

Protective and Predictive Relays

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Protective and Predictive Relays

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Specifications

See Eaton's *Product Specification Guide*, available on CD or on the Web.

CSI Format:	1995	2010	
DT-3000	Section 16903	26 09 11	Paragraph 2.04.A
FP-5000	Section 16903	26 09 11	Paragraph 2.04.B
MP-3000	Section 16903	26 09 11	Paragraph 2.02.C
MP-4000	Section 16903	26 09 11	Paragraph 2.02.G
EDR-3000	Section 16903	26 09 11	Paragraph 2.04.C
EDR-5000	Section 16903	26 09 11	Paragraph 2.04.D
EMR-3000	Section 16903	26 09 11	Paragraph 2.02.C
EMR-4000	Section 16903	26 09 11	Paragraph 2.02.D
EMR-5000	Section 16903	26 09 11	Paragraph 2.02.E
ETR-4000	Section 16903	26 09 11	Paragraph 2.04.F
ETR-5000	Section 16903	26 09 11	Paragraph 2.04.G
EGR-5000	Section 16903	26 09 11	Paragraph 2.04.E
Universal RTD Module ...	Section 16901	26 27 13.11	Paragraph 2.04.A
InsulGard	Section 16950A	26 13 13.41	Paragraph 2.03.A
	Section 16950C	26 11 13.11	Paragraph 2.03.A
	Section 16950D	26 32 13.11	Paragraph 2.03.A

General Description

Selection Chart

Table 4.0-1. Selection Chart

Device Name		Feeder Protection			
Description	IEEE Device Number	DT-3000	EDR-3000	EDR-5000	FP-5000
					
Page Number		Page 4.1-1	Page 4.1-16	Page 4.1-20	Page 4.1-11

Protection Functions

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
Zone selective interlocking		■	■	■	■
Phase directional control ①	67			■	■
Ground directional control ①	67N			■	■
Phase voltage restrained OC	51VR			■	■
Undervoltage	27			■	■
Current unbalance	46		■	■	■
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 ②	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	■	■	■	■

① Directional elements are controlled by reverse, forward, or both directions.

② When communicating to an external URTD device.

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Feeder Protection			
Description	IEEE Device Number	DT-3000	EDR-3000	EDR-5000	FP-5000
					
Page Number		Page 4.1-1	Page 4.1-16	Page 4.1-20	Page 4.1-11

Protection Functions

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				

Control Functions

Remote open/close		■	■	■	■
Programmable I/O		■	■	■	■
Digital inputs	1	1	4 or 8	8	8
Relay outputs	2	2	3 or 5	10	6
Supervisory/alarm output	1	1	1	1	1
Programmable logic control			■	■	■
Multiple settings groups			4	4	4
Adaptive parameters			■	■	
Reduced voltage starting					
Analog outputs					
Analog inputs					

Metering Functions

Ampere		■	■	■	■
Ampere Demand		■	■	■	■
Voltage (L-N and L-L)				■	■
Phase angle			■	■	■
Pos., neg., and zero sequence			■	■	■
Watts				■	■
Watt Demand				■	■
Watt-hour				■	■
VARs				■	■
VAR demand				■	■
VAR-hour				■	■
VA				■	■
VA Demand				■	■
VA-hour				■	■
Frequency				■	■
Minimum/maximum recording			■	■	■
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					

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Feeder Protection			
Description	IEEE Device Number	DT-3000	EDR-3000	EDR-5000	FP-5000
					
Page Number		Page 4.1-1	Page 4.1-16	Page 4.1-20	Page 4.1-11

Monitoring Functions

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

Front access interface					
Local human machine interface		■	■	■	■
RS-232			■	■	■
USB			②	②	
Rear communication port interface					
RS-485		■	Option	Option	■
Ethernet copper (RJ45)			Option	Option	
Fiber optic ST ②			②	②	
Fiber optic LC ②			②	②	
Protocol					
INCOM		■			Option
Modbus-RTU		■	Option	Option	Option
Modbus-TCP			Option	Option	
IEC 61850			Option	Option	
DNP 3.0 ②			②	②	
Profibus ②			②	②	
IRIG-B			Option	■	
SNTP			Option	Option	

Construction

Panel mount case		■	Semi-flush or projected	Semi-flush or projected	■
Drawout case		Option	Removable terminals	Removable terminals	Option
Self-shorting CT terminals			■	■	
Operating Temperature Range		-30 °C to +55 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C
Power supply range (Vac)		120–240 Vac	40–250 Vac	40–250 Vac	48–125 Vdc
Power supply range (Vdc)		24–250 Vdc	19– 300 Vdc	19–300 Vdc	48–125 Vdc
AC current inputs		■	■	■	■
AC voltage inputs				■	■
Wye VT configuration				■	■
Open delta VT configuration				■	■
Sensitive ground	50/51G		Option	Option	
Local display / HMI		■	Backlit LCD w/8 pushbuttons	Backlit LCD w/8 pushbuttons	■
LEDs (local targets)		■	Programmable	Programmable	■

Standards

ANSI		■	■	■	■
IEC		■	■	■	■
UL		■	■	■	■
CE		DT-3030 only	■	■	■
CSA		■	■	■	■

① When communicating to an external URTD device.

② Option available beginning in late 2015.

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection		
Description	IEEE Device Number	C306 Bimetallic OLR	C440/XT Solid-State OLR	C441 Solid-State OLR
				
Page Number		Page 4.2-1	Page 4.2-1	Page 4.2-5

Protection Functions

Motor Protection				
Thermal overload protection	49	Bi-metallic	Microprocessor-based	Microprocessor-based
Trip class		■ 10 or 20 Selectable via heater packs	■ 10A, 10, 20, 30 Selectable via DIP switches	■ 5–30 Selectable via user interface
Adjustable FLA		■ Adjustable via dial (range approx.1.6:1)	■ Adjustable via dial (range 5:1)	■ Adjustable via user interface (range 9:1 and 18:1)
Locked rotor/stall current	49S/51	■	■	■
Phase loss—current	46		Selectable on/off (90% setting)	Selectable on/off (60% setting)
Phase imbalance	46		Selectable on/off (50% setting)	Adjustable (0–30% setting), off
Ground fault	51N		Fixed at 50% of FLA setting	Programmable threshold, and alarm or trip mode
Jam/current level protection	50			Instantaneous and adjustable
Phase reversal	47			■
Load Protection				
Undercurrent				■
Low power (kW)				■
High power (kW)				■
Voltage Protection				
Overvoltage	59			■
Undervoltage	27			■
Voltage imbalance	47			■
Voltage phase loss	47			■
Power-up delay				■

Control Functions

Manual reset		■	■	■
Automatic reset		■	■	■
Electronic remote reset			■	■
Network command reset			■	■

Output Contacts

NO contacts		1	1 B600	1 B300 (Form A or Form C)
NC contacts		1	1 B600	1 B300 (Form B or Form C)
Ground fault shunt relay ^①				1 B300 (Form A)
Independently programmable contacts ^①				■

Control Power

Self (line) powered			■	■
Separate 24 Vdc supply			■	
Separate 120 Vac supply				■

Metering Functions (via Local Display)

Amperes				
Individual phase				■
Average				■
Current imbalance %				■
Voltage				
Individual phase				■
Average				■
Voltage imbalance %				■

^① Depends on the catalog number ordered.

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection		
Description	IEEE Device Number	C306 Bimetallic OLR	C440/XT Solid-State OLR	C441 Solid-State OLR
				
Page Number		Page 4.2-1	Page 4.2-1	Page 4.2-5

Metering Functions (via Local Display) (continued)

Kilowatts				■
Power factor				■
Trip status				■
Diagnostics (10 fault queue)				■
Overload indication				■
Thermal capacity				■
Frequency				■
Run hours				■
Ground fault current				■

Monitoring Functions (via Communications)

Overload indication		■	■	■
Operating LED			■	■
Trip status		■	■	■
Configured settings			■	■
Thermal memory (time until reset)			■	■
Thermal capacity			■	■
Ground fault current			■	■
Frequency			■	■
Motor starts				■
Motor run hours				■
Power motor kW				■
Power factor				■

Current

Individual Phase I rms			■	■
Average Phase I rms			■	■
Current imbalance %			■	■

Voltage

Individual Phase V rms				■
Average Phase V rms				■
Voltage imbalance %				■

Fault Indication

Overload			■	■
Phase loss			■	■
Phase imbalance			■	■
Ground fault			■	■
Phase reversal				■
Jam/stall/current level				■
Undercurrent				■
Low power				■
High power				■
Voltage imbalance				■
Undervoltage				■
Overvoltage				■

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection		
Description	IEEE Device Number	C306 Bimetallic OLR	C440/XT Solid-State OLR	C441 Solid-State OLR
				
Page Number		Page 4.2-1	Page 4.2-1	Page 4.2-5

Communications

Modbus RTU RS-485			■	■
Modbus RTU with I/O			■	■
DeviceNet with I/O			■	■
PROFIBUS with I/O			■	■
EtherNet/IP with I/O			■	■
Modbus TCP with I/O			■	■

Mounting

Panel mounting		■	■	■
Contactors mounting		■	■	
DIN rail mounting		■	■	
Optional remote mounted display				■

Standards

UL		■	■	■
CSA		■	■	■
CE		■	■	■
NEMA		■	■	■
IEC			■	■
RoHS			■	■

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection					Transformer Protection		Generator Protection
Description	IEEE Device Number	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
									
Page Number		Page 4.2-11	Page 4.2-17	Page 4.2-22	Page 4.2-29	Page 4.2-37	Page 4.3-1	Page 4.3-7	Page 4.3-18

Protection Functions

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	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	■	■	■	■	■		■	■
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 ②	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	■	■	■	■	■	■	■	■

① Directional elements are controlled by reverse, forward, or both directions.

② When communicating to an external URTD device.

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection					Transformer Protection		Generator Protection
Description	IEEE Device Number	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
									
Page Number		Page 4.2-11	Page 4.2-17	Page 4.2-22	Page 4.2-29	Page 4.2-37	Page 4.3-1	Page 4.3-7	Page 4.3-18

Protection Functions

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								■

Control Functions

Remote open/close		Open only	Open only	■	■	■	■	■	■
Programmable I/O		■	■	■	■	■	■	■	■
Digital inputs		2	2	4	8	8 or 16	8	8	8 or 16
Relay outputs		4	4	3	4	8	8	8	8
Supervisory/alarm output		1	1	1	1	1	1	1	1
Programmable logic control				■	■	■	■	■	■
Multiple settings groups				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

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									■

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection					Transformer Protection		Generator Protection
Description	IEEE Device Number	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
									
Page Number		Page 4.2-11	Page 4.2-17	Page 4.2-22	Page 4.2-29	Page 4.2-37	Page 4.3-1	Page 4.3-7	Page 4.3-18

Monitoring Functions

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

Front access interface									
Local human machine interface		■	■	■	■	■	■	■	■
RS-232				■	■	■	■	■	■
USB				②	②	②	②	②	②
Rear communication port interface									
RS-485				Option	Option	Option	Option	Option	Option
Ethernet copper (RJ45)				Option	Option	Option	Option	Option	Option
Fiber optic ST ②				②	②	②	②	②	②
Fiber optic LC ②				②	②	②	②	②	②
Protocol									
INCOM		Option	Option						
Modbus RTU		Option	Option	Option	Option	Option	Option	Option	Option
Modbus TCP				Option	Option	Option	Option	Option	Option
IEC 61850				Option	Option	Option	Option	Option	Option
DNP 3.0 ②				②	②	②	②	②	②
Profibus ②				②	②	②	②	②	②
IRIG-B				■	■	■	■	■	■
SNTP				Option	Option	Option	Option	Option	Option

① When communicating to an external URTD device.

② Option available beginning in late 2015.

General Description

Table 4.0-1. Selection Chart (Continued)

Device Name		Motor Protection					Transformer Protection		Generator Protection
Description	IEEE Device Number	MP-3000	MP-4000	EMR-3000	EMR-4000	EMR-5000	ETR-4000	ETR-5000	EGR-5000
									
Page Number		Page 4.2-11	Page 4.2-17	Page 4.2-22	Page 4.2-29	Page 4.2-37	Page 4.3-1	Page 4.3-7	Page 4.3-18

Construction

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
Drawout case		Option	Option	Removable terminals	Removable terminals	Removable terminals	Removable terminals	Removable terminals	Removable terminals
Self-shorting CT terminals				■	■	■	■	■	■
Operating Temperature Range		-20 °C to +60 °C	-20 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C	-40 °C to +60 °C
Power supply range (Vac)		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)				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
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
LEDs (local targets)		■	■	Programmable	Programmable	Programmable	Programmable	Programmable	Programmable

Standards

ANSI		■	■	■	■	■	■	■	■
IEC		■	■	■	■	■	■	■	■
UL		■	■	■	■	■	■	■	■
CE				■	■	■	■	■	■
CSA		■	■	■	■	■	■	■	■

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Digitrip 3000 Feeder Protection Relay



Digitrip 3000 Front View

General Description

Eaton's Digitrip® 3000 protection relay is a multi-function, 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 Digitrip 3000 is available in an optional quick-release drawout case for panel-flush mounting. For AC control power applications, an optional Dual-Source Power Supply (DSPS) is recommended. See **Page 4.1-6** for details. The Digitrip 3000 design provides true rms 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 Digitrip 3000 relay operates from the 5 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.

The Digitrip 3000 features a user-friendly operator panel to monitor, program and test the relay. Operating parameters and troubleshooting information are displayed in the two highly visible display windows. In addition, all data and information can be communicated to a host computer equipped with the appropriate software. A "Communication Trip" and "Communication Close" control command can also be initiated by a host computer with an authorized access code.

Features

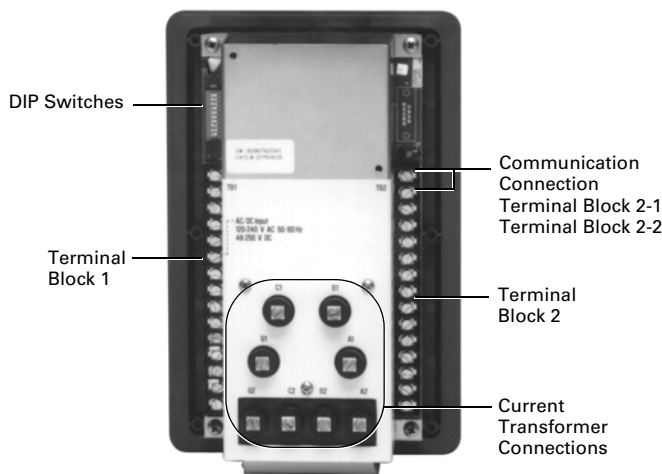
General

- ANSI or IEC applications
- User-friendly front panel
- Non-volatile memory
- View settings any time
- Set CT ratios
- Metered currents in primary amperes
- Individual phase targeting of fault
- Integral test mode (phase and ground)
- Program and test mode security access cover with meter seal provision

- Continuous internal circuitry self-testing
- Programmable lockout/self reset after trip
- Relay failure alarm contact
- Trip alarm contact
- Optional Dual-Source Power Supply (DSPS), see **Page 4.1-6**
- Optional quick-release drawout case, see **Page 4.1-8**

Table 4.1-1. Catalog Numbers

Description	Catalog Number
Digitrip 3000	DT3000
Digitrip 3000 drawout relay	DT3001
Digitrip 3000 drawout inner chassis	DT3001-IC
Digitrip 3000 drawout outer case	DT3001-OC
Digitrip 3000 with 120 Vac dual-source power supply	DT3010
Digitrip 3000 with 240 Vac dual-source power supply	DT3020
Digitrip 3000 with 24/48 Vdc power supply and CE mark	DT3030
Digitrip 3000 with 24/48 Vdc power supply and CE mark in drawout case	DT3031



Digitrip 3000 Rear View

System Protection

- True rms sensing of each phase and ground current
- Selectable curve shapes: ANSI, IEC or thermal curves
- Phase overcurrent protection per time-current curve
- Independent ground fault protection per time-current curve
- Time overcurrent reset time delay
- Ground element capable of residual, zero sequence or external source connections
- Instantaneous phase and ground OC
- Short delay phase and ground OC
- Selectable true making current release (discriminator)
- Configurable trip outputs
- Zone selective interlocking (phase and ground) for bus protection and reduced arc flash energy

Information and Data Delivery

- Displays individual phase currents
- Displays ground current
- Displays magnitude and phase of current causing trip
- Displays peak demand current for each phase and ground since last reset
- Displays current transformer ratio
- Indicates cause of trip (time or instantaneous)
- Data/information transmission
- Provides breaker "Open" or "Close" status to a remote location via Eaton's PowerNet™

Application Description

General

The 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, as in **Figure 4.1-1**.

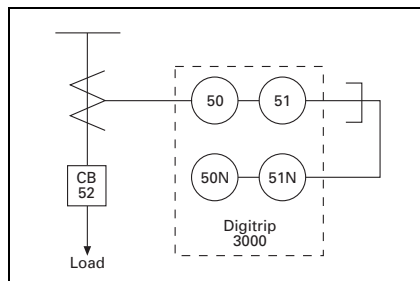


Figure 4.1-1. Primary Feeder Protection

The Digitrip 3000 may be applied as the transformer primary protection or as backup to the differential protection, as in **Figure 4.1-2**.

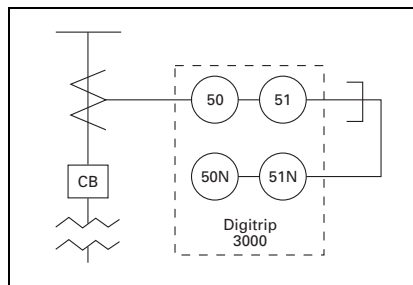


Figure 4.1-2. Transformer Protection

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 4.1-3**).

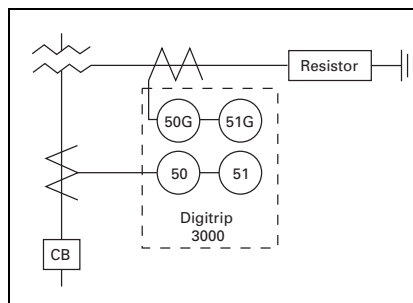


Figure 4.1-3. Transformer Secondary Protection with Ground CT Connection

The Digitrip 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 more detail on **Page 4.1-4**.

Time Overcurrent Reset

The Digitrip 3000 includes time delay reset characteristic for the time overcurrent functions. This improves the overcurrent protection response to arcing fault conditions. The current during an arcing fault may vary above and below the pickup level. The time above pickup will accumulate until trip occurs.

Overcurrent Protection

The Digitrip 3000 provides complete three-phase and ground protection with separate elements and settings. The relay can be used with CT ratios from 5/5 to 5000/5. 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 as in **Figure 4.1-4** and **Figure 4.1-5**.

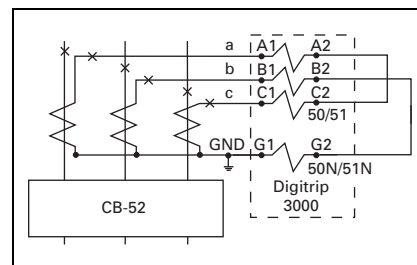


Figure 4.1-4. Residual Ground Connections

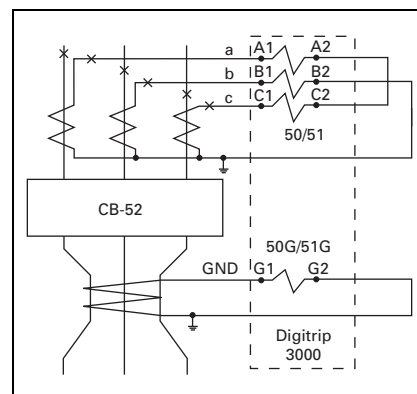


Figure 4.1-5. Separate Zero Sequence Ground CT Connections

The phase and ground overcurrent characteristics are defined by six parameters.

- ① Curve shape
- ② Overcurrent pickup
- ③ Time multiplier or dial
- ④ Short delay pickup
- ⑤ Short delay time
- ⑥ Instantaneous pickup

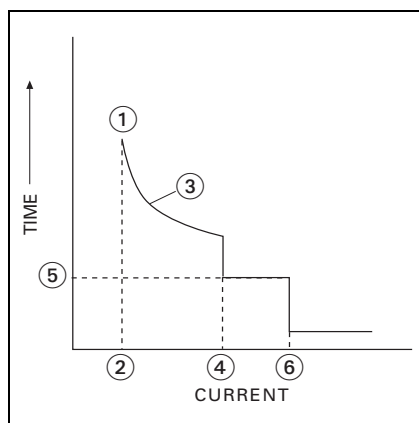


Figure 4.1-6. Phase or Ground Overcurrent Characteristics

Phase Curve Shape

The Digitrip 3000 includes the thermal, ANSI and IEC family of curves, which make it easy to coordinate with any conventional protection scheme. The user can select Moderately Inverse, Very Inverse, Extremely Inverse or Definite Time characteristics. The thermal curves I_t , I^2_t , I^4_t and flat slopes can also be selected.

Phase Time Overcurrent Protection

Time overcurrent (overload and fault) protection is defined by the current pickup setting and time multiplier.

Phase Short Time Protection

Short time (fault) protection responds to short-circuit conditions. It is similar to the Phase Long Time Protection in that current and time settings are offered. It differs, however, in two ways: (1) "NONE" is a Short Delay Pickup setting that, if selected, will disable the Phase Short Time Protection, and (2) a slope selection is not available for the time line.

Instantaneous Protection

Instantaneous (short-circuit) protection reacts to high level fault currents. If "NONE" is selected for the instantaneous setting, the instantaneous trip function is disabled and a true making current release (discriminator) function is provided. If selected, the discriminator is functional for 10 cycles and will trip the breaker instantaneously, if the fault current is above 11 times (I_n).

Ground Fault Protection

The ground fault protection function is a composite of the ground:

- Ground curve shape
- Time overcurrent and pickup time settings
- Short delay current and time settings
- Instantaneous setting

A "NONE" setting selection disables that characteristic of the ground fault protection.

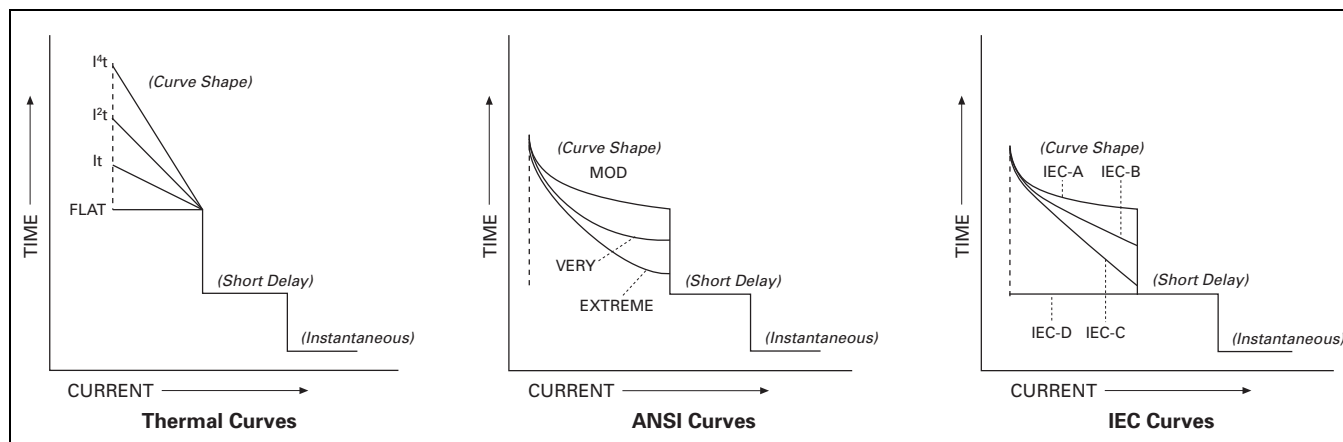


Figure 4.1-7. Digitrip 3000 Selective Curve Types

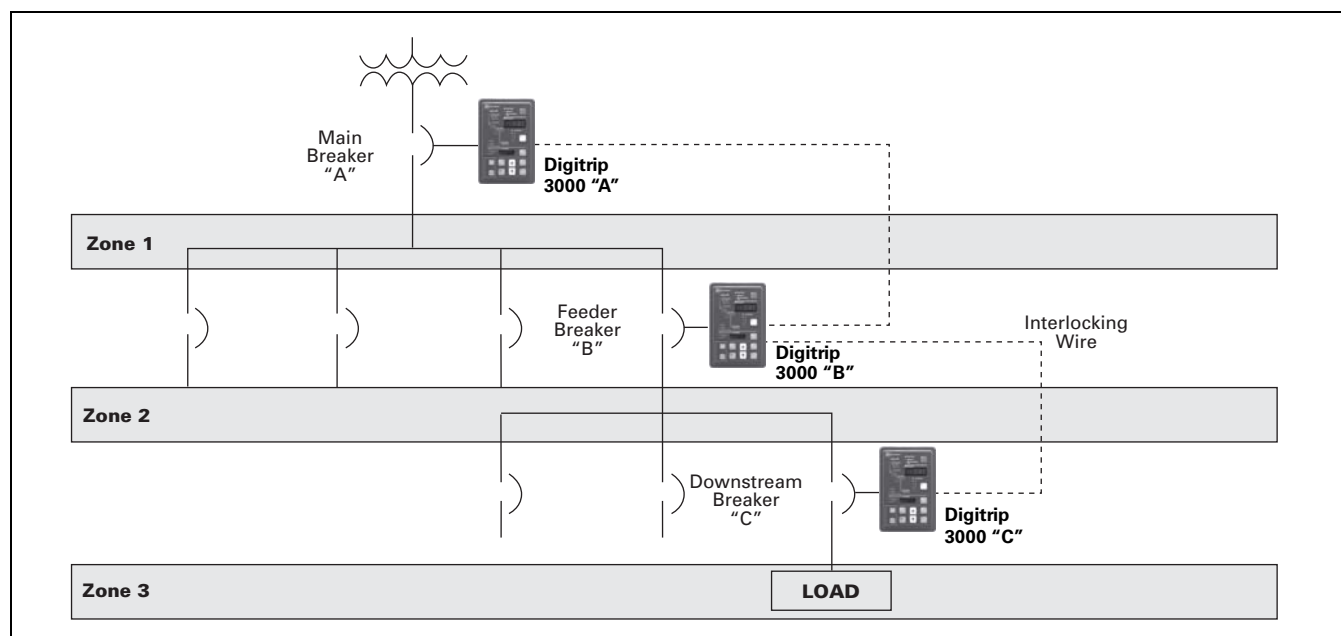


Figure 4.1-8. Sample Zone Selective Interlocking System

Zone Selective Interlocking (Phase and Ground)

Zone selective interlocking is a protection function to minimize equipment damage resulting from a phase fault 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 used, an immediate trip is initiated when the fault is in the breaker’s zone of protection, and no restraining signal received regardless of its preset time delay. When the “Phase Zone Interlocking” feature is used, 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, and no restraining signal received regardless of its preset time delay. The time overcurrent phase element will initiate an immediate trip when the fault is in the breaker’s zone of protection, and no restraining signal received regardless of its preset time delay only when the current being sensed by the Digitrip 3000 exceeds 300% ($3 \times I_N$) of the current transformer rating.

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. It provides standard coordinated tripping when the fault is located outside the zone of protection.

In the sample zone interlocking system shown above, 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% ($3 \times I_N$) 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 withholds its trip command. 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% ($3 \times I_N$) 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 because 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 it did not receive a 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% ($3 \times I_N$) 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.

Technical Data and Specifications

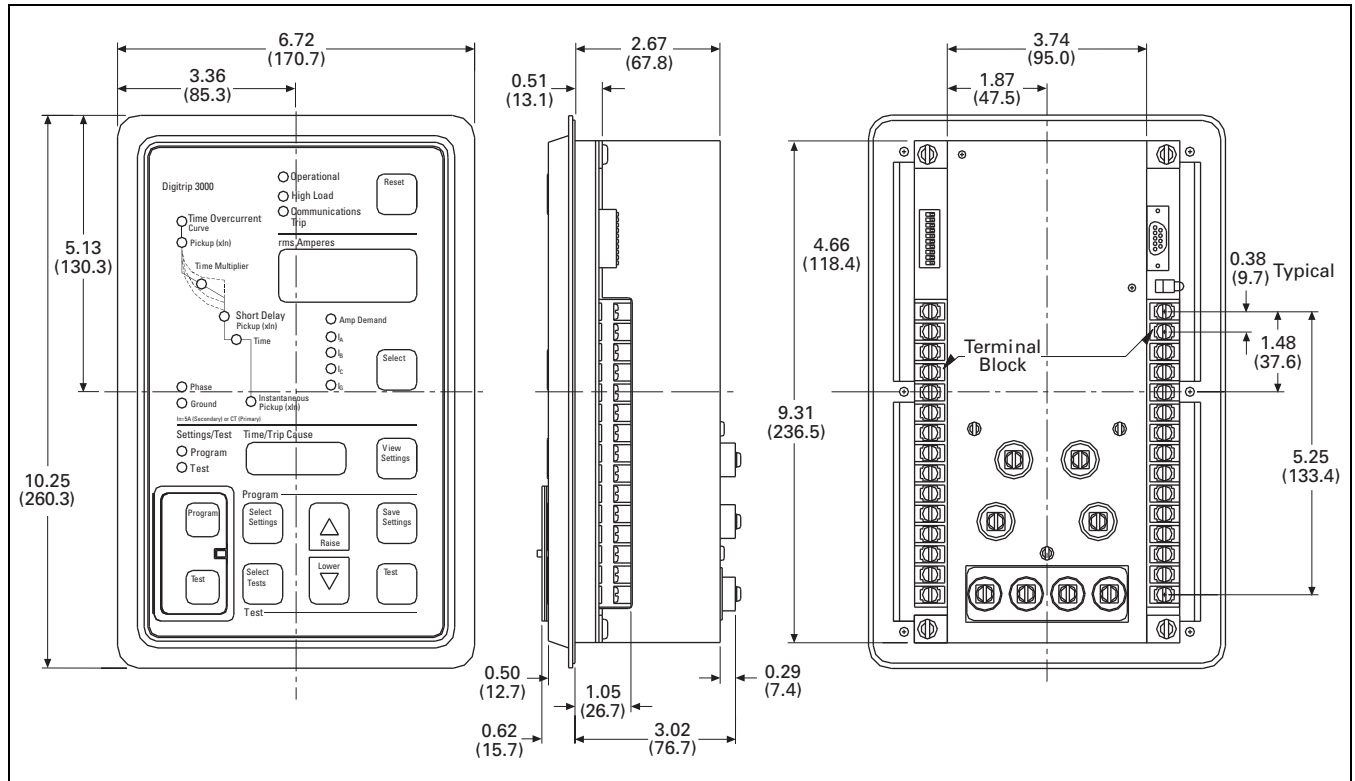


Figure 4.1-9. Digitrip 3000 Fixed Mount—Dimensions in Inches (mm)

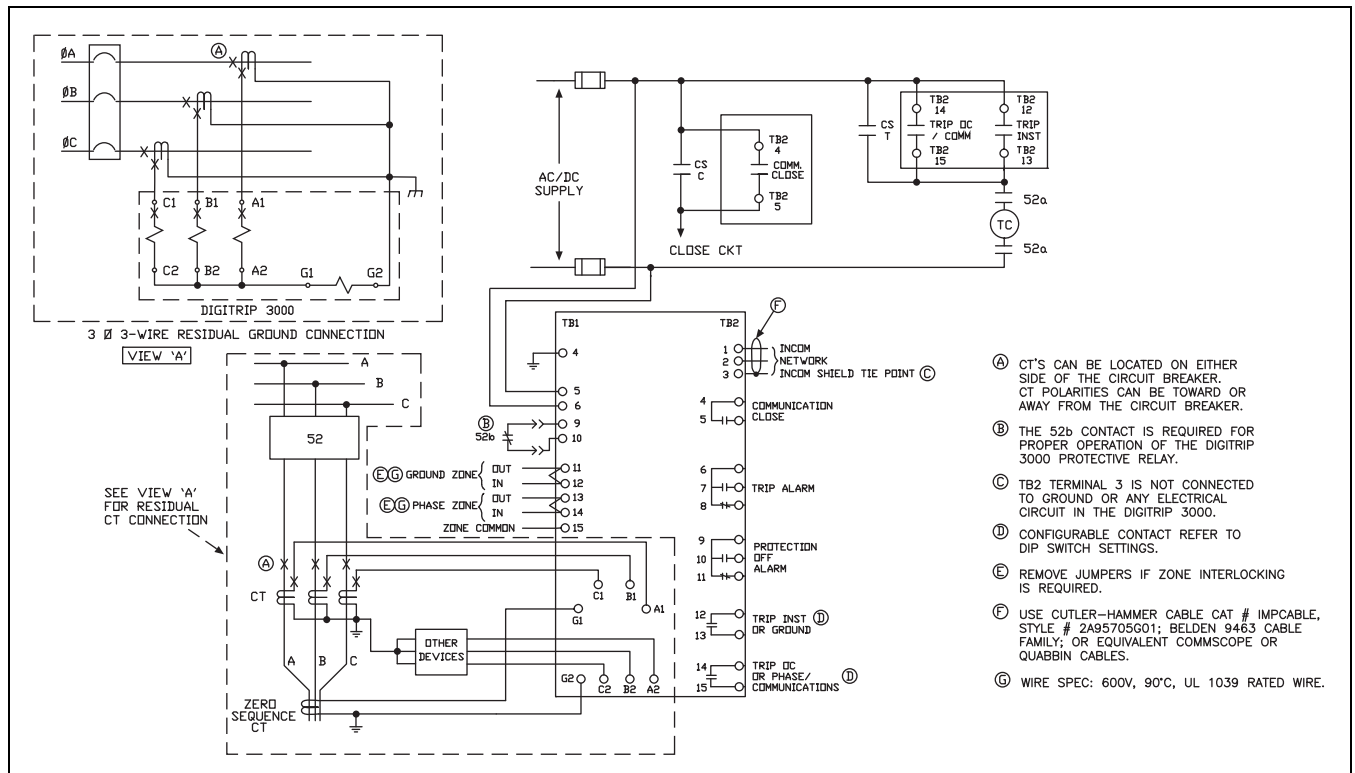


Figure 4.1-10. Digitrip 3000 Typical Schematic and Wiring Diagram

Digitrip 3000 Relay with Dual-Source Power Supply



Digitrip 3000 with Dual-Source Power Supply

General Description

Eaton's Digitrip 3000 with Dual-Source Power Supply (DSPS) is a micro-processor-based feeder overcurrent protection relay designed for AC auxiliary power applications. The DSPS versions, Digitrip 3010 and Digitrip 3020, include an integral power supply module that:

- Powers the relay from nominal 120 Vac, 50/60 Hz (Digitrip 3010 model) or 240 Vac, 50/60 Hz (Digitrip 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
- The transition from external auxiliary AC power to current power is smooth with no time delay

The CT powering capability is critical for tripping if the AC auxiliary supply or its fuses fail prior to the fault; or if the fault itself collapses, the supply voltage at the critical moment when tripping is needed.

The Digitrip 3000 with Dual-Source Power Supply design offers significant performance and reliability benefits over the electromechanical or "self-powered" relays. It provides a full-time metering display, remote communications and self-monitoring functions. In addition, there is no calibration required. The burden is lower than most electromechanical and solid-state self-powered relays.

The Digitrip 3000 with DSPS provides long-term, robust, maintenance-free performance, which can't be achieved with an energy-storing uninterruptible power supply (UPS). The DSPS will operate anytime there is a fault even after an extended power outage.

Functional Description

The Dual-Source Power Supply 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 power. 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 V for Digitrip 3010 or 140 V for Digitrip 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 9A, 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 Digitrip 3000 relay trip time accuracy when the Dual-Source Power Supply switches from normal AC voltage to fault-current power.

Technical Data and Specifications

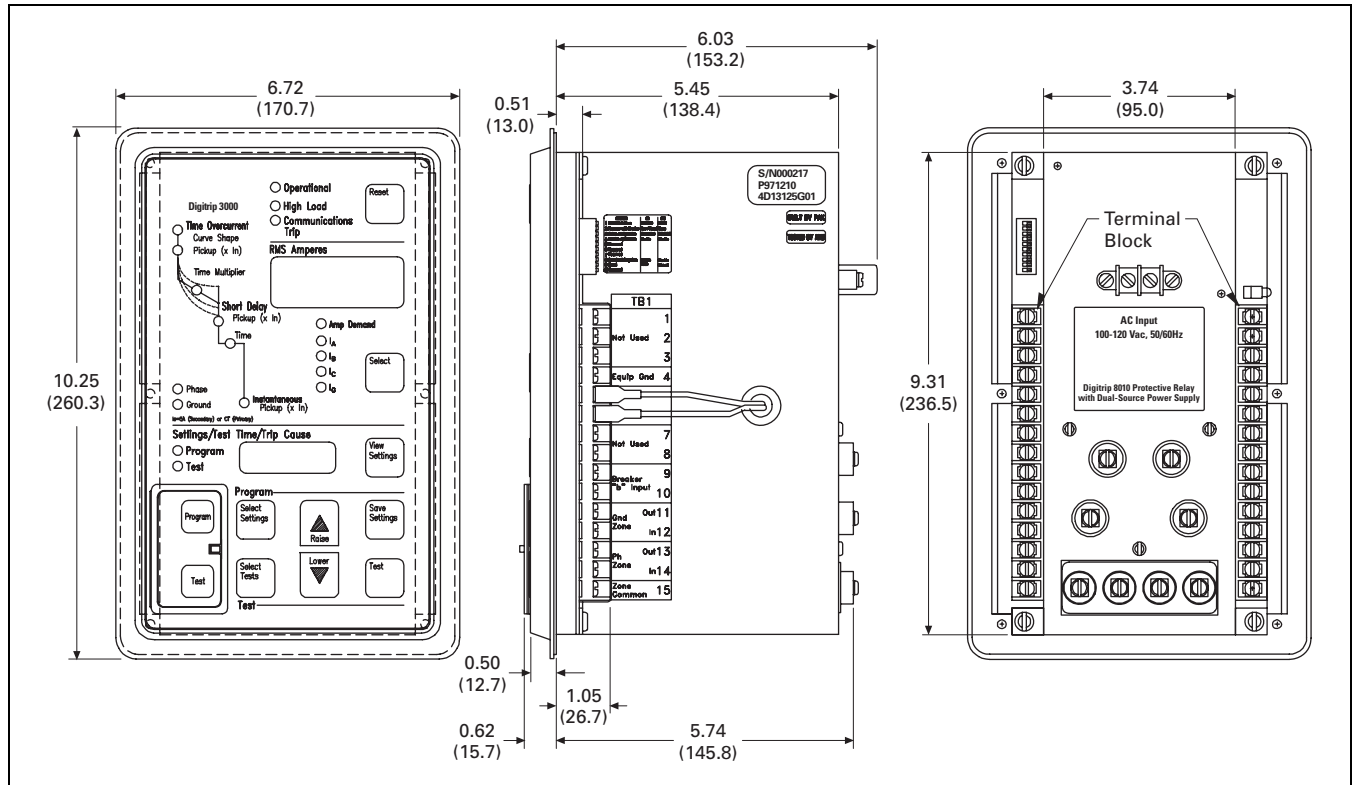


Figure 4.1-11. Digitrip 3010/3020 Dual-Source Power Supply—Dimensions in Inches (mm)

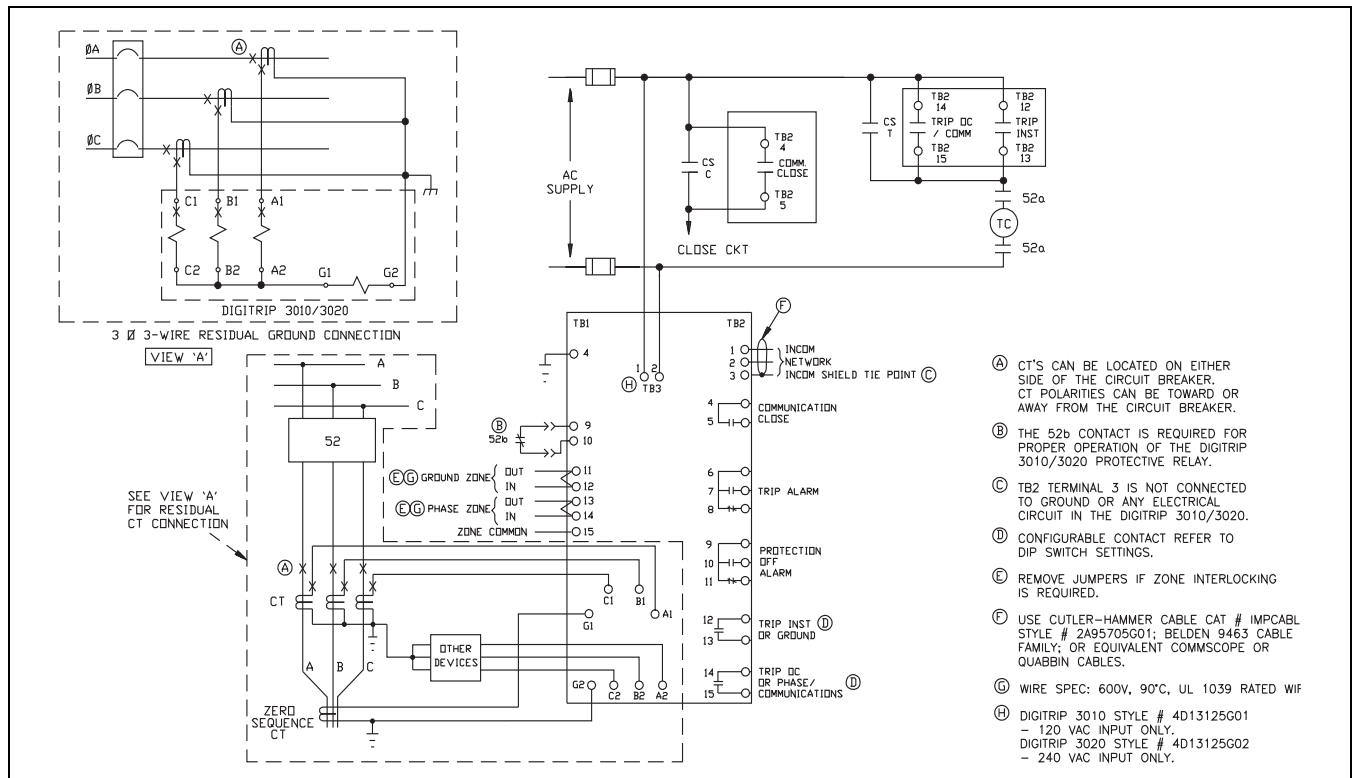


Figure 4.1-12. Digitrip 3010/3020 Typical Schematic and Wiring Diagram

General Description—Drawout Case

Digitrip 3000— Drawout Case Option



Digitrip 3000 Drawout Relay

General Description

The quick-release Drawout Case option permits easy removal and replacement of the protective unit without disruption of the wiring. The CT circuits are self-shorting with make-before-break operation on removal. All voltage inputs, discrete inputs and contact outputs are disconnected while maintaining security against false tripping.

