040
IC695ACC400	IC695ALG808	IC695ECM850	IC695PSA140
IC695ACC401	IC695CEP001	IC695EDS001	IC695PSD040
IC695ACC650	IC695CHS007	IC695EIS001	IC695PSD140
IC695ACC651	IC695CHS012	IC695ETM001	IC695RMX128
IC695FTB001	IC695CHS016	IC695GCG001	IC695RMX228
		IC695HSC304	

Specifications Group 1

EMC EMISSIONS

Radiated (Group 1, Class A)	CISPR 11/EN 55011/ EN55016-2-3	30 – 230 MHz 50.4 dB μ V/m 230 – 1000 MHz 57.4 dB μ V/m
	47 CFR 15	30 – 88 MHz 49.5 dB μ V/m 88 – 216 MHz 53.9 dB μ V/m 216 -960 MHz 56.8 dB μ V/m \geq 960 MHz 59.9 dB μ V/m

EMC IMMUNITY⁹³

Electrostatic Discharge	EN 61000-4-2 ⁹⁴	\pm 8 kV Air, \pm 4 kV Contact
RF Susceptibility	EN 61000-4-3 ⁹⁴	10 V _{rms} /m, 80 to 1000 MHz, 80% AM, 1 kHz sine-wave
Fast Transient Burst	EN 61000-4-4 ⁹⁴	AC/DC Input Power: \pm 2 kV direct Discrete I/O, Communication: \pm 1kV (clamp) ⁹⁴ Analog I/O: \pm 0.25 kV (clamp)
Damped Oscillatory Wave	ANSI/IEEE C37.90a, EN 61000-4-12 ⁹⁴ EN 61000-4-18	AC/DC Input Power: +2.5 kV I/O, Communication: +2.5 kV ⁹⁵
Voltage Surge	EN 61000-4-5 ⁹⁴	AC/DC Input Power: \pm 2 kV (12 Ω) CM I/O, Communication: \pm 1 kV (42 Ω) CM ⁹⁵
Conducted RF	EN 61000-4-6 ⁹⁴	Communication: 10V _{rms} , 0.15 to 80 MHz, 80% AM ⁹⁶
Voltage Dips and Interrupts	EN 61000-4-11 ⁹⁴	AC/DC Input Power: 30% and 100% Nominal (10ms)
Voltage Variation	EN 61000-4-11 ⁹⁴	AC Input Power: \pm 10% (10s) DC Input Power: \pm 20% (10s)

⁹³ Although a few modules were tested according to the Voltage Surge test, modules were primarily tested to the Damped Oscillatory Wave test.

⁹⁴ EN 61000-4-x series of tests are technically equivalent to the IEC 61000-4-x series.

⁹⁵ Not applicable to communication or I/O lines with maximum installed length less than 30 m (98 ft).

⁹⁶ Not applicable to communication lines with maximum installed length less than 30 m (98 ft).

Specifications Group 2

EMC EMISSIONS

Radiated (Group 1, Class A)	CISPR 11/EN 55011 / EN55016-2-3	30 – 230 MHz 50.4 dB μ V/m 230 – 1000 MHz 57.4 dB μ V/m
	47 CFR 15	30 – 88 MHz 49.5 dB μ V/m 88 – 216 MHz 53.9 dB μ V/m 216 – 960 MHz 56.8 dB μ V/m \geq 960 MHz 59.9 dB μ V/m
Conducted (Group 1, Class A)	CISPR 11/EN 55011 / EN55016-2-1 47 CFR 15	0.15 – 0.5 MHz: 79/66 dB μ V (qp/avg) 0.5 – 30 MHz: 73/60 dB μ V (qp/avg)
Harmonic	EN61000-3-2	Class A

EMC IMMUNITY

Electrostatic Discharge	EN 61000-4-2 ⁹⁷	\pm 8 kV Air, \pm 4 kV Contact
RF Susceptibility	EN 61000-4-3 ⁹⁷	10 V _{rms} /m, 80 to 1000 MHz, 80% AM, 1kHz sine-wave 3 V _{rms} /m, 1.0 to 2.7 GHz, 80% AM, 1 kHz sine-wave
	ENV 50140/ ENV 50204	10 V _{rms} /m, 900 \pm 5 MHz, 100% PM, 200 Hz square-wave
Fast Transient Burst ⁹⁸	EN 61000-4-4 ⁹⁷	AC/DC Power: \pm 2 kV direct Signal: \pm 1 kV cap coupled
Voltage Surge	EN 61000-4-5 ⁹⁷	Equipment Power AC: \pm 2 kV CM, \pm 1 kV DM DC ⁹⁹ : \pm 0.5 kV CM, \pm 0.5 kV DM I/O Power and Auxiliary Output Power AC: \pm 2 kV CM, \pm 1 kV DM DC ⁹⁹ : \pm 0.5 kV CM, \pm 0.5 kV DM Shielded Signal ¹⁰⁰ : \pm 1 kV CM Unshielded Communication Signal ¹⁰⁰ : \pm 1 kV CM Unshielded I/O Signal ¹⁰⁰ : \pm 1kV CM, \pm 0.5 kV DM
Damped Oscillatory Wave	ANSI/IEEE C37.90a, EN 61000-4-12 ⁹⁷ EN 61000-4-18	1 MHz, 400 Hz rep rate AC Power: \pm 2.5 kV CM and DM (200 Ω) DC Power ⁹⁸ : \pm 2.5 kV CM and DM (200 Ω) Signal: \pm 2.5 kV CM (200 Ω)
Conducted RF	EN 61000-4-6 ⁹⁷	AC/DC Power, Signal: 10 V _{rms} , 0.15 to 80 MHz, 80% AM ¹⁰¹
Voltage Dips & Interrupts	EN 61000-4-11 ⁹⁷	AC Input Power: 30% Nominal (0.5 period); 60% Nominal (5.50 periods); >95% Nominal (250 periods)
Voltage Variation	EN 61000-4-11 ⁹⁷	AC Input Power: \pm 10% (50,000 periods)
Voltage Flicker	EN 61000-3-3	AC Input Power: d _{max} \leq 4%

⁹⁷ EN 61000-4-x series of tests are technically equivalent to the IEC 61000-4-x series.

⁹⁸ Not applicable for communication, I/O, I/O power, Auxiliary power output or DC Input power lines where the maximum installed length is less than 3 m (9.1ft).

⁹⁹ Not applicable to ports limited to 30 m (98 ft) or less.

¹⁰⁰ Not applicable to RS232 ports and those ports limited to 30 m (98 ft) or less

¹⁰¹ Not applicable to communication or I/O lines with maximum installed length 3 m (09.1 ft) or less

A-5 Government Regulations

U.S., Canadian, Australian, and European regulations are intended to prevent equipment from interfering with approved transmissions or with the operation of other equipment through the AC power source.

The PACSystems RX3i family of products has been tested and found to meet or exceed the requirements of U.S. (47 CFR 15), Canadian (ICES-003), Australian (AS/NZS 3548), and European (EN55011) regulations for Class A digital devices when installed in accordance with the guidelines noted in this manual. These various regulations share commonality in content and test levels with that of CISPR 11 and based on this commonality testing to the each individual standard was deemed inappropriate.

The FCC requires the following note to be published according to FCC guidelines:

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

Industry Canada requires the following note to be published:

Note: This Class A digital apparatus complies with Canadian ICES-003.

Modules released after August 2012 require the following information be marked on the unit or appear in user documentation:

CAN ICES-3 (A)/NMB-3 (A)

A-6 Installation Guidelines for Conformance to Standards

To meet U.S., Canadian, Australian, and European regulations for Class A digital devices and maintain CE Mark compliance, RX3i installations that include the products listed in the following table must be installed in a metal enclosure with external wiring routed in metal conduit as described in this appendix. Modules not listed must still be installed in a protective enclosure as described in Chapter 2, Installation.

Modules Requiring Installation in a Metal Enclosure

Description	Catalog Number
Series 90-30 Input Analog 4pt Voltage	IC693ALG220
Series 90-30 Input Analog 16sgl/8diff Current	IC693ALG223
RX3i Input Analog 16sgl Current	IC694ALG223
Series 90-30 Output Analog 2pt Voltage	IC693ALG390
RX3i Output Analog 2pt Voltage	IC694ALG390
Series 90-30 Output Analog 2pt Current	IC693ALG391
RX3i Output Analog 2pt Current	IC694ALG391
RX3i Analog Output 8-Channel Current/Voltage	IC694ALG392
Series 90-30 Analog Combination Current/Voltage 4in/2out	IC693ALG442
RX3i Analog Combination Current/Voltage 4in/2out	IC694ALG442
RX3i Analog Module 4-Input 2-Output Current/Voltage with Advanced Diagnostics	IC694ALG542
Series 90-30 I/O Link Module (Slave)	IC693BEM320
RX3i I/O Link Interface Module	IC694BEM320
Series 90-30 I/O Link Module (Master)	IC693BEM321
RX3i I/O Link Master Module	IC694BEM321
Series 90-30 10-Slot Expansion Backplane	IC693CHS392
RX3i 10-Slot Serial Expansion Backplane	IC694CHS392
Series 90-30 Remote Baseplate, 10 Slots	IC693CHS393
Series 90-30 Remote Baseplate, 5 Slots	IC693CHS399
RX3i Control Memory Xchange Module	IC695CMX128
Series 90-30 DSM314 Motion Controller	IC693DSM314
RX3i DSM314 Motion Controller	IC694DSM314
RX3i DSM324 Motion Controller	IC694DSM324
Series 90-30 Mixed I/O 8-Pt 120 V ac In / 8-Pt Relay Out	IC693MAR590
Series 90-30 Input 120 V ac 8-Pt Isolated	IC693MDL230
RX3i Input 120 V ac 8-Pt Isolated	IC694MDL230
Series 90-30 Input 240 V ac 8-Pt Isolated	IC693MDL231
RX3i Input 240 V ac 8-Pt Isolated	IC694MDL231
Series 90-30 Input 120 V ac 16Pt	IC693MDL240
RX3i Input 120 V ac 16Pt	IC694MDL240
Series 90-30 Input 24Vac 16Pt	IC693MDL241
RX3i Input 24Vac 16Pt	IC694MDL241
Series 90-30 Output 120 V ac 0.5 12Pt	IC693MDL310

Description	Catalog Number
RX3i Output 120 V ac 0.5 A 12 Point	IC694MDL310
Series 90-30 Output 120/240 V ac 2A 8-Pt	IC693MDL330
RX3i Output 120/240 V ac 2 A 8-Pt	IC694MDL330
Series 90-30 Output 120 V ac 0.5A 16Pt	IC693MDL340
RX3i Output 120 V ac 0.5 A 16-Pt	IC694MDL340
Series 90-30 Output 120/240 V ac 2A 5-Pt Isolated	IC693MDL390
RX3i Output 120/240 V ac 2 A 5-Pt Isolated	IC694MDL390
Series 90-30 Input 125Vdc 8-Pt Pos/Neg Logic	IC693MDL632
RX3i Input 125Vdc 8-Pt Pos/Neg Logic	IC694MDL632
Series 90-30 Input 5/12Vdc (TTL) 32Pt Pos/Neg	IC693MDL654
RX3i Input 5/12Vdc (TTL) 32Pt Pos/Neg	IC694MDL654
Series 90-30 Output 12/24Vdc 0.5A 8-Pt Positive Logic	IC693MDL732
RX3i Output 12/24Vdc 0.5 A 8-Pt Positive Logic	IC694MDL732
Series 90-30 Output 12/24Vdc 0.5A 8-Pt Negative Logic	IC693MDL733
Series 90-30 Output 125Vdc 1A 6Pt Isolated Pos/Neg	IC693MDL734
RX3i Output 125Vdc 1 A 6 Point Isolated Pos/Neg	IC694MDL734
Series 90-30 Output 5/24Vdc (TTL) 0.5A 32Pt Negative Logic	IC693MDL752
RX3i Output 5/24Vdc (TTL) 0.5 A 32-Pt Negative Logic	IC694MDL752
Series 90-30 Solenoid Out 11Pt/24Vdc Out 5-Pt Positive Logic	IC693MDL760
Series 90-30 Output Relay 4A 8-Pt Isolated	IC693MDL930
RX3i Output Relay N.O. 4 A 8-Pt Isolated	IC694MDL930
Series 90-30 Mixed I/O 8-Pt 24Vdc In / 8-Pt Relay Out	IC693MDR390
RX3i Mixed I/O 24Vdc Input (8-Pt) N.O. Relay Output (8-Pt)	IC694MDR390
RX3i Redundancy Memory Xchange Module, Multi-mode fiber	IC695RMX128
RX3i Redundancy Memory Xchange Module, Single-mode fiber	IC695RMX228

Requirements for Installation in a Metal Enclosure

- Backplanes must be mounted in a metal enclosure with a metal-on-metal connection around the door or the equivalent. All surfaces of the enclosure must be adequately grounded to adjacent surfaces to provide electrical conductivity.
- Wiring external to the enclosure must be routed in metal conduit or the equivalent. Using shielded cables and power line filtering, as detailed in the section, *Shielded Cable Alternative to Conduit*, is equivalent to using metal conduit.
- The conduit must be mounted to the enclosure using standard procedures and hardware to ensure electrical conductivity between the enclosure and conduit. The termination for the shielded cable alternative to conduit is detailed in the section, *Shielded Cable Alternative to Conduit*.

A-7 Shielded Cable Alternative to Conduit

This section describes the installation requirements for using shielded cable as an alternative to metal conduit for meeting radiated emissions requirements (EN 55011, 47CFR15, and such). The following practices could be used in place of conduit for systems or cables that require conduit or the equivalent.

Communication Cables

All communication lines should be double-shielded. The outside braided shield (85% coverage) must be terminated at the entrance to the enclosure and not continue within the enclosure. The inside shield should be left intact since it shields the communication line from noise within the enclosure and is terminated to the connector shell. The RX3i communication port connector shells are directly tied to frame ground. To prevent ground loop currents, one cable end of the inside shield should be capacitively-coupled to its shell. The outside shield is classified as an RF shield and should be insulated from the inside shield.

An alternative to double-shielded cable for Genius bus communications is Eupen* CMS cable, equivalent Genius cables with an RF-absorptive material outer coating. The shield should be terminated per standard Genius wiring guidelines.

*Telephone: 32 87 55 47 71 (Europe), 908-919-1100 (U.S.A.)

I/O Cables

All I/O lines leaving the enclosure must have at least 85% braided shield coverage terminated at the entrance to the enclosure. This 85% RF shield should not continue into the enclosure. Eighty-five percent braided shield is a standard cable available with various wire sizes and quantities from many cable manufacturers.

Analog/High Speed Cables

Analog or high-speed lines, which require shielded cable for immunity, should be double-shielded. The outside braided shield should be terminated at the entrance to the enclosure and not continue within the enclosure. The inside shield should be terminated per standard installation instructions. The outside shield is classified as an RF shield and should be insulated from the inside shield.

Power Input to Enclosure (for IC694 Power Supplies)

An alternative to shielded input cables is to use RF filters to minimize the noise coupled back onto the power supply inputs. If RF filters are used at the point of enclosure entry, unshielded wires may be used inside and outside the enclosure.

AC Power Input RF Filter Requirements

- Type: Common mode/Differential mode line filter
- Effective range: between 30–300 MHz
- Leakage current: <0.8 mA
- Insertion loss >30 decibels at 30 MHz, >20 decibels at 100 MHz, >15 decibels at 300 MHz

DC Power Input RF Filter Requirements

- Type: Feed-through, π type EMI ceramic filter
- Capacitance: 1500 pF (minimum)
- WVDC: 100 V
- Current rating: As needed for application
- Insertion Loss: >50 decibels at 100 MHz

Shield Termination

Termination of RF shields is extremely important in the reduction of RF emissions. The RF shields should be terminated at the entrance to the enclosure with a 360 degree contact between the shield and the enclosure wall.

Compression Connectors

Compression connectors are standard hardware available for the termination of conduit. The diameter of the connectors is not of significant importance other than to make sure the wires can actually fit through them. The compression connector provides a metal ring for shield termination and compression.

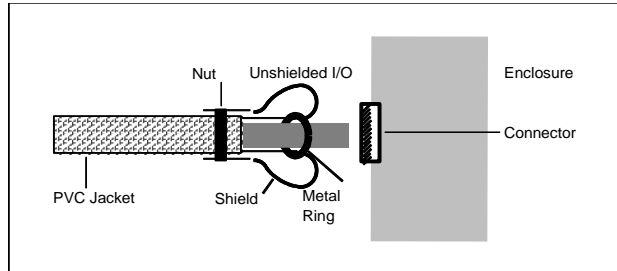


Figure 449: Unshielded I/O Cable, Single Shield (Side View)

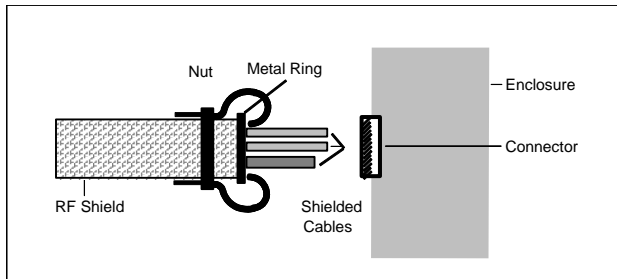


Figure 450: Multiple Communication/High-Speed Cables, Single RF Shield (Side View)

Specialty Shielded Cable Vendors

Eupen specializes in RF-absorptive material outer coating cables (CMS cables). Ask for equivalent Genius cables.

Glenair, Inc. specializes in convoluted tubing (Series 72 and 74) and in flexible metal-core conduit (Series 75). They also carry various kinds of shield termination connectors.

Zippertubing Co. specializes in after installation zip-on shielding where different types of shielding can be selected. Recommended types of shielding are SHN-3, SH1, and SH3 to provide 85% coverage.

A-8 Safety-Related Guidelines for Installation in the European Union

This section provides safety-related guidelines specifically for control system products to be installed in the European Union. It is assumed that personnel who install, operate, and maintain automation systems that include GE products are trained and qualified to perform those functions

1. General:

GE product manuals provide information required for the intended use of these products. The product manuals are written for technically qualified personnel such as engineers, programmers, or maintenance specialists who have been specifically trained and are experienced in the field of automation control. Such personnel must possess the knowledge to correctly interpret and apply the safety guidelines provided in the product manuals. If you require further information or face special problems that are not covered in sufficient detail in the product manuals, please contact your local sales or service office, or authorized distributor.

2. Qualified Personnel:

Only qualified personnel should be allowed to specify, apply, install, operate, maintain, or perform any other function related to the products described in the product manuals. Examples of such qualified persons are defined as follows:

- System application and design engineers who are familiar with the safety concepts of automation equipment.
- Installation, startup, and service personnel who are trained to install and maintain such automation equipment.
- Operating personnel trained to operate automation equipment and trained on the specific safety issues and requirements of the particular equipment.

3. Proper Usage:

The equipment/system or the system components may be used only as described in the product manuals. Our control system products have been developed, manufactured, tested, and the documentation compiled in keeping with the relevant safety standards. Handling instructions and safety guidelines described for planning, installation, proper operation and maintenance must be followed to ensure safe application and use of the products.

4. Guidelines for the Application Planning and Installation of the Product:

RX3i control system products generally form part of larger systems or installations. These guidelines are intended to help integrate RX3i control system products into systems and installations without constituting a source of danger. The following precautions must be followed:

- Compliance with EN292-1 and EN292-2 (Safety of Machinery) as well as EN60204/IEC204 (Electrical Equipment of Industrial Machines) must be observed during the design phase.
- Opening the housing or the protective cover exposes certain parts of this equipment/system, which could have a dangerously high voltage level.
- Only qualified personnel should be allowed access to this equipment/system. These persons must be knowledgeable of potential sources of danger and maintenance measures as described in the product manuals.
- Personnel must strictly adhere to applicable safety and accident prevention rules and regulations.
- A suitable isolating switch or fuses must be provided in the building wiring system. The equipment must be connected to a protective ground (PE) conductor.
- For equipment or systems with a fixed connecting cable but no isolating switch that disconnects all poles, a power socket with the grounding pin must be installed.
- Before switching on the equipment, make sure that the voltage range setting on the equipment corresponds to the local power system voltage.
- In the case of equipment operating on 24Vdc, make sure that proper electrical isolation is provided between the main supply and the 24Vdc supply. Use only power supplies that meet EN60204 (IEC204) requirements.
- The RX3i control system AC power supply must be supplied through an IEC-rated isolation transformer.
- Power supply to the RX3i control system must be controlled not to exceed over-voltage category II per EN60204-1 (IEC204).
- Do not exceed the input specifications of the power supply. Otherwise, functional failures or dangerous conditions can occur in the electronic modules/equipment.
- Emergency shutoff devices in accordance with EN60204/IEC204 must be effective in all operating modes of the automation equipment. Resetting the emergency off device must not result in any uncontrolled or undefined restart of the equipment.
- Automation equipment and its operating elements must be installed in such a manner as to prevent unintentional operation.
- Suitable measurements must be taken to ensure that operating sequences interrupted by a voltage dip or power supply failure resume proper operation when the power supply is restored. Care must be taken to ensure that dangerous operating conditions do not occur even momentarily. If necessary, the equipment must be forced into the *emergency off* state.
- Negative Logic Input and Output Modules cannot be used.
- Cable shielding and grounding are the responsibility of the machine builder. Applicable installation instructions and guidelines must be followed.
- Install the power supply and signal cables in such a manner as to prevent inductive and capacitive interference voltages from affecting automation functions.
- When interfacing the inputs and outputs of the automation equipment, measures must be taken to prevent an undefined state from being assumed in the case of a wire break in the signal lines.

Appendix B Calculating Heat Dissipation

This section explains how to find the total heat dissipation of PACSystems RX3i equipment.

PACSystems RX3i equipment must be mounted in a protective enclosure. The enclosure must be able to properly dissipate the heat produced by all the devices mounted inside. This includes the modules, discrete output devices, and discrete input devices. Each device manufacturer publishes these values. If an exact value is not available for a device, you can make a close estimate by obtaining the value for a similar device.

B-1 Module Heat Dissipation

For each backplane and module except power supplies (discussed separately), look up the power in Watts from the table of Module Load Requirements, *Section 4.2*. If the module uses more than one voltage type (for example, 3.3V and 24V relay), find its total power requirement. Then, add together the heat dissipation values for all the modules in the enclosure.

Example:

The Load Requirements table shows that the 12-Slot Universal Backplane IC695CHS012 draws:

- 1.98 Watts from the 3.3Vdc supply
- +1.20 W from the 5Vdc supply
- =3.18 Watts total heat dissipation of backplane IC695CHS012

B-2 Power Supply Heat Dissipation

In general, power supplies are 66% efficient. The power supply dissipates approximately 1 Watt of power in the form of heat for every 2 Watts of power it delivers to the PLC.

After finding the total power requirement for all of the modules in the backplane served by a power supply above, divide the total by 2 to find the power supply dissipation value. Do not use the rating of the power supply (such as 30 W) for this calculation because the application may not use the full capacity of the power supply.

If the +24Vdc output on an Expansion Power Supply is being used, calculate the power drawn, divide the value by 2, and add it to the total for the power supply.

Heat Dissipation for Discrete Output Modules

In addition to the module power calculations done above, discrete solid-state output modules require a calculation for their output circuits, which are powered from another supply. (This calculation is not required for Relay Output modules.) To calculate output circuit power dissipation:

- In the specification table of the module, find the value for Output Voltage Drop.
- Using the manufacturer's documentation or other reference information, find the required current value for each device (such as a relay, pilot light, solenoid, etc.) connected to an output point on the module. Estimate the percent of "on-time" of each device based on its intended use in the application.
- Multiply the Output Voltage Drop times the current value times the estimated percent of on-time to arrive at average power dissipation for that output.

Repeat these steps for all outputs on the module, and then for all discrete output modules in the backplane.

Example:

The specifications table for the IC694MDL340 16-Point Discrete 120 V ac Output Module lists its Output Voltage Drop as: 1.5 V maximum

Use that value for all of the calculations for the module.

In this example, two output points drive solenoids that control the advance and retract travel of a hydraulic cylinder. The solenoid manufacturer's datasheet shows that each solenoid draws 1.0 Amp. The cylinder advances and retracts once every 60 seconds that the machine is cycling. It takes 6 seconds to advance and 6 seconds to retract. Because the cylinder takes equal time to advance and retract, both solenoids are on for equal lengths of time: 6 seconds out of every 60 seconds, which is 10% of the time. Therefore, since both solenoids have equal current draws and on-times, one calculation can be applied to both outputs.

Use the formula Average Power Dissipation = Voltage Drop x Current Draw (in Amps) x Percent (expressed as a decimal) of on-time:

$$1.5 \times 1.0 \times 0.10 = 0.15 \text{ W per solenoid}$$

Then multiply this result by 2 for two identical solenoids:

$$0.15 \text{ W} \times 2 \text{ Solenoids} = 0.30 \text{ W total for the two solenoids}$$

Also in this example, the other 14 output points on the 16-point module operate pilot lights on an operator's panel. Each pilot light requires .05 Amps of current. Seven of the pilot lights are on 100% of the time and seven are on an estimated 40%.

For the seven lights that are on 100% of the time:

$$1.5 \times .05 \times 1.00 = 0.075 \text{ W per light}$$

Then multiply this value by 7:

$$0.075 \text{ W} \times 7 \text{ lights} = 0.525 \text{ W total dissipation for the first 7 lights}$$

For the 7 lights that are on 40% of the time:

$$1.5 \times .05 \times 0.40 = .03 \text{ W per light}$$

Then multiply this value by 7:

$$0.03 \text{ W} \times 7 \text{ lights} = 0.21 \text{ W total dissipation for the other 7 lights}$$

Adding up the individual calculations, we get:

$$0.30 + 0.525 + 0.21 = 1.035 \text{ W for the total output calculation for the module.}$$

Heat Dissipation for Discrete Input Modules

In addition to the module power calculations described above, a discrete input module requires another calculation for its input circuits, because the power dissipated by the input circuits comes from a separate power source. This calculation assumes that all input circuit power delivered to these modules is eventually dissipated as heat. The procedure is:

- In the specification table of the module, find the value for Input Current.
- For DC input modules, multiply the input voltage times the current value times the estimated percent of on-time to arrive at average power dissipation for that DC input.
- For AC input modules only, multiply the input voltage times the current value times the estimated percent of on-time times 0.10 to arrive at average power dissipation for that AC input.

Repeat these steps for all inputs on the module, and then for all discrete input modules in the backplane.

Example:

The Specifications table for the IC693MDL240 16-Point Discrete 120 V ac Input Module gives the following information:

Input Current: 12 mA (typical) at rated voltage

Use this value for all of the input calculations for this module.

In this example, eight of the input points are used for switches that, for normal operation, stay on (closed) 100% of the time. These include the Emergency Stop, Over Temperature, Lube Pressure OK, and similar switches.

Use the formula Average Power Dissipation = Input Voltage × Input Current (in Amps) × Percent (expressed as a decimal) of on-time:

$$120 \times .012 \times 1.0 = 1.44 \text{ W per input}$$

Then multiply this result by 8:

$$1.44 \text{ W} \times 8 \text{ inputs} = 11.52 \text{ W total for the 8 inputs}$$

Also in this example, two input points on this 16-point module are for the Control On and Pump Start pushbuttons. Under normal conditions, these pushbuttons are only pressed once per day for about one second – just long enough to start up the control and pump. Therefore, their effect on our power calculation is negligible:

$$0.0 \text{ Watts total for two inputs}$$

For the remaining six inputs of the 16 point module, it is estimated that they will be on for an average of 20% of the time. So the following calculation is made for these 6 inputs:

Using the formula of Average Power Dissipation = Input Voltage × Input Current (in Amps) × Percent (expressed as a decimal) of on-time:

$$120 \times .012 \times 0.20 = 0.288 \text{ W per input}$$

Then multiply this result by 6:

$$0.288 \text{ W} \times 6 \text{ inputs} = 1.728 \text{ W total for the 6 inputs}$$

Finally, add up the individual calculations:

$$11.52 + 0.0 + 1.728 = 13.248 \text{ W for the total input calculation for the module.}$$

Total Heat Dissipation

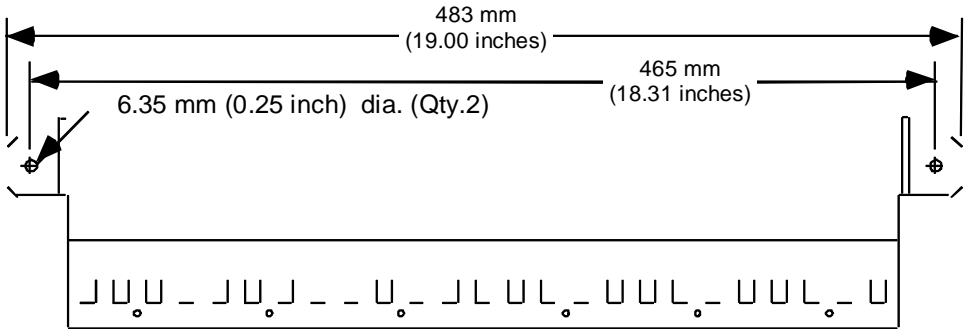
After the individual power dissipations have been calculated, add them together to obtain total PLC heat dissipation. It is usually not necessary to include analog modules because their power dissipation values are negligible when compared with the total.

Appendix C Cable Shield Clamping Assembly

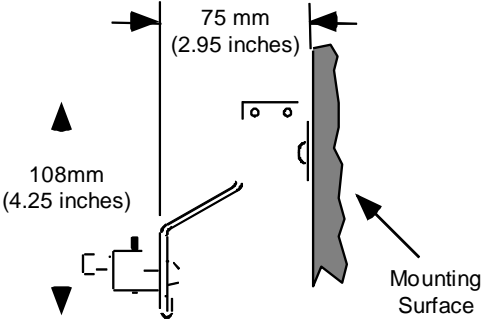
Cable Shield Clamping Assembly, IC697ACC736, contains the parts necessary for providing higher EMC immunity for shielded cables in severe industrial environments. Shield grounding is provided by the ground plate and cable clamps in the kit.

The Cable Shield Clamping Assembly package includes:

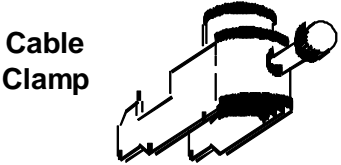
- One ground plate
- Six cable clamps
- Four #6 self-tapping screws



Front View with Mounting Dimensions



Side View with Spacing Requirements



(Six cable clamps included with assembly.)

* Additional cable clamps available (12 per package), catalog number IC697ACC737.

Figure 451: Cable Clamp IC697ACC736 Diagrams

C-1 Installing the Cable Clamp Assembly

The ground plate should be mounted near the baseplate. The cable clamp provides mechanical relief as well as electrical grounding. The cable clamp attaches to the ground plate by sliding it into two adjacent slots at the selected cable location. The cable is inserted between the ground plate and the cable clamp after removing the required section of the outer cover of the cable. Tighten the cable clamp by turning the thumbscrew clockwise. *Do not over-tighten the thumbscrew: hand-tighten or tighten lightly with a tool.*

If you are installing the ground plate on a painted surface, the paint must be removed where the ground plate is to be mounted to ensure a good ground connection between the plate and mounting surface.

Cable Diameter

The largest diameter cable that can be used with the cable clamp is 0.51 inches (13mm). The smallest cable diameter that can be used with the clamp is 0.24 inches (6mm). Multiple cables can be placed in the clamp if the cable diameter is smaller than the minimum.

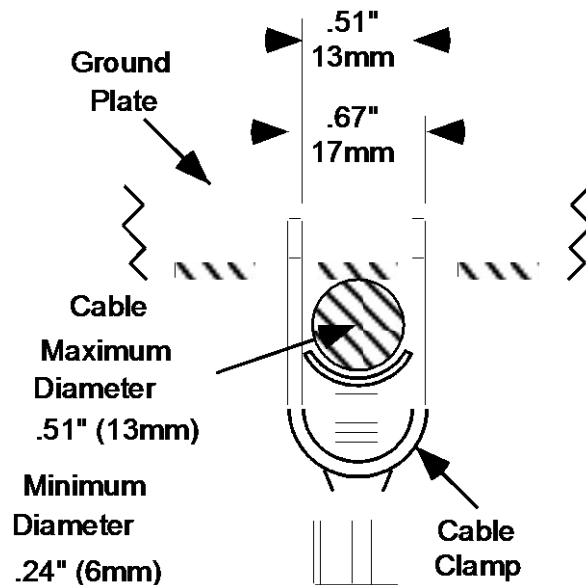


Figure 452: Cable Diameter Maximum with Cable Clamp

Removing the Insulating Cover

The insulating cover on the shielded cable must be removed to allow maximum contact between the cable shield and the cable clamp as displayed in Figure 453.

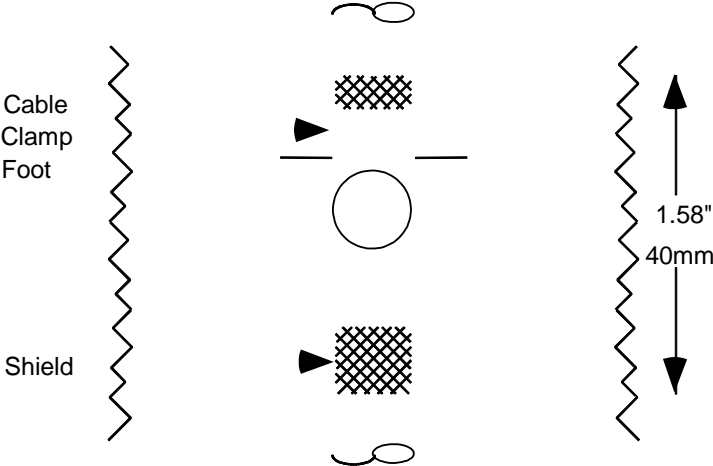


Figure 453: Insulation Cover Removal

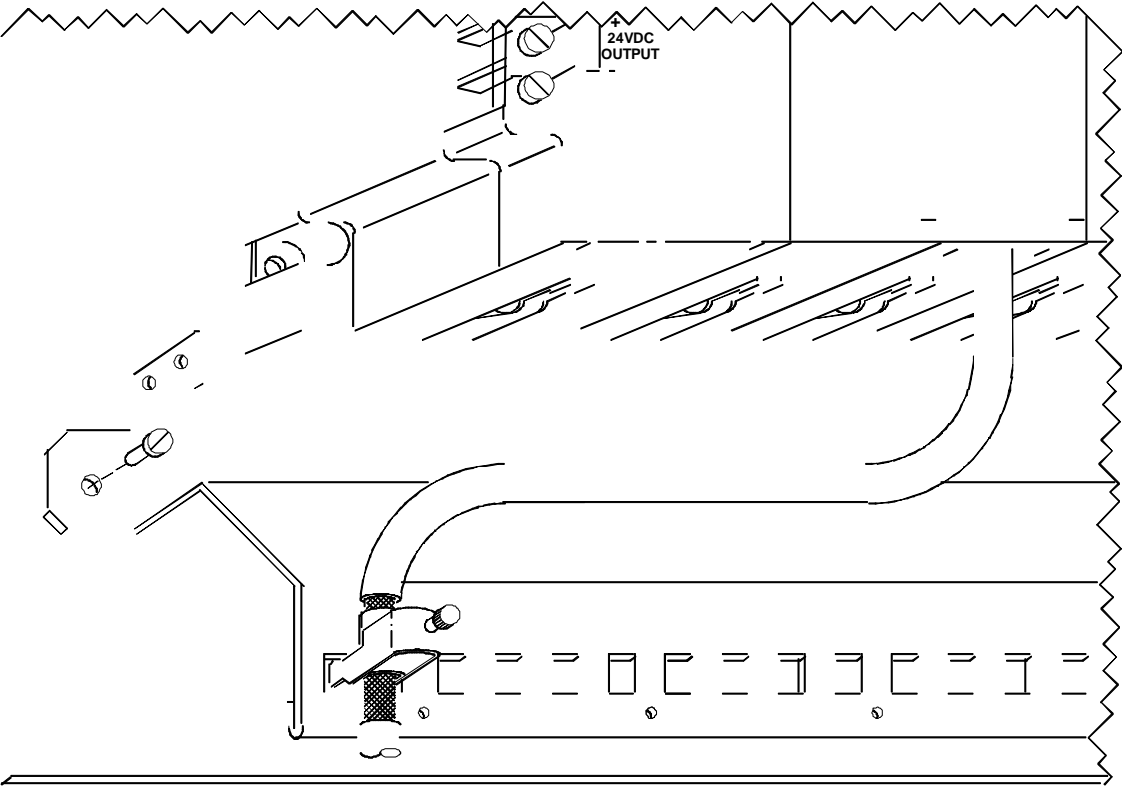


Figure 454: Typical Cable Clamp Assembly installation with Expansion Backplane



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GFK-2314M

QuickPanel+ Operator Interface

IC755CxW07CDx (7" Display)

IC755CxS10CDx (10" Display)

IC755CxS12CDx (12" Display)

IC755CxS15CDx (15" Display)

User Manual



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Please send documentation comments or suggestions to controls.doc@ge.com

Safety Symbol Legend



Warning

Indicates a procedure, condition, or statement that, if not strictly observed, could result in personal injury or death.



Caution

Indicates a procedure, condition, or statement that, if not strictly observed, could result in damage to or destruction of equipment.



Attention

Indicates a procedure, condition, or statement that should be strictly followed to improve these applications.

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Solution Provider	solutionprovider.ip@ge.com

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International Americas Direct Dial	1-780-420-2010 (if toll free 800 option is unavailable)
Technical Support Email	support.ip@ge.com
Customer Care Email	customercare.ip@ge.com
Primary language of support	English

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Technical Support Email	support.emea.ip@ge.com
Customer Care Email	customercare.emea.ip@ge.com
Primary languages of support	English, French, German, Italian, Czech, Spanish

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Phone	+ 86-400-820-8208 + 86-21-3217-4826 (India, Indonesia, and Pakistan)
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Customer Care Email	customercare.apo.ip@ge.com customercare.cn.ip@ge.com (China)

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1 Introduction

The QuickPanel+ Operator Interface is an all-in-one microcomputer designed for maximum flexibility. The design is based on an advanced ARM core microprocessor to combine a high-resolution touchscreen operator interface with a variety of communications options. Users can connect to most industrial equipment through the QuickPanel+ communications ports.

The QuickPanel+ is equipped with several memory types to satisfy the most demanding applications. A section of DRAM is split between the operating system, an object store, and application memory. A section of non-volatile flash memory functioning as a virtual hard drive is divided between the operating system and persistent storage for application programs. Retentive memory is a battery-backed SRAM to store and protect valuable data during a power failure.

1.1 Specifications

1.1.1 General Specifications

Item		IC755CxW07CDx	IC755CxS10CDx	IC755CxS12CDx	IC755CxS15CDx
Processor		Freescale i.MX535 (1 GHz ARM Cortex A8)			
Memory	RAM	DDR2 SDRAM 512 MB	DDR3 SDRAM 1 GB		
	ROM	SLC NAND 256 MB	SLC NAND 512 MB		
	SRAM	512 KB (with battery backup)			
Operating System		Microsoft Windows Embedded Compact 7			
Display	Type	7" Widescreen TFT LCD	10.4" Standard TFT LCD	12.1" Standard TFT LCD	15" Standard TFT LCD
	Resolution	800(W) x 480(H) pixels WVGA	800(W) x 600(H) pixels SVGA		1024(W) x 768(H) pixels XGA
	Color	65,536			
	Brightness	310 cd/m ²	400 cd/m ²	450 cd/m ²	310 cd/m ²
	Backlight	LED			
Touchscreen	Touch Panel Type	Projected capacitive			
	Multi-touch	Two-point			
Communi- cations	Ethernet Port	1x 10/100BaseT (RJ-45)	2x 10/100BaseT (RJ-45) 1x 10/100BaseT (RJ-45) for IC755CxS12CDA		
	Serial Port	1x RS-232 UART port (5-pin connector)	1x RS-232 UART port, 1x RS-232/485 port (2x 5-pin connector) (1x 10-pin connector for IC755CxS12CDA)		
	USB, Host	2x USB 2.0 (Type-A) Max power (5 V at 0.5 A)			
	USB, Device	1x USB 2.0 (Mini Type-B)			
Storage		1x SD/SDHC card slot			

Item		IC755CxW07CDx	IC755CxS10CDx	IC755CxS12CDx	IC755CxS15CDx
Audio		1x Mic In (Mono) (3.5 mm jack)	1x Line Out (Stereo) (3.5 mm jack)		
		1x Line Out (Stereo) (3.5 mm jack)			
Noise Immunity		Noise voltage: 1500 V p-p Pulse duration: 1µs Rise time: 1ns			
Input power	Rated Voltage	+24 V dc ±20% (3-pin connector)	+12/24 V dc ±20% (3-pin connector)		
	Power Consumption	15 W (max), 0.625 A	18 W (max), 1.5/0.75 A	30 W (max), 2.5/1.25 A	
	Frame Ground (FG)	Frame GND is connected to Signal GND internally			

1.1.2 Physical Specifications and Mounting Options

Item		IC755CxW07CDx	IC755CxS10CDx	IC755CxS12CDx	IC755CxS15CDx
Dimensions (L×W×D)		192 × 137 × 36 mm (7.56 × 5.39 × 1.42 in)	278 × 222 × 65 mm (10.95 × 8.74 × 2.56 in)	314 × 248 × 65 mm (12.36 × 9.76 × 2.56 in)	399 × 323 × 70 mm (15.71 × 12.72 × 2.76 in)
Weight		0.80 kg (1.76 lbs)	2.40 kg (5.29 lbs)	3 kg (6.61 lbs)	4.46 kg (9.83 lbs)
Mounting Options	Panel cutout dimensions	183.50 × 128.50 mm (7.22 × 5.06 in)	266 × 210 mm (10.47 × 8.27 in)	302 × 228 mm (11.89 × 8.98 in)	379 × 305 mm (14.92 × 12.01 in)
	VESA mount	75 x 75 mm (2.95 x 2.95 in)	100 x 100 mm (3.94 x 3.94 in)		

1.1.3 Environmental Specifications

For additional product standards and agency approvals, refer to [Appendix A](#).

Note Install the QuickPanel+ in a well-ventilated location that is not exposed to dust, corrosive gases or liquids, rain, strong ultraviolet light or direct sunlight, and meets the specifications listed in the following table.

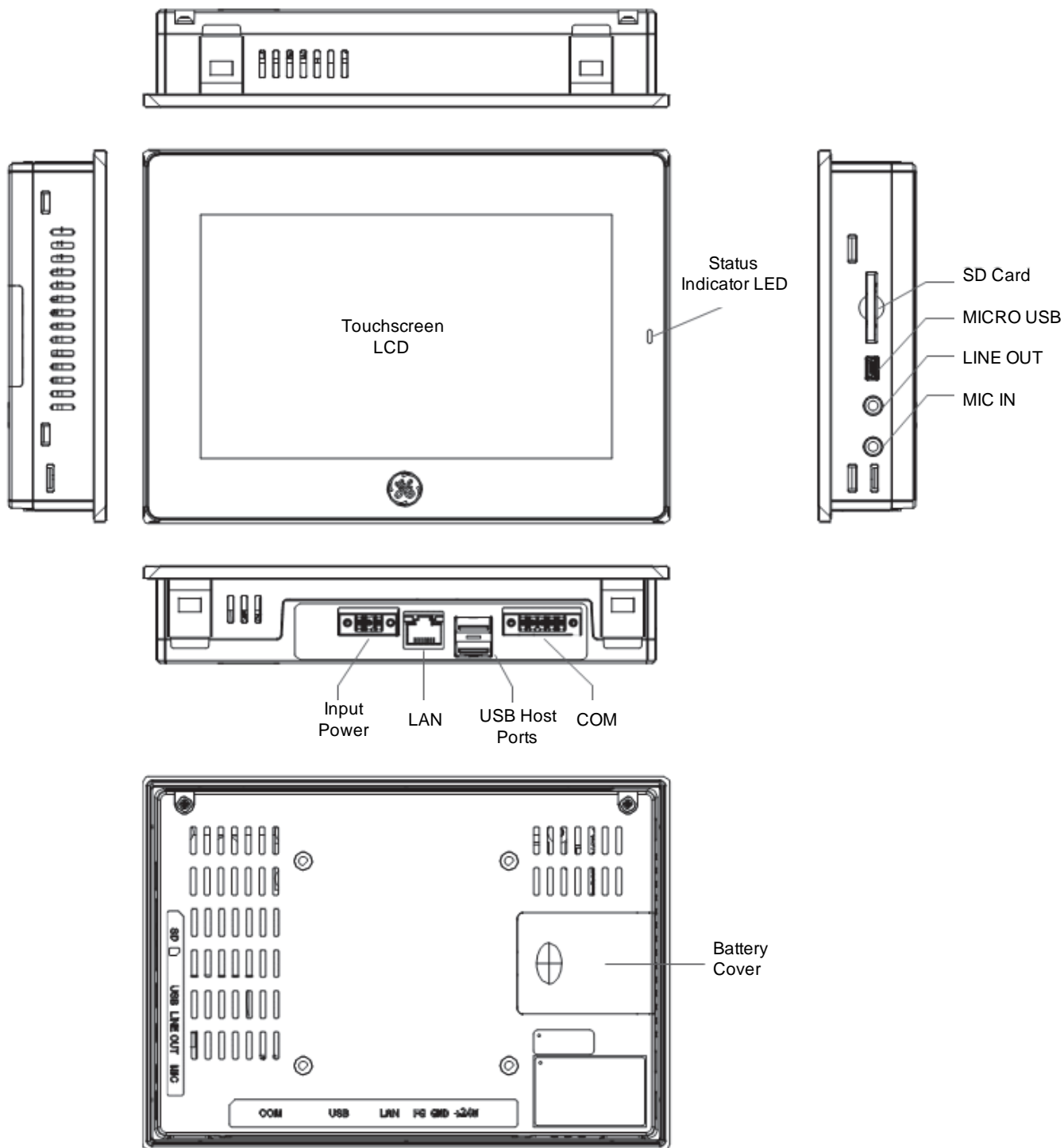
Item	IC755CxW07CDx	IC755CxS10CDx	IC755CxS12CDx	IC755CxS15CDx
Cooling	Natural convection			
Ambient Operating Temperature	0 to +55°C (32 to 131 °F)			
Ambient Storage Temperature	-10 to +60°C (14 to 140 °F)			
Ambient Humidity (Operating and Storage)	85% RH Non-condensing, wet-bulb temperature: 30°C (86 °F) or less			
Environment	Pollution Degree 2, Indoor use only			
Vibration Resistance	5 to 9 Hz single-amplitude 3.5 mm; 9 to 150 Hz constant-accelerated velocity 9.8 m/s ² ; X, Y, Z directions 10 time (100 minutes) (Compliance 3502, IEC61131-2 JIS B)			
Altitude	800~1114 hPa, altitude up to 2000 m (6561.68 ft)			
ROHS	Compliant with EU RoHS Directive 2011/65/EU			
Enclosure Rating	IP65 in panel mount only	UL Type 4X rating; IP65 in panel mount only	IP65 in panel mount only	UL Type 4X rating; IP65 in panel mount only

1.2 QuickPanel+ Hardware User Features

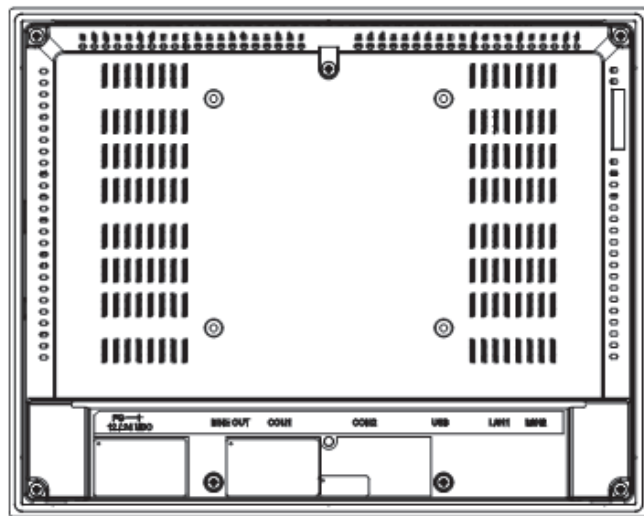
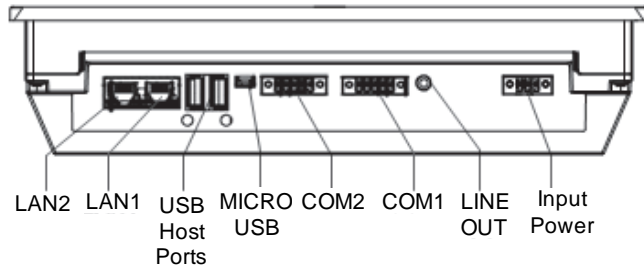
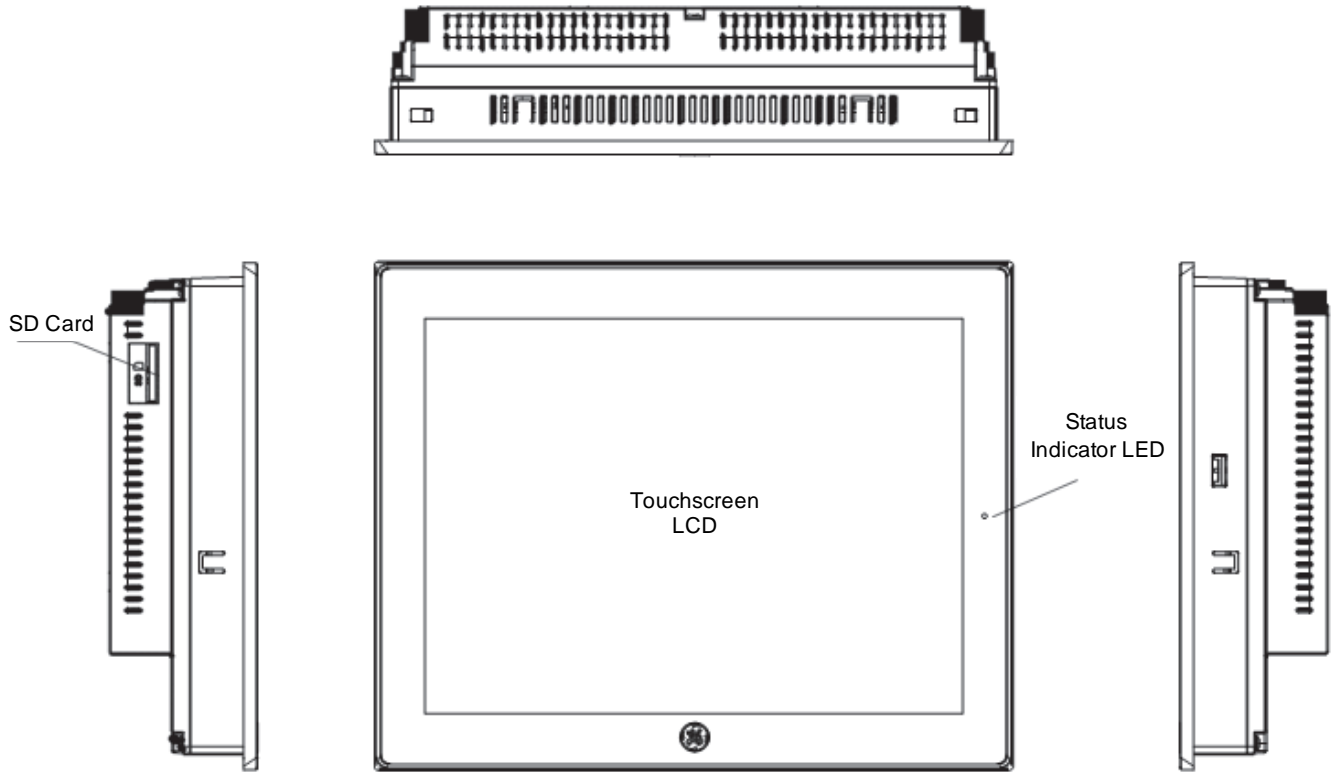
In addition to the primary touchscreen interface, the QuickPanel+ Operator Interface supports a variety of communication ports.

1.2.1 Physical Overview

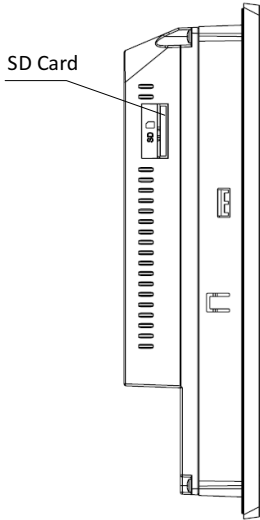
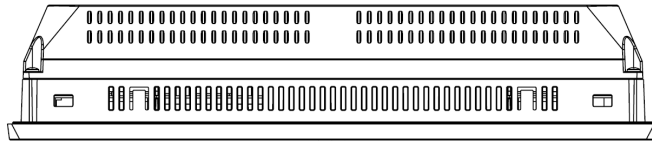
The following diagrams display the physical layout of the QuickPanel+, including locations of status LEDs, communications ports, and connectors.



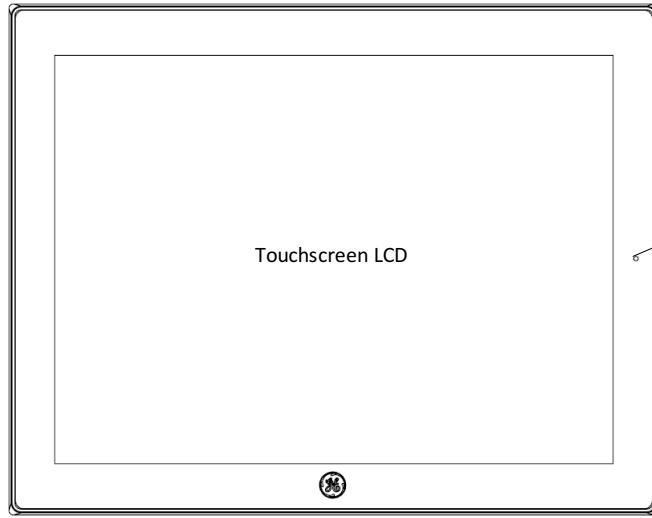
IC755CxW07CDx Hardware Features



IC755CxS10CDx Hardware Features

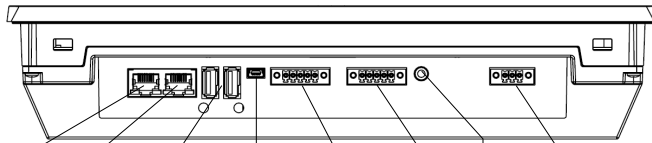
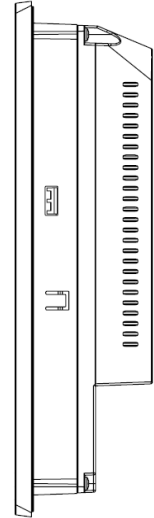


SD Card

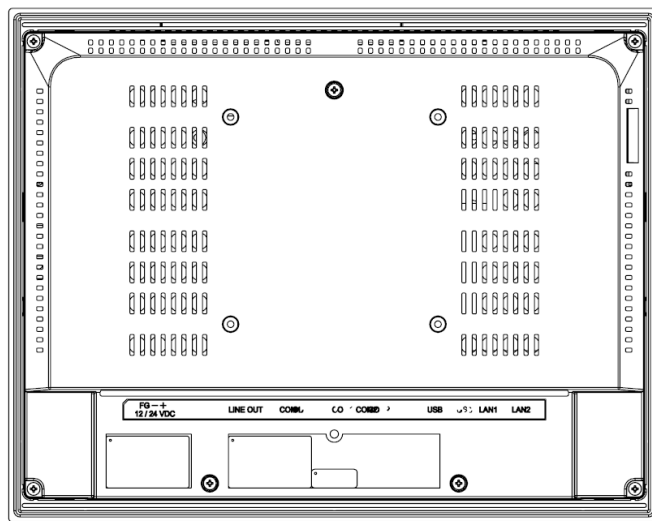


Touchscreen LCD

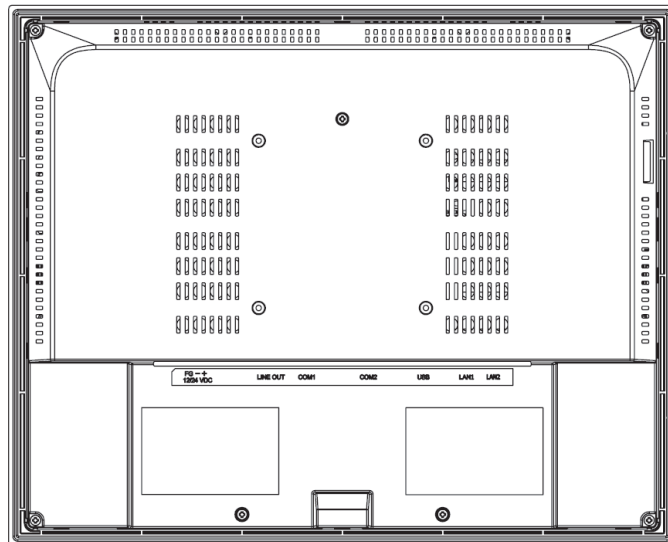
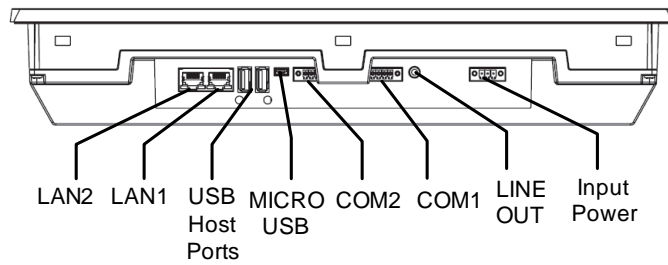
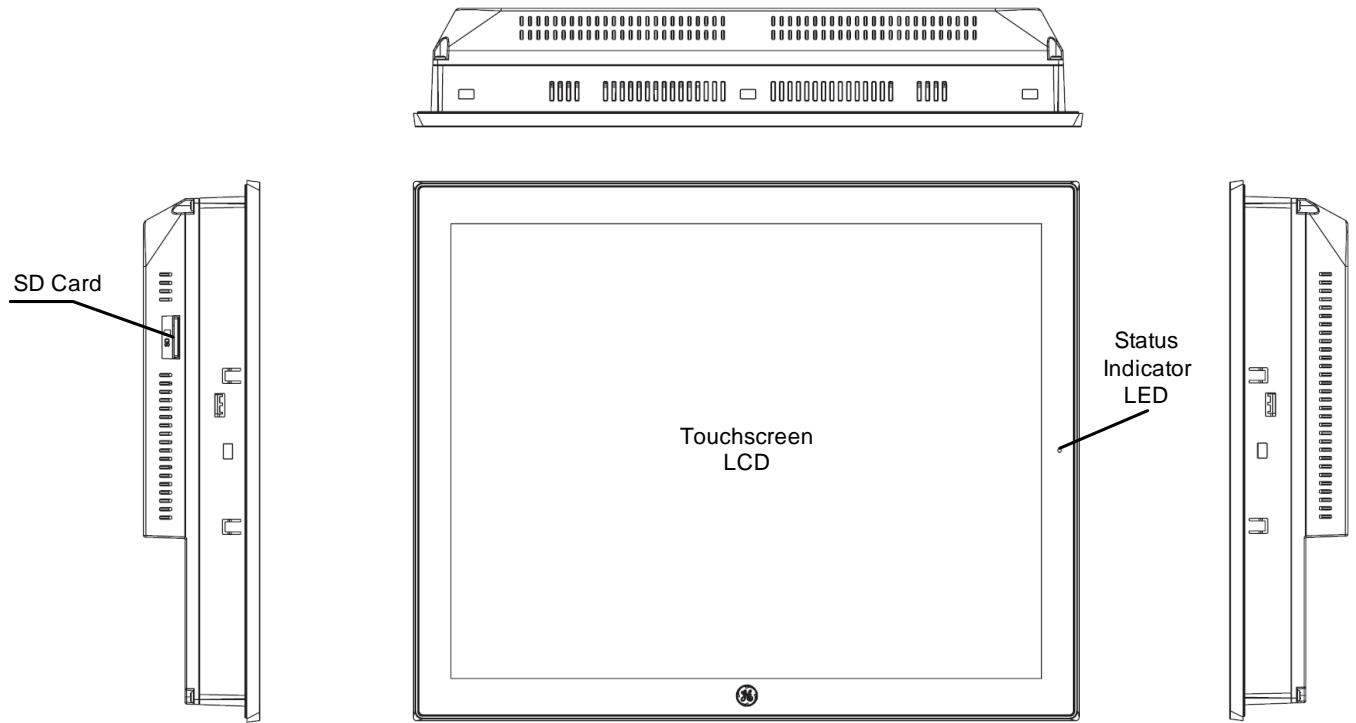
Status Indicator LED



LAN2 LAN1 USB Host Ports MICRO COM2 COM1 LINE Input OUT Power



IC755CxS12CDx Hardware Features



IC755CxS15CDx Hardware Features

1.2.2 Status Indicators

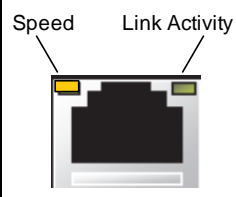
The QuickPanel+ has a tri-color LED that provides visual status indications for IC755CxW07CDx and IC755CxSxxCDx units.

1.2.2.1 Status LED Operation

LED State	QuickPanel+ State
Amber, solid	Operating system starting
Green, solid	Normal operating state
Green, blinking	Backlight off
Red, blinking	Backlight failure
Off	Power not applied to the unit

1.2.2.2 Ethernet Port LED Operation

The Ethernet port has two LED indicators: Speed and Link Activity.

	LED	LED State	Operating State
	Speed	On, Yellow	10/100
Link Activity	On, Green	Link status	

2 Pre-installation Checks

This chapter provides information for performing a pre-installation check of the QuickPanel+ Operator Interface.

Before installing and using the QuickPanel+, complete the following procedures:

- [Unpacking and Inspection](#)
- [Basic Setup](#)
- [Initial Startup](#)
- [Runtime Setup](#)
- [Firmware Updates](#)
- [Shutdown](#)

2.1 Unpacking and Inspection

Upon receipt of the QuickPanel+ Operator Interface, carefully inspect all shipping containers for damage. If any part of the system is damaged, notify the carrier immediately. The damaged shipping container should be saved as evidence for inspection by the carrier. It is the consignee's responsibility to register a claim with the carrier for damage incurred during shipment. However, we will fully cooperate should such action be necessary.

For phone numbers and email addresses, refer to the section, [Contact Information](#).

After unpacking the unit, **record all serial numbers**. Serial numbers are required if you need to contact Customer Care during the warranty period. Shipping containers and packing material should be saved in case it is necessary to transport or ship the unit. Verify that all system components have been received and agree with the order. If the system received does not agree with your order, contact Customer Care.

Before initial powerup, inspect the unit for loose or damaged components. If damage is found (such as bent component leads or loose components), contact GE Intelligent Platforms for additional instructions.

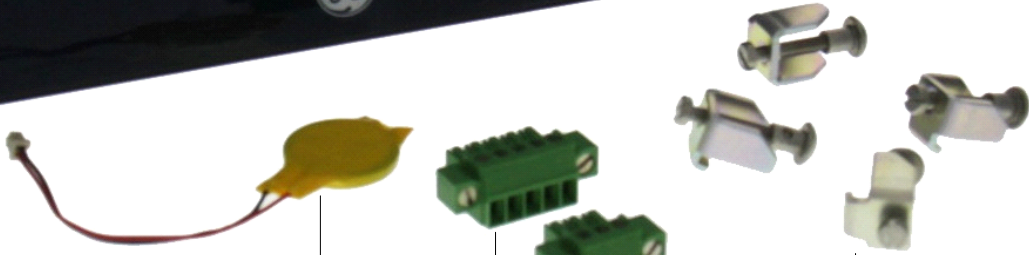


Caution

Do not apply power to the unit if it has visible damage. Applying power to a unit with damaged components may cause additional damage.



QuickPanel+
Operator Interface



- Battery (Qty 1) (pre-installed)
- Serial Port Connector (Qty 1)
- Power Connector (Qty 1)
- Mounting Brackets (Qty 4)

Protective Sheet (Qty 1) (not shown)
 Gasket (Qty 1) (not shown, pre-installed)

IC755CxW07CDx Example Package Contents

2.2 Basic Setup

The QuickPanel+ Operator Interface is shipped ready for use after [initial configuration](#).

To power up the unit, [connect a dc power supply](#) using the supplied quick-connect plug. Depending on the application, you may also want to connect and configure optional input devices, communications ports, and expansion adapters.



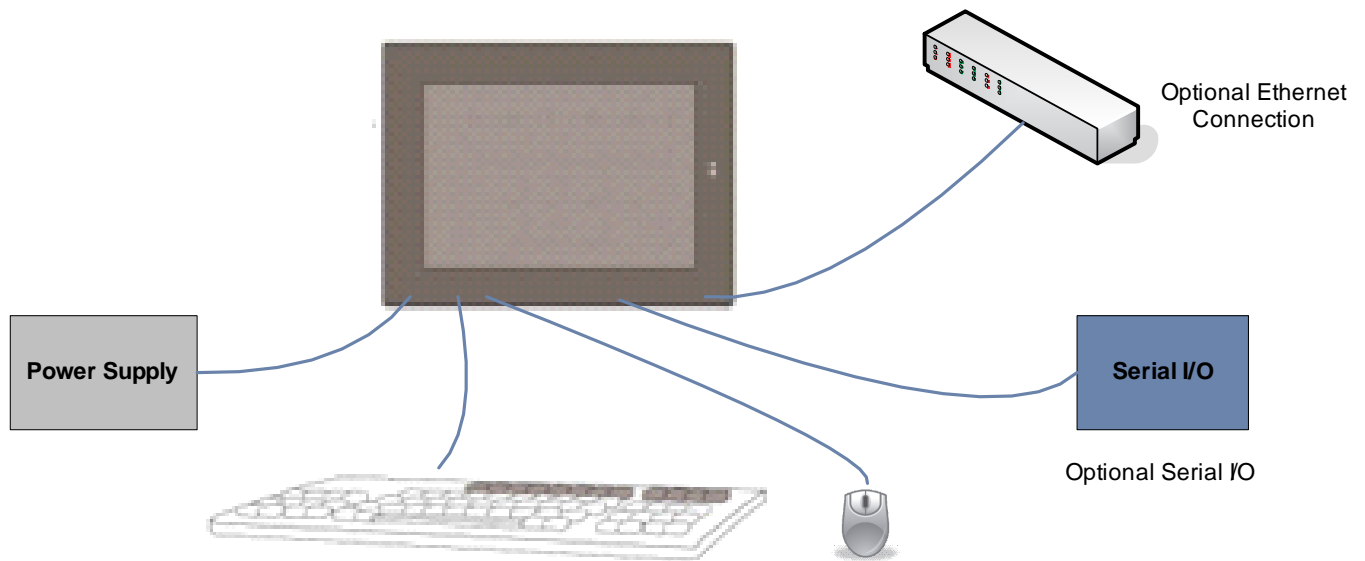
Warning

ELECTRICAL SHOCK HAZARD — To avoid personal injury or damage to equipment, ensure that the dc supply is disconnected from power and that the leads are not energized before attaching them to the unit's power supply plug.



Warning

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.



Basic Setup Diagram

2.3 Initial Startup

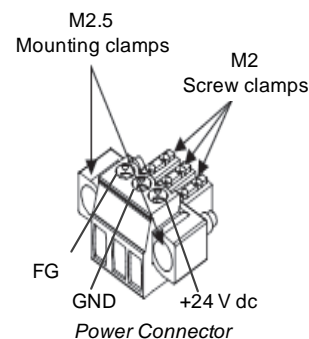
You will need the following:

- A Safety Extra Low Voltage (SELV) and Limited Energy Circuit or SELV and Class 2 dc power supply.
- The power terminal block is supplied with the product. For voltage and requirements, refer to the *Input Power* specifications in the table, [General Specifications](#).
- The mating power terminal block supports stranded 30 – 14 AWG (0.05 – 2.00 mm²) wires. The user calculates proper gauge wiring for current carrying capacity and loss according to local regulations.
- At a minimum, the cable must be rated for 75°C (167 °F) or more.
- USB-compatible keyboard (optional)
- USB-compatible mouse (optional)

2.3.1 Connecting Input Power

➤ **To connect input power**

1. Verify that the power cable is not energized.
2. Loosen the screw clamps on the mating power connector.
3. Strip the insulation from the power cables.
4. Secure the power cable to the mating connector, noting polarity, and tighten the screw clamps. The torque for the attaching screws is 0.3 Nm (2.66 in-lb).
5. Apply dc power to the unit. During normal startup and operation, the QuickPanel+ status LED indicator displays as follows:
 - *Solid amber* while the QuickPanel+ is starting up
 - *Solid green* during normal operation
6. Once power is applied, the QuickPanel+ begins initializing. The first thing to display is the splash screen.




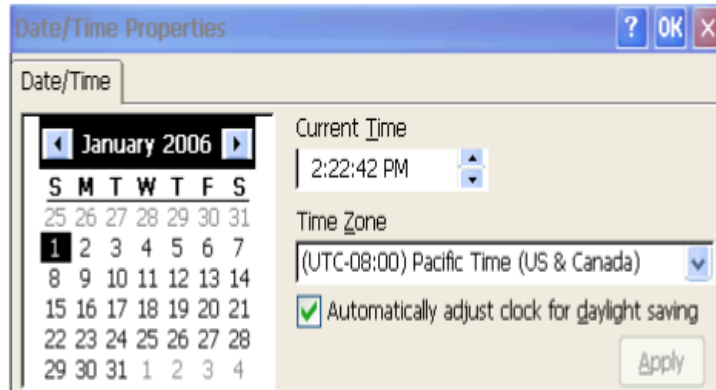
To skip running any programs included in the StartUp folder, tap **Don't run Startup programs**. The Microsoft Windows Embedded Compact 7 starts automatically.

2.3.2 Initial Configuration

When you first start up the QuickPanel+, a few configuration steps are necessary.

➤ **To configure the QuickPanel+**

1. Tap **Start** , point to **Settings**, then tap **Control Panel**.
2. From the Control Panel, double-tap **Date and Time** to configure the system clock.



3. From the Control Panel, double-tap **System** to configure a Network Device Name. Many applications, including Proficy Historian, require a unique Device Name.



Attention

It is recommended to set a unique Device Name for the QuickPanel+ to avoid future conflicts.

4. From the Control Panel, double-tap **Network and Dial-up Connections** to configure network settings.
5. Run the [Backup Utility](#) to save the settings.

2.4 Runtime Setup

To download an application to a QuickPanel+ Operator Interface, set up a data link between the unit and your development workstation. Refer to the section [Ethernet for IC755CxW07CDx and IC755CxSxxCDx](#), and the Proficy Machine Edition (PME) online help, *Downloading a Machine Edition Project*.

2.5 Firmware Updates

Update the unit to the most recent released version of the firmware with the latest feature upgrades and issues addressed. Firmware updates for the QuickPanel+ are available on the [Support website](#).

2.6 Shutdown

There are no specific dangers associated with a power failure or other unplanned shutdown of the QuickPanel+. In general, programs are retained in flash memory and user data can be retained in battery-backed SRAM. Some operating system settings are retained only with user intervention. We recommend the following procedure to shut down the QuickPanel+.

➤ **To shut down the QuickPanel+**

1. Quit any programs that are running and wait for all file operations to complete.
2. If you have not changed operating system settings (for example, brightness or touchscreen sensitivity) or do not want to save the changes, remove ac power from the dc supply.
3. To save changes to operating system settings run Backup. When the Backup dialog box displays *Completed Successfully*, remove power from the dc power supply connected to the QuickPanel+.

3 Software

This chapter provides general information on the QuickPanel+ software and procedures for completing some of the most common tasks.

3.1 Operating System

Refer to <http://windows.microsoft.com>.

Microsoft Windows Embedded Compact 7 is the operating system for the QuickPanel+. It is a full 32-bit O/S with a graphical user interface. The QuickPanel+ operating system is stored in flash memory and copied to a block of DRAM for execution. The operating system starts automatically following a powerup or reset of the QuickPanel+.

3.2 Backup Utility



Attention

Run the Backup Utility whenever you make configuration changes to the operating system or installed applications, and before shutting down the QuickPanel+ Operator Interface.

The Backup Utility saves the changes made to the Windows Registry or Desktop to Flash Memory. This is required because the QuickPanel+ is not battery powered. Specifically, the Backup Utility achieves the following:

- Stores the Windows Embedded Compact 7 registry (including any control panel settings) in Flash memory.
- Stores any changes (or additions) made to the *Windows* sub-tree of the file system in the user block of flash memory.

3.3 Storage Manager

Storage Manager, accessed from the Control Panel folder, is a Microsoft product for which online help is available.

Use Storage Manager to repair or format lost or corrupted data volumes. Storage Manager can repair data volumes existing either in SD Card, battery-backed SRAM (BBSRAM), or USB Flash Keys (thumb drives). Data volumes existing in the main flash file system of the QuickPanel+ may not be repaired by Storage Manager.

3.4 Copying Project to SD Card

This is a custom utility for transferring Proficy Machine Edition View and Control projects between compatible QuickPanel+ units via SD cards.



Caution

Ensure that the copy or update operation is complete such as no busy or wait cursor displays) before disconnecting power.

➤ To copy a Machine Edition project to SD card

1. Ensure there is a blank SD card in the SD card port.
2. Double tap the **Copy Project to SD Card** icon on the desktop.
3. Tap **Yes** when the *Copy Project Query* confirmation dialog box appears.



Caution

Copying a project while the Proficy Machine Edition runtimes are active may cause an incomplete copy to be created if the runtimes are also writing to files in the project folders. The utility can detect this situation and will notify you to stop the runtimes before making the backup. You will not be able to create a backup while the runtimes are writing files.

3.5 Updating a Machine Edition Project

You can update a Machine Edition application currently stored on the QuickPanel+ with a revision stored on a flash device, such as a SD card.

➤ **To update a Machine Edition project**

1. Insert the flash device containing an upgraded version of the Machine Edition project into the appropriate port.
2. Reboot the machine.

Note Depending on options set, the update may or may not be enabled, or may automatically update. If there is more than one flash device with a valid project copy present, a *Select Media* confirmation dialog displays, allowing you to choose which flash device to update with. Select the device from the list and select **OK** to continue. When a valid project is found on the flash device, you will be prompted to install the project or skip it. Tap **OK** to install or **Cancel** to skip the install and continue to boot. If an invalid project is found, an error message appears in a dialog box. This dialog box must be closed before boot will continue.

3. Remove the flash device from the port.

3.6 FTP Server

The FTP server included with the QuickPanel+ supports standard (RFC 959). It does not support SFTP or implicit FTPS, which uses different ports and is based on SSH rather than SSL.

The FTP server is configured with the Quick Panel+ Setup Tool. By default, the server is not enabled. Once enabled, a background program will run, waiting for clients to connect. Up to ten connections are supported. Sessions that are idle for five minutes are terminated by the server.

The server supports non-secure operation. All information including username, password, and data is transmitted with no encryption and susceptible to packet sniffing and various FTP attacks.

Note If the server status is changed, the QuickPanel+ must be re-booted before changes take effect.

The FTP root directory is available from the QuickPanel+ as \ and is the root of the flash device.

3.6.1 Authentication of Remote Users

The server only supports anonymous login: Anonymous with password requested (but not validated). This may prevent some types of attacks and is required by some clients. Once connected, a remote user is logged into the FTP root directory.

3.6.2 FTP with Removable Flash Devices

All removable flash devices appear to remote FTP users as directories off the FTP root directory. Computer Flash card partitions display as directories such as *\SDMemory* and USB Flash Keys as directories such as *\Hard Disk*. Full access privileges are granted for the client in these folders/devices.

Removable flash device directories are captured when a session is opened and are not changed while the session exists. If you start without an SD Card installed, you will have to close your session and login again to see the SD Card directory. If the SD Card existed when you logged in and is removed and inserted, it will still work, provided the SD Card's device name did not change during reinsertion.

3.7 HTTP Server

The HTTP server included with the QuickPanel+ supports standard (RFC 2616). The HTTP server is configured with the Quick Panel+ Setup Tool. By default, the server is not enabled. Once enabled, a background program will run, waiting for clients to connect. The default web page is located in `\Windows\www\wwwpub` on the QuickPanel+ Operator Interface.

The server supports non-secure port 80 operation.

Note If the server status is changed, the QuickPanel+ must be re-booted before changes take effect.

3.8 SNTP Server

The SNTP server included with the QuickPanel+ supports SNTP Version 4 for IPv4, IPv6 and OSI. The SNTP server is configured with the Quick Panel+ Setup Tool. By default, the server is not enabled. Once enabled, the server will refresh the time specified in the setup tool configuration. Pressing the *Update Now* button immediately obtains the time from the configured time server.

The SNTP server supports non-secure UDP port 123 operation.

Notes

4 Installation

This chapter provides the following procedures for installing the QuickPanel+ Operator Interface:

- [*Installing the Protective Sheet*](#)
- [*Choosing a Mounting Location*](#)
- [*Panel Mounting*](#)
- [*Mounting on a VESA Arm*](#)
- [*Installing and Replacing the Battery*](#)
- [*Connectors*](#)

4.1 Installing the Protective Sheet

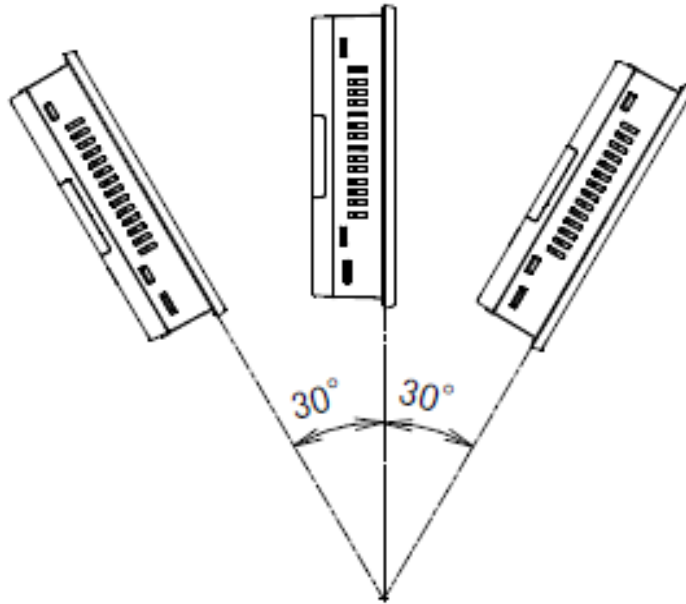
➤ To install the protective sheet

1. Remove the protective film on the screen of the QuickPanel+.
2. Wipe the display of any dust or fingerprints.
3. Peel a corner of the clear side of the protective sheet.
4. Begin applying the corner to the display.
5. Slowly apply the rest of the protective sheet, smoothing out as you go.
6. Peel the green curing film from the protective sheet.

4.2 Choosing a Mounting Location

Refer to the section,
[Environmental Specifications](#).

When mounting the QuickPanel+ Operator Interface, make sure the mounting area allows room to insert and remove the SD card, cables, and mounting brackets. Choose a [location](#) that will allow natural convection air flow from bottom to top of the QuickPanel+ enclosure. Do not mount the QuickPanel+ at an angle more than 30° from the vertical, as illustrated in the following figure.



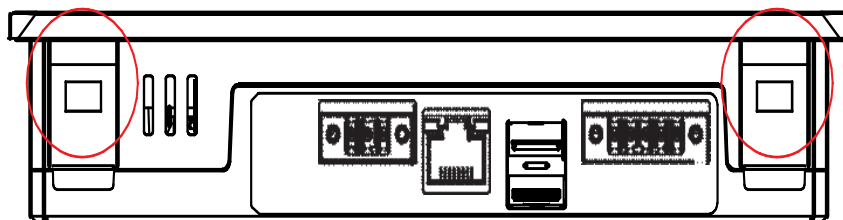
Mounting Angle

4.3 Panel Mounting

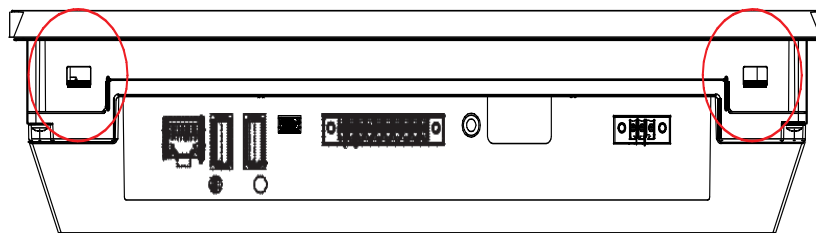
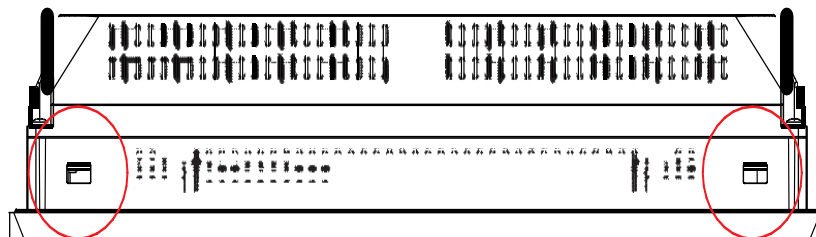
To mount the QuickPanel+ in an enclosure, you will need:

- One #2 Phillips head screwdriver
- Mounting brackets (supplied)

The IC755CxW07CDx, IC755CxS10CDx, and IC755CxS12CDx mounting holes are located on the top and bottom sides of the unit.

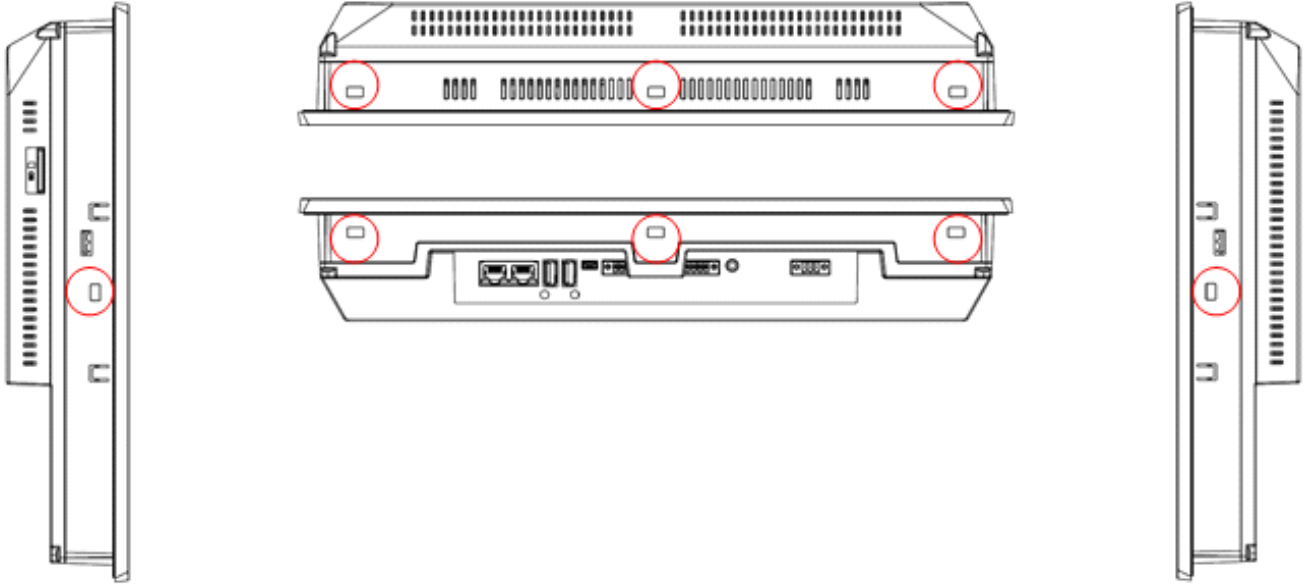


IC755CxW07CDx Mounting Holes



IC755CxS10CDx and IC755CxS12CDx Mounting Holes

The IC755CxS15CDx mounting holes are located on the top, bottom, and sides of the unit.



IC755CxS15CDx Mounting Holes

4.4 Installation Procedure

Observe the following guidelines to properly mount and install the QuickPanel+ Operator Interface:

To order replacement gaskets, refer to the part number listed in [Appendix B](#).

- To properly mount the QuickPanel+, the enclosure should be of metal material.
- The metal enclosure panel should ensure proper thickness and rigidity suitable to minimize impact to the QuickPanel+.
- To avoid gasket degradation, limit repeated insertions or removals of the unit and retightening of the mounting clips. For full protection, always use a fresh gasket.
- The unit will not fit through the cutout with any cables connected, or with the power supply plug inserted in the socket.



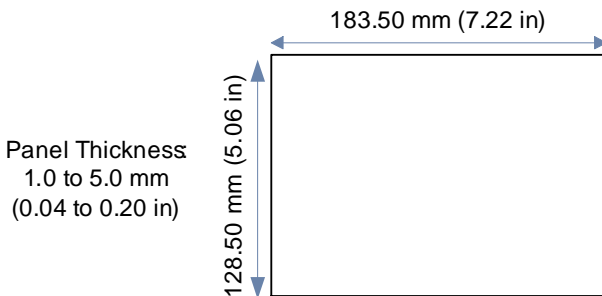
Caution

When installing the QuickPanel+ into the panel, pay careful attention while handling the unit so it does not drop and damage the unit.

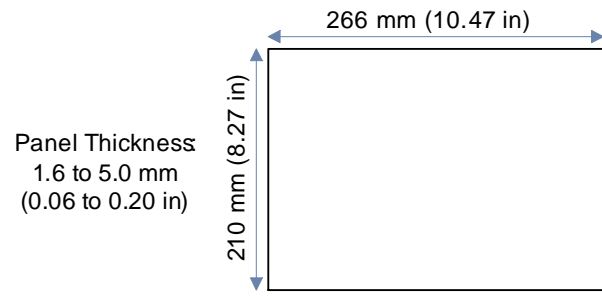
➤ **To install the QuickPanel+**

1. Cut an opening in the panel according to the specifications in the following figures.

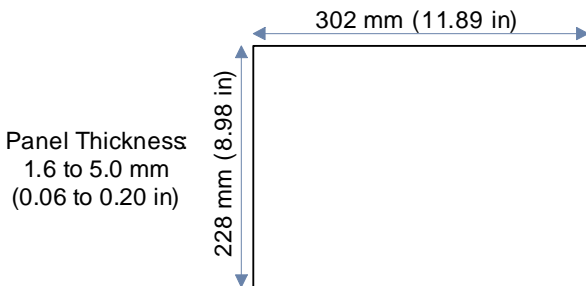
Note Panel cutout tolerances are +0.50, -0.00 mm (+0.02, -0.00 in).



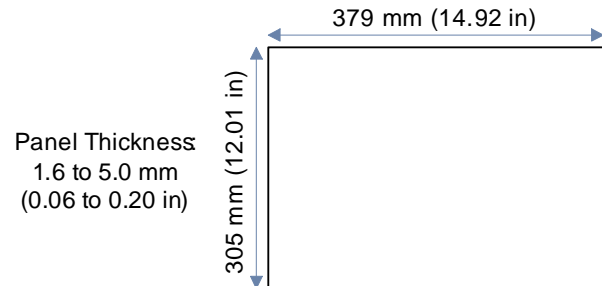
IC755CxW07CDx Panel Cutout Dimensions



IC755CxS10CDx Panel Cutout Dimensions

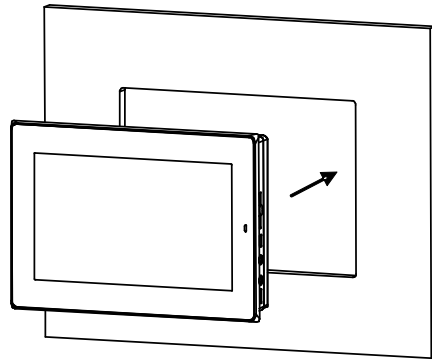


IC755CxS12CDx Panel Cutout Dimensions

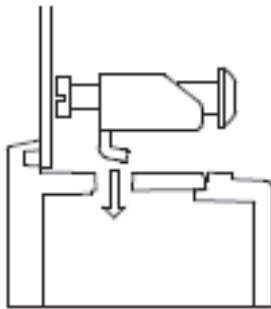


IC755CxS15CDx Panel Cutout Dimensions

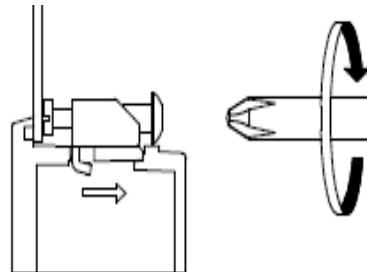
2. Verify that the gasket is present and properly seated in the bezel channel located on the sides of the unit.
3. Insert the QuickPanel+ into the mounting panel cutout.



4. Insert the hook of the mounting bracket into the mounting hole as displayed in the following figure.



5. Tighten the screws on the mounting bracket in a clock-wise direction.



Torque Range for Mounting Clamp Screws

Unit	Torque Range
IC755CxW07CDx	0.3 Nm (2.66 in-lb)
IC755CxS10CDx	0.7 Nm (6 in-lb)
IC755CxS12CDx	1.0 to 1.2 Nm (8.9 to 10.6 in-lb)
IC755CxS15CDx	1.0 to 1.2 Nm (8.9 to 10.6 in-lb)

4.5 Mounting on a VESA Arm

The QuickPanel+ can be installed on a commercially available Video Electronics Standards Association (VESA) MIS-D arm, stand, or apparatus that is listed to comply with the UL1678 standard.

Refer to the mounting arm manual for instructions.

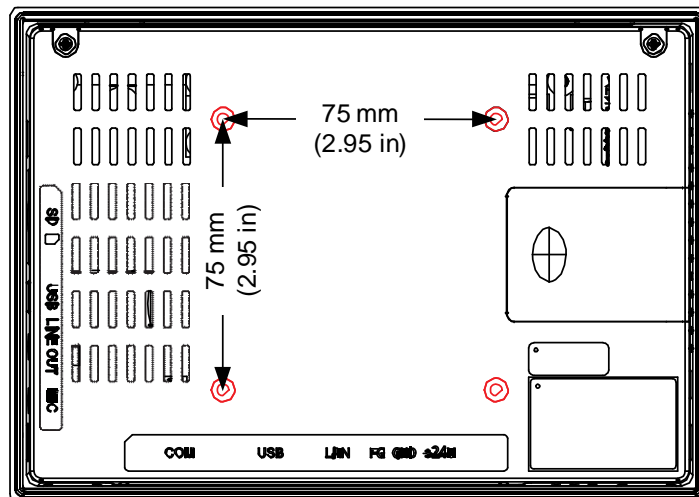
- **To mount the QuickPanel+:** use the mounting holes located on the back of the unit as displayed in the following figures.

The IC755CxW07CDx mounting holes attach with M4 screws that are 6 mm (0.24 in) or less in length.

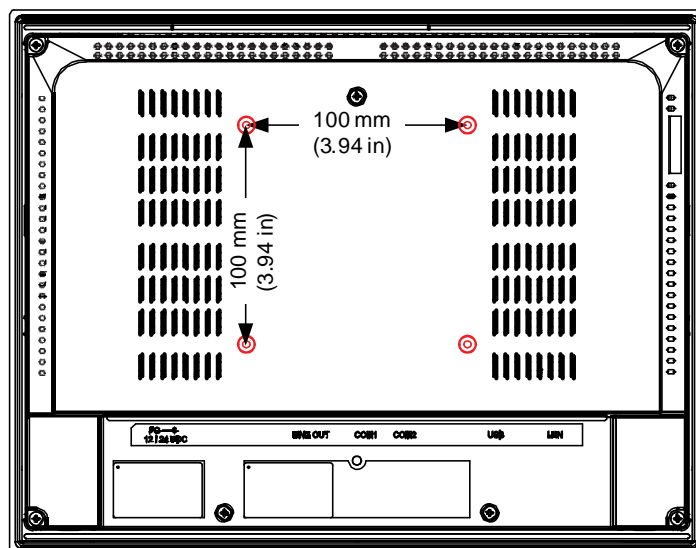
The IC755CxSxxCDx mounting holes attach with M4 screws that are 8 mm (0.32 in) or less in length.

Torque Range for Mounting M4 Screws

Unit	Torque Range
IC755CxW07CDx	0.7 to 0.8 Nm (6.2 to 7.1 in-lb)
IC755CxSxxCDx	1.0 to 1.2 Nm (8.9 to 10.6 in-lb)



IC755CxW07CDx VESA Mounting Holes



IC755CxSxxCDx VESA Mounting Holes

4.6 Installing and Replacing the Battery



Warning

Batteries may present a risk of fire, explosion, or chemical burn if mistreated. Do not crush, disassemble, short-circuit, or dispose of in fire.

Use of batteries not specified for use with the QuickPanel+ product may present a risk of fire or explosion.



Warning

Do not recharge, disassemble, heat or incinerate lithium batteries.

Dispose of lithium batteries in accordance with federal, state, and local regulations. Be sure to consult with the appropriate regulatory agencies before disposing of batteries.



Caution

1) Replacing the battery should only be performed by trained personnel and in a non-hazardous location.

2) If the QuickPanel+ Operator Interface is VESA mounted, detach from the VESA arm when replacing the battery.

3) The battery should only be replaced when the unit is powered off.

4) Care should be taken to protect and insert the battery with correct polarity.

5) Do not use any metallic item to remove the battery (such as screwdrivers, knives, pliers, and so forth).

6) Be careful to not drop the battery or any associated screws into the unit.

7) Be careful of edges on internal sides of the enclosure and frame.

4.6.1 IC755CxW07CDx

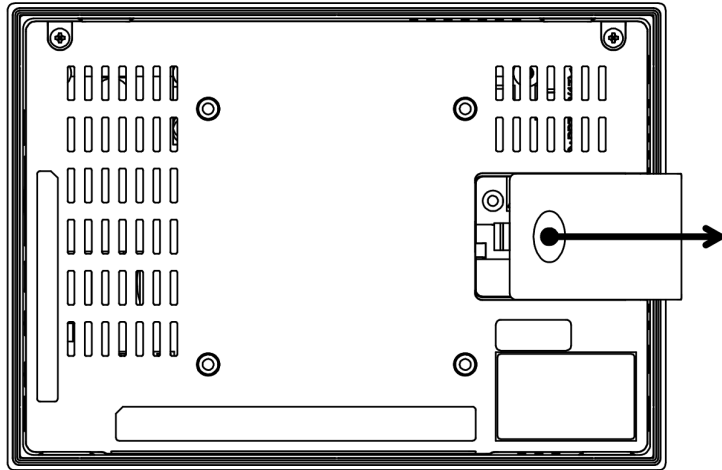
- To install or replace the battery for the IC755CxW07CDx



Caution

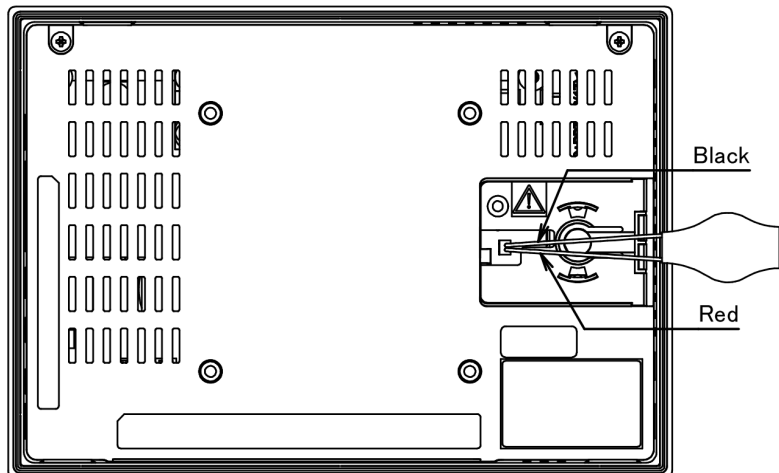
Replace the battery for the IC755CxW07CDx only with battery part number IC755ACCBATT.

1. Remove the battery cover by pressing down while sliding outward.



IC755CxW07CDx Battery Cover Removal

2. Connect the battery harness connector to the header, noting keyed orientation.

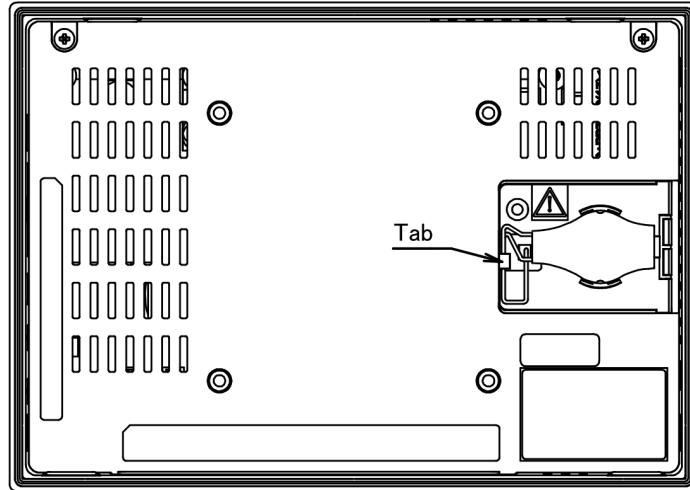


Battery Part Number IC755ACCBATT

Battery Harness Connection

3. Verify that positive (red) is down and negative (black) is up.

4. Wrap the harness connector around to match the following figure. Do not let the harness connector go above the tab.



Harness Connector Orientation

5. Slide the battery cover into place, taking care not to pinch the harness connector.

4.6.2 IC755CxSxxCDx

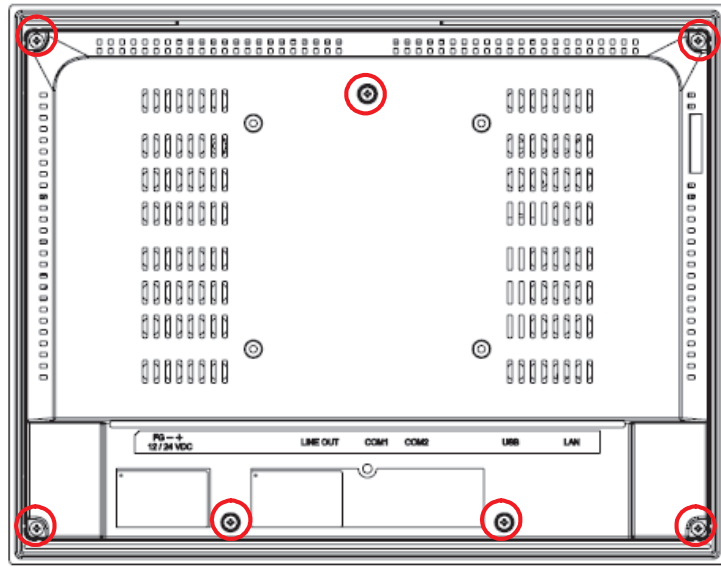
- To install or replace the battery for the IC755CxSxxCDx



Caution

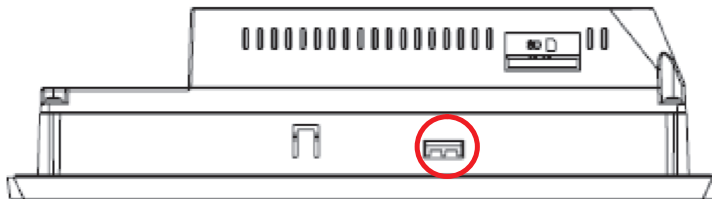
Replace the battery for the IC755CxSxxCDx only with battery part number IC755ACCBATTNL.

1. Remove seven screws from the back cover.



IC755CxSxxCDx Screw Locations (Back Cover)

2. Gently press on either side tab to release the back cover.



Side Tab for Cover Release

3. Lift up the back cover to remove.

The battery will be exposed on the back of the unit.



Battery Part Number IC755ACCBATTNL

IC755CxSxxCDx Battery

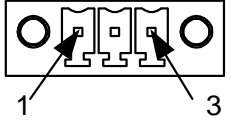
4. Gently remove the coin battery and replace with a new one, noting the polarity of the battery.
5. Replace the battery cover and tighten all screws to 0.5 Nm (4.4 in-lb).

4.7 Connectors

4.7.1 Power Connector Pin-out for IC755CxW07CDx and IC755CxSxxCDx

To connect the power supply, refer to the section, [Connecting Input Power](#).

Connector: Terminal Euro (Tyco Electronics 284539-3)
Mating Connector: (Tyco Electronics 284510-3)

Pin #	Signal Name	Pin-out
1	+24 V dct	
2	GND	
3	FG	

† IC755CxSxxCDx supports both +12 V dc or +24 V dc IN

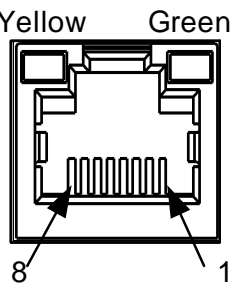
4.7.2 Ethernet for IC755CxW07CDx and IC755CxSxxCDx

Refer to the section, [Ethernet Port LED Operation](#).

The QuickPanel+ is equipped with 10BaseT/100-BaseTX Ethernet port(s). You can connect an Ethernet network cable (unshielded, twisted pair, UTP CAT 5) to the unit through the RJ-45 connector(s) on the bottom of the enclosure. LED indicators on the port indicate channel status. The port can be accessed by Windows Embedded Compact 7 network communications or by your application.

4.7.2.1 Ethernet Port Details

Interface: Ethernet 10BASE-T/100BASE-TX

Pin #	Signal Name	Pin-out
1	TX+	
2	TX-	
3	RX+	
4	NC	
5	NC	
6	RX-	
7	NC	
8	NC	

4.7.2.2 Setting an IP Address

The QuickPanel+ Operator Interface provides two methods to set an IP address:

- **DHCP (Dynamic Host Configuration Protocol)**
The network server assigns an IP address during QuickPanel+ initialization. (You must be connected to the network.) There must be a DHCP server on the connected network for a valid IP address to be assigned. Contact your network administrator to ensure correct DHCP server configuration.
- **Manual Method**
Specify the numeric addresses obtained from your network administrator for the QuickPanel+ IP Address, Subnet Mask and Default Gateway (if applicable).

Note Run the [Backup utility](#) to save the settings.

4.7.3 Serial Port

4.7.3.1 IC755CxW07CDx Serial Port Details

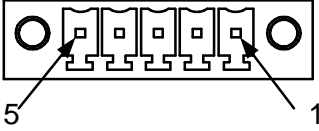
- A terminal block is supplied.
- The mating terminal block supports stranded 30-14 AWG (0.05 – 2.00 mm²) wires.
- At a minimum, the cable must be rated for 75°C (167 °F) or more.
- Secure the serial cable to the mating connector while noting signal orientation and tighten the screw clamps.
- The torque for the attaching screws is 0.3 Nm (2.66 in-lb).

Interface: x1 RS-232

Connectors: Euro Terminal (Tyco Electronics 284539-5)

Mating Connector: (Tyco Electronics 284510-5)

COM1 Pin Details

Pin #	Signal Name	Pin-out
1	TXD	
2	RXD	
3	RTS	
4	CTS	
5	SGND	

4.7.3.2 IC755CxSxxCDx Serial Port Details

For an IC755CxS12CDA serial port, refer to [Appendix C IC755CxS12CDA Serial Port Details](#).

- Terminal blocks are supplied.
- The mating terminal blocks support stranded 30 to 14 AWG (0.05 to 2.00 mm²) wires.
- At a minimum, the cable must be rated for 75°C (167 °F) or more.
- Secure the serial cable to the mating connector while noting signal orientation and tighten the screw clamps.
- The torque for the attaching screws is 0.3 Nm (2.66 in-lb).

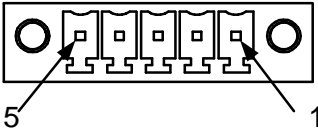
Connectors: Euro Terminal (Tyco Electronics 284539-5)

Mating Connectors: Tyco Electronics 284510-5

4.7.3.2.1 Serial Port COM1

Interface: RS-232

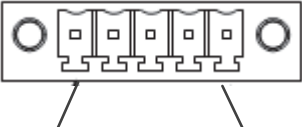
COM1 Pin Details

Pin #	Signal Name	Pin-out
1	TXD	
2	RXD	
3	RTS	
4	CTS	
5	SGND	

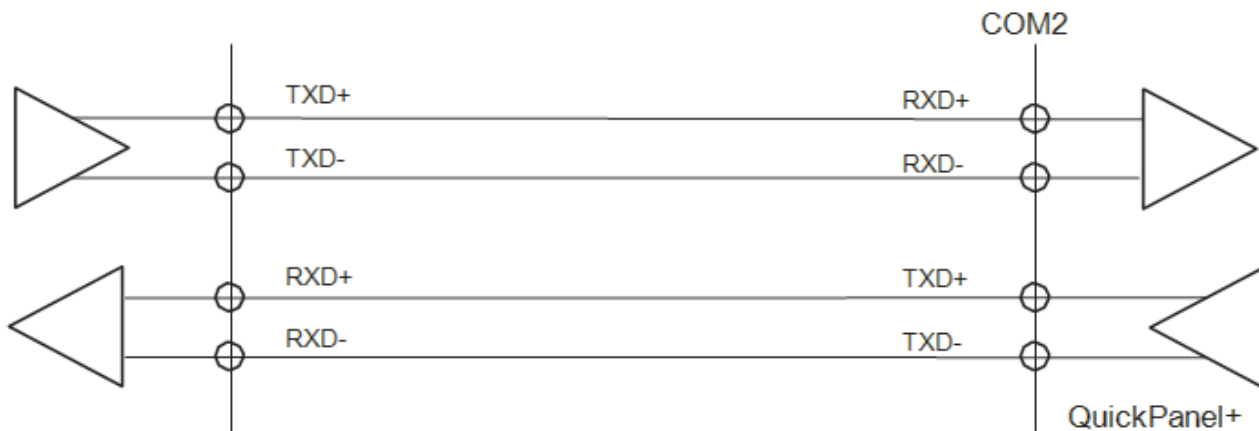
4.7.3.2.2 Serial Port COM2

Interface: RS-232C/485 (default is RS-485 Half-duplex)

COM2 Pin Details

Pin #	RS-232	RS-485		Pin-out
	Signal Name	Signal Name (Full-duplex†)	Signal Name (Half-duplex†)	
1	TXD	TXD+	DATA++	
2	RXD	TXD-	DATA-‡	
3	RTS	RXD+	DATA++	
4	CTS	RXD-	DATA- ‡	
5	SGND	SG	SG	

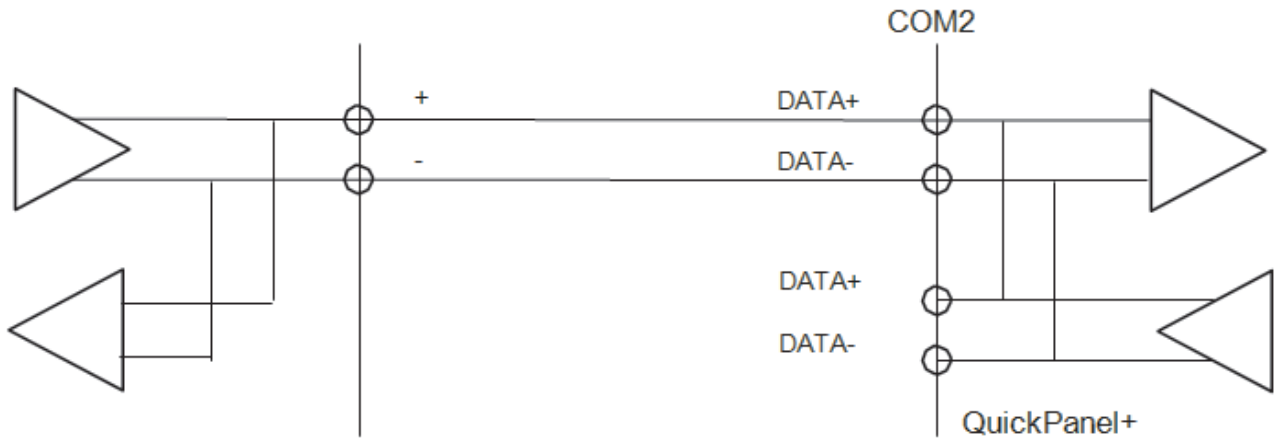
† Full-duplex RS-485 is backwards compatible to RS-422 mode.
‡ Pins 1-3 and 2-4 are connected internally.



Example of Full-duplex (RS-485 Mode) Connection

COM2 DIP Switch Setting

DIP SW	Bit	ON/OFF	DIP SW	Bit	ON/OFF
SW2	1	OFF	SW4	1	ON
	2	OFF		2	ON
	3	OFF		3	OFF
	4	OFF		4	OFF
	5	ON		5	ON
	6	ON		6	ON
	7	OFF		7	OFF
	8	ON		8	OFF
SW3	1	OFF	SW5	1	OFF
	2	ON		2	OFF
	3	OFF		3	OFF
	4	OFF		4	OFF



Example of Half-duplex (RS-485 Mode) Connection

COM2 DIP Switch Setting

DIPSW	Bit	ON/OFF	DIPSW	Bit	ON/OFF
SW2	1	OFF	SW4	1	ON
	2	OFF		2	ON
	3	ON		3	ON
	4	OFF		4	ON
	5	ON		5	ON
	6	ON		6	ON
	7	OFF		7	OFF
	8	ON		8	OFF
SW3	1	OFF	SW5	1	OFF
	2	ON		2	OFF
	3	OFF		3	OFF
	4	ON		4	OFF

4.7.4 Universal Serial Bus (USB) Ports

4.7.4.1 USB Host Port Details for IC755CxW07CDx and IC755CxSxxCDx

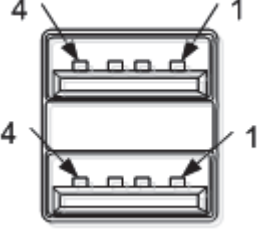
The QuickPanel+ has two full-speed USB 2.0 host ports. A variety of third party USB peripheral devices are also available. Each connected USB device requires a specific driver. The driver supplied with the QuickPanel+ is for optional keyboard or mouse support; other devices require installation of the custom driver software.

Interface: USB 2.0

Number of Ports: Two

Connectors: Type-A connector

Maximum Supply Current: 0.5 A (per port)

Pin #	Signal Name	Pin-out
1	USB_VCC	
2	USB_D-	
3	USB_D+	
4	USB_GND	

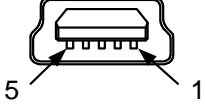
4.7.4.2 USB Device Port Details for IC755CxW07CDx and IC755CxSxxCDx

The USB device port allows the QuickPanel+ Operator Interface to be used as Slave device.

Interface: USB 2.0

Number of Ports: One

Connectors: Type-B Mini connector

Pin #	Signal Name	Pin-out
1	VCC	
2	D-	
3	D+	
4	NC	
5	GND	

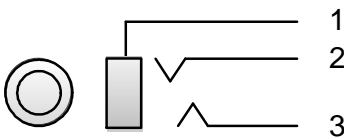
4.7.5 Audio (LINE OUT) Details for IC755CxW07CDx and IC755CxSxxCDx

Interface: LINE OUT (stereo)

Number of Ports: One

Connectors: ϕ 3.5 mm jack

Maximum output level: 1 Vrms

Pin #	Signal Name	Pin-out
1	GND	
2	Lineout R	
3	Lineout L	

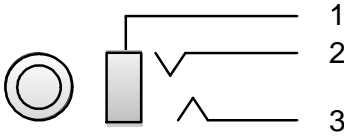
4.7.6 Audio (MIC IN) Details (only applicable to IC755CxW07CDx)

Interface: MIC IN (monaural)

Number of Ports: One

Connectors: ϕ 3.5 mm jack

Maximum output level: 250 mVrms

Pin #	Signal Name	Pin-out
1	GND	
2	Lineout R	
3	Lineout L	

4.7.7 SD Card Slot

The QuickPanel+ is equipped with one standard SD Card port. SD/SDHC memory cards are supported. The SD card slot is spring-loaded for easy insertion and removal.

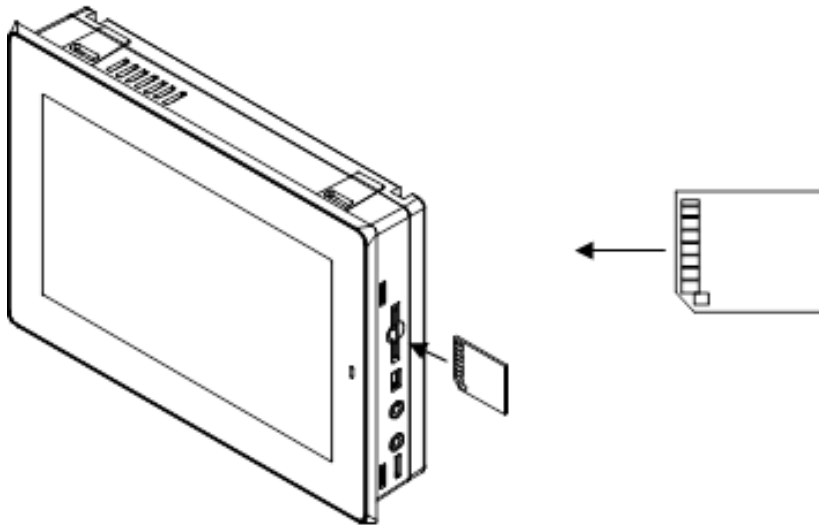
4.7.7.1 SD Card Storage Details

Connectors: SD card slot (push in-push out method)

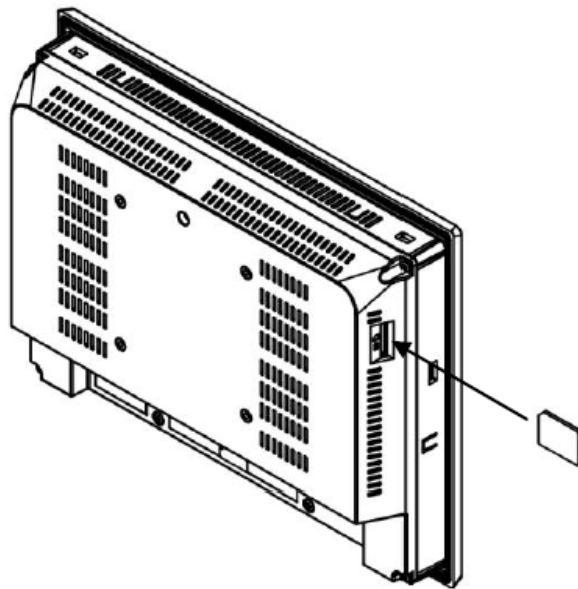
Card support: SD/SDHC memory card

Maximum capacity: 32 GB

Note During insertion, observe the orientation of the SD card as displayed in the following figures.



IC755CxW07CDx SD Card Location



IC755CxSxxCDx SD Card Location

5 Operation

5.1 Touchscreen Display

The QuickPanel+ Operator Interface features a LED Backlit LCD touchscreen display with two-point touch technology. The touch technology is based on projected capacitance, which allows tracking of the finger without pressured contact and is conducive to smooth scrolling and multi-touch gesturing capability. Display brightness and backlight operation can be set using the operating system Control Panel.



Although we recommend the use of the protective sheet, do not operate the touchscreen with any hard materials, such as a screwdriver. This could damage the touchscreen display.

5.1.1 Adjusting the Display Brightness

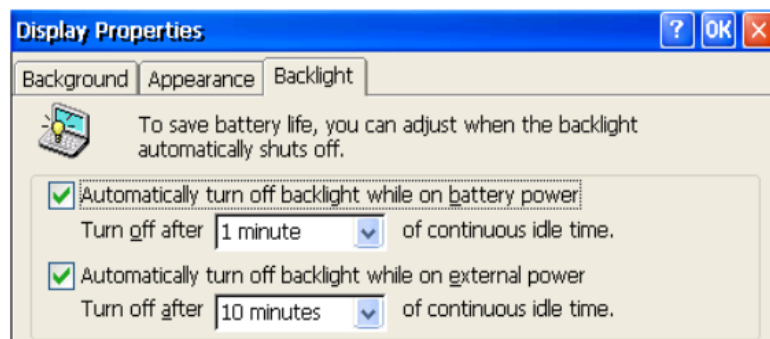
➤ To adjust the brightness of the display

1. From the Control Panel, double-tap **Display** and select the **Brightness** tab to display the Brightness window.
2. Drag the Brightness slider bar between Lowest and Highest.
3. Tap **OK** to exit the control panel.
4. Run the [Backup Utility](#) to save the settings.

5.1.2 Configuring the Backlight

➤ To configure the backlight

1. From the Control Panel, double-tap **Display** and select the **Backlight** tab to display the Backlight Display Properties window.
2. Select **Automatically turn off backlight while on external power**.



Backlight Display Properties

3. Tap **OK** to exit the control panel.
4. Run the [Backup Utility](#) to save the settings.

5.1.3 Re-calibrating the Touchscreen

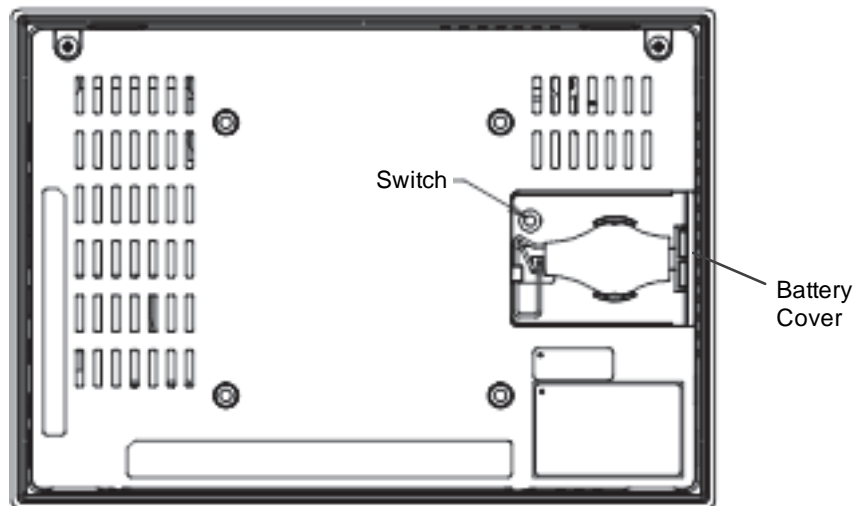
The QuickPanel+ touchscreen is shipped pre-calibrated. However, If there are any issues with touchscreen responsiveness, it may need to be re-calibrated.

➤ **To re-calibrate the touchscreen**

1. Open the **QuickPanel+ Setup** tool.
2. Select the **TouchPanel** tab.
3. Select **Recalibrate Touch Screen**.
4. Select **Recalibrate Touch Sensor**.

Note During IC755CxW07CDx touchscreen sensor re-calibration, the user is prompted to activate a switch located in the battery compartment. This is not applicable to any other panel sizes.

5. Remove the battery cover and press the switch.



Touchscreen Sensor Calibration Switch

6. Replace the battery cover.

5.2 Keyboard

The QuickPanel+ Operator Interface can be configured to use either or both a hardware keyboard and a software emulation keyboard as operator data input devices. Typically, an optional external hardware keyboard is used when in development mode, while the included Soft Input Panel (SIP) is more applicable in an operational environment.

5.2.1 External Keyboard (Optional)

Any USB-compatible keyboard may be used as an input device for the unit. The USB driver for the keyboard is included with the operating system and no configuration is required. To use an external keyboard, simply plug and play.

5.2.2 Soft Input Panel

The Soft Input Panel (SIP) is a touchscreen version of a standard keyboard that may be used in place of a standard hardware keyboard. An icon in the system tray enables the user to view or hide the SIP.

- **To show or hide the SIP:** from the system tray located on the task bar, tap the icon and select **Hide Input Panel**.

Note When visible, the SIP can be moved around the screen by dragging the title bar to reveal parts of the screen that would be obstructed from view by the SIP.

5.3 Mouse

Any USB-compatible mouse may be used as an input device for the unit. The USB driver for the mouse is included with the operating system and no configuration is required. To use an external mouse, plug it into the appropriate port.

5.4 Memory

5.4.1 Dynamic RAM Memory

The QuickPanel+ Operator Interface is equipped with dynamic RAM (DRAM). Part of the DRAM is reserved for the Windows operating system and is not accessible by user applications. The remaining memory is split between two functions: an object store for temporary file storage and the main memory for running programs.

Typically, compressed programs stored in flash memory are expanded and moved to DRAM for execution. Temporary storage of program variables or data files is also provided by DRAM. Any data stored in DRAM is not retained through a power cycle or reboot.

The split between program memory and storage memory can be adjusted as necessary to make more room for one or the other, depending on your specific application needs. For example, if you find that an application is short of memory, alter the DRAM memory allocation from the System Properties window.



Caution

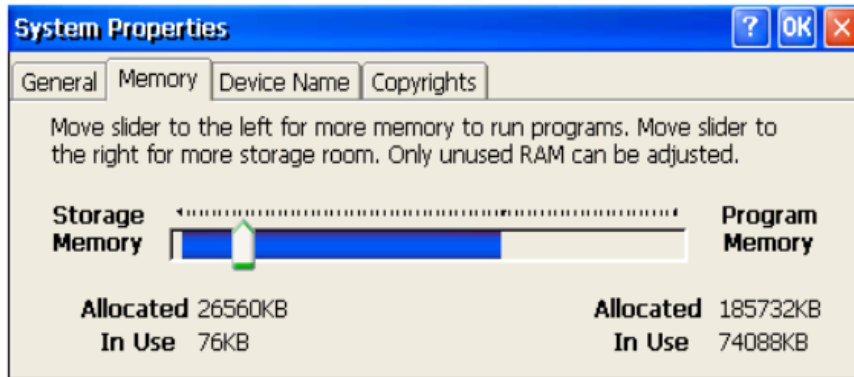
Setting the Program Memory too low may prevent additional applications from starting, or may cause currently running applications to fail due to lack of memory.

Setting the Storage Memory too low may prevent the saving of files into the object store portion of the file system, which may also cause application failures.

5.4.2 Modifying Memory Allocation

➤ To change the memory allocation

1. From the Control Panel, double-tap **System** to display the System Properties window.
2. From the **Memory** tab, drag the slider bar to divide into Storage and Program memory. The amount of memory allocated to and used by each area is displayed in the window. The blue slider bar indicates the current amount of unallocated SDRAM and determines the boundaries within which the slider can move.



System Memory Slider Bar

Note Storage memory is limited to a maximum of 128 MB. Using the slider bar to increase storage memory will provide more RAM-based storage in the folder *\Object Store*.

