Littelfuse
STARTCO

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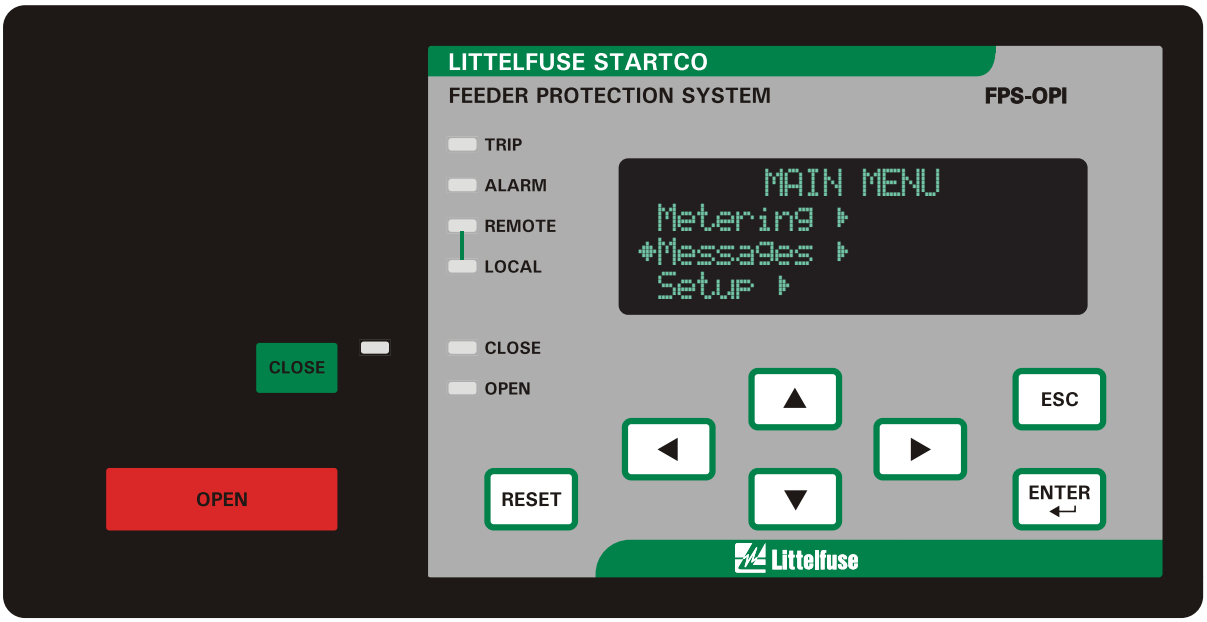
FPS MANUAL

FEEDER PROTECTION SYSTEM

Revision 1-C-031615



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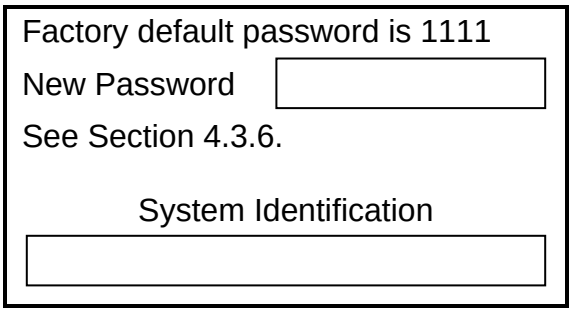
Factory default password is 1111
New Password
See Section 4.3.6.
System Identification

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DISCLAIMER

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1. INTRODUCTION

1.1 GENERAL

The Feeder Protection System (FPS) is a modular system with integrated protection, control, metering, and data-logging functions. The Control Unit (FPS-CTU) is the core module. It can operate as a stand-alone unit or with the Operator Interface (FPS-OPI), and an RTD Module (MPS-RTD). The CTU can be programmed using the OPI or the communications network. Programmable inputs and outputs provide a flexible hardware platform and custom software can be easily loaded from a PC to the CTU's flash memory. The FPS block diagram is shown in Fig. 1.1.

1.2 FPS FEATURES

1.2.1 PROTECTION

- Overload (49, 51)
- Definite-time overcurrent (50, 51)
- Inverse-time overcurrent (50, 51, IEC, IEEE)
- Definite-time earth fault (50G/N, 51G/N)
- Inverse-time earth fault (50G/N, 51G/N, IEC, IEEE)
- Unbalance (voltage and current) (46, 47)
- Phase loss (voltage and current) (46, 47)
- Phase reverse (voltage and current) (46, 47)
- Overvoltage (59)
- Undervoltage (27)
- Power factor (55)
- Reversepower (32)
- Overfrequency (81)
- Underfrequency (81)
- PTC overtemperature (49)
- RTD overtemperature (49)
- RTD undertemperature (49)
- Two setting groups

1.2.2 BREAKER CONTROL

- Open and close control
- Local, remote, or network control
- Status verification and indication

1.2.3 METERING

- Line currents
- Current unbalance
- Positive-sequence current
- Negative-sequence current
- Earth-leakage current
- Line to line voltages
- Line frequency
- Voltage unbalance
- Positive-sequence voltage
- Negative-sequence voltage
- Power
  - Apparent, reactive, real, and power factor
- Energy
  - kWh, kVAh, and kVARh
- Used thermal capacity
- Thermal trend
- RTD temperature
- Analog input and output

1.2.4 DATA LOGGING

- Sixty-four records
  - Date and time of event
  - Event type
  - Line currents
  - Current unbalance
  - Earth-leakage current
  - Line-to-line voltages
  - Voltage unbalance
  - Thermal capacity
  - Analog-input value
  - RTD temperatures
- Trip counters
- Running hours
- Frequency
- Power (P, S, Q, PF)

1.2.5 INPUTS AND OUTPUTS

- Three ac-current inputs
- Three ac-voltage inputs
- Earth-leakage-current input
- Seven programmable digital (ac/dc) inputs
- 24-Vdc source for digital input
- 4-20-mA analog input and output
- PTC thermistor temperature input
- Up to eight RTD inputs
- Five programmable output relays
- Network communications
- IRIG-B time-code input

1.2.6 FPS-OPI OPERATOR INTERFACE

- 4 x 20 vacuum-fluorescent display
- Control keys
- Display-control and programming keys
- LED status indication
- Remote operation up to 1.2 km (4,000')
- Powered by FPS-CTU

1.2.7 MPS-RTD MODULE

- One eight-input module
- Individually selectable RTD types
- Solid-state multiplexing
- Remote operation up to 1.2 km (4,000')
- Powered by FPS-CTU

1.2.8 COMMUNICATIONS

The standard network communications interface is an RS-485 port with Modbus® RTU and A-B® DF1 protocol support. In addition to the standard interface, network communications options include DeviceNet™, Profibus®, Modbus® TCP, and Ethernet/IP..

1.3 ORDERING INFORMATION

See Fig. 1.2 for FPS-CTU, FPS-OPI, and MPS-RTD model numbers.

Earth-Fault Current Sensors:

EFCT-1	Earth-Fault CT, 5-A-primary rating, 82-mm (3.2”) window
EFCT-1FC	Flux Conditioner for EFCT-1, 70-mm (2.7”) window
EFCT-2	Earth-Fault CT with Flux Conditioner, 5-A-primary rating, 139-mm (5.5”) window
EFCT-26	Earth-Fault CT, 5-A-primary rating, 26-mm (1”) window

(All EFCT’s include 6 m (19.5’) of 22 AWG (0.33 mm^2) shielded cable).

Other Earth-Fault CT’s .. Contact factory

Phase CT’s ..... Protection-class CT’s, contact factory

Accessories:

SE-IP65CVR-M	Hinged Transparent OPI Cover
SE-485-PP	Port-Powered Serial Converter
SE-485-DIN	Serial Converter, Industrial, 24 Vdc

Software:

SE-Comm-RIS	PC Communication Software(1)
SE-Flash	Firmware Upgrade Software(1)

(1) Available at www.littelfuse.com/relayscontrols.

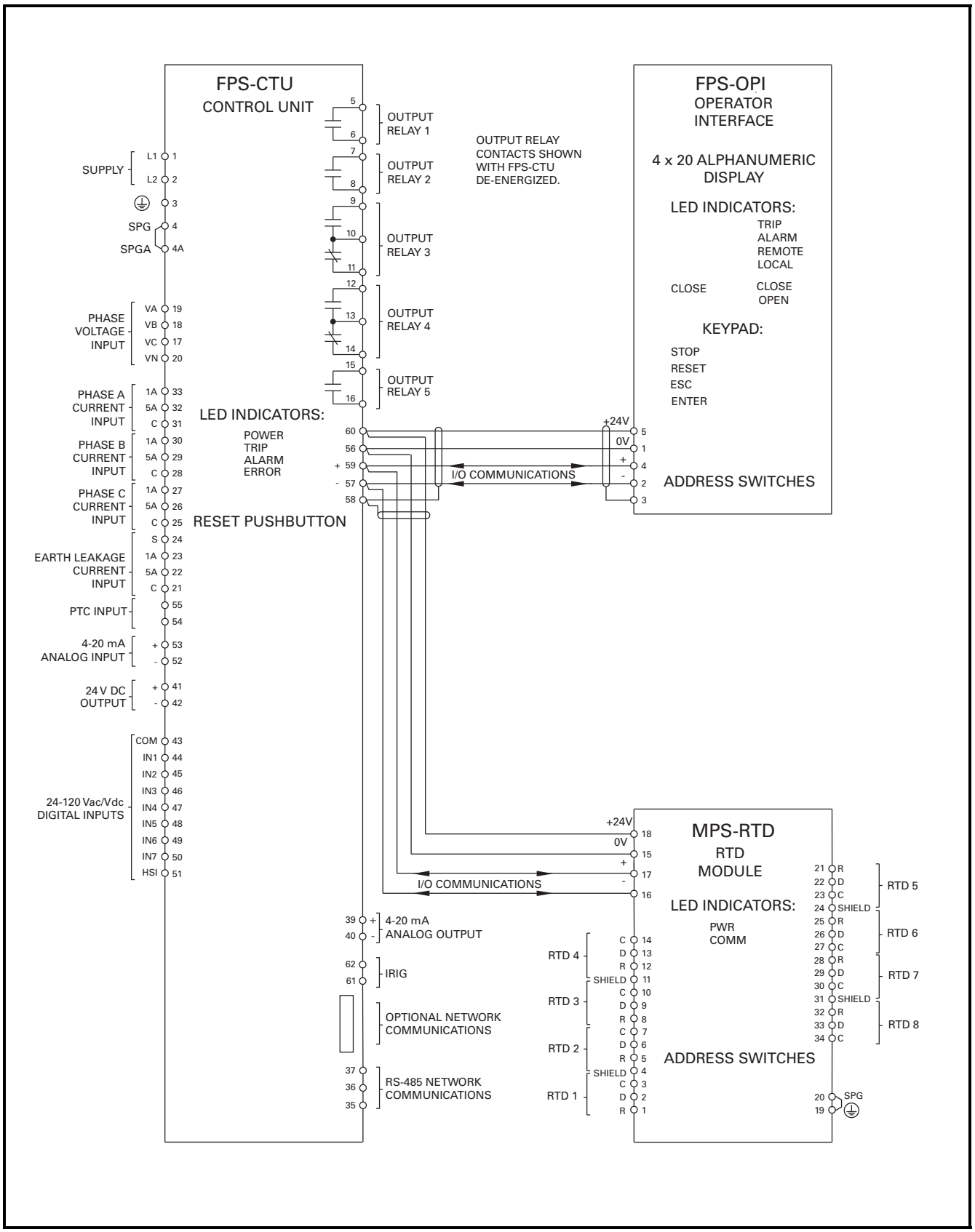
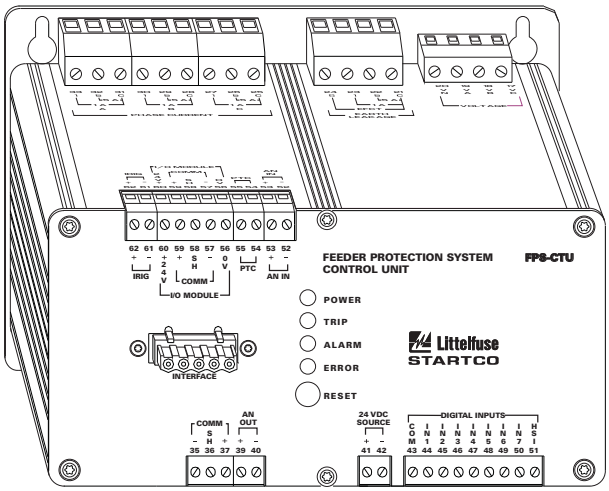


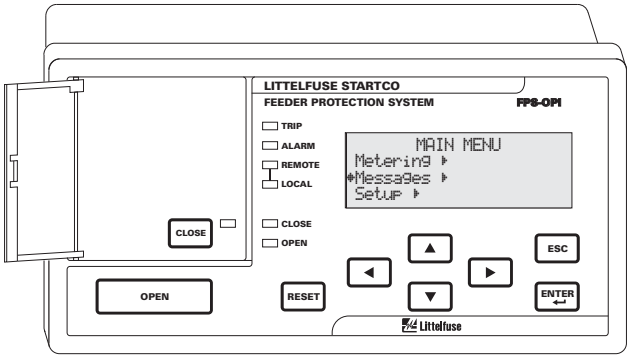
FIGURE 1.1 Feeder Protection System Block Diagram.



FPS-CTU ☐☐ - ☐☐

Communications:
- 01 Standard RS-485. Includes A-B® & Modbus® Protocols
- 02 DeviceNet and standard RS-485
- 03 Profibus® and standard RS-485
- 04 Ethernet and standard RS-485

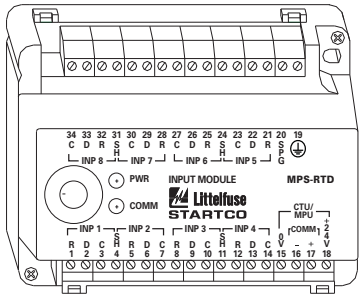
Future Options:
- 00 No Options



FPS-OPI ☐☐ - ☐☐

Display:
- 01 Vacuum Fluorecent

Future Options:
- 00 No Options



MPS-RTD ☐☐ - ☐☐

Configuration:
- 01 8 RTD

Future Options:
- 00 No Options

Supplied Interconnect Cable:

3124A . . . . . I/O Module to MPS-CTU Interconnect Cable, 4 m (13') included with FPS-OPI, MPS-RTD.

FIGURE 1.2 FPS Ordering Information.

2. INSTALLATION

2.1 GENERAL

A basic Feeder Protection System (FPS) consists of an FPS-CTU and three customer-supplied current transformers (CT's) for measuring phase current. For core-balance earth-fault detection, a 1-A, 5-A, EFCT-1, or EFCT-2 CT is required. The residual phase-CT connection can also be used for earth-fault detection. Voltage inputs do not require potential transformers (PT's) for system voltages up to 600 Vac. For RTD-temperature measurement an MPS-RTD module can be connected to the FPS-CTU. The FPS-OPI provides an operator interface for the FPS.

The FPS power-factor corrected switch-mode power supply is rated 65 to 265 Vac and 80 to 275 Vdc.

All modules can be mounted in any orientation.

2.2 FPS-CTU CONTROL UNIT

The Control Unit is configured for surface mounting.

Outline and mounting details for the FPS-CTU are shown in Fig. 2.1.

2.3 FPS-OPI OPERATOR INTERFACE

Outline and mounting details for the FPS-OPI are shown in Fig. 2.2. It is certified for use in Class I, Zone 2 and Class I, Division 2 hazardous locations.

The Operator Interface is configured for panel mounting or it can be mounted on the FPS-CTU as shown in Fig. 2.3.

2.4 MPS-RTD RTD MODULE

Outline and mounting details for the MPS-RTD are shown in Fig. 2.4. The MPS-RTD is certified for use in Class I, Zone 2 and Class I, Division 2 hazardous locations. The MPS-RTD can be surface or DIN-rail mounted.

2.5 EARTH-FAULT CT'S

Outline and mounting details for the EFCT-1, EFCT-2, and EFCT-26 are shown in Figs. 2.5, 2.6, and 2.7.

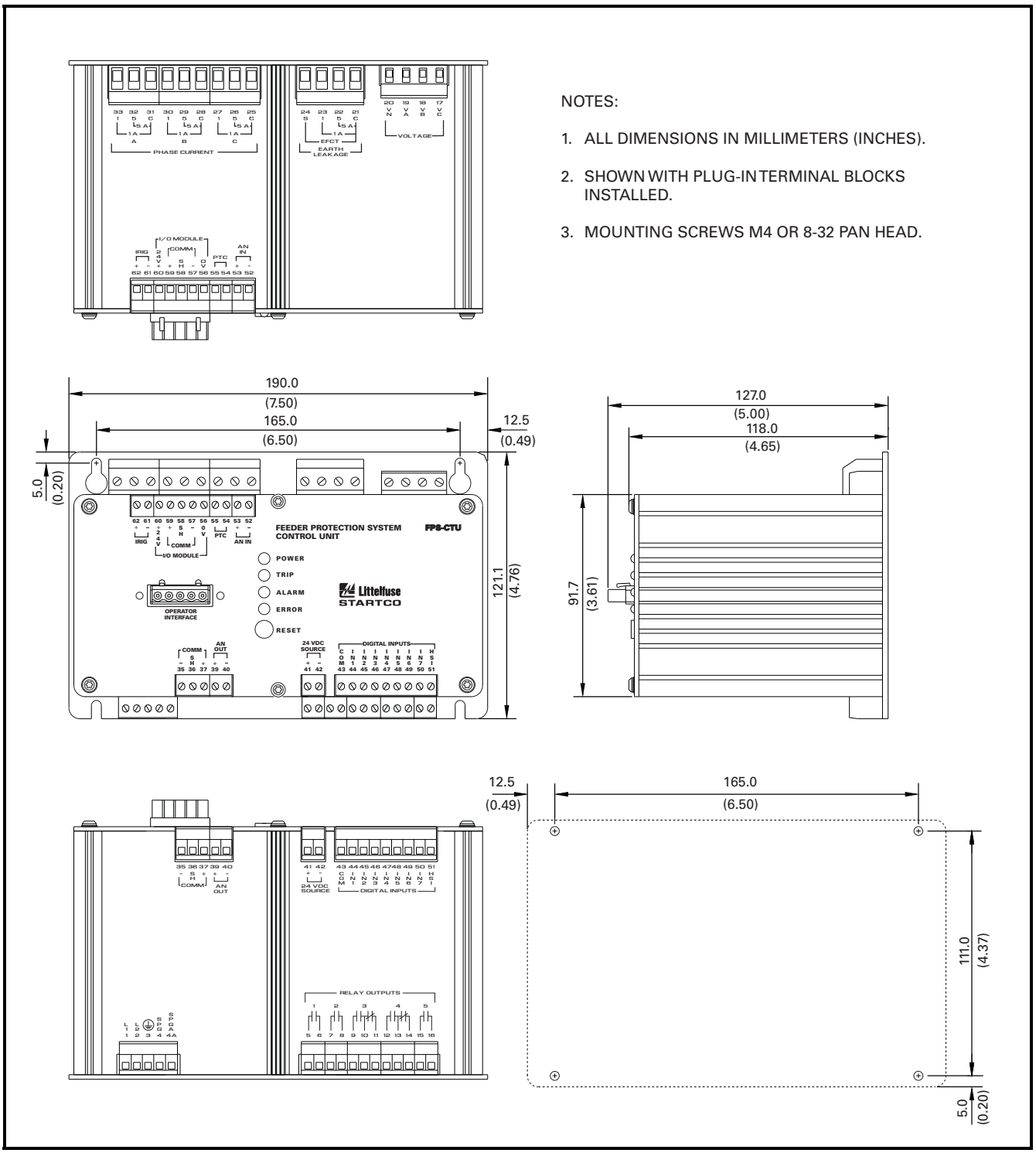


FIGURE 2.1 FPS-CTU Outline and Mounting Details.

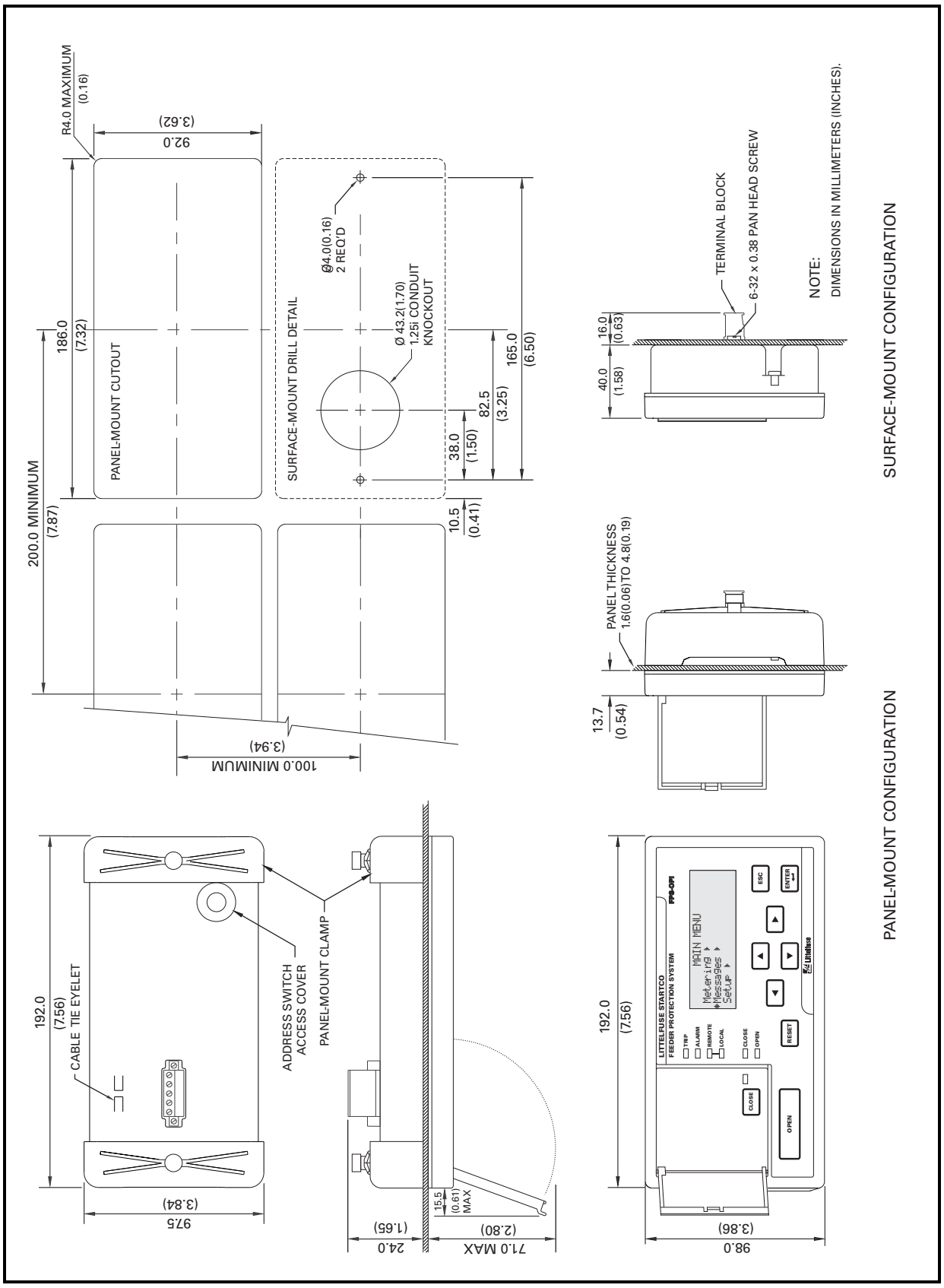


FIGURE 2.2 FPS-OPI Outline and Mounting Details.

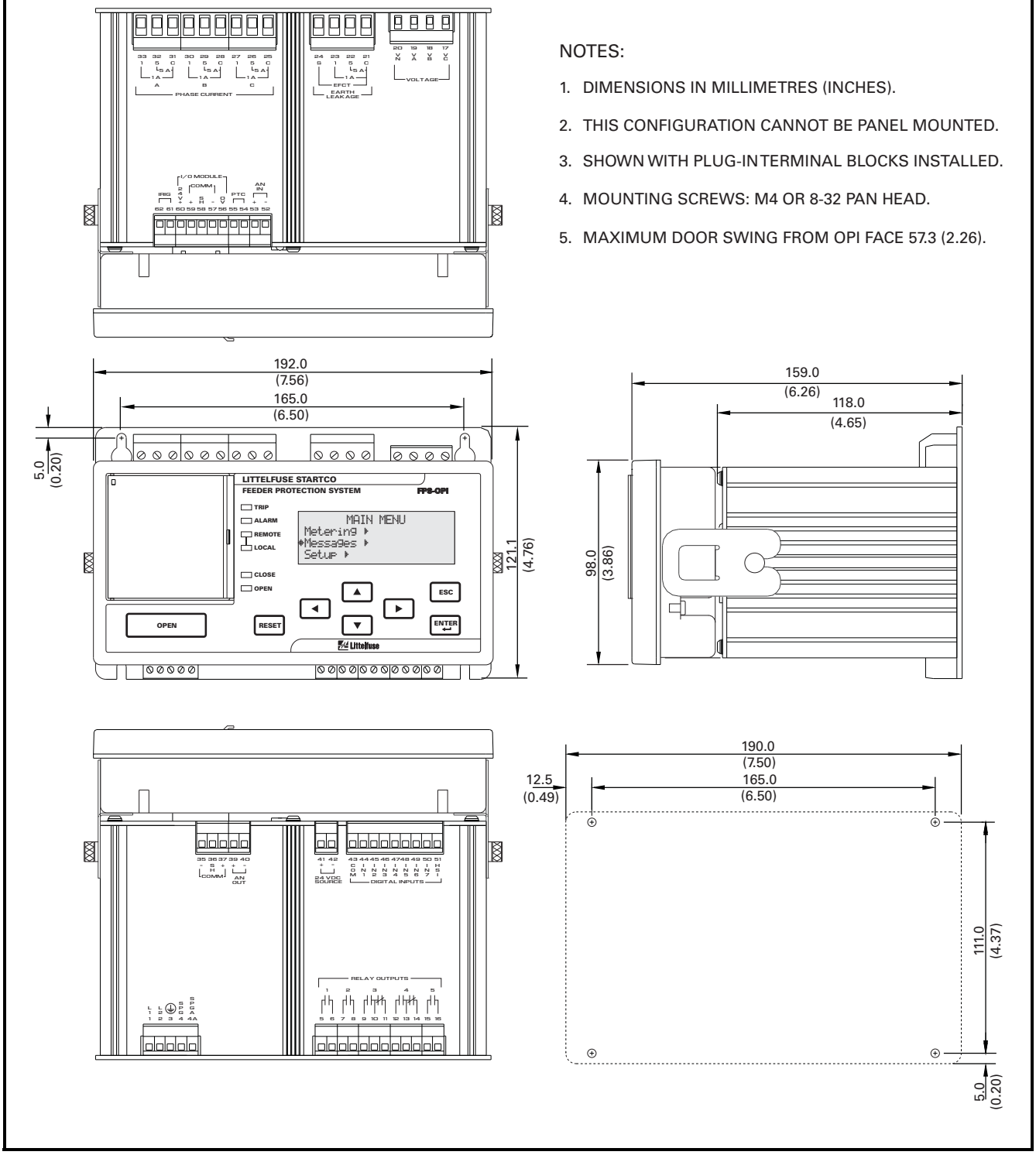
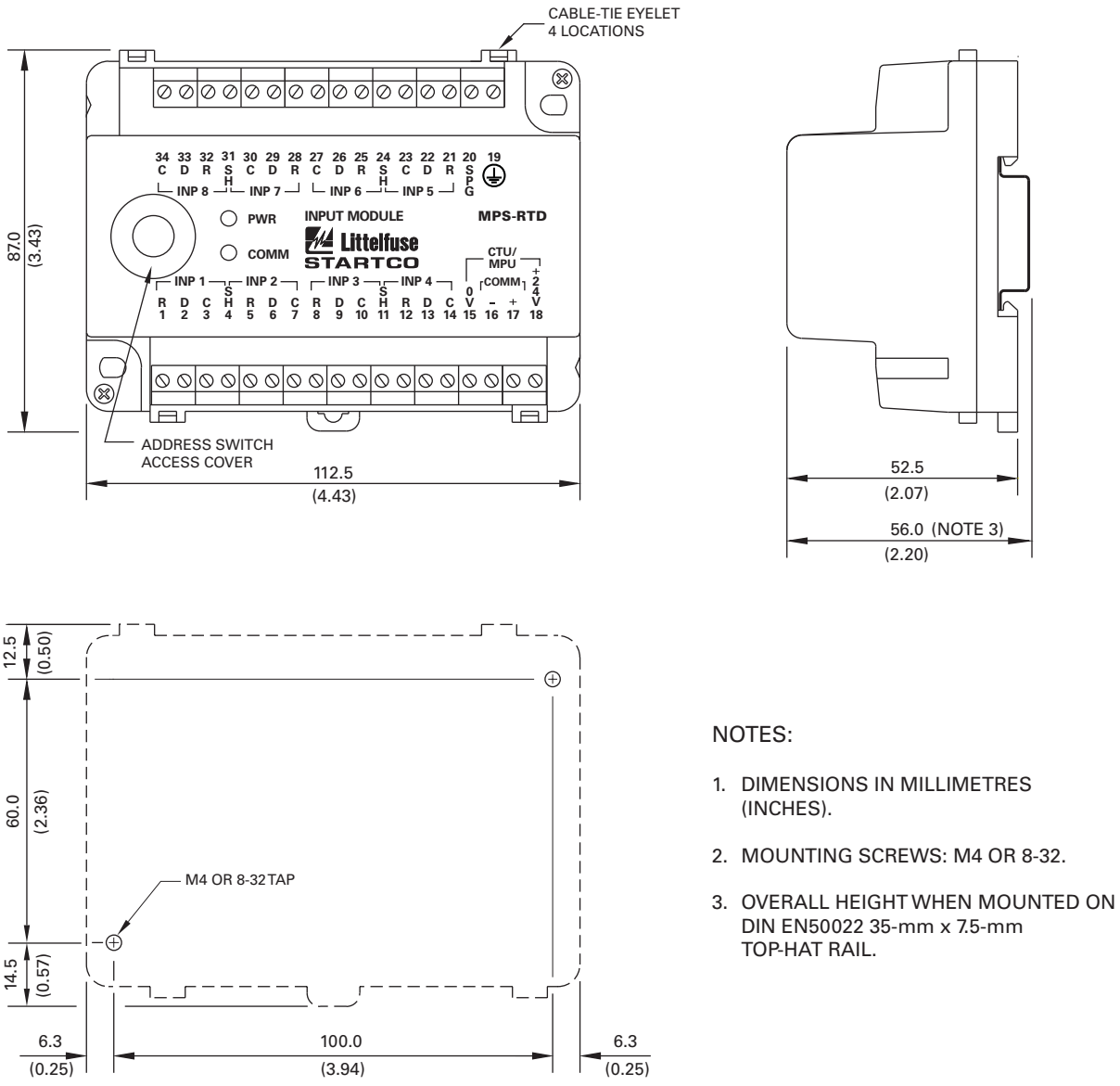


FIGURE 2.3 FPS-CTU with OPI Outline and Mounting Details.



NOTES:

1. DIMENSIONS IN MILLIMETRES (INCHES).
2. MOUNTING SCREWS: M4 OR 8-32.
3. OVERALL HEIGHT WHEN MOUNTED ON DIN EN50022 35-mm x 7.5-mm TOP-HAT RAIL.

FIGURE 2.4 MPS-RTD Outline and Mounting Details.

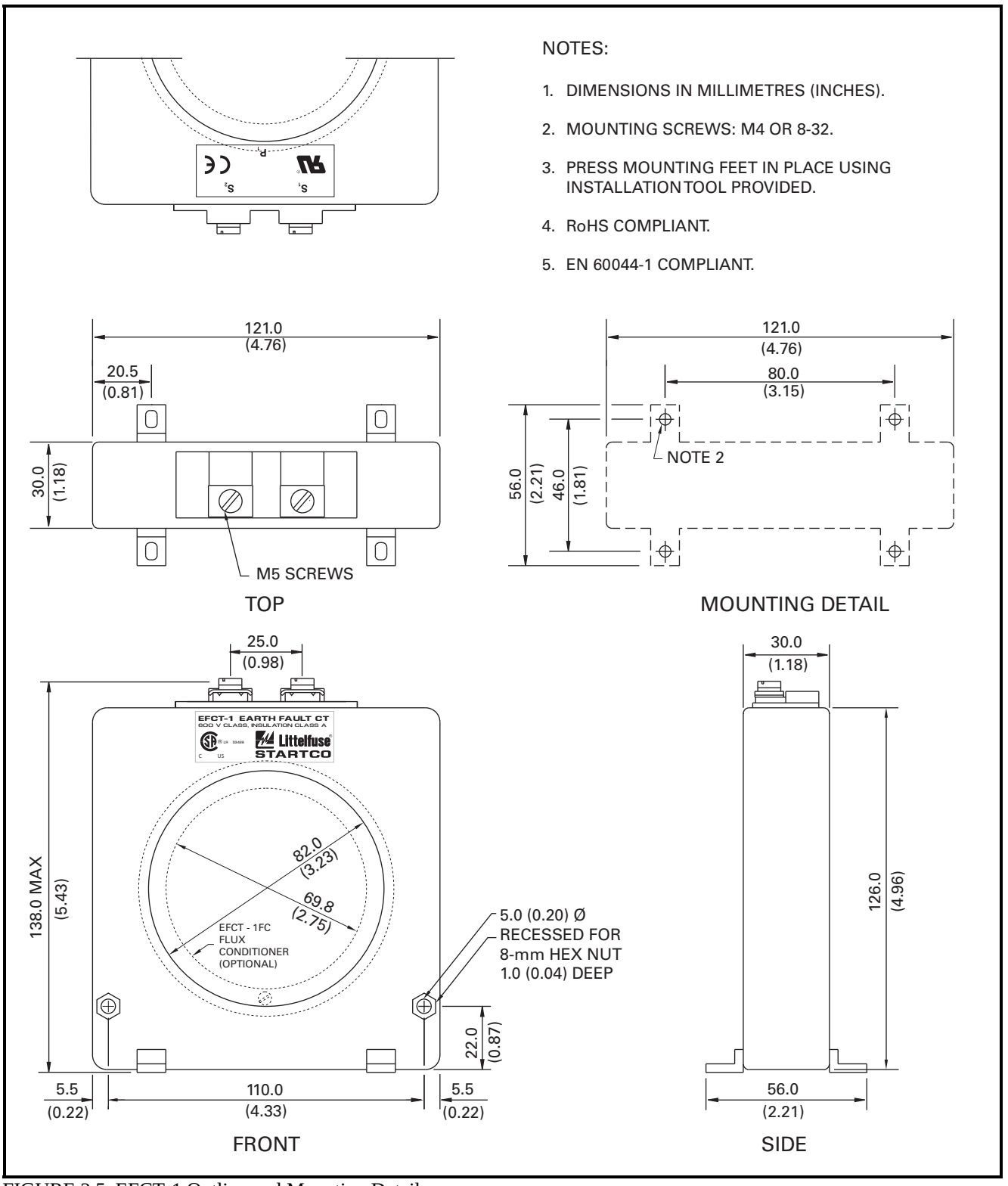


FIGURE 2.5 EFCT-1 Outline and Mounting Details.

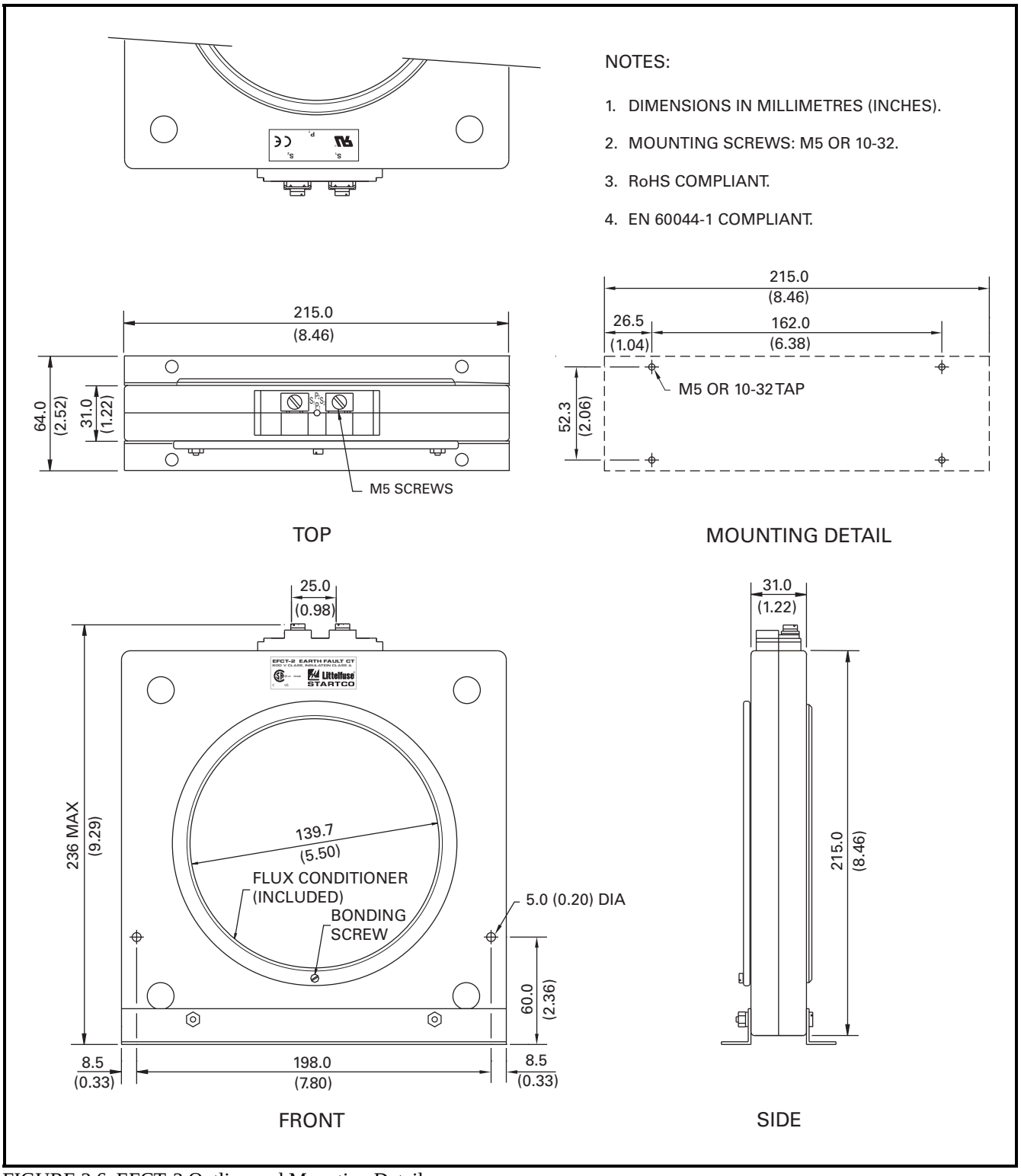
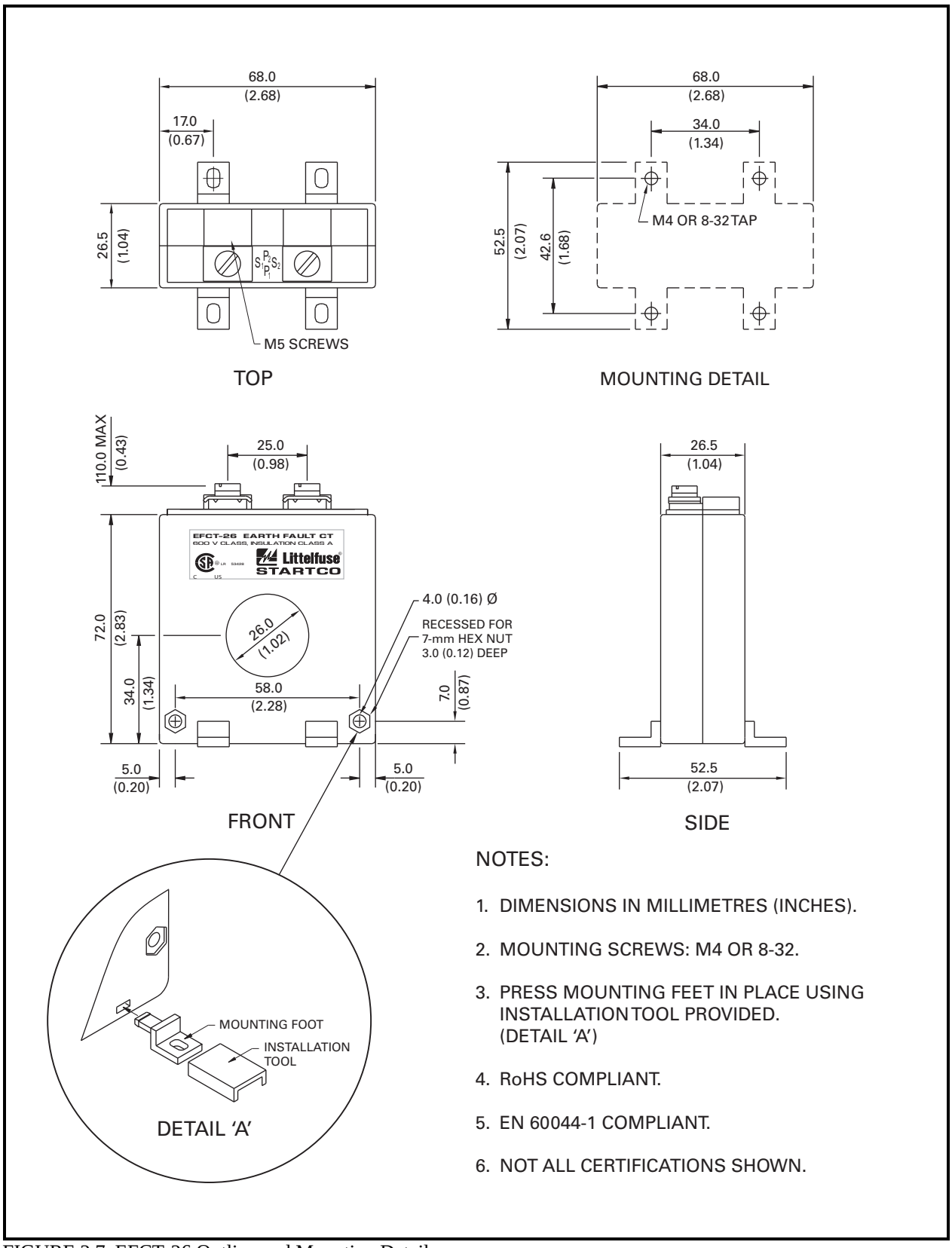


FIGURE 2.6 EFCT-2 Outline and Mounting Details.



