FP-5000 feeder protection

Contents

Description   **Page**

Powering Business Worldwide

FP-5000 feeder protection

Feeder Protection FP-5000

FP-5000 product description

- Microprocessor-based protection with monitoring and control for medium voltage main and feeder applications
- Current, voltage, and frequency protection for electric power distribution systems
- Complete metering of voltage, currents, power, energy, minimum/maximum, and demand functions
- Programmable logic control functions for main-tie-main transfer schemes
- Trip logs, event logs, and waveform capture for better fault analysis and system restoration
- Data Logger to provide energy usage profiles for better planning, utilization, and energy usage
- Compact, drawout case design or fixed case design
- Meets ANSI and UL® standards

Application description

Eaton's FP-5000 feeder protection relay provides complete three-phase and ground overcurrent and voltage protection plus metering in a single, compact drawout case. It may be used as primary protection on feeders, mains, and tie circuit breaker applications, and as backup protection for transformers, high voltage lines, and differential protection. The relay is most commonly used on medium voltage switchgear applications.

The FP-5000 takes full advantage of its microprocessor technology, providing the user new freedoms and a wealth of data-gathering features. The relay performs self-checking of all major hardware and firmware protection elements to ensure their operation in the event of a system or component electrical failure or fault. Protection functions are well suited for main and distribution feeder circuit applications. Programmable logic control functions make the FP-5000 relay ideally suited for main-tie-main and main 1/main 2 transfer schemes.

The zone interlocking feature can be used for bus protection instead of an expensive and complicated bus differential (87B) scheme. The FP-5000 works directly with the Eaton Digitrip® 3000 and Digitrip MV relays. New breaker failure logic provides faster remote backup clearing times for stuck breaker operation.

The FP-5000 provides trip and close circuit monitoring and alarming features. It continually monitors the complete trip and close circuits for continuity and readiness to trip. Open and close pushbuttons are conveniently located on the front of the relay for local breaker operation.

Loss-of-vacuum monitoring is activated when the breaker is open. Residual current is monitored and alarmed if detected.

When an electrical fault or disturbance occurs, the FP-5000 begins to store the following in non-volatile memory:

- Voltage and current sampled data
- Calculated values
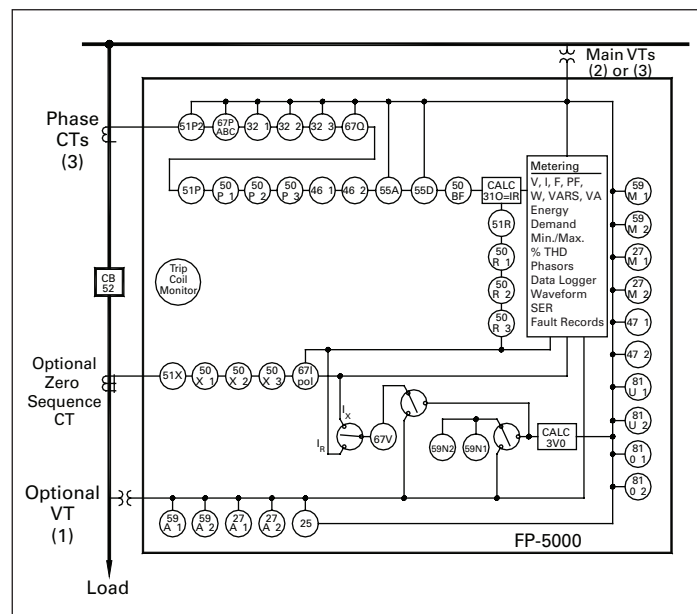- Status of internal protection functions, logic, and contact inputs and outputs