3. Tap **OK** to apply the new setting.
4. Run the [Backup Utility](#) to save the settings.



Notes

Appendix A Product Certifications and Installation Guidelines

The QuickPanel+ Operator Interface is intended for use in industrial environments and, when properly installed, shall comply with the agency approvals listed in this chapter.

Agency Approvals

Note The agency approvals listed in the following table and on the Declaration of Conformities are believed to be accurate; however, the product's agency approvals should be verified by the marking on the unit itself.

Description	Agency Marking	Comments
N.A. Safety for Programmable Controller for use in Hazardous locations Class I Division 2 Groups A,B,C,D		Certification by Underwriter's Laboratories to UL 61010-1; UL61010-2-201; CSA C22.2 No 142 – M1987; CSA 61010-1; CSA 61010-2-201 ISA 12.12.01 standard and CSA C22.2 No 213-M1987
Electromagnetic Compatibility Directive European Electromagnetic Compatibility (EMC) for Industrial Control Equipment		Self-declaration in accordance with European Directives EN61000-6-2, EN61000-6-4

Conditions of Safe Use for Installation in Hazardous Locations

The following information applies to products bearing the UL marking for Hazardous areas for explosive atmospheres:

Suitable for use in Class I Division 2 Groups A, B, C, D.



EXPLOSION HAZARD — Class I Division 2 Groups A, B, C, D; do not disconnect equipment unless power has been removed or the area is known to be non-hazardous.

EXPLOSION HAZARD — Substitution of components may impair suitability.

EXPLOSION HAZARD — DO NOT VESA MOUNT. Panel mount only with enclosures that shall only be able to be opened with the use of a tool.

Government Regulations

The FCC requires the following note to be published according to FCC guidelines:

Note This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications to this unit that are not expressly approved by GE Intelligent Platforms could void the user's authority to operate the equipment.

Industry Canada requires the following note to be published:

Note This Class A digital apparatus complies with Canadian CAN ICES 3 (A)/NMB 3 (A).

EMC Installation and Operation Considerations

This equipment has been tested and found to comply with a minimum level of EMC performance as defined by EN 61000-6-2 and EN 61000-6-4 standards. To meet these requirements, the following installation and operation considerations were taken into account:

- Shielding USB cables
- Limiting RS-232 cables to 15 m (49.2 ft) in length
- Using Audio ports only during operational maintenance

Although these considerations were deliberated during testing, actual EMC environments vary greatly. Therefore, these considerations may not be necessary. Likewise, additional measures, such as filtering, wire separation, and cable routing, may need to be considered to ensure intended operation of the overall system.

Appendix B Orderable Part Numbers

QuickPanel+ Operator Interface Part Numbers

Part Number	Description
IC755CSW07CDx	QuickPanel+ 7" Color TFT Widescreen with Multi-touch Projected Capacitive Screen, 24 V dc Powered
IC755ACC07GAS	QuickPanel+ 7" Replacement Gasket
IC755ACC07MNT	QuickPanel+ 7" Accessory Kit - Replacement Mounting Clips, Power and Serial Port Connectors
IC755ACC07PRO	QuickPanel+ 7" Replacement Screen Protectors (Qty 3)
IC755ACC07ADP	QuickPanel+ Panel Adapter Kit - 8" QuickPanel View/Control to QuickPanel+ 7"
IC755ACCBATT	QuickPanel+ 7" Replacement Battery Pack
IC755CSS10CDx	QuickPanel+ 10" Color TFT with Multi-touch Projected Capacitive Screen, 12/24 V dc Powered
IC755ACC10GAS	QuickPanel+ 10" Replacement Gasket
IC755ACC10MNT	QuickPanel+ 10" Accessory Kit - Replacement Mounting Clips, Power and Serial Port Connectors
IC755ACC10PRO	QuickPanel+ 10" Replacement Screen Protectors (Qty 3)
IC755CSS12CDx	QuickPanel+ 12" Color TFT with Multi-touch Projected Capacitive Screen, 12/24 V dc Powered
IC755ACC12GAS	QuickPanel+ 12" Replacement Gasket
IC755ACC12MNT	QuickPanel+ 12" Accessory Kit - Replacement Mounting Clips, Power and Serial Port Connectors
IC755ACC12PRO	QuickPanel+ 12" Replacement Screen Protectors (Qty 3)
IC755CSS15CDx	QuickPanel+ 15" Color TFT with Multi-touch Projected Capacitive Screen, 12/24 V dc Powered
IC755ACC15GAS	QuickPanel+ 15" Replacement Gasket
IC755ACC15MNT	QuickPanel+ 15" Accessory Kit - Replacement Mounting Clips, Power and Serial Port Connectors
IC755ACC15PRO	QuickPanel+ 15" Replacement Screen Protectors (Qty 3)
IC755ACCBATTNL	QuickPanel+ 10", 12", 15" Replacement Battery Pack

Notes

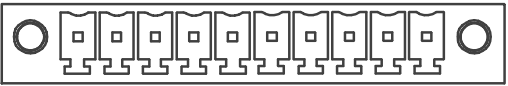
Appendix C IC755CxS12CDA Serial Port Details

- A terminal block is supplied.
- The mating terminal block supports stranded 30-14 AWG (0.05 – 2.00 mm²) wires.
- At a minimum, the cable must be rated for 75°C (167 °F) or more.
- Secure the serial cable to the mating connector while noting signal orientation and tighten the screw clamps.
- The torque for the attaching screws is 0.3 Nm (2.66 in-lb).

Interface: x1 RS-232, x1 RS-232/485 (default is RS-485)

Connectors: Euro Terminal (Tyco Electronics 1-284539-0)

Mating Connector: (Tyco Electronics 1-284510-0)

Pin #	Signal Name	Pin-out
COM1		
1	TXD	
2	RXD	
3	RTS	
4	CTS	
5	SGND	
COM2 (RS-232/485†)		
6	TXD/TXD+/DATA+	
7	RXD/TXD-/DATA-	
8	RTS/RXD+/DATA+	
9	CTS/RXD-/DATA-	
10	SG	
† RS-485 mode shorts pins 6-8 and 7-9		

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Cisco SFP and SFP+ Transceiver Module Installation Notes

Revised: September 13, 2012

Product Numbers:	SFP-10G-SR=	SFP-10G-LR=	SFP-10G-LRM=	SFP-OC48-LR2=
	SFP-GE-Z=	SFP-OC3-MM=	SFP-OC3-SR=	SFP-OC12-LR2=
	SFP-OC3-LR2=	SFP-GE-L=	SFP-OC12-SR=	GLC-SX-MM-RGD=
	SFP-OC3-LR1=	SFP-OC48-SR=	SFP-OC48-IR1=	GLC-ZX-SM-RGD=
	SFP-GE-S=	GLC-SX-MM=	SFP-OC3-IR1=	GLC-FE-100FX=
	GLC-ZX-SM=	SFP-OC12-IR1=	GLC-T=	GLC-FE-100FX-RGD=
	GLC-LH-SM=	GLC-BX-D=	GLC-BX-U=	GLC-FE-100BX-D=
	GLC-FE-100BX-U=	GLC-FE-100EX=	GLC-FE-100LX=	GLC-FE-100ZX=
	SFP-H10GB-CU1M=	SFP-H10GB-CU3M=	SFP-H10GB-CU5M=	SFP-10G-ER=
	SFP-OC12-MM=	DWDM-SFP-xxxx=	SFP-OC12-LR1=	CWDM-SFP-xxxx=
	GLC-LX-SM-RGD=	GLC-GE-100FX=	GLC-FE-100LX-RGD=	GLC-EX-SMD=
	SFP-H10GB-ACU7M=	SFP-H10GB-ACU10M=	GLC-SX-MMD=	GLC-LH-SMD=
	GLC-2BX-D=	SFP-10G-ZR=	SFP-10G-SR-X=	SFP-10G-LR-X=
	SFP-H10GB-CU1-5M=	SFP-H10GB-CU2M=	SFP-H10GB-CU2-5M=	SFP-10G-AOC1=
	SFP-10G-AOC2M=	SFP-10G-AOC3M=	SFP-10G-AOC5M=	SFP-10G-AOC7M=
	SFP-10G-AOC10M=	DWDM-SFP10G-xx.xx=	GLC-ZX-SMD=	

This installation note provides the installation instructions for the Cisco small form-factor pluggable (SFP) and SFP+ transceiver modules. These transceiver modules are hot-swappable input/output (I/O) devices that plug into 100BASE, 1000BASE and 10GBASE ports (for SFP+), which connect the module port with the fiber-optic or copper network.



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Contents

This document contains these sections:

- [Overview, page 2](#)
- [Safety, page 17](#)
- [Required Tools, page 22](#)
- [Installing SFP and SFP+ Transceiver Modules, page 23](#)
- [Removing SFP and SFP+ Transceiver Modules, page 28](#)
- [Obtaining Documentation and Submitting a Service Request, page 36](#)

Overview

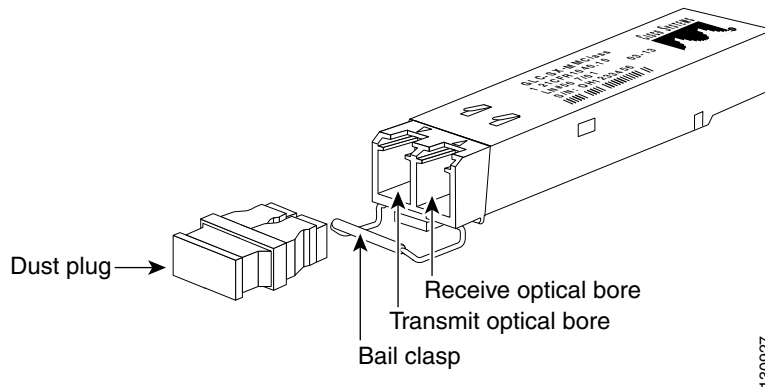
The SFP transceiver modules are hot-pluggable I/O devices that plug into module sockets. The transceiver connects the electrical circuitry of the module with the optical or copper network.

You can use any combination of SFP transceiver modules that your Cisco device supports. The only restrictions are that each port must match the wavelength specifications on the other end of the cable and that the cable must not exceed the stipulated cable length for reliable communications.

Use only Cisco SFP transceiver modules on your Cisco device. Each SFP transceiver module supports the Cisco Quality Identification (ID) feature which allows a Cisco switch or router to identify and validate that the transceiver module is certified and tested by Cisco.

An optical SFP transceiver module is shown in [Figure 1](#).

Figure 1 SFP Transceiver Module (Fiber-Optic LC Connector)

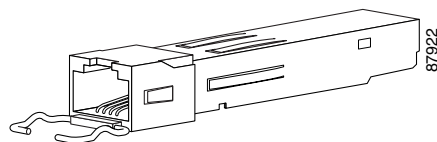


Note

SFP transceiver modules that operate with single-strand SMF, have only one optical bore; the other bore is blocked off.

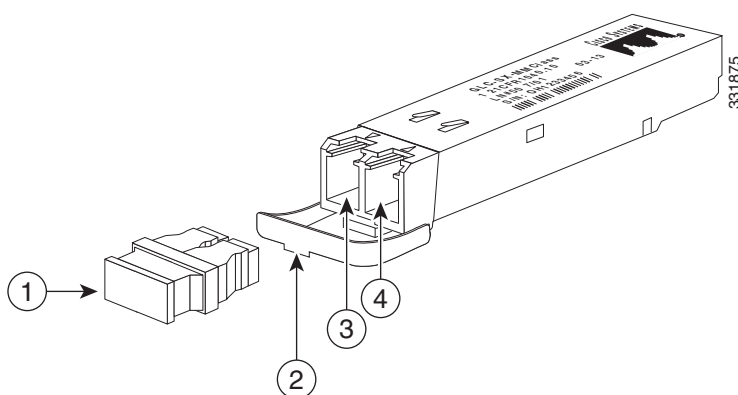
A copper SFP transceiver module is shown in [Figure 2](#).

Figure 2 1000BASE-T SFP Transceiver Module (RJ-45 Connector)



An SFP+ transceiver module is shown in [Figure 3](#).

Figure 3 SFP+ Transceiver Module (Fiber-Optic LC Connector)



1	Dust plug	3	Transmit bore
2	Bail clasp with clasp tab	4	Receive bore

The product numbers and brief description of the SFP and SFP+ transceiver modules are listed in [Table 1](#).

Table 1 Product Numbers and Descriptions

SFP Transceiver Module Product Number	Transceiver Description
10-Gigabit Ethernet	
SFP-10G-SR	Cisco 10GBASE-SR SFP+ transceiver module for MMF, 850-nm wavelength
SFP-10G-SR-X	Cisco 10GBASE-SR SFP+ transceiver module for MMF, 850-nm wavelength, extended temperature range
SFP-10G-LR	Cisco 10GBASE-LR SFP+ transceiver module for SMF, 1310-nm wavelength
SFP-10G-LR-X	Cisco multirate 10GBASE-LR/10GBASE-LW/OTU2e SFP+ transceiver module for SMF, 1310-nm wavelength, extended temperature range
SFP-10G-LRM	Cisco 10GBASE-LRM SFP+ transceiver module for MMF and SMF, 1310-nm wavelength
SFP-10G-ER	Cisco 10GBASE-ER SFP+ transceiver module for SMF, 1550-nm wavelength
SFP-10G-ZR	Cisco 10GBASE-ZR SFP+ transceiver module for SMF, 1550-nm wavelength

Table 1 Product Numbers and Descriptions (continued)

SFP Transceiver Module Product Number	Transceiver Description
SFP-H10GB-CU1M	Cisco 10GBASE-CU passive Twinax SFP+ cable assembly, 1 meter
SFP-H10GB-CU1-5M	Cisco 10GBASE-CU passive Twinax SFP+ cable assembly, 1.5 meters
SFP-H10GB-CU2M	Cisco 10GBASE-CU passive Twinax SFP+ cable assembly, 2 meters
SFP-H10GB-CU2-5M	Cisco 10GBASE-CU passive Twinax SFP+ cable assembly, 2.5 meters
SFP-H10GB-CU3M	Cisco 10GBASE-CU passive Twinax SFP+ cable assembly, 3 meters
SFP-H10GB-CU5M	Cisco 10GBASE-CU passive Twinax SFP+ cable assembly, 5 meters
SFP-H10GB-ACU7M	Cisco 10GBASE-CU active Twinax SFP+ cable assembly, 7 meters
SFP-H10GB-ACU10M	Cisco 10GBASE-CU active Twinax SFP+ cable assembly, 10 meters
SFP-10G-AOC1M	Cisco 10GBASE-AOC Active Optical Cable SFP+ assembly, 1 meter
SFP-10G-AOC2M	Cisco 10GBASE-AOC Active Optical Cable SFP+ assembly, 2 meters
SFP-10G-AOC3M	Cisco 10GBASE-AOC Active Optical Cable SFP+ assembly, 3 meters
SFP-10G-AOC5M	Cisco 10GBASE-AOC Active Optical Cable SFP+ assembly, 5 meters
SFP-10G-AOC7M	Cisco 10GBASE-AOC Active Optical Cable SFP+ assembly, 7 meters
SFP-10G-AOC10M	Cisco 10GBASE-AOC Active Optical Cable SFP+ assembly, 10 meters
1-Gigabit Ethernet	
GLC-SX-MM=	Cisco 1000BASE-SX SFP transceiver module for MMF, 850-nm wavelength, commercial operating temperature range.
GLC-SX-MM-RGD=	Cisco 1000BASE-SX SFP transceiver module for MMF, 850-nm wavelength, industrial operating temperature range.
SFP-GE-S=	Cisco 1000BASE-SX SFP transceiver module for MMF, 850-nm wavelength, extended operating temperature range.
GLC-SX-MMD=	Cisco 1000BASE-SX SFP transceiver module for MMF, 850-nm wavelength, extended operating temperature range.
GLC-LH-SM=	Cisco 1000BASE-LX/LH SFP transceiver module for MMF and SMF, 1300-nm wavelength, commercial operating temperature range.
GLC-LX-SM-RGD=	Cisco 1000BASE-LX/LH SFP transceiver module for MMF and SMF, 1300-nm wavelength, industrial operating temperature range.
SFP-GE-L=	Cisco 1000BASE-LX/LH SFP transceiver module for MMF and SMF, 1300-nm wavelength, extended operating temperature range.
GLC-LH-SMD=	Cisco 1000BASE-LX/LH SFP transceiver module for MMF and SMF, 1300-nm wavelength, extended operating temperature range.
GLC-EX-SMD=	Cisco 1000BASE-EX SFP transceiver module for SMF, 1310-nm wavelength, extended operating temperature range.
GLC-ZX-SM=	Cisco 1000BASE-ZX SFP transceiver module for SMF, 1550-nm wavelength, commercial operating temperature range.
GLC-ZX-SM-RGD=	Cisco 1000BASE-ZX SFP transceiver module for SMF, 1550-nm wavelength, industrial operating temperature range.
SFP-GE-Z=	Cisco 1000BASE-ZX SFP transceiver module for SMF, 1550-nm wavelength, extended operating temperature range.

Table 1 **Product Numbers and Descriptions (continued)**

SFP Transceiver Module Product Number	Transceiver Description
GLC-ZX-SMD=	Cisco 1000BASE-ZX SFP transceiver module for SMF, 1550-nm wavelength, extended operating temperature range.
GLC-T=	1000BASE-T SFP transceiver module for copper networks, commercial operating temperature range.
SFP-GE-T=	1000BASE-T SFP transceiver module for copper networks, extended operating temperature range.
GLC-BX-D=	1000BASE-BX10 SFP module for single-strand SMF, 1490-nm TX/1310-nm RX wavelength, commercial operating temperature range.
GLC-BX-U=	1000BASE-BX10 SFP module for single-strand SMF, 1310-nm TX/1490-nm RX wavelength, commercial operating temperature range.
GLC-2BX-D=	Dual-channel 1000BASE-BX10 SFP module for single-strand SMF, 1490-nm TX/1310-nm RX wavelength, commercial operating temperature range.
Fast Ethernet	
GLC-FE-100FX=	100BASE-FX SFP module for 100-Mb ports, MMF, 1310-nm wavelength, commercial operating temperature range.
GLC-FE-100FX-RGD=	100BASE-FX SFP module for 100-Mb ports, MMF, 1310-nm wavelength, industrial operating temperature range.
GLC-GE-100FX=	100BASE-FX SFP module for Gigabit Ethernet ports, MMF, 1310-nm wavelength, commercial operating temperature range.
GLC-FE-100LX=	100BASE-LX10 SFP module for 100-Mb ports, SMF, 1310-nm wavelength, commercial operating temperature range.
GLC-FE-100LX-RGD=	100BASE-LX10 SFP module for 100-Mb ports, SMF, 1310-nm wavelength, industrial operating temperature range.
GLC-FE-100BX-D=	100BASE-BX10-D SFP module for single-strand SMF, 1550-nm TX/1310-nm RX wavelength, commercial operating temperature range.
GLC-FE-100BX-U=	100BASE-BX10-U SFP module for single-strand SMF, 1310-nm TX/1550-nm RX wavelength, commercial operating temperature range.
GLC-FE-100EX=	100BASE-EX SFP module for 100-Mb ports, SMF, 1310-nm wavelength, commercial operating temperature range.
GLC-FE-100ZX=	100BASE-ZX SFP module for 100-Mb ports, SMF, 1550-nm wavelength, commercial operating temperature range.

Table 1 Product Numbers and Descriptions (continued)

SFP Transceiver Module Product Number	Transceiver Description
SONET/SDH	
SFP-OC3-MM	SFP OC-3/STM-1 Multimode
SFP-OC3-SR	SFP OC-3/STM-1 Short-Reach
SFP-OC3-IR1	SFP OC-3/STM-1 Intermediate-Reach
SFP-OC3-LR1	SFP OC-3/STM-1 Long-Reach (40 km)
SFP-OC3-LR2	SFP OC-3/STM-1 Long-Reach (80 km)
SFP-OC12-MM	SFP OC-12/STM-4 Multimode
SFP-OC12-SR	SFP OC-12/STM-4 Short-Reach
SFP-OC12-IR1	SFP OC-12/STM-4 Intermediate-Reach
SFP-OC12-LR1	SFP OC-12/STM-4 Long-Reach (40 km)
SFP-OC12-LR2	SFP OC-12/STM-4 Long-Reach (80 km)
SFP-OC48-SR	SFP OC-48/STM-16 Short-Reach
SFP-OC48-IR1	SFP OC-48/STM-16 Intermediate-Reach
SFP-OC48-LR2	SFP OC-48/STM-16 Long-Reach (80 km)
CWDM (OC-12/STM4, 1-Gigabit Ethernet, 1-Gigabit Fiber Channel, 2-Gigabit Fiber Channel, OC-48/STM-16)	
CWDM-SFP-1470=	Longwave 1470-nm laser, single mode
CWDM-SFP-1490=	Longwave 1490-nm laser, single mode
CWDM-SFP-1510=	Longwave 1510-nm laser, single mode
CWDM-SFP-1530=	Longwave 1530-nm laser, single mode
CWDM-SFP-1550=	Longwave 1550-nm laser, single mode
CWDM-SFP-1570=	Longwave 1570-nm laser, single mode
CWDM-SFP-1590=	Longwave 1590-nm laser, single mode
CWDM-SFP-1610=	Longwave 1610-nm laser, single mode
DWDM (OC-12/STM4, 1-Gigabit Ethernet, 1-Gigabit Fibre Channel, 2-Gigabit Fibre Channel, OC-48/STM-16)	
DWDM-SFP-6141=	Longwave 1561.42-nm laser (100-GHz ITU channel 20), single mode
DWDM-SFP-6061=	Longwave 1560.61-nm laser (100-GHz ITU channel 21), single mode
DWDM-SFP-5979=	Longwave 1559.79-nm laser (100-GHz ITU channel 22), single mode
DWDM-SFP-5898=	Longwave 1558.98-nm laser (100-GHz ITU channel 23), single mode
DWDM-SFP-5817=	Longwave 1558.17-nm laser (100-GHz ITU channel 24), single mode
DWDM-SFP-5736=	Longwave 1557.36-nm laser (100-GHz ITU channel 25), single mode
DWDM-SFP-5655=	Longwave 1556.55-nm laser (100-GHz ITU channel 26), single mode
DWDM-SFP-5575=	Longwave 1555.75-nm laser (100-GHz ITU channel 27), single mode
DWDM-SFP-5494=	Longwave 1554.94-nm laser (100-GHz ITU channel 28), single mode
DWDM-SFP-5413=	Longwave 1554.13-nm laser (100-GHz ITU channel 29), single mode

Table 1 **Product Numbers and Descriptions (continued)**

SFP Transceiver Module Product Number	Transceiver Description
DWDM-SFP-5332=	Longwave 1553.33-nm laser (100-GHz ITU channel 30), single mode
DWDM-SFP-5252=	Longwave 1552.52-nm laser (100-GHz ITU channel 31), single mode
DWDM-SFP-5172=	Longwave 1551.72-nm laser (100-GHz ITU channel 32), single mode
DWDM-SFP-5092=	Longwave 1550.92-nm laser (100-GHz ITU channel 33), single mode
DWDM-SFP-5012=	Longwave 1550.12-nm laser (100-GHz ITU channel 34), single mode
DWDM-SFP-4931=	Longwave 1549.32-nm laser (100-GHz ITU channel 35), single mode
DWDM-SFP-4851=	Longwave 1548.51-nm laser (100-GHz ITU channel 36), single mode
DWDM-SFP-4772=	Longwave 1547.72-nm laser (100-GHz ITU channel 37), single mode
DWDM-SFP-4692=	Longwave 1546.92-nm laser (100-GHz ITU channel 38), single mode
DWDM-SFP-4612=	Longwave 1546.12-nm laser (100-GHz ITU channel 39), single mode
DWDM-SFP-4532=	Longwave 1545.32-nm laser (100-GHz ITU channel 40), single mode
DWDM-SFP-4453=	Longwave 1544.53-nm laser (100-GHz ITU channel 41), single mode
DWDM-SFP-4373=	Longwave 1543.73-nm laser (100-GHz ITU channel 42), single mode
DWDM-SFP-4294=	Longwave 1542.94-nm laser (100-GHz ITU channel 43), single mode
DWDM-SFP-4214=	Longwave 1542.14-nm laser (100-GHz ITU channel 44), single mode
DWDM-SFP-4134=	Longwave 1541.35-nm laser (100-GHz ITU channel 45), single mode
DWDM-SFP-4056=	Longwave 1540.56-nm laser (100-GHz ITU channel 46), single mode
DWDM-SFP-3977=	Longwave 1539.77-nm laser (100-GHz ITU channel 47), single mode
DWDM-SFP-3898=	Longwave 1538.98-nm laser (100-GHz ITU channel 48), single mode
DWDM-SFP-3819=	Longwave 1538.19-nm laser (100-GHz ITU channel 49), single mode
DWDM-SFP-3739=	Longwave 1537.40-nm laser (100-GHz ITU channel 50), single mode
DWDM-SFP-3661=	Longwave 1536.61-nm laser (100-GHz ITU channel 51), single mode
DWDM-SFP-3582=	Longwave 1535.82-nm laser (100-GHz ITU channel 52), single mode
DWDM-SFP-3504=	Longwave 1535.04-nm laser (100-GHz ITU channel 53), single mode
DWDM-SFP-3425=	Longwave 1534.25-nm laser (100-GHz ITU channel 54), single mode
DWDM-SFP-3346=	Longwave 1533.47-nm laser (100-GHz ITU channel 55), single mode
DWDM-SFP-3268=	Longwave 1532.68-nm laser (100-GHz ITU channel 56), single mode
DWDM-SFP-3190=	Longwave 1531.90-nm laser (100-GHz ITU channel 57), single mode
DWDM-SFP-3112=	Longwave 1531.12-nm laser (100-GHz ITU channel 58), single mode
DWDM-SFP-3033=	Longwave 1530.33-nm laser (100-GHz ITU channel 59), single mode

Table 1 *Product Numbers and Descriptions (continued)*

SFP Transceiver Module Product Number	Transceiver Description
10-Gigabit DWDM SFP+ (10G LAN, 10G WAN, OTU2/OTU2e)	
DWDM-SFP10G-61.41=	10GBASE-DWDM 1561.41-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-60.61=	10GBASE-DWDM 1560.61-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-59.79=	10GBASE-DWDM 1559.79-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-58.98=	10GBASE-DWDM 1558.98-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-58.17=	10GBASE-DWDM 1558.17-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-57.36=	10GBASE-DWDM 1557.36-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-56.55=	10GBASE-DWDM 1556.55-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-55.75=	10GBASE-DWDM 1555.75-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-54.94=	10GBASE-DWDM 1554.94-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-54.13=	10GBASE-DWDM 1554.13-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-53.33=	10GBASE-DWDM 1553.33-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-52.52=	10GBASE-DWDM 1552.52-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-51.72=	10GBASE-DWDM 1551.72-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-50.92=	10GBASE-DWDM 1550.92-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-50.12=	10GBASE-DWDM 1550.12-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-49.32=	10GBASE-DWDM 1549.32-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-48.51=	10GBASE-DWDM 1548.51-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-47.72=	10GBASE-DWDM 1547.72-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-46.92=	10GBASE-DWDM 1546.92-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-46.12=	10GBASE-DWDM 1546.12-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-45.32=	10GBASE-DWDM 1545.32-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-44.53=	10GBASE-DWDM 1544.53-nm SFP+ (100-GHz ITU grid)

Table 1 **Product Numbers and Descriptions (continued)**

SFP Transceiver Module Product Number	Transceiver Description
DWDM-SFP10G-43.73=	10GBASE-DWDM 1543.73-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-42.94=	10GBASE-DWDM 1542.94-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-42.14=	10GBASE-DWDM 1542.12-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-41.35=	10GBASE-DWDM 1541.35-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-40.56=	10GBASE-DWDM 1540.56-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-39.77=	10GBASE-DWDM 1539.77-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-38.98=	10GBASE-DWDM 1538.98-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-38.19=	10GBASE-DWDM 1538.19-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-37.40=	10GBASE-DWDM 1537.40-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-36.61=	10GBASE-DWDM 1536.61-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-35.82=	10GBASE-DWDM 1535.82-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-35.04=	10GBASE-DWDM 1535.04-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-34.25=	10GBASE-DWDM 1534.25-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-33.47=	10GBASE-DWDM 1533.47-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-32.68=	10GBASE-DWDM 1532.68-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-31.90=	10GBASE-DWDM 1531.90-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-31.12=	10GBASE-DWDM 1531.12-nm SFP+ (100-GHz ITU grid)
DWDM-SFP10G-30.33=	10GBASE-DWDM 1530.33-nm SFP+ (100-GHz ITU grid)

The SFP+ and SFP transceiver module cabling and optical transmit and receive specifications are listed in [Table 2](#) through [Table 9](#).

Table 2 SFP+ Optical Transceiver Module Cabling Specifications

SFP+ Transceiver Module Model	Wavelength (nm)	Fiber Type	Core Size (µm) ¹	Modal Bandwidth (MHz/km) ²	Cable Distance (ft/m)
SFP-10G-SR SFP-10G-SR-X	850	MMF	62.5 62.5 50.0 50.0 50.0 50.0	160 (FDDI) 200 (OM1) 400 (400/400) 500 (OM2) 2000 (OM3) 4700 (OM4)	85/26 108/33 216/66 269/82 984/300 1312/400
SFP-10G-LR SFP-10G-LR-X	1310	SMF	G.652	—	6.2 miles (10 km)
SFP-10G-LRM	1310	MMF SMF	62.5 50.0 50.0 G.652	500 400 500 —	722/220 328/100 722/220 984/300
SFP-10G-ER	1550	SMF	G.652	—	24.86 miles (40 km) ³
SFP-10G-ZR	1550	SMF	G.652	—	49.72 miles (80 km)

1. G.652, listed under core size for single mode fiber (SMF), refers to a ITU-T standard of commonly deployed non-dispersion-shifted single mode fiber with a core size of approximately 8 to 10 microns (µm).
2. At specified wavelength.
3. For distances up to 30 km, no special link design rules need to be considered. Link distances beyond 30 km require that you verify the cable characteristics, especially the cable's loss value.

Table 3 SFP+ Transceiver Module Optical Transmit and Receive Specifications

SFP+ Transceiver Module Model	Transceiver Type	Transmit Power (dBm)	Receive Power (dBm)	Transmit and Receive Wavelength (nm)
SFP-10G-SR SFP-10G-SR-X	10GBASE-SR, 850-nm MMF	-1.3 (Max) -7.3 (Min)	-1.0 (Max) -9.9 (Min)	840 to 860
SFP-10G-LR SFP-10G-LR-X	10GBASE-LR, 1310-nm SMF	0.5 (Max) -8.2 (Min)	0.5 (Max) -14.4 (Min)	1260 to 1355
SFP-10G-LRM	10GBASE-LRM, 1310-nm MMF and SMF	0.5 (Max) -6.5 (Min)	0.5 (Max) -8.4 (Min average) -6.4 (Min in OMA)	1260 to 1355
SFP-10G-ER ¹	10GBASE-ER, 1550-nm SMF	4.0 (Max) -4.7 (Min)	-1.0 (Max) -15.8 (Min)	1530 to 1565
SFP-10G-ZR ²	10GBASE-ZR, 1550-nm SMF	4.0 (Max) 0 (Min) ³	-7.0 (Max) -24.0 (Min)	1530 to 1565

1. Requires a 5-dB, 1550-nm, fixed loss attenuator for distances less than 20 km.
2. Requires a 5- or 10-dB fixed loss attenuator for distances less than 40 km. Please keep receive power below -7 dBm.
3. Receiver sensitivity for 10G Ethernet links with no FEC. With FEC-capable receiver ports and for OTU2/OTU2e links, receiver sensitivity is improved to -27 dBm. Also a 3 dB dispersion penalty should be taken into account for both FEC and non-FEC cases.

Table 4 100-Mb and 1-Gigabit Optical SFP Transceiver Module Cabling Specifications

SFP Module Model	Wavelength (nanometers)	Fiber Type	Core Size (micron) ¹	Modal Bandwidth (MHz/km)	Cable Distance
GLC-SX-MM SFP-GE-S GLC-SX-MM-RGD GLC-SX-MMD	850	MMF	62.5 62.5 50.0 50.0 50.0	160 200 400 500 2000	722 feet (220 m) 902 feet (275 m) 1640 feet (500 m) 1804 feet (550 m) 3281 feet (1 km)
GLC-LH-SM SFP-GE-L GLC-LX-SM-RGD GLC-LH-SMD	1310	MMF ² SMF	62.5 50.0 50.0 G.652	500 400 500 —	1804 feet (550 m) 1804 feet (550 m) 1804 feet (550 m) 6.2 miles (10 km)
GLC-BX-D GLC-2BX-D	1490 (downstream)	SMF	G.652	—	6.2 miles (10 km)
GLC-BX-U	1310 (upstream)	SMF	G.652	—	6.2 miles (10 km)
GLC-EX-SMD	1310	SMF	G.652	—	24.9 miles (40 km)
GLC-ZX-SM GLC-ZX-SM-RGD SFP-GE-Z GLC-ZX-SMD	1550	SMF	G.652	—	43.4 to 62 miles (70 to 100 km)
GLC-FE-100FX GLC-FE-100FX-RGD	1310	MMF	62.5 62.5 50.0 50.0	160 200 400 500	1.24 miles (2 km)
GLC-FE-100LX GLC-FE-100LX-RGD	1310	SMF	G.652	—	6.2 miles (10 km)
GLC-FE-100BX-D	1550 (downstream)	SMF	G.652	—	6.2 miles (10 km)
GLC-FE-100BX-U	1310 (upstream)	SMF	G.652	—	6.2 miles (10 km)
GLC-FE-100EX	1310	SMF	G.652	—	24.9 miles (40 km)
GLC-FE-100ZX	1550	SMF	G.652	—	49.7 miles (80 km)

1. G.652, listed under core size for single mode fiber (SMF), refers to a ITU-T standard of commonly deployed non-dispersion-shifted single mode fiber with a core size of approximately 8 to 10 microns (µm).
2. A mode-conditioning patch cord is required at all times per IEEE specifications.



Note

For the GLC-ZX-SM, the minimum attenuation between the transmit bore (TX) and the receive bore (RX) is 8 dB. When using shorter distances of single-mode fiber cable, you might need to insert an inline optical attenuator in the link to avoid overloading the receiver.

Copper SFP transceiver modules can operate at 10, 100, or 1000 Mbps on some Cisco devices. To find the supported speeds for the 1000BASE-T SFP transceiver modules in your Cisco device, see the *Compatibility Matrix for 1000BASE-T Small Form-Factor Pluggable Modules*.

Copper 1000BASE-T SFP transceiver modules use standard four twisted-pair, Category 5 cable at lengths up to 328.08 feet (100 meters).

Table 5 100M and 1-Gigabit SFP Transceiver Module Optical Transmit and Receive Specifications

SFP Transceiver Module Model	Transceiver Type	Transmit Power (dBm)	Receive Power (dBm)	Transmit and Receive Wavelength (nm)
GLC-SX-MM SFP-GE-S GLC-SX-MM-RGD GLC-SX-MMD	1000BASE-SX, 850-nm MMF	-3 (Max) -9.5 (Min)	0 (Max) -17 (Min)	770 to 860
GLC-LH-SM SFP-GE-L GLC-LX-SM-RGD GLC-LH-SMD	1000BASE-LX/LH, 1310-nm SMF	-3 (Max) -9.5 (Min)	-3 (Max) -20 (Min)	1260 to 1355
GLC-BX-D GLC-2BX-D	1000BASE-BX-D, 1490-nm SMF	-3 (Max) -9 (Min)	-3 (Max) -19.5 (Min)	1480 to 1500 (transmit), 1260 to 1360 (receive)
GLC-BX-U	1000BASE-BX-U, 1310-nm SMF	-3 (Max) -9 (Min)	-3 (Max) -19.5 (Min)	1260 to 1360 (transmit), 1480 to 1500 (receive)
GLC-EX-SMD	1000BASE-EX, 1310 nm	+3 (Max) -1 (Min)	+1 (Max) -22 (Min)	1290 to 1335
GLC-ZX-SM GLC-ZX-SM-RGD SFP-GE-Z GLC-ZX-SMD	1000BASE-ZX, 1550 nm SMF	+5 (Max) 0 (Min)	-3 (Max) -23 (Min)	1500 to 1580
GLC-FE-100FX GLC-FE-100FX-RGD GLC-GE-100FX	100BASE-FX, 1310 nm MMF	-14 (Max) -20 (Min)	-14 (Max) -31 (Min)	1270 to 1380
GLC-FE-100LX GLC-FE-100LX-RGD	100BASE-LX, 1310 nm SMF	-8 (Max) -15 (Min)	-8 (Max) -28 (Min)	1260 to 1360
GLC-FE-100BX-D	100BASE-BX-D, 1550 nm SMF	-8 (Max) -14 (Min)	-3 (Max) -28.2 (Min)	1480 to 1580 (transmit), 1260 to 1360 (receive)
GLC-FE-100BX-U	100BASE-BX-U, 1310 nm SMF	-8 (Max) -14 (Min)	-3 (Max) -28.2 (Min)	1260 to 1360 (transmit), 1480 to 1580 (receive)
GLC-FE-100EX	100BASE-EX, 1310 nm SMF	0 (Max) -5 (Min)	-8 (Max) -28 (Min)	1260 to 1360
GLC-FE-100ZX	100BASE-ZX, 1550 nm SMF	+2 (Max) -3 (Min)	-8 (Max) -30 (Min)	1480 to 1600

Table 6 SONET/SDH Optical SFP Transceiver Module Cabling Specifications

SFP Module Model	Wavelength (nanometers)	Fiber Type	Core Size (micron) ¹	Modal Bandwidth (MHz/km)	Cable Distance
SFP-OC3-MM	1310	MMF	62.5 50.0	500 500	1.24 miles (2 km) 1.24 miles (2 km)
SFP-OC3-SR	1310	SMF	G.652	—	1.24 miles (2 km)
SFP-OC3-IR1	1310	SMF	G.652	—	9.3 miles (15 km)
SFP-OC3-LR1	1310	SMF	G.652	—	24.9 miles (40 km)
SFP-OC3-LR2	1550	SMF	G.652	—	49.7 miles (80 km)
SFP-OC12-MM	1310	MMF	62.5 50.0	500 500	1640 feet (500 m) 1640 feet (500 m)
SFP-OC12-SR	1310	SMF	G.652	—	1.24 miles (2 km)
SFP-OC12-IR1	1310	SMF	G.652	—	9.3 miles (15 km)
SFP-OC12-LR1	1310	SMF	G.652	—	24.9 miles (40 km)
SFP-OC12-LR2	1550	SMF	G.652	—	49.7 miles (80 km)
SFP-OC48-SR	1310	SMF	G.652	—	1.24 miles (2 km)
SFP-OC48-IR1	1310	SMF	G.652	—	9.3 miles (15 km)
SFP-OC48-LR2	1550	SMF	G.652	—	49.7 miles (80 km)

1. G.652, listed under core size for single mode fiber (SMF), refers to a ITU-T standard of commonly deployed non-dispersion-shifted single mode fiber with a core size of approximately 8 to 10 microns (µm).

Table 7 SONET/SDH SFP Transceiver Module Optical Transmit and Receive Specifications

SFP Transceiver Module Model	Transceiver Type	Transmit Power (dBm)	Receive Power (dBm)	Transmit and Receive Wavelength (nm)
SFP-OC3-MM	OC3-SR0, 1310 nm MMF	-14 (Max) -19 (Min)	-5 (Max) -30 (Min)	1270 to 1380
SFP-OC3-SR	OC3-SR1/STM1-I-1, 1310 nm SMF	-8 (Max) -15 (Min)	-8 (Max) -23 (Min)	1260 to 1360
SFP-OC3-IR1	OC3-IR1/STM1-S-1.1, 1310 nm SMF	-8 (Max) -15 (Min)	-8 (Max) -28 (Min)	1261 to 1360
SFP-OC3-LR1	OC3-LR1/STM1-L-1.1, 1310 nm SMF	0 (Max) -5 (Min)	-10 (Max) -34 (Min)	1263 to 1360
SFP-OC3-LR2	OC3-LR2/STM1-L-1.2, 1550 nm SMF	0 (Max) -5 (Min)	-10 (Max) -34 (Min)	1480 to 1580
SFP-OC12-MM	OC12-SR0, 1310 nm MMF	-14 (Max) -20 (Min)	-6 (Max) -26 (Min)	1270 to 1380
SFP-OC12-SR	OC12-SR1/STM4-I-4, 1310 nm SMF	-8 (Max) -15 (Min)	-8 (Max) -23 (Min)	1261 to 1360

Table 7 SONET/SDH SFP Transceiver Module Optical Transmit and Receive Specifications (continued)

SFP Transceiver Module Model	Transceiver Type	Transmit Power (dBm)	Receive Power (dBm)	Transmit and Receive Wavelength (nm)
SFP-OC12-IR1	OC12-IR1/STM4-S-4.1, 1310 nm SMF	-8 (Max) -15 (Min)	-8 (Max) -28 (Min)	1293 to 1334
SFP-OC12-LR1	OC12-LR1/STM4-L-4.1, 1310 nm SMF	+2 (Max) -3 (Min)	-8 (Max) -28 (Min)	1280 to 1335
SFP-OC12-LR2	OC12-LR2/STM4-L-4.2, 1550 nm SMF	+2 (Max) -3 (Min)	-8 (Max) -28 (Min)	1480 to 1580
SFP-OC48-SR	OC48-SR/STM16-I-16, 1310 nm SMF	-3 (Max) -10 (Min)	-3 (Max) -18 (Min)	1266 to 1360
SFP-OC48-IR1	OC48-IR1/STM16-S-16.1, 1310 nm SMF	0 (Max) -5 (Min)	0 (Max) -18 (Min)	1260 to 1360
SFP-OC48-LR2	OC48-LR2/STM16-L-16.2, 1550 nm SMF	+3 (Max) -2 (Min)	-9 (Max) -28 (Min)	1500 to 1580

Table 8 CWDM SFP Transceiver Module Optical Parameters

Parameter	Minimum	Typical	Maximum	Units	Notes and Conditions
Transmitter Center Wavelength	(x-4)	—	(x + 7)	nm	Available center wavelengths are 1470, 1490, 1510, 1530, 1550, 1570, 1590, and 1610 nm
Side-Mode Suppression Ratio	30	—		dB	
Transmitter Optical Output Power	0	—	5.0	dBm	Average power coupled into single-mode fiber
Receiver Optical Input Power (BER <10 ⁻¹² with PRBS 2-7-1)	-28.0	—	-7.0	dBm	Measured at 2.12 Gbps, 140°F (60°C) case temperature
Receiver Optical Input Power (BER <10 ⁻¹² with PRBS 2-7-1)	-29.0	—	-7.0	dBm	Measured at 1.25 Gbps, 140°F (60°C) case temperature
Receiver Optical Input Wavelength	1450	—	1620	nm	
Transmitter Extinction Ratio	9	—		dB	
Dispersion Penalty at 100 km	—	—	3	dB	Measured at 2.12 Gbps
Dispersion Penalty at 100 km	—	—	2	dB	Measured at 1.25 Gbps

Table 9 DWDM SFP Transceiver Module Optical Parameters

Parameter	Minimum	Typical	Maximum	Units	Notes and Conditions
Transmitter					
Spectral Width	—	—	0.2	nm	Full width, -20dB from maximum, with resolution bandwidth (RBW) = 0.01 nm
Transmitter Center Wavelength	x - 100	x	x + 100	pm	See Table 1 for center wavelengths
Side-Mode Suppression Ratio	30	—	—	dB	—
Transmitter Extinction Ratio	8.2	—	—	dB	—
Transmitter Optical Output Power	0	—	4.0	dBm	Average power coupled into single-mode fiber
Receiver					
Receiver Optical Input Wavelength	1530	—	1565	nm	—
Receiver Damage Threshold	—	—	+5	dBm	—
Power-Limited Performance at OSNR of 20 dB (1 GbE or 1-Gbps FC) or 21 dB (2 Gbps FC) at 0.1-nm RBW					
Optical Input Power	-28.0	—	-9.0	dBm	—
Dispersion Power Penalty < 1 GbE and 1 Gbps FC	—	—	3	dB	-800/+3600 ps/nm
Dispersion Power Penalty > 2 Gbps FC	—	—	3	dB	-800/+2400 ps/nm
Noise-Limited Performance at OSNR of 19 dB 1 GbE or 1 Gbps FC) or 20 dB (2 Gbps FC) at 0.1-nm RBW					
Optical Input Power	-22.0	—	-9.0	dB	—
Dispersion OSNR Penalty < 1 GbE and 1 Gbps FC	—	—	2	dB	-800/+3600 ps/nm
Dispersion OSNR Penalty > 2 Gbps FC	—	—	3	—	-800/+2400 ps/nm

Table 10 10-Gigabit DWDM SFP+ Transceiver Module Optical Parameters

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes and Conditions
Transmitter						
Spectral width				0.2	nm	Full width, -20 dB from maximum, with resolution bandwidth (RBW)=0.01 nm
Transmitter center wavelength		x-100	x	x+100	Pm	See Table 1 for center wavelengths
Side-mode suppression ratio	SMSR	30			dB	
Transmitter extinction ratio		9			dB	
Transmitter optical output power	P _{out}	-1.0		3.0	dBm	Average power coupled into single-mode fiber

Table 10 10-Gigabit DWDM SFP+ Transceiver Module Optical Parameters

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes and Conditions
Receiver						
Receiver optical input wavelength		1530		1565	nm	
Receiver damage threshold		4.0			dBm	
Receiver overload		-7			dBm	

Table 11 10-Gigabit DWDM SFP+ Transceiver Module Receiver Power Performance

Specification	Range	Notes and Conditions
Performance at 10G LAN and 10G WAN rates (No FEC Applications)		
Input power range	-7 to -23 dBm	At BER=1E-12, back-to-back unamplified link
Input power range (dispersion-limited)	-7 to -20 dBm	At BER=1E-12, -500 to +1600 ps/nm chromatic dispersion, unamplified link
Input power range (dispersion-limited and noise-limited)	-7 to -17 dBm	At BER=1E-12, -500 to +1600 ps/nm chromatic dispersion, amplified link with minimum 27 dB OSNR (0.1 nm RBW)
Performance at OTU/OTU2e rates (FEC Applications)		
Input power range	-7 to -27 dBm	At BER=1E-3 (pre-EFEC), back-to-back, unamplified link
Input power range (dispersion-limited)	-7 to -24 dBm	At BER=1E-3 (pre-EFEC), -500 to +1300 ps/nm chromatic dispersion, unamplified link
Input power range (dispersion-limited and noise-limited)	-7 to -17 dBm	At BER=1E-3 (pre-EFEC) -500 to +1100 ps/nm chromatic dispersion, amplified link with minimum 16 dB OSNR (0.1 nm RBW)
Input power range (dispersion-limited and noise-limited)	-7 to -17 dBm	At BER=1E-5 (pre-GFEC), -500 to +1100 ps/nm chromatic dispersion, amplified link with minimum 19 dB OSNR (0.1 nm RBW)

**Note**

Up to 1600 ps/nm chromatic dispersion is supported for fiber links between two Cisco DWDM SFP+ transceiver modules. For connections between a Cisco DWDM SFP+ transceiver module and a Cisco DWDM XENPAK, X2, or XFP transceiver module, limit the chromatic dispersion to 1300 ps/nm.

Safety

Safety warnings appear throughout this publication in procedures that may harm you if performed incorrectly or are ignored. A warning symbol precedes each warning statement.

Statement 1071—Warning Definition



Warning

IMPORTANT SAFETY INSTRUCTIONS

This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device.

SAVE THESE INSTRUCTIONS

Waarschuwing

BELANGRIJKE VEILIGHEIDSINSTRUCTIES

Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van de standaard praktijken om ongelukken te voorkomen. Gebruik het nummer van de verklaring onderaan de waarschuwing als u een vertaling van de waarschuwing die bij het apparaat wordt geleverd, wilt raadplegen.

BEWAAR DEZE INSTRUCTIES

Varoitus

TÄRKEITÄ TURVALLISUUSOHJEITA

Tämä varoitusmerkki merkitsee vaaraa. Tilanne voi aiheuttaa ruumiillisia vammoja. Ennen kuin käsittelit laitteistoa, huomioi sähköpiirien käsittelyyn liittyvät riskit ja tutustu onnettomuuksien yleisiin ehkäisytapoihin. Turvallisuusvaroitusten käännökset löytyvät laitteen mukana toimitettujen käännettyjen turvallisuusvaroitusten joukosta varoitusten lopussa näkyvien lausuntonumeroiden avulla.

SÄILYTÄ NÄMÄ OHJEET

Attention

IMPORTANTES INFORMATIONS DE SÉCURITÉ

Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures ou des dommages corporels. Avant de travailler sur un équipement, soyez conscient des dangers liés aux circuits électriques et familiarisez-vous avec les procédures couramment utilisées pour éviter les accidents. Pour prendre connaissance des traductions des avertissements figurant dans les consignes de sécurité traduites qui accompagnent cet appareil, référez-vous au numéro de l'instruction situé à la fin de chaque avertissement.

CONSERVEZ CES INFORMATIONS

Warnung WICHTIGE SICHERHEITSHINWEISE

Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu Verletzungen führen kann. Machen Sie sich vor der Arbeit mit Geräten mit den Gefahren elektrischer Schaltungen und den üblichen Verfahren zur Vorbeugung vor Unfällen vertraut. Suchen Sie mit der am Ende jeder Warnung angegebenen Anweisungsnummer nach der jeweiligen Übersetzung in den übersetzten Sicherheitshinweisen, die zusammen mit diesem Gerät ausgeliefert wurden.

BEWAHREN SIE DIESE HINWEISE GUT AUF.

Avvertenza IMPORTANTI ISTRUZIONI SULLA SICUREZZA

Questo simbolo di avvertenza indica un pericolo. La situazione potrebbe causare infortuni alle persone. Prima di intervenire su qualsiasi apparecchiatura, occorre essere al corrente dei pericoli relativi ai circuiti elettrici e conoscere le procedure standard per la prevenzione di incidenti. Utilizzare il numero di istruzione presente alla fine di ciascuna avvertenza per individuare le traduzioni delle avvertenze riportate in questo documento.

CONSERVARE QUESTE ISTRUZIONI

Advarsel VIKTIGE SIKKERHETSINSTRUKSJONER

Dette advarselssymbolet betyr fare. Du er i en situasjon som kan føre til skade på person. Før du begynner å arbeide med noe av utstyret, må du være oppmerksom på farene forbundet med elektriske kretser, og kjenne til standardprosedyrer for å forhindre ulykker. Bruk nummeret i slutten av hver advarsel for å finne oversettelsen i de oversatte sikkerhetsadvarslene som fulgte med denne enheten.

TA VARE PÅ DISSE INSTRUKSJONENE

Aviso INSTRUÇÕES IMPORTANTES DE SEGURANÇA

Este símbolo de aviso significa perigo. Você está em uma situação que poderá ser causadora de lesões corporais. Antes de iniciar a utilização de qualquer equipamento, tenha conhecimento dos perigos envolvidos no manuseio de circuitos elétricos e familiarize-se com as práticas habituais de prevenção de acidentes. Utilize o número da instrução fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham este dispositivo.

GUARDE ESTAS INSTRUÇÕES

¡Advertencia! INSTRUCCIONES IMPORTANTES DE SEGURIDAD

Este símbolo de aviso indica peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considere los riesgos de la corriente eléctrica y familiarícese con los procedimientos estándar de prevención de accidentes. Al final de cada advertencia encontrará el número que le ayudará a encontrar el texto traducido en el apartado de traducciones que acompaña a este dispositivo.

GUARDE ESTAS INSTRUCCIONES

Varning! VIKTIGA SÄKERHETSANVISNINGAR

Denna varningssignal signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanliga förfaranden för att förebygga olyckor. Använd det nummer som finns i slutet av varje varning för att hitta dess översättning i de översatta säkerhetsvarningar som medföljer denna anordning.

SPARA DESSA ANVISNINGAR**Figyelem FONTOS BIZTONSÁGI ELOÍRÁSOK**

Ez a figyelmeztető jel veszélyre utal. Sérülésveszélyt rejtő helyzetben van. Mielőtt bármely berendezésen munkát végezte, legyen figyelemmel az elektromos áramkörök okozta kockázatokra, és ismerkedjen meg a szokásos balesetvédelmi eljárásokkal. A kiadványban szereplő figyelmeztetések fordítása a készülékhez mellékelt biztonsági figyelmeztetések között található; a fordítás az egyes figyelmeztetések végén látható szám alapján kereshető meg.

ORIZZE MEG EZEKET AZ UTASÍTÁSOKAT!**Предупреждение ВАЖНЫЕ ИНСТРУКЦИИ ПО СОБЛЮДЕНИЮ ТЕХНИКИ БЕЗОПАСНОСТИ**

Этот символ предупреждения обозначает опасность. То есть имеет место ситуация, в которой следует опасаться телесных повреждений. Перед эксплуатацией оборудования выясните, каким опасностям может подвергаться пользователь при использовании электрических цепей, и ознакомьтесь с правилами техники безопасности для предотвращения возможных несчастных случаев. Воспользуйтесь номером заявления, приведенным в конце каждого предупреждения, чтобы найти его переведенный вариант в переводе предупреждений по безопасности, прилагаемом к данному устройству.

СОХРАНИТЕ ЭТИ ИНСТРУКЦИИ**警告 重要的安全性说明**

此警告符号代表危险。您正处于可能受到严重伤害的工作环境中。在您使用设备开始工作之前，必须充分意识到触电的危险，并熟练掌握防止事故发生的标准工作程序。请根据每项警告结尾提供的声明号码来找到此设备的安全性警告说明的翻译文本。

请保存这些安全性说明

警告 安全上の重要な注意事項

「危険」の意味です。人身事故を予防するための注意事項が記述されています。装置の取り扱い作業を行うときは、電気回路の危険性に注意し、一般的な事故防止策に留意してください。警告の各国語版は、各注意事項の番号を基に、装置に付属の「Translated Safety Warnings」を参照してください。

これらの注意事項を保管しておいてください。

주의 **중요 안전 지침**

이 경고 기호는 위험을 나타냅니다. 작업자가 신체 부상을 일으킬 수 있는 위험한 환경에 있습니다. 장비에 작업을 수행하기 전에 전기 회로와 관련된 위험을 숙지하고 표준 작업 관례를 숙지하여 사고를 방지하십시오. 각 경고의 마지막 부분에 있는 경고문 번호를 참조하여 이 장치와 함께 제공되는 번역된 안전 경고문에서 해당 번역문을 찾으십시오.

이 지시 사항을 보관하십시오.

Aviso **INSTRUÇÕES IMPORTANTES DE SEGURANÇA**

Este símbolo de aviso significa perigo. Você se encontra em uma situação em que há risco de lesões corporais. Antes de trabalhar com qualquer equipamento, esteja ciente dos riscos que envolvem os circuitos elétricos e familiarize-se com as práticas padrão de prevenção de acidentes. Use o número da declaração fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham o dispositivo.

GUARDE ESTAS INSTRUÇÕES**Advarsel** **VIGTIGE SIKKERHEDSANVISNINGER**

Dette advarselssymbol betyder fare. Du befinder dig i en situation med risiko for legemeskadedigelse. Før du begynder arbejde på udstyr, skal du være opmærksom på de involverede risici, der er ved elektriske kredsløb, og du skal sætte dig ind i standardprocedurer til undgåelse af ulykker. Brug erklæringsnummeret efter hver advarsel for at finde oversættelsen i de oversatte advarsler, der fulgte med denne enhed.

GEM DISSE ANVISNINGER**تحذير****إرشادات الأمان الهامة**

يوضح رمز التحذير هذا وجود خطر. وهذا يعني أنك متواجد في مكان قد ينتج عنه التعرض لإصابات. قبل بدء العمل، احذر مخاطر التعرض للصدمة الكهربائية وكن على علم بالإجراءات القياسية للحيلولة دون وقوع أي حوادث. استخدم رقم البيان الموجود في آخر كل تحذير لتحديد مكان ترجمته داخل تحذيرات الأمان المترجمة التي تأتي مع الجهاز. قم بحفظ هذه الإرشادات

Upozorenje **VAŽNE SIGURNOSNE NAPOMENE**

Ovaj simbol upozorenja predstavlja opasnost. Nalazite se u situaciji koja može prouzročiti tjelesne ozljede. Prije rada s bilo kojim uređajem, morate razumjeti opasnosti vezane uz električne sklopove, te biti upoznati sa standardnim načinima izbjegavanja nesreća. U prevedenim sigurnosnim upozorenjima, priloženima uz uređaj, možete prema broju koji se nalazi uz pojedino upozorenje pronaći i njegov prijevod.

SAČUVAJTE OVE UPUTE

Upozornění DŮLEŽITÉ BEZPEČNOSTNÍ POKYNY

Tento upozorňující symbol označuje nebezpečí. Jste v situaci, která by mohla způsobit nebezpečí úrazu. Před prací na jakémkoliv vybavení si uvědomte nebezpečí související s elektrickými obvody a seznamte se se standardními opatřeními pro předcházení úrazům. Podle čísla na konci každého upozornění vyhledejte jeho překlad v přeložených bezpečnostních upozorněních, která jsou přiložena k zařízení.

USCHOVEJTE TYTO POKYNY**Προειδοποίηση ΣΗΜΑΝΤΙΚΕΣ ΟΔΗΓΙΕΣ ΑΣΦΑΛΕΙΑΣ**

Αυτό το προειδοποιητικό σύμβολο σημαίνει κίνδυνο. Βρίσκεστε σε κατάσταση που μπορεί να προκαλέσει τραυματισμό. Πριν εργαστείτε σε οποιοδήποτε εξοπλισμό, να έχετε υπόψη σας τους κινδύνους που σχετίζονται με τα ηλεκτρικά κυκλώματα και να έχετε εξοικειωθεί με τις συνηθισμένες πρακτικές για την αποφυγή ατυχημάτων. Χρησιμοποιήστε τον αριθμό δήλωσης που παρέχεται στο τέλος κάθε προειδοποίησης, για να εντοπίσετε τη μετάφρασή της στις μεταφρασμένες προειδοποιήσεις ασφαλείας που συνοδεύουν τη συσκευή.

ΦΥΛΑΞΤΕ ΑΥΤΕΣ ΤΙΣ ΟΔΗΓΙΕΣ**אזהרה****הוראות בטיחות חשובות**

סימן אזהרה זה מסמל סכנה. אתה נמצא במצב העלול לגרום לפציעה. לפני שתעבוד עם ציוד כלשהו, עליך להיות מודע לסכנות הכרוכות במגעלים חשמליים ולהכיר את הנהלים המקובלים למניעת תאונות. השתמש במספר ההוראה המסופק בסופה של כל אזהרה כדי לאתר את התרגום באזהרות הבטיחות המתורגמות שמצורפות להתקן.

שמור הוראות אלה**Opomena ВАЖНИ БЕЗБЕДНОСНИ НАПАТСТВИЈА**

Симболот за предупредување значи опасност. Се наоѓате во ситуација што може да предизвика телесни повреди. Пред да работите со опремата, бидете свесни за ризикот што постои кај електричните кола и треба да ги познавате стандардните постапки за спречување на несреќни случаи. Искористете го бројот на изјавата што се наоѓа на крајот на секое предупредување за да го најдете неговиот период во преведените безбедносни предупредувања што се испорачани со уредот.

ЧУВАЈТЕ ГИ ОБИЕ НАПАТСТВИЈА

Ostrzeżenie WAŻNE INSTRUKCJE DOTYCZĄCE BEZPIECZEŃSTWA

Ten symbol ostrzeżenia oznacza niebezpieczeństwo. Zachodzi sytuacja, która może powodować obrażenia ciała. Przed przystąpieniem do prac przy urządzeniach należy zapoznać się z zagrożeniami związanymi z układami elektrycznymi oraz ze standardowymi środkami zapobiegania wypadkom. Na końcu każdego ostrzeżenia podano numer, na podstawie którego można odszukać tłumaczenie tego ostrzeżenia w dołączonym do urządzenia dokumencie z tłumaczeniami ostrzeżeń.

NINIEJSZE INSTRUKCJE NALEŻY ZACHOWAĆ**Upozornenie DÔLEŽITÉ BEZPEČNOSTNÉ POKYNY**

Tento varovný symbol označuje nebezpečenstvo. Nachádzate sa v situácii s nebezpečenstvom úrazu. Pred prácou na akomkoľvek vybavení si uvedomte nebezpečenstvo súvisiace s elektrickými obvodmi a oboznámte sa so štandardnými opatreniami na predchádzanie úrazom. Podľa čísla na konci každého upozornenia vyhľadajte jeho preklad v preložených bezpečnostných upozorneniach, ktoré sú priložené k zariadeniu.

USCHOVAJTE SI TENTO NÁVOD**Warning****Class 1 laser product.** Statement 1008**Warning****Laser radiation is present when the system is open and interlocks bypassed.** Statement 1014**Warning****Only trained and qualified personnel should be allowed to install, replace, or service this equipment.** Statement 1030

Required Tools

You will need these tools to install the SFP transceiver module:

- Wrist strap or other personal grounding device to prevent ESD occurrences.
- Antistatic mat or antistatic foam to set the transceiver on.
- Fiber-optic end-face cleaning tools and inspection equipment. For complete information on inspecting and cleaning fiber-optic connections, see the white-paper document at this URL:

http://www.cisco.com/en/US/tech/tk482/tk876/technologies_white_paper09186a0080254eba.shtml

Installing SFP and SFP+ Transceiver Modules

SFP transceiver modules can have three types of latching devices to secure an SFP transceiver module in a port socket:

- [Figure 4](#) shows an SFP transceiver module with a Mylar tab latch.
- [Figure 5](#) shows an SFP transceiver module with an actuator button latch.
- [Figure 6](#) shows an SFP transceiver module that has a bail clasp latch.
- [Figure 7](#) shows an SFP+ transceiver module that has a bail clasp latch.

Determine which type of latch your SFP transceiver module uses before following the installation and removal procedures.



Caution

Do not install or remove the SFP transceiver module with fiber-optic cables still attached to it. Doing so may damage cables, cable connectors, or the optical interfaces and may interfere with the SFP transceiver module latching properly into its socket connector. Disconnect all cables before removing or installing an SFP transceiver module.

Removing and installing an SFP transceiver module can shorten its useful life. Do not remove and insert SFP transceiver modules more often than is absolutely necessary.



Caution

The SFP transceiver modules are static sensitive devices. Always use an ESD wrist strap or similar individual grounding device when handling SFP transceiver modules or coming in contact with modules.

Figure 4 *SFP Transceiver Module with a Mylar Tab Latch*

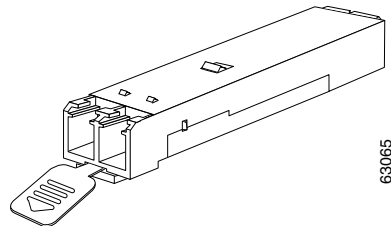


Figure 5 *SFP Transceiver Module with an Actuator Button Latch*

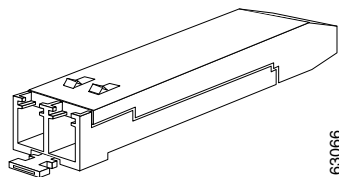


Figure 6 SFP Module with a Bail Clasp Latch

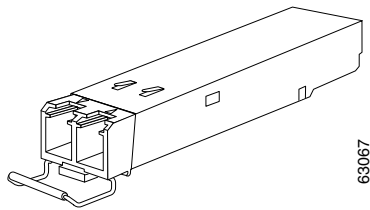
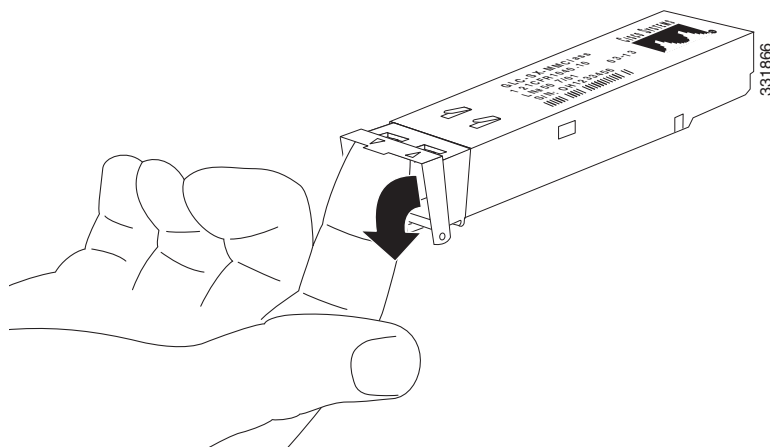


Figure 7 SFP+ Module with a Bail Clasp Latch



To install an SFP transceiver module, follow these steps:

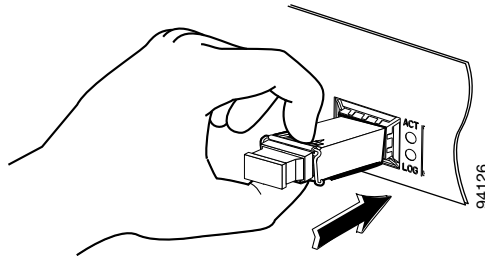
-
- Step 1** Attach an ESD-preventive wrist strap to your wrist and to the ESD ground connector or a bare metal surface on your chassis.
 - Step 2** Remove the SFP transceiver module from its protective packaging.
-
- Note** Do not remove the optical bore dust plugs until directed to do so later in the procedure.
-
- Step 3** Check the label on the SFP transceiver module body to verify that you have the correct model for your network.
 - Step 4** Find the send (TX) and receive (RX) markings that identify the top side of the SFP transceiver module.
-
- Note** On some SFP transceiver modules, the TX and RX marking might be replaced by arrowheads pointing from the SFP transceiver module connector (transmit direction or TX) and toward the connector (receive direction or RX).
-
- Step 5** Position the SFP transceiver module in front of the socket opening.



Note Different Cisco devices have different SFP module socket configurations. Your Cisco device could have either a latch-up or a latch-down orientation. Ensure that you are installing the SFP transceiver module in the correct orientation for your Cisco device. For more details, see the hardware installation instructions that came with your Cisco device.

- Step 6** Holding it as shown in [Figure 8](#), insert the SFP into the socket until you feel the connector latch into place.

Figure 8 *Inserting an SFP Transceiver Module into a Module Socket*

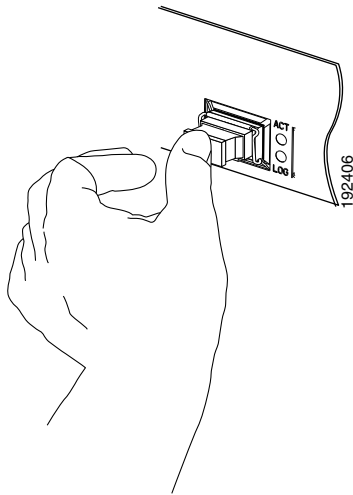


Step 7 Press the SFP into the slot firmly with your thumb as shown in [Figure 9](#).



Note For SFP transceiver modules equipped with an actuator latch, you must press firmly on both the transceiver faceplate and the actuator button to ensure that the transceiver is properly latched in the socket.

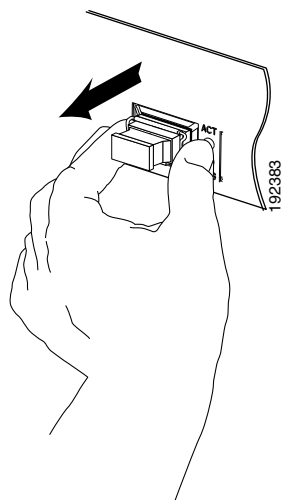
Figure 9 Latching the SFP



Step 8 To verify that the SFP is seated and latched properly:

- a. Grasp the SFP as shown in [Figure 10](#) and try to remove it without releasing the latch.
- b. If the SFP can not be removed, it is installed and seated properly. If the SFP can be removed, reinsert it and press harder with your thumb, repeating if necessary until it is latched securely into the socket.

Figure 10 Verifying SFP Installation



**Note**

For optical SFP transceiver modules, before removing the dust plugs and making any optical connections, observe the following guidelines:

- Always keep the protective dust plugs on the unplugged fiber-optic cable connectors and the transceiver optical bores until you are ready to make a connection.
- Always inspect and clean the LC connector end-faces just before making any connections. See the Tip on this page for a pointer to a fiber-optic inspection and cleaning white paper.
- Always grasp the LC connector housing to plug or unplug a fiber-optic cable.

Step 9 Remove the dust plugs from the network interface cable LC connectors. Save the dust plugs for future use.

Step 10 Inspect and clean the LC connector's fiber-optic end-faces. See the following Tip for a pointer to a fiber-optic inspection and cleaning white paper.

**Tip**

For complete information on inspecting and cleaning fiber-optic connections, see the white-paper document at this URL:

http://www.cisco.com/en/US/tech/tk482/tk876/technologies_white_paper09186a0080254eba.shtml

Step 11 Remove the dust plugs from the SFP transceiver module optical bores.

Step 12 Immediately attach the network interface cable LC connector to the SFP transceiver module.

Step 13 To connect 1000BASE-T SFP transceiver modules to a copper network, follow these substeps:

**Caution**

To comply with GR-1089 intrabuilding lightning immunity requirements, you must use grounded, shielded, twisted-pair Category 5 cabling.

- Insert the Category 5 network cable RJ-45 connector into the SFP transceiver module RJ-45 connector.

**Note**

When connecting to a 1000BASE-T-compatible server, workstation, or router, use four twisted-pair, straight-through Category 5 cabling for the SFP transceiver module port. When connecting to a 1000BASE-T-compatible switch or repeater, use four twisted-pair, crossover Category 5 cabling.

- Insert the other end of the network cable into an RJ-45 connector on a 1000BASE-T-compatible target device.

Step 14 Observe the port status LED:

- The LED turns green when the SFP transceiver module and the target device have an established link.
- The LED turns amber while the STP feature discovers the network topology and searches for loops. This process takes about 30 seconds, and then the LED turns green.
- If the LED is off, the target device might not be turned on, there might be a cable problem, or there might be a problem with the adapter installed in the target device. See the Troubleshooting section of your switch hardware guide for solutions to cabling problems.

Step 15 Reconfigure and reboot the target device if necessary.

Removing SFP and SFP+ Transceiver Modules



Caution

The SFP and SFP+ transceiver modules are static sensitive devices. Always use an ESD wrist strap or similar individual grounding device when handling the transceiver modules or coming in contact with modules.



Caution

Be careful when removing GLC-GE-100FX SFPs from a WS-C3750G-12S-S switch. The SFP transceiver module temperature might go over 160°F (70°C) and be too hot to touch with bare hands.

If you are removing an SFP or SFP+ transceiver module, follow these steps:

Step 1 Attach an ESD-preventive wrist strap to your wrist and to the ESD ground connector or a bare metal surface on your chassis.

Step 2 Disconnect the network fiber-optic cable or network copper cable from the transceiver module connector. For optical transceiver modules, immediately reinstall the dust plugs in the transceiver module's optical bores and the fiber-optic cable LC connectors.



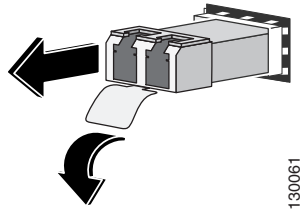
Tip

For reattachment of fiber-optic cables, note which connector plug is send (TX) and which is receive (RX).

Step 3 Release and remove the transceiver module from the socket connector, as shown in [Figure 11](#), [Figure 12](#), [Figure 13](#), or

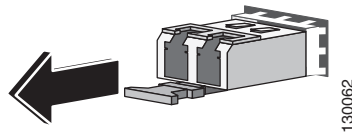
- If the SFP transceiver module has a Mylar tab latch, pull the tab gently in a slightly downward direction until the transceiver disengages from the socket connector, and then pull the SFP transceiver module straight out. Do not twist or pull the Mylar tab because you could detach it from the SFP transceiver module.

Figure 11 *Removing an SFP Transceiver Module Equipped with a Mylar Tab*



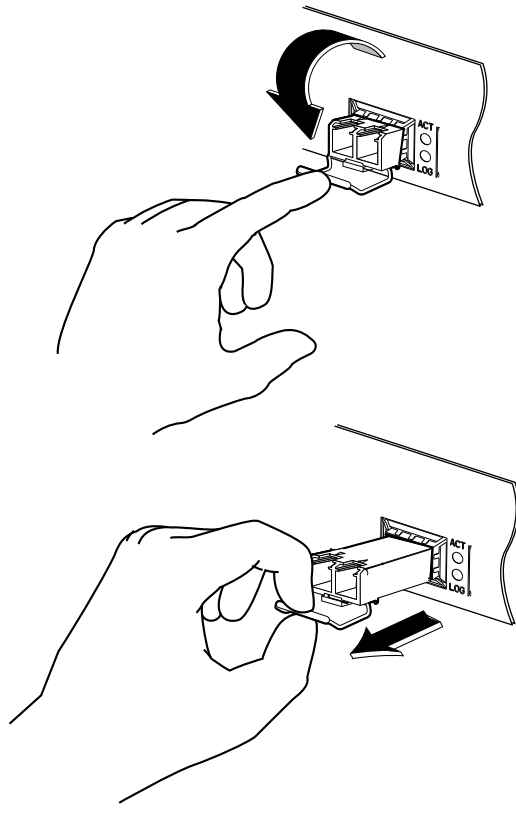
- If the SFP transceiver module has an actuator button latch, gently press the actuator button on the front of the SFP transceiver module until it clicks and the latch mechanism releases the SFP transceiver module from the socket connector. Grasp the actuator button between your thumb and index finger, and carefully pull the SFP transceiver module straight from the module slot.

Figure 12 *Removing an SFP Transceiver Module Equipped with an Actuator Button Latch*



- If the SFP transceiver module has a bail clasp latch, pull the latch out and down to eject the SFP transceiver module from the socket connector. If the bail clasp latch is obstructed and you cannot use your index finger to open it, use a small, flat-blade screwdriver or other long, narrow instrument to open the bail clasp latch. Grasp the SFP transceiver module between your thumb and index finger, and carefully remove it from the socket.

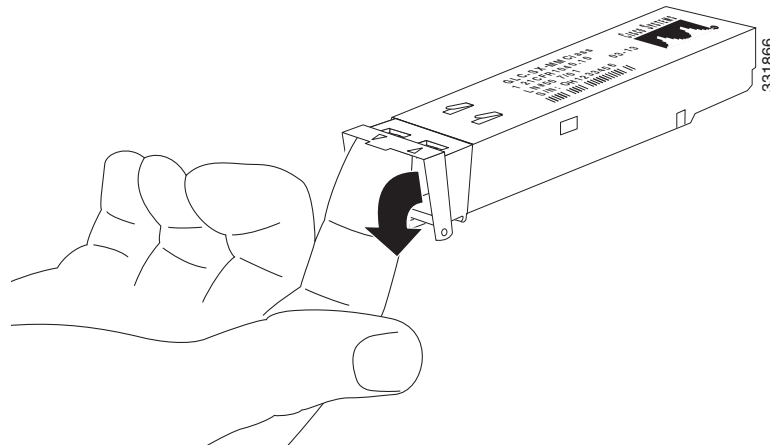
Figure 13 *Removing an SFP Transceiver Module Equipped with a Bail Clasp Latch*



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- The SFP+ transceiver uses a bail clasp style latch which is slightly different than the bail clasp latch for the SFP transceiver. The SFP+ transceiver bail clasp has a small tab protruding down from the bail clasp handle. To release the SFP+ bail clasp, push the small tab up and outwards with your index finger to release the bail clasp. Grasp the SFP+ transceiver between your thumb and index finger and carefully remove the transceiver from the socket.

Figure 14 Removing an SFP+ Transceiver Equipped with a Bail Clasp Latch with Tab



Step 4 Place the removed transceiver module in an antistatic bag or other protective environment.

Standards and Compliance Specifications for SFP and SFP+ Optical Transceivers

This section provides compliance information for the SFP and SFP+ optical transceivers.

FCC Class A Compliance

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case users will be required to correct the interference at their own expense.

You can determine whether your equipment is causing interference by turning it off. If the interference stops, it was probably caused by the Cisco equipment or one of its peripheral devices. If the equipment causes interference to radio or television reception, try to correct the interference by using one or more of the following measures:

- Turn the television or radio antenna until the interference stops.
- Move the equipment to one side or the other of the television or radio.
- Move the equipment farther away from the television or radio.
- Plug the equipment into an outlet that is on a different circuit from the television or radio. (That is, make certain the equipment and the television or radio are on circuits controlled by different circuit breakers or fuses.)

Modifications to this product not authorized by Cisco Systems could void the FCC approval and negate your authority to operate the product.

Class 1 Laser Compliance

This product has been tested and found to comply with the limits for Class 1 laser for IEC60825, EN60825, and 21CFR1040 specifications.

Translated Safety Warnings

This section repeats in multiple languages the basic warnings that appear in this document.

Statement 1008—Class 1 Laser Product



Warning

Class 1 laser product.

Waarschuwing

Klasse-1 laser produkt.

Varoitus

Luokan 1 lasertuote.

Attention

Produit laser de classe 1.

Warnung

Laserprodukt der Klasse 1.

Avvertenza

Prodotto laser di Classe 1.

Advarsel

Laserprodukt av klasse 1.

Aviso

Producto laser de classe 1.

¡Advertencia!

Producto láser Clase I.

Varning!

Laserprodukt av klass 1.

Figyelem

Class 1 besorolású lézeres termék.

Предупреждение

Лазерное устройство класса 1.

警告

这是 1 类激光产品。

警告

クラス1レーザー製品です。

주의	클래스 1 레이저 제품.
Aviso	Produto a laser de classe 1.
Advarsel	Klasse 1 laserprodukt.
تحذير	Class 1 Laser منتج ١
Upozorenje	Laserski proizvod klase 1
Upozornění	Laserový výrobek třídy 1.
Προειδοποίηση	Προϊόν λέιζερ κατηγορίας 1.
אזהרה	מוצר לייזר Class 1.
Opomena	Ласерски производ од класа 1.
Ostrzeżenie	Produkt laserowy klasy 1.
Upozornenie	Laserový výrobok triedy 1.
Opozorilo	Laserski izdelek 1. razreda.

Statement 1014—Laser Radiation



Warning

Laser radiation is present when the system is open and interlocks bypassed.

Waarschuwing

Laserstraling is aanwezig wanneer het systeem open is en onderlinge vergrendelingen ongedaan zijn gemaakt.

Varoitus

Lasersäteitä järjestelmän ollessa avoinna ja suojauslaitteiden ohitettuna.

Attention

Production d'un rayonnement laser en position ouverte avec les verrouillages désactivés.

Warnung

Laserstrahlung in geöffnetem Zustand oder bei deaktivierter Verriegelung.

Avvertenza

Emissione di radiazioni laser quando il sistema è aperto e i dispositivi di blocco sono disattivati.

Advarsel	Laserstråling er til stede når enheten er åpen og låsemekanismene er omgått.
Aviso	Radiação presente quando o sistema estiver aberto e os bloqueios estiverem desviados.
¡Advertencia!	Radiación láser presente si el sistema está abierto y con los enclavamientos desirados.
Varning!	Laserstrålning pågår när enheten är öppen och förregleringen är förbikopplad.
Figyelem	A rendszer burkolatának eltávolítása és a védőkapcsolók kiiktatása esetén lézersugárzás van jelen.
Предупреждение	Открытое устройство с неподключенными соединителями испускает лазерное излучение.
警告	打开系统和互锁旁路都会发生激光辐射。
警告	システムを開きインターロックを外した状態では、レーザーが放射されています。

Statement 1030—Equipment Installation



Warning	Only trained and qualified personnel should be allowed to install, replace, or service this equipment.
Waarschuwing	Deze apparatuur mag alleen worden geïnstalleerd, vervangen of hersteld door bevoegd geschoold personeel.
Varoitus	Tämän laitteen saa asentaa, vaihtaa tai huoltaa ainoastaan koulutettu ja laitteen tunteva henkilökunta.
Attention	Il est vivement recommandé de confier l'installation, le remplacement et la maintenance de ces équipements à des personnels qualifiés et expérimentés.
Warnung	Das Installieren, Ersetzen oder Bedienen dieser Ausrüstung sollte nur geschultem, qualifiziertem Personal gestattet werden.
Avvertenza	Questo apparato può essere installato, sostituito o mantenuto unicamente da un personale competente.
Advarsel	Bare opplært og kvalifisert personell skal foreta installasjoner, utskiftninger eller service på dette utstyret.
Aviso	Apenas pessoal treinado e qualificado deve ser autorizado a instalar, substituir ou fazer a revisão deste equipamento.

¡Advertencia!	Solamente el personal calificado debe instalar, reemplazar o utilizar este equipo.
Varning!	Endast utbildad och kvalificerad personal bör få tillåtelse att installera, byta ut eller reparera denna utrustning.
Figyelem	A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.
Предупреждение	Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.
警告	只有经过培训且具有资格的人员才能进行此设备的安装、更换和维修。
警告	この装置の設置、交換、保守は、訓練を受けた相応の資格のある人が行ってください。
주의	교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.
Aviso	Somente uma equipe treinada e qualificada tem permissão para instalar, substituir ou dar manutenção a este equipamento.
Advarsel	Kun uddannede personer må installere, udskifte komponenter i eller servicere dette udstyr.
تحذير	يسمح للمنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.
Upozorenje	Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.
Upozornění	Instalaci, výměnu nebo opravu tohoto zařízení směji provádět pouze proškolené a kvalifikované osoby.
Προειδοποίηση	Η τοποθέτηση, η αντικατάσταση και η συντήρηση του εξοπλισμού επιτρέπεται να γίνονται μόνο από καταρτισμένο προσωπικό με τα κατάλληλα προσόντα.
אזהרה	רק עובדים מיומנים ומוסמכים רשאים להתקין, להחליף, או לטפל בצידוד זה.
	Местењето, заменувањето и сервисирањето на оваа опрема треба да му биде дозволено само на обучен и квалификуван персонал.
Ostrzeżenie	Do instalacji, wymiany i serwisowania tych urządzeń mogą być dopuszczone wyłącznie osoby wykwalifikowane i przeszkolone.
Upozornenie	Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.

Opozorilo Opremo lahko priključi, zamenja ali popravi le za to usposobljeno osebje.

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Cisco IE 2000 Switch Hardware Installation Guide

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Preface

Audience

This guide is for the network or computer technician responsible for installing Cisco IE 2000 series switches. We assume that you are familiar with the concepts and terminology of Ethernet and local area networks.

Purpose

This guide documents the hardware features of the Cisco IE 2000 switches. It describes the physical and performance characteristics of each switch, explains how to install a switch, and provides troubleshooting information.

This guide does not describe system messages that you might receive or how to configure your switch. For more information, see the Cisco IE2000 documentation at

http://www.cisco.com/en/US/products/ps12451/tsd_products_support_series_home.html

For information about the standard Cisco IOS commands, see

<http://www.cisco.com/cisco/web/psa/configure.html?mode=prod&level0=268438303>

Conventions

This document uses the following conventions.

Conventions	Indication
bold font	Commands and keywords and user-entered text appear in bold font .
<i>italic font</i>	Document titles, new or emphasized terms, and arguments for which you supply values are in <i>italic font</i> .
[]	Elements in square brackets are optional.
{x y z }	Required alternative keywords are grouped in braces and separated by vertical bars.
[x y z]	Optional alternative keywords are grouped in brackets and separated by vertical bars.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.
courier font	Terminal sessions and information the system displays appear in courier font.
< >	Nonprinting characters such as passwords are in angle brackets.
[]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

Note: Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the manual.

Caution: Means *reader be careful*. In this situation, you might perform an action that could result in equipment damage or loss of data.

Warning: IMPORTANT SAFETY INSTRUCTIONS

Means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device.

SAVE THESE INSTRUCTIONS

Regulatory: Provided for additional information and to comply with regulatory and customer requirements.

The safety warnings for this product are translated into several languages in the *Regulatory Compliance and Safety Information for the Cisco IE 2000 Switch* that ships with the product. The EMC regulatory statements are also included in that guide.

Related Publications

Before installing, configuring, or upgrading the switch, see the release notes on Cisco.com for the latest information.

These documents provide complete information about the switch and are available on Cisco.com:

- *Cisco IE 2000 Switch Getting Started Guide*
- *Regulatory Compliance and Safety Information for the Cisco IE 2000 Switch*
- *Release Notes for the Cisco IE 2000 Switch*
- *Cisco IE 2000 Switch Software Configuration Guide*
- *Cisco IE 2000 Switch Command Reference*
- *Cisco IE 2000 Switch System Message Guide*
- Device Manager online help (available on the switch)
- *Cisco Small Form-Factor Pluggable Modules Installation Notes*

These compatibility matrix documents are available from this Cisco.com site:

http://www.cisco.com/en/US/products/hw/modules/ps5455/products_device_support_tables_list.html

- *Cisco Gigabit Ethernet Transceiver Modules Compatibility Matrix* (not orderable but available on Cisco.com)
- *Cisco Small Form-Factor Pluggable Modules Compatibility Matrix* (not orderable but available on Cisco.com)

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Product Overview

This chapter discusses the following topics:

- [Switch Models, page 8](#)
- [Front Panel Overview, page 10](#)
- [Ports and Slots, page 14](#)
- [Power Connectors, page 17](#)
- [Alarm Connector, page 18](#)
- [SFP Modules, page 19](#)
- [LEDs, page 20](#)
- [Flash Memory Card, page 25](#)
- [Rear Panel, page 25](#)
- [Management Options, page 26](#)
- [Network Configurations, page 27](#)

Overview

This switch provides a rugged and secure switching infrastructure for harsh environments. It is suitable for industrial Ethernet applications, including factory automation, intelligent transportation systems (ITSs), substations, oil and gas installations, and other deployments in harsh environments.

You can connect this switch to office networking devices such as Cisco IP phones, Cisco Wireless Access Points workstations, and other devices such as servers, routers, and other switches. In industrial environments, you can connect any Ethernet-enabled industrial communication devices, including programmable logic controllers (PLCs), human-machine interfaces (HMIs), drives, sensors, video devices, traffic signal controllers, and intelligent electronic devices (IEDs).

You can mount the switch on a DIN rail in an industrial enclosure. Its components are designed to withstand extremes in temperature, vibration, and shock common to industrial environments.

Switch Models

Table 1 on page 8 describes the switch models.

Table 1 Switch Descriptions

Model	Description	Software Image
Cisco IE-2000-4S-TS-G-B	4 10/100BASE-TX SFP module downlink slots 2 Gigabit Ethernet SFP uplink slots	LAN Base
Cisco IE-2000-4S-TS-G-L	4 10/100BASE-TX SFP module downlink slots 2 Gigabit Ethernet SFP uplink slots	LAN Lite
Cisco IE-2000-4T-B	4 10/100BASE-T downlink ports 2 10/100BASE-T uplink ports	LAN Base
Cisco IE-2000-4T-G-B	4 10/100BASE-T downlink ports 2 10/100/1000BASE-T uplink ports	LAN Base
Cisco IE-2000-4T-G-L	4 10/100BASE-T downlink ports 2 10/100/1000BASE-T uplink ports	LAN Lite
Cisco IE-2000-4T-L	4 10/100BASE-T downlink ports 2 10/100BASE-T uplink ports	LAN Lite
Cisco IE-2000-4TS-B	4 10/100BASE-T Ethernet ports 2 100 Mb/s SFP module uplink slots	LAN Base
Cisco IE-2000-4TS-G-B	4 10/100BASE-T downlink ports 2 100/1000 Mb/s SFP module uplink slots	LAN Base
Cisco IE-2000-4TS-G-L	4 10/100BASE-T downlink ports 2 100/1000 Mb/s SFP module uplink slots	LAN Lite
Cisco IE-2000-4TS-L	4 10/100BASE-T downlink ports 2 100 Mb/s SFP (small form-factor pluggable) module uplink slots	LAN Lite
Cisco IE-2000-8TC-B	8 10/100BASE-T downlink ports 2 Fast Ethernet dual-purpose uplink ports	LAN Base
Cisco IE-2000-8TC-L	8 10/100BASE-T downlink ports 2 Fast Ethernet dual-purpose uplink ports	LAN Lite
Cisco IE-2000-8TC-G-B	8 10/100BASE-T downlink ports 2 Gigabit Ethernet dual-purpose uplink ports	LAN Base
Cisco IE-2000-8TC-G-E	8 10/100BASE-T downlink ports 2 Gigabit Ethernet dual-purpose uplink ports Supports the IEEE-1588 standard for synchronizing clocks. Can enable Network Address Translation (NAT) by license upgrade.	LAN Base with 1588
Cisco IE-2000-8TC-G-L	8 10/100BASE-T downlink ports 2 Gigabit Ethernet dual-purpose uplink ports	LAN Lite

Table 1 Switch Descriptions (continued)

Model	Description	Software Image
Cisco IE-2000-8TC-G-N	<p>8 10/100BASE-T downlink ports</p> <p>2 Gigabit Ethernet dual-purpose uplink ports</p> <p>Supports the IEEE-1588 standard for synchronizing clocks and NAT.</p>	LAN Base with 1588 and NAT
Cisco IE-2000-16PTC-G-E	<p>12 10/100BASE-T downlink ports</p> <p>2 Gigabit Ethernet dual-purpose uplink ports</p> <p>4 Power over Ethernet (PoE) ports</p> <p>Note: The four PoE ports can operate as PoE or PoE+ if provided sufficient external power source.</p> <p>Supports the IEEE-1588 standard for synchronizing clocks.</p> <p>Can enable NAT by license upgrade.</p>	LAN Base with 1588
Cisco IE-2000-16PTC-G-L	<p>12 10/100BASE-T downlink ports</p> <p>2 Gigabit Ethernet dual-purpose uplink ports</p> <p>4 Power over Ethernet (PoE) ports</p> <p>Note: The four PoE ports can operate as PoE or as PoE+ if provided sufficient external power source.</p>	LAN Lite
Cisco IE-2000-16PTC-G-NX	<p>12 10/100BASE-T downlink ports</p> <p>2 Gigabit Ethernet dual-purpose uplink ports</p> <p>4 Power over Ethernet (PoE) ports</p> <p>Note: The four PoE ports can operate as PoE or as PoE+ if provided sufficient external power source.</p> <p>Supports the IEEE-1588 standard for synchronizing clocks and NAT.</p>	LAN Base with 1588 and conformal coat
Cisco IE-2000-16TC-B	<p>16 10/100BASE-T downlink ports</p> <p>2 Fast Ethernet dual-purpose uplink ports</p> <p>2 100 Mb/s SFP module uplink slots</p>	LAN Base
Cisco IE-2000-16TC-G-E	<p>16 10/100BASE-T downlink ports</p> <p>2 Gigabit Ethernet dual-purpose uplink ports</p> <p>2 100 Mb/s SFP module uplink slots</p> <p>Supports the IEEE-1588 standard for synchronizing clocks.</p> <p>Can enable NAT by license upgrade.</p>	LAN Base with 1588
Cisco IE-2000-16TC-G-L	<p>16 10/100BASE-T downlink ports</p> <p>2 Gigabit Ethernet dual-purpose uplink ports</p> <p>2 100 Mb/s SFP module uplink slots</p>	LAN Lite

Table 1 Switch Descriptions (continued)

Model	Description	Software Image
Cisco IE-2000-16TC-G-N	16 10/100BASE-T downlink ports 2 Gigabit Ethernet dual-purpose uplink ports Supports the IEEE-1588 standard for synchronizing clocks and NAT.	LAN Base with 1588 and NAT
Cisco IE-2000-16TC-G-X	16 10/100BASE-T downlink ports 2 Gigabit Ethernet uplink ports 2 100 Mb/s SFP module uplink slots Supports the IEEE-1588 standard for synchronizing clocks. Can enable NAT by license upgrade.	LAN Base with 1588 and conformal coat
Cisco IE-2000-16TC-L	16 10/100BASE-T downlink ports 2 Fast Ethernet dual-purpose uplink ports 2 100 Mb/s SFP module uplink slots	LAN Lite

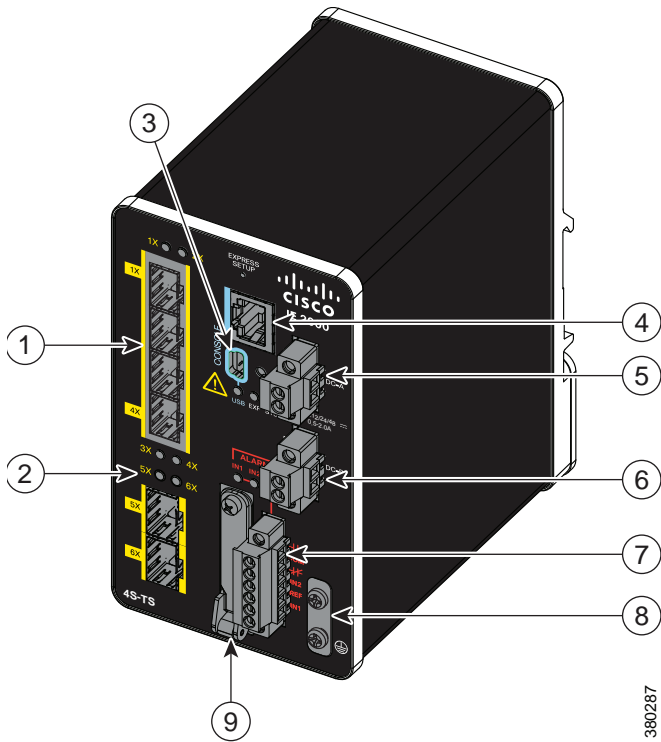
Front Panel Overview

This section describes the front panel components:

- 4, 8, or 16 10/100BASE-T Ethernet ports
- 10/100/1000 uplink ports (available on some models, see [Table 1 on page 8](#))
- Dual-purpose ports (available on some models, see [Table 1 on page 8](#))
- SFP module slots (available on some models, see [Table 1 on page 8](#))
- RJ-45 console port
- USB mini-Type B (console) port
- LEDs
- Power connectors
- Alarm connector
- Flash memory card slot

All IE 2000 switches have similar components, as shown in [Figure 1 on page 11](#), [Figure 2 on page 12](#), [Figure 3 on page 13](#), and [Figure 4 on page 14](#).

Figure 1 Cisco IE-2000-4S-TS-G-B Front Panel View



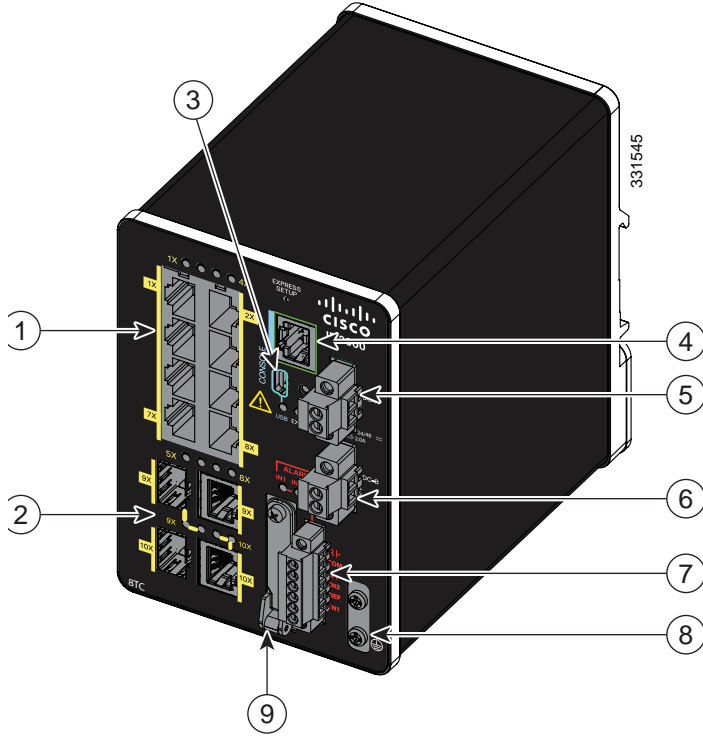
- | | |
|---|---------------------------------------|
| 1 SFP module slots (downlink ports) | 6 Power connector DC-B ² |
| 2 SFP module slots (uplink ports) | 7 Alarm connector |
| 3 USB mini-Type B (console) port ¹ | 8 Protective ground connection |
| 4 RJ-45 console port | 9 Flash memory card slot ¹ |
| 5 Power connector DC-A ² | |

¹ Use a screwdriver to remove the port cover and access the port.

² Remove the plastic cover to access the power connector.

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Figure 2 Cisco IE-2000-8TC-L Front Panel View

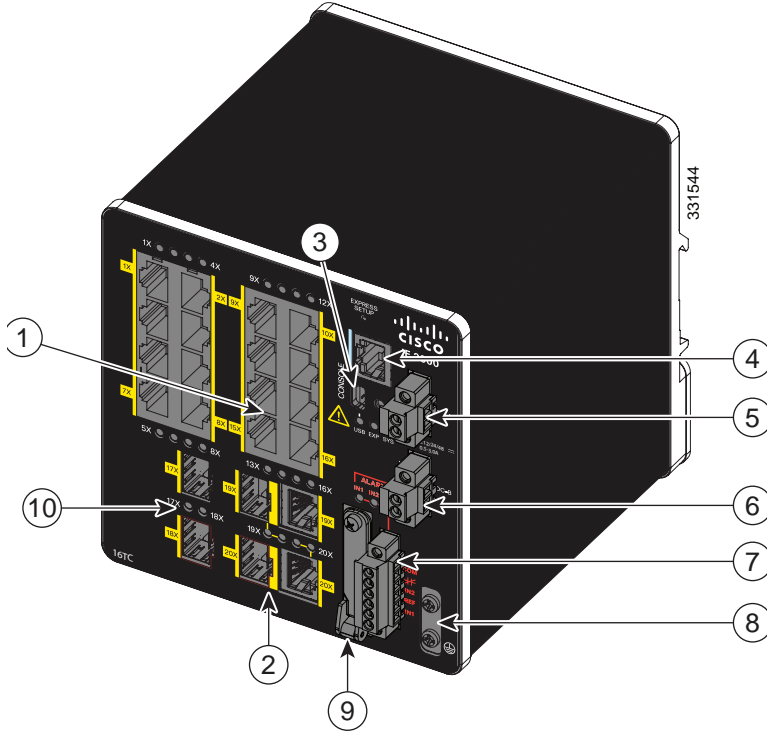


- | | | | |
|---|---|---|-------------------------------------|
| 1 | 10/100 Ethernet ports (downlink ports) | 6 | Power connector DC-B ² |
| 2 | Dual-purpose ports (uplink ports) | 7 | Alarm connector |
| 3 | USB mini-Type B (console) port ¹ | 8 | Protective ground connection |
| 4 | RJ-45 console port | 9 | Flash memory card slot ¹ |
| 5 | Power connector DC-A ² | | |

¹ Use a screwdriver to remove the port cover and access the port.

² Remove the plastic cover to access the power connector.

Figure 3 Cisco IE-2000-16TC-L Front Panel View

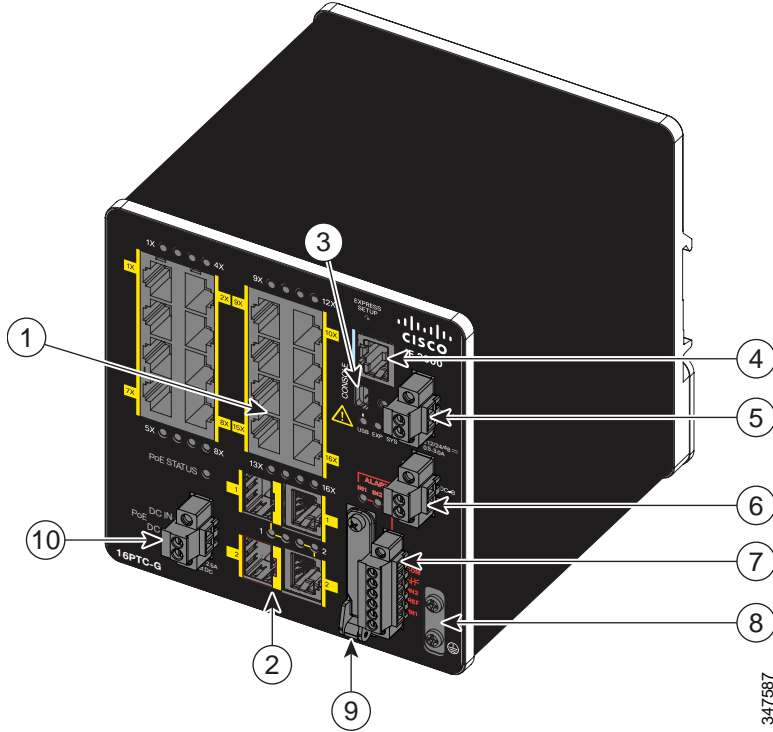


- | | |
|---|---------------------------------------|
| 1 10/100 Ethernet ports (downlink ports) | 6 Power connector DC-B ² |
| 2 Dual-purpose ports (uplink ports) | 7 Alarm connector |
| 3 USB mini-Type B (console) port ¹ | 8 Protective ground connection |
| 4 RJ-45 console port | 9 Flash memory card slot ¹ |
| 5 Power connector DC-A ² | 10 SFP module slots (uplink ports) |

¹ Use a screwdriver to remove the port cover and access the port.

² Remove the plastic cover to access the power connector.

Figure 4 Cisco IE-2000-16PTC-G-E Front Panel View



- | | | | |
|---|---|----|-------------------------------------|
| 1 | 10/100 Ethernet ports (downlink ports) | 6 | Power connector DC-B ² |
| 2 | Dual-purpose ports (uplink ports) | 7 | Alarm connector |
| 3 | USB mini-Type B (console) port ¹ | 8 | Protective ground connection |
| 4 | RJ-45 console port | 9 | Flash memory card slot ¹ |
| 5 | Power connector DC-A ² | 10 | PoE power connector |

¹ Use a screwdriver to remove the port cover and access the port.

² Remove the plastic cover to access the power connector.

Ports and Slots

- [10/100BASE-T Downlink Ports, page 15](#)
- [10/100BASE-T Uplink Ports, page 15](#)
- [10/100/1000BASE-T Uplink Ports, page 15](#)
- [100 Mb/s SFP Module Downlink Slots, page 15](#)
- [100/1000 Mb/s SFP Module Uplink Slots, page 15](#)
- [Dual-Purpose Fast Ethernet Uplink Ports, page 15](#)
- [Dual-Purpose Gigabit Ethernet Uplink Ports, page 16](#)
- [Power over Ethernet Ports, page 16](#)
- [Management Ports, page 16](#)

10/100BASE-T Downlink Ports

You can set the 10/100BASE-T downlink ports to operate at 10 or 100 Mb/s in full-duplex or half-duplex mode. You can also set these ports for speed and duplex autonegotiation in compliance with IEEE 802.3ab. (The default setting is autonegotiate.) When set for autonegotiation, the port senses the speed and duplex settings of the attached device and advertises its own capabilities. If the connected device also supports autonegotiation, the switch port negotiates the best connection (that is, the fastest line speed that both devices support, and full-duplex transmission if the attached device supports it) and configures itself accordingly. In all cases, the attached device must be within 328 feet (100 meters). 100BASE-TX traffic requires CAT5 cable. 10BASE-T traffic can use Category 3 or Category 4 cables.

When connecting the switch to workstations, servers, routers, and Cisco IP phones, make sure that the cable is a straight-through cable.

You can use the **mdix auto** interface configuration command in the command-line interface (CLI) to enable the automatic medium-dependent interface crossover (auto-MDIX) feature. When the auto-MDIX feature is enabled, the switch detects the required cable type for copper Ethernet connections and configures the interfaces accordingly. For configuration information for this feature, see the switch software configuration guide or the switch command reference.

10/100BASE-T Uplink Ports

The IEEE 802.3u 10/100BASE-T uplink ports provide full-duplex 10, 100 Mb/s connectivity over CAT5 unshielded twisted pair (UTP) copper cabling. The default setting is autonegotiate. The cable can be up to 100 m (0.1 km) in length.

10/100/1000BASE-T Uplink Ports

The IEEE 802.3u 10/100/1000BASE-T uplink ports provide full-duplex 10, 100 or 1000 Mb/s connectivity over CAT5 unshielded twisted pair (UTP) copper cabling. The default setting is autonegotiate. The cable can be up to 100 m (0.1 km) in length.

100 Mb/s SFP Module Downlink Slots

The IEEE 802.3u 100 Mb/s SFP module downlink slots provide full-duplex 100 Mb/s connectivity over multi-mode (MM) fiber cables or single-mode (SM) fiber cables. These ports use a SFP fiber-optic transceiver module that accepts a dual local connector (LC). Check the [SFP Module Cables, page 90](#) for the cable type and length.

100/1000 Mb/s SFP Module Uplink Slots

The IEEE 802.3u 100 Mb/s SFP module uplink slots provide full-duplex 100 or 1000 Mb/s connectivity over multi-mode fiber (MMF) or single-mode fiber (SMF) cables, or CAT5 (or later) cables. These ports use a SFP fiber-optic transceiver module that accepts a dual LC connector. See [SFP Module Cables, page 90](#) for cable type and length.

10/100/1000BASE-T Copper SFP Module Uplink Slots

The IEEE 802.3 1000BASE-T copper SFP module slots provide full-duplex 1000Base-T connectivity over copper wire. These ports use a copper SFP transceiver module that accepts an RJ-45 connector. See [SFP Module Cables, page 90](#) for cable type and length.

Dual-Purpose Fast Ethernet Uplink Ports

You can configure the dual-purpose Fast Ethernet uplink ports on the switch as either 10/100BASE-T ports or as 100 Mb/s SFP-module ports. You can set the 10/100 ports to autonegotiate, or you can configure them as fixed 10 or 100 Mb/s ports.

By default, the switch selects the medium for each dual-purpose port (10/100BASE-T or SFP). When a link is achieved on one media type, the switch disables the other media type until the active link goes down. If links are active on both media, the SFP-module port has priority, but you can use the **media-type** interface configuration command to manually designate the port as an RJ-45 port or an SFP port.

You can configure the speed and duplex settings consistent with the selected media type. For information on configuring interfaces, see the switch software configuration guide.

Dual-Purpose Gigabit Ethernet Uplink Ports

You can configure the dual-purpose Gigabit Ethernet uplink ports on the switch as either 10/100/1000BASE-T ports or as 100/1000 Mb/s SFP-module ports. You can set the 10/100/1000BASE-T ports to autonegotiate, or you can configure them as fixed 10, 100, or 1000 Mb/s (Gigabit) Ethernet ports.

By default, the switch selects the medium for each dual-purpose port (10/100/1000BASE-T or SFP). When a link is achieved on one media type, the switch disables the other media type until the active link goes down. If links are active on both media, the SFP-module port has priority, but you can use the **media-type** interface configuration command to manually designate the port as an RJ-45 port or an SFP port.

You can configure the speed and duplex settings consistent with the selected media type. For information on configuring interfaces, see the switch software configuration guide.

Power over Ethernet Ports

On certain models of the IE 2000 switch, four of the 10/100BASE-T ports are available as PoE ports. The four ports can operate as PoE (IEEE 802.3af) ports or can be configured to operate as PoE+ (IEEE 802.3at) ports. Each PoE port requires 15.4 Watts of power while PoE+ requires 30 Watts. A 54VDC /1.2A power source (65W) can support 4 PoE ports or 2 PoE+ ports. A 170W power source is needed to power 4 PoE+ ports.

Cable lengths of up to 328 ft (100 m) are supported.

Management Ports

You can connect the switch to a PC running Microsoft Windows or to a terminal server through either the RJ-45 console port or the USB mini-Type B console port, also referred to as the USB-mini console port. These ports use the following connectors:

- RJ-45 console port uses an RJ-45-to-DB-9 female cable.
- USB-mini console port (5-pin connector) uses a USB Type A-to-5-pin mini-Type B cable.

The USB-mini console interface speeds are the same as the RJ-45 console interface speeds.

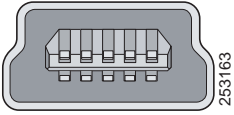
To use the USB-mini console port, you must install the Cisco Windows USB device driver on the device that is connected to the USB-mini console port and that is running Microsoft Windows.

Note: For information about downloading the Cisco USB device driver, see [Installing the Cisco Microsoft Windows XP, 2000, Vista, 7, 8, and 10 USB Device Driver, page 105](#).

With the Cisco Windows USB device driver, connecting and disconnecting the USB cable from the console port does not affect Windows HyperTerminal operations. Mac OS X or Linux require no special drivers.

Note: The 5-pin mini-Type B connectors resemble the 4-pin mini-Type B connectors, but they are not compatible. Use only the 5-pin mini-Type B. See [Figure 5 on page 17](#).

Figure 5 USB Mini-Type B Port



The configurable inactivity timeout reactivates the RJ-45 console port if the USB-mini console port is activated, but no input activity occurs for a specified time period. When the USB-mini console port deactivates due to a timeout, you can restore its operation by disconnecting and reconnecting the USB cable. For information on using the CLI to configure the USB-mini console interface, see the switch software guide.

Power Connectors

- [DC Power Connector, page 17](#)
- [PoE Power Connector, page 17](#)

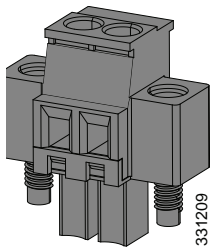
DC Power Connector

You connect the DC power to the switch through the front panel connectors. The switch has a dual-feed DC power supply; two connectors provide primary and secondary DC power (DC-A and DC-B). The DC power connectors are near the top right of the front panel (see [Figure 2 on page 12](#)). Each power connector has an LED status indicator.

The switch power connectors are attached to the switch chassis. Each power connector has screw terminals for terminating the DC power (see [Figure 6 on page 17](#)). All connectors are attached to the switch front panel with the provided captive screws.

The power connector labeling is on the panel. The positive DC power connection is labeled “+”, and the return connection is labeled “-”.

Figure 6 Power Connector



The switch can operate with a single power source or with dual power sources. When both power sources are operational, the switch draws power from the DC source with the higher voltage. If one of the two power sources fail, the other continues to power the switch.

In systems configured with the redundant power option, connect each of the two power supplies to separate independent power sources. If you fail to do this, your system might be susceptible to total power failure due to a fault in the external wiring or a tripped circuit breaker.

PoE Power Connector

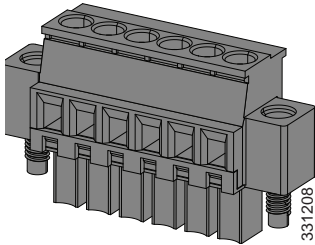
The IE 2000 switch models with PoE capability (IE-2000-16PTC-G-E, IE-2000-16PTC-G-L, and IE-2000-16PTC-G-NX) are equipped with an additional DC input terminal block. This DC terminal block allows the connection of a second power supply (see [Power over Ethernet Ports, page 16](#)), or a second input from site source DC power to operate the PoE ports. The PoE terminal block accepts 48 VDC or 54 VDC at 2.5 A.

Alarm Connector

You connect the alarm signals to the switch through the alarm connector. The switch supports two alarm inputs and one alarm output relay. The alarm connector is on the bottom right of the front panel. See [Figure 3 on page 13](#).

The alarm connector provides six alarm wire connections. The connector is attached to the switch front panel with the provided captive screws.

Figure 7 Alarm Connector



Both alarm input circuits can sense if the alarm input is open or closed. The alarm inputs can be activated for environmental, power supply, and port status alarm conditions. From the CLI, you can configure each alarm input as an open or closed contact.

The alarm output circuit is a relay with a normally open and a normally closed contact. The switch is configured to detect faults that are used to energize the relay coil and change the state on both of the relay contacts: normally open contacts close, and normally closed contacts open. The alarm output relay can be used to control an external alarm device, such as a bell or a light.

See the switch software configuration guide for instructions on configuring the alarm relays.

For more information about the alarm connector, see [Cable and Connectors, page 87](#).

SFP Modules

The switch Ethernet SFP modules provide connections to other devices. These field-replaceable transceiver modules provide the uplink interfaces. LC connectors provide fiber-optic connections; RJ-45 connectors for copper connections. You can use any combination of the supported SFP modules listed in [Table 2 on page 19](#).

Table 2 SFP Module Maximum Operating Temperature by Model

SFP Module	Model
Rugged and Industrial SFPs -40 to 185° F (-40 to 85° C)	<ul style="list-style-type: none"> ■ GLC-SX-MM-RGD ■ GLC-LX-SM-RGD ■ GLC-FE-100LX-RGD ■ GLC-FE-100FX-RGD ■ GLC-FE-T-I ■ GLC-ZX-SM-RGD ■ GLC-BX40-D-I with digital optical monitoring (DOM) support ■ GLC-BX40-DA-I with DOM support ■ GLC-BX80-D-I with DOM support ■ GLC-BX40-U-I with DOM support ■ GLC-BX80-U-I with DOM support
Commercial SFPs 32 to 158° F (0 to 70° C)	<ul style="list-style-type: none"> ■ GLC-BX-D with DOM support ■ GLC-BX-U with DOM support ■ GLC-FE-100LX ■ GLC-FE-100BX-D ■ GLC-FE-100BX-U ■ GLC-FE-100FX ■ GLC-FE-100EX ■ GLC-FE-100ZX ■ GLC-T ■ CWDM with DOM support ■ DWDM with DOM support

Table 2 SFP Module Maximum Operating Temperature by Model (continued)

SFP Module	Model
Extended temperature SFPs 23 to 185° F (-5° C to 85° C)	<ul style="list-style-type: none">■ SFP-GE-L with DOM support■ SFP-GE-S with DOM support■ SFP-GE-T■ SFP-GE-Z with DOM support■ GLC-LH-SMD with DOM support■ GLC-EX-SMD with DOM support■ GLC-SX-MMD with DOM support■ GLC-TE■ GLC-ZX-SMD with DOM support

For minimum software requirements, refer to the Release Notes for your platform.

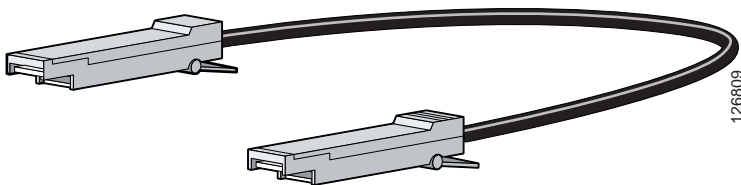
For an up-to-date list of supported SFP models for Cisco Industrial Ethernet switches, see http://www.cisco.com/en/US/docs/interfaces_modules/transceiver_modules/compatibility/matrix/OL_6981.html#wp138176

For installation instructions, see your SFP module documentation and the [Installing and Removing SFP Modules, page 66](#). For cable specifications, see [SFP Module Cables, page 90](#).

SFP Module Patch Cable

The switch uses an SFP-module patch cable, a 0.5-meter, copper, passive cable with SFP module connectors at each end (see [Figure 8 on page 20](#)). The patch cable connects two switches in a cascaded configuration.

Figure 8 SFP-Module Patch Cable



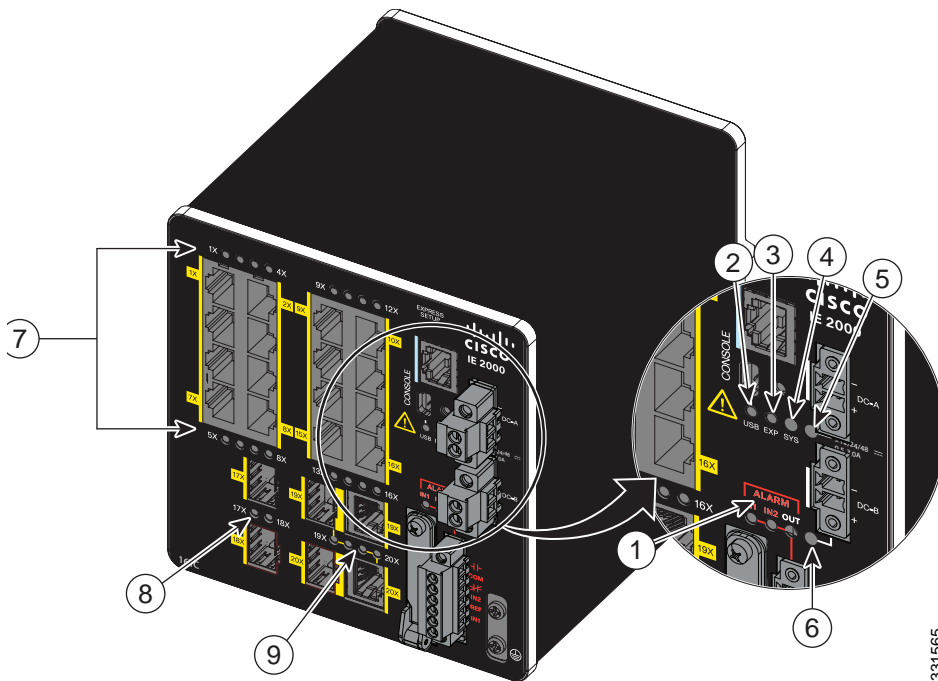
See [Installing and Removing SFP Modules, page 66](#) for information about using the SFP module patch cable.

You can order this cable (part number CAB-SFP-50CM=).

LEDs

You can use the LEDs to monitor the switch status, activity, and performance. [Figure 9 on page 21](#) and [Table 9 on page -24](#) show the front panel LEDs.

Figure 9 LEDs on the Cisco IE 2000 Switch



- | | |
|--------------------------------------|-----------------------------------|
| 1 Alarm LEDs | 6 Power connector DC-B LED |
| 2 USB mini-Type B (console) port LED | 7 10/100BASE-T downlink port LEDs |
| 3 Express Setup LED | 8 SFP module slot LEDs |
| 4 System LED | 9 Dual-purpose uplink port LEDs |
| 5 Power connector DC-A LED | |

Note: On IE 2000 switches with PoE support, the two SFP ports and the associated LEDs are replaced by a PoE DC-input terminal block and a PoE LED. For more information, see [PoE Status LED, page 24](#).

Express Setup LED

The Express Setup LED displays the express setup mode for the initial configuration.

Table 3 Express Setup LED

Color	Setup Status
Off (dark)	Switch is configured as a managed switch.
Solid green	Switch is operating normally.
Blinking green	Switch is in initial setup, in recovery, or initial setup is incomplete.
Solid red	Switch failed to start initial setup or recovery because there is no available switch port to which to connect the management station. Disconnect a device from a switch port, and then press the Express Setup button.

System LED

The System LED shows whether the system is receiving power and is functioning properly.

Table 4 System LED

Color	System Status
Off	System is not powered on.
Blinking green	Boot fast is in progress.
Green	System is operating normally.
Red	Switch is not functioning properly.

USB-Mini Console LED

The USB-mini console LED shows which console port is in use. See [Figure 9 on page 21](#) for the LED location. If you connect a cable to a console port, the switch automatically uses that port for console communication. If you connect two console cables, the USB-mini console port has priority.

Table 5 USB-Mini Console LED

Color	Description
Green	USB-mini console port is active. RJ-45 console port LED is not active.
Off	Port is not active. RJ-45 console port is active.

Alarm LEDs

[Table 6 on page -22](#) and [Table 7 on page -22](#) list the alarm LED colors and their meanings.

Table 6 Alarm OUT LED

Color	System Status
Off	Alarm OUT is not configured, or the switch is off.
Green	Alarm OUT is configured, no alarm detected.
Blinking red	Switch has detected a major alarm.
Red	Switch has detected a minor alarm.

Table 7 Alarm IN1 and IN2 Status LEDs

Color	System Status
Off	Alarm IN1 or IN2 not configured.
Green	Alarm IN1 or IN2 configured, no alarm detected.
Blinking red	Major alarm detected.
Red	Minor alarm detected.

Power Status LEDs

The switch can operate with one or two DC power sources. Each DC input has an associated LED that shows the status of the corresponding DC input. If power is present on the circuit, the LED is green. If power is not present, the LED color depends on the alarm configuration. If alarms are configured, the LED is red when power is not present; otherwise, the LED is off.

If the switch has dual power sources, the switch draws power from the power source with the higher voltage. If one of the DC sources fails, the alternate DC source powers the switch, and the corresponding power status LED is green. The power status for the failed DC source is either off or red, depending on the alarm configuration.

Table 8 Power Status LEDs

Color	System Status
Green	Power is present on the associated circuit, system is operating normally.
Off	Power is not present on the circuit, or the system is not powered up.
Red	Power is not present on the associated circuit, and the power supply alarm is configured.

The Power A and Power B LEDs show that power is not present on the switch if the power input drops below the low valid level. The power status LEDs only show that power is present if the voltage at the switch input exceeds the valid level.

For information about the power LED colors during the boot fast sequence, see [Verifying Switch Operation, page 72](#).

Port Status LEDs

Each port and SFP uplink slot has a status LED, as shown in [Figure 9 on page 21](#) and [Figure 10 on page 24](#).

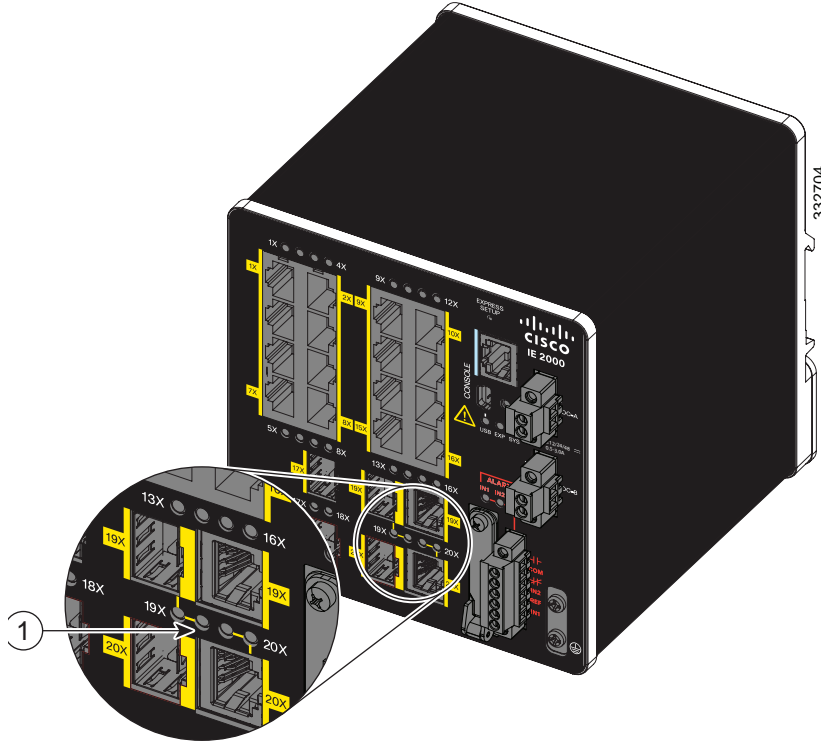
Table 9 Port Status LEDs

Color	System Status
Off	No link.
Solid green	Link present.
Blinking green	Activity. Port is sending or receiving data.
Alternating green-amber	Link fault. Error frames can affect connectivity, and errors such as excessive collisions, CRC errors, and alignment and jabber errors are monitored for a link-fault indication.
Solid amber	Port is not forwarding. The port was disabled by management, an address violation, or STP. Note: After a port is reconfigured, the port LED can remain amber for up to 30 seconds while STP checks the switch for possible loops.