NOTES:

1. DIMENSIONS IN MILLIMETRES (INCHES).
2. MOUNTING SCREWS: M4 OR 8-32.
3. PRESS MOUNTING FEET IN PLACE USING INSTALLATION TOOL PROVIDED. (DETAIL 'A')
4. RoHS COMPLIANT.
5. EN 60044-1 COMPLIANT.
6. NOT ALL CERTIFICATIONS SHOWN.

FIGURE 2.7 EFCT-26 Outline and Mounting Details.

3. SYSTEM WIRING

3.1 GENERAL

A typical connection diagram is shown in Fig. 3.1. The FPS-CTU provides the 24-Vdc supply for the peripheral modules and it communicates with them using an RS-485 interface. The total length of the I/O communication system must be less than 1.2 km (4,000'). The power supply in the FPS-CTU will not support more than three I/O modules. An external 24-Vdc power supply is required if more than three modules are used.

The FPS-CTU voltage inputs can be directly connected to a system with line-to-line voltages up to 600 Vac. PT's are required for system voltages higher than 600 Vac. Input resistance of the voltage inputs is 3.4 MΩ.

NOTE: The current and voltage inputs must be phase sequenced A-B-C with correct polarity observed.

Breaker or contactor OPEN and CLOSE commands can be issued through the digital inputs, the network interface, or the FPS-OPI. Breaker or contactor control and interlock contacts can be wired to any of the programmable digital inputs. The five programmable output relays can be used for control, protection, and interlock functions. Relay 5 is a solid-state, low-level output relay not recommended for breaker control. See Section 9 for relay ratings.

NOTE: The default configuration has no assignments for digital inputs and relay outputs.

3.2 WIRING CONNECTIONS

3.2.1 FPS-CTU CONNECTIONS

The FPS-CTU CT-input terminal blocks accept 22 to 10 AWG (0.3 to 4.0 mm^2) conductors. The remaining FPS-CTU clamping blocks accept 24 to 12 AWG (0.2 to 2.5 mm^2) conductors. Terminal blocks unplug to allow the FPS-CTU to be easily replaced.

3.2.1.1 SUPPLY VOLTAGE

Connect supply voltage to terminals 1 and 2 (L1 and L2) as shown in Fig. 3.1. In 120-Vac systems, L2 is usually designated as the neutral conductor. For direct-current power supplies, use L1 for the positive terminal and L2 as the negative terminal. Earth terminal 3 (⏚).

Internal surge-protection devices are connected to terminals 4 (SPG) and 4A (SPGA) to allow dielectric-strength testing. Terminals 4 and 4A must be connected except during dielectric-strength testing.

The 24-Vdc I/O module supply (terminals 56 and 60) can support three I/O modules. An external 24-Vdc supply is required if more than three modules are used.

3.2.1.2 CURRENT INPUTS

The FPS-CTU uses 1-A or 5-A CT's for phase-current measurement. To maintain specified accuracy, phase CT's should be selected with a primary rating between 100 and 300% of feeder current rating. Current threshold is 1.5% of CT-primary rating.

All CT inputs can withstand a common-mode voltage of 120 Vac so that the FPS-CTU can be connected in series with other CT loads. The connection diagram in Fig. 3.1 shows a typical connection where the FPS-CTU is the only device connected to the phase CT's. The FPS-CTU requires the phase sequence to be A-B-C with correct polarity.

A 1-A, 5-A, or sensitive CT is used for core-balance earth-leakage measurement.

3.2.1.3 VOLTAGE INPUTS

For all input-voltage connections, the FPS-CTU requires the phase sequence to be A-B-C with correct polarity.

If voltage inputs are not used, connect VA, VB, and VC to VN.

NOTE: A voltage input is required for line-frequency metering.

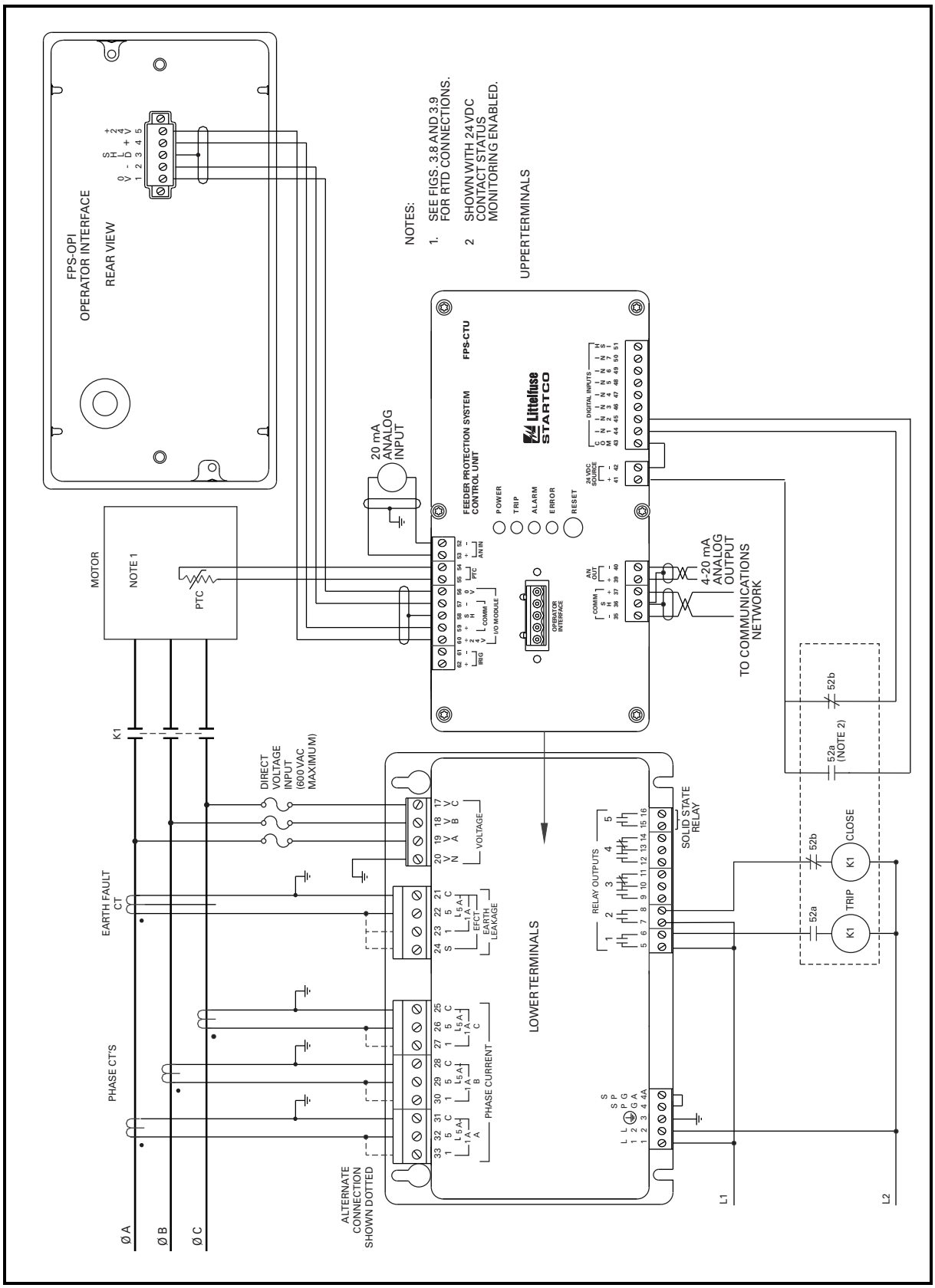


FIGURE 3.1 Typical FPS Connection Diagram.

3.2.1.3.1 DIRECT CONNECTION

Potential transformers (PT's) are not required for system voltages up to 600 Vac line-to-line. Connect the voltage inputs as shown in Figs. 3.1 and 3.2.

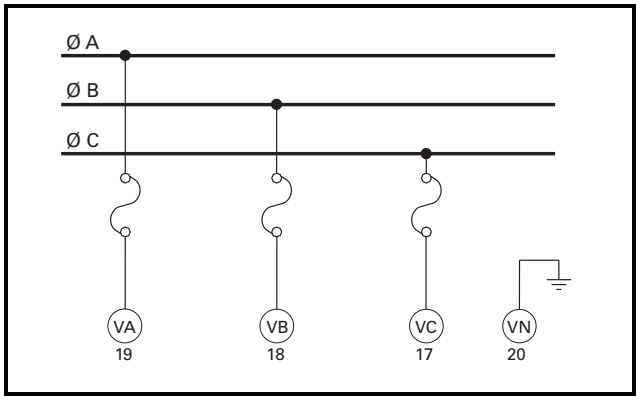


FIGURE 3.2 Direct Connection.

3.2.1.3.2 1-PT CONNECTION

The 1-PT connection is shown in Fig. 3.3. Connect the PT between phase A and phase B. The PT-secondary voltage must be less than 350 Vac.

NOTE: The 1-PT connection does not allow detection of voltage unbalance.

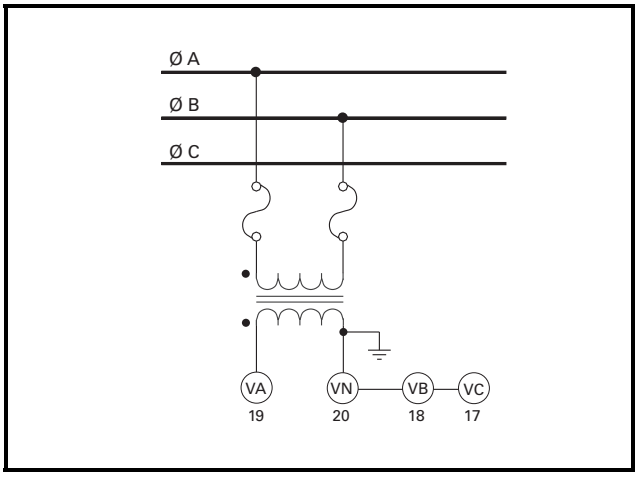


FIGURE 3.3 1-PT Connection.

3.2.1.3.3 2-PT CONNECTION

The 2-PT connection is shown in Fig. 3.4. The PT-secondary voltages must be less than 350 Vac. Connect the PT secondaries in open delta.

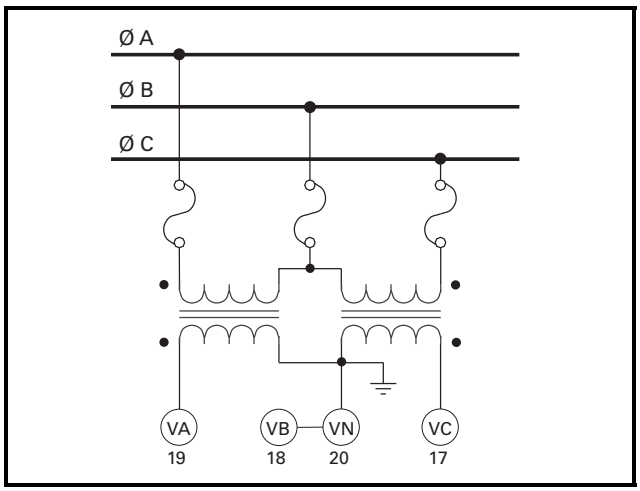


FIGURE 3.4 2-PT Connection.

3.2.1.3.4 3-PT CONNECTION

The 3-PT connection is shown in Fig. 3.5. The PT-secondary voltages must be less than 350 Vac. Since the FPS-CTU measures line-to-line voltage, there is no advantage in using a 3-PT connection over a 2-PT connection.

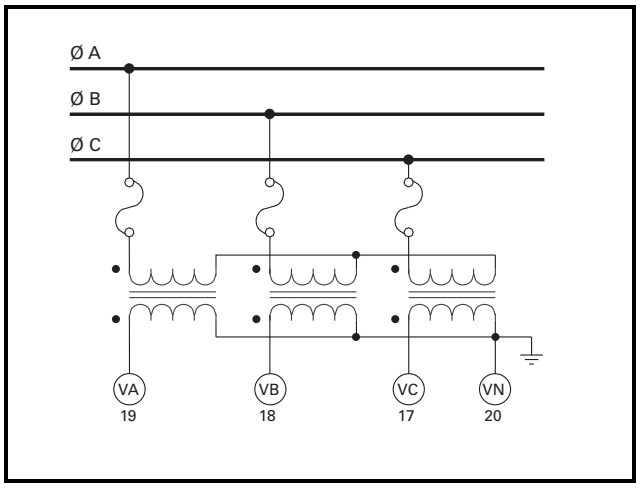


FIGURE 3.5 3-PT Connection.

3.2.1.4 DIGITAL INPUTS

Digital inputs 1 to 8 (terminals 44 to 51) are referenced to COM (terminal 43). These inputs are isolated from all other terminals and operate over a 24 to 130 Vac/Vdc range. Inputs 1 to 7 have programmable functions. See Table 4.2.

3.2.1.4.1 DC OPERATION

Supply voltage for dc-input operation can be obtained from the 24-Vdc source (terminals 41 and 42), or it can be obtained from an external 24- to 130-Vdc supply.

The internal source is current limited at 100 mA and is referenced to the analog output (terminal 40) and the I/O Supply (terminal 56). Connect the "–" terminal of the dc source to COM and connect field inputs between "+" and the digital-input terminals.

3.2.1.4.2 AC OPERATION

Inputs operate over a 24- to 130-Vac range. Connect the ac neutral to COM and connect field inputs between line and the digital inputs.

3.2.1.4.3 COMBINED AC AND DC OPERATION

If both ac and dc inputs are used, connect both the ac-supply neutral and dc-supply "–" to COM.

3.2.1.5 ANALOG INPUT (AN IN)

The analog input (terminal 52 and 53) is a 4–20-mA current input with a 100-Ω input impedance.

NOTE: The analog input is referenced to an internal supply with 100-kΩ resistors. Maximum common-mode voltage is ± 5 Vdc with respect to FPS-CTU terminal 4.

3.2.1.6 ANALOG OUTPUT (AN OUT)

The analog output is a self-powered current-source output. The current-source output is the "+" (terminal 39) and the common is "–" (terminal 40).

NOTE: The analog output (terminal 40) is internally referenced to the 24-Vdc source (terminal 42) and the I/O supply (terminal 56).

3.2.1.7 PTC INPUT

Terminals 54 and 55 are provided for PTC over-temperature protection. See Section 9 for specifications.

3.2.1.8 IRIG-B INPUT

Terminals 61 and 62 are used for an IRIG-B time-code signal. When an IRIG-B signal is detected, the real-time clock (RTC) synchronizes with it. The user must set the FPS date value because the IRIG-B day-of-the-year parameter is not supported.

If the time-code generator does not have a local-time adjustment, the IRIG Offset set points can be used to adjust the hour and minute values so that the FPS will read local time.

3.2.1.9 I/O MODULE COMMUNICATION

The I/O module communications interface (terminals 56 through 60) is used to support optional modules. The connector labeled Operator Interface on the FPS-CTU top panel is in parallel with terminals 50 to 56. It is used for direct FPS-OPI mounting. See Section 2.3.

I/O module communication is based on the two-wire multi-drop RS-485 standard. Overall line length must not exceed 1.2 km (4,000'). For line lengths exceeding 10 m (33'), 150-Ω terminations are required at the cable ends. See Fig. 3.7.

3.2.1.10 RS-485 NETWORK COMMUNICATIONS

Terminals 35, 36, and 37 are used for the standard RS-485 interface. See Section 4.2.15.

3.2.2 FPS-OPI CONNECTIONS AND ADDRESS SELECTION

Connect the FPS-OPI to the FPS-CTU using shielded cable (Belden® 3124A or equivalent). The 24-Vdc supply for the FPS-OPI is provided by the FPS-CTU. The cable shield must be connected at both ends so that FPS-OPI transient protection is operational. See Fig. 3.7.

The FPS-OPI has two switches to select its network address. See Figs. 2.2 and 3.6. Up to three FPS-OPI modules can be connected to the I/O MODULE bus, and each active OPI must have a unique address. If one OPI is used, address 1 must be used. If two OPI's are used, addresses 1 and 2 must be used. If three OPI's are used, addresses 1, 2, and 3 must be used.

Table 3.1 and Fig. 3.6 shows the addressing selection format.

TABLE 3.1 FPS-OPI ADDRESS SELECTION

ADDRESS	SWITCH 1	SWITCH 2
0 (Factory Test)	Open	Open
1 (First OPI)	Closed	Open
2 (Second OPI)	Open	Closed
3 (Third OPI)	Closed	Closed

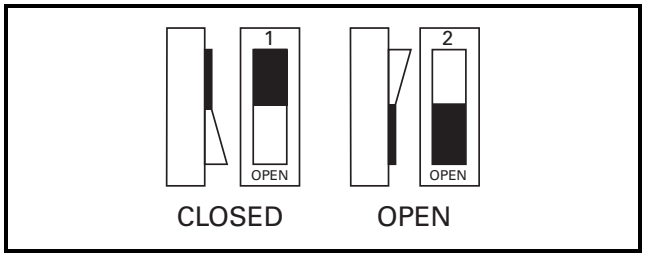


FIGURE 3.6 Address Selection Switch Detail.

3.2.3 MPS-RTD CONNECTIONS AND ADDRESS SELECTION

MPS-RTD terminal blocks accept 24 to 12 AWG (0.2 to 2.5 mm^2) conductors.

Connect the MPS-RTD to the FPS-CTU using the four-conductor shielded cable (Belden 3124A or equivalent) as shown in Fig. 3.7.

Connect RTD's to the MPS-RTD as shown in Fig 3.7.

Connect the surge-protection (SPG) terminal 20 to terminal 19 (⏚), and earth terminal 19.

The MPS-RTD has two switches to select its network address. See Figs. 3.6 and 3.8. Only one RTD module is supported. Select address 1 to enable RTD module communication.

Table 3.2 shows the addressing selection format.

3.2.4 DIELECTRIC-STRENGTH TESTING

Dielectric-strength testing should be performed only on CT inputs, PT inputs, output relays, and digital inputs. Unplug all other I/O and remove the SPG connection (terminal 4 to terminal 4A) on the FPS-CTU during dielectric-strength testing.

TABLE 3.2 MPS-RTD ADDRESS SELECTION

ADDRESS	SWITCH 1	SWITCH 2
0 (Offline)	Open	Open
1 (RTD Module Enabled)	Closed	Open
2 (Reserved)	Open	Closed
3 (Reserved)	Closed	Closed

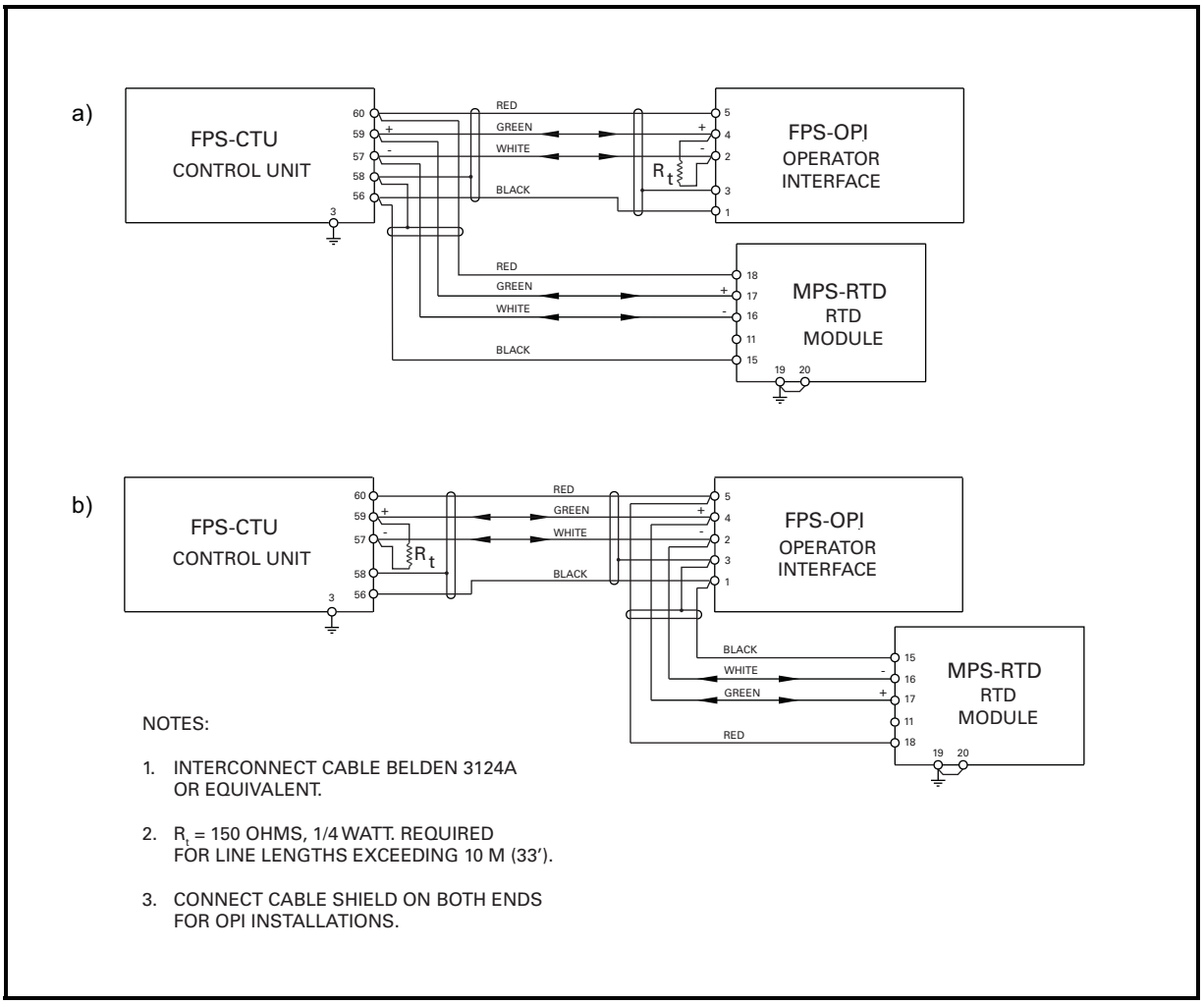


FIGURE 3.7 Two Examples of I/O Module Connections.

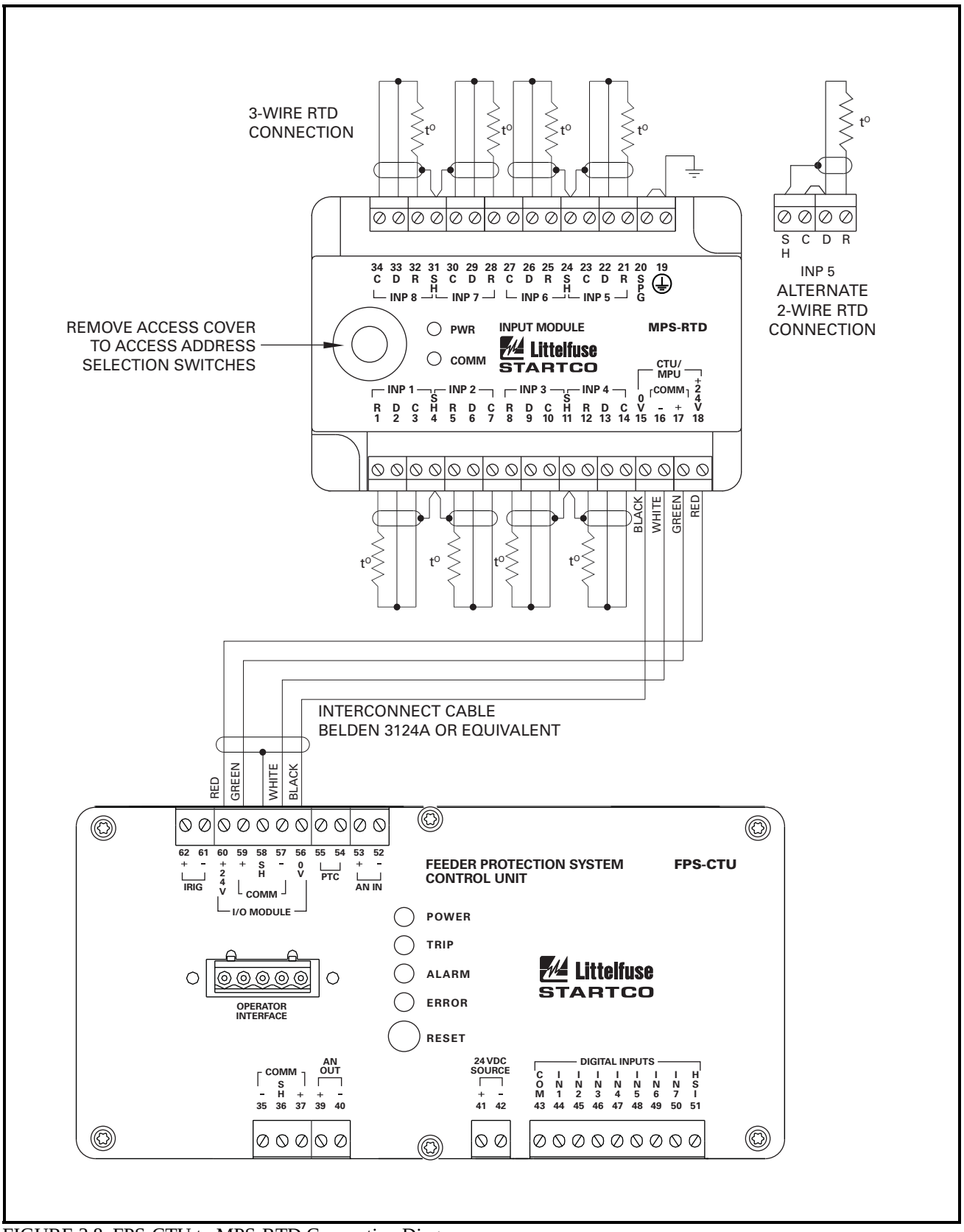


FIGURE 3.8 FPS-CTU to MPS-RTD Connection Diagram.

4. OPERATION AND SETUP

4.1 GENERAL

The FPS-CTU can operate independently. It can also operate in conjunction with network communications, the FPS-OPI, and the MPS-RTD. All settings are stored in the FPS-CTU and can be accessed using the OPI or the network communications interface. Use SE-Comm-RIS software and an SE-485PP or SE-485-DIN serial converter to program with a personal computer.

In the following sections, menu items and setup parameters are listed in italics and are shown in the format displayed on the OPI. The OPI cannot display subscripts and superscripts.

Menu selection is in the following format:
Menu 1 | *Sub Menu 1* | *Sub Menu 2* | *Sub Menu 3* |……

Example: For the menu item shown in Fig. 4.1, the notation is *Setup* | *System Ratings* | *CT Primary*

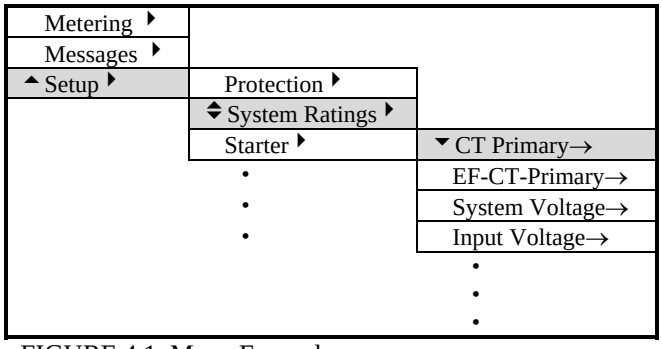


FIGURE 4.1 Menu Example.

Fig. 4.2 shows the symbols that assist in navigating the menu system and how these symbols relate to the arrow keys on the FPS-OPI. See the menu map in Appendix A.

4.2 FPS-CTU

4.2.1 LED INDICATION

The four LED's on the FPS-CTU indicate POWER (green), TRIP (red), ALARM (yellow), and ERROR (red). The POWER LED is ON when supply voltage is present. The TRIP and ALARM LED's indicate a trip or alarm condition. The ERROR LED is ON during firmware updates or when there is an FPS-CTU failure.

4.2.2 RESET SWITCH

The reset switch is used to simultaneously reset all trips. Trips cannot be held off by a maintained closure.

4.2.3 PHASE-CT INPUTS

OPI Menu: *Setup* | *System Ratings* | *CT Primary*

The setting range for the CT-primary rating is 1 to 5,000 A. To maintain specified accuracy, phase CT's should be selected with a primary rating between 100 and 300% of rated current.

Current unbalance will indicate "–" if the current sequence is B-A-C. If B-A-C sequence is indicated, correct the CT connections so that power measurements will be valid.

NOTE: B-A-C sequence will cause a trip if current phase-reverse protection is enabled.

NOTE: Phase-unbalance and phase-loss testing requires three-phase inputs to the FPS.

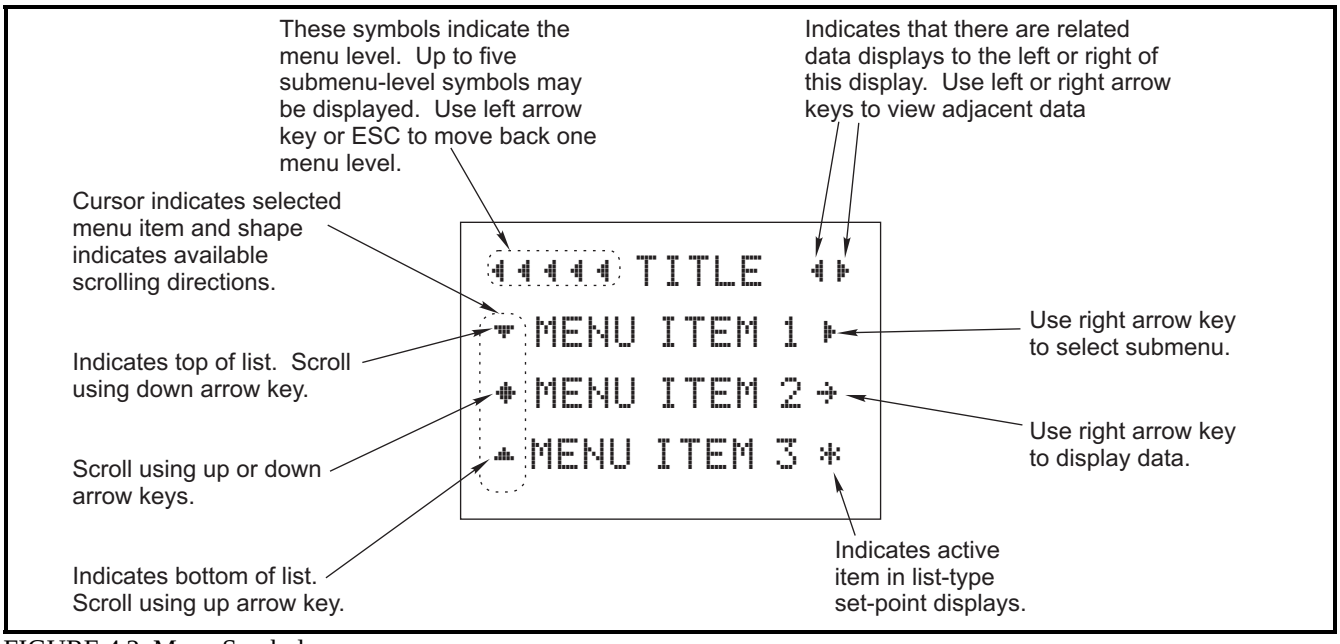


FIGURE 4.2 Menu Symbols.

4.2.4 EARTH-FAULT-CT INPUT

OPI Menu: *Setup* | *System Ratings* | *EF-CT Primary*

The setting range for the earth-fault-CT-primary rating is 1 to 5,000 A. The CT-primary rating is 5 A for sensitive CT's—EFCT-1 and EFCT-2.

4.2.5 VOLTAGE INPUTS

OPI Menu: *Setup* | *System Ratings*

Select the voltage-connection type (1 PT line-line, 2 PT line-line, 3 PT line-neutral/direct) to enable voltage-measuring functions. *System Voltage* is the system line-to-line voltage. The system voltage range is 120 V to 75 kV. For the 1-PT and 2-PT connections, *Input Voltage* is the PT-secondary voltage when system voltage is applied. For the 3-PT connection, the *Input Voltage* is the PT-secondary line-to-line voltage (208 V for 120-V-secondary PT's). For the direct connection, set *Input Voltage* the same as the *System Voltage* setting. In all cases, line-to-line voltages are displayed.

Voltage unbalance will indicate "–" if the voltage sequence is B-A-C. If B-A-C sequence is indicated, correct the PT connections so that power measurements will be valid.

NOTE: The 1-PT connection does not allow detection of voltage unbalance.

NOTE: B-A-C sequence will cause a trip if voltage phase-reverse protection is enabled.

4.2.6 FREQUENCY

OPI Menu: *Setup* | *System Ratings* | *Frequency*

Set *Frequency* at 50 or 60 Hz.

4.2.7 SET-POINT GROUP

OPI Menu: *Setup* | *System Ratings*

The FPS-CTU supports two set-point groups. The *Setup* | *System Ratings* | *Set-Point Group* menu specifies the active set-point group as Group1 or Group2. If the digital input is used to select the set-point group, it has priority over the menu setting.

4.2.8 OUTPUT RELAY ASSIGNMENT

OPI Menu: *Setup* | *Relay Outputs* | *Relay x*

Each of the five output relays can be assigned to one of the functions listed in Table 4.1. More than one relay can be assigned the same function. Note that Relay 5 is a solid-state relay with a low current rating.

Relay function *CB Open*, *CB Close*, and *Contactor* operate in conjunction with the breaker or contactor control functions. A control type other than *Protection Only* must be selected in the *Breaker Control* | *Control Type* menu. See Section 6. Breaker or contactor close status can be monitored using auxiliary contacts and the digital inputs. See Section 4.2.9.

TABLE 4.1 OUTPUT-RELAY FUNCTIONS

FUNCTION	ASSIGNMENT OR ACTION
Trip1	Relay operates when a trip occurs in a protective function assigned Trip1, Trip1&2, Trip1&3, or Trip1,2,&3. Fail-safe or non-fail-safe mode selection is active.
Trip2	Relay operates when a trip occurs in a protective function assigned Trip2, Trip1&2, Trip2&3, or Trip1,2,&3. Fail-safe or non-fail-safe mode selection is active.
Trip3	Relay operates when a trip occurs in a protective function assigned Trip3, Trip1&3, Trip2&3, or Trip1,2,&3. Fail-safe or non-fail-safe mode selection is active.
Alarm1	Relay operates when an alarm occurs in a protective function assigned Alarm1, Alarm1&2, Alarm1&3, or Alarm1,2,&3. Fail-safe or non-fail-safe mode selection is active.
Alarm2	Relay operates when an alarm occurs in a protective function assigned Alarm2, Alarm1&2, Alarm2&3, or Alarm1,2,&3. Fail-safe or non-fail-safe mode selection is active.
Alarm3	Relay operates when an alarm occurs in a protective function assigned Alarm3, Alarm1&3, Alarm2&3, or Alarm1,2,&3. Fail-safe or non-fail-safe mode selection is active.
CB Open (3)	Relay energized momentarily to open circuit breaker.
CB Close (3)	Relay energized momentarily to close circuit breaker.
Contactor (3)	Relay energized to close contactor, de-energized to open/trip contactor.
Trip1 Pulse (1)	Trip1 energizes the relay for the time duration specified by the *RY Pulse Time* set point.
Local	Relay energized when Local control is selected.
Interlock	Relay is energized when all digital-input interlocks are completed.
Current	Relay is energized when current is detected.
Network Control	Relay controlled via network.
Group2	Relay is energized when Group2-setpoints are active.
Watchdog	Relay is energized when the supply voltage is applied and the FPS is operating properly.
None (2)	No Assignment (Default)

(1) Assign this function to only one relay. Non-fail-safe operation only.
(2) Relay outputs must be assigned. Default is None.
(3) Only active if a control type is enabled.