Retrieval and viewing of the data is easy, aiding in the quick analysis and restoration of your electric power system.
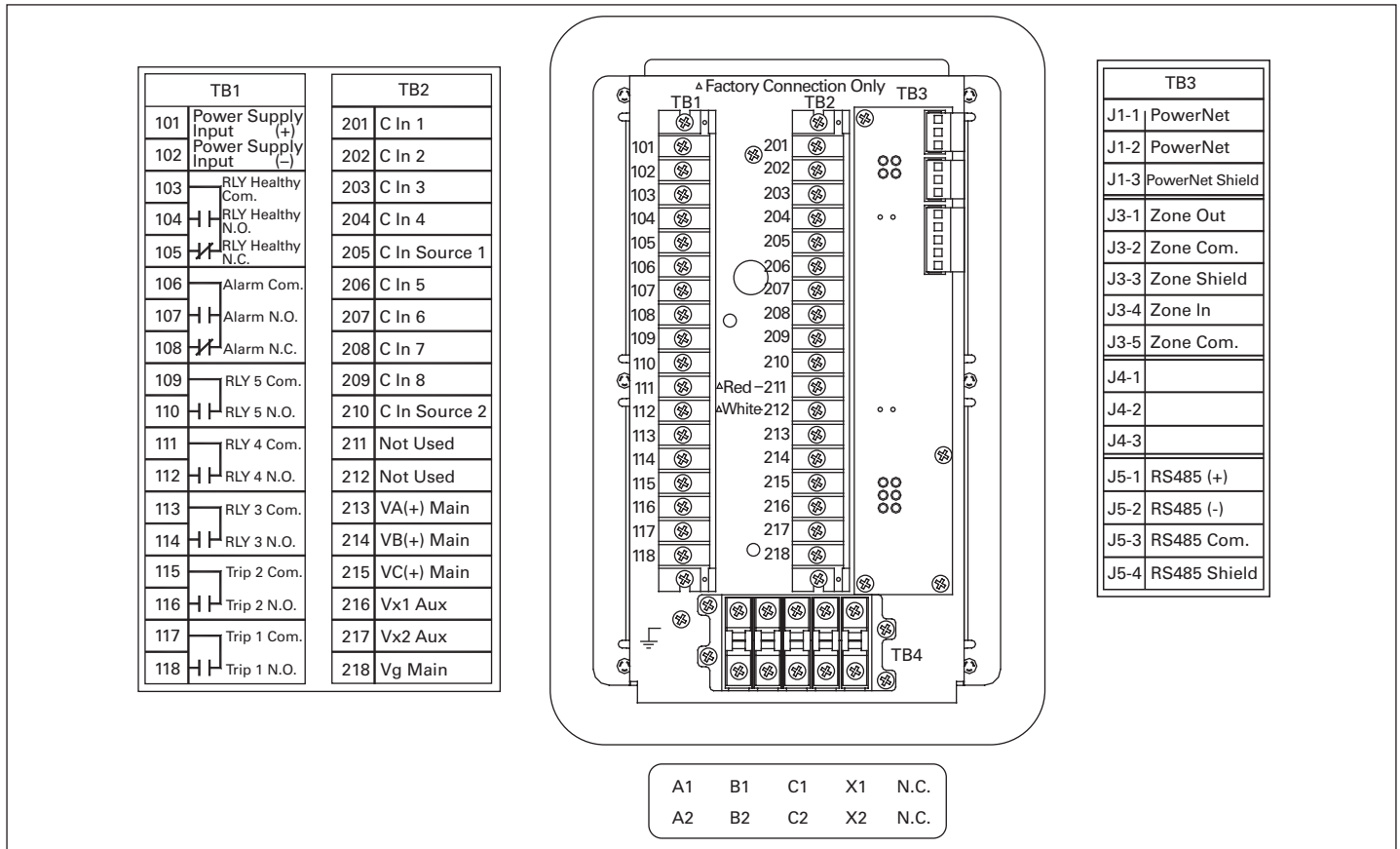
When the FP-5000 isn't responding to disturbances in the power system, it's providing valuable metering information at the relay and remotely. It provides energy usage and demand reading, and can alarm when usage reaches a set value. Power factor measurements can be used for cap bank switching to control kVAR demand. Onboard data trending can provide load profiles for up to 40 days.

The protection functions are listed below and shown in **Figure 1**.

