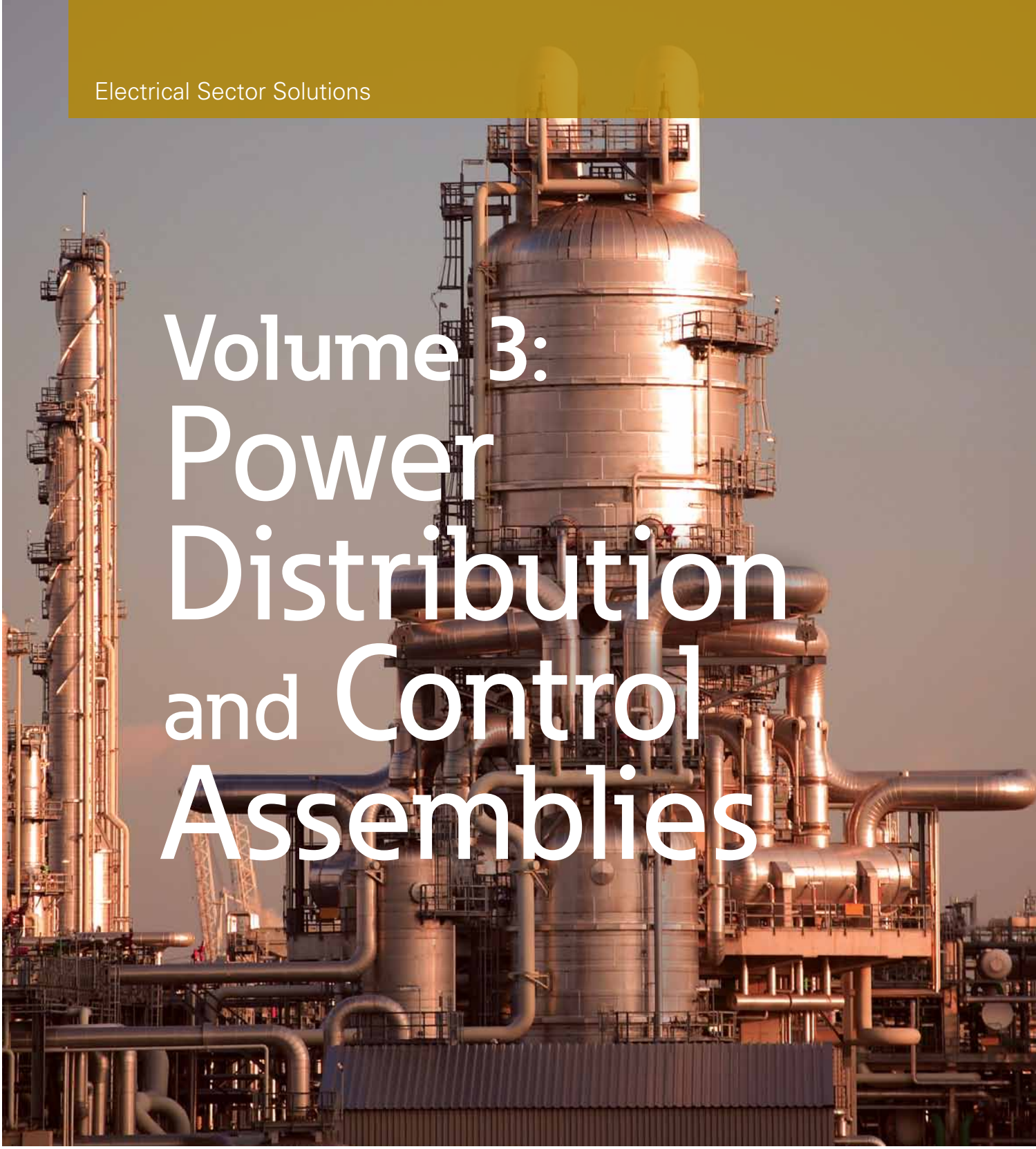
Electrical Sector Solutions



Volume 3: Power Distribution and Control Assemblies

Powering Business Worldwide

Volume 3—Power Distribution and Control Assemblies

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Powering Business Worldwide

Eaton is a global leader in power distribution, power quality, control and automation, and monitoring products.

At Eaton, we believe a reliable, efficient and safe power system is the foundation of every successful enterprise. Through innovative technologies, cutting-edge products and our highly skilled services team, we empower businesses around the world to achieve a powerful advantage.

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Eaton takes the complexity out of power systems management with a holistic and strategic approach, leveraging our industry-leading technology, solutions and services. We focus on the following three areas in all we do:

- Reliability—maintain the appropriate level of power continuity without disruption or unexpected downtime
- Efficiency—minimize energy usage, operating costs, equipment footprint and environmental impact
- Safety—identify and mitigate electrical hazards to protect what you value most

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As we grow, it becomes increasingly difficult to include all products in one or two comprehensive catalogs. Knowing that each user has their specific needs, we have created a library of catalogs for our products that when complete, will contain 15 volumes. Since the volumes will continuously be a work in progress and updated, each volume will stand alone. Refer to our volume directory, MZ08100001E, for a quick glance of where to look for the products you need. The 15 volumes include:

- Volume 1—Residential and Light Commercial (CA08100002E)
- Volume 2—Commercial Distribution (CA08100003E)
- Volume 3—Power Distribution and Control Assemblies (CA08100004E)
- Volume 4—Circuit Protection (CA08100005E)
- Volume 5—Motor Control and Protection (CA08100006E)
- Volume 6—Solid-State Motor Control (CA08100007E)
- Volume 7—Logic Control, Operator Interface and Connectivity Solutions (CA08100008E)
- Volume 8—Sensing Solutions (CA08100010E)
- Volume 9—Original Equipment Manufacturer (CA08100011E)
- Volume 10—Enclosed Control (CA08100012E)
- Volume 11—Vehicle and Commercial Controls (CA08100013E)
- Volume 12—Aftermarket, Renewal Parts and Life Extension Solutions (CA08100014E)
- Volume 13—Counters, Timers and Tachometers (CA08100015E)—Available in electronic format only
- Volume 14—Fuses (CA08100016E)—Available in electronic format only
- Volume 15—Solar Inverters and Electrical Balance of System (CA08100018E)

These volumes are not all-inclusive of every product, but they are meant to be an overview of our product lines. For our full range of product solutions and additional product information, consult Eaton.com/electrical and other catalogs and product guides in our literature library. These references include:

- The Consulting Application Guide (CA08104001E)
- The Eaton Power Quality Product Guide (COR01FYA)

If you don't have the volume that contains the product or information that you are looking for, not to worry. You can access every volume of the catalog library at Eaton.com/electrical in the Literature Library.

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Nonsegregated Phase 600V—Bus Run Section

End View

1.1 Medium Voltage Busway—Nonsegregated Phase Bus

Learn Online

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Nonsegregated Phase 600V, 10 kV BIL–5 kV, 60 kV BIL–15 kV, 95 kV BIL–38 kV, 170 kV BIL

Typical 5/15 kV Bus Run Section

End View

Contents

Application Description

Eaton's nonsegregated phase bus runs are designed for use on circuits whose importance requires greater reliability than power cables provide. Typical of such applications are the connections from transformers to switchgear assemblies in unit substations, connections from switchgear assemblies to rotating apparatus, and tie connections between switchgear assemblies. Nonsegregated phase bus is an assembly of bus conductors with associated connections, joints and insulating supports confined within a metal enclosure without interphase barriers. The conductors are adequately separated and insulated from each other and ground by insulating bus supports. Each conductor for 2400V service and above is insulated with a fluidized bed epoxy coating throughout that reduces the possibility of corona and electrical tracking.

Features, Benefits and Functions

Ease of Installation

Because of its compact dimensions, relative light weight and user-friendly design, nonsegregated phase bus is easily installed. The inherent rigidity of the design permits hanging rods to be spaced approximately every 4 ft (1.2m) for indoor bus runs, and allows supporting frames to be spaced approximately every 8 ft (2.4m) for outdoor runs. Standard length of bus run sections is 100 inches (2540 mm) or less.

Short-Circuit Force Withstand Ability

Nonsegregated phase bus runs in 600V, 5 kV and 15 kV are designed to withstand three-phase and phase-to-ground short-circuit current of 78 kA rms asymmetrical (132 kA peak) for 10 cycles and 50 kA rms symmetrical for 2 seconds. Momentary 4-cycle withstand ratings up to 158 kA peak (98.8 kA rms asymmetrical) are also available. For 27 kV nonsegregated phase bus runs, short-circuit withstand ratings of 64 kA rms asymmetrical (108 kA peak) for 10 cycles and 40 kA rms symmetrical for 2 seconds are standard.

Construction

Enclosures are fabricated from 11-gauge aluminum, and are welded for maximum rigidity. 11-gauge steel and stainless steel are options. Removable covers are secured with bolts for ease of access when making joints and subsequent and periodic inspection.

Enclosures are painted with a baked-on polyester powder coat paint system resulting in a very durable finish with uniform thickness and gloss. This cosmetically pleasing finish minimizes the risk of problems in harsh environments. The standard color is ANSI-61 light gray, and special paint colors are available upon request. Stainless steel hardware option is available.

Expansion joints are supplied in all straight bus runs at approximately 50 ft (15.2m) intervals to allow for the expected expansion when the conductors are energized and are carrying rated current.

A variety of terminations is available to accommodate most termination requirements. Bus runs can be terminated with flexible shunts, potheads, porcelain bushings, or conductor stub ends for connection to riser bars in switchgear assemblies.

Conductors

All conductors are 100% conductivity copper bars. Bus joints are made by solidly bolting the bus bars together with splice plates on each side. All joint surfaces are silver-plated to ensure maximum conductivity through the joint. Tin-plating is also available. After bolting, each standard joint is covered by a preformed, flame-retardant insulating boot, providing full insulation for bus conductors. These boots are easily removable for inspection of the joints at any future time.

Temperature Rise

The bus will be capable of carrying rated current continuously without exceeding a conductor temperature rise of 65°C above an outside ambient temperature of 40°C, as required by ANSI Standard C37.23.

Standards and Certifications

The metal-enclosed bus runs are designed for 600V, 5 kV, 15 kV, 27 kV and 38 kV service in accordance with ANSI C37.23. 600V, 5 kV and 15 kV bus is available with continuous current ratings of 1200, 2000, 3000, 3200 or 4000A. 27 kV and 38 kV bus is available in 1200 and 2000A continuous ratings.

Tests

The design of nonsegregated bus runs has been tested per ANSI C37.23. Certification of momentary current testing, impulse testing and heat rise are available upon request.

Seismic Application

Bus run assemblies are designed to meet Uniform Building Code (UBC) and California Code Title 24 for Seismic Zones 4, 3, 2A, 2B, 1 and 0. Complete guidelines for proper supports are provided on each seismic specified order.

Additional Information

- Technical Data: TD01702001E
- Brochure: BR01702001E
- Final Fit Program: SA01702001E
- *Consulting Application Guide*, CA08104001E

Technical Data and Specifications

Available Nonsegregated Bus Ratings per ANSI/IEEE Standard C37.23-1987

Rated Maximum Voltage kV rms	Rated Power Frequency Hz	Power Frequency Withstand 1 Min. Dry kV rms	Impulse Withstand (1.2 x 50 microsec) kV Peak	Rated Continuous Current Amperes	Rated Short-Time Short-Circuit Withstand Current (kA rms Symmetrical)		Rated Momentary Short-Circuit Withstand Current	
					2 Sec.	1 Sec. ①	10 Cycle kA Peak	kA rms Asym.
0.635	60	2.2	10	1200 2000 3000 4000 5000	49	69	132 ②	78 ②
0.635	60	2.2	10	1200 2000 3000 3200	63	89	170	100.8
4.76	60	19	60	1200 2000 3000 4000 5000	49	—	132	78
4.76	60	19	60	1200 2000 3000 3200	63	—	170	100.8
8.25	60	36	95	1200 2000 3000 4000 5000	41	—	111	66
8.25	60	36	95	1200 2000 3000 3200	63	—	170	100.8
15	60	36	95	1200 2000 3000 4000 5000	48	—	130	77
15	60	36	95	1200 2000 3000 3200	63	—	170	100.8
27	60	60	125	1200 2000	40	—	108	64
38	60	80	170	1200 2000 3000 3200 4000 5000	40	—	104	64

Notes

① This is a value calculated from 2 second short-circuit current withstand rating based on relationship I^2t = constant.

② For 600V application, 4-cycle momentary current withstand rating up to 158 kA peak (98.8 kA rms asymmetrical) is also available.

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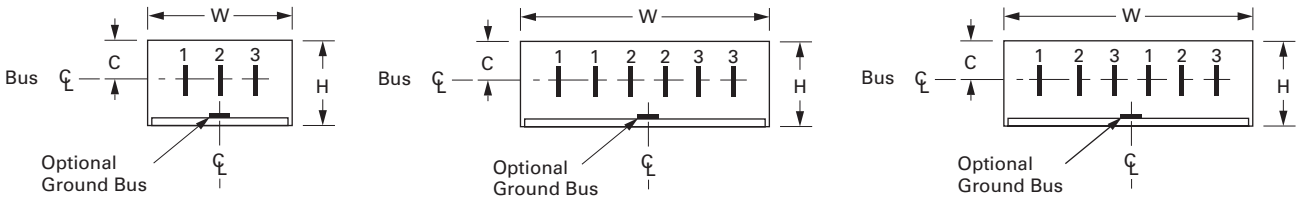
Medium Voltage Nonsegregated Phase Bus—Standard Configurations



Layout 1 **Layout 2** **Layout 3**

Bus Duct Rated 49 kA rms Symmetrical 2 Seconds

Wire	Voltage (kV) ①	Ampere Rating	Layout Number	Width	Height	Conductor Centerline	Conductor Size	Phase-Phase Conductor Spacing	Bracing Supports ②	Optional Ground Bus	Average Weight Per Foot Lbs (kg) ③	Standards Listing
Aluminum Enclosures												
3	0.635/5/15	1200	1	20.00	17.38	8.13	(1) 0.5 x 3	5.38	Glass polyester	0.25 x 2	38 (17)	CSA
	0.635/5/15	2000	1	20.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 2	47 (21)	CSA
	0.635/5/15	3000	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	68 (31)	CSA
	0.635/5/15	3200	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	68 (31)	—
	0.635/5/15	4000	2	35.75	17.38	8.13	(2) 0.5 x 6	5.38	Glass polyester	0.25 x 2	101 (46)	CSA
	0.635/5/15	5000	2	35.75	17.38	8.13	(2) 0.5 x 8	5.38	Glass polyester	0.25 x 2	118 (54)	CSA
4	0.635/5/15	1200	4	26.00	17.38	8.13	(1) 0.5 x 3	5.38	Glass polyester	0.25 x 2	48 (22)	CSA
	0.635/5/15	2000	4	26.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 2	60 (27)	CSA
	0.635/5/15	3000	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	88 (40)	—
	0.635/5/15	3200	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	88 (40)	—
	0.635	4000	5	35.75	17.38	8.13	(2) 0.5 x 6	4.00	Glass polyester	0.25 x 2	127 (58)	—
Steel Enclosures (Steel, Stainless Steel and Galvanized Steel)												
3	0.635/5/15	1200	1	20.00	17.38	8.13	(1) 0.5 x 3	5.38	Glass polyester	0.25 x 2	58 (26)	CSA
	0.635/5/15	2000	1	20.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 2	67 (30)	CSA
	0.635/5/15	3000	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	106 (48)	—
	0.635/5/15	3200	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	106 (48)	—
	0.635/5/15	4000	2	35.75	17.38	8.13	(2) 0.5 x 8	5.38	Glass polyester	0.25 x 2	154 (70)	—
	0.635/5/15	5000	3	35.75	17.38	8.13	(2) 0.5 x 8	5.38	Glass polyester	0.25 x 2	154 (70)	—
4	0.635/5/15	1200	4	26.00	17.38	8.13	(1) 0.5 x 3	5.38	Glass polyester	0.25 x 2	72 (33)	CSA
	0.635/5/15	2000	4	26.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 2	84 (38)	CSA
	0.635/5/15	3000	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	124 (56)	—
	0.635/5/15	3200	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 2	124 (56)	—
	0.635	4000	5	35.75	17.38	8.13	(2) 0.5 x 8	4.00	Glass polyester	0.25 x 2	188 (85)	—

Notes

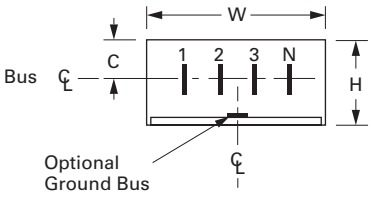
① All phase conductors above 635V are fully insulated with epoxy insulation for the rated maximum voltage. Epoxy insulation is available at 600V as an option.

② Optional poly/porcelain or poly/epoxy bracing supports are available. Consult factory.

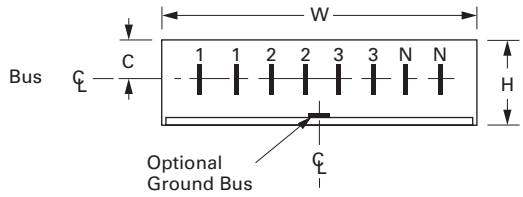
③ Add 3 lbs to the weights shown when using poly/porcelain or poly/epoxy support bracing.

For dimensions in mm, multiply inches by 25.4.

Medium Voltage Nonsegregated Phase Bus—Standard Configurations



Layout 4



Layout 5

Bus Duct Rated 63 kA rms Symmetrical 2 Seconds

Wire	Voltage (kV) ①	Ampere Rating	Layout Number	Width	Height	Conductor Centerline	Conductor Size	Phase-Phase Conductor Spacing	Bracing Supports ②	Ground Bus	Average Weight Per Foot Lbs (kg) ③	Standards Listing
Aluminum Enclosures												
3	0.635/5/15	1200	1	20.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	48 (22)	CSA
	0.635/5/15	2000	1	20.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	48 (22)	CSA
	0.635/5/15	3000	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	78 (35)	CSA
	0.635/5/15	3200	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	78 (35)	—
	0.635/5/15	4000	2	35.75	17.38	8.13	(2) 0.5 x 6	5.38	Glass polyester	0.25 x 3	105 (48)	—
	0.635/5/15	5000	2	35.75	17.38	8.13	(2) 0.5 x 8	5.38	Glass polyester	0.25 x 3	121 (55)	—
4	0.635/5/15	1200	4	26.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	61 (28)	—
	0.635/5/15	2000	4	26.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	61 (28)	—
	0.635/5/15	3000	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	101 (46)	—
	0.635/5/15	3200	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	101 (46)	—
	0.635	4000	5	35.75	17.38	8.13	(2) 0.5 x 6	4.00	Glass polyester	0.25 x 3	128 (58)	—
Steel Enclosures (Steel, Stainless Steel and Galvanized Steel)												
3	0.635/5/15	1200	1	20.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	68 (31)	—
	0.635/5/15	2000	1	20.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	68 (31)	—
	0.635/5/15	3000	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	89 (40)	—
	0.635/5/15	3200	1	20.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	89 (40)	—
	0.635/5/15	4000	2	35.75	17.38	8.13	(2) 0.5 x 6	5.38	Glass polyester	0.25 x 3	134 (61)	—
	0.635/5/15	5000	3	35.75	17.38	8.13	(2) 0.5 x 8	5.38	Glass polyester	0.25 x 3	160 (73)	—
4	0.635/5/15	1200	4	26.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	85 (39)	—
	0.635/5/15	2000	4	26.00	17.38	8.13	(1) 0.375 x 6	5.38	Glass polyester	0.25 x 3	85 (39)	—
	0.635/5/15	3000	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	115 (52)	—
	0.635/5/15	3200	4	26.00	17.38	8.13	(1) 0.5 x 8	5.38	Glass polyester	0.25 x 3	115 (52)	—
	0.635	4000	5	35.75	17.38	8.13	(2) 0.5 x 6	4.00	Glass polyester	0.25 x 3	188 (85)	—

Notes

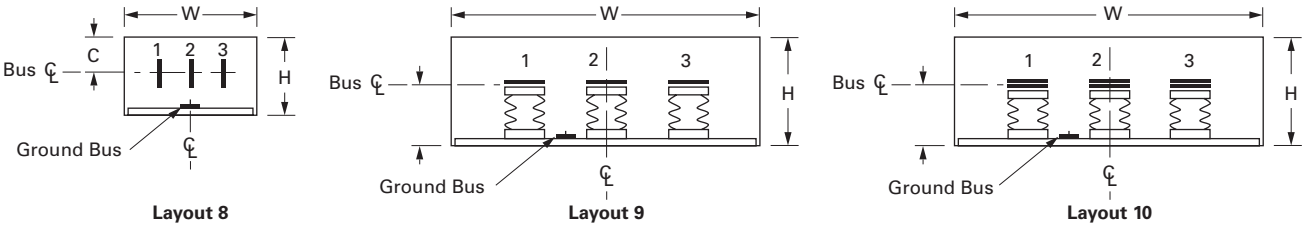
① All phase conductors above 635V are fully insulated with epoxy insulation for the rated maximum voltage. Epoxy insulation is available at 600V as an option.

② Optional poly/porcelain or poly/epoxy bracing supports are available. Consult factory.

③ Add 3 lbs to the weights shown when using poly/porcelain or poly/epoxy support bracing.

For dimensions in mm, multiply inches by 25.4.

27 kV/38 kV Nonsegregated Phase Bus—–Standard Configurations



Layout 8 **Layout 9** **Layout 10**

27 kV Bus Rated up to 108 kA Peak Momentary, 40 kA rms Symmetrical 2 Second

Wire Type	Rated Maximum Voltage kV ①	Rated Cont. Current Amperes	Layout No.	Enclosure Material Std.	Enclosure Material Opt.	Enclosure Size (Inches) W	Enclosure Size (Inches) H	Enclosure Size (Inches) C	Number of Bars Ph and Size, Cu (Inches) ①	Ph-Ph Bus Spacing (Inches)	Insulating Supports Std.	Insulating Supports Opt. ②	Optional Ground Bus, Cu (Inches)	Approx. Average Weight per Foot Lbs (kg) ③	Listing CSA	Listing UL
3	27	1200	8	Aluminum	—	30.00	21.13	10.00	(1) 0.25 x 4	7.00	④	⑤ ⑥	0.25 x 2	37 (17)	Yes	No
	27	2000	8	Aluminum	—	30.00	21.13	10.00	(1) 0.50 x 4	7.00	④	⑤ ⑥	0.25 x 2	49 (22)	Yes	No
	27	1200	8	—	Steel	30.00	21.13	10.00	(1) 0.25 x 4	7.00	④	⑤ ⑥	0.25 x 2	37 (17)	Yes	No
	27	2000	8	—	Steel	30.00	21.13	10.00	(1) 0.50 x 4	7.00	④	⑤ ⑥	0.25 x 2	49 (22)	Yes	No

38 kV Bus Rated up to 104 kA Peak Momentary, 40 kA rms Symmetrical 2 Second

Wire Type	Rated Maximum Voltage kV ①	Rated Cont. Current Amperes	Layout No.	Enclosure Material Std.	Enclosure Material Opt.	Enclosure Size (Inches) W	Enclosure Size (Inches) H	Enclosure Size (Inches) C	Number of Bars Ph and Size, Cu (Inches)	Ph-Ph Bus Spacing (Inches)	Insulating Supports Std.	Insulating Supports Opt. ②	Optional Ground Bus, Cu (Inches)	Approx. Average Weight per Foot Lbs (kg) ③	Listing CSA	Listing UL
3	38	1200	9	Aluminum	—	40.25	21.50	11.00	(1) 0.25 x 4	10.50	Epoxy	— —	0.25 x 3	61 (28)	Yes	No
	38	2000	10	Aluminum	—	40.25	21.50	11.00	(1) 0.38 x 4	10.50	Epoxy	— —	0.25 x 3	89 (40.4)	Yes	No
	38	1200	9	—	Steel	40.25	21.50	11.00	(1) 0.25 x 4	10.50	Epoxy	— —	0.25 x 3	88 (40)	No	No
	38	2000	10	—	Steel	40.25	21.50	11.00	(1) 0.38 x 4	10.50	Epoxy	— —	0.25 x 3	116 (53)	No	No

Notes

① All bus bars for applications above 600V are fully insulated with fluidized epoxy coating for the rated maximum voltage.

② Check with Eaton for availability.

③ Add 3 lbs to the weights shown when using poly/porcelain or epoxy insulating supports in place of glass polyester.

④ Glass polyester.

⑤ Polyester/porcelain.

⑥ Epoxy.

For dimensions in mm, multiply inches by 25.4.

Nonsegregated Phase Bus Electrical Properties and Watt Loss Data

Wire Type	Rated Max. Voltage kV	Cont. Rated Current Ampere	Conductor (Copper) No./Ph	Thick Inch	Width Inch	Phase Arrang.	Enclosure Material	Size W x H (Inches)	Electrical Properties µOHM/PH/FT DC R 20°C	60 Hz R	X_L	$Z = R+jX_L$	µµF/PH/FT Cap to Grd Cg
3	0.635/5/15	1200	1	0.50	3.00	1-2-3	Aluminum	20.00 x 17.38	5.5	7.1	49.8	50.3	2.2
	0.635/5/15	2000	1	0.38	6.00	1-2-3	Aluminum	20.00 x 17.38	3.7	4.7	37.0	37.3	4.4
	0.635/5/15	3000	1	0.50	8.00	1-2-3	Aluminum	20.00 x 17.38	2.1	2.	31.1	31.3	5.9
	0.635/5/15	3200	1	0.50	8.00	1-2-3	Aluminum	20.00 x 17.38	2.1	2.7	31.1	31.3	5.9
3	0.635/5/15	4000	2	0.50	6.00	1-1-2-2-3-3	Aluminum	35.75 x 17.38	1.4	1.8	35.6	35.6	5.9
	0.635/5/15	5000	2	0.50	8.00	1-1-2-2-3-3	Aluminum	35.75 x 17.38	1.0	1.3	32.9	32.9	7.8
	0.635/5/15	1200	1	0.50	3.00	1-2-3	Steel	20.00 x 17.38	5.5	7.1	49.8	50.3	2.2
	0.635/5/15	2000	1	0.38	6.00	1-2-3	Steel	20.00 x 17.38	3.7	4.7	37.0	37.3	4.4
3	0.635/5/15	3000	1	0.50	8.00	1-2-3	Steel	20.00 x 17.38	2.1	2.7	31.1	31.3	5.9
	0.635/5/15	3200	1	0.50	8.00	1-2-3	Steel	20.00 x 17.38	2.1	2.7	31.	31.	5.9
	0.635/5/15	4000	2	0.50	8.00	1-1-2-2-3-3	Steel	35.75 x 17.38	1.0	1.3	32.9	32.9	7.8
	0.635/5/15	5000	2	0.50	8.00	1-2-3-1-2-3	Steel	35.75 x 17.38	1.0	1.3	14.6	14.6	7.4
4	0.635/5/15	1200	1	0.50	3.00	1-2-3-N	Aluminum	26.00 x 17.38	5.5	7.1	49.8	50.3	1.5
	0.635/5/15	2000	1	0.38	6.00	1-2-3-N	Aluminum	26.00 x 17.38	3.7	4.7	37.0	37.3	3.1
	0.635/5/15	3000	1	0.50	8.00	1-2-3-N	Aluminum	26.00 x 17.38	2.1	2.7	31.1	31.3	4.1
	0.635/5/15	3200	1	0.50	8.00	1-2-3-N	Aluminum	26.00 x 17.38	2.1	2.7	31.1	31.3	4.1
	0.635	4000	2	0.50	6.00	1-1-2-2-3-3-N-N	Aluminum	35.75 x 17.38	1.4	1.8	35.6	35.6	4.9
4	0.635/5/15	1200	1	0.50	3.00	1-2-3-N	Steel	26.00 x 17.38	5.5	7.1	49.8	50.3	1.5
	0.635/5/15	2000	1	0.38	6.00	1-2-3-N	Steel	26.00 x 17.38	3.7	4.7	37.0	37.3	3.1
	0.635/5/15	3000	1	0.50	8.00	1-2-3-N	Steel	26.00 x 17.38	2.1	2.7	41.1	41.2	4.1
	0.635	3200	1	0.50	8.00	1-2-3-N	Steel	26.00 x 17.38	2.1	2.7	41.1	41.2	4.1
	0.635	4000	2	0.50	8.00	1-1-2-2-3-3-N-N	Steel	35.75 x 17.38	1.0	1.3	32.9	32.9	6.6
3	27	1200	1	0.25	4.00	1-2-3	Aluminum	30.00 x 21.00	8.3	10.6	51.6	52.7	1.7
	27	2000	1	0.50	4.00	1-2-3	Aluminum	30.00 x 21.00	4.1	5.3	24.8	25.4	1.7
	27	1200	1	0.25	4.00	1-2-3	Steel	30.00 x 21.00	8.3	10.6	51.6	52.7	1.7
	27	2000	1	0.50	4.00	1-2-3	Steel	30.00 x 21.00	4.1	5.3	24.8	25.4	1.7
3	38	1200	1	0.25	4.00	1-2-3	Aluminum	40.25 x 21.50	8.3	10.6	61.3	62.3	2.0
	38	2000	2	0.38	4.00	1-2-3	Aluminum	40.25 x 21.50	4.1	5.3	59.0	59.2	2.0
	38	1200	1	0.25	4.00	1-2-3	Steel	40.25 x 21.50	8.3	10.6	61.3	62.3	2.0
	38	2000	2	0.38	4.00	1-2-3	Steel	40.25 x 21.50	4.1	5.3	59.0	59.2	2.0

Note

For dimensions in mm, multiply inches by 25.4.

SPD, Power Conditioning, PF Capacitors and Harmonic Filters

Industrial Surge Protection Products

2.1 Surge Protection and Power Conditioning

2.2 Power Factor Correction and Harmonic Filtering

Industrial and Commercial Surge Protection

Contents

Introduction

Industrial and Commercial Surge Protection

- SPD Series for Integration into Electrical Distribution Equipment
- SPD Series for Mounting External to Electrical Distribution Equipment

SPD Series Integrated Units

Specification grade surge protective devices installed within Eaton's electrical assemblies.

SPD Series Integrated Unit

SPD Series Sidemount Units

Specification grade surge protective devices for installation external to electrical distribution equipment.

SPD Series Sidemount Unit

Critical Load Protection

Series filtering and surge protection for critical single-phase loads.

- Current ratings up to 60 A
- 120 and 240 Vac units
- 24 and 48 Vdc units
- DIN mounting available on some models
- Up to 80 kA of peak surge protection
- AC units are UL 1449 4th Edition and UL 1283 7th Edition listed

AEGIS Products

Commercial and Light Industrial Surge Protection

The SPC Series offers robust protection in a compact, flexible design and is configurable for a wide range of commercial and light industrial applications. The SPC combines surge suppression components and the options of EMI/RFI filtering, Form C contacts and an audible alarm.

Surges (also known as transients), due to lightning, utility grid switching, switching of external/internal inductive or capacitive loads, and other sources, travel on power line conductors throughout the electrical distribution system, causing system operating problems and equipment downtime.

SPC Series

Surge Protection for Sub-Panel and OEM Applications

In today's business environment that calls for 24 hours a day, 7 days a week uptime and reliability, Eaton's CVX050 and CVX100 surge protective devices (SPDs) ensure that a customer's investment in equipment and processes is protected from the damaging effects of voltage transients. Designed for installation on service entrance, branch panels or individual equipment disconnects, the CVX050/100 provides enhanced surge protection for mission-critical applications.

Panelboards with Integrated Surge Protective Devices

- Available in standard and custom configurations
- Ratings:
  - 120/240 Vac, single-phase, three-wire
  - 208Y/120 Vac, three-phase, four-wire
  - 480Y/277 Vac, three-phase, four-wire
  - 600Y/347 Vac, three-phase, four-wire (other voltage configurations are available)
- Copper bus
- 12, 18, 24, 30, 36 and 42 circuits
- Bolt-on branch breakers
- A full range of factory installed modifications and accessories
- Fully rated or series rated

Surge Protective Devices can be Integrated within a variety of Eaton Electrical Assemblies

Power Conditioning

Sag Ride-Through (SRT2)

The sag ride-through (SRT2) is a power conditioner that corrects voltage sags to maintain uptime and productivity.

Sag Ride-Through (SRT2)

Power-Sure 700 (T700)

The Power-Sure 700 (T700) is designed to meet the needs of customers who experience voltage regulation problems due to brownout conditions from their electric utilities.

Power-Sure 700 (T700)

Facility-Wide Power Protection Solutions

A facility-wide protection approach should be employed to address power quality issues. This approach minimizes overall lifecycle costs and optimizes facility uptime. The following is a recommended design approach for implementing facility-wide Eaton power protection solutions.

The most accepted design methodology is based on two concepts:

1. Ensure proper grounding conditions exist. All forms of power protection/conditioning rely on good grounding, bonding and earthing practices.
2. Surge protection should be installed at key distribution panels and critical loads.

Application Description

2

Application Recommendations for Surge Products

Application Type	Eaton's Surge Product	Features and Competitive Advantages
Light Commercial		
Design build	SPD Series integrated units	Ideal package for any commercial facility
Chain stores	SPD Series sidemount units	Cost-effective, reliable protection using the SPD Series or SPC units
Small facilities	SPC units	
	CVX units	
	SP1 units	
Large Projects		
Including:	SPD Series integrated units in panelboards, switchboards, MCCs, switchgear, busway and automatic transfer switches	Able to meet competitors' surge protection specifications
Commercial		Increased surge protection performance by using integrated SPD Series units
Government	SPD Series sidemount units	Wall space savings by using integrated SPD Series units
Schools	SPD MAX units	Quick-ship capabilities from Eaton assembly satellites and service centers
Institution	AEGIS units for critical load applications	Power conditioning capability for a wide variety of applications
Military	Power conditioners (T700, T800 and T100 and SRT2 units)	
Industrial		
Including:	SPD Series integrated units in panelboards, switchboards, MCCs, switchgear, busway and automatic transfer switches	Increased surge protection performance by using integrated SPD Series units
Small and large facilities		Wall space savings by using integrated SPD Series units
WWTP	SPD Series sidemount units	MCCs with SPD Series units installed protect drives from damage
	SPD MAX units	AEGIS products protect expensive critical loads from harmful damage
	AEGIS units for critical load applications such as PLCs, robotics applications, etc.	T700 and T800 units correct voltage regulation problems
	Power conditioners (T700, T800 and T100 and SRT2 units)	SRT2 units correct voltage sag problems
OEM		
Any OEM customer including:	SPD Series integrated units	Years of experience in a variety of OEM applications
Integrators	SPD Series sidemount units	Application assistance and recommendations
Medical equipment	CVX units	Small footprint enables integration in a variety of applications
	SPC units	Ability to meet customized requirements
Automation and control	SP1 units	
	SP2 units	
	AEGIS units for critical load applications	
Telecommunications		
Including:	Panelboards and automatic transfer switches with integrated SPD Series units	Ability to meet customized requirements
Cellular sites	SPD Series sidemount units	Application assistance and recommendations
Microwave	CVX units	
	SPC units	
PCS	SP1 units	
Paging systems	SP2 units	

SPD Series Sidemount Units

Contents

Learn Online

Product Overview

Product Description

Eaton's SPD series surge protective devices are the latest and most advanced UL® 1449 4th Edition certified surge protectors. Units are available integrated within Eaton electrical assemblies, including panelboards, switchboards, motor control centers, switchgear, automatic transfer switches and bus plugs.

SPD Series Integrated Units

A complete offering of sidemount units designed for mounting external to electrical distribution equipment is also available. Application of SPD Series units throughout a facility will ensure that equipment is protected with the safest and most reliable surge protective devices available. SPD Series units are available in all common voltages and configurations and also in a variety of surge current capacity ratings from 50 through 400 kA. Three feature package options are also available to choose from, ensuring the proper unit is available for a variety of applications.

Features, Benefits and Functions

- Uses thermally protected metal oxide varistor (MOV) technology
- Three feature package options
- True protection status indicators report the status of the protection elements, not the status of the applied power
- Available integrated within the following Eaton electrical assemblies: panelboards, switchboards, motor control centers, switchgear, automatic transfer switches and bus plugs
- 10-year warranty (15-year warranty with online registration)

Safety Features

- All units use thermally protected metal oxide varistor technology (MOV) as their core surge suppression component. Usage of this technology ensures safe operation when the unit is subjected to abnormal conditions such as temporary overvoltage or high fault current conditions. Under such conditions, the self-protected MOVs are removed from the circuit quickly and safely before a potentially unsafe condition can occur
- SPD Series units contain no replaceable parts such as surge modules, fuses, or surge counter memory backup batteries. This prevents potential arc flash and shock hazards, as the units require no periodic service or user intervention after installation
- Integrated versions of the unit are factory installed and sidemount versions are factory sealed. These important safety measures further enhance user safety

Three Feature Package Options Available

The SPD Series provides users with the option of selecting between three feature packages. These feature packages are the basic, standard and standard with surge counter. The proper feature package can be selected based on the requirements of the application or specification. A side by side comparison of the individual features found in each package is below.

Basic Feature Package

The basic feature package is perfect for applications where basic, cost-effective, safe and reliable surge protection is required, but budgets don't allow for extra, additional features. Rather than sacrifice performance or safety due to cost, SPD Series units with the basic feature package provide you with high-performing surge protection without sacrificing safety or reliability. The basic feature package provides the same level of surge protection and safety provided by the standard and standard with surge counter feature packages minus some of the features found in them. The package contains dual-colored protection status LEDs that report the true status of the protection in each phase/mode. All four-wire plus ground units also contain an additional set of dual-colored protection status LEDs that report the status of the protection in the neutral/ground mode.

Standard Feature Package

The standard feature package includes all of the features found in the basic feature package, plus an audible alarm with silence button, EMI/RFI filtering, and a form 'C' relay contact that can be used for remote annunciation of the SPD's status. The audible alarm activates and the form 'C' relay contact changes state when any loss of protection is detected or a fault condition exists with the unit. Should such a condition occur, the audible alarm can be silenced by pressing the silence button. The EMI/RFI filter provides up to 50 dB of noise attenuation over the range of 10 kHz through 100 MHz.

Standard with Surge Counter Feature Package

The standard with surge counter feature package includes all of the features found in the standard feature package plus a six-digit surge counter with a reset button. The surge counter indicates the ongoing count of the number of surges the unit has been exposed to and stores them in nonvolatile memory. Should power to the SPD Series unit be completely interrupted, the surge counter will recall and display the surge count prior to the interruption when power is restored. Unlike many surge protectors, the SPD Series' surge counter memory feature does not require a backup battery that would require periodic replacement in order to achieve its memory functionality.

Side-By-Side Comparison of the SPD Series' Available Feature Packages

Feature Package Comparison	Basic	Standard	Standard with Surge Counter
Surge protection using self-protected MOV technology	■	■	■
Dual-colored protection status indicators for each phase	■	■	■
Dual-colored protection status indicators for the N-G protection mode	■	■	■
Audible alarm with silence button		■	■
Form 'C' relay contact		■	■
EMI/RFI filtering, providing up to 50 dB of noise attenuation from 10 kHz to 100 MHz		■	■
Surge counter with reset button			■

Standards and Certifications

- Integrated versions of the unit are UL 1449 4th Edition recognized components for the United States and Canada, covered by Underwriters Laboratories certification and follow-up service
- Sidemount versions are UL 1449 4th Edition listed devices and are also CSA approved

Technical Data and Specifications

- 20 kA nominal discharge current (I_n) rating (maximum rating assigned by UL)
- 50 through 400 kA surge current capacity ratings
- 200 kA short-circuit current rating (SCCR)

SPD Series Unit Integrated within an Eaton Panelboard

Contents

SPD Series for Integration into Electrical Distribution Equipment

Product Description

Eaton's SPD Series surge protective devices are the latest and most advanced UL 1449 4th Edition certified surge protectors. SPD Series units are available in all common voltages and configurations, and also in a variety of surge current capacity ratings from 50 to 400 kA.

Application Description

The SPD Series is available as an integrated device within the following Eaton electrical assemblies:

- Panelboards
- Switchboards
- Motor control centers
- Switchgear
- Automatic transfer switches
- Bus plugs

Features, Benefits and Functions

- Uses thermally protected metal oxide varistor (MOV) technology
- Three feature package options
- 10-year warranty (15-year with online registration)

The Integrated SPD Performance Advantage

Installation conductor length is the single most important factor related to an SPD's performance. Performance decreases as the connected conductor length increases. Integrating the SPD within the electrical assembly provides the best possible surge protection by keeping installation conductor lead lengths as short as possible. Integrating the SPD within an electrical assembly can decrease let-through voltages by hundreds of volts, providing you with the best possible surge protection for sensitive electronic loads.

Remote Display Mounting Option Available

The SPD Series offers the option of mounting its display remotely from the device. This is useful for applications where OEMs or other integrators would like to embed the unit within a piece of equipment and still be able to view its display.

In this installation, the SPD Series is mounted directly to the panelboard's bus bars. This type of installation will provide the best possible surge protection by minimizing the connected lead length.

The SPD Series is also available as an integrated unit interfaced via a circuit breaker resident in the electrical assembly. This installation keeps connected lead lengths short while providing a means of disconnecting power to the unit quickly and easily.

Standards and Certifications

- UL 1449 4th Edition recognized component for the United States and Canada, covered by Underwriters Laboratories certification and follow-up service
- UL 1283 7th Edition (Type 2 SPDs only)

Catalog Number Selection

SPD Series Units Mounted Internal to Electrical Distribution Equipment

SPD 250 480D 2 J

Series
SPD = Surge protective device

kA Rating
050 = 50 kA per phase
080 = 80 kA per phase
100 = 100 kA per phase
120 = 120 kA per phase
160 = 160 kA per phase
200 = 200 kA per phase
250 = 250 kA per phase
300 = 300 kA per phase
400 = 400 kA per phase

Voltage Code
240S = 120/240 single split-phase
208Y = 120/208 wye (4W+G)
220Y = 127/220 wye (4W+G)
400Y = 230/400 wye (4W+G)
480Y = 277/480 wye (4W+G)
600Y = 347/600 wye (4W+G)
240D = 240 delta (3W+G)
480D = 480 delta (3W+G)
600D = 600 delta (4W+G)
240H = 240 high-leg delta (4W+G) on 'B' phase ①

Feature Package
1 = Basic
2 = Standard
3 = Standard + surge counter

Application—Integrated Units ②
A = Panelboards (PRL1a, 2a, 3a, 3E), direct bus mounted
B = Switchgear (includes remote display)
C = Panelboards (PRL1a, 2a, 3a, 3E, 4), switchboards, busway
J = Motor control centers

Notes

① Please consult the factory for 240 high-leg delta (4W+G) applications with high leg on 'C' phase.

② Units used in PRL1a, 2a, 3a and 3E panelboard applications are available in 50–200 kA ratings only. Use the 'C' option for PRL1a, 2a, 3a and 3E panelboard applications when unit is connected through a circuit breaker.

Example: SPD250480D2J = SPD Series, 250 kA per phase, 480D voltage, standard feature package, motor control center application.

Technical Data and Specifications

SPD Series Specifications

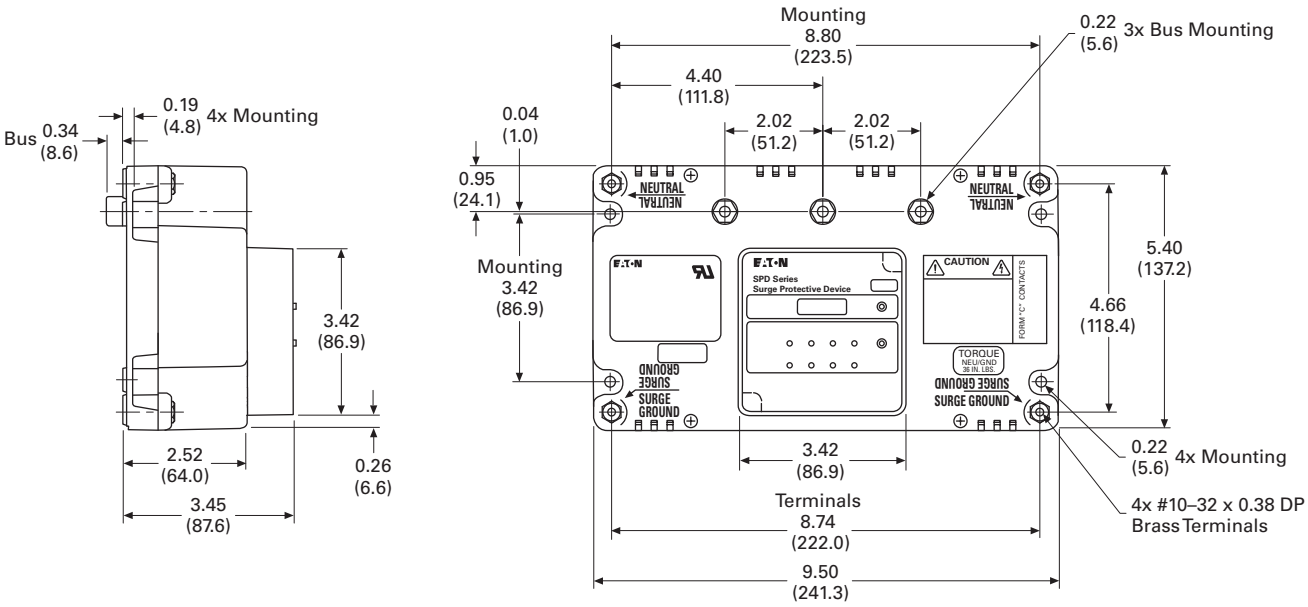
Description	Specification	
Surge capacity ratings available	50, 80, 100, 120, 160, 200, 250, 300, 400 kA per phase	
Nominal discharge current (I_n)	20 kA (maximum rating assigned by UL)	
Short-circuit current rating (SCCR)	200 kA	
SPD type	Basic feature package = Type 1 (can also be used in Type 2 applications) Standard and standard with surge counter feature packages = Type 2	
Single split-phase voltages available	120/240	
Three-phase wye system voltages available	120/208, 127/220, 230/400, 277/480, 347/600	
Three-phase delta system voltages available	240, 480, 600	
Input power frequency	50/60 Hz	
Power consumption (basic units):		
208Y, 220Y, 240S, 240D and 240H voltage codes	0.5 W	
400Y, 480Y and 480D voltage codes	1.1 W	
600Y and 600D voltage codes	1.3 W	
Power consumption (standard and standard with surge counter units):		
208Y, 220Y, 240S, 240D and 240H voltage codes	0.6 W	
400Y, 480Y and 480D basic voltage codes	1.7 W	
600Y and 600D voltage codes	2.1 W	
Protection modes	Single split-phase	L-N, L-G, N-G, L-L
	Three-phase wye	L-N, L-G, N-G, L-L
	Three-phase delta	L-G, L-L
	Three-phase high-leg delta	L-N, L-G, N-G, L-L
Maximum continuous operating voltage (MCOV):		
240S, 208Y, 220Y and 240H MCOV	150 L-N, 150 L-G, 150 N-G, 300 L-L	
400Y and 480Y MCOV	320 L-N, 320 L-G, 320 N-G, 640 L-L	
600Y MCOV	420 L-N, 420 L-G, 420 N-G, 840 L-L	
240D MCOV	320 L-G, 320 L-L	
480D MCOV	640 L-G, 640 L-L	
600D MCOV	840 L-G, 840 L-L	
Ports	1	
Operating temperature	–40 °F through 122 °F (–40 °C through 50 °C)	
Operating humidity	5% through 95%, noncondensing	
Operating altitude	Up to 16,000 ft (5000 m)	
Seismic withstand capability	Meets or exceeds the requirements specified in IBC 2006, CBC 2007 and UBC Zone 4	
Form C relay contact ratings	150 Vdc or 125 Vac, 1 A maximum	
Form C relay contact logic	Power ON, normal state—NO contact = open, NC contact = closed Power OFF or fault state—NO contact = closed, NC contact = open	
EMI/RFI filtering attenuation	Up to 50 dB from 10 kHz to 100 MHz	

Dimensions

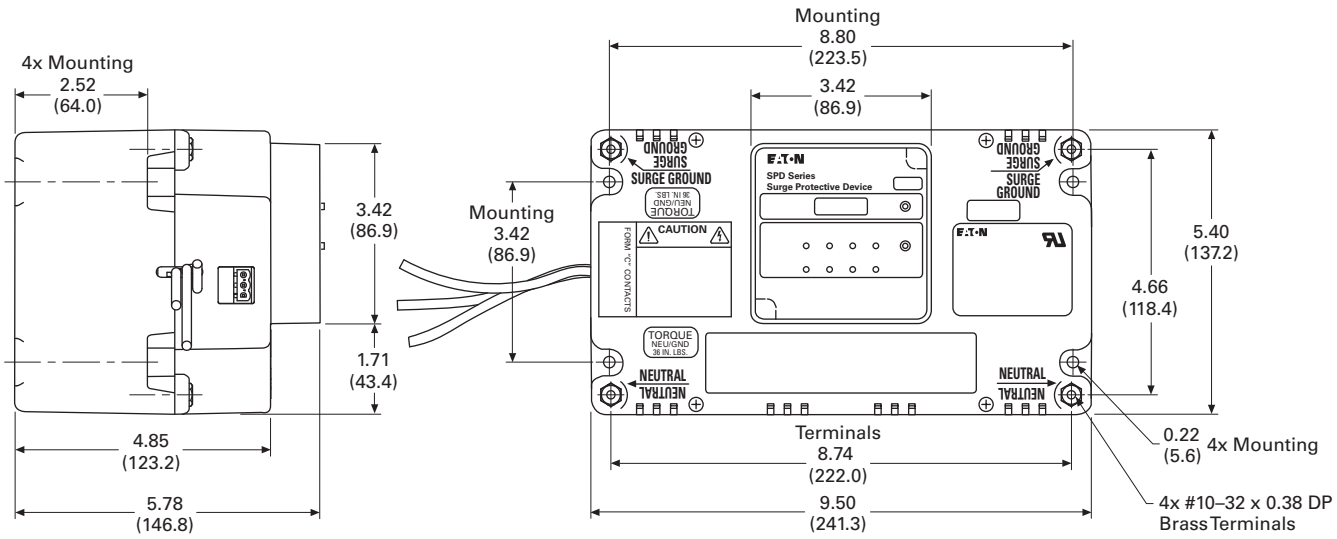
Approximate Dimensions in Inches (mm)

2

50–200 kA Integrated Units



250–400 kA Integrated Units



Weights

- 50–200 kA units approximately 3.5 lb (1.6 kg)
- 250–400 kA units approximately 7.0 lb (3.2 kg)

Eaton SPD Series Sidemount Unit Mounted Externally to an Eaton Panelboard

Contents

SPD Series for Mounting External to Electrical Distribution Equipment

Product Description

Eaton's sidemount versions of the SPD Series surge protective devices are the latest and most advanced UL 1449 4th Edition listed surge protectors. Application of SPD Series units throughout a facility will ensure that equipment is protected with the safest and most reliable surge protective devices available. Units are available in all common voltages and configurations, and also in a variety of surge current capacity ratings from 50 through 400 kA. Three feature package options are also available to choose from.

Features, Benefits and Functions

- Uses self-protected metal oxide varistor (MOV) technology
- Three feature package options
- 10-year warranty (15-year with registration)

Standards and Certifications

- UL 1449 4th Edition listed device
- Canadian Standards Association (CSA)
- UL 1283 7th Edition (Type 2 SPDs only)

Listed

All SPD Series sidemount units come prewired and include a factory-installed conduit interface, making installation very easy.

All SPD Series units are factory sealed, ensuring that the user/installer has no potential of coming into contact with harmful voltages present inside the unit.

Catalog Number Selection

2

SPD Series Units for Mounting External to Electrical Distribution Equipment

SPD 250 480D 2 K

Series
SPD = Surge protective device

kA Rating
050 = 50 kA per phase
080 = 80 kA per phase
100 = 100 kA per phase
120 = 120 kA per phase
160 = 160 kA per phase
200 = 200 kA per phase
250 = 250 kA per phase
300 = 300 kA per phase
400 = 400 kA per phase

Voltage Code
240S = 120/240 single split-phase
208Y = 120/208 wye (4W+G)
220Y = 127/220 wye (4W+G)
400Y = 230/400 wye (4W+G)
480Y = 277/480 wye (4W+G)
600Y = 347/600 wye (4W+G)
240D = 240 delta (3W+G)
480D = 480 delta (3W+G)
600D = 600 delta (4W+G)
240H = 240 high-leg delta (4W+G) on 'B' phase ①

Feature Package
1 = Basic
2 = Standard
3 = Standard + surge counter

Application—Sidemount Units
K = NEMA 1 enclosure
L = NEMA 1 flushmount enclosure ②
M = NEMA 1 enclosure with internal disconnect
N = NEMA 4 enclosure
O = NEMA 4 enclosure with internal disconnect
P = NEMA 4X enclosure (stainless steel)
Q = NEMA 4X enclosure with internal disconnect (stainless steel)

Notes

① Please consult the factory for 240 high-leg delta (4W+G) applications with high leg on 'C' phase.

② NEMA 1 flushmount units are available in 50–200 kA ratings only.

Example: SPD250480D2K = SPD Series, 250 kA per phase, 480D voltage, standard feature package, housed in NEMA 1 enclosure.

Technical Data and Specifications

SPD Series Specifications

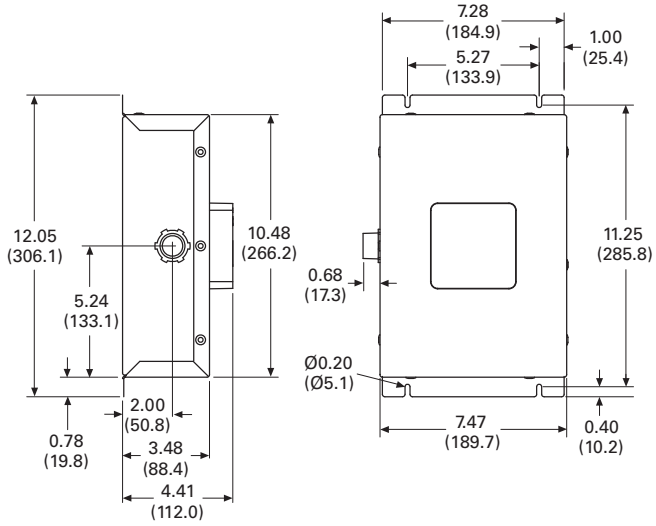
Description	Specification	
Surge capacity ratings available	50, 80, 100, 120, 160, 200, 250, 300, 400 kA per phase	
Nominal discharge current (I_n)	20 kA (maximum rating assigned by UL)	
Short-circuit current rating (SCCR)	200 kA	
SPD type	Basic feature package = Type 1 (can also be used in Type 2 applications) Standard and standard with surge counter feature packages = Type 2	
Single split-phase voltages available	120/240	
Three-phase wye system voltages available	120/208, 127/220, 230/400, 277/480, 347/600	
Three-phase delta system voltages available	240, 480, 600	
Input power frequency	50/60 Hz	
Power consumption (basic units):		
208Y, 220Y, 240S, 240D and 240H voltage codes	0.5 W	
400Y, 480Y and 480D voltage codes	1.1 W	
600Y and 600D voltage codes	1.3 W	
Power consumption (standard and standard with surge counter units):		
208Y, 220Y, 240S, 240D and 240H voltage codes	0.6 W	
400Y, 480Y and 480D basic voltage codes	1.7 W	
600Y and 600D voltage codes	2.1 W	
Protection modes	Single split-phase	L-N, L-G, N-G, L-L
	Three-phase wye	L-N, L-G, N-G, L-L
	Three-phase delta	L-G, L-L
	Three-phase high-leg delta	L-N, L-G, N-G, L-L
Maximum continuous operating voltage (MCOV):		
240S, 208Y, 220Y and 240H MCOV	150 L-N, 150 L-G, 150 N-G, 300 L-L	
400Y and 480Y MCOV	320 L-N, 320 L-G, 320 N-G, 640 L-L	
600Y MCOV	420 L-N, 420 L-G, 420 N-G, 840 L-L	
240D MCOV	320 L-G, 320 L-L	
480D MCOV	640 L-G, 640 L-L	
600D MCOV	840 L-G, 840 L-L	
Ports	1	
Operating temperature	–40 °F to 122 °F (–40 °C to 50 °C)	
Operating humidity	5% through 95%, noncondensing	
Operating altitude	Up to 16,000 ft (5000 m)	
Seismic withstand capability	Meets or exceeds the requirements specified in IBC 2006, CBC 2007 and UBC Zone 4	
Enclosure dimensions and weights	Refer to figures on **Pages V3-T2-14–V3-T2-15** for enclosure dimensions and weights	
Form C relay contact ratings	150 Vdc or 125 Vac, 1 A maximum	
Form C relay contact logic	Power ON, normal state—NO contact = open, NC contact = closed Power OFF or fault state—NO contact = closed, NC contact = open	
EMI/RFI filtering attenuation	Up to 50 dB from 10 kHz to 100 MHz	

Dimensions

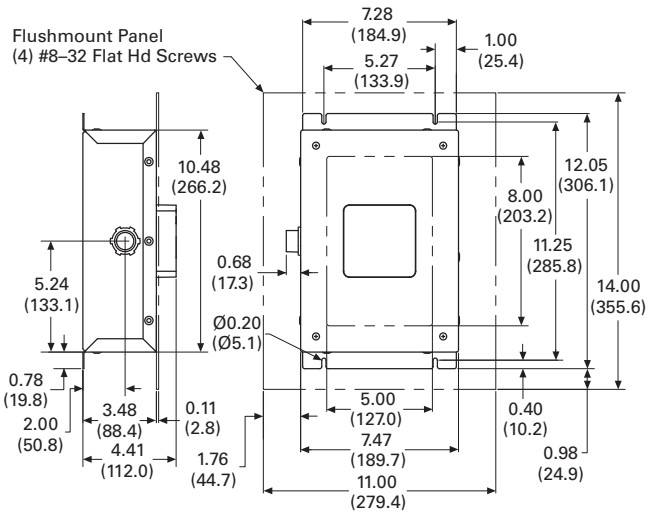
Approximate Dimensions in Inches (mm)

2

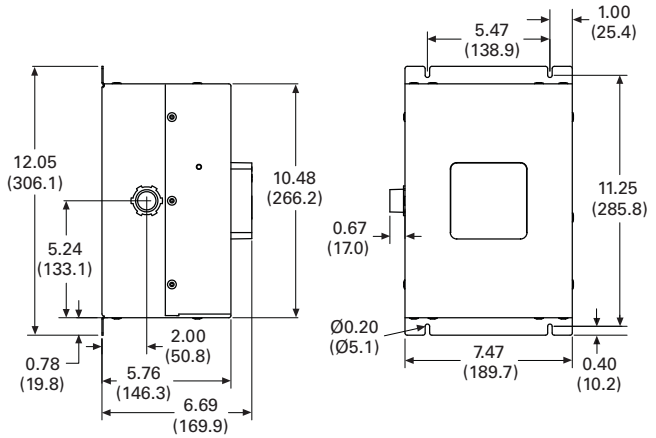
50–200 kA Units in a NEMA 1 Rated Enclosure, Weight = 6.8 Lb



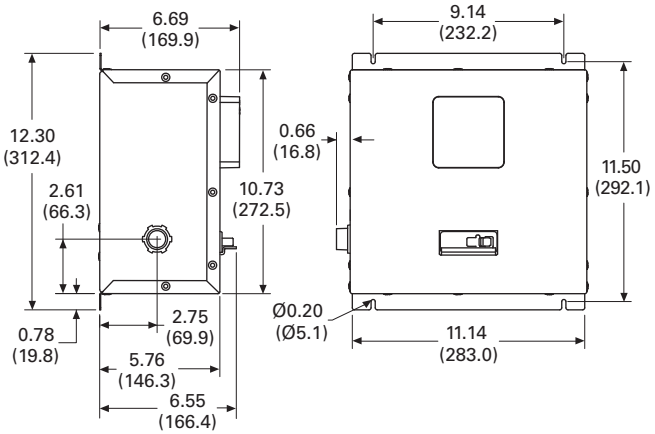
50–200 kA Units in a NEMA 1 Rated Flushmount Enclosure, Weight = 6.8 Lb



250–400 kA Units in a NEMA 1 Rated Enclosure, Weight = 13.5 Lb

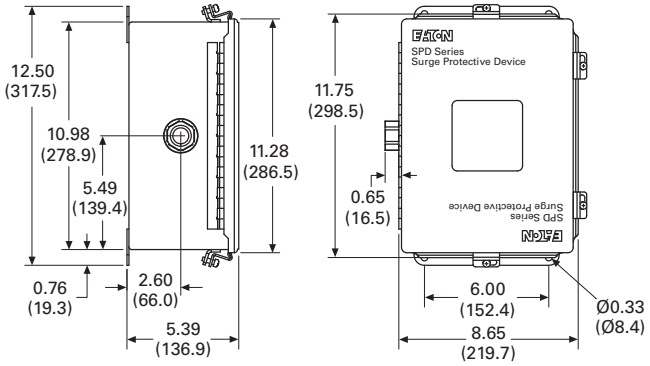


50–400 kA Units in a NEMA 1 Rated Enclosure with Internal Disconnect, Weight = 14.7 Lb

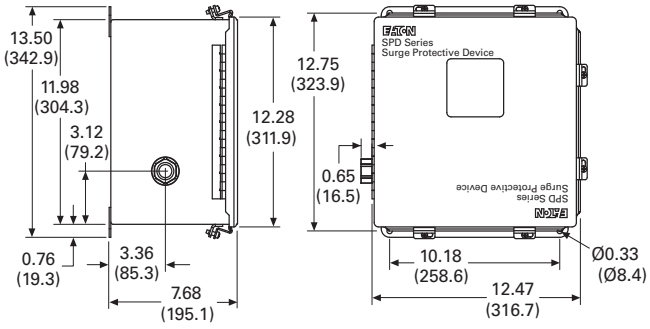


Approximate Dimensions in Inches (mm)

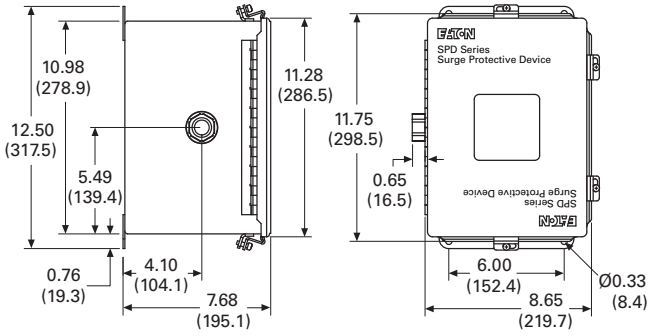
50–200 kA Units in a NEMA 4 or 4X Rated Enclosure, Weight = 14.6 Lb



50–400 kA Units in a NEMA 4 or 4X Rated Enclosure with Internal Disconnect, Weight = 27.5 Lb



250–400 kA Units in a NEMA 4 or 4X Rated Enclosure, Weight = 14.6 Lb



SPD MAX

2

Contents

SPD MAX Series Surge Protection

Product Description

Eaton's SPD MAX Series side-mounted surge protective devices are the latest and most advanced UL 1449 4th Edition certified surge protectors. Applying SPD MAX Series units at main service entrances and critical loads will ensure that equipment is protected with the safest and most reliable surge protective devices (SPDs) available. Units are available in all common voltages and configurations, and also in a variety of surge current capacity ratings from 100 kA through 800 kA. Additionally, you may choose from two feature package options.

Application Description

The breadth of the SPD MAX Series' features, options and configurations ensures that the correct unit is available for all electrical applications, including service entrances, main switchgear, motor control centers, distribution switchboards, panelboards and point-of-use applications.

Features

- Uses thermally protected metal oxide varistor (MOV) technology
- Lockout and tagout provisions
- Safety barriers
- 20 kA nominal discharge current (I_n) rating (maximum rating assigned by UL)
- 100 kA through 800 kA surge current capacity ratings
- Installation flexibility, #10 to 1/0 wire may be used
- Two feature package options
- 200 kA short-circuit current rating (SCCR) (maximum rating assigned by UL)
- Field serviceable
- 15-year warranty standard, additional 5 years with product registration

Standards and Certifications

- UL 1449 4th Edition
- UL 1283 7th Edition
- Canadian Standards Association (CSA)
- Built in an ISO 9001 facility
- Designed and tested in accordance with:
  - IEEE C62.41.1
  - IEEE C62.41.2
  - IEEE C62.43-2005
  - IEEE C62.45-2002
  - IEEE C62.48-2005
  - IEEE C62.62-2010

c UL us Listed

Catalog Number Selection

SPD MAX Series Surge Protection

SPM 250 480D 3 R

Series
SPM

kA Rating
100 = 100 kA per phase
120 = 120 kA per phase
160 = 160 kA per phase
200 = 200 kA per phase
250 = 250 kA per phase
300 = 300 kA per phase
320 = 320 kA per phase
400 = 400 kA per phase
600 = 600 kA per phase
800 = 800 kA per phase

Voltage Code Options ①
240S = 120/240 split-phase
208Y = 120/208 wye (4W+G)
220Y = 127/220 wye (4W+G)
400Y = 230/400 wye (4W+G)
600Y = 347/600 wye (4W+G)
240D = 240 delta (3W+G)
480D = 480 delta (3W+G)
600D = 600 delta (4W+G)
240H = 240 delta high-leg (4W+G) on 'B' phase
230L = 230 single-phase

Application Suffix
S = 2 module, NEMA 4 enclosure with internal circuit breaker
T = 1 module, NEMA 4 enclosure with internal terminal block
U = 2 module, NEMA 4 enclosure with internal terminal block
V = 1 module, NEMA 4X enclosure with internal circuit breaker
W = 2 module, NEMA 4X enclosure with internal circuit breaker
X = 1 module, NEMA 4X enclosure with internal terminal block
Y = 2 module, NEMA 4X enclosure with internal terminal block

Feature Package Options
1 = Basic Dual-colored LED per phase to indicate protection status Dual-colored LED to indicate protection status of the N–G mode on units with a neutral wire
3 = Standard with surge counter Dual-colored LED per phase to indicate protection status Dual-colored LED to indicate protection status of the N–G mode on units with a neutral wire Audible alarm with silence button Form C relay contact EMI/RFI filtering that provides up to 50 dB of noise attenuation from 10 kHz to 100 MHz Surge counter with alarm silence (reset) button

Notes

① Please consult the factory for 240 high-leg delta (4W+G) applications with high leg on 'C' phase.

SPD250480D3R = SPD MAX Series, 250 kA per phase, 480D voltage, standard with counter features package, NEMA 4 enclosure with internal circuit breaker.

Technical Data and Specifications

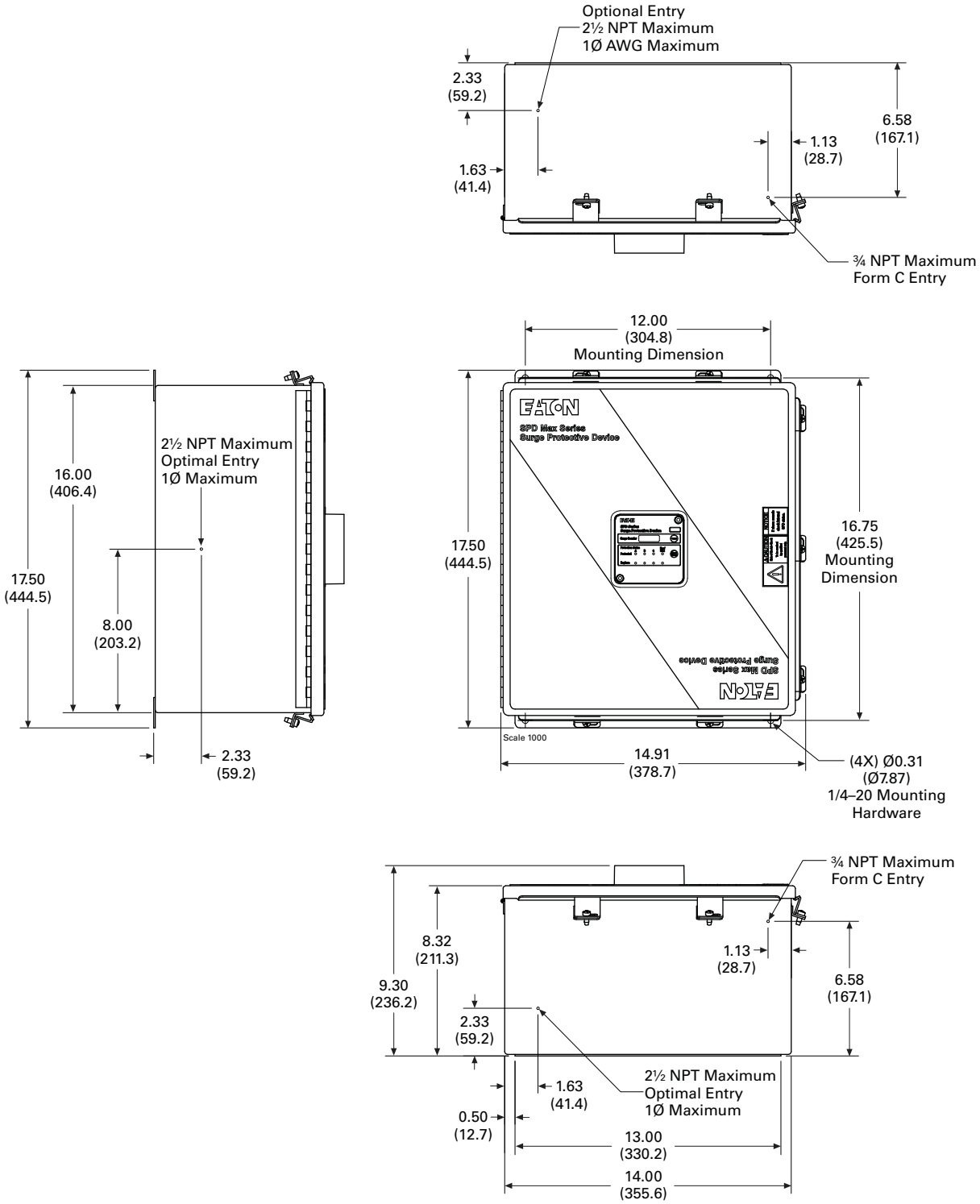
SPD MAX Series Surge Protection

Description	Specification
Surge current capacity per phase	100 kA, 120 kA, 160 kA, 200 kA, 250 kA, 300 kA, 320 kA, 400 kA, 600 kA, 800 kA ratings available
Nominal discharge current (I_n)	20 kA
Short-circuit current rating (SCCR)	200 kA
SPD type	Basic feature package = Type 1 (can also be used in Type 2 applications)
	Standard with surge counter feature package = Type 2
Enclosure types	NEMA 4, NEMA 4X enclosure
Circuit breaker—30 A	Eaton catalog number: FDC3030L
Circuit Breaker Load and Line	
Terminal torque specifications	#10 AWG 35 lb-in; #8 AWG 40 lb-in; #6–#4 AWG 45 lb-in; #3–1/0 AWG 50 lb-in (SPD maximum wire range #10–1/0 AWG)
Standard split-phase voltages available	120/240
Single-phase	230
Three-phase wye system voltages available	120/208, 127/220, 230/400, 277/480, 347/600
Three-phase delta system voltages	240, 480, 600
Three-phase high leg delta system voltages	120/240 high leg phase wire will be identified with a tag from the factory
Input power frequency	50/60 Hz
Power Consumption (Standard with Surge Counter Units)	
208Y, 220Y, 230L, 240S, 240D and 240H voltage codes	0.6 W
400Y, 480Y and 480D basic voltage codes	1.7 W
600Y and 600D voltage codes	2.1 W
Protection modes	Single split-phase L–N, L–G, N–G, L–L, single-phase L–N, L–G, N–G, three-phase delta L–G, L–L, three-phase wye L–N, L–G, N–G, L–L, three-phase high leg delta L–N, L–G, N–G, L–L
Maximum Continuous Operating Voltage (MCOV)	
230 V single-phase	320 V L–N, 320 V L–G, 320 V N–G
127 V/220 V wye, 120 V/240 V single split phase	150 V L–N, 150 V L–G, 150 V N–G, 300 V L–L
120 V/240 V hi leg	150 V L–N, 150 V L–G, 150 V N–G, 300 V L–L, 320 V H–N, 320 V H–G, 470 V H–L
230 V/400 V wye, 277 V/480 V wye	320 V L–N, 320 V L–G, 320 V N–G, 640 V L–L
347 V/600 V wye	420 V L–N, 420 V L–G, 420 V N–G, 840 V L–L
240 V delta	300 V L–G, 300 V L–L
480 V delta	640 V L–G, 640 V L–L
600 V delta	840 V L–G, 840 V L–L
Ports	1 or 2
Operating temperature and humidity	–20 °C through +50 °C (–4 °F through +122 °F), 5% through 95%, noncondensing
Storage temperature	–20 °C through +50 °C (–4 °F through +122 °F)
Operating altitude	Up to 16,000 ft (5000 m)
Weight	Not to exceed 52 lb
Form C relay contact ratings	Maximum 0.46 A, 150 Vac, 1 A, 30 Vdc
Form C terminal block ratings	Rated 300 V, 16 A, 30–12 AWG solid or stranded wire. Torque range 5–7 lb-in
Form C relay contact logic	Power on, normal state—NO contact = OPEN, NC contact = CLOSED Power off, fault state—NO contact = CLOSED, NC contact = OPEN
EMI/RFI filtering attenuation (standard with surge counter)	Up to 50 dB from 10 kHz to 100 MHz
Standards / agency certifications	UL 1449 Edition 4—standard for surge protective devices
	UL 1283 Edition 7—standard for EMI filters (Type 2 SPDs only)
	CSA Electrical Notice No. 516 Edition 1—surge/transient voltage suppressor (excludes 230 L voltage code)
	CSA 22.2 NO. 8-M1986 Edition 4—EMI filters
Warranty	15 years from the date of delivery to the purchaser, 20 years if the product is properly registered at www.eaton.com
RoHS compliant	Yes

Dimensions

Approximate Dimensions in Inches (mm)

SPD MAX Series Surge Protection



SPC

Contents

SPC Surge Protective Device

Product Description

Eaton's SPC Series surge protective devices are UL, 1449 4th Edition, certified surge protectors. Application of SPC Series units throughout a facility will ensure that equipment is protected with the safest and most reliable surge protective devices available. The compact design and NEMA 4X enclosure of the SPC Series allows for installation external to an electrical assembly in a variety of environments.

SPC Series units are available in all common voltages and configurations, and in a variety of peak surge current capacity ratings from 50 through 200 kA per phase. Several feature package options, including filtering, audible alarm and Form C contacts, are available to choose from. A range of configurable options is available to customize the SPC Series features for most electrical applications, including service entrances, distribution panelboards and point-of-use applications. The SPC Series belongs to Eaton's complete family of surge protection solutions, providing coverage for any application.

Application Description

Surge events—short-term transients in voltage threatening critical downstream equipment—happen for many reasons. The most common source, though, is internal devices powering on and off: motors, transformers, photocopiers, fluorescent lighting ballasts, light dimmers, fax machines and more. They can also be generated externally by events like lightning, grid switching or electrical equipment in adjacent buildings.

While seemingly innocent, surge events can wreak serious havoc on unprotected and inadequately protected facilities. They can disrupt, damage or destroy sensitive microprocessor-based devices (computers, programmable logic controls, etc.), resulting in premature aging of equipment, process interruptions and catastrophic failures.

The best way to prevent downtime from an electrical surge is through facility-wide cascaded surge protection at all stages of the electrical distribution system. When properly installed, surge protective devices can mitigate problems with susceptible equipment, keeping it and its related processes running reliably without surge-related disruptions.

Eaton's SPC Series surge protective device (SPD) is a key component to your cascaded protection strategy. It's compact, flexible and configurable to protect most electrical applications, including service entrances, distribution panelboards and point-of-use applications.

Features

- Thermally protected metal oxide varistor (MOV) technology
- Tri-colored LED protection status indicators
- 20 kA nominal discharge current (I_n) rating (maximum rating in the UL 1449 4th Edition standard)
- 50 through 200 kA per phase peak surge current capacity ratings
- Configure-to-order with eight custom feature combinations
- Corrosion-resistant NEMA 4X enclosure with mounting feet
- 200 kA short-circuit current rating (SCCR)
- Factory prewired with 36 inches of 10 AWG wire
- No user-serviceable parts or items requiring periodic maintenance
- 5-year warranty that can be extended to 10 years with product registration at Eaton.com/spc

Standards and Certifications

- UL 1449 4th Edition Type 1 and Type 2
- UL 1283 7th Edition (Feature packages: 2, 6, 7 and 8)
- Canadian Standards Association (CSA) Type 1 and Type 2

Listed

Catalog Number Selection

SPC

SPC 200 208Y 8 P

Series
SPC

kA Rating (Options)
050 = 50 kA per phase
080 = 80 kA per phase
100 = 100 kA per phase
120 = 120 kA per phase
150 = 150 kA per phase
160 = 160 kA per phase
200 = 200 kA per phase

Voltage Code (Options)	
120N	= 120 V single-phase (2 W +G)
240N	= 240 V single-phase (2 W +G)
277N	= 277 V single-phase (2 W +G)
480N	= 480 V single-phase (2 W +G)
240S	= 120/240 V split-phase (3 W +G)
240D	= 240 V delta (3 W +G)
480D	= 480 V delta (3 W +G)
600D	= 600 V delta (3 W +G)
240H	= 240 V high leg delta (4 W +G)
208Y	= 120/208 V wye (4 W +G)
415Y	= 240/415 V wye (4 W +G)
480Y	= 277/480 V wye (4 W +G)
600Y	= 347/600 V wye (4 W +G)

Features	
Options	**SPD Application**
1 = No options (standard configuration)	Type 1
2 = Filtering, UL 1283 7th Edition	Type 2
3 = Audible alarm	Type 1
4 = Form C relay	Type 1
5 = Audible alarm and Form C relay	Type 1
6 = Filtering and audible alarm	Type 2
7 = Filtering and Form C relay	Type 2
8 = Filtering, audible alarm and Form C relay	Type 2

Enclosure
P = NEMA 4X

Technical Data and Specifications

SPC

Description	Specification
Peak surge current capacity ratings available	50, 80, 100, 120, 150, 160, 200 kA per phase
Nominal discharge current (I_n)	20 kA
Short-circuit current rating (SCCR)	200 kA
Single-phase voltages available (2 W + G)	120, 240, 277, 480
Split-phase voltages available (3 W +G)	120/240
Three-phase wye system voltages available (4 W + G)	120/208, 240/415, 277/480, 347/600
Three-phase delta system voltages available (3 W + G)	240, 480, 600
Three-phase high leg delta system voltage available (4 W + G)	240
Input power frequency	50/60 Hz
Protection modes	Single-phase: L-N, N-G, L-G Split-phase: L-N, N-G, L-G, L-L Wye: L-N, N-G, L-G, L-L Delta: L-G, L-L
Maximum continuous operating voltage (MCOV):	
120N	150 L-N, 150 L-G, 150 N-G
240N, 277N	320 L-N, 320 L-G, 320 N-G
480N	550 L-N, 550 L-G, 550 N-G
240S, 208Y	150 L-N, 150 L-G, 150 N-G, 300 L-L
240H	150 L-N, 150 L-G, 150 N-G, 300 L-L, 470 H-L, 320 H-N, 320 H-G
415Y and 480Y	320 L-N, 320 L-G, 320 N-G, 640 L-L
600Y	320 L-N, 320 L-G, 320 N-G, 840 L-L
240D	320 L-G, 300 L-L
480D	550 L-G, 640 L-L
600D	840 L-G, 840 L-L
Ports	1
Operating temperature	–40 °F to 140 °F (–40 °C to 60 °C)
Storage temperature	–40 °F to 140 °F (–40 °C to 60 °C)
Operating humidity	5% through 95%, noncondensing
Operating altitude	Up to 2000 m (6561 ft)
Agency certification/listing	UL 1449 4th edition, UL 1283 7th edition, CSA C22.2 No. 269.1-14 for Type 1 SPD, CSA C22.2 No. 269.2-13 for Type 2 SPD, CSA C22.2 no. 8-13 for EMI Filter
Durability Repetitive Strike Test	Passed 15,000 strikes to ANSI/IEEE C62.41 (20 kV, 10 kA) Category C Waveform
SPD type	UL 1449 4th edition and CSA Type 1 and Type 2 SPD (dependent on feature options)
Enclosure dimensions and weights	Refer to **Page V3-T2-23** for enclosure dimensions and weights
Enclosure rating	NEMA 4X enclosure ①
Form C relay contact ratings	2A at 30 Vdc or 250 Vac
Form C relay contact logic	Power ON, normal state; NO contact = open, NC contact = closed Power OFF or fault state; NO contact = closed, NC contact = open
EMI/RFI filtering attenuation	Up to 40 dB from 10 kHz to 100 MHz
RoHS compliant	Yes
Warranty	5 years standard, 10 years with product registration on www.eaton.com/spc

SPC voltage configurations per enclosure size

P1 Enclosure	P2 Enclosure
120N/240N/277N/480N = 50–200 kA	240S = 120–200 kA
240S = 50–100 kA	208Y/415Y/480Y/600Y = 120–200 kA
208Y/415Y/480Y/600Y = 50–100 kA	240D/480D = 120–200 kA
240D/480D = 50–00 kA	600D = 50–200 kA
240H = 50–100 kA	240H = 120–200 kA

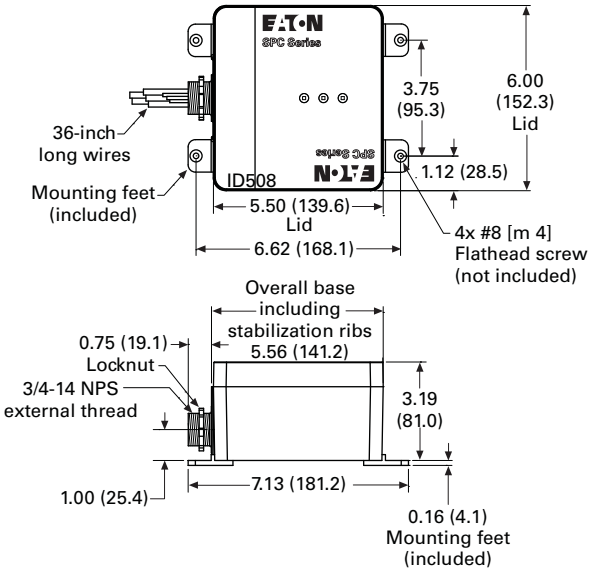
Note

① Mounting feet required to achieve NEMA 4X rating.

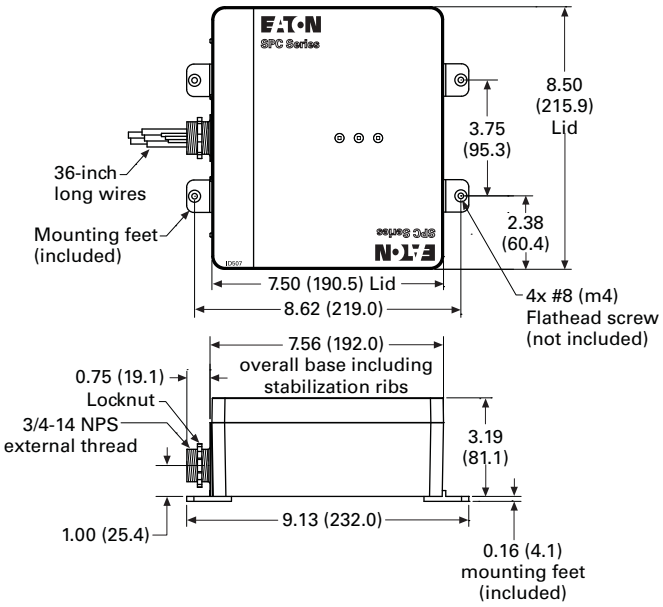
Dimensions

Approximate Dimensions in Inches (mm)

P1



P2



CVX050/100

Contents

CVX050/100

Product Description

With over two decades of experience in the surge suppression industry and extensive R&D initiatives, Eaton is considered a world leader in surge protective device (SPD) manufacturing. All of Eaton's products are manufactured in an ISO® 9001:2000 and ISO 14001 certified facility.

Eaton's CVX050/100 models are rugged, cost-effective, high-quality SPDs that feature self-protected MOVs that eliminate the failure characteristics of standard metal oxide varistors. This technology results in a fail-safe device that monitors the status of the metal oxide disk and disconnects itself from the power system when the disk is approaching breakdown.

The CVX050/100 is easy to install adjacent or even internal to electrical equipment. When installing an SPD in a retrofit environment, it is important to mount the device as close to the electrical equipment as possible. Keep the wiring (lead length) between the electrical equipment and SPD as short as possible, and twist or wire tie the conductors together to reduce the wire's impedance factor.

Application Description

Eaton's CVX050 and CVX100 SPDs protect electronic equipment from damaging transients. These units are suitable for medium and low exposure level applications that require cost-effective, high quality system protection including:

- Residential/small business
- Light industrial
- Light commercial
- Branch panel protection
- OEM applications

Features, Benefits and Functions

- Advanced surge path technology for high fault current capacity, low impedance, high frequency design
- Rugged NEMA® 4X (IP65) enclosure
- Large diameter, self-protected metal oxide varistors provide long life and fail-safe operation
- LED monitoring of each phase
- Wide range of voltage applications from 100 to 600 Vac and 48 and 125 Vdc
- 5-year free replacement warranty

Optional Features

- External mounting feet (catalog number MNTGFTX)
- Flush mounting plate (catalog number FLUSHMNTPLATE12)

Standards and Certifications

- UL 1449 4th Edition for surge protective devices
- CE marked
- Vibration tested IEC 60255-21-1 and -2

Note: CE, CSA and UL on AC unit only.

Catalog Number Selection

CVX050/100

CVX 050 - 240S

Per Phase Peak Surge Current
050 = 50 kA
100 = 100 kA

Configuration and Voltage Ranges	
230L	= Single-phase—200, 208, 220, 230, 240, 277 Vac
480L	= Single-phase—480 Vac
240S	= Split-phase—100/200, 110/220, 120/240 Vac
240H	= Three-phase high leg delta—120/240 Vac
208Y	= Three-phase wye (star)—100/174, 110/190, 120/208, 127/220 Vac
480Y	= Three-phase wye (star)—220/380, 230/400, 240/415, 277/480 Vac
600Y	= Three-phase wye (star)—305/525, 347/600 Vac
240D	= Three-phase delta—200, 208, 220, 230, 240 Vac
480D	= Three-phase delta—380, 400, 415, 440, 480 Vac
600D	= Three-phase delta—525, 600 Vac (600D available in 50 kA only)
048DC	= Direct current—48 Vdc ①
125DC	= Direct current—125 Vdc ①

Technical Data and Specifications

CVX050/100 Model Specifications

Description	Specification
Peak kA per phase	50, 100
Peak kA per mode	50
Nominal discharge current	20 kA ①
Short-circuit current rating	100 kA
Single-phase voltages	200, 208, 220, 230, 240, 277, 380, 400, 440, 460, 480 Vac
Split-phase voltages	100/200, 110/220/ 120/240 Vac
High leg delta voltages	240 Vac
Wye system voltages	100/175, 110/190, 120/208, 127/220, 220/380, 230/400, 240/415, 277/480, 305/525, 347/600 Vac
Delta system voltages	200, 208, 220, 230, 240, 380, 400, 415, 440, 480, 525, 600 Vac
Direct current Voltage ②	48 Vdc, 125 Vdc
Input power frequency	47–420 Hz (50/60 Hz typical)
Protection modes	Single-phase: L-N, N-G, L-G Split-phase: L-N, N-G, L-G, L-L High leg delta: L-N, N-G, L-G, L-L, H-N, H-G, H-L Wye: L-N, N-G, L-G, L-L Delta: L-G, L-L Direct current ① (DC): L-L, L-G
Number of ports	1
Specific energy	100 kJ/Ohm
Weight	≈2.0 lb (1.0 kg)
Operating temperature	–13 °F (–25 °C) to +140 °F (+60 °C)
Vibration tested	IEC 60255-21-1 and IEC 60255-21-2

Notes

① 480L, 600D and 600Y units rated 10 kA I_n.

② DC models only available in 50 kA.

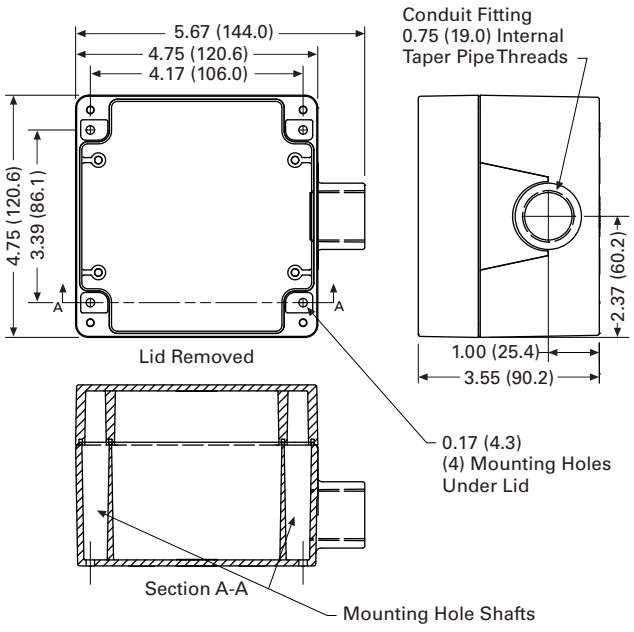
CVX050/100 Voltage Ratings

Model	System Configuration	Nominal System Voltage	MCOV L-L	MCOV L-N	MCOV L-G	MCOV N-G	UL 1449-4 VPR ① L-L	UL 1449-4 VPR ① L-N	UL 1449-4 VPR ① L-G	UL 1449-4 VPR ① N-G
CVX050										
230L	Single-phase two-wire + ground	200, 208, 220, 230, 240, 277	—	320	640	320	—	1200	1200	1200
480L	Single-phase two-wire + ground	380, 400, 440, 460, 480	—	550	1100	550	—	1800	4000	1800
240S	Split-phase three-wire + ground	100/200, 110/220, 120/240	300	150	300	150	1200	700	1200	800
208Y	Three-phase wye (star) four-wire + ground	100/175, 110/190, 120/208, 127/220	300	150	300	150	1200	700	1200	800
480Y	Three-phase wye (star) four-wire + ground	220/380, 230/400, 240/415, 277/480	640	320	640	320	2500	1200	2000	1200
600Y	Three-phase wye (star) four-wire + ground	305/525, 347/600	840	420	840	420	2500	1500	2500	1500
240D	Three-phase delta three-wire + ground	200, 208, 220, 230, 240	640	—	320	—	2000	—	1200	—
240H	Three-phase high leg delta	240	300	150	150	640	1500	700	1200	700
480D	Three-phase delta three-wire + ground	380, 400, 415, 440, 480	1100	—	550	—	3000	—	1800	—
600D	Three-phase delta three-wire + ground	525, 600	1100	—	700	—	3000	—	2500	—
048DC	Direct current	48 Vdc ②	130	—	65	—	—	—	—	—
125DC	Direct current	125 Vdc ②	288	—	144	—	—	—	—	—
CVX100										
230L	Single-phase two-wire + ground	200, 208, 220, 230, 240, 277	—	320	320	320	—	1200	1200	1200
480L	Single-phase two-wire + ground	380, 400, 440, 460, 480	—	550	550	550	—	1800	1800	1800
240S	Split-phase three-wire + ground	100/200, 110/220, 120/240	300	150	150	150	1200	700	800	700
208Y	Three-phase wye (star) four-wire + ground	100/175, 110/190, 120/208, 127/220	300	150	150	150	1000	600	700	700
480Y	Three-phase wye (star) four-wire + ground	220/380, 230/400, 240/415, 277/480	640	320	320	320	1800	1200	1200	1200
600Y	Three-phase wye (star) four-wire + ground	305/525, 347/600	840	420	420	420	2500	1500	1500	1500
240D	Three-phase delta three-wire + ground	200, 208, 220, 230, 240	640	—	320	—	1800	—	1200	—
240H	Three-phase high leg delta	240	300	150	150	150	1200	700	700	700
480D	Three-phase delta three-wire + ground	380, 400, 415, 440, 480	1100	—	550	—	3000	—	1800	—

Dimensions

Approximate Dimensions in Inches (mm)

CVX050/100 Standard Dimensions



Dimensions are in Inches (mm)

Notes

① UL 1449 4th Edition VPR (voltage protection rating) test environment: All tests performed with 6-inch lead length, positive polarity.

② DC units available in 50 kA only. Voltages shown are the maximum suggested operating voltages and are not UL certified.

SP1 Surge Protective Device

Contents

SP1 Surge Protective Device

Product Description

Eaton's SP1 is a UL 1449 4th Edition-listed surge protective device that provides reliable, cost-effective surge protection. This Type 1 SPD is capable of being installed on either the line or the load side of the service entrance disconnect, and can be used as a replacement for devices formerly known as secondary surge arresters or lightning arresters, which could not be manufactured after UL 1449 4th Edition went into effect on September 29, 2009. The unit is available in many common voltages and configurations. Multiple mounting options coupled with a compact footprint enables installation of the SP1 in a wide range of applications, including panel-boards, loadcenters, pump panels, control cabinets, and other electrical assemblies and applications.

Installation and operation of the SP1 is simple. The unit comes pre-wired with 24.00 inches of 10-gauge wire and is mounted via the half-inch nipple that is molded into its enclosure. Wall or DIN rail mounting can also be accomplished with the addition of an optional kit. When powered, the unit's light-emitting diode (LED) indicator reports the status of the protection elements and is active when all of them are intact and providing protection. Any loss of protection is signaled when the LED extinguishes.

Features

- Type 1 SPD capable of installation on either the line or the load side of the service entrance disconnect
- 20 kA nominal discharge current rating (I_n) on most models
- 50 kA per phase surge current capacity
- Compact footprint—4.80-inch L x 2.90-inch W x 2.50-inch D
- Pre-wired with 24.00 inches of 10-gauge wire
- Half-inch nipple molded into enclosure enables quick and easy mounting
- Optional kit enables wall or DIN rail mounting
- Two-year warranty

Standards and Certifications

- UL 1449 4th Edition-listed device

Catalog Number Selection

SP1

2

SP1 - XXXX

Series	Voltage Code
SP1	**240S** = 120/240 V single split-phase **208Y** = 120/208 wye **480Y** = 277/480 wye **600Y** = 347/600Y wye **240D** = 240 delta **480D** = 480 delta **600D** = 600 delta

SP1MNTGKIT = optional wall or DIN rail mounting kit
(order separately—not included with SP1 unit)

Technical Data and Specifications

SP1

Description	Ratings
Surge current capacity per phase	50 kA
Nominal discharge current (I_n)	20 kA for SP1-240S, 208Y, 480Y, 240D and 480D
	10 kA for SP1-600Y and 600D
Short-circuit current rating (SCCR)	200 kA
SPD type	Type 1 (can also be used in Type 2 applications)
System voltages available (Vac)	
Single split-phase	120/240
Three-phase wye	120/208, 277/480, 347/600
Three-phase delta	240, 480, 600
Protection modes	
Single split-phase and three-phase wye	L-N, L-L
Three-phase delta	L-G, L-L
Maximum continuous operating voltage (MCOV)	
SP1-240S and SP1-208Y	150 L-N, 300 L-L
SP1-480Y	320 L-N, 640 L-G
SP1-600Y	420 L-N, 840 L-G
SP1-240D	300 L-G, 300 L-L
SP1-480D	640 L-G, 640 L-L
SP1-600D	840 L-G, 840 L-L
Input power frequency	50/60 Hz
Enclosure rating	NEMA 4
Operating temperature	–20 °C to 50 °C (–4 °F to 122 °F)
Operating humidity	5–95%, noncondensing
Operating altitude	Up to 16,000 ft (5000 m)
Agency certification and approvals	UL 1449 4th Edition Listed device
Warranty	2 years

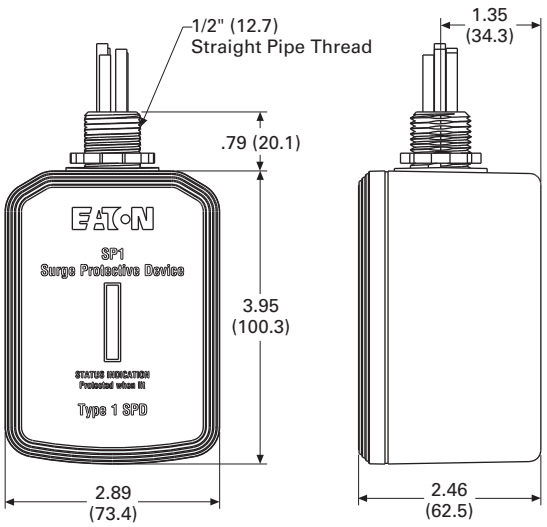
ANSI/UL 1449 4th Edition Voltage Protection Ratings

Catalog Number	Protection Mode L-N	L-G	L-L
SP1-240S	600	N/A	1000
SP1-208Y	600	N/A	1000
SP1-480Y	1200	N/A	2000
SP1-600Y	1500	N/A	2500
SP1-240D	N/A	1000	1000
SP1-480D	N/A	2000	2000
SP1-600D	N/A	2500	2500

Dimensions

Approximate Dimensions in Inches (mm)

SP1



SP2 Surface Protective Device

Surge Protection for Light Commercial and UL 508A Panel Applications

Contents

SP2 Surge Protective Device

Product Description

The SP2 provides basic surge protection for light commercial electrical systems and OEM equipment requirements. The SP2 is available in the most popular voltage and system configurations and delivers superior surge protection using MOV thermal disconnect technology that eliminates the need for additional overcurrent protection.

Application Description

By providing surge protection, the SP2 can suppress the transients that are prevalent throughout the power distribution system to support reliable operations in applications including:

- HVAC systems
- Control panels
- Automation cabinets
- Pumping systems
- Lighting systems
- Commercial facilities
- Food processing
- Warehouses
- Retail facilities
- Manufacturing operations

Features, Benefits and Functions

- Ease of installation—Compact design allows for easy installation on an electrical panel or meter socket, or integrated into control cabinets
- Type 1 UL 1449 4th Edition listed SP2s are easily selected and installed on the loadside or lineside of the service entrance overcurrent protective device
- Thermal disconnect technology eliminates the need for additional overcurrent protection
- Compact UV-resistant NEMA 4X enclosure for indoor or outdoor applications
- LED status indicators provide surge protection status at a glance—green when good, red to replace
- Voltage-specific models protect electrical systems and equipment, improving performance by more than 110% over "one-size-fits-all" economy surge arresters
- Compact enclosure takes up less space and can be installed in tight spaces
- Can be used on single-phase, split-phase, wye, delta, and high-leg delta systems
- All SP2 devices are individually marked with a serial number for easy tracking and identification
- Two-year warranty

Standards and Certifications

- UL 1449 4th Edition Type 1 SPD File No. E109835, cULus
- Built in an ISO 9001 facility
- Flammability rating UL 94VO
- Designed and tested in accordance with:
  - IEEE C62.41.1
  - IEEE C62.41.2
  - IEEE C62.43-2005
  - IEEE C62.45-2002
  - IEEE C62.48-2005
  - IEEE C62.62-2010

UL Listed

Product Selection

SP2

Nominal System Voltage	Maximum Continuous Operating AC Voltage (MCOV)	System Type	Voltage Protection Ratings (VPR)	Connection Points	Catalog Number
120	150	Single-phase, two-wire	700 L–N	2	**SP2-120**
240	320	Single-phase, two-wire	1200 L–N	2	**SP2-240**
120/240	150	Split-phase, three-wire	700 L–N, 1200 L–L	3	**SP2-240S**
240	320	Three-phase delta, three-wire + ground	1200 L–G, 2500 L–L	4	**SP2-240D**
480	550	Three-phase delta, three-wire + ground	1800 L–G, 3000 L–L	4	**SP2-480D**
120/208	150	Three-phase wye, three-wire + ground	700 L–G, 1200 L–L	4	**SP2-208Y**
277/480	320	Three-phase wye, three-wire + ground	1200 L–G, 2500 L–L	4	**SP2-480Y**
347/600	420	Three-phase wye, three-wire + ground	1500 L–G, 2500 L–L	4	**SP2-600Y**

Technical Data and Specifications

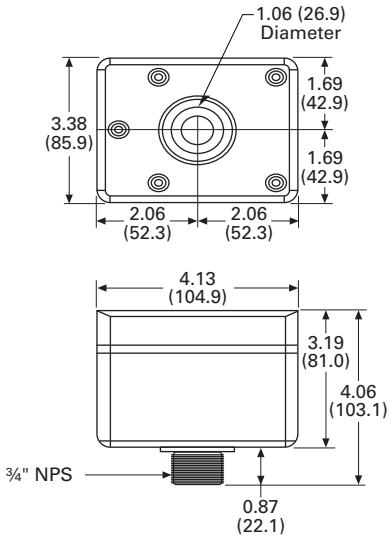
SP2

Description	Specification
Markets	Light commercial and UL 508 A panels
Product warranty	2 years
System types	Single, split, delta, and wye
Nominal system voltage	120, 208, 240, 480, 600 Vac
Installation	Two-, three-, four-wire
Maximum continuous operating AC voltage	Matched to nominal voltage
MCOV	150–550 Vac (see table above)
L–N protection	Yes (single-phase units)
L–L protection	Yes
L–G protection	Yes (three-phase units)
Protection	Surges and transients
SCCR	200 kA
Nominal discharge current (8 x 20 µs) In	10 kA
Maximum discharge current (8 x 20 µs) Imax	45 kA per phase
Response time tA	<25 ns
Voltage protection ratings (VPRs)	See table above
Overcurrent device (if required by local code)	Circuit breaker or fuse sized to protect wires per local codes
Frequency	50/60 Hz
Operating status / fault indication	One bi-color LED—green (good) / red (replace)
Conductor gauge/length	10 AWG stranded copper / 18 inches
Mounting	Chase nipple (¾" NPS)
Enclosure rating	NEMA 4X—UL 94-5VA
Degree of protection (installed state)	IP20 (finger-safe)
Install location	Indoor/outdoor
Circuit location	Lineside/loadside
Standards / agency information	UL 1449 4th Edition Type 1 Listed SPD—cULus, RoHS compliant
Operating temperature	–40 °C to +65 °C
Maximum operating altitude	12,000 ft (3657.6 m)
Weight	17 oz (476 g)

Dimensions

Approximate Dimensions in Inches (mm)

SP2 Enclosure



AEGIS Solutions

Contents

AEGIS Powerline Filters

Product Description

Eaton AEGIS™ Series line filters and surge protectors are specifically designed to protect sensitive electronics from hazards that exist within a facility. The AEGIS Series hybrid filter reacts instantly to changes in voltage regardless of phase angle or polarity. In comparison to other line filters, this technology provides a higher level of suppression, reliability and life expectancy.

Application Description

By providing surge protection and line filtering, AEGIS devices can suppress the noise and transients prevalent throughout the power distribution system to support reliable operations in applications including:

- Instrumentation
- Water treatment facilities
- Pulp and paper operations
- Refrigeration and heating plants
- Petrochemical and refinery
- Food processing
- Textiles
- Automotive assembly
- Manufacturing operations

No matter where transients originate, the application of AEGIS Series devices will help protect sensitive electronic equipment including:

- Programmable logic controllers (PLCs)
- Scanning devices
- Automatic teller machines (ATMs)
- Cash registers
- Alarm systems
- Microprocessor-controlled
- OEM products
- Robotics
- CAD/CAM systems
- Control equipment
- Medical electronics and devices

AEGIS Series devices are available in a variety of common voltages and configurations.

Why Should Sensitive Electronic Loads be Protected?

PLC manufacturers and service technicians recommend the use of power line filters and surge suppressors to prevent downtime and equipment damage due to surges and electrical line noise. Studies have shown that failure to protect sensitive electronic loads costs American manufacturing and commercial and service industries over $39 billion per year in lost time and revenue. Preventing these losses is a major cost-saving opportunity.

Features, Benefits and Functions

- Compact design with multiple mounting options
- Meets new UL safety standards for surge and filtering protection
- AC models available with up to 80 kA surge current capacity ratings
- DIN rail mounting available on most models
- Contains no replaceable parts or items that require periodic maintenance
- Alarm contact available
- Five- to ten-year warranty standard dependent on model; warranty extended an additional five years if registered

The breadth of the AEGIS Series' features, options and configurations ensures that the correct unit is available for all critical electrical applications, including control panels, security systems, measurement systems, lab equipment and other point-of-use applications.

The AEGIS PH Series Protects Critical Loads up to 20 A

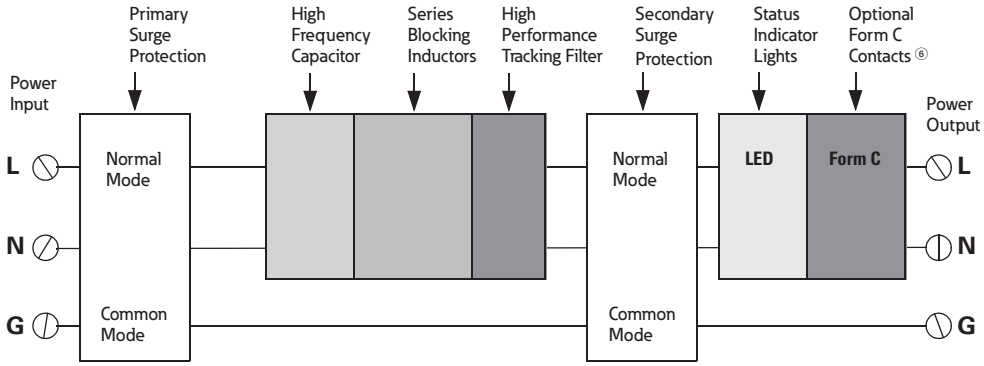
The AEGIS PV Series Protects Critical Loads up to 5 A

AEGIS Summary

Specifications	PH	PV	CF	CN
Voltage	120/240 Vac	120/240 Vac	120/240 Vac ① 24/48 Vdc	120/230 Vac ① 24/48 Vdc
Current range	3–20 A	1–5 A	10–60 A	30 A
DIN mounting	Yes	Yes	Yes ②	No
UL 1283 7th Edition & UL 1449 4th Edition	Yes	Yes	Yes ③	Yes ③
Filtering	Yes	Yes	Yes	No
EMI/RFI filtering attenuation at 100 kHz	75 dB	50 dB	40 dB	N/A
L to G, L to N & N to G protection modes	Yes	Yes	Yes	Yes
Peak kA per phase / mode	60/30	40/20	80/40	80/40
UL nominal discharge current (I_n)	5 kA	5 kA	5 kA	5 kA
UL voltage protection rating (VPR) L–G / L–N ④	330/400	330/400	500/500	500/500
Short-circuit current rating (SCCR)	5 kA	5 kA	10 kA	10 kA
Alarm contacts	Yes	No	Yes ⑤	No
Standard warranty / registered warranty (years)	10/15	10/15	5/10	5/10
Communication line protection (UL 497A)	No	No	Yes ⑤	No

AEGIS PH and PV Series Hybrid Powerline Filters

Three-Wire Design has Normal and Common Mode Protection (L-N, L-G, N-G)



Notes

① Voltage rating of 240 Vac applies to CF24010-DIN2 unit only. Voltage rating of 230 Vac applies to 15 and 30 A units.
② Standard on 10 A; optional on 15 A, 30 A and 60 A with DIN mounting kit.
③ Vac models only.
④ Ratings shown for 120 Vac models, other voltages listed in Technical Data.
⑤ Optional on 30 A and 60 A models only.
⑥ Available on the PH Series only.

AEGIS Products

Standards and Certifications

- UL 1449 4th Edition
- UL 1283 7th Edition
- Built in an ISO® 9001 facility
- Designed and tested in accordance with:
  - IEEE® C62.41.1
  - IEEE C62.41.2
  - IEEE C62.43-2005
  - IEEE C62.45-2002
  - IEEE C62.48-2005
  - IEEE C62.62-2010
- RoHS compliant

Catalog Number Selection

AEGIS

AG _ _ _ _ _

Product Family
AG

Protection/Filtering	Voltage	Amperage	Options
PH = Premium protection with hybrid filtering	**120** = 120 Vac **240** = 240 Vac	**03** = 3 A **05** = 5 A **10** = 10 A **15** = 15 A **20** = 20 A	—
PV = Premium protection with filtering	**120** = 120 Vac **240** = 240 Vac	**01** = 1 A **03** = 3 A **05** = 5 A	—
CF = Critical protection with filtering	**120** = 120 Vac **240** = 240 Vac	**10** = 10 A	**DIN2** = DIN2 mount (1 inch wide) **CP** = Compact ①
	024 = 24 Vdc **048** = 48 Vdc	**10** = 10 A	**DIN** = DIN mount (2.5 inch wide)
	230 = 230 Vac	**15** = 15 A	Optional DIN mount kit—DINRAILKIT-30ACF
	120 = 120 Vac **230** = 230 Vac	**30** = 30 A	**RJ** = Telcom protection and Form C status contacts Optional DIN mount kit—DINRAILKIT-30ACF
		60 = 60 A ②	**RJ** = Telcom protection and Form C status contacts Optional DIN mount kit—DINRAILKIT-60ACF
CN = Critical protection without filtering	**120** = 120 Vac **230** = 230 Vac **024** = 24 Vdc **048** = 48 Vdc	**30** = 30 A	—

Notes

① Only available in the 10 A, 120 Vac CF version.
② Only available in the 120 Vac version.

Technical Data and Specifications

AEGIS PH and PV

Specifications	PH 120 Vac 3, 5, 10, 15, 20 A	PH 240 Vac 3, 5, 10, 15, 20 A	PV 120 Vac 1, 3, 5 A	PV 240 Vac 1, 3, 5 A
DIN mounting	Yes	Yes	Yes	Yes
UL 1283 7th Edition and UL 1449 4th Edition	Yes	Yes	Yes	Yes
RoHS compliant	Yes	Yes	Yes	Yes
Filtering	Yes	Yes	Yes	Yes
EMI/RFI filtering attenuation at 100 kHz	75 dB	75 dB	50 dB	50 dB
L–G, L–N and N–G protection modes	Yes	Yes	Yes	Yes
Peak kA per phase/mode	60/30	60/30	40/20	40/20
UL nominal discharge current (I_n)	5 kA	5 kA	5 kA	5 kA
UL voltage protection rating (VPR) L–G / L–N / N–G	330/400/330	600/700/600	330/400/330	600/700/600
MCOV	150	275	150	275
Short-circuit current rating (SCCR)	5 kA	5 kA	5 kA	5 kA
Alarm contacts	Yes	Yes	No	No
Standard warranty / registered warranty (years)	10/15	10/15	10/15	10/15
Communication line protection (UL 497A)	No	No	No	No

AEGIS CF

Specifications	CF 24 Vdc 10 A	10 A	CF 48 Vdc 10 A	10 A	CF 120 Vac 10 A	10 A	30 A	60 A	CF 230 Vac 15 A	30 A	CF 240 Vac 10 A
DIN mounting	Yes	No	Yes	No	Yes	No	Yes ①	Yes ①	No	No	Yes
UL 1283 7th Edition and UL 1449 4th Edition	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RoHS compliant	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Filtering	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
EMI/RFI filtering attenuation at 100 kHz	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB	40 dB
L–G, L–N and N–G protection modes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peak kA per phase/mode	6/2	6/2	20/6	20/6	30/10	40/20	80/40	80/40	24/8	56/24	30/10
UL nominal discharge current (I_n)	N/A	N/A	N/A	N/A	3 kA	5 kA	5 kA	5 kA	N/A	N/A	3 kA
UL voltage protection rating (VPR) L–G / L–N / N–G	N/A	N/A	N/A	N/A	500/500/500	500/500/500	500/500/500	500/500/500	N/A	N/A	900/800/900
MCOV	30	30	50	50	150	150	150	150	275	275	275
Short-circuit current rating (SCCR)	10 kA	10 kA	10 kA	10 kA	10 kA	10 kA	10 kA	10 kA	10 kA	10 kA	10 kA
Alarm contacts	No	No	No	No	No	No	No	No	No	No	No
Standard warranty / registered warranty (years)	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10
Communication line protection (UL 497A)	No	No	No	No	No	No	Yes ①	Yes ①	No	Yes ①	No

Note

① Optional.

AEGIS CN

Specifications	24 Vdc 30 A	48 Vdc 30 A	120 Vac 30 A	230 Vac 30 A
DIN mounting	No	No	No	No
UL 1283 7th Edition and UL 1449 4th Edition	—	—	Yes	Yes
RoHS compliant	Yes	Yes	Yes	Yes
Filtering	No	No	No	No
EMI/RFI filtering attenuation at 100 kHz	N/A	N/A	N/A	N/A
L–G, L–N and N–G protection modes	Yes	Yes	Yes	Yes
Peak kA per phase/mode	20/6	46/20	80/40	56/24
UL nominal discharge current (I_n)	N/A	N/A	5 kA	N/A
UL voltage protection rating (VPR) L–G / L–N / N–G	N/A	N/A	500/500/500	N/A
MCOV	30	50	150	275
Short-circuit current rating (SCCR)	10 kA	10 kA	10 kA	10 kA
Alarm contacts	No	No	No	No
Standard warranty / registered warranty (years)	5/10	5/10	5/10	5/10
Communication line protection (UL 497A)	No	No	No	No

Maximum EMI/RFI Attenuation—MIL-STD-220

Model	10 kHz	100 kHz	1 MHz	10 MHz	100 MHz	Maximum Attenuation Frequency
AGPH120AG	30 dB	74 dB	76 dB	37 dB	36 dB	101 dB at 0.5 MHz
AGPV120AG	27 dB	56 dB	55 dB	36 dB	28 dB	66 dB at 0.085 MHz
AGCF12010-CP	16 dB	35 dB	62 dB	40 dB	50 dB	68 dB at 1.25 MHz
AGCF12010-DIN	16 dB	35 dB	56 dB	29 dB	51 dB	66 dB at 0.7 MHz
AGCF12010	17 dB	35 dB	64 dB	33 dB	51 dB	64 dB at 1.0 MHz
AGCF12030	24 dB	44 dB	58 dB	42 dB	53 dB	67 dB at 0.6 MHz
AGCF12060	20 dB	48 dB	53 dB	29 dB	46 dB	69 dB at 0.4 MHz

Let-Through Voltages Based on IEEE Std. C62.62-2010 Testing Waveforms ①

Test Impulse	AEGIS Series AGPH120AG	AGPV120AG	AGCF12010	AGCF12010-DIN	AGCF12010-CP	AGCF12030AGx	AGCF12060AGx	AGCN12030
IEEE Category A 100 kHz ring wave 6000 V, 200 A	25 V	30 V	150 V	300 V	300 V	150 V	90 V	400 V
IEEE Category B 100 kHz ring wave 6000 V, 500 A	35 V	40 V	330 V	400 V	400 V	330 V	230 V	500 V
IEEE Category B combination wave 6000 V, 3000 A (UL 1449-3 VPR)	360 V	370 V	470 V	480 V	460 V	460 V	450 V	460 V

Note

① All tests conducted on 120 Vac units.

Sag Ride-Through (SRT2)

2

Contents

Sag Ride-Through (SRT2)

Product Description

Eaton's sag ride-through is the first of its kind.

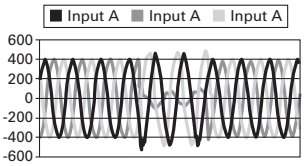
The SRT2 power conditioner prevents expensive electrical downtime. The SRT2 represents Eaton's state-of-the-art solution to today's power conditioning challenges.

The Problem—Voltage Sags and Brownouts

The ability of a plant to ride-through voltage sags can have a significant impact on operations and competitiveness. In the United States, voltage sags cost billions of dollars in lost production, interruption, damaged materials, retooling and scrap. In addition, sags can cause: increased operating costs, the need for product reworks, safety hazards, equipment damage and/or failure, reduced product quality, increased clean-up, additional labor costs, increased scrap material and costs associated with investigations into the problem.

Today's industrial and large commercial electricity customers are becoming more sensitive to power disturbances and are demanding better electric quality. However, the quality of power grids is not significantly improving. Customers still experience power quality problems that affect plant operations and profitability.

Deep, Single-Phase Sag



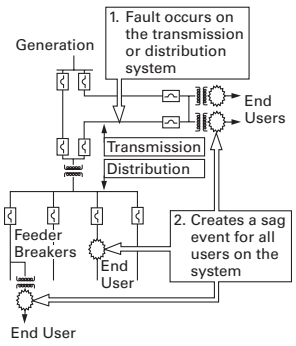
Definition of Voltage Sag

A voltage sag is a sudden, momentary decrease in supply voltage. It can last from a cycle to several seconds. Voltage sags are most often caused by faults on the electrical transmission or distribution system. They can be caused by lightning strikes, animal contact, starting of large motors or an internal fault within a customer's facility.

Depending on the proximity to the fault, which can be hundreds of miles away, the voltage during the sag is typically 40%–90% of nominal utility voltage. The operation of circuit breakers, fuses and reclosers limits most sags to less than 15 cycles.

Voltage sags are experienced 10 to 20 times more frequently than complete outages. However, voltage sags are equally disruptive to sensitive equipment.

Voltage Sags

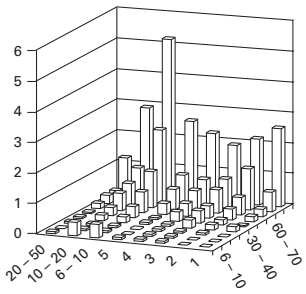


Regularity of Voltage Sags

EPRI conducted a two-year study of power quality levels on distribution systems in the United States. A variation event was recorded every time the voltage dropped below 90% of the nominal. The results are shown below.

A typical distribution system customer experiences about 50 events per year when the voltage drops below 90%, and only about two events per year when the voltage drops below 30% of nominal. The utility study concluded that sags represented almost all of the events experienced at a typical facility.

Events per Year



Application Description

Industries and Applications Affected by Sags

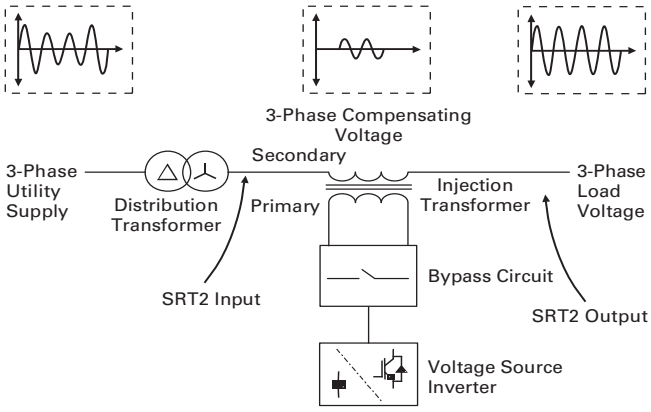
Key industries:

- Semi-conductor manufacturers
- Communications
- Steel mills
- Petroleum and chemical processing
- Health care
- Paper mills
- Automotives
- Textile
- Printing
- Plastics
- Other manufacturing

Equipment or processes:

- Manufacturing process controllers
- Variable speed drives
- Robotics
- Motor conductor
- Telephone systems
- HID lighting
- HVAC controls
- Medical equipment
- Computers

Block Diagram of the SRT2 Active Voltage Conditioner



Features, Benefits and Functions

Sag Correction Using the SRT2

The SRT2 is a high performance, inverter-based voltage conditioning device developed to provide protection to sensitive loads against commonly occurring voltage sags.

The SRT2 monitors the incoming supply voltage and when it deviates from the nominal voltage level, the SRT2 achieves voltage conditioning by injecting the appropriate correction voltage in series with the power supply. The SRT2 provides an extremely fast reaction time and subcycle response to sag events that would otherwise cause loads to drop out.

The SRT2 is designed for low voltage systems and is also offered in medium voltage applications from up to 50 MVA. Installation is simple and the SRT2 provides customers with a new solution to improve productivity and reduce downtime for sag related problems.

The SRT2 meets the stringent requirements of the Semi-F47 standard; a key requirement for SAG correction in the semi-conductor industry.

- Complete correction of single-phase voltage sags down to 63% for 30 seconds
- Partial correction of three-phase sags down to 50% for 30 seconds
- Correction of utility voltage unbalance (from network side of transformer)
- Attenuation of voltage flicker

Continuous Regulation

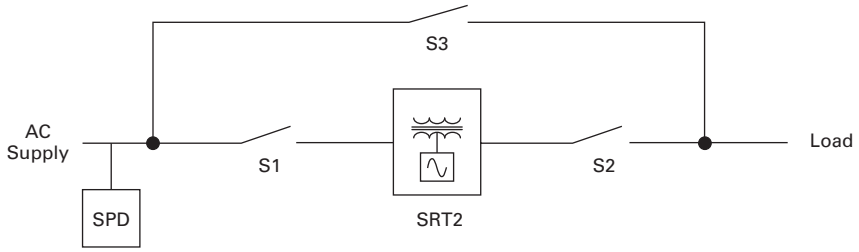
The Sag Ride-Through is an active voltage conditioner. This means it will constantly respond to voltage sags and swells in the +/–10% range with a regulated output in the +/–1% range. The SRT2 can be applied to the main service entrance, at branch locations or in front critical loads. The SRT2 provides an outstanding return on investment. It delivers operation productivity that is just not possible with traditional tap switching or ferroresonant technologies. The SRT2 consists of a voltage source inverter, bypass circuit and an injection transformer connected in series between the incoming utility supply and the load, as shown in the figure below. For the standard sag correcting model, the injection transformer consists of a boost component. The SRT2 monitors the incoming supply voltage and when it deviates from the nominal voltage level the SRT2 inserts an appropriate compensating voltage using the IGBT inverter and series injection transformer. Energy is sourced from the supply during this time. This regulates the load voltage to its nominal value, thus eliminating voltage disturbances from the utility supply affecting the load.

Product Selection

SRT2 ①

Load Capacity at Nominal Voltage 480 V (kVA) ②	Terminal Cabinet ③	Fault Capacity (kVA)	System Efficiency (%)	System Dissipation (Worst Case) (kW)	Airflow (m3/min)	Cabinet Dimensions H x W x D in Inches (mm)	Catalog Number ④
150	No	40	97.5	3.8	18	85.00 x 32.00 x 32.00 (2159.0 x 812.8 x 812.8)	**SRT20150480AA**
150	Yes	40	97.5	3.8	18	85.00 x 32.00 x 32.00 (2159.0 x 812.8 x 812.8)	**SRT20150480AA-TC**
225	No	40	97.7	5.2	18	85.00 x 32.00 x 32.00 (2159.0 x 812.8 x 812.8)	**SRT20225480AA**
225	Yes	40	97.7	5.2	18	85.00 x 32.00 x 32.00 (2159.0 x 812.8 x 812.8)	**SRT20225480AA-TC**
300	No	40	98.0	6.1	18	85.00 x 40.00 x 32.00 (2159.0 x 1016 x 812.8)	**SRT20300480AA**
300	Yes	40	98.0	6.1	18	85.00 x 40.00 x 32.00 (2159.0 x 1016 x 812.8)	**SRT20300480AA-TC**
450	No	40	98.2	8.0	36	85.00 x 40.00 x 32.00 (2159.0 x 1016 x 812.8)	**SRT20450480AA**
450	Yes	40	98.2	8.0	36	85.00 x 40.00 x 32.00 (2159.0 x 1016 x 812.8)	**SRT20450480AA-TC**
600	No	40	98.4	9.8	36	85.00 x 40.00 x 32.00 (2159.0 x 1016 x 812.8)	**SRT20600480AA**
600	Yes	40	98.4	9.8	36	85.00 x 40.00 x 32.00 (2159.0 x 1016 x 812.8)	**SRT20600480AA-TC**
750	No	40	98.4	12.2	54	85.00 x 96.00 x 48.00 (2159.0 x 2438.4 x 1219.2)	**SRT20750480AA**
750	Yes	40	98.4	12.2	54	85.00 x 96.00 x 48.00 (2159.0 x 2438.4 x 1219.2)	**SRT20750480AA-TC**
900	No	40	98.5	13.2	54	85.00 x 96.00 x 48.00 (2159.0 x 2438.4 x 1219.2)	**SRT20900480AA**
1200	No	40	98.5	18.1	72	85.00 x 126.00 x 96.00 (2159.0 x 3200.4 x 2438.4)	**SRT21200480AA**
1500	No	50	98.7	20.2	90	85.00 x 126.00 x 96.00 (2159.0 x 3200.4 x 2438.4)	**SRT21500480AA**
1800	No	50	98.8	22.1	108	85.00 x 126.00 x 96.00 (2159.0 x 3200.4 x 2438.4)	**SRT21800480AA**

SRT2 with External Maintenance Bypass Block Diagram



Note: A terminal cabinet may be needed if a bypass cabinet is not used. SRT2 units 900 kVA and larger do not require a terminal cabinet; however, an external three-breaker mechanical bypass with integrated surge protection is recommended.

Notes

① For 50 Hz international applications, consult factory.
② 480 V is standard. If additional voltage is needed, consult factory.
③ Eaton external three-breaker maintenance bypass cabinet is recommended. If a bypass is not used, a terminal cabinet may be required. Contact factory.
④ TC in the model number denotes terminal cabinet, which is not required for units of 900 kVA and larger.

Technical Data and Specifications

SRT2 Specifications

Features	Specifications
Load Capacity	
Capacity	150–1800 kVA (consult factory for custom design; up to 36 kVA available)
Displacement power factor of connected load	0 lagging to 0.9 leading
Crest factor for rated kVA	3 at 100% of rated load
Overload capacity (>90% supply voltage)	150%, 30 seconds, once per 500 s
Input Supply	
Nominal supply voltage (according to model)	480 V Voltages up to 36 kV available as custom applications ①
Power system type	Three-phase, center ground referenced
Supply voltage category	Level III transient voltage capability
Fault capacity	Refer to model tables
Operating Voltage Range for Regulation	
Supply voltage for regulation	90–110% of nominal input voltage unit rating
Output Supply	
Nominal voltage (V)	Set to match nominal supply voltage
Three-phase V regulation range	±10% continuous
Three-phase V regulation accuracy	±1%
Three-phase balanced sag/swell correction ability: 40% model	 +40% / –10% at least 30 s at full load
Sag correction accuracy (within specified range)	±2.5%
Sag correction response: Initial Complete	 <250 µs <0.25 cycle
Single-phase sag correction ability: 40% model (15% retained voltage / 85% sag)	 90% nominal
Equivalent series impedance (operating)	<4% typical
Efficiency of system	0.98 to 0.99 (refer to model tables)
Bypass	
Capacity	100% model rating (kVA)
Maximum overload capacity (in bypass): For 10 minutes For 1 minute For 1 second For 200 milliseconds Transfer time: Inverter to bypass	 125% 150% 500% 2000% <0.5 ms
Equivalent series impedance (in bypass)	<2.5% typical
Interface	
Access protocol	Ethernet connectivity; Modbus® TCP, dry contacts
Environmental	
Enclosure rating	NEMA® 1, IP20
Pollution degree rating	2
Minimum operating temperature	0 °C
Maximum operating temperature	40 °C
Temperature derating	Above 40 °C derate at 2% per °C to a maximum of 50 °C
Capacity elevation derating	–2% every 100 m above 1000 m
Cooling: Inverter Transformer	 Forced ventilation Fan assisted ventilation
Humidity	<95%, noncondensing
EMC emissions	CISPR 22 level G
Noise	65 dBA
Warranty	1 year

Note

① 480 V is standard. If additional voltage is needed, consult factory.

Power-Sure 700 (T700)

Contents

Power-Sure 700 (T700)

Product Description

Eaton's Power-Sure 700 (T700) is the ideal solution for keeping your facility and equipment up and running during brownouts, undervoltage conditions and other power problems. The Power-Sure 700 (T700) can significantly reduce the costs of equipment damage and downtime when these situations occur. The state-of-the-art design provides rapid response time, high efficiency, high inrush current capability, and operating advantages exclusive to Eaton.

The Power-Sure 700 (T700) maintains a tightly regulated output voltage by automatically activating the appropriate transformer tap through a silicone controlled rectifier (SCR). Tap changer response time is initiated at one cycle, ensuring rapid and precise regulation. Switching at zero current enables noise reduction during tap transitions.

Brownouts

In the United States, most facilities have sufficient voltage regulation. However, in some U.S. locations and many developing countries, regulation problems occur because of overstressed utility distribution systems.

In some cases, due to the excessive demand on the utility system, voltage may be below 10% of nominal (–10%) during the day. This condition is called a **voltage dip or brownout.** Customers may notice dim lights and reduced power. During the evening, voltage may rise above 10% of nominal (+10%) because large facilities and loads are shut down. This shutdown reduces the power demand on the grid and results in a voltage increase.

The IEEE defines voltage regulation as overvoltage or undervoltage. Voltage regulation events last from a **few minutes to many hours** with voltage varying by ±20%. Long-term regulation problems differ from short duration sags and dips, which are much deeper voltage drops.

The Solution

Prior to installing an expensive solution, Eaton encourages customers to monitor incoming voltage to determine if voltage regulation is a problem. The local utility may also be able to provide information on voltage expected at the facility.

Using a meter, it can quickly be determined if a voltage regulation problem or brownout condition exists. The appropriate solution would be a Power-Sure 700 (T700). The Power-Sure 700 (T700) can be installed at the service entrance, branch panel or at critical loads.

Eaton's Power-Sure 700 (T700) is a solid-state tap changing power conditioner designed to protect against brownouts and long duration voltage regulation problems.

Features and Benefits

- Coordinated with standard thermal-magnetic breakers to allow motor starts
- Optional 50 kA or 100 kA per phase surge protection
- Input frequency range operation from 57–63 Hz
- Integral manual rotary maintenance bypass switch standard on 50 to 500 kVA units and optional on smaller units
- Not affected by load power factor. Can operate effectively in low-load applications due to "unique leakage reactance" technology
- Fail-safe bypass circuit, isolation transformer and overtemperature protection
- Less than 1% THD
- Optional Standard and Premium metering to monitor voltage, current, frequency, power, energy, PF with minimum and maximum, and communication capabilities

Catalog Number Selection

Power-Sure 700 (T700)

T ___ ___ - ___ ___ ___ k - ___ ___

Nominal Input Voltage
(Delta Input: L, L, L, G)

B = 208
C = 240
H = 400
D = 480
E = 600

Nominal Output Voltage
(Wye Output: L, L, L, N, G)

L = 120/208
M= 230/400
N = 277/480
P = 347/600

kVA Ratings and Dimensions

kVA	Weight Lb	BTUs/ hr	Bypass	Metering	Dimensions in Inches (mm) (H x W x D)
010	440	1,025	Optional	No	30.20 x 22.20 x 29.00 (767.1 x 563.9 x 736.6)
010	520	1,205	Optional	Yes	44.20 x 22.20 x 29.00 (1122.7 x 563.9 x 736.6)
015	520	1,540	Optional	No	30.20 x 22.20 x 29.00 (767.1 x 563.9 x 736.6)
015	600	1,540	Optional	Yes	44.20 x 22.20 x 29.00 (1122.7 x 563.9 x 736.6)
025	870	2,560	Optional	Yes	44.20 x 22.20 x 29.00 (1122.7 x 563.9 x 736.6)
030	890	3,090	Optional	Yes	44.20 x 22.20 x 29.00 (1122.7 x 563.9 x 736.6)
045	950	4,600	Optional	Yes	44.30 x 45.90 x 29.00 (1125.2 x 1165.9 x 736.6)
050	1,176	7,332	Yes	Yes	66.00 x 29.00 x 35.50 (1676.4 x 736.6 x 901.7)
075	1,575	9,514	Yes	Yes	76.00 x 34.40 x 35.50 (1930.4 x 873.8 x 901.7)
100	2,014	11,833	Yes	Yes	76.00 x 34.40 x 35.50 (1930.4 x 873.8 x 901.7)
125	2,137	14,748	Yes	Yes	76.00 x 34.40 x 35.50 (1930.4 x 873.8 x 901.7)
150	2,240	17,698	Yes	Yes	76.00 x 34.40 x 35.50 (1930.4 x 873.8 x 901.7)
225	3,300	23,000	Yes	Yes	77.40 x 56.00 x 41.50 (1966.0 x 1422.4 x 1054.1)
300	4,000	30,750	Yes	Yes	77.40 x 56.00 x 41.50 (1966.0 x 1422.4 x 1054.1)
500	5,500	51,250	Yes	Yes	77.00 x 72.40 x 48.40 (1955.8 x 1839.0 x 1229.4)

Options ①

Blank = No options
B = Bypass switch ②
M1 = Standard metering (IQ 130)
M2 = Premium metering (IQ 150)
S = Surge

Frequency

6 = 60 Hz
5 = 50 Hz

Technical Data and Specifications

Power-Sure 700 (T700) Specification (10 to 500 kVA)

Feature	Description
Technology	Electronic tap changer
Input voltages	208–600 V, three-phase (three-wire)
Input voltage range	+10% to –23% of nominal rated input
Output voltage	±3% of nominal
Response time	1/2 cycle
Frequency	60 Hz, ±3%
Efficiency	97% typical
Line regulation	Output is ±3% of nominal for input variations of +10% to –23% of nominal
Load regulation	Output is maintained within 3% of nominal from no load to full load
Correction time	Output will be corrected to within ±3% of nominal in 1.5 cycles or less
Harmonic distortion	Less than 1.0% added to the output waveform under any dynamic linear loading conditions presented to the line regulator
Noise attenuation	
Common mode	146 dB
Normal mode	3 dB down at 1000 Hz, 40 dB/decade to below 50 dB with resistive load
Turn-on characteristics	When energized, voltage overshoot will be less than 5% of nominal for 1 cycle or less
Overload rating	1000% for 1 cycle and 200% for 10 seconds
Ambient rating	–10 ° to 40 °C
Monitoring	Three green LEDs (phase power on indication), one red LED (alert indication)
Surge protection (optional)	CVX 50 kA SPD device 50 kVA and below, CVX 100 kA SPD device 75 kVA and above
Input breaker	MCCB rated 125% of full rated current
Bypass switch	Normal and bypass selector
Metering (optional)	Standard metering (IQ 130)—voltage and current with minimum and maximum
	Premium metering (IQ 150)—voltage, current, frequency, power, energy, PF, with minimum and maximum, communications capabilities
Warranty	1-year parts

Notes

① Units with no surge protection option, bypass option or metering will have blanks in the last three spaces in the catalog number.
② Bypass is standard on 50 kVA and larger units and an option on 45 kVA and smaller units.

All weights are approximate. Monitor option includes main input circuit breaker. Refer to PAD for pricing and availability.

Listings—UL Listed, CSA Certified, except for 600 V; no UL, CSA on 600V units.

For output distribution, call factory.

K factor–rated units available on request.

Power-Sure 800

Superior Power Conditioning for Industrial and Commercial

Contents

Power-Sure 800 (T800)

Product Description

Eaton's Power-Sure 800 (T800)™ cleans up and purifies fluctuating and erratic power that exists in commercial and industrial facilities so that sensitive electronic equipment is not affected.

The Power-Sure 800 (T800) is a self-regulating isolation transformer. It was developed to protect against fluctuating voltages, brownouts, line noise, short-duration power outages, sags, surges, spikes and transients. The Power-Sure 800 also has one of the highest K-factors—K-30—and eliminates harmonic current in the power line, which helps prevent damage to building wiring.

Application Description

The Power-Sure 800 (T800) is ideal for use in industrial applications, such as computer programmable controllers and robotics. Use the Power-Sure 800 (T800) whenever continuous, well-regulated, transient-free power is required.

Features

- Superior isolation
- Tight voltage regulation
- High immunity to distortion
- Lightning and surge protection
- Protection against power interruptions
- Power factor correction
- Bi-directional harmonic filtering
- K-30 rated design
- Warranty: two years

Eaton's Power-Sure 800 (T800) power conditioners provide high-quality power with inherent surge protection, noise and bi-directional harmonic filtering, as well as superior isolation. These units range from office models to floor- or wall-/panel-mounted industrial models and provide an excellent solution for any application with noisy or poor power quality.

Standards and Certifications

- UL 1012, UL 544 and cUL listed
- Meets ANSI standards for computers with inputs as low as 50% of nominal

Listed

Catalog Number Selection

Power-Sure 800

T800 X - XXXXX X X - X

Configuration
R = Receptacles
P = Hardwired wall-/panel-mount
F = Hardwired floor-mount

VA rating
01000
01500
01600
02000
02100
02500
03000
03500
03501
05000
07500
08000
10000
15000
20000
25000

Receptacles
Quantity of: Blank for hardwire

Option/Frequency
Blank = 60 Hz
5 = 50 Hz

Custom Receptacle Options				
Code	**No. of Output Panels (Max. 4)**	**NEMA®**	**Volts**	**Amps**
A	1	(1) 5-15R	120	15
B	1	(2) 5-15R	120	15
C	1	(1) 5-20R	120	20
D	1	(2) 5-20R	120	20
E	1.5	(1) 5-30R	120	30
F	1	(1) 6-15R	208/240	15
G	1	(2) 6-15R	208/240	15
H	1	(1) 6-20R	208/240	20
I	1	(2) 6-20R	208/240	20
J	1.5	(1) 6-30R	208/240	30
K	1.5	(1) 6-50R	208/240	50
L	1	(1) 14-20R	120/240	20
M	1.5	(1) 14-30R	120/240	30
N	1	(1) L5-15R	120	15
P	1	(2) L5-15R	120	15
R	1	(1) L5-20R	120	20
S	1	(1) L5-30R	120	30
T	1	(1) L6-15R	208/240	15
U	1	(2) L6-15R	208/240	15
V	1	(1) L6-20R	208/240	20
W	1	(1) L6-30R	208/240	30
X	1	(1) L14-20R	120/240	20
Y	1	(1) L14-30R	120/240	30

Product Selection

Power-Sure 800 Models

Rating (VA/Watts)	Input Voltage	Output Voltage	Input Interface	Output Interface	Part Number
Office Models (with Receptacles)					
1000/700	120	120	5-15P	(4) 5-20R	**T800R-01000**
1600/1200	120	120	5-15P	(4) 5-20R	**T800R-01600**
2100/1500	120	120	5-20P	(4) 5-20R	**T800R-02100**
2500/1750	120	120	5-30P	(4) 5-20R	**T800R-02500**
3500/2450	120	120/240	5-50P	(4) 5-20R	**T800R-03500**
3500/2450	208/240	120/240	6-20P	(4) 5-20R	**T800R-03501**
5000/3500	208/240	120/240	Hardwired	Custom ①	**T800R-05000**
7500/5250	208/240	120/240	Hardwired	Custom ①	**T800R-07500**
10,000/7000	208/240	120/240	Hardwired	Custom ①	**T800R-10000**
15,000/10,500	208/240	120/240	Hardwired	Custom ①	**T800R-15000**
Industrial Models (Hardwired Wall-/Panel-Mount)					
500/500	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-00500**
750/750	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-00750**
1000/1000	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-01000**
1500/1500	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-01500**
2000/2000	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-02000**
3000/3000	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-03000**
5000/5000	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800P-05000**
8000/8000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800P-08000**
10,000/10,000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800P-10000**
Industrial Models (Hardwired Floor-Mount)					
5000/5000	Range 1 ②④	Range 3 ⑤	Hardwired	Hardwired	**T800F-05000**
8000/8000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800F-08000**
10,000/10,000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800F-10000**
15,000/15,000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800F-15000**
20,000/20,000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800F-20000**
25,000/25,000	Range 2 ③④	Range 3 ⑤	Hardwired	Hardwired	**T800F-25000**

Notes

① See Catalog Numbering Selection on **Page V3-T2-43**; 5 panels available for distribution; HW output utilizes 1 panel, other 4 panels can be used for receptacle interface or cabling.

② Range 1: 120/208/240/480.

③ Range 2: 208/240/480.

④ Input and output voltage is field configurable; units will ship from the factory configured as follows: Range 1—120 V (input/output); Range 2—240 V (input/output).

⑤ Range 3: 120/208/240.

Technical Data and Specifications

- Line regulation: ±3% V-out for +10% to -20% V-in at 100% load
- Load regulation: ±3%for 0–75% load ±2%for 100% load
- Immunity to distortion: at 40% THD V-in, 5% max. THD V-out at 50% load or higher
- Ride-through capability: 1 cycle
- Voltage recovery: 2 cycles to 95%, 3 cycles to 100%
- K-factor: K-30 rated
- Power factor correction: input of 0.95 typical
- Harmonic attenuation: –23 dB for load-reflected harmonics
- Galvanic isolation: NEC 250.5d, 0.001 PF
- Surge protection: 330 V let-through voltage when tested to ANSI/IEEE® 62.41-Cat B3
- Common mode noise attenuation: 140 dB
- Transverse mode noise attenuation: 120 dB
- Reliability: 200,000 hours (MTBF)
- Audible noise: 52–56 dB measured at 1 meter, A scale
- Efficiency: approximately 92% at full load
- Operating temperature: –20 °C to +40 °C

Dimensions

Approximate Dimensions in Inches (mm)

Power-Sure 800 Models

Dimensions, W x D x H	Weight, Lb (kg)	Part Number
Office Models (with Receptacles)		
8.50 x 12.75 x 17.50 (215.9 x 323.9 x 444.5)	46 (21)	**T800R-01000**
8.50 x 12.75 x 17.50 (215.9 x 323.9 x 444.5)	62 (28)	**T800R-01600**
8.50 x 12.75 x 17.50 (215.9 x 323.9 x 444.5)	65 (29)	**T800R-02100**
8.50 x 12.75 x 17.50 (215.9 x 323.9 x 444.5)	68 (31)	**T800R-02500**
8.50 x 12.75 x 17.50 (215.9 x 323.9 x 444.5)	72 (33)	**T800R-03500**
8.50 x 12.75 x 17.50 (215.9 x 323.9 x 444.5)	73 (33)	**T800R-03501**
15.00 x 23.75 x 22.50 (381.0 x 603.3 x 571.5)	176 (80)	**T800R-05000**
15.00 x 23.75 x 22.50 (381.0 x 603.3 x 571.5)	210 (95)	**T800R-07500**
15.00 x 23.75 x 22.50 (381.0 x 603.3 x 571.5)	256 (116)	**T800R-10000**
15.00 x 23.75 x 22.50 (381.0 x 603.3 x 571.5)	314 (142)	**T800R-15000**
Industrial Models (Hardwired Wall-/Panel-Mount)		
9.00 x 14.00 x 10.00 (228.6 x 355.6 x 254.0)	52 (24)	**T800P-00500**
9.00 x 14.00 x 10.00 (228.6 x 355.6 x 254.0)	60 (27)	**T800P-00750**
9.00 x 14.00 x 10.00 (228.6 x 355.6 x 254.0)	82 (37)	**T800P-01000**
13.00 x 16.50 x 14.75 (330.2 x 419.1 x 374.7)	106 (48)	**T800P-01500**
13.00 x 16.50 x 14.75 (330.2 x 419.1 x 374.7)	125 (57)	**T800P-02000**
13.00 x 16.50 x 14.75 (330.2 x 419.1 x 374.7)	157 (71)	**T800P-03000**
27.00 x 22.50 x 28.50 (685.8 x 571.5 x 723.9)	437 (198)	**T800P-05000**
27.00 x 22.50 x 28.50 (685.8 x 571.5 x 723.9)	495 (225)	**T800P-08000**
27.00 x 22.50 x 28.50 (685.8 x 571.5 x 723.9)	537 (244)	**T800P-10000**
Industrial Models (Hardwired Floor-Mount)		
23.00 x 20.00 x 28.50 (584.2 x 508.0 x 723.9)	407 (185)	**T800F-05000**
23.00 x 20.00 x 28.50 (584.2 x 508.0 x 723.9)	465 (211)	**T800F-08000**
23.00 x 20.00 x 28.50 (584.2 x 508.0 x 723.9)	507 (230)	**T800F-10000**
35.00 x 25.00 x 39.50 (889.0 x 635.0 x 1003.3)	830 (376)	**T800F-15000**
35.00 x 25.00 x 39.50 (889.0 x 635.0 x 1003.3)	950 (431)	**T800F-20000**
35.00 x 25.00 x 39.50 (889.0 x 635.0 x 1003.3)	1070 (485)	**T800F-25000**

Eaton Power-Suppress 100

Ultra-Isolator Noise Suppressor and Isolation Provider

Contents

Power-Suppress 100 (T100)

Product Description

Eaton's Power-Suppress™ 100 ultra-isolator noise suppressors protect sensitive equipment from electrical noise disturbances. Using exclusive double shielding techniques, the Power-Suppress 100 blocks all forms of electrical noise including radio frequency interface (RFI)/ electromagnetic interference (EMI), over a broad range of frequencies. Furthermore, the noise suppression is achieved without impeding normal power flow.

Power-Suppress 100 ultra-isolator noise suppressors can reduce a 6000-volt spike to an insignificant 0.0030 volt. These high-voltage transients contain enough energy to completely destroy the electrical circuit components that are vital to daily operation.

Application Description

Applications for the Power-Suppress 100 include audio and video equipment, computer and process equipment, telecommunications systems, and virtually any sensitive electronic instruments.

Features

- Traps unwanted harmonics
- Removes surge voltages and minimizes reflected THD
- Cleans and conditions the sine wave
- Eliminates load-generated feedback
- Available in both hardwired or line cord/receptacle models
- Fast and easy installation
- Long-life operation
- Small footprint—saves valuable space
- Two-year warranty complete unit, five-year warranty core and coil

Standards and Certifications

- UL 1012, UL 1449, cUL listed, ANSI/IEEE C57.12.91
- Meets FCC Category A, IEEE C62.41 Category A3

Listed

Catalog Number Selection

Power-Suppress 100

T100 __ - __ - __

Connection Method	
R	= Receptacles
H	= Hardwired

Size (VA)	
0500	= 500 VA
0750	= 750 VA
1000	= 1000 VA
1800	= 1800 VA
2400	= 2400 VA
2500	= 2500 VA
5000	= 5000 VA
5001	= 5000 VA ①
7500	= 7500 VA
7501	= 7500 VA ①

Option/Frequency	
Blank	= 60 Hz
5	= 50 Hz

Product Selection

Power-Suppress 100 Models

Input Voltages ②	Output Voltages ②	Output VA ③	I/O Interfaces (NEMA)	Catalog Number
Line-Cord/Receptacle Models				
120	120	500	5-15P/(1) 5-20R2	**T100R-0500**
120	120	750	5-15P/(1) 5-20R2	**T100R-0750**
120	120	1000	5-15P/(1) 5-20R2	**T100R-1000**
120	120	1800	L5-20P/(2) 5-20R2	**T100R-1800**
120	120	2400	L5-30P/(2) 5-20R2	**T100R-2400**
Terminal Style Models				
120/240	120/240	500	Hardwired	**T100H-0500**
120/240	120/240	750	Hardwired	**T100H-0750**
120/240	120/240	1000	Hardwired	**T100H-1000**
120/240	120/240	1800	Hardwired	**T100H-1800**
120/240	120/240	2500	Hardwired	**T100H-2500**
120/240	120/240	5000	Hardwired	**T100H-5000**
240/480	120/240	5000	Hardwired	**T100H-5001** ①
120/240	120/240	7500	Hardwired	**T100H-7500**
240/480	120/240	7500	Hardwired	**T100H-7501** ①

Notes

① Models T100H-5001 and T100H-7501 will ship configured to 240 V input and output voltage.
② Input and output voltages can be field configured for either 120 Vac or 240 Vac, 240 Vac or 480 Vac, as indicated above.
③ 500 VA to 7500 VA hardwired models will ship configured to 120 V input and output voltage.

Technical Data and Specifications

Technical Specifications

Description	Specifications
Input voltage/frequency	120, 240, 480 V ①/60 Hz
Common-mode noise	140 dB at100 kHz
Normal-mode noise	65 dB at100 kHz
Overload capacity	600% for 1 cycle, 300% for 30 seconds
Dielectric strength	2,500 Vac minimum
Frequency	60 Hz ±5%
Impedance	3–6% typical
Efficiency	93–97% typical
Input voltage range	±10% of nominal rated voltage
Harmonic distortion	Adds less than 1% THD, under linear loading
Coil insulation	200 °C
Temperature rise	115 °C max rise above a 40 °C ambient, depending on model
Electromagnetic interference	<0.2 gauss at 36 inches

Environments

Description	Specifications
Audible noise	Less than 50 dBA measured at 3 ft from the noise suppressor
Operating temperature	0 to 40 °C
Storage temperature	–20 to 50 °C
Operating altitude	Up to 12,000 ft (3657.6 m) (without derating)
Operating humidity	95% relative (noncondensing)

Plug and Receptacle Configuration Models

Rating	Input Plug	Output Receptacle
500–1000 VA	5-15P	5-20R duplex
1.8 kVA	L5-20P	2 x 5-20R duplex
2.4 kVA	L5-30P	2 x 5-20R duplex

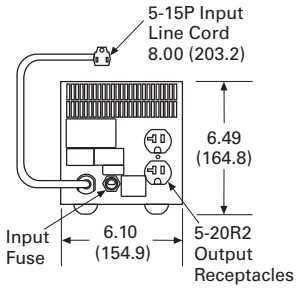
Dimensions

Approximate Dimensions in Inches (mm)

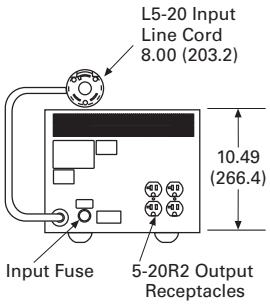
Power-Suppress 100 Models

Dimensions, W x D x H	Weight, Lb (kg)	Catalog Number
Line-Cord/Receptacle Models		
6.49 x 6.10 x 12.00 (164.8 x 154.9 x 304.8)	22 (10)	**T100R-0500**
6.49 x 6.10 x 12.00 (164.8 x 154.9 x 304.8)	28 (13)	**T100R-0750**
6.49 x 6.10 x 12.00 (164.8 x 154.9 x 304.8)	31 (14)	**T100R-1000**
10.49 x 11.10 x 17.00 (266.4 x 281.9 x 431.8)	54 (24)	**T100R-1800**
10.49 x 11.10 x 17.00 (266.4 x 281.9 x 431.8)	58 (26)	**T100R-2400**
Terminal Style Models		
6.42 x 6.10 x 12.00 (163.1 x 154.9 x 304.8)	22 (10)	**T100H-0500**
6.42 x 6.10 x 12.00 (163.1 x 154.9 x 304.8)	28 (13)	**T100H-0750**
6.42 x 6.10 x 12.00 (163.1 x 154.9 x 304.8)	31 (14)	**T100H-1000**
10.28 x 11.10 x 17.00 (261.1 x 281.9 x 431.8)	54 (24)	**T100H-1800**
10.28 x 11.10 x 17.00 (261.1 x 281.9 x 431.8)	58 (26)	**T100H-2500**
10.28 x 11.10 x 17.00 (261.1 x 281.9 x 431.8)	86 (39)	**T100H-5000**
10.49 x 11.10 x 17.00 (266.4 x 281.9 x 431.8)	92 (42)	**T100H-5001**
10.28 x 11.10 x 17.00 (261.1 x 281.9 x 431.8)	116 (53)	**T100H-7500**
10.28 x 11.10 x 17.00 (261.1 x 281.9 x 431.8)	111 (50)	**T100H-7501**

Line-Cord Style



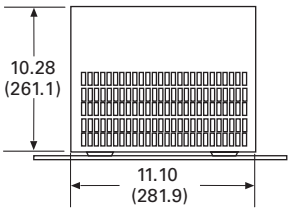
500 VA–1 kVA



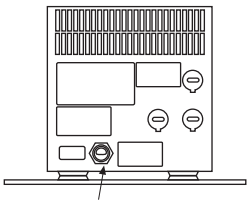
1.8–2.4 kVA

Terminal Style

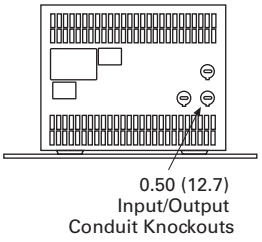
1.8–7.5 kVA Front View



500–1000 VA Rear View



1.8–7.5 kVA Rear View



Note

① 480 V available for 5 and 7.5 kVA models only.

Capacitor Cell with Cage Clamp Terminals

Contents

Product Overview

Product Description

Eaton's power factor correction capacitors and harmonic filters are an essential part of modern electric power systems. Power factor correction capacitors are the simplest and most economical means of increasing the capacity of any power system, minimizing energy losses and correcting load power factor. In addition, power factor penalties can be reduced and power quality can be greatly enhanced.

There are several reasons to correct poor power factor. The first is to reduce or eliminate a power factor penalty charged by the utility. Another reason is that your existing transformer is, or shortly will be, at full capacity and installing power factor correction capacitors can be a very cost-effective solution to installing a brand new service. Depending on the amount of power factor correction (kvar that needs to be injected into the electrical system to improve the power factor) and the dynamic nature of the load, a fixed or switched capacitor bank may be the best solution.

When capacity becomes a problem, the choice of a solution will be dependent upon the size of the increase needed. Like all power quality solutions, there are many factors that need to be considered when determining which solution will be best to solve your power factor problem.

Harmonic Filtering

As the world becomes more dependent on electric and electronic equipment, the likelihood that the negative impact of harmonic distortion increases dramatically. The efficiency and productivity gains from these increasingly sophisticated pieces of equipment have a negative side effect…increased harmonic distortion in the power lines. The difficult thing about harmonic distortion is determining the cause. Once this has been determined, the solution can be easy. Active harmonic filtering equipment will mitigate specific harmonic issues, and correct poor power factor as well.

Product Selection

2

Capacitor Cell Chart

Dimensions in Inches (mm)

Voltage	kvar ①	D	H	Weight in Lb (kg)	Catalog Number
240	1.5	3.1 (79.5)	7.9 (200.0)	1.1 (0.5)	**643PCRMB**
240	2	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**8B43PCRMB**
240	2.5	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**1043PCRMB**
240	3	3.5 (89.5)	9.4 (238.0)	1.8 (0.8)	**12X43PCRMB**
240	4	3.1 (79.5)	7.9 (200.0)	1.1 (0.5)	**423PCRMB**
240	5	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**2043PCRMB**
240	6.3	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**6B23PCRMB**
240	7.5	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**7X23PCRMB**
240	8.3	3.5 (89.5)	9.4 (238.0)	3.3 (1.5)	**8B23PCRMB**
240	10	3.5 (89.5)	9.4 (238.0)	2.0 (0.9)	**1023PCRMB**
240	12.5	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**12X23PCRMB**
240	15	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**1523PCRMB**
480	1.5	2.1 (53.0)	5.0 (125.8)	0.7 (0.3)	**1X43PCRMA**
480	2	2.5 (63.5)	5.5 (140.8)	0.9 (0.4)	**243PCRMA**
480	2.5	2.5 (63.5)	5.5 (140.8)	0.9 (0.4)	**2X43PCRMA**
480	3	2.5 (63.5)	5.5 (140.8)	0.9 (0.4)	**343PCRMA**
480	4	2.5 (63.5)	6.5 (165.8)	0.9 (0.4)	**443PCRMA**
480	5	2.5 (63.5)	6.5 (165.8)	0.9 (0.4)	**543PCRMA**
480	6	3.1 (79.5)	7.9 (200.0)	1.1 (0.5)	**643PCRMB**
480	7.5	3.1 (79.5)	7.9 (200.0)	1.1 (0.5)	**7X43PCRMB**
480	8.3	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**8B43PCRMB**
480	9	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**943PCRMB**
480	10	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**1043PCRMB**
480	12.5	3.5 (89.5)	9.4 (238.0)	1.8 (0.8)	**12X43PCRMB**
480	15	3.5 (89.5)	9.4 (238.0)	1.8 (0.8)	**1543PCRMB**
480	18	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**1843PCRMB**
480	20	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**2043PCRMB**
480	25	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**2543PCRMB**
600	5	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**563PCRMB**
600	7.5	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**7X63PCRMB**
600	10	3.1 (79.5)	9.4 (238.0)	1.3 (0.6)	**1063PCRMB**
600	12.5	3.5 (89.5)	9.4 (238.0)	1.8 (0.8)	**12X63PCRMB**
600	15	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**1563PCRMB**
600	17.5	3.5 (89.5)	12.3 (313.0)	2.6 (1.2)	**17X63PCRMB**
600	20	3.5 (89.5)	12.3 (313.0)	3.3 (1.5)	**2063PCRMB**
600	25	3.5 (89.5)	15.3 (388.0)	3.3 (1.5)	**2563PCRMB**

Heavy-Duty Capacitor Cell Chart

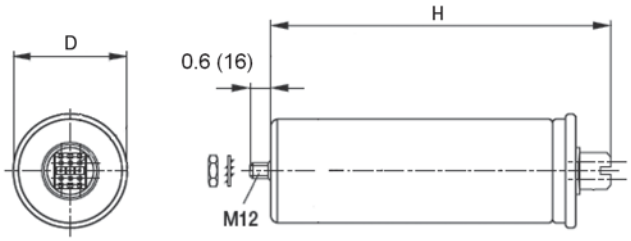
Dimensions in Inches (mm)

Name-plate Voltage	kvar	D	H	Internal Voltage Rating	Weight in Lb (kg)	Catalog Number
240	12.5	3.5 (89.5)	15.3 (388.0)	360	3.3 (1.5)	**12X23PHRMB**
480	15.0	3.5 (89.5)	12.3 (313.0)	525	2.6 (1.2)	**1543PHRMB**
480	16.7	3.5 (89.5)	15.3 (388.0)	600	3.3 (1.5)	**16S43PHRMBS**
480	20.0	3.5 (89.5)	15.3 (388.0)	525	3.3 (1.5)	**2043PHRMB**
480	25.0	3.5 (89.5)	15.3 (388.0)	525	3.3 (1.5)	**2543PHRMB**
600	12.3	3.5 (89.5)	12.3 (313.0)	660	2.6 (1.2)	**12A63PHRMB**
600	14.7	3.5 (89.5)	15.3 (388.0)	660	3.3 (1.5)	**14S63PHRMB**
600	16.7	3.5 (89.5)	15.3 (388.0)	660	3.3 (1.5)	**16S63PHRMB**

Dimensions

Approximate Dimensions in Inches (mm)

Capacitor Cell



Note

① kvar rating standard. Standard kvar tolerance is 0% to +5%. Part number shown is for three-phase units. Up to 5 kvar at 480 V—quick disconnect terminals are standard. Above 5 kvar at 480 V (and on all other voltages)—cage clamp terminals are standard.

UNIPUMP

Contents

UNIPUMP

Product Description

Non-fused capacitors for outdoor irrigation and oil field installations.

- Designed expressly for outdoor pumping applications
- Pole or wall mounting
- Small, light-weight enclosure for easy installation
- SO-WA type flexible cable facilitates installation (4-conductor)
- Gland-type weatherproof bushings
- Strong outer case

Application Description

Outdoor irrigation and oil and gas field pumping.

Features, Benefits and Functions

Configuration

- **Outer case**: Heavy, No. 14 gauge steel finished with durable powder coat finish. Integral strap mounting bracket with keyhole at top for pole or wall installation. No knockouts

Capacitor Cells

- **Terminals**: Insulated finger-safe terminals rated for 3 kVAC withstand
- **Dielectric fill**: Dry-type cells use soft organic polymer resin—Resinol
- Eliminates potential for corona/partial discharge/ electrochemical oxidation
- Excellent heat dissipation
- Flash point: +444 °F (+229 °C)
- Fire point: +840 °F (+449 °C)
- **Design**: Self-healing metallized high crystalline polypropylene with ramp metallization film. Total losses less than 0.45 watt per kvar. (Dielectric losses less than 0.2 watt per kvar)
- **Ramp metallization**: Provides thicker film at higher current density areas, allowing for reduced internal losses, lower operating temperatures and longer life expectancy. Also prevents chain reaction breakdown by limiting propagation of film vaporization
- **Pressure sensitive interrupter**: Built-in, three-phase pop-up interrupter design. UL recognized. Removes capacitor from line before internal pressure can cause case rupture. Bulged capacitor cell top provides easy visual indication of interrupter operation
- **Ceramic discharge resistors**: Reduce residual voltage to less than 50 volts within one minute of de-energization. Selected for 20-year nominal life. Exceeds NEC requirements
- **Capacitor operating temperature**: -40 °F (–40 °C) to +115 °F (+46 °C)
- **Case**: Weatherproof aluminum housing
- **Warranty**: The longest in the industry—two full years of warranty on capacitor cells

Standards and Certifications

- UL 810 and C22.2 No. 190 listed

Product Selection

UNIPUMP

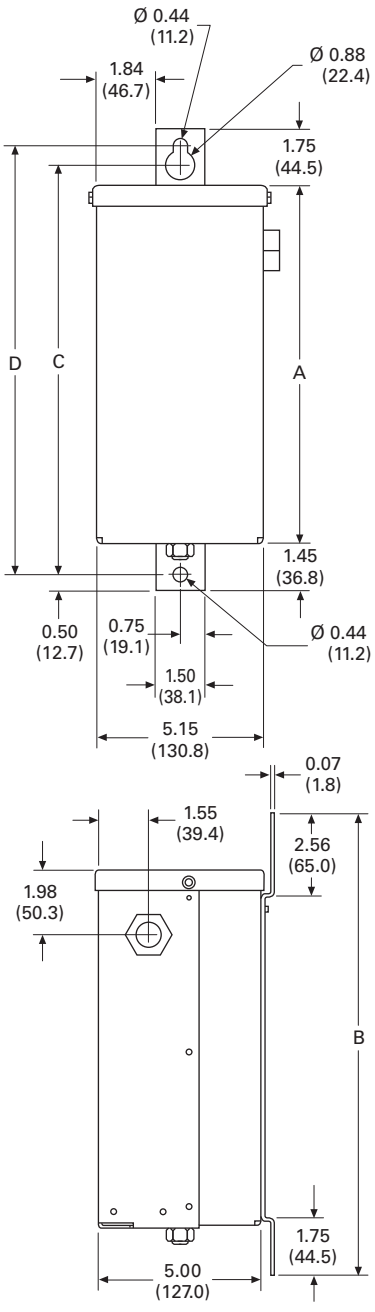
UNIPUMP

kvar	Rated Current	Case Size	Cable Size	Shipping Weight in Lb (kg)	Catalog Number
240 Vac					
2	4.8	AA	14	10.0 (4.5)	**223JMR**
2.5	6.0	AA	14	10.0 (4.5)	**2X23JMR**
3	7.2	AA	14	10.0 (4.5)	**323JMR**
4	9.6	AA	14	11.0 (5.0)	**423JMR**
5	12.0	BB	12	11.0 (5.0)	**523JMR**
6	14.4	BB	12	15.0 (6.8)	**623JMR**
7.5	18.0	BB	12	15.0 (6.8)	**7X23JMR**
480 Vac					
2	2.4	AA	14	10.4 (4.7)	**243JMR**
2.5	3.0	AA	14	10.4 (4.7)	**2X43JMR**
3	3.6	AA	14	10.4 (4.7)	**343JMR**
4	4.8	AA	14	10.4 (4.7)	**443JMR**
5	6.0	AA	14	10.4 (4.7)	**543JMR**
6	7.2	AA	14	10.6 (4.8)	**643JMR**
7.5	9.0	AA	14	10.6 (4.8)	**7X43JMR**
10	12.0	AA	14	10.8 (4.9)	**1043JMR**
12.5	15.0	BB	12	15.0 (6.8)	**12X43JMR**
15	18.0	BB	12	15.0 (6.8)	**1543JMR**
17.5	21.0	BB	8	15.8 (7.2)	**17X43JMR**
20	24.0	BB	8	16.8 (7.6)	**2043JMR**
25	30.0	BB	8	16.8 (7.6)	**2543JMR**
600 Vac					
5	4.9	AA	14	10.8 (4.9)	**563JMR**
7.5	7.4	AA	14	10.8 (4.9)	**7X63JMR**
10	9.8	AA	14	10.8 (4.9)	**1063JMR**
12.5	12.3	BB	12	15.0 (6.8)	**12X63JMR**
15	14.7	BB	12	15.8 (7.2)	**1563JMR**
17.5	17.2	BB	8	16.8 (7.6)	**17X63JMR**
20	19.6	BB	8	16.8 (7.6)	**2063JMR**

Dimensions

Approximate Dimensions in Inches (mm)

UNIPUMP



UNIPUMP Dimension Chart

Size Code	A	B	C	D
AA	11.00 (279.4)	14.20 (360.7)	12.60 (320.0)	13.20 (335.3)
BB	14.00 (355.6)	17.10 (434.3)	15.50 (393.7)	16.10 (408.9)

UNIPAK

Contents

UNIPAK

Product Description

UNIPAK Low Voltage Fixed Capacitor Banks

- Two-year warranty on capacitor cells (units with standard-duty cells)
- Five-year warranty on capacitor cells (units with heavy-duty cells)
- Indoor/outdoor service
- Wall-mount (up to C2) and floor-mounted units available
- Short lead-times
- Slim profile allows reduced footprint, conserving valuable floor space

UNIPAK with Heavy-Duty Capacitor Cells

- Standard fixed capacitor systems using heavy-duty capacitor cells
- For use in moderate harmonic environments where engineering evaluation allows in place of detuned filter designs
- Provides future conversion capability into a detuned filter system when required by facility growth or increased nonlinear load levels

UNIPAK Low Voltage Fixed Detuned Filters

- Detuned filter systems for low voltage, heavy-duty applications
- Correct power factor in high harmonic environments
- Two-enclosure design isolates capacitors from high-temperature operating reactors and allows for flexible installation
- Five-year cell warranty/ one-year reactor warranty
- Three-phase cell capacitor construction

Application Description

Designed for power factor correction in plants experiencing harmonics problems due to high amounts of nonlinear loads.

Features, Benefits and Functions

UNIPAK Low Voltage Fixed Capacitor Banks

- **Outer enclosure:** Heavy, No. 14 gauge steel finished with durable baked powder coat finish. Wall-mounting flanges and floor-mounting feet. Elimination of knockouts permits indoor/outdoor use. Manufactured to NEMA 1 and 3R requirements
- Elevated floor-mounting feet allow access for easy maintenance
- **Cover:** "L" shaped gasketed cover with multiple fasteners provides front opening for ease of installation and service
- **UNIPAK operating temperature:** –40 °F to +115 °F (–40 °C to +46 °C)
- **UNIPAK storage temperature:** –40 °F to +131 °F (–40 °C to +55 °C)
- **Power and ground terminal lugs:** Furnished inside enclosure
- **Pressure-sensitive interrupter:** All units have built-in UL recognized pressure-sensitive interrupter, and thermally or mechanically activated disconnecting link removes capacitor from the supply before dangerous pressure buildup or excessive fault current occurs. Bulged capacitor cell top provides easy visual indication of interrupter operation
- **Standard fusing:**
  - **Size Code A1:** Three midget-type fuses with 100,000 A interrupting capacity
  - **Size Code A2 and larger:** Slotted-blade type fuses with 200,000 A interrupting capacity; fuses mounted on stand-off bushings; solderless connectors for easy hookup of incoming line conductors
  - **Fuse indicating lights:** Red, neon cleared-fuse indicating lights are protected by transparent weatherproof guard
- **Options:**
  - Non-fused units available, selected sizes
  - Heavy-duty capacitor cells, selected sizes

UNIPAK Low Voltage Fixed Detuned Filters

- **Enclosures:** Standard NEMA 1 enclosures have durable baked powder coat finish
- **UNIPAK detuned filter operating temperature:** –40 °F to +115 °F (–40 °C to +46 °C)
- **UNIPAK detuned filter storage temperature:** –40 °F to +131 °F (–40 °C to +55 °C)
- **Power and ground terminal lugs:** Furnished inside enclosures

Standards and Certifications

UNIPAK Low Voltage Fixed Capacitor Banks

- UL 810 and CSA C.22.2 No.190 Listed

UNIPAK Low Voltage Fixed Detuned Filters

- UL 508A and CSA C22.2 No. 190 Listed

Listed

Product Selection

UNIPAK Low Voltage Fixed Capacitor Banks

UNIPAK

240 Vac UNIPAK Selection Chart

kvar	Rated Current (Amperes)	Enclosure	Shipping Weight in Lb (kg)	Catalog Number
1	2.4	A1	18 (8)	**123PMURF**
1.5	3.6	A1	18 (8)	**1X23PMURF**
2	4.8	A1	19 (9)	**223PMURF**
2.5	6	A1	19 (9)	**2X23PMURF**
3	7.2	A1	19 (9)	**323PMURF**
4	9.6	A1	20 (9)	**423PMURF**
5	12	A2	29 (13)	**523PMURF**
6	14.4	A2	29 (13)	**623PMURF**
7.5	18	A2	30 (14)	**7X23PMURF**
8	19.2	A2	31 (14)	**823PMURF**
10	24	A2	31 (14)	**1023PMURF**
12.5	30	A2	32 (14)	**12X23PMURF**
15	36	A2	33 (15)	**1523PMURF**
17.5	42	B1	44 (20)	**17X23PMURF**
20	48	B1	45 (20)	**2023PMURF**
22.5	54	B1	46 (21)	**22X23PMURF**
25	60	B1	46 (21)	**2523PMURF**
30	72	B1	47 (21)	**3023PMURF**
32.5	78	C1	47 (22)	**32X23PMURF**
35	84	C1	48 (22)	**3523PMURF**
37.5	90	C1	60 (27)	**37X23PMURF**
40	96	C1	64 (29)	**4023PMURF**
42.5	102	C1	65 (30)	**42X23PMURF**
45	108	C1	66 (30)	**4523PMURF**
50	120	C1	68 (31)	**5023PMURF**
60	144	C1	69 (31)	**6023PMURF**
70	168	C2	99 (45)	**7023PMURF**
75	180	C2	100 (46)	**7523PMURF**
80	192	C2	101 (46)	**8023PMURF**
90	216	C2	103 (47)	**9023PMURF**
100	240	D1	104 (47)	**10023PMURF**
120	288	D1	133 (60)	**12023PMURF**
140	336	E1	137 (62)	**14023PMURF**
150	360	E1	140 (64)	**15023PMURF**
160	384	E1	175 (80)	**16023PMURF**
180	432	E1	182 (83)	**18023PMURF**
200	480	E1	189 (86)	**20023PMURF**

Notes

Multiply the 240 Vac kvar rating by 0.75 to calculate the kvar value at 208 Vac.

Fused with blown-fuse indication available standard. Non-fused and no lights also available—please consult the factory.

Other ratings available, consult factory.

For dimensional information, refer to **Page V3-T2-61**.

Part Numbers:

PMURF—three fuses + three lights

PMURN—non-fused

480 Vac UNIPAK Selection Chart

kvar	Rated Current (Amperes)	Enclosure	Shipping Weight in Lb (kg)	Catalog Number
1.5	1.8	A1	17 (8)	**1X43PMURF**
2	2.4	A1	18 (8)	**243PMURF**
2.5	3	A1	18 (8)	**2X43PMURF**
3	3.6	A1	19 (9)	**343PMURF**
4	4.8	A1	19 (9)	**443PMURF**
5	6	A1	19 (9)	**543PMURF**
6	7.2	A1	19 (9)	**643PMURF**
7.5	9	A1	20 (9)	**7X43PMURF**
8	9.6	A1	20 (9)	**843PMURF**
9	10.8	A1	20 (9)	**943PMURF**
10	12	A1	20 (9)	**1043PMURF**
12.5	15	A2	29 (13)	**12X43PMURF**
15	18	A2	29 (13)	**1543PMURF**
17.5	21	A2	30 (14)	**17X43PMURF**
20	24	A2	31 (14)	**2043PMURF**
22.5	27	B1	44 (20)	**22X43PMURF**
25	30	A2	32 (15)	**2543PMURF**
27.5	33	B1	44 (20)	**27X43PMURF**
30	36	B1	44 (20)	**3043PMURF**
32.5	39	B1	45 (20)	**32X43PMURF**
35	42	B1	45 (20)	**3543PMURF**
37.5	45	B1	46 (21)	**37X43PMURF**
40	48	B1	46 (21)	**4043PMURF**
42.5	51	B1	47 (21)	**42X43PMURF**
45	54	B1	47 (22)	**4543PMURF**
50	60	B1	48 (22)	**5043PMURF**
55	66	C1	48 (22)	**5543PMURF**
60	72	C1	48 (22)	**6043PMURF**
65	78	C1	64 (29)	**6543PMURF**
70	84	C1	65 (30)	**7043PMURF**
75	90	C1	65 (30)	**7543PMURF**
80	96	C1	66 (30)	**8043PMURF**
85	102	C1	68 (31)	**8543PMURF**
90	108	C1	68 (31)	**9043PMURF**
100	120	C1	69 (31)	**10043PMURF**
120	144	C2	69 (31)	**12043PMURF**
125	150	C2	99 (45)	**12543PMURF**
140	168	C2	100 (46)	**14043PMURF**
150	180	C2	101 (46)	**15043PMURF**
160	192	D1	103 (47)	**16043PMURF**
180	216	D1	104 (47)	**18043PMURF**
200	240	D1	137 (62)	**20043PMURF**
225	270	D1	140 (64)	**22543PMURF**
250	300	E1	170 (77)	**25043PMURF**
300	360	E1	175 (80)	**30043PMURF**
350	420	E1	182 (83)	**35043PMURF**
400	480	E1	189 (86)	**40043PMURF**

600 Vac UNIPAK Selection Chart

kvar	Rated Current (Amperes)	Enclosure	Shipping Weight in Lb (kg)	Catalog Number
5	4.9	A1	19 (9)	**563PMURF**
7.5	7.4	A1	19 (9)	**7X63PMURF**
10	9.8	A1	20 (9)	**1063PMURF**
12.5	12.3	A1	20 (9)	**12X63PMURF**
15	14.7	A2	29 (13)	**1563PMURF**
17.5	17.2	A2	29 (13)	**17X63PMURF**
20	19.6	A2	30 (14)	**2063PMURF**
22.5	22.1	B1	44 (20)	**22X63PMURF**
25	24.5	B1	31 (14)	**2563PMURF**
27.5	27.0	B1	44 (20)	**27X63PMURF**
30	29.4	B1	45 (20)	**3063PMURF**
32.5	31.9	B1	45 (20)	**32X63PMURF**
35	34.3	B1	46 (21)	**3563PMURF**
37.5	36.8	B1	46 (21)	**37X63PMURF**
40	39.2	B1	47 (21)	**4063PMURF**
42.5	41.7	B1	47 (22)	**42X63PMURF**
45	44.1	B1	48 (22)	**4563PMURF**
50	49.0	B1	48 (22)	**5063PMURF**
55	53.9	C1	64 (29)	**5563PMURF**
60	58.8	C1	64 (29)	**6063PMURF**
65	63.7	C1	65 (30)	**6563PMURF**
70	68.6	C1	65 (30)	**7063PMURF**
75	73.5	C1	66 (30)	**7563PMURF**
80	78.4	C1	68 (31)	**8063PMURF**
85	83.3	C1	68 (31)	**8563PMURF**
90	88.2	C1	69 (31)	**9063PMURF**
100	98.0	C1	69 (31)	**10063PMURF**
120	117.6	C2	99 (45)	**12063PMURF**
125	122.5	C2	100 (46)	**12563PMURF**
140	137.2	C2	101 (46)	**14063PMURF**
150	147.0	C2	103 (47)	**15063PMURF**
160	156.8	D1	135 (61)	**16063PMURF**
180	176.4	D1	137 (62)	**18063PMURF**
200	196.0	D1	140 (64)	**20063PMURF**
225	220.5	D1	143 (65)	**22563PMURF**
250	245.0	E1	170 (77)	**25063PMURF**
300	294.0	E1	175 (80)	**30063PMURF**
350	343.0	E1	182 (83)	**35063PMURF**
400	392.0	E1	189 (86)	**40063PMURF**

Notes

Fused with blown-fuse indication available standard.

Non-fused and no lights also available—please consult the factory.

Other ratings available, consult factory.

For dimensional information, refer to **Page V3-T2-61**.

Part Number
PMURF—three fuses + three lights
PMURN—non-fused

UNIPAK—with Harmonic Cells

Harmonic Cells

Low Voltage Fixed Capacitor Systems with Heavy-Duty Cells

kvar	Rated Current (Amperes)	Case Size	Shipping Weight in Lb (kg)	Catalog Number
240 V				
15	36	B1	38.4 (17)	**1523HURF**
25	60	B1	38.4 (17)	**2523HURF**
30	72	C1	55.2 (25)	**3023HURF**
50	120	C1	57.6 (26)	**5023HURF**
60	144	C2	100.8 (46)	**6023HURF**
75	180	C2	104.4 (47)	**7523HURF**
100	240	D1	136.8 (62)	**10023HURF**
125	300	E1	189.6 (86)	**12523HURF**
480 V				
15	18	B1	25.2 (11)	**1543HURF**
25	30	B1	37.2 (17)	**2543HURF**
30	36	B1	38.4 (17)	**3043HURF**
50	60	C1	39.6 (18)	**5043HURF**
60	72	C1	52.8 (24)	**6043HURF**
75	90	C2	55.2 (25)	**7543HURF**
100	120	C2	57.6 (26)	**10043HURF**
125	150	D1	100.8 (46)	**12543HURF**
150	180	D1	104.4 (47)	**15043HURF**
200	240	E1	136.8 (62)	**20043HURF**
250	300	E1	186.0 (84)	**25043HURF**
600 V				
15	14.7	B1	37.2 (17)	**1563HURF**
25	24.5	B1	38.4 (17)	**2563HURF**
30	29.4	B1	39.6 (18)	**3063HURF**
50	49	C1	55.2 (25)	**5063HURF**
60	58.8	C1	57.6 (26)	**6063HURF**
75	73.5	C2	100.8 (46)	**7563HURF**
100	98	C2	104.4 (47)	**10063HURF**
125	122.5	D1	136.8 (62)	**12563HURF**
150	147	D1	136.8 (62)	**15063HURF**
200	196	E1	186.0 (84)	**20063HURF**
250	245	E1	189.6 (86)	**25063HURF**

Notes

Fused with blown-fuse indication standard.

Other ratings available, consult factory.

UNIPAK Low Voltage Fixed Detuned Filters

Fixed UNIPAK Detuned Filters

kvar	Rated Current (Amperes)	Capacitor Enclosure Size	Shipping Weight in Lb (kg)	Reactor Enclosure Case Size	Reactor Shipping Weight in Lb (kg)	Combined Shipping Weight in Lb (kg)	Catalog Number
240 V							
15	36	B1	48.4 (22.0)	R	90.0 (40.9)	138.4 (62.8)	**15232HMURFY**
25	60	B1	48.4 (22.0)	R	105.0 (47.7)	153.4 (69.6)	**25232HMURFY**
30	72	C1	65.2 (29.6)	R	110.0 (49.9)	175.2 (79.5)	**30232HMURFY**
50	120	C1	67.6 (30.7)	R	130.0 (59.0)	197.6 (89.7)	**50232HMURFY**
60	144	C2	110.8 (50.3)	R	160.0 (72.6)	270.8 (122.9)	**60232HMURFY**
75	180	C2	114.4 (51.9)	R	185.0 (84.0)	299.4 (135.9)	**75232HMURFY**
100	240	D1	146.8 (66.6)	R	240.0 (109.0)	386.8 (175.6)	**100232HMURFY**
125	300	E1	199.6 (90.6)	S	280.0 (127.1)	479.6 (217.7)	**125232HMURFY**
150	360	E1	220.0 (99.9)	S	280.0 (127.1)	500.0 (227.0)	**150232HMURFY**
480 V							
15	18	B1	35.2 (16.0)	R	90.0 (40.9)	125.2 (56.8)	**15432HMURFY**
25	30	B1	47.2 (21.4)	R	105.0 (47.7)	152.2 (69.1)	**25432HMURFY**
30	36	B1	48.4 (22.0)	R	110.0 (49.9)	158.4 (71.9)	**30432HMURFY**
50	60	C1	49.6 (22.5)	R	130.0 (59.0)	179.6 (81.5)	**50432HMURFY**
60	72	C1	62.8 (28.5)	R	160.0 (72.6)	222.8 (101.2)	**60432HMURFY**
75	90	C2	65.2 (29.6)	R	185.0 (84.0)	250.2 (113.6)	**75432HMURFY**
100	120	C2	67.6 (30.7)	R	240.0 (109.0)	307.6 (139.7)	**100432HMURFY**
125	150	D1	110.8 (50.3)	R	280.0 (127.1)	390.8 (177.4)	**125432HMURFY**
150	180	D1	114.4 (51.9)	S	280.0 (127.1)	394.4 (179.1)	**150432HMURFY**
200	240	E1	146.8 (66.6)	S	330.0 (149.8)	476.8 (216.5)	**200432HMURFY**
250	300	E1	196.0 (89.0)	T	570.0 (258.8)	766.0 (347.8)	**250432HMURFY**
600 V							
15	14.7	B1	47.2 (21.4)	R	90.0 (40.9)	137.2 (62.3)	**15632HMURFY**
25	24.5	B1	48.4 (22.0)	R	90.0 (47.7)	153.4 (69.6)	**25632HMURFY**
30	29.4	B1	49.6 (22.5)	R	105.0 (49.9)	159.6 (72.5)	**30632HMURFY**
50	49	C1	65.2 (29.6)	R	110.0 (59.0)	195.2 (88.6)	**50632HMURFY**
60	58.8	C1	67.6 (30.7)	R	130.0 (72.6)	227.6 (103.3)	**60632HMURFY**
75	73.5	C2	110.8 (50.3)	R	160.0 (84.0)	295.8 (134.3)	**75632HMURFY**
100	98	C2	114.4 (51.9)	R	185.0 (109.0)	354.4 (160.9)	**100632HMURFY**
150	147	D1	146.8 (66.6)	S	280.0 (127.1)	426.8 (193.8)	**150632HMURFY**
200	196	E1	196.0 (89.0)	T	330.0 (149.8)	526.0 (238.8)	**200632HMURFY**
250	245	E1	199.6 (90.6)	T	570.0 (258.8)	769.6 (349.4)	**250632HMURFY**

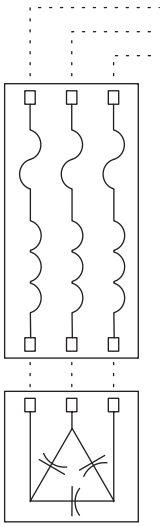
Notes

Other ratings available, consult factory.

Fused with blown-fuse indication standard.

Wiring Diagram

Filter Schematic with Wiring Interconnects



Power Lines from Disconnect

Lugs

Fuses

Reactor Enclosure

Lugs

Interconnects (Provided by Customer) ①

Lugs

Capacitor Enclosure

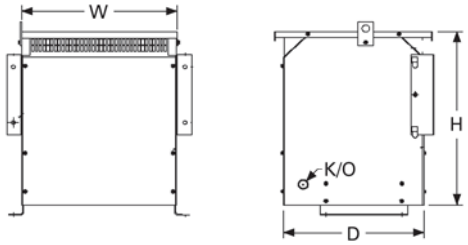
Note

① Refer to NEC.

Dimensions

Approximate Dimensions in Inches (mm)

Reactor Cabinet

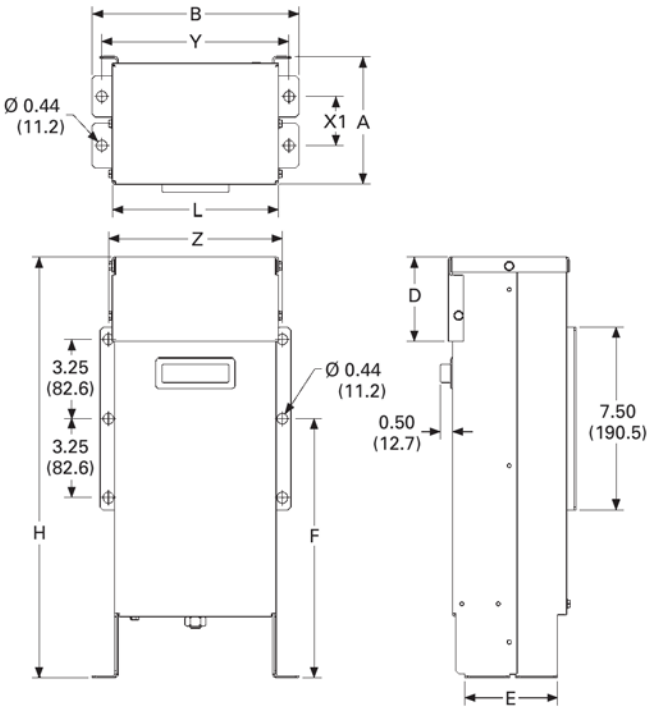


Reactor Cabinet

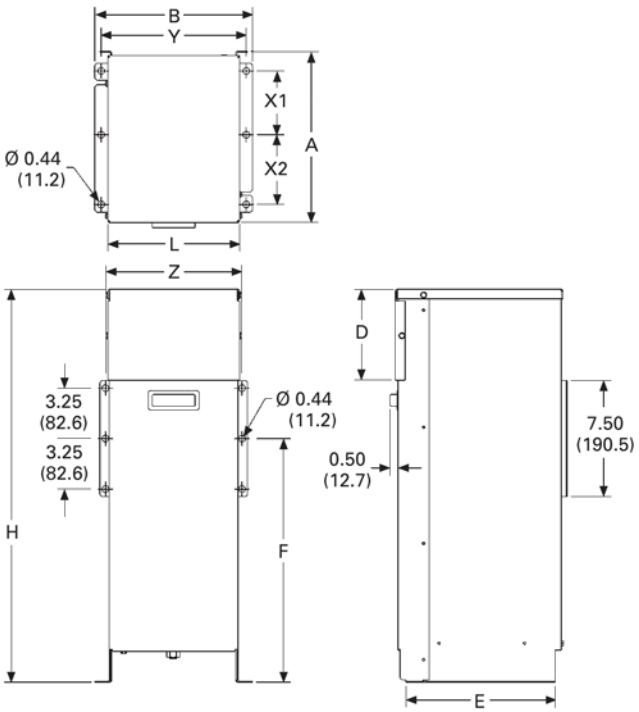
Case Size	Height	Width	Depth
R	24.75 (628.7)	20.00 (508.0)	18.13 (460.5)
S	25.00 (635.0)	24.25 (616.0)	20.25 (514.4)
T	31.00 (787.4)	25.00 (635.0)	32.75 (831.9)

Low Voltage Fixed Capacitor Banks and Fixed Harmonic Filters

Case A1, A2



Case B1



UNIPAK Enclosures

Case Size	A	B	D	E	F	H	L	X1	X2	X3	Y	Z
A1	5.30 (134.6)	8.50 (215.9)	3.50 (88.9)	3.80 (96.5)	10.60 (269.2)	17.30 (439.4)	6.80 (172.7)	2.00 (50.8)	N/A	N/A	7.70 (195.6)	7.20 (182.9)
A2	6.00 (152.4)	8.50 (215.9)	5.60 (142.2)	4.50 (114.3)	13.30 (337.8)	22.30 (566.4)	6.80 (172.7)	2.30 (58.4)	N/A	N/A	7.70 (195.6)	7.20 (182.9)
B1	11.10 (281.9)	10.10 (256.5)	5.80 (147.3)	9.60 (243.8)	15.70 (398.8)	25.30 (642.6)	8.50 (215.9)	4.10 (104.1)	4.50 (114.3)	N/A	9.30 (236.2)	8.80 (223.5)

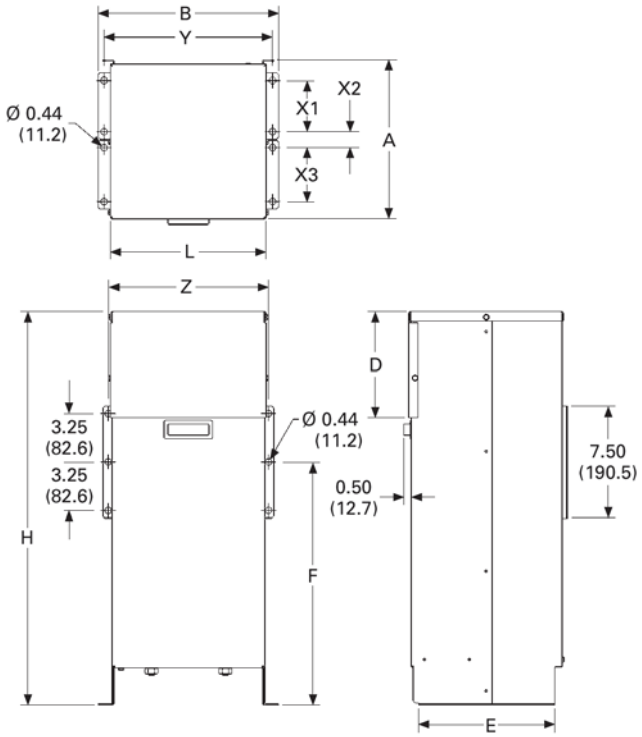
Legend:

A = Total depth
B = Total width
D = Height of removable front cover
E = Depth of feet
F = Height of middle mounting hole in wall bracket
H = Total height
L = Width without feet and brackets
X = Depth between front and rear mounting holes in inches
Y = Width between floor mounting holes
Z = Width between wall bracket mounting holes

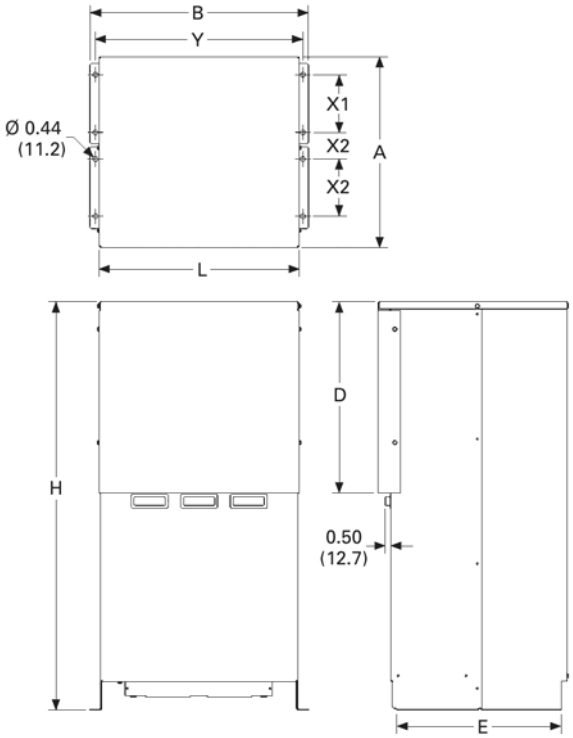
2

Approximate Dimensions in Inches (mm)

Case C1, C2



Case D1, E1

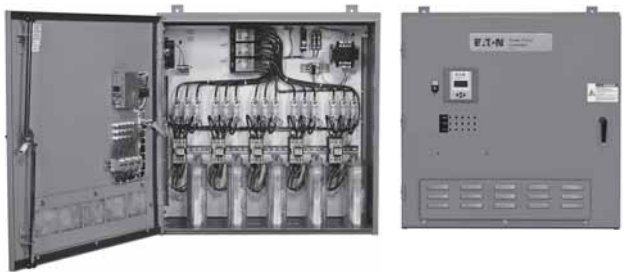


UNIPAK Enclosures

Case Size	A	B	D	E	F	H	L	X1	X2	X3	Y	Z
C1	10.60 (269.2)	12.10 (307.3)	7.10 (180.3)	9.10 (231.1)	16.20 (411.5)	26.30 (668.0)	10.40 (264.2)	3.40 (86.4)	1.10 (27.9)	3.60 (91.4)	11.30 (287.0)	10.70 (271.8)
C2	12.00 (304.8)	19.30 (490.2)	16.90 (429.3)	9.50 (241.3)	16.30 (414.0)	36.00 (914.4)	17.70 (449.6)	3.00 (76.2)	1.50 (38.1)	3.80 (96.5)	18.30 (464.8)	18.00 (457.2)
D1	16.80 (426.7)	19.30 (490.2)	16.90 (429.3)	14.60 (370.8)	N/A	36.00 (914.4)	17.70 (449.6)	5.10 (129.5)	2.40 (61.0)	5.00 (127.0)	18.30 (464.8)	N/A
E1	22.30 (566.4)	24.40 (619.8)	16.80 (426.7)	19.50 (495.3)	N/A	36.00 (914.4)	22.70 (576.6)	6.50 (165.1)	4.40 (111.8)	5.00 (127.0)	22.40 (569.0)	N/A

Legend:
A = Total depth
B = Total width
D = Height of removable front cover
E = Depth of feet
F = Height of middle mounting hole in wall bracket
H = Total height
L = Width without feet and brackets
X = Depth between front and rear mounting holes in inches
Y = Width between floor mounting holes
Z = Width between wall bracket mounting holes

AUTOVAR 300



Contents

AUTOVAR 300 Automatic Power Factor Correction Capacitor Systems

Product Description

Automatically switched power factor correction systems for low voltage applications.