The terminal blocks feature a two-stage disconnect operation. Removal of the Eaton's Digitrip 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 activated before the trip circuits are activated. **This feature provides added security against false tripping.**

Technical Data and Specifications

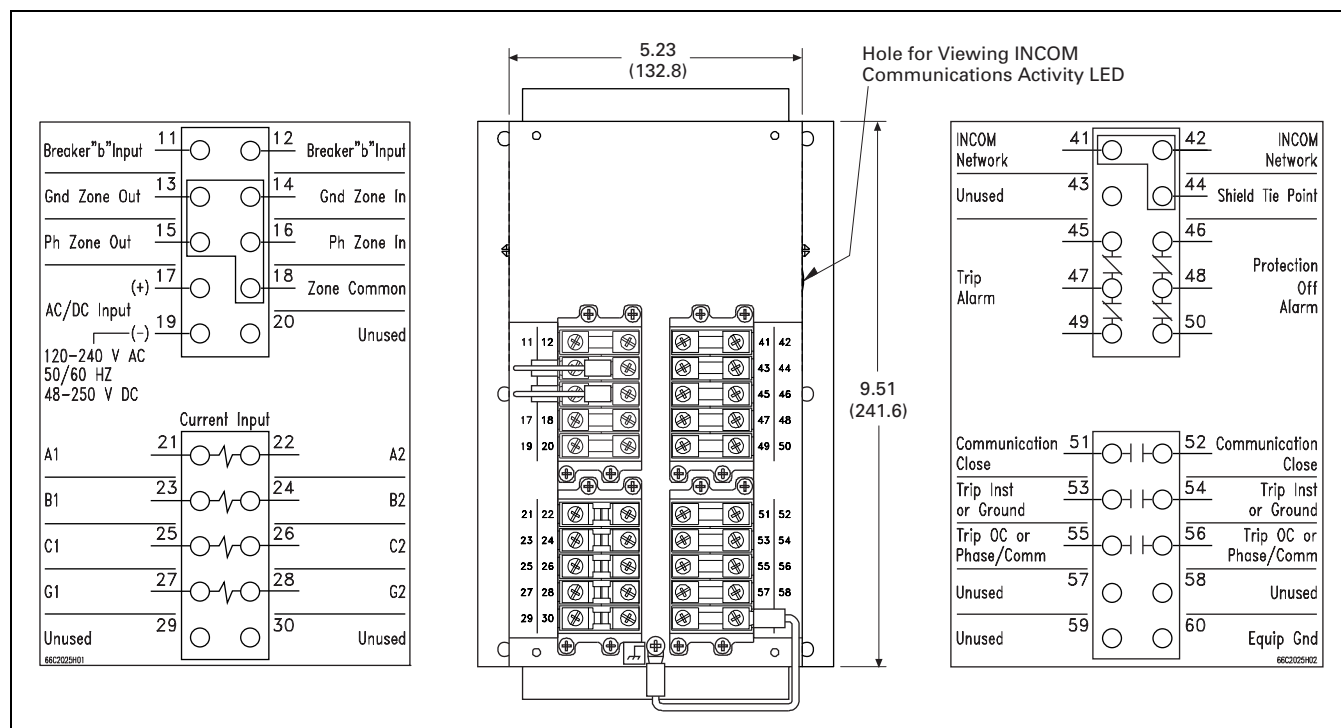


Figure 4.1-13. Rear View of Digitrip 3000 Drawout Outer Case—Terminal Layout

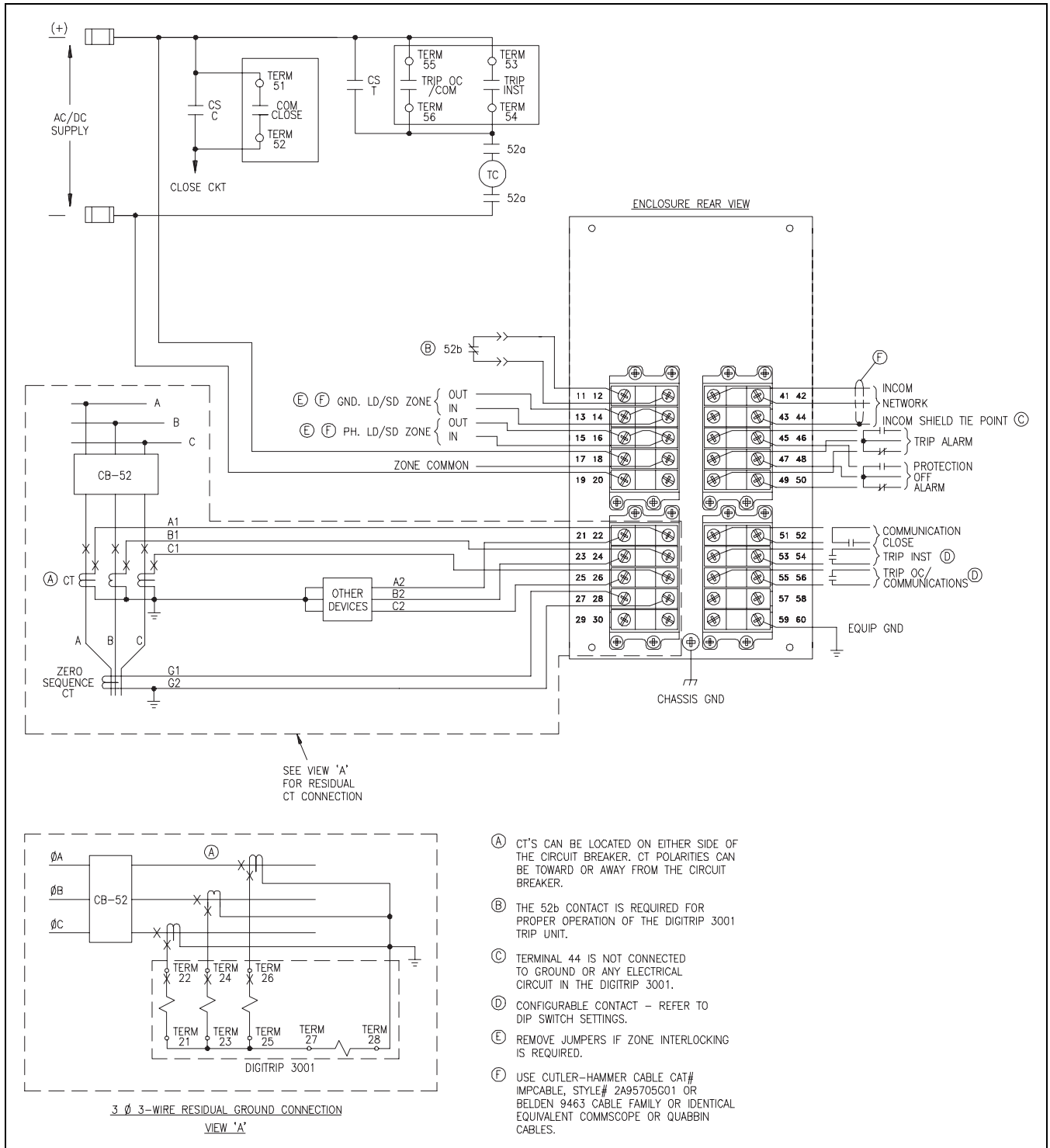


Figure 4.1-14. Digitrip 3000 Drawout Relay Typical Schematic and Wiring Diagram

Standards, Certifications and Ratings

Table 4.1-2. Digitrip 3000 Specifications

Current Inputs							Environment				Ground Overcurrent Pickup Ranges			
CTs: 5 A secondary CT burden: <0.004 ohm ① <0.1 VA at rated current (5 A) I _n : 5 A (secondary) or CT (primary) Momentary: 100 x I _n for 1 second							Operating temperature: -30 °C to +55 °C Operating humidity: 0% to 95% Relative humidity (noncondensing) Storage temperature: -40 °C to +70 °C				Inverse time Overcurrent setting: 0.1 to 2.0) x I _n , None (26 settings) Short delay setting: (1 to 11) x I _n , None (25 settings) Instantaneous setting: (1 to 25) x I _n , None (30 settings)			
CT (Primary) Settings Available							Auxiliary Alarm Contacts				Time Delay Settings			
Phase and ground: 5/10/25/50/75/100/ 150/200/250/200/ 250/300/400/500/ 600/630/800/1000/ 1200/1250/1500/ 1600/2000/2400/ 2500/3000/3200/ 4000/5000							5 A continuous 5 A break at 120/240 Vac				Inverse time overcurrent time multiplier: I _t , I _t ² , I _t ⁴ Curve: 0.2 to 40 (47 settings) FLAT: 0.2 to 2 (21 settings) ANSI (all): 0.1 to 5.0 (50 settings) IEC (all): 0.025 to 1.00 (40 settings) Short delay time: 0.05 to 1.5 sec (22 settings)			
Input Voltage DT-30XX							Tests				Current Monitoring			
Nominal: 22 to 250 Vdc 120 to 240 Vac 50/60 Hz							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 Standards: ANSI C3790, C3790.1, C3790.2 IEC 255 UL 1053				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: 85% of inverse time overcurrent setting			
Operating range: 28 to 280 Vdc 90 to 254 Vac 50/60 Hz							Phase and Ground Time-Current Curves				Timing Accuracy ②			
Power consumption:							Thermal: I _t (moderately inverse) I _t ² (very inverse) I _t ⁴ (extremely inverse) FLAT (definite time)				Inverse time overcurrent time: ±10% at >1.5 x pickup Short delay time: ±50 ms Standards: ANSI C3790 IEC 255 UL 1053			
24 48 125 250 120 240							ANSI: (per ANSI C37.112, 1996)				Moderately inverse Very inverse Extremely inverse			
Vdc Vdc Vdc Vdc Vdc Vac							IEC: (per IEC 255-3, 1989)				IEC-A (moderately inverse) IEC-B (very inverse) IEC-C (extremely inverse) IEC-D (definite time)			
10W 10W 10W 10W 10 VA 18 VA														
DT 3010 3020 3030														
Nominal: 120 Vac 240 Vac 24/48 Vdc														
operating range: 70– 140– —														
132 Vac 264 Vac														
Power consumption: 15 VA 15 VA —														
Trip and Communications Close Output Contacts							Phase Overcurrent Pickup Ranges				Communications			
■ Make 30 A for 0.25 seconds ■ 0.25 A break at 250 Vdc ■ 5 A break at 120/240 Vac ■ Meets ANSI C3790, paragraph 6.7							Inverse time overcurrent setting: (0.2 to 2.2) x I _n (28 settings) Short delay setting: (1 to 11) x I _n , None (25 settings) Instantaneous setting: (1 to 25) x I _n , None (30 settings)				PowerNet compatible: Built-in INCOM Baud rate: 1200 or 9600 baud			

① Refer to Burden Curves for Digtrip 3010/3020.

② For Ground Pickup $\leq 0.2\mu\text{s}$: Time Tolerance $\pm 15\%$.

FP-5000 Feeder Protection Relay



FP-5000 Relay

General Description

Eaton's FP-5000 feeder protection relay is a multi-functional, microprocessor-based relay for feeder circuits of all voltage levels. It may be used as primary protection for main, feeder and tie circuit breaker applications, transformers and as backup protection for high voltage lines and differential protection.

The FP-5000 feeder protection relay provides complete current and voltage protection and metering in a single, compact drawout case. The relay has four current inputs rated for 5 A or 1 A 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, delta or open delta configuration. The fourth voltage is for independent single-phase undervoltage/overvoltage protection.

The multiple settings groups can be used for arc flash mitigation when an alternate settings group, set to have instantaneous elements only, is activated using a selector switch and the programmable I/O in the FP-5000.

An integral keypad and display is provided for direct user programming and retrieval of data. LEDs provide quick indication of relay status. A front port is provided for direct computer connection. An INCOM communication port on the back of the relay is standard for local area networking. Optional communication ports and protocols are available.

The FP-5000 feeder protection relay includes programmable logic functions. Six gates and timers may be defined and arranged for customized applications. 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 or contact input.

The FP-5000 feeder protection relay has a mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 100 sequence of event records, detailed trip logs, minimum/maximum values, load profiles, breaker wear information and oscillography data.

The FP-5000 feeder protection relay has eight programmable binary inputs, five normally opened heavy-duty outputs and one Form C signal relay. It can be powered from 48 Vdc to 125 Vdc or 120 Vac to auxiliary power.

Features

Protection

- 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 current (67)
 - 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, 50R-2)
 - Inverse time overcurrent (51X, 51R)
 - Ground directional polarizing (67N)
 - 3 V_0 , I_{p0} , negative sequence
 - 10 standard curves
 - Instantaneous or time delay reset
- Breaker failure (50BF)
- Phase unbalance negative sequence overcurrent (46)
- Phase voltage unbalance and sequence protection (47)
- Under/overvoltage (27/59)
- Under/overfrequency (81U/81O)
- Reverse/forward power (32-1, 32-2)

- Sync check (25)
- Power factor (55)
- Zone interlocking for bus protection (87B)

Metering

- 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, lag and net)
- Power factor
- Frequency
- % THD V and I
- Magnitude THD V and I
- Minimum/maximum recording
- Trending (load profile over time)

Monitoring

- Trip coil monitor
- Close coil monitor
- Breaker wear (accumulated interrupted current)
- Oscillography (up to 16 events)
- Fault data logs (up to 16 events)
- Sequence of events report (up to 100 events)
- Clock (1 ms time stamping)

Communication

- Local HMI
- Password protected
- Addressable
- Local communication port
- Remote communication port:
 - FSK
 - RS-232
 - RS-485
- Protocols:
 - INCOM
 - Modbus
- Configuration software

Control Functions

- Remote open/close
- Programmable I/O
- Programmable logic gates and timers
- Multiple setting groups
- Bus transfer logic
- Cold load pickup
- Loss of potential (PT blown fuses)

General Description—FP-5000

Table 4.1-3. Catalog Numbering Selection

FP5 2 00 - 0 1			
Current Range	Packaging	Control Voltage	Communications
2 = 5 A 3 = 1 A	0 = Drawout 1 = Fixed case	0 = 48–125 Vac/dc 1 = 100–240 Vac/dc	0 = INCOM 1 = Modbus

Protection Functions

Eaton's FP-5000 feeder 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.

Directional Overcurrent Protection

The FP-5000 feeder protection relay provides complete three-phase and ground directional overcurrent protection. There are two independent ground overcurrent elements. The first ground element "X" uses the independently measured ground (or neutral) current from a separate current-sensing input. The second ground element "R" uses a calculated $3I_0$ 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.

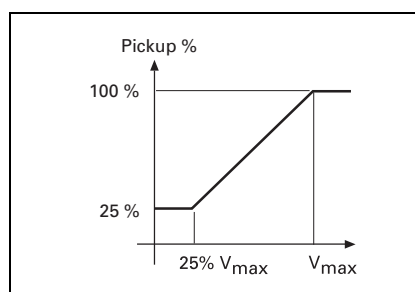
Each of the phase and ground overcurrent elements provides three protection functions. Each element contains an inverse-time overcurrent (51) function and two instantaneous overcurrent (50) functions with adjustable timers.

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 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). This modification of the pickup overcurrent level is compared to the corresponding phase input voltage. The FP-5000 uses the simple linear model below to determine the effective pickup value.


Figure 4.1-15. Voltage Restraint Coil Pickup Characteristics

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 two 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.

Inverse-Time Characteristics

There are 10 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 FP-5000 feeder 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 FP-5000 feeder 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.

Flexible Phase Rotation

The FP-5000 feeder 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 FP-5000 relay provides under/over frequency (81U/81O) protection on the Main VT inputs. Each element has an independent threshold set point and adjustable time delay.

Metering

The FP-5000 feeder protection relay provides complete and accurate metering of the voltages, currents, frequency, power, power factor and energy. Information is available on the individual phase magnitude, angles and the symmetrical component values of positive, negative and zero sequence current and voltage.

The FP-5000 feeder protection relay includes a programmable demand feature and stores the maximum demand of current, kW, kVAR and kVA since last reset. The demand is user-configurable for fixed or sliding window, the time interval is adjustable and the demand interval can be synchronized to a demand pulse.

Energy usage direction and net values are given for kWh, kVARh and kVAh. The relay monitors, logs and time stamps minimum and maximum values for current, voltage, watts, VARs, VA, power factor and frequency.

The FP-5000 feeder protection relay has metered set points that can be used to activate an output for an alarm, control or trip function. For example, you might want to close a contact to insert a capacitor bank if the power factor is less than 0.9 lagging or provide an alarm if the demand is greater than a preset value.

Loading Profile

The FP-5000 feeder protection relay has memory available to store metered data on a predetermined interval. The log holds data from 1024 time sample intervals. This information can be retrieved and plotted with a PC to show the loading profile of a given circuit over a period of time. For example, if the time interval is set for 15 minutes, then the relay will store a metered data profile over an approximate 10-day period.

Sequence of Events Records

The FP-5000 feeder protection relay records a maximum of 100 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 an FIFO in chronological order.

Trip Log

The FP-5000 feeder protection relay will store a maximum of 16 trip records in an FIFO trip log. Each trip record will be date and time stamped to a 1 ms resolution and reference an event number associated with oscillographic and sequence of event data. 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

The FP-5000 feeder protection relay provides oscillography-recording capabilities. The relay will record all voltage and current signals along with the binary signals of pickup, trip, logic and contact closures. The FP-5000 relay can record 16 records of 16 cycles of data. Fewer records of longer duration can be selected and recorded. The waveform capture is initiated by a trip, pickup, external contact, front panel interface or through the remote communications port.

Programmable Logic

The FP-5000 feeder protection relay provides six 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 six independent timers that have adjustable pickup and dropout delay settings.

Integral User Interface

The front panel user interface has a 4 x 20-inch (101.6 x 508.0 mm) alphanumeric vacuum fluorescent display for wide angle viewing in all light conditions. LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Pushbuttons are provided for operation mode selection, scrolling through data and settings. A security door restricts access to the program and test modes. In addition, the relay settings and test functions can be password protected.

System 1		System 2/Tools		Settings Overview Grp. 1		Settings Grp. 1 Phase OC		Settings Grp. 1 IX OC		Settings Grp. 1 IX OC	
Previous	New	Previous	New	Previous	New	Previous	New	Previous	New	Previous	New
51P	Enabled	Enabled	46-1	Disabled	Disabled	50P-3	Disabled	Disabled			
50P-1	Enabled	Enabled	47-1	Disabled	Disabled	50X-3	Disabled	Disabled			
50P-2	Enabled	Enabled	2/M-1	Disabled	Disabled	50R-3	Disabled	Disabled			
51X	Enabled	Enabled	59M-1	Disabled	Disabled	27M-2	Disabled	Disabled			
50X-1	Enabled	Enabled	27A-1	Disabled	Disabled	59M-2	Disabled	Disabled			
50X-2	Enabled	Enabled	59A-1	Disabled	Disabled	27A-2	Disabled	Disabled			
51IR	Enabled	Enabled	50BF	Disabled	Disabled	59A-2	Disabled	Disabled			
50R-1	Enabled	Enabled	55A	Disabled	Disabled	81U-2	Disabled	Disabled			
50R-2	Enabled	Enabled	55N	Disabled	Disabled	81O-2	Disabled	Disabled			
			Zone	Disabled	Disabled	46-2	Enabled	Enabled			
			81O-1	Disabled	Disabled	47-2	Enabled	Enabled			
			81U-1	Disabled	Disabled						

FP-5000 Set Point Overview

General Description—FP-5000

4

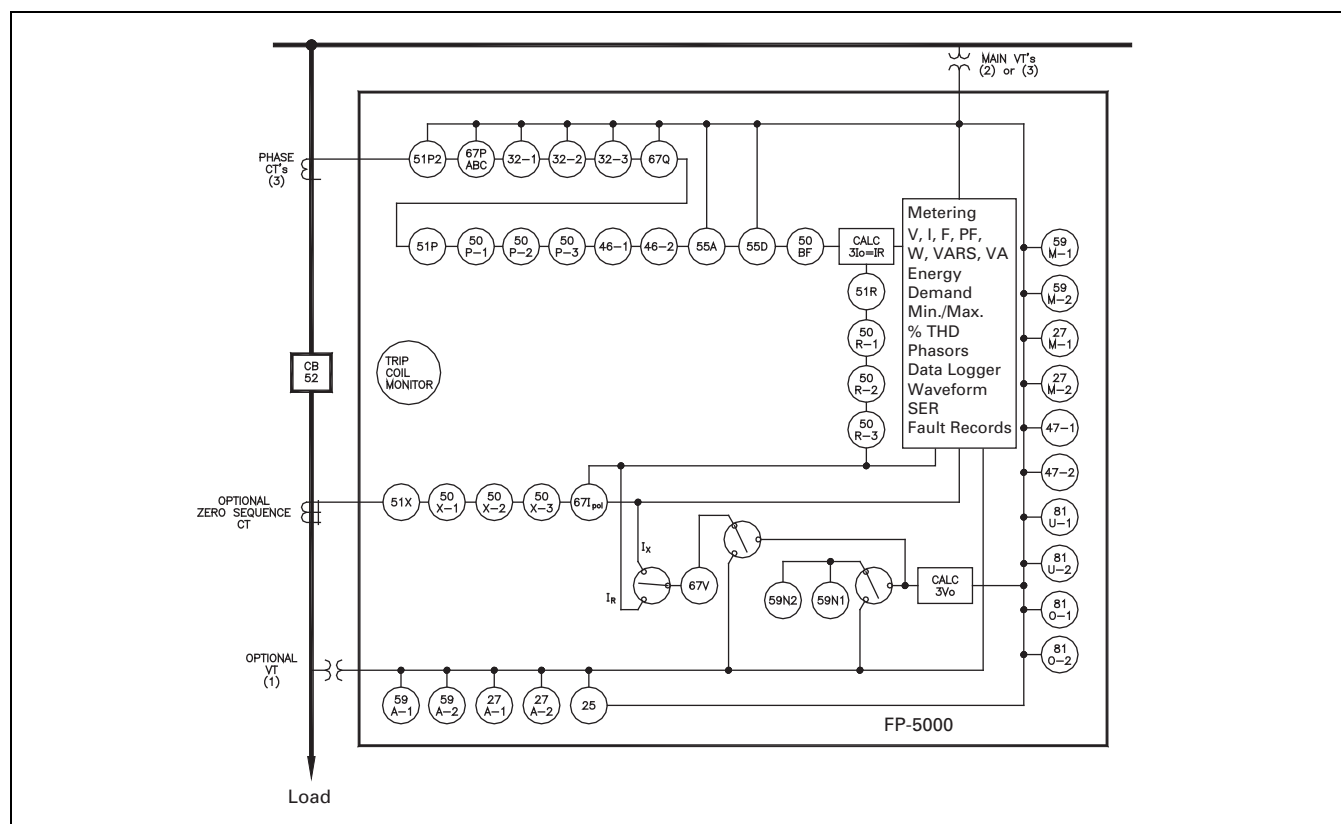


Figure 4.1-16. FP-5000 Relay Typical One-Line Diagram

Programmable I/O

The FP-5000 feeder protection relay provides five heavy-duty, trip-rated, normally open contacts and two Form C auxiliary contacts. Two trip rated contacts are fitted with a circuit continuity feature for monitoring the trip or close circuits. 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 dry contact. Each input and output is user-programmable for maximum application flexibility.

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 the Eaton Web site at www.eaton.com.

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.

Transview

Transview is a COMTRADE file viewer that is required in addition to the PowerNet waveform client to view FP-5000 waveforms. Users can view individual voltage and current waveforms, as well as phasors and digital input/output and internal protection functions such as undervoltage and current unbalance.

Standards, Certifications and Ratings

Table 4.1-4. FP-5000 Specifications

Compliance UL Recognized, File # E154862 UL 1053 (1994) Recognized ANSI C37.90 (1989) EN 55011 (1991) EN 61000-6-2 (1999)	Metering Accuracy (Continued) Input signal frequency necessary for accurate operation: 60 Hz nominal, 57–63 Hz (±5%) 50 Hz nominal, 47–53 Hz (±5%) Free running ±1 Minute/month at 25°C Clock accuracy: Clock automatically updated by PowerNet host when present.	Discrete Inputs Number of contact inputs: 8 Rating: 48 Vdc wetting voltage provided with internal ground only
Emission Tests EN 55011 (1991): Group 1 Class A (CISPR-11, Class A) FCC 47 CFR Chapter 1: Part 15 Subpart b Class A	Protective Functions Phase and Ground Overcurrent Protection (50/51) Inverse time over-current characteristics 51, 51N, 51G: Moderate, very, extremely, IECA, IECB, IECC, It, I ² t, I ⁴ t, Flat Inverse time over-current pickup ranges 51, 51N, 51G: 0.1 to 4.0 per unit in 0.01 steps Inverse time over-current multipliers 51, 51N, 51G: 0.05 to 10.0 in 0.01 steps Inverse time delay range 51, 51N, 51G: 0 to 9999 cycles in 1 cycle steps Instantaneous over-current pickup ranges 50, 50N, 50G: 0.1 to 20.0 per unit in 0.01 steps Pickup accuracy 50/51: ±1% (at 0.1–2 per unit) Time accuracy 51, 51N, 51G: ±3% or ±30 ms Directional 67, 67N, 67G: Reverse overcurrent—same data as above for reverse	Output Contacts Number of output contacts: Five Form A and Two Form C
Immunity Tests ANSI C37.90.1 (1989): Surge withstand capability ANSI C37.90.2 (1995): EMI immunity to 35 V/m EN 61000-4-2 (1995): ESD rating of 8 kV EN 61000-4-3 (1997): Radiated EM field at 10 V/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 10 V/m EN 61000-4-11 (1994): Voltage dips and variations		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 Vac Continuous: 5 A at 120 Vac 5 A at 30 Vdc
Control Power Control voltage: 48–250 Vdc 100–240 Vac Operating voltage: 55–264 Vac 38–300 Vdc Interruption ride-through time: 20 cycle interruption of nominal AC supply Power consumption: 20 VA maximum	Voltage Unbalance (47) Threshold (Minimum Voltage) 1 to 100 V in 1 V steps. % V2/V1: 4 to 40% in 1% steps Time delay: 0 to 9999 cycles in 1 cycle steps	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
Current Inputs Nominal (I _N): 1 A or 5 A CT rating: 2 × I _N continuous 50 × I _N for 1 second CT burdens: < 0.25 VA at 5 A (nominal) < 0.05 VA at 1 A (nominal)	Current Unbalance (46) Threshold (minimum current) 0.1 to 20.0 per unit in 0.01 steps. % I2/I1: 4 to 40% in 1% steps Time delay: 0 to 9999 cycles in 1 cycle steps	INCOM Communications Baud rate: 9600 fixed Maximum distance: 10,000 feet (3048 m) Protocol: INCOM
Voltage Inputs Nominal: 120 Vac Operating range: 69–150 Vac Burden: < 0.015 at 120 Vac 1 megaohm	Under/Overvoltage Protection (27/59) Pickup range: 10 to 150 V in 1 volt steps Time delay: 0 to 9999 cycles in 1 cycle steps	RS-485 Communication, Rear Panel Baud rate: 9.2k, 9.6k Protocol: Modbus RTU
Metering Accuracy Phase current: ±0.5% or ±0.025 A from 0.02 to 20.0 per unit fully offset current waveform Ground current: ±0.5% of full scale (I _N) from 0.02 to 2.0 per unit fully offset current waveform Phase voltage: ±0.5% or ±0.2 V from 0–160 Vac Frequency measurement Accuracy: ±0.02 Hz Phase angle: ±1° Power metering accuracy: ±1.5% Metering accuracy temperature range: 0 °C to 50°C Temperature range: ±5% for operation below 0 °C and above 50 °C	Under/Overfrequency Protection (81U/81O) Pickup range: 45 to 65 Hz in 0.01 Hz steps Time delay: 0 to 9999 cycles in 1 cycle steps Breaker Failure Protection (50BF) Pickup range: 0.1 to 5.0 per unit in 0.01 steps Time delay: 0 to 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° Slip frequency: 0.1 to 2 Hz Voltage differential: 1 to 100 V Breaker close time: 0 to 9999 cycles Power Factor (55) Trigger/reset threshold: 0.5 lag to 0.5 lead in 0.01 steps Time delay: 0 to 1000 seconds in 1 second steps	RS-232 Communication, Front Panel Baud rate: 38.4k, 19.2k, 9.6k Connector standard nine-pin subminiature, three-wire protocol: INCOM
		Environmental Ratings Operating temperature: –40 °C to +60 °C (–40 °F to +140 °F) product tested to +85 °C Storage temperature: –40 °C to +85 °C (–40 °F to +185 °F) Humidity: 5% to 95% Relative humidity (noncondensing) Altitude: 0 to 6350 feet (0 to 2500 m) above mean sea level
		Dimensions Behind Panel Height: 6.70 inches (170.2 mm) Width: 5.30 inches (134.6 mm) Depth: 6.90 inches (175.3 mm) In Front of Panel Height: 11.34 Inches (288.0 mm) Width: 7.72 Inches (196.1 mm) Depth: 0.80 Inches (20.3 mm) Weight 12.5 lbs (5.7 kg)

EDR-3000 Distribution Relay



EDR-3000 Relay

General Description

The EDR-3000 protection 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 to program the relay. Operating parameters and troubleshooting information are displayed in the 128 x 64 LCD display. 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.

Application Description

General

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, as in Figure 4.1-17.

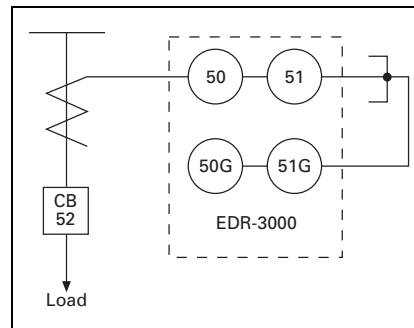


Figure 4.1-17. Primary Feeder Circuit Protection

The EDR-3000 may be applied as the transformer primary protection or as backup to the differential protection, as in Figure 4.1-18.

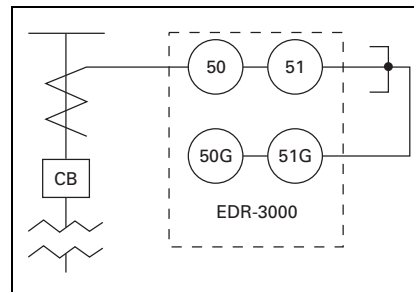


Figure 4.1-18. Transformer Overcurrent Protection

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 (see Figure 4.1-19).

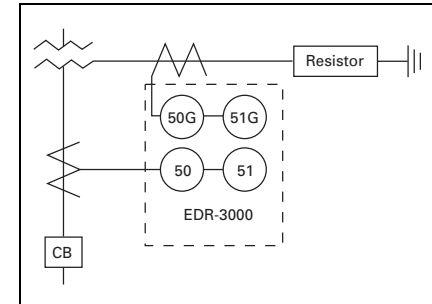
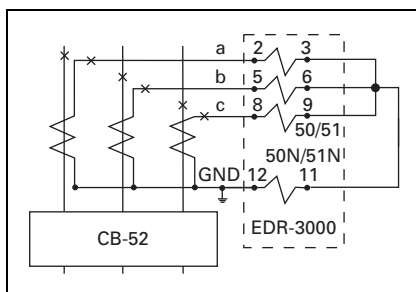
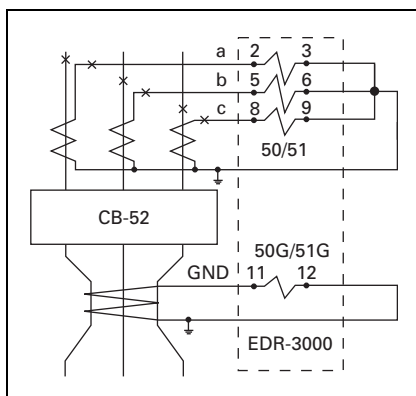


Figure 4.1-19. Transformer Secondary Protection with Neutral CT Connection

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 the following sections. In addition, the EDR-3000 has multiple setting groups that can be used to reduce arc flash hazard with instantaneous elements.

Overcurrent Protection

The EDR-3000 provides complete three-phase and ground protection with separate elements and settings. The relay can be used with CT ratios from 1 to 50,000 for 1 A models and 1 to 10,000 for 5 A models. 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, as in **Figure 4.1-20** and **4.1-21**.

**Figure 4.1-20. Residual Ground Connection****Figure 4.1-21. Separate Zero Sequence Ground CT Connection****Zone Selective Interlocking (Phase and Ground)**

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 used, 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 used, 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 in **Figure 4.1-23**, circuit breakers A, B and C are equipped with EDR-3000 overcurrent relays.

Table 4.1-5. Catalog Numbering Selection for EDR-3000 Distribution Relay Removable Terminals

EDR-3000 A 0 B A 1				
Hardware Option 1 A = Four digital inputs, four outputs, removable terminals B = Eight digital inputs, six outputs, removable terminals, trip coil monitor C = Four digital inputs, four 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	Communication Options ① B = Modbus-RTU (RS-485) I = Modbus-TCP (RJ-45)	Conformal Coating Options A = None B = Conformal coated circuit boards	Mounting Options 0 = Standard mount 1 = Projection panel mount

① Beginning in 2016, consult factory for the availability of the following new communication options.
 - Protocols: DNP3.0, PROFIBUS
 - Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

General Description—EDR-3000

Fault Location Zone 3

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

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. As a result, the EDR-3000 of the downstream breaker C does not see this fault because 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

signal to the EDR-3000 of feeder breaker B. Because 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

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.

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.

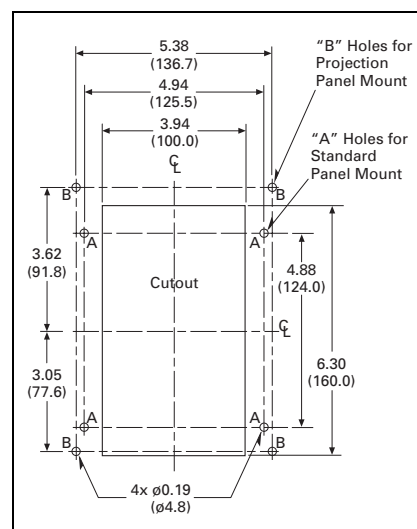


Figure 4.1-22. Drilling Pattern

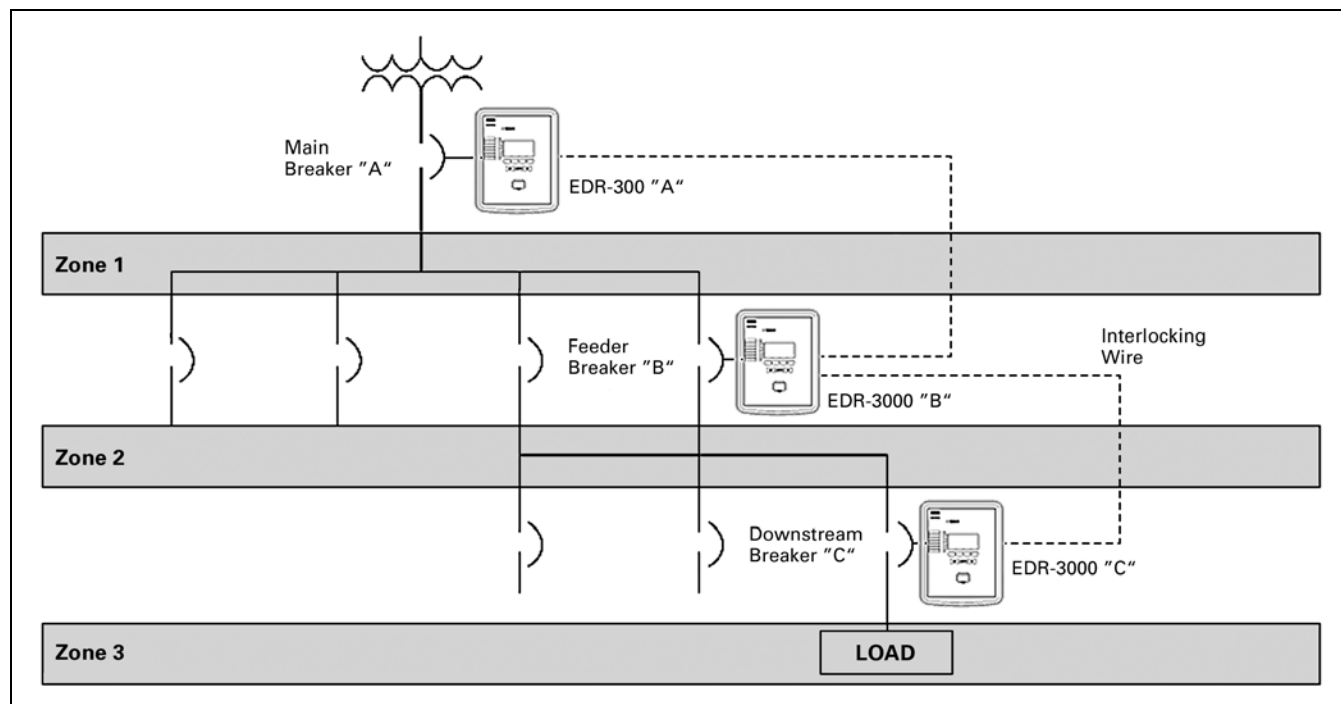


Figure 4.1-23. Sample Zone Selective Interlocking System

Standards, Certifications and Ratings

Table 4.1-6. EDR-3000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.08 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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 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/dc 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug RS-485 Master/slave: Slave Connection: Six screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)
Power Consumption Power supply range: 19–300 Vdc: 6W idle mode/ 8W max. power 40–250 Vac: 6W idle mode/ 8W max. power (for frequencies of 40–70 Hz) Power consumption: Phase current inputs at $I_N = 1$ A burden = 0.15 mVA at $I_N = 5$ A burden = 0.15 mVA Ground current input: at $I_N = 1$ A burden = 0.35 mVA at $I_N = 5$ A burden = 0.35 mVA	Binary Output Relays Continuous current: 5 A AC/DC Switch-on current: 25 A AC/DC for 4s 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	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: <2000m (6561.67 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.

General Description—EDR-5000

Metering

- 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, lag 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

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (6000 cycles total)
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)

Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485

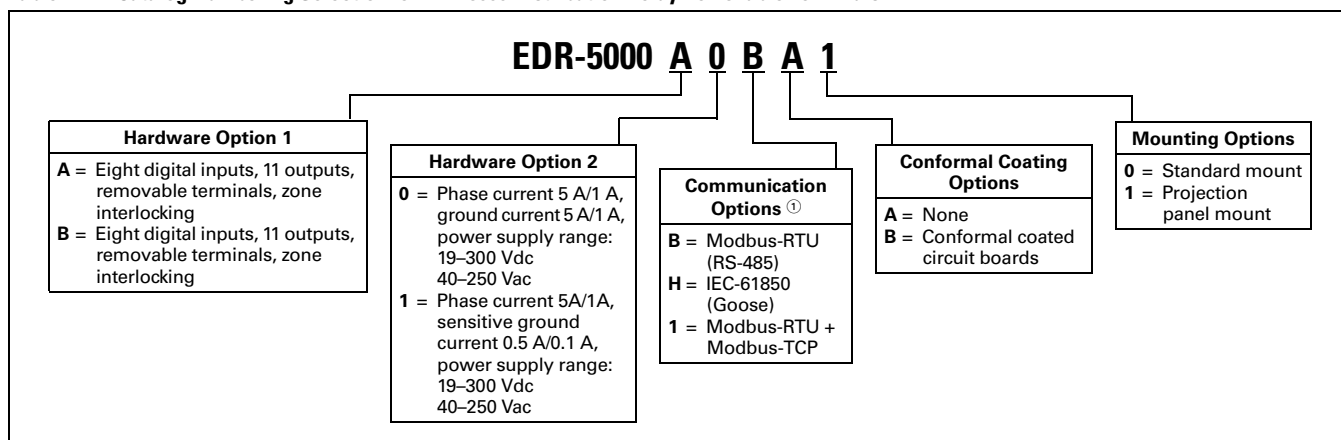
Protocols:

- Modbus RTU
- Modbus TCP (optional)
- IEC 61850 (optional)

Configuration software**Control Functions**

- Breaker open/close
- Remote open/close
- Programmable I/O
- Programmable logic
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Table 4.1-7. Catalog Numbering Selection for EDR-5000 Distribution Relay Removable Terminals



^① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS

- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

General Description—EDR-5000

4

Protection and Control Functions

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.