The FP-5000 provides phase overcurrent (forward, reverse, or both):

- Two-stage instantaneous with timers (50P-1 and 50P-2)
- Two inverse time overcurrent (50P-1 and 50P-2)
- Directional control
- 10 standard curves
- Instantaneous or time delay reset
- Voltage restrained time overcurrent (51VR)

Figure 1. FP-5000 One-Line Drawing

TB1	
101	Power Supply Input (+)
102	Power Supply Input (−)
103	RLY Healthy Com.
104	RLY Healthy N.O.
105	RLY Healthy N.C.
106	Alarm Com.
107	Alarm N.O.
108	Alarm N.C.
109	RLY 5 Com.
110	RLY 5 N.O.
111	RLY 4 Com.
112	RLY 4 N.O.
113	RLY 3 Com.
114	RLY 3 N.O.
115	Trip 2 Com.
116	Trip 2 N.O.
117	Trip 1 Com.
118	Trip 1 N.O.

TB2	
201	C In 1
202	C In 2
203	C In 3
204	C In 4
205	C In Source 1
206	C In 5
207	C In 6
208	C In 7
209	C In 8
210	C In Source 2
211	Not Used
212	Not Used
213	VA(+) Main
214	VB(+) Main
215	VC(+) Main
216	Vx1 Aux
217	Vx2 Aux
218	Vg Main

TB3	
J1-1	PowerNet
J1-2	PowerNet
J1-3	PowerNet Shield
J3-1	Zone Out
J3-2	Zone Com.
J3-3	Zone Shield
J3-4	Zone In
J3-5	Zone Com.
J4-1	
J4-2	
J4-3	
J5-1	RS485 (+)
J5-2	RS485 (-)
J5-3	RS485 Com.
J5-4	RS485 Shield

A1	B1	C1	X1	N.C.
A2	B2	C2	X2	N.C.

Figure 2. FP-5000 Rear View and Terminal Designations

The FP-5000 provides ground overcurrent:

- Two independent ground directional overcurrent elements, one measured (Ix) and one calculated (IR):
  - Two-stage instantaneous with timers (50X and 50X-2) (50R-1 and 50R-2)
  - Inverse time overcurrent (51X and 51R)
  - Ground directional polarizing (67N) -3vo, I pol, negative sequence
  - 10 standard curves
  - Instantaneous or time delay reset
  - Voltage restrained time overcurrent (51VR)

The FP-5000 also provides the following protective features:

- 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)
- Under/overfrequency (81U-1, 81U-2, 81O-1, 81O-2)
- Auxiliary single-phase under/overvoltage (27A-1, 27A-2, 59A-1, 59A-2)
- Apparent and displacement power factor (55A, 55D)
- Forward/reverse power protection (32)
- Sync check (25)
- Zone interlocking for bus protection (87B). The FP-5000 feeder relay includes a zone selective interlocking feature that can be used with other devices like the Digitrip 3000 overcurrent relay

The FP-5000 provides the following metering functions:

- Amperes (rms, phasor, and sequence)
- Amperes demand and peak demand
- Volts (rms, phasor, and sequence)
- VA and VA demand
- Watts and kW demand and peak demand
- Forward/reverse/net kWh
- VARS and kVAR demand and peak demand
- Lead/lag/net kVARh
- Power factor
- Frequency
- Voltage and current
- %THD and magnitude THD
- Minimum/maximum recording with date/time stamp
- Trending (load profile over time)

The FP-5000 provides the following monitoring and data recording functions that enhance the security of the protection system, and provides useful information for scheduling maintenance:

- Trip circuit monitoring
- Close circuit monitoring
- Loss-of-vacuum monitoring
- Breaker wear (accumulated interrupted current)
- Waveform capture (256 cycles total, up to 16 events)
- Fault data logs (up to 16 events)
- Sequence of events report (up to 100 events)

The FP-5000 provides standard control functions plus user-configurable custom control capabilities. This logic can be used for applications such as main-tie-main transfer schemes.