- Wallmount design is ideal for minimum space requirements
- Programmable to automatically add/subtract capacitor stages to maintain preset target power factor
- Heavy-duty, three-phase capacitor construction
- Two-year warranty of cells against manufacturing defects

Application Description

AUTOVAR 300 is an ideal capacitor bank to automatically regulate power factor where floor space is limited and expansion of the facility's electrical load is not expected.

Features

Configuration

- **Cabinet**: Wallmounting 12 gauge steel with ANSI 61 gray, NEMA 1 (gasketed)
- **Power line interconnect**: Rugged, power distribution block connection. Typical power distribution block can accommodate phase wire sizes from 4 AWG to 500 kcmil; typical ground lug can accommodate wire sizes from 14 AWG to 2/0 AWG. Consult equipment approval drawings for actual lug size
- **Control wiring**: UL type MTW/AWM, CSA TEW 105 °C copper wire is standard
- **Fusing**: 200,000 A interrupting capacity provided on all three phases of each stage. Blade-type fuses mounted on insulator stand-offs with cleared-fuse indicating lights
- **Cleared-fuse lights**: Cleared-fuse neon indicating lights for each phase and stage located on the door
- **Door interlock:** Door interlock automatically disengages capacitors. Power continues to be provided to the unit until the disconnect is open
- **Exhaust fan**: Provides ventilation; dust filtering included
- **Safety**: Ground fault interruption provides protection in case of accidental contact with control power and ground
- **Conduit/cable entry**: Available in top/side cable entry
- **Thermal sensing**: Built-in thermal sensing, alarming, and protection feature allows the unit to operate in optimal temperature while alerting the user of ambient temperature exceeding the nominal operating range. Stages will be automatically switched off if temperature exceeds the maximum specified temperature
- **Temperature range**: The operating temperature range is –20 °C to +46 °C, and the storage temperature range is –40 °C to +55 °C. For optimal equipment life, the temperature should not exceed 35 °C annual average, and the environment should not exceed Pollution Degree 2 as defined in UL 61010-1

Controller

- Visual indication of incorrect CT polarity
- Digital display of power factor and number of energized stages
- Automatic setting of c/k value (sensitivity based on CT ratio and kvar available)
- Visual indication of insufficient kvar to reach target power factor
- Automatic sensing of kvar values per step
- Optional communications capable controller (RS-485/ Modbus®)
- Standard metering capability:
  - Voltage
  - Current (sensed phase only)
  - Frequency
  - Active power (kW)
  - Reactive power (kvar)
  - Apparent power (kVA)
  - Total voltage harmonic distortion (VTHD)
  - Individual harmonic voltage distortion (odd orders up to the 19th harmonic)
- Built-in manual mode allows for testing and manual operation of stages
- Multiple user-friendly alarm displays. Controller provides easy-to-understand alarms for various conditions, such as:
  - Undervoltage or overvoltage
  - Undercurrent or overcurrent
  - Target power factor not met
  - Harmonic overload
  - Faulty step/stages
  - Overtemperature alarm

Contactor

- Fully rated for capacitor switching
- Integral pre-charge/pre-insertion module standard. The contactor reduces damaging switching transients, providing safety and durability for the system
  - Lessens the chance of disrupting sensitive electronic equipment
  - Reduced inrush current extends the life of the capacitor cells

Options

- Optional main molded-case circuit breaker
- NEMA 3R weather-resistant enclosure
- Hand-Off-Auto switches
- Remote alarm relay terminal block
- Communications capable controller

Support and Service

- Renewal parts are available through local Eaton distributors
- Factory trained service personnel are available through Eaton's Electrical Services & Systems

Standards and Certifications

- UL/CSA listed and recognized
- Entire cabinet assembly is UL 508A and CSA C22.2 No. 190 Listed
- Capacitors are UL 810 recognized
- Contactor is UL/CSA recognized and IEC 6b rated

Listed

Product Selection

Wallmounted AUTOVAR 300 Switched Capacitor Banks—Low Voltage Applications

kvar	Step x kvar	Rated Current Amperes	Base Shipping Weight in Lb (kg) ①	Catalog Number
240 V				
25	5 x 5	60	217 (98.5)	**25MCSR2313**
50	5 x 10	120	255 (115.8)	**50MCSR2313**
75	5 x 15	180	260 (118.0)	**75MCSR2313**
100	5 x 20	240	270 (122.6)	**100MCSR231**
125	5 x 25	300	292 (132.6)	**125MCSR231**
480 V				
50	5 x 10	60	200 (90.8)	**50MCSR4313**
75	5 x 15	90	210 (95.3)	**75MCSR4313**
100	5 x 20	120	210 (95.3)	**100MCSR4313**
125	5 x 25	150	240 (109.0)	**125MCSR4313**
150	5 x 30	180	240 (109.0)	**150MCSR4313**
175	5 x 35	210	260 (118.0)	**175MCSR431**
200	5 x 40	241	270 (122.6)	**200MCSR431**
225	5 x 45	270	290 (131.7)	**225MCSR431**
250	5 x 50	300	292 (132.6)	**250MCSR431**
600 V				
50	5 x 10	48	200 (90.8)	**50MCSR6313**
75	5 x 15	72	210 (95.3)	**75MCSR6313**
100	5 x 20	96	210 (95.3)	**100MCSR6313**
125	5 x 25	120	240 (109.0)	**125MCSR6313**
150	5 x 30	144	240 (109.0)	**150MCSR6313**
175	5 x 35	168	260 (118.0)	**175MCSR631**
200	5 x 40	192	270 (122.6)	**200MCSR631**
225	5 x 45	216	290 (131.7)	**225MCSR631**
250	5 x 50	240	292 (132.6)	**250MCSR631**

Spare Fuses

kvar Rating/Bank

240 V	480 V	600 V	Amperes	Eaton Fuse Part Number
5	10	10	30	**SP030217-0029J**
—	15	20	50	**SP030217-0037D**
10	20	—	60	**SP030217-0037E**
—	25	25–30	80	**SP030217-0037G**
15	30	40	100	**SP030217-0037J**
20	40	50	125	**SP030217-0037K**
25	50	—	150	**SP030217-0037L**

Renewal Parts

Description	Catalog Number
Replacement PF controller, ACX type	**SP039010-0035U**
Replacement contactor, 72 A	**SP039010-0014B**
Replacement contactor, 32 A	**SP039010-0014C**

Options

Description	Option Code
Remote alarm relay terminal block—relay terminal block for a remote alarm to indicate controller alarm status	**A**
Communicating controller (Modbus RS-485)	**C**
Hand-Off-Auto switch—provides manual control to connect or disconnect capacitor stages regardless of controller output ②	**H**
Molded-case circuit breaker (see circuit breaker section)	**M**
Weather-resistant enclosure (NEMA 3R gasketed)	**W**

Integrated Main Breakers—AUTOVAR 300

kvar	AUTOVAR Rated Current Amperes	Breaker Size (Amperes) ③	Breaker Interrupting Rating (kA)	Breaker Weight in Lb (kg)	Standard Wire Lug Size ④
240 V					
25	60	125	100	10 (4.5)	(1) #3–350
50	120	250	100	10 (4.5)	(1) #3–350
75	180	250	100	10 (4.5)	(1) #3–350
100	240	400	100	10 (4.5)	(2) #3/0–250
125	300	600	100	25 (11.4)	(2) #3/0–350
480 V					
50	60	125	65	10 (4.5)	(1) #3–350
75	90	125	65	10 (4.5)	(1) #3–350
100	120	250	65	10 (4.5)	(1) #3–350
125	150	250	65	10 (4.5)	(1) #3–350
150	180	250	65	10 (4.5)	(1) #3–350
175	210	400	65	10 (4.5)	(2) #3/0–250
200	240	400	65	10 (4.5)	(2) #3/0–250
225	270	400	65	10 (4.5)	(2) #3/0–250
250	300	600	65	25 (11.4)	(2) #3/0–350
600 V					
50	48	125	35	10 (4.5)	(1) #3–350
75	72	125	35	10 (4.5)	(1) #3–350
100	96	250	35	10 (4.5)	(1) #3–350
125	120	250	35	10 (4.5)	(1) #3–350
150	144	250	35	10 (4.5)	(1) #3–350
175	168	250	35	10 (4.5)	(1) #3–350
200	192	400	35	10 (4.5)	(2) #3/0–350
225	216	400	35	10 (4.5)	(2) #3/0–350
250	240	400	35	10 (4.5)	(2) #3/0–350

Notes

① To calculate AUTOVAR 300 weight:
1. Obtain base unit weight from table above.
2. Add option weights as necessary:
   A = 1 lb
   C = 1 lb
   H = 5 lb
   W = 10 lb
   M = 50 lb enclosure weight adder plus circuit breaker weight (see circuit breaker table)
   S = Consult Eaton's Technical Resource Center (TRC) at 1-800-809-2772, choose option #4, then option #2

Heavy-duty cells, 50 Hz units, and other ratings available, please consult factory. A minimum of one CT is required per AUTOVAR unit. kvar output is voltage and frequency dependent. 60 Hz units are shown. For other voltages and frequencies, consult Eaton Technical Resource Center (TRC) at 1-800-809-2772, choose option #4, then option #2.

② Manual control is always available through controller menu system, even if the H option is not selected.

③ Breakers are sized at a minimum of 135% of the unit rated Amperes per the NEC®.

④ See equipment drawings for actual lug sizes.

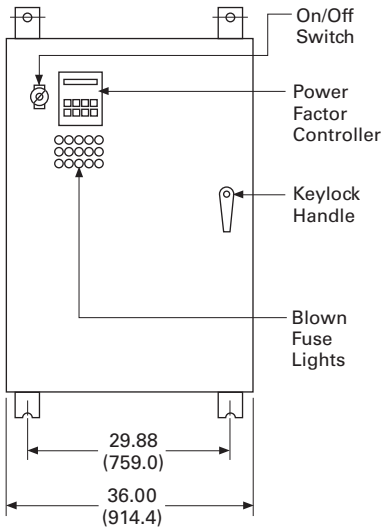
Dimensions

Approximate Dimensions in Inches (mm)

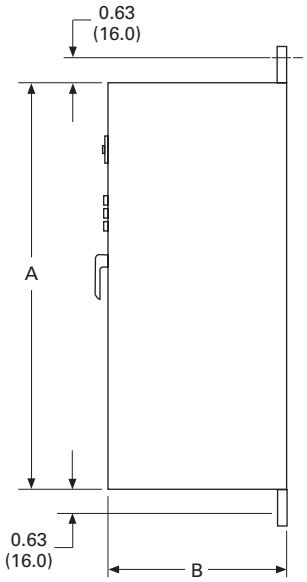
2

Enclosure J

Front View



Side View



Description	Height A	Depth B
J1	36.00 (914.4)	14.00 (355.6)
J2	60.00 (1524.0)	14.00 (355.6)

AUTOVAR 600

Contents

AUTOVAR 600 Automatic Power Factor Correction Capacitor Systems

Product Description

- Programmable to automatically add/subtract capacitor stages to maintain preset target power factor
- Three-phase capacitor cell construction
- Two-year warranty of cells against manufacturing defects
- Cool operating, 100% copper wound, thermal-protected reactors are sized up to 150% of rated capacitor current (AUTOVAR detuned filter only)

Application Description

- Service entrance or substation power factor correction installations requiring precise maintenance of target power factor (AUTOVAR 600)
- Service entrance or substation power factor correction installations requiring precise maintenance of target power factor in three-phase, nonlinear, high harmonic environments (AUTOVAR detuned filter)
- Typically connected at main low voltage switchgear

Features

Configuration

- **Cabinet**: 12 gauge steel with ANSI 61 gray, baked finish. Removable lift bolts standard, NEMA 1 (gasketed)
- **Power line interconnect**: Rugged, copper busbar connection with access provided for top entry. Contact factory for availability of bottom entry. Busbars are braced for 65 kA (optional 100 kA rating available). All internal power wiring connections from bus are laid out on a most direct basis with minimum bends for ease of troubleshooting. Clear barrier limiting access to live parts included standard
- **Modular tray design**: Capacitor stages arranged in modular trays with capacitors, fuses, cleared-fuse indicating lights, and contactors grouped in a logical, easily understood layout. This permits easy access, quick identification of operating problems, and ease of expandability
- **Fusing**: UL recognized, 200,000 A interrupting capacity provided on all three phases of each stage. Blade-type fuses mounted on insulator stand-offs
- **Cleared-fuse indicating lights**: LEDs located door-mounted and neon at individual fuses to facilitate tracing of cleared fuses
- **Push-to-test**: Allows testing of door-mounted LED cleared fuse indicating lights
- **AutoLocate**: When door is open and bus is energized, fuse circuit automatically checks for cleared fuses. If a fuse has cleared, the light at the fuse turns on for easy troubleshooting
- **Door interlock**: Door interlock automatically turns off control circuit when engaged. Power continues to be provided to the unit until disconnect is open
- **Exhaust fans**: Two side louver fans per cabinet provide cooling and reduce operator exposure to discharge. Replaceable dust filtering provided. Dust filters can be replaced without opening cabinet
- **Ease of expansion**: Capacitor stage nests are self-contained and can be added in the field. Two bolts mount the nest in the field. Control wire plugs connect to factory standard wire harness on the left side of the cabinet
- **Ease of replacement**: Cells can be easily replaced individually by removing the mounting bolt and lifting out of the nest without removal of any other components
- **Thermal sensing**: Built-in thermal sensing, alarming, and protection feature allows the unit to operate in optimal temperature while alerting the user of ambient temperature exceeding the nominal operating range. Stages will be automatically switched off if temperature exceeds the maximum specified temperature
- **Temperature range**: The operating temperature range is –20 °C to +46 °C, and the storage temperature range is –40 °C to +55 °C. For optimal equipment life, the temperature should not exceed 35 °C annual average, and the environment should not exceed Pollution Degree 2 as defined in UL 61010-1

Controller

- Visual indication of incorrect CT polarity
- Digital display of power factor and number of energized stages
- Automatic setting of c/k value (sensitivity based on CT ratio and kvar available)
- Visual indication of insufficient kvar to reach target power factor
- Automatic sensing of kvar values per step
- Optional communications capable controller (RS-485/ Modbus)
- Standard metering capability:
  - Voltage
  - Current (sensed phase only)
  - Frequency
  - Active power (kW)
  - Reactive power (kvar)
  - Apparent power (kVA)
  - Total voltage harmonic distortion (VTHD)
  - Individual harmonic voltage distortion (odd orders up to the 19th harmonic)
- Built-in manual mode allows for testing and manual operation of stages
- Multiple user-friendly alarm displays. Controller provides easy-to-understand alarms for various conditions, such as:
  - Undervoltage or overvoltage
  - Undercurrent or overcurrent
  - Target power factor not met
  - Harmonic overload
  - Faulty step/stages
  - Overtemperature alarm

Contactor

- Fully rated for capacitor switching
- Integral pre-charge/pre-insertion module standard. The contactor reduces damaging switching transients, providing safety and durability for the system
  - Lessens the chance of disrupting sensitive electronic equipment
  - Reduced inrush current extends the life of the capacitor cells

Reactors

- **Detuning**: Standard reactor designs are detuned to the 4.2nd harmonic and recommended to protect capacitors against harmonic resonance. Detuning to the 4.7th harmonic is available as an option. The harmonic spectrum should be evaluated for applications involving reactors detuned to the 4.7th harmonic to ensure optimal equipment life, specifically when used in conjunction with six-pulse motor drives
- **Windings**: 80 °C temperature rise design 100% copper windings for minimal losses
- **Thermal overload protection**: Each reactor includes three normally closed, auto reset thermostats that open at 180 °C. When thermostats engage, the contactor opens
- **Insulation**: 220 °C insulation system
- **Warranty**: One-year replacement of reactors

Additional Features

- Optional molded-case main circuit breaker
- Ground fault interruption provides protection in case of accidental contact with control power and ground
- Control wiring—standard NEC color-coded modular bundles with quick disconnect feature for ease of troubleshooting or ease of expendability. UL type MTW/AWM, CSA TEW 105 °C copper wire is standard.
- Optional digital metering—IQ 250
- Mechanical wire lugs are included as standard equipment. Typical phase lugs range from (2) 6 AWG–350 kcmil to (4) 3 AWG–750 MCM. Typical ground lug can accept wire from 6 AWG to 350 kcmil. Lugs are compatible with copper wire 90 °C
- Heavy-duty capacitor cells are standard on AUTOVAR detuned filter and optional on AUTOVAR 600. For 480 V units, standard-duty cells are 525 V rated, and heavy-duty cells are 600 V rated

Support and service

- Renewal parts are available through local Eaton distributors
- Factory trained service personnel are available through Eaton's Electrical Services & Systems

AUTOVAR 600—Interior View

Modular Step Nest Assembly

Dust Filter Tray

Standards and Certifications

- Entire cabinet assembly is UL 508A and CSA C22.2 No. 190 Listed
- Capacitors are UL 810 recognized
- Contactor is UL/CSA recognized and IEC 6b rated

Listed

Product Selection

Options—AUTOVAR 600 and AUTOVAR Detuned Filter

Description	Option Code
Remote alarm relay terminal block—relay terminal block for a remote alarm to indicate controller alarm status	**A**
Fully insulated main bus	**B**
Communicating PF controller (Modbus RS-485)	**C**
Hand-off-auto switch provides manual control to connect or disconnect capacitor stages regardless of controller output ①	**H**
Integrated main breaker	**M**
Integrated main breaker with high interrupting rating (see breaker table for more information), includes 100 kA busbar bracing	**M1**
100 kA busbar bracing	**N1**
Integrated CVX series surge protection, without sine wave tracking	**T1**
Integrated SPD series surge protection, 160 kA per phase, with sine wave tracking	**T2**
IQ 250 electronic meter ②	**Q**
Weather resistant enclosure (NEMA 3R gasketed) ③	**W**
Standard filter detuned to the 4.2nd harmonic ④	**Y**

Notes

① Manual control is always available through menu controller on system, even if the H option is not selected.

② Not available on NEMA 3R units (W option).

③ Only available on AUTOVAR 600 with heavy-duty cells and AUTOVAR detuned filters using 'L + L', 'L + KK', and 'KK + KK' enclosures.

④ Tuning to the 4.2nd harmonic is the preferred option. Other tunings available. Contact Eaton's Technical Resource Center (TRC) power factor application engineers at 1-800-809-2772, choose option #4, then option #2.

To calculate AUTOVAR 600 or AUTOVAR detuned filter weight:

Obtain base unit weight from tables on **Pages V3-T2-70–V3-T2-72** (as appropriate).

Add option weights as necessary:
A = 1 lb (0.5 kg)
B = 10 lb (4.5 kg)
C = 1 lb (0.5 kg)
H = 10 lb (4.5 kg)
M = Circuit breaker weight (see circuit breaker table)
M1 = 10 lb (4.5 kg) hardware weight adder plus circuit breaker weight (see circuit breaker table)
N1 = 10 lb (4.5 kg)
T1 = 5 lb (2.3 kg)
T2 = 10 lb (4.5 kg)
Q = 5 lb (2.3 kg)
W = 10 lb (4.5 kg) per door
Y = 0 lb (0 kg)

AUTOVAR 600 Floor-Mounted Switched Capacitor Banks Units with Standard-Duty Cells—Low Voltage Applications

kvar ①	Step x kvar	Rated Current Amperes	Base Shipping Weight in Lb (kg)	Base Catalog Number
240 Vac				
75	3 x 25	180	644 (292.4)	**75TPCSR231**
100	4 x 25	240	692 (314.2)	**100TPCSR231**
125	5 x 25	300	740 (336.0)	**125TPCSR231**
150	6 x 25	361	788 (357.8)	**150TPCSR231**
200	8 x 25	481	884 (401.3)	**200TPCSR231**
250	10 x 25	600	944 (428.6)	**250TPCSR231**
300	12 x 25	720	1022 (464.0)	**300TPCSR231**
350	7 x 50	844	1616 (734.0)	**350TPCSR231**
400	8 x 50	965	1704 (774.0)	**400TPCSR231**
480 Vac				
100	2 x 50	120	588 (266.7)	**100TPCSR431**
150	3 x 50	180	632 (287.0)	**150TPCSR431**
200	4 x 50	240	676 (306.9)	**200TPCSR431**
250	5 x 50	300	720 (326.9)	**250TPCSR431**
300	6 x 50	360	764 (346.9)	**300TPCSR431**
350	7 x 50	420	808 (366.8)	**350TPCSR431**
400	8 x 50	480	852 (386.8)	**400TPCSR431**
450	9 x 50	540	896 (406.8)	**450TPCSR431**
500	10 x 50	600	944 (428.6)	**500TPCSR431**
550	11 x 50	660	984 (446.7)	**550TPCSR431**
600	12 x 50	720	1022 (464.0)	**600TPCSR431**
660	11 x 60	792	1010 (458.5)	**660TPCSR431**
700	7 x 100	840	1616 (734.0)	**700TPCSR431**
720	12 x 60	864	1050 (476.7)	**720TPCSR431**
800	8 x 100	960	1704 (774.0)	**800TPCSR431**
900	9 x 100	1080	1792 (814.0)	**900TPCSR431**
1000	10 x 100	1200	1888 (857.0)	**1000TPCSR431**
1100	11 x 100	1320	1966 (893.0)	**1100TPCSR431**
1200	12 x 100	1440	2044 (928.0)	**1200TPCSR431**
600 Vac				
100	2 x 50	46	588 (266.7)	**100TPCSR631**
150	3 x 50	144	632 (287.0)	**150TPCSR631**
200	4 x 50	192	676 (306.9)	**200TPCSR631**
250	5 x 50	240	720 (326.9)	**250TPCSR631**
300	6 x 50	288	764 (346.9)	**300TPCSR631**
350	7 x 50	336	808 (366.8)	**350TPCSR631**
400	8 x 50	384	852 (386.8)	**400TPCSR631**
450	9 x 50	432	896 (406.8)	**450TPCSR631**
500	10 x 50	480	944 (428.6)	**500TPCSR631**
550	11 x 60	528	984 (446.7)	**550TPCSR631**
600	12 x 50	576	1022 (464.0)	**600TPCSR631**
660	11 x 60	634	1010 (458.5)	**660TPCSR631**
700	7 x 100	672	1616 (734.0)	**700TPCSR631**
720	12 x 60	692	1050 (476.7)	**720TPCSR631**
800	8 x 100	768	1704 (774.0)	**800TPCSR631**
900	9 x 100	864	1792 (814.0)	**900TPCSR631**
1000	10 x 100	960	1888 (857.0)	**1000TPCSR631**
1100	11 x 100	1056	1966 (893.0)	**1100TPCSR631**
1200	12 x 100	1152	2044 (928.0)	**1200TPCSR631**

AUTOVAR 600 Sizing Chart for Units with Standard-Duty Cells

kvar	Step x kvar	Enclosure Size ② NEMA 1, without Main Breaker, No Suffix	NEMA 1, with Main Breaker, M Suffix
240 V			
75	3 x 25	L	L
100	4 x 25	L	L
125	5 x 25	L	L
150	6 x 25	L	L
200	8 x 25	L	L
250	10 x 25	L	L
300	12 x 25	L	L
350	7 x 50	KK	KK
400	8 x 50	KK	C/F
480 V			
100	2 x 50	L	L
150	3 x 50	L	L
200	4 x 50	L	L
250	5 x 50	L	L
300	6 x 50	L	L
350	7 x 50	L	L
400	8 x 50	L	L
450	9 x 50	L	L
500	10 x 50	L	L
550	11 x 50	L	L
600	12 x 50	L	L
660	11 x 60	L	L
700	14 x 50	KK	KK
720	12 x 60	L	L
800	8 x 100	KK	C/F
900	9 x 100	KK	C/F
1000	10 x 100	KK	C/F
1100	11 x 100	KK	C/F
1200	12 x 100	KK	C/F
600 V			
100	2 x 50	L	L
150	3 x 50	L	L
200	4 x 50	L	L
250	5 x 50	L	L
300	6 x 50	L	L
350	7 x 50	L	L
400	8 x 50	L	L
450	9 x 50	L	L
500	10 x 50	L	L
550	11 x 50	L	L
600	12 x 50	L	L
660	11 x 60	L	L
700	14 x 50	KK	KK
720	12 x 60	L	L
800	8 x 100	KK	KK
900	9 x 100	KK	KK
1000	10 x 100	KK	C/F
1100	11 x 100	KK	C/F
1200	12 x 100	KK	C/F

Notes

① Other ratings available. Please consult factory. kvar output is voltage and frequency dependent. 60 Hz units are shown. For other voltages and frequencies, consult Eaton Technical Resource Center (TRC) at 1-800-809-2772, choose option #4, then option #2.

② Enclosure sizing for units with integrated surge protection or bottom entry can vary and may not be available on all kvar sizes. Contact Eaton's Technical Resource Center at 1-800-809-2772, choose option #4, then option #2.

C/F = Consult factory

AUTOVAR 600 Floor-Mounted Switched Capacitor Banks Units with Heavy-Duty Cells—Low Voltage Applications

kvar ①	Step x kvar	Rated Current Amperes	Base Shipping Weight in Lb (kg)	Base Catalog Number
240 Vac				
75	3 x 25	180	659 (298.9)	**75TPHSR231**
100	4 x 25	240	712 (323.0)	**100TPHSR231**
125	5 x 25	300	765 (347.0)	**125TPHSR231**
150	6 x 25	361	818 (371.0)	**150TPHSR231**
200	8 x 25	481	924 (419.1)	**200TPHSR231**
250	10 x 25	601	994 (450.9)	**250TPHSR231**
300	12 x 25	720	1082 (490.8)	**300TPHSR231**
350	7 x 50	844	1686 (764.8)	**350TPHSR231**
400	8 x 50	965	1784 (809.2)	**400TPHSR231**
480 Vac				
100	2 x 50	120	617 (279.9)	**100TPHSR431**
150	3 x 50	180	677 (307.1)	**150TPHSR431**
200	4 x 50	240	736 (333.8)	**200TPHSR431**
250	5 x 50	300	795 (360.6)	**250TPHSR431**
300	6 x 50	360	854 (387.4)	**300TPHSR431**
350	7 x 50	420	913 (414.1)	**350TPHSR431**
400	8 x 50	480	972 (440.9)	**400TPHSR431**
450	9 x 50	540	1031 (467.7)	**450TPHSR431**
500	10 x 50	600	1094 (496.2)	**500TPHSR431**
550	11 x 50	660	1149 (521.2)	**550TPHSR431**
600	12 x 50	720	1202 (545.2)	**600TPHSR431**
700	14 x 50	792	1826 (828.3)	**700TPHSR431**
800	8 x 100	462	1944 (881.8)	**800TPHSR431**
900	9 x 100	1083	2062 (935.3)	**900TPHSR431**
1000	10 x 100	1203	2198 (997.0)	**1000TPHSR431**
1100	11 x 100	1323	2296 (1041.4)	**1100TPHSR431**
1200	12 x 100	1443	2404 (1090.4)	**1200TPHSR431**
600 Vac				
100	2 x 50	96	617 (279.9)	**100TPHSR631**
150	3 x 50	144	677 (307.1)	**150TPHSR631**
200	4 x 50	192	736 (333.8)	**200TPHSR631**
250	5 x 50	240	795 (360.6)	**250TPHSR631**
300	6 x 50	288	854 (387.4)	**300TPHSR631**
350	7 x 50	336	913 (414.1)	**350TPHSR631**
400	8 x 50	384	972 (440.9)	**400TPHSR631**
450	9 x 50	432	1031 (467.7)	**450TPHSR631**
500	10 x 50	480	1094 (496.2)	**500TPHSR631**
550	11 x 60	529	1149 (521.2)	**550TPHSR631**
600	12 x 50	576	1202 (545.2)	**600TPHSR631**
700	7 x 100	672	1826 (828.3)	**700TPHSR631**
800	8 x 100	768	1944 (881.8)	**800TPHSR631**
900	9 x 100	864	2062 (935.3)	**900TPHSR631**
1000	10 x 100	962	2198 (997.0)	**1000TPHSR631**
1100	11 x 100	1058	2296 (1041.4)	**1100TPHSR631**
1200	12 x 100	1155	2404 (1090.4)	**1200TPHSR631**

AUTOVAR 600 Sizing Chart for Units with Heavy-Duty Cells

		Enclosure Size ②			
kvar	Step x kvar	NEMA 1, without Main Breaker, No Suffix	NEMA 1, with Main Breaker, M Suffix	NEMA 3R, without Main Breaker, W Suffix	NEMA 3R, with Main Breaker, MW Suffix
240 V					
75	3 x 25	L	L	L	L
100	4 x 25	L	L	L	L
125	5 x 25	L	L	L	L
150	6 x 25	L	L	L	L
200	8 x 25	L	L	L	L
250	10 x 25	L	L	L	L
300	12 x 25	L	L	L	L
350	7 x 50	L	KK	KK	KK
400	8 x 50	KK	C/F	KK	C/F
480 V					
100	2 x 50	L	L	L	L
150	3 x 50	L	L	L	L
200	4 x 50	L	L	L	L
250	5 x 50	L	L	L	L
300	6 x 50	L	L	L	L
350	7 x 50	L	L	L	L
400	8 x 50	L	L	L	L
450	9 x 50	L	L	L	L
500	10 x 50	L	L	L	L
550	11 x 50	L	L	L	L
600	12 x 50	L	L	L	L
700	14 x 50	KK	KK	KK	KK
800	8 x 100	KK	C/F	KK	C/F
900	9 x 100	KK	C/F	KK	C/F
1000	10 x 100	KK	C/F	KK	C/F
1100	11 x 100	KK	C/F	KK	C/F
1200	12 x 100	KK	C/F	KK	C/F
600 V					
100	2 x 50	L	L	L	L
150	3 x 50	L	L	L	L
200	4 x 50	L	L	L	L
250	5 x 50	L	L	L	L
300	6 x 50	L	L	L	L
350	7 x 50	L	L	L	L
400	8 x 50	L	L	L	L
450	9 x 50	L	L	L	L
500	10 x 50	L	L	L	L
550	11 x 50	L	L	L	L
600	12 x 50	L	L	L	L
700	14 x 50	KK	KK	KK	KK
800	8 x 100	KK	KK	KK	KK
900	9 x 100	KK	KK	KK	KK
1000	10 x 100	KK	C/F	KK	C/F
1100	11 x 100	KK	C/F	KK	C/F
1200	12 x 100	KK	C/F	KK	C/F

Notes

① Other ratings available. Please consult factory. kvar output is voltage and frequency dependent. 60 Hz units are shown. For other voltages and frequencies, consult Eaton Technical Resource Center (TRC) at 1-800-809-2772, choose option #4, then option #2.

② Enclosure sizing for units with integrated surge protection or bottom entry can vary and may not be available on all kvar sizes. Contact Eaton's Technical Resource Center at 1-800-809-2772, choose option #4, then option #2.

C/F = Consult factory

Floor-Mounted Switched Detuned Filters—Low Voltage

kvar ①	Step x kvar	Rated Current Amperes	Base Shipping Weight in Lb (kg)	Base Catalog Number
240 Vac				
150	6 x 25	361	1830 (830.8)	**150THFSR232Y**
200	8 x 25	481	2222 (1008.8	**200THFSR232Y**
250	10 x 25	601	2525 (1146.4)	**250THFSR232Y**
300	12 x 25	720	2830 (1284.8)	**300THFSR232Y**
350	7 x 50	844	3090 (1401.6)	**350THFSR231Y**
400	8 x 50	965	3560 (1614.8)	**400THFSR232Y**
480 Vac				
100	2 x 50	120	1105 (501.2)	**100THFSR431Y**
150	3 x 50	180	1242 (564.6)	**150THFSR431Y**
200	4 x 50	240	1438 (652.9)	**200THFSR431Y**
250	5 x 50	300	1634 (741.8)	**250THFSR431Y**
300	6 x 50	360	1830 (830.8)	**300THFSR432Y**
350	7 x 50	420	2026 (919.8)	**350THFSR432Y**
400	8 x 50	480	2222 (1008.8)	**400THFSR432Y**
450	9 x 50	540	2371 (1076.4)	**450THFSR432Y**
500	10 x 50	600	2525 (1146.4)	**500THFSR432Y**
550	11 x 50	660	2750 (1248.5)	**550THFSR432Y**
600	12 x 50	720	2830 (1284.8)	**600THFSR432Y**
700	7 x 100	792	3090 (1401.6)	**700THFSR431Y**
800	8 x 100	962	3560 (1614.8)	**800THFSR432Y**
900	9 x 100	1083	3900 (1769.0)	**900THFSR432Y**
1000	10 x 100	1203	4240 (1923.2)	**1000THFSR432Y**
1100	11 x 100	1323	4500 (2041.2)	**1100THFSR432Y**
600 Vac				
100	2 x 50	96	1105 (501.2)	**100THFSR631Y**
150	3 x 50	144	1242 (564.6)	**150THFSR631Y**
200	4 x 50	192	1438 (652.9)	**200THFSR631Y**
250	5 x 50	240	1634 (741.8)	**250THFSR631Y**
300	6 x 50	288	1830 (830.8)	**300THFSR632Y**
350	7 x 50	336	2026 (919.8)	**350THFSR632Y**
400	8 x 50	384	2222 (1008.8)	**400THFSR632Y**
450	9 x 50	432	2371 (1076.4)	**450THFSR632Y**
500	10 x 50	480	2525 (1146.4)	**500THFSR632Y**
550	11 x 50	529	2750 (1248.5)	**550THFSR632Y**
600	12 x 50	576	2830 (1284.8)	**600THFSR632Y**
700	7 x 100	672	3090 (1401.6)	**700THFSR631Y**
800	8 x 100	768	3560 (1614.8)	**800THFSR632Y**
900	9 x 100	864	3900 (1769.0)	**900THFSR632Y**
1000	10 x 100	962	4240 (1923.2)	**1000THFSR632Y**
1100	11 x 100	1058	4500 (2041.2)	**1100THFSR632Y**

AUTOVAR Detuned Filter Sizing Chart

		Enclosure Size ②			
kvar	Step x kvar	NEMA 1 without Main Breaker, No Suffix	NEMA 1 with Main Breaker, M Suffix	NEMA 3R without Main Breaker, W Suffix	NEMA 3R with Main Breaker, MW Suffix
240 V					
150	6 x 25	L + L ③	L + L ③	L + L ③	L + L ③
200	8 x 25	L + L ③	L + L ③	L + L ③	L + L ③
250	10 x 25	L + L ③	L + L ③	L + L ③	L + L ③
300	12 x 25	L + L ③	KK	L + L ③	KK
350	7 x 50	KK	L + KK ③	L + KK ③	KK
400	8 x 50	L + KK ③	C/F	L + KK ③	C/F
480 V					
100	2 x 50	L	L	L + L ③	L + L ③
150	3 x 50	L	L	L + L ③	L + L ③
200	4 x 50	L	L	L + L ③	L + L ③
250	5 x 50	L	L + L ③	L + L ③	L + L ③
300	6 x 50	L + L ③	L + L ③	L + L ③	L + L ③
350	7 x 50	L + L ③	L + L ③	L + L ③	L + L ③
400	8 x 50	L + L ③	L + L ③	L + L ③	L + L ③
450	9 x 50	L + L ③	L + L ③	L + L ③	L + L ③
500	10 x 50	L + L ③	L + L ③	L + L ③	L + L ③
550	11 x 50	L + L ③	KK	L + L ③	L + KK ③
600	12 x 50	L + L ③	KK	L + L ③	L + KK ③
700	7 x 100	KK	KK	L + KK ③	L + KK ③
800	8 x 100	L + KK ③	C/F	L + KK ③	C/F
900	9 x 100	KK + KK ③	C/F	KK + KK ③	C/F
1000	10 x 100	KK + KK ③	C/F	KK + KK ③	C/F
1100	11 x 100	KK + KK ③	C/F	KK + KK ③	C/F
600 V					
100	2 x 50	L	L	L + L ③	L + L ③
150	3 x 50	L	L	L + L ③	L + L ③
200	4 x 50	L	L	L + L ③	L + L ③
250	5 x 50	L	L + L ③	L + L ③	L + L ③
300	6 x 50	L + L ③	L + L ③	L + L ③	L + L ③
350	7 x 50	L + L ③	L + L ③	L + L ③	L + L ③
400	8 x 50	L + L ③	L + L ③	L + L ③	L + L ③
450	9 x 50	L + L ③	L + L ③	L + L ③	L + L ③
500	10 x 50	L + L ③	L + L ③	L + L ③	L + L ③
550	11 x 50	L + L ③	KK	L + L ③	L + KK ③
600	12 x 50	L + L ③	KK	L + L ③	L + KK ③
700	7 x 100	KK	KK	L + KK ③	L + KK ③
800	8 x 100	L + KK ③	L + KK ③	L + KK ③	L + KK ③
900	9 x 100	KK + KK ③	KK + KK ③	KK + KK ③	KK + KK ③
1000	10 x 100	KK + KK ③	C/F	KK + KK ③	C/F
1100	11 x 100	KK + KK ③	C/F	KK + KK ③	C/F

Notes

① kvar output is voltage and frequency dependent. 60 Hz units are shown. For other voltages and frequencies, consult Eaton Technical Resource Center (TRC) at 1-800-809-2772, choose option #4, then option #2.

② Enclosure sizing for units with integrated surge protection or bottom entry can vary and may not be available on all kvar sizes. Contact Eaton's Technical Resource Center at 1-800-809-2772, choose option #4, then option #2.

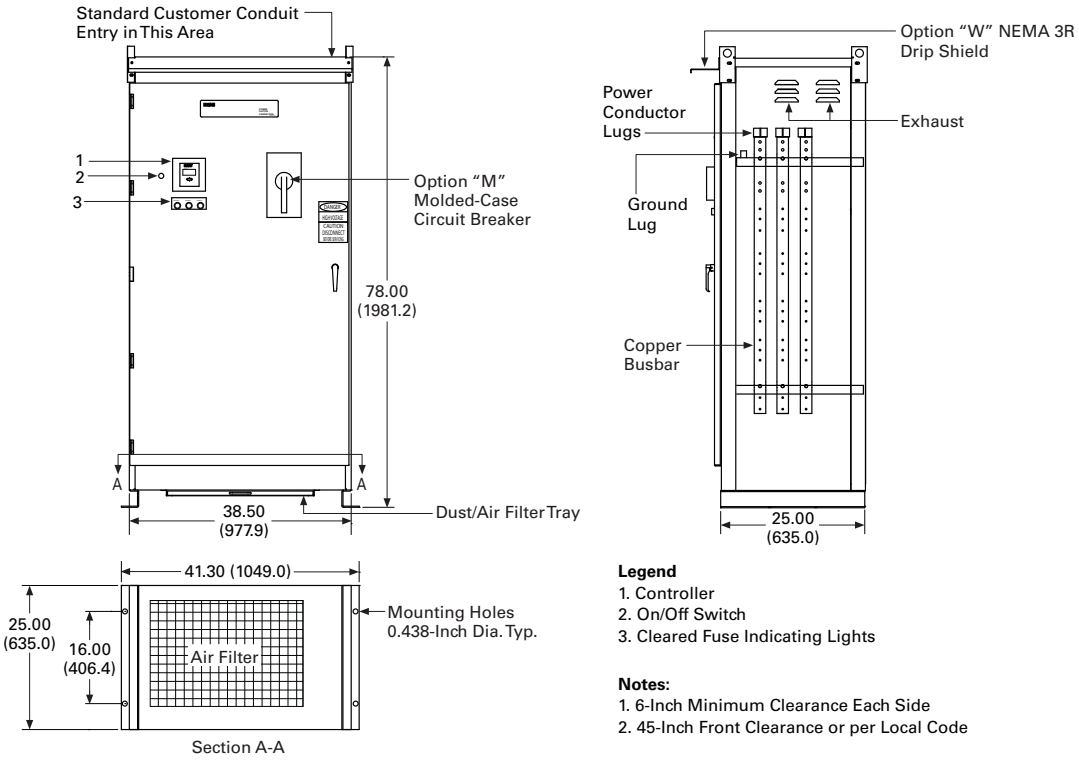
③ Dual enclosure design requires customer installation of factory supplied interconnecting wires.

C/F = Consult factory

Dimensions

Approximate Dimensions in Inches (mm)

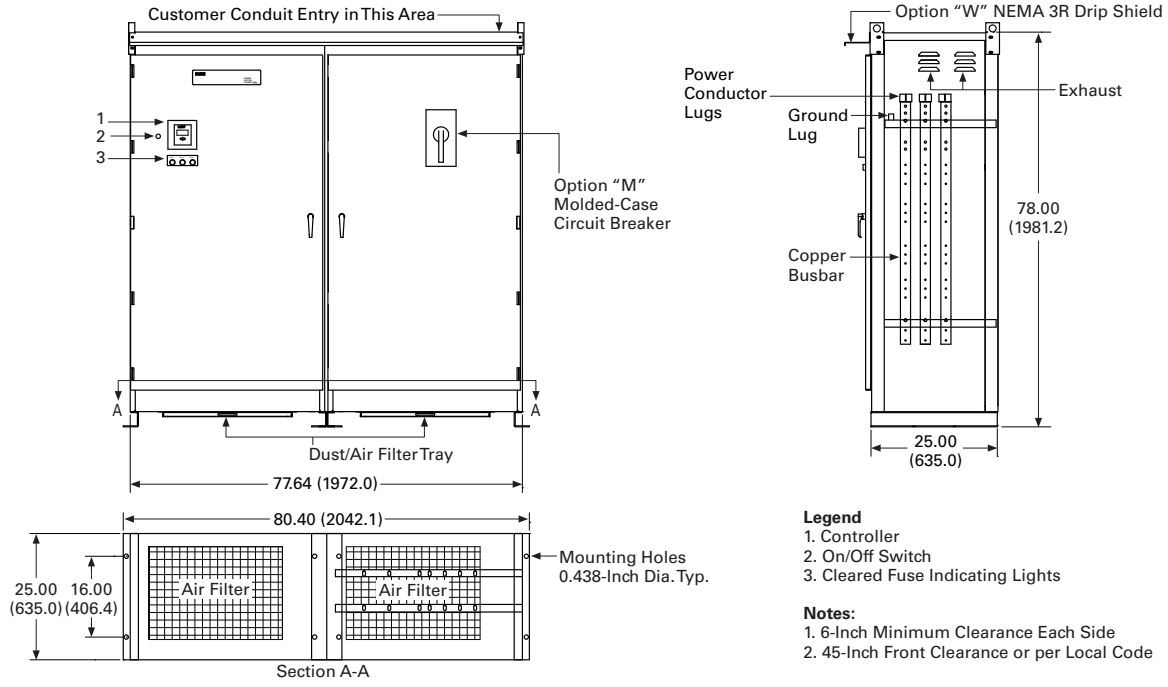
Enclosure L Front View



Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code

Enclosure KK Front and Side Views



Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code

AUTOVAR Filter

Contents

AUTOVAR Filter—LV Automatic Detuned Filter

Product Description

- Programmable to automatically add/subtract capacitor stages to maintain preset target power factor
- Three-phase capacitor cell construction
- Five-year warranty of cells against manufacturing defects
- Cool operating, 100% copper wound, thermal-protected reactors are sized up to 150% of rated capacitor current (AUTOVAR detuned filter only)

Application Description

- Service entrance or substation power factor correction installations requiring precise maintenance of target power factor (AUTOVAR 600)
- Service entrance or substation power factor correction installations requiring precise maintenance of target power factor in three-phase, nonlinear, high harmonic environments (AUTOVAR detuned filter)
- Typically connected at main low voltage switchgear

Features

Configuration

- **Cabinet**: 12 gauge steel with ANSI 61 gray, baked finish. Removable lift bolts standard, NEMA 1 (gasketed)
- **Power line interconnect**: Rugged, copper busbar connection with access provided for top entry. Contact factory for availability of bottom entry. Busbars are braced for 65 kA (optional 100 kA rating available). All internal power wiring connections from bus are laid out on a most direct basis with minimum bends for ease of troubleshooting. Clear barrier limiting access to live parts included standard
- **Modular tray design**: Capacitor stages arranged in modular trays with capacitors, fuses, cleared-fuse indicating lights, and contactors grouped in a logical, easily understood layout. This permits easy access, quick identification of operating problems, and ease of expandability
- **Fusing**: UL recognized, 200,000 A interrupting capacity provided on all three phases of each stage. Blade-type fuses mounted on insulator stand-offs
- **Cleared-fuse indicating lights**: LEDs located door-mounted and neon at individual fuses to facilitate tracing of cleared fuses
- **Push-to-test**: Allows testing of door-mounted LED cleared fuse indicating lights
- **AutoLocate**: When door is open and bus is energized, fuse circuit automatically checks for cleared fuses. If a fuse has cleared, the light at the fuse turns on for easy troubleshooting
- **Door interlock**: Door interlock automatically turns off control circuit when engaged. Power continues to be provided to the unit until disconnect is open
- **Exhaust fans**: Two side louver fans per cabinet provide cooling and reduce operator exposure to discharge. Replaceable dust filtering provided. Dust filters can be replaced without opening cabinet
- **Ease of expansion**: Capacitor stage nests are self-contained and can be added in the field. Two bolts mount the nest in the field. Control wire plugs connect to factory standard wire harness on the left side of the cabinet
- **Ease of replacement**: Cells can be easily replaced individually by removing the mounting bolt and lifting out of the nest without removal of any other components
- **Thermal sensing**: Built-in thermal sensing, alarming, and protection feature allows the unit to operate in optimal temperature while alerting the user of ambient temperature exceeding the nominal operating range. Stages will be automatically switched off if temperature exceeds the maximum specified temperature
- **Temperature range**: The operating temperature range is –20 °C to +46 °C, and the storage temperature range is –40 °C to +55 °C. For optimal equipment life, the temperature should not exceed 35 °C annual average, and the environment should not exceed Pollution Degree 2 as defined in UL 61010-1

Controller

- Visual indication of incorrect CT polarity
- Digital display of power factor and number of energized stages
- Automatic setting of c/k value (sensitivity based on CT ratio and kvar available)
- Visual indication of insufficient kvar to reach target power factor
- Automatic sensing of kvar values per step
- Optional communications capable controller (RS-485/ Modbus)
- Standard metering capability:
  - Voltage
  - Current (sensed phase only)
  - Frequency
  - Active power (kW)
  - Reactive power (kvar)
  - Apparent power (kVA)
  - Total voltage harmonic distortion (VTHD)
  - Individual harmonic voltage distortion (odd orders up to the 19th harmonic)
- Built-in manual mode allows for testing and manual operation of stages
- Multiple user-friendly alarm displays. Controller provides easy-to-understand alarms for various conditions, such as:
  - Undervoltage or overvoltage
  - Undercurrent or overcurrent
  - Target power factor not met
  - Harmonic overload
  - Faulty step/stages
  - Overtemperature alarm

Contactor

- Fully rated for capacitor switching
- Integral pre-charge/pre-insertion module standard. The contactor reduces damaging switching transients, providing safety and durability for the system
  - Lessens the chance of disrupting sensitive electronic equipment
  - Reduced inrush current extends the life of the capacitor cells

Reactors

- **Detuning**: Standard reactor designs are detuned to the 4.2nd harmonic and recommended to protect capacitors against harmonic resonance. Detuning to the 4.7th harmonic is available as an option. The harmonic spectrum should be evaluated for applications involving reactors detuned to the 4.7th harmonic to ensure optimal equipment life, specifically when used in conjunction with six-pulse motor drives
- **Windings**: 80 °C temperature rise design 100% copper windings for minimal losses
- **Thermal overload protection**: Each reactor includes three normally closed, auto reset thermostats that open at 180 °C. When thermostats engage, the contactor opens
- **Insulation**: 220 °C insulation system
- **Warranty**: One-year replacement of reactors

Additional Features

- Optional molded-case main circuit breaker
- Ground fault interruption provides protection in case of accidental contact with control power and ground
- Control wiring—standard NEC color-coded modular bundles with quick disconnect feature for ease of troubleshooting or ease of expendability. UL type MTW/AWM, CSA TEW 105 °C copper wire is standard.
- Optional digital metering—IQ 250
- Mechanical wire lugs are included as standard equipment. Typical phase lugs range from (2) 6 AWG–350 kcmil to (4) 3 AWG–750 MCM. Typical ground lug can accept wire from 6 AWG to 350 kcmil. Lugs are compatible with copper wire 90 °C
- Heavy-duty capacitor cells are standard on AUTOVAR detuned filter and optional on AUTOVAR 600. For 480 V units, standard-duty cells are 525 V rated, and heavy-duty cells are 600 V rated

Support and service

- Renewal parts are available through local Eaton distributors
- Factory trained service personnel are available through Eaton's Electrical Services & Systems

AUTOVAR Filter—Reactor Cabinet

Standards and Certifications

- Entire cabinet assembly is UL 508A and CSA C22.2 No. 190 Listed
- Capacitors are UL 810 recognized
- Contactor is UL/CSA recognized and IEC 6b rated

Listed

Product Selection

Options—AUTOVAR 600 and AUTOVAR Detuned Filter

Description	Option Code
Remote alarm relay terminal block—relay terminal block for a remote alarm to indicate controller alarm status	**A**
Fully insulated main bus	**B**
Communicating PF controller (Modbus RS-485)	**C**
Hand-off-auto switch provides manual control to connect or disconnect capacitor stages regardless of controller output ①	**H**
Integrated main breaker	**M**
Integrated main breaker with high interrupting rating (see breaker table for more information), includes 100 kA busbar bracing	**M1**
100 kA busbar bracing	**N1**
Integrated CVX series surge protection, without sine wave tracking	**T1**
Integrated SPD series surge protection, 160 kA per phase, with sine wave tracking	**T2**
IQ 250 electronic meter ②	**Q**
Weather resistant enclosure (NEMA 3R gasketed) ③	**W**
Standard filter detuned to the 4.2nd harmonic ④	**Y**

Notes

① Manual control is always available through menu controller on system, even if the H option is not selected.

② Not available on NEMA 3R units (W option).

③ Only available on AUTOVAR 600 with heavy-duty cells and AUTOVAR detuned filters using 'L + L', 'L + KK', and 'KK + KK' enclosures.

④ Tuning to the 4.2nd harmonic is the preferred option. Other tunings available. Contact Eaton's Technical Resource Center (TRC) power factor application engineers at 1-800-809-2772, choose option #4, then option #2.

To calculate AUTOVAR 600 or AUTOVAR detuned filter weight:

Obtain base unit weight from table on **Page V3-T2-77** (as appropriate).

Add option weights as necessary:
A = 1 lb (0.5 kg)
B = 10 lb (4.5 kg)
C = 1 lb (0.5 kg)
H = 10 lb (4.5 kg)
M = Circuit breaker weight (see circuit breaker table)
M1 = 10 lb (4.5 kg) hardware weight adder plus circuit breaker weight (see circuit breaker table)
N1 = 10 lb (4.5 kg)
T1 = 5 lb (2.3 kg)
T2 = 10 lb (4.5 kg)
Q = 5 lb (2.3 kg)
W = 10 lb (4.5 kg) per door
Y = 0 lb (0 kg)

Floor-Mounted Switched Detuned Filters—Low Voltage

kvar ①	Step x kvar	Rated Current Amperes	Base Shipping Weight in Lb (kg)	Base Catalog Number
240 Vac				
150	6 x 25	361	1830 (830.8)	**150THFSR232Y**
200	8 x 25	481	2222 (1008.8	**200THFSR232Y**
250	10 x 25	601	2525 (1146.4)	**250THFSR232Y**
300	12 x 25	720	2830 (1284.8)	**300THFSR232Y**
350	7 x 50	844	3090 (1401.6)	**350THFSR231Y**
400	8 x 50	965	3560 (1614.8)	**400THFSR232Y**
480 Vac				
100	2 x 50	120	1105 (501.2)	**100THFSR431Y**
150	3 x 50	180	1242 (564.6)	**150THFSR431Y**
200	4 x 50	240	1438 (652.9)	**200THFSR431Y**
250	5 x 50	300	1634 (741.8)	**250THFSR431Y**
300	6 x 50	360	1830 (830.8)	**300THFSR432Y**
350	7 x 50	420	2026 (919.8)	**350THFSR432Y**
400	8 x 50	480	2222 (1008.8)	**400THFSR432Y**
450	9 x 50	540	2371 (1076.4)	**450THFSR432Y**
500	10 x 50	600	2525 (1146.4)	**500THFSR432Y**
550	11 x 50	660	2750 (1248.5)	**550THFSR432Y**
600	12 x 50	720	2830 (1284.8)	**600THFSR432Y**
700	7 x 100	792	3090 (1401.6)	**700THFSR431Y**
800	8 x 100	962	3560 (1614.8)	**800THFSR432Y**
900	9 x 100	1083	3900 (1769.0)	**900THFSR432Y**
1000	10 x 100	1203	4240 (1923.2)	**1000THFSR432Y**
1100	11 x 100	1323	4500 (2041.2)	**1100THFSR432Y**
600 Vac				
100	2 x 50	96	1105 (501.2)	**100THFSR631Y**
150	3 x 50	144	1242 (564.6)	**150THFSR631Y**
200	4 x 50	192	1438 (652.9)	**200THFSR631Y**
250	5 x 50	240	1634 (741.8)	**250THFSR631Y**
300	6 x 50	288	1830 (830.8)	**300THFSR632Y**
350	7 x 50	336	2026 (919.8)	**350THFSR632Y**
400	8 x 50	384	2222 (1008.8)	**400THFSR632Y**
450	9 x 50	432	2371 (1076.4)	**450THFSR632Y**
500	10 x 50	480	2525 (1146.4)	**500THFSR632Y**
550	11 x 50	529	2750 (1248.5)	**550THFSR632Y**
600	12 x 50	576	2830 (1284.8)	**600THFSR632Y**
700	7 x 100	672	3090 (1401.6)	**700THFSR631Y**
800	8 x 100	768	3560 (1614.8)	**800THFSR632Y**
900	9 x 100	864	3900 (1769.0)	**900THFSR632Y**
1000	10 x 100	962	4240 (1923.2)	**1000THFSR632Y**
1100	11 x 100	1058	4500 (2041.2)	**1100THFSR632Y**

AUTOVAR Detuned Filter Sizing Chart

		Enclosure Size ②			
kvar	Step x kvar	NEMA 1 without Main Breaker, No Suffix	NEMA 1 with Main Breaker, M Suffix	NEMA 3R without Main Breaker, W Suffix	NEMA 3R with Main Breaker, MW Suffix
240 V					
150	6 x 25	L + L ③	L + L ③	L + L ③	L + L ③
200	8 x 25	L + L ③	L + L ③	L + L ③	L + L ③
250	10 x 25	L + L ③	L + L ③	L + L ③	L + L ③
300	12 x 25	L + L ③	KK	L + L ③	KK
350	7 x 50	KK	L + KK ③	L + KK ③	KK
400	8 x 50	L + KK ③	C/F	L + KK ③	C/F
480 V					
100	2 x 50	L	L	L + L ③	L + L ③
150	3 x 50	L	L	L + L ③	L + L ③
200	4 x 50	L	L	L + L ③	L + L ③
250	5 x 50	L	L + L ③	L + L ③	L + L ③
300	6 x 50	L + L ③	L + L ③	L + L ③	L + L ③
350	7 x 50	L + L ③	L + L ③	L + L ③	L + L ③
400	8 x 50	L + L ③	L + L ③	L + L ③	L + L ③
450	9 x 50	L + L ③	L + L ③	L + L ③	L + L ③
500	10 x 50	L + L ③	L + L ③	L + L ③	L + L ③
550	11 x 50	L + L ③	KK	L + L ③	L + KK ③
600	12 x 50	L + L ③	KK	L + L ③	L + KK ③
700	7 x 100	KK	KK	L + KK ③	L + KK ③
800	8 x 100	L + KK ③	C/F	L + KK ③	C/F
900	9 x 100	KK + KK ③	C/F	KK + KK ③	C/F
1000	10 x 100	KK + KK ③	C/F	KK + KK ③	C/F
1100	11 x 100	KK + KK ③	C/F	KK + KK ③	C/F
600 V					
100	2 x 50	L	L	L + L ③	L + L ③
150	3 x 50	L	L	L + L ③	L + L ③
200	4 x 50	L	L	L + L ③	L + L ③
250	5 x 50	L	L + L ③	L + L ③	L + L ③
300	6 x 50	L + L ③	L + L ③	L + L ③	L + L ③
350	7 x 50	L + L ③	L + L ③	L + L ③	L + L ③
400	8 x 50	L + L ③	L + L ③	L + L ③	L + L ③
450	9 x 50	L + L ③	L + L ③	L + L ③	L + L ③
500	10 x 50	L + L ③	L + L ③	L + L ③	L + L ③
550	11 x 50	L + L ③	KK	L + L ③	L + KK ③
600	12 x 50	L + L ③	KK	L + L ③	L + KK ③
700	7 x 100	KK	KK	L + KK ③	L + KK ③
800	8 x 100	L + KK ③	L + KK ③	L + KK ③	L + KK ③
900	9 x 100	KK + KK ③	KK + KK ③	KK + KK ③	KK + KK ③
1000	10 x 100	KK + KK ③	C/F	KK + KK ③	C/F
1100	11 x 100	KK + KK ③	C/F	KK + KK ③	C/F

Notes

① kvar output is voltage and frequency dependent. 60 Hz units are shown. For other voltages and frequencies, consult Eaton Technical Resource Center (TRC) at 1-800-809-2772, choose option #4, then option #2.

② Enclosure sizing for units with integrated surge protection or bottom entry can vary and may not be available on all kvar sizes. Contact Eaton's Technical Resource Center at 1-800-809-2772, choose option #4, then option #2.

③ Dual enclosure design requires customer installation of factory supplied interconnecting wires.

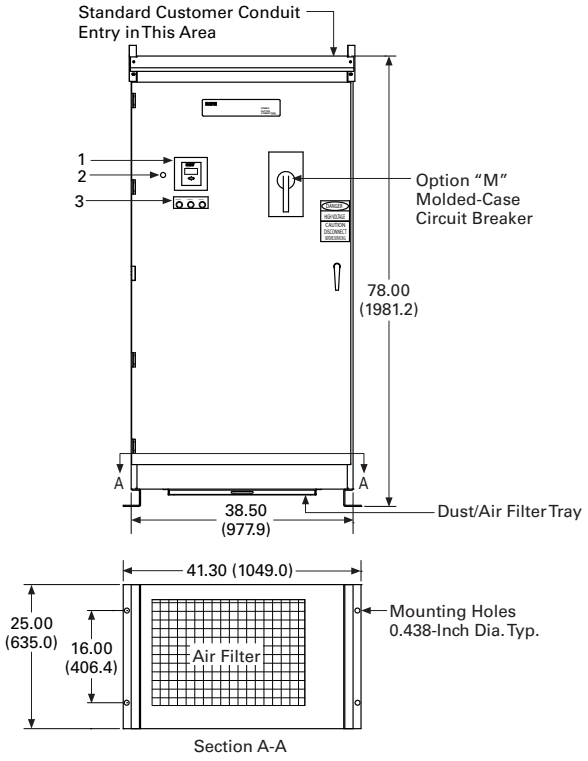
C/F = Consult factory

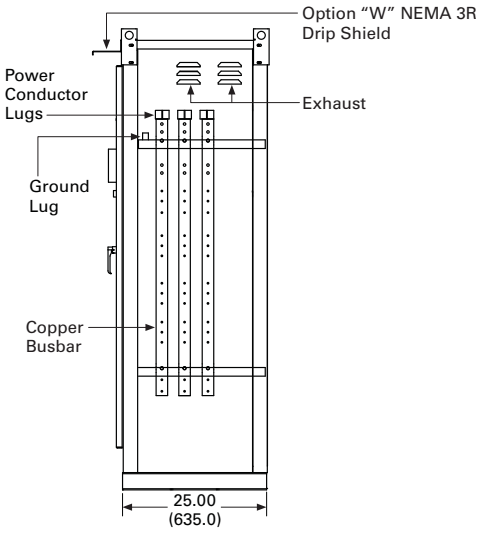
Dimensions

Approximate Dimensions in Inches (mm)

2

AUTOVAR "L" (Single Door) Enclosure

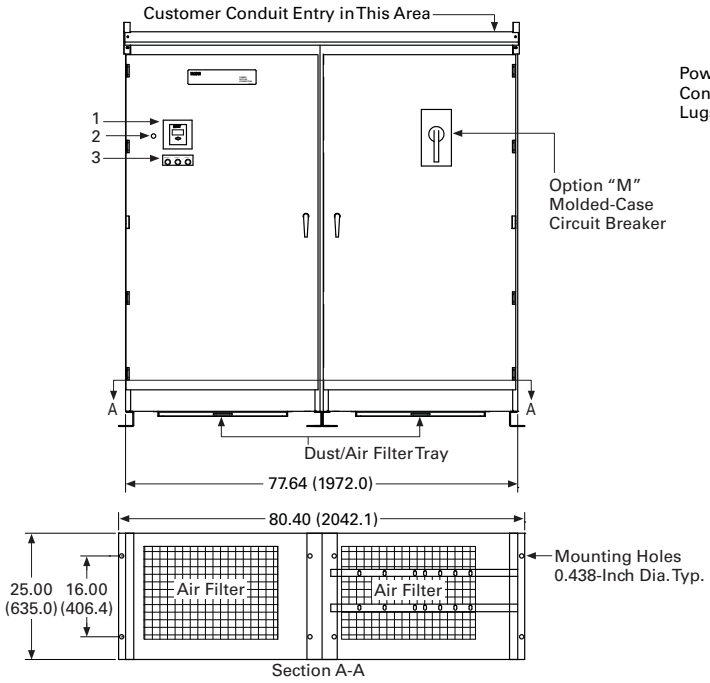


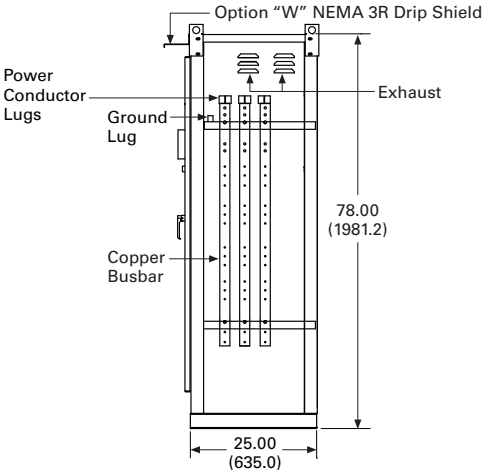


Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code

AUTOVAR "KK" (Double Door) Enclosure



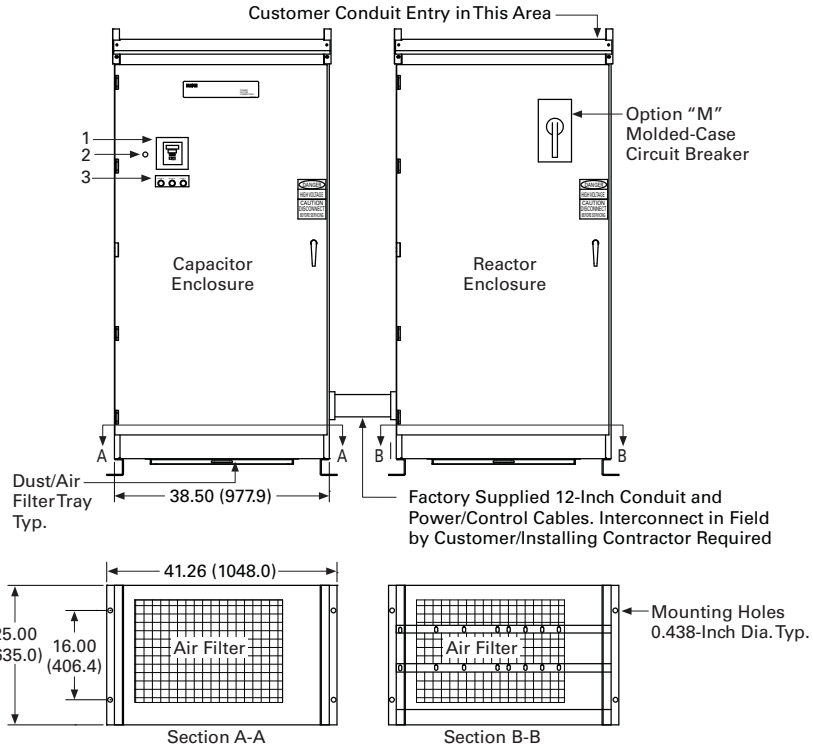


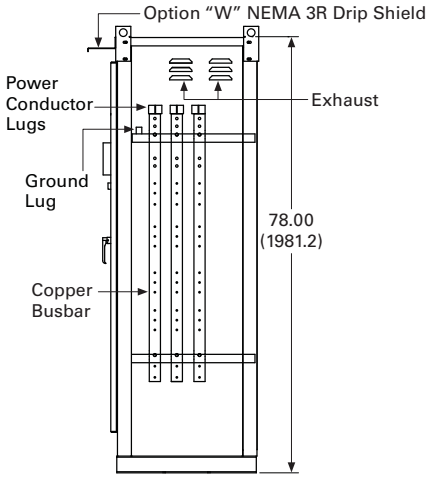
Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code

Approximate Dimensions in Inches (mm)

AUTOVAR "L + L" (2 Single Door) Enclosures

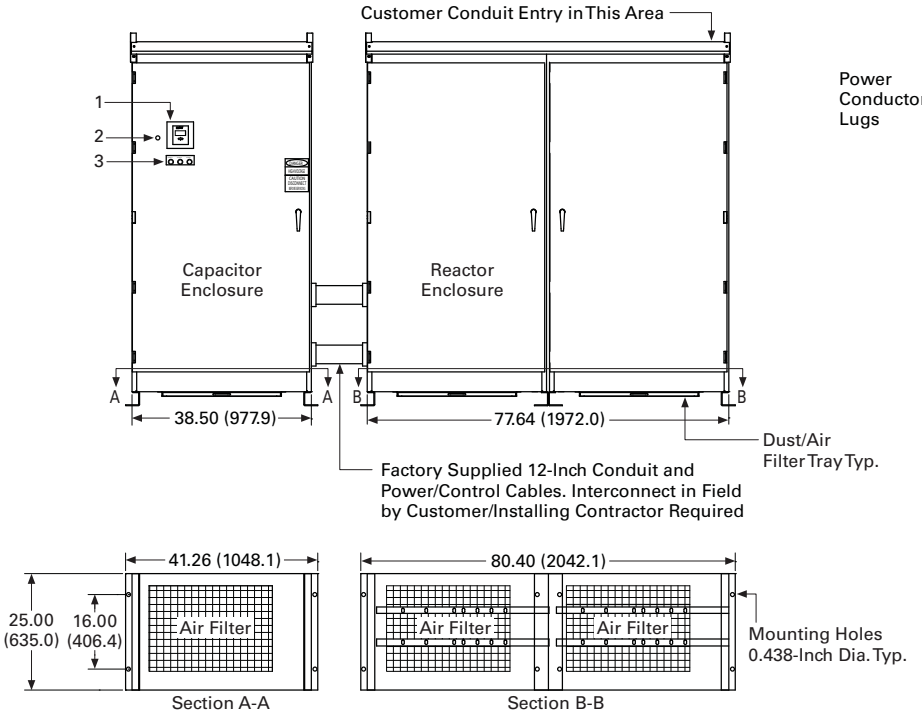


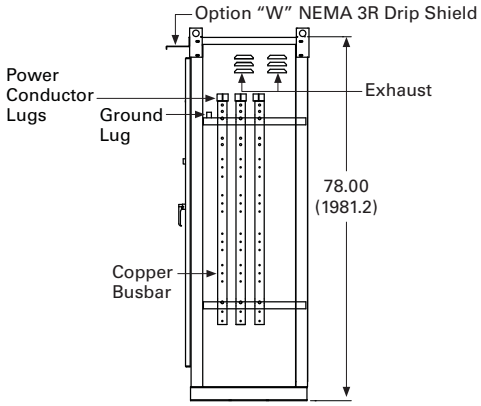


Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code
3. 12-Inch Minimum Separation Between Enclosures

L + KK Enclosure (AUTOVAR Detuned Filter Only)



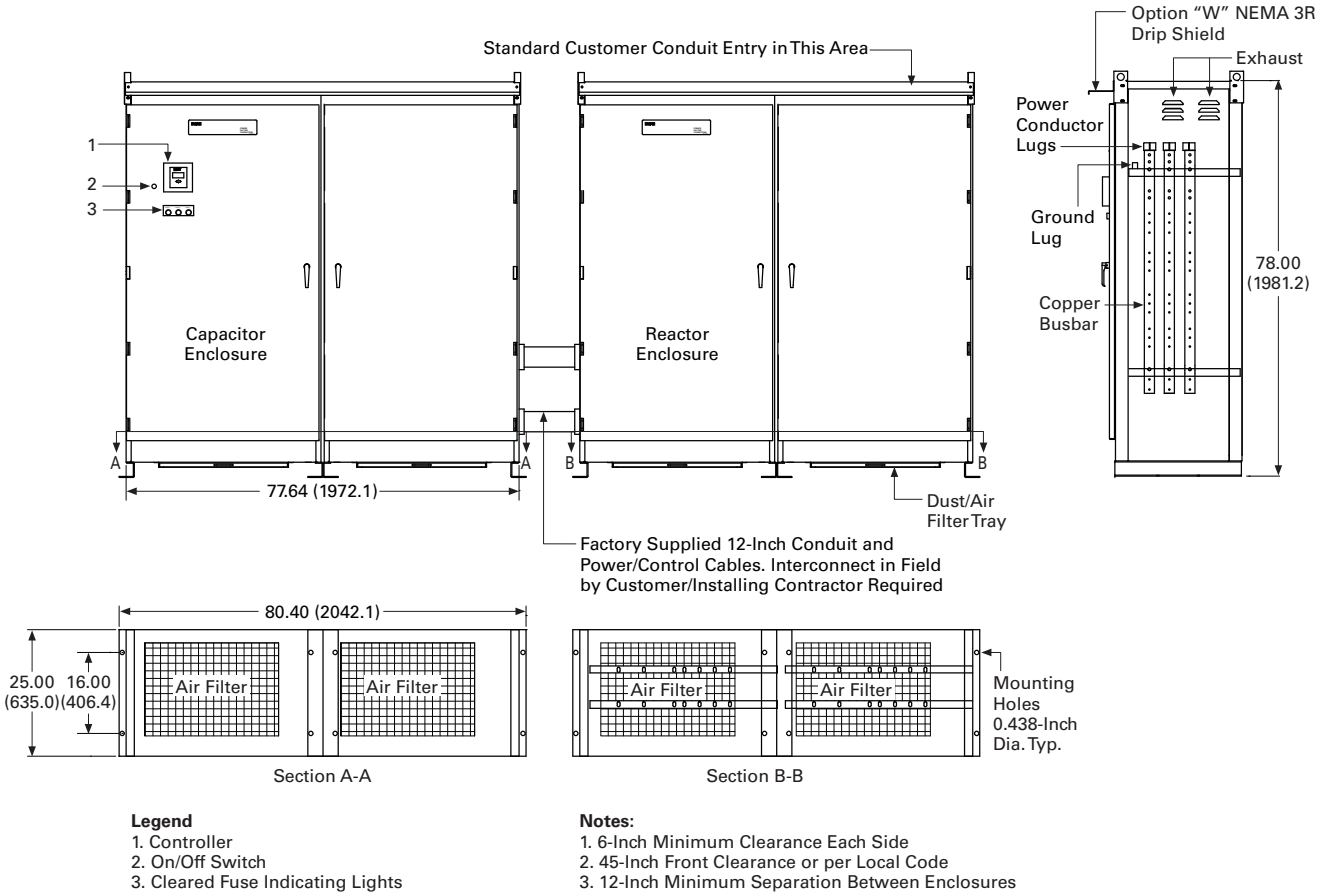


Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code
3. 12-Inch Minimum Separation Between Enclosures

Approximate Dimensions in Inches (mm)

2 AUTOVAR "KK + KK" Enclosures



Legend
1. Controller
2. On/Off Switch
3. Cleared Fuse Indicating Lights

Notes:
1. 6-Inch Minimum Clearance Each Side
2. 45-Inch Front Clearance or per Local Code
3. 12-Inch Minimum Separation Between Enclosures

Transient-Free Power Factor Correction System

Contents

Transient-Free Static Switching Power Factor Correction Units

Product Description

Transient-free statically switch capacitor units are available in two models.

The FTE model is a real-time transient-free system, used to compensate extremely rapid loads within one cycle of operation (typically 5–20 msec).

The FTA model is a fast transient-free system, used to compensate any loads within 3–4 seconds.

The FTA and FTE units employ a fast or real-time response, and include the ability to switch larger steps without creating significant line noise. These relatively maintenance-free units reside in a smaller footprint and are ideal for use in applications such as flicker control, large motor starting, bus voltage stabilization, fault ride-through solutions, power factor correction and many more.

Application Description

- Motor starting
- On-site generation support
- Spot welding
- Wind turbines
- Other dynamic loads

Three current transformers with a 5 ampere secondary are required to operate this capacitor bank.

Rating based on Service Entrance Ampacity. For other ratios, please consult factory.

- Startup and Commissioning by factory trained personnel is required for proper operation and warranty of this system

Standards and Certifications

Enclosure

- EMC—EN50081-2, EN50082-2, EN55011, EN61000-4-2/3/4/5, ENV50204, ENV50141
- CE Mark—73/23/EEC am. 93/68, 98/37/EC art. 4(2)
- Safety—EN61010-1, EN60439-1, EN60204
- UL 508
- CSA

Product Selection

Transient-free reactive power compensation systems

The transient-free systems are custom engineered to order.

The Eaton transient-free statically switched capacitor systems represent the "next level" of power system enhancements by using semi-conductor devices to switch capacitors at the same potential or zero potential difference, thereby eliminating the possible problem of transients caused by capacitor switching and increasing the speed of capacitive var compensation.

This level of performance is needed when high-current loads rapidly switch on and off and require power factor, voltage flicker, sag, or harmonic improvement. These disturbances can be found in many industries, including rockcrushing, arc-welding, plastic injection molding, and crane applications.

Please call Eaton's Technical Resource Center at 1-800-809-2772, option #4, suboption #2 to discuss your application. See TD02607012E for additional technical information on Eaton's transient-free reactive power compensation systems. Pricing and availability is available through Eaton's Technical Resource Center. Please fill out the following questionnaire before requesting a quotation.

Transient-Free Reactive Power Compensation Systems Questionnaire

Type of industry	_____	(Automotive, alternative energy, lumber, etc.)
Type of application	_____	(Welding, wind turbine, sawmill, etc.)
Project objectives	_____	(PF correction, voltage control, reactive power control, damping of power oscillations, unbalance control, motor starting)
Amount of kvar required (if known)	_____	kvar (300 to 3000 kvar)
Nominal system voltage	_____	V
Nominal system frequency	_____	Hz
Integral main breaker needed	_____	(Yes/No)
Harmonic tuning order required (if known)	_____	(2.67, 3.8, 4.5, or other)
Compensation time required (if known)	_____	(3–4 seconds or 5–20 milliseconds)

HCU2 Active Harmonic Filters

Contents

HCU2 Harmonic Correction Unit

Product Description

Eaton's HCU2 active harmonic filters are engineered to provide dynamic harmonic correction by actively injecting the required currents into an electrical distribution system to cancel the entire spectrum of harmonic currents at the point of connection.

HMI Home Screen Shot

Application Description

Typical applications include locations with large amounts of nonlinear loads including 6- and 12-pulse PWM alternating current (AC) variable frequency drives, direct current (DC) drives, as well as other switch-mode power supply equipment. This equipment can be found in water and wastewater treatment facilities, industrial manufacturing and warehousing plants, military bases and commercial locations.

Unlike passive filters, Eaton's HCU2 can provide effective harmonic correction for varying load conditions and harmonic spectrums by providing dynamic correction up to their rated capacity. The HCU2 also has the secondary benefit of providing power factor correction with any excess capacity after correcting all harmonic conditions.

Features, Benefits and Functions

- Fast-acting harmonic correction
- NEMA 1, NEMA 2, NEMA 12, IP31, IP54 enclosures, and chassis mount versions available
- 60, 120, 200 and 300 A units available (ampere rating given at 380–480 V)
- Touchscreen human machine interface (HMI)
- Communications connectivity
- Designed for use in environmentally controlled conditions
- Can be sized to meet specific levels of harmonic correction, providing compliance with IEEE® 519 recommended levels
- Engineered to prevent overloading
- Scalable design can be expanded without impacting performance
- Broad spectrum of cancellation for robust protection (2nd to 51st harmonic)
- Helps improve power factor to maximize efficiency
- Easier and less expensive installation than passive filters, as active filter design reduces the need for detailed engineering studies
- HMI provides comprehensive control through icon-driven interface

Improvements from HCUE to HCU2

- Closed loop control: A higher degree of harmonic correction is available with closed loop control than open loop control
- Reduced kW losses: Lower kW losses result in lower operating expenses and reduced requirements for equipment room HVAC systems. The maximum heat loss for a 300 A, 480 V unit is 7.1 kW
- Reduced footprint: Wall-mounted 480 V NEMA® 1 units are available in 60, 120, 200 and 300 A ratings
- Ease of maintenance and service: A standard USB service port is provided for firmware updates

Standards and Certifications

- UL/CSA approved

Catalog Number Selection

2

HCU2 Harmonic Correction Unit

HCU2 060 D5 N2

Equipment Type
HCU2 = Harmonic correction unit

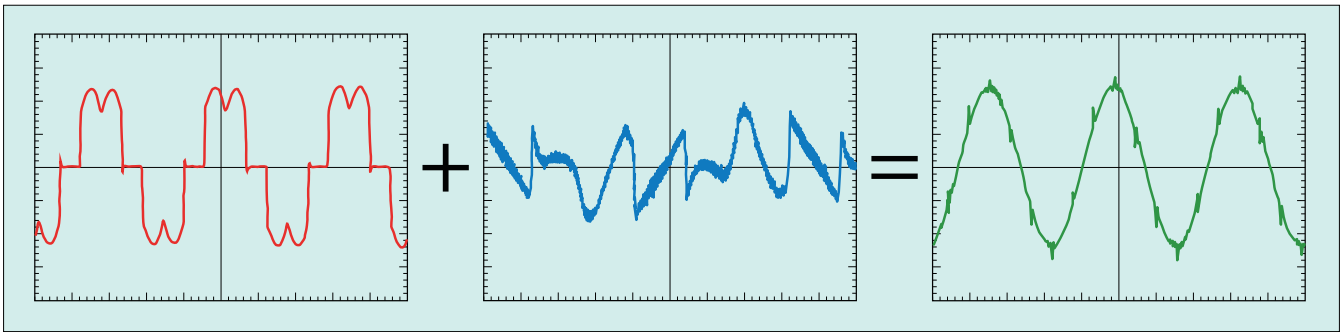
Ampere Rating
380–480 V only
060 = 60 A **120** = 120 A **200** = 200 A **300** = 300 A
600 V only
047 = 47 A **094** = 94 A **157** = 157 A **235** = 235 A
690 V only
040 = 40 A **080** = 80 A **133** = 133 A **200** = 200 A

Voltage	
D5 = 380–480 V	**D7** = 3690 V
D6 = 600 V	

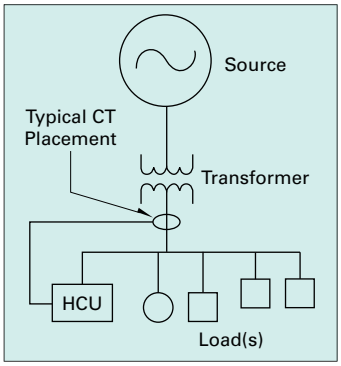
Enclosure Type	
IP00	= Chassis mount
N1	= NEMA 1 wall mount
N2	= NEMA 2 floor mount
N12	= NEMA 12 floor mount
IP31	= IP31 floor mount
IP54	= IP54 floor mount

Technical Data and Specifications

Typical Uncorrected 6-Pulse Rectifier (Before) Current + HCU2 Injection Current = Corrected (After) Current



Recommended Placement



Eaton HCU2 Specifications

Specification	Description
Technical Specifications	
Standard rms output current ratings	60 A, 120 A, 200 A, 300 A at 380 Vac to 480 Vac 47 A, 94 A, 157 A, 235 A at 600 Vac 40 A, 80 A, 133 A, 200 A at 690 Vac
Nominal frequency	50/60 Hz, ±3 Hz auto sensing
Number of phases	3-phase
Topology	Digital harmonic FFT Digital reactive power
Losses	To 480 Vac <3%; to 690 Vac <5%
CT VA loading	1.0 VA (5 A CT secondary)
Spectrum cancellation	2nd to 51st, discrete; fully selectable per harmonic order (amplitude and on/off)
Control basis	Closed loop (for new installations) Open loop compatible for retrofit applications
Harmonic attenuation	Closed loop: <3% THD(i); max. 20:1 THD(i) reduction with load harmonic current above 50% of HCU2 rating Open loop: <5% TDD Requires 3% or higher inductive impedance per nonlinear load
Harmonic operational features	% THDi set point % THDv set point
Harmonic avoidance	Output at specific harmonic order turned off if resonance or lack-of impedance detected; or manually turned off
Parallel operation	Up to 10 units per set of CT (to 51st order), any size combination Backward compatibility with Eaton HCUE operated in parallel Contact Eaton for applications of more than 10 units
Parallel operation options	Master/master Master/slave Multi-master/multi-slave Same as Eaton HCUE for retrofits
Parallel sequence options	Lead/lag with unit rotation: one unit operates to full capacity before next unit turns on; timed rotation Load share: All operating units function at the same ouput percentage
Parallel HMI control	Any unit permits viewing and changing parameter settings of complete system or any other unit in parallel system
Parallel communications	Proprietary COM bus between operating units
Power factor correction	Optimized unity PF, leading (capacitive) or lagging (inductive) power factor (Cos f) to target
Control response time	25 µs
Harmonic correction time	2 cycles
Reactive correction time	1/4 cycle
Display	144 mm QVGA TFT 64k-color touchscreen
Display parameters	Hundreds of parameters are available. Examples include THDi, THDv, oscilloscope for viewing many selected parameters, phasor diagrams, load power, measured currents for Ih, Is, If, I neg seq, PF (Cos f), injected currents for Ih, I reactive, I neg seq, etc.

Specification	Description
Technical Specifications (Continued)	
Communications capability	Modbus® RTU, Modbus TCP/IP
Discrete input/outputs	4 input and 4 output dry contacts; assignable
Noise level (ISO3746)	<70 dB at 1 meter from unit surface
Earthing (grounding) systems	EMC filter ground switch for Isolated Terra, high resistance
Environmental Condition	
Operating temperature	0 °C to 40 °C
Relative humidity	0–95%, noncondensing
Seismic rating	Complies with IBC and ASCE7
Operating altitude	1000 m, (derate 1%/100 m above), maximum 4800 m
Automatic rollback of output	Occurs whenever heatsink temperature sensor exceeds temperature limit
Ambient temperature protection	Absolute shutdown if air inlet temperature reaches 51 °C
Preset output limits (rms)	Programmable set limit due to altitude or ambient temperature—becomes fixed output limit
Reference Standards	
Design	CE EMC Certification IEC/EN 60439-1, EN 61000-6-4 Class A, EN 61000-6-2
Protection (enclosure)	IP00, IP20, IP31, IP54, NEMA 1, NEMA 2, NEMA 12, UL Type Open (chassis mount)
Standards compliance/ certification	cULus (UL 508 , CSA 22.2 No. 14) CE Certified, ABS, Lloyds, other local standards
Installation	
Wall mount	Chassis mount (UL Type open) and NEMA 1 configurations
Free-standing	IP31, IP54, NEMA 2 and NEMA 12
Circuit protection	NEMA 1 and chassis mount—external means required Free-standing enclosures—incoming circuit breaker with mechanical door interlock
AIC rating (input circuit breaker)	To 415 Vac—200 kA cULus; 125 kA IEC To 480 Vac—200 kA cULus; 75 kA IEC To 600 Vac—100 kA cULus; 100 kA IEC To 690 Vac—No cULus; 100 kA IEC
Cable entry	Wall mount and chassis mount—bottom only Free-standing—top and bottom entry through gland plates
PCBA protection	Conformal coating on all PCBs Pollution Degree 2
Cooling configuration	Separate air plenums for heatsink section and PCBA section: Heatsink (high heat plenum) input from bottom and exhaust out top. All components in high heat plenum rated IP54 or better ≥ no filtering required PCBA air supply must be clean and dry (filtering may be required) No conductive particles permitted

Harmonic Correction Unit Ratings

Model	Voltage (V)	Frequency (Hz)	Total Current Amperes (rms)	Watt Losses (kW)	HCU2 Enclosure Type	Version	Integral Disconnect
HCU2060D5N1	380–480	50/60	60	1.3	Wall mount NEMA 1	UL/CSA	No
HCU2120D5N1	380–480	50/60	120	2.8	Wall mount NEMA 1	UL/CSA	No
HCU2200D5N1	380–480	50/60	200	5.4	Wall mount NEMA 1	UL/CSA	No
HCU2300D5N1	380–480	50/60	300	7.1	Wall mount NEMA 1	UL/CSA	No
HCU2060D5IP00	380–480	50/60	60	1.3	Chassis mount	UL/CSA	No
HCU2120D5IP00	380–480	50/60	120	2.8	Chassis mount	UL/CSA	No
HCU2200D5IP00	380–480	50/60	200	5.4	Chassis mount	UL/CSA	No
HCU2300D5IP00	380–480	50/60	300	7.1	Chassis mount	UL/CSA	No
HCU2060D5IP31	380–480	50/60	60	1.3	Floor mount IP31	CE	Yes
HCU2120D5IP31	380–480	50/60	120	2.8	Floor mount IP31	CE	Yes
HCU2200D5IP31	380–480	50/60	200	5.4	Floor mount IP31	CE	Yes
HCU2300D5IP31	380–480	50/60	300	7.1	Floor mount IP31	CE	Yes
HCU2060D5N2	380–480	50/60	60	1.3	Floor mount NEMA 2	UL/CSA	Yes
HCU2120D5N2	380–480	50/60	120	2.8	Floor mount NEMA 2	UL/CSA	Yes
HCU2200D5N2	380–480	50/60	200	5.4	Floor mount NEMA 2	UL/CSA	Yes
HCU2300D5N2	380–480	50/60	300	7.1	Floor mount NEMA 2	UL/CSA	Yes
HCU2060D5N12	380–480	50/60	60	1.3	Floor mount NEMA 12	UL/CSA	Yes
HCU2120D5N12	380–480	50/60	120	2.8	Floor mount NEMA 12	UL/CSA	Yes
HCU2200D5N12	380–480	50/60	200	5.4	Floor mount NEMA 12	UL/CSA	Yes
HCU2300D5N12	380–480	50/60	300	7.1	Floor mount NEMA 12	UL/CSA	Yes
HCU2060D5IP54	380–480	50/60	60	1.3	Floor mount IP54	CE	Yes
HCU2120D5IP54	380–480	50/60	120	2.8	Floor mount IP54	CE	Yes
HCU2200D5IP54	380–480	50/60	200	5.4	Floor mount IP54	CE	Yes
HCU2300D5IP54	380–480	50/60	300	7.1	Floor mount IP54	CE	Yes
HCU2047D6IP31	600	50/60	47	1.8	Floor mount IP31	CE	Yes
HCU2094D6IP31	600	50/60	94	3.9	Floor mount IP31	CE	Yes
HCU2157D6IP31	600	50/60	157	7.2	Floor mount IP31	CE	Yes
HCU2235D6IP31	600	50/60	235	9.9	Floor mount IP31	CE	Yes
HCU2047D6N2	600	50/60	47	1.8	Floor mount NEMA 2	UL/CSA	Yes
HCU2094D6N2	600	50/60	94	3.9	Floor mount NEMA 2	UL/CSA	Yes
HCU2157D6N2	600	50/60	157	7.2	Floor mount NEMA 2	UL/CSA	Yes
HCU2235D6N2	600	50/60	235	9.9	Floor mount NEMA 2	UL/CSA	Yes
HCU2047D6IP54	600	50/60	47	1.8	Floor mount IP54	CE	Yes
HCU2094D6IP54	600	50/60	94	3.9	Floor mount IP54	CE	Yes
HCU2157D6IP54	600	50/60	157	7.2	Floor mount IP54	CE	Yes
HCU2235D6IP54	600	50/60	235	9.9	Floor mount IP54	CE	Yes
HCU2047D6N12	600	50/60	47	1.8	Floor mount NEMA 12	UL/CSA	Yes
HCU2094D6N12	600	50/60	94	3.9	Floor mount NEMA 12	UL/CSA	Yes
HCU2157D6N12	600	50/60	157	7.2	Floor mount NEMA 12	UL/CSA	Yes
HCU2235D6N12	600	50/60	235	9.9	Floor mount NEMA 12	UL/CSA	Yes
HCU2040D7IP31	690	50/60	40	2.1	Floor mount IP31	CE	Yes
HCU2080D7IP31	690	50/60	80	4.5	Floor mount IP31	CE	Yes
HCU2133D7IP31	690	50/60	133	8.2	Floor mount IP31	CE	Yes
HCU2200D7IP31	690	50/60	200	11.4	Floor mount IP31	CE	Yes
HCU2040D7N2	690	50/60	40	2.1	Floor mount NEMA 2	UL/CSA	Yes
HCU2080D7N2	690	50/60	80	4.5	Floor mount NEMA 2	UL/CSA	Yes
HCU2133D7N2	690	50/60	133	8.2	Floor mount NEMA 2	UL/CSA	Yes
HCU2200D7N2	690	50/60	200	11.4	Floor mount NEMA 2	UL/CSA	Yes
HCU2040D7IP54	690	50/60	40	2.1	Floor mount IP54	CE	Yes
HCU2080D7IP54	690	50/60	80	4.5	Floor mount IP54	CE	Yes
HCU2133D7IP54	690	50/60	133	8.2	Floor mount IP54	CE	Yes
HCU2200D7IP54	690	50/60	200	11.4	Floor mount IP54	CE	Yes
HCU2040D7N12	690	50/60	40	2.1	Floor mount NEMA 12	UL/CSA	Yes
HCU2080D7N12	690	50/60	80	4.5	Floor mount NEMA 12	UL/CSA	Yes
HCU2133D7N12	690	50/60	133	8.2	Floor mount NEMA 12	UL/CSA	Yes
HCU2200D7N12	690	50/60	200	11.4	Floor mount NEMA 12	UL/CSA	Yes

Freedom

Freedom Arc-Resistant MCC

Freedom FlashGard

Learn Online

Freedom, Freedom Arc-Resistant and Freedom FlashGard

Contents

Product Overview

MCC Operation

Eaton's motor control center (MCC) product line is headquartered in Fayetteville, NC. At Fayetteville, the most progressive engineering team in the industry can custom design motor control centers for the most demanding applications. Most MCCs can be shipped six to eight weeks after receipt of a released order.

The MCC product line also offers a FAST motor control center (MCC) quick shipment program. The program includes integration of a number of commonly used components and assemblies in MCC applications as well as configuration options for each. The FAST program also includes expedited delivery of customer approval drawings when predefined pilot/control device configurations for unit assemblies are selected. MCCs meeting the FAST criteria are shipped within 4 weeks after receipt of a released order.

Customer Manufacturing Solution Centers

One of the most unique aspects of the Eaton MCC operation is the ability to provide customized product to meet delivery requirements through a Customer Manufacturing Solution Center (CMSC). There are nine of these facilities located throughout the U.S. serving key geographic markets. Each CMSC has the ability to provide standard NEMA® 1B wired product in as little as one to three days. Please contact the facility in your area to discuss customer opportunities and MCC support for your specific marketplace.

Customer Manufacturing Solution Centers

Location	Telephone
Atlanta	678-309-4270
Chicago	630-260-6304
Denver	303-366-9949
Hartford	860-683-4221
Houston	713-939-9696
Los Angeles	562-944-6413
Portland	503-582-2700

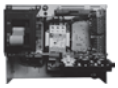
Seismic Qualification

The Freedom and ***XT*** MCC families have been qualified to meet the seismic requirements of both the Uniform Building Code® (UBC) and the California Building Code (CBC) for equipment operation after seismic activity. This equipment, along with Eaton's low and medium voltage switchgear assemblies, medium voltage starter assemblies and low voltage switchboards, which meet seismic requirements, provide the user with a complete seismic qualified assemblies package that meet CBC and IBC requirements. Please contact your Eaton sales engineer for more details.

Bid Manager™

One of the most exciting new tools developed for the MCC product line is the Bid Manager program. Bid Manager is a PC-based pricing program that is capable of providing complete bills of material, front views and prices for MCCs. This program can configure an MCC to meet a multitude of specific applications and provide accurate bills of material and front view drawings in a matter of moments. The program operates on a user-friendly, Windows®-based format that offers the most extensive product selection found in the industry. A complete line of adjustable frequency drives and reduced voltage solid-state control, along with insulated case breakers, high ampacity molded case breakers and automatic transfer switches are featured in the program. Control and distribution product can be packaged in a multitude of variations. Please contact your Eaton sales engineer for more details.

Aftermarket Products

XT	Freedom	*IT.*	Advantage	Series 2100/ 5 Star	Freedom Unitrol	F10 Unitrol	Type W	9800 Unitrol	11-300
									
Motor Control Center Production Years									
2012–Present	1995–present	2002–2011	1992–2010	1987–1995/ 1975–1987	1988–1994	1972–1989	1965–1975	1956–1974	1935–1965

Background

Over 50 years ago, Cutler-Hammer® and Westinghouse® low voltage motor control centers were introduced, enabling the group mounting of low voltage (600 V class) electrical controls. This allowed for supervision and safe operation of motor starter units, feeder tap units and auxiliary equipment in a flexible structure arrangement at a centralized location.

The foundation for today's MCCs is a modular plug-in combination motor controller assembly with components of proven electrical and mechanical integrity. These assemblies are enclosed in metal structures that prevent accidental contact with live electrical parts.

The MCC structure consists of structural steel, horizontal and vertical wireways for conduit and load cable entry and exit, and vertical and horizontal bus systems for distributing power throughout the MCC. The starter unit consists of a rugged steel shell (wrapper) for mounting the unit components, a combination motor starter with factory wired control, a handle mechanism for ON/OFF operation, and a rigid unit door.

Aftermarket Service

Eaton's MCCs are manufactured with high quality structural parts designed to provide many years of service.

Eaton is dedicated to providing replacement units or add-on units to handle additional loads for motor control centers manufactured since 1935 for both the Westinghouse and Cutler-Hammer product lines.

The following descriptions and needed order entry information will be useful in identifying and processing a vintage MCC aftermarket unit.

1. Motor control center type: (11-300, Type W, 5-Star, Advantage, 9800, F-10, Freedom FlashGard, Freedom, Freedom arc-resistant ***IT.***, ***XT*** and ***XT*** FlashGard)
2. Class of unit (Non-reversing, Reversing, Two Speed)
3. Service voltage
4. Control voltage
5. Starter size or horsepower rating
6. Disconnect type (HMCP, Fusible)
7. Clip size and type (if Fusible)
8. Unit modifications (Lights, Pushbuttons, etc.)
9. Catalog Number (if available)

Product Availability

Replacement units for the 5-Star, Series 2100, Advantage, 11-300, 9800, Type W, F-10, F2100, Freedom FlashGard, Freedom, Freedom arc-resistant ***IT.***, ***IT.*** FlashGard, ***XT*** and ***XT*** FlashGard motor control center lines may be obtained from the Fayetteville manufacturing plant or any of the regionally located Customer Manufacturing and Solution Centers (CMSCs).

Competitive MCC units can be obtained from the Fayetteville manufacturing plant or CMSCs.

They are located in:

Customer Manufacturing Solution Centers

Location	Telephone
Atlanta	678-309-4270
Chicago	630-260-6304
Denver	303-366-9949
Hartford	860-683-4221
Houston	713-939-9696
Los Angeles	562-944-6413
Portland	503-582-2700

MCC Renewal Parts

MCC Type	Dates	Eaton's Cutler-Hammer Renewal Parts Publication
XT	2012–present	—
XT FlashGard	2012–present	—
IT.	2002–2011	—
IT. FlashGard	2007–2011	—
Freedom	1995–present	RP04304001E
Freedom FlashGard	2008–present	—
Advantage	1992–2011	RP04304002E
Series 2100	1987–1995	RP04304003E
5 Star	1975–1987	RP04304003E
Freedom Unitrol	1988–1994	RP04304004E
F10 Unitrol	1972–1989	RP04304005E
Type W	1965–1975	RP04304006E
9800 Unitrol	1956–1974	RP04304007E
11-300	1935–1965	RP04304008E

Product Description

Eaton's offering of motor control centers (MCCs) features the Freedom, Freedom arc-resistant, Freedom FlashGard, ***XT*** and ***XT*** FlashGard. These MCCs incorporate the newest NEMA electromechanical starters in the industry along with the most complete, NEMA rated package of distribution and control equipment. The FlashGard MCCs are the industry's first MCCs designed for comprehensive arc flash prevention.

Application Description

Eaton's MCCs are custom-made assemblies of conveniently grouped control equipment primarily used for control of motors and for distribution of power. MCCs are designed for three-phase, 230 V applications up to 300 hp, or three-phase, 480 V applications up to 600 hp. The Freedom FlashGard and ***XT*** FlashGard MCCs are equipped with a state-of-the-art stab racking mechanism (RotoTract™) that provides bus isolation, stab indication and lockout features that proactively prevent the initiation of arc flash.

Features, Benefits and Functions

Structure Design

Eaton's MCCs are 20.00 inches (508.0 mm) wide and 90.00 inches (2286.0 mm) high with vertical compartments having 72.00 inches (1828.8 mm) of unit mounting space in 6.00-inch (152.4 mm) increments.

Structure depth is 16.00 inches (406.4 mm) or 21.00 inches (533.4 mm) deep front-mounted only and 21.00 inches (533.4 mm) deep for back-to-back mounted units.

The unique framed design permits the highest flexibility in component and structure configuration.

Accessibility

All parts and wiring are front accessible. Terminal blocks are side mounted in each unit. 4.00-inch (101.6 mm) or 8.00-inch (203.2 mm) vertical wireways separate from control units provide safe and convenient access to wiring and conduits without de-energizing any equipment.

Flexibility

Modular, framed design permits structure arrangement to be tailored to exactly meet any control requirements with a minimum of unusable space. Vertical compartments are incremented for maximum space utilization and unit interchangeability. Compact starter and feeder units provide users with the ability to solve demanding space requirements and still meet all NEMA and UL® standards.

Safety

Design tested at Eaton's power laboratory to ensure maximum protection for control equipment. The FlashGard option ensures maximum safety for personnel working on or around the equipment.

Hardwired Control

With choices for 1A to 2C wiring schemes, the Eaton MCC offers many options for traditional or supervisory control schemes.

Industrial Communications

Eaton MCCs come with the most advanced and flexible industrial factory installed and tested communication connectivity in the marketplace with protocols that include DeviceNet, Modbus and Modbus TCP, EtherNet/IP and PROFIBUS. Eaton smart MCCs facilitate faster startup, safer working conditions and enhanced diagnostics and monitoring.

Intelligent Products

Eaton MCCs include intelligent starters, soft starters, VFDs, meters and feeder breakers that can all be connected to an embedded PLC and operator interface.

Standards and Certifications

UL Listing

Standard structures and units are provided with UL label.

Contact Eaton for details and part numbers for CSA approved units.

Comparison of Key MCC Features and Attributes by MCC Type/Family

MCC Type/ Family	Serves Applications 480 V and Below	Serves 600 V Applications	Compact Unit Offering Standard ①	Compact Unit Offering Optional ①	120 Vac Control Power	24 Vdc Control Power	Tested and Certified Per Arc-Resistant Guidelines	FlashGard Technology ②	FlashGard Technology with Test Position ②③	Optional Communications Capability
Freedom	■	■		■	■					■
Freedom Arc-Resistant	■	■		■	■		■			■
Freedom FlashGard	■	■			■			■		■

Notes

① Compact offering has size 1 and 2 FVNR starter units in 1X and size 3 and 4 in 2X. Add 1X to each for FVR versions.

② FlashGard technology enables stabs to be retracted from and engaged onto the vertical bus while the unit's door is closed.

③ FlashGard test position enables control power to be delivered to the unit while its stabs are removed from the vertical bus (no line power present within unit).

Catalog Number Selection

Aftermarket MCC Starter Buckets

FZ 206E E A S C12 P57

MCC Type Catalog Codes
- **F** = Free-standing NEMA 1
- **FZ** = Freedom
- **FK** = Advantage
- **FS** = Series 2100/5 Star
- **FD** = Freedom Unitrol
- **FR** = F10 Unitrol
- **FT** = Type W
- **FN** = 9800 Unitrol
- **FJ** = 11-300
- **FM** = ***IT.***
- **SZ** = FlashGard
- **GD** = ITE 5600
- **GE** = GE 7700/8000
- **AB** = Allen-Bradley Centerline
- **SQ** = Square D Model 6
- **SS** = Furnas 89

Starter Type
See tables on **Page V3-T3-6**

Service Voltage
- **A** = 120 V
- **B** = 208 V
- **C** = 240 V
- **D** = 380 V
- **E** = 480 V
- **F** = 575 V

Control Voltage
- **A** = 120 V
- **B** = 208 V
- **C** = 240 V
- **D** = 380 V
- **E** = 480 V
- **F** = 575 V

Space Option Code
- **S** = Standard height
- **C** = Compact
- **X** = Oversized

CPT
- **C10** = Separate source control fuse
- **C12** = 100 VA for sz. 1–2
- **C13** = 150 VA for sz. 3–4

Modification Codes
See tables on **Page V3-T3-6**

Aftermarket MCC Feeder Buckets/Units

FZ F 1 D S 12

MCC Type Catalog Codes
- **FZ** = Freedom
- **FK** = Advantage
- **FS** = Series 2100/5 Star
- **FD** = Freedom Unitrol
- **FR** = F10 Unitrol
- **FT** = Type W
- **FN** = 9800 Unitrol
- **FJ** = 11-300
- **FM** = ***IT.***
- **SZ** = FlashGard
- **GD** = ITE 5600
- **GE** = GE 7700/8000
- **AB** = Allen-Bradley Centerline
- **SQ** = Square D Model 6
- **SS** = Furnas 89

Device Type
- **F** = HFD
- **J** = HJD
- **K** = HKD
- **L** = HLD
- **Z** = Fusible Switch

Unit Type
- **1** = Single Disconnect
- **2** = Dual Disconnect

Trip or Clip Rating (Left Feeder)
- **A** = 15
- **B** = 20
- **C** = 25
- **D** = 30 ①
- **E** = 40
- **F** = 50
- **G** = 60 ①
- **H** = 70
- **J** = 80
- **K** = 90
- **L** = 100 ①

Trip or Clip Rating (Right Feeder) Dual Unit Only
- **M** = 125
- **N** = 150
- **P** = 175
- **Q** = 200 ①
- **R** = 225
- **S** = 250
- **T** = 300 ①
- **W** = 350
- **X** = 400
- **Y** = 500
- **Z** = 600 ①

Unit Size
- **12** = 12″
- **14** = 14″
- **18** = 18″ or 18-2/3″
- **24** = 24″
- **28** = 28″
- **30** = 30″
- **36** = 36″
- **48** = 48″

Aftermarket Service

Eaton's MCCs are manufactured with high quality structural parts designed to provide many years of service.

Eaton is dedicated to providing replacement units or add-on units to handle additional loads for motor control centers manufactured since1935 for both the Westinghouse and Cutler-Hammer product lines.

The following descriptions and needed order entry information will be useful in identifying and processing a vintage MCC aftermarket unit.

1. Motor control center type (refer to MCC types listed above for both starter and feeder units)
2. Class of unit (non-reversing, reversing, two speed)
3. Service voltage
4. Control voltage
5. Starter size or horsepower rating
6. Disconnect type (HMCP, Fusible)
7. Clip size and type (if fusible)
8. Unit modifications (lights, pushbuttons, etc.)
9. Catalog number (if available)

Note

① Fusible disconnect sizes.

Aftermarket MCC Starter types

Full-Voltage Non-Reversing Combination Starter—HMCP Disconnect

NEMA Size	Maximum Horsepower 208 V	240 V	380 V	480 V	600 V	HMCP Ampere Size	Starter Class Code
1	0.50	0.33	1	1	1.50	3	**206A**
1	1	1	2	3	3	7	**206B**
1	3	3	5	7.50	7.50	15	**206C**
1	7.50	7.50	10	10	15	30	**206D**
2	10	15	25	25	30	50	**206E**
3	25	30	50	50	50	100	**206H**
4	40	50	75	100	100	150	**206L**

Full-Voltage Reversing Combination Starter—HMCP Disconnect

NEMA Size	Maximum Horsepower 208 V	240 V	380 V	480 V	600 V	HMCP Ampere Size	Starter Class Code
1	0.50	0.33	1	1	1.50	3	**216A**
1	1	1	2	3	3	7	**216B**
1	3	3	5	7.50	7.50	15	**216C**
1	7.50	7.50	10	10	15	30	**216D**
2	10	15	25	25	30	50	**216E**
3	25	30	50	50	50	100	**216H**
4	40	50	75	100	100	150	**216L**

Full-Voltage Non-Reversing Combination Starter—Fusible Disconnect

NEMA Size	Maximum Horsepower 208 V	240 V	380 V	480 V	600 V	Fuse Ampere Size	Starter Class Code
1	7.50	7.50	10	10	15	30	**204D**
2	10	15	25	25	30	50	**204E**
3	25	30	50	50	50	100	**204H**
4	40	50	75	100	100	150	**204L**

Full-Voltage Reversing Combination Starter—Fusible Disconnect

NEMA Size	Maximum Horsepower 208 V	240 V	380 V	480 V	600 V	Fuse Ampere Size	Starter Class Code
1	7.50	7.50	10	10	15	30	**214D**
2	10	15	25	25	30	50	**214E**
3	25	30	50	50	50	100	**214H**
4	40	50	75	100	100	150	**214L**

Common Modifications

Abbreviated list of common modification codes

Note: Please contact your local Service Center for all available modifications and to learn which modifications will work for your aftermarket needs.

Modification Codes	Option Description
B10	Breaker shunt trip—120 V
B11	Breaker auxiliary switch—1NO/1NC
B19	Breaker auxiliary switch—2NO/2NC
C10	Control fuse wired for separate source in lieu of CPT
C11	Control fuse/disconnect for separate source in lieu of CPT
C12	CPT 100 VA for size 1 and 2 starters, fused
C13	CPT 150 VA for size 3 and 4 starters, fused
C18	Full capacity CPT for size 5 starters, fused
M12	Mini elapsed time meter
M16	IQ 200 Meter with three CTs
O19	Overload relay heater/heater pack
O20	Standard solid-state overload relay
P10	Red 'RUN' light
P11	Green 'STOPPED' light
P15	Red 'RUN' Push-to-Test light
P16	Green 'STOPPED' Push-to-Test light
P20	Special function light
P32	'START/STOP' pushbutton
P35	'ON/OFF' pushbutton
P36	'FORWARD/REVERSE/STOP' pushbutton
P38	'FAST/OFF/SLOW' pushbutton
P41	Special function pushbutton
P50	'ON-OFF' selector switch
P53	'START-STOP' selector switch
P55	'FORWARD-REVERSE' selector switch
P56	Special function 2-position selector switch
P57	'HAND-OFF-AUTO' selector switch
P58	'LOCAL-OFF-REMOTE' selector switch
P59	'FAST-OFF-SLOW' selector switch
P60	'HIGH-OFF-LOW' selector switch
P61	Special function 3-position selector switch
R24	D15 four-pole control relay
S11	1NO-1NC starter auxiliary contacts
S22	2NO-2NC starter auxiliary contacts
T10	Pull-apart type terminal blocks (standard on all vintages except Type W and 11-300)
U10	Surge suppressor on coil
U11	Type SIS control wire
U14	Wiremarkers—sleeve type on all control wire
U17	Wiring diagram inside starter unit door

Accessories and Options

Control and Distribution Equipment Packaging

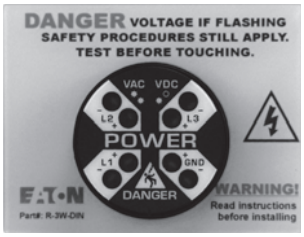
Eaton's MCCs provide the best packaged solutions for the control needs of today's users. Structural characteristics allow the user to select a complete package of control and distribution equipment in a minimum amount of space. The ability to package a wide range of solid-state products, including SVX9000 drives, S811+ soft starters and PLCs meet the most demanding user process needs. The option to provide high ampacity molded case breakers gives the user the flexibility to minimize switchboard or switchgear structures and thereby saves valuable space and reduces design costs. Additional safety accessories are available such as Motorguard (automatic insulation tester), Voltage Vision (voltage presence indicator), FlashGard remote racking accessory and FlashGard locking accessory. Other packaged products, including automatic transfer switches and panelboards, again reduce space requirements and save time and money on equipment and installation costs. A motor load terminal block that enables quick connect/disconnect of 480 V power is available as standard on the Freedom FlashGard as well as the ***XT*** and ***XT*** FlashGard MCCs. This feature is optional on the Freedom and Freedom arc-resistant MCCs.

FlashGard Remote Racking Accessory

Remote Racking Accessory

- Performs RotoTract racking safely behind NFPA arc flash boundaries
- 120 Vac motor driven
- Mounts to RotoTract mechanism
- Wired pendant station for "rack-in"/"rack-out" operation
- Momentary jog
- Mounting offset bracket to clear device panel

Voltage Presence Indicator (VoltageVision™)



Voltage Presence Indicator (VoltageVision)

- Hardwired voltage detector connected to load side of disconnect
- Enables operator to "pre-verify" voltage presence with unit door closed
- Installable in a 30 mm pilot device knockout
- Dual redundant circuitry for reliability
- Phase insensitive

FlashGard Locking Accessory

FlashGard Locking Accessory

- Locks out RotoTract operation during maintenance
- Allows operation of FlashGard units by authorized personnel only
- Heavy-gauge steel construction

Automatic Insulation Tester (Motorguard)

Automatic Insulation Tester (Motorguard)

- "Meggers" equipment motor insulation to continuously monitor integrity of insulation for the period that the equipment is de-energized
- Applies 500 Vdc potential at current-limited, operator-safe maximum amperage of 200 microamperes
- Alarms upon detection of a threshold leakage to ground current
- Visual alarm indication and lockout; Form C contact available for remote alarm status

Freedom Arc-Resistant Motor Control Center

Contents

Freedom Arc-Resistant Motor Control Center

Product Description

An arc flash is a dangerous condition associated with the explosive release of energy caused by an electrical arc due to either a phase-to-ground or a phase-to-phase fault. This fault can result from many factors, including dropped tools, accidental contact with electrical systems, buildup of conductive dust, corrosion and improper work procedure. An arc-flash event releases a tremendous amount of energy in the form of thermal heat, toxic fumes, pressure waves, blinding light, sound waves and explosions that can result in serious injury, including critical burns, collapsed lungs, loss of vision, ruptured eardrums, puncture wounds and even death.

Temperatures can reach 35,000 °F, which is three times hotter than the temperature of the sun. These excessive temperatures cause the air and metal in the path of the arc to expand and explode, creating an arc blast. Throughout the world, arc flash threatens personnel safety, and companies face lost man-hours, lawsuits, fines, equipment damage, facility downtime and lost production.

In continuation with the legacy of Eaton's leadership in arc flash safety products, the Freedom arc-resistant motor control center (MCC) is designed to provide personnel with increased protection from the dangers of arc flash hazards. This enhanced version of Eaton's flagship Freedom MCC includes additional features specifically designed to contain the arc blast energy should an arc flash event be triggered within the assembly. The Freedom arc-resistant MCC has a Type 2 accessibility rating, meaning that arc-resistant designs or features are present on the front, back and sides of the assembly. This Type 2 rating translates to enhanced safety around the entire perimeter of the MCC should an arc flash event occur.

Features and Benefits

No Exhaust Plenums or Roof Flaps Required

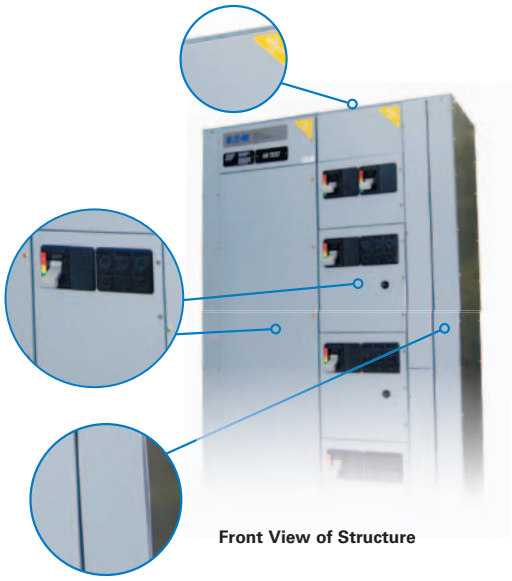
Eaton's arc-resistant Freedom MCC requires no exhaust plenums or roof flaps. This aids in the ease of installation, as additional clearance or venting ductwork is not required above the assembly.

12 Gauge Steel Doors, Side Sheets and Back Sheets

Usage of 12 gauge steel on all MCC doors, side sheets and back sheets serve to increase the structural integrity of the MCC and aid in the containment of arc blast energy, further enhancing personnel safety should an arc flash event occur.

4 Inch Sections

A four-inch section is added to the first and last structures of the MCC lineup, regardless of the number of structures. These sections increase the structural integrity of the MCC lineup, further ensuring it can withstand the arc blast energy.



Front View of Structure

Enhanced Door Hinges and Latches

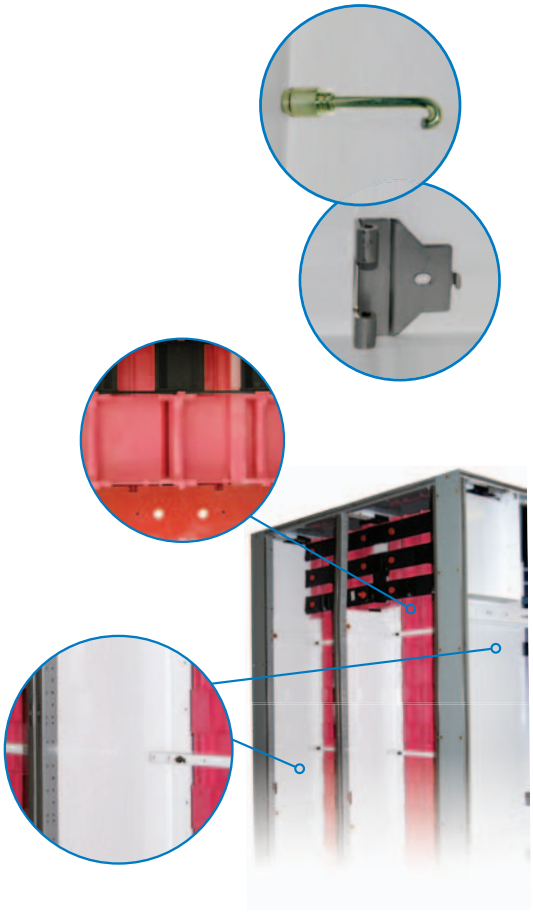
Hinges and door latches play a vital role in the containment of arc blast energy during an arc flash event. The design and implementation of enhanced door hinges and latches on the Freedom arc-resistant MCC serves to keep doors closed and latched securely during an arc flash event, further preventing the propagation of arc blast energy toward personnel. As an additional measure, the quantity of door hinges and latches applied to the MCC unit doors has also been increased.

Insulated Horizontal and Vertical Buses

Insulation of the horizontal and vertical buses aids in the prevention of arc flash incidents. When an arc flash incident does occur, the insulation serves to prevent further propagation of the arc fault throughout the entire MCC. Automatic vertical bus shutters are included.

Isolation Barriers Between Adjacent Structures

Isolation barriers placed between adjacent structures serve to isolate the arc blast energy to a single area within the MCC.



Rear View of Structure with Back and Side Sheets Removed

Standards and Certifications

Eaton's Freedom arc-resistant MCC has been tested and verified per the criteria found in the Institute of Electrical and Electronics Engineers (IEEE) guideline C37.20.7 titled "IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults."

The MCC also meets the criteria found in Canadian Standards Association (CSA) standard C22.2 No. 0.22-11, titled "Evaluation Methods for Arc Resistance Ratings of Enclosed Electrical Equipment." This standard was originally published in 2012 and is currently the only official North American standard or guideline that contains low voltage MCCs within the scope of coverage. CSA C22.2 No. 0.22-11 was based in large part on the guidelines and testing criteria found in IEEE C37.20.7.

Technical Data and Specifications

Specifications

Item	Description
Freedom Arc-Resistant MCC	
Applicable guidelines and standards	Tested and verified per IEEE guideline C37.20.7 and CSA standard 22.2 No. 0.22-11
Agency approvals	UL and cUL per UL 845
Voltage rating	600 V maximum
Interrupting rating	Maximum 65 kA at 480 V and 600 V
Arc duration rating	100 mS at 480 V, 50 ms at 600 V
Accessibility type ①	Type 2 (contains arc-resistant protection designs or features on the front, sides, and rear of the equipment)
Main incoming breaker (required)	2500 A frame 1200 A–2500 A trip range), 80% rated 1200 A frame (400 A–1200 A trip range), 80% rated
Structure environmental ratings	NEMA 1, 2
Structure depth	21 inches
Horizontal bus	Minimum 800 A, maximum 2500 A ②
Vertical bus	Maximum 1200 A
Bus insulation	Horizontal and vertical buses both insulated
Available Units, Assemblies and Options	
Interrupting devices ③	Thermal-magnetic circuit breakers and motor circuit protectors
Main breakers ④	2500 A frame (800 A–2500 A range) 1200 A frame (320 A–1200 A range)
Starters	NEMA size 1–5 full voltage non-reversing (FVNR), full voltage reversing (FVR) and multi-speed All overload options available, including bimetallic and solid-state
Feeders	Maximum 600 A, 80% rated
Variable frequency drives (VFDs)	Maximum 150 hp ⑤
Soft starters	Maximum 200 hp
Other units and assemblies available	Relay panels Relay structures Meters Transformers Panelboards Surge protective devices Power factor correction capacitors Active harmonic correction units
Communications	Communications on all major fieldbus protocols, including Modbus, Modbus TCP, EtherNet/IP, DeviceNet, and PROFIBUS

Notes

① Freedom arc-resistant MCCs containing clean power drives carry a Type 1 accessibility type (contains arc-resistant protection designs on the front).

② 2500 A maximum with 65 °C temperature rise bus, 2000 A maximum with 50 °C temperature rise bus.

③ Fused switches and air circuit breakers not available.

④ An incoming main breaker is required to be configured in the lineup. Incoming main lugs, fused switches and air circuit breakers not available as main devices.

⑤ FR8 min size enclosure only up to 150 hp.

Incoming Line

Incoming Line—Main Lugs Only ①②

Bus Rating	X-Space
600	2
	3
	4
800	3
	4
	6
1000	4
	6
	8
1200	5
	6
1600	12
2000	12
2500	12
3200 ③	12

Incoming Line—Main Circuit Breaker ①④

Frame Size (Amperes)	Circuit Breaker Type	Dimensions in Inches (mm) Freedom, Freedom Arc-Resistant and Freedom FlashGard Unit Size	Enclosure Width
150	HFD ②	18.00 (457.2)	20.00 (508.0)
	FDC ②	18.00 (457.2)	20.00 (508.0)
225	HFD ②	18.00 (457.2)	20.00 (508.0)
	FDC ②	18.00 (457.2)	20.00 (508.0)
250	HJD ②	30.00 (762.0)	20.00 (508.0)
	JDC ②	30.00 (762.0)	20.00 (508.0)
400	HKD ②	30.00 (762.0)	20.00 (508.0)
	KDC ②	30.00 (762.0)	20.00 (508.0)
	CHKD ②⑤	30.00 (762.0)	20.00 (508.0)
	CKDC ②⑤	30.00 (762.0)	20.00 (508.0)
600	HLD ②	24.00 (609.6) ⑨⑩⑪	20.00 (508.0)
	LDC ②	24.00 (609.6) ⑨⑩⑪	20.00 (508.0)
	CHLD ②③⑤	24.00 (609.6) ⑨⑩⑪	20.00 (508.0)
	CLDC ②③⑤	24.00 (609.6) ⑨⑩⑪	20.00 (508.0)
800	HMDL ②	30.00 (762.0) ⑨⑪	20.00 (508.0)
	CHMDL ②③⑤	48.00 (1219.2) ⑨⑪	20.00 (508.0)
	NGH ④⑥⑦	42.00 (1066.8) ⑨⑪	20.00 (508.0)
	NGC ②⑥⑦	42.00 (1066.8) ⑨⑪	20.00 (508.0)
	NGH-C ③⑥⑦⑧	72.00 (1828.8) ⑨	20.00 (508.0)
	NGC-C ②⑥⑦	72.00 (1828.8) ⑨	20.00 (508.0)
1200	NGH ④⑥⑦	42.00 (1066.8) ⑨⑪	20.00 (508.0)
	NGC ②⑥⑦	42.00 (1066.8) ⑨⑪	20.00 (508.0)
	NGH-C ②③④⑥⑦⑧	72.00 (1828.8) ⑨	20.00 (508.0)
	NGC-C ②③⑥⑦	72.00 (1828.8) ⑨	20.00 (508.0)
1600	RGH ④⑥⑦	72.00 (1828.8) ⑨⑫	20.00 (508.0)
	RGC ②⑥⑦	72.00 (1828.8) ⑨⑫	20.00 (508.0)
	RGH-C ②④⑥⑦⑧	72.00 (1828.8) ⑨⑫	20.00 (508.0)
	RGC-C ②⑥⑦⑧	72.00 (1828.8) ⑨⑫	20.00 (508.0)
2000	RGH ④⑥⑦	72.00 (1828.8) ⑨⑫	20.00 (508.0)
	RGC ②⑥⑦	72.00 (1828.8) ⑨⑫	20.00 (508.0)
	RGH-C ②④⑥⑦⑧	72.00 (1828.8) ⑨⑫	20.00 (508.0)
	RGC-C ②⑥⑦⑧	72.00 (1828.8) ⑨⑫	20.00 (508.0)
2500	RGH ④⑥⑦	72.00 (1828.8) ⑨⑪⑫	24.00 (609.6)
	RGC ②⑥⑦	72.00 (1828.8) ⑨⑪⑫	24.00 (609.6)

Notes

① Table common to Freedom, Freedom arc-resistant and Freedom FlashGard.
② Not available in Freedom arc-resistant MCC.
③ NEMA 1 gasketed only.
④ An NGH or RGH main breaker is required in the Freedom arc-resistant MCC. The NGH requires a complete vertical section (72 inches) in the Freedom arc-resistant MCC only.
⑤ 100% rated when 90° cable applied at 75° ampacity for 100% rating. Digitrip™ 310 LS is required and included in the price.
⑥ Digitrip 310+ LSI is standard and included in the pricing.
⑦ Arcflash Reduction Maintenance System (ARMS) available. Requires Digitrip 310+ ALSI or ALSIG.
⑧ 100% rated when 90° cable applied at 75° ampacity for 100% rating.
⑨ Fixed assembly. Not available with FlashGard RotoTract assembly.
⑩ Add 6.00 inches (152.4 mm) for top entry of incoming cables.
⑪ Install at top for cable top entry or at bottom for bottom cable entry.
⑫ The main breaker requires the complete vertical section. The rear is unusable.

Structure Modifications

Structure Modifications

Description
Enclosure
NEMA 1 gasketed
NEMA 12—dust-tight ①
NEMA 3R front-mounted only ①
NEMA 3R front and rear ①
NEMA 3R walk-in ①
NEMA 3R tunnel ①
Space heater
Thermostat
Bottom plate
Channel sills
12.00-inch (304.8 mm) pull box
100 kA bus bracing ①
Vertical Bus
600 A
800 A
1200 A
Horizontal Ground Bus
300 A copper
600 A copper
800 A copper
Standard Structures
16.00-inch (406.4 mm) front-mounted only ①
21.00-inch (533.4 mm) front-mounted only
21.00-inch (533.4 mm) front and rear ①
Main Horizontal Bus—65°C Rise ①
600 A copper ①
800 A copper
1200 A copper
1600 A copper
2000 A copper
2500 A copper
3200 A copper ①
Vertical Bus Barrier
Labyrinth barrier with shutters ②

Neutral Bus (Bottom)

Ampere Rating
300
600 or 800
1000
1200
1600
2000
2500
3200 ①③

Incoming Line Metering

Meter	X-Space Freedom, Freedom Arc-Resistant and Freedom FlashGard
IQ 130/140/150	2
IQ 250/260	2
IQ DP-4130	2
IQ Analyzer	2
Power Xpert 2250/2260/2270	2
Power Xpert 4000/6000/8000	3

Surge Protective Device—Units with Circuit Breaker Disconnect

Three feature packages are available to choose from. Individual features vary by package.

Surge Current Per Phase	X-Space Freedom, Freedom Arc-Resistant and Freedom FlashGard
100 kA Model SPD ④	3
120 kA Model SPD ④⑤	3
160 kA Model SPD ④	3
200 kA Model SPD ④	3
250 kA Model SPD ⑥	3
300 kA Model SPD	3
400 kA Model SPD	3

Notes

① Not available in Freedom arc-resistant MCC.
② Labyrinth barrier with automatic shutter is standard on the Freedom arc-resistant MCC.
③ Available NEMA 1 gasketed enclosures only.
④ Optional integral IQ 200 Meter in 3X unit for 100 kA–200 kA.
⑤ Recommended for branch entrance.
⑥ Recommended for service entrance.

Combination Starters

Circuit Breaker Starters (HMCP) Non-Reversing (F206) ①

Size	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
1	2	2
2	2	2
3	3	3
4	3	4
5	6	7
6	9	9

Compact Circuit Breaker Starters (HMCP) Non-Reversing (F206)

Size	X-Space Freedom and Freedom Arc-Resistant
1	1
2	1
3	2
4	2

Compact Circuit Breaker Starters (HMCP) Reversing (F216)

Size	X-Space Freedom and Freedom Arc-Resistant
1	2
2	2
3	3
4	3

Circuit Breaker Starters ①

Size	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
Full Voltage Reversing (F216)		
1	3	3
2	3	3
3	4	4
4	5	5
2S1W (F946)		
1	4	4
2	4	5
3	6	7
4	6	8
2S2W (F956)		
1	4	4
2	4	4
3	5	5
4	5	7
Reduce Voltage Auto Transformer (F606) ②		
3	8	9
4	8	9
5 ③	12	12
6 ④	12	12
Vacuum Starters (V206) Non-Reversing		
4	3	4
5	6	7
6	8	9

Fusible Disconnect Starters ①

Size	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
Full Voltage Non-Reversing (F204)		
1	2	3
2	2	3
3	4	4
4	6	6
5	10	11
Full Voltage Reversing (F214)		
1	4	4
2	4	4
3	5	5
4	8	10
Fusible Non-Reversing 2S 1W (F944)		
1	4	4
2	4	5
3	6	6
4	10	10
Fusible Non-Reversing 2S 2W (F954)		
1	4	4
2	4	5
3	5	6
4	8	10

Contactor Only Units

Size	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
Circuit Breaker (F208)		
1	2	2
2	2	2
3	3	3
4	3	4
5	6	7
6	9	9
Fusible (F209) ⑤		
1	2	3
2	2	3
3	4	4
4	6	6
5	10	11

Notes

① All starter configurations use the Freedom contactor as standard. It is possible to order the starter configuration with the A200 contactor, which may affect X space.
② Must be located at bottom.
③ 24.00 inches (609.6 mm) wide.
④ 28.00 inches (711.2 mm) wide.
⑤ Not available in Freedom arc-resistant MCC.

Starter Modifications

Control Options

Description
Selector switch 2/3—Pos.
Push-to-test light 6 V transformer
Tx indicating light—standard
Auxiliary switch—in breaker
Mini meters AMM VMM ETM
Relay surge suppressor
Timer—pneumatic
Timer—solid-state
Relay—AR—600 V two-pole
Relay—general purpose 300 V
Standard solid-state overload relay ①②
NEMA size 1–3
NEMA size 4–6

Industrial Communications ③

Networked-enabled components in MCCs eliminate up to 90% of the control wiring versus traditional hardwired designs.

The industrial network is prewired throughout the MCC and factory tested for conformance.

Motor Control Communication Options

Device	DeviceNet	Modbus	PROFIBUS	EtherNet/IP	Modbus TCP
C306 Over Load	C441KS	C441N	C441SS	C441R	C441R
C440 Over Load	C441K	C441NS	C441SS	C441R	C441R
C441 Over Load	C441K	C441N	C441S	C441R	C441R
SVX Drives	OPTC7	OPTC2	OPTC3	OPTCIQ	OPTCI
Feeders	C441KS	C441N	C441SS	C441R	C441R
S811+ Soft Starter	C441KS	Resident in S811+	Via gateway	C441V	C441V

S811+ Soft Starters with Integral Bypass

	X-Space			X-Space	
Maximum hp	Freedom and Freedom Arc-Resistant	Freedom FlashGard	Maximum hp	Freedom	Freedom FlashGard
1.15 Service Factor—Standard Duty			**1.15 Service Factor—Severe Duty**		
20	2	3	10	2	3
40	2	3	25	2	3
60	3	4	40	3	4
75	3	4	50	3	4
125	6	7	75	6	7
150	6	7	100	6	7
200	6	7	125	6	9
300 ④	9	9	150	9	10
350 ④	9	9	200	9	10
450 ④	12	12	250 ④	9	10
500 ④	12	12	300 ④	9	10
600 ④	12	12	350 ④	9	10
700 ④	12 ⑤	12	450 ④	12 ⑤	12

S811+ Control Options ⑥

Description
Pump control
MOV protection

S811+ Power Options ⑥

NEMA Bypass Contactor
Size 1
Size 2
Size 3
Size 4
Size 5
Size 6
Size 7

Notes

① Feature Overload provides same features as standard model plus ground fault, stall/jam protection, selectable trip class —10, 15 and 20.

② Size 4 units require additional 6-inch (152.4 mm) (1X) space.

③ This table is common for Freedom, Freedom arc-resistant and Freedom FlashGard MCCs.

④ Not available in Freedom arc-resistant MCC.

⑤ Requires 24.00-inch (609.6 mm) wide, rear is unusable, bottom exit only.

⑥ Options apply to both HMCP and breaker models.

Motor Isolation Contactors

Sizes
1
2
3
4
5
6
7

MMX Adjustable Frequency Drives—NEMA 1 (480 V Maximum)

hp	X-Space Freedom, Freedom Arc-Resistant and Freedom FlashGard
1	2
2	2
3	3
5	3
7.5	3
10	3

MMX Drive Options

Description
3% load reactor
5% load reactor
Three contactor bypass

SVX9000 Adjustable Frequency Drives—Plug-in Units NEMA 1 (480 V Maximum) Constant/Variable Torque Rated ①

hp	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
3	3	6
5	4	7
7.5	4	7
10	4	7
15	4	7
20	6	10
25	6	10
30	6	10

SVX9000 Options

Description
DeviceNet communications
PROFIBUS communications
Modbus RTU
Modbus TCP
EtherNet/IP
2000-foot (609.6m) dV/dT filter (3 hp)
2000-foot (609.6m) dV/dT filter (5–15 hp)
2000-foot (609.6m) dV/dT filter (20–30 hp)
Input line fuses (3–30 hp)
RFI filter (3–30 hp)

SVX9000 Adjustable Frequency Drives—Non-Plug-in Units NEMA 1 (480 V Maximum) Constant/Variable Torque Rated

hp	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
40	9	9
50	9	9
60	9	9
75 ②	9	9
100	12	12
125	12	12
150	12	12
200	12	12
250 ③	12	12
300 ③	12	12
400 ③	12	12
500 ③	12	12
600 ③	12	12
700 ③	12	12

Note: Consult *Eaton's Consulting Application Guide* for complete details on Drive/ Option Assembly Dimensions.

Note: SVX9000 Non-Plug-in Units with HMCP disconnect, 3% input line reactor, 3% output line reactor, door mounted Keypad, CPT.

Note: VT—Variable Torque drives are capable of producing 200% starting torque for 10 seconds and are rated for 10 seconds, and are rated 110% overload for 1 minute.

Note: CT—Variable Torque drives are capable of producing 200% starting torque for 10 seconds and are rated for 10 seconds, and are rated 150% overload for 1 minute.

SVX9000 Options

Description
DeviceNet communications
PROFIBUS communications
Modbus RTU
Modbus TCP
EtherNet/IP
2000-foot (609.6m) dV/dT filter (40–75 VT hp)
2000-foot (609.6m) dV/dT filter (100–150 VT hp)
2000-foot (609.6m) dV/dT filter (200–250 VT hp)
2000-foot (609.6m) dV/dT filter (300–400 VT hp) ③
2000-foot (609.6m) dV/dT filter (500–600 VT hp) ③
Input line fuses (40–150 VT hp) ③
Input line fuses (200–250 hp) ③
Input line fuses (300–400 hp) ③

Active Harmonic Correction for AC Drives

Description	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
50 A harmonic correction	12 ④	12 ④
100 A harmonic correction	12 ④	12 ④

18-Pulse Clean Power Drives—NEMA 1, (480 V Maximum) Variable Torque Rated ⑤

hp	X-Space Inches (mm) Wide ⑥
100	12, 40.00 (1016.0)
150	12, 40.00 (1016.0)
200	12, 60.00 (1524.0)
250 ③	12, 60.00 (1524.0)
300 ③⑦	12, 60.00 (1524.0) ⑦
400 ③	12, 60.00 (1524.0) ⑦
500 ③⑦	12, 106.00 (2692.4) ⑦

Notes

① SVX9000 plug-in units with HMCP disconnect, 3% input line reactor, 3% output line reactor, door-mounted keypad, CPT.

② X-space for 75 hp CT rated drive is 12X.

③ Not available in Freedom arc-resistant MCC.

④ Requires 24.00-inch (609.6 mm) wide structure.

⑤ Includes 5% input line reactor, 18-pulse rectifier, delta differential transformer.

⑥ X-space shown is common for both Freedom and Freedom FlashGard MCCs.

⑦ Extra space required for bypass contactor, consult factory.

Feeders

Note: FlashGard RotoTract assembly available on circuit breakers 400 A and below.

Circuit Breaker

Amperes	X-Space Freedom and Freedom Arc-Resistant	Freedom FlashGard
Standard Circuit Breakers		
HFD 50 ①	2	2
HFD 100 ①	2	2
HFD 150 ①	2	2
HJD 250	3	3
HKD 400	4	5
HLD 600	4	4 ②
NGH 1200	7 ③	7 ②
6.00-Inch (152.4 mm) Circuit Breakers		
EG125	1	N/A
JG250	1	N/A
Dual HFD Circuit Breakers		
50/50	2	④
50/100	2	④
100/100	2	④
100/150	2	④
150/150	2	④

Fusible Disconnect—Fusible Switch ⑤

Amperes	X-Space Freedom	Freedom FlashGard
30 or 60	2	3
100	3	3
200	6	5
400	6	7
600	8	8

Fusible Disconnect—Dual Fusible Switch ④⑤

Amperes	Freedom X-Space
30	2
60	3
30	2

Notes

① HFDE breakers with RMS 310+ electronic trip unit available in 80 AF and 225 AF in 2X space.

② Fixed assembly, no RotoTract.

③ NGH breaker requires a full structure (12X) in the Freedom arc-resistant MCC.

④ Not available in Freedom FlashGard.

⑤ Not available in Freedom arc-resistant MCC.

NEMA 3R Drives ①

Constant/Variable Torque Rated (480 V Maximum)

Horsepower	X-Space, Width ②
1.5	5X, 24.00 (609.6)
2	5X, 24.00 (609.6)
3	5X, 24.00 (609.6)
5	5X, 24.00 (609.6)
7.5	12X, 24.00 (609.6)
10	12X, 24.00 (609.6)
15	12X, 24.00 (609.6)
20	12X, 24.00 (609.6)
25	12X, 24.00 (609.6)
30	12X, 24.00 (609.6)
40	12X, 24.00 (609.6)
50	12X, 32.00 (812.8)
60	12X, 32.00 (812.8)
75	12X, 32.00 (812.8)
100	12X, 32.00 (812.8)
125	12X, 32.00 (812.8)
150	12X, 32.00 (812.8)
200	12X, 32.00 (812.8) ③

Transformers

Transformers ②④

kVA	Primary Breaker Only X-Space	Primary and Secondary Breakers X-Space
Single-Phase		
3	4	4
5	4	4
7.5	4	4
10	4	4
15 ⑦	6	6
20 ⑦	6	6
25 ⑦	6	6
30 ⑦	6	6
45 ⑦	7	8
Three-Phase		
9 ⑦	6	6
15 ⑦	6	6
25 ⑦	6	6
30 ⑦	6	6
45 ⑦	6	6

Panelboards

Panelboards (240 V Maximum) ②⑤

Circuits	X-Space
18	4
30	5
42	6

Panelboards (480 V Maximum) ②⑤

Circuits	X-Space
14	6
26	8
32	8
42	10

Automatic Transfer Switches ①

Open Transition Three-Pole Only

Ampere Rating	Unit Width Inches (mm)	X-Space ②
100 ⑥	20.00 (508.0)	6
150 ⑥	20.00 (508.0)	6
100	20.00 (508.0)	8
150	20.00 (508.0)	8
225	20.00 (508.0)	8
300	20.00 (508.0)	8
400	24.00 (609.6) ⑦	12
600	24.00 (609.6) ⑦	12
800	24.00 (609.6) ⑦	12
1000	24.00 (609.6) ⑦	12
1000	44.00 (1117.6) ⑧	12
1200	44.00 (1117.6) ⑧	12
1600	44.00 (1117.6) ⑨	12
2000	44.00 (1117.6) ⑨	12

Notes

① Not available in Freedom arc-resistant.
② X-space shown is common for Freedom, Freedom arc-resistant and Freedom FlashGard MCCs.
③ Extra space required for bypass section. Consult factory.
④ Must have primary breaker. Must be located at bottom of structure.
⑤ Space for MLO. Branch breakers included.
⑥ Manually operated switch:
NTVS = Electronically operated non-automatic.
MTVX = Single handle manual operation.
⑦ Requires 21.00-inch (533.4 mm) deep structure.
⑧ Requires 37.00-inch (939.8 mm) deep structure, flush at the rear. 4.00-inch (101.6 mm) filler required.
⑨ Requires 42.00-inch (1066.8 mm) deep structure. 4.00-inch (101.6 mm) filler required.

Application Guide

Motor Circuit Protector Selection Guide ①

	Maximum Horsepower						
NEMA	200 V	208 V	230 V	380 V	460 V	575 V	HMCP
1	—	—	—	3/4	3/4	1	3
	3/4	1	1	2	2	3	7
	2	2	2	3	5	7-1/2	15
	5	5	5	10	10	10	30
	7-1/2	7-1/2	7-1/2	—	—	—	50
2	—	—	—	—	—	15	30
	10	10	10	15	20	25	50
	—	—	15	25	25	—	70
3	—	—	—	—	—	30	50
	15	20	20	30	40	50	100
	25	25	30	50	50	—	150
4	40	40	40	60	100	100	150
	—	—	50	75	—	—	250
5	50	50	60	—	125	150	250
	75	75	75	150	200	200	400
	—	—	100	—	—	—	600
6	150	150	200	300	350	400	600
	—	—	—	—	400	—	1200

Circuit Breaker Application Chart ②

		Interrupting Rating (kA Symmetrical Amperes)		
Frame	Frame Rating (Amperes)	208/240 V	480 V	600 V
Standard Rating Molded Case Circuit Breakers				
HFD	150	65	65	25
HJD	250	65	65	25
HKD	400	65	65	35
HLD	600	65	65	35
NGH	1200	65	65	35
RGH	2500	65	65	50
High Interrupting Rating Molded Case Circuit Breakers				
FDC	150	100	100	35
JDC	250	100	100	35
KDC	400	100	100	50
LDC	600	100	100	50
NGC	1200	100	100	50
RGC	2500	100	100	65
Current Limiting Molded Case Circuit Breakers				
HFD/CL	150	100	100	100
HFD/CL	225	100	100	100
NBTRIPAC	300–800	100	100	100
Magnum DS Air Circuit Breakers				
MDS-608	800	65	65	65
MDS-C08	800	100	100	100
MDS-616	1600	65	65	65
MDS-C16	1600	100	100	100
MDS-620	2000	65	65	65
MDS-C20	2000	100	100	100
MDS-632	3200	65	65	65
MDS-C32	3200	100	100	100

Notes

① Suitable for use with NEMA Design B and D (high efficiency) motors.

② Refer back to charts for main breakers and feeder breakers for available product families.

Circuit breakers can be supplied with optional CPT and optional shunt trip.

Individual CPT Sizes

Starter Size	Standard Transformer (VA)	Maximum Size in Standard Unit (VA)
FVNR, FVR, 2S2W		
1, 2	100	150
1, 2–6	100	100
3, 4	150	250
5, 6	500	500
4	150	250
5	150	250
6	250	350
RVAT		
3, 4	150	250
5, 6	500	500
2S1W		
1, 2, 3, 4	200	250
5, 6	500	500
Vacuum		
4	150	250
5	150	250
6	250	350

Product Specifications

Structure

- NEMA 1, 2, 3R or 12 enclosure
- Copper horizontal bus 600–3200 A ①
- Fully rated copper vertical bus 600–1200 A
- Isolated vertical bus barrier standard on Freedom MCCs
- Optional insulated horizontal bus and/or insulated labyrinth vertical bus on Freedom MCCs
- Optional isolating barriers between structures ②
- Insulated horizontal bus and insulated labyrinth vertical bus is standard on Freedom arc-resistant and Freedom FlashGard MCCs
- Heavy-duty spring operated quarter-turn door latches
- 65 kA and 100 kA bus bracing ③

Units

- Freedom Motor Starters:
  - NEMA size 1–7 ④
  - Bimetallic overload relay
  - Single-phase protection
  - Class 10 and 20 protection
  - Widest heater range with fewest styles in the industry
  - Optional solid-state overload relays
- HMCP with combination starter ratings of 65 kAIC and 100 kAIC at 480 V ⑤
- Plug-in units up to 400 A
- Handle mechanism with positive trip indication
- Side-mounted positive latch terminal block
- Motor load terminal block is standard on FlashGard MCC and optional on Freedom and Freedom arc-resistant
- Compact units available
- Soft Starters:
  - S811+ (20–800 hp) ⑥
- Adjustable Frequency Drives:
  - MMX (1–10 hp)
  - SVX9000 (2–700 hp) ⑦
- K-Switch visible blade fused disconnect: ⑧
  - 30–800 A
  - 100 kAIC at 600 V
- 10250T 30.5 mm heavy-duty oiltight pushbuttons
- Surge protection:
  - SPD Series (100–400 kA)
- Energy monitoring:
  - IQ 100 (amperes, volts)
  - IQ 250 (adds, Hz, watts, PF)
  - IQ 260 (adds THD, Contact I/O)
  - IQ Analyzer (adds trending, waveform display)
  - Power Xpert (adds high-end metering, power quality analysis, open communications and Web server gateway)

Notes

① 800–2500 A copper horizontal bus available in Freedom arc-resistant MCC.
② Isolating barriers standard in Freedom arc-resistant MCC.
③ 65 kA bus bracing available in Freedom arc-resistant MCC. 100 kA not available.
④ NEMA size 1–5 motor starters available in Freedom arc-resistant MCC.
⑤ Starter combination ratings 65 kAIC maximum in Freedom arc-resistant MCC.
⑥ 20–200 hp S811+ soft starters available in Freedom arc-resistant MCC.
⑦ 2–200 hp SVX9000 drives available in Freedom arc-resistant MCC.
⑧ Fused disconnects not available in Freedom arc-resistant MCC

Freedom and Freedom FlashGard

Contents

Description

Motor Control Center Takeoff Check Sheet

Customer/Job Name	**Neg No.**
MCC Model	
Freedom	Freedom FlashGard
Service **60 Hz**	208 V/230 V/**480 V**/575 V
Service 50 Hz	380 V/415 V
DC	125 V/250 V
Three-wire/four-wire	
Structure Configuration	
16-inch front mount	21-inch front mount
21-inch front and rear mount	
42-inch front mount back-to-back	
32-inch front mount back-to-back	
NEMA 1A/2DP/12/3RNWI/3R aisle/3R tunnel	
Enclosure Modifications	
Space heaters (150 W) 120 V/240 V	
Channel sills	CBC/IBC seismic qualified
Thermostat	Split proof
Bottom plates	Split rear cover
Corner structure	Vertical section barrier
8-inch vertical wireway	Special paint color (adder)
	ABS Certification
Handle extensions (“two meter rule”)	
Top hat (certain sections)	12-inch/18-inch/24-inch
Top hat (all sections)	12-inch/18-inch/24-inch

Bus Rating and Options	
Horizontal bus	**600**/800/1200/1600
21-inch deep structure only	2000/2500/3200
Bus plating	Silver (AG)/**tin (SN)**
Bus temp rise	50 °C/**65 °C**
Insulated horizontal bus	
Vertical bus	600/800/1200
Ground bus	300/600/800
Location	**Top**/bottom
Vertical ground bus	Lugs: **incoming**/each end
Neutral bus (4 W only)	Half/full/**lug pad**
Bus bracing	42K/**65K**/100K
Vertical bus barrier	**STD Glastic sheet**
	Labyrinth with/without shutter
Incoming Line Metering	
IQ 130/140/150	
IQ 250/260	
IQ DP-4130	
IQ Analyzer	
Power Xpert 2250/2260/2270	
Power Xpert 4000/6000/8000	
Incoming Protection	
SPD Series surge protective device	
Incoming Line MLO/Breaker/Switch	
Cable—top/bottom/bus duct	
Main trip: LS/LSI/LSG/LSIG/other	
Crimp lugs	Screw type lugs
Main tie main (MTM)	Auto throw over
Kirk key	Service entrance (SUSE)

MCC Spec Review Checklist, continued

Breaker Options	
Aux. contacts (1NO 1NC) (2NO 2NC)	
LS/LSI/LSIG/LSG trip units	
Under voltage release	Shunt trip
Panelboards	
14/18/26/30/32/42 count	1-pole/2-pole/3-pole
Starter Disconnect Type	
HMCP/TM. bkr./fusible	
NEMA wiring class	
1A/**1B**/2B/1C/2C/1S/2S	
If any type "C" choose MTB location: Master terminal blocks (MTBs) top/bottom/relay structure	
Terminal Blocks	
Side latch pull apart (Std) (2x7-point)	
Spare points = _____% (call DSE)	Front utility (call DSE)
Nameplates: Black with White Letters / White with Black Letters	
Starter OL Types	
Bimetallic (C306)	Advanced solid-state (C441)
Solid-state (C440)	
Plug-In Starter Bucket Unit Features	
# 16 MTW wire	Coil surge suppression
# 14 SIS wire	Blown fuse indicators
# 14 MTW	Ground fault relays
Wiremarkers each end	
Ring wire lugs control	Riley current sensor
Spade wire lugs	Heater packs
Ring power wire lugs	
Wiring diagram on door	
SIS power wire	Vacuum contactors

Control Power	
Size 1 **100 VA** (Std)/150 VA max.	
Size 2 **100 VA** (Std)/150 VA max.	
Size 3 **150 VA** (Std)/250 VA max.	
Size 4 **150 VA** (Std)/250 VA max.	
Size 5 **250 VA** (Std)/300 VA max.	
Size 6 **250 VA** (Std)/300 VA max.	
Separate source power	
Auxiliary Starter Contacts	
NO 1/2/3/4	NC 1/2/3/4
Control Devices	
Pushbutton 1 unit/2 unit/reset	VoltageVision
Selector switch 2pos/3pos/4pos	Motorguard
Light—Std Xfmr/PTT/LED bulb	Motor load block
On/off run/stop	
Mini ETM	Panel ETM
AMM (mini/panel)	VM (mini/panel)
Riley transducer (Loop/Self Pwr)	
CTs for remote metering	
Ground fault	
IP relay—size 1/2/3/4/5/6	Voltage
Relays 300 V or 600 V	Timers
Communications	
DeviceNet direct	Modbus RTU
EtherNet/IP	Power Xpert Gateway
Modbus TCP	PROFIBUS DP
S811+ Soft Starters	
Isolation contactor	MOVs
Pump control software	Bypass starter
VFDs	SVX/MMX/CPX
EMI/RFI	Line fuses
dV/dT filter 600 ft or 1000 ft	3-contactor bypass
Harmonic Correction Unit	
50 A/100 A	

Component Count Sheet

FVNR Starters

Size	Quantity
1	
2	
3	
4	
5	
6	
7	

FVR Starters

Size	Quantity
1	
2	
3	
4	
5	
6	

Feeder Breakers

Single	Quantity	Dual	Quantity
50 A		50/50	
100 A		100/50	
150 A		100/100	
225 A		150/100	
250 A		150/150	
400 A			
600 A			
800 A			
1200 A			
1600 A			
2000 A			
2500 A			
3200 A			

VFDs

HP	Quantity	Type	
1.5		CT/VT	
2		CT/VT	
3		CT/VT	
5		CT/VT	
7.5		CT/VT	
10		CT/VT	
20		CT/VT	
25		CT/VT	
30		CT/VT	
40		CT/VT	
50		CT/VT	
60		CT/VT	
75		CT/VT	
100		CT/VT	
125		CT/VT	
150		CT/VT	
200		CT/VT	
250		CT/VT	
300		CT/VT	
400		CT/VT	
500		CT/VT	
600		CT/VT	
700		CT/VT	

Two Speed, One Winding

Size	Quantity
1	
2	
3	
4	

Two Speed, Two Winding

Size	Quantity
1	
2	
3	
4	

Fusible Feeders

Single	Quantity	Dual	Quantity
30 A		30/30	
60 A		60/60	
100 A			
200 A			
400 A			
600 A			
800 A			
1200 A			

Starter Circuit Protection	
HMCP	Thermal Magnetic
HMCPE	
Fusible	

Future Space

Size	Quantity
2X	
3X	
4X	

Relay Panels

Size	Quantity
2X	
3X	
4X	
5X	
6X	
7X	
8X	
9X	
10X	
11X	
12X	

Component Count Sheet, continued

Soft Starters

HP	Quantity	Duty	Cable Exit
20		Std/severe	
40		Std/severe	
60		Std/severe	
75		Std/severe	
125		Std/severe	
200		Std/severe	
300		Std/severe	Top/bottom
350		Std/severe	Top/bottom
450		Std/severe	Top/bottom
500		Std/severe	Top/bottom
600		Std/severe	Top/bottom
700		Std/severe	Top/bottom

Transformers

Single-Phase	Quantity	Three-Phase	Quantity
3 kVA		9 kVA	
5 kVA		15 kVA	
7.5 kVA		25 kVA	
10 kVA		30 kVA	
15 kVA		45 kVA	
20 kVA			
25 kVA			
30 kVA			
45 kVA			

Freedom Arc-Resistant MCC

Contents

Description

Motor Control Center Takeoff Check Sheet

Customer/Job Name	**Neg No.**
MCC Model	
Freedom Arc-Resistant	
Service **60 Hz**	208 V/230 V/**480 V**/575 V
Service 50 Hz	380 V/415 V
Three-wire/four-wire	
Structure Configuration	
42-inch front mount back-to-back	21-inch front mount
NEMA 1A/2DP	
Enclosure Modifications	
Space heaters (150 W) 120 V/240 V	
Channel sills	CBC/IBC seismic qualified
Thermostat	Split proof
Bottom plates	Split rear cover
Corner structure	**Vertical section barrier**
8-inch vertical wireway	Special paint color (adder)
	ABS Certification
Handle extensions (“two meter rule”)	

Bus Rating and Options	
Horizontal bus	**800**/1200/1600/2000/2500
Bus plating	Silver (AG)/**tin (SN)**
Bus temp rise	50 °C/**65 °C**
Insulated horizontal bus	
Vertical bus	600/800/1200
Ground bus	300/600/800
Location	**Top**/bottom
Vertical ground bus	Lugs: **incoming**/each end
Neutral bus (4W only)	Half/full/**lug pad**
Bus bracing	**65K**
Vertical bus barrier	Labyrinth with shutter
Incoming Line Metering	
IQ 130/140/150	
IQ 250/260	
IQ DP-4130	
IQ Analyzer	
Power Xpert 2250/2260/2270	
Power Xpert 4000/6000/8000	
Incoming Protection	
SPD Series surge protective device	
Incoming Line	
Breaker	
Cable—top/bottom	
Main trip: LS/LSI/LSG/LSIG/other	
Crimp lugs	Screw type lugs
Main tie main (MTM)	Auto throw over
Kirk key	Service entrance (SUSE)

MCC Spec Review Checklist, continued

Breaker Options	
Aux. contacts (1NO 1NC) (2NO 2NC)	
LS/LSI/LSIG/LSG trip units	
Under voltage release	Shunt trip
Panelboards	
14/18/26/30/32/42 count	1-pole/2-pole/3-pole
Starter Disconnect Type	
HMCP/TM. bkr.	
NEMA wiring class	
1A/**1B**/2B/1C/2C/1S/2S	
If any type "C" choose MTB location: Master terminal blocks (MTBs) top/bottom/relay structure	
Terminal Blocks	
Side latch pull apart (Std) (2x7-point)	
Spare points = _____% (call DSE)	Front utility (call DSE)
Nameplates: Black with White Letters / White with Black Letters	
Starter OL Types	
Bimetallic (C306)	Advanced solid-state (C441)
Solid-state (C440)	
Plug-In Starter Bucket Unit Features	
# 16 MTW wire	Coil surge suppression
# 14 SIS wire	Blown fuse indicators
# 14 MTW	Ground fault relays
Wiremarkers each end	
Ring wire lugs control	Riley current sensor
Spade wire lugs	Heater packs
Ring power wire lugs	
Wiring diagram on door	
SIS power wire	Vacuum contactors

Control Power	
Size 1 **100 VA** (Std)/150 VA max.	
Size 2 **100 VA** (Std)/150 VA max.	
Size 3 **150 VA** (Std)/250 VA max.	
Size 4 **150 VA** (Std)/250 VA max.	
Size 5 **250 VA** (Std)/300 VA max.	
Separate source power	
Auxiliary Starter Contacts	
NO 1/2/3/4	NC 1/2/3/4
Control Devices	
Pushbutton 1 unit/2 unit/reset	VoltageVision
Selector switch 2pos/3pos/4pos	Motorguard
Light—Std Xfmr/PTT/LED bulb	Motor load block
On/off run/stop	
Mini ETM	Panel ETM
AMM (mini/panel)	VM (mini/panel)
Riley transducer (Loop/Self Pwr)	
CTs for remote metering	
Ground fault	
IP relay—size 1/2/3/4/5/6	Voltage
Relays 300 V or 600 V	Timers
Communications	
DeviceNet direct	Modbus RTU
EtherNet/IP	Power Xpert Gateway
Modbus TCP	PROFIBUS DP
S811+ Soft Starters	
Isolation contactor	MOVs
Pump control software	Bypass starter
VFDs	SVX/MMX/CPX
EMI/RFI	
dV/dT filter 600 ft or 1000 ft	3-contactor bypass
Harmonic Correction Unit	
50 A/100 A	

Component Count Sheet

FVNR Starters

Size	Quantity
1	
2	
3	
4	
5	

FVR Starters

Size	Quantity
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2	
3	
4	
5	

Feeder Breakers

Single	Quantity	Dual	Quantity
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100 A		100/50	
150 A		100/100	
225 A		150/100	
250 A		150/150	
400 A			
600 A			
800 A			
1200 A			
1600 A			
2000 A			
2500 A			

VFDs

HP	Quantity	Type	
1.5		CT/VT	
2		CT/VT	
3		CT/VT	
5		CT/VT	
7.5		CT/VT	
10		CT/VT	
20		CT/VT	
25		CT/VT	
30		CT/VT	
40		CT/VT	
50		CT/VT	
60		CT/VT	
75		CT/VT	
100		CT/VT	
125		CT/VT	
150		CT/VT	
200		CT/VT	

Two Speed, One Winding

Size	Quantity
1	
2	
3	
4	

Two Speed, Two Winding

Size	Quantity
1	
2	
3	
4	

Starter Circuit Protection

HMCP	Thermal Magnetic
HMCPE	

Relay Panels

Size	Quantity
2X	
3X	
4X	
5X	
6X	
7X	
8X	
9X	
10X	
11X	
12X	

Future Space

Size	Quantity
2X	
3X	
4X	

Component Count Sheet, continued

Soft Starters

HP	Quantity	Duty	Cable Exit
20		Std/severe	
40		Std/severe	
60		Std/severe	
75		Std/severe	
125		Std/severe	
200		Std/severe	

Transformers

Single-Phase	Quantity	Three-Phase	Quantity
3 kVA		9 kVA	
5 kVA		15 kVA	
7.5 kVA		25 kVA	
10 kVA		30 kVA	
15 kVA		45 kVA	
20 kVA			
25 kVA			
30 kVA			
45 kVA			

Magnum DS Switchgear

Magnum DS Switchgear with Power Circuit Breaker

Contents

Cross-Reference

Aftermarket

Eaton's Low Voltage Assembly supports vintage and current switchgear breakers and parts that date as far back as the 1950s, including the Magnum® DS, DSII and SPB families.

For more information, refer to the following Eaton catalogs: CA08100014E, RP01301001E or call 1-800-BKR-FAST (257-3278).

For technical details of current product configurations, reference Eaton's *Consulting Application Guide* CA08104001E.

Product Description

Eaton's Magnum DS switchgear has a 50-year history of power circuit breaker and switchgear development that has set industry standards for quality, reliability, maintainability and extended operating life. Magnum DS switchgear is an assembled metal enclosure that houses drawout power circuit breakers and typically includes control and metering devices. Low voltage switchgear is applied at 600 V and less.

Application Description

Switchgear is used for protection, control and monitoring of low voltage distribution systems in all types of industrial, commercial and utility environments requiring up to 600 V distribution between 1600 A and 10,000 A continuous loads, and between 42,000 A and 200,000 A interrupting current.

Product Offering

- Indoor NEMA 1
- Rear access
- Front access
- Arc resistant (2B)
- Integrated switchboard, MCC and ATS
- Unit substation transformer integration
- Outdoor NEMA 3R rear access
- Outdoor NEMA 3R front access

Features, Benefits and Functions

Standard Finish—The light gray paint finish (ANSI 61) uses a modern, completely automated and continuously monitored electrostatic powder coating. This continuously monitored system includes spray de-grease and clean, spray rinse, iron phosphate spray coating spray rinse, non-chemical seal, oven drying, electrostatic powder spray paint coating and oven curing.

Integral Base—The rugged formed base greatly increases the rigidity of the structure and reduces the possibility of damage during the installation of the equipment and is suitable for rolling, jacking and handling. A lifting angle is permanently welded into the bus compartment structure for increased strength.

Heavy-Duty Door Hinges—Each breaker door is mounted with hinge pins. Removal of the door is easily accomplished by just lifting the hinge pin. This allows easy access to the breaker internal compartment for inspection and maintenance.

Rear Cover/Doors—In Magnum DS Switchgear, standard rear covers with captive hardware are the bolt-on type. They are split into two sections to facilitate handling during removal and installation. Optional rear doors are also available.

Through-the-Door Design—The following functions may be performed without the need to open the circuit breaker door: levering the breaker between positions, operate manual charging system and view the spring charge status flag, close and open breaker, view and adjust trip unit, and read the breaker rating nameplate.

Through-the-Door Design

Front Accessible—When the door is open or removed, each breaker compartment provides front access to isolated, vertical wireways, primary disconnects, cell current transformers and other breaker compartment accessories for ease of field wiring and troubleshooting field connections.

Four-Position Drawout—Breakers can be in connected, test, disconnected or removed position. The breaker compartment door can be closed in the connected, test and disconnected positions.

Closing Spring Automatic Discharge—Mechanical interlocking automatically discharges the closing springs when the breaker is removed from its compartment.

Breaker Cell

Breaker Inspection—When withdrawn on the rails, breaker is completely accessible for visual inspection; tilting is not necessary. The rails are permanent parts of every breaker compartment.

Interference interlocks are supplied on breakers and in compartments where the compartments are of the same physical size to ensure that an incorrect breaker cannot be inserted.

Features—Bus

Buses and Connections—Vertical and cross bus ratings in Magnum DS Switchgear are based on a UL® and ANSI standard temperature rise of 65°C above a maximum ambient air temperature of 40°C.

Bus Ampacities—Vertical and cross bus ratings in Magnum DS are 2000, 3200, 4000, 5000 and 6000 amperes. In addition, 8000 and 10,000 amperes continuous cross bus ratings are also available.

Bus Bracing—Unique vertical bus configuration provides an optional short-circuit withstand rating of 150,000 amperes without the need for preceding current limiting fuses. Standard bracing is 100,000 amperes. The U-shaped bar is the heart of the Magnum DS vertical bus. This configuration provides a much higher mechanical strength. To further demonstrate the strength and rigidity of this bus system, it has been verified through testing to withstand 85,000 amperes short-circuit for a full 60 cycles.

Silver Plating—Bolted, silver-plated copper main buses are standard. The plating is over the entire length of the bar, not just at the joints. Optional tin-plated copper buses are available.

Bus Joints—All joints are bolted and secured with Belleville-type spring washers for maximum joint integrity. These washers reduce the potential of joint hardware loosening during the change of joint temperature associated with variations of the loads. As an option, maintenance-free hardware can be provided.

Full Neutral—For four-wire applications, the neutral bus is rated 100% of main bus rating as standard.

Ground—A ground bus is furnished for the full length of the switchgear assembly and is fitted with terminals for purchaser's connections.

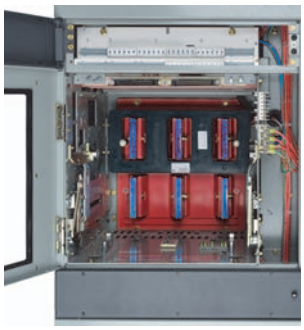
Glass-Reinforced Polyester Stand-Off Insulation System—Glass-reinforced polyester has been used on both low and medium voltage switchgear for decades. By combining this industry-proven material with our other insulation materials, a total system providing exceptional mechanical and dielectric withstand strength, as well as high resistance to heat, flame and moisture, is produced. Substantial testing to demonstrate accelerated effects of heating and cooling on the mechanical and dielectric properties of this system prove it to provide superior performance for decades of trouble-free operation.

Features—Wiring

Cable Compartment—The cable compartment gives ample room for terminating the power cables. Removable top roof sheets allow for easy conduit hub installation. The floor of the cable compartment is open to allow cable entry from underground duct banks. Optional floor plates are available.

Lug Pad—The lugs are located on the breaker run-backs to accommodate lug orientations at a 45° angle to reduce the bending radius of the cable needed for making the connections, thus reducing installation and maintenance time. Mechanical setscrew type lugs are standard. Optional NEMA two-hole compression lugs are available as an option.

Control Wireway—An isolated vertical wireway is provided for routing of factory and field wiring in each switchgear section. Breaker secondary terminal blocks are mounted as standard above each circuit breaker. The terminal blocks are rated 30 amperes and will accept bare wire, ring or spade terminals for wire size ranges of #22 to #10. Extruded loops are punched in side sheets of the vertical wireway to allow securing of customer control wiring without the use of adhesive wire anchors.



Control Wireway

Control Wire—Standard wire is Type SIS insulated stranded copper, extra flexible No. 14 AWG minimum.

Control Wire Marking—Each wire is imprinted with ink cured under ultraviolet light for durability and for easy identification by the user. The enhanced solvent resistance and durability of the aerospace-grade UV cure ink has been tested for severe environments. The imprinting is made periodically along the length of the wire, with the ends being imprinted more frequently. The point of origin, wire designation and point of destination are imprinted in the following format: <origin zone/wire name/destination zone>. Each device has a uniquely designated zone. "<" indicates the direction of the wire origination and ">" indicates the direction of the wire destination. As an option, wire marking can be made using sleeve type or heat shrink sleeve type.

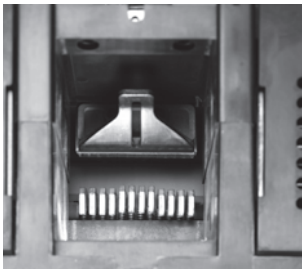
Control Wire Marking

Secondary Terminal Compartment Door—The customer's secondary terminal connections are located behind a separate door providing access to these connections without the need to open the breaker compartment door.

Shipping Split Connection—At each shipping split, the control connections are made with plug-in terminal blocks rated 600 volts, 40 amperes. The terminal blocks interlock mechanically without removing the line or load connections. This method of making the shipping split control connections increases the speed of installation and reduces the potential of incorrect connections.

Features—Breaker Contacts—The Magnum DS has silver tungsten moving contacts and silver graphite stationary contacts. The contacts provide a long-wearing, low-resistance joint. The contacts are protected from arcing damage even after repeated interruptions by the "heel-toe" action that causes the integral arcing contacts to mate before the main contacts part. The arcing contacts then part last, striking the arc away from the main contacts.

The main contacts are of the butt type and are composed of a multiplicity of fingers to give many points of contact without alignment being critical.



Magnum DS Breaker Contacts (Arc Chutes Removed)

Stored-Energy Mechanism—A cam-type closing mechanism closes the breaker. It receives its energy from a spring that can be charged by a manual handle on the front of the breaker or by a universal electric motor.

Release of the stored energy is accomplished by manually depressing a button on the front of the breaker or electrically energizing a releasing solenoid.

Arc Chute—There are three basic means of extinguishing an arc: lengthening the arc path; cooling by gas blast or contraction; and deionizing or physically removing the conduction particles from the arc path.

The DE-ION® principle is incorporated in all Magnum DS circuit breakers. This makes possible faster arc extinction for a given contact travel, and ensures positive interruption and minimum contact burning.

Levering Mechanism—The worm gear levering mechanism is self-contained on the breaker drawout element and engages slots in the breaker compartment. A removable crank is used to lever the breaker between the connected, test and disconnected positions.

Mechanical interlocking is arranged so that levering cannot be accomplished unless the breaker is in the opened position.

Protection During Levering Operation—When levering the breaker between the connected, test and disconnected positions, the operator is protected from contact with live parts by the breaker door.

Levering Magnum DS Breaker

True Two-Step Stored Energy Closing—This sequence is required to charge and close the breaker.

The breaker closing springs are charged either through the manual-charging handle or by the optional charging motor. The breaker is mechanically interlocked to prevent closing of the breaker until the closing springs are fully charged.

With the closing springs fully charged, the breaker can then be closed by pressing the manual close pushbutton on the breaker, or by the optional spring release coil through a remote electrical signal.

This means that the energy required to open the breaker is always prestored following a closing operation.

"Stored energy" is energy held in waiting, ready to open or close the breaker within five cycles or less. The unique cam and spring design provides necessary energy for a single close-open sequence, as well as the energy for multiple charge-close operations such as this possible sequence: charge-close-recharge-open-close-open.

The closing springs are interlocked with the breaker racking mechanism to ensure that the closing springs are discharged before the breaker can be removed from the compartment.

Manually Operated Breakers—Manually operated breakers are equipped with a manual charging handle to charge the closing springs. Manual closing and tripping pushbuttons are utilized to operate the breaker. Remote closing and tripping can be accomplished by installing optional electric spring release and shunt trip coils. The breaker closing springs must be charged manually, then remote closing and tripping signals can be sent to the breaker.

Electrically Operated Breakers—Electrically operated breakers are equipped with a spring charging motor and electrically operated spring release and shunt trip coils. The breaker manual charging handle can be used to charge the closing springs when power is not available to the charging motor.

Provisions for Padlocking—All breakers include provision for padlocking open to prevent electrical or manual closing. This padlocking can secure the breaker in the connected, test or disconnected position by preventing levering of the breaker.

Ease of Inspection and Maintenance—Magnum DS breakers are designed for maximum accessibility and the utmost ease of inspection and maintenance.

Magnum DS Switchgear—Trip Units

Digitrip® RMS Trip Unit—The Digitrip RMS trip units feature a dependent curve that is depicted in the nameplate by a blue shaded area of the trip curve. The dependent curve affords better protection flexibility. Additionally, all of the trip units have, as standard, thermal memory, 50/60 Hz operation and thermal self-protection at 90°C.

Digitrip RMS Integral Microprocessor-Based Breaker Overcurrent Trip Systems—These systems provide maximum reliability with true rms sensing as standard, gives excellent repeatability, and requires minimum maintenance. No external control source is required for its protective functions.

Trip Functions—Magnum DS trip units provide the maximum in flexibility and are available in the following configurations: LSI, LSIG and LSIA (ground fault alarm only). In each case, either the short delay or the instantaneous function (not both) may be defeated. This reduces the need for spare breaker inventories and provides maximum utilization of interchangeable breakers.

Accessories

Magnum Remote Racking Device (MRR1000)

The MRR1000 permits the operator to remotely open and close a breaker from up to 25 feet away during the rack-in or rack-out process, a distance well beyond the arc flash boundary for traditional LV switchgear.

For more information, refer to product documentation PA01900008E.

Digitrip Test Kit (MTK2000)

The MTK2000 Trip Unit Test Kit is used to test and verify the pickup levels and time delay settings of a breaker's trip unit.

For more information, refer to technical documentation IL01906008E.

Standards and Certifications

Magnum DS Switchgear assemblies have undergone an extensive seismic qualification program. The test program utilized ANSI standard C37.81, the Uniform Building Code® (UBC) and the California Building Code (CBC) as a basis for the test program. The assemblies have been tested and qualified to exceed these requirements.

Magnum DS Switchgear conforms to the following standards: CSA®, ANSI C37.20.1, C37.51, and UL Standard 1558, and is built in an ISO® certified facility.

American Bureau of Shipping (ABS) certification is also available.

Contact Eaton for details and part numbers for CSA-approved units.

Product Selection

Refer to TB1901001E for application data.

Contact Eaton for configurations, pricing and availability.

Technical Data and Specifications

Product Specifications

Refer to Section 16426A of the *Product Specification Guide*.

Available Bus Ratings

Cross Bus Ampacity	Bus Bracing kA	Vertical Bus Ampacity
2000	100, 150, 200	2000
3200	100, 150, 200	3200
4000	100, 150, 200	4000
5000	100, 150, 200	5000
6000	100, 150, 200	①
8000	100, 150, 200	—
10,000	100, 150, 200	—

Vertical section bus is sized per main cross bus maximum rating or by ANSI C37.20.1 Section 7.4.13 Table 11 to a maximum of 5000 amperes.

Note: In addition to the available bus bracings shown above, the bus has been tested for short-circuit values of 85,000 amperes for a full 60 cycles.

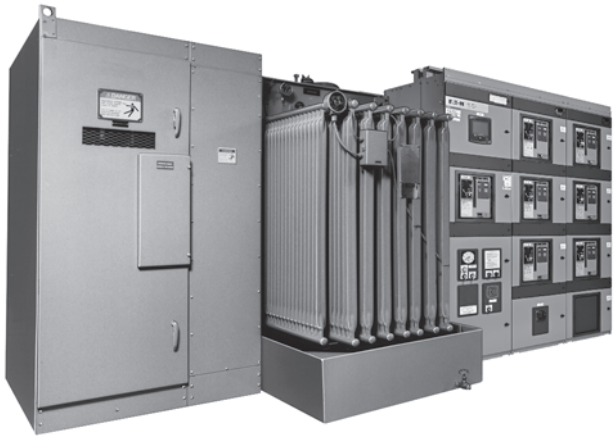
Magnum DS Breaker Ratings

For Magnum breaker ratings, refer to the power circuit breaker section of Eaton's *Consulting Application Guide* CA08104001E.

Note

① 6000 amp riser available in true 44-inch sections.

MVS Primary Switch and Low Voltage Metal-Enclosed Switchgear



Contents

Product Description

Unit Substations

Most switchgear assemblies are configured as unit substations.

A unit substation, as referred to in this publication, is defined as a coordinated assembly consisting of three-phase transformers with high-voltage incoming line sections and an assembly of low voltage distribution sections.

Unit substations may be indoor or outdoor, with a selection of high voltage incoming sections, a choice of transformer types and an arrangement of switchgear to suit the application.

Eaton's unit substations follow the system concept of locating transformers as close as practicable to areas of load concentration at usage voltages, thus minimizing the lengths of secondary distribution cables and buses. This concept provides several basic advantages, such as:

- Reduced power losses
- Improved voltage regulation
- Improved service continuity
- Reduced likelihood of faults
- Increased flexibility
- Minimized installation expense
- Elimination of the need for vaults due to availability of non-flammable types of transformers
- Efficient space utilization

Application Description

Advantages of Unit Substations

- Complete coordination, both mechanical and electrical
- Extreme flexibility with wide choice of components and ratings to meet exact application requirements
- Optimum safety to operators
- Modern design
- Meets all applicable ANSI, IEEE®, NEMA and UL standards

Product Selection

Unit substations are engineered to order and have multiple configurations. Contact Eaton for configurations, pricing and availability.

Unit Substations

	Description	Industry Applications	Standards
Dry-Type Transformers 	**Dry-Type Transformers** ■ VPI, VPE, RESIBLOC®, Cast ■ 113 kVA–25 MVA ■ Up to 46 kV, 150 kV BIL primary ■ Up to 15 kV secondary	■ Commercial and institutional ■ Industrial users (petrochemical, oil & gas, pulp & paper/forest) ■ Utilities	■ ANSI C57.12.01/C57.12.91 ■ UL available ■ Seismic Zone 4 certification
Liquid-Filled Transformers 	**Liquid-Filled Transformers** ■ Primary and secondary unit substations, power substations ■ 112.5 kVA–20 MVA ■ Up to 69 kV primary ■ Up to 34.5 kV secondary ■ Mineral oil, R-Temp®, silicone or BIOTEMP™	■ Commercial and institutional ■ Industrial users (petrochemical, oil & gas, pulp & paper/forest) ■ Utilities	■ Complies with ANSI C57.12.00 and C57.12.90, CSA–C88 ■ UL, FM available ■ Seismic Zone 4 certification
Pad-Mounted Transformers 	**Pad-Mounted Transformers** ■ Small 75–3000 kVA ■ Large 3000–7500 kVA ■ Up to 34.5 kV high voltage ■ Up to 5 kV low voltage ■ Underground cable fed ■ Mineral oil, R-Temp, silicone or BIOTEMP	■ Commercial and institutional ■ Industrial users (petrochemical, oil & gas, pulp & paper/forest) ■ Utilities	■ Complies with ANSI C57.12.00 and C57.12.90, CSA–C88 ■ UL, FM available ■ Seismic Zone 4 certification

Medium-Voltage Motor Control Assemblies

Arc Resistant Ampgard

5.1 Ampgard Motor Control

5

Ampgard Motor Control Assembly with Main Breaker, SC 9000 AFD, RVSS and Two-High FVNR

Contents

Product Description

Eaton's Ampgard® medium-voltage starter family provides flexibility never before available. Rated at 2200–15,000 volts up to 8000 hp, they are the first starters designed as integrated, complete units precisely matched to motor ratings, and engineered to provide component-to-component circuitry and front accessibility of all components and terminals. Ampgard starters are used in a variety of industrial process applications, such as pulp and paper, petrochemical, HVAC (chillers), where proper control and protection of the motor and system are critical to the user. Ampgard has been the industry leader in medium-voltage motor control for over 60 years in these applications, and our starters have been designed with that experience behind them.

Application Description

Ampgard starters are equipped with current limiting power fuses to interrupt the short-circuit faults shown below. The contactor and fuses are completely coordinated.

Squirrel Cage Motor Starters: Starters for squirrel cage motors are available in full or reduced voltage designs in all ratings. Full voltage starters are available one-high or two-high in a factory-assembled structure. Electromechanical reduced voltage starters are available in either reactor or autotransformer type. Both provide closed transition from reduced to full voltage. See table on **Page V3-T5-6** for application data.

SC 9000 Adjustable Frequency Drive (AFD)

This newest member of the Ampgard family was designed for maximum flexibility in the control of medium-voltage motors. The SC 9000™ combines innovative technology with the reliable design and construction the industry has come to expect of the Ampgard products. Rated at 2400 volts up to 2500 hp and 4160 volts up to 4500 hp, the SC 9000 delivers the smallest footprint in the industry. The standard 24-pulse phase shifting isolating transformer and rectifier minimizes any harmonic noise sent back on to the supply.

The SC 9000 is a fully integrated, three-line-in—three-line-out, plug-and-play product that includes highly reliable Ampgard medium-voltage components on the input (isolation switch, power fuses and SL vacuum contactor), isolating transformer, rectifier, inverter and controls. The SC 9000 uses the same keypad and programming software as the Eaton SVX9000 line of low-voltage drives for a reliable, easy-to-use system that does not require time spent in learning new software. In addition, the SC 9000 can interface with many control systems, such as Modbus®, Ethernet, DeviceNet™, CANbus® and PROFIBUS® DP.

In an industry first, the SC 9000 can be placed in a lineup with other Ampgard and Eaton motor control products on a common bus known as Ampgard Medium-Voltage Integrated Control Gear. Now, all types of motor starters, load break switches, integrated AFDs, AFD synchronous transfer control, AFD bypasses, and main and feeder breakers can be integrated into a single line. The Integrated Control Gear capabilities and reliable design make the SC 9000 the perfect choice for speed control in industries such as petrochemical, water/waste water, utility, HVAC, pulp and paper, and many more.

Reduced Voltage Solid-State Starters: Offered as an alternative to traditional reactor or auto-transformer type reduced voltage starter, the Ampgard RVSS allows the user to fine-tune starting parameters to meet a wide variety of unique load conditions. The onboard user-friendly microprocessor provides the ability to select the proper combination of initial current, maximum current and ramp time, resulting in smooth, stepless load acceleration while minimizing mechanical shock to system components.

The Ampgard RVSS is available as a standalone starter or can be incorporated into a lineup with other Ampgard starters. Adding to an existing Ampgard installation is easy via a simple splice kit. Starters are available in 400 ampere and 720 ampere frame sizes.

Arc-Resistant Ampgard: When specified, Ampgard is available in special arc-resistant construction. Ampgard AR is available in a 49 kA, 0.5 second, Type 2B rating, and is supplied with a plenum and exhaust ducts to carry an internal arc fault away from the operator and into a remote isolated area. Type 2B construction is defined as arc-resistant at front, back and sides of the enclosure with the low-voltage compartment door open. All types of 400 ampere and 800 ampere starters, as well as 24-inch wide incoming cable sections are available in arc-resistant construction. Ampgard and LBS Load Break Switches are not available in arc-resistant construction. Consult Eaton for more details.

Main Breaker Ampgard (MBA): The MBA is the industry's first truly integrated medium-voltage metal-enclosed main breaker and starter assembly combination.

The MBA comprises a metal-enclosed drawout vacuum circuit breaker section that is integrally connected via main bus to the balance of the Ampgard starter assembly it protects.

The main bus configuration is in the same top-mounted location as on all Ampgard assemblies, allowing for ease of installation with adjacent sections and addition for future sections.

Front aligned, rear aligned, or front and rear aligned with back-to-back starters are available.

The main breaker is the industry-leading Type VCP-W drawout vacuum circuit breaker, which provides the performance our customers expect.

Lead-time is dramatically reduced, typically 50% less than the industry norm. Our single-source approach has cut delivery time from months to weeks. The extended waiting period between order placement and delivery has been eliminated.

Other Motor Starters: Starters for wound rotor and multispeed motors are available. However, each application must be reviewed for proper motor protection and operation. Refer to the factory for pricing and equipment details.

Features, Benefits and Functions

Personnel Safety: A positive mechanical isolating switch with visible disconnect completely grounds and isolates the starter from the line connectors with a mechanically driven isolating shutter, leaving no exposed high-voltage. Additional safety features include:

- Isolated cable entry for added safety. The starters and cables are completely isolated from each other by steel barriers
- All new low-voltage wireway. Low-voltage wire is isolated from the medium-voltage compartment, and customer terminal blocks are accessible through the low-voltage control panel
- Easily accessible low-voltage panel completely isolated from the medium-voltage compartment that offers generous device mounting space
- Standard viewing window for visual verification of isolation switch operation
- Optional remote operator for isolation switch allows user to open and close switch while remaining outside the equipment flash boundary

Ease of Installation: Current limiting fuses, contactor assembly and isolating switch assembly are easily removed from the enclosure; line and load terminals are completely accessible from the front. Standard structures are 36.00 W x 92.00 H x 30.00 in D (914.4 W x 2336.8 H x 762.0 mm D) including a 12.00 in (304.8 mm) top-mounted main bus compartment. The main bus compartment is top, side and front accessible, making maintenance and lineup extensions easy.

Ease of Maintenance: All components are front accessible, facilitating routine inspection or parts replacement. Isolation switch life is 10,000 operations.

Vacuum Contactor: The Type SL vacuum contactors were designed and engineered specifically for use in Ampgard starters. They are self-supporting, compact, bolt-in or stab-in three-pole contactors. The contactors utilize a solid-state control board, allowing the user maximum flexibility to change control voltages and dropout times in the field, simply by adjusting DIP switch settings. To permit application matching of the starter to the motor rating, contactors are available for 2200–7200 volts at ratings of 400 and 800 amperes, and 15 kV at 250 amperes.

The 400 ampere contactor interrupting rating is the highest in the industry at 8500 amperes, allowing for higher levels of coordination with power fuses. The 800 ampere contactor has an interrupting rating of 12,500 amperes, also the highest in the industry.

Note: For full starter/contactor horsepower ratings and other technical data (including power fuse coordination), refer to Volume 4, Tab 3.

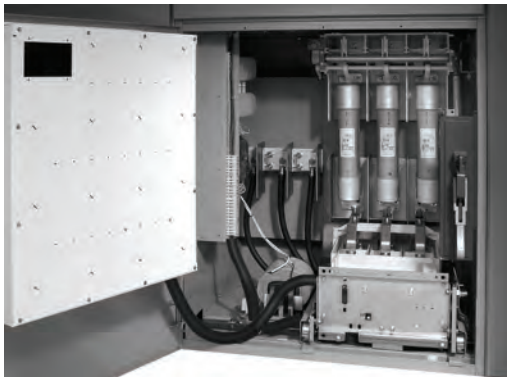
Motor Protective Relay: When a motor protective relay is required, the Ampgard starters are provided with the EMR-3000 or EMR-4000 microprocessor-based motor protective relay as standard. This package offers benefits like a 20-cycle voltage sag ride-through, UL 1053 certification for ground fault sensing that is internal to the relay, arm/disarm capability, a drawout case option, Intel-I-Trip overload protection for custom curve setting to precisely match your motor's requirements, and optional PowerNet™ or Modbus communications capability.

15 kV Starter: A 15 kV rated Ampgard starter is available with the same features and capabilities as described for the 7.2 kV rated starter. The starter is supplied with a 300 ampere vacuum contactor and three power fuses (maximum 400 amp) for motors rated to 7500 horsepower. These starters may be supplied with the Eaton InsulGard™ relay for partial discharge detection.

Low-Voltage and High-Voltage Compartments

Isolated Low-Voltage Control Panel

Optional Stab-In Contactor, Bolted Main Fuses and Optional Blown Fuse Indicator



Standards and Certifications

UL and CSA Certification

Ampgard starters are designed, assembled and tested to meet all applicable standards. Ampgard meets ANSI, NEMA® and IEC standards, and is UL, CSA, cUL® and KEMA third-party certified. The major components, i.e., contactor, isolating switch, fuses, MP-3000, MP-4000, IQ DP-4000 and IQ Analyzer, are UL recognized.

UL or CSA labeling of a specific starter requires review to ensure that all requested modifications and auxiliary devices meet the appropriate standards. Refer to factory when specified.

Arc-resistant Ampgard is tested to IEEE C37.20.7-2007.

Seismic Certification

Ampgard starters are seismically tested and seismically qualified, and exceed requirements of both the International Building Code (IBC) and California Building Code Title 24.

Reference Information

- Ampgard Brochure **BR02003002E**
- Ampgard RVSS Brochure **PA02003003E**
- Renewal Parts **RP.48J.01.T.E** and **TD020001EN**
- Ampgard Main Breaker **PA020003EN**
- Remote Operator **PA02003002E**
- Arc-Resistant Ampgard **SA02003003E**
- 720A RVSS **PA02000001E**

Product Selection

Ampgard RVSS

Ampgard RVSS

Description	Catalog Number
400 A RVSS	**SP10B4B**
720 A RVSS	**SP10B8S**

Main Breaker Ampgard

Main Breaker Ampgard

Description	Catalog Number
1200 A, 250 MVA Main Breaker	**BLR12**
2000 A, 350 MVA Main Breaker	**BLR23**
3000 A, 350 MVA Main Breaker	**BLR33**

15 kV Starter with InsulGard

15 kV Starter

Description	Catalog Number
13.8 kV FVNR Starter	**S210B2SBB**
13.8 kV Autotransformer Starter	**S610B2SBB**

Technical Data and Specifications

Main Breaker Ampgard

Description	Ratings Amperes	Volts	Horsepower
Main breaker	1200, 2000 and 3000	2200–7200	—
Starters	400 and 800	2200–7200	Up to 8000
Starters	250	10,000–15,000	Up to 5000

Starting Characteristics

Starter Type	% Motor Voltage	% Motor Current	% Line Current	% Torque
Reactor Reduced Voltage				
80% tap	80	80	80	64
65% tap ①	65	65	65	42
50% tap	50	50	50	25
Autotransformer Reduced Voltage				
80% tap	80	80	67	64
65% tap ①	65	65	45	42
50% tap	50	50	28	25

Interrupting Capacity—kVA

Starter Maximum Horsepower	NEMA Class E2 2300 Volt	4600 Volt	6600 Volt
3000	200,000	—	—
5000	1,190,000	—	—
5500	—	400,000	—
8000	—	—	570,000

Note

① Factory set on 65% tap.

Medium Voltage Metal-Enclosed Switches

Outdoor Medium Voltage Switch

Outdoor Medium Voltage Switch

Contents

Introduction

Product Selection Guide

Product Offering Chart—Metal-Enclosed ①

Description	MVS	MEB	MSB	UPC	Mini-MVS
Voltage	5, 15, 27, 38 kV	5, 15 kV	5, 15 kV	5, 15 kV	5 kV only
Operation duty cycle	Low	High	High	Low	Low
Enclosure	Indoor, outdoor aisleless	Indoor, outdoor aisleless	Indoor, outdoor aisleless	Indoor only	Indoor, outdoor aisleless
Listed	UL®, CSA®	—	—	—	UL, CSA
Assembly standards	ANSI/IEEE®, C37.30.3, C37.20.4, C37.22, C37.57, C37.58, CSA 22.2 #31 ②	ANSI/IEEE, C37.30.3, C37.20.4, C37.22, C37.57, C37.58, CSA 22.2 #31	ANSI/IEEE, C37.30.3, C37.20.4, C37.22, C37.57, C37.58, CSA 22.2 #31	—	ANSI/IEEE, C37.30.3, C37.20.4, C37.22, C37.57, C37.58, CSA 22.2 #31 ②
Circuit breaker type	N/A	VCP-W	VCP-TR (5, 15 kV), VCP-W 27 kV	N/A	N/A
Circuit breaker mounted	N/A	Drawout	Fixed	N/A	N/A
Seismically rated Zone 4 to California Building Code Title 24	Yes	Yes	Yes	Yes	Yes
BIL ratings	60 kV (5 kV)	60 kV (5 kV)	60 kV (5 kV)	60 kV (5 kV)	60 kV (5 kV)
	95 kV (15 kV)	95 kV (15 kV)	95 kV (15 kV)	95 kV (15 kV)	
	125 kV (27 kV)		125 kV (27 kV)		
	150 kV (38 kV)				
Main bus ratings	800, 1200A (5/15/27/38 kV)	800, 1200A (5/15 kV)	800, 1200A (5/15/27 kV)	N/A	N/A, cable in, cable out application
Breaker ratings	N/A	1200A (5/15 kV)	600, 800, 1200A (5/15/27 kV)	N/A	N/A
Overcurrent protective device	Yes (fused)	Yes	Yes	Yes (fused)	Yes (fused)
Short-circuit interrupting capacity	Per fuse IC	29, 41, 63 kA (5 kV)	16, 20, 25, 40 kA (5/15 kV)	Per fuse IC	Per fuse IC
		18, 28, 37, 63 kA (15 kV)	25 kA (27 kV)		
Conduit entry	Top or bottom	Top or bottom	Top or bottom	Top or bottom	Top or bottom

Notes

① Additional products not shown include medium voltage transfer, high resistance ground and low profile switchgear.

② Listings are voltage dependant. See individual product sheets for detail.

Indoor Medium Voltage Switch—MVS Bus Connection to Dry-Type Transformer

Contents

An Eaton Green Solution

Product Description

Eaton's MVS load interrupter switchgear is a metal-enclosed assembly consisting of a switch, bus and fuses.

MVS switchgear is available in one or more vertical section assemblies. The three-pole switch will interrupt its rated load current with its quick-make, quick-break mechanism. Optional fuses ensure short-circuit protection at all times.

