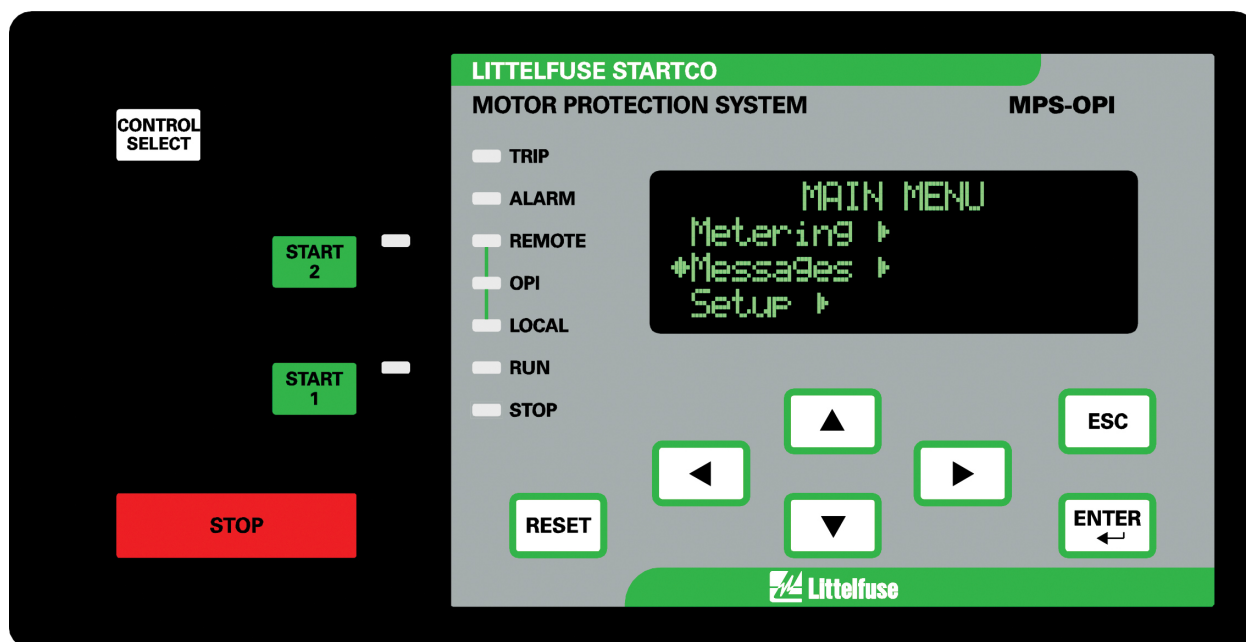


## MPS MANUAL

### MOTOR PROTECTION SYSTEM

Revision 6-F-022117



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Factory default password is 1111

New Password

See Section 4.3.6.

Motor Identification

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## **DISCLAIMER**

Specifications are subject to change without notice. Littelfuse Startco is not liable for contingent or consequential damages, or for expenses sustained as a result of incorrect application, incorrect adjustment, or a malfunction.

## 1. INTRODUCTION

### 1.1 GENERAL

The Littelfuse Startco Motor Protection System (MPS) is a modular system with integrated protection, control, metering, and data-logging functions. The Control Unit (MPS-CTU) is the core module. It can operate as a stand-alone unit or with the Operator Interface (MPS-OPI), RTD Modules (MPS-RTD), and Differential Module (MPS-DIF). 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 MPS block diagram is shown in Fig. 1.1.

### 1.2 MPS FEATURES

#### 1.2.1 PROTECTION

- Overload (49, 51)
- Overcurrent (50, 51)
- Earth fault (50G/N, 51G/N)
- Unbalance (voltage and current) (46, 47)
- Phase loss (voltage and current) (46, 47)
- Phase reverse (voltage and current) (46, 47)
- Jam
- Undercurrent (37)
- Failure to accelerate
- Underspeed (14)
- Overvoltage (59)
- Undervoltage (27)
- Underpower (37)
- Reversepower (32)
- Power factor (55)
- Overfrequency (81)
- Underfrequency (81)
- PTC overtemperature (49)
- RTD temperature (38, 49)
- Starts per Hour (66)
- Differential (87)

#### 1.2.2 CONTROL—STARTING METHODS <sup>(1)</sup>

- Non-reversing
  - Reversing
  - Soft start
  - Soft start with bypass
  - Adjustable-speed drive
  - Two speed
  - Wye-delta (open or closed transition)
  - Reactor (open or closed transition)
  - Resistor (open or closed transition)
  - Autotransformer
  - Part winding
  - Slip ring
  - Two winding
  - Double delta
- <sup>(1)</sup> Only three CT's required for all starting methods.

### 1.2.3 METERING

- Line currents
- Current unbalance
- Positive-sequence current
- Negative-sequence current
- Earth-leakage current
- Differential currents
- 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
- Motor speed
- RTD temperatures
- 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
  - Differential currents
  - Line-to-line voltages
  - Voltage unbalance
  - Thermal capacity
  - Thermal capacity used during starts
  - Start time
  - Analog-input value
  - Frequency
  - Power (P, S, Q, PF)
  - RTD temperatures
- Trip counters
- Running hours
- Waveform Capture
  - 5 seconds of pre-trip waveform data
  - 16 samples per cycle
  - COMTRADE and CSV file generation

### 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 inputs
- Tachometer (high-speed pulse) input
- 4-20-mA analog input
- 4-20-mA analog output
- PTC thermistor temperature input

- Up to twenty-four RTD inputs
- Five programmable output relays
- Network communications
- IRIG-B time-code input

### 1.2.6 MPS-OPI OPERATOR INTERFACE

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

### 1.2.7 MPS-RTD MODULE

- Eight inputs per module
- Individually selectable RTD types
- RTD Voting
- Solid-state multiplexing
- Up to three modules per system
- Remote operation up to 1.2 km (4,000')
- Powered by MPS-CTU

### 1.2.8 MPS-DIF DIFFERENTIAL MODULE

- 3-CT core-balance connection
- 6-CT summation connection
- Remote operation up to 1.2 km (4,000')
- Powered by MPS-CTU

### 1.2.9 COMMUNICATIONS INTERFACE

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

## 1.3 ORDERING INFORMATION

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

Earth-Fault Current Sensors:

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

(All EFCT's include 6 m (19.5') of 22 AWG (0.33 mm<sup>2</sup>) shielded cable.)

|                  |                                                                                            |
|------------------|--------------------------------------------------------------------------------------------|
| SE-CS30-4 .....  | Current Sensor,<br>30-A-primary rating,<br>c/w Flux Conditioner,<br>95.0 mm (3.7") window  |
| SE-CS30-5 .....  | Current Sensor,<br>30-A-primary rating,<br>c/w Flux Conditioner,<br>130.0 mm (5.1") window |
| SE-CS30-8 .....  | Current Sensor<br>30-A-primary rating,<br>c/w Flux Conditioner,<br>200.0 mm (7.9") window  |
| SE-CS30-26.....  | Current Sensor,<br>30-A-primary rating,<br>26 mm (1.0") window                             |
| SE-CS30-70 ..... | Current Sensor,<br>30-A-primary rating,<br>70 mm (2.7") window                             |

Phase CT's..... Protection-Class CT's,  
Contact factory

Accessories:

|                   |                                         |
|-------------------|-----------------------------------------|
| SE-IP65CVR-M..... | Hinged Transparent OPI<br>Cover         |
| SE-485-PP.....    | Port-Powered Serial<br>Converter        |
| SE-485-DIN.....   | Serial Converter,<br>Industrial, 24 Vdc |

Software:

|                   |                                             |
|-------------------|---------------------------------------------|
| SE-Comm-RIS ..... | PC Communication<br>Software <sup>(1)</sup> |
| SE-Flash.....     | Firmware Upgrade<br>Software <sup>(1)</sup> |

<sup>(1)</sup> Available at [www.littelfuse.com/relayscontrols](http://www.littelfuse.com/relayscontrols).

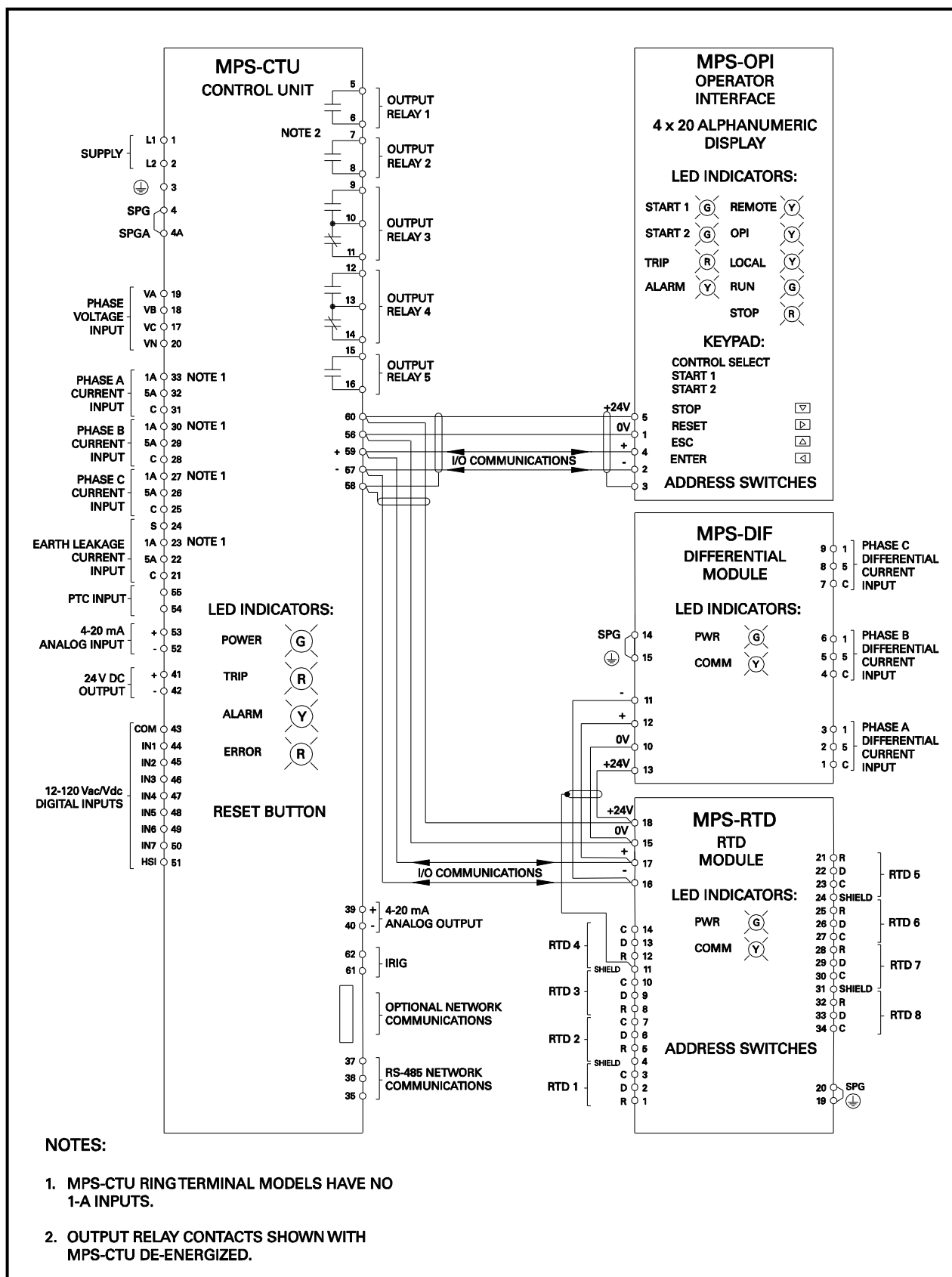
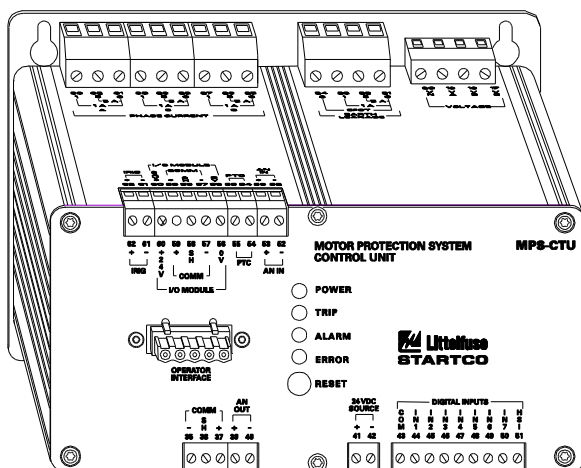
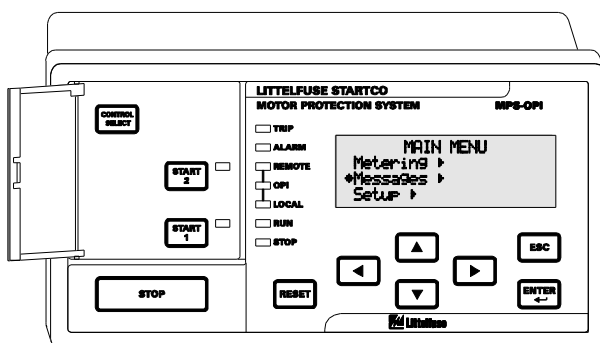


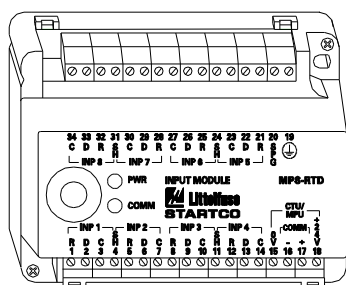
FIGURE 1.1 Motor Protection System Block Diagram.

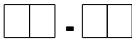
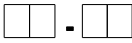


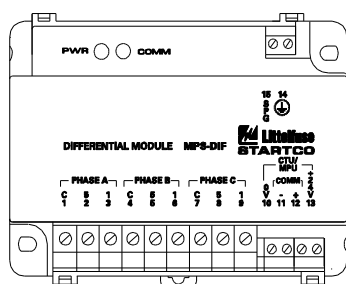
- MPS-CTU-**  - 
- Communications:
- 01 Standard RS-485. Includes A-B® & Modbus® Protocols
  - 02 DeviceNet and standard RS-485
  - 03 Profibus® and standard RS-485
  - 04 Ethernet and standard RS-485
- Options:
- 00 No Options
  - 01 Ring Terminal

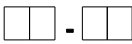
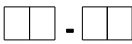


- MPS-OPI-**  - 
- Display:
- 01 Vacuum Fluorecent
- Future Options:
- 00 No Options



- MPS-RTD-**  - 
- Configuration:
- 01 8 RTD
- Future Options:
- 00 No Options



- MPS-DIF-**  - 
- Configuration:
- 01 5/1 A Isolated Input
- Future Options:
- 00 No Options

**NOTES:**

1. MPS-CTU TERMINAL BLOCKS ARE PRE-INSTALLED.
2. MPS-OPI TERMINAL BLOCK IS INCLUDED BUT NOT INSTALLED.
3. MPS-RTD AND MPS-DIF TERMINAL BLOCKS ARE NOT REMOVABLE.

**Supplied Interconnect Cable:**

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

FIGURE 1.2 MPS Ordering Information.

## **2. INSTALLATION**

### **2.1 GENERAL**

A basic Motor Protection System (MPS) consists of an MPS-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. For the optional Ring Terminal MPS-CTU, the 1-A connection is not available. 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, up to three MPS-RTD modules can be connected to the MPS-CTU. For differential protection, an MPS-DIF module can be connected to the MPS-CTU. The MPS-OPI provides an operator interface for the MPS.

The MPS 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 MPS-CTU CONTROL UNIT**

The Control Unit is configured for surface mounting. Outline and mounting details for the MPS-CTU are shown in Figs. 2.1 and 2.1.1.

### **2.3 MPS-OPI OPERATOR INTERFACE**

Outline and mounting details for the MPS-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 MPS-CTU as shown in Fig. 2.3. The Operator Interface can also be mounted on the MPS-CTU ring terminal as shown in Fig. 2.3.1 (surface mount only).

If an optional SE-IP65CVR-M is used, follow the included installation instructions. See Figs. 2.4 and 2.5.

### **2.4 MPS-RTD MODULE**

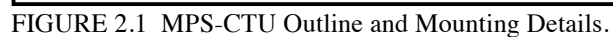
Outline and mounting details for the MPS-RTD are shown in Fig. 2.6. The MPS-RTD will fit inside most motor RTD-termination junction boxes and it is certified for use in Class I, Zone 2 and Class I, Division 2 hazardous locations. The MPS-RTD can be surface or DIN-rail mounted.

### **2.5 MPS-DIF DIFFERENTIAL MODULE**

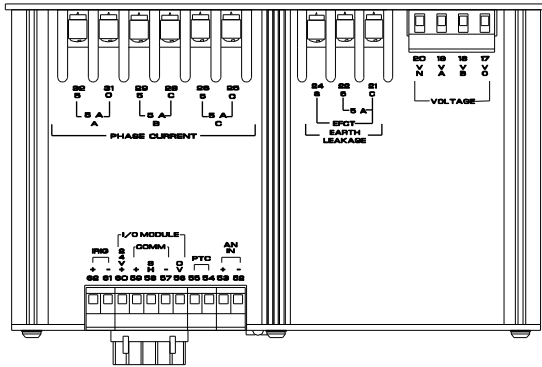
Outline and mounting details for the MPS-DIF are shown in Fig 2.7. The MPS-DIF can be surface or DIN-rail mounted.

### **2.6 EARTH-FAULT CT'S**

Outline and mounting details for the EFCT-1, EFCT-2, EFCT-26, and SE-CS30 series are shown in Figs. 2.8, 2.9, 2.10, 2.11, and 2.12.







**NOTES:**

1. ALL DIMENSIONS IN MILLIMETERS (INCHES).
2. SHOWN WITH PLUG-IN TERMINAL BLOCKS INSTALLED.
3. MOUNTING SCREWS M4 OR 8-32 PAN HEAD.

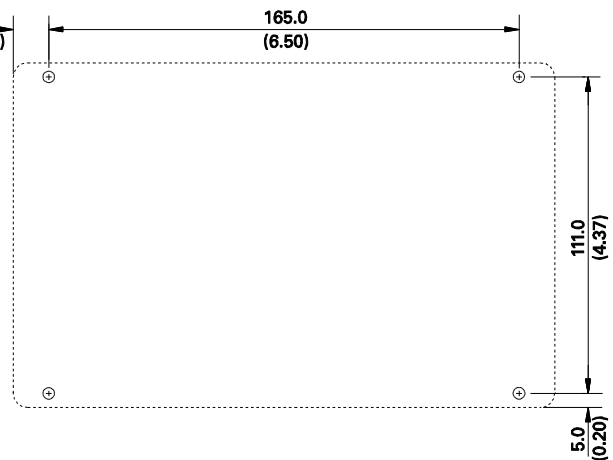
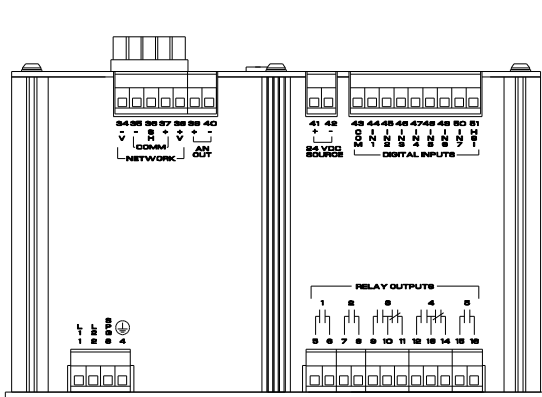
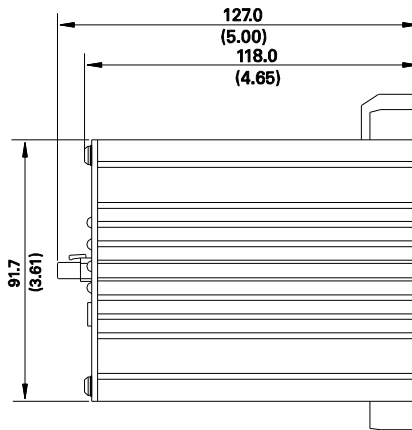
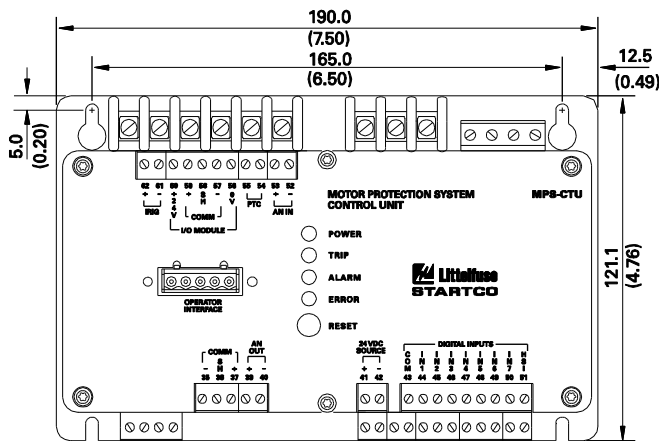


FIGURE 2.1.1 MPS-CTU-XX-X1 Ring Terminal Outline and Mounting Details.

FIGURE 2.2 MPS-OPI Outline and Mounting Details.

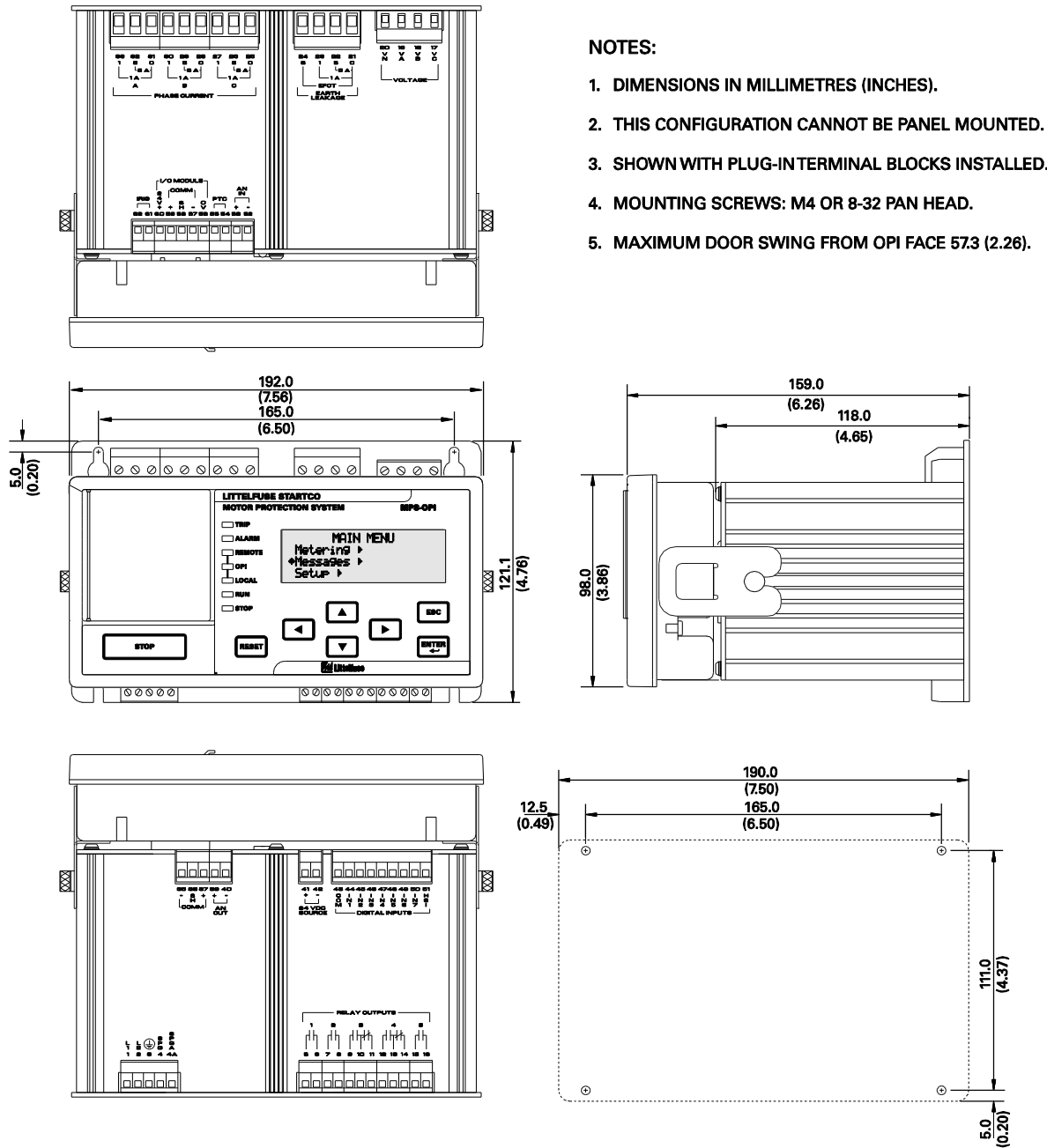


FIGURE 2.3 MPS-CTU with OPI Outline and Mounting Details.

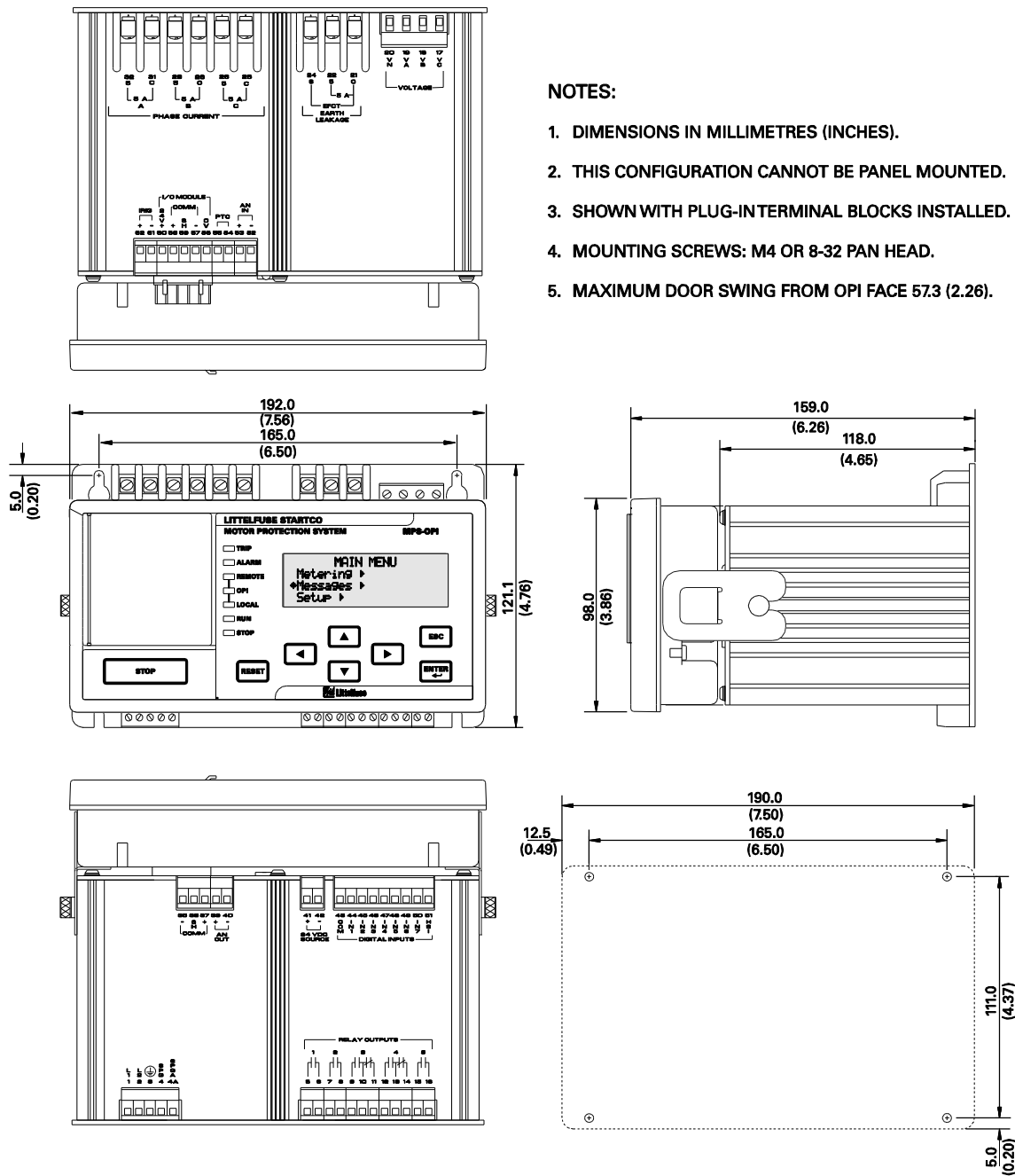


FIGURE 2.3.1 MPS-CTU Ring Terminal with OPI Outline and Mounting Details.

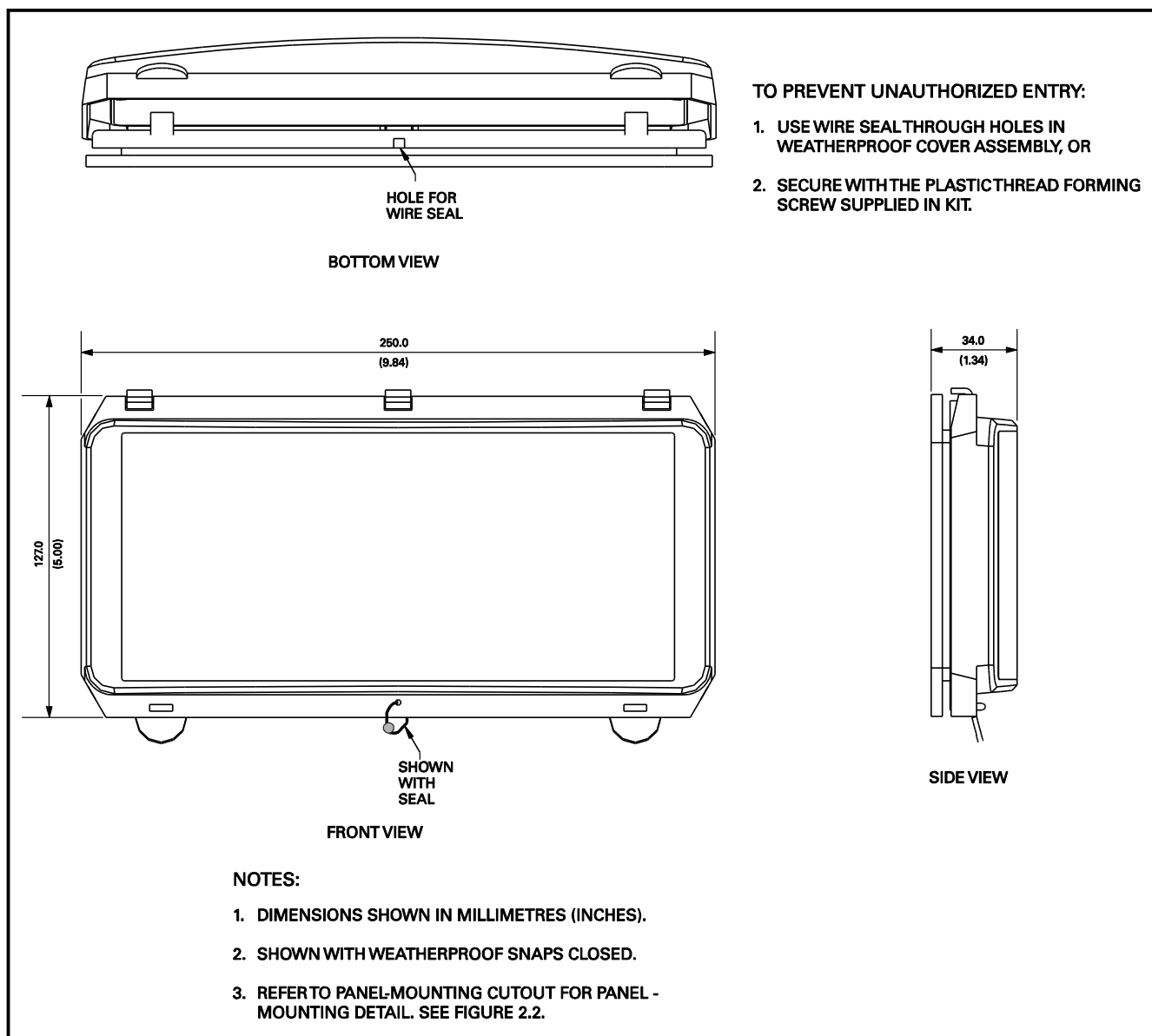


FIGURE 2.4 SE-IP65CVR-M Weatherproof Cover Outline.

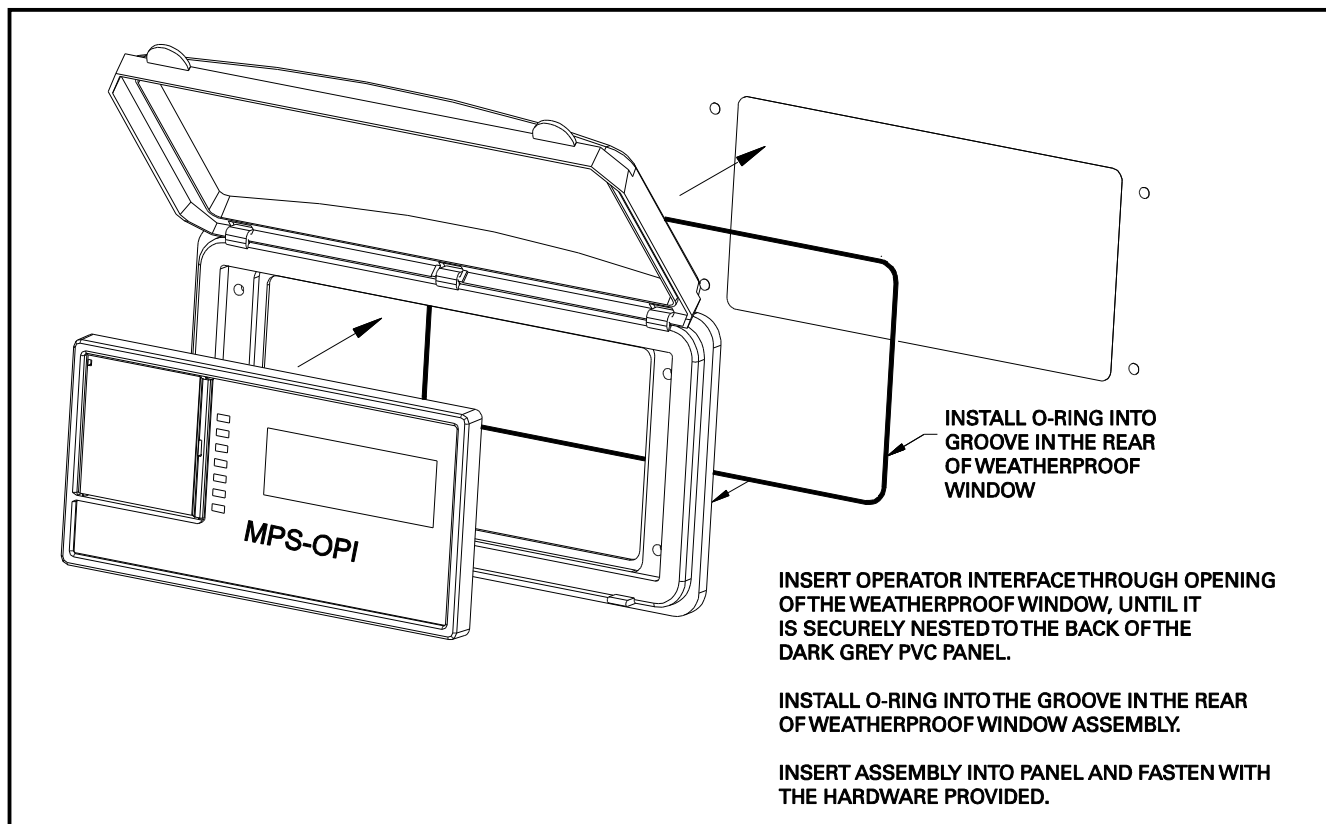
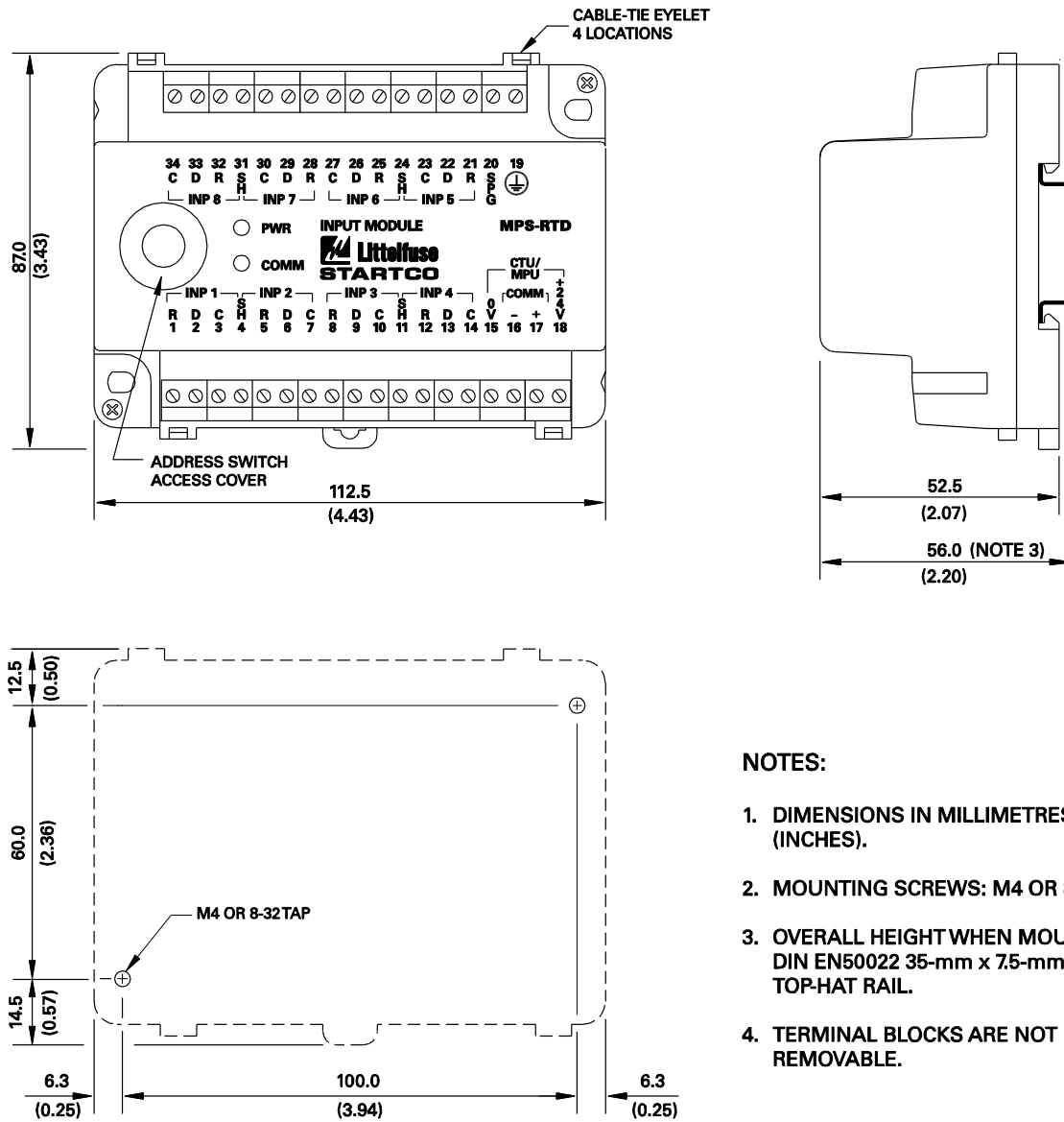


FIGURE 2.5 SE-IP65CVR-M Weatherproof Cover Installation.



#### 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.
4. TERMINAL BLOCKS ARE NOT REMOVABLE.

FIGURE 2.6 MPS-RTD Outline and Mounting Details.

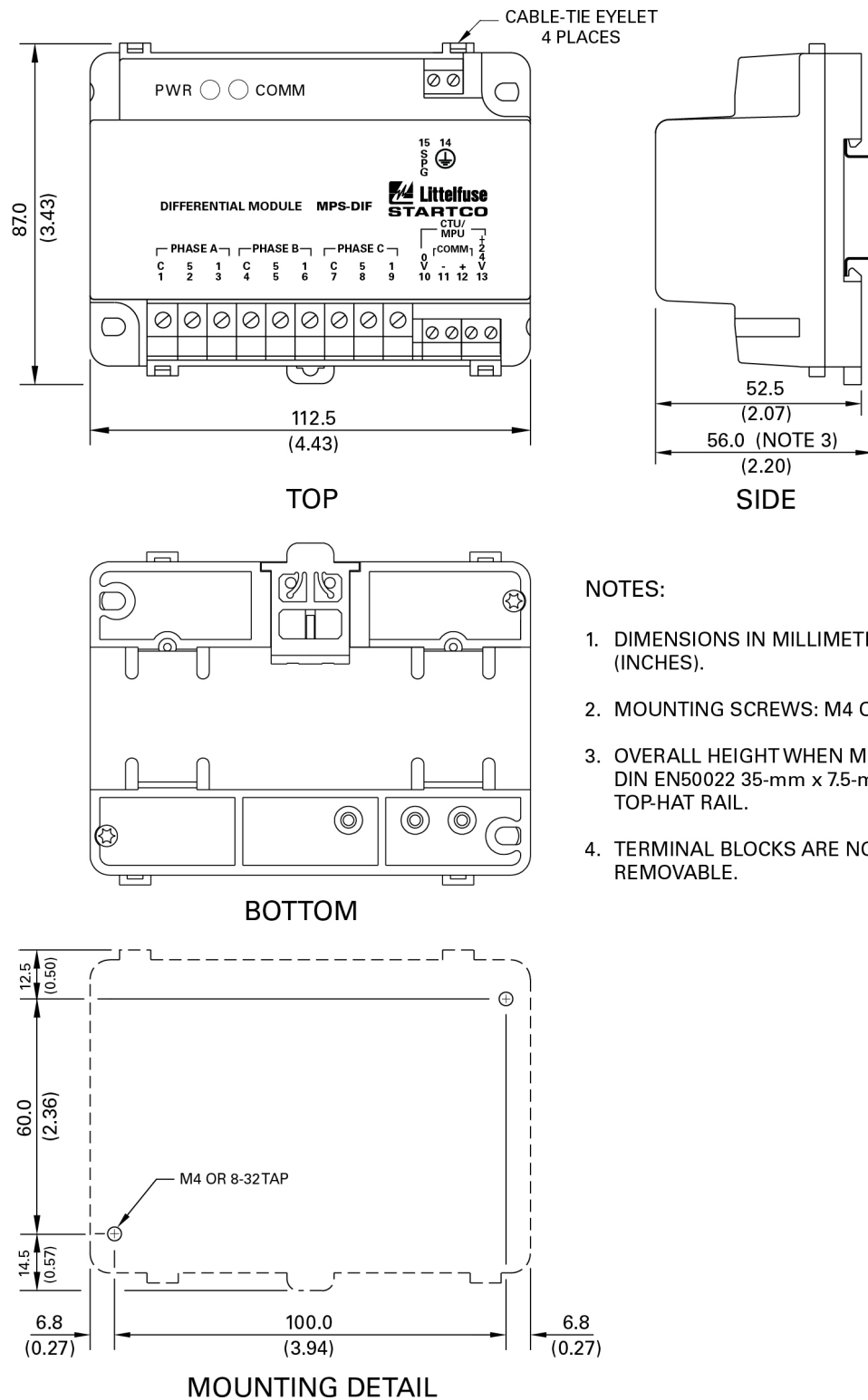


FIGURE 2.7 MPS-DIF Outline and Mounting Details.



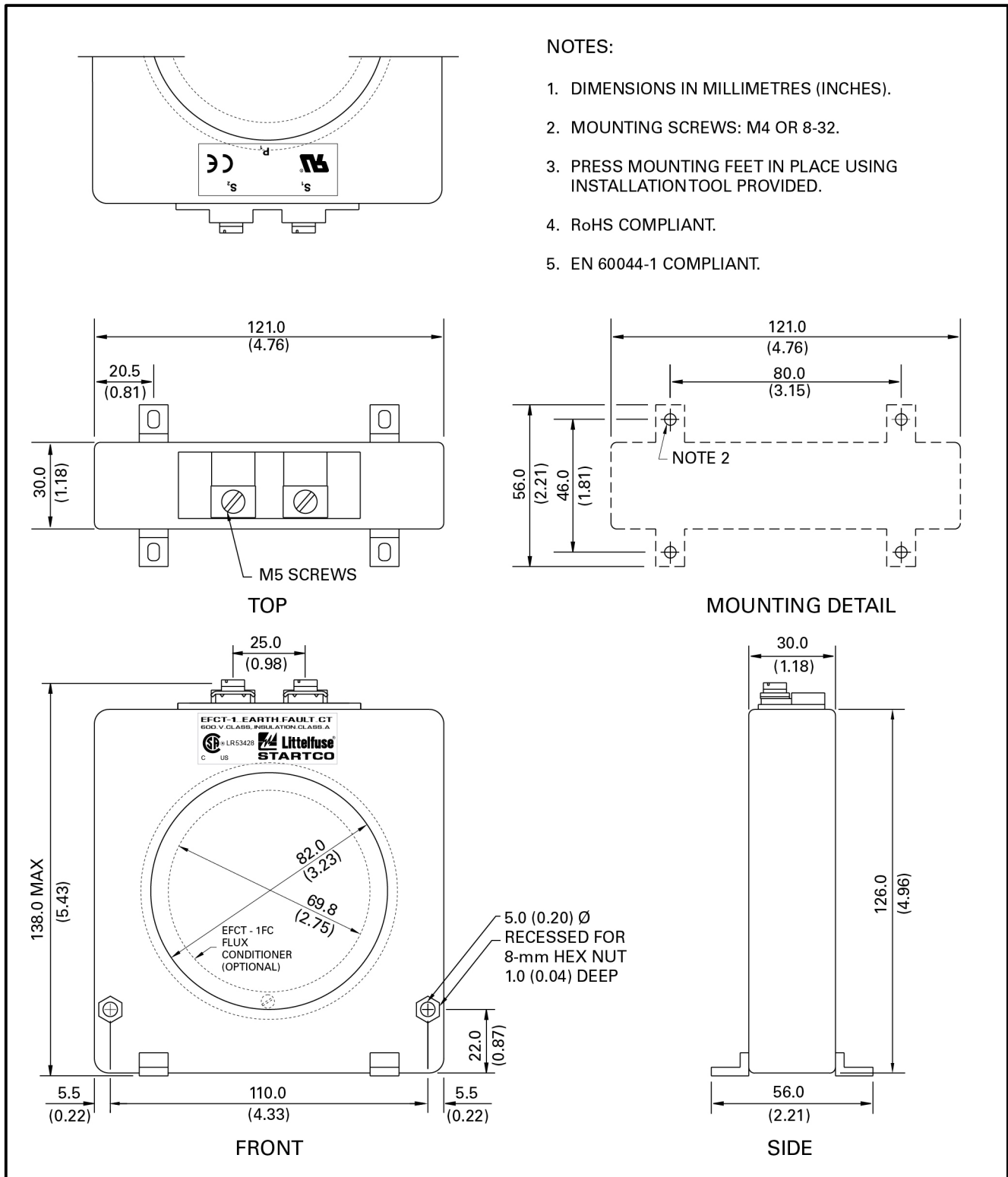


FIGURE 2.8 EFCT-1 Outline and Mounting Details.

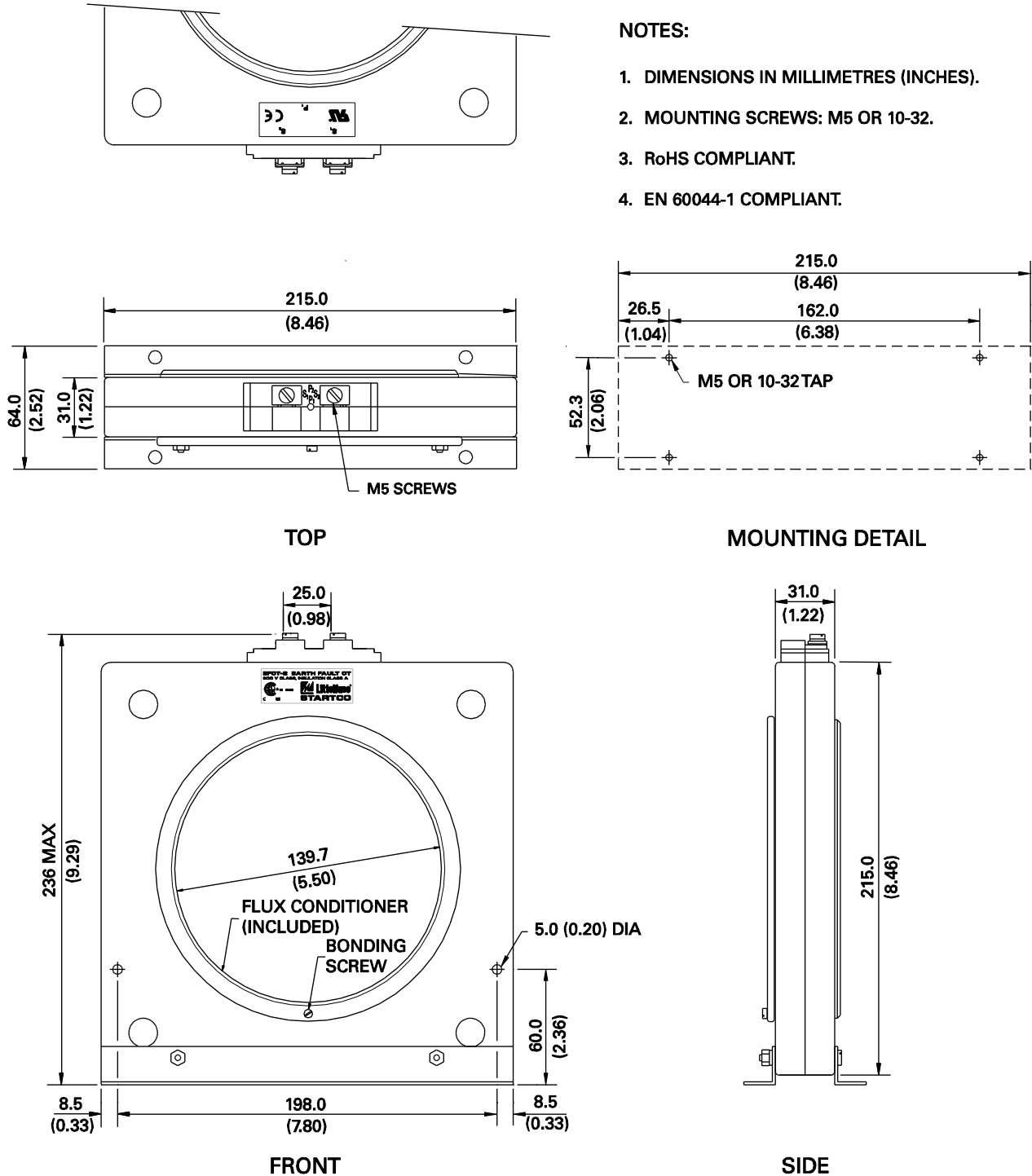


FIGURE 2.9 EFCT-2 Outline and Mounting Details.