When a trip occurs, control relays operate to open the breaker or contactor and relays assigned the *Trip1, Trip2,* or *Trip3* function operate. The trip signal may originate from a protective function, from a digital input assigned the *Trip1* function, or from a communications network command. See Sections 4.2.9 and 6.

Relays assigned a trip or alarm function operate in fail-safe or non-fail-safe mode. Set the mode using the *Setup | Relay Outputs | Relay x | Mode* menu.

Except for overload trips, which can be selected to auto-reset, trips must be reset with an FPS-OPI, a digital input, or a network command. A trip cannot be reset when the trip condition is present.

When a protective function issues an alarm, relays assigned to the corresponding Alarm1, Alarm2, or Alarm3 function operate. Alarms auto-reset when the alarm condition is corrected.

Relays assigned the *Interlock* function energize when all digital inputs assigned the *Interlock* function are valid (voltage detected at digital input).

4.2.9 DIGITAL INPUTS 1 TO 7

OPI Menu: *Setup | Digital Inputs | Digital Input x | Input x Function*
OPI Menu: *Setup | Digital Inputs | Digital Input x | In x Start Bypass*
OPI Menu: *Setup | Digital Inputs | Digital Input x | In x Bypass Delay*
OPI Menu: *Setup | Digital Inputs | Digital Input x | In x Trip Delay*

Each digital input can be assigned to one of the functions listed in Table 4.2. More than one digital input can be assigned the same function.

Close inputs are not active when *Protection Only* is selected as the control type. OPEN on the FPS-OPI is always active. When *Control Type* is set to None, OPEN initiates a *Trip1* signal.

Close Bypass, *Bypass Delay*, and *Trip Delay* set points apply only when *Trip1* is selected. When *Close Bypass* is enabled, the *Trip1* function is bypassed when a close is detected for the duration specified by *Bypass Delay*. After the *Bypass Delay*, the *Trip1* function is enabled and a trip occurs if the digital-input voltage is removed for the time specified by the *Trip Delay*. If *Close Bypass* is disabled, *Bypass Delay* is not used and the *Trip1* function is always enabled.

Reset inputs are "one-shot" resets that require a transition from open to closed. Maintaining a reset switch closure does not inhibit trips.

LOCAL is selected using the digital input, or by network communications. The *Local Select* source is responsible for de-selecting. For example if both the digital input and the network communications select LOCAL, both must also de-select LOCAL. In the event that the network fails to deselect LOCAL, de-selection can be performed using the *Setup | System Config | Maintenance | Unlock Local Menu*.

When assigned to Set-Point Group, one of the two groups is selected. The digital-input selection has priority over the *Setup | System Ratings | Set-Point Group* setting.

TABLE 4.2 DIGITAL-INPUT FUNCTIONS

FUNCTION	STATE (1)
Group2 Settings	1 = Group2 Set Points Active 0 = Group1 Set Points Active
Local Control	1 = Local Control Mode 0 = Remote Control Mode
Permissive	1 = Close Allowed 0 = Close Not Allowed (Device Open)
3-Wire Close	1 = Close Device (Momentary, 3-Wire Open/Close)
2-Wire Close	1 = Close Device (Maintained) 0 = Open Device
3-Wire Close Local (3)	1 = Close Device (Momentary, 3-Wire Open/Close)
2-Wire Close Local (3)	1 = Close Device (Maintained) 0 = Open Device
52a Close Status	1 = Device Closed 0 = Device Open
52b Open Status	1 = Device Open 0 = Device Closed
Interlock (2)	1 = Close Allowed (If All Interlocks are Valid) 0 = Close Not Allowed
Trip1	1 = No Trip1 0 = Trip1 (Delays Selectable)
Reset	1 = Reset trips
+ Trig	1 = Positive-Edge Record Trigger
- Trig	1 = Negative-Edge Record Trigger
+ - Trig	1 = Transition Trigger
Control Power	1 = Voltage Present on Input 0 = No Voltage Present on Input
None	No Assignment (Default)

(1) 1 = Input voltage applied, 0 = Input voltage not applied.
(2) Interlocks bypassed in LOCAL.
(3) Operational only in LOCAL.

The following rules apply when multiple inputs are assigned the same function:

- *3-Wire Close and 3-Wire Close Local*: Momentary voltage on any input will initiate a close. (FPS must be in LOCAL for *Local Close* operation.)
- *Permissive:* Voltage must be present on all inputs to allow an FPS-controlled close.
- *Interlock:* Voltage must be present on all inputs to allow an FPS-controlled close and to energize an interlock output relay. Digital inputs programmed as *Interlock* are bypassed in LOCAL.
- *52a Close Status*: Voltage must be present on all inputs when device is closed and not present when device is open.
- *Reset*: Voltage applied to any input will reset trips.
- *2-Wire Close*: Voltage on any input will initiate a close. All inputs must be removed for valid open.
- *52b Open Status*: Voltage must be present when device open and not present when device is closed.

The *Permissive* and *Interlock* settings are used in conjunction with the breaker or contactor control functions. Both must be valid to allow a close operation. The permissive input is typically connected to a normally closed push-button when 3-wire control is used. The distinguishing feature between permissive and interlock inputs is that interlocks are bypassed in LOCAL while permissive inputs must be valid for both REMOTE and LOCAL modes of operation.

Device open and close status is monitored by inputs programmed as *52a Close Status* and *52b Open Status*. The 52a inputs must be valid (voltage present) when the device is closed and the 52b inputs must be valid (voltage present) when the device is open. See Section 6.2.1.

For maximum control integrity and immunity to power fluctuations, the 24-Vdc source voltage provided on terminals 41 and 42 should be used for digital-input operation. If external ac voltage is used for digital-input control, it is recommended to connect control voltage to one of the digital inputs programmed for *Control Power*. This input is used to indicate the presence of control voltage. When voltage is not detected on this input, a 500 ms delay is active on all other inputs to allow the FPS to "ride-through" voltage fluctuations and power-off conditions without a false trip caused by loss of voltage on a digital input.

4.2.10 ANALOG OUTPUT

OPI Menu: *Setup* | *Analog Output* | *Output Parameter*

A 4-20-mA programmable current output is provided on the CTU. Analog-output parameters are shown in Table 4.3.

Factory calibration is 4-20 mA. If calibration is required, use the *Analog Output* menus.

Zero Calibration:

- Select *Zero* in the *Output Parameter* menu.
- Measure the output current and adjust the *Zero Calibrate* setting for the desired output. The calibration number for 4 mA will be in the range of 100 to 110.

Full-Scale Calibration:

- Select *Full Scale* in the *Output Parameter* menu.
- Measure the output current and adjust the *FS Calibrate* setting for the desired output. The calibration number for 20 mA will be in the range of 540 to 550.

Calibration numbers are not changed when factory defaults are loaded.

4.2.11 ANALOG INPUT

OPI Menu: *Setup* | *4-20 Analog In* | *Input Function*

The analog input function is selectable as *Metering or Protection*.

4.2.11.1 METERING ONLY

OPI Menu: *Setup* | *4-20 Analog In* | *Metering Only*

When *Metering Only* is selected, an analog input does not affect FPS operation, but its value can be observed in the *Metering* menu.

4.2.11.2 PROTECTION

OPI Menu: *Setup* | *4-20 Analog In* | *Protection*

The *Protection* analog input has high- and low-level trip and alarm set points. A high-level trip or alarm occurs when the 4-20-mA input exceeds the high-level trip or alarm set point. A low-level trip or alarm occurs when the 4-20-mA input is lower than the low-level trip or alarm set point.

TABLE 4.3 ANALOG-OUTPUT PARAMETERS

PARAMETER	FULL SCALE	COMMENTS
Phase Current	PH-CT-Primary Rating	Maximum of 3 Phases
Earth Leakage	EFCT-Primary Rating	
Used I^2t Capacity	100% I^2t	
Group A Temperature [(1)]	200°C	Maximum of Group A RTD's
Group B Temperature [(1)]	200°C	Maximum of Group B RTD's
Group C Temperature [(1)]	200°C	Maximum of Group C RTD's
Ambient Temperature [(1)]	200°C	Maximum of Ambient RTD's
Voltage	System Voltage	Maximum Line-to-Line Voltage
Unbalance (I)	1.0 per Unit or 100%	I_2/I_1
Power Factor	1.0	Absolute Value
Real Power	CT Primary × System Voltage × √3	Absolute Value
Reactive Power	CT Primary × System Voltage × √3	Absolute Value
Apparent Power	CT Primary × System Voltage × √3	Absolute Value
Zero	Not Applicable	Used for Zero Calibration
Full Scale	Not Applicable	Used for Full-Scale Calibration

(1) Output range is 0 to 200°C. The output defaults to the calibrated zero output for an open or shorted RTD sensor.

4.2.12 BREAKER CONTROL

OPI Menu: *Setup* | *Control*

As a default, *Control Type* is set to *Protection Only*. When a *Control Type* is selected, an output relay must be assigned for breaker control. See Section 4.2.8. Digital inputs must be assigned if breaker-status feedback is required. See Section 4.2.9.

See Section 6 for breaker control information.

4.2.13 PROTECTION

OPI Menu: *Setup* | *Protection*

OPI Menu: *Setup* | *System Ratings* | *Run Mode Delay*

See Section 5 for protective function details.

4.2.14 MISCELLANEOUS CONFIGURATION

OPI Menu: *Setup* | *System Config*

System Name	Appears on many of the display screens and can be set by the user. (18-character alphanumeric field)
Password	Used to change the 4-character alphanumeric password.
Clock Setting	Used to set the date, 24-hour clock, and IRIG set points. Daylight savings time is not supported.
Password Timeout	Used to set the password time-out delay. Delay is measured from last key press.
Maintenance	Used to clear event records, trip counters, and energy values. Used to load defaults. Used to view firmware version and serial numbers. Used to unlock local control if communication is lost. Used for firmware updates

4.2.15 NETWORK COMMUNICATIONS

OPI Menu: *Setup* | *Hardware* | *Network Comms*

The standard interface on the FPS is an RS-485 network. This network supports Modbus® RTU and A-B® DF1 protocols.

The protocol, network ID (address), error checking, and baud rate are selectable. See Appendices C, D, E, and F.

If equipped with an optional network interface, refer to the appropriate FPS communications interface manual.

4.3 FPS-OPI

4.3.1 GENERAL

See Fig. 4.2. The Operator Interface (OPI) is used to perform control functions, display meter readings, and program the FPS-CTU. Set points are not resident in the OPI. Control voltage for the FPS-OPI (24 Vdc) is supplied by the CTU and communications with the CTU is through an RS-485 link. This allows the FPS-OPI to be mounted up to 1.2 km (4,000') from the CTU. Up to three OPI's can be used with each CTU.

4.3.2 CONFIGURING THE FPS-CTU FOR OPI OPERATION

OPI Menu: *Setup* | *Hardware* | *OPI Display*

Select the number of OPI's in the *Number of OPI's* menu. The FPS-CTU supports up to three OPI's. In multiple-OPI systems, all OPI's display the same information and the CTU will process key presses from all OPI's. If an OPI is not used, set number of OPI's to 1 (default).

A loss-of-communication trip can be enabled in the *OPI-Loss Trip* menu. Display intensity can be set in the *Intensity* menu.

To extend the life of the vacuum-florescent display, a screen saver is provided and enabled using the *Screen Saver* menu. The screen saver activation time is defined by the *Setup* | *System Config* | *Password Timeout* setting.

4.3.3 BREAKER CONTROL

OPI Menu: *Setup* | *Control* | *Control Select Type*

A control type other than *Protection Only* must be selected for breaker control functions to become operational.

Breaker control operates in one of two modes; REMOTE or LOCAL. REMOTE mode is the default. LOCAL mode is selected using one of the digital inputs, see Table 4.2, or a network command. The OPI REMOTE or LOCAL LED's indicate the control mode.

4.3.3.1 LOCAL CONTROL

OPI Menu: *Setup* | *Digital Inputs* | *Digital Input x* | *Input x Function*

Local control can also be selected with a network command or by a digital input programmed for *Local Select.*

When the LOCAL LED is ON, the FPS is under local control and the digital inputs programmed as *3-Wire Close Local* are the only close sources the FPS will respond to.

NOTE: The I^2t *Close Inhibit* function and digital inputs programmed as *Interlock* are bypassed in local control.

Each local control source must release local control to allow the FPS to return to Remote Control.

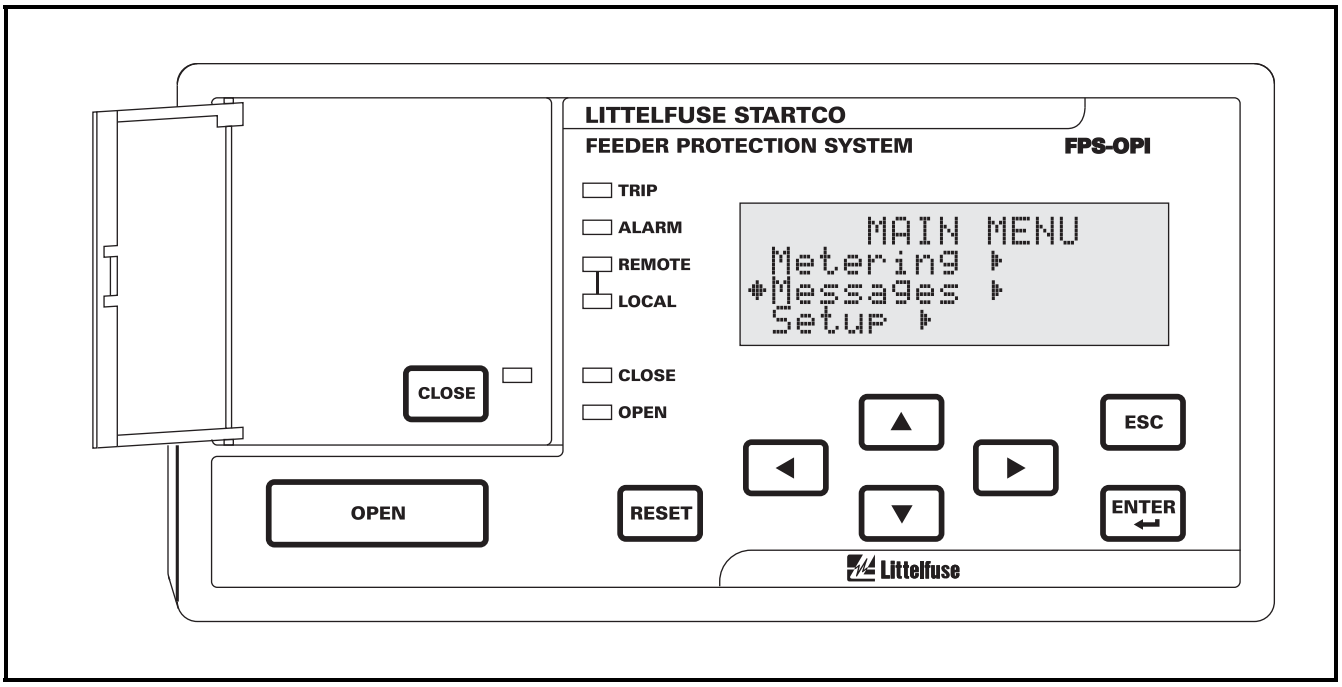


FIGURE 4.3 FPS-OPI Interface.

4.3.3.2 REMOTE CONTROL

OPI Menu: *Setup* | *Control* | *Remote Group*

When the REMOTE LED is ON, FPS control is from the sources enabled in the *Remote Group* menu. Source selections are *Digital Inputs, OPI,* and *Network.* If *Digital Inputs* is enabled, digital inputs programmed for *Close*, and *2-Wire Close* are enabled. If *OPI* is enabled, the close key on the OPI is enabled and if *Network* is enabled, close commands from the network are enabled.

NOTE: The OPI OPEN key and digital OPEN inputs always cause an open.

4.3.4 METERING

OPI Menu: *Metering*

OPI Menu: *Setup* | *Hardware* | *OPI Display* | *Meter Summary*

When *Metering* is selected in the main menu, press the right-arrow key to access a list of metering displays. Use the up- and down-arrow keys to scroll through the display list. Pressing the right-arrow key displays the selected metering information. See FPS-OPI menu map in Appendix A.

RESET is a "hot key" that is active in all meter displays. Pressing RESET causes a jump to the *Trip and Alarm* display to allow trips to be viewed and reset. Pressing ESC or the left-arrow key causes a return to the *Metering* display.

Many displays include per unit (pu) values where 1.0 pu is equal to 100%. I_a, I_b, I_c, I_1, and I_2 are in per unit of full-load current. I_g is in per unit of earth-fault-CT-primary rating.

The unbalance display indicates minus (-) if current inputs are not sequenced A-B-C.

The IEEE convention is used for power displays:

+Watts, +Vars, -PF (Lag)	Importing Watts, Importing Vars
+Watts, -Vars, +PF (Lead)	Importing Watts, Exporting Vars
-Watts, -Vars, -PF (Lag)	Exporting Watts, Exporting Vars
-Watts, +Vars, +PF (Lead)	Exporting Watts, Importing Vars

Operating range for energy values is ±4E±304, however the maximum display range is ±2E±34.

The *Setup* | *Hardware* | *OPI Display* | *Meter Summ*ary menu is used to configure the type of metering display selected by the *Metering* | *Summary* menu. In order to view the maximum amount of data, no menu title is displayed.

Display selections for the *Summary* menu are:

IDR Current-based metering *(I)*, digital inputs *(D)*, and relay outputs *(R)*:

Average current, current unbalance, earth leakage, used I^2t, digital input and relay output status.

I: xxxx A Iu: xxxx
Ig:xxxx A I2t:xx%
Di: 1..7: xxxxxxx
Ry: 1..5: xxxxx

This selection is the default for the summary display.

IVP Current-based metering *(I)*, voltage *(V)*, unbalance, and power *(P)*:

Average current, current unbalance, earth leakage, used I^2t, average voltage, voltage unbalance, power and power factor.

I: xxxx A Iu: x.xx
Ig:xxxx A I2t: xx%
V: xx.xx kV Vu: x.xx
P: xx.x kW PF: x.xx

This selection is applicable for an FPS using voltage inputs.

IVPA Current-based metering *(I)*, voltage *(V)*, power *(P)*, and analog I/O *(A)*:

Average current, average voltage, earth leakage, used I^2t, power, power factor, and analog currents.

I: xxxx A V: xx.xx kV
Ig:xxxx A I2t:xx%
P: xx.x kW PF: x.xx
Ai:xxx% Ao: xxx%

This selection is applicable when the FPS analog output is used in a process control loop. The analog input and output values provide indication of control-system operation.

For each metering display, Table 4.4 shows the information that can be displayed.

4.3.5 MESSAGES

OPI Menu: *Messages*

Selecting this menu item allows trip and alarm messages, status messages, event records, and statistical data to be viewed and resets to be performed.

4.3.5.1 TRIP RESET

OPI Menu: *Messages* | *Trip and Alarm*

Up to fifteen trip and alarm messages can be displayed in a scrollable-list format. Trip messages must be individually selected and reset when the OPI RESET key is used. All trips are simultaneously reset by digital-input reset, with the FPS-CTU RESET key or with a communications-network command. Alarms are non-latching and are displayed only for the time that the alarm condition exists.

RESET is a "hot key" to the *Trip and Alarm* display, except during set-point entry. In the *Trip and Alarm* display, pressing ESC or the left-arrow key causes a return to the display shown when RESET was pressed.

4.3.5.2 STATUS

OPI Menu: *Messages* | *Status Messages*

This menu is used to display status messages. Status messages are shown in Table 4.5.

4.3.5.3 DATA LOGGING

OPI Menu: *Messages* | *Event Records*

Trip-record data, start-record data, and Emergency Thermal Resets (ETR) are logged. Trip-record data includes the time of trip, cause of trip, and pre-trip [(1)] data. ETR records contain a snapshot of the data prior to an ETR.

Trip or ETR records include:

- Time Stamp YY/MM/DD HH:MM:SS
- V_{ab}, V_{bc}, V_{ca}, I_a, I_b, I_c, and I_g at time of trip or ETR
- Unbalance (I_2/I_1, V_2/V_1) at time of trip or ETR
- P, Q, S, and PF at time of trip or ETR [(1)]
- Used I^2t at time of trip or ETR
- PTC/RTD temperature data if applicable

Record Type .....Trip/ETR
Number of Records.....64 (First In First Out)

[(1)] Recorded values for power quantities (P, Q, S, PF) are averages of measurements over the previous 16 cycles.

4.3.5.4 STATISTICAL DATA

OPI Menu: *Messages* | *Statistics*
OPI Menu: *Setup* | *System Config* | *Maintenance*

The FPS records the following statistical data:

- Running hours (Hours with current detected)
- Counters for all trips

Statistical data can be cleared in the *Maintenance* menu.

4.3.5.5 EMERGENCY THERMAL RESET

OPI Menu: *Messages* | *Emerg I2t Reset*

The *Emerg I^2t Reset* menu is used to reset the thermal memory. See Section 5.2.2.

TABLE 4.4 METERING DISPLAY

METERING MENU	INFORMATION DISPLAY (1)
Summary	Displays values as per the *Meter Summary* menu. IDR, IVP, or IVPA.
Current	I_a, I_b, I_c in A and per unit of I_p.
Unbalance (I)	I_1, I_2, in per unit of I_p, I_2/I_1 in per unit.
Earth Leakage	I_g in A and per unit of I_e.
Thermal Capacity	Used I^2t in percent. Trend I^2t in percent. Displays reset time when tripped on I^2t. Displays time to trip if in overload. Displays time to I^2t Inhibit removal.
Voltage	V_{ab}, V_{bc}, V_{ca} in kV and per unit of V_p.
Unbalance (V)	V_1, V_2, in per unit of V_p, V_2/V_1 in per unit.
Power	P in kW, Q in kVA, S in kVAR, PF.
Energy	kWh, kVAh, kVARh.
Frequency	Frequency in Hz from Phase A voltage input.
RTD Temperatures	Summary shows maximum and minimum temperatures for A1, A2, and A3 groups RTD's in degrees C. RTD ID, name, function, temperature in degrees C for each enabled RTD.
I/O Status	Analog input in mA, digital inputs and relay outputs in binary.
System State	Displays control state when breaker control is enabled. Displays set-point group. Displays ETR mode.
Comm State	Displays DF1 state as online or timed out. Displays Modbus state as online or timed out. Displays Anybus module error and status. Displays DeviceNet errors and status.

(1) All but Summary, RTD, and System State metering displays show System Name.

TABLE 4.5 STATUS MESSAGES

MESSAGES	DESCRIPTION
INx Interlock Open	The interlock assigned to digital input x is open, preventing a close.
INx Open	The OPEN switch assigned to digital input x is open, preventing a close.
t° Disabled by ETR	Indicates that the FPS is in ETR mode. Does not prevent a close.

4.3.6 PASSWORD ENTRY AND PROGRAMMING

OPI Menu: *Setup* | *System Config* | *Password Timeout*

NOTE: Factory default password is 1111.

All set points are locked from changes until the four-character password is entered. If set-point access is locked, the user is prompted to enter the password. Once entered, set-point access is allowed and remains enabled until a key has not been pressed for the time defined by the *Password Timeout* set point.

EXAMPLE:

Prior to password entry:

```
I2T PICKUP
= 1.00 x Ip
Locked! Press ↵ To
Enter Password.
```

When ENTER is pressed, the *Password Entry* display is shown:

```
PASSWORD ENTRY
Enter Password
And Press ↵
[****]
```

Use the left- and right-arrow keys to select the position of the flashing cursor. Use the up- and down-arrow keys to select password characters. Press ENTER.

When the correct password is entered, a flashing cursor is displayed, the set-point range and units are shown, and set points can be changed.

```
I2T PICKUP
= 1.00 x Ip
(0.10 → 1.25) x Ip
[00001.00]
```

Use the up- and down-arrow keys to change a set-point update-field character, and use the left- and right-arrow keys to move between characters. Press ENTER

to update the set point, or press ESC to exit the display without changing the set point. A set point is set to the minimum or maximum value of its range if an out-of-range value is entered. Press ESC to exit the set-point-update screen.

The sequence for set-point characters depends upon the set-point type. The character sequence for numeric set points is:

. . . 0 1 2 3 4 5 6 7 8 9 . 0 1 2 3 . . . . .

The character sequence for string set points is:

. . . [0…9] [A…Z] [a…z] SP - . / [0…9] [A…Z] . . . . .

Characters forming a series are shown in brackets and "SP" represents the space character.

For set points requiring selection from a list, the up and down arrow keys are used to scroll through the items. In the same manner as menu items, selections are displayed using one of the three cursor symbols (▼▲◆) preceding the item. Pressing ENTER selects the item and that item is indicated by the "*" symbol to its right.

EXAMPLE:

```
  PHASE INVERSE
  IEEE Moderate Inverse
◆ IEEE Very Inverse *
  IEEE Extreme Inverse
```

4.4 MPS-RTD

OPI Menu: *Setup* | *Hardware* | *RTD Modules*

OPI Menu: *Setup* | *Protection* | *RTD Temperature*

The MPS-RTD module extends FPS protective functions to include multiple-RTD temperature monitoring. It has eight inputs that can be individually configured for RTD type, trip and alarm settings, name, and function. The RTD types are 10-Ω copper, 100-Ω nickel, 120-Ω nickel, and 100-Ω platinum. Three function assemblies (A1, A2, A3) are available. Minimum and maximum temperatures are available for each assembly and for ambient temperature.

Control voltage for the MPS-RTD (24 Vdc) is supplied by the FPS-CTU and communication is through an RS-485 link. This allows the MPS-RTD to be mounted up to1.2 km (4,000') from the FPS-CTU.

To enable RTD protection, select enable in the *RTD Module* menu.

When the hardware has been configured, temperature set points and sensor-failure action selections in the *RTD Temperature* menu are used for RTD temperature protection. See Section 5.22.

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5. PROTECTIVE FUNCTIONS

5.1 GENERAL

The FPS measures true RMS, peak, and fundamental-frequency values of current and voltage. Fundamental-frequency values (magnitude and phase angle) are obtained using Discrete-Fourier Transform (DFT) filtering that rejects dc and harmonics. The type of measurement used for a protective function is indicated in each section.

Each protective function can be assigned a trip action that defines the output contact(s) used. Except for overload protection which has auto-reset available, FPS trips are latched. Trips are logged, alarm actions are not.

Trip-action selections are:
- Disable
- Trip1
- Trip2
- Trip3
- Trip1 and Trip2
- Trip1 and Trip3
- Trip1 and Trip2 and Trip3
- Trip2 and Trip3

Most protection functions can be assigned an alarm action. Alarms auto-reset and are not logged.

Alarm-action selections are:
- Disable
- Alarm1
- Alarm2
- Alarm3
- Alarm1 and Alarm2
- Alarm1 and Alarm3
- Alarm1 and Alarm2 and Alarm3
- Alarm2 and Alarm3

To operate output contacts, trip and alarm actions must be assigned to output relays using the *Setup | Relay Outputs* menu. See Section 4.2.8.

For phase-overcurrent protection, three protection elements are available—overload, inverse time, and definite time. Each can be enabled or disabled as required and are individually annunciated.

IEC and IEEE inverse-time curves are supported. An IEC time multiplier setting range of 0.05 to 1.0 is provided. For consistency, the same multiplier is used for IEEE curves. For equations and curves see Figs. 5.1 to 5.9 in Section 5.3.

For earth-fault protection, inverse time and definite-time elements are available for the calculated zero-sequence component ($3I_0$). For the earth-fault CT inputs, only definite-time protection is provided. Calculated ($3I_0$) and CT-input protection elements can be enabled simultaneously to provide low- and high-level earth-fault protection in solidly grounded systems.

Phase-overcurrent and earth-fault protection functions have two setting groups; Group 1 and Group 2. Set points are entered for each group and the active group is selected using the menu system, communications, or a digital input. See Section 4.2.9. Group selection allows setting two levels of protection. This is useful in feeder applications where the connected load changes as in tie-breaker systems, or in applications where the feeder is in maintenance mode and operation with reduced trip levels is required. Reduced current settings allows meeting *NEC 240.87 Arc Energy Reduction (B) (3) Energy-reducing maintenance switching with local status indicator*.

SE-Comm-RIS PC-interface software can be used to plot FPS protection curves. See Section 8.1.2.

NOTE: See Appendix B for default set-point values. Per-unit notation (pu) is used. 1 pu = 100%.

5.2 OVERLOAD

5.2.1 I^2t PROTECTION

Menu: *Setup | Protection | Overload*

Unlike IEC and IEEE inverse-time overcurrent protection, the I^2t protection tracks thermal capacity for currents below the pickup setting.

The I^2t protection algorithm uses the square of the maximum phase current as an input.

The cold-curve time-to-trip (t) in seconds for currents above the *I^2t Pickup* setting is defined by:

$$t = 60 \times \tau \times \ln \left(\frac{I_M^2}{I_M^2 - 1} \right)$$

Where:

τ = Time Constant setting in minutes

$$I_M = \frac{I_{Measured}}{I_{Pickup}}$$

The time constant for overload protection is set in the *Setup | Protection | Overload | Groupx | Time Constant* menu. This value is specified in minutes.

From a given curve, the time constant can be determined by knowing the trip time at six times the pickup value (t_6). For this case, the time constant simplifies to:

$$\tau = 0.591 \times t_6$$

Where:

T_6 = Time in seconds at 6 × pickup level

τ = Time Constant setting in minutes

The FPS provides indication of thermal trend and used thermal capacity. Thermal trend is the value that used thermal capacity is tending toward and it is a function of the square of load current. For currents greater than or equal to the pickup current, time-to-trip is displayed in *Metering | Thermal Capacity.* The thermal trend value (*Trend I^2t*) in percent is:

$$Trend\ I^2t = I_M{}^2 \times 100\%$$

For currents less than *I^2t Pickup* current, *Trend I^2t* in percent is a function of the *Hot Factor* setting given by:

$$Trend\ I^2t = I_M{}^2 \times HF \times 100\%$$

Where :

HF = Hot Factor setting

Selected I^2t overload cold curves are shown in Fig. 5.1. FPS I^2t overload protection is dynamic. Time to trip at any overload current depends on the value of *Used I^2t*—as *Used I^2t* increases, time to trip decreases. The FPS I^2t overload cold and warm protection curves can be plotted using SE-Comm-RIS PC-interface software.

An overload trip occurs when *Used I^2t* reaches 100%. When an overload trip occurs, reset is not allowed until *Used I^2t* falls below the *I^2t Reset Level* set point. The time-to-reset in minutes is:

$$t = -\tau \times Cooling\ Factor \times \ln(I^2t\ Reset\ Level)$$

Time-to-reset is displayed in *Metering | Thermal Capacity.*

The thermal model has three different reset modes; Normal, Auto, and Rapid. The I^2t-overload reset mode is set using the *Setup | Protection | Overload | I^2t Reset Type* menu, and applies to both set-point groups.

A thermal-overload trip reset is not allowed until *Used I^2t* falls below the *I^2t Reset Level* setting. In *Normal* mode a reset input is required to reset a trip. *Normal* is the default reset mode.

In *Auto* mode, an I^2t-overload trip is automatically reset when *Used I^2t* falls below the *I^2t Reset Level* setting.

In *Rapid* mode, *Used I^2t* decreases exponentially with a fixed two-second time constant when current is not detected. A reset input is required to reset a trip.

Cooling Factor	0.10 to 10.00 x Thermal Time Constant
Time Constant	1.00 to 60.00 minutes
I^2t Pickup	0.10 to 1.25 pu of CT-Primary Rating (I_p)
Hot Factor	0.10 to 1.00
I^2t Alarm	0.50 to 1.00 pu
I^2t Trip	1.00 pu
Protection	Enable/Disable Trip1, 2, 3 Enable/Disable Alarm1, 2, 3
Measurement Method	RMS
Set-Point Groups	Group 1 and Group 2
I^2t Reset Level	0.10 to 0.90 pu (Applies to both groups)

5.2.2 EMERGENCY THERMAL RESET

Menu: *Messages | Emerg I2t Reset | Reset I2t Memory*

Emergency Thermal Reset (ETR) sets *Used I^2t* to 0% and disables PTC and RTD temperature trips. Password entry is required. Disabled-temperature protection is indicated by *t° Disabled by ETR* in the *System State* display. If PTC or RTD temperature protection is not enabled, *t° Disabled by ETR* will not be displayed. RTD or PTC trips are reset when ETR is performed regardless of measured temperatures. Temperature protection must be re-enabled in the *Messages | Emerg I^2t Reset | Reenable Temp* menu, or by cycling supply voltage.

Temperature alarms and sensor verification remain enabled during ETR.

CAUTION: Temperature protection is not automatically re-enabled after an Emergency Thermal Reset.

5.3 INVERSE-TIME OVERCURRENT

Menu: *Setup | Protection | Phase Inverse*

The FPS supports the inverse-time curves listed in Table 5.1.

TABLE 5.1 CURVE TYPES

CURVE TYPE	FIGURE
IEC Normal Inverse, Curve Type A	5.2
IEC Very Inverse, Curve Type B	5.3
IEC Extreme Inverse, Curve Type C	5.4
IEC Short Inverse, Curve Type A	5.5
IEC Long Inverse, Curve Type B	5.6
IEEE Moderate Inverse Curves	5.7
IEEE Very Inverse Curves	5.8
IEEE Extreme Inverse Curves	5.9

NOTE: The FPS time-multiplier setting of 1.0 corresponds to the IAC/CO "time-dial" setting of 15.

The *Curve* menu is used to select one of the curve shapes listed in Table 5.1. *Pickup* is in per unit of phase-CT rating and specifies the location of the curve's vertical asymptote ($I_M = I_{DFT}/I_{pickup} = 1$). *Time Multiplier* selects the specific curve within the curve type.

The FPS uses the same time-multiplier range of 0.05 to 1.0 for both IEC and IEEE curves.

For each curve, t_{reset} defines the time to reset after a trip has occurred ($I_M = 0$)

The *Metering | Inverse Status* menu indicates whether current is above or below *Pickup.*

Curve ..... See Table 5.1
Pickup ..... 0.10 to 10.00 x CT-Primary Rating (I_p)
Pickup Curve Threshold ..... 1.1 x Pickup setting
Reset Curve Threshold ..... 0.9 x Pickup setting
Time Multiplier ..... 0.05 to 1.00
Protection ..... Enable/Disable Trip1, 2, 3
Measurement Method ..... DFT
Set-Point Groups ..... Group 1 and Group 2

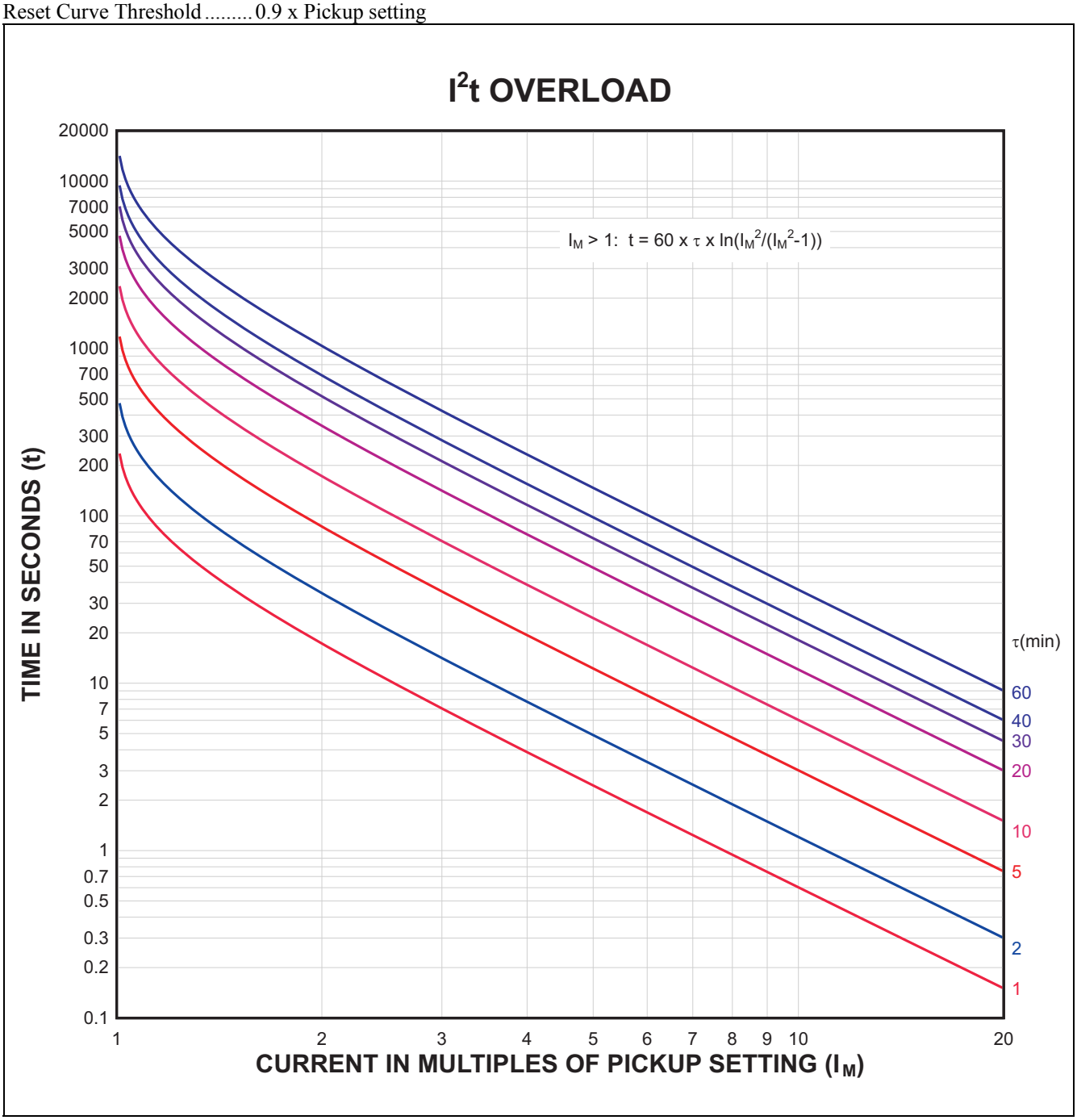

FIGURE 5.1 Class-20 Overload Curve.