MVS Arc-Resistant

Eaton's 5/15 kV MVS metal-enclosed load interrupter switchgear is now available with arc-resistant construction with accessibility Type 2B in accordance with IEEE C37.20.7. MVS arc-resistant switchgear is designed for indoor use. It can also be used outdoor with space heaters. It can be configured for a variety of applications. Switches can be supplied with manual or electrical operating mechanisms and with or without primary fuses. Per IEEE C37.20.7, the Type 2B accessibility rating provides arc-resistant features and protection at the freely accessible exterior (front, back and sides) of the equipment as well as in front of the instrument/control compartment with the instrument/control compartment door opened while the equipment is energized and operating normally.

Application Description

MVS switchgear provides safe, reliable switching and fault protection for medium voltage circuits where high duty cycle operation is not needed.

- Single switch and transformer primary
- Duplex switch
- Selector switch
- Automatic transfer control

Features, Benefits and Functions

Quick-make, quick-break mechanism: A reliable heavy-duty coil spring mechanism drives the switch blades at high speed into either the open or the closed position. The speed of operation is independent of the person operating the switch.

Direct drive mechanism: A metal-to-metal direct drive mechanism eliminates chains or cables that may break or need adjusting.

DE-ION® arc interruption: DE-ION arc chambers and spring-loaded auxiliary blades ensure fast load current interruption and eliminate arcing damage to the main contacts.

Positive switch position indication: Red and green multilingual (English/Spanish/French) labels located directly on the switch operating mechanism give visual indication of switch position.

Interlocked for safety: Mechanical interlocks prevent closing the switch when the compartment door is open, or the opening of the door when the switch is closed.

Safety under fault conditions: The switch, depending upon the rated voltage, is available with three or four fault-closing operations with ratings up to 61,000 amperes rms asymmetrical, exceeding the industry standards one time operation.

Safety barrier: A hinged solid metal barrier with a perforated metal viewing area shields the disconnect switch when the compartment door is opened.

Short-circuit protection: A full range of Eaton fusing options is available for short-circuit protection.

Eaton's SF_6-free switchgear: Eaton medium voltage switchgear use vacuum switches combined with solid insulation material. This environmentally-friendly technology avoids the use of SF_6 as an insulation gas.

Standards and Certifications

MVS switchgear meets or exceeds IEEE® C37.20.3 as it applies to metal-enclosed switchgear.

Either Underwriters Laboratories® (UL) or Canadian Standards Association® (CSA) listing is available for MVS switchgear in many configurations, with a number of options.

MVS switchgear is available seismically qualified to meet the requirements of the Uniform Building Code® (UBC), California Title 24 and BOCA® requirements in many configurations with a number of options.

Reference Information

See *Consulting Application Guide* for detailed list of ratings and options. For renewal parts, see CA08105001E.

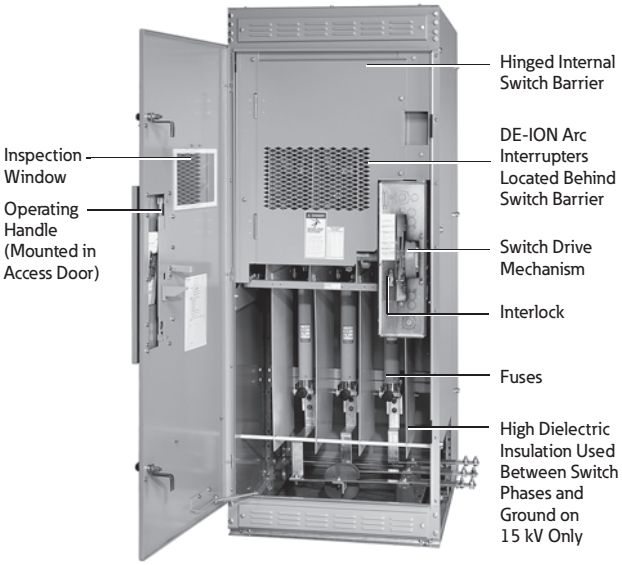
Product Selection

Contact Eaton for pricing.

Technical Data and Specifications

- Rated maximum voltage classes of 5, 15, 27 and 38 kV
- Rated impulse levels, kV BIL: 60, 95, 125, 150
- Continuous and load-break ratings: 600 amperes available at all voltage classes; 1200 amperes available at 5 and 15 kV
- Designs available in indoor and outdoor non-walk-in configurations
- Manual or motor operated

Indoor Medium Voltage Switch—MVS Bus Connection to Dry-Type Transformer



Indoor Medium Voltage Switch and Fixed Breaker—MSB

Contents

An Eaton Green Solution

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Product Description

Eaton's MSB switchgear is an integrated assembly of a visible load-break disconnect switch, fixed-mounted vacuum circuit breaker, and control devices that are integrated electrically and mechanically for circuit protection. All major components are manufactured by Eaton, establishing one source of responsibility for the equipment and ensuring high standards in quality, coordination, reliability and service. MSB switchgear would typically be used where both cost and protection are important design parameters.

Application Description

Applications include ground fault protection, primary and/or secondary switching, and protection on unit substations, automatic transfer switching at medium voltage levels, capacitor switching, high duty cycle and tight system coordination protection.

MSB switchgear can also be an economic benefit in single-ended substations because it may allow the customer to eliminate the secondary main protection and switching device.

- Low resistance ground schemes
- Single-ended substation designs
- Overcurrent protection

Features, Benefits and Functions

- Visible isolation
- Fully rated fixed vacuum circuit breaker
- Electrical operation
- No fuses
- Improved coordination capability
- Improved transformer protection
- Ground fault protection
- Capacitor switching
- High switching duty cycle
- Integral overcurrent protection

Eaton's SF_6-free switchgear: Eaton medium voltage switchgear use vacuum switches combined with solid insulation material. This environmentally-friendly technology avoids the use of SF_6 as an insulation gas.

Standards and Certifications

MSB switchgear meets or exceeds IEEE C37.20.3 as it applies to metal-enclosed switchgear.

CSA listing is available for MSB switchgear in many configurations with a number of options.

MSB switchgear is available seismically qualified to meet the requirements of the Uniform Building Code, California Title 24 and BOCA requirements in many configurations with a number of options.

Reference Information

See *Consulting Application Guide* for detailed list of ratings and options. For renewal parts, see CA08105001E.

Product Selection

Contact Eaton for pricing.

Technical Data and Specifications

- Rated maximum voltages of 4.76–15 kV
- Continuous current ratings up to 1200 amperes
- 25 and 40 kA rms symmetrical short-circuit interrupting capacity
- Designs available in indoor and outdoor non-walk-in configurations
- Single vertical section and transformer primary configurations
- Lineups consisting of MSB and MVS vertical sections

Indoor Metal-Enclosed Drawout Vacuum Breaker—MEB Used as Main for Two Fused Switches

Contents

Product Description

Eaton's MEB switchgear is a metal-enclosed assembly of single high drawout VCP-W vacuum circuit breakers and control devices that are integrated electrically for circuit protection. (For drawout vacuum breaker metal-clad switchgear, type VacClad-W, see **Volume 3, Tab 7**) All major components are manufactured by Eaton, establishing one source of responsibility for the equipment and ensuring high standards in quality, coordination, reliability and service.

Application Description

MEB can be applied as the primary main device and integrated with fused feeder switches in a lineup of fused MVS switchgear.

Applications include ground fault protection, primary and/or secondary switching, and protection on unit substations, automatic transfer switching at medium voltage levels, capacitor switching, high duty cycle and tight system coordination protection.

MEB switchgear can also be an economic benefit in single-ended substations because it may allow the customer to eliminate the secondary main protection and switching device.

- Low resistance ground schemes
- Single-ended substation designs
- Overcurrent protection

Features, Benefits and Functions

- Fully rated drawout vacuum circuit breaker
- Electrical operation
- Improved coordination capability
- Improved transformer protection
- Ground fault protection
- Capacitor switching
- High switching duty cycle
- Integral overcurrent protection

Metal-Enclosed Breaker—MEB

Standards and Certifications

MEB switchgear meets or exceeds IEEE C37.20.3 as it applies to metal-enclosed switchgear.

CSA listing is available for MEB switchgear in many configurations with a number of options.

MEB switchgear is available seismically qualified to meet the requirements of the Uniform Building Code, California Title 24 and BOCA requirements in many configurations with a number of options.

Reference Information

See *Consulting Application Guide* for detailed list of ratings and options. For renewal parts, see CA08105001E.

Product Selection

Contact Eaton for pricing.

Technical Data and Specifications

- Rated maximum voltages of 4.76 and 15 kV
- Continuous current rating of 1200 or 2000 amperes
- Short-circuit current ratings up to 38 kA rms symmetrical
- Designs available in indoor and outdoor non-walk-in configurations
- Single vertical section and transformer primary configurations
- Lineups consisting of MEB vertical sections and MVS vertical sections

Indoor Unitized Power Centers

Bottom Cable Entry and Top Cable Entry

Contents

Product Description

Eaton's Unitized Power Centers combine an MVS primary disconnect switch, a ventilated dry-type transformer and Pow-R-Line 4 secondary distribution devices in a compact, factory-assembled integral unit. These self-contained units provide maximum kVA in minimum space, and their unitized construction simplifies installation.

Other advantages include:

- Front accessibility
- Against-the-wall mounting
- Dimensions consistent with standard doorways
- Liberal space for primary and secondary cables
- Molded case circuit breaker or fusible switch secondary distribution

Features, Benefits and Functions

The primary disconnect switch is a manually operated, two-position, quick-make, quick-break type MVS. Distribution class surge arresters protect the transformer from surge voltages, and current limiting fuses protect against fault currents. Insulated cable passes through a steel barrier to connect the switch to the transformer.

The power transformer is of a ventilated, dry-type, core-form construction. Standard Class 220°C insulation allows normal operation at 150°C temperature rise above a 30°C nominal ambient and a 40°C peak ambient.

The secondary distribution section consists of group mounted Series C® molded case circuit breakers or FDP-W fusible switches separated from the transformer by steel barriers. Additional vertical sections may be added for additional low voltage distribution.

Standards and Certifications

Power transformer core and coil assemblies meet all applicable IEEE/ANSI/NEMA® standards.

Reference Information

See *Consulting Application Guide* for detailed list of ratings and options.

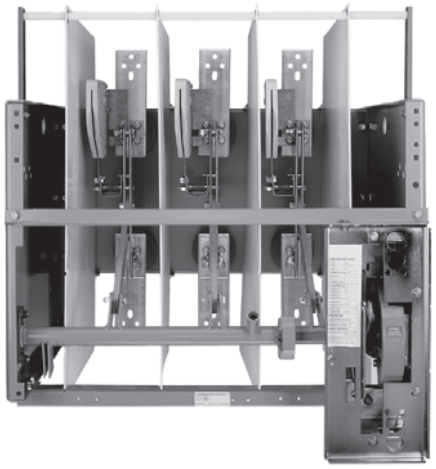
Product Selection

Contact Eaton for pricing.

Technical Data and Specifications

- Indoor enclosure only
- Maximum primary voltages:
  - 3 kV through 15 kV
  - Three-phase, 60 Hz, delta primary
- Primary BIL:
  - Voltages not exceeding 2.5 kV maximum—20 kV BIL
  - Voltages above 2.5 kV up to 7.2 kV maximum—30 kV BIL
  - Voltages above 7.2 kV up to 15 kV maximum—60 kV BIL
- Transformer:
  - 12.5–1000 kVA
  - Winding material, copper type, ventilated dry
- Insulation:
  - Class H 220°C rise (standard)
  - 150°C, 115°C and 80°C rise available
  - Fan cooling available to increase kVA rating by $33^{1}/_{3}$%
  - Taps: ±(2) 2.5% FCAN and FCBN
- Secondary voltages:
  - 208Y/120 volts—four-wire
  - 240 volts—three-wire
  - 480Y/277 volts—four-wire
  - 575 volts—four-wire
- Secondary BIL: 10 kV BIL

OEM Fusible Switches



MVS-C Switch

Contents

Product Description

MVS-C switches are open frame switches that must be mounted in a suitable enclosure for the OEM market. Eaton's MVS-C load interrupter switches are available in many ratings. When properly applied, they will provide safe, low-cost switching where occasional or infrequent disconnecting means is desired. The three-pole switch, with its quick-make, quick-break mechanism, will interrupt its rated load current.

Application Description

MVS-C switches can be applied in suitable enclosures for many switching duties whether manual or automatic operation is specified:

- Transformer primary switching
- Transformer secondary switching
- Power distribution switching

Features, Benefits and Functions

Plug & Play™: The switch and operating mechanism install as a single entity. No handle and chains or cables to mount and adjust. Improves productivity in assembly reducing overall cost.

Quick-make, quick-break mechanism: A reliable heavy-duty coil spring mechanism drives the switch blades at high speed into either the open or the closed position.

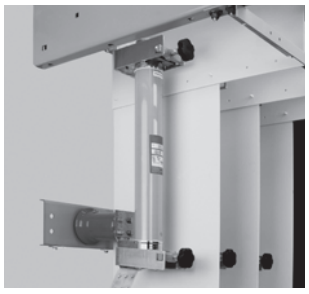
DE-ION arc interruption: DE-ION arc chambers and spring-loaded auxiliary blades ensure safe, fast load current interruption and eliminate arcing damage to the main contacts.

Positive switch position indication: Red and Green multilingual (English/Spanish/French) labels located directly on the switch operating mechanism give visual indication of switch position.

Interlocked for safety: When properly installed to utilize the built-in design feature, mechanical interlocks prevent closing the switch when the enclosure door is open, or opening the door when the switch is closed. As an alternate interlock method, key interlock provisions are included.

Safety under fault conditions: The switch, depending upon the rated voltage, is available with three or four fault-closing operations with ratings up to 61,000 amperes rms asymmetrical, exceeding the industry standards one-time operation.

Fuse mountings: Complete three-phase fuse mounting assemblies or fuse live parts are available that are fully compatible with MVS-C switches. The fuse mountings are intended for use with Eaton's fuses.



MVS-C Fuse Mounting

Direct drive mechanism: A metal-to-metal direct drive mechanism eliminates chains or cables that need adjusting or break.

Standards and Certifications

- MVS-C switches meet or exceed ANSI C37.22 ratings
- UL and CSA recognized component listing services are available for 5 and 15 kV manual and motor operated MVS-C switches

Reference Information

For renewal parts, see CA08105001E.

Product Selection

Contact Eaton for pricing.

Technical Data and Specifications

- Rated maximum voltage classes of 5, 15, 27 and 38 kV
- Rated impulse levels, kV BIL: 60, 95, 125, 150
- Continuous and load-break ratings: 600 amperes available at all voltage classes; 1200 amperes available at 5 and 15 kV
- Rated momentary and fault close currents, 40 and 61 kA rms asymmetrical; 40 kA available at all voltage classes; 61 kA available at 5, 15 and 27 kV
- Manual, motor or shunt-trip operated

Medium Voltage Switchgear

Indoor Type VCP-W Metal-Clad Switchgear Assembly (5/15 kV shown)

Learn Online

7.1 Medium Voltage Switchgear

Introduction

Indoor Type VCP-W Metal-Clad Switchgear Assembly (5/15 kV shown)

Contents

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Product Selection Guide

Product Offering Chart—Metal-Clad ①

Description	MVA Standard	Narrow Design	MVA Arc Resistant
Voltage	5, 15, 27, 38 kV	5 kV	5, 15, 27, 38 kV
Operation duty cycle	High	High	High
Enclosure	Indoor (5–38 kV)	Indoor only	Indoor only
	Outdoor aisleless (5–38 kV)		
	Outdoor aisle (5–15 kV)		
	Outdoor common aisle (5–15 kV)		
Listed	UL, CSA	UL, CSA	CSA only
Assembly standards	ANSI/IEEE, C37.04, C37.06, C37.54, C37.20.2, C37.55, CSA 22.2 #31 ②	ANSI/IEEE, C37.04, C37.06, C37.54, C37.20.2, C37.55, CSA 22.2 #31 ②	ANSI/IEEE, C37.04, C37.06, C37.54, C37.20.2, C37.20.7, C37.55, CSA 22.2 #31 ②
Circuit breaker type	VCP-W	VCP-W ND	VCP-W
Circuit breaker mounted	5 kV drawout, direct roll-in breaker option	Drawout 5 kV only	5 kV drawout, direct roll-in breaker option
	15 kV drawout, direct roll-in breaker option		15 kV drawout, direct roll-in breaker option
	27 kV drawout, direct roll-in breaker option		27 kV drawout, direct roll-in breaker option
	38 kV direct roll-in breakers		38 kV direct roll-in breakers
Seismically rated Zone 4 to California Building Code Title 24	Yes	Yes	Yes
BIL ratings	60 kV (5 kV)	60 kV (5 kV only)	60 kV (5 kV)
	95 kV (15 kV)		95 kV (15 kV)
	125 kV (27 kV)		125 kV (27 kV)
	170 kV (38 kV)		170 kV (38 kV)
Main bus ratings	1200, 2000, 3000, 4000A (5 kV)	1200A (5 kV only)	1200, 2000, 3000A (5 kV)
	1200, 2000, 3000, 4000A (15 kV)	2000A, 3000A	1200, 2000, 3000A (15 kV)
	1200, 2000A (27 kV)		1200, 2000A (27 kV)
	1200, 2000, 3000A depending on kA rating (38 kV)		1200, 2000, 3000A (38 kV)

Notes

① Additional products not shown include medium voltage transfer, high resistance ground and low profile switchgear.

② Listings are voltage dependant. See individual product sheets for detail.

Product Offering Chart—Metal-Clad, continued ①

Description	MVA Standard	Narrow Design	MVA Arc Resistant
Breaker ratings	1200, 2000, 3000A (5 kV)	1200A (5 kV only)	1200, 2000, 3000A (5 kV)
	1200, 2000, 3000A (15 kV)		1200, 2000, 3000A (15 kV)
	1200, 2000A (27 kV)		1200, 2000A (27 kV)
	1200, 1600, 2500A depending on kA rating (38 kV)		1200A (38 kV)
Overcurrent protective device	Yes	Yes	Yes
Short-circuit interrupting capacity	29, 41, 63 kA (5 kV)	29 kA (5 kV)	37 kA (5 kV) ②
	33 kA (8.25 kV)		—
	18, 28, 37, 63 kA (15 kV)		37 kA (15 kV) ②
	16, 22, 25, 40 kA (27 kV)		25 kA (27 kV) ②
	16, 21, 25, 32, 40 kA (38 kV)		25 kA (38 kV) ②
			40, 50, 63 kA (5 kV) ②
			40, 50, 63 kA (15 kV) ②
			25, 40 kA (27 kV) ②
			25, 40 kA (38 kV) ②
Conduit Entry	Top or bottom	Top or bottom	Top or bottom

Notes

① Additional products not shown include medium voltage transfer, high resistance ground and low profile switchgear.

② Ratings are arc ratings, not interrupting capacity.

VCP-W Breaker

Contents

An Eaton Green Solution

Product Overview

Product Description

Eaton has been manufacturing metal-clad switchgear for over 50 years, and vacuum circuit breakers for over 30 years. Tens of thousands of Eaton vacuum circuit breakers, used in a wide variety of applications, have been setting industry performance standards for years.

With reliability as a fundamental goal, Eaton's engineers have simplified the VCP-W switchgear design to minimize problems and gain trouble-free performance. Special attention was given to material quality and maximum possible use was made of components proven over the years in Eaton switchgear.

Maintenance requirements are minimized by the use of enclosed long-life vacuum interrupters. When maintenance or inspection is required, the component arrangements and drawers allow easy access. The VCP-W's light weight simplifies handling and relocation of the breakers.

The VCP-W meets or exceeds all applicable ANSI, NEMA® and IEEE design standards, and additionally offers many outstanding safety features.

To ensure reliability and quality, the testing of VCP-W switchgears has been extensive. UL and CSA listed switchgear is available for 5 and 15 kV. CSA is available for 27 and 38 kV.

MVA Arc-Resistant

Eaton has been manufacturing arc-resistant metal-clad switchgear since 1990. We now offer Type 2 and 2B arc-resistant switchgear assemblies, designed and tested in accordance with the IEEE C37.20.7 with VCP-W drawout vacuum circuit breakers. The NEC calls for an arc flash boundary of zero around medium voltage switchgear if it has been successfully certified as arc-resistant switchgear per IEEE C37.20.7. Eaton's switchgear is available in Type 2B; arc flash boundaries are eliminated even when the control compartment doors are open (for Eaton switchgear, this includes the control compartment door in front of the circuit breaker). Eaton offers a wide variety of tested switchgear configurations and bus transitions certified by UL to protect personnel from arcing faults of up to 63,000A rms for a duration of 0.5 seconds.

Application Description

Eaton's VCP-W metal-clad switchgear with type VCP-W vacuum breakers provides centralized control and protection of medium voltage power equipment and circuits in industrial, commercial and utility installations involving generators, motors, feeder circuits, and transmission and distribution lines.

VCP-W switchgear is available in maximum voltage ratings from 4.76 kV through 38 kV, and interrupting ratings as shown on **Page V3-T7-10**. VCP-W offers a total design concept of cell, breaker and auxiliary equipment, which can be assembled in various combinations to satisfy user application requirements. Two-high breaker arrangements are standard up to 15 kV. One-high arrangements can be furnished when required.

Features, Benefits and Functions

Endurance

High power laboratory tests prove VCP-W breakers are capable of 50 to 200 full fault current interruptions.

Vacuum Interrupter, Current Transfer Conductor

Eaton's stiff-flexible design eliminates sliding/rolling contacts in the main conductor, which provides excellent electrical and thermal transfer, and long vacuum interrupter life.

Grounded Steel Safety Shutters

Prevents accidental contact with live primary voltage connections when breaker is withdrawn.

Breaker Rails

On 5–27 kV units, the breaker can be withdrawn on rails for inspection and maintenance without the need for a separate lifting device.

Direct Roll-In Beakers

5–38 kV switchgear is available with direct roll-in breakers. Direct roll-in breakers can be supplied in two-high configurations with fully interchangeable breakers. Rails or a special direct roll-in lift pan can be used if desired to withdraw upper breakers for inspection.

Reduced Breaker Maintenance

Vacuum interrupter requires only periodic check for contact erosion. Integral wear indicator provided. No contact adjustments are required.

Front Accessible Mechanism

Front accessible mechanism is standard on all VCP-W breakers.

Front Accessible CTs (5–38 kV)

Up to 12 CTs per breaker can be mounted for easy access.

Drawout Auxiliary Compartments

Up to four drawers per vertical section can be equipped with CPTs or VTs up to 15 kV. Primary isolation shutters are standard.

Fluidized Bed Epoxy Bus Insulation

Excellent track resistant and flame retardant properties.

Standardized Functional Designs

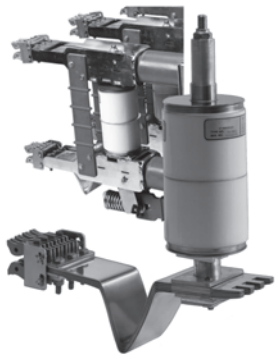
Shortens order cycle time.

Protective Relays

Eaton's E-Series microprocessor-based protective relays offer reliable, secure and complete protection and control of power generation and distribution systems. The hardware and software commonality across the E-Series family platform makes it easy for users to program simple to complex settings or schemes for each of their unique applications. The powerful multi-core processors and intuitive user interface provide for flexible configurations and simple alarming and notifications. Please refer to **Volume 3, Tab 9** or www.eaton.com/pr for additional information.

Options and Accessories

Supplemental Devices



World-Class VCP-W Vacuum Circuit Breakers are Designed with a V-Flex Nonsliding Current Transfer System

Ground and Test Device

The ground and test device is a drawout element that may be inserted into a metal-clad switchgear housing in place of a circuit breaker to provide access to the primary circuits to permit the temporary connection of grounds or testing equipment to the high voltage circuits. High potential testing of cable or phase checking of circuits are typical tests that may be performed. The devices are insulated to suit the voltage rating of the switchgear and will carry required levels of short-circuit current.

Before using ground and test devices, it is recommended that each user develop detailed operating procedures consistent with safe operating practices. Only qualified personnel should be authorized to use ground and test devices.

Manual and electrical ground and test devices are available. These devices include six studs for connection to primary circuits. On the manual device, selection and grounding is accomplished by cable connection. On the electrical-type device, grounding is accomplished by an electrically operated grounding switch.

Standard Accessories

- One test jumper
- One levering crank
- One maintenance tool
- One lifting yoke (5–38 kV)
- Two sets of rails (5–27 kV)
- One turning handle (5th wheel, 38 kV)

Optional Accessories

- One transport dolly (5–27 kV)
- One portable lifter (5–27 kV)
- One test cabinet
- One electrical levering device (5–27 kV)
- One ramp for lower breaker (5–27 kV)
- One manual or electrical ground and test device. Electrical ground up to 15 kV only
- One hi-pot tester
- One offset manual racking device

Technical Data and Specifications

- Maximum voltages:
  - 4.76 kV, 8.25 kV, 15 kV, 27 kV, 38 kV
- Interrupting ratings:
  - 4.76 kV:
    250 MVA (29 kA)
    350 MVA (41 kA)
    500 MVA (63 kA)
  - 8.25 kV:
    500 MVA (33 kA)
  - 15 kV:
    500 MVA (18 kA)
    750 MVA (28 kA)
    1000 MVA (37 kA)
    1500 MVA (63 kA)
  - 27 kV:
    16 kA, 22 kA,
    25 kA, 40 kA
  - 38 kV:
    16 kA, 25 kA,
    31.5 kA, 40 kA
    2300 MVA (35 kA)
- Continuous current: circuit breakers
  - 1200A, 2000A, 3000A (5 and 15 kV)
  - 4000A forced cooled (5 and 15 kV)
  - 1200A, 2000A, (27 kV)
  - 600A, 1200A, 1600A, 200A, 2500A (38 kV)
  - 3000A forced cooled (38 kV)
- Continuous current: main bus
  - 1200A, 2000A, 3000A, 4000A (5 and 15 kV)
  - 1200A, 2000A, (27 kV)
  - 1200A, 2000A, 2500A, 3000A (38 kV)

Typical Indoor Assembly with a Breaker Withdrawn on Rails

Contents

26-Inch Wide, 5 kV, 250 MVA, 1200A Switchgear

Product Description

26-inch wide VCP-W switchgear was designed for use in instances where floor space requirements would not allow the industry standard 36-inch (914.4 mm) wide switchgear.

Application Description

Typical applications include not only new construction, but also replacement switchgear for installations previously equipped with 26-inch (660.4 mm) wide airbreak devices. This new line of switchgear has also proven very popular among Generator Control manufacturers where 5 kV, 250 MVA, 1200A applications are commonplace.

Features, Benefits and Functions

Functionality is the name of the game. Available configurations include breaker over breaker, one or two auxiliaries over breaker, breaker over one or two auxiliaries, or up to four auxiliaries in one vertical section.

In addition to the tremendous floor space saving offered by the 26-inch (660.4 mm) wide design, a savings in the height of the switchgear is also available. Where height is an issue, such as an outdoor powerhouse or in a mobile power container, the standard 95-inch (2413 mm) height can be reduced to an 80-inch (2032 mm) tall model with a single-high breaker with one auxiliary and/or control cubical. In addition, the low-profile structure is designed to accommodate Voltage Transformers that are front mounted. Shallow-depth versions are also available for applications where depth is an issue. Contact your local Eaton representative for more information on special dimensional requirements.

For installations requiring 2000A main breakers with 1200A feeders, lineups can be built with standard 36-inch (914.4 mm) wide main breaker cubicles and 26-inch (660.4 mm) wide feeders.
The main bus connections are 100% compatible with standard 36-inch (914.4 mm) wide vertical sections. As a result, add-ons to existing installations can be simply and rapidly performed without costly system modifications and transition sections.

Standards and Certifications

At the heart of the new switchgear line is Eaton's world-class VCPW-ND "Narrow Design" vacuum circuit breaker. The 26-inch (660.4 mm) wide offering includes breakers and gear that are rated for use on 5 kV, 250 MVA, 1200A, 60 kV BIL maximum systems. Main bus ratings of up to 2000A are available.

The 26-inch (660.4 mm) wide VCP-W switchgear meets or exceeds ANSI, NEMA and IEEE design standards. UL and CSA listed switchgear is also available.

Listed

Technical Data and Specifications

Available Type VCP-W Vacuum Circuit Breakers Rated on Symmetrical Current Basis, Per ANSI Standards (Rated K=1)

	Drawout Circuit Breaker Type				
Rated Values	**50 VCP-W 25**	**50 VCP-W 40**	**50 VCP-W 50**	**50 VCP-W 63**	**75 VCP-W 40**
Maximum voltage (V) (kV rms)	4.76	4.76	4.76	4.76	8.25
Power frequency (Hz) ①	60	60	60	60	60
Insulation level					
Power frequency withstand voltage (1 min.) (kV rms)	19	19	19	19	36
Lightning impulse withstand voltage (1.2 x 50 ms) (kV peak)	60	60	60	60	95
Continuous current (A rms) ②	1200 2000 3000	1200 2000 3000	1200 2000 3000	1200 2000 3000	1200 2000 3000
Short-circuit ratings (reference C37.04-1999 and C37.06-2009 except as noted ③)					
Symmetrical interrupting circuit (I) (kA rms sym) ④	25	40	50	63	40
DC component (%DC) (%) ⑤	50	50	44	55	50
Asymmetrical interrupting current (I_t) (kA rms asym total) ⑥	31	49	59	80	49
Closing and latching current (2.6 x I) (kA peak)	65	104	130	164	104
Short-time withstand current (rms) ⑦	25	40	50	63	40
Transient recovery voltage parameters are based on TD-4					
Peak voltage (E_2) = (u_c) (kV peak)	8.2	8.2	8.2	8.2	14
Time to peak ($T_2 = t_3$ x 1.137) (msec)	50	50	50	50	59
TRV rise time (t_3) (msec)	44	44	44	44	52
RRRV = u_c/t_3 (kV/msec) ⑧	0.19	0.19	0.19	0.19	0.27
Interrupting time (ms, cycles (60 Hz))	50, 3	50, 3	50, 3	50, 3	50, 3
Operating duty (duty cycle)	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO
Mechanical endurance (no-load operations) ⑨⑩	10,000	10,000	10,000	10,000	10,000
Capacitance current switching capability (reference C47.04a-2003, C37.06-2009 and C37.09a-2005)					
Cable-charging current (class, A rms)	C2, 3–10	C2, 3–10	C2, 3–10	C2, 7.5–25	C2, 7.5–25
Isolated shunt capacitor bank current (class, A rms)	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600
Back-to-back capacitor switching					
Capacitor bank current (class, A rms)	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600	C2, 75–630 75–1000 75–1600
Inrush current (kA peak)	6	6	6	6	6
Inrush frequency (kHz)	0.8 0.5 0.3	0.8 0.5 0.3	0.8 0.5 0.3	0.8 0.5 0.3	0.8 0.5 0.3
Out-of-phase switching					
Voltage = 1.44 x V (kV rms)	7	7	7	7	12
Current = 0.25 x I (kA rms)	6.3	10	12.5	15.8	10

Notes

① All circuit breakers are tested at 60 Hz, however, they can also be applied at 50 Hz with no de-rating.

② 4000A fan cooled rating is available for 3000A circuit breakers.

③ These circuit breakers were tested to the preferred TRV ratings specified in C37.06-2000.

④ Because the voltage range factor K=1, the short-time withstand current and the maximum symmetrical interrupting current are equal to the rated symmetrical interrupting current.

⑤ Based on the standard DC TIME constant of 45 ms (corresponding to X/R of 17 for 60 Hz) and the minimum contact parting time as determined from the minimum opening time plus the assumed minimum relay time of 1/2 cycle (8.33 ms for 60 Hz).

⑥ The asymmetrical interrupting current, I total, is given by (I_t) = I x Sqrt (1 + 2 x %DC x %DC) kA rms asym total.

⑦ Duration of short-time current and maximum permissible tripping delay are both two seconds for all circuit breakers listed in this table, as required in C37.04-1999, C37.06-2000 and C37.06-2009.

⑧ RRRV can also be calculated as = 1.137 x E_2/T_2.

⑨ Each operation consists of one closing plus one opening.

⑩ All 40 and 50 kA circuit breakers exceed required 5000 no-load operations; all 63 kA circuit breakers exceed the required 2000 no-load ANSI operations.

Available Type VCP-W Vacuum Circuit Breakers Rated on Symmetrical Current Basis, Per ANSI Standards (Rated K=1), continued

	Drawout Circuit Breaker Type				
Rated Values	**75 VCP-W 50**	**150 VCP-W 25**	**150 VCP-W 40**	**150 VCP-W 50**	**150 VCP-W 63**
Maximum voltage (V) (kV rms)	8.25	15	15	15	15
Power frequency (Hz) ①	60	60	60	60	60
Insulation level Power frequency withstand voltage (1 min.) (kV rms)	36	36	36	36	36
Lightning impulse withstand voltage (1.2 x 50 ms) (kV peak)	95	95	95	95	95
Continuous current (A rms) ②	1200 2000 3000	1200 ③ 2000 3000	1200 2000 3000	1200 2000 3000	1200 ③ 2000 ③ 3000 ③
Short-circuit ratings (reference C37.04-1999 and C37.06-2009 except as noted ③) Symmetrical interrupting circuit (I) (kA rms sym) ④	50	25	40	50	63
DC component (%DC) (%) ⑤	44	50	50	44	55
Asymmetrical interrupting current (I_t) (kA rms asym total) ⑥	59	31	49	59	80
Closing and latching current (2.6 x I) (kA peak)	130	65	104	130	164
Short-time withstand current (rms) ⑦	50	25	40	50	63
Transient recovery voltage parameters are based on TD-4 Peak voltage (E_2) = (u_c) (kV peak)	14	28 ③ 25.7	25.7	25.7	28 ③
Time to peak ($T_2 = t_3$ x 1.137) (msec)	59	75	75	75	75
TRV rise time (t_3) (msec)	52	66	66	66	66
RRRV = u_c/t_3 (kV/msec) ⑧	0.27	0.42 0.39	0.39	0.39	0.42
Interrupting time (ms, cycles (60 Hz))	50, 3	50, 3	50, 3	50, 3	50, 3
Operating duty (duty cycle)	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO	O-0.3s-CO-3m-CO
Mechanical endurance (no-load operations) ⑨⑩	10,000	10,000	10,000	10,000	10,000
Capacitance current switching capability (reference C47.04a-2003, C37.06-2009 and C37.09a-2005) Cable-charging current (class, A rms)	C2, 7.5–25	C2, 7.5–25	C2, 7.5–25	C2, 7.5–25	C2, 7.5–25
Isolated shunt capacitor bank current (class, A rms)	C2, 75–630 75–1000 75–1600	C2, 75–630 C2, 75–1000 C1, 75–1000	C2, 75–630 C2, 75–1000 C1, 75–1600	C2, 75–630 C2, 75–1000 C1, 75–1600	C2, 75–630 75–1000 75–1600
Back-to-back capacitor switching					
Capacitor bank current (class, A rms)	C2, 75–630 75–1000 75–1600	C2, 75–630 C2, 75–1000 C1, 75–1000	C2, 75–630 C2, 75–1000 C1, 75–1600	C2, 75–630 C2, 75–1000 C1, 75–1600	C2, 75–630 75–1000 75–1600
Inrush current (kA peak)	6	6	6	6	6
Inrush frequency (kHz)	0.8 0.5 0.3	0.8 0.5 0.3	0.8 0.5 0.3	0.8 0.5 0.3	0.8 0.5 0.3
Out-of-phase switching Voltage = 1.44 x V (kV rms)	12	22	22	22	22
Current = 0.25 x I (kA rms)	12.5	6.3	10	12.5	15.8

Notes

① All circuit breakers are tested at 60 Hz, however, they can also be applied at 50 Hz with no de-rating.

② 4000A fan cooled rating is available for 3000A circuit breakers.

③ These circuit breakers were tested to the preferred TRV ratings specified in C37.06-2000.

④ Because the voltage range factor K=1, the short-time withstand current and the maximum symmetrical interrupting current are equal to the rated symmetrical interrupting current.

⑤ Based on the standard DC time constant of 45 ms (corresponding to X/R of 17 for 60 Hz) and the minimum contact parting time as determined from the minimum opening time plus the assumed minimum relay time of 1/2 cycle (8.33 ms for 60 Hz).

⑥ The asymmetrical interrupting current, I total, is given by (I_t) = I x Sqrt (1 + 2 x %DC x %DC) kA rms asym total.

⑦ Duration of short-time current and maximum permissible tripping delay are both two seconds for all circuit breakers listed in this table, as required in C37.04-1999, C37.06-2000 and C37.06-2009.

⑧ RRRV can also be calculated as = 1.137 x E_2/T_2.

⑨ Each operation consists of one closing plus one opening.

⑩ All 40 and 50 kA circuit breakers exceed required 5000 no-load operations; all 63 kA circuit breakers exceed the required 2000 no-load ANSI operations.

Available VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards ①②

	Circuit Breaker Type							
	50 VCP-WND 250	**50 VCP-W 250**	**50 VCP-W 350**	**50 VCP-W 63**	**75 VCP-W 500**	**150 VCP-W 500**	**150 VCP-W 750**	**150 VCP-W 1000**
Identification								
Nominal voltage class kV	4.16	4.16	4.16	4.16	7.2	13.8	13.8	13.8
Nominal three-phase MVA class	250	250	350	—	500	500	750	1000
Rated Values								
Voltage Rated maximum voltage V kV rms	4.76	4.76	4.76	4.76	8.25	15	15	15
Rated voltage range factor K ③	1.24	1.24	1.19	1.0	1.25	1.30	1.30	1.30
Insulation level—rated withstand test voltage Normal frequency kV rms	19	19	19	19	36	36	36	36
1.2 x 50 µsec. impulse kV crest	60	60	60	60	95	95	95	95
Current Rated continuous current at 60 Hz amp ④	1200	1200	1200	1200	1200	1200	1200	1200
	—	2000	2000	2000	2000	2000	2000	2000
	—	3000	3000	3000	3000	3000	3000	3000
Rated short-circuit current (at rated maximum kV)—I kA rms ③	29	29	41	63	33	18	28	37
Rated transient recovery voltage Rated crest voltage —E_2 kV crest	8.9	8.9	8.9	8.9	15.5	28	28	28
Rated time to crest—T_2 µs	50	50	50	50	60	75	75	75
Rate of rise of recovery voltage kV/µs ⑤	0.2	0.2	0.2	0.2	0.29	0.42	0.42	0.42
Rated interrupting time cycles ⑥	5	5	5	5	5	5	5	5
Rated permissible tripping delay—Y sec. ⑦	2	2	2	2	2	2	2	2
Rated reclosing time ms ⑧	300	300	300	300	300	300	300	300
Related Required Capabilities								
Rated maximum voltage divided by K—V/K kV rms	3.85	3.85	4.0	4.76	6.6	11.5	11.5	11.5
Current values K times rated short-circuit current ③ Maximum sym. interrupting capability—KI kA rms	36	36	49	63	41	23	36	48
Three-second short-time current carrying capability—KI kA rms	36	36	49	63	41	23	36	48
Closing and latching capability (momentary) ⑨ 2.7K times rated short-circuit current—2.7 KI kA crest	97	97	132	170	111	62	97	130
1.6K times rated short-circuit current—1.6 KI kA rms asym. ⑩	58	58	78	101	66	37	58	77
Asymmetry Factor for VCP-W Breakers (S) ⑪	1.2	1.2	1.2	1.27	1.2	1.2	1.2	1.2

Notes

① For capacitor switching, refer to **Page V3-T7-13**.

② 5 and 15 kV circuit breakers are UL listed. 27 and 38 kV breakers are not UL listed.

③ For three-phase and line-to-line faults, the symmetrical interrupting capability at an operating voltage

$$I_{sc} = \frac{V}{V_0} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

Single line-to-ground fault capability at an operating voltage

$$I_{sc} = 1.15 \frac{V}{V_0} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

The above apply on predominately inductive or resistive three-phase circuits with normal-frequency line-to-line recovery voltage equal to the operating voltage.

④ 4000A continuous rating is available for 5/15 kV. 3000A continuous rating is available for 38 kV. Contact Eaton for details.

⑤ $RRRV = 1.137 \frac{E_2}{T_2}$

⑥ Three-cycle rating available, refer to **Page V3-T7-13**.

⑦ Tripping may be delayed beyond the rated permissible tripping delay at lower values of current in accordance with the following formula:

$$T \text{ (seconds)} = Y \left(\frac{\text{(K Times Rated Short-Circuit Current)}}{\text{Short-Circuit Current Through Breaker}} \right)^2$$

The aggregate tripping delay on all operations within any 30-minute period must not exceed the time obtained from the above formula.

⑧ For reclosing service, there is **No De-Rating** necessary Eaton's VCP-W family of circuit breakers. **R = 100%**. Type VCP-W breaker can perform the O-C-O per ANSI C37.09; O-0.3s-CO-15s-CO per IEC 56; and some VCP-Ws have performed O-0.3s-CO-15s-CO-15s-CO-15s-CO; **all with no derating**. Contact Eaton for special reclosing requirements.

⑨ For higher close and latch ratings, refer to **Page V3-T7-13**.

⑩ Included for reference only.

⑪ Asymmetrical interrupting capability = "S" times symmetrical interrupting capability, both at specified operating voltage.

Available VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards, continued ①②

	Circuit Breaker Type				
	150 VCP-W 63	**270 VCP-W 750**	**270 VCP-W 1000**	**270 VCP-W 1250**	**270 VCP-W 40**
Identification					
Nominal voltage class kV	13.8	27	27	27	27
Nominal three-phase MVA class	—	—	—	—	—
Rated Values					
Voltage					
Rated maximum voltage kV rms	15	27	27	27	27
Rated voltage range factor K ③	1.0	1.0	1.0	1.0	1.0
Insulation level—rated withstand test voltage					
Normal frequency kV rms	36	60	60	60	60
1.2 x 50 µsec. impulse kV crest	95	125	125	125	125
Current					
Rated continuous current at 60 Hz amp ④	1200	600	600	600	1200
	2000	1200	1200	1200	2000
	3000	2000	2000	2000	—
Rated short-circuit current (at rated maximum kV)—I kA rms ③	63	16	22	25	40
Rated transient recovery voltage					
Rated crest voltage —E_2 kV crest	28	51	51	51	51
Rated time to crest—T_2 µs	75	105	105	105	105
Rate of rise of recovery voltage kV/µs ⑤	0.42	0.55	0.55	0.55	0.55
Rated interrupting time cycles ⑥	5	5	5	5	5
Rated permissible tripping delay—Y sec. ⑦	2	2	2	2	2
Rated reclosing time ms ⑧	300	300	300	300	300
Related Required Capabilities					
Rated maximum voltage divided by K—V/K kV rms	15	27	27	27	27
Current values					
K times rated short-circuit current ③					
Maximum sym. interrupting capability—KI kA rms	63	16	22	25	40
Three-second short-time current carrying capability—KI kA rms	63	16	22	25	40
Closing and latching capability (momentary) ⑨					
2.7K times rated short-circuit current—2.7 KI kA crest	170	43	60	68	108
1.6K times rated short-circuit current—1.6 KI kA rms asym. ⑩	100	26	35	40	64
Asymmetry Factor for VCP-W Breakers (S) ⑪	1.27	1.2	1.2	1.2	1.2

Notes

① For capacitor switching, refer to **Page V3-T7-13**.

② 5 and 15 kV circuit breakers are UL listed. 27 and 38 kV breakers are not UL listed.

③ For three-phase and line-to-line faults, the symmetrical interrupting capability at an operating voltage

$$I_{sc} = \frac{V}{V_0} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

Single line-to-ground fault capability at an operating voltage

$$I_{sc} = 1.15 \frac{V}{V_0} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

The above apply on predominately inductive or resistive three-phase circuits with normal-frequency line-to-line recovery voltage equal to the operating voltage.

④ 4000A continuous rating is available for 5/15 kV. 3000A continuous rating is available for 38 kV. Contact Eaton for details.

⑤ $RRRV = 1.137 \frac{E_2}{T_2}$

⑥ Three-cycle rating available, refer to **Page V3-T7-13**.

⑦ Tripping may be delayed beyond the rated permissible tripping delay at lower values of current in accordance with the following formula:

$$T \text{ (seconds)} = Y \left(\frac{\text{(K Times Rated Short-Circuit Current)}}{\text{Short-Circuit Current Through Breaker}} \right)^2$$

The aggregate tripping delay on all operations within any 30-minute period must not exceed the time obtained from the above formula.

⑧ For reclosing service, there is **No De-Rating** necessary for Eaton's VCP-W family of circuit breakers. **R = 100%**. Type VCP-W breaker can perform the O-C-O per ANSI C37.09; O-0.3s-CO-15s-CO per IEC 56; and some VCP-Ws have performed O-0.3s-CO-15s-CO-15s-CO-15s-CO; **all with no derating**. Contact Eaton for special reclosing requirements.

⑨ For higher close and latch ratings, refer to **Page V3-T7-13**.

⑩ Included for reference only.

⑪ Asymmetrical interrupting capability = "S" times symmetrical interrupting capability, both at specified operating voltage.

Available VCP-W Vacuum Circuit Breaker Types Rated on Symmetrical Current Rating Basis, Per ANSI Standards, continued ①②

	Circuit Breaker Type				
	380 VCP-W 16	**380 VCP-W 21**	**380 VCP-W 25**	**380 VCP-W 32**	**380 VCP-W 40**
Identification					
Nominal voltage class kV	34.5	34.5	34.5	34.5	34.5
Nominal three-phase MVA class	—	—	—	—	—
Rated Values					
Voltage Rated maximum voltage kV rms	38	38	38	38	38
Rated voltage range factor K ③	1.0	1.65	1.0	1.0	1.0
Insulation level—rated withstand test voltage Normal frequency kV rms	80	80	80	80	80
1.2 x 50 µsec. impulse kV crest ⑫	170 ⑫	170 ⑫	170 ⑫	170 ⑫	170 ⑫
Current Rated continuous current at 60 Hz amp ④	600	1200	600	600	600
	1200	2000	1200	1200	1200
	1600	—	1600	1600	1600
	2000	—	2000	2000	2000
	—	—	—	2500	2500
Rated short-circuit current (at rated maximum kV)—I kA rms ③	16	21	25	31.5	40
Rated transient recovery voltage					
Rated crest voltage —E_2 kV crest	71	71	71	71	71
Rated time to crest—T_2 µs	125	125	125	125	125
Rate of rise of recovery voltage kV/µs ⑤	0.64	0.64	0.64	0.64	0.64
Rated interrupting time cycles ⑥	5	5	5	5	5
Rated permissible tripping delay—Y sec. ⑦	2	2	2	2	2
Rated reclosing time ms ⑧	300	300	300	300	⑬
Related Required Capabilities					
Rated maximum voltage divided by K—V/K kV rms	38	23	38	38	38
Current values K times rated short-circuit current ③ Maximum sym. interrupting capability—KI kA rms	16	35	25	31.5	40
Three-second short-time current carrying capability—KI kA rms	16	35	25	31.5	40
Closing and latching capability (momentary) ⑨ 2.7K times rated short-circuit current—2.7 KI kA crest	43	95	68	85	108
1.6K times rated short-circuit current—1.6 KI kA rms asym. ⑩	26	56	40	51	64
Asymmetry Factor for VCP-W Breakers (S) ⑪	1.2	1.2	1.2	1.2	1.2

Notes

① For capacitor switching, refer to **Page V3-T7-13**.

② 5 and 15 kV circuit breakers are UL listed. 27 and 38 kV breakers are not UL listed.

③ For three-phase and line-to-line faults, the symmetrical interrupting capability at an operating voltage

$$I_{sc} = \frac{V}{V_0} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

Single line-to-ground fault capability at an operating voltage

$$I_{sc} = 1.15 \frac{V}{V_0} \text{ (Rated Short-Circuit Current)}$$

But not to exceed KI.

The above apply on predominately inductive or resistive three-phase circuits with normal-frequency line-to-line recovery voltage equal to the operating voltage.

④ 4000A continuous rating is available for 5/15 kV. 3000A continuous rating is available for 38 kV. Contact Eaton for details.

⑤ $RRRV = 1.137 \frac{E_2}{T_2}$

⑥ Three-cycle rating available, refer to **Page V3-T7-13**.

⑦ Tripping may be delayed beyond the rated permissible tripping delay at lower values of current in accordance with the following formula:

$$T \text{ (seconds)} = Y \left(\frac{\text{(K Times Rated Short-Circuit Current)}}{\text{Short-Circuit Current Through Breaker}} \right)^2$$

The aggregate tripping delay on all operations within any 30-minute period must not exceed the time obtained from the above formula.

⑧ For reclosing service, there is **No De-Rating** necessary for Eaton's VCP-W family of circuit breakers. **R = 100%**. Type VCP-W breaker can perform the O-C-O per ANSI C37.09; O-0.3s-CO-15s-CO per IEC 56; and some VCP-Ws have performed O-0.3s-CO-15s-CO-15s-CO-15s-CO; **all with no derating**. Contact Eaton for special reclosing requirements.

⑨ For higher close and latch ratings, refer to **Page V3-T7-13**.

⑩ Included for reference only.

⑪ Asymmetrical interrupting capability = "S" times symmetrical interrupting capability, both at specified operating voltage.

⑫ ANSI standard requires 150 kV BIL. All 38 kV ratings are tested to 170 kV BIL.

⑬ Type 380 VCP-2 40 circuit breaker is not rated for rapid reclosing.

Extra Capability Type VCP-WC Ratings (Symmetrical Current Basis)

	Circuit Breaker Type				
	50 VCP-W 25C	**50 VCP-W 40C**	**50 VCP-W 50C**	**50 VCP-W 63C**	**75 VCP-W 50C**
Rated Values					
Voltage Maximum voltage V kV rms	5.95	5.95	5.95	5.95	10.3
Voltage range factor K	1	1	1	1	1
Insulation level—withstand test Power frequency (1 min.) kA rms total	24	24	24	24	42
Lighting impulse 1.2 x 50 µs kV peak	75	75	75	75	95
Continuous current at 60 Hz A rms	1200	1200	1200	1200	1200
	2000	2000	2000	2000	2000
	3000 ④	3000 ④	3000 ④	3000 ④	3000 ④
Short-circuit current Sym. interrupting at voltage (Isc) kA rms total	25	40	50	63	50
% DC component (Idc)	50	75	57	62	57
	75	—	57	—	57
	75	—	52	—	52
Asym. interrupting (I_t) kA rms	31	58	64	83	64
	36	—	64	—	64
	36	—	62	—	62
Closing and latching capability kA peak	97	139	139	175	139
Short-time current for 3 seconds kA rms ①	25	40	50	63	50
Interrupting time ms ②	50	50	50	50	50
Maximum permissible tripping delay sec.	2.0	2.0	2.0	2.0	2.0
Rate of rise of recovery voltage (RRRV) kV/µs ③	0.9	0.9	0.9	1.1	0.9
	0.9	0.9	0.9	—	0.9
	0.8	0.8	0.8	—	0.8
Capacitor switching ratings General purpose—isolated shunt capacitor bank current A rms	400 and 630	630 ⑤	630 ⑤	250	630 ⑤
	1000 ⑤	1000 ⑤	1000 ⑤	—	1000 ⑤
	250	250	250	—	250
Definite purpose—back-to-back capacitor switching Capacitor bank current A rms	400 and 630	630 ⑥	630 ⑥	200, 1600 ⑦	630 ⑥
	1000 ⑥	1000 ⑥	1000 ⑥	200, 1600 ⑦	1000 ⑥
	—	—	—	200, 1600 ⑦	—
Inrush current kA peak	20 and 20	15	15	7.7	15
	18	18	18	7.7	18
	—	—	—	7.7	—
Inrush frequency kHz	6.5 and 5.5	3.5	3.5	465	3.5
	2.7	2.7	2.7	465	2.7
	—	—	—	465	—
Mechanical Endurance—No-Load Operations	10,000	10,000	10,000	10,000	10,000
	10,000	10,000	10,000	10,000	10,000
	5000	5000	5000	5000	5000

Notes

① Except as noted.
② Three cycles.
③ Contact Eaton for higher RRRV or for more information.
④ 4000A FC rating available.
⑤ Breaker tested to 2700A single bank switching for momentary load (thermal de-rating must consider harmonic content of current waveform).
⑥ Breaker tested to 1270A back-to-back switching for momentary load (thermal de-rating must consider harmonic content of current waveform).
⑦ C37.04.a-2003 Class C2 at 15 kV.

38 kV, 2500A and 3000A WC breakers are not rated for rapid reclosing.

Extra Capability Type VCP-WC Ratings (Symmetrical Current Basis), continued

	Circuit Breaker Type				
	150 VCP-W 25C	**150 VCP-W 40C**	**150 VCP-W 50C**	**150 VCP-W 63C**	**270 VCP-W 25C**
Rated Values					
Voltage					
Maximum voltage V kV rms	17.5	17.5	17.5	15	27
Voltage range factor K	1	1	1	1	1
Insulation level—withstand test					
Power frequency (1 min.) kA rms total	42	42	42	42	60
Lighting impulse 1.2 x 50 µs kV peak	95	96	95	95	125
Continuous current at 60 Hz A rms	1200	1200	1200	1200	1200
	2000	2000	2000	2000	1600
	3000 ④	3000 ④	3000 ④	3000 ④	—
Short-circuit current					
Sym. interrupting at voltage (Isc) kA rms total	25	40	50	63	25
% DC component (Idc)	50	75	57	62	75
	75	—	57	—	—
	75	—	52	—	—
Asym. interrupting (I_t) kA rms	31	58	64	83	36
	36	—	64	—	—
	36	—	62	—	—
Closing and latching capability kA peak	97 ⑤	139	139	175	85
Short-time current for 3 seconds kA rms ①	25	40	50	63	25 ⑥
Interrupting time ms ②	50	50	50	50	50
Maximum permissible tripping delay sec.	2.0	2.0	2.0	2.0	2.0
Rate of rise of recovery voltage (RRRV) kV/µs ③	0.9	0.9	0.9	1.1	1.1
	0.9	0.9	0.9	—	—
	0.8	0.8	0.8	—	—
Capacitor switching ratings					
General purpose—isolated shunt capacitor bank current A rms	400A and 630 ⑦	630 ⑦⑧	630 ⑦⑧	250	400
	1000 ⑦⑧	1000 ⑦⑧	1000 ⑦⑧	—	—
	250 ⑦	250 ⑦	250 ⑦	—	—
Definite purpose—back-to-back capacitor switching					
Capacitor bank current A rms	400 and 600 ⑦	630 ⑦⑨	630 ⑦⑨	200, 1600 ⑩	400
	1000 ⑦⑨	1000 ⑦⑨	1000 ⑦⑨	200, 1600 ⑩	—
	—	—	—	200, 1600 ⑩	—
Inrush current kA peak	20 and 20	15	15	7.7	20
	18	18	18	7.7	—
	—	—	—	7.7	—
Inrush frequency kHz	6.5 and 5.5	3.5	3.5	465	4.2
	2.7	2.7	2.7	465	—
	—	—	—	465	—
Mechanical Endurance—No-Load Operations	10,000	10,000	10,000	10,000	5000
	10,000	10,000	10,000	10,000	—
	5000	5000	5000	5000	—

Notes

① Except as noted.
② Three cycles.
③ Contact Eaton for higher RRRV or for more information.
④ 4000A FC rating available.
⑤ Close and latch current for 1200A Type 150 VCP-W 25C is proven at 15 kV. For sealed interrupters at high altitudes, switching voltage is not de-rated.
⑥ 2.5 seconds.
⑦ Capacitor switching ratings are proven at 15 kV. For sealed interrupters at high altitudes, switching voltage is not de-rated.
⑧ Breaker tested to 2700A single bank switching for momentary load (thermal de-rating must consider harmonic content of current waveform).
⑨ Breaker tested to 1270A back-to-back switching for momentary load (thermal de-rating must consider harmonic content of current waveform).
⑩ C37.04.a-2003 Class C2 at 15 kV.

38 kV, 2500A and 3000A WC breakers are not rated for rapid reclosing.

Extra Capability Type VCP-WC Ratings (Symmetrical Current Basis), continued

	Circuit Breaker Type					
	270 VCP-W 32C	**270 VCP-W 40C**	**380 VCP-W 16C**	**380 VCP-W 25C**	**380 VCP-W 32C**	**380 VCP-W 40C**
Rated Values						
Voltage Maximum voltage V kV rms	27	27	38	38	38	38
Voltage range factor K	1	1	1	1	1	1
Insulation level—withstand test Power frequency (1 min.) kA rms total	60	60	80	80	80	80
Lighting impulse 1.2 x 50 µs kV peak	125	125	170	170	170	170
Continuous current at 60 Hz A rms	1200	1200	600	600	600	1200
	1600	1600	1200	1200	1200	2000
	—	—	1600	1600	1600	2500
	—	—	2000	2000	2000	3000FC ④
	—	—	—	—	2500	—
	—	—	—	—	3000FC ⑤	—
Short-circuit current Sym. interrupting at voltage (Isc) kA rms total	31.5	40	16	25	33.1	40
% DC component (Idc)	55	50	75	65	57	63
Asym. interrupting (I_t) kA rms	40	49	23.3	34.0	42.5	53.5
Closing and latching capability kA peak	100	112	50	75	91	107
Short-time current for 3 seconds kA rms ①	31.5 ⑥	40 ⑦	16	25	31.5 ⑧	40
Interrupting time rms ②	50	50	50	50	50	50
Maximum permissible tripping delay sec.	2.0	2.0	2.0	2.0	2.0	2.0
Rate of rise of recovery voltage (RRRV) kV/µs ③	1.1	1.1	0.7	0.7	0.7	0.7
	—	—	0.7	0.7	0.7	—
	—	—	1.3	1.3	0.7	—
	—	—	—	—	1.3	—
	—	—	—	—	0.7	—
	—	—	—	—	1.3	—

Notes

① Except as noted.
② Three cycles.
③ Contact Eaton for higher RRRV or for more information.
④ 2500A FC to 3000A.
⑤ 2000A FC to 3000A.
⑥ 1.6 seconds.
⑦ 1 second.
⑧ 2.5 seconds.

38 kV, 2500A and 3000A WC breakers are not rated for rapid reclosing.

Extra Capability Type VCP-WC Ratings (Symmetrical Current Basis), continued

	Circuit Breaker Type					
	270 VCP-W 32C	270 VCP-W 40C	380 VCP-W 16C	380 VCP-W 25C	380 VCP-W 32C	380 VCP-W 40C
Rated Values, continued						
Capacitor switching ratings						
General purpose—isolated shunt capacitor bank current A rms	400	400	250	250	250	—
	—	—	250	250	250	—
	—	—	250	250	250	—
	—	—	250 and 1000	250 and 1000	250 and 1000	—
	—	—	—	—	—	—
	—	—	—	—	250 and 1000	—
Definite purpose—back-to-back capacitor switching						
Capacitor bank current A rms	400	400	250	250	250	—
	—	—	250	250	250	—
	—	—	250	250	250	—
	—	—	250 and 1000	250 and 1000	250 and 1000	—
	—	—	—	—	—	—
	—	—	—	—	250 and 1000	—
Inrush current kA peak	20	20	20	20	20	—
	—	—	20	20	20	—
	—	—	20 and 20	20 and 20	20 and 20	—
	—	—	—	—	—	—
	—	—	—	—	20 and 20	—
Inrush frequency kHz	4.2	4.2	4.4	4.4	4.4	—
	—	—	4.4	4.4	4.4	—
	—	—	4.4	4.4	4.4	—
	—	—	5 and 5	5 and 5	5 and 5	—
	—	—	—	—	—	—
	—	—	—	—	5 and 5	—
Mechanical Endurance—No-Load Operations	5000	5000	10,000	10,000	10,000	10,000

Note

38 kV, 2500A and 3000A WC breakers are not rated for rapid reclosing.

C-HRG Free-Standing NEMA 1 Unit

Contents

Product Description

Where continuity of service is a high priority, high resistance grounding can add the safety of a grounded system while minimizing the risk of service interruptions due to grounds. The concept is a simple one: provide a path for ground current via a grounding transformer (with adjustable resistance across its secondary) that limits the current magnitude and a monitor to determine when an abnormal condition exists.

The ground current path is provided at the point where the service begins, by placing a predominantly resistive impedance in the connection from system neutral to ground. Control equipment continuously measures ground current; a relay detects when the current exceeds a predetermined level. An alarm alerts building personnel that a ground exists. The system has built-in fault tracing means to assist in finding the source of the ground. A 120 Vac supply (remote) is required for control power for the system.

Application Description

This member of Eaton's MV metal-clad switchgear family has actually been around for many years. The free-standing C-HRG provides a standalone unit that can be added to existing installations. The C-HRG is used to protect an electrical distribution system from damaging transient overvoltages caused by ground faults. It also provides a means to locate the ground fault, therefore extending the life of the distribution system.

Ratings and Configurations

The C-HRG MV is offered at the 5 kV class rating. It can be applied to delta or wye ungrouped three-wire distribution systems.

4200V (Maximum) Delta Systems

To add high resistance grounding to an ungrounded delta-connected system, a neutral point must be created. Three single-phase transformers can be interconnected in a wye-broken delta configuration to provide such a neutral point. The transformers and grounding resistors are chosen to limit the ground current to a maximum value of 6A.

Note: The neutral point may not be used to serve phase-to-neutral loads. Also, this technique may be applied on wye-connected sources when the neutral point is not conveniently accessible from the service entrance location. This method is shown in the illustration shown on **Page V3-T7-23**. One delta high resistance grounding would ground the 5 kV system.

4200V (Maximum) Wye Systems

To add high resistance grounding to a wye-connected system, resistors are placed across the secondary of a grounding transformer whose primary is placed in series with the neutral-to-ground connection of the power source. The resistors are chosen to limit the current to a maximum value of 6A.

Note: Per 1993 NEC® 250.5b, exception No. 5, line-to-neutral loads may not be connected to a system in which the neutral is resistance grounded. Also, if the system has two switchable sources not permanently connected to the bus, two wye-type grounding systems are required as shown on **Page V3-T7-23.**

Ground Current Detection

Any time a system is energized, a small ground current called the "capacitive charging current" will be observed. For medium voltage (4200V and below) systems, this naturally occurring current is typically 3A or less.

When one phase becomes grounded, additional current above the charging level will flow. As all ground current must flow through the grounding resistor/grounding transformer assembly, an ammeter in this circuit will read the total amount of ground current. By placing a current-sensing relay in series with the ammeter, the current relay can be adjusted to pick up at a level in excess of the capacitive charging current, thus indicating the abnormal condition.

Alternatively, an optional voltmeter-relay can be connected across the grounding resistors. The voltage across the resistors is proportional to the amount of ground current. The voltmeter-relay's pickup adjustment is set above the capacitive charging current, to the desired detection level.

In both current and voltage detection methods, the ground current ammeter provides a direct reading of the total actual ground current present in the system at that time. It will be helpful to periodically note the ammeter's reading: a trend toward higher values may indicate the need for equipment maintenance, and hence reduce the occurrence of unplanned shutdowns.

Indication and Alarm Circuits

When a fault is detected, an adjustable time delay is provided to override transients. When the time delay has been exceeded, the green "normal" light will turn off, the red "ground fault" light will turn on, and the ground alarm contacts will transfer. If equipped with the optional alarm horn, it will sound.

The grounding transformer secondary breaker must be closed for the system to be operational. Should this breaker be opened at any time, the system will signal a ground fault condition as a fail-safe feature. The breaker must be closed to clear the alarm signal.

When the fault is cleared, the current/voltage relay will reset. If the reset control is set on "auto," the lights will return to "normal" on, "ground fault" off, and the ground alarm contacts will re-transfer. If the reset control is set on "manual," the lights and relay contacts will remain latched until the operator turns the reset control to "reset." The lights and ground alarm contacts will then return to normal. The system can be reset only if the fault has been cleared.

During a fault, the optional alarm horn can be silenced at any time by using the "alarm silence" pushbutton. It will not re-sound until either the system is reset, or the re-alarm timer expires. The re-alarm timer is activated by the "alarm silence" control. If the horn has been silenced but the fault has not been cleared, the timer will run. It has a range of 2–48 hours. When the timer times out, the horn will re-sound, alerting maintenance personnel that the fault has not been cleared.

Test Circuit

A test circuit is provided to allow the user to quickly determine that the system is working properly. The test circuit will operate only under normal conditions—it will not allow testing if the system is sensing a fault. The test operation does not simulate an actual system ground fault. It does, however, test the complete controls of the fault indication and pulsing circuitry. The system then reacts as it would under actual system ground conditions —lights transfer, alarm contacts transfer and the (optional) horn sounds.

Pulser Circuit

The pulser circuit offers a convenient means to locate the faulted feeder and trace the fault to its origin. The pulser is available any time a fault has been detected. The pulse intervals are controlled by an adjustable recycle timer. The "pulse" light flashes on and off, corresponding to the on-off cycles of the pulser contactor. The pulser contactor switches a bank of resistors on and off, thus allowing a momentary increase in the ground current (approximately a 4A current pulse above the ground current).

Locating a Ground Fault

The current pulses can be noted with a clamp-on ammeter when the ammeter is placed around the cables or conduit feeding the fault. The operator tests each conduit or set of cables until the pulsing current is noted. By moving the ammeter along the conduit, or checking the conduit periodically along its length, the fault can be traced to its origin. The fault may be located at the point where the pulsing current drops off or stops.

If little or no change in the pulsing current is noted along the entire length of a conduit, then the fault may be in the connected load. If the load is a panelboard, distribution switchboard or motor control center, repeat the process of checking all outgoing cable groups and conduits to find the faulted feeder. If the fault is not found in an outgoing feeder, the fault may be internal to that equipment.

Note: It may not be possible to precisely locate faults within a conduit. The ground current may divide into many components, depending on the number of cables per phase, number of conduits per feeder, and the number and resistance of each ground point along the conduits. The resulting currents may be too small to allow detection or may take a path that the ammeter cannot trace. An important note to keep in mind is that while the pulser can greatly aid in locating a fault, there may be certain conditions under which the pulses cannot be readily traced, and other test procedures (megohm, high-potential, etc.) may be needed.

Sequence of Operations

Normal

- Green "normal" light on
- Red "ground fault" light off
- White "pulse" light off
- System control switch in "normal" position
- Reset control switch in either "auto" or "manual"

Test

Turn and hold the system control switch in the "test" position. This mode will test the control circuitry only. It will bypass the sensing circuit and cause the green "normal" light to turn off and the red "ground fault" light to turn on. The pulser will be activated as well. The white "pulse" light will turn on and off as the pulser contactor closes and opens. However, the ground current ammeter will not display the total ground current, including the incremental pulse current. When ready, return the system control switch to "normal." The pulser will stop. If the reset control is in the "manual" position, turn it to "reset" to reset the fault sensing circuit. The red "ground fault" light will turn off, and the green "normal" light will turn on. Test mode is not available if the system is detecting a ground. The sensing circuit will disable the test circuit.

Ground Fault

When the sensing circuit detects a fault, the green "normal" light will turn off and the red "ground fault" light will turn on. The ground current ammeter will indicate the total ground current. To use the pulser, turn the system control switch to "pulse." The pulser contactor will cycle on and off as controlled by the recycle timer relay. Use the clamp-on ammeter to locate the faulted feeder. Open the feeder and clear the fault. If the reset control switch is in the "manual" position, turn it to "reset" to reset the sensing circuit. (If reset control is in "auto," it will reset itself.) When ready to restore service to the load, close the feeder. Return the system control to "normal."

Features, Benefits and Functions

When a ground fault occurs on an ungrounded system, high transient voltages can occur, which may cause more frequent equipment failures than if the equipment were grounded. These transient overvoltages, as high as four times the normal voltage, reduce the life of the system's insulation resulting in:

- Motor failure
- Transformer failure
- Coil failure
- Electronic equipment failure
- Cable insulation failure

By using a high resistance ground system, many facilities can gain the benefit of a grounded system without impairing the continuity of service to their equipment. The concept behind high resistance grounding is to provide a path for the ground current to flow while limiting its magnitude by using a resistor. The ground current path is provided at the point where service begins. Control equipment continuously monitors the magnitude of the ground current.

When the ground current exceeds a predetermined level, the built-in alarm relay alerts building personnel that a ground fault exists. In addition, the C-HRG MV "safe ground" system has a built-in fault pulsing as a means to assist in finding the source of the ground fault without interrupting service.

- Current sensing ground fault detection (2–10A pickup/ 0.5–20 second delay)
- Ground current transformer (10/10 ratio)
- Control circuit pull fuseblock
- Ground current ammeter (0–10A, 1% accuracy)
- Indicating lights:
  - Red (ground fault)
  - Green (normal)
  - White (pulse)
- Adjustable pulsing timer (0–10 seconds)
- Tapped resistors (limits primary current to 3–6A)
- Three-position selector switch (normal, pulse, test)
- Control switch for manual or automatic reset
- Ground fault contacts (1NO/1NC)
- Shorting terminal block for ground current CT
- UL label
- Wiremarkers

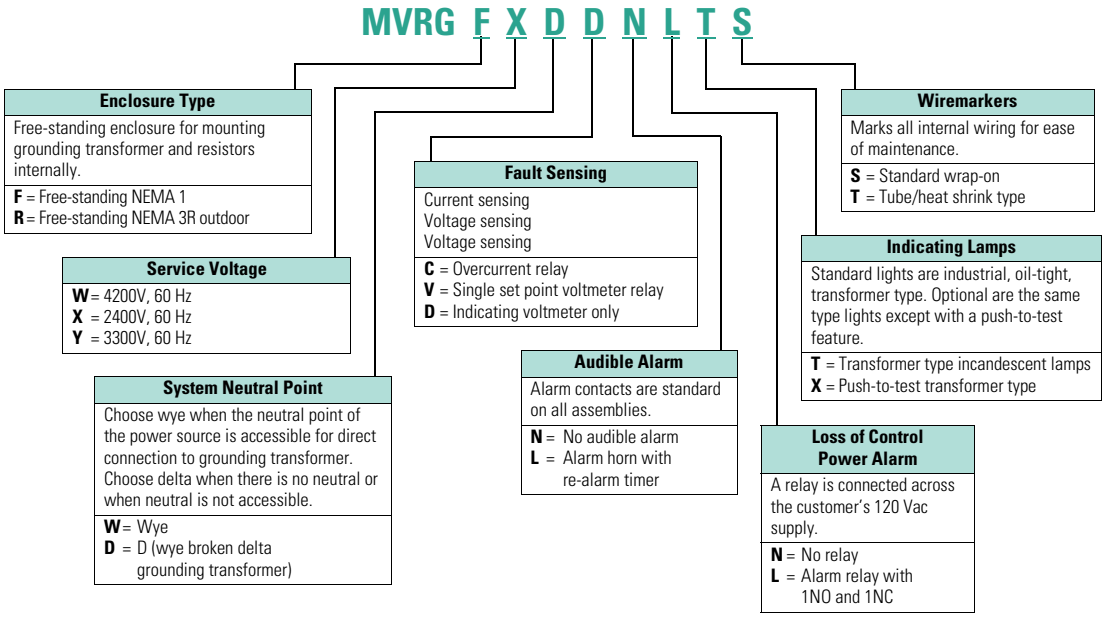
Standards and Certifications

The system shall be completely assembled, wired and tested at the factory in accordance with NEMA and UL requirements. A certified production test report shall be shipped with the unit.

Catalog Number Selection

A C-HRG High Resistance Grounding Assembly can be completely described by an 8-digit catalog number: MVRG-_ _ _ _ _ _ _ _

High Resistance Grounding Systems



Example: MVRG-FWWCLLTS defines a free-standing NEMA 1 enclosure, 4200V/60 Hz, wye-connected system, current-sensing control scheme, alarm horn with re-alarm timer, alarm relay with 1NO and 1NC, transformer type incandescent lights, wrap-on wiremarkers.

Technical Data and Specifications

General

Provide a high resistance grounding system as a means to provide a path for ground current via a resistance that limits the current magnitude. While monitoring the ground current, the system must be able to determine when an abnormal condition exists. Once the abnormality is detected, the system shall alert building personnel that a ground exists. The system shall be suitable for 5000V maximum service, and designed and tested for that voltage class in accordance with the latest standards of NEMA and UL.

- Tapped resistors supply primary ground current between 3 and 6A in 1A increments
- Pulse current is an additional 4A. (pulse currents of a lower magnitude may be difficult to detect)
- Pulse timer is adjustable from 3 to 60 pulses per minute
- Time delay for current sensing relay is 0.5 to 20 seconds with a 2 to 10A pickup. Time delay for voltage sensing relay is 1 to 60 seconds
- "Pull-type" fuse disconnects are supplied for control equipment protection
- All exterior nameplates are fastened with stainless steel screws
- Nameplates are 2-ply with 3/16-inch (4.8 mm) lettering. The nameplate size is 1-inch (25.4 mm) x 2-1/2-inch (63.5 mm). White background with black lettering is standard
- Top and bottom cable entry areas
- Phase and neutral terminals accept #4 AWG to 500 kcmil
- Ground terminal accepts wire sizes from #4 AWG to 500 kcmil. Ground bus is 1/4-inch (6.35 mm) x 2-inch (50.8 mm) copper
- The powder paint is applied to the parts electrostatically. Metal surfaces are prepared by spray cleaning and phosphatizing. The powder paint is a polyester urethane. The standard color is ANSI 61, light gray. The paint is applied to a thickness of 1.5 mil
- Appropriate current limit drawout type fuses are provided. The chassis is mechanically interlocked with a secondary circuit breaker to prevent its withdrawal under load conditions
- Resistors are grid type to provide the maximum area for heat dissipation
- No. 4 AWG wire is used for internal connections from the neutral point to ground. Control connections are a minimum of #14 gauge. All control wires insulation is type SIS
- Recommended spare parts list
- Steel pocket on the inside of the door is provided to hold drawings and manuals

Note: The C-HRG units can be applied on any three-wire distribution system, regardless of the manufacturer of the distribution equipment or source power transformer.

System Ratings and Features

Provide a UL-labeled high-resistance grounding system equal to Eaton catalog number _____ for use on a system with a short-circuit capacity of __kA at ____ volts. The structure shall be a [free-standing NEMA 1] [free-standing NEMA 3R]. The system neutral point shall be provided by [the power transformer's wye neutral point] [wye-broken delta grounding transformers]. The ground current shall be detected with [an overcurrent relay] [a single set point voltmeter relay]. [An alarm horn with re-alarm timer is required.] [An alarm to indicate the loss of control power is required.] The indicating lights shall be [transformer-type incandescent lamps] [push-to-test transformer type lamps]. Control wiring shall be marked using [wrap-on type] [heat-shrink sleeve type] wiremarkers. [A portable clamp on detector with 1/2/5/10/20A scales, a shorting switch and a storage case is required].

In addition to the components specified, the following shall be supplied with each system:

- Ground current transformer (10/10 ratio)
- Control circuit disconnect switch (fused)
- Ground current ammeter (0–10A, 1% accuracy)
- Control switch for manual or automatic reset
- Ground fault contacts (1NO/1NC) for customer use
- Shorting terminal block for ground current CT
- Adjustable pulsing timer (0–10 seconds)
- Tapped resistors (across neutral forming transformer secondary, limiting primary current to 3–6A)
- Three-position selector switch (normal, pulse, test)
- Indicating lights:
  Red (ground fault)
  Green (normal)
  White (pulse)

Components and Connections

Phase and neutral terminals shall accept #4 AWG to 500 kcmil wire. Ground terminals shall accept wire sizes from #8 AWG to 500 kcmil. Ground bus shall be 1/4-inch (6.35 mm) x 2-inch (50.8 mm) copper. #4 AWG wire shall be used for all internal connections from the neutral point to ground. Control connections shall be a minimum of #14 gauge. All control wire insulation shall be type SIS. All control wiring shall be labeled at each end. Wiring within the resistor assembly shall be rated for 200°C service.

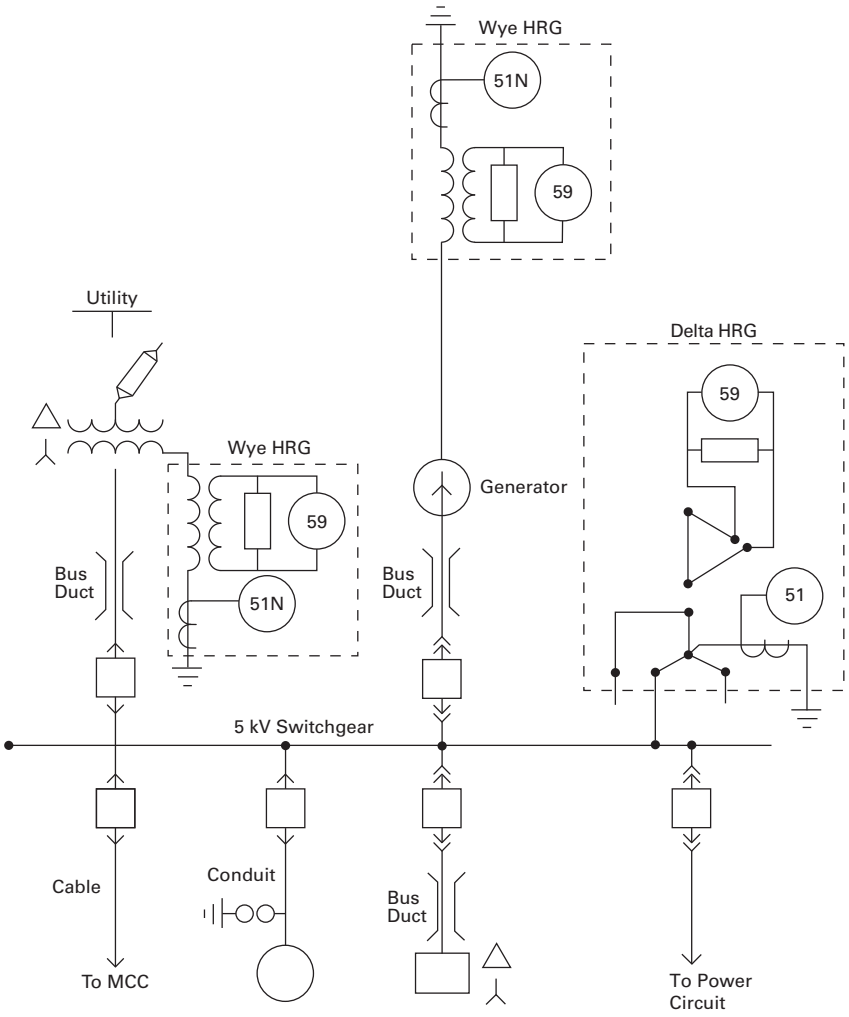
Structure

The unit shall be free-standing and house the resistor bank within an isolated section of the structure. Access to the resistor shall be via a bolted-on cover. The rear cover shall be removable. The structure shall provide top and bottom cable entry points. Lifting angles shall be provided to facilitate the installation of the unit. The structure shall be suitable for moving on rollers and shall be skidded for shipment in a manner suitable for handling by a forklift.

All steel parts (except for plated parts) shall be thoroughly cleaned and phosphatized prior to the application of the light gray ANSI No. 61 finish. A pocket is required on the inside of the control compartment door to store drawings and manuals.

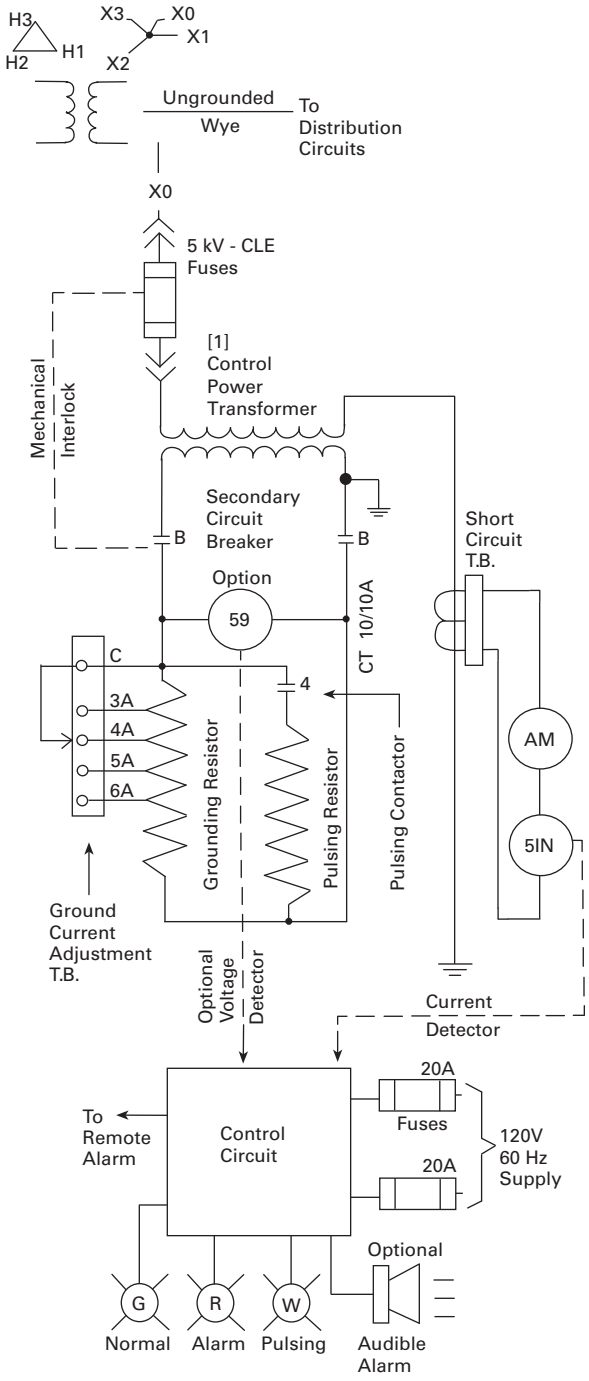
Wiring Diagram

HRG—High Resistance Grounding System

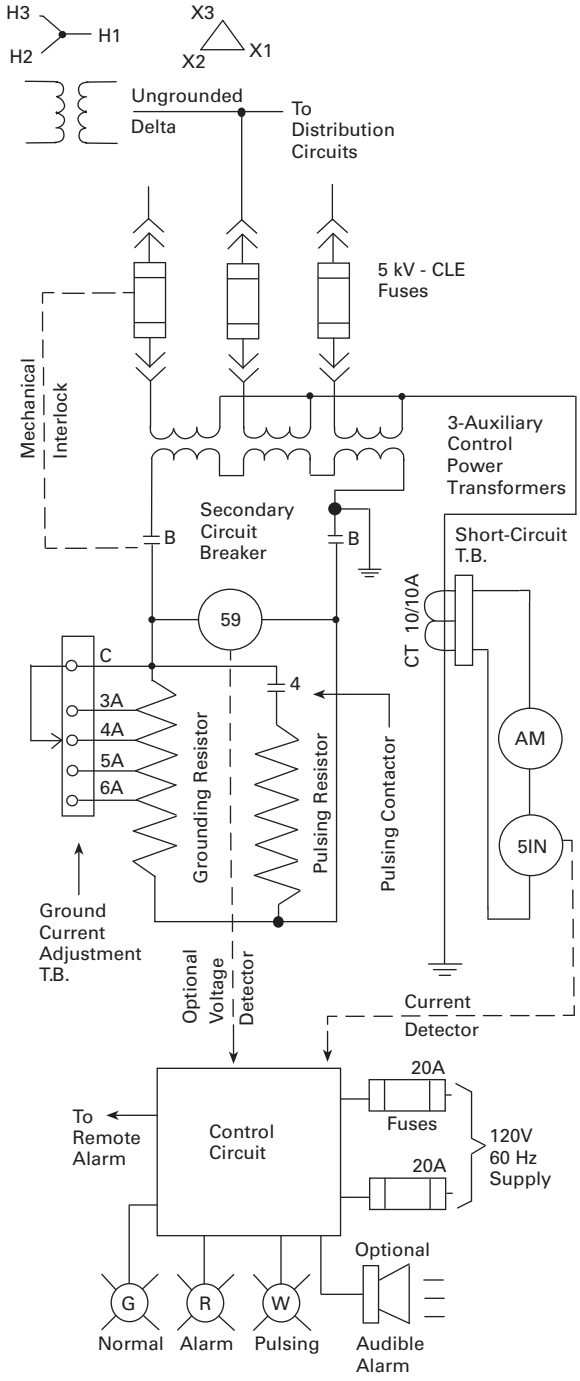


Circuit Diagrams

Ungrounded Wye System (with standard current and optional voltage relay fault detectors)



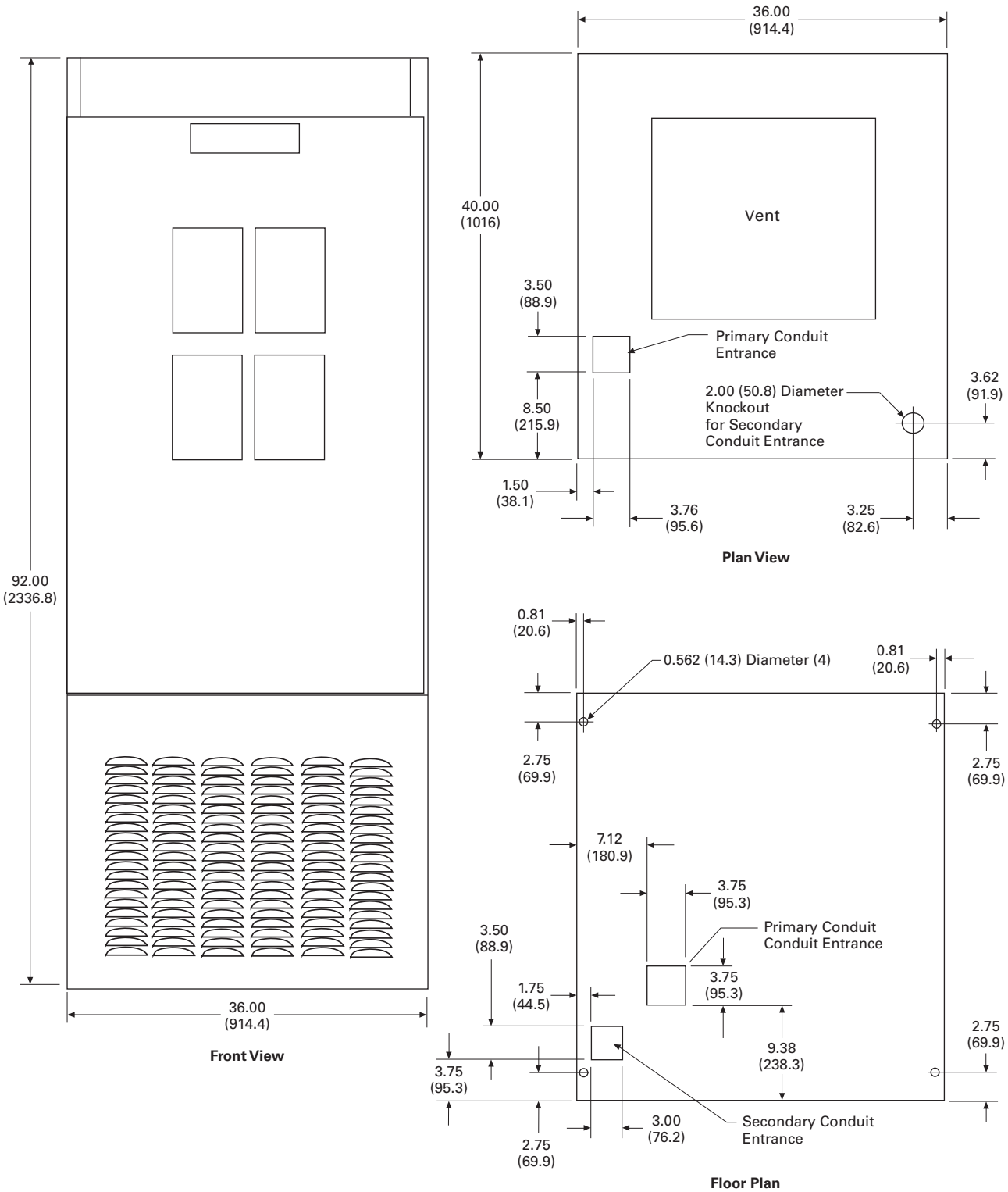
Ungrounded Delta System (with standard current and optional voltage relay fault detectors)



Dimensions

Approximate Dimensions in Inches (mm)

NEMA 1 Free-Standing



CM52 Network Protector

CM52 Network Protector

Contents

Network Protectors—CM52

Product Description

Network protectors are special self-contained air power breaker units having a full complement of current, potential and control transformers, as well as relay functions to protect the integrity of the low voltage network bus. The network protector can be in NEMA® housing, submersible housing, or suitable for mounting within a low voltage switchgear assembly. Several network protector models exist including the CM52, CMD and CM-22. The most recent model, the CM52 network protector, is highlighted in the following paragraphs.

Application Description

Network protectors are mainly used by utilities around the world. They are configured in either a spot or grid network. Most installations of network protectors are in underground vaults and require a submersible enclosure. Commercial applications also exist for customers that require highly reliable, stable power. These applications typically use a NEMA enclosure and are configured in a spot network. Some examples of commercial users are government buildings, hospitals, universities and industrial plants.

Features, Benefits and Functions

Eaton's Type CM52 is designed for improved safety, higher quality, ease of maintenance and inventory reduction.

CM52—Highlight of Relay Module

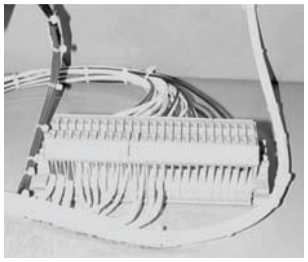
- Standardized breaker elements throughout entire electrical ratings allow for the use of common parts and accessories
- Smaller breaker element is less than half the weight of existing network designs
- The CM52 is the first network protector to pass 10 kV BIL, giving an additional measure of safety and performance
- Ratings of 800–6200A, 216–600V, internal or external fuses and NEMA or submersible enclosures, completely cover the needs of the network protector industry
- Deadfront 4-position drawout breaker helps protect the user from accidental contact with live circuits and makes maintenance and troubleshooting easier

Deadfront, Drawout Breaker

- More diagnostics through the Indicating Diagnostic Module (IDM)

Indicating Diagnostic Module (IDM)

- Front-mounted test points give easy access and quick test cable connection
- Color-coded Teflon® wiring for easier troubleshooting



Color-Coded Wiring

- The CM52 breakers are all wired the same regardless of system voltage (216V, 480V and 600V)
- 3NO and 3NC dry contacts are standard as spare

Options

Arc Flash

VaultGard™ Arcflash Reduction Maintenance System™ Indicating Diagnostic Module

The CM52 Network Protector is available with the NPARMs module (Arcflash Reduction Maintenance System).

This device is internal to the Network Protector and can be remotely activated usually through a switch mounted at the vault entrance or through communications. This will enable the "ARMS" device on all CM52s in a spot network. Once activated, the NPARMs places the protectors in a sensitive mode, sensing both forward and reverse current directions. This device will actuate in 3–4 ms and call for all CM52 breakers to trip if a fault is sensed on an adjacent network protector or collector bus. It has been shown that this device limits the total incident energy to less than 8 cal/cm^2.

Remote Racking System

The CM52 Network Protector is also available with an integral remote racking system. The system remotely racks the breaker off the energized bus work while the door is still closed to the "test" position either through an external pendant or through communications.

Remote Racking System

Standards and Certifications

- Meets or exceeds the standards in IEEE® C57.12.44
- The CM52 Network Protector is UL labeled and approved in the NEMA housing at all ratings

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Technical Data and Specifications

CM52 Ratings Comparison Table—Ratings Tested at 600V

Continuous Current Rating (Amperes)	Breaker Element Width in Inches (mm)	CM52 Interrupting Rating (kA)	CM52 Close and Latch Rating (kA)	IEEE/ANSI Interrupting Rating (kA)	IEEE/ANSI ① Close and Latch Rating (kA)
800	17.00 (431.8)	42	35	30	25
1200	17.00 (431.8)	42	35	30	25
1600/1875	17.00 (431.8)	42	35	30	25
2000	17.00 (431.8)	42	35	35	35
2500/2825	22.00 (558.8)	65	45	60	40
3000	22.00 (558.8)	65	45	60	40
3500	35.00 (889.0)	85	65	60	40
4500	35.00 (889.0)	85	65	60	40
6200 ②	35.00 (889.0)	85	65	Product not defined	Product not defined

Notes

① Close and latch ratings apply only to spring close and stored energy mechanisms. The CM22 does not have a close and latch rating.

② Open frame only, tested at 500V.

MPCV Communications Relay

Contents

Network Relay—MPCV

Product Description

Type MPCV Network Protector Communications Relays for 216V and 480V Systems

- Eaton's programmable MPCV network relay brings the proven performance of microprocessor-based technology to new network protectors...or those already in service regardless of age or manufacturer
- The MPCV contains industry exclusive features such as:
  - Gull Wing Trip Characteristic
  - Remote Protective Close
  - Anti-Pumping Algorithm
- With the MPCV, you can select the characteristic curves to monitor and control the network protector through Eaton products such as the VaultGard, DNPMINT and NPView

Application Description

Factory or Field Installation

Eaton can factory mount MPCV relays on new network protectors...or personnel can easily field mount them on these existing network protectors:

- Eaton Types CM52, CMD, CM-22 or CMR-8
- General Electric® Types MG-8, MG-9 or MG-14

Field installation is accomplished without breaker modification or any rewiring of the breaker control harness. MPCV relays operate on 216V and 480V systems. Relay potential transformers are required for 480V applications.

Features, Benefits and Functions

Communications Capability

Each MPCV relay has the capability of communicating information and allowing control over a shielded twisted pair communications wire. Communications can be provided by a Web-enabled interface or direct DNP 3.O to SCADA systems. Eaton has multiple choices for communication interfaces such as VaultGard for total vault communications, NPView- simple Web server or DNPMINT.

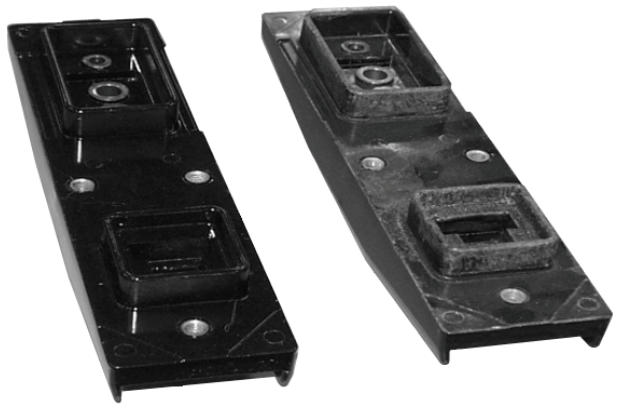
For localized access, the MPCV relay has the capability of wireless communication, monitoring and control with the Eaton wireless products.

- The MPCV is built for the harshest environments, with an operation temperature of –40°F (–40°C) up to 257°F (125°C). The MPCV is housed in a 0.25-inch (6.35 mm) thick solid cast brass can
- Access and display information from the MPCV such as: voltage, current, power, power factor, date and time stamped trip events, internal temperature and operations counter of breaker
- Through auxiliary inputs on the MPCV relay, operators can monitor other vault environment parameters such as transformer top oil temperature, water in the network vault, fire alarm or network enclosure pressure
- Event trending, threshold alarms and e-mail forwarding
- Multiple MPCVs can be connected together either as a daisy chain, T-configuration or a combination.

MPCV Communications Relay for Eaton Network Protectors

MPCV Communications Relay for General Electric Network Protectors

Rebuild Program



Contents

Network Protector Rebuild and Parts Program

Parts

- Renewal parts for all network protector models:
  - Eaton, Westinghouse®: CM-22, CMD, CM52 and CMR-8
  - General Electric: MG-8, MG-9 and MG-14
- 24-hour shipment when required for parts in stock

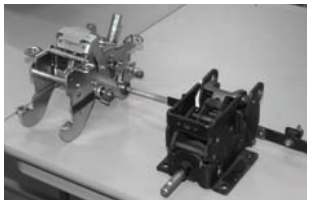
Rebuild Services

Eaton's Electrical Sector is setting the standard of reliability with a reconditioning process that involves total breaker and enclosure disassembly, material specific component cleaning, detailed inspection and state-of-the-art testing, all done to uniform documented specifications.

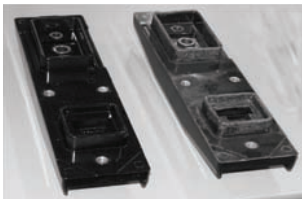
Eaton offers a CM52 retrofit breaker for legacy CMD and GE Network Protectors. The breaker can be installed in existing network protector enclosures without having to remove the enclosure from the vault or having to remove the secondary cable connections, saving both time and money.

Quick Ship

Eaton can build and ship brand new CM-22 or CMD network protectors in 4 to 6 weeks.

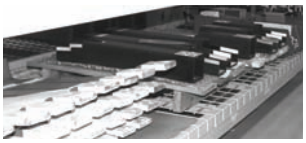


Retrobuild Before



Retrobuild After

Parts



Parts

Metering Devices, Protective Relays, Software and Connectivity

Power Xpert Insight

Contents

An Eaton Green Solution

Power Xpert Insight

Product Description

Power Xpert Insight® is a power and energy monitoring system that is amazingly simple—simple to install, simple to use, simple to add new devices and simple to obtain the information needed to make important operating decisions every day. Power Xpert Insight provides the insight into your customers' electrical system and takes the complexity out of power and energy management.

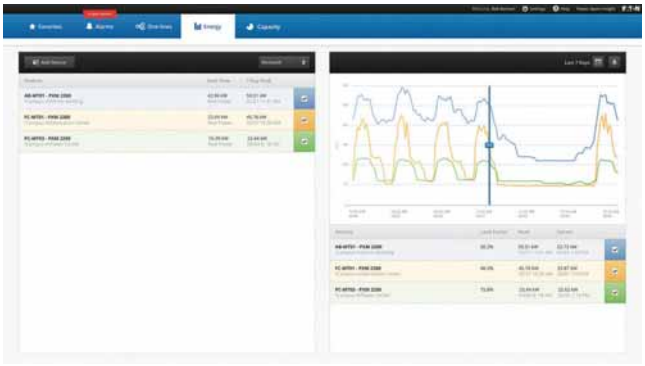
A Web-based software, Power Xpert Insight is designed to be quick to install and configure so that systems can be up and running quickly. Developed after extensive study and testing with users, the software allows customers to view only the device information that they want to see, simplify alarm management, view energy usage and demand data, compare and trend data, and view a one-line representation of their electrical system.

Power Xpert Insight provides the energy and power information you need to:

- Keep the lights on with real-time, actionable alarms across desktop and mobile
- Save money and energy with easy-to-use and share energy reports
- Stay up to speed on your most critical devices with adjustable dashboards
- Drill into problems quickly with powerful graphics and detailed data
- Understand current issues and plan for future investments using trends and visualizations

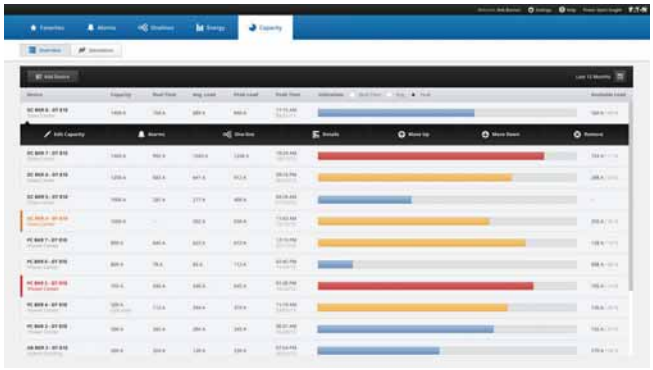
Features

Energy



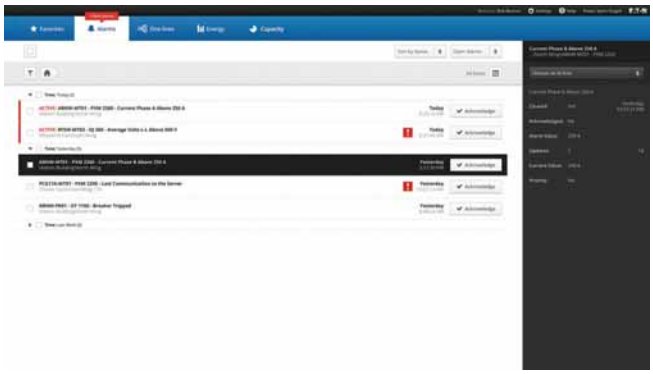
- View energy usage and demand
- Select the desired devices and time range, 24 hours to a custom range
- Choose the type of graph that best suits; line or stacked bar chart
- Move the cursor over the graph to view detailed data
- Export data to a CSV-format file
- Expand to the Trend Viewer for additional information
- Energy usage is automatically summed for the devices shown in the table

Capacity



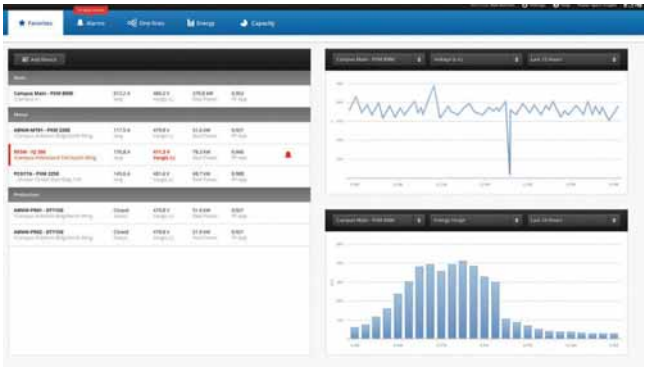
- Benchmark capacity usage in real-time to determine tripping points and avoid downtime
- Custom trigger thresholds for cautionary and critical levels support all types of electrical environments and changing needs
- Simulate and trend with line graphics load additions prior to device installation to avoid tripping and downtime
- Forecast, budget and plan capacity requirements
- Proactively predict overall electrical system performance by modeling capabilities

Alarms



- View color-coded alarms on one page (Black = Normal, Red = Alarm, Orange = Loss of Communication)
- Sort alarms by Time, Device or Priority for a specified time range, view by Alarm Status
- Acknowledge Alarms by individual device or group together
- Open the Alarm Pop Out to view additional data and add notes
- Export alarm history to a CSV-format file

Favorites Dashboard



- Each user can create a unique dashboard to focus on the devices or systems that they are interested in
- Devices are displayed by device type (Main, Meter, Protection) and populate the top 4 channels for that device
- Alarm color-coding is automatically propagated across pages
- A quick Trend Graph and Energy Graph are also displayed for a selected device and channel over a time range up to 24 hours
- Quickly add or remove devices from the Favorites dashboard

One-lines

- Build an electrical one-line representation of the system with device widgets and the symbols library
- Drag-and-drop devices, lines, symbols where needed, add text boxes. Easily updated when devices are removed or added to service
- The top 4 device channels are automatically populated on the device widgets and alarm color-coding carries through on the one-lines
- Upload a unique background image
- Use the Device Tree to set up the one-line structure

Offline Configuration

- Power Xpert Insight provides the ability to completely configure a system in advance. The more you know about the final system, the more complete the offline configuration process will be
- Configure Power Xpert Insight in advance using an Excel® spreadsheet (template available at Eaton.com/pxi)
- Upload the spreadsheet to an offline Power Xpert Insight system
- Set up one-line graphics in the offline Power Xpert Insight system
- Extract the entire system configuration
- Upload the configuration into the target system when ready and connect when the devices are online

Product Selection

Power Xpert Insight

Description	Catalog Number
PXI for up to 10 device connections	**PXI-A**
PXI for up to 25 device connections	**PXI-B**
PXI for up to 50 device connections	**PXI-C**
PXI for up to 100 device connections	**PXI-D**
PXI for up to 200 device connections	**PXI-E**

PXI Device Count Upgrades

Description	Catalog Number
PXI 10 to 25 upgrade	**PXI-A2B**
PXI 10 to 50 upgrade	**PXI-A2C**
PXI 10 to 100 upgrade	**PXI-A2D**
PXI 10 to 200 upgrade	**PXI-A2E**
PXI 25 to 50 upgrade	**PXI-B2C**
PXI 25 to 100 upgrade	**PXI-B2D**
PXI 25 to 200 upgrade	**PXI-B2E**
PXI 50 to 100 upgrade	**PXI-C2D**
PXI 50 to 200 upgrade	**PXI-C2E**
PXI 100 to 200 upgrade	**PXI-D2E**

Service Packs

Description	Catalog Number
Power Xpert 1-day startup service pack	**PX-1S**
Power Xpert 2-day startup service pack	**PX-2S**
Power Xpert 5-day startup service pack	**PX-5S**

Technical Data and Specifications

Hardware Requirements

Power Xpert Insight requires a server-class machine with the following minimum hardware specifications:

Hardware	Specification
Processor	Quad core
Memory	16 GB
Disk space required for application	100 GB—5 years estimated data storage
Disk space required for database	A typical database will grow to 2 GB within a year. If you have a large number of devices, reserve additional storage space
Video resolution	1920 by 1080 pixels

Software Requirements

Supported Operating Systems

Software	Specification
Server	Windows® Server 2008 R2, Standard and Enterprise, SP1
	Windows Sever 2012 Standard and Datacenter
Client	Windows 7 Professional, Ultimate or Enterprise, x64, SP1
	Windows 8 Professional and Enterprise, x64
Supported versions of Microsoft® SQL Server	
SQL Server 2008 R2 Standard (and Standard for Small Business) SP2	
SQL Server 2008 R2 Enterprise	
SQL Server 2012 Express with Advanced Services, Standard, Enterprise, Enterprise Core and Business Intelligence	

Note: If you do not have one of the above versions installed, Power Xpert Insight will install SQL Server 2012 Express with Advanced Services.

Supported Web Browsers

- Microsoft Internet Explorer® (IE) 9, 10 or 11
- Google Chrome™
- Firefox®
- Other browsers (such as Opera and Safari®) that support Silverlight® may also work, but are not officially supported by Eaton

Metering Products Family

Contents

Product Overview

Eaton's metering products provide solutions needed to monitor and manage all aspects of an electrical distribution system.

When greater reliability, increased productivity and significant cost savings are called for to remain competitive in today's market, Eaton's metering products fit the bill. These innovative meters and communications systems, along with Power Management software, make it possible to successfully take control of the electrical distribution system.

Power Xpert Meters

Power Xpert Meters are the benchmark for intelligent Web-enabled top-quality metering devices for the power system. Power Xpert Meters provide measurement of the critical elements found in the power system, whether that be voltage, power, current, transients, harmonics or even time. Power Xpert Meters provide Web-enabled communications for use with the Power Xpert Insight. All Power Xpert Meters provide a standard communications protocol for easy integration into other systems.

Features and Benefits

Greater Reliability

Eaton's metering products give the ability to receive an early warning of potential problems, eliminate unnecessary trips, isolate faults to ensure minimum downtime and shed or equalize loads while a problem is being corrected.

Increased Productivity

Equipment downtime resulting from voltage or frequency variations can be very costly to an operation. Monitoring power quality with Eaton's metering products throughout the electrical distribution system provides data to identify, isolate and correct problems quickly and efficiently.

Reduced Energy and Operating Costs

When we think about meters and power quality, the common thread throughout the basket of solutions is information. Collecting, monitoring and managing data from the electrical distribution system can help reduce costs for those facilities prepared to define and analyze present electrical energy usage levels and patterns. Data provided by Eaton's metering products comprise the data for verifying utility bills for energy management and lowering operating costs. Deregulation in some geographical locations permits energy users to select a utility provider and negotiate rate structures. For large users with heavy utility bills, this may be an incentive to verify the utility bill, identify an opportunity for savings, negotiate a better utility rate and apply the savings directly to the bottom line. Users are also empowered to decrease energy consumption, thereby lowering peak demand charges and decreasing operating costs.

When an Eaton meter is used with Eaton trip units and relays incorporating built-in metering capabilities, the entire electrical distribution system can be cost-effectively managed.

Eaton is an industry leader offering a complete integrated solution to oversee your entire electrical distribution system. As a global manufacturer of low and medium voltage electrical distribution system equipment and components, Eaton is an experienced innovator of metering products that incorporate cutting-edge technology. These innovations result from our scientific and engineering expertise, physical resources and the ongoing R&D programs at our technology centers.

Product Selection Guide

Metering Selection Chart

Device Name Accessories See Page V3-T9-90	Power Xpert Meter 4000/6000/8000 Series	Power Xpert Meter 2000 Series	IQ 250/260 Series
			
Section Page Number	**V3-T9-13**	**V3-T9-26**	**V3-T9-35**
Electrical Parameters			
Volts	0.1% of RV + 0.02% FS	0.1% of RV	0.1% of RV
Amperes	0.05% of RV + 0.01% FS	0.1% of RV	0.1% of RV
Current range (% of nominal)	0.005–20A (400%)	0.1–200%	0.1–200%
Watts	0.1% of RV + 0.0025% FS	0.2% of RV	0.2% of RV
VARs	0.1% of RV + 0.0025% FS	0.2% of RV	0.2% of RV
VA	0.1% of RV + 0.0025% FS	0.2% of RV	0.2% of RV
PF-apparent	0.1%	0.2% of RV	0.2% of RV
PF-displacement	0.1%	—	—
Frequency	±0.01 Hz	±0.03 Hz	±0.03 Hz
THD-voltage	127th	40th ②③④⑤	40th ⑥
THD-current	127th	40th ②③④⑤	40th ⑥
Watthours	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①
VAR-hours	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①
VA-hours	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①
Ampere-demand	0.05% of RV + 0.01% FS	±0.1% per ANSI C12.20 0.2 Class	±0.1% per ANSI C12.20 0.2 Class
Watt-demand	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①
VAR-demand	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①
VA-demand	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①	±0.2% per ANSI C12.20 0.2 Class ①
Revenue accuracy	±0.2% per ANSI C12.20 0.2 Class ①	ANSI C12.20 (0.2%)	ANSI C12.20 (0.2%)
Individual ampere harmonics	85th ⑦	40th ③④⑤	—
Individual voltage harmonics	85th ⑦	40th ③④⑤	—
Interharmonics	Yes	—	—
Minimum and/or Maximum Values			
Volts	L-L, L-N, N-G, VAUX L-L	L-L, L-N	L-L, L-N
Current	A, B, C, N, G	A, B, C, N	A, B, C
Power	Watt, VAR, VA	Watt, VAR, VA	Watt, VAR, VA
Power Factor	Apparent/displacement	Apparent	Apparent
Frequency	Hertz	Hertz	Hertz
THD	Amperes/volts (L-L, L-N, AUX L-L)	Amperes/volts ②③④⑤	Amperes/volts ⑥
Demand values	kW, kVAR, kVA, amperes	kW, kVAR, kVA, amperes	kW, kVAR, kVA, amperes
Trend analysis	2 / 4 ⑧ / 8 ⑨ GB	256 / 512 ② / 768 ③④⑤ MB	128 KB ⑩
Event logging	2 / 4 ⑧ / 8 ⑨ GB	100,000 alarms/events with timestamp	⑪
Disturbance recording	2 / 4 ⑧ / 8 ⑨ GB 60 cycles per event	768 MB ④⑤ up to 64 cycles per event ④⑤	—

Notes

① Under typical operating conditions.
② PXM 2260 only.
③ PXM 2270 only.
④ PXM 2280 only.
⑤ PXM 2290 only.
⑥ IQ 260 only.
⑦ Individual values reported to 85th harmonic; anti-alias filtering prevents higher frequencies from distorting readings (see IEC 61000-4-7).
⑧ PMX 6000 only.
⑨ PXM 8000 only.
⑩ Optional.
⑪ At computer only.

Legend: PG = Programmable
FS = Full scale
RV = Read value
Auxiliary voltage (optional) = Provides three additional voltage inputs to the meter: Va2, Vb2, Vc2.
Interharmonics = Power Xpert Meter 6000/8000 supported.

Metering Selection Chart, continued

Device Name Accessories See Page V3-T9-90	Power Xpert Meter 4000/6000/8000 Series	Power Xpert Meter 2000 Series	IQ 250/260 Series
			
Section Page Number	**V3-T9-13**	**V3-T9-26**	**V3-T9-35**
Other Features			
Storage	2 / 4 ① / 8 ② GB	256 / 512 ③ / 768 ④ MB Standard	128 KB for logging, up to 8 parameters every 15 minutes for 30 days
PG output relays	5 maximum	Optional (2) Form C, 5A or (4) Form A, 120 mA	Optional (2) Form C, 5A or (4) Form A, 120 mA
PG analog outputs	—	Optional (4) 4–20 mA or (4) 0–1 mA	Optional (4) 4–20 mA or (4) 0–1 mA
Discrete contact inputs	8	Optional (2) or (4)	Optional (2) or (4)
Analog inputs	—	—	—
Synch-input kW utility	Via status input	Via end of interval pulse with optional digital inputs	Via end of interval pulse with optional digital inputs
Auxiliary voltage ⑤	Yes	—	—
kWh pulse initiator	Yes	Yes	Yes
Waveform display	Local/computer	⑥	—
Waveform capture, samples/cycle	Yes, 512 (4096 oversampling)	Yes, up to 64 ⑦, up to 512 ⑧	—
Frequency distribution display	—	—	—
Display type	LCD ⑨	Red LED	Red LED
Display lines/character	Color graphic	3 lines, 4 characters	3 lines, 4 characters
Display character height	—	0.56 (14.2) H	0.56 (14.2) H
Communications	Serial: Modbus RTU, Modbus ASCII ⑨ Network: Modbus TCP, Ethernet TCP/IP, HTTP, SNMP, SMTP, FTP, DNP 3.0	Serial: Modbus RTU, Modbus ASCII, DNP 3.0 Network: Modbus TCP, BACnet/IP, Ethernet TCP/IP, HTTP, HTTPS, SNMP, SMTP, ⑦⑧ Waveform FTP	Serial: Modbus RTU, Modbus ASCII, DNP 3.0 Network: Modbus TCP via Power Xpert Gateway
Setup configuration	Via Web browser	Via Web browser/display	Via configuration software/display
Dimensions	Refer to TD02601007E	Refer to TD02601017E	Refer to TD02601016E
Operating temperature range	–20° to 60°C display unit –20° to 70°C meter base unit	–20° to 70°C	–20° to 70°C
Reference literature	TD02601007E	TD02601017E	TD02601016E

Notes

① PXM 6000 only.
② PXM 8000 only.
③ PXM 2260 only.
④ PXM 2270 only.
⑤ The auxiliary voltage option adds three additional voltage input channels to Power Xpert Meters.
⑥ At computer only.
⑦ PXM 2280 only.
⑧ PXM 2290 only.
⑨ Optional

Legend: PG = Programmable
FS = Full scale
RV = Read value
Auxiliary voltage (optional) = Provides three additional voltage inputs to the meter: Va2, Vb2, Vc2.
Interharmonics = Power Xpert Meter 6000/8000 supported.

Metering Selection Chart, continued

Device Name Accessories See Page V3-T9-90	IQ 130/140/150 Series	IQ 150S/250S Series	IQ 35M Series
			
Section Page Number	**V3-T9-41**	**V3-T9-46**	**V3-T9-51**
Electrical Parameters			
Volts	±0.25% of RV	0.1% of RV	0.4% +0.015% per °C deviation from 25°C
Amperes	±0.25% of RV	0.1% of RV	0.4% (5–100%), 0.8% (1–5%) +0.015% per °C from 25°C
Current range (% of nominal)	0.1–200%	0.1–200%	1–120%
Watts	0.5% of RV ①	0.2% of RV	0.5% per ANSI C12.20 and IEC 62053-22 Class 0.5S
VARs	0.5% of RV ①	0.2% of RV	2.0% per IEC 62053-23 Class 2
VA	0.5% of RV ①	0.2% of RV	Calculated: vector sum of watts and VARs
PF-apparent	0.5% of RV ①	0.2% of RV	Calculated: Watts / VAs
PF-displacement	—	—	—
Frequency	±0.03% Hz ①	±0.03 Hz	±0.02 Hz
THD-voltage	—	—	—
THD-current	—	—	—
Watthours	±0.5% per ANSI C12.20 0.5 Class ②	±0.2% per ANSI C12.20 0.2 Class	0.5% per ANSI C12.20 and IEC 62053-22 Class 0.5S
Varhours	±0.5% per ANSI C12.20 0.5 Class ②	±0.2% per ANSI C12.20 0.2 Class	±2.0% per IEC 62053-23 Class 2
VA-hours	±0.5% per ANSI C12.20 0.5 Class ②	±0.2% per ANSI C12.20 0.2 Class	—
Ampere-demand	±0.5% per ANSI C12.20 0.5 Class ②	±0.1% per ANSI C12.20 0.2 Class	—
Watt-demand	±0.5% per ANSI C12.20 0.5 Class ②	±0.2% per ANSI C12.20 0.2 Class	0.5% per ANSI C12.20 and IEC 62053-22 Class 0.5S
VAR-demand	±0.5% per ANSI C12.20 0.5 Class ②	±0.2% per ANSI C12.20 0.2 Class	2.0% per IEC 62053-23 Class 2
VA-demand	±0.5% per ANSI C12.20 0.5 Class ②	±0.2% per ANSI C12.20 0.2 Class	Calculated: vector sum of watts and VARs
Revenue accuracy	ANSI C12.20 (0.5%)	ANSI C12.20 (0.2%)	0.5% per ANSI C12.20 and IEC 62053-22 Class 0.5S
Individual ampere harmonics	—	—	—
Individual voltage harmonics	—	—	—
Interharmonics	—	—	—
Minimum and/or Maximum Values			
Volts	L-L, L-N	L-L, L-N	—
Current	A, B, C	A, B, C	—
Power	Watt, VAR, VA	Watt, VAR, VA	—
Power factor	Apparent ①	Apparent	Apparent (low alert)
Frequency	Hertz ①	Hertz	Hertz (out of range alert)
THD	Ampere/Volts	—	—
Demand values	kW, kVAR, kVA, amperes ①	kW, kVAR, kVA, amperes	kW, kVAR, kVA; Maximum kW, kVAR, kVA
Trend analysis	③	2 MB ⑤	—
Event logging	③	2 MB ⑤	Logging on demand interval or Modbus command ④
Disturbance recording	—	—	—

Notes

① IQ 140 and IQ 150.
② IQ 150 only.
③ At computer only.
④ Optional.
⑤ IQ 250S only.

Legend: PG = Programmable
FS = Full scale
RV = Read value

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Metering Selection Chart, continued

Device Name Accessories See Page V3-T9-90	IQ 130/140/150 Series	IQ 150S/250S Series	IQ 35M Series
			
Section Page Number	**V3-T9-41**	**V3-T9-46**	**V3-T9-51**
Other Features			
Storage	—	2 MB ②	10 registers (16 bit) by 5760 entries each (115 KB) ①
PG output relays	—	—	—
PG analog outputs	—	—	—
Discrete contact inputs	—	—	2 pulse inputs with BACnet
Analog inputs	—	—	—
Synch-input kW Utility	—	—	Optional demand synchronization via Modbus
Auxiliary voltage ③	—	—	—
kWh pulse initiator	①	Yes	Yes
Waveform display	—	—	—
Waveform capture	—	—	—
Frequency distribution display	—	—	—
Display type	Red LED	Red LED	Backlit LCD
Display lines/character	3 lines, 4 characters	3 lines, 4 characters	2 lines by 5 characters ea (full alphanumeric top row)
Display character height	0.56 (14.2) H	0.56 (14.2) H	7.5 mm
Communications	Serial: Modbus RTU, Modbus ASCII ① Network: Modbus TCP ①	Serial: Modbus RTU, Modbus ASCII, DNP 3.0 Network: Modbus TCP, wired or wireless	Serial: Modbus RTU ①, BACnet MS/TP ① Network: Modbus TCP via Power Xpert Gateway
Setup configuration	Via configuration software/display	Via configuration software/display	Via display/configuration software
Dimensions	4.85 (123.2) H x 4.85 (123.2) W x 4.97 (126.2) D	7.90 (200.7) H x 7.50 (190.5) W x 3.10 (78.7) D	3.60 (91.4) H x 4.20 (106.7) W x 2.30 (58.4) D
Operating temperature range	–20 to 70°C	–20 to 70°C	–20 to 70°C
Reference literature	TD02601015E	TD02601019E	TD02601015E

Notes

① Optional.

② IQ 250S only.

③ The auxiliary voltage option adds three additional voltage input channels to Power Xpert Meters.

Legend: PG = Programmable
FS = Full scale
RV = Read value

Metering Selection Chart, continued

Device Name Accessories See Page V3-T9-90	IQ Analyzer 6000 Series 	IQ DP-4000 Series 	Power Xpert Multi-Point Meter 
Section Page Number	**V3-T9-54**	**V3-T9-62**	**V3-T9-68**
Electrical Parameters			
Volts	±0.2% FS ①	±0.3% FS	±0.2% RV
Amperes	±0.2% FS ①	±0.3% FS	±0.2% RV
Current range (% of nominal)	3–800%	10–250%	—
Watts	0.4% FS, 6 RV ②	±0.6% FS	±0.5% RV
VARs	0.4% FS, 6 RV ③	±0.6% FS	±0.5% RV
VA	0.4% FS, 6 RV ②	±0.6% FS	±0.5% RV
PF-apparent	0.8% FS ①	±1.0% FS	±0.5% RV
PF-displacement	0.8% FS ①	±1.0% FS	—
Frequency	0.04% ① or 0.01 Hz	±0.17% FS	±0.1 Hz
THD-voltage	50th	31st	—
THD-current	50th	31st	—
Watthours	0.5% RV ②	±0.6% FS	±0.5% per ANSI C12.20 0.5 class
Varhours	1% RV ③	±0.6% FS	±0.5% per ANSI C12.20 0.5 class
VA-hours	0.5% RV ②	±0.6% FS	±0.5% per ANSI C12.20 0.5 class
Ampere-demand	±0.2% FS ①	±0.3%	—
Watt-demand	±0.4% FS ①	±0.6%	±0.5% per ANSI C12.20 0.5 class
VAR-demand	±0.4% FS ①	±0.6%	±0.5% per ANSI C12.20 0.5 class
VA-demand	±0.4% FS ①	±0.6%	±0.5% per ANSI C12.20 0.5 class
Revenue accuracy	ANSI C12.20 (0.5%)	—	ANSI C12.20 (0.5%)
Individual ampere harmonics	50th	—	—
Individual voltage harmonics	50th	—	—
Interharmonics	—	—	—
Minimum and/or Maximum Values			
Volts	L-L, L-N	L-L, L-N	L-L, L-N
Current	A, B, C, N, G	A, B, C	A, B, C
Power	Watt, VAR, VA	Watt, VAR, VA	Watts, VAR, VA
Power factor	Apparent/displacement	Apparent/displacement	Apparent
Frequency	Hertz	Hertz	Hertz
THD	Amperes/volts	Amperes/volts	—
Demand values	All	All	Watts (Delivered & Received), Watts (Q1–Q4), VA (Q1, Q4), VA (Q2, Q3)
Trend analysis	Time/date	2 alarms	Interval data
Event logging	504 events w/timestamp	④	20 latest events and historical
Disturbance recording	10 waveform events	—	—

Notes

① From 3–300% of FS.
② At unity power factory and 5–300% of FS.
③ At a power factor <±0.5 and 5–300% of FS.
④ At computer only.

Legend: PG = Programmable
FS = Full scale
RV = Read value

Metering Selection Chart, continued

Device Name Accessories See Page V3-T9-90	IQ Analyzer 6000 Series 	IQ DP-4000 Series 	Power Xpert Multi-Point Meter 
Section Page Number	**V3-T9-54**	**V3-T9-62**	**V3-T9-68**
Other Features			
Storage	90 KB	15 parameters	256 MB standard, 2 GB optional
PG output relays	(4) 10A Form C ①	(3) 10A Form C ②	1 standard, 8 each module ①
PG analog outputs	(4) 0–10/4–20 mA	—	3 standard, 8 each module ①
Discrete contact inputs	(3) + 30 Vdc differential	(1) kW Demand ②	—
Analog inputs	(1) 0–20/4–20 mA	—	Via communications and digital input
Synch-input kW Utility	At device or via communications	At device or via communications ②	—
Auxiliary voltage	—	—	Aggregate or main-digital output, LED output on meter modules (accuracy check)
kWh pulse initiator	Yes	Yes ②	—
Waveform display	Local ②/computer	—	—
Waveform capture, samples/cycle	Yes, 128	—	—
Frequency distribution display	Local ②/computer	—	—
Display type	Graphic LCD with LED backlight	7 Segment LED	LCD color touchscreen ①
Display lines/character	7 lines, 147 characters	1 line, 7 characters	6-inch diagonal
Display character height	Up to 7 lines	1 line	Graphics
Communications	Serial: INCOM ③ Network: via Power Xpert Gateway ③	Serial: INCOM ③ Network: via Power Xpert Gateway ③	Serial: Modbus RTU ① Network: Modbus TCP, BACnet/IP, Ethernet TCP/IP, HTTP, HTTPS, SNMP, SMTP, SFTP
Setup configuration	Via configuration software/display	Via configuration software/display	Via PXMP configuration software
Dimensions	Refer to TD1702BTE	Refer to TD1703ATE	Refer to TD150006EN (see Page V3-T9-110)
Operating temperature range	–20° to 70°C	–20° to 70°C	–20° to 70°C
Reference literature	—	—	TD150006EN

Notes

① Relays programmable to operate on any measured function.
② Optional.
③ An IPONI is required.
④ IQ 230M only.

Legend: PG = Programmable
FS = Full scale
RV = Read value

Power Xpert 4000/6000/8000 Series Display and Meter

Contents

An Eaton Green Solution

Power Xpert Meter 4000/6000/8000 Series

Product Description

The Power Xpert Meter 4000/6000/8000 Series monitors the critical aspects of an electrical distribution system. This premier power quality metering instrument is simple to use, powerful, scalable and highly flexible.

The Power Xpert Meter 4000/6000/8000 offers a new level of intuitive user interface design, presenting critical electrical distribution system information in simple-to-navigate and easy-to-understand information architecture. The Power Xpert Meter 4000/6000/8000 graphic display visualizes the information from up to 16 meter modules. The embedded Web server displays complex power quality data using standard Internet browsers and allows for device configuration from the browser.

Both the local display and the embedded Web server present real time, historical and event information in a browser-style graphical format to help the user interpret key circuit information, such as:

- Current loading
- Voltage and power levels
- Power factor
- Energy usage
- I/O status
- Power quality measurements
- Harmonic plots
- Disturbance and transient waveforms
- ITIC disturbance summary screen

The Power Xpert Meter 4000/6000/8000 color touchscreen displays allow the user to easily view meter parameters and historical data.

The Web server provides the energy and demand readings required to help manage the cost of energy. It also provides critical information regarding power quality, such as harmonic distortion, flicker, crest factor, K-factor and more.

Note: Features and functionality may vary depending on the meter model and options being used. Review the Features and Benefits chart on **Page V3-T9-16** for details.

Standards and Certifications

- Safety: EN61010-1, UL/cUL 61010-1
- Accuracy: IEC/EN60687 0.2 Class, ANSI C12.20 0.2 Class
- EMC: FCC Part 15 Subpart B Class A EN55011 Class A
- Measurement Canada Approval No. AE-1898 (4000/6000 meters)
- Immunity IEC 61326
- CE Mark

UL Listed c UL Listed CE

Application Description

Identify Power Quality Problems to Help:

- Identify harmonics, sags, swells and transients damaging or disrupting sensitive, mission-critical IT equipment
- Boost IT equipment's service life to the maximum
- Analyze sequence of events up to 1 millisecond time resolution
- Protect motors from damage
- Preserve the integrity of processes and batches
- Prevent blown capacitor bank fuses
- Protect transformers and conductors from overheating

Detect and Record High-Speed Transients to Help:

- Avoid equipment damage and disruption
- Identify equipment malfunction

Monitor Circuit Loading to Help:

- Avoid overloads and nuisance overload trips
- Maximize equipment utilization
- Manage emergency overloads

Manage Energy Utilization to Help:

- Reduce peak demand charges and power factor penalties
- Identify excessive energy consumption

Metered/Monitored Parameters

Note: See **Page V3-T9-16**.

- Volts: L-L, L-N, Avg. L-L, Avg. L-N, N-G
- Phase neutral and ground currents
- Power: real, reactive and apparent
- Frequency
- Power factor: apparent and displacement
- Energy
- Demand
- % THD
- Minimum and maximum values
- Harmonics
- Flicker
- Individual harmonics
- Interharmonics
- % TDD
- ITIC events plot, duration, magnitude
- Energy comparisons
- Demand comparisons
- Event calendar
- Event timeline and sequence
- Number of 9s of availability
- Phasors
- Sequence components
- Crest factor
- K-factor
- PQ Index

Accuracy

- Currents: 0.05% RV + 0.025%FS
- Voltage: 0.1% RV + 0.025% FS
- Energy and demand power: 0.2% in accordance with ANSI C12.20
- Frequency: ±0.01 Hertz
- Power factor:
  - 0.10% at Unity PF
  - 0.30% at 0.5 PF

Communications

Multiple communications ports including:

Standard

- RS-485 remote display port
- RS-485 Modbus RTU slave port
- RJ-45 10/100Base-T local configuration port (local Web server connection)
- HTTP (local), FTP, COMTRADE

Optional

- Communications Expansion Card (CEC
  - Selectable 100FX or 10/100Base-T Ethernet network port
  - RS-485 Modbus RTU selectable master/slave port
  - RS-232 Modbus RTU slave port

Communication Protocols Supported

- Modbus RTU
- Modbus TCP
- Ethernet TCP/IP
- HTML
- NTP (Network Time Protocol)
- FTP (File Transfer Protocol)
- SMTP (Simple Mail Transfer Protocol)
- SNMP (Simple Network Management Protocol)
- COMTRADE (IEEE C37.111-1999)
- DNP 3.0 over Ethernet (Distributed Network Protocol)

Display/Meter Mounting Options

- The 6-inch color touchscreen display can be mounted back-to-back with one Power Xpert meter module on opposite sides of a panel

Meter Base Unit Characteristics

- NEMA rating: NEMA 1, IP30

Display Unit Characteristics

- NEMA rating: NEMA 12, IP42 front of panel rating

Power Xpert Meter 4000/6000/8000 Displays (Option)

The Power Xpert Meter 4000/6000/8000 has two display options: a 6-inch color touchscreen display (PXM468K-DISP-6) and a 12-inch advanced color touchscreen display (PXM468K-DISP-12).

The 6-inch color touchscreen display allows access to real-time metered values, min/max values, power quality, I/O (input/output), events and graphical trend charts.

The advanced 12-inch touchscreen display provides access to all measured and stored parameters in the meter. It supports graphical real-time information, trend charts of key circuit measurements, waveforms, harmonics and calendar displays.

All meter setup and programming can be performed through the display.

Inputs and Outputs

Power Xpert Meter 4000/6000/8000 is available with an optional digital I/O card, which includes:

- Eight digital inputs—self sourced 24 Vdc
- Three relay outputs—5A max. continuous, 240 Vac max., 30 Vdc max.
- Two solid-state outputs—80 mA max. continuous, 30 Vdc max.

Each of the 8 inputs are interrupt driven, allowing for 1 ms accuracy of digital events time stamps (1 ms accuracy requires local NTP TimeServer). Inputs can also be configured for demand synch and pulse counting. Inputs selected for pulse counting can be scaled. Interval by interval pulse recordings are maintained in profile memory and can be displayed graphically. Outputs can be used for KYZ, or alarm annunciation.

Ratings

- Application to 500 kV, no PTs to 600V
- CT ratios selectable from standard 120/600 Vac line
- CT inputs accept 5A secondary
- Power supply:
  - Standard 120/240 Vac or 110/250 Vdc

Storage Capacity

Power Xpert Meter 4000/6000/8000 Estimated Memory and Storage Capacity with 2/4/8 GB Memory Capacity

				Occurrence Per Month ①		Memory Usage (MB)		Months of Capacity ②	
Model	**Memory**	**Event**	**File Size (KB)**	**Typical**	**Severe**	**Typical**	**Severe**	**Typical**	**Severe**
PXM 4000	2 GB	Subcycle Disturbance	1260	10	60	12.3	73.8	166	28
PXM 6000	4 GB	ITIC Event	1260	5	20	6.2	24.6	666	166
		Subcycle Disturbance	1260	10	60	12.3	73.8	333	55
		ITIC + Subcycle Disturbance	Total--->	15	80	18.5	98.4	222	42
PXM 8000	8 GB	ITIC Event	1260	5	20	6.2	24.6	1332	333
		Subcycle Disturbance	1260	10	60	12.3	73.8	666	111
		Transients	2048	3	30	6.0	60.0	1365	137
		ITIC + Subcycle Disturbance + Transients	Total--->	18	110	24.5	158.4	335	52

Notes

① The typical and server power quality event occurrences are estimates and may vary depending on the electrical environment.

② Memory is not allocated by event category; memory is used first come, first served.

Features and Benefits

Power Xpert Meter 4000

- Harmonics, including individual harmonics
- Disturbance capture
- Low frequency transient detection and capture
- Standard power quality index

Power Xpert Meter 6000

- Interharmonics
- Flicker calculations
- ITIC performance curve
- Event calendar view
- Events timeline view
- Sequence of events waveform plot
- Enhanced power quality index

Power Xpert Meter 8000

- Impulsive transient capture at 6 MHz
- 100,000 samples per cycle
- Premium power quality index

Power Xpert Meter 4000/6000/8000

	Power Xpert Meter			
Feature	**4000**	**6000**	**8000**	**Benefit**
General				
Embedded Web server	■	■	■	Use a standard Web browser to monitor and manage the meter over the network, Internet
TOU metering support	■	■	■	Time of usage can be set up to support 4 different schedules
Firmware flash update support	■	■	■	Enables you to flash the meter with the latest firmware updates
Self-learning capability (characterizes "normal" per circuit)	■	■	■	The meter can automatically adjust to the environment and alarm only when "real" events occur
Power, Energy and Demand				
Voltage, current: per phase minimum, maximum, average, trend graph analysis, export, print	■	■	■	Review voltage and current trends, export, print and analyze parameters right on the meter or external software
Energy and demand plot comparisons month-to-month, week-to-week	■	■	■	Plot two months or two weeks for vivid energy or demand comparison
Power: power factor, apparent, real, reactive, frequency	■	■	■	Review power usage and power factor and avoid potential PF penalties
Energy, demand: forward, reverse, net, sum, tou, profile, previous month comparison, graph analysis, export, print	■	■	■	Keep track of your energy usage, compare time of usage and usage against previous month, identify peaks to conserve energy usage
Power Quality Analysis				
Statistical analysis (min., max., average)	■	■	■	Review statistical trends, identify past and future problem areas
Sag and swell monitoring, management and recording	■	■	■	Capture electrical sags and swells and analyze the waveforms
Symmetrical Components: Zero, Negative, Positive	■	■	■	Analyze possibly unbalanced three-phase power systems
Low frequency transient detection and capture	■	■	■	Capture lower frequency transient waveforms for retrospective analysis or e-mailing
Sampling rate, maximum samples/cycle	4096 ①	4096 ①	100,000	Extremely high sampling rate will effectively capture impulsive transients
"Number of Nines" uptime data (e.g., 6 nines = 99.9999%)	■	■	■	Review uptime availability per cent
K-factor	■	■	■	Review the ratio of eddy current losses, e.g., when driving nonlinear and linear loads
Crest factor	■	■	■	Review the peak-to-average ratio of the waveform
Security				
Secure 5 level user access privileges	■	■	■	Define appropriate security access level per user
Communications and I/O				
Modbus TCP	■	■	■	Easy integration with standard protocol to power management and other software
Modbus RTU	■	■	■	Integrate meters to existing Modbus networks, daisy chain several (1–16) meters together
HTML	■	■	■	Communicate to the meter over the Internet via standard Web browser
SNMP (simple network management protocol)	■	■	■	Communicate with the meter via Simple Network Protocol; hook to existing NMS system
SMTP (simple mail transfer protocol)	■	■	■	Send e-mail messages via standard Simple Mail Transfer Protocol
FTP (file transfer protocol)	■	■	■	Access, copy, paste, cut waveform capture files on the meter with an FTP Client
NTP (network time protocol)	■	■	■	Network Time Protocol support enables the meter to synchronize time over the network up to the 1 millisecond resolution
COMTRADE, open IEEE Standard file format for Waveform capture export	■	■	■	Import waveform captures in standard IEEE (C37.111-1999) COMTRADE file format to third-party software
DNP 3.0 over Ethernet (Distributed Network Protocol)	■	■	■	Communicate with the meter via DNP 3.0 over Ethernet; hook to existing utility systems

Notes

These specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and User Manual for detailed specifications.

① Delta-Sigma A/D oversampling rate.

Power Xpert Meter 4000/6000/8000, continued

Feature	Power Xpert Meter 4000	6000	8000	Benefit
Communications and I/O, continued)				
Trend measurements CSV file export	■	■	■	Easily export trend measurements to third-party applications, e.g., Microsoft Excel in standard CSV file format
I/O (8 digital inputs, 3 relay outputs, 2 solid-state KYZ outputs)	■	■	■	The Power Xpert I/O Card is extremely flexible and can be used in a large variety of different applications. Digital inputs and relay outputs can be programmed to interact during various conditions defined by the user. Various third-party devices, such as alarm, pulse meters, trip units, sensors can be easily integrated to the Power Xpert Meter. Triggers and events can be tied to the meters standard functions such as e-mail, logs and trends
Time Synchronization				
NTP time synchronization up to 1 millisecond accuracy	■	■	■	Network Time Protocol support enables the meter to synchronize time over the network up to the 1 millisecond resolution
GPS time synchronization up to 1 millisecond accuracy	■ ①	■ ①	■ ①	The GPS option allows the meter to synchronize time over the GPS satellite positioning system up to the 1 millisecond resolution
Logs				
Trend logging	■	■	■	Log trend information for easy statistical analysis
Load profile	■	■	■	Review the load profile graph to get a better understanding of your electrical load versus time
Event logging	■	■	■	Log events for retrospective event analysis
Memory and Storage				
Standard memory, GB	2	4	8	Store large amounts of waveform captures and events for historical analysis
Harmonics				
Harmonic levels	127	127	127	Provides extremely fast, high resolution D/A conversion
Total harmonic distortion (THD)	■	■	■	Review the total harmonic distortion level directly on the meter
Delta-Sigma D/A conversion technology	■	■	■	Provides extremely fast, high resolution D/A conversion
Harmonics over-sampling (4096 samples per cycle)	■	■	■	Over-sampling enables the usage of Anti-Aliasing technology, increasing accuracy
Anti-alias filtering	■	■	■	Technology to remove out-of-band signal components resulting in more accurate data
Individual harmonics	■	■	■	Review individual harmonic levels directly on the meter
Total demand distortion (TDD)	■	■	■	Identify harmful harmonics in e.g. lightly loaded variable-speed drive environments where THD may be high but not relative
Interharmonics		■	■	Interharmonics allow you to see what is going on between the integer multiples of the fundamental. Zoom in on the harmonics trend graph and review frequency content every 5 Hz instead of every 60 Hz
Highlights				
Sub-cycle disturbance capturing	■	■	■	Capture fast voltage changes/low frequency transient (e.g. capacitor switching transient)
dV/dt triggers for sub-cycle oscillatory transients	■	■	■	Detect and record a large magnitude oscillation transient resulting in equipment damage
Absolute threshold and dV/dt triggering	■	■	■	Detect and record if a surge suppressor is necessary
Power quality index—standard (includes dv/dt count, %TDDi and %THDv)	■	■	■	Complex power quality data put into simple graphic format
Power quality index—enhanced (includes Standard Index plus Sag level, Swell level and Flicker)		■	■	Complex power quality data put into simple graphic format (includes ITIC events and flicker calculations)
Flicker calculations		■	■	Detect and quantify low frequency rms voltage variations causing incandescent lighting flicker
Automatic trigger setting		■	■	Trigger thresholds are automatically set according to ITIC (CBEMA) standard, no need to figure this out by yourself
Automatic event severity analysis		■	■	Automatically analyze the severity of the event with the ITIC (CBEMA) performance curve plot, see where the event actually hit

Notes

These specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and User Manual for detailed specifications.

① When used with third-party device and I/O option.

Power Xpert Meter 4000/6000/8000, continued

Feature	Power Xpert Meter 4000	6000	8000	Benefit
Highlights, continued				
Event severity counters		■	■	An ITIC (CBEMA) event counter keeps track of the number of all sags, swells and transients
ITIC (Information Technology Industry Council), previously CBEMA performance curve		■	■	ITIC (Information Technology Industry Council), previously CBEMA performance curve for easy power problem evaluation
Custom ITIC (CBEMA) plot with individual event magnitude and duration		■	■	Review custom ITIC (CBEMA) plots of individual events showing you the actual magnitude, duration and hit are in a simple graphical representation
Event calendar view		■	■	The Events Timeline calendar view provides instant insight to the frequency of power events and helps detect reoccurring problems
Events timeline view		■	■	View and understand the sequence of events that have occurred during a period of time
Sequence of events and events plot on waveform		■	■	Plot color-coded events on a captured waveform to gain insight into the sequence of events cycle per cycle
Power quality index—premium (at-a-glance "thermometer" view of power quality)			■	Complex power quality data put into simple graphic format (includes ITIC events and flicker calculations)
High-Speed Transient Capture and Detection				
6 MHz capture of impulsive transients			■	Capture impulsive transients by taking 6 samples every millionth of a second
Transient Capture Duration: ~20 ms/6 MHz ~120 ms/1 MHz			■	Record and analyze transients during a longer timeframe
Waveform recorded at 100,000 samples per cycle			■	High-speed ensures impulsive transients are correctly captured (fast rise time)
Three-phase voltage and neutral-to-ground fast transient capture			■	Capture impulsive transients on all 4 channels

Discrete Contact Inputs

The optional PXMIO-B expansion card offers 8 digital inputs that are useful for a variety of applications such as:

- Status indication with time stamping of transitions (1 ms precision).
- Pulse counting of KYZ or other utility pulses such as air, water or gas.
- High-speed triggering of waveforms based on events such as breaker trips or static transfers
- Demand interval timing taken from a master utility meter end of interval pulse

Status inputs are self sourced providing a nominal 24 Vdc (20–30 Vdc) across the circuit.

Names can be configured for each input for ease of use.

Relay Outputs

The optional PXMIO-B card includes three 5A form C relay outputs rated for 240 Vac or 30 Vdc. These outputs can be used for applications such as:

- Alarm annunciation
- KYZ pulse output

Alarm outputs can be driven from triggers based on metering values. Output modes include:

- Normal—relay energized during alarm condition
- Latched—relay energized by event trigger, de-energized by acknowledgement
- Timed—relay energized by event trigger, maintained for a programmed interval.

Communications Expansion Card (CEC)

The optional PXMCE-B Card offers two Ethernet connection options, 10/100Base-T and a fiber-optic port that can be used for the following applications:

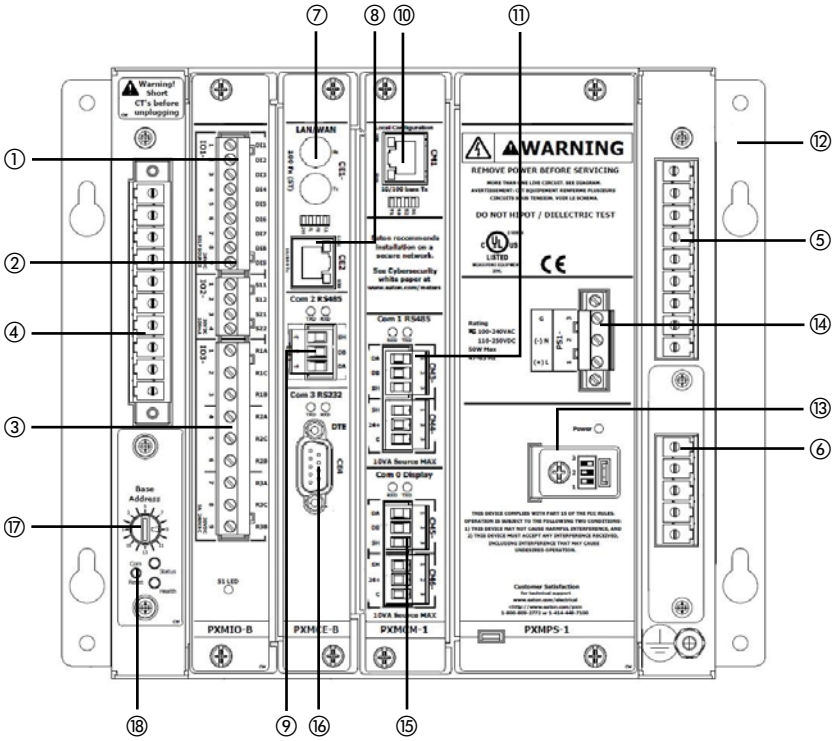
- Monitoring, managing and configuring the meter remotely using a standard Web browser interface like Microsoft Internet Explorer
- Alarm notifications via e-mail, SMTP
- Enabling access to the meter's FTP server (energy, trend and waveform logs)
- Providing Modbus TCP/IP or RTU communications to BMS systems
- Providing DNP 3.0 over Ethernet to utility systems
- Providing SNMP communications to NMS systems
- Synchronizing with an NTP server for 1ms timestamping resolution
- Asset management via SNMP to Network Management Systems
- Updating firmware on the meter

Notes

These specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list.

Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and User Manual for detailed specifications.

Power Xpert Meter 4000/6000/8000 Module Layout



I/O Card

① Digital inputs 1–8 (option)
② Solid-state outputs 1–2 (option)
③ Relay outputs 1–3 (option)

CT and Voltage Connections

④ CT input connections
⑤ Standard three-phase voltage phase inputs
⑥ Aux. channel voltage inputs (option)

Communication Expansion Card (LAN/WAN Ethernet Networking)

⑦ 100FX ST-type Ethernet (multi-mode) (option)
⑧ 10/100Base-T Ethernet (option)
⑨ RS-485 (two-wire w/shield)—24V accessory power (com 2)

Standard Features

⑩ Local RJ-45 config. port (non-networkable Ethernet)
⑪ RS-485 (two-wire w/shield) Modbus RTU (com 1)
⑫ Meter mounting brackets
⑬ Sealable mode switch cover
⑭ Control power (100–240 Vac and 110–250 Vdc) (±20%)
⑮ Display RS-485 Network port (up to 15 meters)—24V accessory power (com 0)
⑯ RS-232 (Tx Rx) Modbus RTU (com (3) (option)
⑰ Meter base address
⑱ Com Reset Button

Catalog Number Selection

To order a Power Xpert Meter 4000/6000/8000, the catalog number should be determined using the chart shown below. The chart illustrates how to include the desired factory options as part of a catalog number. Option cards that are selected at time of order entry will be installed at the factory. Option cards are also field installable for field upgrades.

If a display is required, it should be ordered separately. Power Xpert Meter modules include panel mounting brackets. The color touchscreen displays are designed to mount separately. If back-to-back meter to display panel mounting is desired, a mounting bracket kit is available (**PX-PMBD**) for the 6-inch color touchscreen display. The 12-inch advanced color touchscreen display cannot be back-to-back mounted.

Example 1: PXM8251A1BB (PXM 8000 Meter, w/ VAUX, Std. Pwr, Com. Exp. & I/O Cards)

Example 2: PXM6251A1BA (PXM 6000 Meter, w/ VAUX, Std. Pwr, Com. Exp. Card)

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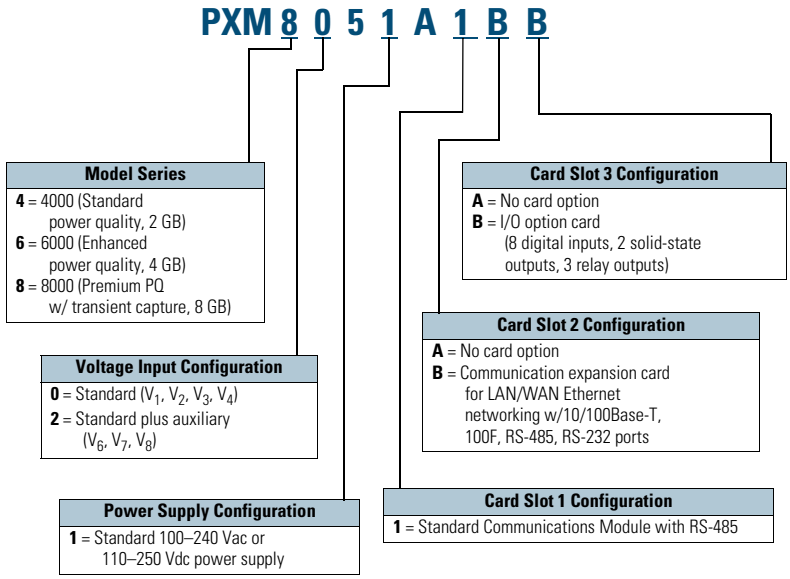
Power Xpert Meter 4000/6000/8000



Example 1: **PXM8251A5BB** (PXM 8000 meter, w/ VAUX, std. pwr., com. exp. and I/O cards)
Example 2: **PXM6251A6BA** (PXM 6000 meter, w/ VAUX, std. pwr., com. exp.card)

Accessories

Power Xpert Meter 4000/6000/8000

Description	Catalog Number
6-inch color touchscreen display	**PXM468K-DISP-6**
12-inch advanced color touchscreen display	**PXM468K-DISP-12**
Communication expansion card for LAN/WAN Ethernet networking: 100FX fiber-optic, 10/100T, RS-485, RS-232	**PXMCE-B** ①
Digital I/O card: eight digital input, two solid-state output, three relay output	**PXMIO-B** ①
Panel mounting bracket assembly for back-to-back meter to 6-inch color touchscreen display mounting	**PX-PMBD**
Panel mounting bracket assembly for retrofitting a 6-inch color touchscreen display to IQ Analyzer cutout	**PX-PMBE**
Panel mounting bracket assembly for retrofitting a 6-inch color touchscreen display to PXD-MMG cutout	**PX-PMBF**

Notes

① These items can be ordered separately or preinstalled in the meter by selecting option B in the model number.

Communication cable (standard Modbus RTU) is not included in the package for meter module connection.

Technical Data and Specifications

Environmental Conditions
- Operating temperature:
  - Meter: –20 to +70°C
  - Display: –20 to +60°C operating
  - Storage temperature: –40 to +85°C
  - Operating humidity: 5% to 95% condensing
  - Device weight: 7.1 lbs—meter 2.1 lbs—display
  - Meter and back of display are pollution degree 2
  - Elevation to 6562 ft (2000m)

Current Inputs (Each Channel)
- Conversion: 4096 samples per cycle delta-sigma converter digitally filtered down to 512 samples per cycle
- CT Input: 4096 rms samples per cycle delta-sigma converter digitally filtered down to 512 samples per cycle for anti-aliasing
- Burden: less than 10 milliohms
- Overload withstand: 500A for 1 second, non-repeating
- Range: 0.005–20A continuous
- Accuracy: 0.05% or reading plus 0.01% of full scale (from 50 milliamps to 20A)

Voltage Inputs (Each Channel)
- Conversion: 4096 rms samples per cycle delta-sigma converter digitally filtered down to 512 samples per cycle for anti-aliasing
- PT input: 120V–500,000V primary
- Input range: 600V L-L, 347 L-N direct connect
- Nominal full scale: 1000V rms
- Input impedance: 2 megohms

Frequency Range
- 47–63 Hz

Harmonic Response (Voltage, Current)
- 127th harmonic

Accuracy
- ANSI C12.20 0.2 Class
- IEC 687 0.2 Class

Discrete Inputs
- Self sourced: 24 Vdc

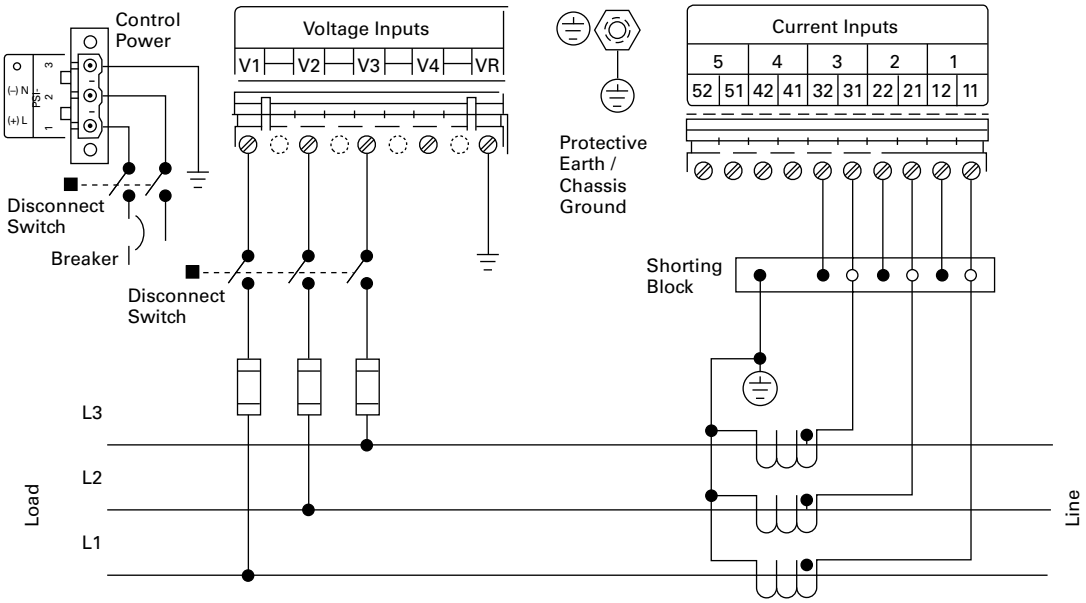
Relay Output Contacts
- 5A maximum, 240 Vac maximum, 30 Vdc maximum
- Lifetime: 1,000,000 no load operations
- 100,000 under rated voltage and load

Solid-State Outputs
- Maximum load: 100 milliamps
- Maximum voltage: 30V (externally sourced)

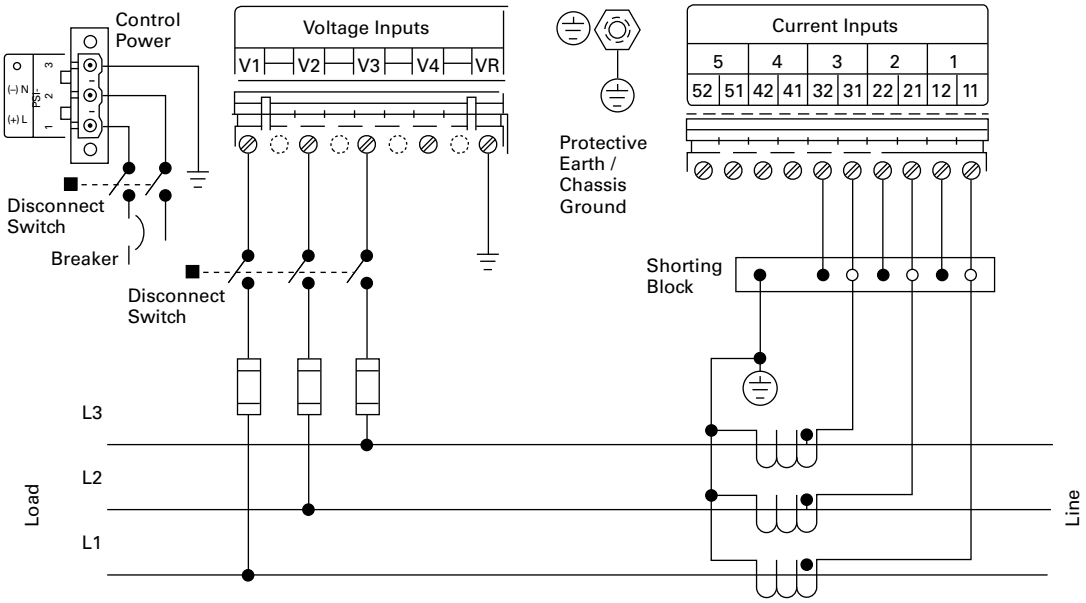
Control Power Input
- Input range AC: 100–240 Vac (±20%)
- Frequency range: 47–63 Hz
- Input range DC: 110–250 Vdc ±20%
- Burden 50 VA
- Ride-through: 1–5s

Wiring Diagrams

Three-Phase, Three-Wire Delta (Up to 600 Volts)



Three-Phase, Three-Wire Delta (Above 600 Volts)

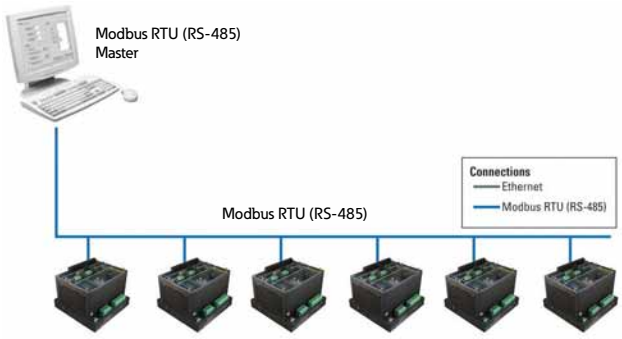


Note

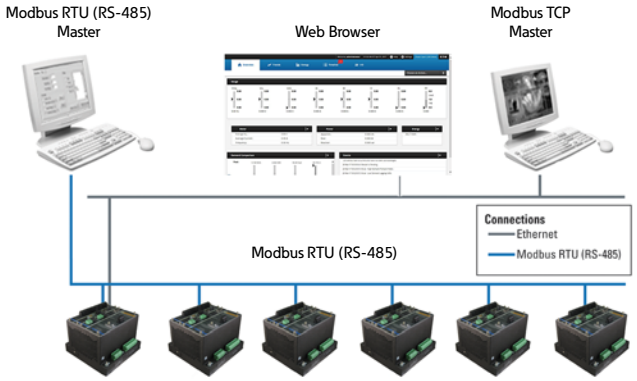
Based upon the voltage rating, you may need a control power transformer for the control power.

Power Xpert Meters Configuration and Wiring Examples

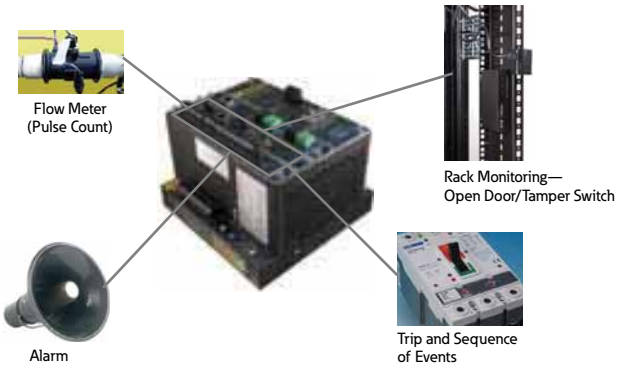
Modbus RTU (RS-485)—Non-Web Enabled



Web Enabled—Browser and Modbus TCP

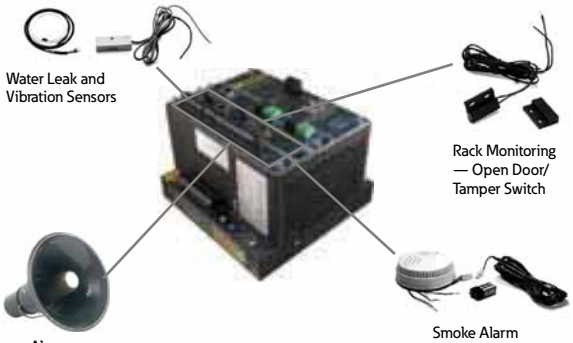


Accessories—I/O Card (Option)



- Eight Programmable Digital Inputs
- Two Solid-State Programmable Outputs
- Three Relay Programmable Outputs

IT Configuration Examples—Accessories—I/O Card (Option



- 8 Programmable Digital Inputs
- 2 Solid-State Programmable Outputs
- 3 Relay Programmable Outputs

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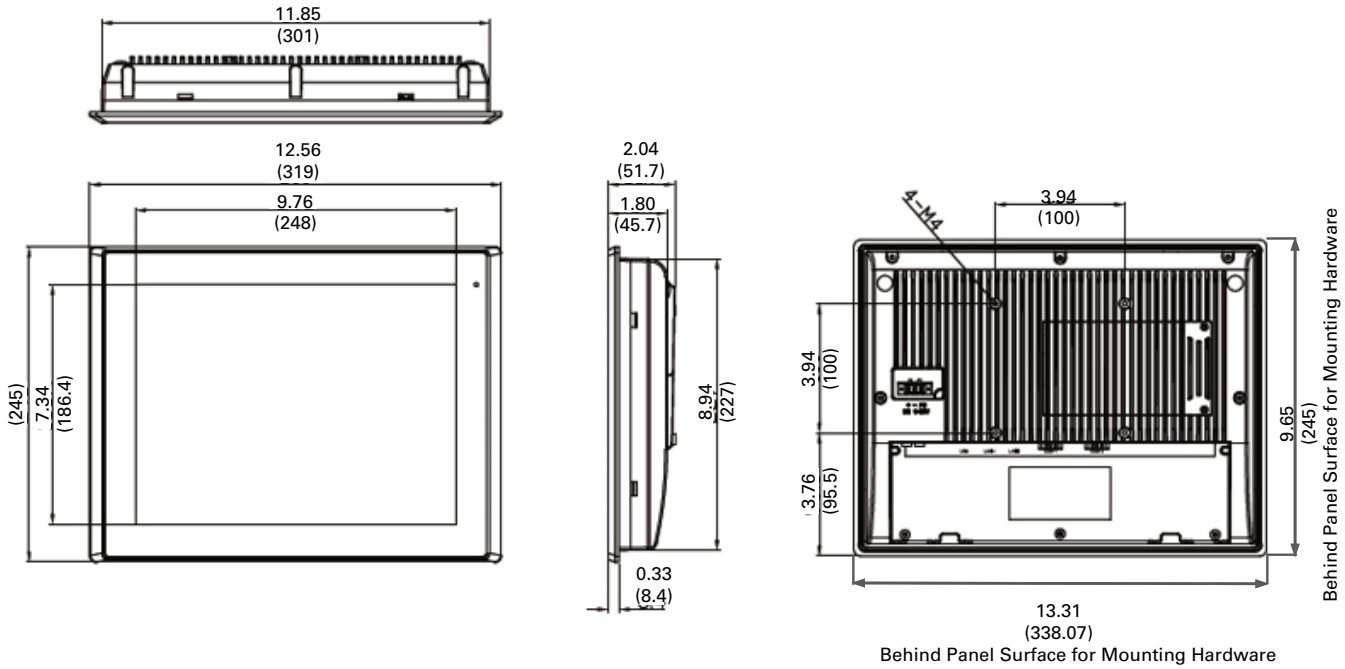
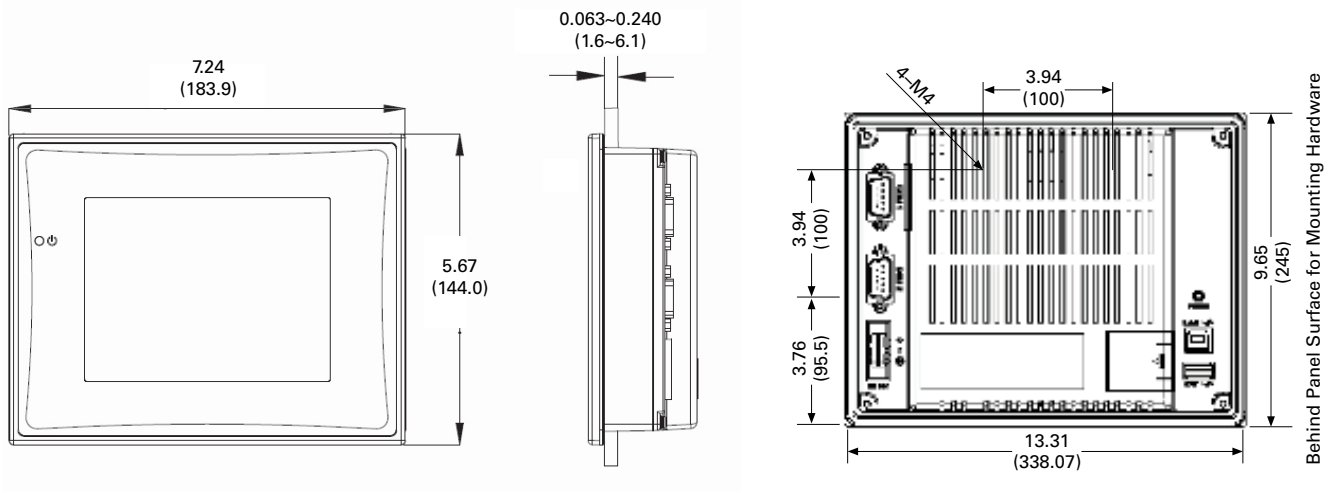
Dimensions

Approximate Dimensions in Inches (mm)

Power Xpert Meter 4000/6000/8000 12-Inch Advanced Color Touchscreen Display (PXM468K-DISP-12)—Sold Separately

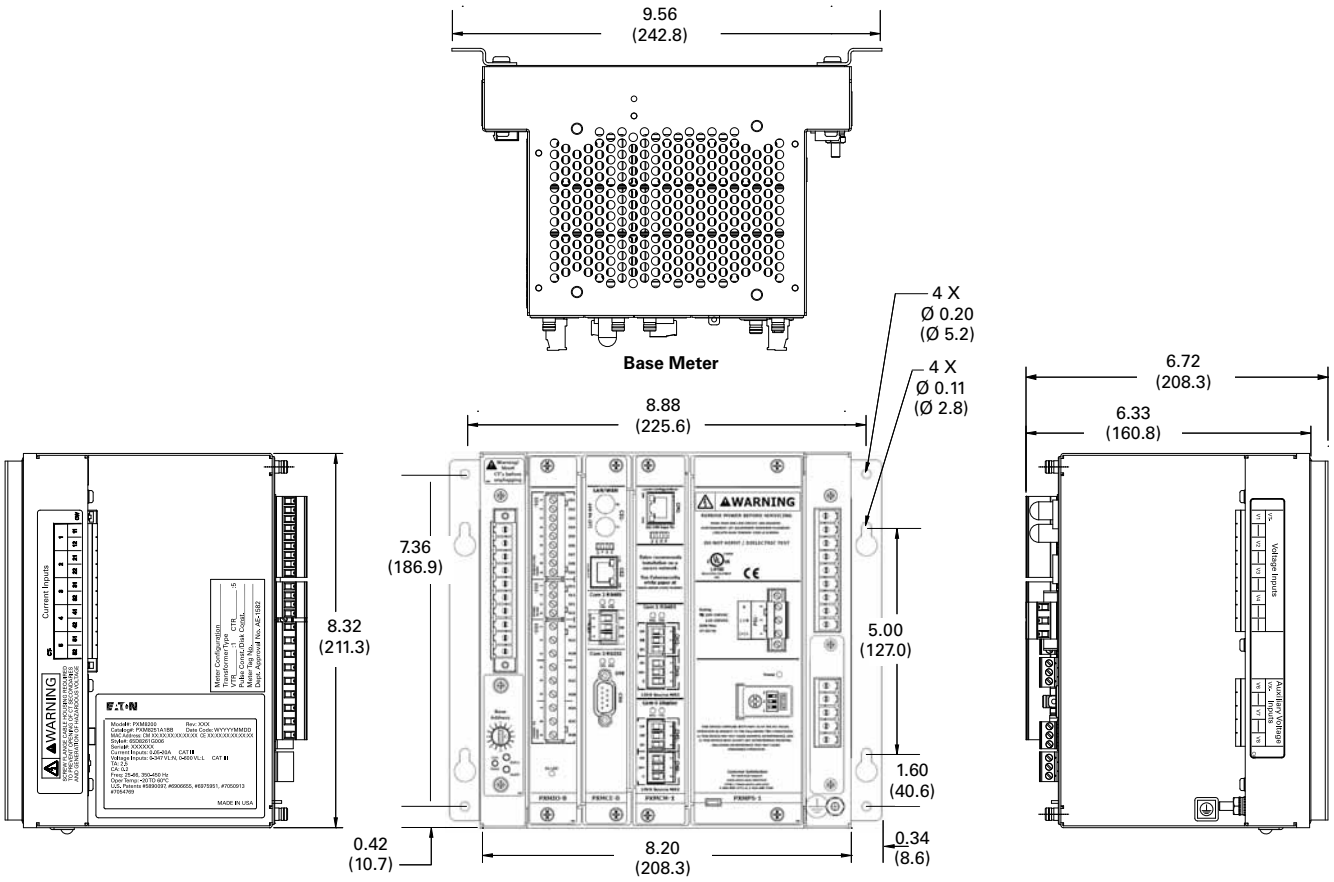


Power Xpert Meter 4000/6000/8000 6-Inch Color Touchscreen Display (PXM468K-DISP-6)—Sold Separately



Approximate Dimensions in Inches (mm)

Power Xpert Meter 4000/6000/8000 Module



Meter Base Unit

Width	Height	Depth
9.56 (242.8)	8.88 (225.6)	6.72 (170.8) ①

Display Unit

Height	Width	Depth
Projection In Front of Panel Surface		
9.02 (229.0)	7.80 (198.1)	1.04 (26.3)
Behind Panel Surface		
9.02 (229.0)	7.80 (198.1)	1.45 (36.8)

Note

① Including optional wall mounting brackets.

Power Xpert Meter 2000 Series

Contents

An Eaton Green Solution

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Power Xpert Meter 2000 Series

Product Description

The Power Xpert Meter 2000 Series power quality instrument monitors the most critical aspects of an electrical distribution system. This premier power quality metering instrument uses the latest in advanced technology to make it simple to use, powerful, scalable and highly flexible. The Power Xpert Meter 2000 offers the same level of intuitive user interface design as the Power Xpert Meter 4000/6000/8000, presenting critical electrical distribution system information in a simple to navigate and easy-to-understand information architecture.

The embedded Web server displays comprehensive power quality data using standard Internet browsers and allows for device configuration from the browser. The embedded Web server presents real time, historical and event information in a browser-style graphical format to help the user interpret information such as current loading, voltage and power levels, power factor, energy usage, I/O status, power quality measurements, as well as harmonic plots. The embedded Web server also allows for waveform capture and for visualizing steady-state harmonic content that is critical for power quality analysis.

The Web server provides the energy and demand readings required to help manage the cost of energy.

Application Description

Identify Power Quality Problems to Help:

- Protect motors from damage
- Preserve the integrity of processes and batches
- Prevent blown capacitor bank fuses
- Protect transformers and conductors from overheating

Monitor Circuit Loading to Help:

- Avoid overloads and nuisance overload trips
- Maximize equipment utilization
- Manage emergency overloads

Manage Energy Utilization to Help:

- Reduce peak demand charges and power factor penalties
- Identify excessive energy consumption

Features, Benefits and Functions

Metered/Monitored Parameters

Note: See Table on **Page V3-T9-28**.

- Volts: L-L, L-N, Avg. L-L, Avg. L-N
- Phase and neutral currents
- Power: real, reactive and apparent
- Frequency
- Power factor: apparent
- Energy: real, forward, reverse, sum
- Demand: peak with date and time
- % THD
- Minimum and maximum values
- Harmonics
- Individual harmonics
- Demand comparisons
- Phasors

Accuracy

Note: Under typical operating conditions.

- Currents: 0.1% RV
- Voltage: 0.1% RV
- Energy and demand power: 0.2% in accordance with ANSI C12.20
- Frequency: ±0.03 Hz
- Power factor: 0.2% RV

Communications

Multiple communications ports including:

Standard

- RS-485 Modbus RTU slave port
- 10/100Base-T Ethernet network port

Communication Protocols Supported

- Modbus RTU
- Modbus TCP
- BACnet/IP
- Ethernet TCP/IP
- HTTP, HTTPS
- NTP (Network Time Protocol)
- SMTP (Simple Mail Transfer Protocol)
- SNMP (Simple Network Management Protocol) v1, v3
- DNP 3.0

Physical Characteristics

Format

- Power Xpert Meter 2000 with integral display
- Power Xpert Meter 2000 transducer only (no display) meter module
- NEMA rating: NEMA 12, IP42 front of panel rating

Inputs and Outputs

Power Xpert Meter 2000 is available with a standard KYZ output and optional digital I/O cards that includes:

- Two relay outputs/two status inputs
- Four KYZ pulses/four status inputs
- Four analog outputs 0–1 mA
- Four analog outputs 4–20 mA

Inputs can also be configured for demand synch and pulse counting. Inputs selected for pulse counting can be scaled. Accumulated pulse recordings are maintained in profile memory. Outputs can be used for alarm annunciation.

Ratings

- Application to any PT ratio, no PTs required to 600 Vac
- CT ratios to any CT ratio
- CT inputs available as 5 or 1A secondary
- Separate source control power input:
  - 90–265 Vac or 100–370 Vdc
  - Low voltage 18–60 Vdc

Displayed Information

- Monitored information is available locally through the display, the Web browser or system power management software
- True rms values through 40th harmonic
- ANSI C12.20 Class.2% revenue metering specification

Relay Outputs

The optional I/O card includes two 5A Form C relay outputs rated for 240 Vac or 30 Vdc or four Form A solid-state outputs. These outputs can be used for applications such as:

- Alarm annunciation
- KYZ pulse output

Alarm outputs can be driven from triggers based on metering values.

Analog Outputs

The optional IO card includes either four 4–20 mA outputs or 0–1 mA outputs. These outputs can be used for applications such as:

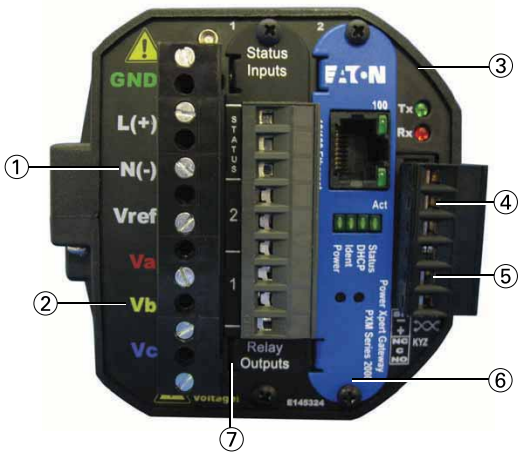
- Input to BMS or PLC systems for tracking a measured meter parameter

Standard Communications Card

The standard communications card provides one Ethernet connection and 10/100Base-T port (copper only) that can be used for the following applications:

- Monitoring, managing and configuring the meter remotely using a standard Web browser interface
- Alarm notifications via email, SMTP
- Providing Modbus TCP/IP, RTU and BACnet/IP communications to BMS systems
- Providing SNMP communications to NMS systems
- Synchronizing with an NTP server
- Asset management
- Updating firmware on the meter

PXM 2000 Rear View



① Power supply inputs
② System voltage inputs
③ NEMA 12 gasket
④ RS-485
⑤ KYZ out
⑥ Meter gateway card
⑦ I/O slot

Power Xpert Meter 2250

- Measures basic meter parameters
- 256 MB for data logging
- Ethernet
- On-board gateway card limits/alarms

Power Xpert Meter 2260

Features of PXM 2250 plus:

- Harmonics
- On-board meter hardware limits to activate optional relay outputs
- Visual indication of limits exceeded at meter face
- 512 MB for data logging

Power Xpert Meter 2270

Features of PXM 2260 plus:

- Harmonics, including individual
- Waveform view to visualize steady-state harmonic content
- 768 MB for data logging

The Power Xpert Meter 2280

Features of PXM 2270 plus:

- Records waveforms at up to 64 samples per cycles
- Configures the total, pre- and post-event cycles

Power Xpert Meter 2290

Features of PXM 2280 plus:

- Records waveforms at up to 512 samples per cycles

Power Xpert Meters 2250/2260/2270/2280/2290

Feature	Power Xpert Meter 2250	2260	2270	2280	2290	Benefit
General						
Embedded Web server	■	■	■	■	■	Use a standard Web browser to monitor and manage the meter over the network
Firmware flash upgrade support	■	■	■	■	■	Enables you to flash the meter with the latest firmware upgrades
Power, Energy and Demand						
Voltage, current: per phase minimum, maximum, average, trend graph analysis, export, print	■	■	■	■	■	Review voltage and current trends, export, print and analyze parameters right on the meter or external software
Demand: forward, reverse, net sum, profile, export, print, plot comparisons month-to-month, week-to-week	■	■	■	■	■	Plot two months or two weeks for vivid demand comparison, receive e-mails with trend logs
Power, apparent, real, reactive, power factor	■	■	■	■	■	Review power usage and power factor and avoid potential PF penalties
Energy: forward, reverse, net, sum	■	■	■	■	■	Keep track of your energy usage, identify peaks to conserve energy usage, receive e-mails with trend logs
Power Quality Analysis						
Statistical analysis (min., max., average)	■	■	■	■	■	Review statistical trends, identify past and future problem areas
Sampling rate, maximum samples/cycle	400	400	400	400	400	High sampling rate resulting in high accuracy
Security						
Secure two level user access privileges	■	■	■	■	■	Define appropriate security access level per user
Communications						
Modbus TCP	■	■	■	■	■	Easy integration with standard protocol to power management and other software
Modbus RTU	■	■	■	■	■	Integrate meters to existing Modbus networks, daisy chain several (1–32) meters together
BACnet/IP	■	■	■	■	■	Easily integrate into existing building management systems without the need for external protocol adapters
HTTP, HTTPS	■	■	■	■	■	Communicate to the meter over the Internet via standard Web browser
SNMP (Simple Network Management Protocol)	■	■	■	■	■	Communicate with the meter via Simple Network Protocol; hook to existing NMS system
SMTP (Simple Mail Transfer Protocol)	■	■	■	■	■	Send e-mail messages via standard Simple Mail Transfer Protocol
NTP (Network Time Protocol)	■	■	■	■	■	Network Time Protocol support enables the meter to synchronize time over the network
DNP 3.0	■	■	■	■	■	Easy integration with DNP networks (serial)
Trend measurements CSV file export	■	■	■	■	■	Easily export trend measurements to third-party applications, in standard CSV file format

Note

These specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and User Manual for detailed specifications.

Power Xpert Meters 2250/2260/2270, continued

Feature	Power Xpert Meter 2250	2260	2270	2280	2290	Benefit
Logs						
Trend logging	■	■	■	■	■	Log trend information for easy statistical analysis
Load profile	■	■	■	■	■	Review the load profile graph to get a better understanding of your electrical load versus time
Event logging	■	■	■	■	■	Log events for retrospective event analysis
Memory and Storage						
Memory, MB	256	512	768	768	768	Store trend data and events for historical analysis
Harmonics						
Harmonic levels		40th	40th	40th	40th	Allows you to identify potential harmful harmonics
Total harmonic distortion (THD)		■	■	■	■	Review the total harmonic distortion level directly on the meter
Individual harmonics			■	■	■	Provides simple metric for power quality viewable from the embedded Web server
Waveform						
Waveform display			■	■	■	A single-cycle waveform view on a PC, through embedded Web server, to visualize steady-state harmonic content to identify power quality issues
Waveform recording				64	512	Ability to record waveforms up to specified samples/cycle
I/O						
I/O (two relay outputs/two status inputs, four KYZ pulses/four status inputs, four analog outputs 0–1 mA, four analog outputs 4–20 mA)	Opt	Opt	Opt	Opt	Opt	The Power Xpert meter 2000 I/O Cards are extremely flexible and can be used in a large variety of different applications. Digital inputs and relay outputs can be programmed to interact during various conditions defined by the user. Various third-party devices, such as alarms, pulse meters, trip units and sensors, can be easily integrated to the Power Xpert Meter 2000. Triggers and events can be tied to the meter's standard functions such as e-mail, logs and trends. Analog outputs can be programmed to output meter parameters to BMS or PLC systems

Note

These specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and User Manual for detailed specifications.

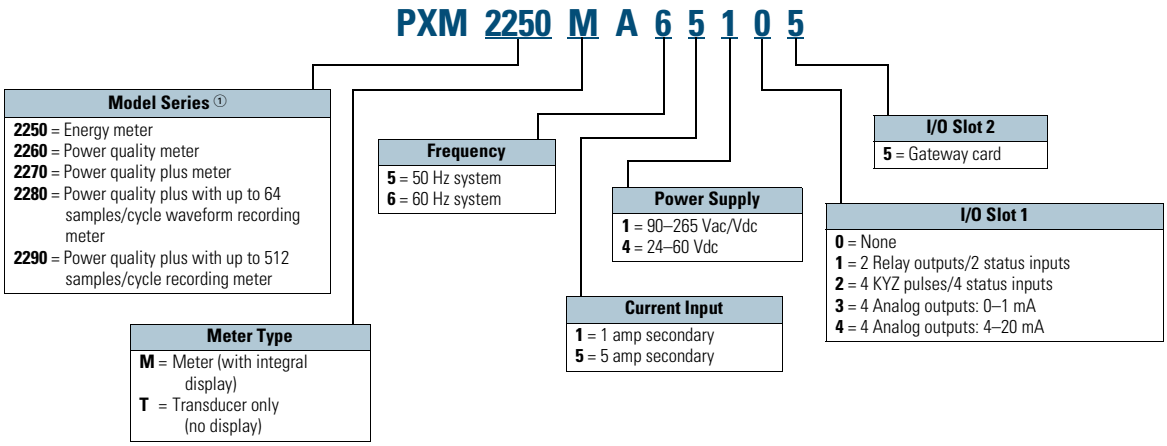
Standards and Certifications

- UL/cUL Electrical and Electronic Measuring and Test Equipment 22CZ
- Accuracy: IEC/EN60687 0.2 Class, ANSI C12.20 0.2 Class
- ANSI C62.41 Burst
- CE Mark

Listed Listed

Catalog Number Selection

Power Xpert Meter 2000



Example 1:**PXM2270MA65145** (PXM 2270 Meter/Display 60 Hz, 5A, 90–265 Vac/Vdc W/4AO)
Example 2:**PXM2250MA65105** (PXM 2250 Meter/Display 60 Hz, 5A, 90–265 Vac/Vdc)

Note

① Refer to **Page V3-T9-29** for model-specific features.

To order a Power Xpert Meter 2000, the catalog number should be determined using the chart shown above. The chart illustrates how to include the desired factory options as part of a catalog number. Option cards that are selected at time of order entry will be installed at the factory. Option cards are also field installable for future upgrades.

Power Xpert meter modules include panel mounting brackets.

Example 1:
PXM2270MA65145 (PXM 2270 Meter/Display 60 Hz, 5A, 90–265 Vac/Vdc W/4AO).

Example 2:
PXM2250MA65105 (PXM 2250 Meter/Display 60 Hz, 5A, 90–265 Vac/Vdc).

Accessories

Power Xpert Meter 2000

Description	Catalog Number
Panel mounting bracket assembly for retrofitting a PXM 2000 to an IQ analyzer/IQ DP4000/IQ data cutout	**IQ250-PMAK**
PXM 2000 Gateway card kit to upgrade an IQ 250/260 to a PXM 2000	**PXM2000-GCK**

Power Xpert Meter 2000 I/O Cards

Description	Catalog Number
PXM 2000 I/O card—2 relay outputs/2 status inputs	**IQ250/260-IO1**
PXM 2000 I/O card—4 KYZ Pulses/4 status inputs	**IQ250/260-IO2**
PXM 2000 I/O card—4 analog outputs—0–1 mA	**IQ250/260-IO3**
PXM 2000 I/O card—4 analog outputs—4–20 mA	**IQ250/260-IO4**

Technical Data and Specifications

PXM 2250/2260/2270 Electronic Power Meter Technical Information

Current Inputs

- Class 10: 5 amp nominal, 10 amp maximum
- Class 2: 1 amp nominal, 2 amp maximum
- Fault current withstand:
  - 100 amps for 10 seconds
  - 300 amps for 3 seconds
  - 500 amps for 1 second
- Continuous current withstand: 20 amps for screw terminated or pass-through connections
- Programmable current: full scale to any CT ratio
- Burden: 0.005 VA per phase maximum at 11 amps
- Pickup current: 0.1% of nominal
  - Class 10: 5 mA
  - Class 2: 1 mA
- Connections:
  - Pass-through wire gauge dimension: 0.177 inches (4.5 mm)
  - Quick connect: 0.25-inch (6.35 mm) male tab

Voltage Inputs

- Range:
  - Line-to-neutral 20–576 Vac
  - Line-to-Line 0–721 Vac
- Programmable voltage range: full scale to any PT ratio
- Supported systems:
  - Three element wye, 2.5 element wye
  - Two element delta, four-wire delta systems
- Input impedance: 1 megohm/phase.
- Burden: 0.36 VA/phase maximum at 600V; 0.014 VA at 120V
- Connection: 7-pin 0.400-inch pluggable terminal block, AWG #12–26 (0.129–3.31 mm^2)

Isolation

- All inputs and outputs are galvanically isolated to 2500 volts

Environmental Ratings

- Operating temperature: –20°C to +70°C
- Storage temperature: –20°C to +70°C
- Operating humidity: to 95% RH noncondensing
- Faceplate rating:
  - NEMA 12
  - Mounting gasket included

Sensing Method

- Voltage, current: true rms
- Power: sampling at over 400 samples per cycle on all channels
- Harmonics resolution: 40th order

Update Rate

- Watts, VAR and VA: 100 msec at 60 Hz
- All other parameters: 1 second at 60 Hz

Power Supply

- AC/DC voltage option: 90–265 Vac at 50/60 Hz or 100–370 Vdc, universal AC/DC supply
- DC voltage option: 18–60 Vdc
- Burden: 10 VA maximum

Serial Communications Format

- Connection type: RS-485 (through back plate)
- Com port baud rate: 9600–57,600 bauds
- Com port address: 01–247
- Data format: 8-bit, no parity
- Protocols: Modbus ASCII, RTU or DNP 3.0

Network Communications Format

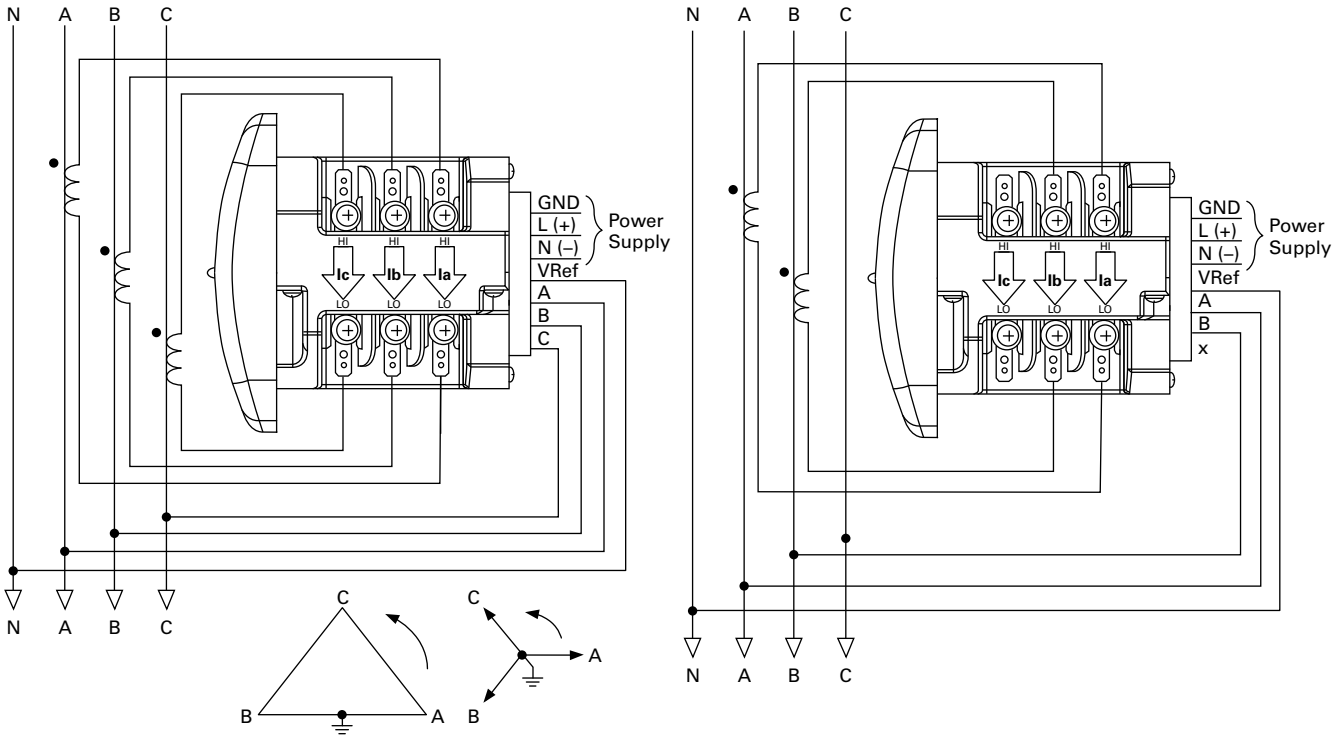
- Connection type: RJ-45 10/100Base-T Ethernet network port
- Protocols: Ethernet TCP/IP, Modbus TCP, BACnet/IP, HTTP, HTTPS, NTP, SMTP, SNMP

KYZ Pulse

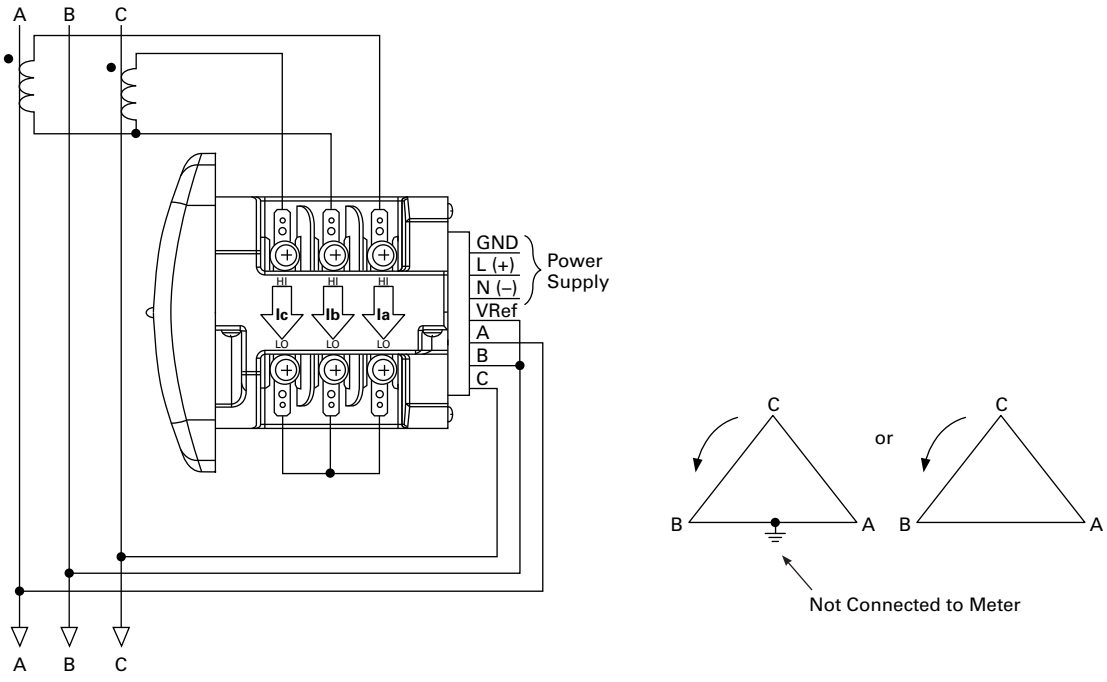
- Contacts: one Form A
- On resistance, maximum: 35 ohms
- Peak switching voltage: 350 Vdc
- Continuous load current: 120 mA
- Peak load current: 350 mA (10 ms)
- Off-state leakage current at 350 Vdc: 1 uA
- Opto-isolation: 3750 Vac

Wiring Diagrams

Service: Wye or Delta, Four-Wire with No PTs, Two or Three CTs



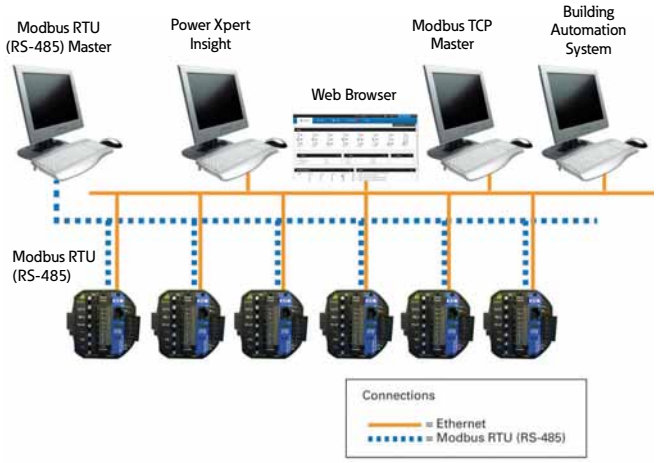
Service: Delta, Three-Wire with No PTs, 2 CTs



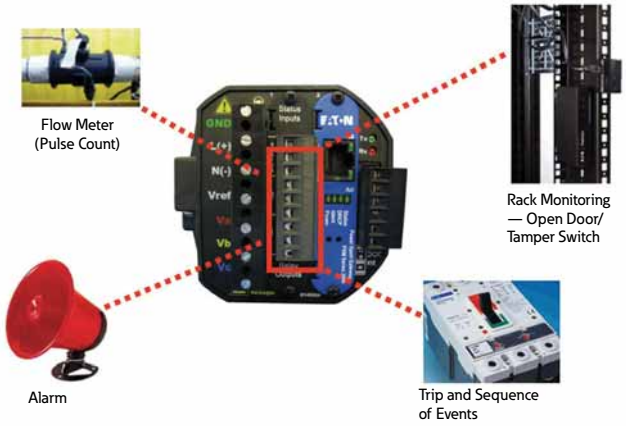
Note: Based upon the voltage rating, you may need a control power transformer for the control power.