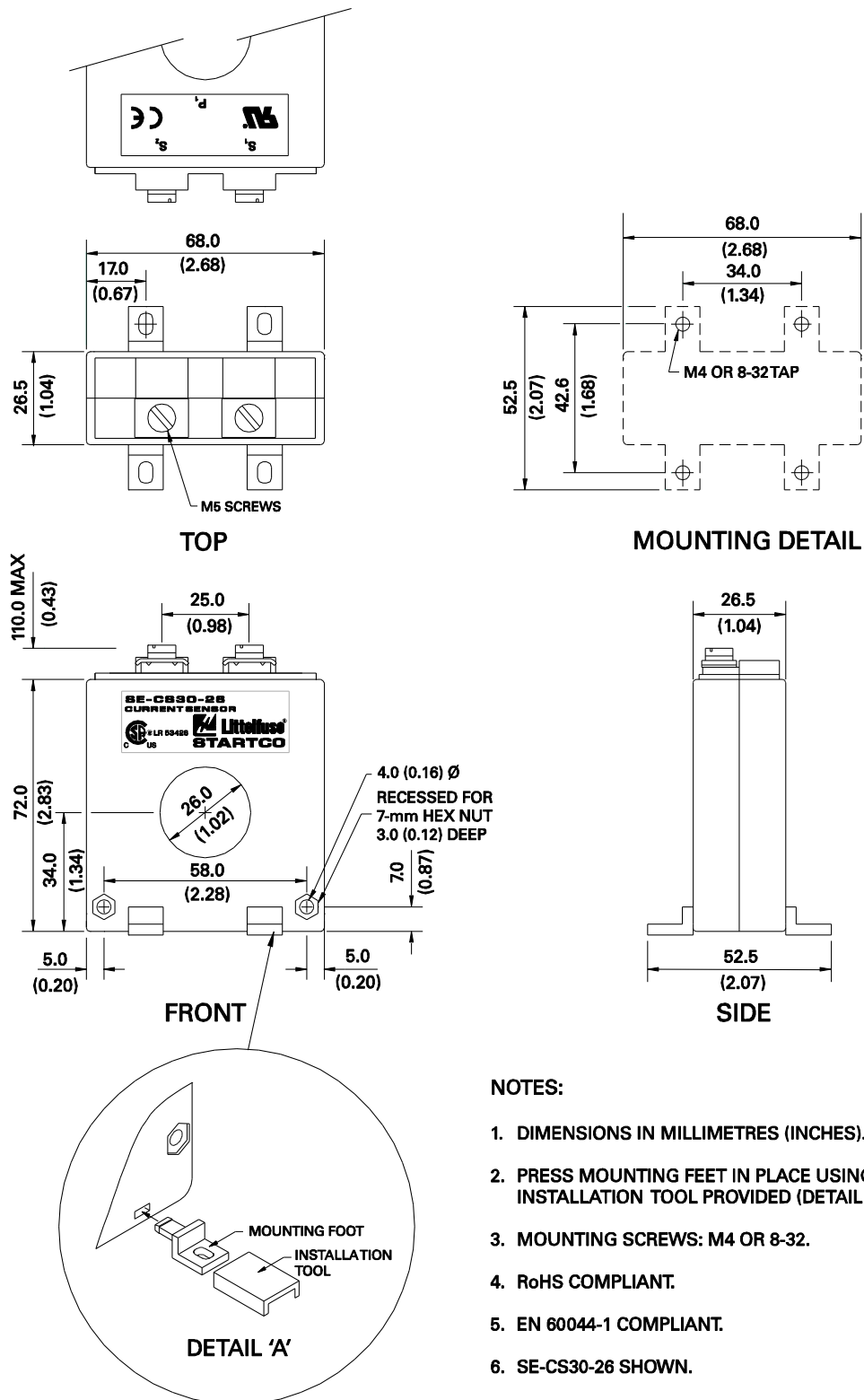


FIGURE 2.10 EFCT-26 and SE-CS30-26 Outline and Mounting Details.

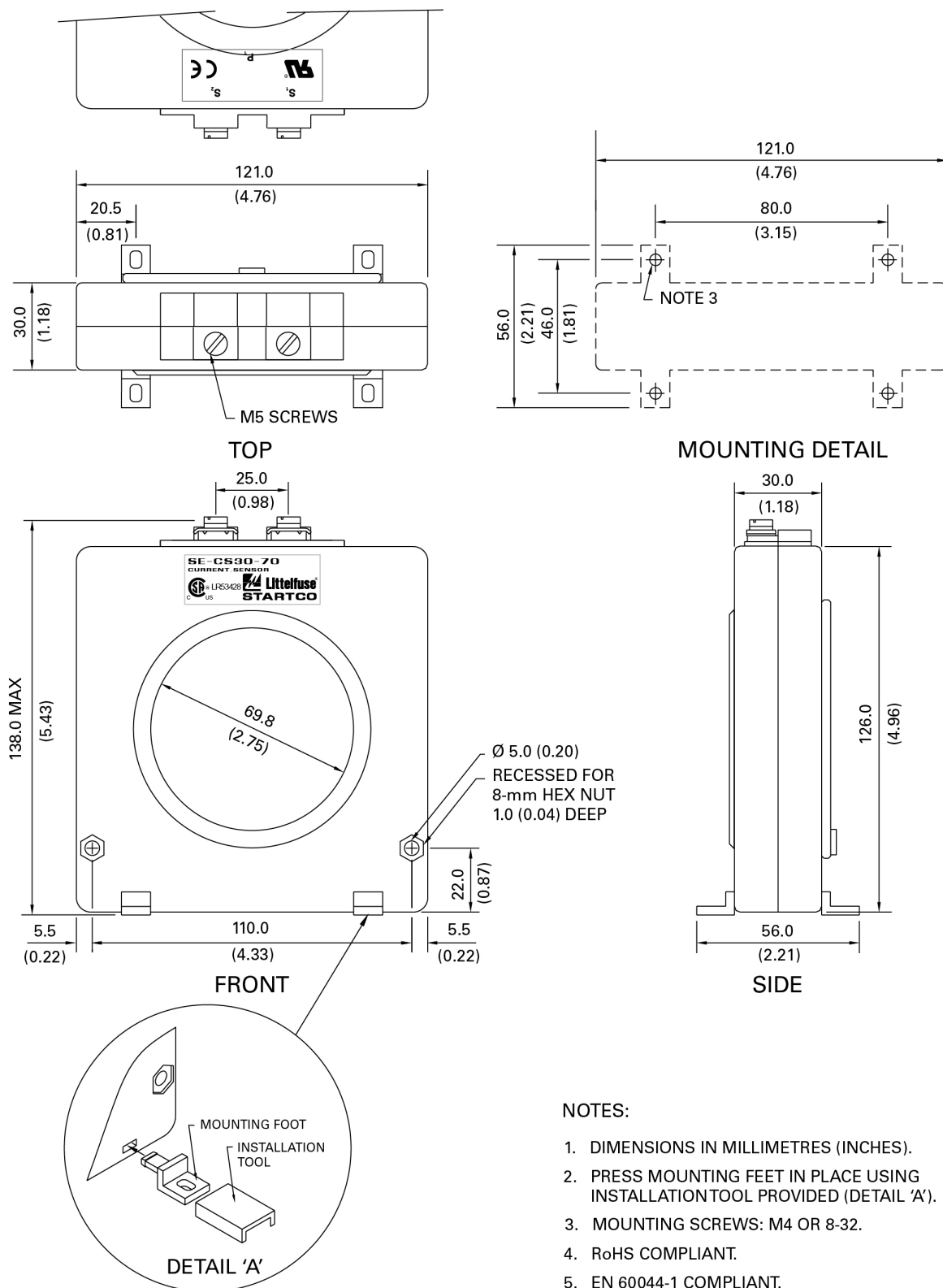


FIGURE 2.11 SE-CS30-70 Outline and Mounting Details.

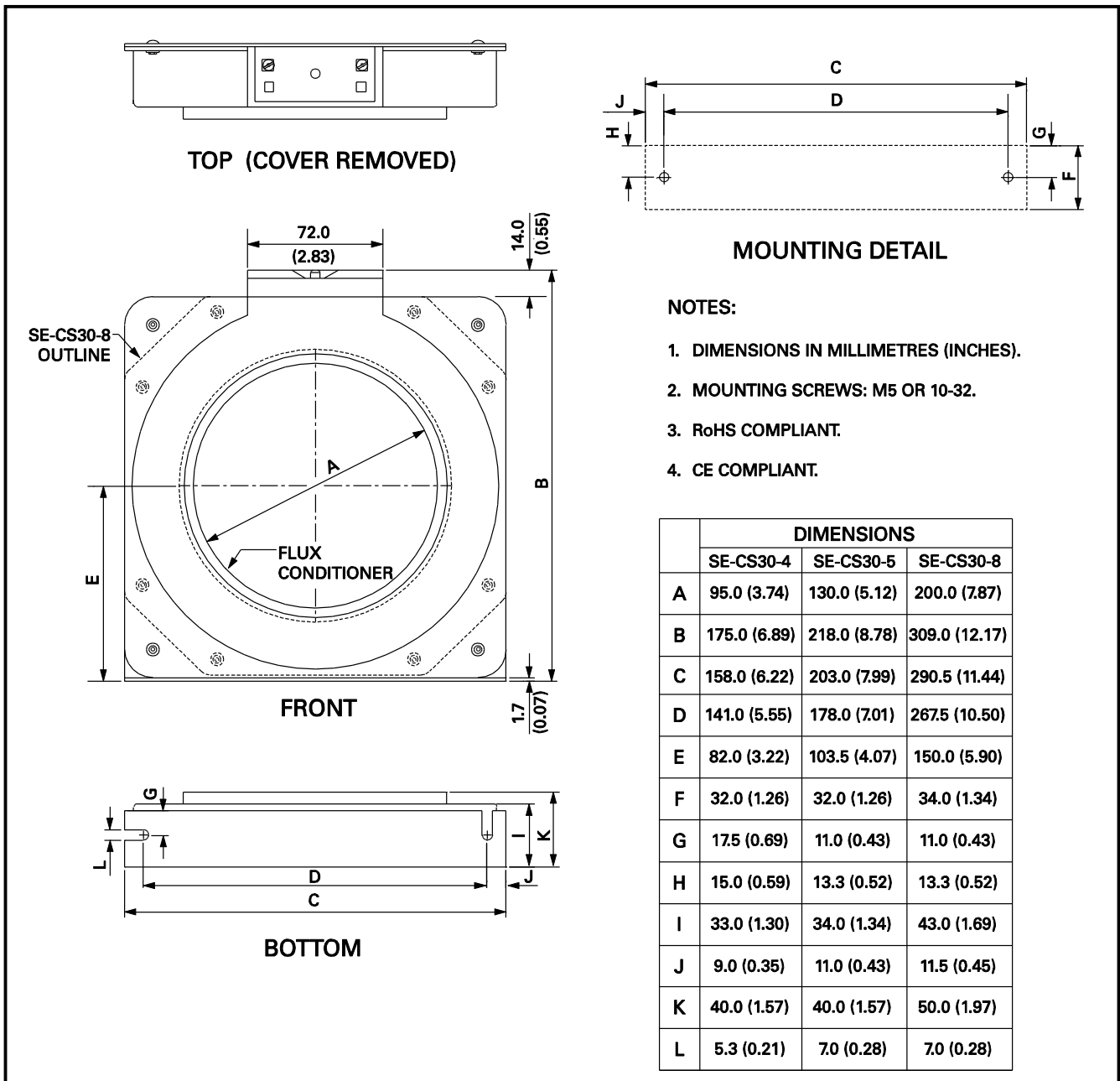


FIGURE 2.12 SE-CS30-4, -5, and -8 Outline and Mounting Details.

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### 3. SYSTEM WIRING

#### 3.1 GENERAL

A typical connection diagram is shown in Fig. 3.2. The MPS-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'). I/O communications addressing supports up to three modules of each type; however, the power supply in the MPS-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 MPS-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.

START1, START2, and STOP starter-control commands can be issued through the digital inputs, the network interface, or the MPS-OPI. Start, stop, and interlock contacts can be wired to any of the programmable digital inputs. The five programmable output relays can be used for starting control, protection, and interlock functions. Relay 5 is a solid-state, low-level output relay not recommended for starter 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 MPS-CTU CONNECTIONS

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

The MPS-CTU Ring Terminal CT-input terminal block accept a maximum ring width of 8 mm (0.315"). These terminal blocks cannot be unplugged.

##### 3.2.1.1 SUPPLY VOLTAGE

Derive supply voltage from the line side of the motor controller or from an independent source. Connect supply voltage to terminals 1 and 2 (L1 and L2) as shown in Fig. 3.2. 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 MPS-CTU uses 1-A or 5-A CT's for phase-current measurement. The MPS-CTU Ring Terminal uses 5-A CT's for phase-current measurement. To maintain specified accuracy, phase CT's should be protection class and selected with a primary rating between 100 and 300% of motor full-load current (FLA). Current threshold is a function of full-load current and CT-primary rating as defined by the following formula.

$$\text{Current Threshold (\%)} = 1.5 \times \frac{\text{CT Primary Rating}}{\text{FLA}}$$

The Current Threshold is also used to determine when the motor is in Run mode. Several protective functions are only enabled when in Run mode. See Section 5.1 for a description of Run mode.

For synchronous-motor applications, the CT-primary rating should be selected such that the current threshold is less than the idle current, typically less than 5%. All CT inputs can withstand a common-mode voltage of 120 Vac so that the MPS-CTU can be connected in series with other CT loads. The connection diagram in Fig. 3.2 shows a typical connection where the MPS-CTU is the only device connected to the phase CT's. The MPS-CTU requires the phase sequence to be A-B-C with correct polarity.

The I<sub>p</sub> Threshold sets the current level where unbalance protection becomes active. See Section 5.8.

A 1-A, 5-A, or sensitive CT is used for core-balance earth-leakage measurement. The MPS-CTU Ring Terminal has no 1-A input. See Fig. 3.1 for the phase-CT residual connection for earth-fault detection.

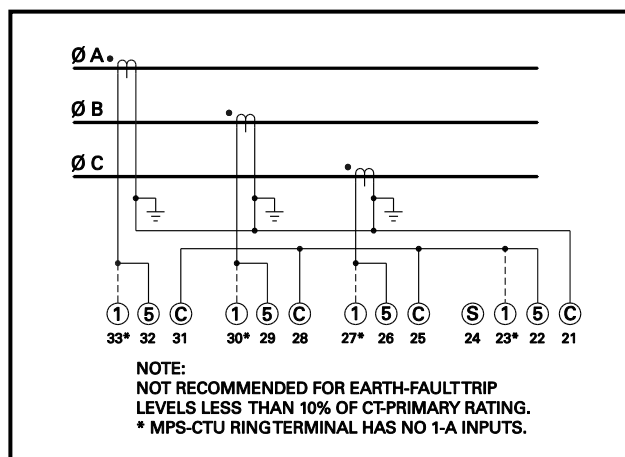


FIGURE 3.1 Residual Phase-CT Connection.

##### 3.2.1.3 VOLTAGE INPUTS

For all input-voltage connections, the MPS-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.





### 3.2.1.3.1 DIRECT CONNECTION

PT's are not required for system voltages up to 600 Vac line-to-line. Connect the voltage inputs as shown in Figs. 3.2 and 3.3.

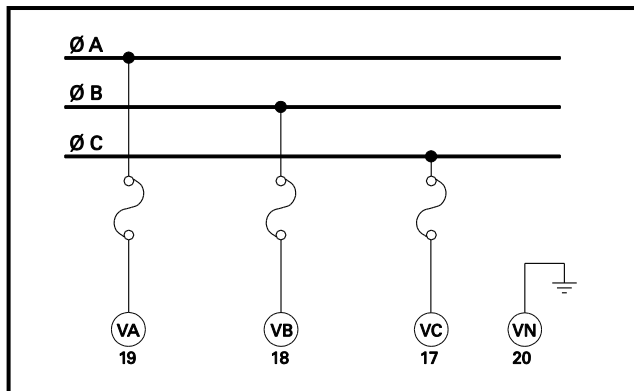


FIGURE 3.3 Direct Connection.

### 3.2.1.3.2 1-PT CONNECTION

The 1-PT connection is shown in Fig. 3.4. 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.

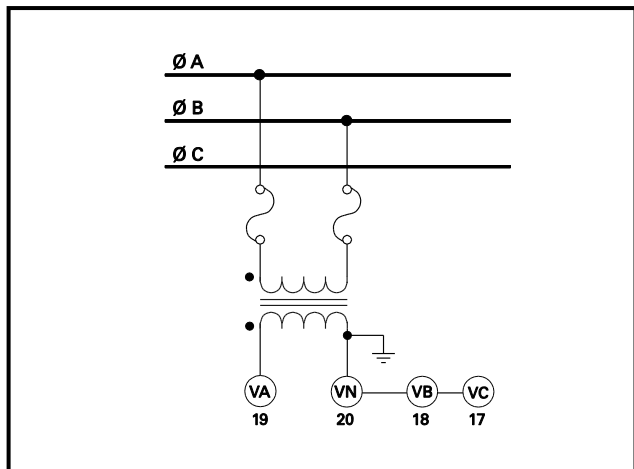


FIGURE 3.4 1-PT Connection.

### 3.2.1.3.3 2-PT CONNECTION

The 2-PT connection is shown in Fig. 3.5. The PT-secondary voltages must be less than 350 Vac. Connect the PT secondaries in open delta.

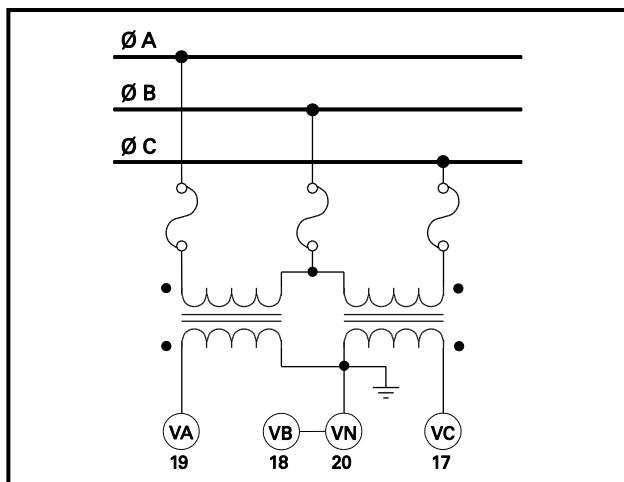


FIGURE 3.5 2-PT Connection.

### 3.2.1.3.4 3-PT CONNECTION

The 3-PT connection is shown in Fig. 3.6. The PT-secondary voltages must be less than 350 Vac. Since the MPS-CTU measures line-to-line voltage, there is no advantage in using a 3-PT connection over a 2-PT connection.

**NOTE:** This connection relies on PT primary-magnetization current for voltage balance. Do not connect any other secondary loads.

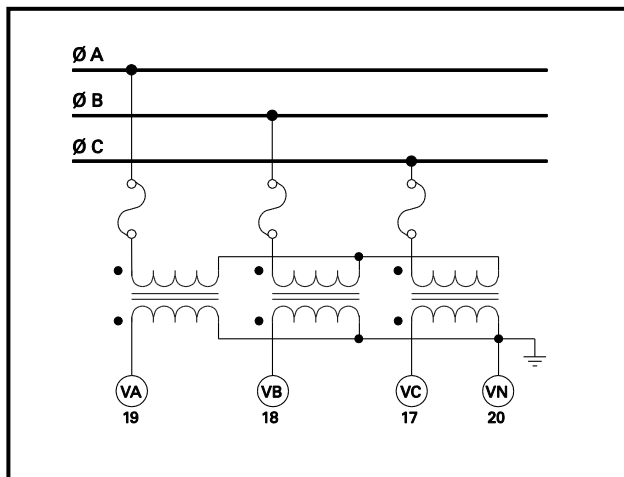


FIGURE 3.6 3-PT Connection.

### 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 12 to 120 Vac/Vdc range. Inputs 1 to 7 have programmable functions. See Table 4.2. Input 8 is a high-speed input (HSI) for a tachometer sensor.

### 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 12- to 120-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 12- to 120-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 common and dc-supply “-” to COM.

### 3.2.1.4.4 TACHOMETER INPUT (HSI)

A tachometer sensor can be used to provide motor-speed measurement. Connect a logic-output PNP tachometer as shown in Fig. 3.7.

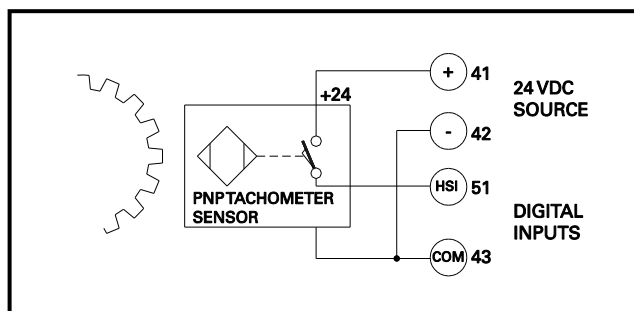


FIGURE 3.7 Digital Tachometer Input (HSI).

### 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- $\Omega$  input impedance.

**NOTE:** The analog input is referenced to an internal supply with 100-k $\Omega$  resistors. Maximum common-mode voltage is  $\pm 5$  Vdc with respect to MPS-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 MPS 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 MPS 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 MPS-CTU top panel is in parallel with terminals 50 to 56. It is used for direct MPS-OPI mounting. See Section 2.3.

I/O module communication is based on the 2-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- $\Omega$  terminations are required at the cable ends. See Fig. 3.9.

### 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 MPS-OPI CONNECTIONS AND ADDRESS SELECTION

Connect the MPS-OPI to the MPS-CTU using shielded cable (Belden® 3124A or equivalent). The 24-Vdc supply for the MPS-OPI is provided by the MPS-CTU. The cable shield must be connected at both ends so that MPS-OPI transient protection is operational. See Fig. 3.9.

The MPS-OPI has two switches to select its network address. See Figs. 2.2 and 3.8. Up to three MPS-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. 3.8 shows the addressing selection format.

TABLE 3.1 MPS-OPI ADDRESS SELECTION

| ADDRESS             | SWITCH 1 | SWITCH 2 |
|---------------------|----------|----------|
| 0<br>(Factory Test) | Open     | Open     |
| 1<br>(First OPI)    | Closed   | Open     |
| 2<br>(Second OPI)   | Open     | Closed   |
| 3<br>(Third OPI)    | Closed   | Closed   |

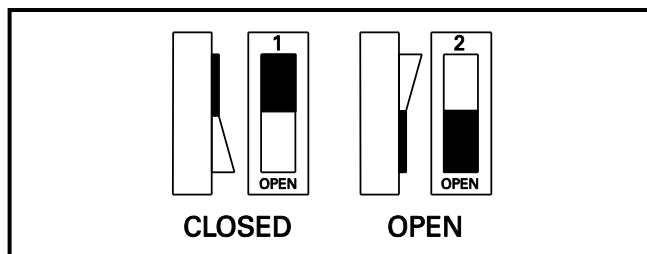


FIGURE 3.8 Address Selection Switch Detail.

### 3.2.3 MPS-RTD CONNECTIONS AND ADDRESS SELECTION

MPS-RTD terminal blocks accept 24 to 12 AWG (0.2 to 2.5 mm<sup>2</sup>) conductors.

Connect the MPS-RTD to the MPS-CTU using the four-conductor shielded cable (Belden 3124A or equivalent) as shown in Fig. 3.9. The MPS-CTU 24-Vdc supply can power up to three MPS-RTD modules.

Connect RTD's to the MPS-RTD as shown in Fig. 3.9. When the RTD module is installed in a motor junction box, RTD-lead shielding is not required.

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

The MPS-RTD has two switches to select its network address. See Figs. 3.8 and 3.10. Up to three MPS-RTD modules can be connected to the I/O MODULE bus, and each RTD-module address must be unique. If one module is used, address 1 must be used. If two RTD modules are used, addresses 1 and 2 must be used. If three RTD modules are used, addresses 1, 2, and 3 must be used.

Table 3.2 shows the addressing selection format.

TABLE 3.2 MPS-RTD ADDRESS SELECTION

| ADDRESS                  | SWITCH 1 | SWITCH 2 |
|--------------------------|----------|----------|
| 0<br>(Offline)           | Open     | Open     |
| 1<br>(First RTD Module)  | Closed   | Open     |
| 2<br>(Second RTD Module) | Open     | Closed   |
| 3<br>(Third RTD Module)  | Closed   | Closed   |

### 3.2.4 MPS-DIF CONNECTIONS

The MPS-DIF CT-input terminal blocks accept 22 to 10 AWG (0.3 to 4.0 mm<sup>2</sup>) conductors. The remaining MPS-DIF clamping blocks accept 24 to 12 AWG (0.2 to 2.5 mm<sup>2</sup>) conductors.

Connect the MPS-DIF to the MPS-CTU using four-conductor shielded cable (Belden 3124A or equivalent) as shown in Fig. 3.9.

Connect the surge-protection (SPG) terminal 15 to terminal 14 ( $\oplus$ ), and earth terminal 14.

#### 3.2.4.1 CORE BALANCE

The core-balance connection is shown in Fig. 3.11. To minimize power-cable and CT-lead length, both the differential CT's and the MPS-DIF can be located near the motor. The primary rating of the differential CT does not have to match the phase-CT primary rating and is usually selected with a lower ratio resulting in more sensitive differential protection. The core-balance method avoids CT-matching issues and is the preferred connection.

#### 3.2.4.2 MPS SUMMATION

The MPS summation connection uses three phase CT's and three differential CT's as shown in Fig. 3.12. Both CT ratio and CT-saturation characteristics must be matched to avoid differential currents under motor starting and running conditions. The MPS-DIF module should be located near the MPS-CTU to minimize CT wire length. It is preferred to use three dedicated phase CT's and three core-balance differential CT's as described in Section 3.2.4.1.

For the delta connection, the MPS *FLA Rating* is set equal to the motor's full-load current multiplied by  $\sqrt{3}$ . Power, power factor and energy measurements are not correct for the delta connection.

#### 3.2.4.3 DIF SUMMATION

The DIF summation connection uses six differential CT's as shown in Fig. 3.13. Both CT-ratio and CT-saturation characteristics must be matched to avoid differential currents under motor starting and running conditions. It is preferred to use three core-balance CT's as described in Section 3.2.4.1. This six CT connection allows the CT's and MPS-DIF to be placed near the motor to minimize power-cable and CT-lead length.

### 3.2.5 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 MPS-CTU during dielectric-strength testing.

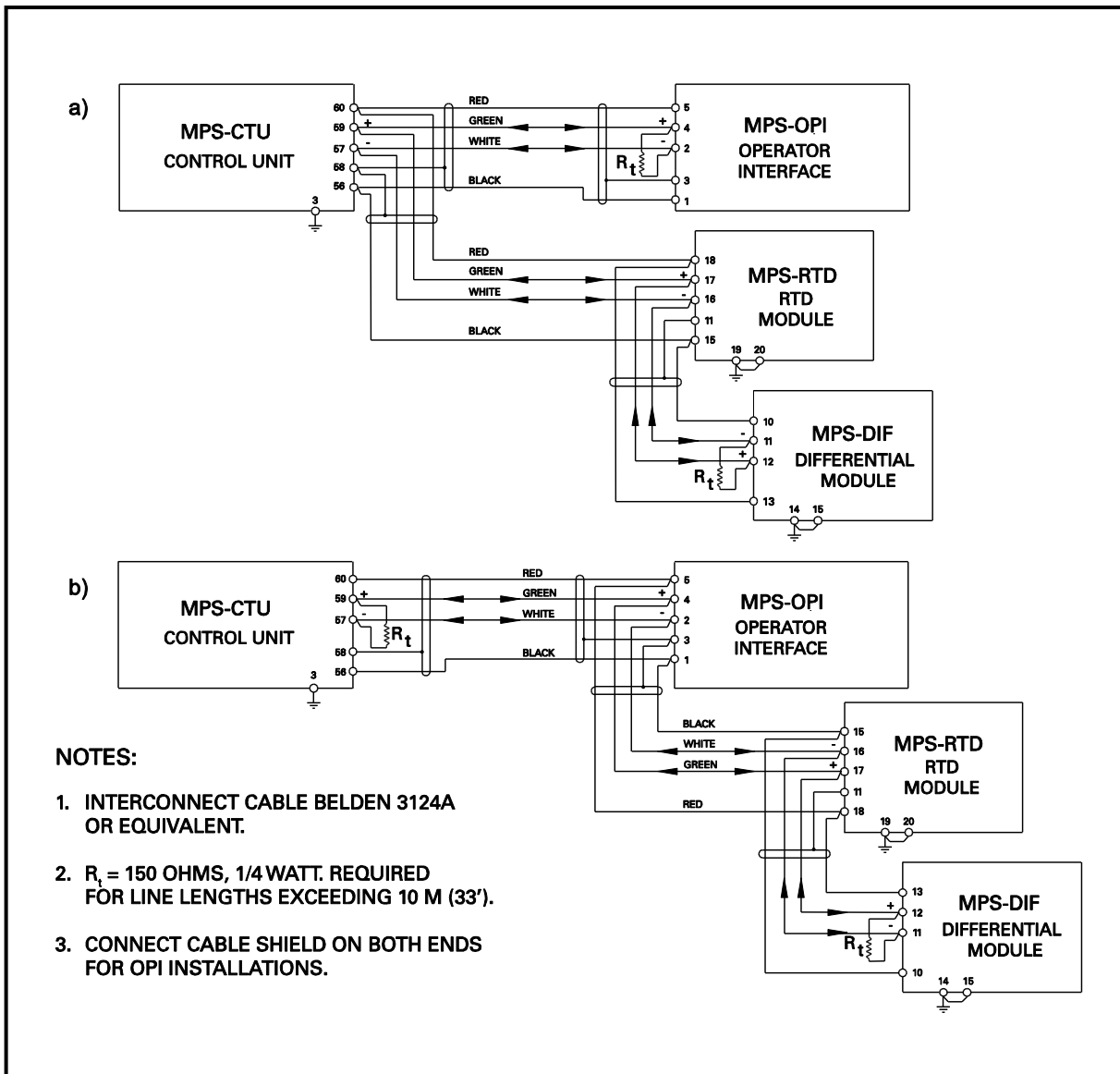


FIGURE 3.9 Two Examples of I/O Module Connections.



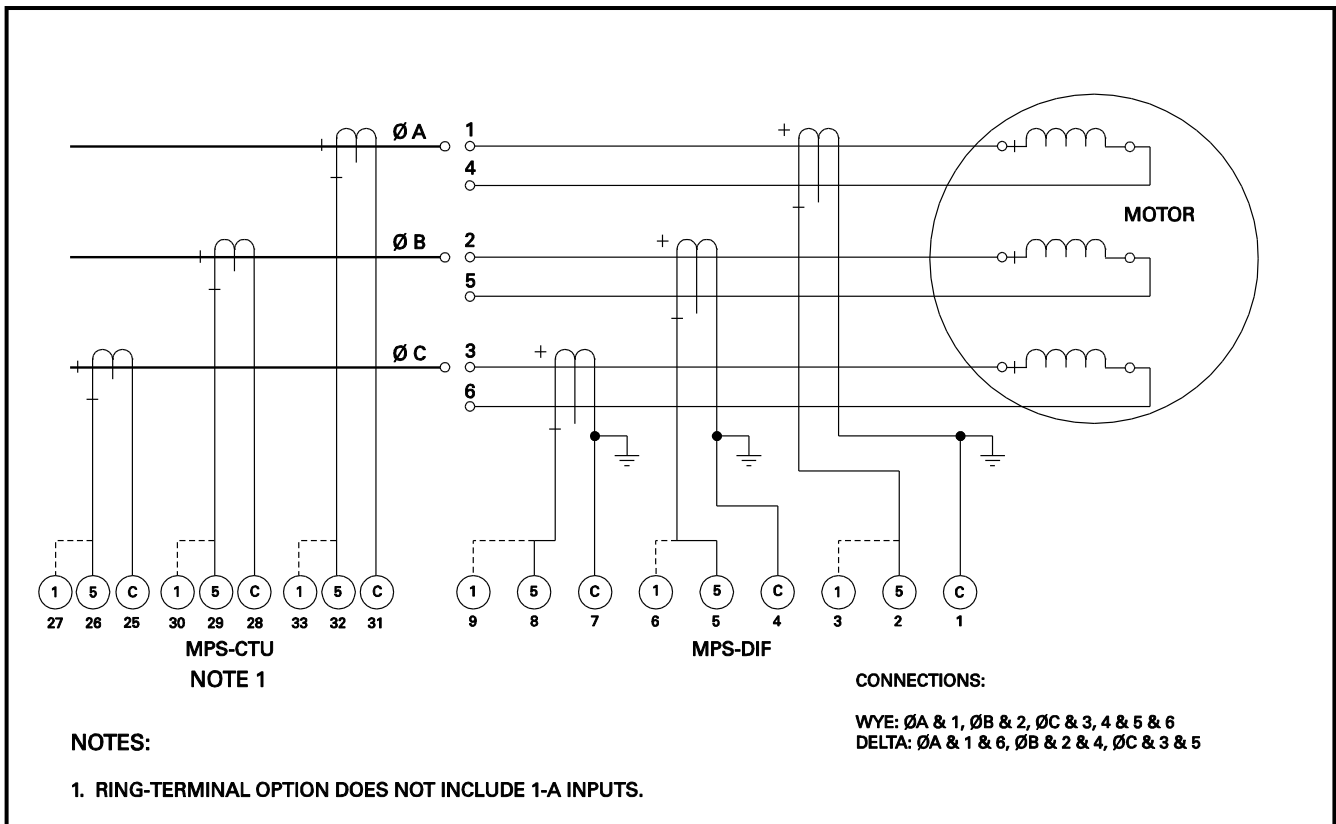


FIGURE 3.11 Core Balance Connection.

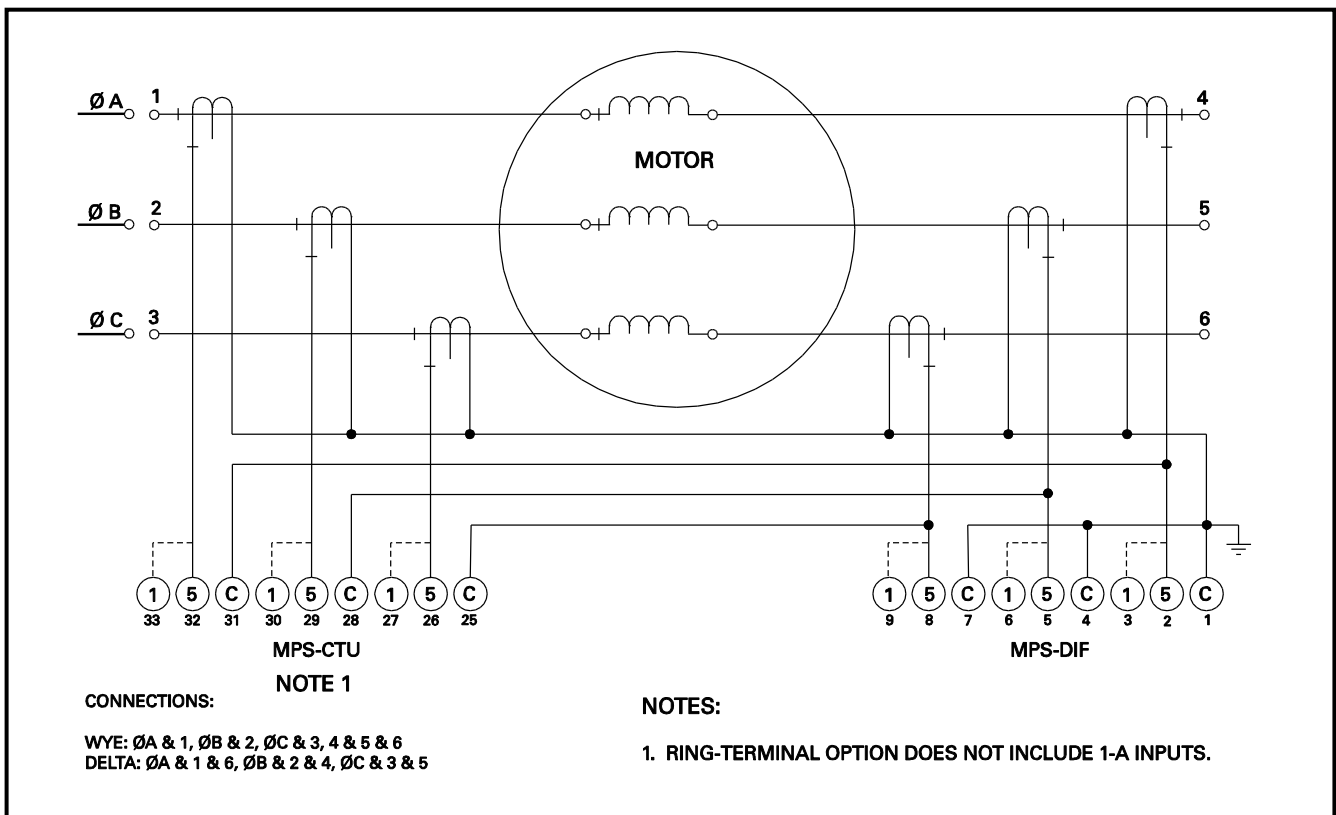


FIGURE 3.12 MPS Summation Connection.

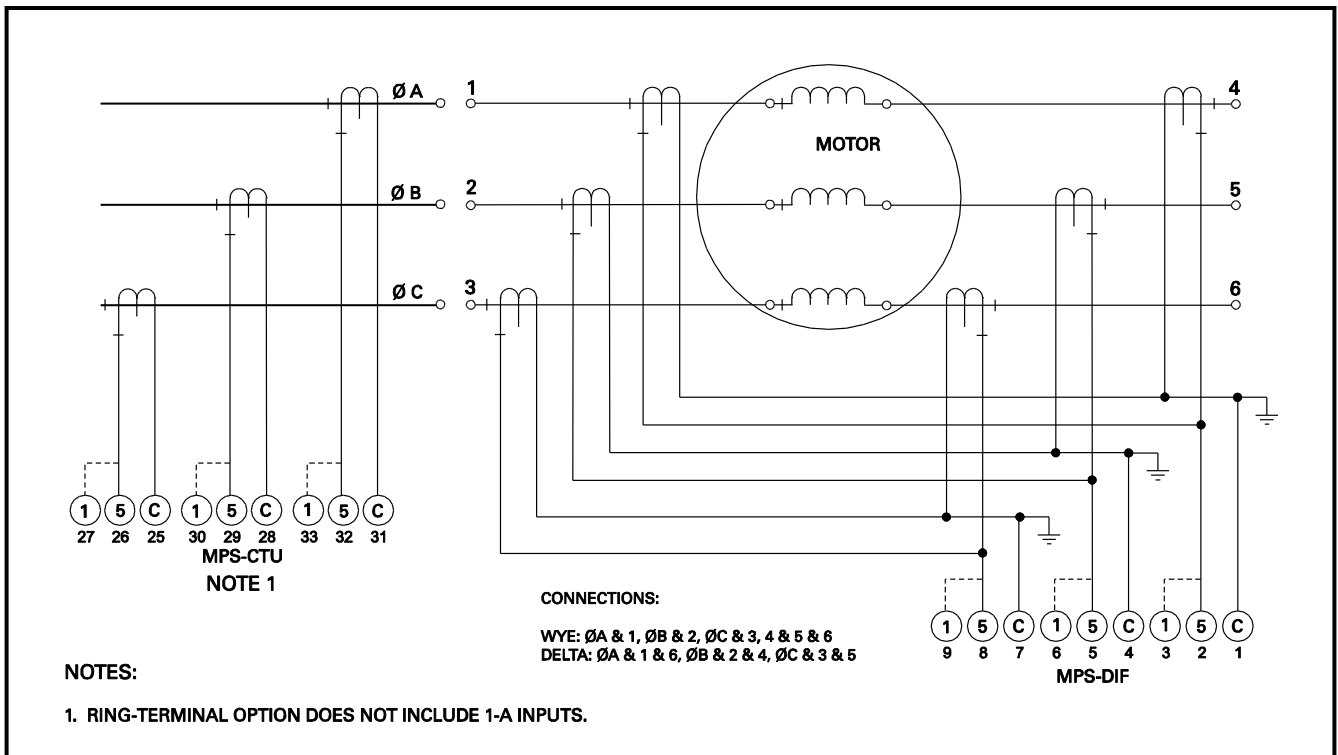


FIGURE 3.13 DIF Summation Connection.

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## 4. OPERATION AND SETUP

### 4.1 GENERAL

The MPS-CTU can operate independently. It can also operate in conjunction with network communications, the MPS-OPI, MPS-RTD and the MPS-DIF. All settings are stored in the MPS-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*

|            |                    |
|------------|--------------------|
| Metering ▶ |                    |
| Messages ▶ |                    |
| ▲ Setup ▶  | Protection ▶       |
|            | ◆ System Ratings ▶ |
|            | Starter ▶          |
|            | •                  |
|            | •                  |
|            | •                  |
|            | ▼ CT Primary→      |
|            | EF-CT-Primary→     |
|            | System Voltage→    |
|            | Input Voltage→     |
|            | •                  |
|            | •                  |
|            | •                  |

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 MPS-OPI. See the menu map in Appendix A.

### 4.2 MPS-CTU

#### 4.2.1 LED INDICATION

The four LED's on the MPS-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 MPS-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 motor full-load 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 MPS.

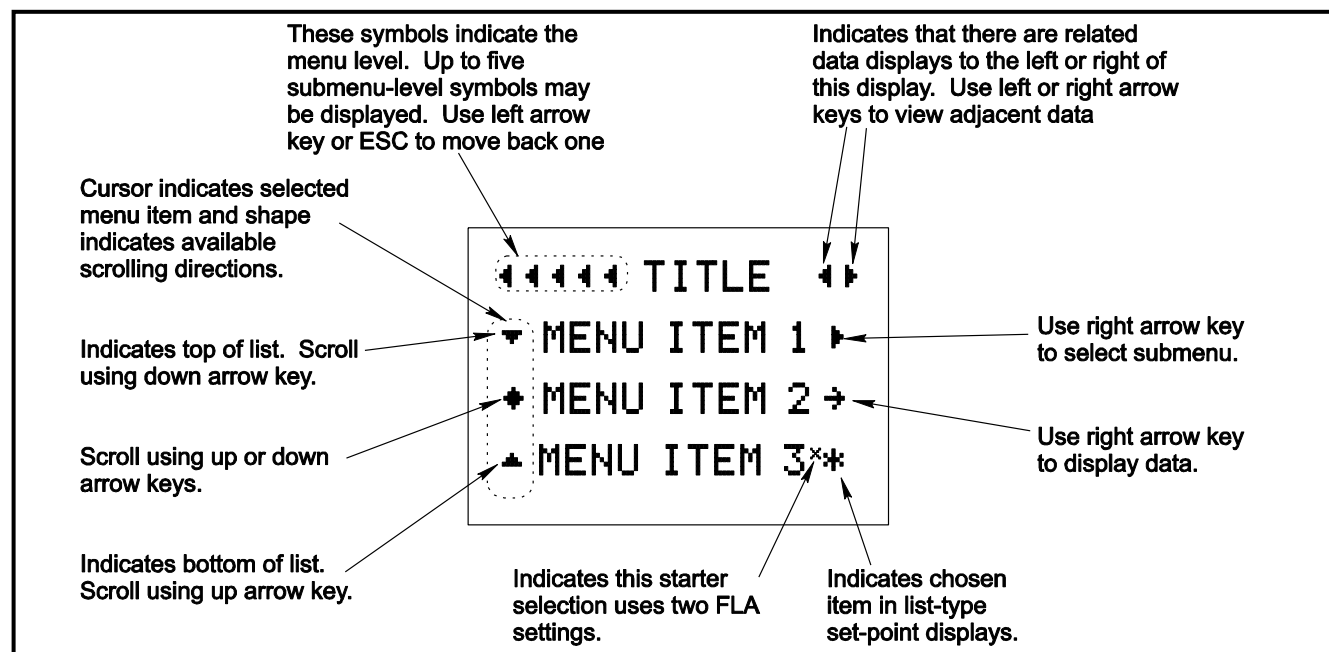


FIGURE 4.2 Menu Symbols.

#### 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 25 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. 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 MOTOR DATA

OPI Menu: *Setup | System Ratings*

OPI Menu: *Setup | Protection | Overload*

Motor data must be entered for the *FLA Rating*, *Frequency*, and *Service Factor*. If a tachometer is used, the *Sync Speed* is required. If the starter selected requires two FLA ratings, *FLA Rating 2* must be entered.

The *Frequency* setting determines the sampling rate used by the MPS for current and voltage measurements. If *Sync* to *ASD* is selected as the analog-input type, the *Frequency* setting is not used and the analog output from an adjustable-speed drive determines the sampling rate used by current- and voltage-measuring algorithms. See Section 5.29.2.

Locked-rotor current, cold locked-rotor time, and hot locked-rotor time must be entered in the *Protection | Overload* menu to provide customized overload protection. See Section 5.2.

#### 4.2.7 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 and should only be used for interlocks or annunciation.

Relay assignments *Starter RLYA*, *Starter RLYB*, *Starter RLYC*, and *Starter RLYD* operate in conjunction with

MPS starting functions to control the motor-starter contactor(s). See Section 6. Contactor status can be monitored using auxiliary contacts and the digital inputs. See Section 4.2.8 and Figs. 6.9 to 6.23.

TABLE 4.1 OUTPUT-RELAY FUNCTIONS

| FUNCTION                   | ASSIGNMENT OR ACTION                                                                                                                                                   |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Starter RLYA               | Relay is assigned to the Starter Relay A function.                                                                                                                     |
| Starter RLYB               | Relay is assigned to the Starter Relay B function.                                                                                                                     |
| Starter RLYC               | Relay is assigned to the Starter Relay C function.                                                                                                                     |
| Starter RLYD               | Relay is assigned to the Starter Relay D function.                                                                                                                     |
| 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.       |
| Trip1 Pulse <sup>(1)</sup> | Trip1 energizes the relay for the time duration specified by the <i>RY Pulse Time</i> set point.                                                                       |
| 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. |
| Local                      | Relay energized when Local starter control is selected.                                                                                                                |
| Interlock                  | Relay is energized when all digital-input interlocks are completed.                                                                                                    |
| Current                    | Relay is energized when current is detected.                                                                                                                           |
| Run Mode                   | Relay is energized when motor is running. (Current <125% for <i>Run-Mode Delay</i> )                                                                                   |
| Sequence Complete          | Relay is energized when the starter <i>Start Time</i> has elapsed.                                                                                                     |
| Start Inhibit              | Relay is energized when in an <i>I<sup>2</sup>t</i> or starts-per-hour inhibit condition.                                                                              |
| Watchdog                   | Relay is energized when the supply voltage is applied and the MPS is operating properly.                                                                               |
| Reduced OC                 | Relay is energized when in maintenance mode (ROC = On).                                                                                                                |
| None <sup>(2)</sup>        | No Assignment (Default).                                                                                                                                               |

<sup>(1)</sup> Assign this function to only one relay. Non-fail-safe operation only.

<sup>(2)</sup> Relay outputs must be assigned. Default is None.

When a trip occurs, all assigned starter-control relays (*Starter RLYA* to *Starter RLYD*) are de-energized 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 4.2.8 and 6.

Relays assigned to trip or alarm functions 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 MPS-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).

#### 4.2.8 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.

Start inputs are not active when *Protection Only* is selected as the starter type. The STOP function is always active. In *Protection Only* mode, STOP initiates a *Trip1* signal.

Each digital input assigned the *Trip1* function has *Start Bypass*, *Bypass Delay*, and *Trip Delay* set points. When *Start Bypass* is enabled, the *Trip1* function is bypassed during a start for the duration specified by *Bypass Delay*. Since start detection is based on motor current, this feature can be used in the *Protection Only* mode. 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 *Start Bypass* is disabled, *Bypass Delay* is not used and the *Trip1* function is always enabled. The bypass feature can be used in pump-control applications to allow time for a pressure switch to close.