Dual-Purpose Port LEDs

[Figure 10 on page 24](#) shows the LEDs on a dual-purpose port. The LEDs show how the port is being used (Ethernet or SFP module). The LED colors have the same meanings as for the [Port Status LEDs, page 23](#).

Figure 10 Dual-Purpose Port LEDs



1 Dual-purpose port LEDs

PoE Status LED

The PoE STATUS LED is located on the front panel of the IE 2000 switch models that are equipped with PoE ports. The LED displays the functionality and status of the PoE ports.

Table 10 PoE Status LED

Color	PoE Status
Off	PoE is off. If the powered device is receiving power from a non-PoE power source, the port LED is off even if the powered device is connected to the switch port.
Green	PoE is on. The port LED is green only when the PoE port is providing power.
Alternating green and amber	PoE is denied because providing power to the powered device will exceed the switch power capacity.
Flashing amber	PoE is off due to a fault. Caution: Non-compliant cabling or powered devices can cause a PoE port fault. Use only standard-compliant cabling to connect Cisco pre-standard IP Phones and wireless access points or IEEE 802.3af-compliant devices. You must remove any cable or device that causes a PoE fault.
Amber	PoE for the port is disabled. (PoE is enabled by default.)

Flash Memory Card

The switch supports a flash memory card that makes it possible to replace a failed switch without reconfiguring the new switch. The slot for the flash memory card is on the front of the switch. The flash card is hot swappable and can be accessed on the front panel. A cover protects the flash card and holds the card firmly in place. The cover is hinged and closed with a captive screw. This prevents the card from coming loose and protects against shock and vibration.

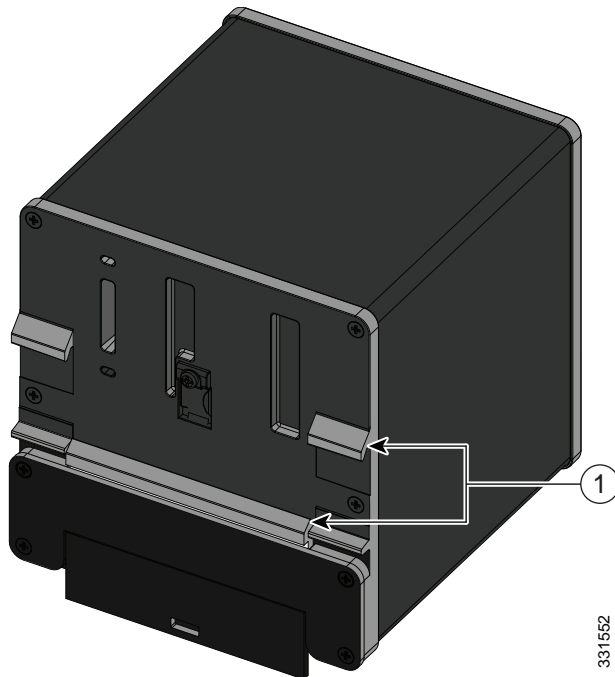
For more information on inserting and removing the flash memory card, see [Installing or Removing the Flash Memory Card \(Optional\)](#), page 33.

Note: The replacement SD card part number is SD-IE-1GB.

Rear Panel

The rear panel of the switch has a latch for installation on a DIN rail. See [Figure 11 on page 26](#). The latch is spring-loaded to move down to position the switch over a DIN rail and return to the original position to secure the switch to a DIN rail.

Figure 11 Cisco IE 2000 Switch Rear Panel



1 Latch

Management Options

The switch supports these management options:

- Cisco Network Assistant

Cisco Network Assistant is a PC-based network management GUI application optimized for LANs of small- and medium-sized businesses. Using the GUI, you can configure and manage switch clusters or standalone switches. Cisco Network Assistant is available at no cost and can be downloaded from this URL:

http://www.cisco.com/en/US/products/ps5931/tsd_products_support_series_home.html

For information on starting the Cisco Network Assistant application, see the *Getting Started with Cisco Network Assistant* guide on Cisco.com.

- Device Manager

You can use Device Manager, which is in the switch memory, to manage individual and standalone switches. This web interface offers quick configuration and monitoring. You can access Device Manager from anywhere in your network through a web browser. For more information, see [Running Express Setup, page 97](#) and the Device Manager online help.

- Cisco IOS CLI

The switch CLI is based on Cisco IOS software and is enhanced to support desktop-switching features. You can fully configure and monitor the switch. You can access the CLI either by connecting your management station directly to the switch management port, or a console port, or by using Telnet from a remote management station. See the switch command reference on Cisco.com for more information.

-
- Cisco Prime LAN Management Solution 4.2

http://www.cisco.com/en/US/docs/net_mgmt/ciscoverworks_lan_management_solution/4.2/device_support/table/ms42sdt.html#Cisco IE 2000 Series Switches

- SNMP network management

You can manage switches from a SNMP-compatible management station that is running platforms such as HP OpenView or SunNet Manager. The switch supports a comprehensive set of Management Information Base (MIB) extensions and four Remote Monitoring (RMON) groups. See the switch software configuration guide on Cisco.com and the documentation that came with your SNMP application for more information.

- Common Industrial Protocol

The Common Industrial Protocol (CIP) management objects are supported. The Cisco IE 2000 can be managed by CIP-based management tools, allowing the user to manage an entire industrial automation system with one tool.

- PROFINET TCP/IP and RT

This switch supports PROFINET TCP/IP and RT and can be managed by Siemens' automation software such as STEP 7.

Network Configurations

See the switch software configuration guide on Cisco.com for network configuration concepts and examples of using the switch to create dedicated network segments and interconnecting the segments through Gigabit Ethernet connections.



Switch Installation

This chapter describes how to install your switch, verify the boot fast, and connect the switch to other devices. It also includes information specifically for installations in hazardous environments.

Read these topics, and perform the procedures in this order:

- [Preparing for Installation, page 29](#)
- [Installing or Removing the Flash Memory Card \(Optional\), page 33](#)
- [Connecting to a Console Port, page 35](#)
- [Connecting to Power, page 39](#)
- [Installing the Switch, page 55](#)
- [Connecting Alarm Circuits, page 60](#)
- [Connecting Destination Ports, page 64](#)
- [Verifying Switch Operation, page 72](#)
- [Where to Go Next, page 72](#)

Preparing for Installation

This section provides information about these topics:

- [Warnings, page 29](#)
- [Additional Information for Installation in a Hazardous Environment, page 30](#)
- [Installation Guidelines, page 32](#)
- [Verifying Package Contents, page 33](#)

Warnings

These warnings are translated into several languages in the *Regulatory Compliance and Safety Information* for this switch.

Warning: Before working on equipment that is connected to power lines, remove jewelry (including rings, necklaces, and watches). Metal objects will heat up when connected to power and ground and can cause serious burns or weld the metal object to the terminals. Statement 43

Warning: Do not work on the system or connect or disconnect cables during periods of lightning activity. Statement 1001

Warning: Before performing any of the following procedures, ensure that power is removed from the DC circuit. Statement 1003

Warning: Read the installation instructions before you connect the system to its power source. Statement 1004

Warning: This unit is intended for installation in restricted access areas. A restricted access area can be accessed only through the use of a special tool, lock and key, or other means of security. Statement 1017

Warning: This equipment must be grounded. Never defeat the ground conductor or operate the equipment in the absence of a suitably installed ground conductor. Contact the appropriate electrical inspection authority or an electrician if you are uncertain that suitable grounding is available. Statement 1024

Warning: This unit might have more than one power supply connection. All connections must be removed to de-energize the unit. Statement 1028

Warning: Only trained and qualified personnel should be allowed to install, replace, or service this equipment. Statement 1030

Warning: Ultimate disposal of this product should be handled according to all national laws and regulations. Statement 1040

Warning: For connections outside the building where the equipment is installed, the following ports must be connected through an approved network termination unit with integral circuit protection. 10/100/1000 Ethernet Statement 1044

Warning: To prevent the system from overheating, do not operate it in an area that exceeds the maximum recommended ambient temperature of: 140° F (60° C) Statement 1047

Warning: Installation of the equipment must comply with local and national electrical codes. Statement 1074

Caution: Airflow around the switch must be unrestricted. To prevent the switch from overheating, there must be the following minimum clearances:

- Top and bottom: 2.0 in. (50.8 mm)
- Sides: 2.0 in. (50.8 mm)
- Front: 2.0 in. (50.8 mm)

Additional Information for Installation in a Hazardous Environment

Hazardous Area Installation Warnings

Warning: Exposure to some chemicals could degrade the sealing properties of materials used in the sealed relay device. Statement 381

Warning: Failure to securely tighten the captive screws can result in an electrical arc if the connector is accidentally removed. Statement 397

Warning: When you connect or disconnect the power and/or alarm connector with power applied, an electrical arc can occur. This could cause an explosion in hazardous area installations. Be sure that all power is removed from the switch and any other circuits. Be sure that power cannot be accidentally turned on or verify that the area is nonhazardous before proceeding. Statement 1058

Warning: In switch installations in a hazardous location, the DC power source could be located away from the vicinity of the switch. Before performing any of the following procedures, locate the DC circuit to ensure that the power is removed and cannot be turned on accidentally, or verify that the area is nonhazardous before proceeding. Statement 1059

Warning: This equipment is supplied as “open type” equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The interior of the enclosure must be accessible only by the use of a tool. The enclosure must meet IP 54 or NEMA type 4 minimum enclosure rating standards. Statement 1063

Warning: When used in a Class I, Division 2, hazardous location, this equipment must be mounted in a suitable enclosure with proper wiring method, for all power, input and output wiring, that complies with the governing electrical codes and in accordance with the authority having jurisdiction over Class I, Division 2 installations. Statement 1066

Warning: Use twisted-pair supply wires suitable for 86° F (30° C) above surrounding ambient temperature outside the enclosure. Statement 1067

Warning: This equipment is intended for use in a Pollution Degree 2 industrial environment, in overvoltage Category II applications (as defined in IEC publication 60664-1), and at altitudes up to 2000 meters without derating. Statement 1068

Warning: Do not connect or disconnect cables to the ports while power is applied to the switch or any device on the network because an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed from the switch and cannot be accidentally be turned on, or verify that the area is nonhazardous before proceeding. Statement 1070

Warning: If you connect or disconnect the console cable with power applied to the switch or any device on the network, an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding. Statement 1080

Warning: Explosion Hazard—Do not connect or disconnect wiring while the field-side power is on; an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or that the area is nonhazardous before proceeding. Statement 1081

Warning: Explosion Hazard—The area must be known to be nonhazardous before installing, servicing, or replacing the unit. Statement 1082

Warning: Explosion Hazard—Substitution of components may impair suitability for Class I, Division 2/Zone 2. Statement 1083

Warning: Do not insert and remove SFP modules while power is on; an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding. Statement 1087

Caution: This equipment is only suitable for use in Class I, Division 2, Groups A, B, C, D, or nonhazardous locations.

North American Hazardous Location Approval

The following information applies when operating this equipment in hazardous locations:

English: Products marked "Class I, Div 2, GP A, B, C, D" are suitable for use in Class I Division 2 Groups A, B, C, D, Hazardous Locations and nonhazardous locations only. Each product is supplied with markings on the rating nameplate indicating the hazardous location temperature code. When combining products within a system, the most adverse temperature code (lowest "T" number) may be used to help determine the overall temperature code of the system. Combinations of equipment in your system are subject to investigation by the local Authority Having Jurisdiction at the time of installation.

Français: Informations sur l'utilisation de cet équipement en environnements dangereux:

Les produits marqués "Class I, Div 2, GP A, B, C, D" ne conviennent qu'à une utilisation en environnements de Classe I Division 2 Groupes A, B, C, D dangereux et non dangereux. Chaque produit est livré avec des marquages sur sa plaque d'identification qui indiquent le code de température pour les environnements dangereux. Lorsque plusieurs produits sont combinés dans un système, le code de température le plus défavorable (code de température le plus faible) peut être utilisé pour déterminer le code de température global du système. Les combinaisons d'équipements dans le système sont sujettes à inspection par les autorités locales qualifiées au moment de l'installation.

EMC Environmental Conditions for Products Installed in the European Union

This section applies to products to be installed in the European Union.

The equipment is intended to operate under the following environmental conditions with respect to EMC:

- A separate defined location under the user's control.
- Earthing and bonding shall meet the requirements of ETS 300 253 or CCITT K27.
- AC-power distribution shall be one of the following types, where applicable: TN-S and TN-C as defined in IEC 364-3.

In addition, if equipment is operated in a domestic environment, interference could occur.

Installation Guidelines

When determining where to place the switch, observe these guidelines.

Environment and Enclosure Guidelines

Review these environmental and enclosure guidelines before installation:

- This equipment is intended for use in a Pollution Degree 2 industrial environment, in overvoltage Category II applications (as defined in IEC publication 60664-1), at altitudes up to 9842 ft (3 km) without derating.
- This equipment is considered Group 1, Class A industrial equipment, according to IEC/CISPR Publication 11. Without appropriate precautions, there may be potential difficulties ensuring electromagnetic compatibility in other environments due to conducted as well as radiated disturbance.
- This equipment is supplied as open-type equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The enclosure must have suitable flame-retardant properties to prevent or minimize the spread of flame, complying with a flame-spread rating of 5VA, V2, V1, V0 (or equivalent) if nonmetallic. The interior of the enclosure must be accessible only by the use of a tool. Subsequent sections of this publication might contain additional information regarding specific enclosure-type ratings that are required to comply with certain product safety certifications.

General Guidelines

Before installation, observe these general guidelines:

Caution: Proper ESD protection is required whenever you handle Cisco equipment. Installation and maintenance personnel should be properly grounded by using ground straps to eliminate the risk of ESD damage to the switch.

Caution: Do not touch connectors or pins on component boards. Do not touch circuit components inside the switch. When not in use, store the equipment in appropriate static-safe packaging.

- If you are responsible for the application of safety-related programmable electronic systems (PES), you need to be aware of the safety requirements in the application of the system and be trained in using the system.
- This product is grounded through the DIN rail to chassis ground. Use zinc-plated yellow-chromate steel DIN rail to assure proper grounding. The use of other DIN rail materials (such as aluminum, plastic, and so on) that can corrode, oxidize, or are poor conductors can result in improper or intermittent grounding. Secure the DIN rail to the mounting surface approximately every 7.8 in. (200 mm), and use end-anchors appropriately.

When determining where to place the switch, observe these guidelines:

- Before installing the switch, first verify that the switch is operational by powering it on and observing boot fast. Follow the procedures in [Verifying Switch Operation, page 72](#).

-
- For 10/100 ports and 10/100/1000 ports, the cable length from a switch to an attached device cannot exceed 328 feet (100 meters).
 - For 100BASE-FX fiber-optic ports, the cable length from a switch to an attached device cannot exceed 6562 ft (2 km).
 - Operating environment is within the ranges listed in [Technical Specifications, page 81](#)
 - Clearance to front and rear panels meets these conditions:
 - Front-panel LEDs can be easily read.
 - Access to ports is sufficient for unrestricted cabling.
 - Front-panel direct current (DC) power connectors and the alarm connector are within reach of the connection to the DC power source.
 - Airflow around the switch must be unrestricted. To prevent the switch from overheating, you must have the following minimum clearances:
 - Top and bottom: 2.0 in. (50.8 mm)
 - Sides: 2.0 in. (50.8 mm)
 - Front: 2.0 in. (50.8 mm)
 - Temperature surrounding the unit does not exceed 140°F (60°C).

Note: When the switch is installed in an industrial enclosure, the temperature within the enclosure is greater than normal room temperature outside the enclosure.

Note: The temperature inside the enclosure cannot exceed 140°F (60°C), the maximum ambient enclosure temperature of the switch.
 - Cabling is away from sources of electrical noise, such as radios, power lines, and fluorescent lighting fixtures.
 - Connect the unit only to a Class 2 DC power source.

Verifying Package Contents

The *Cisco IE 2000 Switch Getting Started Guide* on Cisco.com describes the box contents. If any item is missing or damaged, contact your Cisco representative or reseller for support.

Installing or Removing the Flash Memory Card (Optional)

The software /firmware is stored on the internal flash memory in the Cisco IE2000 switch. Optionally, you can order and install an SD memory card (SD-IE-1GB=) to store the software and the configuration changes. If you need to replace the switch, you can simply insert the SD memory card instead of configuring the new switch.

Warning: Do not insert or remove the flash card while power is on; an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding. Statement 379

To install or replace the flash memory card, follow these steps:

1. On the front of the switch, locate the door that protects the flash memory card slot. Loosen the captive screw at the top of the door using a Phillips screwdriver to open the door. See [Figure 12 on page 34](#).

Figure 12 Installing the Flash Memory Card in the Switch

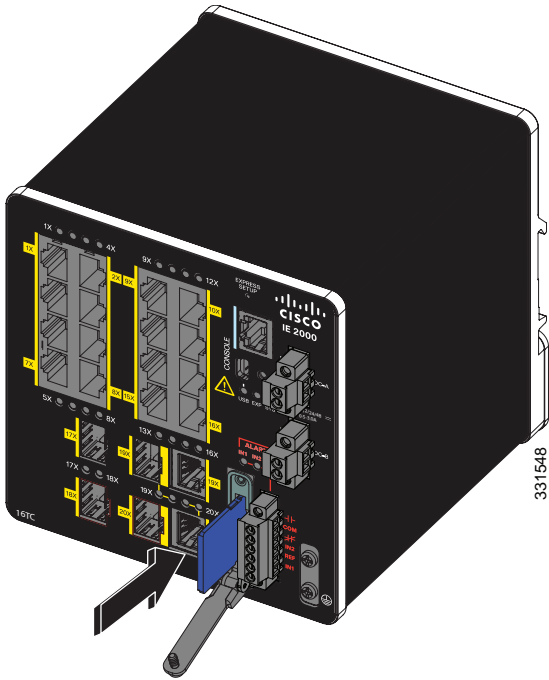
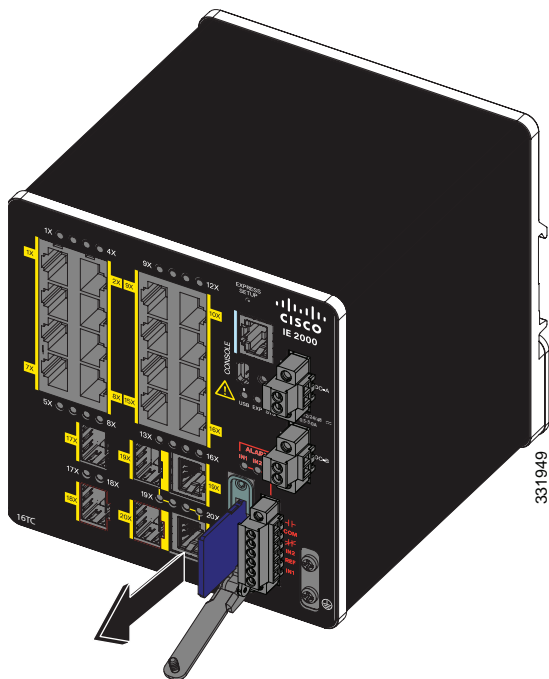


Figure 13 Removing the Flash Memory Card from the Switch



2. Install or remove the card:

- To install a card, slide it into the slot, and press it in until it clicks in place. The card is keyed so that you cannot insert it the wrong way.
- To remove the card, push it in until it releases for it to pop out. Place it in an antistatic bag to protect it from static discharge.

3. After the card is installed, close the guard door and fasten the captive screw using a Phillips screwdriver to keep the door in place.

Connecting to a Console Port

You can enter Cisco IOS commands and parameters through the CLI. Use one of these options to access the CLI:

- [RJ-45 Console Port, page 35](#)
- [USB Mini-Type B Console Port, page 36](#)

Warning: If you connect or disconnect the console cable with power applied to the switch or any device on the network, an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding.

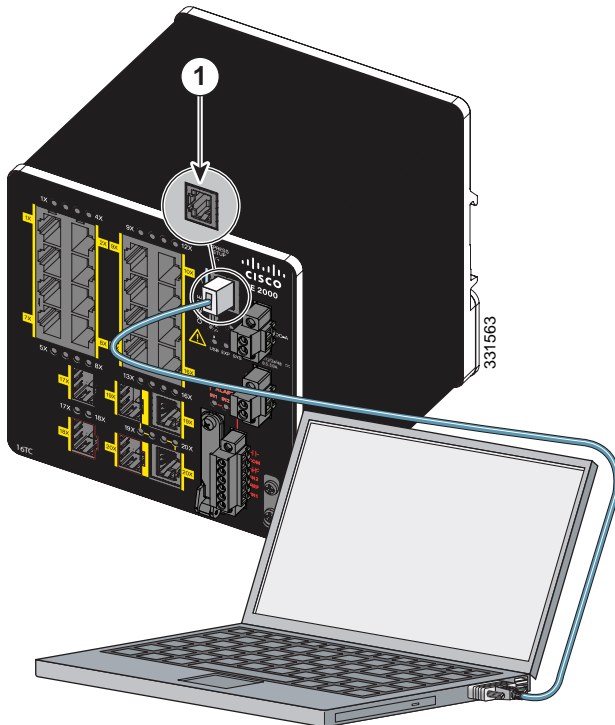
Statement 1080

RJ-45 Console Port

1. Connect the RJ-45-to-DB-9 adapter cable to the 9-pin serial port on the PC (see [Figure 14 on page 35](#)).
2. Connect the other end of the cable to the switch console port.
3. Start the terminal-emulation program on the PC or the terminal.

The program, frequently a PC application such as HyperTerminal or PuTTY, makes communication between the switch and your PC or terminal possible.

Figure 14 Connecting the Console Cable



1	RJ-45 console port	2	Console cable (RJ-45-to-DB-9 adapter cable)
---	--------------------	---	---

4. Configure the baud rate and character format of the PC or terminal to match the console port characteristics:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity
- None (flow control)

5. Connect power to the switch as described in [Connecting to Power, page 39](#).

The PC or terminal displays the bootloader sequence.

6. Press **Enter** to display the setup prompt.

7. Follow the steps in [Completing the Setup Program, page 106](#).

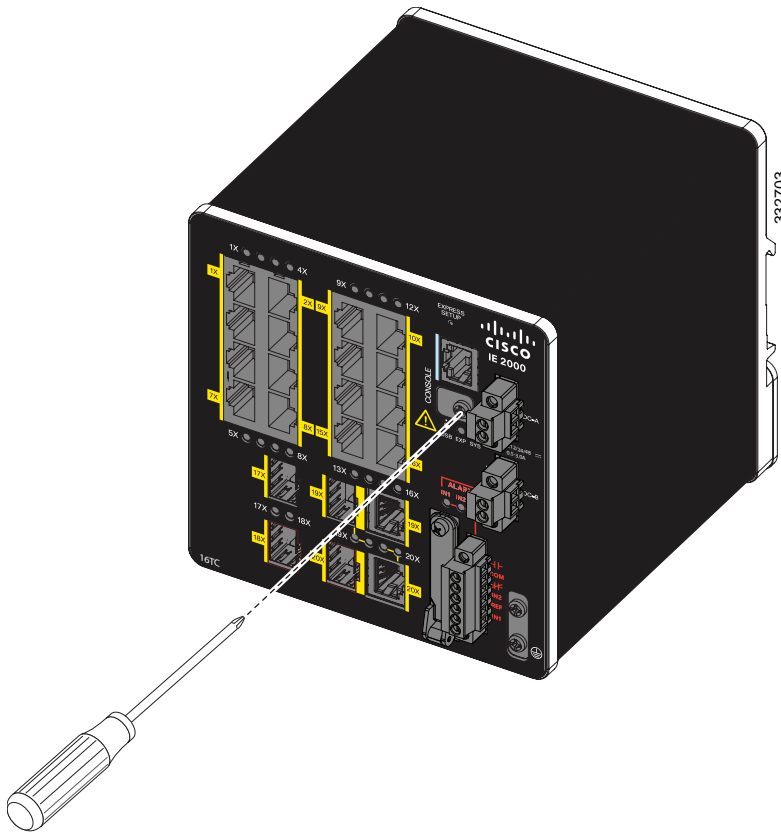
USB Mini-Type B Console Port

If you are connecting the switch USB-mini console port to a Windows-based PC for the first time, install a USB driver. See [Installing the Cisco Microsoft Windows XP, 2000, Vista, 7, 8, and 10 USB Device Driver, page 105](#) for more information.

To remove the cover from the USB mini-type B console port:

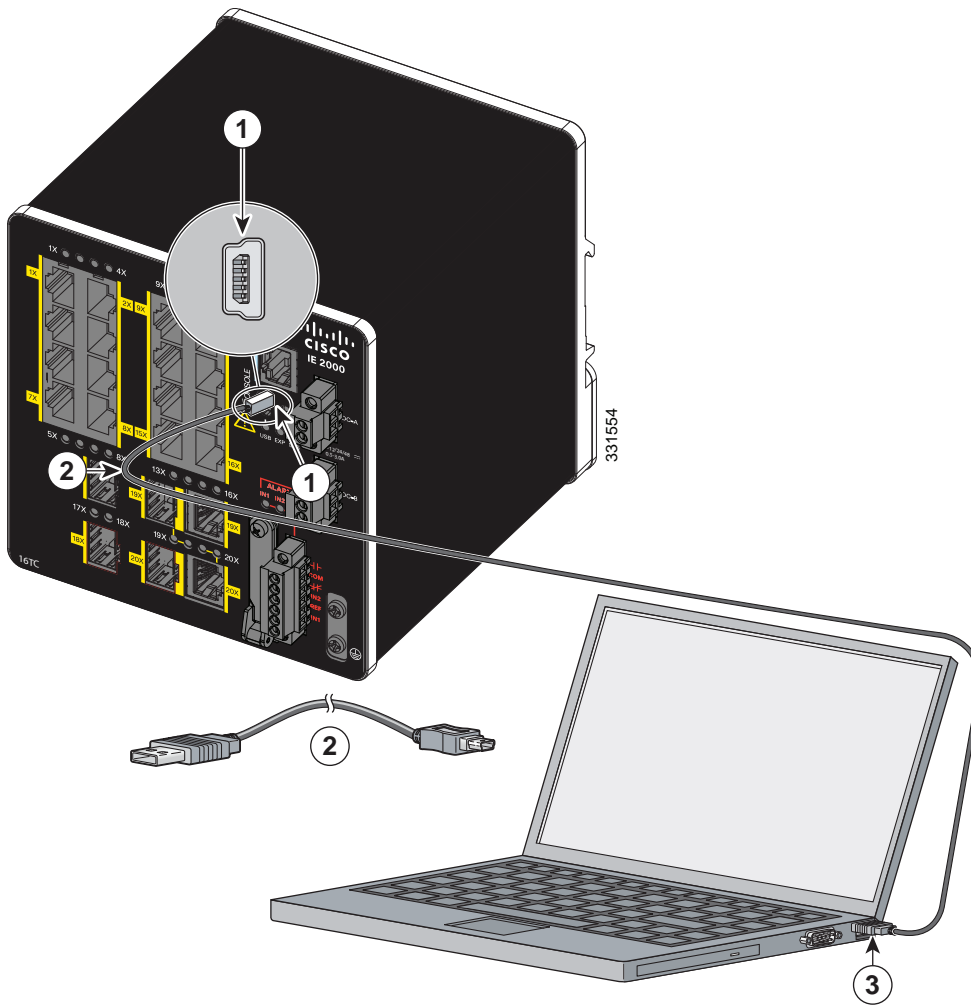
1. Use a Phillips screwdriver to loosen the captive screw on the USB mini-type B console port cover. See [Figure 15 on page 37](#).
2. Remove the cover.

Figure 15 Removing the USB Mini-Type B Console Port Cover



3. Connect a USB cable to the PC USB port.
4. Connect the other end of the cable to the switch mini-B (5-pin connector) USB-mini console port. See [Figure 16 on page 38](#).

Figure 16 Connecting the USB-Mini Console Cable



1	USB-mini console port	3	USB port on the PC
2	USB cable		

5. Identify the COM port assigned to the USB-mini console port:

- a. Choose **Start > Control Panel > Systems**.
- b. Click the **Hardware** tab and choose **Device Manager**. Expand the **Ports** section. The assigned COM port appears in parenthesis at the end of the line with this entry: Cisco USB System Management Console.

6. Start the terminal-emulation program on the PC or the terminal.

The program, frequently a PC application such as HyperTerminal or ProcommPlus, makes communication possible between the switch and your PC or terminal.

7. Configure the COM port.

8. Configure the baud rate and character format of the PC or terminal to match the console port characteristics:

- 9600 baud
- 8 data bits

- 1 stop bit
- No parity
- None (flow control)

9. Connect power to the switch as described in [Connecting to Power, page 39](#).

10. When the PC or terminal displays the bootloader sequence, press **Enter** to display the setup prompt.

11. Follow the steps in [Completing the Setup Program, page 106](#).

Connecting to Power

In systems configured with the redundant power option, connect each of the two power supplies to separate independent power sources. If you fail to do this, your system might be susceptible to total power failure due to a fault in the external wiring or a tripped circuit breaker.

Tools and Equipment

Obtain these necessary tools and equipment:

- Ratcheting torque flathead screwdriver that exerts up to 15 in-lb (1.69 N-m) of pressure.
- For the protective ground connector, obtain a single or pair of stud size 6 ring terminals (such as Hollingsworth part number R3456B or equivalent).
- Crimping tool (such as Thomas & Bett part number WT2000, ERG-2001, or equivalent).
- 10-gauge copper ground wire (such as Belden part number 9912 or equivalent).
- For DC power connections, use UL- and CSA-rated, style 1007 or 1569 twisted-pair copper appliance wiring material (AWM) wire (such as Belden part number 9318).
- Wire-stripping tools for stripping 10- and 18-gauge wires.
- A number-2 Phillips screwdriver.
- A flat-blade screwdriver.

Supported Power Supplies

The supported power supplies are listed in [Table 11 on page 39](#).

Table 11 Supported Power Supplies

	PWR-IE170W-PC-DC=	PWR-IE170W-PC-AC=	PWR-IE65W-PC-DC=	PWR-IE65W-PC-AC=	PWR-IE50W-AC-IEC=	PWR-IE50W-AC=
Current	DC-DC	AC-DC	DC-DC	AC-DC	AC-DC	AC-DC
Input	10.8-60 VDC	90-264 VAC or 106-300 VDC	18-60 VDC/4.3 Amp	110/220 VAC and 88-300 VDC	110/220 VAC	110/220VAC and 88-300 VDC
Output	54 VDC/3.15 A	54 VDC/3.15 A	54VDC/1.2 Amp	54VDC/1.2 Amp	24VDC/2.1Amp	24 VDC / 2.1Amp

Table 11 Supported Power Supplies

Dimensions	5.93 in H x 4.47 in. W x 5.75 in. D	5.93 in H x 3.72 in. W x 5.60 in. D	5.9 in H x 2.1 in. W x 4.9 in. D	5.9 in. H x 2.1 in. W x 4.9 in. D	5.8 in. H x 2 in. W x 4.4 in. D	5.8 in. H x 2 in. W x 4.4 in. D
Attachable?	Non-attachable	Non-attachable	Non-attachable	Non-attachable	Attachable unit	Attachable unit
Usage	Designed for PoE modules, can be used to power the switch.	Designed for PoE modules, can be used to power the switch.	Designed for PoE ¹ modules, can be used to power the switch.	Designed for PoE modules, can be used to power the switch.	Powers the switch. Cannot be used to power PoE modules, which require 48V DC.	Powers the switch. Cannot be used to power PoE modules, which require 48V DC.

¹. The models that support PoE provide up to four ports of either PoE (15.4 W per port; IEEE 802.3af) or PoE+ (30 W per port; IEEE 802.3at), depending on the power source used. See [Power Requirements, page 82](#).

Installing the Power Converter on a DIN Rail, Wall, or Rack Adapter

You install the power converter on a DIN rail, wall, or rack as you would a switch module.

Warning: This equipment is supplied as “open type” equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The interior of the enclosure must be accessible only by the use of a tool. The enclosure must meet IP 54 or NEMA type 4 minimum enclosure rating standards. Statement 1063

Caution: To prevent the switch assembly from overheating, there must be a minimum of 3 inches (76.19 mm) between any other device and the top, bottom, or sides of the switch assembly.

Grounding the Switch

Follow the grounding requirements at your site.

Warning: This equipment must be grounded. Never defeat the ground conductor or operate the equipment in the absence of a suitably installed ground conductor. Contact the appropriate electrical inspection authority or an electrician if you are uncertain that suitable grounding is available. Statement 1024

Warning: This equipment is intended to be grounded to comply with emission and immunity requirements. Ensure that the switch functional ground lug is connected to earth ground during normal use. Statement 1064

Caution: To ensure that the equipment is reliably connected to earth ground, follow the grounding procedure instructions, and use a UL-listed ring terminal lug suitable for number 10-to-12 AWG wire, such as Hollingsworth part number R3456B or equivalent)

Caution: Use at least a 4 mm² conductor to connect to the external grounding screw.

The ground lug is not supplied with the switch. You can use one of the these options:

- Single ring terminal
- Two single ring terminals

To ground the switch to earth ground by using the ground screw, follow these steps:

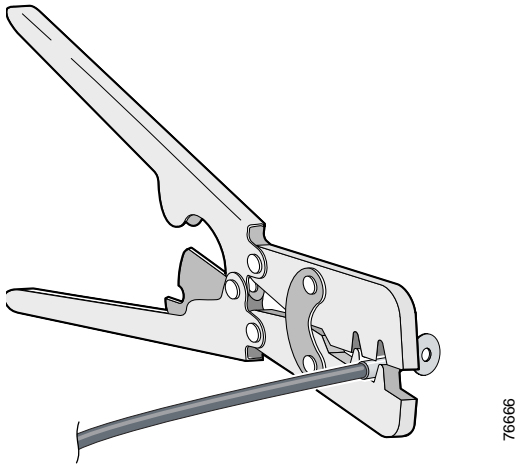
1. Use a standard Phillips screwdriver or a ratcheting torque screwdriver with a Phillips head to remove the ground screw from the front panel of the switch.

Store the ground screw for later use.

-
2. Use the manufacturer's guidelines to determine the wire length to be stripped.
 3. Insert the ground wire into the ring terminal lug, and using a crimping tool, crimp the terminal to the wire. See [Figure 17 on page 41](#).

If two ring terminals are being used, repeat this action for a second ring terminal.

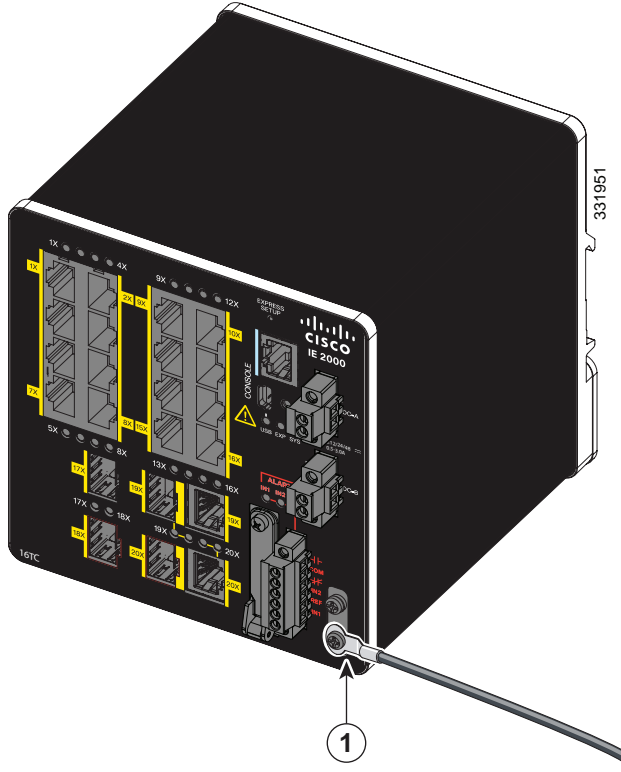
Figure 17 Crimping the Ring Terminal



4. Slide the ground screw through the terminal.
5. Insert the ground screw into the functional ground screw opening on the front panel.
6. Use a ratcheting torque screwdriver to tighten the ground screws and ring terminal to the switch front panel to 3.5 in-lb (0.4 N-m). See [Figure 18 on page 42](#) or [Figure 19 on page 43](#).

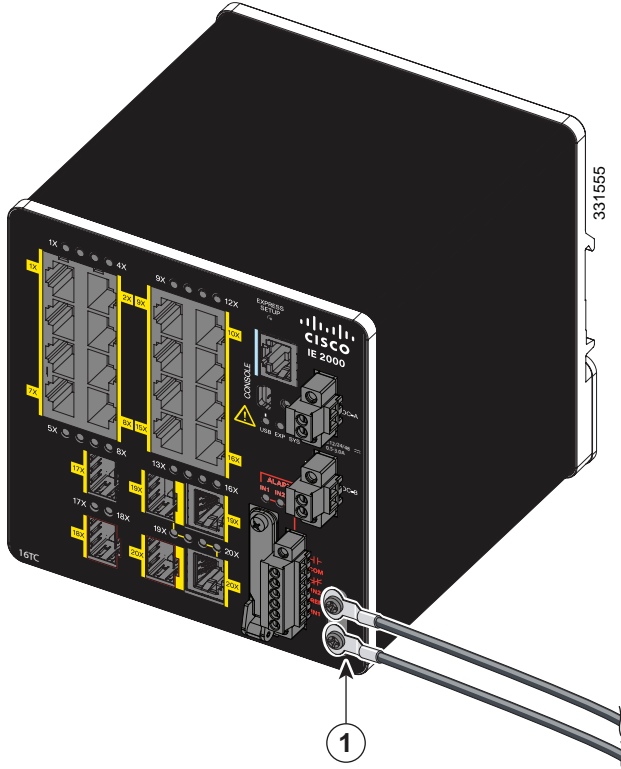
Note: Do not exceed 3.5 in-lb (0.4 N-m) of torque.

Figure 18 Installing the Ground-Lug Screw (Single Ring Terminal)



- | | |
|---|--------------|
| 1 | Ground cable |
|---|--------------|

Figure 19 Installing the Ground-Lug Screws (Two Single Ring Terminals)



1	Ground cable
---	--------------

7. Attach the other end of the ground wire to a grounded bare metal surface, such as a ground bus, a grounded DIN rail, or a grounded bare rack.

Connecting the Power Converter to an AC Power Source

These sections describe the steps required to connect the power converter to an AC power source:

- [Preparing the AC Power Connection, page 43](#)
- [Connecting the AC Power Source to the Power Converter, page 44](#)

Preparing the AC Power Connection

To connect the power converter to an AC power source, you need an AC power cord. Power cord connector types and standards vary by country. Power-cord wiring color codes also vary by country. You must have a qualified electrician select, prepare, and install the appropriate power cord to the power supply.

Use copper conductors only, rated at a minimum temperature of 167° F (75° C).

This section does not apply to PWR-IE50W-AC-IEC, which has pluggable IEC connector.

Connecting the AC Power Source to the Power Converter

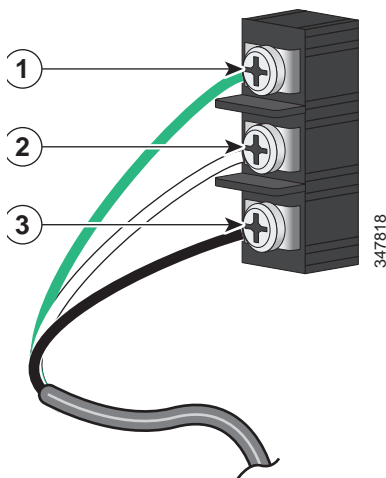
Caution: AC power sources must be dedicated AC branch circuits. Each branch circuit must be protected by a dedicated two-pole circuit breaker.

Caution: Do not turn on AC power until the wiring is secured.

1. Remove the plastic cover from the input power terminals and set it aside.
2. Insert the exposed ground wire lead into the power converter ground wire connection.

Ensure that only wire *with insulation* extends from the connector. See [Figure 20 on page 44](#), item 1. Note that the position of the power converter may vary on different switch models.

Figure 20 Connecting AC Power



1	Ground	3	AC line
2	AC neutral		

3. Tighten the ground wire terminal block screw.

Note: Torque to 8 in.-lb, not to exceed 10 in.-lb.

4. Insert the line and neutral wire leads into the terminal block line and neutral connections. See [Figure 20 on page 44](#), items 2 and 3.

Ensure that you cannot see any wire lead, and that only wire *with insulation* extends from the connectors.

5. Tighten the line and neutral terminal block screws to 8 in.-lb torque.

Note: Do not exceed 10 in.-lb torque.

6. Replace the plastic cover over the terminal block.
7. Connect the other end of the wiring to your AC power source.

Connecting the Power Converter to a DC Power Source

You can also connect the power converter to a DC power source. Several power supplies can be used. Refer to [Table 11 on page 39](#) for the appropriate DC input ratings.

Use copper conductors only, rated at a minimum temperature of 167°F (75°C).

1. Measure a single length of stranded copper wire long enough to connect the power converter to the earth ground.

The wire color differs depending on country.

For connections from the power converter to earth ground, use shielded 18-AWG stranded copper wire, such as Belden part number 9912 or the equivalent.

2. Measure a length of twisted-pair copper wire long enough to connect the power converter to the DC power source.

For DC connections from the power converter to the DC source, use 18-AWG twisted-pair copper wire, such as Belden part number 9344 or the equivalent.

3. Using a 18-gauge wire-stripping tool, strip the ground wire and both ends of the twisted pair wires to 0.25 inch (6.3 mm) ± 0.02 inch (0.5 mm).

Note: Do not strip more than 0.27 inch (6.8 mm) of insulation from the wires. Stripping more than the recommended amount of wire can leave exposed wire from the power and relay connector after installation.

4. Connect one end of the stranded copper wire to a grounded bare metal surface, such as a ground bus, a grounded DIN rail, or a grounded bare rack.

5. Insert the other end of the exposed ground wire lead into the earth-ground wire connection on the power converter terminal block.

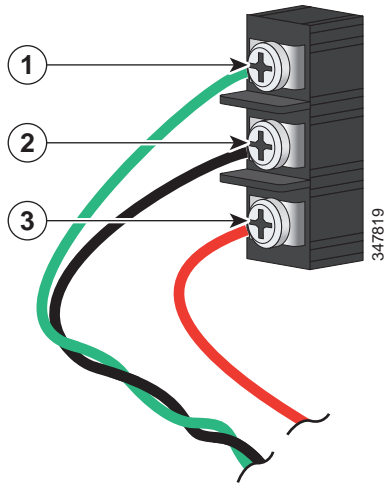
Only wire *with insulation* should extend from the connection. See [Figure 21 on page 46](#), item 1.

The position of the power converter varies on different switch models.

6. Tighten the earth-ground wire connection terminal block screw to 8 in.-lb torque.

Note: Do not exceed 10 in.-lb torque.

Figure 21 AC/DC Power Input Terminal Block Wire Connections to a DC Source



1	Earth ground wire connection	3	Positive DC connection
2	Return wire connection (to DC return)		

Warning: An exposed wire lead from a DC-input power source can conduct harmful levels of electricity. Be sure that no exposed portion of the DC-input power source wire extends from the power and relay connector. Statement 122

7. Insert the twisted-pair wire leads into the terminal block line and neutral connections.

8. Insert the wire (labeled number 1 in [Figure 21 on page 46](#)) lead into the neutral wire connection and the wire (labeled number 2 in [Figure 21 on page 46](#)) lead into the line wire connection.

Ensure that only wire *with insulation* extends from the connectors. See [Figure 21 on page 46](#).

9. Tighten the line and neutral terminal block screws to 8 in.-lb torque.

note: Do not exceed 10 in.-lb torque.

10. Connect the red wire to the positive pole of the DC power source, and connect the black wire to the return pole.

Ensure that each pole has a current-limiting-type fuse rated to at least 600 VAC/DC (such as the KLKD Midget fuse).

Wiring the DC Power Source

Read these cautions and warnings before wiring the switch the DC power source.

Caution: This product is intended to be supplied by a Listed Class 2 power source marked with Class 2 and rated from 9.6V to 60VDC, 2.1A.

Warning: A readily accessible two-poled disconnect device must be incorporated in the fixed wiring. Statement 1022

Warning: This product relies on the building's installation for short-circuit (overcurrent) protection. Ensure that the protective device is rated not greater than: 3A. Statement 1005

Warning: Installation of the equipment must comply with local and national electrical codes. Statement 1074

Warning: Before performing any of the following procedures, ensure that power is removed from the DC circuit. Statement 1003

Warning: Only trained and qualified personnel should be allowed to install, replace, or service this equipment.
Statement 1030

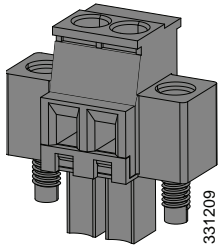
Caution: For wire connections to the power and alarm connectors, you must use UL- and CSA-rated, style 1007 or 1569 twisted-pair copper appliance wiring material (AWM) wire (such as Belden part number 9318).

To wire the switch to a DC power source, follow these steps:

1. Locate the two power connectors on the switch front panel labeled DC-A and DC-B (see [Figure 22 on page 47](#))

note: On the PoE-capable models of the switch, there is a third DC-input power connector on the switch front panel labeled PoE. See [Connecting Power to the Switch PoE DC-Input \(Optional\)](#), page 52.

Figure 22 Power Connector



2. Identify the connector positive and return DC power connections.

The labels for power connectors DC-A and DC-B are on the switch panel as displayed in [Table 12 on page 47](#).

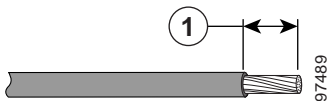
Table 12 DC-A and DC-B Power Connector Labels

Label	Connection
+	Positive DC power connection
-	Return DC power connection

3. Measure two strands of twisted-pair copper wire (18-to-20 AWG) long enough to connect to the DC power source.
4. Using an 18-gauge wire-stripping tool, strip each of the two twisted pair wires coming from each DC-input power source to 0.25 inch (6.3 mm) \pm 0.02 inch (0.5 mm).

Note: Do not strip more than 0.27 inch (6.8 mm) of insulation from the wire. Stripping more than the recommended amount of wire can leave exposed wire from the power connector after installation.

Figure 23 Stripping the Power Connection Wire

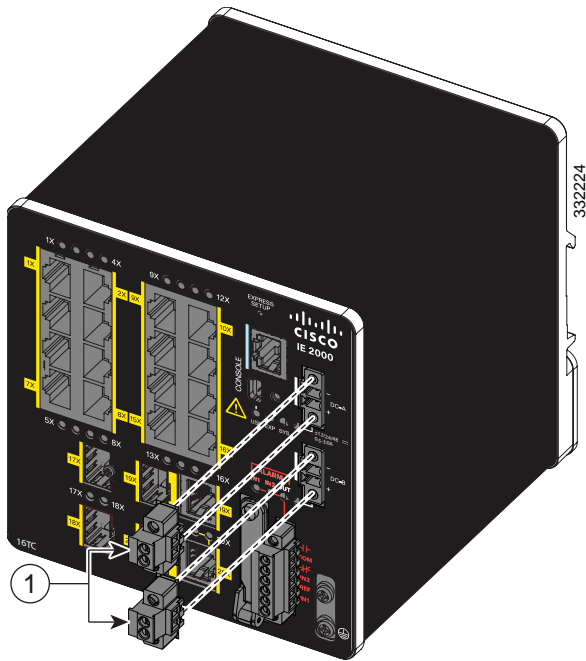


1	0.25 in. (6.3 mm) \pm 0.02 in. (0.5 mm)
---	---

5. Remove the two captive screws that attach the power connector to the switch, and remove the power connector.

Remove both connectors if you are connecting to two power sources. See [Figure 24 on page 48](#).

Figure 24 Removing the Power Connectors from the Switch



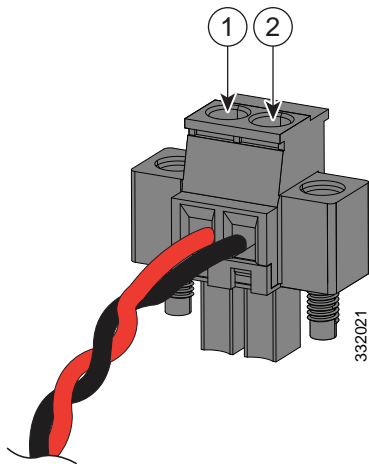
1	Power connectors
---	------------------

6. On the power connector, insert the exposed part of the positive wire into the connection labeled “+” and the exposed part of the return wire into the connection labeled “-”. See [Figure 25 on page 48](#).

Ensure that you cannot see any wire lead. Only wire *with insulation* should extend from the connector.

Warning: An exposed wire lead from a DC-input power source can conduct harmful levels of electricity. Be sure that no exposed portion of the DC-input power source wire extends from the connector(s) or terminal block(s).
Statement 122

Figure 25 Inserting Wires in the Power Connector

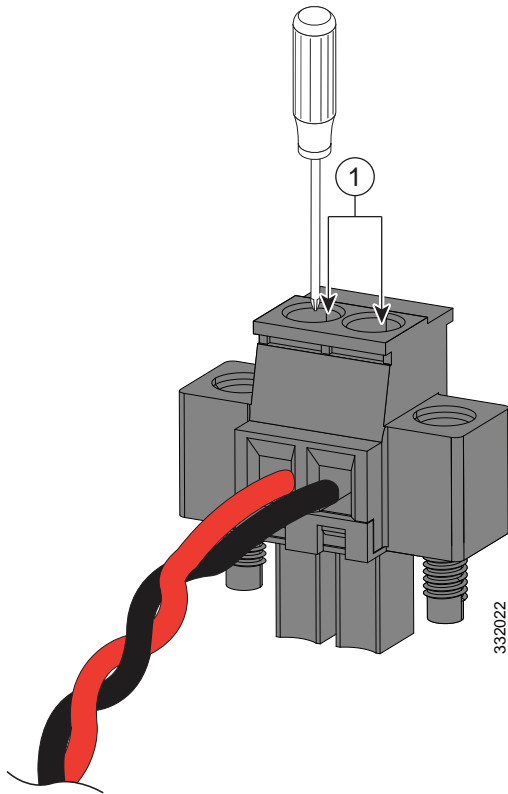


1	Power source positive connection	2	Power source return connection
---	----------------------------------	---	--------------------------------

7. Use a ratcheting torque flathead screwdriver to torque the power connector captive screws (above the installed wire leads) to 2 in-lb (0.23 N-m). See [Figure 26 on page 49](#).

Note: Do not over-torque the power connector's captive screws. The torque should not exceed 2 inch-lbs (0.23 N-m).

Figure 26 Torquing the Power Connector Captive Screws



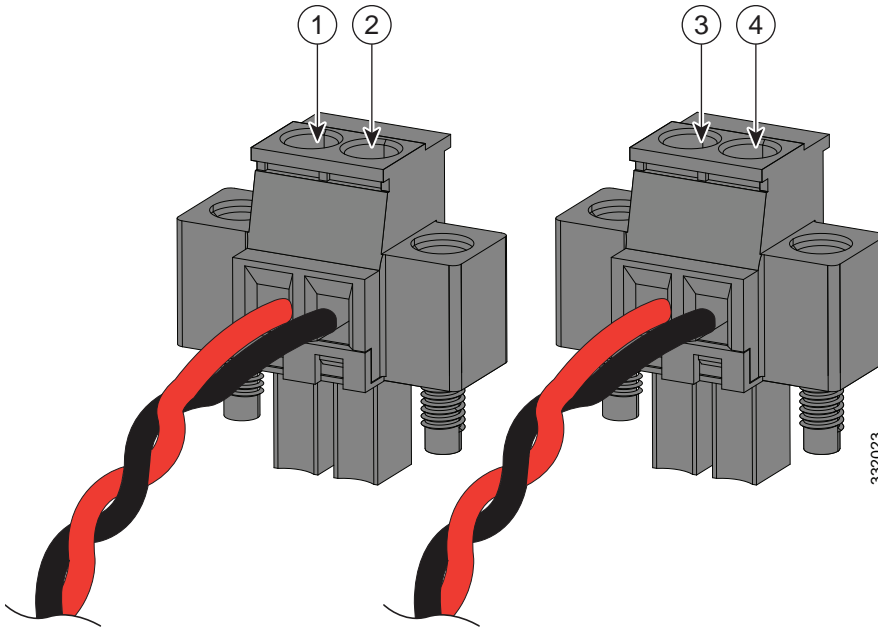
1	Power connector captive screws
---	--------------------------------

8. Connect the other end of the positive wire to the positive terminal on the DC power source, and connect the other end of the return wire to the return terminal on the DC power source.

When you are testing the switch, one power connection is sufficient. If you are installing the switch and are using a second power source, repeat steps 4 through 8 using the second power connector.

[Figure 27 on page 50](#) shows the completed DC-input wiring on a power connector for a primary power source and an optional secondary power source.

Figure 27 Completed DC Power Connections on the Power Connectors



1	Power source A positive connection	3	Power source B positive connection
2	Power source A return connection	4	Power source B return connection

For a -48 VDC power source, this table describes the wiring connections for [Figure 27 on page 50](#).

1	Power source A return connection	3	Power source B return connection
2	Power source A -48 VDC connection	4	Power source B -48 VDC connection

Attaching the Power Connectors to the Switch

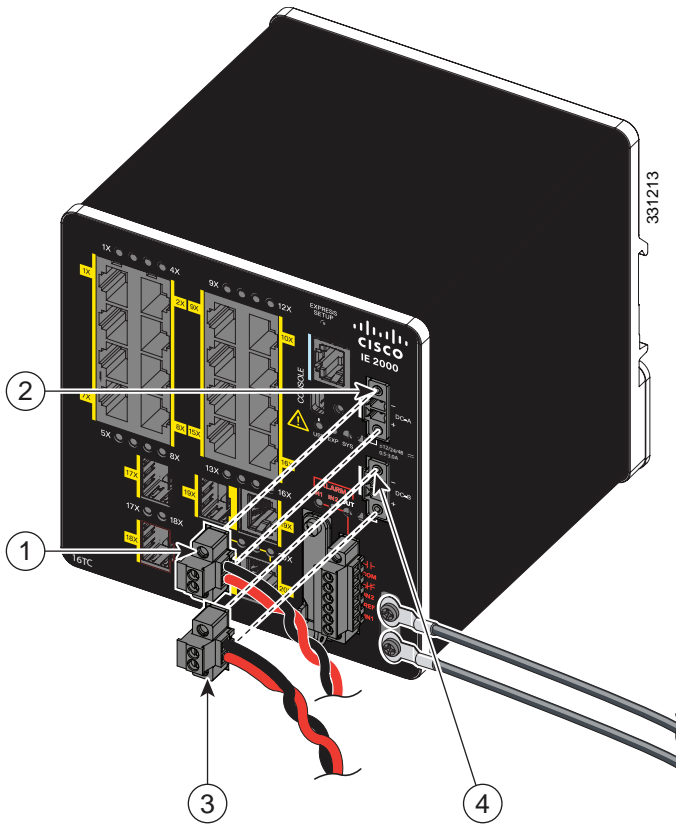
To attach the power connectors to the front panel of the switch, follow these steps:

1. Insert one power connector into the DC-A receptacle on the switch front panel, and the other into the DC-B receptacle. See [Figure 28 on page 51](#).

Warning: Failure to securely tighten the captive screws can result in an electrical arc if the connector is accidentally removed. Statement 397

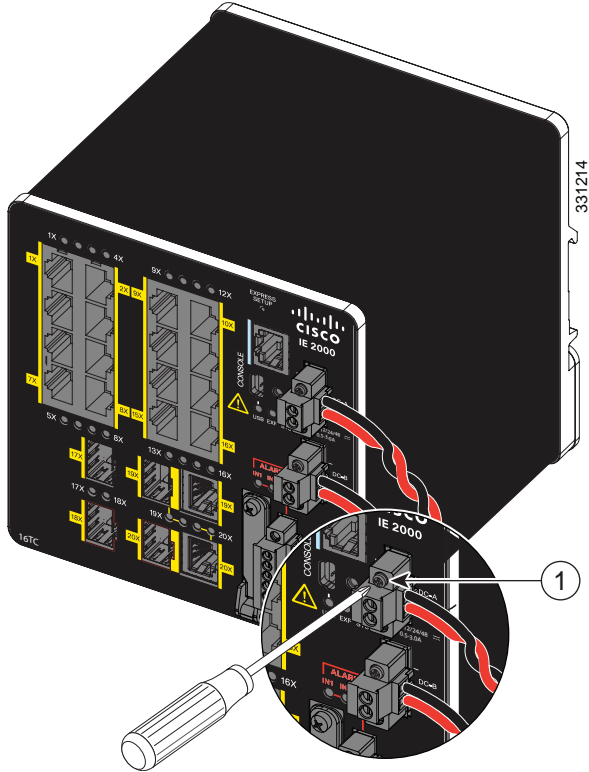
Warning: When you connect or disconnect the power and/or alarm connector with power applied, an electrical arc can occur. This could cause an explosion in hazardous area installations. Be sure that all power is removed from the switch and any other circuits. Be sure that power cannot be accidentally turned on or verify that the area is nonhazardous before proceeding. Statement 1058

Figure 28 Attaching the Power Connectors to the Switch



1	DC-A power connector	3	DC-B power connector
2	DC-A power connection	4	DC-B power connection

Figure 29 Connecting the Power Connectors to the Switch



1	DC-A power connector upper captive screw
---	--

2. Use a ratcheting torque flathead screwdriver to tighten the captive screws on the sides of the power connectors.

When you are testing the switch, one power source is sufficient. If you are installing the switch and are using a second power source, repeat this procedure for the second power connector (DC-B), which installs just below the primary power connector (DC-A).

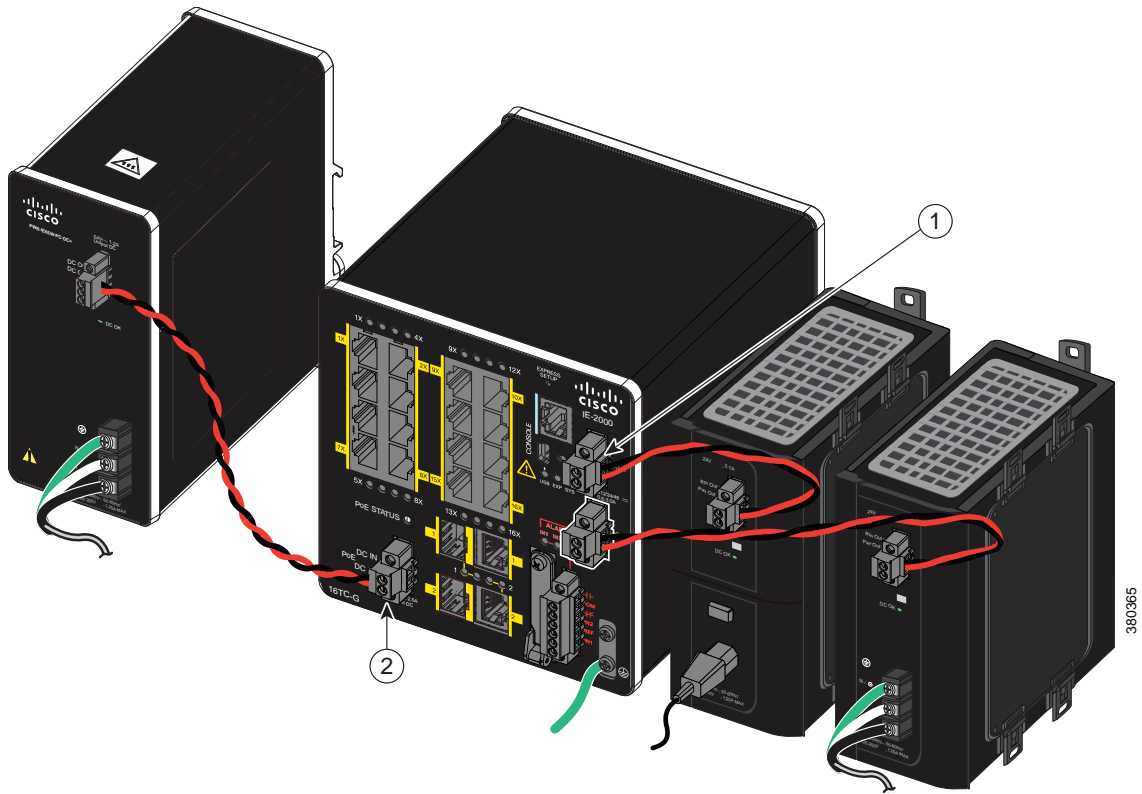
When you are installing the switch, secure the wires coming from the power connector so that they cannot be disturbed by casual contact. For example, use tie wraps to secure the wires to the rack.

Connecting Power to the Switch PoE DC-Input (Optional)

This procedure is applicable only to the IE 2000 switch models that are PoE capable. If you have a PoE capable IE 2000 switch and do not plan on using PoE, you do not need to attach power to the PoE DC-input connector; the switch can operate without the connection being made.

Figure 30 shows how a second power supply is connected to the switch to support PoE. PoE-capable Switch with PoE Power Supply Module Connected.

Figure 30 PoE-capable Switch with PoE Power Supply Module Connected



1	Power connector
2	PoE power connector

Warning: An exposed wire lead from a DC-input power source can conduct harmful levels of electricity. Be sure that no exposed portion of the DC-input power source wire extends from the connector(s) or terminal block(s).
Statement 122

Caution: Do not over-torque the PoE power connector's captive screws. The torque should not exceed 2 in-lb (0.23 N-m).

Note: The input rating is 48/54VDC 2.5A.

1. Verify that power is off to the DC circuit that you are going to attach to the switch PoE DC-input connector.

This can be either of the two power supplies (AC-input or DC-input) or site source DC.

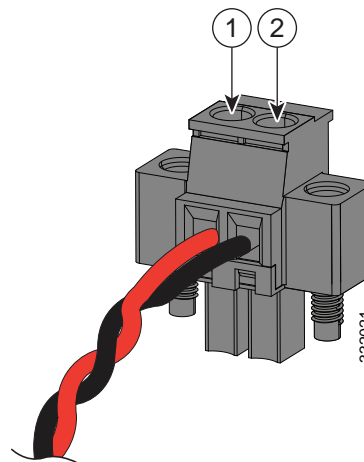
As an added precaution, place the appropriate safety flag and lockout devices at the source power circuit breaker, or place a piece of adhesive tape over the circuit breaker handle to prevent accidental power restoration while you are working on the circuit.

2. Locate the PoE DC-input power connector, which is labeled PoE, on the switch front panel.
3. Loosen the power connector's two screws and remove the plug portion of the connector from the switch.
4. Measure two strands of twisted-pair copper wire (18 AWG (0.8 mm²) long enough to connect the switch to the DC power source.
5. Using a wire-stripping tool, strip each of the two twisted pair wires coming from each DC-input power source to 0.25 inch (6.3 mm) ± 0.02 inch (0.5 mm).

Note: Do not strip more than 0.27 inch (6.8 mm) of insulation from the wire. Stripping more than the recommended amount of wire can leave exposed wire from the power connector after installation.

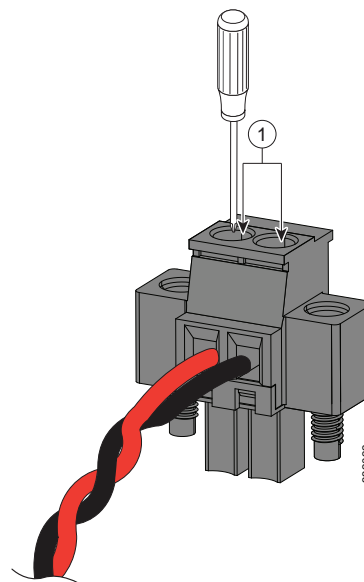
6. Loosen the two captive screws on the PoE power plug and insert the exposed part of the positive wire into the connection labeled "+" and the exposed part of the return wire into the connection labeled "-".

Ensure that you cannot see any wire lead. Only wire *with insulation* should extend from the connector.



1—Power source positive connection
2—Power source return connection

7. Use a ratcheting torque flathead screwdriver to tighten the power connector captive screws (above the installed wire leads) to 2 in-lb (0.23 N-m).



1—Power connector captive screws

-
8. Connect the other end of the positive wire to the positive terminal on the DC power source, and connect the other end of the return wire to the return terminal on the DC power source.
 9. Insert the wired power plug into the switch PoE power connector and tighten the two screws to secure the plug.

Applying Power to the Power Converter

Move the circuit breaker for the AC outlet or the DC control circuit to the *on* position.

The LED on the power converter front panel is green when the unit is operating normally. The LED is off when the unit is not powered or is not operating normally. After the power is connected, the switch automatically begins the power-on self- test (POST), a series of tests that verifies that the switch functions properly.

Running Boot Fast

When the switch powers on, it automatically initiates a boot fast sequence. The boot fast sequence allows the switch to boot up in less than 60 seconds. To test the switch, follow the steps in these sections:

- [Powering On the Switch, page 55](#)
- [Verifying Boot Fast, page 55](#)
- [Disconnecting Power, page 55](#)

Powering On the Switch

To apply power to a switch that is directly connected to a DC power source, locate the circuit breaker on the panel board that services the DC circuit, and switch the circuit breaker to the ON position.

Verifying Boot Fast

When you power on the switch, it automatically begins a boot fast sequence. The System LED blinks green as the Cisco IOS software image loads. If the boot fast sequence fails, the System LED turns red.

Note: Boot fast failures are usually fatal. Call Cisco TAC immediately if your switch does not complete boot fast successfully. See [Obtaining Documentation and Submitting a Service Request](#).

Note: You can disable the boot fast and run POST by using the Cisco IOS CLI. See the *Cisco IE 2000 Switch Software Configuration Guide* and the *Cisco IE 2000 Switch Command Reference* for more information.

Disconnecting Power

To disconnect power after successfully running boot fast, follow these steps:

1. Turn off power to the switch.
2. Disconnect the cables.

Installing the Switch

This section describes how to install the switch:

- [Installing the Switch on a DIN Rail, page 56](#)
- [Removing the Switch from a DIN Rail, page 57](#)

- [Installing the Switch on the Wall, page 58](#)

Warning: This equipment is supplied as “open type” equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The interior of the enclosure must be accessible only by the use of a tool. The enclosure must meet IP 54 or NEMA type 4 minimum enclosure rating standards.
Statement 1063

Warning: When used in a Class I, Division 2, hazardous location, this equipment must be mounted in a suitable enclosure with proper wiring method, for all power, input and output wiring, that complies with the governing electrical codes and in accordance with the authority having jurisdiction over Class I, Division 2 installations.
Statement 1066

Caution: To prevent the switch from overheating, ensure these minimum clearances:

- Top and bottom: 2.0 in. (50.8 mm)
- Exposed side (not connected to the module): 2.0 in. (50.8 mm)
- Front: 2.0 in. (50.8 mm)

Installing the Switch on a DIN Rail

The switch ships with a spring-loaded latch on the rear panel for a mounting on a DIN rail.

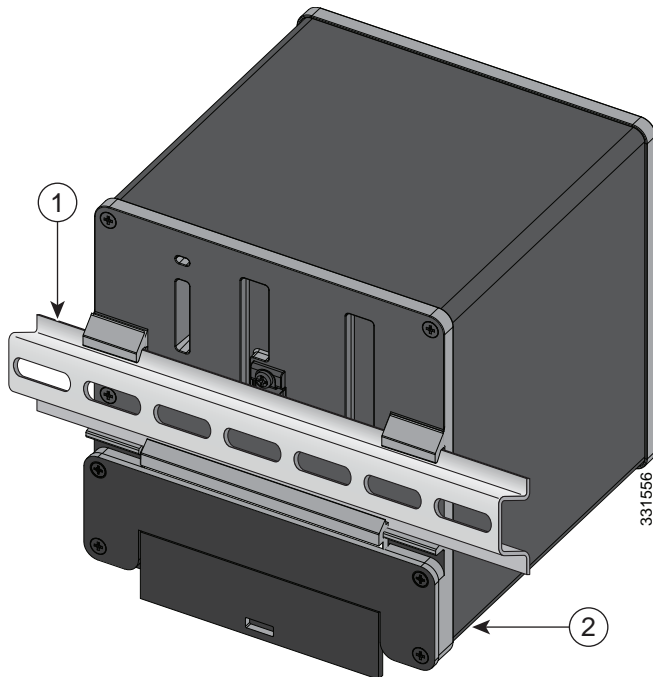
You can install the switch as a standalone device on the DIN rail or with the expansion modules already connected. You must connect expansion modules to the switch before installing the switch on the DIN rail.

To attach the switch to a DIN rail, follow these steps:

1. Position the rear panel of the switch directly in front of the DIN rail, making sure that the DIN rail fits in the space between the two hooks near the top of the switch and the spring-loaded latch near the bottom.
2. Holding the bottom of the switch away from the DIN rail, place the two hooks on the back of the switch over the top of the DIN rail. See [Figure 31 on page 57](#).

Caution: Do not stack any equipment on the switch.

Figure 31 Position the Hooks Over the DIN Rail



1	DIN Rail	2	Switch
---	----------	---	--------

3. Push the switch toward the DIN rail to cause the spring-loaded latch at the bottom rear of the switch to move down, and snap into place.

After the switch is mounted on the DIN rail, connect the power and alarm wires, as described in [Connecting Alarm Circuits, page 60](#).

For configuration instructions about the CLI setup program, see [Configuring the Switch with the CLI-Based Setup Program, page 101](#)

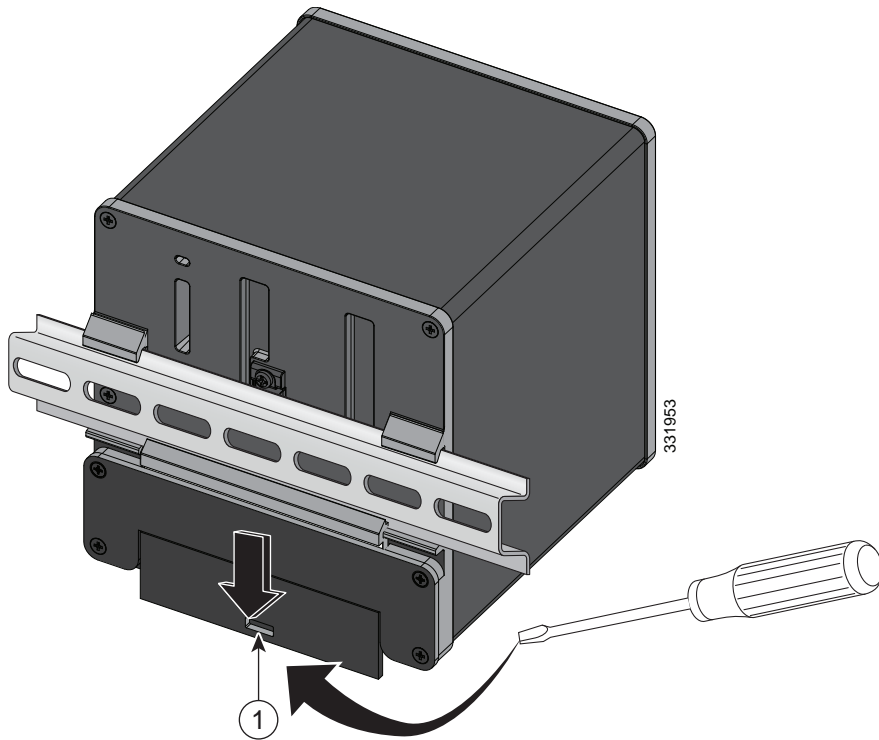
For instructions on how to remove the switch from a DIN rail, see [Removing the Switch from a DIN Rail, page 57](#).

Removing the Switch from a DIN Rail

To remove the switch from a DIN rail, follow these steps:

1. Ensure that power is removed from the switch, and disconnect all cables and connectors from the front panel of the switch.
2. Insert a tool such as a flathead screwdriver in the slot at the bottom of the spring-loaded latch and use it to release the latch from the DIN rail. See [Figure 32 on page 58](#).
3. Pull the bottom of the switch away from the DIN rail, and lift the hooks off the top of the DIN rail. See [Figure 32](#).

Figure 32 Releasing the Spring-Loaded Latch from the DIN Rail



1	Push latch down
---	-----------------

4. Remove the switch from the DIN rail.

Installing the Switch on the Wall

Use the wall mount bracket to install the switch on the wall. According to the model of your IE2000 switch, choose one of the following wall mount bracket model:

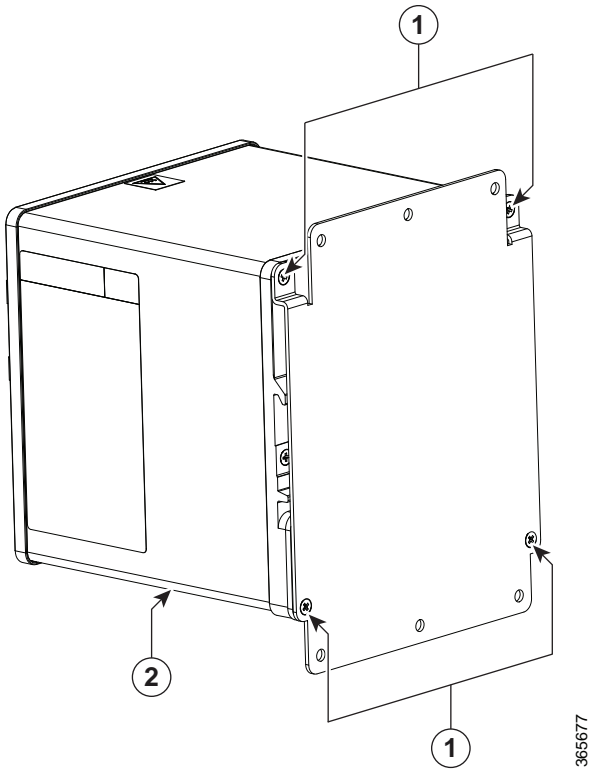
- WALLMOUNT-IE2K-04
- WALLMOUNT-IE2K-08
- WALLMOUNT-IE2K-16

To attach the switch to a wall, follow these steps.

Warning: Read the wall-mounting instructions carefully before beginning installation. Failure to use the correct hardware or to follow the correct procedures could result in a hazardous situation to people and damage to the system. Statement 378

1. Remove four corner screws from the switch.
2. Align the wall mount bracket to the rear panel of the switch. Thread the 4-40 screws provided with the wall mount kit through each of the corner bores in the bracket and then into the switch rear cover. Tighten the screws, as shown in [Figure 33 on page 59](#).
3. Position the switch with mounted bracket against the wall in the desired location.

Figure 33 Wall Mount Bracket Installed to the Switch

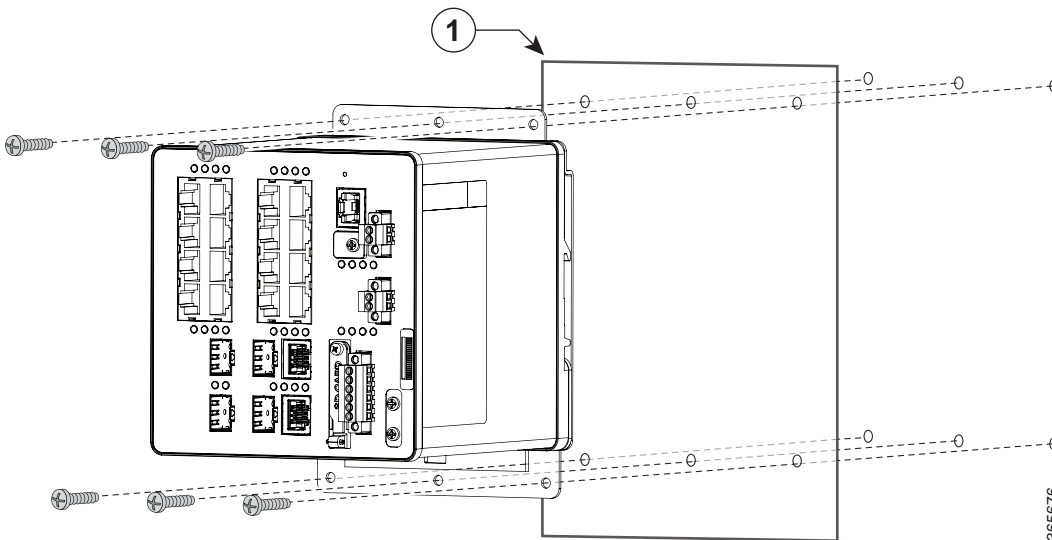


365677

1	4-40x5/8 Phillips Flat Head Screws	2	Switch
---	------------------------------------	---	--------

4. Place six screws and screw them into the wall, as shown in [Figure 34 on page 59](#).

Figure 34 Wall Mount Bracket



365676

1	Wall
---	------

After the switch is mounted on the wall, connect the power, alarm, and ground wires, as described in [Wiring the DC Power Source](#), [Connecting Alarm Circuits](#), and [Grounding the Switch](#).

For configuration instructions about the CLI setup program, see [Configuring the Switch with the CLI-Based Setup Program](#), page 101

Connecting Alarm Circuits

After the switch is installed, you are ready to connect the DC power and alarm connections.

- [Wiring the Protective Ground and DC Power for Alarm Circuits](#), page 60
- [Wiring the External Alarms](#), page 60

Wiring the Protective Ground and DC Power for Alarm Circuits

For instructions on grounding the switch and connecting the DC power, see [Grounding the Switch](#), page 40.

Wiring the External Alarms

The switch has two alarm input and one alarm output relay circuits for external alarms. The alarm input circuits are designed to sense if the alarm input is open or closed relative to the alarm input reference pin. Each alarm input can be configured as an open or closed contact. The alarm output relay circuit has a normally open and a normally closed contact.

Alarm signals are connected to the switch through the six-pin alarm connector. Three connections are dedicated to the two alarm input circuits: alarm input 1, alarm input 2, and a reference ground. An alarm input and the reference ground wiring connection are required to complete a single alarm input circuit. The three remaining connections are for the alarm output circuit: a normally open output, a normally closed output, and a common signal. An alarm output and the common wiring connection are required to complete a single alarm output circuit.

The labels for the alarm connector are on the switch panel and are displayed in [Table 13 on page 60](#).

Table 13 Alarm Connector Labels (Top to Bottom)

Label	Connection
NO	Alarm Output Normally Open (NO) connection
COM	Alarm Output Common connection
NC	Alarm Output Normally Closed (NC) connection
IN2	Alarm Input 2
REF	Alarm Input Reference Ground connection
IN1	Alarm Input 1

Warning: Explosion Hazard—Do not connect or disconnect wiring while the field-side power is on; an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or that the area is nonhazardous before proceeding. Statement 1081

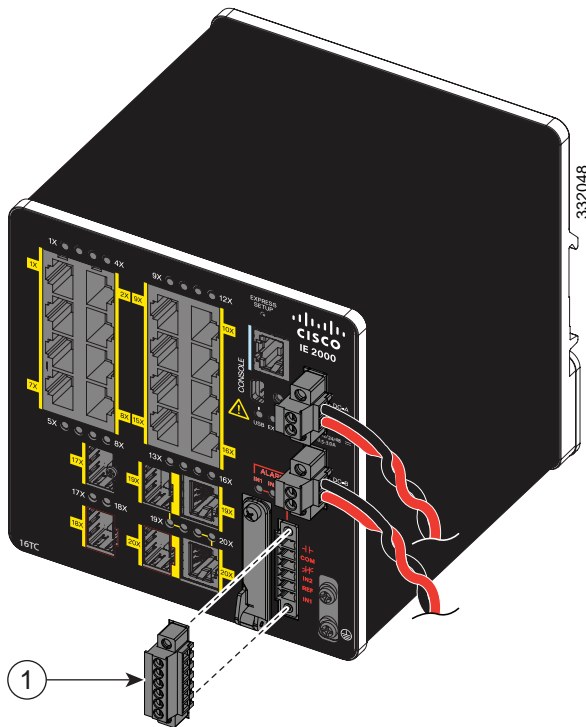
Caution: The input voltage source of the alarm output relay circuit must be an isolated source and limited to less than or equal to 24 VDC, 1.0 A or 48 VDC, 0.5 A.

Note: Wire connections to the power and alarm connectors must be UL- and CSA-rated, style 1007 or 1569 twisted-pair copper appliance wiring material (AWM) wire (such as Belden part number 9318).

To wire the switch to an external alarm device, follow these steps:

1. Remove the captive screws that hold the alarm connector on the switch, and remove the connector from the switch chassis.

Figure 35 Removing the Alarm Connector

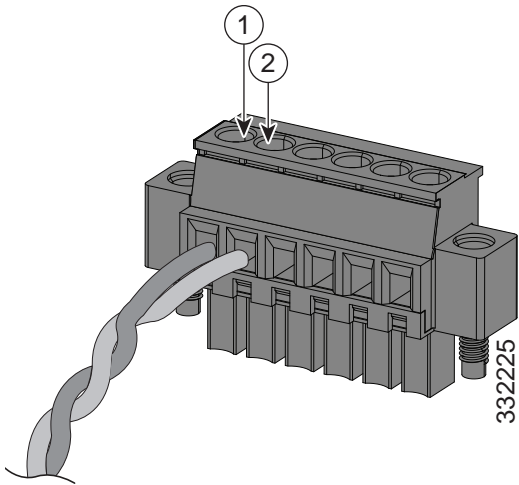


1	Alarm connector
---	-----------------

2. Measure two strands of twisted-pair wire (18-to-20 AWG) long enough to connect to the external alarm device.
You can choose between setting up an external alarm input or output circuit.
3. Use a wire stripper to remove the casing from both ends of each wire to 0.25 inch (6.3 mm) ± 0.02 inch (0.5 mm).
Do not strip more than 0.27 inch (6.8 mm) of insulation from the wires. Stripping more than the recommended amount of wire can leave exposed wire from the alarm connector after installation.
4. Insert the exposed wires for the external alarm device into the connections based on an alarm input or output circuit setup (see [Table 13 on page 60](#)).

For example, to wire an alarm input circuit, complete the IN1 and REF connections (See [Figure 36 on page 62](#)).

Figure 36 Inserting Wires into the Alarm Connector (Alarm Input Circuit)

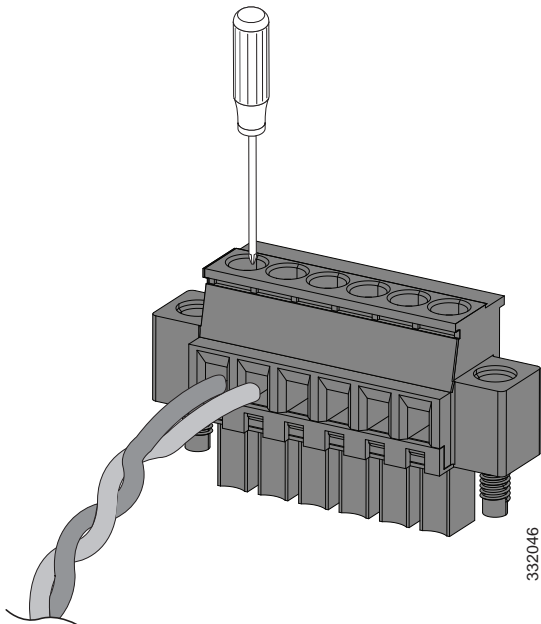


1	IN1 - External device connection 1	2	REF - External device connection 2
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5. Use a ratcheting torque flathead screwdriver to tighten the alarm connector captive screw (above the installed wire leads) to 2 in-lb (0.23 N-m). (See [Figure 37 on page 62.](#))

Note: Do not over-torque the power and alarm connectors' captive screws. Do not exceed 2 inch-lbs (0.23 N-m) torque.

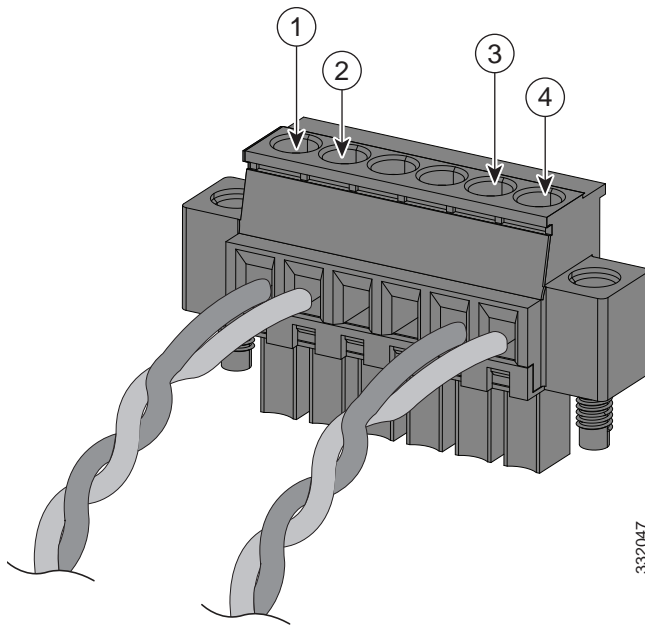
Figure 37 Securing the Alarm Connector Captive Screws



6. Repeat the above steps to insert the input and output wires of one additional external alarm device into the alarm connector.

[Figure 38 on page 63](#) shows the completed wiring for two external alarm devices. The first alarm device circuit is wired as an alarm input circuit; the IN1 and REF connections complete the circuit. The second alarm device circuit is wired as an alarm output circuit that works on a normally open contact basis; the NO and COM connections complete the circuit.

Figure 38 Completed Connections for Three External Alarm Devices on the Alarm Connector



1	IN1 wired connection	3	COM wired connection
2	REF wired connection	4	NO wired connection

Attaching the Alarm Connector to the Switch

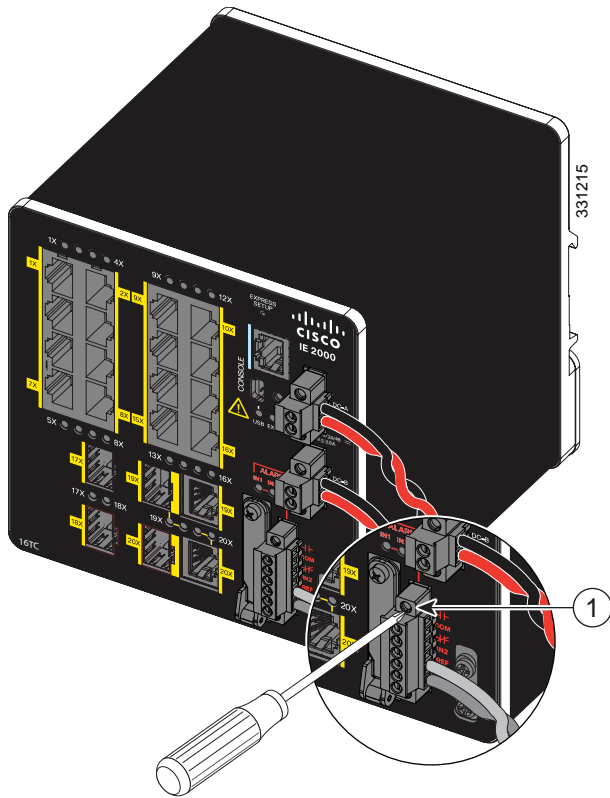
Warning: Failure to securely tighten the captive screws can result in an electrical arc if the connector is accidentally removed. Statement 397

Warning: When you connect or disconnect the power and/or alarm connector with power applied, an electrical arc can occur. This could cause an explosion in hazardous area installations. Be sure that all power is removed from the switch and any other circuits. Be sure that power cannot be accidentally turned on or verify that the area is nonhazardous before proceeding. Statement 1058

To attach the alarm connector to the front panel of the switch:

1. Insert the alarm connector into the receptacle on the switch front panel. See [Figure 39 on page 64](#).

Figure 39 Connecting the Alarm Connector to the Switch



1 Alarm connector upper captive screw

2. Use a ratcheting torque flathead screwdriver to tighten the captive screws on the sides of the alarm connector.

Connecting Destination Ports

These section provide more information about connecting to the destination ports:

- [Connecting to 10/100 and 10/100/1000 Ports, page 64](#)
- [Installing and Removing SFP Modules, page 66](#)
- [Connecting to SFP Modules, page 69](#)
- [Connecting to a Dual-Purpose Port, page 71](#)

Connecting to 10/100 and 10/100/1000 Ports

The switch 10/100/1000 ports automatically configure themselves to operate at the speed of attached devices. If the attached ports do not support autonegotiation, you can explicitly set the speed and duplex parameters. Connecting devices that do not autonegotiate or that have their speed and duplex parameters manually set can reduce performance or result in no linkage.

Warning: Do not connect or disconnect cables to the ports while power is applied to the switch or any device on the network because an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed from the switch and cannot be accidentally be turned on, or verify that the area is nonhazardous before proceeding. Statement 1070

To maximize performance, choose one of these methods for configuring the Ethernet ports:

- Let the ports autonegotiate both speed and duplex.
- Set the port speed and duplex parameters on both ends of the connection.

The models that support PoE provide up to four ports of either PoE (15.4 W per port; IEEE 802.3af) or PoE+ (30 W per port; IEEE 802.3at), depending on the power source used. For more information, see [Technical Specifications, page 81](#).

Caution: To prevent electrostatic-discharge (ESD) damage, follow standard board and component handling procedures.

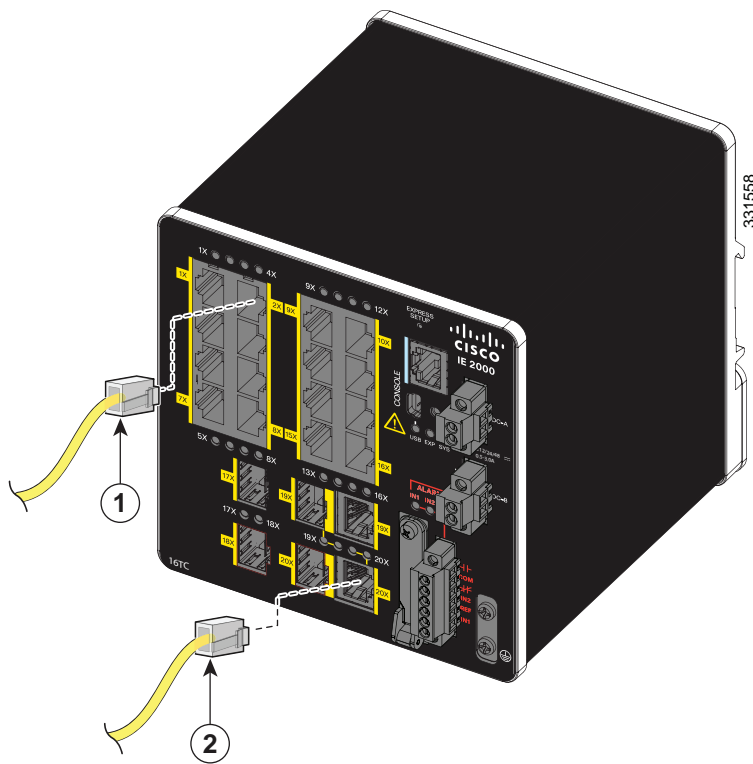
To connect to 10BASE-T, 100BASE-TX or 1000BASE-T devices, follow these steps:

1. When connecting to workstations, servers, routers, and Cisco IP phones, connect a straight-through cable to an RJ-45 connector on the front panel. See [Figure 40 on page 65](#).

When connecting to 1000BASE-T-compatible devices, use a twisted four-pair, CAT5 or higher cable.

The auto-MDIX feature is enabled by default. For configuration information for this feature, see the *Cisco IE 2000 Switch Software Configuration Guide* or the *Cisco IE 2000 Switch Command Reference*.

Figure 40 Connecting to an Ethernet Port



1	10/100 port	2	10/100 or 10/100/100 port (depending on model)
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2. Connect the other end of the cable to an RJ-45 connector on the other device.

The port LED turns on when both the switch and the connected device establish the link.

The port LED is amber while Spanning Tree Protocol (STP) discovers the topology and searches for loops. This can take up to 30 seconds, and then the port LED turns green. If the port LED does not turn on:

- The device at the other end might not be turned on.
- There might be a cable problem or a problem with the adapter installed in the attached device. For solutions to cabling problems, see [Troubleshooting, page 75](#)

3. Reconfigure and reboot the connected device if necessary.

4. Repeat Steps 1 through 3 to connect each device.

Installing and Removing SFP Modules

These sections describe how to install and remove SFP modules. SFP modules are inserted into SFP module slots on the front of the switch. Field-replaceable SFP modules provide the uplink interfaces, send (TX) and receive (RX).

You can use any combination of rugged SFP modules. See [Table 2 on page 19](#) for a list of supported modules. Each SFP module must be of the same type as the SFP module on the other end of the cable, and the cable must not exceed the stipulated cable length for reliable communications. See [Table 2 on page 19](#) for cable stipulations for SFP module connections.

Caution: When you use commercial SFP modules such as CWDM and 1000BX-U/D, reduce the maximum operating temperature by 59° F (15° C). The minimum operating temperature is 32° F (0° C).

Caution: To prevent electrostatic-discharge (ESD) damage, follow standard board and component handling procedures.

Warning: Do not insert and remove SFP modules while power is on; an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed or the area is nonhazardous before proceeding. Statement 1087

[Figure 41 on page 66](#) shows an LC SFP module with a bale-clasp latch.

Caution: Do not install or remove the LC SFP module with fiber-optic cables attached because of potential damage to the cables, the cable connector, or the optical interfaces in the SFP module. Disconnect all cables before removing or installing an SFP module. Removing and installing an SFP module can shorten its useful life. Do not remove and insert SFP modules more often than is absolutely necessary.

Figure 41 LC SFP Module with Open Bale-Clasp Latch

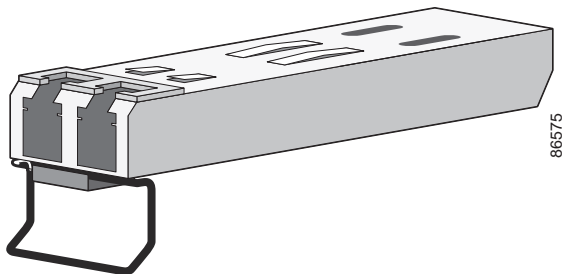
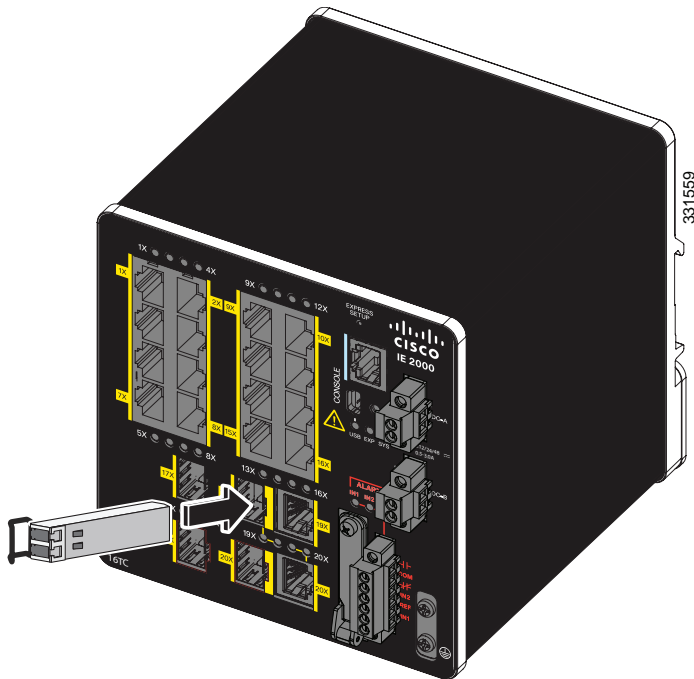


Figure 42 Installing an SFP Module into an SFP Module Slot



Installing LC SFP Modules

To insert an LC SFP module into the SFP module slot:

1. Attach an ESD-preventive wrist strap to your wrist and to a grounded bare metal surface.
2. Find the send (TX) and receive (RX) markings that identify the correct side of the SFP module.

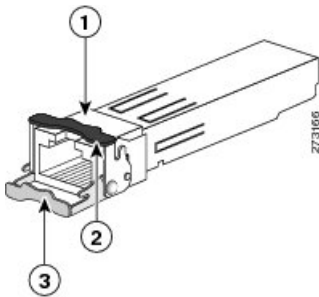
On some SFP modules, the send and receive (TX and RX) markings might be replaced by arrows that show the direction of the connection, either send or receive (TX or RX).
3. Align the SFP module sideways in front of the slot opening.
4. Insert the SFP module into the slot until the connector on the module snaps into place in the rear of the slot. See [Figure 42 on page 67](#).
5. Remove the dust plugs from the SFP module optical ports and store them for later use.

Caution: Do not remove the dust plugs from the SFP module port or the rubber caps from the fiber-optic cable until you are ready to connect the cable. The plugs and caps protect the SFP module ports and cables from contamination and ambient light.
6. Insert the LC cable connector into the SFP module.

Installing 1000BASE-T SFP Modules

The 1000BASE-T (copper) SFP transceiver, see [Figure 43 on page 68](#), has a bale-clasp locking mechanism that secures the transceiver in the module socket. An RJ-45 connector provides the transceiver's interface point to the network.

Figure 43 1000BASE-T SFP Transceiver



1	RJ-45 connector	3	Open bale-clasp latch (unlocked)
2	Closed bale-clasp latch mechanism (locked)		

Caution: To comply with GR-1089 intrabuilding lightning immunity requirements, you must use grounded, shielded, twisted-pair, CAT5 cabling.

When connecting to a 1000BASE-T-compatible server, workstation, or router, use four twisted-pair, straight-through CAT5 cabling for the SFP transceiver port. When connecting to a 1000BASE-T-compatible switch or repeater, use four twisted-pair, crossover CAT5 cabling.

To install a 1000BASE-T SFP transceiver:

1. Attach an ESD-preventive wrist strap to your wrist and to the ESD ground connector on the chassis or to a properly grounded bare metal surface.

Caution: To avoid ESD damage, handle the SFP by its sides; do not touch the connector pins.

2. Remove the new 1000BASE-T SFP module from its protective packaging.
3. Check the markings on the SFP transceiver to verify that you have the correct model for your network.
4. Position the SFP transceiver in front of the port socket opening.

Note: Different Cisco devices have different SFP transceiver socket configurations. Your Cisco device might require that the SFP transceiver be installed with the bale-clasp either in a latch-up or a latch-down orientation. Verify that the SFP transceiver is oriented correctly when you position it in front of the port socket.

5. With the bale-clasp closed (locked), slide the SFP transceiver into the socket until you feel it snap in place in the socket. You may hear an audible click as the SFP transceiver latch engages in the socket ([Figure 42 on page 67](#)).
6. Connect the network interface cable RJ-45 plug to the SFP RJ-45 connector.
7. Observe the port status LED:
 - Green indicates that the SFP transceiver and the target device established a link.
 - Amber indicates that the port is discovering the network topology and searching for loops. This process takes about 30 seconds, and then the LED turns green.
 - Off indicates that the target device might not be turned on, there might be a cable problem, or there might be a problem with the adapter installed in the target device. Refer to [Troubleshooting, page 75](#) for solutions to cabling problems.

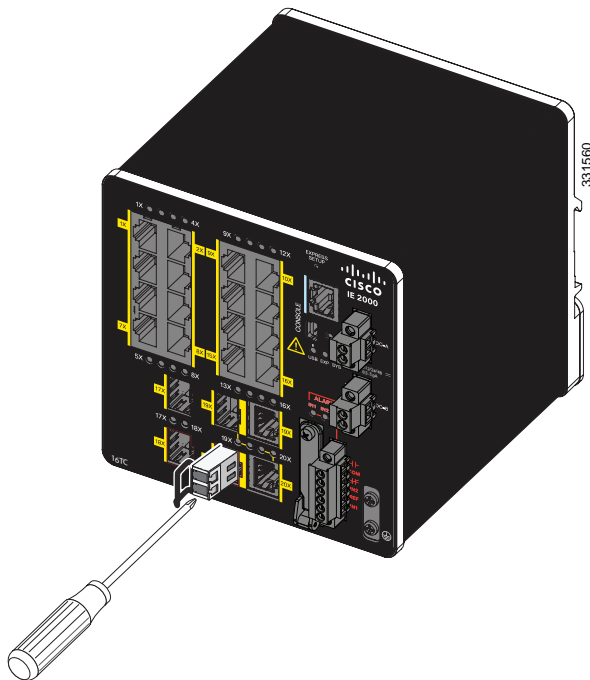
Removing SFP Modules from SFP Module Slots

To remove an SFP module from a module receptacle:

1. Attach an ESD-preventive wrist strap to your wrist and to a grounded bare metal surface.
2. Disconnect the LC from the SFP module.
3. Insert a dust plug into the optical ports of the SFP module to keep the optical interfaces clean.
4. Unlock and remove the SFP module.

If the module has a bale-clasp latch, pull the bale out and down to eject the module. If the bale-clasp latch is obstructed and you cannot use your index finger to open it, use a small, flat-blade screwdriver or other long, narrow instrument to open the bale-clasp latch. See [Figure 44 on page 69](#).

Figure 44 Opening a Bale-Clasp Latch on an SFP Module Using a Flat-Blade Screwdriver



1	Bale clasp
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5. Grasp the SFP module between your thumb and index finger, and carefully remove it from the module slot.
6. Place the removed SFP module in an antistatic bag or other protective environment.

Connecting to SFP Modules

This section describes how to connect to a fiber-optic or copper SFP port. To connect to an RJ-45 Gigabit Ethernet port, see [Connecting to a Dual-Purpose Port, page 71](#). For instructions on how to install or remove an SFP module, see [Installing and Removing SFP Modules, page 66](#).

Warning: Class 1 laser product. Statement 1008

Warning: Do not connect or disconnect cables to the ports while power is applied to the switch or any device on the network because an electrical arc can occur. This could cause an explosion in hazardous location installations. Be sure that power is removed from the switch and cannot be accidentally be turned on, or verify that the area is nonhazardous before proceeding. Statement 1070

Caution: Do not remove the rubber plugs from the SFP module port or the rubber caps from the fiber-optic cable until you are ready to connect the cable. The plugs and caps protect the SFP module ports and cables from contamination and ambient light.

Caution: Before connecting to the SFP module, be sure that you understand the port and cabling guidelines in [Preparing for Installation, page 29](#). See [Cable and Connectors, page 87](#) for information about the LC on the SFP module.

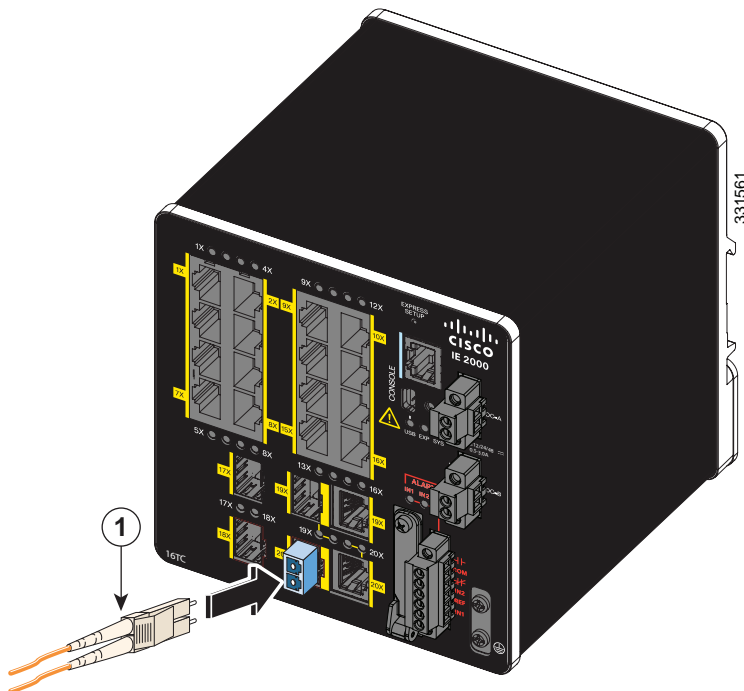
Caution: To prevent ESD damage, follow standard board and component handling procedures.

Connecting to a Fiber Optic SFP Module

To connect a fiber-optic cable to an SFP module, follow these steps:

1. Remove the rubber plugs from the module port and fiber-optic cable, and store them for future use.
2. Insert one end of the fiber-optic cable into the SFP module port. See [Figure 45 on page 70](#).

Figure 45 Connecting to a Fiber-Optic SFP Module Port



1	LC connector
---	--------------

3. Insert the other cable end into a fiber-optic receptacle on a target device.
4. Observe the port status LED:
 - The LED turns green when the switch and the target device have an established link.
 - The LED turns amber while the STP discovers the network topology and searches for loops. This process takes about 30 seconds, and then the port LED turns green.

-
- If the LED is off, the target device might not be turned on, there might be a cable problem, or there might be a problem with the adapter installed in the target device. See [Troubleshooting, page 75](#) for solutions to cabling problems.

5. If necessary, reconfigure and restart the switch or the target device.

Connecting to a 1000BASE-T SFP Module

Follow these steps to connect a CAT5 cable to a 1000BASE-T SFP module:

1. When connecting to servers, workstations, and routers, insert a four twisted-pair, straight-through cable in the RJ-45 connector. When connecting to switches or repeaters, insert a four twisted-pair, crossover cable.

When connecting to a 1000BASE-T device, use a four twisted-pair CAT5 cable.

2. Insert the other cable end in an RJ-45 connector on a target device.
3. Observe the port status LED.
 - The LED turns green when the switch and the target device have an established link.
 - The LED turns amber while the STP discovers the network topology and searches for loops. This process takes about 30 seconds, and then the port LED turns green.
 - If the LED is off, the target device might not be turned on, there might be a cable problem, or there might be problem with the adapter installed in the target device. See [Troubleshooting, page 75](#) for solutions to cabling problems.
4. If necessary, reconfigure and restart the switch or target device.

Connecting to a Dual-Purpose Port

The dual-purpose port is a single port with two interfaces, one for an RJ-45 cable and another for an SFP module. Only one interface can be active at a time. If both interfaces are connected, the SFP module has priority. For more information about dual-purpose ports, see [Power Connectors, page 17](#).

Warning: Class 1 laser product. Statement 1008

Caution: Do not remove the rubber plugs from the SFP module port or the rubber caps from the fiber-optic cable until you are ready to connect the cable. The plugs and caps protect the SFP module ports and cables from contamination and ambient light.

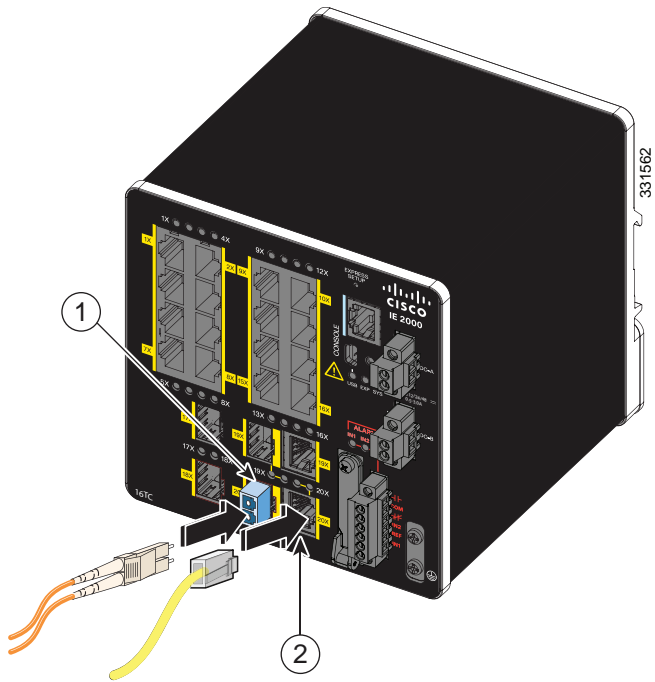
Caution: Before connecting to the SFP module, be sure that you understand the port and cabling stipulations in [Preparing for Installation, page 29](#). See [Cable and Connectors, page 87](#) for information about the LC on the SFP module.

To connect to a dual-purpose port, follow these steps:

1. Connect an RJ-45 connector to the 10/100/1000 port, or install an SFP module into the SFP module slot, and connect a cable to the SFP module port. See [Figure 46 on page 72](#).

For more information about RJ-45 connections, SFP modules, and optical connections, see [Connecting to 10/100 and 10/100/1000 Ports, page 64](#), [Installing and Removing SFP Modules, page 66](#), and [Connecting to SFP Modules, page 69](#).

Figure 46 Connecting to a Dual-Purpose Port



1	LC connector (optical)	2	RJ-45 connector (copper)
---	------------------------	---	--------------------------

2. Connect the other end of the cable to the other device.

By default, the switch detects whether an RJ-45 connector or SFP module is connected to a dual-purpose port and configures the port accordingly. You can change this setting and configure the port to recognize only an RJ-45 connector or only an SFP module by using the **media type** interface configuration command. For more information, see the *Cisco IE 2000 Switch Command Reference*.

Verifying Switch Operation

Before installing the switch in its final location, power on the switch, and verify that the switch powers up in boot fast style. The boot fast sequence allows the switch to boot up in less than 60 seconds.

Where to Go Next

If the default configuration is satisfactory, the switch does not need further configuration. You can use any of these management options to change the default configuration:

- Start Device Manager, which is in the switch memory, to manage individual and standalone switches. This is an easy-to-use web interface that offers quick configuration and monitoring. You can access Device Manager from anywhere in your network through a web browser. For more information, see [Running Express Setup, page 97](#) and the Device Manager online help.
- Start the Cisco Network Assistant application, which is described in the *Getting Started with Cisco Network Assistant* guide. Using the GUI, you can configure and monitor a switch cluster or an individual switch.
- Use the CLI to configure the switch as an individual switch from the console. See the *Command Reference* on Cisco.com for information about using the CLI.
- Start an SNMP application such as the CiscoView application.

-
- Start the Common Industrial Protocol (CIP) management tool. You can manage an entire industrial automation system with the CIP-based tools.



Troubleshooting

This chapter provides these topics for troubleshooting problems:

- [Diagnosing Problems, page 75](#)
- [How to Recover Passwords, page 78](#)
- [Finding the Switch Serial Number, page 78](#)

Diagnosing Problems

The switch LEDs provide troubleshooting information about the switch. They show boot fast failures, port-connectivity problems, and overall switch performance. You can also get statistics from Device Manager, the CLI, or an SNMP workstation. See the *Cisco IE 2000 Switch Software Configuration Guide*, the *Cisco IE 2000 Switch Command Reference* on Cisco.com, or the documentation that came with your SNMP application for details.

Switch Boot Fast

See [Verifying Switch Operation, page 72](#) for information on boot fast.

Note: Boot fast failures are usually fatal. Contact your Cisco TAC representative if your switch does not successfully complete boot fast.

Note: You can disable the boot fast and run POST by using the Cisco IOS CLI, see the *Cisco IE 2000 Switch Software Configuration Guide* and the *Cisco IE 2000 Switch Command Reference* for more information.

Switch LEDs

Look at the port LEDs information when troubleshooting the switch. See [LEDs, page 20](#) for a description of the LED colors and their meanings.

Switch Connections

Bad or Damaged Cable

Always examine the cable for marginal damage or failure. A cable might be just good enough to connect at the physical layer, but it could corrupt packets as a result of subtle damage to the wiring or connectors. You can identify this problem because the port has many packet errors or it constantly flaps (loses and regains link).

- Exchange the copper or fiber-optic cable with a known good cable.
- Look for broken or missing pins on cable connectors.
- Rule out any bad patch panel connections or media converters between the source and the destination. If possible, bypass the patch panel, or eliminate media converters (fiber-optic-to-copper).
- Try the cable in another port to see if the problem follows the cable.

Ethernet and Fiber-Optic Cables

Ensure that you have the correct cable:

- For Ethernet, use Category 3 copper cable for 10 Mb/s UTP connections. Use either CAT5, CAT5e, or CAT6 UTP for 10/100, 10/100/1000 Mb/s, and PoE connections.
- Verify that you have the correct fiber-optic cable for the distance and port type. Make sure that the connected device ports match and use the same type encoding, optical frequency, and fiber type.
- Determine if a copper crossover cable was used when a straight-through was required or the reverse. Enable auto-MDIX on the switch, or replace the cable.

Link Status

Verify that both sides have a link. A broken wire or a shutdown port can cause one side to show a link even though the other side does not have a link.

A port LED that is on does not guarantee that the cable is functional. It might have encountered physical stress, causing it to function at a marginal level. If the port LED does not turn on:

- Connect the cable from the switch to a known good device.
- Make sure that both ends of the cable are connected to the correct ports.
- Verify that both devices have power.
- Verify that you are using the correct cable type. See [Cables and Adapters, page 90](#) for information.
- Look for loose connections. Sometimes a cable appears to be seated but is not. Disconnect the cable, and then reconnect it.

10/100 and 10/100/1000 Port Connections

If a port appears to malfunction:

- Verify the status of all ports by checking the LEDs. For more information, see [Switch LEDs, page 75](#).
- Use the **show interfaces** privileged EXEC command to see if the port is error-disabled, disabled, or shut down. Reenable the port if necessary.
- Verify the cable type. See [Cable and Connectors, page 87](#).

SFP Module

Use only Cisco SFP modules. Each Cisco module has an internal serial EEPROM that is encoded with security information. This encoding verifies that the module meets the requirements for the switch.

- Inspect the SFP module. Exchange the suspect module with a known good module.
- Verify that the module is supported on this platform. (The switch release notes on Cisco.com list the SFP modules that the switch supports.)
- Use the **show interfaces** privileged EXEC command to see if the port or module is error-disabled, disabled, or shutdown. Reenable the port if needed.
- Ensure that all fiber-optic connections are clean and securely connected.

Interface Settings

Verify that the interface is not disabled or powered off. If an interface is manually shut down on either side of the link, it does not come up until you re-enable the interface. Use the **show interfaces** privileged EXEC command to see if the interface is error-disabled, disabled, or shut down on either side of the connection. If needed, re-enable the interface.

Ping End Device

Ping from the directly connected switch first, and then work your way back port by port, interface by interface, trunk by trunk, until you find the source of the connectivity issue. Make sure that each switch can identify the end device MAC address in its Content-Addressable Memory (CAM) table.

Spanning Tree Loops

STP loops can cause serious performance issues that look like port or interface problems.

A unidirectional link can cause loops. It occurs when the traffic sent by the switch is received by the neighbor, but the traffic from the neighbor is not received by the switch. A broken cable, other cabling problems, or a port issue can cause this one-way communication.

You can enable UniDirectional Link Detection (UDLD) on the switch to help identify unidirectional link problems. For information about enabling UDLD on the switch, see the “Understanding UDLD” section in the switch software configuration guide on Cisco.com.

Switch Performance

Speed, Duplex, and Autonegotiation

Port statistics that show a large amount of alignment errors, frame check sequence (FCS), or late-collisions errors, might mean a speed or duplex mismatch.

A common issue occurs when duplex and speed settings are mismatched between two switches, between a switch and a router, or between the switch and a workstation or server. Mismatches can happen when manually setting the speed and duplex or from autonegotiation issues between the two devices.

To maximize switch performance and to ensure a link, follow one of these guidelines when changing the duplex or the speed settings.

- Let both ports autonegotiate both speed and duplex.
- Manually set the speed and duplex parameters for the interfaces on both ends of the connection.
- If a remote device does not autonegotiate, use the same duplex settings on the two ports. The speed parameter adjusts itself even if the connected port does not autonegotiate.

Autonegotiation and Network Interface Cards

Problems sometimes occur between the switch and third-party network interface cards (NICs). By default, the switch ports and interfaces autonegotiate. Laptops or other devices are commonly set to autonegotiate, yet sometimes issues occur.

To troubleshoot autonegotiation problems, try manually setting both sides of the connection. If this does not solve the problem, there could be a problem with the firmware or software on the NIC. You can resolve this by upgrading the NIC driver to the latest version.

Cabling Distance

If the port statistics show excessive FCS, late-collision, or alignment errors, verify that the cable distance from the switch to the connected device meets the recommended guidelines. See [Cables and Adapters, page 90](#).

Resetting the Switch

These are reasons why you might want to reset the switch to the factory default settings:

- You installed the switch in your network and cannot connect to it because you assigned the wrong IP address.
- You want to reset the password on the switch.

Note: Resetting the switch deletes the configuration and reboots the switch.

Caution: If you press the Express Setup button when you power on, the automatic boot sequence stops, and the switch enters bootloader mode.

To reset the switch:

1. Press and hold the Express Setup button for about 10 seconds. The switch reboots. The system LED turns green after the switch completes rebooting.
2. Press the Express Setup button again for 3 seconds. A switch 10/100 Ethernet port blinks green.

The switch now behaves like an unconfigured switch. You can configure the switch by using the CLI setup procedure described in [Configuring the Switch with the CLI-Based Setup Program, page 101](#). You can also configure the switch by using Express Setup as described in [Running Express Setup, page 97](#).

How to Recover Passwords

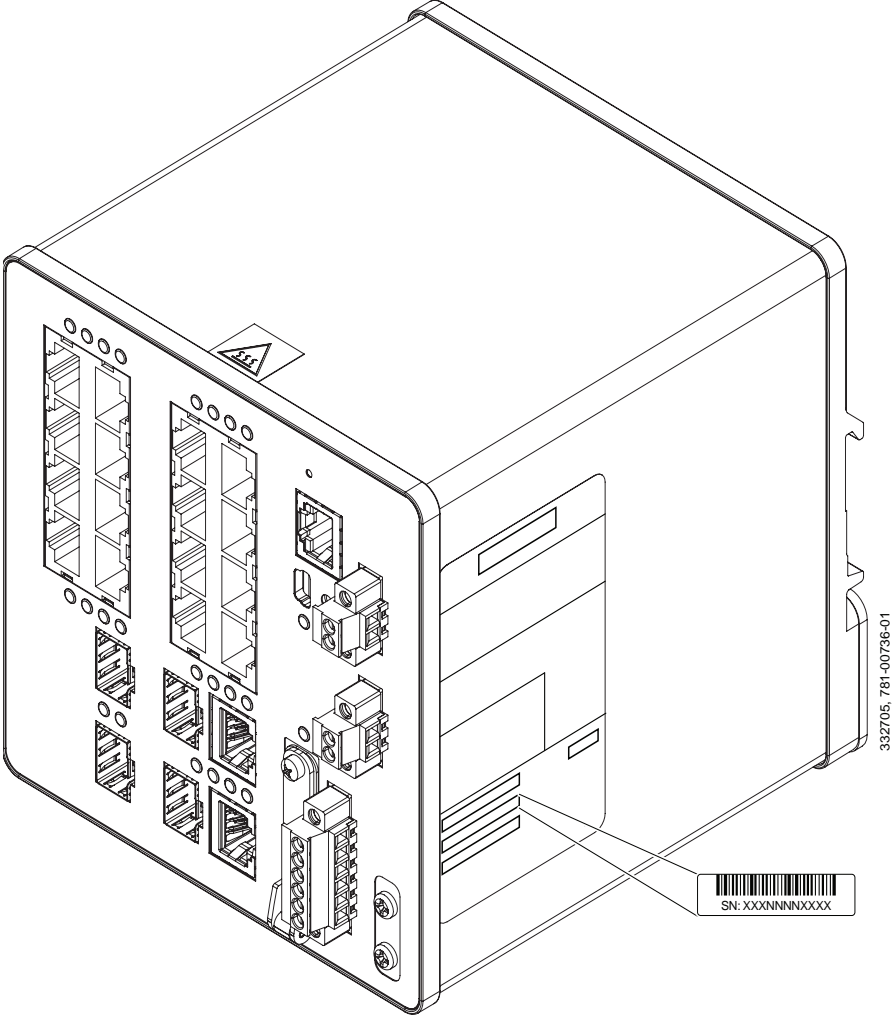
Password recovery is a feature that a system administrator can enable or disable. If password recovery is disabled, the only way to recover from a lost or forgotten password is to clear the switch configuration entirely. For this procedure, see [How to Recover Passwords, page 78](#).

The *Cisco IE 2000 Switch Software Configuration Guide* provides details about enabling and disabling the password recovery feature and the procedure for recovering passwords.

Finding the Switch Serial Number

If you contact Cisco Technical Assistance, you need to know the serial number of your switch. The serial number is on the compliance label on the right-hand side of the switch. See [Figure 47 on page 79](#). You can also use the **show version** privileged EXEC command to obtain the switch serial number.

Figure 47 Serial Number Location for the Cisco IE-2000 Switches





Technical Specifications

This appendix provides the technical specification for the Cisco IE 2000 switches.

Operating Temperature Specifications

Table 14 on page 81 lists the operating temperatures for the Cisco IE 2000 switches in three different environments.

Table 14 Operating Temperature for the Cisco IE 2000 Switches

	Industrial Automation and Hazardous Locations	Substation	Traffic Signal
Enclosure types	Sealed enclosures For example: NEMA4, NEMA4X, NEMA12, NEMA13, IP54, and IP66.	Vented enclosures For example: NEMA1, IP20, and IP21.	Fan or blower-equipped enclosures For example: NEMA TS-2. Note: The minimum airflow is 150 lfm ¹ .
¹ lfm = linear feet per minute.			

Note:

- The maximum ambient temperature of the IE-2000-16TC-G-X and IE-2000-16PTC-G-NX model is +65°C due to its conformal coating feature. The maximum ambient temperature of the IE-2000-16PTC-G-L, IE-2000-16PTC-G-E, and IE-2000-16PTC-G-NX model is +65°C if powering four PoE+ ports of 30 Watt each.
- The safety certifications apply only to ambient temperatures under 140°F (60°C). However, the Cisco IE 2000 switch can function in the substation and traffic signal installations under the environmental conditions shown in Table 14 on page 81.

Technical Specifications

Table 15 on page 81 lists the technical specifications for the Cisco IE 2000 switches.