Directional Overcurrent Protection

The EDR-5000 distribution protection relay provides complete three-phase and ground directional overcurrent protection. There are eight 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 3I₀ 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]). 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.

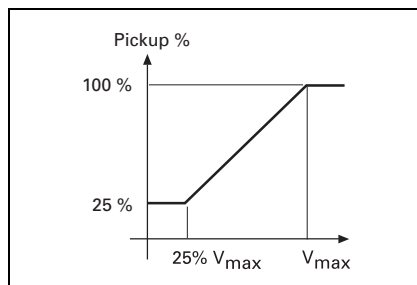


Figure 4.1-24. Voltage Restraint Coil Pickup Characteristics

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 the 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 to 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 (3V₀) 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 six frequency elements that 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 six 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 help to reduce the possibility of injury.

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 an FIFO log in chronological order.

Trip Log

The EDR-5000 protection relay will store a maximum of 20 trip records in an 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

The EDR-5000 distribution 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 EDR-5000 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 eight 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. 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, trip-rated, two normally open and eight 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.

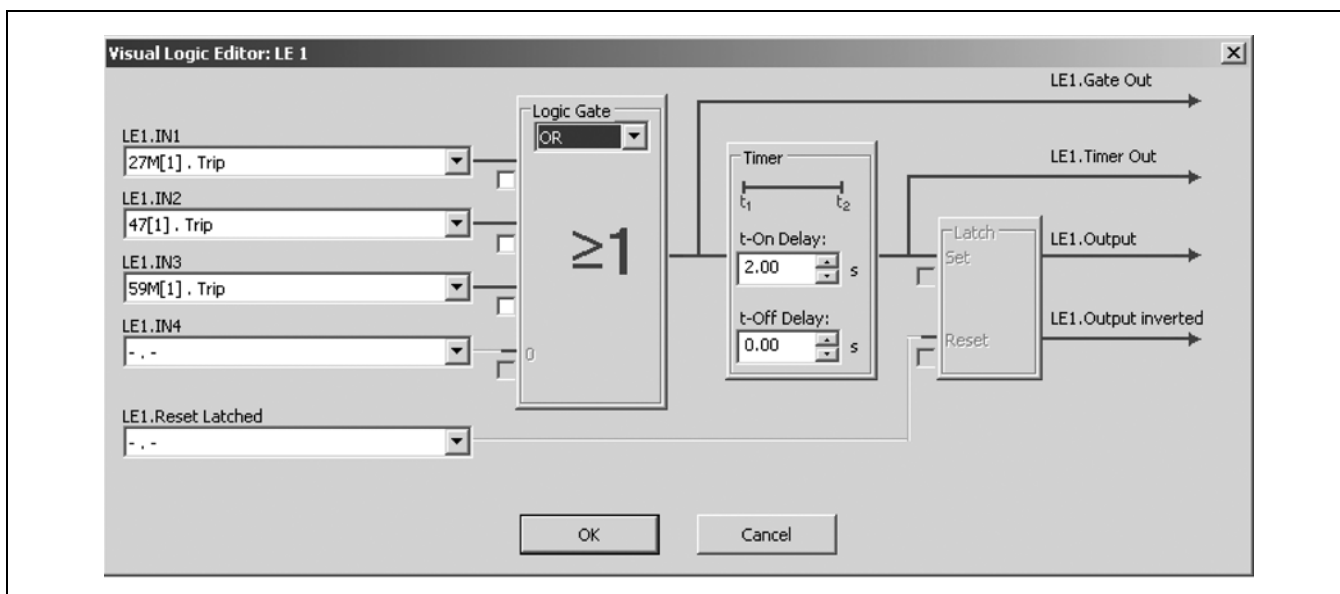


Figure 4.1-25. Visual Logic Editor



Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. 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-E is free and can be downloaded from the Eaton Web site at www.eaton.com/pr.

The second package is Power Xpert Software. Power Xpert Software is a power management software package that is designed for continuous,

remote monitoring of many devices. It provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

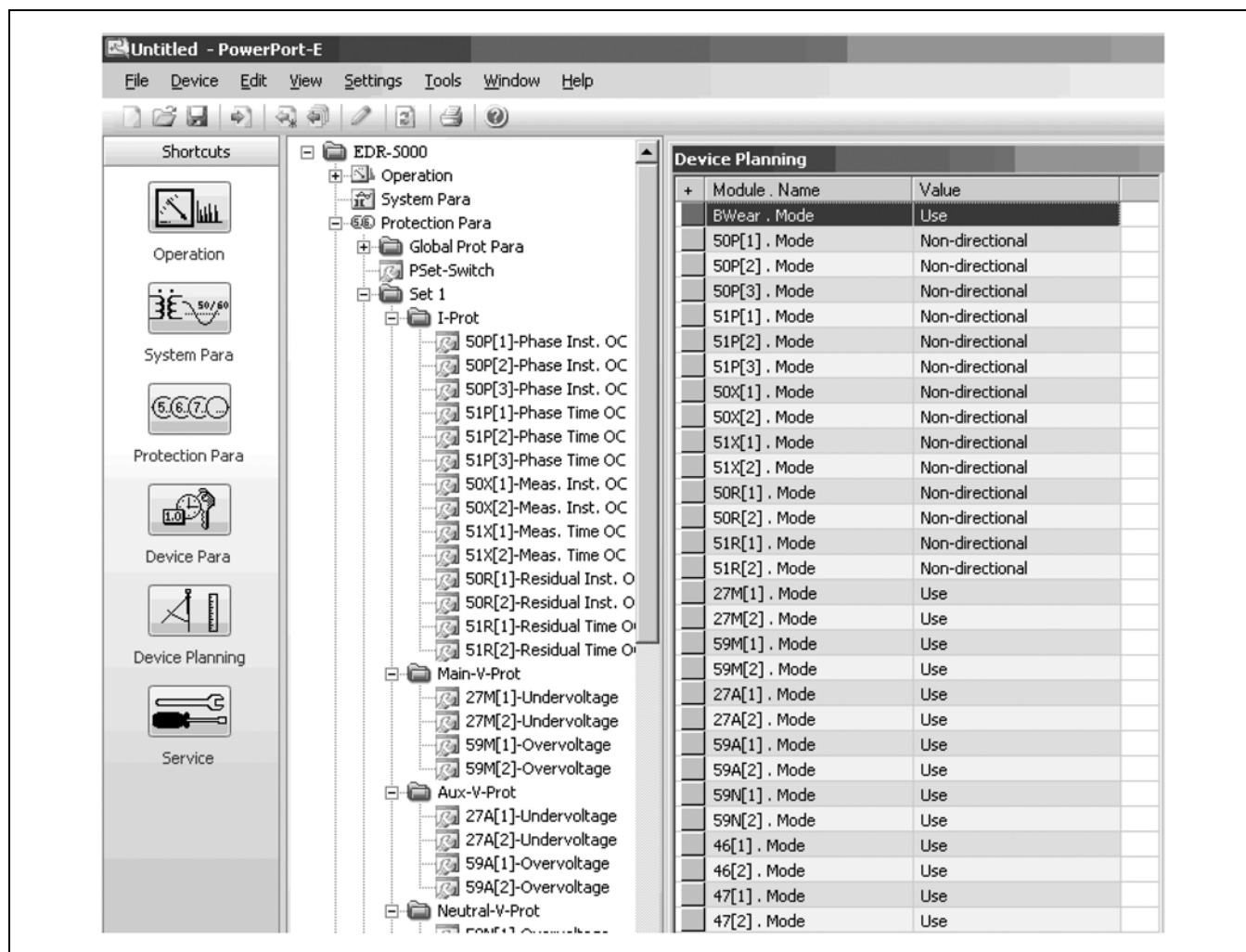


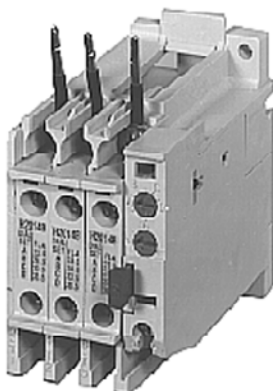
Figure 4.1-28. PowerPort-E EDR-5000 Device Planning

Standards, Certifications and Ratings

Table 4.1-8. EDR-5000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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 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/dc 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	Zone Interlocking NOTICE: ONLY FOR ZONE INTERLOCK TRIPPING OUTPUTS (ZONE INTERLOCK, SEMI-CONDUCTOR 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)
Power Consumption Power supply range: 24–270 Vdc: 7W idle mode/ approx. 13W max. power 48–230 Vac: 7 VA idle mode/ approx. 13 VA max. power (for frequencies of 40–70 Hz) 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	Relay Outputs Continuous current: 5 A AC/DC Max. 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 Vac according to ANSI IEEE Std. C37.90-2005 Max. breaking current: 5 A AC up to 125 Vdc 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug RS-485 Master/slave: Slave Connection: Six screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal) Climatic Environmental Conditions Storage temperature: –30 °C to +70 °C (–22 °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: <2000 m (6561.67 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.

Freedom Overload Relays



32 A Overload—C306DN3B

General Description

C306 Overload Relays are designed for use with CE or CN non-reversing and reversing contactors. Four sizes are available for overload protection up to 144 A.

Features

- Selectable manual or automatic reset operation
- Interchangeable heater packs adjustable $\pm 24\%$ to match motor FLA and calibrated for use with 1.0 and 1.15 service factor motors. Heater packs for 32 A overload relay will mount in 75 A overload relay—useful in derating applications such as jogging
- Class 10 or 20 heater packs
- Load lugs built into relay base
- Bimetallic, ambient compensated operated. Trip free mechanism
- Electrically isolated NO-NC contacts (pull RESET button to test). (Electrical ratings see tables in Volume 5—Motor Control and Protection, CA08100006E, Tab 33, Section 33.1)
- Overload trip indication
- Shrouded or fingerproof terminals to reduce possibility of electrical shock

Standards and Certifications

- Meets UL 508 single-phasing requirements
- UL listed, CSA certified, NEMA compliance and CE mark

Reference

Refer to Volume 5—Motor Control and Protection, CA08100006E, Tab 33, Section 33.1 for additional product information.

C440/XT Electronic Overload Relay



C440/XT Electronic Overload Relay

General Description

Eaton's electronic overload relay (EOL) is the most compact, high-featured, economical product in its class. Designed on a global platform, the new EOL covers the entire power control spectrum including NEMA, IEC and DP contactors. The NEMA and DP versions are offered with the C440 designation while the IEC offering has the **XT** designation. The electronic design provides reliable, accurate and value driven protection and communications capabilities in a single compact device. It is the flexible choice for any application requiring easy-to-use, reliable protection.

Eaton has a long history of innovations and product development in motor control and protection, including both traditional NEMA, as well as IEC control. It was from this experience that the C440 was developed, delivering new solutions to meet today's demands.

C440 is a self-powered electronic overload relay available up to 100 A as a self contained unit. With external CTs, C440 can protect motor up to 1500 FLA. Available add-on accessories include remote reset capability and communication modules with I/O for DeviceNet, PROFIBUS, and Modbus.

Features and Benefits

Features

- Reliable, accurate, electronic motor protection
- Easy to select, install and maintain
- Compact size
- Flexible, intelligent design
- Global product offering—available with NEMA, IEC and DP power control

Size/Range

- Broad FLA range (0.33–1500 A)
- Selectable trip class (10 A, 10, 20, 30)
- Direct mounting to NEMA, IEC and DP contactors
- Most compact electronic overload in its class

Motor Control

- Two B600 alarm (NO) and fault (NC) contacts
- Test/Trip button

Motor Protection

- Thermal overload
- Phase loss
- Selectable (ON/OFF) phase imbalance
- Selectable (ON/OFF) ground fault

User Interface

- Large FLA selection dial
- Trip status indicator
- Operating mode LED
- DIP switch selectable trip class, phase imbalance and ground fault
- Selectable Auto/Manual reset

Feature Options

- Remote reset
 - 120 Vac
 - 24 Vac
 - 24 Vdc
- Tamper-proof cover
- Communications modules
 - Modbus RTU RS-485
 - DeviceNet with I/O
 - PROFIBUS with I/O
 - Modbus RTU with I/O (Q4 2010)
 - EtherNet/IP (planned)

General Description—Overload Relays

Benefits

Reliability and Improved Uptime

- C440 provides the users with peace of mind knowing that their assets are protected with the highest level of motor protection and communication capability in its class
- Extends the life of plant assets with selectable motor protection features such as trip class, phase imbalance and ground fault
- Protects against unnecessary downtime by discovering changes in your system (line/load) with remote monitoring capabilities
- Status LED provides added assurance that valuable assets are protected by indicating the overload operational status

Flexibility

- Available with NEMA, IEC and DP contactors
- Improves return on investment by reducing inventory carrying costs with wide FLA adjustment (5:1) and selectable trip class
- Design incorporates built-in ground fault protection thus eliminating the need for separate CTs and modules
- Flexible communication with optional I/O enables easy integration into plant management systems for remote monitoring and control
- Available as an open component and in enclosed control and motor control center assemblies

Monitoring Capabilities

- Individual phase currents rms
- Average three-phase current rms
- Thermal memory
- Fault indication (overload, phase loss, phase imbalance, ground fault)

Safety

- IP 20 rated terminal blocks
- Available in Eaton's industry leading FlashGard MCCs
- Tested to the highest industry standards such as UL, CSA, CE and IEC
- RoHS compliant

Standards and Certifications

- UL
- CSA
- CE
- NEMA
- IEC/EN 60947 VDE 0660
- ISO 13849-1 (EN954-1)
- RoHS
- ATEX directive 94/9/EC
- Equipment Group 2, Category 2

Table 4.2-1. Electronic Overload Education

Description	Definition	Cause	Effect if not Protected	C440/XT Protection
Motor Protection				
Thermal overload	Overload is a condition in which current draw exceeds 115% of the full load amperage rating for an inductive motor.	• An increase in the load or torque that is being driven by the motor. • A low voltage supply to the motor causes the current to go high to maintain the power needed. • A poor power factor causing above normal current draw.	• Increase in current draw leads to heat and insulation breakdown, which can cause system failure. • Increase in current can increase power consumption and waste valuable energy.	• Thermal trip behavior is defined by UL, CSA and IEC standards. • Trip class is settable from 10 A, 10, 20, 30
Ground fault	A line to ground fault.	A current leakage path to ground.	An undetected ground fault can burn through multiple insulation windings, ultimately leading to motor failure, not to mention risk to equipment or personnel	Fixed protective setting that takes the starter offline if ground fault current exceeds 50% of the FLA dial setting, i.e., if the FLA dial is set to 12 A, the overload relay will trip if the ground current exceeds 6 A.
Imbalanced phases (voltage and current)	Uneven voltage or current between phases in a three-phase system.	When a three-phase load is powered with a poor quality line, the voltage per phase may be imbalanced.	Imbalanced voltage causes large imbalanced currents and as a result this can lead to motor stator windings being overloaded, causing excessive heating, reduced motor efficiency and reduced insulation life.	Fixed protective setting that takes the starter offline if a phase drops below 50% of the other two phases.
Phase loss—current (single-phasing)	One of the three-phase voltages is not present.	Multiple causes, loose wire, improper wiring, grounded phase, open fuse, etc.	Single-phasing can lead to unwanted motor vibrations in addition to the results of imbalanced phases as listed above.	Fixed protective setting that takes the starter offline if a phase drops below 50% of the other two phases.

Modbus Communication Module

The Modbus module combined with an expansion module and a communication adapter provide Modbus communication capability to the C440 electronic overload relay.

*Modbus Communication Module***Features and Benefits**

- The Modbus communication module is capable of baud rates up to 115K
- The Modbus address and baud rate configuration can be easily changed using the HMI user interface
- Modbus address and baud rate are set via convenient DIP switches; LEDs are provided to display Modbus traffic
- Configuration with common Modbus configuration tools
- Terminals
 - Unique locking mechanism provides for easy removal of the terminal block with the field wiring installed
 - Each terminal is marked for ease of wiring and troubleshooting
- Selectable I/O assemblies
 - 4IN/2OUT
 - Signal types include 24 Vdc I/O and 120 Vac I/O
 - Each I/O module is optically isolated between the field I/O and the network adapter to protect the I/O and communication circuits from possible damage due to transients and ground loops
 - Input Module features a user-definable input debounce, which limits the effects of transients and electrical noise
 - Output Module supports a user-definable safe state for loss of communication; hold last state, ON or OFF

DeviceNet Communication Modules

The DeviceNet Communication Module provides monitoring and control for the C440 overload relay from a single DeviceNet node. These modules also offer convenient I/O in two voltage options, 24 Vdc and 120 Vac.

*DeviceNet Communication Module***Features and Benefits**

- Communication to DeviceNet uses only one DeviceNet MAC ID
- Configuration
 - DeviceNet MAC ID and Baud rate are set via convenient DIP switches with an option to set from the network
 - Advanced configuration available using common DeviceNet tools
- Terminals
 - Unique locking mechanism provides for easy removal of the terminal block with the field wiring installed
 - Each terminal is marked for ease of wiring and troubleshooting
- Selectable I/O assemblies
 - 4IN/2OUT
 - Signal types include 24 Vdc I/O and 120 Vac I/O
 - Each I/O module is optically isolated between the field I/O and the network adapter to protect the I/O and communication circuits from possible damage due to transients and ground loops
 - Input Module features a user-definable input debounce, which limits the effects of transients and electrical noise
 - Output Module supports a user-definable safe state for loss of communication; hold last state, ON or OFF
- Combined status LED

PROFIBUS Communication Modules

The PROFIBUS module combined with an expansion module and a communication adapter provide Modbus communication capability to the C440 electronic overload relay.

*PROFIBUS Communication Module***Features and Benefits**

- The PROFIBUS communication module is capable of baud rates up to 12 Mb
- PROFIBUS address is set via convenient DIP switches; LEDs are provided to display PROFIBUS status
- Intuitive configuration with common PROFIBUS configuration tools
- Terminals
 - Unique locking mechanism provides for easy removal of the terminal block with the field wiring installed
 - Each terminal is marked for ease of wiring and troubleshooting
- Selectable I/O assemblies
 - 4IN/2OUT
 - Signal types include 24 Vdc I/O and 120 Vac I/O
 - Each I/O module is optically isolated between the field I/O and the network adapter to protect the I/O and communication circuits from possible damage due to transients and ground loops
 - Input Module features a user-definable input debounce, which limits the effects of transients and electrical noise
 - Output Module supports a user-definable safe state for loss of communication; hold last state, ON or OFF

Product Selection—Overload Relays

Technical Data and Specifications

Table 4.2-2. Electronic Overload Relays up to 1500 A

Description	Specification	
	45 mm	55 mm
Electrical Ratings		
Operating voltage (three-phase) and frequency	690 Vac (60/50 Hz)	690 Vac (60/50 Hz)
FLA Range		
	0.33–1.65 A 1–5A 4–20 A 9–45 A	20–100 A
Use with Contactors		
XT IEC frames	B, C, D	F, G
Freedom NEMA sizes	00, 0, 1, 2	3
Trip Class		
	10 A, 10, 20, 30 Selectable	10 A, 10, 20, 30 Selectable
Motor Protection		
Thermal overload setting	1.05 x FLA: does not trip 1.15 x FLA: overload trip	1.05 x FLA: does not trip 1.15 x FLA: overload trip
Feature		
Phase loss	Fixed threshold 50%	Fixed threshold 50%
Phase imbalance (selectable: enable/disable)	Fixed threshold 50%	Fixed threshold 50%
Ground fault (selectable: enable/disable)	50% of FLA dial setting >150% = 2 sec >250% = 1 sec	50% of FLA dial setting >150% = 2 sec >250% = 1 sec
Reset	Manual/automatic	Manual/automatic
Indicators		
Trip status	Orange flag	Orange flag
Mode LED	One flash: Overload operating properly Two flashes: Current is above FLA dial setting — pending trip	One flash: Overload operating properly Two flashes: Current is above FLA dial setting — pending trip
Options		
Remote reset	Yes	Yes
Reset bar	Yes	Yes
Communication expansion module	Yes	Yes
Communication adapter	Yes	Yes
Capacity		
Load terminals		
Terminal capacity	12–10 AWG (4–6 mm ²) 8–6 AWG (6–16 mm ²)	6–1 AWG (16–50 mm ²)
Tightening torque	20–25 lb-in (2.3–2.8 Nm) 25–30 lb-in (2.8–3.4 Nm)	25–30 lb-in (2.8–3.4 Nm)
Input, auxiliary contact and remote reset terminals		
Terminal capacity	2 x (18–12) AWG	2 x (18–12) AWG
Tightening torque	5.3 lb-in (0.8–1.2 Nm)	5.3 lb-in (0.8–1.2 Nm)
Voltages		
Insulation voltage U _i (three-phase)	690 Vac	690 Vac
Insulation voltage U _i (control)	500 Vac	500 Vac
Rated impulse withstand voltage	6000 Vac	6000 Vac
Overvoltage category/pollution degree	III/3	III/3

C441 Overload Relays



C441 Motor Insight Overload and Monitoring Relay

General Description

Eaton's C441 Motor Insight®, the first product in the Intelligent Power Control Solutions family, is a highly configurable motor, load and line protection device with power monitoring, diagnostics and flexible communications allowing the customer to save energy, optimize their maintenance schedules and configure greater system protection, thus reducing overall costs and downtime.

C441 Motor Insight is available in either a line-powered or 120 Vac control powered design, capable of monitoring voltages up to 660 Vac. Each of these units is available in a 1–9 A or a 5–90 A FLA model. With external CTs, Motor Insight can protect motors up to 540 A FLA. Available add-on accessories include communication modules for Modbus®, DeviceNet™ and PROFIBUS®, all with I/O options. For ease-of-use and operator safety, C441 Motor Insight offers a remote display that mounts easily with two 30 mm knockouts.

Features and Benefits

Features

Size/Range

- Broad FLA range of 1–540 A
- Selectable trip class (5–30)
- Four operating voltage options
 - Line-powered from 240 Vac, 480 Vac, 600 Vac
 - Control-powered from 120 Vac

Motor Control

- Two output relays
 - One B300 Form C fault relay and one B300 ground fault shunt relay
 - Other relay configurations are available, including one Form A and one Form B SPST (fault and auxiliary relays), allowing programmable isolated relay behavior and unique voltages

- One external remote reset terminal
- Trip status indicator

Motor Protection

- Thermal overload
- Jam protection
- Current imbalance
- Current phase loss
- Ground fault
- Phase reversal

Load Protection

- Undercurrent
- Low power (kW)
- High power (kW)

Line Protection

- Overvoltage
- Undervoltage
- Voltage imbalance
- Voltage phase loss

Monitoring Capabilities

- Current—average and phase rms
- Voltage—average and phase rms
- Power—motor kW
- Power factor
- Frequency
- Thermal capacity
- Run hours
- Ground fault current
- Current imbalance %
- Voltage imbalance %
- Motor starts
- Motor run hours

Options

- Type 1, 12 remote display
- Type 3R remote display kit
- Communication modules
 - Modbus
 - Modbus with I/O
 - DeviceNet with I/O
 - PROFIBUS with I/O
 - Modbus TCP with I/O (contact product line)
 - Ethernet IP (contact product line)

Benefits

Reliability and Improved Uptime

- Advanced diagnostics allows for quick and accurate identification of the root source of a motor, pump or power quality fault; reducing trouble-shooting time and the loss of productivity, reducing repeat faults due to misdiagnosis, and increasing process output and profitability

- Provides superior protection of motors and pumps before catastrophic failure occurs
- Increases profitability with greater process uptime and throughput, reduced costs per repair, reduced energy consumption and extended equipment life
- Adjustments to overload configuration can be made at any time

Safety

- IP20 rated terminal blocks
- Terminal blocks are set back from the display to reduce operator shock hazard
- Remote display (optional) does not require that the operator open the panel to configure the device

Flexibility

- Communications modules
 - Offered in a variety of configurations
 - External snap-on modules provide support for multiple communications protocols
- Advanced power, voltage and current monitoring capabilities
- Communications modules and remote display can be used simultaneously
- Highly configurable fault and reset characteristics for numerous applications
- Fully programmable isolated fault and auxiliary relays

Ease of Use

- Bright LED display with easy-to-understand setting and references
- Powered from line voltage or 120 Vac control power
- Remote display powered from base unit
- Full word descriptions and units on user interface

Standards and Certifications

- cULus listed NKCR, NKCR7, 508
- UL 1053 applicable sections for ground fault detection
- CSA certified (Class 3211-02)
- CE
- NEMA
- IEC EN 60947-4-1
- RoHS

Product Selection—Overload Relays

Table 4.2-3. Advanced Overload Education

Description	Definition	Source	Result	C441 Motor Insight Protection
Motor Protection				
Thermal overload	Overload is a condition in which current draw to a motor exceeds 115% of the full load amperage rating over a period of time for an inductive motor.	An increase in the load or torque that is being driven by the motor. A low voltage supply to the motor would cause the current to go high to maintain the power needed. A poor power factor would cause above normal current draw.	Increase in current draw. Current leads to heat and insulation breakdown, which can cause system failure. Additionally, an increase in current can increase power consumption and waste valuable energy.	Thermal trip behavior is defined by UL, CSA and IEC standards. Trip class is settable from 5–30 by 1 Provides power factor monitoring and low voltage protection features.
Jam	Jam is similar to thermal overload in that it is a current draw on the motor above normal operating conditions.	Mechanical stall, interference, jam or seizure of the motor or motor load.	The motor attempts to drive the load, which has more resistive force due to the mechanical interference. In order to drive the load, the motor draws an abnormal amount of current, which can lead to insulation breakdown and system failure.	Provides a configurable Jam setting that is active during “motor run state” to avoid nuisance trips. Trip Threshold 150–400% of FLA. Trip Delay 1–20 seconds.
Ground fault	A line to ground fault.	A current leakage path to ground.	An undetected ground fault can burn through multiple insulation windings, ultimately leading to motor failure.	Motor Insight has ground fault protection capability down to 0.15 amps estimated from the existing three-phase CTs using the residual current method. That is, the three-phase current signals should sum to zero unless a ground fault (GF) condition is present. In the case of a GF, Motor Insight can alarm, trip the starter, or trip an alternative relay that can be used to shunt trip a breaker or light up a warning light. GF current can also be monitored in real-time through the advanced monitoring capabilities. Note: GF settable thresholds vary with motor FLA. 0.15 A may not be available in all cases.
Imbalanced phases (voltage and current)	Uneven voltage or currents between phases in a three-phase system.	When a three-phase load is powered with a poor quality line, the voltage per phase may be imbalanced.	Imbalanced voltage causes large imbalanced currents and as a result this can lead to motor stator windings being overloaded, causing excessive heating, reduced motor efficiency and reduced insulation life.	Provides two protection settings that address this problem. The user can choose to set current imbalance thresholds or voltage imbalance thresholds, each of which can trip the starter. Additionally, both of these may be monitored through Motor Insight’s advanced monitoring capabilities, allowing the customer to notice in real-time when and where a condition is present.
Phase loss—current (single-phasing)	One of the three-phase current is not present.	Multiple causes, loose wire, improper wiring, grounded phase, open fuse, etc.	Single-phasing can lead to unwanted motor vibrations in addition to the results of imbalanced phases as listed above.	Fixed protective setting that takes the starter offline if a phase drops below 60% of the other two phases.
Phase rotation (phase-reversal)	Improper wiring, leading to phases being connected to the motor improperly.	A miswired motor. Inadvertent phase-reversal by the utility.	Phase-reversal can cause unwanted directional rotation of a motor. In the event that the load attached to the motor can only be driven in one direction, the result could be significant mechanical failure and/or injury to an operator.	Configurable phase protection, allowing the user to define the phase sequencing intended for that application. If no phase sequence is required, the user has the ability to disable this feature.
Frequency variance	When line frequency is inconsistent.	Malfunctioning alternator speed regulator, or poor line quality caused by an overload of a supply powered by individual sources.	Variations in frequency can cause increases in losses, decreasing the efficiency of the motor. In addition, this can result in interference with synchronous devices.	Advanced monitoring capabilities allow the user to monitor frequency in real-time.

Product Selection—Overload Relays

Table 4.2-3. Advanced Overload Education (Continued)

Description	Definition	Source	Result	C441 Motor Insight Protection
Load Protection				
Undercurrent or low power	Average rms current provided to the motor falls below normal operating conditions.	Undercurrent is usually associated with a portion of the user's load disappearing. Examples of this would be a broken belt, a dry-pump (low suction head) or a dead-headed centrifugal pump.	If undercurrent goes undetected, a mechanical failure can and has occurred. In the case of a pump, running a pump dry or running a pump in a dead-headed condition can cause excessive heating, damaging expensive seals and breaking down desired fluid properties.	Motor Insight has two protection settings to detect this: undercurrent and low power. Low power is a more consistent way of ensuring detection as power is linear with motor load, where as current is not. An unloaded motor may draw 50% of its rated current, but the power draw will be less than 10% of rated power due to a low power factor.
High power	The motor load is drawing more power than it should at normal operating conditions.	This is typical of batch processing applications where several ingredients flow into a mixer. When a substance's consistency changes and viscosity increases from what is expected, the motor may use more power to blend the mixture. Out-of-tolerance conditions can be detected using the High Power and Low Power settings.	If a high-power fault goes undetected, the result may be a batch of material that does not meet specification.	Monitors the three-phase real power. If the real power value is estimated above the set threshold for the set length of time, a fault is detected and the overload will trip the starter. Additionally, power can be monitored in real-time.
Line Protection				
Overvoltage	When the line voltage to the motor exceeds the specified rating.	Poor line quality.	An overvoltage condition leads to a lower than rated current draw and a poor power factor. A trip limit of 110% of rated voltage is recommended. Overvoltage can also lead to exceeding insulation ratings.	Monitors the maximum rms value of the three-phase voltages. If the rms value rises above the set threshold for the set length of time, a fault is detected and the overload can trip the starter or send and display an alarm of the condition. All line-related faults have an "alarm-no-trip" mode.
Undervoltage	When the line voltage to the motor is below the specified rating.	Poor line quality.	An undervoltage condition leads to excessive current draw. This increases the heating of the motor windings and can shorten insulation life. A trip limit set to 90% of rated voltage is recommended.	Monitors the minimum rms value of the three-phase voltages. If the rms value drops below the set threshold for the set length of time, a fault is detected and the overload can trip the starter or send and display an alarm of the condition. All line-related faults have an "alarm-no-trip" mode.
Power-up delay	Allows for starting motors and loads in a deliberate fashion.	When there is a power failure, or power cycle, multiple loads come online simultaneously.	Multiple loads starting simultaneously can cause sags affecting the operation of devices that may prevent successful startup. If power is lost to a motor driving a pump, it may be necessary to delay a restart to allow the pump to come to a complete stop to prevent starting a motor during backspin.	Configurable to delay closing the fault relay on power-up. For each Motor Insight controlling a motor, a different setting can be programmed, helping to maintain the integrity of your line power.

Accessories

Modbus Communication Module

The C441 Motor Insight Modbus Communication Module is a side-mounted device providing Modbus communication capability to the C441 Motor Insight overload relay.

The Modbus Communication Module with I/O provides communication, monitoring and control for the C441 Motor Insight overload relay.

Features and Benefits

- The Modbus communication module is capable of baud rates up to 115K
- The Modbus address and baud rate configuration can be easily changed using the Motor Insight user interface (C441M only)
- Modbus address and baud rate are set via convenient DIP switches (C441N and C441P); LEDs are provided to display Modbus traffic
- Configuration with common Modbus configuration tools
- Terminals
 - Unique locking mechanism provides for easy removal of the terminal block with the field wiring installed
 - Each terminal is marked for ease of wiring and troubleshooting
- Selectable I/O assemblies
 - 4IN/2OUT
 - Signal types include 24 Vdc I/O and 120 Vac I/O
 - Each I/O module is optically isolated between the field I/O and the network adapter to protect the I/O and communication circuits from possible damage due to transients and ground loops
 - Input Module features a user-definable input debounce, which limits the effects of transients and electrical noise
 - Output Module supports a user-definable safe state for loss of communication; hold last state, ON or OFF

Table 4.2-4. Modbus Communication Module

Description	I/O	Catalog Number
 Modbus Module	None	C441M
 Modbus with I/O Module	Modbus Communication Module 4IN/2OUT	120 Vac C441N
	Modbus Communication Module 4IN/2OUT	24 Vdc C441P

DeviceNet Communication Modules

The DeviceNet Communication Module provides monitoring and control for the Motor Insight overload relay from a single DeviceNet node. These modules also offer convenient I/O in two voltage options, 24 Vdc and 120 Vac.

Features and Benefits

- Communication to DeviceNet uses only one DeviceNet MAC ID
- Configuration
 - DeviceNet MAC ID and Baud rate are set via convenient DIP switches with an option to set from the network
 - Advanced configuration available using common DeviceNet tools
- Terminals
 - Unique locking mechanism provides for easy removal of the terminal block with the field wiring installed
 - Each terminal is marked for ease of wiring and troubleshooting

- Selectable I/O assemblies
 - 4IN/2OUT
 - Signal types include 24 Vdc I/O and 120 Vac I/O
 - Each I/O module is optically isolated between the field I/O and the network adapter to protect the I/O and communication circuits from possible damage due to transients and ground loops
 - Input Module features a user-definable input debounce, which limits the effects of transients and electrical noise
 - Output Module supports a user-definable safe state for loss of communication; hold last state, ON or OFF
- Combined status LED

Table 4.2-5. DeviceNet Modules

Description	I/O	Catalog Number
 DeviceNet Module	120 Vac	C441K
DeviceNet Communication Module	24 Vdc	C441L

PROFIBUS Communication Module

The C441 Motor Insight PROFIBUS Communication Module is a side-mounted device providing PROFIBUS communication capability to the C441 Motor Insight overload relay.

The PROFIBUS Communication Module with I/O provides communication, monitoring and control for the C441 Motor Insight overload relay.

Features and Benefits

- The PROFIBUS communication module is capable of baud rates up to 12 Mb
- PROFIBUS address is set via convenient DIP switches (C441Q and C441S); LEDs are provided to display PROFIBUS status
- Intuitive configuration with common PROFIBUS configuration tools
- Terminals
 - Unique locking mechanism provides for easy removal of the terminal block with the field wiring installed
 - Each terminal is marked for ease of wiring and troubleshooting
- Selectable I/O assemblies
 - 4IN/2OUT
 - Signal types include 24 Vdc I/O and 120 Vac I/O
 - Each I/O module is optically isolated between the field I/O and the network adapter to protect the I/O and communication circuits from possible damage due to transients and ground loops
 - Input Module features a user-definable input debounce, which limits the effects of transients and electrical noise
 - Output Module supports a user-definable safe state for loss of communication; hold last state, ON or OFF

Table 4.2-6. PROFIBUS Communication Module

Description	I/O	Catalog Number
 PROFIBUS with I/O Module	PROFIBUS Communication Module 4IN/2OUT	120 Vac
	PROFIBUS Communication Module 4IN/2OUT	24 Vdc
		C441S
		C441Q

Approximate Dimensions in Inches (mm)

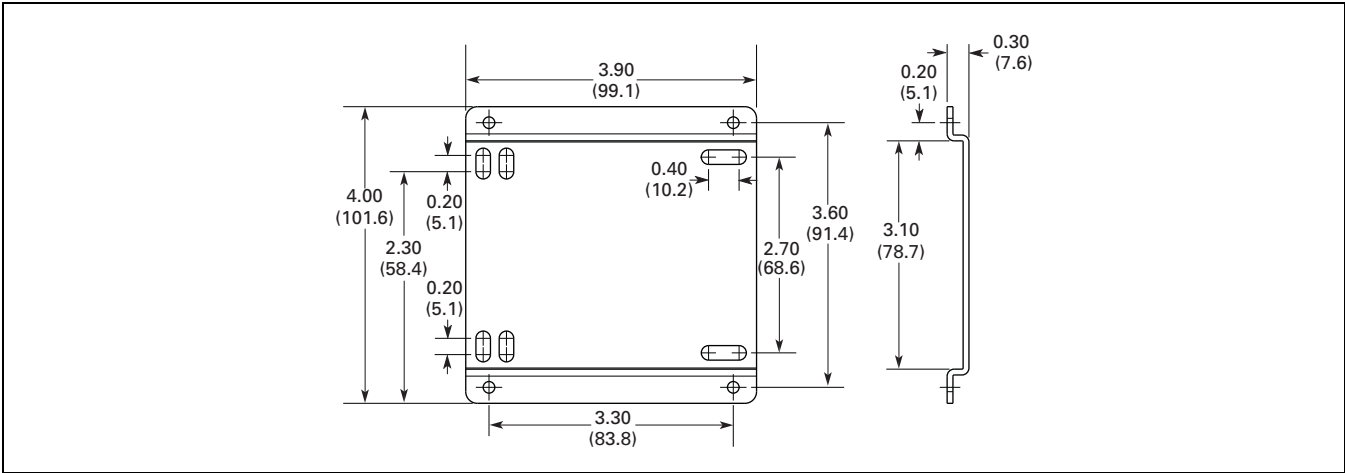


Figure 4.2-1. C441 Motor Insight Conversion Plate

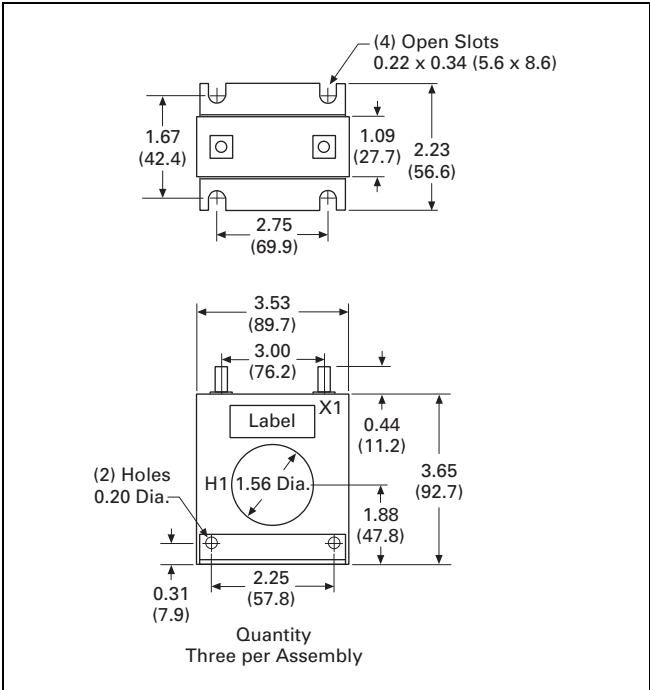


Figure 4.2-2. Applicable for C441CTKIT150, C441CTKIT300 and C441CTKIT600

**MP-3000
Motor Protection Relay****MP-3000 Motor Protection Relay****General Description**

Eaton's MP-3000 motor protection relay is a multi-functional microprocessor-based protective relay for the protection of any size motor at all voltage levels. It is most commonly applied on medium voltage starters and on critical or larger motors. The MP-3000 relay is a current only device that provides complete and reliable motor protection, monitoring and starting control functions.

The MP-3000 motor protection relay is available in either a fixed mount, semi-flush case or in a semi-flush quick-release drawout case. Both housings are compact and fit a standard IQ cutout.

The optional quick-release drawout case features two-stage contact disconnection and self-shorting CT circuit terminals. A spare self-shorting terminal pair is available for use as relay removal alarm or for continuous motor operation (non-failsafe mode) on relay removal. The optional communication module is externally mounted on the fixed mount case and internally mounted in the drawout case.

The MP-3000 motor protection relay has three phase and one ground current inputs. Both a 5 A and 1 A version are available. The ground protection and metering functions 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 relay is programmable for 60 Hz or 50 Hz operation.

The MP-3000 motor protection relay has two discrete inputs, four Form C (1NO and 1NC) contacts and one 4 to 20 mA analog output. The relay provides maximum user flexibility to configure the I/O. All inputs and outputs (except for the trip output) are user-programmable. In addition, the relay has 10 LEDs for the indication of protection on, program mode, monitor mode, view setting mode, history mode, log mode, trip, alarm, auxiliary 1 and auxiliary 2 operation. A test page in the program mode provides display indication of the discrete input states and testing of the output relays, target LEDs and analog circuit.