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

TABLE 4.2 DIGITAL-INPUT FUNCTIONS

| FUNCTION                    | STATE <sup>(1)</sup>                                                             |
|-----------------------------|----------------------------------------------------------------------------------|
| Start1                      | 1 = Start1 (Momentary)                                                           |
| Start2                      | 1 = Start2 (Momentary)                                                           |
| Local Select -              | 1 = Per CONTROL SELECT Setting<br>0 = Local Control                              |
| Local Select +              | 0 = Local Control <sup>(2)</sup><br>1 = Per CONTROL SELECT Setting               |
| Local Start1 <sup>(2)</sup> | 1 = Start1 (Momentary)                                                           |
| Local Start2 <sup>(2)</sup> | 1 = Start2 (Momentary)                                                           |
| 2-Wire Start1               | 1 = Start1 (Maintained)<br>0 = Stop                                              |
| 2-Wire Start2               | 1 = Start2 (Maintained)<br>0 = Stop                                              |
| Stop                        | 1 = Start Allowed<br>0 = Stop                                                    |
| RLYA Status                 | 1 = Contactor Closed<br>0 = Contactor Open                                       |
| RLYB Status                 | 1 = Contactor Closed<br>0 = Contactor Open                                       |
| RLYC Status                 | 1 = Contactor Closed<br>0 = Contactor Open                                       |
| RLYD Status                 | 1 = Contactor Closed<br>0 = Contactor Open                                       |
| Interlock                   | 1 = Start Allowed (If all interlocks are valid.)<br>0 = Start Not Allowed        |
| Trip1                       | 1 = No Trip1<br>0 = Trip1 (Delays Selectable)                                    |
| Reset                       | 1 = Reset Trips                                                                  |
| FLA2 Select <sup>(3)</sup>  | 1 = Select FLA2<br>0 = Select FLA1                                               |
| Limit1 Stop                 | 1 = Start1 Allowed<br>0 = Start1 Stop                                            |
| Limit2 Stop                 | 1 = Start2 Allowed<br>0 = Start2 Stop                                            |
| Reduced OC                  | 1 = Reduced OC Set Point Not Operational<br>0 = Reduced OC Set Point Operational |
| None                        | No Assignment (Default)                                                          |

<sup>(1)</sup> 1 = Input voltage applied, 0 = Input voltage not applied.

<sup>(2)</sup> Interlocks bypassed in LOCAL.

<sup>(3)</sup> Applies only to *Protection Only* mode.

LOCAL is selected using the OPI, 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. The *Local Select* – and *Local Select* + selections allow the digital input to select LOCAL control. Both positive and negative logic versions allow implementation of various “Hand-Off-Auto” control schemes. See Section 6 for CONTROL SELECT operation.

In applications where MPS starter functions are not used, *FLA2 Select* can be used to switch between FLA1 and FLA2. This applies only to *Protection Only* mode. The selected FLA is displayed in the *Metering | System State* menu.

*Limit1 Stop* and *Limit2 Stop* are limit-switch inputs typically used with reversing starters. *Limit1 Stop* is a stop input associated with *Start1* and *Limit2 Stop* is a stop input associated with *Start2*.

The *Reduced OC* selection operates in conjunction with the reduced overcurrent set point which must be enabled. See Section 5.5.

When *Reduced OC* is selected and no digital input voltage is applied, the reduced overcurrent set point is operational. When digital input voltage is applied, the reduced overcurrent set point is not operational.

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

- *Start1, Start2, Local Start1, and Local Start2*: Momentary voltage on any input will initiate a start. (MPS must be in LOCAL for *Local Start1* and *Local Start2* operation.)
- *Stop*: Voltage must be present on all inputs to allow an MPS-controlled start.
- *Interlock*: Voltage must be present on all inputs to allow an MPS-controlled start and to energize an interlock output relay. Digital inputs programmed as *Interlock* are bypassed in LOCAL. Interlocks must remain valid while the motor is running.
- *RLYA, RLYB, RLYC, and RLYD Status*: Voltage applied to any input programmed for a contactor status results in contactor-closed status.
- *Reset*: Voltage applied to any input will reset trips.
- *2-Wire Start1 and 2-Wire Start2*: Voltage on any input will initiate a start. All inputs must be open for a stop.
- *FLA2 Select*: Voltage on one or more inputs assigned to *FLA2 Select* will select FLA2.

#### 4.2.9 TACHOMETER INPUT (HSI)

OPI Menu: *Setup | System Ratings | Sync Speed*

OPI Menu: *Setup | Digital Inputs | Tachometer*

This input is provided for connection to a 24-Vdc proximity sensor for speed measurement. Set the number of pulses per revolution and enable the High-Speed Input in the *Tachometer* menu. Pulse-frequency range is 10 Hz to 10 kHz. These two settings are required for RPM readings.

If Failure to Accelerate protection is used, set the motor's synchronous speed in the *Sync Speed* menu. To fully utilize a speed-setting range from 10 to 100%, a full-speed frequency of at least 100 Hz is required.

The MPS averages 16 pulse periods to determine speed.

#### 4.2.10 ANALOG OUTPUT

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

A 25-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.

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              |                                 |
| Differential Current               | DF-CT-Primary Rating             | Maximum of 3 Currents           |
| Used I <sup>2</sup> t Capacity     | 100% I <sup>2</sup> t            |                                 |
| Stator Temperature <sup>(1)</sup>  | 200°C (392°F)                    | Maximum of Stator RTD's         |
| Bearing Temperature <sup>(1)</sup> | 200°C (392°F)                    | Maximum of Bearing RTD's        |
| Load Temperature <sup>(1)</sup>    | 200°C (392°F)                    | Maximum of Load RTD's           |
| Ambient Temperature <sup>(1)</sup> | 200°C (392°F)                    | Maximum of Ambient RTD's        |
| Voltage                            | System Voltage                   | Maximum Line-to-Line Voltage    |
| Unbalance (I)                      | 1.0 per unit or 100%             | I <sub>2</sub> /I <sub>1</sub>  |
| 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 |
| Speed                              | Synchronous Speed                |                                 |

<sup>(1)</sup> Output range is 0 to 200°C (32°F to 392°F). The output defaults to the calibrated zero output for an open or shorted RTD sensor.

#### 4.2.11 ANALOG INPUT

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

The analog input function is selectable as *Metering Only*, *Protection*, *Sync to ASD*, or *Motor Speed*.

##### 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 MPS operation, but its value can be observed in the Metering menu and with a communications network.

##### 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.

##### 4.2.11.3 SYNCHRONIZE TO ASD

OPI Menu: *Setup | 4-20 Analog In | Sync to ASD*

When *Sync to ASD* is selected the MPS uses the 4-20 mA input to set the internal sampling rate for current and voltage inputs. Select drive-frequency values corresponding to 4 and 20 mA.

##### 4.2.11.4 MOTOR SPEED

OPI Menu: *Setup | 4-20 Analog In | Motor Speed*

This selection overrides the selections for the high-speed tachometer input – failure-to-accelerate protection and speed metering use the analog input as the source of speed information.

#### 4.2.12 STARTER

OPI Menu: *Setup | Starter*

As a default, *Starter Type* is set to *Protection Only*. When a starter type is selected, output relays must be assigned for contactor control. See Section 4.2.7. Digital inputs must be assigned if contactor-status feedback is required. See Section 4.2.8.

See Section 6 for starter information.

#### 4.2.13 PROTECTION

OPI Menu: *Setup | Protection*

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

See Section 5 for protective function details. As a minimum, locked-rotor current and time must be set for overload protection.

Some protective functions are active after the *Run-Mode Delay*.

#### 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, energy values, and run hours
- Load defaults
- View firmware version and serial numbers
- Unlock local control if communication is lost
- Update Firmware

#### 4.2.15 NETWORK COMMUNICATIONS

OPI Menu: *Setup | Hardware | Network Comms*

The standard interface on the MPS is an RS-485 network. Modbus<sup>®</sup> RTU and A-B<sup>®</sup> DF1 protocols are supported.

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 optional communications-interface manual.

#### 4.3 MPS-OPI

##### 4.3.1 GENERAL

See Fig. 4.3. The Operator Interface (OPI) is used to perform motor-control functions, display meter readings, and program the MPS-CTU. Set points are not resident in the OPI. Control voltage for the MPS-OPI (24 Vdc) is supplied by the CTU and communications with the CTU is through an RS-485 link. This allows the MPS-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 MPS-CTU FOR OPI OPERATION

OPI Menu: *Setup | Hardware | OPI Display*

Select the number of OPI's in the *Number of OPI's* menu. The MPS-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 STARTER CONTROL

OPI Menu: *Setup | Starter | Starter Type*

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

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

The OPI has a CONTROL SELECT key and three yellow LED's (labeled REMOTE, OPI, and LOCAL) to select and indicate the start sources that the MPS will respond to. Each of the start sources can be enabled or disabled in the *OPI Ctrl Select* menu, and the CONTROL SELECT key allows the operator to choose from among the enabled start sources. The factory default has all sources enabled and REMOTE selected. Regardless of the control setting, all stop sources are always enabled.

#### 4.3.3.1 OPI CONTROL

If only the OPI LED is on, the MPS is under OPI control and start keys on the OPI are the only start source the MPS will respond to. If the OPI has been enabled as a start source for remote control, the OPI LED will also be on when remote control is selected. In this case, the MPS will also respond to the other sources enabled in remote control (*Remote Group*).

#### 4.3.3.2 LOCAL CONTROL

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

When the LOCAL LED is on, the MPS is under local control and digital inputs programmed as *Local Start 1* or

*Local Start 2* are the only start sources the MPS will respond to.

**NOTE:** The *I<sup>2</sup>t Start Inhibit* function and digital inputs programmed as *Interlock* are bypassed in local control.

Local control can also be selected with a network command or by a digital input programmed for *Local Select*—both have priority over the CONTROL SELECT key. If either or both methods force the MPS into local control and then release local control, the MPS will return to the previous control setting. Each local-control source must release local control to allow the MPS to return to the previous control setting.

#### 4.3.3.3 REMOTE CONTROL

OPI Menu: *Setup | Starter | Remote Group*

When the REMOTE LED is on, MPS start control is from the start sources enabled in the *Remote Group* menu. Start source selections are *Digital Inputs*, *OPI*, and *Network*. If *Digital Inputs* is enabled, digital inputs programmed for *Start1*, *Start2*, *2-Wire Start1*, and *2-Wire Start2* are enabled. If *OPI* is enabled, the start keys on the OPI are enabled and if *Network* is enabled, start commands from the network are enabled.

**NOTE:** The OPI STOP key and digital STOP inputs always cause a stop.

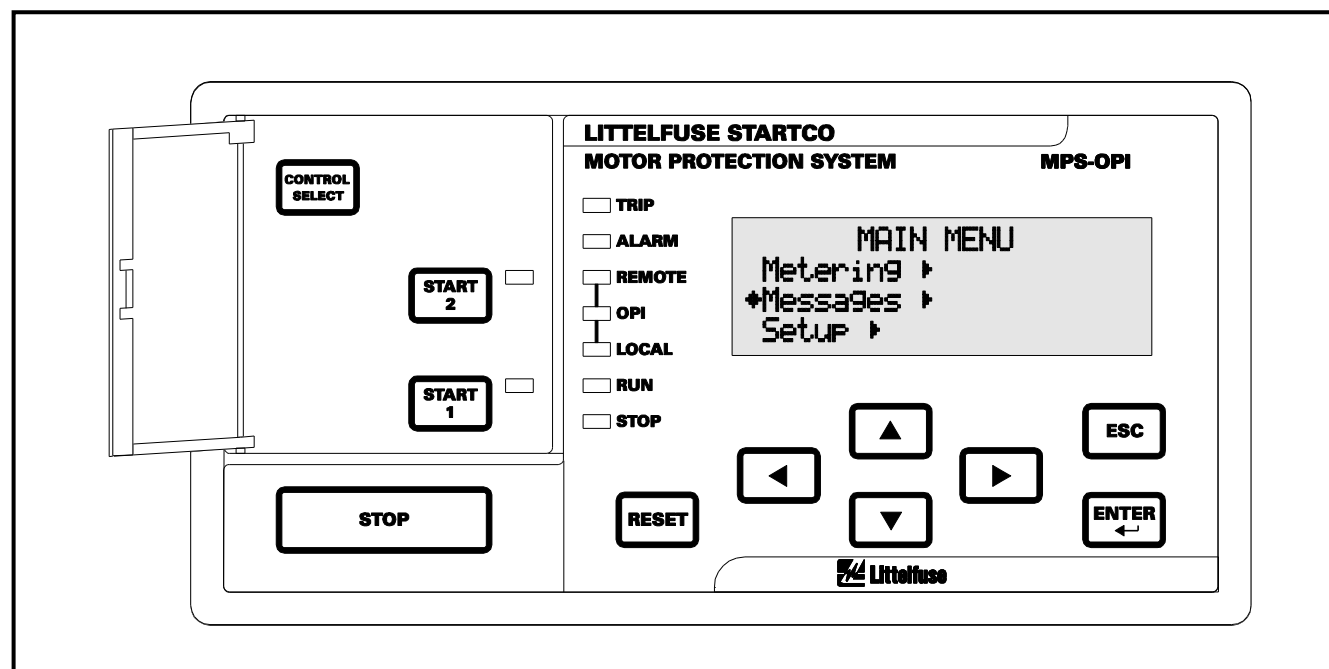


FIGURE 4.3 MPS-OPI Interface.

#### 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 the MPS-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. Press RESET again to reset a trip. 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.  $V_{ab}$ ,  $V_{bc}$ , and  $V_{ca}$  are in per unit of System Voltage.

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,<br>Importing Vars |
| +Watts, -Vars, +PF (Lead) | Importing Watts,<br>Exporting Vars |
| -Watts, -Vars, -PF (Lag)  | Exporting Watts,<br>Exporting Vars |
| -Watts, +Vars, +PF (Lead) | Exporting Watts,<br>Importing Vars |

The operating range for energy values is  $\pm 2E \pm 1024$ , however the maximum OPI display range is  $\pm 2E \pm 34$ .

The *Setup | Hardware | OPI Display | Meter Summary* 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: x.xx  
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 MPS 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 MPS 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 MPS-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, press ESC or the left-arrow key to 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.

TABLE 4.4 METERING DISPLAY

| METERING MENU    | INFORMATION DISPLAY <sup>(1)</sup>                                                                                                                                                                                                                                                     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Summary          | Displays values as per the <i>Meter Summary</i> menu.<br>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.<br>Trend $I^2t$ in percent.<br>Displays reset time when tripped on $I^2t$ .<br>Displays time to trip if in overload.<br>Displays time to $I^2t$ Inhibit removal.<br>Displays time to Starts-Per-Hour Inhibit removal.<br>Displays number of available starts.  |
| 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.                                                                                                                                                                                                                          |
| Unbalance (I)    | $I_1$ , $I_2$ , in per unit of FLA, $I_2/I_1$ in per unit.                                                                                                                                                                                                                             |
| Differential (A) | DIF <sub>a</sub> , DIF <sub>b</sub> , DIF <sub>c</sub> in A and per unit of $I_d$ .                                                                                                                                                                                                    |
| Power            | P in kW, Q in kVA, S in kVAR, PF.                                                                                                                                                                                                                                                      |
| Energy           | kWh, kVAh, kVARh.                                                                                                                                                                                                                                                                      |
| Frequency        | $V_{ab}$ voltage in per unit of $V_p$ and frequency in Hz.                                                                                                                                                                                                                             |
| RTD Temperatures | Summary shows maximum and minimum temperatures for stator, bearing, and load RTD's in degrees C.<br>Module and input numbers, 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     | Date and Time, Motor Mode (Stopped, Start, Run)<br>Displays starter state when starter is enabled.<br>Displays active FLA when in protection-only mode.<br>Displays RPM if tachometer input is enabled.<br>Displays Reduced Overcurrent mode (ROC: ON, ROC: OFF)<br>Displays ETR mode. |
| Comm State       | Displays DF1 state as online or timed out.<br>Displays Modbus state as online or timed out.<br>Displays Anybus module error and status.<br>Displays DeviceNet errors and status.                                                                                                       |

<sup>(1)</sup> 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 start.                                                                                                     |
| INx Stop Open         | The stop switch assigned to digital input x is open, preventing a start.                                                                                                   |
| INx Limit1 Open       | The Limit1 switch assigned to digital input x is open, preventing a <i>Start1</i> .                                                                                        |
| INx Limit2 Open       | The Limit2 switch assigned to digital input x is open, preventing a <i>Start2</i> .                                                                                        |
| $I^2t$ Start Inhibit  | The <i>Used <math>I^2t</math></i> has exceeded the <i><math>I^2t</math> Inhibit level</i> . A start is prevented if <i><math>I^2t</math> Start Inhibit</i> is enabled.     |
| Sph Start Inhibit     | The number of starts per hour has been exceeded. A start is prevented if a starts-per hour trip or alarm is enabled.                                                       |
| $t^o$ Disabled by ETR | Indicates that the MPS is in ETR mode. Does not prevent a start.                                                                                                           |
| Backspin Timer On     | When a stop is issued and the backspin timer is enabled, a start is prevented until the backspin timer times out. This message is displayed when the backspin timer is on. |



#### 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 <sup>(1)</sup> 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  $3I_0$  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 <sup>(1)</sup>
- Used  $I^2t$  at time of trip or ETR
- PTC/RTD temperature data if applicable
- Differential module data if applicable

Start records <sup>(2)</sup> are triggered by motor current and include:

- Time Stamp YY/MM/DD HH:MM:SS
- Maximum values of  $I_a$ ,  $I_b$ ,  $I_c$ , and  $3I_0$  during the start
- Maximum value of  $I_2/I_1$  <sup>(4)</sup>,  $V_2/V_1$  during the start
- Minimum values of  $V_{ab}$ ,  $V_{bc}$ ,  $V_{ca}$  during the start
- Maximum differential currents during the start if applicable
- $I^2t$  used during the start <sup>(3)</sup>
- Start duration
- PTC/RTD temperature data if applicable

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

- <sup>(1)</sup> Recorded values for power quantities (P, Q, S, PF) are averages of measurements over the previous 16 cycles.
- <sup>(2)</sup> Values updated at 0.5-s intervals during a start. Record logged when the Run mode is entered.
- <sup>(3)</sup> Starting  $I^2t$  can be used to determine the  $I^2t$  Lockout Level. See Section 5.2.
- <sup>(4)</sup> Measurements enabled 0.5 s after start current is detected.

#### 4.3.5.4 STATISTICAL DATA

OPI Menu: *Messages | Statistics*

OPI Menu: *Setup | System Config | Maintenance*

The MPS records the following statistical data:

- Running hours.
- 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 I2t Reset* menu is used to reset the thermal memory. See Section 5.2.3.

#### 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:

```
LR CURRENT
= 6.75 x FLA
Locked! Press  $\leftarrow$  To
Enter Password.
```

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

```
PASSWORD ENTRY
Enter Password
And Press  $\leftarrow$ 
[****]
```

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.

```
LR CURRENT
= 6.75 x FLA
(1.00 ÷ 10.00 x FLA)
[00005.25]
```

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:

```

STARTER TYPE
Full U Non Reverse
* Adj. Speed Drive *
Soft Start
    
```

#### 4.4 MPS-RTD

OPI Menu: *Setup | Hardware | RTD Modules*

OPI Menu: *Setup | Protection | RTD Temperature*

The MPS-RTD module extends MPS 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. Functions are stator, bearing, load, and ambient.

Control voltage for the MPS-RTD (24 Vdc) is supplied by the MPS-CTU and communication is through an RS-485 link. This allows the MPS-RTD to be mounted up to 1.2 km (4,000') from the MPS-CTU.

To enable RTD protection, the total number of modules must be selected in the *Total Modules* menu and Temperature Trip Action or Alarm Action must be enabled. If RTD protection is disabled, metering information is still provided. Up to three modules can be used. In the *RTD Modules* menu, the action to be taken by the MPS-CTU in response to loss of communication is selected.

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 5.27.

#### 4.5 MPS-DIF

OPI Menu: *Setup | Hardware | DIF Module*

OPI Menu: *Setup | Protection | Differential*

The MPS-DIF Differential Module extends MPS protective functions to include phase-differential monitoring. It has three differential-CT inputs that can be used in a three-CT core-balance connection, a six-differential-CT connection, or a six-CT connection that includes phase-CT MPS inputs. The core-balance, three-CT connection is recommended.

Control voltage for the MPS-DIF (24 Vdc) is supplied by the MPS-CTU and communication is through an RS-485 link. This allows the MPS-DIF to be mounted up to 1.2 km (4,000') from the MPS-CTU, and the link can be shared by other MPS I/O modules.

Enable the module and loss-of-communications protection in the *Hardware | Dif Module* menu, and choose protection settings in the *Protection | Differential* menu. See Section 5.25.

#### 4.6 WAVEFORM CAPTURE

The MPS continuously samples seven channels of data consisting of the three-phase currents, three-phase voltages, and the earth leakage current. The sample rate is fixed at 16 samples/cycle and sample data (Trace Data) for each channel are stored in a 4800 sample memory. This provides a record depth of 300 cycles, or 5 seconds of pre-trip data at 60 Hz.

When a trip occurs, Trace Data capture is halted and a date and time stamp is added. Trace Data values are retrieved using SE-Comm-RIS which generates an industry-standard COMTRADE and CSV file. See Appendix E for data mapping definitions and conversion formulas.

The *Setup | System Config | Trace Auto-Start* menu is used to set the Trace Data start mode after a trip has occurred. When enabled, Trace Data capture automatically starts when reset is pressed. When disabled, Trace Data capture requires a manual re-start using the *Messages | Re-Start Trace*. This allows the MPS to be reset and the trip data to be analyzed at a later time. Trace Data start can also be activated using Command 13 via the communications interface.

Trace Data are stored in volatile memory and are lost if the MPS loses supply voltage. Regardless of the *Trace Auto-Start* setting, waveform capture starts automatically on power-up if there are no previous trips.

## 5. PROTECTIVE FUNCTIONS

### 5.1 GENERAL

The MPS 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.

Unless otherwise indicated, protective functions have a programmable definite-time characteristic. 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, MPS trips are latched. Trips are logged.

Trip-action selections are:

- Disable
- Trip1 <sup>(1)</sup>
- Trip2 <sup>(2)</sup>
- Trip3 <sup>(2)</sup>
- Trip1 and Trip2
- Trip1 and Trip3
- Trip1 and Trip2 and Trip3
- Trip2 and Trip3

<sup>(1)</sup> Initiates a starter stop. See Section 6.

<sup>(2)</sup> Does not initiate a starter stop. See Section 6.

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 4.2.7.

**NOTE:** When starter functions are used, only set points with a Trip Action that includes Trip1 will cause the starter to stop when a trip occurs.

When enabled, Jam, Power-Factor, Undercurrent, and Underpower protection are not active during a start and are active in the Run mode. The Run mode is initiated when motor current is between 1.5 x (CT-Primary Rating/FLA) and 125% FLA for the duration of the setting in the *Setup | System Ratings | Run Mode Delay* menu.

*Run Mode Delay* is adjustable from five to 120 seconds. Run-mode status is displayed in the *Metering | System State* menu. One of three states are indicated: Motor:Start, Motor:Run, or Motor:Off. The motor status line also indicates one of two states for the Reduced Overcurrent (ROC) feature: ROC:OFF or ROC:ON. See Section 5.5.

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

### 5.2 OVERLOAD

At a minimum, for customized thermal-overload protection, motor data, must be entered for Full-Load Current, Service Factor, Locked-Rotor Current, Cold Locked-Rotor Time, and Hot Locked-Rotor Time.

#### 5.2.1 THERMAL MODEL

OPI Menu: *Setup | Protection | Overload*

OPI Menu: *Setup | System Ratings*

A NEMA- or K-factor-based thermal-model algorithm can be selected.

The NEMA-based algorithm uses the square of the maximum RMS phase current as the thermal-model input:

$$I^2 = I_{max\ rms}^2 \quad I \text{ in per unit of FLA}$$

The K-factor-based algorithm uses a thermal-model input based on true positive- and negative-sequence component values:

$$I^2 = I_1^2 + kI_2^2 \quad I \text{ in per unit of FLA}$$

Where:

$I_1$  = positive sequence current

$I_2$  = negative sequence current

$k$  = factor relating the heat produced by  $I_2$  relative to  $I_1$

A conservative value for k is:

$$k = \frac{230}{I_L^2}$$

Where:

$$I_L = \frac{\text{locked rotor current}}{\text{full load current}}$$

The thermal time constant ( $\tau$ ) used by the thermal model to provide starting and running  $I^2t$  protection is:

$$\tau = \frac{T_C}{-\ln\left(1 - \frac{sf^2}{I_L^2}\right)}$$

Where :

$T_C$  = cold locked rotor time in seconds

$sf$  = service factor in per unit

When the motor is stopped, the thermal model uses a time constant that is user selectable as a multiple (*Cooling Factor*) of the thermal time constant ( $\tau$ ).

The cold-curve time-to-trip ( $t$ ) for current above  $FLA \times sf$  is:

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

The MPS 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 motor current. For currents greater than or equal to  $FLA \times sf$ , time-to-trip is displayed in *Metering | Thermal Capacity*. The thermal trend value (Trend  $I^2t$ ) is:

$$\text{Trend } I^2t = \left(\frac{I^2}{sf^2}\right) \times 100\%$$

For currents less than  $FLA \times sf$ , the thermal trend value is:

$$\text{Trend } I^2t = \left(\frac{I^2}{sf^2}\right) \times \left(\frac{T_C - T_H}{T_C}\right) \times 100\%$$

Where :

$T_H$  = hot locked rotor time in seconds

The curve shown in Fig. 5.1 is a Class-20 thermal-protection curve (20-s trip @ 600% FLA) with a service factor of 1.15. FLA multiplied by service factor is the current at which used thermal capacity begins to trend towards a trip. Time-to-trip approaches infinity when  $I = FLA \times sf$ . Service factor has little influence on time-to-trip when motor current is greater than 300% FLA.

MPS thermal-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. This is illustrated in Fig. 5.1 by the protection curves labelled 25% *Used  $I^2t$* , 50% *Used  $I^2t$* , and 75% *Used  $I^2t$* . Programming software SE-Comm-RIS has a plot function to display and export MPS protection curves.

An overload alarm occurs when *Used  $I^2t$*  reaches the  *$I^2t$  Alarm Level* set point.

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  *$I^2t$  Inhibit Level* set point. The time-to-reset in minutes is:

$$t = -\tau \times \text{Cooling Factor} \times \ln(I^2t \text{ Inhibit Level}) / 60$$

Time-to-reset is displayed in the *Metering | Thermal Capacity* menu. The thermal model has three reset modes; *Normal*, *Auto*, and *Multiple Motor Seq.* The thermal-overload reset mode is set using the *Setup | Protection | Overload |  $I^2t$  Reset Type* menu.

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

In the *Auto* mode, a thermal-overload trip is automatically reset when *Used  $I^2t$*  falls below the  *$I^2t$  Inhibit Level* setting.

**NOTE:** If the starter circuit is configured for 2-wire control, the motor can start without warning when *Auto* mode is selected. A warning label may be required.

In the *Multiple Motor Seq.* mode, *Used  $I^2t$*  decreases exponentially with a fixed two-second time constant when there is no motor current. This mode is used in applications where one overload relay is used to protect several motors operating in sequence with only one motor running at any one time. A two-second stop is required between starts so that *Used  $I^2t$*  decreases sufficiently to allow the next motor to start. It is assumed that each motor is allowed to cool between starts. Motor life may be decreased if this feature is used in single-motor applications. When an overload trip occurs, the trip is latched but can be reset two seconds after the trip.

When  *$I^2t$  Start Inhibit* is enabled, the  *$I^2t$  Inhibit Level* set point can be used to prevent a start with insufficient  $I^2t$  available. When *Used  $I^2t$*  is above the  *$I^2t$  Inhibit Level* set point and motor current is not detected, Alarm1 is issued, starter functions Start1 and Start2 are disabled, and the relay assigned to *Start Inhibit* is energized. The time until a start is permitted is displayed in *Metering | Thermal Capacity*, and  *$I^2t$  Inhibit Alarm* is displayed in the *Trip and Alarm* message window. When *Used  $I^2t$*  falls below the  *$I^2t$  Inhibit Level* set point, the relay assigned to *Start Inhibit* is de-energized, the inhibit alarm is cancelled, and starter functions Start1 and Start2 are enabled. Trips require a manual reset.  *$I^2t$  Start Inhibit* is removed when current is detected. This applies in both Starter and Protection-only modes. The Start-Inhibit relay is shared with the Starts-Per-Hour function. See Section 5.23.

If the motor is equipped with RTD sensors, the thermal model can compensate for high ambient temperature and loss of ventilation. See Section 5.27.

$I^2t$  used during each start is recorded in *Messages | Event Records*. This information can be used to determine the  *$I^2t$  Inhibit Level* set point to ensure sufficient  $I^2t$  is available to complete a start, and to minimize thermal-overload-reset time.

|                             |                                              |
|-----------------------------|----------------------------------------------|
| FLA Rating .....            | 1.00 to 5,000.00 A                           |
| Service Factor .....        | 1.00 to 1.25                                 |
| Locked-Rotor Current.....   | 1.50 to 10.00 x FLA                          |
| Hot Locked-Rotor Time ..... | 0.10 to 100.00 s                             |
| Cold Locked-Rotor Time..... | 0.10 to 100.00 s                             |
| Cooling Factor .....        | 0.10 to 10.00                                |
| Model Type: .....           | NEMA, K-Factor                               |
| $I^2t$ Reset Type.....      | Normal, Auto,<br>Multiple Motor Sequence     |
| K-Factor .....              | 1.00 to 10.00                                |
| $I^2t$ Alarm .....          | 0.50 to 1.00 pu                              |
|                             | $I^2t$ Inhibit Level      0.10<br>to 0.90 pu |

$I^2t$  Start Inhibit .....Enable/Disable  
Protection.....Enable/Disable Trip1, 2, 3  
Enable/Disable Alarm1, 2, 3

Measurement Method .....DFT or RMS

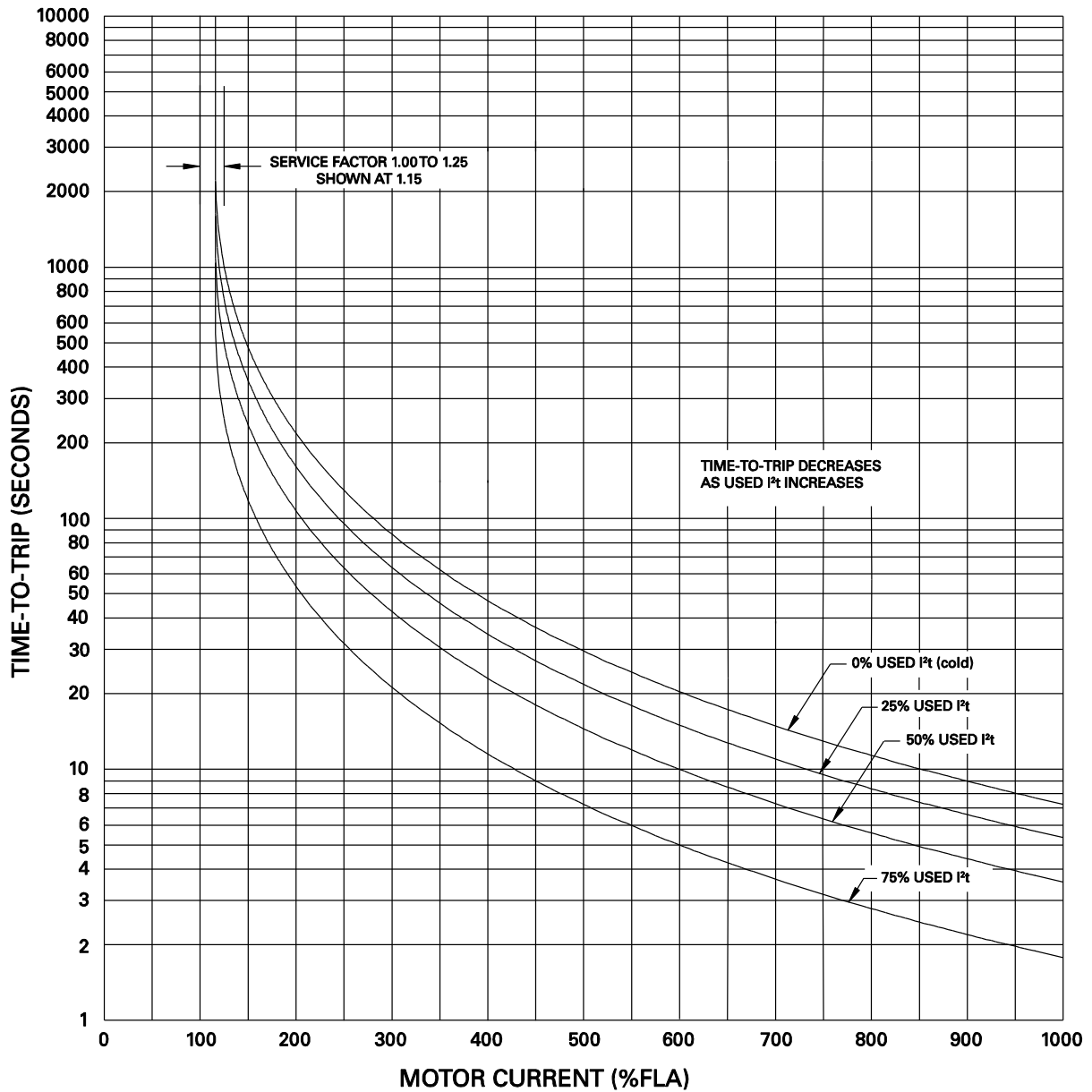


FIGURE 5.1 Class-20 Overload Curve.

### 5.2.2 LOCKED-ROTOR TIMES

In all cases, values for  $T_H$  and  $T_C$  should be obtained from the motor manufacturer. The following information is provided to assist in selecting values for  $T_H$  and  $T_C$  only if manufacturer data is not available.

Heater-style overload elements are available as Class 10, Class 20, or Class 30. Class 20 is recommended for general applications, Class 10 is used for motors with short locked-rotor time capability, and Class 30 is used in high-inertia applications to allow additional accelerating time where motors are within Class-30 performance requirements. These overloads can be replicated by setting  $T_C = 10, 20, \text{ or } 30 \text{ s}$ ;  $T_H = 0.1 \text{ s}$ ; and Locked-Rotor Current =  $6.00 \times \text{FLA}$ .

An induction motor built to the NEMA MG 1 standard is capable of:

- two starts in succession (coasting to rest between starts) with the motor initially at ambient temperature (cold start)
- one start with the motor initially at a temperature not exceeding its rated-load operating temperature (hot start).

Since the connected load has a direct influence on motor heating during a start, NEMA MG 1 defines the load torque and the load inertia ( $Wk^2$ ) for these starts as a function of the motor's rated power and synchronous speed. To satisfy the cold-start requirement, a start must not use more than 50% thermal capacity. To satisfy the hot-start requirement, used thermal capacity at steady state must be less than 50%.

If the thermal model in the MPS has the correct value of  $T_C$  and if  $Used I^2t$  increases by 50% during a start, the load is equal to the NEMA-defined load and two starts from cold will be permitted. If  $Used I^2t$  increases by more than 50% during a start, the load is greater than the NEMA-defined load and two starts from cold should not be permitted — a delay is required between starts. The appropriate delay can be obtained by enabling  $I^2t \text{ Start Inhibit}$  and setting the  $I^2t \text{ Inhibit Level}$  equal to 100% minus the  $I^2t$  used during a start (a slightly lower level is recommended to allow for supply and load variations). If  $Used I^2t$  increases by less than 50% during a start, the load is less than the NEMA-defined load and two starts from cold will be permitted.

The magnitude of  $T_H$  relative to  $T_C$  determines if a hot start will be permitted if  $I^2t \text{ Start Inhibit}$  is enabled and the  $I^2t \text{ Inhibit Level}$  is set as described above. If  $Used I^2t$  increases by 50% or less during a start, a hot start will be permitted if  $T_H$  is equal to or greater than 50% of  $T_C$ . Increasing  $T_H$  above 50% of  $T_C$  is not recommended unless specific information is available with respect to  $T_H$ .

### 5.2.3 EMERGENCY THERMAL RESET

OPI Menu: *Messages | Emerg I<sup>2</sup>t Reset | Reset I<sup>2</sup>t Memory*

Emergency Thermal Reset (ETR) sets  $Used I^2t$  to 0%, resets starts-per-hour variables, and disables PTC and RTD temperature trips. Program access (password) is required. Disabled-temperature protection is indicated by  $t^\circ \text{ Disabled by ETR}$  in the *Status Messages* display. If PTC or RTD temperature protection is not enabled,  $t^\circ \text{ Disabled by ETR}$  will not be displayed. Stator 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<sup>2</sup>t Reset | Reenable Temp* menu, or by cycling supply voltage.

Temperature alarms and sensor verification remain enabled during ETR.

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

### 5.3 OVERCURRENT

OPI Menu: *Setup | Protection | Overcurrent*

Overcurrent protection is based on the largest fundamental-frequency component (DFT) of the three phase currents. An alarm-level setting is not provided.

When enabled, overcurrent protection is active at all times. It is not bypassed during a start.

Trip Level ..... 1.00 to 15.00 x CT-Primary Rating ( $I_p$ )  
 Trip Delay (TD) ..... 0.00 to 10.00 s  
 (See Tables 5.1 and 5.2)  
 Protection ..... Enable/Disable Trip1, 2, 3  
 Measurement Method ..... DFT

TABLE 5.1 TRIP TIME

| FAULT LEVEL<br>(multiples of trip-level setting) <sup>(1)</sup> | TRIP RELAYS<br>(ms)<br>(± 10 ms) | STARTER<br>RELAYS (ms)<br>(± 15 ms) |
|-----------------------------------------------------------------|----------------------------------|-------------------------------------|
| 2                                                               | TD + 35                          | TD + 45                             |
| 5                                                               | TD + 30                          | TD + 40                             |
| 10                                                              | TD + 27                          | TD + 37                             |
| 18                                                              | TD + 26                          | TD + 36                             |

<sup>(1)</sup> For overcurrent faults less than  $18 \times I_p$ .  
 For earth faults less than  $1 \times I_e$ .

TABLE 5.2 FAULT DURATION REQUIRED FOR TRIP

| FAULT LEVEL<br>(multiples of trip-level setting) <sup>(1)</sup> | FAULT DURATION<br>(ms) |            |
|-----------------------------------------------------------------|------------------------|------------|
|                                                                 | TD ≤ 20 ms             | TD > 20 ms |
| 2                                                               | 10                     | TD – 10    |
| 5                                                               | 5                      | TD – 15    |
| 10                                                              | 2                      | TD – 18    |
| 18                                                              | 1                      | TD – 19    |

<sup>(1)</sup> For overcurrent faults less than  $18 \times I_p$ .  
 For earth faults less than  $1 \times I_e$ .

The asymmetrical-current multipliers for RMS and DFT measuring methods are shown in Fig. 5.2. X/R is the ratio of system reactance to system resistance. 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. As shown by the graph, the DFT filters the dc component so that the overcurrent setting can be set closer to the symmetrical fault value.

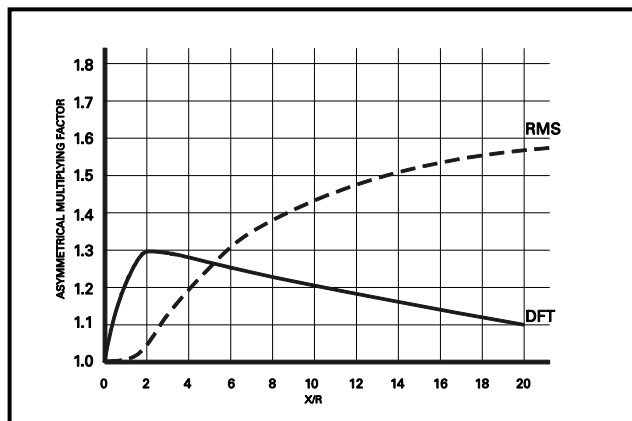


FIGURE 5.2 Asymmetrical-Current Multipliers.

#### 5.4 AUXILIARY OVERCURRENT

OPI Menu: *Setup | Protection | Aux Overcurrent*

Auxiliary overcurrent is the same as overcurrent protection. This function is intended to be used when backup protection for the overcurrent function is required.

Trip Level .....1.00 to 15.00 x CT-Primary Rating ( $I_p$ )  
Trip Delay .....0.00 to 10.00 s  
(See Tables 5.1 and 5.2)  
Protection.....Enable/Disable Trip1, 2, 3  
Measurement Method .....DFT

#### 5.5 REDUCED OVERCURRENT

OPI Menu: *Setup | Protection | Reduced OC*

Reduced overcurrent is used to reduce the overcurrent set point when performing maintenance while a motor is running. This mode of operation can be used to meet *NEC 240.87 Arc Energy Reduction (B) (3) Energy-reducing maintenance switching with local status indicator*.

Reduced overcurrent is controlled by a digital input assigned to *Reduced OC*. When the digital input is not applied, this set point is operational and when the digital input is applied, this set point is not operational. When reduced overcurrent is selected, ROC:ON is displayed in the *Metering | System State* menu and a relay assigned to *Reduced OC* will be energized.

The Protection selection must include Trip1, Trip2, or Trip3. If *Disable* is selected, *Reduced OC* mode is disabled.

Trip Level .....1.00 to 15.00 x CT-Primary Rating ( $I_p$ )  
Trip Delay .....Fixed at 0.00 (Instantaneous)  
See Tables 5.1 and 5.2  
Protection.....Enable/Disable Trip1, 2, 3  
Measurement Method .....DFT

#### 5.6 JAM

OPI Menu: *Setup | Protection | Jam*

A trip or alarm occurs if a jam condition is detected. Jam protection is active when the motor is in the Run mode, allowing protection to be set below motor-starting current.

Trip Level .....1.00 to 10.00 x FLA  
Trip Delay .....1.00 to 100.00 s  
Alarm Level .....1.00 to 10.00 x FLA  
Alarm Delay .....1.00 to 100.00 s  
Protection.....Enable/Disable Trip1, 2, 3  
Enable/Disable Alarm1, 2, 3  
Measurement Method .....DFT

#### 5.7 EARTH FAULT

OPI Menu: *Setup | Protection | Earth Fault*

Earth-fault protection is based on the fundamental-frequency component of zero-sequence current.

Trip Level .....0.05 to 1.00 x EF-CT-Primary Rating ( $I_e$ )  
Trip Delay .....0.00 to 100.00 s  
(See Tables 5.1 and 5.2)  
Alarm Level .....0.05 to 1.00 x  $I_e$   
Alarm Delay .....0.00 to 100.00 s  
Protection .....Enable/Disable Trip1, 2, 3  
Enable/Disable Alarm1, 2, 3  
Measurement Method .....DFT

#### 5.8 CURRENT UNBALANCE

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

OPI Menu: *Setup | System Config |  $I_p$  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. Negative unbalance will be indicated if current inputs are connected B-A-C. Severe unbalance may be indicated if phase-CT polarity is incorrect.

Lightly loaded systems, especially with synchronous motors, may cause false current unbalance trips. The  $I_p$  Threshold sets the current level where unbalance protection becomes active. The  $I_p$  Threshold is based on the maximum of the three-phase currents.

For example, if the CT-primary rating ( $I_p$ ) is 100 A, and  $I_p$  Threshold is set to 0.25, current unbalance protection will be active above 25 A.

|                                |                                                           |
|--------------------------------|-----------------------------------------------------------|
| 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<br>Enable/Disable Alarm1, 2, 3 |
| I <sub>p</sub> Threshold ..... | 0.10 to 0.50 x CT-primary<br>rating (I <sub>p</sub> )     |
| Measurement Method .....       | DFT                                                       |

## 5.9 PHASE LOSS—CURRENT

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

Phase loss is a severe form of unbalance. When phase loss occurs, negative-sequence current (I<sub>2</sub>) is equal to positive-sequence current (I<sub>1</sub>) and current unbalance is 100% or 1.00 pu. The phase-loss algorithm considers I<sub>2</sub>/I<sub>1</sub> from 0.90 to 1.00 to be a phase loss. This occurs when one phase is open resulting in two current vectors at 180°. Set the phase-loss-trip delay lower than the unbalance trip delay to avoid an unbalance trip in the event of a phase loss.

**NOTE:** An open CT will result in I<sub>2</sub>/I<sub>1</sub>=0.5 because the phase angle between the other two phases remain at 120°. This is not considered a phase loss.

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

## 5.10 PHASE REVERSE—CURRENT

OPI 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.

|                                           |                                                           |
|-------------------------------------------|-----------------------------------------------------------|
| Trip and Alarm Delay <sup>(1)</sup> ..... | 1.00 to 100.00 s                                          |
| Protection .....                          | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |
| Measurement Method .....                  | DFT                                                       |

<sup>(1)</sup> Single set point applies to Trip and Alarm.

## 5.11 UNDERCURRENT

OPI Menu: *Setup | Protection | Undercurrent*

Undercurrent protection is loss-of-load protection and is active when the motor is in the Run mode. A trip or alarm is initiated if current remains below the set point for the programmed delay.

|                          |                                                           |
|--------------------------|-----------------------------------------------------------|
| Trip Level .....         | 0.10 to 1.00 x FLA                                        |
| Trip Delay .....         | 1.00 to 100.00 s                                          |
| Alarm Level .....        | 0.10 to 1.00 x FLA                                        |
| Alarm Delay .....        | 1.00 to 100.00 s                                          |
| Protection .....         | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |
| Measurement Method ..... | DFT                                                       |

## 5.12 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<br>Voltage Rating (V <sub>p</sub> ) |
| Trip Delay .....         | 1.00 to 500.00 s                                          |
| Alarm Level .....        | 1.00 to 1.40 x V <sub>p</sub>                             |
| Alarm Delay .....        | 1.00 to 500.00 s                                          |
| Protection .....         | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |
| Measurement Method ..... | DFT                                                       |

## 5.13 VOLTAGE UNBALANCE

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

Positive-sequence voltage (V<sub>1</sub>) and negative-sequence voltage (V<sub>2</sub>) are used to determine voltage unbalance (V<sub>2</sub>/V<sub>1</sub>). 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<br>Enable/Disable Alarm1, 2, 3 |
| Measurement Method ..... | DFT                                                       |

## 5.14 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<sub>2</sub>) is equal to positive-sequence voltage (V<sub>1</sub>) and voltage unbalance is 100% or 1.00 pu. The phase-loss algorithm considers V<sub>2</sub>/V<sub>1</sub> 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                        |

## 5.15 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 <sup>(1)</sup> ..... | 1.00 to 100.00 s                                          |
| Protection .....                          | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |
| Measurement Method .....                  | DFT                                                       |

<sup>(1)</sup> Single set point applies to Trip and Alarm.



## 5.16 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<br>Enable/Disable Alarm1, 2, 3 |
| Measurement Method ..... | DFT                                                       |

## 5.17 UNDERPOWER

OPI Menu: *Setup | Protection | Underpower*

Apparent power (S) is defined by  $S = P + jQ$ . A trip or alarm is initiated when the real power (P) magnitude remains below the set point for the programmed delay. Protection is enabled when the motor is in the Run mode. See Section 7.2.

The Underpower setting is in per unit of rated power where 1.00 pu is defined as the *System Voltage x FLA Rating* x  $\sqrt{3}$ . The absolute value of power is used.

|                   |                                                           |
|-------------------|-----------------------------------------------------------|
| 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<br>Enable/Disable Alarm1, 2, 3 |

## 5.18 REVERSEPOWER

OPI Menu: *Setup | Protection | Reversepower*

Apparent power (S) is defined by  $S = P + jQ$ . 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 FLA Rating* x  $\sqrt{3}$ . 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<br>Enable/Disable Alarm1, 2, 3 |

## 5.19 POWER FACTOR—QUADRANT 4

OPI Menu: *Setup | Protection | PF Quadrant4*

OPI Menu: *Setup | System Config |  $I_p$  Threshold*

A trip or alarm occurs if the absolute value of power factor in quadrant 4 is less than the set point. In quadrant 4, both Watts and Vars are positive (Importing).

Power-factor protection is active when the motor is in the Run mode. Run mode is defined in Section 5.1.

The  $I_p$  Threshold sets the point where power-factor protection becomes active.

|                       |                                                           |
|-----------------------|-----------------------------------------------------------|
| Trip Level .....      | 0.50 to 1.00                                              |
| Trip Delay .....      | 0.20 to 500.00 s                                          |
| Alarm Level .....     | 0.50 to 1.00                                              |
| Alarm Delay .....     | 0.20 to 500.00 s                                          |
| $I_p$ Threshold ..... | 0.10 to 0.50 x CT-primary rating ( $I_p$ )                |
| Protection .....      | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |

## 5.20 POWER FACTOR—QUADRANT 3

OPI Menu: *Setup | Protection | PF Quadrant3*

OPI Menu: *Setup | System Config |  $I_p$  Threshold*

A trip or alarm occurs if the absolute value of power factor in quadrant 3 is less than the set point. In quadrant 3, Watts are negative (Exporting) and Vars are positive (Importing).

Power-factor protection is active when the motor is in the Run mode. Run mode is defined in Section 5.1.

The  $I_p$  Threshold sets the point where power-factor protection becomes active.

|                       |                                                           |
|-----------------------|-----------------------------------------------------------|
| Trip Level .....      | 0.50 to 1.00                                              |
| Trip Delay .....      | 0.20 to 500.00 s                                          |
| Alarm Level .....     | 0.50 to 1.00                                              |
| Alarm Delay .....     | 0.20 to 500.00 s                                          |
| $I_p$ Threshold ..... | 0.10 to 0.50 x CT-primary rating ( $I_p$ )                |
| Protection .....      | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |

## 5.21 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 .....  | 0.50 to 500.00 s                                          |
| Alarm Level ..... | 30.00 to 80.00 Hz                                         |
| Alarm Delay ..... | 0.5 to 500.00 s                                           |
| Protection .....  | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |

## 5.22 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 input ( $V_p$ ).

Trip Level .....30.00 to 80.00 Hz  
Trip Delay .....0.50 to 500.00 s  
Alarm Level .....30.00 to 80.00 Hz  
Alarm Delay .....0.50 to 500.00 s  
Protection.....Enable/Disable Trip1, 2, 3  
Enable/Disable Alarm1, 2, 3

## 5.23 STARTS PER HOUR / TIME BETWEEN STARTS

OPI Menu: *Setup | Protection | Starts Per Hour*

Starts-Per-Hour and Time-Between-Starts are useful limits in a protective relay that incorrectly responds to current below FLA. If the relay's thermal model accurately tracks a motor's used thermal capacity under all conditions, Starts-Per-Hour and Time-Between-Starts are features that provide no additional protection. The MPS does not require these features to provide protection, but they are included to satisfy protection strategies designed for protective relays without dynamic thermal modeling.