Power Xpert Meters Configuration and Wiring Examples

PXM 2000 Display Front View



Accessories—I/O Cards (Option)



- Two relay programmable outputs/two programmable inputs
- Four KYZ pulses/four programmable inputs
- Four programmable analog outputs

IT Configuration Examples—Accessories—I/O Cards (Option)

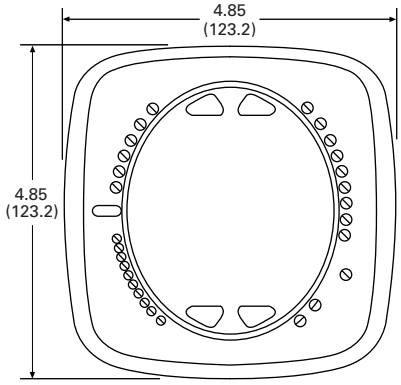
- Two relay programmable outputs/two programmable inputs
- Four KYZ pulses/four programmable inputs
- Four programmable analog outputs

9

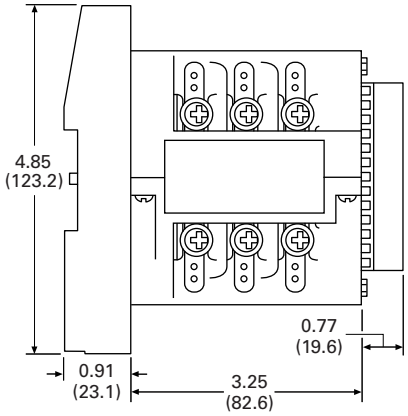
Dimensions

Approximate Dimensions in Inches (mm)

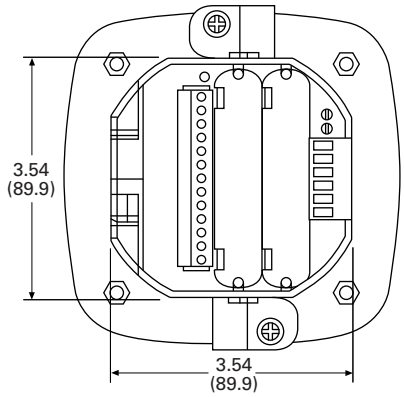
PXM 2000 Display Front View



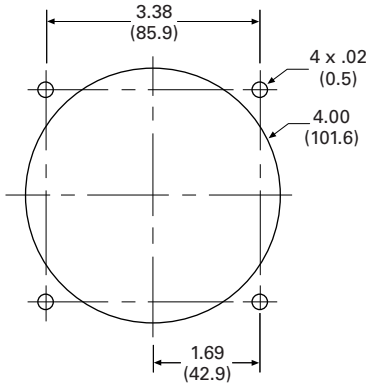
PXM 2000 Transducer Only Side View



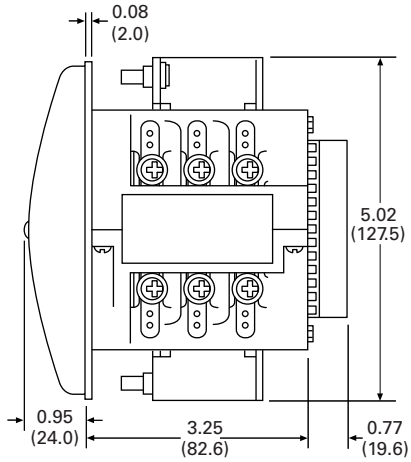
PXM 2000 Rear View



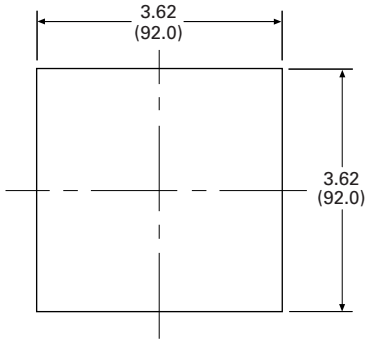
ANSI Mounting Panel Cutout



PXM 2000 Meter/Display Side View



DIN Mounting Cutout



Description	Specifications
Weight	2 lbs (0.9 kg)
Basic unit	5.00 (127.0) H x 4.90 (124.5) W x 5.00 (127.0) L
PXM 2250/2260/2270	Mounts in 3.62-inch (92.0) mm DIN and ANSI C39.1 round cut-outs
Shipping container dimensions	6-inch cube
Tolerance	±0.1 inches (2.54 mm)
Projection in front of panel surface	4.85 (123.2) H x 4.85 (123.2) W x 1.01 (25.6) L
Projection behind panel surface	4.85 (123.2) H x 4.85 (123.2) W x 1.01 (25.6) L

IQ 250 and 260 Electronic Power Meters

Contents

9

IQ 250/260 Series Electronic Power Meters

Product Description

The IQ 250 and IQ 260 Meters provide capabilities you would not normally expect in affordable, ultra-compact meters, such as fast sampling rate and accurate metering for a full range of power attributes. Providing the first line of defense against costly power problems, Eaton's IQ 250 and IQ 260 electronic power meters can perform the work of an entire wall of legacy metering equipment using today's technology.

When space is at a premium, yet you need ANSI C12.20 accuracy, the IQ 250/ 260 series fit the bill. These meters are ideal for electrical equipment assemblies, machine control panels, such as panelboard and switchboard mains and feeders, low voltage metal-enclosed switchgear feeders and motor control centers. Requiring far less space than other meters with similar functionality, IQ 250/260 series fit into a standard ANSI or IEC cutout on a panelboard or other electrical equipment, and therefore fit easily into retrofit applications.

Application Description

- Utility and commercial metering
- Substations, industrial facilities, power generation sites and campuses
- Sub-metering
- Load studies and voltage recording
- Analog meter replacement

Features and Benefits

- Measure and display real-time information about critical power parameters with a sampling rate of 400 samples per cycle
- Monitor power utilization and quality with ANSI C12.20 accuracy (0.2 percent)
- Optional 128 KB for data logging, which guards against loss of historical data
- Verify meter accuracy with KYZ test pulse self-certification capabilities
- Standard Modbus RTU communications
- Available as transducer only or with display
- Designed to accommodate upgrades
- Integrate into Eaton's Power Xpert architecture for a holistic system-level view

Additional Features

Features of IQ 250 and IQ 260 Electronic Power Meters

Features	IQ 250	IQ 260
Instrumentation		
Current, per phase	■	■
Current demand	■	■
Calculated neutral current	■	■
Voltage, per phase (L-L, L-N)	■	■
Frequency	■	■
Power, Energy and Demand		
Real, reactive and apparent power, total and per phase (kW, kVAR, kVA)	■	■
Real, reactive and apparent energy, total and per phase (kWh, kVARh, kVAh)	■	■
Real, reactive and apparent power demand	■	■
Power factor, total and per phase	■	■
Min./max. readings, I, V, PF, F, THD (IQ 260), kW, kVAR, kVA	■	■
Demand Methods		
Block interval (sliding, fixed)	■	■
Communications		
RS-485	■	■
KYZ output	■	■
Modbus RTU	■	■
Modbus ASCII	■	■
DNP 3.0	■	■
Data Logging		
128 KB for data logging	Opt.	Opt.
I/O		
Two digital in /two digital out ①	Opt.	Opt.
Four digital in/four KYZ out	Opt.	Opt.
Four analog output (4–20 mA) ②	Opt.	Opt.
Four analog output (0–1 mA)	Opt.	Opt.
Power Quality Analysis		
Total harmonic distortion (THD) voltage and current per phase		■
Alarming		
Set point driven alarm		■

Notes

① Digital out with IQ 250 requires external command.
② Requires external power supply.

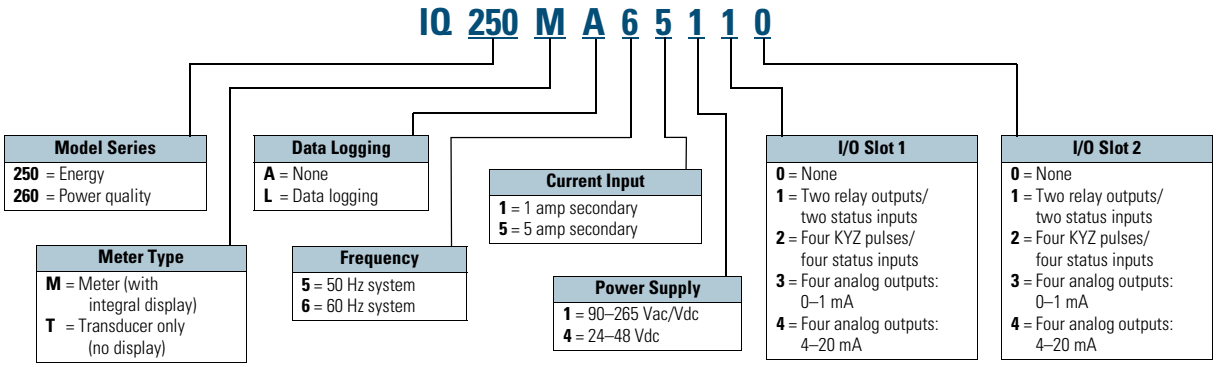
Standards and Certifications

- IEC 687: 0.2% accuracy
- ANSI C12.20: 0.2% accuracy
- ANSI C62.41: Burst
- UL/cUL: Electrical and electronic measuring and test equipment 22CZ

Listed Listed

Catalog Number Selection

IQ 250/260 Meter



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Accessories

IQ 250/260 Meter

Description	Catalog Number
Panel mounting adapter for retrofitting an IQ 250/260 to an IQ Analyzer/IQ DP-4000/IQ data cutout	**IQ250-PMAK**
PXM 2000 Gateway card kit to upgrade an IQ 250/260 to a PXM 2000	**PXM2000-GCK**

IQ 250/260 Meter I/O Cards

Description	Catalog Number
IQ 250/260 I/O card—2 relay outputs/2 status inputs	**IQ250/260-IO1**
IQ 250/260 I/O card—4 KYZ pulses/4 status inputs	**IQ250/260-IO2**
IQ 250/260 I/O card—4 analog outputs—0–1 mA	**IQ250/260-IO3**
IQ 250/260 I/O card—4 analog outputs—4–20 mA	**IQ250/260-IO4**

Technical Data and Specifications

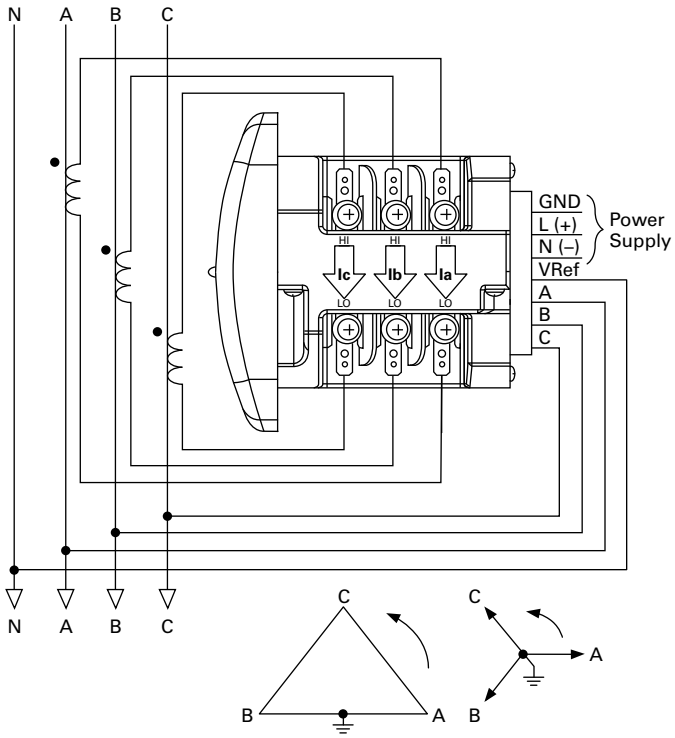
IQ 250/260 Electronic Power Meter

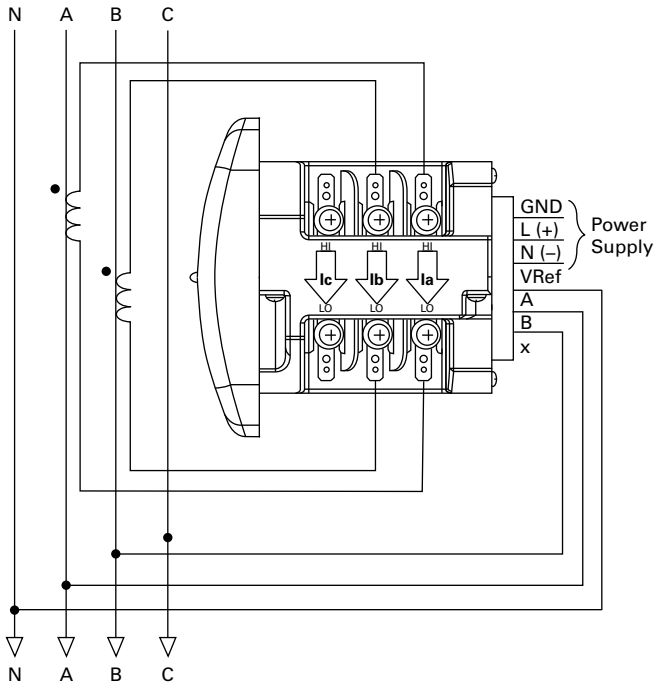
Description	Specifications
Current Inputs	
Class 10	5 amp nominal, 10 amp max.
Class 2	1 amp nominal, 2 amp max.
Fault current withstand 100 amps for: 300 amps for: 500 amps for:	 10 seconds 3 seconds 1 second
Continuous current withstand	20 amps for screw terminated or pass-through connections
Programmable current	Full scale to any CT ratio
Burden	0.005 VA per phase max. at 11 amps
Pickup current Class 10 Class 2	0.1% of nominal 5 mA 1 mA
Connections Pass-through wire gauge dimension Quick connect	 0.177 inches (4.5 mm) 0.25-inch male tab
Voltage Inputs	
Range Line-to-neutral Line-to-line	 20–576 Vac 0–721 Vac
Programmable voltage range	Full scale to any PT ratio
Supported systems	3 element wye, 2.5 element wye, 2 element delta, four-wire delta systems
Input impedance	1 meg ohm/phase
Burden	0.36 VA/phase max. at 600V; 0.014 VA at 120V
Connection	7-pin 0.400-inch pluggable terminal block, AWG #12–26 (0.129–3.31 mm^2)
Isolation	
All inputs and outputs are galvanically isolated to 2500 volts.	
Environmental Ratings	
Operating temperature	–20°C to +70°C
Storage temperature	–20°C to +70°C
Operating humidity	To 95% RH noncondensing
Faceplate rating	NEMA 12 Water-resistant Mounting gasket included

Description	Specifications
Sensing Method	
Voltage, current	True rms
Power	Sampling at over 400 samples per cycle on all channels
Harmonics resolution	40th order
Update Rate	
Watts, VAR and VA	100 msec at 60 Hz
All other parameters	1 second at 60 Hz
Power Supply	
AC/DC voltage option	90–265 Vac at 50/60 Hz or 100–370 Vdc, universal AC/DC supply
DC voltage option	18–60 Vdc
Burden	10 VA max.
Standard Communications Format	
Connection type	RS-485 (through back plate)
Com port baud rate	9600–57,600 bauds
Com port address	01–247
Data format	8-bit, no parity
Protocols	Modbus ASCII, RTU or DNP 3.0
KYZ Pulse	
Contacts	1 Form A
On resistance, max.	35 ohms
Peak switching voltage	350 Vdc
Continuous load current	120 mA
Peak load current	350 mA (10 ms)
Off-state leakage current at 350 Vdc	1 uA
Opto-isolation	3750 Vac

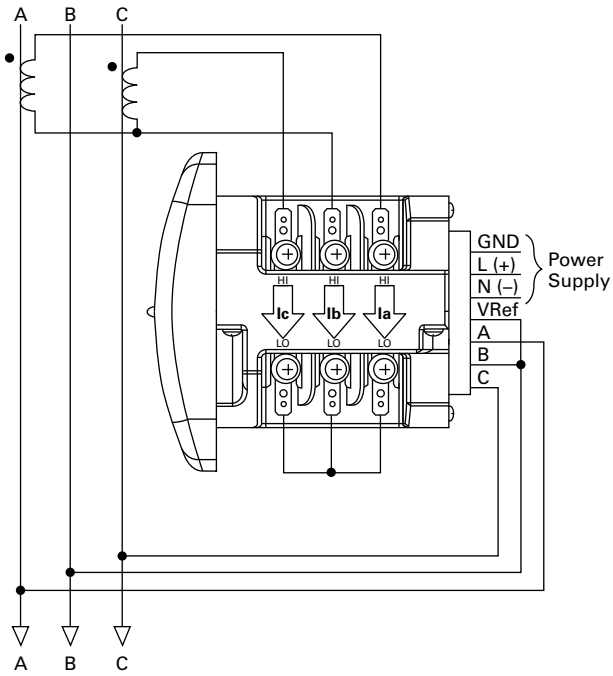
Wiring Diagrams

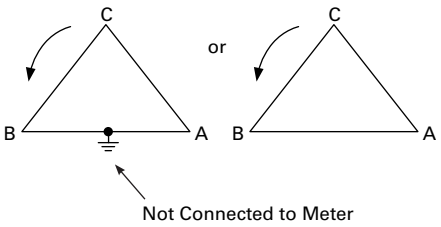
Service: Wye or Delta, Four-Wire with No PTs, Two or Three CTs





Service: Delta, Three-Wire with No PTs, 2 CTs



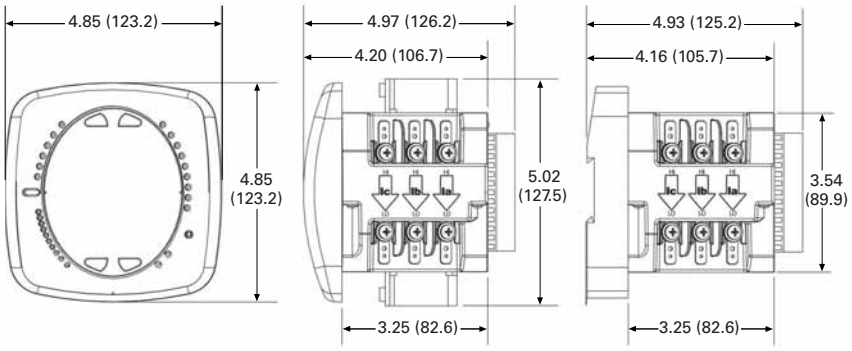


Note: Based upon the voltage rating, you may need a control power transformer for the control power.

Dimensions

Approximate Dimensions in Inches (mm)

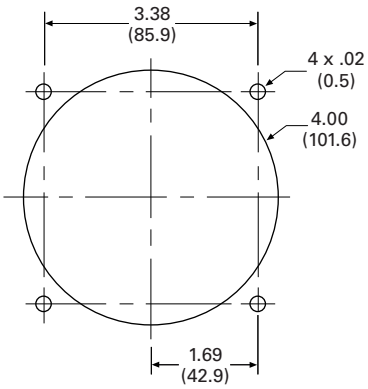
IQ 250/260 Meter—Face and Side Views



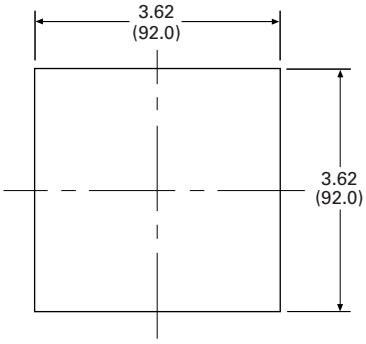
IQ 250/260 Face | IQ 250/260M Side | IQ 250/260T Side

Expandable IQ Componentry

ANSI Mounting Panel Cutout



DIN Mounting Cutout



Description	Specifications
Weight	2 lbs (0.9 kg)
Basic unit	5.00 (127.0) H x 4.90 (124.5) W x 5.00 (127.0) L
IQ 250/260	Mounts in 92 mm DIN and ANSI C39.1 round cut-outs
Shipping container dimensions	6-inch cube
Tolerance	±0.1 inches (2.54 mm)
PXM 2250/2260/2270	Mounts in 3.62-inch (92.0) mm DIN and ANSI C39.1 round cut-outs
Projection in front of panel surface	4.85 (123.2) H x 4.85 (123.2) W x 1.01 (25.6) L
Projection behind panel surface	4.85 (123.2) H x 4.85 (123.2) W x 1.01 (25.6) L

IQ 100

Contents

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IQ 130/140/150 Series Electronic Power Meters

Product Description

The IQ 100 Meter family provides capabilities you would not normally expect in affordable, compact meters, such as fast sampling rate and accurate metering for a full range of power attributes. Providing the first line of defense against costly power problems, Eaton's IQ 100 series electronic power meters can perform the work of an entire wall of legacy metering equipment utilizing today's technology.

When space is at a premium, yet you need ANSI C12.20 accuracy, the IQ 100 series fit the bill. These meters are ideal for electrical equipment assemblies, machine control panels, such as panelboard and switchboard mains and feeders, low voltage metal-enclosed switchgear feeders and motor control centers. Requiring far less space than other meters with similar functionality, IQ 100 series fit into a standard ANSI or IEC cutout on a panelboard or other electrical equipment, and therefore fit easily into retrofit applications.

Application Description

- Utility and commercial metering
- Substations, industrial facilities, power generation sites and campuses
- Sub-metering
- Load studies and voltage recording
- Analog meter replacement

Features and Benefits

- Measure and display real-time information about critical power parameters with a sampling rate of 400 samples per cycle
- Monitor power utilization and quality with ANSI C12.20 accuracy (0.5%)
- Verify meter accuracy with KYZ test pulse self-certification capabilities
- Optional Modbus RTU or TCP communications
- Available as transducer only or with display
- Designed to accommodate upgrades
- Integrate into Eaton's Power Xpert Architecture for a holistic system-level view

IQ 100 Electronic Power Meters

Features	IQ 130	IQ 140	IQ 150
Instrumentation			
Current, per phase	■	■	■
Current demand	■	■	■
Calculated neutral current	■	■	■
Voltage, per phase (L-L, L-N)	■	■	■
Min/max. readings, I, V	■	■	■
Min./max. readings, I, V, PF, F, W, VAR, VA		■	■
Frequency		■	■
Power			
Real, reactive and apparent power, total (W, VAR, VA)		■	■
Power factor, total		■	■
Real, reactive and apparent power demand		■	■
Demand Methods			
Block interval (sliding, fixed)		■	■
Energy			
Real, reactive and apparent energy, total (Wh, VAR, VAh)			■
Communications			
RS-485, Modbus RTU, Modbus ASCII, KYZ output	Opt.	Opt.	Opt.
RJ45, Modbus TCP, KYZ output	Opt.	Opt.	Opt.

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Standards and Certifications

- IEC 687: 0.5% accuracy
- ANSI C12.20: 0.5% accuracy
- ANSI C62.41: Burst
- CE
- UL/cUL: Electrical and Electronic Measuring and Test Equipment 22CZ

Listed Listed

Catalog Number Selection

IQ 100 Meter

IQ 150 M A 6 5 1 1

Model Series
130 = Volts/amps
140 = Power
150 = Energy

Meter Type
M = Meter (with integral display)
T = Transducer only (no display)

Frequency
5 = 50 Hz system
6 = 60 Hz system

Current Input
1 = 1A secondary
5 = 5A secondary

Power Supply
1 = 90–265 Vac/dc
4 = 24–48 Vdc

Communications
0 = None
1 = Modbus RTU and KYZ pulse
2 = Modbus TCP and KYZ output (RJ45)

Accessories

IQ 100 Meter

Description	Catalog Number
Panel Mounting Adapter for retrofitting an IQ 100 to an IQ Analyzer/IQ DP-4000/IQ Data Cutout	**IQ250-PMAK**

Technical Data and Specifications

IQ 100 Electronic Power Meters

Description	Specifications
Current Inputs	
Class 10	5A nominal, 10A max.
Class 2	1A nominal, 2A max.
Fault current withstand 100A for: 300A for: 500A for:	 10 seconds 3 seconds 1 second
Continuous current withstand	20A for screw terminated or pass-through connections
Programmable current	Full scale to any CT ratio
Burden	0.005 VA per phase max. at 11A
Pickup current Class 10 Class 2	0.1% of nominal 5 mA 1 mA
Connections Pass-through wire gauge dimension Quick connect	 0.177-inch (4.5 mm) 0.25-inch male tab
Voltage Inputs	
Range Line-to-neutral Line-to-line	 20–416 Vac 20–721 Vac
Programmable voltage range	Full scale to any PT ratio
Supported systems	3 element wye, 2.5 element wye, 2 element delta, four-wire delta systems
Input impedance	1 megohm/phase
Burden	0.36 VA/phase max. at 600V; 0.014 VA at 120 volts
Connection	7-pin 0.400-inch pluggable terminal block, AWG #12–26 (0.129–3.31 mm^2)
Isolation	
All inputs and outputs are galvanically isolated to 2500 volts.	
Environmental Ratings	
Operating temperature	–20°C to +70°C
Storage temperature	–40°C to +85°C
Operating humidity	To 95% RH noncondensing
Faceplate rating	NEMA 12 water-resistant mounting gasket included

IQ 100 Electronic Power Meters, continued

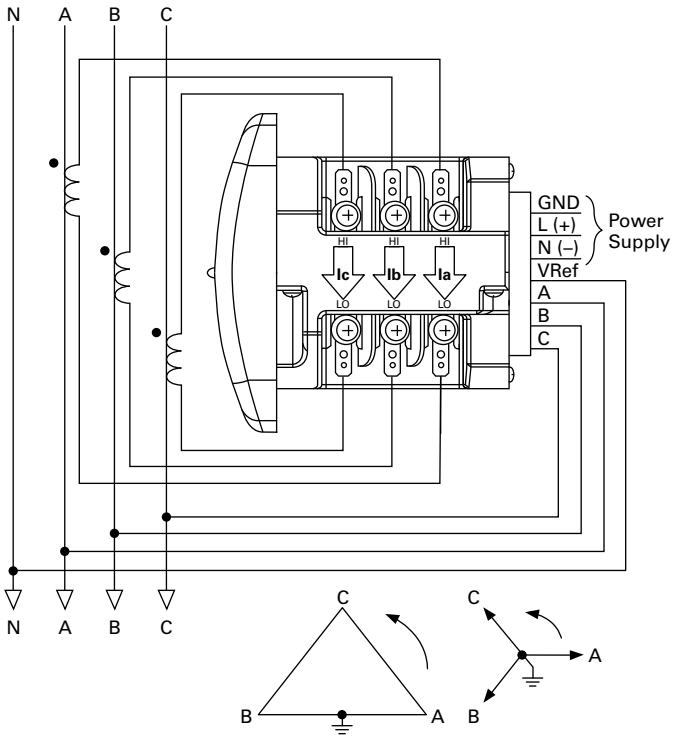
Description	Specifications
Sensing Method	
Voltage, current	True RMS
Power	Sampling at over 400 samples per cycle on all channels
Update Rate	
Watts, VAR and VA	100 msec at 60 Hz
All other parameters	1 second at 60 Hz
Power Supply	
AC/DC voltage option	90–265 Vac at 50/60 Hz or 100–370 Vdc, Universal AC/DC supply
DC voltage option	18–60 Vdc
Burden	10 VA max.
Optional Communications Format	
Connection type	RS-485 or RJ45 (through back plate)
Com port baud rate	9600–57,600 bauds
Com port address	01–247
Data format	8-bit, no parity
Protocols	Modbus ASCII, RTU, TCP
Optional KYZ Pulse	
Contacts	1 Form A
On resistance, max.	35 ohms
Peak switching voltage	350 Vdc
Continuous load current	350 mA (10 ms)
Off-state leakage current at 350 Vdc	1 uA
Opto-isolation	3750 Vac

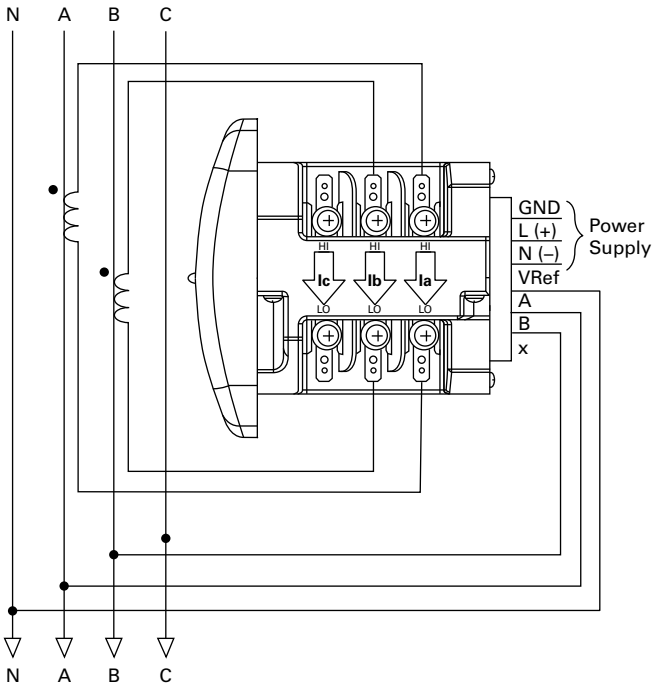
Note

These specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and User Manual for detailed specifications.

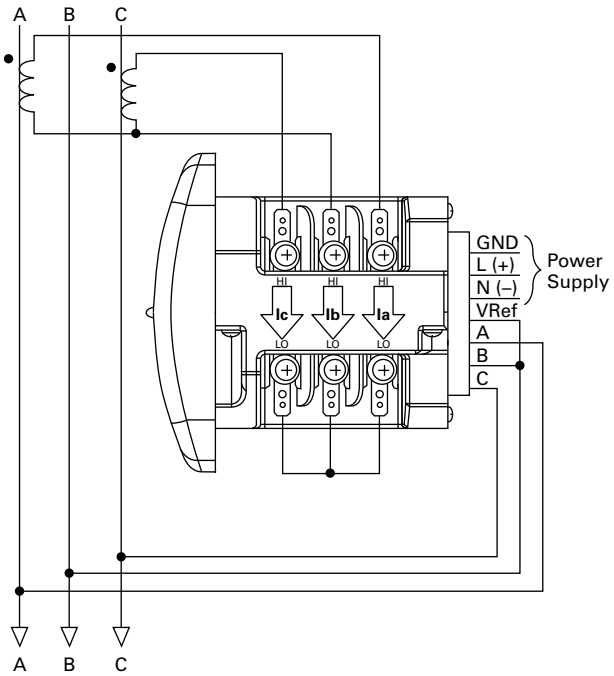
Wiring Diagrams

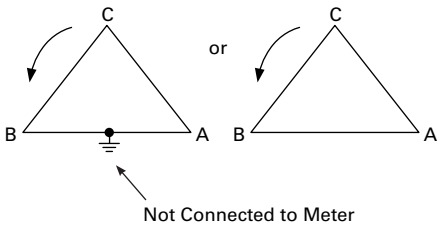
Service: Wye or Delta, Four-Wire with No PTs, Two or Three CTs





Service: Delta, Three-Wire with No PTs, 2 CTs



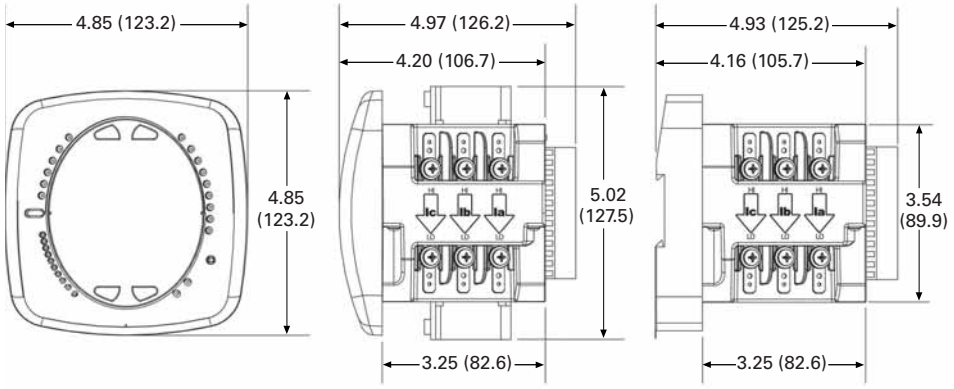


Note: Based upon the voltage rating, you may need a control power transformer for the control power.

Dimensions

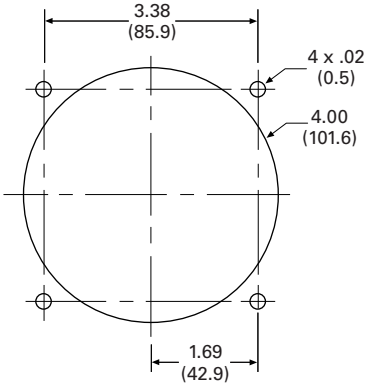
Approximate Dimensions in Inches (mm)

IQ 100 Meter—Face and Side Views

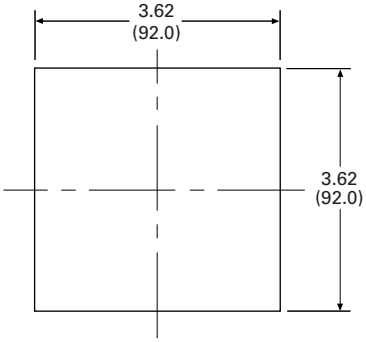


IQ 100 Face | IQ 100 Side | IQ 100 Side

ANSI Mounting Panel Cutout



DIN Mounting Cutout



Description	Specifications
Weight	2 lbs (0.9 kg)
Basic unit	5.00 (127.0) H x 4.90 (124.5) W x 5.00 (127.0) L
IQ 100	Mounts in 92 mm DIN and ANSI C39.1 round cut-outs
Shipping container dimensions	6-inch cube
Tolerance	±0.1 inches (2.54 mm)

IQ 150S/250S Self-Enclosed Electronic Meters

Contents

IQ 150S/250S Self-Enclosed Electronic Meters

Product Description

With energy costs skyrocketing, you need the ability to verify the accuracy of utility billing and allocation of energy costs among business units, different manufacturing areas or facilities, and tenants. Production equipment and IT systems are vulnerable to power anomalies; therefore, you must ensure that power is always up to specifications. If your infrastructure is an established facility, you may not currently have metering or may have addressed these concerns by deploying a variety of analog gauges and meters—one for volts, one for amperes and so on, with separate meters for each measurement.

If you're planning an upgrade or a new power infrastructure, no doubt you would like to capitalize on the latest technology to improve upon that cumbersome architecture and its patchwork view.

Application Description

- Industrial and commercial buildings, metering and submetering
- Government facilities and military
- Universities and airports
- Load studies and voltage recording

Features and Benefits

- Self-enclosed, these meters are an ideal solution for surface mounting next to a selected piece of equipment for energy monitoring
- NEMA 12 enclosure with a large, easy-to-read faceplate, consistent with other Eaton meter models, designed with "knockouts" for easy installation
- Ethernet communications option for either wired or wireless setup, allowing for additional ease of installation and integration into existing networks
- Available data and alarm recording for historical records/trending
- Integrate into Eaton's Power Xpert® Architecture for a holistic system-level view

Wireless and High-End Capabilities you would not Expect from a Self-Enclosed, Compact Meter

Providing the first line of defense against costly power problems, Eaton's IQ 150S/250S electronic self-enclosed meters can perform the work of an entire wall of legacy metering equipment using today's secure wireless technology. Eaton's IQ 150S/250S meters use 24-bit AD converters that sample at more than 400 samples per cycle and meet IEC 687 (0.2% accuracy) and ANSI C12.20 (0.2% accuracy) standards. With such high-performance measurement capability, these meters can be confidently used for primary revenue metering and submetering applications.

Either model will help you monitor energy demand, while the IQ 250S provides the extra benefit of also monitoring and recording the changes in the characteristics of your power.

Eaton's IQ 150S/250S meters provide direct-reading metered values for the most critical power aspects, such as watts, watt demand, watthours, voltage amperes (VA), VA-hours, VARs, VAR-hours and power factor. They have high sampling speed and accuracy.

These meters are self-enclosed in a NEMA 12 enclosure with "knockouts" on the bottom for communication and power, providing for an easy installation.

Perhaps you don't have network drops in all the right places. The IQ 150S/250S offers a wireless communications option. The transmissions are encrypted using 128-bit Wired Equivalent Privacy (WEP) for security.

Industry-Standard Communication Protocols

Standard Modbus RS-485 Communication
Standard communication includes an RS-485 output speaking Modbus protocol. This allows the unit to be connected to any serial RS-485 bus using the Modbus interface. The unit communicates easily with most building automation, Power Xpert Insight or other software systems. Baud rates are up to 57.6K baud to provide fast update times.

Wi-Fi or Land-Based Ethernet
The unit offers an Ethernet option—configured either as an RJ45 or Wi-Fi connection. The Wi-Fi configuration allows the 150S/250S to be used on standard Wi-Fi base stations. The unit is assigned an IP address; it communicates Modbus protocol over Ethernet TCP/IP. Wireless Ethernet is reliable and easy to integrate, making it the superior solution for mass meter deployment.

KYZ Pulse
For applications in which a pulse is needed, the unit also provides a KYZ output that pulses proportional to the amount of energy consumed. This feature is used for pulse counting applications into building management systems where serial or Ethernet protocol is not available.

Verify Energy Bills
The IQ 150S/250S models provide a traceable watthour test pulse (used with a watthour pulse recorder or totalizer), so you can verify the accuracy of your meter and in turn, the accuracy of billing from your utility company and to internal customers.

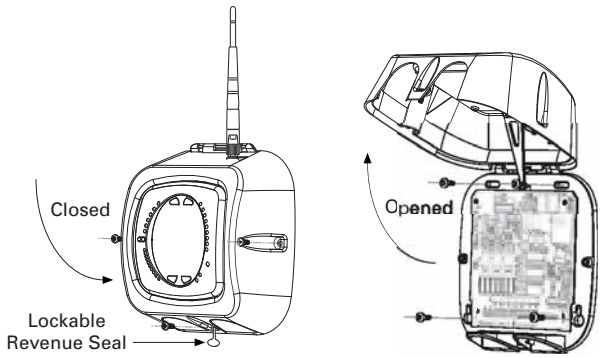
Integrated with Eaton's Power Xpert Architecture
IQ 150S/250S meters integrate into Eaton's Power Xpert Architecture, where meters, gateways and monitoring devices collaborate to create a unified, centralized view of the end-to-end power and facility infrastructure. When used in this architecture, either with a Power Xpert Gateway or directly via Ethernet, the meters with the Modbus RTU option can provide Web-based graphics of current power conditions. Simply connect your meter to a Power Xpert Gateway to translate Modbus-based information from the meter into HTML-based Web pages that are accessible from any standard Web browser. If you select a model with the Ethernet option, the meter can easily be monitored remotely via Power Xpert Insight or another third-party monitoring system. With access to accurate, real-time information from IQ 150S/250S meters, Power Xpert Architecture can transform your power system into an integrated, agile system, and an easily managed entity that performs better and costs less.

Designed for the User
When space is at a premium, yet you need ANSI C12.20 accuracy, Eaton IQ 150S/250S meters fit the bill. These ultra-compact meters are ideal for surface mounting next to a selected piece of equipment for energy monitoring. Requiring far less space than other meters with similar functionality, and offering a NEMA 12 enclosure and a large, easy-to-read faceplate, consistent with other Eaton meter models, these meters are designed with "knockouts" for easy retrofit installation.

Most meters in this class have small or dark displays that can be hard to see, especially from a distance. Eaton's IQ 150S/250S meters have a large, bright red, three-line LED display, each line more than a half-inch tall. This display is very easy to read, even if the meter is installed at a height or distance. Using the keypad and menus on the local display, users can display a variety of electrical system values or program the meter.

Installation Diagram

IQ 150S/250S Installation



Features of IQ 150S/250S Electronic Power Meters

Features	IQ 150S	IQ 250S
Instrumentation		
Current, per phase	■	■
Calculated neutral current	■	■
Voltage, per phase (L-L, L-N)	■	■
Frequency	■	■
Minimum/maximum readings, I ①, V ①, PF, F, W, VAR, VA	Total	Total and per phase
Power		
Real, reactive and apparent power (W, VAR, VA)	Total	Total and per phase
Power factor	Average	Average and per phase
Demand Methods		
Block interval (fixed, sliding)	■	■
Current demand	■	■
Real, reactive and apparent power demand	Total	Total and per phase
Energy		
Real, reactive and apparent energy (Wh, VARh, VAh)	Total	Total and per phase
Real and reactive, net and positive and negative (Wh, VARh)	Total	Total and per phase
I/O		
Pulse output	■	■
Communications		
RS-485, Modbus RTU, DNP 3.0	■	■
RJ45 or 802.11b, Modbus TCP ②	Optional	Optional
Data Logging		
2 MB for data logging		■
Alarming		
Set point driven alarm		■

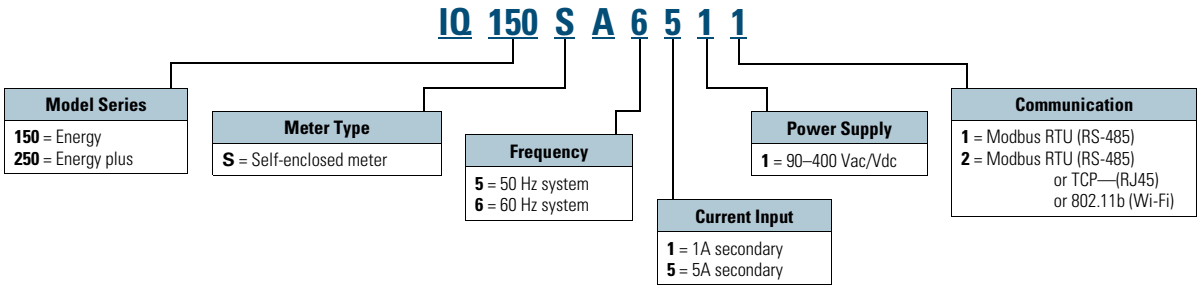
Notes

① Per phase only.

② If configured for Ethernet, RS-485 not available.

Catalog Number Selection

IQ 150S/250S Meter



Technical Data and Specifications

IQ 150S/250S Electronic Meter Technical Information

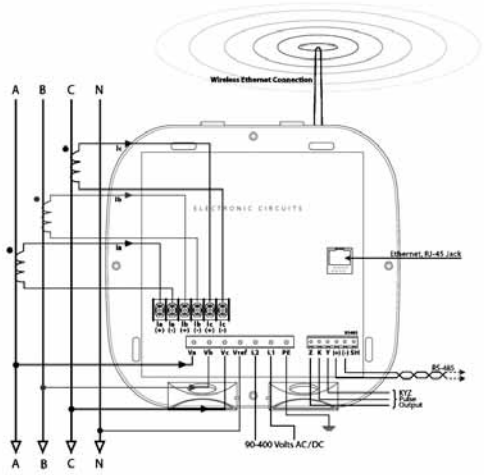
Description	Specifications
Current Inputs	
Class 10	5A nominal, 10A maximum
Class 2	1A nominal, 2A maximum
Fault Current Withstand	
20A for:	10 seconds
60A for:	3 seconds
100A for:	1 second
Programmable current	Full scale to any CT ratio
Burden	0.005 VA per phase maximum at 11A
Pickup Current	0.1% of nominal
Class 10	5 mA
Class 2	1 mA
Connections	
Screw terminal	#6–32 screws
Voltage Inputs	
Range	
Line-to-neutral	20–416 Vac (IQ150S), 20–576 Vac (IQ250S)
Line-to-line	20–721 Vac
Programmable voltage range	Full scale to any PT ratio
Supported systems	3 element wye, 2.5 element wye, 2 element delta, four-wire delta systems
Input impedance	1 megohm/phase
Burden	0.36 VA/phase maximum at 600V; 0.014 VA at 120V
Connection	7-pin, 0.400-inch screw terminal block, AWG #12–26 (0.129–3.31 mm^2)
Isolation	
All inputs and outputs are galvanically isolated to 2500V	
Environmental Ratings	
Operating temperature	–20° to +70°C
Storage temperature	–20° to +70°C
Operating humidity	To 95% RH noncondensing
Faceplate rating	NEMA 12
Sensing Method	
Voltage, current	rms
Power	Sampling at over 400 samples per cycle on all channels

Description	Specifications
Update Rate	
Watts, VAR and VA	100 msec at 60 Hz
All other parameters	1 second at 60 Hz
Power Supply	
AC/DC voltage option	90–400 Vac at 50/60 Hz or 100–370 Vdc, universal AC/DC supply
Burden	16 VA maximum
Standard Serial Communications Format	
Connection type	RS-485
Communications port baud rate	9600–57,600 Bauds
Communications port address	01–247
Data format	8-bit, no parity
Protocols	Modbus ASCII, RTU, DNP 3.0
Optional Ethernet Communications Format	
Connection type	RJ45 or 802.11b (wireless)
Protocols	Modbus TCP
KYZ Pulse	
Contacts	1 Form A
On resistance, maximum	35 Ohms
Peak switching voltage	350 Vdc
Continuous load current	120 mA
Peak load current	350 mA (10 ms)
Off-state leakage current at 350 Vdc	1 uA
Opto-isolation	3750 Vac
Dimensions and Shipping	
Weight	4 lbs
Basic unit	H 7.90 x W 7.50 x D 3.10 inches
Compliance	
IEC 687	0.2% accuracy
ANSI C12.20	0.2% accuracy
ANSI C62.41	Burst
ANSI (IEEE) C37.90.1	Surge withstand
UL/cUL	Electrical and electronic measuring and test equipment 22CZ

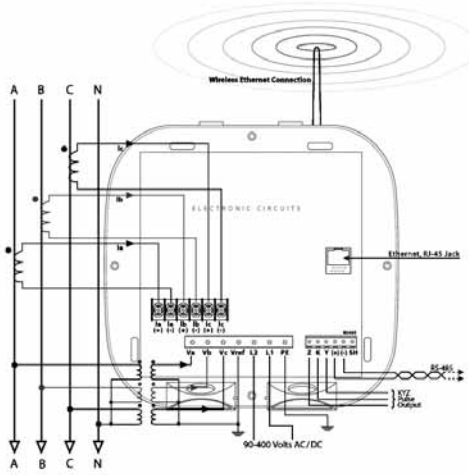
Note: Specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to User Manual for detailed specifications.

Wiring Diagrams

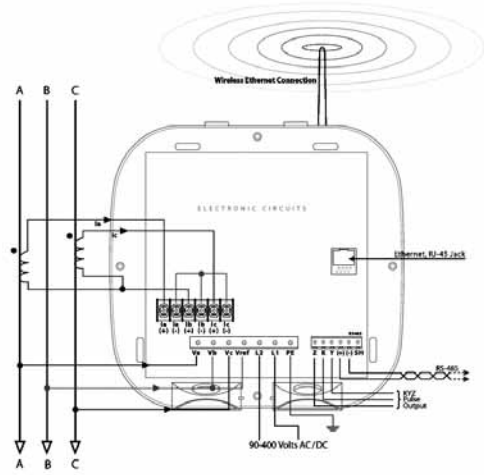
IQ 150S/250S Electronic Meter



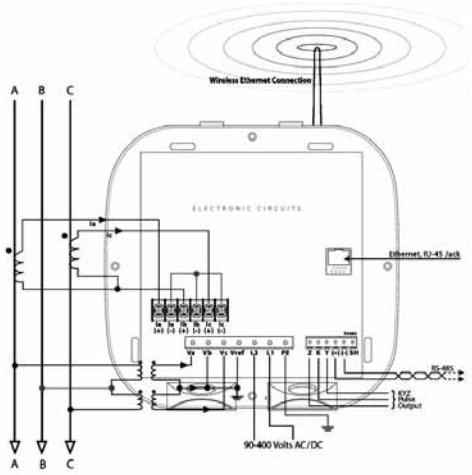
Three-Phase Four-Wire WYE Direct



Three-Phase Four-Wire WYE with PTS



Three-Phase Three-Wire DELTA Direct

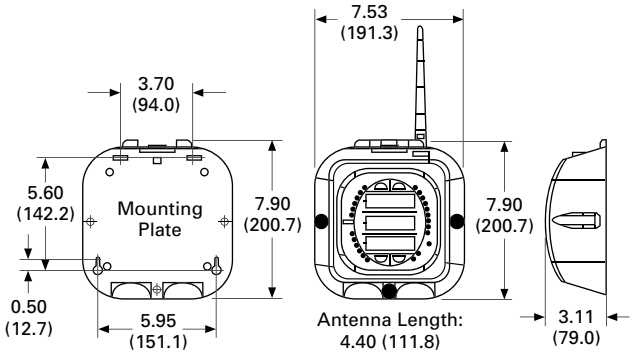


Three-Phase Three-Wire DELTA Direct

Dimensions

Approximate Dimensions in Inches (mm)

IQ 150S/250S Electronic Meter



IQ 35M

Contents

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IQ 35M

Product Description

The Eaton IQ 35M Meter is a DIN rail meter that combines exceptional performance and easy installation to deliver a cost-effective solution for energy and power monitoring applications, as well as sub-metering applications. Most models include pulse output, alarm contact and phase alarms for true versatility. The BACnet version offers two digital inputs for accumulating other meter pulses in place of the digital output and alarm contact. The Modbus output options offer added flexibility for configuration and data analysis. The IQ 35M allows you to:

- Verify energy bills
- Make informed load shifting and shedding decisions
- Fairly and accurately allocate energy costs to users
- Identify wasteful practices
- Decrease unnecessary usage
- Produce an energy profile
- Secure the optimum utility rate structure

Application Description

- Commercial submetering
- Energy management
- Industrial monitoring
- Cost allocation

Features

- Economical and compact watthour meter with demand
- Backlit LCD display for local reading
- Compatible with the Power Xpert Gateway for remote monitoring
- Monitors
  - Voltage, current, power factor, frequency
  - Power and energy: real, reactive and apparent
- Optional data logging capability
- Optional serial communications (Modbus-RTU or BACnet)
- Revenue grade, ANSI C12.20 0.5% accuracy, IEC 62053-22 Class 0.5S
- Compatible with economical solid-core and split-core CTs
- User-enabled password protection
- On-board diagnostics

Catalog Number Selection

IQ 35M Meter

IQ35M A 1 1

Meter Series

Energy Type

1 = Standard energy
2 = Four quadrant energy

Output Option

1 = Pulse output only
2 = Pulse output + Modbus
3 = Pulse output + Modbus + data logging
5 = Pulse inputs + BACnet + data logging

Product Selection

IQ 35M Current Transformers

Description	Catalog Number
Solid Core	
IQ35M CT, solid core, 5A:0.33 Vac, 0.30 inch	**IQ35M-SO-030-5**
IQ35M CT, solid core, 20A:0.33 Vac, 0.30 inch	**IQ35M-SO-030-20**
IQ35M CT, solid core, 50A:0.33 Vac, 0.50 inch	**IQ35M-SO-050-50**
IQ35M CT, solid core, 50A:0.33 Vac, 0.75 inch	**IQ35M-SO-075-50**
IQ35M CT, solid core, 100A:0.33 Vac, 1.25 inch	**IQ35M-SO-125-100**
IQ35M CT, solid core, 200A:0.33 Vac, 1.25 inch	**IQ35M-SO-125-200**
IQ35M CT, solid core, 250A:0.33 Vac, 1.25 inch	**IQ35M-SO-125-250**
IQ35M CT, solid core, 300A:0.33 Vac, 1.25 inch	**IQ35M-SO-125-300**
IQ35M CT, solid core, 400A:0.33 Vac, 1.25 inch	**IQ35M-SO-125-400**
Split Core	
IQ35M CT, split core, 5A:0.33 Vac, 0.75 inch	**IQ35M-SP-075-5**
IQ35M CT, split core, 30A:0.33 Vac, 0.75 inch	**IQ35M-SP-075-30**
IQ35M CT, split core, 50A:0.33 Vac, 0.75 inch	**IQ35M-SP-075-50**
IQ35M CT, split core, 100A:0.33 Vac, 0.75 inch	**IQ35M-SP-075-100**
IQ35M CT, split core, 200A:0.33 Vac, 0.75 inch	**IQ35M-SP-075-200**
IQ35M CT, split core, 250A:0.33 Vac, 1.25 inch	**IQ35M-SP-125-250**
IQ35M CT, split core, 300A:0.33 Vac, 1.25 inch	**IQ35M-SP-125-300**
IQ35M CT, split core, 400A:0.33 Vac, 1.25 inch	**IQ35M-SP-125-400**
IQ35M CT, split core, 600A:0.33 Vac, 1.25 inch	**IQ35M-SP-125-600**
IQ35M CT, split core, 800A:0.33 Vac, 2.50 inch	**IQ35M-SP-253-800**
IQ35M CT, split core, 1000A:0.33 Vac, 2.50 inch	**IQ35M-SP-255-1000**
IQ35M CT, split core, 1200A:0.33 Vac, 2.50 inch	**IQ35M-SP-255-1200**
IQ35M CT, split core, 1600A:0.33 Vac, 2.50 inch	**IQ35M-SP-255-1600**
IQ35M CT, split core, 2000A:0.33 Vac, 2.50 inch	**IQ35M-SP-255-2000**
IQ35M CT, split core, 2400A:0.33 Vac, 2.50 inch	**IQ35M-SP-255-2400**

Accessories

IQ 35M Accessories

Description	Catalog Number
IQ35M enclosure, NEMA 4X	**IQ35M-ENC**
IQ35M fuse pack, single, 1/2A slow-blow	**IQ35M-FP1**
IQ35M fuse pack, double, 1/2A slow-blow	**IQ35M-FP2**
IQ35M fuse pack, triple, 1/2A slow-blow	**IQ35M-FP3**
IQ35M replacement mounting clips	**IQ35M-RMC**
IQ35M DIN rail	**IQ35M-DR**
IQ35M DIN rail stop clips (10 pack)	**IQ35M-DRSC**

Note: Specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to User Manual for detailed specifications.

Technical Data and Specifications

- Voltage input
  UL: 90V (L-N) to 600V (L-L)
  CE: 90V (L-N) to 300V (L-L)
- Current input
  Scaling: 5–32,767A
  Input range: 0–0.333V or
  0–1V (selectable)
- Control power
  UL: 90V (L-N) to 600V (L-L)
  CE: 90V (L-N) to 300V (L-L)

Accuracy

- Real power and energy
  0.5% (ANSI C12.20, IEC 62053-22 Class 0.5S)

Outputs

- IQ35MAx1 thru 3:
  Real energy pulse: NO static; alarm contacts: NC static
- IQ35MA11
  Reactive energy pulse 30 Vac/Vdc
- IQ35MAx2, IQ35MAx3
  RS-485 two-wire Modbus RTU
- IQ35MA15 RS-485 two-wire BACnet MS/TP

Inputs

- IQ35MA15
  Two pulse accumulators

Mechanical

- Mounting
  DIN rail or 3-point screwmount

Environmental

- Operating temperature range
  Meter: –30° to 70°C (–22° to 158°F)
  Display: –10° to 50°C (14° to 122°F)
- Storage temperature range
  Meter: –40° to 85°C (–40° to 185°F)
  Display: –10° to 60°C (14° to 140°F)
- Humidity range
  <95% RH noncondensing

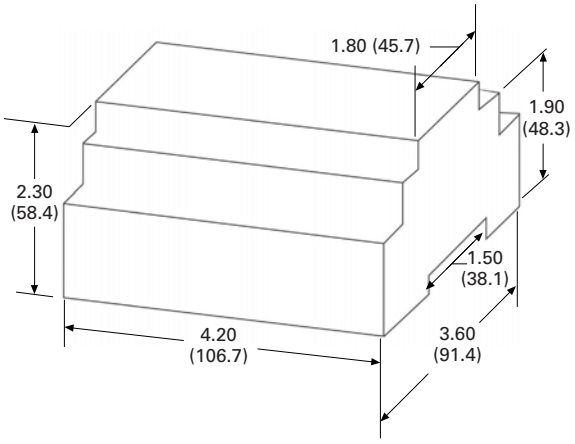
Data Outputs

- kW, kWh: Total
- Current: Three-phase average and per phase
- Voltage: Three-phase average, per phase, and line-line and line-neutral
- Power: Real, reactive and apparent;
  Three-phase total and per phase
- Power factor: Three-phase average and per phase
- Frequency
- Power demand: most recent and peak
- Demand configuration: fixed, rolling block and external sync
- Data logging (IQ35MAx3)
  10 configurable data buffers;
  configurable demand subinterval (when set at a 15-minute interval, buffers store data for 60 days)
- Data logging (IQ35MA15)
  6 configurable data buffers;
  configurable demand subinterval (when set at a 15-minute interval, buffers store data for 60 days)
- Trending requires communication network to retrieve data

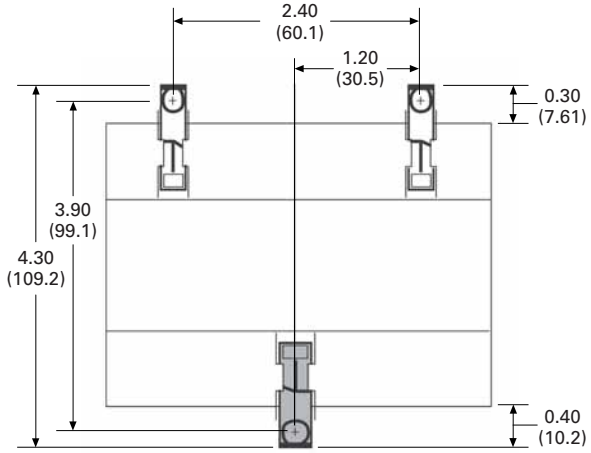
Dimensions

Approximate Dimensions in Inches (mm)

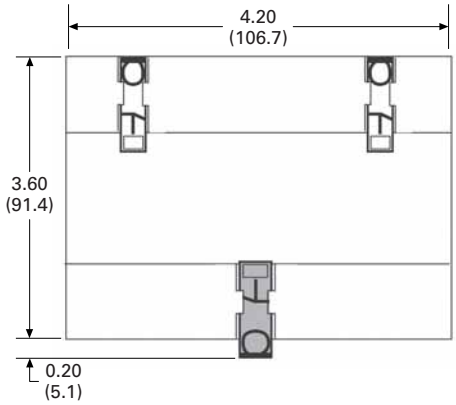
IQ 35M Dimensional Drawing



IQ 35M Wall Mount Configuration



IQ 35M DIN Mount Configuration



9

IQ Analyzer 6400/6600 Series

IQ Analyzer—Comprehensive Electrical Distribution Monitoring

Contents

IQ Analyzer 6400/6600 Series

Product Description

Eaton's IQ Analyzer is a complete solution for users who want to monitor and manage all aspects of their electrical distribution system. Based on input from customers and consultants, it provides extensive metering, power quality analysis, remote input monitoring, control relaying, analog input/outputs and communications capability.

Its high performance metering exceeds ANSI C12.16 (1%) specification for revenue meters and meets ANSI C12.20 Class 0.5%, provides quality true rms readings through the 50th harmonic, accurately measures nonsinusoidal waveforms up to a 3.0 crest factor, and displays even and odd multiples of the fundamental current and voltage through the 50th harmonic. Both magnitude and phase angle of the harmonics are displayed.

The unique operator interface, which includes a reverse mode LCD display, easy to use *Meter Menu* screens and detailed *Analysis* screens, is designed to allow a wealth of real-time and recorded information to be accessed easily by an operator. All programming can be accomplished through the faceplate or the communications port. The comprehensive on-line Help feature provides useful information on device operation, programming and troubleshooting.

Application Description

- Monitoring of over 150 electrical parameters
- Power quality management
- Energy management

Features, Benefits and Functions

Metered and Monitored Parameters

- rms sensing
- Phase neutral, and ground currents
- Volts: L-L, L-N, Avg. L-L, Avg. L-N, N-G
- Power: real, reactive, apparent (system and per phase)
- Frequency
- Power factor: apparent and displacement (system and per phase)
- Energy and demand (forward, reverse, net) real, reactive apparent at four different utility rates
- Individual current and voltage harmonics: magnitude, phase angle
- % THD: current and voltage
- Waveform capture
- Minimum and maximum values
- Event logging/disturbance recording
- ANSI C12.20 Class 0.5% revenue metering accuracy, IEC687 Class 0.5%
- Industry Canada 0.5% revenue accuracy

Communications

- Optional interface capability to computer network for data collection, storage and/or printout via Eaton's Power Management Software

Physical Characteristics

- Graphical reverse mode LCD display with LED backlight
- Up to seven lines of information
- Membrane faceplate NEMA 3R and 12 rated

Disturbance Information

With the communications option and Eaton's Power Management Software and Waveform Display software, a *Waveform Analysis* will construct waveforms of up to 56 cycles of all currents and voltages (including neutral and ground) to help troubleshoot undervoltage/sag and overvoltage/swell conditions. (See CBEMA Trend Logging section.) By programming a reset threshold, the duration of the voltage disturbance can also be indicated.

The IQ Analyzer 6600 series with Graphic Waveform Display offers the ability to view the captured waveform right at the device. The 6600 series also offers the ability to detect and capture sub-cycle voltage disturbances.

Extensive Harmonic Distortion Analysis

Current *and* voltage distortion data are displayed at the device and accessible through the communications port. This includes % THD, K-Factor, Crest Factor, CBEMA factor, and both magnitudes and phase angles of all harmonics through the 50th. A snapshot sample of this information may be activated by user commands, discrete inputs or programmable thresholds to capture distortion data during conditions of real interest. To help eliminate nuisance alarms, harmonic distortion information can be captured and relay outputs activated when THD exceeds a programmable percentage of fundamental or a programmable magnitude (e.g., amperes) threshold.

Time-of-Use Metering

The IQ Analyzer offers the ability to store energy usage data for time of use revenue metering. It can be programmed for any combination of weekday, Saturday, Sunday, 22 holidays, 8 seasons, 32 schedules and 10 time periods per schedule. The IQ Analyzer will keep track of the following parameters for four different utility rates:

- Watthours
- VAR hours
- VA hours
- Current demand
- Watt demand
- VA demand
- VAR demand

Historical Trend Logging

The IQ Analyzer is equipped with onboard logging capability, which includes the ability to log a total of 24 parameters with intervals ranging from 0.13 seconds (every eight cycles) to twice a week (5040 minutes). The trending function can begin immediately or can be triggered upon receipt of a discrete input into the IQ Analyzer. Onboard logging provides a cost-effective means of distributed data storage where real-time communications may not be feasible or for applications where data storage redundancy is desired. Four trend data logs are stored in non-volatile memory aboard the IQ Analyzer and can be retrieved at the display or via communications for viewing using Eaton's Power Management Software.

- Up to 24 parameters with storage capacity for up to 90,000 data points
- Up to 234 days of data can be stored when recording a parameter every 15 minutes
- Trends 1, 2 and 3 can save data on a discrete contact input
- Trend 4 can save data on a power quality or meter event
- Minimum and maximum recording (minimum and maximum three-phase average current, maximum I_G, minimum and maximum three-phase average V_{LL} and V_{LN}, maximum V_{NG}, maximum system watts, VARs and VA, minimum and maximum apparent and displacement PF). Using this feature, minimum and maximums reached during each trend interval are recorded.

CBEMA Trend Logging

The IQ Analyzer can be configured to store the necessary data so that the software can display a sag or swell voltage event on the industry standard CBEMA (now ITIC) curve for predictive maintenance and troubleshooting. This application utilizes the IQ Analyzer waveform capture for high-0speed events along with historical trend logging for longer term voltage disturbances. Once this data is uploaded to a PC running the Power Management Software's Event Viewer the information is analyzed, displayed and stored. Automatic uploading of CBEMA events can be selected in the software. A three-phase event will be correctly displayed as a single point on the CBEMA curve.

Event Logging

The IQ Analyzer will store in non-volatile memory the time and reason for last 504 events. These events can be viewed from the graphical display or accessed via communications. In addition to all of the meter events listed in the Event Conditions section (**Page V3-T9-56**), the following events are entered into the event log:

Time and date of:

- Alarms
- Meter power up
- All resets
- All setting changes
- Communications established or lost

Event logging is another powerful troubleshooting tool within the IQ Analyzer.

Extensive I/O and Communications Capability

One analog and three digital inputs are provided to interface with sensors and transducers. Three analog outputs and four relay contacts are furnished to share data with PLCs and control systems and to actuate alarms and control relays. Terminals are captive clamp type and finger safe. With the communications option, the device can be remotely monitored, controlled and programmed.

Ratings

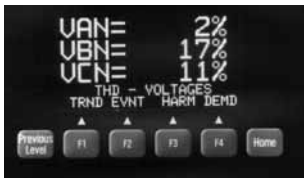
- Application to 500 kV, no PTs to 600 volts
- CT ratios selectable from 5:5A to 10,000:5A
- Standard 120/600 Vac line
- Three-phase power supply module, 100–600 Vac. Separate source power supply module available, 100–240 Vac or 100–250 Vdc
- DC only separate source power module also available, 24–48 Vdc

Displayed Information Features

- All information accessible at device or through communications port via Eaton's Power Management Software
- Quality true rms readings through 50th harmonic
- Complies with the accuracy portion of ANSI C12.20 Class 0.5% revenue metering specification
- Accurate readings for nonsinusoidal waveforms with up to 3.0 crest factor
- Screens display auto ranging units, kilo units, mega units as needed
- 10-digit energy readings
- Displays multiple parameters at the same time
- Programmable custom screens

Meter Menu Screens

Meter Menu



Examples of Meter Menu

Custom Screen

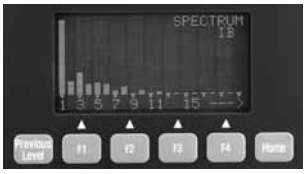
Custom Screen

The IQ Analyzer allows a user to view commonly used parameters by scrolling through its LED indicator Meter Menu.

Meter Menu Displayed Information

- Current
  - Phases A, B, C, average
  - Neutral
  - Ground (separate CT)
- Voltage
  - Phases A-B, B-C, C-A, average
  - Phases A-N, B-N, C-N, average
  - Neutral-ground
- Power
  - Real (watts)
  - Reactive (VARs)
  - Apparent (VA)
  - Phases A, B, C and system
- Energy (forward, reverse and net)
  - Real (kWh)
  - Reactive (kVARh)
  - Apparent (kVAh)—no reverse or net
- Frequency, time and date
- Demand
  - System current (amperes)
  - Systems real power (kW)
  - System reactive power (kVAR)
  - System apparent power (kVA)
- Power factor (Phases A, B, C and system)
  - Displacement
  - Apparent
- %THD current
  - Phases A, B, C, N
- %THD voltage
  - Phases A-B, B-C, C-A
  - Phases A-N, B-N, C-N
- K-factor
- CBEMA (ITIC) derating factor (displayed as "Z")
- Crest Factor
- Discrete input and output status
- Analog input reading
- Custom—user may program four screens to show any combination of seven Meter Menu parameters per screen

Harmonic Analysis Screens



Harmonic Spectrum Available with Model 6600

Minimum and Maximum Values

- Current
  - Phases A, B, C, N, G
- Voltage
  - Phases A-B, B-C, C-A
  - Phases A-N, B-N, C-N, N-G
- Power
  - Real (Watts)
  - Reactive (VARs)
  - Apparent (VA)
  - Phases A, B, C and System
- Power factor
  - Apparent and Displacement (three-phase and system)
- Frequency
- THD (amperes, volts and %):
  - Current (Phases A, B, C, N)
  - Voltage (Phases A-B, B-C, C-A, A-N, B-N, C-N)

All minimum/maximum values may be reset via reset pushbutton on faceplate, discrete input or communications command. Values are updated at least once every 16 line cycles.

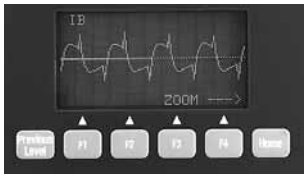
The F3 function key accesses the Harmonic Analysis screens. Two cycles of data sampled at 128 ***samples/cycle*** are ***simultaneously*** recorded for:

- Current
  - Phases A, B, C, N, G
- Voltage
  - Phases A-B, B-C, C-A
  - Phases A-N, B-N, C-N
  - Neutral to Ground

Magnitudes (or % of fundamental) of odd ***and even*** multiples of the fundamental from 2nd–50th are displayed. The phase angle associated with each multiple of the fundamental is also displayed.

Event/Alarm Analysis Screens

Example of Event Analysis Screens



Waveform Screen Available with Model 6600

Pressing the F2 function key accesses the Event Analysis screens. These display the following data for up to ten event/alarm conditions:

- Description, date and time of event/alarm with 10 millisecond resolution
- Current, voltages, power readings, demand readings, frequency and % THD at time of event/alarm
- Current and voltage distortion information available on Harmonic Analysis screens

Event data is stored in non-volatile memory. If a reset threshold is programmed, the *duration* of the event (e.g., undervoltage) is also displayed. With Eaton's communications option and software, waveforms and harmonic profiles may be displayed on a PC.

Event Conditions

Events may be triggered by up to seven of any of the following conditions:

Voltage Disturbances

- Undervoltage/sag—any V_{L-L}, V_{L-N} (40–100%)

Note: 60% minimum for self-powered unit.

- Overvoltage/swell—any V_{L-L}, V_{L-N} (100–750%)

If zero time delay is programmed, any disturbance lasting two cycles (less if magnitude is sufficient to effect rms readings) will trigger a voltage disturbance event/alarm.

- Sub-cycle transient capture/excess dv/dt on V_{A-N}, V_{B-N}, V_{C-N}

Note: 6600 series only.

- Sub-cycle voltage interruption on V_{A-N}, V_{B-N}, V_{C-N}

Note: 6600 series only.

Maximum Threshold Exceeded

- Currents—phases A, B, C, Neutral and Ground
- Voltage—Neutral to Ground
- System Power—Watts, VA, VARs
- System Power Factor—Displacement and Apparent
- Demand
- Currents—Phase A, B, C and AVG
- System Power—Watts, VARs, VA
- Frequency
- Percent Total Harmonic Distortion or Magnitude Total Harmonic Distortion:
  - Currents—Phases A, B, C, Neutral
  - Voltage—V_{A-N}, V_{B-N}, V_{C-N}, V_{A-B}, V_{B-C}, V_{C-A}

Minimum Threshold Exceeded

- Currents—Phases A, B, C
- System Power—Watts, Vars, VA
- System Power Factor—Displacement and Apparent
- Frequency

Voltage Phase Unbalance

- Voltage L-L, L-N

Current Phase Unbalance

- Current—Phases A, B, C

Discrete Input Energized

- Input 1, 2, 3
- Remote command through communications port or front panel

All trigger conditions have programmable time delays from 0.1–60 seconds in 0.1 second increments (except Voltage Disturbances—programmable from 2–3600 cycles in two-cycle increments, and Eaton's Power Management Software commands—no programmable delay).

Demand Recording

Peak Demands are date and time stamped for:

- Current Phases A, B, C and Average
- System Power:
  - Real (watts)
  - Reactive (VARs)
  - Apparent (VA)

Input/Output

Extensive input/output capability is standard on the IQ Analyzer. In addition to monitoring three-phase currents and voltages, separate inputs are provided for both ground and neutral currents. Voltage of neutral-to-ground is also monitored to indicate the presence of harmonics and potential downstream grounding problems. Analog and digital I/O provide interfaces for transducers, relays, PLCs and control systems.

Current Inputs

Five ampere secondary CT connections for:

- Phases A, B, C
- Ground
- Neutral
- Separate ground and neutral CT inputs
- CT range 5:5–10,000: 5 (any integer)

Voltage Inputs

- Phases A, B, C (from 120 Vac–500 kV AC)
- 120/240 Vac control power input standard—not required with optional line power module
- Separate ground-to-neutral voltage reference
- PT range 120:120–500,000:120 (any integer)

External 120-volt secondary PTs are required above 600 Vac, optional from 120–600 Vac.

Discrete Contact Inputs

Three dry contact discrete inputs may be programmed by the user to:

- Trigger Event Analysis—the information described in "Event Analysis Screens," including Harmonic Analysis information, can be recorded when external devices trip or change state by wiring their auxiliary contacts into these inputs
- Act as a synch.-pulse input to synchronize power demand windows with utility provided synch. pulse
- Actuate a relay output
- Reset relay output, peak demands, Trend Analysis records and Event Analysis records
- With communications option, provide remote status indication on Eaton's communication network
- Status of input contacts is displayed in the Meter Menu Custom screen

Relay Output Contacts

Four Form-C (NO/NC) relay contacts may be independently programmed to:

- Act as a kWh, kVARh or kVAh pulse initiator output
- Actuate on one or more event conditions—including discrete input software commands (through communications port)
- Reverse sequence alarm

Each relay may be set for Auto or Manual Reset with 0–30 minute release delay (one second increments). Relays are Form-C NO/NC. Relay(s) programmed to actuate on undervoltage also have a programmable 0–30 minute delay on power-up for transfer applications.

Analog Input and Outputs

One analog input and four analog outputs may be configured as 0–20 or 4–20 mA. The analog input is displayed at the device as a percentage and is accessible through the communications port. The analog input provides an interface with gas flow meters, temperature transducers or other analog devices.

The analog outputs may be programmed to reflect any of the following:

- Current—Phases A, B, C, Average, N, G
- Voltage—L-L, L-N, N-G
- Power:
  - Real (watts)
  - Reactive (VARs)
  - Apparent (VA)
  - Phases A, B, C and System
- % THD:
  - Current (Phases A, B, C, N)
  - Voltage (L-L, L-N)
- Frequency–System
- Power Factor:
  - System Displacement PF
  - System Apparent PF

Standards and Certifications

- UL listed, File E62791, NKCR File E185559 (CE versions)
- cUL listed #1010.1 C22.2
- CE mark EN61010-1 (1993) EN50082-2 (1994)
- Measurement Canada Electricity Meter AE-0782
- CSA approved

9

Product Selection

IQ Analyzer

IQ Analyzer

Description	Catalog Number
IQ Analyzer, separate source power module	**IQA6410**
IQ Analyzer, 24–48 Vdc power module	**IQA6420**
IQ Analyzer, three-phase power module	**IQA6430**
IQ Analyzer, separate source power module with waveform display and sub-cycle voltage disturbance capture	**IQA6610**
IQ Analyzer, 24–48 Vdc power module with waveform display and sub-cycle voltage disturbance capture	**IQA6620**
IQ Analyzer, three-phase power module with waveform display and sub-cycle voltage disturbance capture	**IQA6630**
IQ Flange, to provide extra clearance when mounting	**IQFLANGE**
45-inch (1143.0 mm) extension cable for remote mounting of power module	**IQA45CABLE**
24–48 Vdc separate source power module	**IQMDCPM**
100–240 Vac and 100–250 Vdc separate source power module	**IQMSSPM**
Three-phase, self-powered power module	**IQM3PPM**
INCOM communication module	**IPONI**
RS-485 communication module with Modbus protocol	**MPONI**

Accessories

IQ Analyzer Auxiliary Power Supply

The optional IQ Analyzer Auxiliary Power Supply allows set point programming of the IQ meter while the monitored line power is turned off and locked out, thus eliminating the presence of dangerous line voltages. The Auxiliary Power Supply is easy to install and has been specifically designed to connect to the power supply connector on the IQ meter and then plug into a standard electrical wall outlet.

Technical Data and Specifications

IQ Analyzer 6400/6600 Series

Fuses

- Self-powered units with IQMSSPM have 3/4 ampere, 600 volts Bus Type KTK-R-3/4 fuses (three required).
- Separate source dual-voltage units with IQMSSPM have a single 5 x 20 mm 1/4 ampere fuse
- Separate source DC units with IQMDCPM do not have user replaceable fuses

Environmental Conditions

- Operating temperature: –20°–70°C
- Storage temperature: –30°–85°C
- Operating humidity: 5–95% relative humidity

Current Inputs (Each Channel)

- Conversion: true rms, 32 sample/cycle (all samples used in all rms calculations)
- CT input: 5 ampere secondary (any integer 5:5 to10,000:5)
- Burden: 0.05 VA
- Overload withstand: 40 amperes AC continuous, 300 amperes AC 1 second
- Range: 8 x CT continuous
- Accuracy: 0.1% of CT primary rating, 0.2% of reading above 150% of rating, sinusoidal (see accuracy below for non-sinusoidal specifications)
- Input impedance: 0.002 ohm

Voltage Inputs (Each Channel)

- Conversion: True rms, 32 sample/cycle (all samples used in all rms calculations)
- PT input: direct or any integer 120:120–500,000:120
- Range: 30–660 Vac (separate source and DC source)
- Nominal full scale: 100–600 Vac
- Burden: 21 VA (self-powered only)
- Overload withstand: 635 Vac, continuous 700 Vac, 1 second
- Input impedance: 1 megohm

Frequency Range

- 20–66 Hz fundamental (up to 50th harmonic)

Harmonic Response (Voltages, Currents)

- 50th harmonic

Accuracy (in Percent Full Scale)

Accuracy from 3–300% of Full Scale and from –0.5. to 1.00 to 0.5 power factor

- Current and voltage: ±0.20%
- Power, energy and demand: 0.40%
- Frequency: 0.04%
- Power factor: 0.80%
- THD: 1.00%

Specific Current Accuracies

- ±0.20% of full scale to 200% of full scale and 150% crest factor
- ±0.20% of full scale to 150% of full scale and 200% crest factor
- ±0.20% of full scale to 100% of full scale and 300% crest factor
- ±0.40% of reading for currents to 800% of full scale
- Power and energy: Start recording with an average of 3 mA secondary current

Discrete Inputs (Dry Contact)

- +30 Vdc differential across each discrete input pair of terminals. Minimum pulse width: 1.6 msec
- Optically isolated inputs to protect IQ Analyzer circuitry

Analog Outputs (4)

- 0–20 mA/4–20 mA into maximum 750 ohm load. Accuracy: 1%

Analog Input (1)

- 0–20 mA/4–20 mA into 200 ohm load. Accuracy: 1%

Relay Output Contacts (4)

- Form C Dry Contact: 10 amperes at 120/240 Vac (Resistive) 10A at 30 Vdc (Resistive) 30A make (50 mS) at 240 Vac/240 Vdc
- Minimum pulse width: 4 cycles (68 mS)
- Withstand rating: 1000 Vac, 1 minute across contacts 5000 Vac (contacts to coil, 1 minute) 10,000 Vac (contacts to coil, surge voltage)

Relay Response Time

(Excluding programmed time delays):

- Two line cycles for Discrete Input, Eaton's software commands (communications port)
- Four to five line cycles for Voltage Disturbance, Voltage Unbalance
- Nine to 10 line cycles for all others

IQ Analyzer Auxiliary Power Supply

- Input voltage: 100–250 Vac
- Input frequency: 50/60 Hz
- Output voltage/current: +24 Vdc at 0–0.45A
- Output ripple: 100 mV maximum (peak to peak)
- Rated output power: 10.8 watts
- Turn on/turn off overshoot 5% maximum
- Turn on delay: 0.5 second maximum
- Operating temperature: 0°–40°C
- Storage temperature: –40°–80°C

Control Power Input

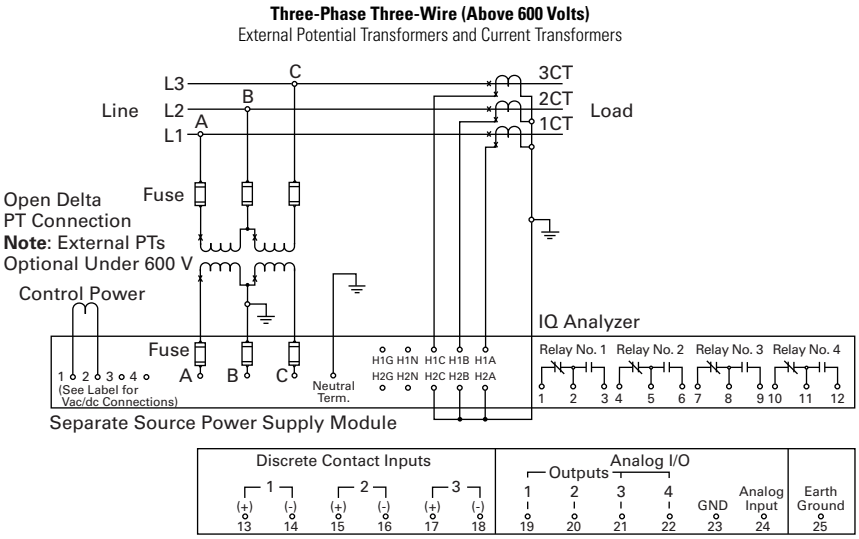
Description	Separate Source	Self Powered ①	DC Source
Input range, AC	110–240 Vac ±10%	110–600 Vac ±10%	N/A
Frequency range	45–66 Hz	45–66 Hz	N/A
Input range, DC	110–250 Vdc ±10%	N/A	24–48 Vdc ±20%
Burden	21 VA	21 VA	21 VA

Note

① When directly wired to 480 Vac, IQ Analyzer can ride through a continuous sag that is 20% of rated voltage.

Wiring Diagram

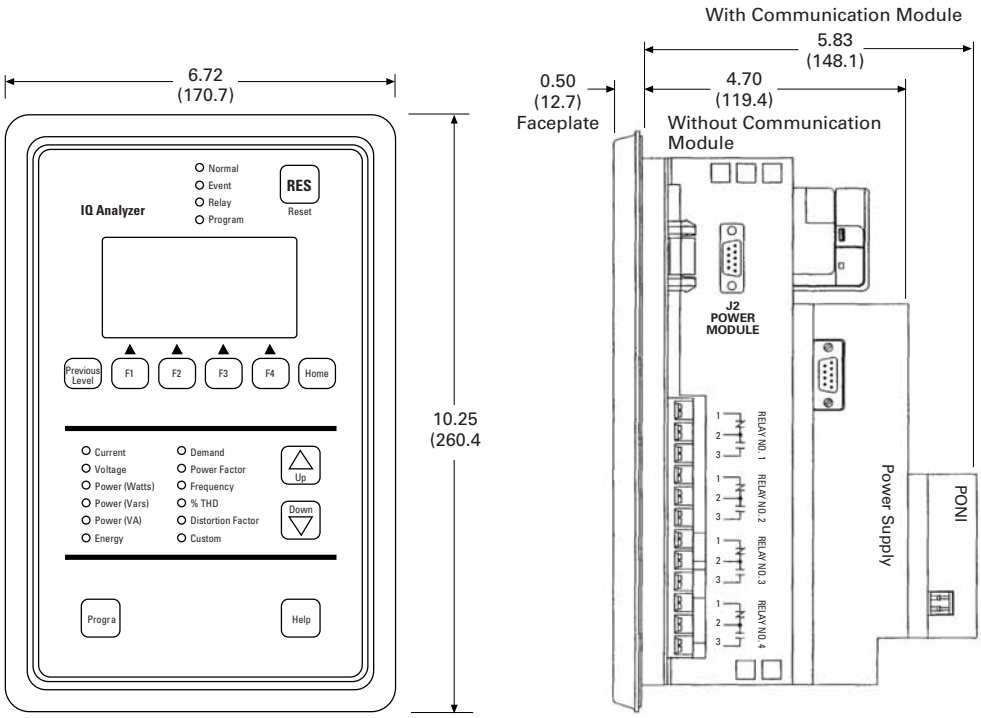
Field Wiring Connections—Separate Source Power Supply Shown Here (For Three-Phase Power Supply, No Separate Control Power is Required)



Dimensions

Approximate Dimensions in Inches (mm)

IQ Analyzer 6000 Series



Approximate Dimensions in Inches (mm)

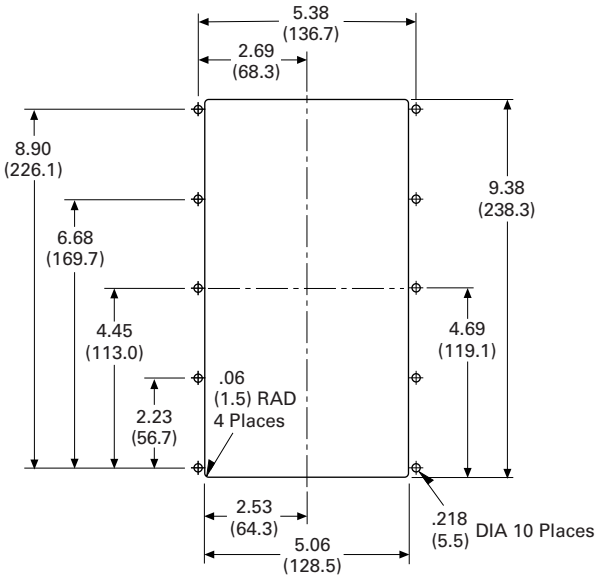
IQ Analyzer Auxiliary Power Supply

Width	Height	Depth	Shipping Weight Lbs (kg)
2.40 (61.0)	4.00 (101.6)	1.11 (28.2)	5.8 (3.6)

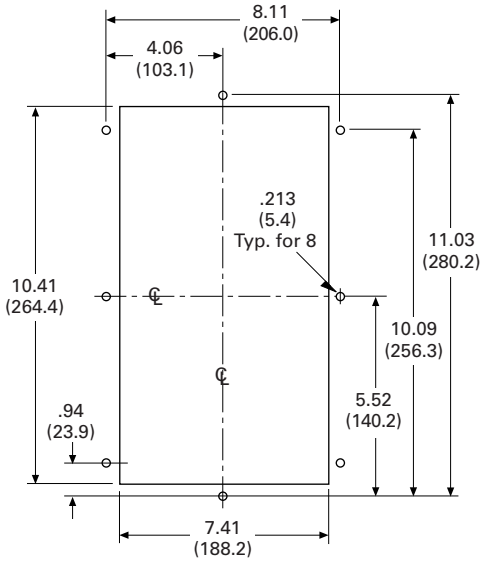
IQ Analyzer 6000 Series

Height	Width	Depth
Without PONI		
10.25 (260.4)	6.72 (170.7)	4.70 (119.4)
With PONI		
10.25 (260.4)	6.72 (170.7)	5.83 (148.1)

Drilling Pattern



Drilling Pattern for Flange Mounting



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IQ DP-4000

Contents

IQ DP-4000 Series

Product Description

Eaton's IQ DP-4000 is a microprocessor-based monitoring and protective device that provides complete electrical metering and system voltage protection. In one compact, standard package, the IQ DP-4000 will provide an alternative to individually mounted and wired conventional meters and switches. The DP-4000 also monitors Apparent Power (VA), Reactive Energy (VAR-hours), Apparent Energy (VA-hours) and percent THD to provide the user with basic power quality information. The IQ DP-4000 meets and surpasses UL/CSA/CE standards.

The IQ DP-4000's rugged construction is designed to withstand harsh conditions such as temperature variations, outdoor applications and industrial environments. The membrane faceplate pushbuttons are easy to use and both the parameter LED and window displays are easily visible.

Application Description

- Monitoring of all common electrical parameters
- Optional protective alarm functions

Retrofit Opportunities

- Retrofit of existing electrical distribution systems with the IQ DP-4000 for power, quality, load and energy monitoring
- Mounting flange option for application where additional door mounting space is required; see **Page V3-T9-93**

Features, Benefits and Functions

Historical Values

- Present demand current (per phase) 5, 10, 15, 20, 25, 30, 45 or 60 minute windows
- Present demand watts, VARs and VA 5, 10, 15, 20, 25, 30, 45 or 60 minute windows:
  - Sliding or fixed window for power Sync pulse input (Model 4100) Eaton's PowerNet broadcast demand sync
- Minimum and maximum values current (per phase):
  - Voltage (per phase, L-L, L-N)
  - Watts, VARs and VA
  - Power factor (displacement and apparent)
  - Frequency
- Peak values:
  - Percent THD parameters
  - Demand parameters

Protective and Event Alarming

- Undervoltage
- Overvoltage
- Current phase loss
- Voltage phase loss
- Phase reversal
- Phase unbalance
- Optional current and powerdemand threshold

Metered and Monitored Parameters

- rms sensing
- Phase currents
- Volts: L-L, L-N
- Power: real, reactive, apparent
- Energy: real, reactive, apparent
- Frequency
- Power factor
- % THD: current and voltage
- Minimum and maximum values
- Fixed or sliding demand windows

Communications

- Optional interface capability to computer network for data collection, storage and/or printout via Eaton's Power Management Software

Physical Characteristics

- Large visible LED display
- Membrane Faceplate NEMA 3R and 12 rated

Alarm and Protective Functions

- Alarm/Protective functions (all models) include:
  - Overvoltage
  - Undervoltage
  - Current phase loss
  - Voltage phase loss
  - Phase unbalance
  - Phase reversal
- User-programmable alarm and reset threshold levels and delay intervals
- Optional current and power demand threshold

Description of Protection Functions

Overvoltage

Range 105–140% (5% increments).

Undervoltage

Range 60–95% (5% increments).

Phase Unbalance

Deviation between any two phases percentage of nominal line voltage preset by DIP switches. Range 5–40% (5% increments).

Phase Reversal

Any two phases become reversed for the selected delay.

Voltage Phase Loss

Less than 50% of the nominal line voltage detected.

Current Phase Loss

Smallest phase current is less than1/16 of the largest phase current.

Delay

Allows a delay before an alarm occurs. (Range 1–20 seconds in 1 second increments.)

Note: Unit must be powered for this to occur.

Inputs and Outputs (4100 Model)

- Three Form C relay outputs selectable: Trip, Alarm, kWh pulse initiator
- One synch input for kW utility demand sync

Standards and Certifications

Listings and Certifications

- UL/cUL/CSA listed
- CE mark EN61010-1, EN50082-2

Listed Listed

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Product Selection

IQ DP-4000

IQ DP-4000

Description	Catalog Number
4 indicates an IQ DP-4000 model x = 0 indicates no I/O; x = 1 indicates I/O y = 1 indicates separate source supply, 110–240 Vac and 110–250 Vdc y = 2 indicates 24–48 Vdc power supply, y = 3 indicates three-phase power supply, 110–600 Vac	**IQDP4XY0**
Separate source control power without I/O	**IQDP4010**
Separate source control power without I/O, DC supply	**IQDP4020**
Three-phase power supply without I/O	**IQDP4030**
Separate source control power with three Form C relay output contacts and one sync pulse input	**IQDP4110**
Separate source control power with three Form C relay output contacts and one sync pulse input, DC supply	**IQDP4120**
Three-phase power supply with three Form C relay output contacts and one sync pulse input	**IQDP4130**
2 Form C relay outputs for protective alarming functions, 1 Form C relay output selectable for KYZ pulse output or load shedding, 1 demand sync pulse input	**DP4IOMOD**
IQ flange, to provide extra clearance when mounting	**IQFLANGE**
45-inch (1143.0 mm) extension cable for remote mounting of power module	**IQA45CABLE**
24–48 Vdc separate source power module	**IQMDCPM**
100–240 Vac and 100–250 Vdc separate source power module	**IQMSSPM**
Three-phase, self-powered power module	**IQM3PPM**
INCOM communication module	**IPONI**
RS-485 communication module with Modbus protocol	**MPONI**

Accessories

IQ DP-4000 I/O Module

For applications where field modification to add or change Input/Output (I/O) capability to the IQ DP-4000 is required, Eaton offers I/O cards. These field-installable modules can be easily inserted into an existing IQ DP-4000 where input/output application needs change.

- Power requirements: 10 VA
- Frequency: 50/60 Hz
- Operating temperature: 25°–70°C
- Operating humidity: 0–95% noncondensing
- Dry contact input: 24 Vdc differential across input pair of terminals; minimum pulse width, 50 mS

Technical Data and Specifications

Accuracy

- Maintained from 10–250% of CT primary rating

Current Inputs (Each Channel)

- Nominal full scale current: 5 amperes AC
- Current range for rated accuracy: 0–15 amperes AC
- Overload withstand: 15 amperes ac continuous 300 amperes AC 1 second
- Burden: 0.003 VA

Voltage Inputs (Each Channel)

- Voltage range (nominal): 90–600 Vac
- Nominal full scale voltage: 120–600 Vac
- Overload withstand: 660 Vac continuous 4 kV 1.2/50 µs
- Burden: three-phase power module 10 VA

Fuses

Supplied with three-phase power module only. 3/4 ampere, 600 volt bus type KTK-R-3/4 (three required).

Contact Rating (Model 4100)

- 10 amperes at 120/240 Vac (resistive)
- 10 amperes at 30 Vdc (resistive)

Compatible with the Following Systems

- Three-phase, three-wire
- Three-phase, four-wire

Ratings

- Application to 500 kV, no PTs to 600 volts
- CT ratios selectable from 5:5 A to 12800: 5A
- Standard 120/600 Vac line three-phase power supply module. Two separate source power supply modules available. One module from 110– 240 Vac and 110–250 Vdc; the other module 24–48 Vdc only

Model 4100 Input and Output

Model	Input	Output
4000	0	0
4100	1 digital (dry contact)	3 relays

Control Power Input

Description	Separate Source	Self Powered	DC Source
Input range, AC Frequency range	110–240 Vac ±10% 45–66 Hz	110–600 Vac ±10% 45–66 Hz	N/A N/A
Input range, DC Burden	110–250 Vac ±10% 10 VA	N/A 10 VA	24–48 Vdc ±20% 10 VA

Displayed Values

Description	Displayed Through Eaton's PowerNet System	Local Display
AC amperes, phases A, B, C	±0.3%	±0.3% ±1 digit
AC voltage, phase A-B, B-C, C-A	±0.3%	±0.3% ±1 digit
Phase A-N, B-N, C-N	±0.3%	±0.3% ±1 digit
Watts	±0.6%	±0.6% ±1 digit
Vars	±0.6%	±0.6% ±1 digit
VA	±0.6%	±0.6% ±1 digit
Watt-hours	±0.6%	±0.6% ±1 digit
VAR-hours	±0.6%	±0.6% ±1 digit
VA-hours	±0.6%	±0.6% ±1 digit
Power factor	±1%	±1%
Frequency	±0.1 Hz	±0.1 Hz
% THD	Through 31st harmonic	Through 31st harmonic

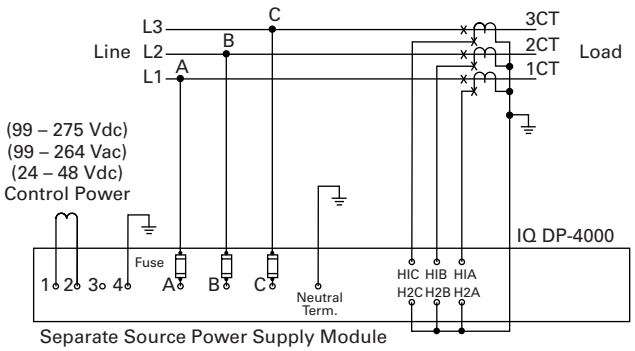
Note

All accuracy is measured as a percentage of full scale.

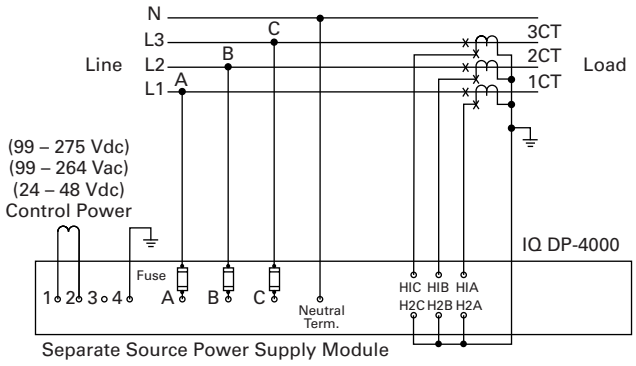
Wiring Diagrams

Field Wiring Connections

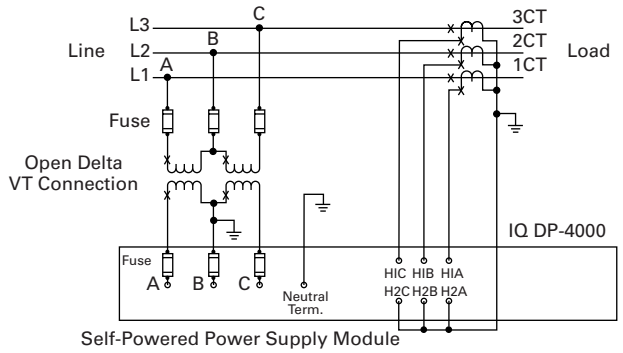
Three-Phase Three-Wire (Up to 600 Volts)
Direct Voltage Connection and External Current Transformers



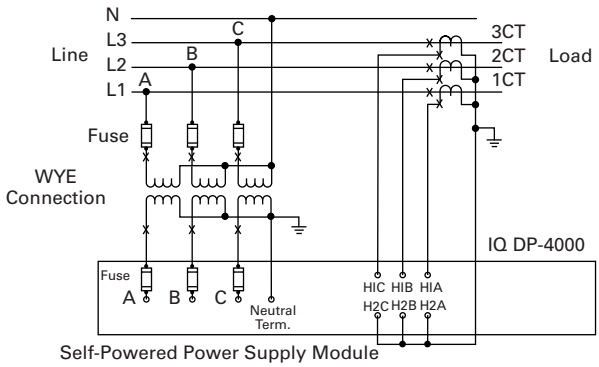
Three-Phase Four-Wire (Up to 600 Volts)
Direct Voltage Connection and External Current Transformers



Three-Phase Three-Wire (Above 600 Volts)
External Voltage Transformers and Current Transformers



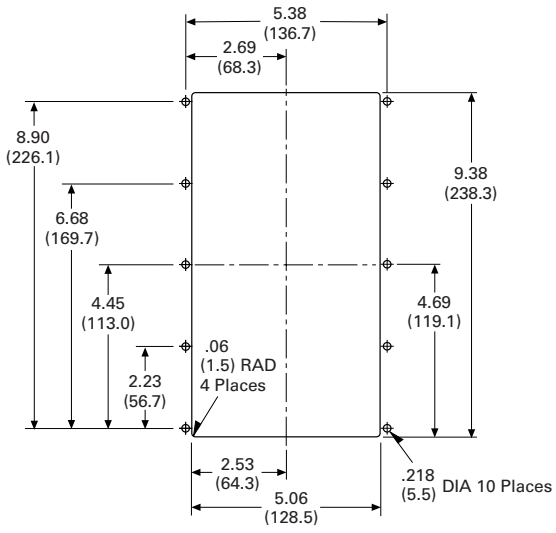
Three-Phase Four-Wire (Above 600 Volts)
External Voltage Transformers and Current Transformers



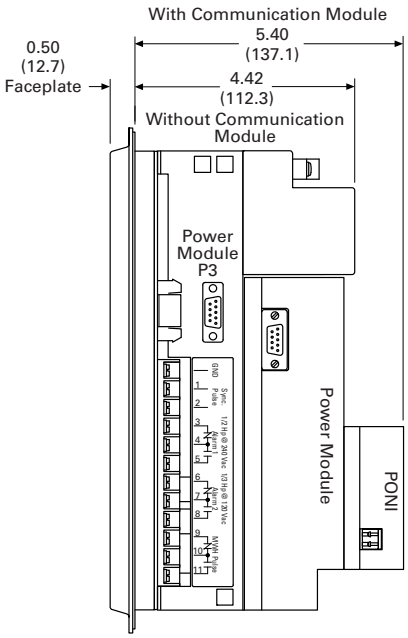
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Pattern



IQ DP-4000 Side View



LED Display

Height	Width	Depth	Shipping Weight Lbs (kg)
PONI			
10.25 (260.4)	6.72 (170.7)	5.40 (137.2)	6.50 (3.0)
Without PONI			
9.02 (229.0)	7.80 (198.1)	4.42 (112.3)	12.5 (5.7)

IQ DP-4000 Auxiliary Power Supply

Width	Height	Depth
2.40 (61.0)	4.00 (101.6)	1.11 (28.2)

Power Xpert Multi-Point Meter

Contents

Power Xpert Multi-Point Meter

Product Overview

Eaton's Power Xpert™ Multi-Point Meter is an ANSI C12.20 revenue class Web-enabled electronic submetering device that can be mounted in panelboards switchboards or enclosures. When mounted in a panelboard or a switchboard, the Power Xpert Multi-Point Meter provides customers with an integrated power distribution and energy metering solution that saves space, reduces installation labor and lowers total cost.

The Eaton Power Xpert Multi-Point Meter (PXMP Meter) offers a highly modular approach to high-density metering applications in electrical power distribution systems. The PXMP Meter is compatible with most three-phase industrial, commercial and single-phase residential low voltage electrical power systems. The PXMP is equipped with two Modbus® RTU communication ports for local display and remote serial communications. The PXMP also has optional pulse input and digital output modules along with one standard digital output and three digital inputs. The PXMP Energy Portal Module is Web enabled, making it suitable for use with Ethernet networks and modems.

Product Description

The Power Xpert Multi-Point Meter can measure up to any of the following number of circuits:

- Sixty single-phase, two-wire (single-pole)
- Thirty single-phase, three-wire (two-pole)
- Twenty three-phase, four-wire (three-pole)

The circuits listed above can be mixed provided that the total number of current sensors does not exceed 60. The meter provides current; voltage; power factor; demand and active, reactive, and real power (VA, VAR, kW); and active, reactive, and real energy (VA, VAR, kWh) measurements for each load. The unit also provides up to two years at 15-minute intervals or eight years at one-hour intervals of demand data logging storage in non-volatile memory for up to 60 submeters.

The Power Xpert Multi-Point Meter can be used with three different ratings of current sensors: 100 mA, 10 mA or 333 mV. Switchboard/panelboard applications will use the 100 mA current sensors, which are highly accurate, self-protecting in the event of an open circuit condition under load and are supplied with an integral plug-in connector. The PXMP automatically detects the rating of the current sensor that is connected.

The PXMP can also use 10 mA current sensors that were previously installed for IQMESII retrofit applications. Additionally, the PXMP can use 333 mV split core current sensors for retrofit applications where metering has not previously existed. The 10 mA and 333 mV current sensors are also self-protecting in the event of an open circuit condition under load.

Application Description

The Power Xpert Multi-Point Meter is ideally suited to handle submetering in low voltage power distribution equipment applications such as distribution boards in multi-tenant buildings, comprehensive main and feeder metering in commercial/industrial switchboards or medium voltage distribution equipment with the use of voltage and current transformers.

The Power Xpert Multi-Point Meter provides a cost-effective solution for residential or commercial metering installations. Typical installations include:

- High-rise buildings
- Government institutions
- K–12, universities and campuses
- Office buildings
- Medical facilities
- Apartment and condominium complexes
- Airports
- Shopping malls
- Industrial sites
- Mixed-use facilities

Features

- Monitors power and energy for up to 60 current sensors; space-saving modular design allows measurement from 1 to 60 circuits
- Built-in communication interfaces
- Monitors single-phase and three-phase loads from 120 to 600 Vac
- Monitors current, voltage, power factor, frequency, power and energy
- Stores extensive energy profile data for each metering point; can be used to identify coincidental peak demand contribution
- LEDs provide status of unit communication activity and verify sensor connections
- Meets rigid ANSI C12.20 accuracy specifications for revenue meters
- Three standard digital inputs and eight pulse inputs per optional module to monitor WAGES (water, air, gas, electric, or steam)
- One standard digital output and eight digital outputs per optional module for alarm indication
- Three types of meter modules to support 10 mA, 100 mA or 333 mV sensors
- Can be directly mounted in a UL Listed panelboard, switchboard or enclosure
- 256 MB of memory in meter base for up to two years of 15-minute interval data (eight years of one-hour interval data) for eight demand values up to 60 submeters

Communication Capabilities

With the Power Xpert Multi-Point Meter's built-in communication capabilities, remote meter reading and monitoring functions can be integrated into both new and retrofit applications.

- Standard Modbus RTU
- Optional Modbus TCP / BACnet/IP / SNMP / HTTP / SMTP / NTP /SFTP communications

Software Compatibility

The Power Xpert Multi-Point Meter:

- Can be used as part of an electrical energy monitoring and cost allocation system
- Can be remotely monitored via onboard Web pages with Eaton's optional Energy Portal Module
- Is compatible with third-party software platforms and interface devices

Configuration

- The Power Xpert Multi-Point Meter is fully configurable using Power Xpert Multi-Point configuration software that can be down-loaded free from the Eaton website at www.eaton.com/meters
- Each Power Xpert Multi-Point Meter module can be configured for up to six metering points in any combination of single-phase and three-phase metering points corresponding to the voltage wiring of the meter base
- Power Xpert Multi-Point configuration software simplifies system commissioning and startup; PXMP configuration software supports both online and offline configurations

Easy to Install

- UL Listed for mounting inside panelboards (e.g., PRL4), switchboards, and NEMA 12 enclosures
- Quick connect terminals for current sensors, Modbus communications, and bus voltages make wiring the unit quick and easy

Features

Description	Main/Aggregate	Channel Data	Tenant
Instrumentation			
Current, per phase	■ ①	■	—
Voltage, per phase (L-L, L-N)	■	■	—
Frequency	—	■	■
Minimum/maximum readings, V	Per phase	—	—
Minimum/maximum readings, W, VAR, VA	Total and per phase	—	—
Minimum/maximum readings, PF, F	Total	—	—
Power			
Real, reactive, and apparent power (W, VAR, VA)	Total and per phase	Total and per phase	Total
Power factor	—	Average	Average
Demand			
Block interval (fixed, sliding)	■	—	—
Real, reactive and apparent power demand	Total and per phase	—	—
Minimum/maximum readings, PF, W, VAR, VA	Total and per phase	Total	—
Energy			
Real, reactive and apparent energy (Wh, VARh, VAh)	Total	—	Total
Real, forward and reverse, and total (Wh)	■	—	■

Note

① Main only.

Standards and Certifications

Environmental

The PXMP Meter and current sensors must be housed in a NEMA or UL enclosure that keeps the internal environment within the PXMP's environmental specification ranges and provides suitable fire and mechanical protection in the end product installation.

- Temperature range: –20 to +70°C (–4 to +158°F)
- Storage temperature range: –40 to 85°C
- Humidity: 5–95% noncondensing environment
- Pollution degree: II
- Elevation: 0 to 9843 ft (0 to 3000m)
- Housing: IP20
- CE Mark
- EMC EN61326

Emissions Conducted and Radiated

- FCC part 15 Class B
- CISPR 11 Class B

Electromagnetic Immunity

Standard	Description	Level
EN61000-4-2	ESD	3
EN61000-4-3	RF radiated	3
EN61000-4-4	Electrical fast transient	3
EN61000-4-5	Surge	3 ①
EN61000-4-6	RF conducted	3
EN61000-4-11	Volt sag/swell/variation	—

Product Safety

- IEC/EN61010-1
- UL 61010-1 File E185559
- CNL evaluation to CAN/C22.2 No 1010.1.92

Accuracy

- ANSI C12.20—Accuracy Class 0.5% with either CSXXX or PXMP-CSXXX sensors
  - Measurement Canada Approval Pending

UL Listed

Product Selection

The Power Xpert Multi-Point Meter, current sensors, and other accessories can be ordered from Eaton distributors. Refer to the following catalog numbers when ordering.

Power Xpert Multi-Point Meter Products

Product Description	Catalog Number
Meter Bases and Meter Modules with ABCN Voltage Inputs	
PXMP meter base—three-phase with ABCN voltage inputs	**PXMP-MB**
PXMP meter module with six 100 mA inputs for use with PXMP current sensors	**PXMP-MM100MA**
PXMP meter module with six 10 mA inputs for use with IQMESII current sensors	**PXMP-MM10MA**
PXMP meter module with six 333 mV inputs for use with 333 mV current sensors	**PXMP-MM333MV**
Meter Bases and Meter Modules with ABN Voltage Inputs	
PXMP meter base—single-phase, three-wire with ABN voltage inputs	**PXMP-MB-AB**
PXMP meter module with six 100 mA inputs for use with PXMP current sensors	**PXMP-MM100MA-AB**
PXMP meter module with six 10 mA inputs for use with IQMESII current sensors	**PXMP-MM10MA-AB**
PXMP meter module with six 333 mV inputs for use with 333 mV current sensors	**PXMP-MM333MV-AB**
IO Modules	
PXMP meter pulse input module with eight inputs	**PXMP-PIM**
PXMP meter digital output module with eight outputs	**PXMP-DOM**
Communication Module	
PXMP meter energy portal module	**PXMP-EPM**
Current Sensor Kits	
KIT, PXMP CS125 sensor, quantity of 3	**PXMP-CS125-3**
KIT, PXMP CS250 sensor, quantity of 3	**PXMP-CS250-3**
KIT, PXMP CS400 sensor, quantity of 3	**PXMP-CS400-3**
Current Sensor Cable Kits	
KIT, PXMP sensor cable, 4 ft (1.2m), quantity of 3	**PXMP-SC4-3**
KIT, PXMP sensor cable, 6 ft (1.8m), quantity of 3	**PXMP-SC6-3**
KIT, PXMP sensor cable, 8 ft (2.4m), quantity of 3	**PXMP-SC8-3**
KIT, PXMP sensor cable, 12 ft (3.7m), quantity of 3	**PXMP-SC12-3**
Current Sensor Extension Cable Kits	
KIT, PXMP sensor extension cable, 8 ft (2.4m), quantity of 3	**PXMP-SCE-8-3**
KIT, PXMP sensor extension cable, 16 ft (4.9m), quantity of 3	**PXMP-SCE-16-3**
Interface Modules	
PXMP current sensor interface module for 333 mV, kit X 3	**PXMP-IM333MV-3**

Note

Total sensor lead length must not exceed 28 ft (8.5m).

The Pulse Input Module (PXMP-PIM) can be used to totalize pulse outputs from water meters, gas meters, steam meters or even old electrical meters with KZ pulse outputs. The PXMP-PIM can also be used for status monitoring in applications where status indication updates of 6 seconds over Modbus satisfies the application requirement.

Support products for the Power Xpert Multi-Point Meter include the HMI display, IMPCABLE and power supplies as described in the table below.

Power Xpert Multi-Point Meter Support Products

Product Description	Catalog Number
Communication cable, 1000 ft (305m), 600V insulation	**IMPCABLE**
PXMP meter display—6-inch color touchscreen (with cable)	**PXMP-DISP-6**
Power supply—single-phase 90–264 Vac, 24 Vdc at 2.5A	**PSG60E**
Power supply—three-phase 360–575 Vac, 24 Vdc at 2.5A	**PSG60F**
Power supply—three-phase 600 Vac, 24 Vdc	**PSS55D**

Meter Selection

	Meter Base		Typical Applications			
Meter Module	Three-Phase Application or Single-Phase with ABCN	Single-Phase Application with ABN	New Switchboards PXMP Current Sensors, Solid Core, PXMP-CSXXX, Ampere Ratings	Retrofit Existing IQMESII Sensors, Solid Core, CS-XXX, Ampere Ratings	Enclosed PXMP 333MV Sensors, Split Core, CS-SP-X-XXXX-333MV, Ampere Ratings	Enclosed PXMP Interface Modules
PXMP-MM100MA	**PXMP-MB**	**—**	125, 250, 400	—	—	**—**
PXMP-MM333MV	**PXMP-MB**	**—**	—	—	100, 200, 300, 400, 600, 800, 1000, 1200, 1600, 2000 ①	**PXMP-IM333MV**
PXMP-MM10MA	**PXMP-MB**	**—**	—	5, 50, 70, 125, 200, 400	—	**—**
PXMP-MM100MA-AB	**—**	**PXMP-MB-AB**	125, 250, 400	—	—	**—**
PXMP-MM333MV-AB	**—**	**PXMP-MB-AB**	—	—	100, 200, 300, 400, 600, 800, 1000, 1200, 1600, 2000 ①	**PXMP-IM333MV**
PXMP-MM10MA-AB	**—**	**PXMP-MB-AB**	—	5, 50, 70, 125, 200, 400	—	**—**

Note

① For applications requiring more than 2000A current sensors, use a CS005 with 5A CT in conjunction with PXMP-MM10MA.

Technical data and Specifications

External Circuit Group Specifications

PXMP-MB (-AB) Meter base

Discrete Output

- Quantity 1—solid-state relay Form A NO Bidirectional FET
- Polarity of external source is not important
- Isolation circuit to ground 2 kV/1 min.
- Maximum external source voltage 28 Vdc
- Line-to-line TVS clamp across switching element at 32 Vdc
- Solid-state relay on resistance 35 ohms maximum
- Maximum load current 80 mA
- Minimum pulse width 20 milliseconds
- Fixed 25 milliseconds for pulse initiator function
- Maximum pulse rate 25 Hz
- Wiring to two-position removable terminal plug
  - 12–18 AWG (3.31–0.82 mm^2), wire ferrules recommended
  - T1 (polarity not important)
  - T2 (polarity not important)

Discrete Inputs

- Quantity 3, common circuits inputs 1–3
- Group isolation 2 kV
  - No input-to-input circuit isolation
- All inputs per module share a common external 24V (±10%) supply
  - 24V externally sourced between common and inputs
  - Design to interface with external dry contact
  - Input impedance ~2.2K ohms
  - Input current draw ~10 mA per input
- Minimum pulse width 10 milliseconds
- Maximum pulse rate 20 Hz
- Wiring to four-position removable terminal plug
  - 12–18 AWG (3.31–0.82 mm^2), wire ferrules recommended
  - T3—Common (connect ext. 24 common here)
  - T4—Input 1 (dry contact to 24V hot)
  - T5—Input 2 (dry contact to 24V hot)
  - T6—Input 3 (dry contact to 24V hot)

COM1 and COM2 RS-485 Serial Ports

- No D+/D– biasing reliance on fail-safe driver and biasing at Master
- Baud rate configurable between 9600–115K baud (default)
- Use cable designed for RS-485 communications
  - Low L:L capacitance
  - Impedance of ~100–120 ohms
  - Shield—Mylar for high frequency; Braid for low frequency
  - Separate common and shield for best noise immunity
  - Maximum cable length is 4000 ft (1219.2m) with 32 nodes at 19.2K baud increased data rates will reduce maximum cable distance
  - 2000 ft (609.6m) with 32 total nodes at 115.2K baud
- Isolation 300V to ground due to TVS diode clamps
- Modbus RTU slave protocol, address defined by rotary switch
- Green Rx and Red Tx LEDs per channel
- Data + > Data—during idle marked, logic 1 state
- End of Line Termination resistance should match cable impedance (typ. 100–120 ohms)
- Four-position removable terminal plug 18–22 AWG (0.82–0.33 mm^2) typical, wire ferrules recommended
  - COM1
    - T7—Shield
    - T8—RS-485 common
    - T9—Data –
    - T10—Data +
  - COM2
    - T11—Shield
    - T12—RS-485 common
    - T13—Data –
    - T14—Data +

PXMP-MB Power Supply Input

- 24 Vdc ±20%
- 15W maximum load
- 1 kV isolation barrier internal to PXMP-MB
- Externally fuse circuit to protect wire
- Green power OK LED
- Three-position terminal block 16–12 AWG (1.31–3.31 mm^2), wire ferrules recommended
  - T15—24 Vdc – (common)
  - T16—24 Vdc + (Hot)
  - T17—Shield (optional) capacitively referenced to chassis ground for enhanced EMC performance

Meter Voltage Inputs

- Overvoltage CAT III
- Maximum voltage rating
  - 480VL:G (corner grounded delta)
  - 347VL:N
  - 600VL:L
- Frequency rating 47–63 Hz
- Metering range (temporary transitions)
- 30–700VL:N
- 30–700VL:L
- Abuse withstand rating 1000V sustained
- High pot withstand rating 2500V/1min
- Input impedance 4M ohms
- Fuse inputs rated to protect wiring to mains. External fuses
- must be installed between the meter voltage terminal and the mains disconnect switch to the main lines to protect the lines. 600V 1 A BUSS type KTK-R-1 Fast Acting or equivalent fuses
- are recommended.
- Wiring to removable terminal plug 10–18 AWG (5.26–0.82 mm^2), wire ferrules recommended
- T18—N (VR)
- T19—C (V3)
- T20—B (V2)
- T21—A (V1)

PXMP meter modules (PXMP-MMs)

Compatible with all PXMP Meter Base slots 1–10 LED indicators:

- Health and status green, blink to show activity
- Pulse energy output one red per group of three loads
- Load energy direction red/green pair per load

All variations support six load inputs.

Current sensor connection is one 2 x 2 connector per load.

Compatible with PXMP-SCXX sensor cables, total cable length to the sensor should not exceed 28 ft (8.5m).

Note that -AB suffix only affects what voltage channels the loads are paired with for metering purposes.

PXMP-MM10MA supports the CSXXX series of 10 mA maximum secondary output current transformers.

PXMP-MM100MA supports the PXMP-CSXXX series of 100 mA maximum secondary output current transformers.

PXMP-MM333MV supports 333 mV maximum secondary output current transformers with the use of the PXMP-IM333MV interface module.

PXMP digital output module (PXMP-DOM)

- Compatible with all PXMP-MB slots 1–10
- LED indicators
  - Health and status green, blink to show activity
  - Output On/Off status one green per output
  - Eight individual solid-state relay outputs
- Each circuit rated for 24 Vdc (±20%) with an 80 mA load maximum
- 24 Vdc is externally sourced
- Group isolation to ground 2 kV
- Each circuit has its own separate common, circuit-to-circuit isolation 120V
- 16-position removable terminal plug
- 12–18 AWG (3.31–0.82 mm^2), wire ferrules recommended

PXMP pulse input modules (PXMP-PIMs)

- Compatible with all PXMP-MB slots 1–10
- LED indicators
  - Health and status green, blink to show activity
  - Input On/Off status one green per pulse input
- Eight pulse inputs to external dry contacts
- Maximum pulse rate is 20 Hz
- Minimum pulse width is 20 milliseconds
- External circuit groups rated for 24 Vdc (±20%)
  - All circuits share the same electrical common
- External supply connects to the module with a two-position removable terminal plug
- The supply is internally fanned out to all circuits
- Group isolation limited to 300V to ground due to TVS diode clamp
- Input impedance ~2.2K causing a 10 mA load per input when energized
- External circuit groups connect with a 16-position removable terminal plug
  - Terminals support 12–18 AWG (3.31–0.82 mm^2), wire ferrules recommended

PXMP energy portal module (PXMP-EPM)

- Only functionally compatible with PXMP-MB slot 10
- LED indicators
  - Top health and status green, blink to show activity
  - Com. reset button—reset to defaults
  - Local IP 192/10
  - RJ45 front-facing Ethernet configuration port LEDs
    - Link (Tx/Rx blink)
    - 10/100 speed
- LED four-stack for bottom LAN/WAN Ethernet port
  - Link (Tx/Rx blink)
  - 10/100 speed
  - DHCP/Fixed
  - TX active
- Config. Ethernet RJ45 Cat5 STP/UTP
  - 10Base-T/100Base-Tx
  - Auto crossover capability supported
  - Java Web browser interface
- Bottom facing LAN/WAN Ethernet port
  - RJ45 Cat5 STP/UTP 10Base-T/100Base-Tx
  - STP required for full electromagnetic immunity
  - Auto crossover capability supported
  - Supports Modbus TCP and Java Web browser interface
- Bottom-facing telephone modem interface
  - Modem type V92/56K baud
  - RJ11 field interface

Power Xpert Multi-Point Meter System—Hardware Specifications

Components	Field Circuit	Power Source	Rated Voltage	Rated Current	Circuit Impedance	Isolation	Note 1	Note 2
PXMP-MB PXMP-MB-AB	Digital output	External	24 ±20% ①	0.080A maximum	35 ohms maximum	2.0 kV	—	—
	Digital input	External	24 ±20% ①	0.01A	2.22K	2.0 kV	Opto drops supply by 2V	Group are electrically common
	COM1 RS-485	Internal	5V ①	—	50–60 ohms	300V	TVS diode clamped to PE	—
	COM2 RS-485	Internal	5V ①	—	50–60 ohms	300V	TVS diode clamped to PE	—
	Power supply input	External	24 ±20% ①	0.7A maximum	N/A	1.0 kV	Installation Class II input	15W maximum
	Voltage inputs A (V1)/ B (V2)/ C (V3)/ N (VR)	External mains	480V L:G ②	0.12 mA	4M ohms	N/A	Installation Class III	High pot 2500V/1 minimum
			347V L:N ②	0.09 mA	4M ohms	N/A	Installation Class III	High pot 2500V/1 minimum
			600V L:L ②	0.09 mA	4M ohms	N/A	Installation Class III	High pot 2500V/1 minimum
PXMP-MM100MA	CT secondary	External	N/A	100 mA	14.6 ohms	N/A	20% over-range	See sensor for primary isolation
PXMP-MM10MA	CT secondary	External	N/A	10 mA	67 ohms	N/A	20% over-range	See sensor for primary isolation
PXMP-MM333MV	CT secondary	External	0.333V ②	N/A	50,000 ohms	N/A	20% over-range	See sensor for primary isolation
PXMP-DOM	Digital output	External	24 ±20% ①	0.080A maximum	10 ohms maximum	2 kV group	120V isolation circuit-to-circuit	Isolation dependent on external source
PXMP-PIM	Pulse input	External	24 ±20% ①	0.01A	2.22K ohms	300V to ground	TVS diode clamped to PE; group isolated, all circuits common to 24V external source	Note: Opto creates 2.2V drop sourced by 2.2K ohms; isolation dependent on external source
PXMP-EPM	Ethernet 100 Bt	Internal	—	N/A	N/A	1 kV	—	—
	POT modem	Internal	—	N/A	N/A	—	—	—

Notes

① DC.

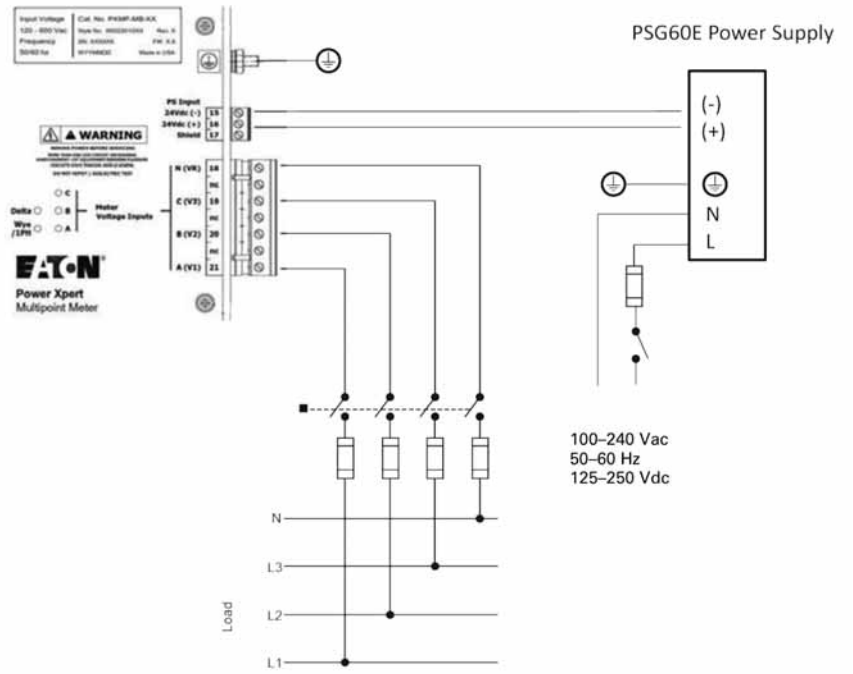
② AC RMS.

Wiring Diagrams

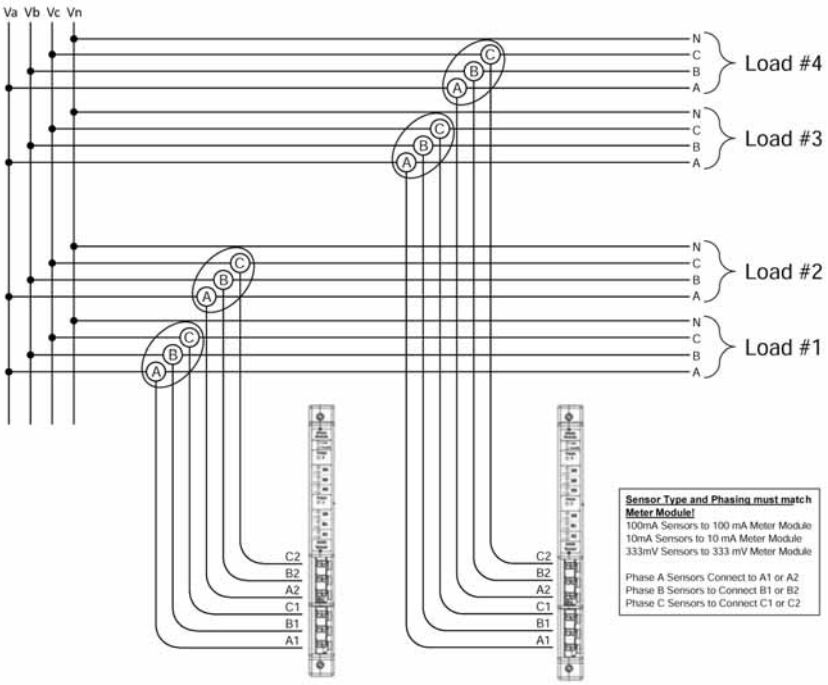
Wiring for PXMB-MB

Note: For all voltage connections—fuses should be sized in accordance with best practices to protect the instrumentation wire.

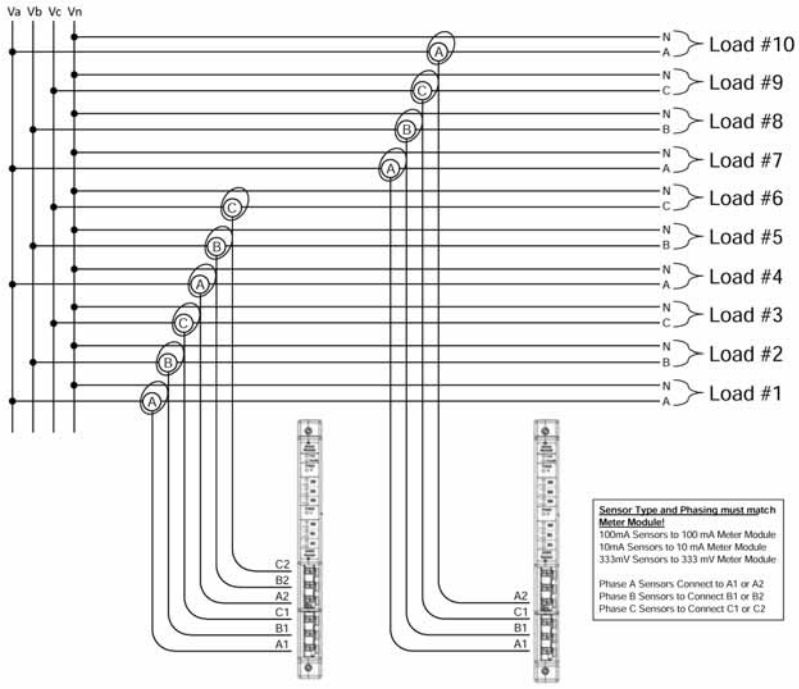
Four-Wire Wye Voltage Connection Inputs



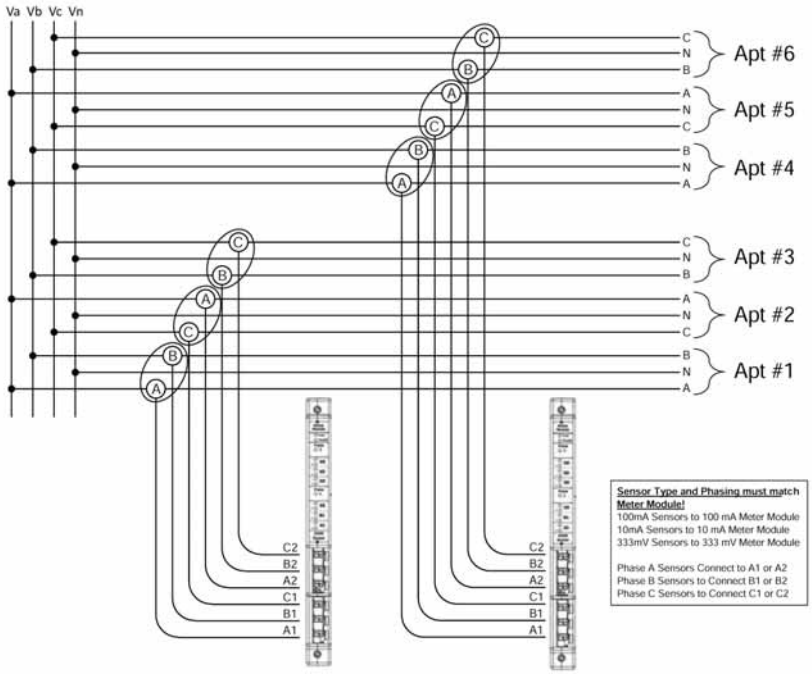
Three-Phase, Four-Wire Service Current Sensor Connections



Three-Phase, Four-Wire Service (Ten Single-Phase, Single-Pole) Current Sensor Connections



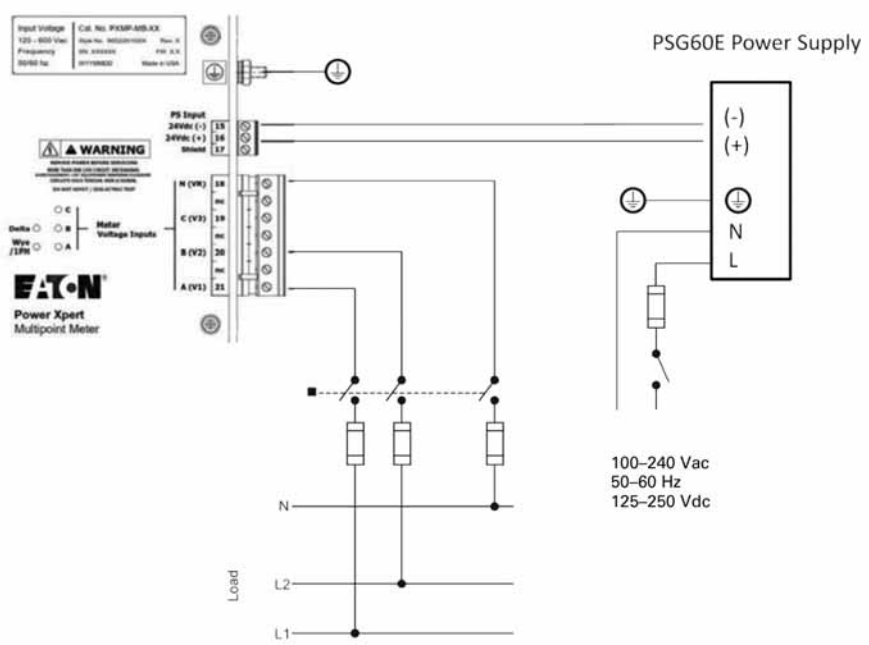
Network 120/208 Three-Wire Apartment Service Current Sensor Connections



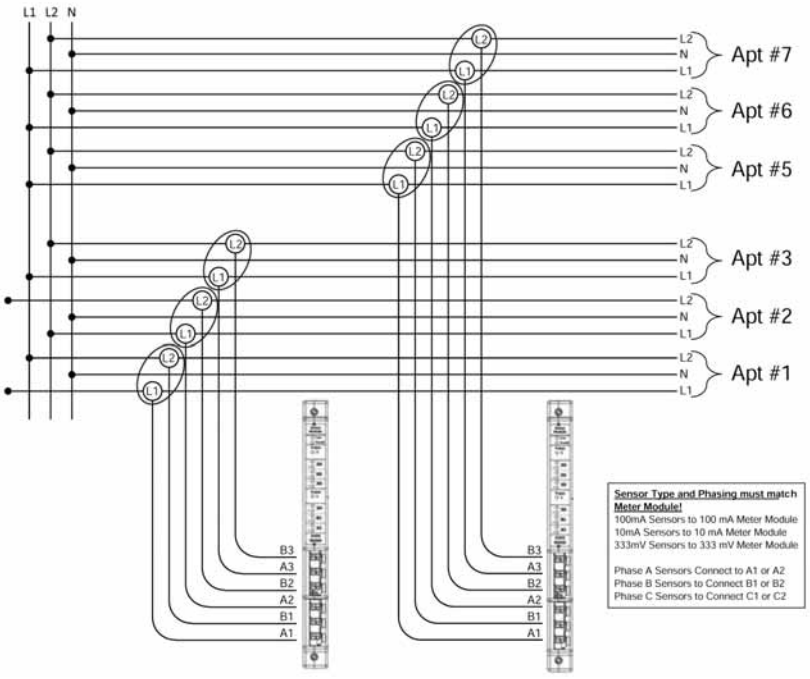
Wiring for PXMB-MB-AB

Note: For all voltage connections—fuses should be sized in accordance with best practices to protect the instrumentation wire.

Single-Phase, Three-Wire 120/240 Voltage Connection Inputs



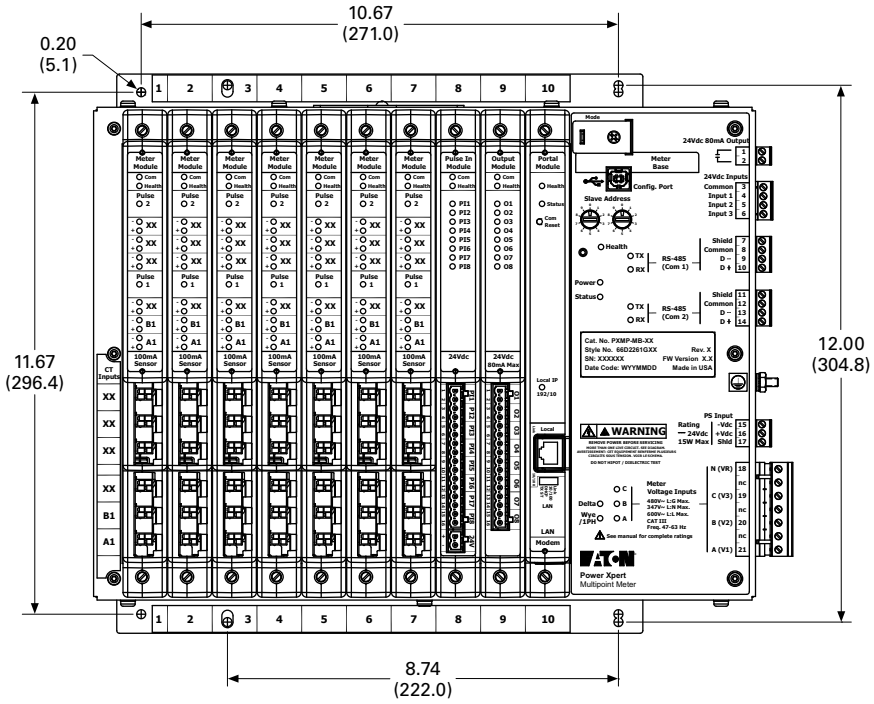
120/240 Single-Phase, Three-Wire Service Current Sensor Connections



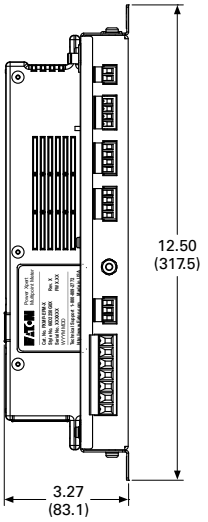
Dimensions

Approximate Dimensions in Inches (mm)

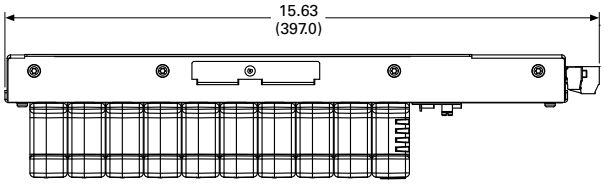
Single Unit—Front View



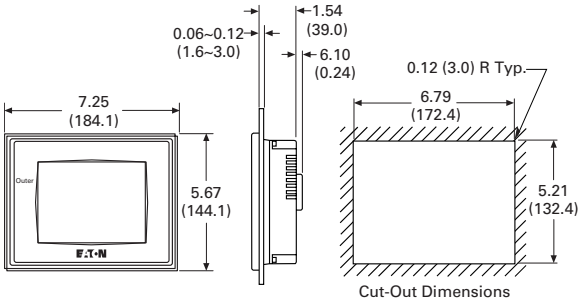
Single Unit—Side View



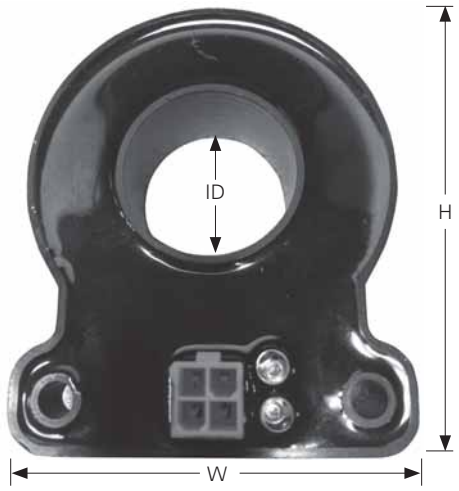
Single Unit—Top View



PXMP Color Touchscreen Display



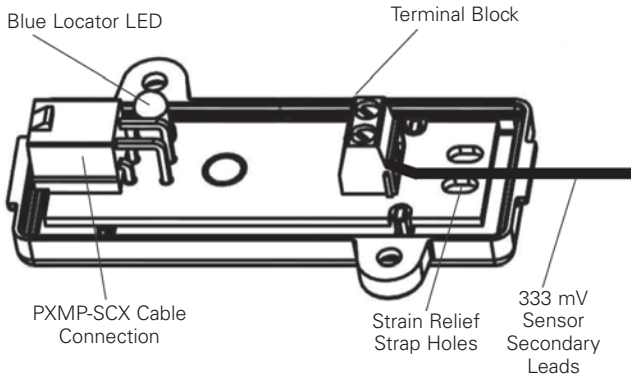
Current Sensor Dimensions



Current Sensor Dimensions

Sensor	H	W	D
PXMP-CS125	2.66 (67.6)	1.66 (42.1)	0.53 (13.5)
PXMP-CS250	2.96 (75.2)	2.42 (61.5)	1.12 (28.4)
PXMP-CS400	3.64 (92.5)	3.03 (73.2)	1.74 (44.2)

Open Interface Module (PXMP-IM333MV)



PM3 Modules

Power Monitoring and Metering with Modbus RTU

Contents

PM3 Monitoring and Metering Module

Product Description

For information on our PM3 product, please refer to **Volume 4, Tab 2**.

Current Transformers (CTs)

Contents

Current Transformers (CTs)

Product Description

Eaton's low voltage current transformers are available in both solid core and split core designs. Engineered for electronic metering applications, all solid core designs and selected split core designs offer ANSI metering quality accuracy. The solid core designs also meet ANSI C57.13 relay accuracy requirements including over-ranging capabilities. The current transformer offering has a 5 ampere secondary at the rated primary current.

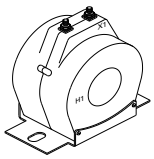
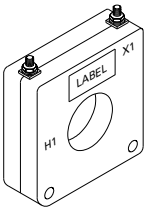
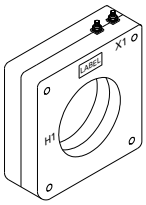
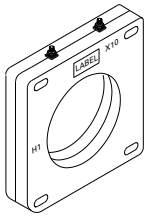
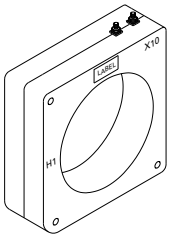
Split core CTs are specifically designed to be installed around primary conductors without disconnecting wires or breaking the circuit to be monitored. These current transformers are perfect solutions for energy management applications and are manufactured for installation ease.

Application Description

For new construction and retrofit applications where no current transformer exists, Eaton offers a complete selection of low voltage (up to 600V) current transformers. These current transformers can be used in commercial-grade applications, such as control panels and panelboards. Additionally, they can be used for most industrial metering and relaying applications in switchboards, switchgear and motor control centers. These CTs are intended for use with the Power Xpert Meter 2000/4000/6000/8000, IQ 250/260, IQ 130/140/150, IQ Analyzer 6400/6600, IQ DP-4000 and IQ 230 series.

Product Selection

Solid Core ANSI Metering Accuracy

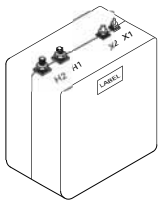
Primary Current Rating	ANSI B0.1 Metering Class at 60 Hz (Accuracy in %)	Window Size in Inches (mm) Diameter	Catalog Number	Mounting Bracket Catalog Number
S060				
				
1.25 (31.8) Window				
50	1.2	1.25 (31.8)	**S060-500**	①
100	0.6	1.25 (31.8)	**S060-101**	①
150	0.3	1.25 (31.8)	**S060-151**	①
200	0.3	1.25 (31.8)	**S060-201**	①
S050				
				
1.56 (39.6) Window				
300	0.3	1.56 (39.6)	**S050-301**	**S050BRAC**
400	0.3	1.56 (39.6)	**S050-401**	**S050BRAC**
500	0.3	1.56 (39.6)	**S050-501**	**S050BRAC**
600	0.3	1.56 (39.6)	**S050-601**	**S050BRAC**
750	0.3	1.56 (39.6)	**S050-751**	**S050BRAC**
800	0.3	1.56 (39.6)	**S050-801**	**S050BRAC**
1000	0.3	1.56 (39.6)	**S050-102**	**S050BRAC**
1200	0.3	1.56 (39.6)	**S050-122**	**S050BRAC**
S080				
				
3.25 (82.6) Window				
400	0.3	3.25 (82.6)	**S080-401**	**S080BRAC**
500	0.3	3.25 (82.6)	**S080-501**	**S080BRAC**
600	0.3	3.25 (82.6)	**S080-601**	**S080BRAC**
750	0.3	3.25 (82.6)	**S080-751**	**S080BRAC**
800	0.3	3.25 (82.6)	**S080-801**	**S080BRAC**
1000	0.3	3.25 (82.6)	**S080-102**	**S080BRAC**
1200	0.3	3.25 (82.6)	**S080-122**	**S080BRAC**
S090				
				
4.25 (108.0) Window				
500	0.3	4.25 (108.0)	**S090-501**	**S090BRAC**
600	0.3	4.25 (108.0)	**S090-601**	**S090BRAC**
750	0.3	4.25 (108.0)	**S090-751**	**S090BRAC**
800	0.3	4.25 (108.0)	**S090-801**	**S090BRAC**
1000	0.3	4.25 (108.0)	**S090-102**	**S090BRAC**
1200	0.3	4.25 (108.0)	**S090-122**	**S090BRAC**
1500	0.3	4.25 (108.0)	**S090-152**	**S090BRAC**
1600	0.3	4.25 (108.0)	**S090-162**	**S090BRAC**
2000	0.3	4.25 (108.0)	**S090-202**	**S090BRAC**
2500	0.3	4.25 (108.0)	**S090-252**	**S090BRAC**
3000	0.3	4.25 (108.0)	**S090-302**	**S090BRAC**
S025				
				
6.31 (160.3) Window				
600	0.3	6.31 (160.3)	**S025-601**	**S025BRAC**
750	0.3	6.31 (160.3)	**S025-751**	**S025BRAC**
800	0.3	6.31 (160.3)	**S025-801**	**S025BRAC**
1000	0.3	6.31 (160.3)	**S025-102**	**S025BRAC**
1200	0.3	6.31 (160.3)	**S025-122**	**S025BRAC**
1500	0.3	6.31 (160.3)	**S025-152**	**S025BRAC**
1600	0.3	6.31 (160.3)	**S025-162**	**S025BRAC**
2000	0.3	6.31 (160.3)	**S025-202**	**S025BRAC**
2500	0.3	6.31 (160.3)	**S025-252**	**S025BRAC**
3000	0.3	6.31 (160.3)	**S025-302**	**S025BRAC**
3500	0.3	6.31 (160.3)	**S025-352**	**S025BRAC**
4000	0.3	6.31 (160.3)	**S025-402**	**S025BRAC**

Note

① Contact Eaton for further information.

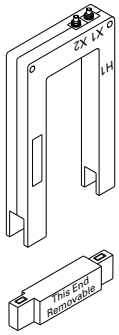
Split Core ANSI Metering Accuracy

W190



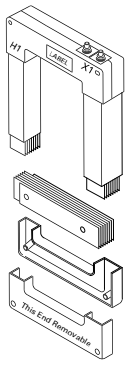
Primary Current Rating	ANSI B0.1 Metering Class at 60 Hz (Accuracy in %)	Window Size in Inches (mm)	Catalog Number
Wound and Primary CTs			
25	0.3	Wound	**W190-025**
50	0.3	Primary	**W190-050**

M000



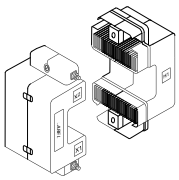
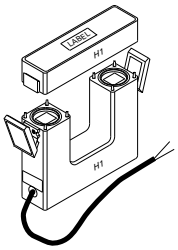
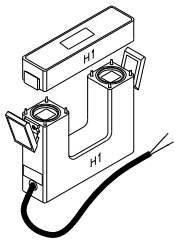
2.00 x 5.50 (50.8 x 139.7)			
400	2.4	2.00 x 5.50 (50.8 x 139.7)	**M000-401**
500	2.4	2.00 x 5.50 (50.8 x 139.7)	**M000-501**
600	2.4	2.00 x 5.50 (50.8 x 139.7)	**M000-601**
800	1.2	2.00 x 5.50 (50.8 x 139.7)	**M000-801**
1000	1.2	2.00 x 5.50 (50.8 x 139.7)	**M000-102**
1200	0.6	2.00 x 5.50 (50.8 x 139.7)	**M000-122**
1500	0.6	2.00 x 5.50 (50.8 x 139.7)	**M000-152**
1600	0.6	2.00 x 5.50 (50.8 x 139.7)	**M000-162**
2000	0.6	2.00 x 5.50 (50.8 x 139.7)	**M000-202**

M050



4.10 x 7.10 (104.1 x 180.3)			
600	4.8	4.10 x 7.10 (104.1 x 180.3)	**M050-601**
750	4.8	4.10 x 7.10 (104.1 x 180.3)	**M050-751**
800	2.4	4.10 x 7.10 (104.1 x 180.3)	**M050-801**
1000	2.4	4.10 x 7.10 (104.1 x 180.3)	**M050-102**
1200	1.2	4.10 x 7.10 (104.1 x 180.3)	**M050-122**
1500	1.2	4.10 x 7.10 (104.1 x 180.3)	**M050-152**
2000	0.6	4.10 x 7.10 (104.1 x 180.3)	**M050-202**
2500	0.6	4.10 x 7.10 (104.1 x 180.3)	**M050-252**
3000	0.6	4.10 x 7.10 (104.1 x 180.3)	**M050-302**
3500	0.6	4.10 x 7.10 (104.1 x 180.3)	**M050-352**
4000	0.3	4.10 x 7.10 (104.1 x 180.3)	**M050-402**

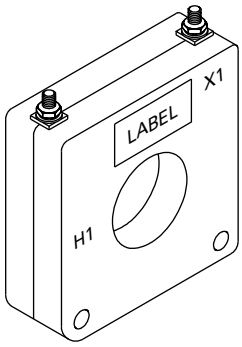
Split Core Current Transformers

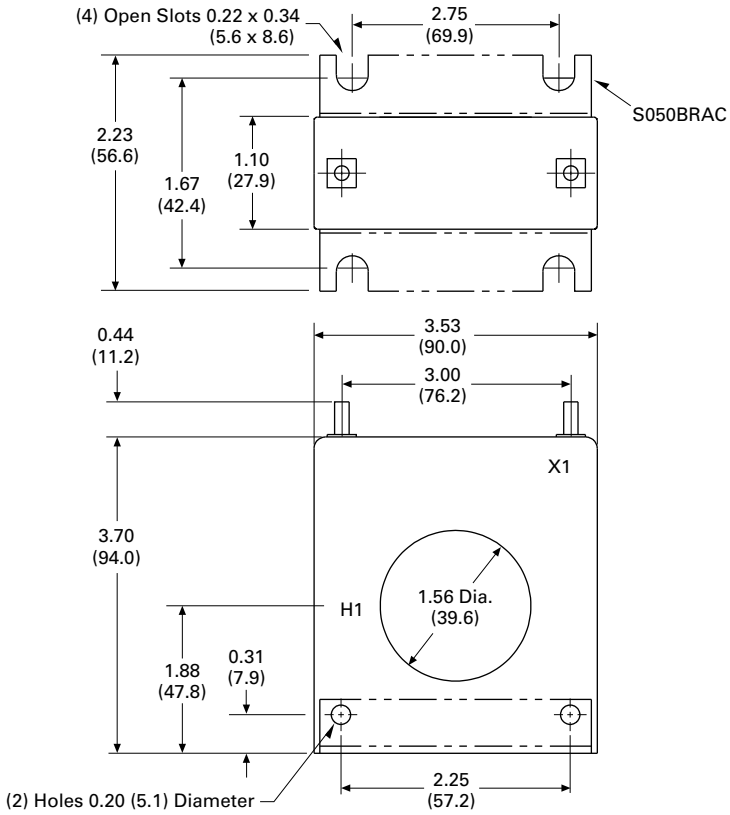
	Primary Current Rating	Accuracy at 60 Hz (in %)	Window Size in Inches (mm)	Catalog Number
M030	**0.80 x 1.95 (20.3 x 49.5)**			
	100	5.0	0.80 x 1.95 (20.3 x 49.5)	**M030-101**
	150	5.0	0.80 x 1.95 (20.3 x 49.5)	**M030-151**
	200	4.0	0.80 x 1.95 (20.3 x 49.5)	**M030-201**
	300	2.0	0.80 x 1.95 (20.3 x 49.5)	**M030-301**
	400	2.0	0.80 x 1.95 (20.3 x 49.5)	**M030-401**
M040	**1.42 x 1.53 (36.1 x 38.9)**			
	100	5.0	1.42 x 1.53 (36.1 x 38.9)	**M040-101**
	150	4.0	1.42 x 1.53 (36.1 x 38.9)	**M040-151**
	200	1.5	1.42 x 1.53 (36.1 x 38.9)	**M040-201**
	300	1.5	1.42 x 1.53 (36.1 x 38.9)	**M040-301**
	400	1.5	1.42 x 1.53 (36.1 x 38.9)	**M040-401**
M060	**2.60 x 2.75 (66.0 x 69.9)**			
	200	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-201**
	300	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-301**
	400	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-401**
	500	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-501**
	600	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-601**
	750	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-751**
	800	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-801**
	1000	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-102**
	1200	1.0	2.60 x 2.75 (66.0 x 69.9)	**M060-122**
M080	**2.60 x 6.25 (66.0 x 158.8)**			
	500	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-501**
	600	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-601**
	800	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-801**
	1000	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-102**
	1200	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-122**
	1500	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-152**
	1600	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-162**
	2000	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-202**
	2500	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-252**
	3000	1.0	2.60 x 6.25 (66.0 x 158.8)	**M080-302**

Dimensions

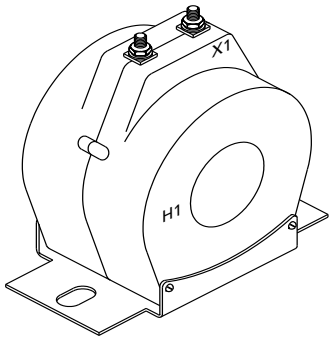
Approximate dimensions in inches (mm)

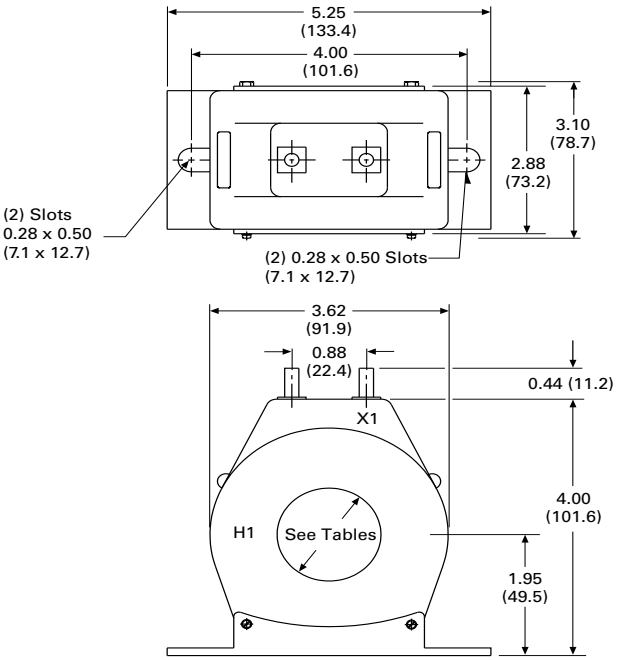
S050





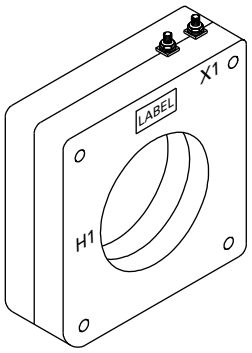
S060

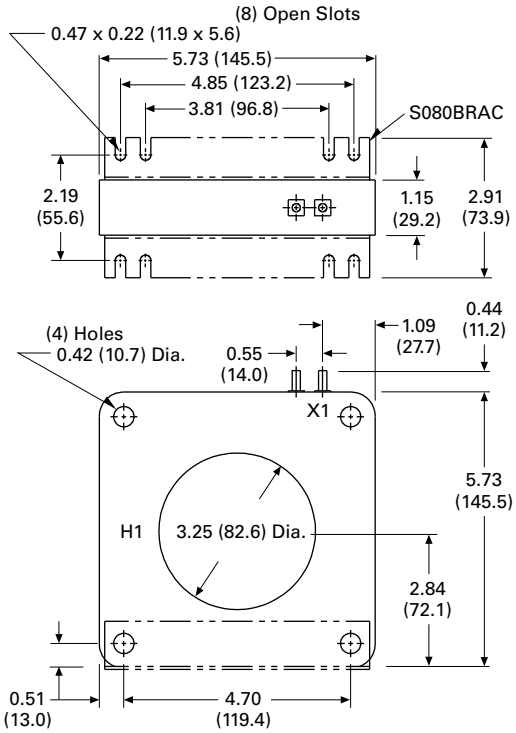




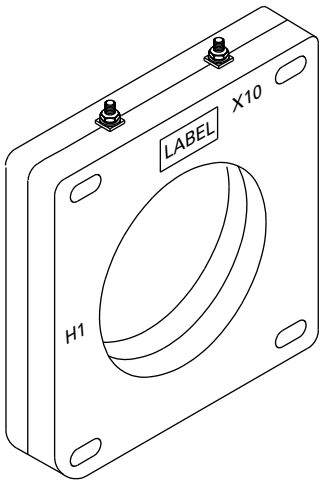
Approximate dimensions in inches (mm)

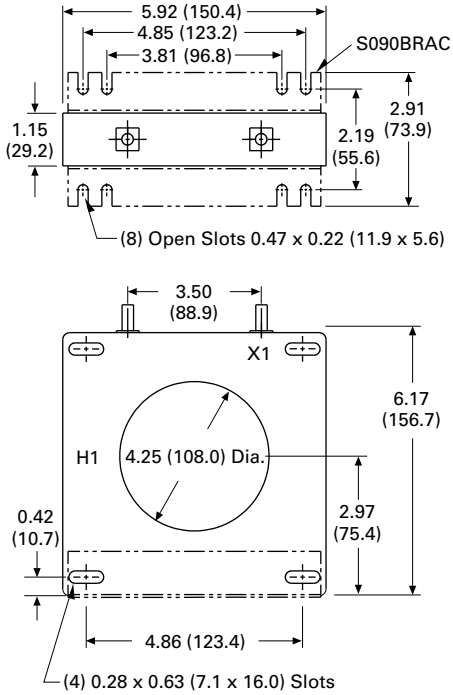
S080





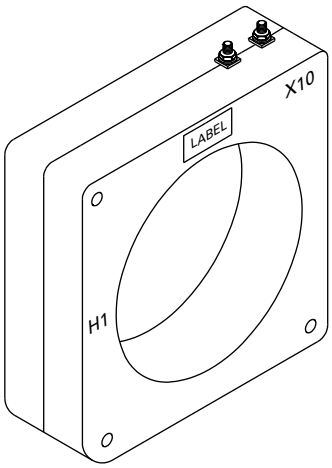
S090

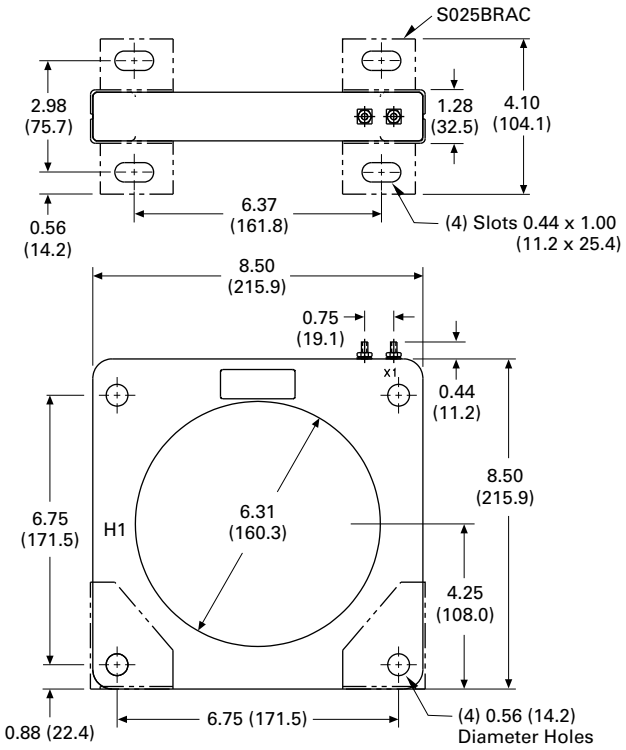




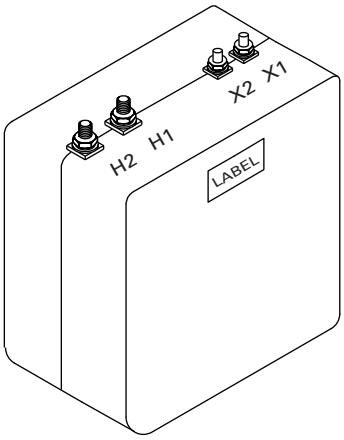
Approximate dimensions in inches (mm)

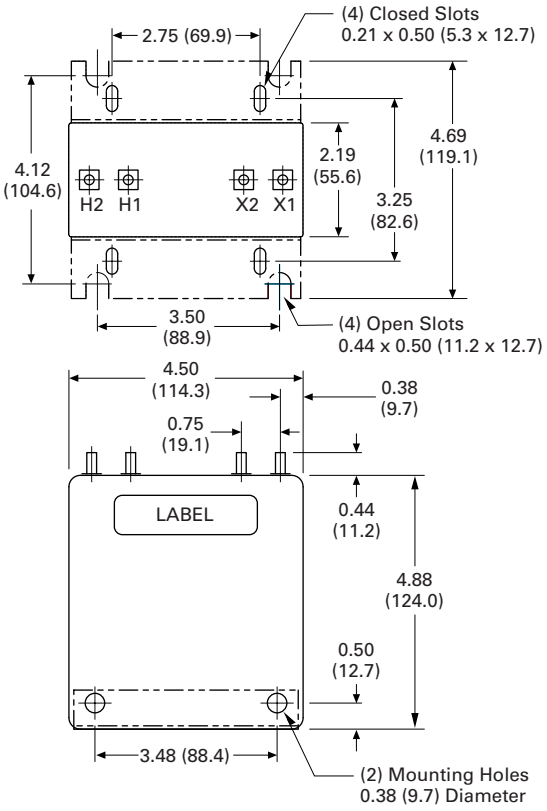
S025





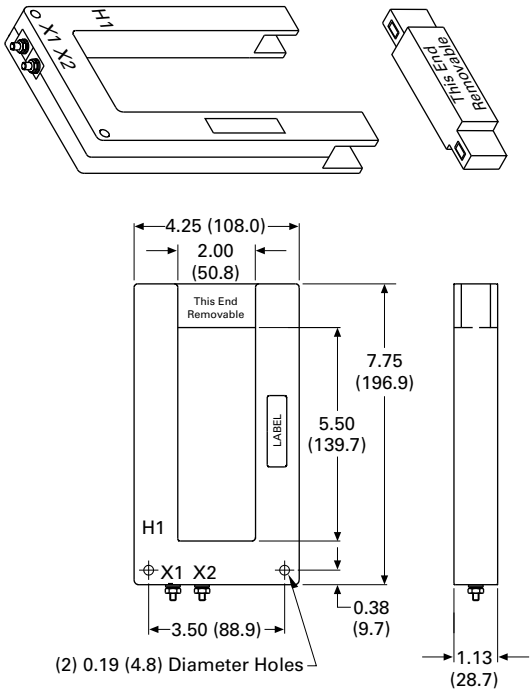
W190



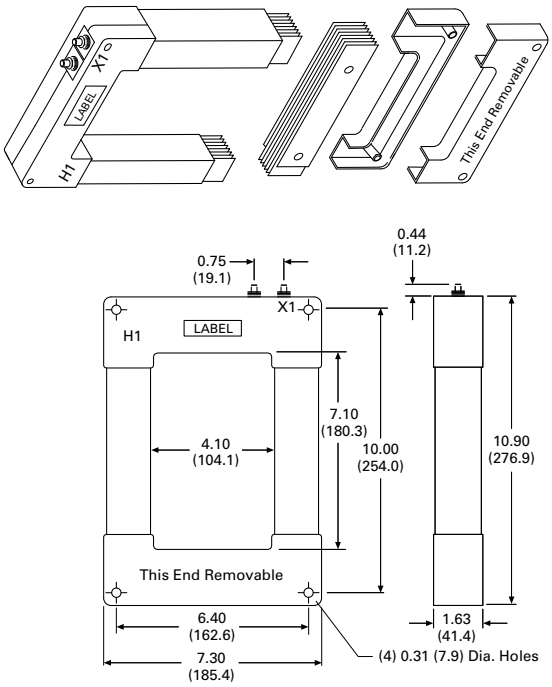


Approximate dimensions in inches (mm)

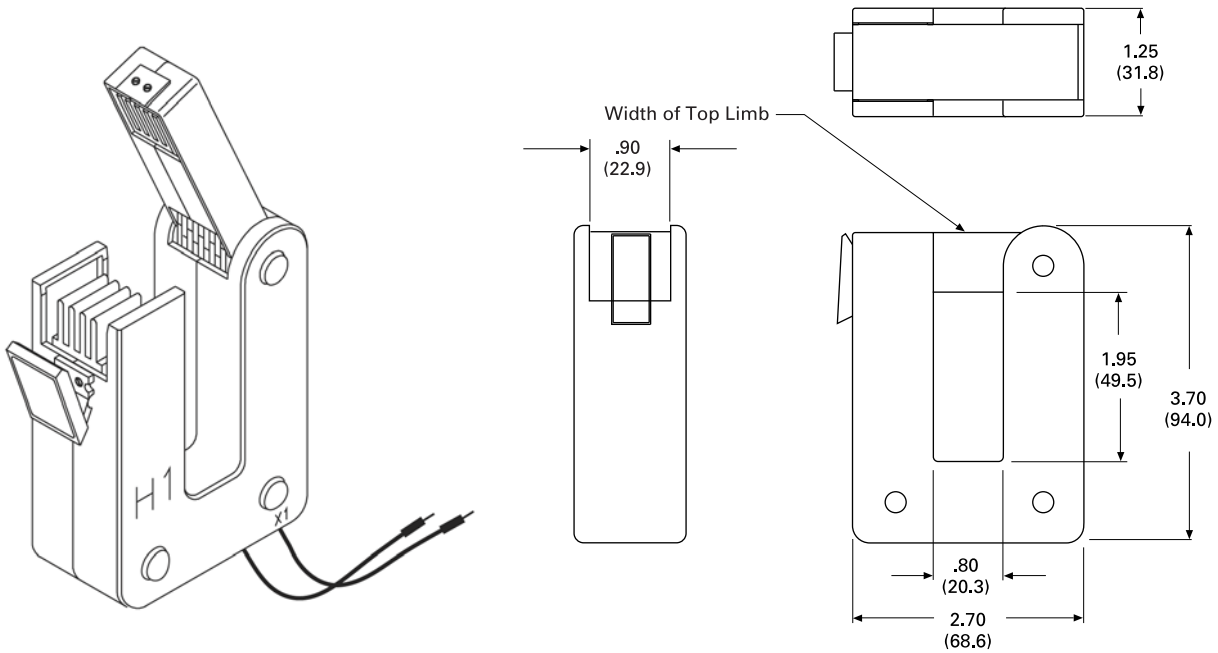
M000



M050

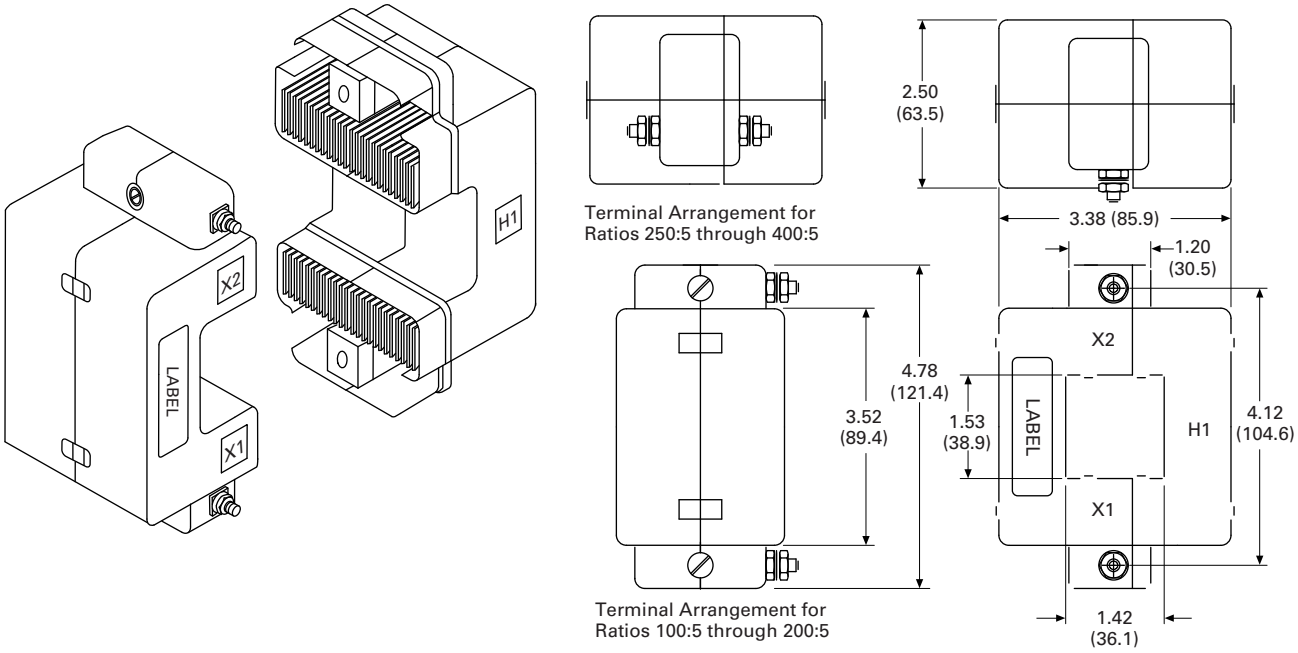


M030



Approximate dimensions in inches (mm)

M040



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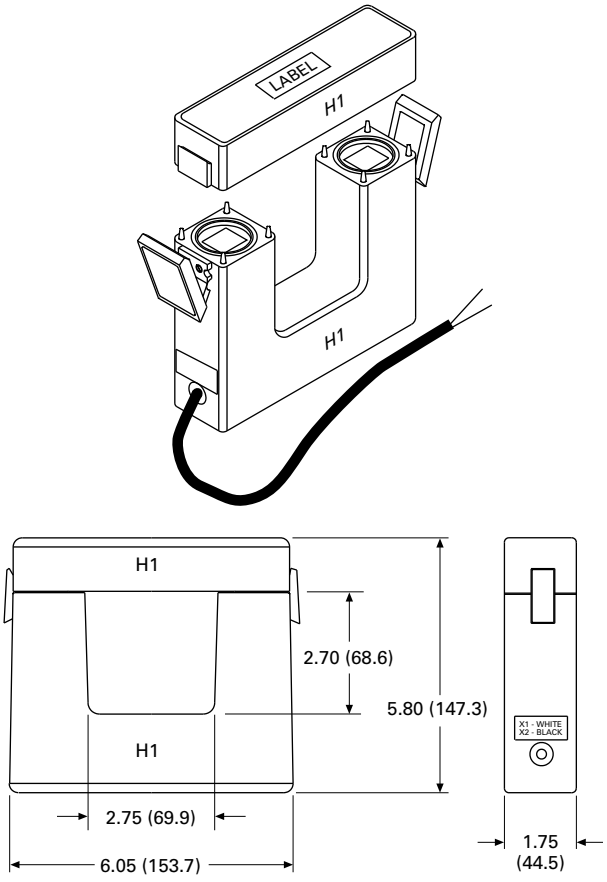
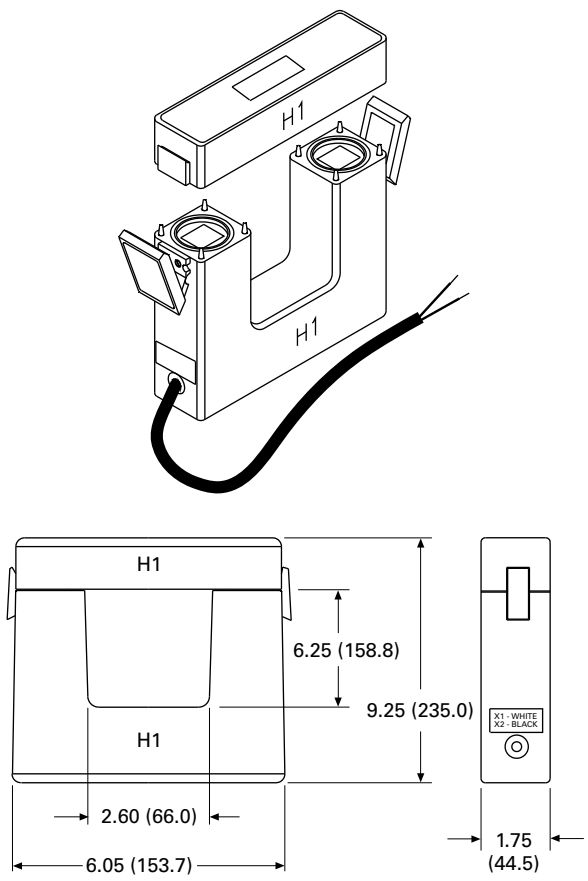
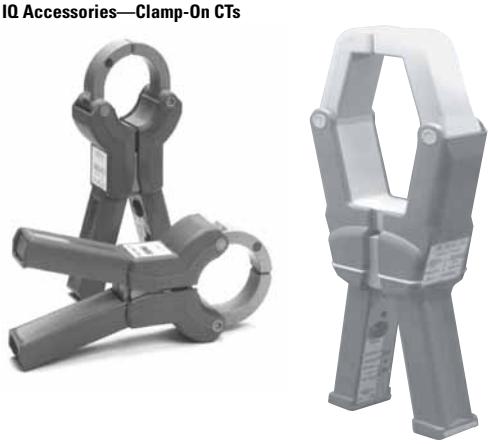


M080



IQ Accessories—Clamp-On CTs



Contents

Clamp-On Current Transformers

Product Description

Eaton's optional Clamp-on Current Transformers (CTs) are designed to be used in cases where there are no existing CTs or the existing CTs cannot be accessed, these clamp-on CTs can be used.

These clamp-on CTs are packaged individually. Most applications will require at least three clamp-on CTs, one for each phase.

Application Description

- There are two models that cover current ranges from 150 to 1500 amperes
- These clamp-on CTs are designed to fit around 600 volt insulated cable and bus bar

Features, Benefits and Functions

- Each clamp-on CT comes with a 12-foot (3.7m) cable and twist lock connector
- All models have a 5 ampere output at three different primary current ratings

Standards and Certifications

- Meets IEC 1010-1 Category III
- CE mark for applications where European compliance is required

CE

Product Selection

Ordering Information

	Current Ranges	Catalog Number
150–300–600A	150–300–600A	**IQAPORT0600CT**
500–1000–1500A	500–1000–1500A	**IQAPORT1500CT**

Technical Data and Specifications

- Operating temperature: 14°F to 122°F (–10°C to 50°C)
- Operating humidity: 5 to 90% maximum noncondensing
- Altitude: 10,000 ft (3048m)
- Environment: indoor use only
- Operating voltage: 600 Vac maximum
- Isolation test: 5.55 kV for 1 minute
- Current over range: 200% for 3 minutes
- Connector: twist-lock

Current Ranges

Each of the two models of clamp-on CTs has three primary current ranges. The primary current range is selected at the clamp-on by connecting to the indicated terminals.

150A/300A/600A Clamp-On CT Specifications

- Current ratings:
  - 150 to 5 amperes
  - 300 to 5 amperes
  - 600 to 5 amperes

500A/1000A/1500A Clamp-On CT Specifications

- Current ratings:
  - 500 to 5 amperes
  - 1000 to 5 amperes
  - 1500 to 5 amperes

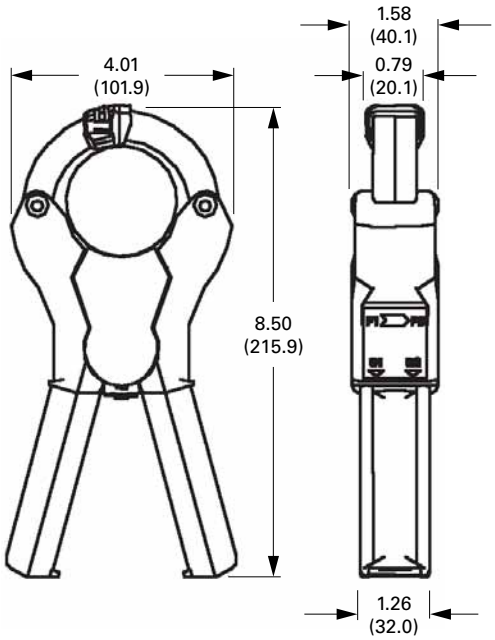
Electrical Characteristics

Current Ranges	Load (Ohms)	Phase Shift (Degree)	Frequency Range (3%)	Frequency Range (–3 db)
150–600A	0.10–1.0	0.5–1.0	40–5000	30–10,000
500–1500A	0.01–4.0	0.5–1.0	40–2000	30–5000

Dimensions

Approximate Dimensions in Inches (mm)

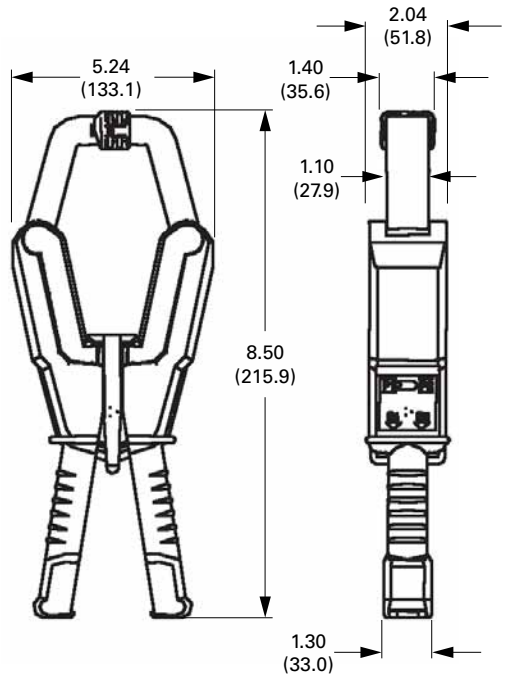
150A/300A/600A Clamp-On CT



150A/300A/600A Clamp-On CT

- Maximum cable size:
  - 2.00 inches (50.8 mm)
- Maximum bus bar size:
  - 2.00 x 0.47 inches (50.8 x 12.0 mm)
  - 1.60 x 1.40 inches (40.6 x 35.6 mm)
- Dimensions (without cable):
  - 4.00 x 8.50 x 1.60 inches (101.6 x 215.9 x 40.6 mm)
- Weight (with cable):
  - 2.0 lbs (0.9 kg)

500A/1000A/1500A Clamp-On CT



500A/1000A/1500A Clamp-On CT

- Maximum cable size:
  - 2.68 inches (68.1 mm)
- Maximum bus bar size:
  - 4.84 x 1.40 (122.9 x 35.6 mm)
  - 4.00 x 1.70 inches (101.6 x 43.2 mm)
- Dimensions (without cable):
  - 5.20 x 13.20 x 2.00 inches (132.1 x 335.3 x 50.8 mm)
- Weight (with cable):
  - 6.0 lbs (2.7 kg)

IQ Accessories—IQ Flange

Contents

9

IQ Flange

Product Description

Eaton's IQ Flange is intended for use with the IQ Data, IQ Generator, IQ Data Plus II, IQ Analyzer and any other such device sharing the same mounting dimensions.

The door mounting flange provides extra depth behind a panel if there is not enough clearance to accommodate the device.

Application Description

Retrofit Applications

For applications where extra door mounting space is required, a flange-mounting unit is available. The IQ Flange provides an extra 2.5 inches (63.5 mm) of clearance for the device. The IQ Flange can be used with any IQ device with a 5.38-inch (136.7 mm) x 9.38-inch (238.0 mm) cutout.

Product Selection

IQ Flange

IQ Flange

Description	Catalog Number
IQ Flange	**IQFLANGE**

Panel Mounting Adapter Kit for IQ 100/200 Series and PXM 2000 Meters

Contents

Panel Mounting Adapter Kit for IQ 100/200 Series and PXM 2000 Meters

Product Description

The flange adapter plate can be installed as follows:

1. Remove the old meter from the panel or door. Many IQ metering products use the typical IQ drilling pattern shown at right for mounting
2. Install the flange adapter plate. Mount it from the rear using the six screws provided in the kit. The flange adapter plate screw hole pattern shown at right should match the typical IQ drilling pattern. If not, perform the next step
3. Drill six holes in the panel or the door to mount the flange adapter plate. Follow the typical IQ drilling pattern. You need only the top, center and bottom sets of holes
4. Install the new IQ 100/200 Series or PXM 2000 meter in the flange adapter plate. Secure it from behind with four flat washers, lock washers and nuts provided with the meter

Product Selection

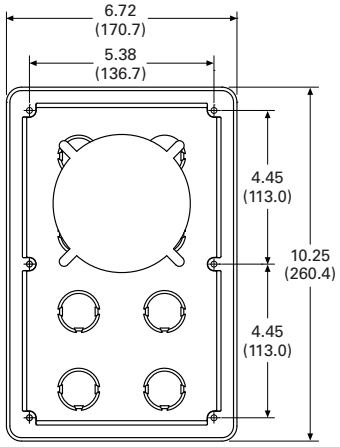
Panel Mounting Adapter Kit

Panel Mounting Adapter Kit

Description	Catalog Number
Panel mounting adapter kit IQ 100/200 and PXM 2000 Series adapter kit to IQ Analyzer/ IQ DP-4000/IQ Data	**IQ250-PMAK**

Dimensions

Flange Adapter Plate Screw Hole Pattern



NEMA 12 Single- and Multi-Unit Enclosed Meters

Contents

Enclosed Meters

Product Description

The Eaton enclosed meter line provides a complete energy metering and data acquisition solution in a single enclosure. Designed for Eaton's IQ 35M, IQ 150, IQ 250/260, and Power Xpert® 2000/4000/6000/8000 and Multi-Point Meters, Eaton's enclosed meter line offers mounting and installation flexibility, especially in retrofit applications where no metering compartment or mounting space is available in the existing electrical distribution equipment or where installation time is a premium. Factory designed and wired, Eaton's enclosed meter line offers savings in labor and installation costs because input current and voltage wiring as well as I/O wiring is prewired to terminal blocks inside the enclosure.

The enclosed meter line has two standard offerings: single-, prewired unit (specific IQ 150, IQ 250/260, PXM 2000, PXM 4000/6000/8000 or PXMP) and a multi-unit (specific IQ 150, IQ 250/260 or IQ 35M models). Because the multi-unit can be configured to include Eaton's Power Xpert Gateway 900, it can facilitate measurement and verification of the energy usage on processes and in buildings. This provides a convenient way to monitor energy usage from multiple points, collect and log specific energy use parameters, and display and generate logs for historical energy usage reports. Simply put, Eaton's multi-unit enclosed meter solution helps meet any measurement and verification requirement to show energy efficiency improvements and results. In addition to the standard offering, Eaton can also provide an enclosed metering solution tailored around your project needs.

Application Description

Factory designed and wired to fit various Eaton power and energy meters at varying price points, Eaton's enclosed meter line offers savings in labor and installation costs because input current and voltage wiring, as well as I/O wiring, is prewired to terminal blocks inside the enclosure. Standalone, enclosed meters are ideal for new metering applications where no metering existed previously, for retrofit installations where energy monitoring is a must or where ease of installation is required.

- Health care facilities
- Educational facilities and campuses
- Industrial facilities
- Commercial facilities
- Government facilities

The multi-unit offering consolidates energy-related data available from the meters in the enclosure, but also allows for external meters to be added to the embedded Power Xpert Gateway 900, if selected to be included in the enclosed meter. Through the Power Xpert Gateway 900's embedded Web server, information can be presented in a variety of ways; a standard Web browser being the most widely used method.

The enclosed product is a standalone solution that is ideal for many infrastructure designs. Further, as needs change and grow, the enclosed product can be integrated through Power Xpert Insight into a broader solution that encompasses other intelligent hardware and can integrate with third-party network management systems (NMS) or building management systems (BMS) for system-wide monitoring and reporting of energy and power.

Features and Benefits

- Saves installation time and cost
- One part number to order; no need to worry that any part has been left out
- Pick the meter or meters you need as it is designed to fit various Eaton power and energy meters, at varying price points

Factory Wired

Most electrical contractors are very familiar with wiring meters. However, it does take time to place the disconnect, the CT shorting blocks, the terminal blocks, the control power transformer and so on, and the associated wiring. It is not uncommon for errors to be introduced during the installation of multiple meters; it's just inherent in wiring. With Eaton's enclosed meter line, everything is wired at the factory—the shorting block, the terminal blocks and so on—assuring that it's done right. Further, to ensure safety, Eaton's enclosed meter line includes a primary fusible disconnect for line voltage, which can be turned off during meter maintenance.

For applications with line voltages above the rated power supply of the meter, an optional control power transformer is supplied in the enclosure. Control voltage can also be supplied via a separate source that is wired to the field installation terminal block. CT inputs for the meter are wired directly to the shorting terminal blocks for easy field installation.

Factory-wired products also save on installation time and costs. The meters are flush mounted on the enclosure door with all inputs/outputs factory wired to the terminal blocks.

A meter subpanel assembly is also available, which includes all the internal components of the single-unit enclosed meter for the IQ 150/250/260 and PXM 2000 Meters wired and mounted on a subpanel to be installed into an existing electrical structure. It comes with a 48-inch lead for flexibility in mounting the meters at various distances.

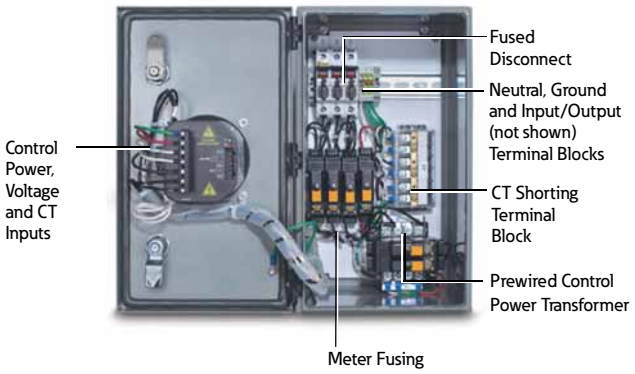
NEMA Rated

NEMA 12 enclosure prevents dust and other materials from entering the equipment. Internal gaskets also prevent air irritants from harming the vital equipment inside. This quality enclosure meets most indoor application needs.

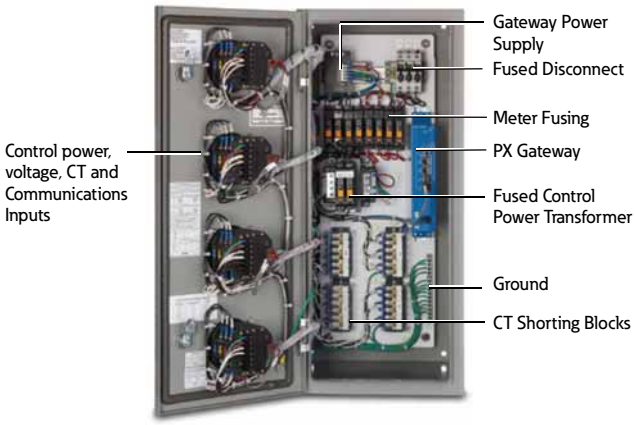
NEMA 3R enclosure is constructed for either indoor or outdoor use. It helps to protect personnel from access to hazardous parts and provides a degree of protection for equipment inside the enclosure against ingress of solid foreign objects (falling dirt), harmful effects of water (rain, sleet, snow) and external formation of ice on the enclosure.

NEMA 4X enclosure provides the same degree of protection as the NEMA 3R with the additional protection against windblown dust, splashing and hose-directed water, and corrosion.