A user-friendly operator interface and display provides quick access to the settings, monitored values, motor history and operational logs. Large LED alphanumeric character display provides easy viewing from any angle in any light. Simple keypad operation provides quick and easy navigation through all settings and stored data. The program mode and emergency override buttons are access restricted via a latched cover which can be sealed if required. An integrated help function provides an online description display of functions, abbreviations and operations.

Optimum Motor Protection

The MP-3000 motor protection relay has been designed for maximum motor operation and protection. It permits running the motor as close to its design limits while protecting it against excessive heating and damaging overload conditions. The MP-3000 field proven protection algorithms were developed based on motor designs and operating parameters for optimum operation and protection while minimizing nuisance tripping.

The MP-3000 motor protection relay uses a protection algorithm and measurement technique based on proven positive and negative (unbalance) sequence current sampling and true rms calculations.

Features**General**

- Microprocessor-based
- Self diagnostics
- User-friendly interface
- Large LED display
- Built-in help program
- Built-in test mode
- LED mode and target indication
- Remote communications
- Programmable discrete inputs
- Programmable outputs

Protection

- I²t 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)
- Failsafe or non-failsafe trip modes

Alarming

- Ground fault
- I²t overload
- Jam/stall
- Underload
- Phase unbalance

Control

- Transition for reduced voltage starts:
 - ☐ Transition on current level
 - ☐ Transition on time
 - ☐ Transition on current level or time
 - ☐ Transition on current level and time
- Incomplete sequence monitoring
- Permits number of cold starts
- Limits number of starts per time
- Time between starts
- Anti-backspin time delay
- Mechanical load shedding
- Zero speed switch for long acceleration motors
- Motor stop input for synchronous motor applications
- Remote trip input
- Differential trip input
- Emergency override

Monitoring Functions

- Motor currents:
 - Average current (I ave)
 - Individual phase and ground current in primary amperes
 - % of full load
 - % phase unbalance

- RTD temperatures:
 - Individual winding
 - Motor bearing
 - Load
 - Auxiliary temperatures

- Motor conditions:
 - % of I²t thermal bucket
 - Time before start
 - Remaining starts allowed
 - Oldest start time

History

- Motor history:
 - Operational counter
 - Run time
 - Highest starting and running currents
 - Highest % phase unbalance
 - Maximum winding, bearing and load RTD temperatures
 - Number of emergency overrides

- Trip history (number of trips):
 - Ground faults
 - Overloads
 - Instantaneous overcurrent
 - JAM
 - Underload
 - Phase unbalance
 - RTDs
 - Phase reversal
 - Incomplete sequence
 - Remote, differential
 - Communication
 - Starts exceeded
 - Time between starts
 - Transition

- Alarms history (number of alarms):
 - Ground faults
 - Overloads
 - JAM
 - Underload
 - Phase unbalance
 - RTDs
 - Starts exceeded

- Total history (record which cannot be reset):
 - Total trips
 - Run time
 - Operations count

Logging

- Log book (chronological list of last 100 events with date and time stamp)
- Event log (detailed information of last 20 trips and alarms with date and time stamp)
- Start log (data on most recent four starts with date and time stamp)

User Interface

The MP-3000 motor protection relay has a user-friendly interface that makes it easy to retrieve important information or make setting changes. LEDs provide visual indication of display and keypad mode. The push-buttons are clearly labeled and quickly access the desired information.

Protection Functions

The MP-3000 motor protection relay provides protection against motor overloads, short circuits and abnormal operating conditions.

I²t Overload

Motor overloads are typically limited by the rotor thermal capabilities but the measuring quantities are from the stator. This requires accurate measurements and good motor thermal models to provide reliable protection.

The MP-3000 motor protection relay uses a field proven measurement and motor thermal protection model. The relay samples the current waveforms 36 times per cycle providing accurate measurements of the positive and negative sequence currents. The negative sequence component of current causes greater heating effect on the rotor and has a greater impact on the thermal model in the relay. This same algorithm has been used to protect thousands of motors since 1984.

The MP-3000 motor protection relay overload protection is easy to set and apply. Simply input motor nameplate information and CT ratios and the characteristic is automatically set.

When using the MP-3000 motor protection relay, it is recommended that the ratio of CT primary rating to the motor full load amperes (CT Pri/Motor FLA) is selected to fall between 0.25 and 1.5. The thermal model adapts its tripping characteristics if RTDs are connected.

Instantaneous Overcurrent

The MP-3000 motor protection relay provides an instantaneous phase overcurrent function to trip the motor for high fault current levels. This function can be disabled and has an adjustable time delay on starting to avoid nuisance tripping on inrush.

Phase Unbalance Protection

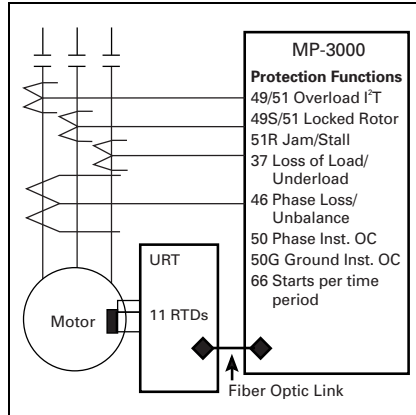
Motor supply circuits are often fed through fuses and can be run with a single-phase fuse blown. The motor may still see three-phase voltage but will only have current on two phases, referred to as single-phasing the motor. The MP-3000 motor protection relay measures the current unbalance and can be used to alarm or trip the motor before damage occurs. Pickup, start and run timers and a separate alarm setting are provided.

Ground Fault Protection

A separate circuit measures ground fault current. A ground CT is recommended for more sensitive protection against winding fault 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 separate alarm setting are provided.



**Figure 4.2-3. MP-3000
Motor Protection Relay Functions**

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 separate alarm setting are provided.

Reduced Voltage Starting

Eaton's MP-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 or on time.

Anti-Backspin

For certain applications, for example, pumping fluid up a pipe, the motor may be driven backward for a period of time after it stops. The MP-3000 relay provides an anti-backspin 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, hot starts, starts per time period and time between starts that are permitted without damage. The MP-3000 motor protection relay incorporates these timers to prevent starting the motor beyond its capabilities.

Load Shedding

The MP-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

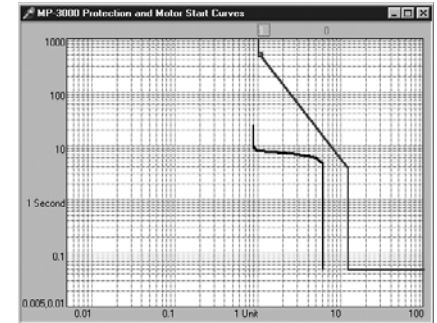
The MP-3000 motor protection relay has a user-programmable feature that will let the operator reset the start control timers and thermal overload bucket. This function is intended for use in emergency conditions only and may result in motor damage or failure.

Long Acceleration Motors

Large motors with high inertia loads may experience starting currents that exceed the locked rotor current and time. The MP-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 rotor time allowing the motor to start.

Remote/Differential Trip

One of the binary inputs can be programmed to accept a contact input from a separate differential relay, such as the MD-3000 or other device to trip the motor. This provides local and remote target information and uses the trip contacts of the MP-3000 motor protection relay. It will also record and log the motor information at the time of the trip.



Motor Starting Profile Time/Current Chart

Motor Starting Profile

The MP-3000 relay records the average current of the motor for the last two starts. This information is available over the communications port. The motor current can then be plotted and compared to the motor overload protection curve. Available in PowerPort or the PowerNet Event Viewer Client.

Product Selection

Table 4.2-7. 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

Technical Data and Specifications

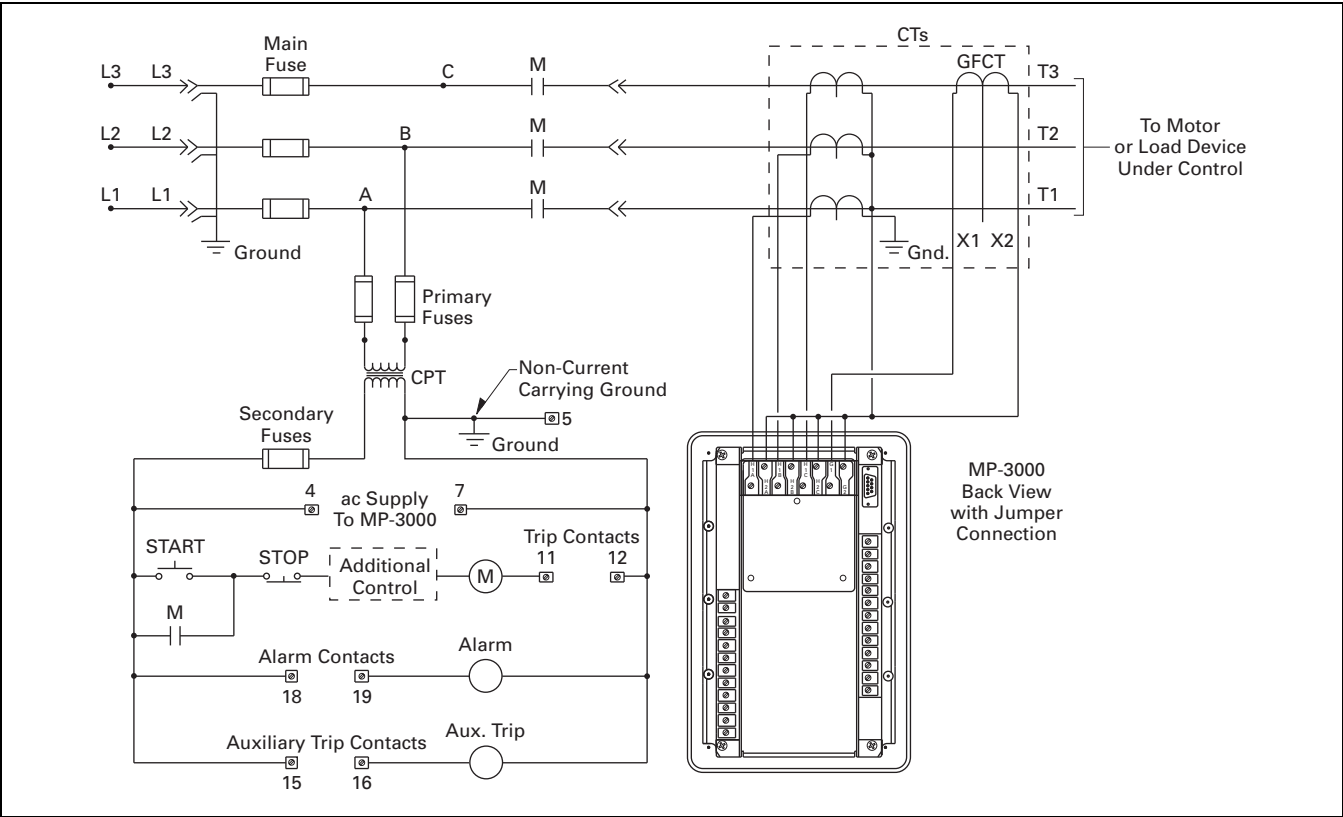


Figure 4.2-4. MP-3000 Wiring

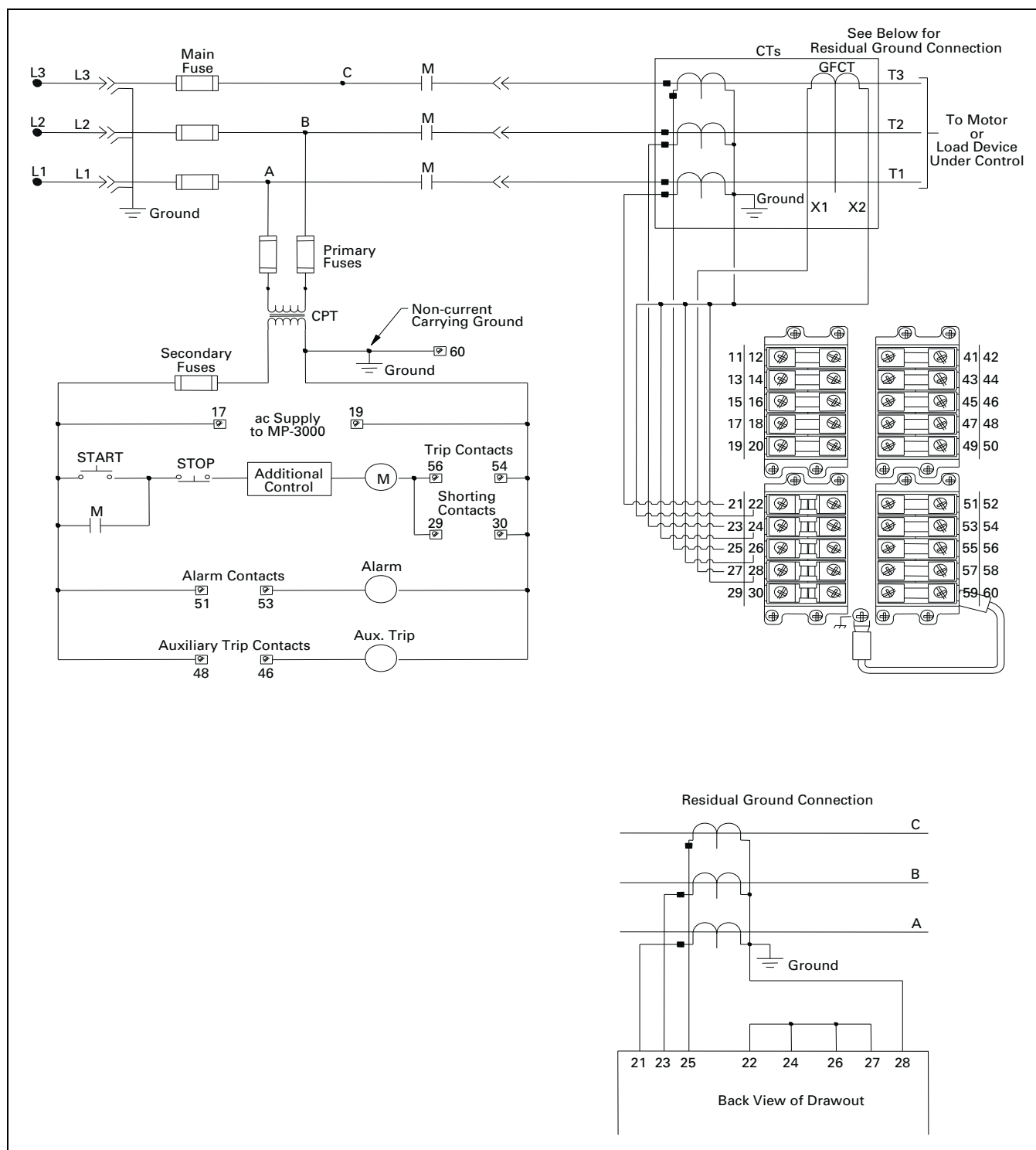


Figure 4.2-5. MP-3000 Drawout Typical CT Circuits and Motor Control Wiring

Standards, Certifications and Ratings

Table 4.2-8. MP-3000 Specifications

Control Power Nominal rating: 120 Vac or 240 Vac (+10%, -25%) Frequency: 50 or 60 Hz Power use: 20 VA maximum URTD: 6 VA maximum IPONI: 1 VA maximum Operating range: 120 Vac: 90–132 Vac 240 Vac: 180–264 Vac Ride through time: 30 cycles at nominal Vac	Motor Overload Protection (I^2t) Full load amperes: 10 to 3000 A Locked rotor current: 300% to 1200% FLA Locked rotor time: 1 to 120 seconds Ultimate trip current: 85% to 150% FLA Phase CT ratio: 10 to 4000: I_N Ground CT ratio: 10 to 4000: I_N Timing accuracy: $\pm 2.5\%$ or ± 30 ms For $I > 1.1 \times \text{U.T.C.}$	Start Control Functions Starts per time: Off, 1 to 10 starts Time for starts per time: Off, 1 to 240 minutes Time between starts: Off, 1 to 240 minutes Number of cold starts: 1 to 5 starts Motor transition current: 10% to 300% FLA Time for transition: 0 to 1200 seconds Inc. sequence timer: Off, 1 to 240 seconds Long acceleration timer: Off, 1 to 1200 seconds Anti-backspin timer: Off, 1 to 3600 minutes
Current Inputs Nominal (I_N): 1 A or 5 A CT rating: $2 \times I_N$ continuous $40 \times I_N$ for 1 second Phase burden: VA at I_N Ground burden: VA at I_N Saturation: $\times I_N$	Trip Setting Range Ground fault (GF): Off, 2% to 55% CT ratio GF Start and run time delay: 2 to 60 cycles Timer accuracy: ± 20 ms Instantaneous O.C.: Off, 300% to 1600% FLA IOC start time delay: 0 to 60 cycles Timer accuracy: ± 20 ms JAM trip: Off, 100% to 1200% FLA Underload trip: Off, 1% to 90% FLA Phase unbalance trip: Off, 4% to 40% $I_{\text{neg}}/I_{\text{pos}}$ 0 to 1200 seconds	Clock Accuracy: ± 1 minute/month at 25 °C
Metering Accuracy Phase current: $\pm 1\%$ of I_N (5%–100%) Ground current: $\pm 1.5\%$ of I_N (0%–55%)	JAM, Underload and Phase Unbalance Time Delay Start delay timers: 0 to 120 seconds Run delay timers: 0 to 240 seconds Timer accuracy: $\pm 0.5\% + 100$ ms	Communications DPONI Type: 5-wire Baud rate: 500K, 250K, 125K, Auto Protocol: DeviceNet Functions: Read/write set points Read metered values Read trip/alarms Read events/history View starting profile IPONI Type: 2-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 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
Discrete Inputs Number of inputs: 2 Programmable Rating: 1.2 VA at 120 Vac Maximum OFF = 36 Vac Minimum ON = 86 Vac	Alarm Setting Range Ground fault: Off, 2% to 75% CT ratio Overload I^2t : Off, 60% to 99% I^2t JAM: Off, 100% to 1200% FLA Underload: Off, 1% to 90% FLA Phase unbalance: Off, 4% to 40% $I_{\text{neg}}/I_{\text{pos}}$ Run delay timers: 0 to 240 seconds	Environmental Ratings Operating: Temperature: -20 °C to +60 °C Storage: Temperature: -45 °C to +85 °C Humidity: 0% to 95% (noncondensing)
Output Contacts Number of outputs: 4 Form C, Programmable Momentary: Make 30 A AC/DC for 0.25 second (Resistive) 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	Logging Log book: 100 events Log event: 20 trips and alarms Log start: Last 4 starts Start profile: Last start (communication only) History records: Motor, trips, alarms and permanent records	Dimensions in Inches (mm) Height: 10.25 (260.4) Width: 6.72 (170.7) Depth: 3.70 (94.0) Weight: 7 lbs (3 kg)
Analog Output Rating: ± 4 to 20 mA Programmable Maximum load: 1K ohm Accuracy: 1%	UL Recognized File Number E154862 UL 1053 ANSI C37.90, C37.90.1, C37.90.2 CSA	

MP-4000 Motor Protection Relay with Voltage Inputs



MP-4000 Motor Protection Relay

General Description

Eaton's MP-4000 motor protection relay is a multi-functional microprocessor-based protective relay for the protection of any size motor at all voltage levels. It is most commonly applied on medium voltage starters and on critical or larger motors. The MP-4000 relay provides complete and reliable motor protection, monitoring and starting control functions.

The MP-4000 motor protection relay is available in either a fixed mount, semi-flush case or in a semi-flush quick-release drawout case.

The optional quick-release drawout case features two-stage contact disconnection and self-shorting CT circuit terminals. A spare self-shorting terminal pair is available for use as relay removal alarm or for continuous motor operation (non-failsafe mode) on relay removal. The optional communication module is externally mounted on the fixed mount case and internally mounted in the drawout case.

The MP-4000 motor protection relay has three phase and one ground current inputs. The MP-4000 also has three voltage inputs. Both a 5 A and 1 A version are available. The ground protection and metering functions 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 relay is programmable for 60 Hz or 50 Hz operation.

The MP-4000 motor protection relay has two discrete inputs, four Form C (1NO and 1NC) contacts and one 4 to 20 mA analog output. The relay provides maximum user flexibility to configure the I/O. All inputs and outputs (except for the trip output) are user-programmable. In addition, the relay has 10 LEDs for the indication of protection on, program mode, monitor mode, view setting mode, history mode, log mode, trip, alarm, auxiliary 1 and auxiliary 2 operation. A test page in the program mode provides display indication of the discrete input states and testing of the output relays, target LEDs and analog circuit.

A user-friendly operator interface and display provides quick access to the settings, monitored values, motor history and operational logs. Large LED alphanumeric character display provides easy viewing from any angle in any light. Simple keypad operation provides quick and easy navigation through all settings and stored data. The program mode and emergency override buttons are access restricted via a latched cover that can be sealed if required. An integrated help function provides an online description display of functions, abbreviations and operations.

Optimum Motor Protection

The MP-4000 motor protection relay has been designed for maximum motor operation and protection. It permits running the motor as close to its design limits while protecting it against excessive heating and damaging overload conditions. The MP-4000 field proven protection algorithms were developed based on motor designs and operating parameters for optimum operation and protection while minimizing nuisance tripping.

The MP-4000 motor protection relay uses a protection algorithm and measurement technique based on proven positive and negative (unbalance) sequence current sampling and true rms calculations.

Features

General

- Microprocessor-based
- Self diagnostics
- User-friendly interface
- Large LED display
- Built-in help program
- Built-in test mode
- LED mode and target indication
- Remote communications
- Programmable discrete inputs
- Programmable outputs

Protection

- I²t overload protection (49/51)
- Locked rotor (49S/51)
- Ultimate trip current (51)
- Undervoltage (27)
- Overvoltage (59)
- Under power (32)
- Negative sequence phase unbalance (46)
- Negative sequence voltage unbalance (47)
- Instantaneous overcurrent (50)
- Ground fault protection (50G)
- RTD trip and alarm with URTD module (49/38)
- Underload trip (37)
- Power factor (55)
- Starts per time (66)
- Jam or stall (51R)
- Auto or manual reset (86)
- Failsafe or non-failsafe trip modes

Alarming

- Ground fault
- I²t overload
- Jam/stall
- Underload
- Phase unbalance
- Voltage unbalance

Control

- Transition for reduced voltage starts:
 - Transition on current level
 - Transition on time
 - Transition on current level or time
 - Transition on current level and time
- Incomplete sequence monitoring
- Permits number of cold starts
- Limits number of starts per time
- Time between starts
- Anti-backspin time delay
- Mechanical load shedding
- Zero speed switch for long acceleration motors
- Motor stop input for synchronous motor applications
- Remote trip input
- Differential trip input
- Emergency override

Monitoring Functions

- Metering
- RTD temperatures:
 - Individual winding
 - Motor bearing
 - Load
 - Auxiliary temperatures
- Motor conditions:
 - % of I^2t thermal bucket
 - Time before start
 - Remaining starts allowed
 - Oldest start time

History

- Motor history:
 - Operational counter
 - Run time
 - Highest starting and running currents
 - Highest % current unbalance
 - Highest % voltage unbalance
 - Highest starting and running voltages
 - Maximum winding, bearing and load RTD temperatures
 - Number of emergency overrides
- Trip history (number of trips):
 - Ground faults
 - Overloads
 - Instantaneous overcurrent
 - JAM
 - Underload
 - Phase unbalance
 - Voltage unbalance
 - Overvoltage
 - Undervoltage
 - Overfrequency
 - Underfrequency
 - Under power
 - Power factor
 - RTDs
 - Phase reversal
 - Incomplete sequence
 - Remote, differential
 - Communication
 - Starts exceeded
 - Time between starts
 - Transition

■ Alarms history (number of alarms):

- Ground faults
- Overloads
- JAM
- Underload
- Current unbalance
- Voltage unbalance
- Overvoltage
- Undervoltage
- Overfrequency
- Underfrequency
- Under power
- Power factor
- RTDs
- Starts exceeded

■ Total history (record which cannot be reset):

- Total trips
- Run time
- Operations count

Logging

- Log book (chronological list of last 100 events with date and time stamp)
- Event log (detailed information of last 20 trips and alarms with date and time stamp)
- Start log (data on most recent four starts with date and time stamp)

User Interface

The MP-4000 motor protection relay has a user-friendly interface that makes it easy to retrieve important information or make setting changes. LEDs provide visual indication of display and keypad mode. The push-buttons are clearly labeled and quickly access the desired information.

Protection Functions

The MP-4000 motor protection relay provides protection against motor overloads, short circuits and abnormal operating conditions.

2t Overload

Motor overloads are typically limited by the rotor thermal capabilities but the measuring quantities are from the stator. This requires accurate measurements and good motor thermal models to provide reliable protection.

The MP-4000 motor protection relay uses a field-proven measurement and motor thermal protection model. The relay samples the current waveforms 36 times per cycle providing accurate measurements of the positive and negative sequence currents. The negative sequence component of current causes greater heating effect on the rotor and has a greater impact on the thermal model in the relay. This same algorithm has been used to protect thousands of motors since 1984.

The MP-4000 motor protection relay overload protection is easy to set and apply. Simply input motor nameplate information and CT ratios and the characteristic is automatically set.

When using the MP-4000 motor protection relay, it is recommended that the ratio of CT primary rating to the motor full load amperes (CT Pri/Motor FLA) is selected to fall between 0.25 and 1.5. The thermal model adapts its tripping characteristics if RTDs are connected.

Instantaneous Overcurrent

The MP-4000 motor protection relay provides an instantaneous phase overcurrent function to trip the motor for high fault current levels. This function can be disabled and has an adjustable time delay on starting to avoid nuisance tripping on inrush.

Product Selection**Table 4.2-9. 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

Technical Data and Specifications

Current Unbalance Protection

Motor supply circuits are often fed through fuses and can be run with a single-phase fuse blown. The motor may still see three-phase voltage but will only have current on two phases, referred to as single-phasing the motor. The MP-4000 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 separate alarm setting are provided.

Voltage Unbalance Protection

The MP-4000 will calculate negative sequence voltage from three-phase voltages. The presence of negative sequence voltage identifies either a phase unbalance or reverse phase rotation condition. The MP-4000 provides both alarm and trip functionality.

Ground Fault Protection

A separate circuit measures ground fault current. A ground CT is recommended for more sensitive protection against winding fault 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.

Frequency Protection

The MP-4000 provides over/under protection on the Main VT inputs. Each element has an independent threshold and time delay.

Voltage Protection

The MP-4000 voltage protection can be used to generate a trip or alarm if the voltage exceeds (overvoltage 59) a specified threshold for a specific time delay or drops below (under-voltage 27) a specified threshold for a specified time delay. Voltage elements can act on one, two or three phases.

Power Factor

The power factor function in the MP-4000 can be used for many applications. For a synchronous motor, it can be used to indicate field loss. The power factor protection can generate a trip or alarm when the power factor falls between specified thresholds.

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 separate alarm setting 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 separate alarm setting are provided.

Reduced Voltage Starting

Eaton's MP-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 or on time.

Anti-Backspin

For certain applications, for example, pumping fluid up a pipe, the motor may be driven backward for a period of time after it stops. The MP-4000 relay provides an anti-backspin 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, hot starts, starts per time period and time between starts that are permitted without damage. The MP-4000 motor protection relay incorporates these timers to prevent starting the motor beyond its capabilities.

Load Shedding

The MP-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

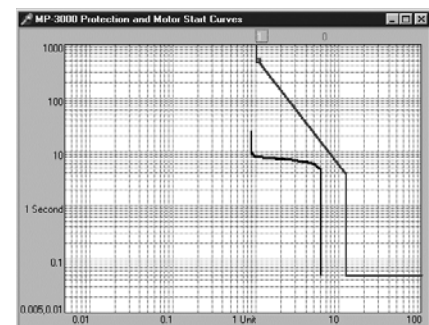
The MP-4000 motor protection relay has a user-programmable feature that will let the operator reset the start control timers and thermal overload bucket. This function is intended for use in emergency conditions only and may result in motor damage or failure.

Long Acceleration Motors

Large motors with high inertia loads may experience starting currents that exceed the locked rotor current and time. The MP-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

One of the binary inputs can be programmed to accept a contact input from a separate differential relay, such as the MD-3000, or other device to trip the motor. This provides local and remote target information and uses the trip contacts of the MP-4000 motor protection relay. It will also record and log the motor information at the time of the trip.



Motor Starting Profile Time/Current Chart

Motor Starting Profile

The MP-4000 relay records the average current of the motor for the last two starts. This information is available over the communications port. The motor current can then be plotted and compared to the motor overload protection curve. Available in PowerPort or the PowerNet Event Viewer Client.

Standards, Certifications and Ratings

Table 4.2-10. MP-4000 Specifications

Control Power Nominal rating: 120 Vac or 240 Vac (+10%, -25%) Frequency: 50 or 60 Hz Power use: 20 VA maximum URTD: 6 VA maximum IPONI: 1 VA maximum Operating range: 120 Vac: 90–132 Vac 240 Vac: 180–264 Vac Ride through time: 30 cycles at nominal Vac	Motor Overload Protection (I^2t) Full load amperes: 10 to 3000 A Locked rotor current: 300% to 1200% FLA Locked rotor time: 1 to 120 seconds Ultimate trip current: 85% to 150% FLA Phase CT ratio: 10 to 4000: I_n Ground CT ratio: 10 to 4000: I_n Timing accuracy: $\pm 2.5\%$ or ± 30 ms For $I > 1.1 \times$ U.T.C.	Logging Log book: 100 events Log event: 20 trips and alarms Log start: Last 4 starts Start profile: Last start (communicaion only) History records: Motor, trips, alarms and permanent records
Current Inputs Nominal (I_n): 1 A or 5 A CT rating: $2 \times I_n$ continuous 40 $\times I_n$ for 1 second Phase burden: VA at I_n Ground burden: VA at I_n Saturation: $\times I_n$	Trip Setting Range Ground fault (GF): Off, 2% to 55% CT Ratio GF Start and run time delay: 2 to 60 cycles Timer accuracy: ± 20 ms Instantaneous O.C.: Off, 300% to 1600% FLA IOC Start time delay: 0 to 60 cycles Timer accuracy: ± 20 ms JAM trip: Off, 100% to 1200% FLA Underload trip: Off, 1% to 90% FLA Current unbalance trip: Off, 4% to 40% I_{neg}/I_{pos} 0 to 1200 seconds	Start Control Functions Starts per time: Off, 1 to 10 starts Time for starts per time: Off, 1 to 240 minutes Time between starts: Off, 1 to 240 minutes No. of cold starts: 1 to 5 starts Motor transition current: 10% to 300% FLA Time for transition: 0 to 1200 seconds Inc. sequence timer: Off, 1 to 240 seconds Long acceleration timer: Off, 1 to 1200 seconds Anti-Backspin Timer: Off, 1 to 3600 minutes
Voltage Inputs Nominal rating: 120 Vac Operating range: 69 to 150 Vac Burden: 2 VA	Voltage unbalance (47) Threshold: OFF, 1 to 100 V % V2/V1: 4% to 40% Time delay: 0 to 1200 seconds Under/overvoltage (27/59) Pickup range: OFF, 10 to 150 V Time delay: 0 to 1200 seconds Under/overfrequency (81U/81O) Pickup range: Off, 15 to 60 Hz Time delay: 0 to 60 seconds Power protection (32) Threshold: OFF, 0.06 to 0.90 *FLA *VT Time delay: 0 to 1200 seconds Power factor (55) Threshold: OFF, 0.05 to 0.99 Time delay: 0 to 60 seconds	Clock Accuracy: ± 1 minute/month at 25 °C
Metering Accuracy Phase current: $\pm 1\%$ of I_n (5%–100%) Ground current: $\pm 1.5\%$ of I_n (0%–55%)	JAM, Underload and Phase Unbalance Time Delay Start Delay timers: 0 to 120 seconds Run Delay timers: 0 to 240 seconds Timer accuracy: $\pm 0.5\% + 100$ ms	Communications DPONI Type: 5-wire Baud rate: 500K, 250K, 125K, Auto Protocol: DeviceNet Functions: Read/write set points Read metered values Read trip/alarms Read events/history View starting profile IPONI Type: 2-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 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
Discrete Inputs Number of Inputs: 2 Programmable Rating: 1.2 VA at 120 Vac Maximum OFF = 36 Vac Minimum ON = 86 Vac	Alarm Setting Range Ground fault: Off, 2% to 75% CT Ratio Overload I^2t : Off, 60% to 99% I^2t JAM: Off, 100% to 1200% FLA Underload: Off, 1% to 90% FLA Phase unbalance: Off, 4% to 40% I_{neg}/I_{pos} Run Delay timers: 0 to 240 seconds	Environmental Ratings Operating: Temperature: -20 °C to +60 °C Storage: Temperature: -45 °C to +85 °C Humidity: 0% to 95% (noncondensing)
Output Contacts Number of outputs: 4 Form C, Programmable Momentary: Make 30 A AC/DC for 0.25 second (Resistive) 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	Analog Output Rating: ± 4 to 20 mA Programmable Maximum load: 1K ohm Accuracy: 1%	Dimensions in Inches (mm) Height: 10.25 (260.4) Width: 6.72 (170.7) Depth: 3.70 (94.0) Weight: 7 lbs (3 kg) UL Recognized File Number E154862 UL 1053 ANSI C37.90, C37.90.1, C37.90.2 CSA

General Description—EMR-3000

EMR-3000 Motor Protection Relay



EMR-3000

General Description

Eaton's EMR-3000 motor protection relay is a multifunctional micro-processor-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 MP-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 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 user programmable for 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 (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 five latest start profiles, motor trending, breaker wear information and oscillography data.

The EMR-3000 motor protection relay has four discrete inputs and one fiber optic input, one Form C and two NO programmable contacts, and one 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.

Features, Benefits and Functions

- Microprocessor-based protection with monitoring and control for medium voltage motors
- 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 in 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 face-plate or remotely via communications
- Fast and 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

- 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])
 - Eleven 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])
 - Eleven standard curves
 - Instantaneous or time delay reset
- Jam or Stall protection (50J[1] and 50J[2])
- Phase unbalance negative sequence overcurrent (46[1] and 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

- Amperes: positive, negative and zero sequence
- Ampere demand
- Phase angles
- Frequency
- % THD I
- Magnitude THD I
- Minimum/maximum recording
- Phase angles
- Temperature with remote URTD module

Monitoring

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (6000 cycles total)
- 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 five motor start profiles
- Motor start trending
- CT supervision
- Clock (1 ms time stamping)

Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485
- Protocols:
 - Modbus RTU
 - Modbus TCP (optional)
 - IEC 61850 (optional)
- Configuration software

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

Protection and Control Functions

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 uses a 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-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 uses field-proven measurement techniques and a 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 uses 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 to 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.

General Description—EMR-3000

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 uses 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 help to reduce the possibility of injury.

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

The EMR-3000 motor 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 EMR-3000 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 eight 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. 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-3000 stores a motor start report and adds this data to the motor statistics buffer. With the motor statistics you can track motor start data for the past 18 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, trip rated, 2NO and one 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.

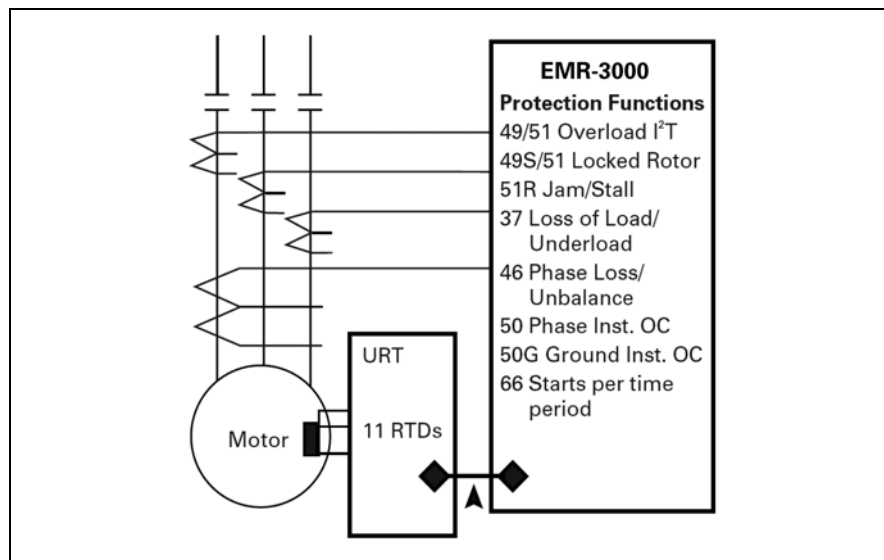


Figure 4.2-6. Typical One-Line Diagram

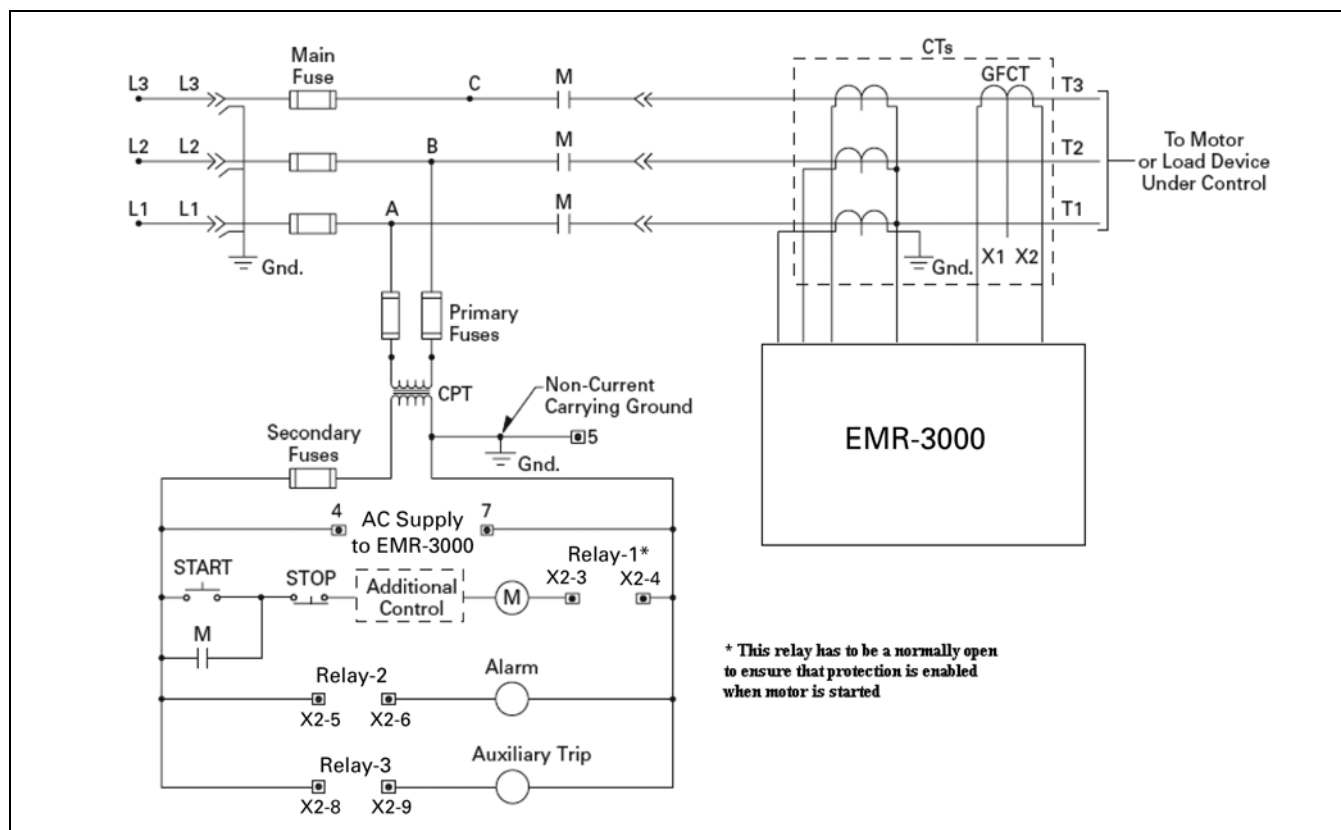


Figure 4.2-7. Typical Control Diagram

General Description—EMR-3000

Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. 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-E is free and can be downloaded from the Eaton Web site at www.eaton.com/pr.
The second package is Power Xpert Software. Power Xpert Software is a power management software package that is designed for continuous,

remote monitoring of many devices. It provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