The Starts-Per-Hour feature ensures that the programmed number of starts per hour is not exceeded and the Time-Between-Starts feature ensures that the programmed time has elapsed between starts. The available number of starts and time between starts is also a function of the thermal model's *Used I<sup>2</sup>t* value. Consequently, the allowed number of starts may be less than the starts-per-hour value and the time between starts may be longer than the set-point value.

The number of starts and time between starts is checked when the motor is stopped. A *Starts/Hour Trip* or *Starts/Hour Alarm* is issued if a start will exceed the # *Starts Per Hour* setting or if the time since the previous start is less than the *Time Between* setting.

When a *Starts/Hour Trip* or *Starts/Hour Alarm* is issued, the output relay assigned to *Start Inhibit* is energized. The *Start Inhibit* relay is non-latching and can be used as a start permissive. A *Starts/Hour Trip* will remain latched until a reset is issued. The *Start Inhibit* relay is shared with the thermal model's *I<sup>2</sup>t Inhibit* feature.

If motor current is detected regardless of the alarm or trip condition, the *Starts/Hour Alarm* is removed, and *Starts/Hour Trip* can be reset. The starts-per-hour algorithm remains active but any trips or alarms are suppressed until the motor is stopped.

The status of Starts-Per-Hour and Time-Between-Starts is displayed in the *Metering | Thermal Capacity* menu. If there are no trips or alarms, the number of available starts (*Sph Available*) is displayed and if a trip or alarm is present, the inhibit time (*Sph Inhibit*) is displayed. Since

the *Metering | Thermal Capacity* menu is also used to display the thermal model status, messages are prioritized as follows:

- I<sup>2</sup>t Reset Time<sup>(1)</sup>
- I<sup>2</sup>t Trip Time<sup>(1)</sup>
- I<sup>2</sup>t Inhibit Time<sup>(1)</sup>
- Starts Per Hour Inhibit Time<sup>(3)</sup>
- Starts Available<sup>(2) (3)</sup>

An Emergency Thermal Reset (ETR) can be used to initialize all thermal and starts-per-hour variables and to reset a starts-per-hour trip. See Section 5.2.3.

Time Between Starts.....0.00 to 500.00 Minutes  
Starts Per Hour<sup>(2)</sup>.....1 to 10  
Protection.....Enable/Disable Trip 1, 2, 3  
Enable/Disable Alarm 1, 2, 3

- <sup>(1)</sup> Calculated from thermal model data.
- <sup>(2)</sup> The display range for the number of available starts is -9 to +10.
- <sup>(3)</sup> Initialized when supply voltage is cycled.

## 5.24 FAILURE TO ACCELERATE AND UNDERSPEED

OPI Menu: *Setup | Protection | Underspeed*

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

OPI Menu: *Setup | Digital Inputs | Tachometer*

Failure-to-accelerate and underspeed protection are available if the MPS has a tachometer signal. The tachometer signal can originate from the High Speed Input (HSI) or the analog input. If the analog input is set to *Motor Speed*, it is used as the input to the algorithm, otherwise the digital tachometer (HSI) is used. The failure-to-accelerate algorithm is activated whenever a start is detected. Start detection is based on motor current. Set points 1 to 3 (for both speed and time) are sequentially checked to confirm acceleration.

Motor at Full Speed (refer to Type T28, Bit 2 in Appendix F) will be set when the measured tachometer speed exceeds the Speed 3 threshold setting and the Underspeed protection feature is enabled. If the Speed 3 threshold is not reached within Time 3, the MPS will trip on failure-to-accelerate.

While running, the tachometer signal is continuously measured and a trip occurs if the speed falls below the Speed 3 setting.

Time 1 must be set less than or equal to Time 2 and Time 2 must be set less than or equal to Time 3.

To enable display of the speed in the *Metering | System State* menu, select Enable in the *Setup | Digital Input | Tachometer | Enable/Disable* menu, when the HSI input is used.

Speed 1 .....1.00 to 100% Sync Speed  
Time 1 .....1.00 to 1000.00 s  
Speed 2 .....1.00 to 100% Sync Speed  
Time 2 .....1.00 to 1000.00 s  
Speed 3 .....1.00 to 100% Sync Speed  
Time 3 .....1.00 to 1000.00 s  
Protection.....Enable/Disable Trip1, 2, 3

## 5.25 DIFFERENTIAL CURRENT PROTECTION

OPI Menu: *Setup | Protection | Differential*  
OPI Menu: *Setup | Hardware | DIF Module*  
OPI Menu: *Setup | System Ratings | DF-CT Primary*

The MPS-DIF provides three-phase differential protection. It is intended to be used specifically for motor protection and not intended for feeder or transformer differential protection.

Enable the module and communications-loss protection using the *Setup | Hardware | DIF Module* menu. The module uses I/O module communications and both trip and alarm actions are available in the event of communications loss.

Set *DF-CT Primary* equal to the differential-CT-primary rating. For the MPS summation connection, *PH-CT Primary* and *DF-CT Primary* must be equal.

Trip and alarm settings are based on multiples of the *DF-CT Primary* rating ( $I_d$ ).

|                          |                                                       |
|--------------------------|-------------------------------------------------------|
| Trip Level .....         | 0.10 to 15.00 x $I_d$                                 |
| Trip Delay .....         | 0.00 to 10.00 s                                       |
| Alarm Level .....        | 0.10 to 15.00 x $I_d$                                 |
| Alarm Delay .....        | 0.00 to 10.00 s                                       |
| Protection .....         | Enable/Disable Trip1,2,3<br>Enable/Disable Alarm1,2,3 |
| Measurement Method ..... | DFT c/w CT saturation<br>compensation.                |

## 5.26 PTC TEMPERATURE

OPI Menu: *Setup | Protection | PTC Temperature*

A positive-temperature-coefficient (PTC) thermistor input is provided on the MPS-CTU. The total resistance of series-connected PTC thermistors must be less than 1,500  $\Omega$  at 20°C (68°F). A trip or alarm will occur when series resistance exceeds 2,900  $\Omega$ .

**NOTE:** During Emergency Thermal Reset, a PTC trip is reset and PTC-temperature protection is disabled. See Section 5.2.3.

|                  |                                                           |
|------------------|-----------------------------------------------------------|
| Protection ..... | Enable/Disable Trip1, 2, 3<br>Enable/Disable Alarm1, 2, 3 |
|------------------|-----------------------------------------------------------|

## 5.27 RTD TEMPERATURE

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

Up to three RTD modules can be connected to the MPS-CTU. Select the number of modules in the *Setup | Hardware | RTD Modules* menu. Each module can monitor eight RTD's for a total of twenty-four RTD's. RTD type, function, and trip and alarm set points are programmable for each RTD.

When an RTD type is selected, trip and alarm functions are determined by Temperature Trip and Alarm settings.

During Emergency Thermal Reset, an RTD trip is reset and RTD-temperature protection is disabled. See Section 5.2.3.

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.

The MPS supports three MPS-RTD modules with each module supporting eight RTDs. Each RTD can be assigned to one of eight function groups; *Stator*, *Bearing*, *Load*, *Ambient*, *Stator Voting*, *Bearing Voting*, *Load Voting*, and *Ambient Voting*. The specific assignment is set using the *Setup | Protection | RTD Temperature | Module x | Function* menu. Regardless of the assigned function, individual RTD trip and alarm setpoints remain active.

When an RTD is assigned to a voting group, it participates in the voting logic. Within a voting group, two RTDs must indicate a temperature above their trip setpoint in order to cause a trip. The first two RTDs that indicate a high temperature will generate a trip. Subsequent trips resulting from other RTDs in the group are not locked out. Trips must be individually reset and all trips must be reset to allow a start.

Failed sensors do not participate in the RTD voting logic. For example if six sensors are set to Stator Voting and two sensors fail, only four participate in RTD voting. When RTD voting is used, it is assumed that continuity of service is of high importance. In this case it is recommended to set the sensor-failure action to alarm only or to set the trip action to a value different than the Temperature Trip Action.

If only one RTD is assigned to a group, or if only one RTD is active because of sensor failures, RTD protection is the same as the corresponding non-voting function. RTD voting is not available for alarm setpoints.

RTD voting is contained within the specific function group and within the RTD module. An RTD in one module does not participate in the voting logic of another module.

|                     |                                                                                                                                               |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Name .....          | 18 Character, Alphanumeric                                                                                                                    |
| Type .....          | Disable, Pt100, Ni100,<br>Ni120, Cu10                                                                                                         |
| Function .....      | Stator, Bearing, Load,<br>Ambient, Stator Voting,<br>Bearing Voting, Load<br>Voting, Ambient Voting                                           |
| Trip Range .....    | 40.00 to 200.00°C (104°F to<br>392°F)                                                                                                         |
| Alarm Range .....   | 40.00 to 200.00°C (104°F to<br>392°F)                                                                                                         |
| Display Range ..... | -40.00 to 200.00°C (-40°F to<br>392°F)                                                                                                        |
| Error Codes .....   | -100 = No Sensor<br>-90 = Open Sensor<br>-80 = Shorted Sensor<br>-70 = No Data/Module Error<br>(Codes accessed via network<br>communications) |

## 5.28 HOT-MOTOR COMPENSATION

OPI Menu: *Setup | Protection | RTD Temperature*

If hot-motor compensation (HMC) is enabled, the maximum stator-RTD temperature is used to bias the thermal model by increasing *Used I<sup>2</sup>t* when the RTD temperature is greater than the thermal-model temperature.

Two set points are used to define the compensation. See Fig. 5.3. *HMC Minimum Bias* is the stator temperature where compensation begins at 0% *I<sup>2</sup>t*. *HMC Maximum Bias* is the stator temperature where compensation ends at 100% *I<sup>2</sup>t*.

Although the bias calculation is based on 0% and 100% *I<sup>2</sup>t* values, the *Used I<sup>2</sup>t* adjustment is limited to 90% *I<sup>2</sup>t*. An actual overload condition is required to cause a trip at 100% *I<sup>2</sup>t*.

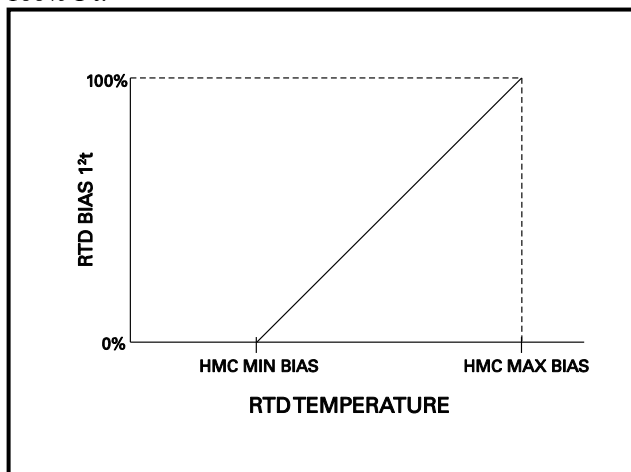


FIGURE 5.3 Used *I<sup>2</sup>t* Bias Curve.

HMC Minimum Bias .....40.00 to 200.00°C (104°F to 392°F)

HMC Maximum Bias .....40.00 to 200.00°C (104°F to 392°F)

Protection .....Enable/Disable

**NOTE:** Hot-motor compensation will not be active unless the *HMC High* set point is at least 10°C above the *HMC Low* set point.

## 5.29 ANALOG INPUT

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

The analog input function is selectable as *Metering Only*, *Protection*, *Sync to ASD*, or *Motor Speed*.

### 5.29.1 PROTECTION

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

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.

Trip action is fixed at *Trip1* and alarm action is fixed at *Alarm1*.

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

### 5.29.2 SYNCHRONIZE TO ASD

OPI Menu: *Setup | 4-20 Analog In | Sync to ASD*

When *Sync to ASD* is selected, the MPS uses the 4-20-mA input to set the internal sampling rate for current and voltage inputs so that protection and metering functions use accurate RMS and DFT values from 10.00 to 70.00 Hz.

4-mA Frequency (lower) .....0.00 to 70.00 Hz  
20-mA Frequency (upper) ....0.00 to 70.00 Hz  
Frequency Range .....10.00 to 70.00 Hz

### 5.29.3 MOTOR SPEED

OPI Menu: *Setup | 4-20 Analog In | Motor Speed*

When the analog-input type is selected as *Motor Speed*, the 4-20-mA analog input is used as the speed input. This selection overrides the selections for the high-speed tachometer input and failure-to-accelerate protection uses the analog input as the source of speed information.

4-mA Speed .....0.00 to 100% Sync Speed  
20-mA Speed .....0.00 to 100% Sync Speed

### 5.29.4 METERING ONLY

When the analog-input type is selected as *Metering Only*, an analog input does not affect MPS operation, but its value can be observed in the Metering menu and with a communications network.

## 6. STARTER FUNCTIONS

OPI Menu: *Setup | Starter*

### 6.1 GENERAL

All common starter types are supported. From the OPI *Starter Type* menu, select one of seventeen starter types or select *Protection Only*. Starter types requiring two FLA settings are indicated by the “\*” symbol in the OPI display.

When *Protection Only* is selected, all starter functions except STOP are disabled and all OPI control-select LED’s will be off. Any STOP signal will initiate a *Trip1* when the MPS is in *Protection Only*.

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

When *Protection Only* is selected, the OPI STOP and RUN LED’s are controlled by motor current. When motor current is below the minimum Current Threshold defined in Section 3.2.1.2, the STOP LED is on and RUN LED is off. When motor current is above the minimum Current Threshold, the STOP LED is off and RUN LED is on. When a starter type is selected, the STOP and RUN LED’s are under starter control and not based on motor current.

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

Three control modes are available and selected using the OPI CONTROL SELECT key. In addition, a digital input can be used to select LOCAL. Each control mode has specific start sources that can be programmed as shown in Table 6.1. REMOTE control can be configured to operate with start sources from the digital input, OPI and the network. OPI Control uses the OPI start keys as the start sources. LOCAL control uses the Local Start1 or Local Start2 start sources or the OPI. In LOCAL mode, OPI control can be enabled or disabled. Control selection is indicated by the REMOTE, OPI, and LOCAL LED’s on the OPI.

The digital inputs allow concurrent operation of three start-control methods; 3-wire start/stop, 2-wire start/stop, and 3-wire local start/stop. Three-wire control requires two digital inputs, one programmed for *Start1* or *Start2* (N.O. momentary start switch) and one programmed for *Stop* (N.C. momentary stop switch) as shown in Fig. 6.1. Two-wire control uses one input, programmed as *2-Wire Start1* or *2-Wire Start2*, for start/stop control and can be used where a single contact provides start/stop operation. See Fig. 6.2. If a start was activated by a 2-wire start input, any other STOP will initiate a latching *Trip1*. In all other cases, STOP does not cause a trip.

Digital inputs programmed for *Limit1 Stop* and *Limit2 Stop* are used to provide stop control for *Start1* and *Start2*. This is typically used in reversing starter applications. The forward-direction limit switch is connected to the *Limit1 Stop* input and the reverse-direction limit switch is connected to the *Limit2 Stop* input.

With this control method, a *Start1* requires limit switch 1 to be closed and limit switch 2 is ignored. In a similar manner, *Start2* requires, limit switch 2 to be closed while limit switch 1 is ignored.

**NOTE:** When starter functions are used, protective functions with the trip action set to *Trip1* will cause the starter to stop when a trip occurs. Reset is required.

Table 6.1 indicates the available start sources.

TABLE 6.1 START-SOURCE SUMMARY <sup>(1)</sup>

| CONTROL <sup>(7)</sup><br>SELECTION | START SOURCE                     |                                                                                          |
|-------------------------------------|----------------------------------|------------------------------------------------------------------------------------------|
| REMOTE <sup>(2)</sup>               | DIGITAL<br>INPUTS <sup>(3)</sup> | Start1 Input (3-wire control)<br>Start2 Input (3-wire control)                           |
|                                     |                                  | 2-W Start1 (2-wire control) <sup>(4)</sup><br>2-W Start2 (2-wire control) <sup>(4)</sup> |
|                                     | OPI <sup>(3)</sup>               | START1 Key<br>START2 Key                                                                 |
| OPI                                 | NETWORK<br><sup>(3)</sup>        | Start1 Command<br>Start2 Command                                                         |
|                                     | OPI START1 Key<br>OPI START2 Key |                                                                                          |
| LOCAL<br><sup>(5) (6)</sup>         | DIGITAL<br>INPUTS                | Local Start1 (3-wire)<br>Local Start2 (3-wire)                                           |
|                                     | OPI <sup>(8)</sup>               | START1 Key<br>START2 Key                                                                 |

<sup>(1)</sup> All STOP sources are always enabled.

<sup>(2)</sup> Factory default has all sources enabled and REMOTE selected.

<sup>(3)</sup> Can be enabled or disabled using the *Setup | Starters | Remote Group* menu.

<sup>(4)</sup> STOP causes a latching trip.

<sup>(5)</sup> LOCAL can also be 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 MPS to return to the previous control setting.

<sup>(6)</sup> *Pt Start Inhibit*, *Starts per Hour* alarms and *Interlocks* are bypassed.

<sup>(7)</sup> At least one Control Selection must be enabled even when *Protection Only* is selected.

<sup>(8)</sup> Can be enabled or disabled using the *Setup | Starters | Local Group* menu.

Up to four timers (*Stage 1* to *3 Delay*, and *Start Time*) control the start sequence. These timers control *Starter RLYA*, *Starter RLYB*, *Starter RLYC*, and *Starter RLYD* as shown in the timing diagrams in Section 6.2. These functions can be assigned to any output relay. Digital

inputs can be programmed to monitor contactor status. Contactor status corresponding to *Starter RLYA*, *Starter RLYB*, *Starter RLYC*, and *Starter RLYD* outputs are designated as *RLYA Status*, *RLYB Status*, *RLYC Status*, and *RLYD Status*. The MPS will issue a *Trip1* and indicate *Relay Status Trip* if the status contact does not follow within 500 ms of the command to operate the respective relay output. In addition, a transition must not occur prior to its intended time.

When the starting sequence is complete, contactor status is checked every 500 ms and a *Relay Status Trip* will occur if the status changes.

**NOTE:** Relay Status is not checked when the starter is in the stopped state.

The *Start Time* set point is the maximum start time allowed. The starting process will terminate and generate a *Trip1* unless current is between  $1.5 \times (\text{CT-Primary Rating} / \text{FLA})$  and 125% FLA when the *Start Time* timer times out.

In reduced-voltage-starting applications, the MPS can use time-based or current-based transfer from the starting to the running connection. The transfer type is selected as *Time Transfer* or *Current Transfer* using the *Transfer Type* menu.

When *Current Transfer* is selected, the start-connection delay (*Stage 1 Delay* or *Stage 2 Delay*, see Table 6.2 and Figs 6.5, 6.6, 6.7, and 6.8) defines the minimum starting-connection time. The transfer to the run connection occurs when the start-connection delay has expired and current is below the *Transfer Current*. When current is above the *Transfer Current*, the transfer will be delayed up to the maximum time defined by the *Start Time*. If current is below  $1.5 \times (\text{CT-Primary Rating} / \text{FLA})$  when the start-connection delay expires or if the *Start Time* is exceeded, the MPS will issue a *Trip1* and indicate *Starter Trip*.

When *Time Transfer* is selected, the start-connection delay set point (*Stage 1 Delay* or *Stage 2 Delay*) is used to determine the transfer time. Transfer to the run connection occurs after the start-connection delay has expired.

In both current- and time-transfer modes, the MPS will issue a *Trip1* and indicate *Starter Trip* if load current is above 125% FLA or below  $1.5 \times (\text{CT-Primary Rating} / \text{FLA})$  when the *Start Time* expires. The *Start Time* set point must be long enough to allow the starting sequence to complete and for the motor current to drop below 125% FLA.

Table 6.2 summarizes starter types and shows which starter set points are active.

The backspin timer is available when a delay is required between starts. The backspin timer is enabled in the *BkSpin En/Disable* menu, and the delay time is set in the *Backspin Delay* menu. The backspin timer is

activated by a STOP or when supply voltage is cycled on the MPS. While the backspin timer is on, the *Backspin Timer On* message is displayed in the *Status Message* menu and starts are not allowed.

The connection diagrams, Figs. 6.9 to 6.23, show typical control circuits with 120-Vac contactor coils and the 24-Vdc source on the MPS-CTU used for status contacts. Other supply voltages can be used within the limits of the digital-input and relay-contact ratings. The use of status contacts is optional.

**NOTE:** Stop and start control, electrical interlocks, and mechanical interlocks are not shown in connection diagrams.

**NOTE:** Connection diagrams show typical output relay assignments that must be set using the *Setup | Relay Outputs | Relay x | Relay x Function* menu.

**NOTE:** To cancel a long backspin time, enter new backspin parameters and restart the MPS using the *Setup | System Config | Maintenance | Restart MPS-CTU* menu or cycle supply voltage.

TABLE 6.2 STARTER SUMMARY

| STARTER TYPE                                         | SEQ. NO. | TIMERS USED <sup>(1)</sup> | START-CONNECTION<br>TIMER<br>NUMBER <sup>(1)</sup> | ACTIVE FLA SETPOINTS <sup>(2)</sup> |       | RELAYS AND CONTACTOR STATUS <sup>(3)</sup> |      |      |      |
|------------------------------------------------------|----------|----------------------------|----------------------------------------------------|-------------------------------------|-------|--------------------------------------------|------|------|------|
|                                                      |          |                            |                                                    | FLA                                 | FLA 2 | RLYA                                       | RLYB | RLYC | RLYD |
| Full-Voltage Non-Reversing                           | 1        | 4                          |                                                    | x                                   |       | x                                          |      |      |      |
| Adjustable-Speed Drive                               | 1        | 4                          |                                                    | x                                   |       | x                                          |      |      |      |
| Soft-Start                                           | 1        | 4                          |                                                    | x                                   |       | x                                          |      |      |      |
| Full-Voltage Reversing                               | 2        | 4                          |                                                    | x                                   |       | x                                          | x    |      |      |
| Two-Speed Two-Winding                                | 2        | 4                          |                                                    | x                                   | x     | x                                          | x    |      |      |
| Reactor or Resistor Closed-Transition <sup>(4)</sup> | 3        | 1,4                        | 1                                                  | x                                   |       | x                                          | x    |      |      |
| Slip-Ring <sup>(4)</sup>                             | 3        | 1,4                        | 1                                                  | x                                   |       | x                                          | x    |      |      |
| Part-Winding <sup>(4)</sup>                          | 3        | 1,4                        | 1                                                  | x                                   | x     | x                                          | x    |      |      |
| Double-Delta <sup>(4)</sup>                          | 3        | 1,4                        | 1                                                  | x                                   | x     | x                                          | x    |      |      |
| Soft-Start-with-Bypass <sup>(4)</sup>                | 3        | 1,4                        | 1                                                  | x                                   |       | x                                          | x    |      |      |
| Reactor or Resistor Open-Transition <sup>(4)</sup>   | 4        | 1,4                        | 1                                                  | x                                   |       | x                                          | x    |      |      |
| Two-Winding <sup>(4)</sup>                           | 4        | 1,4                        | 1                                                  | x                                   | x     | x                                          | x    |      |      |
| Wye-Delta Open-Transition <sup>(4)</sup>             | 5        | 1,2,3,4                    | 2                                                  | x                                   | x     | x                                          | x    | x    |      |
| Autotransformer Closed-Transition <sup>(4)</sup>     | 5        | 1,2,3,4                    | 2                                                  | x                                   |       | x                                          | x    | x    |      |
| Wye-Delta Closed-Transition <sup>(4)</sup>           | 6        | 1,2,4                      | 2                                                  | x                                   | x     | x                                          | x    | x    | x    |

<sup>(1)</sup> TIMERS  
 1: Stage 1 Delay  
 2: Stage 2 Delay  
 3: Stage 3 Delay  
 4: Start Time

<sup>(2)</sup> FLA SETPOINTS  
 FLA: Full-Load Current  
 FLA2: Full-Load Current 2

<sup>(3)</sup> RELAYS AND CONTACTOR STATUS  
*Starter RLYA, Starter RLYB, Starter RLYC, and Starter RLYD* are not automatically assigned. The user must assign these functions to individual relays. Status is assignable to any digital input.

<sup>(4)</sup> Current transfer capability when enabled

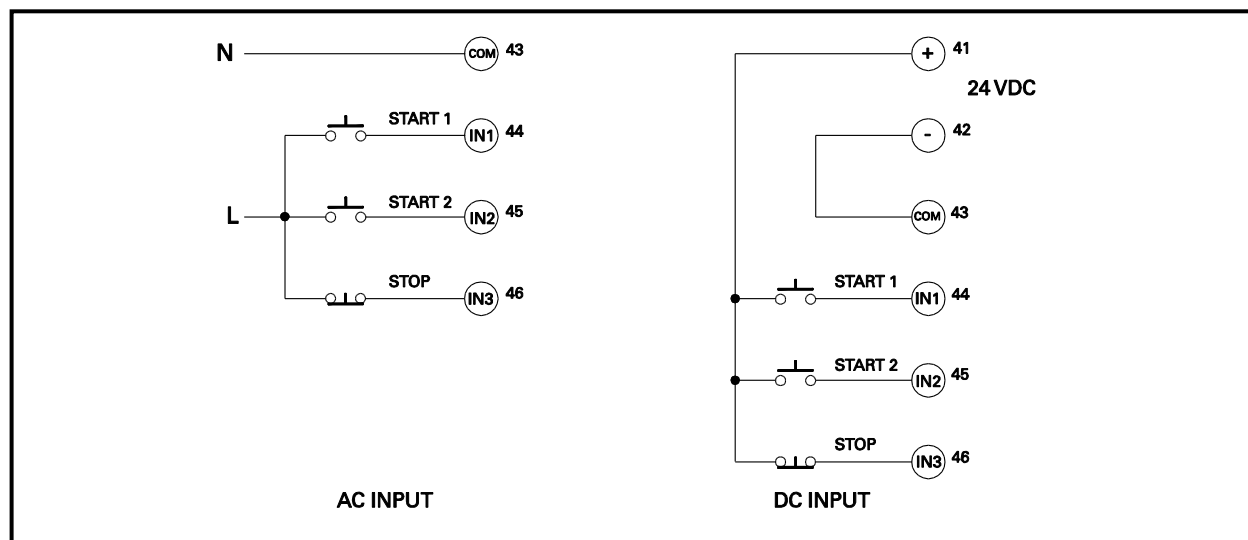


FIGURE 6.1 Typical 3-Wire Control.

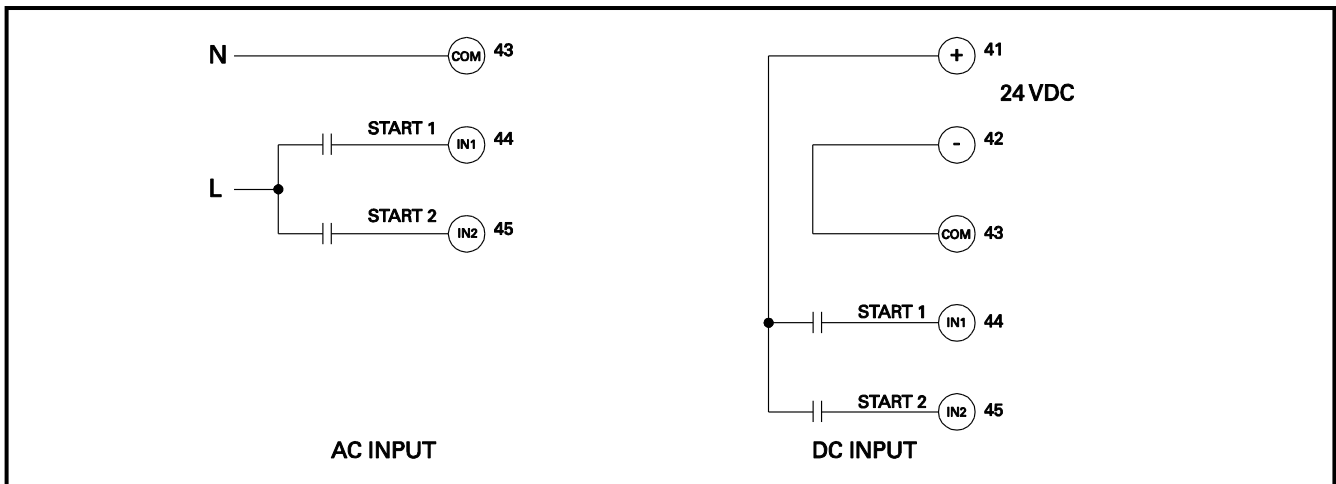


FIGURE 6.2 Typical 2-Wire Control.

## 6.2 STARTER TIMING SEQUENCES

The MPS uses one of six timing sequences to implement the various starter types. These time-based starter sequences are shown in Figs. 6.3 to 6.8.

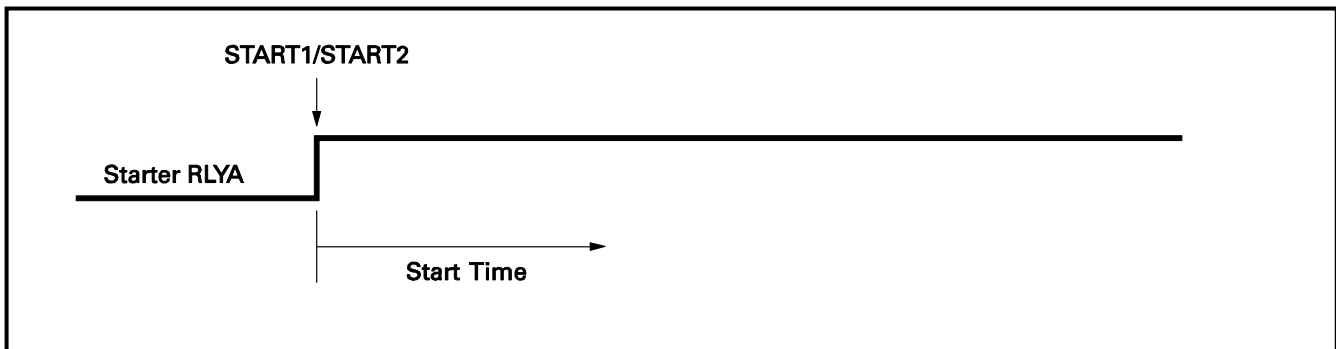


FIGURE 6.3 Starter Sequence 1.

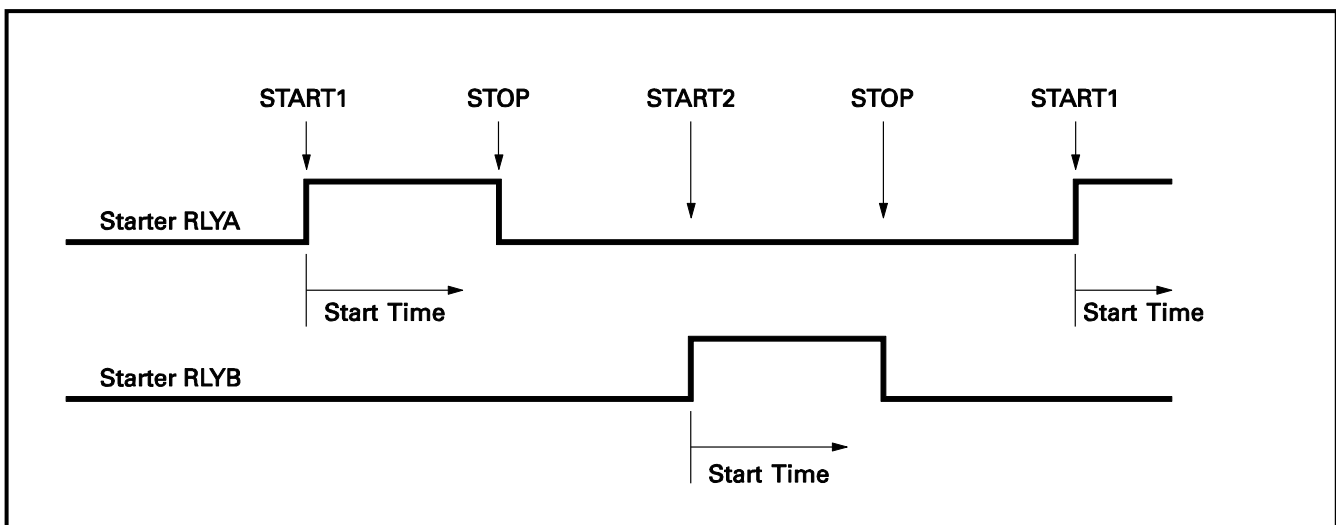


FIGURE 6.4 Starter Sequence 2.



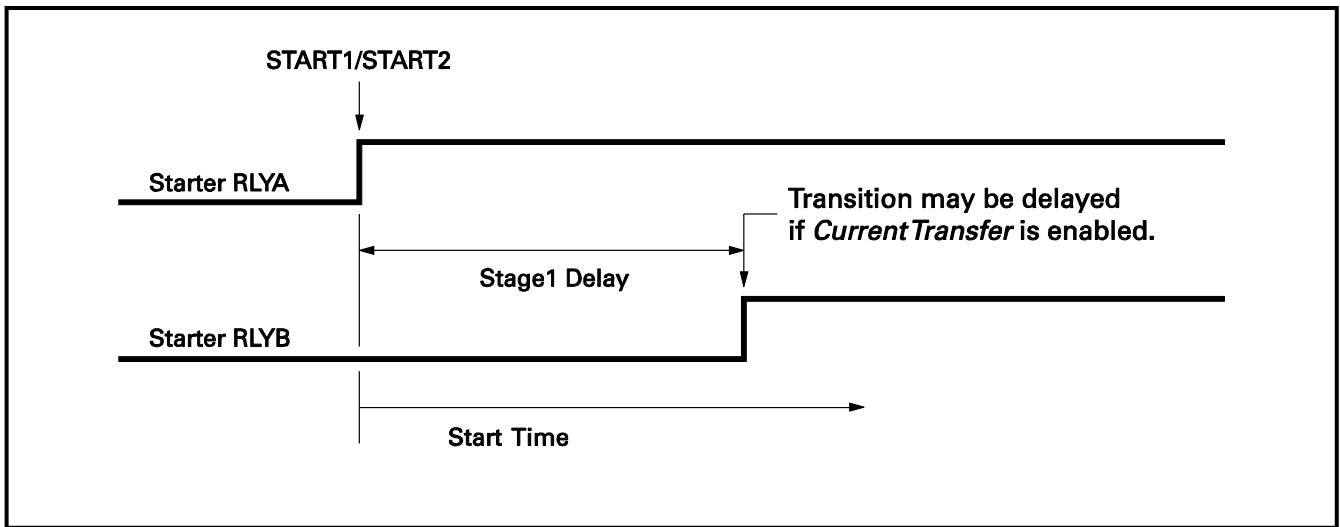


FIGURE 6.5 Starter Sequence 3.

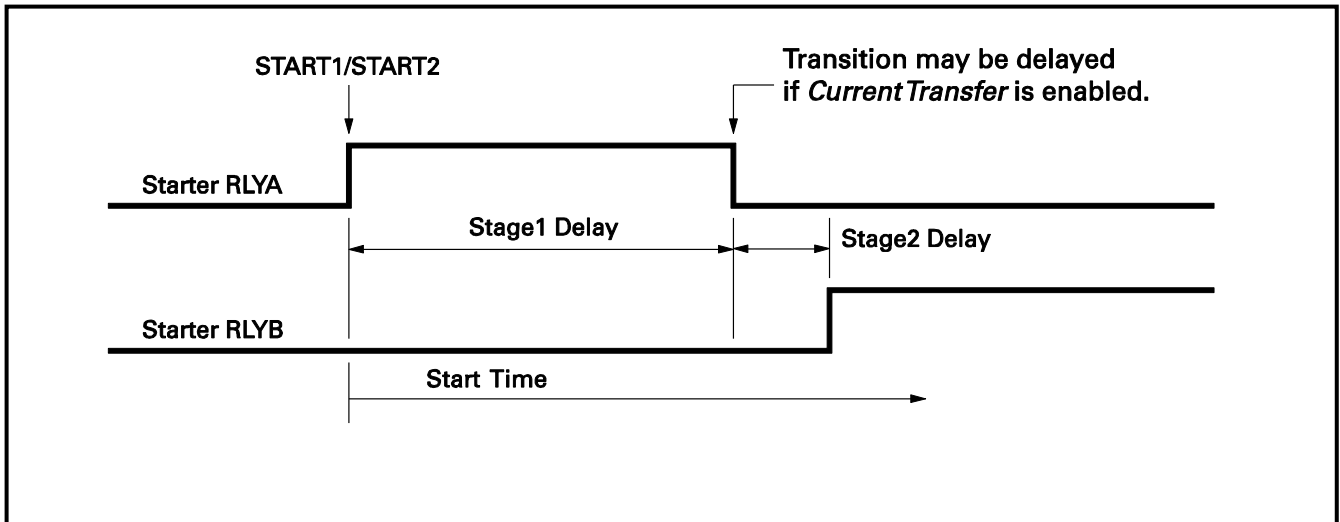


FIGURE 6.6 Starter Sequence 4.

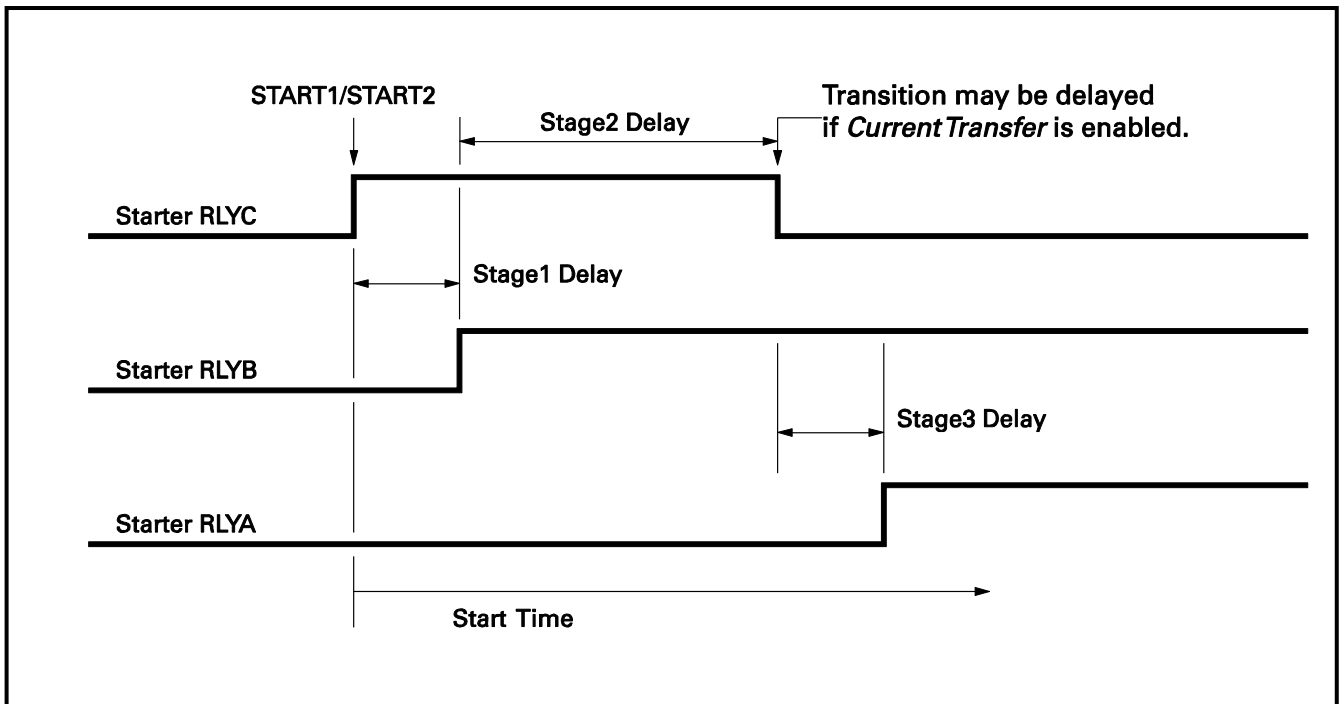


FIGURE 6.7 Starter Sequence 5.

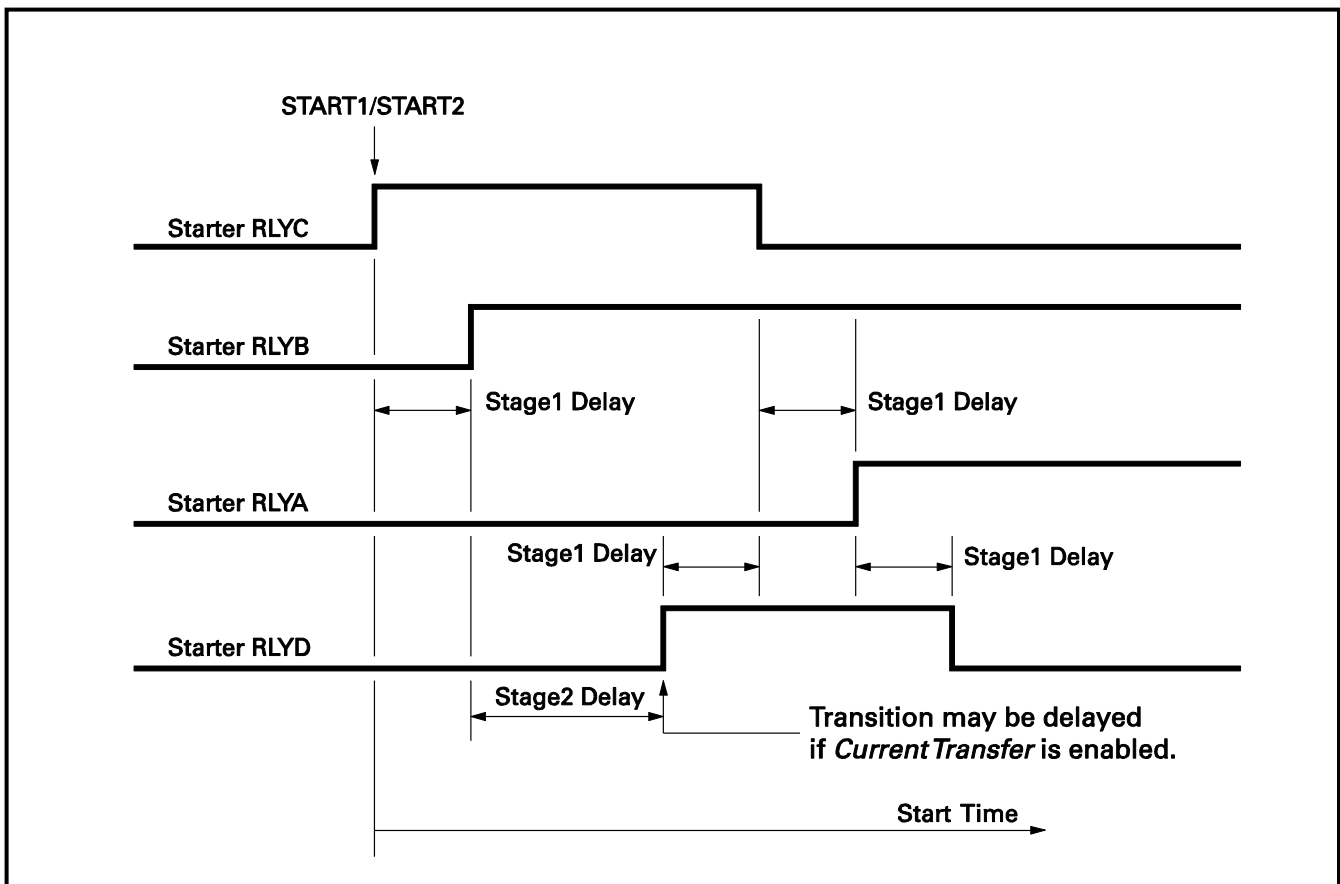


FIGURE 6.8 Starter Sequence 6.

### 6.3 FULL-VOLTAGE NON-REVERSING STARTER

Sequence: Fig. 6.3  
Connection: Fig. 6.9  
Current Transfer: Not available

START1 or START2 is the start command and *Starter RLYA* is used as the output to control the contactor.

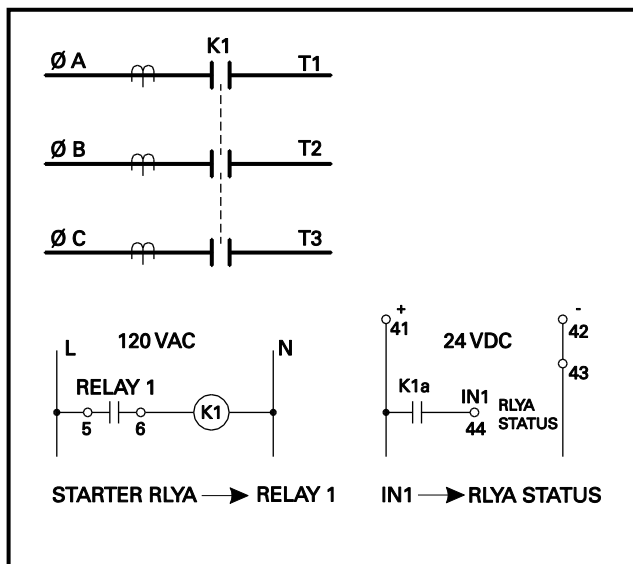


FIGURE 6.9 Full-Voltage Non-Reversing-Starter Connection.

### 6.4 ADJUSTABLE-SPEED DRIVE

Sequence: Fig. 6.3  
Connection: Fig. 6.10  
Current Transfer: Not available

The MPS-CTU provides the start input to an adjustable-speed drive (ASD). START1 or START2 is the start command and *Starter RLYA* is used as the output to control the ASD.

The MPS-CTU has a 4-20 mA input that should be used to synchronize its sampling rate to the ASD output frequency so that all protection and metering values are valid for an ASD output frequency from 10 to 70 Hz. In ASD applications, voltage and current inputs must be derived from the load side of the ASD, and undervoltage protection must be disabled.

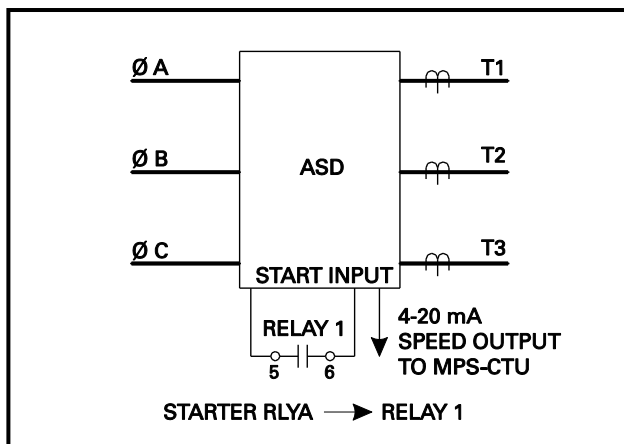


FIGURE 6.10 Adjustable-Speed-Drive Connection.

### 6.5 SOFT-START STARTER

Sequence: Fig. 6.3  
Connection: Fig. 6.11  
Current Transfer: Not available

The MPS-CTU provides the start input to a solid-state starter. START1 or START2 is the start command and *Starter RLYA* is used as the output to control the starter.

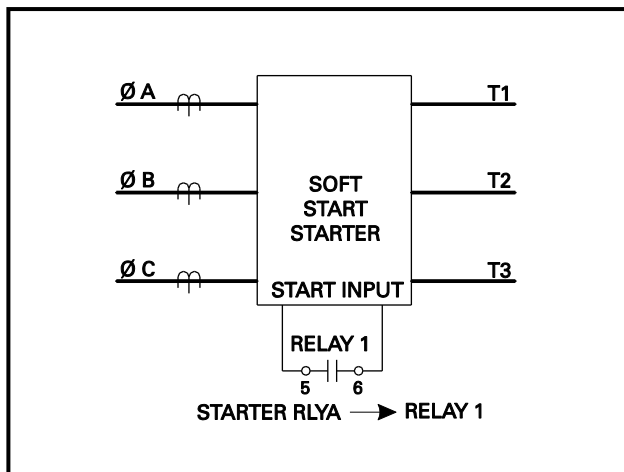


FIGURE 6.11 Soft-Start-Starter Connection.

## 6.6 FULL-VOLTAGE REVERSING STARTER

Sequence: Fig. 6.4  
Connection: Fig. 6.12  
Current Transfer: Not available

The full-voltage reversing starter uses START1 to activate *Starter RLYA* for forward control and START2 to activate *Starter RLYB* for reverse control. *RLYA Status* is the status corresponding to *Starter RLYA* and *RLYB Status* is the status corresponding to *Starter RLYB*.

For OPI and 3-wire start/stop control, a direction change requires a STOP command prior to a START1 or START2 command. For 2-wire control a STOP command is not required.

Fig. 6.12 shows the use of forward and reverse limit switches. When *Start1* is issued, K1 is energized. If a STOP is issued or LSF opens, K1 is de-energized. Provided LSR is closed, *Start2* will energize K2 to allow operation in the reverse direction.