Table 15 Cisco IE 2000 Series Technical Specifications

Environmental Ranges	
Operating temperature ¹	-40°C to +74°C <ul style="list-style-type: none"> ■ -40°C to +70°C (Vented Enclosure Operating) ■ -40°C to +60°C (Sealed Enclosure Operating) ■ -34°C to +74°C (100LFM or more Fan or Blower equipped Enclosure Operating) ■ -40°C to +85°C (Type Tested to +85°C for 16 hours)²
Storage temperature	-40 to 185°F (-40 to 85°C)

Table 15 Cisco IE 2000 Series Technical Specifications (continued)

Operating humidity	5 to 95% (non-condensing)
Operating shock	30 g at 11 ms
Operating altitude	Up to 13,000 ft (3962 m)
Storage altitude	Up to 40,000 ft (12,192 m)
Power Requirements	
DC input voltage	<ul style="list-style-type: none"> ■ Maximum operating range: 9.6 to 60 VDC ■ Nominal: 12, 24, or 48 VDC ■ The DC-input power supply is an SELV circuit, and it can only be connected to another SELV circuit. ■ Input voltage for power supplies: <ul style="list-style-type: none"> – To power the switch, PWR-IE50W-AC-IEC and PWR-IE50W-AC provide 24 VDC at 2.1 A. – To support PoE, power supplies PWR-IE65W-PC-AC and PWR-IE65W-PC-DC provide 54 VDC at 1.2 A. – To support PoE, power supplies PWR-IE170W-PC-AC and PWR-IE170W-PC-DC provide 54 VDC at 3.15 A. ■ The IE 2000 switch models with PoE capability are equipped with an additional DC input terminal block that allows the connection of a second power supply or a second input from site source DC power to operate the PoE ports. The PoE terminal block accepts 48 VDC or 54 VDC at up to 2.5 A, depending on the amount of power that is provided to the connected devices. <ul style="list-style-type: none"> – PoE mode: 48 VDC (nominal)/44-57 VDC (absolute range) – PoE+ mode: 54 VDC (nominal)/50-57 VDC (absolute range)
Maximum DC input current	<ul style="list-style-type: none"> ■ 1 A @ 48 VDC ■ 2 A @ 24 VDC ■ Switch models with PoE capability: 48 VDC or 54 VDC at 2.5 A

Table 15 Cisco IE 2000 Series Technical Specifications (continued)

<p>Power consumption¹</p>	<p>6-port models—9.5 W (typical), 15 W (maximum)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-4T-L ■ Cisco IE-2000-4T-B ■ Cisco IE-2000-4T-G-L ■ Cisco IE-2000-4T-G-B ■ Cisco IE-2000-4TS-L ■ Cisco IE-2000-4TS-B ■ Cisco IE-2000-4TS-G-L ■ Cisco IE-2000-4TS-G-B <p>6-port models—12W (typical), 18W (maximum)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-4S-TS-G-L ■ Cisco IE-2000-4S-TS-G-B
<p>Power consumption¹ (continued)</p>	<p>10-port models—12.5 W (typical), 17 W (maximum)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-8TC-L ■ Cisco IE-2000-8TC-B ■ Cisco IE-2000-8TC-G-L ■ Cisco IE-2000-8TC-G-B ■ Cisco IE-2000-8TC-G-N <p>10-port models—15 W (typical), 20 W (maximum)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-8TC-G-E <p>18-port models—11 W (typical), 18 W (maximum)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-16PTC-G-E ■ Cisco IE-2000-16PTC-G-L ■ Cisco IE-2000-16PTC-G-NX <p>20-port models—21 W (typical), 30 W (maximum)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-16TC-L ■ Cisco IE-2000-16TC-B ■ Cisco IE-2000-16TC-G-L ■ Cisco IE-2000-16TC-G-E ■ Cisco IE-2000-16TC-G-N ■ Cisco IE-2000-16TC-G-X

Table 15 Cisco IE 2000 Series Technical Specifications (continued)

Physical Dimensions	
Weight	<p>6-port models—2.45 lbs (1.11 kg)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-4T-L ■ Cisco IE-2000-4T-B ■ Cisco IE-2000-4T-G-L ■ Cisco IE-2000-4T-G-B ■ Cisco IE-2000-4TS-L ■ Cisco IE-2000-4TS-B ■ Cisco IE-2000-4TS-G-L ■ Cisco IE-2000-4TS-G-B ■ Cisco IE-2000-4S-TS-G-L ■ Cisco IE-2000-4S-TS-G-B
Weight (continued)	<p>10-port models—2.75 lbs (1.25 kg)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-8TC-L ■ Cisco IE-2000-8TC-B ■ Cisco IE-2000-8TC-G-L ■ Cisco IE-2000-8TC-G-B ■ Cisco IE-2000-8TC-G-N <p>10-port models—3.45 lbs (1.57 kg)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-8TC-G-E <p>18- and 20-port models: 4.35 lbs (1.98 kg)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-16PTC-G-E ■ Cisco IE-2000-16PTC-G-L ■ Cisco IE-2000-16PTC-G-NX ■ Cisco IE-2000-16TC-L ■ Cisco IE-2000-16TC-B ■ Cisco IE-2000-16TC-G-L ■ Cisco IE-2000-16TC-G-E ■ Cisco IE-2000-16TC-G-N ■ Cisco IE-2000-16TC-G-X

Table 15 Cisco IE 2000 Series Technical Specifications (continued)

<p>Dimensions ² (H x W x D) including DIN rail</p>	<p>6-port models—5.1 x 2.95 x 4.51 in. (12.7 x 7.37 x 11.46 cm)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-4S-TS-G-L ■ Cisco IE-2000-4S-TS-G-B ■ Cisco IE-2000-4T-L ■ Cisco IE-2000-4T-B ■ Cisco IE-2000-4T-G-L ■ Cisco IE-2000-4T-G-B ■ Cisco IE-2000-4TS-L ■ Cisco IE-2000-4TS-B
<p>Dimensions ² (H x W x D) including DIN rail (continued)</p>	<p>10-port models—5.1 x 3.6 x 4.51 in. (12.7 x 8.89 x 11.46 cm)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-8TC-L ■ Cisco IE-2000-8TC-B ■ Cisco IE-2000-8TC-G-L ■ Cisco IE-2000-8TC-G-B ■ Cisco IE-2000-8TC-G-N
	<p>10-port models—5.1 x 3.6 x 5.26 in. (12.7 x 8.89 x 13.36 cm)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-8TC-G-E
	<p>18-port and 20-port models—5.1 x 5.0 x 5.26 in. (12.7 x 12.45 x 13.36 cm)</p> <ul style="list-style-type: none"> ■ Cisco IE-2000-16TC-L ■ Cisco IE-2000-16TC-B ■ Cisco IE-2000-16TC-G-L ■ Cisco IE-2000-16TC-G-E ■ Cisco IE-2000-16TC-G-N ■ Cisco IE-2000-16TC-G-X ■ Cisco IE-2000-16PTC-G-E ■ Cisco IE-2000-16PTC-G-L ■ Cisco IE-2000-16PTC-G-NX
<p>¹Typical power consumption is with a 24 VDC input voltage at a 40°C (104°F) ambient temperature. Maximum power consumption is the extreme level at any operational DC input voltage over the entire operating temperature range.</p> <p>² To calculate the depth excluding the rail, subtract 0.22 in. (0.6 cm).</p>	

1. Operating temperatures exceeding 60°C are not covered by the product safety certifications and approvals. However, the switch can function in the installations under the environmental conditions listed.
2. The maximum operating temperature of the switch varies depending on the type of SFP module that you use.

Alarm Ratings

Table 16 on page 86 lists the alarm ratings for the Cisco IE 2000 switches.

Table 16 Alarm Input and Output Ratings

Alarm Ratings	Specification
Alarm input electrical specification	No power required—open or closed state detected.
Alarm output electrical specification	1.0 A @ 24 VDC or 0.5 A @ 48 VDC

Hazardous Locations Standards

Table 17 on page 86 lists the hazardous location standards for the Cisco IE 2000 switches.

Table 17 Hazardous Locations Standards

The following standards were used for the hazardous locations approvals and certifications:	Les normes suivantes ont été appliquées pour les approbations et les certifications dans le cadre d'environnements dangereux :
ANSI/ASA 12.12.01-2013	ANSI/ASA 12.12.01-2013
CAN/CSA C22.2 No. 60079-0: 11	CAN/CSA C22.2 n° 60079-0 : 11
CAN/CSA C22.2 No. 60079-15:12	CAN/CSA C22.2 n° 60079-15 :12
CSA C22.2 No. 213-M1987	CSA C22.2 n° 213-M1987
EN 60079-0:2012	EN 60079-0:2012
EN 60079-15:2010	EN 60079-15:2010
IEC 60079-0 6th Edition	IEC 60079-0, 6e édition
IEC 60079-15 4th Edition	IEC 60079-15, 4e édition
UL 60079-0, 5th Ed, 2009-10-21	UL 60079-0, 5e éd., 21-10-2009
UL 60079-15, 3rd Ed, 2009-7-17	UL 60079-15, 3e éd., 17-07-2009



Cable and Connectors

- [Connector Specifications, page 87](#)
- [Cables and Adapters, page 90](#)

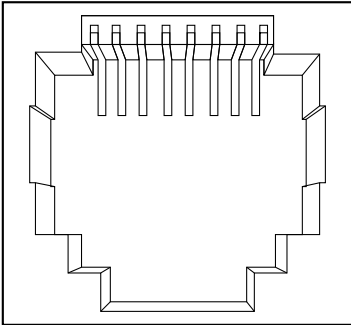
Connector Specifications

- [10/100 Ports, page 87](#)
- [SFP Module Connectors, page 88](#)
- [Dual-Purpose Ports, page 88](#)
- [Alarm Port, page 89](#)

10/100 Ports

The 10/100 Ethernet ports on the switches use RJ-45 connectors. [Figure 48 on page 87](#) shows the pinouts.

Figure 48 10/100 Port Pinouts

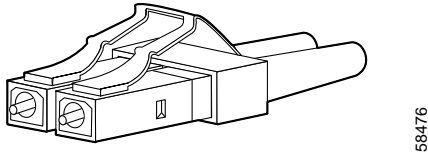
Pin	Label	1	2	3	4	5	6	7	8
1	RD+								
2	RD-								
3	TD+								
4	NC								
5	NC								
6	TD-								
7	NC								
8	NC								

For the three models of IE 2000 switch that support PoE, connector pins 4 and 5 supply +48 VDC and pins 7 and 8 are the DC voltage return lines.

SFP Module Connectors

Figure 49 on page 88 shows the MT-RJ SFP module fiber-optic local connector (LC).

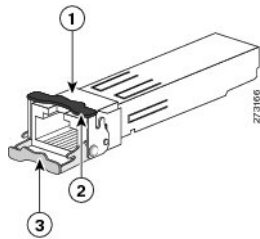
Figure 49 Fiber-Optic SFP Module LC Connector



Warning: Invisible laser radiation may be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments. Statement 1051

Figure 50 on page 88 shows the 1000BASE-T SFP module RJ-45 connector.

Figure 50 1000BASE-T SFP Module Connector



- 1 RJ-45 connector
- 2 Bale-clasp latching mechanism in the closed (locked) position
- 3 Bale-clasp latching mechanism in the open (unlocked) position

Dual-Purpose Ports

The 10/100/1000 Ethernet ports on the dual-purpose ports use RJ-45 connectors. Figure 51 on page 88 shows the pinouts.

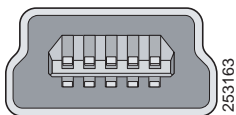
Figure 51 10/100/1000 Port Pinouts

Pin	Label	1	2	3	4	5	6	7	8
1	TP0+								
2	TP0-								
3	TP1+								
4	TP2+								
5	TP2-								
6	TP1-								
7	TP3+								
8	TP3-								

Console Port

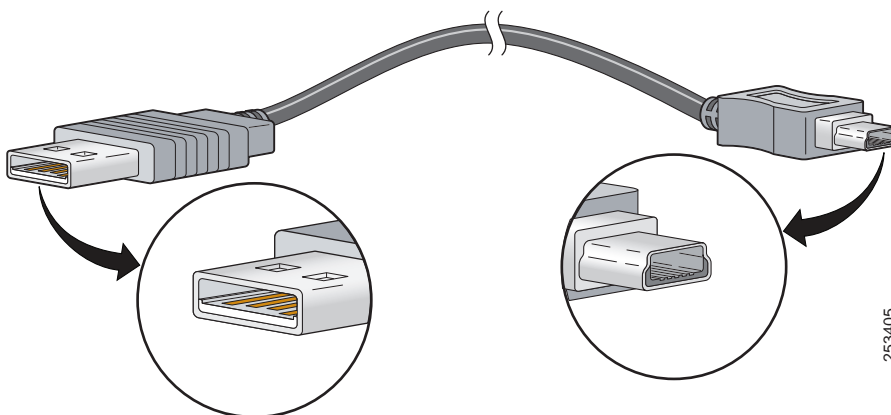
The switch has two console ports: a USB 5-pin mini-Type B port on the front panel (see [Figure 52 on page 89](#)) and an RJ-45 console port on the rear panel.

Figure 52 USB Mini-Type B Port



The USB console port uses a USB Type A to 5-pin mini-Type B cable, shown in [Figure 53 on page 89](#). The USB Type A-to-USB mini-Type B cable is not supplied. You can order an accessory kit (part number 800-33434) that contains this cable.

Figure 53 USB Type A-to-USB 5-Pin Mini-Type B Cable



The RJ-45 console port uses an 8-pin RJ-45 connector (see [Table 22 on page 95](#) and [Table 23 on page 95](#)). The supplied RJ-45-to-DB-9 adapter cable is used to connect the console port of the switch to a console PC. You need to provide an RJ-45-to-DB-25 female DTE adapter if you want to connect the switch console port to a terminal. You can order a kit (part number ACS-DSBUASYN=) containing that adapter. For console port and adapter pinout information, see [Table 22 on page 95](#) and [Table 23 on page 95](#).

Alarm Port

For information on alarm ratings, see [Alarm Ratings, page 86](#).

The labels for the alarm connector pin-outs are on the switch panel and are displayed in [Table 18 on page 89](#).

Table 18 Alarm Connector Labels (Top to Bottom)

Label	Connection
NO	Alarm Output Normally Open (NO) connection
COM	Alarm Output Common connection
NC	Alarm Output Normally Closed (NC) connection
IN2	Alarm Input 2
REF	Alarm Input Reference Ground connection
IN1	Alarm Input 1

Cables and Adapters

- [SFP Module Cables, page 90](#)
- [Cable Pinouts, page 93](#)
- [Console Port Adapter Pinouts, page 94](#)

SFP Module Cables

Each port must match the wave-length specifications on each end of the cable, and for reliable communications, the cable must not exceed the allowable length. Copper 1000BASE-T SFP transceivers use standard four twisted-pair, CAT5 (or greater) cable at lengths up to 328 feet (100 meters).

Notes

- The maximum operating temperature of the switch varies depending on SFP module type. See [Table 2 on page 19](#) for supported temperature ranges.
- Modal bandwidth applies only to multimode fiber (MMF).
- A mode-field diameter/cladding diameter = 9 micrometers/125 micrometers.
- 1000BASE-LX/LH SFP modules connected with MMF over a short link distance require a mode-conditioning patch cord.

Ordinary patch cords can cause transceiver saturation, resulting in an elevated bit error rate (BER). Using the 1000BASE-LX/LH SFP module with 62.5-micron diameter multimode fiber (MMF) requires a mode-conditioning patch cord between the single mode fiber (SMF) SFP module and the MMF cable on both the send and receive link ends.

- Link distances greater than 984 feet (300 m) require a mode-conditioning patch cord.
- 1000BASE-ZX SFP modules can send data up to 62 miles (100 km) by using dispersion-shifted SMF or low-attenuation SMF. The distance depends on fiber quality, the number of splices, and the connectors.
- Fiber-optic cable spans less than 15.43 miles (25 km) require a 5-decibel (dB) or 10-dB inline optical attenuator between the fiber-optic cable plant and the receiving port on the 1000BASE-ZX SFP module.

Table 19 Industrial and Rugged SFPs—Fiber-Optic SFP Module Port Cabling Specifications

Type of SFP Module	Model	Wavelength (nanometers)	Fiber Type	Core Size/Cladding Size (micron)	Modal Bandwidth (MHz/km)	Cable Distance
1000BASE-LX/LH	GLC-LX-SM-RGD	1310	M	62.5	500	1804 feet (550 m)
			SMF	50.0	400	1804 feet (550 m)
1000BASE-SX	GLC-SX-MM-RGD	850	MMF	50.0	500	1804 feet (550 m)
				G.652	—	6.2 miles (10 km)
				62.5/125	160	722 feet (220 m)
				62.5/125	200	902 feet (275 m)
1000BASE-ZX	GLC-ZX-SM-RGD	1550	SMF	50/125	400	1640 feet (500 m)
				G.652	500	1804 feet (550 m)
					—	43.4 to 62 miles (70 to 100 km)

Table 19 Industrial and Rugged SFPs–Fiber-Optic SFP Module Port Cabling Specifications (continued)

Type of SFP Module	Model	Wavelength (nanometers)	Fiber Type	Core Size/Cladding Size (micron)	Modal Bandwidth (MHz/km)	Cable Distance
100BASE-FX	GLC-FE-100FX-RGD	1310	MMF	62.5/125 62.5/125 50/125 50/125	160 200 400 500	1.24 miles (2 km)
100BASE-LX10	GLC-FE-100LX-RGD	1310	SMF	G.652	–	6.2 miles (10 km)
1000BASE-BX-D	GLC-BX40-D-I GLC-BX40-DA-I GLC-BX80-D-I)	1550 1490 1570	SMF	G.652	–	24.9 miles (40 km) 24.9 miles (40 km) 49.8 miles (80 km)
1000BASE-BX-U	GLC-BX40-U-I GLC-BX80-U-I	1310 1490	SMF	G.652	–	24.9 miles (40 km) 49.8 miles (80 km)

Table 20 Commercial SFPs–Fiber-Optic SFP Module Port Cabling Specifications

Type of SFP Module	Model	Wavelength (nanometers)	Fiber Type	Core Size/Cladding Size (micron)	Modal Bandwidth (MHz/km)	Cable Distance
1000BASE-BX10-D	GLC-BX-D	1490 TX 1310 RX	SMF	G.652	–	6.2 miles (10 km)
1000BASE-BX10-U	GLC-BX-U	1490 TX 1310 RX	SMF	G.652	–	6.2 miles (10 km)
1000BASE-LX/LH	GLC-LH-SM	1310	MMF SMF	62.5/125 50/125 50/125 G.652	500 400 500 –	1804 feet (550 m) 1804 feet (550 m) 1804 feet (550 m) 6.2 miles (10 km)
1000BASE-SX	GLC-SX-MM	850	MMF	62.5/125 62.5/125 50/125 50/125	160 200 400 500	722 feet (220 m) 902 feet (275 m) 1640 feet (500 m) 1804 feet (550 m)
100BASE-BX10-D	GLC-FE-100BX-D	1310 TX 1550 RX	SMF	G.652	–	6.2 miles (10 km)
100BASE-BX10-U	GLC-FE-100BX-U	1310 TX	SMF	G.652	–	6.2 miles (10 km)
100BASE-EX	GLC-FE-100EX	1310	SMF	G.652	–	24.9 miles (40 km)
100BASE-FX SFP	GLC-FE-100FX	1310	MMF	50/125 62.5/125	500	6562 feet (2 km)
100BASE-LX10	GLC-FE-100LX	1310	SMF	G.652	–	6.2 miles (10 km)
100BASE-ZX	GLC-FE-100ZX	1550	SMF	G.652	–	49.7 miles (80 km)

Table 20 Commercial SFPs–Fiber-Optic SFP Module Port Cabling Specifications (continued)

Type of SFP Module	Model	Wavelength (nanometers)	Fiber Type	Core Size/ Cladding Size (micron)	Modal Bandwidth (MHz/km)	Cable Distance
1000BASE-CWDM	CWDM	1470, 1490, 1510, 1530, 1550, 1570, 1590, 1610	SMF	G.652	–	62 miles (100 km)
1000BASE-DWDM	DWDM	1530.33, 1531.12, 1531.90, 1532.68, 1534.25, 1535.04, 1535.82, 1538.19, 1539.77, 1539.98, 1539.77, 1540.56, 1542.14, 1542.94, 1544.53, 1546.12, 1546.92, 1547.72, 1548.51, 1550.12, 1550.92, 1551.72, 1552.52, 1554.13, 1554.94, 1555.75, 1556.55, 1558.17, 1558.98, 1559.79, 1560.61	SMF	G.652	–	62 miles (100 km)
1000BASE-T	GLC-T	–	MMF	–	–	328 ft. (100 m)

View the CWDM data sheet at

http://www.cisco.com/en/US/prod/collateral/modules/ps5455/ps6575/product_data_sheet09186a00801a557c_ps4999_Products_Data_Sheet.html

View the DWDM data sheet at

http://www.cisco.com/en/US/prod/collateral/modules/ps5455/ps6576/product_data_sheet0900aecd80582763.html

Table 21 Extended Temperature SFPs–Fiber-Optic SFP Module Port Cabling Specifications

Type of SFP Module	Model	Wavelength (nanometers)	Fiber Type	Core Size/ Cladding Size (micron)	Modal Bandwidth (MHz/km)	Cable Distance
1000BASE-LX/LH	SFP-GE-L	1300	MMF or SMF	62.2 50 50 9/10	500 400 500 –	1804 feet (550 m) 1804 feet (550 m) 1804 feet (550 m) 6.2 miles (10 km)
1000BASE-LX/LH	GLC-LH-SMD	1310	MMF SMF	62.5 50.0 50.0 G.652	500 400 500 –	1804 feet (550 m) 1804 feet (550 m) 1804 feet (550 m) 6.2 miles (10 km)
1000BASE-EX	GLC-EX-SMD	1310	SMF	G.652	–	24.9 miles (40 km)

Table 21 Extended Temperature SFPs–Fiber-Optic SFP Module Port Cabling Specifications (continued)

Type of SFP Module	Model	Wavelength (nanometers)	Fiber Type	Core Size/ Cladding Size (micron)	Modal Bandwidth (MHz/km)	Cable Distance
1000BASE-SX	SFP-GE-S	850	MMF	62.5 62.5 50.0 50.0	160 200 400 500	722 feet (220 m) 902 feet (275 m) 1640 feet (500 m) 1804 feet (550 m)
1000BASE-SX	GLC-SX-MMD	850	MMF	62.5 62.5 50.0 50.0 50.0	160 200 400 500 2000	722 feet (220 m) 902 feet (275 m) 1640 feet (500 m) 1804 feet (550 m) 3281 feet (1 km)
1000BASE-ZX	SFP-GE-Z	1550	SMF SMF	9/10 8	–	43.5 miles (70 km) 62 miles (100 km)

Cable Pinouts

Figure 54 Two Twisted-Pair Straight-Through Cable Schematic for 10/100 Ports

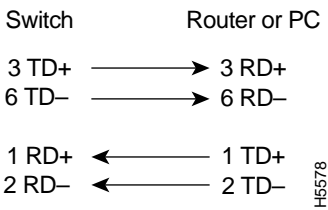


Figure 55 Two Twisted-Pair Crossover Cable Schematic for 10/100 Ports

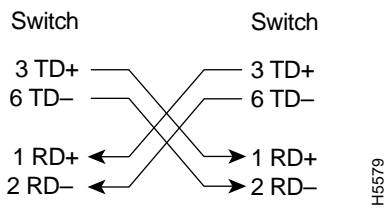


Figure 56 Four Twisted-Pair Straight-Through Cable Schematic for 1000BASE-T Ports

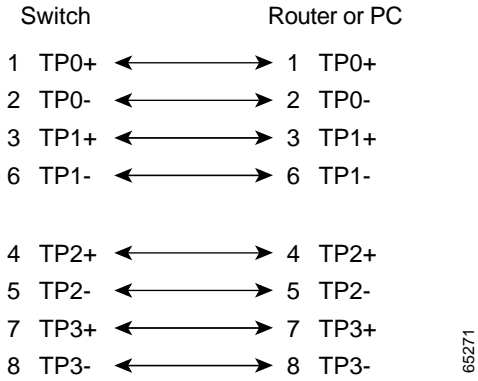
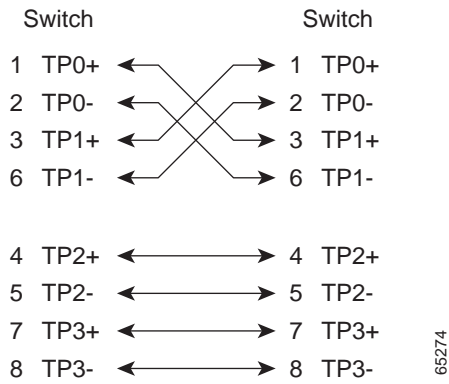
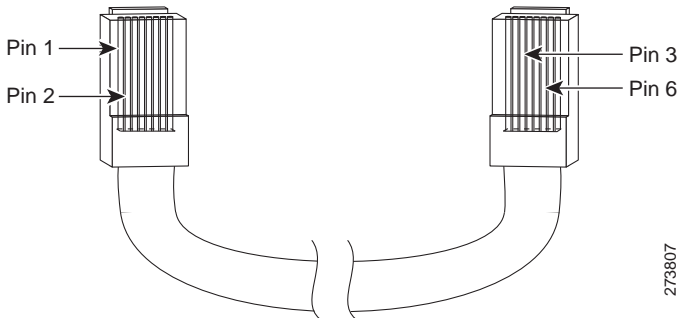


Figure 57 Four Twisted-Pair Crossover Cable Schematics for 1000BASE-T Ports



To identify a crossover cable, hold the cable ends side-by-side, with the tab at the back. The wire connected to pin 1 on the left end should be the same color as the wire connected to pin 3 on the right end. The wire connected to pin 2 on the left end should be the same color as the wire connected to pin 6 on the right end.

Figure 58 Identifying a Crossover Cable



Console Port Adapter Pinouts

The console port uses an 8-pin RJ-45 connector, which is described in b and [Table 23 on page 95](#). If you did not order a console cable, you need to provide an RJ-45-to-DB-9 adapter cable to connect the switch console port to a PC console port. You need to provide an RJ-45-to-DB-25 female DTE adapter if you want to connect the switch console

port to a terminal. You can order an adapter (part number ACS-DSBUASYN=). For console port and adapter pinout information, see [Table 22 on page 95](#) and [Table 23 on page 95](#).

[Table 22 on page 95](#) lists the pinouts for the console port, the RJ-45-to-DB-9 adapter cable, and the console device.

Table 22 Console Port Signaling Using a DB-9 Adapter

Switch Console Port (DTE)	RJ-45-to-DB-9 Terminal Adapter	Console Device
Signal	DB-9 Pin	Signal
RTS	8	CTS
DTR	6	DSR
TxD	2	RxD
GND	5	GND
RxD	3	TxD
DSR	4	DTR
CTS	7	RTS

[Table 23 on page 95](#) lists the pinouts for the switch console port, RJ-45-to-DB-25 female DTE adapter, and the console device.

Note: The RJ-45-to-DB-25 female DTE adapter is not supplied with the switch. You can order this adapter from Cisco (part number ACS-DSBUASYN=).

Table 23 Console Port Signaling Using a DB-25 Adapter

Switch Console Port (DTE)	RJ-45-to-DB-25 Adapter	Console Device
Signal	DB-25 Pin	Signal
RTS	5	CTS
DTR	6	DSR
TxD	3	RxD
GND	7	GND
RxD	2	TxD
DSR	20	DTR
CTS	4	RTS



Running Express Setup

When you first set up the switch, you should use Express Setup to enter the initial IP information. This process enables the switch to connect to local routers and the Internet. You can then access the switch through the IP address for additional configuration.

You need this equipment to set up the switch:

- PC with Windows XP, Vista, or Windows 7
- Web browser (Internet Explorer 6.0, 7.0 or Firefox 1.5, 2.0, 3.0 or later) with JavaScript enabled
- Straight-through or crossover Category 5 or higher grade cable

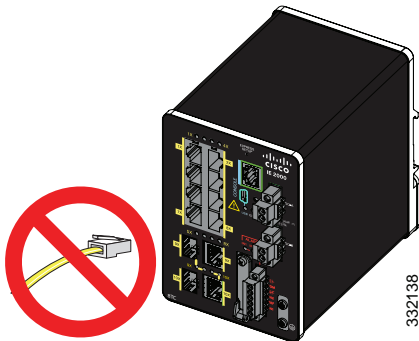
Before running Express Setup, disable any pop-up blockers or proxy settings on your browser and any wireless client running on your PC.

To run Express Setup:

1. Make sure that nothing is connected to the switch.

During Express Setup, the switch acts as a DHCP server. If your PC has a static IP address, temporarily configure your PC settings to use DHCP before going to the next step.

Note: Write down the static IP address. You will need this IP address in Step 13.



2. Connect power to the switch.

See the wiring instructions in [Grounding the Switch, page 40](#) and [Wiring the DC Power Source, page 46](#).

3. After the switch powers on, it begins the boot fast sequence, which can take up to 60 seconds.

During boot fast, the SYS LED blinks green, and the other LEDs turn green.

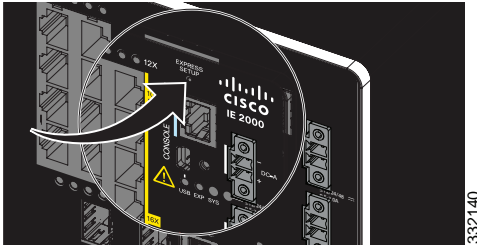
When boot fast is complete, the SYS LED turns green, and the other LEDs turn off.

Troubleshooting:

If the SYS LED is off (system not powered on), continues to blink green (POST in progress), or is solid red (Fault), contact the Cisco Technical Assistance Center (TAC). The SYS LED should be solid green when operating normally in Cisco IOS.

4. Press the Express Setup button for 2 to 3 seconds. This button is recessed behind the front panel, so you can use a simple tool, such as a paper clip.

When you press the Express Setup button, a switch port LED begins blinking green.



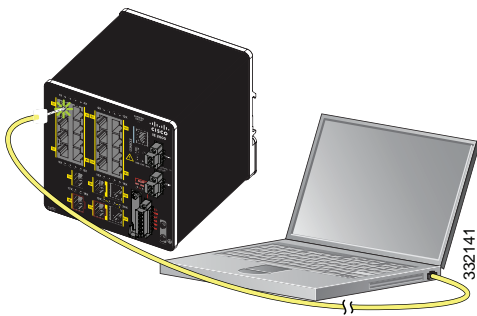
5. Connect a Category 5 Ethernet cable (not provided) from the blinking switch port to the Ethernet port on your PC.

The port LEDs on your PC and on the switch blink green while the switch configures the connection. The green port LEDs indicate a successful connection.

Troubleshooting:

If the port LEDs do not turn green after about 30 seconds, make sure that:

- You connected the Ethernet cable to one of the downlink switch ports (not to an uplink port such as the dual-purpose port).
- You are using an undamaged Category 5 or higher grade cable.
- The other device is turned on.



6. When the Setup LED turns solid green, start a browser session on the PC. A login prompt appears.
7. Leave the username blank and enter the default password, *cisco*.

Note: The switch ignores text in the username field.

The Express Setup window appears.

Troubleshooting:

If the Express Setup window does not appear, make sure that any pop-up blockers or proxy settings on your browser are disabled and that any wireless client is disabled on your PC or laptop.

8. Enter all entries in English letters and Arabic numbers.

Required Fields

In the Network Settings fields:

- **Management Interface (VLAN):** We recommend using the default, **VLAN 1**. The management VLAN establishes an IP connection to the switch.

Note: Enter a new VLAN ID only if you want to change the management interface through which you manage the switch. The VLAN ID range is 1 to 1001.

- **IP Assignment Mode:** We recommend using the default, **Static**, so that the switch always has the IP address that you assign. Use the **DHCP** setting when you want the switch to automatically obtain an IP address from a DHCP server.
- **IP Address:** Enter the IP address for the switch. You can later use the IP address to access the switch through Device Manager.
- **Subnet Mask:** Select a mask from the drop-down list.
- **Default Gateway:** Enter the IP address of the router.
- **Switch Password:** Enter a password. The password can be from 1 to 25 alphanumeric characters, can start with a number, is case sensitive, allows embedded spaces, but does not allow spaces at the beginning or end. In the **Confirm Password** field, enter the password again.

Note: You must change the password from the default password, *cisco*.

9. Enter the Control Industrial Protocol (CIP) VLAN settings:

- **CIP VLAN:** Enter the VLAN on which CIP will be enabled. The CIP VLAN can be the same as the management VLAN, or you can isolate CIP traffic on another VLAN that is already configured on the switch. The default CIP VLAN is VLAN 1. Only one VLAN on a switch can have CIP enabled.
- **IP Address:** Enter the IP address for the CIP VLAN. If the CIP VLAN is different from the management VLAN, you must specify an IP address for the CIP VLAN. Make sure that the IP address that you assign to the switch is not being used by another device in your network.
- **Subnet Mask:** Select a mask from the drop-down list.

For more information about the CIP VLAN settings, click Help on the toolbar.

10. Optional settings

You can enter the optional information now, or enter it later by using Device Manager. For more information about the Express Setup fields, see the online help for the Express Setup window.

Click **Submit** to save your changes and to complete the initial setup.

For more information about the optional settings, click **Help** on the toolbar.

11. After you click **Submit, these events occur:**

- The switch is configured and exits Express Setup mode.
- The browser displays a warning message and tries to connect with the earlier switch IP address. Typically, connectivity between the PC and the switch is lost because the configured switch IP address is in a different subnet from the IP address on the PC.

-
12. Turn off DC power at the source, disconnect all cables to the switch, and install the switch in your network. See [Management Options, page 26](#) for information about configuring and managing the switch.
 13. If you changed the static IP address on your PC in Step 1, change it to the previously configured static IP address.
 14. You can now manage the switch by using the Cisco Network Assistant, Device Manager, or the Cisco IOS Command Line Interface (CLI). See [Management Options, page 26](#) for information about configuring and managing the switch.

You can display Device Manager by following these steps:

- a. Start a web browser on your PC or laptop.
- b. Enter the switch IP address, username, and password (assigned in Step 7) in the web browser, and press **Enter**. The Device Manager page appears.

Troubleshooting

If the Device Manager page does not appear:

- Confirm that the port LED for the switch port connected to your network is green.
- Confirm that the PC or laptop that you are using to access the switch has network connectivity by connecting it to a well-known web server in your network. If there is no network connection, troubleshoot the network settings on the PC or laptop.
- Make sure that the switch IP address in the browser is correct.
- If the switch IP address in the browser is correct, the switch port LED is green, and the PC or laptop has network connectivity, continue troubleshooting by reconnecting the PC or laptop to the switch. Configure a static IP address on the PC or laptop that is in the same subnet as the switch IP address. For example:
 - If your switch IP address is 172.20.20.85 and your PC or laptop IP address is 172.20.20.84, both devices are in the same network.
 - If your switch IP address is 172.20.20.85 and your PC or laptop IP address is 10.0.0.2, the devices are in different networks and cannot communicate directly.
- When the LED on the switch port connected to the PC or laptop is green, reenter the switch IP address in a web browser to display the Device Manager. When Device Manager appears, you can continue with the switch configuration.



Configuring the Switch with the CLI-Based Setup Program

This appendix provides a command-line interface (CLI)-based setup procedure for a switch. For information about setting up the switch by using Express Setup, see [Running Express Setup, page 97](#).

Before connecting the switch to a power source, review the safety warnings in [Warnings, page 29](#).

For installation procedures, see [Switch Installation, page 29](#).

Accessing the CLI Through the Console Port

You can enter Cisco IOS commands and parameters through the CLI. Use one of these options to access the CLI:

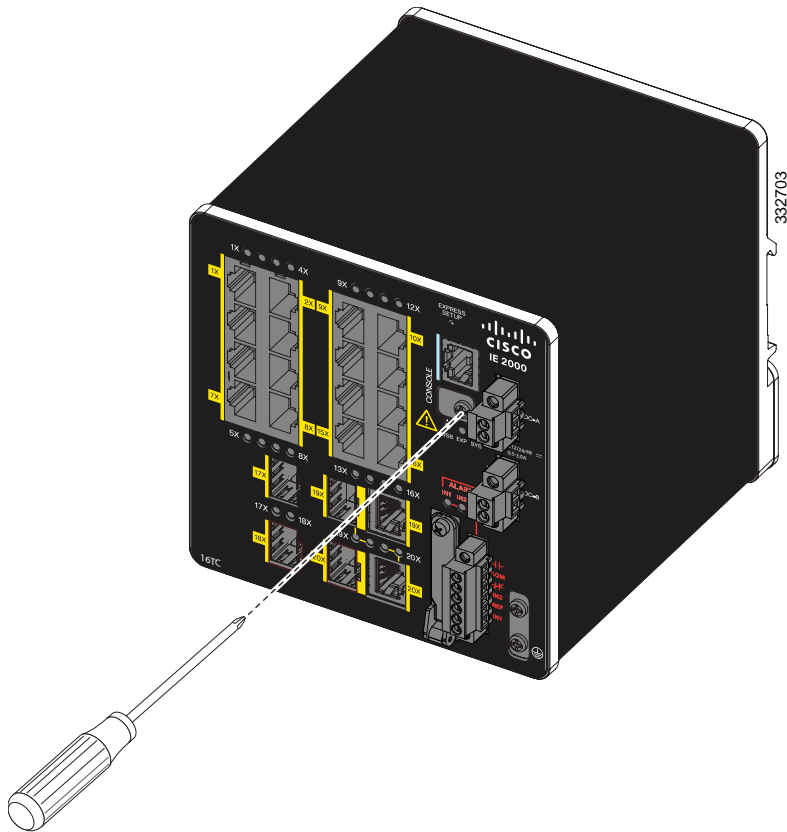
- [RJ-45 Console Port, page 102](#)
- [USB Mini-Type B Console Port, page 103](#)

Removing the USB Mini-Type B Console Port Cover

To remove the cover from the USB mini-type B console port:

1. Use a Phillips screwdriver to loosen the captive screw on the USB mini-type B console port cover. See [Figure 59 on page 102](#).
2. Remove the cover.

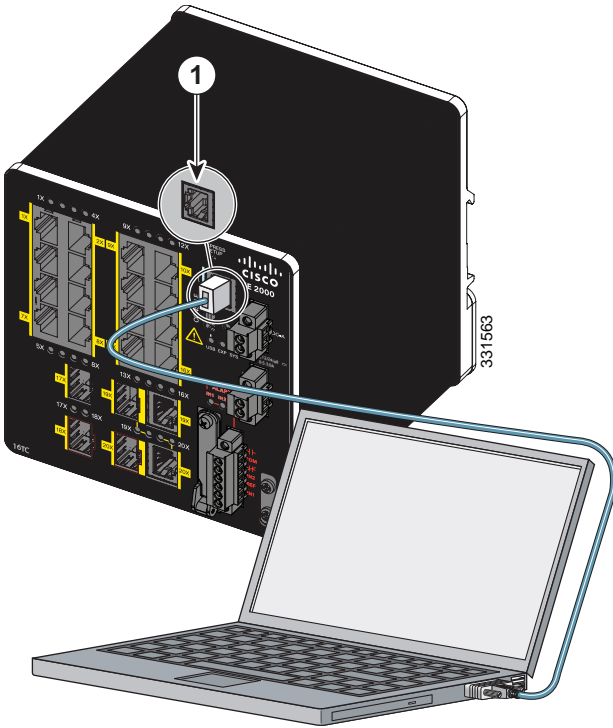
Figure 59 Removing the USB Mini-Type B Console Port Cover



RJ-45 Console Port

1. Connect the RJ-45-to-DB-9 adapter cable to the 9-pin serial port on the PC. Connect the other end of the cable to the switch console port.
2. Start the terminal-emulation program on the PC or the terminal. The program, frequently a PC application such as HyperTerminal or ProcommPlus, makes communication between the switch and your PC or terminal possible.

Figure 60 Connecting the Console Cable



- 1 RJ-45 console port
- 2 Console cable (RJ-45-to-DB-9 adapter cable)

3. Configure the baud rate and character format of the PC or terminal to match the console port characteristics:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity
- None (flow control)

4. Connect power to the switch as described in [Connecting to Power, page 39](#).

The PC or terminal displays the bootloader sequence.

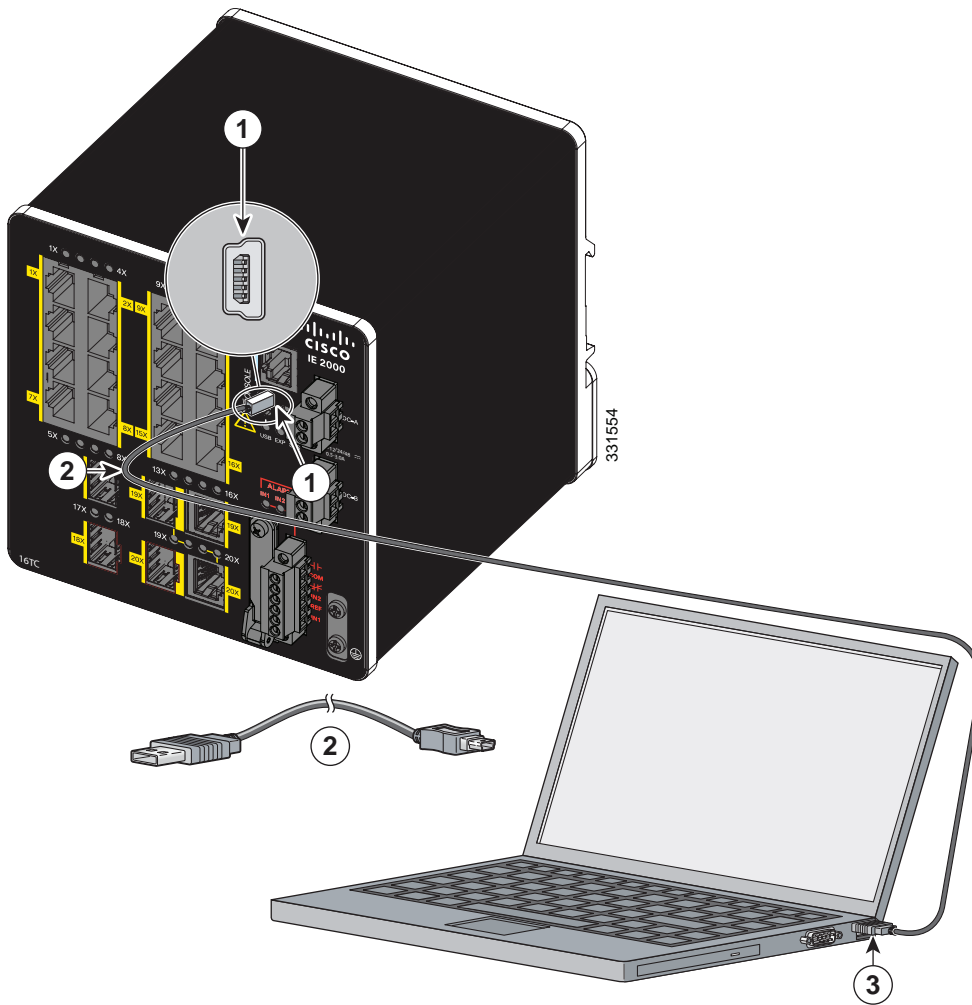
5. Press **Enter** to display the setup prompt.

6. Follow the steps in [Completing the Setup Program, page 106](#).

USB Mini-Type B Console Port

1. If you are connecting the switch USB-mini console port to a Windows-based PC for the first time, install a USB driver. See [Installing the Cisco Microsoft Windows XP, 2000, Vista, 7, 8, and 10 USB Device Driver, page 105](#) for more information.

Figure 61 Connecting the USB-Mini Console Cable



- 1 USB-mini console port 3 USB port on the PC
- 2 USB cable

2. Connect an USB cable to the PC USB port, and connect the other end of the cable to the switch mini-B (5-pin-connector) USB-mini console port. See [Figure 61](#).

3. Identify the COM port assigned to the USB-mini console port:

a. Choose **Start > Control Panel > Systems**.

b. Click the **Hardware** tab and choose **Device Manager**. Expand the **Ports** section. The assigned COM port appears in parenthesis at the end of the line with this entry: Cisco USB System Management Console.

4. Start the terminal-emulation program on the PC or the terminal.

The program, frequently a PC application such as HyperTerminal or ProcommPlus, makes communication possible between the switch and your PC or terminal.

5. Configure the COM port.

6. Configure the baud rate and character format of the PC or terminal to match the console port characteristics:

-
- 9600 baud
 - 8 data bits
 - 1 stop bit
 - No parity
 - None (flow control)
7. Connect power to the switch as described in [Connecting to Power, page 39](#).
The PC or terminal displays the bootloader sequence.
 8. Press **Enter** to display the setup prompt.
 9. Follow the steps in [Completing the Setup Program, page 106](#).

Installing the Cisco Microsoft Windows XP, 2000, Vista, 7, 8, and 10 USB Device Driver

A USB device driver must be installed the first time a Microsoft Windows-based PC is connected to the USB console port on the switch. Use this procedure to install the USB driver on Windows XP, Windows 2000, Windows Vista, Windows 7, Windows 8, and Windows 10.

1. Obtain the file `Cisco_usbconsole_driver_3_1.zip` from the Cisco.com website <https://software.cisco.com/download/release.html?mdfid=282979369&softwareid=282855122&release=3.1>

The file details are as follows:

- Description: `Cisco_usbconsole_driver_3_1.zip`
 - Release: 3.1
 - Release Date: 27/Nov/2014
 - File Name: `Cisco_usbconsole_driver_3_1.zip`
 - Size: 14.35 MB (15045453 bytes)
 - MD5 Checksum: `eff2e955edcdc70209e6f9c8f6bd59cd`
2. Unzip the file and install the corresponding exe file.
 3. Navigate to the **Device Manager** window by performing a search in Windows for **Device Manager** and opening it.
 4. Connect the USB cable from the Windows PC to the Cisco switch.
 5. From the **Device Manager** page, expand **Ports (COM & LPT)**. Select **USB Serial Port**. Right-click and select **Update Driver Software ...**
 6. In the Update Driver Software window, select **Browse my computer for driver software**. Then choose **Let me pick from a list of device drivers on my computer** and click **Next**.
 7. Enable **Show compatible hardware** and choose **Cisco Serial** as the model. Click **Next**.
After the update is completed, Windows displays **Windows has successfully updated your driver software**.
 8. Click **Close**.

Uninstalling the Cisco Microsoft Windows XP, 2000, Vista, 7, 8, and 10 USB Driver

Note: Disconnect the switch console terminal before uninstalling the driver.

1. Run setup.exe for Windows 32-bit or setup(x64).exe for Windows-64bit.
2. Click **Next**.
3. When the InstallShield Wizard for Cisco Virtual Com appears, click **Next**.
4. When the Program Maintenance window appears, select the **Remove** radio button.
5. Click **Next**.
6. When the Remove the Program window appears, click **Remove**.

If a User Account Control warning appears, click **Allow - I trust this program to proceed**.

7. When the InstallShield Wizard Completed window appears, click **Finish**.

Entering the Initial Configuration Information

To set up the switch, you must complete the setup program, which runs automatically after the switch is powered on. Assign an IP address and any other configuration information necessary for the switch to communicate with the local routers and the Internet. This information is also required if you plan to use Device Manager or Cisco Network Assistant to configure and manage the switch.

IP Settings

Gather this information from your network administrator before completing the setup program:

- Switch IP address
- Subnet mask (IP netmask)
- Default gateway (router)
- Enable secret password
- Enable password
- Telnet password

Completing the Setup Program

To complete the setup program and to create an initial configuration for the switch:

1. Enter **Yes** at these two prompts:

```
Would you like to enter the initial configuration dialog? [yes/no]: yes
```

```
At any point you may enter a question mark '?' for help.  
Use ctrl-c to abort configuration dialog at any prompt.  
Default settings are in square brackets '[]'.
```

```
Basic management setup configures only enough connectivity  
for management of the system, extended setup will ask you  
to configure each interface on the system.
```

```
Would you like to enter basic management setup? [yes/no]: yes
```

2. Enter a hostname for the switch, and press **Return.**

On a command switch, the hostname is limited to 28 characters; on a member switch, it is limited to 31 characters. Do not use *-n*, where *n* is a number, as the last character in a hostname for any switch.

```
Enter host name [Switch]: host_name
```

3. Enter an enable secret password, and press **Return.**

The password can be from 1 to 25 alphanumeric characters, can start with a number, is case sensitive, allows spaces, but ignores leading spaces. The secret password is encrypted, and the enable password is in plain text.

```
Enter enable secret: secret_password
```

4. Enter an enable password, and press **Return.**

```
Enter enable password: enable_password
```

5. Enter a virtual terminal (Telnet) password, and press **Return.**

The password can be from 1 to 25 alphanumeric characters, is case sensitive, allows spaces, but ignores leading spaces.

```
Enter virtual terminal password: terminal-password
```

6. (Optional) Configure Simple Network Management Protocol (SNMP) by responding to the prompts.

You can also configure SNMP later through the CLI, Device Manager, or the Cisco Network Assistant application.

To configure SNMP later, enter **no**.

```
Configure SNMP Network Management? [no]: no
```

7. Enter the interface name (physical interface or VLAN name) of the interface that connects to the management network, and press **Return.**

For this release, always use **vlan1** as that interface.

```
Enter interface name used to connect to the  
management network from the above interface summary: vlan1
```

8. Configure the interface by entering the switch IP address and subnet mask and pressing **Return.**

The IP address and subnet masks shown here are examples.

```
Configuring interface vlan1:  
Configure IP on this interface? [yes]: yes  
IP address for this interface: 10.4.120.106  
Subnet mask for this interface [255.0.0.0]: 255.0.0.0
```

9. Enter **Y to configure the switch as the cluster command switch. Enter **N** to configure it as a member switch or as a standalone switch.**

If you enter **N**, the switch appears as a candidate switch in the Cisco Network Assistant GUI. You can configure the switch as a command switch later through the CLI, Device Manager, or the Cisco Network Assistant application.

To configure it later, enter **no**.

```
Would you like to enable as a cluster command switch? [yes/no]: no
```

You have now completed the initial configuration of the switch, and the switch displays its initial configuration script:

The following configuration command script was created:

```
hostname Switch
enable secret 5 $1$ZQRe$DPuLYXyQLm77v/a4Bmu6Y.
enable password cisco
line vty 0 15
password cisco
no snmp-server
!
!
interface Vlan1
no shutdown
ip address 10.4.120.106 255.0.0.0
!
interface FastEthernet1/1
!
interface FastEthernet1/2
!
interface FastEthernet1/3
!
...(output abbreviated)
!
interface GigabitEthernet1/1
!
interface GigabitEthernet1/2
!
end
```

These choices appear:

- [0] Go to the IOS command prompt without saving this config.
- [1] Return back to the setup without saving this config.
- [2] Save this configuration to nvram and exit.

If you want to save the configuration and use it the next time the switch reboots, save it in NVRAM by selecting option 2.

Enter your selection [2]:2

10. Make your selection, and press **Return**.

After you complete the setup program, the switch can run the default configuration that you created. To change this configuration or perform other management tasks, use one of these tools:

- Command-line interface (CLI)
- Cisco Network Assistant (for one or more switches)

To use the CLI, enter commands at the Switch> prompt through the console port by using a terminal emulation program or through the network by using Telnet.

For configuration information, see the *Cisco IE 2000 Switch Software Configuration Guide* or the *Cisco IE 2000 Switch Command Reference*.

To use the Cisco Network Assistant, see the *Getting Started with Cisco Network Assistant* guide on Cisco.com.

Zelio[®] Plug-In Relays

RXM, RPM, RUM, RPF, RSB

Class 8501

Catalog
8501CT0601R1/08

08



CONTENTS

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RXM●AB2F7

RXM Miniature Relays (page 4)

2 pole relays; 12 A, 1/2 hp (IEC rating = 12 A)
 3 pole relays; 10 A, 1/3 hp (IEC rating = 10 A)
 4 pole relays; 8 A, 1/3 hp (IEC rating = 6 A)
 4 pole relays; 3 A (low level), 1/16 hp (IEC rating = 3 A)

- Mechanical “relay status” indicator on all relays
- Pilot light option available
- Manual operator optional for all relays
- Built-in marking area



RPM32F7

RPM Miniature Power Relays (page 13)

1 pole relays; 15 A, 1/2 hp (IEC rating = 15 A)
 2 pole relays; 15 A, 1/2 hp (IEC rating = 15 A)
 3 pole relays; 15 A, 1/2 hp (IEC rating = 15 A)
 4 pole relays; 15 A, 1/2 hp (IEC rating = 15 A)

- Mechanical “relay status” indicator on all relays
- Pilot light option available
- Manual operator optional for all relays
- Built-in marking area



RUM●●AB2B7

RUM Universal Relays (page 21)

2 pole relays; 8-pin, tube type; 16 A, 1/3 hp (IEC rating = 10 A)
 3 pole relays; 11-pin, tube type; 16 A, 1/3 hp (IEC rating = 10 A)
 2 pole relays; 8 blade type; 16 A, 1/3 hp (IEC rating = 10 A)
 3 pole relays; 11 blade type; 16 A, 1/3 hp (IEC rating = 10 A)

- Mechanical “relay status” indicator on all relays
- Pilot light option available
- Manual operator optional for all relays
- Built-in marking area



RPF2B●●

RPF Power Relays (page 30)

Two Form C contacts; 30 A
 Two Normally Open contacts; 30 A

- DIN track mountable
- Can be mounted directly to a panel



RSB1A160BD
+ RSZE1S48M

RSB Interface Relays (page 33)

Two Form C contacts; 8 A
 One Form C contact; 12 A
 One Form C contact; 16 A

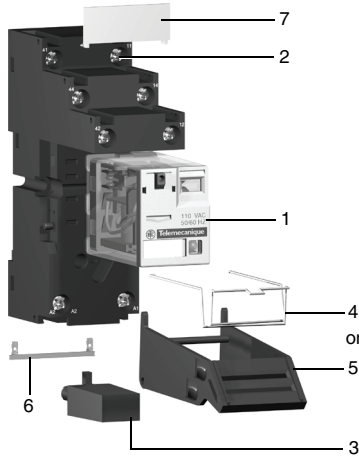
General Technical Information (page 38)

Relay contact types
 Utilization categories
 Protection categories
 Protection modules

Zelio® Plug-in Relays

Product Description

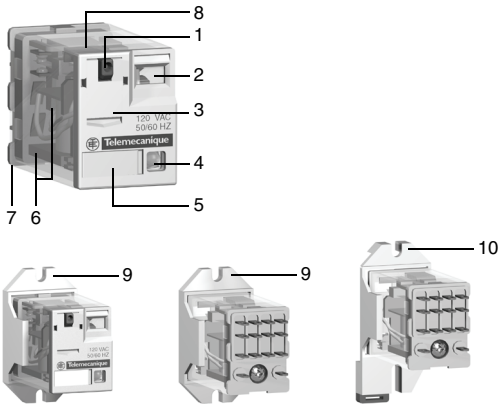
RXM Miniature Relays



Product Description

The RXM miniature relay range consists of:

- 12 A relays with DPDT contacts, 10 A relays with 3PDT contacts, 6 A relays with 4PDT contacts, and 3 A “low level” relays with 4PDT contacts. All of these relays have the same dimensions.
- Sockets with mixed or separate contact terminals.
- Protection modules (diode, RC circuit or varistor). All these modules are common to all sockets.
- A metal hold-down clip for all sockets.
- A plastic hold-down clip for all sockets.
- A 2-pole bus jumper that can be used on sockets with separate contact terminals to simplify wiring when creating a jumper between the coil terminals.
- Clip-in markers for all the sockets except RXZ E2M114.



Relay Description

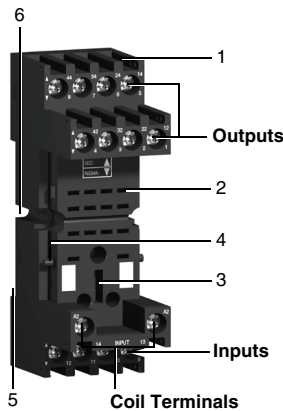
- Spring return push button for testing the contacts (green: DC, red: AC).
- Mechanical “relay status” indicator.
- Optional removable lock-down door and push button, enabling forced maintaining of the contacts for test or maintenance purposes. During operation, this lock-down door must always be in the closed position.
- Bipolar LED (depending on version) indicating the relay status.
- Removable marker for relay identification.
- Four notches for DIN rail mounting adapter or panel mounting adapter.
- Eight, eleven, or fourteen pins.
- Area by which the product can be easily gripped.
- Mounting adapter enabling direct mounting of the relay on a panel.
- Mounting adapter enabling direct mounting of the relay on a DIN rail.

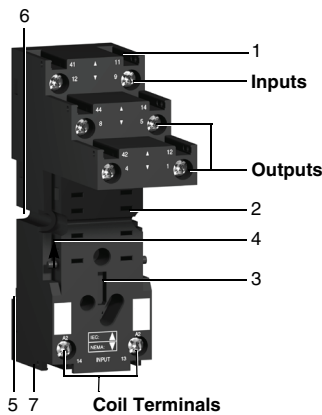
Socket Description

Sockets with Mixed Contact Terminals

- Connection by screw clamp terminals or box lug connector.
- Fourteen female contacts for the relay pins.
- Location for protection modules.
- Locking components for plastic and metal hold-down clips.
- Locating slot for mounting on DIN rail.
- Two or four mounting holes for panel mounting.

NOTE: The inputs are mixed with the relay coil terminals, with the outputs being located on the opposite side of the socket.





Sockets with Separate Contact Terminals

1. Box lug connector.
2. Eight, eleven, or fourteen female contacts for the relay pins.
3. Location for protection modules.
4. Locking components for plastic and metal hold-down clips.
5. Locating slot for mounting on DIN rail.
6. Two mounting holes for panel mounting.
7. Location for bus jumpers (see mounting on sockets on page 11).

NOTE: The inputs and outputs are separated from the relay coil terminals.

General characteristics

Conforming to standards		IEC/EN 61810-1 (iss. 2), UL 508, CSA C22-2 n° 14
Product certifications		cULus File E164862 CCN NLDX, NLDX7; cURus File E164862 CCN NLDX2, NLDX8; CSA pending; CE; RoHS compliant
Ambient air temperature around the device	Storage	-40–185 °F (-40–85 °C)
	Operation	-40–131 °F (-40–55 °C)
Vibration resistance	Conforming to IEC/EN 60068-2-6	> 6 gn (10–50 Hz)
Degree of protection	Conforming to IEC/EN 60529	IP 40
Shock resistance conforming to IEC/EN 60068-2-27	Opening	10 gn
	Closing	5 gn
Protection category (see page 38)		RT I
Mounting position		Any

Insulation characteristics

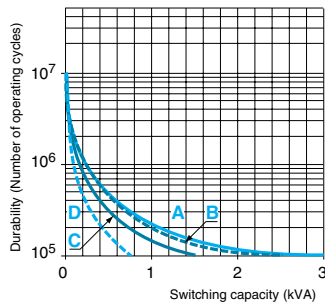
Rated insulation voltage (Ui)		250 V (IEC), 300 V (UL, CSA)
Rated impulse withstand voltage (Uimp)		3.6 kV (1.2/50 μs)
Dielectric strength (rms voltage)	Between coil and contact	2,500 Vac
	Between poles	2,500 Vac
	Between contacts	1,500 Vac

Contact characteristics

Relay type		RXM2AB●●●	RXM3AB●●●	RXM4AB●●●	RXM4GB●●●
Number and type of contacts (see page 12)		DPDT	3PDT	4PDT	4PDT
Contact materials		AgNi			AgAu–Bifurcated
Conventional thermal current (Ith)	For ambient temperature ≤ 131 °F (55 °C)	12 A	10 A	6 A	3 A
	Rated operational current	Conforming to IEC in utilization category AC-1	N.O. 12 A N.C. 6 A	10 A 5 A	6 A 3 A
Conforming to UL Resistive @277 Vac, hp @120 Vac		12 A, 1/2 hp	10 A, 1/3 hp	8 A, 1/3 hp	3 A, 1/16 hp
Maximum operating rate In operating cycles/hour	No load	18,000			
	Under load	1,200			
Switching voltage		Maximum 250 Vac/Vdc			
Switching capacity	Minimum	10 mA on 17 V			2 mA on 5 V
	Maximum	3,000 VA	2,500 VA	1,500 VA	750 VA
Utilization coefficient		20%			
Mechanical durability in millions of operating cycles		10			
Electrical durability in millions of operating cycles		Resistive load 0.1			

Electrical durability of contacts

Resistive load AC



A=RXM2AB●●● B=RXM3AB●●● C=RXM4AB●●● D=RXM4GB●●●

Coil characteristics

Average consumption	AC	1.2 VA									
	DC	0.9 W									
Drop-out voltage threshold	AC	≥ 0.15 Uc									
	DC	≥ 0.1 Uc									
Operating time (response time)	Between coil energization and making of the N.O. contact	AC	20 ms								
		DC	20 ms								
	Between coil de-energization and making of the N.C. contact	AC	20 ms								
		DC	20 ms								
Coil voltage Uc	12 V	24 V	48 V	110 V	120 V	125 V	220 V	230 V	240 V		
Relay coil voltage codes	JD	BD	ED	FD	—	GD	MD	—	—		
DC	Average resistance at 68 °F (20 °C) ± 10%	160 Ω	650 Ω	2,600 Ω	11,000 Ω	—	11,000 Ω	14,000 Ω	—	—	
	Operating voltage limits	Min.	9.6 V	19.2 V	38.4 V	88 V	—	100 V	176 V	—	—
		Max.	13.2 V	26.4 V	52.8 V	121 V	—	138 V	242 V	—	—
Relay coil voltage codes	—	B7	E7	—	F7	—	M7	P7	U7		
AC	Average resistance at 68 °F (20 °C) ± 15%	—	180 Ω	770 Ω	—	4,430 Ω	—	15,000 Ω	15,000 Ω	15,500 Ω	
	Operating voltage limits	Min.	—	19.2 V	38.4 V	—	96 V	—	176 V	184 V	192 V
		Max.	—	26.4 V	52.8 V	—	132 V	—	242 V	253 V	264 V

Socket characteristics

Socket type	RXZE2S108M	RXZE2S111M	RXZE2S114M	RXZE2M114	RXZE2M114M
Relay types used	RXM2●●●●●	RXM3●●●●●	RXM4●●●●●	RXM2●●●●● ¹ RXM4●●●●●	RXM2●●●●● ¹ RXM4●●●●●
Product certifications	cURus File E172326 CCN SWIV2, SWIV8; CSA (pending); CE; RoHS compliant				
Conventional thermal current (Ith)	12 A	10 A			
Degree of protection	Conforming to IEC/EN 60529 IP 20				
Connection	Solid wire without cable end	1 conductor: AWG 20–12 (0.5–2.5 mm ²) 2 conductors: AWG 20–14 (0.5–1.5 mm ²)			
	Flexible wire with cable end	1 conductor: AWG 24–14 (0.2–2.5 mm ²) 2 conductors: AWG 24–16 (0.2–1.5 mm ²)			
	Flexible wire without cable end	1 conductor: AWG 24–14 (0.2–2.5 mm ²) 2 conductors: AWG 24–16 (0.2–1.5 mm ²)			
Maximum tightening torque	5.3 lbf-in (0.6 Nm) (M3 screw)				
Contact terminal arrangement	Separate			Mixed	
Bus jumper Ith: 5 A	Yes			No	

¹ When mounting relay RXM2●●●●● on socket RXZE2M●●●●●, the thermal current must not exceed 10 A.



RXM2AB2F7

Miniature relays with lockable test button, without LED (sold in lots of 10)

Coil Voltage	Number and type of contacts - Thermal current (Ith)								
	DPDT - 12 A			3PDT - 10 A			4PDT - 6 A		
	Catalog Number	Weight		Catalog Number	Weight		Catalog Number	Weight	
lb.		kg	lb.		kg	lb.		kg	
12 Vdc	RXM2AB1JD	0.082	0.037	RXM3AB1JD	0.084	0.038	RXM4AB1JD	0.080	0.036
24 Vdc	RXM2AB1BD	0.082	0.037	RXM3AB1BD	0.084	0.038	RXM4AB1BD	0.080	0.036
48 Vdc	RXM2AB1ED	0.082	0.037	RXM3AB1ED	0.084	0.038	RXM4AB1ED	0.080	0.036
110 Vdc	RXM2AB1FD	0.082	0.037	RXM3AB1FD	0.084	0.038	RXM4AB1FD	0.080	0.036
220 Vdc	—	—	—	—	—	—	RXM4AB1MD	0.080	0.036
24 Vac	RXM2AB1B7	0.082	0.037	RXM3AB1B7	0.084	0.038	RXM4AB1B7	0.080	0.036
48 Vac	RXM2AB1E7	0.082	0.037	RXM3AB1E7	0.084	0.038	RXM4AB1E7	0.080	0.036
120 Vac	RXM2AB1F7	0.082	0.037	RXM3AB1F7	0.084	0.038	RXM4AB1F7	0.080	0.036
230 Vac	RXM2AB1P7	0.082	0.037	RXM3AB1P7	0.084	0.038	RXM4AB1P7	0.080	0.036
240 Vac	—	—	—	—	—	—	RXM4AB1U7	0.080	0.036

Miniature relays with lockable test button, with LED (sold in lots of 10)

12 Vdc	RXM2AB2JD	0.082	0.037	RXM3AB2JD	0.084	0.038	RXM4AB2JD	0.080	0.036
24 Vdc	RXM2AB2BD	0.082	0.037	RXM3AB2BD	0.084	0.038	RXM4AB2BD	0.080	0.036
48 Vdc	RXM2AB2ED	0.082	0.037	RXM3AB2ED	0.084	0.038	RXM4AB2ED	0.080	0.036
110 Vdc	RXM2AB2FD	0.082	0.037	RXM3AB2FD	0.084	0.038	RXM4AB2FD	0.080	0.036
125 Vdc	—	—	—	—	—	—	RXM4AB2GD	0.080	0.036
24 Vac	RXM2AB2B7	0.082	0.037	RXM3AB2B7	0.084	0.038	RXM4AB2B7	0.080	0.036
48 Vac	RXM2AB2E7	0.082	0.037	RXM3AB2E7	0.084	0.038	RXM4AB2E7	0.080	0.036
120 Vac	RXM2AB2F7	0.082	0.037	RXM3AB2F7	0.084	0.038	RXM4AB2F7	0.080	0.036
230 Vac	RXM2AB2P7	0.082	0.037	RXM3AB2P7	0.084	0.038	RXM4AB2P7	0.080	0.036



RXM4GB2F7

Miniature relays with low level contacts, without LED (sold in lots of 10)

Number and type of contacts - Thermal current (Ith)			
4PDT - 3 A			
Coil Voltage	Catalog Number	Weight	
		lb.	kg
12 Vdc	RXM4GB1JD	0.080	0.036
24 Vdc	RXM4GB1BD	0.080	0.036
48 Vdc	RXM4GB1ED	0.080	0.036
110 Vdc	RXM4GB1FD	0.080	0.036
24 Vac	RXM4GB1B7	0.080	0.036
48 Vac	RXM4GB1E7	0.080	0.036
120 Vac	RXM4GB1F7	0.080	0.036
230 Vac	RXM4GB1P7	0.080	0.036

Miniature relays with low level contacts, with LED (sold in lots of 10)

Number and type of contacts - Thermal current (Ith)			
4PDT - 3 A			
Coil Voltage	Catalog Number	Weight	
		lb.	kg
12 Vdc	RXM4GB2JD	0.080	0.036
24 Vdc	RXM4GB2BD	0.080	0.036
48 Vdc	RXM4GB2ED	0.080	0.036
110 Vdc	RXM4GB2FD	0.080	0.036
24 Vac	RXM4GB2B7	0.080	0.036
48 Vac	RXM4GB2E7	0.080	0.036
120 Vac	RXM4GB2F7	0.080	0.036
230 Vac	RXM4GB2P7	0.080	0.036
240 Vac	RXM4GB2U7	0.080	0.036



RXM●AB3F7

Miniature relays without lockable test button, with LED

		Number and Type of Contacts—Thermal Current (Ith)					
		DPDT - 12 A			4PDT - 6 A		
Coil Voltage	Catalog No.	Weight		Catalog No.	Weight		
		lb.	kg		lb.	kg	
Sold in lots of 10							
12 Vdc	RXM2AB3JD	0.082	0.037	RXM4AB3JD	0.080	0.036	
24 Vdc	RXM2AB3BD	0.082	0.037	RXM4AB3BD	0.080	0.036	
48 Vdc	RXM2AB3ED	0.082	0.037	RXM4AB3ED	0.080	0.036	
110 Vdc	RXM2AB3FD	0.082	0.037	RXM4AB3FD	0.080	0.036	
125 Vdc	—	—	—	RXM4AB3GD	0.080	0.036	
24 Vac	RXM2AB3B7	0.082	0.037	RXM4AB3B7	0.080	0.036	
48 Vac	RXM2AB3E7	0.082	0.037	RXM4AB3E7	0.080	0.036	
120 Vac	RXM2AB3F7	0.082	0.037	RXM4AB3F7	0.080	0.036	
230 Vac	RXM2AB3P7	0.082	0.037	RXM4AB3P7	0.080	0.036	
Sold in lots of 100							
24 Vdc	RXM2AB3BDTQ	0.082	0.037	RXM4AB3BDTQ	0.080	0.036	
24 Vac	RXM2AB3B7TQ	0.082	0.037	RXM4AB3B7TQ	0.080	0.036	
230 Vac	RXM2AB3P7TQ	0.082	0.037	RXM4AB3P7TQ	0.080	0.036	

Miniature relays with low level contacts,
without lockable test button, with LED

		4PDT (low level) - 3 A		
Coil Voltage	Catalog No.	Weight		
		lb.	kg	
Sold in lots of 10				
12 Vdc	RXM4GB3JD	0.080	0.036	
24 Vdc	RXM4GB3BD	0.080	0.036	
48 Vdc	RXM4GB3ED	0.080	0.036	
110 Vdc	RXM4GB3FD	0.080	0.036	
125 Vdc	—	—	—	
24 Vac	RXM4GB3B7	0.080	0.036	
48 Vac	RXM4GB3E7	0.080	0.036	
120 Vac	RXM4GB3F7	0.080	0.036	
230 Vac	RXM4GB3P7	0.080	0.036	

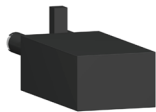
See page 9 for sockets and accessories.



RXZ E2M114M with relay RXM4AB2P7TQ



RXZ E2S114M with relay RXM4AB2F7TQ



RXM 041



REXL4



RXZ400

Miniature relays with lockable test button, without LED (sold in lots of 100)

Coil Voltage	Number and type of contacts - Thermal current (Ith)					
	DPDT - 12 A			4PDT - 6 A		
	Catalog Number	Weight		Catalog Number	Weight	
		lb.	kg		lb.	kg
12 Vdc	—	—	—	RXM4AB1JDTQ	0.080	0.036
24 Vdc	RXM2AB1BDTQ	0.082	0.037	RXM4AB1BDTQ	0.080	0.036
48 Vdc	—	—	—	RXM4AB1EDTQ	0.080	0.036
110 Vdc	—	—	—	RXM4AB1FDTQ	0.080	0.036
220 Vdc	—	—	—	RXM4AB1MDTQ	0.080	0.036
24 Vac	RXM2AB1B7TQ	0.082	0.037	RXM4AB1B7TQ	0.080	0.036
48 Vac	—	—	—	RXM4AB1E7TQ	0.080	0.036
120 Vac	RXM2AB1F7TQ	0.082	0.037	RXM4AB1F7TQ	0.080	0.036
230 Vac	RXM2AB1P7TQ	0.082	0.037	RXM4AB1P7TQ	0.080	0.036

Miniature relays with LED (sold in lots of 100)

24 Vdc	—	—	—	RXM4AB2BDTQ	0.080	0.036
24 Vac	RXM2AB2B7TQ	0.082	0.037	RXM4AB2B7TQ	0.080	0.036
230 Vac	RXM2AB2P7TQ	0.082	0.037	RXM4AB2P7TQ	0.080	0.036

Sockets (sold in lots of 10)

Contact terminal arrangement	Connection	Relay type	Catalog Number	Weight	
				lb.	kg
Mixed	Screw clamp terminals	RXM2●●●● ¹ RXM4●●●●	RXZE2M114 ²	0.11	0.048
	Box lug connector	RXM2●●●● ¹ RXM4●●●●	RXZE2M114M ²	0.12	0.056
Separate	Box lug connector	RXM2●●●●	RXZE2S108M ³	0.13	0.058
		RXM3●●●●	RXZE2S111M ²	0.15	0.066
		RXM4●●●●	RXZE2S114M ²	0.15	0.070

¹ When mounting relay RXM2●●●● on socket RXZE2M●●●●, the thermal current must not exceed 10 A.

² Thermal current Ith: 10 A

³ Thermal current Ith: 12 A

Protection modules (sold in lots of 20)

Description	Voltage	For use with	Catalog Number	Weight	
				oz.	g
Diode	6–250 Vdc	All sockets	RXM040W	0.11	3.0
RC circuit	24–60 Vac	All sockets	RXM041BN7	0.35	10.0
	110–240 Vac	All sockets	RXM041FU7	0.35	10.0
Varistor	6–24 Vac/Vdc	All sockets	RXM021RB	1.06	30.0
	24–60 Vac/Vdc	All sockets	RXM021BN	1.06	30.0
	110–240 Vac/Vdc	All sockets	RXM021FP	1.06	30.0

Timing relays

Description	For use with	Catalog Number	Weight	
			lb.	kg
2 timed DPDT contacts (function A—On-delay)	Sockets RXZ E●●●●	REXL2●● ⁴	0.09	0.042
4 timed 4PDT contacts (function A—On-delay)		REXL4●● ⁴	0.09	0.042

⁴ Please refer to the Zelio® Time - Timers catalog (9050CT0001R2/05).

Accessories (sold in lots of 10)

Description	For use with	Catalog Number	Weight	
			oz.	g
Metal hold-down clip	All sockets	RXZ400	0.04	1.0
Plastic hold-down clip	All sockets	RXZR335	0.18	5.0
Bus jumper, 2-pole (Ith: 5 A)	All sockets with separate contacts	RXZS2	0.18	5.0
Mounting adapter for DIN rail ⁵	All relays	RXZE2DA	0.14	4.0
Mounting adapter for mounting directly to a panel	All relays	RXZE2FA	0.07	2.0
Clip-in markers	All relays (sheet of 108 markers)	RXZL520	2.82	80.0
	All sockets except RXZE2M114	RXZL420	0.04	1.0

⁵ Test button becomes inaccessible.

Zelio® Plug-in Relays

Dimensions

RXM Miniature Relays

Relays

RXM●●●●●

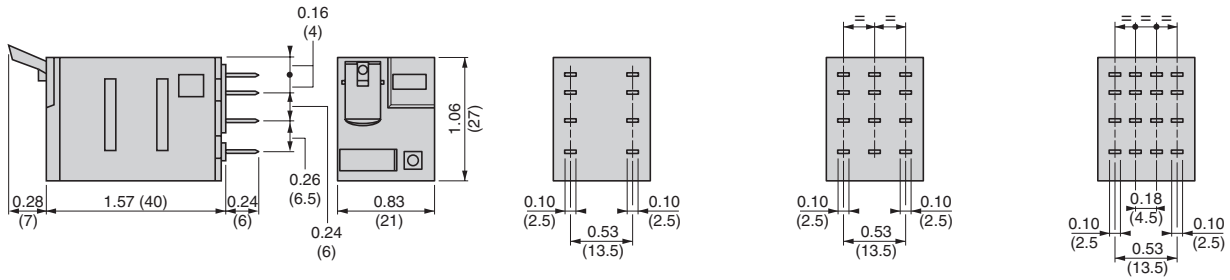
RXM2

RXM3

RXM4

Common view

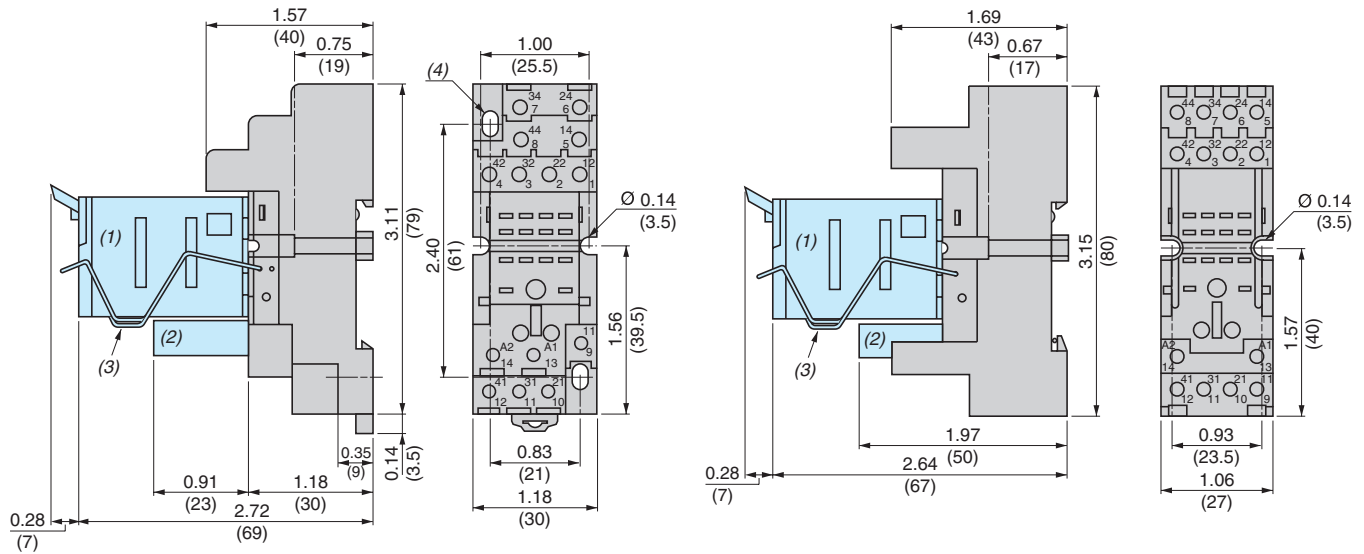
Pin side view



Sockets

RXZE2M114

RXZE2M114M



RXZE2S●●●●

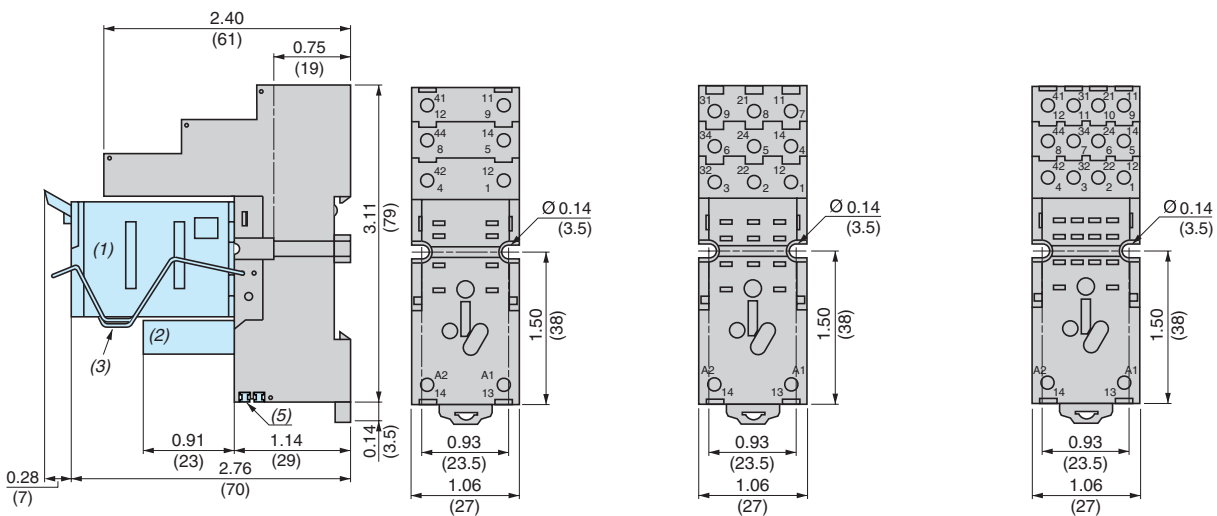
RXZE2S108M

RXZE2S111M

RXZE2S114M

Common side view

Pin side view

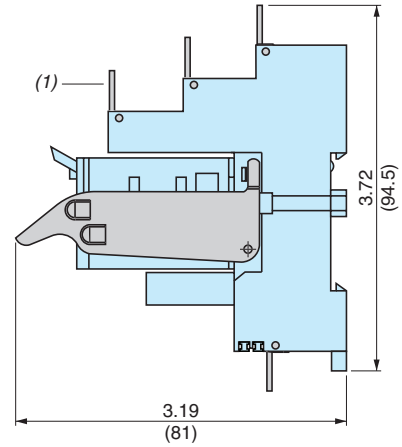
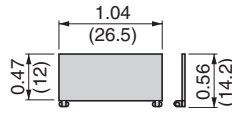
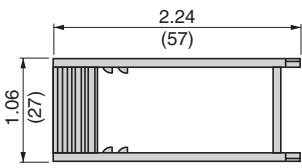


- (1) Relays
- (2) Add-on protection module
- (3) Hold-down clip
- (4) 2 elongated holes $\text{Ø} 0.14 \times 0.26$ (3.5 x 6.5)
- (5) 2 bus jumpers

Dimensions = Inches
(mm)

Plastic clamp and clip-in markers

RXZR335	RXZL420	Mounting on all sockets
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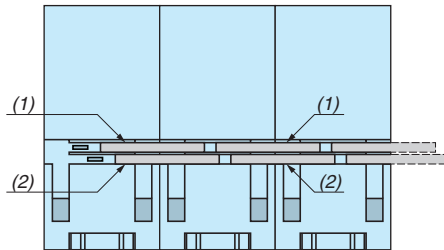
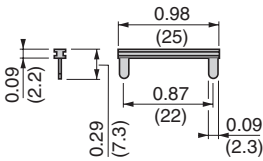


(1) Clip-in markers for all sockets except RXZE2M114.

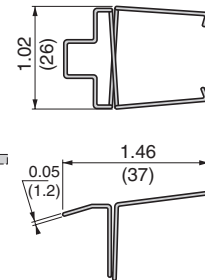
Bus jumper

RXZS2	Mounting on sockets with separate contacts (view from below)	Metal clamp RXZ400
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Example of bus jumper mounting on sockets

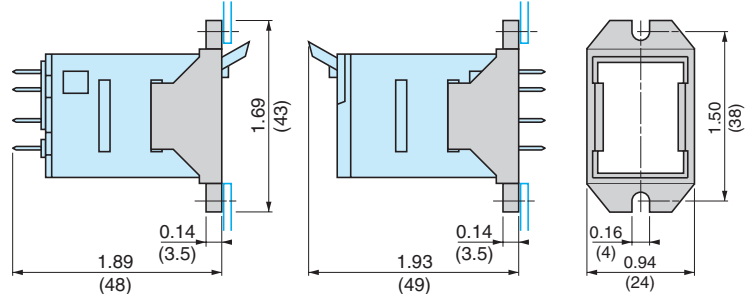
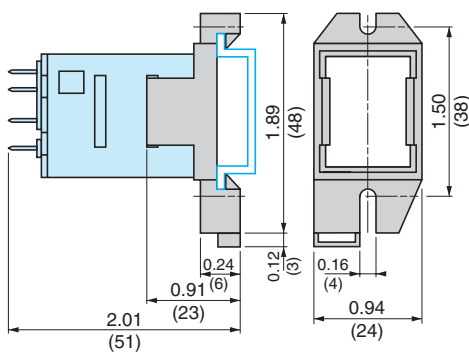


(1) 2 bus jumpers (polarity A2)
(2) 2 bus jumpers (polarity A1)



Mounting adapter for rail¹

RXZE2DA	Mounting adapter for panel RXZE2FA
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¹ Test button becomes inaccessible

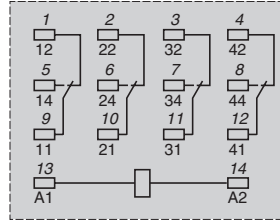
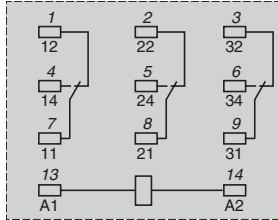
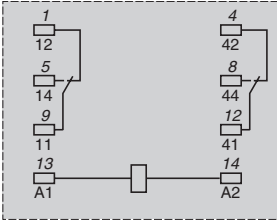
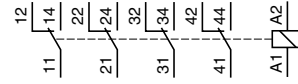
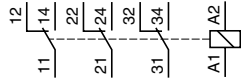
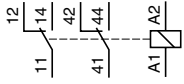
Dimensions = Inches
(mm)

Miniature relays

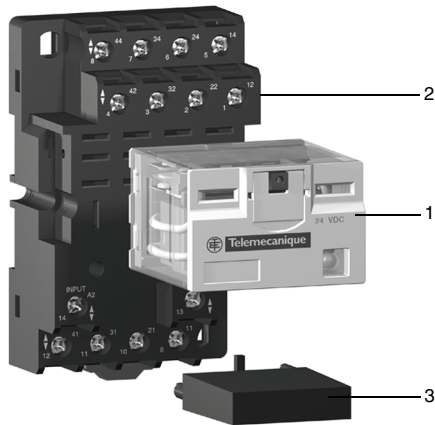
RXM2●●●●●

RXM3●●●●●

RXM4●●●●●



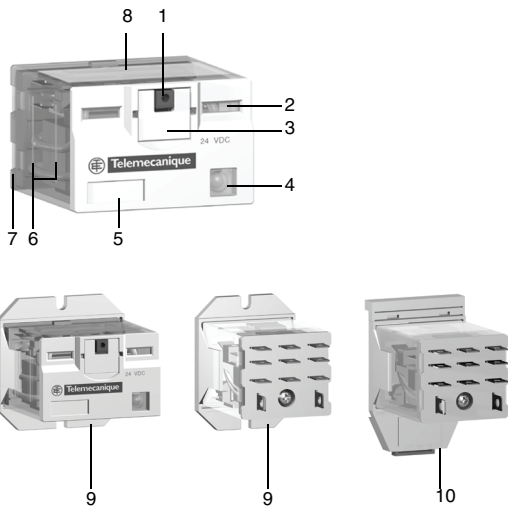
Numbers shown in *italics* correspond to NEMA marking. Viewed from pin end.



Product Description

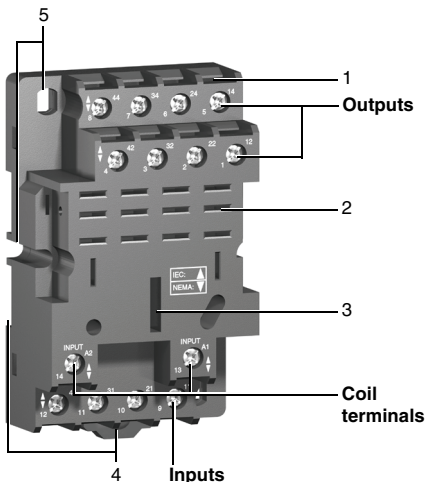
The RPM miniature relay range consists of:

1. 15 A relays with SPDT, DPDT, 3PDT, and 4PDT contacts.
2. Sockets with mixed contact terminals.
3. Protection modules (diode, RC circuit, or varistor) or 1 timer module. All these modules are common to all the sockets except for the timer module, which can only be used on the 3-pole or 4-pole sockets.
4. A metal hold-down clip for SPDT relays.



Relay Description

1. Spring return push button for testing the contacts (green: DC, red: AC).
2. Mechanical “relay status” indicator.
3. Optional removable lock-down door and push button, enabling forced maintaining of the contacts for test or maintenance purposes. During operation, this lock-down door must always be in the closed position.
4. Bipolar LED (depending on version) indicating the relay status.
5. Removable legend for relay identification.
6. Four notches for DIN rail mounting adapter or panel mounting adapter.
7. Five, eight, eleven, or fourteen pins.
8. Area by which the product can be easily gripped.
9. Mounting adapter enabling direct mounting of the relay on a panel.
10. Mounting adapter enabling direct mounting of the relay on a DIN rail.



Socket Description

Sockets with mixed contact terminals

1. Connection by screw clamp terminals.
2. Five, eight, eleven, or fourteen female contacts for the relay pins.
3. Location for protection modules or the timer module.
4. Locating slot for mounting on DIN rail with mounting clip.
5. Two or four mounting holes for panel mounting.

NOTE: The inputs are mixed with the relay coil terminals, with the outputs being located on the opposite side of the socket.

General characteristics

Conforming to standards		IEC/EN 61810-1 (iss. 2), UL 508, CSA C22-2 n° 14
Product certifications		cULus File E164862 GCN NLDX, NLDX7; cURus File E164862 GCN NLDX2, NLDX8; CSA pending; CE; RoHS compliant
Ambient air temperature around the device	Storage	-40–185 °F (-40–85 °C)
	Operation	-40–131 °F (-40–55 °C)
Vibration resistance	Conforming to IEC/EN 60068-2-6	6 gn (10–50 Hz)
Degree of protection	Conforming to IEC/EN 60529	IP 40
Shock resistance conforming to IEC/EN 60068-2-27	Opening	10 gn
	Closing	10 gn
Protection category (see page 38)		RT I
Mounting position		Any

Insulation characteristics

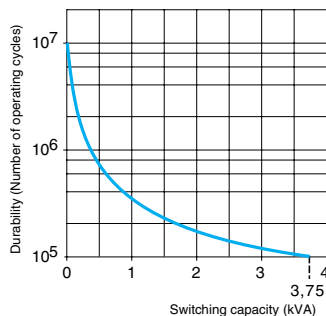
Rated insulation voltage (Ui)	Conforming to IEC/EN 60947	250 V (IEC), 300 V (UL, CSA)
Rated impulse withstand voltage (Uimp)		3.6 kV (1.2/50 µs)
Dielectric strength (rms voltage)	Between coil and contact	2,500 Vac
	Between poles	2,500 Vac
	Between contacts	1,500 Vac

Contact characteristics

Relay type		RPM1●●●	RPM2●●●	RPM3●●●	RPM4●●●
Number and type of contacts (see page 20)		SPDT	DPDT	3PDT	4PDT
Contact materials		AgNi			
Conventional thermal current (Ith)	For ambient temperature ≤ 131 °F (55 °C)	15 A			
	Conforming to IEC in utilization category AC-1	N.O. N.C.	15 A 7.5 A		
Rated operational current	Conforming to UL Resistive @277 Vac, hp @ 120 Vac	15 A, 1/2 hp			
	Maximum operating rate In operating cycles/hour	No load	18,000		
Switching voltage	Under load	1,200			
	Maximum	250 Vac/Vdc			
Switching capacity	Minimum	10 mA on 17 V			
	Maximum	3,750 VA			
Utilization coefficient		20%			
Mechanical durability in millions of operating cycles		10			
Electrical durability in millions of operating cycles	Resistive load	0.1			0.06

Electrical durability of contacts

Resistive load AC



Coil characteristics

Relay type		RPM1●●●	RPM2●●●	RPM3●●●	RPM4●●●			
Average consumption	AC	0.9 VA	1.2 VA	1.5 VA	1.5 VA			
	DC	0.7 W	0.9 W	1.7 W	2 W			
Drop-out voltage threshold	AC	≥ 0.15 U _c						
	DC	≥ 0.1 U _c						
Operating time (response time)	Between coil energization and making of the N.O. contact	AC	20 ms	25 ms	25 ms	20 ms		
		DC	20 ms	25 ms	25 ms	20 ms		
	Between coil de-energization and making of the N.C. contact	AC	20 ms					
		DC	20 ms					
Control circuit voltage U _c		12 V	24 V	48 V	110 V	120 V	230 V	
Relay control voltage codes		JD	BD	ED	FD	—	—	
DC	Average resistance at 68 °F (20 °C) ± 10%	RPM1●●●	180 Ω	750 Ω	2,600 Ω	13,100 Ω	—	—
		RPM2●●●	160 Ω	650 Ω	2,600 Ω	11,000 Ω	—	—
		RPM3●●●	100 Ω	400 Ω	2,600 Ω	8,600 Ω	—	—
		RPM4●●●	96 Ω	388 Ω	1,550 Ω	7,340 Ω	—	—
	Operating voltage limits	Min.	9.6 V	19.2 V	38.4 V	88 V	—	—
		Max.	13.2 V	26.4 V	52.8 V	121 V	—	—
Relay control voltage codes		—	B7	E7	—	F7	P7	
AC	Average resistance at 68 °F (20 °C) ± 15%	RPM1●●●	—	160 Ω	720 Ω	—	4,430 Ω	15,720 Ω
		RPM2●●●	—	180 Ω	770 Ω	—	4,430 Ω	15,000 Ω
		RPM3●●●	—	103 Ω	770 Ω	—	2,770 Ω	12,000 Ω
		RPM4●●●	—	84.3 Ω	338 Ω	—	2,220 Ω	9,120 Ω
	Operating voltage limits	Min.	—	19.2 V	38.4 V	—	96 V	184 V
		Max.	—	26.4 V	52.8 V	—	132 V	253 V

Socket characteristics

Socket type		RPZF1	RPZF2	RPZF3	RPZF4	
Relay types used		RPM1●●●	RPM2●●●	RPM3●●●	RPM4●●●	
Protection module types used		RXM02●●● RXM04●●●	RXM02●●● RXM04●●●	RUW24●●●	RUW24●●●	
Product certifications		cURus File E172326 CCN SWIV2, SWIV8; CSA (pending); CE; RoHS compliant				
Conventional thermal current (I _{th})		16 A				
Degree of protection		Conforming to IEC/EN 60529 IP 20				
Connection	Solid wire without cable end	1 conductor: AWG 20–12 (0.5–2.5 mm ²) 2 conductors: AWG 20–14 (0.5–1.5 mm ²)				
	Flexible wire with cable end	1 conductor: AWG 24–14 (0.2–2.5 mm ²) 2 conductors: AWG 24–16 (0.2–1.5 mm ²)				
	Flexible wire without cable end	1 conductor: AWG 24–14 (0.2–2.5 mm ²) 2 conductors: AWG 24–16 (0.2–1.5 mm ²)				
Maximum tightening torque		7.1 lbf-in (0.8 N•m) (M3.5 screw)				
Contact terminal arrangement		Mixed				

Power relays with lockable test button, without LED (sold in lots of 10)

Number and type of contacts - Thermal current (Ith)												
SPDT - 15 A												
Coil Voltage	Catalog Number	Weight		DPDT - 15 A			3PDT - 15 A			4PDT - 15 A		
		lb.	kg	Catalog Number	Weight	Catalog Number	Weight	Catalog Number	Weight	Catalog Number	Weight	
					lb.	kg		lb.	kg		lb.	kg
12 Vdc	RPM11JD	0.05	0.024	RPM21JD	0.08	0.036	RPM31JD	0.12	0.054	RPM41JD	0.15	0.068
24 Vdc	RPM11BD	0.05	0.024	RPM21BD	0.08	0.036	RPM31BD	0.12	0.054	RPM41BD	0.15	0.068
48 Vdc	RPM11ED	0.05	0.024	RPM21ED	0.08	0.036	RPM31ED	0.12	0.054	RPM41ED	0.15	0.068
110 Vdc	RPM11FD	0.05	0.024	RPM21FD	0.08	0.036	RPM31FD	0.12	0.054	RPM41FD	0.15	0.068
24 Vac	RPM11B7	0.05	0.024	RPM21B7	0.08	0.036	RPM31B7	0.12	0.054	RPM41B7	0.15	0.068
48 Vac	RPM11E7	0.05	0.024	RPM21E7	0.08	0.036	RPM31E7	0.12	0.054	RPM41E7	0.15	0.068
120 Vac	RPM11F7	0.05	0.024	RPM21F7	0.08	0.036	RPM31F7	0.12	0.054	RPM41F7	0.15	0.068
230 Vac	RPM11P7	0.05	0.024	RPM21P7	0.08	0.036	RPM31P7	0.12	0.054	RPM41P7	0.15	0.068



RPM22F7

Power relays with lockable test button, with LED (sold in lots of 10)

Number and type of contacts - Thermal current (Ith)												
SPDT - 15 A												
Coil Voltage	Catalog Number	Weight		DPDT - 15 A			3PDT - 15 A			4PDT - 15 A		
		lb.	kg	Catalog Number	Weight	Catalog Number	Weight	Catalog Number	Weight	Catalog Number	Weight	
					lb.	kg		lb.	kg		lb.	kg
12 Vdc	RPM12JD	0.05	0.024	RPM22JD	0.08	0.036	RPM32JD	0.12	0.054	RPM42JD	0.15	0.068
24 Vdc	RPM12BD	0.05	0.024	RPM22BD	0.08	0.036	RPM32BD	0.12	0.054	RPM42BD	0.15	0.068
48 Vdc	RPM12ED	0.05	0.024	RPM22ED	0.08	0.036	RPM32ED	0.12	0.054	RPM42ED	0.15	0.068
110 Vdc	RPM12FD	0.05	0.024	RPM22FD	0.08	0.036	RPM32FD	0.12	0.054	RPM42FD	0.15	0.068
24 Vac	RPM12B7	0.05	0.024	RPM22B7	0.08	0.036	RPM32B7	0.12	0.054	RPM42B7	0.15	0.068
48 Vac	RPM12E7	0.05	0.024	RPM22E7	0.08	0.036	RPM32E7	0.12	0.054	RPM42E7	0.15	0.068
120 Vac	RPM12F7	0.05	0.024	RPM22F7	0.08	0.036	RPM32F7	0.12	0.054	RPM42F7	0.15	0.068
230 Vac	RPM12P7	0.05	0.024	RPM22P7	0.08	0.036	RPM32P7	0.12	0.054	RPM42P7	0.15	0.068



RPM32F7

Power relays without lockable test button, with LED

Number and type of contacts - Thermal current (Ith)												
SPDT - 15 A												
Coil Voltage	Catalog Number	Weight		DPDT - 15 A			3PDT - 15 A			4PDT - 15 A		
		lb.	kg	Catalog Number	Weight	Catalog Number	Weight	Catalog Number	Weight	Catalog Number	Weight	
					lb.	kg		lb.	kg		lb.	kg
Sold in lots of 10												
12 Vdc	RPM13JD	0.05	0.024	RPM23JD	0.08	0.036	RPM33JD	0.12	0.054	RPM43JD	0.15	0.068
24 Vdc	RPM13BD	0.05	0.024	RPM23BD	0.08	0.036	RPM33BD	0.12	0.054	RPM43BD	0.15	0.068
48 Vdc	RPM13ED	0.05	0.024	RPM23ED	0.08	0.036	RPM33ED	0.12	0.054	RPM43ED	0.15	0.068
110 Vdc	RPM13FD	0.05	0.024	RPM23FD	0.08	0.036	RPM33FD	0.12	0.054	RPM43FD	0.15	0.068
24 Vac	RPM13B7	0.05	0.024	RPM23B7	0.08	0.036	RPM33B7	0.12	0.054	RPM43B7	0.15	0.068
48 Vac	RPM13E7	0.05	0.024	RPM23E7	0.08	0.036	RPM33E7	0.12	0.054	RPM43E7	0.15	0.068
120 Vac	RPM13F7	0.05	0.024	RPM23F7	0.08	0.036	RPM33F7	0.12	0.054	RPM43F7	0.15	0.068
230 Vac	RPM13P7	0.05	0.024	RPM23P7	0.08	0.036	RPM33P7	0.12	0.054	RPM43P7	0.15	0.068



RPM43BD

See page 17 for sockets and accessories.



RPZF2 + relay RPM22F7

Sockets (sold in lots of 10)

Contact terminal arrangement	Connection	Relay type	Catalog Number	Weight	
				lb.	kg
Mixed	Screw clamp terminals	RPM1●●●	RPZF1	0.09	0.042
		RPM2●●●	RPZF2	0.12	0.064
		RPM3●●●	RPZF3	0.16	0.072
		RPM4●●●	RPZF4	0.21	0.094

Protection modules

Description	Voltage	For use with	Sold in lots of	Catalog Number	Weight	
					oz.	g
Diode	6–250 Vdc	RPZF1 RPZF2	20	RXM040W	0.11	3.0
		RPZF3 RPZF4	10	RUW240BD	0.14	4.0
RC circuit	24–60 Vac	RPZF1 RPZF2	20	RXM041BN7	0.35	10.0
	110–240 Vac	RPZF1 RPZF2	20	RXM041FU7	0.35	10.0
		RPZF3 RPZF4	10	RUW241P7	0.14	4.0
	Varistor	6–24 Vac/Vdc	RPZF1 RPZF2	20	RXM021RB	0.11
24–60 Vac/Vdc		RPZF1 RPZF2	20	RXM021BN	0.11	3.0
110–240 Vac/Vdc		RPZF1 RPZF2	20	RXM021FP	0.11	3.0
		RPZF3 RPZF4	10	RUW242B7	0.14	4.0
240 Vac/Vdc		RPZF3 RPZF4	10	RUW242P7	0.14	4.0



RXM041●●●

Timer module¹ (sold in lots of 10)

Description	Voltage	Socket Type	Catalog Number	Weight	
				lb.	kg
Multifunction	24–240 Vac/Vdc	RPZF3 RPZF4	RUW101MW	0.04	0.02

¹ See timer module description (selection of functions and time delays) on page 29.

Accessories (sold in lots of 10)

Description	For use with	Catalog Number	Weight	
			oz.	g
Metal hold-down clip (for single-pole relays)	RPZF1	RPZR235	0.04	1.0
Mounting adapters for DIN rail ²	RPM1●●●	RPZ1DA	0.14	4.0
	RPM2●●●	RXZE2DA	0.14	4.0
	RPM3●●●	RPZ3DA	0.14	4.0
	RPM4●●●	RPZ4DA	0.21	6.0
Mounting adapters for mounting directly to a panel	RPM1●●●	RPZ1FA	0.07	2.0
	RPM2●●●	RXZE2FA	0.07	2.0
	RPM3●●●	RPZ3FA	0.11	3.0
	RPM4●●●	RPZ4FA	0.14	4.0
Clip-in markers (sheet of 108 markers)	All relays	RXZL520	2.82	80

² Test button becomes inaccessible.



RPZ1DA



RPZ3FA

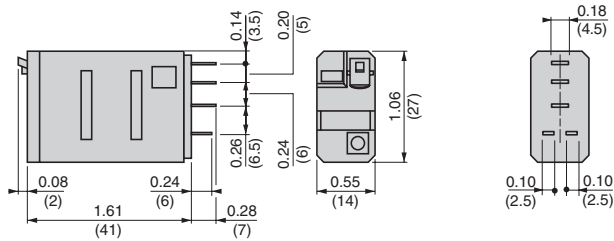
Zelio® Plug-in Relays

Dimensions

RPM Miniature Power Relays

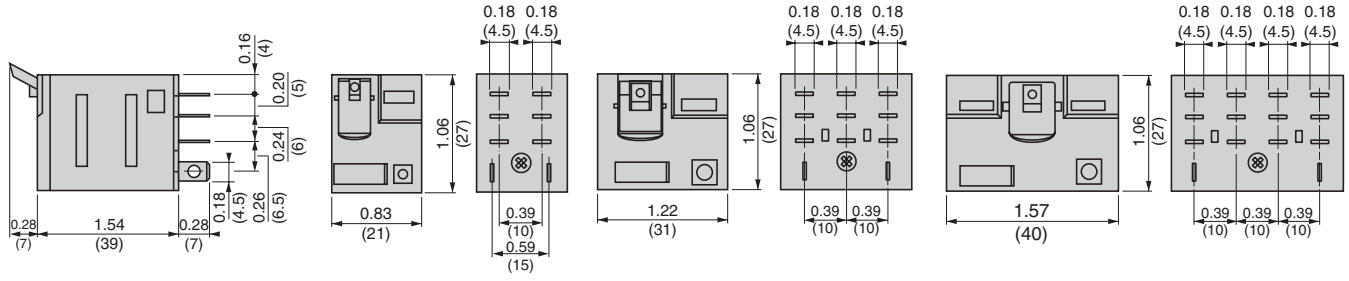
Power relays

RPM1



Dimensions = Inches
(mm)

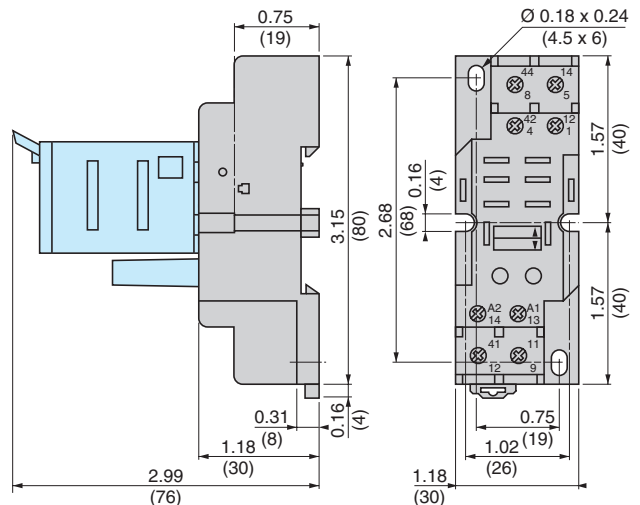
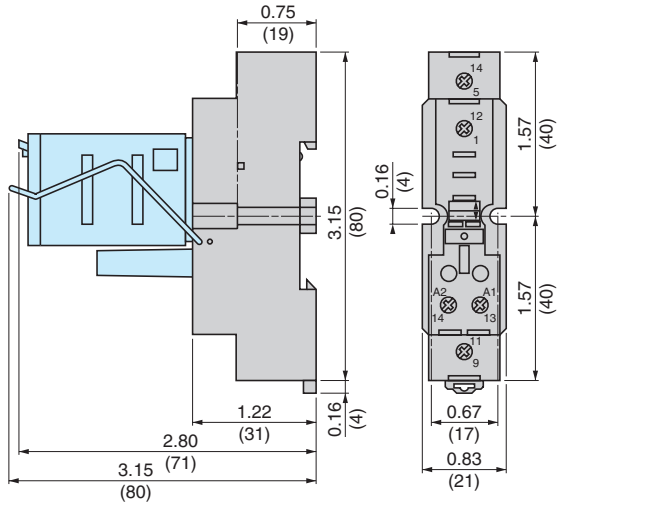
Common side view RPM2 RPM3 RPM4



Sockets

RPZF1

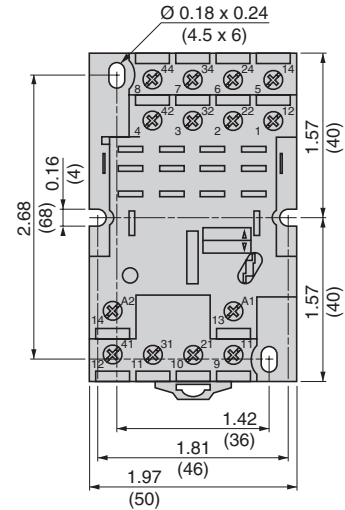
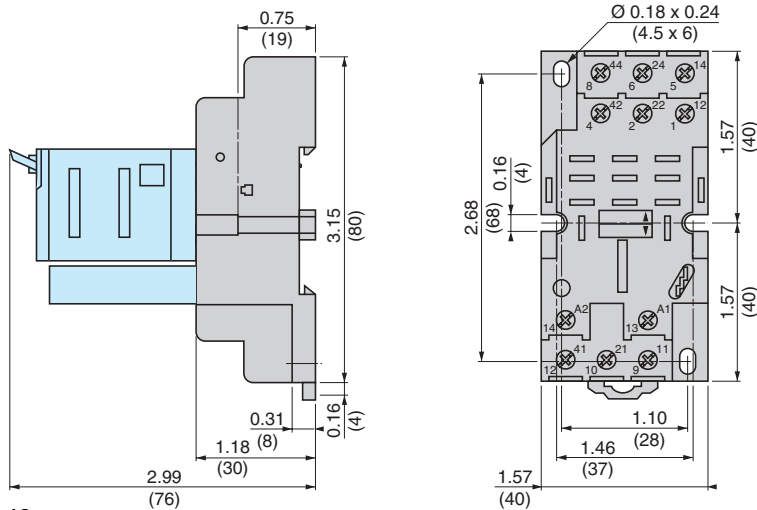
RPZF2



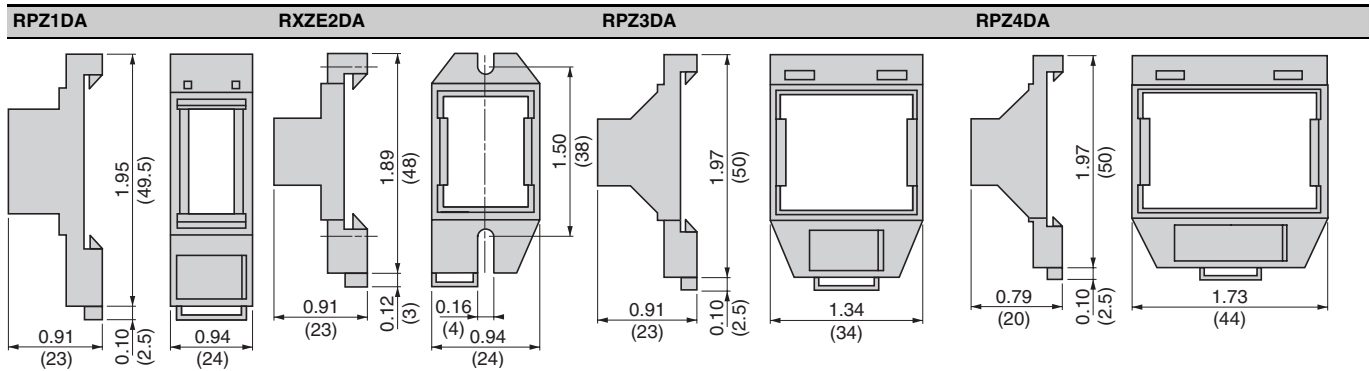
Common side view

RPZF3

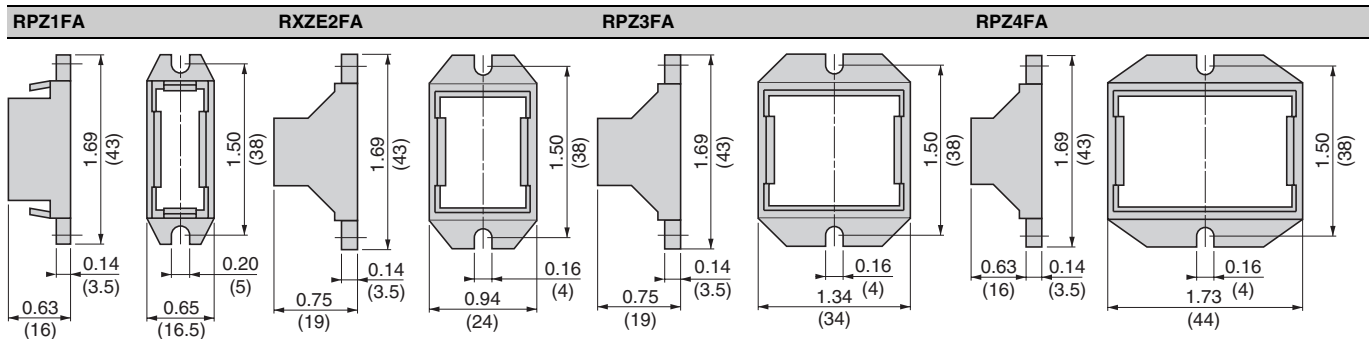
RPZF4



Mounting adapters for DIN rail

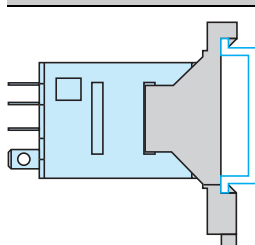


Mounting adapters for mounting directly to a panel

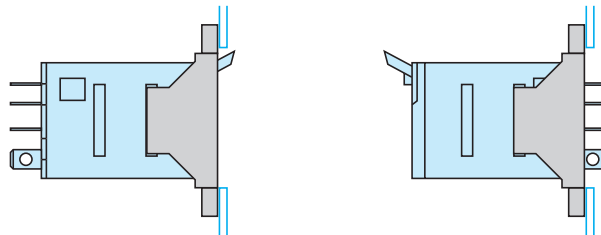


Mounting

Mounting adapters for DIN rail ¹



Mounting adapters for mounting directly to a panel

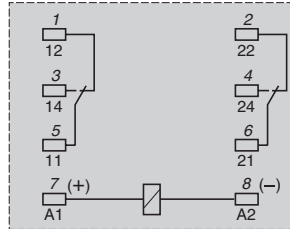
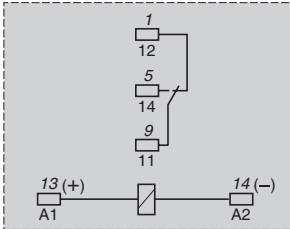
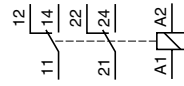
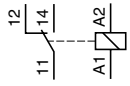


¹ Test button becomes inaccessible

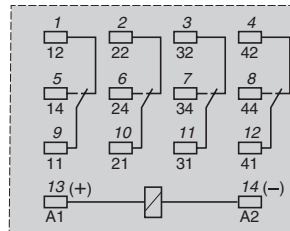
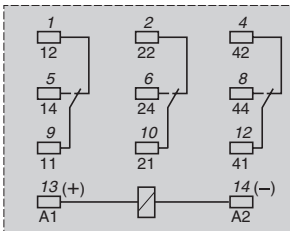
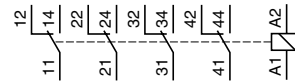
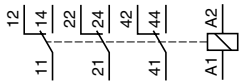
Dimensions = $\frac{\text{Inches}}{\text{(mm)}}$

Power relays

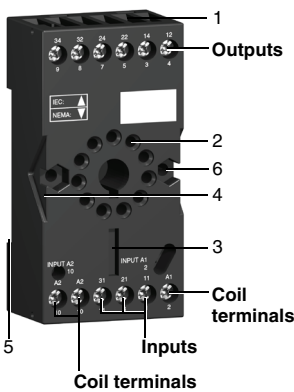
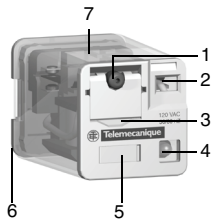
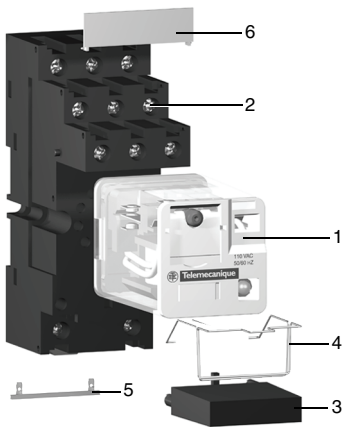
RPM1●●● RPM2●●●



RPM3●●● RPM4●●●



Numbers shown in *italics* correspond to NEMA marking. Viewed from pin end.



Product Description

The RUM universal relay range consists of:

1. 10 A relays with DPDT and 3PDT contacts, with cylindrical or flat pins, and 3 A “low level” relays with 3PDT contacts, with cylindrical pins. All these relays have the same dimensions.
2. Sockets with mixed or separate contact terminals.
3. Protection modules (diode, RC circuit, or varistor) or 1 timer module. All these modules are common to all sockets.
4. A metal hold-down clip for all sockets.
5. A 2-pole bus jumper that can be used on sockets with separate contact terminals to simplify cabling when creating a jumper between the coil terminals.
6. Clip-in markers for the sockets.

Relay Description

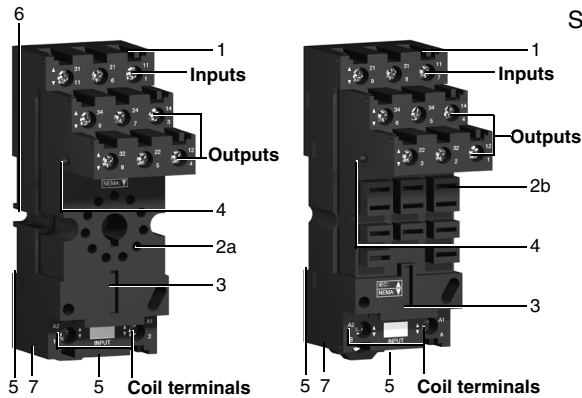
1. Spring return push button for testing the contacts (green: DC, red: AC).
2. Mechanical “relay status” indicator.
3. Optional removable lock-down door and push button, enabling forced maintaining of the contacts for test or maintenance purposes. During operation, this lock-down door must always be in the closed position.
4. Bipolar LED (depending on version) indicating the relay status.
5. Removable marker for relay identification.
6. Eight or eleven cylindrical or flat pins.
7. Area by which the product can be easily gripped.

Socket Description

Sockets with mixed contact terminals

1. Box lug connectors.
2. Eight or eleven female contacts for the relay cylindrical pins.
3. Location for protection modules or the timer module.
4. Locking component for metal hold-down clip.
5. Locating slot for DIN rail mounting.
6. Two mounting holes for panel mounting.

NOTE: The inputs are mixed with the relay coil terminals, with the outputs being located on the opposite side of the socket.



Sockets with separate contact terminals

1. Box lug connectors.
2. a. Eight or eleven female contacts for the relay cylindrical pins.
b. Eleven female contacts for the relay flat pins.
3. Location for protection modules or the timer module.
4. Locking component for metal hold-down clip.
5. Locating slot for mounting on DIN rail.
6. Two mounting holes for panel mounting.
7. Location for bus jumpers (see mounting on sockets on page 28).

NOTE: The inputs and outputs are separated from the relay coil terminals.