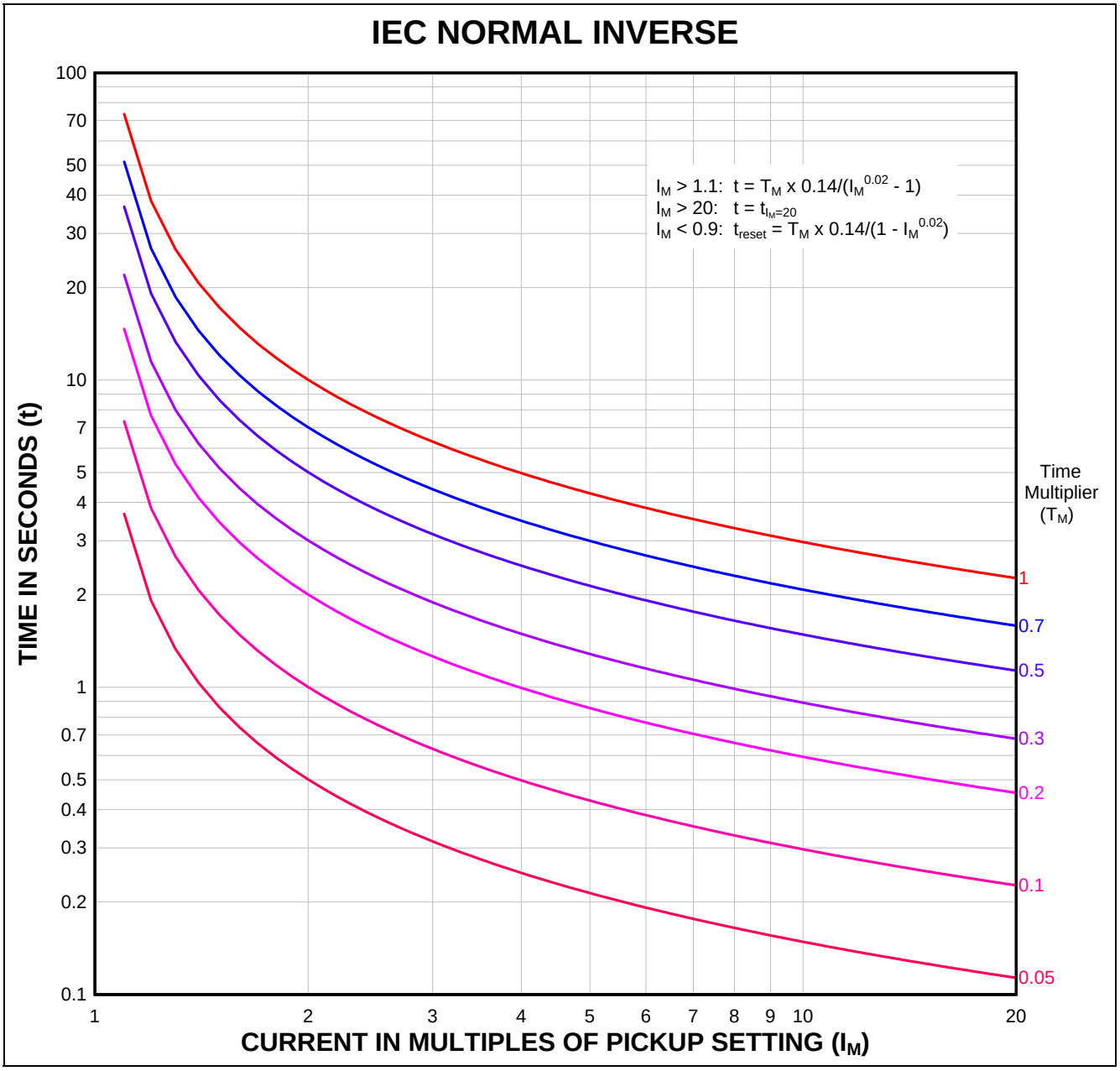

FIGURE 5.2 IEC Normal Inverse, Curve Type A.

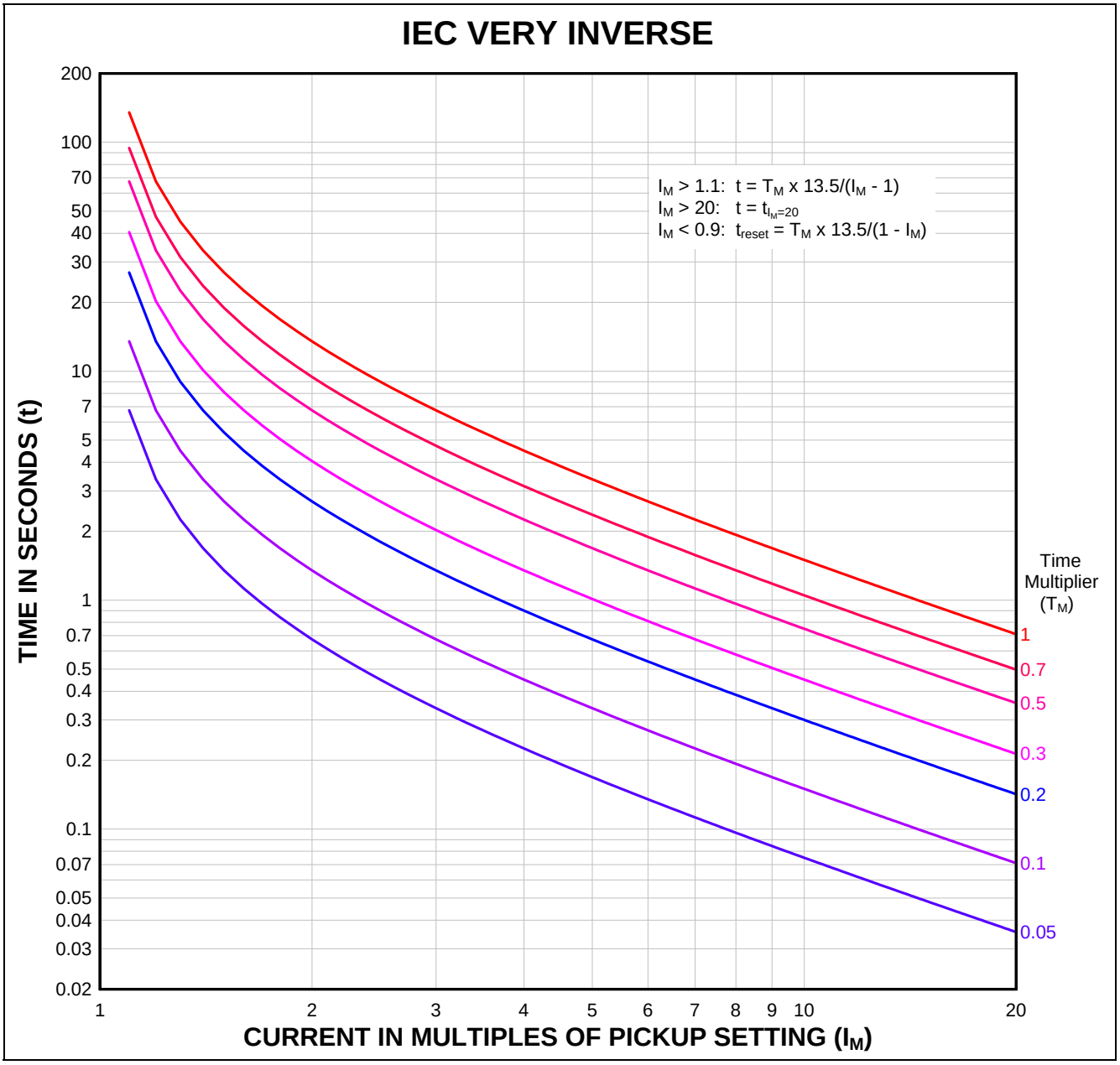

FIGURE 5.3 IEC Very Inverse, Curve Type B.

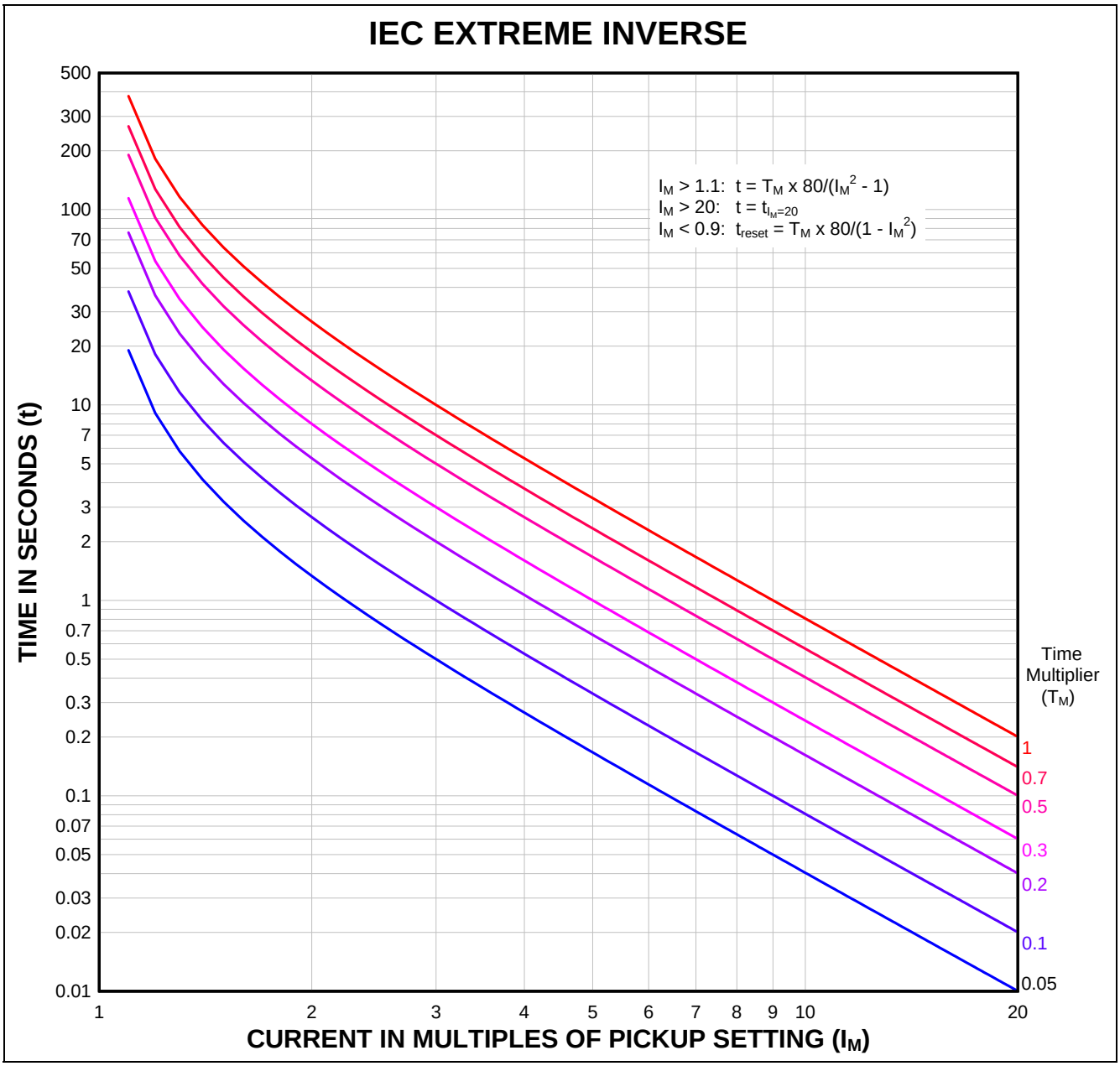

FIGURE 5.4 IEC Extreme Inverse, Curve Type C.

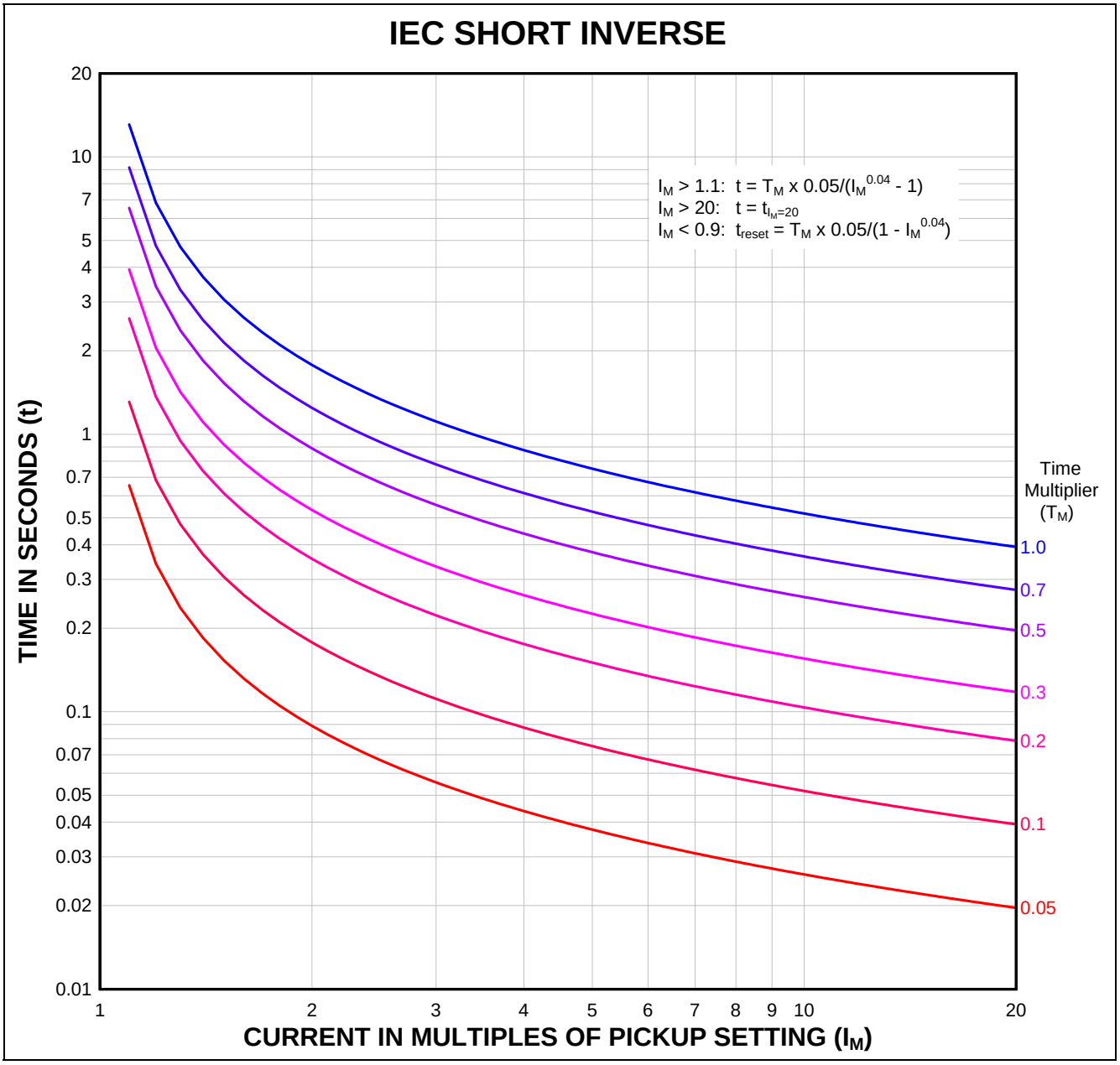

FIGURE 5.5 IEC Short Inverse, Curve Type A.

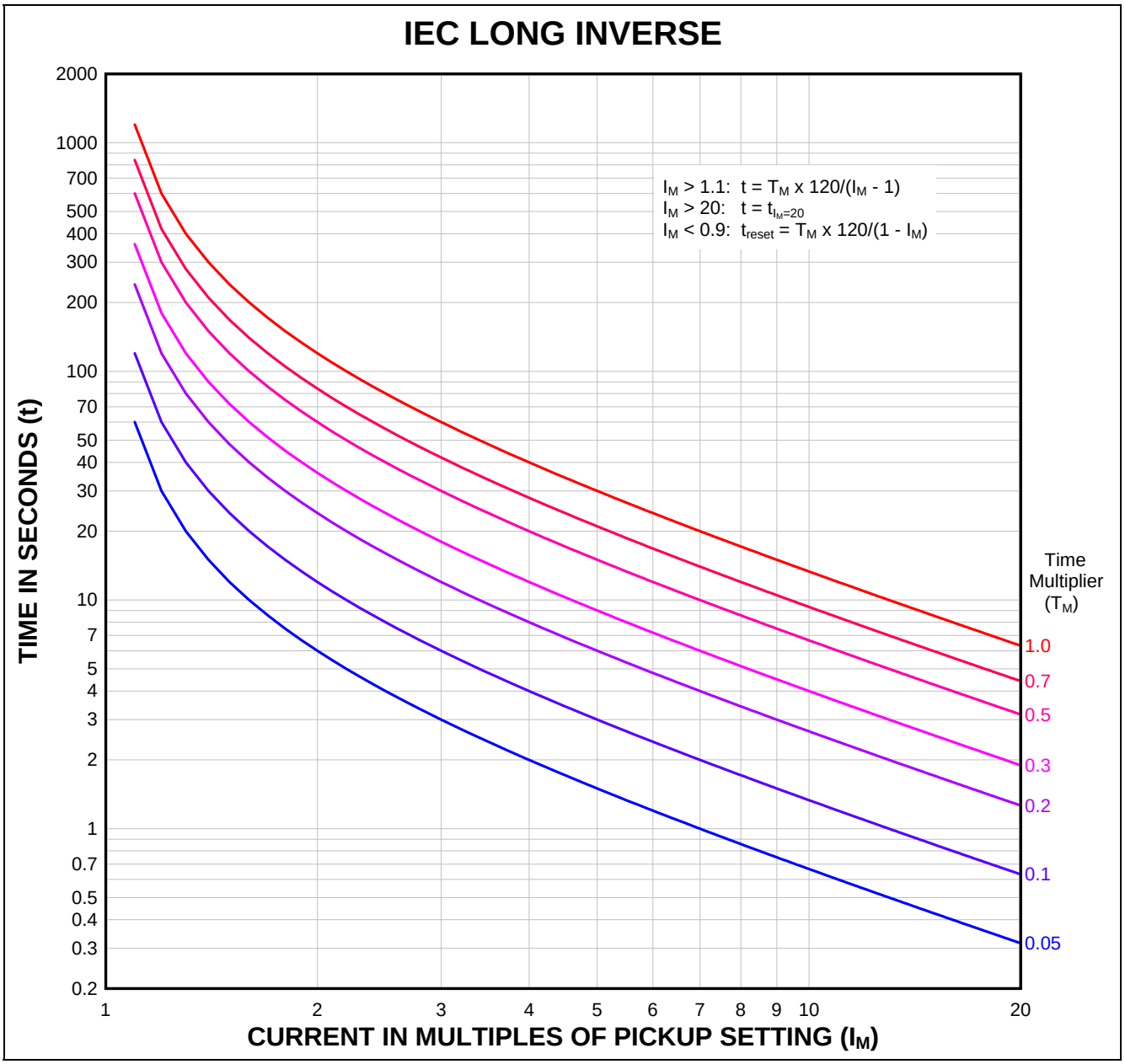

FIGURE 5.6 IEC Long Inverse, Curve Type B.

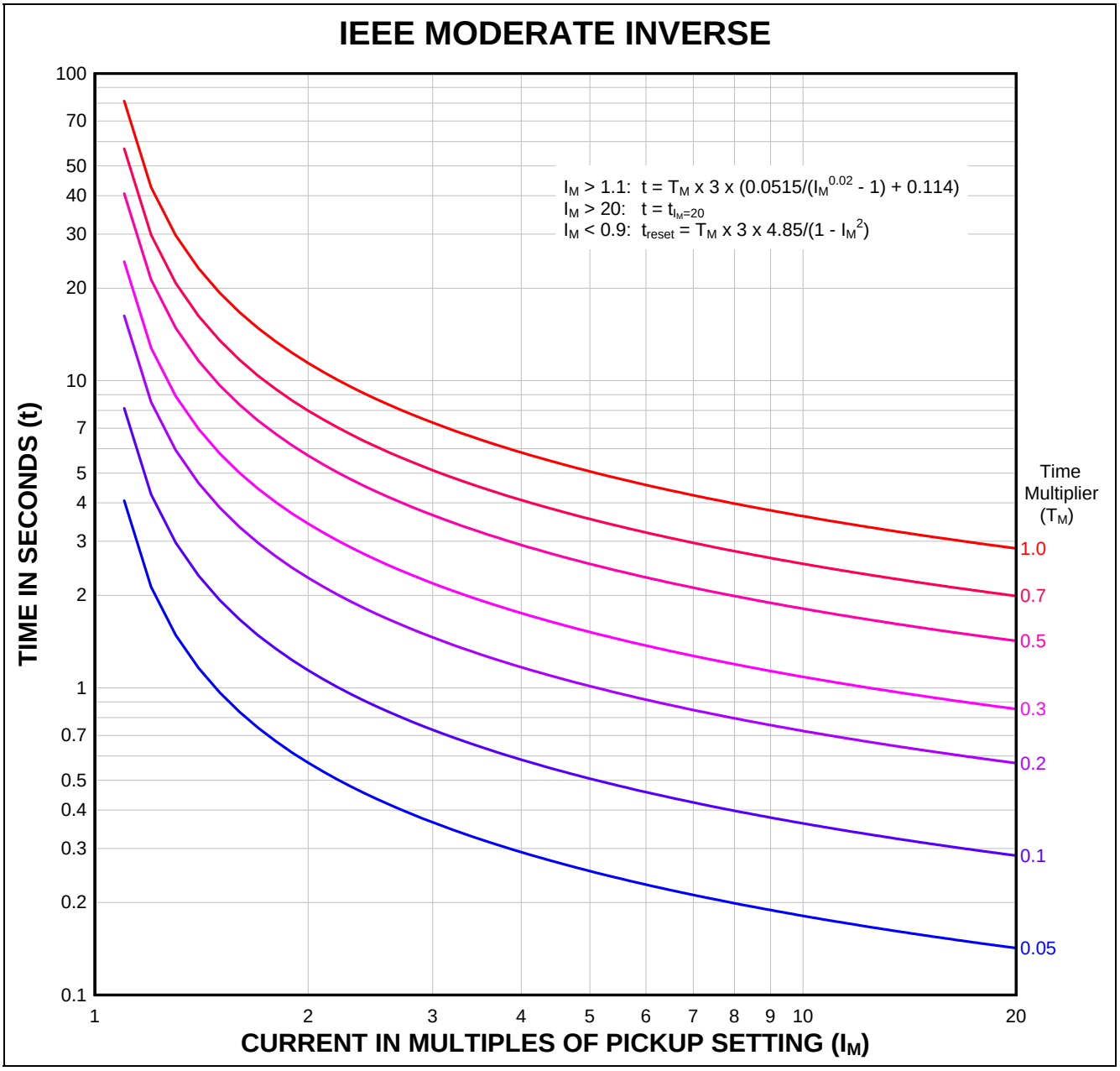

FIGURE 5.7 IEEE Moderate Inverse Curves.

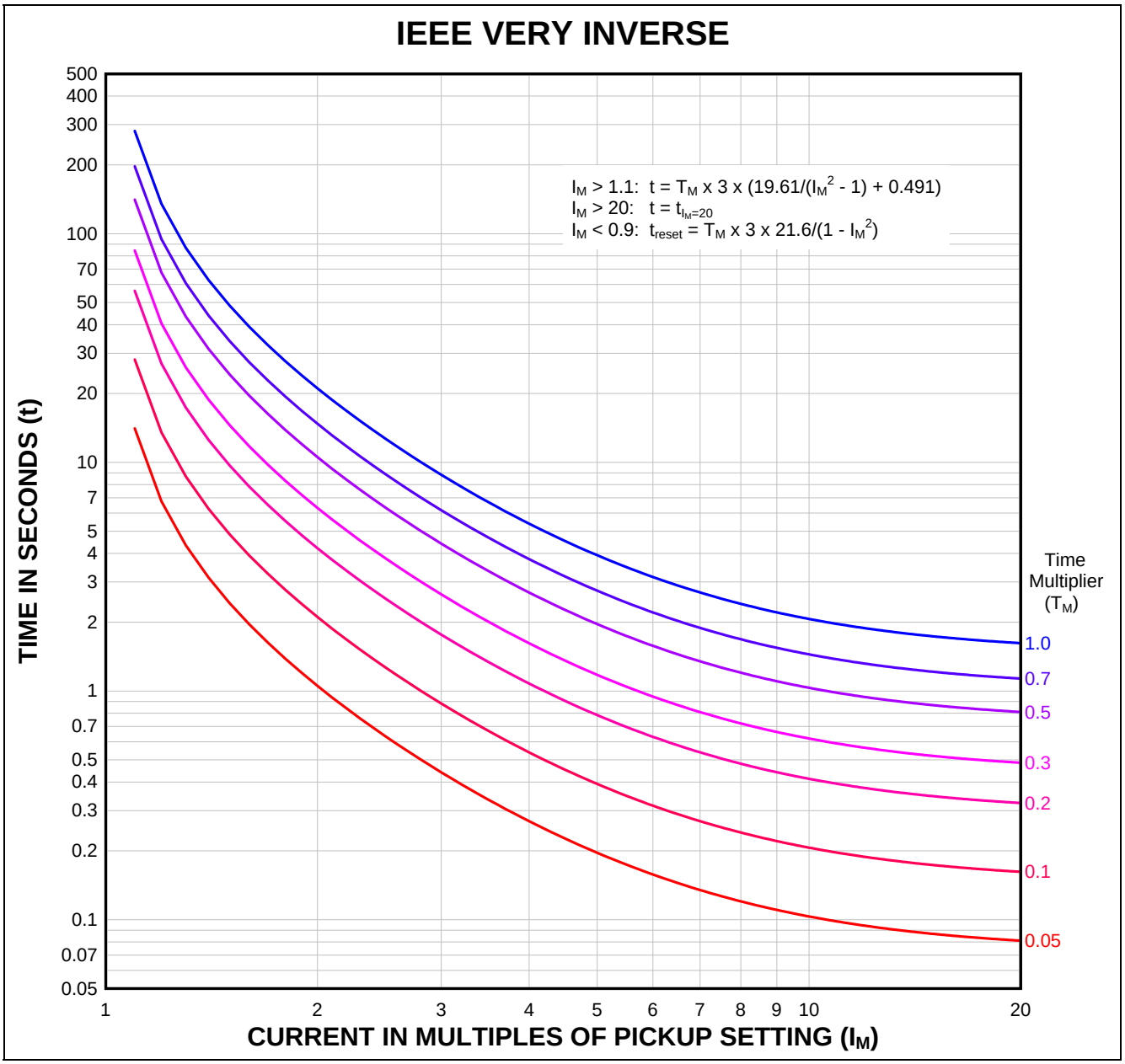

FIGURE 5.8 IEEE Very Inverse Curves.

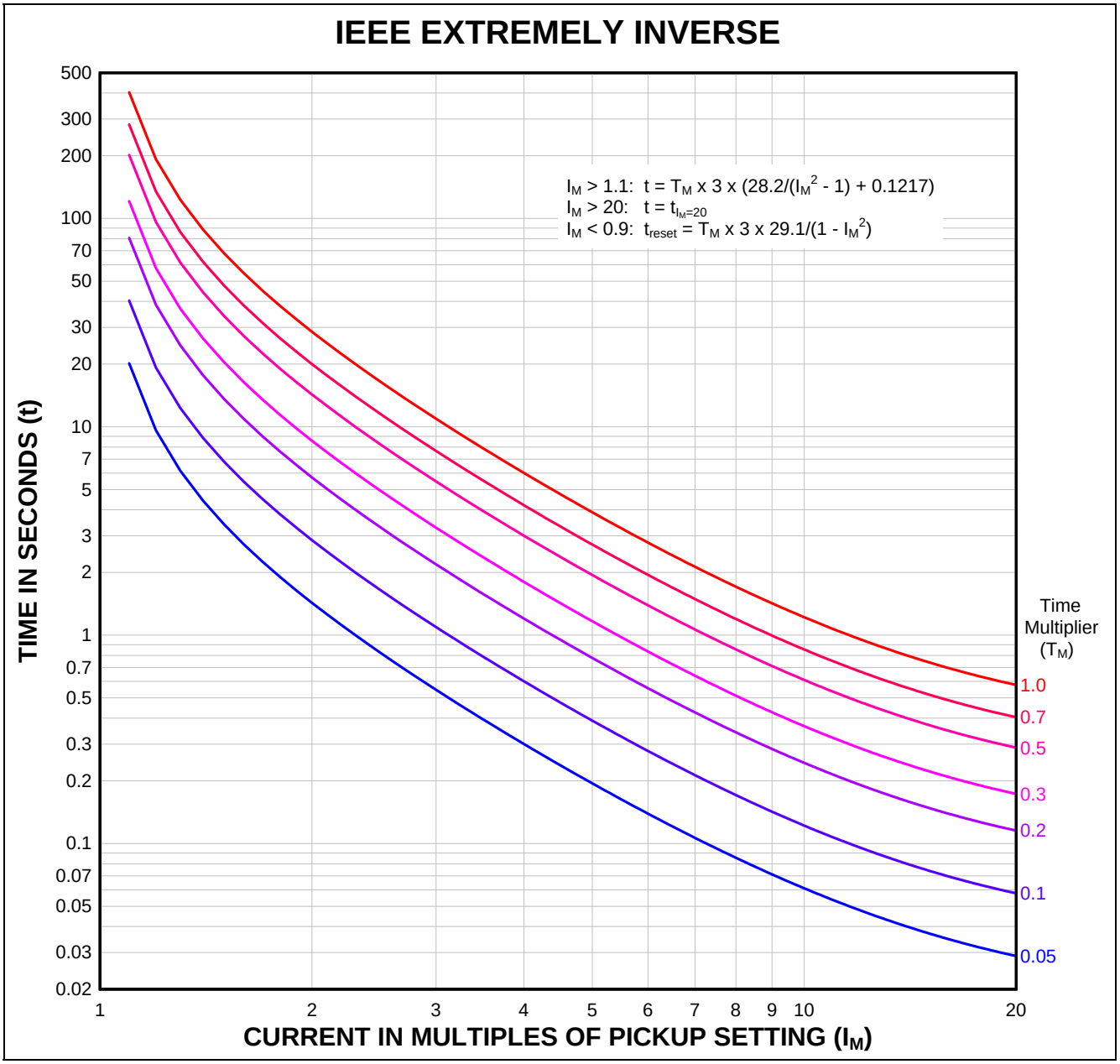

FIGURE 5.9 IEEE Extremely Inverse Curves.

5.4 DEFINITE-TIME OVERCURRENT

Menu: *Setup* | *Protection* | *Ph Def Time*

The definite-time overcurrent function has both trip and alarm settings. With the DFT measurement method it may be possible to set the overcurrent protection closer to the desired value as compared to an RMS measurement method.

The asymmetrical-current multipliers for RMS and DFT measuring methods are shown in Fig. 5.10. Typical X/R values are 6.6 for a low-voltage system, 15 for a medium-voltage system, and can be as high as 25 for a high-voltage system. The DFT filters the dc component so that the overcurrent setting can be set closer to the symmetrical fault value.

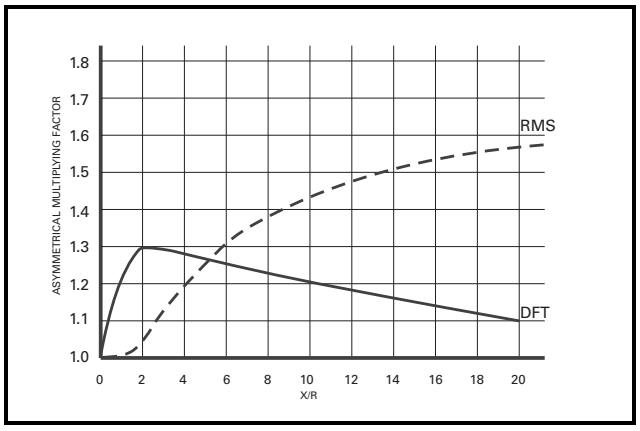

FIGURE 5.10 Asymmetrical-Current Multipliers.

Total clearing time is the sum of minimum fault duration (FD, Table 5.2), delay time (D), output relay operating time (for D < 45 ms), and interrupting device operating time.

TABLE 5.2 FAULT DURATION REQUIRED FOR TRIP[1][2]

FAULT LEVEL (Multiples of trIp-Level Setting)	FAULT DURATION (FD) (ms)	
	D ≤ 30 ms [3]	D > 30 ms [3]
2	10	D - 20
5	5	D - 25
10	5	D - 28

[1] For overcurrent less than 15 x CT-Primary Rating. For earth faults less than 1 x EF-CT-Primary Rating. Fixed frequency, 60 Hz.
[2] Minimum relay operating time: 25 to 45 ms.
[3] D is the trip-time setting.

Trip Level..... 0.10 to 15.00 x CT-Primary Rating (I_p)
Trip Delay (D)..... 0.00 to 10.00 s (see Table 5.2)
Alarm Level ..... 0.10 to 15.00 x I_p
Alarm Delay (D) ..... 0.00 to 10.00 s (see Table 5.2)
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3
Measurement Method ..... DFT
Set-Point Groups..... Group 1 and Group 2

5.5 INVERSE-TIME $3I_0$ EARTH FAULT

Menu: *Setup* | *Protection* | *$3I_0$ Inverse*

This protection function is based on the zero-sequence current calculated from the three phase currents.

The *Curve* menu is used to select one of the curve shapes listed in Table 5.1. *Pickup* is in per unit of phase CT rating and specifies the location of the curve's vertical asymptote ($I_M = I_{DFT}/I_{pickup} = 1$). *Time Multiplier* selects the specific curve within the curve type.

The FPS uses the same time multiplier range of 0.05 to 1.0 for both IEC and IEEE curves.

The *Metering* | *Inverse Status* menu indicates whether current is above or below *Pickup.*

Curve..... Table 5.1
Pickup ..... 0.10 to 10.00 x CT-Primary Rating (I_p)
Pickup Curve Threshold..... 1.1 x Pickup setting
Reset Curve Threshold..... 0.9 x Pickup setting
Time Multiplier..... 0.05 to 1.00
Protection ..... Enable/Disable Trip1, 2, 3
Measurement Method ..... DFT – derived $3I_0$
Set-Point Groups..... Group 1 and Group 2

NOTE: For IEEE curves, a multiplier of 1 corresponds to a IAC/CO "time-dial" setting of 15.

5.6 DEFINITE-TIME $3I_0$ EARTH FAULT

Menu: *Setup* | *Protection* | *$3I_0$ Def Time*

This protection is based on the zero-sequence current calculated from the phase currents.

Trip Level..... 0.10 to 15.00 x CT-Primary Rating (I_p)
Trip Delay (D)..... 0.00 to 10.00 s (see Table 5.2)
Alarm Level ..... 0.10 to 15.00 x I_p
Alarm Delay (D) ..... 0.00 to 10.00 s (see Table 5.2)
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3
Measurement Method ..... DFT—derived $3I_0$
Set-Point Groups..... Group 1 and Group 2

5.7 DEFINITE-TIME EARTH FAULT

Menu: *Setup* | *Protection* | *Ict Def Time*

This protection function uses the earth-fault-CT input. The protection setting range is equal to the earth-fault-CT-primary rating (I_e).

Trip Level	0.01 to 1.00 x Earth-Fault CT primary rating (I_e)
Trip Delay (D)	0.00 to 100.00 s (see Table 5.2)
Alarm Level	0.01 to 1.00 x I_e
Alarm Delay (D)	0.00 to 100.00 s (see Table 5.2)
Protection	Enable/Disable Trip1, 2, 3 Enable/Disable Alarm1, 2, 3
Measurement Method	DFT c/w saturation compensation
Set-Point Groups	Group 1 and Group 2

5.8 CURRENT UNBALANCE

Menu: *Setup* | *Protection* | *Unbalance (I)*

Menu: *Setup* | *System Config* | *I_2/I_1 Threshold*

Positive-sequence current (I_1) and negative-sequence current (I_2) are used to determine current unbalance (I_2/I_1). The unbalance display range is 0.00 to 1.00 where 1.00 is 100% unbalance—a single-phase condition. Single-phase loads generate unbalance that may cause false trips when feeder currents are low. The *I_2/I_1 Threshold* sets the current level where unbalance protection becomes active. The threshold is based on the maximum of the three-phase currents. Set this value above the single-phase load value to avoid false trips. Negative unbalance is indicated when current inputs are connected B-A-C (negative-sequence current is greater than positive-sequence current). Severe unbalance may also be indicated if phase-CT polarity is incorrect.

Trip Level	0.05 to 1.00
Trip Delay	1.00 to 100.00 s
Alarm Level	0.05 to 1.00
Alarm Delay	1.00 to 100.00 s
Protection	Enable/Disable Trip1, 2, 3 Enable/Disable Alarm1, 2, 3
Threshold	0.10 to 0.50 x I_p
Measurement Method	DFT

5.9 PHASE LOSS—CURRENT

Menu: *Setup* | *Protection* | *Phase Loss (I)*

Phase loss is a severe form of unbalance and can be used to detect open-circuit faults. When phase loss occurs on a three-phase load, negative-sequence current (I_2) is equal to positive-sequence current (I_1). The phase-loss algorithm considers I_2/I_1 from 0.90 to 1.00 to be a phase loss. Set the phase-loss trip delay shorter than the unbalance trip delay to avoid an unbalance trip in the event of a phase loss.

The phase-loss threshold is fixed at 10% of the CT-primary rating (I_p).

Trip Delay	1.00 to 100.00 s
Alarm Delay	1.00 to 100.00 s
Protection	Enable/Disable Trip1, 2, 3 Enable/Disable Alarm1, 2, 3
Measurement Method	DFT

5.10 PHASE REVERSE—CURRENT

Menu: *Setup* | *Protection* | *Phase Rev (I)*

If the current phase sequence is B-A-C, the magnitude of negative-sequence current will be larger than the magnitude of positive-sequence current. To maintain magnitude consistency for set points, the I_2/I_1 ratio is inverted for the protection algorithm when phase sequence is B-A-C. A negative unbalance is indicated in the meter display for B-A-C sequence.

The phase-reverse threshold is fixed at 10% of the CT-primary rating (I_p).

Trip Delay	1.00 to 100.00 s
Alarm Delay	1.00 to 100.00 s
Protection	Enable/Disable Trip1, 2, 3 Enable/Disable Alarm 1, 2, 3
Measurement Method	DFT

5.11 OVERVOLTAGE

OPI Menu: *Setup* | *Protection* | *Overvoltage*

A trip or alarm occurs if the maximum line-to-line voltage exceeds the set point.

Trip Level	1.00 to 1.40 x System Voltage Rating (V_p)
Trip Delay	1.00 to 500.00 s
Alarm Level	1.00 to 1.40 x V_p
Alarm Delay	1.00 to 500.00 s
Protection	Enable/Disable Trip1, 2, 3 Enable/Disable Alarm1, 2, 3
Measurement Method	DFT

5.12 VOLTAGE UNBALANCE

OPI Menu: *Setup* | *Protection* | *Unbalance (V)*

Positive-sequence voltage (V_1) and negative-sequence voltage (V_2) are used to determine voltage unbalance (V_2/V_1). The unbalance display range is 0.00 to 1.00 where 1.00 is 100% unbalance—a single-phase condition. A negative unbalance will be indicated if voltage inputs are connected B-A-C.

Trip Level ..... 0.05 to 1.00
Trip Delay ..... 1.00 to 100.00 s
Alarm Level ..... 0.05 to 1.00
Alarm Delay ..... 1.00 to 100.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3
Measurement Method ..... DFT

5.13 PHASE LOSS—VOLTAGE

OPI Menu: *Setup* | *Protection* | *Phase Loss (V)*

Phase loss is a severe form of unbalance. When phase loss occurs, negative-sequence voltage (V_2) is equal to positive-sequence voltage (V_1) and voltage unbalance is 100% or 1.00 pu. The phase-loss algorithm considers V_2/V_1 from 0.90 to 1.00 to be a phase loss. Set the phase-loss trip delay lower than the unbalance trip delay to avoid an unbalance trip in the event of a phase loss.