**NOTE:** Phase CT's should be located upstream of the contactors.

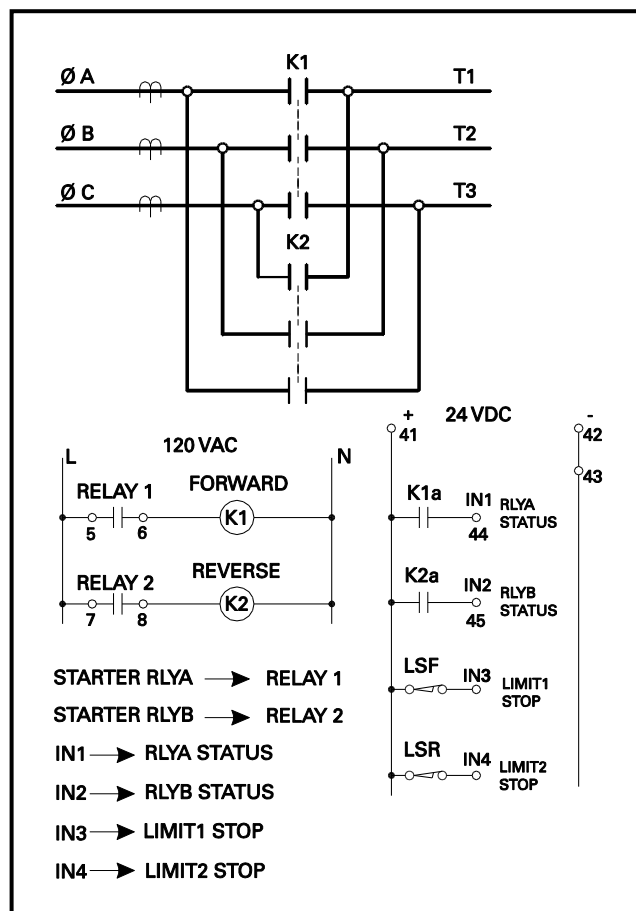


FIGURE 6.12 Full-Voltage-Reversing-Starter Connection.

## 6.7 TWO-SPEED STARTER

Sequence: Fig. 6.4  
Connection: Fig. 6.13, 6.14, and 6.15  
Current Transfer: Not available

The two-speed starter uses START1 to activate *Starter RLYA* for high-speed control and START2 to activate *Starter RLYB* for low-speed control. *RLYA Status* is the status corresponding to *Starter RLYA* and *RLYB Status* is the status corresponding to *Starter RLYB*. A speed change requires a STOP command prior to a START1 or START2 command. This starter can be used on motors with two separate windings (Fig. 6.13) or on motors with reconnectable windings (Figs. 6.14 and 6.15).

This starter requires two FLA settings. Use *FLA Rating* for the high-speed connection and *FLA Rating 2* for the low-speed connection.

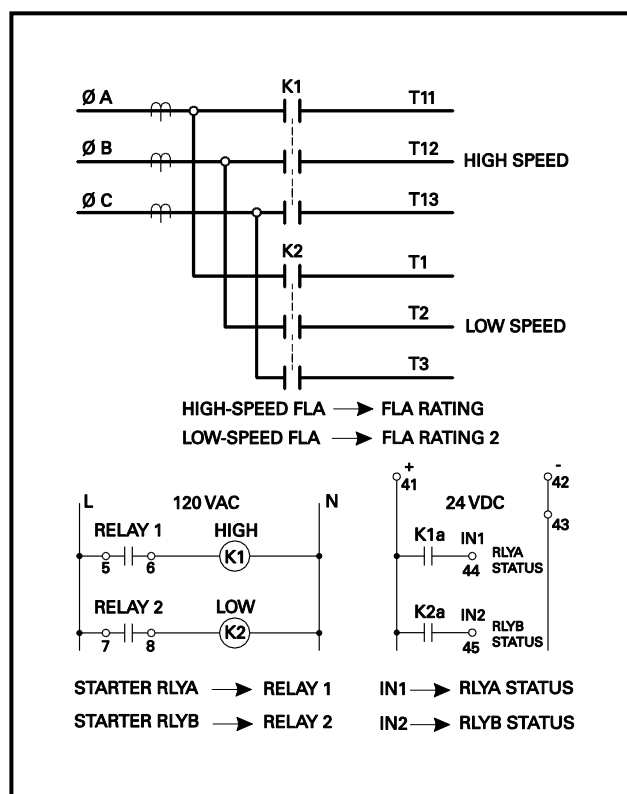


FIGURE 6.13 Two-Speed Two-Winding-Starter Connection.

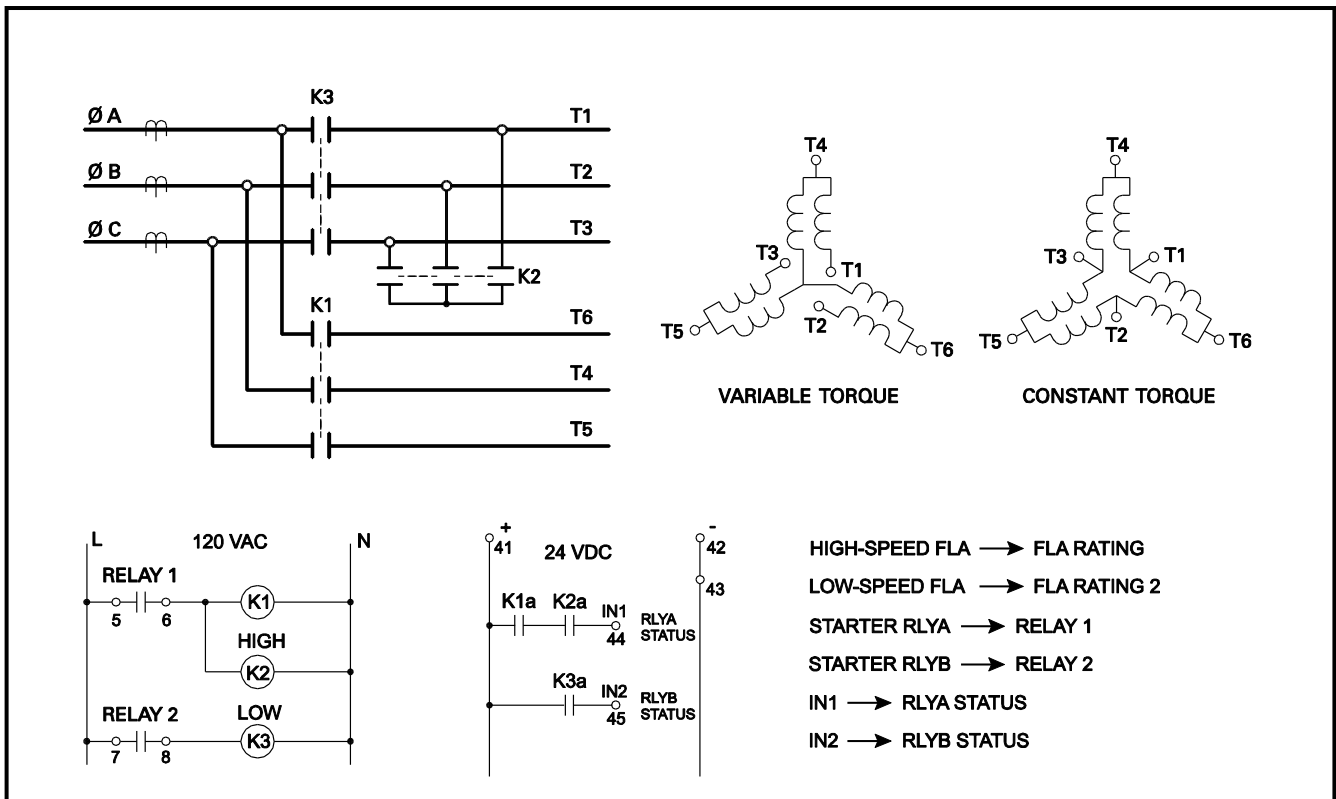


FIGURE 6.14 Two-Speed Constant- and Variable-Torque-Starter Connections.

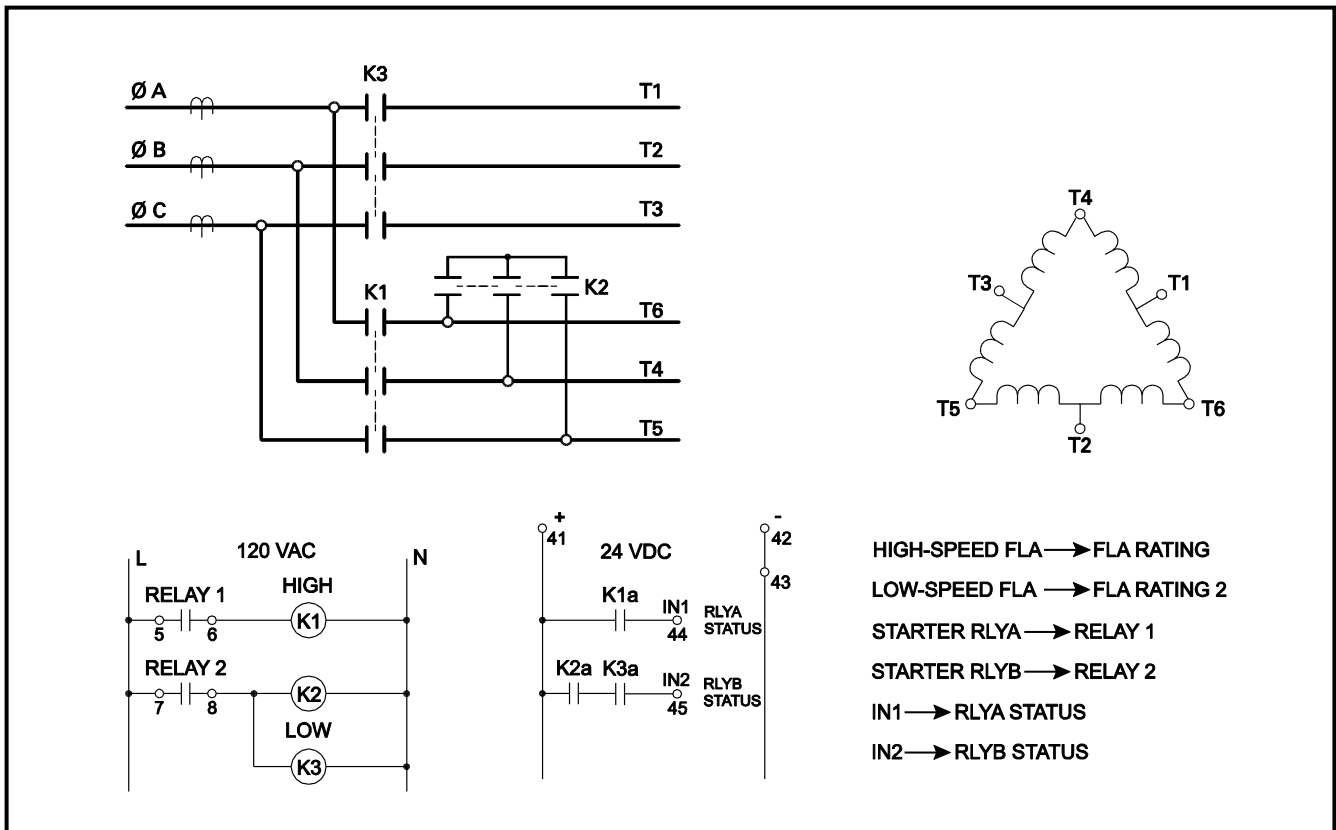


FIGURE 6.15 Two-Speed Constant-Horsepower-Starter Connection.

## 6.8 REACTOR OR RESISTOR CLOSED-TRANSITION STARTER

Sequence: Fig. 6.5  
Connection: Fig. 6.16  
Current Transfer: Available

This starter uses a reactor or resistor to provide reduced-voltage starting and the reactor or resistor contactor (K1) remains closed during running.

START1 or START2 initiates the starting sequence by activating *Starter RLYA*. *Starter RLYB* activates after the *Stage1 Delay*.

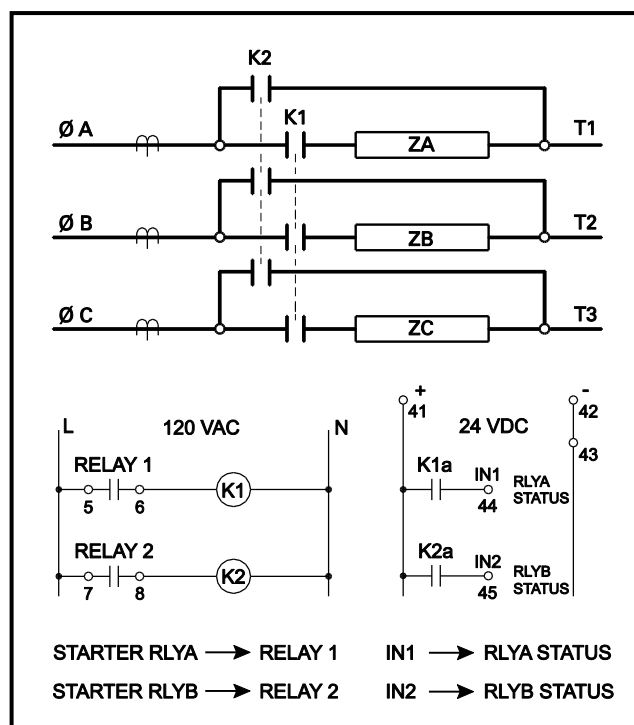


FIGURE 6.16 Reactor or Resistor-Starter Connection.

## 6.9 SLIP-RING STARTER

Sequence: Fig. 6.5  
Connection: Fig. 6.17  
Current Transfer: Available

The slip-ring starter is a single-stage wound-rotor starter with a single contactor (K2) controlling the rotor resistor bank.

START1 or START2 initiates the starting sequence by activating *Starter RLYA*. *Starter RLYB* activates after the *Stage1 Delay*.

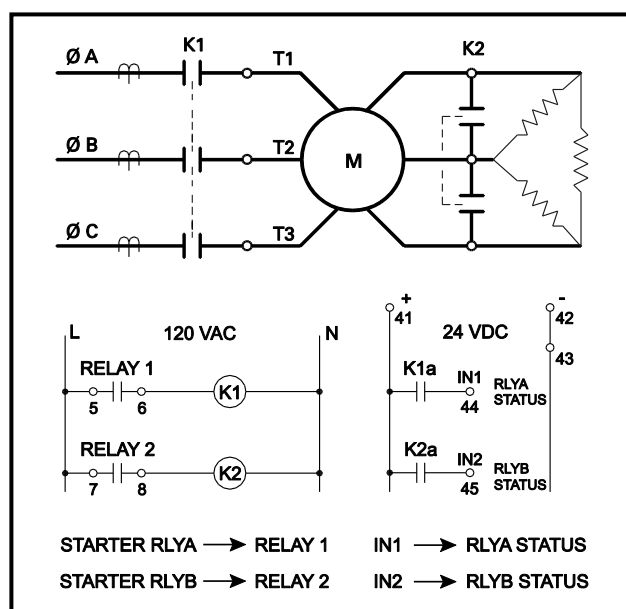


FIGURE 6.17 Slip-Ring-Starter Connection.

## 6.10 PART-WINDING AND DOUBLE-DELTA STARTERS

Sequence: Fig. 6.5  
Connection: Fig. 6.18  
Current Transfer: Available

The part-winding starter is used on motors with two stator windings and the double-delta starter has a delta winding that is parallel connected during running.

START1 or START2 initiates the starting sequence by activating *Starter RLYA*. *Starter RLYB* activates after the *Stage1 Delay*.

Both starters require two FLA settings. *FLA Rating 2* is the full-load current for the starting connection and *FLA Rating* is the full-load current for the running connection.

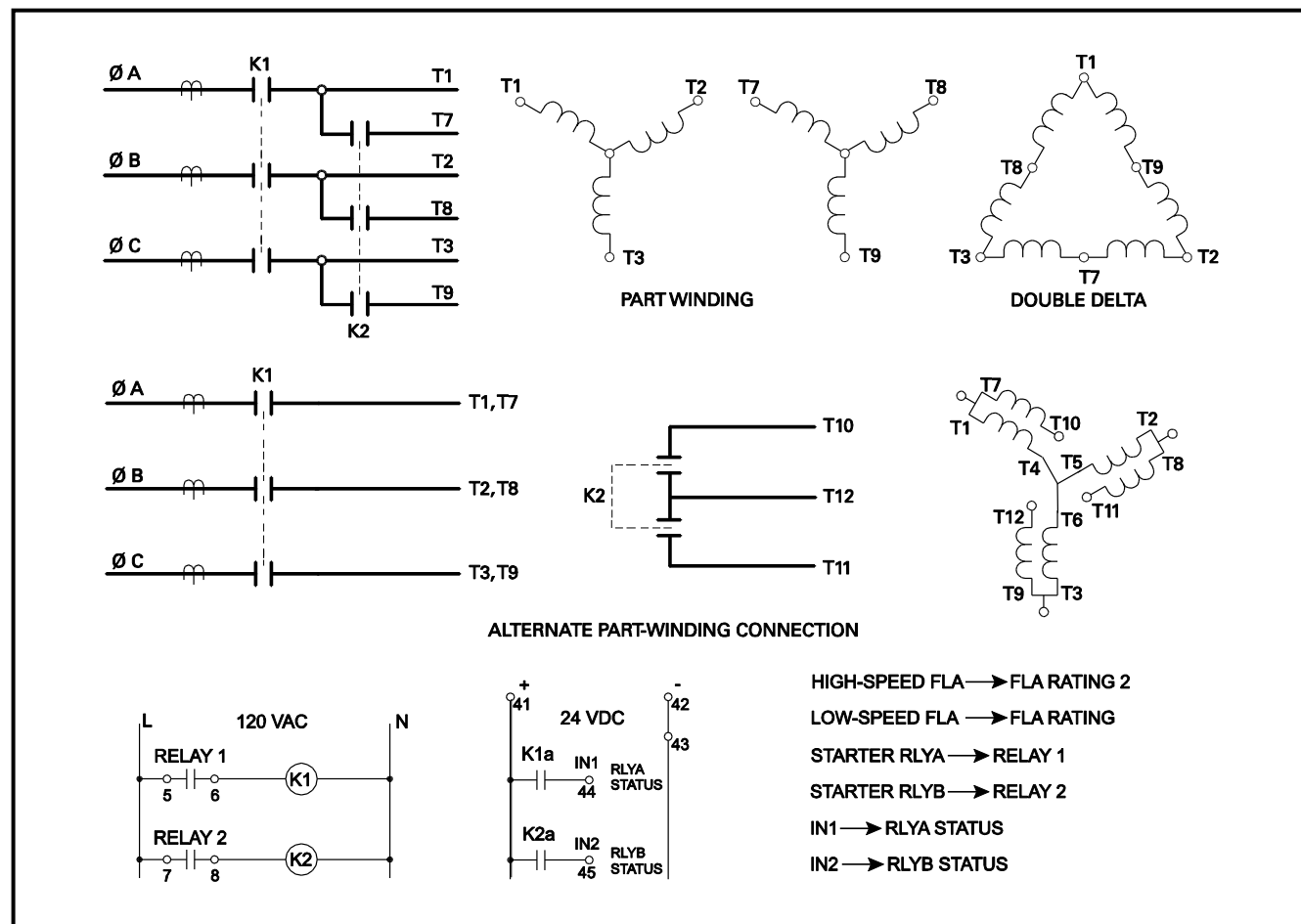


FIGURE 6.18 Part-Winding and Double-Delta-Starter Connections.

### 6.11 SOFT-START-WITH-BYPASS STARTER

Sequence: Fig. 6.5  
Connection: Fig. 6.19  
Current Transfer: Available

START1 or START2 initiates the starting sequence by activating *Starter RLYA*. *Starter RLYB* activates after the *Stage1 Delay* to close the bypass contactor.

Although *RLYA Status* can be selected as a digital input, it is not usually available for this starter.

For a soft-start where the bypass function is included, a bypass signal from the soft-start can be used as an input to the MPS. There are two solutions:

- 1) This option coordinates the MPS *Starter RLYB* signal with the soft-start and ensures the status input does not validate prior to the intended time. Assign an MPS output relay with the *Starter RLYB* function as per Fig. 6.19. Connect this output-relay contact in series with the bypass contact from the soft-start (K1a) and connect this signal to a digital input programmed as *RLYB Status*. Set the *Stage 1 Delay* longer than the soft-start bypass time.
- 2) This option uses a digital input programmed as *Trip1* in conjunction with the MPS trip-bypass feature. Connect the bypass signal from the soft-start to a digital input assigned as *Trip1*. Enable *Trip Bypass* and set the *Bypass Delay* longer than the start time of the soft-start. Note that this feature is based on current and during a stop requires the input to remain valid until current is not detected. If the soft-start has a ramp-down feature, set the *INx Trip Delay* greater than the ramp-down time to prevent a trip when the soft-start stops. See Section 4.2.8.

### 6.12 REACTOR OR RESISTOR OPEN-TRANSITION STARTER

Sequence: Fig. 6.6  
Connection: Fig. 6.16  
Current Transfer: Available

START1 or START2 activates *Starter RLYA* for the duration of the *Stage1 Delay*. After *Starter RLYA* de-activates for the *Stage2 Delay*, *Starter RLYB* activates.

### 6.13 TWO-WINDING STARTER

Sequence: Fig. 6.6  
Connection: Fig. 6.20  
Current Transfer: Available

This starter is an open-transition starter for two-winding motors that run with only one winding energized.

START1 or START2 activates *Starter RLYA* for the time specified by the *Stage1 Delay*. After *Starter RLYA* de-activates for the *Stage2 Delay*, *Starter RLYB* activates.

This starter requires two full-load current set points. *FLA Rating 2* is the full-load current for the starting connection (*Starter RLYA*) and *FLA Rating 1* is the full-load current for the running connection (*Starter RLYB*).

### 6.14 WYE-DELTA OPEN-TRANSITION STARTER

Sequence: Fig. 6.7  
Connection: Fig. 6.21  
Current Transfer: Available

START1 or START2 initiates the sequence. *Starter RLYC* activates to close the neutral contactor (K3). *Starter RLYB* activates the wye contactor (K2) after the *Stage1 Delay*. *Starter RLYC* de-activates to open the neutral contactor after the *Stage2 Delay* and *Starter RLYA* activates to close the delta contactor (K1) after the *Stage3 Delay*. Stage-1 and Stage-3 delays are contactor-transfer times and should be set in the range of 0.1 to 0.5 seconds.

Locate CT's on the line side of the starter.

This starter uses two full-load current settings. Set *FLA Rating* to the delta full-load current and *FLA Rating 2* to the wye full-load current.

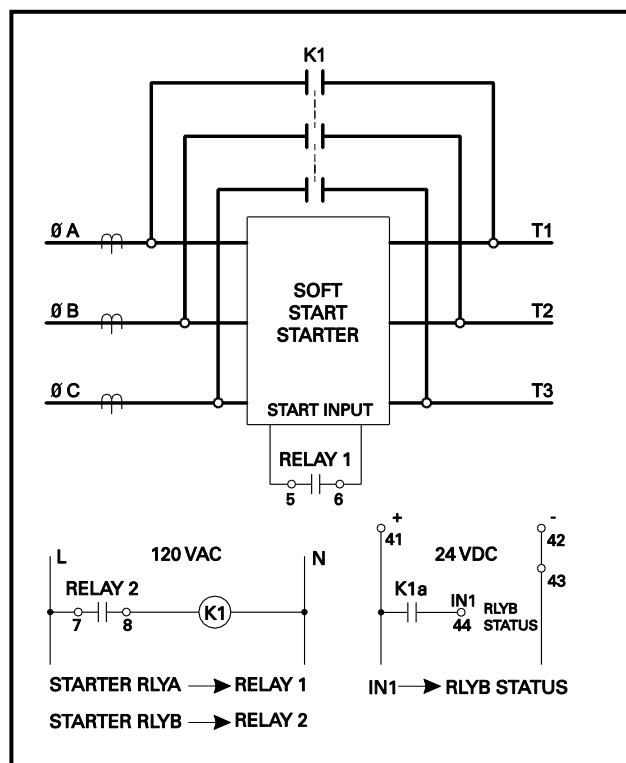


FIGURE 6.19 Soft-Start-With-Bypass-Starter Connection.



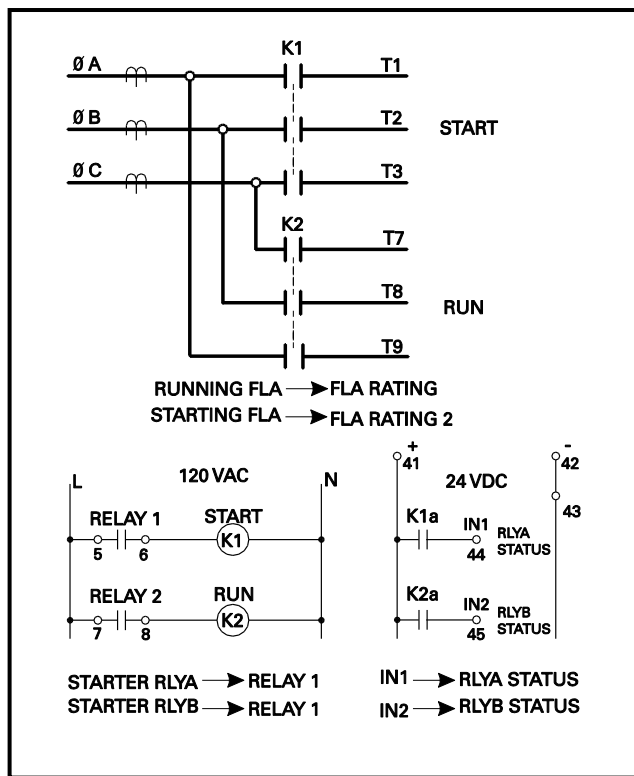


FIGURE 6.20 Two-Winding-Starter Connection.

### 6.15 AUTOTRANSFORMER CLOSED-TRANSITION STARTER

Sequence: Fig. 6.7  
Connection: Fig. 6.22  
Current Transfer: Available

START1 or START2 initiates the sequence. *Starter RLYC* activates to close the neutral contactor (K3) on the autotransformer. *Starter RLYB* activates to close the main autotransformer contactor (K2) after the *Stage1 Delay*. *Starter RLYC* de-activates to open the autotransformer neutral contactor after the *Stage2 Delay*, and *Starter RLYA* activates to close the main motor contactor (K1) after the *Stage3 Delay*. Stage-1 and Stage-3 delays are contactor-transfer times and should be set in the range of 0.1 to 0.5 seconds.

### 6.16 WYE-DELTA CLOSED-TRANSITION STARTER

Sequence: Fig. 6.8  
Connection: Fig. 6.23  
Current Transfer: Available

START1 or START2 initiates the start sequence. *Starter RLYC* activates to close the neutral contactor (K3). *Starter RLYB* activates to close the wye contactor (K2) after the *Stage1 Delay*. *Starter RLYD* activates to close the resistor contactor (K4) after the *Stage2 Delay*. This is followed by de-activation of *Starter RLYC*, activation of *Starter RLYA* to close the main motor contactor (K1), and de-activation of *Starter RLYD*, all displaced by the *Stage1 Delay*.

Locate CT's on the line side of the starter. Set *FLA Rating* to the delta full-load current and *FLA Rating 2* to the wye full-load current. Stage-1 delay is a contactor-transfer time and should be set in the range of 0.1 to 0.5 seconds.

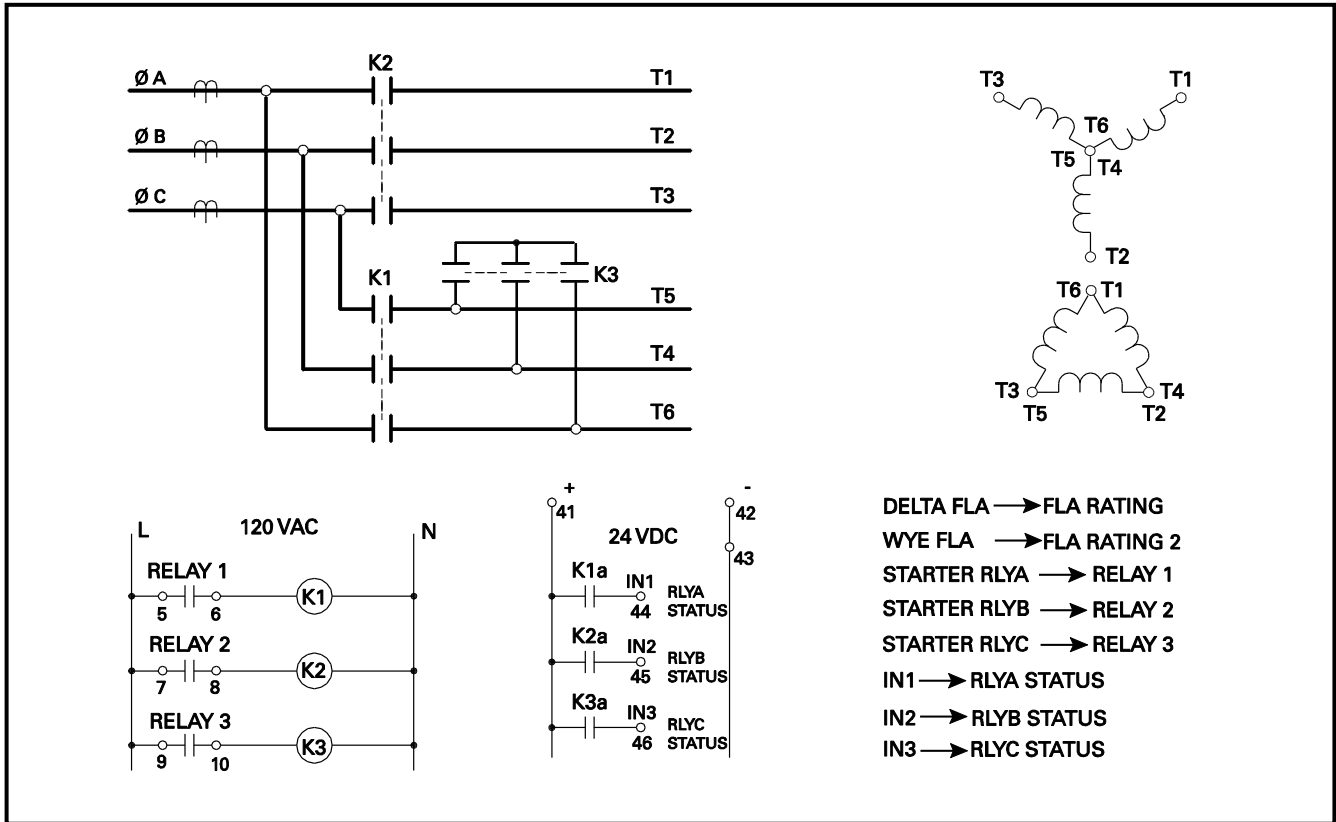


FIGURE 6.21 Wye-Delta Open-Transition-Starter Connection.

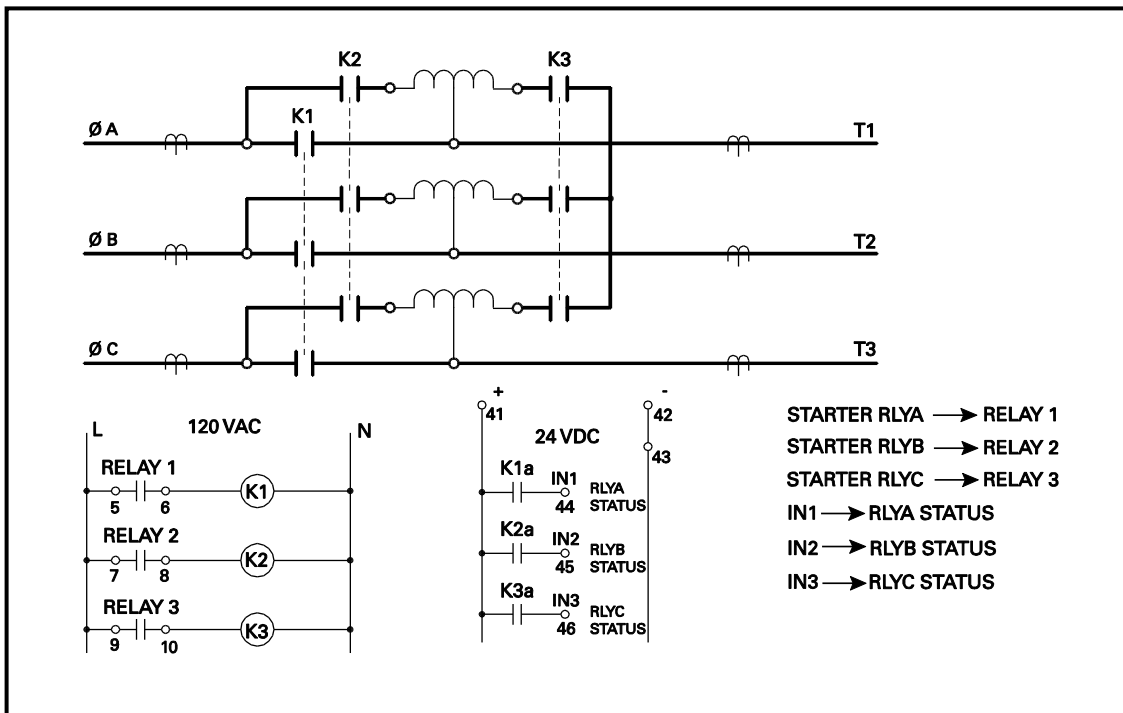


FIGURE 6.22 Autotransformer Closed-Transition-Starter Connection.

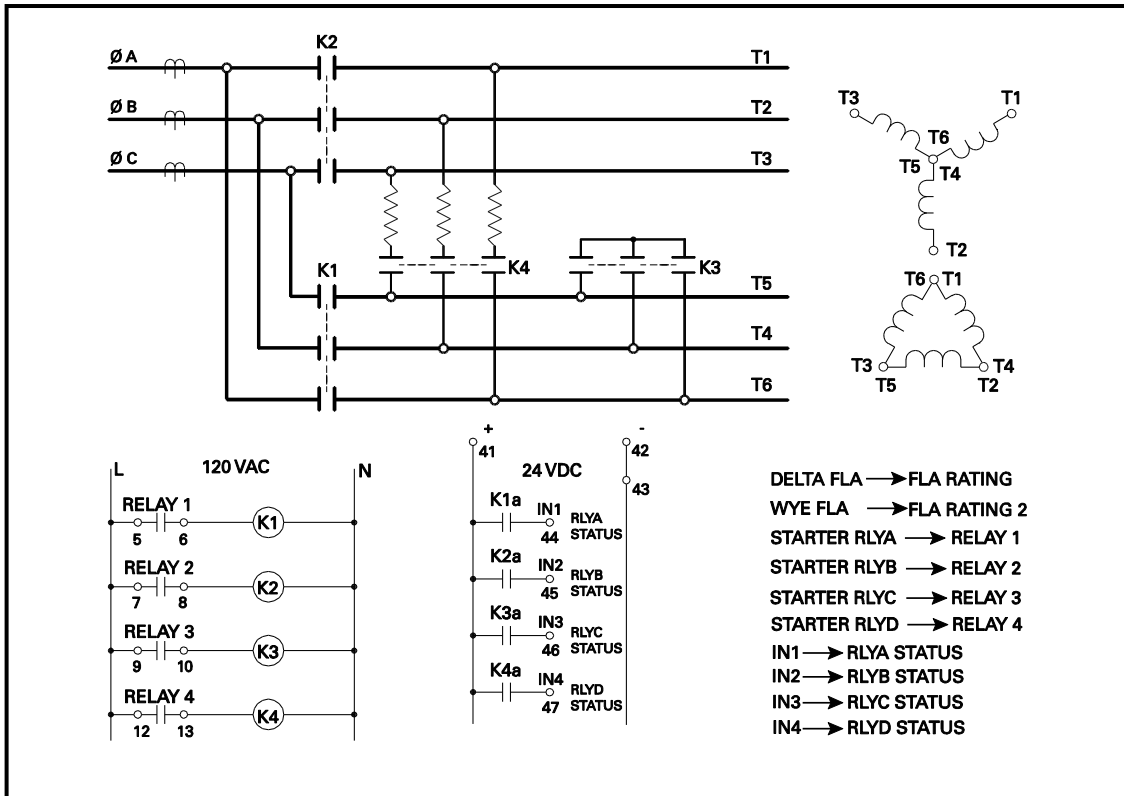


FIGURE 6.23 Wye-Delta Closed-Transition-Starter Connection.

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## 7. THEORY OF OPERATION

### 7.1 SIGNAL-PROCESSING ALGORITHMS

The sampling frequency of the MPS is variable. It can be set for 50-Hz, 60-Hz, or variable-frequency applications. The MPS obtains sixteen samples per cycle of each current and voltage signal. For an adjustable-speed drive (ASD) application, a speed or frequency output from the ASD can be connected to the 4-20-mA input to synchronize the sampling rate to the ASD output frequency. This maintains accurate measurements of power and sequential components.

The 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 8<sup>th</sup> 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 MPS 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 3-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 (MPS-OPI)

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

The OPI contains a microprocessor used to communicate with the MPS-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 MPS-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 MPS-CTU where temperature monitoring occurs.

### 7.5 DIFFERENTIAL MODULE (MPS-DIF)

The differential module obtains 32 samples per cycle of the differential current. A Discrete-Fourier-Transform (DFT) algorithm is used to obtain the magnitude of the three differential currents. Frequency of operation is set by the MPS-CTU unit and allows differential protection to be used in variable-frequency drive applications. The DFT values are sent to the MPS-CTU where differential protection is performed.

### 7.6 FIRMWARE DIAGNOSTICS

Starting with firmware 2.01, diagnostic error handling has been added. 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     |
| 300:      | Starter-Control 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.

When upgrading an MPS that did not previously support the diagnostic error code, the initial value of the diagnostic code is not valid and should be cleared.

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

## 8. COMMUNICATIONS

### 8.1 PERSONAL-COMPUTER INTERFACE

#### 8.1.1 FIRMWARE UPGRADE

The MPS-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 MPS-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](http://www.littelfuse.com/relayscontrols).

#### 8.1.2 SE-COMM-RIS

SE-Comm-RIS is a Windows-based program used to access MPS functions with a personal computer (PC) via the RS-485 network interface or Modbus® TCP<sup>(1)</sup>. Use SE-Comm-MPS to program an MPS either by changing individual set points or by downloading set-point files. Existing MPS set points can be transferred to the PC. Metered values can be viewed simultaneously and the MPS can be controlled with the computer. SE-Comm-RIS extends the event-record storage capability of the MPS 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](http://www.littelfuse.com/relayscontrols).

<sup>(1)</sup> Requires Ethernet option and firmware 2.50 or higher.

### 8.2 NETWORK INTERFACE

Each MPS-CTU is equipped with an RS-485 interface and can be optionally equipped with a DeviceNet, Ethernet, or Profibus interface. Communications interfaces are mutually exclusive; only one can be used at a time.

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

#### 8.2.1 RS-485 COMMUNICATIONS

SE-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)
- Extended Contactor
- Extended Motor Starter

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

Starting with firmware 2.50, Modbus® TCP provides access to all MPS registers and supports SE-Comm-RIS.

#### 8.2.4 PROFIBUS COMMUNICATIONS

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

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## 9. TECHNICAL SPECIFICATIONS

### 9.1 CONTROL UNIT (MPS-CTU)

Supply .....25 VA, 120 to 240 Vac  
(+10, -45%),  
40 to 400 Hz, power  
factor corrected;  
25 W, 110 to 250 Vdc  
(+10, -25%)

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

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

24-Vdc Source <sup>(1)</sup> .....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  
Variable .....10 to 70 Hz, sync via  
4-20 mA signal from  
ASD

#### Phase-Current Inputs: <sup>(2)</sup>

Range.....18 x CT-Primary Rating  
( $I_p$ )

#### Accuracy: <sup>(3)</sup>

$I < I_p$  .....1%  $I_p$   
 $I > I_p$  .....1% Reading

Burden .....< 0.01  $\Omega$

Unbalance Accuracy .....0.01 pu

Common-Mode Voltage.....120 Vac maximum

#### Thermal Withstand:

Continuous.....5 x  $I_p$   
1-Second.....80 x  $I_p$

#### Earth-Leakage Input:

Range.....1.5 x Earth-Fault-CT-  
Primary Rating ( $I_e$ )

Accuracy <sup>(3)</sup> .....1%  $I_e$

Burden .....< 0.01  $\Omega$  (1- and 5-A  
inputs), 10  $\Omega$  for EFCT

Common-Mode Voltage.....120 Vac maximum

#### Thermal Withstand:

Continuous.....5 x  $I_e$   
1-Second.....80 x  $I_e$

#### Phase-Voltage Inputs: <sup>(4,5)</sup>

Nominal Input .....30 to 600 Vac line-to-line

Input Resistance .....3.4 M $\Omega$

Range.....1.4 x PT-Primary Rating  
( $V_p$ )

Voltage-Input Fuse .....0.3 A, Class CC  
Littelfuse KLKR.300

Voltage-Input Wire<sup>(9)</sup> .....18 AWG to 14 AWG  
(0.82 to 2.08 mm<sup>2</sup>), 600 V

#### Accuracy: <sup>(3)</sup>

$V < V_p$  .....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: <sup>(1)</sup>

Cold Resistance .....1500  $\Omega$  maximum at 20°C  
(68°F)

Trip Level .....2,800  $\Omega \pm 100 \Omega$

Sensor Current.....2 mA maximum

#### 4-20 mA Analog Input:

Input Burden.....100  $\Omega$

Common-Mode

Voltage <sup>(6)</sup> ..... $\pm 5$  Vdc

#### 4-20 mA Analog Output: <sup>(1)</sup>

Load.....500  $\Omega$  maximum

Range.....0 to 25 mA

Update Time .....500 ms

#### Tachometer Input: <sup>(7)</sup>

Type.....Active pickup, 24-V logic  
output, sourcing, PNP  
output  
TURCK Bi1.5-EG08-  
AP6X-V1131 or  
equivalent

Pulses Per Revolution .....1 to 120

Pulse Frequency .....10 Hz to 10 kHz

Accuracy .....1%

#### Timing Accuracies: <sup>(8)</sup>

Set Points.....-10%, +0%  
(minimum 25 to 45 ms)

Overload .....Greater of 2% or  
+ 200 ms (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:

## Break:

|          |                     |
|----------|---------------------|
| dc ..... | 200 W resistive,    |
| ac ..... | 3,040 VA resistive, |
|          | 1,000 VA inductive  |
|          | (PF = 0.4)          |

Subject to maximums of 8 Aac and 5 Adc,  
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,<br>8 A resistive 30 Vdc |

## Supplemental Contact Ratings:

|                   |             |
|-------------------|-------------|
| Make/Carry .....  | 30 A, 0.2 s |
| Rating Code ..... | B300        |

## Break:

|          |                         |
|----------|-------------------------|
| dc ..... | 50 W resistive, 150 Vdc |
| ac ..... | 2,500 VA resistive,     |
|          | 360 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 $\Omega$ maximum      |

Digital Inputs: <sup>(1)</sup>

|                      |                                     |
|----------------------|-------------------------------------|
| Range .....          | 24 to 130 V (ac or dc),<br>5 mA     |
| Guaranteed On .....  | 12 Vdc at 3 mA,<br>20 Vac at 3 mA   |
| Guaranteed Off ..... | 3 Vdc at 2 mA,<br>2.5 Vac at 0.3 mA |

## IRIG-B:

|                 |                                  |
|-----------------|----------------------------------|
| Format .....    | Amplitude Modulated<br>IRIG-B122 |
| Amplitude ..... | 1 to 10 Vpp                      |
| Impedance ..... | 10 k $\Omega$                    |
| Ratio .....     | 3:1 to 6:1                       |

## I/O Module Interface (OPI, RTD and DIF):

|                                    |                               |
|------------------------------------|-------------------------------|
| Module Supply <sup>(1)</sup> ..... | 24 Vdc, 400 mA maximum        |
| Configuration .....                | RS-485, 2-wire multi-drop     |
| Bus Length .....                   | 1.2 km (4,000') maximum       |
| Cable .....                        | Belden 3124A or<br>equivalent |

## Standard Network Communications:

|                     |                                    |
|---------------------|------------------------------------|
| Configuration ..... | RS-485, 2-wire multi-drop          |
| Baud Rate .....     | 1.2, 2.4, 4.8, 9.6, 19.2<br>kbit/s |
| Protocols .....     | Modbus RTU and<br>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) |

## Tightening Torque:

|                           |                               |
|---------------------------|-------------------------------|
| Ordering Option .....     | MPS-CTU-XX-00                 |
| All Terminals .....       | 0.6 N·m (5.31 lbf·in) maximum |
| Ordering Option .....     | MPS-CTU-XX-01                 |
| CT Input Terminals .....  | 0.79 N·m (7.0 lbf·in) maximum |
| All Other Terminals ..... | 0.6 N·m (5.31 lbf·in) maximum |

## 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 176°F) |
| Humidity .....              | 85% Non-Condensing         |

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

Certification .....CSA, Canada and USA



UL Recognized<sup>(10)</sup>



Australia



## To:

CSA C22.2 No. 14 Industrial Control Equipment  
UL 60947-4-1 Low-voltage switchgear and control  
gear - Part 4-1: Contactors and motor-starters -  
Electromechanical Contactors and motor-starters.  
UL 1053 Ground Fault Sensing and Relaying  
Equipment  
Australia, Regulatory Compliance Mark (RCM)

## 9.2 OPERATOR INTERFACE (MPS-OPI)

Supply<sup>(1)</sup> .....24 Vdc Nominal (20 to 30 Vdc), 80 mA

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

Interconnection Cable:

Type.....Belden® 3124A or equivalent

Maximum Length .....1.2 km (4,000')

Supplied length.....4 m (13')

Tightening Torque .....0.6 N·m (5.31 lbf·in) maximum

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



UL Recognized<sup>(10)</sup>



Australia



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 60947-4-1 Low-voltage switchgear and control

gear - Part 4-1: Contactors and motor-starters -

Electromechanical Contactors and motor-starters.

UL 1053 Ground Fault Sensing and Relaying

Equipment

Australia, Regulatory Compliance Mark (RCM)

## 9.3 RTD MODULE (MPS-RTD)

Supply<sup>(1)</sup> .....16 to 32 Vdc, 90 mA

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')

Tightening Torque .....0.6 N·m (5.31 lbf·in) maximum

Dimensions:

Height .....87 mm (3.4")

Width .....113 mm (4.4")

Depth .....53 mm (2.1")

Shipping Weight .....0.4 kg (0.9 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


UL Recognized<sup>(10)</sup>


Australia


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  
UL 60947-4-1 Low-voltage switchgear and control  
gear - Part 4-1: Contactors and motor-starters -  
Electromechanical Contactors and motor-starters.  
UL 1053 Ground Fault Sensing and Relaying  
Equipment  
CSA E60079-15: 02 Electrical Apparatus for  
Explosive Gas Atmospheres  
CSA C22.2 No. 213-M1987 - Non-Incendive  
Electrical Equipment for use in Class I,  
Division 2 Hazardous Locations  
UL 60079-15 Electrical Apparatus for Explosive  
Gas Atmospheres  
Australia, Regulatory Compliance Mark (RCM)

## 9.4 DIFFERENTIAL MODULE (MPS-DIF)

Supply<sup>(1)</sup> .....16 to 32 Vdc, 90 mA

CT Inputs:

Thermal Withstand:

Continuous .....5 x CT Primary Rating ( $I_d$ )

1-Second .....80 x  $I_d$ 

Burden .....0.01  $\Omega$ 

Terminal-Block Ratings:

CT Inputs .....25 A, 500 Vac

10 AWG (4.0 mm<sup>2</sup>)

Tightening Torque .....0.6 N·m (5.31 lbf·in)  
maximum

Differential-Current Measurement:

Metering Range .....15 x  $I_d$ 

Protection Range .....80 x  $I_d$ 

Metering Accuracy:

 $I < I_d$  .....2%  $I_d$ 
 $I > I_d$  .....2% Reading

Timing Accuracy .....5%, minimum trip time,  
Range is set point +20 ms  
to set point +150 ms,  
median 81 ms

Interconnection Cable:

Type .....Belden® 3124A or  
equivalent

Maximum Length .....1.2 km (4,000')

Supplied length .....4 m (13')

Dimensions:

Height .....87 mm (3.4")

Width .....113 mm (4.4")

Depth .....53 mm (2.1")

Shipping Weight .....0.4 kg (0.9 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 176°F)

Humidity .....85% Non-Condensing

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

## NOTES:

<sup>(1)</sup> 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.

<sup>(2)</sup> Current Threshold (%) is defined in Section 3.2.1.2. 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 motor full-load current.

<sup>(3)</sup> Transformer accuracy not included.

<sup>(4)</sup> Voltage unbalance is not displayed for positive-sequence voltage levels below 20% of system voltage setting.

<sup>(5)</sup> Direct connection for system-voltages up to 600 Vac line-to-line. UL certification requires the voltage-input fault current to be limited to 5 kA. Use Class CC fuses, 3/10 A, Littelfuse KLKR.300. A self-adhesive label stating this limitation is provided.

<sup>(6)</sup> Common-mode voltage relative to CTU terminal 3.

<sup>(7)</sup> Referenced to COM.

<sup>(8)</sup> Also see Tables 5.1 and 5.2.

<sup>(9)</sup> When direct connection is used.

<sup>(10)</sup> A 600Y/347 or 480Y/277 system is required when the MPS direct-voltage connection is used.

<sup>(11)</sup> UL has evaluated the MPS for use with 60°/ 75° C conductors.