- Remote open/close
- Optional local open/close
- Programmable I/O
- Programmable logic gates and timers
- Multiple setting groups (up to 4)
- Bus transfer logic
- Cold load pickup
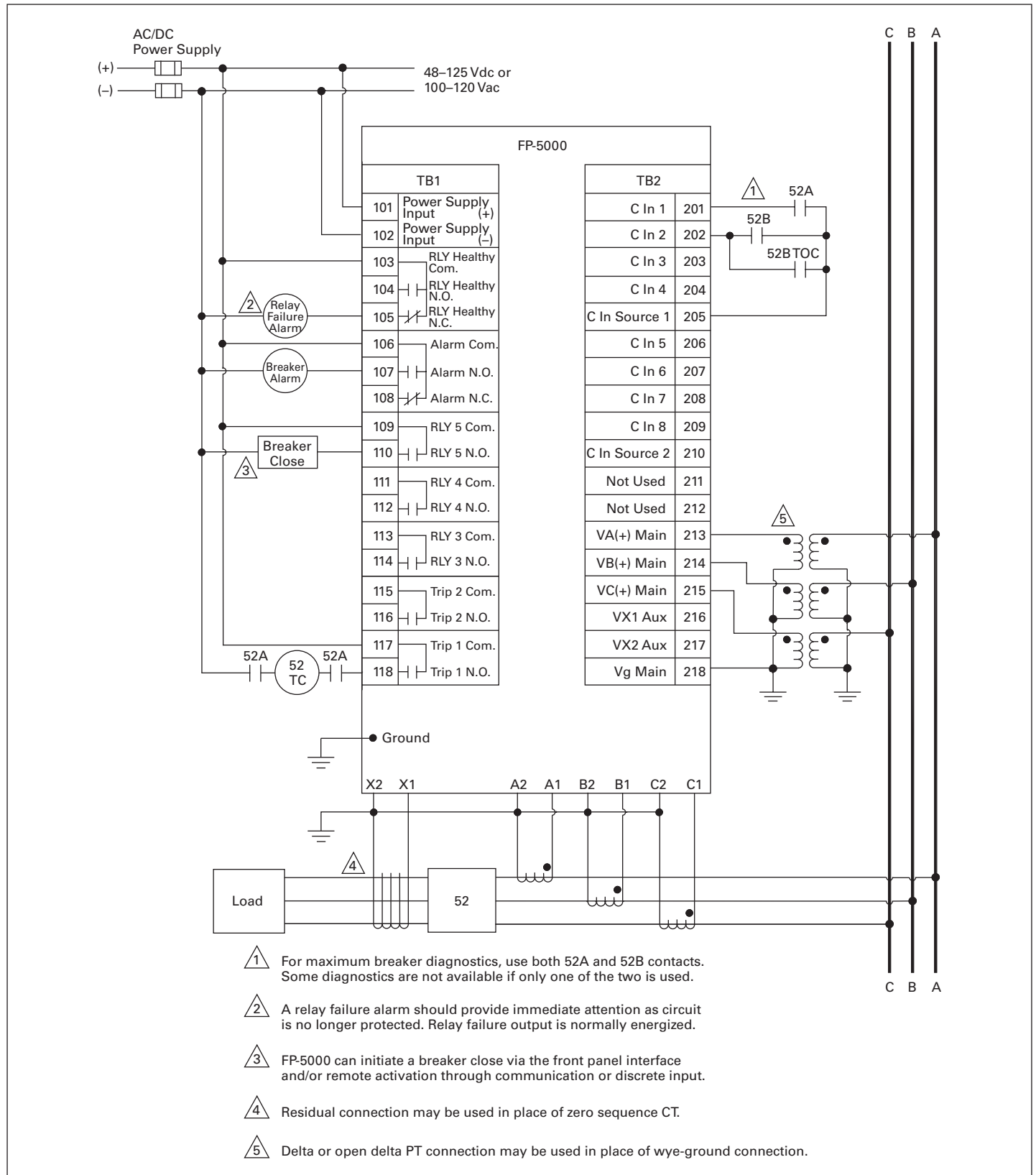- Loss of potential (PT blown fuses)

The FP-5000 supports the following communication options:

- Local HMI
- Password protected
- Addressable
- Front RS-232 port
- Rear RS-485 port
- Rear FSK port
- Protocols:
  - INCOM™
  - Modbus® RTU