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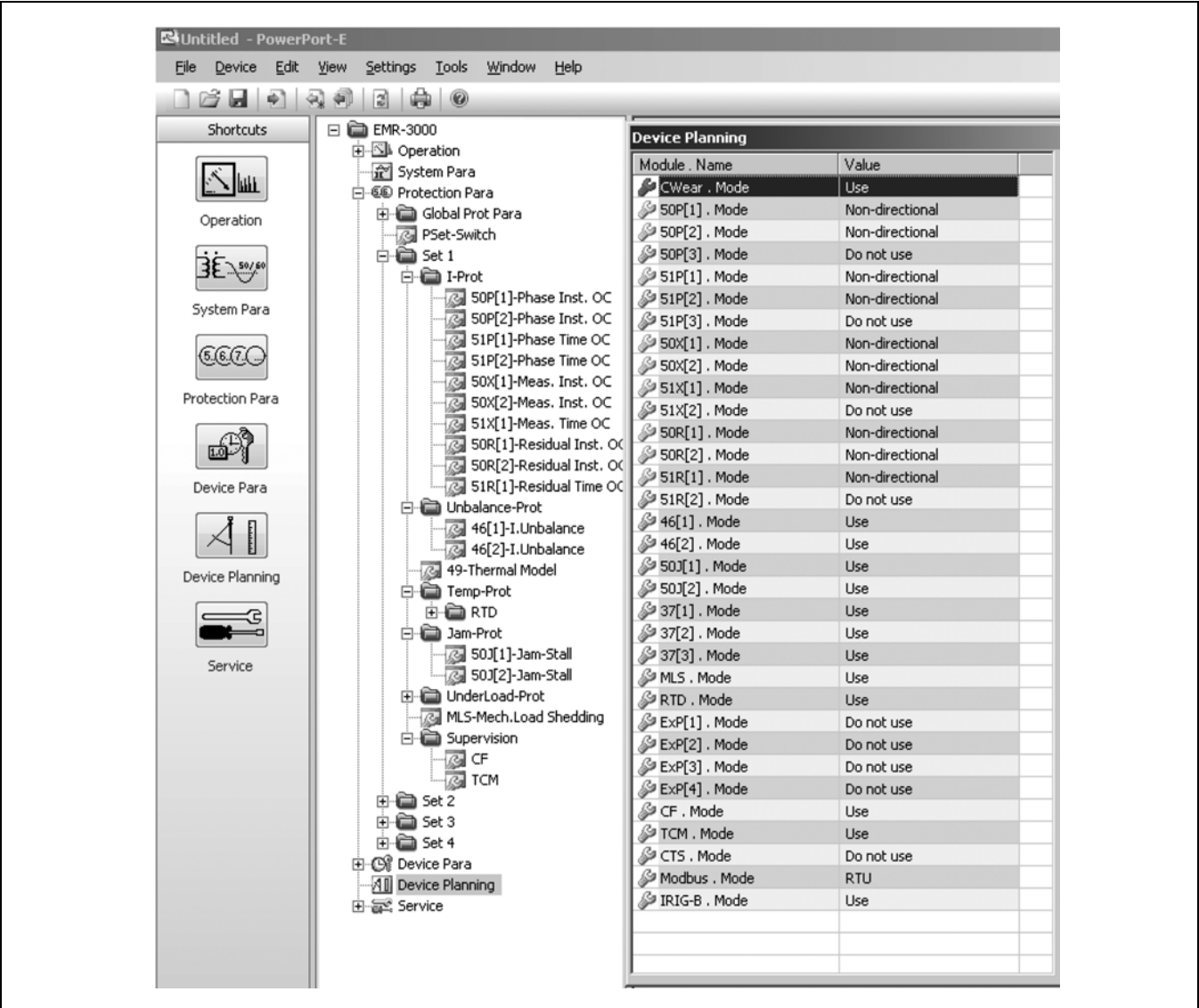
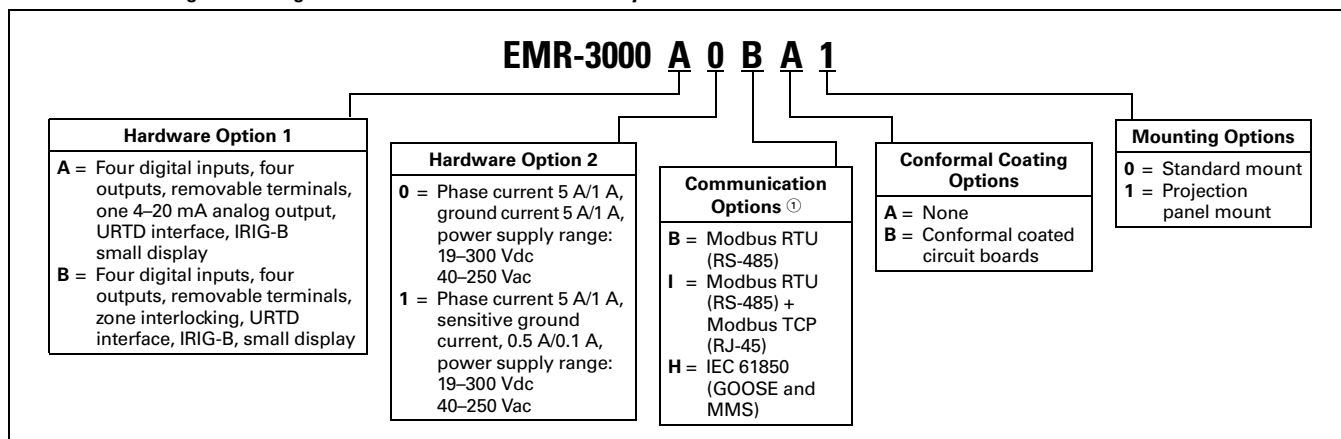


Figure 4.2-8. PowerPort-E EMR-3000 Device Planning

Table 4.2-11. Catalog Numbering Selection for EMR-3000 Motor Relay Removable Terminals



^① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS
- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

Standards, Certifications and Ratings

Table 4.2-12. EMR-3000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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 Switching threshold 1 ON: Min. 19.2 Vdc Switching threshold 1 OFF: Max. 9.6 Vdc Un = 48V/60 Vdc Switching threshold 2 ON: Min. 42.6 Vdc Switching threshold 2 OFF: Max. 21.3 Vdc Un = 110/120 Vac/dc 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug
Power Consumption Power supply range: 19–300 Vdc: 6W idle mode/ 8W max. power 40–250 Vac: 6W idle mode/ 8W max. power (for frequencies of 40–70 Hz) Power consumption: Phase current inputs at $I_n = 1$ A burden = 0.15 mVA at $I_n = 5$ A burden = 0.15 mVA Ground current input: at $I_n = 1$ A burden = 0.35 mVA at $I_n = 5$ A burden = 0.35 mVA	Binary Output Relays Continuous current: 5 A AC/DC Max. make current: 25 A AC/25 A DC for 4s Max. breaking current: 5 A AC up to 125 Vdc 5 A DC up to 30 V (resistive) 0.2 A DC at 300V Max. switching voltage: 250 Vac/300 Vdc Switching capacity: 2000 VA Contact type: 1 changeover contact Terminals: Screw-type terminals	RS-485 Master/slave: Slave Connection: Six 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 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: <2000 m (6561.67 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.

**EMR-4000
Motor Protection Relay****EMR-4000****General Description**

Eaton's EMR-4000 motor protection relay is a multifunctional micro-processor-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 A or 1 A 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 user programmable for 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 (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 non-volatile memory. The relay allows for four preprogrammed setting groups that 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 five latest start profiles, motor trending, breaker/contact wear information and oscillography data.

The EMR-4000 motor protection relay has eight discrete inputs, one fiber optic input, two Form C and 2NO output programmable contacts, and one 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 to 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.

General Description—EMR-4000 Motor Protection Relay

Features

Protection

- 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] and 50J[2])
- Phase unbalance negative sequence overcurrent (46[1] and 46[2])
- Underload protection (37[1], 37[2], 37[3])
- 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: overfrequency, underfrequency, 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

- 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, lag 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

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (6000 cycles total)
- 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 five motor start profiles
- Motor start trending
- CT supervision
- VT supervision
- Clock (1 ms time stamping)

Diagnostic

- Broken rotor bar (Beta version)

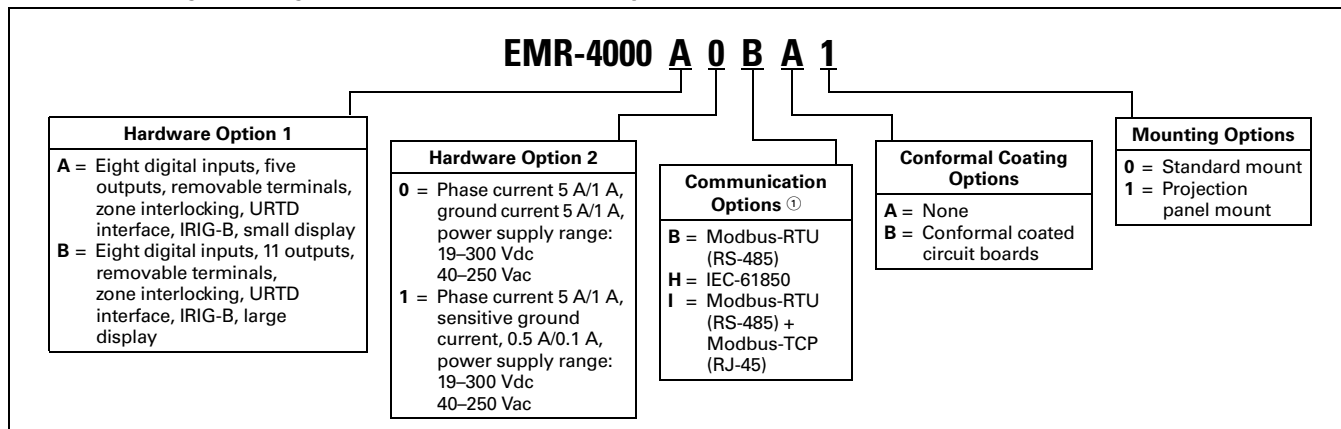
Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485
- Protocols:
 - Modbus-RTU (optional)
 - Modbus-TCP (optional)
 - IEC-61850 (optional)
- Configuration software

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/contactors open-close/stop-start
- Remote open-close (stop-start)
- Programmable I/O
- Programmable LEDs
- Programmable logic
- Multiple setting groups

Table 4.2-13. Catalog Numbering Selection for EMR-4000 Motor Relay Removable Terminals



① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS

- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

Protection and Control Functions

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 uses a protection algorithm and measurement technique based on proven positive and negative (unbalance) sequence current sampling and true rms calculations.

Intel-I-Trip (I²t) 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 uses field proven measurement techniques and a 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 uses 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 to 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 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 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.

General Description—EMR-4000

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 that are potentially hazardous to the motor.

Reduced Voltage Starting

The EMR-4000 motor protection relay provides a transition and an 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-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 uses 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 to 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 help to reduce the possibility of injury.

Diagnostic Features

Broken Rotor Bar (Beta Version)

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 it 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 for 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-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.

Waveform Capture

The EMR-4000 motor 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 EMR-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 eight 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. Seven programmable LEDs provide quick and easy visual display of power on, mode of operation, alarm and trip indication. Soft keys are provided for operating 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-3000 stores a motor start report and adds this data to the motor statistics buffer. With the motor statistics you can track motor start data for the past 18 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, 2NO and one Form C contacts. One isolated input 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.

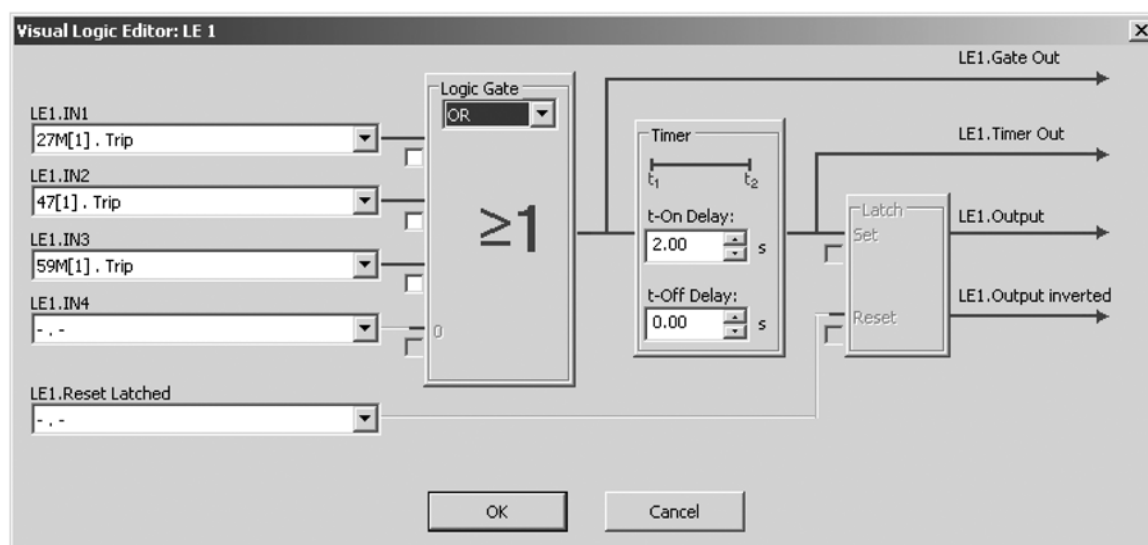


Figure 4.2-9. Visual Logic Editor

General Description—EMR-4000

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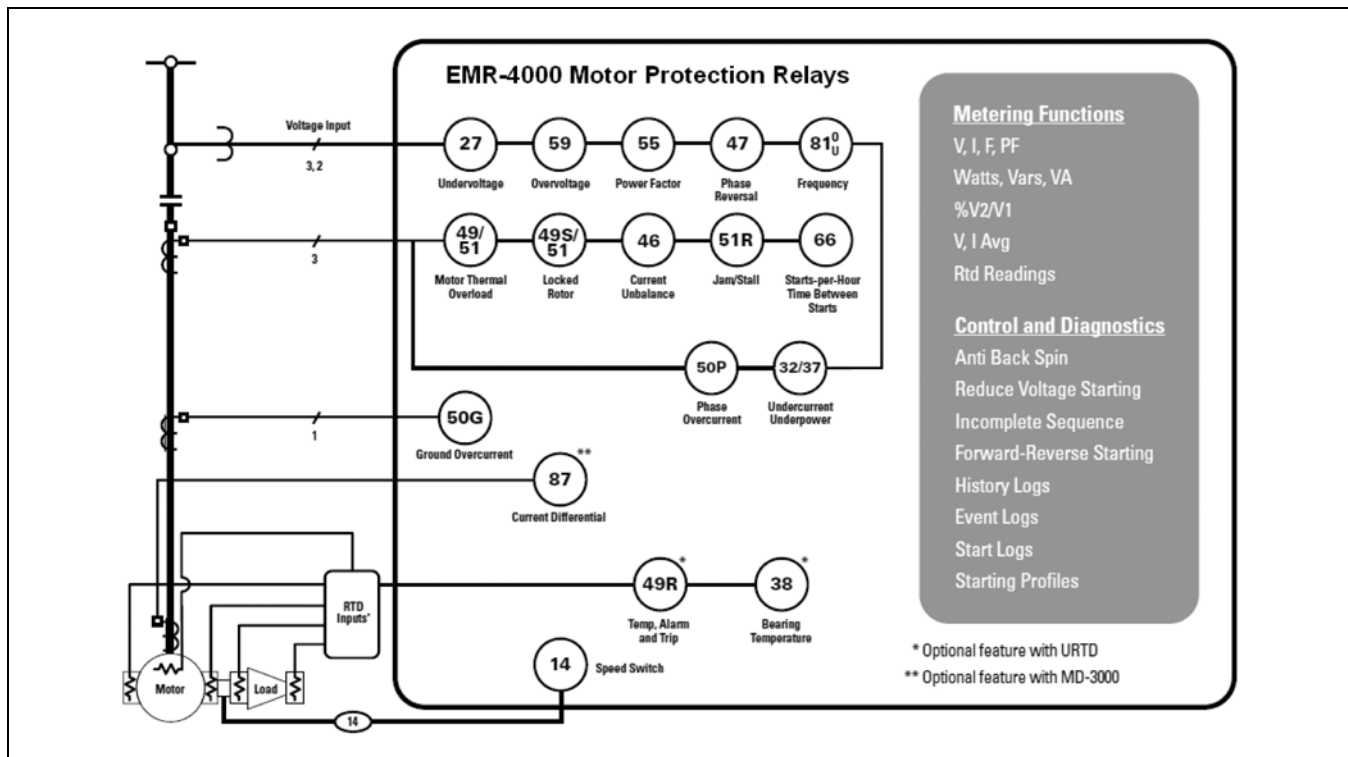


Figure 4.2-10. Typical One-Line Diagram

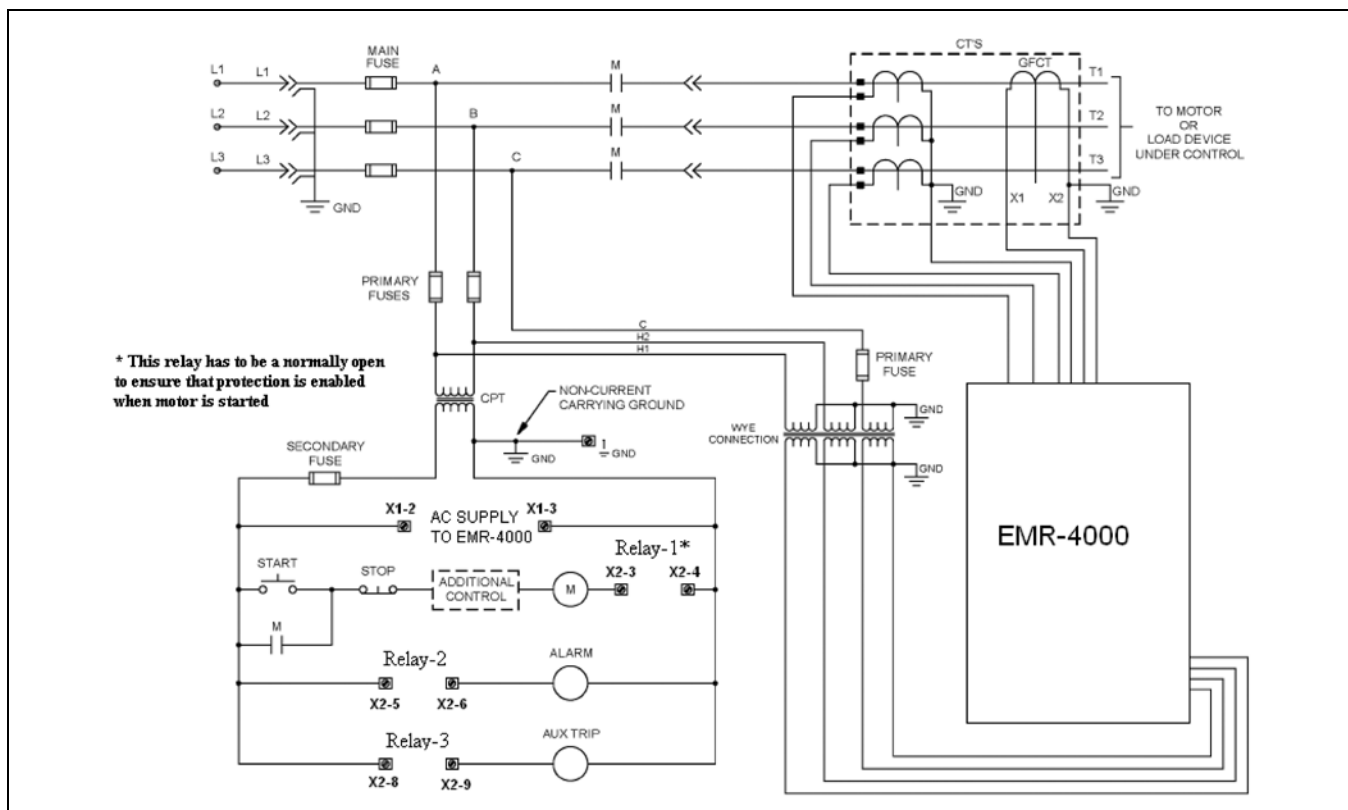


Figure 4.2-11. Typical Control Diagram

General Description—EMR-4000

Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. It runs on a PC or a laptop for easy access to a single relay to change set points or configuration and to view metered values and stored

data. PowerPort-E is free and can be downloaded from the Eaton Web site at www.eaton.com/pr.

The second package is Power Xpert Software. Power Xpert Software is a power management software package that is designed for continuous,

remote monitoring of many devices. It provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

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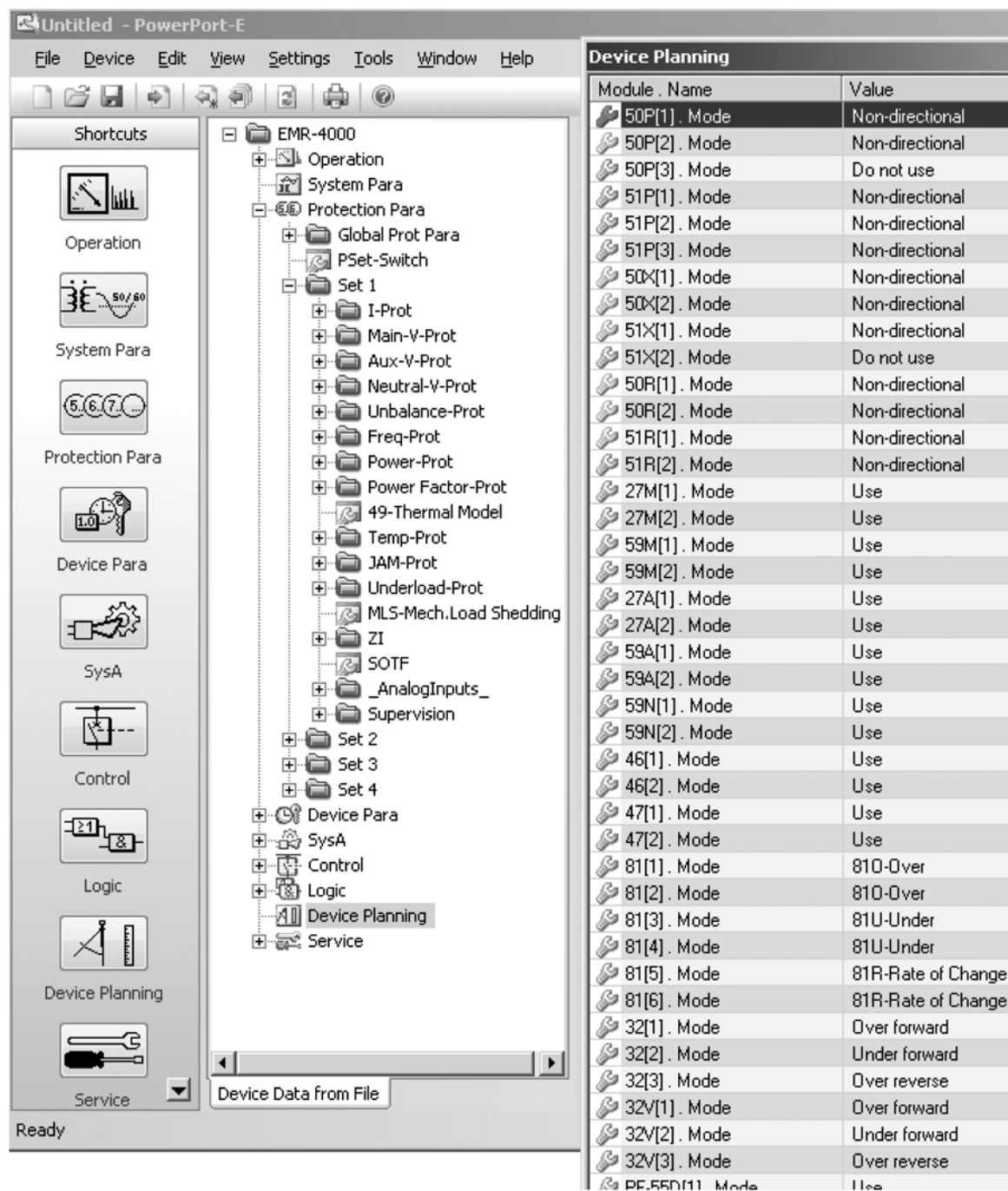


Figure 4.2-12. PowerPort-E EMR-4000 Device Planning

Standards, Certifications and Ratings

Table 4.2-14. EMR-4000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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 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/dc 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	Zone Interlocking NOTICE: ONLY FOR ZONE INTERLOCK TRIPPING OUTPUTS (ZONE INTERLOCK, SEMI-CONDUCTOR 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)
Power Consumption Power supply range: 24–270 Vdc: 7W idle mode/ approx. 13W max. power 48–230 Vac: 7 VA idle mode/ approx. 13 VA max. power (for frequencies of 40–70 Hz) 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	Relay Outputs Continuous current: 5 A AC/DC Max. 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 Vac according to ANSI IEEE Std. C37.90-2005 Max. breaking current: 5 A AC up to 125 Vdc 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug
		RS-485 Master/slave: Slave Connection: Six 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
		Climatic Environmental Conditions Storage temperature: –30 °C to +70 °C (–22 °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: <2000 m (6561.67 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.

**EMR-5000
Motor Protection Relay****EMR-5000****General Description**

Eaton's EMR-5000 motor protection relay is a multifunctional micro-processor-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 A or 1 A 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 under-voltage/overvoltage protection. The unit is user programmable for 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 (14) programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 and an Ethernet port in the back are optional for local area networking use. 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 non-volatile memory. The relay allows for four preprogrammed setting groups, which 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/contactors 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 two normally opened 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.

General Description—EMR-5000 Motor Protection Relay

Features

Protection

- 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

- 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, lag 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

- Trip coil monitor
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (6000 cycles total)
- 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

- Broken rotor bar (Beta version)

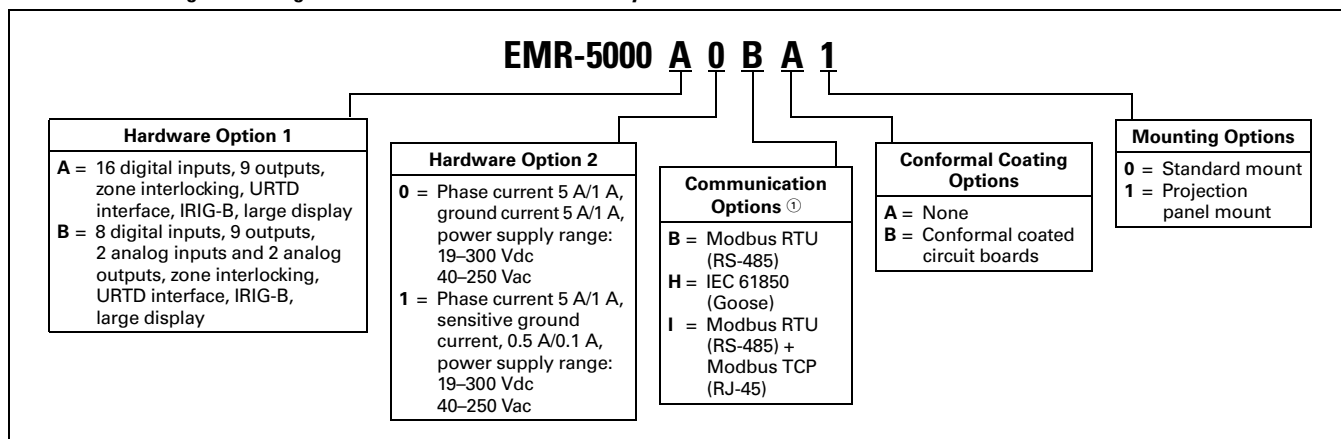
Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485
- Protocols:
 - Modbus RTU (optional)
 - Modbus TCP (optional)
 - IEC 61850 (optional)
- Configuration software

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/contactors open-close/stop-start
- Remote open-close (stop-start)
- Programmable I/O
- Programmable LEDs
- Programmable logic
- Multiple setting groups

Table 4.2-15. Catalog Numbering Selection for EMR-5000 Motor Relay



① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS
- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

Protection and Control Functions

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 (I²t) 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.

General Description—EMR-5000 Motor Protection Relay

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 motor 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 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-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.

Diagnostic Features

Broken Rotor Bar (Beta Version)

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.

Waveform Capture

The EMR-5000 motor 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 EMR-5000 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. 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 input 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.

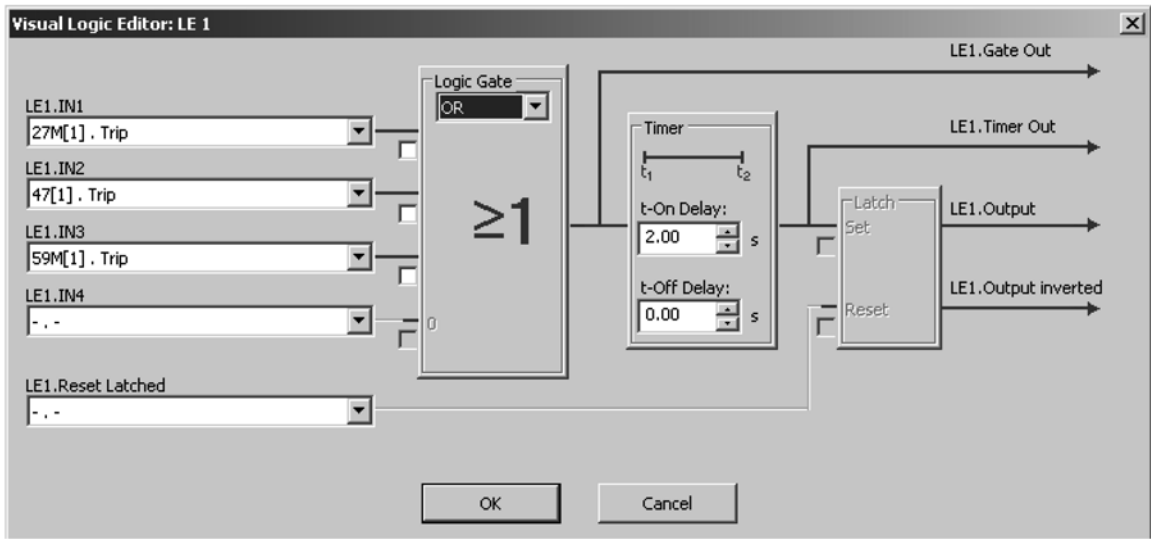


Figure 4.2-13. Programmable Logic

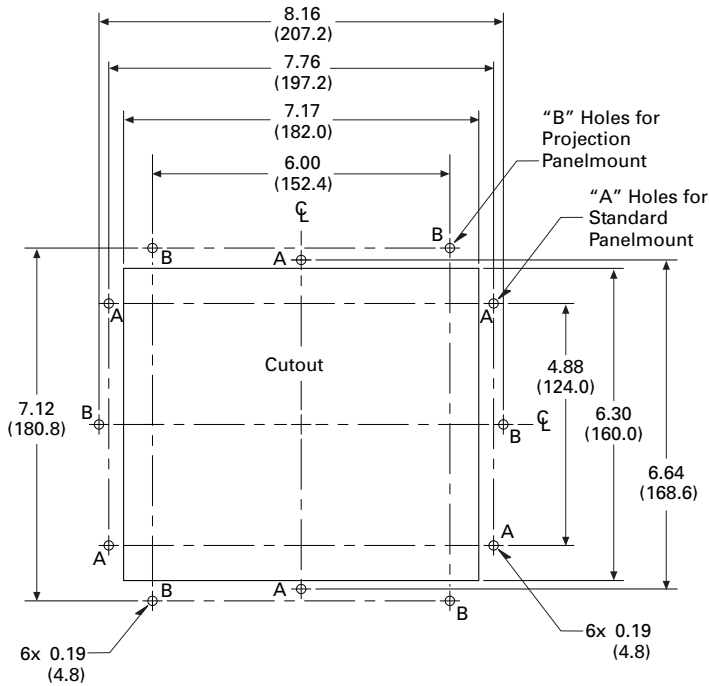


Figure 4.2-14. Drilling Plan

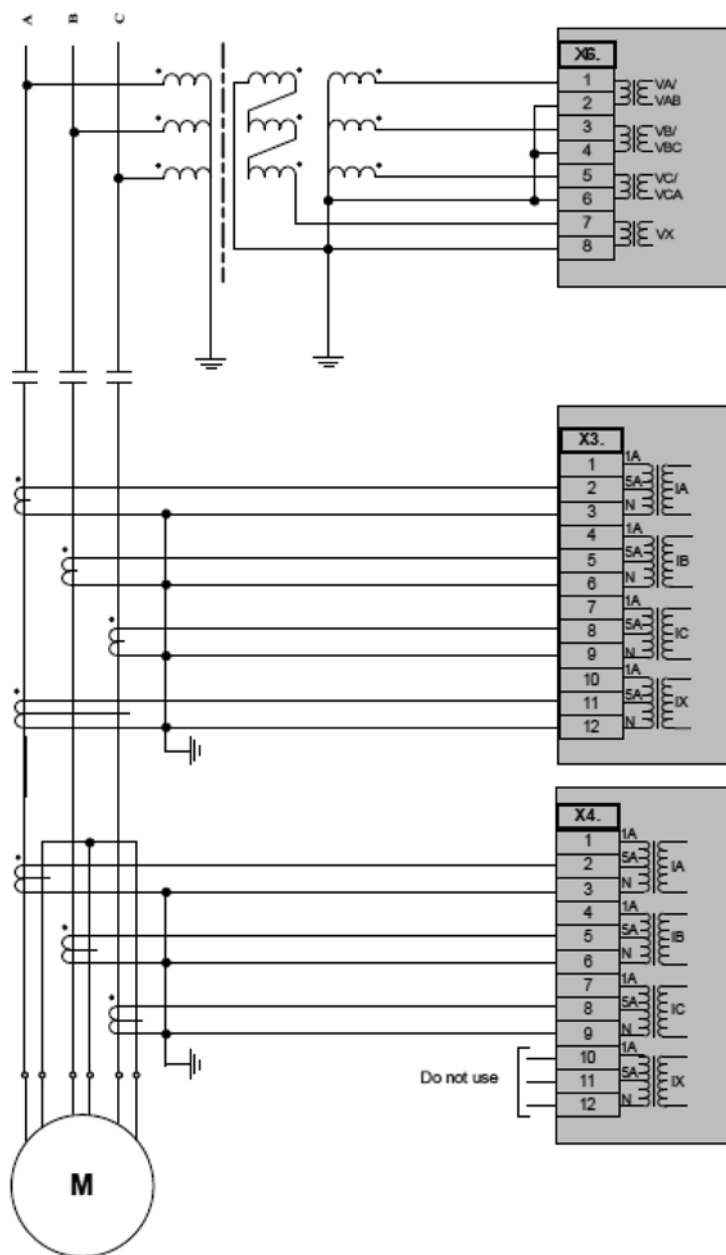


Figure 4.2-15. Typical AC Connections. Wye VTs, 5A CTs, and Ground Current Measured by Residual Connection

Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. 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-E is free and can be

downloaded from the Eaton Web site at www.eaton.com/pr.

The second package is Power Xpert Software, which is a power management software package that is designed for continuous, remote monitoring of many devices.

Power Xpert provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

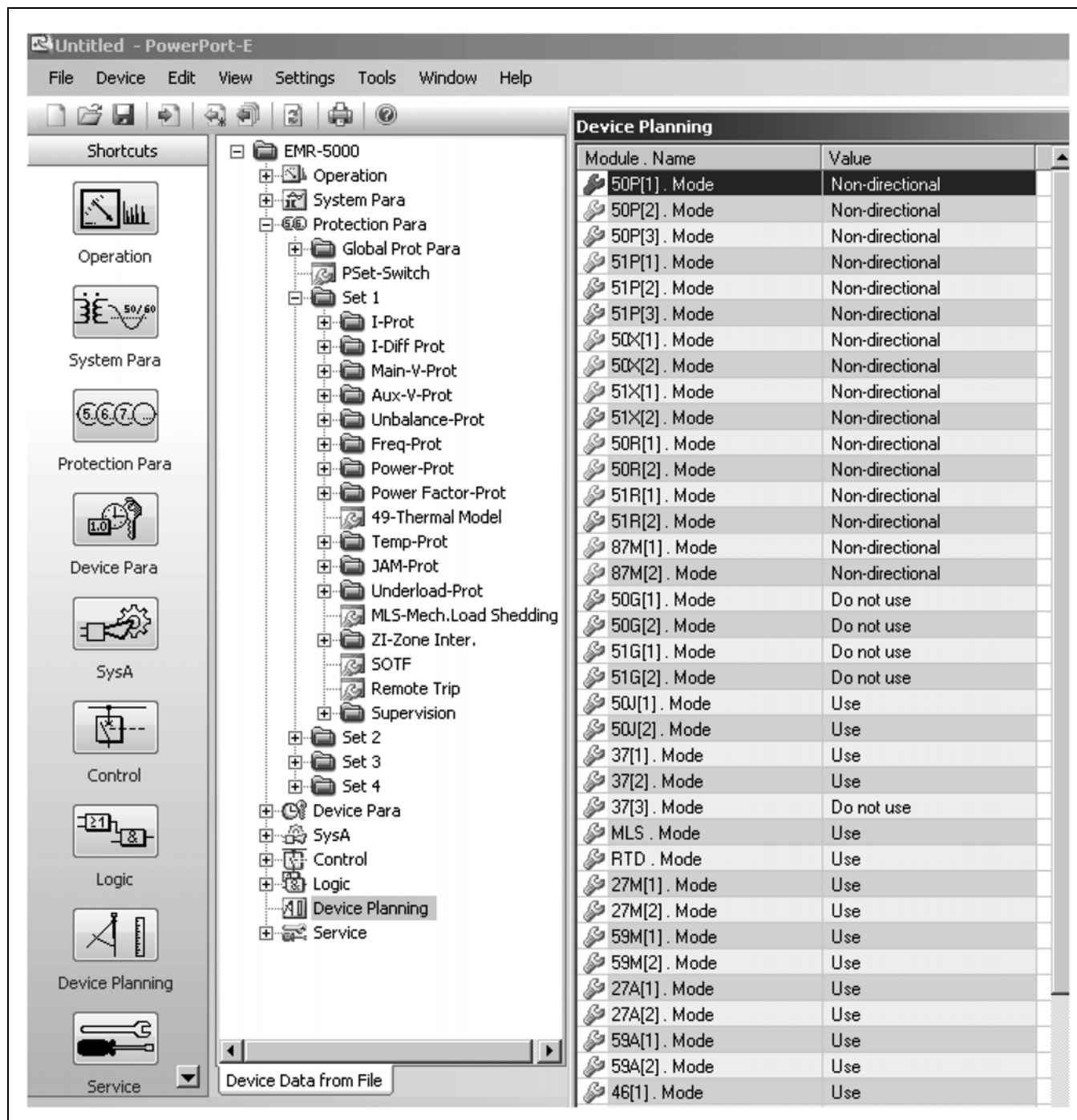


Figure 4.2-18. PowerPort-E EMR-5000 Device Planning

Standards, Certifications and Ratings

Table 4.2-16. EMR-5000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	Digital Inputs Max. input voltage: 300 Vdc/259 Vac Input current: <4 mA Reaction time: <20 ms Drop-out time: <30 ms Shorted inputs: <90 ms Open inputs: <90 ms	Zone Interlocking NOTICE: ONLY FOR ZONE INTERLOCK TRIPPING OUTPUTS (ZONE INTERLOCK, SEMI-CONDUCTOR 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)
Power Consumption Power supply range: 24–270 Vdc: 7 W idle mode/ approx. 13 W max. power 48–230 Vac: 7 VA idle mode/ approx. 13 VA max. power (for frequencies of 50–60 Hz) 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	Relay Outputs 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 Vac according to ANSI IEEE Std. C37.90-2005 Max. breaking current: 5 A AC up to 240 Vdc 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug
		RS-485 Master/slave: Slave Connection: Six 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
		Climatic Environmental Conditions Storage temperature: –30 °C to +70 °C (–22 °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: <2000 m (6561.67 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.

Universal RTD Module



Universal RTD Module

General Description

Eaton's Universal Resistance Temperature Detector module (URTD) is an electronic temperature monitoring device used to measure transformer, motor or generator embedded RTDs. The URTD can be used as a stand-alone RTD

temperature converter, communicating the measured RTD values as Modbus RTU data over RS-485, or the URTD can be used to communicate the measured temperature values directly via a fiber optic cable with a maximum distance of 400 ft (122 m) to one of Eaton's protection relays where alarm and trip thresholds can be set. The URTD module can be used with any one of Eaton's FP-6000, MP-3000, MP-4000, IQ-1000, EMR-3000, EMR-4000, EMR-5000, ETR-4000, ETR-5000, EGR-4000 or EGR-5000 protection relays.

The URTD module can be used to monitor up to 12 RTD inputs (either two- or three-wire RTD lead type)—four groups consisting of six motor windings, two motor bearings, two load bearings and two auxiliary. The URTD module can be programmed to accept any of the following types of RTD inputs as long as each RTD group uses a consistent RTD input type (for example, the motor winding RTDs must all be of type 10 ohm copper and the motor bearing RTDs must both be of type 100 ohm platinum): 10 ohm copper, 100 ohm platinum, and 100 and 120 ohm nickel.

Table 4.2-17. Catalog Numbers

Description	Catalog Number
Universal RTD Module 48–250 AC/DC	UTRDII-01
Universal RTD Module 24–48 Vdc	UTRDII-02

Technical Data and Specifications

Dimensions in Inches (mm)

- Height: 7.77 (197.4)
- Width: 4.35 (110.4)
- Depth: 2.00 (50.8)

Communications

Eaton's URTD module stores all measured temperature values in standard Modbus register format available over Modbus RTU communication via the RS-485 port. Additionally, the URTD can directly communicate via fiber optic cable to Eaton's protection relays.