## 10. WARRANTY

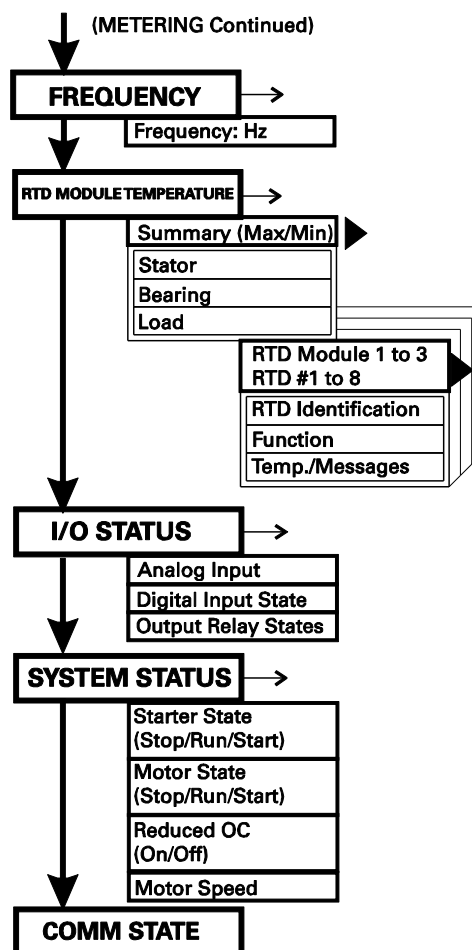
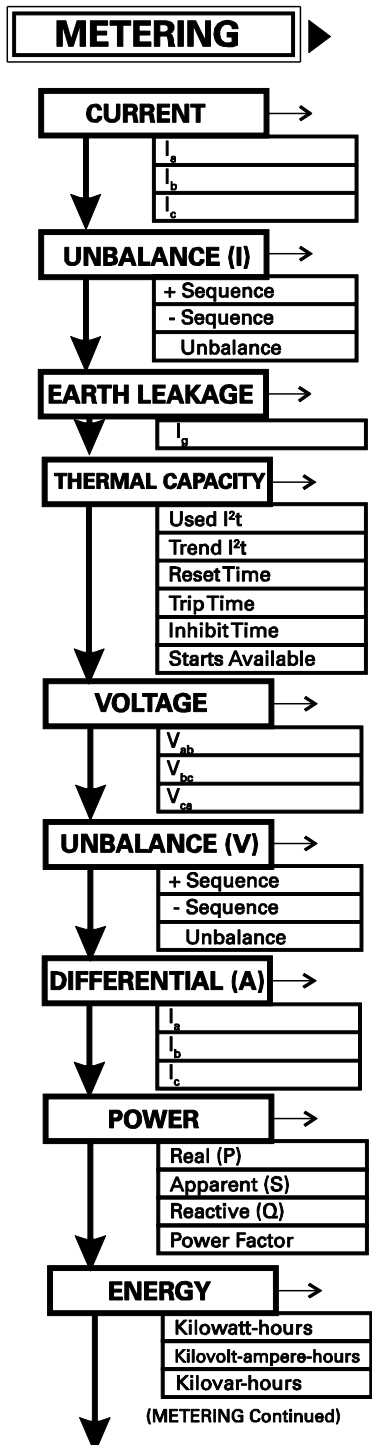
The MPS Motor Protection System is warranted to be free from defects in material and workmanship for a period ten years from the date of purchase.

Littelfuse Startco will (at Littelfuse Startco's option) repair, replace, or refund the original purchase price of an MPS-CTU, MPS-OPI, MPS-RTD, or MPS-DIF that is determined by Littelfuse Startco to be defective if it is returned to the Littelfuse Startco 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.

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## APPENDIX A MPS-OPI MENU MAP

### MAIN MENU

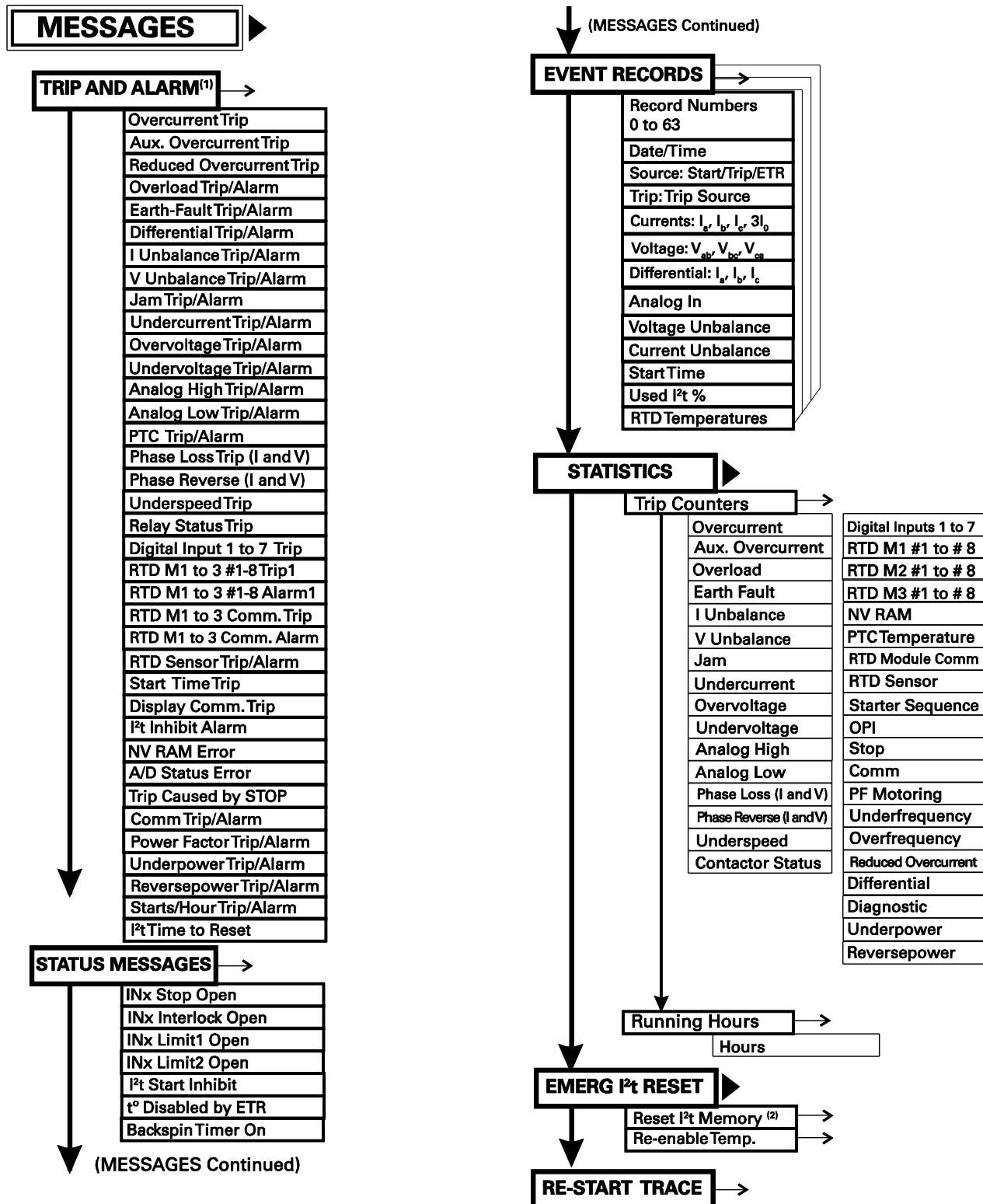


#### Notes:

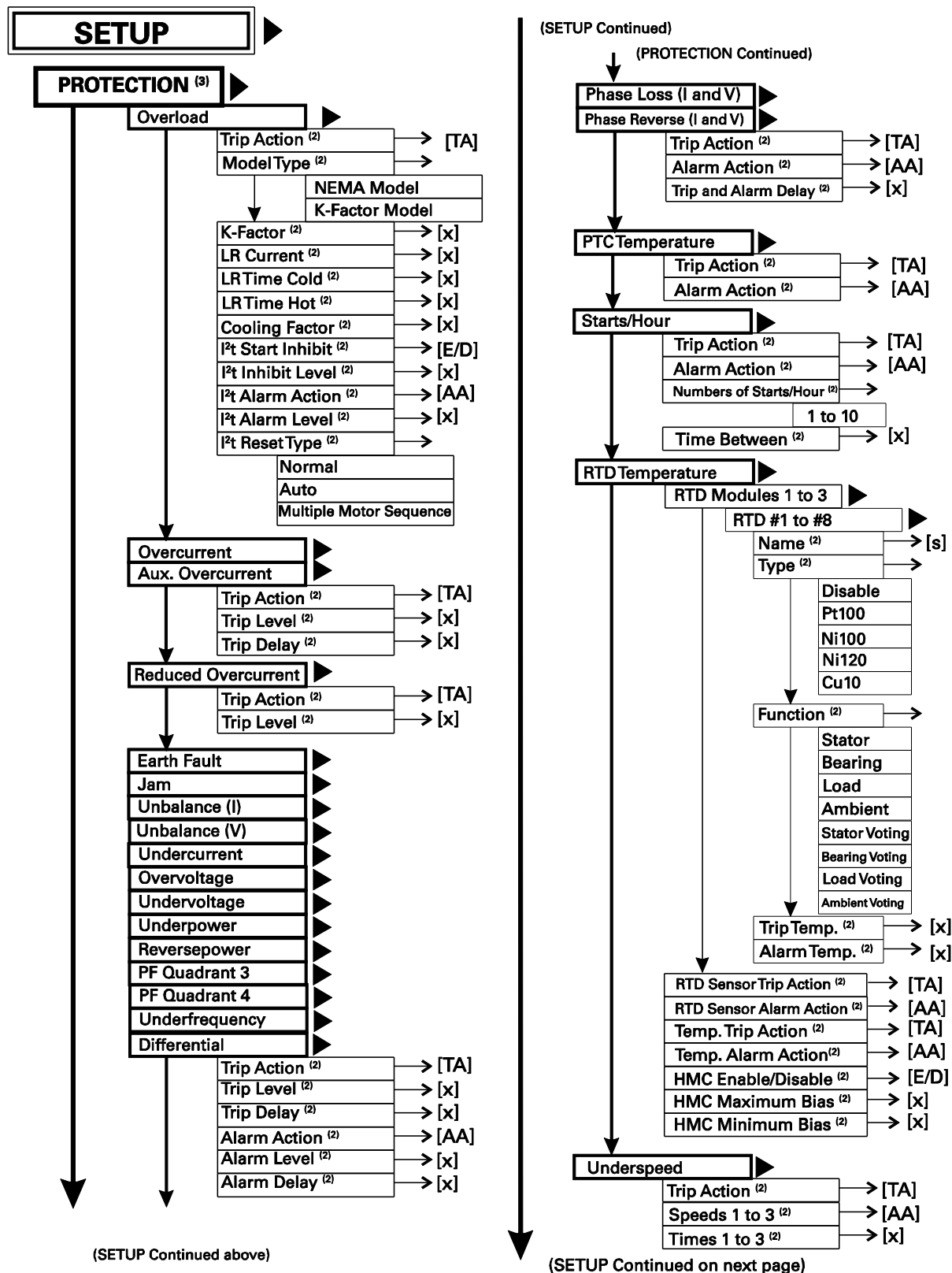
- (1) List indicates possible trips and alarms.
- (2) Password required.
- (3) Lists do not match MPS-OPI menu order.
- (4) Password is required and the set point is locked when the motor is running.

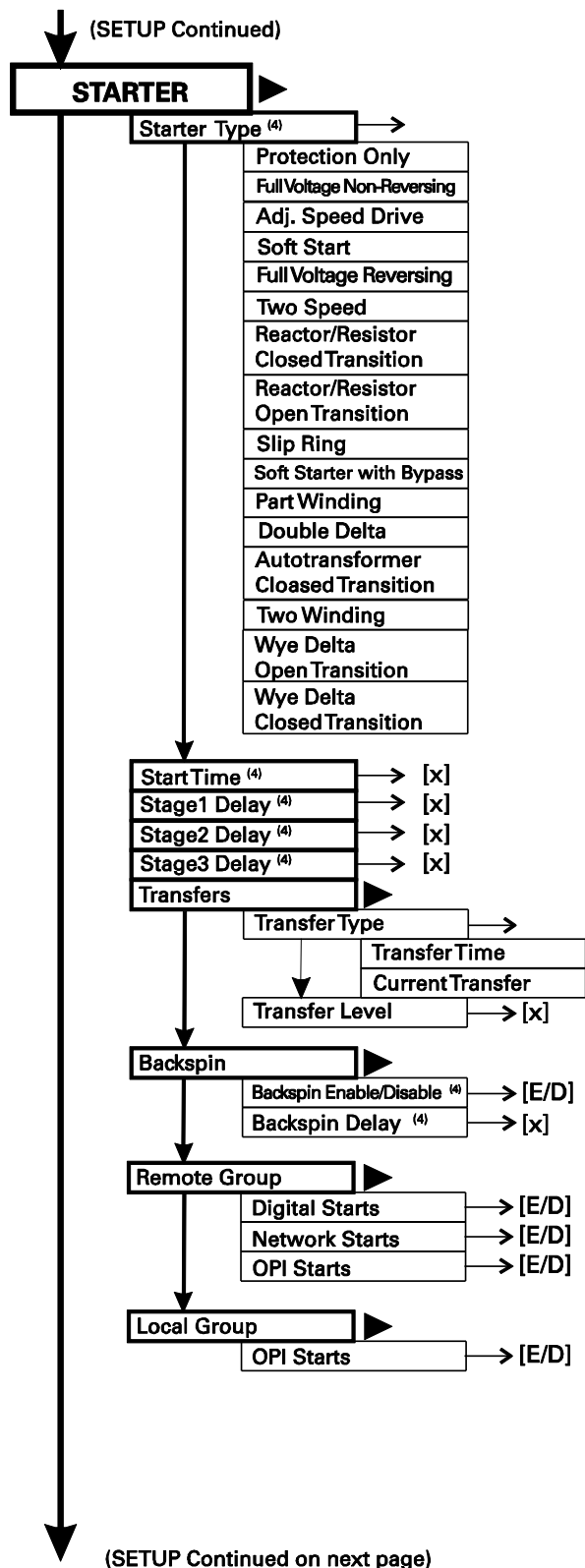
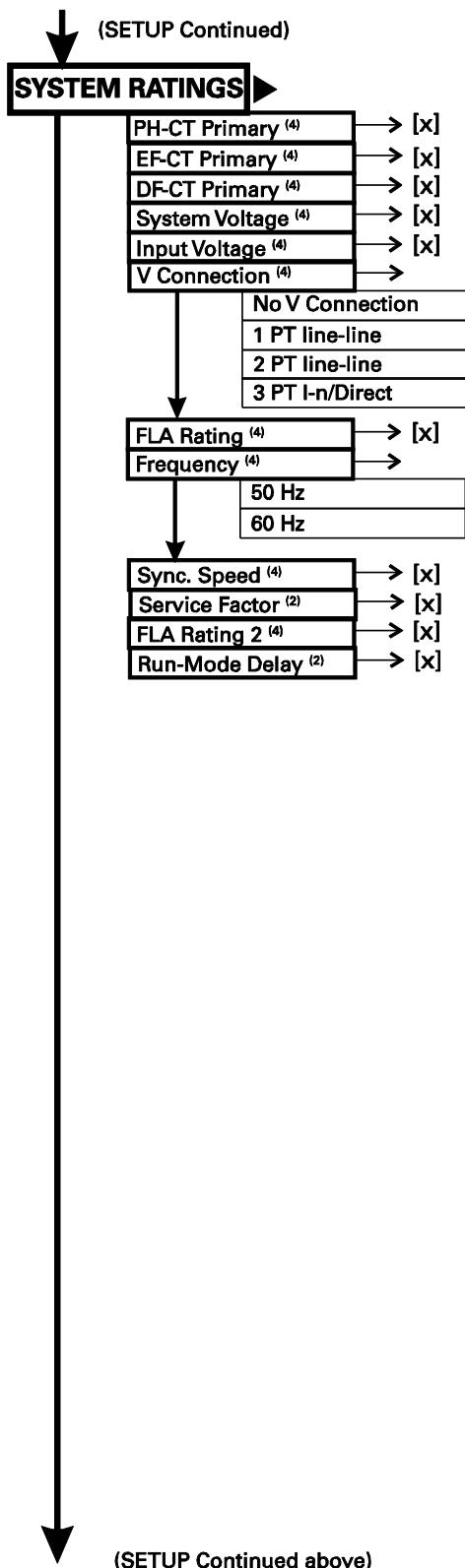
#### Legend:

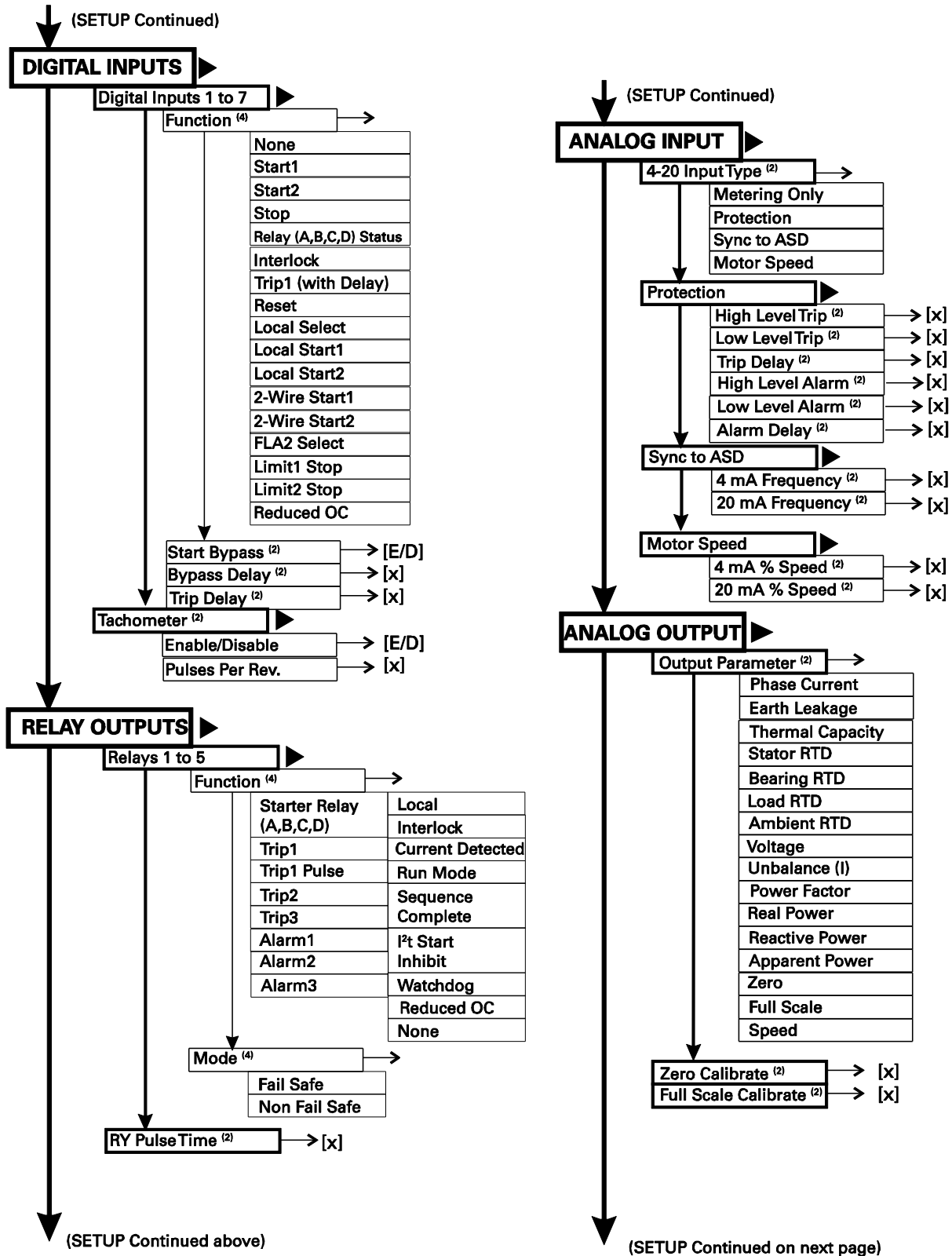
- [x] Enter numeric
- [s] Enter string
- [E/D] Enable/Disable
- [TA] Trip Action: Disable; Trip1; Trip2; Trip3
- [AA] Alarm Action: Disable; Alarm1; Alarm2; Alarm3
- [EA] Ethernet address

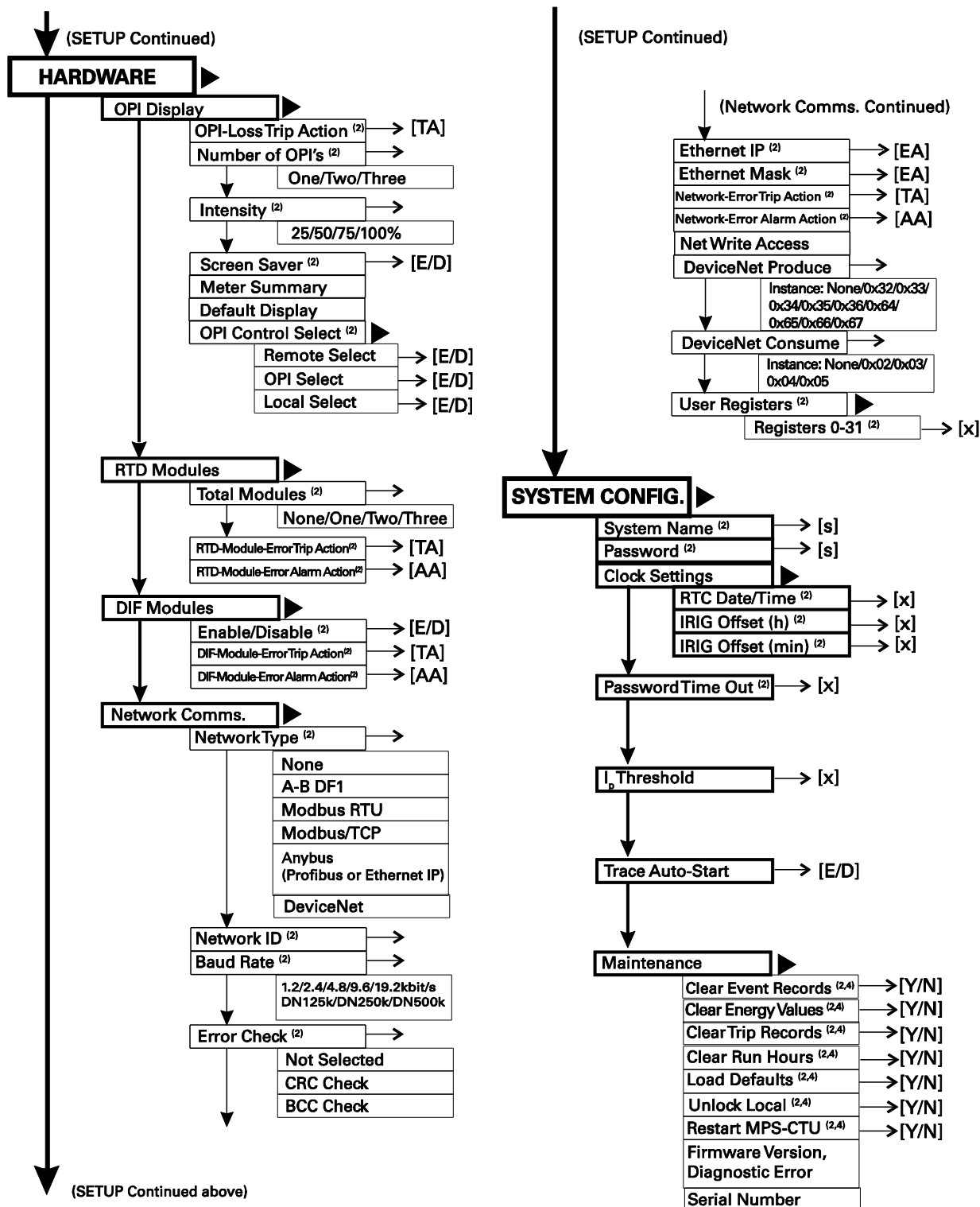












## APPENDIX B MPS SET-UP RECORD

Motor: \_\_\_\_\_ MPS S/N: \_\_\_\_\_ Date: \_\_\_\_\_

Firmware Revision: \_\_\_\_\_

### PART I: SYSTEM AND MOTOR PARAMETERS

| PARAMETER AND SETTINGS   | MIN                                     | DEFAULT  | MAX   | UNIT | PROGRAM SELECTION                                                                                                              |
|--------------------------|-----------------------------------------|----------|-------|------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>System Ratings</b>    |                                         |          |       |      |                                                                                                                                |
| PH-CT Primary ( $I_n$ )  | 1                                       | 100.00   | 5,000 | A    |                                                                                                                                |
| EF-CT Primary ( $I_e$ )  | 1                                       | 5.00     | 5,000 | A    |                                                                                                                                |
| DF-CT Primary ( $I_d$ )  | 1                                       | 100.00   | 5,000 | A    |                                                                                                                                |
| System Voltage           | 0.12                                    | 0.60     | 25    | kV   |                                                                                                                                |
| Input Voltage            | 0.06                                    | 0.12     | 0.6   | kV   |                                                                                                                                |
| Input Voltage Connection |                                         | None     |       |      | <input type="checkbox"/> None <input type="checkbox"/> 2PT<br><input type="checkbox"/> 1PT <input type="checkbox"/> 3PT/Direct |
| Full-Load Current        | 1                                       | 100.00   | 5,000 | A    |                                                                                                                                |
| Frequency                |                                         | 60       |       | Hz   | <input type="checkbox"/> 50 <input type="checkbox"/> 60                                                                        |
| Synchronous Speed        | 10                                      | 1,800.00 | 10k   | rpm  |                                                                                                                                |
| Service Factor           | 1                                       | 1.00     | 1.25  | pu   |                                                                                                                                |
| FLA Rating 2             | 1                                       | 100.00   | 5,000 | A    |                                                                                                                                |
| Run-Mode Delay           | 5                                       | 10.00    | 120   | s    |                                                                                                                                |
| <b>Digital Inputs</b>    | See Table 4.2 Input Function Definition |          |       |      |                                                                                                                                |
| Input 1: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> Disable                                                               |
| Bypass Delay             | 0.5                                     | 5.00     | 100   | s    |                                                                                                                                |
| Trip Delay               | 0.01                                    | 0.10     | 100   | s    |                                                                                                                                |
| Input 2: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> Disable                                                               |
| Bypass Delay             | 0.5                                     | 5.00     | 100   | s    |                                                                                                                                |
| Trip Delay               | 0.01                                    | 0.10     | 100   | s    |                                                                                                                                |
| Input 3: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> Disable                                                               |
| Bypass Delay             | 0.5                                     | 5.00     | 100   | s    |                                                                                                                                |
| Trip Delay               | 0.01                                    | 0.10     | 100   | s    |                                                                                                                                |
| Input 4: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> Disable                                                               |
| Bypass Delay             | 0.5                                     | 5.00     | 100   | s    |                                                                                                                                |
| Trip Delay               | 0.01                                    | 0.10     | 100   | s    |                                                                                                                                |
| Input 5: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> Disable                                                               |
| Bypass Delay             | 0.5                                     | 5.00     | 100   | s    |                                                                                                                                |
| Trip Delay               | 0.01                                    | 0.10     | 100   | s    |                                                                                                                                |
| Input 6: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> Disable                                                               |
| Bypass Delay             | 0.5                                     | 5.00     | 100   | s    |                                                                                                                                |
| Trip Delay               | 0.01                                    | 0.10     | 100   | s    |                                                                                                                                |
| Input 7: Function        |                                         | Not Used |       |      |                                                                                                                                |
| Start Bypass             |                                         | Disable  |       |      | <input type="checkbox"/> Enable <input type="checkbox"/> 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                                |                                        |
|------------------------------|------------------------------------------|---------------|-----|------|--------------------------------------------------|----------------------------------------|
| <b>Tachometer</b>            |                                          | Disable       |     |      | <input type="checkbox"/> Enable                  | <input type="checkbox"/> Disable       |
| Pulses per Revolution        | 1                                        | 60.00         | 100 |      |                                                  |                                        |
| <b>Relay Outputs</b>         | See Table 4.1 Output Function Definition |               |     |      |                                                  |                                        |
| Relay 1: Function            |                                          | None          |     |      |                                                  |                                        |
| Mode                         |                                          | Fail-Safe     |     |      | <input type="checkbox"/> Fail-Safe               | <input type="checkbox"/> Non-Fail-Safe |
| Relay 2: Function            |                                          | None          |     |      |                                                  |                                        |
| Mode                         |                                          | Fail-Safe     |     |      | <input type="checkbox"/> Fail-Safe               | <input type="checkbox"/> Non-Fail-Safe |
| Relay 3: Function            |                                          | None          |     |      |                                                  |                                        |
| Mode                         |                                          | Fail-Safe     |     |      | <input type="checkbox"/> Fail-Safe               | <input type="checkbox"/> Non-Fail-Safe |
| Relay 4: Function            |                                          | None          |     |      |                                                  |                                        |
| Mode                         |                                          | Fail-Safe     |     |      | <input type="checkbox"/> Fail-Safe               | <input type="checkbox"/> Non-Fail-Safe |
| Relay 5: Function            |                                          | None          |     |      |                                                  |                                        |
| Mode                         |                                          | Fail-Safe     |     |      | <input type="checkbox"/> Fail-Safe               | <input type="checkbox"/> Non-Fail-Safe |
| RY Pulse Time                | 0.05                                     | 0.25          | 10  | s    |                                                  |                                        |
| <b>Analog Input</b>          |                                          |               |     |      |                                                  |                                        |
| 4-20 Input Type              |                                          | Metering Only |     |      | <input type="checkbox"/> Metering Only           | <input type="checkbox"/> Sync. to ASD  |
|                              |                                          |               |     |      | <input type="checkbox"/> Protection              | <input type="checkbox"/> 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    |                                                  |                                        |
| Sync to ASD Set Points:      |                                          |               |     |      |                                                  |                                        |
| 4-mA Frequency               | 0                                        | 10.00         | 70  | Hz   |                                                  |                                        |
| 20-mA Frequency              | 0                                        | 60.00         | 70  | Hz   |                                                  |                                        |
| Motor Speed Set Points:      |                                          |               |     |      |                                                  |                                        |
| 4-mA Percent Speed           | 0                                        | 10.00         | 100 | %    |                                                  |                                        |
| 20-mA Percent Speed          | 0                                        | 100.00        | 100 | %    |                                                  |                                        |
| <b>Analog Output</b>         |                                          |               |     |      |                                                  |                                        |
| Output Parameter             |                                          | Phase Current |     |      | See Table 4.3 Analog Output Parameter Definition |                                        |
| Zero Calibrate               | Factory Calibrated                       |               |     |      |                                                  |                                        |
| Full-Scale Calibrate         | Factory Calibrated                       |               |     |      |                                                  |                                        |
| <b>OPI Display</b>           |                                          |               |     |      |                                                  |                                        |
| OPI-Loss Trip                |                                          | Trip1         |     |      | <input type="checkbox"/> Disable                 | <input type="checkbox"/> Trip1         |
|                              |                                          |               |     |      | <input type="checkbox"/> Trip2                   | <input type="checkbox"/> Trip3         |
| Number of OPI's              |                                          | 1             |     |      | <input type="checkbox"/> 1                       | <input type="checkbox"/> 3             |
|                              |                                          |               |     |      | <input type="checkbox"/> 2                       |                                        |
| Intensity                    |                                          | 100           |     | %    | <input type="checkbox"/> 25                      | <input type="checkbox"/> 75            |
|                              |                                          |               |     |      | <input type="checkbox"/> 50                      | <input type="checkbox"/> 100           |
| Screen Saver                 |                                          | Enable        |     |      | <input type="checkbox"/> Enable                  | <input type="checkbox"/> Disable       |
| <b>OPI Control Select</b>    |                                          |               |     |      |                                                  |                                        |
| Remote Select                |                                          | Enable        |     |      | <input type="checkbox"/> Enable                  | <input type="checkbox"/> Disable       |
| OPI Select                   |                                          | Enable        |     |      | <input type="checkbox"/> Enable                  | <input type="checkbox"/> Disable       |
| Local Select                 |                                          | Enable        |     |      | <input type="checkbox"/> Enable                  | <input type="checkbox"/> Disable       |
| <b>RTD Modules</b>           |                                          |               |     |      |                                                  |                                        |
| Total Modules                |                                          | 0             |     |      | <input type="checkbox"/> 0                       | <input type="checkbox"/> 2             |
|                              |                                          |               |     |      | <input type="checkbox"/> 1                       | <input type="checkbox"/> 3             |
| RTD-Module-Error Trip Action |                                          | Disable       |     |      | <input type="checkbox"/> Disable                 | <input type="checkbox"/> Trip1         |
|                              |                                          |               |     |      | <input type="checkbox"/> Trip2                   | <input type="checkbox"/> Trip3         |

| PARAMETER AND SETTINGS                                                  | MIN                                                             | DEFAULT         | MAX  | UNIT             | PROGRAM SELECTION                                                                                                                                                                                     |                                                                                                                                                                   |
|-------------------------------------------------------------------------|-----------------------------------------------------------------|-----------------|------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RTD-Module-Error Alarm Action                                           |                                                                 | Disable         |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2                                                                                                                                   | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3                                                                                                |
| Temperature Trip Action                                                 |                                                                 | Trip1           |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                                                                                                                                    | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3                                                                                                  |
| Temperature Alarm Action                                                |                                                                 | Alarm1          |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2                                                                                                                                   | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3                                                                                                |
| <b>DIF Module</b>                                                       |                                                                 |                 |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Enable/Disable                                                          |                                                                 | Disable         |      |                  | <input type="checkbox"/> Enable                                                                                                                                                                       | <input type="checkbox"/> Disable                                                                                                                                  |
| DIF-Module-Error Trip Action                                            |                                                                 | Disable         |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                                                                                                                                    | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3                                                                                                  |
| DIF-Module-Error Alarm Action                                           |                                                                 | Disable         |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                                                                                                                                    | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3                                                                                                  |
| <b>Network Communications</b>                                           |                                                                 |                 |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Network Type                                                            |                                                                 | Modbus          |      |                  | <input type="checkbox"/> None<br><input type="checkbox"/> Allen-Bradley<br><input type="checkbox"/> Modbus                                                                                            | <input type="checkbox"/> DeviceNet<br><input type="checkbox"/> Anybus<br><input type="checkbox"/> Modbus TCP                                                      |
| Network ID                                                              | 0                                                               | 254             | 255  |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Baud Rate                                                               |                                                                 | SCI 9600        |      |                  | <input type="checkbox"/> SCI 1200<br><input type="checkbox"/> SCI 2400<br><input type="checkbox"/> SCI 4800<br><input type="checkbox"/> SCI 9600<br><input type="checkbox"/> SCI 19200 <sup>(1)</sup> | <input type="checkbox"/> DN125<br><input type="checkbox"/> DN250<br><input type="checkbox"/> DN500                                                                |
| Error Checking                                                          |                                                                 | Not Selected    |      |                  | <input type="checkbox"/> Not Selected<br><input type="checkbox"/> CRC                                                                                                                                 | <input type="checkbox"/> BCC                                                                                                                                      |
| Ethernet IP                                                             |                                                                 | 192.168.000.001 |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Ethernet Mask                                                           |                                                                 | 255.255.255.000 |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Default Gateway                                                         |                                                                 | 0.0.0.0         |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Network-Error Trip Action                                               |                                                                 | Disable         |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                                                                                                                                    | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3                                                                                                  |
| Network-Error Alarm Action                                              |                                                                 | Disable         |      |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2                                                                                                                                   | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3                                                                                                |
| DeviceNet Producing Assembly                                            |                                                                 | 0x36            |      |                  | <input type="checkbox"/> None<br><input type="checkbox"/> 0x33<br><input type="checkbox"/> 0x35<br><input type="checkbox"/> 0x64<br><input type="checkbox"/> 0x66                                     | <input type="checkbox"/> 0x32<br><input type="checkbox"/> 0x34<br><input type="checkbox"/> 0x36<br><input type="checkbox"/> 0x65<br><input type="checkbox"/> 0x67 |
| DeviceNet Consuming Assembly                                            |                                                                 | None            |      |                  | <input type="checkbox"/> None<br><input type="checkbox"/> 0x03<br><input type="checkbox"/> 0x05                                                                                                       | <input type="checkbox"/> 0x02<br><input type="checkbox"/> 0x04                                                                                                    |
| System Name                                                             | Startco MPS                                                     |                 |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Change Password                                                         |                                                                 | 1111            |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Password Timeout                                                        | 1                                                               | 10.00           | 60   | min.             |                                                                                                                                                                                                       |                                                                                                                                                                   |
| I <sub>p</sub> Threshold<br>(I <sub>p</sub> is Phase-CT-Primary Rating) | 0.10                                                            | 0.10            | 0.50 | x I <sub>p</sub> |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Firmware Revision                                                       | See Protection   System Config   Maintenance   Firmware Version |                 |      |                  |                                                                                                                                                                                                       |                                                                                                                                                                   |
| Trace Auto-Start                                                        |                                                                 | Disable         |      |                  | <input type="checkbox"/> Enable                                                                                                                                                                       | <input type="checkbox"/> Disable                                                                                                                                  |

<sup>(1)</sup> Error rate is 1 byte/120 kB. For high reliability, use SCI9600.

## PART II: STARTER PARAMETERS

| SET POINT                           | MIN             | DEFAULT | MAX   | UNIT  | PROGRAM SELECTION               |                                  |
|-------------------------------------|-----------------|---------|-------|-------|---------------------------------|----------------------------------|
| <b>Starter Type</b> (see Table 6.2) | Protection Only |         |       |       |                                 |                                  |
| Start Time                          | 0.1             | 20.00   | 500   | s     |                                 |                                  |
| Stage 1 Delay                       | 0.1             | 20.00   | 500   | s     |                                 |                                  |
| Stage 2 Delay                       | 0.1             | 20.00   | 500   | s     |                                 |                                  |
| Stage 3 Delay                       | 0.1             | 20.00   | 500   | s     |                                 |                                  |
| <b>Backspin Timer</b>               |                 | Disable |       |       | <input type="checkbox"/> Enable | <input type="checkbox"/> Disable |
| Backspin Delay                      | 0.1             | 5.00    | 3,600 | s     |                                 |                                  |
| <b>Remote Group</b>                 |                 |         |       |       |                                 |                                  |
| Digital Inputs                      |                 | Enable  |       |       | <input type="checkbox"/> Enable | <input type="checkbox"/> Disable |
| Network                             |                 | Enable  |       |       | <input type="checkbox"/> Enable | <input type="checkbox"/> Disable |
| OPI                                 |                 | Enable  |       |       | <input type="checkbox"/> Enable | <input type="checkbox"/> Disable |
| <b>Transfer</b>                     |                 |         |       |       |                                 |                                  |
| Type                                |                 | Time    |       |       | <input type="checkbox"/> Time   | <input type="checkbox"/> Current |
| Level                               | 1.0             | 1.25    | 3.0   | x FLA |                                 |                                  |

## PART III: PROTECTION SET POINTS

| FUNCTION & SET POINT                                                        | MIN  | DEFAULT | MAX | UNIT             | PROGRAM SELECTION                                                                   |                                                                    |
|-----------------------------------------------------------------------------|------|---------|-----|------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Overload</b>                                                             |      |         |     |                  |                                                                                     |                                                                    |
| Trip Action                                                                 |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Model Type                                                                  |      | NEMA    |     |                  | <input type="checkbox"/> NEMA                                                       | <input type="checkbox"/> K-Factor                                  |
| K-Factor                                                                    | 1    | 6.00    | 10  |                  |                                                                                     |                                                                    |
| Locked-Rotor Current                                                        | 1.5  | 6.00    | 10  | x FLA            |                                                                                     |                                                                    |
| Locked-Rotor Time Cold                                                      | 0.10 | 10.00   | 100 | s                |                                                                                     |                                                                    |
| Locked-Rotor Time Hot                                                       | 0.10 | 5.00    | 100 | s                |                                                                                     |                                                                    |
| Cooling Factor                                                              | 0.10 | 2.00    | 10  |                  |                                                                                     |                                                                    |
| I <sup>2</sup> t Start Inhibit                                              |      | Disable |     |                  | <input type="checkbox"/> Enable                                                     | <input type="checkbox"/> Disable                                   |
| I <sup>2</sup> t Inhibit Level<br>(Per Unit Based on 100% I <sup>2</sup> t) | 0.10 | 0.30    | .90 | pu               |                                                                                     |                                                                    |
| I <sup>2</sup> t Alarm Action                                               |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2                 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| I <sup>2</sup> t Overload Alarm Level                                       | 0.50 | 1.00    | 1   | pu               |                                                                                     |                                                                    |
| Reset Type                                                                  |      | Normal  |     |                  | <input type="checkbox"/> Normal<br><input type="checkbox"/> Multiple Motor Sequence | <input type="checkbox"/> Auto                                      |
| <b>Overcurrent</b>                                                          |      |         |     |                  |                                                                                     |                                                                    |
| Trip Action                                                                 |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(I <sub>p</sub> is Phase-CT-Primary Rating)                   | 1    | 10.00   | 15  | x I <sub>p</sub> |                                                                                     |                                                                    |
| Trip Delay                                                                  | 0    | 0.05    | 10  | s                |                                                                                     |                                                                    |
| <b>Auxiliary Overcurrent</b>                                                |      |         |     |                  |                                                                                     |                                                                    |
| Trip Action                                                                 |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2                  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(I <sub>p</sub> is Phase-CT-Primary Rating)                   | 1    | 10.00   | 15  | x I <sub>p</sub> |                                                                                     |                                                                    |
| Trip Delay                                                                  | 0    | 0.05    | 10  | s                |                                                                                     |                                                                    |



| FUNCTION & SET POINT                                              | MIN  | DEFAULT | MAX | UNIT             | PROGRAM SELECTION                                                   |                                                                    |
|-------------------------------------------------------------------|------|---------|-----|------------------|---------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Reduced Overcurrent</b>                                        |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(I <sub>p</sub> is Phase-CT-Primary Rating)         | 1    | 2.00    | 15  | x I <sub>p</sub> |                                                                     |                                                                    |
| <b>Earth Fault</b>                                                |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(I <sub>e</sub> is EF-CT-Primary Rating)            | 0.05 | 0.40    | 1   | x I <sub>e</sub> |                                                                     |                                                                    |
| Trip Delay                                                        | 0    | 0.25    | 100 | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level<br>(I <sub>e</sub> is EF-CT-Primary Rating)           | 0.05 | 0.20    | 1   | x I <sub>e</sub> |                                                                     |                                                                    |
| Alarm Delay                                                       | 0    | 1.00    | 100 | s                |                                                                     |                                                                    |
| <b>Jam</b>                                                        |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level                                                        | 1    | 6.00    | 10  | x FLA            |                                                                     |                                                                    |
| Trip Delay                                                        | 1    | 5.00    | 100 | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                                                       | 1    | 3.00    | 10  | x FLA            |                                                                     |                                                                    |
| Alarm Delay                                                       | 1    | 5.00    | 100 | s                |                                                                     |                                                                    |
| <b>Unbalance (I)</b>                                              |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(Per Unit Based on I <sub>2</sub> /I <sub>1</sub> ) | 0.05 | 0.25    | 1   | pu               |                                                                     |                                                                    |
| Trip Delay                                                        | 1    | 15.00   | 100 | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                                                       | 0.05 | 0.10    | 1   | pu               |                                                                     |                                                                    |
| Alarm Delay                                                       | 1    | 10.00   | 100 | s                |                                                                     |                                                                    |
| <b>Phase Loss (I)</b>                                             |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Phase Loss Delay                                                  | 1    | 5.00    | 100 | s                |                                                                     |                                                                    |
| <b>Phase Reverse (I)</b>                                          |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Alarm Action                                                      |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Trip and Alarm Delay                                              | 1    | 2.00    | 100 | s                |                                                                     |                                                                    |

| FUNCTION & SET POINT                                              | MIN  | DEFAULT | MAX | UNIT             | PROGRAM SELECTION                                                   |                                                                    |
|-------------------------------------------------------------------|------|---------|-----|------------------|---------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Unbalance (V)</b>                                              |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Trip1   |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(Per Unit Based on V <sub>2</sub> /V <sub>1</sub> ) | 0.05 | 0.10    | 1   | pu               |                                                                     |                                                                    |
| Trip Delay                                                        | 1    | 15.00   | 100 | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                                                       | 0.05 | 0.05    | 1   | pu               |                                                                     |                                                                    |
| Alarm Delay                                                       | 1    | 10.00   | 100 | s                |                                                                     |                                                                    |
| <b>Phase Loss (V)</b>                                             |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Phase Loss Delay                                                  | 1    | 5.00    | 100 | s                |                                                                     |                                                                    |
| <b>Phase Reverse (V)</b>                                          |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Alarm Action                                                      |      | Alarm1  |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Phase Reverse<br>Trip and Alarm Delay                             | 1    | 2.00    | 100 | s                |                                                                     |                                                                    |
| <b>Undercurrent</b>                                               |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level                                                        | 0.1  | 0.50    | 1   | x FLA            |                                                                     |                                                                    |
| Trip Delay                                                        | 1    | 10.00   | 100 | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                                                       | 0.1  | 0.80    | 1   | x FLA            |                                                                     |                                                                    |
| Alarm Delay                                                       | 1    | 20.00   | 100 | s                |                                                                     |                                                                    |
| <b>Differential</b>                                               |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(I <sub>d</sub> is DF-CT-Primary Current)           | 0.1  | 1.00    | 15  | x I <sub>d</sub> |                                                                     |                                                                    |
| Trip Delay                                                        | 0    | 0.10    | 10  | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level<br>(I <sub>d</sub> is DF-CT-Primary Current)          | 0.1  | 0.50    | 15  | x I <sub>d</sub> |                                                                     |                                                                    |
| Alarm Delay                                                       | 0    | 0.10    | 10  | s                |                                                                     |                                                                    |
| <b>PF Quadrant 4</b>                                              |      |         |     |                  |                                                                     |                                                                    |
| Trip Action                                                       |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level                                                        | 0.5  | 0.80    | 1   |                  |                                                                     |                                                                    |
| Trip Delay                                                        | 0.1  | 5.00    | 500 | s                |                                                                     |                                                                    |
| Alarm Action                                                      |      | Disable |     |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                                                       | 0.5  | 0.90    | 1   |                  |                                                                     |                                                                    |
| Alarm Delay                                                       | 0.1  | 5.00    | 500 | s                |                                                                     |                                                                    |

| FUNCTION & SET POINT                     | MIN | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                   |                                                                    |
|------------------------------------------|-----|---------|-----|------|---------------------------------------------------------------------|--------------------------------------------------------------------|
| PF Quadrant 3                            |     |         |     |      |                                                                     |                                                                    |
| Trip Action                              |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level                               | 0.5 | 0.80    | 1   |      |                                                                     |                                                                    |
| Trip Delay                               | 0.1 | 5.00    | 500 | s    |                                                                     |                                                                    |
| Alarm Action                             |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                              | 0.5 | 0.90    | 1   |      |                                                                     |                                                                    |
| Alarm Delay                              | 0.1 | 5.00    | 500 | s    |                                                                     |                                                                    |
| Underpower                               |     |         |     |      |                                                                     |                                                                    |
| Trip Action                              |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(Per Unit of Rated Power)  | 0.1 | 0.80    | 1   | pu   |                                                                     |                                                                    |
| Trip Delay                               | 0.5 | 5.00    | 500 | s    |                                                                     |                                                                    |
| Alarm Action                             |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level<br>(Per Unit of Rated Power) | 0.1 | 0.80    | 1   | pu   |                                                                     |                                                                    |
| Alarm Delay                              | 0.5 | 1.00    | 500 | s    |                                                                     |                                                                    |
| Reversepower                             |     |         |     |      |                                                                     |                                                                    |
| Trip Action                              |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(Per Unit of Rated Power)  | 0.1 | 0.20    | 1   | pu   |                                                                     |                                                                    |
| Trip Delay                               | 0.5 | 5.00    | 500 | s    |                                                                     |                                                                    |
| Alarm Action                             |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level<br>(Per Unit of Rated Power) | 0.1 | 0.20    | 1   | pu   |                                                                     |                                                                    |
| Alarm Delay                              | 0.5 | 1.00    | 500 | s    |                                                                     |                                                                    |
| Underfrequency                           |     |         |     |      |                                                                     |                                                                    |
| Trip Action                              |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level                               | 30  | 45      | 80  | Hz   |                                                                     |                                                                    |
| Trip Delay                               | 0.5 | 5       | 500 | s    |                                                                     |                                                                    |
| Alarm Action                             |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                              | 30  | 48      | 80  | Hz   |                                                                     |                                                                    |
| Alarm Delay                              | 0.5 | 1       | 500 | s    |                                                                     |                                                                    |
| Overfrequency                            |     |         |     |      |                                                                     |                                                                    |
| Trip Action                              |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level                               | 30  | 65      | 80  | Hz   |                                                                     |                                                                    |
| Trip Delay                               | 0.5 | 5       | 500 | s    |                                                                     |                                                                    |
| Alarm Action                             |     | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level                              | 30  | 62      | 80  | Hz   |                                                                     |                                                                    |
| Alarm Delay                              | 0.5 | 1       | 500 | s    |                                                                     |                                                                    |

| FUNCTION & SET POINT                              | MIN | DEFAULT | MAX   | UNIT             | PROGRAM SELECTION                                                   |                                                                    |
|---------------------------------------------------|-----|---------|-------|------------------|---------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>PTC Temperature</b>                            |     |         |       |                  |                                                                     |                                                                    |
| Trip Action                                       |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Alarm Action                                      |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| <b>RTD-Sensor-Error Trip Action</b>               |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| <b>RTD-Sensor-Error Alarm Action</b>              |     | Alarm1  |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| <b>Hot-Motor Compensation (HMC)</b>               |     | Disable |       |                  | <input type="checkbox"/> Enable                                     | <input type="checkbox"/> Disable                                   |
| HMC High                                          | 40  | 150.00  | 200   | °C               |                                                                     |                                                                    |
| HMC Low                                           | 40  | 40.00   | 200   | °C               |                                                                     |                                                                    |
| <b>Acceleration Failure—Underspeed</b>            |     |         |       |                  |                                                                     |                                                                    |
| Trip Action                                       |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Speed 1 (Percent Sync Speed)                      | 1   | 30.00   | 100   | % SS             |                                                                     |                                                                    |
| Time 1                                            | 1   | 5.00    | 1,000 | s                |                                                                     |                                                                    |
| Speed 2                                           | 1   | 60.00   | 100   | % SS             |                                                                     |                                                                    |
| Time 2                                            | 1   | 10.00   | 1,000 | s                |                                                                     |                                                                    |
| Speed 3                                           | 1   | 90.00   | 100   | % SS             |                                                                     |                                                                    |
| Time 3                                            | 1   | 15.00   | 1,000 | s                |                                                                     |                                                                    |
| <b>Overvoltage</b>                                |     |         |       |                  |                                                                     |                                                                    |
| Trip Action                                       |     | Trip1   |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(V <sub>p</sub> is system voltage)  | 1   | 1.20    | 1.4   | x V <sub>p</sub> |                                                                     |                                                                    |
| Trip Delay                                        | 1   | 5.00    | 500   | s                |                                                                     |                                                                    |
| Alarm Action                                      |     | Alarm1  |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level<br>(V <sub>p</sub> is system voltage) | 1   | 1.10    | 1.4   | x V <sub>p</sub> |                                                                     |                                                                    |
| Alarm Delay                                       | 1   | 5.00    | 500   | s                |                                                                     |                                                                    |
| <b>Undervoltage</b>                               |     |         |       |                  |                                                                     |                                                                    |
| Trip Action                                       |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Trip Level<br>(V <sub>p</sub> is system voltage)  | 0.5 | 0.70    | 1     | x V <sub>p</sub> |                                                                     |                                                                    |
| Trip Delay                                        | 1   | 5.00    | 500   | s                |                                                                     |                                                                    |
| Alarm Action                                      |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Alarm Level<br>(V <sub>p</sub> is system voltage) | 0.5 | 0.80    | 1     | x V <sub>p</sub> |                                                                     |                                                                    |
| Alarm Delay                                       | 1   | 5.00    | 500   | s                |                                                                     |                                                                    |
| <b>Starts/Hour</b>                                |     |         |       |                  |                                                                     |                                                                    |
| Trip Action                                       |     | Disable |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Trip2  | <input type="checkbox"/> Trip1<br><input type="checkbox"/> Trip3   |
| Alarm Action                                      |     |         |       |                  | <input type="checkbox"/> Disable<br><input type="checkbox"/> Alarm2 | <input type="checkbox"/> Alarm1<br><input type="checkbox"/> Alarm3 |
| Number of Starts/Hour                             | 1   | 5       | 10    |                  |                                                                     |                                                                    |
| Time Between Starts                               | 0   | 0.00    | 500   | min              |                                                                     |                                                                    |

| FUNCTION & SET POINT                             | MIN             | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------|-----------------|---------|-----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RTD TEMPERATURE</b><br>Requires RTD Module(s) |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #1:</b>                                |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                                             | RTD Module 1 #1 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                                             |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function                                         |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                                             | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                                            | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #2:</b>                                |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                                             | RTD Module 1 #2 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                                             |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function                                         |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                                             | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                                            | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #3:</b>                                |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                                             | RTD Module 1 #3 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                                             |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function                                         |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                                             | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                                            | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #4:</b>                                |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                                             | RTD Module 1 #4 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                                             |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function                                         |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                                             | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                                            | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |

| FUNCTION & SET POINT | MIN             | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                                                                                                                                                                                                                                                    |
|----------------------|-----------------|---------|-----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RTD M1 #5:</b>    |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                 | RTD Module 1 #5 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #6:</b>    |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                 | RTD Module 1 #6 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #7:</b>    |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                 | RTD Module 1 #7 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| <b>RTD M1 #8:</b>    |                 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Name                 | RTD Module 1 #8 |         |     |      |                                                                                                                                                                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Pt100 Ω <input type="checkbox"/> Cu10 Ω<br><input type="checkbox"/> Ni100 Ω                                                                                                                            |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator <input type="checkbox"/> Load<br><input type="checkbox"/> Bearing <input type="checkbox"/> Ambient<br><input type="checkbox"/> Stator Voting <input type="checkbox"/> Load Voting<br><input type="checkbox"/> Bearing Voting <input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                                                                                                                                                                      |

| FUNCTION & SET POINT | MIN             | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                                                                                                        |                                                                                                                                                      |
|----------------------|-----------------|---------|-----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RTD M2 #1:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #1 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M2 #2:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #2 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M2 #3:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #3 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M2 #4:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #4 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |

| FUNCTION & SET POINT | MIN             | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                                                                                                        |                                                                                                                                                      |
|----------------------|-----------------|---------|-----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RTD M2 #5:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #5 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M2 #6:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #6 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M2 #7:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #7 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M2 #8:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 2 #8 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |



| FUNCTION & SET POINT | MIN             | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                                                                                                        |                                                                                                                                                      |
|----------------------|-----------------|---------|-----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RTD M3 #1:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #1 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M3 #2:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #2 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M3 #3:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #3 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M3 #4:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #4 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |

| FUNCTION & SET POINT | MIN             | DEFAULT | MAX | UNIT | PROGRAM SELECTION                                                                                                                                        |                                                                                                                                                      |
|----------------------|-----------------|---------|-----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RTD M3 #5:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #5 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M3 #6:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #6 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M3 #7:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #7 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| <b>RTD M3 #8:</b>    |                 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Name                 | RTD Module 3 #8 |         |     |      |                                                                                                                                                          |                                                                                                                                                      |
| Type                 |                 | Disable |     |      | <input type="checkbox"/> Disable<br><input type="checkbox"/> Pt100 Ω<br><input type="checkbox"/> Ni100 Ω                                                 | <input type="checkbox"/> Ni120 Ω<br><input type="checkbox"/> Cu10 Ω                                                                                  |
| Function             |                 | Stator  |     |      | <input type="checkbox"/> Stator<br><input type="checkbox"/> Bearing<br><input type="checkbox"/> Stator Voting<br><input type="checkbox"/> Bearing Voting | <input type="checkbox"/> Load<br><input type="checkbox"/> Ambient<br><input type="checkbox"/> Load Voting<br><input type="checkbox"/> Ambient Voting |
| Trip                 | 40              | 130.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |
| Alarm                | 40              | 110.00  | 200 | °C   |                                                                                                                                                          |                                                                                                                                                      |

## APPENDIX C MPS MODBUS PROTOCOL

### C.1 PROTOCOL

The MPS 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 MPS-CTU slaves connected using a 2-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 MPS 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 MPS 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 MPS will respond with an exception response code.