General characteristics

Conforming to standards		IEC/EN 61810-1 (iss. 2), UL 508, CSA C22-2 n° 14
Product certifications		cULus File E164862 CCN NLDX, NLDX7; cURus File E164862 CCN NLDX2, NLDX8; CSA pending; CE; RoHS compliant
Ambient air temperature around the device	Storage	-40–185 °F (-40–85 °C)
	Operation	-40–131 °F (-40–55 °C)
Vibration resistance	Conforming to IEC/EN 60068-2-6	4 gn (10–50 Hz)
Degree of protection	Conforming to IEC/EN 60529	IP 40
Shock resistance conforming to IEC/EN 60068-2-27	Opening	10 gn
	Closing	5 gn
Protection category (see page 38)		RT I
Mounting position		Any

Insulation characteristics

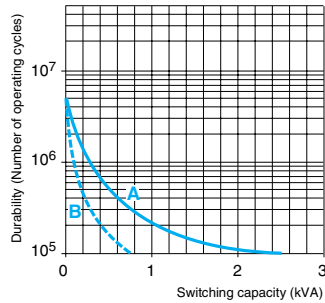
Rated insulation voltage (Ui)		250 V (IEC), 300 V (UL, CSA)
Rated impulse withstand voltage (Uimp)		3.6 kV (1.2/50 µs)
Dielectric strength (rms voltage)	Between coil and contact	2,500 Vac
	Between poles	2,500 Vac
	Between contacts	1,500 Vac

Contact characteristics

Relay type		RUMF2●●●	RUMF3B●●●	RUMC2●●●	RUMC3A●●●
Number and type of contacts (see page 28)		DPDT	3PDT	DPDT	3PDT
Contact materials		AgNi			
Conventional thermal current (Ith)	For ambient temperature ≤ 131 °F (55 °C)	10 A			
	Conforming to IEC in utilization category AC-1	N.O.	10 A	N.C.	5 A
Rated operational current	Conforming to UL Resistive @277 Vac, hp @ 120 Vac	16 A, 1/3 hp			
	No load	36,000			
Maximum operating rate In operating cycles/hour	Under load	3,600			
	Maximum	250 Vac/Vdc			
Switching capacity	Minimum	10 mA on 17 V			
	Maximum	2,500 VA			
Utilization coefficient		20%			
Mechanical durability in millions of operating cycles		5			
Electrical durability in millions of operating cycles	Resistive load	0.1			

Electrical durability of contacts

Resistive load AC



A=RUMF●●●●●, RUMC2●●●, RUMC3A●●●, B=RUMC3G●●●

Coil characteristics

Average consumption	AC	2-3 VA									
	DC	1.4 W									
Drop-out voltage threshold	AC	≥ 0.15 U _c									
	DC	≥ 0.1 U _c									
Operating time (response time)	Between coil energization and making of the N.O. contact	AC	20 ms								
		DC	20 ms								
	Between coil de-energization and making of the N.C. contact	AC	20 ms								
		DC	20 ms								
Coil voltage U _c		12 V	24 V	48 V	60 V	110 V	120 V	125 V	220 V	230 V	
Relay coil voltage codes		JD	BD	ED	ND	FD	—	GD	MD	—	
DC	Average resistance at 68 °F (20 °C) ± 10%	120 Ω	470 Ω	1,800 Ω	2,790 Ω	10,000 Ω	—	10,000 Ω	3,700 Ω	—	
	Operating voltage limits	Min.	9.6 V	19.2 V	38.4 V	48 V	88 V	—	100 V	176 V	—
		Max.	13.2 V	26.4 V	52.8 V	66 V	121 V	—	138 V	242 V	—
Relay coil voltage codes		—	B7	E7	—	—	F7	—	—	P7	
AC	Average resistance at 68 °F (20 °C) ± 15%	—	72 Ω	290 Ω	—	—	1,700 Ω	—	—	7,200 Ω	
	Operating voltage limits	Min.	—	19.2 V	38.4 V	—	—	96 V	—	—	184 V
		Max.	—	26.4 V	52.8 V	—	—	132 V	—	—	253 V

Socket characteristics

Socket type		RUZC2M	RUZC3M	RUZSC2M	RUZSC3M	RUZSF3M
Relay types used		RUMC2●●●●●	RUMC3●●●●●	RUMC2●●●●●	RUMC3●●●●●	RUMF●●●●●
Product certifications		cURus File E172326 CCN SWIV2, SWIV8; CSA (pending); CE; RoHS compliant				
Conventional thermal current (I _{th})		12 A				
Degree of protection	Conforming to IEC/EN 60529	IP 20				
Connection	Solid wire without cable end	1 conductor: AWG 20-12 (0.5-2.5 mm ²) 2 conductors: AWG 20-14 (0.5-1.5 mm ²)				
	Flexible wire with cable end	1 conductor: AWG 24-14 (0.2-2.5 mm ²) 2 conductors: AWG 24-16 (0.2-1.5 mm ²)				
	Flexible wire without cable end	1 conductor: AWG 24-14 (0.2-2.5 mm ²) 2 conductors: AWG 24-16 (0.2-1.5 mm ²)				
Maximum tightening torque		5.3 lbf-in (0.6 N•m) (M3 screw)				
Contact terminal arrangement		Mixed				Separate
Bus jumper I _{th} : 5 A		No				Yes

Relays for standard applications with lockable test button, without LED (sold in lots of 10)

		Number and type of contacts - Thermal current (Ith)					
		DPDT - 10 A				3PDT - 10 A	
Pins	Coil Voltage	Catalog Number	Weight		Catalog Number	Weight	
			lb.	kg		lb.	kg
Cylindrical	12 Vdc	RUMC2AB1JD	0.186	0.084	RUMC3AB1JD	0.194	0.088
	24 Vdc	RUMC2AB1BD	0.186	0.084	RUMC3AB1BD	0.194	0.088
	48 Vdc	RUMC2AB1ED	0.186	0.084	RUMC3AB1ED	0.194	0.088
	60 Vdc	—	—	—	RUMC3AB1ND	0.194	0.088
	110 Vdc	RUMC2AB1FD	0.186	0.084	RUMC3AB1FD	0.194	0.088
	125 Vdc	—	—	—	RUMC3AB1GD	0.194	0.088
	220 Vdc	—	—	—	RUMC3AB1MD	0.194	0.088
	24 Vac	RUMC2AB1B7	0.186	0.084	RUMC3AB1B7	0.194	0.088
	48 Vac	RUMC2AB1E7	0.186	0.084	RUMC3AB1E7	0.194	0.088
	120 Vac	RUMC2AB1F7	0.186	0.084	RUMC3AB1F7	0.194	0.088
Flat	230 Vac	RUMC2AB1P7	0.186	0.084	RUMC3AB1P7	0.194	0.088
	12 Vdc	RUMF2AB1JD	0.177	0.080	RUMF3AB1JD	0.186	0.084
	24 Vdc	RUMF2AB1BD	0.177	0.080	RUMF3AB1BD	0.186	0.084
	48 Vdc	RUMF2AB1ED	0.177	0.080	RUMF3AB1ED	0.186	0.084
	110 Vdc	RUMF2AB1FD	0.177	0.080	RUMF3AB1FD	0.186	0.084
	24 Vac	RUMF2AB1B7	0.177	0.080	RUMF3AB1B7	0.186	0.084
	48 Vac	RUMF2AB1E7	0.177	0.080	RUMF3AB1E7	0.186	0.084
	120 Vac	RUMF2AB1F7	0.177	0.080	RUMF3AB1F7	0.186	0.084
	230 Vac	RUMF2AB1P7	0.177	0.080	RUMF3AB1P7	0.186	0.084

Relays for standard applications with lockable test button, with LED (sold in lots of 10)

Cylindrical	12 Vdc	RUMC2AB2JD	0.186	0.084	RUMC3AB2JD	0.194	0.088
	24 Vdc	RUMC2AB2BD	0.186	0.084	RUMC3AB2BD	0.194	0.088
	48 Vdc	RUMC2AB2ED	0.186	0.084	RUMC3AB2ED	0.194	0.088
	60 Vdc	—	—	—	RUMC3AB2ND	0.194	0.088
	110 Vdc	RUMC2AB2FD	0.186	0.084	RUMC3AB2FD	0.194	0.088
	125 Vdc	—	—	—	RUMC3AB2GD	0.194	0.088
	24 Vac	RUMC2AB2B7	0.186	0.084	RUMC3AB2B7	0.194	0.088
	48 Vac	RUMC2AB2E7	0.186	0.084	RUMC3AB2E7	0.194	0.088
	120 Vac	RUMC2AB2F7	0.186	0.084	RUMC3AB2F7	0.194	0.088
	230 Vac	RUMC2AB2P7	0.186	0.084	RUMC3AB2P7	0.194	0.088
Flat	12 Vdc	RUMF2AB2JD	0.186	0.084	RUMF3AB2JD	0.190	0.086
	24 Vdc	RUMF2AB2BD	0.186	0.084	RUMF3AB2BD	0.190	0.086
	48 Vdc	RUMF2AB2ED	0.186	0.084	RUMF3AB2ED	0.190	0.086
	110 Vdc	RUMF2AB2FD	0.186	0.084	RUMF3AB2FD	0.190	0.086
	24 Vac	RUMF2AB2B7	0.186	0.084	RUMF3AB2B7	0.190	0.086
	48 Vac	RUMF2AB2E7	0.186	0.084	RUMF3AB2E7	0.190	0.086
	120 Vac	RUMF2AB2F7	0.186	0.084	RUMF3AB2F7	0.190	0.086
	230 Vac	RUMF2AB2P7	0.186	0.084	RUMF3AB2P7	0.190	0.086



RUM●●AB2B7



RUM●●AB2F7



RUMC●AB3F7

Universal relays without lockable test button, with LED

Number and type of contacts - Thermal current (Ith)						
DPDT - 10 A				3PDT - 10 A		
Coil Voltage	Catalog Number	Weight		Catalog Number	Weight	
		lb.	kg		lb.	kg
With cylindrical pins (sold in lots of 10)						
12 Vdc	RUMC2AB3JD	0.186	0.084	RUMC3AB3JD	0.194	0.088
24 Vdc	RUMC2AB3BD	0.186	0.084	RUMC3AB3BD	0.194	0.088
48 Vdc	RUMC2AB3ED	0.186	0.084	RUMC3AB3ED	0.194	0.088
60 Vdc	—	—	—	RUMC3AB3ND	0.194	0.088
110 Vdc	RUMC2AB3FD	0.186	0.084	RUMC3AB3FD	0.194	0.088
125 Vdc	—	—	—	RUMC3AB3GD	0.194	0.088
24 Vac	RUMC2AB3B7	0.186	0.084	RUMC3AB3B7	0.194	0.088
48 Vac	RUMC2AB3E7	0.186	0.084	RUMC3AB3E7	0.194	0.088
120 Vac	RUMC2AB3F7	0.186	0.084	RUMC3AB3F7	0.194	0.088
230 Vac	RUMC2AB3P7	0.186	0.084	RUMC3AB3P7	0.194	0.088
With flat pins (sold in lots of 10)						
12 Vdc	RUMF2AB3JD	0.177	0.08	RUMF3AB3JD	0.186	0.084
24 Vdc	RUMF2AB3BD	0.177	0.08	RUMF3AB3BD	0.186	0.084
48 Vdc	RUMF2AB3ED	0.177	0.08	RUMF3AB3ED	0.186	0.084
110 Vdc	RUMF2AB3FD	0.177	0.08	RUMF3AB3FD	0.186	0.084
125 Vdc	—	—	—	RUMF3AB3GD	0.186	0.084
24 Vac	RUMF2AB3B7	0.177	0.08	RUMF3AB3B7	0.186	0.084
48 Vac	RUMF2AB3E7	0.177	0.08	RUMF3AB3E7	0.186	0.084
120 Vac	RUMF2AB3F7	0.177	0.08	RUMF3AB3F7	0.186	0.084
230 Vac	RUMF2AB3P7	0.177	0.08	RUMF3AB3P7	0.186	0.084

See page 26 for sockets and accessories.



RUZC3M +
relay RUMC3●●●●●

Sockets (sold in lots of 10)

Contact terminal arrangement	Connection	Relay type	Catalog Number	Weight	
				lb.	kg
Mixed	Box lug connector	RUMC2●●●●●	RUZC2M	0.12	0.054
		RUMC3●●●●●	RUZC3M	0.12	0.054
Separate		RUMC2●●●●●	RUZSC2M	0.21	0.095
		RUMC3●●●●●	RUZSC3M	0.22	0.100
		RUMF2●●●●●	RUZSF3M	0.21	0.095
		RUMF3●●●●●			



RUW241P7

Protection modules (sold in lots of 10)

Description	For use with	Voltage	Catalog Number	Weight	
				oz.	g
Diode	All sockets	6–250 Vdc	RUW240BD	0.14	4.0
RC circuit		110–240 Vac	RUW241P7	0.14	4.0
Varistor		24 Vac/Vdc	RUW242B7	0.14	4.0
		240 Vac/Vdc	RUW242P7	0.14	4.0



RUW101MW

Timer module

Description	For use with	Voltage	Catalog Number	Weight	
				oz.	g
Multifunction	All sockets	24–240 Vac/Vdc	RUW101MW	0.71	20.0

Timing relay

Description	For use with	Catalog Number
2 timed DPDT contacts (single-function or multi-function)	On sockets RUZ C●M	RE48A●● ¹

¹ Please refer to the *Zelio® Time - Timers* catalog (9050CT0001R2/05).



RUZC200



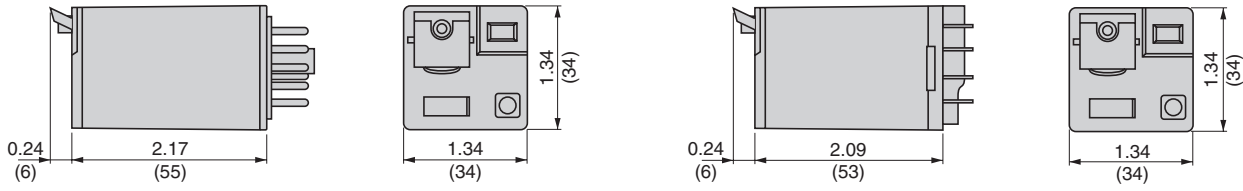
RUZS2

Accessories (sold in lots of 10)

Description	For use with	Catalog Number	Weight	
			oz.	g
Metal hold-down clip	All sockets	RUZC200	0.04	1.0
Bus jumper, 2-pole (Ith: 5 A)	All sockets with separate contacts	RUZS2	0.18	5.0
Clip-in markers	All relays (sheet of 108 markers)	RXZL520	2.82	80.0
	All sockets with separate contacts	RUZL420	0.04	1.0

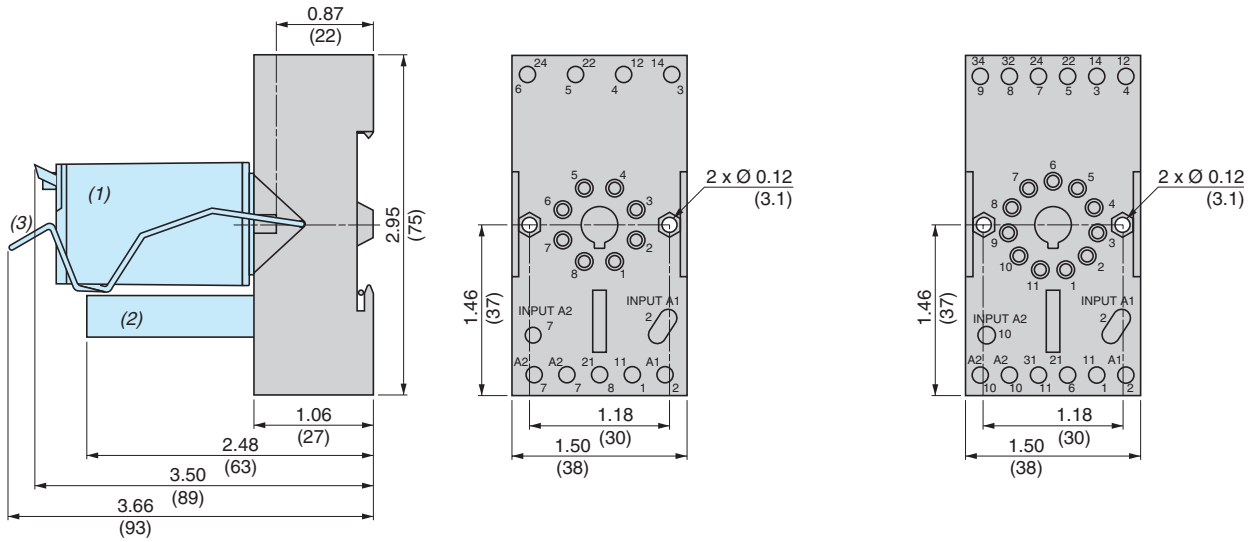
Universal relays

RUMC●● RUMF●●

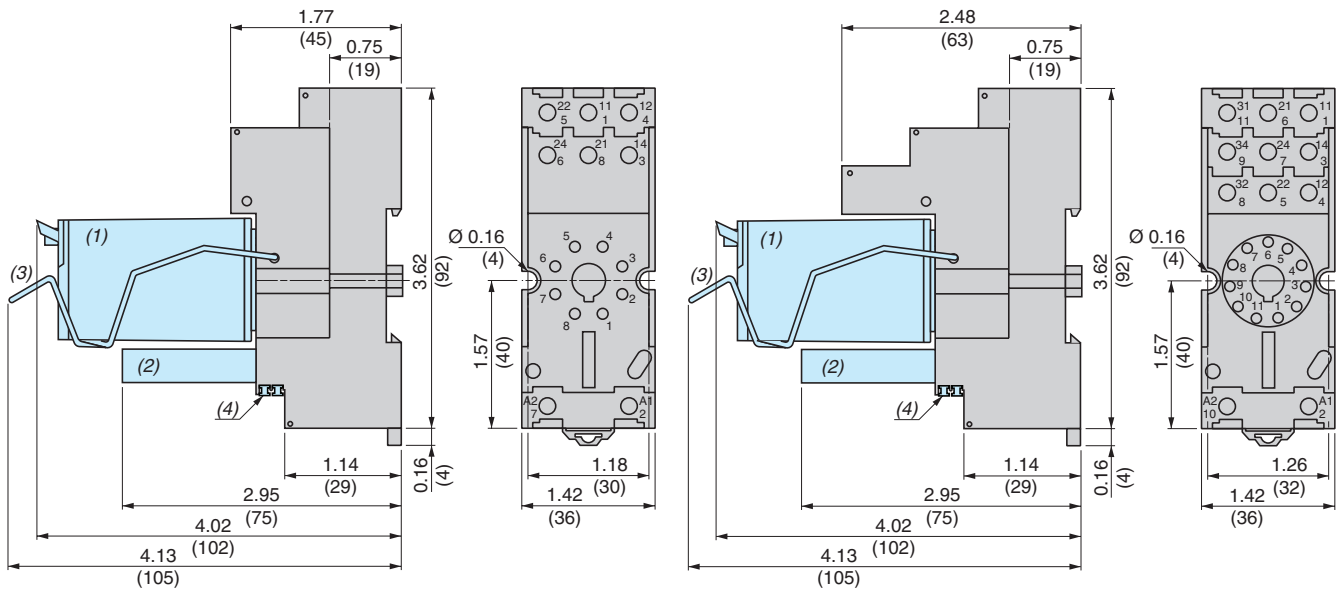


Sockets

Common side view RUZC2M RUZC3M



RUZSC2M RUZSC3M

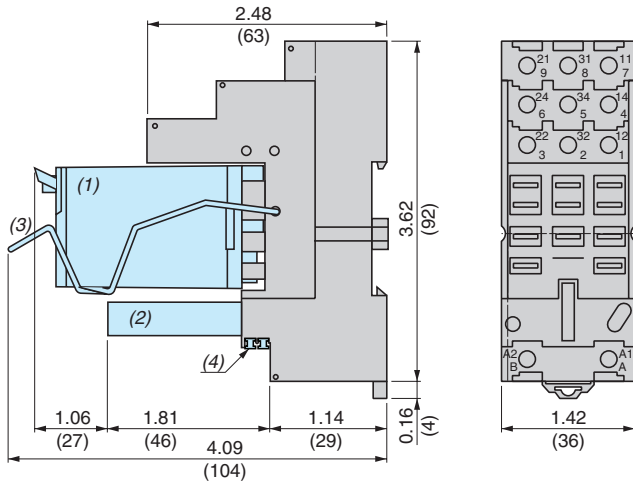


- (1) Relay
- (2) Protection module
- (3) Hold-down clip
- (4) 2 bus jumpers

Dimensions = Inches
(mm)

Sockets (continued)

RUZSF3M



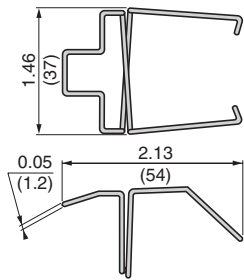
- (1) Relay
- (2) Protection module
- (3) Hold-down clip
- (4) 2 bus jumpers

Dimensions = Inches
(mm)

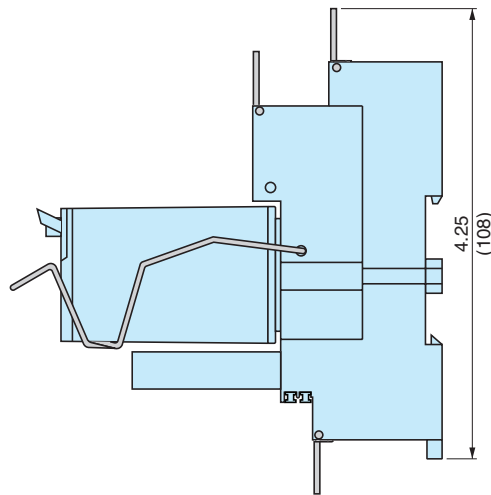
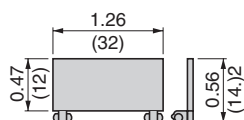
Metal hold-down clips and plastic markers

RUZC200

Mounting

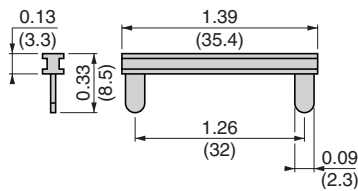


RUZL420



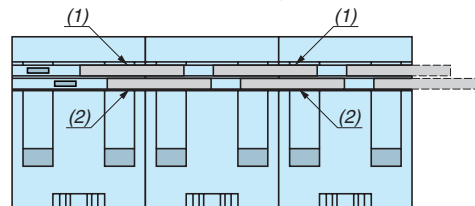
Bus jumper

RUZS2



Mounting on sockets with separate contacts (view from below)

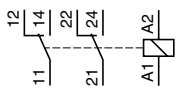
Example of bus jumper mounting on sockets



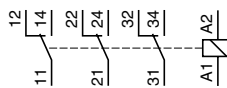
- (1) 2 bus jumpers (polarity A2)
- (2) 2 bus jumpers (polarity A1)

Wiring diagrams—universal relays

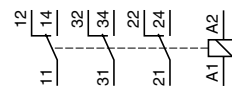
RUM2AB●●●



RUMC3●●●●●



RUMF3AB●●●

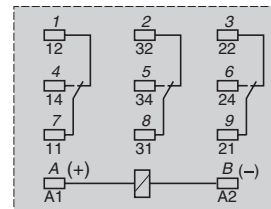
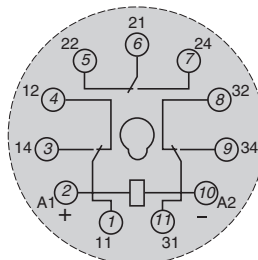
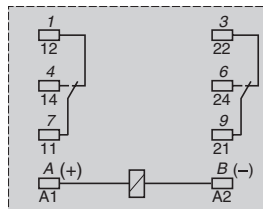
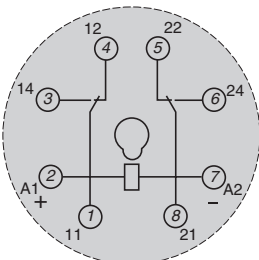


RUMC2AB●●●

RUMF2AB●●●

RUMC3●●●●●

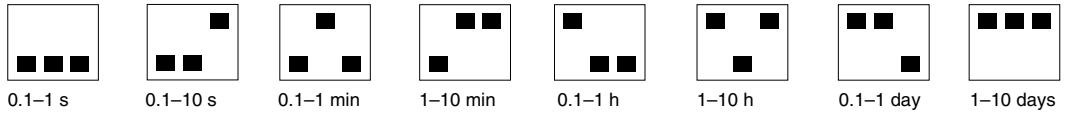
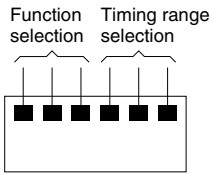
RUMF3AB●●●



Numbers shown in *italics* correspond to NEMA marking. Viewed from pin end.

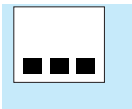
Multifunction timer module RUW101MW

Programming Timing range selection



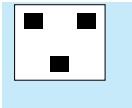
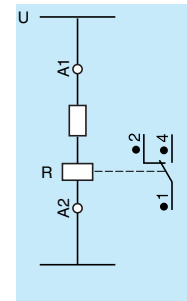
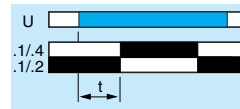
Function selection

Selection	Function	Control	Function diagram	Control scheme
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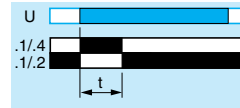
On-delay timer E

Series control



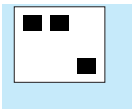
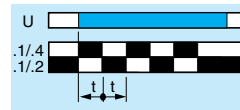
Interval timer Wu

Series control



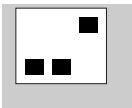
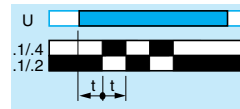
Repeat cycle timer, starting On-delay Bi

Series control



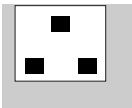
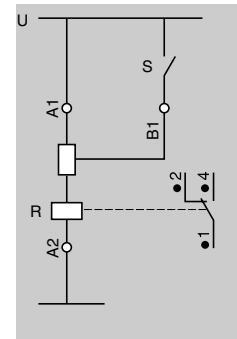
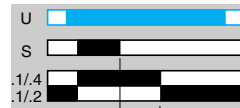
Repeat cycle timer, starting Off-delay Bp

Series control



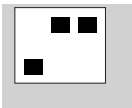
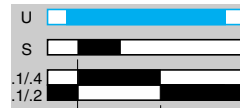
Off-delay timer R

Control by external contact (S)



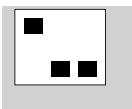
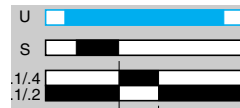
One-shot timer Ws

Control by external contact (S)



Timing on de-energization Wa

Control by external contact (S)



On-delay timer Es

Control by external contact (S)



Power off

Contact open

U: voltage

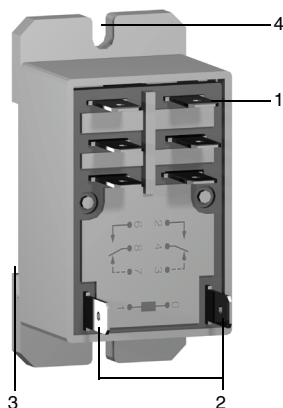
S: external control

Power on

Contact closed

R: relay RUM●●●

t: adjustable time delay



Product Description

RPF power relays with DPDT or 2 normally open (N.O.) DPST contacts consist of:

1. Four or six input/output, flat pins.
2. Two coil, flat pins.
3. A locating slot for mounting on DIN rail.
4. Two mounting holes for panel mounting.

General characteristics

Conforming to standards	IEC/EN 61810-1 (iss. 2), UL 508, CSA C22-2 n° 14	
Product certifications	cURus File E164862 CCN NLDX2, NLDX8; CSA pending; CE; RoHS compliant	
Ambient air temperature around the device	Storage	-40–185 °F (-40–85 °C)
	Operation	-40–131 °F (-40–55 °C)
Vibration resistance	Conforming to IEC/EN 60068-2-6	10 gn (10–55 Hz)
Degree of protection	Conforming to IEC/EN 60529	IP 40
Shock resistance conforming to IEC/EN 60068-2-27	Opening	10 gn
	Closing	10 gn
Protection category (see page 38)	RT IV	
Mounting position	Any	

Insulation characteristics

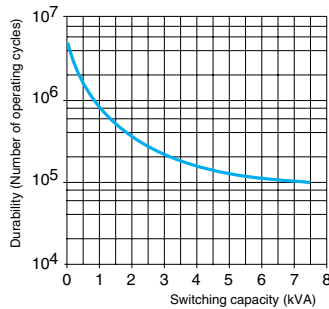
Rated insulation voltage (Ui)	Conforming to IEC/EN 60947	250 V
Rated impulse withstand voltage (Uimp)	3.6 kV (1.2/50 μs)	
Dielectric strength (rms voltage)	Between coil and contact	2,500 Vac
	Between poles	2,500 Vac
	Between contacts	1,500 Vac

Contact characteristics

Relay type		RPF2A●●	RPF2B●●
Number and type of contacts (see page 32)		DPST (N.O.)	DPDT
Contact materials		AgSnO ₂	
Conventional thermal current (I _{th})	For ambient temperature ≤ 104 °F (40 °C)	30 A (when mounted with 13mm gap between two relays) 25 A (when mounted side by side without a gap)	
Rated operational current	Conforming to IEC in utilization category AC-1	N.O.	30 A
		N.C.	3 A
	Conforming to UL (resistive @ 277 Vac)		30 A
Maximum operating rate In operating cycles/hour	No load	18,000	
	Under load	1,200	
Switching voltage	Maximum	250 Vac/Vdc	
	Minimum	10 mA on 17 Vdc	
Switching capacity	Minimum	7,200 VA	
	Maximum		
Utilization coefficient		10%	
Mechanical durability in millions of operating cycles		5	
Electrical durability in millions of operating cycles	Resistive load	0.05 (N.O. contact only)	

Electrical durability of contacts

Resistive load AC



A=RPF2●●● (30 A) B=RPF2●●● (25 A)

Coil characteristics

Average consumption		AC	4 VA				
		DC	1.7 W				
Drop-out voltage threshold		AC	≥ 0.15 U _c				
		DC	≥ 0.1 U _c				
Operating time (response time)	Between coil energization and making of the N.O. contact	AC	20 ms				
		DC	20 ms				
	Between coil de-energization and making of the N.C. contact	AC	20 ms				
		DC	20 ms				
Coil voltage U_c		12 V	24 V	110 V	120 V	230 V	
Relay coil voltage codes		JD	BD	FD	—	—	
DC	Average resistance at 68 °F (20 °C) ± 10%	86 Ω	350 Ω	7,255 Ω	—	—	
	Operating voltage limits	Min.	9.6 V	19.2 V	88 V	—	—
		Max.	13.2 V	26.4 V	121 V	—	—
Relay coil voltage codes		—	B7	—	F7	P7	
AC	Average resistance at 68 °F (20 °C) ± 15%	—	250 Ω	—	1,600 Ω	6,500 Ω	
	Operating voltage limits	Min.	—	19.2 V	—	96 V	184 V
		Max.	—	26.4 V	—	132 V	253 V

Zelio® Plug-in Relays

Ordering Information, Dimensions, and Wiring Diagrams

RPF Power Relays



RPF2B●●

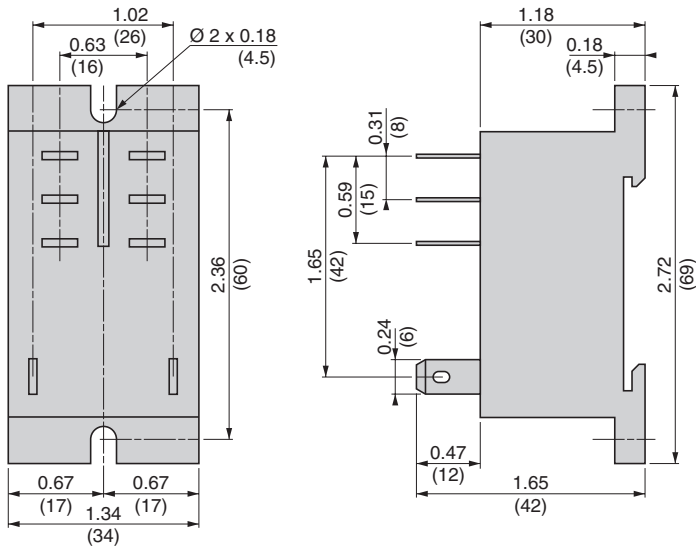
Power relays (sold in lots of 10)

Coil Voltage	Number and type of contacts - Thermal current (Ith)					
	DPST (N.O.) - 30 A ¹			DPDT - 30 A ¹		
	Catalog Number	Weight		Catalog Number	Weight	
lb.		kg	lb.		kg	
12 Vdc	RPF2AJD	0.19	0.086	RPF2BJD	0.19	0.086
24 Vdc	RPF2ABD	0.19	0.086	RPF2BBD	0.19	0.086
110 Vdc	RPF2AFD	0.19	0.086	RPF2BFD	0.19	0.086
24 Vac	RPF2AB7	0.19	0.086	RPF2BB7	0.19	0.086
120 Vac	RPF2AF7	0.19	0.086	RPF2BF7	0.19	0.086
230 Vac	RPF2AP7	0.19	0.086	RPF2BP7	0.19	0.086

¹ 30 A when mounted with 13 mm gap between two relays
25 A when mounted side by side without a gap.

Dimensions

RPF2A●●, RPF2B●●

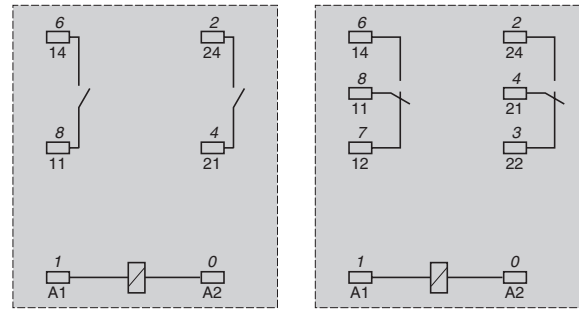


Dimensions = $\frac{\text{Inches}}{\text{(mm)}}$

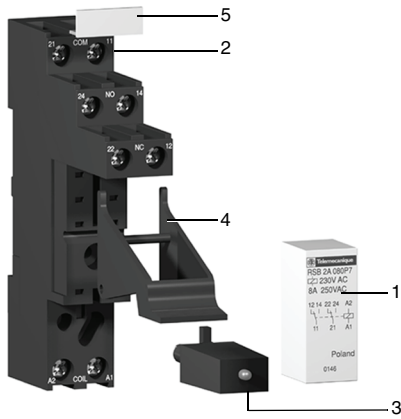
Wiring diagrams

RPF2A●●

RPF2B●●



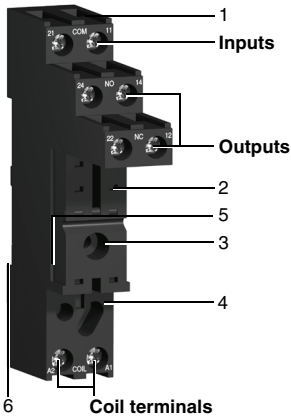
Numbers shown in italics correspond to NEMA marking. Viewed from pin end.



Product Description

The RSB interface relay range consists of:

1. 12 A relays with SPDT contact, 16 A relays with SPDT contact, and 8 A relays with DPDT contacts.
2. Sockets with separate contact terminals.
3. Protection modules (diode, diode + LED, RC circuit, or varistor + LED). All these modules are common to all sockets.
4. A plastic hold-down clip for all sockets.
5. Clip-in markers for the sockets.



Socket Description

Sockets with Separate Contact Terminals

1. Box lug connectors.
2. Five or eight female contacts for the relay pins.
3. A mounting hole for panel mounting.
4. Location for protection modules.
5. Locking components for plastic hold-down clip.
6. Locating slot for mounting on DIN rail.

NOTE: The inputs and outputs are separate from the coil terminals.

General characteristics

Conforming to standards	IEC/EN 61810-1 (iss. 2), UL 508, CSA C22-2 n° 14	
Product certifications	cURus File E173076 CNN NRNT2, NRNT8; CSA File 215736 Class 321107; CE; RoHS compliant	
Ambient air temperature around the device	Storage	-40–185 °F (-40–85 °C)
	Operation	Vdc: -40–185 °F (-40–85 °C); Vac: -40–158 °F (-40–70 °C)
Vibration resistance	Conforming to IEC/EN 60068-2-6	> 10 gn (10–150 Hz)
Degree of protection	Conforming to IEC/EN 60529	IP 40
Shock resistance conforming to IEC/EN 60068-2-27	Opening	5 gn
	Closing	10 gn
Protection category (see page 38)	RT I	
Mounting position	Any	

Insulation characteristics

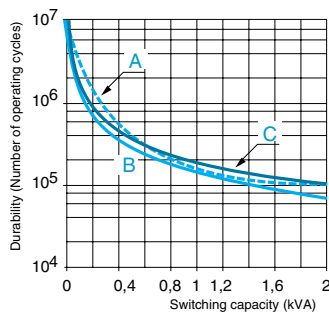
Rated insulation voltage (Ui)	Conforming to IEC/EN 60947	400 V
Rated impulse withstand voltage (Uimp)		3.6 kV (1.2/50 µs)
Dielectric strength (rms voltage)	Between coil and contact	5,000 Vac
	Between poles	2,500 Vac
	Between contacts	1,000 Vac

Contact characteristics

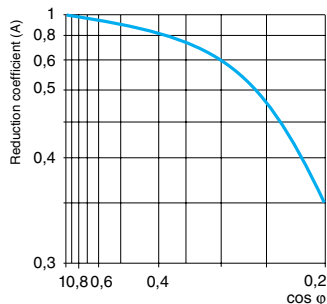
Relay type		RSB1A120●●	RSB1A160●●	RSB2A080●●
Number and type of contacts (see page 37)		SPDT	SPDT	DPDT
Contact materials		AgNi		
Conventional thermal current (Ith)	For ambient temperature ≤ 104 °F (40 °C)	12 A	16 A	8 A
Rated operational current	Conforming to IEC in utilization categories AC-1 and DC-1	N.O.	16 A	8 A
		N.C.	6 A	4 A
Maximum operating rate In operating cycles/hour	No load	72,000		
	Under load	600		
Switching voltage	Maximum	400 Vac, 300 Vdc		
Switching capacity	Minimum	5 mA at 60 V		
	Maximum	3,000 VA	4,000 VA	2,000 VA
Mechanical durability in millions of operating cycles		≥ 30		
Electrical durability in millions of operating cycles	Resistive load	12 A, 250 V: ≥ 0.1	16 A, 250 V: ≥ 0.07	8 A, 250 V: ≥ 0.1
	Inductive load	See curves below		

Electrical durability of contacts

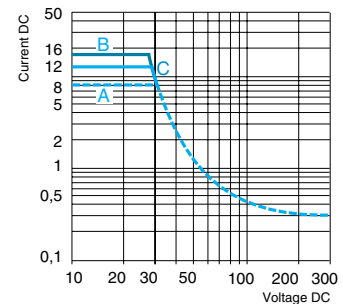
Resistive load AC



Reduction coefficient for inductive load AC (depending on power factor cos φ)



Maximum switching capacity on resistive load DC



A=RSB2A080●● B=RSB1A160●● C=RSB1A120●●

Durability (inductive load) = durability (resistive load) x reduction coefficient.

Coil characteristics

Average consumption	AC	0.75 VA										
	DC	0.45 W										
Drop-out voltage threshold	AC	≥ 0.15 Uc										
	DC	≥ 0.1 Uc										
Operating time (response time)	Between coil energization and making of the N.O. contact	AC	12 ms									
		DC	9 ms									
	Between coil de-energization and making of the N.C. contact	AC	10 ms									
		DC	4 ms									
Coil voltage Uc		6 V	12 V	24 V	48 V	60 V	110 V	120 V	220 V	230 V	240 V	
Relay coil voltage codes		RD	JD	BD	ED	ND	FD	—	—	—	—	
DC	Average resistance at 68 °F (20 °C) ± 10%	90 Ω	360 Ω	1,440 Ω	5,700 Ω	7,500 Ω	25,200 Ω	—	—	—	—	
	Operating voltage limits	Min.	4.8 V	9.6 V	19.2 V	38.4 V	48 V	88 V	—	—	—	
		Max.	6.6 V	13.2 V	26.4 V	52.8 V	68 V	121 V	—	—	—	
Relay coil voltage codes		—	—	B7	E7	—	—	F7	M7	P7	U7	
AC	Average resistance at 68 °F (20 °C) ± 15%	—	—	400 Ω	1,500 Ω	—	—	10,200 Ω	35,500 Ω	38,500 Ω	42,500 Ω	
	Operating voltage limits	Min.	50 Hz	—	—	19.2 V	38.4 V	—	—	96 V	176 V	184 V
			60 Hz	—	—	20.4 V	40.8 V	—	—	102 V	187 V	195.5 V
			Max. 50/60 Hz	—	—	26.4 V	57.6 V	—	—	144 V	264 V	276 V

Socket characteristics

Socket type		RSZE1S35M	RSZE1S48M
Relay types used		RSB1A120●●	RSB2A080●● RSB1A160●● ¹
Product certifications		cURus File E172326 CCN SWIV2; CSA File 212916 Class 3211 07; CE; RoHS compliant	
Conventional thermal current (Ith)		12 A	
Degree of protection	Conforming to IEC/EN 60529	IP 20	
Connection	Solid wire without cable end	1 conductor: AWG 20–12 (0.5–2.5 mm ²) 2 conductors: AWG 20–14 (0.5–1.5 mm ²)	
	Flexible wire with cable end	1 conductor: AWG 24–14 (0.2–2.5 mm ²) 2 conductors: AWG 24–16 (0.2–1.5 mm ²)	
	Flexible wire without cable end	1 conductor: AWG 24–14 (0.2–2.5 mm ²) 2 conductors: AWG 24–16 (0.2–1.5 mm ²)	
Maximum tightening torque		5.3 lbf-in (0.6 Nm) (M3 screw)	
Contact terminal arrangement		Separate	

¹ When using the relay with socket RSZ E1S48M, terminals must be jumpered. See wiring diagrams on page 37.

See page 36 for sockets and accessories.



RSB1A120JD
+ RZM031FPD
+ RSZE1S35M



RSB1A160BD
+ RSZE1S48M



RSB2A080BD
+ RSZE1S48M

Relays for standard applications (sold in lots of 10)

Coil Voltage	Number and type of contacts - Thermal current (Ith)			Weight	
	SPDT - 12 A	SPDT - 16 A	DPDT - 8 A		
	Catalog Number ¹	Catalog Number ¹	Catalog Number ¹	lb.	kg
6 Vdc	RSB1A120RD	RSB1A160RD	RSB2A080RD	0.03	0.014
12 Vdc	RSB1A120JD	RSB1A160JD	RSB2A080JD	0.03	0.014
24 Vdc	RSB1A120BD	RSB1A160BD	RSB2A080BD	0.03	0.014
48 Vdc	RSB1A120ED	RSB1A160ED	RSB2A080ED	0.03	0.014
60 Vdc	RSB1A120ND	RSB1A160ND	RSB2A080ND	0.03	0.014
110 Vdc	RSB1A120FD	RSB1A160FD	RSB2A080FD	0.03	0.014
24 Vac	RSB1A120B7	RSB1A160B7	RSB2A080B7	0.03	0.014
48 Vac	RSB1A120E7	RSB1A160E7	RSB2A080E7	0.03	0.014
120 Vac	RSB1A120F7	RSB1A160F7	RSB2A080F7	0.03	0.014
220 Vac	RSB1A120M7	RSB1A160M7	RSB2A080M7	0.03	0.014
230 Vac	RSB1A120P7	RSB1A160P7	RSB2A080P7	0.03	0.014
240 Vac	RSB1A120U7	RSB1A160U7	RSB2A080U7	0.03	0.014

¹ To order a relay complete with socket (sold in lots of 20): add suffix S to the references selected above.
Example: RSB2A080RD + RSZ E1S48M becomes RSB2A080RDS.

Sockets - 12 A, 300 Vac (sold in lots of 10)

Contact terminal arrangement	Connection	Relay type	Catalog Number	Weight	
				lb.	kg
Separate	Box lug connector	RSB1A120●●	RSZE1S35M	0.13	0.060
		RSB1A160●● ²	RSZE1S48M	0.11	0.050
		RSB2A080●●			

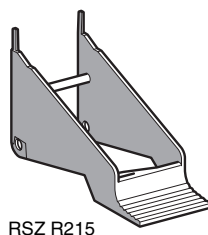
² When using the relay with socket RSZ E1S48M, terminals must be jumpered. See wiring diagrams on page 37.

Protection modules (sold in lots of 10)

Description	For use with	Voltage	Catalog Number	Weight	
				oz.	g
Diode	All sockets	6–230 Vdc	RZM040W	0.11	3.0
RC circuit	All sockets	24–60 Vac	RZM041BN7	0.35	10.0
		110–240 Vac	RZM041FU7	0.35	10.0
Diode + green LED	All sockets	6–24 Vdc	RZM031RB	0.14	4.0
		24–60 Vdc	RZM031BN	0.14	4.0
		110–230 Vdc	RZM031FPD	0.14	4.0
Varistor + green LED	All sockets	6–24 Vac/Vdc	RZM021RB	0.18	5.0
		24–60 Vac/Vdc	RZM021BN	0.18	5.0
		110–230 Vac/Vdc	RZM021FP	0.18	5.0

Accessories (sold in lots of 10)

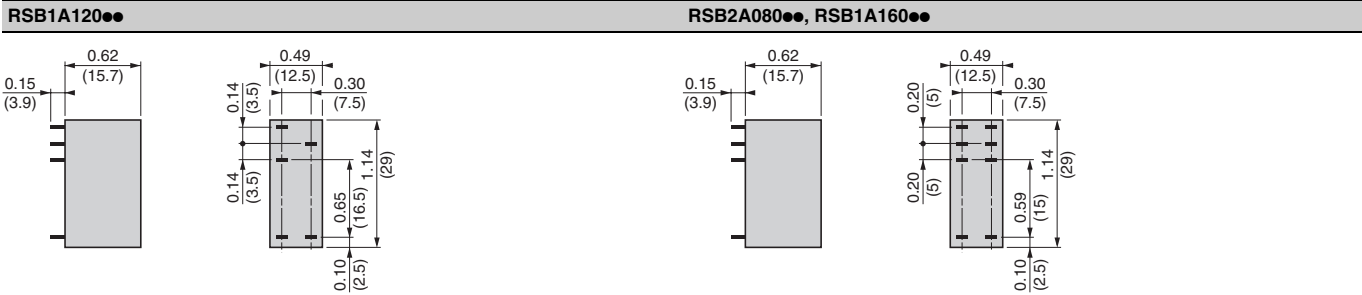
Description	For use with	Catalog Number	Weight	
			oz.	g
Plastic hold-down clip	All sockets	RSZR215	0.07	2.0
Marker	All sockets	RSZL300	0.04	1.0



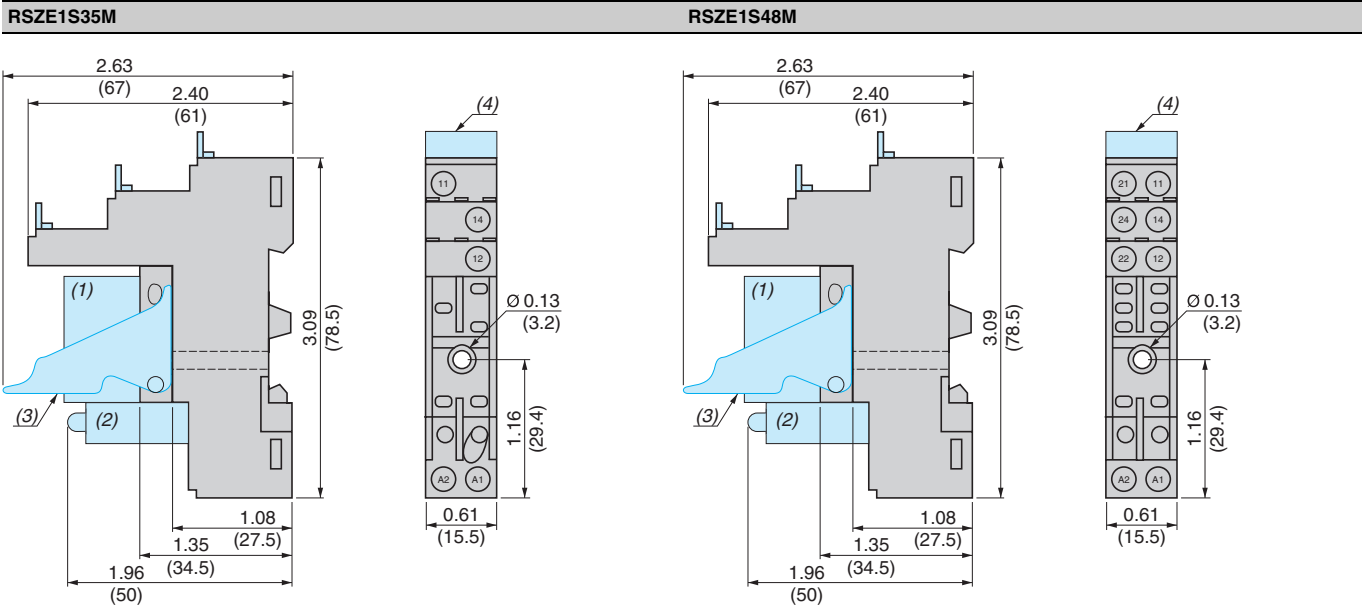
RSZ R215

Dimensions

Interface relays



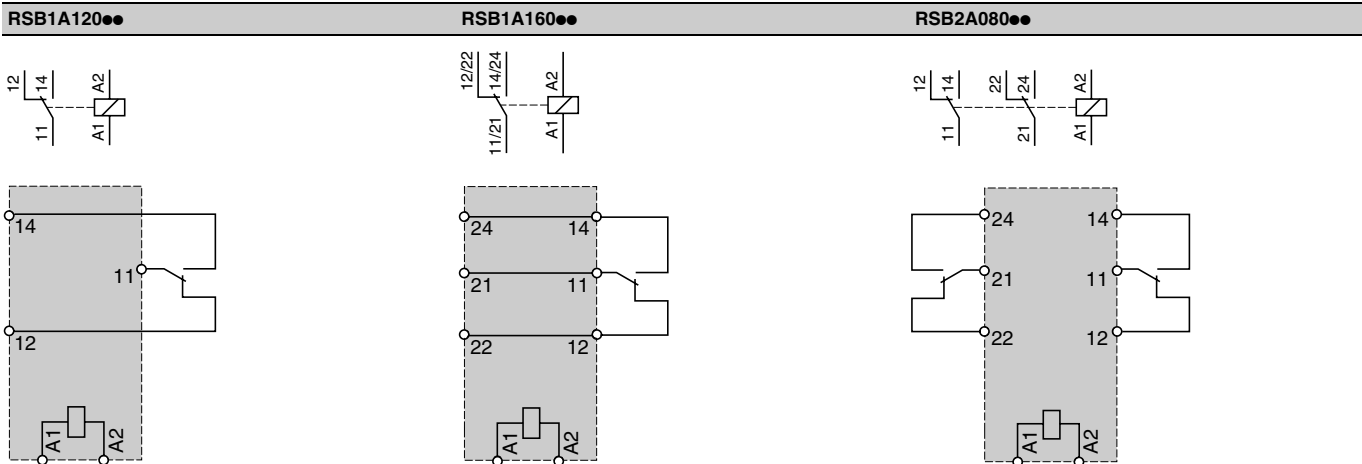
Sockets



(1) Relays (2) Add-on protection module (3) Hold-down clip (4) Marker

Wiring diagrams




Interface relays



When using relay RSB 1A160●● with socket RSZE1S48M, terminals 11 and 21, 14 and 24, and 12 and 22 must be jumpered.

Relays

Contact types

Symbol	Configuration	USA	EU
	Make contact (Normally Open)	SPST-N.O. DPST-N.O. nPST-N.O. ¹	N.O.
	Break contact (Normally Closed)	SPST-N.C. DPST-N.C. nPST-N.C. ¹	N.C.
	Changeover Contact (Form C)	SPDT DPDT nPDT ¹	C/O

¹ n = number of contacts.

Utilization categories

Category	Type of current	Applications
AC-1	AC single-phase AC 3-phase	Resistive or slightly inductive loads.
AC-3	AC 3-phase	Starting and braking of squirrel cage motors; reversing direction of rotation only after stopping of motor.
AC-4	AC 3-phase	Starting of squirrel cage motors, inching. Plugging, reversing direction of rotation.
DC-1	DC	Resistive or slightly inductive loads. ²
AC-14	AC single-phase	Control of electromagnetic loads (< 72 VA), auxiliary control relays, power contactors, electromagnetic solenoid valves and electromagnets.
AC-15	AC single-phase	Control of electromagnetic loads (> 72 VA), auxiliary control relays, power contactors, electromagnetic solenoid valves and electromagnets.
DC-13	DC	Control of electromagnetic loads, auxiliary control relays, power contactors, magnetic solenoid valves and electromagnets.

² The switchable voltage can be doubled, for an equal current, by connecting two contacts in series.

Protection categories

Category	Explanation	Condition
RT 0	Unenclosed relay	Relay not provided with a protective case.
RT I	Dust protected relay	Relay provided with a case which protects its mechanism from dust.
RT II	Flux-proof relay	Relay capable of being automatically soldered without allowing the migration of solder fluxes beyond the intended areas.
RT III	Wash-tight relay	Relay capable of being automatically soldered and then washed to remove flux residues without risk of ingress of flux or washing solvents.
RT IV	Sealed relay	Relay provided with a case which has no venting to the outside atmosphere.
RT V	Hermetically sealed relay	Sealed relay having an enhanced level of sealing.

Protection Modules

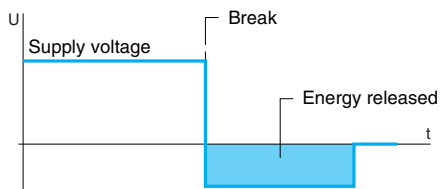
Whenever an inductive load is de-energized (coil of a relay or of a contactor), an overvoltage appears at its terminals. This voltage peak can reach several thousand volts and a frequency of several MHz. It is likely to disturb the operation of automation systems which contain electronic devices.

Protection modules are used to reduce the voltage peak on de-energization and, therefore, limit the energy of interference signals to a level that will not disturb surrounding coils and electronic devices. They are used to avoid:

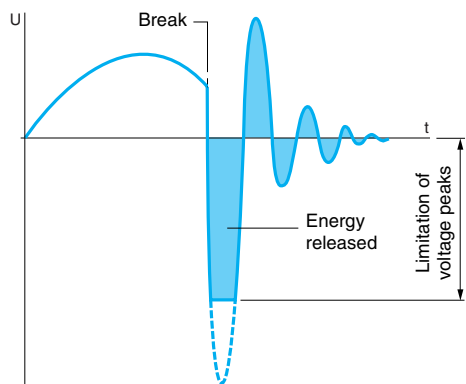
- electromagnetic compatibility problems
- the deterioration of contact materials
- the destruction of insulation due to overvoltage
- the destruction of electronic components

Diode Protection Module (with or without LED)

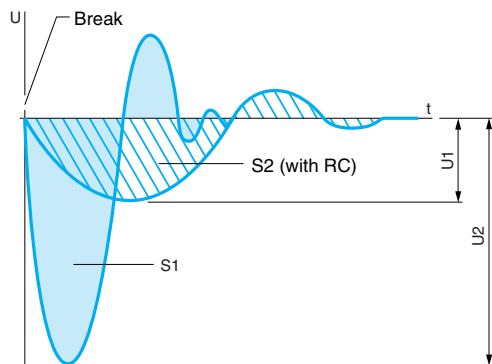
- Advantages
 - accumulation of energy allowing current flow in the same direction
 - absence of any voltage peaks at the coil terminals
 - low cost
- Disadvantages
 - increase in relay drop-out time (3 to 4 times the usual time)
 - no polarity protection



Coil voltage with diode protection module (Vdc only)



Coil voltage with varistor protection module (Vac and Vdc)



Coil voltage with RC circuit protection module (Vac only)

S1 = S2 = Energy released

Protection Module with Varistor

- Advantages
 - can be used with AC and DC supply
 - voltage peak limited to about 2 Un
 - little effect on relay drop-out time
- Disadvantages
 - no modification of coil's own oscillating frequency
 - limitation of switching frequency

Protection Module with RC Circuit

- Advantages
 - coil oscillating frequency reduced to about 150 Hz
 - voltage peak limited to 3 Un
 - little effect on relay drop-out time
- Disadvantages
 - no protection for low voltages

Zelio® Plug-in Relays

Catalog Number Index

RE XL2●●	9	RPM23P7	16	RSB1A120ED	36	RUMC3AB1F7	24
RE XL4●●	9	RPM3	18	RSB1A120F7	36	RUMC3AB1FD	24
RE48A●●	26	RPM31B7	16	RSB1A120FD	36	RUMC3AB1GD	24
RPF2AB7	32	RPM31BD	16	RSB1A120JD	36	RUMC3AB1JD	24
RPF2ABD	32	RPM31E7	16	RSB1A120M7	36	RUMC3AB1MD	24
RPF2AF7	32	RPM31ED	16	RSB1A120ND	36	RUMC3AB1ND	24
RPF2AFD	32	RPM31F7	16	RSB1A120P7	36	RUMC3AB1P7	24
RPF2AJD	32	RPM31FD	16	RSB1A120RD	36	RUMC3AB2B7	24
RPF2AP7	32	RPM31JD	16	RSB1A120U7	36	RUMC3AB2BD	24
RPF2BB7	32	RPM31P7	16	RSB1A160B7	36	RUMC3AB2E7	24
RPF2BBD	32	RPM32B7	16	RSB1A160BD	3, 36	RUMC3AB2ED	24
RPF2BF7	32	RPM32BD	16	RSB1A160E7	36	RUMC3AB2F7	24
RPF2BFD	32	RPM32E7	16	RSB1A160ED	36	RUMC3AB2FD	24
RPF2BJD	32	RPM32ED	16	RSB1A160F7	36	RUMC3AB2GD	24
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RPM11JD	16	RPM33FD	16	RSB2A080E7	36	RUMC3AB3GD	25
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RPM12FD	16	RPM41ED	16	RSB2A080P7	36	RUMF2AB1ED	24
RPM12JD	16	RPM41F7	16	RSB2A080RD	36	RUMF2AB1F7	24
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RPM13F7	16	RPM42E7	16	RUMC2AB1B7	24	RUMF2AB2E7	24
RPM13FD	16	RPM42ED	16	RUMC2AB1BD	24	RUMF2AB2ED	24
RPM13JD	16	RPM42F7	16	RUMC2AB1E7	24	RUMF2AB2F7	24
RPM13P7	16	RPM42FD	16	RUMC2AB1ED	24	RUMF2AB2FD	24
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RPM23ED	16	RPZR235	17	RUMC3AB1B7	24	RUMF3AB2E7	24
RPM23F7	16	RSB1A120B7	36	RUMC3AB1BD	24	RUMF3AB2ED	24
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RPM23JD	16	RSB1A120E7	36	RUMC3AB1ED	24	RUMF3AB2FD	24

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RUMF3AB2P7	24	RXM3	10	RXM4GB1ED	7
RUMF3AB3B7	25	RXM3AB1B7	7	RXM4GB1F7	7
RUMF3AB3BD	25	RXM3AB1BD	7	RXM4GB1FD	7
RUMF3AB3E7	25	RXM3AB1E7	7	RXM4GB1JD	7
RUMF3AB3ED	25	RXM3AB1ED	7	RXM4GB1P7	7
RUMF3AB3F7	25	RXM3AB1F7	7	RXM4GB2B7	7
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RUMF3AB3JD	25	RXM3AB1P7	7	RXM4GB2ED	7
RUMF3AB3P7	25	RXM3AB2B7	7	RXM4GB2F7	7
RUMppAB2B7	3	RXM3AB2BD	7	RXM4GB2FD	7
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RXM041FU7	9, 17	RXM4AB1FDTQ	9	RXZE2S111M	6, 9–10
RXM2	10	RXM4AB1JD	7	RXZE2S114M	6, 9–10
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RXM2AB1E7	7	RXM4AB1P7TQ	9	RZM021BN	36
RXM2AB1ED	7	RXM4AB1U7	7	RZM021FP	36
RXM2AB1F7	7	RXM4AB2B7	7	RZM021RB	36
RXM2AB1F7TQ	9	RXM4AB2B7TQ	9	RZM031BN	36
RXM2AB1FD	7	RXM4AB2BD	7	RZM031FPD	36
RXM2AB1JD	7	RXM4AB2BDTQ	9	RZM031RB	36
RXM2AB1P7	7	RXM4AB2E7	7	RZM040W	36
RXM2AB1P7TQ	9	RXM4AB2ED	7	RZM041BN7	36
RXM2AB2B7	7	RXM4AB2F7	7	RZM041FU7	36
RXM2AB2B7TQ	9	RXM4AB2FD	7		
RXM2AB2BD	7	RXM4AB2GD	7		
RXM2AB2E7	7	RXM4AB2JD	7		
RXM2AB2ED	7	RXM4AB2P7	7		
RXM2AB2F7	7	RXM4AB2P7TQ	9		
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RXM2AB2P7	7	RXM4AB3BD	8		
RXM2AB2P7TQ	9	RXM4AB3BDTQ	8		
RXM2AB3B7	8	RXM4AB3E7	8		
RXM2AB3B7TQ	8	RXM4AB3ED	8		
RXM2AB3BD	8	RXM4AB3F7	8		
RXM2AB3BDTQ	8	RXM4AB3FD	8		
RXM2AB3E7	8	RXM4AB3GD	8		
RXM2AB3ED	8	RXM4AB3JD	8		
RXM2AB3F7	8	RXM4AB3P7	8		
RXM2AB3FD	8	RXM4AB3P7TQ	8		
RXM2AB3JD	8	RXM4GB1B7	7		
RXM2AB3P7	8	RXM4GB1BD	7		

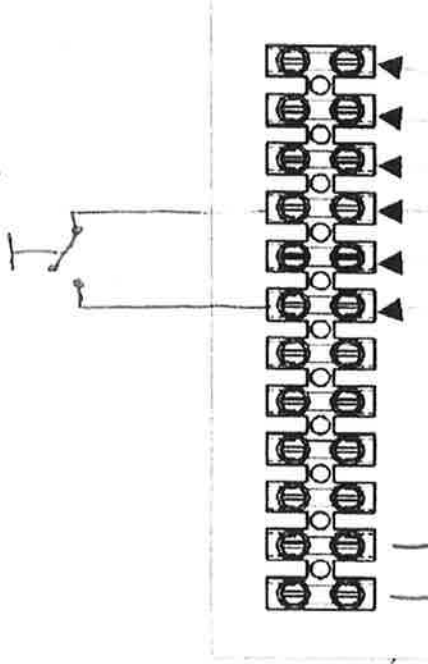
Schneider Electric USA

8001 Highway 64 East
Knightdale, NC 27545
1-888-Square D
1-888-778-2733
www.us.Telemecanique.com

8501CT0601R1/08 © 2005–2008 Schneider Electric All Rights Reserved
Replaces 8501CT0601 dated 06/2006

Large View of Terminal Block in Housing

Aux Relay



Heater (black or blue)

Heater (black or brown)

Earth (green & yellow)

Wiper Run (red)

Wiper Common (blue)

Wiper Park (white)

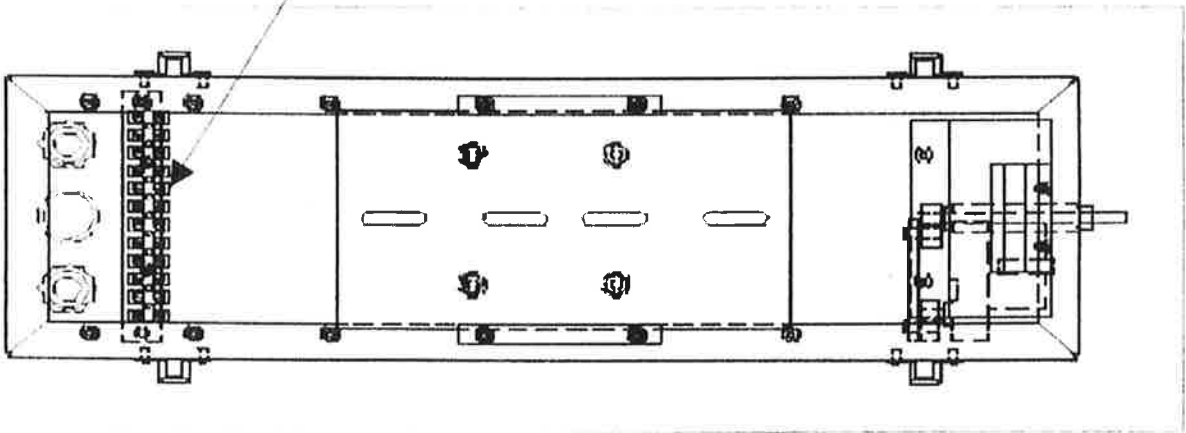
(switched live)

(neutral)

(constant live)

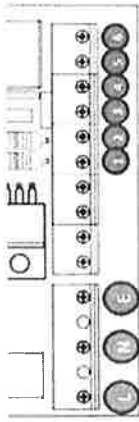
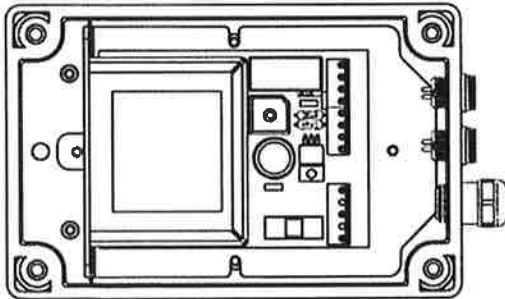
} 24VAC

+ 24VDC Fan
-



Connection Information

Low Voltage Versions

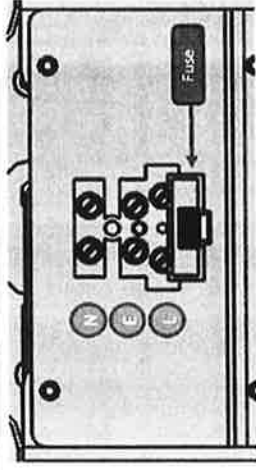
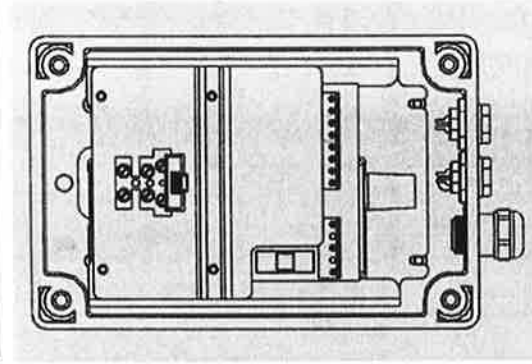


L	(+v) input
N	(-v) input
E	Earth
1	-v to pump (pre-wired to connector)
2	+v to pump (pre-wired to connector)
3	Float switch (pre-wired to connector)*
4	Float switch (pre-wired to connector)*
5	Control
6	Control

Connection Information

Mains Voltage Versions

**IMPORTANT! THE UNIT MUST BE ISOLATED FROM THE POWER BEFORE THE LID IS REMOVED.
FAILURE TO DO SO COULD RESULT IN SERIOUS INJURY**

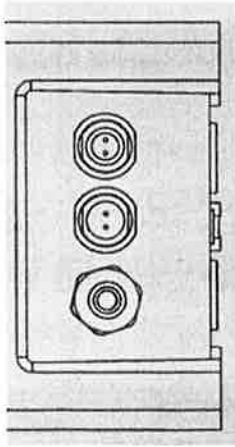


L	Live (+v) input
N	Neutral (-v) input
E	Earth
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X	Pre-wired terminal (DO NOT TOUCH)
X	Pre-wired terminal (DO NOT TOUCH)
X	Pre-wired terminal (DO NOT TOUCH)
1	-v to pump (pre-wired to connector)
2	+v to pump (pre-wired to connector)
3	Float switch (pre-wired to connector)*
4	Float switch (pre-wired to connector)*
5	Control
6	Control

Mains Input Fuse = 2amp
DO NOT CONFUSE WITH FUSE ON PCB

View From Base of PSU – All Models



All models come with a 16mm cable gland and one (or two depending on options) pre-wired connectors.

Connectors are plug/socket male-female, female-male preventing connection errors.

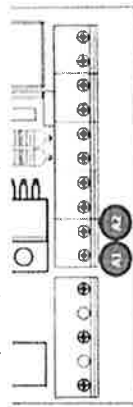
Operational Instructions

The BW series washers can be activated in two different ways. Either by switching the power on and off or by using a relay to close / open the control inputs on the power supply printed circuit board.

The choice of methods will depend on the associated equipment available on the installation.

If the float switch is not being used then the float switch terminals (3 and 4) will be linked.

Alarm Option (Where Fitted)



The alarm output connections (marked A1 and A2 on illustration) are volt-free 100mA rated @ 24v.

The relay output on the alarm option will remain closed whilst the float switch

indicates that the water level is ok.

Relay will change to an open circuit if float switch indicates that the water level is too low.

Pump will only work if the float switch input is closed.

Use the normally open control input to turn the washer on when using a permanent supply. Use volt free contacts. Alternatively link these terminals together if the mains input is to be switched via the telemetry equipment.

Factory-Fitted Options

Float Switch Option

The float switch prevents the washer unit from running dry and therefore causing damage to the pump. When the water level drops too low the switch is activated and the power is cut to the pump.

Note

The float switch is supplied pre-installed with a suitable plug attached. Simply connect to the corresponding socket on the PSU to connect.

Should you wish to refill the reservoir away from the installation remove the tab at the top of the frame, disconnect the float switch plug and slide the reservoir out of the cradle.

Alarm Output Option

The alarm output option has to be used in combination with the float switch option. The purpose of the alarm output option is to allow the washer to be connected to a suitable alarm input on a telemetry device. When the water level drops to a too low, the float switch is activated causing the power to the pump to be cut off (preventing it from running dry and burning out) and activating an alarm that can then be acted upon.

Assembly and Installation

The BW series washer is very flexible in its design allowing the PSU to be mounted on the stainless steel frame or adjacent to the unit on a wall or back plane. This allows the installer to mount the units in areas that have limited space.

If you are mounting the PSU on the frame there are screws supplied to fit it as per page 3. If you choose to mount it on a wall or surface adjacent to frame ensure the plug for the pump can still comfortably reach the connector socket.

Please Note

To protect the appearance of the stainless steel frame it is supplied with a plastic coating. Once you are happy with the location of the washer this coating can be removed.

CONTINUOUS-HINGE WITH CLAMPS, TYPE 4X

INDUSTRY STANDARDS

UL 50, 50E Listed; Type 3R, 4, 4X, 12; File No. E27567
 cUL Listed per CSA C22.2 No 94; Type 3R, 4, 4X, 12; File No. E27567
 UL 508A Listed; Type 3R, 4, 4X, 12; File No. E61997
 cUL Listed per CSA C22.2 No 94; Type 3R, 4, 4X, 12; File No. E61997

NEMA/EEMAC Type 3R, 4, 4X, 12, 13
 CSA File No. 42184: Type 4, 4X, 12
 IEC 60529, IP66
 Meets NEMA Type 3RX requirements

APPLICATION

Used in either indoor or outdoor applications, these enclosures combine a rugged continuous hinge, seamless foam-in-place gasket and stainless steel screw-down clamps for a reliable seal that protects components from corrosive environments.

SPECIFICATIONS

- 16 and 14 gauge Type 304 or 316L stainless steel
- Seams continuously welded and ground smooth
- Seamless foam-in-place gasket
- Stainless steel screws and clamps
- Pull stainless steel continuous hinge pin to remove door
- Weldnuts provided for mounting optional panels and terminal block kits
- Bonding provision on door and body

FINISH

Cover and sides of body have smooth #4 brushed finish.

ACCESSORIES

See also *Accessories*.
 Fast-Operating Clamp-Cover Junction Box Clamp
 Lock Kit for Clamp Cover Junction Boxes
 Panels for Junction Boxes
 Terminal Block Kit Assembly for Junction Boxes Overview

MODIFICATION AND CUSTOMIZATION

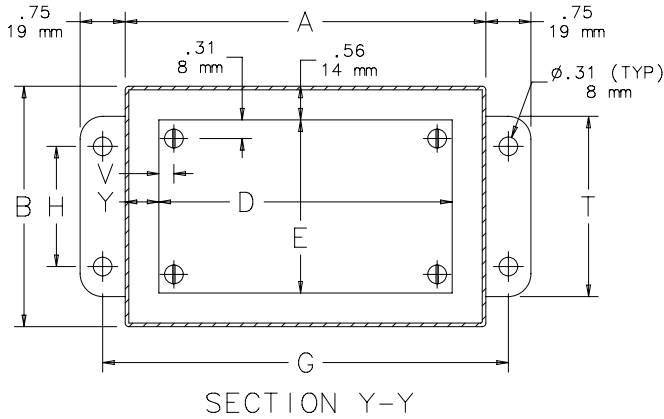
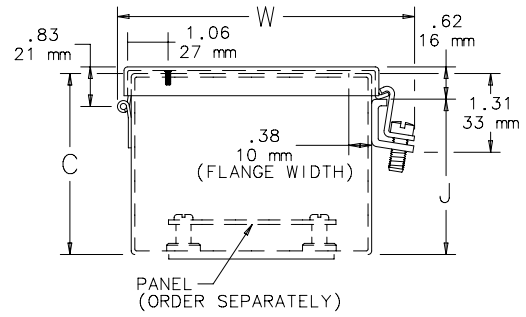
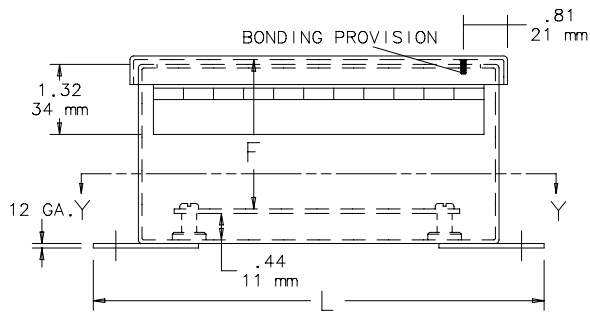
Hoffman excels at modifying and customizing products to your specifications. Contact your local Hoffman sales office or distributor for complete information.

BULLETIN: A51S
Standard Product

Catalog Number	AxBxC in./mm	Stainless Steel Type	UL Listed	Body Gauge	Cover Gauge	Steel Panel	Conductive Panel	Panel Size D x E in./mm	Mounting G x H in./mm	Overall L x W in./mm	F in./mm	J in./mm	N in./mm	T in./mm	V in./mm	Y in./mm
A6044CHNFSS	6.00 x 4.00 x 4.00 152 x 102 x 102	304	508A	16	16	A6P4	A6P4G	4.88 x 2.88 124 x 73	6.75 x 2.00 171 x 51	7.50 x 4.94 191 x 125	3.50 89	3.62 92	2.38 60	3.00 76	0.31 8	0.56 14
A606CHNFSS	6.00 x 6.00 x 4.00 152 x 152 x 102	304	50, 50E	16	16	A6P6	A6P6G	4.88 x 4.88 124 x 124	6.75 x 4.00 171 x 102	7.50 x 6.94 191 x 176	3.50 89	3.62 92	2.38 60	5.00 127	0.31 8	0.56 14
A8064CHNFSS	8.00 x 6.00 x 4.00 203 x 152 x 102	304	50, 50E	14	16	A8P6	A8P6G	6.75 x 4.88 171 x 124	8.75 x 4.00 222 x 102	9.50 x 6.94 241 x 176	3.50 89	3.62 92	1.38 35	5.00 127	0.25 6	0.62 16
A1008CHNFSS	10.00 x 8.00 x 4.00 254 x 203 x 102	304	50, 50E	14	16	A10P8	A10P8G	8.75 x 6.88 222 x 175	10.75 x 6.00 273 x 152	11.50 x 8.94 292 x 227	3.50 89	3.62 92	1.38 35	7.00 178	0.25 6	0.62 16
A12106CHNFSS	12.00 x 10.00 x 6.00 305 x 254 x 152	304	50, 50E	14	16	A12P10	A12P10G	10.75 x 8.88 273 x 225	12.75 x 8.00 324 x 203	13.50 x 10.94 343 x 278	5.50 140	5.62 143	2.38 60	9.00 229	0.25 6	0.62 16
A1212CHNFSS	12.00 x 12.00 x 6.00 305 x 305 x 152	304	50, 50E	14	16	A12P12	A12P12G	10.75 x 10.88 273 x 276	12.75 x 10.00 324 x 254	13.50 x 12.94 343 x 329	5.50 140	5.62 143	2.38 60	11.00 279	0.25 6	0.62 16
A1412CHNFSS	14.00 x 12.00 x 6.00 356 x 305 x 152	304	50, 50E	14	16	A14P12	A14P12G	12.75 x 10.88 324 x 276	14.75 x 10.00 375 x 254	15.50 x 12.94 394 x 329	5.50 140	5.62 143	2.38 60	11.00 279	0.25 6	0.62 16
A1614CHNFSS	16.00 x 14.00 x 6.00 406 x 356 x 152	304	508A	14	16	A16P14	A16P14G	14.75 x 12.88 375 x 327	16.75 x 12.00 425 x 305	17.50 x 14.94 445 x 379	5.50 140	5.62 143	2.38 60	13.00 330	0.25 6	0.62 16
A6044CHNFSS6	6.00 x 4.00 x 4.00 152 x 102 x 102	316L	50, 50E	16	16	A6P4	A6P4G	4.88 x 2.88 124 x 73	6.75 x 2.00 171 x 51	7.50 x 4.94 191 x 125	3.50 89	3.62 92	2.38 60	3.00 76	0.31 8	0.56 14
A606CHNFSS6	6.00 x 6.00 x 4.00 152 x 152 x 102	316L	50, 50E	16	16	A6P6	A6P6G	4.88 x 4.88 124 x 124	6.75 x 4.00 171 x 102	7.50 x 6.94 191 x 176	3.50 89	3.62 92	2.38 60	5.00 127	0.31 8	0.56 14
A8064CHNFSS6	8.00 x 6.00 x 4.00 203 x 152 x 102	316L	50, 50E	14	16	A8P6	A8P6G	6.75 x 4.88 171 x 124	8.75 x 4.00 222 x 102	9.50 x 6.94 241 x 176	3.50 89	3.62 92	1.38 35	5.00 127	0.25 6	0.62 16
A1008CHNFSS6	10.00 x 8.00 x 4.00 254 x 203 x 102	316L	50, 50E	14	16	A10P8	A10P8G	8.75 x 6.88 222 x 175	10.75 x 6.00 273 x 152	11.50 x 8.94 292 x 227	3.50 89	3.62 92	1.38 35	7.00 178	0.25 6	0.62 16
A12106CHNFSS6	12.00 x 10.00 x 6.00 305 x 254 x 152	316L	50, 50E	14	16	A12P10	A12P10G	10.75 x 8.88 273 x 225	12.75 x 8.00 324 x 203	13.50 x 10.94 343 x 278	5.50 140	5.62 143	2.38 60	9.00 229	0.25 6	0.62 16
A1212CHNFSS6	12.00 x 12.00 x 6.00 305 x 305 x 152	316L	50, 50E	14	16	A12P12	A12P12G	10.75 x 10.88 273 x 276	12.75 x 10.00 324 x 254	13.50 x 12.94 343 x 329	5.50 140	5.62 143	2.38 60	11.00 279	0.25 6	0.62 16
A1412CHNFSS6	14.00 x 12.00 x 6.00 356 x 305 x 152	316L	50, 50E	14	16	A14P12	A14P12G	12.75 x 10.88 324 x 276	14.75 x 10.00 375 x 254	15.50 x 12.94 394 x 329	5.50 140	5.62 143	2.38 60	11.00 279	0.25 6	0.62 16
A1614CHNFSS6	16.00 x 14.00 x 6.00 406 x 356 x 152	316L	50, 50E	14	16	A16P14	A16P14G	14.75 x 12.88 375 x 327	16.75 x 12.00 425 x 305	17.50 x 14.94 445 x 379	5.50 140	5.62 143	2.38 60	13.00 330	0.25 6	0.62 16

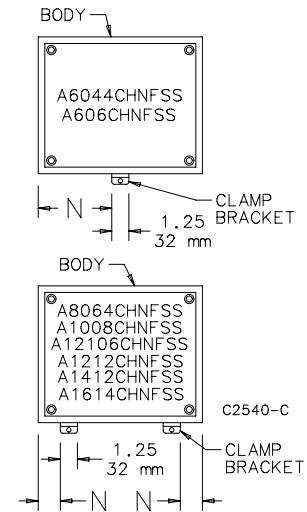
A6044CHNFSS and A6044CHNFSS6 UL 508A Listed. The remaining catalog numbers are UL 50 Listed.

Purchase panels separately. Optional stainless steel, composite and aluminum panels are available for most sizes.



- NOTE:
1. Optional panels are 14 gauge steel, conductive steel or stainless steel
 2. Panel screws are #10-32 pan head

CLAMP BRACKET LOCATIONS



General Safety Instructions:**ENGLISH**

READ SAFETY INSTRUCTIONS

Servicing:

These products are not customer serviceable. TDK-Lambda UK LTD. and their authorised agents only are permitted to carry out repairs.

Critical Components:

These products are not authorised for use as critical components in nuclear control systems, life support systems or equipment for use in hazardous environments without the express written approval of the Managing Director of TDK-Lambda EMEA.

Product Usage:

These products are designed for use within a host equipment which restricts access to authorised competent personnel.

Environmental:

These products are IPX0, and therefore chemicals/solvents, cleaning agents and other liquids must not be used.

Environment:

This power supply is a switch mode power supply for use in applications within a Pollution Degree 2, overvoltage category II environment. Material Group IIIb PCB's are used within it.

Output Loading:

The output power taken from the power supply must not exceed the rating stated on the power supply label, except as stated in the product limitations in this handbook.

Input Parameters:

This product must be operated within the input parameters stated in the product limitations in this handbook.

End of Life Disposal:

The unit contains components that require special disposal. Make sure that the unit is properly disposed of at the end of its service life and in accordance with local regulations.



RISK OF ELECTRIC SHOCK

High Voltage Warning:

Dangerous voltages are present within the power supply. The professional installer must protect service personnel from inadvertent contact with these dangerous voltages in the end equipment.

This product must be reliably earthed and professionally installed in accordance with the prevailing local electrical wiring regulations and safety standards.

The (+) or (-) output(s) can be earthed or left floating.

An internal fuse protects the unit and must not be replaced by the user. In case of internal defect, the unit must be returned to TDK-Lambda UK LTD or one of their authorised agents.

**HOT SURFACE****External Hot Surfaces:**

In accordance with local regulations for Health and Safety at work, manufacturers have an obligation to protect service engineers as well as users. In order to comply with this, a label must be fitted to these products which is clearly visible to service personnel accessing the overall equipment, and which legibly warns that surfaces of these products may be hot and must not be touched when the products are in operation.

The ventilation openings on these products must not be impeded. Ensure that there is at least 25mm spacing between any obstruction and the ventilation openings.

The unit cover/chassis is designed to protect skilled personnel from hazards. They must not be used as part of the external covers of any equipment where they may be accessible to operators, since under full load conditions, part or parts of the unit chassis may reach temperatures in excess of those considered safe for operator access.

Allgemeine Sicherheitsvorschriften:**DEUTSCH**

LESEN SIE DIE SICHERHEITSVORSCHRIFTEN

Wartung:

Diese Produkte können nicht durch den Kunden gewartet werden. Nur TDK-Lambda UK LTD. und deren zugelassene Vertriebshändler sind zur Durchführung von Reparaturen berechtigt.

Kritische Komponenten:

Diese Produkte sind nicht für die Verwendung als kritische Komponenten in nuklearen Kontrollsystemen, Lebenserhaltungssystemen oder Geräten in gefährlichen Umgebungen geeignet, sofern dies nicht ausdrücklich und in Schriftform durch den Geschäftsführer von TDK-Lambda EMEA genehmigt wurde.

Produktverwendung:

Diese Produkte sind zur Verwendung innerhalb von Host-Anlagen gedacht, die einen auf das Fachpersonal beschränkten Zugang haben.

Umwelt:

Diese Produkte sind IPX0, aus diesem Grund dürfen keine Chemikalien/Lösungsmittel, Reinigungsmittel und andere Flüssigkeiten verwendet werden.

Umgebung:

Dieses Netzteil ist ein Schaltnetzteil zur Verwendung in einer Umgebung mit einem Verschmutzungsgrad 2, Überspannungskategorie II. Materialgruppe IIIb mit darin verwendeten PCBs.

Ausgangsstrom:

Der Ausgangsstrom des Netzteiles darf die Leistung, die auf dem Label des Netzteiles vermerkt ist, nur dann überschreiten, wenn dies in den Produktgrenzen dieses Handbuches ausgezeichnet ist.

Eingangsparameter:

Dieses Produkt muss innerhalb der Eingangsparameter, die in den Produktgrenzen dieses Handbuches angegeben sind, betrieben werden.

Entsorgung am Ende der Betriebszeit:

Das Gerät enthält Komponenten die unter Sondermüll fallen. Das Gerät muss am Ende der Betriebszeit ordnungsgemäß und in Übereinstimmung mit den regionalen Bestimmungen entsorgt werden.

NUR AC-DC PRODUKTE

GEFAHR DURCH ELEKTRISCHEN SCHLAG

Hochspannungswarnung:

Innerhalb des Netzteiles gibt es gefährliche Spannungen. Der Elektroinstallateur muss das Wartungspersonal vor versehentlichem Kontakt mit den gefährlichen Spannungen im Endgerät schützen.

Dies Produkt muss sicher geerdet und von qualifiziertem Personal in Übereinstimmung mit den gültigen regionalen Bestimmungen zu Verdrahtungen sowie den Sicherheitsstandards installiert werden.

Die (+) oder (-) Ausgänge können geerdet werden oder unangeschlossen bleiben.

Eine interne Sicherung schützt das Gerät und darf durch den Benutzer nicht ausgetauscht werden. Im Fall von internen Defekten muss das Gerät an TDK-Lambda UK LTD oder einen der autorisierten Vertriebshändler zurückgeschickt werden.

**HEISSE OBERFLÄCHEN****Äußere heiße Oberflächen:**

In Übereinstimmung mit den regionalen Bestimmungen für Gesundheit und Sicherheit bei der Arbeit ist der Hersteller für den Schutz von Wartungspersonal und Benutzern verantwortlich. Um diesen Bestimmungen gerecht zu werden, muss auf den Produkten ein Label angebracht werden, das deutlich sichtbar für das Wartungspersonal mit Zugriff auf die gesamte Anlage ist, und das gut lesbar auf die eventuell heiße Oberfläche des Gerätes hinweist und das Berühren des Produktes in Betrieb untersagt.

Die Belüftungsöffnungen an diesem Produkt dürfen nicht blockiert werden. Achten Sie darauf, dass mindestens 50 mm Abstand zwischen Hindernissen und den Belüftungsöffnungen bleibt.

Die Geräteabdeckung/das Gehäuse ist so entworfen, dass das Fachpersonal vor Gefahren geschützt wird. Sie dürfen nicht als Teil der externen Abdeckung für Geräte verwendet werden, die für den Betreiber zugänglich sein müssen, da Teile oder das gesamte Gerätegehäuse unter voller Auslastung übermäßige Temperaturen erreichen kann, die für den Zugang des Betreibers nicht mehr als sicher betrachtet werden.

Consignes de sécurité générale:**FRANÇAIS**

LIRE LES CONSIGNES DE SECURITE

Entretien:

Ces produits ne peuvent pas être réparés par le client. Seul, TDK-Lambda UK LTD et ses agents agréés sont autorisés à effectuer des réparations.

Composants critiques:

Ces produits ne doivent pas être utilisés en tant que composants critiques dans des systèmes de commande nucléaire, dans des systèmes de sauvetage ou dans des équipements utilisés dans des environnements dangereux, sans l'autorisation écrite express du directeur général de TDK-Lambda EMEA.

Utilisation du produit:

Ces produits sont conçus pour être utilisés dans un équipement hôte dont l'accès n'est autorisé qu'aux personnes compétentes.

Environnement:

Ces produits sont IPX0, et donc on ne doit pas utiliser des produits chimiques/solvants, des produits de nettoyage et d'autres liquides.

Environnement:

Cette alimentation fonctionne en mode commutation pour utilisation dans des applications fonctionnant dans un environnement avec Pollution Degré 2 et catégorie surtension II. Elle utilise des cartes de circuits imprimés (PCB) Groupe IIIb.

Intensité soutirée:

L'intensité soutirée de l'alimentation ne doit pas dépasser l'intensité nominale marquée sur la plaque signalétique, sauf indications contraires dans les limitations du produit dans ce manuel.

Paramètres d'entrée:

Ce paramètre doit être utilisé à l'intérieur des paramètres d'entrée indiqués dans les limitations du produit dans ce manuel.

Elimination en fin de vie:

L'alimentation contient des composants nécessitant des mesures spéciales pour leur élimination. Vérifiez que cette alimentation est éliminée correctement en fin de vie utile et conformément aux réglementations locales.

PRODUITS AC-DC SEULEMENT

RISQUE DE CHOC ELECTRIQUE

Attention-Danger haute tension:

Des tensions dangereuses sont présentes dans l'alimentation. L'installateur doit protéger le personnel d'entretien contre un contact involontaire avec ces tensions dangereuses dans l'équipement final.

Ce produit doit être raccordé à une terre fiable et installé par des professionnels en respectant les réglementations locales de câblages électriques en vigueur et les normes de sécurité.

Les sorties (+) ou (-) peuvent être raccordées à la terre ou laissées flottantes.

Un fusible interne protège le module et ne doit pas être remplacé par l'utilisateur. En cas de défaut interne, le module doit être renvoyé à TDK-Lambda UK LTD ou l'un de ses agents agréés.



SURFACE CHAUDE

Surfaces chaudes extérieures:

Conformément aux réglementations locales concernant la santé et la sécurité sur les lieux de travail, les fabricants doivent protéger les techniciens d'entretien et les utilisateurs. Pour cela, une plaque signalétique doit être installée sur ces produits, et cette plaque doit être bien visible pour les techniciens d'entretien intervenant sur l'équipement, et elle doit indiquer de manière bien visible que les surfaces de ces produits peuvent être chaudes et qu'elles ne doivent pas être touchées lorsque les produits fonctionnent.

Les orifices de ventilation sur ces produits ne doivent pas être obstrués. Vérifiez qu'il y a un espace libre d'au moins 50 mm entre une obstruction et l'orifice de ventilation.

Le couvercle et le châssis du module sont conçus pour protéger des personnels expérimentés. Ils ne doivent pas être utilisés comme couvercles extérieurs d'un équipement, accessible aux opérateurs car en condition de puissance maximum, des parties du châssis peuvent atteindre des températures considérées comme dangereuses pour l'opérateur.

Norme generali di sicurezza:**ITALIANO**

SI PREGA DI LEGGERE LE NORME DI SICUREZZA

Manutenzione:

Il cliente non può eseguire alcuna manutenzione su questi prodotti. L'esecuzione delle eventuali riparazioni è consentita solo a TDK-Lambda UK LTD e ai suoi agenti autorizzati.

Componenti critici:

Non si autorizza l'uso di questi prodotti come componenti critici all'interno di sistemi di controllo nucleari, sistemi necessari alla sopravvivenza o apparecchiature destinate all'impiego in ambienti pericolosi, senza l'esplicita approvazione scritta dell'Amministratore Delegato di TDK-Lambda EMEA.

Uso dei prodotti:

Questi prodotti sono progettati per l'uso all'interno di un'apparecchiatura ospite che limiti l'accesso al solo personale competente e autorizzato.

Condizioni ambientali:

Questi prodotti sono classificati come IPX0, dunque non devono essere utilizzati sostanze chimiche/solventi, prodotti per la pulizia o liquidi di altra natura.

Ambiente:

Questo prodotto è un alimentatore a commutazione, destinato all'uso in applicazioni rientranti in ambienti con le seguenti caratteristiche: Livello inquinamento 2, Categoria sovratensione II. Questo prodotto contiene schede di circuiti stampati in materiali di Gruppo IIIb.

Carico in uscita:

La potenza in uscita ottenuta dall'alimentatore non deve superare la potenza nominale indicata sulla targhetta dell'alimentatore, fatto salvo dove indicato nei limiti per il prodotto specificati in questo manuale.

Parametri di alimentazione:

Questo prodotto deve essere utilizzato entro i parametri di alimentazione indicati nei limiti per il prodotto, specificati in questo manuale.

Smaltimento:

L'unità contiene componenti che richiedono procedure speciali di smaltimento. Accertarsi che l'unità venga smaltita in modo corretto al termine della vita utile e nel rispetto delle normative locali.

SOLO PER I PRODOTTI A CA-CC

RISCHIO DI SCOSSA ELETTRICA

Avvertimento di alta tensione:

All'interno dell'alimentatore sono presenti tensioni pericolose. Gli installatori professionali devono proteggere il personale di manutenzione dal rischio di contatto accidentale con queste tensioni pericolose all'interno dell'apparecchiatura finale.

Questo prodotto deve essere messo a terra in modo affidabile e installato in modo professionale, nel rispetto delle norme di sicurezza e dei regolamenti vigenti in ambito locale in materia di collegamenti elettrici.

Le uscite (+) o (-) possono essere messa a terra o lasciate isolate.

Un fusibile interno protegge l'unità e non deve essere sostituito dall'utente. Nell'eventualità di un difetto interno, restituire l'unità a TDK-Lambda UK LTD o a uno dei suoi agenti autorizzati

**SUPERFICIE CALDA****Superfici esterne calde:**

Coerentemente con le norme locali in materia di salute & sicurezza professionali, i produttori sono tenuti a salvaguardare i tecnici di manutenzione, e inoltre gli utenti. Per far fronte a tali obblighi, i prodotti devono presentare una targhetta, chiaramente visibile al personale di manutenzione che accede all'apparecchiatura nel complesso e che risulti inoltre leggibile e avverta gli addetti del rischio che le superfici di questi prodotti possono scottare e non vanno toccate con i prodotti in funzione.

Le griglie di ventilazione su questi prodotti non devono essere ostruite. Verificare che vi sia una distanza minima di 50 mm fra le griglie di ventilazione e qualsiasi eventuale ostruzione.

Il coperchio/telaio dell'unità è realizzato per proteggere il personale esperto dai pericoli. Non deve essere usato come parte degli involucri esterni di qualsiasi apparecchiatura, se risulta accessibile da parte degli addetti, poiché è possibile che in condizioni di pieno carico una o più parti del telaio dell'unità giunga/giungano a temperature superiori ai limiti considerati sicuri per l'accesso da parte degli addetti.

Instrucciones generales de seguridad:**ESPAÑOL**

LEA LAS INSTRUCCIONES DE SEGURIDAD

Servicio:

Estos productos no pueden ser reparados por los clientes. TDK-Lambda UK LTD. y sus agentes autorizados son los únicos que pueden llevar a cabo las reparaciones.

Componentes fundamentales:

Estos productos no pueden ser utilizados como componentes fundamentales en sistemas de control nuclear, sistemas de soporte vital o equipos a utilizar en entornos peligrosos sin el consentimiento expreso por escrito del Director General de TDK-Lambda EMEA.

Uso de los productos:

Estos productos han sido diseñados para ser utilizados en un equipo central que restrinja el acceso al personal cualificado autorizado.

Medioambiental:

Estos productos son IPX0 y, por tanto, no pueden utilizarse sustancias químicas/disolventes, agentes de limpieza ni otros líquidos.

Medio ambiente:

Esta fuente de alimentación es una fuente de alimentación de modo conmutado a utilizar en aplicaciones dentro de un entorno con un Grado de contaminación 2 y una Categoría de sobretensión II. En él se utilizan policloruros de bifenilo del Grupo de materiales IIIb.

Carga de salida:

La potencia de salida tomada de la fuente de alimentación no puede sobrepasar el valor nominal indicado en la etiqueta de la fuente de alimentación, excepto en los casos indicados en las limitaciones del producto en este manual.

Parámetros de entrada:

Este producto debe ser utilizado dentro de los parámetros de entrada indicados en las limitaciones del producto en este manual.

Desecho de la unidad:

La unidad contiene componentes que deben ser desechados de una manera especial. Asegúrese de desechar correctamente la unidad al final de su vida útil y conforme a las normas locales vigentes.

SÓLO PRODUCTOS CA-CC

PELIGRO DE DESCARGAS ELÉCTRICAS

Advertencia de alta tensión:

En esta fuente de alimentación hay tensiones peligrosas. El instalador profesional debe proteger al personal de servicio contra cualquier contacto accidental con estas tensiones peligrosas en el equipo final.

Este producto se puede conectar de forma fiable a tierra e instalar profesionalmente de conformidad con las regulaciones locales para los cableados eléctricos y las normas de seguridad vigentes.

La salida o salidas (+) o (-) pueden conectarse a tierra o se las puede dejar flotando.

Un fusible interno protege la unidad y este no debe ser nunca reemplazado por el usuario. En caso de existir algún defecto interno, la unidad debe ser enviada a TDK-Lambda UK LTD o a uno de sus agentes autorizados.



SUPERFICIE CALIENTE

Superficies externas calientes:

Según las normas locales relativas a la Salud y Seguridad en el trabajo, los fabricantes están obligados a proteger a los ingenieros de servicio además de a los usuarios. Para que esto se cumpla, debe colocarse una etiqueta en estos productos que pueda ser vista claramente por el personal de servicio que accede al equipo general, y con advertencias legibles de que las superficies de estos productos pueden estar calientes y no deben tocarse cuando los productos se encuentran en funcionamiento.

Las aberturas de ventilación de estos productos no deben obstruirse jamás. Asegúrese de que quede una separación de 50 mm por lo menos entre cualquier obstrucción y las aberturas de ventilación.

La cubierta/chasis de la unidad ha sido diseñada para que proteja a las personas cualificadas de los peligros. No deben ser utilizadas como parte de las cubiertas externas de cualquier equipo al que pueden acceder los operarios, ya que bajo unas condiciones de carga completa, la pieza o piezas del chasis de la unidad pueden alcanzar temperaturas superiores a las consideradas seguras para el acceso de los operarios.

Instruções gerais de segurança:**PORTUGUÊS**

LEIA AS INSTRUÇÕES DE SEGURANÇA

Manutenção:

Estes produtos não são podem ser submetidos a manutenção por parte do cliente. Apenas a TDK-Lambda UK LTD e os seus agentes autorizados têm permissão para realizar reparações.

Componentes essenciais:

Não é autorizada a utilização destes produtos como componentes essenciais de sistemas de controlo nuclear, sistemas de suporte de vida ou equipamento para utilização em ambientes perigosos sem a expressa autorização por escrito do Director-Geral da TDK-Lambda EMEA.

Utilização do produto:

Estes produtos foram concebidos para utilização dentro de um equipamento de alojamento que apenas permita o acesso a pessoal qualificado autorizado.

Ambiental:

Estes produtos são IPX0 e, como tal, não se devem utilizar químicos/solventes, agentes de limpeza e outros líquidos.

Ambiente:

Esta fonte de alimentação é uma fonte de alimentação do modo de comutação para utilização em aplicações com um Nível de Poluição 2 e ambientes da categoria de sobretensão II. São utilizadas placas de circuitos impressos do grupo de materiais IIIb.

Carga de saída:

A potência de saída extraída da fonte de alimentação não deve exceder a classificação assinalada na etiqueta da fonte de alimentação, excepto quando indicado nas limitações do produto neste guia.

Parâmetros de entrada:

Este produto deve ser utilizado dentro dos parâmetros de entrada indicados nas limitações do produto neste guia.

Eliminação no fim de vida:

A unidade contém componentes que necessitam de procedimentos especiais de eliminação. Certifique-se de que a unidade é devidamente eliminada no fim da sua vida útil e que tal é feito em conformidade com os regulamentos locais.

APENAS PRODUTOS CA-CC

RISCO DE CHOQUE ELÉCTRICO

Aviso de alta tensão:

Estão presentes tensões perigosas dentro da fonte de alimentação. O profissional que realizar a instalação deve proteger o pessoal de assistência contra contactos inadvertidos com estas tensões perigosas do equipamento final.

Este produto deve ser ligado à terra de forma fiável e instalado por um profissional, de acordo com as normas de segurança e os regulamentos locais vigentes em relação a cablagens eléctricas.

As saídas (+) e (-) podem ser ligadas à terra ou deixadas soltas.

Existe um fusível interno que protege a unidade e que não deve ser substituído pelo utilizador. Em caso de defeito interno, a unidade deve ser devolvida à TDK-Lambda UK LTD ou a um dos seus agentes autorizados.

**SUPERFÍCIE QUENTE****Superfícies quentes externas:**

Segundo com os regulamentos locais sobre saúde e segurança no local de trabalho, os fabricantes têm a obrigação de proteger os técnicos de manutenção, bem como os utilizadores. De forma a respeitar este regulamento, estes produtos deverão ter uma etiqueta que seja facilmente visível ao pessoal de assistência que aceda ao equipamento em geral, e que alerte, de forma legível, para o facto de as superfícies destes produtos poderem estar quentes, não devendo ser tocadas quando os produtos estão em funcionamento.

As aberturas de ventilação destes produtos não devem ser obstruídas. Certifique-se de que existe um espaçamento de pelo menos 50 mm entre qualquer obstrução e as aberturas de ventilação.

O chassis/cobertura da unidade está concebido de forma a proteger o pessoal especializado de perigos. Não devem ser utilizados como parte das coberturas externas de qualquer equipamento em que possam estar acessíveis aos operadores, uma vez que em condições de carga máxima, algumas peças do chassis da unidade podem atingir temperaturas superiores às consideradas seguras para o acesso do operador.

Special Safety Instructions

Standard Specific Safety Instructions:

Whilst all individual outputs are classed as SELV outputs in accordance with the standard IEC/EN/UL/CSA60950-1 (<60Vdc or 42.4V peak), seriesed combinations of these outputs may exceed these values and become hazardous output voltages.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

If the units are to be installed as Direct Plug-in Power Units and full compliance to UL1310 is required, the units must be installed in an airtight distributor box that conforms to the requirements of UL1310.

Environmental Specifications:

Description	Operation	Storage
Use	Indoor	-
Temperature	-25°C - +71°C (derating at 2.5%/°C from 55°C)	-25°C - +85°C
Humidity	20 - 95% RH, non-condensing	20 - 95% RH, non-condensing
Altitude	2000M	
Orientation	See Fig 1	ALL
Material Group	IIIb	
Pollution Degree	2	
Class	II (Double insulated no earth connection required)	

Level of Insulation:

Dielectric Strength testing is carried out as follows:

Primary mains circuit to earth: - 1500KVAC, 2121VDC

Primary mains circuits to secondary: 3kVAC, 4142VDC*

*This test is not possible with Y capacitors fitted to the unit as damage to these capacitors will occur. It is also necessary to short circuit the output together and to earth.

Safety Approvals:

UL508

UL/cUL60950-1 (2nd Edition)

IEC / EN60950-1(2nd Edition)

CE marking when applied to any **DSP30-xx** product indicates compliance with the Low Voltage Directive (2006/95/EC) in that it complies with EN60950-1 (2nd Edition) and the EMC Directive 2004/108/EC in that it complies with EN61024-3, EN61000-6-3, EN61000-6-2 and EN55024.

Warning: This is a Class A product. In a residential, commercial or light industrial environment it may cause radio interference. This product is not intended to be installed in a residential environment; in a commercial and light industrial environment with connection to the public mains supply, the user may be required to take adequate measures to reduce interference.

Fusing: Internal fuses (F1): **Single fuse in the L line, T3.15AH, 250V, 5x20mm.**

Symbols:



AC



N – Neutral



L – Live

If the earth terminal of the DSP30-XX PSU is connected to the main incoming earth conductor of the end equipment, the installer must cover the earth symbol with a label bearing the earth symbol of IEC60417-5019.

Input Parameters:

Description	Operation
Nominal input voltage	115/230 VAC(Auto select)
Input frequency range	47 – 63Hz
Maximum inrush current	50A

Output Parameters:

Output Watts	Vout (V)	Adjustment range (V)	Output current (A)
30W	5	5 - 5.5	3
	12	11.4 -14.5	2.1
	15	13.5 - 16.5	2
	24	22.5 – 28.5	1.3

Adjusting output voltage beyond the stated range may cause overvoltage protection (OVP) to operate, whereby the output will latch off. To reset for normal operation simply adjust the potentiometer to reduce the output voltage to within its range and cycle the input off then on.

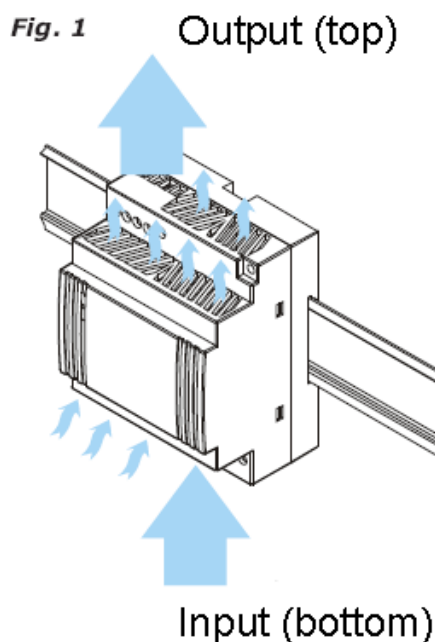
All outputs are SELV **except** under the following circumstance: Outputs connected in series are non-SELV if the total output voltage exceeds 60Vdc
If the total voltage of outputs connected in series exceed the 60Vdc SELV limit then all outputs must be considered non-SELV.

Non-SELV outputs are hazardous and must not be made user accessible. Consideration must be given to service engineers making inadvertent contact with the output terminals in the end equipment.

All outputs have functional spacing to earth, and due consideration must be given to this in the end product design.

Cooling for unit

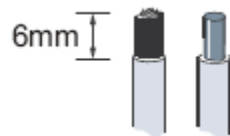
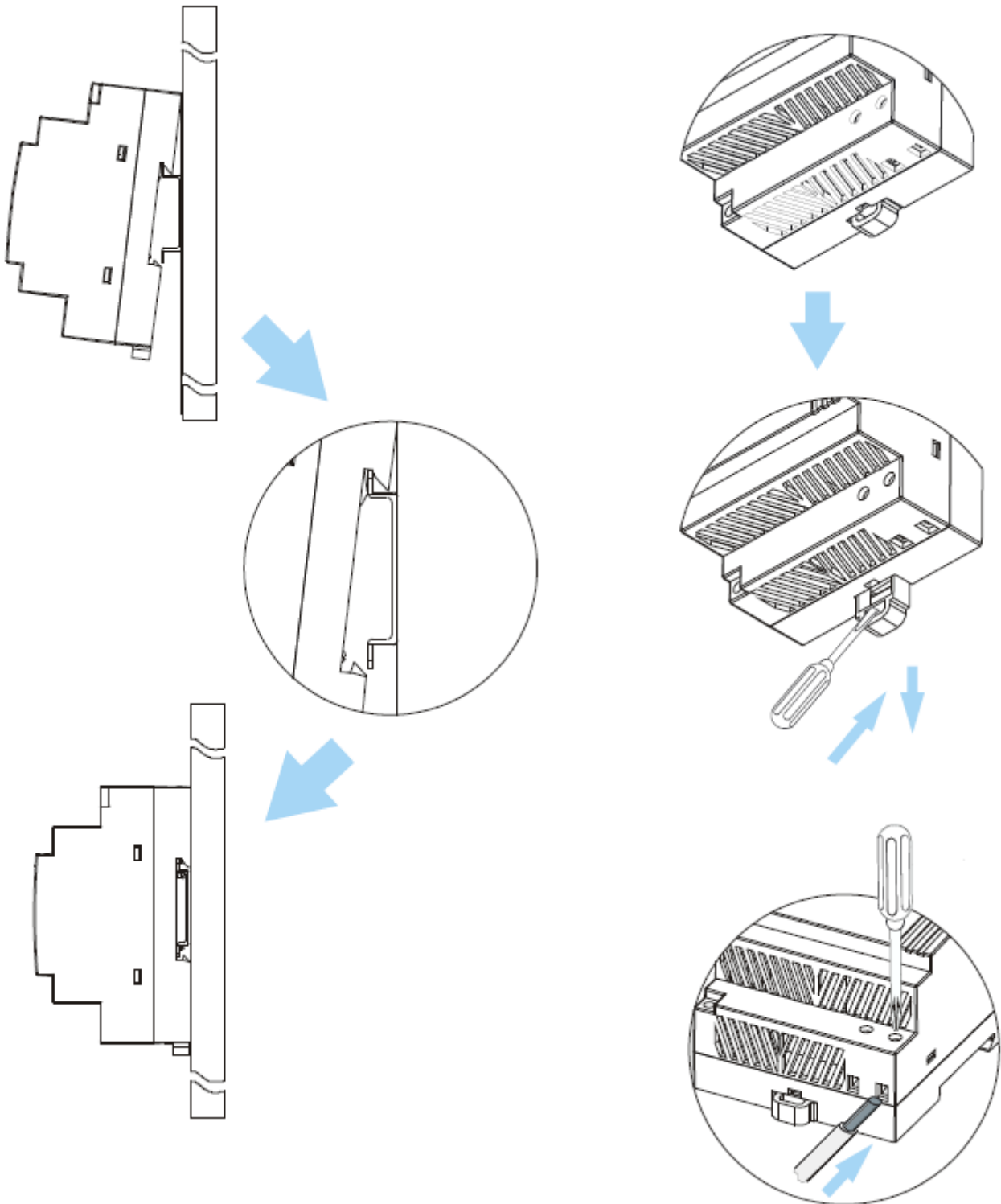
The unit must be mounted on a DIN rail with the output connection uppermost (toward the top of the equipment/installation) as below.



Placement

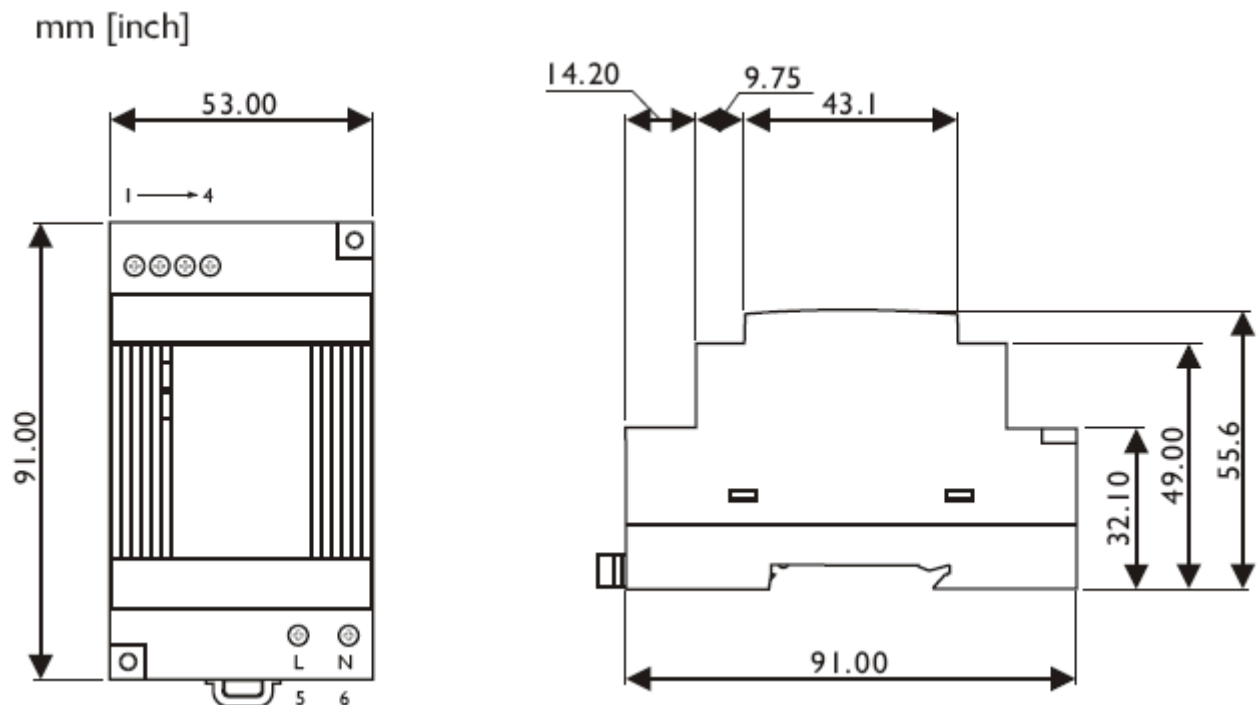
Removal

Fig. 2



Standard screw type connection:
 AWG24 to AWG12 can be used,
 maximum torque rating for the
input/output connector is 0.65Nm (5.5
 Pound-inches).

Mechanical Outline Drawings:



Pin number	Ident	Description	Function
1	+	Positive DC output terminal	Output
2	+		
3	-	Negative DC output terminal	
4	-		
5	L	Live AC input	Input
6	N	Neutral AC Input	
	Vout Adjust	Potentiometer for output voltage adjustment	Control & Signal
	DC ON	Green LED lit	
	DC LOW	Red LED Lit	

TDK-Lambda

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884116

**Universal
Transmitter**

Version no. 103
Revision date 09/09



UNIVERSAL TRANSMITTER

884116

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GENERAL

WARNING

This device is designed for connection to hazardous electric voltages.

Ignoring this warning can result in severe personal injury or mechanical damage.

To avoid the risk of electric shock and fire, the safety instructions of this manual must be observed and the guidelines followed. The specifications must not be exceeded, and the device must only be applied as described in the following.

Prior to the commissioning of the device, this manual must be examined carefully.

Only qualified personnel (technicians) should install this device. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.



HAZARDOUS VOLTAGE

WARNING

Until the device is fixed, do not connect hazardous voltages to the device.

The following operations should only be carried out on a disconnected device and under ESD safe conditions:

General mounting, connection and disconnection of wires.
Troubleshooting the device.



Repair of the device and replacement of circuit breakers must be done by Morsettitalia S.p.A. only.



INSTALLATION

WARNING

To keep the safety distances, the relay contacts on the device must not be connected to both hazardous and non-hazardous voltages at the same time.

884116 must be mounted on a DIN rail according to DIN 46277.



WARNING

Do not open the front plate of the device as this will cause damage to the connector for the display / programming front 884501. This device contains no DIP-switches or jumpers.

SYMBOL IDENTIFICATION



Triangle with an exclamation mark: Warning / demand. Potentially lethal situations.



The CE mark proves the compliance of the device with the essential requirements of the directives.



The double insulation symbol shows that the device is protected by double or reinforced insulation.

SAFETY INSTRUCTIONS

DEFINITIONS:

Hazardous voltages have been defined as the ranges: 75 to 1500 Volt DC, and 50 to 1000 Volt AC.

Technicians are qualified persons educated or trained to mount, operate, and also troubleshoot technically correct and in accordance with safety regulations.

Operators, being familiar with the contents of this manual, adjust and operate the knobs or potentiometers during normal operation.

RECEIPT AND UNPACKING:

Unpack the device without damaging it. The packing should always follow the device until this has been permanently mounted.

Check at the receipt of the device whether the type corresponds to the one ordered.

ENVIRONMENT:

Avoid direct sunlight, dust, high temperatures, mechanical vibrations and shock, as well as rain and heavy moisture. If necessary, heating in excess of the stated limits for ambient temperatures should be avoided by way of ventilation.

All devices fall under Installation Category II, Pollution Degree 1, and Insulation Class II.

MOUNTING:

Only technicians who are familiar with the technical terms, warnings, and instructions in the manual and who are able to follow these should connect the device.

Should there be any doubt as to the correct handling of the device, please contact your local distributor or, alternatively, **Morsettitalia S.p.A. - Via Santi, 87 - 20037 Paderno Dugnano (MI), tel: 02 991 991 1.**

Mounting and connection of the device should comply with national legislation for mounting of electric materials, i.e. wire cross section, protective fuse, and location. Descriptions of input / output and supply connections are shown in the block diagram and side label.

The following apply to fixed hazardous voltages-connected devices:

The max. size of the protective fuse is 10 A and, together with a power switch, it should be easily accessible and close to the device. The power switch should be marked with a label indicating that it will switch off the voltage to the device.

Year of manufacture can be taken from the first two digits in the serial number.

UL INSTALLATION REQUIREMENTS:

Use 60/75°C copper conductors only

For use only in pollution degree 2 or better

Max. ambient temperature 60°C

Max. wire size..... AWG 26-14

CALIBRATION AND ADJUSTMENT:

During calibration and adjustment, the measuring and connection of external voltages must be carried out according to the specifications of this manual. The technician must use tools and instruments that are safe to use.

NORMAL OPERATION:

Operators are only allowed to adjust and operate devices that are safely fixed in panels, etc., thus avoiding the danger of personal injury and damage. This means there is no electrical shock hazard, and the device is easily accessible.

CLEANING:

When disconnected, the device may be cleaned with a cloth moistened with distilled water.

LIABILITY:

To the extent that the instructions in this manual are not strictly observed, the customer cannot advance a demand against Morsettitalia S.p.A. that would otherwise exist according to the concluded sales agreement.

EC DECLARATION OF CONFORMITY

As manufacturer

Morsettitalia S.p.A.

Via Santi, 87)

I - 20037 Paderno Dugnano (MI)

hereby declares that the following product:

Type: 884116

Name: Universal transmitter

is in conformity with the following directives and standards:

The EMC Directive 2004/108/EC and later amendments

EN 61326-1

For specification of the acceptable EMC performance level, refer to the electrical specifications for the module.

The Low Voltage Directive 2006/95/EC and later amendments

EN 61010-1

Rønde, 28 August 2009



Filippo Codara
Manufacturer's signature

HOW TO DEMOUNT 884116

First, remember to demount the connectors with hazardous voltages.



Picture 1:
Detach the device from the DIN rail by lifting the bottom lock.

When front LED lights red / display shows AO.ER

884116 is designed as a SIL 2 device with a high safety level. Therefore, a continuous measurement of the outgoing current is carried out on a 4...20 mA output signal. If the current is 0, an error mode switches on the red front LED and disables the relays. This function is not a default option but must be actively selected in the menu. The error mode can only be reset by switching off and then switching on the supply voltage to the device.

UNIVERSAL TRANSMITTER 884116

- *Input for RTD, TC, Ohm, potentiometer, mA and V*
- *2-wire supply > 16 V*
- *Output for current, voltage and 2 relays*
- *Universal AC or DC supply*

Advanced features

- Programmable via detachable display front (884501), process calibration, signal and relay simulation, password protection, error diagnostics and selection of help text in several languages.

Application

- Linearised, electronic temperature measurement with RTD or TC sensor.
- Conversion of linear resistance variation to a standard analogue current / voltage signal, i.e. from solenoids and butterfly valves or linear movements with attached potentiometer.
- Power supply and signal isolator for 2-wire transmitters.
- Process control with 2 pairs of potential-free relay contacts and analogue output.
- Galvanic separation of analogue signals and measurement of floating signals.
- The 884116 is designed according to strict safety requirements and is thus suitable for application in SIL 2 installations.

Technical characteristics

- When 884116 is used in combination with the 884501 display / programming front, all operational parameters can be modified to suit any application. As the 884116 is designed with electronic hardware switches, it is not necessary to open the device for setting of DIP switches.
- A green / red front LED indicates normal operation and malfunction. A yellow LED is ON for each active output relay.
- Continuous check of vital stored data for safety reasons.
- 4-port 2.3 kVAC galvanic isolation.

884501 DISPLAY / PROGRAMMING FRONT



Functionality

The simple and easily understandable menu structure and the explanatory help texts guide you effortlessly and automatically through the configuration steps, thus making the product very easy to use. Functions and configuration options are described in the section "Configuration / operating the function keys".

Application

- Communications interface for modification of operational parameters in 884116.
- Can be moved from one 884116 device to another and download the configuration of the first transmitter to subsequent transmitters.
- Fixed display for readout of process data and status.

Technical characteristics

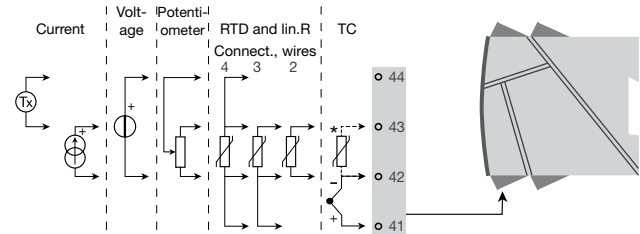
- LCD display with 4 lines; Line 1 (H=5.57 mm) shows input signal, line 2 (H=3.33 mm) shows units, line 3 (H=3.33 mm) shows analogue output or tag no. and line 4 shows communication and relay status.
- Programming access can be blocked by assigning a password. The password is saved in the transmitter in order to ensure a high degree of protection against unauthorised modifications to the configuration.

Mounting / installation

- Click 884501 onto the front of 884116.

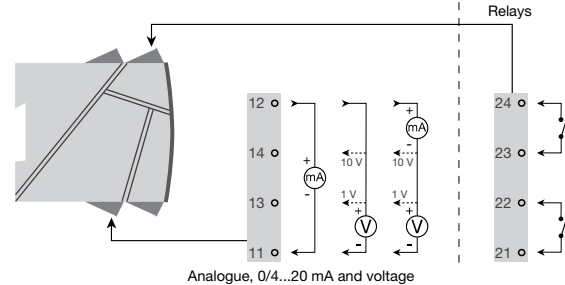
APPLICATIONS

Input signals:

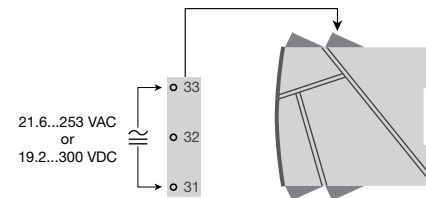


* Order separately for TC via CJC connector: 885910 CJC connector. See connections diagram on page 47

Output signals:



Supply:



Order codes

884116 = Universal transmitter
884501 = Display / programming front
5910 = CJC connector

Electrical specifications

Specifications range -20°C to +60°C

Common specifications:

Supply voltage, universal 21.6...253 VAC,
 or 19.2...300 VDC
 Max. consumption ≤ 2.5 W
 Fuse 400 mA SB / 250 VAC
 Isolation voltage, test / operation 2.3 kVAC / 250 VAC
 Communications interface Programming front 884501
 Signal / noise ratio Min. 60 dB (0...100 kHz)
 Response time (0...90%, 100...10%):
 Temperature input ≤ 1 s
 mA / V input ≤ 400 ms
 Calibration temperature 20...28°C
 Accuracy, the greater of the general and basic values:

General values		
Input type	Absolute accuracy	Temperature coefficient
All	≤ ±0.1% of span	≤ ±0.01% of span / °C

Basic values		
Input type	Basic accuracy	Temperature coefficient
mA	≤ ±4 µA	≤ ±0.4 µA / °C
Volt	≤ ±20 µV	≤ ±2 µV / °C
Pt100	≤ ±0.2°C	≤ ±0.01°C / °C
Linear resistance	≤ ±0.1 Ω	≤ ±0.01 Ω / °C
Potentiometer	≤ ±0.1 Ω	≤ ±0.01 Ω / °C
TC type: E, J, K, L, N, T, U	≤ ±1°C	≤ ±0.05°C / °C
TC type: R, S, W3, W5, LR	≤ ±2°C	≤ ±0.2°C / °C
TC type: B 85...400°C	≤ ±4.5°C	≤ ±0.45°C / °C
TC type: B 400...1820°C	≤ ±2°C	≤ ±0.2°C / °C

EMC immunity influence	< ±0.5% of span
Extended EMC immunity:	
NAMUR NE 21, A criterion, burst	< ±1% of span

Auxiliary supplies:

2-wire supply (terminal 44...43) 25...16 VDC / 0...20 mA
 Max. wire size 1 x 2.5 mm² stranded wire
 Screw terminal torque 0.5 Nm
 Relative humidity < 95% RH (non-cond.)
 Dimensions, without display front (HxBxD) .. 109 x 23.5 x 104 mm
 Dimensions, with display front (HxBxD) 109 x 23.5 x 116 mm
 Protection degree IP20
 Weight 170 g / 185 g with 884501

RTD, linear resistance and potentiometer input:

Input type	Min. value	Max. value	Standard
Pt100	-200°C	+850°C	IEC60751
Ni100	-60°C	+250°C	DIN 43760
Lin. R	0 Ω	10000 Ω	-
Potentiometer	10 Ω	100 kΩ	-

Input for RTD types:

Pt10, Pt20, Pt50, Pt100, Pt200, PT250, Pt300, Pt400, Pt500, Pt1000
 Ni50, Ni100, Ni120, Ni1000
 Cable resistance per wire (max.), RTD 50 Ω
 Sensor current, RTD Nom. 0.2 mA
 Effect of sensor cable resistance
 (3- / 4-wire), RTD < 0.002 Ω / Ω
 Sensor error detection, RTD Yes
 Short circuit detection, RTD < 15 Ω

TC input:

Type	Min. value	Max. value	Standard
B	0°C	+1820°C	IEC 60584-1
E	-100°C	+1000°C	IEC 60584-1
J	-100°C	+1200°C	IEC 60584-1
K	-180°C	+1372°C	IEC 60584-1
L	-200°C	+900°C	DIN 43710
N	-180°C	+1300°C	IEC 60584-1
R	-50°C	+1760°C	IEC 60584-1
S	-50°C	+1760°C	IEC 60584-1
T	-200°C	+400°C	IEC 60584-1
U	-200°C	+600°C	DIN 43710
W3	0°C	+2300°C	ASTM E988-90
W5	0°C	+2300°C	ASTM E988-90
LR	-200°C	+800°C	GOST 3044-84

Cold junction compensation (CJC)

CJC via external sensor in

connector 5910 20...28°C ≤ ±1°C
 -20...20°C and 28...70°C ≤ ±2°C

CJC via internal sensor ±(2.0°C + 0.4°C * Δt)

Δt = internal temperature - ambient temperature

Sensor error detection, all TC types Yes

Sensor error current:

when detecting Nom. 2 µA
 else 0 µA

Current input:

Measurement range 0...20 mA

Programmable measurement ranges 0...20 and 4...20 mA

Input resistance Nom. 20 Ω + PTC 50 Ω

Sensor error detection:

Loop break 4...20 mA Yes

Voltage input:

Measurement range 0...12 VDC

Programmable measurement ranges 0...1 / 0.2...1 / 0...5 / 1...5 /
 0...10 and 2...10 VDC

Input resistance Nom. 10 MΩ

Current output:

Signal range (span) 0...20 mA

Programmable signal ranges 0...20 / 4...20 / 20...0 and 20...4 mA

Load (max.) 20 mA / 800 Ω / 16 VDC

Load stability ≤ 0.01% of span / 100 Ω

Sensor error detection 0 / 3.5 / 23 mA / none

NAMUR NE 43 Upscale / Downscale 23 mA / 3.5 mA

Output limitation:

on 4...20 and 20...4 mA signals 3.8...20.5 mA

on 0...20 and 20...0 mA signals 0...20.5 mA

Current limit ≤ 28 mA

Voltage output:

Signal range 0...10 VDC

Programmable signal ranges 0...1 / 0.2...1 / 0...10 / 0...5 /

1...5 / 2...10 / 1...0 / 1...0.2 / 5...0 /

5...1 / 10...0 og 10...2 V

Load (min.) 500 kΩ

Relay outputs:

Relay functions Setpoint, Window, Sensor error, Latch
 Power and Off

Hysteresis, in % / display counts 0,1...25% / 1...2999

On and Off delay 0...3600 s

Sensor error detection Break / Make / Hold

Max. voltage 250 VRMS

Max. current 2 A / AC or 1 A / DC

Max. AC power 500 VA

Observed authority requirements: Standard:

EMC 2004/108/EC EN 61326-1

LVD 2006/95/EC EN 61010-1

UL, Standard for Safety UL 508

of span = of the currently selected measurement range

Visualisation in the 884501 of sensor error detection and input signal outside range

Sensor error check:		
Device:	Configuration	Sensor error detection:
884116	R1 (relay 1), ERR.ACT=NONE R2 (relay 2), ERR.ACT=NONE, OUT.ERR=NONE.	OFF
	Else:	ON

Outside range readout (IN.LO, IN.HI): If the valid range of the A/D converter or the polynomial is exceeded			
Input	Range	Readout	Limit
VOLT	0...1 V / 0.2...1 V	IN.LO	< -25 mV
		IN.HI	> 1.2 V
	0...10 V / 2...10 V	IN.LO	< -25 mV
		IN.HI	> 12 V
CURR	0...20 mA / 4...20 mA	IN.LO	< -1.05 mA
		IN.HI	> 25.05 mA
LIN.R	0...800 Ω	IN.LO	< 0 Ω
		IN.HI	> 1075 Ω
	0...10 kΩ	IN.LO	< 0 Ω
		IN.HI	< 110 kΩ
POTM	-	IN.LO	< -0.5 %
		IN.HI	> 100.5 %
TEMP	TC / RTD	IN.LO	< temperature range -2°C
		IN.HI	> temperature range +2°C

Display readout below min.- / above max. (-1999, 9999):			
Input	Range	Readout	Limit
All	All	-1999	Display readout < -1999
		9999	Display readout > 9999

Sensor error detection limits

Sensor error detection (SE.BR, SE.SH):			
Input	Range	Readout	Limit
CURR	Loop break (4...20 mA)	SE.BR	<= 3.6 mA; > = 21 mA
POTM	All, SE.BR on all 3-wire	SE.BR	> ca. 126 kΩ
LIN.R	0...800 Ω	SE.BR	> ca. 875 Ω
	0...10 kΩ	SE.BR	> ca. 11 kΩ
TEMP	TC	SE.BR	> ca. 750 kΩ / (1.25 V)
		SE.SH	< ca. 15 Ω
	RTD, 2-, 3-, and 4-wire	SE.BR	> ca. 15 kΩ
		No SE.SH for Pt10, Pt20 and Pt50	SE.SH

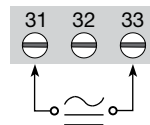
Error indications

Readout at hardware error		
Error search	Readout	Error cause
Test of internal CJC sensor	CJ.ER	CJC sensor defect or temperature outside range
Checksum test of the configuration in FLASH	FL.ER	Error in FLASH
Check measurement of analogue output current	AO.ER	1) No load on the current output (only S4...20/S20...4 mA)
Communications test 884501 / 884116	NO.CO	Connection error
Check that input signal matches input configuration	IN.ER	1) Error levels on input
Check that saved configuration in 884501 matches device	TY.ER	Configuration is not 884116

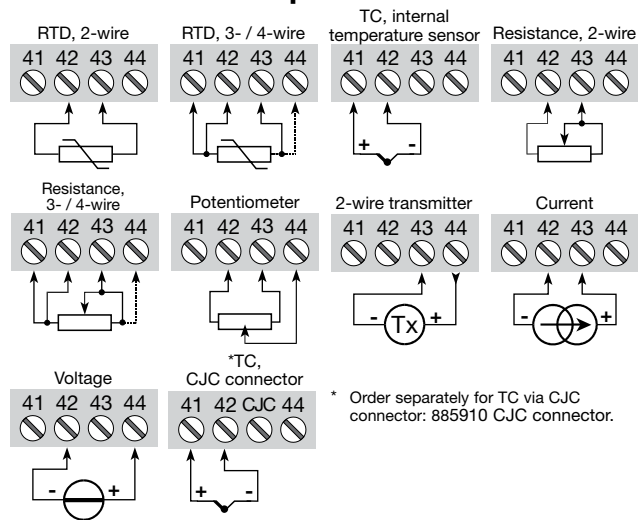
! Error indications in the display flash once per second. The help text explains the error.
1) The error is reset by switching off and then switching on the supply voltage to the device.