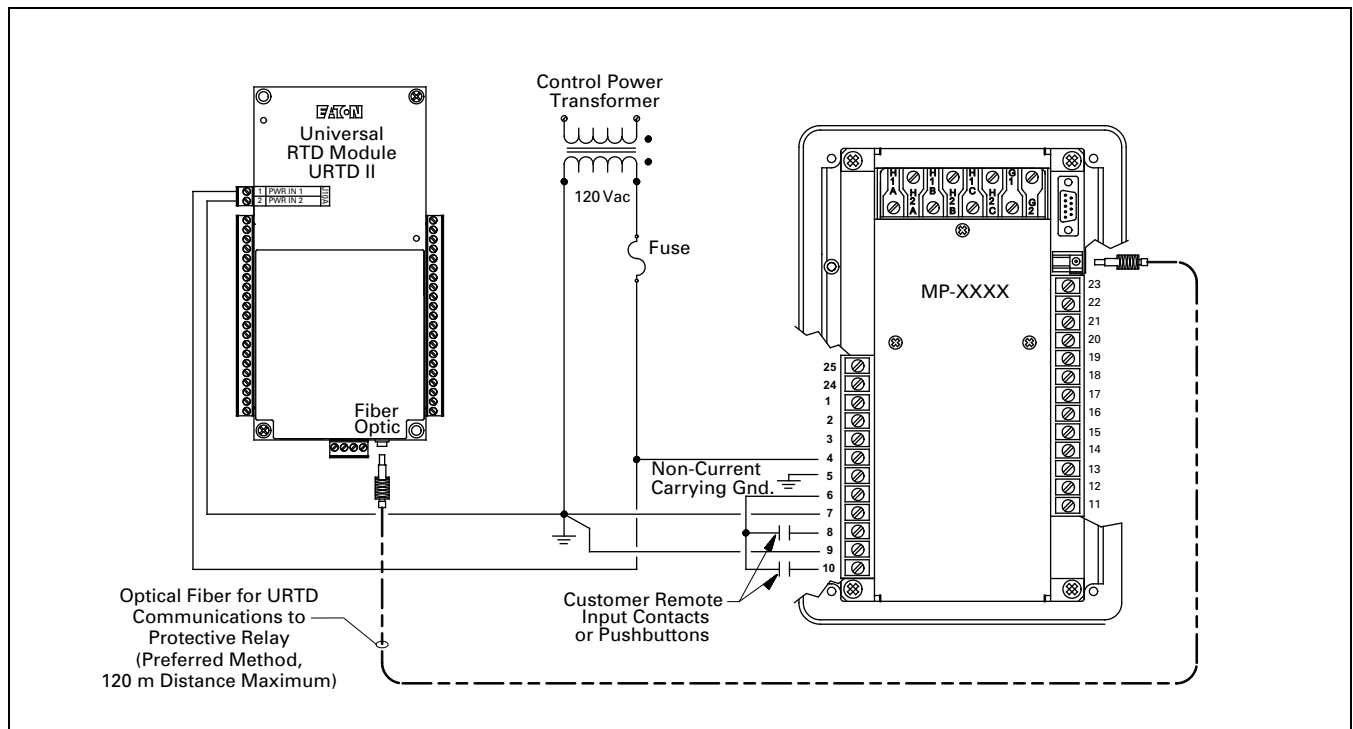


Figure 4.2-19. MP-3000 and URTD Wiring



URTD Module Communications

Fiber optic cable:

Length	Catalog Number
1	MPFO-1
5	MPFO-5
10	MPFO-10
25	MPFO-25
50	MPFO-50
75	MPFO-75
100	MPFO-120

ETR-4000 Transformer Protection Relay



ETR-4000 Transformer Protection Relay

General 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 A or 1 A 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 for 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 (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.

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 a mass memory for data storage and a real-time clock with 1 ms time resolution. The relay will log 300 sequence of events records, 20 detailed trip logs, minimum/maximum values, load profiles, breaker wear information and oscillography data.

The ETR-4000 has eight programmable binary inputs, four normally opened and four 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

Protection

- 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])
 - Eleven 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])
 - Eleven 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])
- Eleven 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
- Zone interlocking for bus protection (87B)

Metering

- Amperes: positive, negative and zero sequence
- Ampere demand
- Current phase angles
- % THD I
- Magnitude THD I
- Minimum/maximum recording
- Trending (load profile over time)
- RTD temperatures

Monitoring

- Trip coil monitor for both primary and secondary breakers
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (3600 cycles total)
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)

Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485

- Protocols:
 - Modbus-RTU
 - Modbus-TCP (optional)
 - IEC 61850

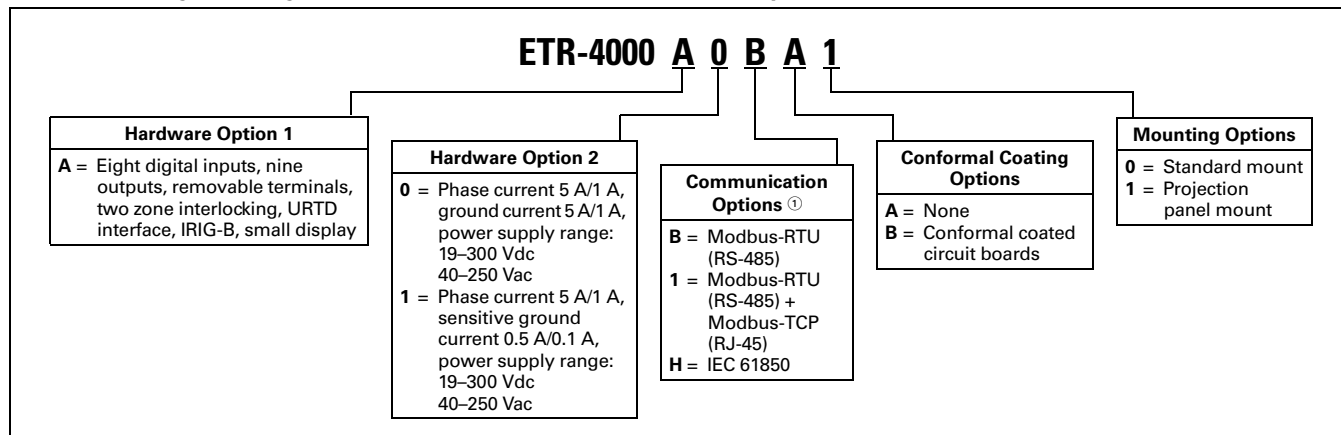
- Configuration software

Control Functions

- Breaker open/close both breakers
- Remote open/close
- Programmable I/O
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

General Description—ETR-4000

Table 4.3-1. Catalog Numbering Selection for ETR-4000 Transformer Protection Relay Removable Terminals



① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS
- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

Protection Functions

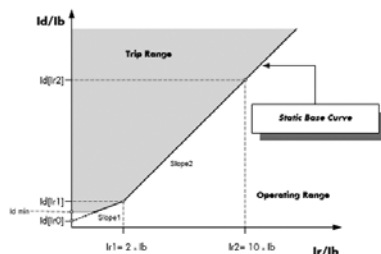
Eaton's ETR-4000 transformer protection relay has been designed for maximum user flexibility and simplicity. The ETR-4000 is suitable for application on small, medium and large two-winding power transformers. Multiple current inputs are used to provide primary protection, control and backup protection 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.

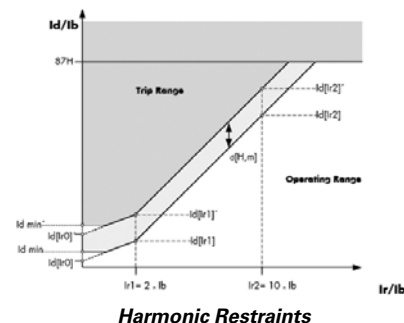


Dual-Slope Operating Characteristics

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 desensitized 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 a over-excitation 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.



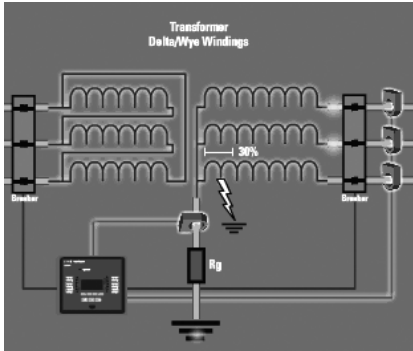
Harmonic Restraints

Unrestrained Differential

An unrestrained differential element is provided for fast tripping on heavy internal faults to limit catastrophic damage to the transformer and to 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

Because 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 can be 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 to 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 help to reduce the possibility of injury.

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 an 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

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 eight 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. 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.

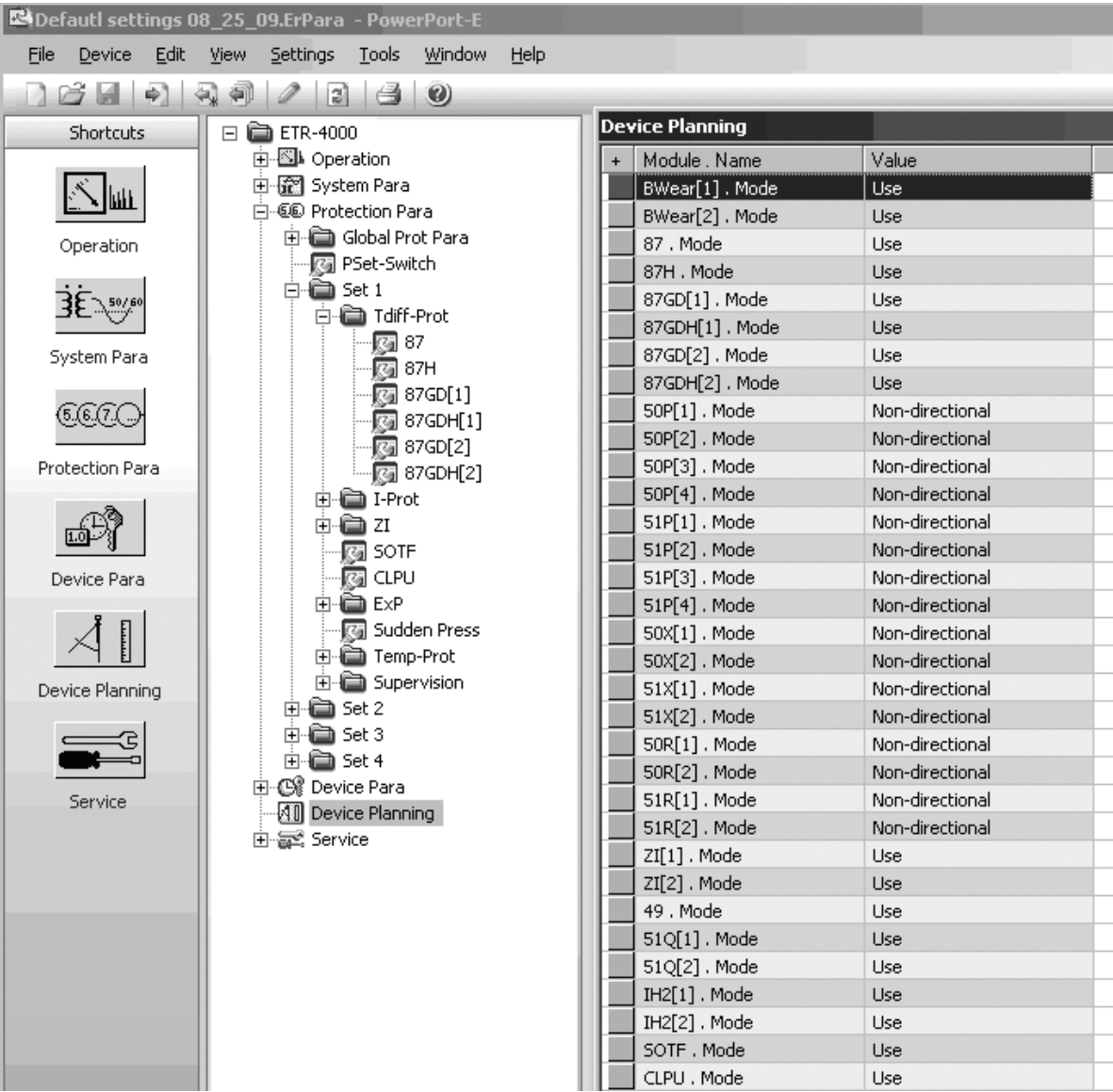


Figure 4.3-1. ETR-4000 Device Planning

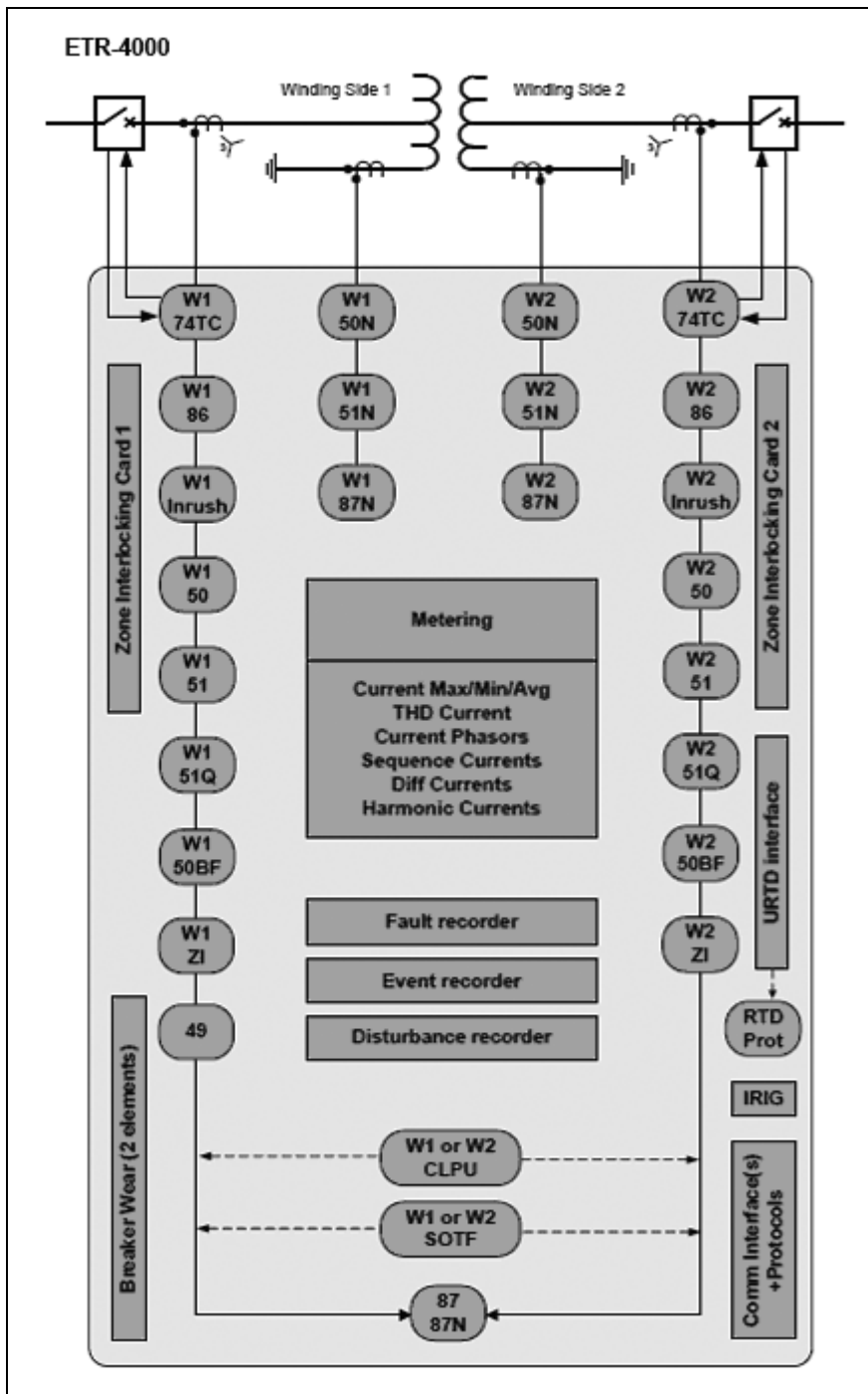


Figure 4.3-2. ETR-4000 Typical One-Line Diagram

Programmable I/O

The ETR-4000 transformer protection relay provides heavy-duty, trip-rated, four normally open and four 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 (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.

Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. 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-E is free and can be downloaded from the Eaton Web site at www.eaton.com/pr.

The second package is Power Xpert Software. Power Xpert Software is a power management software package that is designed for continuous, remote monitoring of many devices. It provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

Standards, Certifications and Ratings

Table 4.3-2. ETR-4000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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 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/dc 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	Zone Interlocking NOTICE: ONLY FOR ZONE INTERLOCK TRIPPING OUTPUTS (ZONE INTERLOCK, SEMI-CONDUCTOR 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)
Power Consumption Power supply range: 24–270 Vdc: 7W idle mode/ approx. 13W max. power 48–230 Vac: 7 VA idle mode/ approx. 13 VA max. power (for frequencies of 40–70 Hz) 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	Relay Outputs Continuous current: 5 A AC/DC Max. 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 Vac according to ANSI IEEE Std. C37.90-2005 Max. breaking current: 5 A AC up to 125 Vdc 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug
		RS-485 Master/slave: Slave Connection: Six 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
		Climatic Environmental Conditions Storage temperature: –30 °C to +70 °C (–22 °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: <2000 m (6561.67 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.

ETR-5000 Transformer
Protection Relay

ETR-5000 Transformer Protection Relay

General 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 A or 1 A 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 under-voltage/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 (14) programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 and an Ethernet port in the back are optional for local area networking use. 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, two analog inputs, two analog outputs, one zone interlocking card or eight programmable binary inputs, and two zone interlocking cards. It has two normally opened and six 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.

Features

Protection

- 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])
 - Eleven 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):
 - Two inverse time overcurrent elements (51Q[1], and 51Q[2])
 - Eleven 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])
 - Eleven 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
- Low voltage ride through (LVRT, 27T)
- Reactive power/undervoltage (27Q)

General Description—ETR-5000

Metering

- 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, lag 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

- Trip coil monitor for both primary and secondary breakers
- Breaker wear primary and secondary (accumulated interrupted current)
- Oscillography (6000 cycles total)
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (1 ms time stamping)

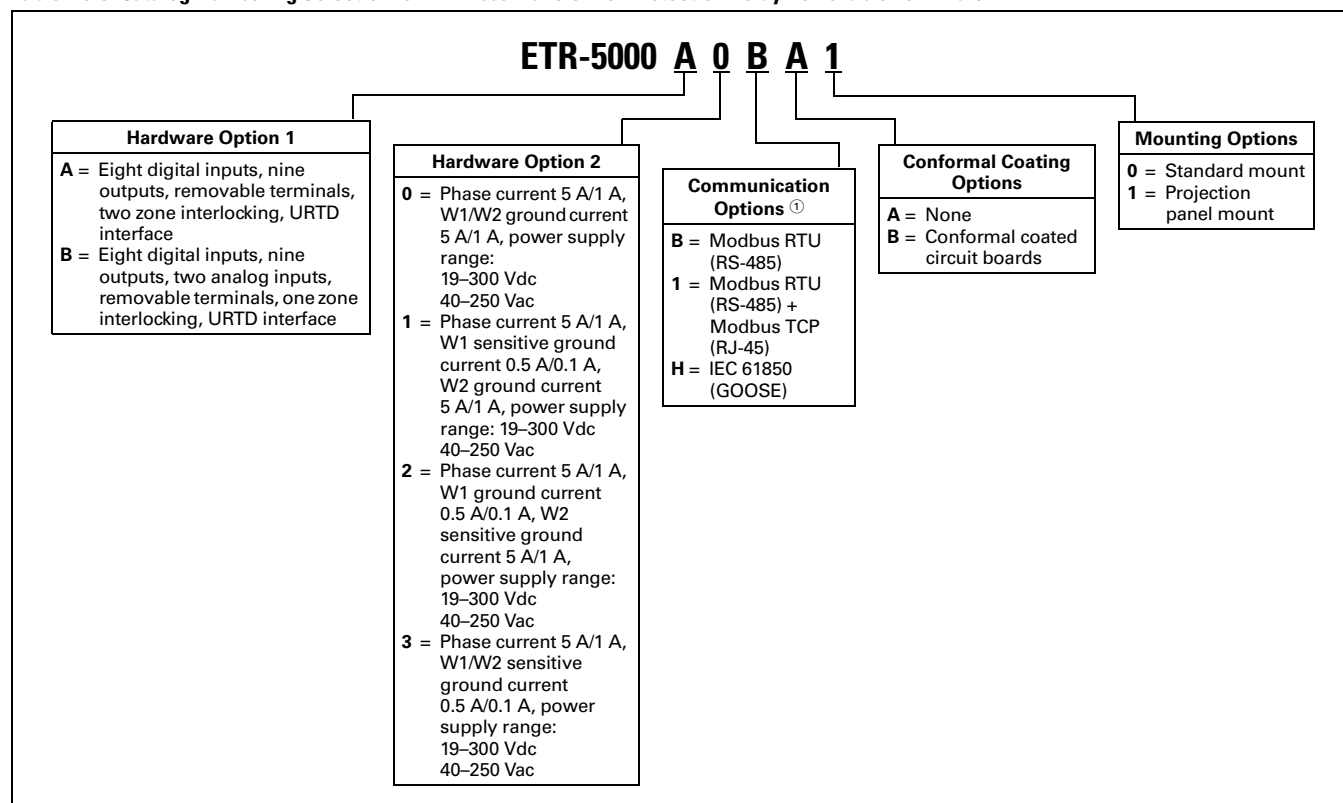
Control Functions

- Breaker open/close both breaker
- Remote open/close
- Programmable I/O
- Programmable Logic
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485
- Protocols:
 - Modbus RTU
 - Modbus TCP (optional)
 - IEC 61850 (optional)
- Configuration software.

Table 4.3-3. Catalog Numbering Selection for ETR-4000 Transformer Protection Relay Removable Terminals



^① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS
- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

Protection Functions

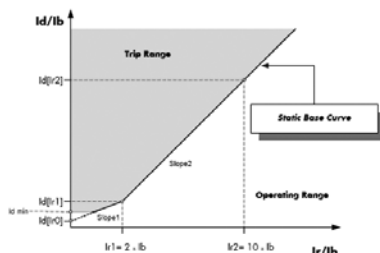
Eaton's ETR-5000 transformer protection relay has been designed for maximum user flexibility and simplicity. The ETR-5000 is suitable for application on small, medium, and large two winding power transformers. Multiple current inputs are used to provide primary protection, control and back-up protection 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.



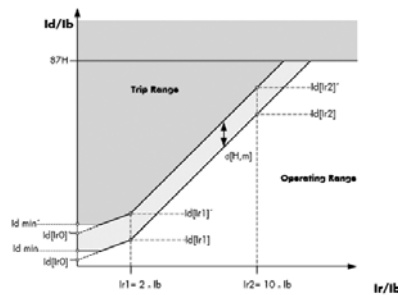
Dual-Slope Operating Characteristics

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 desensitized 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.



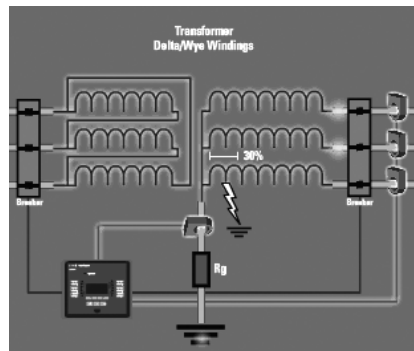
Dynamic Rise of the Operating Characteristic

Unrestrained Differential

An unrestrained differential element is provided for fast tripping on heavy internal faults to limit catastrophic damage to the transformer and to 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

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

Because 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.

General Description—ETR-5000

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 that 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.

Monitoring and Metering

Sequence of Events Records

The ETR-5000 transformer 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 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.

Waveform Capture

The ETR-5000 distribution protection relay provides waveform-recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, logic and contact closures. The ETR-5000 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 Eight 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 (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, two normally open and six 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 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.

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 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 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.

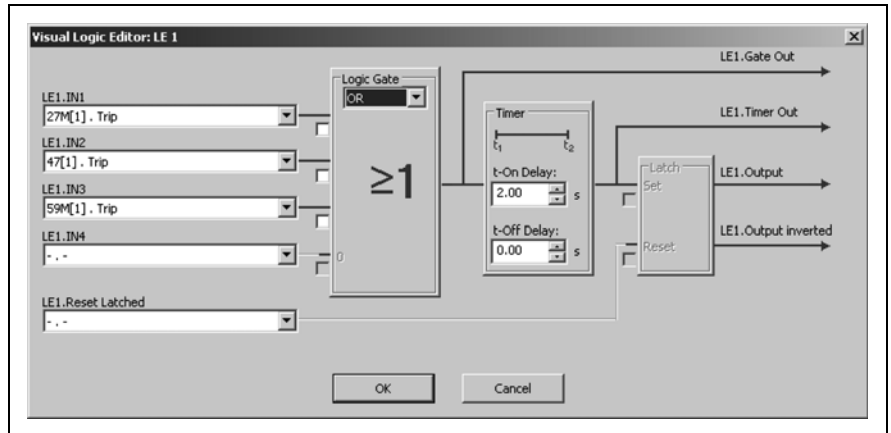


Figure 4.3-3. Visual Logic Editor

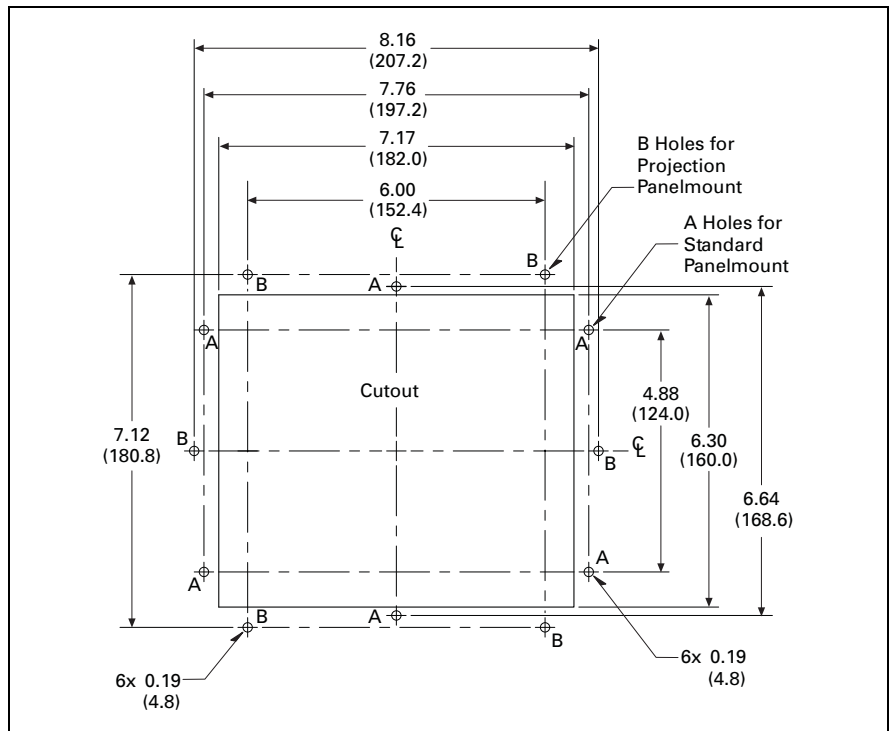
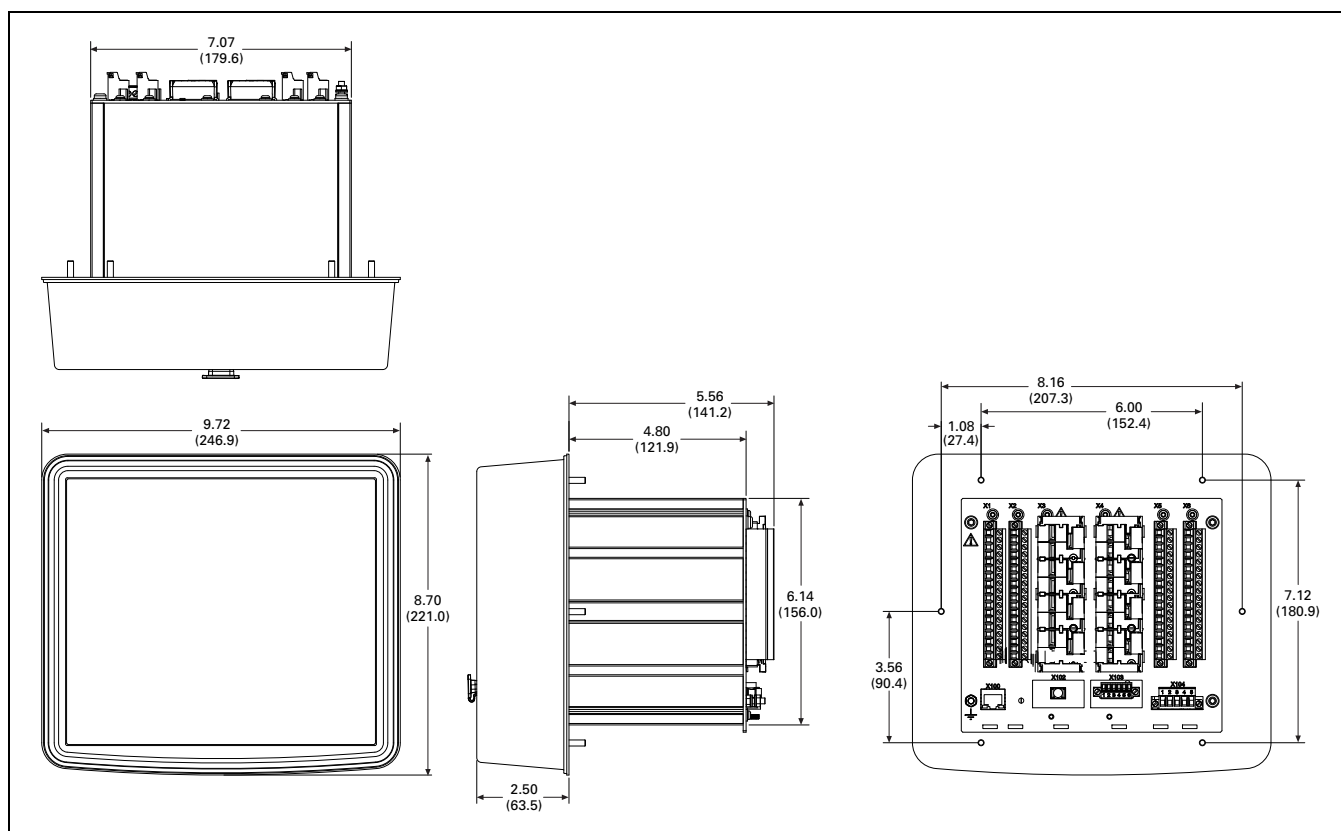


Figure 4.3-4. Drilling Plan

General Description—ETR-5000

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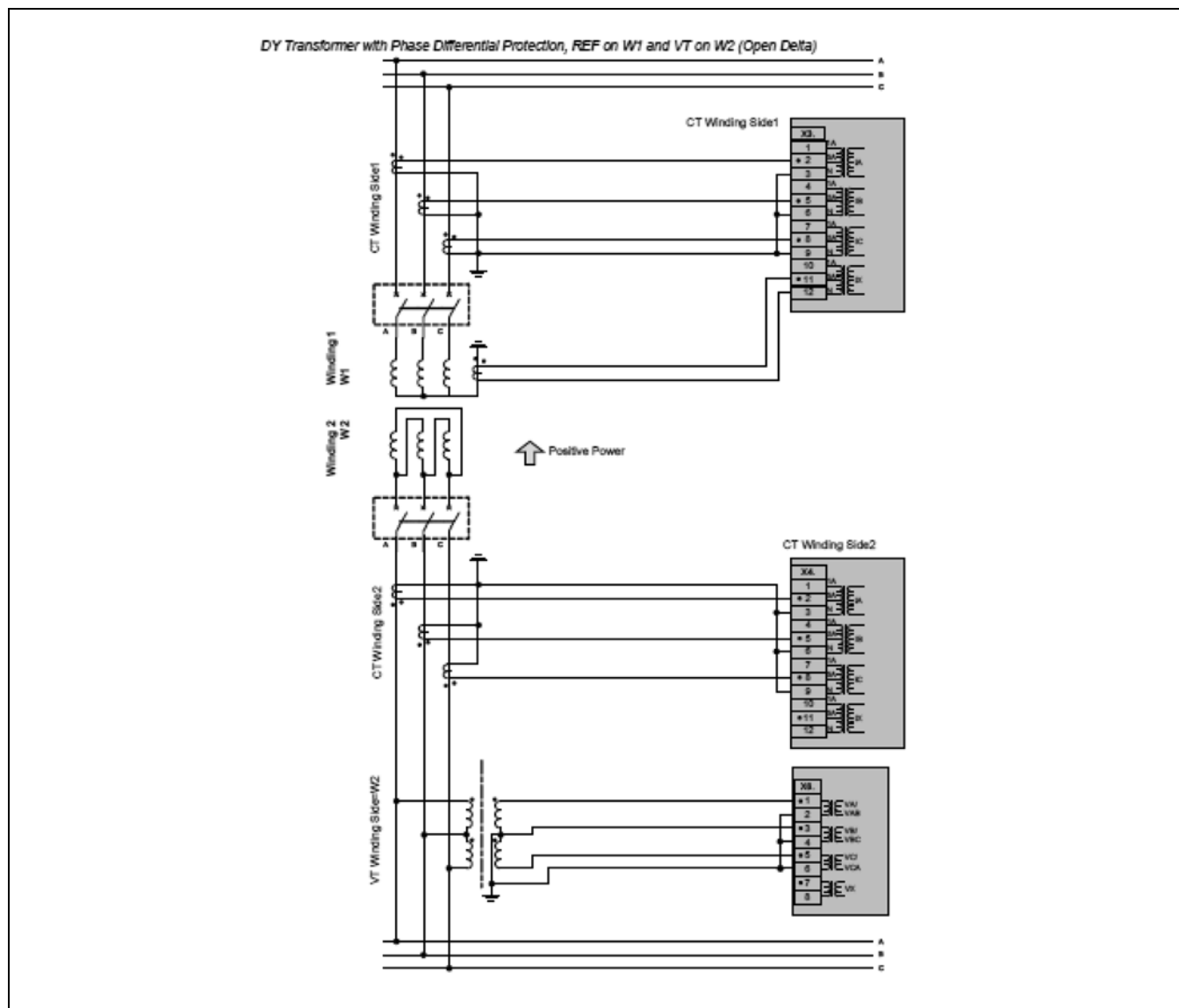


Figure 4.3-6. Typical AC Connections. Delta-Wye Transformer with Wye CTs and Neutral CT

General Description—ETR-5000

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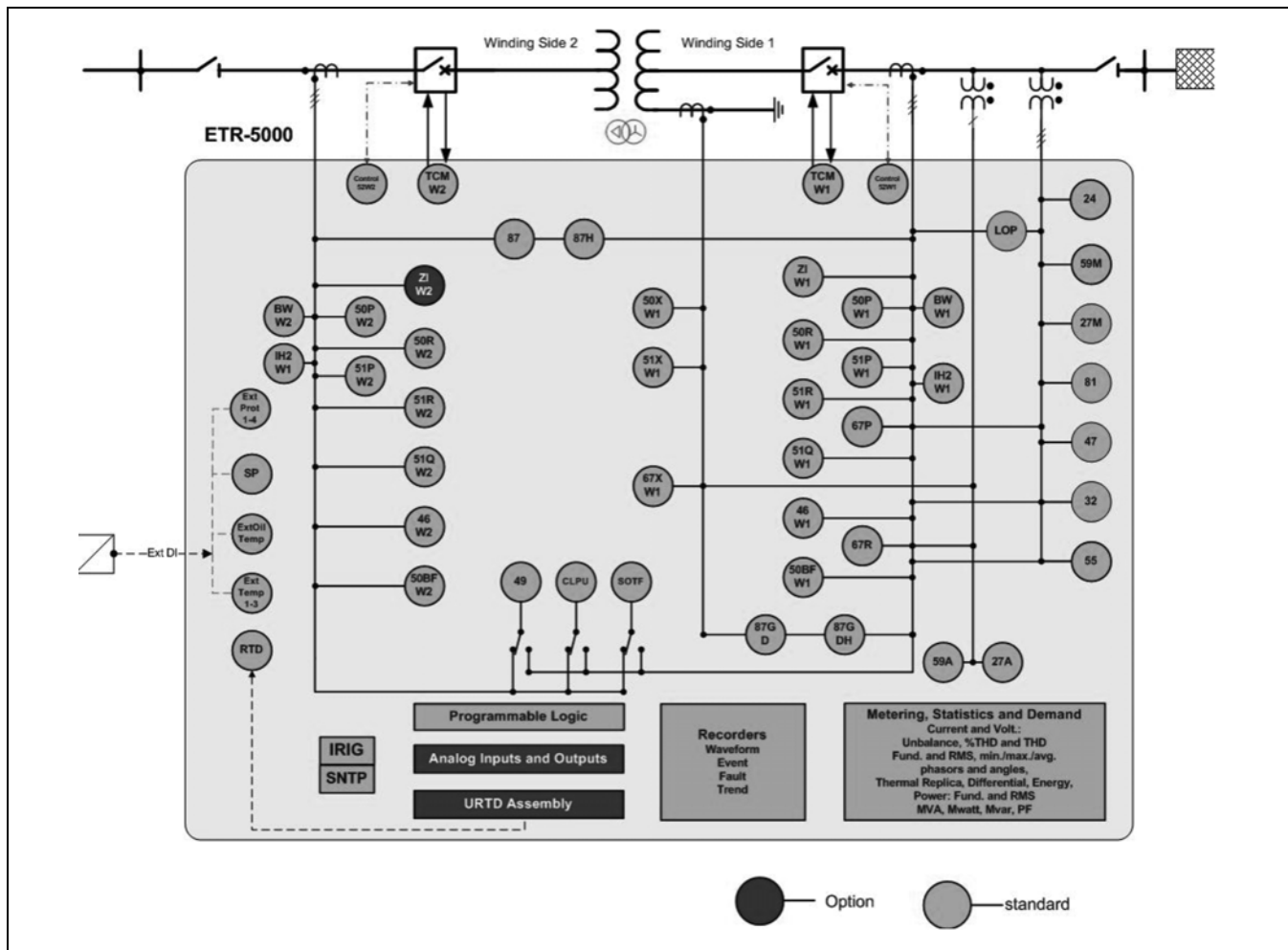


Figure 4.3-7. Typical One-Line Diagram

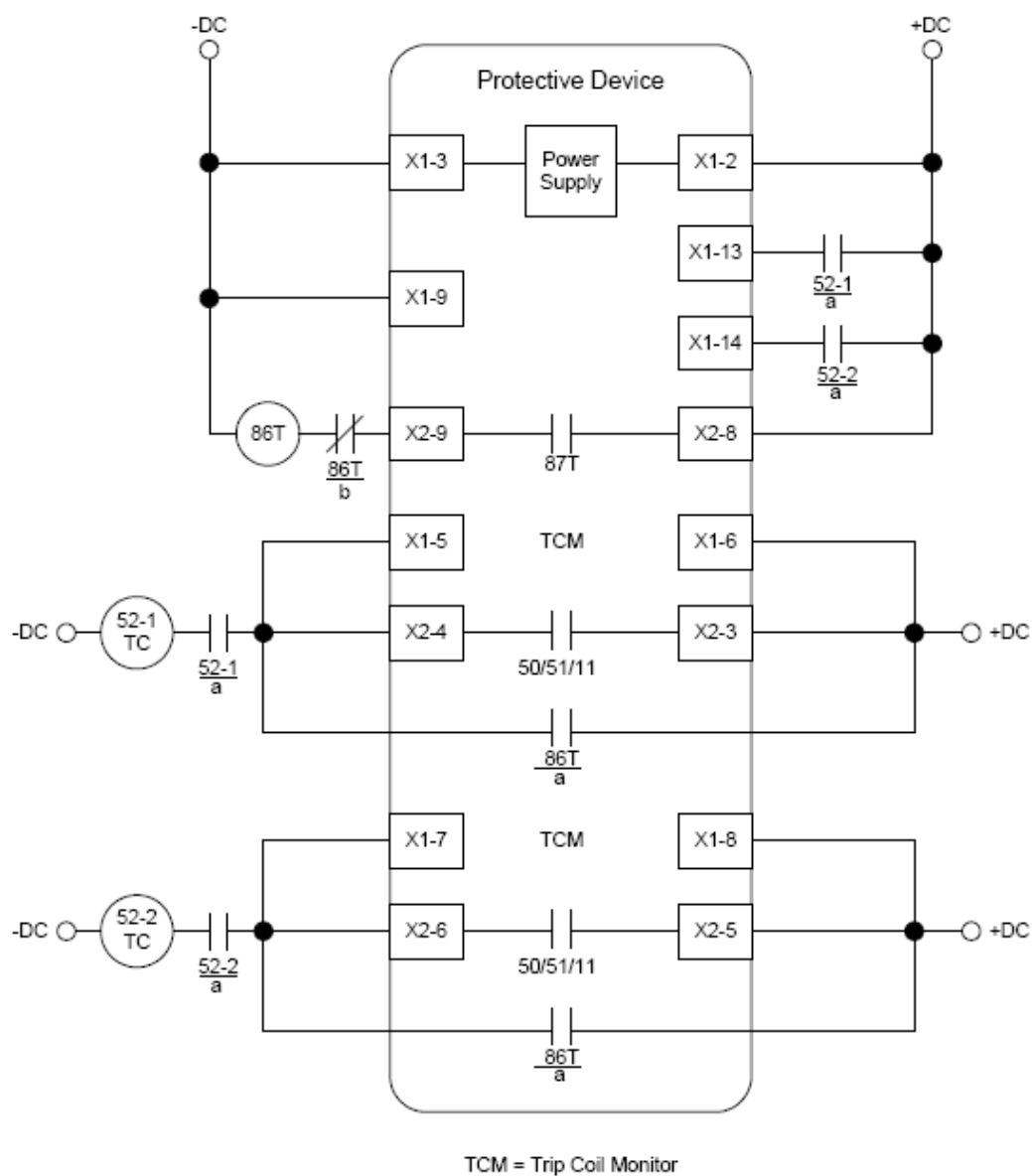


Figure 4.3-8. Typical Control Diagram

General Description—ETR-5000

Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. 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-E is free and can be downloaded from the Eaton Web site at the following URL:
<http://www.eaton.com/pr>

The second package is Power Xpert Software, which is a power management software package that is designed

for continuous, remote monitoring of many devices. It provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

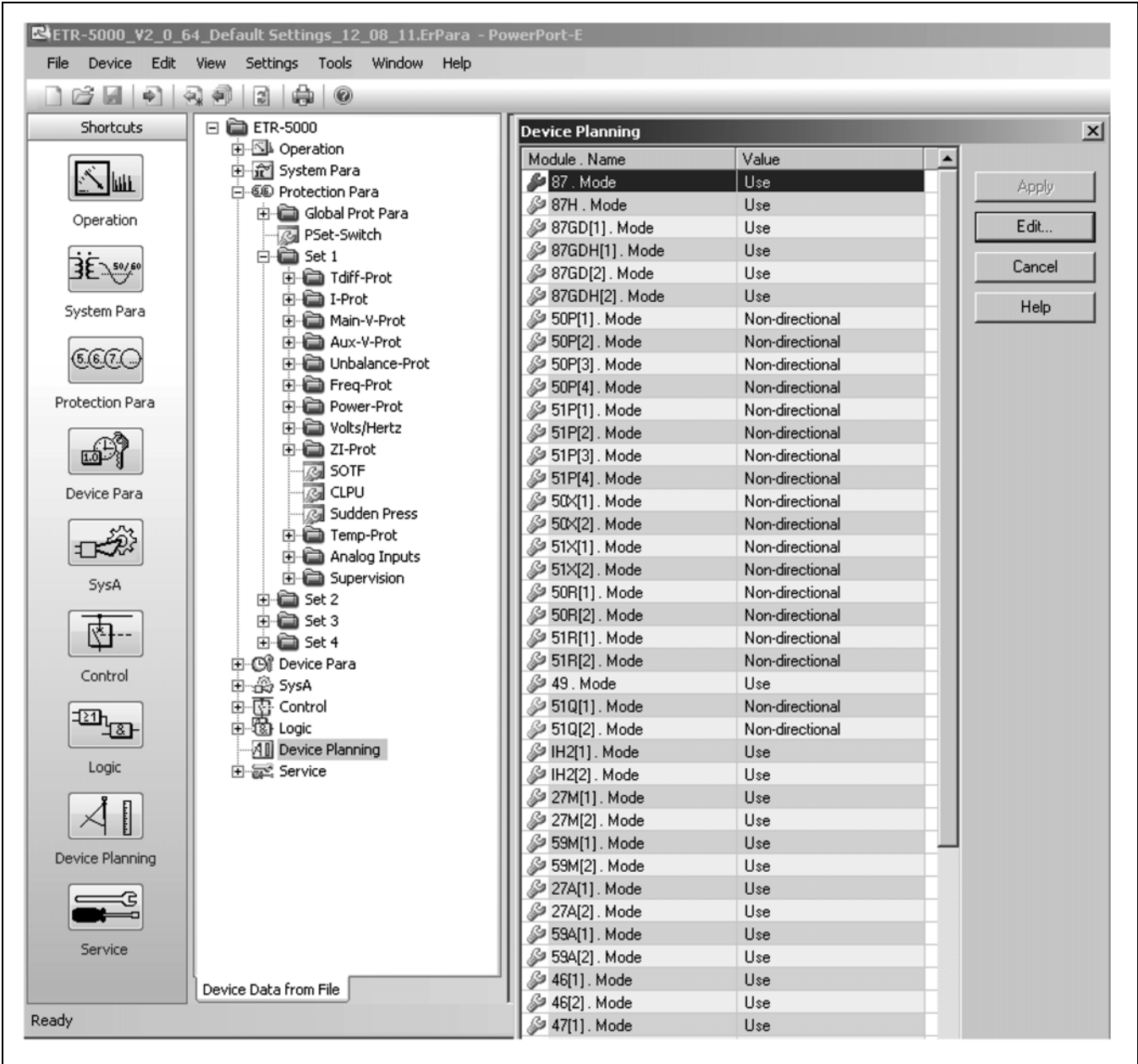


Figure 4.3-9. PowerPort-E ETR-5000 Device Planning

Standards, Certifications and Ratings

Table 4.3-4. ETR-5000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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: 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	Zone Interlocking Nominal input level: 5 V Nominal output level: 5 V Connection: Screw-type terminals (twisted pair)
Power Consumption Power supply range: 19–300 Vdc 40–250 Vac (for frequencies of 40–70 Hz) Power consumption in idle mode: 7 W Max. power consumption: 13 W	Relay Outputs Continuous current: 5 A AC/DC Max. 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 Vac according to ANSI IEEE Std. C37.90-2005 Max. breaking current: 5 A AC up to 125 Vdc 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: Changeover contact or normally open contact Terminals: Screw-type terminals	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug RS-485 Master/slave: Slave Connection: Six screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)
		Climatic Environmental Conditions Storage temperature: –30 °C to +70 °C (–22 °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: <2000 m (6561.67 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.