Features, functions, and benefits

- Complete protection, metering, and control in a single compact case to reduce panel space, wiring, and costs
- Flexible current, voltage, and frequency protection and programmability to cover a broad range of applications while simplifying relay ordering and reducing inventory
- Integral test function reduces maintenance time and expense
- Relay self-diagnostics and reporting improves uptime and troubleshooting
- Breaker trip circuit monitoring improves the reliability of the breaker operation
- Programmable logic control features that can replace and eliminate external auxiliary relays, timers, and wiring
- Zone selective interlocking improves coordination and tripping times and saves money compared to a traditional bus differential scheme
- Trip and event recording in non-volatile memory provides detailed information for analysis and system restoration
- 256 cycles of waveform capture aids in post-fault analysis (viewable using PowerNet™ and FP-5000 waveform viewing software)
- Front RS-232 port and PowerPort software provides local computer access and a user-friendly, Windows®-based interface for relay settings, and configuration and data retrieval
- Drawout case design for quick and easy relay removal and replacement
- Breaker open/close control from relay faceplate or remotely via communications
- Remote communications to PowerNet monitoring system or PC
- Free PowerPort utility software for local PC interface to the FP-5000 for relay settings, monitoring, and control

PowerPort and PowerNet Protection Overview Screen

1 For maximum breaker diagnostics, use both 52A and 52B contacts.
Some diagnostics are not available if only one of the two is used.

2 A relay failure alarm should provide immediate attention as circuit
is no longer protected. Relay failure output is normally energized.

3 FP-5000 can initiate a breaker close via the front panel interface
and/or remote activation through communication or discrete input.

4 Residual connection may be used in place of zero sequence CT.

5 Delta or open delta PT connection may be used in place of wye-ground connection.

Figure 3. FP-5000 Typical Connection Drawing Using Wye PTs
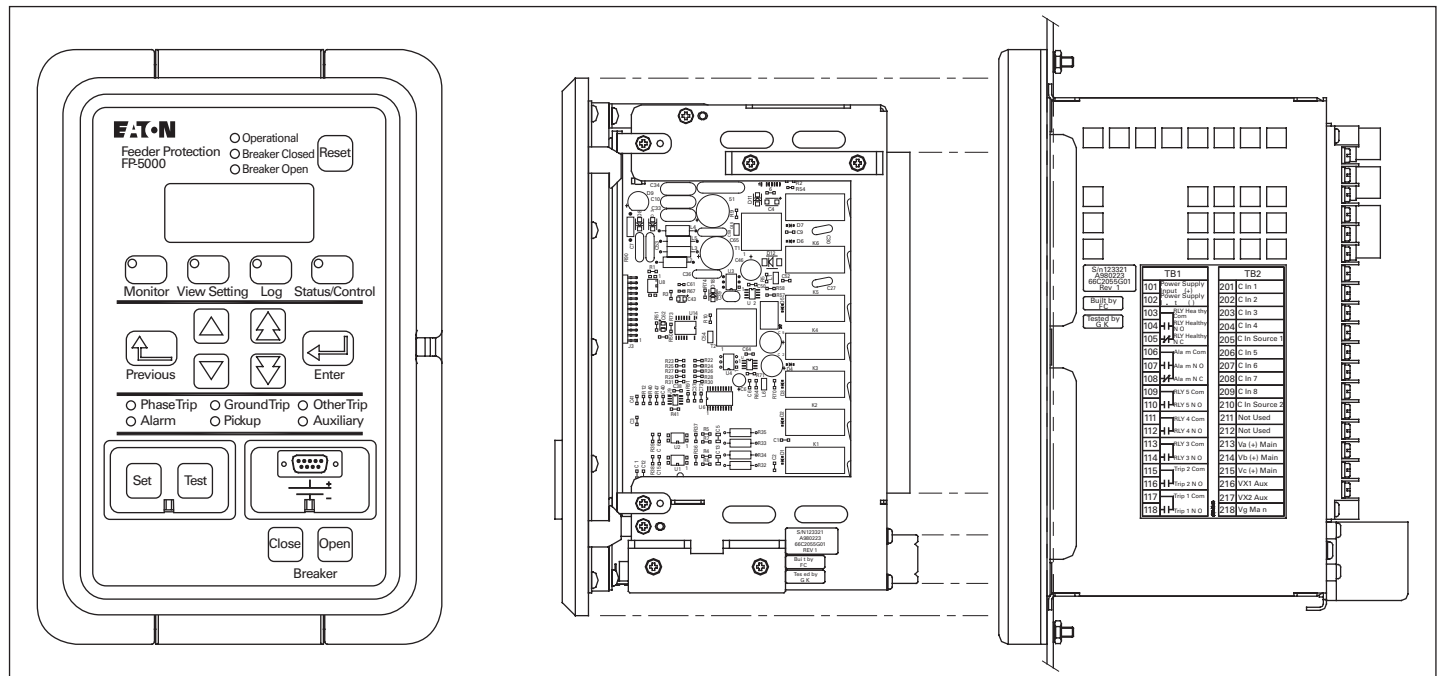
Figure 4. FP-5000 Front View and Drawout Case Side View