Trip Delay ..... 1.00 to 100.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Measurement Method ..... DFT

5.14 PHASE REVERSE—VOLTAGE

OPI Menu: *Setup* | *Protection* | *Phase Rev (V)*

If the voltage phase sequence is B-A-C, the magnitude of the negative-sequence voltage will be larger than the magnitude of the positive-sequence voltage.

Trip and Alarm Delay [(1)] ..... 1.00 to 100.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3
Measurement Method ..... DFT

(1) Single set point applies to Trip and Alarm.

5.15 UNDERVOLTAGE

OPI Menu: *Setup* | *Protection* | *Undervoltage*

A trip or alarm occurs if the minimum line-to-line voltage is less than the set point.

Trip Level ..... 0.50 to 1.00 x System Voltage Rating (V_p)
Trip Delay ..... 1.00 to 500.00 s
Alarm Level ..... 0.50 to 1.00 x V_p
Alarm Delay ..... 1.00 to 500.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3
Measurement Method ..... DFT

5.16 REVERSEPOWER

OPI Menu: *Setup* | *Protection* | *Reversepower*

Apparent power (S) is defined as S = P +jQ. A trip or alarm is initiated when the real reverse power (P) magnitude (negative power) is higher than the set point for the programmed delay. See Section 7.2.

The Reversepower setting is in per unit of rated power where 1.00 pu is defined as the *System Voltage* x PH-CT Primary x √3. The magnitude of the negative power is used and protection is only active when negative power is detected.

Trip Level ..... 0.10 to 1.00
Trip Delay ..... 0.50 to 500.00 s
Alarm Level ..... 0.10 to 1.00
Alarm Delay ..... 0.50 to 500.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.17 POWER FACTOR—LAG

OPI Menu: *Setup* | *Protection* | *PF Lag*
OPI Menu: *Setup* | *System Config* | *I_2/I_1 Threshold*

A trip or alarm occurs if the absolute value of lagging power factor is less than the set point. System conditions have “P positive”, “S positive” (Q1) or “P negative”, “S negative” with lagging (-) power factor (Q3).

The I_2/I_1 Threshold sets the point where power-factor protection becomes active.

Trip Level ..... 0.50 to 1.00
Trip Delay ..... 1.00 to 500.00 s
Alarm Level ..... 0.50 to 1.00
Alarm Delay ..... 1.00 to 500.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.18 POWER FACTOR—LEAD

OPI Menu: *Setup* | *Protection* | *PF Lead*
OPI Menu: *Setup* | *System Config* | *I_2/I_1 Threshold*

A trip or alarm occurs if the absolute value of power factor is less than the set point. System conditions have “P positive”, “S negative” (Q4) or “P negative”, “S positive” with leading (+) power factor (Q2).

The I_2/I_1 Threshold sets the point where power-factor protection becomes active.

Trip Level ..... 0.50 to 1.00
Trip Delay ..... 1.00 to 500.00 s
Alarm Level ..... 0.50 to 1.00
Alarm Delay ..... 1.00 to 500.00 s

Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.19 UNDERFREQUENCY

OPI Menu: *Setup* | *Protection* | *Underfrequency*

A trip or alarm occurs when the frequency of the input voltage (VA) is below the set point.

Underfrequency protection is inhibited when the input voltage is less than 50% of rated input (V_p).

Trip Level..... 30.00 to 80.00 Hz
Trip Delay ..... 1.00 to 500.00 s
Alarm Level ..... 30.00 to 80.00 Hz
Alarm Delay ..... 1.00 to 500.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.20 OVERFREQUENCY

OPI Menu: *Setup* | *Protection* | *Overfrequency*

A trip or alarm occurs when the frequency of the input voltage (VA) is above the set point.

Overfrequency protection is inhibited when the input voltage is less than 50% of rated (V_p).

Trip Level..... 30.00 to 80.00 Hz
Trip Delay ..... 1.00 to 500.00 s
Alarm Level ..... 30.00 to 80.00 Hz
Alarm Delay ..... 1.00 to 500.00 s
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.21 PTC TEMPERATURE

Menu: *Setup* | *Hardware* | *Temp Sensor Type*
Menu: *Setup* | *Protection* | *PTC Local Temp*

Configure the local-temperature-sensor input for a positive-temperature-coefficient (PTC) thermistor sensor using the *Setup* | *Hardware* | *Temp Sensor Type* menu.

The total resistance of series-connected PTC thermistors must be less than 1,500 Ω at 20°C. A trip or alarm will occur when series resistance exceeds 2,800 Ω.

During Emergency Thermal Reset, a PTC trip is reset and PTC-temperature protection is disabled. See Section 5.2.2.

Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.22 RTD TEMPERATURE

OPI Menu: *Setup* | *Protection* | *RTD Temperature*

The FPS supports a single MPS-RTD module. The RTD module can monitor up to eight RTD's Enable the RTD module in the *Setup* | *Hardware* | *RTD Module* menu. RTD type, function, and trip and alarm set points are programmable for each RTD.

When an RTD type is selected, both *Trip1* and *Alarm1* functions are enabled. A trip or alarm occurs when an RTD indicates a temperature above the set point.

During Emergency Thermal Reset, an RTD trip is reset and RTD-temperature protection is disabled. See Section 5.2.2.

RTD failure detection is provided. The actions for an RTD failure are selectable as *Trip1, 2,* or *3* and as *Alarm1, 2,* or *3.* The selections apply to all RTD's.

Name..... 18 Character, Alphanumeric
Type ..... Disable, Pt100, Ni100, Ni120, Cu10
Function ..... Stator, Bearing, Load, Ambient
Trip and Alarm Range..... 40.00 to 200.00°C
Display Range..... -40.00 to 200.00°C
Error Codes ..... -100 = No Sensor
-90 = Open Sensor
-80 = Shorted Sensor
-70 = No Data/Module Error
(Codes accessed via network communications)

5.23 RTD UNDERTEMPERATURE

OPI Menu: *Setup* | *Protection* | *RTD Undertemperature*

When an RTD module is connected, the FPS provides RTD Undertemperature protection for a select range of temperatures between +20 and -20°C. Trip and alarm settings are provided. When a temperature drops below the setting, a trip or alarm is indicated. For alarm settings, a 5°C hysteresis is used (when an alarm occurs, it remains active until the temperature is 5°C above the setting). The alarm feature can be used to implement a "bang-bang" temperature controller.

Undertemperature protection is only provided for RTD's that are assigned to Group A.

Trips can be assigned to *Trip1, 2, and 3* and alarms can be assigned to *Alarm1, 2, and 3*.

Trip Level..... 20, 15, 10, 5, 0, -5, -10, -15, -20°C
Alarm Level ..... 20, 15, 10, 5, 0, -5, -10, -15, -20°C
Protection ..... Enable/Disable Trip1, 2, 3
Enable/Disable Alarm1, 2, 3

5.24 ANALOG INPUT

OPI Menu: *Setup* | *Analog Input* | *4–20 Input Type*

The analog input function is selectable as *Metering Only*, or *Protection*.

In *Metering Only*, the 4-20 mA protection is disabled. In *Protection* mode, 4-20 mA set points are enabled.

The protection input has high-level and low-level trip and alarm set points. A high-level trip or alarm occurs when the 4-20-mA input exceeds the high-level trip or alarm set point, and a low-level trip or alarm occurs when the 4-20-mA input is lower than the low-level trip or alarm set point.

High Level Trip ..... 0.10 to 20.00 mA
Low Level Trip..... 0.10 to 20.00 mA
Trip Delay ..... 0.01 to 100.00 s
High Level Alarm..... 0.10 to 20.00 mA
Low Level Alarm ..... 0.10 to 20.00 mA
Alarm Delay ..... 0.01 to 100.00 s

6. CONTROL METHOD

OPI Menu: *Setup* | *Breaker Control*

6.1 GENERAL

From the OPI *Control Type* menu, select a control type or select *Protection Only*.

When *Protection Only* is selected, all control functions except OPEN are disabled and all OPI control-select LED's will be OFF. Any OPEN signal will initiate a *Trip1* when the FPS is in *Protection Only*.

CAUTION: When *Protection Only* is selected, OPEN will not function if *Trip1* is not assigned to a relay output.

The FPS can operate in one of two control modes, REMOTE or LOCAL. The control source is selected using network communication, or a digital input. In each of the control selections, the Close Source can be selected as shown in Table 6.1.

When a control type is selected, control can be performed with the digital inputs, OPI, or network communications. See Section 4.3.3 for details on selecting breaker-control sources.

The digital inputs allow concurrent operation of two control methods; three-wire open/close and two-wire open/close. Three-wire control requires two digital inputs, one programmed for *3-Wire Close* (N.O. momentary switch) and one programmed for *Permissive* (N.C. momentary switch) as shown in Fig. 6.1. Two-wire control uses one input, programmed as *2-Wire Close*, for open/close control and can be used where a single contact provides open/close operation. See Fig. 6.2. If close was activated by a two-wire input, any other OPEN will initiate a latching *Trip1* as well as operating the *CB Open* output. In all other cases, OPEN does not cause a trip.

NOTE: When control functions are used, protective functions will open operate the *CB Open* output to open the breaker or contactor when a trip occurs. Reset is required.

Table 6.1 indicates the available close sources.

TABLE 6.1 CLOSE-SOURCE SUMMARY (1)

CONTROL (7) SELECTION	CLOSE SOURCE	
REMOTE (2)	DIGITAL INPUTS (3)	3-Wire Close
		2-Wire Close (4)
	OPI (3)	CLOSE Key
	NETWORK (3)	Close Command
LOCAL (5)(6)	DIGITAL INPUTS (3)	3-Wire Close
		2-Wire Close (4)
	OPI (7)	CLOSE Key

(1) All OPEN sources are always enabled.
(2) Factory default has all sources enabled and REMOTE selected.
(3) Can be enabled or disabled using the *Setup* | *Control Method* | *Remote Group* menu.
(4) OPEN causes a latching trip.
(5) LOCAL is selected by a network command or by a digital input programmed for *Local Select*. Each *Local Select* source must de-select local control for the FPS to return to the previous control setting.
(6) *Interlocks* are bypassed.
(7) Can be enabled or disabled using the *Setup* | *Control Method* | *Local Group* menu.

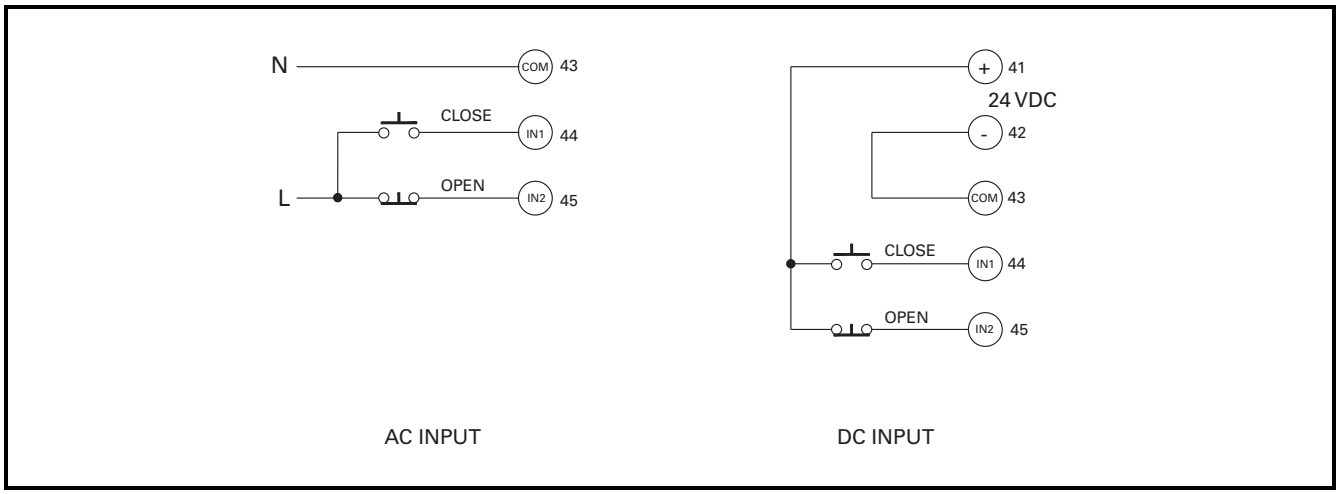

FIGURE 6.1 Typical Three-Wire Control.

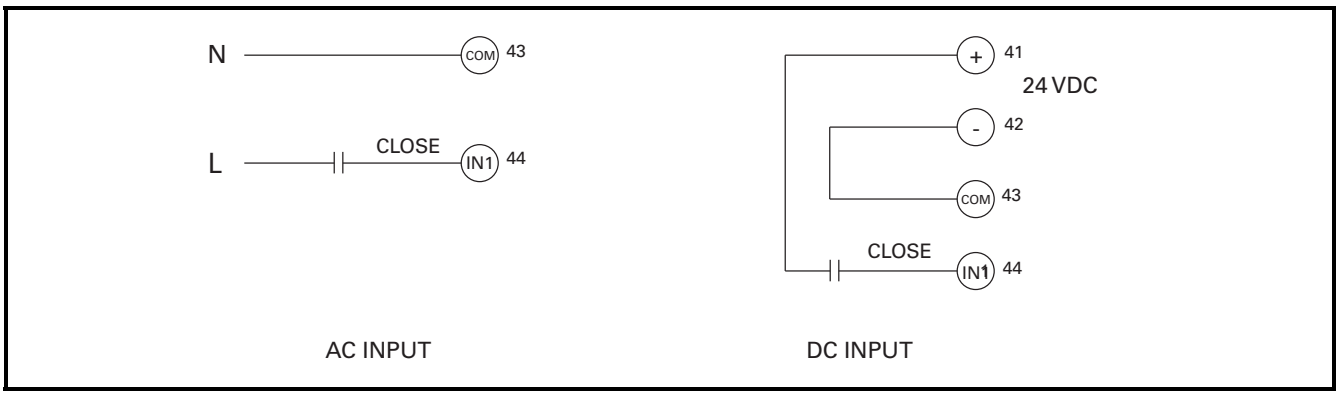

FIGURE 6.2 Typical Two-Wire Control.

6.2 OPEN/CLOSE CONTROL

OPI Menu: *Setup* | *Device Control*
OPI Menu: *Setup* | *Relay Outputs*

Three selections in the *Setup* | *Device Control* | *Control Type* menu define how the assigned output relays operate. The selections are *None*, *Contactor*, and *2-Coil Device*. When set to *None*, control functions are disabled. When set to *Contactor* or *2-Coil Device*, control functions are enabled. Trips can be selected to cause the interrupting device to open or the control function can be set to operate independently. Use the *Setup* | *Control Method* | *Trip Sources* menu to select the combinations of *Trip1*, *Trip2*, or *Trip3* that cause the device to open when a trip occurs. Default is *Trip1*, *Trip2*, or *Trip3*.

NOTE: When two-wire close control is used, *Trip Sources* must include *Trip1* so that when an OPEN command is received while the two-wire input is active, a reclose is prevented. Device will reclose after RESET is performed.

When a control type other than *None* is selected, the yellow OPI CLOSE and OPEN LED's provide indication of the state of the control function. When the breaker or contactor is closed, the CLOSE LED will be on, when the contactor or breaker is open, the OPEN LED will be on. During transitions from open to close, both LED's are on.

Depending on the control state, loss of permissive inputs or interlocks may not generate a trip or alarm condition but may prevent a close operation. The *Messages* | *Status Messages* menu will display a digital-input identifier and related message indicating what is preventing the close operation.

Select a control type of *None* for applications in which a manually operated, electrically tripped device such as a shunt-trip or under-voltage breaker is used. No breaker or contactor open/close control is used and the shunt or under-voltage coil must be connected to an output relay assigned to *Trip1*, *Trip2*, or *Trip3*. The output relay assignments associated with breaker or contactor control (*CB Open*, *CB Close*, *Contactor*) are disabled when the control type is set to *None*. The REMOTE and LOCAL LED's are off with this selection.

For shunt-trip breakers, use a normally open output contact and set the relay mode to *Non-Fail-Safe*. For undervoltage breakers, use a normally open output contact and set the relay mode to *Fail-Safe*.

NOTE: The OPEN key on the OPI is always enabled. When the control type is set to *None* a "Trip1" is generated when pressed.

The *Contactor* control type selection is for applications where an electrically held device such as a contactor is used. An output relay must be assigned to *Contactor*.

In contactor-control mode, the CLOSE and OPEN functions are operational. Control sources include the OPI, digital inputs, and network communications. When there are no trips and CLOSE is issued, the relay assigned to *Contactor* will energize and stay energized until an OPEN command is issued or a trip occurs. An OPEN command operates the output contacts but does not generate a trip, except when two-wire digital-input control is used. In this case, an OPEN command will also issue a "Trip1", requiring a reset.

Use the *2-Coil Device* control type selection to control bi-stable devices such as a two-coil breaker. Two output relays are used to control the device's close and open/trip coils. Assign two FPS output relays as *CB Close* and *CB Open* in the *Setup* | *Relay Outputs* menu.

When a breaker with a close coil and undervoltage-release coil is used, use the normally-closed contact of the output relay that is assigned to *CB Open*. In this configuration the contact opens momentarily to release the breaker on an open request. Figs. 6.3 and 6.4 show two examples of breaker control.

In 2-coil-device mode, the CLOSE and OPEN functions are operational. Control sources include the OPI, digital inputs, and network communications. When there are no trips and CLOSE is issued, the relay assigned to *CB Close* will energize for the maximum time duration

defined by the *Close Pulse Time*. When OPEN is issued, the relay assigned to *CB Open* will energize for the time duration defined by the *Open Pulse Time.* The full *Open Pulse Time* is always used.

If status is not valid after the *Open Pulse Time* has expired, the FPS will attempt an open retry. The retry count is selected between zero (no retries) and five retries. A time delay between successive retries is used and this delay is also defined by the *Open Pulse Time*.

If the open status is not valid on power up, retries are attempted based on the selected settings.

NOTE: For digital inputs set to *2-Wire Close*, an OPEN command generates a Trip1 and the FPS will indicate "CB OPEN Press Trip". *Trip Sources* must be set to enable *Trip1* or the breaker will close as soon as OPEN is released.

6.2.1 CONTACT STATUS MONITOR

For the control type selection of *Contactor* and *2-Coil Device*, the device open/close status can be monitored by a digital input connected to an auxiliary contact. Status monitoring is enabled when a digital input is assigned as *52a Close Status* or *52b Open Status*. When *52a Close Status* is selected, the digital input should have voltage applied (logic 1) when the device is closed and no voltage (logic 0) when the device is open. When *52b Open Status* is selected, the digital input should have voltage applied (logic 1) when the device is open and no voltage (logic 0) when the device is closed.

During device operation, status must be valid within the time specified by the *Close Pulse Time* for device close operation and the *Open Pulse Time* device open operation.

The FPS will issue a *Trip1* and indicate a *CB 52 Contact Trip* if the status contact does not indicate a valid status within the open or close pulse time. When in the open or closed state, contact status is checked every 50 ms and a *CB 52 Contact Trip* will occur if the input status is incorrect. If ac control voltage is used for the digital input, it is recommended to program one of the inputs as *Control Power*. See Section 4.2.9.

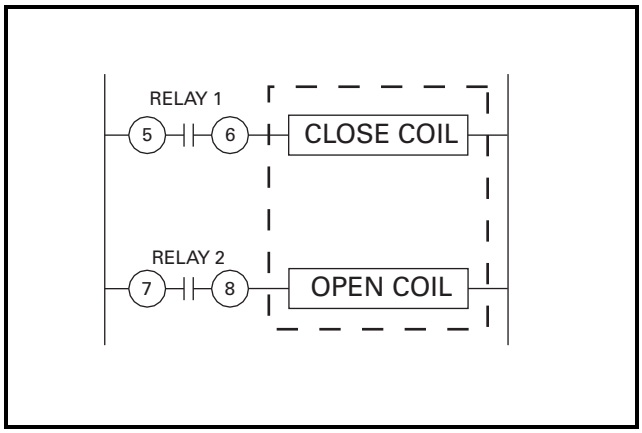

FIGURE 6.3 Breaker with Close and Open Coils.

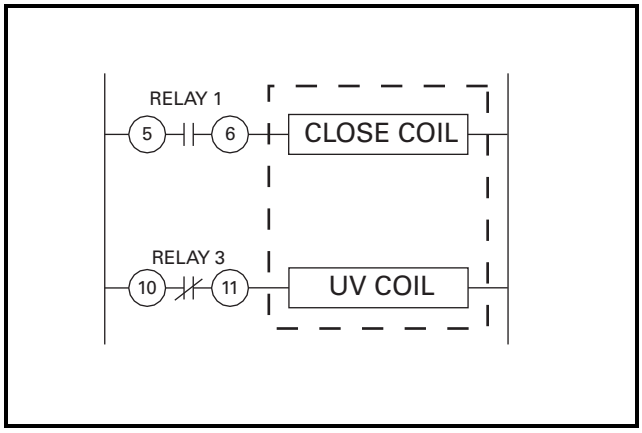

FIGURE 6.4 Breaker with Close and UV Coils.

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7. THEORY OF OPERATION

7.1 SIGNAL-PROCESSING ALGORITHMS

The FPS sampling rate is sixteen samples per cycle of the fundamental frequency. A Discrete-Fourier-Transform (DFT) algorithm is used to obtain the magnitude and phase angles of the fundamental-frequency components of the current and voltage waveforms. These values provide true positive- and negative-sequence components. True RMS values of line currents are calculated for use by the thermal-model algorithm. RMS values include up to the 8th harmonic. All calculated values are updated at the sampling frequency to achieve a fast response to fault conditions. RMS values of the fundamental components of current and voltage are displayed.

The FPS uses the input voltage VA for frequency measurement. The input voltage must be above 30 Vac and a sixteen-cycle interval is used to determine frequency. Frequency protection is inhibited when system voltage is less than 50% of the *System Voltage* setting.

7.2 POWER ALGORITHM

Apparent power (*S*) is calculated by:

$$S = P + jQ$$

Real power (P) is determined from the in-phase components of I and V, and reactive power (Q) is determined from the quadrature components of I with respect to V. Power factor is the magnitude of the ratio of P to S.

The one-PT connection assumes balanced voltages for power calculations. Power calculations for the other connections are valid for both balanced and unbalanced conditions. In all cases, power calculations use the two-wattmeter method and assume three-wire loads.

The IEEE convention is used for power displays:

+Watts, +Vars, -PF (Lag)	Importing Watts, Importing Vars
+Watts, -Vars, +PF (Lead)	Importing Watts, Exporting Vars
-Watts, -Vars, -PF (Lag)	Exporting Watts, Exporting Vars
-Watts, +Vars, +PF (Lead)	Exporting Watts, Importing Vars

7.3 OPERATOR INTERFACE (FPS-OPI)

The OPI is a terminal device used to communicate with the FPS-CTU. All set points, operating parameters, and menus are stored in the FPS-CTU.

The OPI contains a microprocessor used to communicate with the FPS-CTU, read key presses, and perform display functions.

On multiple-OPI systems, all OPI's display the same information. Key presses on any OPI will be processed by the FPS-CTU.

7.4 RTD MODULE (MPS-RTD)

The RTD module contains a microprocessor, A/D converter, and analog multiplexers used to measure up to eight RTD's. The RTD-measuring circuit is isolated from the I/O Module network. All eight RTD's are scanned every three seconds. RTD linearization, open/short detection, and lead compensation are performed by the RTD module. RTD temperature is sent to the FPS-CTU where temperature monitoring occurs.

7.5 FIRMWARE DIAGNOSTICS

In the event of an internal fault, a diagnostic error code is generated and can be viewed with the OPI. The last error code can be viewed by selecting *Setup* | *System Config* | *Maintenance* | *Firmware Version.* The diagnostic code is a two or three digit hexadecimal number.

02 to FF:	Processor Fault
100:	Protection Algorithm Fault
200:	Relay-Control Algorithm Fault
400:	Menu Display Fault
500:	OPI Key Handler Fault
600:	Real-Time Clock Fault
700:	Communication-Handler Fault
800:	RTD Temperature-Handler Fault
900:	A/D Communication-Interface Fault

The last diagnostic error code is saved in non-volatile memory. The diagnostic code is overwritten by any new codes but can also be manually set to zero. To clear the error code, press RESET while in the *Firmware Version* menu.

A diagnostic error generates a Trip1 and increments the trip counter, however, a trip record is not generated.

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8. COMMUNICATIONS

8.1 PERSONAL-COMPUTER INTERFACE

8.1.1 FIRMWARE UPGRADE

The FPS-CTU control program is stored in flash memory. Field updates can be made through the I/O module communications connection. The following are required:

- A Windows® PC, with the SE-Flash program installed
- a file containing the FPS-CTU control program (.s19 file)
- an RS-232/RS-485 converter that operates at 57,600 bit/s. Use the Littelfuse Startco SE-485-PP or SE-485-DIN.

SE-Flash is available at www.littelfuse.com/relayscontrols.

8.1.2 SE-COMM-RIS

SE-Comm-RIS is a Windows-based program used to access FPS functions with a personal computer (PC) via the RS-485 network interface or Modbus® TCP. Use SE-Comm-RIS to program an FPS either by changing individual set points or by downloading set-point files. Existing FPS set points can be transferred to the PC. Metered values can be viewed and the FPS can be controlled with the computer. SE-Comm-RIS extends the event-record storage capability of the FPS by allowing the user to transfer data to PC memory at a programmable interval. Protection curve plotting capability is included. SE-Comm-RIS is available at www.littelfuse.com/relayscontrols.

8.2 NETWORK INTERFACE

For detailed information see Appendices to this manual and applicable communications manuals.

8.2.1 RS-485 COMMUNICATIONS

RS-485 communications support Modbus® RTU and Allen-Bradley® DF1 half-duplex protocols. All set points and meter values are accessible. Commands are provided to perform trips, resets, and starter control.

Modbus® RTU function codes supported:

- Read Holding Registers (Code 3)
- Read Input Registers (Code 4)
- Write Single Register (Code 6)
- Write Multiple Registers (Code 16)
- Command Instruction (Code 5)

DF1 Commands Supported:

- Unprotected Read (CMD = 01)
- Unprotected Write (CMD = 08)
- Typed Read (CMD = 0F, FNC = 68)
- Typed Write (CMD = 0F, FNC = 67)
- Typed Logical Read (CMD = 0F, FNC = A2)
- Typed Logical Write (CMD = 0F, FNC = AA)

8.2.2 DEVICENET COMMUNICATIONS

DeviceNet™ communications support Explicit Messaging and Polled I/O. All set points and meter values are accessible using Explicit Messaging. The Polled I/O connection supports the following ODVA input assemblies:

- Basic Overload (50)
- Extended Overload (51)
- Basic Motor Starter (52)
- Extended Motor Starter 1 (53)
- Extended Motor Starter 2 (53)

In addition to the ODVA assemblies, a user-configurable fixed block of 64 bytes is available.

The Polled I/O connection supports the following ODVA output assemblies:

- Basic Overload (2)
- Basic Motor Starter (3)

An Electronic Data Sheet (EDS) file is provided for use with DeviceNet configuration tools such as RSNetWorx and DeltaV.

8.2.3 ETHERNET COMMUNICATIONS

The FPS supports Modbus® TCP and Ethernet/IP using the Anybus-S module from HMS Fieldbus Systems AB. Data from the FPS consists of a 64-byte assembly representing user-defined register data. A command structure is provided to write set-point and FPS commands.

8.2.4 PROFIBUS DP COMMUNICATIONS

The FPS supports Profibus-DP using the Anybus-S module. Data from the FPS consists of a 64-byte assembly representing user-defined register data. A command structure is provided to write set-point and FPS commands.

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9. TECHNICAL SPECIFICATIONS

9.1 CONTROL UNIT (FPS-CTU)

Supply ..... 25 VA, 65 to 265 Vac, 40 to 400 Hz, power factor corrected. 25 W, 80 to 275 Vdc.

Power-Up Time ..... 800 ms at 120 Vac

Ride-Through Time ..... 100 ms minimum

24-Vdc Source [1] ..... 100 mA maximum

AC Measurements:
- Methods ..... True RMS and DFT, Positive- and negative-sequence components of the fundamental
- Sample Rate ..... 16 samples/cycle

Frequency:
- Fixed ..... 50, 60 Hz

Phase-Current Inputs: [2]
- Range ..... 18 x CT-Primary Rating (I_p)
- Accuracy: [3]
  - $I < I_p$ ..... 1% I_p
  - $I > I_p$ ..... 1% Reading
- Burden ..... < 0.01 Ω
- Unbalance Accuracy ..... 0.01 pu
- Common-Mode Voltage ..... 120 Vac maximum
- Thermal Withstand:
  - Continuous ..... 5 x CT Rating
  - 1-Second ..... 80 x CT Rating

Earth-Leakage Input:
- Range ..... 1.5 x Earth-Fault-CT-Primary Rating (I_e)
- Accuracy [3] ..... 1% I_e
- Burden ..... < 0.01 Ω (1- and 5-A inputs), 10 Ω for EFCT
- Common-Mode Voltage ..... 120 Vac maximum
- Thermal Withstand:
  - Continuous ..... 5 x CT Rating
  - 1-Second ..... 80 x CT Rating

Phase-Voltage Inputs: [4, 5]
- Nominal Input ..... 30 to 600 Vac line-to-line
- Input Resistance ..... 3.4 MΩ
- Range ..... 1.4 x PT-Primary Rating (V_p)
- Accuracy: [3]
  - $V < V_p$ ..... 1% V_p
  - $V > V_p$ ..... 1% Reading
- Unbalance Accuracy ..... 0.01 pu

Frequency Metering:
- Range ..... 5 to 100 Hz Uses VA input, Sine wave assumed
- Accuracy ..... 0.05 Hz

PTC-Thermistor Input: [1]
- Cold Resistance ..... 1500 Ω maximum at 20°C
- Trip Level ..... 2800 Ω ± 100 Ω
- Sensor Current ..... 2 mA maximum

4-20 mA Analog Input:
- Input Burden ..... 100 Ω
- Common-Mode Voltage [6] ..... ± 5 Vdc

4-20 mA Analog Output: [1]
- Load ..... 500 Ω maximum
- Range ..... 0 to 25 mA
- Update Time ..... 500 ms

Timing Accuracies: [7]
- Set Points ..... -10%, +0% (Minimum 25 to 45 ms)
- Overload Curve ..... Greater of 2% or +200 ms (Minimum 25 to 45 ms)
- IEC/IEEE Curves ..... ±5% (Minimum 25 to 45 ms)

Starter-Control Stop Time:
- Digital Input ..... 30 to 80 ms
- OPI ..... 70 to 200 ms
- Network ..... 30 to 80 ms

Relay Contacts (Relays 1 and 2):
- Configuration ..... N.O. (Form A)
- CSA/UL Contact Rating ..... 8 A resistive 250 Vac, 5 A resistive 30 Vdc
- Supplemental Contact Ratings:
  - Make/Carry 0.2 s ..... 30 A

Break:
- dc ..... 75 W resistive, 35 W inductive (L/R = 0.04)
- ac ..... 2,000 VA resistive, 1,500 VA inductive (PF = 0.4)

Subject to maximums of 8 A and 250 V (ac or dc).

Relay Contacts (Relays 3 and 4):
- Configuration ..... N.O. and N.C. (Form C)
- CSA/UL Contact Rating ..... 8 A resistive 250 Vac, 8 A resistive 30 Vdc
- Supplemental Contact Ratings:
  - Make/Carry 0.2 s ..... 20 A
  - Break:
    - dc ..... 50 W resistive, 25 W inductive (L/R = 0.04)
    - ac ..... 2000 VA resistive, 1,500 VA inductive (PF = 0.4)

  Subject to maximums of 8 A and 250 V (ac or dc).

Solid-State Output (Relay 5):
- Configuration ..... N.O. (Form A)
- Rating ..... 100 mA, 250 V (ac or dc)
- On Resistance ..... 30 Ω maximum

Digital Inputs: (1)
- Range ..... 12 to 120 V (ac or dc), 5 mA
- Guaranteed On ..... 12 Vdc at 3 mA, 20 Vac at 3 mA
- Guaranteed Off ..... 3 Vdc at 2 mA, 2.5 Vac at 0.3 mA

IRIG-B:
- Format ..... Amplitude Modulated IRIG-B122
- Amplitude ..... 1 to 10 Vpp
- Impedance ..... 10 kΩ
- Ratio ..... 3:1 to 6:1

I/O Module Interface (OPI and RTD):
- Module Supply (1) ..... 24 Vdc, 400 mA maximum
- Configuration ..... RS-485, 2-wire multi-drop
- Bus Length ..... 1.2 km (4,000') maximum
- Cable ..... Belden 3124A or equivalent

Standard Network Communications:
- Configuration ..... RS-485, 2-wire multi-drop
- Baud Rate ..... 1.2, 2.4, 4.8, 9.6, 19.2 kbit/s
- Protocols ..... Modbus RTU and A-B DF1
- Isolation ..... 120 Vac
- Bus Length ..... 1.2 km (4,000') maximum

Real-Time Clock and Non-Volatile RAM:
- Power-Off Retention ..... 7 Years at 20°C (68°F)
- Battery Shelf Life ..... > 50 Years at 20°C (68°F)

Dimensions:
- Height ..... 121 mm (4.8")
- Width ..... 190 mm (7.5")
- Depth ..... 127 mm (5.0")

Shipping Weight ..... 2.0 kg (4.4 lb)

PWB Conformal Coating ..... MIL-1-46058 qualified UL QMJU2 recognized

Environment:
- Operating Temperature ..... –40 to 60°C (-40 to 140°F)
- Storage Temperature ..... –55 to 80°C (-67 to 160°F)
- Humidity ..... 85% Non-Condensing

Surge Withstand ..... ANSI/IEEE C37.90.1-1989 (Oscillatory and Fast Transient)

Certification ..... CSA, Canada and USA

LR 62897

To:

CSA C22.2 No. 14 Industrial Control Equipment
UL 508 Industrial Control Equipment
UL 1053 Ground Fault Sensing and Relaying Equipment

Australia

N11659

NOTES:
(1) The I/O module supply (terminal 56), PTC (terminal 54), AN OUT (terminal 40), and 24-Vdc source (terminal 42) are referenced to the same common.
(2) Current threshold is 1.5% CT-Primary Rating. Power readings are not displayed for currents below this threshold. To maintain specified accuracy, phase CT's should be selected with a primary rating between 100% and 300% of nominal full-load current.
(3) Transformer accuracy not included.
(4) Voltage unbalance is not displayed for positive-sequence voltage levels below 20% of system voltage setting.
(5) Direct connection for system voltages up to 600 Vac line-to-line.
(6) Common-mode voltage relative to CTU terminal 3.
(7) Also see Tables 5.1 and 5.2.

9.2 OPERATOR INTERFACE (FPS-OPI)

Supply (1) ..... 20 to 30 Vdc, 80 mA

Display Type ..... 4 x 20 Alphanumeric Vacuum Fluorescent

Dimensions:
- Height..... 98 mm (3.9")
- Width ..... 192 mm (7.6")
- Depth..... 113 mm (4.5")

Shipping Weight..... 0.6 kg (1.3 lb)

PWB Conformal Coating ..... MIL-1-46058 qualified
UL QMJU2 recognized

Environment:
- Operating Temperature..... –40 to 60°C (-40 to 140°F)
- Storage Temperature..... –55 to 80°C (-67 to 160°F)
- Humidity..... 85% Non-Condensing

Surge Withstand ..... ANSI/IEEE C37.90.1-1989 (Oscillatory and Fast Transient)

Certification..... CSA, Canada and USA

LR 62897 C US

- Hazardous-Location..... Class I Zone 2 Ex nA II T6
  Class I, Division 2, Groups A, B, C, D

To:
CSA C22.2 No. 14 Industrial Control Equipment
CSA C22.2 No. 213-M1987 – Non-Incendive Electrical Equipment for use in Class I, Division 2 Hazardous Locations
UL 508 Industrial Control Equipment
UL 1053 Ground Fault Sensing and Relaying Equipment

Australia

N11659

NOTES:
(1) The I/O module supply (terminal 56), PTC (terminal 54), AN OUT (terminal 40), and 24-Vdc source (terminal 42) are referenced to the same common.

9.3 RTD MODULE (MPS-RTD)

Supply (1)..... 2 W, 15 to 32 Vdc

Configuration..... 8 inputs, 3-wire RTD

RTD Types Pt100, Ni100, Ni120, Cu10

Measurement Range ..... -40 to 200°C (-40 to 392°F), with open and short detection

Sensor Current..... 2 mA

Lead Compensation ..... 20 Ω maximum

Accuracy:
- Pt100, Ni100, Ni120 RTD..... 1°C
- Cu10 RTD..... 3°C

Interconnection Cable:
- Type ..... Belden® 3124A or equivalent
- Maximum Length..... 1.2 km (4,000')
- Supplied length..... 4 m (13')

Shipping Weight..... 0.4 kg (0.9 lb)
PWB Conformal Coating..... MIL-1-46058 qualified
UL QMJU2 recognized

Dimensions:
- Height..... 87 mm (3.4")
- Width..... 113 mm (4.4")
- Depth..... 53 mm (2.1")

Environment:

Operating Temperature	–40 to 60°C (-40 to 140°F)
Storage Temperature	–55 to 80°C (-67 to 160°F)
Humidity	85% Non-Condensing

Surge Withstand	ANSI/IEEE C37.90.1-1989 (Oscillatory and Fast Transient)

Certification	CSA, Canada and USA

LR 62897

UL Recognized

Hazardous-Location	Class I Zone 2 Ex nA II T6 Class I, Division 2, Groups A, B, C, D

To:

CSA C22.2 No. 14 Industrial Control Equipment
CSA C22.2 No. 213-M1987 – Non-Incendive Electrical Equipment for use in Class I, Division 2 Hazardous Locations
UL 508 Industrial Control Equipment
CSA E60079-15: 02 Electrical Apparatus for Explosive Gas Atmospheres
UL 60079-15 Electrical Apparatus for Explosive Gas Atmospheres

NOTES:

(1) The I/O module supply (terminal 56), PTC (terminal 54), AN OUT (terminal 40), and 24-Vdc source (terminal 42) are referenced to the same common.

10. WARRANTY

The FPS Motor Protection System is warranted to be free from defects in material and workmanship for a period of ten years from the date of purchase.

Littelfuse Startco will (at Littelfuse Startco's option) repair, replace, or refund the original purchase price of an FPS-CTU, FPS-OPI, or MPS-RTD that is determined by Littelfuse Startco to be defective if it is returned to the factory, freight prepaid, within the warranty period. This warranty does not apply to repairs required as a result of misuse, negligence, an accident, improper installation, tampering, or insufficient care. Littelfuse Startco does not warrant products repaired or modified by non-Littelfuse Startco personnel.