CONNECTIONS

Supply:

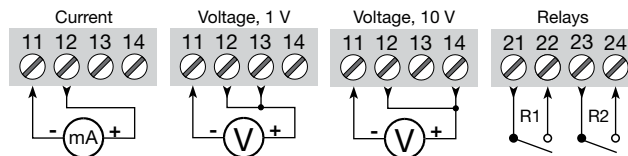


Inputs:

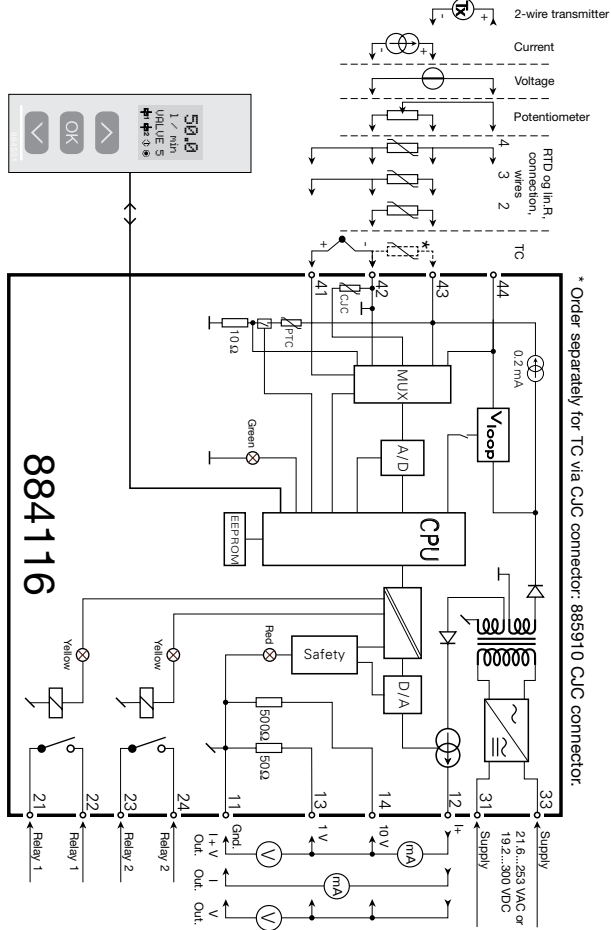


* TC, CJC connector
* Order separately for TC via CJC connector: 885910 CJC connector.

Outputs:



BLOCK DIAGRAM



CONFIGURATION / OPERATING THE FUNCTION KEYS

Documentation for routing diagram.

In general:

When configuring the 884116, you will be guided through all parameters and you can choose the settings which fit the application. For each menu there is a scrolling help text which is automatically shown in line 3 on the display.

Configuration is carried out by use of the 3 function keys:

- ⬆ will increase the numerical value or choose the next parameter
- ⬇ will decrease the numerical value or choose the previous parameter
- Ⓞ will accept the chosen value and proceed to the next menu

When configuration is completed, the display will return to the default state 1.0.

Pressing and holding Ⓞ will return to the previous menu or return to the default state (1.0) without saving the changed values or parameters.

If no key is activated for 1 minute, the display will return to the default state (1.0) without saving the changed values or parameters.

Further explanations:

Fast setpoint adjustment and relay test: These menus allow you to make a quick setpoint change and relay test when the FastSet menu is activated. This function can only be activated when the relays are set for setpoint function and are controlled by a setpoint.

Pressing ⬆ and ⬇ simultaneously will activate a relay test and change the state of the relay.

Pressing Ⓞ will save the setpoint change.

Holding down Ⓞ for more than 1 second will return the unit to the default state without saving the setpoint change.

Password protection: Programming access can be blocked by assigning a password. The password is saved in the transmitter in order to ensure a high degree of protection against unauthorised modifications to the configuration. Default password 2008 allows access to all configuration menus.

Signal and sensor error info via display front 884501

Sensor error (see limits in the table) is displayed as SE.BR (sensor break) or SE.SH (sensor short). Signals outside the selected range (not sensor error, see table for limits) are displayed as IN.LO indicating low input signal or IN.HI indicating high input signal. The error indication is displayed in line 3 as text and at the same time the backlight flashes. Line 4 of the display is a status line which displays status of relay 1 and relay 2, COM (flashing bullet) indicating correct functioning of 884501 and arrow up/down which indicates tendency readout of the input signal. If the figure 1 or figure 2 flashes, the unit has detected that the setpoint has been exceeded and that the relay is in "delay" mode. When the delay time has passed and the relay makes/breaks, the relay sign either displays or disappears.

Signal and sensor error indication without display front

Status of the unit can also be read from the red/green LED in the front of the device.

Green flashing LED 13 Hz indicates normal operation.

Green flashing LED 1 Hz indicates sensor error.

Steady red LED indicates internal error.

Relay functions

6 different settings of relay function can be selected.

Setpoint: The unit works as a single limit switch

Window: The relay has a window that is defined by a low and a high setpoint. On both sides of the window the relay has the same status.

Error function: The relay is activated by sensor error.

Power: The relay is activated as long as the power is on.

Off: The relay is deactivated.

Latch: The relay is latched. Only valid for setpoint and window function.

Increasing/decreasing: The relays can be set to activate at increasing or decreasing input signal.

Delay: An ON and an OFF delay can be set on both relays in the range 0...3600 s.

Hysteresis: A hysteresis can be set at 0.1...25% of the span or between 1 and 2999 counts.

Latch

When the setpoint is exceeded the relay outputs enters an alarm state. The latch function of the 884116 will hold the relays in this state until the function

is deactivated manually. The latch function can be applied when the relay function setpoint or window is selected.

The latch function can be selected separately for each relay output. If the configuration is copied from one device to another by way of the 884501, the latch function must be reconfigured.

The latch function activates and holds the relays when the input signal rises above or falls below the selected setpoints and the relay action has been selected as increasing or decreasing.

The window function is selected by choosing "window" in the menu and defining a high and a low setpoint.

It can be selected for each relay contact whether the contact is open or closed inside the window. This selection is made in the menu R1.cont and R2.cont.

The setpoint function is selected by choosing "setpoint" in the menu and entering the desired limit. The device then works as a single limit switch.

An activated relay means that the contact is closed if the contact function "normally open" is selected, and the contact is open if the contact function "normally closed" is selected.




The delay time for activation and deactivation can be set independently of each other in the menus ON.DEL and OFF DEL respectively.

If the relay function "Error" is active, the relay will latch when a sensor error occurs and will not be deactivated automatically when the sensor error is rectified.

The relay can only be deactivated by an operator and only when the normal conditions for deactivation are met. If the input signal still has a value that will activate the relay, the relay will latch again.

See the graphic depiction of the setpoint and window functions on pages 62 and 63.

Manual deactivation of the latch function



If the relay outputs are activated and thereby latched, it will be indicated in the display. The backlight flashes and the scrolling help text tells you how to deactivate the output. Manual deactivation is carried out by way of the front buttons on the 884501. Use  and  to navigate in the menu and  to validate your selection. If the password protection has been activated, the password must be entered in order to access the deactivation menu. See the menu structure on page 59.

Advanced functions

The device gives access to a number of advanced functions which can be reached by answering "Yes" to the point "adv.set".

Display setup: Here you can adjust the brightness contrast and the backlight. Setup of TAG numbers with 6 alphanumerics. Selection of functional readout in line 3 of the display - choose between readout of analogue output or tag no.

Two-point process calibration: The device can be process-calibrated in 2 points to fit a given input signal. A low input signal (not necessarily 0%) is applied and the actual value is entered. Then a high signal (not necessarily 100%) is applied and the actual value is entered. If you accept to use the calibration, the device will work according to this new adjustment. If you later reject this menu point or choose another type of input signal the device will return to factory calibration.

Process simulation function: If you agree to the point "EN.SIM" it is possible to simulate an input signal by means of the arrow keys and thus control the output signal up or down. When you finalise the point with , the device returns to normal mode. The following point allows you to activate relay 1 and relay 2 by means of the arrow-keys up/down. You must exit the menu by pressing  (no time-out).

Password: Here you can choose a password between 0000 and 9999 in order to protect the device against unauthorised modifications to the configuration. The device is delivered default without password. If you have locked the device with a password by mistake, you can always open the menu by using the master password 2008.

Language: In the menu "lang.setup" you can choose between 7 different language versions of help texts that will appear in the menu. You can choose between UK, DE, FR, IT, ES, SE and DK.

Auto diagnosis

The device performs an advanced auto diagnosis of the internal circuits.

The following possible errors can be displayed in the front unit 884501.

CJ.ER - CJC sensor defect or CJC temperature outside range

FL.ER - Flash error

AO.ER - No load on the current output (only for S4...20 mA / S20...4 mA)

NO.CO - Connection error

IN.ER - Error levels on input

TY.ER - Configuration in 884501 does not match this product type

Selection of units

After choosing the input signal type you can choose which process units should be displayed in text line 2 (see table). By selection of temperature input the process value is always displayed in Celsius or Fahrenheit. This is selected in the menu point after selection of temperature input.

Safety readback

When the device is delivered with default configuration, the SIL function is disabled. The safety readback function (loop surveillance) can be selected in the menu O.RANGE, thus enabling the device to run in SIL mode. In order to enable the SIL functionality, the menu item S4...20 mA must be selected. Please note, however, that when safety readback is enabled, a sensor error will be indicated as an error on the analogue output signal.

CJC

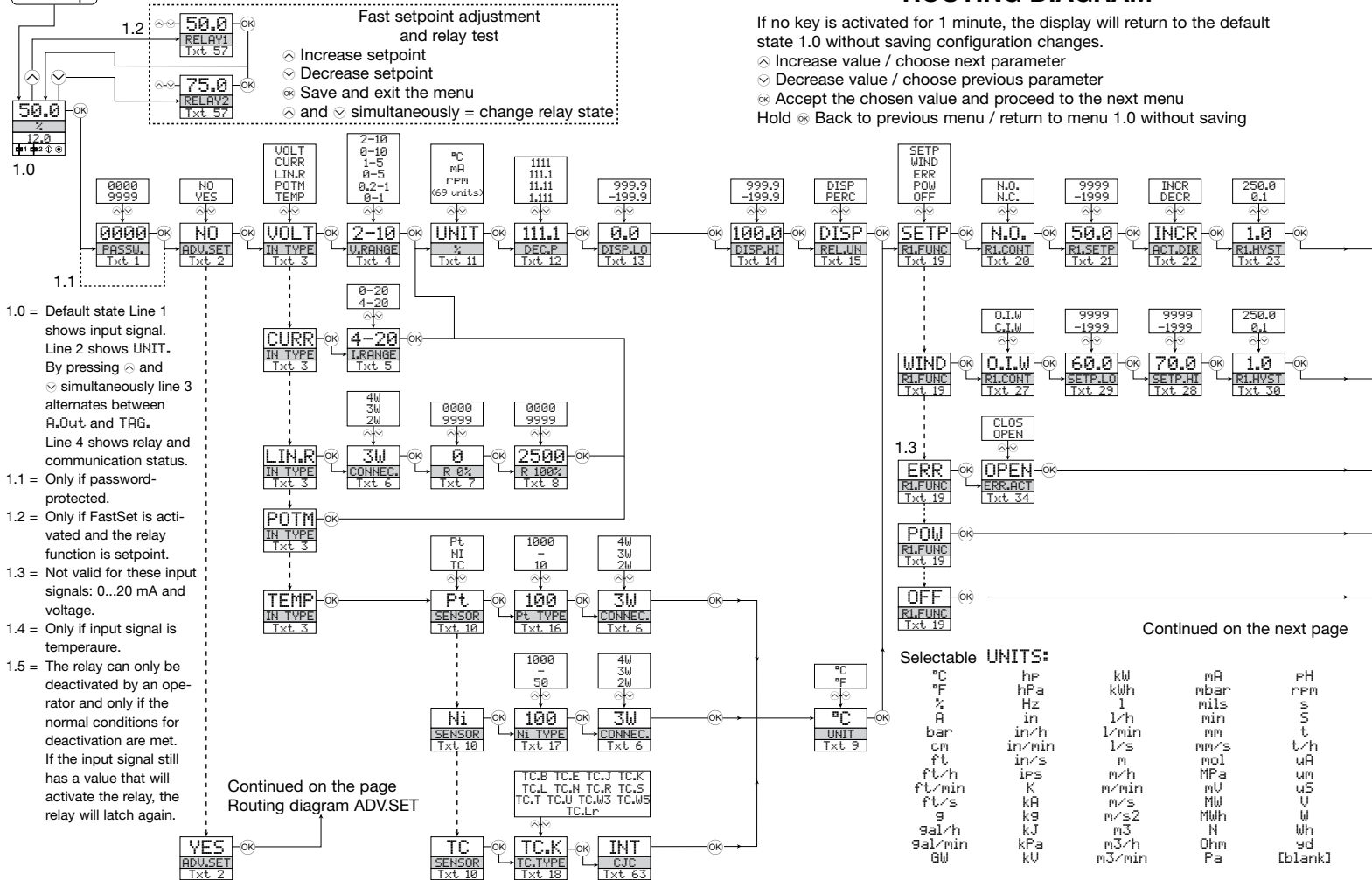
In the CJC menu you can choose between CJC connector and internal cold junction compensation. The CJC connector (885910) must be ordered separately.

Power up

ROUTING DIAGRAM

If no key is activated for 1 minute, the display will return to the default state 1.0 without saving configuration changes.

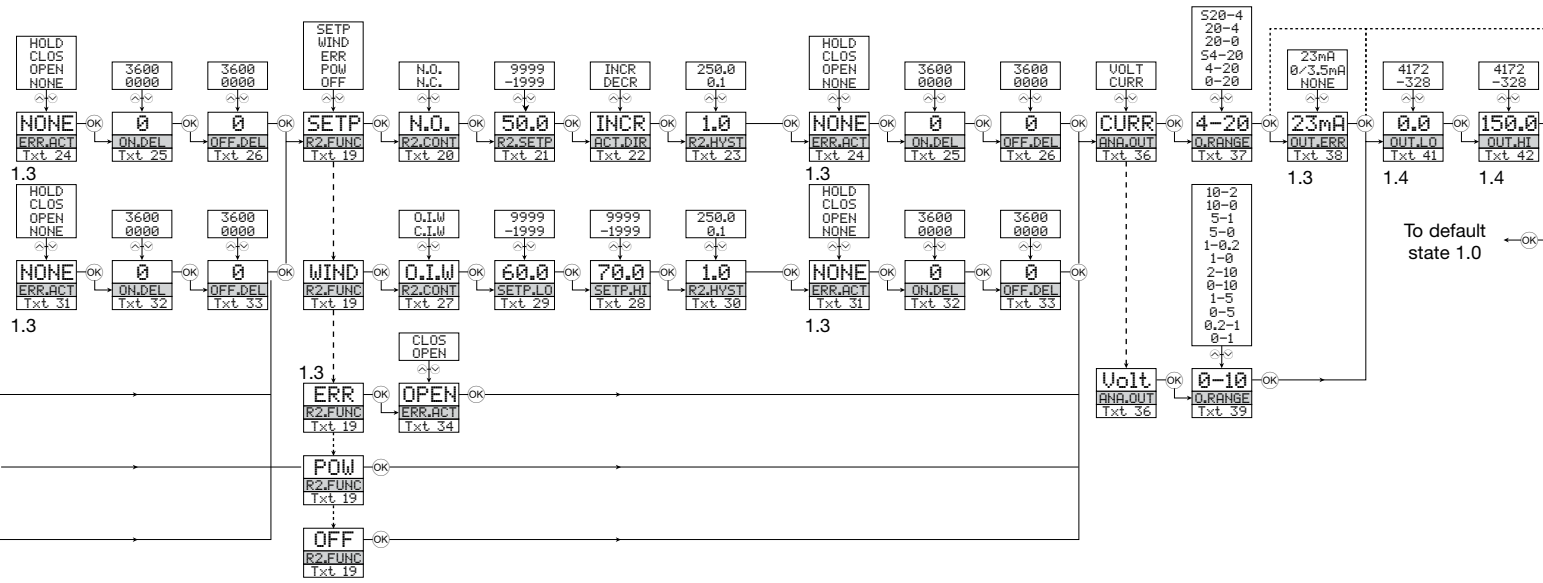
- ⏏ Increase value / choose next parameter
- ⏏ Decrease value / choose previous parameter
- ⏏ Accept the chosen value and proceed to the next menu
- ⏏ Back to previous menu / return to menu 1.0 without saving



- 1.0 = Default state Line 1 shows input signal. Line 2 shows UNIT. By pressing ⏏ and ⏏ simultaneously line 3 alternates between A_{out} and TAG. Line 4 shows relay and communication status.
- 1.1 = Only if password-protected.
- 1.2 = Only if FastSet is activated and the relay function is setpoint.
- 1.3 = Not valid for these input signals: 0...20 mA and voltage.
- 1.4 = Only if input signal is temperature.
- 1.5 = The relay can only be deactivated by an operator and only if the normal conditions for deactivation are met. If the input signal still has a value that will activate the relay, the relay will latch again.

Continued on the next page

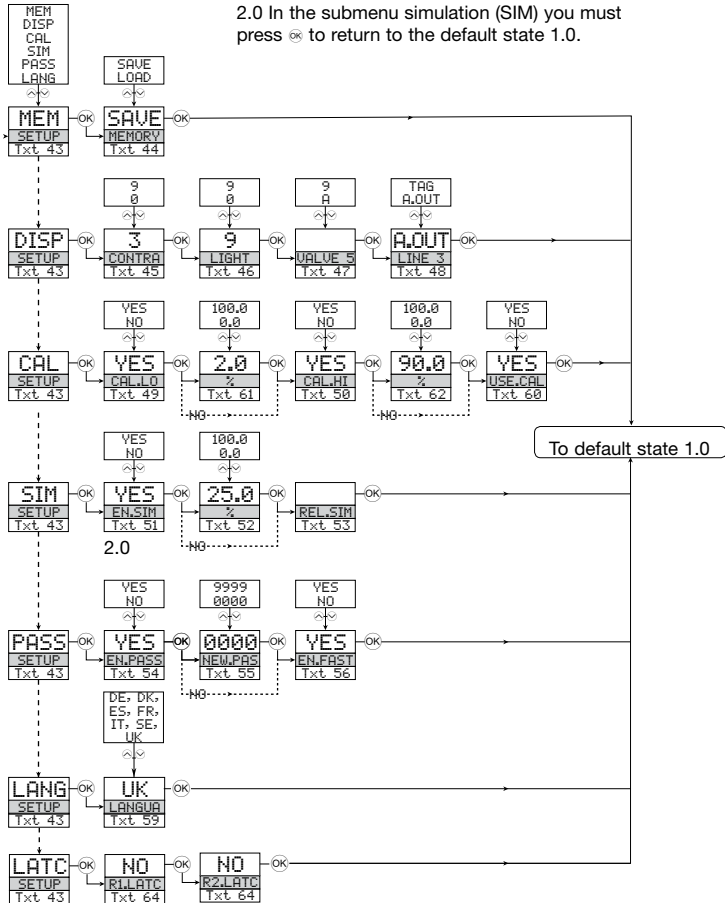
Continued on the page Routing diagram ADV.SET



ROUTING DIAGRAM

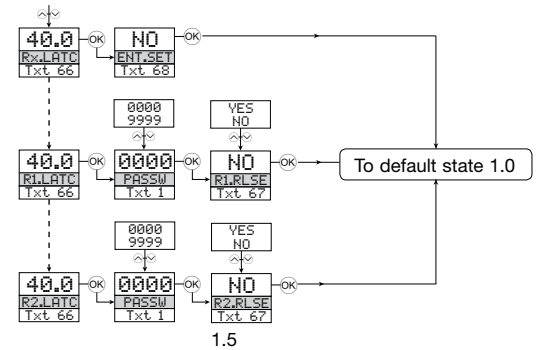
Advanced settings (ADV.SET)

2.0 In the submenu simulation (SIM) you must press **OK** to return to the default state 1.0.



ROUTING DIAGRAM

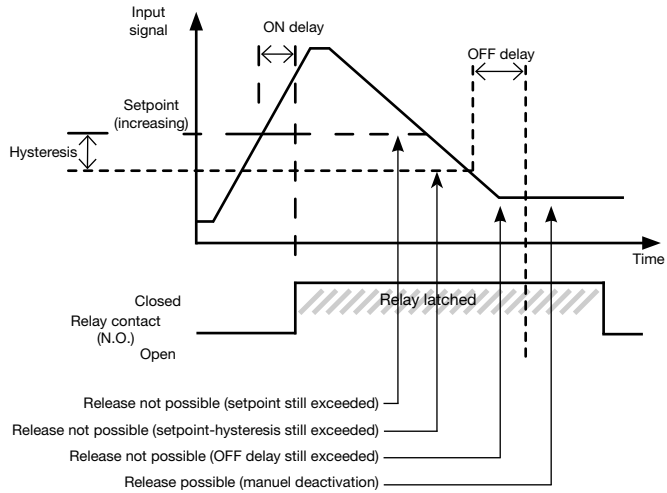
Latch



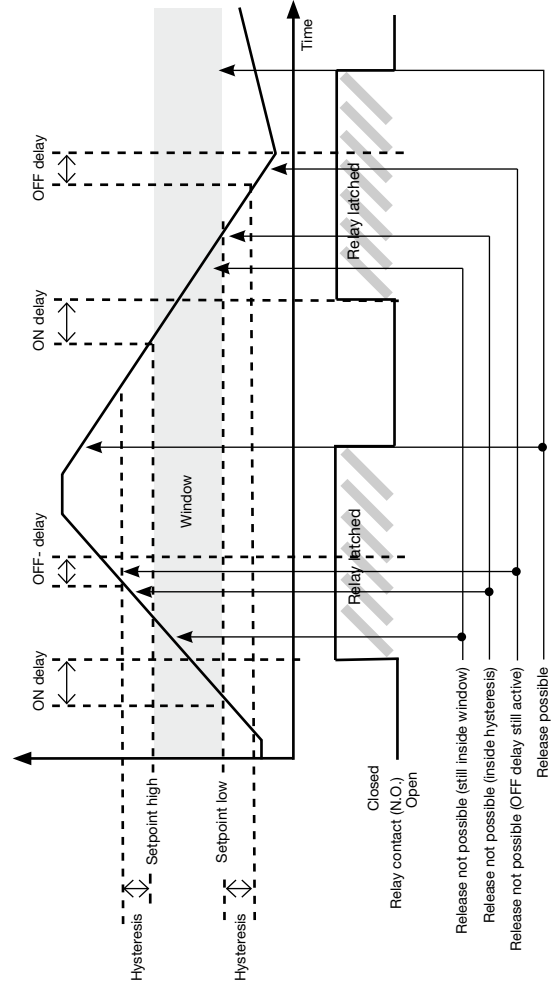
SCROLLING HELP TEXT IN DISPLAY LINE 3

- [01] Set correct password
- [02] Enter advanced setup menu?
- [03] Select temperature input
Select potentiometer input
Select linear resistance input
Select current input
Select voltage input
- [04] Select 0.0-1 V input range
Select 0.2-1 V input range
Select 0-5 V input range
Select 1-5 V input range
Select 0-10 V input range
Select 2-10 V input range
- [05] Select 0-20 mA input range
Select 4-20 mA input range
- [06] Select 2-wire sensor connection
Select 3-wire sensor connection
Select 4-wire sensor connection
- [07] Set resistance value low
- [08] Set resistance value high
- [09] Select Celsius as temperature unit
Select Fahrenheit as temperature unit
- [10] Select TC sensor type
Select Ni sensor type
Select Pt sensor type
- [11] Select display unit
- [12] Select decimal point position
- [13] Set display range low
- [14] Set display range high
- [15] Set relays in % of input range
Set relays in display units
- [16] Select Pt10 as sensor type
Select Pt20 as sensor type
Select Pt50 as sensor type
Select Pt100 as sensor type
Select Pt200 as sensor type
Select Pt250 as sensor type
Select Pt300 as sensor type
Select Pt400 as sensor type
Select Pt500 as sensor type
Select Pt1000 as sensor type
- [17] Select Ni50 as sensor type
Select Ni100 as sensor type
Select Ni120 as sensor type
Select Ni1000 as sensor type
- [18] Select TC-B as sensor type
Select TC-E as sensor type
Select TC-J as sensor type
Select TC-K as sensor type
Select TC-L as sensor type
Select TC-N as sensor type
Select TC-R as sensor type
Select TC-S as sensor type
Select TC-T as sensor type
Select TC-U as sensor type
Select TC-W3 as sensor type
Select TC-W5 as sensor type
Select TC-Lr as sensor type
- [19] Select OFF function - relay is permanently off
Select POWER function - relay indicates power status OK
Select ERROR function - relay indicates sensor error only
Select WINDOW function - relay controlled by 2 setpoints
Select SETPOINT function - relay controlled by 1 setpoint
- [20] Select Normally Closed contact
- [21] Select Normally Open contact
- [22] Set relay setpoint
Activate relay on decreasing signal
Activate relay on increasing signal
- [23] Set relay hysteresis
- [24] No error action - undefined status at error
Open relay contact at error
Close relay contact at error
Hold relay status at error
- [25] Set relay ON delay in seconds
- [26] Set relay OFF delay in seconds
- [27] Relay contact is Closed Inside Window
Relay contact is Open Inside Window
- [28] Set relay window setpoint high
- [29] Set relay window setpoint low
- [30] Set relay window hysteresis
- [31] No error action - undefined status at error
Open relay contact at error
Close relay contact at error
Hold relay status at error
- [32] Set relay ON delay in seconds
- [33] Set relay OFF delay in seconds
- [34] Open relay contact at error
Close relay contact at error
- [36] Select current as analogue output type
Select voltage as analogue output type
- [37] Select 0-20 mA output range
Select 4-20 mA output range
Select S4-20 mA with safety readback
Select 20-0 mA output range
Select 20-4 mA output range
Select S20-4 mA with safety readback
- [38] Select no error action - output undefined at error
Select downscale at error
Select NAMUR NE43 downscale at error
Select NAMUR NE43 upscale at error
- [39] Select 0.0-1 V output range
Select 0.2-1 V output range
Select 0-5 V output range
Select 1-5 V output range
Select 0-10 V output range
Select 2-10 V output range
Select 1-0.0 V output range
Select 1-0.2 V output range
Select 5-0 V output range
Select 5-1 V output range
Select 10-0 V output range
Select 10-2 V output range
- [41] Set temperature for analogue output low
- [42] Set temperature for analogue output high
- [43] Enter password setup
Enter simulation mode
Perform process calibration
Enter display setup
Perform memory operations
Enter relay latch setup
- [44] Load saved configuration into 884116
Save 884116 configuration in 884501
- [45] Adjust LCD contrast
- [46] Adjust LCD backlight
- [47] Write a 6-character device TAG
- [48] Analogue output value is shown in display line 3
Device TAG is shown in display line 3
- [49] Calibrate input low to process value?
- [50] Calibrate input high to process value?
- [51] Enable simulation mode?
- [52] Set the input simulation value
- [53] Relay simulation - use \wedge and \vee to toggle relay 1 and 2
- [54] Enable password protection?
- [55] Set new password
- [56] Enable Fastset functionality?
- [57] Relay setpoint - press ∞ to save
- [58] Relay setpoint - Read only
- [59] Select language
- [60] Use process calibration values?
- [61] Set value for low calibration point
- [62] Set value for high calibration point
- [63] Select CJC connector (accessory)
Select internal temperature sensor
- [64] Enable relay latch function?
- [66] Relay is latched - press ∞ to acknowledge
Relay 1 is latched - press \wedge to release
Relay 2 is latched - press \vee to release
Relays are latched - press \wedge or \vee to release relay 1 or relay 2
- [67] Release relay? (if conditions allow)
- [68] Enter setup menu? (latched relays may release!)

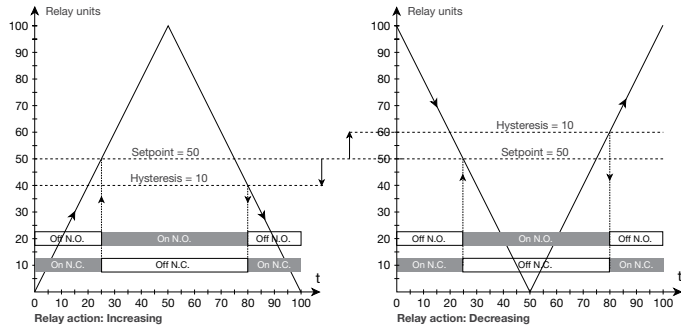
Graphic depiction of latch function setpoint



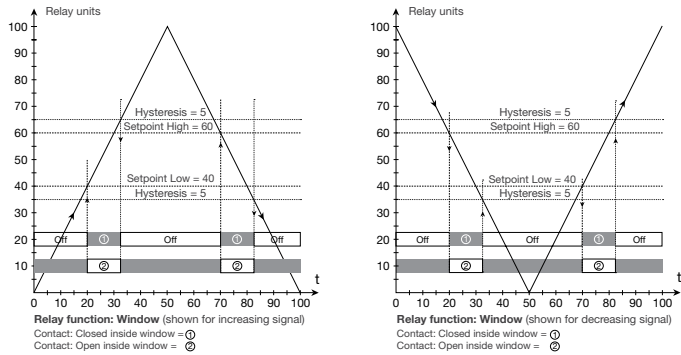
Graphic depiction of latch function window



Graphic depiction of relay action setpoint



Graphic depiction of relay action window





M O R S E T T I T A L I A

Morsettitalia S.p.A.
Via Santi, 87
20037 Paderno Dugnano (MI)
www.morsettitalia.com

Universal Signal Conditioners



Universal Signal Conditioners Features

- Flexibility to accept mA, VDC, thermocouple, RTD, linear resistance or potentiometer signal types
- Selectable input ranges and two point field scalability to handle hundreds of applications
- Direct and reverse acting mA and VDC analog output signal. The 884116 also includes two programmable SPST relay outputs.
- Universal supply voltage, 21.6 to 253 VAC or 19.2 to 300 VDC, polarity insensitive
- 3-way isolation between input, output, and power
- Auxiliary power supply output for 2-wire transmitters and 3-wire potentiometers
- Easy-to-use detachable LCD programming/display module 884501 (Sold separately and required for programming)
- Transfer configuration settings from one signal conditioner to another
- LEDs indicate operation and relay status (884116) when display module is not installed
- Integral 35mm DIN rail mounting adapter
- Removable screw terminal blocks are keyed to ensure correct installation
- UL508 listed, CE marked
- 5 year warranty

The Universal Signal Conditioners from AutomationDirect are extremely, versatile providing the flexibility to convert, transmit, scale and isolate signals from a wide variety of process sensors and controller I/O. With models 884114 and 884116, scalable input signal types supported include mA, VDC, thermocouple with internal cold junction compensation, 2-, 3-, 4-wire RTDs, linear resistance or potentiometer signals. Numerous selectable input ranges and two point field scalability will handle hundreds of applications. Outputs include mA, VDC; two individually programmable relays on the 884116 are used for alarming and control functions. The isolated universal supply voltage input eliminates the need for separate transformers or power supplies. Isolation is also provided between input and output.

The signal conditioners are easily configured with the 884501 menu-structured LCD programming/display module (a computer running special calibration software is not required and there are no confusing DIP switches or jumpers to set). Automatic scrolling Help text identifies each menu item. The detachable programming/display module can store and transfer configuration parameters from one signal conditioner to another, minimizing set-up time in multiple unit applications. Programming is available in seven different languages and the programming/display module can be password protected to prevent unauthorized changes to the configuration. When not used for configuration, the programming/display module can remain on the signal conditioner to display the input signal value and engineering units, output signal, and relay status (if equipped). A process simulation function allows manual manipulation of the input signal to control the output signal for trouble-shooting and checkout.

Universal Signal Conditioners		
Part No.	Description	Price
884114	Signal conditioner and isolator, single input • Accepts milliamps, volts, RTD, thermocouple or potentiometer • Single analog output supports 16 selectable signal ranges • Plastic slim-line housing • Detachable 884501 programming/display module (purchased separately) is required for unit configuration; module may remain affixed for operational display of input and output values	\$185.00
884116	Signal conditioner and isolator, single input • Accepts milliamps, volts, RTD, thermocouple or potentiometer • Single analog output supports 16 selectable signal ranges • Two programmable Form A relay outputs • Plastic slim-line housing • Detachable 884501 programming/display module (purchased separately) is required for unit configuration; module may remain affixed for operational display of input and output values	\$199.00
884501	Programming/display module, detachable, use with 884114 and 884116.	\$51.00

Universal Signal Conditioners

Universal Signal Conditioners 884114/884116 Specifications (with or without 884501)		
General Specifications		
Temperature Range	-20°C to +60°C [-4°F to 140°F]	
Power	AC Power	21.6 to 253 VAC, 50/60 Hz
	DC Power	19.2 to 300 VDC
Consumption	≤ 2.5W	
Fuse	400 mA slow blow / 250 VAC (Not user replaceable)	
Auxiliary Power Supply Output	16-25 VDC, 20 mA max (Terminal 43 and 44)	
Isolation Voltage, Test/Operation	2.3 kVAC/250 VAC	
Configuration Interface	Programming/display module, 884501	
Signal/noise Ratio	Min. 60 dB (0 to 100 kHz)	
Response Time (0 to 90%, 100 to 10%)	Temperature input	≤ 1 sec
	mA / V input	≤ 400 ms
Calibration Temperature	20 to 28°C (68 to 82.4°F)	
Accuracy	The greater of the general and basic values (See Accuracy Table 1)	
Shock	EN61010-1	
Vibration	IEC 60068-2-6, IEC 60068-2-64	
EMC Immunity	≤ ±0.5% of span	
Extended EMC Immunity: NAMUR NE 21, A criterion, burst	≤ ±0.1% of span	
Environmental Conditions	Operating and Storage Temperature	-20 to +60°C [-4 to 140°F]
	Operating and Storage Humidity	95% relative humidity (non-condensing)
Approvals	CE, UL (#E314521, UL 508), EMC 2004/108/EC (EN 61326-1) LVD 2006/95/EC (EN61010-1) RoHS	
Construction	IP 50 enclosure, IP 20 terminals Touch Safe, case body is black high impact plastic. Pollution degree 1.	
Connections	Wire strip length	7.5mm [0.3 in]
	Wire gauge	26 - 14 AWG standard wire
	Torque	0.5 N-m [4.5 inch-lbs]
Weight	884114	145g [5.1 oz], 160 g [5.6 oz]
	884116	170g [5.9 oz], 185 g [6.5 oz]
	884501	15g [0.5 oz]
Dimensions	109 x 23.5 x 100mm [4.3 x .93 x 3.93 in], 109 x 23.5 x 116mm [4.3 x .93 x 4.6 in] with programming module	

Accuracy Table 1		
General Values		
Input Type	Absolute Accuracy	Temperature Coefficient
All	≤ ± 0.1% of span	≤ ± 0.01% of span/°C [0.01% of span/°F]
Basic Values		
Input Type	Basic Accuracy	Temperature Coefficient
mA	≤ ± 4 μA	≤ ± 0.4 μA/°C [±0.22μA/°F]
Volt	≤ ± 20 μV	≤ ± 2 μV/°C [±1.1μV/°F]
Pt100	≤ ± 0.2°C [±0.36°F]	≤ ± 0.01°C/°C [±.01°F/°F]
Linear resistance	≤ ± 0.1 Ω	≤ ± 0.01 Ω/°C [±.0056Ω/°F]
Potentiometer	≤ ± 0.1 Ω	≤ ± 0.01 Ω/°C [±.0056Ω/°F]
TC Type: E, J, K, L, N, T, U	≤ ± 1°C [±1.8°F]	≤ ± 0.05°C/°C [±.05°F/°F]
TC Type: B, R, S, W3, W5, LR	≤ ± 2°C [3.6°F]	≤ ± 0.2°C/°C [±0.2°F/°F]

Universal Signal Conditioners

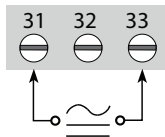
Inputs			
Current Input			
Programmable Ranges	0 to 20 and 4 to 20 mA DC		
Measurement Range	-1 to 25 mA		
Input Resistance	Nom. 70 Ω		
Sensor Error Detection	4 to 20 loop break, ≤3.6mA; ≥21mA		
Voltage Input			
Programmable Ranges	0 to 1, 0.2 to 1, 0 to 5, 1 to 5, 0 to 10, and 2 to 10 VDC		
Measurement Range	-20 mV to 12 VDC		
Input Resistance	Nom. 10 MΩ		
Thermocouple Inputs			
Thermocouple Type	B, E, J, K, L, N, R, S, T, U, W3, W5, and LR		
Cold Junction Compensation	Via internally mounted sensor < ± 2.0°C [$< \pm 3.6^{\circ}\text{F}$]		
Sensor Error Detection	Sensor break, >750kΩ/(1.25V)		
Sensor Error Current	When detecting 2μA, otherwise 0 μA		
Type	Min. value	Max. value	Standard
B	+400°C [+752°F]	+1820°C [+3308°F]	IEC 60584-1
E	-100°C [-148°F]	+1000°C [+1832°F]	IEC 60584-1
J	-100°C [-148°F]	+1200°C [+2192°F]	IEC 60584-1
K	-180°C [-292°F]	+1372°C [+2502°F]	IEC 60584-1
L	-200°C [-328°F]	+900°C [+1652°F]	DIN 43710
N	-180°C [-292°F]	+1300°C [+2372°F]	IEC 60584-1
R	-50°C [-58°F]	+1760°C [+3200°F]	IEC 60584-1
S	-50°C [-58°F]	+1760°C [+3200°F]	IEC 60584-1
T	-200°C [-328°F]	+400°C [+752°F]	IEC 60584-1
U	-200°C [-328°F]	+600°C [+1112°F]	DIN 43710
W3	0°C [+32°F]	+2300°C [+4172°F]	ASTM E988-90
W5	0°C [+32°F]	+2300°C [+4172°F]	ASTM E988-90
LR	-200°C [-328°F]	+800°C [+1472°F]	GOST 3044-84
RTD, Linear Resistance, Potentiometer Inputs			
RTD Types	Pt10, Pt20, Pt50, Pt100, Pt200, Pt250, Pt300, Pt400, Pt500, Pt1000, Ni50, Ni100, Ni120, and Ni1000		
Cable Resistance per Wire	RTD, 50 Ω max		
Sensor Current	RTD, Nom. 0.2 mA		
Sensor Error Detection	Sensor break >15 kΩhm Sensor short <15 Ωhm (N/A for Pt10, Pt20, Pt50)		
Input type	Min. value	Max. value	Standard
Pt100	-200°C [-328°F]	+850°C [+1562°F]	IEC60751
Ni100	-60°C [-76°F]	+250°C [+482°F]	DIN 43760
Linear Resistance	0 Ω	10kΩ	–
Potentiometer	10 Ω	100kΩ	–

Universal Signal Conditioners

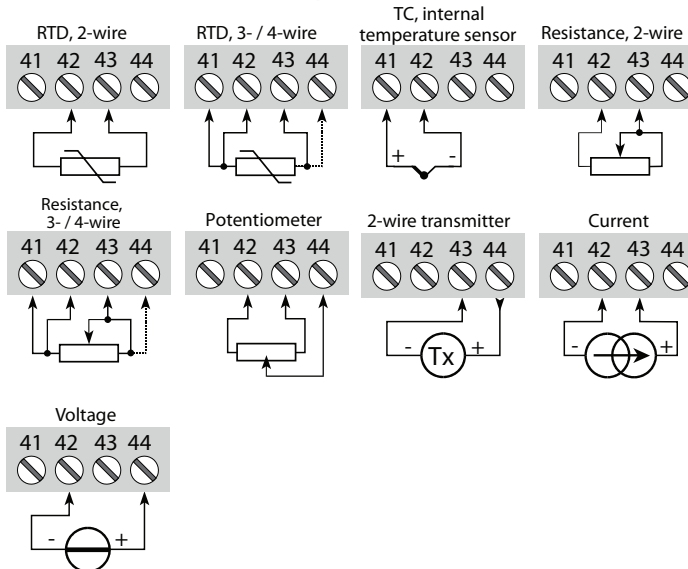
Outputs	
Analog Output - Current	
Signal Range	0 to 20 mA
Programmable Signal Range	0 to 20, 4 to 20, 20 to 0, and 20 to 4 mA
Load Resistance	800 Ω max, 20mA, 16 VDC
Load Stability	0.01% of span, 100 Ω load
Output state on sensor error detection	0 / 3.5 mA / 23 mA / none selectable
Output Limitation	For 4 to 20 and 20 to 4 mA signals: 3.8 to 20.5 mA For 0 to 20 and 20 to 0 mA signals: 0 to 20.5 mA
Current Limit	≤ 28 mA
Analog Output - Voltage	
Signal Range (Span)	0 to 10 VDC
Programmable Signal Ranges	0 to 1, 0.2 to 1, 0 to 10, 0 to 5, 1 to 5, 2 to 10, 1 to 0, 1 to 0.2, 5 to 0, 5 to 1, 10 to 0, and 10 to 2 V
Load	500k Ω min
Relay outputs (884116 only)	
Relay Functions	Setpoint, Window, Sensor Error, Power and Off
Hysteresis	0.1 to 25% (1 to 2999 display counts)
On and Off Delay	0 to 3600 sec
Relay state on sensor error detection	Break / Make / Hold selectable
Relay contact ratings	250 Vrms max; 2 A AC or 1 A DC max; 500 VA max

Wiring Diagrams

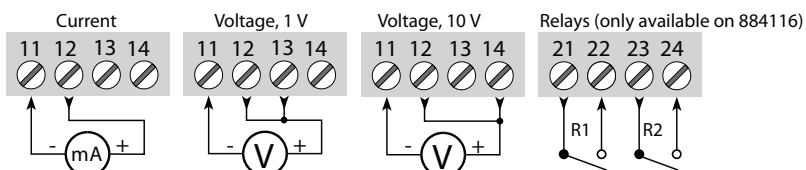
Supply:



Inputs:

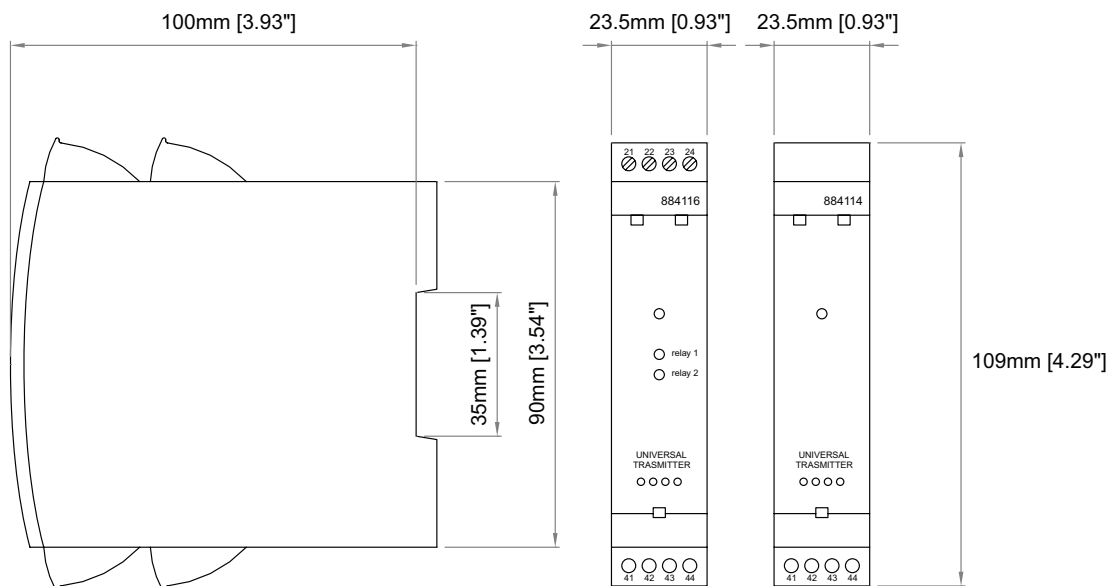


Outputs:



Universal Signal Conditioners

Dimensions 884114 and 884116



Programming/Display Module 884501

Application:

- The AutomationDirect 884501 module easily connects to the front of the Universal Signal Conditioners 884114 and 884116 and is used to enter or adjust the programming of the module.
- Can be moved from one module to another and download the configuration of the first transmitter to subsequent transmitters.
- Fixed display for visualization of process data and status.
- Required for programming modules 884114 and 884116.

Technical characteristics:

- LCD display with 4 lines; Line 1 (H = 5.57 mm, 0.22 in) shows input signal, line 2 (H = 3.33 mm, 0.13 in) shows units, line 3 (H = 3.33 mm, 0.13 in) shows analog output or user defined text and line 4 shows communication and relay status.
- Programming access can be blocked by assigning a password. The password is saved in the transmitter in order to ensure against unauthorized modifications to the configuration.
- Not capable of standalone or remote operation.

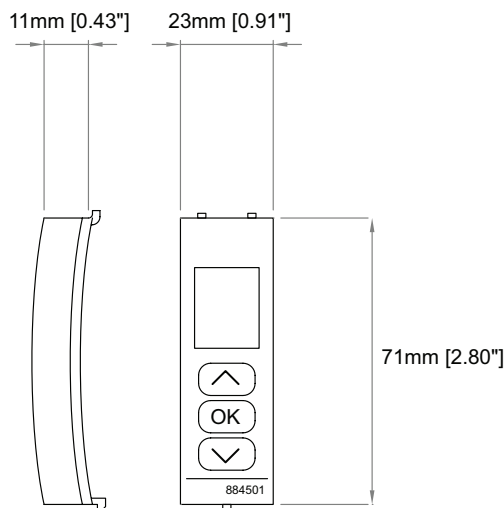


Mounting/Installation:

- Snap 884501 onto the front of the 884114 or 884116 signal conditioners

Selectable Engineering Units

°C	hp	kW	mA	pH
°F	hPa	kWh	mbar	rpm
%	Hz	l	mils	s
A	in	l/h	min	S
bar	in/h	l/min	mm	t
cm	in/min	l/s	mm/s	t/h
ft	in/s	m	mol	uA
ft/h	ips	m/h	MPa	uS
ft/min	K	m/min	mV	V
ft/s	kA	m/s	MW	W
g	kg	m/s ²	MWh	Wh
gal/h	kJ	m ³	N	yd
gal/min	kPa	m ³ /h	Ohm	
GW	kV	m ³ /min	Pa	



Universal Signal Conditioners

Quick Start Guide

AUTOMATIONDIRECT

Models:

3505 HUTCHINSON ROAD
CUMMING, GA 30040-5860

884114 - Universal Transmitter

884116 - Universal Transmitter with (2) relay outputs

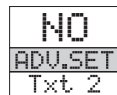
884501 - Display / Programming Module

Universal Transmitter Signal Conditioner models 884114 and 884116 are single input devices that accept milliamper, voltage, RTD, thermocouple or potentiometer inputs. Both models support a selectable single analog output. They feature a plastic slim-line housing, integral 35mm DIN rail mounting adapter, and removable screw terminals. The detachable 884501 programming / display module (purchased separately) is required for unit configuration. The programming / display module may remain affixed for operational display of input and output values.



Configuring a new unit

- Mount the unit on a 35mm DIN rail and connect supply, input and output wires to the appropriate terminals based on the connection diagrams in this Quick Start Guide.
- Snap the 884501 Programming Module on the front of the unit.
- Power up the unit.
- The unit should display the configuration menu similar to the figure below. If not, press **OK** once.



Note: If no sensor is connected to the input terminals, SE.BR will flash in the display when the unit is powered up. Press **OK** once to acknowledge the error and then press **OK** again to display the first screen of the menu as shown above.

- Press **OK** to begin configuration. Press **▲** or **▼** to scroll through options on each step. Press **OK** to confirm an option and move to the next step.
- Press and hold **OK** to step backwards through the configuration menu.

Abbreviations used on the 884501 display

FL.ER = flash memory error	REL.UN = relays set in units or % range
AD.ER = no load for current output (4-20 mA only)	Rx.FUNC = relay 1 / 2 function
NO.CO = connection error	Rx.CONT = relay 1 / 2 contact type
IN.ER = error levels on input	Rx.SETP = relay 1 / 2 setpoint
TY.ER = configuration in 884501 doesn't match this product	Rx.HYST = relay 1 / 2 hysteresis
ADV.SET = advanced settings	ERR.ACT = relay action on error
IN TYPE = input type	ON.DEL = relay on delay
V.RANGE = voltage range	OFF.DEL = relay off delay
I.RANGE = current range	ANA.OUT = analog output
CONNEC. = connecting wires	O.RANGE = output range
Pt. TYPE = Platinum RTD type	OUT.ERR = output action on error
Ni. TYPE = Nickel RTD type	OUT.LO = temp for low output
TC.TYPE = thermocouple type	OUT.HI = temp for high output
DEC.P = decimal place location	EN.PASS = enable password
SE.BR = a sensor wire is not connected	NEW.PAS = new password
DECR = decreasing	CAL.LO = calibrate input low to process value?
ACT.DIR = action direction	CAL.HI = calibrate input high to process value?
DISP.LO = low display range	USE.CAL = Use process calibration value?
DISP.HI = high display range	

Application Example - Voltage Input to Current Output

A level sensor with 0-5 VDC output needs to be connected to a 4-20 mA input on a PLC. The sensor measures fluid level between 0 and 60" in a tank. When using the 884116, low and high alarms will be set at 5" and 55" respectively with a 3" hysteresis and 5 second on delay set for each alarm. In the event of a sensor error, both relays will hold in their current state when the error occurred. Relay switching will work as follows:



- In the configuration menu press **▲** or **▼** until VOLT is displayed on line 1. Press **OK**.
- Select input range. Press **▲** or **▼** until 0-5 is displayed for V.RANGE. Press **OK**.
- Select input units. Press **▲** or **▼** until IN is displayed for UNIT. Press **OK**.
- Select decimal point location. Press **▲** or **▼** until 111.1 is displayed for DEC.P. Press **OK**.
- Set display value for minimum input. Press **▲** or **▼** until 0.0 is displayed for DISP.LO. Press **OK**.
- Set display value for maximum input. Press **▲** or **▼** until 60.0 is displayed for DISP.HI. Press **OK**.
 - 884116 only - select relay 1 function. Press **▲** or **▼** until SETP is displayed for R1.FUNC. Press **OK**.
 - 884116 only - select relay contact type. Press **▲** or **▼** until N.O. is displayed for R1.CONT. Press **OK**.
 - 884116 only - set relay setpoint. Press **▲** or **▼** until 5.0 is displayed for R1.SETP. Press **OK**.
 - 884116 only - select relay activation decreasing mode. Press **▲** or **▼** until DECR is displayed for ACT.DIR. Press **OK**.
 - 884116 only - set relay hysteresis. Press **▲** or **▼** until 3.0 is displayed for R1.HYST. Press **OK**.
 - 884116 only - select to hold relay status on error. Press **▲** or **▼** until HOLD is displayed for ERR.ACT. Press **OK**.
 - 884116 only - set relay on delay in seconds. Press **▲** or **▼** until 5 is displayed for ON.DEL. Press **OK**.
 - 884116 only - set relay off delay in seconds. Press **▲** or **▼** until 0 is displayed for OFF.DEL. Press **OK**.
 - 884116 only - select relay 2 function. Press **▲** or **▼** until SETP is displayed for R2.FUNC. Press **OK**.
 - 884116 only - select contact type. Press **▲** or **▼** until N.O. is displayed for R2.CONT. Press **OK**.
 - 884116 only - set relay setpoint. Press **▲** or **▼** until 60.0 is displayed for R2.SETP. Press **OK**.
 - 884116 only - select relay activation increasing mode. Press **▲** or **▼** until INCR is displayed for ACT.DIR. Press **OK**.
 - 884116 only - set relay hysteresis. Press **▲** or **▼** until 3.0 is displayed for R2.HYST. Press **OK**.
 - 884116 only - select to hold relay status on error. Press **▲** or **▼** until HOLD is displayed for ERR.ACT. Press **OK**.
 - 884116 only - set relay on delay in seconds. Press **▲** or **▼** until 5 is displayed for ON.DEL. Press **OK**.
 - 884116 only - set relay off delay in seconds. Press **▲** or **▼** until 0 is displayed for OFF.DEL. Press **OK**.
- Select output mode. Press **▲** or **▼** until CURR is displayed for ANA.OUT. Press **OK**.
- Select output range. Press **▲** or **▼** until 4-20 is displayed for O.RANGE. Press **OK**.
- Set NAMUR NE43 upscale at error. Press **▲** or **▼** until 23mA is displayed for OUT.ERR. Press **OK**.
- Wait while the settings are stored and the unit switches to run mode.

Once the 884116 has been configured, the relay setpoints can be adjusted very quickly. Press **▲** to adjust RELAY1 and **▼** to adjust RELAY2. Adjust the setpoint up or down and then press **OK** to save the setting and exit the menu. Pressing **▲** and **▼** simultaneously will change the relay's state.

Application Example - Thermocouple Input

An oven's temperature is to be monitored using a type K thermocouple. The unit will output a 0-10 VDC signal for a temperature range of 100-400 °F

- In the configuration menu press **▲** or **▼** until TEMP is displayed on line 1. Press **OK**.
- Select sensor type. Press **▲** or **▼** until TC is displayed for SENSOR. Press **OK**.
- Select TC type. Press **▲** or **▼** until TC.K is displayed for TC.TYPE. Press **OK**.
- Select temperature units. Press **▲** or **▼** until °F is displayed for UNIT. Press **OK**.
 - 884116 only - select relay 1 function. Press **▲** or **▼** until OFF is displayed for R1.FUNC. Press **OK**.
 - 884116 only - select relay 2 function. Press **▲** or **▼** until OFF is displayed for R2.FUNC. Press **OK**.
- Select output mode. Press **▲** or **▼** until VOLT is displayed for ANA.OUT. Press **OK**.
- Select output range. Press **▲** or **▼** until 0-10 is displayed for O.RANGE. Press **OK**.
- Set temperature for analog output low. Press **▲** or **▼** until 100.0 is displayed for OUT.LO. Press **OK**.
- Set temperature for analog output high. Press **▲** or **▼** until 400.0 is displayed for OUT.HI. Press **OK**.
- Wait while the settings are stored and the unit switches to run mode.

Application Example - Voltage Input to Voltage Output with Custom Scaling

A flow sensor delivers a 3-7 VDC output over a range of 0-80 gallons per minute. The signal conditioner will convert the 3-7 VDC input signal to a 0-10 VDC output signal. The unit must first be configured to the voltage output range. The two-point calibration mode in Advanced Settings is then used to set the custom input range.

- In the configuration menu press **▲** or **▼** until VOLT is displayed on line 1. Press **OK**.
- Select input range. Press **▲** or **▼** until 0-10 is displayed for V-RANGE. Press **OK**.
- Select input units. Press **▲** or **▼** until gal/min is displayed for UNIT. Press **OK**.
- Select decimal point location. Press **▲** or **▼** until 111.1 is displayed for DEC.P. Press **OK**.
- Set display for minimum input. Press **▲** or **▼** until 0.0 is displayed for DISP.LO. Press **OK**.
- Set display for maximum input. Press **▲** or **▼** until 80.0 is displayed for DISP.HI. Press **OK**.
 - 884116 only - select relay 1 function. Press **▲** or **▼** until OFF is displayed for R1.FUNC. Press **OK**.
 - 884116 only - select relay 2 function. Press **▲** or **▼** until OFF is displayed for R2.FUNC. Press **OK**.
- Select output mode. Press **▲** or **▼** until VOLT is displayed for ANA.OUT. Press **OK**.
- Set output range. Press **▲** or **▼** until 0-10 is displayed for O.RANGE. Press **OK**.
- Wait while these settings are stored and the unit switches to run mode.
- Press **OK** to return to the configuration menu.

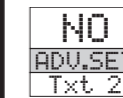
Application Example Continued above.

Application Example - Voltage Input to Voltage Output with Custom Scaling - Cont'd

- Enter Advanced Settings Mode. Press **▲** or **▼** until YES is displayed for ADV.SET. Press **OK**.
- Select custom scaling mode. Press **▲** or **▼** until CAL is displayed for SETUP. Press **OK**.
- Drive the input to a low value. The value does not have to be a minimum. In this example we will use 5.0 VDC (40 gallons per minute).
- Select lowpoint. Press **▲** or **▼** until YES is displayed for CAL.LO. Press **OK**.
- Set low point. Press **▲** or **▼** until 40.0 is displayed for gal/min. Press **OK**.
- Drive the input to a high value. The value does not have to be a maximum. In this example we will use 6.0 VDC (60 gallons per minute).
- Select high point. Press **▲** or **▼** until YES is displayed for CAL.HI. Press **OK**.
- Set high point. Press **▲** or **▼** until 60.0 is displayed for gal/min. Press **OK**.
- Confirm to use custom scaling. Press **▲** or **▼** until YES is displayed for USE.CAL. Press **OK**.
- Wait while the settings are stored and the unit switches to run mode.

Advanced Operations

Several useful functions are in the Advanced Settings Menu. To get to the Advanced Settings Menu, Press **▲** or **▼** until YES is displayed for the first screen of the configuration menu that looks like this:



The configuration of the 884114 or 884116 can be saved into the 884501. The 884501 can then be moved to another unit (must be the same part number) and the configuration loaded into the new unit.

- Enter Advanced Settings menu and then press **▲** or **▼** until MEM is displayed for SETUP. Press **OK**.
- To save the configuration into the 884501. Press **▲** or **▼** until SAVE is displayed for MEMORY. Press **OK**.
- To load the configuration from the 884501 into the 884114 or 884116. Press **▲** or **▼** until LOAD is displayed for MEMORY. Press **OK**.
- Password Protection allows the user to create a 4-digit password (0000-9999) to prevent tampering with configuration settings if the 884501 is left mounted to the front of the signal conditioner.
- Enter Advanced Settings menu and then press **▲** or **▼** until PASS is displayed for SETUP. Press **OK**.
- To enable password protection. Press **▲** or **▼** until YES is displayed for EN.PASS. Press **OK**.
- To set a password. Press **▲** or **▼** until the desired code is displayed for NEW.PAS. Press **OK**.

Note: The default password 2008 allows access to all configuration menus. The default password cannot be changed.

Additional Help and Support

- For product support, specifications, installation and troubleshooting, a Hardware User Manual can be downloaded from the On-line Documentation area of the AutomationDirect web site.
- For additional technical support and questions, call our Technical Support team @ 1-800-633-0405 or 770-844-4200

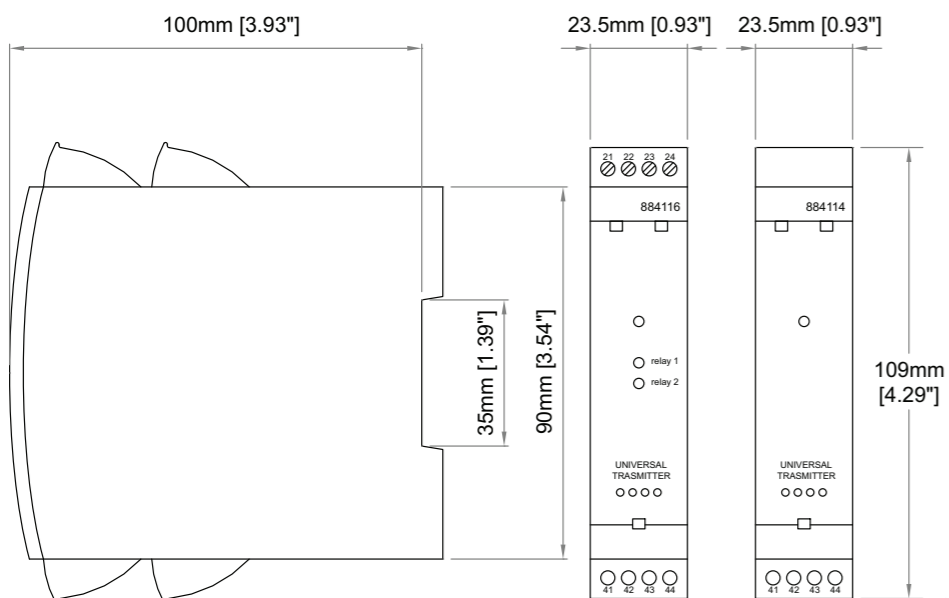


Universal Signal Conditioner Specifications

Universal Signal Conditioners 884114/884116 Specifications (with or without 884501)

General Specifications		
Temperature Range	-20°C to +60°C [-4°F to 140°F]	
Power	AC Power	21.6 to 253 VAC, 50/60 Hz
	DC Power	19.2 to 300 VDC
Consumption	≤ 2.5W	
Fuse	400 mA slow blow / 250 VAC (not user replaceable)	
Auxiliary Power Supply Output	16-25 VDC, 20 mA max (Terminal 43 and 44)	
Isolation Voltage, Test/Operation	2.3 kVAC/250 VAC	
Configuration Interface	Programming/display module, 884501	
Signal/noise Ratio	Min. 60 dB (0 to 100 kHz)	
Response Time (0 to 90%, 100 to 10%)	Temperature input	≤ 1 sec
	mA / V input	≤ 400 ms
Calibration Temperature	20 to 28°C (68 to 82.4°F)	
Accuracy	Dependant upon input type (See hardware user manual for more information)	
Shock	EN61010-1	
Vibration	IEC 60068-2-6, IEC 60068-2-64	
EMC Immunity	≤ ±0.5% of span	
Extended EMC Immunity: NAMUR NE 21, A criterion, burst	≤ ±0.1% of span	
Environmental Conditions	Operating and Storage Temperature	-20 to +60°C [-4 to 140°F]
	Operating and Storage Humidity	95% relative humidity (non-condensing)
Approvals	CE, UL (#E314521, UL 508), EMC 2004/108/EC (EN 61326-1), LVD 2006/95/EC (EN61010-1), RoHS	
	Construction	
	IP 50 enclosure, IP 20 terminals Touch Safe, case body is black high impact plastic. Pollution degree 1.	
Connections	Wire strip length	7.5mm [0.3 in]
	Wire gauge	26 - 14 AWG standard wire
	Torque	0.5 N-m [4.5 inch-lbs]
Weight	884114	145 g [5.1 oz], 160 g [5.6 oz] with programming/display module
	884116	170 g [5.9 oz], 185 g [6.5 oz] with programming/display module
	884501	15g [0.5 oz]
Dimensions	109 x 23.5 x 100mm [4.3 x .93 x 3.93 in], 109 x 23.5 x 116mm [4.3 x .93 x 4.6 in] with programming module	

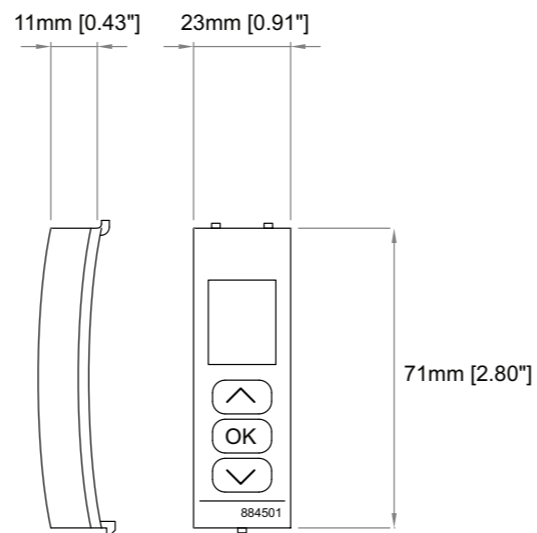
884114 and 884116 Dimensions



Input Specifications

Inputs			
Current Input			
Programmable Ranges	0 to 20 and 4 to 20 mA DC		
Measurement Range	-1 to 25 mA		
Input Resistance	Nom. 20 Ω + PTC 50 Ω		
Sensor Error Detection	4 to 20 loop break, ≤3.6mA; ≥21mA		
Voltage Input			
Programmable Ranges	0 to 1, 0.2 to 1, 0 to 5, 1 to 5, 0 to 10, and 2 to 10 VDC		
Measurement Range	-20 mV to 12 VDC		
Input Resistance	Nom. 10 MΩ		
Thermocouple Inputs			
Thermocouple Type	B, E, J, K, L, N, R, S, T, U, W3, W5, and LR		
Cold Junction Compensation	Via internally mounted sensor < ± 2.0°C [\pm 3.6°F]		
Sensor Error Detection	Sensor break, >750kΩhm/(1.25V)		
Sensor Error Current	When detecting 2μA, otherwise 0 μA		
Type	Min. value	Max. value	Standard
B	+400°C [+752°F]	+1820°C [+3308°F]	IEC 60584-1
E	-100°C [-148°F]	+1000°C [+1832°F]	IEC 60584-1
J	-100°C [-148°F]	+1200°C [+2192°F]	IEC 60584-1
K	-180°C [-292°F]	+1372°C [+2502°F]	IEC 60584-1
L	-200°C [-328°F]	+900°C [+1652°F]	DIN 43710
N	-180°C [-292°F]	+1300°C [+2372°F]	IEC 60584-1
R	-50°C [-58°F]	+1760°C [+3200°F]	IEC 60584-1
S	-50°C [-58°F]	+1760°C [+3200°F]	IEC 60584-1
T	-200°C [-328°F]	+400°C [+752°F]	IEC 60584-1
U	-200°C [-328°F]	+600°C [+1112°F]	DIN 43710
W3	0°C [+32°F]	+2300°C [+4172°F]	ASTM E988-90
W5	0°C [+32°F]	+2300°C [+4172°F]	ASTM E988-90
LR	-200°C [-328°F]	+800°C [+1472°F]	GOST 3044-84
RTD, Linear Resistance, Potentiometer Inputs			
RTD Types	Pt10, Pt20, Pt50, Pt100, Pt200, Pt250, Pt300, Pt400, Pt500, Pt1000, Ni50, Ni100, Ni120, Ni1000, Cu10, Cu20, Cu50, and Cu100		
Cable Resistance per Wire	RTD, 50 Ω max		
Sensor Current	RTD, Nom. 0.2 mA		
Sensor Error Detection	Sensor break >15kΩhm Sensor short <15 Ωhm (N/A for Pt10, Pt20, Pt50)		
Input type	Min. value	Max. value	Standard
Pt100	-200°C [-328°F]	+850°C [+1562°F]	IEC60751
Ni100	-60°C [-76°F]	+250°C [+482°F]	DIN 43760
Linear Resistance	0 Ω	10 kΩ	-
Potentiometer	10 Ω	100 kΩ	-

884501 Dimensions

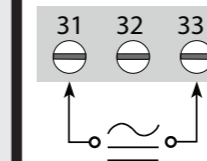


Output Specifications

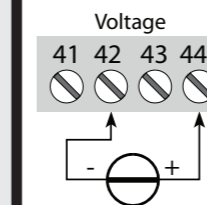
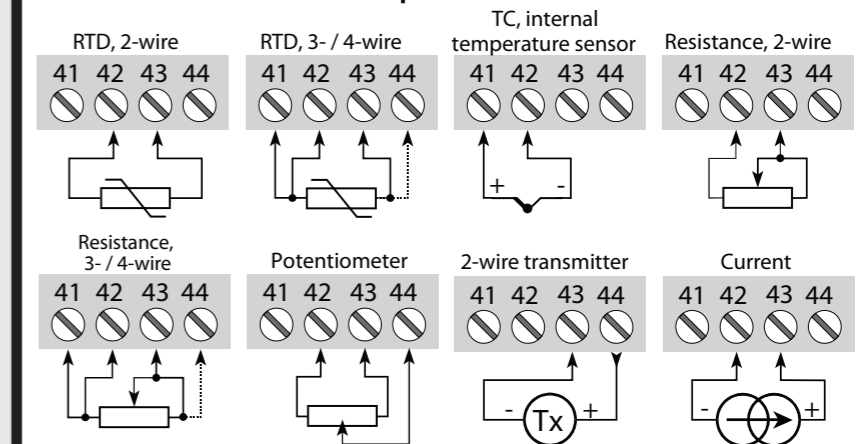
Outputs	
Analog Output - Current	
Signal Range	0 to 20 mA
Programmable Signal Range	0 to 20, 4 to 20, 20 to 0, and 20 to 4 mA
Load Resistance	800 Ω max, 20mA, 16 VDC
Load Stability	0.01% of span, 100 Ω load
Output state on sensor error detection	0 / 3.5 mA / 23 mA / none selectable
Output Limitation	For 4 to 20 and 20 to 4 mA signals: 3.8 to 20.5 mA For 0 to 20 and 20 to 0 mA signals: 0 to 20.5 mA
Current Limit	≤28 mA
Analog Output - Voltage	
Signal Range (Span)	0 to 10 VDC
Programmable Signal Ranges	0 to 1, 0.2 to 1, 0 to 10, 0 to 5, 1 to 5, 2 to 10, 1 to 0, 1 to 0.2, 5 to 0, 5 to 1, 10 to 0, and 10 to 2 V
Load	500 k Ω min
Relay outputs (884116 only)	
Relay Functions	Setpoint, Window, Sensor Error, Power and Off
Hysteresis	0.0 to 100.0% (1 to 2999 display counts)
On and Off Delay	0 to 3600 sec
Relay state on sensor error detection	Break / Make / Hold selectable
Relay contact ratings	250 Vrms max; 2 A AC or 1 A DC max; 500 VA max

Wiring Diagrams

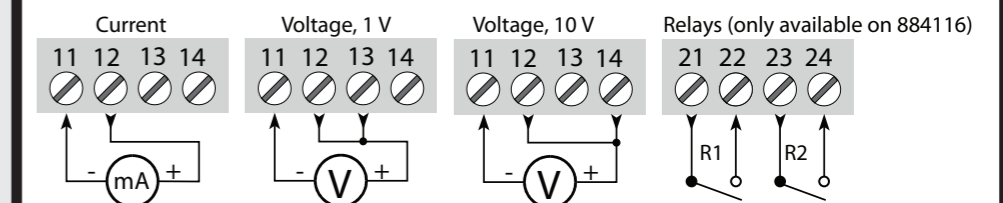
Supply:



Inputs:



Outputs:



DA-4

4 CHANNEL DIMMING AMPLIFIER For Lighting Controller

APPLICATIONS

- Churches
- Offices
- Retail Outlets
- Schools
- Restaurants
- Warehouses



PROJECT	
LOCATION	

FEATURES

- 0-10V buffer amplifier with current sinking capability designed for 0-10V electronic dimming ballasts
- 50mA sink current per channel
- Independent four channel outputs
- Override dip - switches for full ON (maximum brightness) ballast test mode
- 24VDC Power LED indicator
- Voltage supply on both sides of DA-4 unit
- Capable of dimming up to 50 ballasts per channel
- Individual screw connection
- 2 year warranty

DESCRIPTION

The PLC DA-4 is a four channel dimming amplifier which works in conjunction with our small, medium and large LP controllers. The DA-4 is used mainly for offices and warehouses that requires dimming of any fluorescent, electronic, 0-10V dimming ballasts and also HID electronic dimming ballasts.

The DA-4 has a bypass capability and can force the output to go high (10V). Each channel is configured to automatically follow the input voltage. The DA-4 can be mounted on a DIN rail in any orientation. It is equipped with a DIN rail release for easy installation.

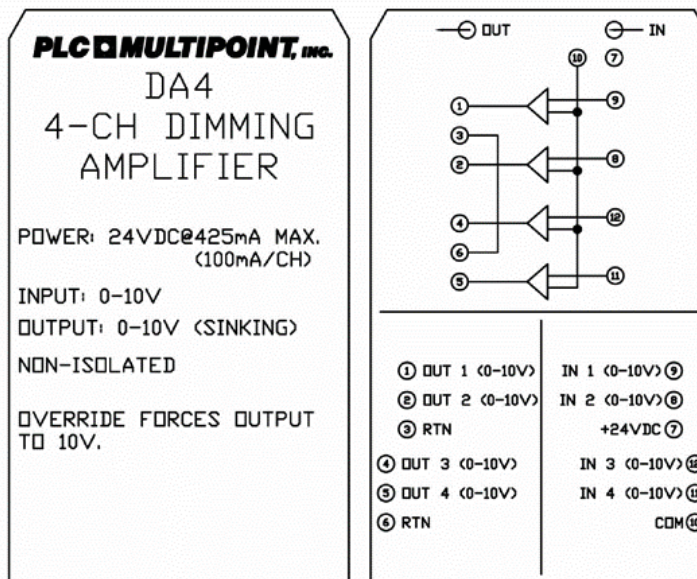
The DA-4 receives a 0-10VDC input voltage that is converted to a maximum output source current of 50mA per channel. Four DA-4 modules are suited for our small and medium LP controller. Six DA-4 modules are the maximum capacity for our large LP controller.

The DA-4 has a green indicator LED that signals that the dimming amplifier is powered on. Typically the DA-4 is used with our lighting control panels that have been specifically designed for 0-10V electronic dimming applications. See back side for a schematic of the connections.

TECHNICAL DATA - DA-4

Operating Voltage	24VDC
Input Voltage:	0-10 VDC
Input Resistance:	> = 500k Ohms
Maximum input current:	< 1mA
Output Voltage:	0-10V
Max output source current:	50mA per channel
Configuration:	Independent four channel outputs
Wire size:	22AWG
Operating Temperature Range:	-20° to + 55°C

ONE-LINE DIAGRAM





Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

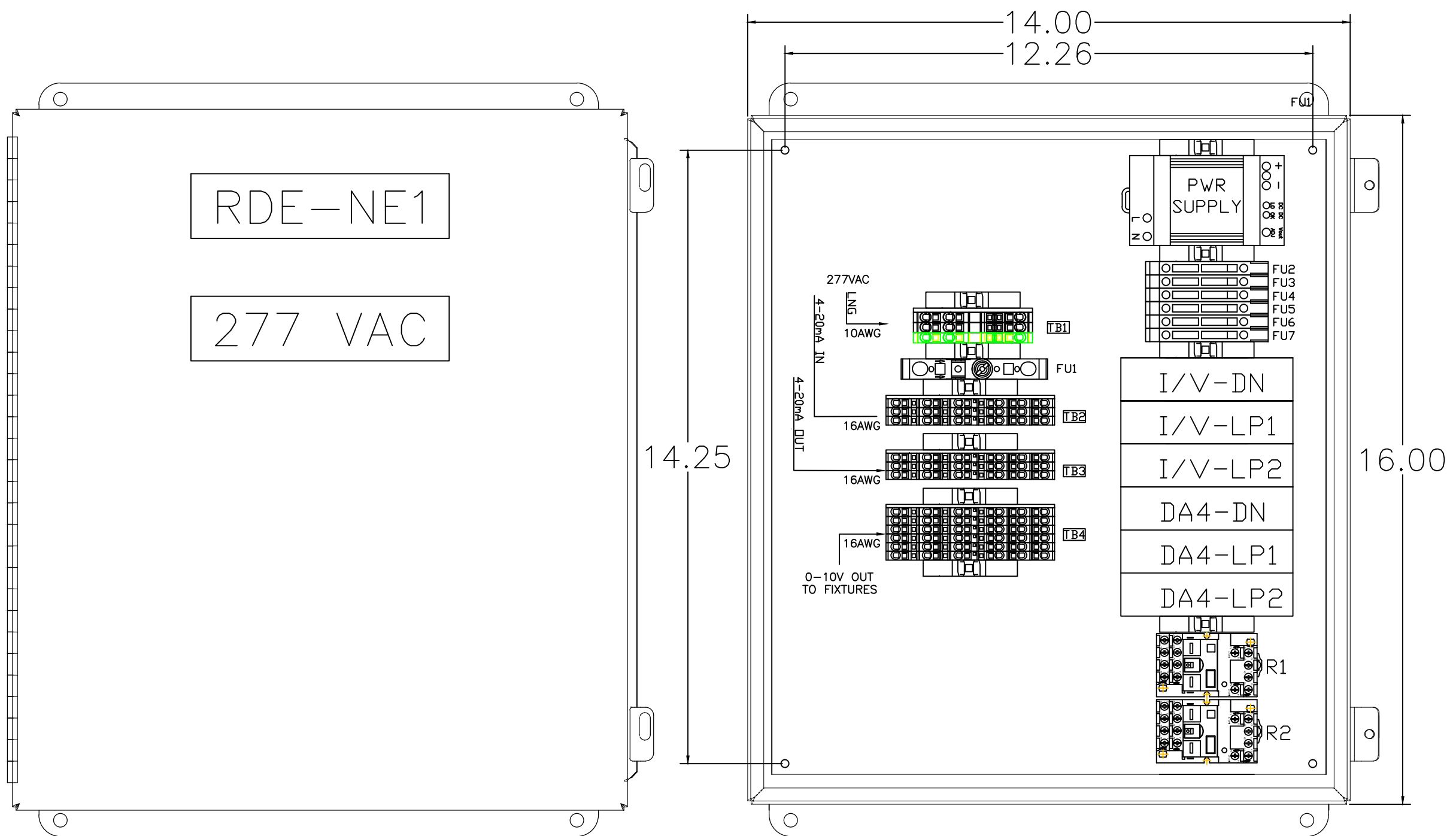
DRAWING INDEX

LYTLE TUNNEL
RDE DIMMING CONTROL CABINETS
T57-6 TUNNEL LIGHTING CONTROL
SYSTEM DRAWING INDEX

<u>SHEET NO.</u>	<u>DRAWING TITLE</u>	<u>DRAWING TYPE</u>	<u>DRAWING NO.</u>	<u>REV NO.</u>
1	RDE DIMMING CC	DRAWING INDEX	300-16T17630I1	REV 1.1
2	RDE DIMMING CC-RDE 3	ASSEMBLY DRAWING	300-16T17630A1	REV 1.1
3	RDE DIMMING CC-RDE 2	ASSEMBLY DRAWING	300-16T17630A2	REV 1.1
4	RDE DIMMING CC-RDE-XX1	WIRING SCHEMATIC	300-16T17630E1	REV 1.1
5	RDE DIMMING CC-RDE-XX2	WIRING SCHEMATIC	300-16T17630E2	REV 1.1
6	RDE DIMMING CC-RDE-XX3	WIRING SCHEMATIC	300-16T17630E3	REV 1.1
7	RDE DIMMING CC-RDE-XX4	WIRING SCHEMATIC	300-16T17630E4	REV 1.1
8	RDE DIMMING SYSTEM NB EW	1-LINE DIAGRAM	300-16T17630B1	REV 1.1
9	RDE DIMMING SYSTEM NB WW	1-LINE DIAGRAM	300-16T17630B2	REV 1.1
10	RDE DIMMING SYSTEM SB EW	1-LINE DIAGRAM	300-16T17630B3	REV 1.1
11	RDE DIMMING SYSTEM SB WW	1-LINE DIAGRAM	300-16T17630B4	REV 1.1
12	RDE DIMMING SYSTEM SR EW	1-LINE DIAGRAM	300-16T17630B5	REV 1.1
13	RDE DIMMING SYSTEM SR WW	1-LINE DIAGRAM	300-16T17630B6	REV 1.1
14	RDE DIMMING SYSTEM	WIRING DETAIL DWG	300-16T17630B7	REV 1.1
15	RDE DIMMING SYSTEM	WIRING DETAIL DWG	300-16T17630B8	REV 1.1

PLC Transportation	PLC TRANSPORTATION	PLC TRANSPORTATION.COM	PLC TRANSPORTATION	PLC TRANSPORTATION	PLC TRANSPORTATION
Control Systems A Division of PLC Multipoint	3101-11th STREET S.W. #F EVERETT, WA 98204	PH:425/353-7552 FAX:425/353-3353			
NO.:	REVISION/ISSUE:	DATE:	NO.:	REVISION/ISSUE:	DATE:
DWG. NO:	300-16T17630I1	DATE:	5/10/2017	SHEET:	1/14
LYTLE TUNNEL	RDE	REMOTE DIMMING ENCLOSURE	DRAWING INDEX	REV	1.1
SIZE: A	SCALE: NONE	DRAFTED: S. HOULE	CHECKED BY:		

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
PLC Transportation <i>Control Systems</i> A Division of PLC Multipoint			3101-111th STREET S.W. #F EVERETT, WA 98204 PH:425/353-7552 FAX:425/353-3353 PLCTRANSPORTATION.COM		
DWG. NO:	DATE:	DWG. NO:	DATE:	DWG. NO:	DATE:
300-16T17630A1	5/10/2017	300-16T17630A1	5/10/2017	300-16T17630A1	5/10/2017
LYTLE TUNNEL RDE REMOTE DIMMING ENCLOSURE ASSEMBLY DWG		S. HOULE			
SIZE:	SCALE:	DRAWN:	CHECKED BY:		
A	NONE	S. HOULE			

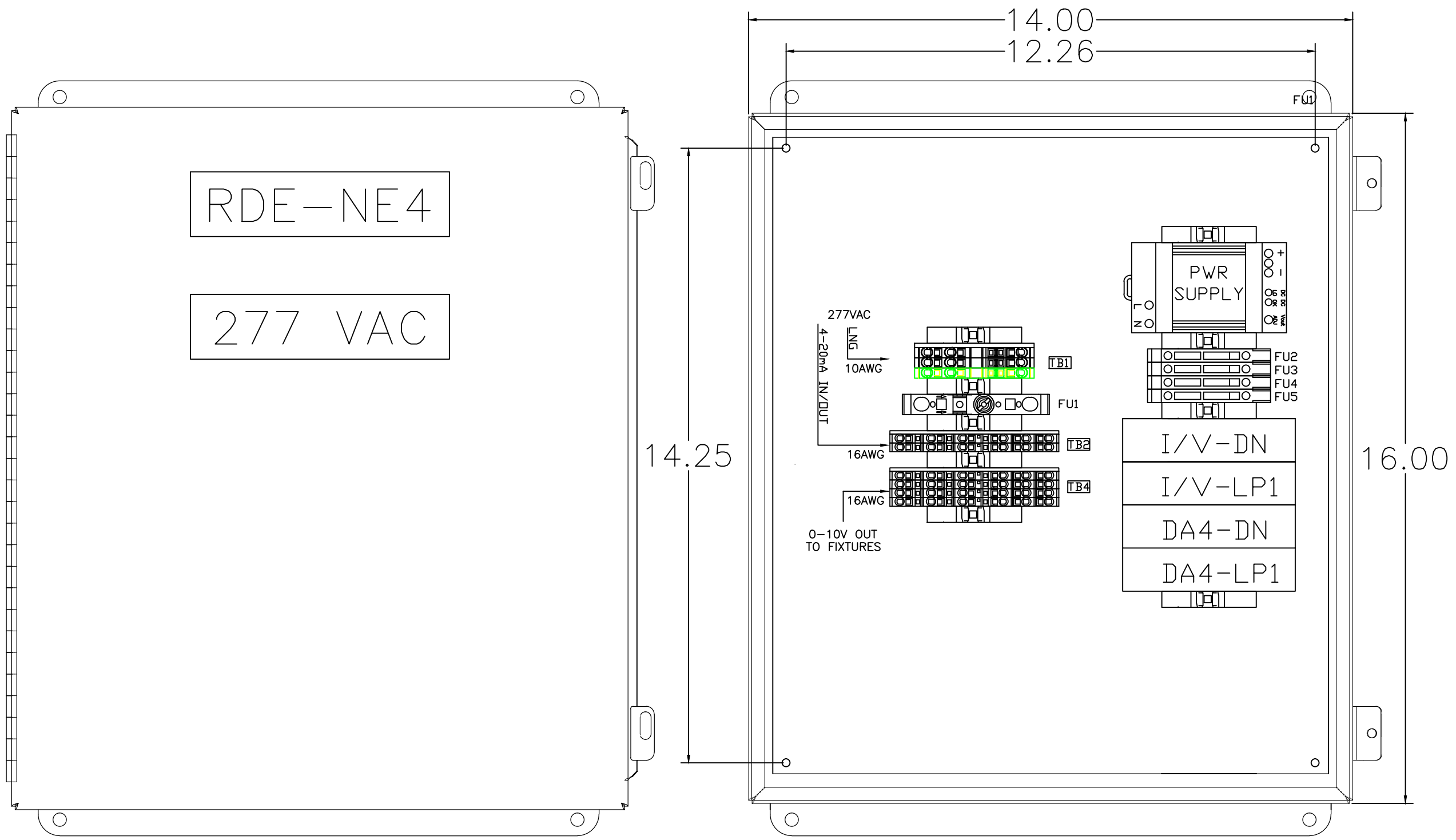


EXTERIOR VIEW
 16"H x 14"W x 6"D

INTERIOR VIEW

TYPICAL OF 18 RDE-3 DIMMING BOXES:
 RDE-NE1, RDE-NE2, RDE-NE3, RDE-NW1,
 RDE-NW2, RDE-NW3, RDE-SE1, RDE-SE2,
 RDE-SE3, RDE-SW1, RDE-SW2, RDE-SW3,
 RDE-SRE1, RDE-SRE2, RDE-SRE3, RDE-SRW1,
 RDE-SRW2, & RDE-SRW3.

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630A2	5/10/2017	3/15	1.1
PLC Transportation <i>Control Systems A Division of PLC Multipoint</i>						3101-111th STREET S.W. #F EVERETT, WA 98204 PH:425/353-7552 FAX:425/353-3353 PLCTRANSPORTATION.COM			
LYTLE TUNNEL RDE REMOTE DIMMING ENCLOSURE ASSEMBLY DWG						SIZE: A SCALE: NONE DRAFTED: S. HOULE CHECKED BY:			



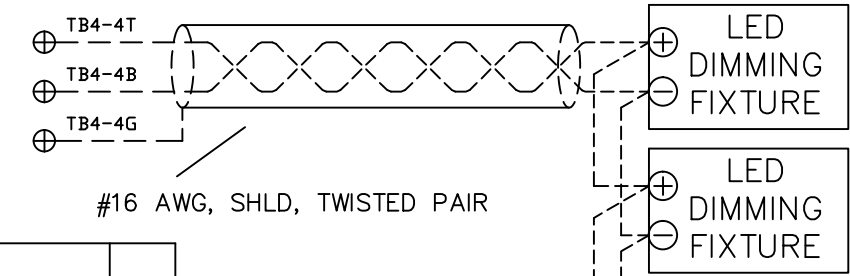
EXTERIOR VIEW
 16"H x 14"W x 6"D

INTERIOR VIEW

TYPICAL OF 6 RDE-2 DIMMING BOXES:
 RDE-NE4, RDE-NW4, RDE-SE4, RDE-SW4,
 RDE-SRE4, & RDE-SRW4.

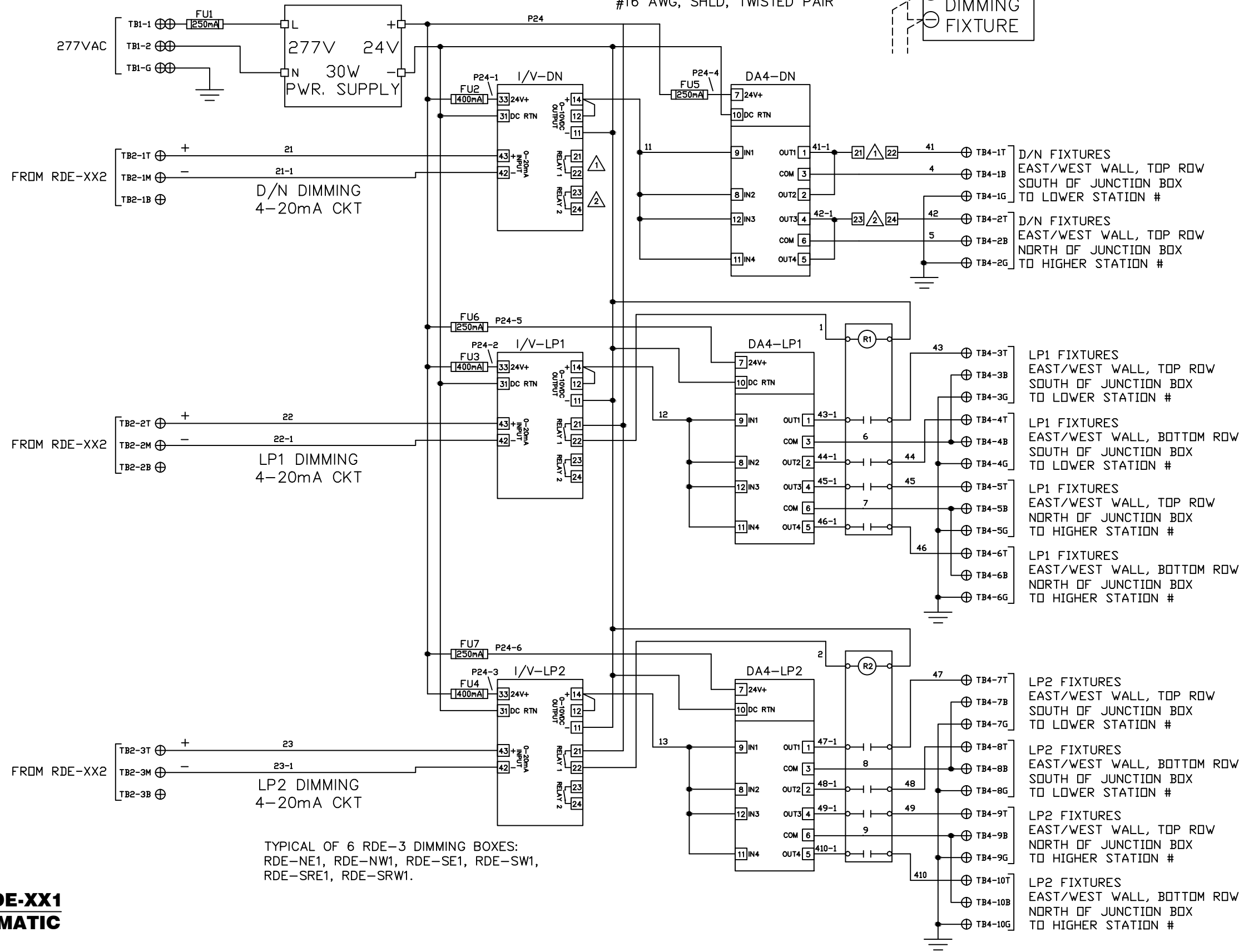
NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630E1	5/10/2017	4/15	1.1

TYPICAL FIELD CONNECTION



NOTES:

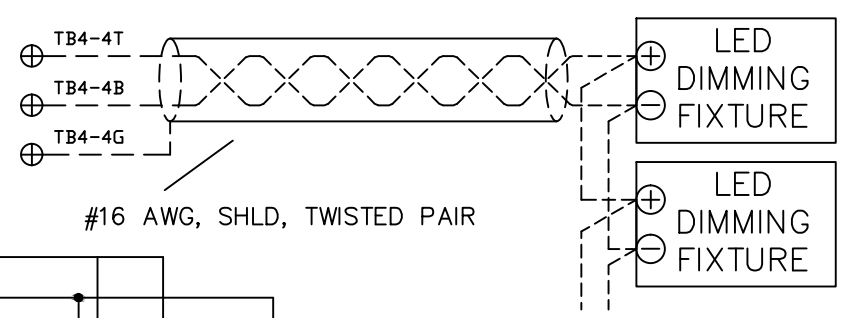
⚠ ALL DIMMING CIRCUITS PASS THROUGH DRY CONTACT RELAY ON SIGNAL CONVERTER TO FAIL DIMMING LEVEL TO 100% IN CASE OF DIMMING SIGNAL FAILURE.



TYPICAL OF 6 RDE-3 DIMMING BOXES:
RDE-NE1, RDE-NW1, RDE-SE1, RDE-SW1,
RDE-SRE1, RDE-SRW1.

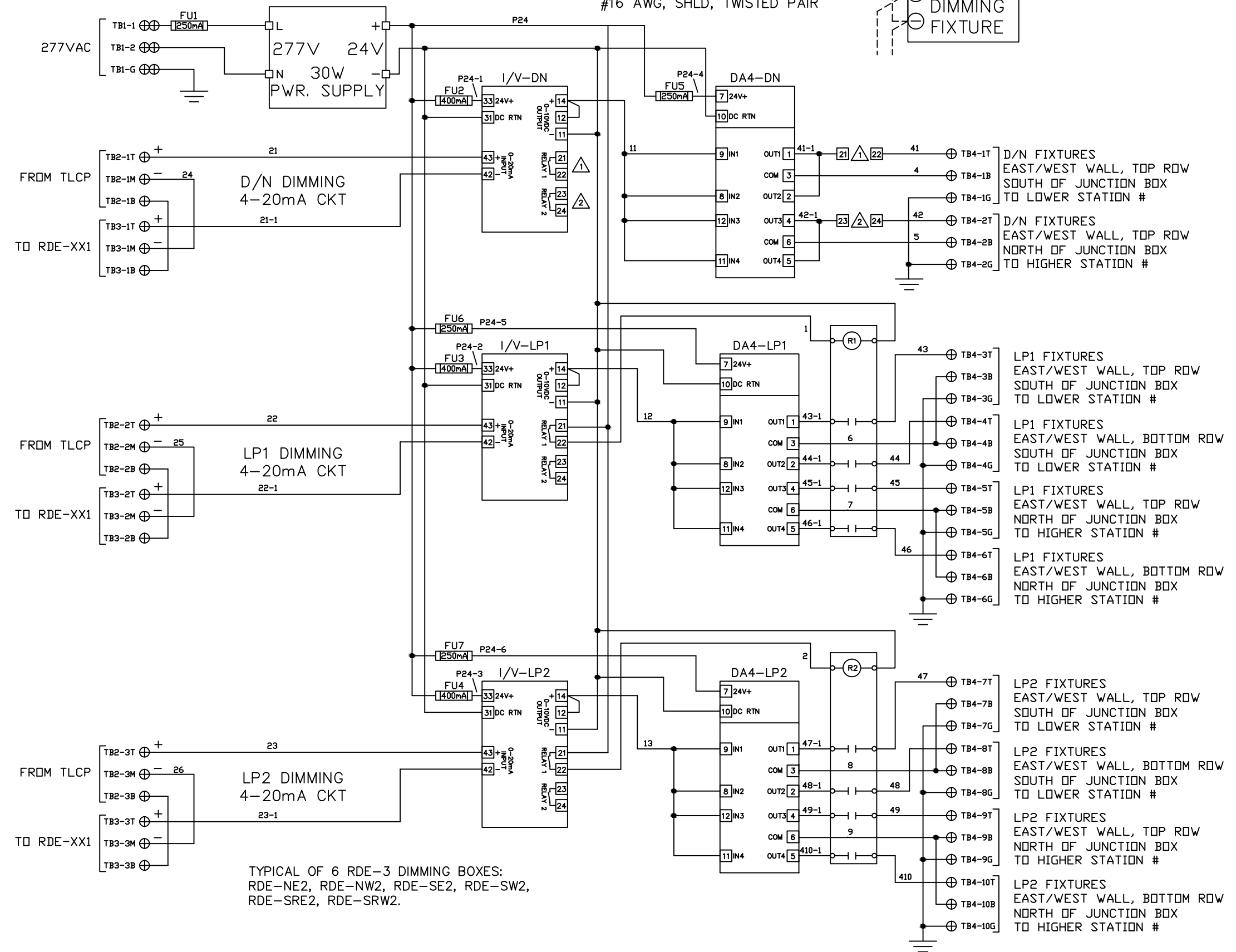
NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630E2	5/10/2017	5/15	1.1

TYPICAL FIELD CONNECTION



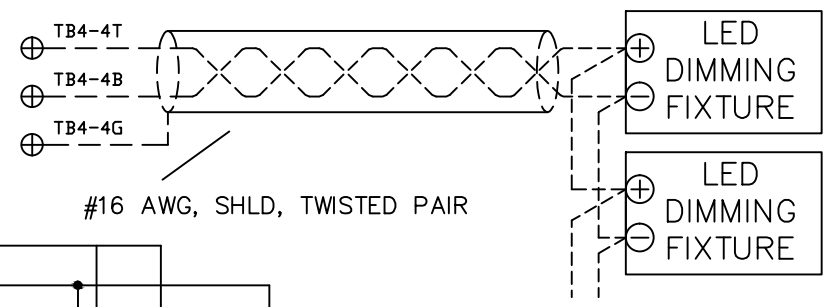
NOTES:

⚠ ALL DIMMING CIRCUITS PASS THROUGH DRY CONTACT RELAY ON SIGNAL CONVERTER TO FAIL DIMMING LEVEL TO 100% IN CASE OF DIMMING SIGNAL FAILURE.

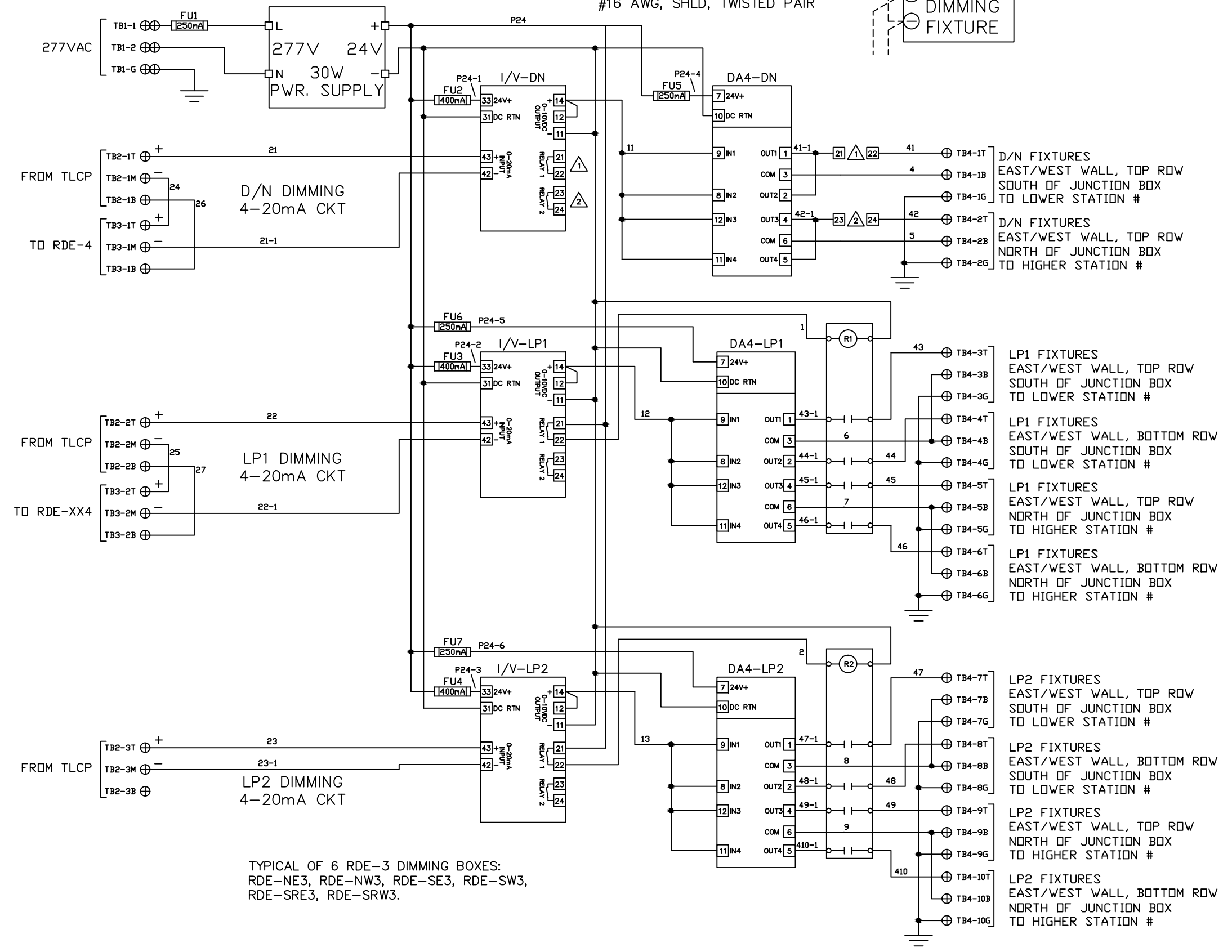


NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
DWG. NO:	300-16T17630E3	DATE:	5/10/2017	REV	6/12
LYTLE TUNNEL					1.1

TYPICAL FIELD CONNECTION



NOTES:
 ⚠ ALL DIMMING CIRCUITS PASS THROUGH DRY CONTACT RELAY ON SIGNAL CONVERTER TO FAIL DIMMING LEVEL TO 100% IN CASE OF DIMMING SIGNAL FAILURE.



TYPICAL OF 6 RDE-3 DIMMING BOXES:
 RDE-NE3, RDE-NW3, RDE-SE3, RDE-SW3,
 RDE-SRE3, RDE-SRW3.

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
DWG. NO:	300-16T17630E4	DATE:	5/10/2017	6/12	REV
				7/15	1.1

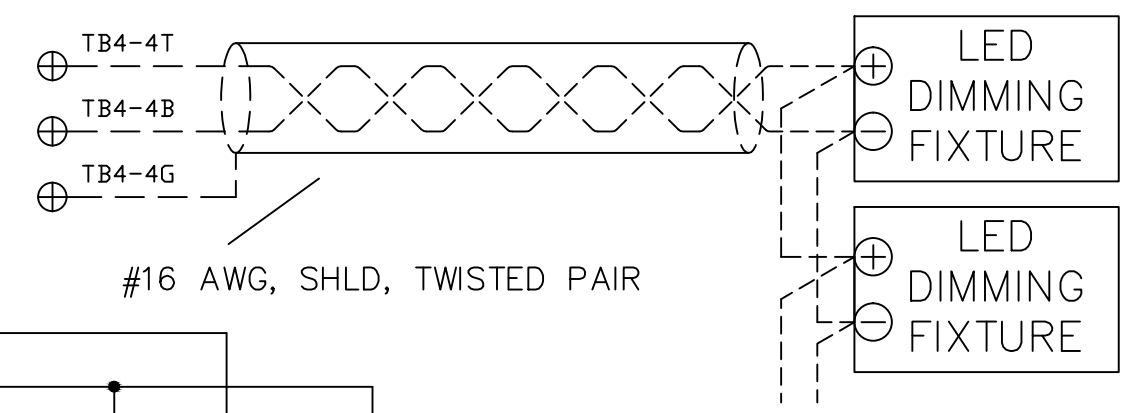
PLC Transportation
 A Division of PLC Multipoint

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 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

LYTLE TUNNEL
 RDE
 REMOTE DIMMING ENCLOSURE
 WIRING SCHEMATIC

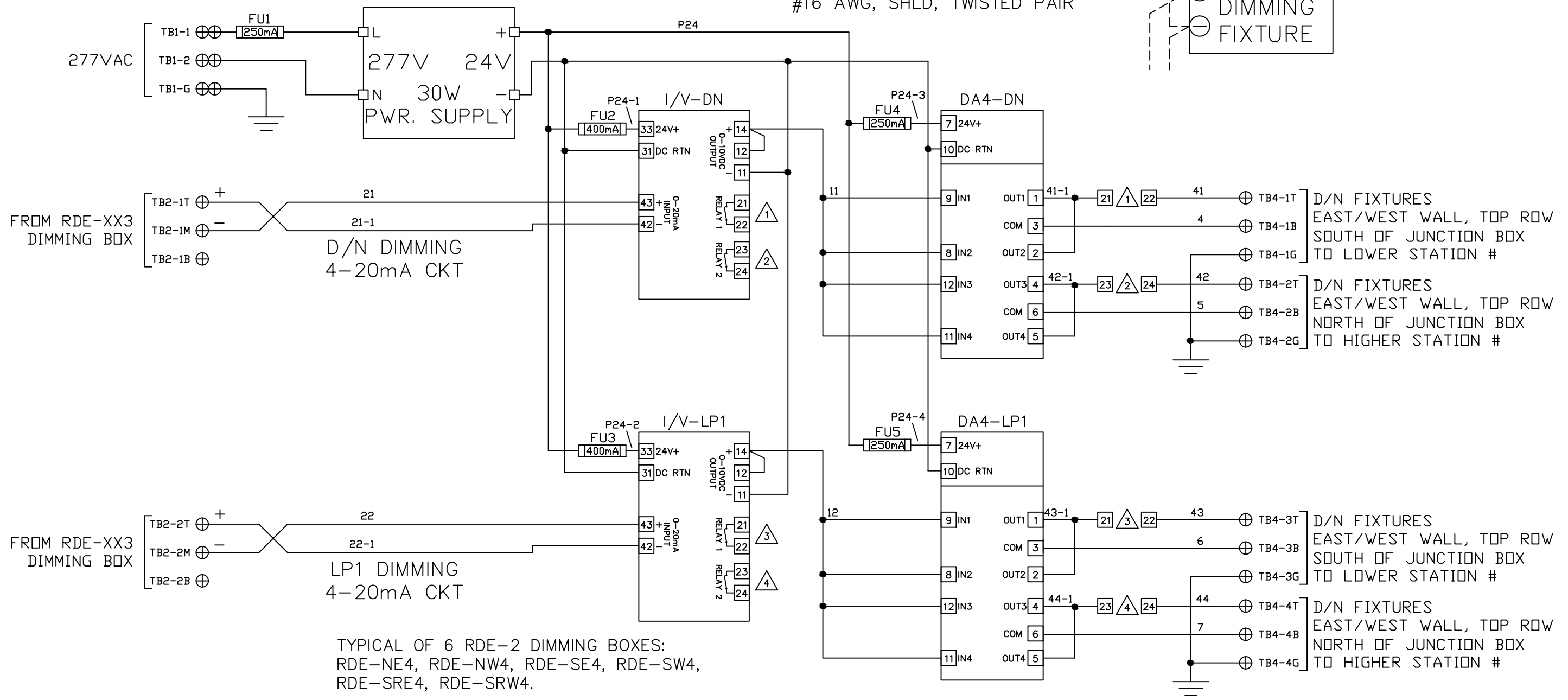
SIZE: A
 SCALE: NONE
 DRAFTED: S. HOULE
 CHECKED BY:

TYPICAL FIELD CONNECTION



NOTES:

⚠ ALL DIMMING CIRCUITS PASS THROUGH DRY CONTACT RELAY ON SIGNAL CONVERTER TO FAIL DIMMING LEVEL TO 100% IN CASE OF DIMMING SIGNAL FAILURE.



TYPICAL OF 6 RDE-2 DIMMING BOXES:
 RDE-NE4, RDE-NW4, RDE-SE4, RDE-SW4,
 RDE-SRE4, RDE-SRW4.

NO.

REVISION/ISSUE:

DATE:

NO.