Standards and certifications

Compliance

- UL Recognized, File #E154862
- UL 1053 (1994) Recognized
- ANSI C37.90 (1989)
- EN 55011 (1991)
- EN 61000-6-2 (1999)

Emission tests

- EN 55011 (1991): Group 1 Class A (CISPR-11, Class A)
- FCC 47 CFR Chapter 1: Part 15 Subpart b Class A

Immunity tests

- ANSI C37.90.1 (1989): Surge Withstand Capability
- ANSI C37.90.2 (1995): EMI Immunity to 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
- EN 61000-4-8: Power Frequency Magnetic Field Immunity

Control power

- Control voltage:
  - 48–125 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

Current inputs

- Nominal (I_n): 1A or 5A
- CT ratings:
  - $2 \times I_n$ continuous
  - $50 \times I_n$ for 1 second
- CT burdens:
  - < 0.25 VA at 5A (nominal)
  - < 0.05 VA at 1A (nominal)

Voltage inputs

- Nominal: 120 Vac
- Operating range: 69 to 150 Vac
- Burden:
  - < 0.015 at 120 Vac
  - 1 megaohm

Metering accuracy

- Phase current: ±0.5% or ±0.025A from 0.02 to 20 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 ±0.2V from 0 to 160 Vac
- Frequency measurement accuracy: ±0.02 Hz
- Phase angle: ±1°
- Power metering accuracy: ±1.5%
- Metering accuracy temperature range: 0ºC to 50ºC
- Temperature range: ±5% for operation below 0ºC and above 50ºC
- Input signal frequency necessary for accurate operation:
  - 60 Hz nominal, 57 to 63 Hz (±5%)
  - 50 Hz nominal, 47 to 53 Hz (±5%)
- Clock accuracy: Free running ±1 minute/month at 25ºC
- Clock automatically updated by PowerNet host when present

Protective functions

Phase and ground overcurrent protection

- Inverse characteristics: Mod, Very, Extremely, IECA, IECB, IECC, It, I^2t, I^4t, Flat
- TOC (51) pickup range: 0.1 to 4.0 per unit in 0.01 steps
- Time multipliers: 0.05 to 10.0 in 0.01 steps
- IOC (50) pickup range: 0.1 to 20.0 per unit in 0.01 steps
- Pickup accuracy: ±1% (at 0.1 to 2 per unit)
- Time delay: 0 to 9999 cycles in 1 cycle steps
- Time accuracy: ±3% or ±30 ms
- Directional (67, 67N, 67G): forward, reverse, or both

Voltage unbalance (47)

- Threshold (minimum voltage) 1 to 100V in 1V steps
- % V2/V1: 4 to 40% in 1% steps
- Time delay: 0 to 9999 cycles in 1 cycle steps

Current unbalance

- 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

Under/overvoltage protection

- Pickup range: 10 to 150V in 1V steps
- Time delay: 0 to 9999 cycles in 1 cycle steps

Under/overfrequency protection

- Pickup range: 45 to 65 Hz in 0.01 Hz steps
- Time delay: 0 to 9999 cycles in 1 cycle steps

Breaker failure protection

- Pickup range: 0.1 to 5.0 per unit in 0.01 steps
- Time delay: 0 to 9999 cycles in 1 cycle steps

Power factor

- Trigger/reset threshold: 0.5 lag to 0.5 lead in 0.01 steps
- Time delay: 0 to 1000 seconds in 1 second steps

Power protection (32)

- Forward/reverse: over/under
- Pickup accuracy: ±1.0%
- Trip time accuracy: 0 to 12 cycles 0.1%, whichever is greater

Sync check (25)

- Phase angle: 1 to 60°
- Slip frequency: 0.1 to 2 Hz
- Voltage differential: 1 to 100V
- Breaker close time: 0 to 9999 cycles

Discrete inputs

- Number of contact inputs: 8
- Rating: 48 Vdc wetting voltage provided with internal ground only