General Description—EGR-5000

EGR-5000 Generator Protection Relay



EGR-5000 Generator Protection Relay

General Description

Eaton's EGR-5000 generator protection relay is a multi-functional, micro-processor-based relay for any size generators. It may be used as a primary or backup protection in standby 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 overvoltage/undervoltage, 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 sync 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 A or 1 A 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 (14) programmable LEDs provide quick indication of relay status.

A front port is provided for direct computer connection. An RS-485 and an Ethernet port in the back are optional for local area networking use. 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, two analog inputs, two analog outputs, or 16 programmable binary inputs. It has two normally opened and six 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.

Features

Protection

- 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])
 - Eleven 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])
 - Eleven 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])

General Description—EGR-5000

- 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
- Low voltage ride through (LVRT, 27T)
- Reactive power/undervoltage (27Q)

Metering

- 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
- Power factor
- Frequency
- Volts/hertz
- 3rd harmonic voltage
- % THD V and I
- Magnitude THD V and I
- Sync values
- Trending (load profile over time)
- Temperature with remote URTD module

Monitoring

- Trip coil monitor
- Breaker wear
- Oscillography (6000 cycles total)
- Fault data logs (up to 20 events)
- Sequence of events report (up to 300 events)
- Clock (one ms time stamping)

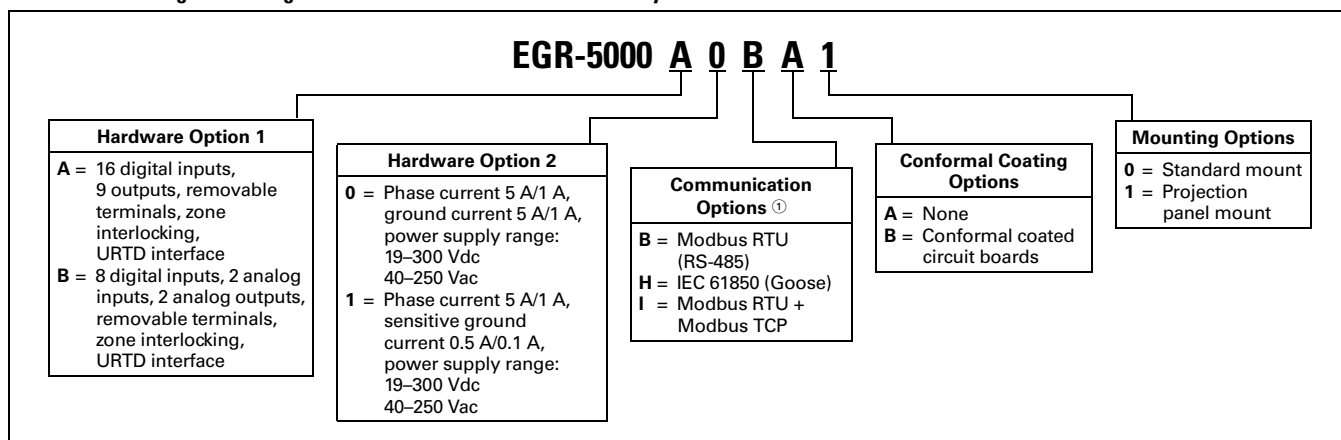
Communication

- Local HMI
- Password protected
- Addressable
- IRIG-B
- Local communication port
- Remote communication port:
 - RS-232
 - RS-485
- Protocols:
 - Modbus RTU (optional)
 - Modbus TCP (optional)
 - IEC 61850 (optional)
- Configuration software

Control Functions

- Breaker open/close
- Remote open/close
- Programmable I/O
- Programmable Logic
- Programmable LEDs
- Multiple setting groups
- Cold load pickup
- CT supervision

Table 4.3-5. Catalog Numbering Selection for EGR-5000 Generator Relay Removable Terminals



① Beginning in 2016, consult factory for the availability of the following new communication options.

- Protocols: DNP3.0, PROFIBUS
- Interface ports: Fiber optic ST, RS-485 D-SUB, fiber optic LC

General Description—EGR-5000

Protection and Control Functions

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 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 3I₀ 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 Restrainted 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.

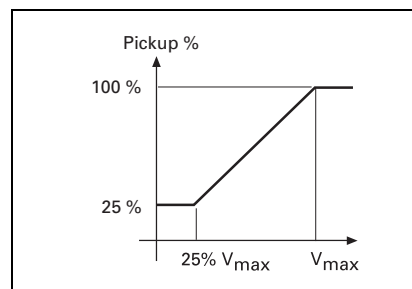


Figure 4.3-10. Voltage Restraint Coil Pickup Characteristics

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 to 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 over-voltage 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% to 95% of the winding. The last 5–10% is protected by detecting the decaying of the 3rd harmonic voltage using a under-voltage 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 that 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 a 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 overcurrent tripping element to ensure the generator stays within its 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 program-mable inverse time characteristic.

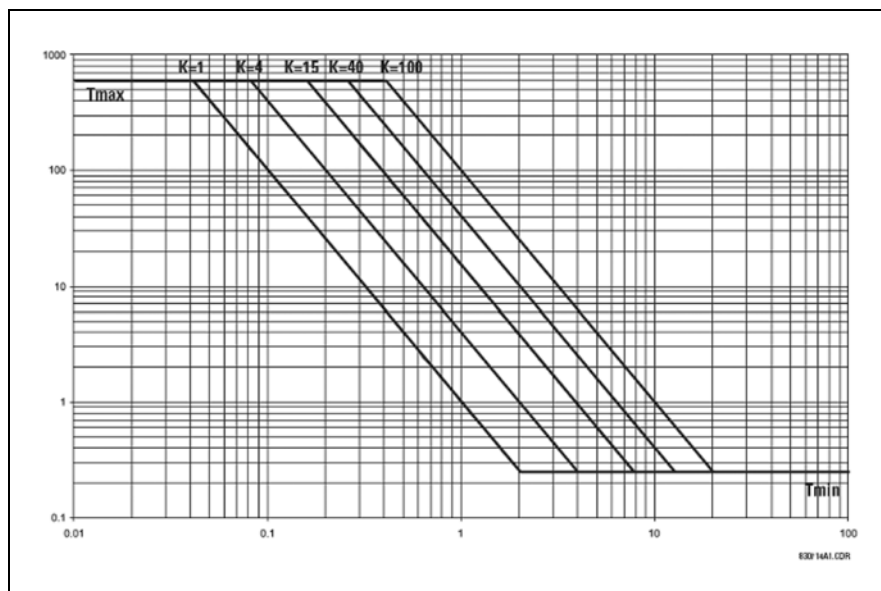


Figure 4.3-11. Overexcitation Protection

General Description—EGR-5000

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.

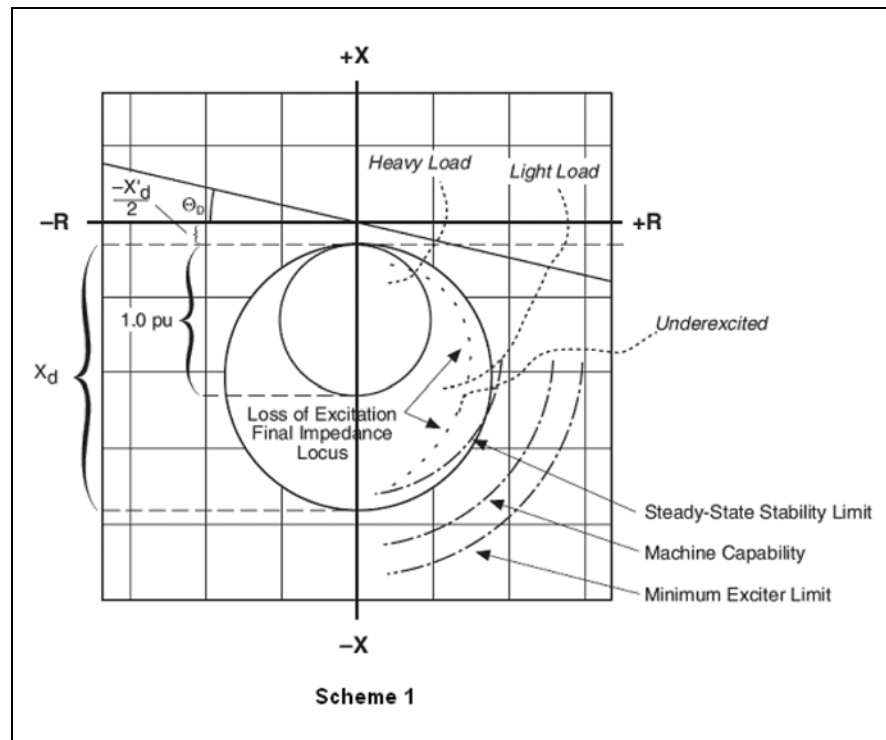


Figure 4.3-12. Scheme 1

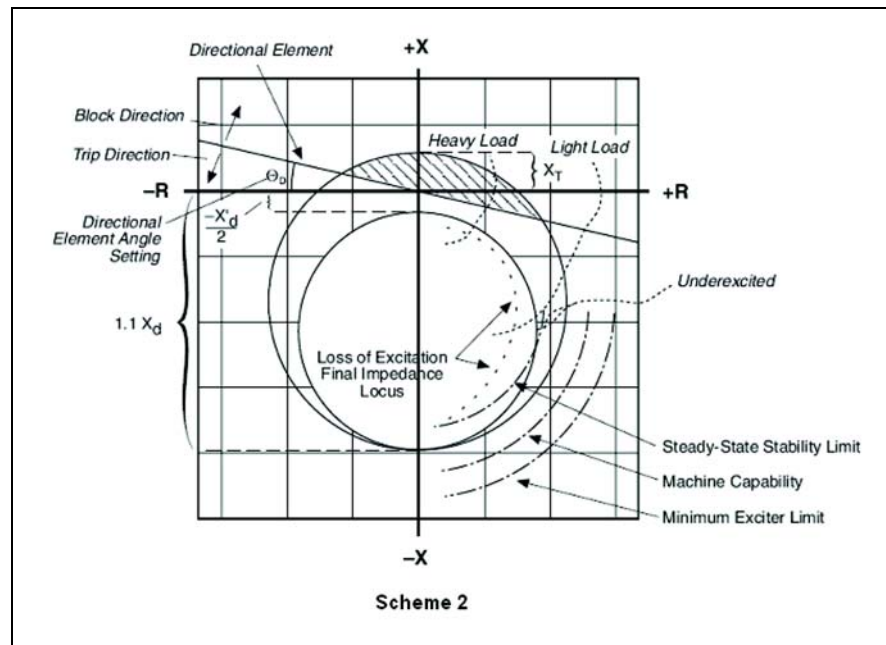


Figure 4.3-13. Scheme 2

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.

Waveform Capture

The EGR-5000 distribution protection relay provides waveform-recording capabilities. The relay will record all measured signals along with the binary signals of pickup, trip, logic and contact closures. The EGR-5000 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 eight 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. Seventeen (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, trip-rated, two normally open and six 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 1–10 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.

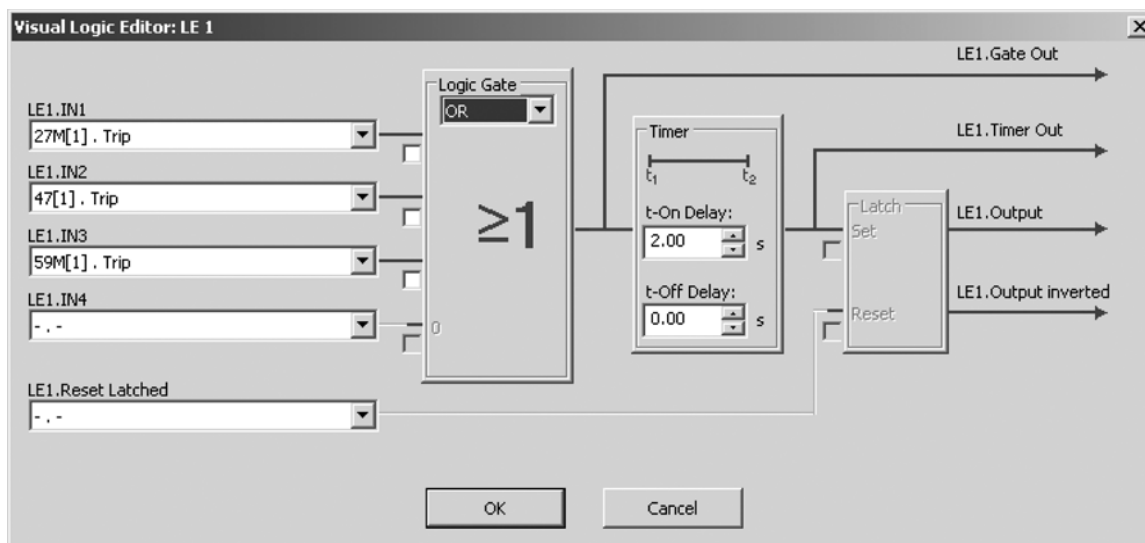


Figure 4.3-14. Visual Logic Editor

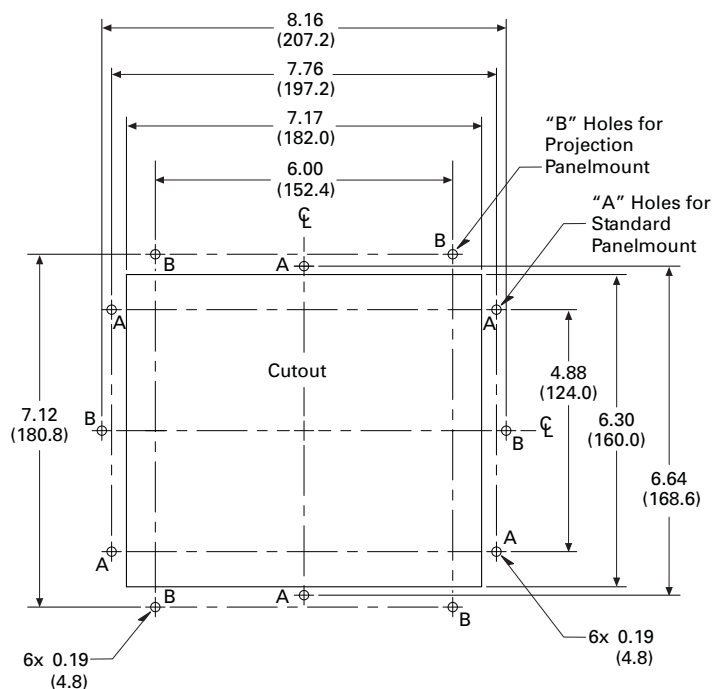


Figure 4.3-15. Drilling

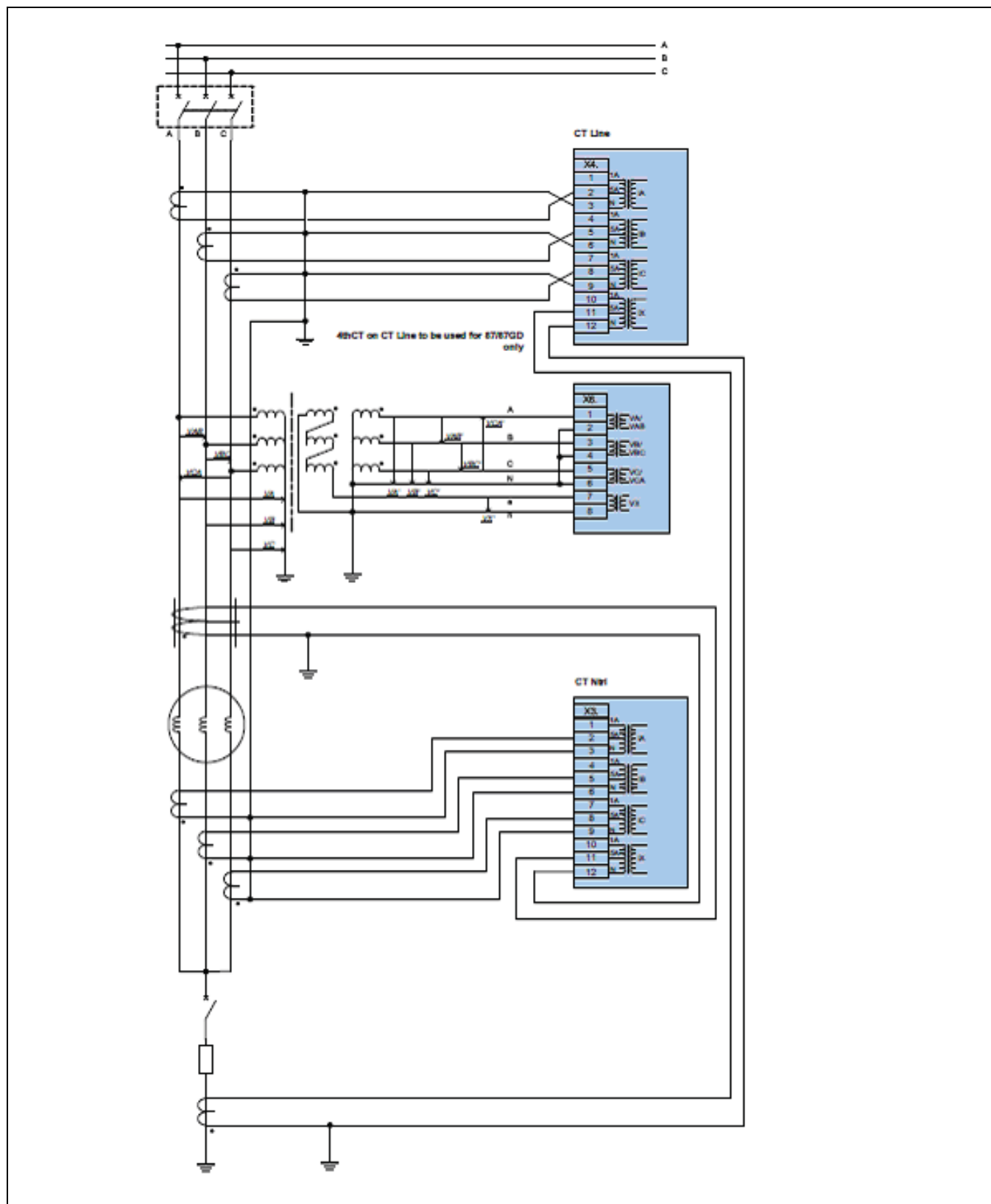


Figure 4.3-16. Typical AC Connections

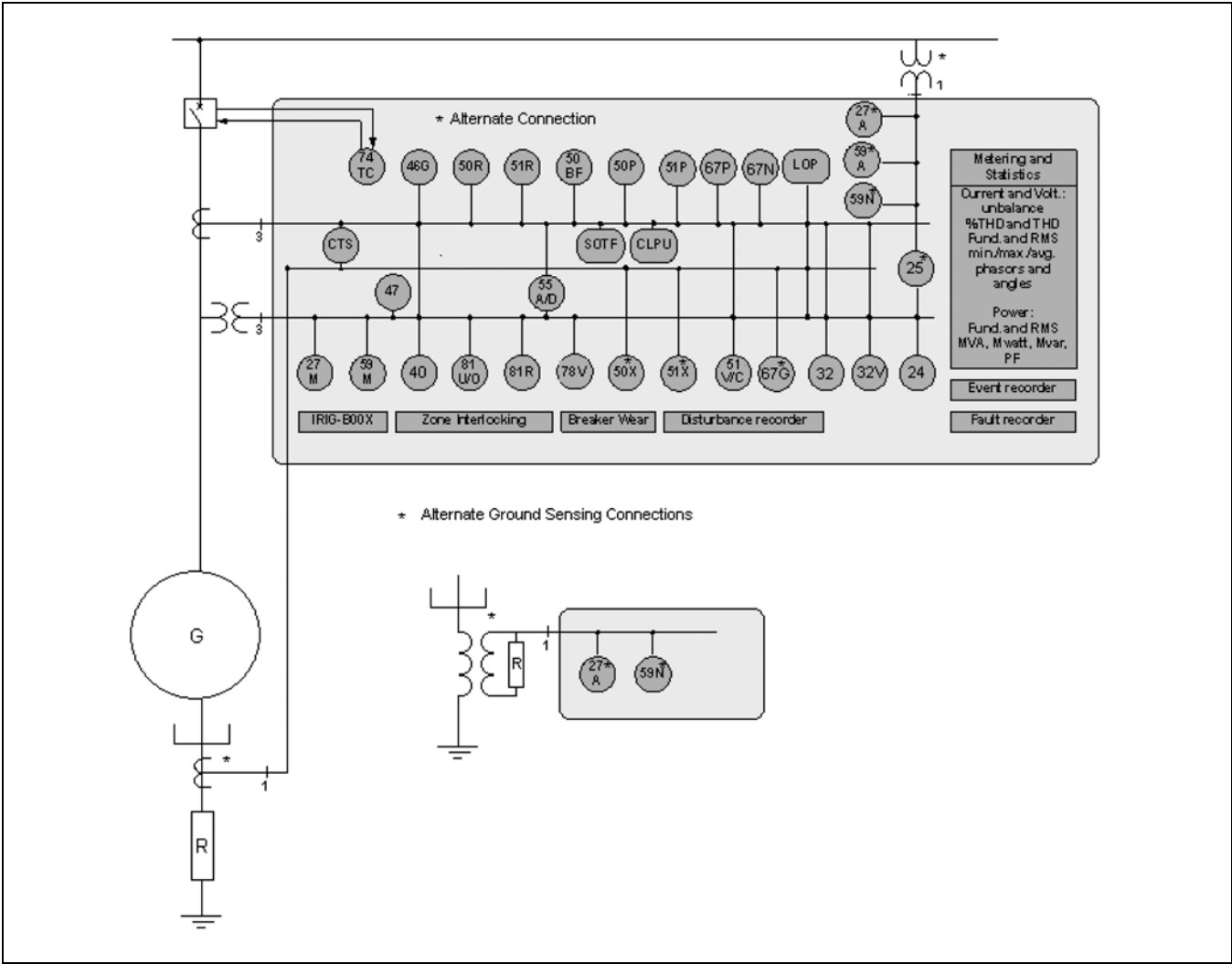


Figure 4.3-17. Typical One-Line Diagram

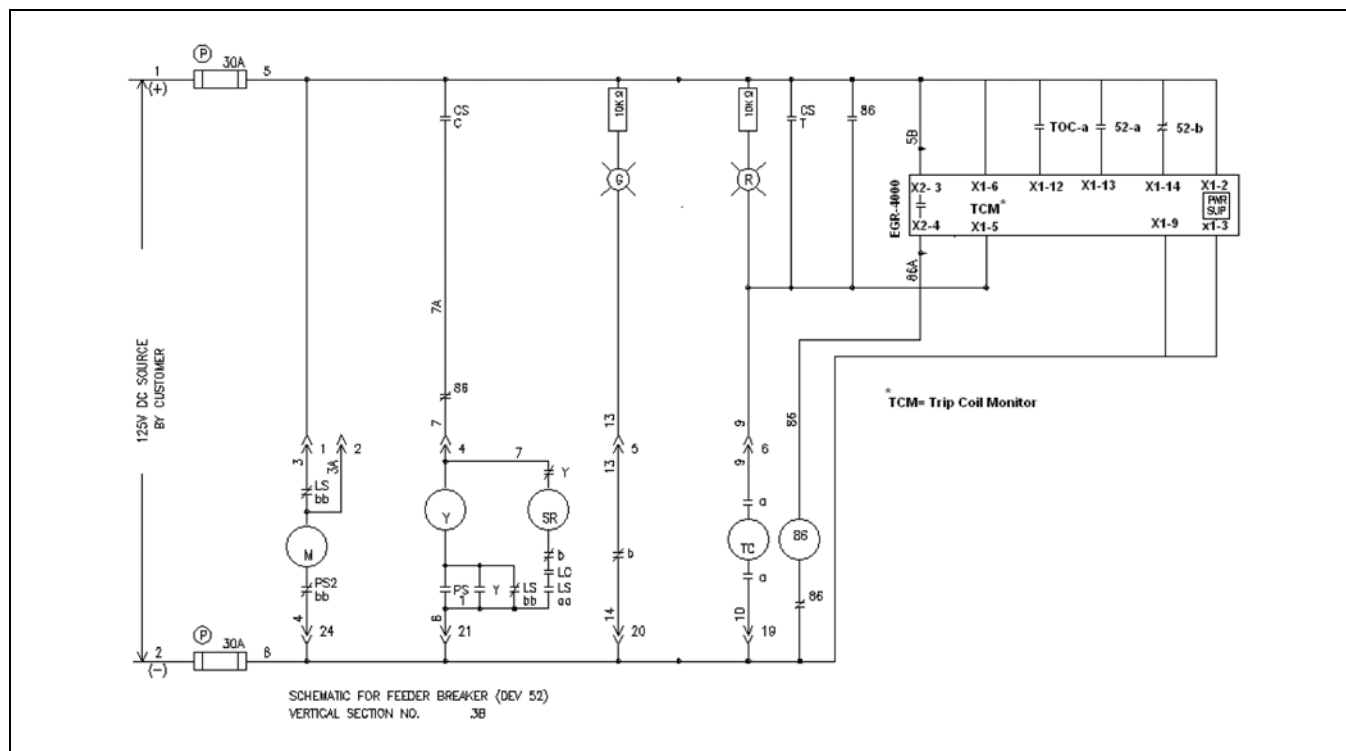


Figure 4.3-18. Typical Control Diagram

General Description—EGR-5000

Communication Software

Eaton provides two types of communication software. The first is PowerPort-E. 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-E is free and can be downloaded from the Eaton website at the following URL: www.eaton.com/pr.

The second package is Power Xpert Software, which is a power management software package that is designed for continuous, remote

monitoring of many devices. It provides additional functions such as billing, trending and graphics. Contact your local Eaton representative for more information on Power Xpert Software.

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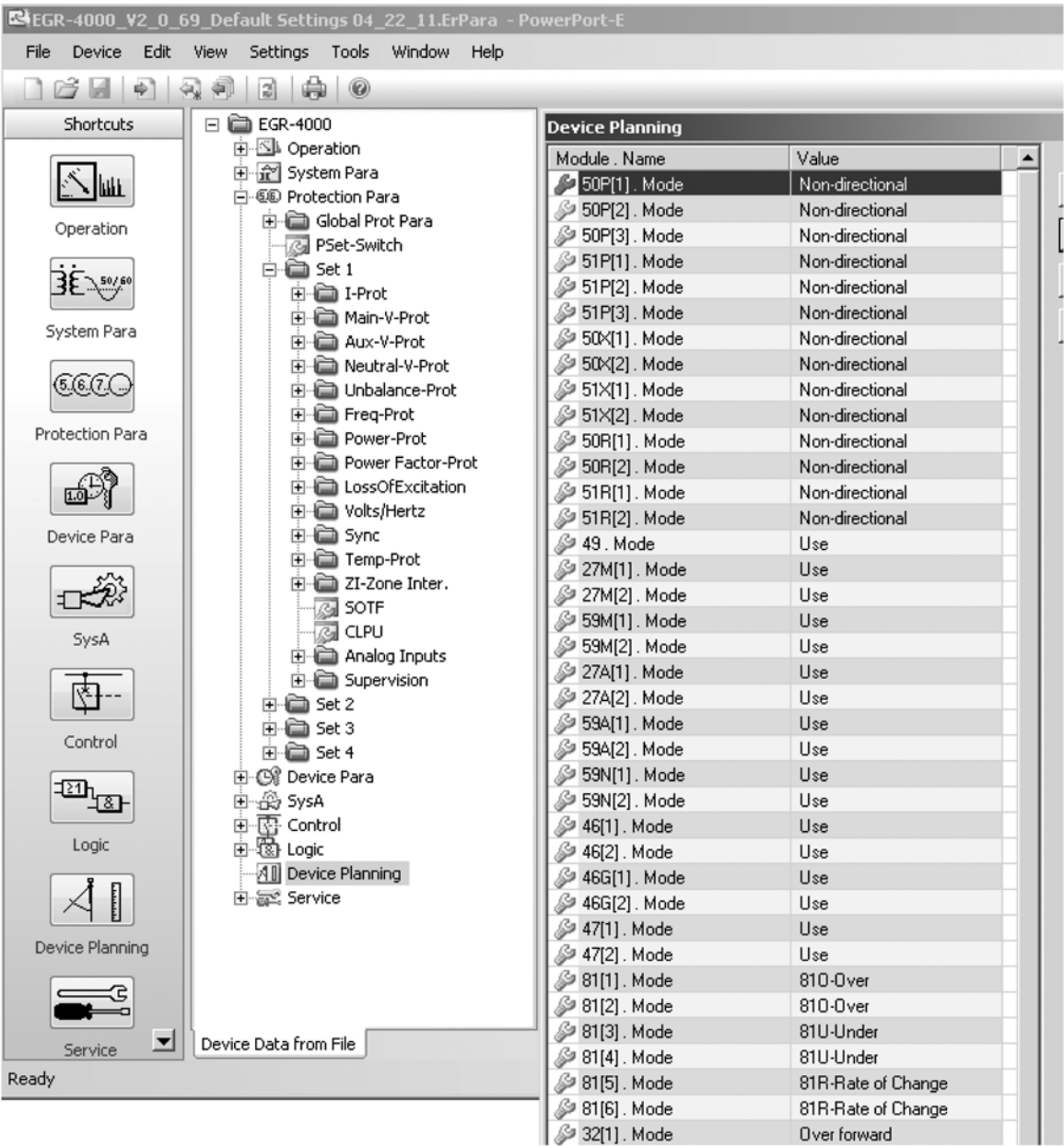


Figure 4.3-19. PowerPort-E EGR-5000 Device Planning

Standards, Certifications and Ratings

Table 4.3-6. EGR-5000 Specifications

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 5.0 x 20.0 mm (approx. 0.20 in. x 0.80 in) according to IEC 60127 3.5 A time-lag miniature fuse 6.3 x 32.0 mm (approx. 0.25 in. x 1.25 in) according to UL 248-14	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 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	Zone Interlocking NOTICE: ONLY FOR ZONE INTERLOCK TRIPPING OUTPUTS (ZONE INTERLOCK, SEMI-CONDUCTOR 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)
Power Consumption Power supply range: 24–270 Vdc: 7 W idle mode/ approx. 13 W max. power 48–230 Vac: 7 VA idle mode/ approx. 13 VA max. power (for frequencies of 40–70 Hz)	Relay Outputs Continuous current: 5 A AC/DC Max. 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 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	Front Interface RS-232 Baud rates: 115,200 Baud Handshake: RTS and CTS Connection: Nine-pole D-Sub plug RS-485 Master/slave: Slave Connection: Six screw-clamping terminals RM 3.5 mm (138 MIL) (terminating resistors internal)
		Climatic Environmental Conditions Storage temperature: –30 °C to +70 °C (–22 °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: <2000 m (6561.67 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.

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TC-100 Transformer Temperature Controller for Dry-Type Transformers



TC-100

General Description

The TC-100 Transformer Temperature Controller monitors up to three ventilated dry-type transformer windings and one ambient temperature. The TC-100 operates relays by comparing the highest winding temperature to stored set point temperatures and displays four thermocouple inputs, as well as the stored maximum temperature and its associated winding. The unit provides fans, alarm and trip output relays. Up to two fans can be controlled via the TC-100. Each fan operating contact is fuse protected. A yellow LED indicates that fans are on. A fan exerciser turns the fans on automatically at periodic intervals to prevent fan motor seizing (on-time and interval is programmable).

Form C contacts are provided for notification of alarm conditions. A red LED illuminates to indicate that the alarm is actuated. An internal audible alarm also sounds when the unit goes into alarm condition. This audible buzzer can be silenced without canceling the alarm. The alarm and trip relays can be configured as a fail-safe relay (normally energized when the unit is powered up). For example, if the alarm relay was configured as a fail-safe; if supply control power to the TC-100 is interrupted, the alarm relay changes state for notification of this condition. The alarm circuit is also used for notification of an open or a missing thermocouple. If a thermocouple were to open, the alarm relay operates and the corresponding channel will read “-” on the LED display. It is important to note that a failed thermocouple will not cause the device to trip the transformer offline.

Form C contacts are provided to trip the transformer offline if any of the winding temperatures exceed the trip setting. A red LED indicates that the trip relay has actuated.

A test function is provided to: test the digital display and all of the LEDs; simulate over-temperature conditions; and check the internal temperature of the monitor.

A 4–20 mA analog signal is provided for remote indication or for use with SCADA systems.

The TC-100 has built-in monitoring functions and logging functions to help you shed some light on the unknowns of the operation of your transformer. Temperature trending lets you understand the hour of the day that the transformer runs hotter, and modify its loading to extend the life of your transformer; logging information lets you restore the operation of your system faster, by letting you correlate tripping and alarming events to the overall conditions of your system; and fan wear information can be used to perform preventive maintenance to increase the uptime in your transformers.