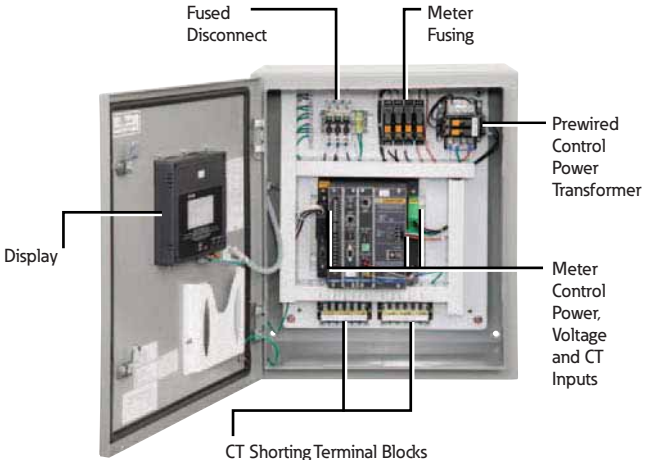
NEMA 12 Front View, Door Open, Prewired and Tested



NEMA 12 Multi-Unit View, Door Open, Prewired and Tested



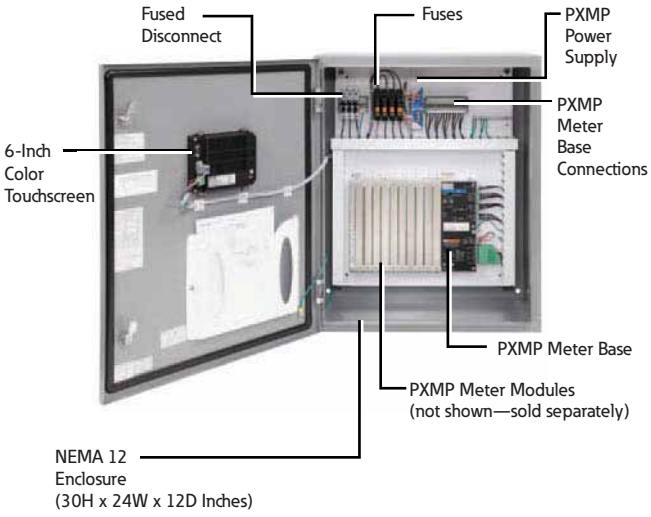
NEMA 12 Single-Unit Enclosed Meter Inside View, PXM 4000/6000/8000 Series



NEMA 3R Single-Unit Closed and Open, IQ 150/250/260 and PXM 2000 Series

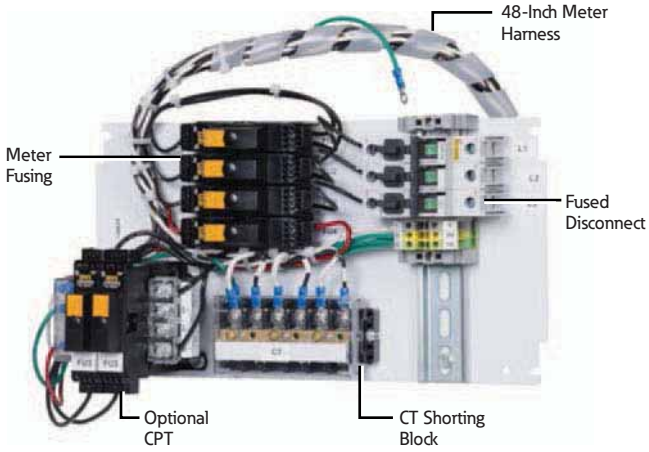
NEMA 4X Single-Unit Closed and Open, IQ 150/250/260 and PXM 2000 Series

Enclosed Power Xpert Multi-Point Meter



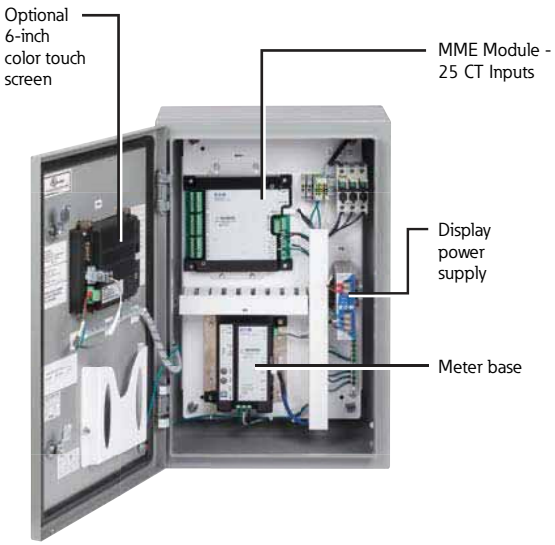
Multi-Unit Enclosed Meter, Inside View of IQ 35M

Prewired Meter Backpan, Single Unit



- Prewired panel to save installation time and cost for retrofits into existing equipment
- Designed for Eaton's:
  - IQ 100 Meter Series
  - IQ 250/260
  - Power Xpert Meter 2000 Series
- With or without CPT, depending on voltage
- Order meters separately

Enclosed Power Xpert Branch Circuit Monitor



Enclosed PXMP Meter

PXMP-MB - 2 B D

Meter Type	NEMA Rating	Power Supply	Display
PXMP-MB **PXMP-MB-AB**	**2** = NEMA 12 **3** = NEMA 3R **4** = NEMA 4X	**A** = None **B** = 120/240 Vac **C** = 480 Vac **D** = 600 Vac	**A** = None **D** = 6-inch color touchscreen

Multi Unit Enclosed Meter

PXBCM-MB - 2 1 - A B

Meter Type	NEMA Rating	CPT Option	Display	Display Power Supply
PXBCM-MB (Meter base + MME) **PXBCM-MME** (MME only—no display)	**2** = NEMA 12 **3** = NEMA 3R **4** = NEMA 4X	**1** = 1 MME (21 branch CT inputs, 4 aux. inputs) **2** = 2 MME (42 branch CT inputs, 8 aux. inputs)	**A** = None **D** = 6-inch color touchscreen	**A** = 120–240 V **B** = 480 V

Multi-Unit Enclosed Meter

IQ150MA6511 - 2 B 4 C

Meter Type	NEMA Rating	CPT Option	Number of Meters	Communications
IQ35MA12 **IQ150MA6511** **IQ250MA65100** **IQ260MA65100**	**2** = NEMA 12 ② **3** = NEMA 3R **4** = NEMA 4X	**A** = 120/240 Vac (no CPT) **B** = 480 Vac ② (control power transformer)	**4** = 4 meters	**C** = Includes PXG-900

Catalog Number Selection

Single Unit Enclosed Meter

PXM2250MA65105 - 2 B - D6

Meter Type	
PXM4051A1BA	**PXM2270MA65105**
PXM4051A1BB	**PXM2270MA65115**
PXM6051A1BA	**PXM2270MA65145**
PXM6051A1BB	**IQ250MA65100**
PXM8051A1BA	**IQ250MA65110**
PXM8051A1BB	**IQ250MA65114**
PXM2250MA65105	**IQ260MA65100**
PXM2250MA65115	**IQ260MA65110**
PXM2250MA65145	**IQ260MA65114**
PXM2260MA65105	**IQ150MA6511**
PXM2260MA65115	**IQ150MA6512**
PXM2260MA65145	

Display	CPT Option	NEMA Rating
D6 = 6-inch display ① **D12** = 12-inch display	**A** = 120/240 Vac (no CPT) **B** = 480 Vac (control power transformer)	**2** = NEMA 12 **3** = NEMA 3R **4** = NEMA 4X

Notes

① Only available for the PXM4000/6000/8000.

② Not available with IQ 35M.

Other meter models available upon request in single- and multi-unit enclosed versions.

Product Selection

Meter Subpanel Assembly

Description	Catalog Number
Meter subpanel assembly for PXM 2000 and IQ 150/250/260 Meters	**PXM2K-MSPA-A**
Meter subpanel assembly with CPT for PXM 2000 and IQ 150/250/260 Meters	**PXM2K-MSPA-B**

Technical Data and Specifications

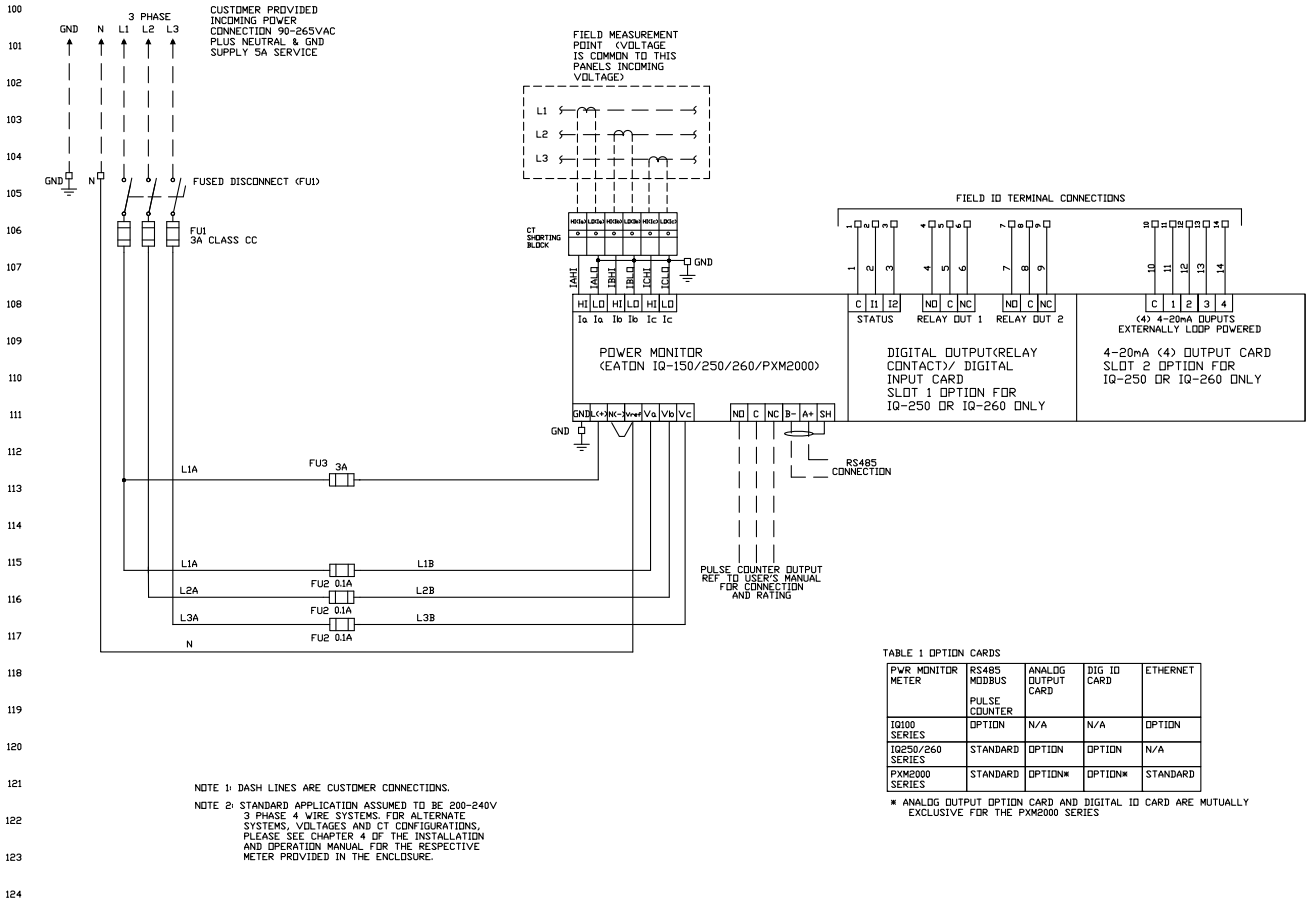
Enclosed Meters

Description	Specification
Enclosure rating	NEMA 12, 3R, 4X
Enclosure operating temperature	–20°C to +40°C **Note:** Temperature range of meter is –20 °C to +70 °C. If applied outside, proper precautions should be taken to avoid exceeding the maximum and minimum temperature ratings of the meter.
Dimensions	Single unit (IQ 150/250/260 and PXM 2000): NEMA 12 (8.00 W x 16.30 H x 10.40 D inches), NEMA 3R/4X (8.00 W x 16.30 H x 9.60 D inches) Single MME (PXBCM): NEMA 12 (16.00 W x 16.00 H x 8.00 D inches) NEMA 3R/4X (20.00 W x 16.00 H x 12.00 D inches) Two MME (PXBCM): NEMA 12 (16.00 W x 24.00 H x 8.00 D inches) NEMA 3R/4X (20.00 W x 24.00 H x 12.00 D inches) Single unit (PXMP): NEMA 12/3R/4X (24.00 W x 30.00 H x 12.00 D inches) Single unit (PXM 4000/6000/8000): NEMA 12 (20.00 W x 24.00 H x 14.10 D inches) NEMA 3R/4X (20.20 W x 24.00 H x 13.90 D inches) Multi unit: NEMA 12 (13.00 W x 30.00 H x 15.20 D inches) NEMA 3R (13.20 W x 30.10 H x 14.60 D inches) NEMA 4X (13.00 W x 30.00 H x 14.00 D inches)
Meters	Single unit: IQ 150, IQ 250/260, PXM 2000/4000/6000/8000 and PXMP models Multi unit: IQ 35M, IQ 150 and IQ 250/26060
Communications (multi unit only)	Power Xpert Gateway 900
Control voltage	120–600 V (PXMP)—power supply required 100–277 Vac L:N (PXBCM)—no CPT required Up to 240 V (IQ 35M/150/250/260 and PXM 2000/4000/6000/8000)—no CPT required Greater than 240 V (IQ 150/250/260 and PXM 2000)—CPT required Separate source control—no CPT required
Basic model	Fusible disconnect—primary voltage Shorting block(s)—not required for IQ 35M or PXMP Ground terminal block Neutral terminal block Eight-point terminal block(s) for input/output modules for IQ 250/260 and PXM 2000
Wiring	Wired for three-phase, four-wire applications. Three-phase, three-wire applications—will need to change the wiring for both the voltage and the current per the wiring diagram in the meter instruction manual.
Certifications	UL® 508A and cUL®
Source control	No separate source control voltage required for applications below 240 Vac (except PXMP)
Prewired	Prewired current transformer, shorting terminal block(s), neutral, ground, voltage, control power, fusible disconnect and input/output terminal block(s)
Latch	Padlocking latch provision
Optional features	Control power transformer—single unit: 50 VA (IQ 150/250/260) and 150 VA (PXM 4000/6000/8000); multi unit: 250 VA control power supply for meter where monitored voltage is 480 Vac (IQ 150/250/260 and PXM 2000/4000/6000/8000)

Note: Specifications are subject to change without notice and represent the maximum capabilities of the product with all options installed. This is not a complete feature list. Features and functionality may vary depending on selected options, firmware version and product model. Please refer to the technical data sheet and the user manual for detailed specifications.

Wiring Diagrams

Single Unit Enclosure—200/240 Vac 50/60 Hz, Three-Phase, Four-Wire System with IQ 150/250/260 or PXM 2000 Meter



NOTE 1: DASH LINES ARE CUSTOMER CONNECTIONS.

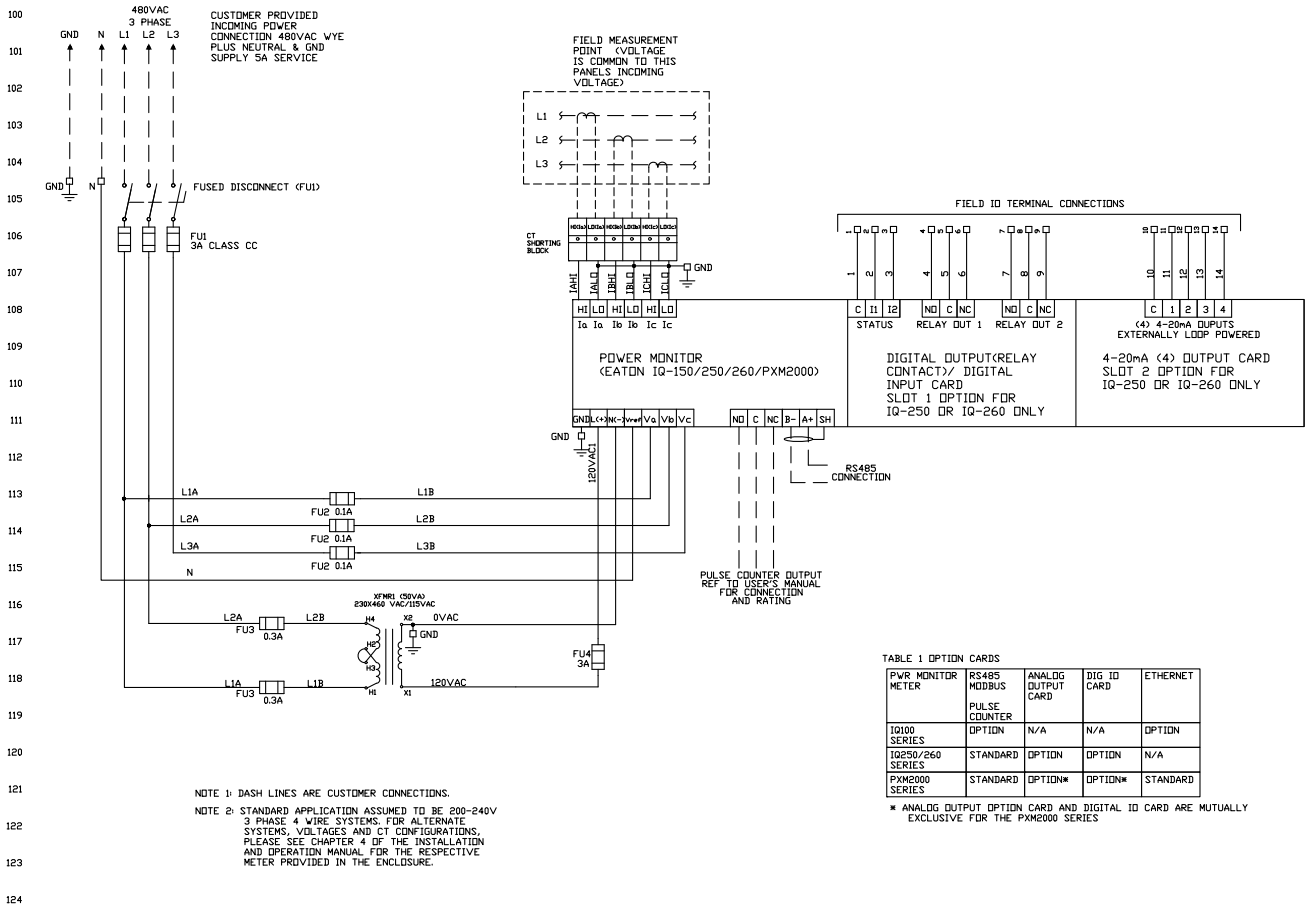
NOTE 2: STANDARD APPLICATION ASSUMED TO BE 200-240V 3 PHASE 4 WIRE SYSTEMS. FOR ALTERNATE SYSTEMS, VOLTAGES AND CT CONFIGURATIONS, PLEASE SEE CHAPTER 4 OF THE INSTALLATION AND OPERATION MANUAL FOR THE RESPECTIVE METER PROVIDED IN THE ENCLOSURE.

TABLE 1 OPTION CARDS

PWR MONITOR METER	RS485 MODBUS PULSE COUNTER	ANALOG OUTPUT CARD	DIG IO CARD	ETHERNET
IQ100 SERIES	OPTION	N/A	N/A	OPTION
IQ250/260 SERIES	STANDARD	OPTION	OPTION	N/A
PXM2000 SERIES	STANDARD	OPTION*	OPTION*	STANDARD

* ANALOG OUTPUT OPTION CARD AND DIGITAL IO CARD ARE MUTUALLY EXCLUSIVE FOR THE PXM2000 SERIES

Single Unit Enclosure—480 Vac 50/60 Hz, Three-Phase, Four-Wire System with IQ 150/250/260 or PXM 2000 Meter



NOTE 1: DASH LINES ARE CUSTOMER CONNECTIONS.

NOTE 2: STANDARD APPLICATION ASSUMED TO BE 200-240V 3 PHASE 4 WIRE SYSTEMS. FOR ALTERNATE SYSTEMS, VOLTAGES AND CT CONFIGURATIONS, PLEASE SEE CHAPTER 4 OF THE INSTALLATION AND OPERATION MANUAL FOR THE RESPECTIVE METER PROVIDED IN THE ENCLOSURE.

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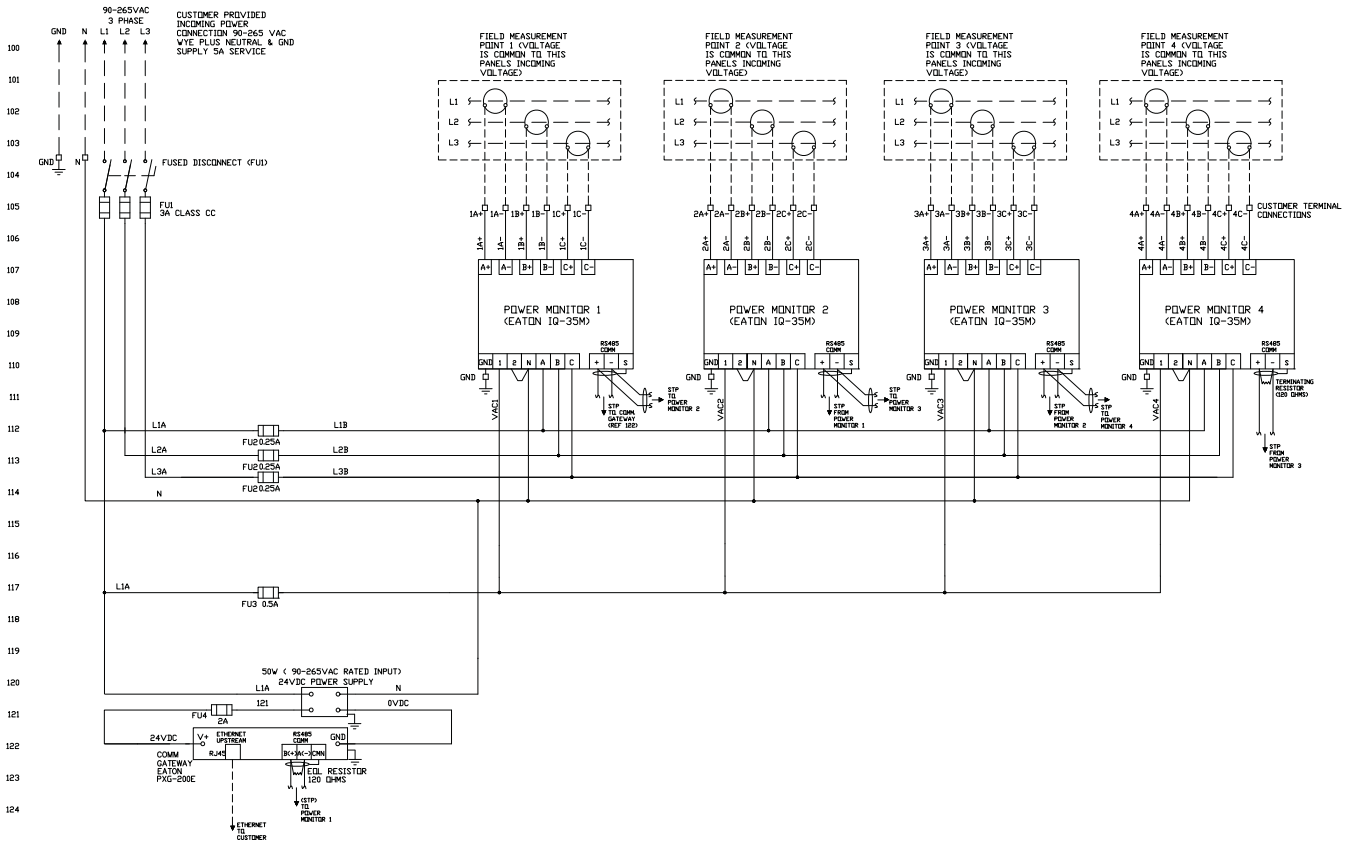
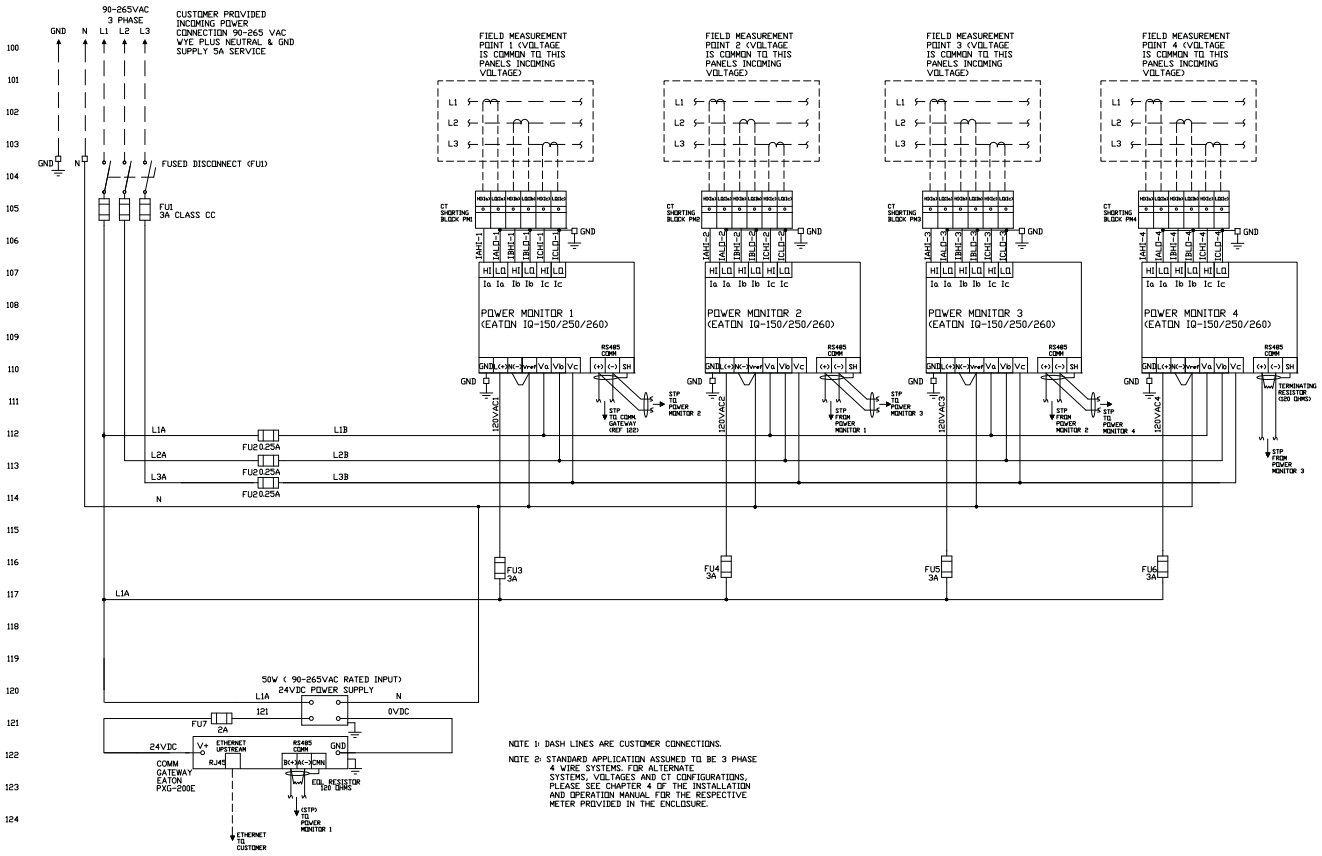
IQ100 SERIES	OPTION	N/A	N/A	OPTION
IQ250/260 SERIES	STANDARD	OPTION	OPTION	N/A
PXM2000 SERIES	STANDARD	OPTION*	OPTION*	STANDARD

* ANALOG OUTPUT OPTION CARD AND DIGITAL IO CARD ARE MUTUALLY EXCLUSIVE FOR THE PXM2000 SERIES

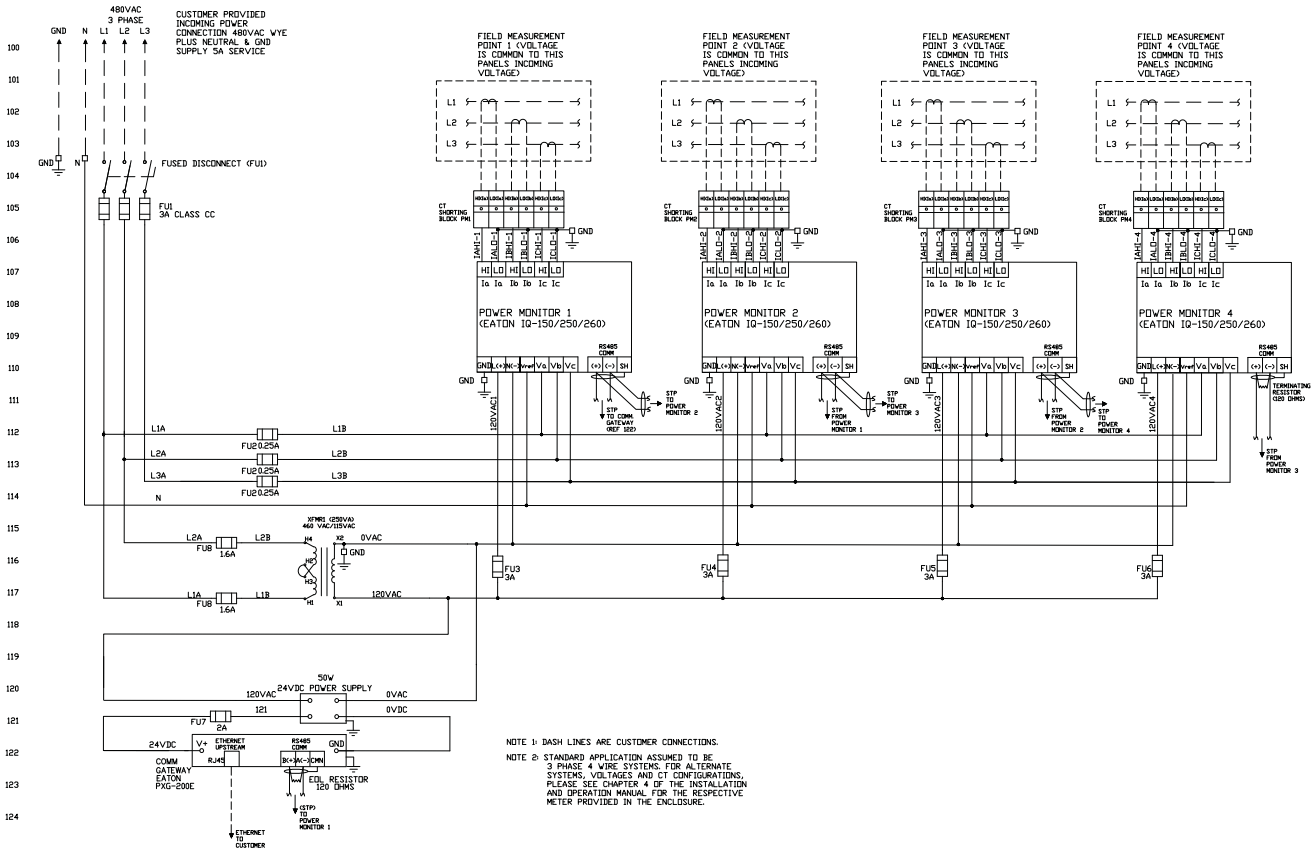
Multi Unit Enclosure—200–240 Vac 50/60 Hz, Three-Phase, Four-Wire System with IQ 35M Meters



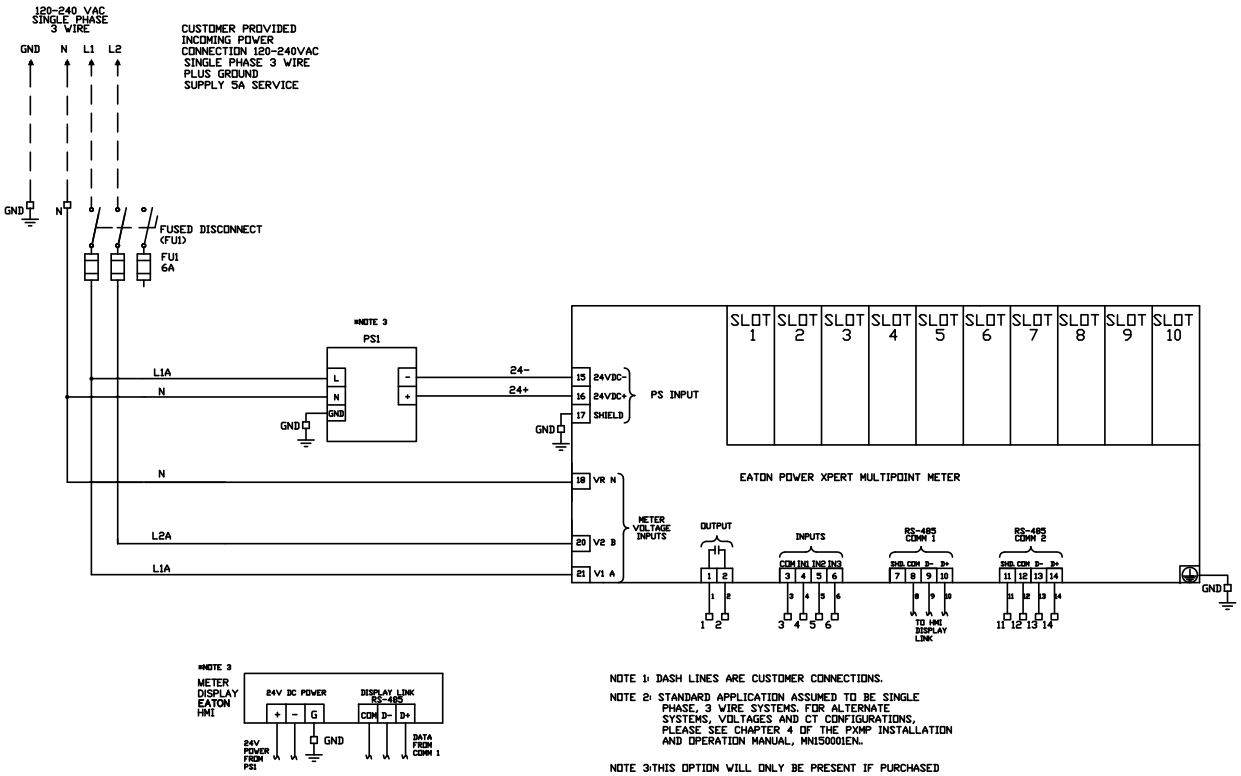
Multi Unit Enclosure—200–240 Vac 50/60 Hz, Three-Phase, Four-Wire System with IQ 150/250/260 Meters



Multi Unit Enclosure—480 Vac 50/60 Hz, Three-Phase, Four-Wire System with IQ 150/250/260 Meters



Single Unit Enclosure—120–240 Vac 50/60 Hz, Three-Wire System with PXMP Meter

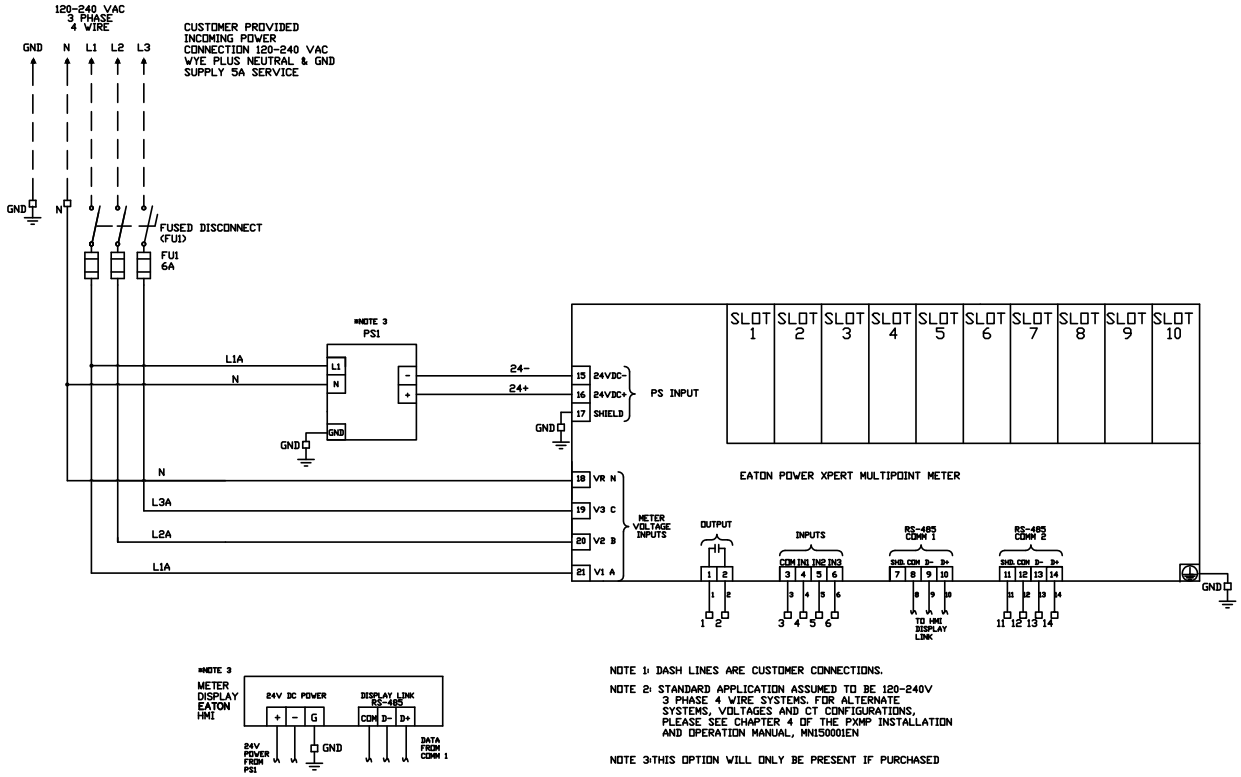


NOTE 1: DASH LINES ARE CUSTOMER CONNECTIONS.

NOTE 2: STANDARD APPLICATION ASSUMED TO BE SINGLE PHASE, 3 WIRE SYSTEMS. FOR ALTERNATE SYSTEMS, VOLTAGES AND CT CONFIGURATIONS, PLEASE SEE CHAPTER 4 OF THE PXMP INSTALLATION AND OPERATION MANUAL, MN150001EN.

NOTE 3: THIS OPTION WILL ONLY BE PRESENT IF PURCHASED

Single Unit Enclosure—120–240 Vac 50/60 Hz, Three-Phase, Four-Wire Wye System with PXMP Meter

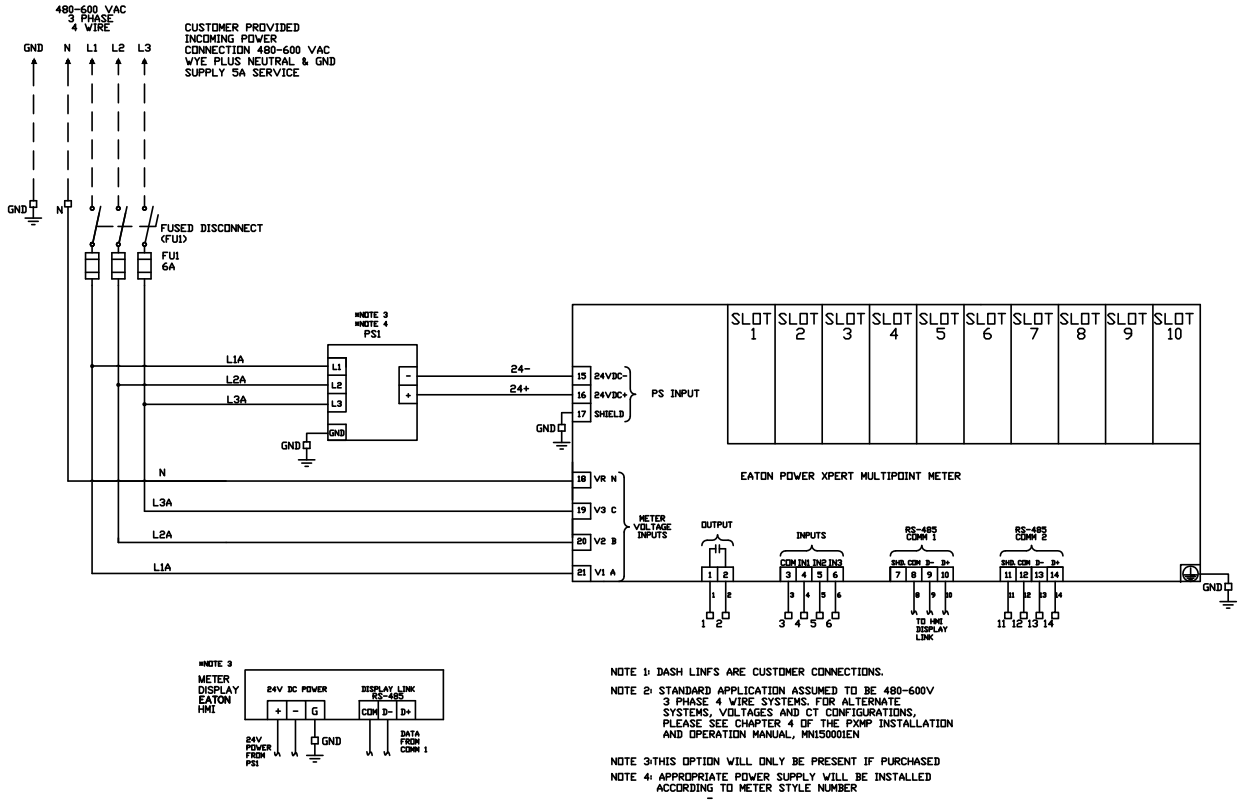


NOTE 1: DASH LINES ARE CUSTOMER CONNECTIONS.

NOTE 2: STANDARD APPLICATION ASSUMED TO BE 120-240V 3 PHASE 4 WIRE SYSTEMS. FOR ALTERNATE SYSTEMS, VOLTAGES AND CT CONFIGURATIONS, PLEASE SEE CHAPTER 4 OF THE PXMP INSTALLATION AND OPERATION MANUAL, MN150001EN

NOTE 3:THIS OPTION WILL ONLY BE PRESENT IF PURCHASED

Single Unit Enclosure—480–600 Vac 50/60 Hz, Three-Phase, Four-Wire Wye System with PXMP Meter



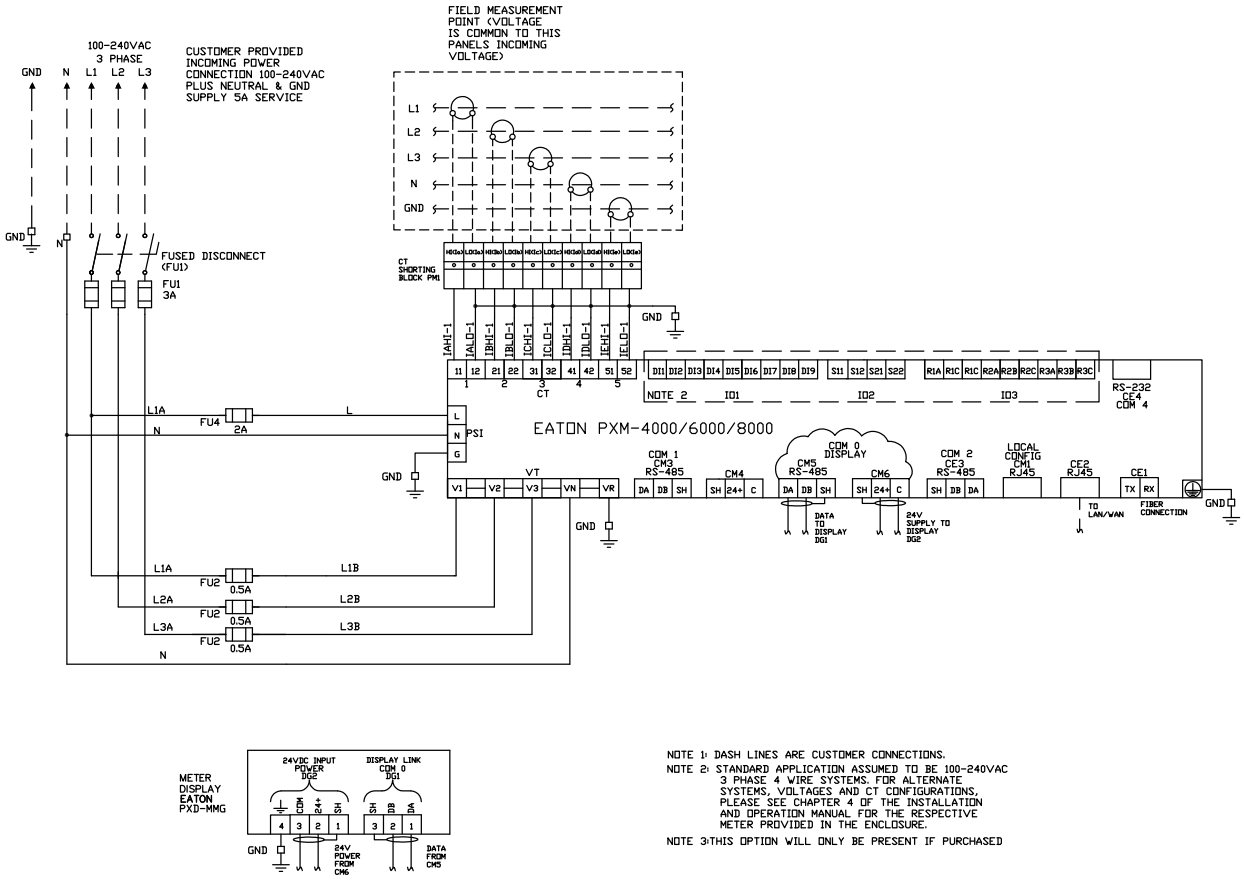
NOTE 1: DASH LINES ARE CUSTOMER CONNECTIONS.

NOTE 2: STANDARD APPLICATION ASSUMED TO BE 480-600V 3 PHASE 4 WIRE SYSTEMS. FOR ALTERNATE SYSTEMS, VOLTAGES AND CT CONFIGURATIONS, PLEASE SEE CHAPTER 4 OF THE PXMP INSTALLATION AND OPERATION MANUAL, MN150001EN

NOTE 3: THIS OPTION WILL ONLY BE PRESENT IF PURCHASED

NOTE 4: APPROPRIATE POWER SUPPLY WILL BE INSTALLED ACCORDING TO METER STYLE NUMBER

Single Unit Enclosure—200–240 Vac 50/60 Hz, Three-Phase, Four-Wire System with PXM 4000/6000/8000 Meter

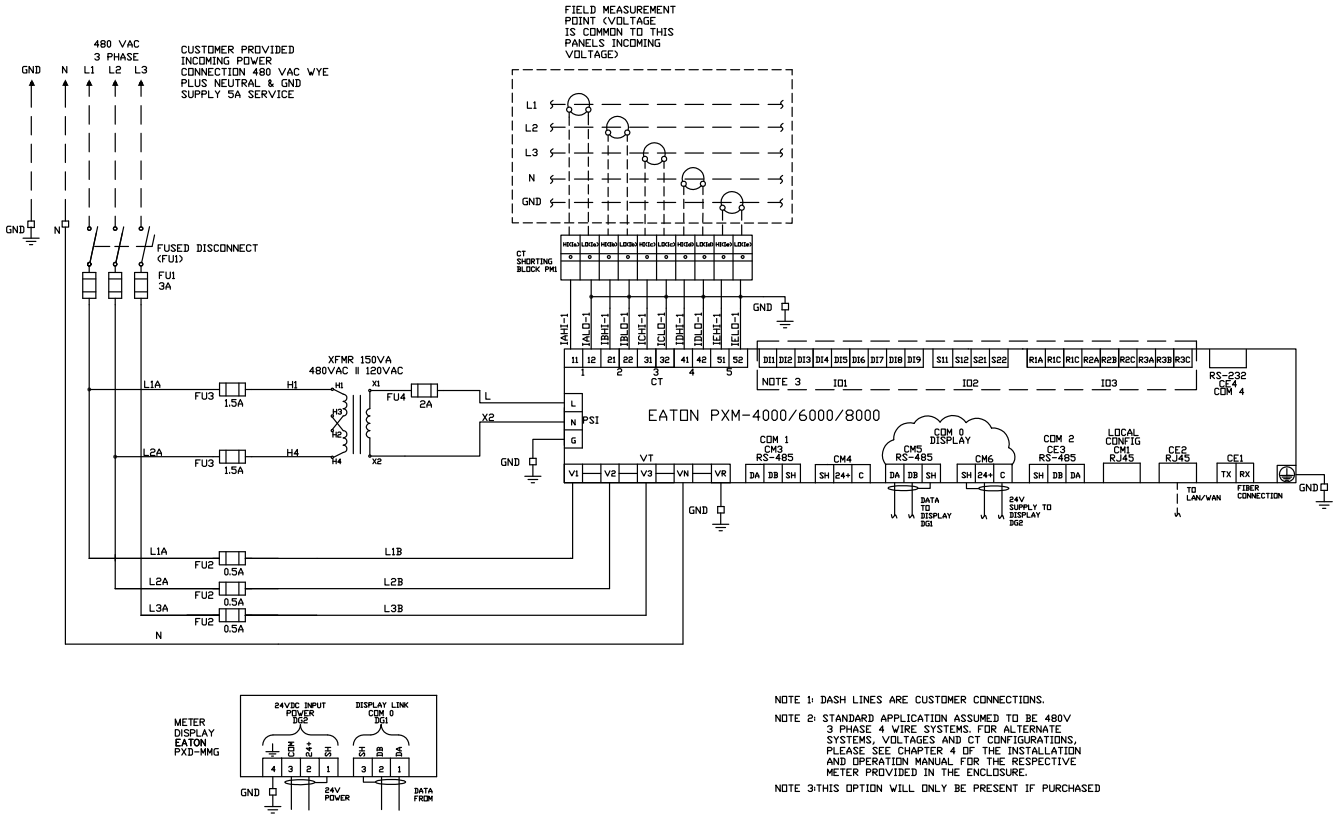


NOTE 1: DASH LINES ARE CUSTOMER CONNECTIONS.

NOTE 2: STANDARD APPLICATION ASSUMED TO BE 100-240VAC 3 PHASE 4 WIRE SYSTEMS. FOR ALTERNATE SYSTEMS, VOLTAGES AND CT CONFIGURATIONS, PLEASE SEE CHAPTER 4 OF THE INSTALLATION AND OPERATION MANUAL FOR THE RESPECTIVE METER PROVIDED IN THE ENCLOSURE.

NOTE 3: THIS OPTION WILL ONLY BE PRESENT IF PURCHASED

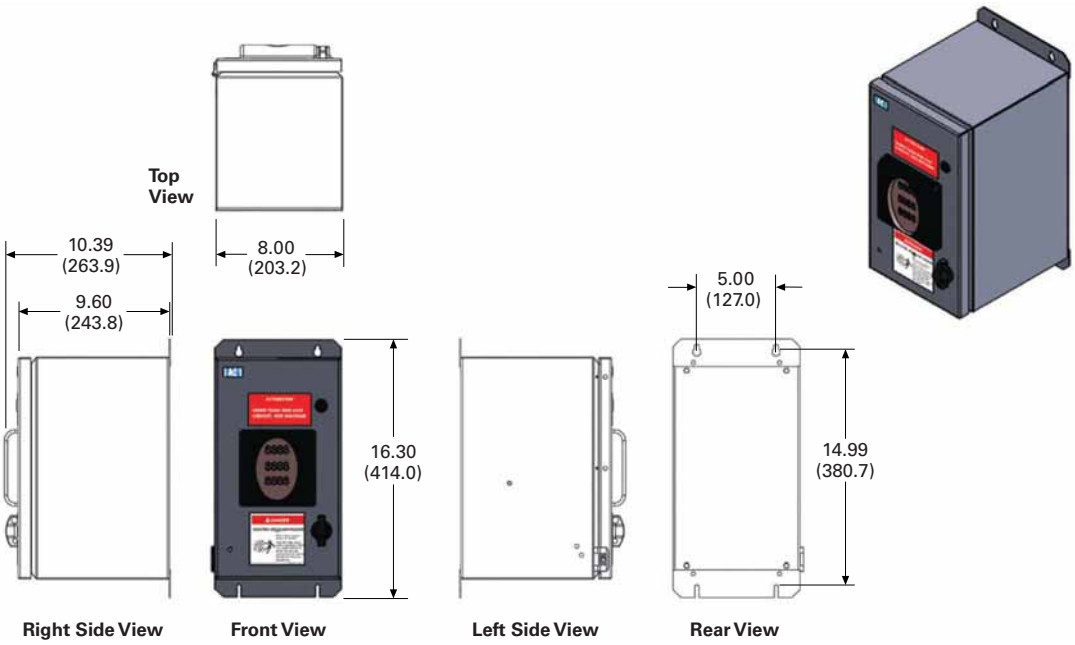
Single Unit Enclosure—480 Vac 50/60 Hz, Three-Phase, Four-Wire System with PXM 4000/6000/8000 Meter



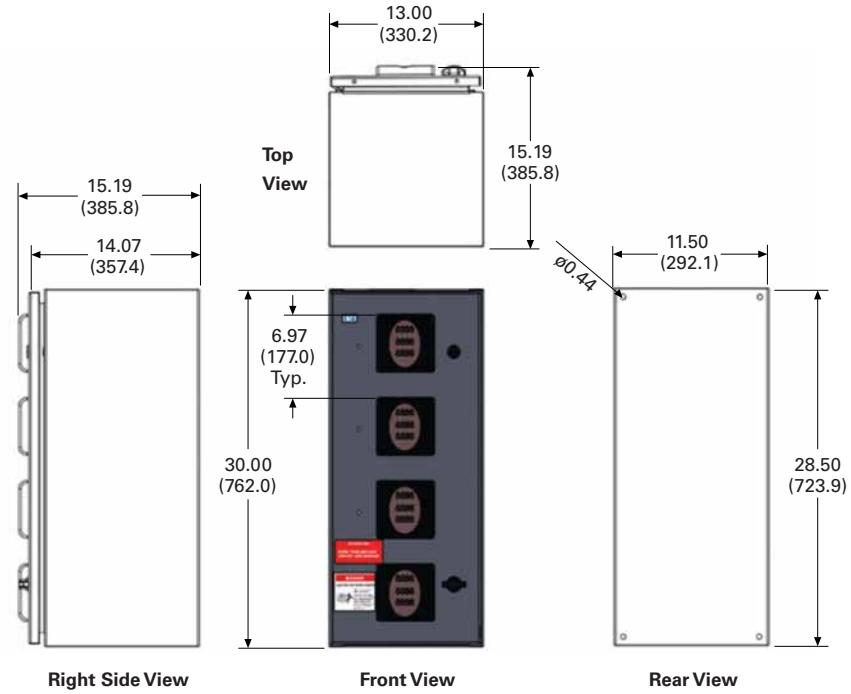
Dimensions

Approximate Dimensions in Inches (mm)

NEMA 12 Single Unit Enclosure

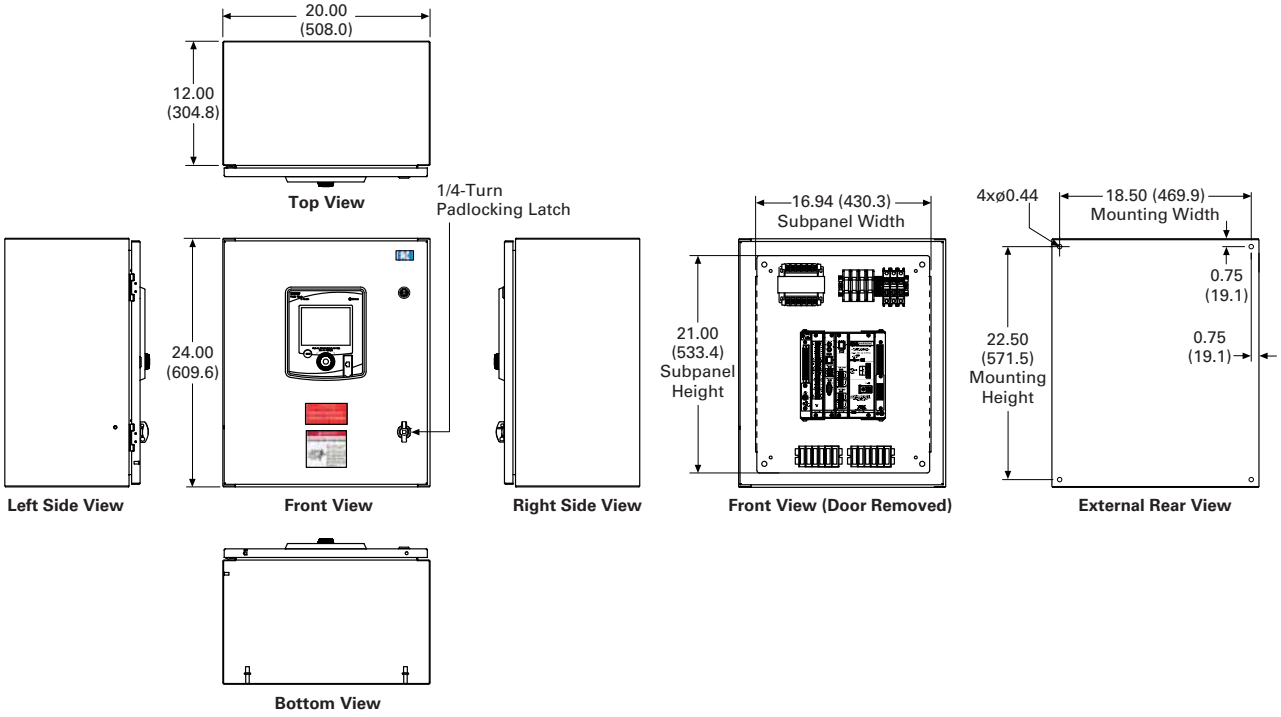


NEMA 12 Multi Unit Enclosure

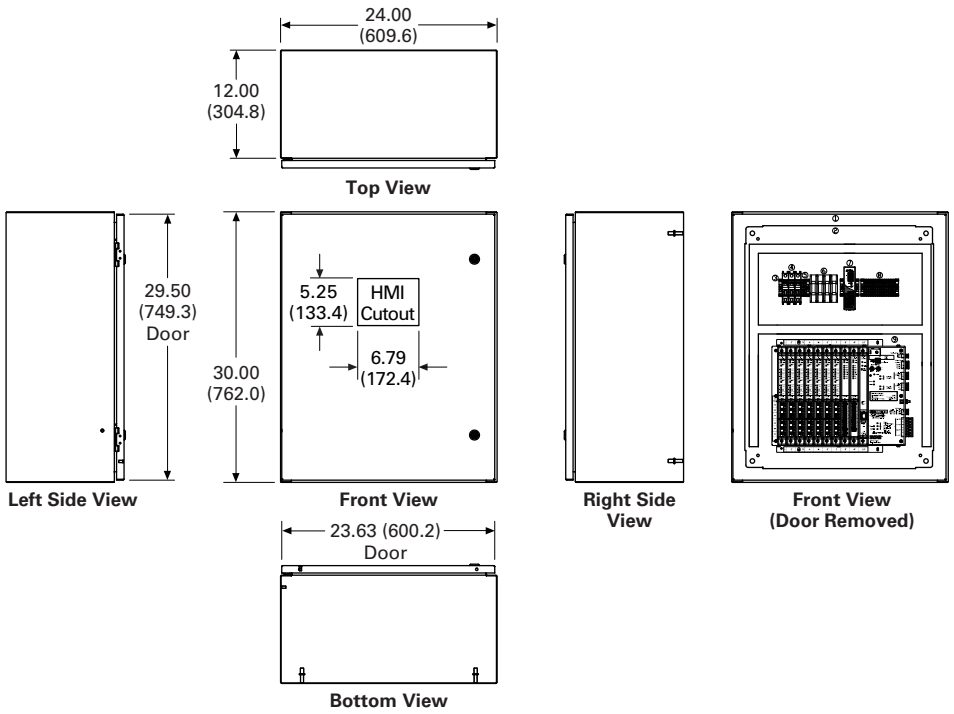


Approximate Dimensions in Inches (mm)

NEMA 12 PXM 4000/6000/8000 Enclosure

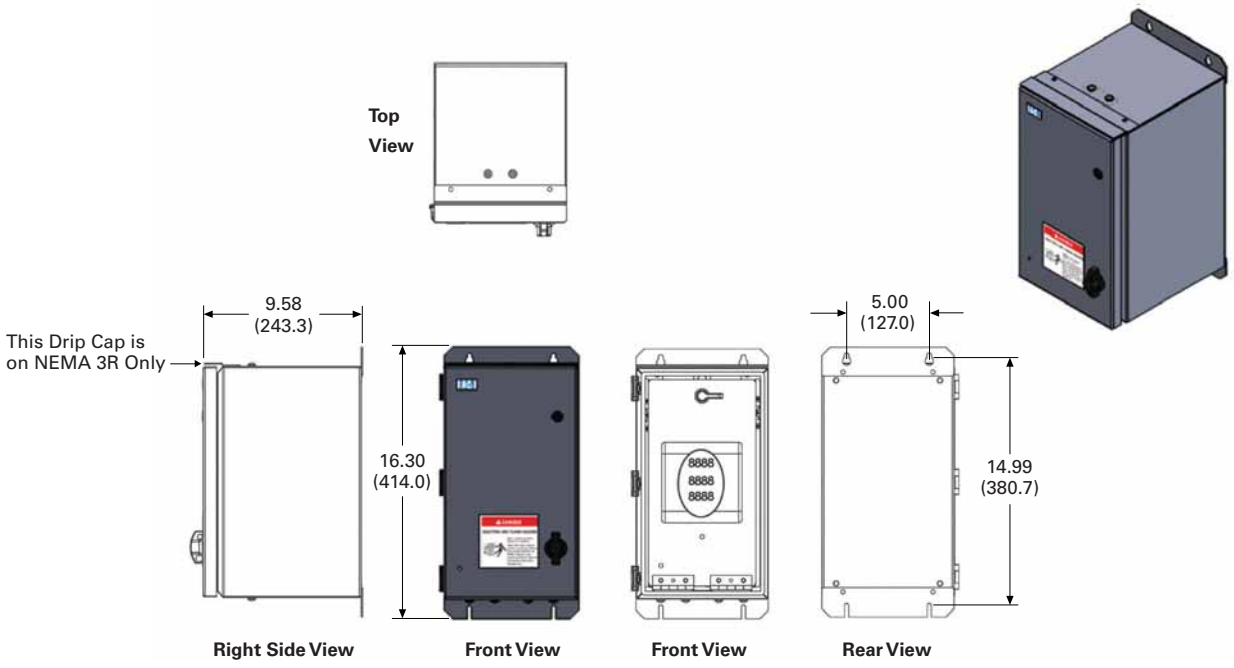


NEMA 12 PXMP Enclosure

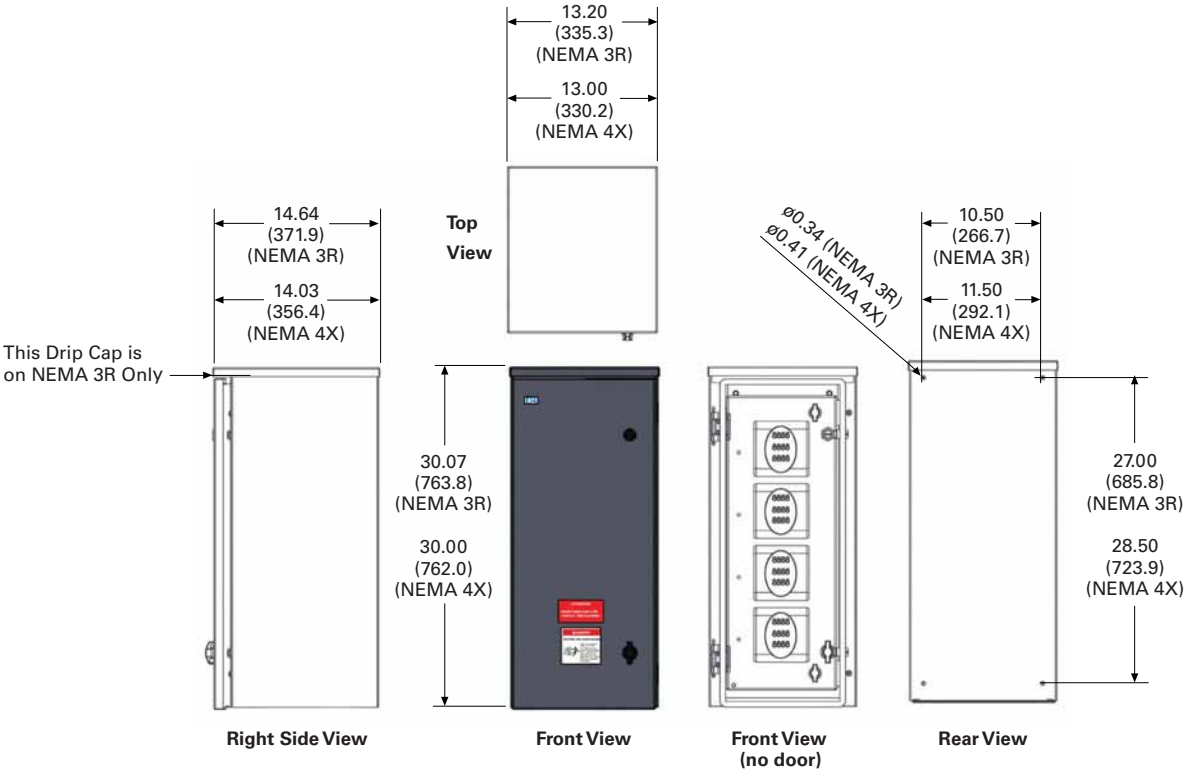


Approximate Dimensions in Inches (mm)

NEMA 3R/4X Single Unit Enclosure

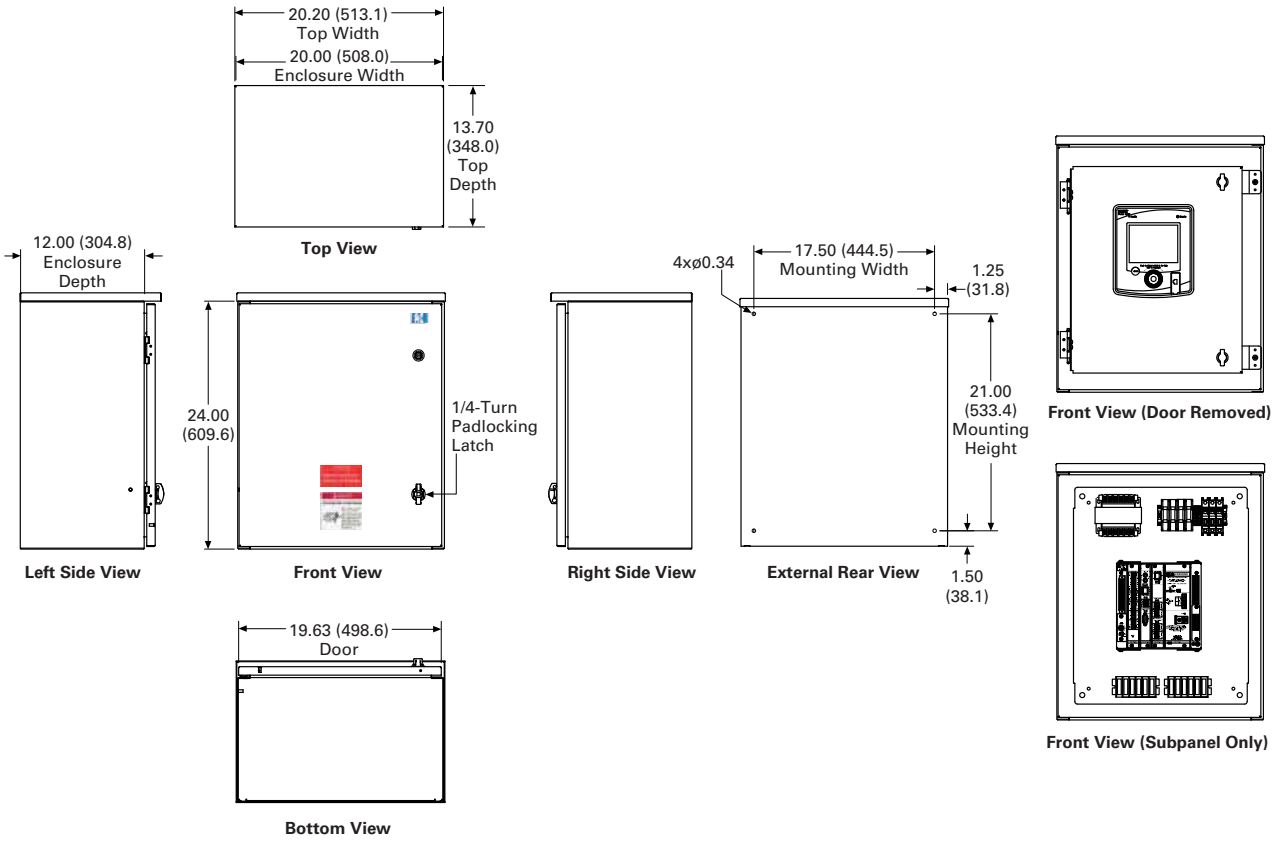


NEMA 3R/4X Multi Unit Enclosure



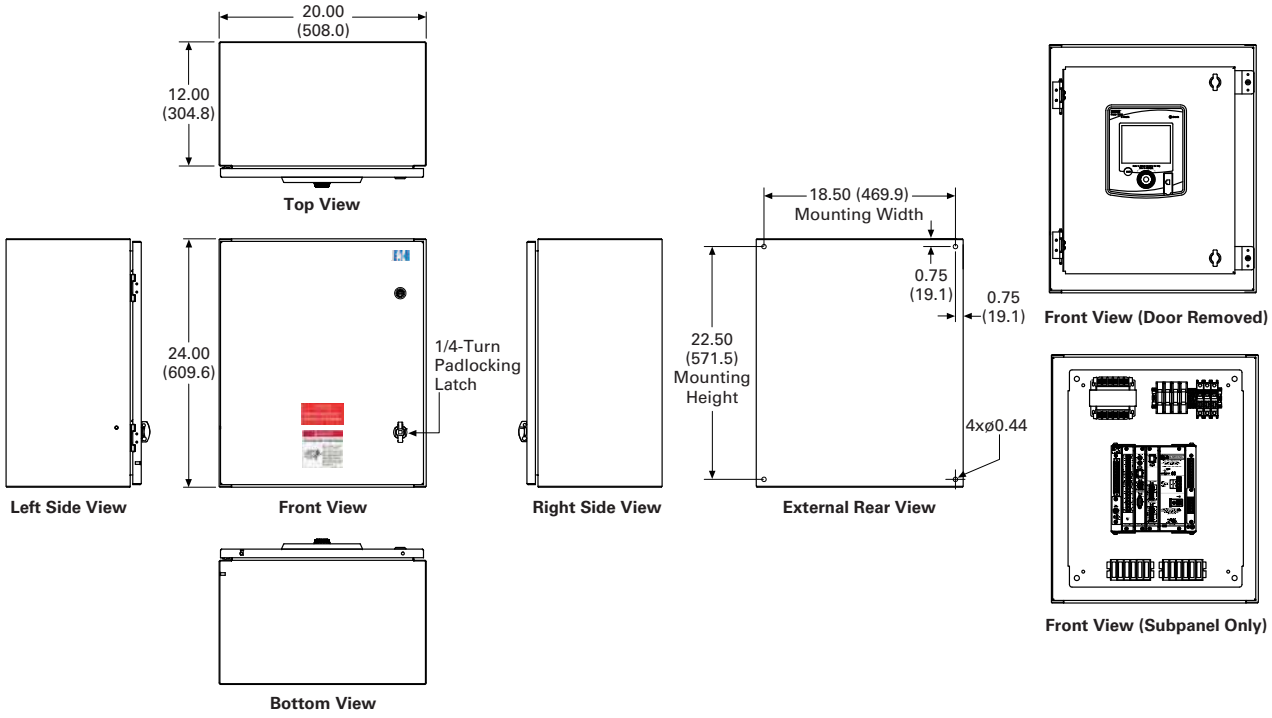
Approximate Dimensions in Inches (mm)

NEMA 3R PXM 4000/6000/8000 Unit Enclosure



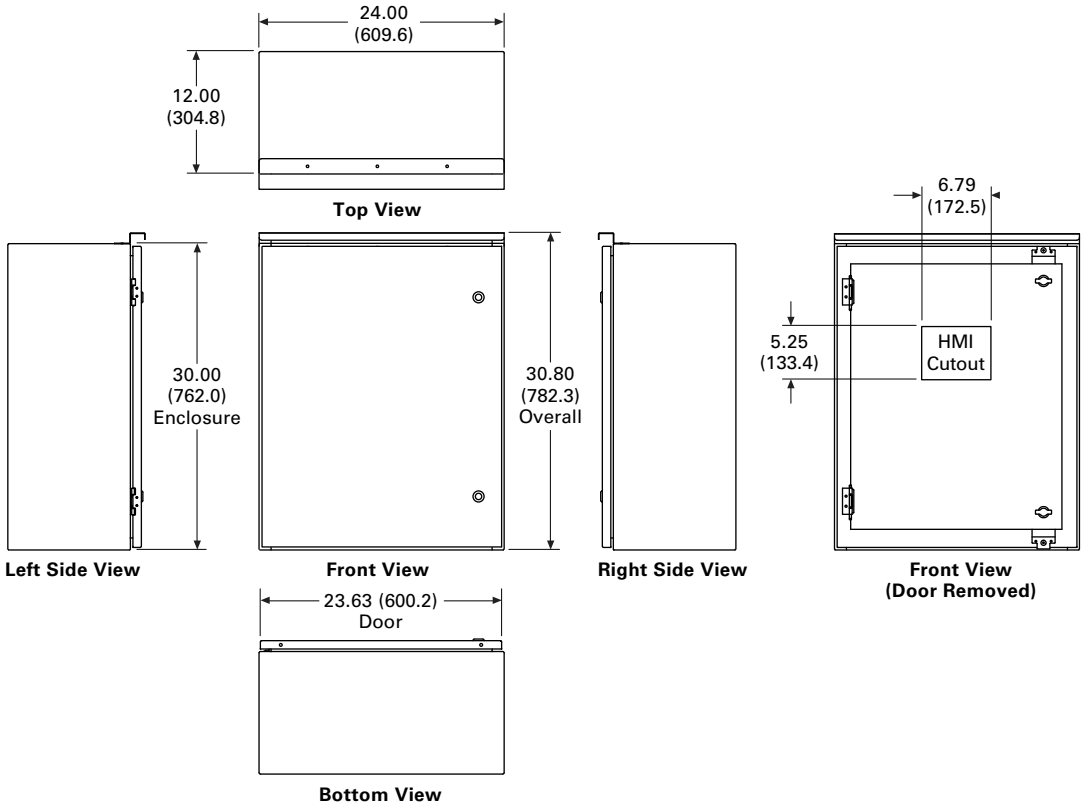
Approximate Dimensions in Inches (mm)

NEMA 4X PXM 4000/6000/8000 Unit Enclosure



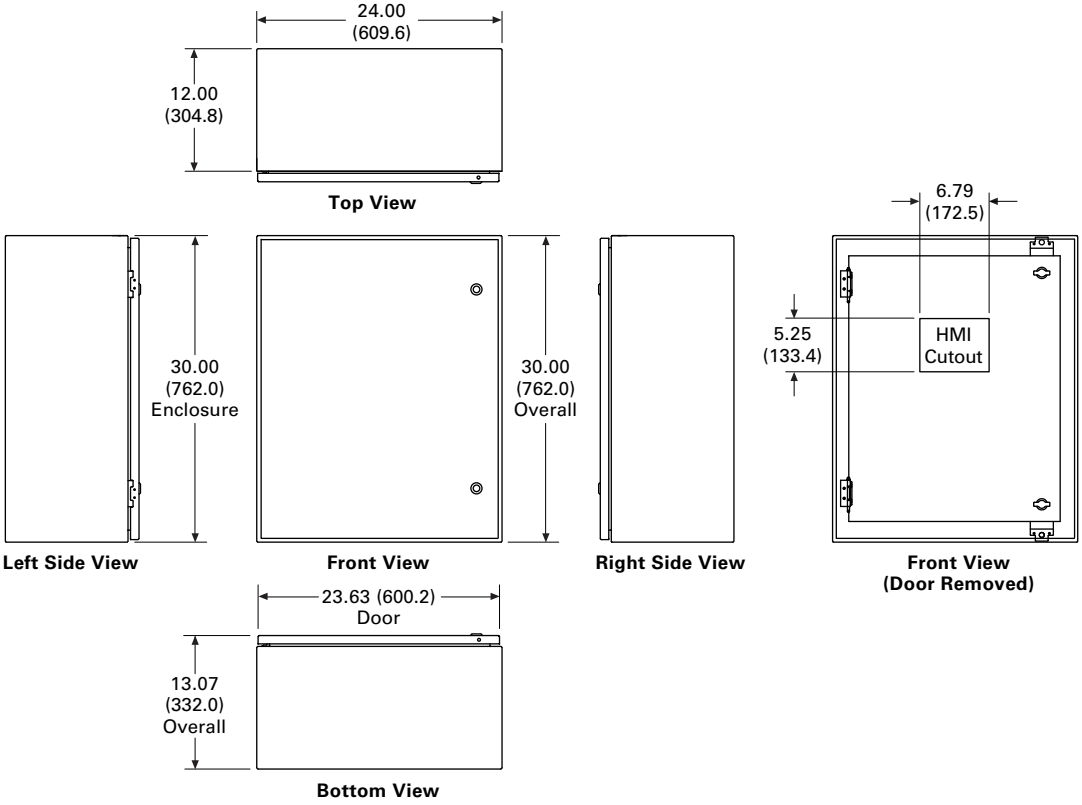
Approximate Dimensions in Inches (mm)

NEMA 3R PXMP Multi Unit Enclosure



Approximate Dimensions in Inches (mm)

NEMA 4X PXMP Multi Unit Enclosure



Contents

Product Selection Guide

Protective Relay Selection Chart

Protection Functions

		Feeder Protection				Motor Protection					Transformer Protection		Generator Protection
	IEEE Device	DT-3000	EDR-3000	EDR-5000	FP-5000	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
Description	**Number**	**V3-T9-123**	**V3-T9-133**	**V3-T9-142**	**V3-T9-155**	**V3-T9-163**	**V3-T9-173**	**V3-T9-179**	**V3-T9-191**	**V3-T9-204**	**V3-T9-123**	**V3-T9-123**	**V3-T9-241**
Phase inst. OC	50	■	■	■	■	■	■	■	■	■	■	■	■
Phase TOC	51	■	■	■	■	■	■	■	■	■	■	■	■
Ground inst. OC (measured)	50G	■	■	■	■	■	■	■	■	■	■	■	■
Ground TOC (measured)	51G	■	■	■	■	■	■	■	■	■	■	■	■
Ground inst. OC (calculated)	50R		■	■	■			■	■	■	■	■	■
Ground TOC (calculated)	51R		■	■	■			■	■	■	■	■	■
No. of curves (ANSI/IEC/thermal)		11	11	11	10			11	11	11	11	11	11
Zone selective interlocking		■	■	■	■			■	■	■	■	■	■
Phase directional control ①	67			■	■				■	■		■	■
Ground directional control ①	67N			■	■				■	■		■	■
Phase voltage restrained OC	51VR			■	■				■	■		■	■
Undervoltage	27			■	■		■		■	■		■	■
Current unbalance	46		■	■	■	■	■	■	■	■		■	■

Note

① Directional elements are controlled by reverse, forward, or both directions.

Protection Functions, continued

Description	IEEE Device Number	Feeder Protection				Motor Protection					Transformer Protection		Generator Protection
		DT-3000	EDR-3000	EDR-5000	FP-5000	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
		V3-T9-123	V3-T9-133	V3-T9-142	V3-T9-155	V3-T9-163	V3-T9-173	V3-T9-179	V3-T9-191	V3-T9-204	V3-T9-123	V3-T9-123	V3-T9-241
Voltage unbalance	47			■	■		■		■	■		■	■
Power factor	55			■	■		■		■	■			■
Overvoltage	59			■	■		■		■	■		■	■
Frequency (over/under)	81			■	■		■		■	■		■	■
Rate of change of frequency	81R			■	■		■		■	■		■	■
Vector surge	78V			■					■	■		■	■
Forward/reverse power	32			■	■	■			■	■		■	■
Forward/reverse VARs	32V			■					■	■		■	■
Sync check	25			■	■								■
Reclosing	79			■								■	■
Ground overvoltage	59N			■									■
Thermal overload ①	49					■	■	■	■	■	■	■	■
Underload	37							■	■	■			
Locked rotor	49S/51					■	■	■	■	■			
Jam/stall	51R					■	■	■	■	■			
Incomplete sequence	48					■	■	■	■	■			
Number of starts limit						■	■	■	■	■			
Starts per hour	66					■	■	■	■	■			
Time between starts						■	■	■	■	■			
Long acceleration time						■	■	■	■	■			
Emergency override						■	■	■	■	■			
Broken rotor bar detection									■	■			
Loss of potential	60LOP			■	■							■	■
Current transformer supervision			■	■				■	■	■	■	■	■
Cold load pickup			■	■	■				■	■	■	■	■
Switch on to fault			■	■								■	■
Breaker failure	50BF		■	■	■			■	■	■	■	■	■
2nd harmonic restraint											■	■	
4th harmonic restraint											■	■	
5th harmonic restraint											■	■	
Differential	87									■	■	■	■
Ground differential	87GD										■	■	■
Trip lock out	86	■	■	■	■	■	■	■	■	■	■	■	■
Negative sequence current	51Q										■	■	■
External protection			■	■		■	■	■	■	■	■	■	■
Overexcitation (Volts/Hz)	24											■	■
Loss of field	40												■
Low voltage ride-through	27T			■								■	■
Reactive power and undervoltage	27Q			■								■	■
Inadvertent energization	50/27												■

Note

① When communicating to an external URTD device.

Control Functions

Description	IEEE Device Number	Feeder Protection				Motor Protection					Transformer Protection		Generator Protection
		DT-3000	EDR-3000	EDR-5000	FP-5000	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
		V3-T9-123	V3-T9-133	V3-T9-142	V3-T9-155	V3-T9-163	V3-T9-173	V3-T9-179	V3-T9-191	V3-T9-204	V3-T9-123	V3-T9-123	V3-T9-241
Remote open/close		■	■	■	■	Open only	Open only	■	■	■	■	■	■
Programmable I/O		■	■	■	■	■	■	■	■	■	■	■	■
Digital inputs		1	4 or 8	8	8	2	2	4	8	8 or 16	8	8	8 or 16
Relay outputs		2	3 or 5	10	6	4	4	3	4	8	8	8	8
Supervisory/alarm output		1	1	1	1	1	1	1	1	1	1	1	1
Programmable logic control			■	■	■			■	■	■	■	■	■
Multiple settings groups			4	4	4			4	4	4	4	4	4
Adaptive parameters			■	■				■	■	■	■	■	■
Reduced voltage starting						■	■	■	■	■			
Analog outputs						1	1		4	Option for 2		Option for 2	Option for 2
Analog inputs										Option for 2		Option for 2	Option for 2

Metering Functions

Description	IEEE Device Number	Feeder Protection DT-3000 V3-T9-123	EDR-3000 V3-T9-133	EDR-5000 V3-T9-142	FP-5000 V3-T9-155	Motor Protection MP-3000 V3-T9-163	MP-4000 V3-T9-173	EMR-3000 V3-T9-179	EMR-4000 V3-T9-191	EMR-5000 V3-T9-204	Transformer Protection ETR-4000 V3-T9-123	ETR-5000 V3-T9-123	Generator Protection EGR-5000 V3-T9-241
Amperes		■	■	■	■		■	■	■	■	■	■	■
Ampere demand		■	■	■	■		■	■	■	■	■	■	■
Voltage (L-N and L-L)				■	■		■		■	■		■	■
Phase angle			■	■	■		■	■	■	■	■	■	■
Pos., neg. and zero sequence			■	■	■		■	■	■	■	■	■	■
Watts				■	■		■		■	■		■	■
Watt demand				■	■		■		■	■		■	■
Watthour				■	■		■		■	■		■	■
VARs				■	■		■		■	■		■	■
VAR demand				■	■		■		■	■		■	■
VAR-hour				■	■		■		■	■		■	■
VA				■	■		■		■	■		■	■
VA Demand				■	■		■		■	■		■	■
VA-hour				■	■		■		■	■		■	■
Frequency				■	■		■		■	■		■	■
Minimum/maximum recording			■	■	■	Max. only	Max. only	■	■	■	■	■	■
Current unbalance			■	■		■	■	■	■	■	■	■	■
Voltage unbalance				■			■		■	■		■	■
Power factor				■	■		■		■	■		■	■
Sync values				■									■
Differential currents										■	■	■	■
2nd, 4th, 5th harmonic currents											■	■	
3rd harmonic voltage													■
THD current			■	■	■		■	■	■	■	■	■	■
THD voltage				■	■		■		■	■		■	■
Volt/Hertz									■	■		■	■
Thermal capacity								■	■	■			■
Generator hours of operation													■

Monitoring Functions

Description	IEEE Device Number	Feeder Protection DT-3000 V3-T9-123	EDR-3000 V3-T9-133	EDR-5000 V3-T9-142	FP-5000 V3-T9-155	Motor Protection MP-3000 V3-T9-163	MP-4000 V3-T9-173	EMR-3000 V3-T9-179	EMR-4000 V3-T9-191	EMR-5000 V3-T9-204	Transformer Protection ETR-4000 V3-T9-123	ETR-5000 V3-T9-123	Generator Protection EGR-5000 V3-T9-241
Trip circuit monitor	74		■	■	■			■	■	■	■	■	■
Breaker wear			■	■	■			■	■	■	■	■	■
Fault recorder			■	■	■			■	■	■	■	■	■
Waveform recorder			■	■	■			■	■	■	■	■	■
Sequence of events recorder			■	■	■	■	■	■	■	■	■	■	■
Trend recorder (load profile)			■	■	■			■	■	■	■	■	■
Clock			■	■	■	■	■	■	■	■	■	■	■
Time synchronization			■	■				■	■	■	■	■	■
RTD temperature ①						■	■	■	■	■	■	■	■
Hottest RTD ①						■	■	■	■	■	■	■	■

Communications

Description	IEEE Device Number	Feeder Protection DT-3000 V3-T9-123	EDR-3000 V3-T9-133	EDR-5000 V3-T9-142	FP-5000 V3-T9-155	Motor Protection MP-3000 V3-T9-163	MP-4000 V3-T9-173	EMR-3000 V3-T9-179	EMR-4000 V3-T9-191	EMR-5000 V3-T9-204	Transformer Protection ETR-4000 V3-T9-123	ETR-5000 V3-T9-123	Generator Protection EGR-5000 V3-T9-241
Front access interface													
Local human machine interface		■	■	■	■	■	■	■	■	■	■	■	■
RS-232			■	■	■			■	■	■	■	■	■
USB			②	②				②	②	②	②	②	②
Rear communication port interface													
RS-485		■	Option	Option	■			Option	Option	Option	Option	Option	Option
Ethernet copper (RJ45)			Option	Option				Option	Option	Option	Option	Option	Option
Fiber optic ST (note)			②	②				②	②	②	②	②	②
Fiber optic LC (note)			②	②				②	②	②	②	②	②
Protocol													
INCOM		■			Option	Option	Option						
Modbus-RTU		■	Option	Option	Option	Option	Option	Option	Option	Option	Option	Option	Option
Modbus-TCP			Option	Option				Option	Option	Option	Option	Option	Option
IEC 61850			Option	Option				Option	Option	Option	Option	Option	Option
DNP 3.0 (note)			②	②				②	②	②	②	②	②
PROFIBUS (note)			②	②				②	②	②	②	②	②
IRIG-B			Option	■				■	■	■	■	■	■
SNTP			Option	Option				Option	Option	Option	Option	Option	Option

Notes

① When communicating to an external URTD device.

② Option available beginning in late 2015.

Construction

Description	IEEE Device Number	Feeder Protection DT-3000 V3-T9-123	EDR-3000 V3-T9-133	EDR-5000 V3-T9-142	FP-5000 V3-T9-155	Motor Protection MP-3000 V3-T9-163	MP-4000 V3-T9-173	EMR-3000 V3-T9-179	EMR-4000 V3-T9-191	EMR-5000 V3-T9-204	Transformer Protection ETR-4000 V3-T9-123	ETR-5000 V3-T9-123	Generator Protection EGR-5000 V3-T9-241
Panel mount case		■	Semi-flush or projected	Semi-flush or projected	■	■	■	Semi-flush or projected	Semi-flush or projected	Semi-flush or projected	Semi-flush or projected	Semi-flush or projected	Semi-flush or projected
Drawout case		Option	Removable terminals	Removable terminals	Option	Option	Option	Removable terminals	Removable terminals	Removable terminals	Removable terminals	Removable terminals	Removable terminals
Self-shorting CT terminals			■	■				■	■	■	■	■	■
Operating temperature range		–30 to +55 °C	–40 to +60 °C	–40 to +60 °C	–40 to +60 °C	–20 to +60 °C	–20 to +60 °C	–40 to +60 °C	–40 to +60 °C	–40 to +60 °C	–40 to +60 °C	–40 to +60 °C	–40 to +60 °C
Power supply range (Vac)		120–240 Vac	40–250 Vac	40–250 Vac	48–125 Vdc	90–264 Vac	90–264 Vac	40–250 Vac	40–250 Vac	40–250 Vac	40–250 Vac	40–250 Vac	40–250 Vac
Power supply range (Vdc)		24–250 Vdc	19–300 Vdc	19–300 Vdc	48–125 Vdc			19–300 Vdc	19–300 Vdc	19–300 Vdc	19–300 Vdc	19–300 Vdc	19–300 Vdc
AC current inputs		■	■	■	■	■	■	■	■	■	■	■	■
AC voltage inputs				■	■		■		■	■		■	■
Wye VT configuration				■	■		■		■	■		■	■
Open delta VT configuration				■	■		■		■	■		■	■
Sensitive ground	50/51G		Option	Option				Option	Option	Option	Option	Option	Option
Local display / HMI		■	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons	■	■	■	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons
LEDs (local targets)		■	Programmable	Programmable	■	■	■	Programmable	Programmable	Programmable	Programmable	Programmable	Programmable

Standards

Description	IEEE Device Number	Feeder Protection DT-3000 V3-T9-123	EDR-3000 V3-T9-133	EDR-5000 V3-T9-142	FP-5000 V3-T9-155	Motor Protection MP-3000 V3-T9-163	MP-4000 V3-T9-173	EMR-3000 V3-T9-179	EMR-4000 V3-T9-191	EMR-5000 V3-T9-204	Transformer Protection ETR-4000 V3-T9-123	ETR-5000 V3-T9-123	Generator Protection EGR-5000 V3-T9-241
ANSI		■	■	■	■	■	■	■	■	■	■	■	■
IEC		■	■	■	■	■	■	■	■	■	■	■	■
UL		■	■	■	■	■	■	■	■	■	■	■	■
CE		DT-3030 only	■	■	■			■	■	■	■	■	■
CSA		■	■	■	■	■	■	■	■	■	■	■	■

DT-3000

Contents

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Digitrip 3000

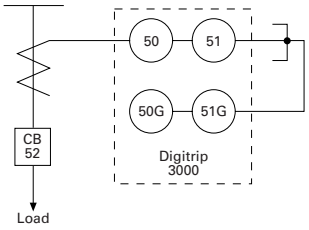
Product Description

- Microprocessor-based, three-phase and ground overcurrent relay
- Independent phase and ground measuring circuits and operation
- Inverse time (51), short delay (50, 2) and instantaneous (50) protection
- Eleven time overcurrent characters including ANSI, IEC and thermal protection curves
- Phase and ground ampmeter and peak demand functions
- INCOM communication port
- Fixed mount or optional quick release drawout case design
- Dual-source power supply option for AC control power applications

Application Description

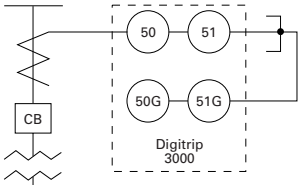
Eaton's Digitrip 3000 microprocessor-based relay provides reliable three-phase and ground overcurrent protection for all voltage levels. It can be used for any application where instantaneous and/or time overcurrent protection is required. It is most commonly used as primary feeder circuit protection, see figure below.

Primary Feeder Circuit Protection



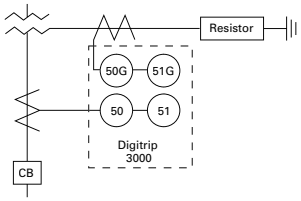
The Digitrip 3000 may be applied as the transformer primary protection or as backup to the differential protection, see figure below.

Transformer Overcurrent Protection



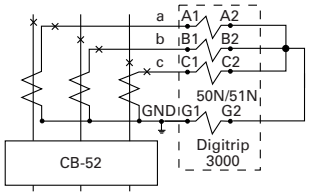
The Digitrip 3000 may be connected to the secondary side of a delta-wye grounded transformer with the ground element connected to a separate CT in the neutral connection of the transformer. With this connection, a lower CT ratio and a pickup setting can be used to provide more sensitive ground fault protection especially for resistance grounded systems, see figure below.

Transformer Secondary Protection with Neutral CT Connection

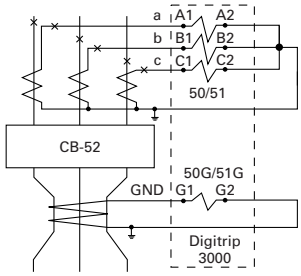


The Digitrip 3000 ground overcurrent element can be connected in the residual circuit of the phase CTs as shown in the top figure or to a separate ground CT as shown in last figure.

Residual Ground Connection



Separate Zero Sequence Ground CT Connection



Zone Selective Interlocking (Phase and Ground)

Note: For the phase time overcurrent element, the current sensed by the Digitrip 3000 must exceed 300% (3 x I_n) for the zone selective interlocking to initiate an immediate trip signal.

Zone Selective interlocking is a protection function to minimize equipment damage resulting from a phase or a ground fault in an area where long-time and/or short-time delay is in use.

When the "Ground Zone Interlocking" feature is utilized, an immediate trip is initiated when the fault is in the breaker's zone of protection, regardless of its preset time delay. When the "Phase Zone Interlocking" feature is utilized, the time overcurrent and short delay phase elements work as follows. The short delay phase element will initiate an immediate trip when the fault is in the breaker's zone of protection, regardless of its preset time delay. For the time overcurrent phase element, the current sensed by the Digitrip 3000 must exceed 300% (3 x I_n) for the zone selective interlocking to initiate an immediate trip signal when the fault is in the breaker's zone of protection.

Upstream Digitrip 3000 protected breakers are restrained from tripping immediately by an interlocking signal from the downstream Digitrip 3000 relay. This interlocking signal requires only a pair of wires from the downstream breaker to the upstream breaker. The Upstream Digitrip 3000 provides time delayed standard coordinated tripping when the fault is located outside the zone of protection.

In the sample zone interlocking system shown below, circuit breakers A, B and C are equipped with Digitrip 3000 overcurrent relays.

Fault Location Zone 3

Note: For the phase time overcurrent element, the current sensed by the Digitrip 3000 must exceed 300% (3 x I_n) for the zone selective interlocking to initiate an immediate trip signal.

If a fault occurs at a point in Zone 3, the Digitrip 3000 of Downstream Breaker C senses the fault and sends a restraining signal to the upstream Digitrip 3000 of Feeder Breaker B.

Having received this signal, the Digitrip 3000 of Feeder Breaker B begins timing for normal final delay tripping. As a result, only Downstream Breaker C is tripped.

Fault Location Zone 2

Note: For the phase time overcurrent element, the current sensed by the Digitrip 3000 must exceed 300% (3 x I_n) for the zone selective interlocking to initiate an immediate trip signal.

If a fault occurs at a point in Zone 2, the Digitrip 3000 of Feeder Breaker B senses the fault and sends a restraining signal to the upstream Digitrip 3000 of Main Breaker A.

The Digitrip 3000 of the Downstream Breaker C does not see this fault since it is situated on the downstream side of the fault.

As a result, the Digitrip 3000 of Downstream Breaker C does not send a restraining signal to the Digitrip 3000 of Feeder Breaker B.

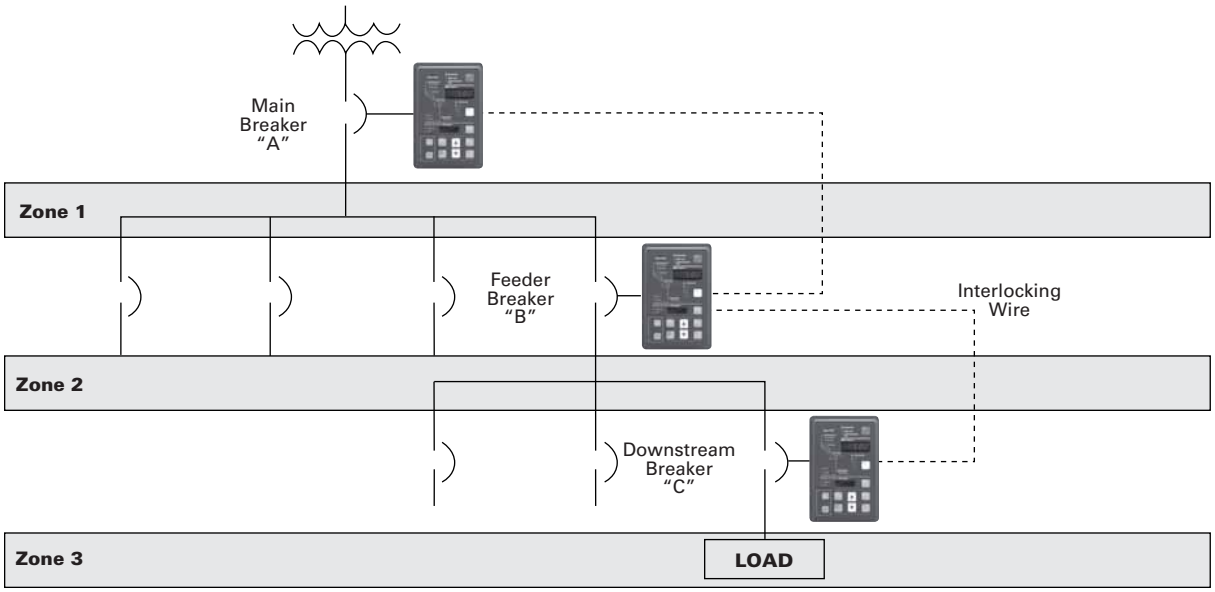
Because there is no restraining signal from the Digitrip 3000 of Downstream Breaker C, the Digitrip 3000 of Feeder Breaker B identifies that the fault is in Zone 2 and immediately trips Feeder Breaker B, regardless of its time setting.

Fault Location Zone 1

Note: For the phase time overcurrent element, the current sensed by the Digitrip 3000 must exceed 300% (3 x I_n) for the zone selective interlocking to initiate an immediate trip signal.

If a fault occurs in Zone 1, no restraining signal is received by the Digitrip of Main Breaker A. As a result, Main Breaker A is immediately tripped by its Digitrip overcurrent relay, regardless of its time setting.

Sample Zone Selective Interlocking System



Features, Benefits and Functions

- Complete current protection and metering in a single compact case reduces panel space, wiring and cost
- Selectable trip characteristics simplify ordering and reduces inventory
- Optional drawout case provides easy and quick removal and replacement of the relay
- Optional dual-source power supply provides reliable protection when applied with ac control power, eliminating the need for batteries or UPS
- Integral ampmeter and display replaces separate meter and switch, saving panel space, wiring and money
- Zone selective interlocking improves coordination and tripping times and can save money by using in place of traditional bus differential
- Integral test function and microprocessor design can reduce maintenance time and expense

Standards and Certifications

- UL recognized
- UL 1053 recognized
- ANSI C37.90
- ANSI C37.90.1 (1989)
- ANSI C37.90.2 (1995)

Note: Fixed case versions meet 35 V/m. Drawout case versions meet 28 V/m.

- IEC 255
- CE (DT3030/3031 version only)

Product Selection

DT-3000

DT-3000

Description	Catalog Number
DT-3000 protective relay	**DT3000**
DT-3000 protective relay Chicago version	**DT3100**
DT-3030 protective relay (24–48 Vdc CE Mark version)	**DT3030**
DT-3000 drawout case protective relay	**DT3001**
DT-3000 Chicago version drawout case protective relay	**DT3101**
DT-3030 drawout case protective relay (24–48 Vdc CE Mark version)	**DT3031**
DT-3000 protective relay with 120 Vac dual-source power supply	**DT3010**
DT-3000 protective relay with 240 Vac dual-source power supply	**DT3020**

9

Options and Accessories

Additional Products by Eaton's Cutler-Hammer Series

Dual-Source Power Supply Option

The Digitrip 3000 with Dual-Source Power Supply (DSPS) is available in two versions, DT-3010 and DT-3020. They include an integral power supply module that:

- Powers the relay from nominal 120 Vac, 50/60 Hz (DT-3010 model) or 240 Vac, 50/60 Hz (DT-3020 model) auxiliary power, which is normally connected and available.
- Operates solely from the main current transformers (CTs) during a fault if the normally connected auxiliary ac voltage is not available, like an electromechanical relay or an electronic "self-powered" relay

Functional Description

The integral Dual-Source Power Supply (DSPS) contains one AC voltage transformer and three AC current transformers. The AC voltage transformer is used to supply nominal ac control power to the unit. The current transformers are used to power the unit from the line current. Normally, the unit will operate from the AC auxiliary voltage.

Because this voltage is usually obtained from the system containing the circuit that the relay is protecting, a fault on the protected line could cause the AC voltage to drop below an acceptable operating level. Below approximately 70 volts for DT-3010 or 140 volts for DT-3020, the DSPS switches over to current powering.

All three current transformer secondaries are connected in series to supply this power. The DSPS will supply enough power to operate the Digitrip 3000 overcurrent relay in the tripped state with currents greater than 1.8 per unit rated secondary current, or 9 A, in a single-phase. The DSPS will operate with three-phase currents in a tripped state with currents greater than 1.2 per unit or 6 A rated secondary current.

Note: There will be no effect to the DT-3000 relay trip time accuracy when the Dual-Source Power Supply switches from normal ac voltage to fault-current power.

Burden Data

In normal operating conditions, the burden is <0.08 ohms with three-phase 1 A CT current, or 0.2 per unit, and drops to less than 0.04 ohms at high current levels. Present CT burden data in ohms and volt-amperes, see **Page V3-T9-128**. In these cases, the burden shown is the total CT terminal value, which is the DSPS plus the relay measuring circuits, for the indicated operating condition.

The trip curve on **Page V3-T9-128**, right, shows burden impedance magnitude in ohms. The two lower curves are the values with AC power applied; the upper two are with CT powering only. For each of these pairs, one curve shows the burden for a single-phase current (representing a single-phase-to-ground fault) and the other for three balanced phases with normally arrayed 120-degree phase angle increments. There is no phase sequence sensitivity.

Page V3-T9-128, trip curve, upper left, shows the burden in volt-amperes for the same four cases.

Digitrip 3000 Optional Drawout Case

The Digitrip 3000 overcurrent protective relay is available in a new drawout case for quick release, removal and replacement of the unit without disruption of the wiring. The CT circuits are self-shortening to prevent damaging voltages from existing across-the-current transformer windings. All voltage inputs, discrete inputs and contact inputs are disconnected while maintaining security against false tripping.

The terminal blocks feature a two-stage disconnect operation. Removal of the DT-3000 Inner Chassis will disconnect the trip circuits and short the CT secondaries before the unit control power is disconnected. Upon insertion of the Inner Chassis, the control power connections are made before the trip circuits are activated. **This feature provides added security against false tripping.**

Technical Data and Specifications

Current Inputs

- CTs: 5 A secondary
- CT Burden:
  - <0.004 ohm at rated current (5 A)
  - <0.1 VA at rated current (5 A)
  - I_n: 5 A (Secondary) or CT (Primary)
- Saturation: 30 x I_n
- CT thermal ratings:
  - 10 A continuous
  - 500 A for 1 second

CT (Primary) Settings Available

- Phase and ground: 5/10/25/50/75/100/150/200/250/300/400/500/600/630/800/1000/1200/1250/1500/1600/2000/2400 2500/3000/3200/4000/5000

Input Voltage DT-3000

- Nominal:
  - 48–250 Vdc
  - 120–240 Vac 50/60 Hz
- Operating range:
  - 28–280 Vdc
  - 90–254 Vac 50/60 Hz

Power Consumption

24	48	125	250	120	240
Vdc 10 W	Vdc 10 W	Vdc 10 W	Vdc 10 W	Vac 10 VA	Vac 18 VA

Input Voltage Digitrip 3030/3031

Description	DT-3010	DT-3020
Nominal	120 Vac	240 Vac
Operating Range	70–132 Vac	140–264 Vac
Power Consumption	15 VA	15 VA

Output Trip Contacts (Trip OC/Comm., Trip Inst. and Comm. Close)

- Momentary:
  - Make 30 A AC/DC for 0.25 seconds
  - Break 0.25 A at 250 Vdc
  - Break 5 A at 120/240 Vac
- Continuous:
  - 5 A at 120/240 Vac
  - 5 A at 30 Vdc
  - Meets ANSI C37.90, Paragraph 6.7

Environmental Conditions

- Operating temperature: –22 °F to +131 °F (–30 °C to +55 °C)
- Operating humidity: 0–95% relative humidity (noncondensing)
- Storage temperature: –40 °F to +185 °F (–40 °C to +70 °C)

Auxiliary Alarm Contacts

- 5 A continuous at 120/240 Vac, 30 Vdc
- 5 A break at 120/240 Vac, 30 Vdc

Tests

- Dielectric strength, current inputs:
  - 3000 Vac for 1 minute
  - Phase-to-phase
- Seismic test: Meets requirements for UBC® and California Building Code Zone 4. ZPA = 3.5

Phase and Ground Time-Current Curves

- Thermal:
  - It (Moderately Inverse)
  - I^2t (Very Inverse)
  - I^4t (Extremely Inverse)
  - FLAT (Definite Time)
- ANSI (Per ANSI C37.112, 1996):
  - Moderately Inverse
  - Very Inverse
  - Extremely Inverse
- IEC (Per IEC 255-3, 1989):
  - IEC-A (Moderately Inverse)
  - IEC-B (Very Inverse)
  - IEC-C (Extremely Inverse)
  - IEC-D (Definite Time)

Overcurrent Functions and Pickup Ranges

Note: Consult factory for sensitive ground fault.

- Long Delay or Inverse Time Overcurrent:
  - Phase: (0.2–2.2) x I_n (29 settings)
  - Ground: (0.1–2.0) x I_n, None (26 settings)
- Short Delay:
  - Phase: (1–11) x I_n, None (25 settings)
  - Ground: (0.1–11) x I_n, None (45 settings)
- Instantaneous:
  - Phase: (1–25) x I_n, None (30 settings)
  - Ground: (0.5–11) x I_n, None (33 settings)

Time Delay Settings

- Inverse Time Overcurrent Time Multiplier:
  - Thermal: 0.2–40 (47 settings)
  - FLAT: 0.2–2 (21 settings)
  - ANSI (all): 0.1–5.0 (50 settings)
  - IEC (all): 0.05–1.00 (20 settings)
- Short Delay Time: 0.05–1.5 seconds (22 settings)

Current Monitoring

Note: Consult factory for sensitive ground fault.

- True rms sensing: three-phase and ground
- Display accuracy:
  - ±1% of Full Scale [I_n] from 0.04 x I_n to 1 x I_n
  - ±2% of Full Scale [I_n] from 1 x I_n to 2 x I_n
- Ampere demand: Average demand over 5 minute sampling window
- High load (with selectable output): 85% of Inverse Time Overcurrent setting

Timing Accuracy

- Inverse Time Overcurrent: ±10% at >1.5 x Pickup
- Short Delay Time: ±50 ms

Communications

- Eaton's PowerNet Compatible
- Built-in INCOM
- Data rate is 1200 or 9600 baud

Drawout Case

- Refer to **Page V3-T9-131** for Drawout Case Dimensions

Terminal Block

- Make/Break rating:
  - 10 A at 240 Vac nominal
  - 0.25 A at 280 Vdc maximum
- Terminal wire gauge: No. 14 to No. 10 AWG
- Screw torque requirements: 18-inch-pounds

Reference Information

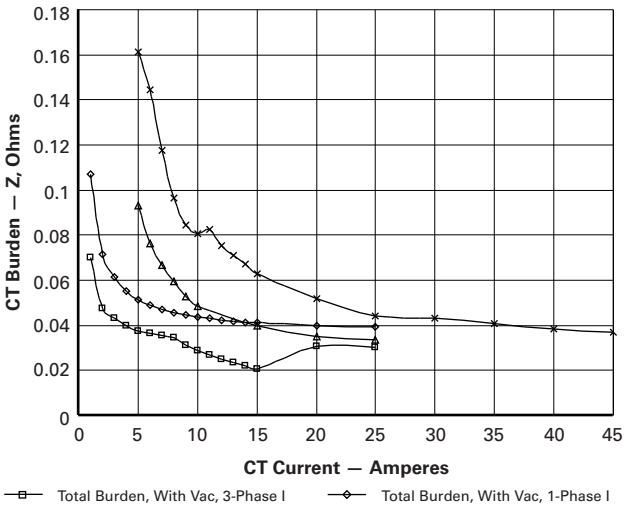
Cross-Reference

There are several products that are equivalent to the Digitrip 3000. The following lists the competitor's name and equivalent product to the Digitrip 3000. In general, the Digitrip 3000 can be used in place of the competitive product.

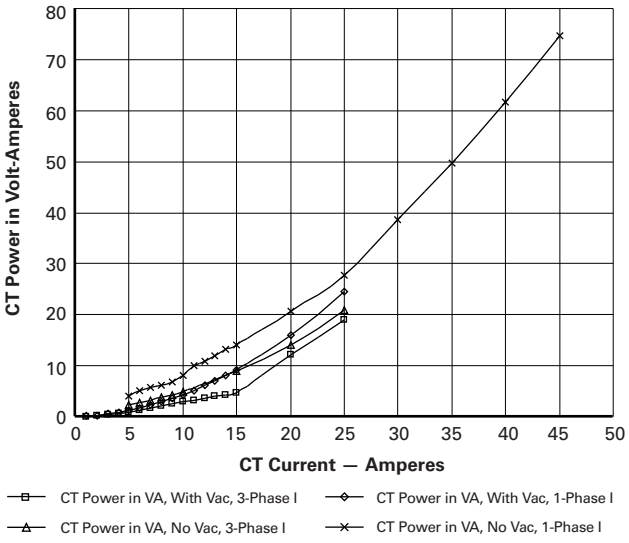
- ABB® MMCO, 51
- Basler Electric® BEI-51
- GE Multilin MDP, 735, 737
- Siemens® 7SJ 511, 7SJ 60

Trip Curve Charts

Digitrip 3000 With Dual-Source Power Supply Burden Curves



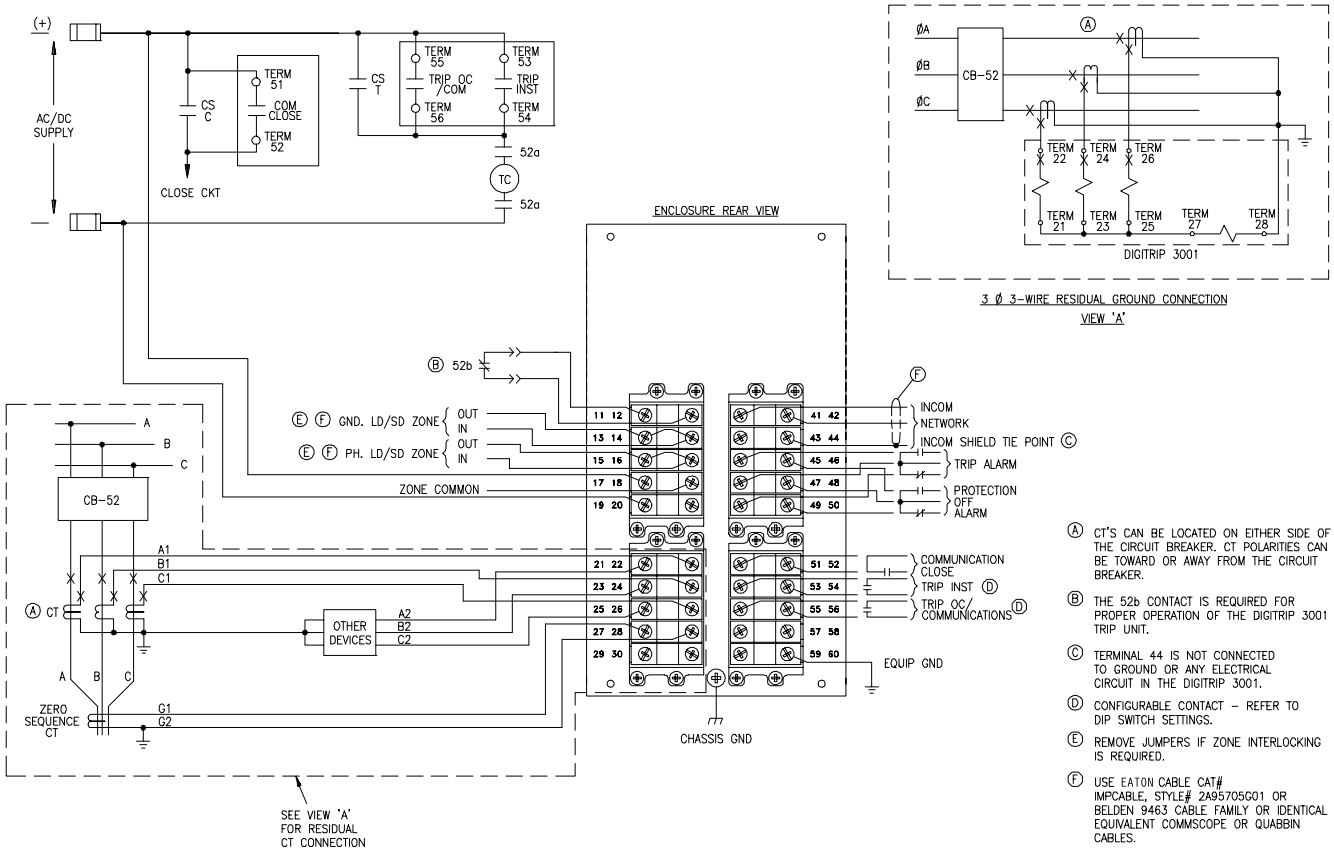
Digitrip 3000 With Dual-Source Power Supply CT Power Volt-Ampere Curves



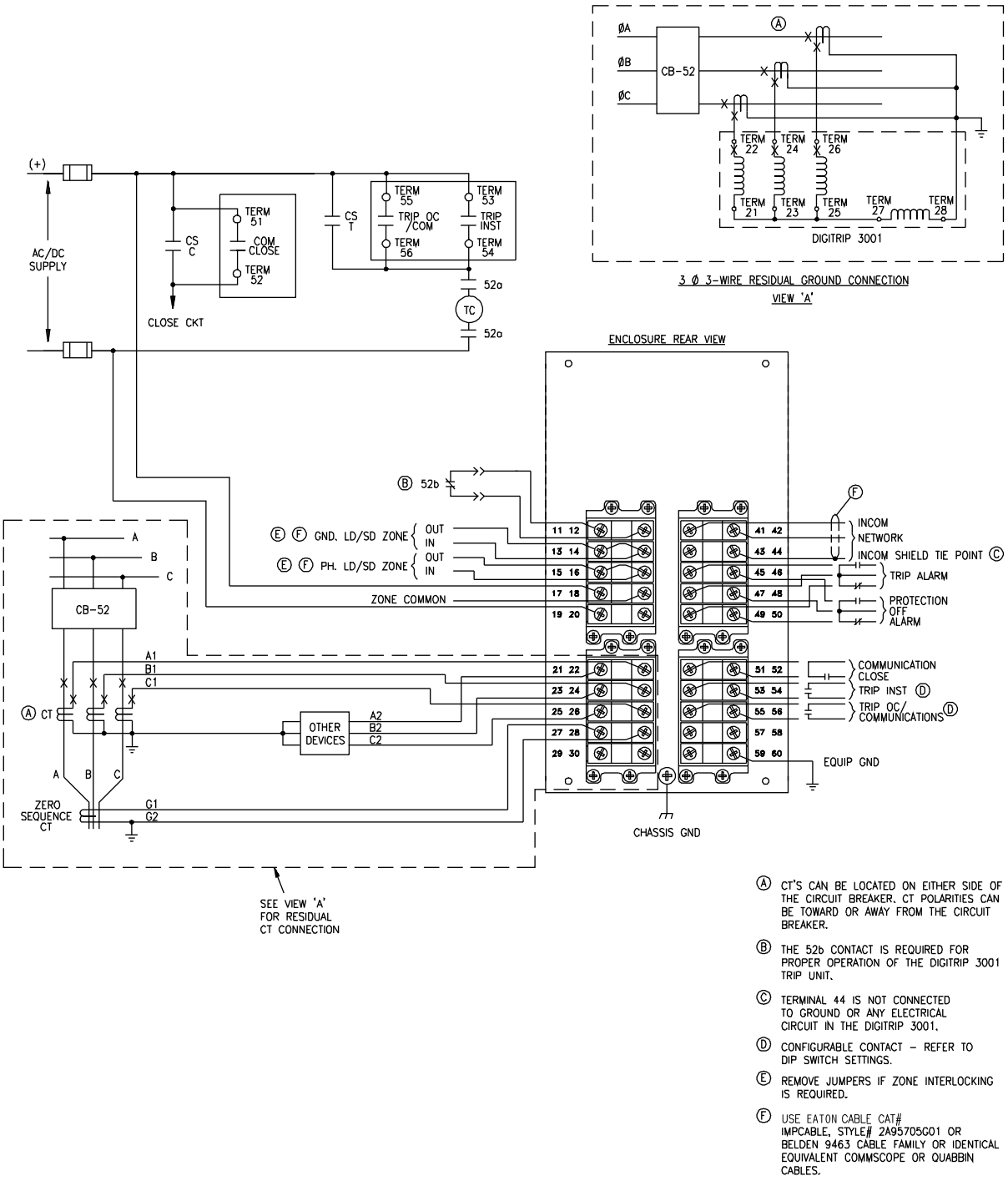
Wiring Diagrams

Digitrip 3001

Typical wiring diagram for the fixed mount version.



Digitrip 3000 Typical Wiring System



Ⓐ CT'S CAN BE LOCATED ON EITHER SIDE OF THE CIRCUIT BREAKER. CT POLARITIES CAN BE TOWARD OR AWAY FROM THE CIRCUIT BREAKER.

Ⓑ THE 52b CONTACT IS REQUIRED FOR PROPER OPERATION OF THE DIGITRIP 3001 TRIP UNIT.

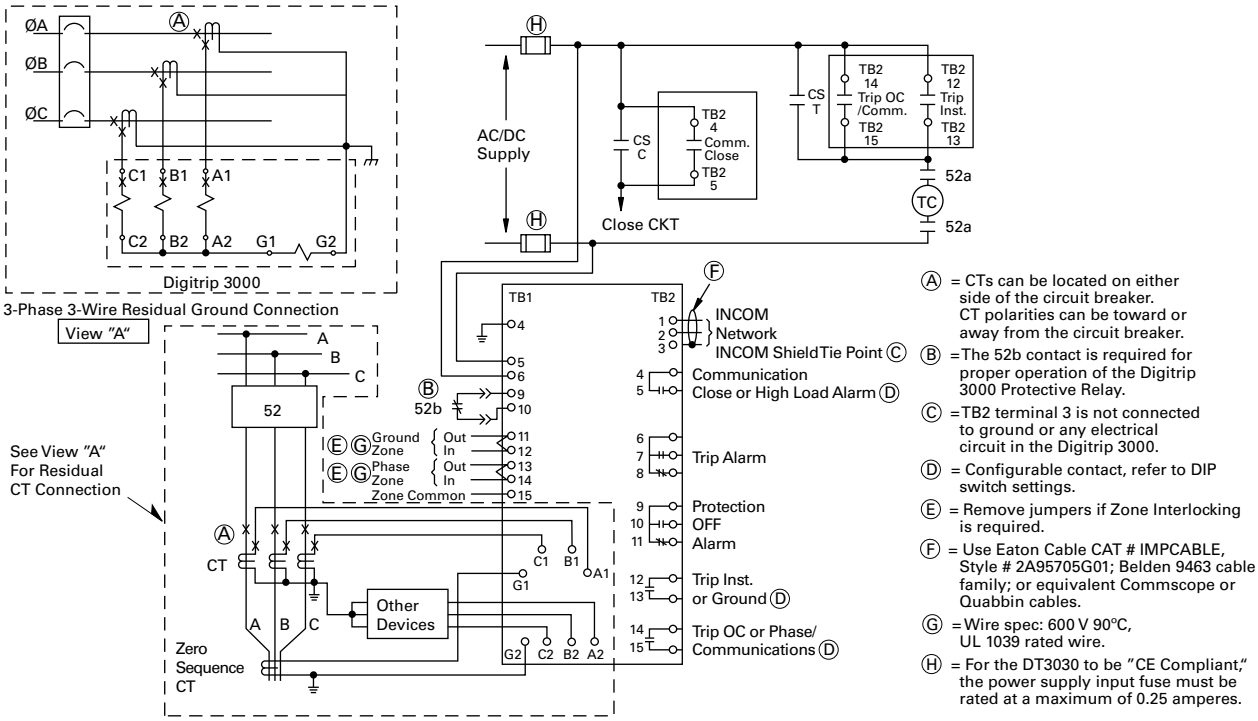
Ⓒ TERMINAL 44 IS NOT CONNECTED TO GROUND OR ANY ELECTRICAL CIRCUIT IN THE DIGITRIP 3001.

Ⓓ CONFIGURABLE CONTACT – REFER TO DIP SWITCH SETTINGS.

Ⓔ REMOVE JUMPERS IF ZONE INTERLOCKING IS REQUIRED.

Ⓕ USE EATON CABLE CAT# IMPCABLE, STYLE# 2A95705G01 OR BELDEN 9463 CABLE FAMILY OR IDENTICAL EQUIVALENT COMMSCOPE OR QUABBIN CABLES.

Digitrip 3000 Typical Wiring Diagram



Ⓐ = CTs can be located on either side of the circuit breaker. CT polarities can be toward or away from the circuit breaker.

Ⓑ = The 52b contact is required for proper operation of the Digitrip 3000 Protective Relay.

Ⓒ = TB2 terminal 3 is not connected to ground or any electrical circuit in the Digitrip 3000.

Ⓓ = Configurable contact, refer to DIP switch settings.

Ⓔ = Remove jumpers if Zone Interlocking is required.

Ⓕ = Use Eaton Cable CAT # IMPCABLE, Style # 2A95705G01; Belden 9463 cable family; or equivalent Commscope or Quabbin cables.

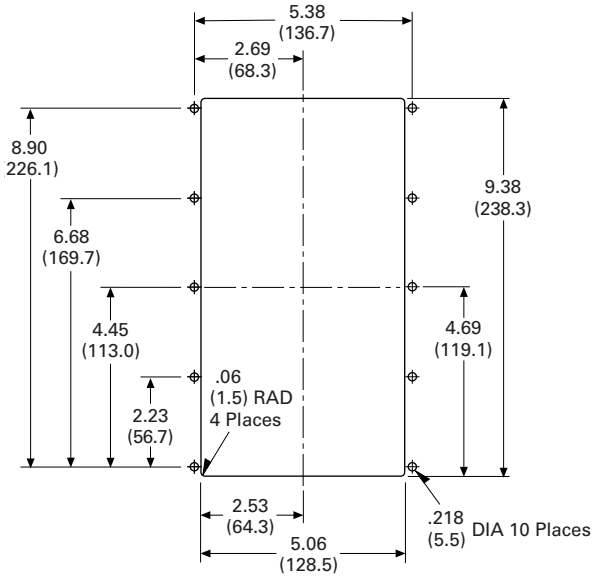
Ⓖ = Wire spec: 600 V 90°C, UL 1039 rated wire.

Ⓗ = For the DT3030 to be "CE Compliant," the power supply input fuse must be rated at a maximum of 0.25 amperes.

Dimensions

Approximate Dimensions in Inches (mm)

Drilling Pattern

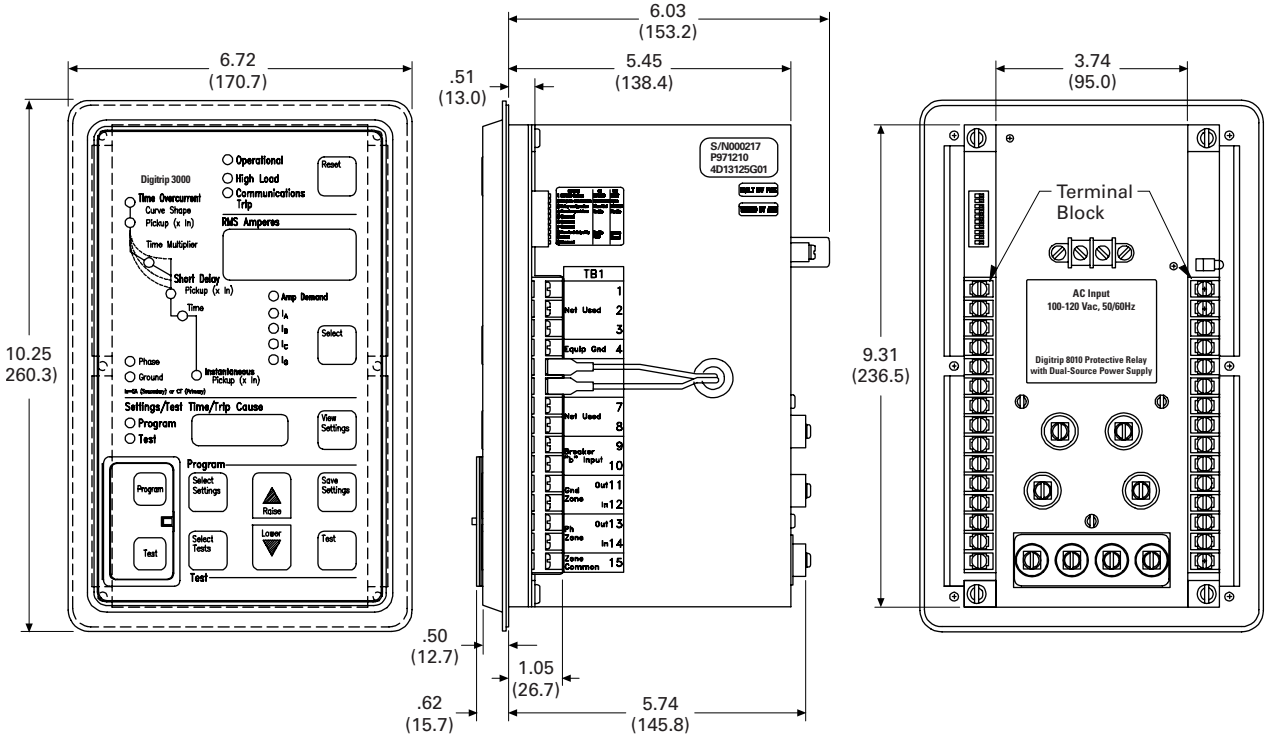


Note

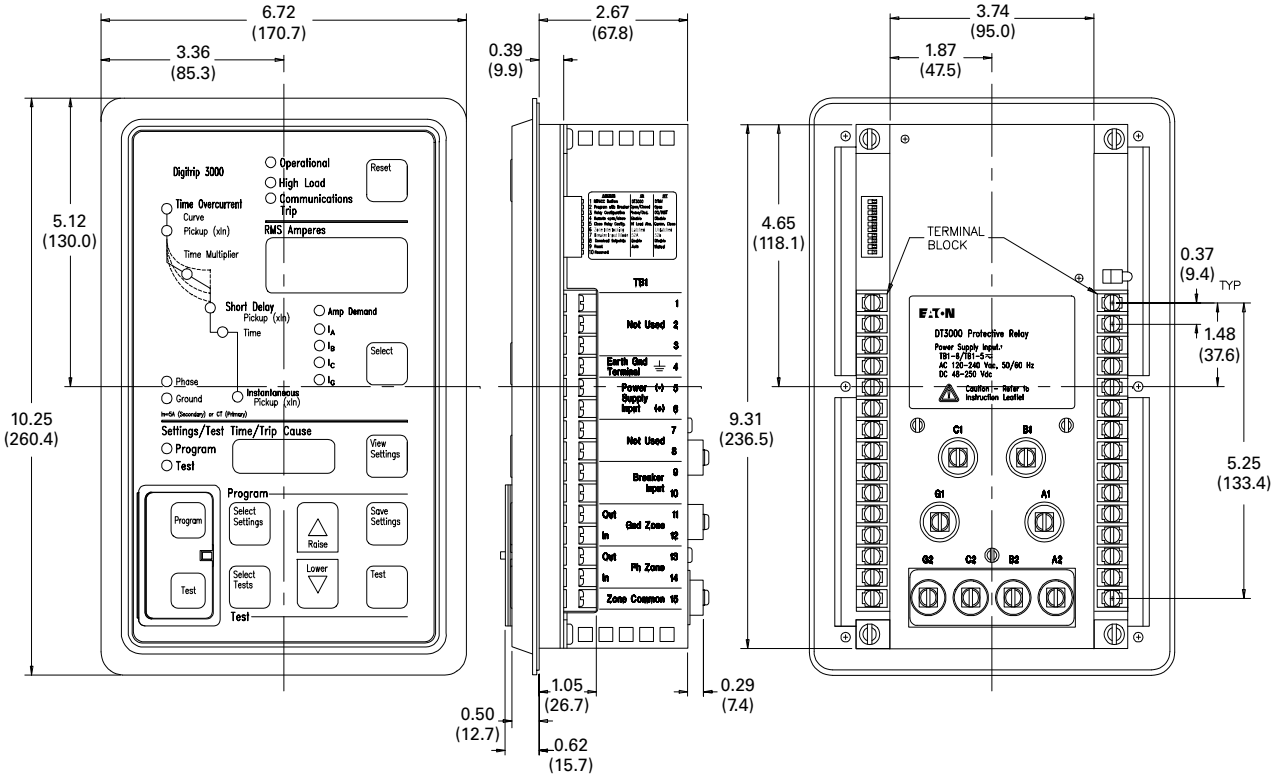
Panel cutout dimensions for all versions of the Digitrip 3000 relay.

Approximate Dimensions in Inches (mm)

Digitrip 3010/3020

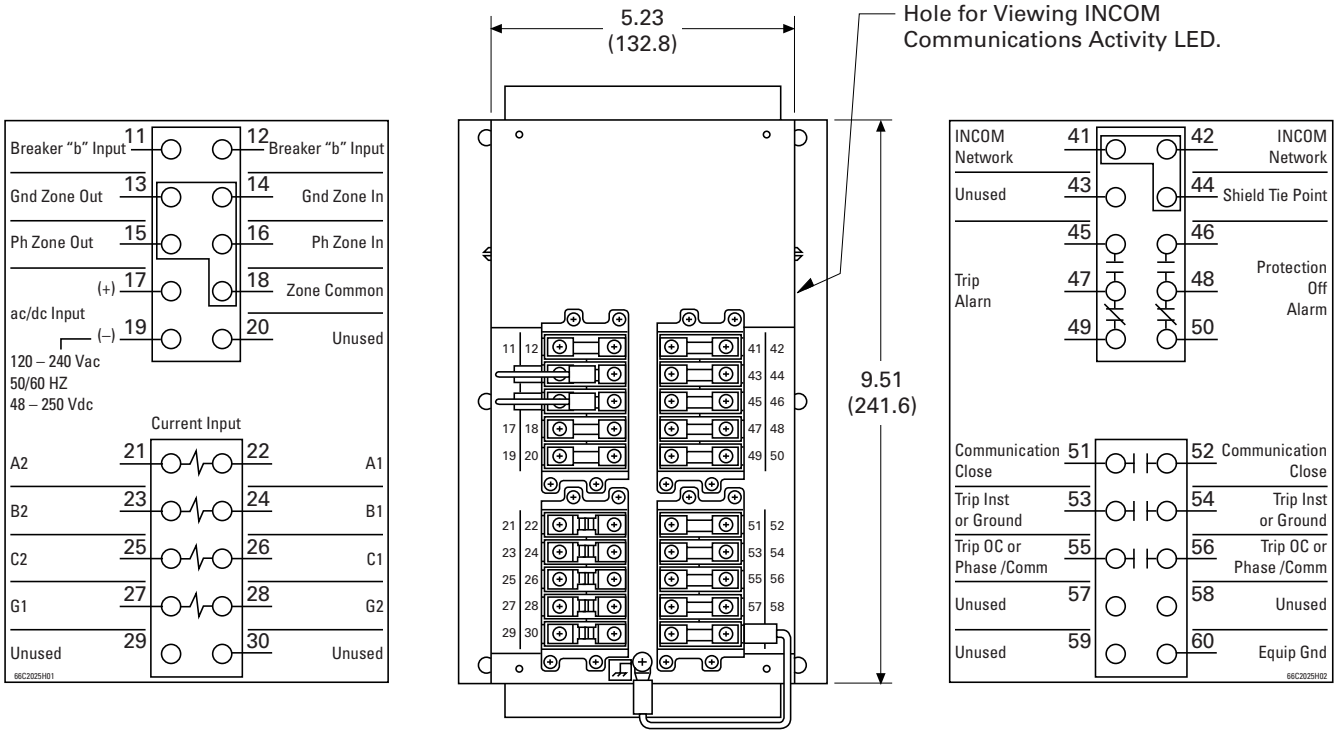


Digitrip 3000



Approximate Dimensions in Inches (mm)

Rear View of Digitrip 3001 Drawout Outer Case Terminal Layout



Digitrip 3000 Feeder Protection Relay (Fixed Case)

Height	Width	Depth	Shipping Weight Lbs (kg)
10.25 (260.4)	6.72 (170.7)	2.96 (75.2)	0.0 (0.0)

EDR-3000

Contents

9

EDR-3000 Feeder Protection

Product Description

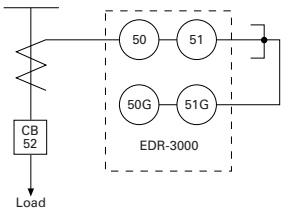
The EDR-3000 Protective Relay is a multifunction, microprocessor-based overcurrent relay designed for both ANSI and IEC applications. It is a panel-mounted, self-contained unit that operates from either AC or DC control power. The EDR-3000 design provides true rms and fundamental sensing of each phase and ground current. Only one unit is required for each three-phase circuit.

Current monitoring and operator selectable protective functions are integral to each relay. The EDR-3000 relay operates from the 5 A or 1 A secondary output of standard current transformers. Current transformer ratio information is quickly programmed into the unit via settings. This enables the relay to display metered current in primary amperes, secondary amperes or per unit values. The EDR-3000 features a user-friendly operations panel to monitor and program the relay. Operating parameters and troubleshooting information are displayed in the 128 x 64 LCD. In addition, all data and information can be communicated to a host computer equipped with PowerPort-E™. A "Communication Trip" and "Communication Close" control command can also be initiated by a host computer with an authorized access code for remote breaker operation.

Application Description

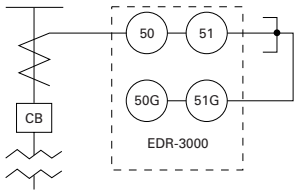
The EDR-3000 microprocessor-based relay provides reliable three-phase and ground overcurrent protection for all voltage levels. It can be used for any application where instantaneous and/or time overcurrent protection is required. It is most commonly used as primary feeder circuit protection, shown below.

Primary Feeder Circuit Protection



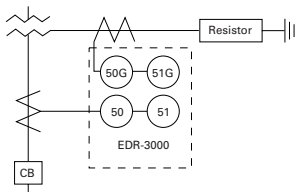
The EDR-3000 may be applied as the transformer primary protection or as backup to the differential protection, see below.

Transformer Overcurrent Protection



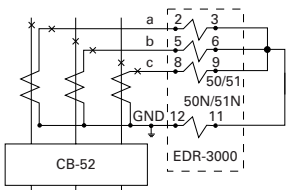
The EDR-3000 may be connected to the secondary side of a delta-wye grounded transformer with the ground element connected to a separate CT in the neutral connection of the transformer. With this connection, a lower CT ratio and a pickup setting can be used to provide more sensitive ground fault protection especially for resistance grounded systems, shown below.

Transformer Secondary Protection with Neutral CT Connection



The EDR-3000 relay has special provisions for connection in a Zone Interlocking scheme that can be used for bus protection or to improve protection coordination in a tight or close system. Zone Interlocking is described in following sections. In addition the EDR-3000 has multiple setting groups that can be used to reduce arc flash hazard with instantaneous elements.

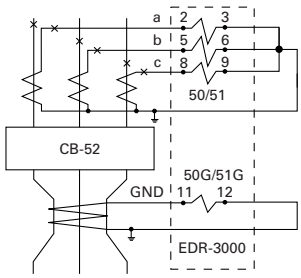
Residual Ground Connection



Overcurrent Protection

The EDR-3000 provides complete three-phase and ground protection with separate elements and settings. The relay can be used with CTs from 1 to 50,000 A of primary current and 1 or 5 A of secondary current. The CT ratio can be set independently for phase and ground, allowing the ground element to be connected in either the residual or the separate ground CT configuration, shown on below.

Separate Zero Sequence Ground CT Connection



Zone Selective Interlocking (Phase and Ground)

Note: Refer to the Ordering Information and (Catalog Ordering Information) for optional features, see **Page V3-T9-136**.

Zone Selective interlocking is a protection function to minimize equipment damage resulting from a phase or a ground fault in an area where long time and/or short time delay is in use.

When the "Ground Zone Interlocking" feature is utilized, an immediate trip is initiated when the fault is in the breaker's zone of protection, regardless of its preset time delay. When the "Phase Zone Interlocking" feature is utilized, the time overcurrent elements work as follows. The instantaneous phase element will initiate an immediate trip when the fault is in the breaker's zone of protection, regardless of its preset time delay. For the time overcurrent phase element, the current sensed by the EDR-3000 must exceed 1.5 times the pickup setting for the zone selective interlocking to initiate an immediate trip signal when the fault is in the breaker's zone of protection.

Upstream EDR-3000 protected breakers are restrained from tripping immediately by an interlocking signal from the downstream EDR-3000 relay. This interlocking signal requires only a pair of wires from the downstream breaker to the upstream breaker. It provides standard coordinated tripping when the fault is located outside the zone of protection.

In the sample zone interlocking system shown below, circuit breakers A, B and C are equipped with EDR-3000 overcurrent relays.

Fault Location Zone 3

Note: For the time overcurrent phase element, the current sensed by the EDR-3000 must exceed 1.5 times the pickup setting for the zone selective interlocking to initiate an immediate trip signal when the fault is in the breaker's zone of protection.

If a fault occurs at a point in Zone 3, the EDR-3000 of downstream breaker C senses the fault and sends a restraining signal to the upstream EDR-3000 of feeder breaker B. Having received this signal, the EDR-3000 of feeder breaker B withholds its trip command. As a result, only downstream breaker C is tripped.

Fault Location Zone 2

Note: For the time overcurrent phase element, the current sensed by the EDR-3000 must exceed 1.5 times the pickup setting for the zone selective interlocking to initiate an immediate trip signal when the fault is in the breaker's zone of protection.

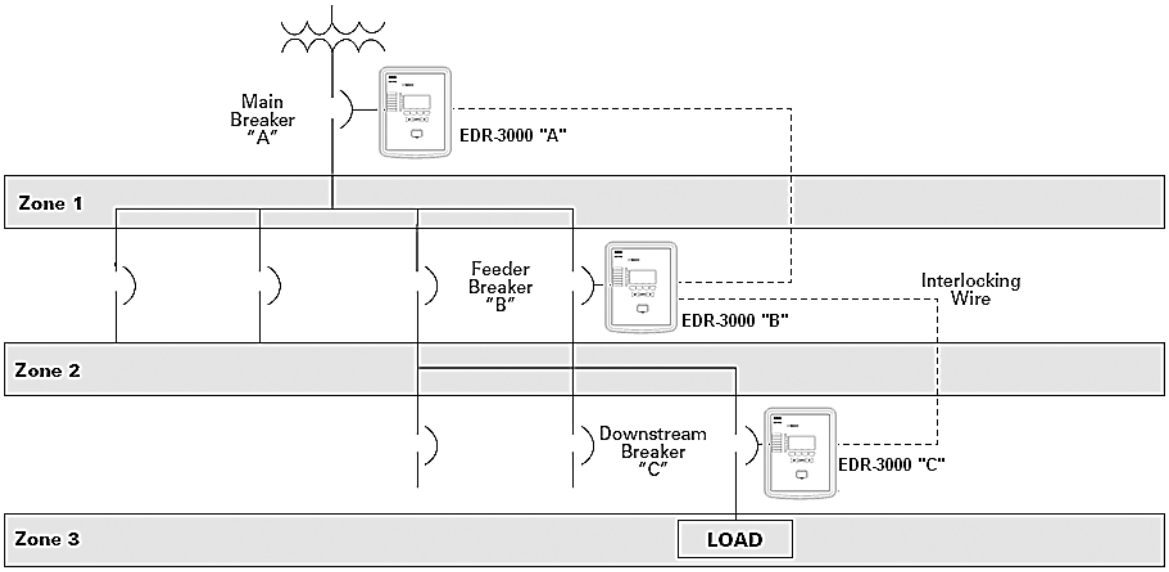
If a fault occurs at a point in Zone 2, the EDR-3000 of feeder breaker B senses the fault and sends a restraining signal to the upstream EDR-3000 of main breaker A. The EDR-3000 of the downstream breaker C does not see this fault since it is situated on the downstream side of the fault. As a result, the EDR-3000 of downstream breaker C does not send a restraining signal to the EDR-3000 of feeder breaker B. Since it did not receive a restraining signal from the EDR-3000 of downstream breaker C, the EDR-3000 of feeder breaker B identifies that the fault is in Zone 2 and immediately trips feeder breaker B, regardless of its time setting.

Fault Location Zone 1

Note: For the time overcurrent phase element, the current sensed by the EDR-3000 must exceed 1.5 times the pickup setting for the zone selective interlocking to initiate an immediate trip signal when the fault is in the breaker's zone of protection.

If a fault occurs in Zone 1, no restraining signal is received by the Digitrip of main breaker A. As a result, main breaker A is immediately tripped by its EDR-3000 overcurrent relay, regardless of its time setting.

Sample Zone Selective Interlocking System



Features, Benefits and Functions

Applications

- Provides reliable three-phase and ground overcurrent protection for all voltage levels
- Primary feeder circuit protection
- Primary transformer protection
- Backup to differential protection
- May be used where instantaneous and/or time overcurrent protection is required
- Ground element capable of residual, zero sequence or external source connections

Protection Functions

- Breaker failure (50BF)
- Phase overcurrent protection per time-current curve (51-1, 51-2, 51-3)
- Calculated ground fault protection per time-current curve (51R-1, 51R-2)
- Independent measured ground or neutral fault protection per time-current curve (51X-1, 51X-2)
- Phase instantaneous overcurrent (50-1, 50-2, 50-3)
- Calculated ground or neutral instantaneous overcurrent (50R-1, 50R-2)
- Independent measured ground or neutral instantaneous overcurrent (50X-1, 50X-2)
- Curve shapes: ANSI, IEC, or thermal curves (11 thermal curves)
- Instantaneous or time delay reset
- True rms or fundamental sensing of each phase and ground current
- Zone selective interlocking (phase and ground) or reverse blocking for bus protection

Note: Refer to the Ordering Information and **Page V3-T9-136** (Catalog Ordering Information) for optional features.

Metered Values

- rms and fundamental phase currents
- rms and fundamental ground currents
- Maximum, minimum and average rms and fundamental phase currents
- Maximum, minimum and average rms and fundamental ground currents

Monitored and Data Recording Values

- Trip circuit monitoring

Note: Refer to the Ordering Information and **Page V3-T9-136** (Catalog Ordering Information) for optional features.

- Breaker wear (accumulated interrupted current)
- Fault data logs (up to 20 events)
- Sequence of event recorder (1 ms time stamp, last 300 events)
- Waveform capture (7200 cycles total)
- Trip Cause displays fault recorder data on HMI after fault event
- CT supervision

Control Functions

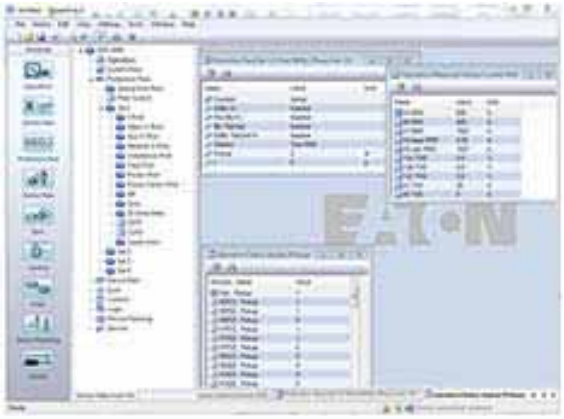
- Remote open/close
- Programmable I/O
- Programmable LEDs
- Multiple setting groups (up to four)

Communication Software

- Local HMI
- Front RS-232 port
- Rear RS-485 port
- Protocols
  - Modbus RTU
  - Modbus TCP (option)
  - IEC 61850 (option)
  - IRIG-B (option)
  - SNTP (option)

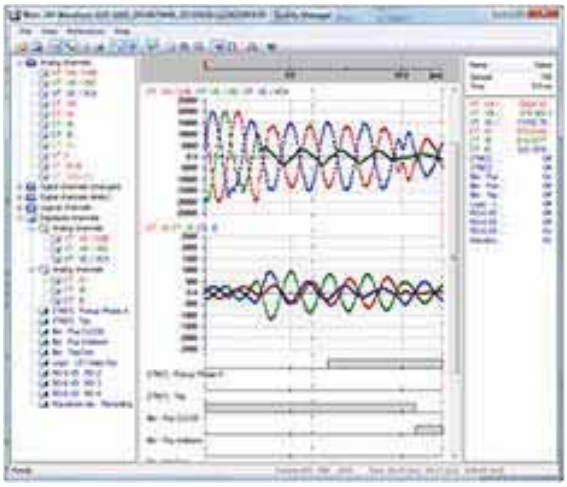
PowerPort-E

PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.



Waveform Capture (Quality Manager)

The EDR-3000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The EDR-3000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles. The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



Standards and Certifications

- Generic standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product standard:
  - EC 60255-6
  - EN 50178
- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 14-95 (Industrial Control Equipment)
- ANSI C37.90
- UL, CSA, CE

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the EDR-3000. For example, if the catalog number is EDR-3000-2A0BA1, the device would have the following:

EDR-3000

(A)–Four digital inputs, four output relays

(0)–Phase current 5 A / 1 A, Ground Current 5 A / 1 A, Power supply: 19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without conformal coating

(1)–Projection panel mount

Relay Removable Terminals

EDR-3000-2A 0 B A 1

Hardware Option 1
- **A** = 4 digital inputs, 4 outputs, removable terminals
- **B** = 8 digital inputs, 6 outputs, removable terminals, trip coil monitor
- **C** = 4 digital inputs, 4 outputs, removable terminals, zone interlocking and IRIG-B

Hardware Option 2
- **0** = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –13 °F to 158 °F (–25 °C up to +70 °C)
- Operating temperature: –4 °F to 140 °F (–20 °C up to +60 °C)
- Permissible humidity at ann. average: <75% rel. (on 56d up to 95% rel.)
- Permissible Installation altitude:
  - <2000 m (6561.67 ft) above sea level
  - If 4000 m (13,123.35 ft) altitude apply, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP30

Routine Test

- Insulation test according to IEC 60255-5: All tests to be carried out against ground and other input and output circuits
- Aux. voltage supply, digital inputs, current measuring inputs, signal relay outputs: 2.5 kV (eff)/50 Hz
- Voltage measuring inputs: 3.0 kV (eff)/50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Material, housing: aluminum extruded section
- Material, front panel: aluminum/foil front
- Mounting position: horizontal (±45° around the X-axis must be permitted)

Plug-in Connector with Integrated Short-Circuiter (Conventional Current Inputs)

- Nominal current: 1 A and 5 A
- Continuous loading capacity: 4 x I_n/ continuously
- Overcurrent withstand: 30 x I_n/10 s
- 100 x I_n/1 s
- 250 x I_n/10 ms (1 half-wave)
- Screws: M4, captive type according to VDEW
- Connection cross-sections:
  - 2 x 2.5 mm^2 (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm^2 (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm^2 (2 x AWG 10) with ring cable sleeve or cable sleeve

Voltage Supply

- Aux. voltage: 19–300 Vdc/ 40–250 Vac
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage communication is permitted to be interrupted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse 5 x 20 mm (approx. 1/5 in x 0.8 in) according to IEC 60127
  - 3.5 A time-lag miniature fuse 6. 3 x 32 mm (approx. 1/4 in x 1 1/4 in) according to UL 248-14

Power Consumption

- Power supply range: Power consumption in idle mode
- Max. power consumption
- 19–300 Vdc: 6 W 8.5 W
- 40–250 Vac
- For frequencies of 40–70 Hz: 6 W 8.5 W

Real-Time Clock

- Running reserve of the real-time clock: 1 year min.

Display

- Display type: LCD with LED background illumination
- Resolution graphics display: 128 x 64 pixel
- LED-type: two colored, red/green
- Number of LEDs, housing B1: 8

Digital Inputs

- Max. input voltage: 300 Vdc/270 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Fallback time: <30 ms (safe state of the digital inputs)
- Four switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac/Vdc, 230 Vac/Vdc Un = 24 Vdc
  - Switching threshold 1 ON
    - Switching threshold 1 OFF
    - Min. 19.2 Vdc
    - Max. 9.6 Vdc
    - Un = 48 V/60 Vdc
  - Switching threshold 2 ON
    - Switching threshold 2 OFF
    - Min. 42.6 Vdc
    - Max. 21.3 Vdc
    - Un = 110/120 Vac/Vdc
  - Switching threshold 3 ON
    - Switching threshold 3 OFF
    - Min. 88.0 Vdc/ 88.0 Vac
    - Max. 44.0 Vdc/ 44.0 Vac
    - Un = 230/240 Vac/Vdc
  - Switching threshold 4 ON
    - Switching threshold 4 OFF
    - Min. 184 Vdc/ 184 Vac
    - Max. 92 Vdc/92 Vac
- Terminals: screw-type terminal

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - up to 40 x I_n (phase currents)
  - up to 25 x I_n (ground current standard)
  - up to 2.5 x I_n (ground current sensitive)
- Continuous loading capacity: 4 x I_n/ continuously
- Overcurrent proof:
  - 30 x I_n/10 s
  - 100 x I_n/1 s
  - 250 x I_n/10 ms (1 half-wave)
- Power consumption: Phase current inputs
  - at I_n = 1 A S = 0.15 MVA
  - at I_n = 5 A S = 0.15 MVA
- Ground current input
  - at I_n = 1 A S = 0.35 MVA
  - at I_n = 5 A S = 0.35 MVA
- Frequency range: 50 Hz/ 60 Hz ±10%
- Terminals: Screw-type terminals with integrated short-circuiters (contacts)

Binary Output Relays

- Continuous current: 5 A AC/DC
- Switch-on current: 25 A AC/DC for 4 s
- Max. breaking current: 5 A AC up to 125 Vac
- 5 A DC up to 50 V (resistive)
- 0.2A DC at 300 V
- Max. switching voltage: 250 Vac/300 Vdc
- Switching capacity: 2000 VA
- Contact type: 1 changeover contact
- Terminals: Screw-type terminals

Front Interface RS-232

- Baud rates: 115,200 baud
- Handshake: RTS and CT
- Connection: 9-pole D-Sub plug

RS-485

- Master/slave: slave
- Connection: 6 screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)

Tolerances of the Real-Time Clock

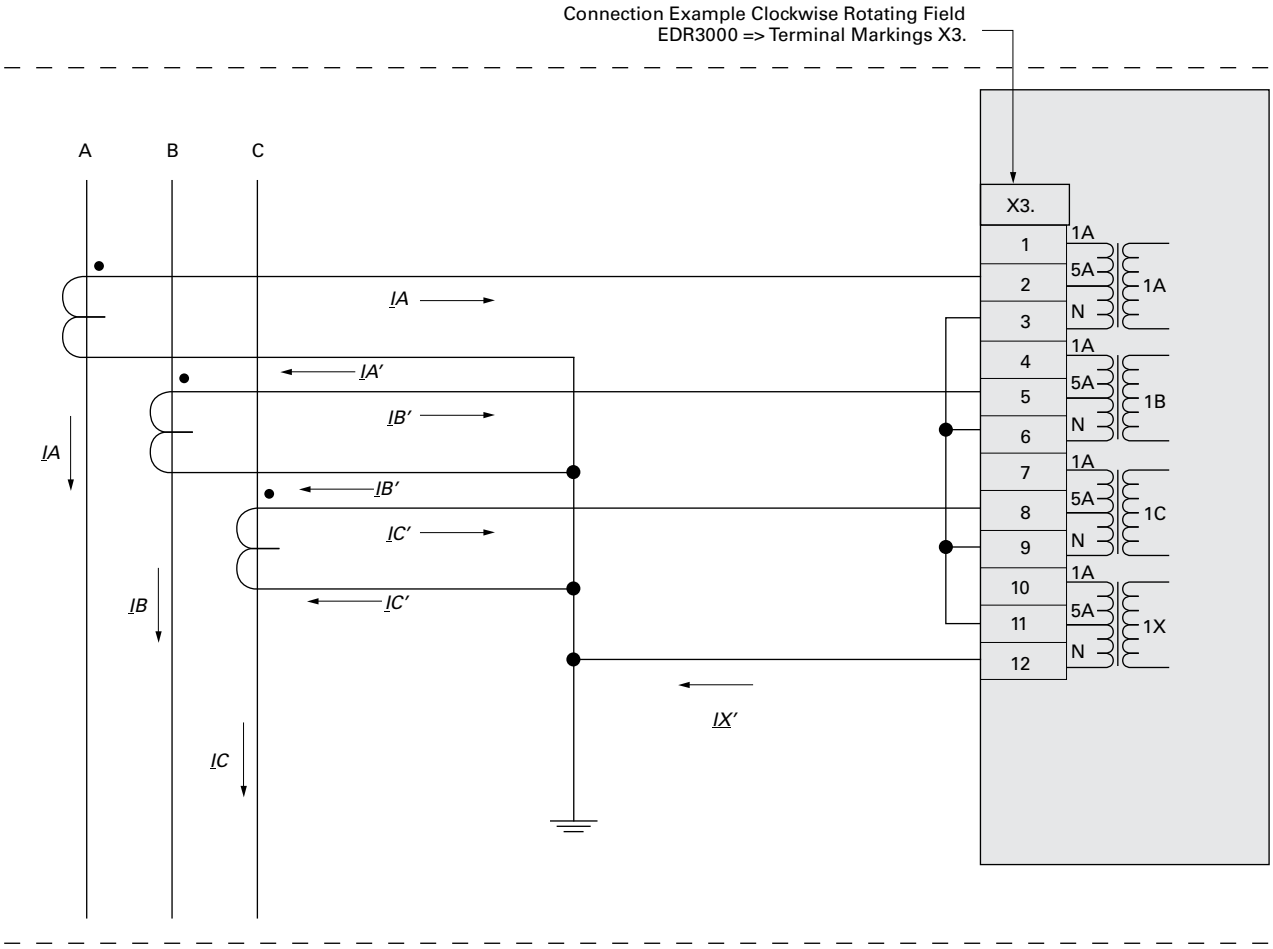
- Resolution: 1 ms
- Tolerance: <1 minute/ month (+20 °C)

Measuring Accuracy

- Max. measuring range: up to 40 x I_n (phase currents) up to 25 x I_n (ground current standard)
- Frequency range: 50 Hz/ 60 Hz ± 10%
- Accuracy: Class 0.5
- Amplitude error if I < I_n: ±0.5% of the rated value
- Amplitude error if I > I_n: ±0.5% of the measured value
- Amplitude error if I > 2 I_n: ±1.0% of the measured value
- Resolution: 0.01 A
- Harmonics up to 20% 3rd harmonic ±2% up to 20% 5th harmonic ±2%
- Frequency influence < ±2%/Hz in the range of ±5 Hz of the parameterized nominal frequency
- Temperature influence <±1% within the range of 0 °C up to +60 °C

Wiring Diagrams

EDR-3000

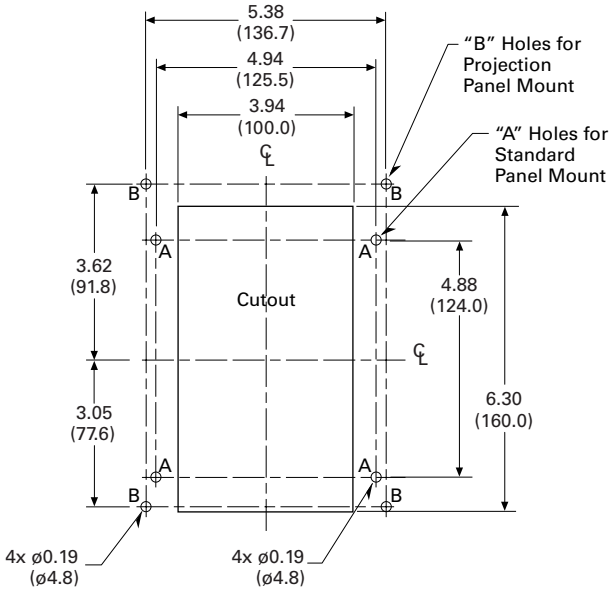


Three-Phase Current Measurement; Inom Secondary = 5 A
Ground Current Measuring via Residual Connection; IGnom Secondary = 5 A

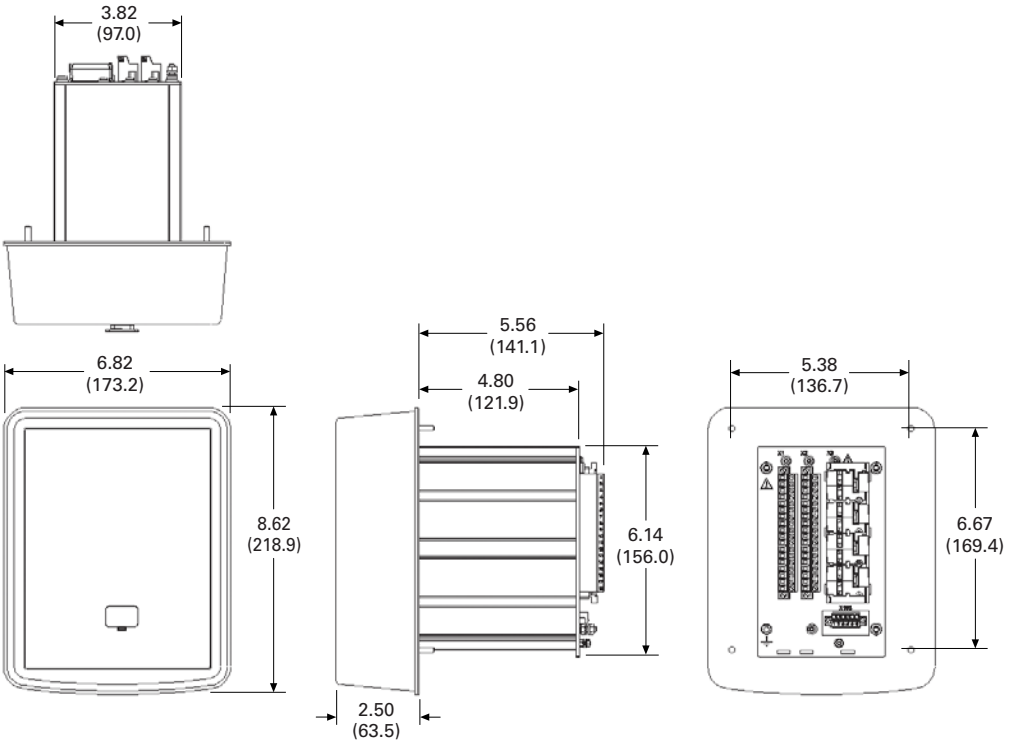
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Pattern

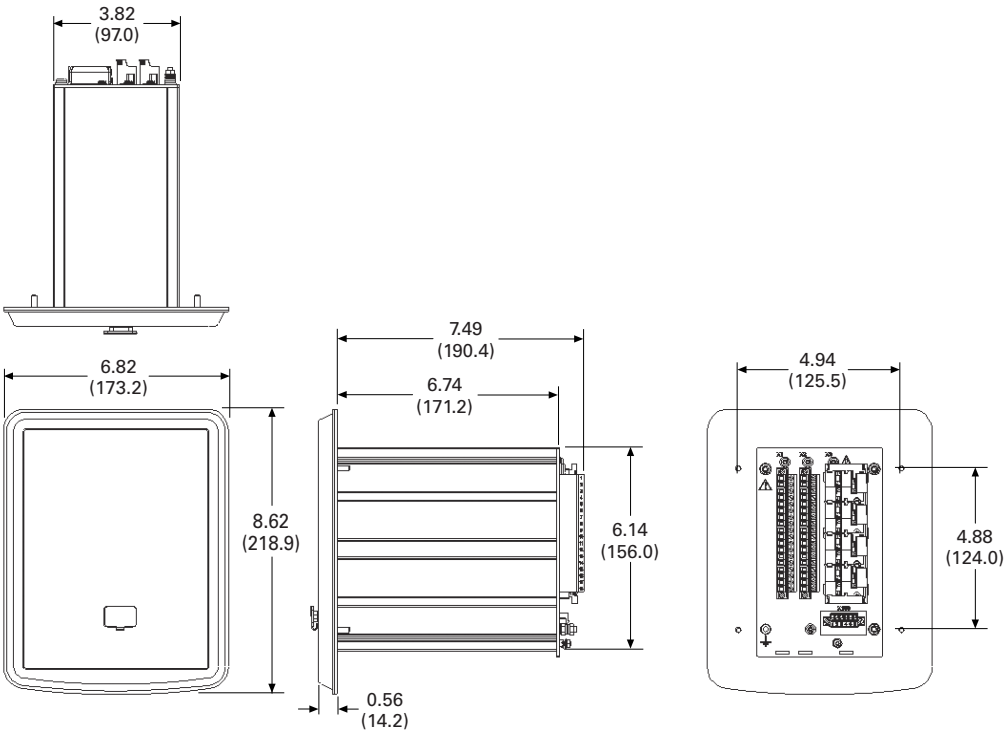


Projection Mounting



Approximate Dimensions in Inches (mm)

Standard Mounting



EDR-3000

Width	Height	Depth
6.82 (173.2)	8.62 (218.9)	7.49 (190.2) ①

EDR-3000 Housing B1

Width	Height	Depth	Shipping Weight Lbs (kg)
5.57 (141.5)	7.21 (183.0)	8.19 (208.0) ②	5.3 (2.4)

Notes

① Depth behind panel with projection mounted enclosure.

② Includes terminals.

EDR-5000 Distribution Protection Relay

Contents

EDR-5000 Distribution Protection Relay

Product Description

Eaton's EDR-5000 distribution protection relay is a multi-functional, microprocessor-based relay for feeder circuits of all voltage levels. It may be used as a primary protection on feeders, mains and tie circuit breaker applications; or as backup protection for transformers, high voltage lines and differential protection. The relay is most commonly used on medium voltage switchgear applications.

The EDR-5000 distribution protection relay provides complete current, voltage, and frequency protection and metering in a single, compact case. The relay has four current inputs rated for either 5 amperes or 1 ampere and four voltage inputs. Three of the voltage inputs are to be connected to the three-phase power voltage for voltage protection and for metering. They can be connected in wye-ground or open delta configuration. The fourth voltage is for independent single-phase undervoltage/ overvoltage protection, sync-check or ground protection for an ungrounded system.

The maintenance mode password protected soft key can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only. The multiple setting groups can also be changed, via communications or a digital input.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. 14 programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 communication port on the back is standard for local area networking using Modbus-RTU. An optional Ethernet port and protocols are available.

The EDR-5000 distribution protection relay includes programmable logic functions. Logic gates and timers may be defined and arranged for customized applications. Programmable logic control functions make the EDR-5000 relay ideally suited for main-tie-main and main 1/main 2 transfer schemes. Flash memory is used for the programming and all settings are stored in nonvolatile memory.

The relay allows for four preprogrammed setting groups which can be activated through software or contact input.

Flash memory is used for the programming and all settings are stored in nonvolatile memory. The relay allows for four preprogrammed setting groups which can be activated through software, the display or a contact input.

The EDR-5000 distribution protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/maximum values, load profiles, breaker wear information and oscillography data.

The EDR-5000 has eight programmable binary inputs, 2 normally opened and 8 Form C heavy-duty outputs and one form C signal alarm relay. It can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Application Description

The Eaton's EDR-5000 distribution protection relay has been designed for maximum user flexibility and simplicity. The base relay includes all the standard current and voltage protection and metering functions.

Applications include distribution feeder protection, primary or backup protection for transformers and generators, utility interconnections and transfer schemes.

Features, Benefits and Functions

Directional Overcurrent Protection

The EDR-5000 distribution protection relay provides complete three-phase and ground directional overcurrent protection. There are 8 independent ground overcurrent elements. The ground elements "X" use the independently measured ground (or neutral) current from a separate current-sensing input. The ground elements "R" uses a calculated 3Io residual current obtained from the sum of the three-phase currents. This calculated current could be used for either the neutral or ground current in a three-phase, four-wire system. Each of the phase and ground overcurrent elements can be selected to operate based on fundamental or RMS current.

Phase direction is a function used to supervise all phase current elements (50, 51). A quadrature voltage is compared to a corresponding phase current to establish the direction of the fault. This function is selectable to operate in the forward, reverse or both directions. Ground direction is used to supervise ground current elements and is accomplished by using ground, negative sequence or residual currents supervised by zero, negative or positive sequence voltages or ground current. This function is selectable to operate in forward, reverse or both directions.

Voltage Restrained Overcurrent

Voltage restraint reduces the overcurrent pickup level (51P[3]). This modification of the pickup overcurrent level is compared to the corresponding phase input voltage. The EDR-5000 uses the simple linear model below to determine the effective pickup value.

Sync Check

The sync check function is provided for double-ended power source applications. The sync check monitors voltage magnitude, phase angle and slip frequency between the bus and line. It also incorporates breaker close time, dead bus dead line, dead bus live line and live bus live line features.

Reverse Power

Reverse power provides control for power flowing through a feeder. There are three elements to be configured: Operate in forward or reverse; or, under or over power conditions. Reverse power is typically applied to generator or motor applications while under power is generally applied to load or generation loss.

Reverse VARs

Reverse vars can be used to detect loss of excitation in synchronous machines. There are three elements to be configured: operate in forward or reverse; or, under or over vars conditions.

Inverse-Time Characteristics

There are 11 user-selectable inverse-time overcurrent curve characteristics. The user can select from the ANSI, IEC or thermal curve families and can select instantaneous or time delay reset characteristics.

Breaker Failure

The EDR-5000 distribution protection relay includes a breaker failure (50BF, 62BF) function that can be initiated from either an internal or external trip signal. This is an independent element that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Voltage Protection

The EDR-5000 distribution protection relay has four voltage-input circuits. There is a three-phase set designated as Main Voltage (M) and a single-phase voltage circuit designated as Auxiliary Voltage (A). Both include undervoltage (27) and overvoltage (59) protection. The three-phase voltage protection can be set to operate on a single-phase, two out of three phases, or all three-phase logic. The Main VTs also provide phase voltage unbalance/reversal (47 negative sequence) protection. Each element has an independent threshold set point and adjustable time delay.

Ground Voltage Protection

In high impedance grounded systems, ground fault protection is provided by the detection of zero sequence voltage (3Vo) voltage in the neutral of the transformer by an overvoltage element (59N) connected to the secondary of the distribution grounding transformer, or in the secondary of a Wye-Broken Delta transformer used when the neutral is not accessible or in Delta system. In the EDR-5000 we can measure this zero sequence voltage through the 4th voltage input; the 59N element has to be desensitized for 3rd harmonic voltages that can be present in the system under normal operation.

Flexible Phase Rotation

The EDR-5000 distribution protection relay can be applied on either an A-B-C or A-C-B phase rotation. A user setting permits correct operation and indication of the actual system configuration.

Frequency Protection

The EDR-5000 relay provides 6 frequency elements than can be used to detect under/over frequency, rate of change, and a vector surge (decoupling of two systems) protection on the Main VT inputs. Each element has an independent threshold set point and adjustable time delay.

Autoreclosing Logic

The EDR-5000 provides a 6 shot-recloser scheme. Autoreclosing is normally used by the utilities in their distribution and transmission lines, but it can be used in commercial and industrial applications with long overhead lines. Nearly 85% of the faults that occur on overhead lines are transient in nature. Tripping of a circuit breaker normally clears a transient fault and reclosing of the circuit breaker restores power back to the circuit.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communication or via a digital Input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Protection Features

- Phase overcurrent elements:
  - Three instantaneous elements with timers (50P[1], 50P[2] and 50P[3])
  - Three inverse time overcurrent elements (51P[1], 51P[2] and 51P[3])
  - 11 standard curves
  - Instantaneous or time delay reset
  - Voltage Restraint (51P[2] and 51P[3])
  - Directional Control (All Elements)
- Ground overcurrent elements:
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
  - Directional control (all elements)
- Breaker failure (50BF)
- Phase unbalance negative sequence overcurrent (46[1], 46[2])
- Phase voltage unbalance and sequence protection (47[1], 47[2])
- Main three-phase under/overvoltage (27M[1], 27M[2], 59M[1], 59M[2])
- Auxiliary single-phase under/overvoltage (27A[1], 27A[2], 59A[1], 59A[2])
- Ground fault overvoltage relay (59N[1], 59N[2])
- 6 Frequency elements that can be assigned to: over frequency, under frequency, rate of change, or vector surge (81[1], 81[2], 81[3], 81[4], 81[5], 81[6])
- Apparent and displacement power factor (55A[1], 55A[2], 55D[1], 55D[2])
- Forward and Reverse Watts (32[1], 32[2], 32[3])
- Forward and Reverse VARs (32V[1], 32V[2], 32V[3])
- Sync check (25)
- Autoreclosing (79)
- Zone interlocking for bus protection (87B)
- Switch onto fault protection
- Cold load pickup

Metering Features

- Amperes: Positive, negative and zero sequence
- Ampere demand
- Volts: Positive, negative and zero sequence
- Phase angles
- Volt-amperes and VA demand
- Watts and kW demand
- kWh (forward, reverse, net)
- VARs and kVAR demand
- kVARh (lead, leg and net)
- Power factor
- Frequency
- % THD V and I
- Magnitude THD V and I
- Minimum/maximum recording.
- Sync Values
- Trending (load profile over time)

Monitoring Features

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (7200 cycles total)
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)
- Trip cause displays fault reorder data on HMI after fault event

Control Functions

- Breaker open/close
- Remote open/close
- Programmable I/O
- Programmable Logic
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Communication Features

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port:
  - RS-232
- Remote communication port:
  - RS-485
  - Ethernet RJ-45
- Protocols:
  - Modbus-RTU
  - Modbus-TCP (optional)
  - IEC-61850 (optional)
- Configuration software

Monitoring and Metering

Sequence of Events Records

The EDR-5000 protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO in chronological order.

Trip Log

The EDR-5000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents and voltages at the time of the fault.

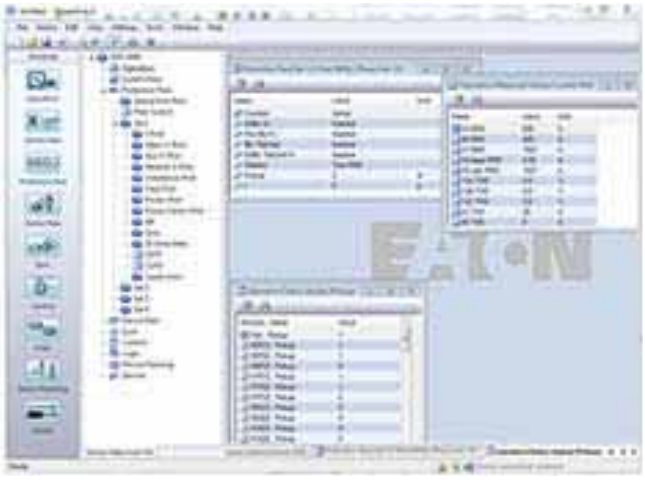
PowerPort-E

PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.

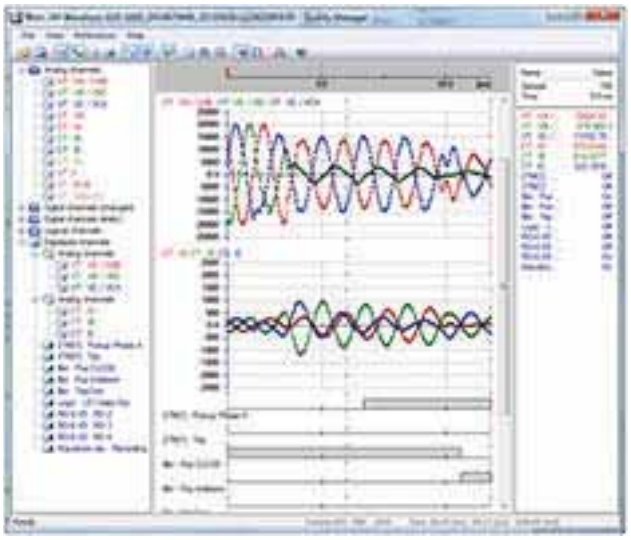
Waveform Capture (Quality Manager)

The EDR-5000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic and contact inputs. The EDR-5000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles.

The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



PowerPort-E



Waveform Capture (Quality Manager)

Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. 17 programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Load Profiling/Trending

The EDR-5000 relay automatically records selected quantities into non-volatile memory every 5, 10, 15, 30 or 60 minutes, depending on the trending report setting.

Programmable I/O

The EDR-5000 distribution protection relay provides heavy-duty, triprated, 2 normally open and 8 Form C contacts. Two isolated inputs can be used for monitoring the trip circuit. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (failsafe) mode.

There are eight user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

Programmable Logic

The EDR-5000 distribution protection relay provides logic gates and timers that the user can customize for special or unique applications. Each gate can be assigned a logic function of either AND, OR, NAND or NOR. Each gate can have a maximum of four input signals and each input signal can be required to be a NOT. Input signals can be external inputs received via the binary inputs or internal values associated with the protection, alarm or metering set points. Each gate has a unique output assignment and designation that can be used as the input to another gate. There are 24 independent timers that have adjustable pickup and dropout delay settings.

Standards and Certifications

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90
- UL-listed file: e217753

Listed

Standards

High Voltage Tests (IEC 60255-6)

- High frequency interference test:
  - IEC 60255-22-1 Class 3
    - Within one circuit—1 kV/2 s
    - Circuit to ground—2.5 kV/2 s
    - Circuit to circuit—2.5 kV/2 s
- Insulation voltage test:
  - IEC 60255-5, EN 50178
    - All circuits to other circuits and exposed conductive parts: 2.5 kV (eff.)/50 Hz, 1 min.
    - Except interfaces: 1.5 kV DC, 1 min.
    - Voltage measuring input: 3 kV (eff.)/ 50 Hz, 1 min.
- Impulse voltage test:
  - IEC 60255-5: 5 kV/0.5J, 1.2/50 µs

EMC Immunity Tests

- Fast transient disturbance immunity test (burst):
  - IEC 60255-22-4: Power supply, mains inputs—±4 kV, 2.5 kHz
  - IEC 61000-4-4 Class 4: Other inputs and outputs—±2 kV, 5 kHz (coupling network)
  - ANSI C37.90.1: ±4 kV, 2.5 kHz (coupling clamp)
- Surge Immunity Test:
  - IEC 61000-4-5 Class 4
    - Within one circuit—2 kV
    - Circuit to ground—4 kV
- Electrical discharge immunity test:
  - IEC 60255-22-2: Air discharge—8 kV
  - IEC 61000-4-2 Class 3: Contact discharge—6 kV
- Radiated radio frequency electromagnetic field immunity test
  - IEC 61000-4-3: 26 MHz – 80 MHz—10 V/m
  - Class X: 80 MHz–1 GHz—35 V/m
  - ANSI C37.90.2: 1 GHz–3 GHz—10 V/m
- Immunity to conducted disturbances induced by radio frequency fields:
  - IEC 61000-4-6 Class 3: 10 V
- Power frequency magnetic field immunity test:
  - IEC 61000-4-8: Continuous—30 A/m
  - Class 4: 3 sec—300 A/m

EMC Emission Tests

- Radio interference suppression test:
  - IEC/CISPR11—Limit value class B
- Radio interference radiation test:
  - IEC/CISPR11—Limit value class B

Environmental Tests

Classification

- IEC 60068-1: Climatic—0/055/56
- IEC 60721-3-1:
  - Classification of ambient conditions (storage)—1K5/1B1/1C1L/1S1/1M2 but min. –13 °F (–25 °C)
- IEC 60721-3-2: Classification of ambient conditions (transportation)—2K3/2B1/2C1/2S1/2M2
- IEC 60721-3-3: Classification of ambient conditions (Stationary use at weather protected locations)—3K6/3B1/3C1/3S1/3M2 but min. 32 °F (0 °C) and 3K8H for 2 h

Test ad: Cold

- IEC 60068-2-1:
  - Temperature—–4 °F (–20 °C)
  - Test duration—16 h

Test Bd: Dry heat

- IEC 60068-2-2:
  - Temperature—131 °F (55 °C)
  - Relative humidity—<50%
  - Test duration—72 h

Test cab: Damp heat (steady state)

- IEC 60068-2-78:
  - Temperature—104 °F (40 °C)
  - Relative humidity—93%
  - Test duration—56 d

Test Db: Damp heat (cyclic)

- IEC 60068-2-30:
  - Temperature—131 °F (55 °C)
  - Relative humidity—95%
  - Cycles (12 + 12-hour)—2

Mechanical Tests

Test Fc: Vibration Response Test

- IEC 60068-2-6, IEC 60255-21-1, Class 1:
  - Displacement: (10 Hz–59 Hz)—0.0014 in (0.035 mm)
  - Acceleration: (59 Hz–150 Hz)—0.5 gn
  - Number of cycles in each axis: 1

Test Fc: Vibration Endurance Test

- IEC 60068-2-6, IEC 60255-21-1, Class 1:
  - Acceleration: (10 Hz–150 Hz)—1.0 gn
  - Number of cycles in each axis: 20

Test Ea: Shock Test

- IEC 60068-2-27, IEC 60255-21-2, Class 1
  - Shock response test: 5 gn, 11 ms, 3 impulses in each direction
  - Shock resistance test: 15 gn, 11 ms, 3 impulses in each direction

Test Eb: Shock Endurance Test

- IEC 60068-2-29, IEC 60255-21-2, Class 1
  - Shock endurance test: 10 gn, 16 ms, 1000 impulses in each direction

Test Fe: Earthquake Test

- IEC 60068-3-3, KTA 3503, IEC 60255-21-3, Class 2
  - Single axis earthquake vibration test:
    - 3–7 Hz: Horizontal 0.394 in (10 mm), 1 cycle each axis
    - 7–35 Hz Horizontal: 2 gn, 1 cycle each axis

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the EDR-5000. For example, if the catalog number is EDR-5000-2A0BA1, the device would have the following:

EDR-5000

(A)–8 digital inputs, 11 output relays

(0)–5 A / 1 A phase and ground CTs, power supply range: 19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without conformal coating

(1)–Projection panel mount

Relay Removable Terminals

EDR-5000-2A 0 B A 1

Hardware Option 1
- **A** = 8 digital inputs, 11 outputs, removable terminals, zone interlocking
- **B** = 8 digital inputs, 11 outputs, removable terminals, zone interlocking and large display

Hardware Option 2
- **0** = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –22 °F to 158 °F (–30 °C to +70 °C)
- Operating temperature: –4 °F to 140 °F (–20 °C to +60 °C)
- Permissible humidity at ann. average: <75% rel. (on 56d up to 95% rel.)
- Permissible installation altitude:
  - 6,561.67 ft (<2000 m) above sea level
  - If 13,123.35 ft (4000 m) altitude applies, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP20

Routine Test

- Insulation test according to IEC 60255-5: All tests to be carried out against ground and other input and output circuits
- Aux. voltage supply, digital inputs: 2.5 kV (eff.)/50 Hz
- Current measuring inputs, signal relay outputs: 2.5 kV (eff.)/50 Hz
- Voltage measuring inputs: 3.0 kV (eff.)/50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Housing B2: Height / Width 7.205 in (183 mm)/ 8.374 in (212.7 mm)
- Housing Depth (Incl. Terminals): 8.189 in (208 mm)
- Material, housing: Aluminum extruded section
- Material, front panel: Aluminum/foil front
- Mounting position: Horizontal (±45° around the X-axis must be permitted)
- Weight: Approx. 9.259 lb (4.2 kg)

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x I_n (phase currents)
  - Up to 25 x I_n (ground current standard)
  - Up to 2.5 x I_n (ground current sensitive)
- Continuous loading capacity: 4 x I_n/ continuously
- Overcurrent proof:
  - 30 x I_n/10 s
  - 100 x I_n/1 s
  - 250 x I_n/10 ms (1 half-wave)
- Power consumption:
  - Phase current inputs
    - At I_n = 1 A S = 0.15 MVA
    - At I_n = 5 A S = 0.15 MVA
  - Ground current input
    - At I_n = 1 A S = 0.35 MVA
    - At I_n = 5 A S = 0.35 MVA
- Frequency range: 50 Hz/ 60 Hz ±10%
- Terminals: Screw-type terminals with integrated short-circuiters (contacts)
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board´s terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Plug-in Connector with Integrated Short-Circuiter (Conventional Current Inputs)

- Nominal current: 1 A and 5 A
- Continuous loading capacity: 4 x I_n/ continuously
- Overcurrent withstand:
  - 30 x I_n/10 s
  - 100 x I_n/1 s
  - 250 x I_n/10 ms (1 half-wave)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board´s terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Control Power Supply

- Aux. voltage: 24–270 Vdc/ 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage interrupted communication is permitted
- Maximum permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse approx. 0.2 x 0.8 in (5 x 20 mm) according to IEC 60127
  - 3.5 A time-lag miniature fuse approx. 0.25 x 1.25 in (6.3 x 32 mm) according to UL 248-14

Voltage and Residual Voltage Measurement

- Nominal voltages: 100 V/ 110 V/ 230 V/ 400 V (can be configured)
- Max. measuring range: 2 x nominal voltage
- Continuous loading capacity: 2 x nominal voltage (800 Vac)
- Power consumption:
  - at Vn = 100 V S = 0.1 MVA
  - at Vn = 110 V S = 0.1 MVA
  - at Vn = 230 V S = 0.4 MVA
  - at Vn = 400 V S = 1.0 MVA
- Frequency range: 50 Hz or 60 Hz ±10%
- Terminals: screw-type terminals

Frequency Measurement

- Nominal frequencies: 50 Hz / 60 Hz

Voltage Supply

- Aux. voltage: 24–270 Vdc/ 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage communication is permitted to be interrupted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse 5 x 20 mm (approx. 0.2 in x 0.8 in) according to IEC 60127
  - 3.5 A time-lag miniature fuse 6.3 x 32 mm (approx. 0.25 in x 1.25 in) according to UL 248-14

Power Consumption

- Power supply range: 24–270 Vdc
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W
- Power supply range: 48–230 Vac (for frequencies of 40–70 Hz)
  - Power consumption in idle mode—7 VA
  - Maximum power consumption—13 VA

Display

- Display type: LCD with LED background illumination
- Resolution graphics display: 128 x 64 pixel
- LED-type: two colored, red/green
- Number of LEDs, housing B2: 15

Front Interface

- Baud rates: 115,200 Baud
- Handshake: RTS and CTS
- Connection: 9-pole D-sub plug

Real-Time Clock

- Running reserve of the real-time clock: 1 year min.