Menu Level
1 2 3 4 5 6 7

APPENDIX A
FPS MENU LEVEL

Metering ▸
- Summary→ {Display based on menu setting}
- Current→ {I_a, I_b, I_c in amperes and per unit}
- Unbalance (I)→ {I_1, I_2, and unbalance (I_2/I_1) in per unit}
- Earth Leakage→ {Measured (I_{ct}) earth leakage in amperes and per unit}
- Thermal Status→ {Thermal capacity, time-to-trip, reset times}
- Voltage→ {V_{ab}, V_{bc}, V_{ca}}
- Unbalance (V) → {V_1, V_2, and unbalance (V_2/V_1) in per unit}
- Power→ {Real, Apparent, Reactive, Power Factor}
- Energy→ {kWh, kVAh, kVARh}
- Frequency→ {Frequency reading from Vab}
- RTD Temperature→{RTD summary and individual temperatures}
- Inverse Status→ {Indicates if current is above the pickup level}
- I/O Status→ {Digital input state, relay-output state}
- System Status→ {Active set-point group, RTC time}
- Network Status→ {Network type and state}

Messages ▸
- Trip and Alarm→ {Trips and Alarms as per Type T90 per Appendix x}
- Status Messages→ {Messages}
- Event Records→ {0 to 63 trip records}
- Statistics→ {Trip counters and run times}
- Emerg I2t Reset ▸
  - Reset I2t Memory→ [Y/N]

Setup ▸
- Protection ▸
  - Overload ▸
    - Group 1 ▸
      - I^2t Trip Action→ [T42]
      - I^2t Pickup→ [X]
      - Hot Factor→ [X]
      - Cooling Factor→ [X]
      - Time Constant→ [X]
      - I^2t Alarm Level→ [X]
      - I^2t Alarm Action→ [T43]
    - Group 2 ▸
      - <same as group 1>
    - I^2t Reset Type→ [T38]

1 2 3 4 5 6 7

Menu Level
1 2 3 4 5 6 7

- I^2t Reset Level→ [X[
- Phase Inverse ▸
  - Group 1 ▸
    - Trip Action→ [T42]
    - Curve→ [T73]
    - Pickup→ [X]
    - Time Multiplier→ [X]
  - Group 2 ▸
    - <same as group 1>
- Phase Definite Time ▸
  - Group 1 ▸
    - Trip Action→ [T42]
    - Trip Level→ [X]
    - Trip Delay→ [X]
    - Alarm Action→ [T43]
    - Alarm Level→ [X]
    - Alarm Delay→ [X]
  - Group 2 ▸
    - <same as group 1>
- 3Io Inverse ▸
  - Group 1 ▸
    - Trip Action→ [T42]
    - Curve→ [T73]
    - Pickup→ [X]
    - Time Multiplier→ [X]
  - Group 2 ▸
    - <same as group 1>
- 3Io Definite Time ▸
  - Group 1 ▸
    - Trip Action→ [T42]
    - Trip Level→ [X]
    - Trip Delay→ [X]
    - Alarm Action→ [T43]
    - Alarm Level→ [X]
    - Alarm Delay→ [X]
  - Group 2 ▸
    - <same as group 1>
- Ict Definite Time ▸
  - Group 1 ▸
    - Trip Action→ [T42]
    - Trip Level→ [X]

1 2 3 4 5 6 7

Menu Level
1 2 3 4 5 6 7

Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Level→ [X]
Alarm Delay→ [X]

Group 2 ▸
<same as group 1>

Unbalance (I) ▸
Trip Action→ [T42]
Trip Level→ [X]
Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Level→ [X]
Alarm Delay→ [X]

Phase Loss (I) ▸
Trip Action→ [T42]
Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Delay→ [X]

Phase Reverse (I) ▸
Trip Action→ [T42]
Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Delay→ [X]

Unbalance (V) ▸
Trip Action→ [T42]
Trip Level→ [X]
Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Level→ [X]
Alarm Delay→ [X]

Phase Loss (V) ▸
Trip Action→ [T42]
Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Delay→ [X]

Phase Reverse (V) ▸
Trip Action→ [T42]
Trip Delay→ [X]
Alarm Action→ [T43]
Alarm Delay→ [X]

Undervoltage ▸

1 2 3 4 5 6 7

Menu Level

1	2	3	4	5	6	7
			Trip Action→			[T42]
			Trip Level→			[X]
			Trip Delay→			[X]
			Alarm Action→			[T43]
			Alarm Level→			[X]
			Alarm Delay→			[X]
		Overvoltage ▸				
			Trip Action→			[T42]
			Trip Level→			[X]
			Trip Delay→			[X]
			Alarm Action→			[T43]
			Alarm Level→			[X]
			Alarm Delay→			[X]
		Underfrequency (V) ▸				
			Trip Action→			[T42]
			Trip Level→			[X]
			Trip Delay→			[X]
			Alarm Action→			[T43]
			Alarm Level→			[X]
			Alarm Delay→			[X]
		Overfrequency (V) ▸				
			Trip Action→			[T42]
			Trip Level→			[X]
			Trip Delay→			[X]
			Alarm Action→			[T43]
			Alarm Level→			[X]
			Alarm Delay→			[X]
		Power Factor Lag ▸				
			Trip Action→			[T42]
			Trip Level→			[X]
			Trip Delay→			[X]
			Alarm Action→			[T43]
			Alarm Level→			[X]
			Alarm Delay→			[X]
		Power Factor Lead ▸				
			Trip Action→			[T42]
			Trip Level→			[X]
			Trip Delay→			[X]
			Alarm Action→			[T43]
			Alarm Level→			[X]
			Alarm Delay→			[X]
		Reversepower ▸				

1	2	3	4	5	6	7

Menu Level

1 2 3 4 5 6 7

- Trip Action → [T42]
- Trip Level→ [X]
- Trip Delay→ [X]
- Alarm Action→ [T43]
- Alarm Level→ [X]
- Alarm Delay→ [X]

PTC Local Temp ▸

- Trip Action→ [T42]
- Alarm Action→ [T43]

RTD Temperature ▸

RTD #1 ▸

- #1 Name → [S]
- #1 Type→ [T20]
- #1 Function→ [T89]
- #1 Trip Level→ [X]
- #1 Alarm Level→ [X]

RTD #2 ▸

- #2 Name → [S]
- #2 Type→ [T20]
- #2 Function→ [T89]
- #2 Trip Level→ [X]
- #2 Alarm Level→ [X]

RTD #3 ▸

- #3 Name → [S]
- #3 Type→ [T20]
- #3 Function→ [T89]
- #3 Trip Level→ [X]
- #3 Alarm Level→ [X]

RTD #4 ▸

- #4 Name → [S]
- #4 Type→ [T20]
- #4 Function→ [T89]
- #4 Trip Level→ [X]
- #4 Alarm Level→ [X]

RTD #5 ▸

- #5 Name → [S]
- #5 Type→ [T20]
- #5 Function→ [T89]
- #5 Trip Level→ [X]
- #5 Alarm Level→ [X]

RTD #6 ▸

1 2 3 4 5 6 7

Menu Level
1 2 3 4 5 6 7

#6 Name → [S]
#6 Type→ [T20]
#6 Function→ [T89]
#6 Trip Level→ [X]
#6 Alarm Level→ [X]
RTD #7 ▸
#7 Name → [S]
#7 Type→ [T20]
#7 Function→ [T89]
#7 Trip Level→ [X]
#7 Alarm Level→ [X]
RTD #8 ▸
#8 Name → [S]
#8 Type→ [T20]
#8 Function→ [T89]
#8 Trip Level→ [X]
#8 Alarm Level→ [X]

Sensor Trip Act→ [T42]
Sensor Alarm Act→ [T43]

Undertemperature ▸
Trip Action → [T42]
Trip Level→ [T108]
Alarm Action→ [T43]
Alarm Level→ [T108]

System Ratings ▸
Phase-CT Primary→ [X]
EF-CT Primary→ [X]
System Voltage→ [X]
Input Voltage→ [X]
V Connection→ [T9]
Frequency→ [T10]
Set-Point Group→ [T81]

Device Control ▸
Control Type→ [T103]
Close Pulse Time→ [X]
Open Pulse Time→ [X]
Open Retry→ [T107]
Trip Sources→ [T104]

1 2 3 4 5 6 7

Menu Level
1 2 3 4 5 6 7

- Remote Group ▸
  - Dig In Control→ [T6]
  - Net Control→ [T6]
  - OPI Control→ [T6]
- Local Group ▸
  - OPI Control→ [T6]

Digital Input ▸
- Digital Input 1 ▸
  - Input 1 Function→ [T86]
  - IN1 Close Bypass → [T6]
  - IN1 Bypass Delay→[X]
  - IN1 Trip Delay→ [X]
- <Repeat for digital input 2 to 7>

Relay Outputs ▸
- Relay 1 ▸
  - Relay 1 Function→ [T76]
  - Relay 1 Mode→ [T14]
- Relay 2 ▸
  - Relay 2 Function→ [T76]
  - Relay 2 Mode→ [T14]
- Relay 3 ▸
  - Relay 3 Function→ [T76]
  - Relay 3 Mode→ [T14]
- Relay 4 ▸
  - Relay 4 Function→ [T76]
  - Relay 4 Mode→ [T14]
- Relay 5 ▸
  - Relay 5 Function→ [T76]
  - Relay 5 Mode→ [T14]
- RY Pulse Time→ [X]

Analog Input ▸
- Input Function→ [T92]
- Protection ▸
  - Trip Action→ [T42]
  - High Level Trip→ [X]
  - Low Level Trip→ [X]
  - Trip Delay→ [X]
  - Alarm Action→ [T43]
  - High Level Alarm→ [X]

1 2 3 4 5 6 7

Menu Level
1 2 3 4 5 6 7

- Low Level Alarm→ [X]
- Alarm Delay→ [X]

- Analog Output ▸
  - Output Parameter→[T87]
  - Zero Calibrate→ [X]
  - FS Calibrate→ [X]

- Hardware ▸
  - Display ▸
    - Trip Action→ [T42]
    - Number of OPI→ [T40]
    - Intensity→ N/A
    - Screen Saver→ [T6]
    - Meter Summary→ N/A
    - OPI Ctrl Select ▸
      - Remote Select→ [T6]
      - OPI Select→ [T6]
  - RTD Module ▸
    - Total Modules→ [T88]
    - Err Trip Action→ [T42]
    - Err Alarm Action→ [T43]
  - Network Comms ▸
    - Network Type→ [T16]
    - Network ID→ [X]
    - Network Baud→ [T17]
    - Net Error Check→ [T18]
    - Ethernet IP→ [EA]
    - Ethernet Mask→ [EA]
    - Default Gateway→ [EA]
    - Net Trip Action→ [T42]
    - Net Alarm Action→ [T43]
    - Net Write Access→ N/A (From OPI Only)
    - Remote Trip Action→ [T42]
    - Remote Alarm Action→ [T43]
    - DeviceNet Produce→ [T84]
    - DeviceNet Consume→ [T85]
    - User Registers ▸
      - Register 0→ [X]
      - <Repeat for 1 to 31 registers>

- System Config

1 2 3 4 5 6 7

Menu Level
1 2 3 4 5 6 7

- System Name→ [S]
- Password→ [S]
- Password Timeout→ [X]
- I_2/I_1 Threshold [X]
- Clock Settings ▸
  - RTC Date/Time → [S]
  - IRIG Offset (h) → [X]
  - IRIG Offset (min) → [X]
- UPI LED→ [T74]
- Maintenance ▸
  - Clr Event Records→ [Y/N]
  - Clr Trip Counts→ [Y/N]
  - Clr Energy Values→ [Y/N]
  - Load Defaults→ [Y/N]
  - Unlock Local→ [Y/N]
  - Restart FPS→ [Y/N]
  - Firmware Update→ [Y/N]
  - Firmware Version→ [S]
  - Serial Number→ [X]

LEGEND

▸: This menu item has a sub menu, press right key view sub menu.
→: Last menu, press right key to view data.
[Y/N]: Yes/No.
[X]: Numeric.
[S]: String. Specific string format may be required.
[E]: Selection is from a list of values.
[EA]: Ethernet Address (xxx.xxx.xxx.xxx).
[E/D]: Enable/Disable.
[Txx]: See Appendix x for data type specified by xx.

1 2 3 4 5 6 7

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APPENDIX B
FPS SET-UP RECORD

Motor:_____FPS S/N: _____ Date: _____

Firmware Revision:_____

PART I: SYSTEM PARAMETERS

PARAMETER AND SETTINGS	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
System Ratings					
PH-CT Primary (I_p)	1	100.00	5,000	A	
EF-CT Primary (I_e)	1	5.00	5,000	A	
System Voltage	0.12	0.60	75	kV	
Input Voltage	0.06	0.12	0.6	kV	
Input Voltage Connection		None			❑ None ❑ 2PT ❑ 1PT ❑ 3PT/Direct
Frequency		60		Hz	❑ 50 ❑ 60
Set-Point Group		Group2			❑ Group1 ❑ Group2
Digital Inputs	See Table 4.2 Input Function Definition				
Input 1: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	
Input 2: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	
Input 3: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	
Input 4: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	
Input 5: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	
Input 6: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	
Input 7: Function		None			
Close Bypass		Disable			❑ Enable ❑ Disable
Bypass Delay	0.5	5.00	100	s	
Trip Delay	0.01	0.10	100	s	

PARAMETER AND SETTINGS	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Relay Outputs	See Table 4.1 Output Function Definition				
Relay 1: Function		None			
Mode		Fail-Safe			❑ Fail-Safe ❑ Non-Fail-Safe
Relay 2: Function		None			
Mode		Fail-Safe			❑ Fail-Safe ❑ Non-Fail-Safe
Relay 3: Function		None			
Mode		Fail-Safe			❑ Fail-Safe ❑ Non-Fail-Safe
Relay 4: Function		None			
Mode		Fail-Safe			❑ Fail-Safe ❑ Non-Fail-Safe
Relay 5: Function		None			
Mode		Fail-Safe			❑ Fail-Safe ❑ Non-Fail-Safe
RY Pulse Time	0.05	0.25	10	s	
Analog Input					
4-20 Input Type		Metering Only			❑ Metering Only ❑ Sync. To ASD ❑ Protection ❑ Motor Speed
Protection:					
High-Level Trip	0.1	16.00	20	mA	
Low-Level Trip	0.1	7.00	20	mA	
Trip Delay	0.01	5.00	100	s	
High-Level Alarm	0.1	14.00	20	mA	
Low-Level Alarm	0.1	9.00	20	mA	
Alarm Delay	0.01	1.00	100	s	
Analog Output					
Output Parameter		Phase Current			See Table 4.3 Analog Output Parameter Definition
Zero Calibrate	Factory Calibrated				
Full-Scale Calibrate	Factory Calibrated				
OPI Display					
OPI-Loss Trip		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Number of OPI's		1			❑ 1 ❑ 3 ❑ 2
Intensity		100		%	❑ 25 ❑ 75 ❑ 50 ❑ 100
Screen Saver		Enable			❑ Enable ❑ Disable
Meter Summary		IDR			❑ IDR ❑ IVPA ❑ IVP
RTD Modules					
Total Modules		0			❑ 0 ❑ 1
RTD-Module-Error Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
RTD-Module-Error Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Network Communications					
Network Type		Modbus			❑ None ❑ DeviceNet ❑ AB DF1 ❑ Anybus ❑ Modbus RTU ❑ Modbus TCP

PARAMETER AND SETTINGS	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Network ID	0	254	255		
Baud Rate		SCI 9600			❑ SCI 1200 ❑ DN125 ❑ SCI 2400 ❑ DN250 ❑ SCI 4800 ❑ DN500 ❑ SCI 9600 ❑ SCI 19200
Error Checking		Not Selected			❑ Not Selected ❑ BCC ❑ CRC
Ethenet IP		192.168. 000.001			
Ethernet Mask		255.255. 255.000			
Default Gateway		000.000 000.000			
Network-Error Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Network-Error Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Net Write Access		All			❑ All ❑ Settings Only ❑ Commands Only ❑ No Write Access
Remote Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Remote Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
DeviceNet Producing Assembly		0x36			❑ None ❑ 0x32 ❑ 0x33 ❑ 0x34 ❑ 0x35 ❑ 0x64
DeviceNet Consuming Assembly		None			❑ None ❑ 0x02 ❑ 0x03
User Registers					
User Register 0	0	0	1399		
User Register 1	0	0	1399		
User Register 2	0	0	1399		
User Register 3	0	0	1399		
User Register 4	0	0	1399		
User Register 5	0	0	1399		
User Register 6	0	0	1399		
User Register 7	0	0	1399		
User Register 8	0	0	1399		
User Register 9	0	0	1399		
User Register 10	0	0	1399		
User Register 11	0	0	1399		
User Register 12	0	0	1399		
User Register 13	0	0	1399		
User Register 14	0	0	1399		
User Register 15	0	0	1399		
User Register 16	0	0	1399		
User Register 17	0	0	1399		
User Register 18	0	0	1399		

PARAMETER AND SETTINGS	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
User Register 19	0	0	1399		
User Register 20	0	0	1399		
User Register 21	0	0	1399		
User Register 22	0	0	1399		
User Register 23	0	0	1399		
User Register 24	0	0	1399		
SYSTEM CONFIG					
System Name		FPS			
Change Password		1111			
Password Timeout	1	10.00	60	min.	
I_2/I_1 Threshold	0.05	0.50	0.50		

PART II: PROTECTION SET POINTS

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Overload – Group1					
I^2t Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
I^2t Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
I^2t Pickup (I_p is Phase-CT-Primary Rating)	0.10	1.00	1.25	x I_p	
Hot Factor	0.10	0.50	1.00		
Cooling Factor	0.10	1.00	10.00		
Time Constant	1.00	10.0	60.00	min	
I^2t Alarm level (Per Unit Based on 100% I^2t)	0.50	0.90	1.00	pu	
Overload – Group2					
I^2t Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
I^2t Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
I^2t Pickup (I_p is Phase-CT-Primary Rating)	0.10	1.00	1.25	x I_p	
Hot Factor	0.10	0.50	1.00		
Cooling Factor	0.10	1.00	10.00		
Time Constant	1.00	10.0	60.00	min	
I^2t Alarm level (Per Unit Based on 100% I^2t)	0.50	0.90	1.00	pu	
Overload Reset Type		Normal			❑ Normal ❑ Rapid ❑ Auto
Overload Reset Level	0.10	0.30	0.90	pu	
Phase Inverse – Group1					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Curve Type		IEC Normal			See Table 5.1
Curve Pickup (I_p is Phase-CT-Primary Rating)	0.10	2.00	10.00	x I_p	
Curve Multiplier	0.05	0.20	1.00		

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Phase Inverse – Group2					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Curve Type		IEC Normal			See Table 5.1
Curve Pickup (I_p is Phase-CT-Primary Rating)	0.10	2.00	10.0	x I_p	
Curve Multiplier	0.05	0.20	1.00		
Phase Definite Time – Group1					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Trip Delay	0.00	0.05	10.00	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Alarm Delay	0.00	0.05	10.00	s	
Phase Definite Time – Group2					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Trip Delay	0.00	0.05	10.00	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Alarm Delay	0.00	0.05	10.00	s	
Earth-Fault $3I_0$ Inverse – Group1					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Curve Type		IEC Normal			See Table 5.1
Curve Pickup (I_p is Phase-CT-Primary Rating)	0.10	2.00	10.00	x I_p	
Curve Multiplier	0.05	0.20	1.00		
Earth-Fault $3I_0$ Inverse – Group2					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Curve Type		IEC Normal			See Table 5.1
Curve Pickup (I_p is Phase-CT-Primary Rating)	0.10	2.00	10.00	x I_p	
Curve Multiplier	0.05	0.20	1.00		

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Earth-Fault $3I_0$ Definite Time – Group1					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Trip Delay	0.00	0.05	10.00	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Alarm Delay	0.00	0.05	10.00	s	
Earth-Fault $3I_0$ Definite Time – Group2					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Trip Delay	0.00	0.05	10.00	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (I_p is Phase-CT-Primary Rating)	0.10	10.00	15.00	x I_p	
Alarm Delay	0.00	0.05	10.00	s	
Earth-Fault CT Input Definite Time – Group1					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (I_e is EF-CT-Primary Rating)	0.01	0.40	1.00	x I_e	
Trip Delay	0.00	0.25	100.00	s	
Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (I_e is EF-CT-Primary Rating)	0.01	0.20	1.00	x I_e	
Alarm Delay	0.00	1.00	100.00	s	
Earth-Fault CT Input Definite Time – Group2					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (I_e is EF-CT-Primary Rating)	0.01	0.40	1.00	x I_e	
Trip Delay	0.00	0.25	100.00	s	
Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (I_e is EF-CT-Primary Rating)	0.01	0.20	1.00	x I_e	
Alarm Delay	0.00	1.00	100.00	s	

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Unbalance (I)					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (Per Unit Based on I_2/I_1)	0.05	0.25	1.00	pu	
Trip Delay	1.00	15.00	100.00	s	
Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (Per Unit Based on I_2/I_1)	0.05	0.10	1.00	pu	
Alarm Delay	1.00	10.00	100.00	s	
Phase Loss (I)					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Delay	1.00	5.00	100.00	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Delay	1.00	2.00	100.00	s	
Phase Reverse (I)					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Delay	1.00	5.00	100.00	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Delay	1.00	2.00	100.00	s	
Reversepower					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (Per Unit of Rated Power)	0.10	0.10	1	pu	
Trip Delay	0.50	5.00	500	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (Per Unit of Rated Power)	0.10	0.10	1	pu	
Alarm Delay	0.50	1.00	500	s	
Unbalance (V)					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (Per Unit Based on V_2/V_1)	0.05	0.10	1	pu	
Trip Delay	1	15.00	100		
Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (Per Unit Based on V_2/V_1)	0.05	0.05	1	pu	
Alarm Delay	1	15.00	100		
Phase Loss (V)					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Phase Loss Delay	1	5.00	100	°C	

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Phase Reverse (V)					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Phase Reverse Trip and Alarm Delay	1	2.00	100	s	
Overvoltage					
Trip Action		Trip1			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (V_p is Input Voltage)	1	1.20	1.4	x V_p	
Trip Delay	1	5.00	500	s	
Alarm Action		Alarm1			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (V_p is Input Voltage)	1	1.10	1.4	x V_p	
Alarm Delay	1	5.00	500		
Undervoltage					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level (V_p is Input Voltage)	0.5	0.70	1	x V_p	
Trip Delay	1	5.00	500	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level (V_p is Input Voltage)	0.5	0.80	1	x V_p	
Alarm Delay	1	5.00	500	s	
Underfrequency					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level	30	45	80	Hz	
Trip Delay	1	5	500	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level	30	48	80	Hz	
Alarm Delay	1	2	500	s	
Overfrequency					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level	30	65	80	Hz	
Trip Delay	1.0	2	500	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level	30	62	80	Hz	
Alarm Delay	1	2	500	s	

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
PF Lag					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level	0.5	0.80	1		
Trip Delay	1	5	500	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level	0.5	0.90	1		
Alarm Delay	1	2	500	s	
PF Lead					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Trip Level	0.5	0.80	1		
Trip Delay	1	5	500	s	
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Alarm Level	0.5	0.90	1		
Alarm Delay	1	2	500	s	
PTC Temperature					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
RTD TEMPERATURE Requires RTD Module(s)					
RTD M1 #1:					
Name	RTD Module 1 #1				
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD M1 #2:					
Name	RTD Module 1 #2				
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD M1 #3:					
Name	RTD Module 1 #3				
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
RTD M1 #4:					
Name		RTD Module 1 #4			
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD M1 #5:					
Name		RTD Module 1 #5			
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD M1 #6:					
Name		RTD Module 1 #6			
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD M1 #7:					
Name		RTD Module 1 #7			
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD M1 #8:					
Name		RTD Module 1 #8			
Type		Disable			❑ Disable ❑ Ni120 Ω ❑ Pt100 Ω ❑ Cu10 Ω ❑ Ni100 Ω
Function		Stator			❑ Stator ❑ Load ❑ Bearing ❑ Ambient
Trip	40	130.00	200	°C	
Alarm	40	110.00	200	°C	
RTD Sensor Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
RTD Sensor Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3

FUNCTION & SET POINT	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
RTD Undertemperature:					
Trip Action		Disable			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3
Alarm Action		Disable			❑ Disable ❑ Alarm1 ❑ Alarm2 ❑ Alarm3
Trip Level		0		°C	❑ + 20 ❑ + 15 ❑ + 10 ❑ + 5 ❑ 0 ❑ - 5 ❑ - 10 ❑ - 15 ❑ - 20
Alarm Level		0		°C	❑ + 20 ❑ + 15 ❑ + 10 ❑ + 5 ❑ 0 ❑ - 5 ❑ - 10 ❑ - 15 ❑ - 20

PART III: CONTROL

PARAMETER	MIN	DEFAULT	MAX	UNIT	PROGRAM SELECTION
Control Type					❑ None ❑ 2-Coil Device ❑ Contactor
Close Pulse Time	0.1	1	5	s	
Open Pulse Time	0.1	1	5	s	
Trip Sources		Trip1 | Trip2 | Trip3			❑ Disable ❑ Trip1 ❑ Trip2 ❑ Trip3 ❑ Trip1 | Trip2 ❑ Trip1 | Trip3 ❑ Trip1 | Trip2 | Trip3 ❑ Trip2 | Trip3
Remote Group:					
Digital Input Control		Enable			❑ Enable ❑ Disable
Network Control		Enable			❑ Enable ❑ Disable
OPI Control		Enable			❑ Enable ❑ Disable
Local Group:					
OPI Control		Disable			❑ Enable ❑ Disable
Breaker Open Retry		0			❑ 0 (None) ❑ 1 Retry ❑ 2 Retries ❑ 3 Retries ❑ 4 Retries ❑ 5 Retries

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APPENDIX C
FPS MODBUS PROTOCOL

C.1 PROTOCOL

The FPS implements the Modbus® RTU protocol as described in the Gould Modbus Reference Guide, Publication PI-MBUS-300 Rev. B.

The communications system consists of a single master and up to thirty-two FPS-CTU slaves connected using a two-wire RS-485 network. If the master does not have an RS-485 port, an RS-232 to RS-485 converter is required. The converter must have automatic send-data control (SD). SD control does not require hand-shaking lines since it uses the data line to control the transmit/receive line on the RS-485 transceivers.

Only the master can initiate a message transaction. Messages can be addressed to individual slaves or they can be broadcast messages. Broadcast messages are executed on the FPS slaves but unlike individually addressed messages, the slaves do not generate a reply message.

C.2 MESSAGE SYNCHRONIZATION

Message synchronization is accomplished by detection of an idle communication line. The communication line is considered idle when no communication exists for an equivalent delay of 3.5 characters.

The first byte received after idle-line detection is interpreted as the address byte of the next message. Message bytes must be transmitted in a continuous stream until the complete message has been sent. If a delay of more than 3.5 characters exists within the message, the message is discarded.

Response messages from the FPS are delayed by at least 3.5 character delays.

C.3 ERROR CHECKING

Modbus RTU uses a 16-bit cyclic redundancy check (CRC). The error check includes all of the message bytes, starting with the first address byte.

When a CRC error is detected, the message is discarded and there will be no response.

If the CRC check is correct but the internal data in the message is not correct, the FPS will respond with an exception response code.

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C.4 FUNCTION CODES SUPPORTED

The FPS Modbus Protocol supports the following function codes:

- Read Holding Registers (Function Code 3)
- Read Input Registers (Function Code 4)
- Write Single Register (Function Code 6)
- Write Multiple Registers (Function Code 16)
- Command Instruction (Function Code 5)

Function Codes 3 and 4 perform the same function in the FPS.

Registers in Modbus start at 40001 decimal and the register address generated for this register is 0.

C4.1 APPLICATION LAYER

The hexadecimal system is used. Value representations use the "C" convention. For hexadecimal, 0x precedes the value.

C.4.2 READ INPUT/HOLDING REGISTERS (CODE 04/03)

The first byte of the read message is the slave address. The second byte is the function code. Bytes three and four indicate the starting register. The next two bytes specify the number of 16-bit registers to read. The last two bytes contain the CRC code for the message.

TABLE C.1 READ REGISTERS (CODE 04/03)

HEX BYTE	DESCRIPTION
Byte 1	Slave Address
Byte 2	Function Code
Byte 3	MSB Register Address
Byte 4	LSB Register Address
Byte 5	MSB Number of Registers
Byte 6	LSB Number of Registers
Byte 7	LSB CRC
Byte 8	MSB CRC

The two-byte values of starting register and number of registers to read are transmitted with the high-order byte followed by the low-order byte.

The CRC value is sent with the LSB followed by the MSB.

The following message will obtain the value of register 1 (Modbus 40002) from slave 1. Note that Modbus registers are numbered from zero (40001 = zero, 40002 = one, etc.):

0x01 | 0x03 | 0x00 | 0x01 | 0x00 | 0x01 | 0xD5 | 0xC

The addressed slave responds with its address and Function Code 3, followed by the information field. The information field contains an 8-bit byte count and the 16-bit data from the slave. The byte count specifies the number of

bytes of data in the information field. The data in the information field consists of 16-bit data arranged so that the MSB is followed by the LSB.

The maximum number of 16-bit registers that can be read is 120.

C.4.3 WRITE TO REGISTER

Function Code 6 or 16 is used to make set-point changes.

C.4.3.1 WRITE SINGLE REGISTER (CODE 6)

The function code format for writing a single register is shown in Table C.2.

The message consists of the FPS address followed by the Function Code 6 and two 16-bit values. The first 16-bit value specifies the register to be modified and the second value is the 16-bit data.

Provided no errors occurred, the slave will re-send the original message to the master. The response message is returned only after the command has been executed by the FPS.

The following message will set register 3 to 300 in slave 5:

0x05 | 0x06 | 0x00 | 0x03 | 0x01 | 0x2C | 0x78 | 0x03

TABLE C.2 WRITE SINGLE REGISTER (CODE 6)

HEX BYTE	DESCRIPTION
Byte 1	Slave Address
Byte 2	Function Code
Byte 3	MSB Register Address
Byte 4	LSB Register Address
Byte 5	MSB of Data
Byte 6	LSB of Data
Byte 7	LSB of CRC
Byte 8	MSB of CRC

C.4.3.2 WRITE MULTIPLE REGISTERS (CODE 16)

The function-code format in Table C.3 can be used for writing single or multiple registers.

TABLE C.3 WRITE MULTIPLE REGISTERS (CODE 16)

BYTE #	DESCRIPTION
Byte 1	Slave Address
Byte 2	Function Code
Byte 3	MSB Register Address
Byte 4	LSB Register Address
Byte 5	MSB of Quantity
Byte 6	LSB of Quantity
Byte 7	Byte Count
.	MSB of Data
.	LSB of Data
.	LSB of CRC
Byte n	MSB of CRC

The FPS will reply with the slave address, function code, register address, and the quantity followed by the CRC code for a total of 8 bytes.

C.4.4 COMMAND INSTRUCTION (CODE 5)

Modbus Function Code 5 (Force Single Coil) is used to issue commands to the FPS. The format for the message is listed in Table C.4 and the command code actions and corresponding coil number are listed in Table C.5.

TABLE C.4 COMMAND FORMAT CODE 5

HEX BYTE	DESCRIPTION
Byte 1	Slave Address
Byte 2	Function Code
Byte 3	MSB of Command Code
Byte 4	LSB of Command Code
Byte 5	Fixed at 0xff
Byte 6	Fixed at 00
Byte 7	LSB of CRC
Byte 8	MSB of CRC

TABLE C.5 SUPPORTED COMMANDS

COMMAND CODE	COIL NUMBER	ACTION
0x0000	1	OPEN
0x0001	2	CLOSE
0x0003	4	Reset Trips
0x0004	5	Set Real-Time Clock
0x0005	6	Clear Data-Logging Records
0x0006	7	Clear Trip Counters
0x0007	8	Clear Energy Totals
0x0008	9	Clear Running Hours
0x0009	10	Emergency I^2t and Trip Reset
0x000A	11	Select Local Control
0x000B	12	De-select Local Control
0x000C	13	Re-enable Temperature Protection
0x000D	14	Remote/Net Trip Set
0x000E	15	Remote/Net Trip Clear
0x000F	16	Remote/Net Alarm Set
0x0010	17	Remote/Net Alarm Clear
0x0011	18	Run1 Set
0x0012	19	Run1 Clear

Except for a broadcast address, the slave will return the original packet to the master.

C.4.5 COMMAND INSTRUCTIONS USING WRITE COMMANDS

For PLC's not supporting Function Code 5, FPS commands can be issued using Write Single Register (Code 6) and Write Multiple Register (Code 16).

Commands are written to FPS register 6 (Modbus register 40007). Supported commands are listed in the COMMAND CODE column in Table C.5.

When using the Write Multiple Registers function code, the write should be to the single FPS Register 6. If multiple registers are written starting at FPS Register 6, the first data element will be interpreted as the command code but no other registers will be written. If the command is successful, the FPS will return a valid response message.

C.4.6 EXCEPTION RESPONSES

The FPS supports the following exception responses:

- Boundry Error (1)—Applies to writes of 32-bit values. The high-order word must be written first followed by the write to the low-order word. If this sequence is not followed, a Boundry Error is returned and the value will not stored. This does not apply on read requests.
- Address Error (2)—All accesses to communication registers must be within the specified address range or the Address Error code is returned.
- Command Error (3)—This error code is returned if the command code is not supported.
- Illegal Function Code (4)—The function code (Byte 2) is not supported.

The exception message consists of the slave address followed by a retransmission of the original function code. The function code will have the most-significant bit set to indicate an error. The 8-bit byte following the function code is the exception response code. The 16-bit CRC is at the end of the message.

C.5 FPS DATABASE

Appendix E contains the Modbus Register in the Communications Database Table. The table starts at register 0 (Modbus 40001) and each register is 16-bits wide. Types "long" and "float" are 32-bit values. For both long and float types, the low-order word is transmitted first followed by the high-order word. Word values have the high byte followed by the low byte. Float types as per IEEE 754 Floating-Point Standard. All bytes of long and float types must be written using one message or an error will result. This does not apply for read commands.

C.5.1 DATA RECORDS

Only one event record can be read at a time. Record data is for the record indicated by the Record Selector. To select a record, write the record number to Record Selector and then read the values in the record. Record Head points to the next available record. The last event record captured is at Record Head minus one.

Both Record Selector and Record Head values are in the range of 0 to 63. Values outside this range will select record 0.

C.5.2 CUSTOM DATA ACCESS

Data access can be customized with the User-Defined Registers and the User-Data Registers.

User-Defined Registers are located in non-volatile memory and contain the register numbers from which data is required. To access the data, read the corresponding User-Data Registers.

The format of the User Data is a function of the corresponding register entered in the User-Defined-Register area.

C.6 NETWORK TIMEOUT

The FPS can be configured to trip or alarm on a network timeout using the *Setup* | *Hardware* | *Network Comms* menu. The *Net Trip Action* and *Net Alarm Action* set points set the actions to be taken when a timeout occurs. To prevent a timeout, a valid message, addressed to the slave, must be received at time intervals less than five seconds.

CAUTION: Set protocol to *None* before selecting *Network Error* actions; then, select protocol.

C.7 SPECIFICATIONS

Interface	Isolated RS-485, 2-wire, multi-drop, half duplex
Protocol	Modbus RTU
Baud Rate	1,200 to 19,200 bit/s
Bit Format	8 bits, no parity, one stop bit[1]
Number of CTU's Connected	Maximum of 32 units
Bus length	1,200 m (4,000') total[2]

(1) Terminal "-" is negative with respect to terminal "+" for a binary 1 (MARK or OFF) state.
Terminal "-" is positive with respect to terminal "+" for a binary 0 (SPACE or ON) state.

(2) For line lengths exceeding 10 m (30'), 150-Ω terminations are required at the cable ends.

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APPENDIX D
FPS A-B DF1 PROTOCOL

D.1 PROTOCOL

The FPS A-B® Protocol is based on the half-duplex master/slave Allen-Bradley (A-B) Data Highway Protocol (DF1) as described in Allen-Bradley Bulletin 1770-6.5.16 October 1996. This publication is available from the A-B web site at www.ab.com.

The communications system consists of a single master and up to thirty-two slaves connected to a two-wire RS-485 multi-drop network. FPS Control Units are slave devices on this network.

If the master does not have an RS-485 port, an RS-232 to RS-485 converter is required. The RS-485 converter should have automatic send-data control (SD). SD control does not require handshaking lines since it uses the data line to control the RS-485 transmitter. The SE-485-DIN converter is recommended. It includes optical isolation and baud rate selections from 9,600 to 57,600 bits per second. For additional information on converters, see Technical Information TI 9.9.

The FPS supports the DF1 commands shown in Table D.1. Each PLC has limitations when using a particular command. Determine the best command to use for a particular application.

TABLE D.1 DF1 COMMANDS

COMMAND	CMD	FNC
Unprotected Read	01	-
Unprotected Write	08	-
Typed Read	0F	68
Typed Write	0F	67
Typed Logical Read	0F	A2
Typed Logical Write	0F	AA

The PLC-5 and SLC 500 support reading and writing to integer files (Type N) and float files (Type F). Since FPS meter values are float types, these will typically be stored in a PLC Type-F file. It is also possible to read float types from the FPS as two integers; however, further processing is required to obtain the float value.

The PLC requires two communication ports—a PLC programming port and an FPS communications port. Typically, a DH+ port will be used for PLC programming and the RS-232 port is used for FPS communications via an SE-485-DIN converter.

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D.2 PLC-5 / SLC 500 CHANNEL-0 SETUP

The RS-232 Channel-0 port is set up for a DF1 half-duplex master. Set the Channel-0 baud rate and CRC to match the FPS settings. The parity bit is not supported on the FPS. Where applicable, set *Reply Message Wait* to 100 ms.

Additional recommended PLC settings:

DF1 Retries = 3
RTS Send Delay = 1 (20 ms)
RTS Off Delay = 0
Ack timeout = 5 (100 ms)
Reply msg wait = 3 (60 ms)

For the polling mode, select MESSAGE BASED (DO NOT ALLOW SLAVE TO INITIATE MESSAGES) or STANDARD (MULTIPLE MESSAGE-TRANSFER PER NODE SCAN). The FPS can buffer up to 3 messages. The selection MESSAGE BASED (DO NOT ALLOW SLAVE TO INITIATE MESSAGES) is recommended.

D.3 TYPED-READ

The Typed-Read message is used to read data from the FPS. The Typed-Read message requires a Control Block where the message configuration is stored. In the SLC, this is normally N7:0 but could be any other file that supports the control-block data. Use the following MSG settings:

Read/Write: Read
Target Device: PLC5
Local/Remote: Local
Control Block: N7:0

NOTE: For the PLC-5, the message block must be of type MG so that the channel number can be set in the message setup screen.

The Setup screen is used to specify file information. In the *This Controller* section, *Data Table Address* is the destination in the PLC where data is to be stored. This can be a float (Fx:x) file or an integer (Nx:x) file. *Element Size* must be set to the number of elements to transfer. This is a decimal value and this value is limited in some controllers. In the SLC 500, the maximum value for integers is 100 and for floats it is 50.

In *Target Device*, set *Data Table Address* to the A-B File address listed in Appendix E. The A-B File in Appendix E is coded as FILE:ELEMENT. To read or write the element as floats, the PLC-5 address would be <F><FILE>:<ELEMENT> (Example F9:222). To read or write the element as integers, add 20 to the file number and preceed with N, <N><FILE+20>:<ELEMENT> (Example N29:222). *Local Address* is the FPS address.