Output contacts

- Number of output contacts: Five Form A and two Form C

Rating of output contacts

- Momentary:
  - Make 30A AC/DC for 0.25 seconds
  - Break 0.25A at 250 Vdc (resistive)
  - Break 5A at 120/240 Vac
- Continuous:
  - 5A at 120/240 Vac
  - 5A at 30 Vdc
- Minimum switching capacity (100 mA, 5 Vdc) ①

Logic and control functions

- Six programmable logic gates for AND, OR, NAND, NOR operation
- Two latching (flip/flop) gates
- Six timer gates provide on/off delays

INCOM communications

- Baud rate: 9600 fixed
- Maximum distance: 10,000 feet (3048m)
- Protocol: INCOM

RS-232 communication, front panel

- Baud rate: 38.4k, 19.2k, 9.6k
- Connector standard 9-pin subminiature, three-wire
- Protocol: INCOM

RS-485 communication, rear panel

- Baud rate: 19.2k, 9.6k
- Protocol: Modbus RTU

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 2500m) 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)

① This value can change due to the switching frequency, environmental conditions, and desired reliability level; therefore, it is recommended to check this with the actual load.
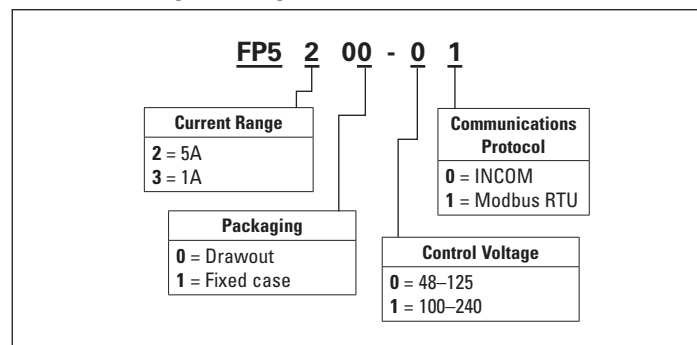
Communication software

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 the following URL: www.Eaton.com; search for "PowerPort."

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.

Product Selection

Table 1. Catalog Ordering Information

FP5 **2** 00 - **0** **1**

Current Range
2 = 5A
3 = 1A

Packaging
0 = Drawout
1 = Fixed case

Communications Protocol
0 = INCOM
1 = Modbus RTU

Control Voltage
0 = 48–125
1 = 100–240

Table 2. Catalog Numbers

Description	Style Number	Catalog Number
5A, INCOM, 48–125 Vac/Vdc, drawout	66D2041G11	**FP5200-00**
1A, INCOM, 48–125 Vac/Vdc, drawout	66D2041G12	**FP5300-00**
5A, INCOM, 100–240 Vac/Vdc, drawout	66D2041G14	**FP5200-10**
1A, INCOM, 100–240 Vac/Vdc, drawout	66D2041G15	**FP5300-10**
5A, Modbus, 100–240 Vac/Vdc, drawout	66D2041G16	**FP5200-11**
1A, Modbus, 100–240 Vac/Vdc, drawout	66D2041G17	**FP5300-11**
5A, Modbus, 48–125 Vac/Vdc, drawout	66D2041G18	**FP5200-01**
1A, Modbus, 48–125 Vac/Vdc, drawout	66D2041G19	**FP5300-01**
5A, INCOM, 48–125 Vac/Vdc, fixed case	66D2120G01	**FP5201-00**
1A, INCOM, 48–125 Vac/Vdc, fixed case	66D2120G02	**FP5301-00**
5A, INCOM, 100–240 Vac/Vdc, fixed case	66D2120G04	**FP5201-10**
1A, INCOM, 100–240 Vac/Vdc, fixed case	66D2120G05	**FP5301-10**
5A, Modbus, 100–240 Vac/Vdc, fixed case	66D2120G06	**FP5201-11**
1A, Modbus, 100–240 Vac/Vdc, fixed case	66D2120G07	**FP5301-11**
5A, Modbus, 48–125 Vac/Vdc, fixed case	66D2120G08	**FP5201-01**
1A, Modbus, 48–125 Vac/Vdc, fixed case	66D2120G09	**FP5301-01**

F·A·T·N
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