Digital Inputs

- Maximum input voltage: 300 Vdc/259 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Fallback time: <30 ms

(Safe state of the digital inputs)

- Four switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac/Vdc, 230 Vac/Vdc
  - Un = 24 Vdc
    - Switching threshold 1 ON: Min. 19.2 Vdc
    - Switching threshold 1 OFF: Max. 9.6 Vdc
  - Un = 48 V / 60 Vdc
    - Switching threshold 2 ON: Min. 42.6 Vdc
    - Switching threshold 2 OFF: Max. 21.3 Vdc
  - Un = 110 / 120 Vac/Vdc
    - Switching threshold 3 ON: Min. 88.0 Vdc / 88.0 Vac
    - Switching threshold 3 OFF: Max. 44.0 Vdc / 44.0 Vac
  - Un = 48–60 Vdc
    - Switching threshold 4 ON: Min. 184 Vdc / 184 Vac
    - Switching threshold 4 OFF: Max. 92 Vdc / 92 Vac
- Terminals: screw-type terminal

Relay Outputs

- Continuous current: 5 A AC/DC
- Maximum make current:
  - 25 A AC / 25 A DC up to 30 V for 4s
  - 30 A/230 Vac according to ANSI IEEE Std. C37.90-2005
  - 30 A/250 Vdc according to ANSI IEEE Std. C37.90-2005
- Maximum breaking current:
  - 5 A AC up to 250 Vac
  - 5 A DC up to 30 V (resistive)
  - 0.3 A DC at 300 V
- Maximum switching voltage: 250 Vac/250 Vdc
- Switching capacity: 1250 VA
- Contact type: Form C or normally open contact
- Terminals: screw-type terminals

Supervision Contact (SC)

- Continuous current: 5 A AC/DC
- Maximum switch-on current: 15 A AC / 15 A DC up to 30 V for 4 s
- Maximum breaking current:
  - 5 A Vac up to 250 Vac
  - 5 A Vdc up to 30 Vdc
  - 0.4 A at 125 Vdc
- Contact type: 1 Form C contact
- Terminals: screw-type

Time Synchronization IRIG-B00X

- Nominal input voltage: 5 V
- Connection: Screw-type terminals (twisted pair)

Zone Interlocking

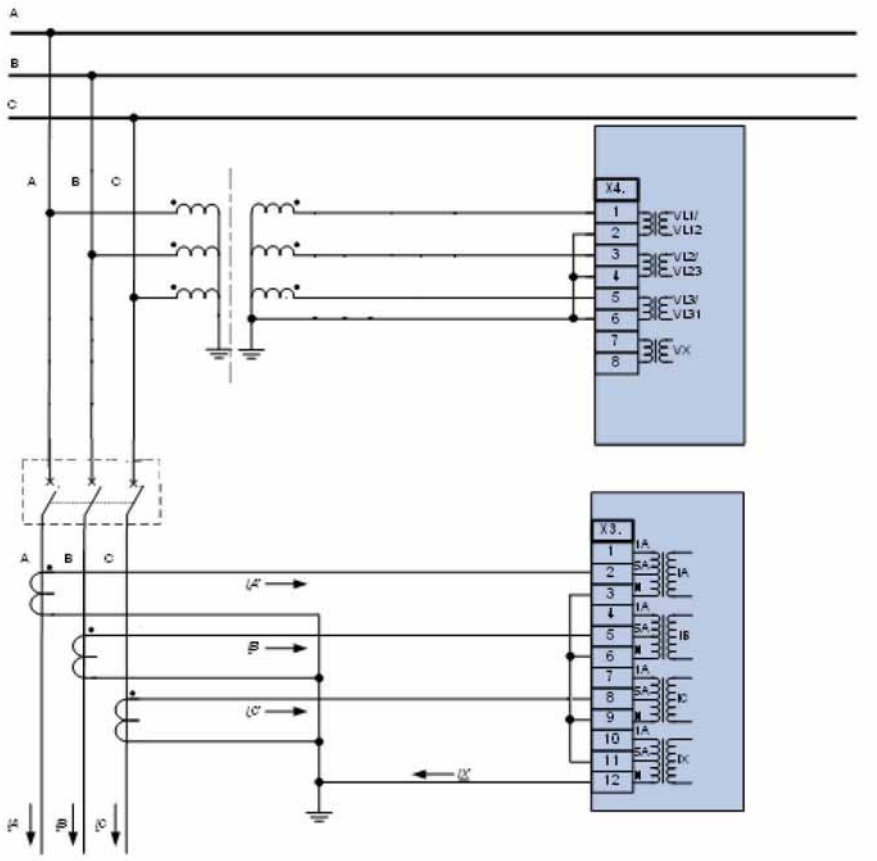
- Zone Out:
  - Output voltage (High) 4.75 to 5.25 Vdc
  - Output voltage (Low) 0.0 to +0.5 Vdc
- Zone In:
  - Nominal input voltage +5 Vdc
  - Max. input voltage +5.5 Vdc
  - Switching threshold ON min. 4.0 Vdc
  - Switching threshold OFF max. 1.5 Vdc
- Galvanic isolation 2.5 kV AC (to ground and other IO)
- Connection: Screw-type terminals (twisted pair)

RS-485

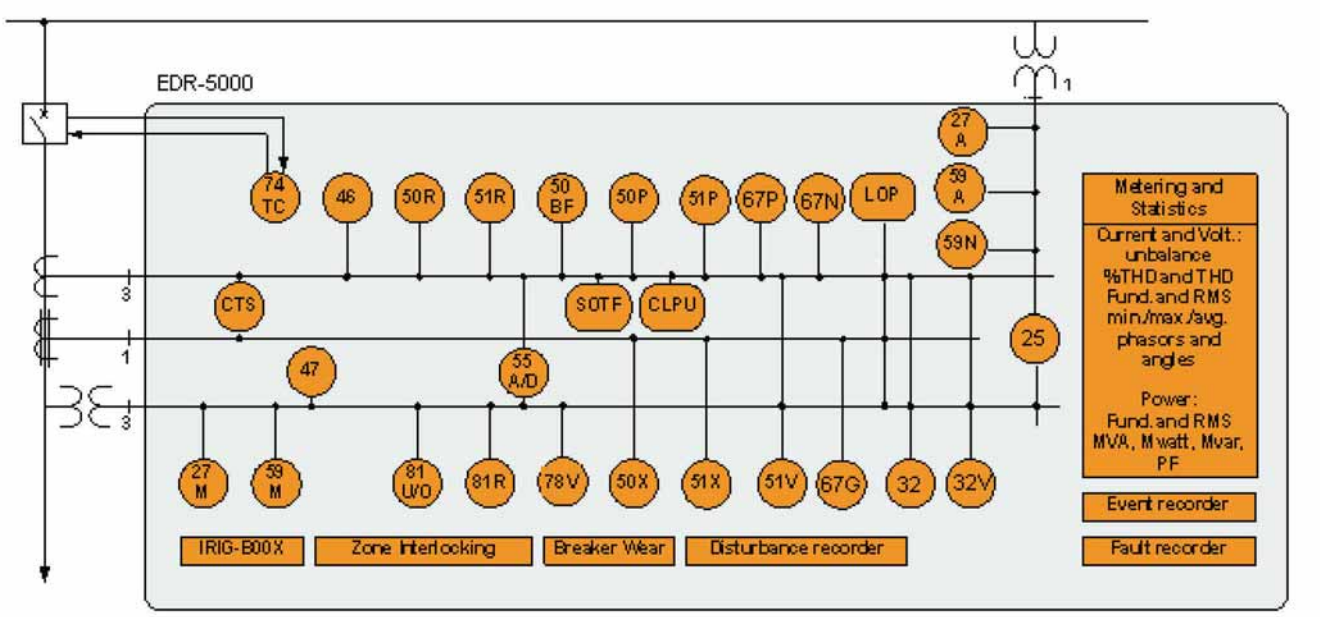
- Master/slave: slave
- Connection: 6 screw-clamping terminals RM 138 MIL (3.5 mm) (terminating resistors internal)

Wiring Diagrams

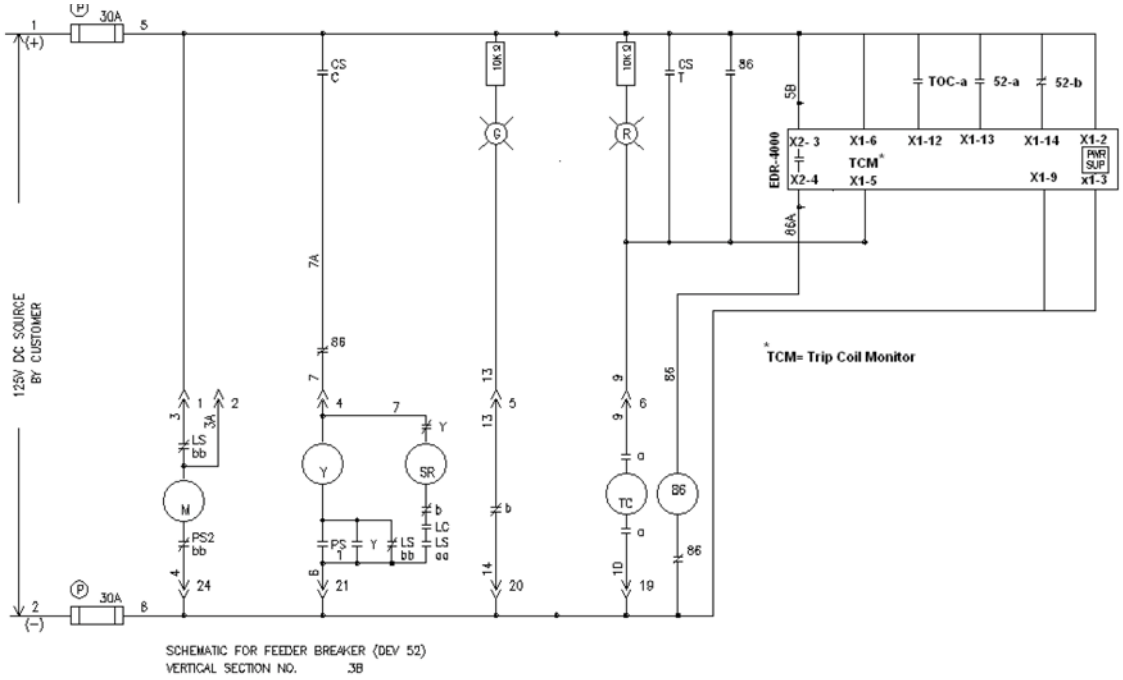
Typical AC Connections—Wye VTs, 5 A CTs and Ground Current Measured by Residual Connection



Typical One-Line Diagram



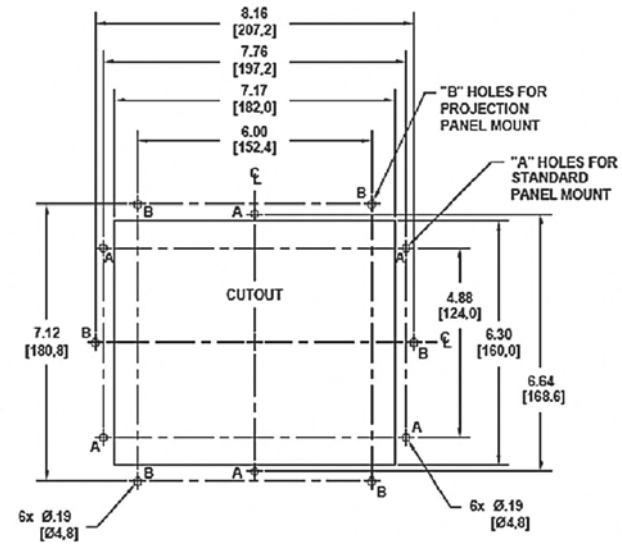
Typical Control Diagram



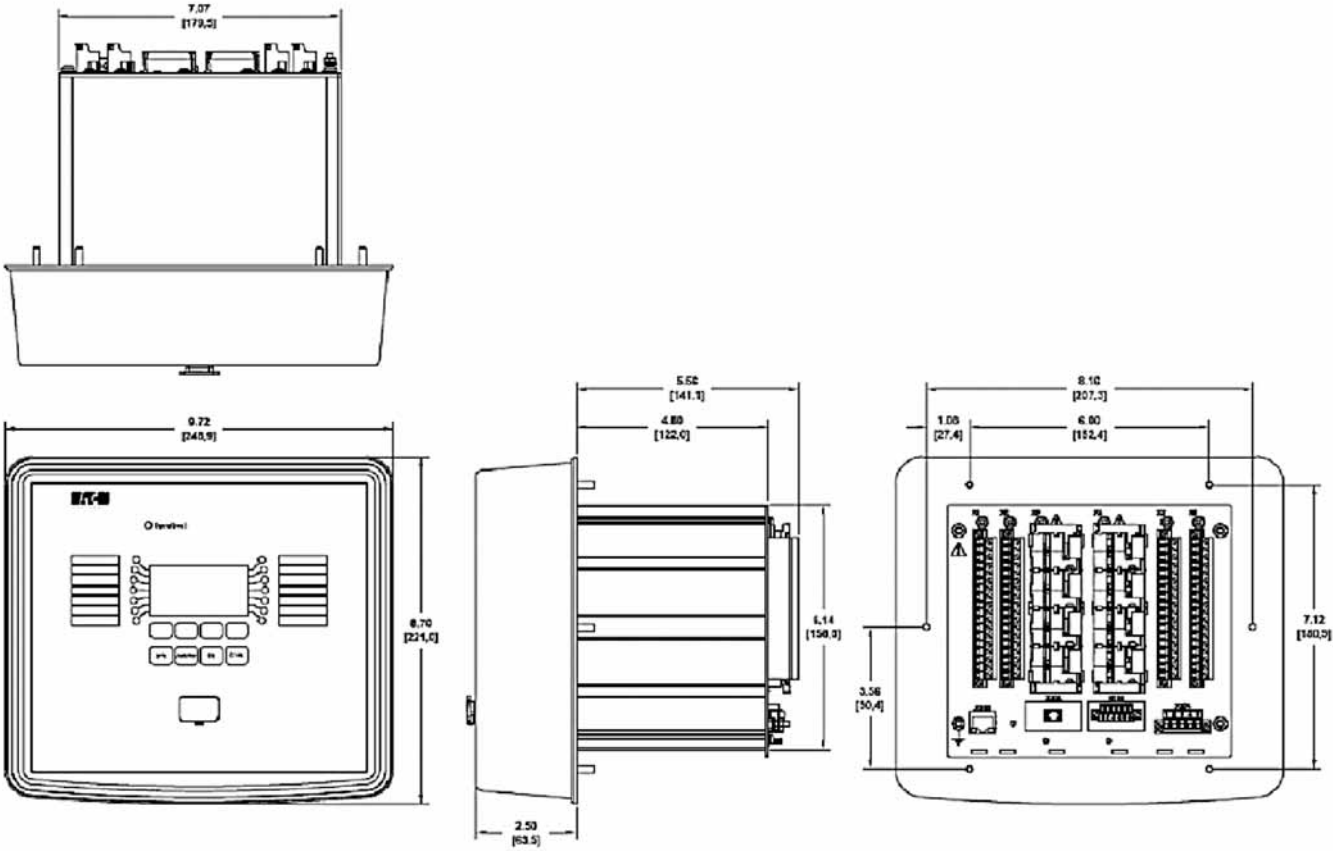
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

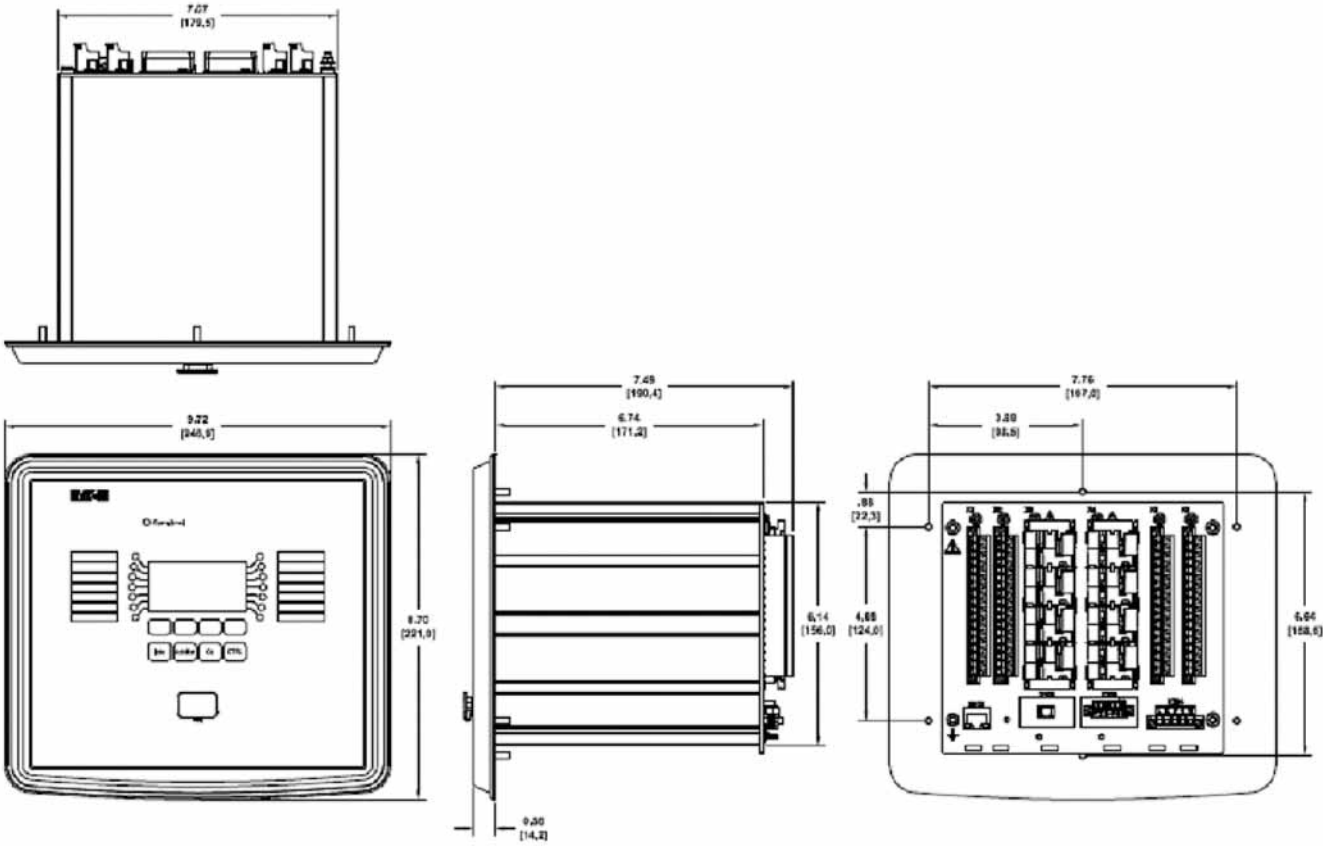


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



Feeder Protection FP-5000

Contents

FP-5000 Feeder Protection

Product Description

- Microprocessor-based protection with monitoring and control for medium voltage main and feeder applications
- Current, voltage, frequency and power protection for electric power distribution systems
- Complete metering of voltage, currents, power, energy, minimum/maximum and demand functions
- Programmable logic control functions for main-tie-main transfer schemes
- Trip logs, event logs and waveform capture for better fault analysis and system restoration
- Data Logger to provide energy usage profiles for better planning, utilization and energy usage
- Compact, drawout case design
- Multiple settings groups
- ANSI, IEC and thermal protection curves for greater flexibility

Application Description

Eaton's FP-5000 Feeder Protection relay provides complete three-phase and ground overcurrent and voltage protection plus metering in a single, compact drawout case. It may be used as primary protection on feeders, mains and tie circuit breaker applications, and as backup protection for transformers, high voltage lines and differential protection. The relay is most commonly used on medium voltage switchgear applications.

The FP-5000 takes full advantage of its microprocessor technology providing the user new freedoms and a wealth of data-gathering features. The relay performs self-checking of all major hardware and firmware protection elements to ensure their operation in the event of a system or component electrical failure or fault. Protection functions are well suited for main and distribution feeder circuit applications.

Programmable logic control functions make the FP-5000 relay ideally suited for main-tie-main and main 1/main 2 transfer schemes.

The Zone Interlocking feature can be utilized for bus protection instead of an expensive and complicated bus differential (87B) scheme. The FP-5000 works directly with Eaton's Digitrip 3000 and Digitrip MV relays. New breaker failure logic provides faster remote backup clearing times for stuck breaker operation.

The multiple settings groups can be utilized for arc flash mitigation when an alternative setting group, set to have instantaneous elements only is activated using a selector switch and the programmable I/O in the FP-5000.

The FP-5000 provides trip and close circuit monitoring and alarming features. It continually monitors the complete trip and close circuits for continuity and readiness to trip.

Open and close pushbuttons are conveniently located on the front of the relay for local breaker operation.

Loss-of-vacuum monitoring is activated when the breaker is open. Residual current is monitored and alarmed if detected.

When an electrical fault or disturbance occurs, the FP-5000 begins to store the following in non-volatile memory:

- Voltage and current sampled data
- Calculated values
- Status of internal protection functions, logic, contact inputs and outputs

Retrieval and viewing of the data is easy, aiding in the quick analysis and restoration of your electric power system.

Features, Benefits and Functions

When the FP-5000 isn't responding to disturbances in the power system, it's providing valuable metering information at the relay and remotely. It provides energy usage and demand reading, and can alarm when usage reaches a set value. Power factor measurements can be used for cap bank switching to control kVAR demand. Onboard data trending can provide load profiles for up to 40 days.

The protection functions are listed below and shown on **Page V3-T9-160**.

- Complete protection, metering and control in a single compact case to reduce panel space, wiring and costs
- Flexible current, voltage and frequency protection and programmability to cover a broad range of applications while simplifying relay ordering and reducing inventory
- Integral test function reduces maintenance time and expense
- Relay self-diagnostics and reporting improves uptime and troubleshooting
- Breaker trip circuit monitoring improves the reliability of the breaker operation
- Programmable logic control features that can replace and eliminate external auxiliary relays, timers and wiring
- Zone-selective interlocking improves coordination and tripping times and saves money compared to a traditional bus differential scheme
- Trip and event recording in non-volatile memory provides detailed information for analysis and system restoration
- 256 cycles of waveform capture aids in post fault analysis
- Front RS-232 port and PowerPort software provides local computer access and a user-friendly, Windows®-based interface for relay settings, and configuration and data retrieval
- Drawout case design for quick and easy relay removal and replacement
- Breaker open/close control from relay faceplate or remotely via communications
- Remote communications to Eaton's PowerNet monitoring system or PC
- Free PowerPort utility software for local PC interface to the FP-5000 for relay settings, monitoring and control

Phase Overcurrent (Forward, Reverse or Both)

- Two-stage instantaneous with timers (50P-1 and 50P-2)
- Two inverse time overcurrent (51P-1 and 51P-2)
- Directional control
- 10 standard curves
- Instantaneous or time delay reset
- Voltage restrained time overcurrent (51VR)
- Two independent ground directional overcurrent elements, one measured (IX) and one calculated (IR)
  - Two-Stage instantaneous with timers (50X-1 and 50X-2) (50R-1 and 50R-2)
  - Inverse time overcurrent (51X and 51R)
  - Ground directional polarizing (67N) -3_{vo}, I_{pol}, negative sequence
  - 10 standard curves
  - Instantaneous or time delay reset
  - Voltage restrained time overcurrent (51VR)
- Breaker failure (50BF)
- Phase unbalance negative sequence overcurrent (46-1, 46-2)
- Phase voltage unbalance and sequence protection (47-1, 47-2)
- Main three-phase under/overvoltage (27M-1, 27M-2, 59M-1, 59M-2)
- Auxiliary single-phase under/over-voltage (27A-1, 27A-2, 59A-1, 59A-2)
- Under/over frequency (81U-1, 81U-2, 81O-1, 81O-2)
- Reverse/forward power (32-1, 32-2)
- Sync check (25)
- Power factor (55)
- Zone interlocking for bus protection (87B). The FP-5000 feeder relay includes a zone selective interlocking feature that can be used with other Eaton devices like the Digitrip 3000 overcurrent relay

The FP-5000 provides the following metering functions:

- Amperes (rms, phasor and sequence)
- Amperes demand and peak demand
- Volts (rms, phasor and sequence)
- VA and VA demand
- Watts and kW demand and peak demand
- Forward/reverse/net kWh
- VARs and kVAR demand and peak demand
- Lead/lag/net kVARh
- Power factor
- Frequency
- Voltage and current
- %THD and magnitude THD
- Minimum/maximum recording with date/time stamp
- Trending (load profile over time)

The FP-5000 provides the following monitoring and data recording functions that enhance the security of the protection system and provides useful information for scheduling maintenance:

- Trip circuit monitoring
- Close circuit monitoring
- Loss-of-vacuum monitoring
- Breaker wear (accumulated interrupted current)
- Waveform capture (256 cycles total, up to 16 events)
- Fault data logs (up to 16 events)
- Sequence of events report (up to 100 events)
- Clock

The FP-5000 provides standard control functions plus user-configurable custom control capabilities. This logic can be used for applications such as main-tie-main transfer schemes.

- Remote open/close
- Programmable I/O
- Programmable logic gates and timers
- Multiple setting groups (up to four)
- Bus transfer logic
- Cold load pickup
- Loss of potential (PT blown fuses)

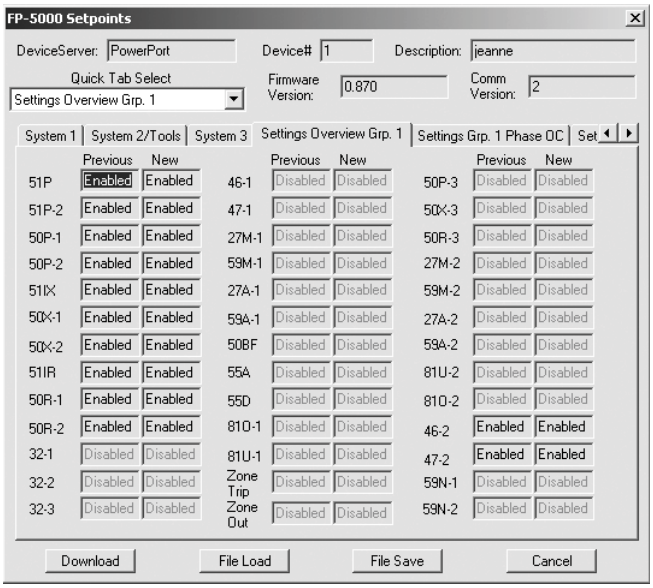
The FP-5000 supports the following communication options:

- Local HMI
- Password protected
- Addressable
- Local communication port
- Remote communication port:
  - FSK
  - RS-232
  - RS-485
- Protocols:
  - INCOM
  - Modbus
- Configuration software

Communication Software

Eaton provides two types of communication software. The first is PowerPort. It runs on a PC or laptop for easy access to a single relay to change set points or configuration and to view metered values and stored data. PowerPort is free and can be downloaded from www.eaton.com; search for 'PowerPort,' then click the download search result.

The second package is PowerNet. PowerNet is a power management software package that is designed for continuous, remote monitoring of many devices. It provides all the functionality of PowerPort plus additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on PowerNet software.



PowerPort and PowerNet Protection Overview Screen

Standards and Certifications

- Meets ANSI, CE and CSA standards

Compliance

- UL Recognized, File # E154862
- UL 1053 (1994) recognized
- ANSI C37.90 (1989)
- EN 55011 (1991)
- EN 61000-6-2 (1999)

Emission Tests

- EN 55011 (1991)—Group 1 Class A (CISPR-11, Class A)
- FCC 47 CFR Chapter 1—Part 15 Subpart b Class A

Immunity Tests

- ANSI C37.90.1 (1989)—Surge Withstand Capability
- ANSI C37.90.2 (1995)—EMI Immunity to 35V/m
- EN 61000-4-2 (1995)—ESD Rating of 8 kV
- EN 61000-4-3 (1997)—Radiated EM Field at 10V/m
- EN 61000-4-4 (1995)—Fast Transient Burst at 2 kV
- EN 61000-4-5 (1995)—Surge Immunity Test
- EN 61000-4-6 (1996)—Conducted RF at 10V/m
- EN 61000-4-11 (1994)—Voltage Dips and Variations
- EN 61000-4-8—Power Frequency Magnetic Field Immunity

Catalog Number Selection

FP-5000 Feeder Protection

FP5 2 00 - 0 1

Current Range	Packaging	Control Voltage	Communications Protocol
2 = 5 Amperes **3** = 1 Ampere	**0** = Drawout **1** = Fixed case	**0** = 48–125 Vac/Vdc **1** = 100–240 Vac/Vdc	**0** = INCOM **1** = Modbus

Technical Data and Specifications

Control Power

- Control voltage:
  - 48–125 Vac/Vdc
  - 100–240 Vac/Vdc
- Operating voltage:
  - 55–264 Vac
  - 38–300 Vdc
- Interruption ride-through time: 20 cycle interruption of nominal ac supply
- Power consumption: 20 VA maximum

Current Inputs

- Nominal (I_n): 1 A or 5 A
- CT rating:
  - 2 x I_n continuous
  - 80 x I_n for 1 second
- CT burdens:
  - < 0.25 VA at 5 A (nominal)
  - < 0.05 VA at 1 A (nominal)

Voltage Transformer Inputs

- Nominal: 120 Vac
- Operating range: 69–150 Vac
- Burden:
  - <0.015 at 120 Vac
  - 1 megaohm

Metering Accuracy

- Phase current:
  - ±0.5% or ±0.025 A from 0.02–20 per unit fully offset current waveform
- Ground current:
  - ±0.5% of full scale (I_n) from 0.02–2.0 per unit fully offset current waveform
- Phase voltage: ±0.5% or ±0.2V from 0–160 Vac
- Frequency measurement accuracy: ±0.02 Hz
- Phase angle: ±1 °C
- Power metering accuracy: ±1.5%
- Metering accuracy temperature range: 32 °F to 122 °F (0 °C to 50 °C)
- Temperature range: ±5% for operation below 32 °F (0 °C) and above 122 °F (50 °C)
- Relay outputs:
  - 2 Form C, NO and NC
  - 5 Form A, NO only
- Input signal frequency necessary for accurate operation:
  - 60 Hz nominal, 57–63 Hz (±5%)
  - 50 Hz nominal, 47–53 Hz (±5%)
- Clock accuracy:
  - Free running ±1 minute/month at 25 °C
  - Clock automatically updated by PowerNet host when present

Protective Functions

Phase and Ground Overcurrent Protection

- Inverse characteristics: Mod, Very, Extremely, IECA, IECB, IECC, It, I^2t, I^4t, Flat
- TOC (51) pickup range: 0.1–4.0 per unit in 0.01 steps
- Time multipliers: 0.05–10.0 in 0.01 steps
- IOC (50) pickup range: 0.1–20.0 per unit in 0.01 steps
- Pickup accuracy: ±1% (at 0.1–2 per unit)
- Time delay: 0–9999 cycles in 1 cycle steps
- Time accuracy: ±3% or ±30 ms
- Directional (67, 67N, 67G): forward, reverse or both

Voltage Unbalance (47)

- Threshold (minimum voltage) 1–100 volts in 1 volt steps
- % V2/V1: 4–40% in 1% steps
- Time delay: 0–9999 cycles in 1 cycle steps

Current Unbalance

- Threshold (minimum current) 0.1–20.0 per unit in 0.01 steps
- % I2/I1: 4–40% in 1% steps
- Time delay: 0–9999 cycles in 1 cycle steps

Under/Overvoltage Protection

- Pickup range: 10–150 volts in 1 volt steps
- Time delay: 0–9999 cycles in 1 cycle steps

Under/Over Frequency Protection

- Pickup range: 45–65 Hz in 0.01 Hz steps
- Time delay: 0–9999 cycles in 1 cycle steps

Breaker Failure Protection

- Pickup range: 0.1–5.0 per unit in 0.01 steps
- Time delay: 0–9999 cycles in 1 cycle steps

Power Protection (32)

- Forward/reverse: over/under
- Pickup accuracy: ±1.0%
- Trip time accuracy: 0 to 12 cycles or 0.1%, whichever is greater

Sync Check (25)

- Phase angle: 1 to 60 °C
- Slip frequency: 0.1 to 2 Hz
- Voltage differential: 1 to 100 volts
- Breaker close time: 0 to 9999 cycles

Power Factor

- Trigger/reset threshold: 0.5 lag to 0.5 lead in 0.01 steps
- Time delay: 0–1000 seconds in 1 second steps

Discrete Inputs

- Number of contact inputs: 8
- Rating: 48 Vdc wetting voltage provided with internal ground only

Output Contacts

- Number of output contacts: Five Form A and two Form C

Rating of Output Contacts

- Momentary:
  - Make 30 A AC/DC for 0.25 seconds
  - Break 0.25 A at 250 Vdc (resistive)
  - Break 5 A at 120/240 Vac
- Continuous:
  - 5 A at 120/240 Vac
  - 5 A at 30 Vdc

Logic and Control Functions

- Six programmable logic gates for AND, OR, NAND, NOR operation
- Two latching (flip/flop) gates
- Six timer gates provide on/off delays

INCOM Communications

- Baud rate: 9600 fixed
- Maximum distance: 10,000 feet (3048 m)
- Protocol: INCOM

RS-485 Communications, Rear Panel

- Baud rate: 19.2 K, 9.6 K
- Protocol: Modbus RTU

RS-232 Communications, Front Panel

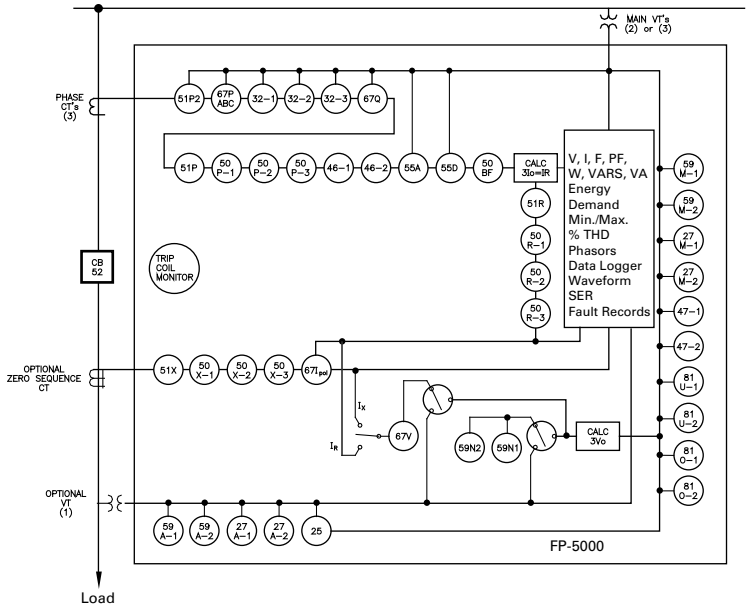
- Baud rate: 38.4 K, 19.2 K, 9.6 K
- Connector standard 9-pin subminiature, three-wire
- Protocol: INCOM

Environmental Ratings

- Operating temperature: –0 °F to +140 °F (–40 °C to +60 °C) Product tested to +185 °F (+85 °C)
- Storage temperature: –40 °F to +185 °F (–40 °C to +85 °C)
- Humidity: 5–95% relative humidity (noncondensing)
- Altitude: 0–6350 feet (0–1935 m) above Mean Sea Level

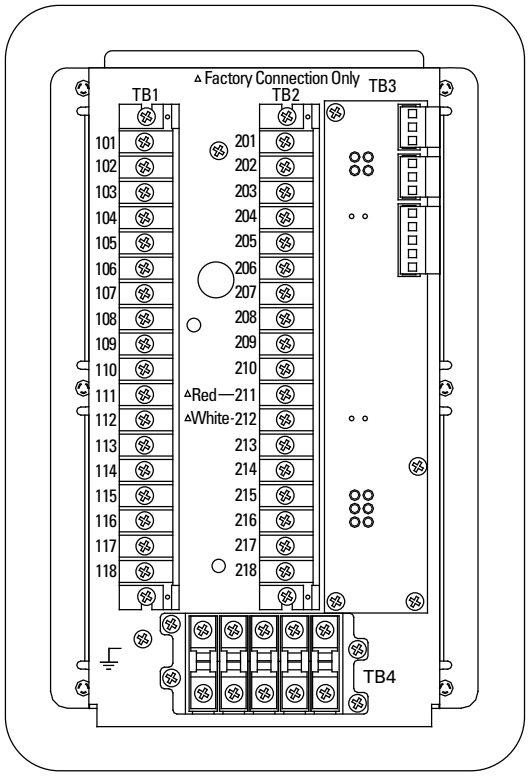
Wiring Diagrams

FP-5000 One-Line Drawing



FP-5000 Rear View and Terminal Designations

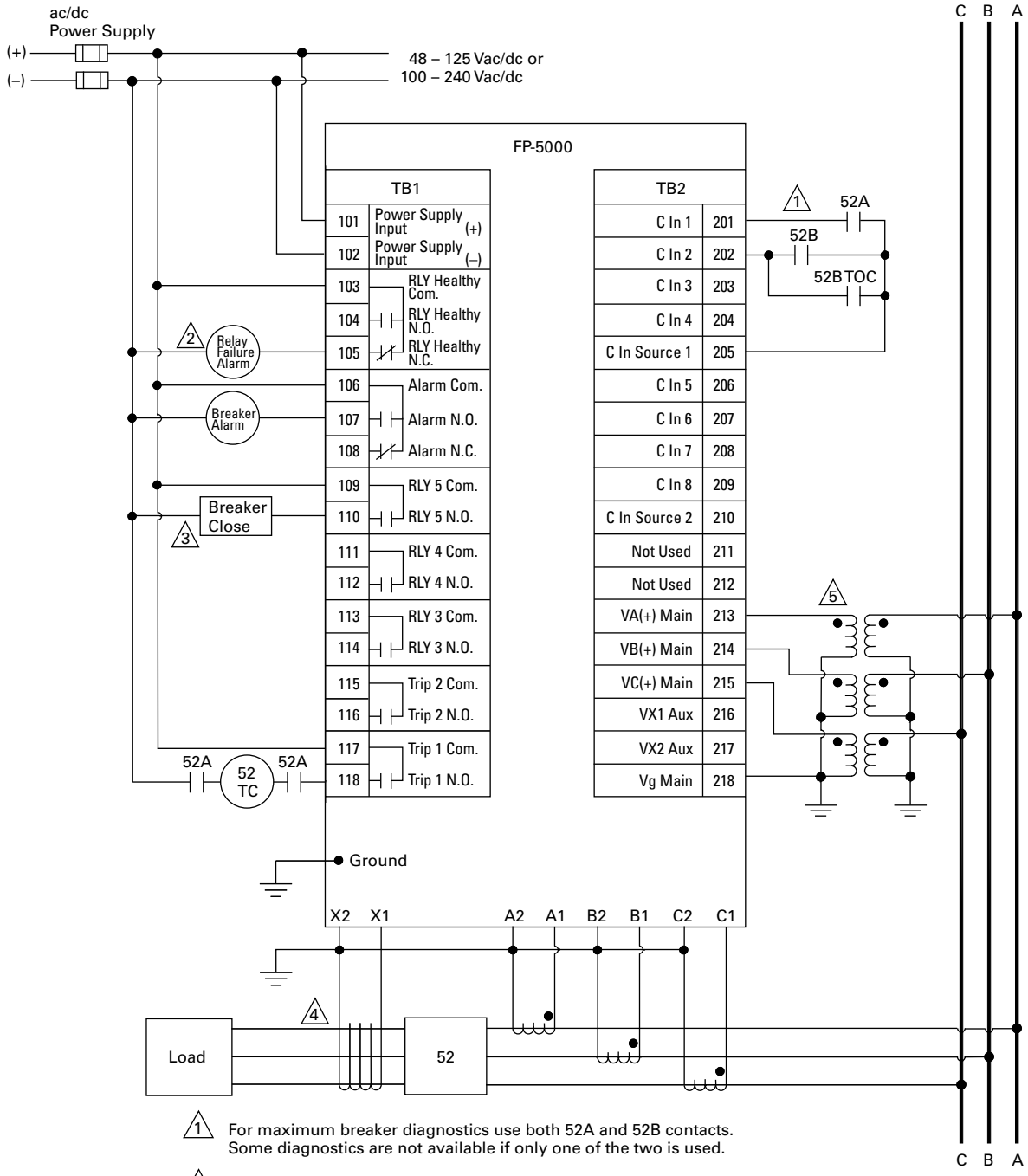
TB1		TB2	
101	Power Supply Input (+)	201	C In 1
102	Power Supply Input (–)	202	C In 2
103	RLY Healthy Com.	203	C In 3
104	RLY Healthy N.O.	204	C In 4
105	RLY Healthy N.C.	205	C In Source 1
106	Alarm Com.	206	C In 5
107	Alarm N.O.	207	C In 6
108	Alarm N.C.	208	C In 7
109	RLY 5 Com.	209	C In 8
110	RLY 5 N.O.	210	C In Source 2
111	RLY 4 Com.	211	Not Used
112	RLY 4 N.O.	212	Not Used
113	RLY 3 Com.	213	VA(+) Main
114	RLY 3 N.O.	214	VB(+) Main
115	Trip 2 Com.	215	VC(+) Main
116	Trip 2 N.O.	216	Vx1 Aux
117	Trip 1 Com.	217	Vx2 Aux
118	Trip 1 N.O.	218	Vg Main



TB3	
J1-1	PowerNet
J1-2	PowerNet
J1-3	PowerNet Shield
J2-1	Accessory Bus
J2-2	Accessory Bus
J2-3	Accessory Bus Shield
J3-1	Zone Out
J3-2	Zone Com.
J3-3	Zone Shield
J3-4	Zone In
J3-5	Zone Com.
J4-1	
J4-2	
J4-3	
J5-1	RS485(+)
J5-2	RS485(-)
J5-3	RS485com
J5-4	RS485shield

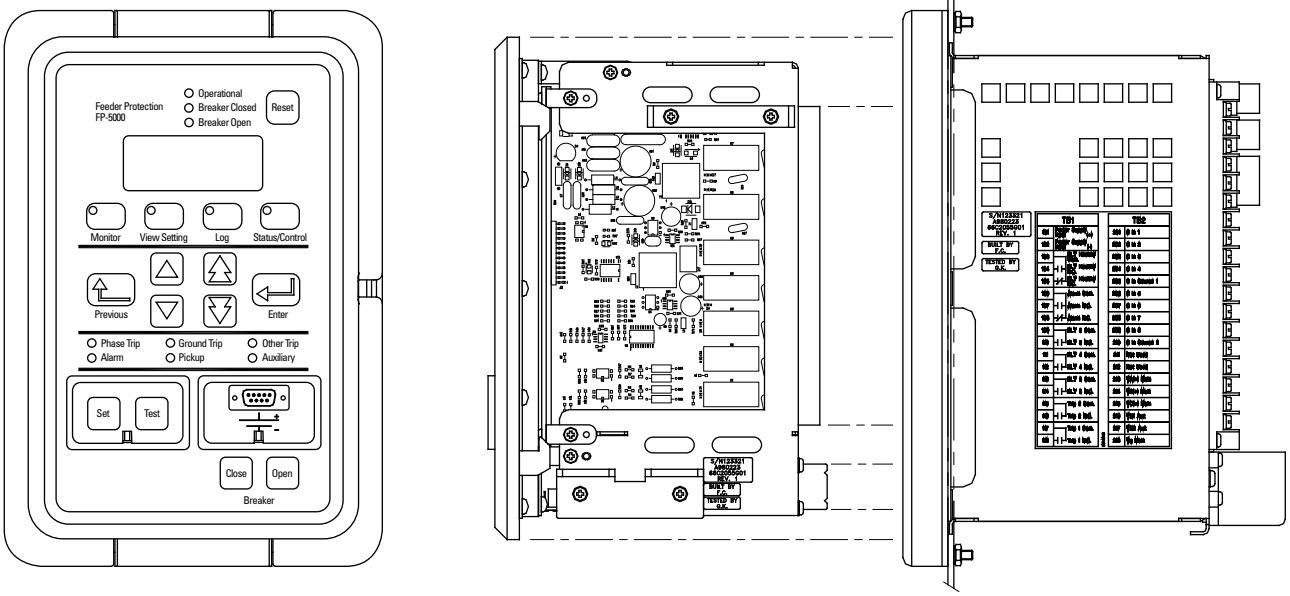
A1	B1	C1	X1	N.C. 1
A2	B2	C2	X2	N.C. 2

FP-5000 Typical Connection Drawing Using Wye PTs



1. For maximum breaker diagnostics use both 52A and 52B contacts. Some diagnostics are not available if only one of the two is used.
2. A relay failure alarm should provide immediate attention as circuit is no longer protected. Relay failure output is normally energized.
3. FP-5000 can initiate a breaker close via the front panel interface and/or remote activation through communication or discrete input.
4. Residual connection may be used in place of zero sequence CT.
5. Delta or open delta PT connection may be used in place of wye-ground connection.

FP-5000 Front View and Drawout Case Side View



Dimensions

Approximate Dimensions in Inches (mm)

FP-5000 Feeder Protection Relay

Height	Width	Depth	Shipping Weight Lbs (kg)
In Front of Panel			
11.34 (288.0)	7.72 (196.1)	0.80 (20.3)	12.5 (5.7)
Behind Panel			
6.70 (170.2)	5.30 (134.6)	6.90 (175.3)	12.5 (5.7)

MP-3000

Contents

MP-3000 Motor Protection

Product Description

- Microprocessor-based, multi-function motor protection
- Current only device—no need to add PTs
- Intel-I-Trip™ overload protection based on motor data
- Event recording and operational logging
- Motor Start Profile™
- Optional Quick Release Drawout Case
- Used on AMPGARD® and medium voltage assemblies
- "Help" menu provides user operational assistance

Application Description

Eaton's MP-3000 motor protection relay is a multifunctional microprocessor-based protective relay for the protection of three-phase AC motors. The MP-3000 motor relay may be applied to any size motor at any voltage level. It is most commonly used on large, medium voltage three-phase induction motors. It has also been widely used on important low voltage (480 volt) motor applications and synchronous motors.

The MP-3000 motor relay is a current only device that monitors three-phase and ground currents. It provides motor overload, stall, short circuit, phase unbalance, single phasing and ground fault motor protection.

It can also be used to provide protection for a load jam or loss of load condition. Please refer to **Page V3-T9-167**.

The MP-3000 motor relay provides start control logic to protect the motor against excessive starts or starting the motor before it has had sufficient time to cool down. The MP-3000 motor relay may be applied to either across the line starters or reduced voltage starters. On reduced voltage starters, the MP-3000 relay can control the switch from reduced voltage to full voltage based on time and/or motor transition. The MP-3000 can protect the starter against failure to transition to full voltage through contact feedback and an incomplete sequence function.

The MP-3000 motor relay is generally used on a motor starter or a breaker used for a motor load. The MP-3000 motor relay provides the intelligence to protect and control the motor against abnormal operating conditions. It monitors the currents from either a 5 A or 1 A secondary of a CT circuit. Ground current may be obtained from either a ground CT or from the residual connection of the phase CTs. It provides a Form C contact output for controlling the starter contacts or breaker operation.

Features, Benefits and Functions

- Complete motor protection and control in a single compact case reduces panel space requirements and wiring costs
- Microprocessor design with self diagnostics eliminates calibration and reduces installation, commissioning and maintenance
- Programmable stop 2–20% of PCT
- Intel-I-Trip overload protection develops customized curve from manufacturer's supplied motor data
- Intel-I-Trip overload protection provides adaptive trip characteristics based on motor temperature when motor RTDs are connected through an optional URTD module
- Meets UL 1053 ground fault protection standards that eliminates the need for a separate ground relay saving cost, space, wiring and time
- Voltage dip/loss ride through capability reduces unnecessary trips caused by poor power quality
- Motor currents, temperatures and conditions are monitored and displayed either locally or remotely
- Event log provides motor operating records for the most recent 20 Trip or Alarm events with date and time stamping. This information can improve troubleshooting and reduce downtime
- Log book records the most recent 100 events such as motor START/STOP and set point changes to provide a log of motor operation with date and time stamping
- RTD diagnostics reduces unnecessary tripping caused by faulty RTD, RTD wiring or communications
- Arm/Disarm feature improves security for critical motor applications
- Motor Start profile verifies protection and motor starting coordination. This feature can be used to develop protection settings on old motors where data is not available
- Optional communication module and Eaton's software simplifies setting, configuration, monitoring, commissioning and data retrieval either locally or remotely
- Optional Quick Release Drawout Case construction simplifies relay removal and replacement

The protection functions are listed below.

- I^2t overload protection (49/51)
- Locked rotor (49S/51)
- Ultimate trip current (51)
- Negative sequence phase unbalance (46)
- Instantaneous overcurrent (50)
- Ground fault protection (50G)
- RTD trip and alarm with URTD module (49/38)
- Underload trip (37)
- Starts per time (66)
- Jam or stall (51R)
- Auto or manual reset (86)
- Fail-safe or non-fail-safe trip modes

The metering functions are:

- Motor currents:
  - Average current (Iave)
  - Individual phase and ground current in primary amperes
  - Percent of full load
  - Percent of phase unbalance
- RTD temperatures:
  - Individual winding
  - Motor bearing
  - Load
  - Auxiliary temperatures
- Motor conditions:
  - Percent of I^2t thermal bucket
  - Time before start
  - Remaining starts allowed
  - Oldest start time

Standards and Certifications

The MP-3000 motor protection was designed to meet the industry standards for protective relays. It is recognized under UL 1053 Ground Fault Protection Standard.

- UL recognized (File No. E154862)
- UL 1053 recognized
- UL 508 recognized
- ANSI C37.90, C37.90.1
- cUL
- CSA

Listed

Product Selection

MP-3000

MP-3000

Description	Catalog Number
MP-3000 Drawout, 5 A with RS-232	**MP3011**
MP-3000 Drawout, INCOM, 5 A with RS-232	**MP3012**
MP-3000 Drawout, Modbus, 5 A with RS-232	**MP3013**
MP-3000 Drawout, DeviceNet, 5 A with RS-232	**MP3014**
MP-3000 Drawout, 1 A with RS-232	**MP3111**
MP-3000 Drawout, INCOM, 1 A with RS-232	**MP3112**
MP-3000 Drawout, Modbus, 1 A with RS-232	**MP3113**
MP-3000 Drawout, DeviceNet, 1 A with RS-232	**MP3114**
MP-3000 Fixed Case, 5 A with RS-232	**MP3010**
MP-3000 Fixed Case, INCOM, 5 A with RS-232	**MP3010-INCOM**
MP-3000 Fixed Case, Modbus, 5 A with RS-232	**MP3010MODBUS**
MP-3000 Fixed Case, DeviceNet, 5 A with RS-232	**MP3010DEVICEN**
MP-3000 Fixed Case, 1 A with RS-232	**MP3110**
MP-3000 Fixed Case, INCOM, 1 A with RS-232	**MP3110-INCOM**
MP-3000 Fixed Case, Modbus, 1 A with RS-232	**MP3110MODBUS**
MP-3000 Fixed Case, DeviceNet, 1 A with RS-232	**MP3110DEVICEN**
MP-3000 Fixed Case, INCOM, 5 A with RS-232, URTD	**MP3010VPI**
MP-3000 Fixed Case, Modbus, 5 A with RS-232, URTD	**MP3010VPM**
MP-3000 Fixed Case, DeviceNet, 5 A with RS-232, URTD	**MP3010VPD**
MP-3000 Fixed Case, INCOM, 1 A with RS-232, URTD	**MP3110VPI**
MP-3000 Fixed Case, Modbus, 1 A with RS-232, URTD	**MP3110VPM**
MP-3000 Fixed Case, DeviceNet, 1 A with RS-232, URTD	**MP3110VPD**

Options and Accessories

Additional Related Products by Eaton's Cutler-Hammer® Series

The MP-3000 is available in either a fixed mount or Quick Release Drawout Case. Both mountings use the same panel cutout. **Page V3-T9-170** shows cutout dimensions. **Page V3-T9-167** shows a typical fixed mountwiring diagram for a medium voltage motor starter application. **Page V3-T9-168** shows the fixed mount terminal designation. **Page V3-T9-170** shows the drawout case panel mounting, and shows the drawout case terminal designation.

The Universal RTD module (URTD) is required when the motor is equipped with RTDs that you wish to monitor and use for protection. The URTD can be mounted near the motor to reduce RTD wiring and costs. **Page V3-T9-169** shows MP-3000 and URTD inter-connection wiring. Please refer to the URTD information described elsewhere in this catalog.

The MP-3000 motor protection is designed to operate from 120 Vac or 240 Vac auxiliary control power. The MP-3000 motor relay can be used with DC control power with the addition of the IQDCPS. The IQDCPS is an inverter from DC to AC.

Technical Data and Specifications

Control Power

- Nominal rating:
  - 120 Vac or 240 Vac
  - +10%, –25%
- Operating range:
  - 120 Vac: 90 132 Vac
  - 240 Vac:180 264 Vac
- Frequency: 50 or 60 Hz
- Power use:
  - 20 VA maximum
  - URTD: 6 VA maximum
  - IPONI: 1 VA maximum
- Ride-through time: 30 cycles from nominal Vac

Current Inputs

- Nominal (I_n): 1 A or 5 A
- CT rating:
  - 2 x I_n continuous
  - 50 x I_n for 1 second
- Burdens:
  - < 0.25 VA at 5 A
  - < 0.05 VA at 1 A

Metering Accuracy

- Phase current: ±1% of I_n (5–100%)
- Ground current: ±1.5% of I_n (0–55%)

Discrete Inputs

- Number of inputs: two programmable
- Ratings:
  - 1.2 VA at 120 Vac
  - Maximum off = 36 Vac
  - Minimum on = 86 Vac

Output Contacts

- Number of outputs: four Form C, programmable
- Momentary:
  - Make 30 A AC/DC for 0.25 seconds
  - Break 0.25 A at 250 Vdc (resistive)
  - Break 5 A at 120 240 Vac
- Continuous:
  - 5 A at 120/240 Vac
  - 5 A at 30 Vdc

Analog Output

- Rating: ± 4–20 mA programmable
- Maximum load: 1K ohm
- Accuracy: 1%

Motor Overload Protection (I^2t)

- Full load amperes: 10–3000 A
- Locked rotor current: 300–1200% FLA
- Locked rotor time: 1–120 seconds
- Ultimate trip current: 85–150% FLA
- Phase CT ratio: 10–4000 (I_n)
- Ground CT ratio: 10–4000 (I_n)
- Timing accuracy: ± 2.5% or ±30 ms for I > 1.1x U.T.C

Trip Setting Range

- Ground fault (GF): Off, 2–55% CT ratio
- GF start time delay: 2–60 cycles
- GF run time delay: 0–60 cycles
- Timer accuracy: ± 20 ms
- Instantaneous O.C.: Off, 300–1600% FLA
- IOC start time delay: 2–60 cycles
- Timer accuracy: ±20 ms
- JAM trip: Off, 100–1200% FLA
- Underload trip: Off, 1–90% FLA
- Phase unbalance trip: Off, 4–40% I_{neg}/I_{pos}
- Start delay timers:
  - 0–120 seconds (underload and phase unbalance)
  - 0–1200 seconds (jam)
- Run delay timers: 0–240 seconds
- Timer accuracy: ±0.5% +100 ms

Alarm Setting Range

- Ground fault: Off, 2–55% CT ratio
- Overload I^2t: Off, 60–99% I^2t
- JAM: Off, 100–1200% FLA
- Underload: Off, 1–90% FLA
- Phase unbalance: Off, 4–40% I_{neg}/I_{pos}
- Run delay timers: 0–240 seconds

Start Control Functions

- Starts per time: 1–10 starts
- Time for starts per time: Off, 1–240 minutes
- Time between starts: Off, 1–240 minutes
- Number of cold starts: 1–5 starts
- Motor transition current: 10–300% FLA
- Time for transition: 0–1200 seconds
- Inc. sequence timer: Off, 1–240 seconds
- Long acceleration timer: Off, 1–1200 seconds
- Anti-Backspin timer: Off, 1–3600 minutes

RTD Inputs (Requires URTD module)

- Sensor types:
  - 10 ohm copper
  - 100 ohm nickel
  - 120 ohm nickel
  - 100 ohm platinum

URTD Module Communications

- Interface:
  - Electrical (three-wire)
  - Fiber optic (preferred)
- Fiber optic cable: Type HBFR-ERS or EUS

Clock

- Accuracy: ±1 minute/ month at 77 °F (25 °C)

IPONI Communications

- Type: two-wire, FSK
- Baud rate: 1200 or 9600 baud
- Protocol: INCOM
- Functions:
  - Read/write set points
  - Read metered values
  - Read trip/alarms
  - Read events/history
  - View starting profile

MPONI Communications

- Type: 5-wire, 485
- Baud rate: 1200 or 9600 baud
- Protocol: Modbus RTU
- Functions:
  - Read/write set points
  - Read metered values
  - Read trip/alarms
  - Read events/history
  - View starting profile

DPONI Communications

- Type: J-wire
- Baud rate: 500 k, 250 k, 125 k
- Protocol: DeviceNet
- Functions:
  - Read metered values
  - Read trip/alarms

Logging

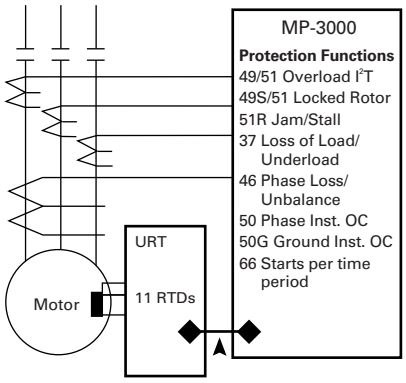
- Log book: 100 events
- Log event: 20 trips and alarms
- Log start: last four starts
- Start profile: last four starts (communication only)
- History records: motor, trips, alarms and total records

Environmental Conditions

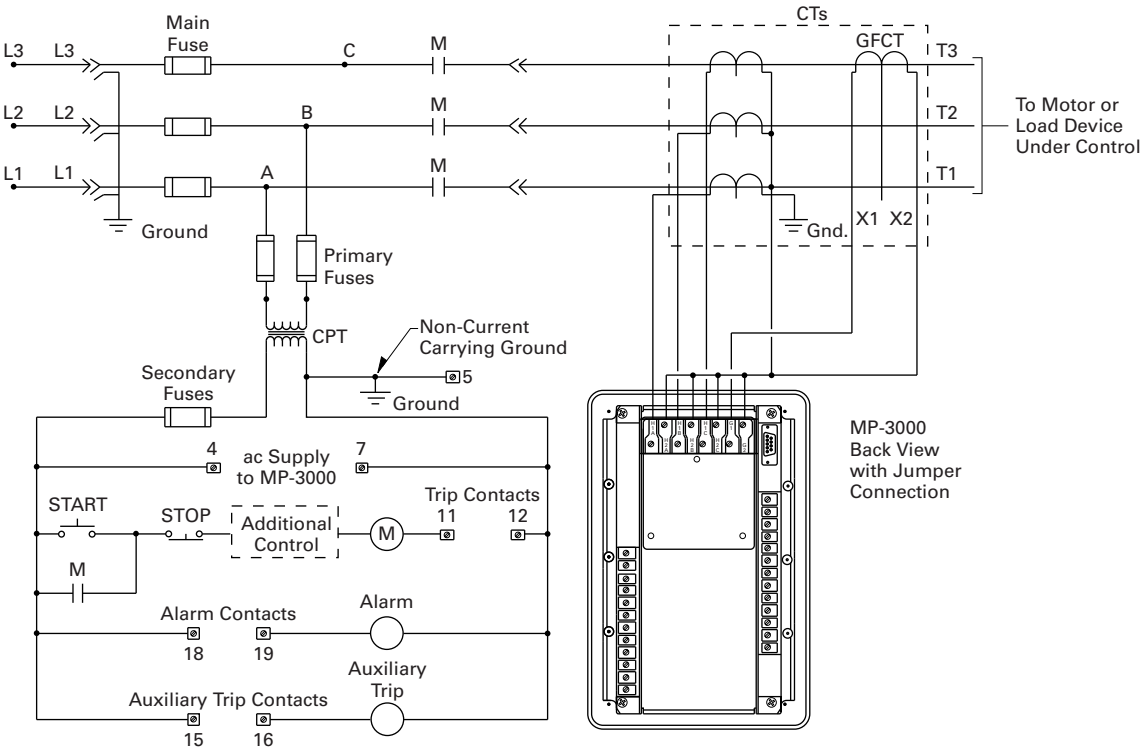
- Operating temperature: –4 °F to 140 °F (–20 °C to +60 °C)
- Storage temperature: –49 °F to +185 °F (–45 °C to +85 °C)
  - Humidity: 0–95% noncondensing

Wiring Diagrams

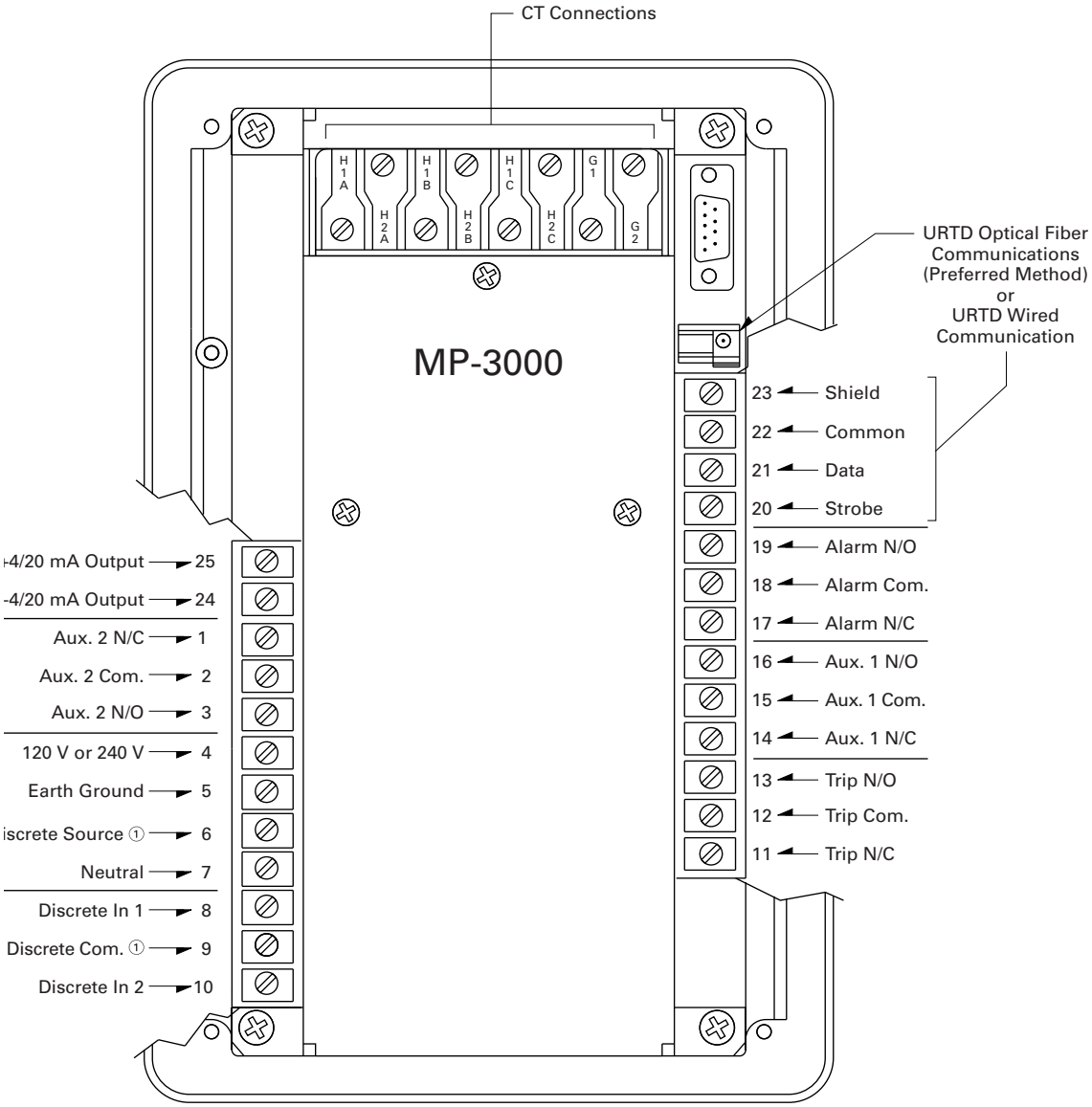
MP-3000 Motor Relay Protection Functions



MP-3000 Fixed Mount Typical



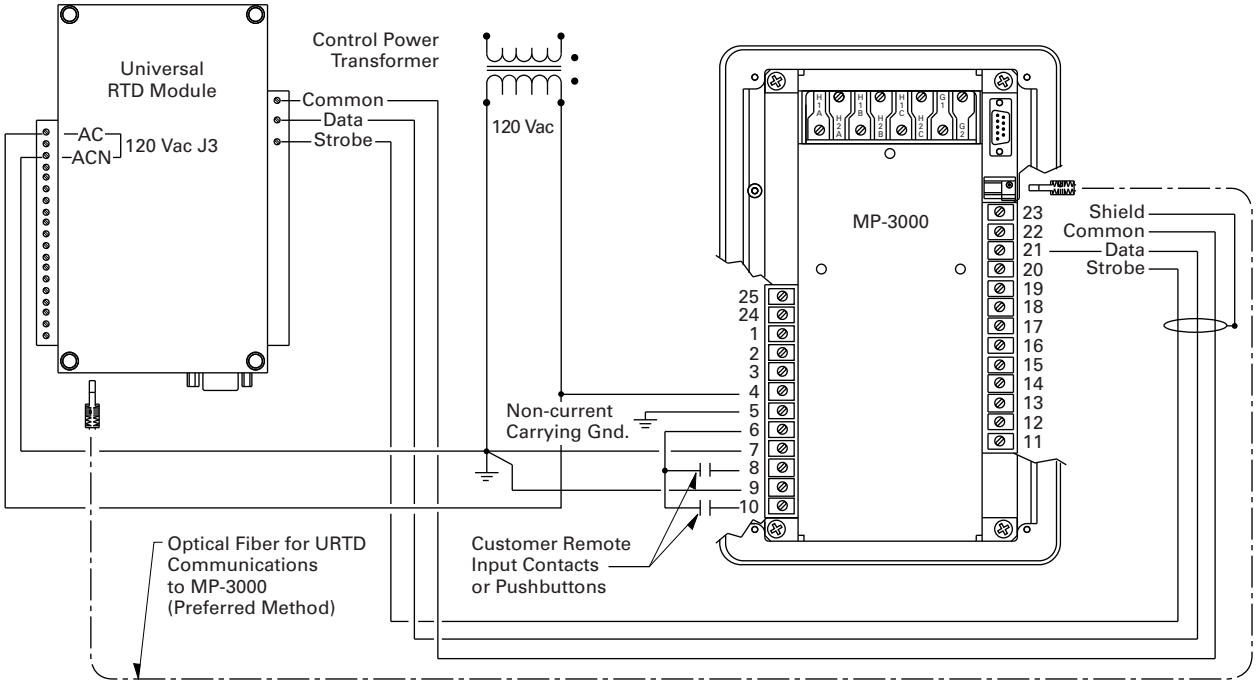
MP-3000 Terminal Identification



Note

① **Caution:** Do not connect terminals 6 and 9 together.

MP-3000 Control and URTD Wiring



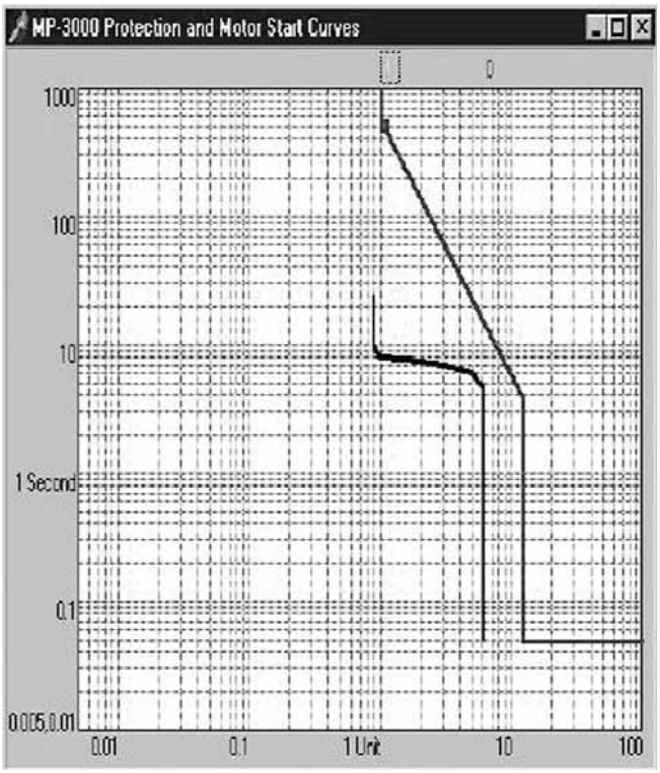
Trip Curve Chart

The MP-3000 motor relay records information on the most recent four starts. It records currents, percent of I^2t used, percent unbalance, RTD temperatures and time to transition and run. In addition, a motor start profile can be downloaded and displayed using Eaton's PowerPort or PowerNet Software. The starting profile shows the motor starting current plotted against the relay protection curve. This provides a quick view of the coordination between the protection and actual motor start current.

When communications are desired, an optional communication module or PONI (Product Operated Network Interface) is required. The MP-3000 is compatible with an INCOM (IPONI), Modbus RTU (MPONI) or Ethernet (EPONI). Future communication modules are planned to interface with other systems using other protocols. Please consult factory for availability of other communication options. **Page V3-T9-172** shows typical mounting of MP-3000 with optional PONI and with URTD module and PONI.

When the MP-3000 is supplied in the optional drawout case, then the INCOM (IPONI) is the only communication option available. The communication option must be selected at the time of order.

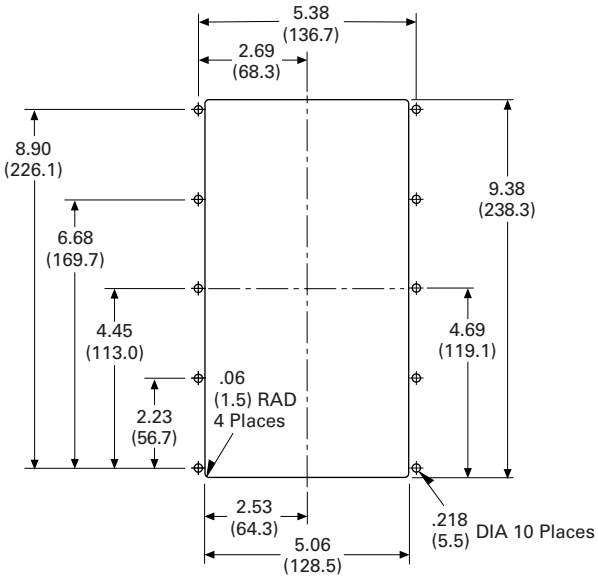
Motor Starting Profile Time/Current Chart



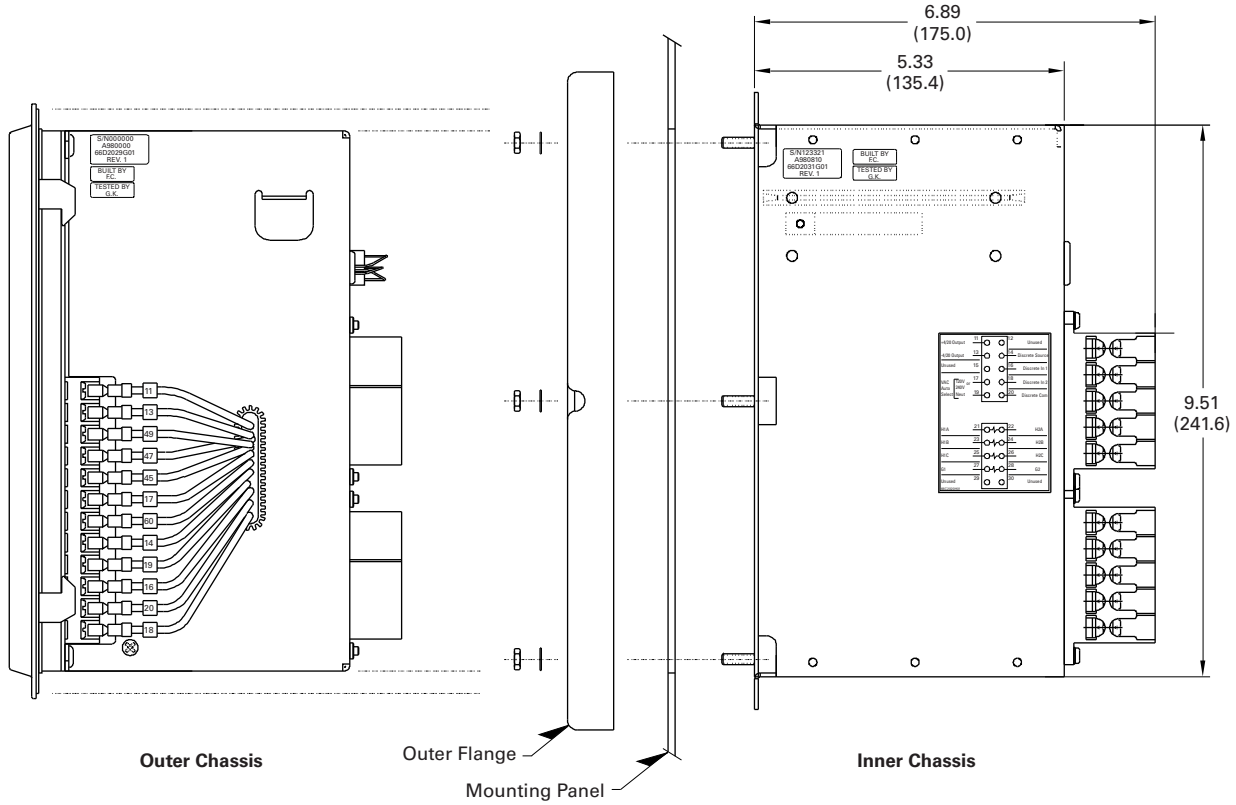
Dimensions

Approximate Dimensions in Inches (mm)

Panel Cutout Diagram

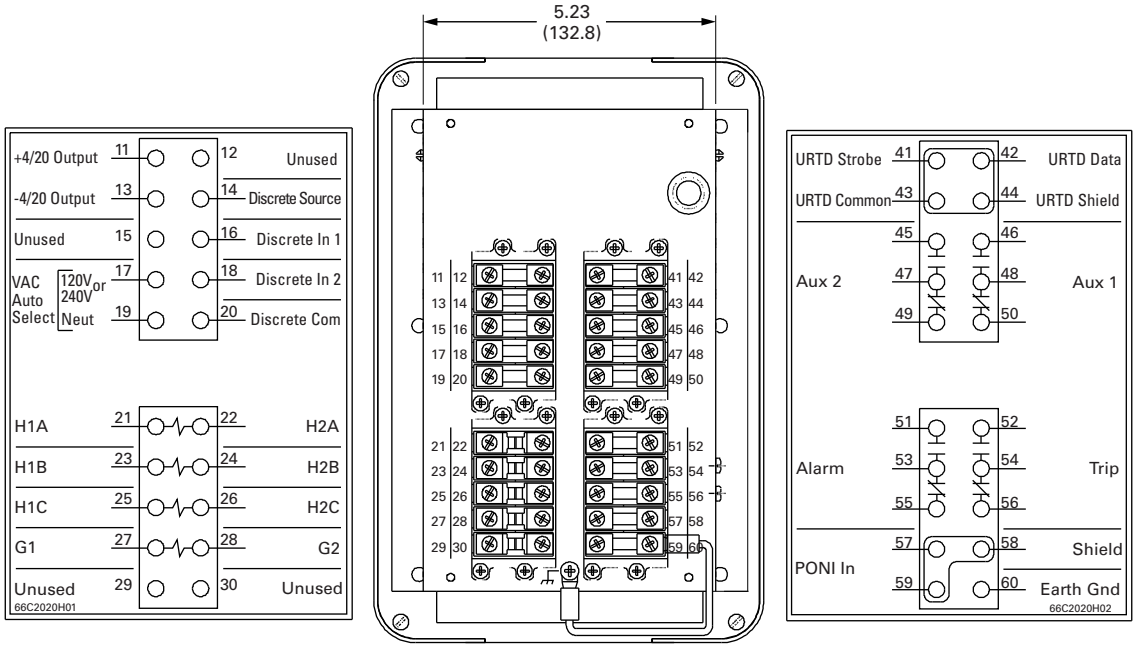


MP-3000 Drawout Panel Mounting



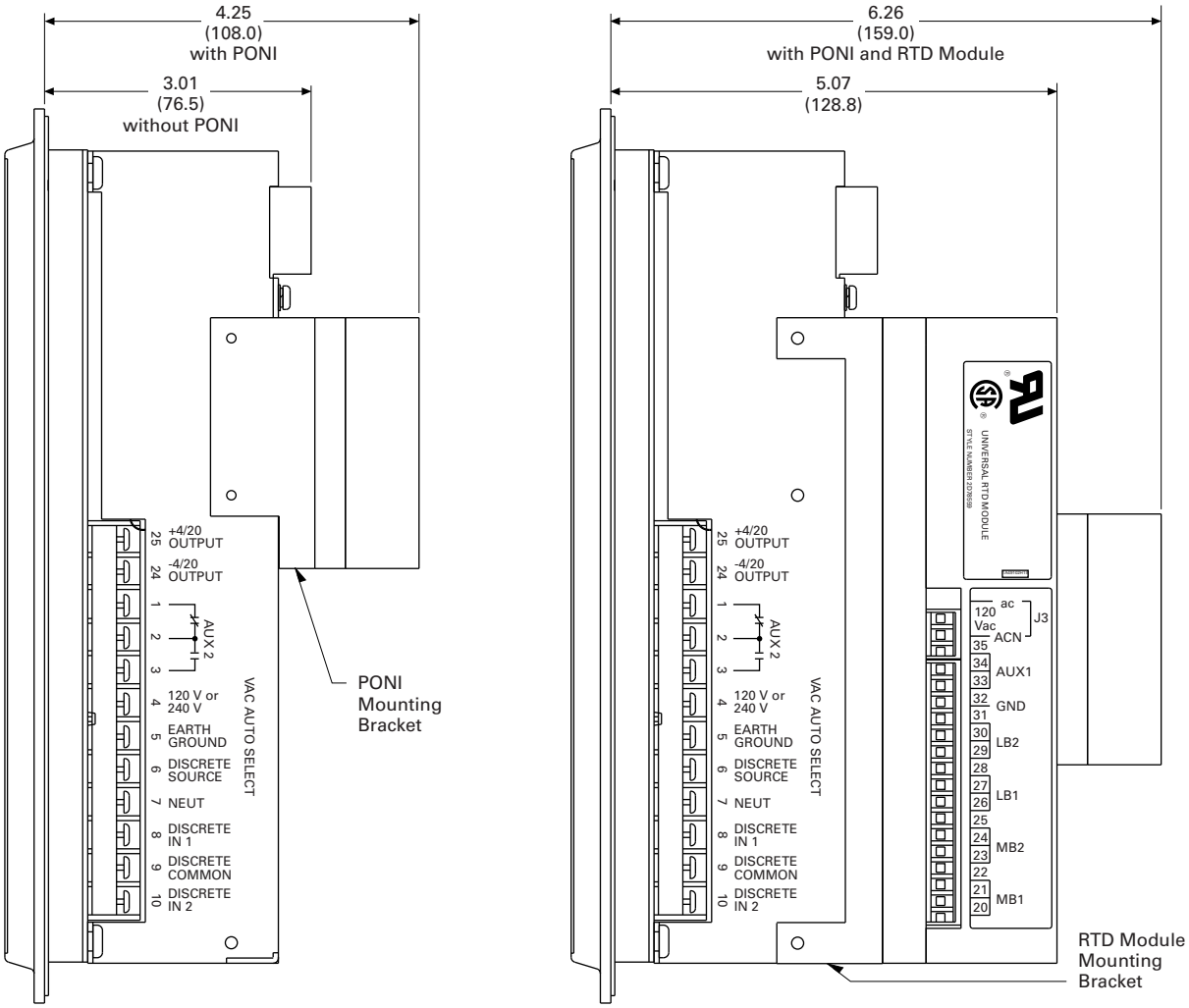
Approximate Dimensions in Inches (mm)

Rear View of MP-3000 Drawout Outer Case



Approximate Dimensions in Inches (mm)

MP-3000 PONI and URTD Mounting



FP-3000 Feeder Protection Relay

Height	Width	Depth	Shipping Weight Lbs (kg)
10.25 (260.4)	6.72 (170.7)	3.70 (94.0)	7.0 (3.2)

MP-4000

Contents

MP-4000 Motor Protection

Product Description

- Microprocessor-based, multi-function motor protection
- Intel-I-Trip overload protection based on motor data
- Event recording and operational logging
- Motor Start Profile
- Optional Quick Release Drawout Case
- Used on AMPGARD and medium voltage assemblies
- "Help" menu provides user operational assistance

Application Description

Eaton's MP-4000 motor protection relay is a multifunctional microprocessor-based protective relay for the protection of three-phase ac motors. The MP-4000 motor relay may be applied to any size motor at any voltage level. It is most commonly used on large, medium voltage three-phase induction motors. It has also been widely used on important low voltage (480 volt) motor applications and synchronous motors.

The MP-4000 motor relay monitors three-phase and ground currents, and three-phase voltages. It provides motor overload, stall, short circuit, phase unbalance, single phasing over/undervoltage, underpower, power factor and ground fault motor protection. It can also be used to provide protection for a load jam or loss of load condition.

The MP-4000 motor relay provides start control logic to protect the motor against excessive starts or starting the motor before it has had sufficient time to cool down. The MP-4000 motor relay may be applied to either across the line starters or reduced voltage starters. On reduced voltage starters, the MP-4000 relay can control the switch from reduced voltage to full voltage based on time and/or motor transition. The MP-4000 can protect the starter against failure to transition to full voltage through contact feedback and an incomplete sequence function.

The MP-4000 motor relay is generally used on a motor starter or a breaker used for a motor load. The MP-4000 motor relay provides the intelligence to protect and control the motor against abnormal operating conditions. It monitors the currents from either a 5 A or 1 A secondary of a CT circuit. Ground current may be obtained from either a ground CT or from the residual connection of the phase CTs. It provides a form C contact output for controlling the starter contacts or breaker operation.

Features, Benefits and Functions

- Complete motor protection and control in a single compact case reduces panel space requirements and wiring costs
- Microprocessor design with self diagnostics eliminates calibration and reduces installation, commissioning and maintenance
- Programmable stop 2–20% of PCT
- Intel-I-Trip overload protection develops customized curve from manufacturer's supplied motor data
- Intel-I-Trip overload protection provides adaptive trip characteristics based on motor temperature when motor RTDs are connected through an optional URTD module
- Meets UL 1053 ground fault protection standards that eliminates the need for a separate ground relay saving cost, space, wiring and time
- Voltage dip/loss ride through capability reduces unnecessary trips caused by poor power quality
- Motor currents, temperatures and conditions are monitored and displayed either locally or remotely
- Event log provides motor operating records for the most recent 20 Trip or Alarm events with date and time stamping. This information can improve troubleshooting and reduce downtime
- Log book records the most recent 100 events such as motor START/STOP and set point changes to provide a log of motor operation with date and time stamping
- RTD diagnostics reduces unnecessary tripping caused by faulty RTD, RTD wiring or communications
- Arm/Disarm feature improves security for critical motor applications
- Motor Start profile verifies protection and motor starting coordination. This feature can be used to develop protection settings on old motors where data is not available
- Optional communication module and Eaton's software simplifies setting, configuration, monitoring, commissioning and data retrieval either locally or remotely
- Optional Quick Release Drawout Case construction simplifies relay removal and replacement

The protection functions are listed below:

- I^2t overload protection (49/51)
- Locked rotor (49S/51)
- Ultimate trip current (51)
- Negative sequence phase unbalance (46)
- Instantaneous overcurrent (50)
- Ground fault protection (50G)
- Undervoltage (27)
- Overvoltage (59)
- Under power (32)
- Negative sequence voltage unbalance (47)
- Power factor (55)
- RTD trip and alarm with URTD module (49/38)
- Underload trip (37)
- Starts per time (66)
- Jam or stall (51R)
- Auto or manual reset (86)
- Fail-safe or non-fail-safe trip modes

The metering functions are:

- Metering:
  - Average current
  - Amperes: magnitude and angle in primary values
  - Amperes: positive, negative and zero sequence
  - Average voltage (V ave)
  - Voltage: magnitude and angle
  - Voltage: positive, negative and zero sequence
  - % of full load
  - % current unbalance
  - % voltage unbalance
  - Power, vars and VA
  - Power factor
  - Frequency
  - Energy metering with time and date stamps
- RTD temperatures:
  - Individual winding
  - Motor bearing
  - Load
  - Auxiliary temperatures
- Motor conditions:
  - Percent of I^2t thermal bucket
  - Time before start
  - Remaining starts allowed
  - Oldest start time

Standards and Certifications

The MP-4000 motor protection was designed to meet the industry standards for protective relays. It is recognized under UL 1053 Ground Fault Protection Standard.

- UL recognized (File No. E154862)
- UL 1053 recognized
- UL 508 recognized
- ANSI C37.90, C37.90.1
- cUL
- CSA

Listed

Reference Information

Cross-Reference

Westinghouse®/Cutler-Hammer

Eaton's Cutler-Hammer MP-3000 motor relay supersedes the Cutler-Hammer (formerly Westinghouse) IQ 1000 II motor relay and can replace the earlier IQ 1000 motor relay version sold under the Westinghouse name. The MP-3000 motor relay fits in the same cut out and provides the protection functions of these older models. The MP-3000 relay provides numerous enhancements and new features over the superseded models. The most notable enhancements are UL 1053 ground fault protection certified, voltage loss ride through capability, data logging, communications features and the addition of a clock for date and time stamping of events.

GE Multilin™

GE Multilin has several product offerings for motor protection. The 269 PLUS is the equivalent model to the MP-3000 with optional URTD module. Eaton offers MP-3000 value packs that include an MP-3000, PONI, URTD module and fiber optic cable at competitive prices.

GE Multilin has both lower and higher end products. The MP-3000 can be used in place of their 239 motor relay. The MP-3000 offers more capabilities than the 239 for a slightly higher price.

GE Multilin 369 and 469 are upgraded end products. The MP-3000 relay offers equivalent overload and current protection functions. It also provides equivalent start control functions. Both the 369 and 469 offer voltage protection and metering functions. An Eaton meter and/or other manufacturers' protective relays may be needed to satisfy the customer's motor protection requirements. The 469 adds differential protection. This function must be supplied by others in addition to the MP-3000 motor relay.

9

Cross-Reference

New Eaton's Series	Old Cutler-Hammer (Westinghouse)	GE Multilin
MP-3000 (URTD module) ①	IQ 1000 II, IQ 1000	269, 269+, 239, base 369
MP-4000 (URTD module) ①	—	369 with voltage option
MP-4000 + MP-3000	—	469

Note

① If RTD monitoring required.

Product Selection

MP-4000

MP-4000 Ordering Information

Description	Catalog Number
MP-4000 drawout, 5 A with RS-232	**MP4011**
MP-4000 drawout, INCOM, 5 A with RS-232	**MP4012**
MP-4000 drawout, Modbus, 5 A with RS-232	**MP4013**
MP-4000 drawout, DeviceNet, 5 A with RS-232	**MP4014**
MP-4000 drawout, 1 A with RS-232	**MP4111**
MP-4000 drawout, INCOM, 1 A with RS-232	**MP4112**
MP-4000 drawout, Modbus, 1 A with RS-232	**MP4113**
MP-4000 drawout, DeviceNet, 1 A with RS-232	**MP4114**
MP-4000 fixed case, 5 A with RS-232	**MP4010**
MP-4000 fixed case, INCOM, 5 A with RS-232	**MP4010INCOM**
MP-4000 fixed case, Modbus, 5 A with RS-232	**MP4010MODBUS**
MP-4000 fixed case, DeviceNet, 5 A with RS-232	**MP4010DEVICEN**
MP-4000 fixed case, 1 A with RS-232	**MP4110**
MP-4000 fixed case, INCOM, 1 A with RS-232	**MP4110INCOM**
MP-4000 fixed case, Modbus, 1 A with RS-232	**MP4110MODBUS**
MP-4000 fixed case, DeviceNet, 1 A with RS-232	**MP4110DEVICEN**
MP-4000 fixed case, INCOM, 5 A with RS-232, URTD	**MP4010VPI**
MP-4000 fixed case, Modbus, 5 A with RS-232, URTD	**MP4010VPM**
MP-4000 fixed case, DeviceNet, 5 A with RS-232, URTD	**MP4010VPD**
MP-4000 fixed case, INCOM, 1 A with RS-232, URTD	**MP4110VPI**
MP-4000 fixed case, Modbus, 1 A with RS-232, URTD	**MP4110VPM**
MP-4000 fixed case, DeviceNet, 1 A with RS-232, URTD	**MP4110VPD**

Options and Accessories

Additional Related Products by Eaton's Cutler-Hammer Series

The MP-4000 is available in either a fixed mount or Quick Release Drawout Case. Both mountings use the same panel cutout.

The Universal RTD module (URTD) is required when the motor is equipped with RTDs that you wish to monitor and use for protection. The URTD can be mounted near the motor to reduce RTD wiring and costs.

The MP-4000 motor protection is design-ed to operate from 120 Vac or 240 Vac auxiliary control power. The MP-4000 motor relay can be used with dc control power with the addition of the IQDCPS. The IQDCPS is an inverter from DC to AC.

Technical Data and Specifications

Control Power
- Nominal rating:
  - 120 Vac or 240 Vac
  - +10%, –25%
- Operating range:
  - 120 Vac: 90 132 Vac
  - 240 Vac:180 264 Vac
- Frequency: 50 or 60 Hz
- Power use:
  - 20 VA maximum
  - URTD: 6 VA maximum
  - IPONI: 1 VA maximum
- Ride-through time: 30 cycles from nominal Vac

Current Inputs
- Nominal (I_n): 1 A or 5 A
- CT rating:
  - 2 x I_n continuous
  - 50 x I_n for 1 second
- Burdens:
  - < 0.25 VA at 5 A
  - < 0.05 VA at 1 A

Voltage Inputs
- Nominal: 120 Vac
- Operating range: 69 to 150 Vac
- Burden: 2 VA

Metering Accuracy
- Phase current: ±1% of I_n (5–100%)
- Ground current: ±1.5% of I_n (0–55%)

Discrete Inputs
- Number of inputs: two programmable
- Ratings:
  - 1.2 VA at 120 Vac
  - Maximum off = 36 Vac
  - Minimum on = 86 Vac

Output Contacts
- Number of outputs: four Form C, programmable.
- Momentary:
  - Make 30 A AC/DC for 0.25 seconds
  - Break 0.25 A at 250 Vdc (Resistive)
  - Break 5 A at 120 240 Vac
- Continuous:
  - 5 A at 120/240 Vac
  - 5 A at 30 Vdc

Analog Output
- Rating: ± 4–20 mA programmable
- Maximum load: 1K ohm
- Accuracy: 1%

Motor Overload Protection (I^2t)
- Full load amperes: 10–3000
- Locked rotor current: 300–1200% FLA
- Locked rotor time: 1–120 seconds
- Ultimate trip current: 85–150% FLA
- Phase CT ratio: 10–4000 (I_n)
- Ground CT ratio: 10–4000 (I_n)
- Timing accuracy: ± 2.5% or ±30 ms for I > 1.1x U.T.C.

Trip Setting Range
- Ground fault (GF): Off, 2–55% CT ratio
- GF start time delay: 2–60 cycles
- GF run time delay: 0–60 cycles
- Timer accuracy: ± 20 ms
- Instantaneous O.C.: Off, 300–1600% FLA
- IOC start time delay: 2–60 cycles
- Timer accuracy: ±20 ms
- JAM trip: Off, 100–1200% FLA
- Underload trip: Off, 1–90% FLA
- Current unbalance trip: Off, 4–40% I_{neg}/I_{pos}
- Start delay timers:
  - 0–120 seconds (underload and phase unbalance)
  - 0–1200 seconds (jam)
- Run delay timers: 0–240 seconds
- Timer accuracy: ±0.5% +100 ms
- Voltage unbalance: Off, 1 to 100 V
- % V2/V1: 4% + 40%
- Voltage unbalance time delay: 0 to 1200 s
- Under/overvoltage time delay: Off, 10 to 150 V
- Under/overvoltage time delay: 0 to 1200 s
- Under/overfrequency: Off, 15 to 60 Hz
- Under/overfrequency time delay: 0 to 60 sec
- Power protection: Off, 0.06 to .90 + FLA VT
- Power time delay: 0 to 1200 sec
- Power factor: Off, 0.05 lag to 0.99 lead
- Power factor time delay: 0 to 60 s

Alarm Setting Range
- Ground fault: Off, 2–55% CT ratio
- Overload I^2t: Off, 60–99% I^2t
- JAM: Off, 100–1200% FLA
- Underload: Off, 1–90% FLA
- Phase unbalance: Off, 4–40% I_{neg}/I_{pos}
- Run delay timers: 0–240 seconds

Start Control Functions
- Starts per time: 1–10 starts
- Time for starts per time: Off, 1–240 minutes
- Time between starts: Off, 1–240 minutes
- Number of cold starts: 1–5 starts
- Motor transition current: 10–300% FLA
- Time for transition: 0–1200 seconds
- Inc. sequence timer: Off, 1–240 seconds
- Long acceleration timer: Off, 1–1200 seconds
- Anti-Backspin timer: Off, 1–3600 minutes

RTD Inputs (Requires URTD module)
- Sensor types:
  - 10 ohm copper
  - 100 ohm nickel
  - 120 ohm nickel
  - 100 ohm platinum

URTD Module Communications
- Interface:
  - Electrical (three-wire)
  - Fiber optic (preferred)
- Fiber optic cable: Type HBFR-ERS or EUS

Clock
- Accuracy: ±1 minute/month at 77 °F (25 °C)

PONI Communications
- Type: two-wire, FSK
- Baud rate: 1200 or 9600 baud
- Protocol: INCOM
- Functions:
  - Read/write set points
  - Read metered values
  - Read trip/alarms
  - Read events/history
  - View starting profile

MPONI Communications
- Type: five-wire, 485
- Baud rate: 1200 or 9600 baud
- Protocol: Modbus RTU
- Functions:
  - Read metered values
  - Read trip/alarms

DPONI Communications
- Type: J-wire
- Baud rate: 500 k, 250 k, 125 k
- Protocol: DeviceNet
- Functions:
  - Read metered values
  - Read trip/alarms

Logging
- Log book: 100 events
- Log event: 20 trips and alarms
- Log start: last four starts
- Start profile: last four starts (communication only)
- History records: motor, trips, alarms and total records

Environmental Conditions
- Operating temperature: –4 °F to +140 °F (–20 °C to +60 °C)
- Storage temperature: –49 °F to +185 °F (–45 °C to +85 °C)
- Humidity: 0–95% noncondensing

Dimensions

Approximate Dimensions in Inches (mm)

MP-4000 Feeder Protection Relay

Height	Width	Depth	Shipping Weight Lbs (kg)
10.25 (260.4)	6.72 (170.7)	3.70 (94.0)	7.0 (3.2)

EMR-3000 Motor Protection Relay

Contents

EMR-3000 Motor Protection Relay

Product Description

Eaton's EMR-3000 motor protection relay is a multifunctional microprocessor- based protective relay for the protection of any size motor at all voltage levels. It is most commonly applied on medium voltage or larger motors. The EMR-3000 relay is a current only device that provides complete and reliable motor protection, monitoring, and starting control functions.

The EMR-3000 motor protection relay has removable terminal blocks, and it has Modbus-RTU communications as standard; and an optional Ethernet port for Modbus-TCP communications. The EMR-3000 motor protection relay has three-phase and one ground current inputs. It can be used with either a 5 A or 1 A CTs. The ground protection can be used with either a zero sequence ground CT or from the residual connection of the phase CTs.

The zero sequence ground CT provides greater ground fault sensitivity than the residual connection. The unit is capable of 60 Hz or 50 Hz operation.

The maintenance mode password protected soft key, can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only. The multiple setting groups can also be changed, via communications or a digital input. Flash memory is used for the programming and all settings are stored in nonvolatile memory.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. 14 programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 communication port on the back is standard for local area networking using Modbus-RTU. An optional Ethernet port and protocols are available.

The EMR-3000 motor protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/maximum values, load profiles, the 5 latest start profiles, motor trending, breaker wear information and oscillography data.

The EMR-3000 motor protection relay has four discrete inputs and 1 fiber optic input, 1 Form C, and 2 NO programmable contacts, 1 Form C healthy contact. It also has an optional 4–20 mA analog output or zone interlocking card. The relay provides maximum user flexibility to configure the I/O. All inputs and outputs (except the healthy output) are user-programmable. The unit also counts with a test mode to force outputs and simulate currents, to facilitate the commissioning of the unit.

It can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Application Description

Eaton's EMR-3000 motor protection relay has been designed for maximum motor operation and protection. It permits running the motor close to its design limits while protecting it against excessive heating and damaging overload conditions. The EMR-3000 field-proven protection algorithms were developed based on motor designs and operating parameters for optimum operation and protection while minimizing nuisance tripping. The EMR-3000 motor protection relay utilizes a patented protection algorithm and measurement technique based on proven positive and negative (unbalance) sequence current sampling and true RMS calculations.

Features, Benefits and Functions

Protection Features

- Thermal protection (49/51)
  - Locked rotor protection (49S/51)
- Phase overcurrent elements:
  - Two instantaneous elements with timers (50P[1], 50P[2] and 50P[3])
  - Three inverse time overcurrent elements (51P[1], 51P[2] and 51P[3])
  - 11 standard curves
  - Instantaneous or time delay reset
- Ground overcurrent elements:
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
- Jam or Stall protection (50J[1], 50J[2])
- Phase unbalance negative sequence overcurrent (46[1], 46[2])
- Underload protection (37[1], 37[2], 37[3])
- Temperature protection with optional URTD (49/38)
- Stars per hour (66)
- Lockout protection (86)
- Breaker failure (50BF)
- Zone interlocking for bus protection (87B)

Metering Features

- Amperes: Positive, negative and zero sequence
- Ampere demand
- % THD I
- Magnitude THD I
- Minimum/maximum recording
- Temperature with remote URTD module

Monitoring Features

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (7200 cycles total)
- Trip Cause displays fault recorder data on HMI after fault event
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Trending (load profile over time)
- Motor history
- Records the last 5 motor start profiles
- Motor start trending
- CT supervision
- Clock (1 ms time stamping)

Control Functions

- Transition for reduced voltage starts
- Incomplete sequence delay
- Permits numbers of cold starts
- Limits numbers of starts per hour
- Anti-backspin time delay
- Mechanical load shedding
- Zero speed switch for long acceleration motors
- Motor stop inputs
- Remote trip input
- Differential trip input
- Emergency override
- Breaker/Contactor open-close/stop-start
- Remote open-close (stop-start)
- Programmable I/O
- Programmable LEDs
- Multiple setting groups

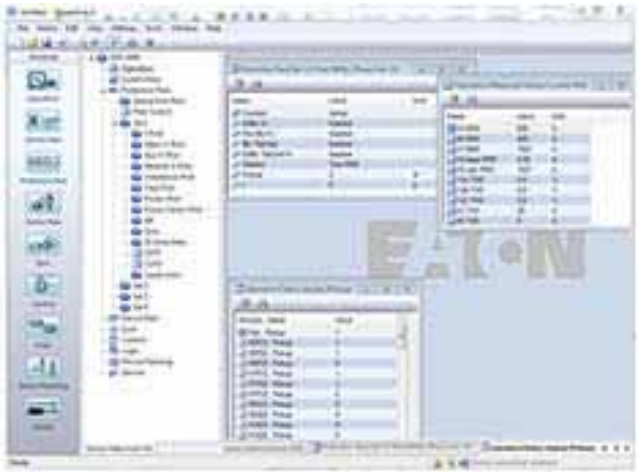
Communication Features

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port.
  - RS-232
- Remote communication port:
  - RS-485
  - Ethernet port
- Protocols:
  - Modbus-RTU
  - Modbus-TCP (optional)
  - IEC 61850 (optional)
- Configuration software
  - PowerPort-E

Monitoring and Metering

Sequence of Events Records

The EMR-3000 protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO in chronological order.



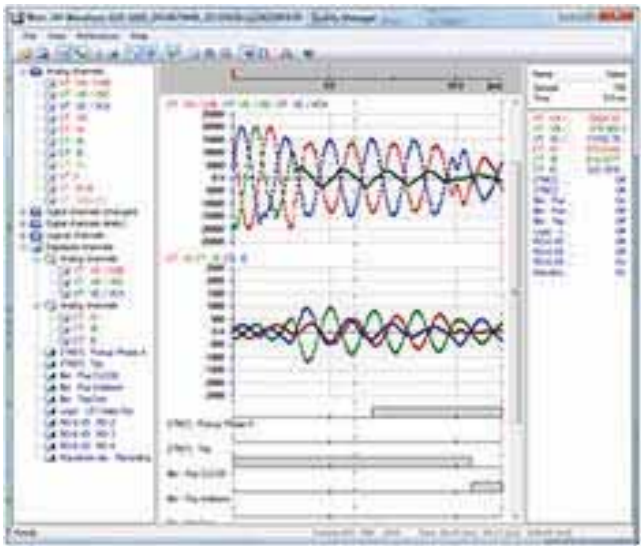
Trip Log

The EMR-3000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents and voltages at the time of the fault.

Waveform Capture (Quality Manager)

The EMR-3000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The EMR-3000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles.

The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. Seven programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Starting Profiles

The EMR-3000 records the average current versus time for the last five starting cycles. This information is available via the communications port through PowerPort-E.

Motor Statistics

For each motor start, the EMR-300 stores a motor start report and add this data to the motor statistics buffer. With the motor statistics you can track motor start data for the past eighteen 30-day periods. For each 30-day interval, the relay records the following information:

- The date the interval began
- The total number of starts in the interval
- The averages of the following quantities:
  - Motor Start Time
  - Start % Rotor Thermal Capacity Used
  - Maximum Start Current

Load Profiling/Trending

The EMR-3000 relay automatically records selected quantities into non-volatile memory every 5, 10, 15, 30 or 60 minutes, depending on the trending report setting.

Programmable I/O

The EMR-3000 motor protection relay provides heavy-duty, triprated, 2 normally open and 1 Form C contacts. One isolated inputs can be used for monitoring the trip circuit. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (failsafe) mode. There are 4 eight user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

Intel-I-Trip (I^2t) Overload Protection

The EMR-3000 motor relay features the exclusive Eaton Intel-I-Trip intelligent overload protection system. Intel-I-Trip develops custom overload curves simply from motor nameplate data. Intel-I-Trip protects motors from potentially damaging overload and abnormal operating conditions. The Intel-I-Trip intelligent overload protection feature utilizes field proven measurement techniques and a patented motor thermal protection model. The EMR-3000 motor relay's unique measurement technique samples the current waveforms 36 times per cycle, providing accurate measurements of the positive and negative sequence currents. The negative sequence current causes a greater heating effect on the rotor and has a greater impact on the thermal model in the relay. Intel-I-Trip utilizes these measurements in its motor model to safely protect the motor against the heating effects of these currents.

The motor thermal model is analogous to a bucket that is being filled and drained at the same time. The fill rate is dependent on the motor currents and the drain is based on motor design principles. The size of the bucket is equivalent to the thermal capacity associated with the mass of the motor. Intel-I-Trip integrates these rates and will issue a trip when the thermal capacity is filled.

Intel-I-Trip features adaptive trip characteristics that adjust the trip times based on measured motor temperature when RTDs are used.

Instantaneous Overcurrent

The EMR-3000 motor protection relay provides an instantaneous phase overcurrent function to trip the motor for high fault current levels and save the fuses. This function can be disabled and has an adjustable time delay on starting to avoid nuisance tripping on inrush.

Phase Unbalance Protection

Motor supply circuits are often fed through fuses and can be run with a single-phase fuse blown, referred to as single phasing the motor. The EMR-3000 motor protection relay measures the current unbalance and can be used to alarm or trip the motor before damage occurs. Pickup, start and run timers, and a second element for alarm purposes are provided.

Ground Fault Protection

A separate measuring circuit is used to measure ground current. A ground CT is recommended for more sensitive protection against winding insulation breakdown to ground. The relay ground circuit can be connected residually from the three-phase CTs. The ground fault protection has pickup and time delay set points or can be disabled.

Jam Protection

The user-selectable Jam function protects motors that are running against a sudden mechanical jam or stall condition. The common application is on motors used on crushers, chippers, or conveyors. It detects an increase of motor current to a level above full load. Pickup, start, and run timers and a second element for alarm purposes are provided.

Underload Protection

The user-selectable underload function is used to detect the loss of load on the motor. Coupling failure is a common cause for loss of load. Pickup, start, and run timers and a second element for alarm purposes are provided.

Reduced Voltage Starting

The EMR-3000 motor protection relay provides a transition and incomplete sequence function for reduced voltage starting. The user can select to transition based on the current level and/or on time.

Antibackspin

The stop function is programmable from 2–20%. For certain applications, such as pumping a fluid up a pipe, the motor may be driven backward for a period of time after it stops. The EMR-3000 relay provides an antibackspin timer to prevent starting the motor while it is spinning in the reverse direction. The timer begins counting from the moment a stop is declared by the relay.

Start Control Timers

Motors typically have limits to the number of cold starts, starts per hour period, or time between starts that are permitted without damage. The EMR-3000 motor protection relay incorporates these timers to prevent starting the motor beyond its capabilities.

Load Shedding

The EMR-3000 motor protection relay provides a mechanical load shedding feature that can be used to control an upstream process. The load-shedding function closes a contact on an overload condition to control an upstream process from adding more load until the overload condition is gone.

Emergency Override

The EMR-3000 motor protection relay has a user-programmable feature that will let the operator reset the start inhibitor timers and thermal overload bucket. This function is intended for use in emergency conditions only, and it may result in motor damage or failure.

Long Acceleration Motors

Large motors with a high inertia may experience starting currents that exceed the locked rotor current and time. The EMR-3000 motor protection relay has logic and provisions for a zero speed switch input to differentiate between a stall and start condition. If the motor is spinning, then the relay will not trip on the normal locked rotortime allowing the motor to start.

Remote/Differential Trip

The digital inputs can be programmed to accept a contact input from a separate differential relay or other device to trip the motor. This provides local and remote target information and utilizes the trip contacts of the EMR-3000 motor protection relay. It will also record and log the motor information at the time of the trip.

Breaker Failure or Stuck Contactor

The EMR-3000 motor protection relay includes a breaker failure (50BF, 62BF) function that can be initiated from either an internal or external trip signal. This is an independent element that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Flexible Phase Rotation

The EMR-3000 motor protection relay can be applied on either an A-B-C or A-C-B phase rotation. A user setting permits correct operation and indication of the actual system configuration.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communication or via a digital Input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Standards and Certifications

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90

9

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the EMR-3000. For example, if the catalog number is EMR-3000-2A0BA1, the device would have the following:

EMR-3000

(A)–Four digital inputs, four output relays, 1 4–20 mA analog output, URTD interface

(0)–5 A / 1 A phase and ground CTs, power supply range: 19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without conformal coating

(1)–Projection panel mount

Motor Relay Removable Terminals

EMR-3000-2A 0 B A 1

Hardware Option 1
- **A** = 4 DI, 4 outputs, removable terminals, 1 4–20 mA analog output, URTD interface, IRIG-B small display
- **B** = 4 DI, 4 outputs, removable terminals, zone interlocking, URTD interface, IRIG-B, small display

Hardware Option 2
- **0** = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Accessories

Standard Accessories EMR-3000

Description	Catalog Number
UNVL RTD Mod with Modbus-RTU 48–240 Vac/48–250 Vdc	**URTDII-01** ①
UNVL RTD Mod with Modbus-RTU 24–48 Vdc	**URTDII-02** ①
E-SERIES 3000 IQ adapter kit projection mounted ②	**ER-IQRETROKIT**

Notes

① See URTD section for fiber optic cables required to communicate to the EMR-3000.

② Retrofitting mounting plate MP-3000 relay, projection panel mount necessary.

Technical Data and Specifications

Climatic Environmental Conditions

- Storage Temperature: –25 °C up to +70 °C (–13 °F to +158 °F)
- Operating temperature: –20 °C up to +60 °C (–4 °F to +140 °F)
- Permissible humidity at Ann. Average: <75% rel. (on 56d up to 95% rel.)
- Permissible Installation Altitude: <2,000 m (6,561.67 ft) above sea level.
- If 4,000 m (13,123.35 ft) altitude applies, a changed classification of the operating and test voltages may be necessary.

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP30

Routine Test

- Insulation test acc. to IEC 60255-5: All tests to be carried out against ground and other input and output circuits.
- Aux. voltage supply, digital inputs, current measuring inputs, signal relay outputs: 2.5 kV (eff.) / 50 Hz
- Voltage measuring inputs: 3.0 kV (eff.) / 50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Housing B1: height / width 183 mm (7.205 in)/ 141.5 mm (5.571 in)
- Housing depth (incl. terminals): 208 mm (8.189 in)
- Material, housing: aluminum extruded section
- Material, front panel: aluminum/foil front
- Mounting position: Horizontal (±45° around the X-axis must be permitted)
- Weight EMR-3000 housing B1: Approx. 2.4 kg (5.291 lb)

Plug-in Connector with Integrated Short-Circuiter (Conventional Current Inputs)

- Nominal current: 1 A and 5 A
- Continuous loading capacity: 4 x I_n/ continuously
- Overcurrent withstand:
  - 30 x I_n/10 s
  - 100 x I_n/1 s
  - 250 x I_n/10 ms (1 half-wave)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
- 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve

Voltage Supply

- Aux. voltage: 24–270 Vdc/ 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage communication is permitted to be interrupted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse 5 x 20 mm (approx. 1/5 in x 0.8 in) according to IEC 60127
- 3.5 A time-lag miniature fuse 6. 3 x 32 mm (approx. 1/4 in x 1 1/4 in) according to UL 248-14

Power Consumption

- Power supply range:
  - 19–300 Vdc: 6 W idle mode/ 8 W max. power
  - 40–250 Vac: 6 W idle mode/ 8 W max. power (For frequencies of 40–70 Hz)

Real Time Clock

- Running reserve of the real time clock: 1 year min.

Display

- Display type: LCD with LED background illumination
- Resolution—graphics display: 128 x 64 pixel
- LED Type: two colored: red / green
- Number of LEDs, housing B1: 8

Digital Inputs

- Max. input voltage: 300 Vdc / 270 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Fallback time: <30 ms
- (Safe state of the digital inputs)
- Switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac / Vdc, 230 Vac / Vdc
  - Un = 24 Vdc
    - Switching threshold 1 ON:
    - Switching threshold 1 OFF:
    - Min. 19.2 Vdc
    - Max. 9.6 Vdc
  - Un = 48 V / 60 Vdc
    - Switching threshold 2 ON:
    - Switching threshold 2 OFF:
    - Min. 42.6 Vdc
    - Max. 21.3 Vdc
  - Un = 110 / 120 Vac/Vdc
    - Switching threshold 3 ON:
    - Switching threshold 3 OFF:
    - Min. 88.0 Vdc / 88.0 Vac
    - Max. 44.0 Vdc / 44.0 Vac
  - Un = 230 / 240 Vac/Vdc
    - Switching threshold 4 ON:
    - Switching threshold 4 OFF:
    - Min. 184 Vdc / 184 Vac
    - Max. 92 Vdc / 92 Vac
- Terminals: screw-type terminal

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x In (phase currents)
  - Up to 25 x In (ground current standard)
  - Up to 2.5 x In (ground current sensitive)
- Continuous loading capacity: 4 x In/ continuously
- Overcurrent proof:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Power consumption: phase current inputs
  - At In = 1 A burden = 0.15 MVA
  - At In = 5 A burden = 0.15 MVA
- Ground current input
  - At In = 1 A burden = 0.35 MVA
  - At In = 5 A burden = 0.35 MVA
- Frequency range: 50 Hz / 60 Hz ±10%
- Terminals: screw-type terminals with integrated short-circuiters (contacts)

Binary Output Relays

- Continuous current: 5 A AC/DC
- Switch-on current: 25 A AC/DC for 4 s
- Max. breaking current:
  - 5 A AC up to 125 V ac
  - 5 A DC up to 50 V (resistive)
  - 0.2 A DC at 300 V
- Max. Switching Voltage: 250 Vac/300 Vdc
- Switching capacity: 2000 VA
- Contact type: 1 changeover contact
- Terminals: screw-type terminals

Front Interface RS-232

- Baud rates: 115200 baud
- Handshake: RTS and CTS
- Connection: 9-pole D-Sub plug

RS-485

- Master/slave: slave
- Connection: 6 screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)

Tolerances of the Real Time Clock

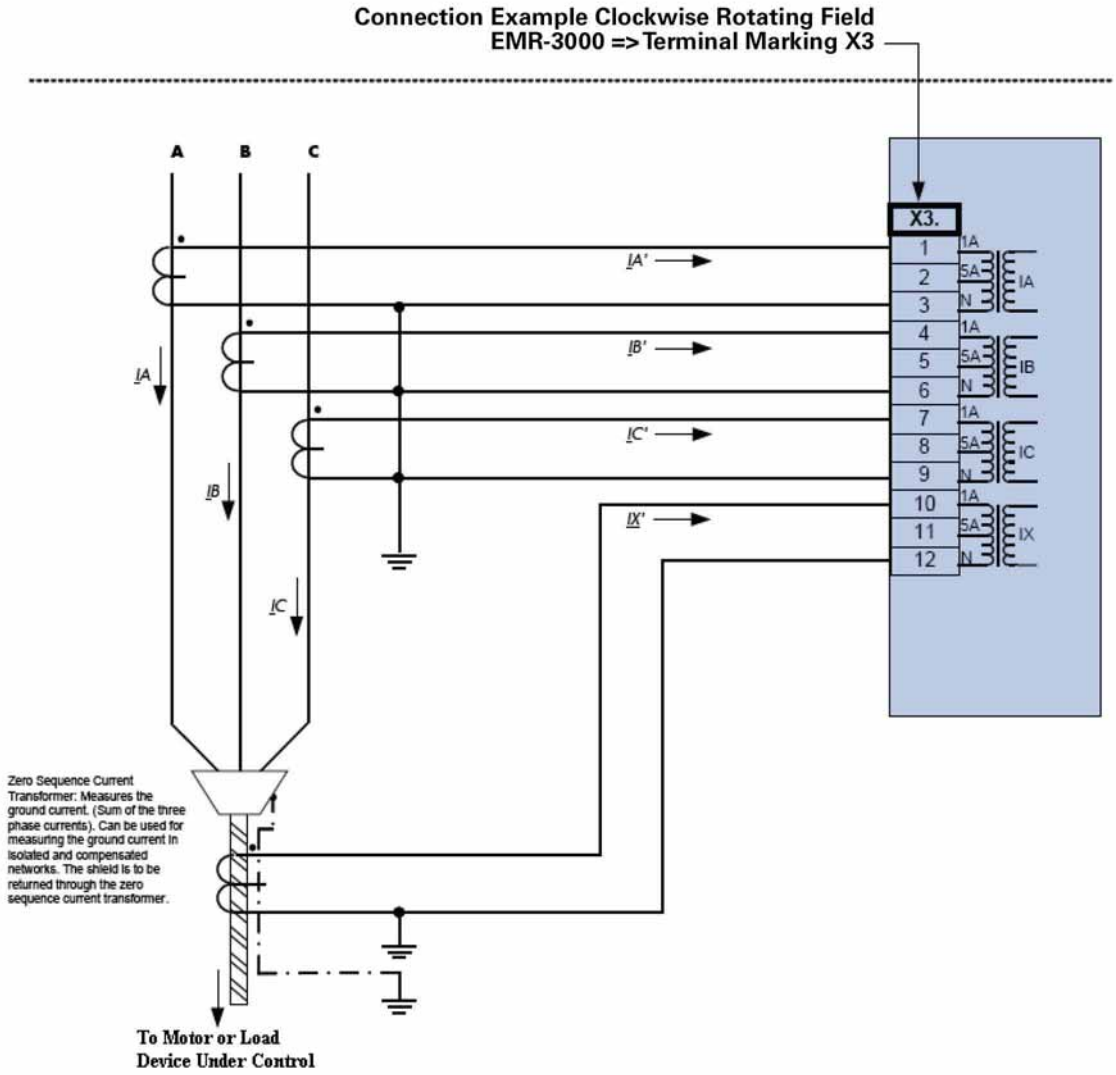
- Resolution: 1 ms
- Tolerance: <1 minute / month (+20 °C)

Measuring Accuracy

- Max. measuring range: Up to 40 x In (phase currents)
- Up to 25 x In (ground current standard)
- Frequency range: 50 Hz / 60 Hz ±10%
- Accuracy: Class 0.5
- Amplitude error if I < 1 In: ±0.5% of the rated value
- Amplitude error if I > In: ±0.5% of the measured value
- Amplitude error if I > 2 In: ±1.0% of the measured value
- Resolution: 0.01 A
- Harmonics: Up to 20% 3rd harmonic ±2% Up to 20% 5th harmonic ±2%
- Frequency influence: <±2% / Hz in the range of ±5 Hz of the parametrized nominal frequency
- Temperature influence: <±1% within the range of 0 °C up to +60 °C

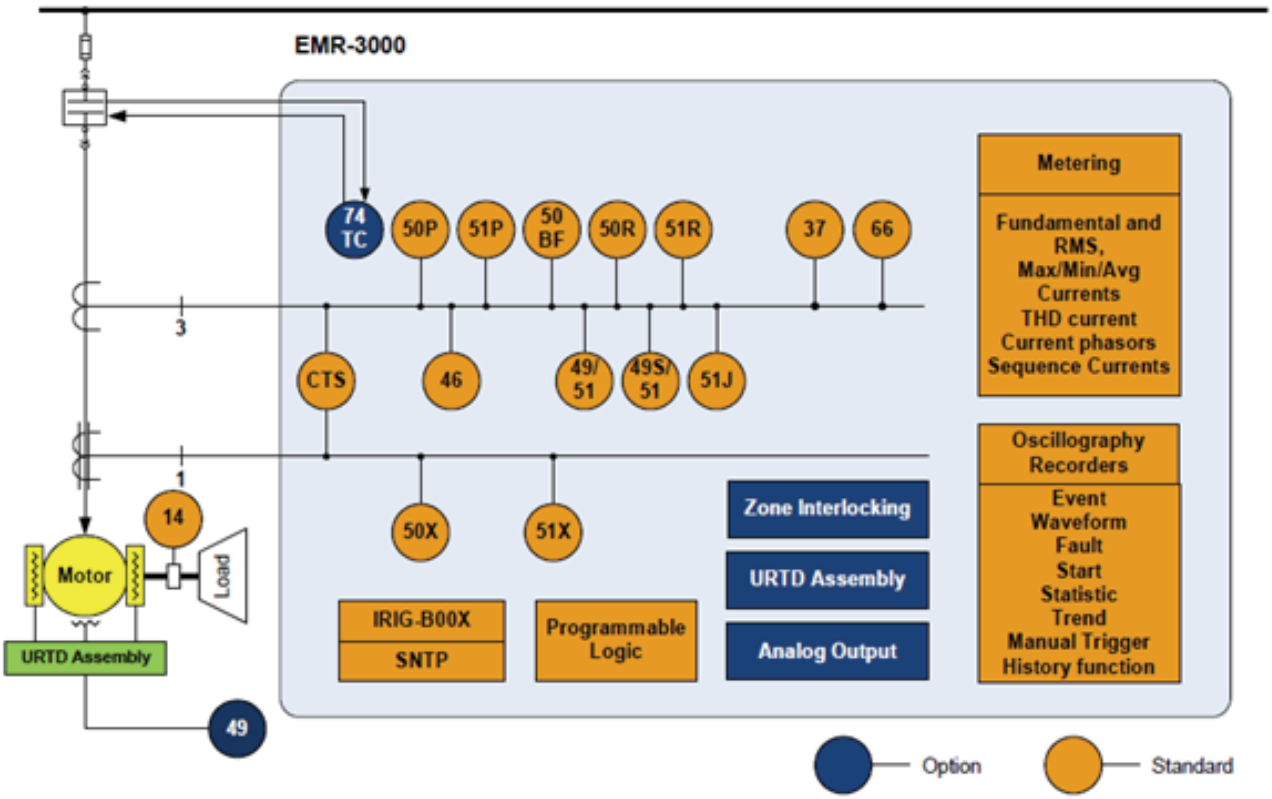
Wiring Diagrams

Typical AC Connections—1 A CTs and Ground Current Measured by Zero Sequence CT

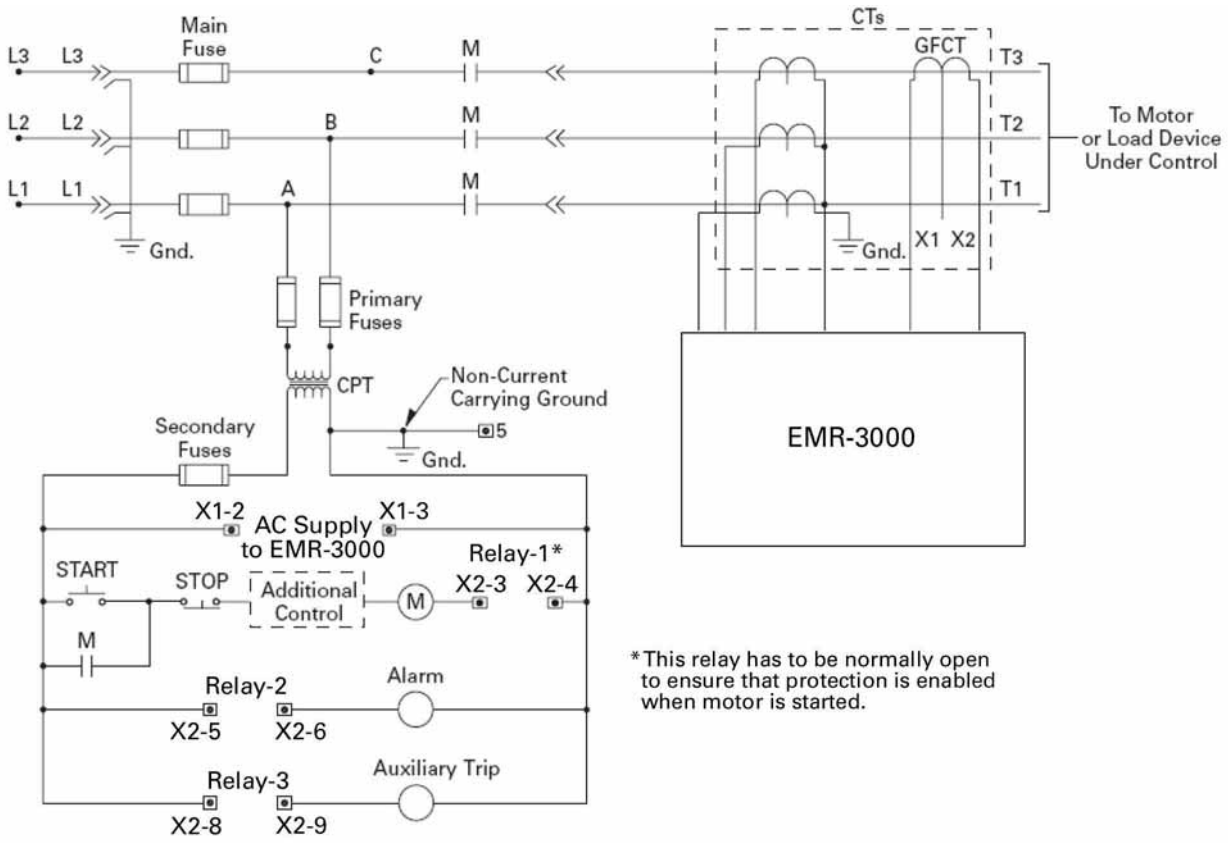


Three Phase Current Measurement; Inom Secondary = 1 A.
Ground Current Measuring via Zero Sequence CT ; IGnom Secondary = 1 A.

Typical One-Line Diagram



Typical Control Diagram

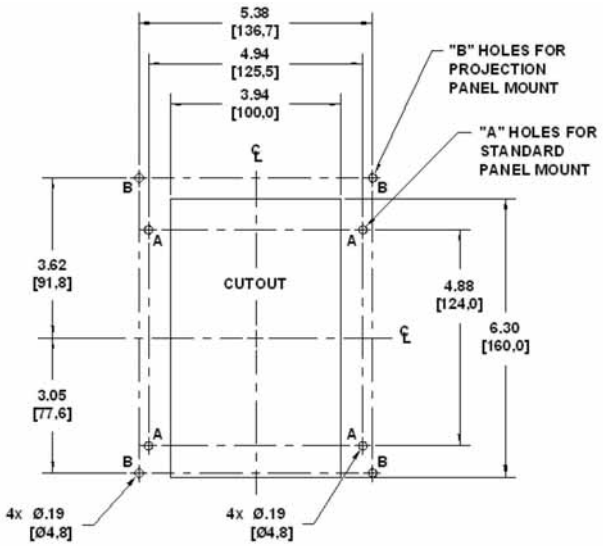


*This relay has to be normally open to ensure that protection is enabled when motor is started.

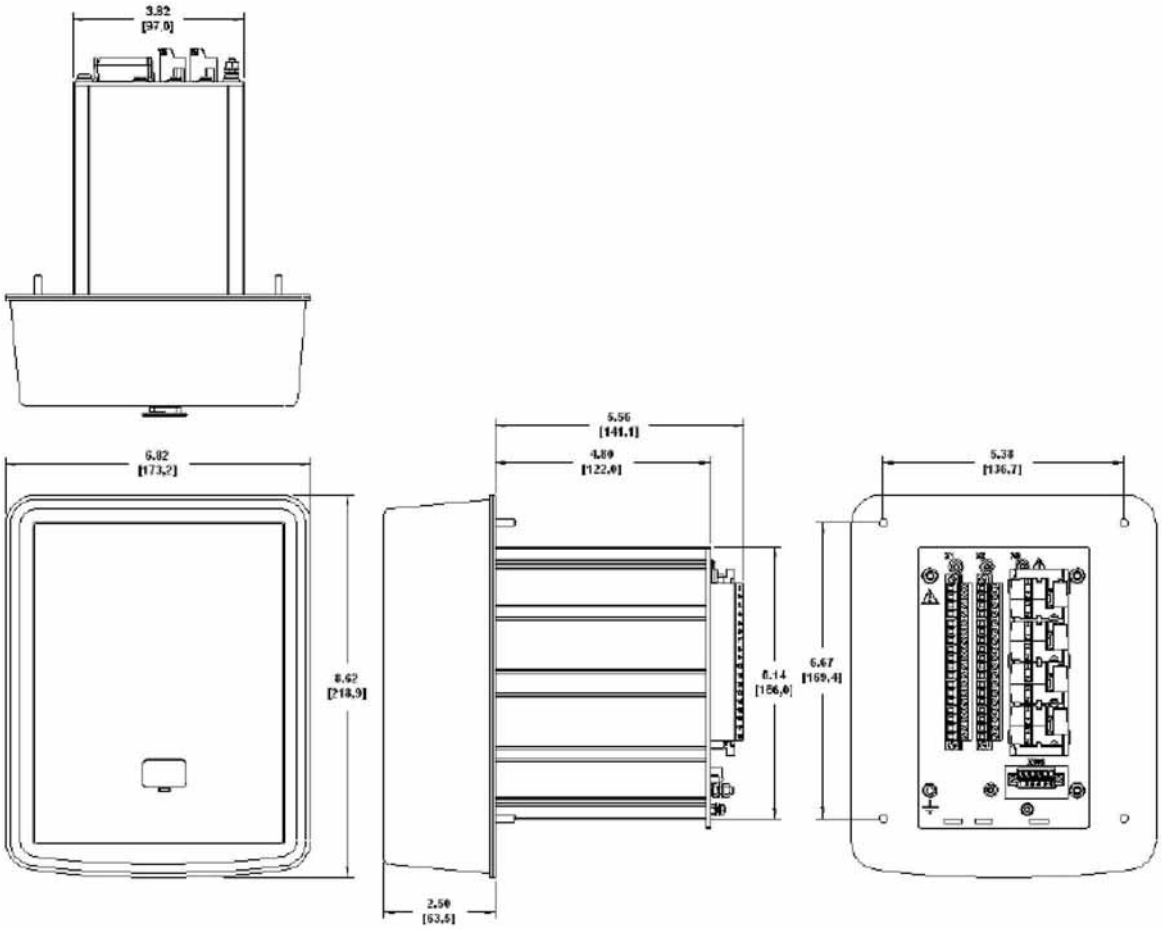
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

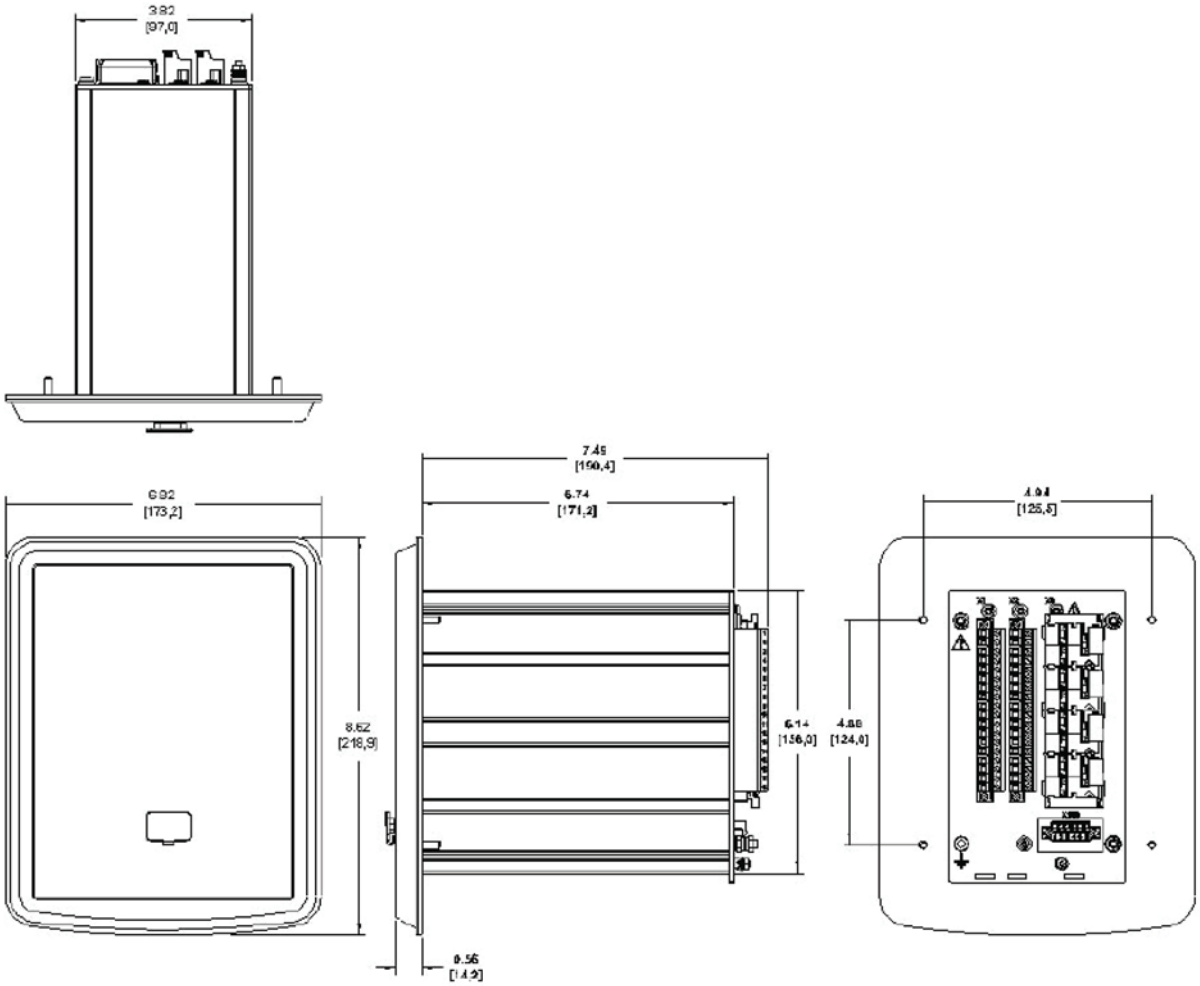


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



EMR-4000 Motor Protection Relay

Contents

EMR-4000 Motor Protection Relay

Product Description

Eaton's EMR-4000 motor protection relay is a multifunctional microprocessor-based protective relay for the protection of any size motor at all voltage levels. It is most commonly applied on medium voltage or larger motors. The EMR-4000 relay is a current and voltage device that provides complete and reliable motor protection, monitoring, diagnostics, metering and starting control functions.

The EMR-4000 motor protection relay has removable terminal blocks, and it has Modbus-RTU communications as standard; and an optional Ethernet port for Modbus-TCP communications or IEC-61850.

The EMR-4000 motor protection relay provides complete current, voltage, and frequency protection in a single compact case. The relay has four current inputs rated for either 5 amperes or 1 ampere and four voltage inputs. Three of the voltage inputs are to be connected to the three-phase power voltage for voltage protection and for metering. They can be connected in wye-ground or open delta configuration. The fourth voltage is for independent single-phase undervoltage/overvoltage protection. The unit is capable of 60 Hz or 50 Hz operation.

The maintenance mode password protected soft key, can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only. The multiple setting groups can also be changed, via communications or a digital input. Flash memory is used for the programming and all settings are stored in nonvolatile memory.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. 14 programmable LEDs provide quick indication of relay status. A front port is provided for direct computer connection. An RS-485 communication port on the back is standard for local area networking using Modbus-RTU. An optional Ethernet port and protocols are available.

The EMR-4000 motor protection relay includes programmable logic functions. Logic gates and timers may be defined and arranged for customized applications. With the programmable logic control functions you can simplify the complexity of your starting schemes by eliminating timers and auxiliary relays. Flash memory is used for the programming and all settings are stored in nonvolatile memory. The relay allows for four preprogrammed setting groups which can be activated through software or contact input.

The EMR-4000 motor protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/maximum values, load profiles, the 5 latest start profiles, motor trending, breaker/contactor wear information and oscillography data.

The EMR-4000 motor protection relay has eight discrete inputs, 1 fiber optic input, 2 Form C, and 2 NO output programmable contacts, and 1 Form C healthy contact. It also has four 4-20 mA analog outputs and one zone interlocking card. The relay provides maximum user flexibility to configure the I/O. All inputs and outputs (except the healthy output) are user-programmable. The unit also counts with a test mode to force outputs and simulate currents, to facilitate the commissioning of the unit. It can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Application Description

Eaton's EMR-4000 motor protection relay has been designed for maximum motor operation and protection. It permits running the motor close to its design limits while protecting it against excessive heating and damaging overload conditions. The EMR-4000 field proven protection algorithms were developed based on motor designs and operating parameters for optimum operation and protection while minimizing nuisance tripping. The EMR-4000 motor protection relay utilizes a patented protection algorithm and measurement technique based on proven positive and negative (unbalance) sequence current sampling and true RMS calculations.

Features, Benefits and Functions

Intel-I-Trip (I^2t) Overload Protection

The EMR-4000 motor relay features the exclusive Eaton Intel-I-Trip intelligent overload protection system. Intel-I-Trip develops custom overload curves simply from motor nameplate data. Intel-I-Trip protects motors from potentially damaging overload and abnormal operating conditions. The Intel-I-Trip intelligent overload protection feature utilizes field proven measurement techniques and a patented motor thermal protection model. The EMR-4000 motor relay's unique measurement technique samples the current waveforms 36 times per cycle, providing accurate measurements of the positive and negative sequence currents. The negative sequence current causes a greater heating effect on the rotor and has a greater impact on the thermal model in the relay. Intel-I-Trip utilizes these measurements in its motor model to safely protect the motor against the heating effects of these currents.

The motor thermal model is analogous to a bucket that is being filled and drained at the same time. The fill rate is dependent on the motor currents and the drain is based on motor design principles. The size of the bucket is equivalent to the thermal capacity associated with the mass of the motor. Intel-I-Trip integrates these rates and will issue a trip when the thermal capacity is filled.

Intel-I-Trip features adaptive trip characteristics that adjust the trip times based on measured motor temperature when RTDs are used.

Instantaneous Overcurrent

The EMR-4000 motor protection relay provides an instantaneous phase overcurrent function to trip the motor for high fault current levels and save the fuses. This function can be disabled and has an adjustable time delay on starting to avoid nuisance tripping on inrush.

Phase Unbalance Protection

Motor supply circuits are often fed through fuses and can be run with a single-phase fuse blown, referred to as single phasing the motor. The EMR-4000 motor protection relay measures the current and voltage unbalance and either can be used to alarm or trip the motor before damage occurs. The EMR-4000 has 2 voltage and 2 current unbalance elements. Pickup, start and run timers are provided for each element.

Ground Fault Protection

A separate measuring circuit is used to measure ground current. A ground CT is recommended for more sensitive protection against winding insulation breakdown to ground. The relay ground circuit can be connected residually from the three-phase CTs. The ground fault protection has pickup and time delay set points or can be disabled.

Jam Protection

The user-selectable Jam function protects motors that are running against a sudden mechanical jam or stall condition. The common application is on motors used on crushers, chippers, or conveyors. It detects an increase of motor current to a level above full load. Pickup, start, and run timers and a second element for alarm purposes are provided.

Underload/Underpower Protection

The user selectable underload/underpower function is used to detect the loss of load on the motor. Coupling failure is a common cause for loss of load. Whenever is possible, it is better to use underpower to detect loss of load. Three power elements and two underload elements are provided in the relay for tripping and alarm purposes. Pickup, start, and run timers are provided for each element.

Frequency Protection

The frequency elements provide the ability to detect when the motor is operating at off-nominal frequencies that can do damage to the process or, to signal to upstream protections or controls to implement load shedding actions.

Power Factor Protection

This protection is used in synchronous motors applications to detect out-of-synchronism conditions.

Undervoltage/Overvoltage Protection

Use the voltage protective functions to detect abnormal system voltage conditions potentially hazardous to the motor.

Reduced Voltage Starting

The EMR-4000 motor protection relay provides a transition and incomplete sequence function for reduced voltage starting. The user can select to transition based on the current level and/or on time.

Antibackspin

The stop function is programmable from 2 to 20%. For certain applications, such as pumping a fluid up a pipe, the motor may be driven backward for a period of time after it stops. The EMR-4000 relay provides an antibackspin timer to prevent starting the motor while it is spinning in the reverse direction. The timer begins counting from the moment a stop is declared by the relay.

Start Control Timers

Motors typically have limits to the number of cold starts, starts per hour period, or time between starts that are permitted without damage. The EMR-4000 motor protection relay incorporates these timers to prevent starting the motor beyond its capabilities.

Load Shedding

The EMR-4000 motor protection relay provides a mechanical load shedding feature that can be used to control an upstream process. The load-shedding function closes a contact on an overload condition to control an upstream process from adding more load until the overload condition is gone.

Emergency Override

The EMR-4000 motor protection relay has a user-programmable feature that will let the operator reset the start inhibitor timers and thermal overload bucket. This function is intended for use in emergency conditions only, and it may result in motor damage or failure.

Long Acceleration Motors

Large motors with a high inertia may experience starting currents that exceed the locked rotor current and time. The EMR-4000 motor protection relay has logic and provisions for a zero speed switch input to differentiate between a stall and start condition. If the motor is spinning, then the relay will not trip on the normal locked rotor time allowing the motor to start.

Remote/differential Trip

The digital inputs can be programmed to accept a contact input from a separate differential relay or other device to trip the motor. This provides local and remote target information and utilizes the trip contacts of the EMR-4000 motor protection relay. It will also record and log the motor information at the time of the trip.

Breaker Failure or Stuck Contactor

The EMR-4000 motor protection relay includes a breaker failure (50BF, 62BF) function that can be initiated from either an internal or external trip signal. This is an independent element that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Flexible Phase Rotation

The EMR-4000 motor protection relay can be applied on either an A-B-C or A-C-B phase rotation. A user setting permits correct operation and indication of the actual system configuration.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communication or via a digital Input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Diagnostic Features

Broken Rotor Bar

The EMR-4000 provides advanced motor diagnostics including a broken rotor bar detection function. The broken rotor bar detection is a condition maintenance function that continuously monitors the motor's health while in operation. The advanced Motor Current Signature Analysis (MCSA) continuously analyzes the motor current signature and based on preset algorithms will determine when a broken rotor bar is present in the motor.

The broken rotor bar function will provide early detection of any rotor problems and advise maintenance personnel of the impending issue allowing for predictive maintenance of the motor and prevention of catastrophic motor failures.

By providing early indication of potential rotor problems, serious system issues such as: reduced starting torque, overloads, torque and speed oscillation and bearing wear can be avoided. With the advanced broken rotor bar detection system, advanced warning of impending problems reduces catastrophic failures, maximizing motor life and system uptime.

Protection Features

- Thermal protection (49/51)
  - Locked rotor protection (49S/51)
- Phase overcurrent elements:
  - Two instantaneous elements with timers (50P[1], 50P[2] and 50P[3])
  - Three inverse time overcurrent elements (51P[1], 51P[2] and 51P[3])
  - 11 standard curves
  - Instantaneous or time delay reset
- Ground overcurrent elements:
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
- Jam or Stall protection (50J[1], 50J[2])
- Phase unbalance negative sequence overcurrent (46[1], 46[2])
- Underload protection (37[1], 37[2])
- Temperature protection with optional URTD (49/38)
- Stars per hour (66)
- Switch onto fault protection
- Phase voltage unbalance and sequence protection (47[1], 47[2])
- Main three-phase under/overvoltage (27M[1], 27M[2], 59M[1], 59M[2])
- Auxiliary single-phase under/overvoltage (27A[1], 27A[2], 59A[1], 59A[2])
- Six frequency elements that can be assigned to: over frequency, under frequency, rate of change, or vector surge (81[1], 81[2], 81[3], 81[4], 81[5], 81[6])
- Apparent and displacement power factor (55A[1], 55A[2], 55D[1], 55D[2])
- Forward and reverse Watts (32[1], 32[2], 32[3])
- Forward and reverse VARs (32V[1], 32V[2], 32V[3])
- Lockout protection (86)
- Breaker failure (50BF)
- Zone interlocking for bus protection (87B)

Metering Features

- Amperes: Positive, negative and zero sequence
- Volts: Positive, negative and zero sequence
- Phase angles
- Volt-amperes and VA demand
- Watts and kW demand
- kWh (forward, reverse, net)
- VARs and kVAR demand
- kVARh (lead, leg and net)
- Power factor
- Frequency
- % THD V and I
- Magnitude THD V and I
- Minimum/maximum recording
- Trending (load profile over time)
- Minimum/maximum recording
- Temperature with remote URTD module

Monitoring Features

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (7200 cycles total)
- Trip Cause displays fault recorder data on HMI after fault event
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Trending (load profile over time)
- Motor history
- Records the last 5 motor start profiles
- Motor start trending
- CT supervision
- VT supervision
- Clock (1 ms time stamping)

Diagnostic Features

- Broken rotor bar

Control Functions

- Transition for reduced voltage starts
- Incomplete sequence delay
- Permits numbers of cold starts
- Limits numbers of starts per hour
- Anti-backspin time delay
- Mechanical load shedding
- Zero speed switch for long acceleration motors
- Motor stop inputs
- Remote trip input
- Differential trip input
- Emergency override
- Breaker/contactor open-close/stop-start
- Remote open-close (stop-start)
- Programmable I/O
- Programmable LEDs
- Programmable logic
- Multiple setting groups

Communication Features

- Local HMI
- Password protected
- Addressable.
- IRIG-B
- Local communication port.
  - RS-232
- Remote communication port:
  - RS-485
  - Ethernet port
- Protocols:
  - Modbus-RTU (optional)
  - Modbus-TCP (optional)
  - IEC-61850 (optional)
- Configuration software

Monitoring and Metering

Sequence of Events Records

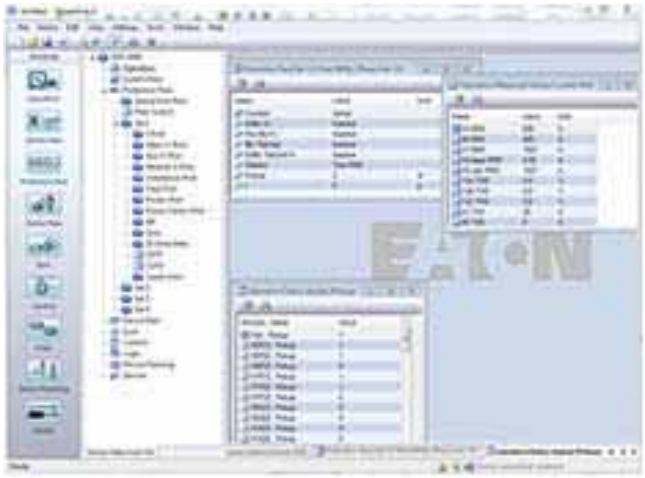
The EMR-4000 protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO in chronological order.

Trip Log

The EMR-4000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents and voltages at the time of the fault.

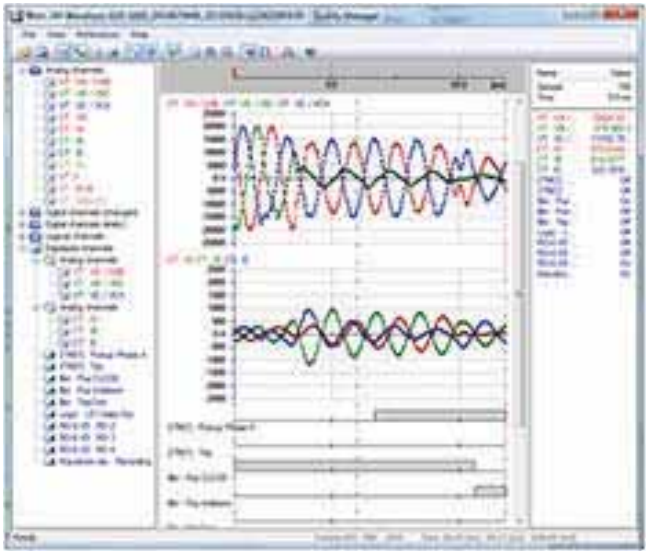
PowerPort-E

PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.



Waveform Capture (Quality Manager)

The EMR-4000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The EMR-4000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles. The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. Seven programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Starting Profiles

The EMR-4000 records the average current versus time for the last five starting cycles. This information is available via the communications port through PowerPort-E

Motor Statistics

For each motor start, the EMR-4000 stores a motor start report and add this data to the motor statistics buffer. With the motor statistics you can track motor start data for the past eighteen 30-day periods. For each 30-day interval, the relay records the following information:

- The date the interval began
- The total number of starts in the interval
- The averages of the following quantities:
  - Motor start time
  - Start % rotor thermal capacity used
  - Maximum start current

Load Profiling/Trending

The EMR-4000 relay automatically records selected quantities into non-volatile memory every 5, 10, 15, 30, or 60 minutes, depending on the trending report setting.

Programmable I/O

The EMR-4000 motor protection relay provides heavy-duty, trip-rated, 2 normally open and 1 Form C contacts. One isolated inputs can be used for monitoring the trip circuit. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (failsafe) mode. There are 4 eight user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

Programmable Logic

The EMR-4000 motor protection relay provides logic gates and timers that the user can customize for special or unique applications. Each gate can be assigned a logic function of either AND, OR, NAND or NOR. Each gate can have a maximum of four input signals and each input signal can be required to be a NOT. Input signals can be external inputs received via the binary inputs or internal values associated with the protection, alarm or metering set points. Each gate has a unique output assignment and designation that can be used as the input to another gate. There are 80 independent timers that have adjustable pickup and dropout delay settings.

Standards and Certifications

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the EMR-4000. For example, if the catalog number were EMR-4000-2A0BA1, the device would have the following:

EMR-4000

(A)–Four digital inputs, four output relays, 1 4-20 mA analog output, URTD interface

(0)–5 A / 1 A phase and ground CTs, power supply range:
19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without conformal coating

(1)–Projection panel mount

Motor Relay Removable Terminals

EMR-4000-2A 0 B A 1

Hardware Option 1
A = 8 DI, 5 outputs, 4AO, removable terminals, zone interlocking, URTD interface, IRIG-B, small display

Hardware Option 2
0 = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
1 = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
B = Modbus/DNP3 RTU over RS-485
C = Modbus/DNP3 TCP over Ethernet RJ-45
D = PROFIBUS-DP over fiber optic ST
E = PROFIBUS-DP over D-Sub / RS-485
F = Modbus RTU or DNP3 RTU over fiber optic ST
G = Modbus/DNP3 RTU over D-Sub / RS-485
H = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
I = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
K = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
L = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
A = None
B = Conformal coated circuit boards

Mounting Options
0 = Standard mount
1 = Projection panel mount

Accessories

Standard Accessories EMR-4000

Description	Catalog Number
UNVL RTD Mod with Modbus-RTU 48–240 Vac/48–250 Vdc	**URTDII-01** ①
UNVL RTD Mod with Modbus-RTU 24–48 Vdc	**URTDII-02** ①

Note

① See URTD section for fiber optic cables required to communicate to the EMR-3000.

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –30 °C to +70 °C (–22 °F to +158 °F)
- Operating temperature: –20 °C to +60 °C (–4°F to +140 °F)
- Permissible humidity at ann. average:<75% rel. (on 56d up to 95% rel.)
  - Permissible Installation Altitude: <2,000 m (6,561.67 ft) above sea level
  - If 4,000 m (13,123.35 ft) altitude applies, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP20

Routine Test

- Insulation test acc. to IEC 60255-5: All tests to be carried out against ground and other input and output circuits
- Aux. voltage supply, digital inputs, current measuring inputs, signal relay outputs: 2.5 kV (eff.) / 50 Hz
- Voltage measuring Inputs: 3.0 kV (eff.) / 50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Housing B2: height / width 183 mm (7.205 in)/ 212.7 mm (8.374 in)
- Housing depth (Incl. Terminals): 208 mm (8.189 in)
- Material, housing: aluminum extruded section
- Material, front panel: aluminum/foil front
- Mounting position: horizontal (±45° around the X-axis must be permitted)
- Weight: approx. 4.2 kg (9.259 lb)

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x In (phase currents)
  - Up to 25 x In (ground current standard)
  - Up to 2.5 x In (ground current sensitive)
- Continuous loading capacity: 4 x In/ continuously
- Overcurrent proof:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Power consumption:
  - Phase current inputs At In= 1 A S=0.15 MVA At In= 5 A S=0.15 MVA
  - Ground Current Input At In= 1 A S=0.35 MVA At In= 5 A S=0.35 MVA
- Frequency range: 50 Hz / 60 Hz ±10%
- Terminals: screw-type terminals with integrated short-circuiters (contacts)
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board´s terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Plug-in Connector with Integrated Short-Circuiter (Conventional Current Inputs)

- Nominal currents: 1 A / 5 A
- Continuous loading Capacity: 4 x In / continuously
- Overcurrent withstand:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board´s terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Control Power Supply

- Aux. voltage: 240–270 Vdc / 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage Interrupted communication is permitted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse approx. 1/5 x 0.8 in (5 x 20 mm) according to IEC 60127
  - 3.5 A time-lag miniature fuse approx. 1/4 x 1 1/4 in (6.3 x 32 mm) according to UL 248-14

Voltage and Residual Voltage Measurement

- Nominal voltages:100 V/ 110 V/ 230 V/ 400 V (can be configured)
- Max. measuring range: 2 x nominal voltage
- Continuous loading capacity: 2 x nominal voltage (800 Vac)
- Power Consumption:
  - at Vn = 100 V S = 0.1 MVA
  - at Vn = 110 V S = 0.1 MVA
  - at Vn = 230 V S = 0.4 MVA
  - at Vn = 400 V S = 1.0 MVA
- Frequency range: 50 Hz or 60 Hz ±10%
- Terminals: screw-type terminals

Frequency Measurement

- Nominal Frequencies: 50 Hz / 60 Hz

Voltage Supply

- Aux. Voltage: 24–270 Vdc / 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure:
  - ≥50 ms at minimal aux. voltage
  - Interrupted communication is permitted.
- Max. permissible making current:
  - 18 A peak value for 0.25 ms
  - 12 A peak value for 1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse approx. 5 x 20 mm (0.2 x 0.8 in) according to IEC 60127
  - 3.5 A time-lag miniature fuse approx. 6.3 x 32 mm (0.25 x 1.25 in) according to UL 248-14

Power Consumption

- Power supply range: 24–270 Vdc
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W
- Power supply range: 48–230 Vac (for frequencies of 40–70 Hz)
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W

Display

- Display Type: LCD with LED background illumination
- Resolution—graphics display: 128 x 64 pixel
- LED type: two colored: red/green
- Number of LEDs, housing B2: 15

Front Interface

- Baud Rates: 115,200 baud
- Handshake: RTS and CTS
- Connection: 9-pole D-Sub plug

Real Time Clock

- Running reserve of the real time clock: 1 year min.

Digital Inputs

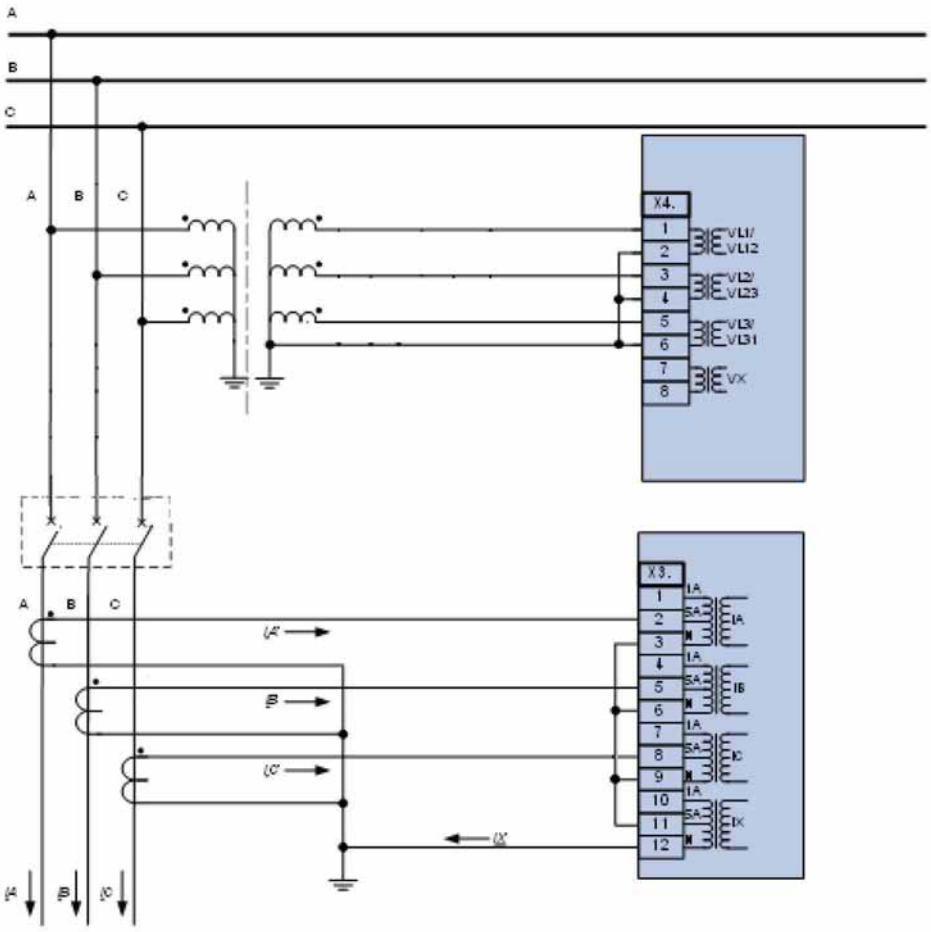
- Max. input voltage: 300 Vdc / 259 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Fallback time: <30 ms
- (Safe State of the Digital Inputs)
- Four switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac / Vdc, 230 Vac / Vdc
  - Un = 24 Vdc
    - Switching threshold 1 ON: Min. 19.2 Vdc
    - Switching threshold 1 OFF: Max. 9.6 Vdc
  - Un = 48 V / 60 Vdc
    - Switching threshold 2 ON: Min. 42.6 Vdc
    - Switching threshold 2 OFF: Max. 21.3 Vdc
  - Un = 110 / 120 Vac / Vdc
    - Switching threshold 3 ON: Min. 88.0 Vdc / 88.0 Vac
    - Switching threshold 3 OFF: Max. 44.0 Vdc / 44.0 Vac
  - Un = 230 / 240 Vac / Vdc
    - Switching threshold 4 ON: Min. 184 Vdc / 184 Vac
    - Switching threshold 4 OFF: Max. 92 Vdc / 92 Vac
- Terminals: screw-type terminal

Relay Outputs

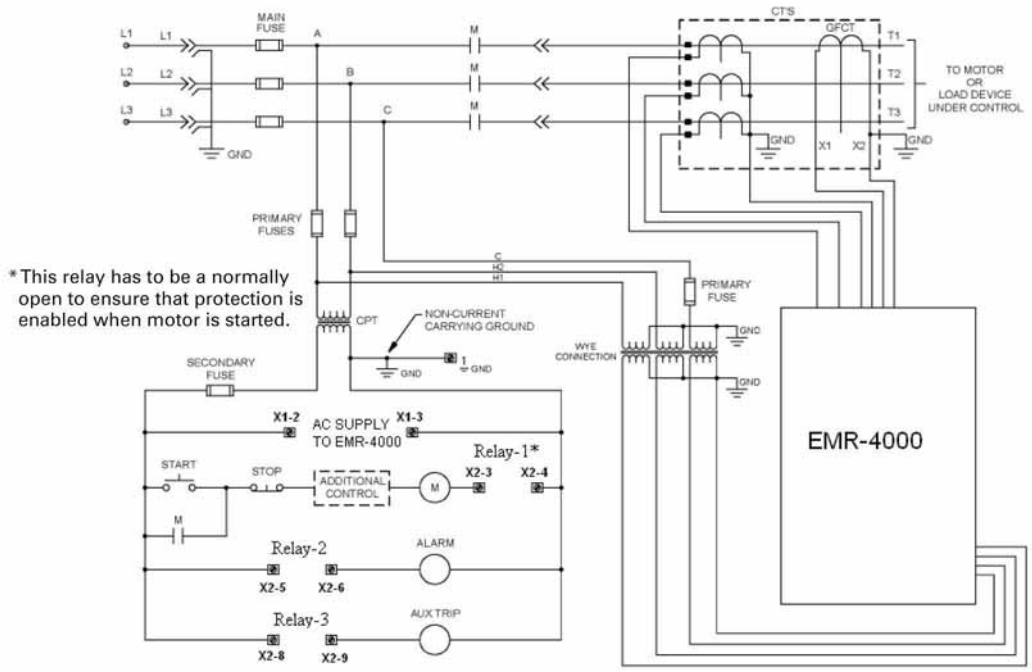
- Continuous current: 5 A AC/DC
- Max. make current:
  - 25 A AC / 25 A DC up to 30 V for 4 s
  - 30 A / 230 Vac according to ANSI IEEE Std C37.90-2005
  - 30 A / 250 Vdc according to ANSI IEEE Std C37.90-2005
- Max. breaking current:
  - 5 A AC up to 250 Vac
  - 5 A DC up to 30 V (resistive)
  - 0.3 A DC at 300 V
- Max. switching voltage: 250 Vac / 250 Vdc
- Switching capacity: 1250 VA
- Contact Type: Form C or normally open contact
- Terminals: screw-type terminals

Wiring Diagrams

Typical AC Connections, Wye VTs 5 A CTs and Ground Current Measured by Residual Connection



Typical Control Diagram



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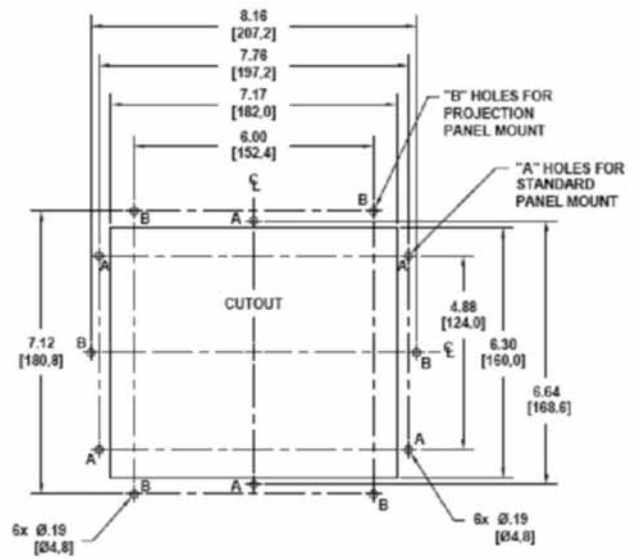
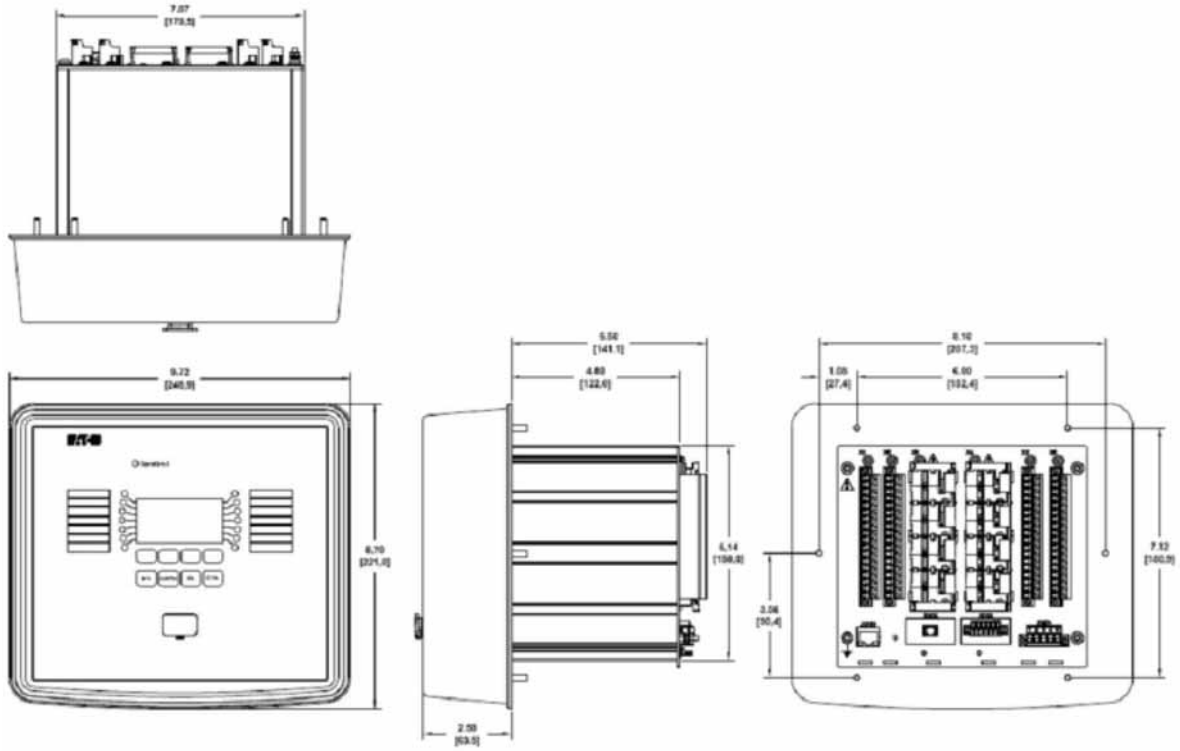
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

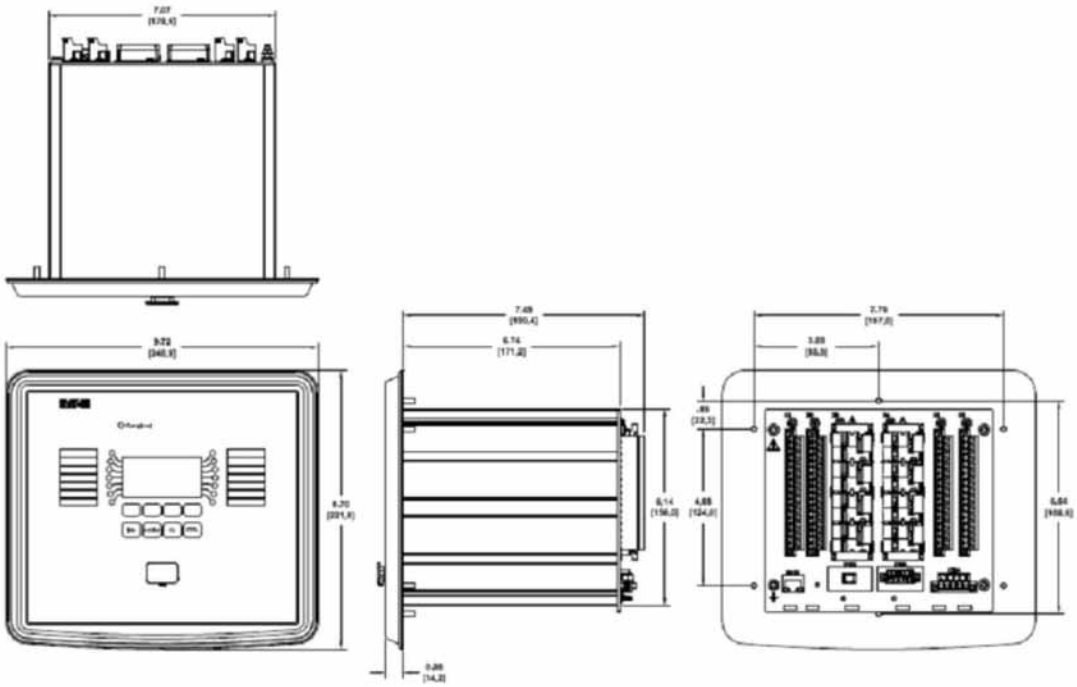


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



EMR-5000 Motor Protection Relay

Contents

EMR-5000 Motor Protection Relay

Product Description

Eaton's EMR-5000 motor protection relay is a multifunctional microprocessor-based protective relay for the protection of any size motor at all voltage levels. It is most commonly applied on medium voltage or larger motors. The EMR-5000 relay is a current and voltage device with built-in differential protection that provides complete and reliable motor protection, monitoring, diagnostics, metering and starting control functions.

The EMR-5000 motor protection relay provides complete current, voltage, and frequency protection in a single compact case. The relay has eight current inputs rated for either 5 amperes or 1 ampere and four voltage inputs. Three of the voltage inputs are to be connected to the three-phase power voltage for voltage protection and for metering. They can be connected in wye-ground or open delta configuration.

The fourth voltage is for independent single-phase undervoltage/overvoltage protection. The unit is capable of 60 Hz or 50 Hz operation.

The maintenance mode password protected soft key, can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only. The multiple setting groups can also be changed, via communications or a digital input. Flash memory is used for the programming and all settings are stored in nonvolatile memory.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. Fourteen programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 and an Ethernet ports in the back are optional for local area networking using. Optional Modbus-RTU, Modbus-TCP or IEC-61850 protocols are supported.

The EMR-5000 motor protection relay includes programmable logic functions. Logic gates and timers may be defined and arranged for customized applications. With the programmable logic control functions you can simplify the complexity of your starting schemes by eliminating timers and auxiliary relays. Flash memory is used for the programming and all settings are stored in nonvolatile memory. The relay allows for four preprogrammed setting groups that can be activated through software, manually, or contact input.

The EMR-5000 motor protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/maximum values, load profiles, the 5 latest start profiles, motor trending, breaker/contactor wear information and waveform data.

The EMR-5000 has either eight programmable binary inputs, two analog inputs, two analog outputs, or 16 programmable binary inputs. It has 2NO and six Form C heavy-duty outputs and one form C signal alarm relay. The relay provides maximum user flexibility to configure the I/O. All inputs and outputs (except the healthy output) are user-programmable. The unit also counts with a test mode to force outputs and simulate currents, to facilitate the commissioning of the unit. It can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Application Description

Eaton's EMR-5000 motor protection relay has been designed for maximum motor operation and protection. It permits running the motor close to its design limits while protecting it against excessive heating and damaging overload conditions. The EMR-5000 field proven protection algorithms were developed based on motor designs and operating parameters for optimum operation and protection while minimizing nuisance tripping. The EMR-5000 motor protection relay utilizes a patented protection algorithm and measurement technique based on proven positive and negative (unbalance) sequence current sampling and true RMS calculations.

Intel-I-Trip (I^2t) Overload Protection

The EMR-5000 motor relay features the exclusive Eaton Intel-I-Trip intelligent overload protection system. Intel-I-Trip develops custom overload curves simply from motor nameplate data. Intel-I-Trip protects motors from potentially damaging overload and abnormal operating conditions. The Intel-I-Trip intelligent overload protection feature utilizes field proven measurement techniques and a patented motor thermal protection model. The EMR-5000 motor relay's unique measurement technique samples the current waveforms 36 times per cycle, providing accurate measurements of the positive and negative sequence currents. The negative sequence current causes a greater heating effect on the rotor and has a greater impact on the thermal model in the relay. Intel-I-Trip utilizes these measurements in its motor model to safely protect the motor against the heating effects of these currents.

The motor thermal model is analogous to a bucket that is being filled and drained at the same time. The fill rate is dependent on the motor currents and the drain is based on motor design principles. The size of the bucket is equivalent to the thermal capacity associated with the mass of the motor. Intel-I-Trip integrates these rates and will issue a trip when the thermal capacity is filled.

Intel-I-Trip features adaptive trip characteristics that adjust the trip times based on measured motor temperature when RTDs are used.

Instantaneous Overcurrent

The EMR-5000 motor protection relay provides an instantaneous phase overcurrent function to trip the motor for high fault current levels and save the fuses. This function can be disabled and has an adjustable time delay on starting to avoid nuisance tripping on inrush.

Differential Protection

This protection function is mostly used to protect induction and synchronous motors against phase-to-phase faults. Differential protection may be considered the first line of protection for internal phase to phase or phase to ground faults. In the event of such faults, the quick response of the differential element may limit the damage that may have otherwise occurred to the motor. While this protection is recommended in all motors above 1500 hp, it can be used in smaller motors depending primarily in the importance and the cost of the motor.

Phase Unbalance Protection

Motor supply circuits are often fed through fuses and can be run with a single-phase fuse blown, referred to as single phasing the motor. The EMR-5000 motor protection relay measures the current and voltage unbalance and either can be used to alarm or trip the motor before damage occurs. The EMR-5000 has two voltage and two current unbalance elements. Pickup, start and run timers are provided for each element.

Ground Fault Protection

A separate measuring circuit is used to measure ground current. A ground CT is recommended for more sensitive protection against winding insulation breakdown to ground. The relay ground circuit can be connected residually from the three-phase CTs. The ground fault protection has pickup and time delay set points or can be disabled.

Jam Protection

The user-selectable Jam function protects motors that are running against a sudden mechanical jam or stall condition. The common application is on motors used on crushers, chippers, or conveyors. It detects an increase of motor current to a level above full load. Pickup, start, and run timers and a second element for alarm purposes are provided.

Underload/Underpower Protection

The user selectable underload/underpower function is used to detect the loss of load on the motor. Coupling failure is a common cause for loss of load. Whenever is possible, it is better to use underpower to detect loss of load. Three power elements and two underload elements are provided in the relay for tripping and alarm purposes. Pickup, start and run timers are provided for each element.

Frequency Protection

The frequency elements provide the ability to detect when the motor is operating at off-nominal frequencies that can do damage to the process or, to signal to upstream protections or controls to implement load shedding actions.

Power Factor Protection

This protection is used in synchronous motors applications to detect out-of-synchronism conditions.

Undervoltage/Overvoltage Protection

Use the voltage protective functions to detect abnormal system voltage conditions potentially hazardous to the motor.

Reduced Voltage Starting

The EMR-5000 motor protection relay provides a transition and incomplete sequence function for reduced voltage starting. The user can select to transition based on the current level and/or on time.

Antibackspin

The stop function is programmable from 2–20%. For certain applications, such as pumping a fluid up a pipe, the motor may be driven backward for a period of time after it stops. The EMR-5000 relay provides an antibackspin timer to prevent starting the motor while it is spinning in the reverse direction. The timer begins counting from the moment a stop is declared by the relay.

Start Control Timers

Motors typically have limits to the number of cold starts, starts per hour period, or time between starts that are permitted without damage. The EMR-5000 motor protection relay incorporates these timers to prevent starting the motor beyond its capabilities.

Load Shedding

The EMR-5000 motor protection relay provides a mechanical load shedding feature that can be used to control an upstream process. The load-shedding function closes a contact on an overload condition to control an upstream process from adding more load until the overload condition is gone.

Emergency Override

The EMR-5000 motor protection relay has a user-programmable feature that will let the operator reset the start inhibitor timers and thermal overload bucket. This function is intended for use in emergency conditions only, and it may result in motor damage or failure.

Long Acceleration Motors

Large motors with a high inertia may experience starting currents that exceed the locked rotor current and time. The EMR-5000 motor protection relay has logic and provisions for a zero speed switch input to differentiate between a stall and start condition. If the motor is spinning, then the relay will not trip on the normal locked rotor time allowing the motor to start.

Remote/Differential Trip

The digital inputs can be programmed to accept a contact input from a separate differential relay or other device to trip the motor. This provides local and remote target information and utilizes the trip contacts of the EMR-5000 motor protection relay. It will also record and log the motor information at the time of the trip.

Breaker Failure or Stuck Contactor

The EMR-5000 motor protection relay includes a breaker failure (50BF, 62BF) function that can be initiated from either an internal or external trip signal. This is an independent element that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Flexible Phase Rotation

The EMR-5000 motor protection relay can be applied on either an A-B-C or A-C-B phase rotation. A user setting permits correct operation and indication of the actual system configuration.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communication or via a digital Input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Features, Benefits and Functions

Protection Features

- Motor differential protection (87M)
- Thermal protection (49/51)
  - Locked rotor protection (49S/51)
- Phase overcurrent elements:
  - Two instantaneous elements with timers (50P[1], 50P[2] and 50P[3])
  - Three inverse time overcurrent elements (51P[1], 51P[2] and 51P[3])
  - 11 standard curves
  - Instantaneous or time delay reset
- Ground overcurrent elements:
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
- Jam or Stall protection (50J[1], 50J[2])
- Phase unbalance negative sequence overcurrent (46[1], 46[2]))
- Underload protection (37[1], 37[2])
- Temperature protection with optional URTD (49/38)
- Stars per hour (66)
- Switch onto fault protection
- Phase voltage unbalance and sequence protection (47[1], 47[2])
- Main three-phase under/overvoltage (27M[1], 27M[2], 59M[1], 59M[2])
- Auxiliary single-phase under/overvoltage (27A[1], 27A[2], 59A[1], 59A[2])
- Six frequency elements that can be assigned to: over frequency, under frequency, rate of change, or vector surge (81[1], 81[2], 81[3], 81[4], 81[5], 81[6])
  - Apparent and displacement power factor (55A[1], 55A[2], 55D[1], 55D[2])
- Forward and reverse watts (32[1], 32[2], 32[3])
- Forward and reverse VARs (32V[1], 32V[2], 32V[3])
- Lockout protection (86)
- Breaker failure (50BF)
- Zone interlocking for bus protection (87B)

Metering Features

- Amperes: Positive, negative and zero sequence
- Volts: Positive, negative and zero sequence
- Differential current
- Volt-amperes and VA demand
- Watts and kW demand
- kWh (forward, reverse, net)
- VARs and kVAR demand
- kVARh (lead, leg and net)
- Power factor
- Frequency
- % THD V and I
- Magnitude THD V and I
- Minimum/maximum recording
- Trending (load profile over time)
- Minimum/maximum recording
- Temperature with remote URTD module

Monitoring Features

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (7200 cycles total)
- Trip Cause displays fault recorder data on HMI after fault event
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Trending (load profile over time)
- Motor history
- Records the last 5 motor start profiles
- Motor start trending
- CT supervision
- VT supervision
- Clock (1 ms time stamping)

Diagnostic Features

- Broken rotor bar

Control Functions

- Transition for reduced voltage starts
- Incomplete sequence delay
- Permits numbers of cold starts
- Limits numbers of starts per hour
- Anti-backspin time delay
- Mechanical load shedding
- Zero speed switch for long acceleration motors
- Motor stop inputs
- Remote trip input
- Emergency override
- Breaker/Contactor open-close/stop-start
- Remote open-close (stop-start)
- Programmable I/O
- Programmable LEDs
- Programmable Logic
- Multiple setting groups

Communication Features

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port:
  - RS-232
- Remote communication port:
  - RS-485
  - Ethernet port
- Protocols:
  - Modbus-RTU (Optional)
  - Modbus-TCP (Optional)
  - IEC-61850 (Optional)
- Configuration software

Diagnostic Features

Broken Rotor Bar

The EMR-5000 provides advanced motor diagnostics including a broken rotor bar detection function. The broken rotor bar detection is a condition maintenance function that continuously monitors the motor's health while in operation. The advanced Motor Current Signature Analysis (MCSA) continuously analyzes the motor current signature and based on preset algorithms will determine when a broken rotor bar is present in the motor.

The broken rotor bar function will provide early detection of any rotor problems and advise maintenance personnel of the impending issue allowing for predictive maintenance of the motor and prevention of catastrophic motor failures.

By providing early indication of potential rotor problems, serious system issues such as: reduced starting torque, overloads, torque and speed oscillation and bearing wear can be avoided. With the advanced broken rotor bar detection system, advanced warning of impending problems reduces catastrophic failures, maximizing motor life and system uptime.

Monitoring and Metering

Sequence of Events Records

The EMR-5000 protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO in chronological order.

Trip Log

The EMR-5000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents and voltages at the time of the fault.

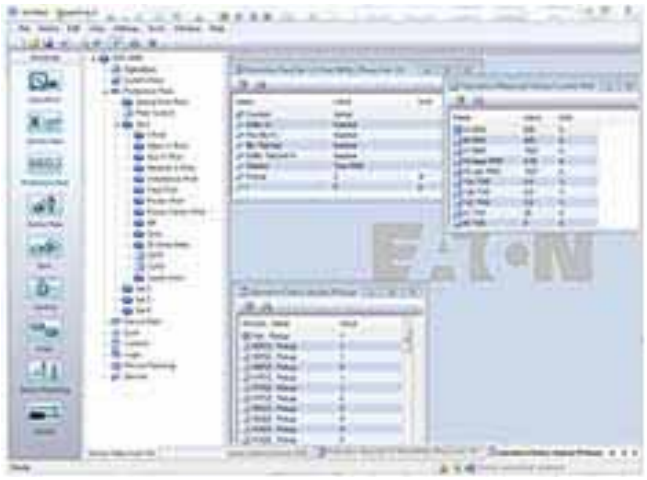
PowerPort-E

PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.

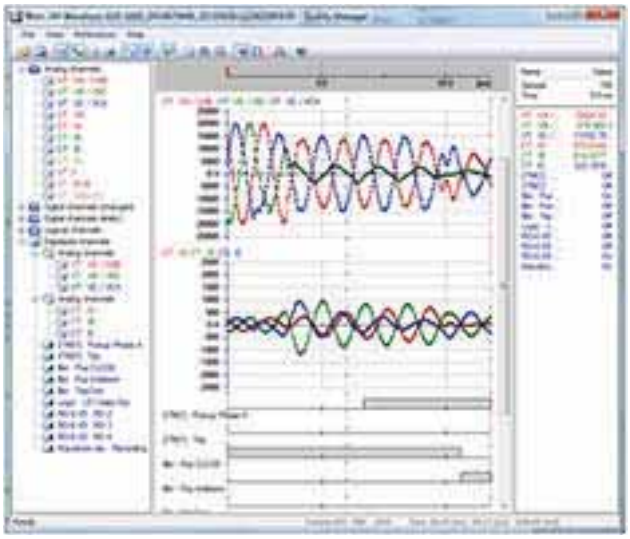
Waveform Capture (Quality Manager)

The EMR-5000relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The EMR-5000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles.

The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



PowerPort-E



Waveform Capture (Quality Manager)

Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. Seven programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Starting Profiles

The EMR-5000 records the average current versus time for the last five starting cycles. This information is available via the communications port through PowerPort-E.

Motor Statistics

For each motor start, the EMR-5000 stores a motor start report and add this data to the motor statistics buffer. With the motor statistics you can track motor start data for the past eighteen 30-day periods. For each 30-day interval, the relay records the following information:

- The date the interval began
- The total number of starts in the interval
- The averages of the following quantities:
  - Motor start time
  - Start % rotor thermal capacity used
  - Maximum start current

Load Profiling/Trending

The EMR-5000 relay automatically records selected quantities into non-volatile memory every 5, 10, 15, 30, or 60 minutes, depending on the trending report setting.

Programmable I/O

The EMR-5000 motor protection relay provides heavy-duty, trip-rated, 2 normally open and 1 Form C contacts. One isolated inputs can be used for monitoring the trip circuit. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (failsafe) mode. There are 4 eight user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

Programmable Logic

The EMR-5000 motor protection relay provides logic gates and timers that the user can customize for special or unique applications. Each gate can be assigned a logic function of either AND, OR, NAND or NOR. Each gate can have a maximum of four input signals and each input signal can be required to be a NOT. Input signals can be external inputs received via the binary inputs or internal values associated with the protection, alarm or metering set points. Each gate has a unique output assignment and designation that can be used as the input to another gate.

Standards and Certifications

Approvals

- UL listed file: E217753

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90

Listed

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the EMR-5000. For example, if the catalog number is EMR-5000-2A0BA, the device would have the following:

EMR-5000

(A)–Four digital inputs, four output relays, 1 4–20 mA analog output, URTD interface

(0)–5 A / 1 A phase and ground CTs, power supply range: 19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without conformal coating

(1)–Projection panel mount

EMR-5000 Eaton Motor Relay

EMR-5000-2A 0 B A 1

Hardware Option 1
- **A** = 16 DI, 9 outputs, zone interlocking, URTD interface, IRIG-B, large display
- **B** = 8 DI, 9 outputs, 2 AI + 2AO, zone interlocking, URTD interface, IRIG-B, large display

Hardware Option 2
- **0** = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –30 °C to +70 °C (–22 °F to 158 °F)
- Operating temperature: –20 °C to +60 °C (–4 °F to 140 °F)
- Permissible humidity at ann. average: <75% rel. (on 56d up to 95% rel.)
- Permissible installation altitude:
  - <2,000 m (6,561.67 ft) above sea level
  - If 4,000 m (13,123.35 ft) altitude applies, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP20

Routine Test

- Insulation test acc. to IEC60255-5: All tests to be carried out against ground and other input and output circuits
- Aux. voltage supply, digital inputs, current measuring inputs, signal relay outputs: 2.5 kV (eff.) / 50 Hz
- Voltage measuring inputs: 3.0 kV (eff.) / 50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Housing B2: height / width 183 mm (7.205 in)/ 212.7 mm (8.374 in)
- Housing depth (incl. terminals): 208 mm (8.189 in)
- Material, housing: aluminum extruded section
- Material, front panel: aluminum/foil front
- Mounting position: horizontal (±45° around the X-axis must be permitted)
- Weight: approx. 4.2 kg (9.259 lb)

Current and Ground Current Measurement

Plug-in connector with integrated short-circuiter (Conventional current inputs)

Phase and ground current inputs:

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x In (phase currents)
  - Up to 25 x In (ground current standard)
- Capacity: 4 x In/ continuously
- Overcurrent proof:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Power consumption:
  - Phase current inputs
    - At In= 1 A S=0.15 MVA
    - At In= 5 A S=0.15 MVA
  - Ground current inputs
    - At In= 1 A S=0.35 MVA
    - At In= 5 A S=0.35 MVA

Sensitive ground current inputs:

- Nominal currents: 1 A / 5 A with 50:0:025 core balance CT
- Max. measuring range: up to 2.5 x In
- Capacity: 2 x In/ continuously
- Overcurrent proof:
  - 10 x In / 10 s
  - 25 x In / 1 s
  - 100 x In / 10 ms (1 half-wave)
- Power consumption:
  - At In= 1 A S=0.35 MVA
  - At In= 5 A S=0.35 MVA
- Frequency range: 50 Hz / 60 Hz ± 10%
- Terminals: screw-type terminals with integrated short-circuiters (contacts)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 1 x or 2 x 2.5 mm^2 (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm^2 (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm^2 (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board's terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Voltage and Residual Voltage Measurement

- Nominal voltages: 60–520 V (can be configured)
- Max. measuring range: 2 x nominal voltage or 800 V
- Continuous loading capacity: 800 Vac
- Power consumption:
  - at Vn= 100 V S=0.1 MVA
  - at Vn= 110 V S=0.1 MVA
  - at Vn= 230 V S=0.4 MVA
  - at Vn= 400 V S=1.0 MVA
- Nominal voltages: 60–520 V (can be configured)
- Frequency range: 50 Hz or 60 Hz ± 10%
- Terminals: screw-type terminals

Frequency Measurement

- Nominal Frequencies: 50 Hz / 60 Hz

Voltage Supply

- Aux. voltage: 24–270 Vdc/ 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage communication is permitted to be interrupted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse 5 x 20 mm (approx. 1/5 in x 0.8 in) according to IEC 60127
  - 3.5 A time-lag miniature fuse 6. 3 x 32 mm (approx. 1/4 in x 1 1/4 in) according to UL 248-14

Power Consumption

- Power supply range: 24–270 Vdc
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W
- Power supply range: 48–230 Vac (for frequencies of 50–60 Hz)
  - Power consumption in idle mode—7 VA
  - Maximum power consumption—13 VA

Display

- Display type: LCD with LED background illumination
- Resolution graphics display: 128 x 128 pixel
- LED type: two colored, red/green
- Number of LEDs, housing B2: 15

Front Interface RS-232

- Baud rates: 115,200 baud
- Handshake: RTS and CTS
- Connection: 9-pole D-Sub plug

Real-Time Clock

- Running reserve of the real-time clock: 1 year min

Digital Inputs

- Max. Input voltage: 300 Vdc / 259 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Drop-out time:
  - Shorted inputs: <30 ms
  - Open inputs: <90 ms

Relay Output Contacts

- Continuous current: 5 A AC/DC
- Max. make current:
  - 25 A AC / 25 A DC for 4 s
  - 30 A / 230 Vac according to ANSI IEEE Std C37.90-2005
  - 30 A / 250 Vdc according to ANSI IEEE Std C37.90-2005
- Max. breaking current:
  - 5 A AC up to 240 Vac
  - 5 A DC up to 30 V (resistive)
- Continuous current: 5 A AC/DC
- Contact Type: Form C or normally open contact
- Terminals: screw-type terminals

Supervision Contact (SC)

- Continuous current: 5 A AC/DC
- Max. switch-on current: 15 A AC / 15 A DC for 4 s
- Max. breaking current:
  - 5 A AC up to 250 Vac
  - 5 A DC up to 30 Vdc (resistive)
  - 0.25 A at 250 Vdc (resistive)
- Max. switching voltage: 250 Vac / 250 Vdc
- Switching capacity: 1250 VA
- Contact type: Form C
- Terminals: screw-type terminals

Analog Outputs

The following technical data only apply to devices, which are equipped with analog outputs. Please refer to the order code of your device.

The mode of each output can be individually selected between current or voltage output. Shielded cable for the analog outputs is recommended. The terminals of the HF shield should be used, when connecting the shield to the ground on both sides of the cable is not possible. On one side of the cable the shield has to be directly connected to ground. In case of the use of unshielded twisted pair cables, the length must not exceed 10 m. All analog outputs have a common potential. Each output has an own common terminal.

- Current mode
  - Range: 0–20 mA
  - Max. load resistance: 1 k ohm
- Voltage mode range: 0–10 V maximum output current 20 mA
- Accuracy 0.5% of the nominal value 20 mA resp. 10 V
- Influence of temperature to accuracy: <1% (within the range of 0 °C to +60 °C (+32 °F to +140 °F)
- Test voltage of outputs (one group) against other electrical groups: 2.5 kV
- Test voltage of outputs (one group) against ground: 1.0 kV

Time Synchronization IRIG-B00X

- Nominal Input Voltage: 5 V
- Connection: screw-type terminals (twisted pair)

Zone Interlocking

- Zone Out:
  - Output voltage (High): 4.75 to 5.25 Vdc
  - Output voltage (Low): 0.0 to +0.5 Vdc
- Zone In:
  - Nominal input voltage: +5 Vdc
  - Max. input voltage: +5.5 Vdc
  - Switching threshold ON: min. 4.0 Vdc
  - Switching threshold OFF: max. 1.5 Vdc
- Galvanic isolation: 2.5 kV AC (to ground and other IO)
- Connection: screw-type terminals (twisted pair)

RS-485

- Master/slave: slave
- Connection: 6 screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)

Fiber Optic

- Master/slave: slave
- Connection: ST-Plug

URTD-Interface

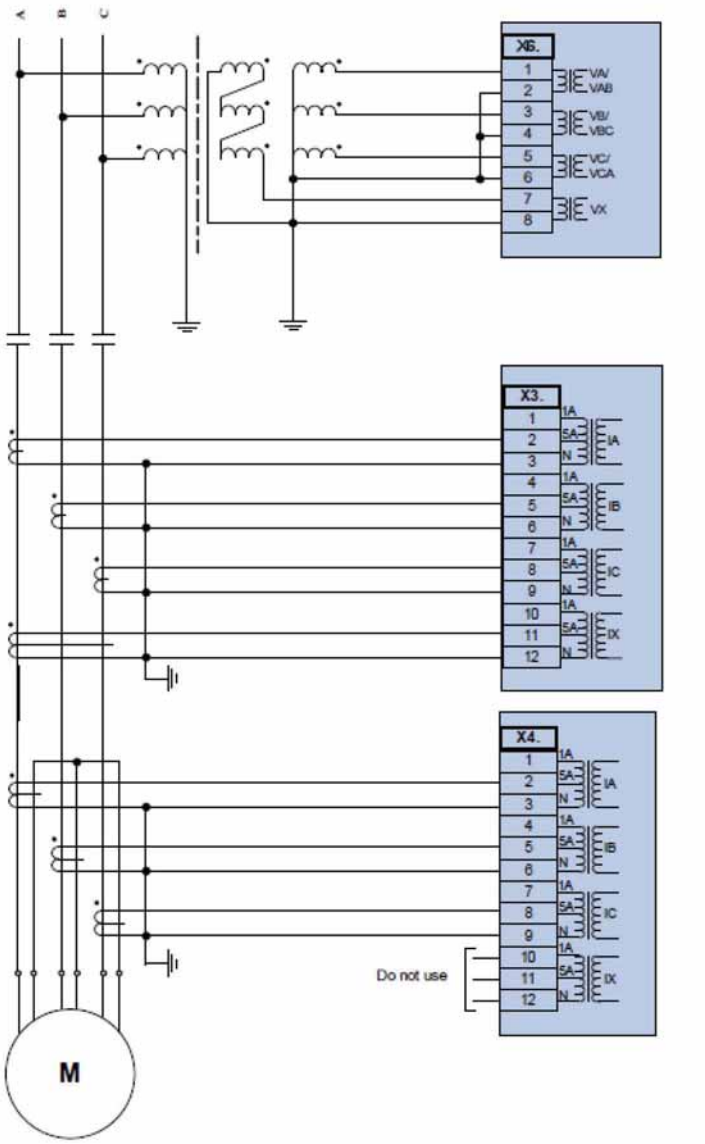
- Connection: versatile link

Boot Phase

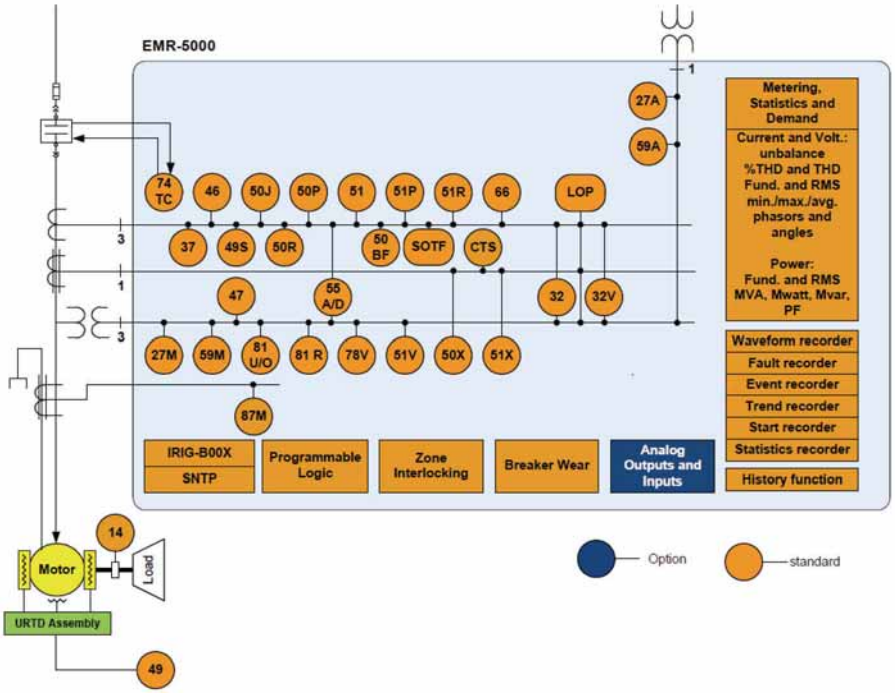
After switching on the power supply, the protection will be available in approximately 19 seconds. After approximately 165 seconds, the boot phase is completed (HMI and communication initialized).