### C.4 FUNCTION CODES SUPPORTED

The MPS 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 MPS.

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

#### C.4.1 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 | 0xCA

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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 MPS 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 MPS.

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 MPS 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 MPS. 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           | STOP                                      |
| 0x0001       | 2           | START1                                    |
| 0x0002       | 3           | START2                                    |
| 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 <sup>2</sup> t and Trip Reset |
| 0x000A       | 11          | Select Local Control                      |
| 0x000B       | 12          | De-select Local Control                   |
| 0x000C       | 13          | Re-enable Temperature Protection          |
| 0x000D       | 14          | Start Trace                               |

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, MPS commands can be issued using Write Single Register (Code 6) and Write Multiple Register (Code 16).

Commands are written to MPS 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 MPS Register 6. If multiple registers are written starting at MPS 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 MPS will return a valid response message.

#### C.4.6 EXCEPTION RESPONSES

The MPS supports the following exception responses:

- Boundary 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 Boundary 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 MPS 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 MPS 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.

**NOTE:** 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 <sup>(3)</sup>              |
| Bit Format .....                | 8 bits, no parity, one stop bit <sup>(1)</sup>    |
| Number of CTU's Connected ..... | Maximum of 32 units                               |
| Bus length.....                 | 1,200 m (4,000') total <sup>(2)</sup>             |

<sup>(1)</sup> 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.

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

<sup>(3)</sup> Error rate is 1 byte/120 kB at 19,200 bit/s. For high reliability, use 9600 bit/s.

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## APPENDIX D MPS A-B DF1 PROTOCOL

### D.1 PROTOCOL

The MPS 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](http://www.ab.com).

The communications system consists of a single master and up to thirty-two slaves connected to a 2-wire RS-485 multi-drop network. MPS 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 MPS 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 MPS 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 MPS 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 MPS communications port. Typically, a DH+ port will be used for PLC programming and the RS-232 port is used for MPS 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 MPS settings. The parity bit is not supported on the MPS. 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 MPS 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 MPS. 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 of SLC for SLC500 or Control Logix  
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 precede with N, <N><FILE+20>:<ELEMENT> (Example N29:222). *Local Address* is the MPS 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 MPS 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 MPS.

Data Table Address: .....N9:0

Element Size: .....100

Target Device Data

Table Address: .....N23:264 (Start of Digital Inputs)

Local Address: .....9 (Must match MPS setting)

If an MPS 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 MPS 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 MPS.

Read/Write: Write

Target Device: PLC5 or SLC for SLC500 or Control Logix

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 MPS, 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 MPS. The MPS will do a range check on all messages to ensure valid data.

*Local Address* is the MPS 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 MPS setting)

Reset commands to the MPS are issued by writing an integer command code to MPS 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 MPS COMMANDS

| COMMAND CODE | ACTION                                    |
|--------------|-------------------------------------------|
| 0x0000       | STOP                                      |
| 0x0001       | START1                                    |
| 0x0002       | START2                                    |
| 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 <sup>2</sup> t and Trip Reset |
| 0x000A       | Select Local Control                      |
| 0x000B       | De-select Local Control                   |
| 0x000C       | Re-enable Temperature Protection          |
| 0x000D       | Start Trace                               |

Example settings for writing an MPS reset command.

Data-Table Address: .....N9:0 (Reset code = 3)

Element Size: .....1

Target-Device Data-

Table Address: .....N23:6 (MPS Command Register location)

Local Address: .....9 (Must match MPS 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 MPS 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-MPS 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 MPS 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 MPS 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 MPS 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.

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

## D.10 SPECIFICATIONS

|                                 |                                                     |
|---------------------------------|-----------------------------------------------------|
| Interface .....                 | Isolated RS-485, 2-wire,<br>multi-drop, half duplex |
| Protocol .....                  | Modbus RTU                                          |
| Baud Rate .....                 | 1,200 to 19,200 bit/s <sup>(3)</sup>                |
| Bit Format .....                | 8 bits, no parity, one stop<br>bit <sup>(1)</sup>   |
| Number of CTU's Connected ..... | Maximum of 32 units                                 |
| Bus length.....                 | 1,200 m (4,000') total <sup>(2)</sup>               |

- <sup>(1)</sup> 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.
- <sup>(2)</sup> For line lengths exceeding 10 m (30'), 150-Ω terminations are required at the cable ends.
- <sup>(3)</sup> Error rate is 1 byte/120 kB at 19,200 bit/s. For high reliability, use 9600 bit/s.

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## APPENDIX E

### COMMUNICATIONS DATABASE TABLE FOR V. 3.04

| MPS REGISTER (DECIMAL)   | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                    | ACCESS     | RANGE                   | TYPE      |
|--------------------------|---------------------------|-----------------------------|--------------------------------|------------|-------------------------|-----------|
| <b>Model Information</b> |                           |                             |                                |            |                         |           |
| 0                        | 40001                     | 3:000                       | Model Code (201)               | Read Only  |                         | T3        |
| 1                        |                           |                             | Software Version               | Read Only  |                         | T3        |
| 2                        |                           |                             | Serial Number                  | Read Only  |                         | T2 (Low)  |
| 3                        |                           |                             |                                |            |                         | T2 (High) |
| 4                        |                           |                             |                                |            |                         |           |
| 5                        |                           |                             | Diagnostic Code                | Read Only  |                         | T3        |
| 6                        | N/A                       |                             | DF1 Command Register           | Write Only |                         | T37       |
|                          |                           |                             |                                |            |                         |           |
| <b>Overload</b>          |                           |                             |                                |            |                         |           |
| 8                        | 40009                     | 3:8                         | Trip Action                    | R/W        | 0 - 7                   | T42       |
| 9                        |                           |                             | Model Type                     | R/W        | 0 - 1                   | T33       |
| 10                       |                           |                             | I <sup>2</sup> t Start Inhibit | R/W        | 0 - 1                   | T6        |
| 11                       |                           |                             | K-Factor                       | R/W        | 0 - 10                  | T1 (Low)  |
| 12                       |                           |                             |                                |            |                         | T1 (High) |
| 13                       |                           |                             | Locked-Rotor Current           | R/W        | 1.5 - 10 x FLA          | T1 (Low)  |
| 14                       |                           |                             |                                |            |                         | T1 (High) |
| 15                       |                           |                             | Locked-Rotor Time Cold         | R/W        | 0.2 - 100 s             | T1 (Low)  |
| 16                       |                           |                             |                                |            |                         | T1 (High) |
| 17                       |                           |                             | Locked-Rotor Time Hot          | R/W        | 0.2 - 100 s             | T1 (Low)  |
| 18                       |                           |                             |                                |            |                         | T1 (High) |
| 19                       |                           |                             | Cooling Factor                 | R/W        | 0.1 - 50                | T1 (Low)  |
| 20                       |                           |                             |                                |            |                         | T1 (High) |
| 21                       |                           |                             | I <sup>2</sup> t Inhibit Level | R/W        | 0.1 - 0.9               | T1 (Low)  |
| 22                       |                           |                             |                                |            |                         | T1 (High) |
| 23                       |                           |                             | I <sup>2</sup> t Alarm level   | R/W        | 0.5 - 1.0               | T1 (Low)  |
| 24                       |                           |                             |                                |            |                         | T1 (High) |
| 25                       |                           |                             | I <sup>2</sup> t Alarm Action  | R/W        | 0 - 7                   | T43       |
| 26                       |                           |                             | I <sup>2</sup> t Reset Type    | R/W        | 0 - 2                   | T38       |
| <b>Overcurrent</b>       |                           |                             |                                |            |                         |           |
| 32                       | 40033                     | 3:32                        | Trip Action                    | R/W        | 0 - 7                   | T42       |
| 33                       |                           |                             | Trip Level                     | R/W        | 1 - 15 x I <sub>p</sub> | T1 (Low)  |
| 34                       |                           |                             |                                |            |                         | T1 (High) |
| 35                       |                           |                             | Trip Delay                     | R/W        | 0 - 10 s                | T1 (Low)  |
| 36                       |                           |                             |                                |            |                         | T1 (High) |
| <b>Aux Overcurrent</b>   |                           |                             |                                |            |                         |           |
| 40                       | 40041                     | 3:40                        | Trip Action                    | R/W        | 0 - 7                   | T42       |
| 41                       |                           |                             | Trip Level                     | R/W        | 1 - 15 x I <sub>p</sub> | T1 (Low)  |
| 42                       |                           |                             |                                |            |                         | T1 (High) |
| 43                       |                           |                             | Trip Delay                     | R/W        | 0 - 10 s                | T1 (Low)  |
| 44                       |                           |                             |                                |            |                         | T1 (High) |

| MPS REGISTER (DECIMAL)     | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION          | ACCESS | RANGE                       | TYPE      |
|----------------------------|---------------------------|-----------------------------|----------------------|--------|-----------------------------|-----------|
| <b>Reduced Overcurrent</b> |                           |                             |                      |        |                             |           |
| 45                         | 40046                     | 3:45                        | Trip Action          | R/W    | 0 - 7                       | T42       |
| 46                         |                           |                             | Trip Level           | R/W    | 1 - 15 x I <sub>p</sub>     | T1 (Low)  |
| 47                         |                           |                             |                      |        |                             | T1 (High) |
| <b>Earth Fault</b>         |                           |                             |                      |        |                             |           |
| 48                         | 40049                     | 3:48                        | Trip Action          | R/W    | 0 - 7                       | T42       |
| 49                         |                           |                             | Spare                |        |                             |           |
| 50                         |                           |                             | Trip Level           | R/W    | 0.05 - 1.0 x I <sub>e</sub> | T1(Low)   |
| 51                         |                           |                             |                      |        |                             | T1(High)  |
| 52                         |                           |                             | Trip Delay           | R/W    | 0 - 100 s                   | T1(Low)   |
| 53                         |                           |                             |                      |        |                             | T1(High)  |
| 54                         |                           |                             | Alarm Level          | R/W    | 0.05 - 1.0 x I <sub>e</sub> | T1(Low)   |
| 55                         |                           |                             |                      |        |                             | T1(High)  |
| 56                         |                           |                             | Alarm Delay          | R/W    | 0 - 100 s                   | T1(Low)   |
| 57                         |                           |                             |                      |        |                             | T1(High)  |
| 58                         |                           |                             | Alarm Action         | R/W    | 0 - 7                       | T43       |
| <b>Jam</b>                 |                           |                             |                      |        |                             |           |
| 64                         | 40065                     | 3:64                        | Trip Action          | R/W    | 0 - 7                       | T42       |
| 65                         |                           |                             | Trip Level           | R/W    | 1 - 10 x FLA                | T1(Low)   |
| 66                         |                           |                             |                      |        |                             | T1(High)  |
| 67                         |                           |                             | Trip Delay           | R/W    | 1 - 100 s                   | T1(Low)   |
| 68                         |                           |                             |                      |        |                             | T1(High)  |
| 69                         |                           |                             | Alarm Level          | R/W    | 1 - 10 x FLA                | T1(Low)   |
| 70                         |                           |                             |                      |        |                             | T1(High)  |
| 71                         |                           |                             | Alarm Delay          | R/W    | 1 - 100 s                   | T1(Low)   |
| 72                         |                           |                             |                      |        |                             | T1(High)  |
| 73                         |                           |                             | Alarm Action         | R/W    | 0 - 7                       | T43       |
| <b>Current Unbalance</b>   |                           |                             |                      |        |                             |           |
| 80                         | 40081                     | 3:80                        | Trip Action          | R/W    | 0 - 7                       | T42       |
| 81                         |                           |                             | Trip Level           | R/W    | 0.05 - 1.0 pu               | T1(Low)   |
| 82                         |                           |                             |                      |        |                             | T1(High)  |
| 83                         |                           |                             | Trip Delay           | R/W    | 1.0 - 100 s                 | T1(Low)   |
| 84                         |                           |                             |                      |        |                             | T1(High)  |
| 85                         |                           |                             | Alarm Level          | R/W    | 0.05 - 1.0 pu               | T1(Low)   |
| 86                         |                           |                             |                      |        |                             | T1(High)  |
| 87                         |                           |                             | Alarm Delay          | R/W    | 1.0 - 100 s                 | T1(Low)   |
| 88                         |                           |                             |                      |        |                             | T1(High)  |
| 89                         |                           |                             | Alarm Action         | R/W    | 0 - 7                       | T43       |
| <b>Phase Reverse (I)</b>   |                           |                             |                      |        |                             |           |
| 95                         | 40096                     | 3:95                        | Alarm Action         | R/W    | 0 - 7                       | T43       |
| 96                         |                           |                             | Trip Action          | R/W    | 0 - 7                       | T42       |
| 97                         |                           |                             | Trip and Alarm Delay | R/W    | 1 - 100 s                   | T1(Low)   |
| 98                         |                           |                             |                      |        |                             | T1(High)  |

| MPS REGISTER (DECIMAL)                 | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION          | ACCESS | RANGE           | TYPE     |
|----------------------------------------|---------------------------|-----------------------------|----------------------|--------|-----------------|----------|
| <b>Phase Loss (I)</b>                  |                           |                             |                      |        |                 |          |
| 99                                     | 40100                     | 3:99                        | Trip Action          | R/W    | 0 - 7           | T42      |
| 100                                    |                           |                             | Trip Delay           | R/W    | 1 - 100 s       | T1(Low)  |
| 101                                    |                           |                             |                      |        |                 | T1(High) |
| <b>Voltage Unbalance</b>               |                           |                             |                      |        |                 |          |
| 104                                    | 40105                     | 3:104                       | Trip Action          | R/W    | 0 - 7           | T42      |
| 105                                    |                           |                             | Trip Level           | R/W    | 0.05 - 1.0 pu   | T1(Low)  |
| 106                                    |                           |                             |                      |        |                 | T1(High) |
| 107                                    |                           |                             | Trip Delay           | R/W    | 1.0 - 100       | T1(Low)  |
| 108                                    |                           |                             |                      |        |                 | T1(High) |
| 109                                    |                           |                             | Alarm Level          | R/W    | 0.05 - 1.0 pu   | T1(Low)  |
| 110                                    |                           |                             |                      |        |                 | T1(High) |
| 111                                    |                           |                             | Alarm Delay          | R/W    | 1.0 - 100       | T1(Low)  |
| 112                                    |                           |                             |                      |        |                 | T1(High) |
| 113                                    |                           |                             | Alarm Action         | R/W    | 0 - 7           | T43      |
| <b>Phase Reverse (V)</b>               |                           |                             |                      |        |                 |          |
| 119                                    | 40120                     | 3:119                       | Alarm Action         | R/W    | 0 - 7           | T43      |
| 120                                    |                           |                             | Trip Action          | R/W    | 0 - 7           | T42      |
| 121                                    |                           |                             | Trip and Alarm Delay | R/W    | 1 - 100 s       | T1(Low)  |
| 122                                    |                           |                             |                      |        |                 | T1(High) |
| <b>Phase Loss (V)</b>                  |                           |                             |                      |        |                 |          |
| 123                                    | 40124                     | 3:123                       | Trip Action          | R/W    | 0 - 7           | T42      |
| 124                                    |                           |                             | Trip Delay           | R/W    | 1 - 100 s       | T1(Low)  |
| 125                                    |                           |                             |                      |        |                 | T1(High) |
| <b>Undercurrent</b>                    |                           |                             |                      |        |                 |          |
| 128                                    | 40129                     | 3:128                       | Trip Action          | R/W    | 0 - 7           | T42      |
| 129                                    |                           |                             | Trip Level           | R/W    | 0.1 - 1.0 x FLA | T1(Low)  |
| 130                                    |                           |                             |                      |        |                 | T1(High) |
| 131                                    |                           |                             | Trip Delay           | R/W    | 1 - 100 s       | T1(Low)  |
| 132                                    |                           |                             |                      |        |                 | T1(High) |
| 133                                    |                           |                             | Alarm Level          | R/W    | 0.1 - 1.0 x FLA | T1(Low)  |
| 134                                    |                           |                             |                      |        |                 | T1(High) |
| 135                                    |                           |                             | Alarm Delay          | R/W    | 1 - 100 s       | T1(Low)  |
| 136                                    |                           |                             |                      |        |                 | T1(High) |
| 137                                    |                           |                             | Alarm Action         | R/W    | 0 - 7           | T43      |
| <b>PTC Temperature</b>                 |                           |                             |                      |        |                 |          |
| 144                                    | 40145                     | 3:144                       | Trip Action          | R/W    | 0 - 7           | T42      |
| 145                                    |                           |                             | Alarm Action         | R/W    | 0 - 7           | T43      |
| <b>Acceleration Failure—Underspeed</b> |                           |                             |                      |        |                 |          |
| 152                                    | 40153                     | 3:152                       | Trip Action          | R/W    | 0 - 7           | T42      |
| 153                                    |                           |                             | Speed 1              | R/W    | 1 - 100% FS     | T1(Low)  |
| 154                                    |                           |                             |                      |        |                 | T1(High) |
| 155                                    |                           |                             | Time 1               | R/W    | 1 - 1,000 s     | T1(Low)  |
| 156                                    |                           |                             |                      |        |                 | T1(High) |

| MPS REGISTER (DECIMAL)           | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION       | ACCESS | RANGE                      | TYPE     |
|----------------------------------|---------------------------|-----------------------------|-------------------|--------|----------------------------|----------|
| 157                              |                           |                             | Speed 2           | R/W    | 1 - 100%-FS                | T1(Low)  |
| 158                              |                           |                             |                   |        |                            | T1(High) |
| 159                              |                           |                             | Time 2            | R/W    | 1 - 1,000 s                | T1(Low)  |
| 160                              |                           |                             |                   |        |                            | T1(High) |
| 161                              |                           |                             | Speed 3           | R/W    | 1 - 100% FS                | T1(Low)  |
| 162                              |                           |                             |                   |        |                            | T1(High) |
| 163                              |                           |                             | Time 3            | R/W    | 1 - 1,000 s                | T1(Low)  |
| 164                              |                           |                             |                   |        |                            | T1(High) |
| <b>Power Factor — Quadrant 4</b> |                           |                             |                   |        |                            |          |
| 166                              | 40167                     | 3:166                       | Trip Action       | R/W    | 0 - 7                      | T42      |
| 167                              |                           |                             | Trip Level        | R/W    | 0.5 - 1.0                  | T1(Low)  |
| 168                              |                           |                             |                   |        |                            | T1(High) |
| 169                              |                           |                             | Trip Delay        | R/W    | 0.2 - 500 s                | T1(Low)  |
| 170                              |                           |                             |                   |        |                            | T1(High) |
| 171                              |                           |                             | Alarm Level       | R/W    | 0.5 - 1.0                  | T1(Low)  |
| 172                              |                           |                             |                   |        |                            | T1(High) |
| 173                              |                           |                             | Alarm Delay       | R/W    | 0.2 - 500 s                | T1(Low)  |
| 174                              |                           |                             |                   |        |                            | T1(High) |
| 175                              |                           |                             | Alarm Action      | R/W    | 0 - 7                      | T43      |
| <b>Overvoltage</b>               |                           |                             |                   |        |                            |          |
| 176                              | 40177                     | 3:176                       | Trip Action       | R/W    | 0 - 7                      | T42      |
| 177                              |                           |                             | Trip Level        | R/W    | 1 - 1.4 x V <sub>p</sub>   | T1(Low)  |
| 178                              |                           |                             |                   |        |                            | T1(High) |
| 179                              |                           |                             | Trip Delay        | R/W    | 1 - 500 s                  | T1(Low)  |
| 180                              |                           |                             |                   |        |                            | T1(High) |
| 181                              |                           |                             | Alarm Level       | R/W    | 1 - 1.4 x V <sub>p</sub>   | T1(Low)  |
| 182                              |                           |                             |                   |        |                            | T1(High) |
| 183                              |                           |                             | Alarm Delay       | R/W    | 1 - 500 s                  | T1(Low)  |
| 184                              |                           |                             |                   |        |                            | T1(High) |
| 185                              |                           |                             | Alarm Action      | R/W    | 0 - 7                      | T43      |
| <b>Undervoltage</b>              |                           |                             |                   |        |                            |          |
| 192                              | 40193                     | 3:192                       | Trip Action       | R/W    | 0 - 7                      | T42      |
| 193                              |                           |                             | Trip Level        | R/W    | 0.5 - 1.0 x V <sub>p</sub> | T1(Low)  |
| 194                              |                           |                             |                   |        |                            | T1(High) |
| 195                              |                           |                             | Trip Delay        | R/W    | 1 - 500 s                  | T1(Low)  |
| 196                              |                           |                             |                   |        |                            | T1(High) |
| 197                              |                           |                             | Alarm Level       | R/W    | 0.5 - 1.0 x V <sub>p</sub> | T1(Low)  |
| 198                              |                           |                             |                   |        |                            | T1(High) |
| 199                              |                           |                             | Alarm Delay       | R/W    | 1 - 500 s                  | T1(Low)  |
| 200                              |                           |                             |                   |        |                            | T1(High) |
| 201                              |                           |                             | Alarm Action      | R/W    | 0 - 7                      | T43      |
| <b>System Ratings</b>            |                           |                             |                   |        |                            |          |
| 206                              |                           |                             | Default Display   | R/W    | 0 - 15                     | T96      |
| 209                              |                           |                             | V-Connection Type | R/W    | 0 - 3                      | T9       |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                         | ACCESS | RANGE                      | TYPE      |
|------------------------|---------------------------|-----------------------------|-------------------------------------|--------|----------------------------|-----------|
| 210                    |                           |                             | Phase-CT Primary                    | R/W    | 1 - 5,000 A                | T1(Low)   |
| 211                    |                           |                             |                                     |        |                            | T1(High)  |
| 212                    |                           |                             | EF-CT Primary                       | R/W    | 1 - 5,000 A                | T1(Low)   |
| 213                    |                           |                             |                                     |        |                            | T1(High)  |
| 214                    |                           |                             | Input-Voltage Rating                | R/W    | 60 V - 600V                | T1(Low)   |
| 215                    |                           |                             |                                     |        |                            | T1(High)  |
| 216                    |                           |                             | Run-Mode Delay                      | R/W    | 5 - 120 s                  | T1(Low)   |
| 217                    |                           |                             |                                     |        |                            | T1(High)  |
| 218                    |                           |                             | Differential-CT Primary Rating      | R/W    | 1 - 5,000 A                | T1 (Low)  |
| 219                    |                           |                             |                                     |        |                            | T1 (High) |
| 220                    |                           |                             | I <sub>p</sub> Threshold            | R/W    | 0.1 – 0.5 x I <sub>p</sub> | T1 (Low)  |
| 221                    |                           |                             |                                     |        |                            | T1 (High) |
| 223                    | 40224                     | 3:223                       | Screen Saver                        | R/W    | 0 - 1                      | T6        |
| 224                    | 40225                     | 3:224                       | Frequency                           | R/W    | 0 - 1                      | T10       |
| 225                    |                           |                             | Full-Load Rating #1                 | R/W    | 1 - 5,000 A                | T1(Low)   |
| 226                    |                           |                             |                                     |        |                            | T1(High)  |
| 227                    |                           |                             | System-Voltage Rating               | R/W    | 120 V - 25 kV              | T1(Low)   |
| 228                    |                           |                             |                                     |        |                            | T1(High)  |
| 229                    |                           |                             | Synchronous Speed                   | R/W    | 10 - 10,000 RPM            | T1(Low)   |
| 230                    |                           |                             |                                     |        |                            | T1(High)  |
| 231                    |                           |                             | Spare                               |        |                            | p         |
| 232                    |                           |                             | Spare                               |        |                            |           |
| 233                    |                           |                             | Service Factor                      | R/W    | 1 - 1.25                   | T1(Low)   |
| 234                    |                           |                             |                                     |        |                            | T1(High)  |
| 235                    |                           |                             | Full-Load Rating #2                 | R/W    | 1 - 5,000 A                | T1(Low)   |
| 236                    |                           |                             |                                     |        |                            | T1(High)  |
| <b>OPI</b>             |                           |                             |                                     |        |                            |           |
| 237                    | 40238                     | 3:237                       | OPI-Loss Trip Action                | R/W    | 0 - 7                      | T42       |
| 238                    |                           |                             | Number of OPI's                     | R/W    | 0 - 2                      | T40       |
| 239                    |                           |                             | Control Enable—REMOTE               | R/W    | 0 - 1                      | T6        |
| 240                    |                           |                             | Control Enable—OPI                  | R/W    | 0 - 1                      | T6        |
| 241                    |                           |                             | Control Enable—LOCAL                |        | 0 - 1                      | T6        |
| <b>Starter</b>         |                           |                             |                                     |        |                            |           |
| 242                    | 40243                     | 3:242                       | Remote Start Sources—Digital Inputs | R/W    | 0 - 1                      | T6        |
| 243                    |                           |                             | Remote Start Sources—Network        | R/W    | 0 - 1                      | T6        |
| 244                    |                           |                             | Remote Start Sources—OPI            | R/W    | 0 - 1                      | T6        |
| 245                    |                           |                             | OPI Starts                          | R/W    | 0 - 1                      | T6        |
| 248                    |                           |                             | Starter Type                        | R/W    | 0 - 15                     | T11       |
| 249                    |                           |                             | Start Time                          | R/W    | 0.1 - 500                  | T1(Low)   |
| 250                    |                           |                             |                                     |        |                            | T1(High)  |
| 251                    |                           |                             | Stage 1 Delay                       | R/W    | 0.1 - 500                  | T1(Low)   |
| 252                    |                           |                             |                                     |        |                            | T1(High)  |
| 253                    |                           |                             | Stage 2 Delay                       | R/W    | 0.1 - 500                  | T1(Low)   |
| 254                    |                           |                             |                                     |        |                            | T1(High)  |

| MPS REGISTER (DECIMAL)   | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION           | ACCESS | RANGE           | TYPE      |
|--------------------------|---------------------------|-----------------------------|-----------------------|--------|-----------------|-----------|
| 255                      |                           |                             | Stage 3 Delay         | R/W    | 0.1 - 500       | T1(Low)   |
| 256                      |                           |                             |                       |        |                 | T1(High)  |
| 257                      |                           |                             | Backspin-Timer Enable |        | 0 - 1           | T6        |
| 258                      |                           |                             | Backspin-Time Delay   |        | 0.1 - 3,600 s   | T1(Low)   |
| 259                      |                           |                             |                       |        |                 | T1(High)  |
| <b>Current Transfers</b> |                           |                             |                       |        |                 |           |
| 260                      | 40261                     | 3:260                       | Transfer Type         | R/W    | 0 - 1           | T41       |
| 261                      |                           |                             | Transfer Level        | R/W    | 1.0 - 3.0 x FLA | T1 (Low)  |
| 262                      |                           |                             |                       |        |                 | T1 (High) |
| <b>Digital Inputs</b>    |                           |                             |                       |        |                 |           |
| 264                      | 40265                     | 3:264                       | Input 1 Function      | R/W    | 0 - 19          | T12       |
| 265                      |                           |                             | Input 1 Bypass Enable | R/W    | 0 - 1           | T6        |
| 266                      |                           |                             | Input 1 Bypass Delay  | R/W    | 0.5 - 100 s     | T1(Low)   |
| 267                      |                           |                             |                       |        |                 | T1(High)  |
| 268                      |                           |                             | Input 1 Trip Delay    | R/W    | 0.01 - 100 s    | T1(Low)   |
| 269                      |                           |                             |                       |        |                 | T1(High)  |
|                          |                           |                             |                       |        |                 |           |
| 274                      |                           |                             | Input 2 Function      | R/W    | 0 - 19          | T12       |
| 275                      |                           |                             | Input 2 Bypass Enable | R/W    | 0 - 1           | T6        |
| 276                      |                           |                             | Input 2 Bypass Delay  | R/W    | 0.5 - 100 s     | T1(Low)   |
| 277                      |                           |                             |                       |        |                 | T1(High)  |
| 278                      |                           |                             | Input 2 Trip Delay    | R/W    | 0.01 - 100 s    | T1(Low)   |
| 279                      |                           |                             |                       |        |                 | T1(High)  |
|                          |                           |                             |                       |        |                 |           |
| 284                      |                           |                             | Input 3 Function      | R/W    | 0 - 19          | T12       |
| 285                      |                           |                             | Input 3 Bypass Enable | R/W    | 0 - 1           | T6        |
| 286                      |                           |                             | Input 3 Bypass Delay  | R/W    | 0.5 - 100 s     | T1(Low)   |
| 287                      |                           |                             |                       |        |                 | T1(High)  |
| 288                      |                           |                             | Input 3 Trip Delay    | R/W    | 0.01 - 100 s    | T1(Low)   |
| 289                      |                           |                             |                       |        |                 | T1(high)  |
|                          |                           |                             |                       |        |                 |           |
| 294                      |                           |                             | Input 4 Function      | R/W    | 0 - 19          | T12       |
| 295                      |                           |                             | Input 4 Bypass Enable | R/W    | 0 - 1           | T6        |
| 296                      |                           |                             | Input 4 Bypass Delay  | R/W    | 0.5 - 100 s     | T1(Low)   |
| 297                      |                           |                             |                       |        |                 | T1(High)  |
| 298                      |                           |                             | Input 4 Trip Delay    | R/W    | 0.01 - 100 s    | T1(Low)   |
| 299                      |                           |                             |                       |        |                 | T1(High)  |
|                          |                           |                             |                       |        |                 |           |
| 304                      |                           |                             | Input 5 Function      | R/W    | 0 - 19          | T12       |
| 305                      |                           |                             | Input 5 Bypass Enable | R/W    | 0 - 1           | T6        |
| 306                      |                           |                             | Input 5 Bypass Delay  | R/W    | 0.5 - 100 s     | T1(Low)   |
| 307                      |                           |                             |                       |        |                 | T1(High)  |
| 308                      |                           |                             | Input 5 Trip Delay    | R/W    | 0.01 - 100 s    | T1(Low)   |
| 309                      |                           |                             |                       |        |                 | T1(High)  |



| MPS REGISTER (DECIMAL)       | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION               | ACCESS | RANGE         | TYPE     |
|------------------------------|---------------------------|-----------------------------|---------------------------|--------|---------------|----------|
| 314                          |                           |                             | Input 6 Function          | R/W    | 0 - 19        | T12      |
| 315                          |                           |                             | Input 6 Bypass Enable     | R/W    | 0 - 1         | T6       |
| 316                          |                           |                             | Input 6 Bypass Delay      | R/W    | 0.5 - 100 s   | T1(Low)  |
| 317                          |                           |                             |                           |        |               | T1(High) |
| 318                          |                           |                             | Input 6 Trip Delay        | R/W    | 0.01 - 100 s  | T1(Low)  |
| 319                          |                           |                             |                           |        |               | T1(High) |
| 324                          |                           |                             | Input 7 Function          | R/W    | 0 - 19        | T12      |
| 325                          |                           |                             | Input 7 Bypass Enable     | R/W    | 0 - 1         | T6       |
| 326                          |                           |                             | Input 7 Bypass Delay      | R/W    | 0.5 - 100 s   | T1(Low)  |
| 327                          |                           |                             |                           |        |               | T1(High) |
| 328                          |                           |                             | Input 7 Delay             | R/W    | 0.01 - 100 s  | T1(Low)  |
| 329                          |                           |                             |                           |        |               | T1(High) |
| 330                          |                           |                             | Digital Tachometer Enable | R/W    | 0 - 1         | T6       |
| 331                          |                           |                             | Pulses Per Revolution     | R/W    | 1 - 120       | T1(Low)  |
| 332                          |                           |                             |                           |        |               | T1(High) |
| <b>Relay Output Function</b> |                           |                             |                           |        |               |          |
| 334                          | 40335                     | 3:334                       | Relay 1 Output Function   | R/W    | 0 - 20        | T13      |
| 335                          |                           |                             | Relay 1 Mode              | R/W    | 0 - 1         | T14      |
| 336                          |                           |                             | Relay 2 Output Function   | R/W    | 0 - 20        | T13      |
| 337                          |                           |                             | Relay 2 Mode              | R/W    | 0 - 1         | T14      |
| 338                          |                           |                             | Relay 3 Output Function   | R/W    | 0 - 20        | T13      |
| 339                          |                           |                             | Relay 3 Mode              | R/W    | 0 - 1         | T14      |
| 340                          |                           |                             | Relay 4 Output Function   | R/W    | 0 - 20        | T13      |
| 341                          |                           |                             | Relay 4 Mode              | R/W    | 0 - 1         | T14      |
| 342                          |                           |                             | Relay 5 Output Function   | R/W    | 0 - 20        | T13      |
| 343                          |                           |                             | Relay 5 Mode              | R/W    | 0 - 1         | T14      |
| 344                          |                           |                             | Relay Pulse Time          | R/W    | 0.05 - 10 s   | T1(Low)  |
| 345                          |                           |                             |                           |        |               | T1(High) |
| <b>Analog Input</b>          |                           |                             |                           |        |               |          |
| 350                          | 40351                     | 3:350                       | Analog-Input Function     | R/W    | 0 - 3         | T34      |
| 351                          |                           |                             | High-Level Trip           | R/W    | 0.1 - 20.0 mA | T1(Low)  |
| 352                          |                           |                             |                           |        |               | T1(High) |
| 353                          |                           |                             | Low-Level Trip            | R/W    | 0.1 - 20.0 mA | T1(Low)  |
| 354                          |                           |                             |                           |        |               | T1(High) |
| 355                          |                           |                             | Trip Delay                | R/W    | .01 - 100 s   | T1(Low)  |
| 356                          |                           |                             |                           |        |               | T1(High) |
| 357                          |                           |                             | High-Level Alarm          | R/W    | 0.1 - 20.0 mA | T1(Low)  |
| 358                          |                           |                             |                           |        |               | T1(High) |
| 359                          |                           |                             | Low-Level Alarm           | R/W    | 0.1 - 20.0 mA | T1(Low)  |
| 360                          |                           |                             |                           |        |               | T1(High) |
| 361                          |                           |                             | Alarm Delay               | R/W    | .01 - 100 s   | T1(Low)  |
| 362                          |                           |                             |                           |        |               | T1(High) |

| MPS REGISTER (DECIMAL)                | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                                          | ACCESS | RANGE     | TYPE     |
|---------------------------------------|---------------------------|-----------------------------|------------------------------------------------------|--------|-----------|----------|
| 363                                   |                           |                             | ASD 4-mA Frequency                                   | R/W    | 0 - 70 Hz | T1(Low)  |
| 364                                   |                           |                             |                                                      |        |           | T1(High) |
| 365                                   |                           |                             | ASD 20-mA Frequency                                  | R/W    | 0 - 70 Hz | T1(Low)  |
| 366                                   |                           |                             |                                                      |        |           | T1(High) |
| 367                                   |                           |                             | Motor 4-mA Speed                                     | R/W    | 0 - 100%  | T1(Low)  |
| 368                                   |                           |                             |                                                      |        |           | T1(High) |
| 369                                   |                           |                             | Motor 20-mA Speed                                    | R/W    | 0 - 100%  | T1(Low)  |
| 370                                   |                           |                             |                                                      |        |           | T1(High) |
| Analog Output                         |                           |                             |                                                      |        |           |          |
| 372                                   |                           |                             | Output Filter                                        | R/W    | 0 - 1     | T6       |
| 373                                   | 40374                     | 3:373                       | Output Parameter                                     | R/W    | 0 - 16    | T15      |
|                                       |                           |                             | (See Register 856-859 for Analog Output Calibration) |        |           |          |
| Network and I/O Module Communications |                           |                             |                                                      |        |           |          |
| 374                                   | 40375                     | 3:374                       | DeviceNet Producing Instance                         | R/W    | 0 - 9     | T82      |
| 375                                   |                           |                             | DeviceNet Consuming Instance                         | R/W    | 0 - 4     | T83      |
| 379                                   | 40380                     | 3:379                       | RTD-Sensor-Error Alarm Action                        | R/W    | 0 - 7     | T43      |
| 380                                   |                           |                             | RTD-Module-Error Alarm Action                        | R/W    | 0 - 7     | T43      |
| 381                                   |                           |                             | Network Alarm Action                                 | R/W    | 0 - 7     | T43      |
| 382                                   |                           |                             | Network Type                                         | R/W    | 0 - 5     | T16      |
| 383                                   |                           |                             | Network Baud Rate                                    | R/W    | 0 - 7     | T17      |
| 384                                   |                           |                             | Error Check                                          | R/W    | 0 - 2     | T18      |
| 385                                   |                           |                             | Network ID                                           | R/W    | 0 - 255   | T1(Low)  |
| 386                                   |                           |                             |                                                      |        |           | T1(High) |
| 387                                   |                           |                             | Network Trip Action                                  | R/W    | 0 - 7     | T42      |
| RTD Module                            |                           |                             |                                                      |        |           |          |
| 388                                   | 40389                     | 3:388                       | RTD-Sensor-Error Trip Action                         | R/W    | 0 - 7     | T42      |
| 389                                   |                           |                             | RTD-Module-Error Trip Action                         | R/W    | 0 - 7     | T42      |
| 390                                   | 40391                     | 4:0                         | Number of RTD Modules                                | R/W    | 0 - 3     | T19      |
| RTD Type                              |                           |                             |                                                      |        |           |          |
| 391                                   | 40392                     | 4:1                         | Module 1 #1 Type                                     | R/W    | 0 - 4     | T20      |
| 392                                   |                           |                             | Module 1 #2 Type                                     | R/W    | 0 - 4     | T20      |
| 393                                   |                           |                             | Module 1 #3 Type                                     | R/W    | 0 - 4     | T20      |
| 394                                   |                           |                             | Module 1 #4 Type                                     | R/W    | 0 - 4     | T20      |
| 395                                   |                           |                             | Module 1 #5 Type                                     | R/W    | 0 - 4     | T20      |
| 396                                   |                           |                             | Module 1 #6 Type                                     | R/W    | 0 - 4     | T20      |
| 397                                   |                           |                             | Module 1 #7 Type                                     | R/W    | 0 - 4     | T20      |
| 398                                   |                           |                             | Module 1 #8 Type                                     | R/W    | 0 - 4     | T20      |
| 399                                   |                           |                             | Module 2 #1 Type                                     | R/W    | 0 - 4     | T20      |
| 400                                   |                           |                             | Module 2 #2 Type                                     | R/W    | 0 - 4     | T20      |
| 401                                   |                           |                             | Module 2 #3 Type                                     | R/W    | 0 - 4     | T20      |
| 402                                   |                           |                             | Module 2 #4 Type                                     | R/W    | 0 - 4     | T20      |
| 403                                   |                           |                             | Module 2 #5 Type                                     | R/W    | 0 - 4     | T20      |
| 404                                   |                           |                             | Module 2 #6 Type                                     | R/W    | 0 - 4     | T20      |
| 405                                   |                           |                             | Module 2 #7 Type                                     | R/W    | 0 - 4     | T20      |
| 406                                   |                           |                             | Module 2 #8 Type                                     | R/W    | 0 - 4     | T20      |

| MPS REGISTER (DECIMAL)            | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION             | ACCESS | RANGE      | TYPE     |
|-----------------------------------|---------------------------|-----------------------------|-------------------------|--------|------------|----------|
| 407                               |                           |                             | Module 3 #1 Type        | R/W    | 0 - 4      | T20      |
| 408                               |                           |                             | Module 3 #2 Type        | R/W    | 0 - 4      | T20      |
| 409                               |                           |                             | Module 3 #3 Type        | R/W    | 0 - 4      | T20      |
| 410                               |                           |                             | Module 3 #4 Type        | R/W    | 0 - 4      | T20      |
| 411                               |                           |                             | Module 3 #5 Type        | R/W    | 0 - 4      | T20      |
| 412                               |                           |                             | Module 3 #6 Type        | R/W    | 0 - 4      | T20      |
| 413                               |                           |                             | Module 3 #7 Type        | R/W    | 0 - 4      | T20      |
| 414                               |                           |                             | Module 3 #8 Type        | R/W    | 0 - 4      | T20      |
| <b>RTD Function</b>               |                           |                             |                         |        |            |          |
| 415                               | 40416                     | 4:25                        | Module 1 #1 Function    | R/W    | 0 - 7      | T21      |
| 416                               |                           |                             | Module 1 #2 Function    | R/W    | 0 - 7      | T21      |
| 417                               |                           |                             | Module 1 #3 Function    | R/W    | 0 - 7      | T21      |
| 418                               |                           |                             | Module 1 #4 Function    | R/W    | 0 - 7      | T21      |
| 419                               |                           |                             | Module 1 #5 Function    | R/W    | 0 - 7      | T21      |
| 420                               |                           |                             | Module 1 #6 Function    | R/W    | 0 - 7      | T21      |
| 421                               |                           |                             | Module 1 #7 Function    | R/W    | 0 - 7      | T21      |
| 422                               |                           |                             | Module 1 #8 Function    | R/W    | 0 - 7      | T21      |
| 423                               |                           |                             | Module 2 #1 Function    | R/W    | 0 - 7      | T21      |
| 424                               |                           |                             | Module 2 #2 Function    | R/W    | 0 - 7      | T21      |
| 425                               |                           |                             | Module 2 #3 Function    | R/W    | 0 - 7      | T21      |
| 426                               |                           |                             | Module 2 #4 Function    | R/W    | 0 - 7      | T21      |
| 427                               |                           |                             | Module 2 #5 Function    | R/W    | 0 - 7      | T21      |
| 428                               |                           |                             | Module 2 #6 Function    | R/W    | 0 - 7      | T21      |
| 429                               |                           |                             | Module 2 #7 Function    | R/W    | 0 - 7      | T21      |
| 430                               |                           |                             | Module 2 #8 Function    | R/W    | 0 - 7      | T21      |
| 431                               |                           |                             | Module 3 #1 Function    | R/W    | 0 - 7      | T21      |
| 432                               |                           |                             | Module 3 #2 Function    | R/W    | 0 - 7      | T21      |
| 433                               |                           |                             | Module 3 #3 Function    | R/W    | 0 - 7      | T21      |
| 434                               |                           |                             | Module 3 #4 Function    | R/W    | 0 - 7      | T21      |
| 435                               |                           |                             | Module 3 #5 Function    | R/W    | 0 - 7      | T21      |
| 436                               |                           |                             | Module 3 #6 Function    | R/W    | 0 - 7      | T21      |
| 437                               |                           |                             | Module 3 #7 Function    | R/W    | 0 - 7      | T21      |
| 438                               |                           |                             | Module 3 #8 Function    | R/W    | 0 - 7      | T21      |
| <b>RTD Trip1/Alarm1 Setpoints</b> |                           |                             |                         |        |            |          |
| 446                               | 40447                     | 4:56                        | Module 1 #1 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 447                               |                           |                             |                         |        |            | T1(High) |
| 448                               |                           |                             | Module 1 #1 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 449                               |                           |                             |                         |        |            | T1(High) |
| 450                               |                           |                             | Module 1 #2 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 451                               |                           |                             |                         |        |            | T1(High) |
| 452                               |                           |                             | Module 1 #2 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 453                               |                           |                             |                         |        |            | T1(High) |
| 454                               |                           |                             | Module 1 #3 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 455                               |                           |                             |                         |        |            | T1(High) |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION             | ACCESS | RANGE      | TYPE     |
|------------------------|---------------------------|-----------------------------|-------------------------|--------|------------|----------|
| 456                    |                           |                             | Module 1 #3 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 457                    |                           |                             |                         |        |            | T1(High) |
| 458                    |                           |                             | Module 1 #4 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 459                    |                           |                             |                         |        |            | T1(High) |
| 460                    |                           |                             | Module 1 #4 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 461                    |                           |                             |                         |        |            | T1(High) |
| 462                    |                           |                             | Module 1 #5 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 463                    |                           |                             |                         |        |            | T1(High) |
| 464                    |                           |                             | Module 1 #5 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 465                    |                           |                             |                         |        |            | T1(High) |
| 466                    |                           |                             | Module 1 #6 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 467                    |                           |                             |                         |        |            | T1(High) |
| 468                    |                           |                             | Module 1 #6 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 469                    |                           |                             |                         |        |            | T1(High) |
| 470                    |                           |                             | Module 1 #7 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 471                    |                           |                             |                         |        |            | T1(High) |
| 472                    |                           |                             | Module 1 #7 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 473                    |                           |                             |                         |        |            | T1(High) |
| 474                    |                           |                             | Module 1 #8 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 475                    |                           |                             |                         |        |            | T1(High) |
| 476                    |                           |                             | Module 1 #8 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 477                    |                           |                             |                         |        |            | T1(High) |
| 478                    |                           |                             | Module 2 #1 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 479                    |                           |                             |                         |        |            | T1(High) |
| 480                    |                           |                             | Module 2 #1 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 481                    |                           |                             |                         |        |            | T1(High) |
| 482                    |                           |                             | Module 2 #2 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 483                    |                           |                             |                         |        |            | T1(High) |
| 484                    |                           |                             | Module 2 #2 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 485                    |                           |                             |                         |        |            | T1(High) |
| 486                    |                           |                             | Module 2 #3 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 487                    |                           |                             |                         |        |            | T1(High) |
| 488                    |                           |                             | Module 2 #3 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 489                    |                           |                             |                         |        |            | T1(High) |
| 490                    |                           |                             | Module 2 #4 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 491                    |                           |                             |                         |        |            | T1(High) |
| 492                    |                           |                             | Module 2 #4 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 493                    |                           |                             |                         |        |            | T1(High) |
| 494                    |                           |                             | Module 2 #5 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 495                    |                           |                             |                         |        |            | T1(High) |
| 496                    |                           |                             | Module 2 #5 Alarm Level | R/W    | 40 - 200°C | T1(Low)  |
| 497                    |                           |                             |                         |        |            | T1(High) |
| 498                    |                           |                             | Module 2 #6 Trip Level  | R/W    | 40 - 200°C | T1(Low)  |
| 499                    |                           |                             |                         |        |            | T1(High) |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION              | ACCESS | RANGE      | TYPE     |
|------------------------|---------------------------|-----------------------------|--------------------------|--------|------------|----------|
| 500                    |                           |                             | Module 2 #6 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 501                    |                           |                             |                          |        |            | T1(High) |
| 502                    |                           |                             | Module 2 #7 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 503                    |                           |                             |                          |        |            | T1(High) |
| 504                    |                           |                             | Module 2 #7 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 505                    |                           |                             |                          |        |            | T1(High) |
| 506                    |                           |                             | Module 2 #8 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 507                    |                           |                             |                          |        |            | T1(High) |
| 508                    |                           |                             | Module 2 #8 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 509                    |                           |                             |                          |        |            | T1(High) |
| 510                    |                           |                             | Module 3 #1 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 511                    |                           |                             |                          |        |            | T1(High) |
| 512                    |                           |                             | Module 3 #1 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 513                    |                           |                             |                          |        |            | T1(High) |
| 514                    |                           |                             | Module 3 #2 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 515                    |                           |                             |                          |        |            | T1(High) |
| 516                    |                           |                             | Module 3 #2 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 517                    |                           |                             |                          |        |            | T1(High) |
| 518                    |                           |                             | Module 3 #3 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 519                    |                           |                             |                          |        |            | T1(High) |
| 520                    |                           |                             | Module 3 #3 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 521                    |                           |                             |                          |        |            | T1(High) |
| 522                    |                           |                             | Module 3 #4 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 523                    |                           |                             |                          |        |            | T1(High) |
| 524                    |                           |                             | Module 3 #4 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 525                    |                           |                             |                          |        |            | T1(High) |
| 526                    |                           |                             | Module 3 #5 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 527                    |                           |                             |                          |        |            | T1(High) |
| 528                    |                           |                             | Module 3 #5 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 529                    |                           |                             |                          |        |            | T1(High) |
| 530                    |                           |                             | Module 3 #6 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 531                    |                           |                             |                          |        |            | T1(High) |
| 532                    |                           |                             | Module 3 #6 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 533                    |                           |                             |                          |        |            | T1(High) |
| 534                    |                           |                             | Module 3 #7 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 535                    |                           |                             |                          |        |            | T1(High) |
| 536                    |                           |                             | Module 3 #7 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 537                    |                           |                             |                          |        |            | T1(High) |
| 538                    |                           |                             | Module 3 #8 Trip Level   | R/W    | 40 - 200°C | T1(Low)  |
| 539                    |                           |                             |                          |        |            | T1(High) |
| 540                    |                           |                             | Module 3 #8 Alarm Level  | R/W    | 40 - 200°C | T1(Low)  |
| 541                    |                           |                             |                          |        |            | T1(High) |
| 548                    |                           |                             | Temperature Trip Action  | R/W    | 0 - 7      | T42      |
| 549                    |                           |                             | Temperature Alarm Action | R/W    | 0 - 7      | T43      |