REVISION/ISSUE:

DATE:

DWG. NO:

300-16T17630B1

DATE:

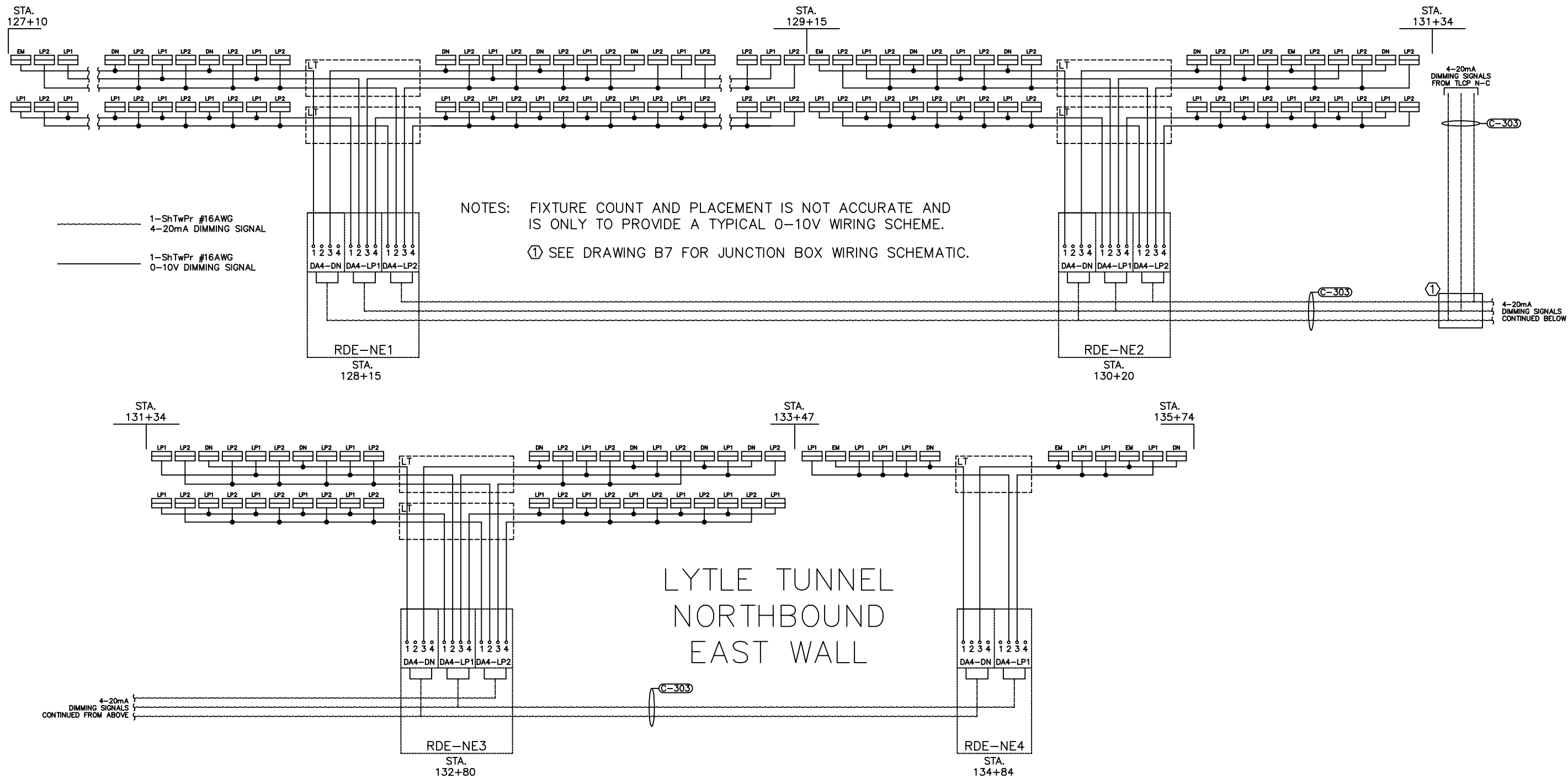
5/10/2017

SHEET:

8/15

REV

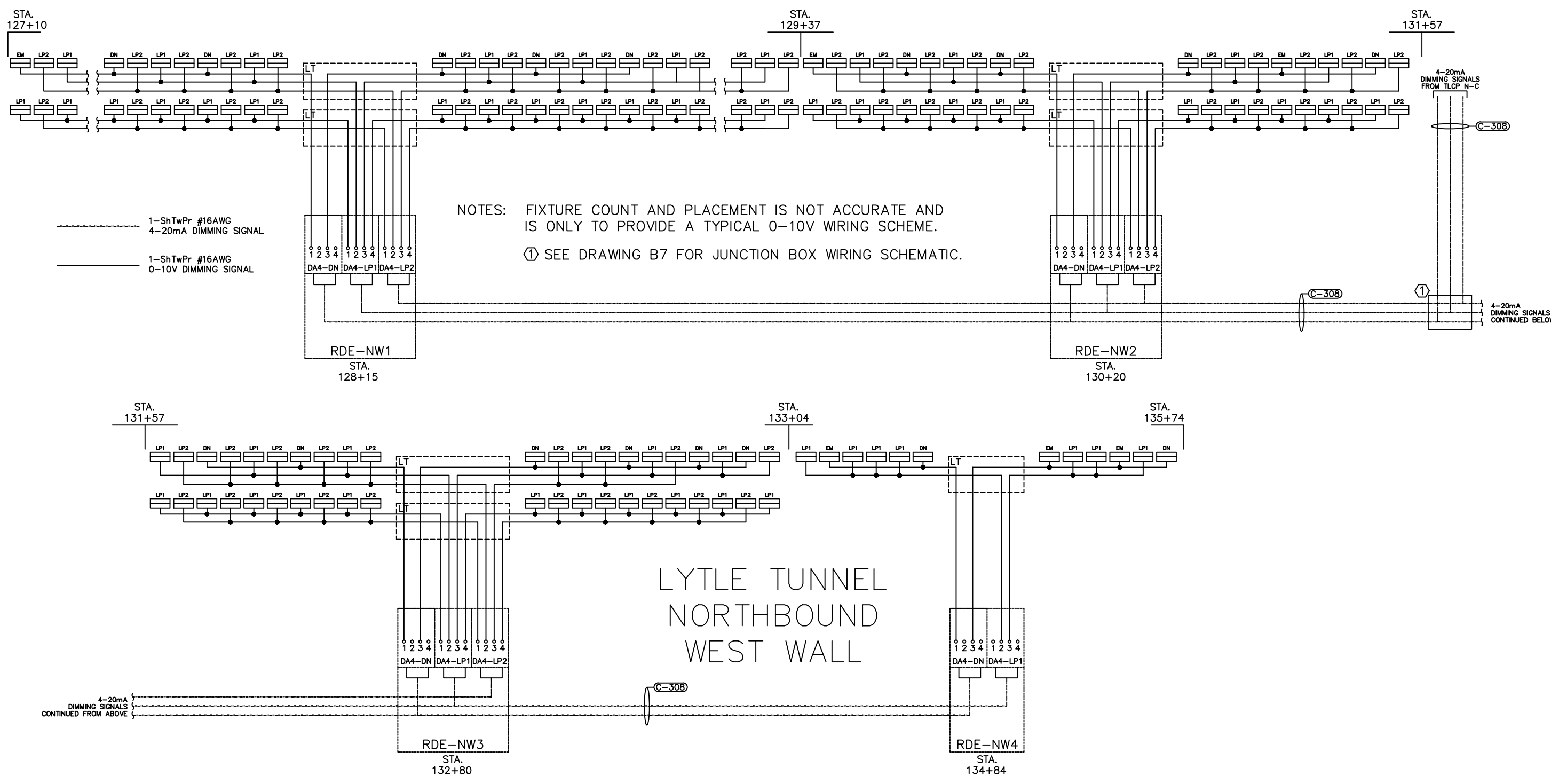
1.1



1
B1 RDE DIMMING SYSTEM
1-LINE DIAGRAM

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630B2	5/10/2017	9/15	1.1

LYTLE TUNNEL	DATE:
RDE	
REMOTE DIMMING SYSTEM	
1-LINE DIAGRAM	
SIZE: A	
SCALE: NONE	
DRAWN: S. HOULE	
CHECKED BY:	

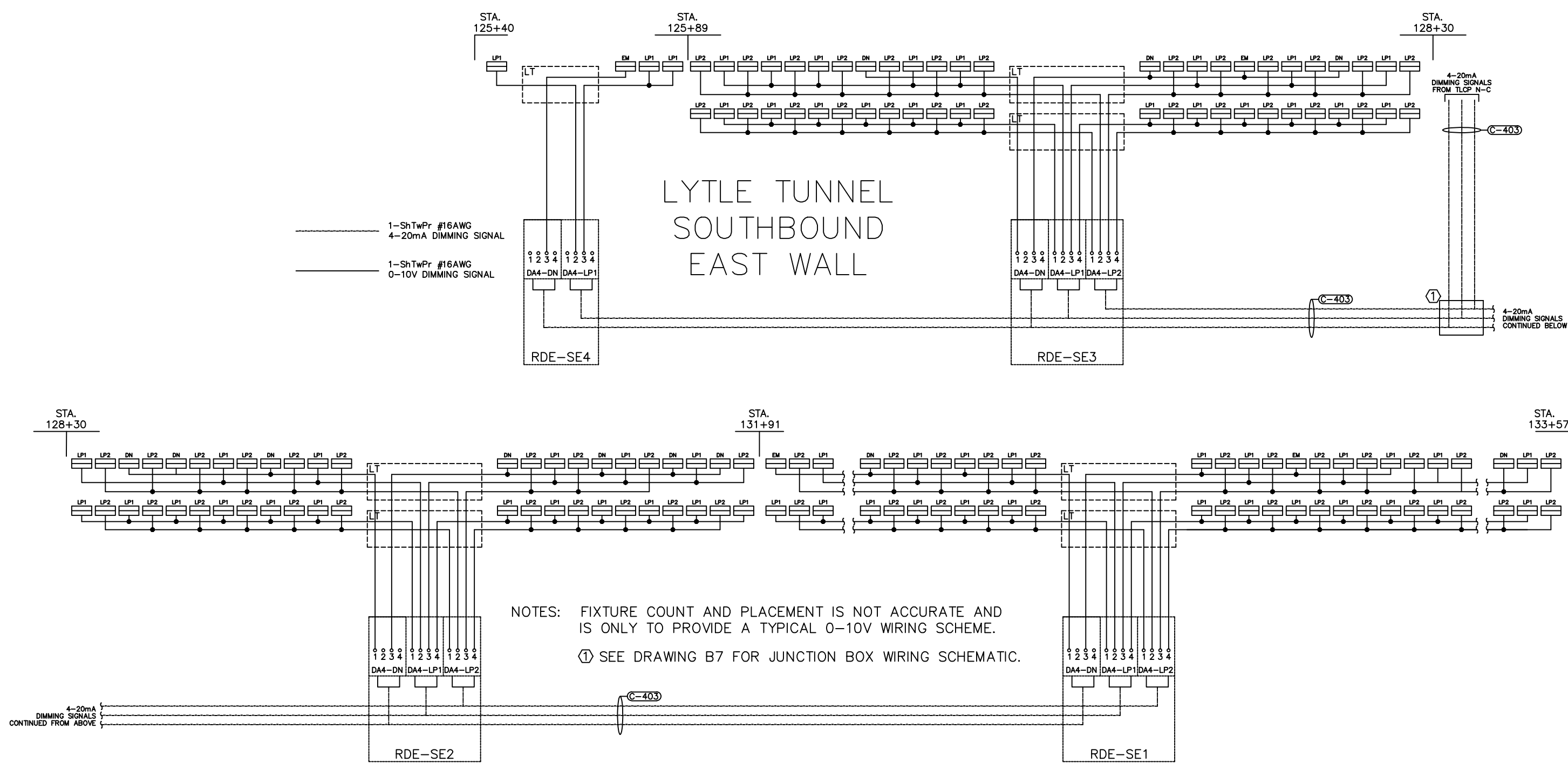


LYTLE TUNNEL
NORTHBOUND
WEST WALL

1
B2 **RDE DIMMING SYSTEM**
1-LINE DIAGRAM

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
DWG. NO:	300-16T17630B3	DATE:	5/10/2017	SHEET:	10/15
REV					1.1

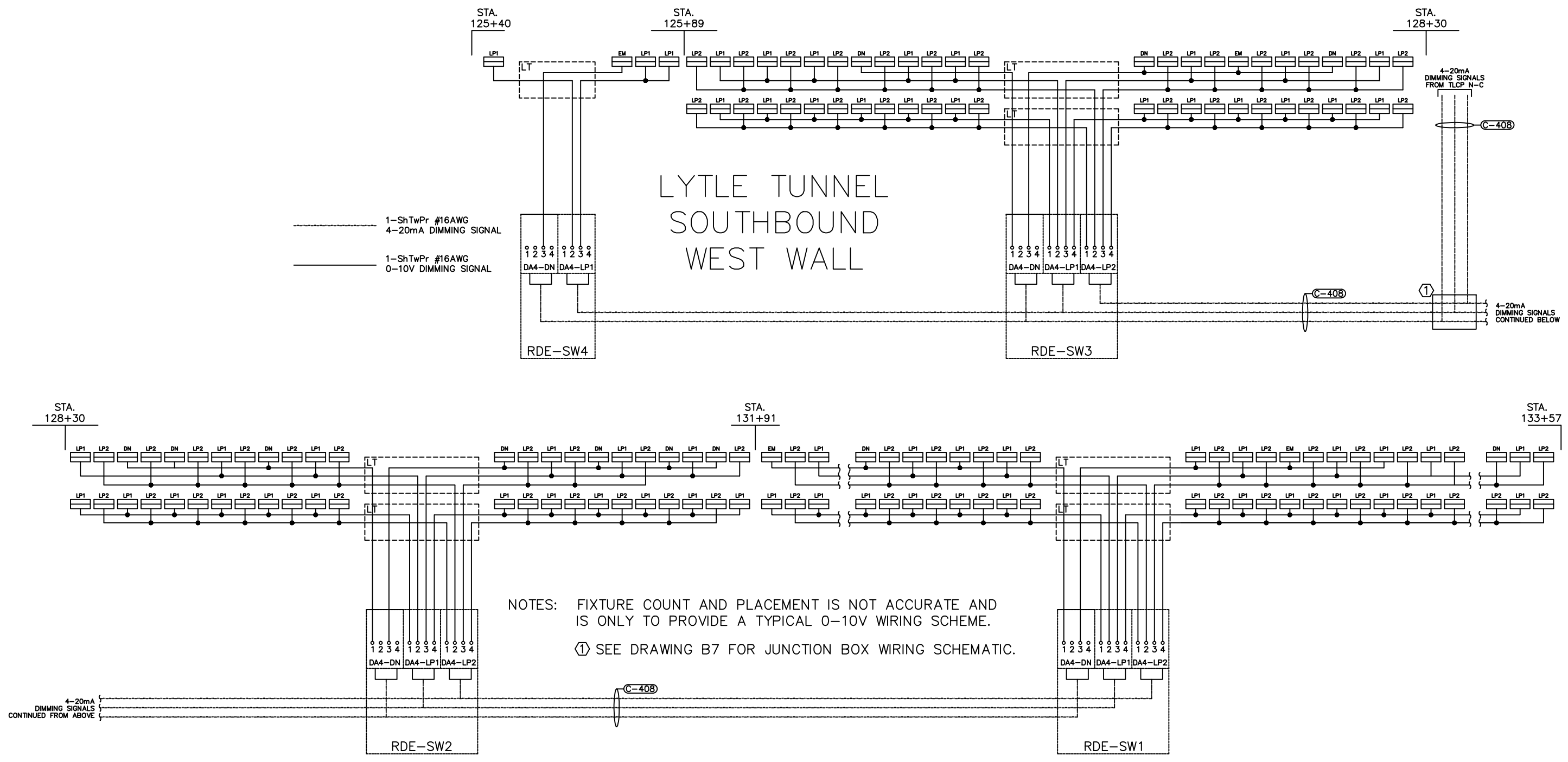
LYTLE TUNNEL	DATE:
RDE	
REMOTE DIMMING SYSTEM	
1-LINE DIAGRAM	
SIZE: A	DRAWN: S. HOULE
SCALE: NONE	CHECKED BY:



1
B3 RDE DIMMING SYSTEM
1-LINE DIAGRAM

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630B4	5/10/2017	11/15	1.1

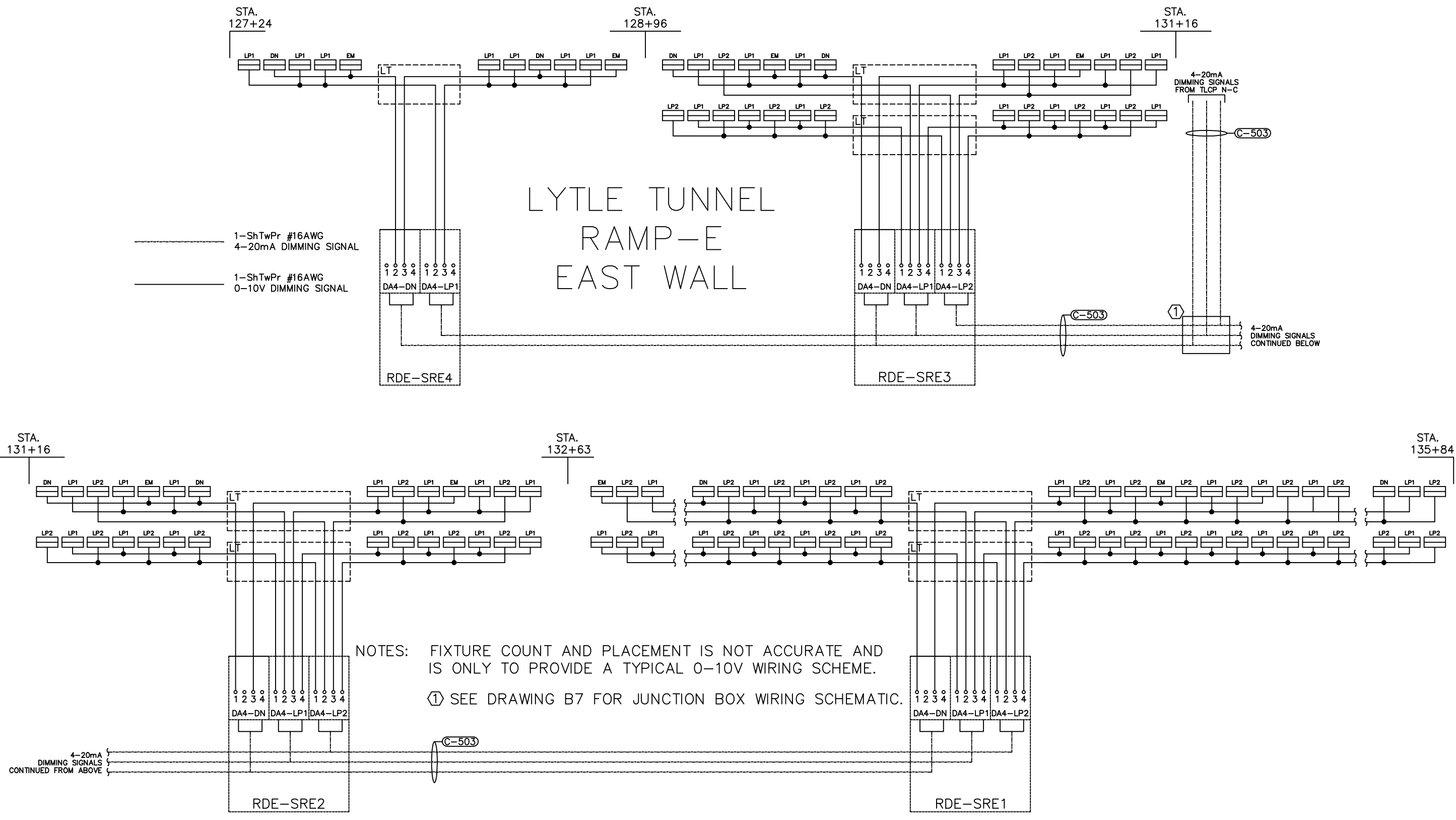
LYTLE TUNNEL	DATE:
RDE	
REMOTE DIMMING SYSTEM	
1-LINE DIAGRAM	
SIZE: A	
SCALE: NONE	
DRAWN: S. HOULE	
CHECKED BY:	



1
B4 RDE DIMMING SYSTEM
1-LINE DIAGRAM

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630B5	5/10/2017	12/15	1.1

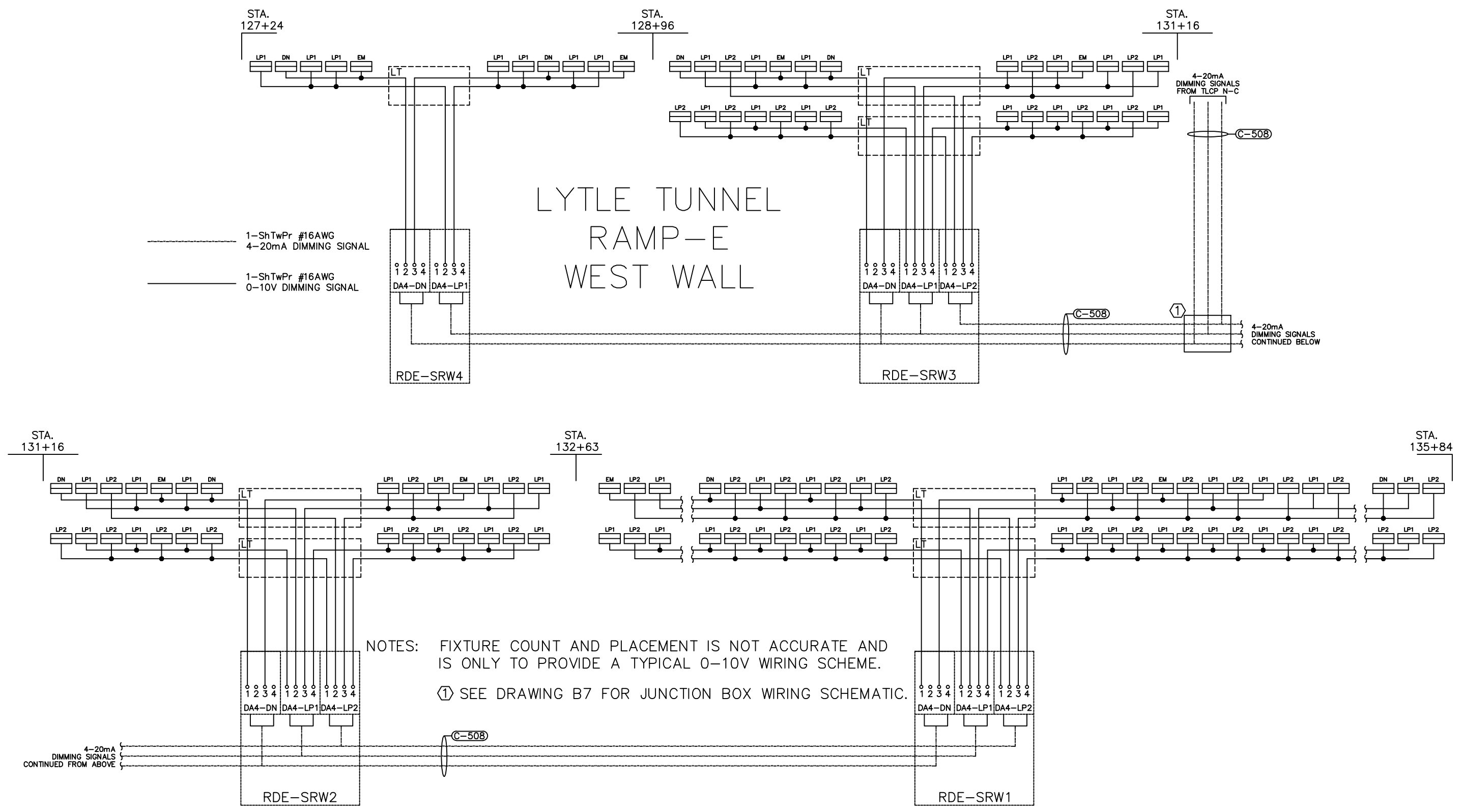
LYTLE TUNNEL	DATE:
RDE	
REMOTE DIMMING SYSTEM	
1-LINE DIAGRAM	
SIZE: A	
SCALE: NONE	
DRAWN: S. HOULE	
CHECKED BY:	



1
B5 RDE DIMMING SYSTEM
1-LINE DIAGRAM

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
DWG. NO:	300-16T17630B6	DATE:	5/10/2017	SHEET:	13/15
REV					1.1

LYTLE TUNNEL	SIZE: A	SCALE: NONE	DRAWN: S. HOULE	CHECKED BY:
RDE REMOTE DIMMING SYSTEM				
1-LINE DIAGRAM				



1 RDE DIMMING SYSTEM
B6 1-LINE DIAGRAM

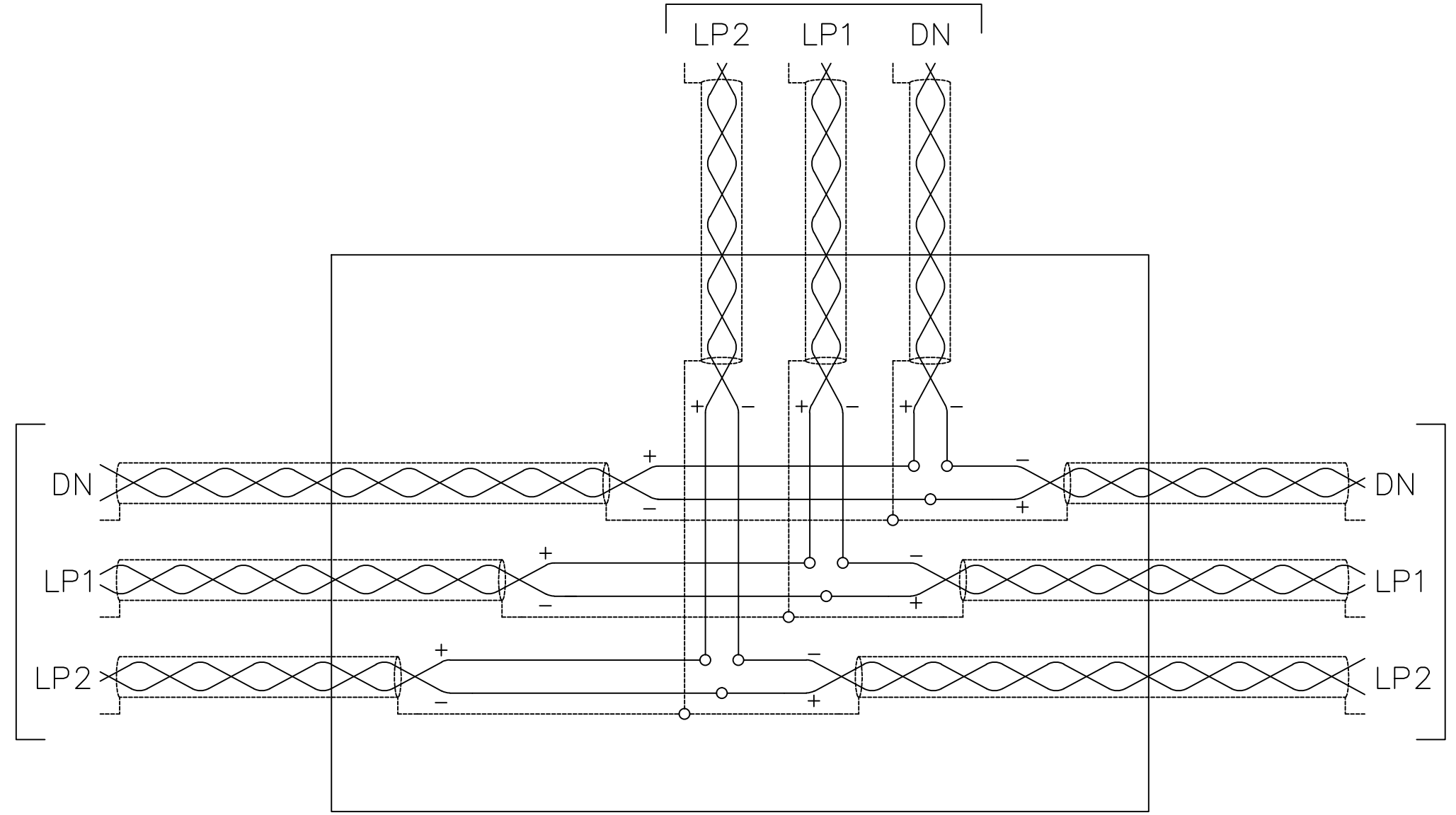
NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						300-16T17630B7	5/10/2017	14/15	1.1

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LYTLE TUNNEL	DRAFTED:	CHECKED BY:
RDE	S. HOULE	
REMOTE DIMMING SYSTEM		
WIRING DETAIL DRAWING		
SIZE: A	SCALE: NONE	

4-20mA
 DIMMING SIGNALS
 FROM TLCP X-C



4-20mA
 DIMMING SIGNALS
 TO RDE-NX2
 OR
 TO RDE-SX3
 OR
 TO RDE-SRX3

4-20mA
 DIMMING SIGNALS
 TO RDE-NX3
 OR
 TO RDE-SX2
 OR
 TO RDE-SRX2

NO.

REVISION/ISSUE:

DATE:

NO.

REVISION/ISSUE:

DATE:

DWG. NO:

300-16T17630B8

DATE:

5/10/2017

SHEET:

15/15

REV

1.1

PLC Transportation

Control Systems A Division of PLC Multipoint

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EVERETT, WA 98204

PH:425/353-7552 FAX:425/353-3353

PLCTRANSPORTATION.COM

LYTLE TUNNEL

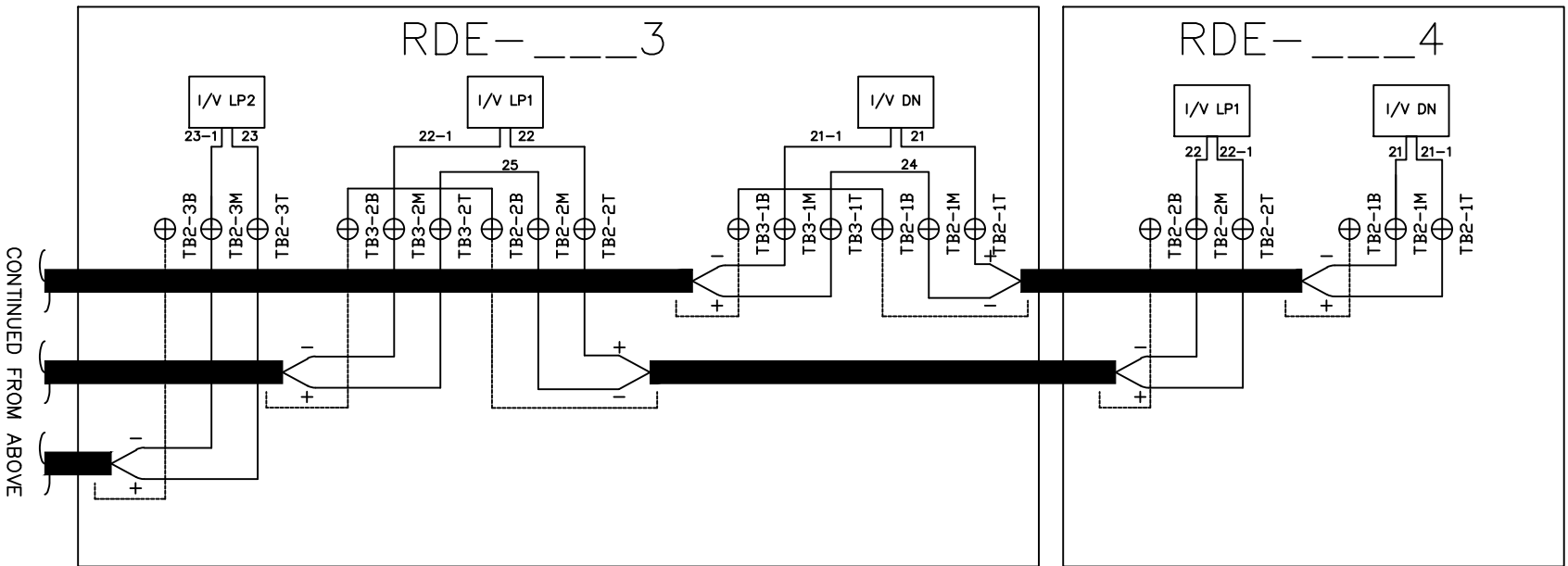
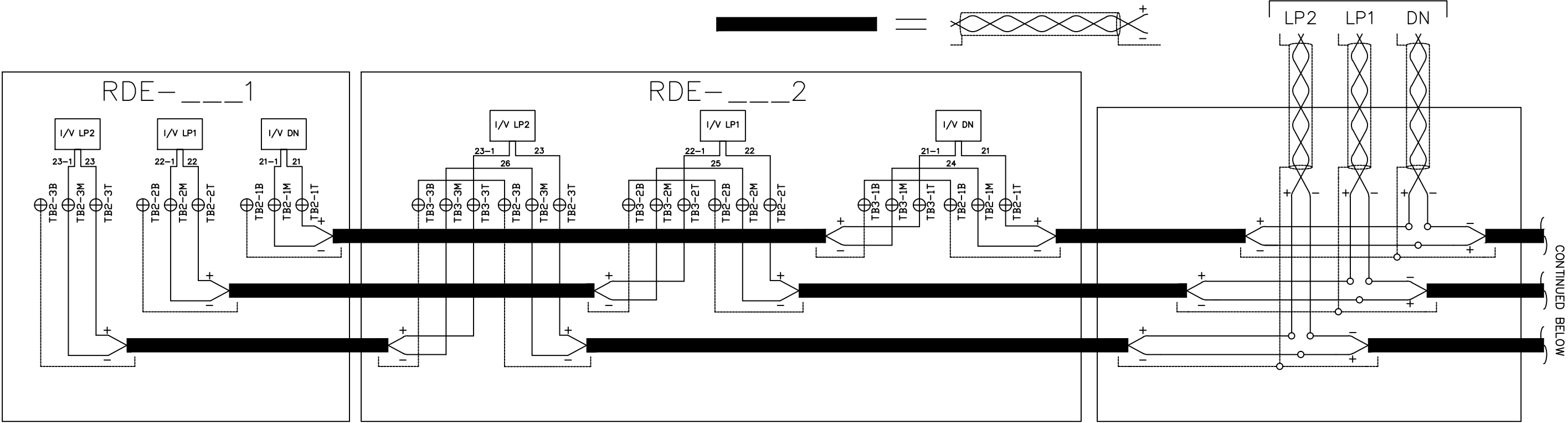
RDE
REMOTE DIMMING SYSTEM
WIRING DETAIL DRAWING

SIZE: A
SCALE: NONE
DRAFTED: S. HOULE

CHECKED BY:


4-20mA
DIMMING SIGNALS
FROM TLCP --C

LP2 LP1 DN



LYTLE TUNNEL
 TLCP N-C
 T57-6 TUNNEL LIGHTING CONTROL
 SYSTEM DRAWING INDEX

<u>SHEET NO.</u>	<u>DRAWING TITLE</u>	<u>DRAWING TYPE</u>	<u>DRAWING NO.</u>	<u>REV NO.</u>
1	TLCP N-C	DRAWING INDEX	100-16T17630I1	REV 1.0
2	TLCP N-C	ASSEMBLY DRAWING	100-16T17630A1	REV 1.0
3	TLCP N-C	ASSEMBLY DRAWING	100-16T17630A2	REV 1.0
4	TLUM N-C	HOUSING ASSEMBLY	100-16T17630A3	REV 1.0
5	TLUM N-C	SENSOR MOUNTING	100-16T17630A4	REV 1.0
6	TU-24	ASSEMBLY DRAWING	100-16T17630A5	REV 1.0
7	TLCP N-C, PWR DISTR	WIRING SCHEMATIC	100-16T17630E1	REV 1.0
8	TLCP N-C, AI	WIRING SCHEMATIC	100-16T17630E2	REV 1.0
9	TU-24	WIRING SCHEMATIC	100-16T17630E3	REV 1.0
10	TLCP N-C, AD	WIRING SCHEMATIC	100-16T17630E4	REV 1.0
11	TLCP N-C, DI 1/2	WIRING SCHEMATIC	100-16T17630E5	REV 1.0
12	TLCP N-C, DI 2/2	WIRING SCHEMATIC	100-16T17630E6	REV 1.0
13	TLCP N-C, DO 1/2	WIRING SCHEMATIC	100-16T17630E7	REV 1.0
14	TLCP N-C, DO 2/2	WIRING SCHEMATIC	100-16T17630E8	REV 1.0
15	TLCP N-C, E-NET COMM	WIRING SCHEMATIC	100-16T17630E9	REV 1.0
1	TLCP N-C, 1-LINE	WIRING BLOCK DIAGRAM	100-16T17630B1	REV 1.0

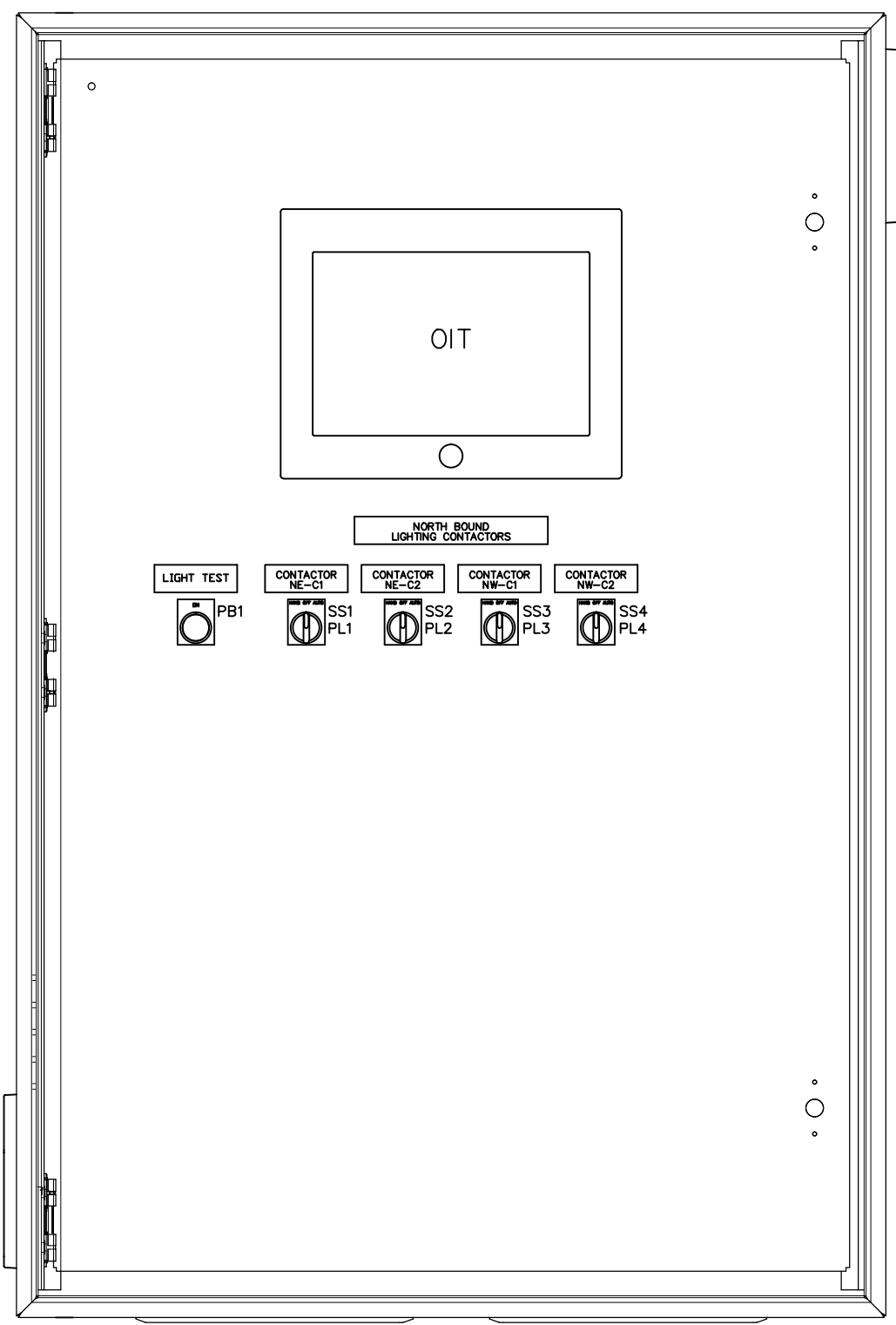
NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
 PLC Transportation <i>Control Systems A Division of PLC Multipoint</i>					
3101-11th STREET S.W. #F EVERETT, WA 98204 PH:425/353-7552 FAX:425/353-3353 PLCTRANSPORTATION.COM					
SIZE:	SCALE:	DRAWN BY:	CHECKED BY:	DWG. NO.:	DATE:
A	NDNE	S. HOULE	N. DITTMANN	100-16T17630I1	11/8/2016
				SHEET:	REV
				1/15	1.0

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO.:	DATE:	SHEET:	REV.
						100-16T17630A1	11/8/2016	2/15	1.0

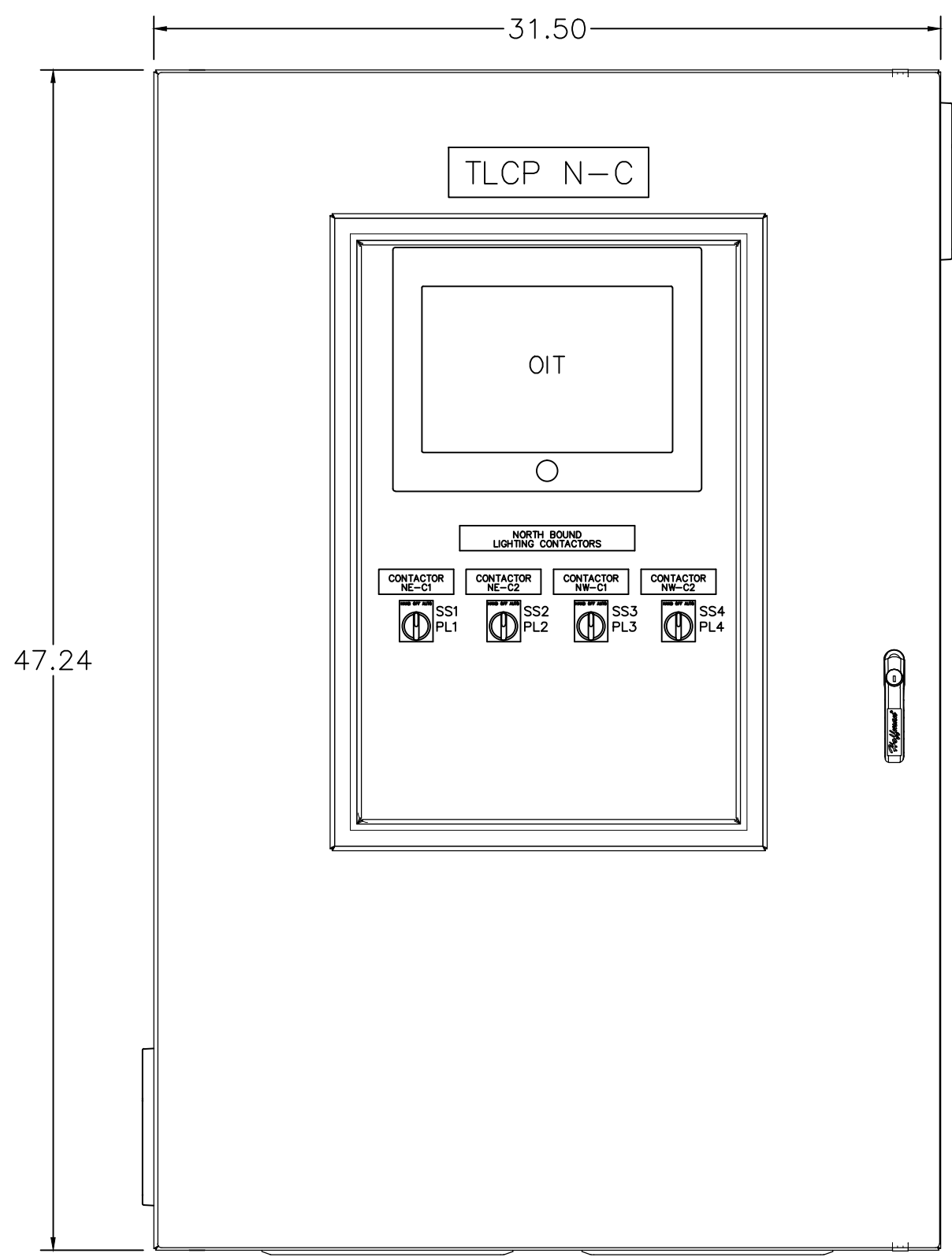
PLC Transportation
Control Systems A Division of PLCMultiPoint

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 EVERETT, WA 98204
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 PLCTRANSPORTATION.COM

LYTLE TUNNEL
 TLCP N-C
 TUNNEL LIGHTING CONTROL PANEL
 ASSEMBLY DWG
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN

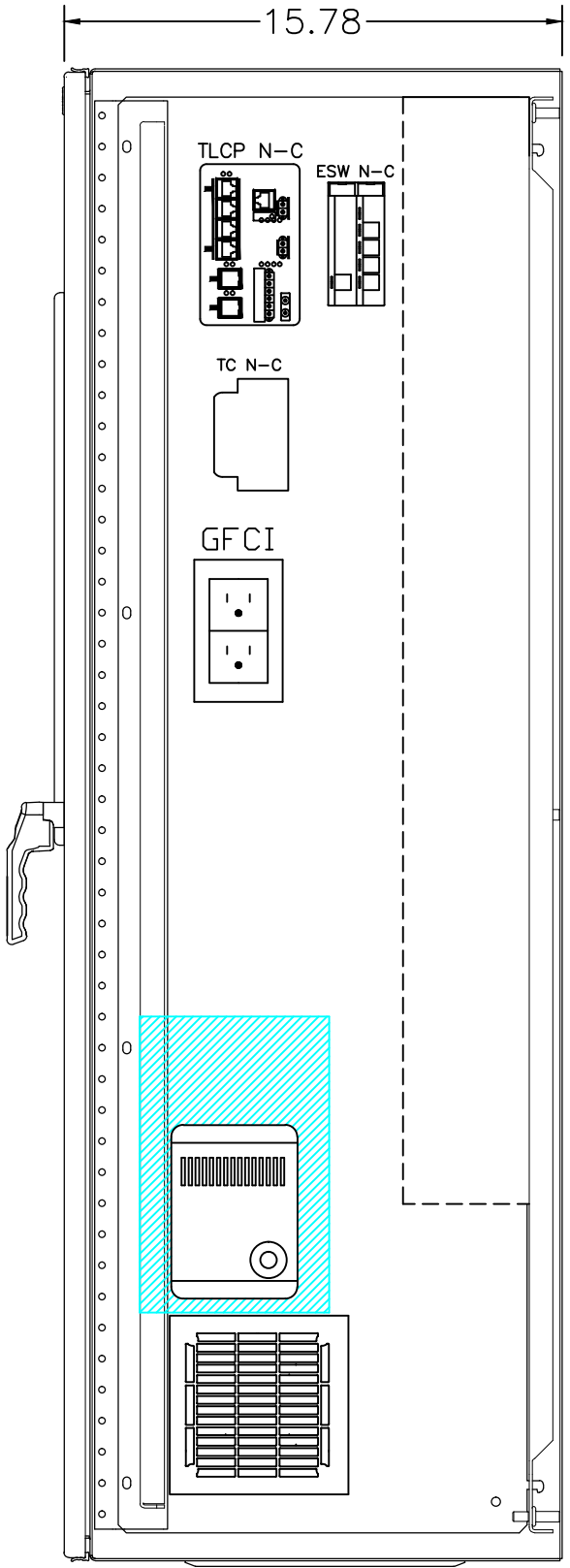
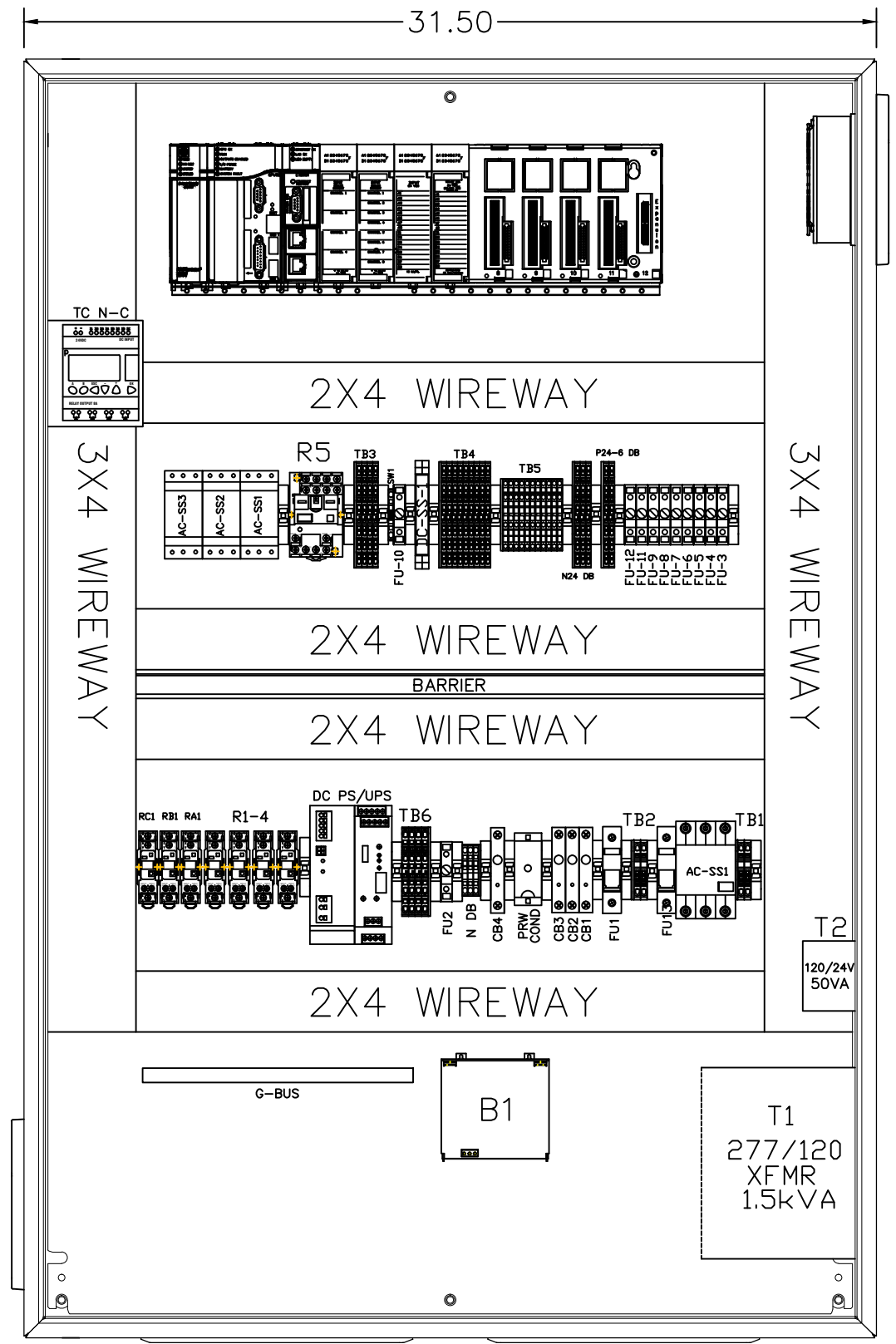
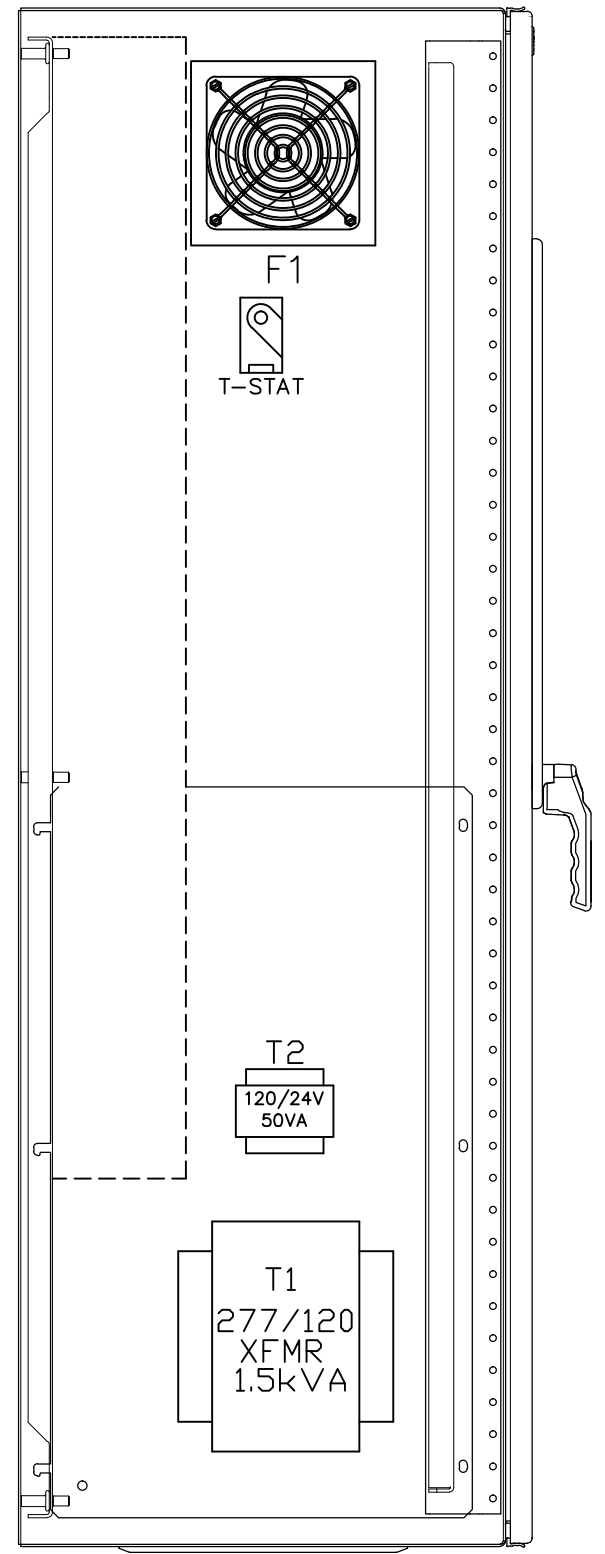


DEAD FRONT



EXTERIOR

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						100-16T17630A2	11/8/2016	3/15	1.0

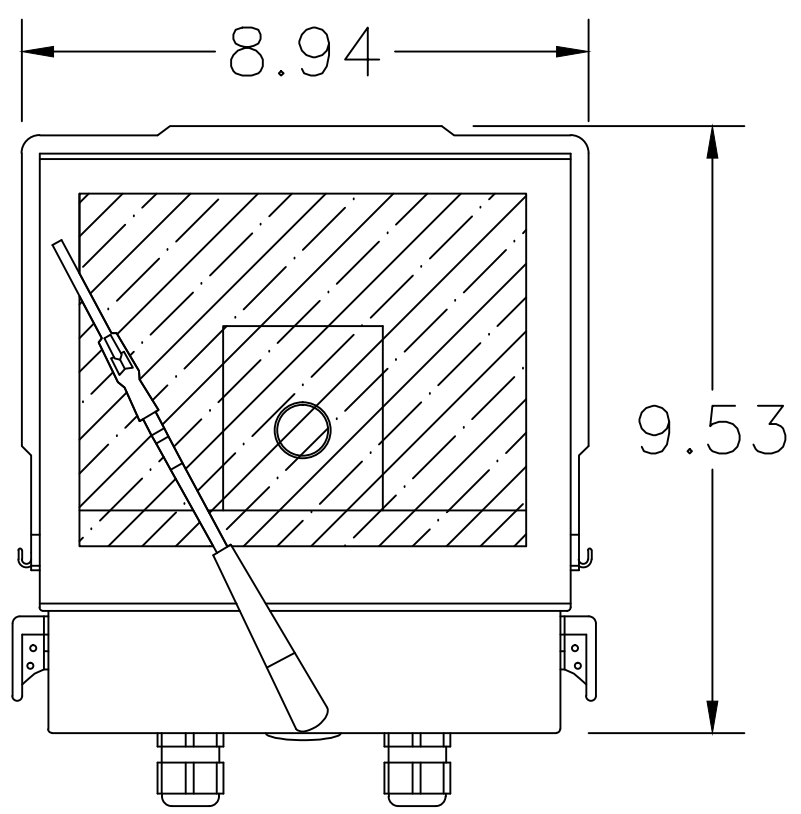


NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						100-16117630A3	11/8/2016	4/15	1.0

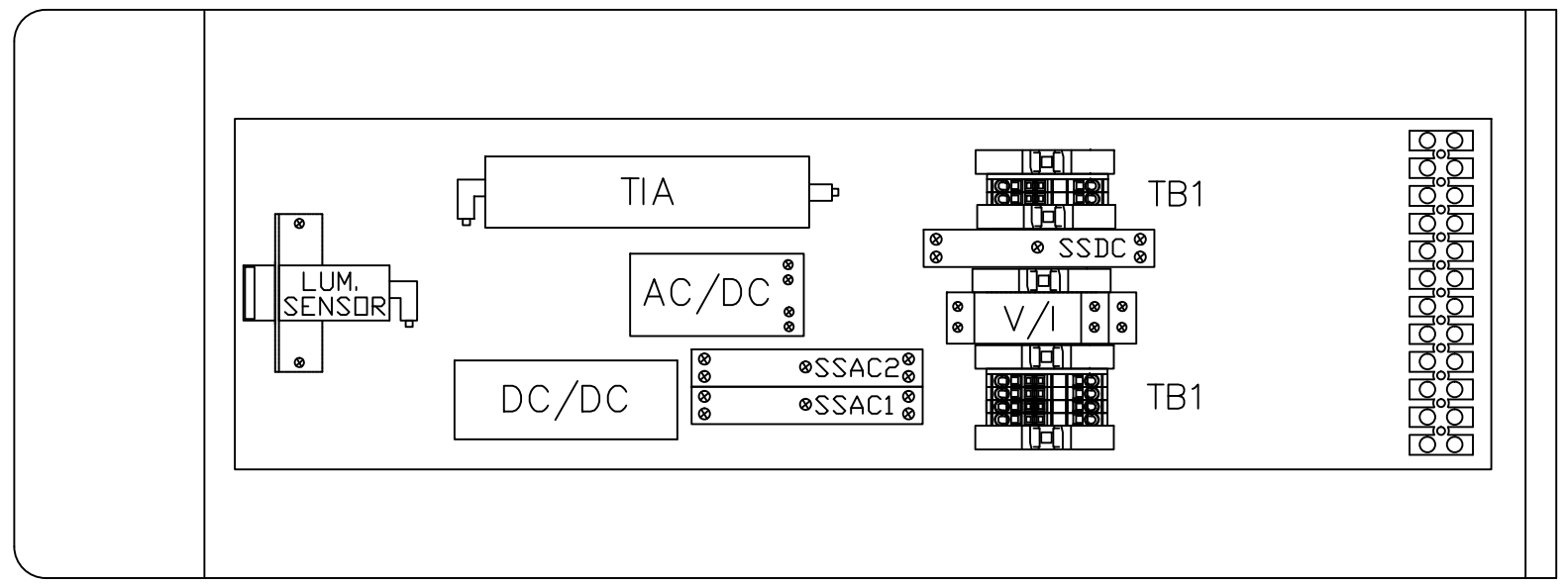
PLC Transportation
Control Systems A Division of PLC Multipoint

3101-111th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

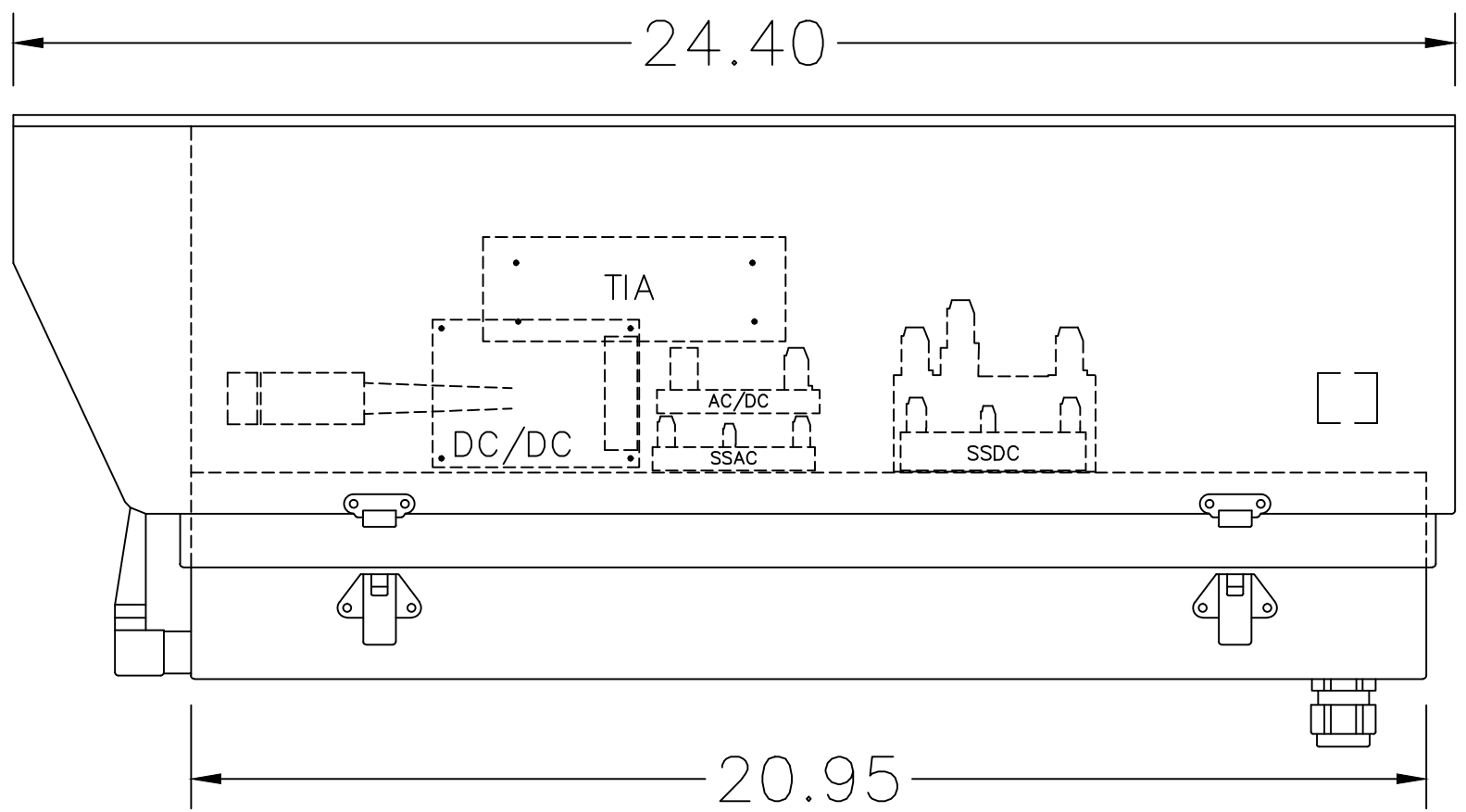
LYTLE TUNNEL
 TLUM N-C
 TUNNEL LIGHTING CONTROL PANEL
 ASSEMBLY DWG
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN



FRONT VIEW



TOP VIEW



SIDE VIEW

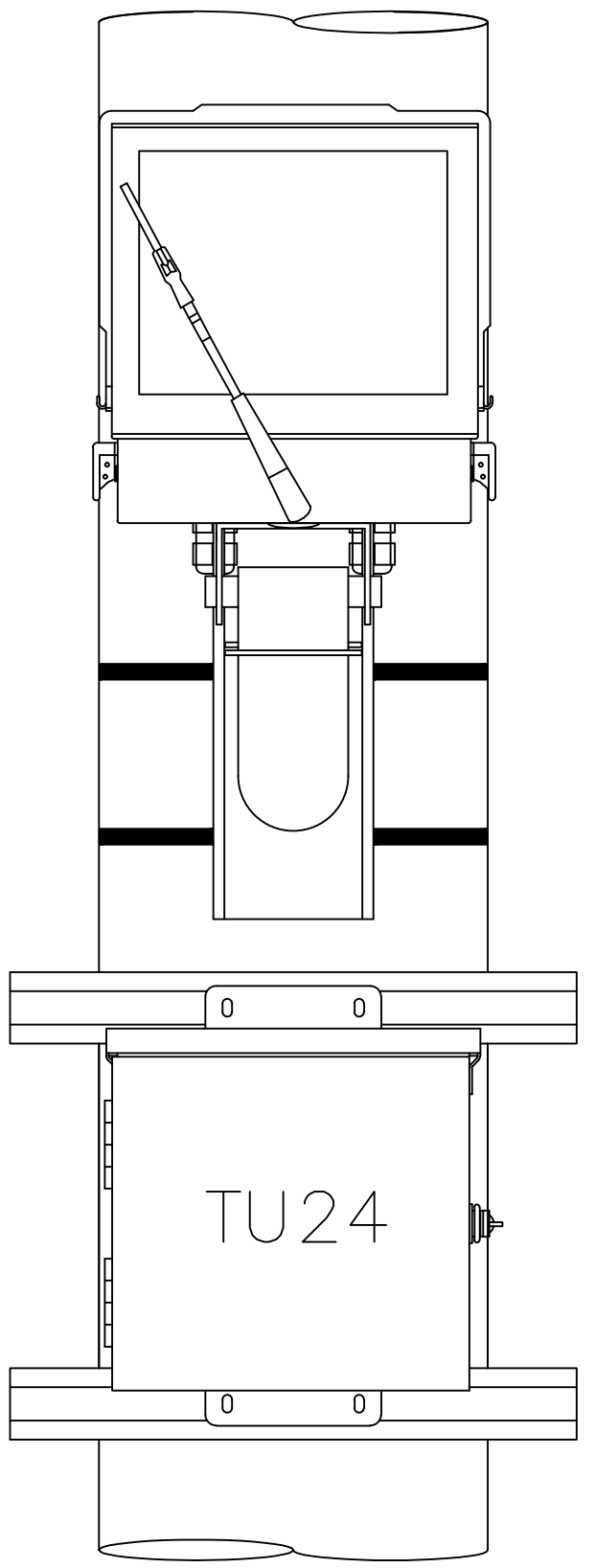
2 x 20MM COMPRESSION GLAND.
 0.47" MAX CABLE DIAMETER.

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						100-16T17630A4	11/8/2016	5/15	1.0

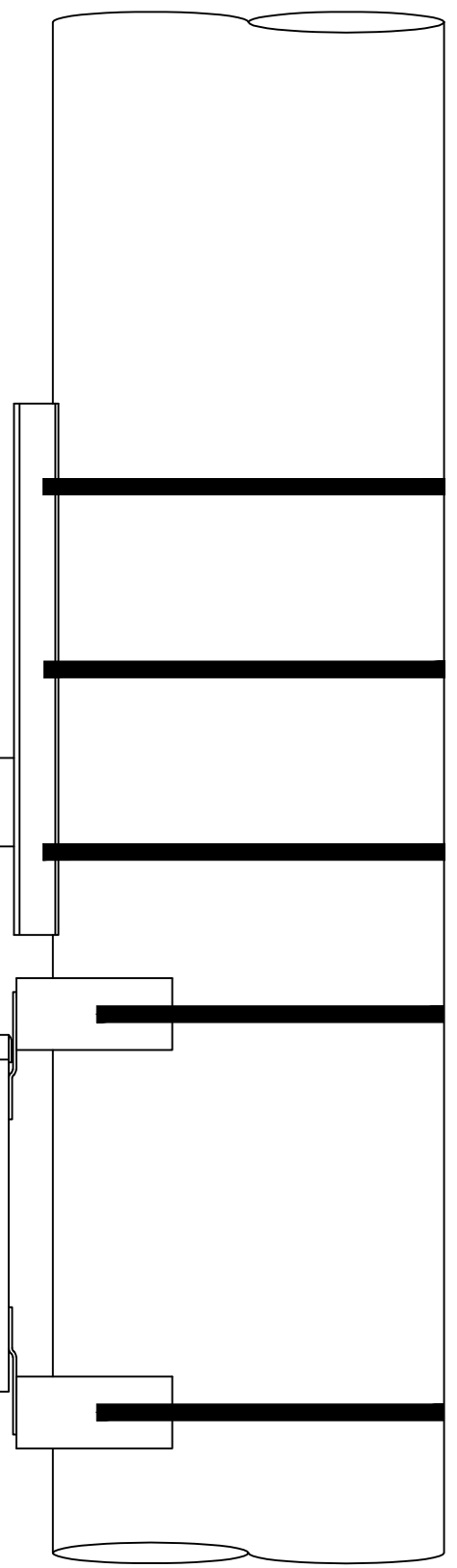
PLC Transportation
Control Systems A Division of PLCMultiPoint

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 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

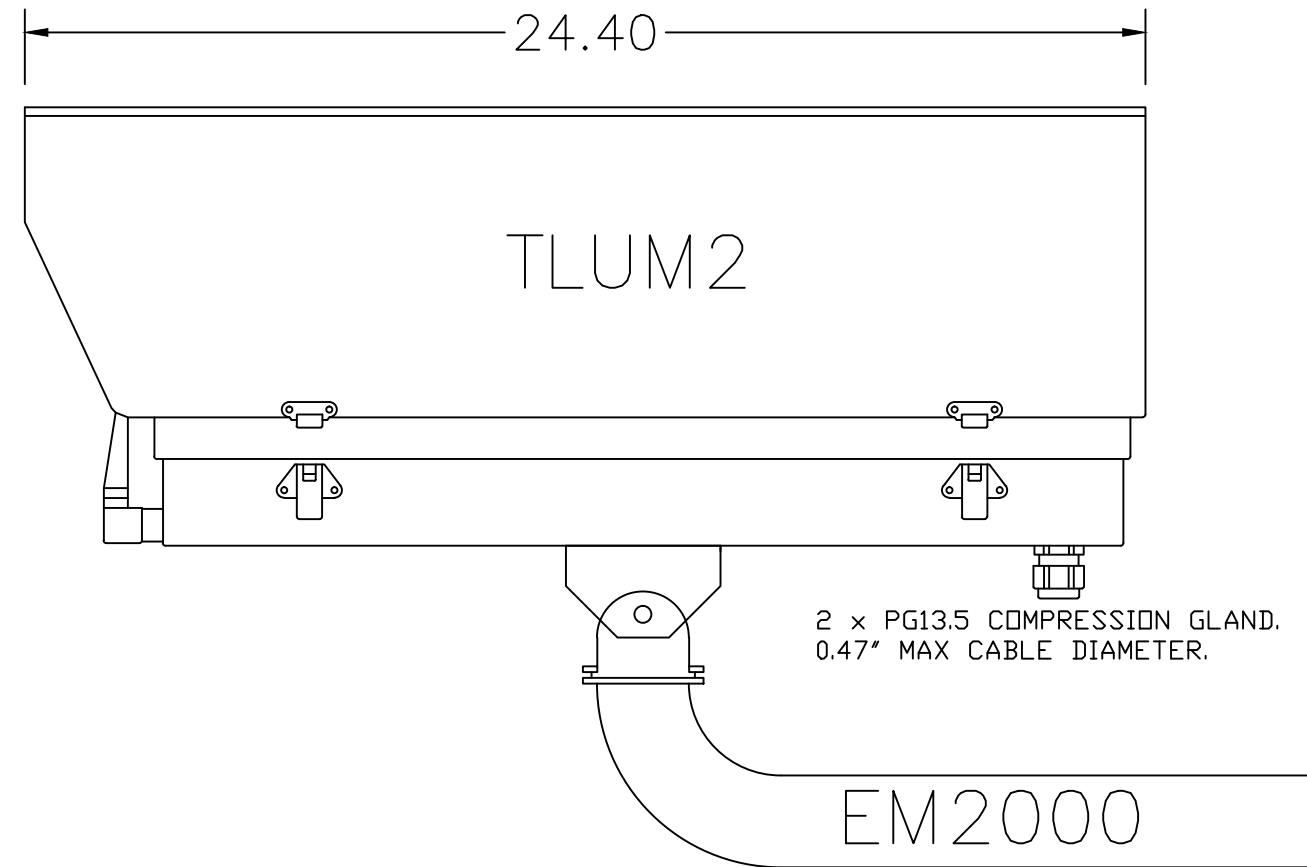
LYTLE TUNNEL
 TUNNEL LIGHTING CONTROL PANEL
 TUNNEL SENSOR MOUNTING
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN



FRONT VIEW



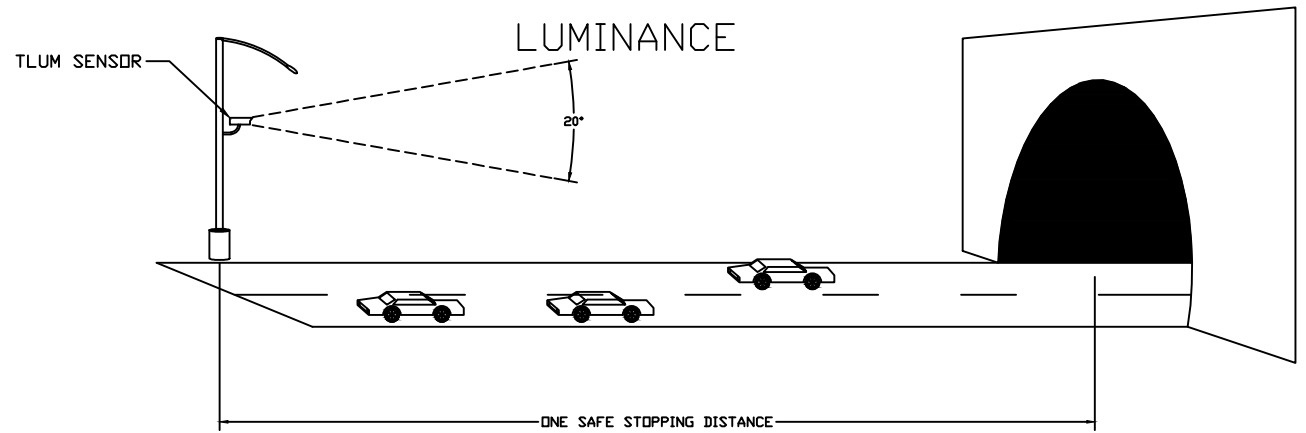
POLE-MOUNT BRACKET*
 W/ ADJUSTABLE TILT
 & SWIVEL HEAD



2 x PG13.5 COMPRESSION GLAND.
 0.47" MAX CABLE DIAMETER.

SIDE VIEW

*WALL MOUNT OPTION
 AVAILABLE.

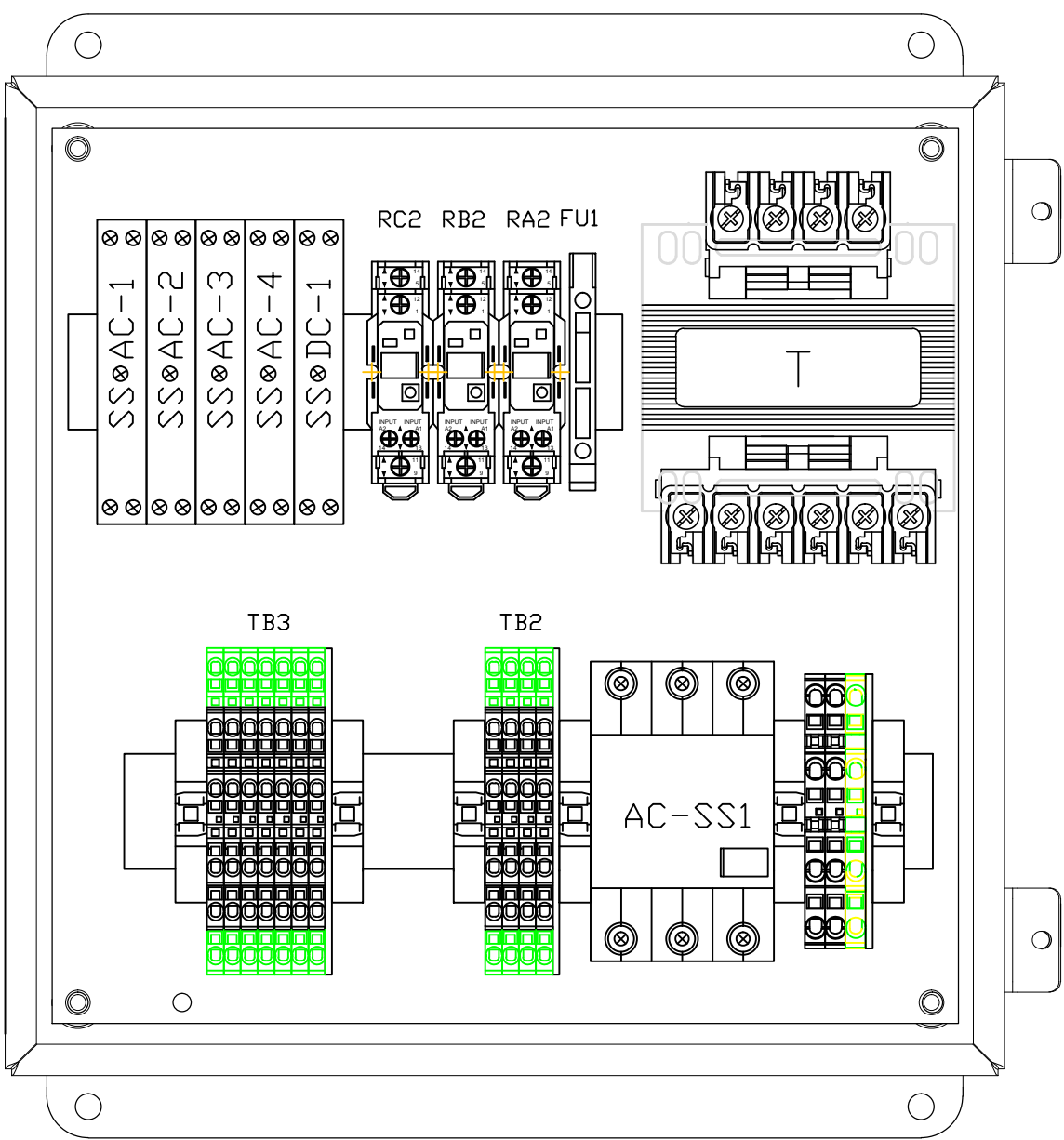


NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						100-16117630A5	11/8/2016	6/15	1.0

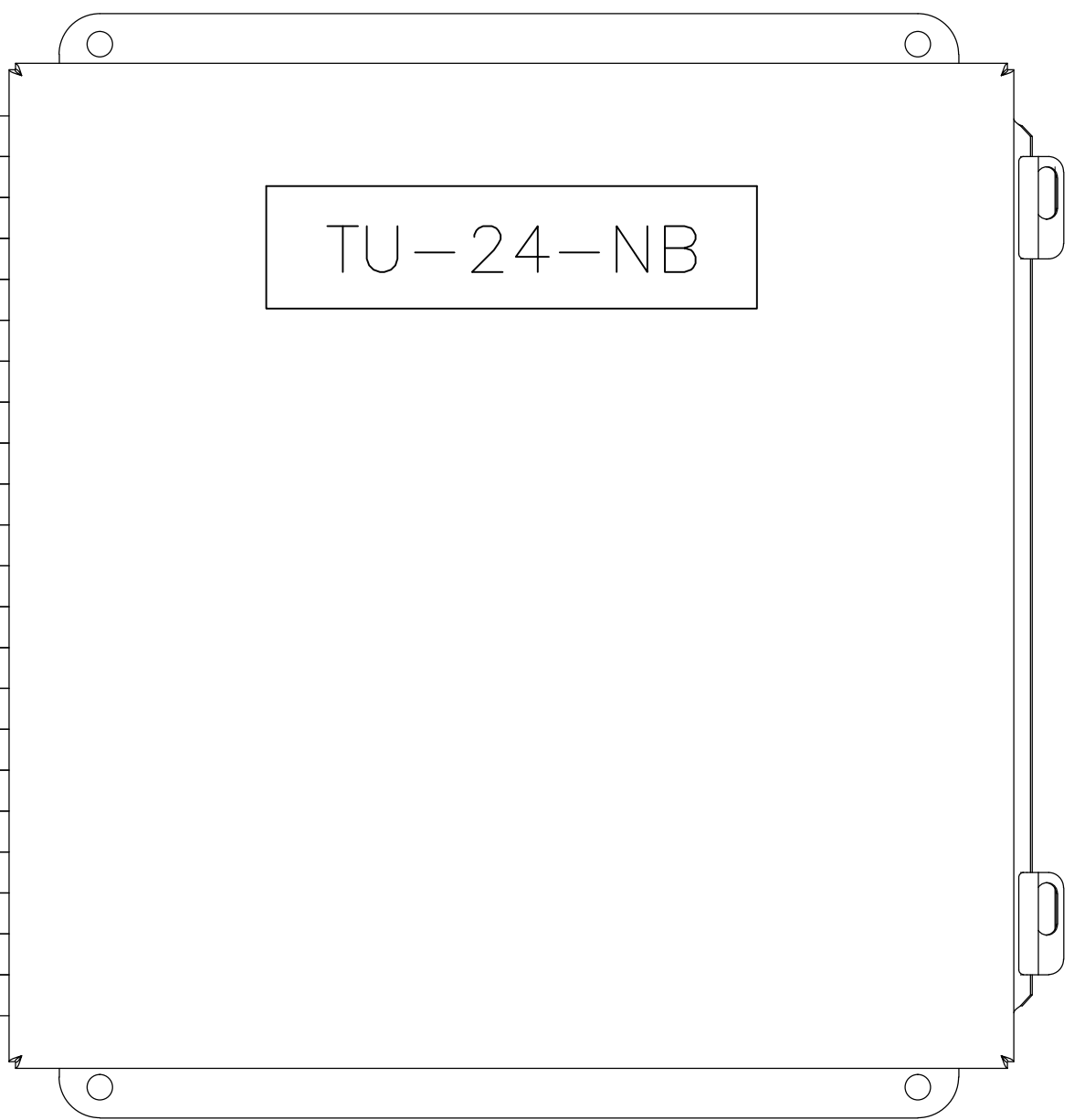
PLC Transportation
Control Systems A Division of PLC Multipoint

3101-1111th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

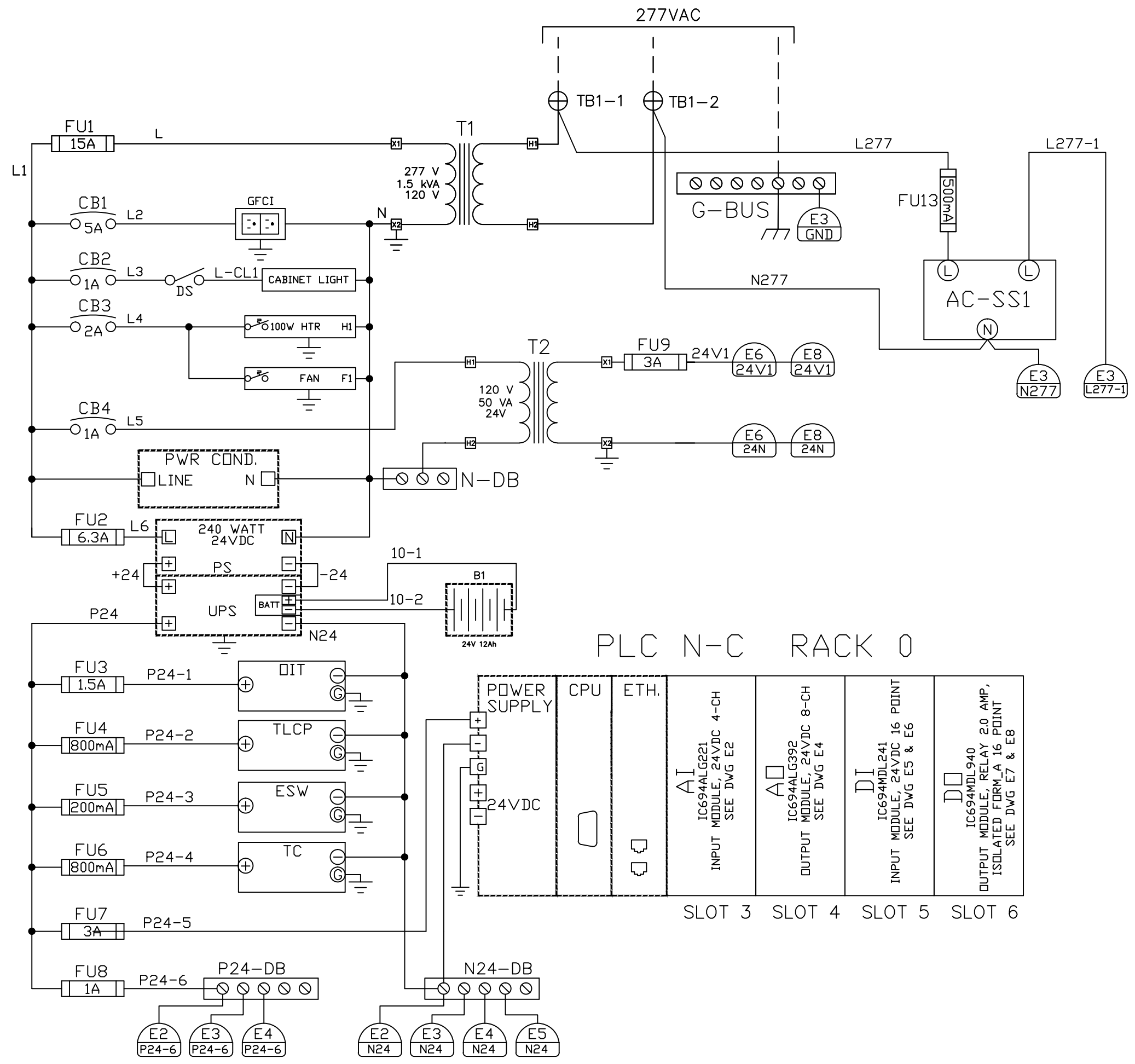
LYTLE TUNNEL
 TU-24
 TUNNEL LIGHTING CONTROL PANEL
 ASSEMBLY DRAWING
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN



INTERIOR VIEW



EXTERIOR VIEW
 12"H x 12"W x 6"D



1
E1 TLCP N-C, PWR DISTR
WIRING SCHEMATIC

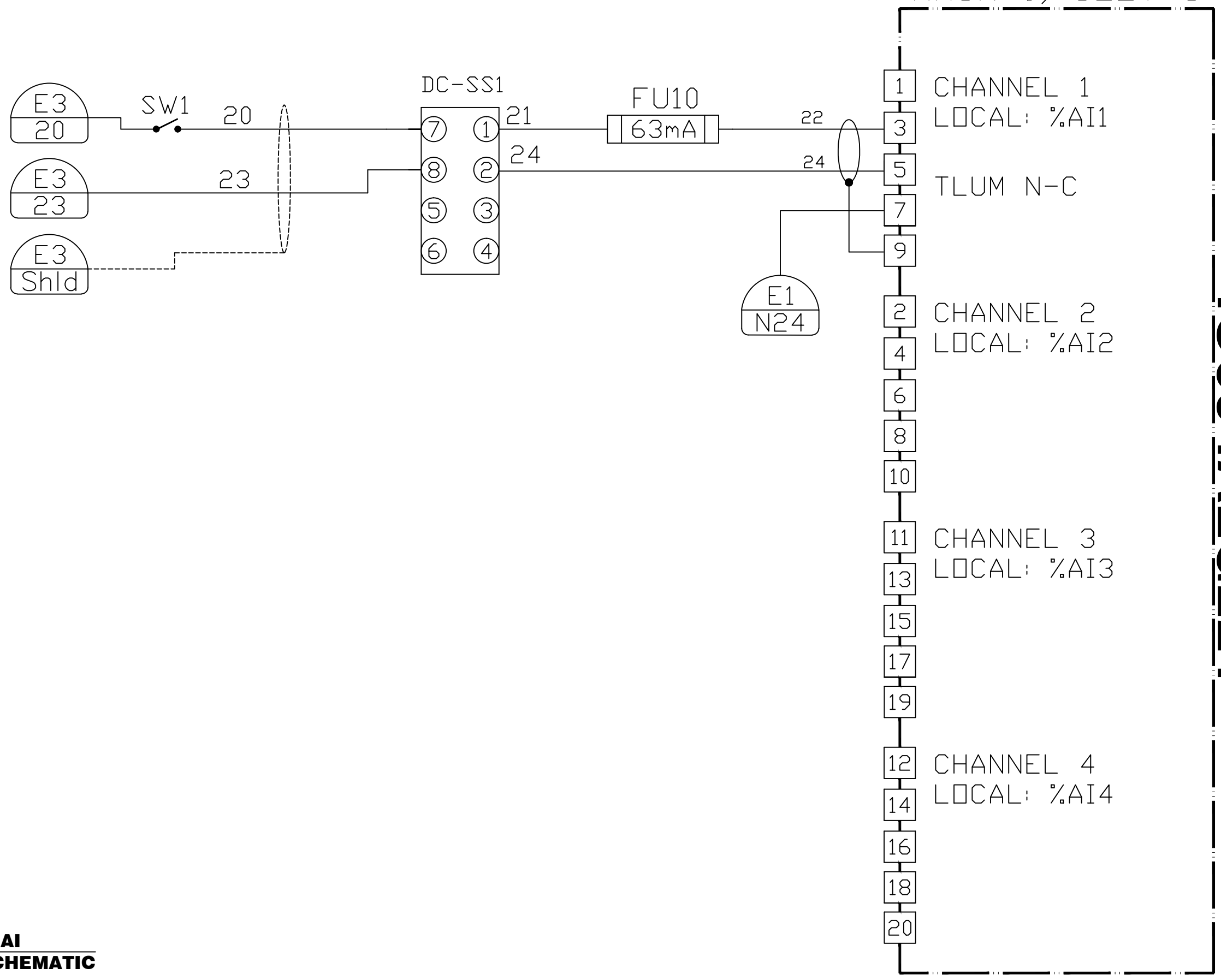
NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						100-16117630E2	11/8/2016	8/15	1.0

PLC Transportation
Control Systems A Division of PLC Multipoint
 3101-111th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

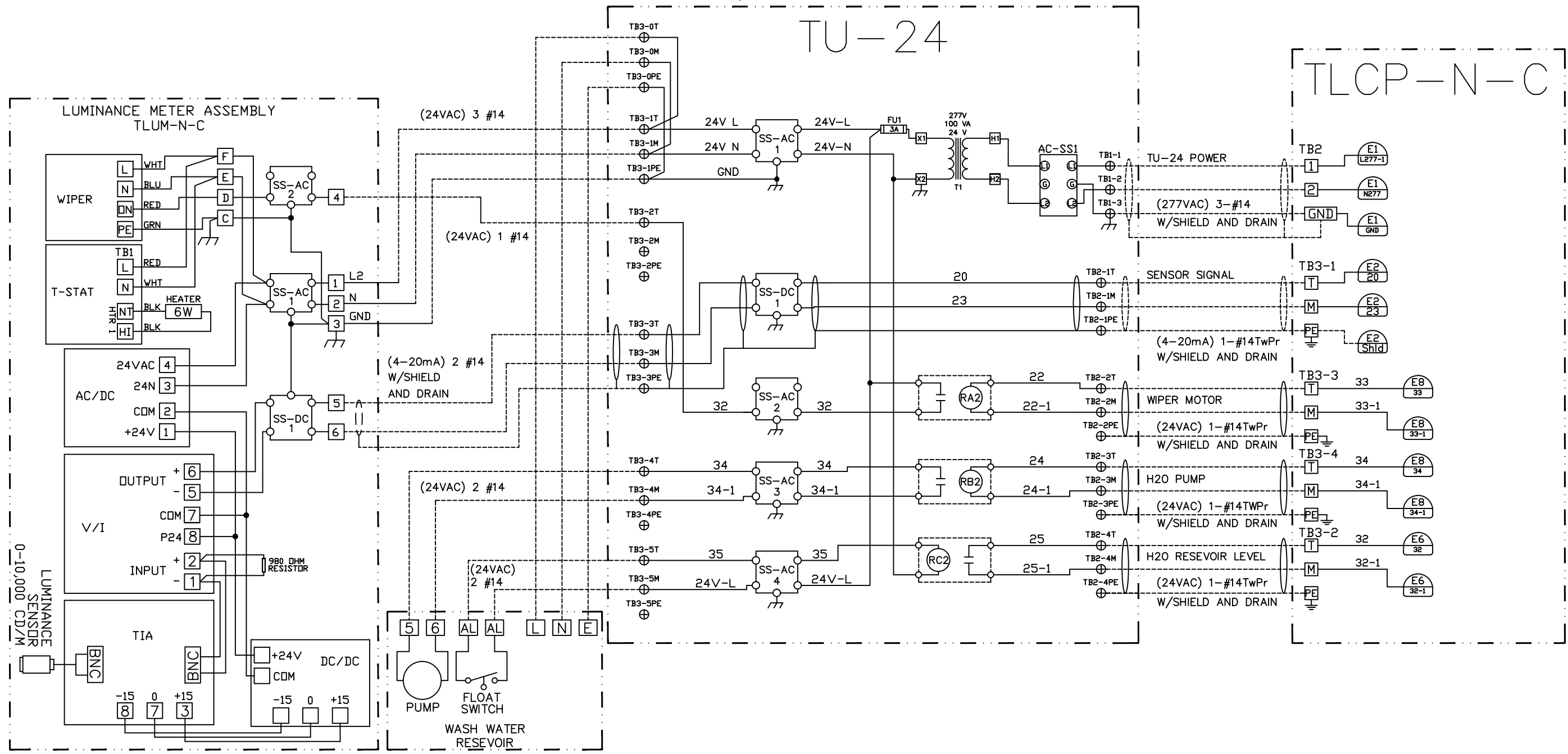
LYTLE TUNNEL
 TLCP N-C, AI
 TUNNEL LIGHTING CONTROL PANEL
 WIRING SCHEMATIC
 SIZE: A
 SCALE: NONE
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN

T57-6 CONTROLLER
 4-CH ANALOG INPUT
 RACK 0, SLOT 3

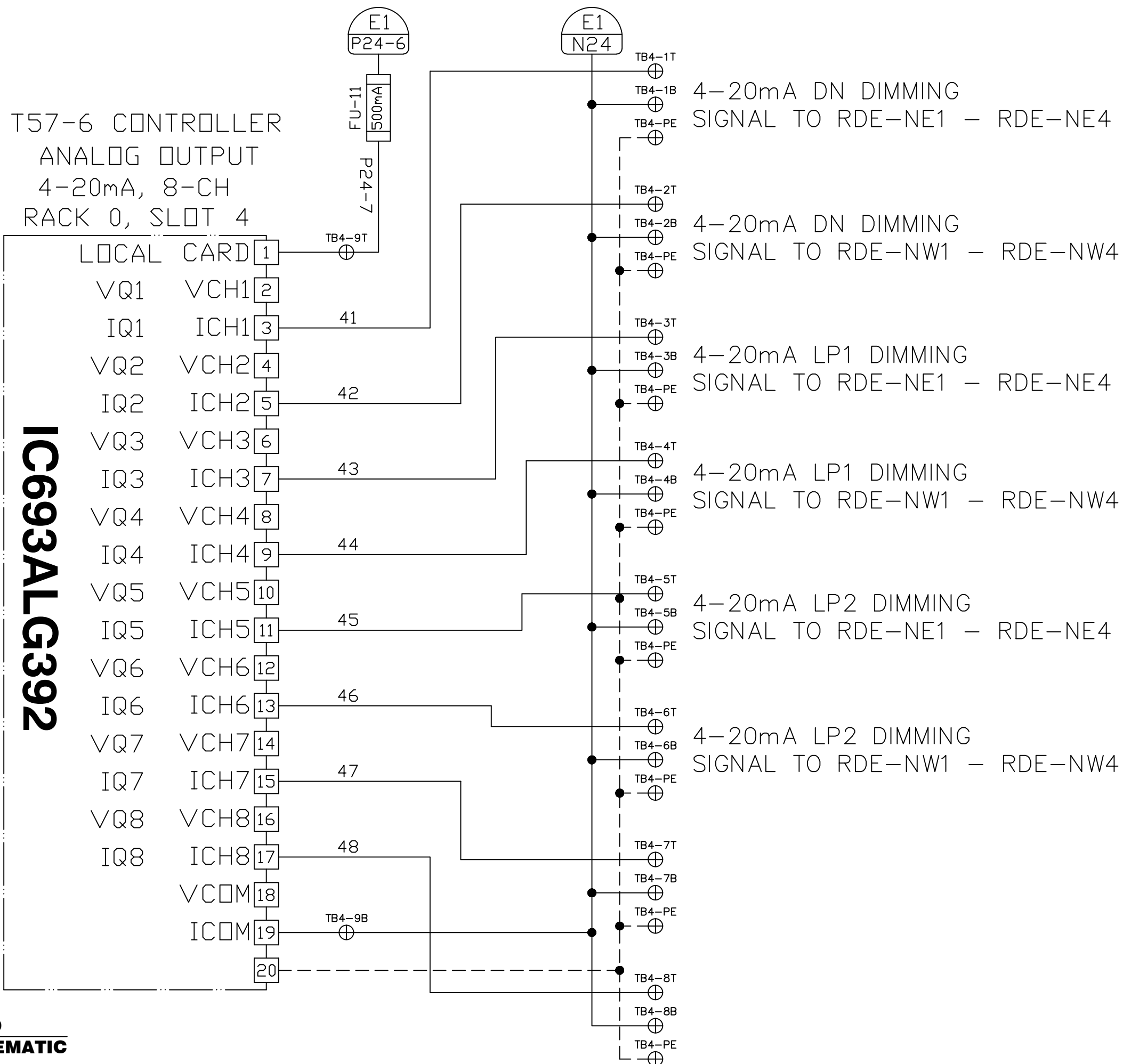
IC694ALG221



TU-24 POLE MOUNTED ENCLOSURE, APPROX 12X12X8

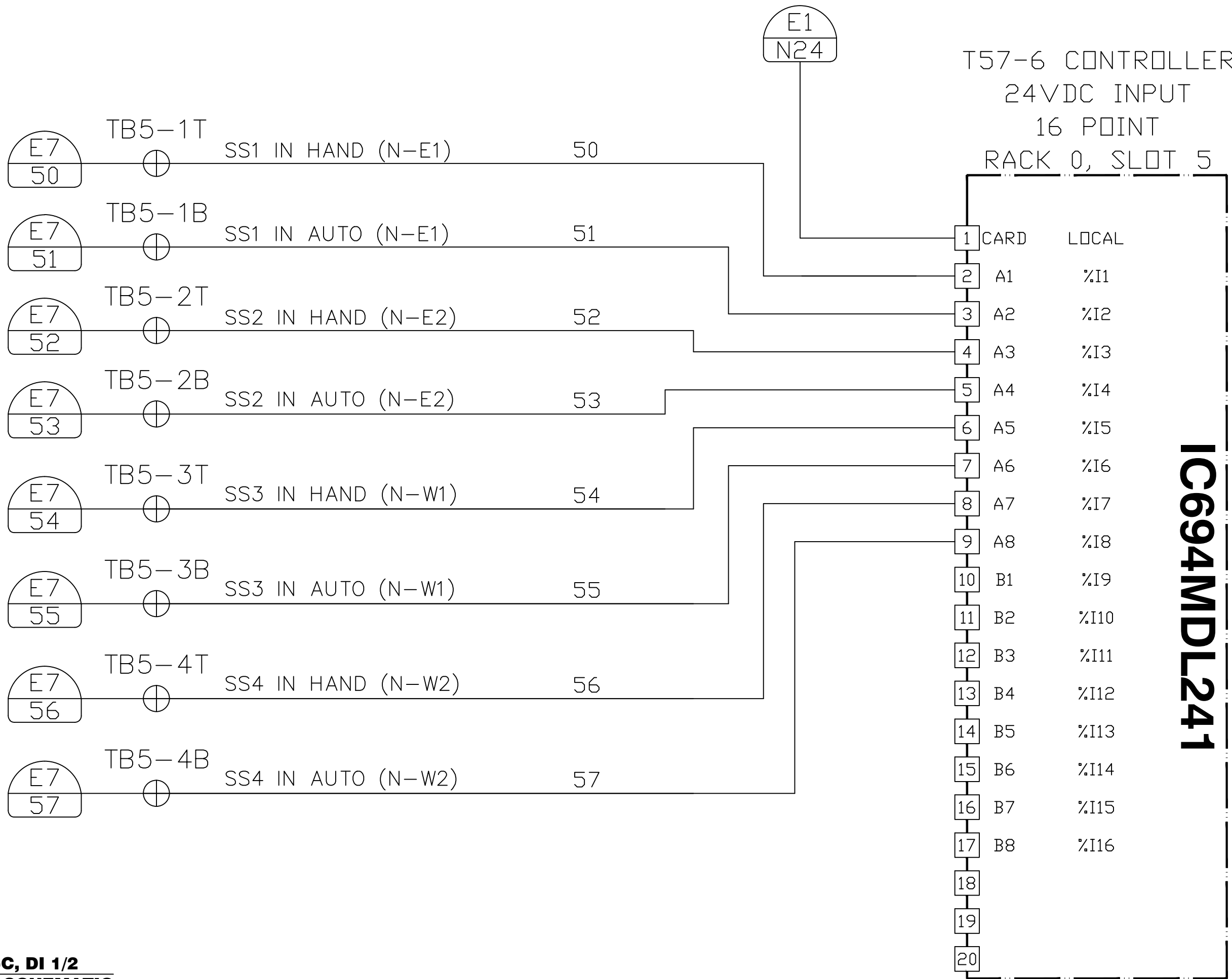


NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:
PLC Transportation <i>Control Systems A Division of PLC Multipoint</i>					
3101-111th STREET S.W. #F EVERETT, WA 98204 PH: 425/353-7552 FAX: 425/353-3353 PLCTRANSPORTATION.COM					
DWG. NO:	DATE:	REV	SCALE:	DRAWN:	CHECKED BY:
100-16117630E3	11/8/2016	9/15	NONE	S. HOULE	N. DITTMANN
LYTLE TUNNEL TLCP TU-24 WIRING TUNNEL LIGHTING CONTROL PANEL WIRING SCHEMATIC					



T57-6 CONTROLLER
 24VDC INPUT
 16 POINT
 RACK 0, SLOT 5

IC694MDL241

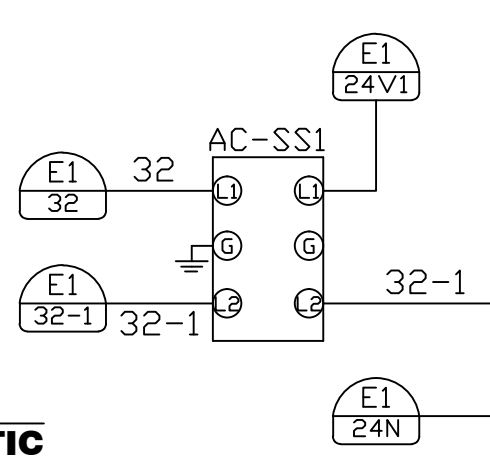
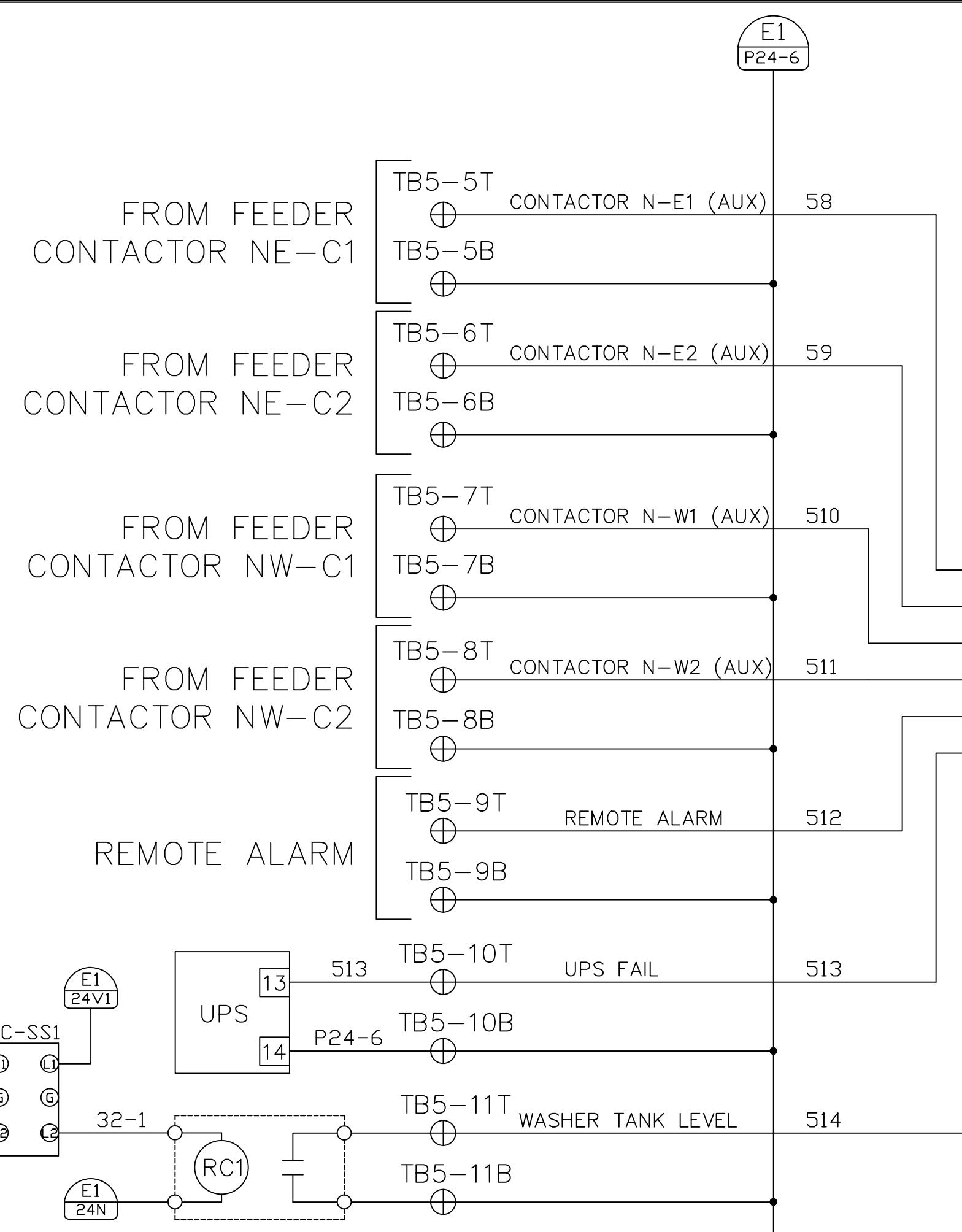
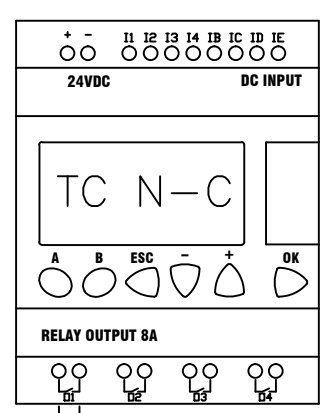


NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						100-16117630E6	11/8/2016	12/15	1.0

T57-6 CONTROLLER
24VDC INPUT
16 POINT
RACK 0, SLOT 5

IC694MDL241

1	CARD	LOCAL
2	A1	%I1
3	A2	%I2
4	A3	%I3
5	A4	%I4
6	A5	%I5
7	A6	%I6
8	A7	%I7
9	A8	%I8
10	B1	%I9
11	B2	%I10
12	B3	%I11
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18		
19		
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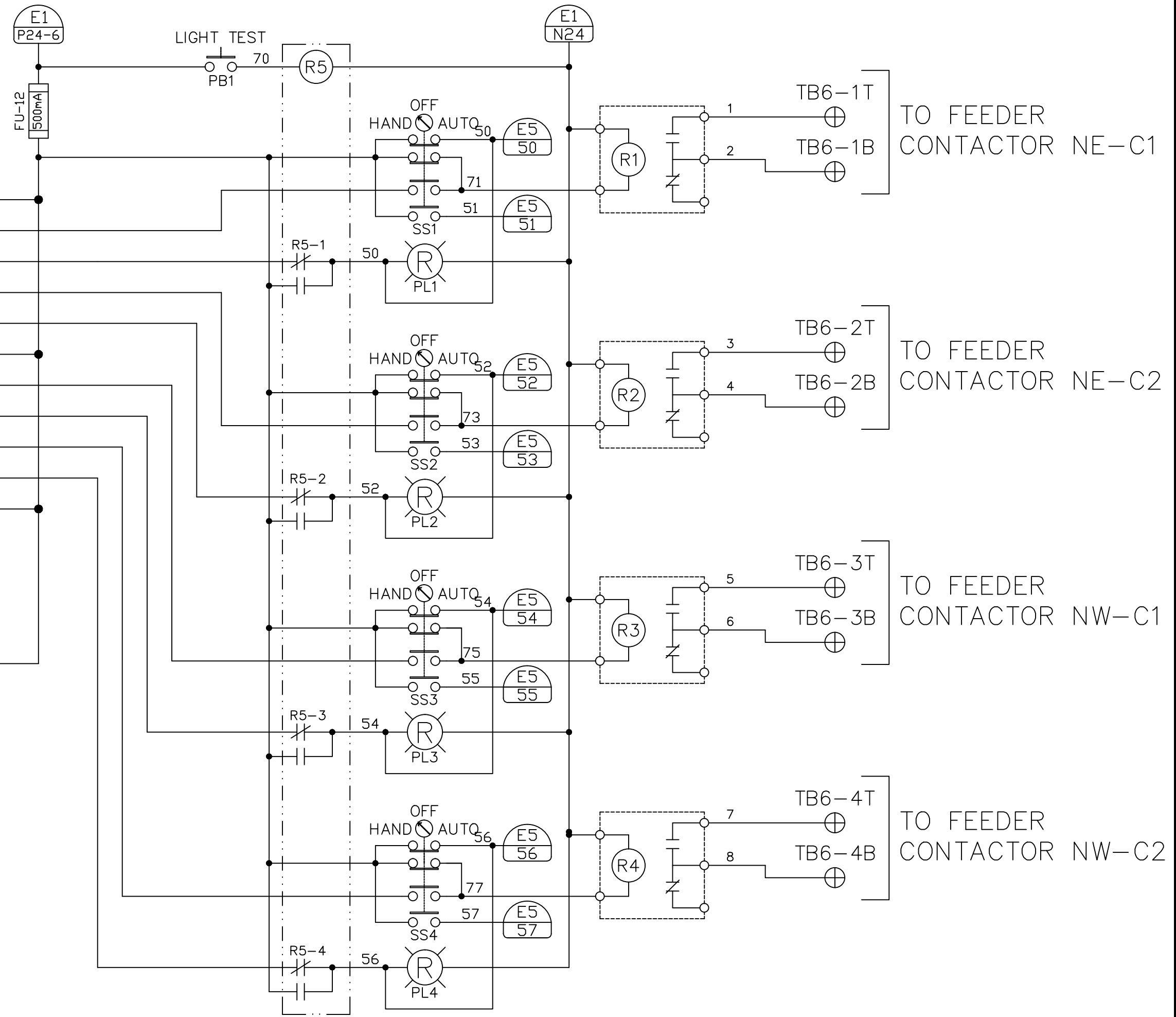
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PLC Transportation
Control Systems A Division of PLC Multipoint
3101-111th STREET S.W. #F
EVERETT, WA 98204
PH:425/353-7552 FAX:425/353-3353
PLCTRANSPORTATION.COM

LYTLE TUNNEL
TLCP N-C, DD 1/2
TUNNEL LIGHTING CONTROL PANEL
WIRING SCHEMATIC
SIZE: A
SCALE: NONE
DRAFTED: S. HOULE
CHECKED BY: N. DITTMANN

T57-6 CONTROLLER
ISOLATED RELAY OUTPUT
16 POINT
RACK 0, SLOT 6

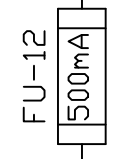
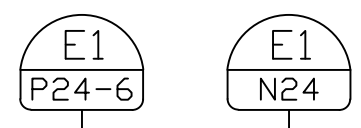
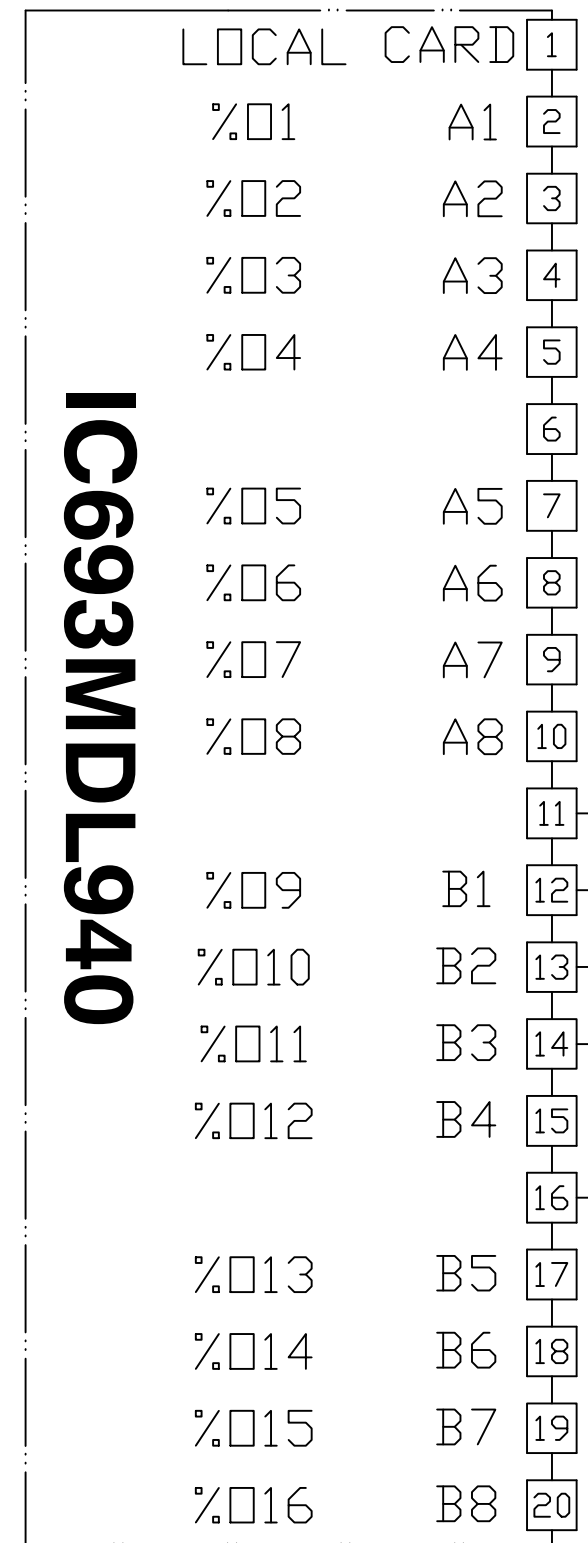
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%06	A6	8	65
%07	A7	9	66
%08	A8	10	67
		11	P24-8
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%010	B2	13	
%011	B3	14	
%012	B4	15	P24-8
		16	
%013	B5	17	
%014	B6	18	
%015	B7	19	
%016	B8	20	



1 TLCP N-C, DO 1/2
E7 WIRING SCHEMATIC

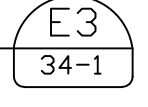
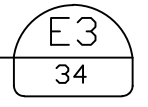
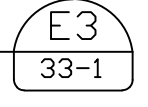
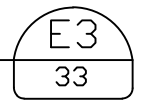
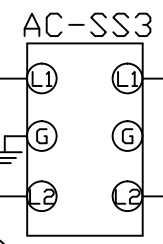
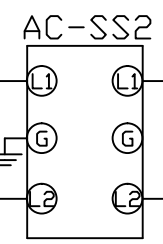
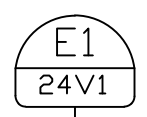
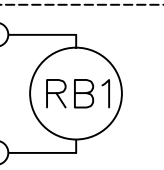
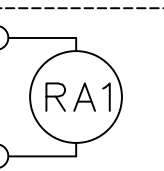
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T57-6 CONTROLLER
ISOLATED RELAY OUTPUT
16 POINT
RACK 0, SLOT 7



WIPER

PUMP



P24-8

68

69

70

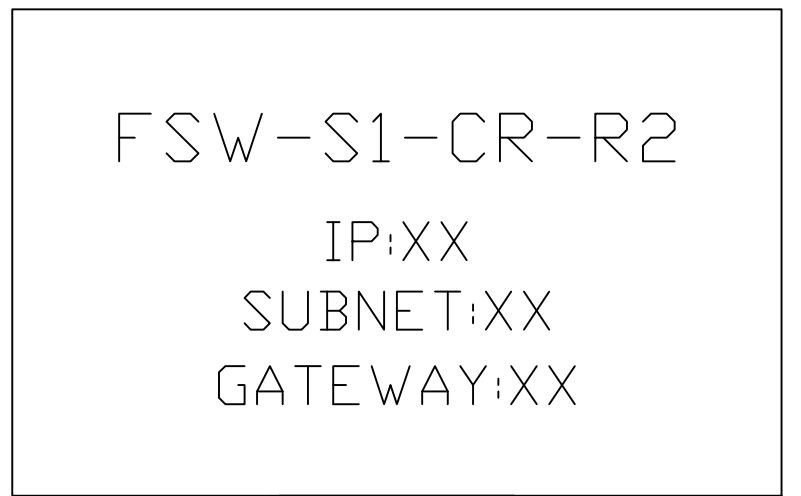
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71

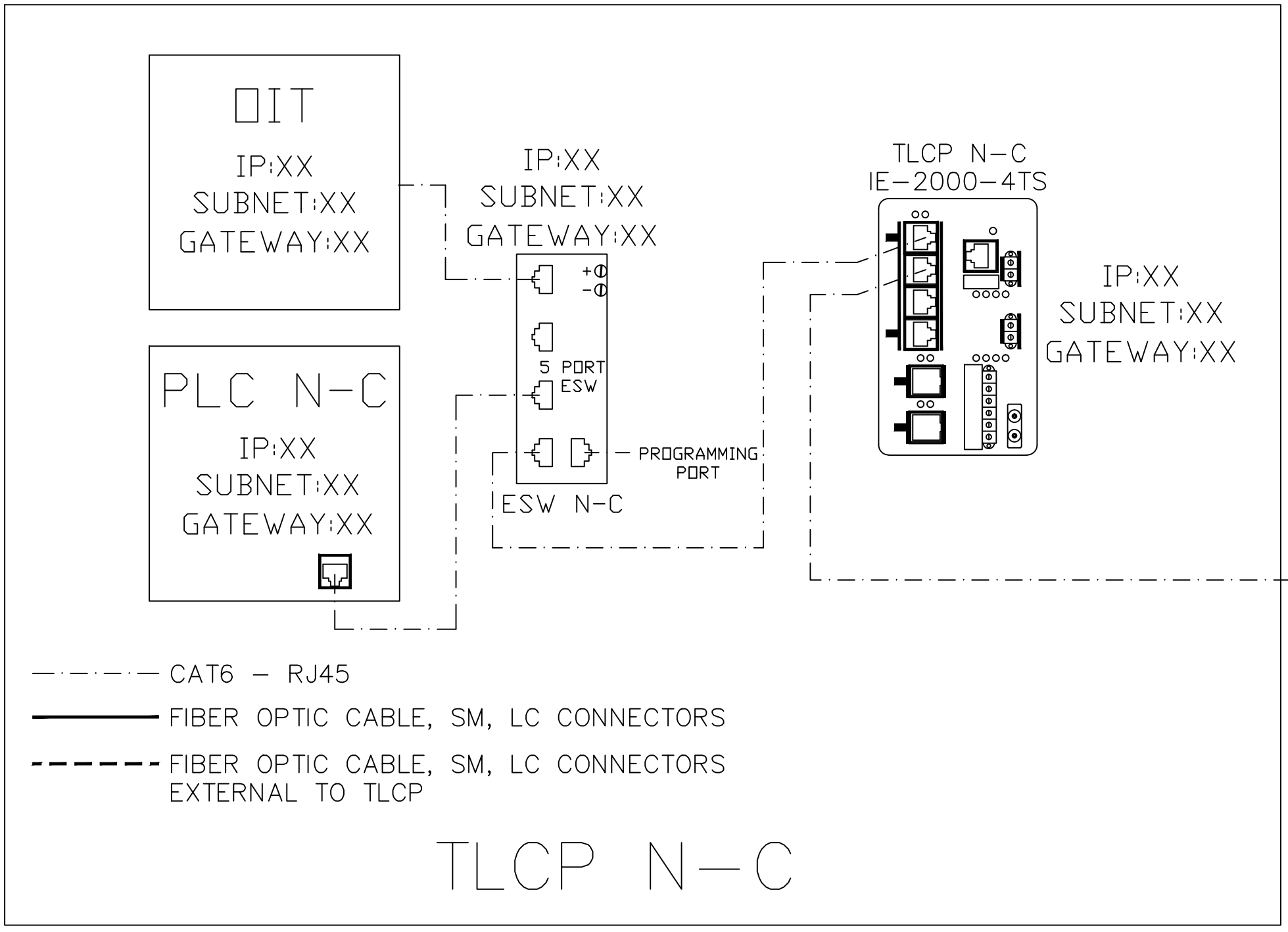
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FAN-PLC CABINET



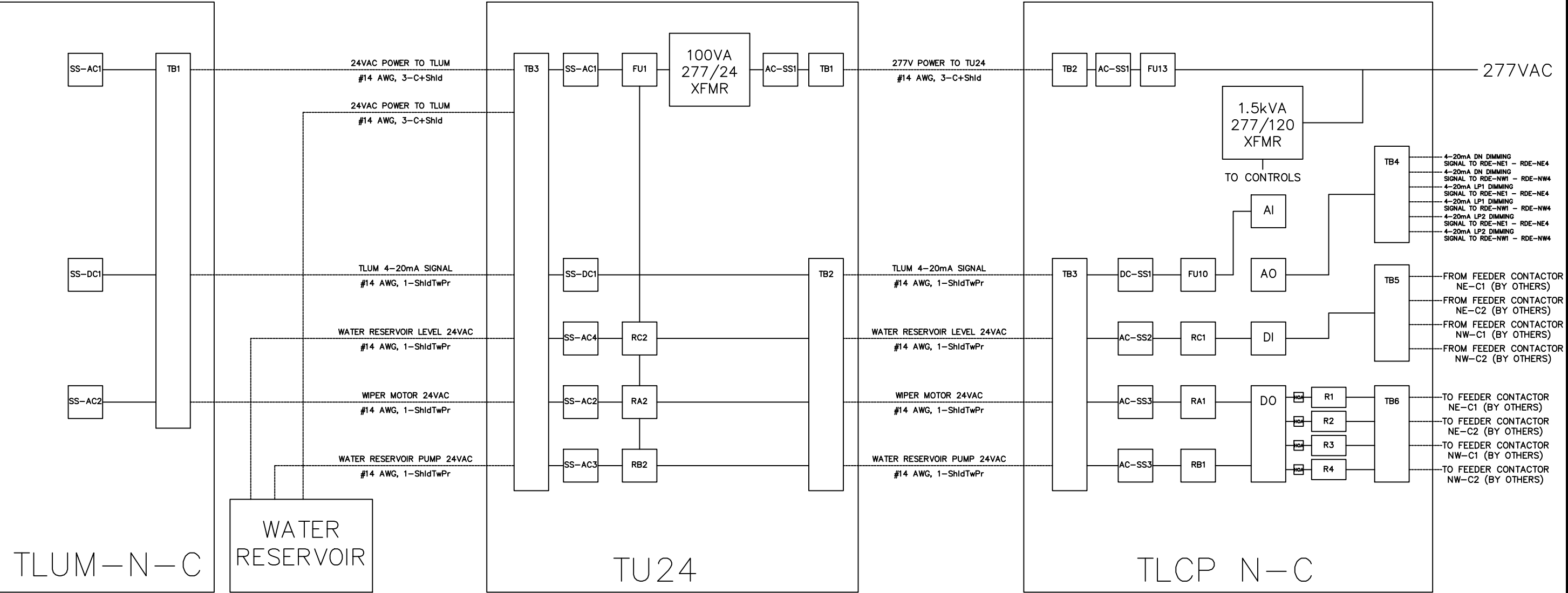
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NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	REV
						100-16117630B1	11/8/2016	1/1
								1.0

PLC Transportation
Control Systems A Division of PLC Multipoint

3101-111th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM




1
B1 TLCP N-C, 1-LINE WIRING DIAGRAM

SIZE	SCALE	DRAFTED	CHECKED BY:
A	NONE	S. HOULE	N. DITTMANN

LYTLE TUNNEL
 TLCP N-C
 TUNNEL LIGHTING CONTROL PANEL
 1-LINE WIRING DIAGRAM

LYTLE TUNNEL
 TLCP S-C
 T57-6 TUNNEL LIGHTING CONTROL
 SYSTEM DRAWING INDEX

<u>SHEET NO.</u>	<u>DRAWING TITLE</u>	<u>DRAWING TYPE</u>	<u>DRAWING NO.</u>	<u>REV NO.</u>
1	TLCP S-C	DRAWING INDEX	200-16T17630I1	REV 1.0
2	TLCP S-C	ASSEMBLY DRAWING	200-16T17630A1	REV 1.0
3	TLCP S-C	ASSEMBLY DRAWING	200-16T17630A2	REV 1.0
4	TLUM S-C	HOUSING ASSEMBLY	200-16T17630A3	REV 1.0
5	TLUM S-C	SENSOR MOUNTING	200-16T17630A4	REV 1.0
6	TU-24 S-C	ASSEMBLY DRAWING	200-16T17630A5	REV 1.0
7	TLCP S-C, PWR DISTR	WIRING SCHEMATIC	200-16T17630E1	REV 1.0
8	TLCP S-C, AI	WIRING SCHEMATIC	200-16T17630E2	REV 1.0
9	TU-24 S-C	WIRING SCHEMATIC	200-16T17630E3	REV 1.0
10	TLCP S-C, AO 1/2	WIRING SCHEMATIC	200-16T17630E4	REV 1.0
11	TLCP S-C, AO 2/2	WIRING SCHEMATIC	200-16T17630E5	REV 1.0
12	TLCP S-C, DI 1/4	WIRING SCHEMATIC	200-16T17630E6	REV 1.0
13	TLCP S-C, DI 2/4	WIRING SCHEMATIC	200-16T17630E7	REV 1.0
14	TLCP S-C, DI 3/4	WIRING SCHEMATIC	200-16T17630E8	REV 1.0
15	TLCP S-C, DI 4/4	WIRING SCHEMATIC	200-16T17630E9	REV 1.0
16	TLCP S-C, DO 1/3	WIRING SCHEMATIC	200-16T17630E10	REV 1.0
17	TLCP S-C, DO 2/3	WIRING SCHEMATIC	200-16T17630E11	REV 1.0
18	TLCP S-C, DO 3/3	WIRING SCHEMATIC	200-16T17630E12	REV 1.0
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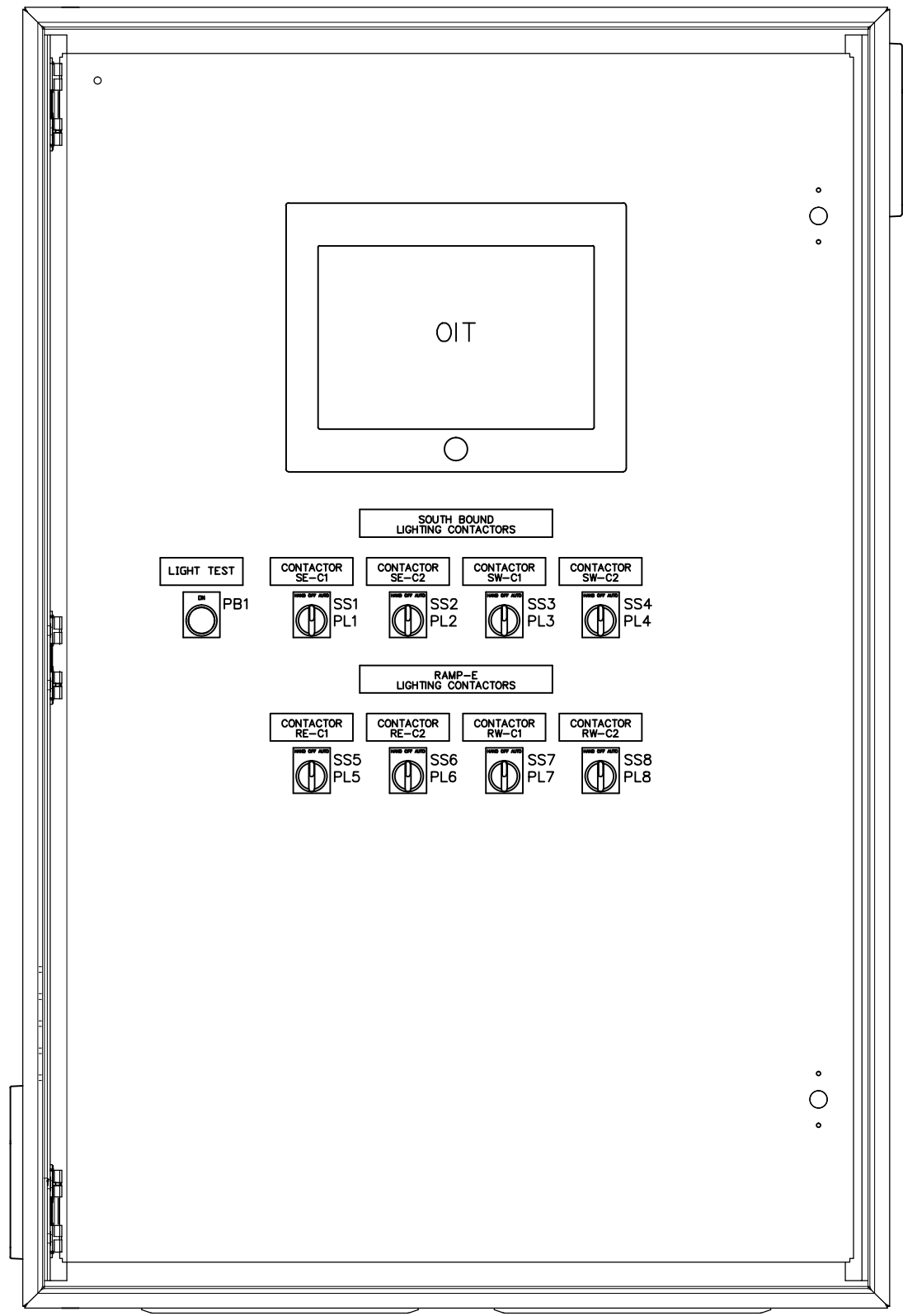
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200-16T1763011		12/7/2016			1/19
 PLC Transportation <i>Control Systems A Division of PLC Multipoint</i>					
3101-11th STREET S.W. #F EVERETT, WA 98204 PH:425/353-7552 FAX:425/353-3353 PLCTRANSPORTATION.COM					
SIZE: A	SCALE: NONE	DRAFTED: S. HOULE	LYTLE TUNNEL TLCP S-C TUNNEL LIGHTING CONTROL PANEL DRAWING INDEX		
			CHECKED BY: N. DITTMANN		

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET	REV
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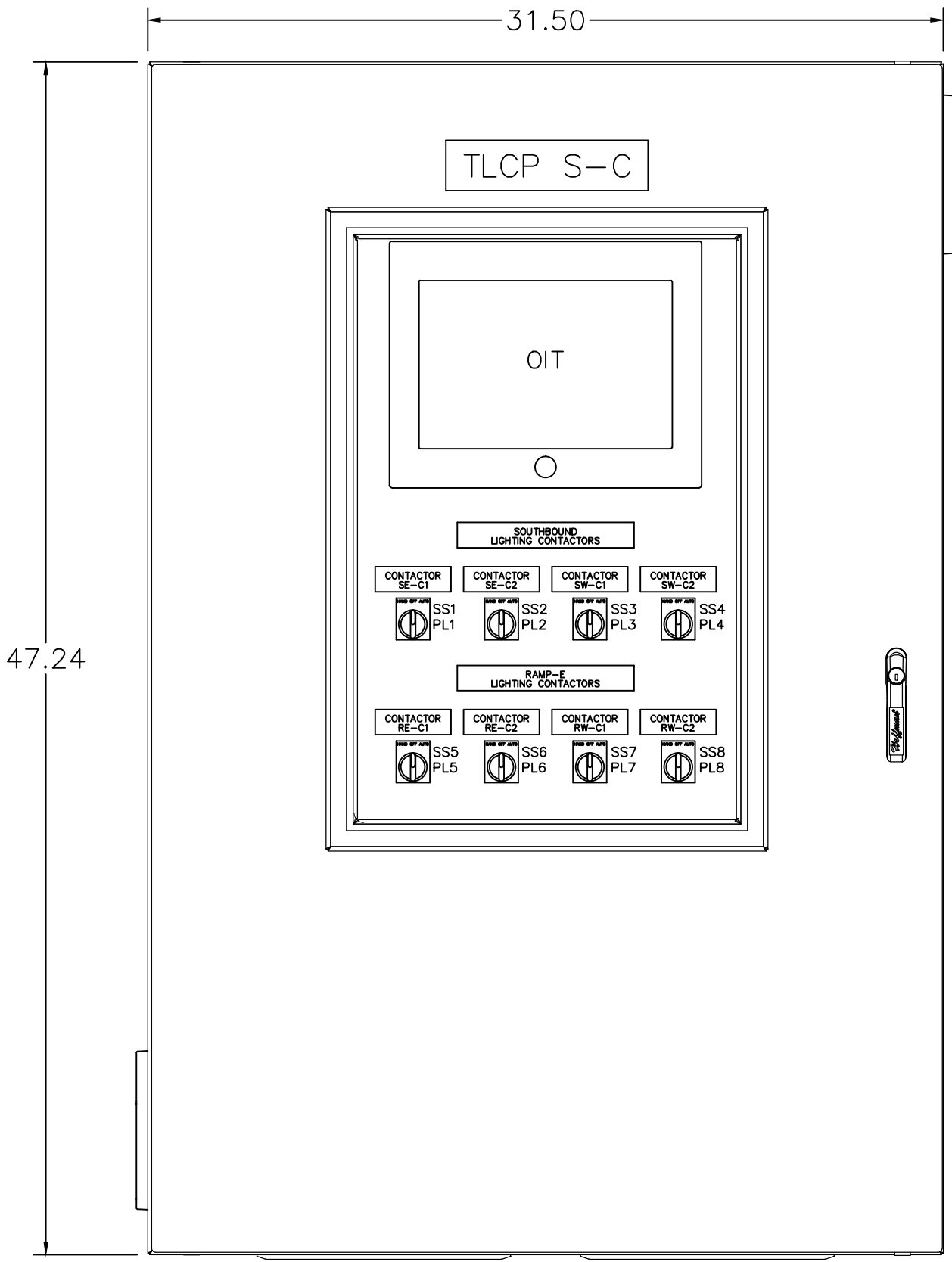
PLC Transportation
Control Systems A Division of PLC Multipoint