Example settings for reading 25 registers as float type (25 meter readings):

Data Table Address: F8:0
Element Size:..... 25
Target Device Data
Table Address:..... F6:0
Local Address:..... 9 (Must match FPS setting)

NOTE: To read float values, both data table addresses must be specified as float (F) type.

Example settings for reading a block of 100 registers (16-bit integer):

This could be a mix of float and integer values since floats can be transferred as two integers in the FPS.

Data Table Address: N9:0
Element Size:..... 100
Target Device Data
Table Address:..... N23:264 (Start of Digital Inputs)
Local Address:..... 9 (Must match FPS setting)

If an FPS float has been read into the PLC as two integers and stored in an N-type file, the float can be recovered by using two copy commands. Assume that the two integers from the FPS read command are stored in N9:0 and N9:1. The first copy command is used to swap the two words so they are in the correct order; copy N9:0 to N9:11, and copy N9:1 to N9:10. The second copy command will copy the two integers to the F-type file; copy N9:10 to F8:0 with a size of 1. The two integers are now combined correctly as a single 4-byte float located in F8:0.

D.4 TYPED-WRITE

The Typed-Write message is used to write data to the FPS.

Read/Write: Write
Target Device: PLC5
Local/Remote: Local
Control Block: N7:0

The Setup screen is used to specify file information. In the *This Controller* section, *Data Table Address* is the source file in the SLC. This can be a float (Fx:x) file or an integer (Nx:x) file. *Element Size* must be set to the number of elements to transfer. For the FPS, the maximum element size is 100 for integers and 50 for floats.

In *Target Device*, set *Data Table Address* to the A-B File address listed in Appendix E. Both integer and float values sent from the SLC are in the correct byte order and interpreted correctly by the FPS. The FPS will do a range check on all messages to ensure valid data.

Local Address is the FPS address.

Example settings for writing a single float to set the FLA Rating:

Data-Table Address: .....F8:0 (Location of FLA value)
Element Size: 1
Target-Device Data-
Table Address: F3:225
Local Address: .....9 (Must match FPS setting)

Reset commands to the FPS are issued by writing an integer command code to FPS Register 6 (N23:6)

A command message should only be issued when the command is required.

Valid commands are shown Table D.2.

TABLE D.2 FPS COMMANDS

COMMAND CODE	ACTION
0x0000	OPEN
0x0001	CLOSE
0x0003	Reset Trips
0x0004	Set Real-Time Clock
0x0005	Clear Data-Logging Records
0x0006	Clear Trip Counters
0x0007	Clear Energy Totals
0x0008	Clear Running Hours
0x0009	Emergency I^2t and Trip Reset
0x000A	Select Local Control
0x000B	De-select Local Control
0x000C	Re-enable Temperature Protection
0x000D	Remote/Net Trip Set
0x000E	Remote/Net Trip Clear
0x000F	Remote/Net Alarm Set
0x0010	Remote/Net Alarm Clear
0x0011	Run1 Set
0x0012	Run1 Clear

Example settings for writing an FPS reset command.

Data-Table Address: .....N9:0 (Reset code = 3)
Element Size: 1
Target-Device Data-
Table Address: .....N23:6 (FPS Command Register location)
Local Address: .....9 (Must match FPS setting)

D.5 UNPROTECTED READ/WRITE

For PLC-2 and PLC-3 processors not supporting Typed Read/Write messages, Unprotected Read/Write commands can be used. For these messages, the data address is the Octal value of the FPS Register in Appendix E. The size is the number of registers. The maximum number of registers that can be transferred in a single message is 100.

Unprotected Read/Write commands are used by the SE-Comm-FPS communication program.

D.6 TYPED LOGICAL READ/WRITE

The Typed Logical Read (CMD = 0F, FNC = A2) and Typed Logical Write (CMD = 0F, FNC = AA) messages are supported by the full line of SLC 500 processors and Prosoft MVIxx-DFCM communication interfaces.

Both float (F) and integer (N) types are supported. Unlike the typed commands in Section D.3 and D.4 a file offset is not required for integer values. Use the A-B file address as listed in the FPS manual Appendix E and precede the address with F for float values and N for integer values.

The maximum number of integers and floats that can be read is 100 and 50 respectively.

Reset commands to the FPS are issued by writing one of the COMMAND CODES listed in Table D.2 to Register 6 (N3:6).

D.7 DATA RECORDS

Only one event record can be read at a time. Data is for the record indicated by the Record Selector. To select a record, write the record number to Record Selector and then read the values in the record. Record-Head points to the next available record. The last event record captured is at Record Head minus one.

Both Record-Selector and Record-Head values are in the range of 0 to 63. Values outside this range will select record 0.

D.8 CUSTOM DATA ACCESS

Data access can be customized with the User-Defined Registers and the User Data Register.

Enter the required data-register numbers in the User-Defined Registers. The format of user data is a function of the corresponding register.

To access the data, read the corresponding User-Data Register.

D.9 NETWORK TIMEOUT

The FPS can be configured to trip or alarm on a network timeout using the *Setup* | *Hardware* | *Network Comms* menu. The *Net Trip Action* and *Net Alarm Action* set points set the actions to be taken when a timeout occurs. To prevent a timeout, a valid message, addressed to the slave, must be received at time intervals less than five seconds.

CAUTION: Set protocol to *None* before selecting *Network Error* actions; then, select protocol.

D.10 SPECIFICATIONS

Interface	Isolated RS-485, 2-wire, multi-drop, half duplex
Protocol	Modbus RTU
Baud Rate	1,200 to 19,200 bit/s
Bit Format	8 bits, no parity, one stop bit [1]
Number of CTU's Connected	Maximum of 32 units
Bus length	1,200 m (4,000') total [2]

[1] Terminal "-" is negative with respect to terminal "+" for a binary 1 (MARK or OFF) state.
Terminal "-" is positive with respect to terminal "+" for a binary 0 (SPACE or ON) state.

[2] For line lengths exceeding 10 m (30'), 150-Ω terminations are required at the cable ends.

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APPENDIX E
COMMUNICATIONS DATABASE TABLE

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
Model Information							
0	40001	1-1-3	3:0	Model Code (202)	Read Only		T3
1	40002	1-1-64	3:1	Software Version	Read Only		T3
2	40003	1-1-6	3:2	Serial Number	Read Only		T2 (Low)
3	40004		3:3				T2 (High)
4							
5				Diagnostic Code	Read Only		T3
6	40007	29-1-64	3:6	Command Register	Write Only		T101
7	40008		3:7	Reserved	R/W	0 - 1	T81
Overload Group1							
8	40009	2C-1-64	3:8	Trip Action	R/W	0 - 7	T42
9	40010	2C-1-65	3:9	Alarm Action	R/W	0 - 7	T43
10	40011		3:10	Reserved			
11	40012	2C-1-67	3:11	Pickup in pu of CT Rating	R/W	0.1 - 1.25	T1 (Low)
12	40013		3:12				T1 (High)
13	40014		3:13	Reserved	R/W	1 - 10	T1 (Low)
14	40015		3:14				T1 (High)
15	40016	2C-1-69	3:15	Hot Factor	R/W	0.1 - 1.0	T1 (Low)
16	40017		3:16				T1 (High)
17	40018	2C-1-6A	3:17	Cold Factor	R/W	0.1 - 1.0	T1 (Low)
18	40019		3:18				T1 (High)
19	40020	2C-1-6B	3:19	Time Constant	R/W	1 - 60 min	T1 (Low)
20	40021		3:20				T1 (High)
21	40022	2C-1-6C	3:21	Alarm Level	R/W	0.5 - 1.0	T1 (Low)
22	40023		3:22				T1 (High)
Overload Group2							
26	40027	2C-2-64	3:26	Trip Action	R/W	0 - 7	T42
27	40028	2C-2-65	3:27	Alarm Action	R/W	0 - 7	T43
28	40029		3:28	Reserved			
29	40030	2C-2-67	3:29	Pickup in pu of CT Rating	R/W	0.1 - 1.25	T1 (Low)
30	40031		3:30				T1 (High)
31	40032		3:31	Reserved	R/W	1 - 10	T1 (Low)
32	40033		3:32				T1 (High)
33	40034	2C-2-69	3:33	Hot Factor	R/W	0.1 - 1.0	T1 (Low)
34	40035		3:34				T1 (High)
35	40036	2C-2-6A	3:35	Cold Factor	R/W	0.1 - 1.0	T1 (Low)
36	40037		3:36				T1 (High)
37	40038	2C-2-6B	3:37	Time Constant	R/W	1 - 60 min	T1 (Low)
38	40039		3:38				T1 (High)
39	40040	2C-2-6C	3:39	Alarm Level	R/W	0.5 - 1.0	T1 (Low)
40	40041		3:40				T1 (High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
Reduced Overcurrent							
44	40045	2C-0-64	3:44	I^2t Reset Type	R/W	0 - 2	T38
45	40046	2C-0-65	3:45	I^2t Reset Level	R/W	0.1 - 0.9	T1 (Low)
46	40047		3:46				T1 (High)
Phase Inverse Group1							
50	40051	65-1-1	3:50	Trip Action	R/W	0 - 7	T42
51	40052	65-1-2	3:51	Curve Type	R/W	0 - 7	T73
52	40053	65-1-3	3:52	Time Multiplier	R/W	0.05 - 1.0	T1(Low)
53	40054		3:53				T1(High)
54	40055	65-1-4	3:54	Pickup in pu of CT Rating	R/W	0.1 - 10 x Ip	T1(Low)
55	40056		3:55				T1(High)
Phase Inverse Group2							
60	40061	65-2-1	3:60	Trip Action	R/W	0 - 7	T42
61	40062	65-2-2	3:61	Curve Type	R/W	0 - 7	T73
62	40063	65-2-3	3:62	Time Multiplier	R/W	0.05 - 1.0	T1(Low)
63	40064		3:63				T1(High)
64	40065	65-2-4	3:64	Pickup in pu of CT Rating	R/W	0.1 - 10 x Ip	T1(Low)
65	40066		3:65				T1(High)
Phase Definite-Time Group1							
70	40071	64-1-1	3:70	Trip Action	R/W	0 - 7	T1(Low)
71	40072	64-1-2	3:71	Alarm Action	R/W	0 - 7	T1(High)
72	40073	64-1-3	3:72	Trip Level	R/W	0.1 - 15 x Ip	T43
73	40074		3:73				T42
74	40075	64-1-4	3:74	Trip Delay	R/W	0 - 10 s	T1(Low)
75	40076		3:75				T1(High)
76	40077	64-1-5	3:76	Alarm Level	R/W	0.1 - 15 x Ip	T1(Low)
77	40078		3:77				T1(High)
78	40079	64-1-6	3:78	Alarm Delay	R/W	0 -10 s	T1(Low)
79	40080		3:79				T1(High)
Phase Definite-Time Group2							
84	40085	64-2-1	3:84	Trip Action	R/W	0 - 7	T1(Low)
85	40086	64-2-2	3: 85	Alarm Action	R/W	0 - 7	T1(High)
86	40087	64-2-3	3:86	Trip Level	R/W	0.1 - 15 x Ip	T43
87	40088		3:87				T42
88	40089	64-2-4	3:88	Trip Delay	R/W	0 - 10 s	T1(Low)
89	40090		3:89				T1(High)
90	40091	64-2-5	3:90	Alarm Level	R/W	0.1 - 15 x Ip	T1(Low)
91	40092		3:91				T1(High)
92	40093	64-2-6	3:92	Alarm Delay	R/W	0 -10 s	T1(Low)
93	40094		3:93				T1(High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
Earth-Fault $3I_0$ Inverse Group1							
100	40101	65-3-1	3:100	Trip Action	R/W	0 - 7	T42
101	40102	65-3-2	3:101	Curve Type	R/W	0 - 7	T73
102	40103	65-3-3	3:102	Time Multiplier	R/W	0.5 - 1.0	T1(Low)
103	40104		3:103				T1(High)
104	40105	65-3-4	3:104	Pickup in pu of CT Rating	R/W	0 - 1.0	T1(Low)
105	40106		3:105				T1(High)
Earth-Fault $3I_0$ Inverse Group2							
110	40111	65-4-1	3:110	Trip Action	R/W	0 - 7	T42
111	40112	65-4-2	3:111	Curve Type	R/W	0 - 7	T73
112	40113	65-4-3	3:112	Time Multiplier	R/W	0.5 - 1.0	T1(Low)
113	40114		3:113				T1(High)
114	40115	65-4-4	3:114	Pickup in pu of CT Rating	R/W	0 - 1.0	T1(Low)
115	40116		3:115				T1(High)
Earth-Fault $3I_0$ Definite-Time Group1							
120	40121	64-3-1	3:120	Trip Action	R/W	0 - 7	T42
121	40122	64-3-2	3:121	Alarm Action	R/W	0 - 7	T43
122	40123	64-3-3	3:122	Trip Level	R/W	0.1 - 15 x Ip	T1(Low)
123	40124		3:123				T1(High)
124	40125	64-3-4	3:124	Trip Delay	R/W	1 - 100 s	T1(Low)
125	40126		3:125				T1(High)
126	40127	64-3-5	3:126	Alarm Level	R/W	0.1 - 15 x Ip	T1(Low)
127	40128		3:127				T1(High)
128	40129	64-3-6	3:128	Alarm Delay	R/W	0 - 10 s	T1(Low)
129	40130		3:129				T1(High)
Earth-Fault $3I_0$ Definite-Time Group2							
136	40137	64-4-1	3:136	Trip Action	R/W	0 - 7	T42
137	40138	64-4-2	3:137	Alarm Action	R/W	0 - 7	T43
138	40139	64-4-3	3:138	Trip Level	R/W	0.1 - 15 x Ip	T1(Low)
139	40140		3:139				T1(High)
140	40141	64-4-4	3:140	Trip Delay	R/W	1 - 100 s	T1(Low)
141	40142		3:141				T1(High)
142	40143	64-4-5	3:142	Alarm Level	R/W	0.1 - 15 x Ip	T1(Low)
143	40144		3:143				T1(High)
144	40145	64-4-6	3:144	Alarm Delay	R/W	0 - 10 s	T1(Low)
145	40146		3:145				T1(High)

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
Earth-Fault CT-Input Definite-Time Group1							
150	40151	64-5-1	3:150	Trip Action	R/W	0 - 7	T42
151	40152	64-5-2	3:151	Alarm Action	R/W	0 - 7	T43
152	40153	64-5-3	3:152	Trip Level	R/W	0.01 - 1 x Ie	T1(Low)
153	40154		3:153				T1(High)
154	40155	64-5-4	3:154	Trip Delay	R/W	0 - 100 s	T1(Low)
155	40156		3:155				T1(High)
156	40157	64-5-5	3:156	Alarm Level	R/W	0.01 - 1 x Ie	T1(Low)
157	40158		3:157				T1(High)
158	40159	64-5-6	3:158	Alarm Delay	R/W	0 - 100 s	T1(Low)
159	40160		3:159				T1(High)
Earth-Fault CT-Input Definite-Time Group2							
166	40167	64-6-1	3:166	Trip Action	R/W	0 - 7	T42
167	40168	64-6-2	3:167	Alarm Action	R/W	0 - 7	T43
168	40169	64-6-3	3:168	Trip Level	R/W	0.01 - 1 x Ie	T1(Low)
169	40170		3:169				T1(High)
170	40171	64-6-4	3:170	Trip Delay	R/W	0 - 100 s	T1(Low)
171	40172		3:171				T1(High)
172	40173	64-6-5	3:172	Alarm Level	R/W	0.01 - 1 x Ie	T1(Low)
173	40174		3:173				T1(High)
174	40175	64-6-6	3:174	Alarm Delay	R/W	0 - 100 s	T1(Low)
175	40176		3:175				T1(High)
Unbalance (I)							
180	40181	64-7-1	3:180	Trip Action	R/W	0 - 7	T42
181	40182	64-7-2	3:181	Alarm Action	R/W	0 - 7	T43
182	40183	64-7-3	3:182	Trip Level	R/W	0.01 - 1 x Ie	T1(Low)
183	40184		3:183				T1(High)
184	40185	64-7-4	3:184	Trip Delay	R/W	0 - 100 s	T1(Low)
185	40186		3:185				T1(High)
186	40187	64-7-5	3:186	Alarm Level	R/W	0.01 - 1 x Ie	T1(Low)
187	40188		3:187				T1(High)
188	40189	64-7-6	3:188	Alarm Delay	R/W	0 - 100 s	T1(Low)
189	40190		3:189				T1(High)
Phase Loss (I)							
192	40193	64-8-1	3:192	Trip Action	R/W	0 - 7	T42
193	40194	64-8-2	3:193	Alarm Action	R/W	0 - 7	T43
194	40195	64-8-4	3:194	Trip Delay	R/W	1 - 100 s	T1(High)
195	40196		3:195				T1(Low)
196	40197	64-8-6	3:196	Alarm Delay	R/W	1 - 100 s	T1(High)
197	40198		3:197				T1(Low)

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
Phase Reverse (I)							
198	40199	64-9-1	3:198	Trip Action	R/W	0 - 7	T42
199	40200	64-9-2	3:199	Alarm Action	R/W	0 - 7	T43
200	40201	64-9-4	3:200	Trip Delay	R/W	1 - 100 s	T1(High)
201	40202		3:201				T1(Low)
202	40203	64-9-6	3:202	Alarm Delay	R/W	1 - 100 s	T1(High)
203	40204		3:203				T1(Low)
Reversepower							
204	40205	64-14-01	3:204	Trip Action	R/W	0 - 7	T42
205	40206	64-14-02	3:205	Alarm Action	R/W	0 - 7	T43
206	40207	64-14-03	3:206	Trip Level	R/W	0.1 - 1 pu	T1(Low)
207	40208		3:207				T1(High)
208	40209	64-14-04	3:208	Trip Delay	R/W	0.5 - 500 s	T1(Low)
209	40210		3:209				T1(High)
210	40211	64-14-05	3:210	Alarm Level	R/W	0.1 - 1 pu	T1(Low)
211	40212		3:211				T1(High)
212	40213	64-14-06	3:212	Alarm Delay	R/W	0.5 - 500 s	T1(Low)
213	40214		3:213				T1(High)
Unbalance (V)							
214	40215	64-0a-1	3:214	Trip Action	R/W	0 - 7	T42
215	40216	64-0a-2	3:215	Alarm Action	R/W	0 - 7	T43
216	40217	64-0a-3	3:216	Trip Level	R/W	0.05 - 1.0	T1(Low)
217	40218		3:217				T1(High)
218	40219	64-0a-4	3:218	Trip Delay	R/W	0 - 100 s	T1(Low)
219	40220		3:219				T1(High)
220	40221	64-0a-5	3:220	Alarm Level	R/W	0.05 - 1.0	T1(Low)
221	40222		3:221				T1(High)
222	40223	64-0a-6	3:222	Alarm Delay	R/W	0 - 100 s	T1(Low)
223	40224		3:223				T1(High)
Phase Loss (V)							
224	40225	64-0b-1	3:198	Trip Action	R/W	0 - 7	T42
225	40226	64-0b-2	3:199	Alarm Action	R/W	0 - 7	T43
226	40227	64-0b-4	3:200	Trip Delay	R/W	1 - 100 s	T1(High)
227	40228		3:201				T1(Low)
228	40229	64-0b-6	3:202	Alarm Delay	R/W	1 - 100 s	T1(High)
229	40230		3:203				T1(Low)
Phase Reverse (V)							
234	40235	64-0c-1	3:198	Trip Action	R/W	0 - 7	T42
235	40236	64-0c-2	3:199	Alarm Action	R/W	0 - 7	T43
236	40237	64-0c-4	3:200	Trip Delay	R/W	1 - 100 s	T1(High)
237	40238		3:201				T1(Low)
238	40239	64-0c-6	3:202	Alarm Delay	R/W	1 - 100 s	T1(High)
239	40240		3:203				T1(Low)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
Undervoltage							
242	40243	64-0d-1	3:242	Trip Action	R/W	0 - 7	T42
243	40244	64-0d-2	3:243	Alarm Action	R/W	0 - 7	T43
244	40245	64-0d-3	3:244	Trip Level	R/W	0.05 - 1.0 x Vp	T1(Low)
245	40246		3:245				T1(High)
246	40247	64-0d-4	3:246	Trip Delay	R/W	0 - 500 s	T1(Low)
247	40248		3:247				T1(High)
248	40249	64-0d-5	3:248	Alarm Level	R/W	0.05 - 1.0 x Vp	T1(Low)
249	40250		3:249				T1(High)
250	40251	64-0d-6	3:250	Alarm Delay	R/W	0 - 500 s	T1(Low)
251	40252		3:251				T1(High)
Undervoltage							
254	40255	64-0e-1	3:254	Trip Action	R/W	0 - 7	T42
255	40256	64-0e-2	3:255	Alarm Action	R/W	0 - 7	T43
256	40257	64-0e-3	3:256	Trip Level	R/W	1 - 1.4 x Vp	T1(Low)
257	40258		3:257				T1(High)
258	40259	64-0e-4	3:258	Trip Delay	R/W	0 - 500 s	T1(Low)
259	40260		3:259				T1(High)
260	40261	64-0e-5	3:260	Alarm Level	R/W	1 - 1.4 x Vp	T1(Low)
261	40262		3:261				T1(High)
262	40263	64-0e-6	3:262	Alarm Delay	R/W	0 - 500 s	T1(Low)
263	40264		3:263				T1(High)
Underfrequency							
270	40271	64-0f-1	3:270	Trip Action	R/W	0 - 7	T42
271	40272	64-0f-2	3:271	Alarm Action	R/W	0 - 7	T43
272	40273	64-0f-3	3:272	Trip Level	R/W	30 - 80 Hz	T1(Low)
273	40274		3:273				T1(High)
274	40275	64-0f-4	3:274	Trip Delay	R/W	0.5 - 500 s	T1(Low)
275	40276		3:275				T1(High)
276	40277	64-0f-5	3:276	Alarm Level	R/W	30 - 80 Hz	T1(Low)
277	40278		3:277				T1(High)
278	40279	64-0f-6	3:278	Alarm Delay	R/W	0.5 - 500 s	T1(Low)
279	40280		3:279				T1(High)
Overfrequency							
280	40281	64-10-1	3:280	Trip Action	R/W	0 - 7	T42
281	40282	64-102	3:281	Alarm Action	R/W	0 - 7	T43
282	40283	64-10-3	3:282	Trip Level	R/W	30 - 80 Hz	T1(Low)
283	40284		3:283				T1(High)
284	40285	64-10-4	3:284	Trip Delay	R/W	0.5 - 500 s	T1(Low)
285	40286		3:285				T1(High)
286	40287	64-10-5	3:286	Alarm Level	R/W	30 - 80 Hz	T1(Low)
287	40288		3:287				T1(High)
288	40289	64-10-6	3:288	Alarm Delay	R/W	0.5 - 500 s	T1(Low)
289	40290		3:289				T1(High)

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
Power-Factor Lag							
294	40295	64-11-1	3:294	Trip Action	R/W	0 - 7	T42
295	40296	64-11-2	3:295	Alarm Action	R/W	0 - 7	T43
296	40297	64-11-3	3:296	Trip Level	R/W	0.5 - 1.0	T1(Low)
297	40298		3:297				T1(High)
298	40299	64-11-4	3:298	Trip Delay	R/W	1 - 500 s	T1(Low)
299	40300		3:299				T1(High)
300	40301	64-11-5	3:300	Alarm Level	R/W	0.5 - 1.0	T1(Low)
301	40302		3:301				T1(High)
302	40303	64-11-6	3:302	Alarm Delay	R/W	1 - 500 s	T1(Low)
303	40304		3:303				T1(High)
Power-Factor Lead							
304	40305	64-12-1	3:304	Trip Action	R/W	0 - 7	T42
305	40306	64-12-2	3:305	Alarm Action	R/W	0 - 7	T43
306	40307	64-12-3	3:306	Trip Level	R/W	0.5 - 1.0	T1(Low)
307	40308		3:307				T1(High)
308	40309	64-12-4	3:308	Trip Delay	R/W	1 - 500 s	T1(Low)
309	40310		3:309				T1(High)
310	40311	64-12-5	3:310	Alarm Level	R/W	0.5 - 1.0	T1(Low)
311	40312		3:311				T1(High)
312	40313	64-12-6	3:312	Alarm Delay	R/W	1 - 500 s	T1(Low)
313	40314		3:313				T1(High)
Undertemperature							
314	40315	68-00-78	3:314	Trip Level	R/W	0 - 8	T108
315	40316	68-00-79	3:315	Alarm Level	R/W	0 - 8	T108
316	40317	68-00-7A	3:316	Trip Action	R/W	0 - 7	T42
317	40318	68-00-7B	3:317	Alarm Action	R/W	0 - 7	T43
PTC Temperature							
324	40325	64-13-1	3:324	Trip Action	R/W	0 - 7	T42
325	40326	64-13-2	3:325	Alarm Action	R/W	0 - 7	T43
RTD Module							
328	40329	68-00-64	3:328	Number of Modules	R/W	0 - 1	T88
329	40330	68-00-67	3:329	Module Error Trip Action	R/W	0 - 7	T43
330	40331	68-00-68	3:330	Module Error Alarm Action	R/W	0 - 7	T42
331	40332	68-00-65	3:331	Sensor Error Trip Action	R/W	0 - 7	T43
332	40333	68-00-66	3:332	Sensor Error Alarm Action	R/W	0 - 7	T43
RTD Type							
336	40337	68-01-01	3:336	#1 Type	R/W	0 - 4	T20
337	40338	68-01-02	3:337	#2 Type	R/W	0 - 4	T20
338	40339	68-01-03	3:338	#3 Type	R/W	0 - 4	T20
339	40340	68-01-04	3:339	#4 Type	R/W	0 - 4	T20
340	40341	68-01-05	3:340	#5 Type	R/W	0 - 4	T20
341	40342	68-01-06	3:341	#6 Type	R/W	0 - 4	T20
342	40343	68-01-07	3:342	#7 Type	R/W	0 - 4	T20
343	40344	68-01-08	3:343	#8 Type	R/W	0 - 4	T20

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
RTD Function							
344	40345	68-01-09	3:344	#1 Function	R/W	0 - 3	T89
345	40346	68-01-0a	3:345	#2 Function	R/W	0 - 3	T89
346	40347	68-01-0b	3:346	#3 Function	R/W	0 - 3	T89
347	40348	68-01-0c	3:347	#4 Function	R/W	0 - 3	T89
348	40349	68-01-0d	3:348	#5 Function	R/W	0 - 3	T89
349	40350	68-01-0e	3:349	#6 Function	R/W	0 - 3	T89
350	40351	68-01-0f	3:350	#7 Function	R/W	0 - 3	T89
351	40352	68-01-10	3:351	#8 Function	R/W	0 - 3	T89
RTD Trip1/Alarm1 Setpoints							
352	40353	68-01-11	3:352	#1 Trip Level	R/W	40 - 200°C	T1(Low)
353	40354		3:353				T1(High)
354	40355	68-01-12	3:354	#1 Alarm Level	R/W	40 - 200°C	T1(Low)
355	40356		3:355				T1(High)
356	40357	68-01-13	3:356	#2 Trip Level	R/W	40 - 200°C	T1(Low)
357	40358		3:357				T1(High)
358	40359	68-01-14	3:358	#2 Alarm Level	R/W	40 - 200°C	T1(Low)
359	40360		3:359				T1(High)
360	40361	68-01-15	3:360	#3 Trip Level	R/W	40 - 200°C	T1(Low)
361	40362		3:361				T1(High)
362	40363	68-01-16	3:362	#3 Alarm Level	R/W	40 - 200°C	T1(Low)
363	40364		3:363				T1(High)
364	40365	68-01-17	3:364	#4 Trip Level	R/W	40 - 200°C	T1(Low)
365	40366		3:365				T1(High)
366	40367	68-01-18	3:366	#4 Alarm Level	R/W	40 - 200°C	T1(Low)
367	40368		3:367				T1(High)
368	40369	68-01-19	3:368	#5 Trip Level	R/W	40 - 200°C	T1(Low)
369	40370		3:369				T1(High)
370	40371	68-01-0a	3:370	#5 Alarm Level	R/W	40 - 200°C	T1(Low)
371	40372		3:371				T1(High)
372	40373	68-01-0b	3:372	#6 Trip Level	R/W	40 - 200°C	T1(Low)
373	40374		3:373				T1(High)
374	40375	68-01-0c	3:374	#6 Alarm Level	R/W	40 - 200°C	T1(Low)
375	40376		3:375				T1(High)
376	40377	68-01-0d	3:376	#7 Trip Level	R/W	40 - 200°C	T1(Low)
377	40378		3:377				T1(High)
378	40379	68-01-0e	3:378	#7 Alarm Level	R/W	40 - 200°C	T1(Low)
379	40380		3:379				T1(High)
380	40381	68-01-0f	3:380	#8 Trip Level	R/W	40 - 200°C	T1(Low)
381	40382		3:381				T1(High)
382	40383	68-01-20	3:382	#8 Alarm Level	R/W	40 - 200°C	T1(Low)
383	40384		3:383				T1(High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
RTD Name							
384	40385	68-01-21	4:0	#1 Name	R/W		T22
394	40395	68-01-22	4:1	#2 Name	R/W		T22
404	40405	68-01-23	4:2	#3 Name	R/W		T22
414	40415	68-01-24	4:3	#4 Name	R/W		T22
424	40425	68-01-25	4:4	#5 Name	R/W		T22
434	40435	68-01-26	4:5	#6 Name	R/W		T22
444	40445	68-01-27	4:6	#7 Name	R/W		T22
454	40455	68-01-28	4:7	#8 Name	R/W		T22
System Ratings							
480	40481	29-01-9c	4:96	Phase CT Primary	R/W	1 - 5,000 A	T1 (Low)
481	40482						T1 (High)
482	40483	29-01-9d		Earth Fault CT Primary	R/W	1 - 5,000 A	T1 (Low)
483	40484						T1 (High)
484	40485	29-01-9e		System Voltage (Line-to-Line)	R/W	120 - 75 kV	T1 (Low)
485	40486						T1 (High)
486	40487	29-01-9f		Input Voltage	R/W	60 - 600 V	T1 (Low)
487	40488						T1 (High)
488	40489	29-01-a0		Voltage Connection Type	R/W	0 - 3	T9
489	40490	29-01-a1		Frequency	R/W	0 - 1	T10
490	40491	29-01-a2		Set-Point Group	R/W	0 - 1	T81
491	40492	29-01-a3		Unbalance-Current Threshold	R/W	0.1 - 0.5 x Ip	T1 (Low)
492	40493						T1 (High)
Operator Interface							
504	40505	29-01-6a	4:120	Display Failure Trip Action	R/W	0 - 7	T42
505	40506	29-01-6b		Number of OPI's	R/W	0 - 2	T40
506	40507	29-01-67		Password Timeout	R/W	1 - 60 min	T1 (Low)
507	40508						T1 (High)
508	40509	NA		Screen Saver	R/W	0 - 1	T6
509	40510	NA		Meter Summary	R/W		
510	40511	NA		Default Display	R/W		T98
Control Method							
520	40521	29-01-73	4:136	Control Type Breaker/Contactor Trip	R/W	0 - 2	T103
521	40522	29-01-74		Source	R/W	0 - 7	T104
524	40525	29-01-70		Remote Group—Din Input Ctl	R/W	0 - 1	T6
525	40526	29-01-71		Remote Group—Network Ctl	R/W	0 - 1	T6
526	40527	29-01-72		Remote Group—OPI Ctl	R/W	0 - 1	T6
527	40528	29-01-77		CB Close Pulse Width	R/W	0.1 - 5 s	T1 (Low)
528	40529						T1 (High)
529	40530	29-01-78		CB Open Pulse Width	R/W	0.1 - 5 s	T1 (Low)
530	40531						T1 (High)
531	40532	29-01-79		Local Group—OPI Ctl	R/W	0 - 1	T6
532	40533	29-01-7A		Breaker Open Retry	R/W	0 - 5	T107

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
Digital Input							
540	40541	66-01-01	4:156	Input 1 Function	R/W		T86
541	40542	66-01-02		Input 1 Bypass Enable	R/W	0 - 1	T6
542	40543	66-01-03		Input 1 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
543	40544						T1 (High)
544	40545	66-01-04		Input 1 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
545	40546						T1 (High)
Digital Input							
550	40551	66-02-01	4:166	Input 2 Function	R/W		T86
551	40552	66-02-02		Input 2 Bypass Enable	R/W	0 - 1	T6
552	40553	66-02-03		Input 2 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
553	40554						T1 (High)
554	40555	66-02-04		Input 2 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
555	40556						T1 (High)
560	40561	66-03-01	4:176	Input 3 Function	R/W		T86
561	40562	66-03-02		Input 3 Bypass Enable	R/W	0 - 1	T6
562	40563	66-03-03		Input 3 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
563	40564						T1 (High)
564	40565	66-03-04		Input 3 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
565	40566						T1 (High)
570	40571	66-04-01	4:186	Input 4 Function	R/W		T86
571	40572	66-04-02		Input 4 Bypass Enable	R/W	0 - 1	T6
572	40573	66-04-03		Input 4 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
573	40574						T1 (High)
574	40575	66-04-04		Input 4 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
575	40576						T1 (High)
580	40581	66-05-01	4:196	Input 5 Function	R/W		T86
581	40582	66-05-02		Input 5 Bypass Enable	R/W	0 - 1	T6
582	40583	66-05-03		Input 5 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
583	40584						T1 (High)
584	40585	66-05-04		Input 5 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
585	40586						T1 (High)
590	40591	66-06-01	4:206	Input 6 Function	R/W		T86
591	40592	66-06-02		Input 6 Bypass Enable	R/W	0 - 1	T6
592	40593	66-06-03		Input 6 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
593	40594						T1 (High)
594	40595	66-06-04		Input 6 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
595	40596						T1 (High)
600	40601	66-07-01	4:216	Input 7 Function	R/W		T86
601	40602	66-07-02		Input 7 Bypass Enable	R/W	0 - 1	T6
602	40603	66-07-03		Input 7 Bypass Delay	R/W	0.5 - 100 s	T1 (Low)
603	40604						T1 (High)
604	40605	66-07-04		Input 7 Trip Delay	R/W	0.01 - 100 s	T1 (Low)
605	40606						T1 (High)