Features and Benefits

Control

- Thermocouple inputs (E or K type thermocouples)
- Automatic correlation throughout entire temperature range to compensate for thermocouple non-linearity
- Programmable on and off set points
- Alarm relay for remote monitoring
- Trip relay for remote monitoring
- Two fan power relays
- Fan failure detection to start a backup fan or alarm
- Fan exerciser (cycle time and duration) to reduce fan wear
- Fans can be operated automatically or manually

Metering

- Average temperature (all three windings)
- Maximum instantaneous temperature (all three windings)
- Maximum temperature memory per winding
- Fans hours of operation
- Winding 1, Winding 2, Winding 3 and ambient temperature

Monitoring

- Trending
- Fan failure
- Fan wear
- Alarm log
- Trip log
- Test mode
- Detect failed sensors
- Self-diagnostics

Communications

- USB port in the front
- Modbus-RTU communications
- Programming and monitoring software (the unit can be completely programmed through the front of the unit)
- 4–20 mA output for integration with SCADA systems

Hardware

- One trip relay (Form C)
- One alarm relay (Form C)
- Two power fan relays (1 NO each)
- Two digital inputs
- 4–20 mA output for integration with SCADA systems
- Local Alarm 95 db
- Available in semi-flush or hinge panel-mounting versions

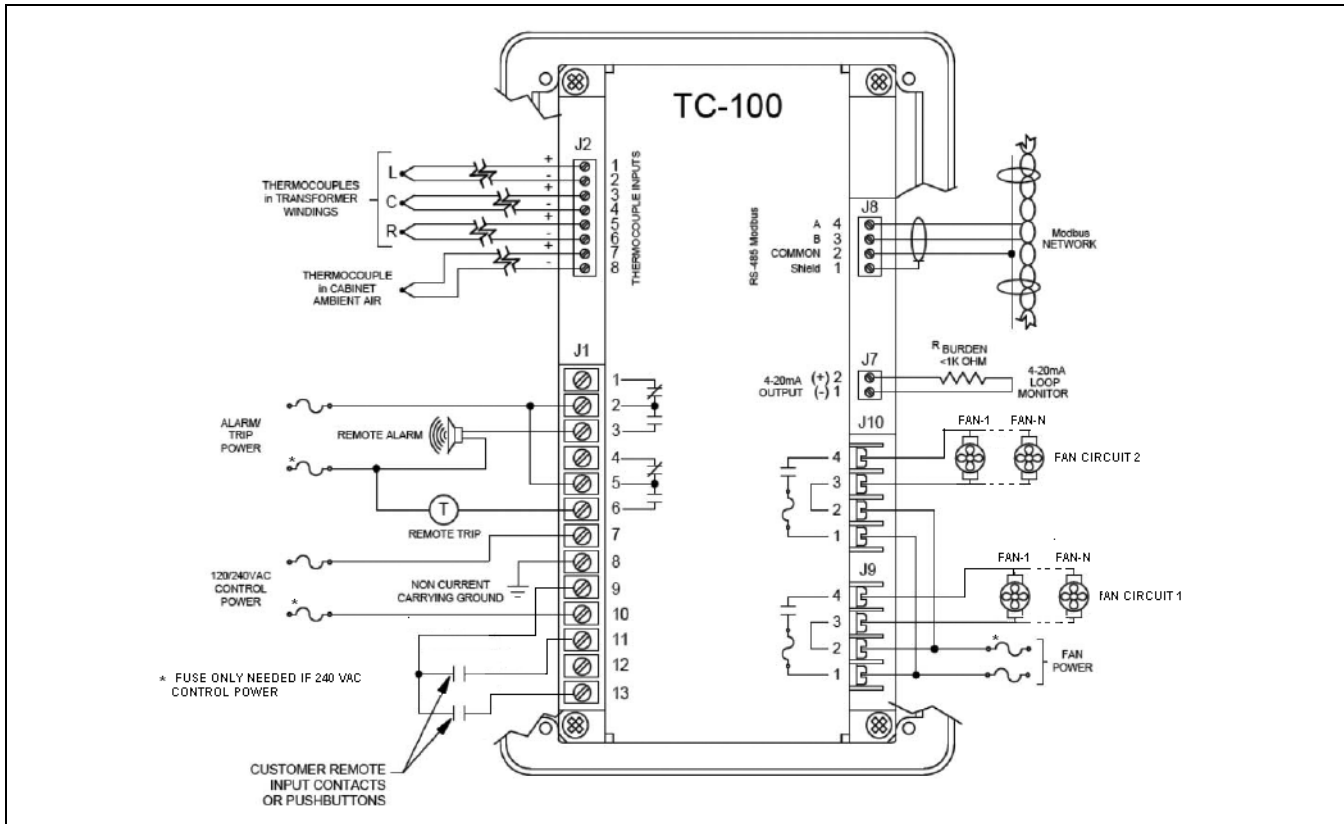


Figure 4.4-1. TC-100 External Wiring Diagram

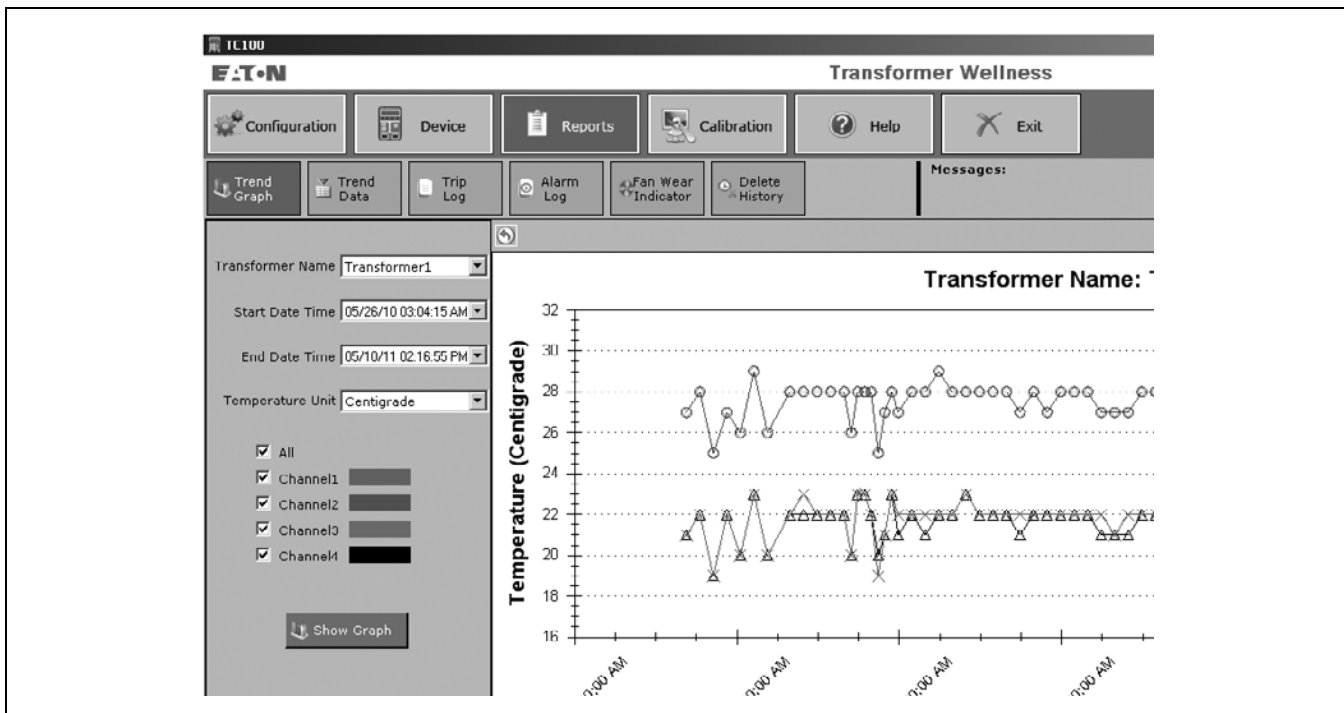


Figure 4.4-2. Programming and Monitoring Software

Technical Data and Specifications

Table 4.4-1. TC-100 Technical Specifications

Description	Specification		
Control Power			
Nominal rating	120 Vac or 240 Vac (+10%, -25%)		
Frequency	50 or 60 Hz		
Power use	15 VA maximum		
Operating range	120 Vac: 90–132 Vac 240 Vac: 180–264 Vac		
Ride-through time	20 cycles at nominal Vac		
Environmental			
Operating temperature	–30 to +72°C		
Storage temperature	–50 to +72°C		
Relative humidity	0 to 90% (noncondensing)		
Measurement Accuracy			
Temperature	±1°C ± one count under normal conditions ±2°C ± one count under extreme conditions Extreme conditions are: Ambient temperature colder than –10°C Winding to unit temperature greater than 210°C		
Discrete Inputs			
Number of inputs	Two programmable		
Rating	1.2 VA at 120 Vac Max. OFF = 36 Vac Min. ON = 86 Vac (built in power source available)		
Outputs			
Output fans	Two individually configurable SPST contacts rated 30 A at 120/240 Vac, 1 hp at 120 Vac, 2 hp at 240 Vac for each contact		
Output alarm	One SPDT contact rated 10 A at 120/240 Vac (resistive) configurable for normal or fail-safe operations		
Output alarm	One SPDT contact rated 10 A at 120/240 Vac (resistive) configurable for normal or fail-safe operation		
Remote analog output	4–20 mA into a load of up to 1000 ohms max. proportional to hottest winding temperature ±1%		
EMC			
Immunity	ANSI/IEEE C37.90.1-2002 - Standard Surge Withstand Capability (SWC) tests for protective relays and relay systems		
	ANSI/IEEE C37.90.2-2004, standard withstand capability of relay systems to radiated electromagnetic interference from transceivers		
	<table> <tr> <td>EN 61000-4-2 EN 61000-4-3 EN 61000-4-4 EN 61000-4-5 EN 61000-4-6 EN 61000-4-8 EN 61000-4-11</td><td>ESD RF Radiated immunity EFT/Burst immunity Surge immunity RF conducted immunity Power frequency magnetic field immunity Voltage variation immunity</td></tr> </table>	EN 61000-4-2 EN 61000-4-3 EN 61000-4-4 EN 61000-4-5 EN 61000-4-6 EN 61000-4-8 EN 61000-4-11	ESD RF Radiated immunity EFT/Burst immunity Surge immunity RF conducted immunity Power frequency magnetic field immunity Voltage variation immunity
EN 61000-4-2 EN 61000-4-3 EN 61000-4-4 EN 61000-4-5 EN 61000-4-6 EN 61000-4-8 EN 61000-4-11	ESD RF Radiated immunity EFT/Burst immunity Surge immunity RF conducted immunity Power frequency magnetic field immunity Voltage variation immunity		
Emissions	EN 50011 CISPR-11, Class A CFR 47 FCC Part 15 Subpart B Class A		
Clock			
Accuracy	+/- 1 minute/month at 25°C		
Logging			
Trend data	100 entries, logging interval programmable from 1 minute to 30 days		
Alarm events	Last 25 alarm events		
Trip events	Last 25 trip events		

Ordering Information

Table 4.4-2. Catalog Ordering Information for TC-100 Transformer Temperature Controller for Dry-Type Transformers

Description	Catalog Number
Barrier cabinet Controller only (semi flush mounting) TC-100 Controller with barrier cabinet (hinge front panel)	TC-100-Barrier TC-100 TC-101

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InsulGard™



InsulGard

General Description

The InsulGard™ is a continuous partial discharge monitor that can be applied to a variety of medium voltage electrical equipment rated 4 kV to 38 kV. It is commonly applied to motors, generators, switchgear, bus duct, unit substations and cable systems. The InsulGard will monitor the quality of insulation while the equipment is in service under normal operating conditions. Through monitoring, it can ascertain the relative condition of insulation, the deterioration of which is the leading cause of electrical failures.

The InsulGard system consists of sensors and a monitor. The monitor can be used as a stand-alone unit, or it can be wired so that it can remotely upload data to your system or to Eaton diagnostics personnel for analysis. While the sensors vary according to application, they are all designed to detect partial discharges—the foundation of the InsulGard technology and one of the best predictors of insulation breakdown.

The term “partial discharge” is a common name for small electrical discharges (arcs) that typically occur within or between insulation materials—usually across a void in the insulation. Partial discharge is also referred to as corona or surface tracking. The visible evidence of corona presents itself as white, powdery residue, typically found on the end windings of motors or generators. Surface-tracking damage appears as tree-like, jagged lines, typically found on switchgear and bus ducts. Surface tracking stems from a contaminated insulation surface, often started by corona. The small arcing activity on the surface of the insulation contributes to further burning, resulting in additional stress points that promote further deterioration. Both corona and surface tracking are the primary causes of insulation breakdown, which can lead to full discharges and electrical failures. It is important to note that traditional methods of detecting corona and surface-tracking damage require taking equipment offline. It also requires disassembling the equipment—a costly procedure. Moreover, corona and surface tracking damage have to be severe to be visible. The InsulGard system allows you to detect partial discharge while the electrical system is energized. It does so by detecting and analyzing the radio signal frequencies emitted by the partial discharges. More specifically, the InsulGard focuses on the 1 MHz to 20 MHz bandwidth range where the majority of partial-discharge activity can be detected. InsulGard allows predictive analysis and maintenance as opposed to preventive analysis and time-based maintenance.

The detection of partial discharge on equipment can indicate if a problem exists. Even more useful is information that can correlate the signal intensity (measured in milliwatts) associated with partial discharges to various states of insulation degradation on similar equipment. Eaton's Predictive Diagnostics Group has studied numerous cases of partial discharge on rotating equipment and switchgear. The knowledge base accumulated has allowed Eaton to develop guidelines and parameters to help one determine the seriousness (failure-time windows) of the partial-discharge activity that the equipment may be exhibiting. Because it is a continuous, online monitoring system, it is easy to monitor conditions over time.

Eaton's InsulGard is a stand-alone microprocessor-controlled continuous partial discharge monitoring device for a wide range of medium voltage power equipment. It is designed to provide an alarm based on PD characteristics at an early stage of insulation degradation. It measures partial discharges from up to 15 different partial discharge sensors and stores the information in internal memory, alarming users if any set points are exceeded. InsulGard can work with constant 50/60 Hz frequency powered equipment, as well as with variable frequency applications.

Various PD sensor types can be used, depending on the application.

InsulGard has three auxiliary inputs for PD data correlation to additional parameters. One of the inputs is designated for temperature, where the other two are commonly used for load, voltage or humidity depending upon the application. InsulGard has several interfaces that allow for easy implementation into any alarm or SCADA system:

- Three C-form dry relay contacts provide Yellow or Red alarm indication, and the Device Status relay indicates any device malfunction
- 4–20 mA optically isolated output can be configured to represent Partial Discharge Intensity (PDI) or maximum discharge magnitude to any SCADA system
- RS-485 optically isolated interface based on Modbus RTU protocol allows for remote device configuration and data download. InsulGard can be networked with an existing Modbus, allowing for up to 231 addressable devices
- Ethernet port, Web page, FTP or Modbus TCP

Communication protocol includes Modbus, proprietary binary and ASCII text options allowing a software programmer to build InsulGard into a high-level software program using simple text type commands. InsulGard is supplied with database software that allows for automated communication to a device or several devices for data acquisition and analysis. The software allows for either direct network or dialup connection to a device by a regular telephone landline or a cellular connection.

General Description—InsulGard

InsulGard has 15 signal inputs (Ch1–Ch15) for partial discharge measurement and a noise input dedicated for noise suppression (Ch16). All 16 inputs have identical conditioning circuits (CC) providing signal isolation, transient suppression and high-pass filtering of the input signals. The frequency band of the InsulGard is from 1 MHz to 20 MHz.

InsulGard acquires PD data in the form of three dimensional phase-resolved pulse height distribution (PRPHD)—PD pulse count as a function of pulse magnitude and 60(50) Hz phase. It has 24 (15°) phase windows and a magnitude dynamic range of about 70 dB, divided in 21 magnitude windows.

The data can be stored in the internal device memory in the form of three-dimensional PRPHD matrixes and/or in the brief form of integral quantities derived from these matrixes. Each record is accompanied by three additional correlation parameters.

Before each measurement, InsulGard performs self-calibration and self-test. If any problem is detected, the status relay dry contacts will open and an appropriate message will appear on the InsulGard display. Loss of power will be indicated in the same way by opening status relay contacts.

InsulGard measures signals from signal inputs sequentially multiplexing them to a single metering channel. Each pulse from each sensor is validated by the allowed pulse width. In the case of non-compliance, InsulGard will not count the pulse.

After each measurement, data from all active signal channels will be compared to alarm thresholds. If any of the Yellow threshold limits are exceeded, the Warning LED will be turned on and the Warning relay dry contacts will close. In the case of a Red level achieved, InsulGard will trigger additional measurement and, if confirmed, an Alarm LED will be turned on and the Alarm relay dry contacts will close. If Red alarm is detected, full measurement data will be stored in the memory.

PD measurements can be performed on a time schedule (up to 50 per day) or in specified time intervals (from 1 minute to 23 hours 59 minutes). Four measurements per day are recommended.

Between scheduled measurements, the “High Alarm” feature is enabled. All signal sensors are connected to a summation unit and further to a separate “High Alarm” channel. InsulGard continuously searches for an appearance of high magnitude pulses and pulse series. Magnitude threshold and repetition in series are configurable. If five events of pulse series were detected between the scheduled measurements, InsulGard will trigger a full PD measurement, and display an alarm, if any.

Full PD measurement by InsulGard involves a measurement of statistical Phase Resolved Partial Discharge Distribution (PRPDD) for every active channel. After each measurement for every active channel, InsulGard calculates PDI, Maximum PD magnitude, PD pulse repetition rate, and trend parameters (rate of PD parameter change). The calculated parameters are compared to alarm set points and alarm status is determined. All calculated and alarm status parameters are stored in the internal memory for each measurement. Additionally, three auxiliary parameters (temperature, % of full load current and operating voltage or humidity) are assigned to the measurement data. PRPDD can, optionally, be stored in the internal memory. There are two modes of PD data storage “Brief” and “Full.”

Full—during this mode PRPDD is stored in the memory with the mentioned above parameters for each active channel and every measurement.

Brief—in order to save a memory, PRPDD can be stored in the memory several times a month. An operator should set a number of days and a measurement number at the current day for storing PRPDD. During the remaining measurements, InsulGard will store the brief version of PD data.

InsulGard has two Megabytes of internal flash memory for data storage allowing for its standalone operation. When the memory is filled, the device starts replacing the oldest data with the latest data. The rate of the memory consumption depends upon a number of active channels, frequency of measurements, and frequency of PRPDD storage. As an example, if all 15 channels are active for measurements four times a day and PRPDD are stored twice a month, the device holds 17 months of the latest PD data in its internal memory. All stored data and settings can be accessed from the keypad, or remotely from a PC.

Alarms

InsulGard has two configurable alarms, Red and Yellow, that connect to two C-form relays. There are two groups of parameters that can generate an alarm. One is if an alarm set point is exceeded (Partial Discharge Intensity (PDI) and its trend or PD pulse magnitude and its trend). One of two, PDI or Magnitude, can be configured for alarm at one time. The same parameter is configured for 4–20 mA interface output automatically. 4–20 mA output provides a signal with the slope of 10% of Red Alarm Threshold per 1mAmp. That means that Red alarm threshold corresponds to 14 mA output.

Alarm set points for PDI are represented in terms of mW. Magnitude is represented in terms of mV.

Trend is set in terms of times per year for both PDI and Magnitude. Alarm on trend is enabled after a training period of 1/3 of the trend-sliding window.

Yellow and Red alarms operate differently. In the case of a Yellow alarm, it will appear on the corresponding relay as received. In the case of a Red alarm, InsulGard will initiate an additional measurement at the time of alarm, and only if confirmed, will indicate the alarm by relay. If the Red alarm is not confirmed, the status of the alarm will be set per the last measurement. If at any measurement the alarm status will be reduced, InsulGard will indicate the reduced alarm status with both an alarm LED reading and relay.

Alarm relays can operate in two modes (configurable). Relays lock in an alarm status received at the last measurements, until the next measurement. Or a relay can operate for a limited configurable time and then open the contacts. At the next measurement, if an alarm status is detected, relays will hold the alarm contacts closed for the same time.

Trend

InsulGard calculates trend of a parameter enabled for alarm. Trend is normalized to the value of the parameter change in times per year. Trend has two alarm thresholds, Yellow and Red, connected to alarm relays and also to the alarm status LED at the front panel of the device. Trend is calculated as a linear approximation of data over specified time interval (default is 18 weeks). This 18-week time window is sliding over time while device monitors partial discharges.

Continuous Watch Feature

Between the scheduled measurements the Continuous Watch feature ("High Alarm") is initiated. At this time all signal sensors are summarized and connected to the separate High Alarm channel. InsulGard is continuously watching for the events of high magnitude pulses (configurable) and their series. If five series of such events are detected, InsulGard starts full PD measurement and, in the case of Red alarm confirmation, InsulGard indicates this alarm and stores full PD data in the internal device memory.

Schedule

PD measurements can be performed at specified times during a day or time interval basis (configurable). The device is shipped with "time basis" schedule enabled and set to record measurements four times a day. This is sufficient for all common applications.

If necessary, InsulGard can be set to measure up to 50 times per day at scheduled times or in specific time intervals varying from 1 minute to 23 hours 59 minutes.

Technical Data—InsulGard

Technical Data and Specifications

Table 4.5-1. Power Source Specifications

Description	Specification
Applications	HV and MV equipment (motors including VFD), switchgears, generators, bus ducts, cable terminations, transformers, est.)
Mounting options	In NEMA 4X enclosure. On the panel. Door (Flash) mount
Installation category	II
Pollution degree	2
Temperature range	–40 °C to +70 °C (+85 °C without enclosure)
Relative humidity	0%RH–90%RH
Maximum altitude	6562 ft (2000 m)
Power source	115 V / 230 Vac $\pm 10\%$ 60 / 50 Hz
Power consumption of device (VA max)	15 VA
Fuse inside InsulGard case: 20 mm, 250 Vac, time lag 5TS type by BEL Inc.	For 115 Vac–5ST200-R (200 mA) For 230 Vac–5ST125-R (125 mA)
Input fuse on the panel (panel mount option): 20 mm, 250 Vac, Fast fuse 5MF type by BEL Inc. (A maximum output current from outlet for 115 Vac–3A)	5MF 3 –R (3 A)
Display	Graphic dot display, two lines
Keypad	Four arrows and four functional keys
LEDs (normal, warning (Alarm 1) or Alarm (Alarm 2) conditions, memory and setting modes	Five LEDs

Approximate Size (Length x Width x Height) and Weight

Main unit	9.20 x 7.00 x 2.50 inches (23.4 x 17.8 x 6.4 cm), 4.2 lb (1.9 kg)
Door-mount option (main unit with sensor interface board)	9.20 x 7.00 x 4.00 inches (23.4 x 17.8 x 10.2 cm), 4.6 lb (2.1 kg)
Panel-mount option	14.80 x 12.90 x 4.00 inches (37.6 x 32.8 x 10.2 cm), 10.3 lb (4.7 kg)
Enclosure (NEMA 4X) mount option	17.20 x 15.40 x 8.80 inches (43.7 x 39.0 x 22.3 cm), 21.6 lb (9.8 kg)

PD Measurement Parameters

PD channels	15
Noise channel	1
Continuous watch (high PD activity) channel	1
Basic type of data	Phase-resolved PD distribution
PD channel dynamic range	68 dB
Number of magnitude windows (3.23 dB each)	21
Number of phase windows (15° each)	24
Power frequency at a monitored equipment	3–20 Hz, 20–400 Hz
Synchronization type	Internal and external
Maximum measured pulse repetition rate	367,300 pulses/second at 60 Hz 306,000 pulses/second at 50 Hz
Calculated parameters for each PD channel	Partial discharge intensity (PDI) or maximum pulse magnitude (Q_{max}), Pulse repetition rate (pps), Trend
Alarming parameters	PDI, Q_{max} , Trend
Data record types	Full/Brief
Internal data memory allows for up to 1000 days data storage at four measurements per day	2 MB
Self-test and self-calibration	At powering up and before every measurement
Setup	Configurable from keypad and PC
Allowed RG-58 coaxial cable length to PD sensors	Up to 150 ft (46 m)

Auxiliary Inputs

Input specified for temperature measurement calibrated for 100 ohm platinum RTD sensor	1
Analog inputs specified for current, voltage or humidity measurement	2
USB Host	For future use

Interfaces

C-form dry-type relays for device status, warning (Alarm 1) and alarm (Alarm 2) PD levels (fully configurable)	3 120 Vac/ 5 A 28 Vdc/ 5 A For other ratings refer to the relay specification
4–20 mA isolated interface represents highest PDI or max. magnitude as % of the alarm (Alarm 2) threshold	Slope is 1 mA per 10%
RS-485 interface optically isolated (231 addresses)	Communication Protocol: Modbus RTU, binary, text commands
Ethernet	Modbus-TCP, Web page, FTP
USB	PC connection
USB host	For future use

Product Selection—InsulGard

General Notes

The three basic InsulGard packages are Switchgear Applications, Motor Applications and Generator Applications. At the beginning of each section to follow are the basic components typically found in each type of application.

Switchgear Applications

Switchgear Applications have three typical components: InsulGard Switchgear Package, Coupling Capacitor Sensors and RFCT Sensors.

InsulGard Systems for Switchgear Applications are sold as “packages.” Packages provide greater value. Standard Equipment with the InsulGard Switchgear Package is shown in **Table 4.5-3**.

Table 4.5-2. Standard Equipment

Description	Quantity
InsulGard	1
Humidity sensor mounted as specified	1
Temperature mounted as specified	1
RS-485 communication port	1
InsulGard software CD	1
Set of instruction manuals	1

Table 4.5-3. InsulGard Switchgear Packages—Order PD Sensors Separately

Description	Catalog Number
Door-mount InsulGard for mounting onto indoor cabinet door cut-out, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ Embedded temperature and humidity sensors ■ InsulGard software CD and one set of instruction manuals	PD-IG-S-E0
Back-panel-mount (no enclosure) for installing InsulGard into an existing enclosure, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ Embedded temperature and humidity sensors ■ InsulGard software CD and set of instruction manuals	PD-IG-S-E1
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ External temperature and humidity sensors (PD-SR-TS, PD-SR-HS) ■ InsulGard software CD and set of instruction manuals	PD-IG-S-E2

Table 4.5-4. Communication Options

Description	Catalog Number
RS-485-to-USB converter—only required if using RS-485 port for extended length, remote connection to PC USB port	PD-USB
Advanced RS-232/485 industrial Modem TD-36485HV (installed on back panel except for door-mounted IG it must be mounted separately)	PD-MODEM

Table 4.5-5. Auxiliary (Dynamic) Sensors

Description	Catalog Number
Auxiliary Sensors for InsulGard, BushingGard	
External temperature sensor for InsulGard (TS) Supplied with default cable L = 65 feet	PD-SR-TS
External humidity sensor for InsulGard (HS) Supplied with default cable L = 65 feet	PD-SR-HS
Load sensor for InsulGard: includes Current Transformer (CT), rated 5 A, with ID = 0.50 inches Connect to secondary winding of the motor (or generator) current transformer Note: Differential current transformer can't be used Supplied with default cable L = 65 feet	PD-SR-CT
Split (Flex)—Core CT rated 500 A. Supplied with preinstalled PD-SR-CT. Should be installed on a motor power supply cable for load measurement if the motor/generator current transformer can't be used (Order separately if required)	PD-SR-CTF

Note: In switchgear applications, humidity and temperature sensors are installed in the same switchgear cubicle (embedded) with the InsulGard.

Product Selection—InsulGard

Table 4.5-6. Coupling Capacitors Sensors

Description	Catalog Number
InsulGard Partial Discharge Sensors	
IPDS-Integrated partial discharge sensor Set of three 5 kV, 80 pF coupling capacitors with mounting kit Supplied with default RG58 cable L = 65 feet	PD-SR-IPDS-5
IPDS-Integrated partial discharge sensor Set of three 7 kV, 80 pF coupling capacitors with mounting kit Supplied with default RG58 cable L = 65 feet	PD-SR-IPDS-7
IPDS-Integrated partial discharge sensor Set of three 15 kV, 80 pF coupling capacitors with mounting kit Supplied with default RG58 cable L = 65 feet	PD-SR-IPDS-15
IPDS-Integrated partial discharge sensor Set of three 27 kV, 80 pF coupling capacitors with mounting kit Supplied with default RG58 cable L = 65 feet	PD-SR-IPDS-27
IPDS-Integrated partial discharge sensor Set of three 38 kV, 80 pF coupling capacitors with mounting kit Supplied with default RG58 cable L = 65 feet	PD-SR-IPDS-38

Note: The number of cubicles will determine the number of coupling capacitors required for the project. One set of three coupling capacitors is required for every three vertical structures. The catalog numbered set includes mounting kits, boots, cables and the like.

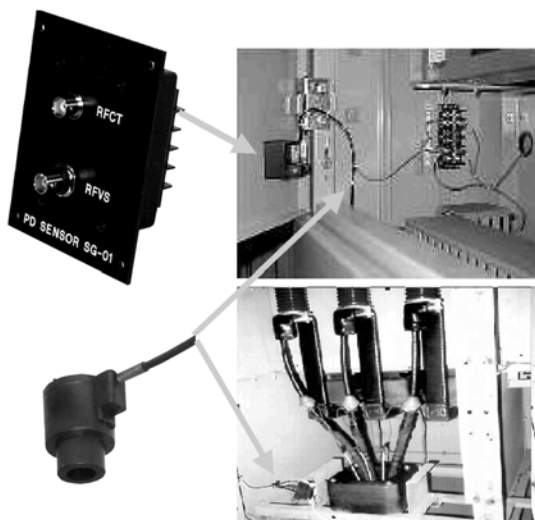
Table 4.5-7. RFCT Sensor

Description	Catalog Number
0.75-inch diameter RFCT, default cable length 65 feet	PD-SR-RFCT-075

The number of RFCTs required is determined by what cables the customer wants to protect (to protect secondary cables leaving the switchgear, incoming feeder cables to the main breaker/switch, etc.). There will be one RFCT per cubicle to protect the cabling (even if there are multiple cables per phase).

The length of cable or “sensitivity zone” of protection depends upon the type of cable, the number of splices, and the number of taps. PLIC Type Cable is protected up to maximum of 1500 ft. EPR (rubber composition) distances are shorter with protection up to a maximum of 300 ft.

In figures shown below, the InsulGard is protecting the six vertical section switchgear layout with the two sets of coupling capacitors and is protecting the feeder cables via the RFCTs installed on the power cable shield. An exploded view of the RFCT is also shown.


Typical Installation of RFCT Sensor

Motor Applications

Generally, the Motor Application components list consists of just the InsulGard Package itself. In some applications, the customer may want to monitor the cable feeding the motor. In those cases, one will need to add the line item for the appropriate RFCT.

InsulGard Systems for Motor Applications are sold as “packages.” Packages provide greater value. Standard Equipment with the InsulGard Motor Package is shown in **Table 4.5-8.**

Table 4.5-8. Standard Equipment

Description	Quantity
InsulGard	1
NEMA 4X enclosure	1
Set of three coupling capacitors	1
Coupling capacitor mounting kit (cabling, hardware, boots, connectors)	1
RTD module (six inputs)	1
External mount humidity sensor (65 ft cable pigtail included)	1
Temperature sensor (65 ft cable pigtail included)	1
RS-485 communication port	1
InsulGard software CD	1
Set of instruction manuals	1

Table 4.5-9. InsulGard Motor Packages

Description	Catalog Number
InsulGard Motor Kits	
■ Stator RTD number ð 8 ■ Motor voltage ð 15 kV ■ For motors with Stator RTD number Š 9 order additional PD-SR-RTD-6	
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-X), X = kV, choose 5, 7 or 17 ■ One RTD-6 sensor board PD-SR-RTD-6 ■ External temperature and humidity sensors (PD-SR-TS, PD-SR-HS) ■ Load sensor CT (PD-SR-CT) ■ InsulGard software CD and set of instruction manuals	PD-IG-M-E2-A1
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-X), X = kV, choose 5, 7 or 17 ■ One RTD-6 sensor board (PD-SR-RTD-6) ■ External humidity sensor (PD-SR-HS) ■ Load sensor CT (PD-SR-CT) ■ Cable for spare stator RTD for temp sensor input ■ InsulGard software CD and set of instruction manuals	PD-IG-M-E2-A2
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-X), X = kV, choose 5, 7 or 17 ■ One RTD-6 sensor board PD-SR-RTD-6 ■ External humidity sensor (PD-SR-HS) ■ Split core CT (PD-SR-CTF) ■ Cable for spare stator RTD for temp sensor input ■ InsulGard software CD and set of instruction manuals	PD-IG-M-E2-A2-CTF

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Table 4.5-10. Communication Options

Description	Catalog Number
RS-485-to-USB converter—only required if using RS-485 port for extended length, remote connection to PC USB port	PD-USB
Advanced RS-232/485 industrial Modem TD-36485HV (installed on back panel except for door-mounted IG it must be mounted separately)	PD-MODEM

Table 4.5-11. Auxiliary (Dynamic) Sensors

Description	Catalog Number
Auxiliary Sensors for InsulGard, BushingGard	
External temperature sensor for InsulGard (TS) Supplied with default cable L = 65 feet	PD-SR-TS
External humidity sensor for InsulGard (HS) Supplied with default cable L = 65 feet	PD-SR-HS
Load sensor for InsulGard: includes current transformer (CT), rated 5 A, with ID = 0.50-inches Connect to secondary winding of the motor (or generator) current transformer Note: Differential current transformer can't be used Supplied with default cable L = 65 feet	PD-SR-CT
Split (flex)—core CT rated 500 A. Supplied with preinstalled PD-SR-CT. Should be installed on a motor power supply cable for load measurement if the motor/generator current transformer can't be used (Order separately if required)	PD-SR-CTF

Note: In most motor applications, the humidity and temperature sensors will be external to the InsulGard Enclosure (typically field mounted in cable termination compartment) and shipped with a 65 foot coaxial pigtail. Mounting in the same cubicle as the InsulGard is not typical for motor applications. Also please indicate if CT input is customer furnished or must be supplied and what type it is/should be.

Table 4.5-12. RFCT Sensor

Description	Catalog Number
0.75-Inch diameter RFCT, default cable length 65 feet	PD-SR-RFCT-075

Product Selection—InsulGard

The length of cable or “sensitivity zone” of protection depends upon the type of cable, the number of splices, and the number of taps. PLIC Type Cable is protected up to maximum of 1500 ft. EPR (rubber composition) distances are shorter with protection up to a maximum of 300 ft.

Generator Applications

Typically, the Generator Package components list consists of the InsulGard Package and occasionally additional sets of coupling capacitors. For part numbers of additional sets of coupling capacitors, please see Switchgear Applications Section on **Page 4.5-5**.

InsulGard Systems for Generator Applications are sold as “packages.” Packages provide greater value. Standard Equipment with the InsulGard Generator Package is shown in **Table 4.5-13**.

Table 4.5-13. Standard Equipment

Description	Quantity
InsulGard	1
NEMA 4X enclosure	1
Set of three coupling capacitors	1
Coupling capacitor mounting kit (cabling, hardware, boots, connectors)	1
RTD module (six inputs)	2
External mount humidity sensor (65' cable pigtail included)	1
Temperature sensor (65' cable pigtail included)	1
RS-485 communication port	1
InsulGard software CD	1
Set of instruction manuals	1

Table 4.5-14. Generator Packages

Description	Catalog Number
InsulGard Generator Kits (Air-Cooled)—Voltage 27 kV	
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-X), X = kV, choose 5, 7 or 17 ■ One RTD-6 sensor board PD-SR-RTD-6 ■ External temperature and humidity sensors (PD-SR-TS, PD-SR-HS) ■ Load sensor CT (PD-SR-CT) ■ InsulGard software CD and set of instruction manuals	PD-IG-M-E2-A1
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-X), X = kV, choose 5, 7 or 17 ■ One RTD-6 sensor board (PD-SR-RTD-6) ■ External humidity sensor (PD-SR-HS) ■ Load sensor CT (PD-SR-CT) ■ Cable for spare stator RTD for temp sensor input ■ InsulGard software CD and set of instruction manuals	PD-IG-M-E2-A2
InsulGard Generator Kits (Air-Cooled)—Voltage 27 kV	
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-27) ■ Two RTD-6 sensor boards (PD-SR-RTD-6) ■ Auxiliary sensors set (PD-SR-A1) ■ InsulGard software CD and set of instruction manuals	PD-IG-GV-E2-A1
InsulGard in NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-27) ■ Two RTD-6 sensor boards (PD-SR-RTD-6) ■ Auxiliary sensors set A2 (PD-SR-A2) ■ InsulGard software CD and set of instruction manuals	PD-IG-GV-E2-A2
InsulGard Generator Kit (Hydrogen-Cooled)—Voltage 16 kV	
InsulGard inside NEMA-4X non-metallic enclosure with transparent window, includes: ■ RS-485 communication port with Modbus RTU protocol ■ Universal communications with USB and Ethernet ports ■ One set of coupling capacitors (PD-SR-IPDS-X), X = kV, choose 5, 7 or 17 ■ Two RTD-6 sensor boards (PD-SR-RTD-6) ■ Load sensor CT (PD-SR-CT) ■ Cable for spare stator RTD for temp sensor input ■ InsulGard software CD and set of instruction manuals	PD-IG-HC-E2-A3

Product Selection—InsulGard

Table 4.5-15. Communication Options

Description	Catalog Number
RS-485-to-USB converter—only required if using RS485 port for extended length, remote connection to PC USB port	PD-USB
Advanced RS232/485 industrial Modem TD-36485HV (installed on back panel except for door-mounted IG it must be mounted separately)	PD-MODEM

Table 4.5-16. Auxiliary (Dynamic) Sensors

Description	Catalog Number
Auxiliary Sensors for InsulGard, BushingGard	
External temperature sensor for InsulGard (TS) Supplied with default cable L = 65 feet	PD-SR-TS
External humidity sensor for InsulGard (HS) Supplied with default cable L = 65 feet	PD-SR-HS
Load sensor for InsulGard: includes current transformer (CT), rated 5 A, with ID = 0.50-inches Connect to secondary winding of the motor (or generator) current transformer Note: Differential current transformer can't be used Supplied with default cable L = 65 feet	PD-SR-CT
Split (Flex) - Core CT rated 500 A. Supplied with preinstalled PD-SR-CT. Should be installed on a motor power supply cable for Load measurement if the motor/generator current transformer can't be used (Order separately if required)	PD-SR-CTF

Note: In most generator applications, the humidity and temperature sensors will be external to the InsulGard enclosure (typically field mounted in cable termination compartment) and shipped with a 65-foot coaxial pigtail. Mounting in the same cubicle as the InsulGard is not typical for generator applications. Also, please indicate if CT input is customer furnished or must be supplied and what type it is/should be.

Connection Diagram—InsulGard

Connection Wiring Diagram

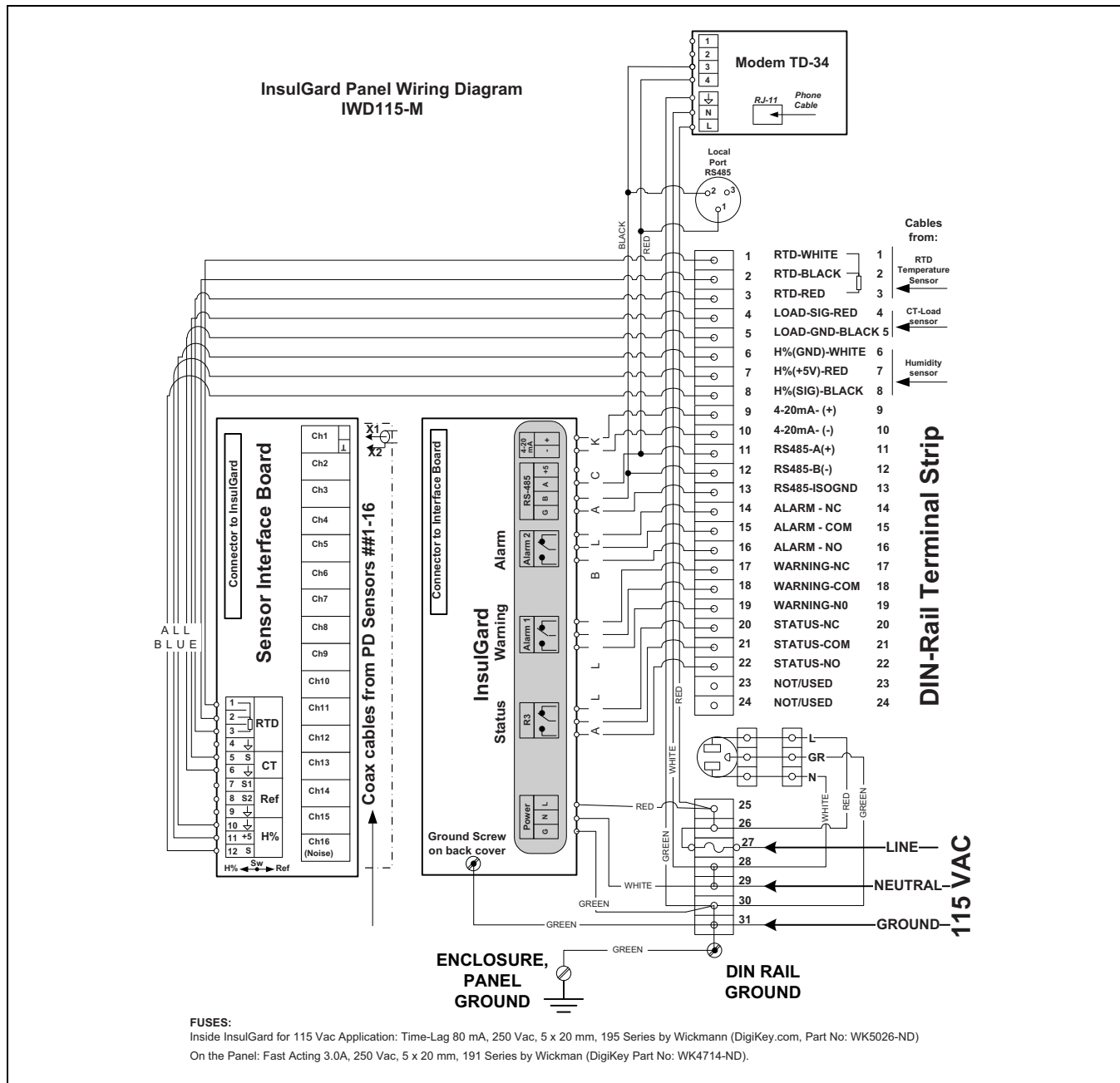


Figure 4.5-1. Typical Connection Diagram

Notes

1. Modem with Power Module are installed if ordered.
2. On motors, an unused RTD can be used as the temperature sensor (wire colors in brackets relate only to TS sensor).
3. In switchgears current sensor (CT) is not used, and if panel is installed without an enclosure, the temperature (TS) and humidity (HS) sensors can be installed directly on the panel. Use a left fitting (hub) on the enclosure for power supply cable and for the cables to the relays (Alarm1&2, R3) and use a right hub for all signal cables.
4. Fuses: Miniature Fuses 5 x 20, 250 Vac, 195 Series by Wickmann (Distributor—DigiKey.com).
5. Fuse inside InsulGard for 120 V application—200 mA (DigiKey Part NO: WK5034-ND), for 230 Vac application—80mA (DigiKey Part NO: WK5026-ND). Fuse on a panel: 1.0 A (DigiKey Part NO: WK5048-ND).
6. Outlet is not installed for 230 Vac application.