3101-111th STREET S.W. #F
 EVERETT, WA 98204
 PH: 425/353-7552 FAX: 425/353-3353
 PLCTRANSPORTATION.COM

LYTLE TUNNEL
 TLCP S-C
 TUNNEL LIGHTING CONTROL PANEL
 ASSEMBLY DWG
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN

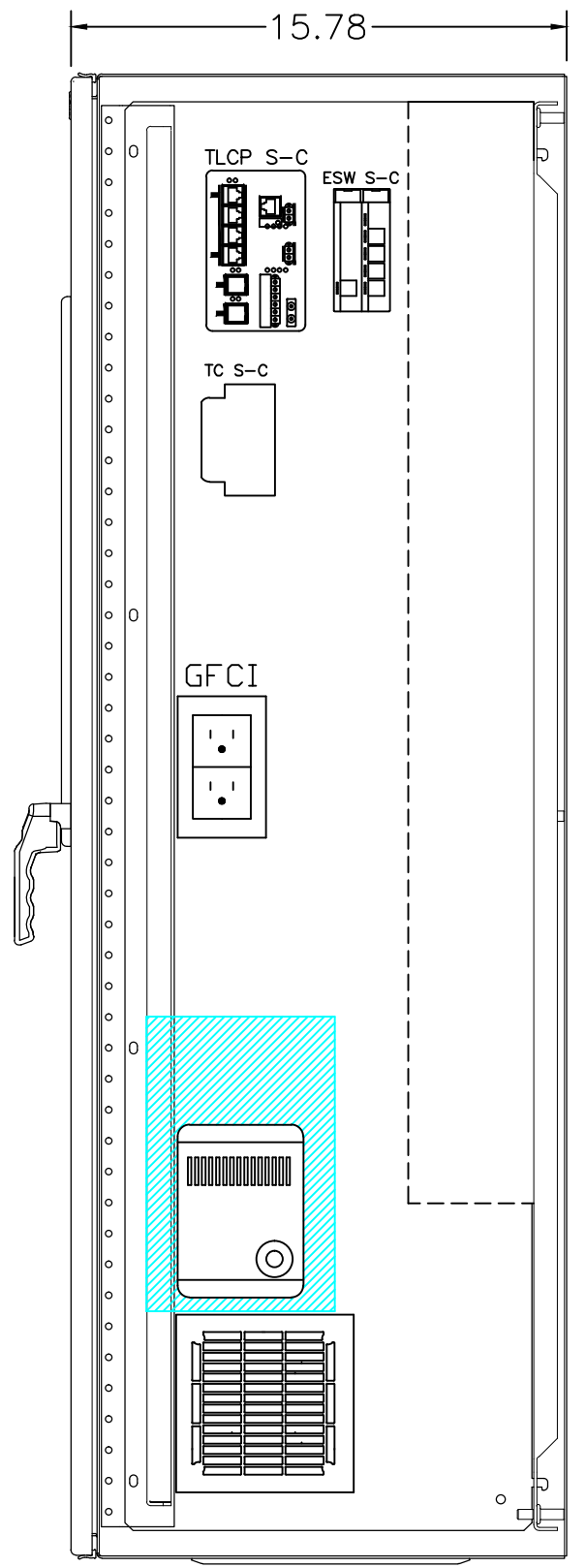
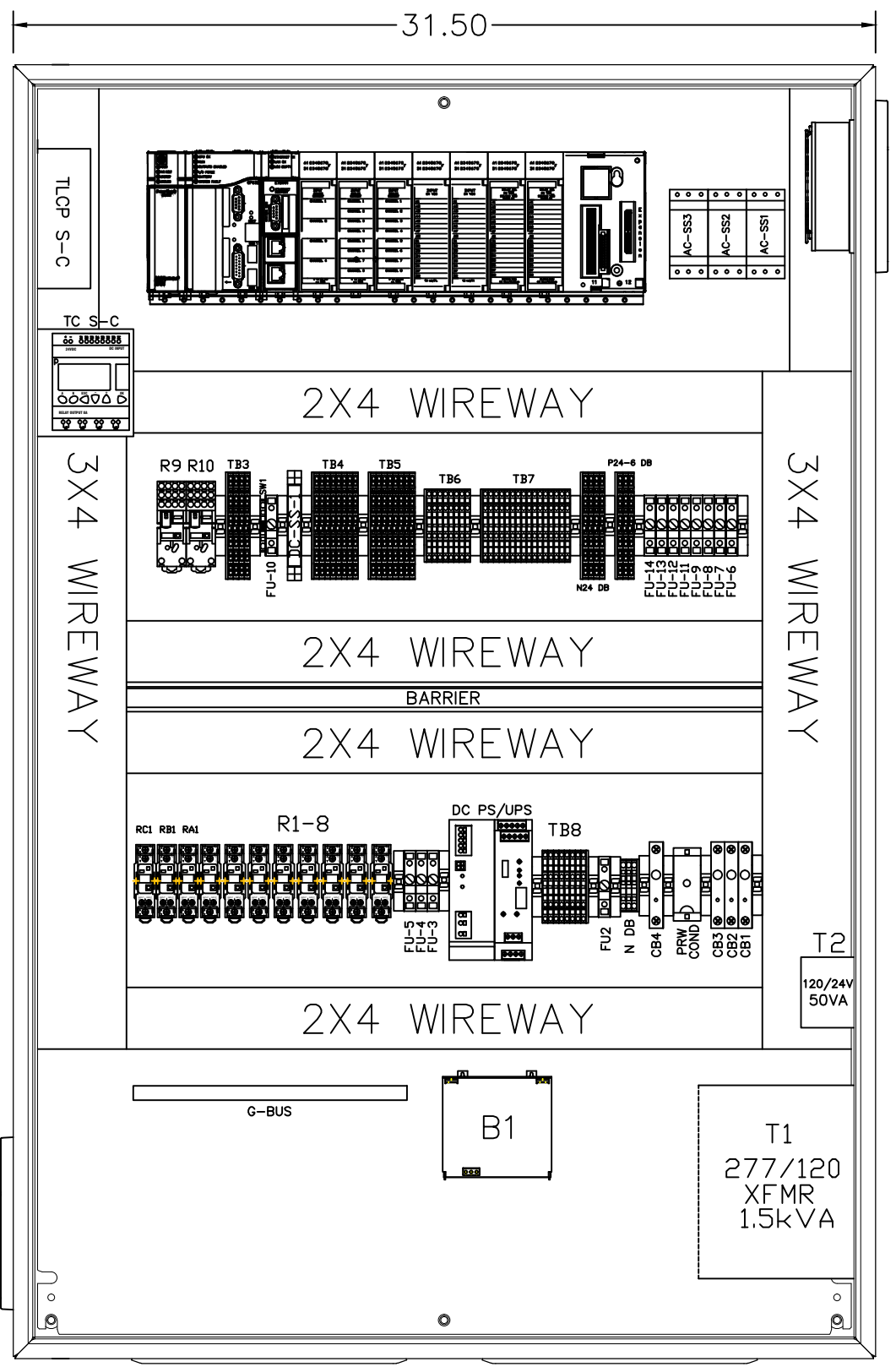
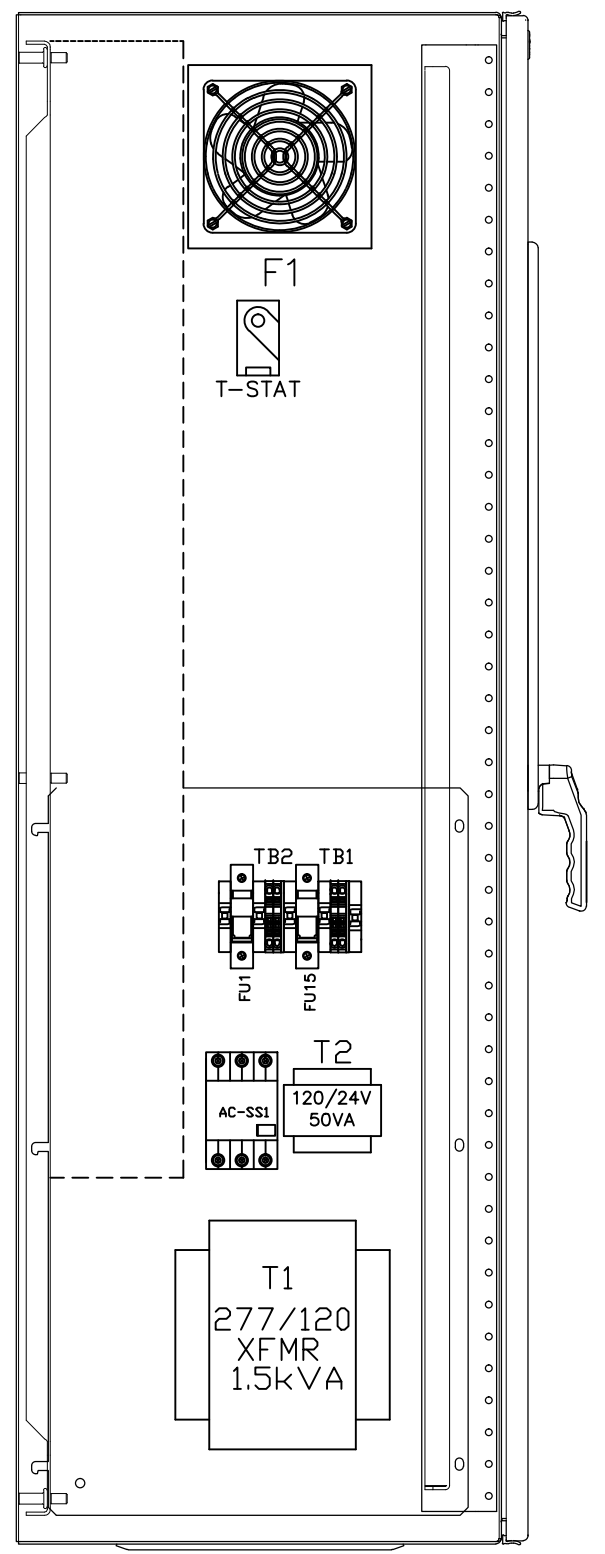


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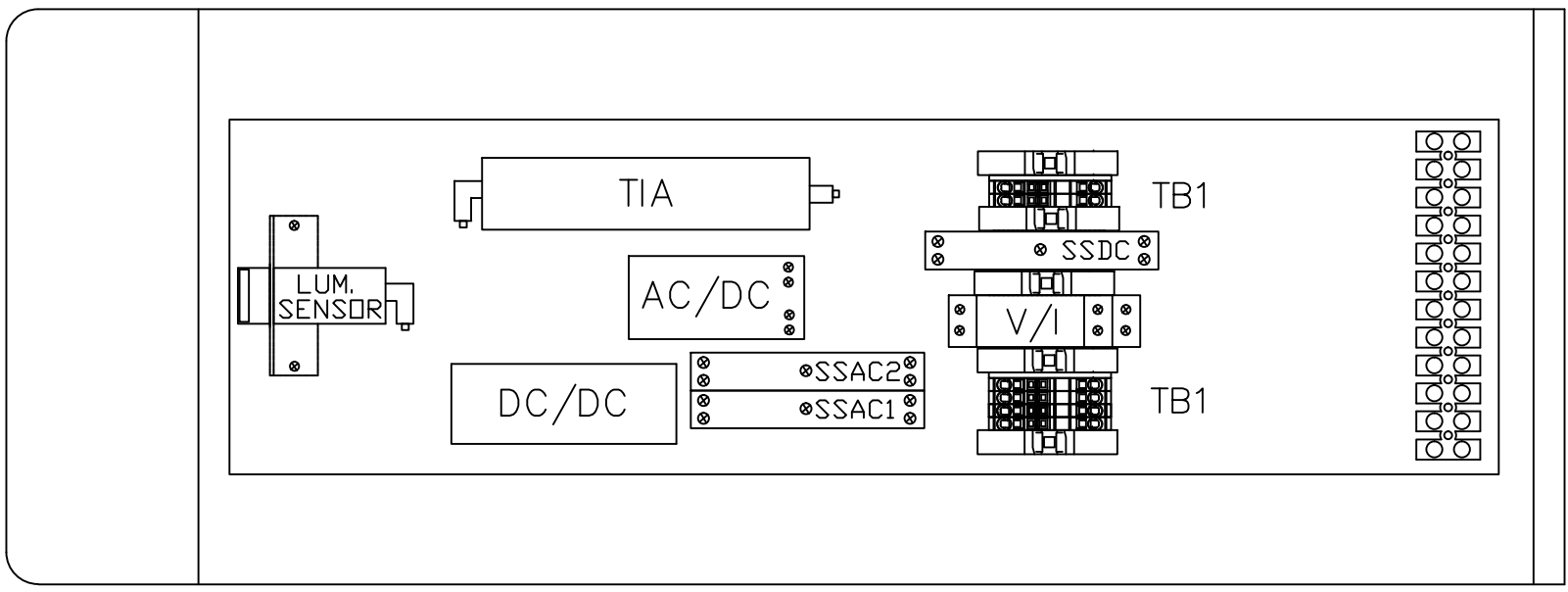


EXTERIOR

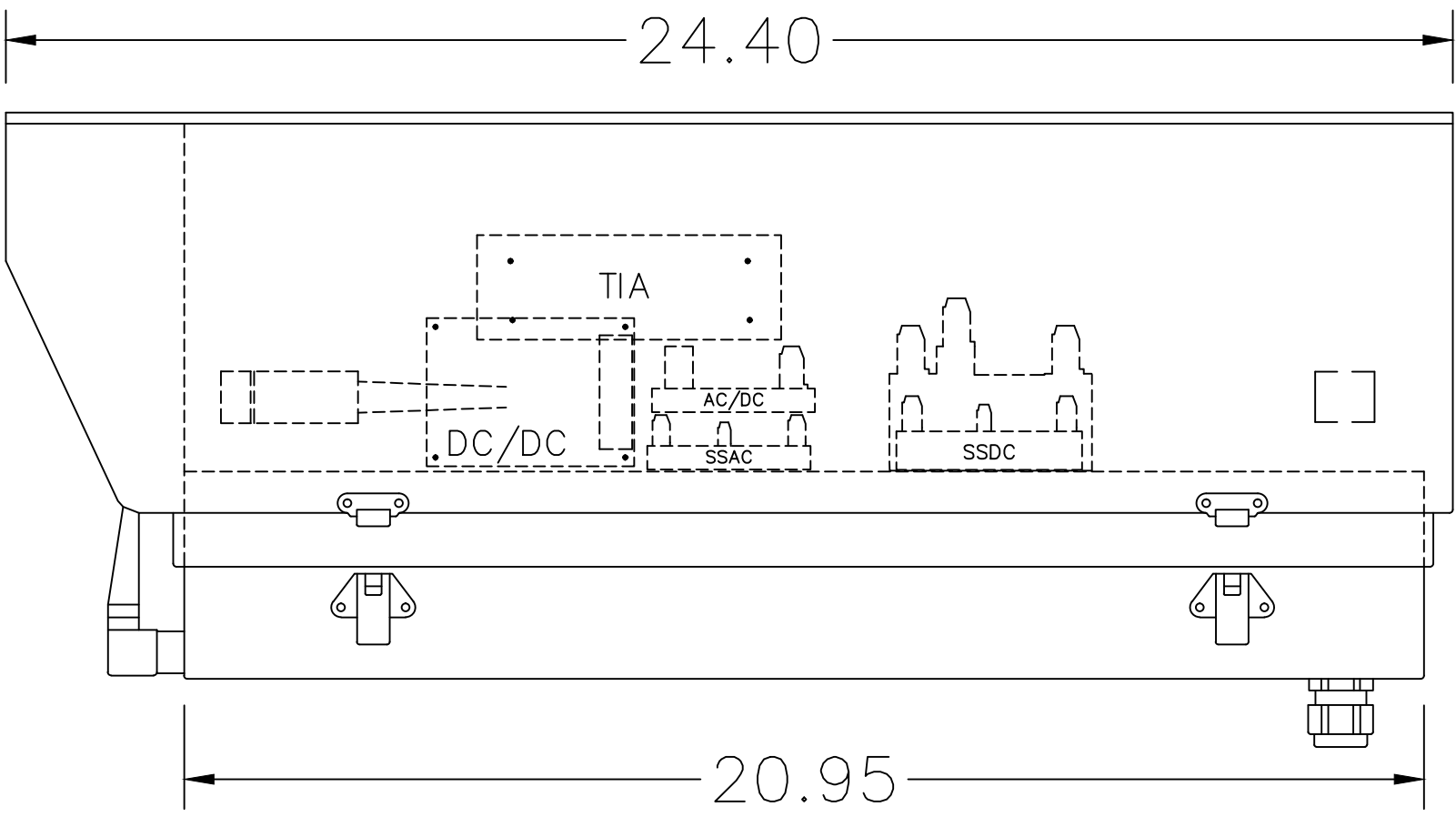
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NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
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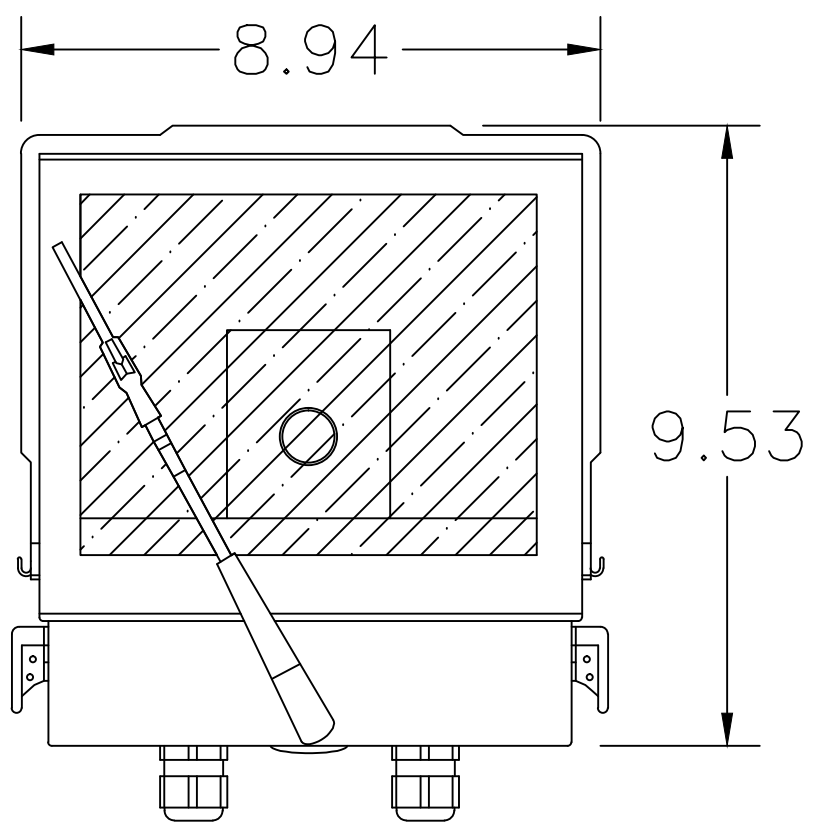


TOP VIEW



SIDE VIEW

2 x 20MM COMPRESSION GLAND.
 0.47" MAX CABLE DIAMETER.



FRONT VIEW

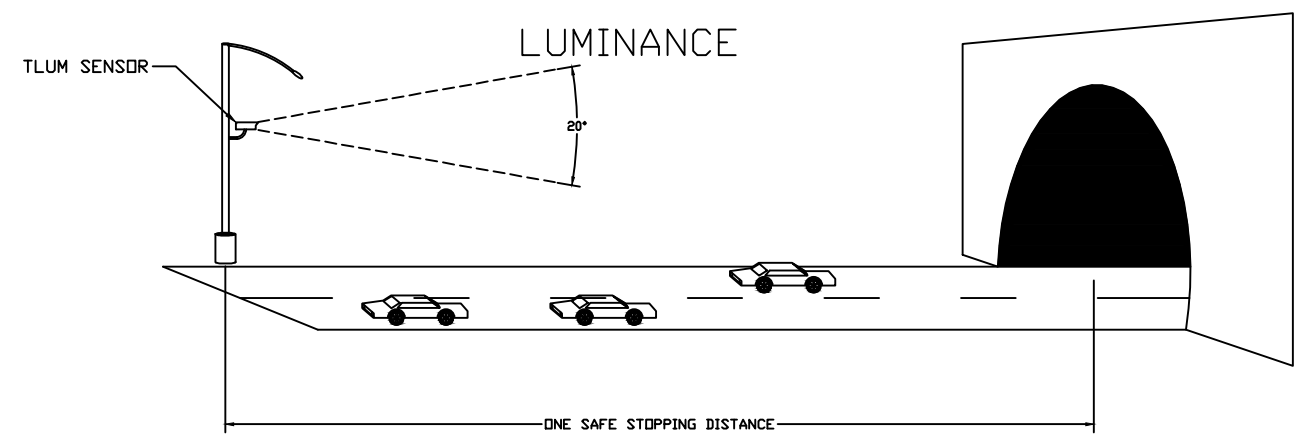
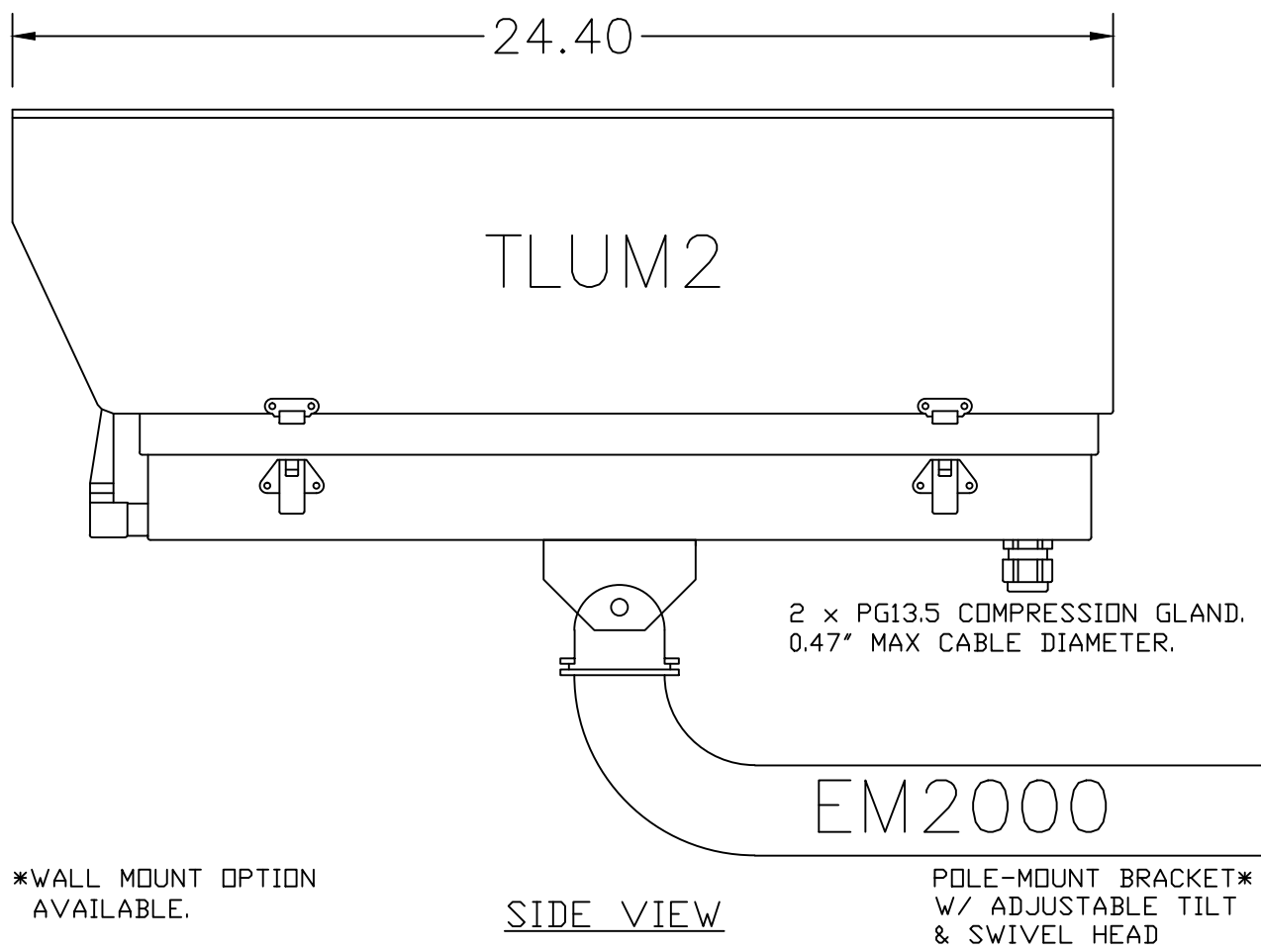
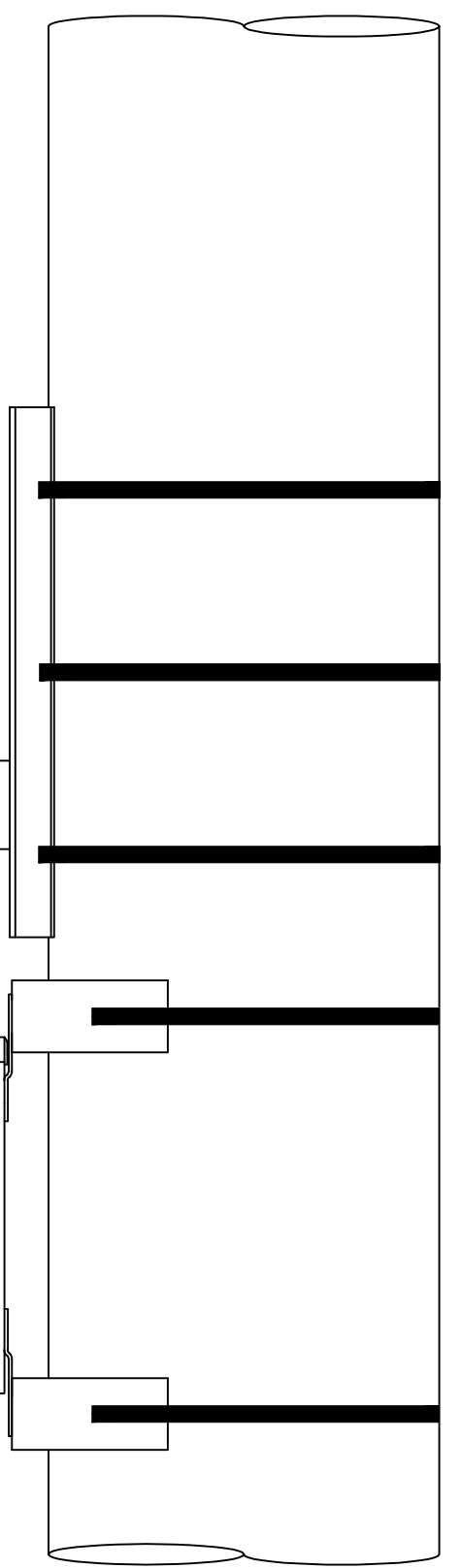
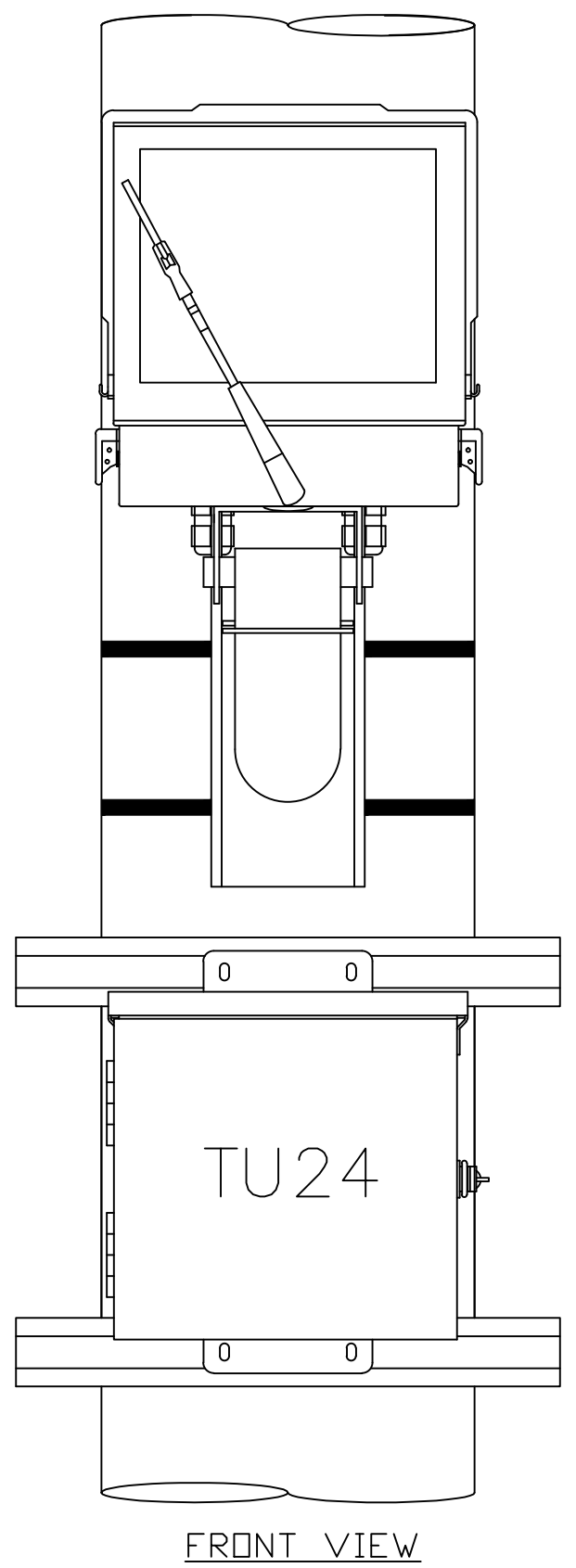
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PLC Transportation
Control Systems A Division of PLCMultiPoint

3101-111th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

LYTLE TUNNEL
 TLUM S-C
 TUNNEL LIGHTING CONTROL PANEL
 TLUM SENSOR MOUNTING

SIZE: A SCALE: NONE DRAFTER: S. HOULE CHECKED BY: N. DITTMANN



NO.

REVISION/ISSUE:

DATE:

NO.

REVISION/ISSUE:

DATE:

DWG. NO:

200-16T17360A5

DATE:

12/7/2016

SHEET:

6/19

REV

1.0

PLC Transportation

Control Systems A Division of PLC Multipoint

3101-111th STREET S.W. #F

EVERETT, WA 98204

PH:425/353-7552 FAX:425/353-3353

PLCTRANSPORTATION.COM

LYTLE TUNNEL

TU-24 S-C

TUNNEL LIGHTING CONTROL PANEL

ASSEMBLY DRAWING

SIZE:

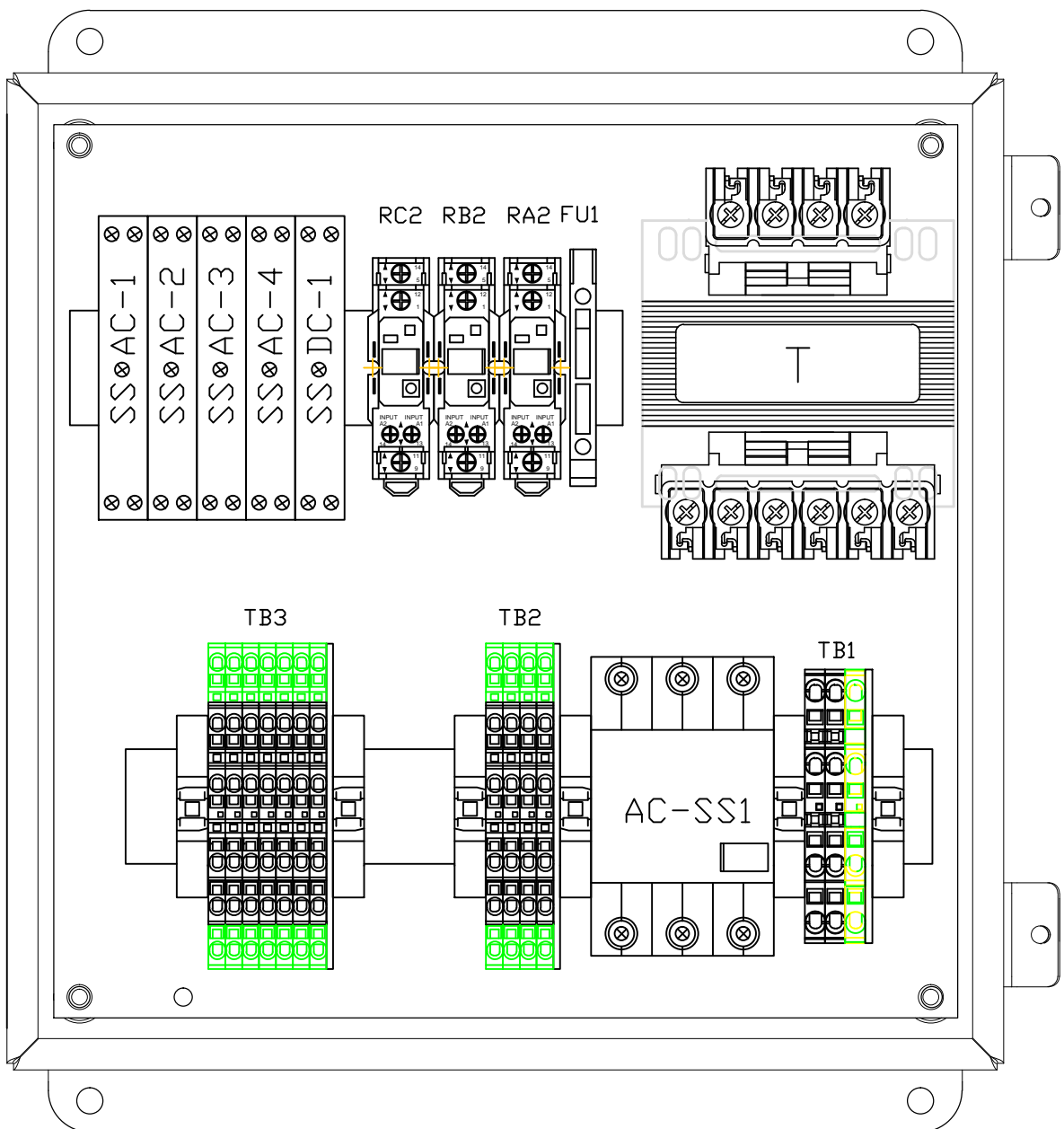
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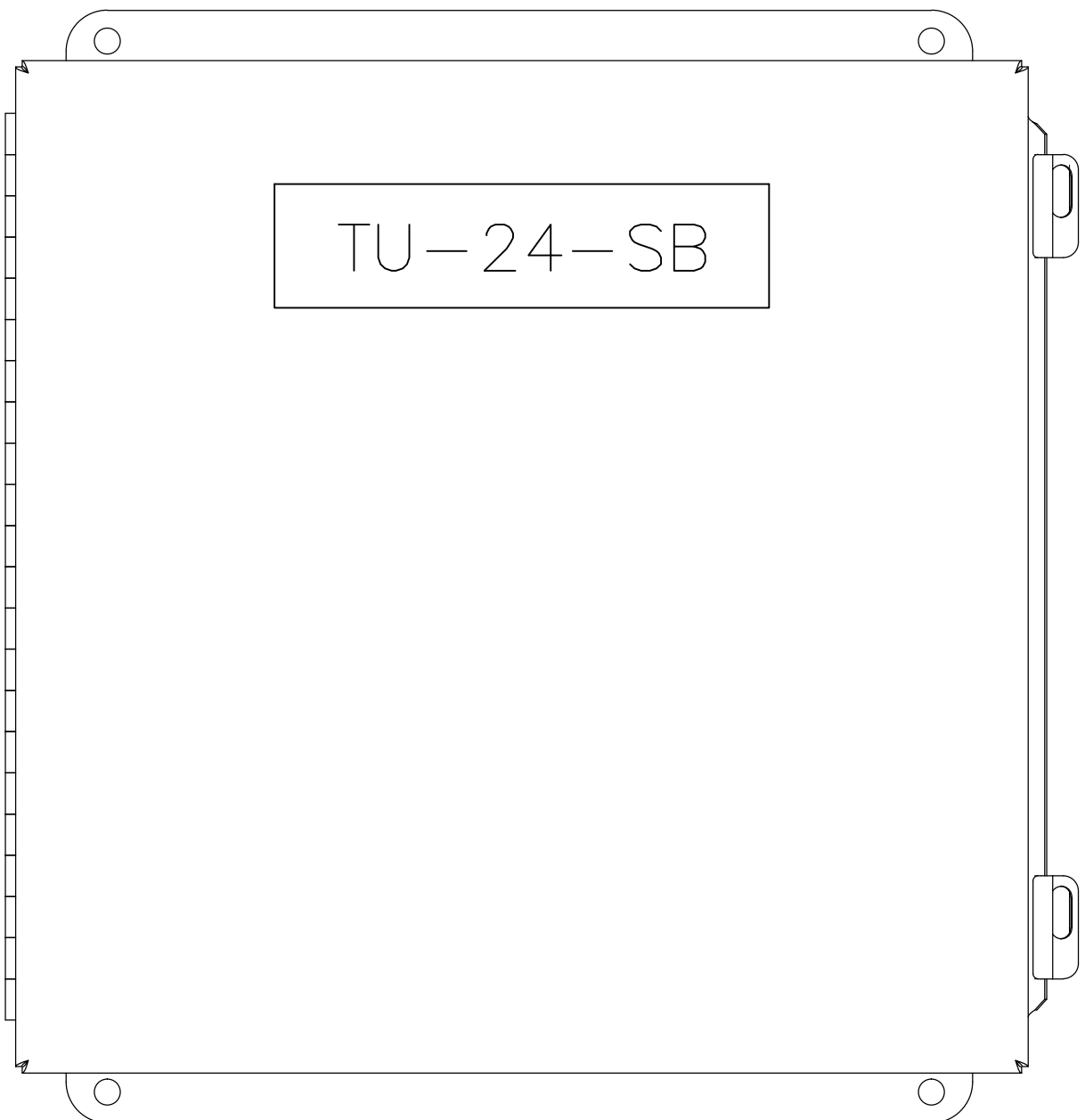
S. HOULE

CHECKED BY:

N. DITTMANN



INTERIOR VIEW

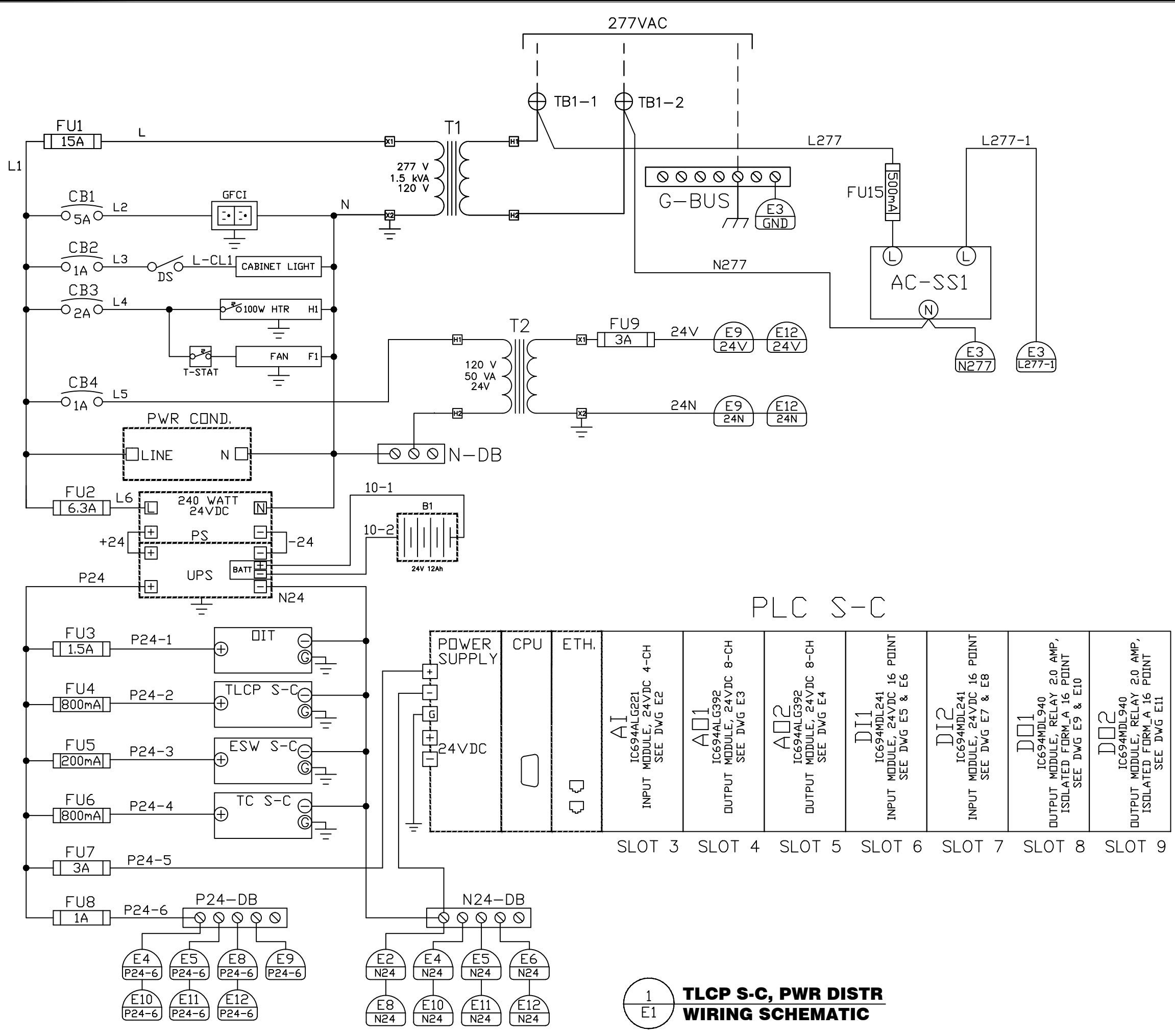


EXTERIOR VIEW

12"H x 12"W x 6"D

1
A5

**LYTLE TNL TU-24 S-C
SENSOR MOUNTING**

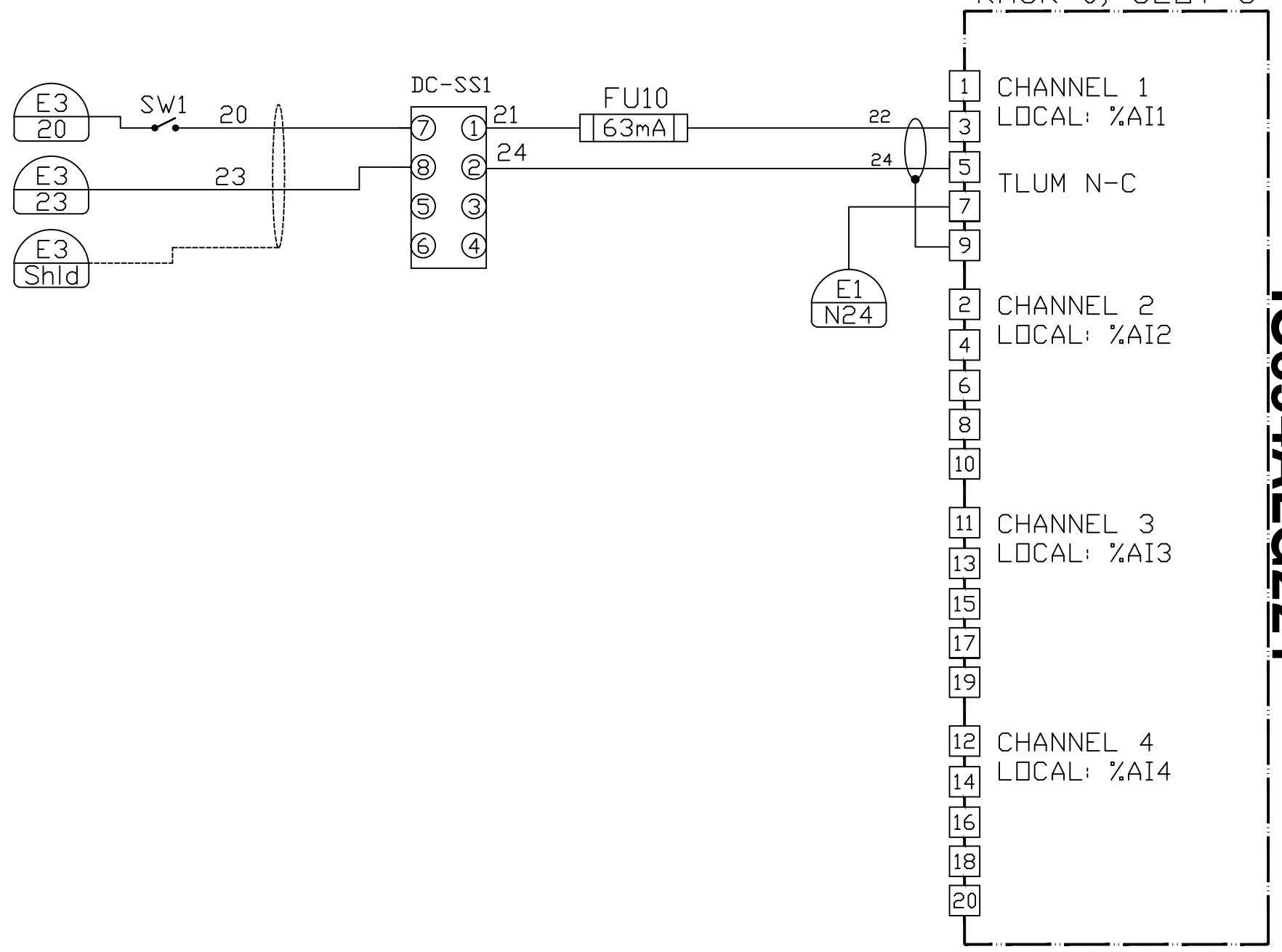


1
E1 **TLCP S-C, PWR DISTR WIRING SCHEMATIC**

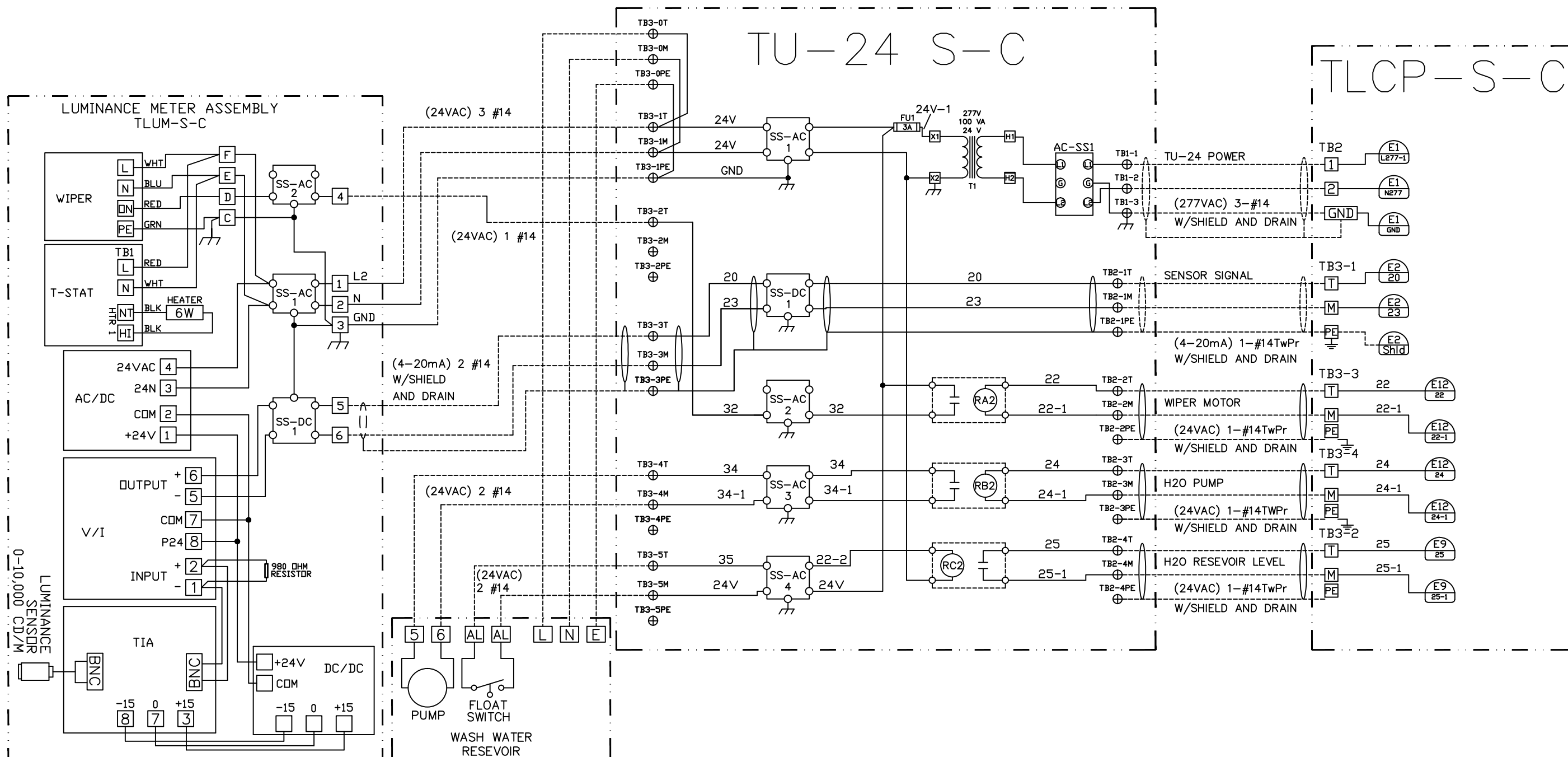
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PLC Transportation <i>Control Systems A Division of PLC Multipoint</i>							3101-111th STREET S.W. #F EVERETT, WA 98204 PH:425/353-7552 FAX:425/353-3353 PLCTRANSPORTATION.COM			
LYTLE TUNNEL TLCP S-C, AI TUNNEL LIGHTING CONTROL PANEL WIRING SCHEMATIC							SIZE: A	SCALE: NONE	DRAFTED: S. HOULE	CHECKED BY: N. DITTMANN

T57-6 CONTROLLER
 4-CH ANALOG INPUT
 RACK 0, SLOT 3

IC694ALG221



TU-24 POLE MOUNTED ENCLOSURE, APPROX 12X12X8



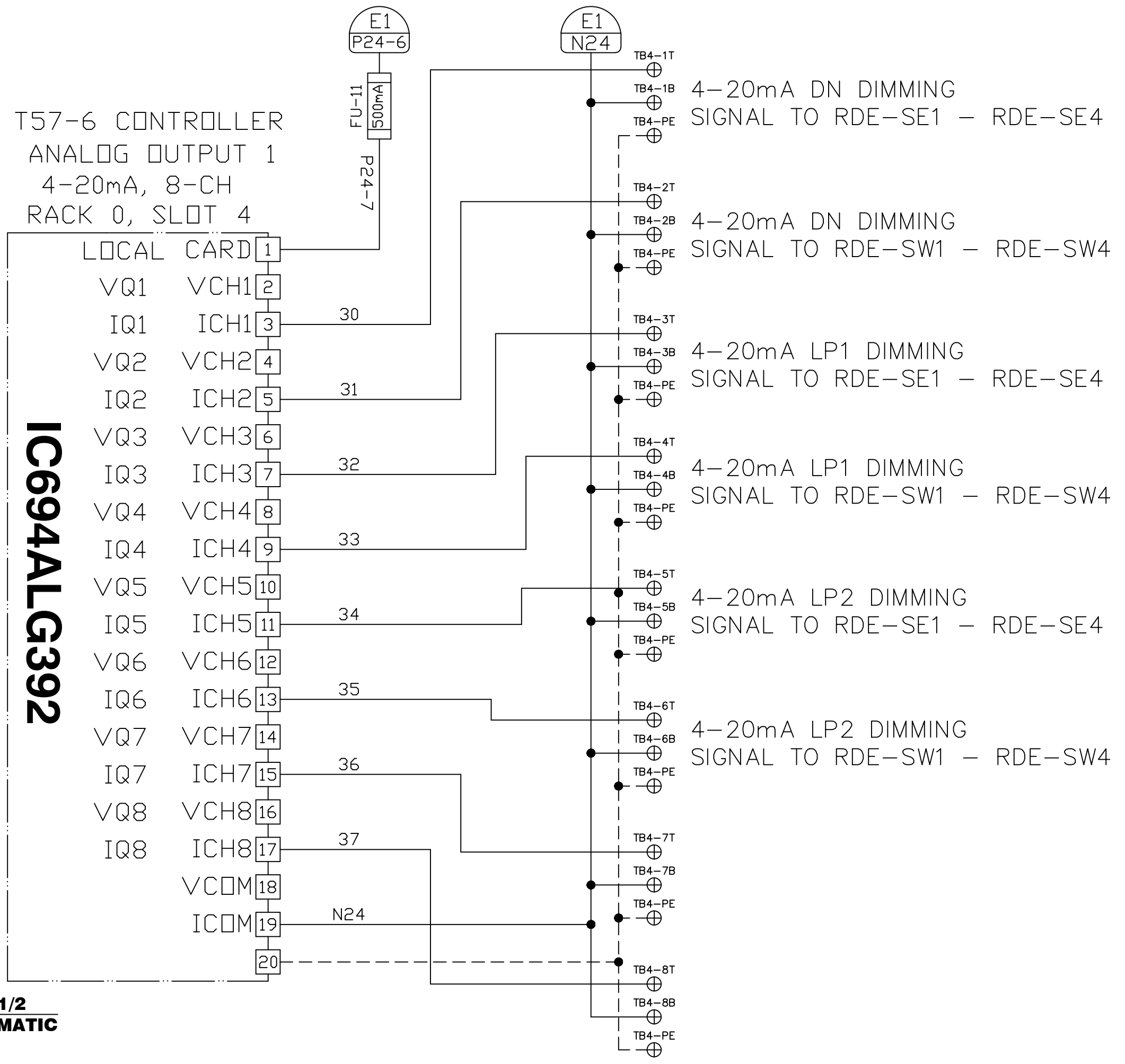
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E3 **TLCP S-C, TU-24 S-C**
WIRING SCHEMATIC

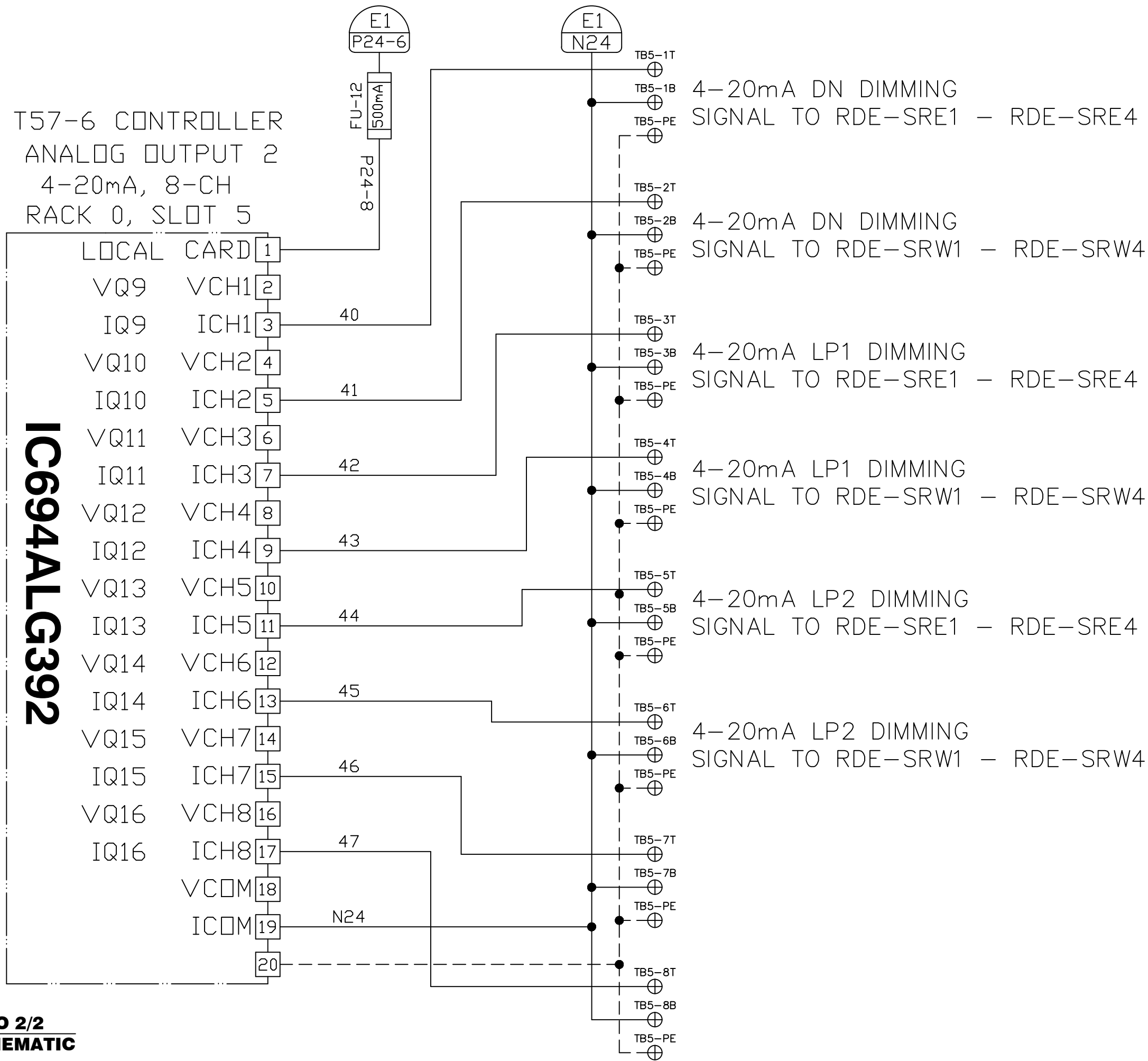
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PLC Transportation <i>Control Systems A Division of PLC Multipoint</i>					
3101-11th STREET S.W. #F EVERETT, WA 98204 PH: 425/353-7552 FAX: 425/353-3353 PLCTRANSPORTATION.COM					
DWG. NO:	DATE:	NO.	DATE:	NO.	DATE:
200-16T17630E3	12/7/2016				
LYTLE TUNNEL TU-24 S-C TUNNEL LIGHTING CONTROL PANEL WIRING SCHEMATIC					
SCALE:	DRAWN:	CHECKED BY:	NO.	DATE:	REV.
NONE	S. HOULE	N. DITTMANN			

NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
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PLC Transportation
 Control Systems A Division of PLC Multipoint
 3101-111th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

LYTLE TUNNEL
 TLCP S-C, AD 1/2
 TUNNEL LIGHTING CONTROL PANEL
 WIRING SCHEMATIC
 SIZE: A
 SCALE: NONE
 DRAFTER: S. HOULE
 CHECKED BY: N. DITTMANN





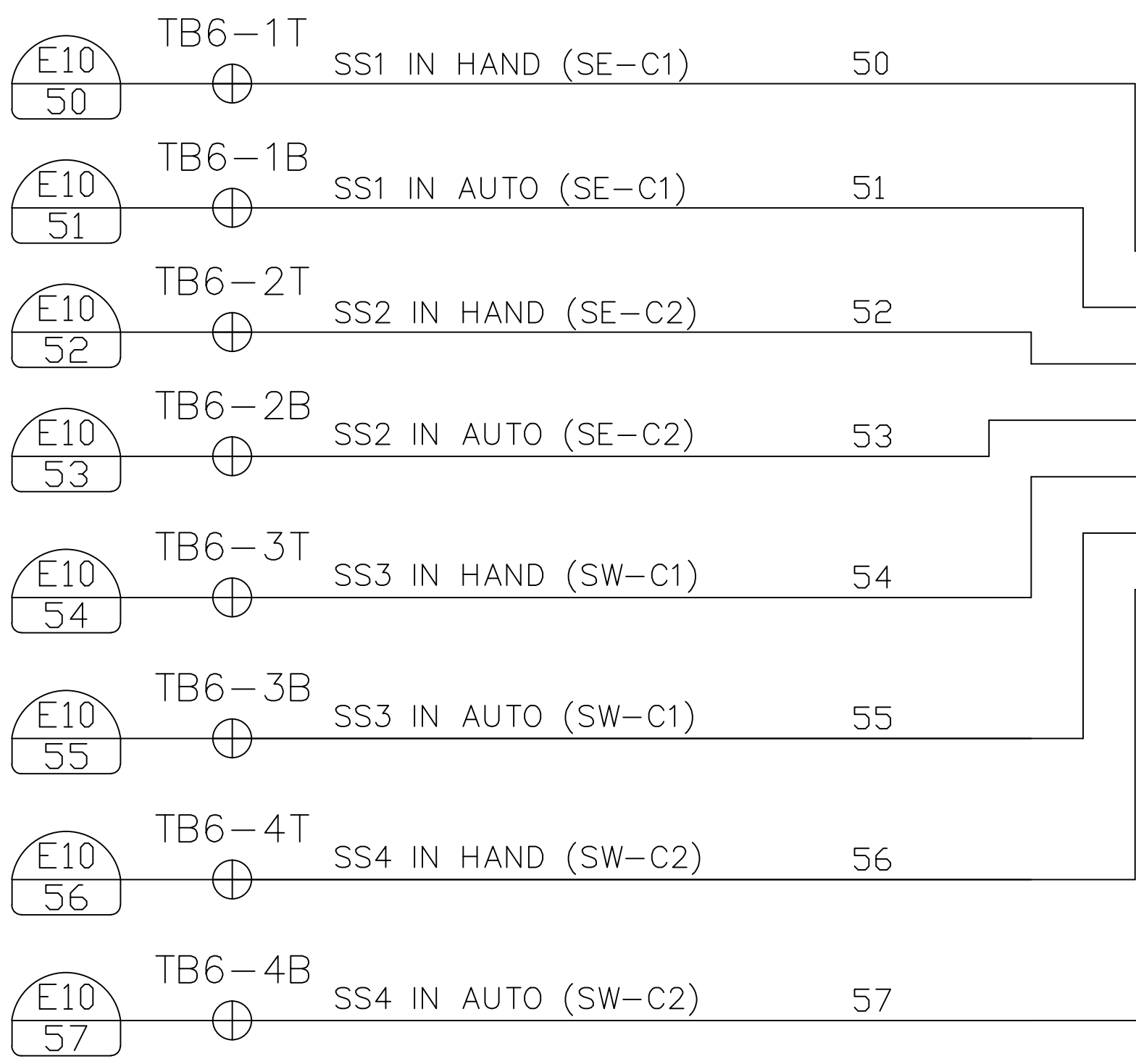
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						200-16T17630E6	12/7/2016	12/19	1.0

T57-6 CONTROLLER
24VDC INPUT 1
16 POINT
RACK 0, SLOT 6

IC694MDL241

1	CARD	LOCAL
2	A1	%I1
3	A2	%I2
4	A3	%I3
5	A4	%I4
6	A5	%I5
7	A6	%I6
8	A7	%I7
9	A8	%I8
10	B1	%I9
11	B2	%I10
12	B3	%I11
13	B4	%I12
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E1
N24



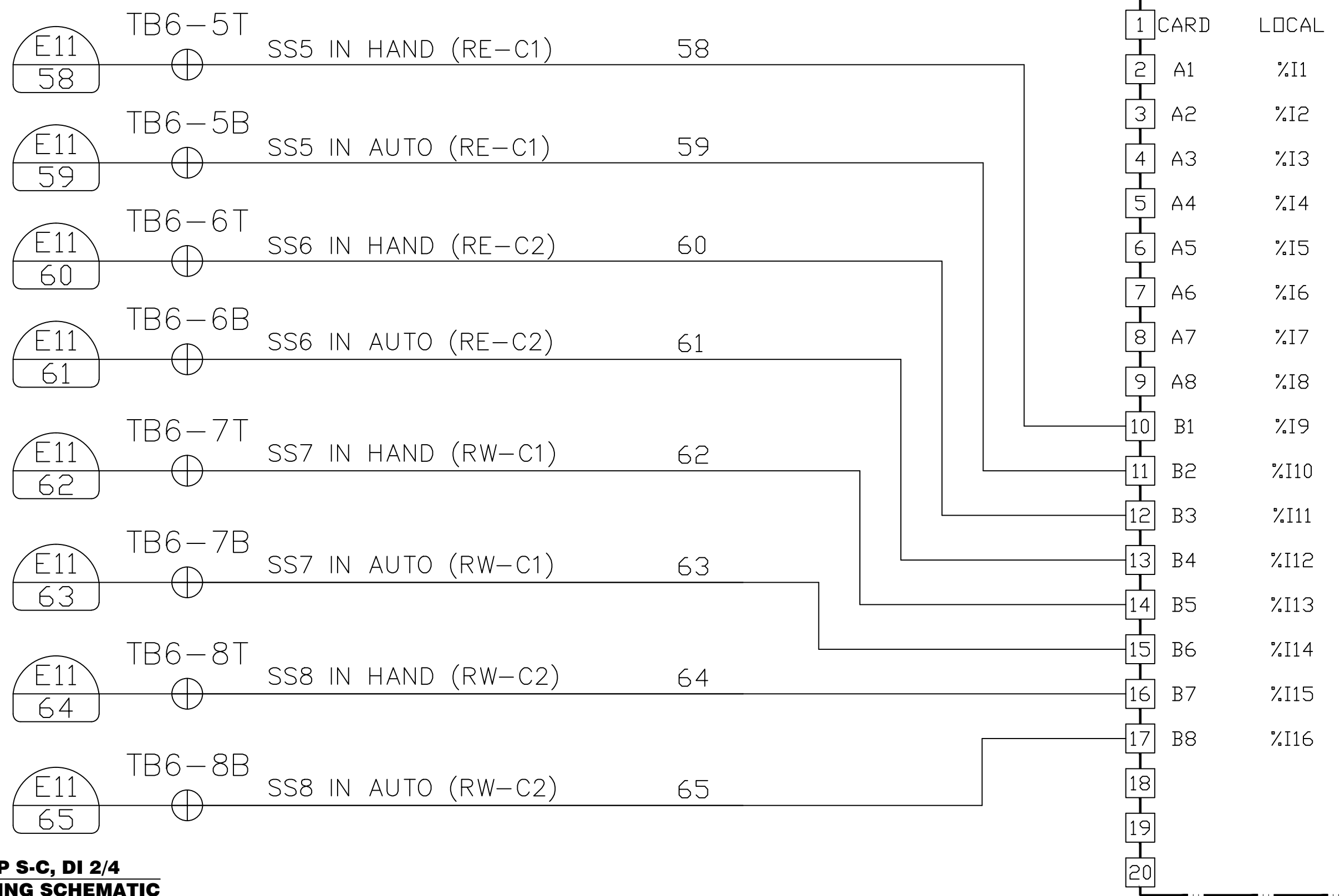
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PLC Transportation
Control Systems A Division of PLC Multipoint
 3101-11th STREET S.W. #F
 EVERETT, WA 98204
 PH:425/353-7552 FAX:425/353-3353
 PLCTRANSPORTATION.COM

LYTLE TUNNEL
 TLCP S-C, DI 2/4
 TUNNEL LIGHTING CONTROL PANEL
 WIRING SCHEMATIC
 SIZE: A
 SCALE: NONE
 DRAFTED: S. HOULE
 CHECKED BY: N. DITTMANN

T57-6 CONTROLLER
 24VDC INPUT 1
 16 POINT
 RACK 0, SLOT 6

IC694MDL241



NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	SHEET:	REV
						200-16T17630E8	12/7/2016	14/19	1.0

PLC Transportation
Control Systems A Division of PLC Multipoint

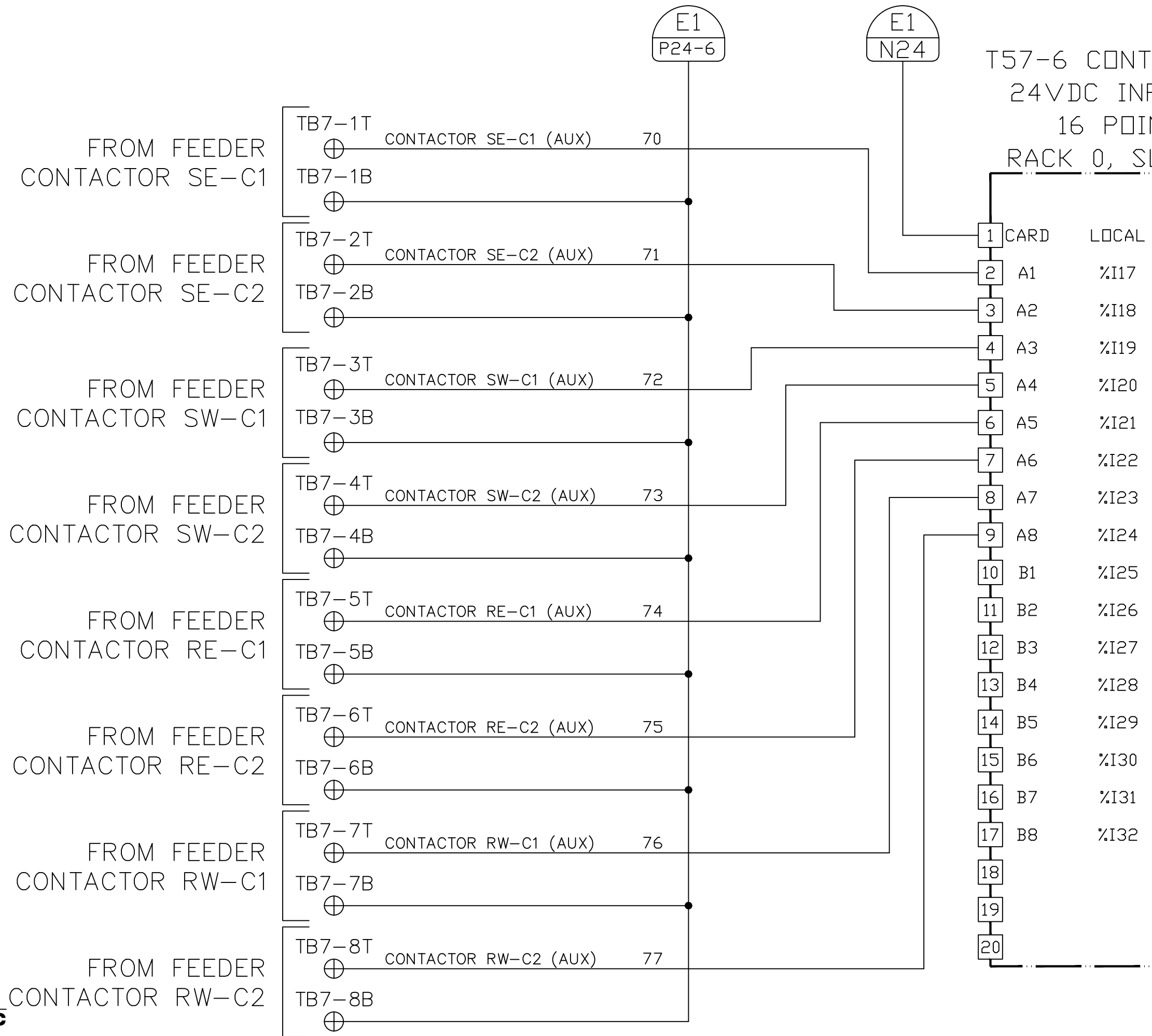
3101-11th STREET S.W. #F
EVERETT, WA 98204
PH:425/353-7552 FAX:425/353-3353
PLCTRANSPORTATION.COM

LYTLE TUNNEL
TLCP S-C, DI 3/4
TUNNEL LIGHTING CONTROL PANEL
WIRING SCHEMATIC

SIZE: A
SCALE: NONE
DRAFTED: S. HOULE
CHECKED BY: N. DITTMANN

T57-6 CONTROLLER
24VDC INPUT 2
16 POINT
RACK 0, SLOT 7

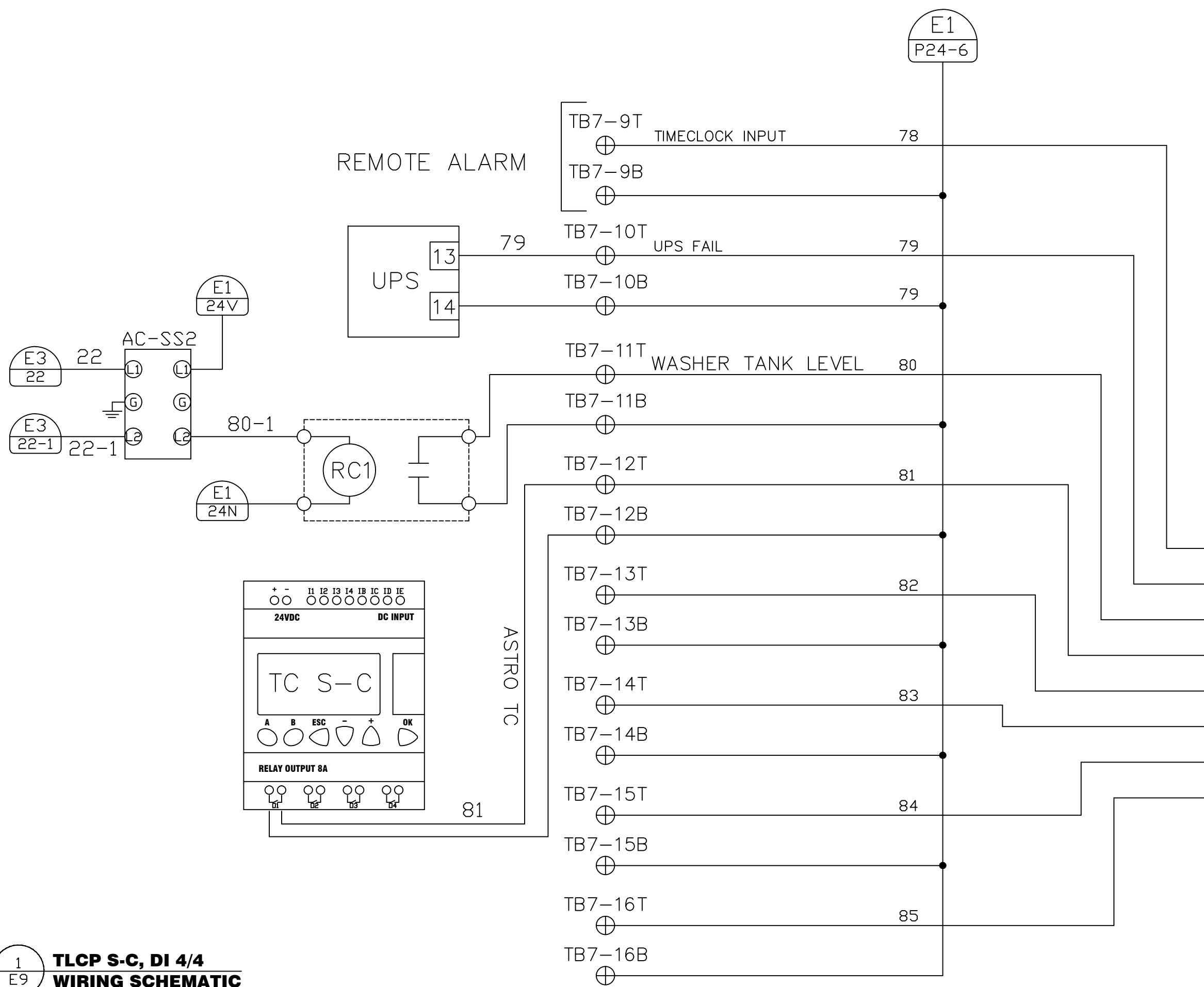
IC694MDL241



T57-6 CONTROLLER
 24VDC INPUT 2
 16 POINT
 RACK 0, SLOT 7

IC694MDL241

1	CARD	LOCAL
2	A1	%.I17
3	A2	%.I18
4	A3	%.I19
5	A4	%.I20
6	A5	%.I21
7	A6	%.I22
8	A7	%.I23
9	A8	%.I24
10	B1	%.I25
11	B2	%.I26
12	B3	%.I27
13	B4	%.I28
14	B5	%.I29
15	B6	%.I30
16	B7	%.I31
17	B8	%.I32
18		
19		
20		



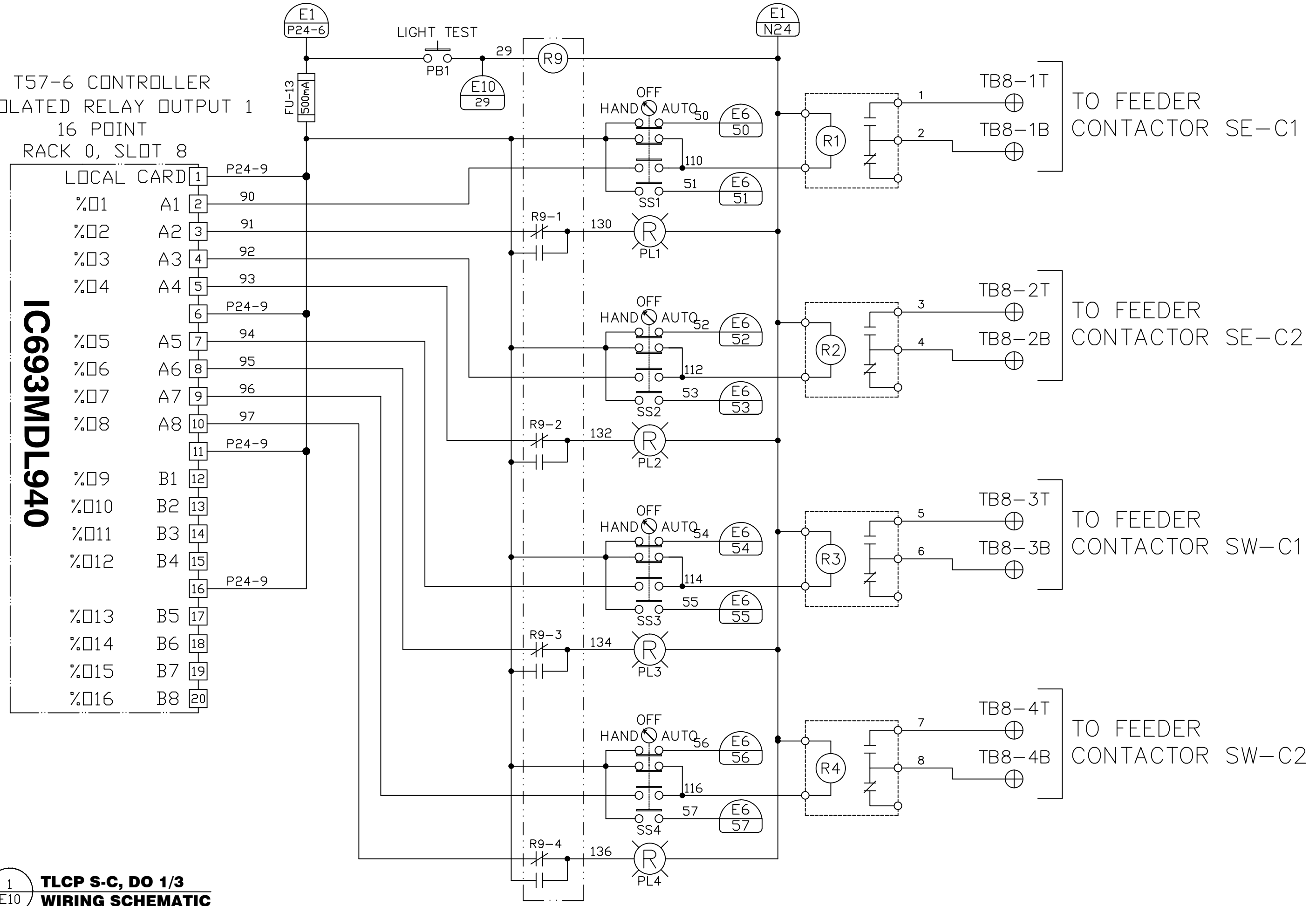
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						200-16117630E10	12/7/2016	16/19	1.0

PLC Transportation
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PLCTRANSPORTATION.COM

LYTLE TUNNEL
TLCP S-C, DD 1/3
TUNNEL LIGHTING CONTROL PANEL
WIRING SCHEMATIC
SIZE: A
SCALE: NONE
DRAFTED: S. HOULE
CHECKED BY: N. DITTMANN

T57-6 CONTROLLER
ISOLATED RELAY OUTPUT 1
16 POINT
RACK 0, SLOT 8

IC693MDL940

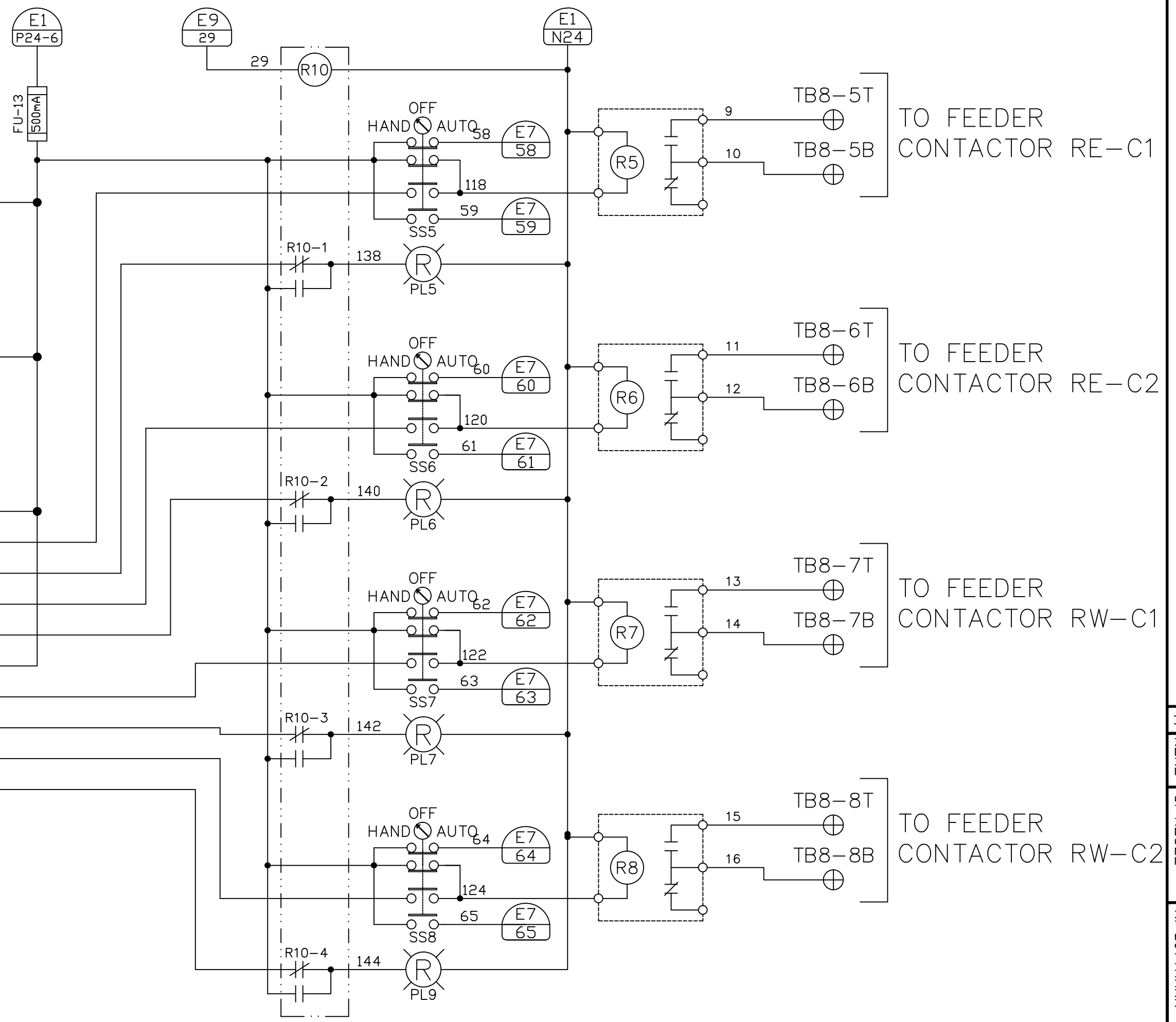


1 TLCP S-C, DO 1/3
E10 WIRING SCHEMATIC

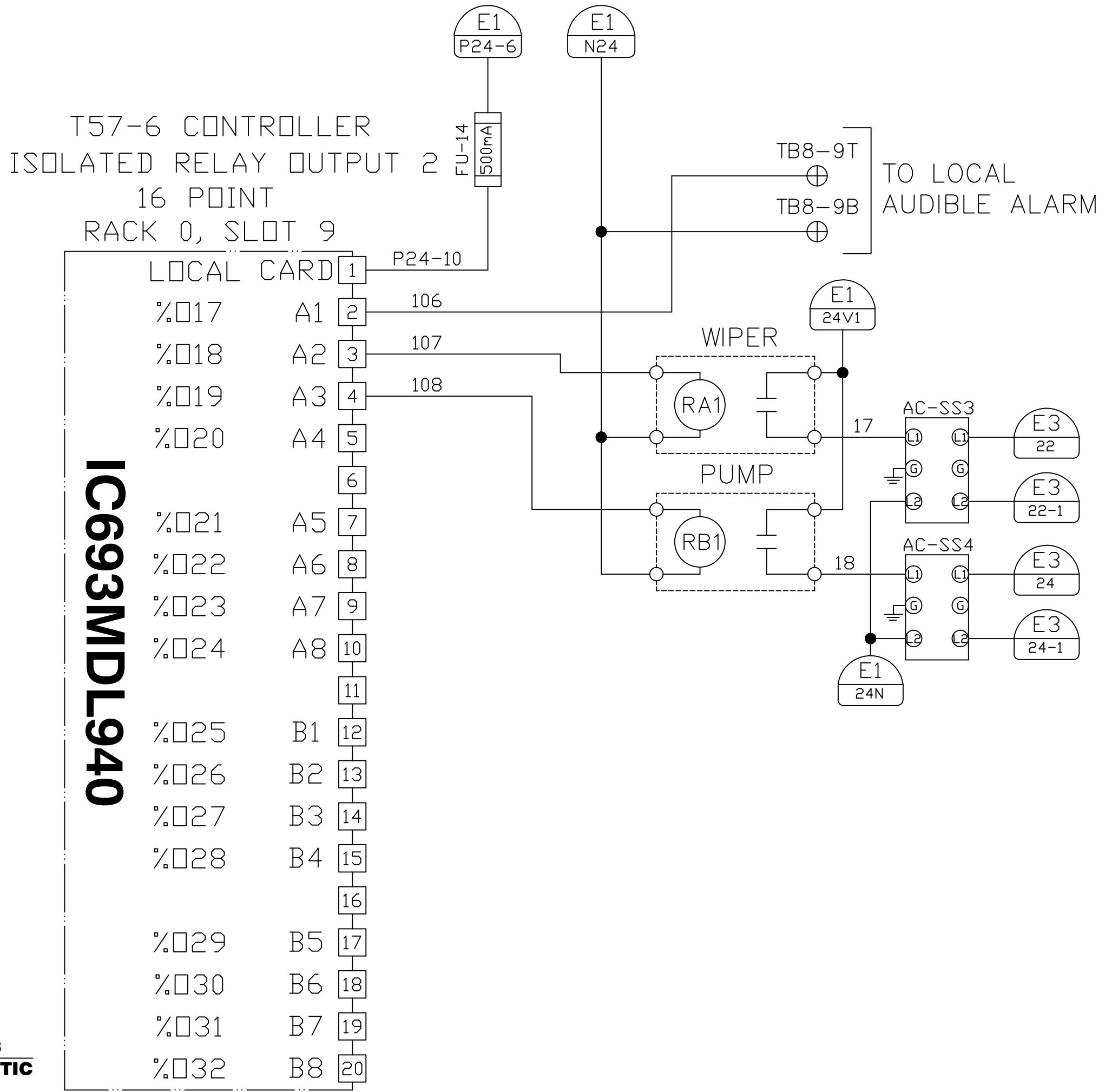
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						200-16117630E11	12/7/2016	17/19	1.0

T57-6 CONTROLLER
ISOLATED RELAY OUTPUT 1
16 POINT
RACK 0, SLOT 8

LOCAL CARD		1	P24-9
%01	A1	2	
%02	A2	3	
%03	A3	4	
%04	A4	5	
		6	P24-9
%05	A5	7	
%06	A6	8	
%07	A7	9	
%08	A8	10	
		11	P24-9
%09	B1	12	98
%010	B2	13	99
%011	B3	14	100
%012	B4	15	101
		16	P24-9
%013	B5	17	102
%014	B6	18	103
%015	B7	19	104
%016	B8	20	105

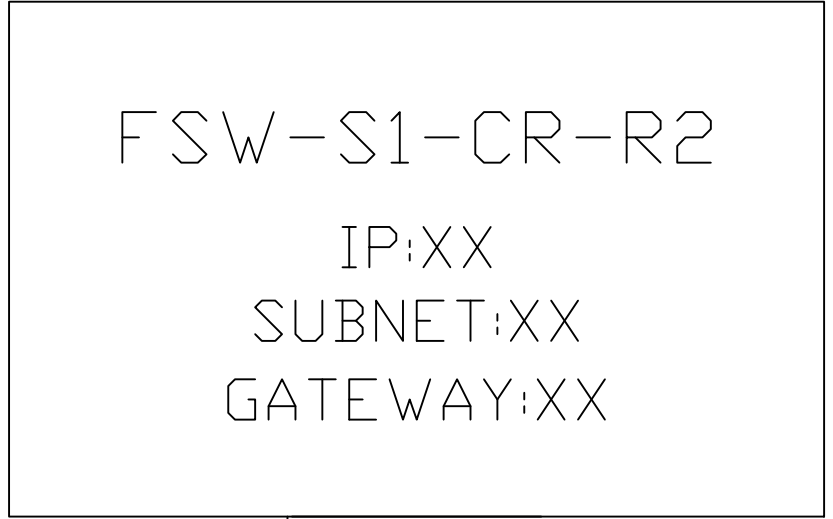


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						200-16117630E12	12/7/2016	18/19	1.0



NO.	REVISION/ISSUE:	DATE:	NO.	REVISION/ISSUE:	DATE:	DWG. NO:	DATE:	13/13	REV
						200-16117630E13	12/7/2016	19/19	1.0

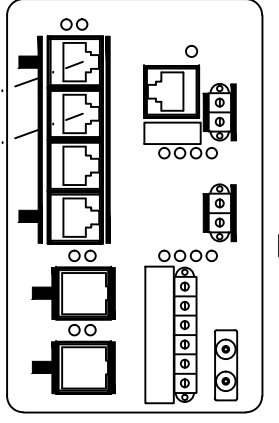
FAN-PLC CABINET



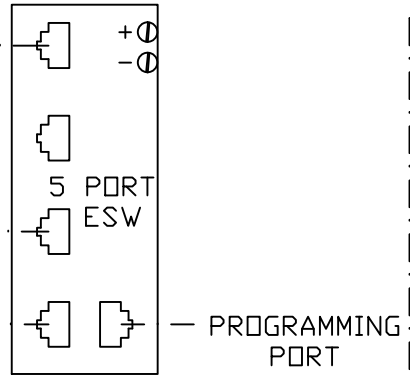
CAT6e

IP:XX
 SUBNET:XX
 GATEWAY:XX

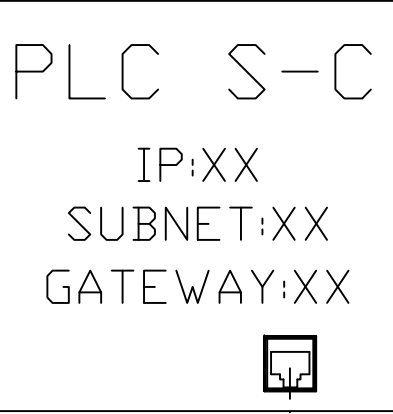
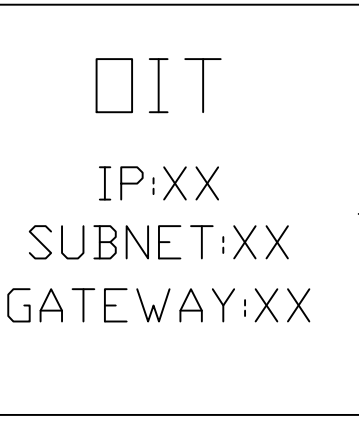
TLCP S-C
 IE-2000-4TS



IP:XX
 SUBNET:XX
 GATEWAY:XX



ESW S-C



- CAT6 - RJ45
- FIBER OPTIC CABLE, SM, LC CONNECTORS
- - - - FIBER OPTIC CABLE, SM, LC CONNECTORS EXTERNAL TO TLCP

TLCP S-C



Buildings • Sensors • Transportation • Industrials

Lytle Tunnel Cincinnati LIGHTING CONTROL SYSTEM

TESTING

Test Procedure for 16T17630 N-C Cincinnati Lytle Tunnel

Rev 1.0

General Organization

The test procedure follows the drawing pages 16T17630 Rev 0.1

Equipment needed

Multimeter

PC with Versamax software

PC with Modbus Master Software

Tested by: Norm Dittmann
Test Date 04/29/17

NOTE: SETUP STEPS ARE SHOWN IN BOLD.

Tested by: Norm D.

Page E1, Sheet 7/15 Rev 0.1

Device	Test Point/Action	Expected Result	Pass/Fail
Apply 120 VAC to TB1-1 and TB1-2 terminals			
Cabinet Light	CB2 closed. Close door switch	Light on	Pass
GFCI	CB1 closed. Probe outlet with DMM	120 VAC	Pass
Power Conditioner	L1 and N	120 VAC	Pass
Transformer T1	X1 & X2	120 VAC	Pass
Surge Suppressor AC-SS1	L1 and L2	24 VAC	Pass
PLC CPU	P24-5 and N24-DB	24VDC	Pass
OIT	P24-1 and N24	24 VDC	Pass
DC Power Supply	P24 and N24	24 VDC	Pass
Heater	CB3 closed +cold	Heater On	Pass
Fan	CB3 closed + heat	Fan On	Pass
Transformer T2	CB4 closed. X1 & X2	24V	Pass
Time Clock	P24	24V DC	Pass
Surge Suppressor AC-SS2	L1 and L2	24 VAC	Pass
Surge Suppressor AC-SS3	L1 and L2	24 VAC	Pass
Surge Suppressor AC-SS4	L1 and L2	24 VAC	Pass
Surge Suppressor AC-SS1	L1 & L2	24V DC	Pass

Page E2, Sheet 6/12 Rev 0.1

Device	Test Point/Action	Expected Result	Pass/Fail
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Luminance Sensor Assambly

Ensure 120 VAC is removed from L & N

Set SW-1 to Open

Connect 24V, 24N & Gnd from Panel TB2-1, 2 and 3 to Meter TB1-L, N and G respectively

Connect Sig+ and Sig - from Panel TB3-1 and 2 to Meter TB1-1 and 2 respectively.

Test Meter Assembly			
Close SW-1			
Close T-Stat in Meter Assembly	Heater Power	Heat On	Pass
Open T-Stat in Meter Assembly	Heater Power	Heat Off	Pass
Observe the PLC address Slot AI1, Ch 1. Operate from 0 - 10000 CD/M ² to simulate 4 - 20 mA.	Slot AI1, Ch 1	Input Ch 1 illuminates. Monitor sensor value in PC.	
Open SW-1			

NOTE: SETUP STEPS ARE SHOWN IN BOLD.

Tested BY: Norm D.

Page E4, Sheet 10/15 Rev 0.1

Device	Test Point/Action	Card	Expected Result	Pass/Fail
Connect PC to panel controller via Ethernet and activate PLC monitoring program.				
Using the IO map, monitor each input and verify activation in the PLC.				

Signal to DN RDE-NE4	Set AO to 0, ~6400, ~32000	AO 0,4 - Ch 1	0, 4, 20 mA	Pass
Signal to DN RDE-NW4	Set AO to 0, ~6400, ~32000	AO 0,4 - Ch 2	0, 4, 20 mA	Pass
Signal to LP1 RDE-NE4	Set AO to 0, ~6400, ~32000	AO 0,4 - Ch 3	0, 4, 20 mA	Pass
Signal to LP1 RDE-NW4	Set AO to 0, ~6400, ~32000	AO 0,4 - Ch 4	0, 4, 20 mA	Pass
Signal to LP2 RDE-NE4	Set AO to 0, ~6400, ~32000	AO 0,4 - Ch 5	0, 4, 20 mA	Pass
Signal to LP2 RDE-NW4	Set AO to 0, ~6400, ~32000	AO 0,4 - Ch 6	0, 4, 20 mA	Pass

Page E5, Sheet 11/15 Rev 0.1

Device	Test Point/Action	Card	Expected Result	Pass/Fail
Connect PC to panel controller via Ethernet and activate PLC monitoring program.				
Using the IO map, monitor each input and verify activation in the PLC.				

SS-1 to Hand (L-D1 S. Lane)	Input A1	DI 0,5 - Ch 1	A1 Illuminates	Pass
SS-1 to Auto (L-D1 S. Lane)	Input A2	DI 0,5 - Ch 2	A2 Illuminates	Pass
SS-1 to Off	Input A2	DI 0,5 - Ch 2	A2&A1 is off	Pass
SS-2 to Hand (L-D1 S. Lane)	Input A3	DI 0,5 - Ch 3	A3 Illuminates	Pass
SS-2 to Auto (L-D1 S. Lane)	Input A4	DI 0,5 - Ch 4	A4 Illuminates	Pass
SS-2 to Off	Input A4	DI 0,5 - Ch 4	A3&A4 is off	Pass
SS-3 to Hand (L-D1 S. Lane)	Input A5	DI 0,5 - Ch 5	A5 Illuminates	Pass
SS-3 to Auto (L-D1 S. Lane)	Input A6	DI 0,5 - Ch 6	A6 Illuminates	Pass
SS-3 to Off	Input A6	DI 0,5 - Ch 6	A5&A6 is off	Pass
SS-4 to Hand (L-D1 S. Lane)	Input A7	DI 0,5 - Ch 7	A7 Illuminates	Pass
SS-4 to Auto (L-D1 S. Lane)	Input A7	DI 0,5 - Ch 7	A8 Illuminates	Pass
SS-4 to Off	Input A8	DI 0,5 - Ch 8	A7&A8 is off	Pass

Page E6, Sheet 12/15 Rev 0.1

Device	Test Point/Action	Card	Expected Result	Pass/Fail
N-E1 AUX to On (L-D1 S. Lane)	Input B1	DI 0,5 - Ch 9	B1 Illuminates	Pass
N-E1 AUX to On (L-D1 S. Lane)	Input B1	DI 0,5 - Ch 9	B1 is off	Pass
N-E2 AUX to On (L-D1 S. Lane)	Input B2	DI 0,5 - Ch 10	B2 Illuminates	Pass
N-E2 AUX to On (L-D1 S. Lane)	Input B2	DI 0,5 - Ch 10	B2 is off	Pass
N-W1 AUX to On (L-2 S. Lane)	Input B3	DI 0,5 - Ch 11	B3 Illuminates	Pass
N-W1 AUX to Off (L-2 S. Lane)	Input B3	DI 0,5 - Ch 11	B3 is off	Pass
N-W2 AUX to On (L-3 S. Lane)	Input B4	DI 0,5 - Ch 12	B4 Illuminates	Pass
N-W2 AUX to Off (L-3 S. Lane)	Input B4	DI 0,5 - Ch 12	B4 is off	Pass
REMOTE ALARM	Input B5	DI 0,5 - Ch 13	B5 Illuminates	Pass
REMOTE ALARM	Input B5	DI 0,5 - Ch 13	B5 is off	Pass
UPS FAIL	Input B6	DI 0,5 - Ch 14	B6 Illuminates	Pass
UPS FAIL	Input B6	DI 0,5 - Ch 14	B6 is off	Pass
WASHER TANK LEVEL	Input B7	DI 0,5 - Ch 15	B7 Illuminates	Pass
WASHER TANK LEVEL	Input B7	DI 0,5 - Ch 15	B7 is off	Pass
Alarm		DI 0,5 - Ch 16	On / Off	Pass

Page E7, Sheet 13/15 Rev 0.1

Device	Test Point/Action	Card	Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.

Using the IO map, activate each relay output and verify for expected results.

In the Versamax program, use the AI-RO-DI table function.

Output 1- Contactor N-E1	Set SS1 to Auto. Activate Output A1 from PC.	DO 0,6 - Ch 1	R5-1, PL1 On	Pass
Output 1- Contactor N-E1	Set SS1 to Off.	DO 0,6 - Ch 1	R5-1, PL1 Off	Pass
Output 2- Contactor N-E2	Set SS2 to Auto. Activate Output A3 from PC.	DO 0,6 - Ch 2	R5-2, PL2 On	Pass
Output 2- Contactor N-E2	Set SS2 to Off.	DO 0,6 - Ch 2	R5-2, PL2 Off	Pass
Output 3 - Contactor N-W1	Set SS3 to Auto. Activate Output A5 from PC.	DO 0,6 - Ch 3	R5-3, PL3 On	Pass
Output 3 - Contactor N-W1	Set SS3 to Off.	DO 0,6 - Ch 3	R5-3, PL3 Off	Pass
Output 4 - Contactor N-W2	Set SS4 to Auto. Activate Output A7 from PC.	DO 0,6 - Ch 4	R5-4, PL4 On	Pass
Output 4 - Contactor N-W2	Set SS4 to Off.	DO 0,6 - Ch 4	R5-4, PL4 Off	Pass

Page E8, Sheet 14/15 Rev 0.1

Device	Test Point/Action	Card	Expected Result	Pass/Fail
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Alarm	Activate B1	DO 0,1	24V on TB14-4T & TB14-4B	Pass
Wiper	Activate B2	DO 0,1	24V AC on TB3-2 & RA1	Pass
Pump	Activate B3	DO 0,1	24V AC on TB3-3 & RB1	Pass

Page E9, Sheet 15/15 Rev 0.1

Device	Test Point/Action	Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.

PLC to OIT	Verify PLC updates OIT screen	screen changes	Pass
PC to OIT	Verify external PC communicates with OIT	screen changes	Pass

Test Procedure for 16T17630 S-C Cincinnati Lytle Tunnel

Rev 1.0

General Organization

The test procedure follows the drawing pages 16T17630 Rev 1.0

Equipment needed

Multimeter

PC with Versamax software

PC with Modbus Master Software

Page E1, Sheet 7/19 Rev 1.0

Device	Test Point/Action	Expected Result	Pass/Fail
Apply 120 VAC to TB1-1 and TB1-2 terminals			
Cabinet Light	CB2 closed. Close door switch	Light on	Pass
GFCI	CB1 closed. Probe outlet with DMM	120 VAC	Pass
Power Conditioner	L1 and N	120 VAC	Pass
Transformer T1	X1 & X2	120 VAC	Pass
Surge Suppressor AC-SS1	L1 and L2	120 VAC	Pass
PLC CPU	P24-5 and N24-DB	24 VDC	Pass
OIT	P24-1 and N24	24 VDC	Pass
DC Power Supply	P24 and N24	24 VDC	Pass
Heater	CB3 closed + cold	Heater On 115.9v	Pass
Fan	CB3 closed + heat	Fan On	Pass
Transformer T2	CB4 closed. X1 & X2	24V	Pass
Time Clock	P24	24V DC	Pass
Surge Suppressor AC-SS2	L1 and L2	24 VAC	Pass
Surge Suppressor AC-SS3	L1 and L2	24 VAC	Pass
Surge Suppressor AC-SS4	L1 and L2	24 VAC	Pass
Surge Suppressor DC-SS1	L1 & L2	24V DC	Pass

TB2-1,2 = 260VAC (277 default)

Page E2-E3, Sheet 9/19 Rev 1.0

Device	Test Point/Action	Expected Result	Pass/Fail
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Luminance Sensor Assambly

Ensure 120 VAC is removed from L & N

Set SW-1 to Open

Connect 24V, 24N & Gnd from Panel TB3-1t, M and B to Meter TB1-L, N and G respectively

Connect Sig+ and Sig - from Panel TB3-3T and M to Meter 5 and 6 respectively.

Test Meter Assembly	%AI Analog Inputs Outputs Enabled		
Close SW-1			Pass
Close T-Stat in Meter Assembly	Heater Power	Heat On	Pass
Open T-Stat in Meter Assembly	Heater Power	Heat Off	Pass
Observe the PLC address Slot AI1, Ch 1. Operating A16 from 0 - 10000 CD/M^2 to simulate 4 - 20 mA.	Slot AI1, Ch 1 TB2-1,2	Input Ch 1 illuminates. Monitor sensor value in PC.	Pass
Open SW-1			

Page E4, Sheet 10/19 Rev 1.0 %AQ = Analog Output

Device	Test Point/Action	Card	Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.
Using the IO map, monitor each input and verify activation in the PLC.

TB4

Signal to DN RDE-SE4	Set AO to 0, ~5000, ~32000	Wire# 30-35	AO 0,6	0, 5, 20 mA	Pass
Signal to DN RDE-SW4	Set AO to 0, ~5000, ~32001		AO 0,6	0, 5, 20 mA	Pass
Signal to LP1 RDE-SE4	Set AO to 0, ~5000, ~32002		AO 0,6	0, 5, 20 mA	Pass
Signal to LP1 RDE-SW4	Set AO to 0, ~5000, ~32003		AO 0,6	0, 5, 20 mA	Pass
Signal to LP2 RDE-SE4	Set AO to 0, ~5000, ~32004		AO 0,6	0, 5, 20 mA	Pass
Signal to LP2 RDE-SW4	Set AO to 0, ~5000, ~32005		AO 0,6	0, 5, 20 mA	Pass

Page E5, Sheet 11/19 Rev 1.0

Device	Test Point/Action	Card	Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.
Using the IO map, monitor each input and verify activation in the PLC.

Signal to DN RDE-SRE4	Set AO to 0, ~5000, ~32000	Wire # 40-45	AO 0,6	0, 5, 20 mA	Pass
Signal to DN RDE-SRW4	Set AO to 0, ~5000, ~32001		AO 0,6	0, 5, 20 mA	Pass
Signal to LP1 RDE-SRE4	Set AO to 0, ~5000, ~32002		AO 0,6	0, 5, 20 mA	Pass
Signal to LP1 RDE-SRW4	Set AO to 0, ~5000, ~32003		AO 0,6	0, 5, 20 mA	Pass
Signal to LP2 RDE-SRE4	Set AO to 0, ~5000, ~32004		AO 0,6	0, 5, 20 mA	Pass
Signal to LP2 RDE-SRW4	Set AO to 0, ~5000, ~32005		AO 0,6	0, 5, 20 mA	Pass

Page E6, Sheet 12/19 Rev 1.0

Device	Test Point/Action	Card	Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.
Using the IO map, monitor each input and verify activation in the PLC.

TB6

SS-1 to Hand (SE-C1)	Input A1	Wire #50-57	DI 0,7	A1 Illuminates	Pass
SS-1 to Auto (SE-C1)	Input A2		DI 0,7	A2 Illuminates	Pass
SS-1 to Off (SE-C1)	Input A2		DI 0,7	A2&A1 off	Pass
SS-2 to Hand (SE-C2)	Input A3		DI 0,7	A3 Illuminates	Pass
SS-2 to Auto (SE-C2)	Input A4		DI 0,7	A4 Illuminates	Pass
SS-2 to Off (SE-C2)	Input A4		DI 0,7	A3&A4 off	Pass
SS-3 to Hand (SW-C1)	Input A5		DI 0,7	A5 Illuminates	Pass
SS-3 to Auto (SW-C1)	Input A6		DI 0,7	A6 Illuminates	Pass
SS-3 to Off (SW-C1)	Input A6		DI 0,7	A5&A6 off	Pass
SS-4 to Hand (SW-C2)	Input A7		DI 0,7	A7 Illuminates	Pass
SS-4 to Auto (SW-C2)	Input A7		DI 0,7	A8 Illuminates	Pass
SS-4 to Off (SW-C2)	Input A8		DI 0,7	A7&A8 off	Pass

Page E7, Sheet 13/19 Rev 1.0

Device	Test Point/Action	Card	Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.
Using the IO map, monitor each input and verify activation in the PLC.

SS-5 to Hand (RE-C1)	Input B1		DI 0,7	B1 Illuminates	Pass
SS-5 to Auto (RE-C1)	Input B2		DI 0,7	B2 Illuminates	Pass
SS-5 to Off (RE-C1)	Input B2		DI 0,7	B2&B1 off	Pass
SS-6 to Hand (RE-C2)	Input B3		DI 0,7	B3 Illuminates	Pass
SS-6 to Auto (RE-C2)	Input B4		DI 0,7	B4 Illuminates	Pass
SS-6 to Off (RE-C2)	Input B4		DI 0,7	B3&B4 off	Pass
SS-7 to Hand (RW-C1)	Input B5		DI 0,7	B5 Illuminates	Pass
SS-7 to Auto (RW-C1)	Input B6		DI 0,7	B6 Illuminates	Pass
SS-7 to Off (RW-C1)	Input B6		DI 0,7	B5&B6 off	Pass
SS-8 to Hand (RW-C2)	Input B7		DI 0,7	B7 Illuminates	Pass
SS-8 to Auto (RW-C2)	Input B7		DI 0,7	B8 Illuminates	Pass
SS-8 to Off (RW-C2)	Input B8		DI 0,7	B7&B8 off	Pass

Page E8, Sheet 14/19 Rev 1.0

Device	Test Point/Action	Card	Expected Result	Pass/Fail
TB7				
S-E1 AUX to On (SE-C1)	Input A1 Wire # 70-77	DI 0,7	B1 Illuminates	Pass
S-E1 AUX to On (SE-C1)	Input A1	DI 0,7	B1 is off	Pass
S-E2 AUX to On (SE-C2)	Input A2	DI 0,7	B2 Illuminates	Pass
S-E2 AUX to On (SE-C2)	Input A2	DI 0,7	B2 is off	Pass
S-W1 AUX to On (SW-C1)	Input A3	DI 0,7	B3 Illuminates	Pass
S-W1 AUX to Off (SW-C1)	Input A3	DI 0,7	B3 is off	Pass
S-W2 AUX to On (SW-C2)	Input A4	DI 0,7	B4 Illuminates	Pass
S-W2 AUX to Off (SW-C2)	Input A4	DI 0,7	B4 is off	Pass
R-E1 AUX to On (RE-C1)	Input A5	DI 0,7	B5 Illuminates	Pass
R-E1 AUX to On (RE-C1)	Input A5	DI 0,7	B5 is off	Pass
R-E2 AUX to On (RE-C2)	Input A6	DI 0,7	B6 Illuminates	Pass
R-E2 AUX to On (RE-C2)	Input A6	DI 0,7	B6 is off	Pass
R-W1 AUX to On (RW-C1)	Input A7	DI 0,7	B7 Illuminates	Pass
R-W1 AUX to Off (RW-C1)	Input A7	DI 0,7	B7 is off	Pass
R-W2 AUX to On (RW-C2)	Input A8	DI 0,7	B8 Illuminates	Pass
R-W2 AUX to Off (RW-C2)	Input A8	DI 0,7	B8 is off	Pass

Page E9, Sheet 15/19 Rev 1.0

Device	Test Point/Action	Card	Expected Result	Pass/Fail
TB7				
REMOTE ALARM	Input B1 Wire # 78-81	DI 0,7	B1 Illuminates	Pass
REMOTE ALARM	Input B1	DI 0,7	B1 is off	Pass
UPS FAIL	Input B2	DI 0,7	B2 Illuminates	Pass
UPS FAIL	Input B2	DI 0,7	B2 is off	Pass
WASHER TANK LEVEL	Input B3	DI 0,7	B3 Illuminates	Pass
WASHER TANK LEVEL	Input B3	DI 0,7	B3 is off	Pass

Page E10, Sheet 16/19 Rev 1.0

%Q Stop Mode, Outputs enabled

Device	Test Point/Action	Card	Expected Result	Pass/Fail
Connect PC to panel controller via Ethernet and activate PLC monitoring program.				
Using the IO map, activate each relay output and verify for expected results.				
In the Rx3i program, use the AI-RO-DI table function.				
Output 1- Contactor S-E1	Set SS1 to Auto. Activate Output A1 from PC.	DO 0,10	R1, PL1 On	Pass
Output 1- Contactor S-E1	Set SS1 to Off.	DO 0,10	R1, PL1 Off	Pass
Output 2- Contactor S-E2	Set SS2 to Auto. Activate Output A3 from PC.	DO 0,10	R2, PL2 On	Pass
Output 2- Contactor S-E2	Set SS2 to Off.	DO 0,10	R2, PL2 Off	Pass
Output 3 - Contactor S-W1	Set SS3 to Auto. Activate Output A5 from PC.	DO 0,10	R3, PL3 On	Pass
Output 3 - Contactor S-W1	Set SS3 to Off.	DO 0,10	R3, PL3 Off	Pass
Output 4 - Contactor S-W2	Set SS4 to Auto. Activate Output A7 from PC.	DO 0,10	R4, PL4 On	Pass
Output 4 - Contactor S-W2	Set SS4 to Off.	DO 0,10	R4, PL4 Off	Pass

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Device	Test Point/Action	Card	Expected Result	Pass/Fail
Connect PC to panel controller via Ethernet and activate PLC monitoring program.				
Using the IO map, activate each relay output and verify for expected results.				
In the Rx3i program, use the AI-RO-DI table function.				
Output 5- Contactor R-E1	Set SS5 to Auto. Activate Output B1 from PC.	DO 0,10	R5, PL5 On	Pass
Output 5- Contactor R-E2	Set SS5 to Off. B2	DO 0,10	R5, PL5 Off	Pass
Output 6- Contactor R-E2	Set SS6 to Auto. Activate Output B3 from PC.	DO 0,10	R6, PL6 On	Pass
Output 6- Contactor R-E3	Set SS6 to Off.	DO 0,10	R6, PL6 Off	Pass
Output 7 - Contactor R-W1	Set SS7 to Auto. Activate Output B5 from PC.	DO 0,10	R7, PL7 On	Pass
Output 7 - Contactor R-W2	Set SS7 to Off.	DO 0,10	R7, PL7 Off	Pass
Output 8 - Contactor R-W2	Set SS8 to Auto. Activate Output B7 from PC.	DO 0,10	R8, PL8 On	Pass
Output 8 - Contactor R-W3	Set SS8 to Off.	DO 0,10	R8, PL8 Off	Pass

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Device	Test Point/Action		Card	Expected Result	Pass/Fail
Alarm	Activate A1	Wire # 106	DO 0,11	24V on TB14-4T & TB14-4B	Pass
Wiper	Activate A2	Wire # 107	DO 0,11	24V AC on TB3-3 & RA1	Pass
Pump	Activate A3	Wire # 108	DO 0,11	24V AC on TB3-4 & RB1	Pass

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Device	Test Point/Action		Expected Result	Pass/Fail
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Connect PC to panel controller via Ethernet and activate PLC monitoring program.

PLC to OIT	Verify PLC updates OIT screen		screen changes	
PC to OIT	Verify external PC communicates with OIT		screen changes	

SOUTHBOUND RAMP

L70 depr safety

LOWEST MAX LEVEL	143%	150%
TH1	249	356 374
TH2	154	220 231
TR1	101	144 152
TR2	27	39 41
N	6	9 9

LEVELS 1-2, 3-4, 5-6 cross over at 50% output

ZONE	BAND %OL	PAVEMENT LUMINANCE CD/M^2			AVERAGE	SAFETY	AVG/SAFETY %	CONTROL % OUTPUT	ABSOLUTE RANGE %
		LEFT	MIDDLE	RIGHT					
TH1	100		660		660	373	177%	-41%	100%
L6	0		575		575	373	154%	50%	100%
L5	100								
L5	0		457		457	489	93%	16%	131%
L4	100		380		380	323	118%	85%	87%
L4	0		268		268	134	200%	50%	36%
L3	100								
L3	0		138		138	177	78%	16%	47%
L2	100		55		55	47	118%	85%	13%
L2	0		36		36	18	200%	50%	5%
L1	100								
L1	0		14		14	9	156%	-12%	2%

ZONE	BAND %OL	PAVEMENT LUMINANCE CD/M^2			AVERAGE	SAFETY	AVG/SAFETY %	CONTROL % OUTPUT	ABSOLUTE RANGE %
		LEFT	MIDDLE	RIGHT					
TH2	100		1058		1058	231	458%	85%	100%
L6	0		893		893	231	387%	50%	100%
L5	100								
L5	0		694		694	752	92%	16%	326%
L4	100		571		571	485	118%	85%	210%
L4	0		405		405	203	200%	50%	88%
L3	100								
L3	0		217		217	274	79%	16%	118%
L2	100		88		88	75	118%	85%	32%
L2	0		59		59	30	200%	50%	13%
L1	100								
L1	0		23		23	9	256%	-22%	4%

SOUTHBOUND RAMP

ZONE	PAVEMENT LUMINANCE CD/M ²				AVERAGE	SAFETY	AVG/SAFETY %	CONTROL % OUTPUT	ABSOLUTE RANGE %
	BAND %OL	LEFT	MIDDLE	RIGHT					
I6	100		570		570	151	377%	85%	100%
L6	0		508		508	151	336%	50%	100%
L5	100								
L5	0		408		408	434	94%	16%	287%
L4	100		350		350	298	118%	85%	197%
L4	0		257		257	129	200%	50%	85%
L3	100								
L3	0		147		147	179	82%	16%	119%
L2	100		78		78	66	118%	85%	44%
L2	0		54		54	27	200%	50%	18%
L1	100								
L1	0		25		25	9	278%	16%	6%

ZONE	PAVEMENT LUMINANCE CD/M ²				AVERAGE	SAFETY	AVG/SAFETY %	CONTROL % OUTPUT	ABSOLUTE RANGE %
	BAND %OL	LEFT	MIDDLE	RIGHT					
I6	100		368		368	40	920%	85%	100%
L6	0		323		323	40	808%	50%	100%
L5	100								
L5	0		273		273	288	95%	16%	721%
L4	100		237		237	201	118%	85%	504%
L4	0		180		180	90	200%	50%	225%
L3	100								
L3	0		112		112	132	85%	16%	330%
L2	100		70		70	60	118%	85%	149%
L2	0		49		49	25	200%	50%	61%
L1	100								
L1	0		26		26	9	289%	-39%	23%

SOUTHBOUND TUNNEL

	END DESIGN	L70 DEPR	SAFETY
LOWEST MAX CD/M^2		143%	150%
TH1	242	346	363
TH2	142	203	213
TR1	99	141	149
TR2	26	37	39
N	6	9	9

LEVELS 1-2, 3-4, 5-6 cross over at 50% output

ZONE	BAND %OUT	PAVEMENT LUMINANCE CD/M^2			AVERAGE	AVG/SAFETY		CONTROL ABSOLUTE	
		LEFT	MIDDLE	RIGHT		SAFETY	%	% OUTPUT	RANGE %
TH1	100	374	368	408	383	363	106%	85%	100%
L6	0	318	290	341	316	158	200%	50%	100%
L5	100								
L5	0	246	225	283	251	272	92%	16%	75%
L4	100	200	184	234	206	175	118%	85%	48%
L4	0	134	128	164	142	71	200%	50%	45%
L3	100								
L3	0	68	65	80	71	93	77%	16%	26%
L2	100	22	24	27	24	21	118%	85%	6%
L2	0	15	15	18	16	8	200%	50%	5%
L1	100								
L1	0	5	6	7	6	9	67%	16%	2%

ZONE	BAND %OUT	PAVEMENT LUMINANCE CD/M^2			AVERAGE	AVG/SAFETY		CONTROL ABSOLUTE	
		LEFT	MIDDLE	RIGHT		SAFETY	%	% OUTPUT	RANGE %
TH2	100	383	405	609	466	213	219%	85%	100%
L6	0	322	365	510	399	213	187%	50%	100%
L5	100								
L5	0	259	290	432	327	349	94%	16%	164%
L4	100	195	227	291	238	202	118%	85%	95%
L4	0	139	170	203	171	85	200%	50%	40%
L3	100								
L3	0	66	81	95	81	106	76%	16%	50%
L2	100	20	25	23	23	19	118%	85%	9%
L2	0	13	26	17	19	9	200%	50%	4%
L1	100								
L1	0	5	6	6	6	9	63%	20%	4%

SOUTHBOUND TUNNEL

ZONE	BAND %OUT	PAVEMENT LUMINANCE CD/M^2			AVERAGE	AVG/SAFETY		CONTROL ABSOLUTE	
		LEFT	MIDDLE	RIGHT		SAFETY	%	% OUTPUT	RANGE %
TR1									
I6	100	200	242	319	254	149	170%	85%	100%
L6	0	180	215	267	221	149	148%	50%	100%
L5	100								
L5	0	190	161	208	186	197	95%	16%	132%
L4	100	115	129	171	138	118	118%	85%	79%
L4	0	82	94	122	99	50	200%	50%	33%
L3	100								
L3	0	43	49	63	52	66	79%	16%	44%
L2	100	18	22	24	21	18	118%	85%	12%
L2	0	12	14	16	14	7	200%	50%	5%
L1	100								
L1	0	5	5	6	5	9	59%	16%	6%

ZONE	BAND %OUT	PAVEMENT LUMINANCE CD/M^2			AVERAGE	AVG/SAFETY		CONTROL ABSOLUTE	
		LEFT	MIDDLE	RIGHT		SAFETY	%	% OUTPUT	RANGE %
TR2									
I6	100	163	161	206	177	39	453%	85%	100%
L6	0	105	138	174	139	39	356%	50%	100%
L5	100								
L5	0	84	114	135	111	122	91%	16%	312%
L4	100	73	97	110	93	79	118%	85%	203%
L4	0	57	77	80	71	36	200%	50%	91%
L3	100								
L3	0	36	45	43	41	50	83%	16%	127%
L2	100	23	24	19	22	19	118%	85%	48%
L2	0	15	16	12	14	7	200%	50%	18%
L1	100								
L1	0	5	6	5	5	9	59%	22%	23%