Wiring Diagrams

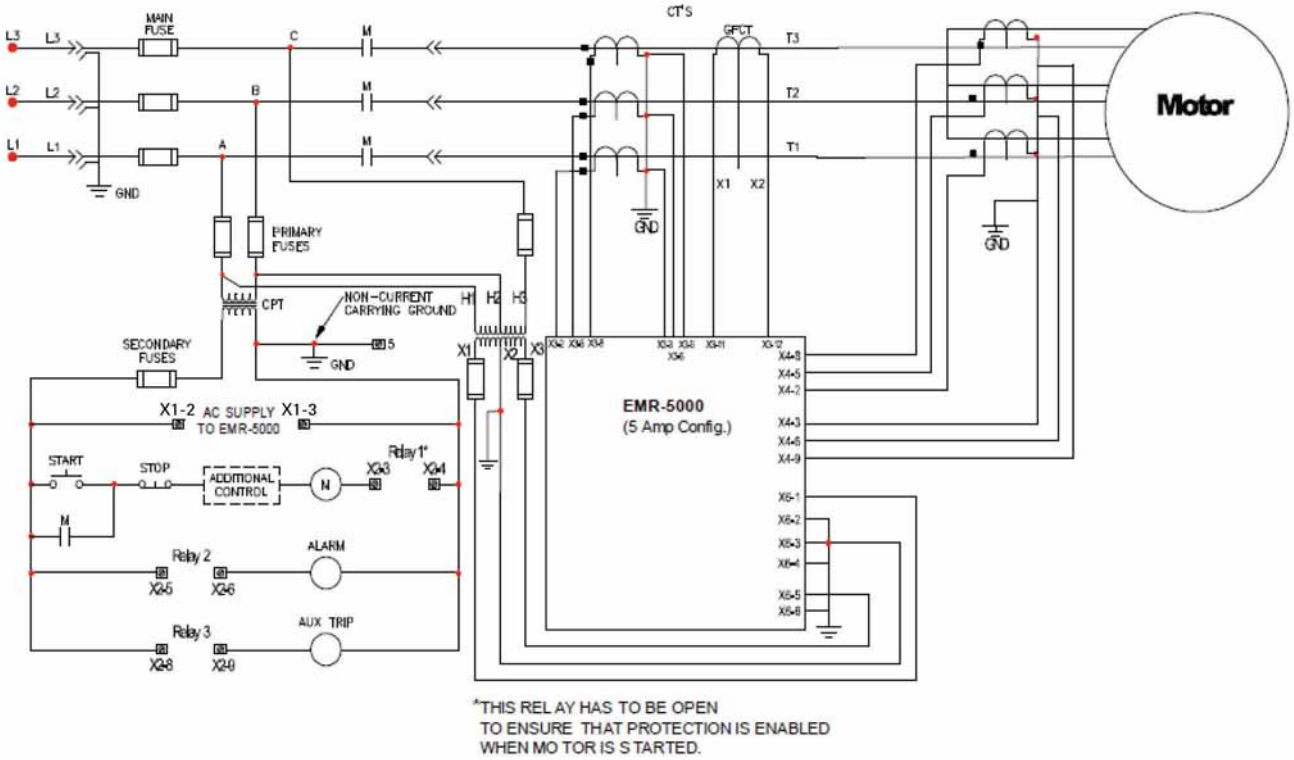
Typical AC Connections—Wye (or Delta) VTs, 5 A CTs, Ground Current Measured by 4th Zero Sequence CT, and 87 Motor Differential



Typical One-Line Diagram



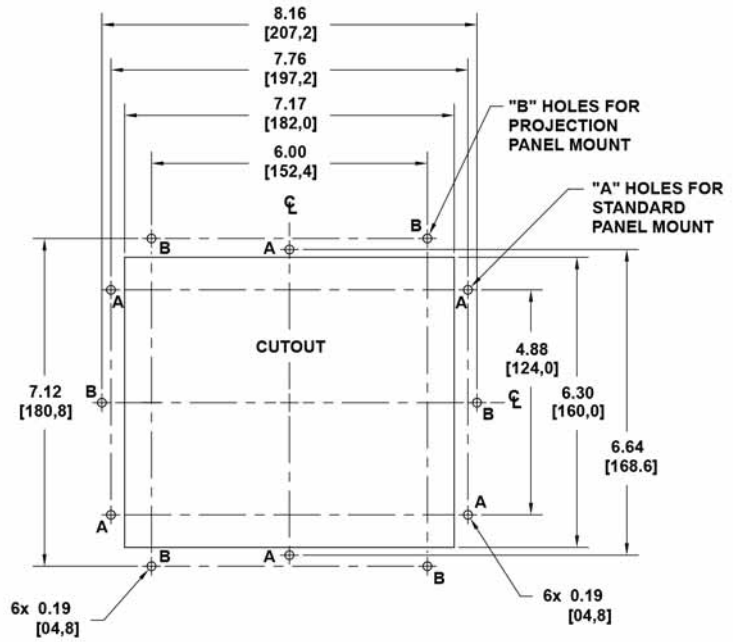
Typical Control Diagram



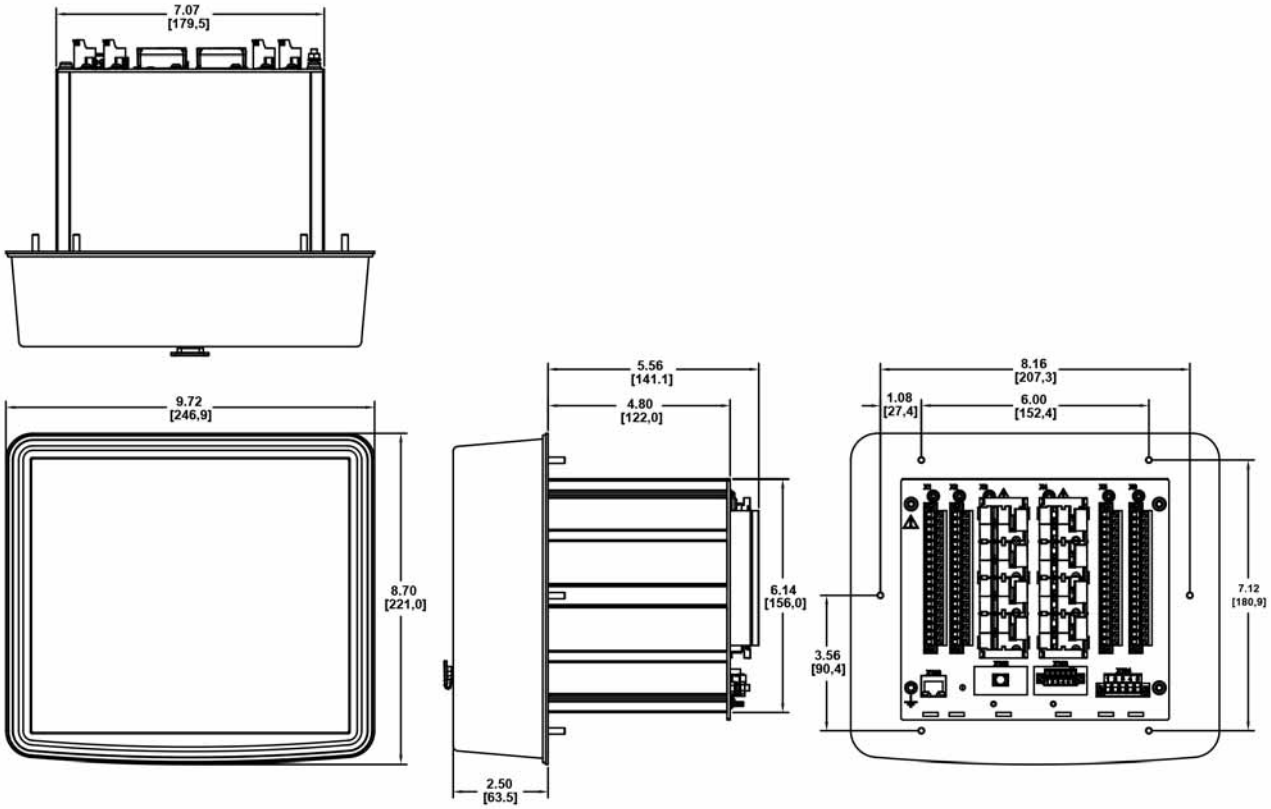
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

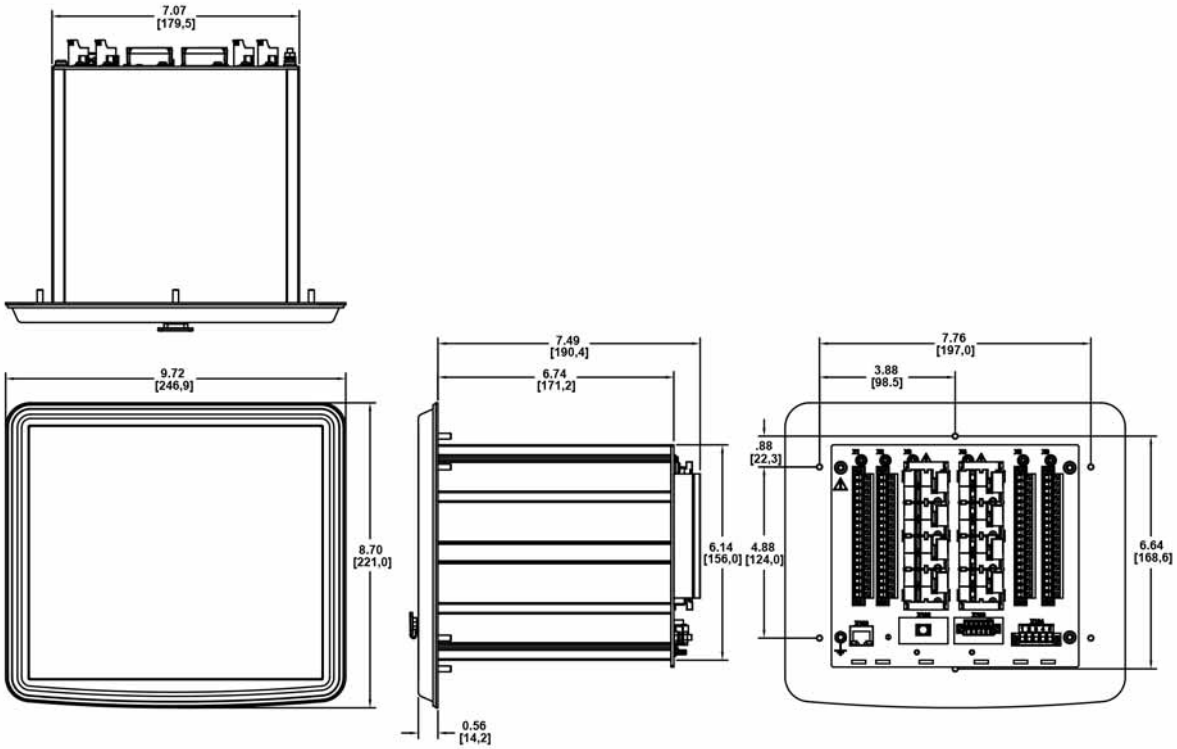


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



ETR-4000

Contents

ETR-4000 Transformer Protection Relay

Product Description

Eaton's ETR-4000 transformer protection relay is a multi-functional, microprocessor-based relay for two winding transformers of all voltage levels. The ETR-4000 provides phase and ground percentage restrained differential protection using a variable dual slope characteristic with phase, negative, residual and neutral overcurrent elements for backup protection. It can also be used to provide restrained differential protection to large motors and generators.

The ETR-4000 has eight current inputs rated for either 5 amperes or 1 ampere to monitor both sides of the transformers. The CTs can be connected in wye in both sides of the transformer; the relay automatically compensates for the connection of the transformer and CT mismatch errors.

The maintenance mode password protected soft key, can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. Fourteen programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 communication port on the back is standard for local area networking using Modbus-RTU. An optional Ethernet port and protocols are available.

Flash memory is used for the programming and all settings are stored in nonvolatile memory. The relay allows for four preprogrammed setting groups that can be activated through software, the display or a contact input.

The ETR-4000 transformer protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/maximum values, load profiles, breaker wear information and oscillography data.

The ETR-4000 has eight programmable binary inputs, 4 normally opened and 4 Form C heavy-duty outputs and one Form C signal alarm relay. It can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Features, Benefits and Functions

- Flexible phase and ground differential protection for two winding transformers, large motors and generators
- Complete protection and control in a single compact case to reduce panel space, wiring and costs
- Integral test function reduces maintenance time and expense
- Zone selective interlocking improves coordination and tripping time, and saves money compared to a traditional bus differential scheme
- Reduce troubleshooting time and maintenance costs. Trip and event recording in non-volatile memory provides detailed information for analysis and system restoration. 6000 cycles of waveform capture aids in post fault analysis (viewable using PowerPort-E software)
- Minimum replacement time. Removable terminal blocks ideal for industrial environments
- Front RS-232 port and PowerPort-E software provides local computer access and user-friendly Windows-based interface for relay settings, configuration and data retrieval
- Breaker open/close from relay faceplate or remotely via communications
- Fast an easy troubleshooting, improved maintenance procedures and increased device security. Provides detailed traceability for system configuration changes
- Relays self-diagnostics and reporting improves uptime and troubleshooting
- Breaker trip circuit monitoring improves the reliability of the breaker operation

Features

Protection Features

- Dual-slope percentage restrained current differential with magnetizing inrush and overexcitation blocking (87R)
- Unrestrained current differential (87H)
- Restricted ground fault/ Ground Differential (87GD)
- Phase overcurrent (elements can be assigned to either side of the transformer):
  - Four instantaneous elements with timers (50P[1], 50P[2], 50P[3] and 50P[4])
  - Four inverse time overcurrent elements (51P[1], 51P[2], 51P[3] and 51P[4])
  - 11 standard curves
  - Inrush Blocking
  - Instantaneous or time delay reset
- Negative sequence phase overcurrent (elements can be assigned to either side of the transformer):
  - Two inverse time overcurrent elements (51Q[1] and 51Q[2])
  - 11 standard curves
  - Instantaneous or time delay reset
- Ground overcurrent (elements can be assigned to either side of the transformer):
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
- Two breaker failure elements (50BF[1] and 50BF[2])
- Phase transformer overload protection (49)
- Switch onto fault protection
- Cold load pickup
- Zone interlocking for bus protection (87B)

Metering Features

- Amperes: positive, negative and zero sequence
- Ampere demand
- Current phase angles
- % THD I
- Magnitude THD I
- Minimum/maximum recording
- Trending
- RTD Temperatures with remote URTD

Monitoring Features

- Trip coil monitor for both primary and secondary breakers
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (7200 cycles total)
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)
- Trip Cause displays fault recorder data on HMI after fault event

Control Functions

- Breaker open/close both breakers
- Remote open/close
- Programmable I/O
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Communication Features

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
  - RS-232
  - RS-485
- Protocols:
  - Modbus-RTU
  - Modbus-TCP (Optional)
- Configuration software

Protection and Control Functions

Eaton's ETR-4000 transformer protection relay has been designed for maximum user flexibility and simplicity. The ETR-4000 is suitable for application on small, medium and large two winding power transformers.

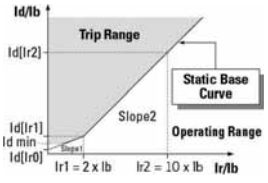
Multiple current inputs are used to provide primary protection, control and back-up protection of transformers, including current differential, restricted ground differential and overcurrent protection.

Dual-Slope Percent Differential Protection

The primary protective element for transformer protection is the percent differential element, which compares the current entering the primary and leaving the secondary of the transformer. The ETR-4000 has built in compensation for the turns-ratio and the phase shift of the transformer, so it's not necessary to compensate for the transformer connection by the connection of the CTs.

The current differential element looks at the vector difference between the current entering and leaving the zone of protection. If the difference exceeds a pre-determined amount, the element will operate.

The operating characteristic of the percent differential element is a dual-slope characteristic to accommodate for CT saturation and CT errors.



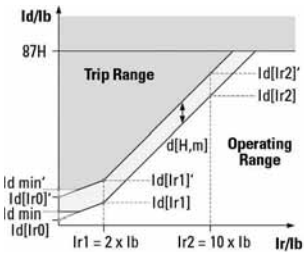
Dual-Slope Operating Characteristic

9

Harmonic Restraints

There are certain conditions like energizing one side of the transformer with the other side de-energized (inrush currents) or the paralleling of two transformers (sympathetic currents) that can create false differential currents. These differential currents if not recognized can cause a false trip; in the case of inrush conditions or sympathetic currents the differential current is characterized by a heavy content of 2nd and 4th harmonic currents. The percentage differential element is desensitize either permanently (stationary conditions) or temporarily (transient conditions), whenever the 2nd or 4th harmonic exceed the value programmed into the relay.

Another condition that can create a false differential current is a sudden change of voltage or frequency, that can put the transformer in an overexcitation state. In this case there is high content of 5th harmonic currents. The percentage differential element is also desensitized when the 5th harmonic content exceeds a predefined value.



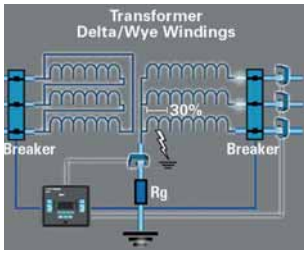
Dynamic Rise of the Operating Characteristic

Unrestrained Differential

An unrestrained differential element is provided for fast tripping on heavy internal faults to limit catastrophic damage to the transformer and minimize risks to the remainder of the power system.

Restricted Ground Fault

Ground differential protection is applied to transformers having impedance grounded wye windings. It is intended to provide sensitive ground fault detection for low magnitude fault currents, which would not be detected by the main percent differential element.



Restricted Ground Fault

Overcurrent Elements

The ETR-4000 can be used to provide backup for transformer and adjacent power system equipment. Instantaneous overcurrent elements can be used for fast clearing of severe internal or external (through) faults. Time overcurrent protection elements per winding allow coordinating with the adjacent protection zones and acting as a backup protection. There are 11 user-selectable inverse-time overcurrent curve characteristics. The user can select from the ANSI, IEC or thermal curve families and can select instantaneous or time delay reset characteristics.

Negative Sequence Overcurrent

Since this element does not respond to balanced load or three-phase faults, the negative-sequence overcurrent element may provide the desired overcurrent protection. This is particularly applicable to delta-wye grounded transformers where only 58% of the secondary p.u. phase-to-ground fault current appears in any one primary phase conductor. Backup protection can be particularly difficult when the wye is impedance grounded. A negative-sequence element can be used in the primary supply to the transformer and set as sensitively as required to protect for secondary phase-to-ground or phase-to-phase faults. This element should be set to coordinate with the low-side phase and ground relays for phase-to-ground and phase-to-phase faults. The negative sequence element must also be set higher than the negative-sequence current due to unbalanced loads.

Breaker Failure

The ETR-4000 transformer protection relay includes two breaker failure (50BF, 62BF) elements that can be initiated from either an internal or external trip signal. These are independent elements that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communications or via a digital input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Monitoring and Metering

Sequence of Events Records

The ETR-4000 protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO in chronological order.

Trip Log

The ETR-4000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents at the time of the fault.

Waveform Capture

The ETR-4000 transformer protection relay provides oscillography-recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, logic and contact closures. The ETR-4000 relay can record up to 6000 cycles of data. The number of records is proportional to the size of each record; the maximum size per record is 600 cycles. The waveform capture is initiated by up to 8 different triggers; it can also be generated manually through the display or via communications.

Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. Fourteen programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Programmable I/O

The ETR-4000 transformer protection relay provides heavy-duty, trip-rated, 4 normally open and 4 Form C contacts. Two isolated inputs can be used for monitoring the trip circuits. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (fail-safe) mode. There are eight user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

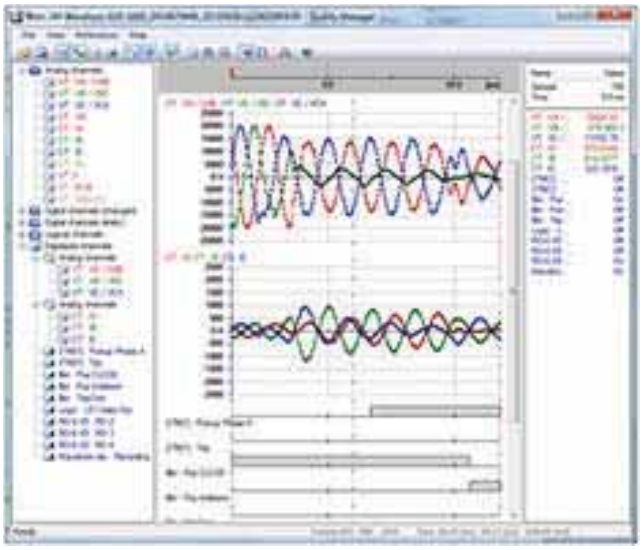
Communication Software

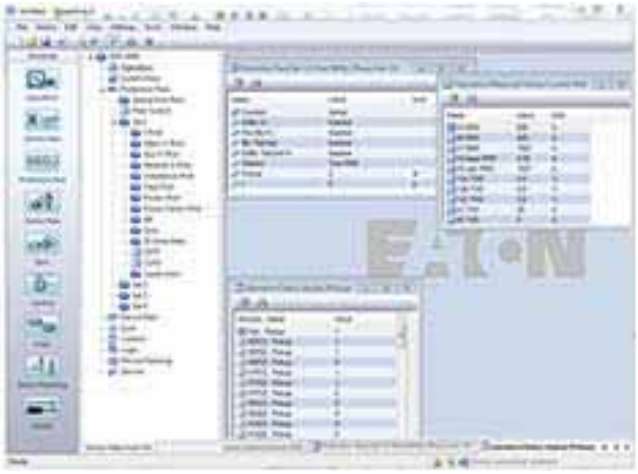
PowerPort-E

PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.

Waveform Capture (Quality Manager)

The ETR-4000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The ETR-4000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles. The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.





Standards and Certifications

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90
- UL listed file: E217753

Listed

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the ETR-4000. For example, if the catalog number is ETR-4000-2A0BA1, the device would have the following:

ETR-4000

(A)–8 Digital Inputs, 9 Output Relays

(0)–5 A / 1 A phase and ground CTs, Power Supply Range: 19-300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without Conformal Coating

(1)–Projection Panel Mount

ETR-4000 Eaton Transformer Protection Relay

ETR-4000-2A 0 B A 1

Hardware Option 1
- **A** = 8 DI, 9 outputs, removable terminals, 2 zone interlocking, URTD interface, IRIG-B, small display
- **B** = 4 DI, 5 outputs, removable terminals, IRIG-B, small display
- **C** = 8 DI, 5 outputs, removable terminals, 1 zone interlocking, IRIG-B, small display

Hardware Option 2
- **0** = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –22 °F to +158 °F (–30 °C to +70 °C)
- Operating temperature: –40 °F to +140 °F (–40 °C ① to +60 °C)
- Permissible humidity at ann. average: <75% rel. (on 56d up to 95% rel.)
- Permissible installation altitude:
  - 6,561.67 ft (<2000 m) above sea level
  - If 13,123.35 ft (4000 m) altitude applies, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP30

Routine Test

- Insulation test according to IEC 60255-5: All tests to be carried out against ground and other input and output circuits
- Aux. voltage supply, digital inputs: 2.5 kV (eff.)/50 Hz
- Current measuring inputs, signal relay outputs: 2.5 kV (eff.)/50 Hz
- Voltage measuring inputs: 3.0 kV (eff.)/50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Material, housing: Aluminum extruded section
- Material, front panel: Aluminum/foil front
- Mounting position: Horizontal (±45° around the X-axis must be permitted)

Plug-in Connector with Integrated Short-Circuiter (Conventional Current Inputs)

- Nominal current: 1 A and 5 A
- Continuous loading capacity: 4 x I_n/continuously
- Overcurrent withstand:
  - 30 x I_n/10 s
  - 100 x I_n/1 s
  - 250 x I_n/10 ms (1 half-wave)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 2 x AWG 14 (1 x or 2 x 2.5 mm^2) with wire end ferrule
  - 2 x AWG 12 (1 x or 2 x 4.0 mm^2) with ring cable sleeve or cable sleeve
  - 2 x AWG 10 (1 x or 2 x 6 mm^2) with ring cable sleeve or cable sleeve

Control Power Supply

- Aux. voltage: 24–270 Vdc/48–230 Vac (–20/+10%)
- Buffer time in case of supply failure: ≥50 ms at minimal aux. voltage interrupted communication is permitted
- Maximum permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse approx. 0.2 x 0.8 in (5 x 20 mm) according to IEC 60127
  - 3.5 A time-lag miniature fuse approx. 0.25 x 1.25 in (6.3 x 32 mm) according to UL 248-14

Note

① Display will stop working at –20 °C.

Power Consumption

- Power supply range: 19–300 Vdc
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W
- Power supply range: 40–250 Vac (for frequencies of 40–70 Hz)
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W

Real-Time Clock

- Running reserve of the real-time clock: 1 year minimum

Display

- Display type: LCD with LED background illumination
- Resolution graphics display: 128 x 64 pixel
- LED type: Two colored—red/green
- Number of LEDs, housing B2: 15

Digital Inputs

- Maximum input voltage: 300 Vdc/270 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Fallback time: <30 ms

(Safe state of the digital inputs)

- 4 switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac/Vdc, 230 Vac/Vdc
  - Un = 24 Vdc
    - Switching threshold 1 ON: Min. 19.2 Vdc
    - Switching threshold 1 OFF: Max. 9.6 Vdc
  - Un = 48–60 Vdc
    - Switching threshold 2 ON: Min. 42.6 Vdc
    - Switching threshold 2 OFF: Max. 21.3 Vdc
  - Un = 110/120 Vac/Vdc
    - Switching threshold 3 ON: Min. 88.0 Vdc/88.0 Vac
    - Switching threshold 3 OFF: Max. 44.0 Vdc/44.0 Vac
  - Un = 230/240 Vac/Vdc
    - Switching threshold 4 ON: Min. 184 Vdc/184 Vac
    - Switching threshold 4 OFF: Max. 92 Vdc/92 Vac
- Terminals: screw-type terminal

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x I_n (phase currents)
  - Up to 25 x I_n (ground current standard)
  - Up to 2.5 x I_n (ground current sensitive)
- Continuous loading capacity: 4 x I_n/continuously
- Overcurrent proof:
  - 30 x I_n/10 s
  - 100 x I_n/1 s
  - 250 x I_n/10 ms (1 half-wave)
- Power consumption:
  - Phase current inputs
    - At I_n = 1 A S = 0.15 MVA
    - At I_n = 5 A S = 0.15 MVA
  - Ground current input
    - At I_n = 1 A S = 0.35 MVA
    - At I_n = 5 A S = 0.35 MVA
- Frequency range: 50 Hz/60 Hz ±10%
- Terminals: Screw-type terminals with integrated short-circuiters (contacts)

Relay Outputs

- Continuous current: 5 A AC/DC
- Maximum make current:
  - 25 A AC/25 A DC up to 30 V for 4s
  - 30 A/230 Vac according to ANSI IEEE Std. C37.90-2005
  - 30 A/250 Vdc according to ANSI IEEE Std. C37.90-2005
- Maximum breaking current:
  - 5 A AC up to 125 Vac
  - 5 A DC up to 30 V (resistive)
  - 0.3 A DC at 300 V
- Maximum switching voltage: 250 Vac/250 Vdc
- Switching capacity: 1250 VA
- Contact type: changeover contact or normally open contact
- Terminals: screw-type terminals

Supervision Contact (SC)

- Continuous current: 5 A at 120/240 Vac or 30 Vdc
- Maximum switch-on current: 15 A at 120/240 Vac or 30 Vdc (max. 4 s)
- Maximum breaking current:
  - 5 A at 120/240 Vac or 30 Vdc
  - 0.4 A at 125 Vdc
- Contact type: 1 changeover contact
- Terminals: screw-type terminals

Time Synchronization IRIG

- Nominal input voltage: 5 V
- Connection: Screw-type terminals (twisted pair)

Front Interface RS-232

- Baud rates: 115,200 baud
- Handshake: RTS and CTS
- Connection: 9-pole D-Sub plug

RS-485

- Master/slave: slave
- Connection: 6 screw-clamping terminals RM 138 MIL (3.5 mm) (terminating resistors internal)

Zone Interlocking

- Nominal input level: 5 V
- Nominal output level: 5 V
- Connection: Screw-type terminals (twisted pair)

Standards

High Voltage Tests (IEC 60255-6)

- High frequency interference test:
  - IEC 60255-22-1 Class 3
    - Within one circuit—1 kV/2 s
    - Circuit to ground—2.5 kV/2 s
    - Circuit to circuit—2.5 kV/2 s
- Insulation voltage test:
  - IEC 60255-5, EN 50178
    - All circuits to other circuits and exposed conductive parts: 2.5 kV (eff.)/50 Hz, 1 min.
    - Except interfaces: 1.5 kV DC, 1 min.
    - Voltage measuring input: 3 kV (eff.)/50 Hz, 1 min.
- Impulse voltage test:
  - IEC 60255-5: 5 kV/0.5J, 1.2/50 µs

EMC Immunity Tests

- Fast transient disturbance immunity test (burst):
  - IEC 60255-22-4: Power supply, mains inputs—±4 kV, 2.5 kHz
  - IEC 61000-4-4 Class 4: Other inputs and outputs—±2 kV, 5 kHz (coupling network)
  - ANSI C37.90.1: ± 4 kV, 2.5 kHz (coupling clamp)
- Surge Immunity Test:
  - IEC 61000-4-5 Class 4
    - Within one circuit—2 kV
    - Circuit to ground—4 kV
- Electrical discharge immunity test:
  - IEC 60255-22-2: Air discharge—8 kV
  - IEC 61000-4-2 Class 3: Contact discharge—6 kV
- Radiated radio frequency electromagnetic field immunity test
  - IEC 61000-4-3: 26 MHz – 80 MHz—10 V/m
  - Class X: 80 MHz–1 GHz—35 V/m
  - ANSI C37.90.2: 1 GHz–3 GHz—10 V/m
- Immunity to conducted disturbances induced by radio frequency fields:
  - IEC 61000-4-6 Class 3: 10 V
- Power frequency magnetic field immunity test:
  - IEC 61000-4-8: Continues—30 A/m
  - Class 4: 3 sec—300 A/m

EMC Emission Tests

- Radio interference suppression test:
  - IEC/CISPR11—Limit value class B
- Radio interference radiation test:
  - IEC/CISPR11—Limit value class B

Environmental Tests

Classification

- IEC 60068-1: Climatic—0/055/56
- IEC 60721-3-1:
  - Classification of ambient conditions (storage)—1K5/1B1/1C1L/1S1/1M2 but min. –13 °F (–25 °C)
- IEC 60721-3-2: Classification of ambient conditions (transportation)—2K3/2B1/2C1/2S1/2M2
- IEC 60721-3-3: Classification of ambient conditions (Stationary use at weather protected locations)—3K6/3B1/3C1/3S1/3M2 but min. 32 °F (0 °C) and 3K8H for 2 h

Test ad: Cold

- IEC 60068-2-1:
  - Temperature—–4 °F (–20 °C)
  - Test duration—16 h

Test Bd: Dry heat

- IEC 60068-2-2:
  - Temperature—131 °F (55 °C)
  - Relative humidity—<50%
  - Test duration—72 h

Test cab: Damp heat (steady state)

- IEC 60068-2-78:
  - Temperature—104 °F (40 °C)
  - Relative humidity—93%
  - Test duration—56d

Test Db: Damp heat (cyclic)

- IEC 60068-2-30:
  - Temperature—131 °F (55 °C)
  - Relative humidity—95%
  - Cycles (12 + 12-hour)—2

Mechanical Tests

Test Fc: Vibration response test

- IEC 60068-2-6, IEC 60255-21-1, Class 1:
  - Displacement: (10 Hz–59 Hz)—0.0014 in (0.035 mm)
  - Acceleration: (59 Hz–150 Hz)—0.5 gn
  - Number of cycles in each axis: 1

Test Fc: Vibration endurance test

- IEC 60068-2-6, IEC 60255-21-1, Class:
  - Acceleration: (10 Hz–150 Hz)—1.0 gn
  - Number of cycles in each axis: 20

Test Ea: Shock test

- IEC 60068-2-27, IEC 60255-21-2, Class 1
  - Shock response test: 5 gn, 11 ms, 3 impulses in each direction
  - Shock resistance test: 15 gn, 11 ms, 3 impulses in each direction

Test Eb: Shock endurance test

- IEC 60068-2-29, IEC 60255-21-2, Class 1
  - Shock endurance test: 10 gn, 16 ms, 1000 impulses in each direction

Test Fe: Earthquake test

- IEC 60068-3-3, KTA 3503, IEC 60255-21-3, Class 2
  - Single axis earthquake vibration test:
    - 3–7 Hz: horizontal 0.394 in (10 mm), 1 cycle each axis
    - 7–35 Hz: horizontal: 2 gn, 1 cycle each axis

Tolerances

Tolerances of the Real-Time Clock

- Resolution: 1 ms
- Tolerance:
  - <1 minute/month (68 °F [+20 °C])
  - <±1 ms if synchronized via IRIG-B

Tolerances of the Measured Value Acquisition

Phase and ground current measuring

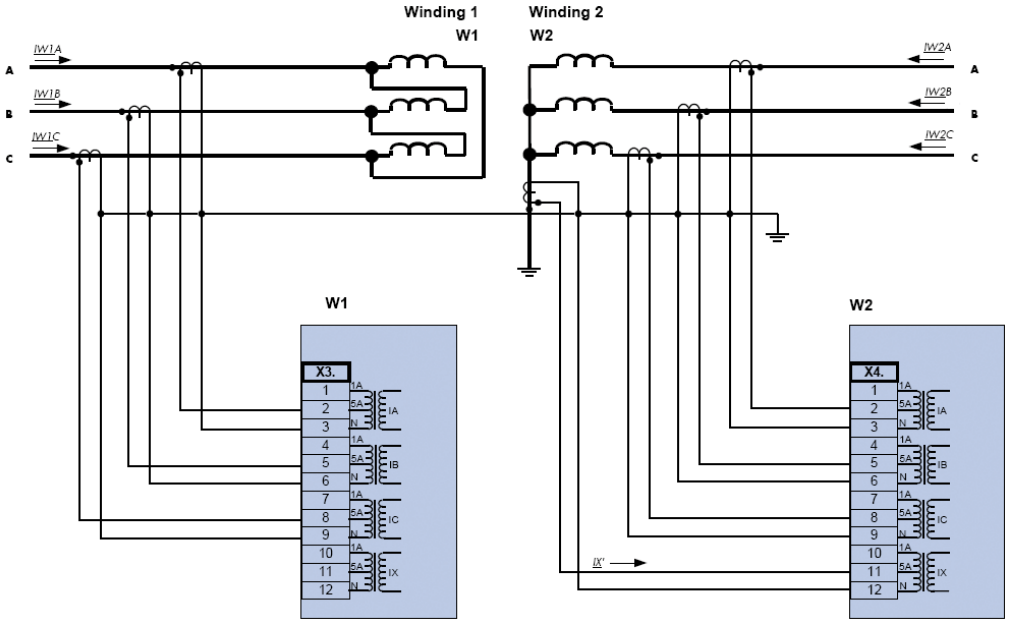
- Maximum measuring range:
  - Up to 40 x I_n (phase currents)
  - Up to 25 x I_n (ground current standard)
  - Up to 2.5 x I_n (earth current sensitive)

Note: The precision does not depend on the nominal value but is referenced to 100 mA (with In =1 A) respectively.
500 mA (with In = 5 A)

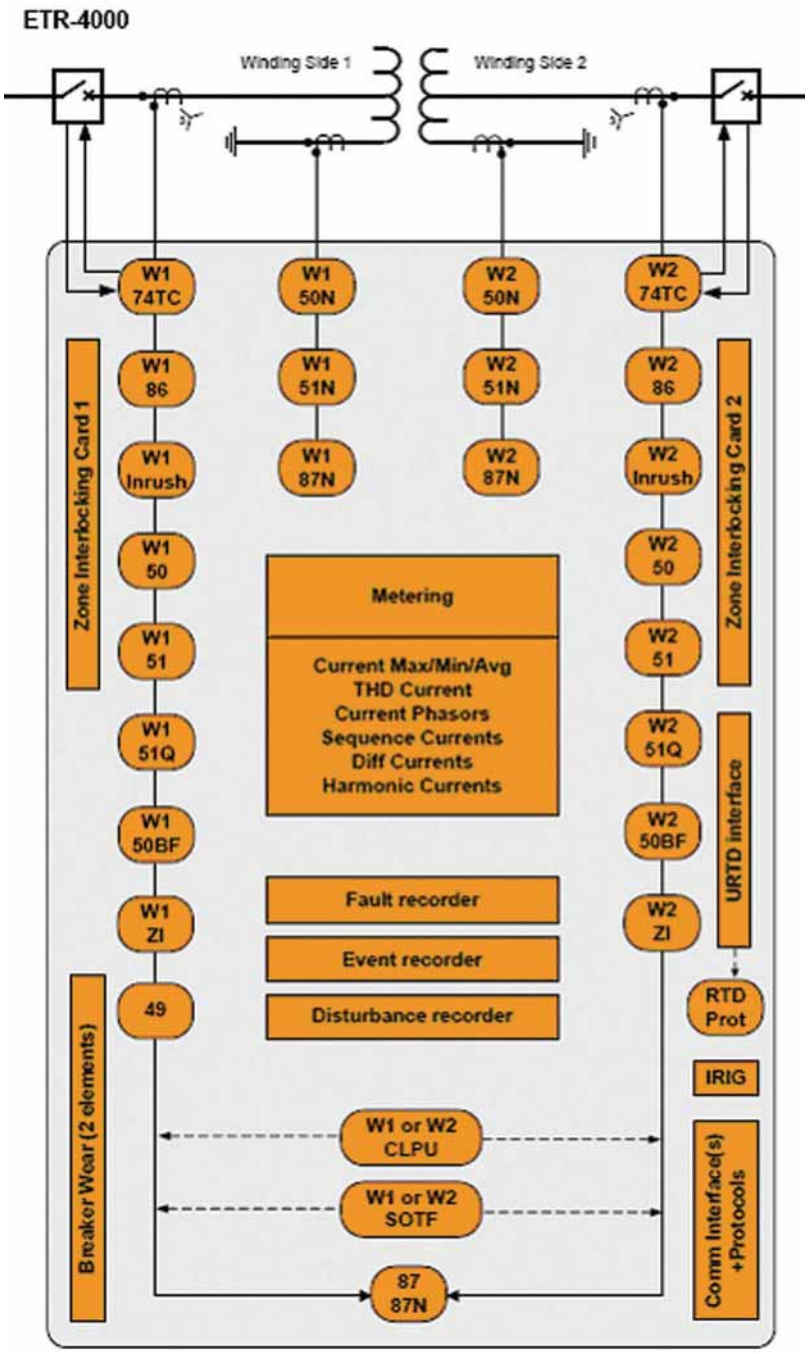
- Frequency range: 50 Hz / 60 Hz ±10%
- Accuracy: Class 0.5
- Amplitude Error if I < 1 I_n: ±0.5% of the rated value
- Amplitude Error if I > I_n: ±0.5% of the measured value
- Amplitude Error if I > 2 I_n: ±1.0% of the measured value
- Resolution: 0.01 A
  - Harmonics: Up to 20% 3rd harmonic ±1%
  - Up to 20% 5th harmonic ±1%
- Frequency influence: < ±2% / Hz in the range of ±5 Hz of the parametrized nominal frequency
- Temperature influence: < ±1% within the range of +32 °F to +140 °F (0 °C to +60 °C)

Wiring Diagrams

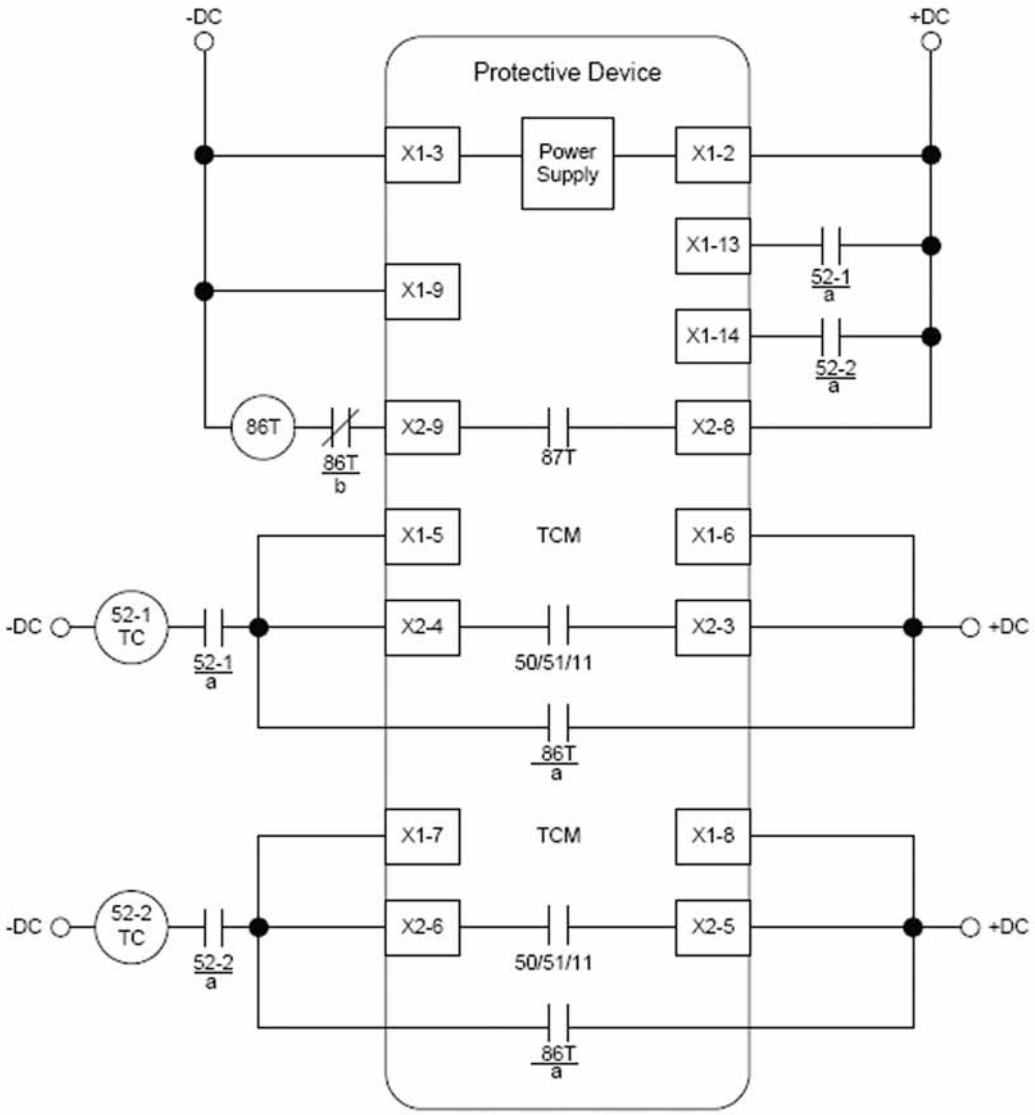
Typical AC Connections Delta-Wye Transformer with Wye CTs and Neutral CT



Typical One-Line Diagram



Typical Control Diagram

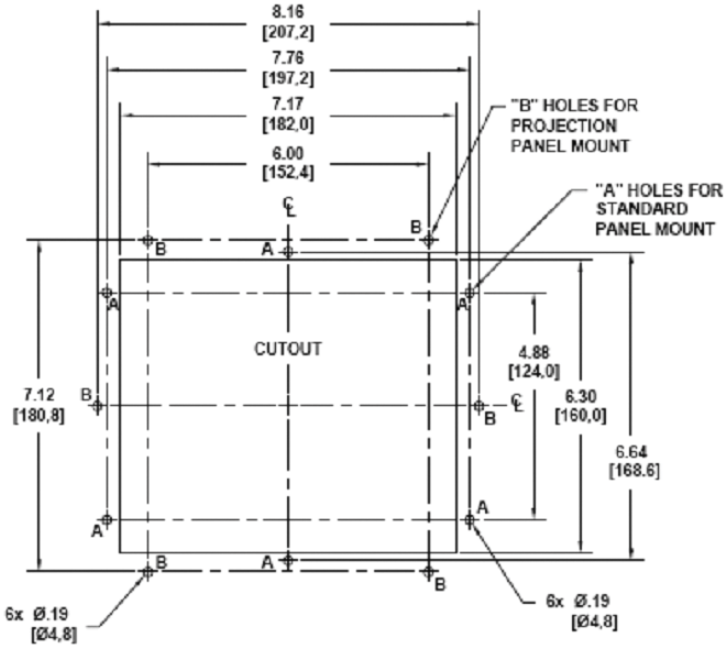


TCM = Trip Coil Monitor

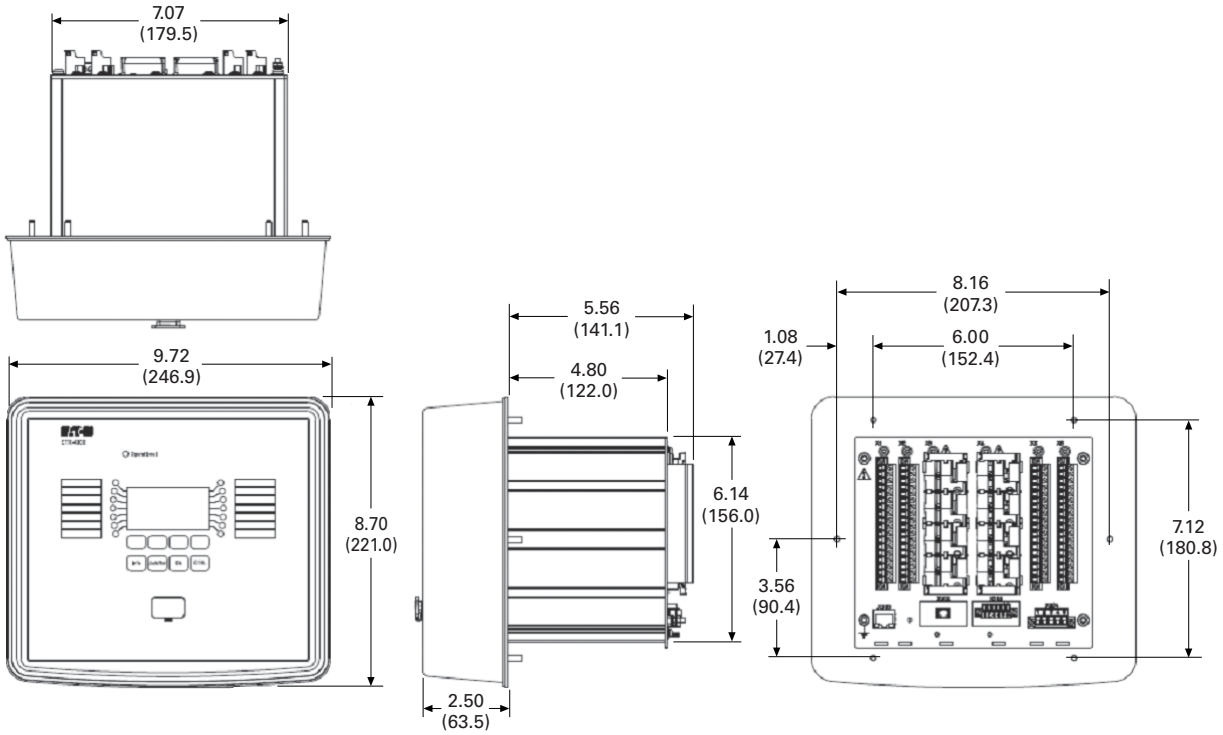
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

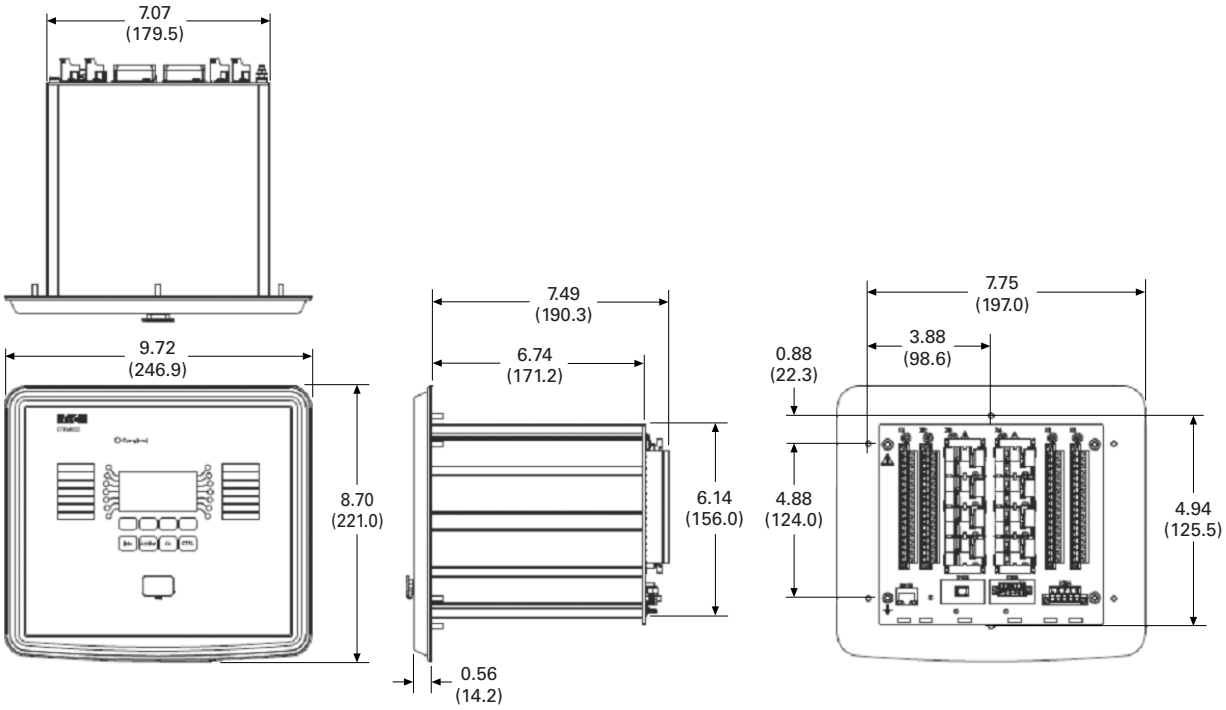


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



ETR-4000 Housing B2

Width	Height	Depth ①	Shipping Weight Lbs (kg)
6.81 (173.0)	8.37 (212.7)	8.19 (208.0)	9.3 (4.2)

Note

① Includes terminals.

ETR-5000 Transformer Protection Relay

Contents

ETR-5000 Transformer Protection Relay

Product Description

Eaton's ETR-5000 transformer protection relay is a multi-functional, microprocessor-based relay for two winding transformers of all voltage levels. The ETR-5000 provides phase and ground percentage restrained differential protection using a variable dual slope characteristic with phase, residual, and neutral directional overcurrent elements for backup protection. Negative sequence overcurrent elements, three phase over/under voltage, voltage unbalance, current unbalance, over/under and rate-of-change frequency, vector surge, directional VARs, directional power, and overexcitation are standard functions.

The ETR-5000 transformer relay provides all required protection, control, monitoring and metering for any size two winding transformer in a single, compact case. The relay has eight current inputs rated for either 5 amperes or 1 ampere and four voltage inputs. The CTs can be connected in wye in both sides of the transformer; the relay automatically compensates for the connection of the transformer, and CT mismatch errors.

Three of the voltage inputs are to be connected to the three-phase power voltage for voltage protection and for metering. They can be connected in wye-ground or open delta configuration. The fourth voltage is for independent single-phase undervoltage/overvoltage protection.

The maintenance mode password protected soft key, can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. Fourteen programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 and an Ethernet ports in the back are optional for local area networking using. Optional Modbus-RTU, Modbus-TCP, or IEC-61850 protocols are supported.

The ETR-5000 transformer protection relay includes programmable logic functions. Logic gates and timers may be defined and arranged for customized applications. Programmable logic control functions make the ETR-5000 very flexible.

Flash memory is used for the programming and all settings are stored in nonvolatile memory.

The ETR-5000 generator protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/maximum values, load profiles, breaker wear information and waveform data.

The ETR-5000 has eight programmable binary inputs, 2 analog inputs, 2 analog outputs, 1 zone intelorking card or eight programmable binary inputs, and 2 zone interlocking cards. It has 2 normally opened and 6 Form C heavy-duty outputs and one Form C signal alarm relay. The ETR-5000 can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Application Description

Eaton's ETR-5000 transformer protection relay has been designed for maximum user flexibility and simplicity. The ETR-5000 is suitable for application on small, medium, and large two winding power transformers. Multiple current inputs are used to provide primary protection, control and back-up protection of transformers, including current differential, restricted ground differential, and overcurrent protection.

Dual-Slope Percent Differential Protection

The primary protective element for transformer protection is the percent differential element, which compares the current entering the primary and leaving the secondary of the transformer. The ETR-5000 has built in compensation for the turns-ratio and the phase shift of the transformer, so it's not necessary to compensate for the transformer connection by the connection of the CTs.

The current differential element looks at the vector difference between the current entering and leaving the zone of protection. If the difference exceeds a pre-determined amount, the element will operate.

The operating characteristic of the percent differential element is a dual-slope characteristic to accommodate for CT saturation and CT errors.

Harmonic Restraints

There are certain conditions like energizing one side of the transformer with the other side de-energized (inrush currents) or the paralleling of two transformers (sympathetic currents) that can create false differential currents. These differential currents if not recognized can cause a false trip; in the case of inrush conditions or sympathetic currents the differential current is characterized by a heavy content of 2nd and 4th harmonic currents. The percentage differential element is desensitize either permanently (stationary conditions) or temporarily (transient conditions), whenever the 2nd or 4th harmonic exceed the value programmed into the relay.

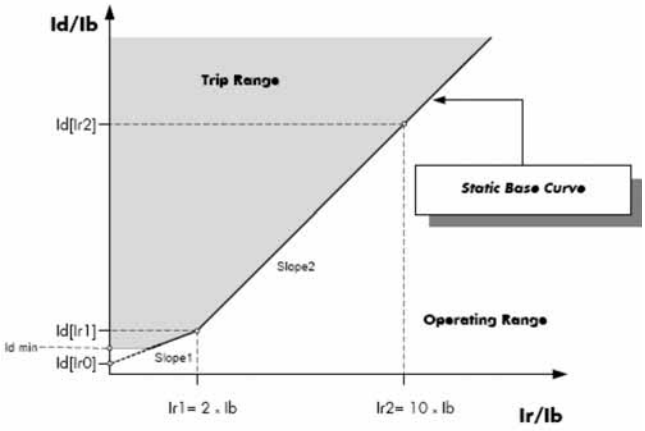
Another condition that can create a false differential current is a sudden change of voltage or frequency, that can put the transformer in an overexcitation state. In this case there is high content of 5th harmonic currents. The percentage differential element is also desensitized when the 5th harmonic content exceeds a predefined value.

Unrestrained Differential

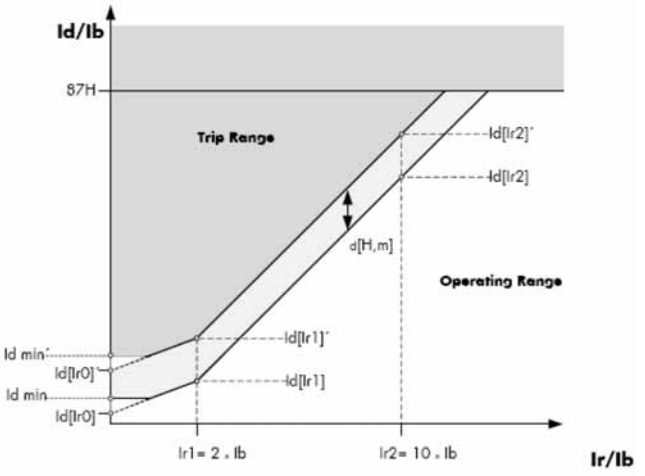
An unrestrained differential element is provided for fast tripping on heavy internal faults to limit catastrophic damage to the transformer and minimize risks to the remainder of the power system.

Restricted Ground Fault

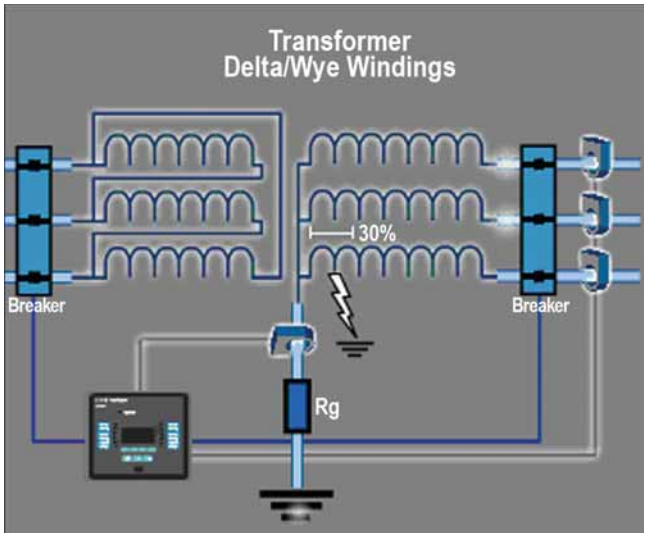
Ground differential protection is applied to transformers having impedance grounded wye windings. It is intended to provide sensitive ground fault detection for low magnitude fault currents, which would not be detected by the main percent differential element.



Dual-Slope Operating Characteristic



Dynamic Rise of the Operating Characteristic.



Restricted Ground Fault

Directional Overcurrent Elements

The ETR-5000 can be used to provide backup for transformer and adjacent power system equipment. Instantaneous overcurrent elements can be used for fast clearing of severe internal or external (through) faults.

Time overcurrent protection elements per winding allow coordinating with the adjacent protection zones and acting as a backup protection. There are 11 user-selectable inverse-time overcurrent curve characteristics. The user can select from the ANSI, IEC or thermal curve families and can select instantaneous or time delay reset characteristics.

Phase direction is a function used to supervise all phase current elements (50, 51). A quadrature voltage is compared to a corresponding phase current to establish the direction of the fault. This function is selectable to operate in the forward, reverse or both directions.

Ground direction is used to supervise ground current elements and is accomplished by using ground, negative sequence or residual currents supervised by zero, negative or positive sequence voltages or ground current. This function is selectable to operate in forward, reverse or both directions.

Directional elements are dependant on the location of the VTs (primary or secondary winding) when voltage is used as the polarizing quantity.

Negative Sequence Overcurrent

Since this element does not respond to balanced load or three-phase faults, the negative-sequence overcurrent element may provide the desired overcurrent protection. This is particularly applicable to delta-wye grounded transformers where only 58% of the secondary p.u. phase-to-ground fault current appears in any one primary phase conductor. Backup protection can be particularly difficult when the wye is impedance grounded. A negative-sequence element can be used in the primary supply to the transformer and set as sensitively as required to protect for secondary phase-to-ground or phase-to-phase faults. This element should be set to coordinate with the low-side phase and ground relays for phase-to-ground and phase-to-phase faults. The negative sequence element must also be set higher than the negative-sequence current due to unbalanced loads.

Overexcitation Protection

Transformer overexcitation occurs when the ratio of voltage versus frequency is too high, and the transformer iron saturates due to high flux density. High flux density results in stray flux in components not designed to carry it, which in turn causes overheating and can potentially damage the transformer. This protection is provided through a Volts/Hertz function with a programmable inverse time characteristic.

Voltage Protection

The ETR-5000 transformer protection relay has four voltage-input circuits. There is a three-phase set designated as Main Voltage (M) and a single-phase voltage circuit designated as Auxiliary Voltage (A). Both include undervoltage (27) and overvoltage (59) protection. The three-phase voltage protection can be set to operate on a single-phase, 2 out of 3 phases, or all three-phase logic. The Main VTs also provide phase voltage unbalance/reversal (47 negative sequence) protection. Each element has an independent threshold set point and adjustable time delay.

Flexible Phase Rotation

The ETR-5000 distribution protection relay can be applied on either an A-B-C or A-C-B phase rotation. A user setting permits correct operation and indication of the actual system configuration.

Frequency Protection

The ETR-5000 relay provides six frequency elements than can be used to detect under/over frequency, rate of change, and a vector surge (decoupling of two systems) protection on the Main VT inputs. Each element has an independent threshold set point and adjustable time delay.

Reverse Power

Reverse power provides control for power flowing through a feeder. There are three elements to be configured: operate in forward or reverse; or, under or over power conditions. Reverse power is typically applied to generator or motor applications while under power is generally applied to load or generation loss.

Reverse VARs

Reverse VARs can be used to detect loss of excitation in synchronous machines. There are three elements to be configured: operate in forward or reverse; or, under or over vars conditions.

Breaker Failure

The ETR-5000 transformer protection relay includes two breaker failure (50BF, 62BF) elements that can be initiated from either an internal or external trip signal. These are independent elements that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communications or via a digital input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Features, Benefits and Functions

Protection Features

- Dual-slope percentage restrained current differential with magnetizing inrush and overexcitation blocking (87R)
- Unrestrained current differential (87H)
- Restricted ground fault/ Ground Differential (87GD)
- Phase overcurrent (elements can be assigned to either side of the transformer):
  - Four instantaneous elements with timers (50P[1], 50P[2], 50P[3] and 50P[4])
  - Four inverse time overcurrent elements (51P[1], 51P[2], 51P[3] and 51P[4])
  - 11 standard curves;
  - Inrush blocking
  - Instantaneous or time delay reset
  - Voltage restraint (all elements)
  - Directional control (all elements)
- Negative sequence phase overcurrent (elements can be assigned to either side of the transformer):
  - 2 inverse time overcurrent elements (51Q[1] and 51Q[2])
  - 11 standard curves
  - Instantaneous or time delay reset
- Ground overcurrent (elements can be assigned to either side of the transformer):
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
  - Directional control (all elements)
- Two breaker failure elements (50BF[1] and 50BF[2])
- Phase transformer overload protection (49)
- Phase unbalance negative sequence overcurrent (46[1], 46[2]))
- Phase voltage unbalance and sequence protection (47[1], 47[2])
- Main three-phase under/ overvoltage (27M[1], 27M[2], 59M[1], 59M[2])
- Auxiliary single-phase under/overvoltage (27A[1], 27A[2], 59A[1], 59A[2])
- Six frequency elements that can be assigned to: over frequency, under frequency, rate of change, or vector surge (81[1], 81[2], 81[3], 81[4], 81[5], 81[6])
- Forward and reverse watts (32[1], 32[2], 32[3]).
- Forward and reverse VARs (32V[1], 32V[2], 32V[3])
- Overexcitation, volts-per-Hertz (24[1], 24[2])
- Lockout (86)
- Loss of potential-LOP
- Zone interlocking for bus protection (87B)
- Switch onto fault protection
- Cold load pickup

Metering Features

- Phase differential current
- Ground differential current
- Amperes: positive, negative and zero sequence
- Ampere demand
- Volts: positive, negative and zero sequence
- Phase angles
- Volt-amperes and VA demand
- Watts and kW demand
- kWh (forward, reverse, net)
- VARs and kVAR demand
- kVARh (lead, leg and net)
- Power factor
- Volts/Hertz
- % THD V and I
- Magnitude THD V and I
- Minimum/maximum recording
- Trending (load profile over time)
- Temperature with remote URTD module

Monitoring Features

- Trip coil monitor for both primary and secondary breakers
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (7200 cycles total)
- Trip Cause displays fault recorder data on HMI after fault event
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)

Control Functions

- Breaker open/close both breakers
- Remote open/close
- Programmable I/O
- Programmable Logic
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Communication Features

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port: RS-232
- Remote communication port:
  - RS-485
  - Ethernet port
- Protocols:
  - Modbus-RTU
  - Modbus-TCP (optional)
  - IEC-61850 (optional)
- Configuration software

Monitoring and Metering

Sequence of Events Records

The ETR-5000 protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO in chronological order.

Trip Log

The ETR-5000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents and voltages at the time of the fault.

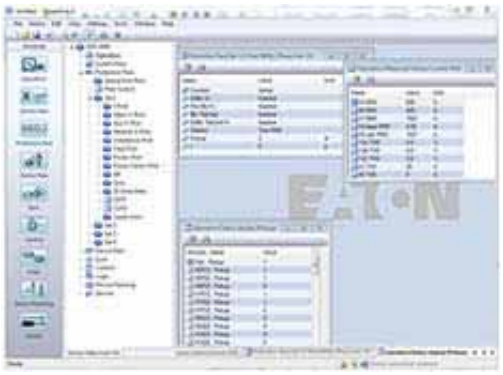
PowerPort-E

PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.

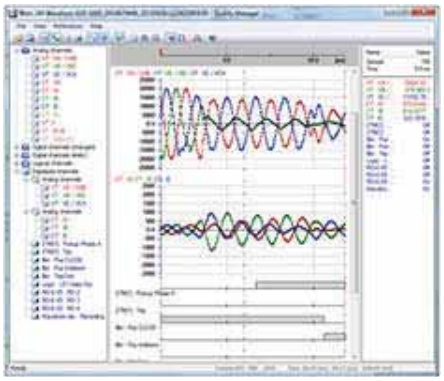
Waveform Capture (Quality Manager)

The ETR-5000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The ETR-5000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles.

The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



PowerPort-E



Waveform Capture (Quality Manager)

Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. 14 programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Load Profiling/Trending

The ETR-5000 relay automatically records selected quantities into non-volatile memory every 5, 10, 15, 30 or 60 minutes, depending on the trending report setting.

Programmable I/O

The ETR-5000 transformer protection relay provides heavy-duty, trip-rated, 2NO and 6 Form C contacts. Two isolated inputs can be used for monitoring the trip circuit. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (failsafe) mode. There are up to 8 user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

The ETR-5000 also offers two optional analog inputs and two optional analog outputs. The analog inputs are available for providing protection. The analog inputs are field programmable to measure transducer signals that operate over a range of 0 to 20 mA, 4 to 20 mA, or 1 to 10V. The two optional analog outputs can be used for signaling the value of measured analog quantities to external process control devices such as PLCs. They can be programmed to operate over a 0 to 20 mA, 4–20 mA, or 1 to 10 V range. The analog outputs can be configured to signal a representation of most analog quantities measured by the ETR-5000 including, current, voltages and RTD temperature.

Programmable Logic

The ETR-5000 transformer protection relay provides logic gates and timers that the user can customize for special or unique applications. Each gate can be assigned a logic function of either AND, OR, NAND or NOR. Each gate can have a maximum of four input signals and each input signal can be required to be a NOT. Input signals can be external inputs received via the binary inputs or internal values associated with the protection, alarm or metering set points. Each gate has a unique output assignment and designation that can be used as the input to another gate.

Standards and Certifications

Approvals

- UL listed file: E217753

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90

Listed

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the ETR-5000. For example, if the catalog number is ETR-5000-2A0BA1, the device would have the following:

ETR-5000

(A)–8 Digital Inputs, 9 Output Relays

(0)–5 A / 1 A phase and ground CTs, Power Supply Range: 19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without Conformal Coating

(1)–Projection Panel Mount

ETR-5000 Eaton Transformer Protection Relay

ETR-5000-2A 0 B A 1

Hardware Option 1
- **A** = 8 DI, 9 outputs, removable terminals, 2 zone interlocking, URTD interface
- **B** = 8 DI, 9 outputs, 2 AI, 2AO, removable terminals, 1 zone interlocking, URTD interface

Hardware Option 2
- **0** = Phase current 5 A / 1 A, W1/W2 ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, W1 sensitive ground current 0.5 A 0.1 A, W2 Ground current 5A/1A, power supply range: 19–300 Vdc, 40–250 Vac
- **2** = Phase current 5 A / 1 A, W1 sensitive ground current 0.5 A 0.1 A, W2 Ground current 5A/1A, power supply range: 19–300 Vdc, 40–250 Vac
- **3** = Phase current 5 A / 1 A, W1 / W2 sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –30 °C to +70 °C (–22 °F to +158 °F)
- Operating temperature: –20 °C to +60 °C (–4 °F to +140 °F)
- Permissible humidity at ann. average: <75% rel. (on 56d up to 95% rel.)
- Permissible installation altitude:
  - <2000 m (6,561.67 ft) above sea level
  - If 4000 m (13,123.35 ft) altitude applies, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP30

Routine Test

- Insulation test acc. to IEC 60255-5: All tests to be carried out against ground and other input and output circuits.
- Aux. voltage supply, digital inputs: 2.5 kV (eff.) / 50 Hz
- Current measuring inputs, signal relay outputs: 2.5 kV (eff.) / 50 Hz
- Voltage measuring inputs: 3.0 kV (eff.) / 50 Hz
- All wire-bound communication interfaces: 1.5 kV DC

Housing

- Housing B2: height/width: 173 mm (6.811 in / 4 U) / 212.7 mm (8.374 in / 42 hp)
- Housing depth (incl. terminals): 208 mm (8.189 in)
- Material, housing: aluminum extruded section
- Material, front panel: aluminum/foil front
- Mounting position: horizontal (±45° around the X-axis must be permitted)
- Weight: ETR-5000 housing B2: approx. 9.259 lb (4.2 kg)

Plug-in Connector with Integrated Short-Circuiter

(Conventional current inputs)

- Nominal current: 1 A and 5 A
- Continuous loading capacity: 4 x In / continuously
- Overcurrent withstand:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve

Control power supply

- Aux. voltage: 24–270 Vdc / 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure:
  - ≥50 ms at minimal aux. voltage
  - Interrupted communication is permitted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse 5 x 20 mm (approx. 1/5 x 0.8 in) according to IEC 60127
  - 3.5 A time-lag miniature fuse 6.3 x 32 mm (approx. 1/4 x 1 1/4 in) according to UL 248-14

Power Consumption

- Power supply range: 19–300 Vdc
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W
- Power supply range: 40–250 Vac (for frequencies of 40–70 Hz)
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W

Real Time Clock

- Running reserve of the real time clock: 1 year min.

Display

- Display type: LCD with LED background illumination
- Resolution—graphics display: 128 x 64 pixel
- LED type: two colored: red/green
- Number of LEDs, Housing B2: 15

Digital Inputs

- Max. Input Voltage: 300 Vdc / 270 Vac
- Input Current: <4 mA
- Reaction Time: <20 ms
- Fallback Time: <30 ms

(Safe state of the digital Inputs)

- 4 Switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac / DC, 230 Vac / DC
  - Un = 24 Vdc
    - Switching threshold 1 ON: Min. 19.2 Vdc
    - Switching threshold 1 OFF: Max. 9.6 Vdc
  - Un = 48 V / 60 Vdc
    - Switching threshold 2 ON: Min. 42.6 Vdc
    - Switching threshold 2 OFF: Max. 21.3 Vdc
  - Un = 110 / 120 Vac / Vdc
    - Switching threshold 3 ON: Min. 88.0 Vdc / 88.0 Vac
    - Switching threshold 3 OFF: Max. 44.0 Vdc / 44.0 Vac
  - Un = 230 / 240 Vac / dc
    - Switching threshold 4 ON: Min. 184 Vdc / 184 Vac
    - Switching threshold 4 OFF: Max. 92 Vdc / 92 Vac
- Terminals: screw-type terminal

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x In (phase currents)
  - Up to 25 x In (ground current standard)
  - Up to 2.5 x In (ground current sensitive)
- Continuous loading capacity: 4 x In/ continuously
- Overcurrent proof:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Power consumption:
  - Phase current inputs
    - At In = 1 A burden = 0.15 MVA
    - At In = 5 A burden = 0.15 MVA
  - Ground current input
    - At In = 1 A burden = 0.35 MVA
    - At In = 5 A burden = 0.35 MVA
- Frequency range: 50 Hz / 60 Hz ±10%
- Terminals: screw-type terminals with integrated short-circuiters (contacts)

Relay Outputs

- Continuous current: 5 A AC/DC
- Maximum make current:
  - 25 A AC/25 A DC up to 30 V for 4 s
  - 30 A/230 Vac according to ANSI IEEE Std. C37.90-2005
  - 30 A/250 Vdc according to ANSI IEEE Std. C37.90-2005
- Maximum breaking current:
  - 5 A AC up to 125 Vac
  - 5 A DC up to 30 V (resistive)
  - 0.3 A DC at 300 V
- Maximum switching voltage: 250 Vac/250 Vdc
- Switching capacity: 1250 VA
- Contact type: changeover contact or NO contact
- Terminals: screw-type terminals

Supervision Contact (SC)

- Continuous current: 5 A at 120/240 Vac or 30 Vdc
- Maximum switch-on current: 15 A 120/240 Vac or 30 Vdc (max. 4 s)
- Maximum breaking current:
  - 5 A Vac up to 2120/240 Vac
  - 5 A Vdc up to 30 Vdc
  - 0.4 A at 125 Vdc
- Contact type: 1 changeover contact
- Terminals: screw-type terminals

Time Synchronization IRIG

- Nominal input voltage: 5 V
- Connection: screw-type terminals (twisted pair)

Front Interface RS-232

- Baud rates: 115,200 baud
- Handshake: RTS and CTS
- Connection: 9-pole D-Sub plug

RS-485

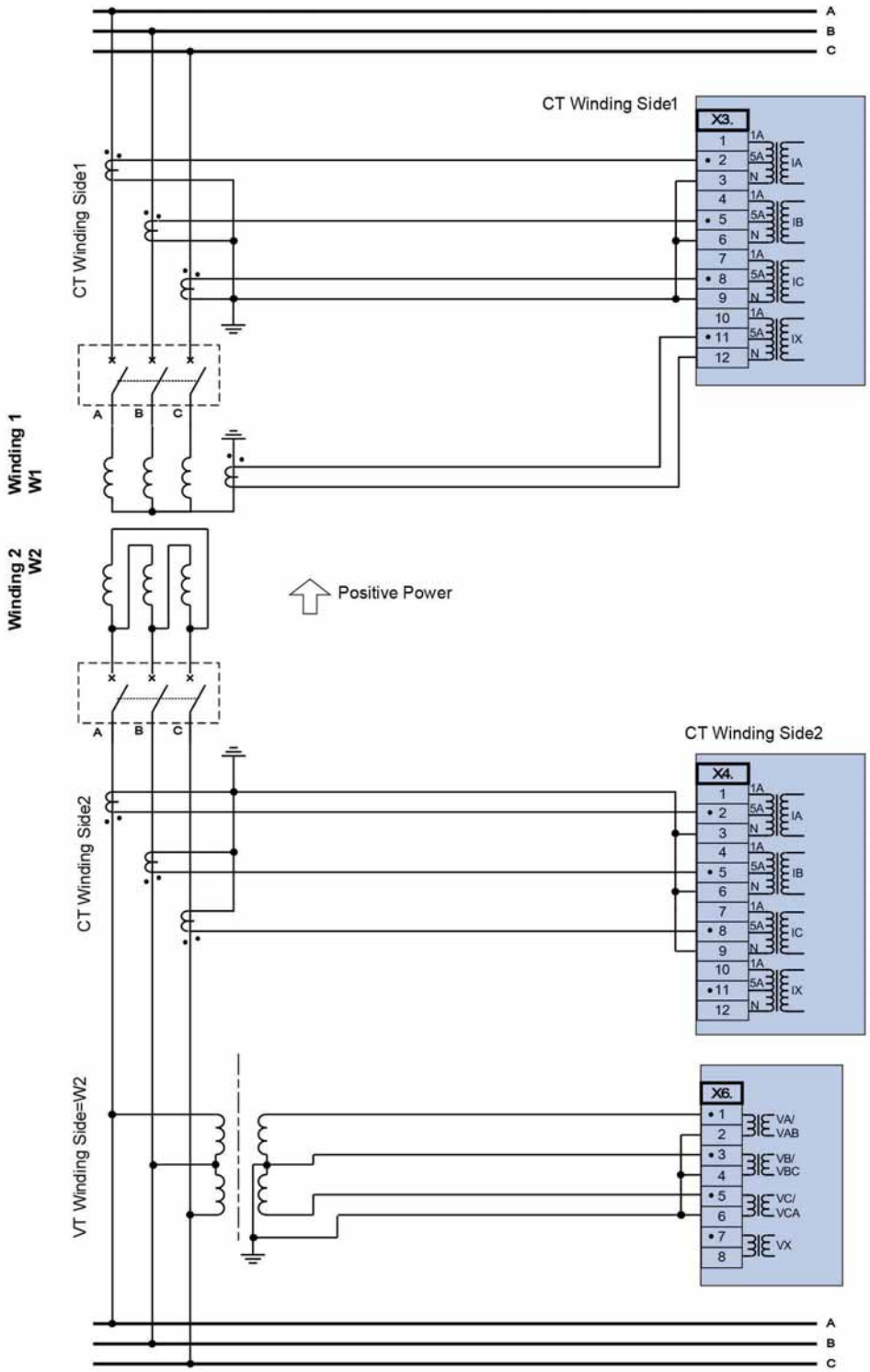
- Master/slave: slave
- Connection: 6 screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)

Zone Interlocking

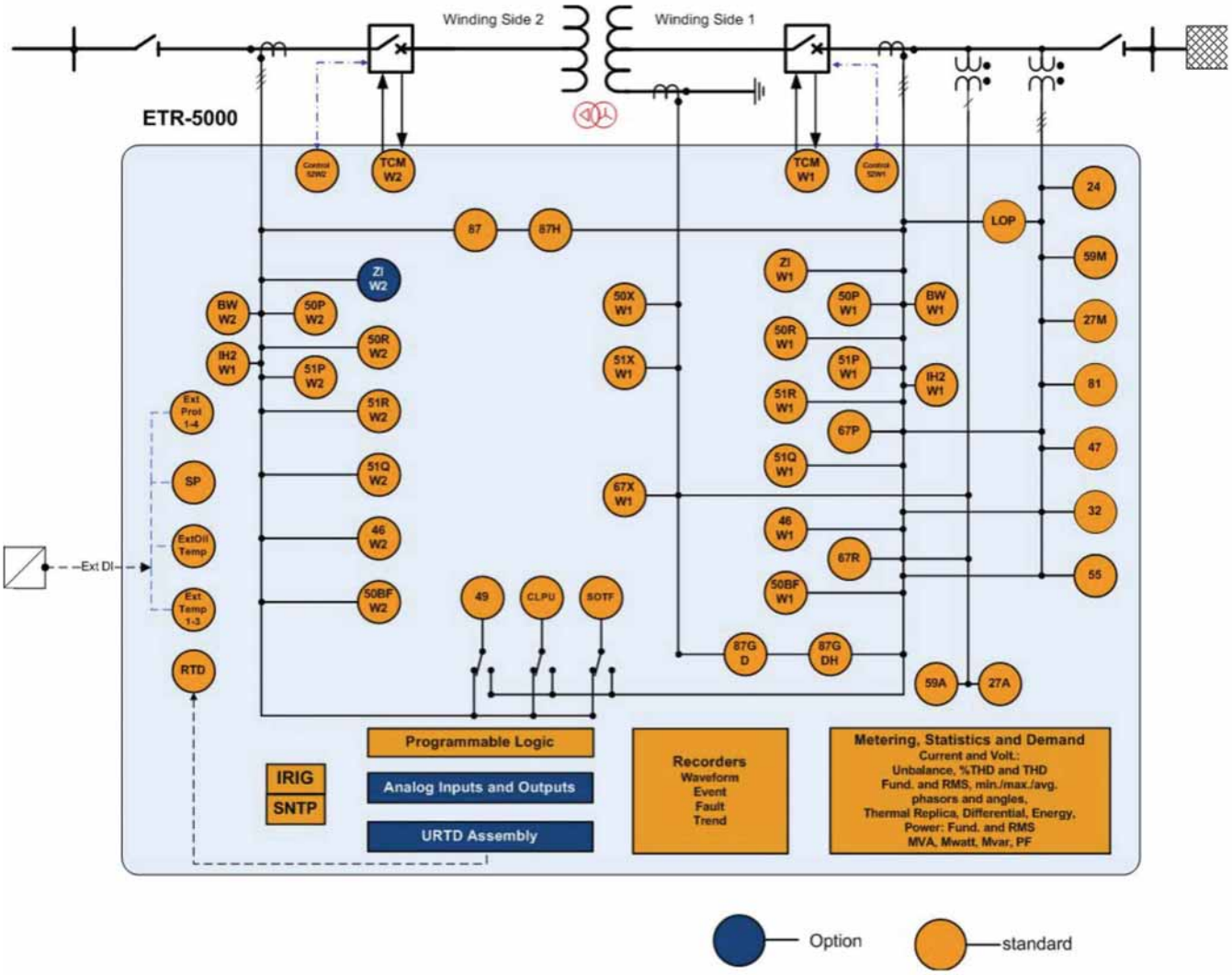
- Nominal input level: 5 V
- Nominal output level: 5 V
- Connection: screw-type terminals (twisted pair)

Wiring Diagrams

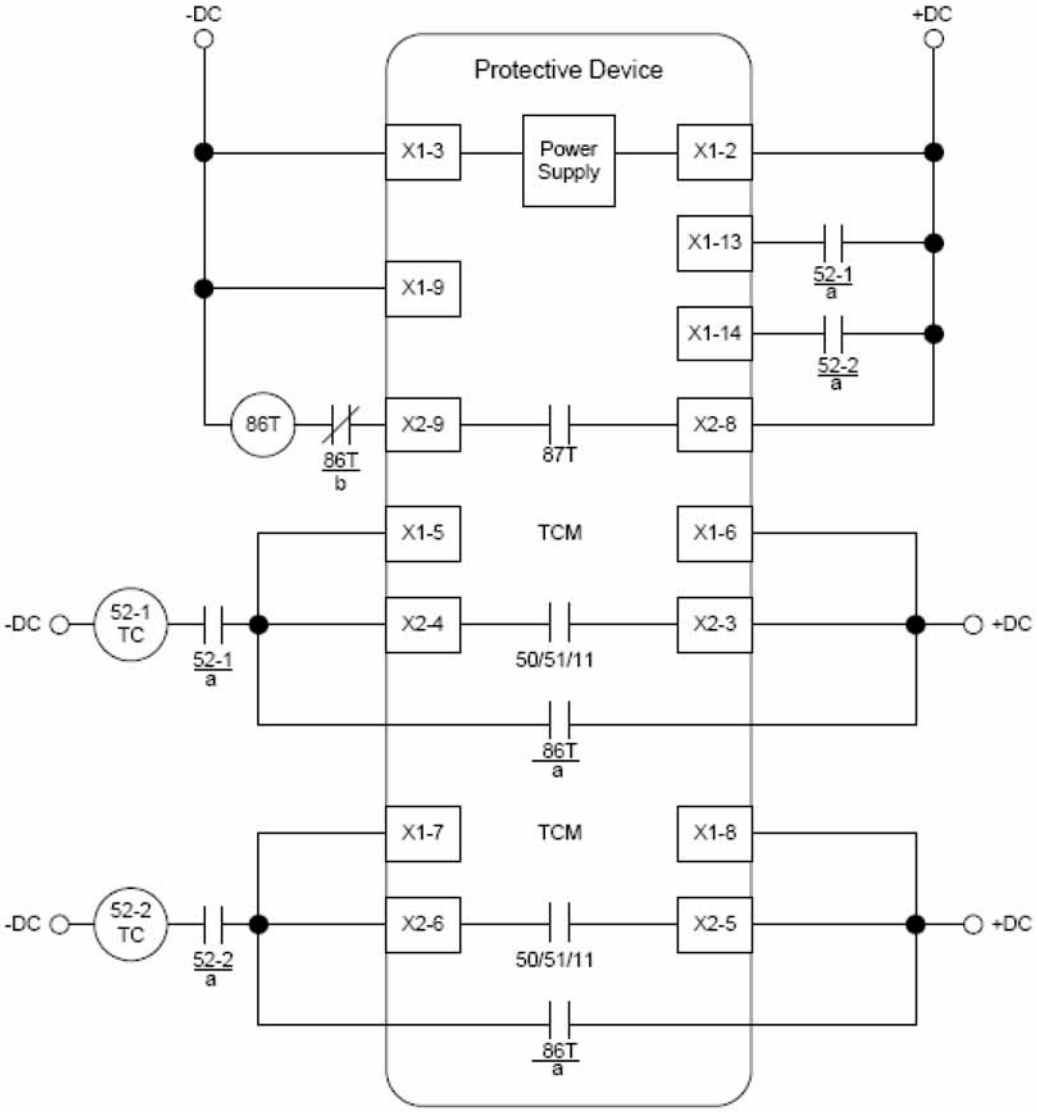
Typical AC Connections—Delta-Wye Transformer with CTs for Phase Overcurrent and Differential on Primary Side (W2) and Secondary Side (W1), Neutral CT for Ground Fault Protection and Open-Delta VT on Primary Side (W2)



Typical One-Line Diagram



Typical Control Diagram

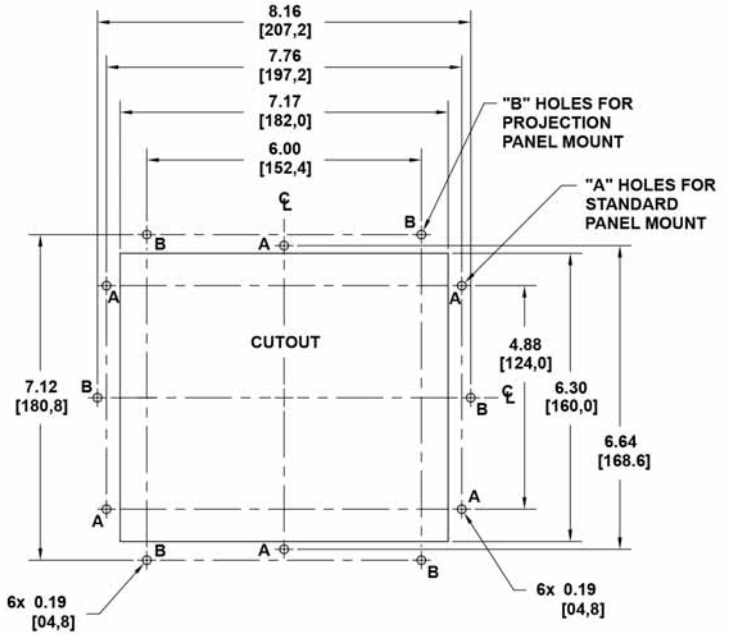


TCM = Trip Coil Monitor

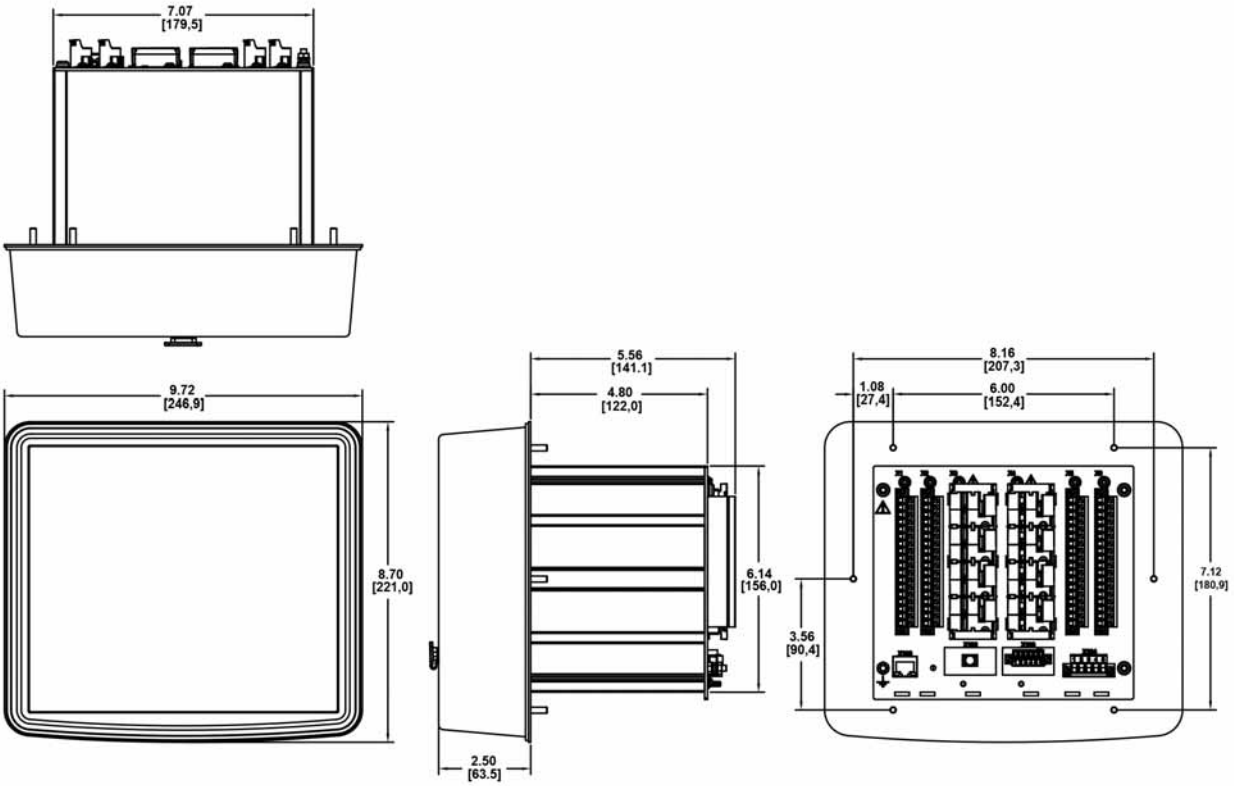
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

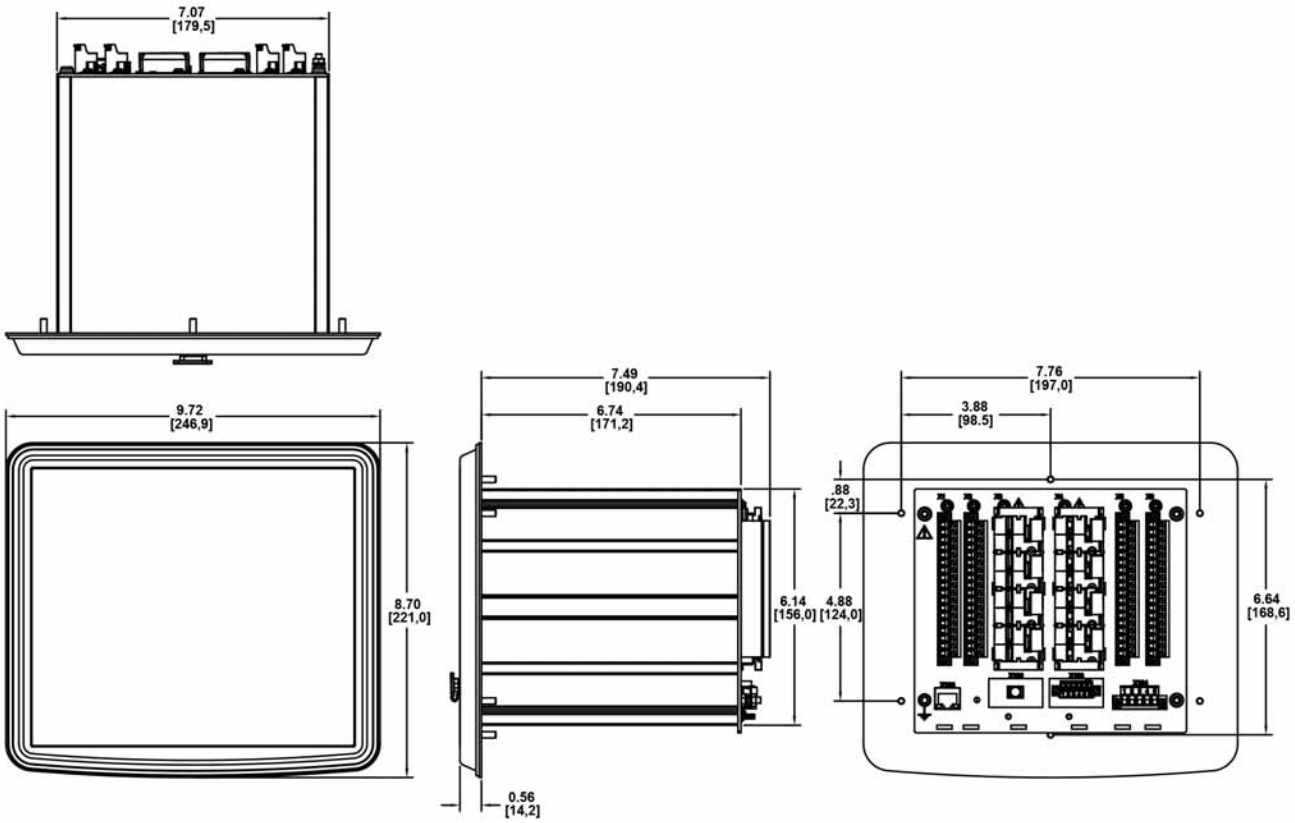


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



EGR-5000 Generation Protection Relay

Contents

9

EGR-5000 Generation Protection Relay

Product Description

Eaton's EGR-5000 generator protection relay is a multi-functional, microprocessor-based relay for any size generators. It may be used as a primary or backup protection in stand by generators, and cogeneration applications. The EGR-5000 generator protection relay provides voltage controlled, voltage restrained, and standard directional three phase overcurrent protection, as well as directional phase-residual and independent ground overcurrent protection, and breaker failure. Three phase over/under voltage, voltage unbalance, current unbalance, over/under and rate-of-change frequency, vector surge, power factor, directional VARs, directional power, loss of excitation, overexcitation, phase differential, ground differential, and synch check functions are standard functions.

The EGR-5000 generator relay provides all required protection, control, monitoring and metering for any size generators in a single, compact case. The relay has eight current inputs rated for either 5 amperes or 1 ampere and four voltage inputs. Three of the voltage inputs are to be connected to the three-phase power voltage for voltage protection and for metering. They can be connected in wye-ground or open delta configuration. The fourth voltage is for independent single-phase undervoltage/overvoltage protection, or 100% ground protection for a high resistance grounded generator.

The maintenance mode password protected soft key, can be used for arc flash mitigation to change to an alternate settings group, set to have instantaneous elements only. The multiple setting groups can also be changed, via communications or a digital input.

An integral keypad and display is provided for direct user programming and retrieval of data without the need of a computer. Fourteen programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 and an Ethernet ports in the back are optional for local area networking using. Optional Modbus-RTU, Modbus-TCP, or IEC-61850 protocols are supported.

The EGR-5000 generator protection relay includes programmable logic functions. Logic gates and timers may be defined and arranged for customized applications. Programmable logic control functions make the EGR-5000 very flexible. Flash memory is used for the programming and all settings are stored in nonvolatile memory.

The EGR-5000 generator protection relay has mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of event records, 20 detailed trip logs, minimum/ maximum values, load profiles, breaker wear information and waveform data.

The EGR-5000 has either eight programmable binary inputs, 2 analog inputs, 2 analog outputs, or 16 programmable binary inputs. It has 2 normally opened and 6 Form C heavy duty outputs and one Form C signal alarm relay. The EGR-5000 can be powered from 19 Vdc to 300 Vdc or 40 Vac to 250 Vac auxiliary power.

Application Description

Eaton's EGR-5000 generator protection relay has been designed for maximum user flexibility and simplicity. The EGR-5000 provides comprehensive protection, metering, and monitoring for any size synchronous or induction generators operating at 50 or 60 Hz. The base relay includes all the standard protection and metering functions. Protection features found in the EGR-5000 include:

Phase Differential Protection

This protection provides a method for rapidly detecting internal generator phase-to-phase or phase-to-ground faults. After the detection of this fault the generator is quickly removed from service to limit the extent of the damage. The EGR-5000 uses a dual slope percentage differential scheme; advanced CT saturation algorithms maintain immunity against external disturbances and ensures the fault is internal to the generator before triggering it to trip.

Ground Differential Protection

In low resistance grounded generators, ground protection may be provided by the 87GD differential, depending on the fault level and the differential relay sensitivity. Higher sensitivity and fast operation for ground faults may be obtained by an additional zero-sequence differential.

Directional Overcurrent Protection

The EGR-5000 generation protection relay provides complete three-phase and ground directional overcurrent protection There are 14 independent ground overcurrent elements. The ground elements "X" use the independently measured ground (or neutral) current from a separate current-sensing input. The ground elements "R" uses a calculated 3Io residual current obtained from the sum of the three-phase currents. This calculated current could be used for either the neutral or ground current in a three-phase, four-wire system. Each of the phase and ground overcurrent elements can be selected to operate based on fundamental or RMS current.

Phase direction is a function used to supervise all phase current elements (50, 51). A quadrature voltage is compared to a corresponding phase current to establish the direction of the fault. This function is selectable to operate in the forward, reverse or both directions.

Ground direction is used to supervise ground current elements and is accomplished by using ground, negative sequence or residual currents supervised by zero, negative or positive sequence voltages or ground current. This function is selectable to operate in forward, reverse or both directions.

Voltage Restrained Overcurrent

Voltage restraint reduces the overcurrent pickup level (51P[2], 51P[3]), to protect the distribution system components against excessive damage and to prevent the generator and its auxiliaries from exceeding their thermal limitations. This modification of the pickup overcurrent level is compared to the corresponding phase input voltage. The EGR-5000 uses the simple linear model below to determine the effective pickup value.

Sync Check

The sync-check function is provided for double-ended power source applications. The sync-check monitors voltage magnitude, phase angle and slip frequency between the bus and line. It also incorporates breaker close time, dead bus dead line, dead bus live line and live bus live line features.

Reverse Power

Reverse power provides control for power flowing through a generator. There are three elements to be configured: operate in forward or reverse; or, under or over power conditions. Reverse power is typically applied to prevent generator motoring that can cause damage to the prime mover; while under power is generally applied to load loss and prevent an overspeed condition that could damage the prime mover.

Reverse VARs

Reverse vars can be used to detect loss of excitation in synchronous machines. There are three elements to be configured: operate in forward or reverse; or, under or over vars conditions.

Inverse Time Characteristics

There are 11 user-selectable inverse-time overcurrent curve characteristics.

The user can select from the ANSI, IEC or thermal curve families and can select instantaneous or time delay reset characteristics.

Breaker Failure

The EGR-5000 generator protection relay includes a breaker failure (50BF, 62BF) function that can be initiated from either an internal or external trip signal. This is an independent element that can be used to operate a lockout relay or trip an upstream breaker. The timer must be longer than the breaker operating time and the protective function reset times.

Voltage Protection

The EGR-5000 generator protection relay has four voltage-input circuits. There is a three-phase set designated as Main Voltage (M) and a single-phase voltage circuit designated as Auxiliary Voltage (A). Both include undervoltage (27) and overvoltage (59) protection. The three-phase voltage protection can be set to operate on a single-phase, two out of three phases, or all three-phase logic. The Main VTs also provide phase voltage unbalance/reversal (47 negative sequence) protection. Each element has an independent threshold set point and adjustable time delay.

100% Ground Stator Protection

In high impedance grounded generators, ground fault protection is provided by the detection of voltage in the neutral of the generator by an overvoltage element (59N) connected to the secondary of the distribution grounding transformer, this overvoltage element has to be desensitized for 3rd harmonic voltages normally present in the generator. Under normal conditions there is no voltage across the secondary of the grounded transformer, when one of the phases goes to ground, voltage appears across the resistor and the overvoltage element operates, indicating a ground conductor. However, the overvoltage element technique described above will protect around 90 percent to 95 percent of the winding. The last 5–10 percent is protected by detecting the decayed of the 3rd harmonic voltage using a undervoltage element (27TN) tuned to the 3rd harmonic voltage. In the EGR-5000 we can provide 100% stator ground protection by measuring the zero sequence voltage through the 4th voltage input, and combining the 59N and 27A elements. The 27A element has to be programmed to operate for 3rd harmonic zero sequence voltages.

Flexible Phase Rotation

The EGR-5000 generator protection relay can be applied on either an A-B-C or A-C-B phase rotation. A user setting permits correct operation and indication of the actual system configuration.

Frequency Protection

Operation of generators at off-nominal frequencies can have extremely detrimental effects on both the generator itself and the associated prime mover, in particular with steam turbine generators operating below normal frequency. The EGR-5000 relay provides six frequency elements than can be used to detect under/over frequency, rate of change, and a vector surge (decoupling of two systems) protection on the Main VT inputs. Each element has an independent threshold set point and adjustable time delay.

Inadvertent Energization

If a generator is inadvertently brought on line with the power system, without being up to speed and synchronized, or it is at standstill when the breaker is closed severe damage could occur. The generator will act as an induction motor and very high currents will be induced in the stator and rotor components, resulting in rapid overheating and damage.

Negative Sequence Protection

Negative sequence overcurrent protection prevents the generators from rotor overheating damage. Unbalanced loads, fault conditions or open phasing will produce a negative sequence current to flow. The unbalanced currents induce double system frequency currents in the rotor, which quickly causes rotor overheating. Serious damage will occur to the generator if the unbalance is allowed to persist. The EGR-5000 provides a negative sequence definite time overcurrent element and a negative sequence timed over current tripping element to ensure the generator stays within it's short time and continuous negative sequence current rated limits.

Overexcitation Protection

Generator overexcitation occurs when the ratio of voltage versus frequency is too high, and the rotor iron saturates due to high flux density. High flux density results in stray flux in components not designed to carry it, which in turn causes overheating and can potentially damage the generator. This protection is provided through a Volts/Hertz function with a programmable inverse time characteristic.

Loss of Excitation

Loss of field protection or loss of excitation is used to avoid unstable operation, potential loss of synchronism, and possible damage to synchronous generators. When a synchronous generator loses its field, the generator can continue to generate power as an induction generator, provided that it can obtain its excitation from the other machines on the system. During this condition, the rotor will quickly overheat due to the slip frequency currents induced in it. Loss of excitation in one machine could jeopardize the operation of other machines beyond their capability, and also the stability of the entire system. The EGR-5000 supports the two typical distance relaying schemes used for detecting the loss excitation. The two schemes differ mainly in that scheme 1 uses a negative offset mho element and scheme 2 uses a positive offset mho element with directional unit supervision.

Maintenance Mode

The Maintenance Mode can improve safety by providing a simple and reliable method to reduce fault clearing time and lower incident energy levels at energized panels. The Maintenance Mode allows the user to switch to more sensitive settings via a password protected soft key, communication or via a digital Input while maintenance work is being performed at an energized panel or device. The more sensitive settings provide greater security for maintenance personnel and helps reduce the possibility of injury.

Features, Benefits and Functions

Protection Features

- Dual-slope percentage restrained phase current differential (87)
- Unrestrained phase current differential (87H)
- Restricted ground fault/ Ground Differential (87GD)
- Unrestrained Restricted ground fault/Ground Differential (87GDH)
- Thermal protection (49/51)
- Phase overcurrent elements:
  - Three instantaneous elements with timers (50P[1], 50P[2] and 50P[3])
  - Three inverse time overcurrent elements (51P[1], 51P[2] and 51P[3])
- 11 standard curves
- Instantaneous or time delay reset
- Voltage restraint (51P[2] and 51P[3])
- Directional control (all elements)
- Ground overcurrent elements:
  - Two instantaneous measured elements with timers (50X[1] and 50X[2])
  - Two instantaneous calculated elements with timers (50R[1] and 50R[2])
  - Two inverse time overcurrent measured elements (51X[1] and 51X[2])
  - Two inverse time overcurrent calculated elements (51R[1] and 51R[2])
  - 11 standard curves
  - Instantaneous or time delay reset
  - Directional control (all elements)
- Breaker failure (50BF)
- Phase unbalance negative sequence overcurrent (46[1], 46[2]))
- Phase voltage unbalance and sequence protection (47[1], 47[2])
- Main three-phase under/ overvoltage (27M[1], 27M[2], 59M[1], 59M[2])
- Auxiliary single-phase under/overvoltage (27A[1], 27A[2], 59A[1], 59A[2])
- Ground fault overvoltage relay (59N[1], 59N[2])
- Six frequency elements that can be assigned to: over frequency, under frequency, rate of change, or vector surge (81[1], 81[2], 81[3], 81[4], 81[5], 81[6])
- Apparent and displacement power factor (55A[1], 55A[2], 55D[1], 55D[2])
- Forward and reverse watts (32[1], 32[2], 32[3])
- Forward and reverse VARs (32V[1], 32V[2], 32V[3])
- Overexcitation, volts-per-hertz (24[1], 24[2])
- 64S, 100% stator ground fault (27TN/ 59N)
- Generator unbalance (46G[1], 46G[2])
- Loss of excitation (40[1],40[2])
- Sync check (25)
- Inadvertent energization (50/27)
- Lockout (86)
- Loss of Potential-LOP
- Zone interlocking for bus protection (87B)
- Switch onto fault protection
- Cold load pickup

Metering Features

- Generator hours of operation
  - Phase Differential Current
  - Ground Differential Current
- Amperes: positive, negative and zero sequence
- Ampere demand
- Volts: positive, negative and zero sequence
- Phase angles
- Volt-amperes and VA demand
- Watts and kW demand
- kWh (forward, reverse, net)
- VARs and kVAR demand
- kVARh (lead, leg and net)
- Power factor
- Frequency
- Volts/Hertz
- 3rd Harmonic Voltage
- % THD V and I
- Magnitude THD V and I
- Minimum/maximum recording
- Sync values
- Trending (load profile over time)
- Temperature with remote URTD module

Monitoring Features

- Trip coil monitor
- Breaker wear
- Oscillography (7200 cycles total)
- Trip cause displays fault recorder data on HMI after fault event
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)

Control Functions

- Breaker open/close
- Remote open/close
- Programmable I/O
- Programmable Logic
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Communication Features

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port:
  - RS-232
- Remote communication port:
  - RS-485
  - Ethernet port
- Protocols:
  - Modbus-RTU (optional)
  - Modbus-TCP (optional)
  - IEC-61850 (optional)
- Configuration software

Monitoring and Metering

Sequence of Events Records

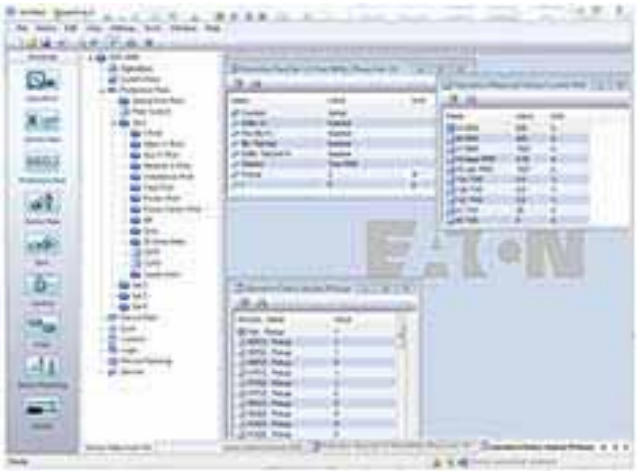
The EGR-5000 generator protection relay records a maximum of 300 events associated with the relay. An event is classified as a change of state as detected by the relay. These include relay pickups, dropouts, trips, contact closure, alarms, setting changes and self-diagnostic failures. Each event is date and time stamped to a 1 ms resolution. The events are stored in a FIFO log in chronological order.

Trip Log

The EGR-5000 protection relay will store a maximum of 20 trip records in a FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution. The trip log record will include information on the type of fault, protection elements that operated, fault location and currents and voltages at the time of the fault.

PowerPort-E

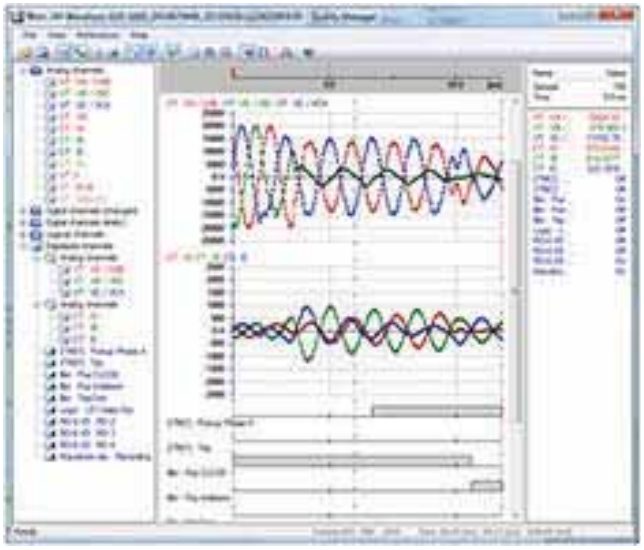
PowerPort-E is the software program used to configure off-line protection setting files for all E-Series relay models. PowerPort-E is also used for viewing measured values of the relays in real-time, uploading/downloading setting files, and retrieving event log and waveform records.



Waveform Capture (Quality Manager)

The EGR-5000 relay provides oscillographic recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, internal logic, and contact inputs. The EGR-5000 can record up to 7200 cycles of data. The number of records is proportional to the programmed size of each record; the maximum size per record is 600 cycles.

The waveform capture is initiated by up to 8 different triggers (i.e., trip/alarm events) or manually via communications or the HMI. PowerPort-E setting software is used to retrieve the records. Quality Manager is a separate software program downloaded with PowerPort-E used for analyzing the waveform and trending files retrieved from the relay.



Integral User Interface

The front panel user interface has a 128 x 64 pixel LCD display with background illumination for wide angle viewing in all light conditions. 17 programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operation mode selection, scrolling through data and settings. In addition, the relay settings and test functions are password protected.

Load Profiling/Trending

The EGR-5000 relay automatically records selected quantities into non-volatile memory every 5, 10, 15, 30 or 60 minutes, depending on the trending report setting.

Programmable I/O

The EGR-5000 generator protection relay provides heavy-duty, triprated, 2NO and 6 Form C contacts. Two isolated inputs can be used for monitoring the trip circuit. One Form C contact is dedicated to the relay failure alarm function and is operated in a normally energized (failsafe) mode. There are up to 16 user-configurable discrete inputs that accept a wet contact and can operate through a wide range of power. Each input and output is user-programmable for maximum application flexibility.

The EGR-5000 also offers two optional analog inputs and two optional analog outputs. The analog inputs are available for providing protection and monitoring of generator bearing vibration. The analog inputs are field programmable to measure transducer signals that operate over a range of 0 to 20 mA, 4 to 20 mA, or 1 to 10 V. The two optional analog outputs can be used for signaling the value of measured analog quantities to external process control devices such as PLCs. They can be programmed to operate over a 0 to 20 mA, 4–20 mA, or 1 to 10 V range. The analog outputs can be configured to signal a representation of most analog quantities measured by the EGR-5000 including, current, voltages, and RTD temperature.

Programmable Logic

The EGR-5000 generator protection relay provides logic gates and timers that the user can customize for special or unique applications. Each gate can be assigned a logic function of either AND, OR, NAND or NOR. Each gate can have a maximum of four input signals and each input signal can be required to be a NOT. Input signals can be external inputs received via the binary inputs or internal values associated with the protection, alarm or metering set points. Each gate has a unique output assignment and designation that can be used as the input to another gate. There are 24 independent timers that have adjustable pickup and dropout delay settings.

Standards and Certifications

Approvals

- UL listed file: E217753

Design Standards

- Generic Standard:
  - EN 61000-6-2
  - EN 61000-6-3
- Product Standard:
  - IEC 60255-6
  - EN 50178
  - UL 508 (Industrial Control Equipment)
  - CSA C22.2 No. 14-95 (Industrial Control Equipment)
  - ANSI C37.90

Listed

Catalog Number Selection

The catalog number identification chart defines the electrical characteristics and operation features included in the EGR-5000. For example, if the catalog number is EGR-5000-2A0BA1, the device would have the following:

EGR-5000

(A)–16 DI, 9 Outputs, Removable Terminals, Zone Interlocking, URTD Interface

(0)–5 A / 1 A Phase and Ground CTs, Power Supply Range: 19–300 Vdc, 40–250 Vac

(B)–Modbus-RTU (RS-485)

(A)–Without conformal coating

(1)–Projection panel mount

EGR-5000 Eaton Motor Relay

EGR-5000-2A 0 B A 1

Hardware Option 1
- **A** = 16 DI, 9 outputs, removable terminals, zone interlocking, URTD interface
- **B** = 8 DI, 9 outputs, 2AI, 2AO, removable terminals, zone interlocking, URTD interface

Hardware Option 2
- **0** = Phase current 5 A / 1 A, ground current 5 A / 1 A, power supply range: 19–300 Vdc, 40–250 Vac
- **1** = Phase current 5 A / 1 A, sensitive ground current 0.5 A / 0.1 A, power supply range: 19–300 Vdc, 40–250 Vac

Communication Options
- **B** = Modbus/DNP3 RTU over RS-485
- **C** = Modbus/DNP3 TCP over Ethernet RJ-45
- **D** = PROFIBUS-DP over fiber optic ST
- **E** = PROFIBUS-DP over D-Sub / RS-485
- **F** = Modbus RTU or DNP3 RTU over fiber optic ST
- **G** = Modbus/DNP3 RTU over D-Sub / RS-485
- **H** = IEC 61850/Modbus/DNP3 TCP over Ethernet RJ-45
- **I** = Modbus/DNP3 RTU over RS-485 or Modbus/DNP3 TCP over Ethernet RJ-45
- **K** = IEC 61850/Modbus/DNP3 TCP over LC duplex fiber optic Ethernet
- **L** = Modbus/DNP3 TCP over LC duplex fiber optic Ethernet

Conformal Coating Options
- **A** = None
- **B** = Conformal coated circuit boards

Mounting Options
- **0** = Standard mount
- **1** = Projection panel mount

Accessories

Standard Accessories EGR-5000

Description	Catalog Number
UNVL RTD Mod with Modbus-RTU 48–240 Vac/48–250 Vdc	**URTDII-01** ①
UNVL RTD Mod with Modbus-RTU 24–48 Vdc	**URTDII-02** ①
E-Series RS-232 Null Modem Cable	**66B2214G01**
E-Series USB to RS-232 Converter	**66B2214G02**
E-Series RS-232 Cable and USB to RS-232 Converter	**66B2214G03**

Note

① See URTD section for fiber optic cables required to communicate to the EGR-5000.

Technical Data and Specifications

Climatic Environmental Conditions

- Storage temperature: –30 °C to +70 °C (–22 °F to +158 °F)
- Operating temperature: –20 °C to +60 °C (–4 °F to +140 °F)
- Permissible humidity at ann. average: <75% rel. (on 56d up to 95% rel.)
- Permissible installation altitude:
  - <2,000 m (6,561.67 ft) above sea level
  - If 4,000 m (13,123.35 ft) altitude applies, a changed classification of the operating and test voltages may be necessary

Degree of Protection EN 60529

- HMI front panel with seal: IP54
- Rear side terminals: IP20

Routine Test

- Insulation test acc. to IEC 60255-5: All tests to be carried out against ground and other input and output circuits
- Aux. voltage supply, digital inputs, current
  - Measuring inputs, signal relay outputs:
    - 2.5 kV (eff.) / 50 Hz
- Voltage measuring inputs: 3.0 kV (eff.) / 50 Hz
- All wire-bound communication interfaces: 1.5 kV DC
- Insulation test acc to IEC60255-5: All tests to be carried out against ground and other input and output circuits

Housing

- Housing B2: height / width 183 mm (7.205 in) / 212.7 mm (8.374 in)
- Housing depth (incl. terminals): 208 mm (8.189 in)
- Material, housing: aluminum extruded section
- Material, front panel: aluminum/foil front
- Mounting position: horizontal (±45° around the X-axis must be permitted)
- Weight: Approx. 4.2 kg (9.259 lb)

Current and Ground Current Measurement

- Nominal currents: 1 A / 5 A
- Max. measuring range:
  - Up to 40 x In (phase currents)
  - Up to 25 x In (ground current standard)
  - Up to 2.5 x In (ground current sensitive)
- Continuous loading capacity: 4 x In / continuously
- Overcurrent proof:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Power consumption:
  - Phase current inputs
    - At In = 1 A S = 0.15 MVA
    - At In = 5 A S = 0.15 MVA
  - Ground current input
    - At In = 1 A S = 0.35 MVA
    - At In = 5 A S = 0.35 MVA
- Frequency range: 50 Hz / 60 Hz ±10%
- Terminals: screw-type terminals with integrated short-circuiters (contacts)
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board´s terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Plug-in Connector with Integrated Short-Circuiter (Conventional Current Inputs)

- Nominal Current: 1 A and 5 A
- Continuous loading capacity: 4 x In / continuously
- Overcurrent withstand:
  - 30 x In / 10 s
  - 100 x In / 1 s
  - 250 x In / 10 ms (1 half-wave)
- Screws: M4, captive type acc. to VDEW
- Connection cross sections:
  - 1 x or 2 x 2.5 mm² (2 x AWG 14) with wire end ferrule
  - 1 x or 2 x 4.0 mm² (2 x AWG 12) with ring cable sleeve or cable sleeve
  - 1 x or 2 x 6 mm² (2 x AWG 10) with ring cable sleeve or cable sleeve
  - The current measuring board´s terminal blocks may be used as with 2 (double) conductors AWG 10,12,14 otherwise with single conductors only

Voltage and Residual Voltage Measurement

- Nominal voltages: 100 V / 110 V / 230 V / 400 V (can be configured)
- Max. measuring range: 2 x nominal voltage
- Continuous loading capacity: 2 x nominal voltage (800 Vac)
- Power consumption:
  - at Vn = 100 V S = 0.1 MVA
  - at Vn = 110 V S = 0.1 MVA
  - at Vn = 230 V S = 0.4 MVA
  - at Vn = 400 V S = 1.0 MVA
- Frequency range: 50 Hz or 60 Hz ±10%
- Terminals: screw-type terminals

Frequency Measurement

- Nominal frequencies: 50 Hz / 60 Hz

Voltage Supply

- Aux. voltage: 24–270 Vdc / 48–230 Vac (–20/+10%)
- Buffer time in case of supply failure:
  - ≥50 ms at minimal aux. voltage
  - Interrupted communication is permitted
- Max. permissible making current:
  - 18 A peak value for <0.25 ms
  - 12 A peak value for <1 ms
- The voltage supply must be protected by a fuse of:
  - 2.5 A time-lag miniature fuse 5 x 20 mm (approx. 0.2 x 0.8 in) according to IEC 60127
  - 3.5 A time-lag miniature fuse 6.3 x 32 mm (approx. 0.25 x 1.25 in) according to UL 248-14

Power Consumption

- Power supply range: 24–270 Vdc
  - Power consumption in idle mode—7 W
  - Maximum power consumption—13 W
- Power supply range: 48–230 Vac (for frequencies of 40–70 Hz)
  - Power consumption in idle mode—7 VA
  - Maximum power consumption—13 VA

Display

- Display type: LCD with LED background illumination
- Resolution—graphics display: 128 x 64 pixel

LED

- LED type: two colored: red/green
- Number of LEDs, Housing B2: 15

Front Interface RS-232

- Baud rates: 115,200 baud
- Handshake: RTS and CTS
- Connection: 9-pole D-Sub plug

Real Time Clock

- Running reserve of the real time clock: 1 year min.

Digital Inputs

- Max. input voltage: 300 Vdc / 259 Vac
- Input current: <4 mA
- Reaction time: <20 ms
- Fallback time: <30 ms

(Safe state of the digital inputs)

- Switching thresholds: Un = 24 Vdc, 48 Vdc, 60 Vdc, 110 Vac / Vdc, 230 Vac / Vdc
  - Un = 24 Vdc
    - Switching threshold 1 ON: Min. 19.2 Vd
    - Switching threshold 1 OFF: Max. 9.6 Vdc
  - Un = 48 V / 60 Vdc
    - Switching threshold 2 ON: Min. 42.6 Vdc
    - Switching threshold 2 OFF: Max. 21.3 Vdc
  - Un = 110 / 120 Vac / Vdc
    - Switching threshold 3 ON: Min. 88.0 Vdc / 88.0 Vac
    - Switching threshold 3 OFF: Max. 44.0 Vdc / 44.0 Vac
  - Un = 230 / 240 Vac / Vdc
    - Switching threshold 4 ON: Min. 184 Vdc / 184 Vac
    - Switching threshold 4 OFF: Max. 92 Vdc / 92 Vac
- Terminals: screw-type terminal

Relay Outputs

- Continuous current: 5 A AC/DC
- Max. make current:
  - 25 A AC / 25 A DC up to 30 V for 4 s
  - 30 A / 230 Vac according to ANSI IEEE Std C37.90-2005
  - 30 A / 250 Vdc according to ANSI IEEE Std C37.90-2005
- Max. breaking current:
  - 5 A AC up to 250 Vac
  - 5 A DC up to 30 V (resistive)
  - 0.3 A DC at 300 V
- Max. switching voltage: 250 Vac / 250 Vdc
- Switching capacity: 1250 VA
- Contact type: Form C or normally open contact
- Terminals: screw-type terminals

Supervision Contact (SC)

- Continuous current: 5 A AC/DC
- Max. switch-on current: 15 A AC / 15 A DC up to 30 V for 4 s
- Max. breaking current:
  - 5 A AC up to 250 Vac
  - 5 A DC up to 30 Vdc
  - 0.4 A at 125 Vdc
- Contact type: 1 Form C contact
- Terminals: screw-type terminals

Time Synchronization IRIG-B00X

- Nominal input voltage: 5 V
- Connection: screw-type terminals (twisted pair)

Zone interlocking

Note: Only for zone interlock tripping outputs (zone interlock, semiconductor output): 5 Vdc, <2 mA for connection to electronic inputs only.

- Zone Out:
  - Output voltage (high) 4.75 to 5.25 Vdc
  - Output voltage (low) 0.0 to +0.5 Vdc
- Zone In:
  - Nominal input voltage +5 Vdc
  - Max. input voltage +5.5 Vdc
  - Switching threshold ON min. 4.0 Vdc
  - Switching threshold OFF max. 1.5 Vdc
  - Galvanic isolation 2.5 kV AC (to ground and other IO)
  - Connection: screw-type terminals (twisted pair)

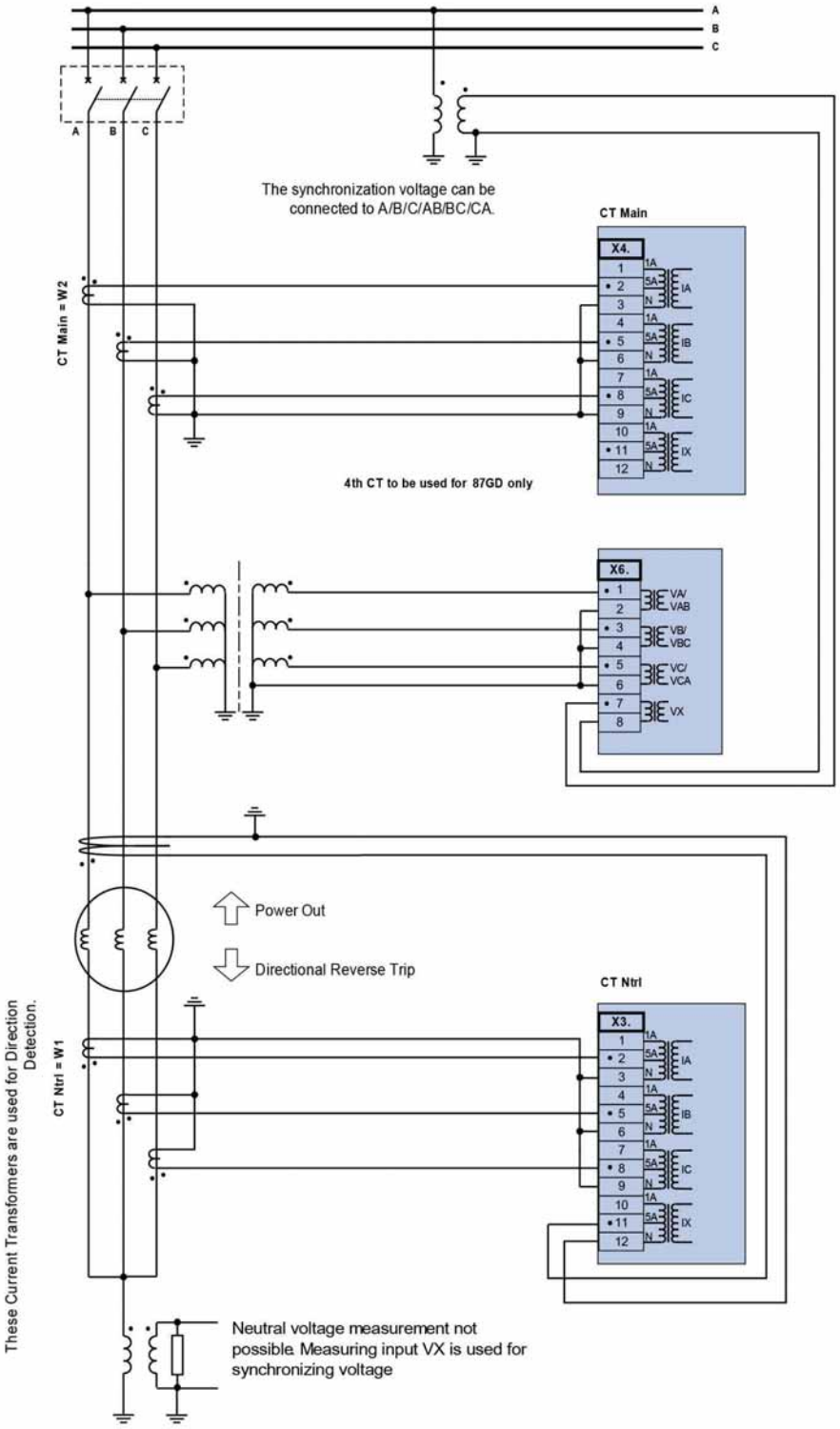
RS-485

- Master/slave: slave
- Connection: six screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)

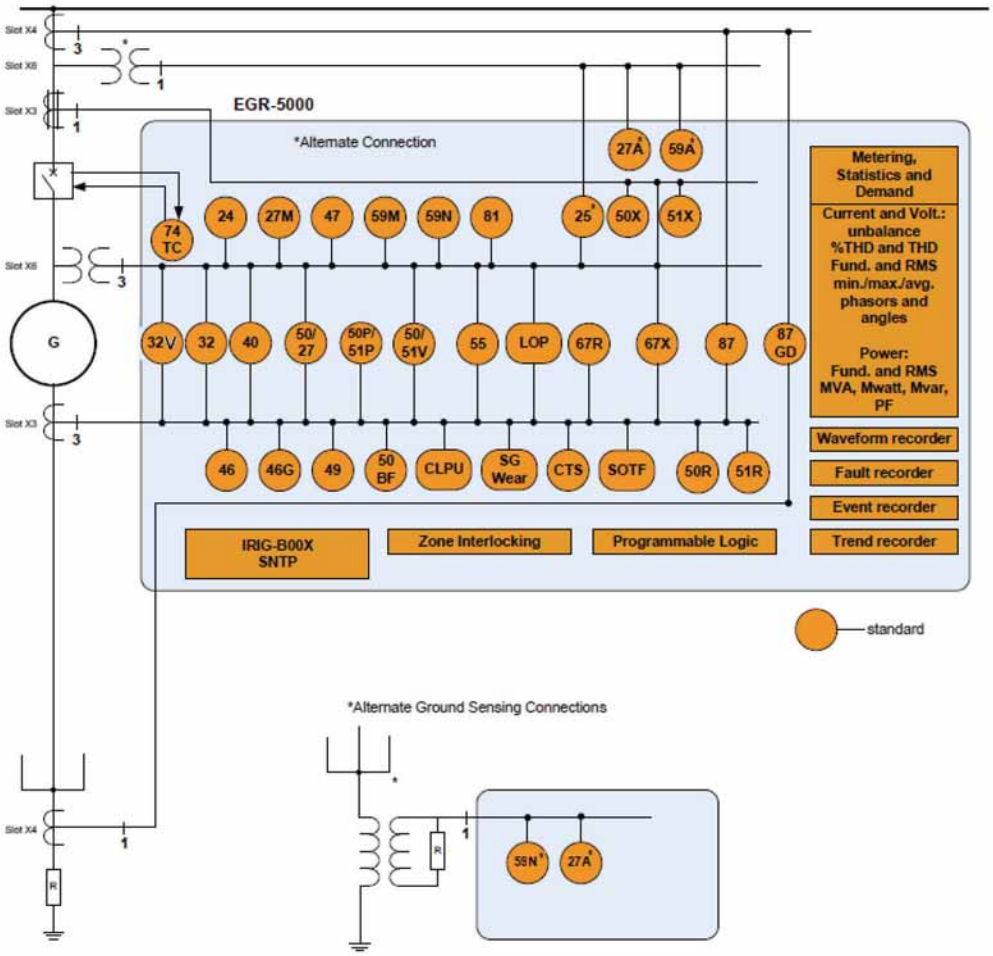
Note: The RS-485 interface is realized via terminals. The communication cable has to be shielded. The shielding has to be fixed at the screw that is marked with the ground symbol (rear side of the device).

Wiring Diagrams

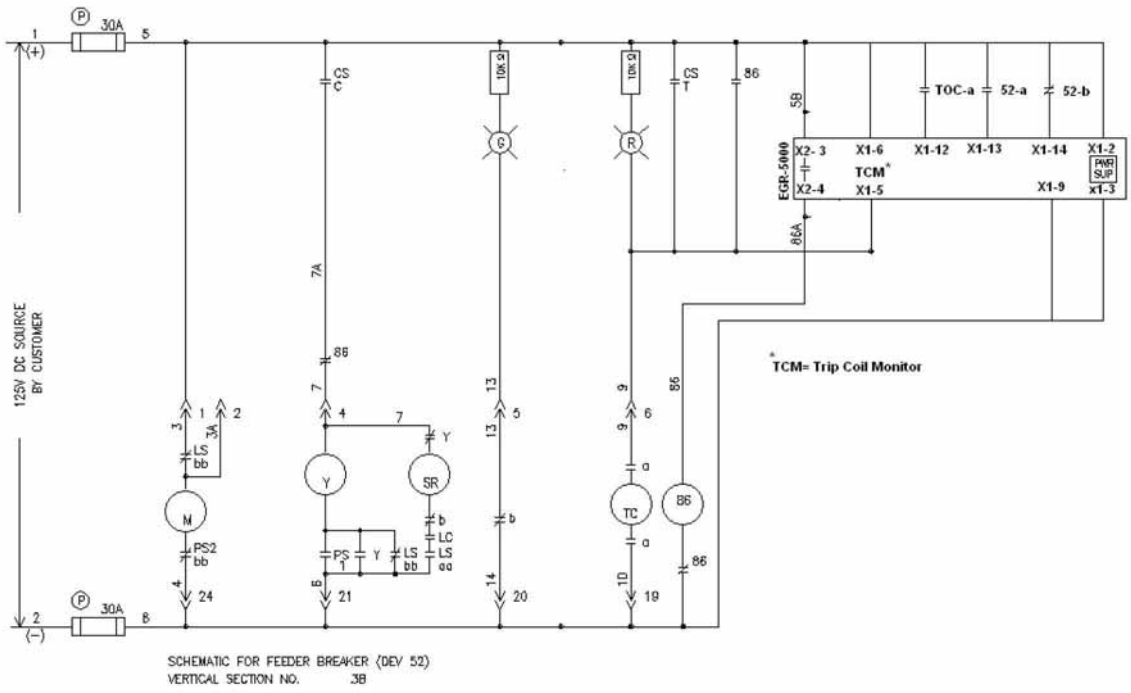
Typical AC Connections—High Impedance Grounded Generator with Phase Differential Protection, Wye VTs, Zero Sequence Ground Protection, and Either Synch-check or 100% Stator Ground Fault Protection



Typical One-Line Diagram



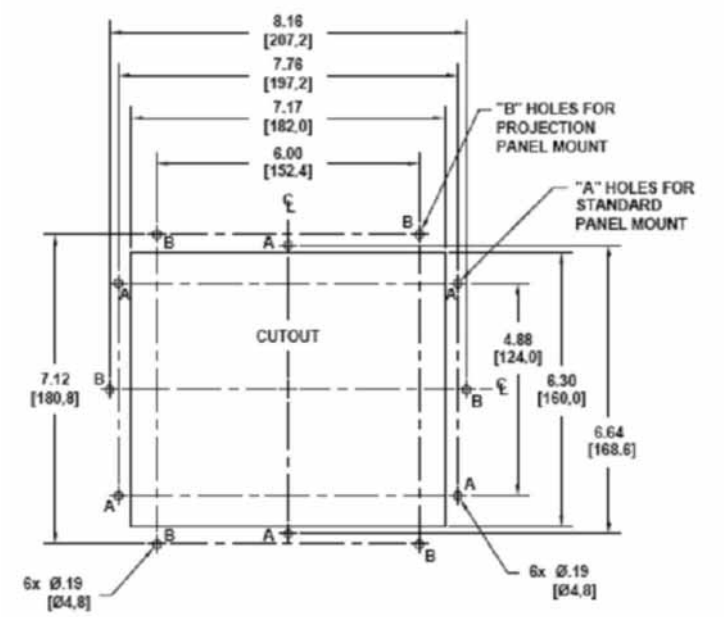
Typical Control Diagram



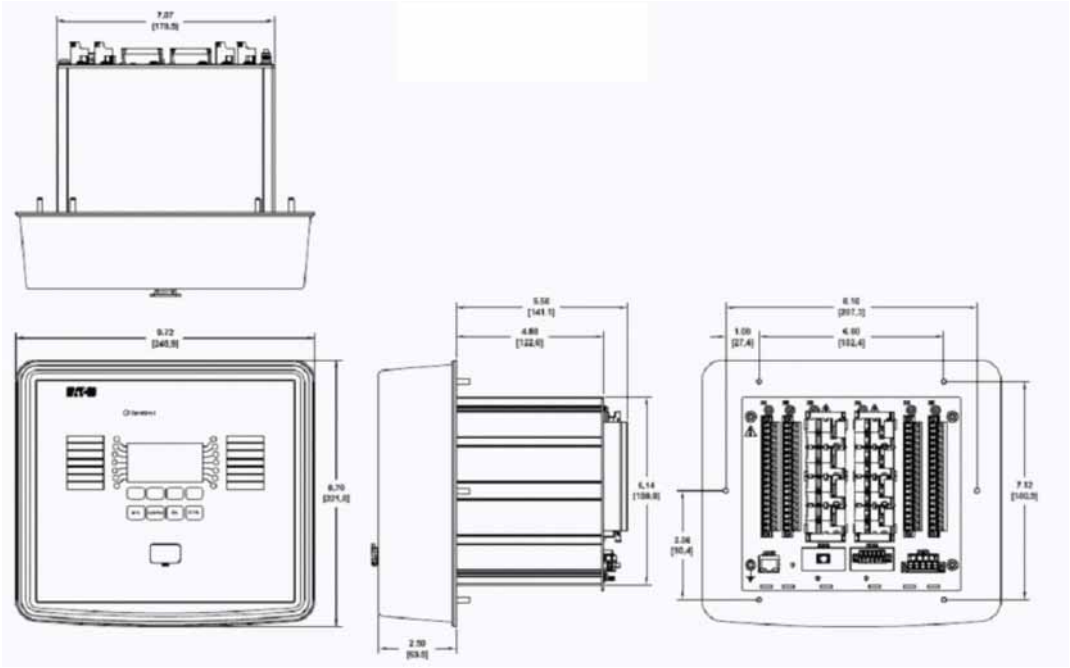
Dimensions

Approximate Dimensions in Inches (mm)

Drilling Plan

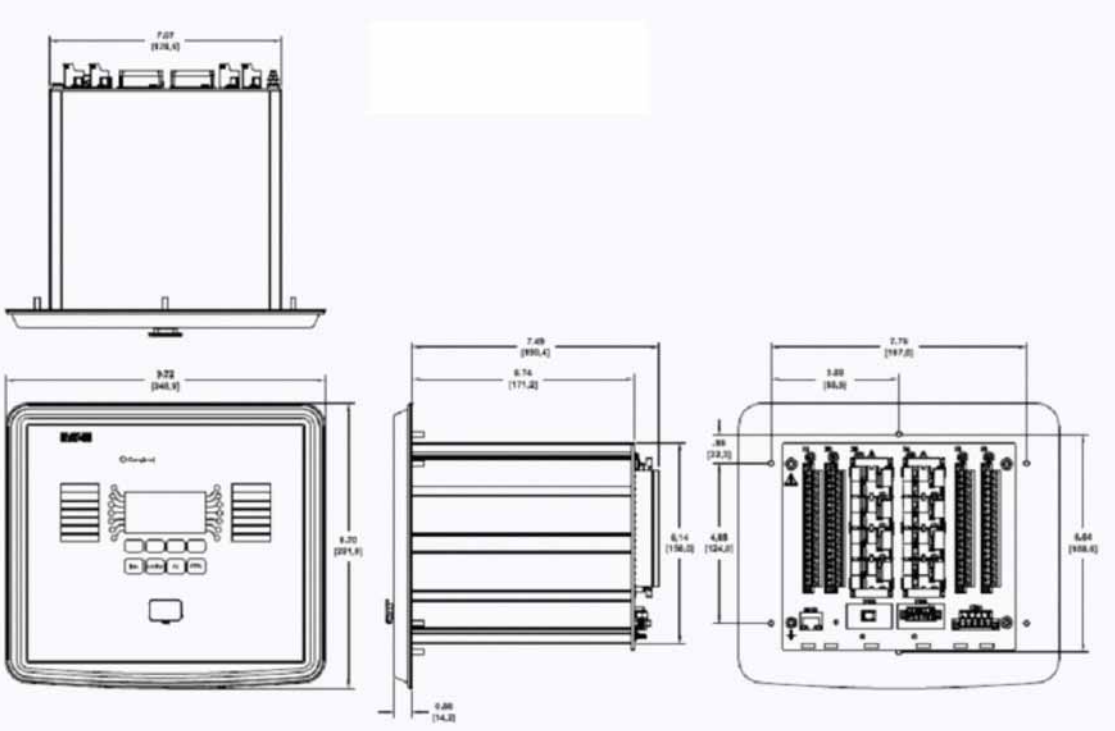


Projection Mount Front and Side Views



Approximate Dimensions in Inches (mm)

Standard Mount Front and Side Views



Ground Fault Relay

Contents

Ground Fault Relay

Product Description

A Type GFR ground fault protection system, when properly installed on a grounded electrical system, will sense phase-to-ground fault currents. When the level of fault current is in excess of the pre-selected current pickup and time delay settings, the GFR relay will initiate a trip action of a disconnect device, which will open the faulted circuit and clear the fault.

The GFR devices are UL Class 1 devices designed to protect electrical equipment against extensive damage from arcing ground faults.

A basic Type GFR ground fault protection system consists of a ground fault relay, a ground fault current sensor and a disconnect device equipped with a shunt trip device. This disconnect device can be a molded case circuit breaker, a power circuit breaker, a bolted pressure switch or other fusible disconnect device, suitable for application with UL Class 1 Ground Fault Sensing and Relaying equipment.

Standards and Certifications

Eaton's GFR ground fault relays, current sensors, test panels and accessory devices are UL listed by Underwriters Laboratories in accordance with their standard for Ground Fault Sensing and Relaying Equipment, UL 1053, under File No. E48381.

Note: Relays are also listed with CSA under File No. 43357.

Listed

Product Selection

Each installation requires:

- One relay unit (select trip ampere as required)
- One current sensor (select configuration required)
- One circuit breaker or disconnect device with shunt trip, or a shunt trip attachment for mounting in existing breaker
- Test panel (optional)

GFR Relay

GFR Relay

GFR Relay Types	Ground Fault Pickup Amperes 1–12 Catalog Number ①	5–60 Catalog Number ①	100–1200 Catalog Number ①
For 120 Volt 50/60 Hz Control			
Electrical reset with zone interlocking	**GFR12EI**	**GFR60EI**	**GFR1200EI**
Electrical reset without zone interlocking	**GFR12E**	**GFR60E**	**GFR1200E**
Mechanical reset with zone interlocking	**GFR12MI**	**GFR60MI**	**GFR1200MI**
Mechanical reset without zone interlocking	**GFR12M**	**GFR60M**	**GFR1200M**
For 120 Vdc Control			
Mechanical reset without zone interlocking	—	—	**GFR1200MD**

Current Sensor

Description—Window Size in Inches (mm)	Catalog Number
Used with Relays Rated 1–12 Amperes	
5.50 (139.7) inside diameter	**1283C45G01**
Used with Relays Rated 5–60 Amperes	
2.50 (63.5) inside diameter	**179C768G01**
5.50 (139.7) inside diameter	**1256C13G01**
7.81 x 11.00 (198.4 x 279.4) rectangular ①	**1257C88G04**
3.31 x 24.94 (84.1 x 760.5) rectangular ①	**1257C92G03**
Used with Relays Rated 100–1200 Amperes	
2.50 (63.5) inside diameter	**179C768G02**
5.50 (139.7) inside diameter	**1256C13G02**
8.25 (209.6) inside diameter	**179C767G02**
7.81 x 11.00 (198.4 x 279.4) rectangular ①	**1257C88G03**
9.94 x 16.94 (252.5 x 430.3) rectangular ①	**1257C90G02**
9.94 x 23.94 (252.5 x 608.1) rectangular ①	**1257C91G02**
15.94 x 19.94 (404.9 x 506.4) rectangular ①	**1257C89G02**
3.31 x 24.94 (84.1 x 633.5) rectangular ①	**1257C92G04**
6.75 x 29.64 (171.5 x 752.9) rectangular ①	**1255C39G03**

Note

① Suitable for either surface or semi-flush mounting.

Options and Accessories

Test Panel (120 Vac)

Used to test the ground fault system, to give an indication the relay has tripped the breaker, and to reset the relay after tripping. These functions may be separately mounted pilot devices.

Note: When a mechanically reset relay is used with a test panel, both the relay and test panel must be reset following either a simulated ground fault test or actual ground fault. Not UL listed.

Ground Fault Warning Indicator

This is an accessory item for use with GFR relays with interlocking circuitry. At approximately 30–50% of the relay pickup setting, the indicator switches separate 120 Vac control power to a lamp or relay (not included) to give an indication of a ground fault. The indicator is rated 110/120 Vac 50/60 Hz for a maximum indicator load of 0.5 amperes.

Indicating Ammeter

The optional indicating ammeter connects to the sensor terminals through a momentary contact pushbutton, and will indicate (in amperes) any ground fault current flowing through the sensor. Kit includes the ammeter and pushbutton.

Not UL listed.

Shunt Trip Attachments

Use 120 Vac shunt trips.

Face Plate

Recommended when these relays are semi-flush mounted, to close the door cutout opening.

Options

Additional optional equipment can be added to the protection system to meet the requirements of the specifying engineer, including:

- Ground fault test panel
- Ground fault warning indicator relay
- Ground fault indicating ammeter

GFR relays are available with zone selective interlocking circuitry to interlock several relays within the same system. This allows the relay, which detects a ground fault, to instantly clear the fault by tripping the disconnect device. The relay simultaneously sends a signal to relay units "upstream" from the fault to time delay or to block their operation completely. Current sensors in various designs provide a range of "window" sizes to accommodate standard bus and cable arrangements.

Shunt trip attachments may be ordered for field mounting in Eaton's molded case circuit breakers, or may be ordered factory installed in the breaker.

Optional Test Panel

Control	Test	Catalog Number
120 volt 50/60 Hz	120 volt 50/60 Hz	**GFRTP**

Ground Fault Warning Indicator

Description	Catalog Number
Manual reset	**1234C67G01**
Self-resetting	**1234C67G02**

Ammeter Kit

GFR System Used with	Kit Catalog Number
1–12 amperes	**752B820G01**
5–60 amperes	**752B820G02**
100–1200 amperes	**752B820G03**

Face Plate

Description	Catalog Number
Face plate	**752B410G01**

Technical Data and Specifications

GFR Relay

- Ground fault detection ranges:
  - 1–12 amperes
  - 5–60 amperes
  - 100–1200 amperes
- Output contacts:
  - 240 Vac, 50/60 Hz: 3 amperes
  - 120 Vac, 50/60 Hz: 6 amperes
  - 28 Vdc: 3 amperes
  - 125 Vdc: 0.5 amperes
- Control power requirements:
  - 120 V, 50/60 Hz: 0.125 amperes, or 125 Vdc (optional)

Current Sensor

- 600 V, 50/60 Hz maximum system voltage

Note

① One end removable for installation.

Instruction Leaflet 15321 available as a PDF at **www.eaton.com**
(Go to Advanced Search and enter 15321).

Universal RTD Module

Contents

9

Universal RTD Module

Product Description

- Electronic Resistance Temperature Detector (RTD) provides motor temperature interface for the MP-3000 Motor Protection Relay
- Monitors up to 11 RTDs consisting of six motor windings, two motor bearings, two load bearings and one auxiliary
- Works with 10 ohm copper, 100 ohm platinum, 100 ohm nickel and 120 ohm nickel type RTDs
- Include fiber optic and electrical communication interfaces to the MP-3000 Motor Protection Relay

Application Description

URTD can be used with MP-3000, MP-4000, EMR-3000, EMR-4000, EMR-5000, ETR-4000, ETR-5000, and EGR-5000.

Eaton's URTD Module is most commonly used to provide motor temperature information to the MP-3000 Motor Protection Relay. The MP-3000 Motor Protection uses this information for monitoring, tripping and alarming. The MP-3000 Intel-I-Trip overload algorithm will adjust its trip characteristics based on the actual motor temperature reported by the URTD Module. This improves the protection by using an actual temperature value instead of the assumed NEMA Standard Ambient Temperature.

The URTD Module may be mounted close to the motor or at the protective relay.

Both electrical and fiber optic interface ports are provided to communicate temperature information to the MP-3000 relay. The electrical interface can transmit information using a three-conductor shielded cable with a maximum cable distance of 500 feet (152 m). The fiber optic link has a maximum distance of 400 feet (122 m).

The URTD Module may be used with the IQ-1000 and IQ-1000 II motor relays. It may also be applied as a standalone temperature monitoring device communicating, for example, transformer temperature information back to a remote computer or PLC. An optional PONI (Product Operated Network Interface) is required for standalone applications.

Features, Benefits and Functions

- Universal design works with any RTD type, simplifying installation and operation and reducing inventory
- Standalone design permits mounting the module close to the motor, reducing RTD wiring costs
- RTD diagnostics detects faulty RTDs and wiring, reducing unnecessary tripping and alarming

Product Selection

Universal RTD Module

Universal RTD Module

Description	Catalog Number
Universal RTD Module	**URTD**
48-240 Vac/48-250 Vdc power supply and Modbus-RTU communications	**URTDII-01**
24-48 Vdc and Modbus-RTU communications	**URRDII-02**

Options and Accessories

Additional Related Products from Eaton's Cutler-Hammer Series

Eaton provides fiber optic cables for connecting to the MP-3000 or IQ-1000 II Motor Protection Relays.

Fiber Optic Cables:

Length	Catalog Number
1	**MPF0-1**
5	**MPF0-5**
10	**MPF0-10**
25	**MPF0-25**
50	**MPF0-50**
75	**MPF0-75**
100	**MPF0-100**

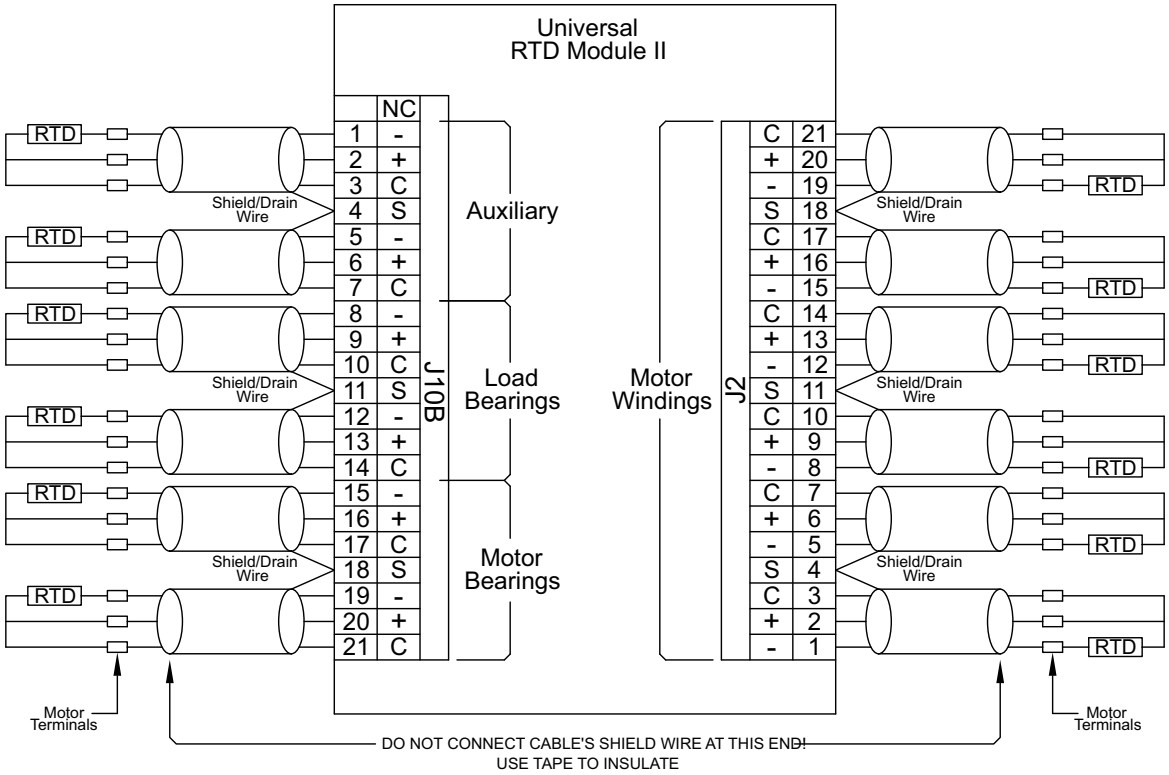
Technical Data and Specifications

Universal RTD Module

Specifications	URTDII-01	URTDII-02
Input power requirements	48–240 Vac / 48–250 Vdc	24–48 Vdc
Frequency	50/60 Hz or DC	DC
Power consumption	3.5 W	1 W
Operating temperature	–20° to +55 °C (–4° to +131 °F)	–20° to +55 °C (–4° to +131 °F)
Storage temperature	–40° to +85 °C (–40° to +185° F)	–40° to +85 °C (–40° to +185 °F)
Humidity	0 to 95% R.H. noncondensing	0 to 95% R.H. noncondensing
Altitude	2000 m	2000 m
Pollution degree	2	2
Installation category	I	I

Wiring Diagram

RTD Wiring (Three-Lead Type)



Note:

1. Each shielded cable conductor must be connected on the URTDII as shown.
2. Use of three-lead RTDs is recommended.
3. RTDs must not be grounded at the motor, and no common connections between RTDs should be made at the motor.
4. A suitable earth ground should be connected to J10B-4, J10B-11, J-10B-18, J2-4, J2-11, or J2-18. It is recommended that a ground connection is made to both sides of the unit.

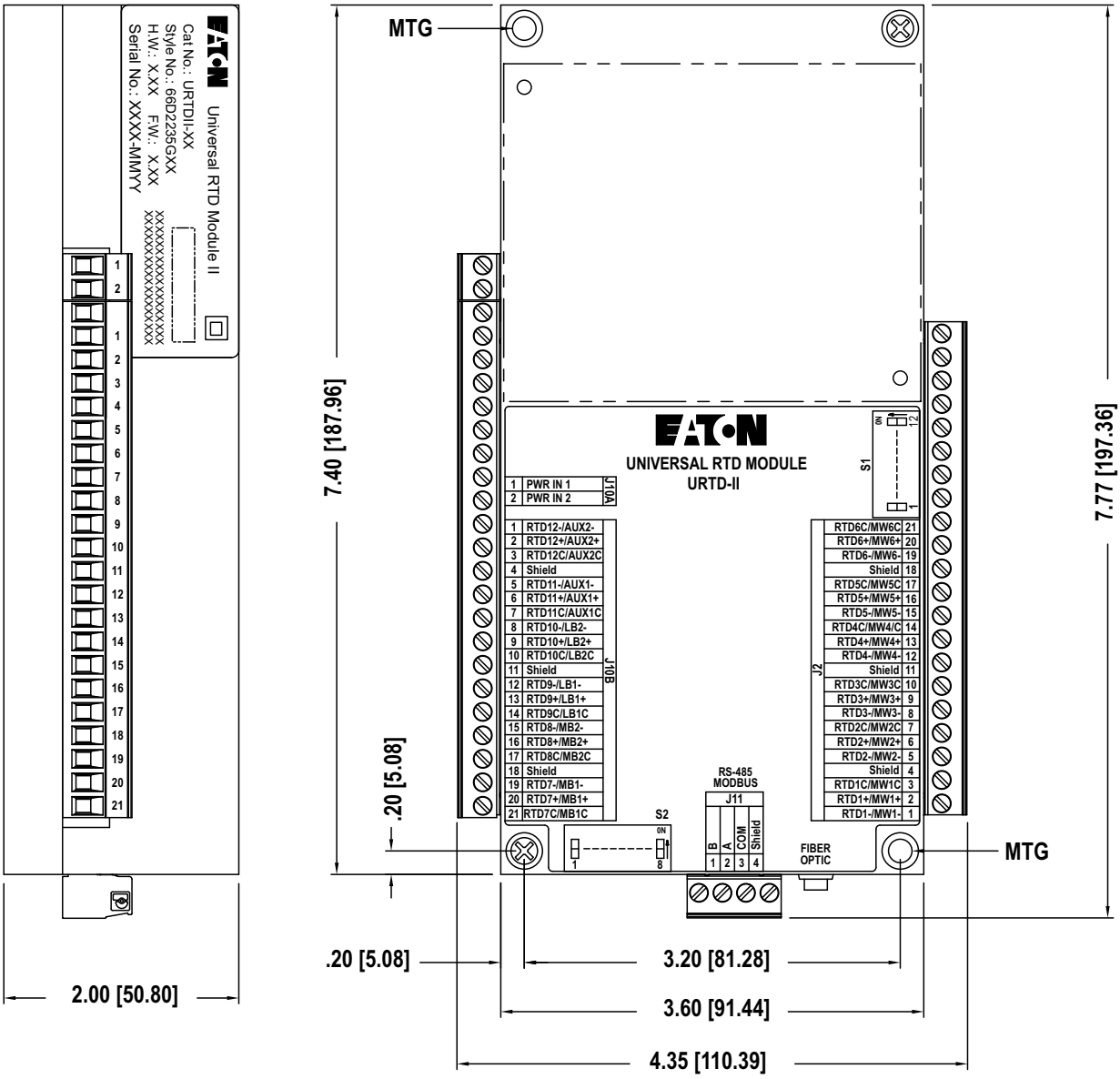
Note

Showing a typical three-lead type RTD wiring connection.

Dimensions

Approximate Dimensions in Inches (mm)

Universal URTD Module



Note

Showing the URTD Module dimensions and terminal designations.

Power Xpert Gateway

Contents

Power Xpert Gateway

Product Overview

- Open communication architecture
  - Connects to both Eaton and third-party electrical equipment; communicates to INCOM™ and Modbus® RTU devices
  - Modbus TCP and BACnet/IP support facilitates integration with third-party monitoring solutions
  - Ethernet/Web-based support uses your existing network infrastructure, reducing costs
- Flexible and expandable solutions
  - Stand-alone or small systems benefit from comprehensive, on-board Web pages; no additional programming or software is necessary for virtually out-of-the-box, plug-and-play functionality
  - Larger systems, such as campus installations or power systems with remote locations can view multiple PXGs via Power Xpert Insight™ or a third-party monitoring system
  - Existing equipment can be connected to the PXG to reap the benefits of Power Xpert Architecture at minimal cost, without the need to upgrade
- Information at a glance
  - Using a standard Web browser, view the PXG's Web interfaces that include a Network tab, Alarms tab, individual device detail pop-outs and One Line graphics tab
  - Comprehensive, well-organized device Web pages present measured parameters such as current, voltage, power, energy, frequency, power factor and voltage THD, just to name a few
  - Combine with Power Xpert Insight for viewing multiple gateways and other power system equipment for more extensive energy monitoring and capacity analysis

Product Description

Through standard on-board Web pages, Power Xpert Insight, or third-party software, Eaton's Power Xpert Gateway (PXG) 900 allows you to closely monitor the performance of your power and energy efficiency with easily accessed, real-time, Web-enabled data. Eaton's PXG 900 provides a central point to connect devices to an Ethernet network. The gateway may be used as a standalone device to view one system or location, or it can be easily integrated into a large, multi-location system.

The PXG is our configurable data acquisition solution for facility equipment like switchgear, switchboards, motor control centers, etc. Power and energy data from the downstream devices are time stamped and stored in non-volatile memory. This interval data can be stored or updated to a destination of the user's choice through CSV. Data can also be accessed through any Web browser directly on the PXG. Users can move data into Power Xpert Insight v. 3.2 or higher, BMS, BAS, building dashboards, custom software applications, or virtually any Web interface.

Application Description

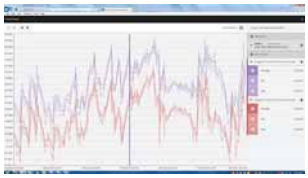
The Power Xpert® Gateway 900 (PXG 900) has been designed to be installed in electrical assemblies or systems—low and medium voltage switchgear, switchboards panelboards, transfer switches, and motor control centers to acquire and consolidate data available from components such as trip units, meters, relays, drives and I/O.

Power Xpert Gateway Screenshots

Network Tab

Device Details

Alarms Tab



Trend Viewer

One-Lines Tab

Product Selection Guide

Data acquisition and Integration Table for Supported Devices

Supported Devices

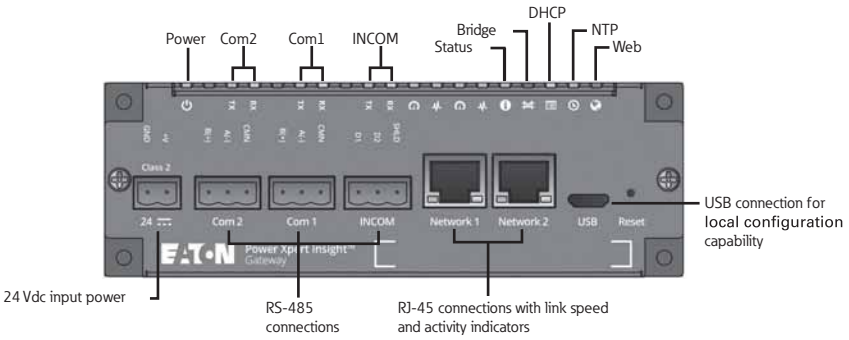
Protocol									
Family	**Model**	**HTTP (Web Browser)**	**Power Xpert Insight**	**Modbus TCP (BMS and SCADA)**	**Pass-through INCOM (PowerNet)**	**SMTP (Email Client)**	**File Export (CSV File Format)**	**File export (COMTRADE File Format)**	**BACnet/IP**
INCOM									
Accessory	BIM II	■	■	■	■	■	■		■
I/O	DIM	■	■	■	■	■	■		■
I/O	DIM-KYZ	■	■	■	■	■	■		■
Meter	IQ 220 / IQ 320	■	■	■	■	■	■		■
Meter	IQ 230 / IQ 330	■	■	■	■	■	■		■
Meter	IQ Analyzer (6000/6200)	■	■	■	■	■	■		■
Meter	IQ Analyzer (6400/6600)	■	■	■	■	■	■	■	■
Meter	IQ Data Plus II	■	■	■	■	■	■		■
Meter	IQ DP-4000	■	■	■	■	■	■		■
Meter	IQ Energy Sentinel	■	■	■	■	■	■		■
Meter	IQ Power Sentinel	■	■	■	■	■	■		■
Meter	IQMESII	■	■	■	■	■	■		■
Meter	PM3	■	■	■	■	■	■		■
Protection	Digitrip 520MC	■	■	■	■	■	■		■
Protection	Digitrip 810	■	■	■	■	■	■		■
Protection	Digitrip 910	■	■	■	■	■	■		■
Protection	Digitrip 1150/DT1150V	■	■	■	■	■	■	■	■
Protection	Digitrip 3000	■	■	■	■	■	■		■
Protection	Digitrip 3200	■	■	■	■	■	■		■
Protection	Digitrip MV	■	■	■	■	■	■		■
Protection	Digitrip OPTIM 550	■	■	■	■	■	■		■
Protection	Digitrip OPTIM 750	■	■	■	■	■	■		■
Protection	Digitrip OPTIM 1050	■	■	■	■	■	■		■
Protection	FP-4000	■	■	■	■	■	■	■	■
Protection	FP-5000	■	■	■	■	■	■	■	■
Protection	FP-6000	■	■	■	■	■	■	■	■
Protection	IQ 500	■	■	■	■	■	■		■
Protection	MP-3000	■	■	■	■	■	■		■
Protection	MP-4000	■	■	■	■	■	■		■
Protection	MPCV Relay	■	■	■	■	■	■		■
Protection	NRX520I	■	■	■	■	■	■		■
Protection	NRX1150I	■	■	■	■	■	■		■
Protection	TC50	■	■	■	■	■	■		■
Protection	TC100	■	■	■	■	■	■		■
Protection	Universal RTD	■	■	■	■	■	■		■
Transfer switch	ATC-400	■	■	■	■	■	■		■
Transfer switch	ATC-600	■	■	■	■	■	■		■
Transfer switch	ATC-800	■	■	■	■	■	■		■

Supported Devices, continued

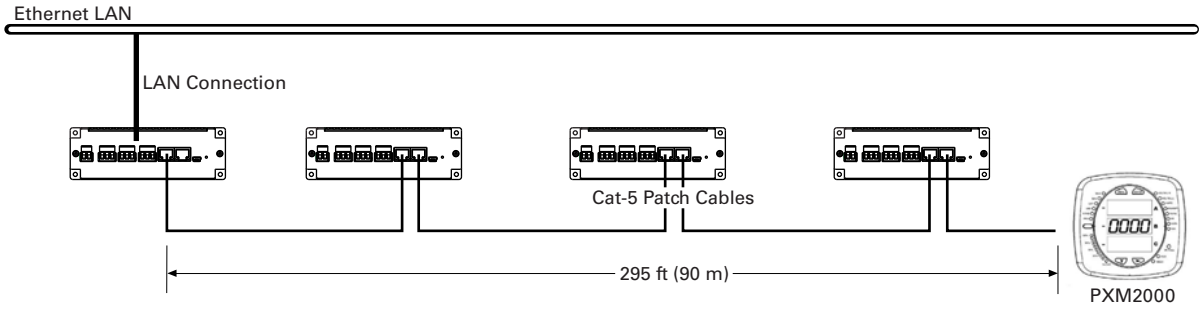
Protocol

Family	Model	HTTP (Web Browser)	Power Xpert Insight	Modbus TCP (BMS and SCADA)	Pass-through INCOM (PowerNet)	SMTP (Email Client)	File Export (CSV File Format)	File export (COMTRADE File Format)	BACnet/IP
Modbus									
Drive	H-Max	■	■	■		■	■		■
Drive	M-Max	■	■	■		■	■		■
Drive	MVX9000	■	■	■		■	■		■
Drive	SVX9000	■	■	■		■	■		■
Meter	E30/E31A042 1 phase BCM	■	■	■		■	■		■
Meter	EM19_M	■	■	■		■	■		■
Meter	ION 7350	■	■	■		■	■		■
Meter	ION 7550	■	■	■		■	■		■
Meter	ION 7650	■	■	■		■	■		■
Meter	IQ 130	■	■	■		■	■		■
Meter	IQ 140	■	■	■		■	■		■
Meter	IQ 150	■	■	■		■	■		■
Meter	IQ 230M / IQ 330M	■	■	■		■	■		■
Meter	IQ 250	■	■	■		■	■		■
Meter	IQ 260	■	■	■		■	■		■
Meter	IQ35MA1	■	■	■		■	■		■
Meter	IQ35MA2	■	■	■		■	■		■
Meter	Nexus 1200 Series	■	■	■		■	■		■
Meter	PM3_Modbus	■	■	■		■	■		■
Meter	SQD CM3000 Series	■	■	■		■	■		■
Meter	SQD CM4000 Series	■	■	■		■	■		■
Meter	SQD PM700 Series	■	■	■		■	■		■
Meter	SQD PM800 Series	■	■	■		■	■		■
Protection	ABB TPU 2000	■	■	■		■	■		■
Protection	C440	■	■	■		■	■		■
Protection	C441	■	■	■		■	■		■
Protection	EDR-3000	■	■	■		■	■		■
Protection	EDR-5000	■	■	■		■	■		■
Protection	EGR-4000	■	■	■		■	■		■
Protection	EGR-5000	■	■	■		■	■		■
Protection	EMR-3000	■	■	■		■	■		■
Protection	EMR-4000	■	■	■		■	■		■
Protection	EMR-5000	■	■	■		■	■		■
Protection	ETR-4000	■	■	■		■	■		■
Protection	ETR-5000	■	■	■		■	■		■
Protection	GE 369 Motor Relay	■	■	■		■	■		■
Protection	GE 469 Motor Relay	■	■	■		■	■		■
Protection	InsulGard	■	■	■		■	■		■
Protection	NRX520M	■	■	■		■	■		■
Protection	NRX1150M	■	■	■		■	■		■
Protection	Qualitrol 118	■	■	■		■	■		■
Starter	S611	■	■	■		■	■		■
Starter	S811	■	■	■		■	■		■
Transfer switch	ATC-300	■	■	■		■	■		■
Transfer switch	ATC-900	■	■	■		■	■		■

Power Xpert Gateway 900



PXG Daisy Chain Application



Note: In this configuration, if any of the PXG units go offline or lose power, the communication to the downstream Ethernet devices will lose connection to the LAN.

Standards and Certifications

- UL® 508, Standard for Programmable Controller Equipment
- FCC, Class A, Part 15, Subpart B, Sections 15.107b and 15.109b
- EN55022: 1994 Class A, Information Technology Equipment
- EN 61000-6-2:2001 Electromagnetic Compatibility (EMC) Party 6-2: Immunity for Industrial Environments

Listed

Product Selection

PXG Part Numbers

	Description	Style Number	Catalog Number
PXG900 	Power Xpert Gateway 900	66D2325G01	**PXG900**
PXG900-2A 	Enclosed version Cost-effective solution to add communications to new or existing equipment that has no physical space to install the PXG in the equipment structure. NEMA 12 enclosure rating. Prewired with a PSG60N24RP power supply and terminal blocks for ease of wiring of incoming power and connected devices.	—	**PXG900-2A**
	Power supply—24 Vdc	PSG60N24RP-A1	**PSG60N24RP**

Technical Data and Specifications

PXG part numbers

Description	Style Number	Catalog Number
Power Xpert Gateway 900	**66D2325G01**	**PXG900**
Power supply—24 Vdc	**PSG60N24RP-A1**	**PSG60N24RP**

Memory
- Flash: 2 GB
- RAM: 1 GB

Communication Ports
- Network ports: Two 10/100Base-T RJ-45 connectors
- Serial ports
  - Two RS-485 ports for connection to Modbus RTU devices
  - One dedicated RS-485 port for INCOM devices
- Configuration port: One USB port

Network Protocols Supported
- Modbus TCP/IP: Supports data access from Modbus TCP clients
- Web server: Supports data access from Web browsers (HTTP and HTTPS)
- DHCP: Supports automatic IP address assignments, if enabled
- NTP: Supports time synchronization via a network time server for PXG synchronization
- SMTP: Supports mail server for email notification
- BACnet/IP: Supports data access from BACnet clients

Serial Protocols Supported
- INCOM
- Modbus RTU

Web Browsers Recommended
- Internet Explorer versions 10 and 11
- Google Chrome

Power Input
- Input voltage, nominal: 24 Vdc; 0.3 A minimum
- Input voltage range: ±10% nominal

Power Consumption
- 8 W maximum

Operating Temperature
- 32 to 140 °F (0 to 60 °C)

Ambient Storage Temperature
- –40 to +185 °F (–40 to +85 °C)

Relative Humidity
- 5 to 95% noncondensing at 122 °F (50 °C)

Size (H x D x L) in Inches
- 2.00 x 4.50 x 6.00

Weight
- 1.7 pounds

Supported Devices and Performance

PXG performance will vary depending upon the number and type of connected devices. This is driven by the following:
- Each supported device has a distinct number of channels to report back to the PXG, ranging from as few as 4 to over 900
- The channels are prioritized
- Device protocol, Modbus or INCOM
- Baud rate setting

For this reason, a PXG performance tool has been developed to assist in understanding the expected performance for a given application since all systems are unique. This tool can be found at www.eaton.com/pxg. For a high level performance comparison, see the table below for three examples.

	For This Combination of Devices (All Times in Seconds)		
How Long Does It Take	**64 INCOM / 32 Modbus**	**15 INCOM / 15 Modbus**	**5 INCOM**
Between value change in the UI (INCOM 9600)—Priority 1	21.9	3.7	1.4
Between value change in the UI (Modbus 57600)—Priority 1	3.5	1.6	—
Between value change in the UI (INCOM 9600)—Priority 2	44.3	7.4	2.6
Between value change in the UI (Modbus 57600)—Priority 2	7.0	3.1	—
Modbus server pass-through response time (57600) (local connection)	0.061	0.059	—
For the UI to show an alarm (INCOM device)	17.0	3.0	3.0
To boot up (all devices communicating)	399.0	85.0	51.0

Note: Features and specifications listed in this document are subject to change without notice and represent the maximum capabilities of the product with all options installed. Although every attempt has been made to ensure the accuracy of information contained within, Eaton makes no representation about the completeness, correctness, or accuracy and assumes no responsibility for any errors or omissions. Features and functionality may vary depending on selected options.

General Wiring Guidelines—RS-485 Network

When communicating over RS-485 networks to Eaton products, the following General Wiring Guidelines should be used.

Rule 1: Cable Selection—Twisted Shielded Pair (TSP)

Note: Cables specifically designed for RS-485 applications are highly recommended.

The RS-485 bus is a length of Twisted Shielded Pair (TSP) that includes a third conductor (used for the common wire), a braided shield accompanied by a drain wire, and nominal impedance of 120 ohms.

- Belden Wire and Cable Company Part Number 3106A or equivalent

Rule 2: Cable Intermixing

Any cable in the Belden 3106A family can be intermixed with each other in the Modbus network.

Rule 3: System Topology, Size and Capacity

- Strict daisy chain must be adhered to. A strict daisy chain configuration is one where the transmission line connects from one RS-485 receiver to the next. The transmission line appears as one continuous line to the RS-485 driver
- Maximum 32 devices
- Line termination: Maximum cable lengths of 4000 feet (1219m); longer bus lengths will slow the data rate

Rule 4: Cable Splicing

The prime goal is to create a secure electrical connection while minimizing exposure to electrical transients. Ferrules are used to dress cable ends. Most devices have built-in terminal blocks that can be used for splicing. Additionally, terminal blocks should be utilized when splicing elsewhere in the gear or facility to ensure a secure electrical connection.

Rule 5: Cable Shielding

The cable shielding and outer jacket should not be stripped back beyond 1-1/2 inches. Three-pole terminal blocks are used to ensure a continuous metallic shield ground path. To ensure a secure electrical connection when daisy chaining devices that have built-in two-pole terminal blocks, mechanically crimp sleeves onto the two shield path drain wires.

Rule 6: Cable Grounding

Ground the communication network at only one point in the network, preferably by terminating the drain wire to ground at the EOL node (same location as the EOLR). A solid earth ground is accomplished by connecting the shield ground path's drain wire to a #14 AWG or larger multi-stranded wire that has an impedance path of 1 ohm or less to a known earth ground.

Note: The building electrical ground may not be effective since it may travel through many connections and considerable distances before reaching earth ground. In such cases, a new ground path will be required since the effectiveness of this shield earth ground connection will affect the integrity of data transferred over the cable.

Rule 7: Cable Termination

End of Line Resistors (EOLR) are necessary to maintain signal strength and minimize reflections. EOLR must match the impedance of the TSP. Two EOLR are needed and should be located at both ends of the RS-485 bus. If there is only one device connected to the Modbus master, it is considered the last device in the network and should be terminated with a 120 ohm 1/4 watt terminating resistor.

Rule 8: Device Addressing

- Each device must have a unique slave address
- No two devices on the same RS-485 network can have the same slave address

Ethernet Cable Specifications

For complete specifications, refer to the IEEE 802.3 Ethernet specification.

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RS-485 Wiring Guide—Three Terminal Devices

Device Name	A (– Wire)	B (+ Wire)	Common Wire	XCVR Common ①	Data Bias
IQ 230M	12 (MOD2)	11 (MOD1)	10 (INCOM 3)	I 26V	None
IQ 250	(–) Older Models are Marked B (–)	(+) Older Models are Marked A (–) or A(+)	SH	I	None
IQ 260	(–) Older Models are Marked B (–)	(+) Older Models are Marked A (–) or A (+)	SH	I	None
IQ 330M	12 (MOD2)	11 (MOD1)	10 (INCOM 3)	I 26V	None
NETLINK	1 (DATA–)	2 (DATA+)	5 (GND)	E	None
InsulGard ②	B	A	None	Floating	None
Bushing Gard ② (InsulGard G3 ②)	B	A	None	Floating	None
Power Xpert Meter 4000/6000/8000	Data A 750B-S	Data B 750B-S	Shield (COM)	I 300V	750 Ohm Switch Sel
Power Xpert Gateway 400//600	A(–)	B(+)	COM	I	—

Notes

① Transceiver (XCVR) Common Connected to:
I = Isolated
NI = Non Isolated
E = Earth Ground

② Center terminal on InsulGard (marked with Ground symbol) is for shield splicing only and is electrically floating.

INCOM Network

INCOM was specifically designed with the intention of delivering a comprehensive and powerful energy management solution for use in electrical distribution environments while ensuring affordability, flexibility, simplicity and noise immunity. An INCOM network installed per the following rules will allow the user to fully realize all of the above advantages. (Refer to Eaton document TD17513 for specific system layout recommendations and details.)

Rule 1: Cable Selection—Twisted Shielded Pair

Approved cable types:

- Any of the cables in the Belden 9463 family
- Quabbin 6205
- CommScope 9022
- Manhattan Electric M4154
- IMPCABLE—a 600V rated cable custom designed for INCOM—Style # 2A95705G01

Rule 2: Cable Intermixing

Due to impedance differences between IMPCABLE and the Belden 9463 family, the main cable run(s) should be entirely for the 9463 family OR IMPCABLE: do not alternate between these types. The cable used for taps can be different from the main run.

Rule 3: System Topology, Size and Capacity

Supports daisy chain, star and multi-level network segment topologies.

Note: Star Segment Topology is not recommended for new designs.

See **Page V3-T9-269**. Surge protection is required for FSK networks that leave a building at the egress/ingress of the building.

- Supports distances up to 10,000 ft (3048m) per segment when designed within the specifications of this guideline
- Supports up to 1000 devices on a single network segment
- Supports sub-network master devices and associated sub-networks
- Supports 1200 or 9600 baud rate
- Attenuation:
  - Total system capacity: 25 dB
  - Attenuation per device: 0.01 dB
  - Attenuation for approved wire types, see tables below

Cable Attenuation

Cable Type	Attenuation/ 1000 Feet (305m)
IMPCABLE	1.6 dB
Belden 9463 family	2.0 dB

Attenuation at Star

Number of Long Lines	Attenuation
3	3.5 dB
4	6 dB
5	8 dB

- Definitions:
  - **Daisy chain**: point-to-point wiring between devices or clusters of devices
  - **Star:** single point with a number of long lines emanating from it
  - **Long line**: >200-foot (61m) wire run
  - **Simple tap**: <200-foot (61m) connection to cluster of devices

Rule 4: Cable Splicing

The goal is to create a secure electrical connection while minimizing exposure to electrical transients. Ferrules are used to dress cable ends in order to avoid problems associated with frayed and loose wires. Besides facilitating cable installation, subsequent data line troubleshooting and downtime are minimized. Most INCOM devices have built-in three-pole terminal blocks for data lines and shield. For older INCOM devices that have only two terminals, shield continuity must be ensured by other means. Additional terminal strips should be utilized when splicing elsewhere in the electrical enclosure or facility to ensure secure electrical connections. All devices, End of Line Termination Resistors and Taps should be wired in parallel across the cable.

Rule 5: Cable Shielding

The cable shielding and outer jacket should not be stripped back beyond 1.5 inches (38 mm). Terminal blocks are used at tap points to ensure a continuous metallic shield ground path. To ensure a secure electrical connection when daisy-chaining INCOM devices that have built-in two-pole terminal blocks, use crimp sleeves to join the two shield drain wires. The cable shield ground path for a main network and sub-network must not be joined. Each should have a separate connection to earth ground reference.

Rule 6: Cable Grounding

The shield should be continuous across a network segment and connected to the building's electrical system grounding electrode conductor. The 2005 NEC provides the following guidance on grounding communication cables:

1. When a communication cable enters a building, a primary protector is required and must be grounded as described in Section 800 IV. Specifically, Paragraphs 800.93 and 800.100 define grounding requirements for the primary protector.
2. Grounding systems are generally covered by Section 250 III. The grounding electrode conductor is specifically covered by Paragraphs 250.62, 250.64, 250.66, 250.68 and 250.70.
3. Bonding requirements between communication systems and the power distribution system is specified by Paragraph 250.94.

A solid earth ground is accomplished by connecting the shield ground path's drain wire to a #14 AWG or larger multi-stranded wire that has an impedance path of 1 ohm or less to the building's grounding electrode conductor.

Rule 7: Cable Termination

Each network segment requires a minimum of two End of Line Termination Resistors (EOLTRs). The EOLTRs maintain signal strength and minimize reflections. The EOLTRs should be 1/2 watt 100 ohm non-inductive resistors, such as carbon composition or metal film. Wire-wound resistors are not acceptable. Taps on network segments should not be terminated. Some INCOM devices have the EOLTR permanently installed and must be located at the end of a main run. Other INCOM devices have an EOLTR that can be switched to optionally terminate the network segment at the device. Care must be exercised when installing devices containing termination resistors that the switches are set appropriately. A minimum of two, up to a maximum of five EOLTRs must be installed on each network segment as dictated by network topology.

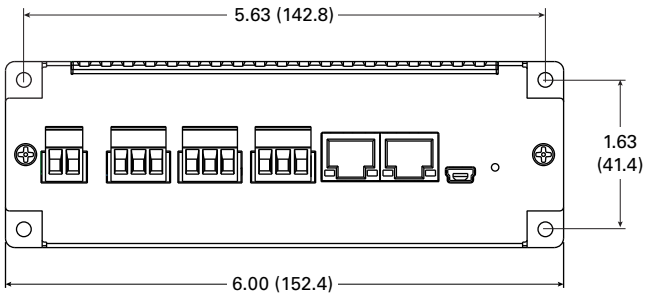
Rule 8: Device Address

In order to avoid the possibility of devices in a Main Network having the same addresses as those in Subnetworks, set Main Network device addresses at 100 or higher excluding addresses 901 to 908.

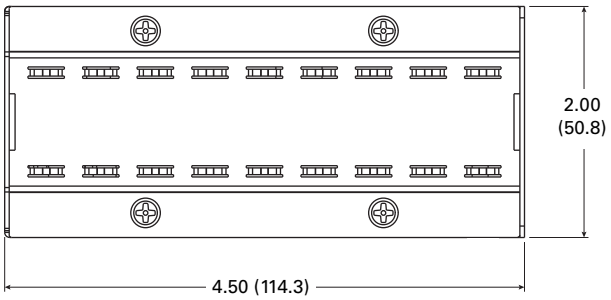
Dimensions

Approximate Dimensions in Inches (mm)

Power Xpert Gateway 900 with Standard Panel Mounting (Brackets Included)

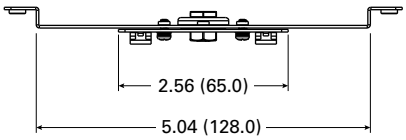


Front View

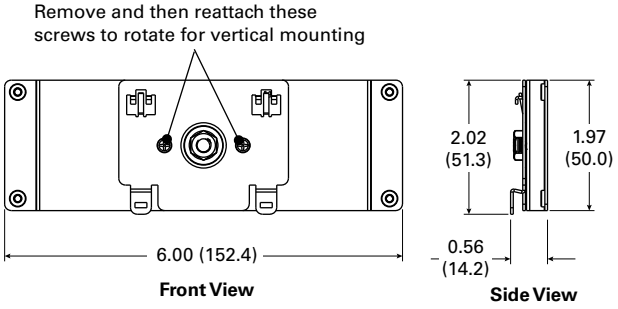


Side View

Power Xpert Gateway 900 with DIN Rail Mounting



Top View



Front View **Side View**

Power Xpert Gateway 900

Width	Height	Depth	Shipping Weight Lbs (kg)
6.00 (152.4)	2.00 (50.8)	4.50 (114.3)	1.70 (0.8)

9

Power Xpert Ethernet Switches

Convenient Network Expansion

Contents

9

Power Xpert Ethernet Switches

Product Description

Eaton's Power Xpert Ethernet Switches are ideal for extending Ethernet networks via CAT5 wiring or fiber in harsh, industrial environments. Built with high-grade components and constructed using special thermal techniques, PXE Switches can withstand the unpredictable conditions of such environments.

Features

- Simultaneous, full-duplex, high-speed communication on all ports—no network performance bottlenecks
- Hardened for factory floor—ideal for both industrial or data center applications
- Unmanaged, plug-and-play implementation—no software or additional hardware required for configuration
- Seamlessly integrates into Eaton's Power Xpert Architecture—quality and reliability of Eaton guaranteed
- Mounting options include standalone panel-mounting, DIN rail mounting, or 19-inch standard rack mounting

PXES 6-Port Switch—10/100 Mb with Optional 100 Mb Fiber

This compact switch provides six Ethernet ports, with flexible configurations. The base models have one of three options:

- Two 100 Mb fiber and four 10/100 copper ports
- One fiber and five copper ports
- Six copper ports

PXES 4-Port Switch—10/100 Mb

For smaller applications requiring fewer connection points and no fiber, the 4-port Power Xpert Ethernet Switch is a versatile option. It provides edge access Ethernet ports in a convenient and compact package.

Standards and Certifications

- UL Listed (UL 60950)
- cUL
- CE
- Emissions meet FCC Part 15, Class A

Product Selection

Ethernet Switch

Power Xpert Ethernet Switches

Description	Catalog Number
4-port Ethernet switch—copper only	**PXES4P24V**
6-port Ethernet switch—copper only	**PXES6P24V**
6-port Ethernet switch—5 copper/1 fiber (ST connector)	**PXES6P24V1ST**
6-port Ethernet switch—4 copper/2 fiber (ST connector)	**PXES6P24V2ST**

Accessories

Ethernet Switch

Power Xpert Ethernet Switches

Description	Catalog Number
Power supply (preferred)—100–240 Vac input DIN rail mount with screw—24 Vdc output terminals	**ELC-PS02**
Power supply (alternate)—120 Vac input Wall plug-in type with 6 ft cord—12 Vdc output	**PXESPS12V**
DIN rail mounting bracket	**PXESDINRL**
19-inch rack mount tray	**PXESTRAY**

Technical Data and Specifications

Operating Environment

Description	Specifications
Ambient temperature ratings	–25°C to 60°C long-term per independent agency tests (UL), or –40°C to 85°C short-term per IEC type tests
Storage temperature	–40° to 185°F (–40°C to 85°C)
Cold start	to –20°C
Ambient relative humidity	5%–95% (noncondensing)
Altitude	–200 to 50,000 ft (–60 to 15,000m)
MTBF	> 15 years

Network Standards

Description
Ethernet IEEE 802.3, IEEE 802.3u; IEEE 802.1p, 100Base-TX, 10Base-T, 100Base-FX

Power Consumption

Description
7.0 watts typical—9 watts maximum

Packaging

Description	Specifications
Enclosure	Robust sheet metal (steel)
Cooling method	Case used as a heat sink

Mounting

Description	Specifications
Metal panel mounting clips	Included
DIN rail mounting	Optional
19-inch rack mount	Optional

Copper Ethernet Cable Wiring Guidelines

The following information can be used as a guide when designing an Ethernet system using Copper Ethernet Cable.

- Cables should not be routed near equipment that generates strong electric or magnetic fields such as motors, drive controllers, arc welders and conduit
- Ethernet cable insulation has a voltage rating of 300 Vac. Use of barriers, cable trays or high voltage sheathing with STP Ethernet cable may be required in installations with cables carrying voltages greater than 300 Vac. This may also be necessary in order to comply with UL requirements. In installations where the cable cannot be physically separated from the power cables (where a physical barrier is not practical) fiber optic cable should be used
- When crossing power conductors with Ethernet cable, cross at right angles
- Shielded Twisted Pair (STP) Ethernet cable should be specified for use in high noise environments. Shielded shrouded connectors must be used and the shield must be connected at both ends of the wire. The mating plug must have a shielded shroud that is terminated to ground at both ends. Where there is a possibility of a difference in ground potential (common mode) voltages between the two terminated ends, fiber optic cable is recommended
- When using conduit or a metal cable tray, each section of the conduit or tray must be bonded to each adjacent section and the conduit or tray needs to be bonded to earth ground. Do not allow the shields to touch the conduit or metal tray at any point
- Only shielded (STP) Ethernet cables should be placed into metal conduit. Some UTP cables may not function properly when installed in conduit, as the metal conduit can affect the electrical properties of an unshielded cable. Consult the cable manufacturer when installing UTP cables in conduit
- As a general rule for noise protection, Ethernet Cable should maintain a minimum distance of 3 inches (8 cm) from electric power conductors for up to 100 volts and 1 inch (3 cm) for each additional 100 volts up to 400 volts. STP cable is recommended
- For Ethernet cable run within conduit, but near conductors with potentially noisy power conductors carrying currents of greater than 20A or voltages greater than 400V, maintain the following distances. STP cable is required.
  - Conductors of less than 20A = 3 inches
  - Conductors of 20A or more and up to 100 kVA = 6 inches
  - Conductors greater than 100 kVA = 12 inches
- For Ethernet cable run near conductors with potentially noisy power conductors carrying currents of greater than 20A or voltages greater than 400V, maintain the following distances. STP cable is recommended
  - Conductors of less than 20A = 6 inches
  - Conductors of 20A or more and up to 100 kVA = 12 inches
  - Conductors greater than 100 kVA = 24 inches
- Route Ethernet cable at least 5 feet (1.5m) from sources of rf/microwave radiation. STP cable is required
- Do not cascade more than four Ethernet repeaters (router, switch or hub) within a network segment
- Environmentally sealed connectors should be specified for cables used in outdoor installations
- Avoid pinching the cable when using cable ties
- Total distance between an Ethernet Transmitter and Receiver at the end points of the network should not exceed 328 feet (100m)
- Total distance from a patch panel to a wall jack (using solid cable) shall not exceed 295 feet (90m). Splices are not permitted
- Patch cords used as cross-connect jumpers in a patch panel should not exceed 20 feet (6m)
- Patch cords from a wall jack to the work area PC (or device) shall not exceed 16 feet (5m)
- Ethernet cable used in harsh environments must be selected to withstand the following conditions: vibration, air born contaminants, chemicals, temperature, electromagnetic interference, combustible atmospheres and local regulatory standards such as UL and NEMA
- Ethernet connectors used in harsh environments must be robust enough to withstand vibration, multiple connection cycles, temperature changes, and provide a proper seal to protect against moisture, dust/dirt and chemical attack
- Different cable media support different bandwidth capabilities. When installing cable in a network, care should be taken to install the cable that will fill current network loading requirements and future expansion needs. In general, fiber optic cable can support the greatest bandwidth (upward of 25,000 gigabits) and UTP has the lowest. CAT5e cabling is designed to operate a bit rates up to 1000 Mb and CAT6 cable up to 2000 Mb
- Operating your cable at maximum speed reduces the distance between network segments. Check with your cable supplier for specifications regarding segment distance vs. speed
- Cable with 5% impedance mismatch or return loss of 27 to 32 dB is recommended. Ethernet cable impedance can vary by as much as 15% (85 to 115 ohms). Average Ethernet cable with 15% impedance variation can have up to 10 dB additional return loss. This discontinuity is referred to as return loss, since it causes some of the signal to be reflected back down the cable instead of propagating forward. It is measured in decibels or ratio of transmitted versus reflected signal

Fiber Optic Technology

The use of fiber optics in telecommunications and wide area networking has been common for many years, but more recently fiber optics have become increasingly prevalent in industrial data communications systems as well. High data rate capabilities, noise rejection and electrical isolation are just a few of the important characteristics that make fiber optic technology ideal for use in industrial and commercial systems.

Although often used for point-to-point connections, fiber optic links are being used to extend the distance limitations of RS-232, RS-422/485 and Ethernet systems while ensuring high data rates and minimizing electrical interference.

Conventional electrical data signals are converted into a modulated light beam, introduced into the fiber and transported via a very small diameter glass or plastic fiber to a receiver that converts the light back into electrical signals.

Optical fibers allow data signals to propagate through them by ensuring that the light signal enters the fiber at an angle greater than the critical angle of the interface between two types of glass. Optical fiber is actually made up of three parts. The center core is composed of very pure glass. Core dimensions are usually in the range of 50 to 125 um for multi-mode cables and 8-9 um for single-mode cables. The surrounding glass, called cladding, is a slightly less pure glass. The diameter of the core and cladding together is in the range of 125 to 440 um.

Surrounding the cladding is a protective layer of flexible silicone called the sheath.

Fiber Optic Cable Wiring Guidelines

The following information can be used as a guide when designing an Ethernet system using Fiber Optic Ethernet Cable:

- Select a fiber cable that is suited for the application, e.g., outdoor, aerial, duct, intra-building, risers, general building and plenum applications
- Fiber optic cable is useful in applications where the environment is combustible, electrically noisy, the cable must be bundles with high voltage wires or where common mode voltages may exist between the earth ground points of the terminating connectors
- Fiber optic cable is available in various operating temperature ranges. Care should be taken to match the temperature rating of the fiber to the environment it will be exposed to. The temperature specification for fiber may be narrower than copper cable. Consult the cable manufacturer for temperature specifications of your cable type
- Sealed fiber connectors are available for use in harsh environments to prevent contamination from entering the connector and fiber. The type of seal required will be application dependant and can vary from dust- and moisture-proof to water-tight
- Mixing fiber cable types is not permitted. The same core dimensions and mode must be used within cable segments
- Care should be taken when purchasing connectors to include strain relief, which reduces mechanical strain (vibration) within the cable, as well as the connector. Strain relief also provides support to the cable to ensure proper bend radius at the connector
- Single-Mode Fiber is used for long distance transmission of up to 120 km. Distance may vary depending on speed and type of converter used
- Multi-Mode Graded-Index Fiber Cable is used for communication over shorter distances of up to 2 km
- Fiber cable is composed of glass and is not well suited for applications requiring tight bend radiuses. Cable radius dimensions vary per manufacturer. If the manufacturer does not provide a bend radius, a typical rule of thumb is a radius not less than 15x the cable diameter
- Fiber cable to connector terminations can be performed in the field using special equipment. This method is not recommended
  - Tier One testing is recommended when diagnosing system irregularities and should be performed in all new installations
  - Tier Two testing is recommended to certify that a system complies with standards set forth by the owner/installer

Dimensions

Packaging

Description	Specifications
Dimensions of PXES4P series	3.5 in H x 3.0 in W x 1.0 in D (8.9 cm x 7.6 cm x 2.5 cm)
Weight of PXES4P series	8.6 oz. (243g)
Dimensions of PXES6P series	3.6 in H x 3.0 in W x 1.7 in D (9.2 cm x 7.6 cm x 4.3 cm)
Weight of PXES6P series	13 oz. (370g)

mMINT Module

Contents

mMINT

Product Description

The mMINT (Modbus Master INCOM Network Translator) Module is an Eaton accessory product that provides communication between a Modbus RTU network and an INCOM (INdustrial COMmunications) network (see **Page V3-T9-275**). This module is transparent to the Modbus network. It communicates to a master on the Modbus network using the Modbus RTU (Remote Terminal Unit) protocol. It communicates to slave devices on the INCOM network using the IMPACC (Integrated Monitoring, Protection, And Control Communication) protocol.

Features

The mMINT module is a slave device on the Modbus network and as such requires a master that will exchange register objects with the mMINT module.

- Handles generic pass-through commands (Modbus/INCOM/Modbus)
- Capable of passing Modbus register objects from Eaton's existing products and newer PnP (Plug-n-Play) products to a Modbus RTU master
- Data in IEEE Floating Point format and fixed point
- Modbus RTU communications data transfer rates of 1200, 9600 or 19,200 baud with one start bit, eight data bits, no parity, and either one or two stop bits
- Up to 32 products connected to INCOM network port (246 unique addresses maximum)
- Flashing Status LED to indicate an active module
- LED indicators for INCOM transmit and receive communications exchanges
- LED indicators for Modbus RS-485 transmit and receive communications exchanges
- Input power for the module from either 120 Vac or 24 to 125 Vdc
- DIN rail mount package
- 0°C to 60°C ambient operation

Standards and Certifications

- UL
- CSA
- CE mark

Listed

Product Selection

The catalog number of this product is mMINT.

Technical Data and Specifications

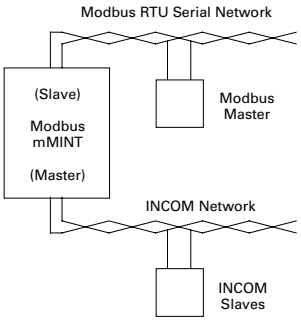
Module Mounting

When mounting the mMINT, verify that an 11 mm H x 28 mm W DIN rail is used and that it is within an enclosed space.

Simplified Wiring Rules

INCOM Network

The following simplified rules apply to a given system consisting of a single daisy-chained main cable link between master and slave devices (see below). For more complex considerations including star configurations, please refer to the IMPACC wiring specification T.D. 17513.



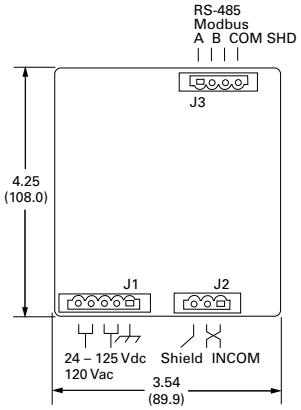
mMINT in a Communications Network

- Recommended INCOM cable styles are Belden 9463 or C-H style 2A957805G01
- The maximum system capacity is 10,000 feet of communications cable and 32 slave devices on the INCOM network under the mMINT
- Non-terminated taps, up to 200 feet in length, off the main link are permitted, but add to the total cable length
- Make sure that there is twisted-pair wire that is recommended for IMPACC network use. Use shielded twisted-pair wire to connect each slave to the INCOM network, daisy-chain style. The polarity of the twisted pair is not important

Modbus RS-485 Network

The following simplified rules apply to a given system consisting of a cable link between master and slave devices (see below). For more complex configurations, please refer to standard Modbus RTU wiring specification rules for the RS-485 network.

- The recommended Modbus cable has twisted-pair wires (24 AWG stranded 7x32 conductors with PVC insulation) having an aluminum/mylar foil shield with drain wire
- The maximum system capacity is 4000 feet of communications cable and 247 devices on the Modbus RTU network
- Make sure that there is twisted-pair wire that is recommended for Modbus RTU network use. Use shielded twisted-pair wire to connect each slave to the Modbus RTU network, daisy-chain style. The polarity of the twisted pair is critically important



mMINT Module Dimensions

Burden

- 24 Vac/dc 3 VA

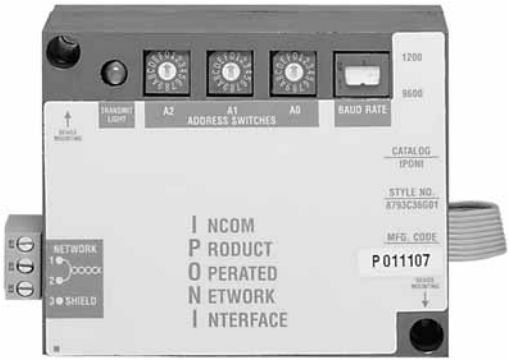
Communications Speed

- INCOM: 1200, 9600 baud
- N2 Bus: 9600 baud

Note: Contact Eaton for availability and support for the N2 Gateway.