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
Relay Output Function							
610	40611	29-01-80	4:226	Relay 1 Output Function	R/W		T106
611	40612	29-01-81		Relay 1 Mode	R/W	0 - 1	T14
612	40613	29-01-82		Relay 2 Output Function	R/W		T106
613	40614	29-01-83		Relay 2 Mode	R/W	0 - 1	T14
614	40615	29-01-84		Relay 3 Output Function	R/W		T106
615	40616	29-01-85		Relay 3 Mode	R/W	0 - 1	T14
616	40617	29-01-86		Relay 4 Output Function	R/W		T106
617	40618	29-01-87		Relay 4 Mode	R/W	0 - 1	T14
618	40619	29-01-88		Relay 5 Output Function	R/W		T106
619	40620	29-01-89		Relay 5 Mode	R/W	0 - 1	T14
620	40621	29-01-8a		Relay Pulse Time	R/W	0.05 - 10 s	T1(Low)
621	40622						T1(High)
Analog Input							
630	40631	67-01-01	4:246	Analog Input Time	R/W		T92
631	40632	67-01-02		Trip Action	R/W	0 - 7	T42
632	40633	67-01-03		Alarm Action	R/W	0 - 7	T43
633	40634	67-01-04		High-Level Trip	R/W	0.1 - 20 mA	T1(Low)
634	40635						T1(High)
635	40636	67-01-05		Low-Level Trip	R/W	0.1 - 20 mA	T1(Low)
636	40637						T1(High)
637	40638	67-01-06		Trip Delay	R/W	0.01 - 100 s	T1(Low)
638	40639						T1(High)
639	40640	67-01-07		High-Level Alarm	R/W	0.1 - 20 mA	T1(Low)
640	40641						T1(High)
641	40642	67-01-08		Low-Level Alarm	R/W	0.1 - 20 mA	T1(Low)
642	40643						T1(High)
643	40644	67-01-09		Alarm Delay	R/W	0.01 - 100 s	T1(Low)
644	40645						T1(High)
Analog Ouput							
650	40651	67-01-0a	4:266	Analog Output Parameter	R/W		T87
651	40652			Zero Calibration	R/W	0 - 1,000	T1(Low)
652	40653						T1(High)
653	40654			Full-Scale Calibration	R/W	0 - 1,000	T1(Low)
654	40655						T1(High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
Network Communication							
660	40661		4:276	Network Type	R/W	0 - 5	T16
661	40662			Network Baud	R/W	0 - 7	T17
662	40663			Modbus RTU/AB DF1 Error Check	R/W	0 - 2	T18
663	40664			Network ID (Slave ID)	R/W	0 - 255	T1(Low)
664	40665						T1(High)
665	40666	03-01-64		Network-Error Trip Action	R/W	0 - 7	T42
666	40667	03-01-65		Network-Error Alarm Action	R/W	0 - 7	T43
667	40668			Remote Trip Action	R/W	0 - 7	T42
668	40669			Remote Alarm Action	R/W	0 - 7	T43
669	40670			DeviceNet Producing Instance	R/W		T84
670	40671			DeviceNet Consuming Instance	R/W		T85
671	40672			Reserved	R/W		
680	40681			Ethernet IP	R/W		T22
690	40691			Ethernet Mask	R/W		T22
Real-Time Clock Reading							
720	40721	69-01-03	4:336	RTC Date	Read Only		T23(Low)
721	40722						T23(High)
722	40723	69-01-04		RTC Time	Read Only		T24(Low)
723	40724						T24(High)
724	40725	69-01-02		IRIG Offset in Minutes	R/W		T1(Low)
725	40726						T1(High)
726	40727	69-01-01		IRIG Offset in Hours	R/W		T1(Low)
727	40728						T1(High)
728	40729	69-01-05		Clock Setting	R/W		T31
Character Strings (10 words, 20 characters)							
740	40741	01-01-66	4:356	Password Setting (4 Chars)	R/W		T22
750	40751	01-01-65	4:366	System Name	R/W		T22
Meter Values							
860	40861	29-01-b0	5:0	I_a (A)	Read Only		T1(Low)
861	40862						T1(High)
862	40863	29-01-b1		I_b (A)	Read Only		T1(Low)
863	40864						T1(High)
864	40865	29-01-b2		I_c (A)	Read Only		T1(Low)
865	40866						T1(High)
866	40867	29-01-b3		I_{ave} (A)	Read Only		T1(Low)
867	40868						T1(High)
868	40869	29-01-b4		Earth Leakage From CT	Read Only		T1(Low)
869	40870						T1(High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
870	40871	29-01-b5		Earth Leakage, Residual (A)	Read Only		T1(Low)
871	40872						T1(High)
872	40873	29-01-b6		V_{ab} (kV)	Read Only		T1(Low)
873	40874						T1(High)
874	40875	29-01-b7		V_{bc} (kV)	Read Only		T1(Low)
875	40876						T1(High)
876	40877	29-01-b8		V_{ca} (kV)	Read Only		T1(Low)
877	40878						T1(High)
878	40879	29-01-b9		V_a (kV)	Read Only		T1(Low)
879	40880						T1(High)
880	40881	29-01-ba		V_b (kV)	Read Only		T1(Low)
881	40882						T1(High)
882	40883	29-01-bb		V_c (kV)	Read Only		T1(Low)
883	40884						T1(High)
884	40885	29-01-bc		Apparent Power (S) in kVA	Read Only		T1(Low)
885	40886						T1(High)
886	40887	29-01-bd		Reactive Power (Q) in kVAR	Read Only		T1(Low)
887	40888						T1(High)
888	40889	29-01-be		Real Power (P) in kW	Read Only		T1(Low)
889	40890						T1(High)
890	40891	29-01-bf		Power Factor (-1 to +1)	Read Only		T1(Low)
891	40892						T1(High)
892	40893	29-01-c0		Thermal Capacity (pu)	Read Only		T1(Low)
893	40894						T1(High)
894	40895	29-01-c1		Thermal Trend (pu)	Read Only		T1(Low)
895	40896						T1(High)
896	40897	29-01-c2		Overload Trip/Reset Time (min)	Read Only		T1(Low)
897	40898						T1(High)
898	40899	29-01-c3		Positive-Sequence Current (pu)	Read Only		T1(Low)
899	40900						T1(High)
900	40901	29-01-c4		Negative-Sequence I (pu)	Read Only		T1(Low)
901	40902						T1(High)
902	40903	29-01-c5		Current Unbalance (pu)	Read Only		T1(Low)
903	40904						T1(High)
904	40905	29-01-c6		Positive-Sequence V (pu)	Read Only		T1(Low)
905	40906						T1(High)
906	40907	29-01-c7		Negative-Sequence V (pu)	Read Only		T1(Low)
907	40908						T1(High)
908	40909	29-01-c8		Voltage Unbalance (pu)	Read Only		T1(Low)
909	40910						T1(High)
910	40911	29-01-c9		Analog Input (mA)	Read Only		T1(Low)
911	40912						T1(High)
912	40913	29-01-ca		Frequency (Hz)	Read Only		T1(Low)
913	40914						T1(High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
914	40915	29-01-cb		Running Time (s)	Read Only		T1(Low)
915	40916						T1(High)
916	40917	29-01-cc		High Speed Input Frequency	Read Only		T1(Low)
917	40918						T1(High)
918	40919	68-01-29		#1 Temperature(3)	Read Only		T1(Low)
919	40920						T1(High)
920	40921	68-01-2a		#2 Temperature(3)	Read Only		T1(Low)
921	40922						T1(High)
922	40923	68-01-2b		#3 Temperature(3)	Read Only		T1(Low)
923	40924						T1(High)
924	40925	68-01-2c		#4 Temperature(3)	Read Only		T1(Low)
925	40926						T1(High)
926	40927	68-01-2d		#5 Temperature(3)	Read Only		T1(Low)
927	40928						T1(High)
928	40929	68-01-2e		#6 Temperature(3)	Read Only		T1(Low)
929	40930						T1(High)
930	40931	68-01-2f		#7 Temperature(3)	Read Only		T1(Low)
931	40932						T1(High)
932	40933	68-01-30		#8 Temperature(3)	Read Only		T1(Low)
933	40934						T1(High)
934	40935	68-00-70		Max Group A Temperature	Read Only		T1(Low)
935	40936						T1(High)
936	40937	68-00-71		Max Group B Temperature	Read Only		T1(Low)
937	40938						T1(High)
938	40939	68-00-72		Max Group C Temperature	Read Only		T1(Low)
939	40940						T1(High)
940	40941	68-00-73		Max Ambient Temperature	Read Only		T1(Low)
941	40942						T1(High)
942	40943	68-00-74		Min Group A Temperature	Read Only		T1(Low)
943	40944						T1(High)
944	40945	68-00-75		Min Group B Temperature	Read Only		T1(Low)
945	40946						T1(High)
946	40947	68-00-76		Min Group C Temperature	Read Only		T1(Low)
947	40948						T1(High)
948	40949	68-00-77		Min Ambient Temperature	Read Only		T1(Low)
949	40950						T1(High)
950	40951	29-01-cd		kW Seconds	Read Only		T4(Word1)
951	40952						T4(Word2)
952	40953						T4(Word3)
953	40954						T4(Word4)
954	40955	29-01-ce		kVA Seconds	Read Only		T4(Word1)
955	40956						T4(Word2)
956	40957						T4(Word3)
957	40958						T4(Word4)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
958	40959	29-01-cf		kVAR Seconds	Read Only		T4(Word1)
959	40960						T4(Word2)
960	40961						T4(Word3)
961	40962						T4(Word4)
Event Records							
980	40981	6b-01-01	6:0	Number of Records	Read Only	0 - 65535	T3
981	40982	6b-01-02		Record Head (Next Record)	Read Only	0 - 99	T3
982	40983	6b-01-03		Record Selector	Read Only	0 - 99	T3
983	40984	6b-01-04		Record Date	Read Only		T23(Low)
984	40985						T23(High)
985	40986	6b-01-05		Record Time	Read Only		T24(Low)
986	40987						T24(High)
987	40988	6b-01-06		Record Type	Read Only		T99
988	40989	6b-01-07		Record Trip/Alarm Code	Read Only		T90
989	40990	6b-01-08		I_a	Read Only		T1(Low)
990	40991						T1(High)
991	40992	6b-01-09		I_b	Read Only		T1(Low)
992	40993						T1(High)
993	40994	6b-01-0a		I_c	Read Only		T1(Low)
994	40995						T1(High)
995	40996	6b-01-0b		Earth Leakage from CT	Read Only		T1(Low)
996	40997						T1(High)
997	40998	6b-01-0c		3I0, Phase Calculation	Read Only		T1(Low)
998	40999						T1(High)
999	41000	6b-01-0d		V_{ab} (kV)	Read Only		T1(Low)
1000	41001						T1(High)
1001	41002	6b-01-0e		V_{bc} (kV)	Read Only		T1(Low)
1002	41003						T1(High)
1003	41004	6b-01-0f		V_{ca} (kV)	Read Only		T1(Low)
1004	41005						T1(High)
1005	41006	6b-01-10		V_a (kV)	Read Only		T1(Low)
1006	41007						T1(High)
1007	41008	6b-01-11		V_b (kV)	Read Only		T1(Low)
1008	41009						T1(High)
1009	41010	6b-01-12		V_c (kV)	Read Only		T1(Low)
1010	41011						T1(High)
1011	41012	6b-01-13		Analog Input	Read Only		T1(Low)
1012	41013						T1(High)
1013	41014	6b-01-14		Current Unbalance	Read Only		T1(Low)
1014	41015						T1(High)
1015	41016	6b-01-15		Voltage Unbalance	Read Only		T1(Low)
1016	41017						T1(High)

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
1017	41018	6b-01-16		Used Thermal Capacity	Read Only		T1(Low)
1018	41019						T1(High)
1019	41020	6b-01-17		Frequency (Hz)	Read Only		T1(Low)
1020	41021						T1(High)
1021	41022	6b-01-18		Apparent Power (S) in kVA	Read Only		T1(Low)
1022	41023						T1(High)
1023	41024	6b-01-19		Real Power (P) in kW	Read Only		T1(Low)
1024	41025						T1(High)
1025	41026	6b-01-1a		Reactive Power (Q) in kVAR	Read Only		T1(Low)
1026	41027						T1(High)
1027	41028	6b-01-1b		Power Factor (-1 to +1)	Read Only		T1(Low)
1028	41029						T1(High)
1029	41030	6b-01-1c		#1 Temperature(3)	Read Only		T1(Low)
1030	41031						T1(High)
1031	41032	6b-01-1d		#2 Temperature(3)	Read Only		T1(Low)
1032	41033						T1(High)
1033	41034	61-01-1e		#3 Temperature(3)	Read Only		T1(Low)
1034	41035						T1(High)
1035	41036	61-01-1f		#4 Temperature(3)	Read Only		T1(Low)
1036	41037						T1(High)
1037	41038	6b-01-20		#5 Temperature(3)	Read Only		T1(Low)
1038	41039						T1(High)
1039	41040	6b-01-21		#6 Temperature(3)	Read Only		T1(Low)
1040	41041						T1(High)
1041	41042	6b-01-22		#7 Temperature(3)	Read Only		T1(Low)
1042	41043						T1(High)
1043	41044	6b-01-23		#8 Temperature(3)	Read Only		T1(Low)
1044	41045						T1(High)
Status							
1110	41111	29-01-90	7:0	T/A, Inverse-Curve Status	Read Only		T94
1111	41112	29-01-91	7:1	Digital Input and Relay Status	Read Only		T93
Message Stack							
1112	41113	29-01-92	7:2	Message 0	Read Only		T45
1113	41114	29-01-93		Message 1	Read Only		T46
1114	41115	29-01-94		Message 2	Read Only		T47
1115	41116	29-01-95		Message 3	Read Only		T48
1116	41117	29-01-96		Message 4	Read Only		T49

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
Trip Counters							
1130	41131	2C-01-6D	7:20	Overload Group 1	Read Only		T3
1131		2C-02-6D		Overload Group 2	Read Only		T3
1132		65-01-05		Phase Inverse Group 1	Read Only		T3
1133		65-02-05		Phase Inverse Group 2	Read Only		T3
1134		64-01-07		Phase Definite Time Group 1	Read Only		T3
1135		64-02-07		Phase Definite Time Group 2	Read Only		T3
1136		65-03-05		EF 3I0 Inverse Group 1	Read Only		T3
1137		65-04-05		EF 3I0 Inverse Group 2	Read Only		T3
1138		64-03-07		3I0 Definite Time Group 1	Read Only		T3
1139		64-04-07		3I0 Definite Time Group2	Read Only		T3
1140		64-05-07		EF CT Definite Time Group 1	Read Only		T3
1141		64-06-07		EF CT Definite Time Group 2	Read Only		T3
1142		64-07-07		Unbalance (I)	Read Only		T3
1143		64-08-07		Phase Loss (I)	Read Only		T3
1144		64-09-07		Phase Reverse (I)	Read Only		T3
1145		64-0a-07		Unbalance (V)	Read Only		T3
1146		64-0b-07		Phase Loss (V)	Read Only		T3
1147		64-0c-07		Phase Reverse (V)	Read Only		T3
1148		64-0e-07		Overvoltage	Read Only		T3
1149		64-0d-07		Undervoltage	Read Only		T3
1150		64-0f-07		Underfrequency	Read Only		T3
1151		64-10-07		Overfrequency	Read Only		T3
1152		64-11-07		PF Lag	Read Only		T3
1153		64-12-07		PF Lead	Read Only		T3
1154				Reserved			
1155		67-01-0b		Analog High	Read Only		T3
1156		67-01-0c		Analog Low	Read Only		T3
1157		64-13-07		PTC Temperature	Read Only		T3
1158		66-01-05		Digital Input 1	Read Only		T3
1159		66-02-05		Digital Input 2	Read Only		T3
1160		66-03-05		Digital Input 3	Read Only		T3
1161		66-04-05		Digital Input 4	Read Only		T3
1162		66-05-05		Digital Input 5	Read Only		T3
1163		66-06-05		Digital Input 6	Read Only		T3
1164		66-07-05		Digital Input 7	Read Only		T3
1165		68-01-31		RTD 1	Read Only		T3
1166		68-01-32		RTD 2	Read Only		T3
1167		68-01-33		RTD 3	Read Only		T3
1168		68-01-34		RTD 4	Read Only		T3
1169		68-01-35		RTD 5	Read Only		T3
1170		68-01-36		RTD 6	Read Only		T3
1171		68-01-37		RTD 7	Read Only		T3
1172		68-01-38		RTD 8	Read Only		T3
1173	41174	68-00-69		RTD Module Comm Error	Read Only		T3

FPS Register (Decimal)	Modbus Register (Decimal)	Object	A-B File (Decimal) (Note 4)	Description	Access	Range	Type
1174	41175	68-00-6c		RTD Sensor Error	Read Only		T3
1175	41176			Reserved			
1176	41177	29-01-7b		Breaker Open SW Pressed	Read Only		T3
1177	41178	29-01-7c		Breaker Contact Status	Read Only		T3
1178	41179			Reserved			
1179	41180			Reserved			
1180	41181			Non-Volatile All	Read Only		T3
1181	41182			Non-Volatile Enum Error	Read Only		T3
1182	41183			Non-Volatile Number Error	Read Only		T3
1183	41184			Non-Volatile String Error	Read Only		T3
1184	41185			Non-Vol. Event Record Error	Read Only		T3
1185	41186			Non-Volatile Thermal Error	Read Only		T3
1186	41187			Operator Interface Error	Read Only		T3
1187	41188			Circuit diagnostic	Read Only		T3
1188	41189			Network Comm Error	Read Only		T3
1189	41190			Remote Trips	Read Only		T3
1190	41191	64-14-07		Reversepower	Read Only		T3
1191	41192	64-14-7C		Undertemperature	Read Only		T3
User Defined Registers							
1400	41401	6a-1-1	8:0	User Register 0	R/W		T3
1401	41402	6a-1-2	8:1	User Register 1	R/W		T3
1402	41403	6a-1-3	8:2	User Register 2	R/W		T3
1403	41404	6a-1-4	8:3	User Register 3	R/W		T3
1404	41405	6a-1-5	8:4	User Register 4	R/W		T3
1405	41406	6a-1-6	8:5	User Register 5	R/W		T3
1406	41407	6a-1-7	8:6	User Register 6	R/W		T3
1407	41408	6a-1-8	8:7	User Register 7	R/W		T3
1408	41409	6a-1-9	8:8	User Register 8	R/W		T3
1409	41410	6a-1-A	8:9	User Register 9	R/W		T3
1410	41411	6a-1-B	8:10	User Register 10	R/W		T3
1411	41412	6a-1-C	8:11	User Register 11	R/W		T3
1412	41413	6a-1-D	8:12	User Register 12	R/W		T3
1413	41414	6a-1-E	8:13	User Register 13	R/W		T3
1414	41415	6a-1-F	8:14	User Register 14	R/W		T3
1415	41416	6a-1-10	8:15	User Register 15	R/W		T3
1416	41417	6a-1-11	8:16	User Register 16	R/W		T3
1417	41418	6a-1-12	8:17	User Register 17	R/W		T3
1418	41419	6a-1-13	8:18	User Register 18	R/W		T3
1419	41420	6a-1-14	8:19	User Register 19	R/W		T3
1420	41421	6a-1-15	8:20	User Register 20	R/W		T3

FPS REGISTER (DECIMAL)	MODBUS REGISTER (DECIMAL)	OBJECT	A-B FILE (DECIMAL) (NOTE 4)	DESCRIPTION	ACCESS	RANGE	TYPE
1421	41422	6a-1-16	8:21	User Register 21	R/W		T3
1422	41423	6a-1-17	8:22	User Register 22	R/W		T3
1423	41424	6a-1-18	8:23	User Register 23	R/W		T3
1424	41425	6a-1-19	8:24	User Register 24	R/W		T3
1425	41426	6a-1-1A	8:25	User Register 25	R/W		T3
1426	41427	6a-1-1B	8:26	User Register 26	R/W		T3
1427	41428	6a-1-1C	8:27	User Register 27	R/W		T3
1428	41429	6a-1-1D	8:28	User Register 28	R/W		T3
1429	41430	6a-1-1E	8:29	User Register 29	R/W		T3
1430	41431	6a-1-1F	8:30	User Register 30	R/W		T3
1431	41432	6a-1-20	8:31	User Register 31	R/W		T3
User Defined Register Data							
1432	41433		9:0	User Register 0 Data	Read Only	*Range and Type defined by user register value*	
1433	41434		9:1	User Register 1 Data	Read Only		
1434	41435		9:2	User Register 2 Data	Read Only		
1435	41436		9:3	User Register 3 Data	Read Only		
1436	41437		9:4	User Register 4 Data	Read Only		
1437	41438		9:5	User Register 5 Data	Read Only		
1438	41439		9:6	User Register 6 Data	Read Only		
1439	41440		9:7	User Register 7 Data	Read Only		
1440	41441		9:8	User Register 8 Data	Read Only		
1441	41442		9:9	User Register 9 Data	Read Only		
1442	41443		9:10	User Register 10 Data	Read Only		
1443	41444		9:11	User Register 11 Data	Read Only		
1444	41445		9:12	User Register 12 Data	Read Only		
1445	41446		9:13	User Register 13 Data	Read Only		
1446	41447		9:14	User Register 14 Data	Read Only		
1447	41448		9:15	User Register 15 Data	Read Only		
1448	41449		9:16	User Register 16 Data	Read Only		
1449	41450		9:17	User Register 17 Data	Read Only		
1450	41451		9:18	User Register 18 Data	Read Only		
1451	41452		9:19	User Register 19 Data	Read Only		
1452	41453		9:20	User Register 20 Data	Read Only		
1453	41454		9:21	User Register 21 Data	Read Only		
1454	41455		9:22	User Register 22 Data	Read Only		
1455	41456		9:23	User Register 23 Data	Read Only		
1456	41457		9:24	User Register 24 Data	Read Only		
1457	41458		9:25	User Register 25 Data	Read Only		
1458	41459		9:26	User Register 26 Data	Read Only		
1459	41460		9:27	User Register 27 Data	Read Only		
1460	41461		9:28	User Register 28 Data	Read Only		
1461	41462		9:29	User Register 29 Data	Read Only		
1462	41463		9:30	User Register 30 Data	Read Only		
1463	41464		9:31	User Register 31 Data	Read Only		

NOTES:

(1) The A-B File is coded as FILE:ELEMENT. To read or write the element as floats, the PLC-5 or SLC 500 address would be <F><FILE>:<ELEMENT> (Example F9:222). To read or write the element as integers using PLC-5 Typed Read and Typed Write commands, add 20 to the file number and precede with N, <N><FILE+20>:<ELEMENT> (Example N29:222). File offset not required for SLC 500 Protected Typed Logical read and write commands.

(2) Undefined registers in this table read zero. Registers greater than 1463 return error.

(3) The following MPS-RTD error codes are supported:

-100 = No RTD Sensor
-90 = Open Sensor
-80 = Shorted Sensor
-70 = No Data/Module Communication Error

(4) The A-B File is coded as FILE:ELEMENT. To read or write the element as floats, the PLC-5 or SLC 500 address would be <F><FILE>:<ELEMENT> (Example F9:222). To read or write the element as integers using PLC-5 Typed Read and Typed Write commands, add 20 to the file number and precede with N, <N><FILE+20>:<ELEMENT> (Example N29:222). File offset not required for SLC 500 Protected Typed Logical read and write commands.

APPENDIX F
REGISTER FORMATS

TYPE	C TYPE	DESCRIPTION
T1	Float	IEEE 32-Bit Floating-Point Number
		Bit 31: Sign
		Bits 30..23: Exponent
		Bits 22..0: Mantissa
		Float (high): Bits 31..16
		Float (low): Bits 15..0
T2	Long	32-Bit Integer
		(High) Bits 31..16
		(Low) Bits 15..0
T3	Short	16-Bit Integer
T4	Double	IEEE 64-Fit Floating-Point Number
		Bit 63: Sign
		Bits 62..52: Exponent
		Bits 51..0: Mantissa
		Word 1 (Least Significant Word) … Word 4 (Most Significant Word)
T6	Short	Enable/Disable
		0: Enabled
		1: Disabled
T9	Short	Voltage-Connection Type
		0: No Voltage Input
		1: 1PT
		2: 2PT
		3: 3PT and Direct Connection
T10	Short	Frequency
		0: 50 Hz
		1: 60 Hz
T14	Short	Relay Mode
		0: Fail Safe
		1: Non Fail Safe
T16	Short	Network Communication Type
		0: None (Disabled)
		1: A-B DF1
		2: Modbus RTU
		3: AnyBus
		4: DeviceNet
		5: Modbus TCP

TYPE	C TYPE	DESCRIPTION
T17	Short	Network Baud Rate
		0: 1.2 kbit/s
		1: 2.4 kbit/s
		2: 4.8 kbit/s
		3: 9.6 kbit/s
		4: 19.2 kbit/s
		5: DeviceNet 125 kbit/s
		6: DeviceNet 250 kbit/s
		7: DeviceNet 500 kbit/s
T18	Short	Error Checking (AB DF1 Only)
		0: Not Selected
		1: CRC Check
		2: BCC Check
T20	Short	RTD Type
		0: Disable
		1: Platinum 100
		2: Nickel 100
		3: Nickel 120
		4: Copper 10
T22	Char	20 ASCII characters
		Register +0: Char[0] and Char[1]. Char [0] at MSByte
		Register +1: Char[2] and Char[3]. Char [2] at MSByte
		Register +2: Char[4] and Char[5]. Char [4] at MSByte
		Register +3: Char[6] and Char[7]. Char [6] at MSByte
		Register +4: Char[8] and Char[9]. Char [8] at MSByte
		Register +5: Char[10] and Char[11]. Char [10] at MSByte
		Register +6: Char[12] and Char[13]. Char [12] at MSByte
		Register +7: Char[14] and Char[15]. Char [14] at MSByte
		Register +8: Char[16] and Char[17]. Char [16] at MSByte
		Register +9: Char[18] and Char[19]. Char [18] at MSByte
		A character value of 0 (NULL) will terminate the string and the following characters will be ignored.
		Ethernet address strings are of the form: “ddd.ddd.ddd.ddd”.
		The MAC address is a hex string of the form: “hhhhhhhhhhhh”.
T23	Long	Date
		Bits 31..16: Year in Binary
		Bits 15..8: 1-12 Months in Binary
		Bits 7..0: 1-31 Days in Binary
T24	Long	Time
		Bits 31..24: 0-23 Hours in Binary
		Bits 23..16: 0-60 Minutes in Binary
		Bits 15..8: 0-60 Seconds in Binary
		Bits 7..0: 0-99 Hundredths of Seconds in Binary

TYPE	C TYPE	DESCRIPTION
T31	Char	RTC ASCII Character Setting String:
		Format: YY/MM/DD HH:mm:SS
		YY: 2-digit Year (Year 2000 - 2099)
		MM: Month 1-12
		DD: Day 1-31
		HH: Hour 0-23
		mm: Minute 0-59
		SS: Seconds 0-59
		RTC is updated when “Set RTC” command is issued.
T32	Short	Free Record Pointer
		Subtract 1 to obtain last record.
		Range is 0 to 63.
T33	Short	Thermal Model Type
		0: NEMA
		1: K-Factor
T38	Short	Overload Reset Type
		0: Normal
		1: Auto Reset
		2: Rapid
T42	Short	Trip Action
		0: Disabled
		1: Trip1
		2: Trip2
		3: Trip3
		4: Trip1 & Trip2
		5: Trip1 & Trip3
		6: Trip1 & Trip2 & Trip3
		7: Trip2 & Trip3
T43	Short	Alarm Action
		0: Disabled
		1: Alarm1
		2: Alarm2
		3: Alarm3
		4: Alarm1 & Alarm2
		5: Alarm1 & Alarm3
		6: Alarm1 & Alarm2 & Alarm3
		7: Alarm2 & Alarm3

TYPE	C TYPE	DESCRIPTION
T67	Short	Trip and Alarm Summary
		Bit 0 .. Bit 3: 0
		Bit 4: 1 = Trip1
		Bit 5: 1 = Trip2
		Bit 6: 1 = Trip3
		Bit 7: 1 = Alarm1
		Bit 8: 1 = Alarm2
		Bit 9: 1 = Alarm3
		Bit 10 .. Bit 15: 0
T73	Short	Inverse Time Curve
		0:IEC Normal Inverse A
		1:IEC Very Inverse B
		2:IEC Extreme Inverse C
		3:IEC Short Inverse A
		4:IEC Long Inverse B
		5:IEEE Moderate Inverse
		6:IEEE Very Inverse
		7:IEEE Extreme Inverse
T80	Short	Record Type
		0: Empty Record
		1: Trip Record
		3: ETR Record
T81	Short	Set Point Group
		0: Group 1
		1: Group 2
T84	Short	DeviceNet Producing Instance
		0: None
		1: 0x32 Basic Overload
		2: 0x33 Extended Overload
		3: 0x34 Basic Motor Starter
		4: 0x35 Extended Motor Starter 1
		5: 0x64 User Registers
T85	Short	DeviceNet Consuming Instance
		0: None
		1: 0x02 Basic Overload
		2: 0x03 Basic Motor Starter

TYPE	C TYPE	DESCRIPTION
T86	Short	Digital Input Function
		0: None
		1: Group2 Settings
		1: Group 2 Set Points Active
		0: Group 1 Set Points Active
		2: Local Control
		1: Local Control Mode Enabled
		0: Local Control Mode Disabled
		3: Permissive
		1: Close is Allowed
		0: Close is Not Allowed
		4: 3-W Close
		1: Close (Momentary)
		0: No Close Action
		5: 2-W Close
		1: Close (Sustained) Any other Open signal causes a trip.
		0: Open
		6: 3-W Close Local
		1: Close (Momentary). 3-Wire, only enabled in LOCAL.
		0: No Close Action
		7: 2-W Close Local
		1: Close (Momentary). 3-Wire, only enabled in LOCAL.
		0: No Close Action
		8: 52a Close Status
		1: Status contact closed when device is closed.
		0: Status contact open when device is open.
		9: 52b Open Status
		1: Status contact closed when device is open.
		0: Status contact open when device is closed.
		10: UV Coil Supervision **RESERVED 10**
		See description in manual.
		11: SH Coil Supervision **RESERVED 11**
		Input signal requirement is defined by coil-sensing setting.
		12: Close Supervision **RESERVED 12**
		Input signal requirement is defined by coil-sensing setting.
		13: Interlock
		1: Close is Allowed
		0: Close is Not Allowed
		14: Trip1
		1: Input is Valid, No Trip
		0: Trip (Trip Delay Active). Trip Bypass Available.
		15: Reset
		16: Positive Edge Record Trigger
		17: Negative Edge Record Trigger
		18: Transition Record Trigger
		19: Control Power 1: Digital inputs updated at 50 ms intervals. 2: Digital inputs held for 500 ms.

TYPE	C TYPE	DESCRIPTION
T87	Short	Analog Output Parameter
		0: Phase Current
		1: Earth Leakage
		2: Thermal Capacity
		3: Group A RTD
		4: Group B RTD
		5: Group C RTD
		6: Ambient RTD
		7: Voltage
		8: Unbalance
		9: Power Factor
		10: Real Power
		11: Reactive Power
		12: Apparent Power
		13: Zero
		14: Full Scale
T88	Short	Number of RTD Modules
		0: No RTD Module
		1: 1 RTD Module
T89	Short	RTD Function
		0: Transformer
		1: Bus
		2: Breaker
		3: Ambient
T90	Short	Trip Code
		0: Overload Trip, G1
		1: Overload Trip, G2
		2: Overload Alarm, G1
		3: Overload Alarm, G2
		4: Phase Inverse O/C Trip G1
		5: Phase Inverse O/C Trip G2
		6: Phase Timed O/C Trip G1
		7: Phase Timed O/C Trip G2
		8: Phase Timed O/C Alarm G1
		9: Phase Timed O/C Alarm G2
		10: 3Io Inverse Trip G1
		11: 3Io Inverse Trip G2
		12: 3Io Timed Trip G1
		13: 3Io Timed Trip G2
		14: 3Io Timed Alarm G1
		15: 3Io Timed Alarm G2

TYPE	C TYPE	DESCRIPTION
T90		16: EFCT Timed Trip G1
		17: EFCT Timed Trip G2
		18: EFCT Timed Alarm G1
		19: EFCT Timed Alarm G2
		20: Unbalance (Current) Trip
		21: Unbalance (Current) Alarm
		22: Phase Loss (Current) Trip
		23: Phase Loss (Current) Alarm
		24: Phase Reverse (Current) Trip
		25: Phase Reverse (Current) Alarm
		26: Unbalance (Voltage) Trip
		27: Unbalance (Voltage) Alarm
		28: Phase Loss (Voltage) Trip
		29: Phase Loss (Voltage) Alarm
		30: Phase Reverse (Voltage) Trip
		31: Phase Reverse (Voltage) Alarm
		32: Overvoltage Trip
		33: Overvoltage Alarm
		34: Undervoltage Trip
		35: Undervoltage Alarm
		36: Underfrequency Trip
		37: Underfrequency Alarm
		38: Overfrequency Trip
		39: Overfrequency Alarm
		40: PF Quadrant 3 Trip
		41: PF Quadrant 3 Alarm
		42: PF Quadrant 4 Trip
		43: PF Quadrant 4 Alarm
		44: Differential Trip
		45: Differential Alarm
		46: Analog-Input-High Trip
		47: Analog-Input-High Alarm
		48: Analog-Input-Low Trip
		49: Analog-Input-Low Alarm
		50: PTC Temperature Trip
		51: PTC Temperature Alarm
		52: Digital 1 Trip
		53: Digital 2 Trip
		54: Digital 3 Trip
		55: Digital 4 Trip
		56: Digital 5 Trip
		57: Digital 6 Trip
		58: Digital 7 Trip
		59: RTD Module 1 INP 1 Trip
		60: RTD Module 1 INP 1 Alarm
		61: RTD Module 1 INP 2 Trip
		62: RTD Module 1 INP 2 Alarm

TYPE	C TYPE	DESCRIPTION
T90		63: RTD Module 1 INP 3 Trip
		64: RTD Module 1 INP 3 Alarm
		65: RTD Module 1 INP 4 Trip
		66: RTD Module 1 INP 4 Alarm
		67: RTD Module 1 INP 5 Trip
		68: RTD Module 1 INP 5 Alarm
		69: RTD Module 1 INP 6 Trip
		70: RTD Module 1 INP 6 Alarm
		71: RTD Module 1 INP 7 Trip
		72: RTD Module 1 INP 7 Alarm
		73: RTD Module 1 INP 8 Trip
		74: RTD Module 1 INP 8 Alarm
		75: RTD Module 1 Trip
		76: RTD Module 1 Alarm
		77: RTD Sensor-Failure Trip
		78: RTD Sensor Failure Alarm
		79: DIF Module Trip
		80: DIF Module Alarm
		81: Open Press Trip
		82: 52a/b Status Trip
		83: Trip-coil Supervision Trip
		84: Close-coil Supervision Trip
		85 to 93 Reserved
		94: Memory Error, All Defaults Loaded
		95: Memory Error, Enum
		96: Memory Error, Numeric
		97: Memory Error, String
		98: Memory Error, Records1
		99: Memory Error, Records2
		100: Display Error
		101: Reserved
		102: Diagnostic Error (A/D)
		103: Network Comm Trip
		104: Network Comm Alarm
		105: Remote Trip via Network
		106: Remote Alarm via Network
		107: Reversepower Trip
		108: Reversepower Alarm
		109: Undertemperature Trip
		110: Undertemperature Alarm
		111 to 250: Reserved
		251: Positive Trigger
		252: Negative Trigger
		253: Transition Trigger
		254: ETR Request
		255: No Trip or Alarm

TYPE	C TYPE	DESCRIPTION
T91	Short	4-20 mA Analog Input Type
		0: Metering Only
		1: Generic 4-20 mA
T92	Short	4-20 mA Analog Input Type
		0: Metering Only
		1: Protection
T93	Short	Digital Input and Relay Status
		Bit 0: Digital Input 1 Valid
		Bit 1: Digital Input 2 Valid
		Bit 2: Digital Input 3 Valid
		Bit 3: Digital Input 4 Valid
		Bit 4: Digital Input 5 Valid
		Bit 5: Digital Input 6 Valid
		Bit 6: Spare
		Bit 7: Spare
		Bit 8: Relay 1 Energized
		Bit 9: Relay 2 Energized
		Bit 10: Relay 3 Energized
		Bit 11: Relay 4 Energized
		Bit 12: Relay 5 Energized
T94	Short	FPS Status
		Bit 0: 1 = Current > Threshold
		Bit 1: 1 = 3Io Inverse Curve Picked Up
		Bit 2: 1 = Ph Inverse Curve Picked Up
		Bit 3: Spare
		Bit 4: 1 = Trip1
		Bit 5: 1 = Trip2
		Bit 6: 1 = Trip3
		Bit 7: 1 = Alarm1
		Bit 8: 1 = Alarm2
		Bit 9: 1 = Alarm3
		Bit 10: 1 = ETR is ON
		Bit 11: 1 = PTC is Open
		Bit 12: 1 = Interlock is Valid
		Bit 13: 1 = Permissive is Valid
		Bit 14: 1 = FPS Control Indicates Breaker Closed.
		Bit 15: Spare
T98	Short	Default Menu
		0: Main
		1: Summary
		2: Current

TYPE	C TYPE	DESCRIPTION
T98		3: Unbalance (I)
		4: Earth Leakage
		5: Thermal Status
		6: Voltage
		7: Unbalance
		8: Power
		9: Energy
		10: Frequency
		11: RTD Temperature
		12: Inverse Status
		13: I/O Status
		14: System Status
		15: Network Status
T99	Short	Trigger Source
		0: Empty Record
		1: Trip Record
		2: Digital Input Positive Edge Trigger Record
		3: Digital Input Negative Edge Trigger Record
		4: Digital Input Transition Trigger Record
T100	Short	User Programmable Indicator
		0: None (LED Off)
		1: Trip1
		2: Trip2
		3: Trip3
		4: Alarm1
		5: Alarm2
		6: Alarm3
		7: Relay1
		8: Relay2
		9: Relay3
		10: Relay4
		11: Relay5
		12: Din1
		13: Din2
		14: Din3
		15: Din4
		16: Din5
		17: Din6
		18: Din7
		19: Current Detected
		20: 3Io Pickup
		21: Phase Pickup
		22: ETR State
		23: Network Run1
		24: Net Activity

TYPE	C TYPE	DESCRIPTION
T101	Short	FPS Communications Command
		0: Open
		1: Close
		2: Reserved
		3: Reset Trips (Not Remote/Network Trips)
		4: Set RTC
		5: Clear Data-Logging Records.
		6: Clear Trip Counters
		7: Clear Energy Totals
		8: Clear running hours
		9: Emergency Thermal Reset
		10: Select Local Control
		11: De-select Local Control
		12: Re-enable Temperature Protection
		13: Remote/Network Trip Set
		14: Remote/Network Trip Reset
		15: Remote/Network Alarm Set
		16: Remote/Network Alarm Reset
		17: Run1 Set
		18: Run1 Clear
T102	Short	FPS Coil Supervision Sense Location
T103	Short	Breaker Control Type
T104	Short	Breaker Trip Source
		0: Disabled
		1: Trip1
		2: Trip2
		3: Trip3
		4: Trip1 or Trip2
		5: Trip1 or Trip3
		6: Trip1 or Trip2 or Trip3
		7: Trip2 or Trip3
T105	Short	Differential Module Number
		0: Disabled
		1: One DIF Module

TYPE	C TYPE	DESCRIPTION
T106	Short	Output Relay Function
		0: None (Relay De-Energized)
		1: Trip1
		2: Trip2
		3: Trip3
		4: Alarm1
		5: Alarm2
		6: Alarm3
		7: CB Close
		8: CB Open
		9: Contactor
		10: Trip1 Pulse
		11: Local
		12: Interlock
		13: Current
		14: Network Run1
		15: Group2
		16: Watchdog
T107	Short	Breaker Open Retry Count
		0: No Retry
		1: 1 Retry
		2: 2 Retries
		3: 3 Retries
		4: 4 Retries
		5: 5 Retries
T108	Short	RTD Undertemperature
		0: +20°C
		1: +15°C
		2: +10°C
		3: +5°C
		4: 0°C
		5: -5°C
		6: -10°C
		7: -15°C
		8: -20°C

NOTES:
(1) All values are actual numbers unless indicated by “Bitx”.
(2) Not a trip code. Used by event records to indicate a start record type.

APPENDIX G
FPS REVISION HISTORY

G.1 FPS-CTU REVISION HISTORY

MANUAL RELEASE DATE	MANUAL REVISION	HARDWARE REVISION(1) (REVISION NUMBER ON PRODUCT LABEL)	FIRMWARE REVISION
March 16, 2015	1-C-031615	01A	1.13
December 1, 2014	1-B-120114		1.12
June 19, 2014	1-A-061914		1.10
		00B	
November 16, 2011	00	01	1.05
		00A, 01	1.04
		00A	1.03
			1.02
		00, 00A	1.01

(1) At time of release.

MANUAL REVISION HISTORY

REVISION 1-C-031615

APPENDIX G

Updated revision history.

REVISION 1-B-120114

SECTION 2

Figs. 2.5 and 2.6 updated.

APPENDIX G

Updated revision history.

REVISION 1-A-061914

SECTION 1

Reversepower, RTD overtemperature, and RTD undertemperature features added.

SECTION 5

Reversepower (5.16) and RTD undertemperature (5.23) sections added.

SECTION 6

Retries explanation added.

APPENDIX A

Reversepower, undertemperature and open retry added to menu levels.

APPENDIX B

Reversepower, undertemperature, and RTD sensor trip and alarm actions added to set-up record. Part III Control added.

APPENDIX E

Reversepower, undertemperature and breaker open retry added to communication database table.

APPENDIX F

Reversepower, undertemperature and breaker open retry count added to register formats table.

APPENDIX G

Added revision history.

REVISION 0

Initial release.

HARDWARE REVISION HISTORY

HARDWARE REVISION 01A

Updated opto-coupler relay drive circuit and RTC battery.

HARDWARE REVISION 01

Power supply updated.

HARDWARE REVISION 00B

Updated opto-coupler relay drive circuit and RTC battery.

HARDWARE REVISION 00A

Processor module memory size increased.

HARDWARE REVISION 00

Initial release.

FIRMWARE REVISION HISTORY

FIRMWARE REVISION 1.13

Corrected current and voltage unbalance error.

FIRMWARE REVISION 1.12

Corrected earth-fault and overcurrent inverse-time error.

FIRMWARE REVISION 1.10

Added reversepower, RTD undertemperature, and breaker-open retry.
Loss of communication trip increased to 10 s.

FIRMWARE REVISION 1.05

Added capability to initiate firmware updates using FPS-OPI.

FIRMWARE REVISION 1.04

Breaker open time no longer truncated by open status indication.

FIRMWARE REVISION 1.03

Fixed RTD reading for unused RTD's.

FIRMWARE REVISION 1.02

Fixed EtherNet/IP issue with Explicit Messaging.

FIRMWARE REVISION 1.01

Added support for alternate DeviceNet controller.

FIRMWARE REVISION 1.00

Added delay to digital input assigned to Control Power.

FIRMWARE REVISION 0.01

Initial release.

G.2 FPS-OPI REVISION HISTORY

MANUAL RELEASE DATE	MANUAL REVISION	HARDWARE REVISION (REVISION NUMBER ON PRODUCT LABEL)	FIRMWARE REVISION
December 1, 2014	1-B-120114	00	1.60
June 19, 2014	1-A-061914		

HARDWARE REVISION HISTORY

HARDWARE REVISION 00

Initial release.

FIRMWARE REVISION HISTORY

FIRMWARE REVISION 1.60

Firmware update to support new display and equivalent LCD version.

G.3 MPS-RTD REVISION HISTORY

MANUAL RELEASE DATE	FPS MANUAL REVISION	PRODUCT REVISION (REVISION NUMBER ON PRODUCT LABEL)
December 1, 2014	1-B-120114	02
June 19, 2014	1-A-061914	

PRODUCT REVISION HISTORY

PRODUCT REVISION 02

New analog PWB and power supply PWB. Increased accuracy. Wider input voltage range.

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