9

IPONI Communication Module



Contents

IPONI

Product Selection Guide

IPONI Selection Chart

Description	IPONI	INCOM on Product	MPONI
IQ Analyzer	■	—	■
IQ DP-4000	■	—	■
IQ 200	—	■	—
IQ Multipoint Energy Submeter II	—	■	—
Energy Sentinel	—	■	—
Power Sentinel	—	■	—
IQ Generator	■	—	—
IQ Data	■	—	—
IQ Data Plus II	—	—	—
IQ 500	—	—	—
IQ Transfer	■	—	—
AEMII	■	—	—
BIM II	■	—	—
CMU	■	—	—
CED	■	—	—
MP-3000	■	—	■
Digitrip 3000	—	■	—
FP-5000	—	■	—

Product Description

The INCOM Product Operated Network Interface card, or IPONI card, adds communication capability to various Eaton products. Each IPONI has three 16-digit address switches to uniquely identify each device on the network. IPONIs are designed to be daisy-chained throughout a unit substation or equipment room to a master device such as a mMINT, MINTII or Power Xpert Gateway. From the master computer, information is distributed through the facility's TCP/IP Ethernet network. A twisted shielded pair network connecting IPONIs may extend up to 10,000 feet (3048m) before terminating a master device. The IPONI comes with mounting hardware and attaches to the back of its associated device.

Technical Data and Specifications

Temperature

- –20°C to 70°C

Humidity

- 5%–95% noncondensing

Power

- 20–30 Vdc maximum, 50 mA nominal, 100 mA maximum

Speed

- 1200 and 9600 baud

Communications

- Three-position removable terminal block for twisted shielded pair INCOM

Product Selection

IPONI Card

PONI Communication Modules

Description	Catalog Number
INCOM PONI	**IPONI**

Contents

DPONI

Product Description

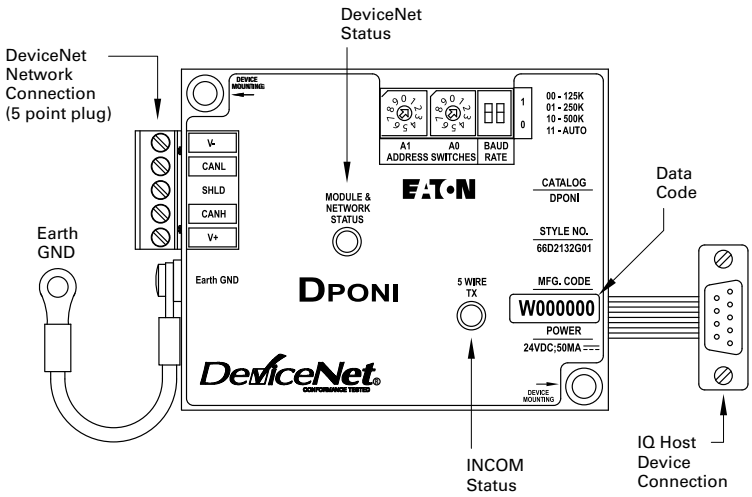
The DeviceNet Product Operated Network Interface (DPONI) enables communication between a DeviceNet network master station and a host device in a Master/Slave format over a DeviceNet network. The DPONI is compatible with the MP-3000 and the MP-4000. The DPONI is powered both by the host product to which it is attached and by the DeviceNet network. The DPONI uses opto-couplers to isolate the two power systems.

The DPONI communicates at 125, 250 or 500 Kbps selected via a front panel DIP switch. All products on the DeviceNet network must be set at the same communication rate.

The DPONI has a bi-color network/module status LED that functions in accordance with the DeviceNet specification. An additional monocolor LED flashes while the DPONI is receiving a message from the host device.

Features

Eaton's DPONI



Product Selection

DPONI

Description	Catalog Number
The DeviceNet Product Operated Network Interface	**DPONI**

Technical Data and Specifications

Temperature
- –20°C to 70°C

Humidity
- 5%–90% noncondensing

Power
- 11–27 Vdc, 40 mA maximum

Speed
- 125, 250 or 500 Kbps

Communications
- Standard five-wire CAN connection

Contents

MPONI

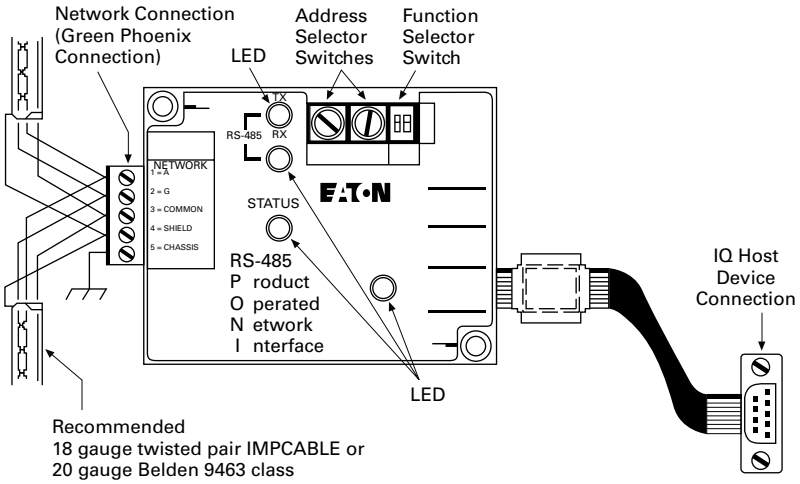
Product Description

The MPONI Product Operated Network Interface card, or MPONI card, enables Modbus communication capability to various Eaton products. Each MPONI contains two rotary address switches to uniquely identify each device on the network and a baud rate DIP switch. A 5-pin connector is provided for wiring to the RS-485 network. Various baud rates are available for networking flexibility, and onboard LEDs indicate operation, error and communication status. The MPONI is applied where a device network exists connected by a dedicated shielded twisted pair conductor. Modbus RS-485 allows a single device or multiple units in a daisy-chain configuration to communicate with another local or remote device and may extend up to 4000 feet (1219m) without a repeater. The MPONI comes with mounting hardware and attaches to the back of its associated device.

Note: Please see IL for detailed register support information for each supported product. Not all device functionality is supported with the RS-485 PONI over the Modbus Protocol.

Features

MPONI



Product Selection

MPONI

Description	Catalog Number
Modbus Product Operated Network Interface Card	**MPONI**

Digital Input Module (DIM)

Contents

9

I/O Devices Digital Input Module (DIM)

Product Description

Eaton's Digital Input Module is a device that interfaces with up to four standard utility (electric, gas, water) meters or monitors eight digital inputs. It translates KYZ pulses from meters into a register count that is maintained and compiled within the DIM module in non-volatile memory. The pulse count can be accessed from the DIM module remotely using Eaton Power Management Software, including the Energy Billing application.

The DIM can also be used to monitor eight digital inputs from switch closures.

Features, Benefits and Functions

- Reads four separate KYZ equipped utility meters
- Pulse counts stored in non-volatile memory
- Each channel independently monitors KYZ counts, pulse counts, or digital indications
- Monitors a maximum of eight individual digital inputs
- Input channels are isolated
- Isolated 24 Vdc power is provided on the I/O connector
- LED indicators on the input channels indicate when the unit is counting
- 10 LED status indicators, 100 ohm termination DIP switch, address selector switches
- DIN rail mounting

Standards and Certifications

- UL 873
- CE mark (48 Vdc operation)
- FCC Part 15, Class A
- IEC 1000-4-x
- CISPR 22, Class A
- IEC 1000-4-2; 1995, Electro Static Discharge
- IEC 1000-4-3; 1995, Radiated RF Immunity
- IEC 1000-4-6; 1996, Conducted RF Immunity
- FCC Part 15 Class A (10 meters) Radiated Emissions
- CISPR 22, Class A (30 meters); 1991, Radiated Emissions
- CISPR 22, Class A; 1991, Conducted Emissions (PowerPort)

Product Selection

DIM

Ordering Information

Description	Catalog Number
Digital Input Module	**DIM**

Technical Data and Specifications

Specifications

Description	Rating
Operating temperature	–20°C to 60°C
Storage temperature	–20°C to 70°C
Operating Humidity	5 to 90% maximum noncondensing
Altitude	10,000 ft. (3048m)
Environment	Indoor use only
Transient overvoltage	Category 2
Pollution	1°
Equipment	Class 1

Frequency Range

- 50/60 Hz

Power

- 85 to 138 Vac (120 Vac nominal) 50/60 Hz; 100 mA
- 48–128 Vdc (48 Vdc nominal); 100 mA
- Brownout operation at 50% and 80% of nominal AC and DC ratings
- Power input is provided from a limited source, isolated from the mains by double isolation
- Power for all inputs is supplied from an internal, isolated 24 Vdc power source

Mounting Information

The DIM module is designed to be DIN rail mountable. DIN rail must be 1/3 inches H x 1-3/8 inches W (8.5 mm H x 34.9 mm W).

Communications

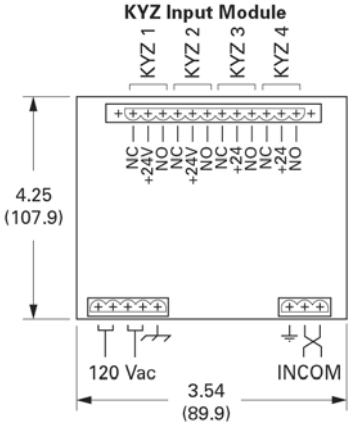
The DIM is a fully compatible Power Management Software communicating device with built-in INCOM communications. The DIM comes complete with a 3-pin connector to receive the shielded twisted pair conductor.

All wiring must be complete as per Instruction Leaflet TD17513, Wiring Specification Base Rules.

Dimensions

Approximate Dimensions in Inches (mm)

KYZ Input Module



KYZ Input Module

Width	Height	Depth
3.54 (89.9)	4.25 (107.9)	3.50 (88.9) ①

Note

① Does include DIN rail.

Addressable Relay II

Contents

Addressable Relay II

Product Description

The Addressable Relay II is designed for use where information or control of non-communicating devices is required remotely. The relays communicate at 9600/1200 baud on the INCOM network. Devices are assigned a three-digit address to uniquely identify them on the daisy-chained twisted shielded pair network.

The Addressable Relay II is a Form C relay on terminals 1, 2 and 3, with output contact ratings as shown in the Contact Ratings table. The Addressable Relay II may be powered by 48–120 Vac or 48–125 Vdc through terminals 11 and 12 of the terminal block. DC polarity is not significant.

Application Description

- Enables remote control of non-communication capable devices on Eaton's PowerNet system
- Monitors two digital status inputs on the PowerNet system

Features, Benefits and Functions

Each Addressable Relay II includes two status indicating circuits (IN1 and IN2) that can be used to transmit the contact status of devices external to the Addressable Relay II. Each input is isolated with its own return. A typical installation using these report-back inputs to the Eaton PowerNet system is shown in the wiring example. Terminals 4 and 5 connect to the status input 1 circuit (IN1) and terminals 6 and 7 connect to the status input 2 circuit (IN2). These status indicating circuits operate with input voltages of 48–120 Vac or 48–125 Vdc circuits.

The Addressable Relay II includes a feature called the "communications watchdog." The communications watchdog monitors communications between the Addressable Relay II and the computer control station. If communications are lost, the communications watchdog will reset the relay to the de-energized (OFF) state. The Addressable Relay II must be updated every 10 seconds when the communications watchdog is enabled or else communications are assumed to be lost. The communications watchdog is enabled when DIP switch 3 is set to the ON position. When the communications watchdog is not enabled, the relay will remain in the state set by the last command issued. **See V3-T9-286** for DIP switch configuration.

Monitored Parameters

- Output relay energized/de-energized
- Input 1 status
- Input 2 status
- Breaker status open/closed
- Protective relay status normal/tripped

Communications

- Built-in INCOM communications for monitoring in Eaton's PowerNet system

The Addressable Relay II also includes a feature called "relay pulse." The relay pulse feature sets the Addressable Relay II to a pulse mode where the relay is energized (ON) for 10 seconds and then is de-energized (OFF). The relay pulse is enabled when DIP switch 2 is set to the ON position and disabled when DIP switch 2 is set to the OFF position. If this feature is not enabled, the relay will remain in the state set by the last command.

Product Selection

Addressable Relay II

Addressable Relay

Description	Catalog Number
Addressable Relay II	**ARII**

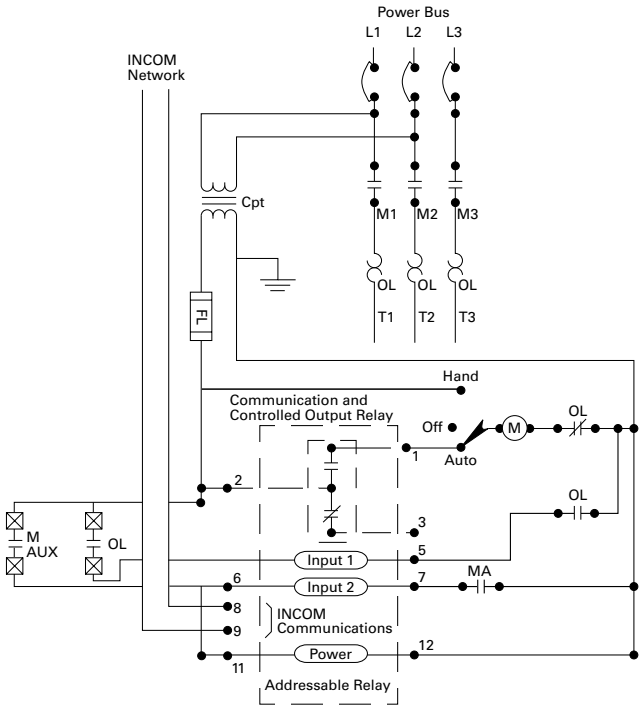
Technical Data and Specifications

- Power: 48–120 Vac; 48–125 Vdc
- Operating temperature range: 32°–158°F (0°–70°C)

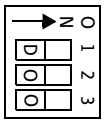
Contact Ratings

Contact Ratings	Make	Break
120–240 Vac	4960 VA	828 VA
24–120 Vac	43A	7.2A
30 Vdc	10A	10A

Wiring Diagram



DIP Switch Functions

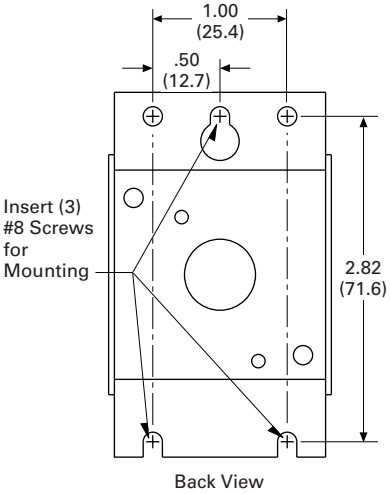


	OFF	ON
Baud Rate	9600	1200
Relay Pulse	Disabled	Enabled
Communications Watchdog	Disabled	Enabled

Dimensions

Approximate Dimensions in Inches (mm)

Mounting



Addressable Relay

Width	Height	Depth
1.75 (44.5)	3.00 (76.2)	4.00 (101.6)

Breaker Interface Module II (BIM II)

Contents

Breaker Interface Module II (BIM II)

Product Description

Eaton's Breaker Interface Module is a panel-mounted device that displays the following parameters.

- Phase current
- Energy
- Present demand watts
- Peak demand watts
- Average demand current
- Cause and magnitude of trip
- Trip history
- % Total Harmonic Distortion (THD) for each phase
- % Harmonic Content for each phase (1st–27th harmonic)
- Custom circuit description

Note: The Breaker Interface Module displays only a portion of the information it receives from the Digitrip RMS 910, 1150 and Power Sentinels. The balance of the information (such as Waveform Analysis and Power Factor) can be passed through the unit to a master computer, where it can be viewed.

Application Description

- 810, 910, 750, 1050, 550, 1150, 520MC, IQ Energy Sentinels and Power Sentinels
- Event logging
- Alarming
- High load indication
- Peak exceeded alarm
- Grouping of meters

An operator can use the Breaker Interface Module to:

- Complete Initial System Setup:
  - Select system frequency (50/60 Hz)
  - Set password
- Configure OPTIM Protective Settings.
  - Select protection options
  - Select alarm levels
- Display Information:
  - Metered values
  - Trip event information
  - Breaker information
  - Time-current set points
- Test OPTIM Trip Unit Performance:
  - Phase and ground
  - Trip/no trip
- Expanded Energy Monitoring:
  - Set addresses for group energy monitoring
  - Group energy readings
- Local and Remote Indication:
  - Remote indication/ alarming
  - Breaker status LED indication
- Expanded Communications:
  - Communicate with:
    - OPTIM Trip Units
    - Digitrip RMS 810, 910 and 1150 Trip Units
    - IQ Energy Sentinels and Universal IQ Energy Sentinels
    - A total of 50 devices

Features, Benefits and Functions

- Monitors and displays parameters from any combination of Digitrip RMS 810, 910, 1150 and Digitrip OPTIM Trip Units, F-/J-/K-Frame Energy Sentinels, and Universal Energy Sentinels, supporting as many as 50 of these devices up to 10,000 feet (3048m) away
- Communicates the information from these protective and energy monitoring devices over Eaton INCOM network to a computer or PLC
- Continuously monitors breakers recording and time-stamping trip events along with approximate fault currents. Events are logged into non-volatile RAM

Physical Characteristics

- Graphical, glass plasma display
- Up to seven lines of information
- Membrane faceplate NEMA 3R and 12 rated

Communications

Depending upon the type of communication protocol used by the main network, an appropriate PONI module can be easily field-mounted to the back of the Breaker Interface Module, enabling the unit to pass the information from its subnetwork to a remote master control unit up to 10,000 feet (3048m) away. No reprogramming of the unit is required when the PONI is added.

The Breaker Interface Module can be mounted directly on the assembly or at a remote location and can be used to access and configure and display information from OPTIM Trip Units.

Password Protection

A user-defined password is included for added security when changing settings or performing breaker tests.

Non-Volatile Memory

The programmed functions, addresses and circuit descriptions are stored in non-volatile memory.

External Power

A 24 Vdc supply is required for the BIM II. (No external power supply is required for the PONI Card.) A 120 or 240 Vac supply is required for the BIMPS.

Rear Access Area

All wiring connections to the Breaker Interface Module are made at the chassis' rear and include:

- Relay connection for "alarm" condition, "high load" condition, "peak exceed" for device or group, and watthour pulse
- Initiator
- 24 Vdc input—BIM II
- 120 or 240 Vac input—BIMPS
- DIP switches for selecting an operating mode
- Three-contact connector with subnetwork
- Connector for PONI card for remote communications Local Display Units

Product Selection

Breaker Interface Module II (BIM II)

Breaker Interface Module

Description	Catalog Number
Breaker Interface Module	**BIMII**
	BIMPSII

Technical Data and Specifications

Power Requirement

- 15 VA maximum

Input Voltage

- 24 Vdc ±5%—BIM II
- 120 or 240 Vac ±10%—BIMPS

Operating Temperature

- 0°C to 70°C (32°C to 158°F)

Humidity

- 5% to 95% R.H. (noncondensing)

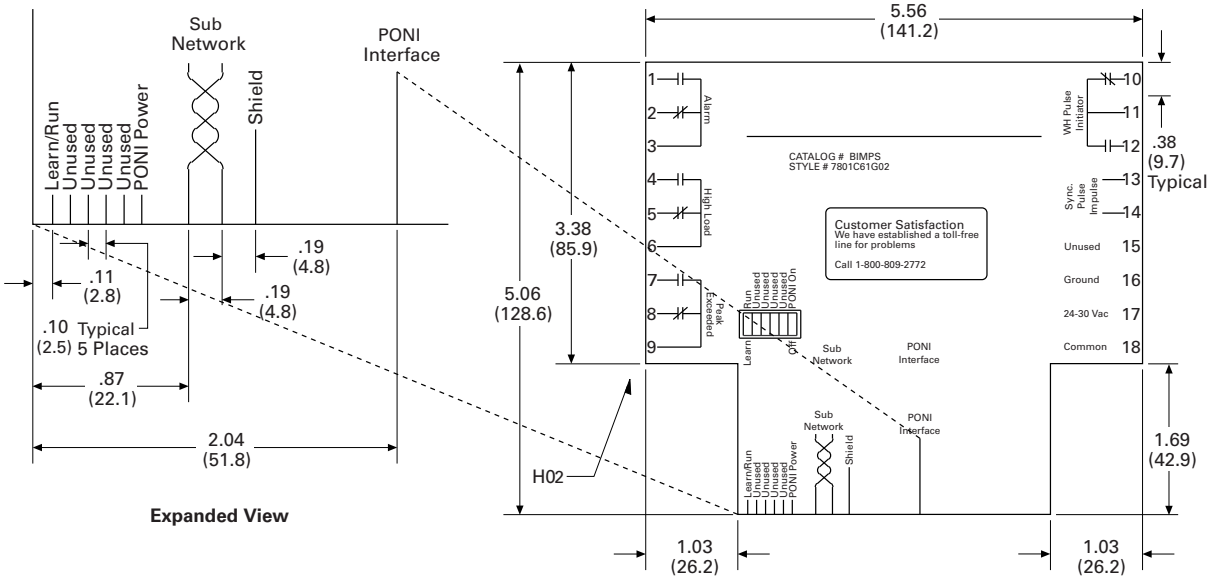
Alarm Contact Ratings

- 10A at 277 Vac (resistive)
- 10A at 30 Vdc (resistive)
- 1/3 hp at 125, 250 Vac

Dimensions

Approximate Dimensions in Inches (mm)

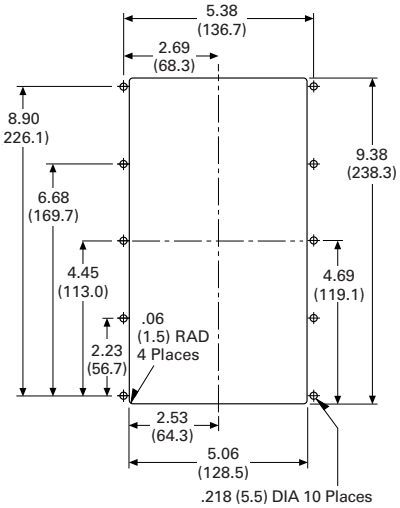
Connections and DIP Switch Rear Label Diagram



Breaker Interface Module

Height	Width	Depth
Without Communications Card		
6.72 (170.7)	10.25 (260.4)	2.60 (66.0)
With Communications Card		
6.72 (170.7)	10.25 (260.4)	3.85 (97.8)

Drilling Pattern



Power System Studies, Field Services and Conversions

Full Service Providers

10.1 Power System Studies, Field Services and Conversions

Overview of Services

Experienced Professional Engineers

Contents

10

Overview

Eaton's Electrical Services & Systems (EESS) provides intelligent PowerChain™ solutions for existing, evolving, unexpected service needs. The solutions can improve electrical system reliability, reduce downtime, extend the useful life of the power distribution system, and minimize electrical operating and maintenance costs.

General Description

This organization supports consultants and end-users on new construction, integrated engineering solutions and facility expansion projects.

EESS can package a complete power distribution system with Eaton manufactured products, supplemented by other OEM components to best satisfy the end-user requirements. EESS can provide optimization of owner's electrical power assets with guarantees and savings.

Also provided is a full complement of services to maintain and modernize electrical power distribution, and process control systems.

End-users include industrials, commercial facilities, utilities, municipalities, institutions, government and military locations.

Service capabilities include:

- Turnkey project management
- System integration
- Training
- Startup and commissioning
- Predictive and preventive maintenance
- Electrical system modernization
- Circuit breaker specialized services

Division-wide capabilities support regional service centers located throughout the U.S. and Canada. Service centers are equipped with the most technologically advanced test and diagnostic equipment. The Power Systems Engineering Group uses industry standard software with advanced system modeling and analysis capabilities.

In addition to the local service centers, aftermarket centers of excellence can furnish the full complement of circuit breaker specialized services.

Division-wide safety and quality programs ensure customer satisfaction, while maintaining safety as a first priority.

Experienced professional engineers, graduate engineers, field engineers and technicians are trained on both Eaton products and competitive electrical power distribution products. This cross-OEM experience allows for the application of new products and services to all manufacturer's electrical equipment.

Turnkey Project Management

Project Team

The following is a detailed listing of engineering service offerings.

- Substation design, management and construction
- Electrical, mechanical and instrumentation services
- Power system studies:
  - Short-circuit
  - Coordination
  - Arc flash
  - Load flow, etc.
- Power quality and harmonic studies
- Renewable energy design and interconnection analysis
- Failure/root-cause analysis
- CAD services
- Equipment relocation
- Turnkey transformer and capacitor replacements

System Integration and Training

Computer Diagnostics

- Plant monitoring, protection and control:
  - Digitrip™/Advantage™
  - PowerNet™/ Power Xpert®
  - DeviceNet/PLC interface
- Energy management/ load shedding
- Distributed generation
- Generator/emergency power systems
- PLC/PC control and open automation systems
- Drive and MCC systems training (scheduled and on-site):
  - Distribution systems analysis
  - Power quality and grounding
  - Electrical equipment maintenance
  - PLCs and drive systems
  - Customized training programs

Predictive Diagnostics

Field Data Collection

Eaton's predictive diagnostics leads the industry in predictive diagnostic tools and services. With the growing demand for reduced outages and increased uptime, online monitoring of electrical insulation systems is becoming an integral part of efficient plant maintenance in the utility, industrial and commercial markets. Eaton predictive diagnostics provides online monitoring services of insulation systems via the effective measurement and analysis of partial discharges. This allows for detection of traditional corona damage, or surface tracking, prior to equipment failure. This advanced technology is applied to medium voltage systems such as: generators, motors, switchgear, transformers and cable systems.

Services are implemented through the network of EESS field locations.

- Medium voltage generator and medium voltage motor partial discharge (PD) detection using existing RTDs with temporary or permanent sensors
- Medium voltage switchgear PD detection using temporary or permanent sensors. Permanent sensors differentiate cable-related PD to switchgear PD
- Transformers (34.5 kV primary and above) PD detection using permanent sensors connected to bushing capacitive taps
- Transformer (34.5 kV primary and above) bushing monitoring, with permanent sensors, of any change in power factor and bushing capacitance

Startup, Commissioning and Maintenance

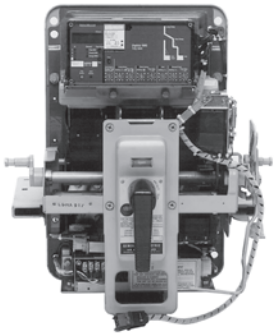
Field Startup

- Installation support and supervision
- Acceptance testing
- Commissioning and energizing
- Startup, training and warranty support
- Exclusive Eaton products 2-year warranty
- Ground fault certifications
- Ground grid testing
- Cable testing and fault identification
- Relay testing and calibration
- PM program design and implementation
- Thermograph surveys
- Predictive, preventive maintenance and troubleshooting
  - Transformers and tap changers
  - High voltage systems
  - Substations medium and low voltage
  - Relay systems
  - Automatic transfer schemes
  - Battery systems
  - Low/medium voltage breakers
  - Motors
  - SF6, OCB, WLI components
  - Network protectors
  - Motor control centers and molded case breakers
- Drive systems
- PLC/control and open automation systems
- Nuclear Class 1E safety-related field service

Electrical System Modernization

Equipment Inspection

- Switchgear bus MVA upgrading
- Bus insulation systems
- Medium voltage vacuum breaker roll-in replacements
- Low voltage breaker replacement
- Low and medium voltage motor starting upgrades
- Low voltage breaker (all OEMs) trip system upgrades—Digitrip
- Low and medium voltage cell retrofits
- Molded case breaker upgrades
- Motor control center buckets upgrades
- Protection, metering, and communications:
  - Low voltage breakers: Digitrip/PowerNet
  - Overload protection
  - Metering systems: IQ family
  - PowerNet implementation
  - Harmonic measurements
- Distribution and substation automation systems
- Power factor control and correction (filtered)
- Ground fault detection systems
- Surge/lightning protection systems
- Automatic transfer scheme upgrades
- Network protector service/ relaying systems
- High resistance grounding and detection
- Generator voltage regulation
- Generator static excitation systems
- Cogeneration switchgear interface relaying
- Reduced voltage/ soft starters
- Drive/PLC system upgrades
- Synchronous field application upgrades



Trip Unit Upgrade

Circuit Breaker Specialized Services

- Low and medium voltage replacement breakers
- Low voltage retrofits (all OEMs: Digitrip RMS kits)
- Medium voltage vacuum roll-in breakers (all OEMs)
- Low and medium voltage recondition and remanufacture
- MCC recondition and remanufacture
- Network protector service
- Navy shipboard breakers
- Nuclear Class 1E safety-related circuit breakers

Manufacturer's Brand Equipment Serviced

- Cutler-Hammer®
- Westinghouse®
- Square D®
- General Electric®
- ITE®/BBC/ABB®
- Allis Chalmers/Siemens®
- Federal Pacific®
- Challenger®
- Obsolete equipment

References

Electrical System Modernization uses advanced Eaton products.

Eaton's Electrical Services & Systems (EESS)

Contents

Asset Optimization, Knowledge Management and Product Life Extension

General Description

A company's facilities exist for a single purpose: to support the mission and objectives of the company's business. It is essential that the power distribution equipment and energy assets that sustain production and services are working as efficiently and effectively as possible.

The core business of Eaton's Electrical Services & Systems (EESS) centers on power distribution and energy management.

1. We offer Powerchain Management solutions and we take care of your systems so you can take care of your business.
2. One area of the PowerChain™ is maintenance solutions.

Eaton knows that a successful maintenance program has the following characteristics:

- Enables you to schedule maintenance based on actual device operation history
- Eliminates unnecessary maintenance work and related production outages
- Reduction of spare parts requirements due to increased accuracy of equipment history
- Reduction of overall maintenance costs

Performance-Based Maintenance (PBM) Program

Eaton offers centrally coordinated management of all procurement, installation, startup and systems required to implement powerful solutions. Whether you have a single site or multiple sites, Eaton has the solutions that fit various project needs.

The PBM Program offers a definitive result and at a guaranteed price. We integrate four proven maintenance programs to positively impact your key business drivers and give you high returns on investment.

1. Planned Maintenance Module: addressing operational performance, as-left conditions, environmental considerations, and testing and calibration results.
2. Predictive Diagnostic Module: focusing on visual observations, environmental and thermal conditions, and predictive indicator results.
3. Reliability-Centered Maintenance Module: concentrating on the potential for injuries, environmental hazards and product losses or process interruptions.
4. Periodic Observations Module: centering on equipment loading, and visual and environmental observations.

Getting a Performance-Based Maintenance Program Started

Getting started with a PBM Program is easy. Highly qualified EESS engineers visit your facility and perform a comprehensive site audit and needs assessment. While implementing electrical system testing and maintenance, EESS engineers review both the "condition" and the "criticality" of each component with plant personnel.

The condition is determined via traditional preventive maintenance procedures (industry-standard, time-based) combined with predictive diagnostic technologies. The criticality rating of each component is established though application of a reliability-centered maintenance approach, taking into account its potential impact on critical processes, safety and the environment.

Then, EESS recommends a maintenance interval (short-, mid- or long-term) for each component, as well as work scopes and periodic observation frequency.

Cost savings are realized when the long-term maintenance interval is lengthened or by the scope of maintenance work during scheduled outages is reduced. Uptime and reliability improve when preventive maintenance is performed more frequently on components with the short-term designation. Additional reliability improvements can result from redirecting some of the savings to performing additional predictive diagnostics and equipment modernization.

EESS delivers a periodic scorecard to plant personnel, summarizing the recommendations, performance and results of the program.

Elements of a Performance-Based Maintenance Program

- Site audit and maintenance needs assessment
- Condition-based maintenance
- Reliability centered maintenance (RCM)
- Predictive diagnostics
- Efficient algorithms to integrate equipment condition results, RCM input, predictive diagnostics and periodic observations
- Recommendations for immediate action, automation, remote monitoring, life extension, spare parts or upgrading
- Periodic observations while energized and operating
- Maintenance implemented based on equipment condition and criticality
- Root-cause failure analysis
- Periodic scorecard and customized reporting of results
- Continuous improvement
- Optional ensured performance improvements and ensured savings—typically, 15% savings over two performance cycles

Asset Optimization Services

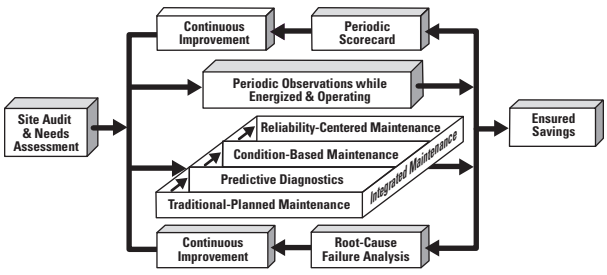
The Electrical Distribution System (EDS) not only represents a significant capital investment, it is essential to maintaining production and critical processes. In order to ensure the maximum possible return on this investment and ensure that power to critical processes is maintained, EESS offers a suite of asset optimization services. This is not just a maintenance program—we combine years of EDS experience, as well as power system engineering and power quality expertise, with the latest in predictive diagnostic and remote monitoring, and knowledge management technology, to deliver a comprehensive program designed to optimize EDS assets. This means lower operating and maintenance costs and improved system reliability and uptime. By outsourcing responsibility for the electrical distribution system assets to EESS, owners can focus on their core business while we deliver maximum return on your investment via increased uptime and decreased operation and maintenance costs. Energy management services and performance contracts are also available by which we will guarantee specific measurable results related to energy savings, system uptime, equipment reliability, and operation and maintenance cost reductions.

With a reputation as the best-in-class power solution strategists, it is obvious why more and more industry leaders are turning to Eaton for uncompromising safe and reliable electrical power distribution systems, in the PowerChain.

By providing the right technology and intellectual resources through outsourcing the ownership, operation and maintenance of the plant electrical distribution system, value can be realized in three areas:

1. Capital funds previously spent on non-core assets are made available to invest in core processes and/or increase shareholder value.
2. Operation and maintenance costs (salary/benefits; risk and insurance related to NFPA and OSHA; training; engineering and purchasing/procurement; test equipment; tools; safety equipment; and parts inventory) are significantly reduced or eliminated completely.
3. Performance guarantees and service level agreements related to uptime, energy, and operating and maintenance costs are realized.

PBM Program Flowchart



Knowledge Management

Eaton has the expertise for electrical distribution systems with a variety of technologies and expert analytical services through our Instant Response Center℠. We aggregate data gathered from your system and use the information to predict equipment failure and identify energy cost reduction opportunities.

Our practices can help you:

- Increase uptime:
  - Avoid outages by predicting equipment failure or system problems
  - Decrease duration of outages (remote troubleshooting 24/7)
- Reduce operating and maintenance costs:
  - Service equipment based on real-time information rather than traditional time-based maintenance
  - Better maintenance with less man-hours
- Reduce energy costs:
  - Optimize utility rate structure
  - Automated demand management
  - Energy usage accountability

Power Systems Engineering Solutions

Not only do we have one of the largest teams of power systems engineers strategically located throughout the world, but many of these professionals have influenced industry standards and are sought after because of their expertise. With an emphasis on precision and accuracy, Eaton's highly trained engineers provide the most focused and systematic approach available to enhance your system's performance. Your system can save you money and increase productivity while meeting the growing and changing demands of your business.

Through surveys, studies, predictive maintenance solutions, energy management, monitoring and evaluation Eaton will help you:

- Maintain IEEE recommended power quality levels, including proper operating voltages
- Reduce costly system disturbances
- Minimize harmonic disturbances created by nonlinear loads
- Provide arc flash levels and personal protective equipment to develop customer safety programs
- With virtually all types of software packages

We offer more than 15 standard and specialized power system studies to precisely target and help correct your specific power issues, utilizing a variety of measurement instruments and specialized software packages.

PSA Group

Contents

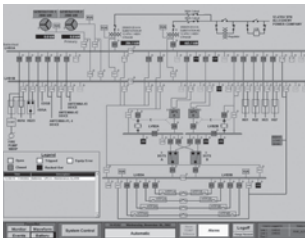
Power Systems Automation Group

General Description

The Power Systems Automation (PSA) group is a full-service systems integrator. Eaton ensures your hardware, software and communication networks perform as a seamless system. PSA provides a unique alternative to conventional manufacturer-integrator-contractor teams by:

- Offering project management and single-point responsibility direct from a major manufacturer of power management and control systems
- Providing unsurpassed expertise in power management and power system control applications across a broad range of industries and end users
- Focusing on applying new products effectively and appropriately, and integrating seamlessly with all major manufacturers' equipment, new or existing
- Bringing a wide range of Eaton resources into a project to address geographic and technical challenges, and managing subcontractors and manufacturers to handle products and services not provided directly by Eaton's Electrical Services & Systems

PSA provides turnkey systems integration projects including system design, programming, panel building, installation, project management, startup, customer training and complete documentation—integrating Eaton's and all major OEM's hardware, software and systems. The following is a summary of services.



Example of a Fully Automated Generator Paralleling and Emergency Power Transfer Scheme for a Mission-Critical Application

Power Systems Automation

- Power monitoring, management and control systems
- Eaton's Power Xpert, Foreseer and PowerNet Systems including Power Xpert Reporting
- Energy cost allocation
- Lighting management systems (Eaton Pow-R-Command™)
- Load management systems
- Load shed and load transfer schemes
- Generator paralleling systems
- Backup and emergency generation systems
- Demand management systems
- Generator and ATS system monitoring control and remote testing
- Utility rate plan optimization
- Health care emergency power supply systems monitoring
- Web-based monitoring services

General Capabilities

- Power Xpert
- Foreseer
- System design—functional specification
- System network architecture
- CAD drawings
- PC control and open automation
- DeviceNet™ applications
- Open protocol systems
- PLC design and programming:
  - Eaton
  - Allen-Bradley®
  - Modicon®
  - GE Fanuc®
  - Siemens
- Human machine interface/ graphical user interface design and configuration:
  - Eaton PanelMate® and PanelMate PC
  - ICONICS GENESIS® and WebHMI®
  - Wonderware®
  - Intellution
  - PanelView™ and RSView™
  - Citect
  - CIMPLICITY
- Full service custom panel shop:
  - UL® listing for industrial control panels
  - Motor starter panels
  - PLC enclosures and operator consoles
  - Design and testing
  - Turnkey capabilities
- Project management—contractors, systems integrators, other OEMs, etc.
  - Installation
  - Startup and commissioning
  - Instruction manuals
  - Customized training
  - Complete documentation
  - Service contracts and maintenance agreements
  - Single-point responsibility

Eaton's Instant Response Center

Contents

Instant Response Center Services

General Description

Eaton's Instant Response Center℠ (IRC) is staffed by power systems engineering and power quality experts, monitoring your electrical distribution system in real-time. The IRC continuously monitors power distribution equipment for changes in performance or other conditions that could signal an impending power failure. When changes exceed predetermined thresholds, the IRC issues alerts to service personnel via Internet e-mail or wireless page.

Eaton power systems experts can then remotely and securely access real-time data from the subscriber's system, often correcting a problem before electrical service is impacted, delivering to customers a quantifiable return on investment based on maximum uptime, extended equipment lifetime, and reduced energy costs.

System outages can be prevented or mitigated, equipment life extended, and operating, maintenance and energy costs reduced by monitoring key system wellness parameters such as:

- Current, voltage and energy
- Power quality and harmonic content
- Partial discharge
- Vibration
- Temperature
- Environmental (such as presence of water)
- Power factor (transformer bushings)
- Key events (oscilligraphy)
- Energy monitoring
- Inverter monitoring
- Environmental condition monitoring

The Instant Response Center is the vanguard of Eaton's Knowledge Management Services. Knowledge management is a broad term that describes the application of a variety of related technologies and expert analytical services that transform data into information, and information into knowledge. Data is collected by remotely monitoring customers' electrical distribution and related systems via the Internet, and trending key parameters related to energy and utilities, power quality, predictive diagnostics, environment and key events. This data is converted to information through expert analysis by power systems engineering, power quality and energy management experts. This information is then transformed into knowledge using data mining techniques and the application of predictive algorithms to extract trends and patterns that will predict equipment failure and identify energy cost reduction opportunities.

Using the latest communications technologies, such as wireless videography, it is also possible to extend this high-end expertise to field technicians or customer personnel to guide them through sophisticated problem diagnosis, troubleshooting or repairs.

Benefits of IRC:

- Experts are readily available
- Eliminates the cost of bringing experts on site
- Event analysis
- No employee turnover

Oil Field HRG-3

Contents

Customized High Resistance Grounding Units

Eaton's Electrical Services & Systems builds custom medium voltage High Resistance Grounding Units (HRGUs). They eliminate the possibility of excessive transient overvoltages due to arcing ground faults on ungrounded systems. There are three categories:

- General industry—these HRGUs typically are freestanding and come with a pulsing contactor design to aid in finding the ground fault
- Medium voltage generators—new IEEE research has proven high risk for low resistance grounded generators with internal ground faults. These systems require low resistance grounding for the system, but when an internal generator ground fault occurs, massive damage can result. Eaton's Electrical Services & Systems has developed a hybrid high resistance grounding unit (HHRG) that allows the system to be low resistance grounded for external ground faults but quickly reverts to high resistance grounded only for internal ground faults
- Oil field wells—electrical submersible pumps used in oil well applications traditionally have been designed to operate ungrounded with the expected history of insulation type failures due to arcing ground faults on ungrounded systems. These HRGU versions are custom designed to match the unique voltages, size and locations (land or platforms) for the oil field industry and supply the proven service continuity and safety high resistance grounding provides

Arc Flash, Short-Circuit and Coordination Studies

Contents

Arc Flash, Short-Circuit and Coordination Studies

General Description

Eaton's Electrical Services & Systems (EESS) can perform short-circuit and coordination studies per the following standards, and others.

- Institute of Electrical and Electronics Engineers, Inc. (IEEE):
  - IEEE 141, Recommended Practice for Electric Power Distribution for Industrial Plants
  - IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
  - IEEE 399, Recommended Practice for Industrial and Commercial Power System Analysis
  - IEEE 241, Recommended Practice for Electric Power Systems in Commercial Buildings
  - IEEE 1015, Recommended Practice for Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
  - IEEE 1584, Methods for calculating flash protection boundary distance and incident energy values. Determine hazard risk category. Select protective clothing and PPE (Personal Protective Equipment)
- American National Standards Institute (ANSI):
  - ANSI C57.12.00: Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
  - ANSI C37.13: Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
  - ANSI C37.010: Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
  - ANSI C37.41: Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
- The National Fire Protection Association 70E, National Electrical Code®, latest edition. Use methods to calculate flash protection boundary distance and incident energy values

Eaton Quality Assurance

The short-circuit and coordination studies will be conducted under the supervision and approval of a registered professional electrical engineer skilled in performing and interpreting the power system studies. The registered professional electrical engineer will be a full-time employee of EESS.

The field engineering service division can administer the power system studies, including acceptance and startup testing. Equipment and component titles used in the studies shall be identical to the equipment and component titles shown on the customer's one-line drawings. The power system studies will be performed with the aid of a digital computer program and will be in accordance with the latest applicable IEEE and ANSI standards.

Following the completion of all studies, acceptance testing and startup by EESS, a 2-year warranty will be provided on all components manufactured by Eaton.

Sequencing and Scheduling

The short-circuit and protective device coordination studies will be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be requested for preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.

Data Collection

The owner's contractor, under the direction of the equipment manufacturer, shall furnish all data as required by the power system studies. The engineer performing the short-circuit and coordination studies will furnish the equipment manufacturer and contractor with a listing of required data after award of the contract. The contractor should expedite collection of the data to ensure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing. Provisions shall be included by the contractor to obtain the services of the equipment manufacturer to support the proper data collection.

Fault contribution of existing motors is included in the study, with motors <100 horsepower typically grouped together. The contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

Short-Circuit and Protective Device Evaluation Study Details

Typical conductor impedances based on IEEE Std. 141-1993 are utilized.

Transformer design impedances are used when test impedances are not available.

The following is included as part of the study:

- Calculation methods and assumptions
- Selected base per unit quantities
- One-line diagram of the system being evaluated
- Source impedance data, including electric utility system and motor fault contribution characteristics
- Tabulations of calculated quantities
- Results, conclusions and recommendations

A calculation of short-circuit momentary and interrupting duties for a three-phase bolted fault is made for the following locations:

- Electric utility's supply termination point
- Incoming switchgear
- Unit substation primary and secondary terminals
- Low voltage switchgear
- Motor control centers
- Standby generators and automatic transfer switches
- Branch circuit panelboards
- Other significant locations throughout the system

For grounded systems, a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study will be provided.

Protective Device Evaluation

The protective device evaluation portion of the study will:

- Evaluate equipment and protective devices short-circuit ratings and compare to calculated available fault current
- Determine the adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
- Determine the adequacy of transformer windings to withstand short-circuit stresses
- Determine the adequacy of cable and busway sizes to withstand short-circuit heating
- Notify owner in writing, of existing circuit protective devices improperly rated for the calculated available fault current

Protective Device Coordination Study

- Proposed protective device coordination time-current curves will be displayed on log-log
- Included on each curve sheet will be a complete title and one-line diagram with legend identifying the specific portion of the system covered
- The device characteristic curves will be terminated at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed
- Identification of the device associated with each curve by manufacturer type and function, and generated using a commercially available software program

The following characteristics will be plotted on the curves, where applicable:

- Electric utility's protective device
- Medium voltage equipment relays
- Medium and low voltage fuses, including manufacturer's minimum melt, total clearing, tolerance and damage bands
- Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
- Transformer full-load current, magnetizing inrush current and ANSI transformer withstand parameters
- Conductor damage curves
- Ground fault protective devices, as applicable
- Pertinent motor starting characteristics and motor damage points
- Pertinent generator short-circuit decrement curve and generator damage point
- Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center

Where possible, adequate time margins will be provided between device characteristics such that selective operation is provided, *while providing proper protection.*

Arc Flash Analysis Details

Background

NFPA 70E Standard, Article 110.7 (F), states that an electrical safety program shall identify a hazard/risk evaluation procedure to be used before work is started on or near live parts. Article 130.7 (A) states that employees working in areas where electrical hazards are present shall be provided with, and shall use, protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed.

Procedure

In accordance with NFPA 70E and IEEE 1584, commercially available software packages provide the calculation of incident energy and flash protection boundary. The equations used in these calculations are based on actual test values. These tests measured the calories per square centimeter (cal/cm^2) radiating from a simulated arcing fault. The measurements were performed at a theorized working distance of 18.00 inches (457.2 mm).

The intent of the NFPA 70E and IEEE 1584 guidelines is to establish standard calculations to determine an Approach Boundary and an associated PPE Hazard Level that will limit the injury to the onset of a second-degree burn to the face and the torso of the worker. An incident energy of 1.2 cal/cm^2 represents the onset of a second-degree burn. The various PPE Hazard Levels are described in the NFPA 70E standard on a scale of 0 to 4. An incident energy greater than 40 cal/cm^2 will be described in this study as "Dangerous" and no Hazard Level can be applied. Thus, no PPE is approved to protect the worker from a potential arc flash hazard and the equipment enclosure should not be opened unless the equipment is de-energized, tagged-out and locked-out.

The arc flash analysis considers each medium and low voltage system location within the scope of the work. IEEE Std. 1584™-2002 states that equipment below 240V need not be considered unless it involves at least one 125 kVA or larger low-impedance transformer in its immediate power supply. Therefore, no detailed calculations will be performed for 120/208V locations supplied by a transformer smaller than 125 kVA, however, labels will be provided for these locations and will be labeled as hazard risk category zero. For the detailed calculations, the software determines the available fault currents for each location and the clearing time of the device protecting the same location. From these determinations, the potential incident energy is calculated for each location. Arc flash computations shall include both line and load side of main breaker calculations, where necessary.

Tabulations

The following tabulations will be provided as part of the study:

Input Data

- Short-circuit reactance of rotating machines
- Cable and conduit materials
- Bus ducts
- Transformers
- Reactors
- Aerial lines
- Circuit resistance and reactance values

Short-Circuit Data

- Source fault impedance and generator contributions
- X to R ratios
- Asymmetry factors
- Motor contributions
- Short-circuit kVA
- Symmetrical and asymmetrical fault currents

Recommended Protective Device Settings

- Phase and ground relays:
  - Current transformer ratio
  - Current setting
  - Time setting
  - Instantaneous setting
  - Specialty non-overcurrent device settings
  - Recommendations on improved relaying systems, if applicable
- Circuit breakers:
  - Adjustable pickups and time delays (long time, short time, ground)
  - Adjustable time-current characteristic
  - Adjustable instantaneous pickup

Arc Flash Results

- Arcing fault magnitude
- Device clearing time
- Duration of arc
- Arc flash boundary
- Working distance
- Incident energy
- Recommendations for new equipment and/or system changes to reduce the calculated arc flash energy level below 40 cal/cm^2 where possible

Submittals

The results of the short-circuit, coordination and arc flash study will be summarized in a final report.

The report will include the following sections:

- One-line diagram
- Descriptions, purpose, basis and scope of the study
- Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short-circuit duties
- Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
- Fault current calculations including a definition of terms and guide for interpretation of the computer printout
- Arc flash analysis calculations including a definition of terms and guide for interpretation of calculated values
- Recommendations for system improvements, where needed
- Executive summary

In addition to the report, EESS can provide field services (at additional cost) to:

- Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the startup and acceptance testing contract portion
- Make minor modifications to equipment as required to accomplish conformance with the short-circuit and protective device coordination studies
- Notify owner in writing of any required major equipment modifications
- Provide arc flash solution engineering and recommendations to lower the incident energy at specific locations where the hazard is unacceptable

Contents

Load Flow/Power Factor Correction Study

General Description

Background

The primary function of the electrical power distribution system is to provide real and reactive powers demanded by the various loads connected to the system. Simultaneously, the frequency and various bus voltages must be kept within specified tolerances, even though the load demands may undergo large and unpredictable changes.

The Load Flow Study is an analysis of the system capability to supply the connected load under steady-state conditions. Optimal management of the power system can be achieved through the use of this analytical tool. Necessary in the planning or expansion of electrical power systems, a load flow study demonstrates the distribution of power and voltage levels throughout the system for selected operating scenarios. These scenarios may include normal and emergency operating modes, present and future circuit arrangements, and alternative designs and equipment components.

Study results include real (kW) and reactive (kVAR) power flow through transformers and cables, voltage levels at system buses, power factor and system losses. These values allow the power system engineer to identify overloaded transformers and cables, provide recommendations for proper transformer tap settings, and determine the need for power factor correction capacitors.

The Load Flow Study is a prerequisite to developing optimum generating strategies and systems controls.

Study Procedure

Investigate the system loading conditions for the normal and contingent operating conditions. All system loads (kW and kVAR components) and power sources are included in the analysis.

The study is processed using state-of-the-art software, which utilizes an iterative technique to calculate real and reactive power flows, and bus voltage levels throughout the system.

The data base for the load flow analysis is established from existing design or nameplate load data or by monitoring the existing feeders with a digital power monitor. Each feeder is monitored for a minimum of two hours, during typical operating periods. The following system data is utilized as input to the load flow program:

- Current and voltage
- kW, kVAR and kVA
- Power factor

The study for the electrical system is based on both present and future loading considerations and switching configurations. A maximum of three load flow study cases are performed to analyze power flow, voltage regulation, power factor, transformer tap settings and other load considerations.

An evaluation of the existing utility billing contract will determine whether power factor correction should be incorporated in the power system. If power factor correction is needed, the appropriate hardware is recommended and located to maintain desired power factor at the metering point. The study also indicates any switching of power factor correction equipment that may be necessary to maintain proper voltage levels.

If the study results indicate that power factor correction equipment is necessary, the approximate payback period will be calculated for equipment purchase and installation.

Results

The Load Flow Study includes the following for each circuit condition analyzed:

- Bus voltages, line currents, power factor and transformer loading in actual quantities and in percent of the device base values
- Recommended transformer tap settings
- Recommended generator dispatch schedules
- Complete set of capacitor recommendations, including calculated payback period based upon energy savings, if additional shunt compensation is required for power factor improvement or voltage support
- Recommended equipment upgrades or circuit reconfigurations to optimize the power flow from the source to the loads

Data Requirements

In addition to the data required for the short-circuit study, the following data is required to complete the load flow study:

- Design, nameplate or measured load data
- Ratings and connections of all power factor correction capacitors
- Reactor impedance and ratings
- Power flow measurements (when available) at utilization transformers

Harmonic Analysis Study

Contents

Harmonic Analysis Study

General Description

Background

The operation of nonlinear loads and in particular variable frequency drives (VFDs) in a power distribution system creates harmonic currents that flow throughout the power system. When considering VFDs, the frequencies and magnitudes of the harmonic currents are functions of the number of drive rectifier pulses, as well as the AC system impedances. Harmonic voltages result from the harmonic current flowing back into the harmonic impedances of the distribution system. The order of the harmonic currents generated is np ± 1, where n is any integer and p is the number of drive pulses. Therefore, for 6-pulse drive, the order of harmonics is 5th, 7th, 11th, 13th, 17th, 19th, etc. For 12-pulse drive, the order of harmonics is 11th, 13th, 23rd, 25th, 35th, 37th, etc.

Harmonic studies can provide calculation of the current and voltage harmonics throughout the electrical distribution system when the generated harmonic current magnitudes and the system 60 Hz impedances are known.

Significant harmonic current and voltage magnitudes can have adverse effects on system components and overall system operation. Harmonic currents cause increased power losses in transformers, motors and cables. The higher power losses increase equipment-operating temperatures, increasing the possibility of overload, increasing thermal stress on insulation, and reducing overall system efficiency.

Power factor correction capacitor banks are particularly vulnerable to the detrimental effects of power system harmonics. Most capacitors are designed to operate at a maximum of 110% of rated voltage and 135% of rated kVAR. Large magnitudes of voltage and current harmonics can exceed these design limits, and cause severe capacitor bank damage. Since capacitive reactance is inversely proportional to frequency, capacitor banks act as sinks for current harmonics in the system. This often causes capacitor fuses to open or capacitor damage when fuses are not present or improperly sized.

A serious condition, with potential for substantial damage, occurs as a result of harmonic parallel resonance. As frequency increases, capacitive reactance decreases and inductive reactance increases. Harmonic resonance occurs at the frequency when the inductive reactance of the source-side circuit equals the capacitive reactance of the power factor correction capacitor. Looking back into the circuit from the harmonic source, the capacitor is in parallel with the substation transformer. The circuit total impedance (including the capacitor) is very high at the resonance frequency. If the VFDs generate harmonic current at the resonance frequency, large harmonic voltages will be developed at the capacitor and transformer bus, and serious equipment damage can occur.

IEEE Std. 519-1992 establishes recommended limits for harmonic voltages and currents in power systems.

Study Procedure

Harmonic analysis of the electrical distribution system for the circuit conditions listed below.

- Existing system configuration
- System with new VFDs or other nonlinear harmonic creating loads in operation

The power system is modeled for the fundamental frequency and appropriate harmonic frequencies. System impedances are calculated for the fundamental frequency as well as for each appropriate harmonic frequency.

The following is calculated for each study:

- System harmonic voltages in rms and % THD
- System harmonic currents in rms and % THD
- An IEEE 519 analysis at the point of common coupling with incoming utility
- Capacitor bank evaluations on the basis of voltage, current and kVA
- The payback period of the total cost (filter equipment, installation and/or relocation) for the three most feasible filter options

In addition, the drive's harmonic generation based upon the drive's loading and characteristics is calculated. If specified, field measurement of the VFD current harmonic generation during the process operation can be made. Each harmonic component is then successively injected into the simulated system, and the resulting harmonic currents and voltages are computed throughout the system.

If the calculated magnitudes of harmonic voltages and/or currents are excessive, the optimal corrective solution will be determined to reduce the harmonic quantities to within acceptable limits.

When a harmonic filter is recommended, a complete equipment specification will be provided. A final study case is conducted to verify that the harmonic filtering equipment will reduce harmonic levels to within acceptable standards.

Results

At the conclusion of the Harmonic Analysis, the following will be submitted for each circuit condition analyzed:

- Description, purpose, basis and scope of the harmonic study and a single-line diagram of the portion of the power system that is included within the scope of the study
- Tables listing the individual harmonic voltages and currents and total harmonic distortions (THDs) for all major buses within the electrical distribution system. Waveforms for all of the calculated harmonic voltages and currents will be displayed
- Plots of frequency versus impedance (harmonic resonance scans) for all shunt capacitor locations
- Complete recommendations for harmonic filters, shunt capacitors and series reactors, required for harmonic suppression
- All computer output and an interpretation guide

Data Requirements

In addition to the data required for a load flow analysis, the following data is also required:

- Complete text report of each measurement location sorted by voltage and current, and listing the individual harmonic component and the total harmonic distortion (THD)
- Waveforms of each measurement sample
- Detailed harmonic spectrums of the harmonic generating loads

Contents

Advanced Analysis and Design Services

Transient Stability

Background

Power system stability is a condition where the various synchronous machines of a system remain in synchronism, or in step, with one another. Instability is the condition when one or more of the machines fall out of step.

With a sudden increment in load, there is a definite upper limit to the load that a machine will carry without pulling out of step. This is defined as the transient stability limit of the system for the given condition. The transient stability limit may have different values for the same system, depending upon the nature and magnitude of the disturbance. Disturbance types include a sudden increase in load, by the disconnection of a parallel line or disconnection of the utility source. The most severe disturbance subjected to the electrical distribution system is a short circuit.
All transient stability studies should include computer simulations that determine the effects of short circuits upon the system transient stability.

Study Procedure

The Transient Stability Study provides an analysis of the transient response of the system and rotating machines following system disturbances, and the behavior of the system in relation to the power company tie.

Data from the study can be used to determine the effect of generator and/or motor performance, system voltage and frequency, all as a function of time. Generator and motor performance are affected by:

- Abrupt changes in load and including the starting and accelerating effect of large motors
- Short Circuits, from which effect the critical operating time for protective relays can be determined
- Partial loss of generation or loss of power company tie, and the corrective effect of a load shedding scheme

Study engineers will analyze system disturbance scenarios using state-of-the-art software. Protective device fault clearing times will be included in the computer simulations and the generator, motor, and tie-line protection and coordination will be evaluated from a system stability perspective.

Load-shedding schemes will be evaluated or developed, based upon the operating requirements of the customer facility.

Results

At the conclusion of the Transient Stability Analysis, Eaton will submit the following:

- Machine variables, including turbine input and generator output power, accelerating power, frequency deviation, rotor angle, field voltage and current, terminal voltage magnitude and angle, and generator current and angle. These are summarized for each machine in time increments over the nominal transient time interval of one or two seconds. For the load shedding study analysis, the time interval would be extended to five seconds or longer
- Plotted swing curves of power angle over the transient time period for each machine
- The magnitude and angle of voltage and frequency deviation for any bus in the system
- Summary of line currents, power flows and apparent impedance on any line
- If required, details of the load shedding scheme, including the sequence of load separation, critical clearing time and type of relay

Switching Transient Analysis

Background

A transient is initiated whenever there is a sudden change of circuit conditions. This most often occurs when a switching operation occurs, such as capacitor switching, transformer energizing and fault current interruption. Some of the most severe and damaging transients are produced by lightning strikes. Voltage transients will result when loads on an electrical distribution system are switched. Industrial and commercial power systems comprise capacitive and inductive components. The transient disturbance occurs because the currents and voltages do not reach their final value instantaneously.

The severity of a voltage transient is a function of the relative power level of the load being switched, and the available fault current magnitude in the supply circuit where the switching takes place. Some circuit components such as motors and transformers are adversely affected by the speed (frequency) of the voltage transient as well as its magnitude. Voltage transient magnitudes should not exceed twice the system voltage when they occur from normal switching operations. Properly rated equipment BIL provides adequate transient or surge protection for these instances.

Complex voltage transients result from abnormal switching operations and current chopping, prestrikes and restrikes cause these disturbances. Voltage magnitudes may approach ten times the system voltage and must be controlled by surge arresters, surge capacitors and/or resistors. These surges can damage the most rugged system components.

Study Procedure

Eaton engineers will discuss with customer personnel all aspects of the disturbance that is being investigated. The circuit configuration and system loading prior to the disturbance and any subsequent equipment damage incurred will be examined.

Engineers will develop a computer model of the electrical circuit with EMTP, Electromagnetic Transients Program. All circuit components, including surge capacitors, equipment capacitance, bushing capacitance, CT and PT capacitance, and transformer saturation characteristics will be modeled in detail.

The suspect switching operations, including all reasonable perturbations such as current chopping, circuit breaker restrike and prestrike, will be simulated with the computer. Voltage and current transient magnitudes will be calculated, and the waveforms will be displayed for all of the transients caused by the switching operation.

If excessive transient voltages or currents are observed, the study engineer will propose corrective measures, which may include surge protection, damping resistors or modified switching procedures. These measures will be analyzed with additional simulations to ensure that excessive switching transients are avoided or reduced to acceptable levels.

Finally, an insulation coordination study, which compares surge arrester ratings with equipment BIL, will be completed to confirm the recommended surge protection system for the circuit being investigated.

Results

At the conclusion of the Switching Transient Analysis, Eaton will submit the following:

- Detailed description of the sequence of events that preceded the switching transient that disrupted the electrical system operation and caused equipment damage
- Magnitudes and waveforms of transient voltages and currents calculated by the computer simulations
- Recommendations for surge protection, such as surge arresters, surge capacitors, RC suppression, damping resistors or TVSSs, for all affected equipment
- Results of the insulation coordination study to evaluate the degree of protection afforded by the recommended surge protection system
- Appendix, including one-line diagrams, computer program output sheets and all other pertinent supporting documentation

Transient Motor Starting Analysis

Background

A motor starting study is conducted to evaluate the motor's impact on the power system and the power system's impact on the motor. Motor starting studies are usually performed for new motor installations to ensure system reliability, provide data for motor protection, and to identify any system modifications that may be necessary to avoid starting problems.

Starting a large motor on a distribution grid with limited capacity may cause severe voltage reduction and not produce enough motor torque to accelerate the motor. One of the most noticeable effects is light flicker during motor starting. Voltage dips may cause problems with voltage sensitive electronic equipment to such as computers and microprocessors.

The study will recommend solutions to any problem discovered. One possible solution may be to install a reduced voltage starter to decrease the motor inrush current and minimize the voltage drop. A system balance must be maintained to minimize impact on the system and allow sufficient motor torque to perform its function.

Eaton will investigate various methods for minimizing system disturbances when starting of motors. These methods include:

- Reduced voltage starting methods such as: auto-transformer, reactor, wye-delta, primary resistor, part winding and solid state
- System modifications, including paralleling circuits, addition of shunt capacitors, adjusting transformer taps and relocating loads

Study Procedure

A Motor Starting Study will determine the system effects of starting and accelerating the motor and associated load from time zero to full speed. The study will calculate the terminal voltages of the motor and other buses when the motor and load is started.

Eaton will develop the circuit model on the digital computer. The procedure requires a Load Flow analysis to be completed initially to determine system conditions prior to motor starting.

Computer simulations of various motor starting methods, motor starting sequences and circuit configurations will follow. From these results, Eaton will recommend the best means of starting motors at that circuit location.

Results

At the conclusion of the Motor Starting Study, Eaton will submit the following for each method analyzed:

- Tables listing voltages at the motor terminals and at other significant locations within the electrical distribution system
- Plots of motor speed, motor current, motor torque, load torque, accelerating torque, accelerating time, power factor, and voltages at the motor terminals and other significant locations in the system
- Recommendations of various options to correct any problems found in starting and accelerating the motor and load

Ground Grid Analysis

Background

A Ground Grid Analysis ensures that the ground grid design provides adequate safety for personnel during ground fault conditions. When fault current flows through the earth from the ground grid of the plant substation, the potential of the plant substation ground is elevated. Voltage potentials along the ground surface may be severe enough to endanger a person walking on the surface, and dangerous potential differences may exist between grounded apparatus, structures, fences and nearby earth.

Study Procedure

Eaton engineers will evaluate your switchyard or substation ground grid to ensure that the performance of the grid adheres to IEEE Standard 80, "Guide for Safety in AC Substation Grounding." This will involve utilizing a computer software program that models the ground grid under fault conditions. All voltages at the surface are calculated, allowing evaluation of Step and Touch potentials, to ensure the safety of plant personnel. The Ground Potential Rise is also calculated to evaluate the potential of damage to interconnected equipment. The following services are available and are an integral part of doing a complete evaluation:

- Inspection and evaluation of existing grid conductors and connectors and continuity
- Soil resistive measurements and interpretation
- Measurement of ground grid impedance
- Safety assessments—step and touch voltage criteria
- Substation ground grid layout design, ground grid equipment specifications, bills-of-materials, requirements to meet IEEE Std. 80
- Recommendations for improving existing grids

Results

At the conclusion of the Ground Grid Analysis, Eaton will submit the following:

- Executive summary, including findings and recommendations
- Study procedures
- Calculation results, including GPR and Step and Touch Potentials
- Data summary, including computer report output
- Appendix, including one-line diagrams, computer program output sheets, and all other pertinent supporting documentation

Electrical Design Services

Eaton's electrical design services can extend from the point of utility connect to the equipment. Design services are integrated with analysis services, resulting in a complete engineered solution. The level of design detail can be customized from minimal design consultation and advice to a complete design package with specifications and drawings.

Typical design services include:

- Distribution System Design—Design and specification of the electrical distribution system from the point of utility interconnection to the downstream utilization equipment
- Substation Design—Complete substation design service is available, including ground grid analysis and design, substation layout, equipment specification, protection and control
- Protection and Control—Design of advanced electrical protection and control, including transmission line protection, system automation and advanced metering
- Renewable energy design, including the AC and DC distribution systems, collector substation and utility interconnection design

Typical construction drawings and documentation for design projects include:

- Demolition plans for the existing equipment and building (if applicable)
- New proposed switchgear arrangement plans and elevation views
- Specifications for all new AC and DC distribution equipment
- All necessary engineering calculations (load flow, short-circuit, etc.)
- Single line diagrams for the AC and DC distribution and auxiliary equipment
- Arrangement plans and details for new structures, bus systems, auxiliary and DC equipment
- Conduit raceway drawings and schedules
- Control panel and terminal board panel design drawings
- Lighting and grounding modifications for the new installation
- Building modification for garage doors, air ventilation, etc.

Field Engineering Services

Contents

Selection Guide

The following tables present the relationship between Eaton's Electrical Sector capabilities and the user's needs:

Consulting and Turnkey Project Management

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
New substation design, management and construction	Support consultant or end-user by offering one-stop shopping and an exclusive 2-year warranty on all Eaton products supplied.	—	Design and construction costs are reduced by a single-source contract. In addition, end-user internal engineering resources can be applied to core-business process improvements, rather than the electrical distribution system.
Electrical, mechanical and instrumentation services	Through networking the experiences of our many service locations, we can add mechanical and instrumentation services to our construction capabilities.	—	
Power system studies Short circuit Device evaluation Coordination Load flow Power factor Harmonics Power quality Grounding Reliability Switching transient Others	New construction requires the proper set of power system studies. We can review your current and future power needs: reliability, loading profiles, emergency power requirements, etc., and determine the necessary studies.	A short-circuit study is required for protection of personnel and equipment. In addition, coordination studies reduce downtime by limiting the power loss to only the faulted feeder. Power quality studies are necessary due to the many new nonlinear loads and their potential effect on critical equipment.	Extending the life of an electrical distribution system should include an updated single-line diagram and the proper complement of Power System Studies to address your current and future needs.
Failure/root-cause analysis	—	Electrical outages can result in extensive downtime and loss production. Critical systems should be investigated to determine the cause of such outages, and corrective actions planned and implemented.	An investigation of critical outages can result in long-range cost reductions by preventing the repeat of such occurrences, and allowing system improvements while funding is available.
Equipment relocation	Changing production needs can be satisfied by the relocation of power distribution components, either by use of internal or sister-plant equipment.	—	Costs can be reduced for new production projects by the allocation of existing equipment, thereby eliminating the need for new purchases.

System Integration

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
Plant monitoring, protection and control Digitrip PowerNet Advantage starters DeviceNet PLC interface	Plant-wide electrical power distribution system monitoring and control can be cost-effectively implemented during new construction. New Eaton electrical products allow for communications through all levels of the power distribution network. Eaton's PowerNet system allows for plant-wide monitoring and control from a single workstation or from any number of workstations connected to a plant LAN, company, intranet or Internet.	Real-time monitoring, and remote control of circuit breakers can greatly improve reliability by providing immediate indication of a problem, allowing for a quick resolution; and if necessary, remote control of power distribution equipment.	Plant electrical distribution systems are being subjected to higher loads, and greater harmonics. Plant-wide monitoring can help identify these areas of rapid deterioration, and implement corrective actions to extend the life of the electrical system. Taking such action will also prevent costly outages and the resultant downtime. In addition, with the advent of utility deregulation, having accurate power usage values will allow for improved negotiating on power purchases.
PLC/PC control and open automation systems	New process and discrete control systems currently employ PLCs for control and monitoring. Eaton PC control and open automation products can be applied for many of these systems with full integration into plant-wide control and information management systems. Integration to other OEM's equipment is also available.	The real-time, self-diagnostic information available with a PC control/open automation system significantly reduces system downtime by allowing the operator to proactively respond to system problems before a shutdown occurs.	PC control/open automation systems provide the greatest level of flexibility when implementing a control system. The open automation concept allows the user to select the "best in class" components without being tied to a single OEM. PC control systems can provide a wealth of information that can be easily integrated into manufacturing and enterprise systems allowing the user to optimize process efficiency.
Drive systems motor control	Eaton drive systems, as well as modernized motor control, provide critical hardware for new efficient process system construction.	Modern drive systems and motor control will greatly improve system reliability by the application of new technology, and allowing for plant-wide communications and control.	The electrical portion of the process-line can have extended life, and develop a lower cost of production. This can be combined with the life extension of the mechanical components.
Energy management load shedding	Eaton maintains application expertise and a full line of products to support energy management systems. Our energy management experts can design and implement an energy management program including financial analysis and justification.	—	With the advent of utility deregulation, in-house power generation and load shedding capabilities can aid your negotiations for reduced electric rates. In-house generation voltage regulation and excitation systems can also add to system life.
Generator/emergency power systems	New power reliability needs may require modern emergency power systems.	Reliability can be improved for critical processes with improved standby power systems.	

Training

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
New product training Electrical power equipment Drive systems PLC systems	Training is offered on all new products supplied by Eaton's Electrical Sector. The construction phase is a beneficial time to incorporate training, from equipment and a funding standpoint.	—	—
Distribution systems analysis training	—	Plant engineers require an understanding of the dynamics of electrical power distribution systems. This training addresses topics to improve existing electrical systems, as well as plan for future expansions.	Life extension of the power distribution system requires a proper analysis by the plant electrical engineer. Appropriate investigations can be completed and recommendations planned for implementation.
Power quality and grounding training	—	Power quality and grounding issues are affecting new sensitive process equipment. This training can provide short- and long-term solutions, as well as recommending methods to accurately measure power quality.	—
Electrical equipment maintenance training	—	Completing proper and timely maintenance on electrical equipment will improve reliability and reduce downtime. This training shall identify simple, yet effective, maintenance tasks, which can be completed by plant personnel.	Proper equipment maintenance will result in system life extension, indirectly by reducing failures. In addition, training in-house personnel to complete several maintenance duties can reduce costs.
Customized training Scheduled On-site	In conjunction with new construction, training can also be integrated to include existing electrical components, regardless of manufacturer. This allows for effective one-time training, on-site if desired, and incorporated into the construction project. A site review would be conducted to identify the training needs, and associated equipment.	A plant-wide custom training program can address specific reliability needs, as well as goals for reduced downtime.	Cost reductions can be achieved by providing maintenance training to operation personnel, thereby possibly combining operating and maintenance duties. This training will also provide operators with a better understanding of the needs of electrical equipment, thereby resulting in life extension through reduced fatigue.

Startup and Commissioning

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
Installation support and supervision	Electrical construction of sophisticated power distribution equipment requires support and/or supervision by factory trained personnel.	Proper installation techniques have been proven to reduce short-term operation problems and the resultant downtime.	Proper installation will result in an extended life, through the proper application of stress and tensions on various electrical components.
Acceptance testing Electrical power equipment: Switchgear Outdoor units Circuit breakers PowerNet, etc. Starters Motor control Transformers Tap changers Network protection Drive systems PLC systems Nuclear safety related 1E	Startup testing should be completed by an independent division of a major electrical equipment manufacturer. Eaton provides an exclusive 2-year warranty on all Cutler-Hammer brand products supplied, when EESS completes engineering studies, startup and acceptance testing.	Proper acceptance testing provides baseline data for future maintenance. This allows the development of predictive maintenance programs, thereby anticipating outages, and identifying correction actions. EESS offers comprehensive ongoing predictive and preventive maintenance programs.	Proper acceptance testing will identify any areas requiring corrective action, thereby resulting in a system with the longest life expectancy.
Startup, training and warranty support	Trained individuals should complete equipment startup. Voltage levels, phasing and proper grounding requires attention to ensure a safe startup. Specific equipment testing and adjustments are also necessary to ensure all electrical safety interlocks are operational and ready for long-term service. Training can be provided immediately following, or during the startup process. Warranty issues can be quickly identified and corrected by factory trained personnel.	Long-term reliability is ensured by the proper startup, training and warranty support, all of which are provided by EESS.	Allowing the training cycle to commence immediately following, or during, the startup of the equipment can reduce training costs. Travel and setup costs are minimized, and plant personnel witness the operation of all associated electrical equipment, as part of the training session.
Exclusive 2-year warranty	Eaton has identified that warranty-related costs may be associated with improper startup and acceptance testing by groups that are not factory trained. This results in construction delays, as well as possible long-term reliability issues. Eaton offers an exclusive 2-year warranty on Cutler-Hammer brand products, when all engineering studies, startup and acceptance testing is completed by EESS.		Startup costs are reduced by allowing EESS to complete all functions since the required OEM presence for equipment installation support can be incorporated into the acceptance testing.

Predictive and Preventive Maintenance

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
PM program design and implementation Electrical power equipment: Switchgear Outdoor units Circuit breakers PowerNet, etc. Starters Motor control Transformers Tap changers Network protection Medium voltage generators Medium voltage motors Drive systems PLC systems Nuclear safety related 1E equipment	Following construction, EESS can develop a long-term predictive/preventive maintenance program. This allows for recording of the necessary baseline data required for effective predictive maintenance programs. Partial discharge sensors installed in new medium voltage switchgear provide years of predictive diagnostics.	Predictive maintenance involves identifying measurable parameters, which when trended, provide an indication of the reliability and the life expectancy of the subject equipment. Preventive maintenance includes specific maintenance tasks that extend the useful life of the subject equipment. A comprehensive program can be developed, whereby plant personnel complete portions, supplemented by EESS personnel. Plant personnel would perform observations, minor maintenance and data recording. Tasks would be developed to complement plant personnel's existing daily duties. Periodic reports would be issued addressing all trends. Immediate corrective actions would be identified, as well as long-term predictive maintenance requirements. Reliability is improved and downtime reduced by the proper and regular implementation of predictive and preventive maintenance programs.	A properly designed program will take advantage of in-house personnel, thereby providing a cost-effective plan. Program implementation and required corrective actions will result in the longest life expectancy possible. EESS can provide a complete short- and long-range PM program to satisfy your life extension and cost reduction needs. Partial discharge detection identifies insulation deterioration prior to permanent damage and ultimate failure. Efficient outage correction actions can be implemented.

Electrical System Modernization

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
Switchgear bus MVA upgrading	Existing switchgear and bus duct can be retrofitted with partial discharge sensors, therefore allowing for online predictive diagnostics.	With possibly greater utility fault currents, new in-house cogeneration and additional motor loads available, existing bus MVA ratings may be exceeded. Engineering inspection, testing and analysis are employed by experienced engineers to determine corrective measures to improve bus MVA ratings. Life extension is achieved for the entire switchgear lineup when combined with breaker MVA upgrading by vacuum replacements.	
Bus insulation systems	Existing switchgear and bus duct can be retrofitted with partial discharge sensors, therefore allowing for online predictive diagnostics.	Replacement fluidized insulated bus systems are supplied to improve the reliability and extend the life expectancy of the switchgear bus system. During the preliminary inspection, the sources of bus contamination, or environmental factors, are reviewed and long-term system corrections are also implemented.	
Medium voltage vacuum retrofit and low voltage Digitrip RMS retrofits	—	As presented in *Circuit Breaker Specialized Services*, medium voltage vacuum replacements improve the reliability and life expectancy of medium voltage breakers; as well as low voltage Digitrip RMS retrofits do the same for low voltage breakers.	
Low and medium voltage motor starting upgrades	—	Eaton's Cutler-Hammer aftermarket products include AMPGARD® retrofit kits with air to vacuum replacements. In addition, for low voltage motor control and DS switchgear, replacement units are manufactured as direct replacements for Westinghouse and other OEM's MCC buckets. Reliability is improved by the replacement of the operating coils and associated contact assemblies.	Life extension is achieved for medium and low voltage motor control centers by replacing the worn components with new production units. In addition, improved motor protection and communications can be incorporated into the upgrade package.
Low and medium voltage cell retrofit	—	To assist in improving reliability of individual feeder cubicles, Eaton can supply a complete circuit breaker and supporting cell for installation into existing switchgear. The result is a new production unit, custom installed into an existing older vintage switchgear lineup. A site inspection is required to determine the best breaker/cell combination to satisfy the system requirement.	Costs are reduced in comparison to modernizing the entire switchgear lineup. Life extension is achieved for a single cubicle feeder only.
Molded case circuit breaker upgrades	—	Older style molded case breakers can be replaced with new Eaton standard or the high interrupting Series C® class of molded case breakers. Long-term reliability is improved.	Life extension is achieved for the entire lineup by application of new production units into the existing switchboard lineup.
Plant monitoring, protection and control Digitrip PowerNet Advantage starters DeviceNet PLC interface	—	Real-time monitoring and remote control of circuit breakers can greatly improve reliability by providing immediate indication of a problem, allowing for a quick resolution; and if necessary, remote control of power distribution equipment.	Plant electrical system life extension can be achieved by improving the monitoring, protection and control of the individual components in a planned and unified manner. Plant electrical distribution systems are being subjected to higher loads and greater harmonics. Plantwide monitoring can help identify these areas of rapid deterioration, and implement corrective actions to extend the life of the electrical system. In addition, with the advent of utility deregulation, having accurate power usage values will allow for improved negotiating on power purchases.
Power factor control and correction	—	—	Utility rates, as well as internal electrical system losses, are related to power factor. Cost reductions are achieved through proper power factor control and correction. For systems with harmonics, filtered power factor capacitor banks should be designed and installed.
Ground fault detection systems	—	Improved system reliability and personnel safety are achieved by a properly applied ground fault detection system. Systems can be applied at MV, or low voltage levels by the use of Eaton products.	Costly outages, and faults related to repeated arcing grounds, can be eliminated, as well as providing an improved environment for personnel safety.
High resistance grounding and detection	—	High resistance grounding systems can be installed on ungrounded systems. These systems will limit the ground fault current, thereby reducing ground fault damage. The advantages of an ungrounded system are maintained with the added feature of ground detection and correction while maintaining system operation.	Costs are reduced by limiting the damaging effects of ground fault current and reducing the troubleshooting time to locate grounds. Ground fault pulsing allows for locating the ground, with portable hand-held sensing devices, during online operation.
Surge/lightning protection systems	—	Outages can be prevented, related to surges or lightning by the proper application of protective devices.	Costly equipment damage can be eliminated.
Automatic transfer scheme upgrades	—	Older automatic transfer schemes employ old relay systems. The relay coils may be at the end of their useful life, and operation can not be assured for the next required automatic transfer. Unfortunately, most defective transfer schemes are not detected until a failed operation has occurred.	Cost reductions related to downtime are eliminated, by a review and upgrade of older transfer schemes, before the first failed automatic transfer operation occurs.

Electrical System Modernization, continued

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
Network protector service/relaying systems	—	Network protector relaying systems require service and testing to ensure continued proper operation. Older relaying systems can be upgraded, and complete network protector service is available to improve reliability.	Life extension is achieved by proper servicing, and/or upgrading of network protector components. Complete network protector reconditioning is also available from Eaton.
Generator voltage regulation and static excitation systems	—	Many older in-house cogeneration units have antiquated voltage regulation and excitation systems. These older systems can not function with the precision of modern replacements, and often require extensive maintenance. Eaton offers a complete range of products to apply to these older systems, thereby improving overall system reliability and reducing downtime.	With the advent of utility deregulation, in-house cogeneration has become a critical source of supplemental electrical power, for peak-shaving and negotiating competitive power usage rates. With the associated maintenance of the mechanical and rotating components, the life expectancy can be extended with the inclusion of a modern electrical control system.
Reduced voltage and soft starters	—	Application of current production starters will improve reliability due to the new components installed.	Starter retrofits can be easily justified based on energy cost savings, and reduced wear-and-tear on the process line during starting.
Synchronous motor field application	—	Many older synchronous motors employ field application panels that are obsolete, with parts support no longer available. Applying a new Eaton field application package will improve reliability and reduce future downtime.	Life extension can be achieved for the synchronous motor field application system by applying new Eaton products.
Drive systems PLC process systems	—	Retrofitting older drive and relay-logic process systems with new drives and PLCs provides for greater reliability and reduced downtime. Older devices are eliminated, thereby eliminating nuisance control problems.	Process cost reductions will be realized by drive system PLC improvements due to greater control of production parameters. Eaton sensors, in conjunction with drive and PLCs, can provide a complete modernized production system.
All OEMs upgraded Westinghouse/GE/ITE BBC/ABB/Square D Allis Chalmers/Siemens/ Federal Pacific/Roller Smith	—	Field personnel are experienced in Eaton equipment, as well as other manufacturer's equipment. This cross-OEM experience allows the application of singular new products to satisfy many OEM upgrading needs and provide uniformity across the various OEM's equipment.	

Circuit Breaker Specialized Services

Engineering Services Capabilities	New Construction and Facility Growth	Improved Reliability and Reduced Downtime	Life Extension and Cost Reductions
Low and medium voltage replacement circuit breakers	Spare cubicles, part of new construction with a planned expansion, can be equipped with low voltage and medium voltage replacement breakers. Eaton circuit breakers and other OEM circuit breakers can be supplied.	Downtime can be substantially reduced by allowing our Aftermarket Centers of Excellence to provide spare replacement breakers.	Aging circuit breakers can be replaced with direct roll-in replacements, thereby extending the life of the entire switchgear assembly.
AR-Series low voltage replacement breakers Westinghouse Allis-Chalmers Federal Pacific and others	—	Eaton's AR-Series low voltage replacement breakers provide a solution tailored to meet safety and reliability concerns while eliminating the need for new switchgear. AR-Series breakers are 100% new and are designed to be electrical and mechanical equivalents of the vintage breakers they replace. They are not "retrofits" and do not reuse any parts from the original breaker. The same safety, reliability and maintainability of new switchgear are obtained for a fraction of the total installed cost.	Life extension is achieved by upgrading existing breakers to the most current breaker technology. The AR-Series solution will result in a number of reduced costs associated with maintaining or replacing vintage equipment. These cost reductions include: reduced maintenance time, decreased outages due to readily available parts, elimination of field engineering costs, reduced spare parts investment increase safety.
Low voltage retrofits Digitrip RMS kits Westinghouse Cutler-Hammer GE ITE/BBC/ABB Allis-Chalmers Siemens Federal Pacific Square D Roller Smith	—	Eaton Digitrip RMS kits have been widely used to modernized low voltage circuit breakers. They offer advanced RMS sensing, digital display of current, improved protection, fault indication, self-testing and communications to Eaton's PowerNet system. Retrofits greatly improve reliability by applying the latest technology to existing circuit breakers.	Life extension is achieved by upgrading the critical trip system on low voltage circuit breakers. In addition, future testing costs are reduced, and in-house testing can be applied by the purchase of a portable test set.
Medium voltage vacuum roll-in circuit breakers Eaton new production breaker element Full ANSI design testing Increased MVA ratings available Field installation and startup	—	Older air circuit breaker contacts, arc chutes, mechanisms, secondary disconnects, etc., are replaced with current production vacuum breakers, incorporating all of the above into a single, fully ANSI tested device. Long-term reliability is improved.	Life extension of medium voltage switchgear assemblies can be accomplished by the replacement of existing air circuit breakers with new vacuum breakers. Eaton's Electrical Sector manufactures widely used vacuum breaker elements for this purpose.
Low and medium voltage recondition Aftermarket centers of excellence (ACE)	—	All components are refurbished, or replaced, depending on the extent of service contracted. Spares are available for interchanging units during scheduled outages, resulting in long-term reliability gains without costly unexpected outages.	The low and medium voltage breaker life is substantially extended. In addition, the service can include the application of modernized rms sensing trip systems. Specialized Navy, or Nuclear Safety Related 1E units are also serviced.
MCC motor starter buckets	—	Replacements provide all new components and added reliability.	Spares are available to provide extended life, during schedule outages.
MCC replacement buckets for other manufacturers	Add buckets or increase starter sizes in existing equipment.	Replacement units are newly manufactured including stabs and all breaker and control components. They utilize state-of-the-art technology increasingly reliability and uptime.	Many designs of vintage MCC are no longer supported. Eaton's replacement units offer a cost-effective means to extend the life or modernize existing equipment without the need to replace the original MCC.

Partial Discharge Testing

Contents

Partial Discharge Testing

General Description

Application

Eaton's Electrical Services & Systems has developed state-of-the-art technology to allow for the long-term predictive diagnostics of medium voltage equipment. New or existing medium voltage switchgear lineups are equipped with partial discharge (PD) sensors to measure PD within the cubicles. The sensing technology provides measurement of all discharges through noninvasive sensing of the electrical power signal. Measurements are performed online, while switchgear equipment is energized under normal operational conditions, using measurement equipment specifically designed for this purpose.

Functionality

PD sensors detect partial discharges, which are the initial indicators of corona or surface tracking. Corona and surface tracking are the primary root-causes of insulation deterioration in medium voltage electrical equipment. The sensitivity of PD sensors and measurement technology is sufficient to detect early stages of defect development by measuring PD of low levels (less than 50 pico-coulombs). PD occurring within the cubicles as well as PD emanated by external sources (cable terminations, cables, bus ducts, connected transformers, motors, etc.) within a limited distance is identified. Sensors allow for periodic partial discharge sensing from the front of each switchgear cubicle without the need to open cubicle doors, using measurement equipment specifically for this purpose.

Eaton provides a PD sensor for each cubicle within the switchgear lineup. Sensing for PD at the ends of the switchgear lineups only is not acceptable due to the signal attenuation of PD. The sensing must occur in each individual cubicle to ensure maximum sensitivity and predictive value of the measurements.

Calibration and Baseline Measurements

New switchgear can be monitored at the factory prior to shipment, and a baseline signature of PD is provided with the switchgear. Field startup service includes obtaining a post-installation signature of the PD. In-service medium voltage switchgear, which is retrofitted with PD sensors, will have an initial baseline measurement obtained, whereas our database of switchgear PD measurements does allow us to provide immediate results concerning the insulation condition.

PD Analysis Instrumentation (for use during periodic PD measurements)

Eaton measurement and analysis instrumentation is capable of periodically detecting partial discharges related to medium voltage switchgear, medium voltage motors and generators, medium voltage cables, transformers and other medium voltage electrical equipment. It completes concurrent sampling of a minimum of four channels, able to effectively suppress electrical noise, eliminate cross-coupling of measured PD signals, maintain a detection sensitivity of 50 pC or better, and disseminate the type of discharge measured. Immediate report documentation is incorporated within the instrumentation software, with analysis and recommendations included in the final report.

Transformer Predictive Diagnostics

(Bushing Power Factor, Partial Discharge and Vibro-Acoustics)

Transformers, with a primary voltage at or above 68 kV, and containing capacitive taps on the primary bushing, should be equipped with a continuous monitoring system to allow for pre- and post-shipment measurement of bushing power factor and internal PD. In addition, vibro-acoustics testing can be completed both prior to shipment and after final installation. Vibro-acoustics testing will indicate any initial internal winding or core looseness prior to shipment, and confirm that no additional internal stress has occurred during shipment and installation. This additional field-testing provides for immediate indication of any problem related to the manufacturer, transportation, installation and startup. Vibro-acoustics also provides indication of internal looseness related to over-drying out of insulation during oil processing, and can provide diagnostic information in preparation for a transformer internal inspection. In addition, these systems provide a method to complete future predictive diagnostics, online, without any equipment outage, therefore providing extended life and increased equipment uptime.

Transformer Bushing Monitoring System

Eaton's system monitors the changes in the bushing insulation, for the set of three bushings in a group, based on changes in bushing capacitance or bushing power factor.

The system detects changes of the power frequency current through the bushing insulation. If the transformer has 6 or 9 bushings (two or three windings), additional systems can be installed as required. The measured current through the bushing insulation can not be less than 2 mA. The system also provides provisions for the connection of instrumentation for periodical PD measurements using portable equipment without requiring a transformer outage, or any modifications to the sensing circuit.

Sensors

The power factor (PF) sensors are connected to the bushing capacitance taps. All sensors are designed for outdoor installation within the ambient temperature minus 50°C to plus 50°C. Insulation level (withstand 1 minute AC voltage) between primary and secondary circuits is: bushing sensor 1.5 kV plus overvoltage protection; neutral sensor 15 kV; tank, core or cable shield grounding 2.5 kV; and 5 sheath 1.5 kV. The sensor system also includes overvoltage protection to suppress all overvoltages, arising during transformer operation, below this level. Temperature sensor, if used with a digital device, is of a standard RTD type. Sensors also provide provisions for periodic PD measurements online, using separate instrumentation designed for this purpose.

Instrumentation

Eaton's predictive analysis instrumentation is capable of precise continuous measurement of the capacitive current through the bushing insulation while the transformer is energized. The minimum detectable change in current is 0.1% of the initial current. The temperature deviation of the signal is the same order. The display is available from the bushing monitoring instrumentation for one complex PF signal per bushing group, which will include the display of the current PF value. The following output signals can also be provided as required: Two alarm signals (dry contacts) for a local alarm system, and additionally 4–20 mA DC output for an analog re-transmitting or serial interface for digital re-transmitting. Instrumentation is completely isolated from high voltages and feature immunity to high voltage transients. Full field calibration procedures are supplied with the instrument's operation manual. All necessary connections for the selected options are supplied with startup and baseline calibration.

Software (Digital Option)

Eaton's monitoring software is compatible with Microsoft® Windows® 95 or high O/S based systems with the following features: display of the PF value for the group of three bushings (up to three groups), storage and trending of the PF value for all monitored groups (up to three), trending PF readings versus temperature, alarm threshold setting, alarming upon PF reaching the preset thresholds, printing and plotting of the historical data.

Calibration, Manuals and Baseline Measurements

Eaton provides full field calibration and startup. A separate independent PF test is performed of each bushing as part of the startup and calibration process. Transformer bushings are calibrated and baseline measurements obtained. Part of the field startup service includes obtaining a post-installation baseline measurements to ensure no detects have resulted during bushing installation and/or transformer transportation, installation and startup. A report with any recommendations is also provided. A complete manual is supplied for both the instrumentation and the software describing the operation of the instrumentation, calibration and troubleshooting.

Remote Monitoring

Eaton can monitor any asset using partial discharge equipment by several secure methods including cellular, Ethernet or dial-in. Eaton has a secure APN that enables the most secure connections available and can provide monthly reporting, alarms and product support.

Online Transformer Partial Discharge Monitoring

Eaton also installs PD sensors to allow for online PD measurements within a transformer. PD measurement can be periodically obtained while the transformer is online and in normal operation, using separate instrumentation designed for this purpose. The measurement system can assess the insulation condition based on PD measurement of the bushings and the transformer windings insulation. The system is also capable of detecting sparking in the core, sparking associated with connections, and sparking associated with the static electrical discharges.

Sensors and Instrumentation

Sensors are noninvasive and have no connection to the energized components. Sensors are designed for outdoor installation within the ambient installation within the ambient temperature –50°C to +50°C. Sensors are connected, as required based on the field conditions, to the following locations: bushing capacitor taps, transformer neutral connection, tank grounding, core grounding, electrostatic shield grounding, surge arresters, isophase bus enclosure bonds and grounds. The sensor frequency range of operation is 500 kHz to 50 MHz. Insulation level (withstand 1 minute AC voltage) between primary and secondary circuits is: bushing sensor 1.5 kV plus overvoltage protection; neutral sensor 15 kV; tank, core or cable shield grounding 2.5 kV; and isophase sheath 1.5 kV. The sensor system also includes overvoltage protection to suppress all overvoltages, arising during transformer operation, below this level.

Part of the field startup service includes obtaining post-installation baseline measurements to ensure no defects have resulted during bushing installation and/or transformer transportation, installation and startup. A report with any recommendations is also provided.

Measurement Parameters

Eaton's instrumentation measures the following: apparent PD magnitude of each impulse, number of impulses per cycle, phase position of each discharge impulse, impulse repetition rate, impulse discharge power, and peak discharge magnitude of the impulses. The following quantities are plotted and displayed in a report format: apparent discharge magnitude of each impulse, number of impulses per cycle, phase position of each discharge impulse, impulse repletion rate, impulse discharge power, peak discharge magnitude of the impulses, impulse count and PD magnitude vs. phase position representation and impulse PD power. The above information is provided to support the findings and recommendations, which are contained in a field report.

Vibro-Acoustic Analysis of Transformers

Eaton can perform vibro-acoustics testing prior to shipment and after final installation. Vibro-acoustics testing indicates any initial internal winding or core looseness prior to shipment, and confirms that no additional internal stress has occurred during shipment and installation.

Periodic Partial Discharge Analysis Software

Eaton's expert monitoring system applies analysis software, during periodic measurements, with the following features: display of PD data, statistical processing of the PD data, data storage and editing, and instrumentation control. All data from the test is automatically saved to a hard disk in a database format. The stored data format is compatible with Microsoft Windows applications Word®, Excel®, Access® and others. All standard "Microsoft Windows" control functions such as printing, and cut and paste operations are available within the software. Upon initiation, the software performs self-diagnostic procedures to ensure all components are operating correctly.

Calibration, Manuals and Baseline Measurements

Part of the field startup service includes obtaining post-installation baseline measurements to ensure no defects have resulted during bushing installation and/or transformer transportation, installation and startup. A report with recommendations is also provided.

Measurements

Vibro-acoustics is based on collecting steady-state vibro-acoustic data from the outside of the transformer tank under two load conditions and subsequent automated analysis of the energy distribution among different frequencies in this vibration data. The first measurement at no-load will be obtained prior to shipment. A subsequent, post-installation, no-load, vibro-acoustic measurement is also completed on-site to verify no internal stresses resulted during shipment or installation.

After the unit is loaded to approximately 50%, or greater, a second set of measurements shall be obtained. Two subsequent measurements, at 6 and 12 months, following continuous online operation, are recommended. Further follow-up measurements will be on an as-determined basis. Measurements are made at 12 locations on the transformer tank, 6 on the HV side of the transformer tank and 6 on the LV side (the HV side indicates the side with HV bushings, and the LV side indicates the side with the LV bushings).

Traditional Transformer Startup and Acceptance Testing

The above transformer predictive diagnostic systems and field startup testing is completed by Eaton in addition to traditional transformer factory and field acceptance testing in accordance with ANSI, IEEE, and other applicable testing standards. For example, a separate independent power factor test is required of each bushing as part of the startup and calibration process. These additional tests provide for immediate indication of any problem related to manufacturer, transportation, installation and startup. In addition, Eaton's predictive diagnostics provides a method to complete future predictive diagnostics, online, without any equipment outage, therefore providing extended life and increased equipment uptime.

InsulGard Predictive Relay

Contents

Medium and High Voltage Predictive Diagnostics Online Monitoring and Partial Discharge Analysis

General Description

Eaton's predictive diagnostics offers predictive diagnostic equipment and systems for medium and high voltage equipment. Much of Eaton's technology is based on the measurement and analysis of partial discharges (PD). PD is a well-known and an industry-accepted indicator of insulation deterioration that leads to equipment failure.

Studies have shown that approximately 80 percent of all equipment failures occur on a random basis and are not age related. The statistic indicates that whatever we are doing today in terms of preventive maintenance is not overly effective and that there are opportunities for major improvements.

Certainly, a well-designed, time-based preventive maintenance program will have a profound positive effect on failure rates, but they are generally invasive in nature. This invasiveness has a tendency to increase failure rates due to the introduction of new defects, resulting in infant-mortality failure patterns.

With industry moving toward fewer and shorter outages, companies are looking for alternative and predictive technologies to protect their investment, lower maintenance costs and increase system reliability. Use of the technologies provided by Eaton will do just that.

Application Description

InsulGard Predictive Relay for Continuous Monitoring and Analysis of PD

Applications of the InsulGard system are available for equipment that are rated for 4000V to 38,000V and include:

- Motors/generators (RTDs are also used as sensors)
- Switchgear systems
- Bus ducts
- Power center transformers
- Gas insulated substations
- Splices and terminations of cables

Features, Benefits and Functions

InsulGard—Transformer Monitoring System

Data gathered from Doble conferences and other scientific papers indicate that bushing failures are responsible for up to 35 percent of all large power transformer failures. This data also states that 52 percent of bushing failures are violent in nature, which presents safety concerns, as well as concerns related to environmental damage.

Among Eaton's capabilities is the ability to continuously monitor the changes in the C1 capacitance, as well as any changes in the dielectric losses of the bushing (bushing power factor). It's like having a continuous online Doble test of the bushings under true electrical stress and temperature. We also have the ability to test the bushings and the power transformer windings for PD on a periodic basis, while the equipment is in operation.

Eaton's comprehensive transformer monitoring system incorporates permanent PD sensors to timely detect a wide range of electrical problems (PDs, surface tracking, arcing, sparking) in bushings, winding insulation, core, laminations, tap changer connections, ground connections, pressboard barriers, etc. Ideal system for critical transformers or to keep your troublesome unit out of trouble! Implementation of Eaton's predictive diagnostics provides an analysis of your critical equipment to reduce the risk of failure and increase uptime.

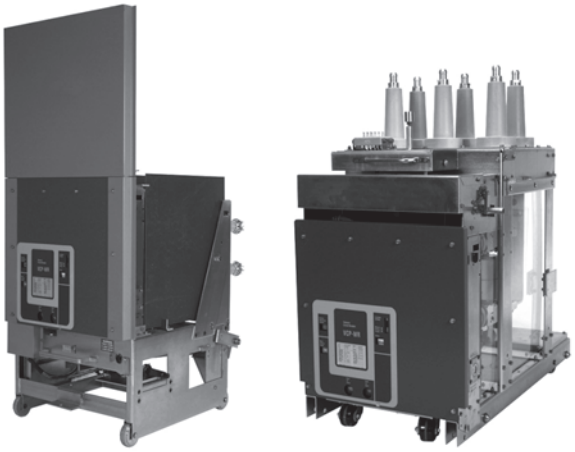
Benefits of Using the InsulGard System

- Saves money
- No labor is required to conduct test
- More efficient deployment of personnel. Labor can be reallocated to fix problems (instead of look for them) and take care of other important matters
- Tests are performed online
- No loss of asset productivity
- More accurate data as tests are conducted under actual operating conditions
- No infant-mortality patterns that are commonly introduced via invasive testing procedures
- Tests are continuous
- Finding a problem is not left to chance (like interval testing). You will know when a problem started and how rapidly it is progressing
- No surprises and no forced outages. Increased safety—you will always be aware of conditions/ problems
- Allows trending of other variables that affect PD activity such as load, temperature and humidity
- Unnecessary maintenance is reduced because you are constantly testing and have more accurate data on which to base decisions
- You have achieved predictive/conditioned-based maintenance versus interval/chance maintenance
- You can prioritize which equipment receives service first—a true maintenance planning tool

Benefits of Remote Monitoring

- Relieves the burden of data analysis
- Experts are readily available
- Safe, secure and reliable data collection
- Cost-effective—eliminates cost of expert traveling to site
- Automatic, easy to understand reports

VR-Series Breakers



Contents

Medium Voltage Vacuum Replacement Circuit Breakers

Product Description

History and Technology

Most medium voltage air magnetic power circuit breakers have been in service for 25 years and some for as long as 60 years. They were reliable and for many years maintainable. Increased short-circuit capabilities in utility and industrial power systems have created "over-duty" situations with many of these breakers. Parts availability has also increased the cost of maintaining the breakers in peak condition.

In the mid 1970s, circuit breaker manufacturers began introducing vacuum technology for medium voltage power circuit breakers. It was desirable and feasible to incorporate the advantages of vacuum technology into replacement breakers that would directly interchange with the existing medium voltage air magnetic power circuit breakers to extend the useful life of their existing switchgear. Most users wanted a replacement that was functionally interchangeable, both electrically and mechanically, with their existing medium voltage air magnetic power circuit breakers.

The market responded by offering "retrofits" that utilized the existing breaker trucks (frames) and vacuum circuit breaker modules. These alternatives provided extended life for electrical equipment, reduced maintenance, and allowed increased capabilities for many distribution systems. IEEE/ANSI established a standard for retrofits (IEEE/ANSI C37.59) in 1991 that put consistency in the retrofit process. However, retrofits were costly, caused inconvenience for users, required months to complete, and the lack of configuration control made it difficult to standardize designs.

Eaton now offers new VR circuit breakers that can be supplied in place of the old retrofit technology. Unlike retrofits, VR power circuit breakers are new from the ground up and offer improved performance, maintainability and convenience over retrofits. They can be supplied in large quantities to facilitate complete substation upgrades in a single outage. System upgrades to handle higher short-circuit levels are available.

Application Description

Eaton's vacuum replacement (VR) circuit breakers are fully engineered and tested to provide the user with a means of modernizing electrical power distribution systems, and in most cases, extending the life of the equipment while improving performance and system reliability.

Medium voltage Type VR circuit breakers are available for 5 kV through 15 kV distribution systems.

Features, Benefits and Functions

Eaton is a world leader in circuit breaker technology. The same reliable vacuum technology is used in our VR circuit breakers. Eaton's vacuum interrupter is used in many manufacturers' switchgear breakers worldwide. Many of the components and sub-assemblies in Eaton medium voltage VacClad-W metal-clad switchgear are the same as those used to manufacture the VR product line. This helps reduce spare parts inventories and the amount of required maintenance training.

Eaton vacuum technology reduces maintenance since the contacts are sealed from contaminants in the environment, no adjustments or cleaning of the main contacts are required, and the main contacts require no special gauges or devices to measure wear or contact pressure. Annual lubrication and testing can be performed in a fraction of the time required for air magnetic circuit breakers.

Eaton's non-sliding current transfer system eliminates the need to check and tighten connections between the vacuum interrupter stem and the main conductors or the circuit breaker. The connection is permanent and provides high conductivity without creating hotspots and Holm effect as found in half-clamp connections.

SURE CLOSE MOC operators are available to provide dependable MOC operation that is decoupled from the main closing function of the VR circuit breaker mechanism. This prevents the VR circuit breaker from stalling or failing to latch during the closing operation. *SURE CLOSE* mechanisms also have adjustable stop positions to control over-travel of MOC switch operators.

Service Life

Most medium voltage air magnetic circuit breakers have been in service for 25 to 60 years. As long as the bus structures, insulation systems and general mechanical condition of the switchgear cells/structures are maintained in good condition, equipment life can easily be prolonged with the addition of VR circuit breakers.

Availability

VR breakers are available in a wide range of ratings and models to replace medium voltage, air magnetic circuit breakers originally manufactured by:

- Westinghouse
- General Electric
- Allis-Chalmers/Siemens
- Federal Pacific Electric
- ITE/ABB
- McGraw-Edison

Required Information

In order to obtain the correct VR circuit breaker, the following information should be provided to Eaton:

- Original switchgear manufacturer
- Original breaker manufacturer
- Breaker type or catalog number
- Maximum voltage rating continuous current rating and maximum short-circuit or MVA rating
- Control voltages
- List of options and/or modifications
- Copy of schematic and wiring diagram
- Year of manufacture of original breaker and switchgear
- MOC requirement

For site-specific specifications, contact your local General Field Sales Force office, or your local Engineering Services center.

Detailed Requirements

General

This section covers the design, testing and manufacturing requirements for new vacuum replacement (VR) circuit breakers for use in medium voltage metal-clad switchgear. The VR circuit breakers will be functional replacements (both mechanically and electrically) for the air magnetic circuit breakers they replace. The VR circuit breakers will be interchangeable (within the limits of the original switchgear) between different types of cells (structures) of the same voltage, MVA and ampere class without cell (structure) modifications.

Note: Retrofits, as defined by IEEE/ANSI C37.59-1996 6.1.4.2 are not covered and will not be considered as an alternative or substitute for new VR circuit breakers.

Scope of Work

Eaton's Electrical Sector will provide all project management, factory and field engineering, short-circuit and coordination studies (if required and at an additional charge), supervision, labor, material, tools, rental, test equipment and transportation as defined for a complete VR circuit breaker replacement of the required existing medium voltage switchgear circuit breakers. The VR circuit breakers will be designed for maximum voltages of either 4.76 kV, 8.25 kV or 15 kV as required.

MVA Ratings

The available MVA rating of the VR circuit breakers are as follows:

All Eaton switchgear structures designated for VR circuit breakers with increased MVA levels will have the existing bus bracing analyzed. EESS will determine if bus bracing is capable of withstanding the maximum (peak) momentary ratings per ANSI C37.09 and ANSI C37.20.2 capabilities of the new VR circuit breakers. EESS will provide documentation to verify that the switchgear bus is sufficiently braced to handle the new ratings or supply the cost as a separate item to increase the bus bracing of all designated switchgear structures in the lineup to comply with the increased MVA ratings. Following the study and/or the bracing modifications, Eaton's service engineer will affix a nameplate to each switchgear structure stating the new MVA rating, the manufacturer's name and the date of verification or upgrade.

VR Ratings

Volts kV	Original MVA ①	New MVA
4.76	100–250 ②	250
4.77	100–250 ②	350
8.25	150–500	500
15	150–500	500
	150–500	750
	150–500	1000
	750	1000
	150–1000	1500

Notes

① MVA is obsolete switchgear terminology and is used for reference only in this document.

② 26-inch (660.4 mm) wide cells only.

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Cubicle Modifications

The VR circuit breakers are designed to be interchangeable with existing breakers of the same continuous current and MVA ratings without required modifications to the existing cubicles in most cases. Any required cell modifications are designed to be reversible. Existing cell coding systems are retained where possible.

VR circuit breakers with upgraded/increased MVA or continuous current ratings do require modifications to the cubicle coding system to prevent the insertion of breakers that do not have the same ratings as the upgraded VR circuit breakers.

Applicable Standards

All VR breakers will be designed, manufactured and tested in accordance with the applicable sections of:

- IEEE C37.59-2007 (cell interface and testing criteria)
- IEEE C37.04
- IEEE C37.06
- IEEE C37.09
- IEEE C37.20.2
- IEEE C37.100
- IEEE C37.100.1
- IEEE STD 4-1995

Materials

All materials used in the manufacturing of the new VR circuit breakers will be new and unused. No parts or materials from the original air-magnetic circuit breakers will be reconditioned and reused in the manufacture of the new VR circuit breakers. All components used in the manufacturing of the new VR circuit breakers including, mechanism, vacuum interrupters and frame components will all be manufactured by Eaton to ensure single-source reliability and responsibility.

Manufacturer's Qualifications

Eaton is currently engaged in the design and manufacturing of medium voltage vacuum circuit breakers and switchgear structures. Eaton has a minimum of 50 years experience in switchgear manufacturing, is a member of the National Electrical Manufacturers Association (NEMA), and has representation on IEEE C37 Switchgear Working and Balloting Groups, and owns and operates an engineering services organization.

Eaton's Electrical Services & Systems (EESS)

- Experienced, factory-trained field engineers and technicians familiar with the installation and startup of medium voltage VR circuit breakers
- A minimum of 30 field service locations staffed with engineers that are available on a 24-hour basis for emergency service
- Capabilities of on-site cell alignment, breaker levering system repairs and control system modifications
- Capabilities to perform computer-generated short-circuit, coordination and load flow studies for final breaker trip settings. All studies will be conducted under the supervision and approval of a registered professional electrical engineer skilled in interpreting studies and test results regarding medium voltage VR circuit breakers. The Registered Professional Electrical Engineer is a full-time employee of EESS

Vacuum Circuit Breaker Module Features

The VR circuit breakers will utilize vacuum circuit breaker modules manufactured by Eaton. Acceptable conversion modules are the VCP-18WR, VCP-20WR, VCP-29WR and the VCP-29WRSE.

Common Pole Shaft

The circuit breaker mechanism will open and close all three phases and any auxiliary devices via a common operating shaft to ensure consistent and simultaneous operation of the main contacts. The shaft will be supported at the ends and along its length with bearings. The main drive shaft will be connected to the individual vacuum interrupters via insulated drive links.

Insulated Drive Links

The mechanism drive shaft will be connected to each moving contact via an insulated drive link made of glass-reinforced polyester for element types VCP-18WR, VCP-20WR and VCP-29WR and cycloaliphatic epoxy for the VCP-29WRSE. The insulated link material is non-hydroscopic and meets the flame-retardant requirements as set forth in IEEE C37.20.2. The drive links are easily removable with single clevis pins at each end and spring retaining clips.

Shock Absorber System

The mechanism will contain a shock absorber system to dampen the opening force of the circuit breaker. The shock absorber has sufficient resilience to prevent contact bounce that could cause a restrike of the main contacts during the opening of the circuit breaker or during a spring discharge. The VCP-20WR, VCP-29WR and VCP-29WRSE vacuum conversion element's mechanism consists of a series of parallel steel plates with spring separators that spread the plates during breaker opening. The shock absorber has a design life of 10,000 breaker opening and closing cycles without the need for repair, replacement or adjustment. The VCP-18WR has a sealed replaceable shock absorber and is capable of being adjusted if replaced or during initial mechanism assembly.

Manual Trip and Close

The mechanism has front accessible manual close and trip operators that are directly connected to the breaker operating mechanism and are an integral part of the electrical close and trip coils.

Operations Counter

Each VR circuit breaker mechanism has a five digit non-resetting mechanical operations counter connected to the operating shaft.

Spring Charged Indicator

Each operating mechanism will be equipped with a visible indicator to show the state of the stored energy mechanism. The indicator will show when the spring is fully charged or discharged.

Auxiliary Contacts

The breaker will have a low inertia, rotary operated auxiliary switch connected to the main pole shaft assembly. Connections will be made via insulated ring-tongue terminals.

Vacuum Bottle Assembly

The vacuum bottle assembly will be constructed from virgin materials and manufactured by Eaton. The contacts will be principally composed of powdered metal, chromium-copper contact material. The powdered metal is fused under high pressure to form a consistent contact material. The contacts are machined to form spiral petal contacts to assist in the swirling of the arc during interruption.

The edges of the ceramic components will be "metallized" and fired prior to assembly. The components are inspected and assembled in a Class 1000 clean room prior to sealing the components. The components are inserted into a vacuum heat chamber and sealed under vacuum. No "pinch tubes" are used.

A stainless steel corrugated bellow achieves isolation of the ambient air and the vacuum. The moving contact stem of the vacuum interrupter has a machined groove to prevent rotation of the contact within the vacuum chamber.

The vacuum interrupter has a visual method of identifying contact wear without the use of gauges or other devices. In addition, a separate visual "T-cutout" is used to verify that the mechanism is applying adequate spring pressure to the contacts when the breaker is in the closed position.

The contacts are self-aligning and do not require adjustments for the life of the vacuum interrupter assembly. The contacts also have a spring system to apply proper contact pressure. The operation of the contacts cause a wiping action to clean the contact surfaces.

Insulated Pole Assemblies

Pole assemblies are insulated from ground with non-hydroscopic insulating materials manufactured from glass-reinforced polyester.

Current Transfer System

The current transfer from the conductor stem to the primary bushing assemblies is via a non-sliding current transfer system consisting of a fused stem assembly and a V-Flex™ silver-plated copper leaf conductor or folded leaf copper shunts. The stems have the adjoining conductors mechanically fused with the stem material. This junction forms a solid current transfer.

Trip-Free Operation

The new VR circuit breaker operation mechanism is a "true Trip-Free" design. When the trip function is mechanically engaged and held, and the close function is initiated either electrically or mechanically, the contacts do not close. The contacts are restricted to 10% of the total travel.

Mechanical Status Indicator

Each new VR circuit breaker has a mechanical status indicator with the word "CLOSED" on a red background when the breakers are closed and the word "OPEN" on a green background when the breakers are open.

Breaker Truck/Frame Assembly

Frame Materials and Plating

The frame is constructed from steel, utilizing a combination of bolting and welding to assemble the frames. All frames are zinc-plated.

Wheels and Casters for Transport

VR circuit breakers are supplied with a transport system that is a functional replacement of the transport system of the original design. The transport system conforms to the requirements of the original design.

Hardware

All hardware is a minimum grade five, zinc-plated with a yellow dichromate finish or black oxide.

Bushing and Interface Conductor Material

Primary and power frequency interface conductors are constructed of 100% IACS electrical grade conductive copper. Conductors are either silver- or tin-plated to a thickness of 0.0001–0.0002 for non-sliding surfaces and 0.001–0.002 for sliding surfaces. The power frequency conductors are sized to carry the full load ampacity of the circuit breaker without exceeding the temperature rise established in IEEE C37.09.

Insulation Systems

All bushings utilize either glass-reinforced polyester or molded cycloaliphatic epoxy insulation systems or engineer approved equal. Fluidized epoxy coatings are used to insulate interface conductors when necessary.

Phase barriers are manufactured from GPO-3 glass-reinforced polyester or equivalent and designed to isolate individual phase conductors. Openings are minimized to reduce the possibility of ionized gas propagation between phases.

Corona Shields

All 8.25 kV and 15 kV class breakers have internal corona shields when bushings are mounted on metallic back planes. The corona shields are permanently grounded. Bushings mounted on nonmetallic back planes do not have internal corona shields.

Primary Connections

Primary connections (finger clusters) are new and designed to carry the full nameplate rating of the replacement breaker without exceeding the allowable temperature rise as stated in ANSI C37.04.5.4.2-1979. In addition, the primary connections are capable of withstanding the full momentary/close and latch rating as well as the K*I current rating for two seconds without melting, arcing or pitting the contact surface.

Ground Contacts

A metal-plated, self-coupling, separable grounding contact shall be supplied.

Control Circuit Wiring

Control wiring is SIS cross-linked polyethylene, #14 AWG minimum except for short runs such as coil and motor leads. Insulated ring tongue terminals are used. Solder or "fast-on" type connections are not used. Upfront, easy access terminal blocks are provided for maintenance and troubleshooting.

Stored Energy Discharge

The replacement breaker incorporates a manual and an automatic system to completely discharge all stored energy before the circuit breaker is fully withdrawn from the switchgear housing. The system will never intentionally discharge the stored energy while in the connected position.

Passive Interlocks

The mechanism will have a passive interlock to block the insertion or removal of a closed breaker. The system also prevents the insertion of the levering tool at any time the breaker is in the closed position.

Active Interlocks

Each breaker has an active interlock system. The system is operated by the insertion or removal of the VR circuit breaker. In the event the passive interlock is defeated, active interlock system will trip and open a connected, closed breaker if an attempt is made to remove it from the connected position. The system also holds the breaker in the "trip-free" position at all times between the test and fully connected positions.

Locking Means

Locking means is provided to lock the circuit breaker while in the fully connected or disconnected positions. The lock prevents the insertion or removal of the breaker. The lock will not prevent the breaker from being operated while in the fully connected position.

Secondary Contact Block

Control wiring connections between stationary structure and the removable breaker are provided with automatic, self-coupling contacts. The secondary blocks will be mold cycloaliphatic epoxy insulation. The pins are drilled and tapped to accept standard 8-32 screws for ease of maintenance and wiring changes. The secondary contact block is made of cycloaliphatic epoxy.

MOC Operator

All breakers will be furnished with MOC operators unless specified. The MOC operator will have sufficient power to operate the largest MOC switch or combination of switches in the switchgear lineup without affecting the breaker's ability to completely close and latch. The MOC driver is completely "decoupled" from the main breaker operating shaft and shall be powered by separate operating springs. The system is *SURE CLOSE* as manufactured by Eaton's Electrical Sector.

Cell Coding System

Eaton will supply or interface with the cell coding system to prevent the accidental insertion of a breaker into a cell of a different voltage, current, interrupting capacity or physical arrangement than the type intended for the switchgear cell receiving the breaker.

Design and Certification (Type) Testing

Each new VR circuit breaker supplied will have type tests performed on its base design to certify it to IEEE/ANSI standards. All Certification (Type) shall be performed in a switchgear cell/structure when required or an equivalent structure where permitted by ANSI C37.09. Written test reports, data logs and digital reproductions of the pulse used to perform the BIL test will be on hand for review by the buyer.

BIL—60 kV for 4.76 kV applications, 95 kV for 8.25 and 15 kV applications as a minimum> crest with 1.2 µsec x 50 µsec x 50% wave shape per IEEE C37.09. The tests will be conducted per IEEE STD 4-1995. This test shall be performed in a breaker cell or cell equivalent with controlled humidity levels. Corrections for barometric pressure and ambient temperature will be applied to the test parameters. The breaker must pass a total of 54 shots.

Mechanical operations tests of each breaker design are performed in a switchgear cell designed to accommodate MOC switches. The maximum number of auxiliary MOC devices or their equivalent force will be applied during the test to ensure that the vacuum breaker has sufficient power to operate the auxiliary devices, successfully closes and latches during each operation, and that no fatigue or failure occurs. Consideration is given to designing a system that will not damage the MOC switch in the switchgear cell structure.

Momentary tests per IEEE C37.20.2 will be performed of the completed vacuum replacement breaker including the vacuum breaker element, bushings, primary disconnects (finger clusters), all bus in the breaker unit, and all insulators and braces per IEEE C37.09.

This test is to prove the mechanical strength and integrity of the conductor and frame assembly of the complete new vacuum replacement breaker. This test is performed in a switchgear cell designed to accommodate the circuit breaker being tested. Anti-rotation devices may be added to the cell if required to prevent rotation. If anti-rotation devices are used in the test breaker, then they will be installed in all the switchgear cells intended to accommodate the new breakers.

Short time current tests for three seconds at K*I current will be performed to confirm the breakers I^2t capability. The test will be performed in a switchgear cell.

Continuous rated current testing per ANSI C37.04-1979 without exceeding 65°C hotspot rise with a maximum ambient not to exceed 40°C. This test is performed in a breaker cell or a cell structure of the same equivalent volume, dimensions and ventilation as the original switchgear structure.

Low Frequency Withstand—19 kV rms for 4.76 kV applications, 36 kV rms for 8.25 kV and 15 kV applications—per IEEE C37.09.

Interlock functional test per IEEE C37.20.2.

All production tests as stated in IEEE C37.09. Timing values per pole will be provided for the vacuum element in msec.

Execution

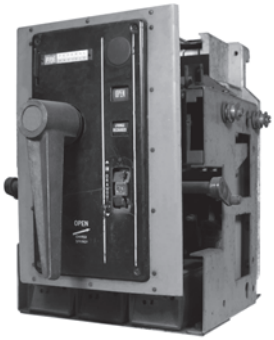
Eaton's factory trained and certified field service engineer(s) can perform the commissioning of each breaker at the customer's site. The field engineer will be familiar with the VR circuit breaker to the point that he/she can offer initial training to the owner's on-site operators and maintenance personnel while performing the commissioning.

Technical Data and Specifications

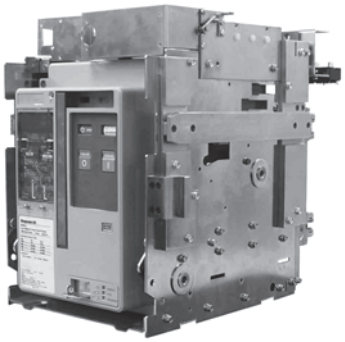
Ratings

- Maximum voltages:
  4.76 kV, 8.25 kV and 15 kV
- Interrupting ratings:
  4.76 kV: 250 MVA (29 kA)
  4.77 kV: 350 MVA (41 kA)
  8.25 kV: 500 MVA (33 kA)
  15 kV: 500 MVA (18 kA)
  750 MVA (28 kA)
  1000 MVA (37 kA)
  1500 MVA (63 kA)
- Continuous current:
  1200A, 2000A, 3000A (5–15 kV)
  4000A forced cooled (5–15 kV)

AR Series Low Voltage Replacement Breakers



FP-25 Original Magnetic Circuit Breaker



FP25-AR Air Replacement Breaker

Contents

AR Series Low Voltage Replacement Breakers

Product Description

Application

Maximum life extension. All AR-Series breakers are brand new from the ground up. They are designed to be electrical and mechanical equivalents of the breakers they replace. Cell modifications, if required, are kept to a minimum. They are not "Retrofits" and no parts are reused from the original breakers. This reduces out-of-service time, yielding consistent product designs, while reducing initial installation costs. AR-Series breakers correctly interface with compartment cell switches, and safety interlocks are maintained or improved.

Solve Parts Availability Problems for Old Breakers

Replacement parts for old breakers are becoming harder and harder to find as technology continually advances. Parts availability issues are basically eliminated with AR-Series breakers. Mechanism parts and control components are current production items and are in stock. Additionally, AR-Series breakers use common components across the product line. This can save in future spare parts investment.

Reduce Maintenance Cost and Downtime with Reliable Magnum™ DS Breaker Technology

Maintenance procedures commonly associated with vintage air magnetic circuit breakers take 8–12 hours on average per breaker. Eaton's Magnum DS breaker technology reduces normal maintenance to 2–6 hours per breaker. The arc chutes, contacts, mechanism and control components can be easily inspected and minor maintenance (such as lubricating the mechanism) can be easily accomplished. Arc chutes can easily be removed with two bolts and visually inspected or replaced. By removing the arc chutes, viewing the main contacts along with their contact wear indicator results in a quick and simple decision to replace if necessary. Spare parts inventory is considerably reduced because AR-Series breakers use common parts throughout the entire product line, including new Magnum DS Switchgear assemblies.

For more information on Magnum DS breaker elements, see **Volume 3, Tab 4**.

Increase Interruption Rating

Dynamic changes resulting from larger transformers, bus ties, parallel generation, and new sources of incoming power can drastically increase the level of available short-circuit current in low voltage power distribution systems. The bus system's momentary capability can be increased and the entire switchgear structure can be re-certified to the new higher levels by Eaton's factory qualified service engineers. Many of the AR-Series breakers are available to increase interrupting capabilities while still maintaining the original circuit breaker dimensions. This provides a savings versus the cost of replacing the switchgear. Cell-to-breaker coding systems are maintained or corrected to comply with IEEE/ANSI standards.

Increase Continuous Current Rating

Changes to industrial and commercial facilities, such as increased manufacturing operations, will typically increase the demand for electrical power within the facility. Often, an increase in electrical demand can cause the load on a circuit to exceed the circuit breaker's continuous current rating. Eaton's factory qualified service engineers can inspect existing low voltage metal-enclosed switchgear, including the existing breaker cubicles, line and load power stabs, load cables, and bus system to verify the application for a circuit breaker ampacity upgrade. Many of the AR-Series breakers are available with increased continuous current ratings.

Features

- AR replacement breakers are 100% rated, UL listed (check factory), and built and tested in an ISO 9001 and 14001 certified facility
- Safety: the cell door can remain closed with the breaker in connect, test or disconnect position. Simultaneously, the trip unit, open-close controls, and breaker nameplate data are all readily visible
- Designed for easy access, inspection and minimal maintenance. The stored energy mechanism, control devices, accessories and secondary contacts are easily accessible by removing the front cover. The contact wear indicator eliminates the need for elaborate testing to determine if the contact assembly needs replacing. The arc chutes can also be easily removed and inspected
- Installation savings and robust interface reduce installation and commissioning time with our unique design concept. No modifications required to the original line/load power stabs or secondary disconnect contacts. Modifications to the original cubicle are often eliminated with an easy-to-install cubicle adapter (cassette). The cassette includes new extension rails and levering-in adapters, resulting in a more robust breaker-to-cubicle interface. We also provide a new door to match the replacement breaker

Availability

Designs available for:

- Westinghouse
- General Electric
- Allis-Chalmers
- Federal Pacific
- ITE/ABB

Standards and Certifications

All AR-Series low voltage power air circuit breakers are designed and tested to meet or exceed IEEE/ANSI C37.59-2002 standards. This ensures compatibility with existing installations and IEEE/ANSI application guidelines. IEEE/ANSI certification and certified factory production test reports are available.

Low Voltage Power Circuit Breaker Reconditioning

Contents

Low Voltage Power Circuit Breaker Reconditioning

General Description

Low voltage power circuit breakers are designed to be serviceable devices over a long service life. These breakers and the associated switchgear have been available in the industry for over 50 years, and a large installed base of equipment by many manufacturers exists throughout the United States and Canada.

The low voltage switchgear is essentially static. It consists of structures, buswork, control wiring and metering components. If periodically cleaned, it will last almost indefinitely.

The low voltage power breakers are the essential elements of the switchgear. They are required to properly conduct the normal load current for the vast majority of time, and still provide the means of interrupting an overload or fault current whenever it may occur.

These breakers contain insulation systems (600 Vac normal three-phase voltage or less), conductors (from 225 to over 5000A continuous), a mechanism to open and close the breaker, a trip system to provide protection of the circuit and the circuit breaker, and an interruption system (arc chutes and contact structures) that can handle fault currents as high as 100,000A.

While some breakers are fixed mounted (bolted into the switchgear), the vast majority are drawout for ease of inspection and maintenance of the breaker, as well as to provide maximum isolation of the load. These drawout breakers include primary disconnects (for the three-phase conductors), secondary disconnects (for breaker control wiring), a levering-in mechanism (to assist in the insertion and withdrawal of the breaker) and an interlock system (to ensure that a closed breaker cannot be inserted or withdrawn from the connected position).

Additional common options to low voltage power circuit breakers include electric operation of the mechanism, shunt trip and close coils for remote operation of the breaker, undervoltage trip systems, and additional auxiliary switches for annunciation and control schemes.

Factors that affect the life of these circuit breaker subsystems include time, ambient temperature, humidity, cleanliness of the environment (contamination and corrosive elements), number of normal load operations, number of fault current interruptions, load current magnitude, and maintenance cycle.

While periodic maintenance, cleaning, lubrication and testing of the circuit breaker can and will prolong its life, at some point, the circuit breaker must either be completely reconditioned or replaced. Failure or mis-operation of any of the breaker's subsystems will render it to be ineffective for its intended purpose and dangerous for personnel or downstream equipment.

Class 1 reconditioning of the low voltage power circuit breaker is a cost-effective method to restore all of the breaker's subsystems to full functionality and prolong the life of the breaker for many additional years.

Manufacturers

Class 1 reconditioning is available for all major manufacturers' low voltage power circuit breakers that have been produced over the last 50 years. These breakers are rated at 600 Vac, 225 to 5000A continuous, 15,000 to 100,000A interrupting. The manufacturers include, but are not limited to:

- Westinghouse
- Cutler-Hammer
- General Electric
- ITE
- ABB
- Allis-Chalmers
- Siemens
- Square D
- Federal Pacific
- Federal Pioneer

Advantages

Eaton's Electrical Sector is the world leader in low voltage power circuit breaker and trip systems technology. EESS is uniquely positioned to provide Class 1 reconditioning of low voltage power circuit breakers.

All Class 1 reconditioning is done at facilities dedicated to the purpose. These are known as Aftermarket Centers of Excellence (ACEs). These facilities utilize state-of-the-art equipment in cleaning, plating, assembly and testing of the breakers. Each facility utilizes identical standards and procedures in the reconditioning process. The reconditioned breakers are tested to the same standards as new production breakers. The breaker test results are stored in a North American database (Pow-R Test), facilitating predictive maintenance and trending. All manufacturers' breaker information is stored in our Pow-R Master Database and available to every ACE performing the work. Breaker trip systems are upgraded to the latest Digitrip technology, the same trip system used in new production DS and SPB breakers. Original OEM replacement parts are exclusively used to replace broken, out of specification or missing components.

Quality Control and National Standards

All reconditioning will be conducted under the direction of a quality control and reconditioning standard, pursuant to ISO® 9001 certification. A quality certificate will document the progress of each breaker through the reconditioning process. Eaton has multiple locations (minimum of five) strategically located throughout North America that share best practices of reconditioning and work to a consistent national standard. They utilize the same task-specific equipment for cleaning and testing at all locations to ensure the quality of the product.

Receiving and Data Collection

Upon receipt at the reconditioning center, the following process will be performed on each breaker.

- Assign a unique job and breaker identification number
- Record all nameplate data, customer identification, existing trip settings, and all numbers unique to each breaker by direct entry into a national computer database archive for future use and retrieval
- If electrically operated, record all accessories included on the circuit breaker, as well as the close, trip and charge volts. The latest copy of the customer's control schematic will be obtained prior to disassembly and/or test. Eaton will have the capability of retrieving control schematics for the breakers it manufactured
- The circuit breaker will be inspected for physical damage. Parts that need to be replaced will be recorded. A quotation will be issued to the customer for replacement of the defective part(s)

Preliminary Testing and Inspection

The breaker will be manually and/or electrically operated. The following tests will be performed.

- All breakers:
  - Each primary pole insulator will be tested for dielectric integrity by applying 1000 Vdc between each conductor and ground and between line and load
  - With the breaker closed, the contact resistance using a 10 ampere conductor will be measured
  - Measure the trip bar force using a force gauge
  - Measure the trip button/actuator device force using a force gauge
  - Verify continuity of current limiting fuses (if equipped) and measure the resistance using a 10 ampere conductor; check blown fuse indicators' integrity
  - Verify overcurrent trip device operation via primary injection (not required if a trip unit retrofit is to be installed)
- Additional tests for Electrically Operated Breakers:
  - Charge the breaker; close and trip electrically
  - Verify undervoltage, pickup and dropout (if equipped)
  - Check auxiliary switch operation and condition

Centralized Database

The results of all the above tests and measurements shall be entered into the Eaton centralized database.

Breaker Disassembly, Cleaning and Preparation

- The circuit breaker will be completely disassembled to its component parts. All parts will be inspected for wear and physical damage
- All heavily carbonized components will be cleaned and degreased in a Vaque® Wet Blast System to produce a smooth finish without degrading the component's surface
- All current carrying parts, main/arcing contacts, ground contacts and primary disconnects will be cleaned, burnished and polished in a TOREX® vibratory system loaded with a medium specifically designed to clean silver plating. Dry blasting or other abrasive cleaning systems that can remove silver plating or distort the contacts' surfaces will not be used
- All pole piece moldings and insulating components will be cleaned in a Giant™ ceramic polisher that cleans and polishes the components surface without scratching

- After cleaning, each component shall be dried to obtain 1000 megohms when megger tested at 1000 Vdc. They will be sealed with a dielectric grade sealant
- All heavily soiled and/or greasy items including mechanisms will be initially cleaned in a non-abrasive agitator filled with a biodegradable cleaning solution capable of degreasing, de-scaling and de-burring without degrading the components surface and without the introduction or embedding of grit or other abrasive materials
- All frames will be stripped to bare metal in preparation for plating
- After cleaning, all ferrous metal frames, mechanism parts and linkages will be yellow zinc dichromate plated to provide superior rust resistance to exposed and hidden surfaces. Painting of covers, handles and indicators will be done
- A detailed inspection will be performed of all mechanism components and linkages to detect stress fractures and excessive wear that can cause premature failure. Magnification will be used on small components if necessary
- Arc chutes will be hand-wiped and cleaned with a clean dry cloth. They will be megger tested at 1000 Vdc. If the megger value is less than 1000 megohms, the arc chute assembly will be dried and retested. If the retest value is greater than 1000 megohms, then arc chute surface will be sealed with the manufacturer's recommended dielectric grade clear sealant. If the retest value is still less than 1000 megohms, then the arc chute will be replaced
- Charging motor (if so equipped) will be removed. The drive shaft bushings will be inspected and replaced if worn. The motor will be cleaned and reconditioned. All ratchet pawls and springs will be inspected and replaced or repaired if necessary.
- Gearbox (if equipped) will be removed, disassembled and fully inspected. Any defective or leaking components will be repaired and cleaned

Circuit Breaker Reassembly and Adjustment will Include:

- The circuit breaker frame will be reassembled using new yellow zinc dichromate plated hardware
- A database of instruction books that list the original manufacturer's information on recommended lubricants. When the recommended lubricants are no longer available or have been changed, the reconditioner's new breaker design group may analyze and recommend newer, high technology lubricants as a substitute
- The operating mechanism will be reassembled, lubricated and reinstalled on the circuit breaker frame
- Reassemble and install the main and arcing contact components, and lubricate as recommended by the original manufacturer's information
- Reassemble, lubricate, install and align the racking mechanism and the electrical and/or mechanical charging mechanism (if applicable)
- Install all electrical components and secure wiring harness (if applicable)
- Align the contacts for proper surface wipe and mating. Perform a contact wipe test. Verify that the percent contact wipe and the wipe width are per the original manufacturer's information
- Adjust the main contacts for proper gap, pressure and contact resistance, and adjust arcing contacts for proper gap per the original manufacturer's information
- Install new Eaton Digitrip microprocessor trip system where specified
- When a new trip device is added to the breaker or when changes are made to the original mechanism or arc interruption system, an additional nameplate shall be installed in accordance with IEEE/ANSI C37.59-1996 Section 8.3 and shall include the unique serial/identification number

Standards and Certifications

The retrofitted breaker will be designed, manufactured, applied, installed and certification tested in accordance with the latest applicable sections of:

- IEEE/ANSI C37.13
- IEEE/ANSI C37.16
- IEEE/ANSI C37.17
- IEEE/ANSI C37.50
- IEEE/ANSI C37.59-1996
- IEEE/ANSI C37.100
- UL 1066 (For originally UL listed and labeled designs)

Test Procedures

General Production Testing

Each reconditioned low voltage power circuit breaker will be tested to the applicable sections of IEEE/ANSI C37.50 Section 6 and UL 1066 if the breaker was originally UL labeled. The testing will include, but not be limited to:

- Measuring and recording trip bar force
- Setting of the microprocessor trip
- Performing control and secondary wiring and device check tests
- Performing dielectric withstand tests
- Performing no-load operations tests
- Verifying interlock and cell interface
- Test position dielectric withstand (original UL labeled breakers only)

Trip Bar Force Measurement

Measure and record the circuit breaker's trip bar force.

Microprocessor Trip Device Setting

Direct-acting trip devices will be tested/calibrated to determine their conformance to published trip characteristic curves. Each breaker will be primary injection tested using a sinusoidal-wave-shape, single-phase 60 Hz current at a convenient voltage. The primary injection test device will be computer controlled to ensure accuracy in the applied currents. The primary injection test device will be capable of direct output of the test results to a printer or storage device. The applicable tests will be performed.

- Long-time-delay-element pickup
- Short-time-delay-element pickup
- Instantaneous-element pickup
- Time delay of long-time-delay-element
- Time delay of short-time-delay-element
- Ground-element pickup
- Time delay of the ground element

Control, Secondary Wiring and Devices Check Test

Perform control, secondary wiring and devices checks per IEEE/ANSI C37.50.6.3 to verify that all connections are correct per the wiring diagram. Those circuits for which operation or testing is not feasible will be checked for continuity.

Dielectric Withstand Tests

Perform dielectric withstand tests per IEEE/ANSI C37.50.6.4. The applied test voltages will be essentially sinusoidal (within 20% of the rated frequency of the circuit breaker being tested) and will have a minimum crest value equal to 1.414 times the specified test voltage potentials. The potential will be increased gradually from zero so as to reach the required test value in 5 to 10 seconds, and will be held at that value for 1 minute, except for the momentary control voltages (listed in number 4 below). The following test values are applied to Class 1 reconditioned low voltage power circuit breakers.

1. 2200 Vac for the primary circuit of a completely assembled circuit breaker.
2. 1500 Vac for secondary control wiring and control devices, including current sensors and magnetic latch, except (3), (4) and (5).
3. 1000 Vac for new or reconditioned motors.
4. 500 Vac momentary for control devices and circuitry operating at 80 Vac rms (110 Vdc) or less that are not connected directly to the primary circuit or external, secondary control circuits.
5. Twice rated voltage plus 1000 Vac for undervoltage trip devices operating at a voltage above 250 Vac.

No-Load Operation Test

Perform no-load operation test per IEEE/ANSI C37.50.6.5.1 (for electrically operated breakers).

- Five closing and five opening operations at minimum control voltage
- Five closing, five opening and five trip-free operations at maximum control voltage
- Two operations to check antipumping, which will be performed in the following manner:
  - Apply uninterrupted control power to the closing circuit of the open circuit breaker as the closing signal
  - Trip the circuit breaker; the circuit to remain open until closing circuit power has been interrupted and then restored
- Check all other devices, both electrical and mechanical, for proper operation

Perform no-load operation tests per IEEE/ANSI C37.50.6.5.2 (for manually operated breakers):

- Five closing and five opening operations
- When shunt trip is used, a minimum of five openings using the shunt trip at the minimum control voltage specified for the coil
- Five trip-free operations
- Check all other devices for proper mechanical operation

Interlock and Cell Interface

Verify the functional operation of all circuit breaker interlocks and cell interfaces in a cell structure, preferably a cell in the reconditioner's facility.

Test Position Dielectric Withstand (UL Listed Breakers Only)

Original UL listed breakers will have their dielectric withstand verified by placing the breaker in the test position, closing the breaker, and applying 2200 Vac across the cell's primary conductors for 1 minute. No dielectric breakdown shall occur.

Open-Fuse Trip Device (If Included)

Test the trip device mechanically or by application of proper voltage to the device to establish positive tripping of the fused circuit breaker.

Undervoltage Test

The undervoltage device will be tested for pickup and dropout voltages.

Breaker Data History

All breaker information, unique identification number, and Eaton test results shall be recorded on the reconditioner test form and in the Eaton centralized database to track each breaker for predictive maintenance. A copy of the test form, with the test results and a quality certificate, shall be delivered with each circuit breaker.

Warranty

Each Class 1 reconditioned low voltage power circuit breaker will include Eaton's 2-year warranty.

ARMS Conversions

Contents

Arcflash Reduction Maintenance System™ Conversions

Product Description

A circuit breaker equipped with an Arcflash Reduction Maintenance System retrofit can improve safety by providing the worker with a simple and reliable method to reduce fault clearing time. A lockable switch that can be incorporated into a Lock Out Tag Out (LOTO) procedure controls the Arcflash Reduction Maintenance System. Workers can easily create and control fast tripping time at the work location by using this new solution. Work locations downstream of a circuit breaker with this retrofit can have a significantly lower incident energy level. The Arcflash Reduction Maintenance System can be applied to any retrofitted low voltage power breaker by modifying an existing Digitrip trip unit or retrofitting a breaker with a Digitrip retrofit kit.

Features, Benefits and Functions

- Increases worker safety by limiting exposure to arc flash energy
- Extremely easy to use
- Enabled with the circuit breaker door closed by a door-mounted lockable switch (no special PPE required)
- Used only for the time required to perform the work and is not enabled continuously
- Preserves overcurrent coordination under normal conditions
- Reduces the arc flash hazard level for the time to perform the work task
- Improves worker comfort and mobility via reduction in incident energy levels that may permit reduced levels of PPE

Retrofit Kits

Contents

10

Digitrip Microprocessor Trip Unit Retrofit Kits

Product Description

Application

Eaton's Digitrip RMS retrofit kits are fully engineered, field installable retrofit kits that enable the user to completely replace an existing tripping system. They are applicable to (600 Vac) low voltage power breakers and are designed for application on both Eaton power breakers and non-Eaton power breakers.

Digitrip RMS retrofit kits provide true rms sensing, the most accurate and current state-of-the-art technology for measuring amperage loads. True rms sensing removes the possibility of false tripping due to harmonic distortion of the power waveform and enables greater accuracy in selective coordination of the power distribution system. The microprocessor-based Digitrip trip unit also allows communications for remote monitoring to a host computer or local AEM via the PowerNet communication system.

Ratings

Digitrip RMS retrofit kits are available for a wide variety of both Eaton and non-Eaton low voltage power breaker frames. Ratings range from 100 to 4000A. Digitrip retrofit kits provide the user with adaptive flexibility due to multi-tapped current sensors and interchangeable rating plugs and programmable pickup and time delay settings.

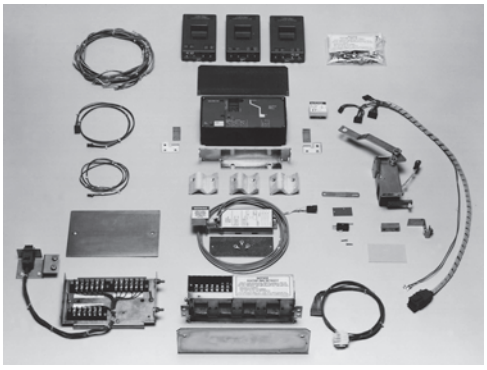
History and Technology

In the past, there have been three types of automatic control for low voltage power breakers. Electromechanical (EM) trip units, solid-state peak sensing trip units, and state-of-the-art true rms sensing trip units.

EM trip units were initially used in the early 1950s and phased out by all manufacturers in the mid-1970s. EM trip units were composed of a solenoid, springs, a diaphragm, seals and air venting apertures. Three trip units were required per breaker. Due to age or harsh environments, these devices would fail or lose calibration. They required a great deal of preventive maintenance.

Peak sensing trip units were an improvement and provided improved reliability and accuracy. Only one trip unit was required per breaker; however, peak sensing trip units were not able to handle harmonic conditions. They caused nuisance tripping and unnecessary downtime.

True rms trip units enable the measuring of current rather than the sensing of current. Since they are microprocessor-based digital devices, they are capable of taking discrete samples of the current waveform in each phase. By applying a mathematical algorithm, the current is accurately mapped out and measured. This method of measurement provides the ability to adapt to a changing harmonic content while providing repeatable and reliable protection.



Kit Components

Features

Digitrip retrofit kits come in several different model types. Among these types, they provide a variety of accommodating features (see Kit Type table on **Page V3-T10-48**).

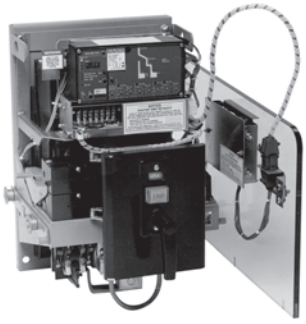
True rms measurement and protection. Extremely accurate and able to accommodate harmonic content and disturbances.

Ground fault protection may be added to an existing power breaker. Ground fault protection is offered in a three-wire and a four-wire version.

Zone interlocking is available on the short time and ground fault modes of protection. This enables enhanced selectivity for high fault and ground fault coordination between the main and feeder breakers.

Local monitoring via a display. A red LED display enables the user to step through and read currents and energy readings for each phase and ground.

Communications via the PowerNet system. This allows all pertinent information, regarding static and dynamic operation of the breaker, to be remotely monitored either by a host computer or local display monitor. This facilitates energy management and power management. Remember: "If you can't measure it, you can't manage it."



Retrofit Breaker

Trip Functions

All Digitrip RMS retrofit kit types are available with the necessary combinations of long, short, instantaneous and ground fault (LSIG) modes of protection as depicted and deemed necessary by industry standards.

The combinations of modes of protection are:

- LI
- LS
- LSI
- LIG
- LSG
- LSIG

The Packaged Kit

Each Digitrip RMS retrofit kit includes a Digitrip trip unit, an auxiliary CT module, a Direct Trip Actuator (DTA), quantity (three or four) current sensors, a rating plug, interconnecting wiring harnesses, mounting brackets, copper connectors (when required), hardware and installation instructions. Digitrip RMS retrofit kits are complete tripping systems specifically engineered for each breaker type and frame rating. All kits are designed for field installation.

Application and Service Condition

In order to ensure that Digitrip RMS retrofit kits are successfully applied, installation must only be done by a qualified individual. Appropriate testing must be performed to qualify the retrofitted breaker prior to placing the breaker in service. Digitrip RMS retrofit kits will provide protection in accordance with their published time-current characteristic curves and in accordance with the original breaker manufacturers specifications on breakers that have been properly maintained and operate in accordance with the original manufacturer's operating instructions.

Service Life

The physical structure, the bus assemblies and control wiring of switchgear are normally in good condition. The replacement of the trip system coupled along with either refurbishment or reconditioning of the breaker will prolong the life of the switchgear and provide modern state-of-the-art protection.

Availability

Digitrip retrofit kits are currently available for select breaker frames for the following manufacturers:

- Eaton
- Westinghouse
- General Electric
- ITE
- Allis-Chalmers
- Federal Pacific
- Roller Smith
- Siemens-Allis

Additional Offerings

- Retrofit kits using OPTIM™ 750 and 1050 trip units are available for use on DS breakers

Kit Type

Digitrip Kit Features	RMS 510	RMS 510 Zone	RMS 610	RMS 810	RMS 910
Cause of trip LED indicators	■	■	■	■	■
Integral self test	■	■	■	■	■
Trip reset button	■	■	■	■	■
Thermal memory hardware driven	—	—	—	—	—
Thermal memory software driven selectable (on/off)	■	■	■	■	■
Discriminator circuit on LS and LSG protection modes	—	—	—	—	—
Discriminator circuit on LS and LSG protection modes selectable (on/off)	■	■	■	■	■
Zone protective interlocking for short-time and ground fault modes of protection	—	■	■	■	■
Auxiliary contact for long time, short-circuit and ground fault functions	—	■	■	■	■
Local display of phase currents	—	—	■	■	■
Local display of ground currents	—	—	■	■	■
Local display of cause of trip	—	—	■	■	■
Local display of energy (MWh)	—	—	—	■	■
Local display of peak demand (MW)	—	—	—	■	■
Local display of present demand (MW)	—	—	—	■	■
Communication with PowerNet communicated data includes: All display values Trip unit status High load alarm Cause of trip Rating plug status Breaker status Reason for breaker status	—	—	—	■	■
Trip settings	—	—	—	■	■
Power factor	—	—	—	■	■
Control via the PowerNet system (open/close)	—	—	—	■	■
Voltage phase-to-phase, displayed on trip unit and communicated via PowerNet communication	—	—	—	—	■
Total current harmonic distortion (THD); phase A, B, C. Displayed on trip unit and communicated via PowerNet communication	—	—	—	—	■
Total current harmonic distortion per harmonic from the 2nd through the 27th harmonic displayed on trip unit and communicated via PowerNet communication	—	—	—	—	■
System power factor. Displayed on trip unit and communicated via PowerNet communication	—	—	—	—	■
Waveform analysis data to PowerNet computer	—	—	—	—	■

Reference Information

Sales Brochure for Digitrip RMS Retrofit Kits: B.22D.01.S.E

Instructions for the Application of Digitrip RMS Retrofit Kits on Power Circuit Breakers: AD 33-855- 4

Digitrip RMS 510 Trip Unit: IL 29-885-B

Digitrip RMS 610 Trip Unit: IL 29-886-A

Digitrip RMS 810 Trip Unit: IL 29-888-A

Digitrip RMS 910 Trip Unit: IL 29-889-A

Time Current Curves for DS and DSL Circuit Breakers: AD 32-870

Retrofit Kit Product Guide call 1-800-937-5487: Doc. #9375487

Illustrates catalog number system for each engineered kit: Volume 12, Aftermarket, Renewal Parts and Life Extension Solutions.

Product Selection

Customer Required Information

In order to obtain the proper kit, the following information should be provided to Eaton:

- Breaker nameplate information:
  - Manufacturer
  - Breaker type
  - Ampere frame size
  - Manually or electrically operated
- Drawout or fixed mounting
- Fused or non-fused
- Digitrip trip unit type required: 510, 610, 810, 910
- Protective functions required: LI, LSI, LS, LIG, LSG, LSIG
- Continuous current rating required (trip rating of breaker)
- Three-wire or four-wire system (determines number of sensors required)

To properly select options, the following questions need to be answered:

- Will customer supply 120 Vac control power or is breaker-mounted CPT needed? **Applies only to Digitrip 610, 810 and 910**
- Are zone interlocks required?
- Does the application require relay outputs from the Digitrip 610, 810 or 910 for remote indication?
- Does the breaker have an existing Amptector or Digitrip trip unit installed? If so, what is it?

DB-25 LV-VSR

Contents

Low Voltage Breaker Drawout Vacuum Starter Replacement

General Description

Eaton's low voltage VSR is a self-contained vacuum starter replacement for a low voltage drawout air circuit breaker used for motor starting applications.

In some cases, LV air circuit breakers are used for motor starting applications. Air circuit breakers are not designed to withstand the frequent switching service and mechanical stresses associated with repetitive motor starting duty. This is due to the breaker mechanism that must be designed to close and latch against a fault. In order to meet these requirements, the mechanism must close at high speeds with a great deal of force. Frequent closing operations stress and deteriorate the breaker mechanisms.

Eaton's LV-VSR is a self-contained replacement vacuum starter for an LV drawout air circuit breaker. The LV-VSR is interchangeable with the drawout breaker element and requires no cell modifications.

Features

Advantages

The use of an LV-VSR vacuum starter can prolong device life and significantly reduce maintenance repair and downtime.

A low voltage air circuit breaker has an effective life of 4000 operations while an LV-VSR vacuum starter has an effective life of 1,000,000 operations. For example, a motor starting application that required two starts per hour on continuous duty would require a major rebuild of the LV breaker within three months. The expected life of an LV-VSR vacuum starter would be over 50 years.

The LV-VSR vacuum starter uses state-of-the-art Eaton vacuum interrupters. The interrupters employ the latest vacuum technology with long life, resistance to environmental contaminants, and positive contact wear indicators.

The integral, solid-state, trip units used on the air circuit breakers are designed primarily for cable and transformer protection. Motors require more precisely set overcurrent devices that prevent motor damage as well as avoiding nuisance tripping. A solid-state relay, Eaton Type C440, provides overload protection and phase unbalance protection. This relay was exclusively designed for motor protection.

Motor Starter

The LV-VSR consists of an Eaton V201 vacuum contactor, Class J current limiting fuses, multi-function motor protective relay, three current transformers and an integral control power transformer.

Vacuum Contactor

Eaton's V201 vacuum contactor is designed for starting and controlling three-phase, 50/60 Hz AC motors. Current interruption is contained within the vacuum bottles and no arc byproducts are vented to the outside environment. Contact condition is given by wear indicators.

Series Current Limiting Fuses

Class J current limiting fuses provide short-circuit protection and allow a combination rating of 100 kA at 480 or 600V.

C440 Electronic Overload Relay

Eaton's C440 multi-function electronic, motor protection relay provides the following features:

- Overload protection, Class 10A, 10, 20 or 30
- Phase unbalance protection, selectable (ON/OFF)
- Ground fault selectable (ON/OFF)
- Remote reset
- Alarm relay output contact
- LED status indication
- Communication modules
  - Modbus RTU RS-485
  - DeviceNet with IO
  - PROFIBUS with IO

VSR Designs

- Westinghouse DS
- GE
- ITE
- and others

Contact EESS at 877-276-9379 for more details.

Life

Exceptional electrical and mechanical life is offered by the V201 contactor—up to 1,000,000 electrical operations and 2,500,000 mechanical operations, even under harsh conditions.

Drawout Capability

The LV-VSR is mounted on a drawout frame and maintains the safety interlocking system of the LV switchgear.

Ease of Installation

The LV-VSR may be inserted into a standard breaker compartment without modification to the compartment. The primary and secondary contact structures and drawout mechanism are identical. The LV-VSR control scheme will interface with standard switchgear wiring with no cell modifications and remote control schemes, if existing, are maintained.

Safety Features

The LV-VSR vacuum starter retains all the safety features of the LV switchgear including:

- Racking the LV-VSR vacuum starter is prevented while the contactor is in the closed position. Closing the LV-VSR vacuum starter is prevented while racking
- Breaker position indication is provided (connected, test, disconnect, remove)
- The LV-VSR vacuum starter is padlockable (optional) in either the connect, test or disconnect positions
- Positive ground connection is maintained
- Closed door tripping
- Closed-door control, if existing, can be maintained

LV-VSR Control Features

LV-VSR vacuum starter offers the following standard control features. Other devices can be supplied on request.

- Start-stop pushbuttons and run pilot light
- Eaton C440 electronic overload relay
- 2A/2B auxiliary contact
- 1A/1B trip contact (overload or short circuit)
- Provision for remote control operation
- Integral control power transformer
- Custom designed wiring schemes

Ease of Maintenance

The LV-VSR control components are front mounted for easy access.

The LV-VSR uses the same line and load finger clusters, secondary contact assemblies and drawout mechanism as the original circuit breaker. Renewal parts are readily available.

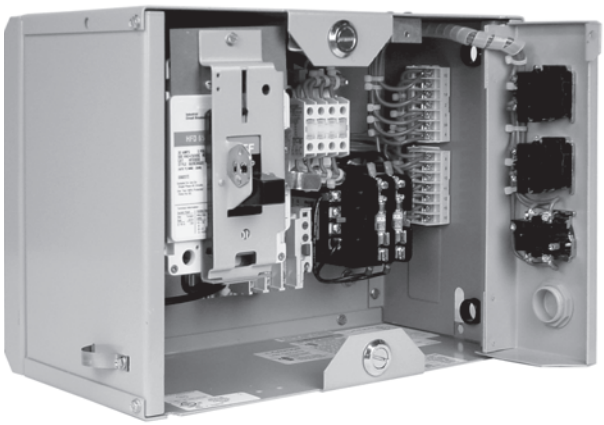
Technical Data and Specifications

Ratings

The LV-VSR vacuum starter is rated as follows:

- Maximum continuous current—425A
- Maximum voltage rating—600V
- Short-circuit rating at 240–600V 200 kA
- Maximum motor hp at 480V 235 hp
- Maximum motor hp at 240V 117 hp
- Maximum motor hp at 600V 294 hp

ITE 5600 Series Motor Control Center Replacement Unit



Contents

MCC Replacement Units

General Description

Eaton's motor control center (MCC) replacement units are newly manufactured, UL labeled units designed for easy installation into existing MCCs. We manufacture units to fit into Westinghouse, Cutler-Hammer and other manufacturers such as GE, Square D and ITE.

Replacement units allow new starters and feeders to be added to existing motor control centers to replace defective units or to upgrade units.

Advantages

Motor starters are used in applications where continuous operation and frequent opening and closing are required. These conditions lead to eventual mechanical failure of contactors despite best maintenance efforts.

Replacement MCC units are the most time-efficient and cost-effective way to restore the original assembly to operational condition.

Complete replacement of the MCC involves costly demolition, removal and re-installation. Downtime is extensive. The MCC assembly often is in good condition since there is very little deterioration of the enclosure, the bus or the control wiring with normal maintenance and proper installation.

Replacement units are newly manufactured and have no used or fatigued parts. Because they can be manufactured to existing wiring diagrams, the installation time is minimal. Only the power connections and those wiring terminations external to the MCC are required to be disconnected and reconnected. The replacement unit interchanges with the existing unit without field modifications. Downtime is significantly reduced.

Features

Brand New Replacement Unit—Not a Retrofit

All motor control units, removable or fixed mounted, are assembled with Eaton components of proven safety, quality and reliability. All components are wired in accordance with NEMA and UL 845 standards.

Eaton has specifically designed bus stabs to form a standardization plug-in cell that meets the highest safety standards. These units fit into the existing space of the customer's original MCC.

Solve Parts Availability Problems for Old Unsupported Products

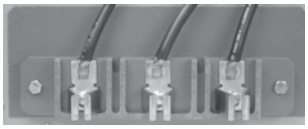
We can also provide additional inventory reduction for the customer by using components, such as starters, which are currently being used in other Eaton MCCs. Unit starter types include many options including: Freedom, A200 and Soft Start. Additional modifications include solid-state overloads, communication possibilities and several cover control options.

HMCP, HFD, HJD, HKD breakers and 10250T series pilot devices will provide the customer with standard features and current product to adequately maintain their MCCs for many years to come.

For additional information, contact 1-800-OLD-UNIT or your local Eaton Service Center.

New Stab Design

- Tin-plated clip surface
- Spring clip for extra pressure
- Sufficient insulating surface



Eaton Designed Stabs

Unit Features

- Holes for top and bottom incoming line
- Self-aligning stab to bus
- Door device panel
- Knockout for terminal blocks

Side Item Stab

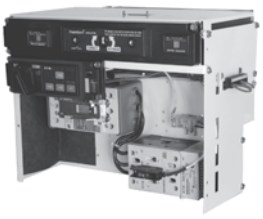
Door Features

- Door latch—1/4 turn
- Door hinge opens farther

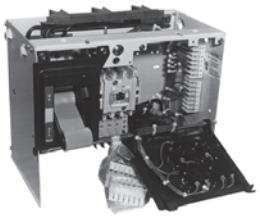
Door Latch Closed

Unit Features

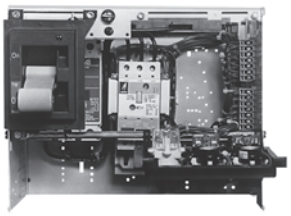
- Easy lock-out handle mechanism
- Easy lock-in bucket tabs
- HMCP/HFD breakers 65k rated
- Additional ground clip
- 10250T series cover controls



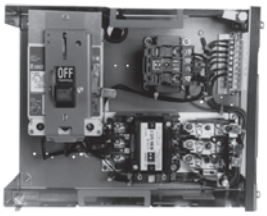
Eaton FlashGard® (2008 to Present)



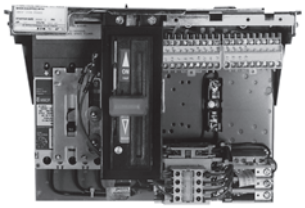
F2100 Replacement Starter Unit (1995 to Present)



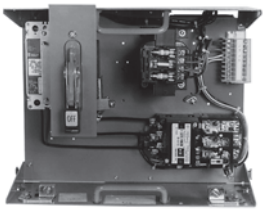
Advantage Replacement Starter Unit (1992 to Present)



F-10 Unitrol Replacement Starter Unit (1972 to 1989)

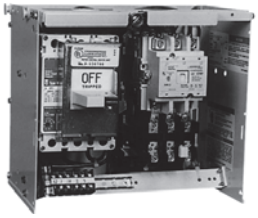


Freedom Unitrol Replacement Starter Unit (1988 to 1994)

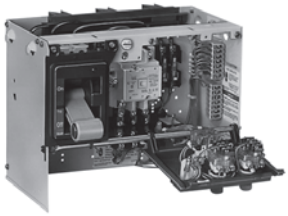


9800 Unitrol Replacement Starter Unit (1956 to 1974)

11-300 Replacement Starter Unit (1935 to 1965)



Type W Replacement Starter Unit (1965 to 1975)



5-Star/Series 2100 Replacement Starter Unit (1975 to 1995)

UL 845 Eaton MCC Aftermarket Units

Name Brand	MCC	Vintage Type
Westinghouse	11-300	1935 to 1965
Cutler-Hammer	9800 Unitrol	1956 to 1974
ITE	5600 Series	1957 to 1976
Gould	5600 Series	1957 to 1976
Telemecanique	5600 Series	1957 to 1976
Westinghouse	Type W	1965 to 1975
Cutler-Hammer	F10 Unitrol	1972 to 1989
Westinghouse	5 Star	1975 to 1986
Cutler-Hammer	Freedom Unitrol	1989 to 1994
Westinghouse	2100 Series ①	1986 to 1995
Westinghouse	Advantage™ ①	1991 to present
Cutler-Hammer	Freedom 2100 ①	1995 to present
Cutler-Hammer	***IT.*** MCC	2002 to present
GE	7700/8000	1975 to present
Allen-Bradley	Centerline	1971 to present
Square D	Model 6	1992 to present
Siemens/Furnas 89	Series 89	1979 to 2001
Eaton	***IT.*** FlashGard	2006 to present
Eaton	Freedom FlashGard	2007 to present

Note

① FlashGard replacement units available.

10

Standards and Certifications

Designed and Tested to NEMA/UL Standards

Eaton MCC replacement units have passed all UL required short-circuit and heat tests. This high standard of testing is important to provide confidence to our customers that UL 845 units mean something for the upkeep of their equipment.

Product Selection

Availability

Replacement units are available for all MCCs manufactured by Eaton, Cutler-Hammer or Westinghouse. Units are available as follows:

Eaton:

- F2100: 1995 to present
- Freedom Unitro: 1988 to 1994
- F-10 Unitrol: 1972 to 1989
- 9800 Unitrol: 1956 to 1974

Westinghouse:

- Advantage: 1992 to present
- Series 2100: 1987 to 1995
- 5 Star: 1975 to 1987
- Type W: 1965 to 1975
- 11-300: 1935 to 1965

All replacement units utilize Eaton HMCP motor circuit protectors allowing the units to be UL 508 combination rated 65 kA. The units can be supplied with either Freedom, Advantage, A200 or Citation starters.

Communication Capability

Eaton's MCC communication solutions include DeviceNet, EtherNet/IP, Modbus RTU, Modbus TCP, PROFIBUS, and Web interface using Eaton's Power Xpert® Architecture.

Information Required

In order to obtain the proper replacement unit, the following information should be provided to Eaton:

- MCC manufacturer
- MCC type
- Required starter hp rating
- Type of starter (i.e., FVNR, FVR, 2S2W, etc.)
- Desired protective features
- Desired control devices
- Desired control scheme

Contents

Description

Performance-Based Maintenance Services

General Description

Approximately 80 percent of all equipment failures occur on a random basis and are not age-related. Certainly, a well-designed, time-based preventive maintenance program can reduce failure rates, but what about these 80 percent of equipment failures that occur on no timetable? You could increase the rate of preventive maintenance activities, but that is no panacea. These maintenance activities tend to be invasive, introducing new defects that can actually increase failure rates.

Under pressure to deliver ever higher levels of availability, facilities managers are looking for a better way. An optimal maintenance program would:

- Enable you to schedule maintenance based on actual device operation history, rather than arbitrary calendar dates
- Eliminate unnecessary maintenance work and related production outages
- Reduce spare parts requirements due to increased accuracy of equipment history
- Reduce overall maintenance costs

You can achieve these results by having Eaton apply predictive analytic technologies to the maintenance program. The result is a strategy that Eaton calls "Performance-Based Maintenance." Services are scheduled and performed based on actual device operating history, not on arbitrary calendar dates. This knowledge-based approach reduces maintenance time, cost and spare parts requirements.

Performance-Based Maintenance (PBM) Program

Eaton offers Performance-Based Maintenance (PBM) solutions that fit various project needs, for single sites or multiple sites, and a full range of equipment types. This maintenance strategy actually integrates four proven maintenance programs to deliver quantifiable results at a guaranteed price:

- **The Planned Maintenance Module** addresses operational performance, as-left conditions, environmental considerations, and testing and calibration results
- **The Predictive Diagnostic Module** focuses on visual observations, environmental and thermal conditions, and predictive indicator results
- **The Reliability-Centered Maintenance Module** concentrates on the potential for injuries, environmental hazards and product losses or process interruptions
- **The Periodic Observations Module** centers on equipment loading, and visual and environmental observations

It is easy to get started on Performance-Based Maintenance program. EESS engineers visit your facility and perform a comprehensive site audit and needs assessment. While implementing electrical system testing and maintenance, EESS engineers review both the "condition" and "criticality" of each component with plant personnel. The condition is determined via traditional preventive maintenance procedures (industry-standard, time-based) combined with predictive diagnostic technologies. The criticality rating of each component is established through application of a reliability-centered maintenance approach, taking into account its potential impact on critical processes, safety and the environment. Then, EESS engineers recommend a maintenance interval (short-, mid- or long-term) for each component, as well as work scopes and periodic observation frequency.

You save money when this analysis reveals an opportunity to lengthen maintenance interviews or reduce the scope of maintenance work performed during scheduled outages. You improve uptime and reliability when this analysis reveals components on which preventive maintenance should be performed more frequently. You can increase reliability even more by redirecting some of your cost savings into additional predictive diagnostics and equipment modernization. EESS delivers a periodic scorecard to plant personnel, summarizing the recommendations, performance and results of the program.

Elements of a Performance-Based Maintenance Program

- Site audit and maintenance needs assessment
- Condition-based maintenance
- Reliability-centered maintenance (RCM)
- Predictive diagnostics
- Efficient algorithms to integrate equipment condition results, RCM input, predictive diagnostics and periodic observations
- Recommendations for immediate action, automation, remote monitoring, life extension, spare parts or upgrading
- Periodic observations while energized and operating
- Maintenance implemented based on equipment condition and criticality
- Root-cause failure analysis
- Periodic scorecard and customized reporting of results
- Continuous improvement
- Optional ensured performance improvements and ensured savings—typically, 15 percent savings over two performance cycles

Our knowledge management practices—when applied to optimize the maintenance program—reduce the potential for outages by predicting equipment failure or system problems, decrease the duration of outages by providing 24/7 remote troubleshooting, and reduce operating and maintenance costs by basing service on real-time equipment information rather than arbitrary timelines. The bottom-line is more effective maintenance service at lower cost.

Contents

Power System Analysis Software

Overview

The extensive line of Eaton's CYME Power Engineering Software features detailed network modeling, advanced analysis and specialized calculations for transmission, distribution and industrial power systems. From design to planning to contingency scenario management, the software allows system operators and engineers to quickly respond to changing network conditions and threats.

The evolution of the CYME software is highly driven by the specific needs of the utilities and electric industries to provide the cutting-edge solution that tackles everyday challenges and solves emerging issues.

General Description

An extensive line of software is offered to help engineers model power systems, manage network assets, improve system reliability and power quality, and optimize network designs and operations to consequently yield an efficient and reliable network. The software offered includes:

- **CYME Power Engineering Software**—transmission, distribution and industrial power network modeling and system analysis
- **CYMCAP**—ampacity and temperature rise calculations for power cable installations
- **CYMTCC**—time overcurrent protection
- **CYMGRD**—substation grounding grid design and optimization

Data integration is also offered to allow combining information from various enterprise systems (GIS, SCADA, MDM/AMI/CIS, OMS, DMS) into a single complete network model within the CYME Power Engineering Software, providing high accuracy for reliable network simulation. Software solutions can also be integrated within different IT environments.

Features, Benefits and Functions

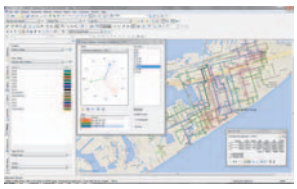
CYME Power Engineering Software

This flagship software is renowned for its analytical capabilities on power systems studies, user-friendly interface and extensive customization. From detailed network modeling to power flow, the CYME Power Engineering Software meets all analysis needs for transmission, distribution and industrial power systems.

Transmission System Analysis

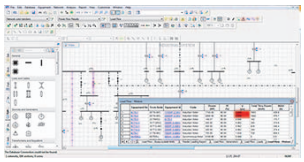
- Detailed modeling of on-site generation: gas, hydro, steam, PV, diesel, wind, etc.
- Modeling of transmission lines, DC line, static VAR compensators, FACTS, STATCOM, UPFC
- Load flow contingency analysis to establish optimal network operation
- Transient stability analysis to simulate electromechanical transients in electrical power systems
- System voltage stability assessment
- Optimal power flow analysis for system performance optimization
- System reliability through distance protection

Distribution System Analysis



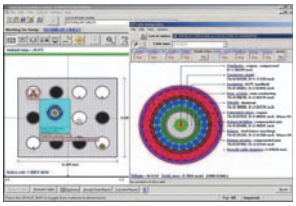
- Modeling of medium and low voltage distribution feeders/circuits and associated equipment
- Secondary network analysis and operation of network protectors
- Distribution capacity planning studies
- Distributed Energy Resources (DER) impact studies
- Contingency scenario simulations and restoration
- Network optimization through capacitor placement, voltage regulator placement, recloser placement, network configuration through switching, load balancing
- Network-wide protection analysis
- Reliability assessment through reliability indices, fault analyses, arc flash hazards calculations
- Leveraging AMI/AMR data using the Steady-State Analysis with load profiles

Industrial System Analysis



- Detailed modeling of motors, variable frequency drives
- Equipment sizing through short-circuit level and machine fault contribution evaluation
- Protective device analysis and coordination
- Motor starting analysis and drive system specifications
- Power quality assessment and filter design
- Arc flash hazard study for risk level assessment
- DC system modeling and analysis
- Sizing of generation facilities for islanding operation

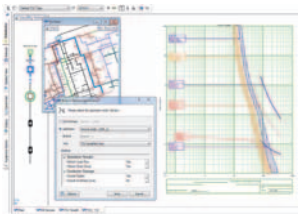
CYMCAP Cable Ampacity Calculation Software



The CYMCAP software is dedicated to rating underground power cables, in order to determine the maximum current that power cables can carry without the risk of damaging their insulation throughout their in-service life. Therefore, the software can help by selecting the proper cable size and type required for a particular application and assessing the ratings of existing cables. CYMCAP is a key tool to optimize the management of existing cable installations and to design new ones, resulting in significant savings in the large capital costs associated with cable installations.

- Detailed cable modeling of any type of power cable: single-core, three-core, belted, pipe-type, sheathed, armored, etc. Both DC and AC circuits are supported
- Support of various bonding arrangements: single-point bonded, bonded at both ends (transposed or not), cross-bonded, etc.
- Modeling of standard and non-standard installations: duct bank, backfill, direct buried, buried in ducts, in air, on riser poles, tunnels, troughs (filled and unfilled), multiple casings, etc.
- Calculation of the steady-state, cyclic, emergency and short-circuit current rating and operating temperatures of cables
- Compliance with IEC 287© and IEC-853© International standards, Neher-McGrath and IEEE© standards
- Additional analysis such as cable rating optimization for cables in duct bank, sequence impedance calculation, electromagnetic field computation and circuits crossing analysis
- Modeling of heat sources/sinks, moisture migration phenomenon (soil dry-out)
- Real-time thermal rating of cables under temperature monitoring (with Distributed Temperature Sensing (DTS) systems, thermocouples, etc.)
- Evaluation of cables operating temperature history, which can help in assessing their remaining in-service life

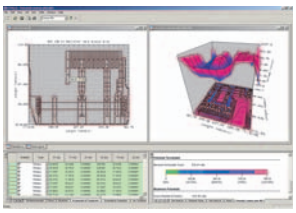
CYMTCC Protective Device Coordination Software



The CYMTCC software addresses time overcurrent protection. With more than 15,000 protective devices from more than 100 manufacturers, this software is equipped with tools and analysis to help engineers validate protection schemes.

- Time-current curve plots, device settings report
- Protective device library of more than 15,000 devices from more than 100 different manufacturers
- IEEE/ANSI and IEC standards
- Cable and conductor damage curves, motor starting, transformer withstand curves
- Coordination, loading, protective reach
- Arc flash

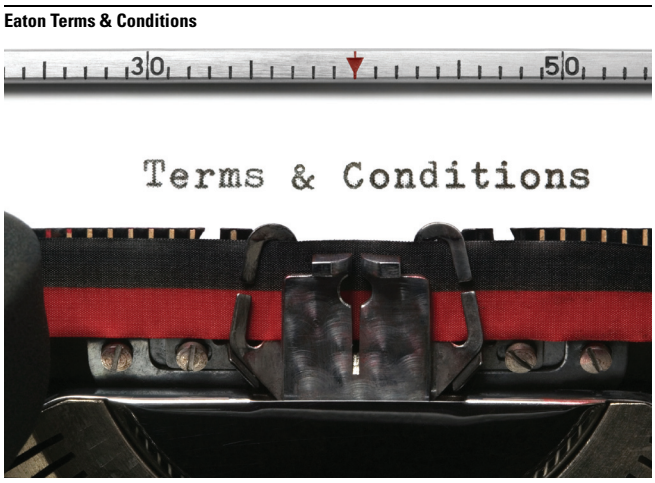
CYMGRD Grounding Grid Design and Analysis Software



The CYMGRD software is a substation grounding grid design and analysis program specially developed to help engineers optimize the design of new grids and reinforce existing grids.

- Design of new grids and modifications to existing grids
- Finite element analysis
- Compliant with IEEE 80-2000
- Calculation of current split factor
- Uniform or two-layer soil model
- Sizing of grid conductors and electrodes
- Computation of grid resistance and ground potential rise
- Safety assessment for touch and step voltages
- Potential contour and profile plots

Effective Date: November 1, 2017



Contents

Selling Policy (Supersedes Selling Policy 25-000, dated November 1, 2008)

Terms and Conditions of Sale

The Terms and Conditions of Sale set forth herein, and any supplements which may be attached hereto, constitute the full and final expression of the contract for the sale of products or services (hereinafter referred to as Product(s) or Services by Eaton Corporation (hereinafter referred to as Seller) to the Buyer, and supersedes all prior quotations, purchase orders, correspondence or communications whether written or oral between the Seller and the Buyer. Notwithstanding any contrary language in the Buyer's purchase order, correspondence or other form of acknowledgment, Buyer shall be bound by these Terms and Conditions of Sale when it sends a purchase order or otherwise indicates acceptance of this contract, or when it accepts delivery from Seller of the Products or Services.

THE CONTRACT FOR SALE OF THE PRODUCTS OR SERVICES IS EXPRESSLY LIMITED TO THE TERMS AND CONDITIONS OF SALE STATED HEREIN. ANY ADDITIONAL OR DIFFERENT TERMS PROPOSED BY BUYER ARE REJECTED UNLESS EXPRESSLY AGREED TO IN WRITING BY SELLER. No contract shall exist except as herein provided.

Complete Agreement

No amendment or modification hereto nor any statement, representation or warranty not contained herein shall be binding on the Seller unless made in writing by an authorized representative of the Seller. Prior dealings, usage of the trade or a course of performance shall not be relevant to determine the meaning of this contract even though the accepting or acquiescing party had knowledge of the nature of the performance and opportunity for objection.

Quotations

Written quotations are valid for 30 days from its date unless otherwise stated in the quotation or terminated sooner by notice.

Verbal quotations, unless accepted, expire the same day they are made.

A complete signed order must be received by Seller within 20 calendar days of notification of award, otherwise the price and shipment will be subject to re-negotiation.

Termination and Cancellation

Products

Any order may be terminated by the Buyer only by written notice and upon payment of reasonable termination charges, including all progress billings and all incurred direct manufacturing costs.

Services

Any order may be terminated by the Buyer only by written notice and upon payment of reasonable termination charges including all costs plus profit.

Seller shall have the right to cancel any order at any time by written notice if Buyer breaches any of the terms hereof, becomes the subject of any proceeding under state or federal law for the relief of debtors, or otherwise becomes insolvent or bankrupt, generally does not pay its debts as they become due or makes an assignment for the benefit of creditors.

Appendix 1—General Terms and Conditions of Sale

Effective Date: November 1, 2017

Prices

All prices are subject to change without notice. In the event of a price change, the effective date of the change will be the date of the new price or discount sheet, letter or telegram. All quotations made or orders accepted after the effective date will be on the new basis. For existing orders, the price of the unshipped portion of an order will be the price in effect at time of shipment.

Price Policy—Products and Services

When prices are quoted as firm for quoted shipment, they are firm provided the following conditions are met:

1. The order is released with complete engineering details.
2. Shipment of Products are made, and Services purchased are provided within the quoted lead time.
3. When drawings for approval are required for any Products, the drawings applicable to those Products must be returned within 30* calendar days from the date of the original mailing of the drawings by Seller. The return drawings must be released for manufacture and shipment and must be marked "APPROVED" or "APPROVED AS NOTED." Drawing re-submittals which are required for any other reason than to correct Seller errors will not extend the 30-day period.

   * 60 days for orders through contractors to allow time for their review and approval before and after transmitting them to their customers.

If the Buyer initiates or in any way causes delays in shipment, provision of Services or return of approval drawings beyond the periods stated above, the price of the Products or Services will be increased 1% per month or fraction thereof up to a maximum of 18 months from the date of the Buyer's order. For delays resulting in shipment or provision of Services beyond 18 months from the date of the Buyer's order, the price must be renegotiated.

Price Policy—BLS

Refer to Price Policy 25-050.

Minimum Billing

Orders less than $1,000 will be assessed a shipping and handling charge of 5% of the price of the order, with a minimum charge of $25.00 unless noted differently on Product discount sheets.

Taxes

The price does not include any taxes. Buyer shall be responsible for the payment of all taxes applicable to, or arising from the transaction, the Products, its sale, value, or use, or any Services performed in connection therewith regardless of the person or entity actually taxed.

Terms of Payment

Products

Acceptance of all orders is subject to the Buyer meeting Seller's credit requirements. Terms of payment are subject to change for failure to meet such requirements. Seller reserves the right at any time to demand full or partial payment before proceeding with a contract of sale as a result of changes in the financial condition of the Buyer. Terms of Payment are either Net 30 days from the date of invoice of each shipment or carry a cash discount based on Product type. Specific payment terms for Products are outlined in the applicable Product discount schedules.

Services

Terms of payment are net within 30 days from date of invoice for orders amounting to less than $50,000.00.

Terms of payment for orders exceeding $50,000.00 shall be made according to the following:

1. Twenty percent (20%) of order value with the purchase order payable 30 days from date of invoice.
2. Eighty percent (80%) of order value in equal monthly payments over the performance period payable 30 days from date of invoice.

Except for work performed (i) under a firm fixed price basis or (ii) pursuant to terms of a previously priced existing contract between Seller and Buyer, invoices for work performed by Seller shall have added and noted on each invoice a charge of 3% (over and above the price of the work) which is related to Seller compliance with present and proposed environmental, health, and safety regulations associated with prescribed requirements covering hazardous materials management and employee training, communications, personal protective equipment, documentation and record keeping associated therewith.

Adequate Assurances

If, in the judgment of Seller, the financial condition of the Buyer, at any time during the period of the contract, does not justify the terms of payment specified, Seller may require full or partial payment in advance.

Delayed Payment

If payments are not made in accordance with these terms, a service charge will, without prejudice to the right of Seller to immediate payment, be added in an amount equal to the lower of 1.5% per month or fraction thereof or the highest legal rate on the unpaid balance.

Freight

Freight policy will be listed on the Product discount sheets, or at option of Seller one of the following freight terms will be quoted.

F.O.B.—P/S—Frt./Ppd. and Invoiced

Products are sold F.O.B. point of shipment freight prepaid and invoiced to the Buyer.

F.O.B.—P/S—Frt./Ppd. and Allowed

Products sold are delivered F.O.B. point of shipment, freight prepaid and included in the price.

F.O.B. Destination—Frt./Ppd. and Allowed

At Buyer's option, Seller will deliver the Products F.O.B. destination freight prepaid and 2% will be added to the net price.

The term "freight prepaid" means that freight charges will be prepaid to the accessible common carrier delivery point nearest the destination for shipments within the United States and Puerto Rico unless noted differently on the Product discount sheets. For any other destination, contact Seller's representative.

Shipment and Routing

Seller shall select the point of origin of shipment, the method of transportation, the type of carrier equipment and the routing of the shipment.

If the Buyer specifies a special method of transportation, type of carrier equipment, routing, or delivery requirement, Buyer shall pay all special freight and handling charges.

When freight is included in the price, no allowance will be made in lieu of transportation if the Buyer accepts shipment at factory, warehouse, or freight station or otherwise supplies its own transportation.

Risk of Loss

Risk of loss or damage to the Products shall pass to Buyer at the F.O.B. point.

Concealed Damage

Except in the event of F.O.B. destination shipments, Seller will not participate in any settlement of claims for concealed damage.

When shipment has been made on an F.O.B. destination basis, the Buyer must unpack immediately and, if damage is discovered, must:

1. Not move the Products from the point of examination.
2. Retain shipping container and packing material.
3. Notify the carrier in writing of any apparent damage.
4. Notify Seller representative within 72 hours of delivery.
5. Send Seller a copy of the carrier's inspection report.

Witness Tests/Customer Inspection

Standard factory tests may be witnessed by the Buyer at Seller's factory for an additional charge calculated at the rate of $2,500 per day (not to exceed eight (8) hours) per Product type. Buyer may final inspect Products at the Seller's factory for $500 per day per Product type.

Witness tests will add one (1) week to the scheduled shipping date. Seller will notify Buyer fourteen (14) calendar days prior to scheduled witness testing or inspection. In the event Buyer is unable to attend, the Parties shall mutually agree on a rescheduled date. However, Seller reserves the right to deem the witness tests waived with the right to ship and invoice Products.

Held Orders

For any order held, delayed or rescheduled at the request of the Buyer, Seller may, at its sole option (1) require payment to be based on any reasonable basis, including but not limited to the contract price, and any additional expenses, or cost resulting from such a delay; (2) store Products at the sole cost and risk of loss of the Buyer; and/or (3) charge to the Buyer those prices under the applicable price policy. Payment for such price, expenses and costs, in any such event, shall be due by Buyer within thirty (30) days from date of Seller's invoice. Any order so held delayed or rescheduled beyond six (6) months will be treated as a Buyer termination.

Drawing Approval

Seller will design the Products in line with, in Seller's judgment, good commercial practice. If at drawing approval Buyer makes changes outside of the design as covered in their specifications, Seller will then be paid reasonable charges and allowed a commensurate delay in shipping date based on the changes made.

Drawing Re-Submittal

When Seller agrees to do so in its quotation, Seller shall provide Buyer with the first set of factory customer approval drawing(s) at Seller's expense. The customer approval drawing(s) will be delivered at the quoted delivery date. If Buyer requests drawing changes or additions after the initial factory customer approval drawing(s) have been submitted by Seller, the Seller, at its option, may assess Buyer drawing charges. Factory customer approval drawing changes required due to misinterpretation by Seller will be at Seller's expense. Approval drawings generated by Bid Manager are excluded from this provision.

Warranty

Warranty for Products

Seller warrants that the Products manufactured by it will conform to Seller's applicable specifications and be free from failure due to defects in workmanship and material for one (1) year from the date of installation of the Product or eighteen (18) months from the date of shipment of the Product, whichever occurs first.

In the event any Product fails to comply with the foregoing warranty, Seller will, at its option, either (a) repair or replace the defective Product, or defective part or component thereof, F.O.B. Seller's facility freight prepaid, or (b) credit Buyer for the purchase price of the Product. All warranty claims shall be made in writing.

Seller requires all non-conforming Products be returned at Seller's expense for evaluation unless specifically stated otherwise in writing by Seller.

This warranty does not cover failure or damage due to storage, installation, operation or maintenance not in conformance with Seller's recommendations and industry standard practice or due to accident, misuse, abuse or negligence. This warranty does not cover reimbursement for labor, gaining access, removal, installation, temporary power or any other expenses, which may be incurred in connection with repair or replacement.

This warranty does not apply to equipment not manufactured by Seller. Seller limits itself to extending the same warranty it receives from the supplier.

Effective Date: November 1, 2017

Extended Warranty for Products

If requested by the Buyer and specifically accepted in writing by Seller, the foregoing standard warranty for Products will be extended from the date of shipment for the period and price indicated below:

- 24 months—2% of Contract Price
- 30 months—3% of Contract Price
- 36 months—4% of Contract Price

Special Warranty (In and Out) for Products

If requested by the Buyer and specifically accepted in writing by Seller, Seller will, during the warranty period for Products, at an additional cost of 2% of the contract price, be responsible for the direct cost of:

1. Removing the Product from the installed location.
2. Transportation to the repair facility and return to the site.
3. Reinstallation on site.

The total liability of Seller for this Special Warranty for Products is limited to 50% of the contract price of the particular Product being repaired and excludes expenses for removing adjacent apparatus, walls, piping, structures, temporary service, etc.

Warranty for Services

Seller warrants that the Services performed by it hereunder will be performed in accordance with generally accepted professional standards.

The Services, which do not so conform, shall be corrected by Seller upon notification in writing by the Buyer within one (1) year after completion of the Services.

Unless otherwise agreed to in writing by Seller, Seller assumes no responsibility with respect to the suitability of the Buyer's, or its customer's, equipment or with respect to any latent defects in equipment not supplied by Seller. This warranty does not cover damage to Buyer's, or its customer's, equipment, components or parts resulting in whole or in part from improper maintenance or operation or from their deteriorated condition. Buyer will, at its cost, provide Seller with unobstructed access to the defective Services, as well as adequate free working space in the immediate vicinity of the defective Services and such facilities and systems, including, without limitation, docks, cranes and utility disconnects and connects, as may be necessary in order that Seller may perform its warranty obligations. The conducting of any tests shall be mutually agreed upon and Seller shall be notified of, and may be present at, all tests that may be made.

Warranty for Power Systems Studies

Seller warrants that any power systems studies performed by it will conform to generally accepted professional standards. Any portion of the study, which does not so conform, shall be corrected by Seller upon notification in writing by the Buyer within six (6) months after completion of the study. All warranty work shall be performed in a single shift straight time basis Monday through Friday. In the event that the study requires correction of warranty items on an overtime schedule, the premium portion of such overtime shall be for the Buyer's account.

Limitation on Warranties for Products, Services and Power Systems Studies

THE FOREGOING WARRANTIES ARE EXCLUSIVE EXCEPT FOR WARRANTY OF TITLE. SELLER DISCLAIMS ALL OTHER WARRANTIES INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

CORRECTION OF NON-CONFORMITIES IN THE MANNER AND FOR THE PERIOD OF TIME PROVIDED ABOVE SHALL CONSTITUTE SELLER'S SOLE LIABILITY AND BUYER'S EXCLUSIVE REMEDY FOR FAILURE OF SELLER TO MEET ITS WARRANTY OBLIGATIONS, WHETHER CLAIMS OF THE BUYER ARE BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY), OR OTHERWISE.

Asbestos

Federal Law requires that building or facility owners identify the presence, location and quantity of asbestos containing material (hereinafter "ACM") at work sites. Seller is not licensed to abate ACM. Accordingly, for any contract which includes the provision of Services, prior to (i) commencement of work at any site under a specific Purchase Order, (ii) a change in the work scope of any Purchase Order, the Buyer will certify that the work area associated with the Seller's scope of work includes the handling of Class II ACM, including but not limited to generator wedges and high temperature gaskets which include asbestos materials. The Buyer shall, at its expense, conduct abatement should the removal, handling, modification or reinstallation, or some or all of them, of said Class II ACM be likely to generate airborne asbestos fibers; and should such abatement affect the cost of or time of performance of the work, then Seller shall be entitled to an equitable adjustment in the schedule, price and other pertinent affected provisions of the contract.

Compliance with Nuclear Regulation

Seller's Products are sold as commercial grade Products not intended for application in facilities or activities licensed by the United States Nuclear Regulatory Commission for atomic purposes. Further certification will be required for use of the Products in any safety-related application in any nuclear facility licensed by the U.S. Nuclear Regulatory Commission.

Returning Products

Authorization and shipping instructions for the return of any Products must be obtained from Seller before returning the Products.

When return is occasioned due to Seller error, full credit including all transportation charges will be allowed.

Product Notices

Buyer shall provide the user (including its employees) of the Products with all Seller supplied Product notices, warnings, instructions, recommendations, and similar materials.

Force Majeure

Seller shall not be liable for failure to perform or delay in performance due to fire, flood, strike or other labor difficulty, act of God, act of any governmental authority or of the Buyer, riot, embargo, fuel or energy shortage, car shortage, wrecks or delays in transportation, or due to any other cause beyond Seller's reasonable control. In the event of delay in performance due to any such cause, the date of delivery or time for completion will be extended by a period of time reasonably necessary to overcome the effect of such delay.

Liquidated Damages

Contracts which include liquidated damage clauses for failure to meet shipping or job completion promises are not acceptable or binding on Seller, unless such clauses are specifically accepted in writing by an authorized representative of the Seller at its headquarters office.

Patent Infringement

Seller will defend or, at its option, settle any suit or proceeding brought against Buyer, or Buyer's customers, to the extent it is based upon a claim that any Product or part thereof, manufactured by Seller or its subsidiaries and furnished hereunder, infringes any United States patent, other than a claim of infringement based upon use of a Product or part thereof in a process, provided Seller is notified in reasonable time and given authority, information and assistance (at Seller's expense) for the defense of same. Seller shall pay all legal and court costs and expenses and court-assessed damages awarded therein against Buyer resulting from or incident to such suit or proceeding. In addition to the foregoing, if at any time Seller determines there is a substantial question of infringement of any United States patent, and the use of such Product is or may be enjoined, Seller may, at its option and expense: either (a) procure for Buyer the right to continue using and selling the Product; (b) replace the Product with non-infringing apparatus; (c) modify the Product so it becomes non-infringing; or (d) as a last resort, remove the Product and refund the purchase price, equitably adjusted for use and obsolescence. In no case does Seller agree to pay any recovery based upon its Buyer's savings or profit through use of Seller's Products whether the use be special or ordinary. The foregoing states the entire liability of Seller for patent infringement.

The preceding paragraph does not apply to any claim of infringement based upon: (a) any modification made to a Product other than by Seller; (b) any design and/or specifications of Buyer to which a Product was manufactured; or (c) the use or combination of Product with other products where the Product does not itself infringe. As to the above-identified claim situations where the preceding paragraph does not apply, Buyer shall defend and hold Seller harmless in the same manner and to the extent as Seller's obligations described in the preceding paragraph. Buyer shall be responsible for obtaining (at Buyer's expense) all license rights required for Seller to be able to use software products in the possession of Buyer where such use is required in order to perform any Service for Buyer.

With respect to a Product or part thereof not manufactured by Seller or its subsidiaries, Seller will attempt to obtain for Buyer, from the supplier(s), the patent indemnification protection normally provided by the supplier(s) to customers.

Compliance with OSHA

Seller offers no warranty and makes no representation that its Products comply with the provisions or standards of the Occupational Safety and Health Act of 1970, or any regulation issued thereunder. In no event shall Seller be liable for any loss, damage, fines, penalty or expenses arising under said Act.

Limitation of Liability

THE REMEDIES OF THE BUYER SET FORTH IN THIS CONTRACT ARE EXCLUSIVE AND ARE ITS SOLE REMEDIES FOR ANY FAILURE OF SELLER TO COMPLY WITH ITS OBLIGATIONS HEREUNDER.

NOTWITHSTANDING ANY PROVISION IN THIS CONTRACT TO THE CONTRARY, IN NO EVENT SHALL SELLER BE LIABLE IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY) OR OTHERWISE FOR DAMAGE TO PROPERTY OR EQUIPMENT OTHER THAN PRODUCTS SOLD HEREUNDER, LOSS OF PROFITS OR REVENUE, LOSS OF USE OF PRODUCTS, COST OF CAPITAL, CLAIMS OF CUSTOMERS OF THE BUYER OR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES WHATSOEVER, REGARDLESS OF WHETHER SUCH POTENTIAL DAMAGES ARE FORESEEABLE OR IF SELLER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

THE TOTAL CUMULATIVE LIABILITY OF SELLER ARISING FROM OR RELATED TO THIS CONTRACT WHETHER THE CLAIMS ARE BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE OR STRICT LIABILITY) OR OTHERWISE, SHALL NOT EXCEED THE PRICE OF THE PRODUCT OR SERVICES ON WHICH SUCH LIABILITY IS BASED.

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