| MPS REGISTER (DECIMAL)        | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                      | ACCESS    | RANGE      | TYPE      |
|-------------------------------|---------------------------|-----------------------------|----------------------------------|-----------|------------|-----------|
| <b>Hot Motor Compensation</b> |                           |                             |                                  |           |            |           |
| 550                           | 40551                     | 4:160                       | HMC Enable                       | R/W       |            | T6        |
| 551                           |                           |                             | HMC Maximum Bias                 | R/W       | 40 - 200°C | T1(Low)   |
| 552                           |                           |                             |                                  |           |            | T1(High)  |
| 553                           |                           |                             | HMC Minimum Bias                 | R/W       | 40 - 200°C | T1(Low)   |
| 554                           |                           |                             |                                  |           |            | T1(High)  |
| <b>IRIG Offset</b>            |                           |                             |                                  |           |            |           |
| 568                           | 40569                     | 4:178                       | IRIG Offset (Hours)              | R/W       | 0 - 23     | T1(Low)   |
| 569                           |                           |                             |                                  |           |            | T1(High)  |
| 570                           |                           |                             | IRIG Offset (Minutes)            | R/W       | 0 - 30     | T1(Low)   |
| 571                           |                           |                             |                                  |           |            | T1(High)  |
| <b>Clock Reading</b>          |                           |                             |                                  |           |            |           |
| 574                           | 40575                     | 5:0                         | RTC Date                         | Read Only |            | T23(Low)  |
| 575                           |                           |                             |                                  |           |            | T23(High) |
| 576                           |                           |                             | RTC Time                         | Read Only |            | T23(Low)  |
| 577                           |                           |                             |                                  |           |            | T23(High) |
| <b>Strings</b>                |                           |                             |                                  |           |            |           |
| 580                           | 40581                     | 5:6                         | Clock String (Setting Only)      | R/W       |            | T31       |
| 590                           |                           |                             | Password (First Four Characters) | R/W       |            | T22       |
| 600                           |                           |                             | System Name                      | R/W       |            | T22       |
| 610                           |                           |                             | RTD Module 1 #1 Name             | R/W       |            | T22       |
| 620                           |                           |                             | RTD Module 1 #2 Name             | R/W       |            | T22       |
| 630                           |                           |                             | RTD Module 1 #3 Name             | R/W       |            | T22       |
| 640                           |                           |                             | RTD Module 1 #4 Name             | R/W       |            | T22       |
| 650                           |                           |                             | RTD Module 1 #5 Name             | R/W       |            | T22       |
| 660                           |                           |                             | RTD Module 1 #6 Name             | R/W       |            | T22       |
| 670                           |                           |                             | RTD Module 1 #7 Name             | R/W       |            | T22       |
| 680                           |                           |                             | RTD Module 1 #8 Name             | R/W       |            | T22       |
| 690                           |                           |                             | RTD Module 2 #1 Name             | R/W       |            | T22       |
| 700                           |                           |                             | RTD Module 2 #2 Name             | R/W       |            | T22       |
| 710                           |                           |                             | RTD Module 2 #3 Name             | R/W       |            | T22       |
| 720                           |                           |                             | RTD Module 2 #4 Name             | R/W       |            | T22       |
| 730                           |                           |                             | RTD Module 2 #5 Name             | R/W       |            | T22       |
| 740                           |                           |                             | RTD Module 2 #6 Name             | R/W       |            | T22       |
| 750                           |                           |                             | RTD Module 2 #7 Name             | R/W       |            | T22       |
| 760                           |                           |                             | RTD Module 2 #8 Name             | R/W       |            | T22       |
| 770                           |                           |                             | RTD Module 3 #1 Name             | R/W       |            | T22       |
| 780                           |                           |                             | RTD Module 3 #2 Name             | R/W       |            | T22       |
| 790                           |                           |                             | RTD Module 3 #3 Name             | R/W       |            | T22       |
| 800                           |                           |                             | RTD Module 3 #4 Name             | R/W       |            | T22       |
| 810                           |                           |                             | RTD Module 3 #5 Name             | R/W       |            | T22       |
| 820                           |                           |                             | RTD Module 3 #6 Name             | R/W       |            | T22       |
| 830                           |                           |                             | RTD Module 3 #7 Name             | R/W       |            | T22       |
| 840                           |                           |                             | RTD Module 3 #8 Name             | R/W       |            | T22       |

| MPS REGISTER (DECIMAL)           | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                      | ACCESS    | RANGE     | TYPE     |
|----------------------------------|---------------------------|-----------------------------|----------------------------------|-----------|-----------|----------|
| <b>Analog Output Calibration</b> |                           |                             |                                  |           |           |          |
| 856                              | 40857                     | 5:282                       | Analog-Output Calibration (Zero) | R/W       | 0 - 1,000 | T1(Low)  |
| 857                              |                           |                             |                                  |           |           | T1(High) |
| 858                              |                           |                             | Analog-Output Calibration (FS)   | R/W       | 0 - 1,000 | T1(Low)  |
| 859                              |                           |                             |                                  |           |           | T1(High) |
| <b>Meter Values</b>              |                           |                             |                                  |           |           |          |
| 860                              | 40861                     | 6:0                         | I <sub>a</sub> (A)               | Read Only |           | T1(Low)  |
| 861                              |                           |                             |                                  |           |           | T1(High) |
| 862                              |                           |                             | I <sub>b</sub> (A)               | Read Only |           | T1(Low)  |
| 863                              |                           |                             |                                  |           |           | T1(High) |
| 864                              |                           |                             | I <sub>c</sub> (A)               | Read Only |           | T1(Low)  |
| 865                              |                           |                             |                                  |           |           | T1(High) |
| 866                              |                           |                             | I <sub>g</sub> (A)               | Read Only |           | T1(Low)  |
| 867                              |                           |                             |                                  |           |           | T1(High) |
| 868                              |                           |                             | V <sub>ab</sub> (kV)             | Read Only |           | T1(Low)  |
| 869                              |                           |                             |                                  |           |           | T1(High) |
| 870                              |                           |                             | V <sub>bc</sub> (kV)             | Read Only |           | T1(Low)  |
| 871                              |                           |                             |                                  |           |           | T1(High) |
| 872                              |                           |                             | V <sub>ca</sub> (kV)             | Read Only |           | T1(Low)  |
| 873                              |                           |                             |                                  |           |           | T1(High) |
| 874                              |                           |                             | Apparent Power (S) in kVA        | Read Only |           | T1(Low)  |
| 875                              |                           |                             |                                  |           |           | T1(High) |
| 876                              |                           |                             | Reactive Power (Q) in kVAR       | Read Only |           | T1(Low)  |
| 877                              |                           |                             |                                  |           |           | T1(High) |
| 878                              |                           |                             | Real Power (P) in kW             | Read Only |           | T1(Low)  |
| 879                              |                           |                             |                                  |           |           | T1(High) |
| 880                              |                           |                             | Power Factor (-1 to +1)          | Read Only |           | T1(Low)  |
| 881                              |                           |                             |                                  |           |           | T1(High) |
| 882                              |                           |                             | Used Thermal Capacity (%)        | Read Only |           | T1(Low)  |
| 883                              |                           |                             |                                  |           |           | T1(High) |
| 884                              |                           |                             | Analog Input (mA)                | Read Only |           | T1(Low)  |
| 885                              |                           |                             |                                  |           |           | T1(High) |
| 886                              |                           |                             | Trend I <sup>2</sup> t (%)       | Read Only |           | T1(Low)  |
| 887                              |                           |                             |                                  |           |           | T1(High) |
| 888                              |                           |                             | Positive-Sequence Current (pu)   | Read Only |           | T1(Low)  |
| 889                              |                           |                             |                                  |           |           | T1(High) |
| 890                              |                           |                             | Negative-Sequence Current (pu)   | Read Only |           | T1(Low)  |
| 891                              |                           |                             |                                  |           |           | T1(High) |
| 892                              |                           |                             | Unbalance (I) (pu)               | Read Only |           | T1(Low)  |
| 893                              |                           |                             |                                  |           |           | T1(High) |
| 894                              |                           |                             | Positive-Sequence V (pu)         | Read Only |           | T1(Low)  |
| 895                              |                           |                             |                                  |           |           | T1(High) |
| 896                              |                           |                             | Negative-Sequence V (pu)         | Read Only |           | T1(Low)  |
| 897                              |                           |                             |                                  |           |           | T1(High) |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                            | ACCESS    | RANGE | TYPE     |
|------------------------|---------------------------|-----------------------------|----------------------------------------|-----------|-------|----------|
| 898                    |                           |                             | Unbalance Voltage (pu)                 | Read Only |       | T1(Low)  |
| 899                    |                           |                             |                                        |           |       | T1(High) |
| 900                    |                           |                             | Motor Speed From Tach. (RPM)           | Read Only |       | T1(Low)  |
| 901                    |                           |                             |                                        |           |       | T1(High) |
| 902                    |                           |                             | Module 1 #1 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 903                    |                           |                             |                                        |           |       | T1(High) |
| 904                    |                           |                             | Module 1 #2 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 905                    |                           |                             |                                        |           |       | T1(High) |
| 906                    |                           |                             | Module 1 #3 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 907                    |                           |                             |                                        |           |       | T1(High) |
| 908                    |                           |                             | Module 1 #4 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 909                    |                           |                             |                                        |           |       | T1(High) |
| 910                    |                           |                             | Module 1 #5 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 911                    |                           |                             |                                        |           |       | T1(High) |
| 912                    |                           |                             | Module 1 #6 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 913                    |                           |                             |                                        |           |       | T1(High) |
| 914                    |                           |                             | Module 1 #7 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 915                    |                           |                             |                                        |           |       | T1(High) |
| 916                    |                           |                             | Module 1 #8 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 917                    |                           |                             |                                        |           |       | T1(High) |
| 918                    |                           |                             | Module 2 #1 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 919                    |                           |                             |                                        |           |       | T1(High) |
| 920                    |                           |                             | Module 2 #2 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 921                    |                           |                             |                                        |           |       | T1(High) |
| 922                    |                           |                             | Module 2 #3 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 923                    |                           |                             |                                        |           |       | T1(High) |
| 924                    |                           |                             | Module 2 #4 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 925                    |                           |                             |                                        |           |       | T1(High) |
| 926                    |                           |                             | Module 2 #5 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 927                    |                           |                             |                                        |           |       | T1(High) |
| 928                    |                           |                             | Module 2 #6 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 929                    |                           |                             |                                        |           |       | T1(High) |
| 930                    |                           |                             | Module 2 #7 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 931                    |                           |                             |                                        |           |       | T1(High) |
| 932                    |                           |                             | Module 2 #8 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 933                    |                           |                             |                                        |           |       | T1(High) |
| 934                    |                           |                             | Module 3 #1 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 935                    |                           |                             |                                        |           |       | T1(High) |
| 936                    |                           |                             | Module 3 #2 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 937                    |                           |                             |                                        |           |       | T1(High) |
| 938                    |                           |                             | Module 3 #3 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 939                    |                           |                             |                                        |           |       | T1(High) |
| 940                    |                           |                             | Module 3 #4 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 941                    |                           |                             |                                        |           |       | T1(High) |



| MPS REGISTER (DECIMAL)              | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                            | ACCESS    | RANGE      | TYPE      |
|-------------------------------------|---------------------------|-----------------------------|----------------------------------------|-----------|------------|-----------|
| 942                                 |                           |                             | Module 3 #5 Temperature <sup>(9)</sup> | Read Only |            | T1(Low)   |
| 943                                 |                           |                             |                                        |           |            | T1(High)  |
| 944                                 |                           |                             | Module 3 #6 Temperature <sup>(9)</sup> | Read Only |            | T1(Low)   |
| 945                                 |                           |                             |                                        |           |            | T1(High)  |
| 946                                 |                           |                             | Module 3 #7 Temperature <sup>(9)</sup> | Read Only |            | T1(Low)   |
| 947                                 |                           |                             |                                        |           |            | T1(High)  |
| 948                                 |                           |                             | Module 3 #8 Temperature <sup>(9)</sup> | Read Only |            | T1(Low)   |
| 949                                 |                           |                             |                                        |           |            | T1(High)  |
| 950                                 |                           |                             | Max Stator Temperature                 | Read Only |            | T1(Low)   |
| 951                                 |                           |                             |                                        |           |            | T1(High)  |
| 952                                 |                           |                             | Max Bearing Temperature                | Read Only |            | T1(Low)   |
| 953                                 |                           |                             |                                        |           |            | T1(High)  |
| 954                                 |                           |                             | Max Load Temperature                   | Read Only |            | T1(Low)   |
| 955                                 |                           |                             |                                        |           |            | T1(High)  |
| 956                                 |                           |                             | Max Ambient Temperature                | Read Only |            | T1(Low)   |
| 957                                 |                           |                             |                                        |           |            | T1(High)  |
| 958                                 |                           |                             | Min Stator Temperature                 | Read Only |            | T1(Low)   |
| 959                                 |                           |                             |                                        |           |            | T1(High)  |
| 960                                 |                           |                             | Min Bearing Temperature                | Read Only |            | T1(Low)   |
| 961                                 |                           |                             |                                        |           |            | T1(High)  |
| 962                                 |                           |                             | Min Load Temperature                   | Read Only |            | T1(Low)   |
| 963                                 |                           |                             |                                        |           |            | T1(High)  |
| 964                                 |                           |                             | Min Ambient Temperature                | Read Only |            | T1(Low)   |
| 965                                 |                           |                             |                                        |           |            | T1(High)  |
| 966                                 |                           |                             | Frequency (Hz)                         | Read Only |            | T1(Low)   |
| 967                                 |                           |                             |                                        |           |            | T1(High)  |
| 968                                 |                           |                             | I <sup>2</sup> t Reset/Trip/Inhibit    | Read Only |            | T1(Low)   |
| 969                                 |                           |                             | Time (Minutes) <sup>(7)</sup>          |           |            | T1(High)  |
| <b>Event Records</b> <sup>(6)</sup> |                           |                             |                                        |           |            |           |
| 973                                 | 40974                     | 7:0                         | Number of New Records                  | Read Only | 0 - 65,535 | T3        |
| 974                                 |                           |                             | Record Head (Next Record)              | Read Only | 0 - 63     | T3        |
| 975                                 |                           |                             | Record Selector                        | R/W       | 0 - 63     | T3        |
| 976                                 |                           |                             | Record Date                            | Read Only |            | T23(Low)  |
| 977                                 |                           |                             |                                        |           |            | T23(High) |
| 978                                 |                           |                             | Record Time                            | Read Only |            | T24(Low)  |
| 979                                 |                           |                             |                                        |           |            | T24(High) |
| 980                                 |                           |                             | Record Type                            | Read Only |            | T26       |
| 981                                 |                           |                             | Message Code                           | Read Only |            | T27       |
| 982                                 |                           |                             | I <sub>a</sub> <sup>(1)</sup>          | Read Only |            | T1(Low)   |
| 983                                 |                           |                             |                                        |           |            | T1(High)  |
| 984                                 |                           |                             | I <sub>b</sub> <sup>(1)</sup>          | Read Only |            | T1(Low)   |
| 985                                 |                           |                             |                                        |           |            | T1(High)  |
| 986                                 |                           |                             | I <sub>c</sub> <sup>(1)</sup>          | Read Only |            | T1(Low)   |
| 987                                 |                           |                             |                                        |           |            | T1(High)  |
| 988                                 |                           |                             | I <sub>g</sub> <sup>(1)</sup>          | Read Only |            | T1(Low)   |
| 989                                 |                           |                             |                                        |           |            | T1(High)  |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                            | ACCESS    | RANGE | TYPE     |
|------------------------|---------------------------|-----------------------------|----------------------------------------|-----------|-------|----------|
| 990                    |                           |                             | $V_{ab}^{(2)}$                         | Read Only |       | T1(Low)  |
| 991                    |                           |                             |                                        |           |       | T1(High) |
| 992                    |                           |                             | $V_{bc}^{(2)}$                         | Read Only |       | T1(Low)  |
| 993                    |                           |                             |                                        |           |       | T1(High) |
| 994                    |                           |                             | $V_{ca}^{(2)}$                         | Read Only |       | T1(Low)  |
| 995                    |                           |                             |                                        |           |       | T1(High) |
| 996                    |                           |                             | Analog Input                           | Read Only |       | T1(Low)  |
| 997                    |                           |                             |                                        |           |       | T1(High) |
| 998                    |                           |                             | Current Unbalance <sup>(1)</sup>       | Read Only |       | T1(Low)  |
| 999                    |                           |                             |                                        |           |       | T1(High) |
| 1000                   |                           |                             | Voltage Unbalance <sup>(1)</sup>       | Read Only |       | T1(Low)  |
| 1001                   |                           |                             |                                        |           |       | T1(High) |
| 1002                   |                           |                             | Start Time                             | Read Only |       | T3       |
| 1003                   |                           |                             | Used $I^2t$ <sup>(3)</sup>             | Read Only |       | T1(Low)  |
| 1004                   |                           |                             |                                        |           |       | T1(High) |
| 1005                   |                           |                             | Module 1 #1 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1006                   |                           |                             |                                        |           |       | T1(High) |
| 1007                   |                           |                             | Module 1 #2 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1008                   |                           |                             |                                        |           |       | T1(High) |
| 1009                   |                           |                             | Module 1 #3 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1010                   |                           |                             |                                        |           |       | T1(High) |
| 1011                   |                           |                             | Module 1 #4 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1012                   |                           |                             |                                        |           |       | T1(High) |
| 1013                   |                           |                             | Module 1 #5 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1014                   |                           |                             |                                        |           |       | T1(High) |
| 1015                   |                           |                             | Module 1 #6 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1016                   |                           |                             |                                        |           |       | T1(High) |
| 1017                   |                           |                             | Module 1 #7 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1018                   |                           |                             |                                        |           |       | T1(High) |
| 1019                   |                           |                             | Module 1 #8 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1020                   |                           |                             |                                        |           |       | T1(High) |
| 1021                   |                           |                             | Module 2 #1 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1022                   |                           |                             |                                        |           |       | T1(High) |
| 1023                   |                           |                             | Module 2 #2 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1024                   |                           |                             |                                        |           |       | T1(High) |
| 1025                   |                           |                             | Module 2 #3 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1026                   |                           |                             |                                        |           |       | T1(High) |
| 1027                   |                           |                             | Module 2 #4 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1028                   |                           |                             |                                        |           |       | T1(High) |
| 1029                   |                           |                             | Module 2 #5 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1030                   |                           |                             |                                        |           |       | T1(High) |
| 1031                   |                           |                             | Module 2 #6 Temperature <sup>(9)</sup> | Read Only |       | T1(Low)  |
| 1032                   |                           |                             |                                        |           |       | T1(High) |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                                     | ACCESS    | RANGE        | TYPE     |
|------------------------|---------------------------|-----------------------------|-------------------------------------------------|-----------|--------------|----------|
| 1033                   |                           |                             | Module 2 #7 Temperature <sup>(9)</sup>          | Read Only |              | T1(Low)  |
| 1034                   |                           |                             |                                                 |           |              | T1(High) |
| 1035                   |                           |                             | Module 2 #8 Temperature <sup>(9)</sup>          | Read Only |              | T1(Low)  |
| 1036                   |                           |                             |                                                 |           |              | T1(High) |
| 1037                   |                           |                             | Differential Current Phase A (A) <sup>(6)</sup> | Read Only |              | T1(Low)  |
| 1038                   |                           |                             |                                                 |           |              | T1(High) |
| 1039                   |                           |                             | Differential Current Phase B (A) <sup>(6)</sup> | Read Only |              | T1(Low)  |
| 1040                   |                           |                             |                                                 |           |              | T1(High) |
| 1041                   |                           |                             | Differential Current Phase C (A) <sup>(6)</sup> | Read Only |              | T1(Low)  |
| 1042                   |                           |                             |                                                 |           |              | T1(High) |
| 1043                   |                           |                             | Reserved                                        | Read Only |              | T1(Low)  |
| 1044                   |                           |                             |                                                 |           |              | T1(High) |
| 1045                   |                           |                             | Reserved                                        | Read Only |              | T1(Low)  |
| 1046                   |                           |                             |                                                 |           |              | T1(High) |
| 1047                   |                           |                             | Reserved                                        | Read Only |              | T1(Low)  |
| 1048                   |                           |                             |                                                 |           |              | T1(High) |
| 1049                   |                           |                             | Reserved                                        | Read Only |              | T1(Low)  |
| 1050                   |                           |                             |                                                 |           |              | T1(High) |
| 1051                   |                           |                             | Reserved                                        | Read Only |              | T1(Low)  |
| 1052                   |                           |                             |                                                 |           |              | T1(High) |
| 1053                   |                           |                             | Frequency                                       | Read Only |              | T1(Low)  |
| 1054                   |                           |                             |                                                 |           |              | T1(High) |
| 1055                   |                           |                             | Power—S (kVA)                                   | Read Only |              | T1(Low)  |
| 1056                   |                           |                             |                                                 |           |              | T1(High) |
| 1057                   |                           |                             | Power—P (kW)                                    | Read Only |              | T1(Low)  |
| 1058                   |                           |                             |                                                 |           |              | T1(High) |
| 1059                   |                           |                             | Power—Q (kVAR)                                  | Read Only |              | T1(Low)  |
| 1060                   |                           |                             |                                                 |           |              | T1(High) |
| 1061                   |                           |                             | Power Factor                                    | Read Only |              | T1(Low)  |
| 1062                   |                           |                             |                                                 |           |              | T1(High) |
| <b>Underpower</b>      |                           |                             |                                                 |           |              |          |
| 1070                   | 41071                     | 7:97                        | Trip Action                                     | R/W       | 0 - 7        | T42      |
| 1071                   |                           |                             | Trip Level                                      | R/W       | 0.1 - 1.0    | T1(Low)  |
| 1072                   |                           |                             |                                                 |           |              | T1(High) |
| 1073                   |                           |                             | Trip Delay                                      | R/W       | 0.5 - 500 s  | T1(Low)  |
| 1074                   |                           |                             |                                                 |           |              | T1(High) |
| 1075                   |                           |                             | Alarm Level                                     | R/W       | 0.1 - 1.0    | T1(Low)  |
| 1076                   |                           |                             |                                                 |           |              | T1(High) |
| 1077                   |                           |                             | Alarm Delay                                     | R/W       | 10.5 - 500 s | T1(Low)  |
| 1078                   |                           |                             |                                                 |           |              | T1(High) |
| 1079                   |                           |                             | Alarm Action                                    | R/W       | 0 - 7        | T43      |
| <b>Reversepower</b>    |                           |                             |                                                 |           |              |          |
| 1080                   | 41081                     | 7:107                       | Trip Action                                     | R/W       | 0 - 7        | T42      |
| 1081                   |                           |                             | Trip Level                                      | R/W       | 0.1 - 1.0    | T1(Low)  |
| 1082                   |                           |                             |                                                 |           |              | T1(High) |
| 1083                   |                           |                             | Trip Delay                                      | R/W       | 0.5 - 500 s  | T1(Low)  |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION            | ACCESS    | RANGE        | TYPE     |
|------------------------|---------------------------|-----------------------------|------------------------|-----------|--------------|----------|
| 1084                   |                           |                             |                        |           |              | T1(Low)  |
| 1085                   |                           |                             | Alarm Level            | R/W       | 0.1 - 1.0    | T1(High) |
| 1086                   |                           |                             |                        |           |              | T1(Low)  |
| 1087                   |                           |                             | Alarm Delay            | R/W       | 10.5 - 500 s | T1(High) |
| 1088                   |                           |                             |                        |           |              | T1(Low)  |
| 1089                   |                           |                             | Alarm Action           | R/W       | 0 - 7        | T43      |
| <b>Status</b>          |                           |                             |                        |           |              |          |
| 1096                   | 41097                     | 8:0                         | Trip and Alarm Summary | Read Only |              | T30      |
| 1097                   |                           |                             | Motor Status           | Read Only |              | T28      |
| 1098                   |                           |                             | Starter Status         | Read Only |              | T29      |
| 1099                   |                           |                             | Digital Inputs         | Read Only |              | T35      |
| 1100                   |                           |                             | Relay Outputs          | Read Only |              | T36      |
| <b>Message Stack</b>   |                           |                             |                        |           |              |          |
| 1104                   | 41105                     | 8:8                         | Message 0              | Read Only |              | T27      |
| 1105                   |                           |                             | Message 1              | Read Only |              | T27      |
| 1106                   |                           |                             | Message 2              | Read Only |              | T27      |
| 1107                   |                           |                             | Message 3              | Read Only |              | T27      |
| 1108                   |                           |                             | Message 4              | Read Only |              | T27      |
| <b>Trip Counters</b>   |                           |                             |                        |           |              |          |
| 1130                   | 41131                     | 8:39                        | Overcurrent            | Read Only |              | T3       |
| 1131                   |                           |                             | AUX Overcurrent        | Read Only |              | T3       |
| 1132                   |                           |                             | Overload               | Read Only |              | T3       |
| 1133                   |                           |                             | Earth Fault            | Read Only |              | T3       |
| 1134                   |                           |                             | Current Unbalance      | Read Only |              | T3       |
| 1135                   |                           |                             | Voltage Unbalance      | Read Only |              | T3       |
| 1136                   |                           |                             | Jam                    | Read Only |              | T3       |
| 1137                   |                           |                             | Undercurrent           | Read Only |              | T3       |
| 1138                   |                           |                             | Overvoltage            | Read Only |              | T3       |
| 1139                   |                           |                             | Undervoltage           | Read Only |              | T3       |
| 1140                   |                           |                             | Analog Input High      | Read Only |              | T3       |
| 1141                   |                           |                             | Analog Input Low       | Read Only |              | T3       |
| 1142                   |                           |                             | PTC                    | Read Only |              | T3       |
| 1143                   |                           |                             | Phase-Loss Current     | Read Only |              | T3       |
| 1144                   |                           |                             | Phase-Reverse Current  | Read Only |              | T3       |
| 1145                   |                           |                             | Phase-Loss Voltage     | Read Only |              | T3       |
| 1146                   |                           |                             | Phase-Reverse Voltage  | Read Only |              | T3       |
| 1147                   |                           |                             | Underspeed             | Read Only |              | T3       |
| 1148                   |                           |                             | Contactor Status       | Read Only |              | T3       |
| 1149                   |                           |                             | Digital 1 Trip         | Read Only |              | T3       |
| 1150                   |                           |                             | Digital 2 Trip         | Read Only |              | T3       |
| 1151                   |                           |                             | Digital 3 Trip         | Read Only |              | T3       |
| 1152                   |                           |                             | Digital 4 Trip         | Read Only |              | T3       |
| 1153                   |                           |                             | Digital 5 Trip         | Read Only |              | T3       |
| 1154                   |                           |                             | Digital 6 Trip         | Read Only |              | T3       |
| 1155                   |                           |                             | Digital 7 Trip         | Read Only |              | T3       |
| 1156                   |                           |                             | RTD Module 1 #1        | Read Only |              | T3       |
| 1157                   |                           |                             | RTD Module 1 #2        | Read Only |              | T3       |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION               | ACCESS    | RANGE | TYPE       |
|------------------------|---------------------------|-----------------------------|---------------------------|-----------|-------|------------|
| 1158                   |                           |                             | RTD Module 1 #3           | Read Only |       | T3         |
| 1159                   |                           |                             | RTD Module 1 #4           | Read Only |       | T3         |
| 1160                   |                           |                             | RTD Module 1 #5           | Read Only |       | T3         |
| 1161                   |                           |                             | RTD Module 1 #6           | Read Only |       | T3         |
| 1162                   |                           |                             | RTD Module 1 #7           | Read Only |       | T3         |
| 1163                   |                           |                             | RTD Module 1 #8           | Read Only |       | T3         |
| 1164                   |                           |                             | RTD Module 2 #1           | Read Only |       | T3         |
| 1165                   |                           |                             | RTD Module 2 #2           | Read Only |       | T3         |
| 1166                   |                           |                             | RTD Module 2 #3           | Read Only |       | T3         |
| 1167                   |                           |                             | RTD Module 2 #4           | Read Only |       | T3         |
| 1168                   |                           |                             | RTD Module 2 #5           | Read Only |       | T3         |
| 1169                   |                           |                             | RTD Module 2 #6           | Read Only |       | T3         |
| 1170                   |                           |                             | RTD Module 2 #7           | Read Only |       | T3         |
| 1171                   |                           |                             | RTD Module 2 #8           | Read Only |       | T3         |
| 1172                   |                           |                             | RTD Module 3 #1           | Read Only |       | T3         |
| 1173                   |                           |                             | RTD Module 3 #2           | Read Only |       | T3         |
| 1174                   |                           |                             | RTD Module 3 #3           | Read Only |       | T3         |
| 1175                   |                           |                             | RTD Module 3 #4           | Read Only |       | T3         |
| 1176                   |                           |                             | RTD Module 3 #5           | Read Only |       | T3         |
| 1177                   |                           |                             | RTD Module 3 #6           | Read Only |       | T3         |
| 1178                   |                           |                             | RTD Module 3 #7           | Read Only |       | T3         |
| 1179                   |                           |                             | RTD Module 3 #8           | Read Only |       | T3         |
| 1180                   |                           |                             | RTD Module 1 Comm         | Read Only |       | T3         |
| 1181                   |                           |                             | RTD Module 2 Comm         | Read Only |       | T3         |
| 1182                   |                           |                             | RTD Module 3 Comm         | Read Only |       | T3         |
| 1183                   |                           |                             | RTD Sensor                | Read Only |       | T3         |
| 1184                   |                           |                             | Start Time Exceeded       | Read Only |       | T3         |
| 1185                   |                           |                             | Display Comm              | Read Only |       | T3         |
| 1186                   |                           |                             | Stop (In Protection Only) | Read Only |       | T3         |
| 1187                   |                           |                             | Lagging Power Factor – Q4 | Read Only |       | T3         |
| 1188                   |                           |                             | Underfrequency            | Read Only |       | T3         |
| 1189                   |                           |                             | Overfrequency             | Read Only |       | T3         |
| 1190                   |                           |                             | A/D                       | Read Only |       | T3         |
| 1191                   |                           |                             | Network                   | Read Only |       | T3         |
| 1192                   |                           |                             | Leading Power Factor – Q3 | Read Only |       | T3         |
| 1193                   |                           |                             | Starts Per Hour           | Read Only |       | T3         |
| 1194                   |                           |                             | Differential Module Trip  | Read Only |       | T3         |
| 1195                   |                           |                             | Differential Current Trip | Read Only |       | T3         |
| 1196                   |                           |                             | Reduced Overcurrent Trip  | Read Only |       | T3         |
| 1197                   |                           |                             | Underpower Trip           | Read Only |       | T3         |
| 1198                   |                           |                             | Reversepower Trip         | Read Only |       | T3         |
| <b>Running Time</b>    |                           |                             |                           |           |       |            |
| 1210                   | 41211                     | 9:0                         | Running Seconds           | Read Only |       | T2(Low)    |
| 1211                   |                           |                             |                           |           |       | T2(High)   |
| <b>Energy</b>          |                           |                             |                           |           |       |            |
| 1212                   | 41213                     | 9:2                         | kW Seconds                | Read Only |       | T4(Word 1) |
| 1213                   |                           |                             |                           |           |       | T4(Word 2) |

| MPS REGISTER (DECIMAL)                  | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                      | ACCESS    | RANGE       | TYPE       |
|-----------------------------------------|---------------------------|-----------------------------|----------------------------------|-----------|-------------|------------|
| 1214                                    |                           |                             |                                  |           |             | T4(Word 3) |
| 1215                                    |                           |                             |                                  |           |             | T4(Word 4) |
| 1216                                    |                           |                             | kVA Seconds                      | Read Only |             | T4(Word 1) |
| 1217                                    |                           |                             |                                  |           |             | T4(Word 2) |
| 1218                                    |                           |                             |                                  |           |             | T4(Word 3) |
| 1219                                    |                           |                             |                                  |           |             | T4(Word 4) |
| 1220                                    |                           |                             | kVAR Seconds                     | Read Only |             | T4(Word 1) |
| 1221                                    |                           |                             |                                  |           |             | T4(Word 2) |
| 1222                                    |                           |                             |                                  |           |             | T4(Word 3) |
| 1223                                    |                           |                             |                                  |           |             | T4(Word 4) |
| <b>Differential Module Meter Values</b> |                           |                             |                                  |           |             |            |
| 1224                                    | 41225                     | 9:14                        | Differential Current Phase A (A) | Read Only |             | T1(Low)    |
| 1225                                    |                           |                             |                                  |           |             | T1(High)   |
| 1226                                    |                           |                             | Differential Current Phase B (A) | Read Only |             | T1(Low)    |
| 1227                                    |                           |                             |                                  |           |             | T1(High)   |
| 1228                                    |                           |                             | Differential Current Phase C (A) | Read Only |             | T1(Low)    |
| 1229                                    |                           |                             |                                  |           |             | T1(High)   |
| <b>Underfrequency</b>                   |                           |                             |                                  |           |             |            |
| 1230                                    | 41231                     | 9:20                        | Trip Action                      | R/W       | 0 - 7       | T42        |
| 1231                                    |                           |                             | Trip Level                       | R/W       | 30 - 80 Hz  | T1(Low)    |
| 1232                                    |                           |                             |                                  |           |             | T1(High)   |
| 1233                                    |                           |                             | Trip Delay                       | R/W       | 0.5 - 500 s | T1(Low)    |
| 1234                                    |                           |                             |                                  |           |             | T1(High)   |
| 1235                                    |                           |                             | Alarm Level                      | R/W       | 30 - 80 Hz  | T1(Low)    |
| 1236                                    |                           |                             |                                  |           |             | T1(High)   |
| 1237                                    |                           |                             | Alarm Delay                      | R/W       | 0.5 - 500 s | T1(Low)    |
| 1238                                    |                           |                             |                                  |           |             | T1(High)   |
| <b>Overfrequency</b>                    |                           |                             |                                  |           |             |            |
| 1239                                    | 41240                     | 9:29                        | Trip Action                      | R/W       | 0 - 7       | T42        |
| 1240                                    |                           |                             | Trip Level                       | R/W       | 30 - 80 Hz  | T1(Low)    |
| 1241                                    |                           |                             |                                  |           |             | T1(High)   |
| 1242                                    |                           |                             | Trip Delay                       | R/W       | 0.5 - 500 s | T1(Low)    |
| 1243                                    |                           |                             |                                  |           |             | T1(High)   |
| 1244                                    |                           |                             | Alarm Level                      | R/W       | 30 - 80 Hz  | T1(Low)    |
| 1245                                    |                           |                             |                                  |           |             | T1(High)   |
| 1246                                    |                           |                             | Alarm Delay                      | R/W       | 0.5 - 500 s | T1(Low)    |
| 1247                                    |                           |                             |                                  |           |             | T1(High)   |
| <b>Underfrequency Alarm Action</b>      |                           |                             |                                  |           |             |            |
| 1248                                    | 41249                     | 9:38                        | Alarm Action                     | R/W       | 0 - 7       | T43        |
| <b>Overfrequency Alarm Action</b>       |                           |                             |                                  |           |             |            |
| 1249                                    | 41250                     | 9:39                        | Alarm Action                     | R/W       | 0 - 7       | T43        |
| <b>Power Factor Quadrant 3</b>          |                           |                             |                                  |           |             |            |
| 1250                                    | 41251                     | 9:40                        | Trip Action                      | R/W       | 0 - 7       | T42        |
| 1251                                    |                           |                             | Trip Level                       | R/W       | 0.5 - 1.0   | T1(Low)    |
| 1252                                    |                           |                             |                                  |           |             | T1(High)   |
| 1253                                    |                           |                             | Trip Delay                       | R/W       | 0.2 - 500 s | T1(Low)    |
| 1254                                    |                           |                             |                                  |           |             | T1(High)   |

| MPS REGISTER (DECIMAL)                     | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION                | ACCESS    | RANGE                     | TYPE                           |
|--------------------------------------------|---------------------------|-----------------------------|----------------------------|-----------|---------------------------|--------------------------------|
| 1255                                       |                           |                             | Alarm Level                | R/W       | 0.5 - 1.0                 | T1(Low)                        |
| 1256                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1257                                       |                           |                             | Alarm Delay                | R/W       | 0.2 - 500 s               | T1(Low)                        |
| 1258                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1259                                       |                           |                             | Alarm Action               | R/W       | 0 - 7                     | T43                            |
| <b>Starts Per Hour/Time Between Starts</b> |                           |                             |                            |           |                           |                                |
| 1267                                       |                           |                             | Starts Remaining           | Read Only | R0                        | T3                             |
| 1268                                       |                           |                             | Starts/Hour Time Remaining | Read Only | R0                        | T1(Low)                        |
| 1269                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1270                                       | 41271                     | 9:60                        | Trip Action                | R/W       | 0 - 7                     | T42                            |
| 1271                                       |                           |                             | Alarm Action               | R/W       | 0 - 7                     | T43                            |
| 1272                                       |                           |                             | Starts per Hour Setting    | R/W       | 0 - 9                     | T25                            |
| 1273                                       |                           |                             | Time Between Starts        | R/W       | 0 - 500 m                 | T1(Low)                        |
| 1274                                       |                           |                             |                            |           |                           | T1(High)                       |
| <b>Differential Module</b>                 |                           |                             |                            |           |                           |                                |
| 1277                                       | 41278                     | 9:67                        | Module Enable              | R/W       | 0 - 1                     | T6                             |
| 1278                                       |                           |                             | Module-Error Trip Action   | R/W       | 0 - 7                     | T42                            |
| 1279                                       |                           |                             | Module-Error Alarm Action  | R/W       | 0 - 7                     | T43                            |
| <b>Differential Protection</b>             |                           |                             |                            |           |                           |                                |
| 1280                                       | 41281                     | 9:70                        | Trip Action                | R/W       | 0 - 7                     | T42                            |
| 1281                                       |                           |                             | Trip Level                 | R/W       | 0.1 - 15 x I <sub>d</sub> | T1(Low)                        |
| 1282                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1283                                       |                           |                             | Trip Delay                 | R/W       | 0 - 10 s                  | T1(Low)                        |
| 1284                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1285                                       |                           |                             | Alarm Level                | R/W       | 0.1 - 15 x I <sub>d</sub> | T1(Low)                        |
| 1286                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1287                                       |                           |                             | Alarm Delay                | R/W       | 0 - 10 s                  | T1(Low)                        |
| 1288                                       |                           |                             |                            |           |                           | T1(High)                       |
| 1289                                       |                           |                             | Alarm Action               | R/W       | 0 - 7                     | T43                            |
| <b>Ethernet</b>                            |                           |                             |                            |           |                           |                                |
| 1300                                       | 41301                     | 9:90                        | IP Address                 | R/W       |                           | T22                            |
| 1310                                       |                           |                             | Address Mask               | R/W       |                           | T22                            |
| 1320                                       |                           |                             | Default Gateway            | R/W       |                           | T22                            |
| <b>Waveform Capture<sup>(8)</sup></b>      |                           |                             |                            |           |                           |                                |
| 1330                                       |                           |                             | Hardware Capable           | R0        | 0 - 1                     | 0 = Not Capable<br>1 = Capable |
| 1331                                       |                           |                             | Trace Auto-Start           | RW        | 0 - 1                     | T6                             |
| 1332                                       |                           |                             | Sample Count               | R0        | 0 - 4800                  | T3                             |
| 1333                                       |                           |                             | Channel Selector           | RW        | 0 - 6                     | T107                           |
| 1334                                       |                           |                             | Sample Index               | RW        | 0 - 4800                  | T3                             |
| 1335                                       |                           |                             | Trace Date                 | R0        |                           | T23 (Low)                      |
| 1336                                       |                           |                             |                            |           |                           | T23 (High)                     |
| 1337                                       |                           |                             | Trace Time                 | R0        |                           | T24(Low)                       |
| 1338                                       |                           |                             |                            |           |                           | T24 (High)                     |
| 1339                                       |                           |                             | Trace Trip Code            | R0        |                           | T27                            |
| 1340                                       |                           |                             | Trace Memory               | R0        |                           | T3                             |
| 1341                                       |                           |                             | Trace Memory               | R0        |                           | T3                             |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION  | ACCESS | RANGE | TYPE |
|------------------------|---------------------------|-----------------------------|--------------|--------|-------|------|
| 1342                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1343                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1344                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1345                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1346                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1347                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1348                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1349                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1350                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1351                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1352                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1353                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1354                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1355                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1356                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1357                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1358                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1359                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1360                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1361                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1362                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1363                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1364                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1365                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1366                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1367                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1368                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1369                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1370                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1371                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1372                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1373                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1374                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1375                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1376                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1377                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1378                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1379                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1380                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1381                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1382                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1383                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1384                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1385                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1386                   |                           |                             | Trace Memory | R0     |       | T3   |
| 1387                   |                           |                             | Trace Memory | R0     |       | T3   |



| MPS REGISTER (DECIMAL)        | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION           | ACCESS    | RANGE                                          | TYPE |
|-------------------------------|---------------------------|-----------------------------|-----------------------|-----------|------------------------------------------------|------|
| <b>User Defined Registers</b> |                           |                             |                       |           |                                                |      |
| 1400                          | 41401                     | 9:190                       | User Register 0       | R/W       |                                                | T3   |
| 1401                          |                           |                             | User Register 1       | R/W       |                                                | T3   |
| 1402                          |                           |                             | User Register 2       | R/W       |                                                | T3   |
| 1403                          |                           |                             | User Register 3       | R/W       |                                                | T3   |
| 1404                          |                           |                             | User Register 4       | R/W       |                                                | T3   |
| 1405                          |                           |                             | User Register 5       | R/W       |                                                | T3   |
| 1406                          |                           |                             | User Register 6       | R/W       |                                                | T3   |
| 1407                          |                           |                             | User Register 7       | R/W       |                                                | T3   |
| 1408                          |                           |                             | User Register 8       | R/W       |                                                | T3   |
| 1409                          |                           |                             | User Register 9       | R/W       |                                                | T3   |
| 1410                          |                           |                             | User Register 10      | R/W       |                                                | T3   |
| 1411                          |                           |                             | User Register 11      | R/W       |                                                | T3   |
| 1412                          |                           |                             | User Register 12      | R/W       |                                                | T3   |
| 1413                          |                           |                             | User Register 13      | R/W       |                                                | T3   |
| 1414                          |                           |                             | User Register 14      | R/W       |                                                | T3   |
| 1415                          |                           |                             | User Register 15      | R/W       |                                                | T3   |
| 1416                          |                           |                             | User Register 16      | R/W       |                                                | T3   |
| 1417                          |                           |                             | User Register 17      | R/W       |                                                | T3   |
| 1418                          |                           |                             | User Register 18      | R/W       |                                                | T3   |
| 1419                          |                           |                             | User Register 19      | R/W       |                                                | T3   |
| 1420                          |                           |                             | User Register 20      | R/W       |                                                | T3   |
| 1421                          |                           |                             | User Register 21      | R/W       |                                                | T3   |
| 1422                          |                           |                             | User Register 22      | R/W       |                                                | T3   |
| 1423                          |                           |                             | User Register 23      | R/W       |                                                | T3   |
| 1424                          |                           |                             | User Register 24      | R/W       |                                                | T3   |
| 1425                          |                           |                             | User Register 25      | R/W       |                                                | T3   |
| 1426                          |                           |                             | User Register 26      | R/W       |                                                | T3   |
| 1427                          |                           |                             | User Register 27      | R/W       |                                                | T3   |
| 1428                          |                           |                             | User Register 28      | R/W       |                                                | T3   |
| 1429                          |                           |                             | User Register 29      | R/W       |                                                | T3   |
| 1430                          |                           |                             | User Register 30      | R/W       |                                                | T3   |
| 1431                          |                           |                             | User Register 31      | R/W       |                                                | T3   |
| <b>User Data</b>              |                           |                             |                       |           |                                                |      |
| 1432                          | 41433                     | 9:222                       | User Register 0 Data  | Read Only | Range and Type defined by user register value. |      |
| 1433                          |                           |                             | User Register 1 Data  | Read Only |                                                |      |
| 1434                          |                           |                             | User Register 2 Data  | Read Only |                                                |      |
| 1435                          |                           |                             | User Register 3 Data  | Read Only |                                                |      |
| 1436                          |                           |                             | User Register 4 Data  | Read Only |                                                |      |
| 1437                          |                           |                             | User Register 5 Data  | Read Only |                                                |      |
| 1438                          |                           |                             | User Register 6 Data  | Read Only |                                                |      |
| 1439                          |                           |                             | User Register 7 Data  | Read Only |                                                |      |
| 1440                          |                           |                             | User Register 8 Data  | Read Only |                                                |      |
| 1441                          |                           |                             | User Register 9 Data  | Read Only |                                                |      |
| 1442                          |                           |                             | User Register 10 Data | Read Only |                                                |      |
| 1443                          |                           |                             | User Register 11 Data | Read Only |                                                |      |
| 1444                          |                           |                             | User Register 12 Data | Read Only |                                                |      |

| MPS REGISTER (DECIMAL) | MODBUS REGISTER (DECIMAL) | A-B FILE (DECIMAL) (NOTE 4) | DESCRIPTION           | ACCESS    | RANGE | TYPE |
|------------------------|---------------------------|-----------------------------|-----------------------|-----------|-------|------|
| 1445                   |                           |                             | User Register 13 Data | Read Only |       |      |
| 1446                   |                           |                             | User Register 14 Data | Read Only |       |      |
| 1447                   |                           |                             | User Register 15 Data | Read Only |       |      |
| 1448                   |                           |                             | User Register 16 Data | Read Only |       |      |
| 1449                   |                           |                             | User Register 17 Data | Read Only |       |      |
| 1450                   |                           |                             | User Register 18 Data | Read Only |       |      |
| 1451                   |                           |                             | User Register 19 Data | Read Only |       |      |
| 1452                   |                           |                             | User Register 20 Data | Read Only |       |      |
| 1453                   |                           |                             | User Register 21 Data | Read Only |       |      |
| 1454                   |                           |                             | User Register 22 Data | Read Only |       |      |
| 1455                   |                           |                             | User Register 23 Data | Read Only |       |      |
| 1456                   |                           |                             | User Register 24 Data | Read Only |       |      |
| 1457                   |                           |                             | User Register 25 Data | Read Only |       |      |
| 1458                   |                           |                             | User Register 26 Data | Read Only |       |      |
| 1459                   |                           |                             | User Register 27 Data | Read Only |       |      |
| 1460                   |                           |                             | User Register 28 Data | Read Only |       |      |
| 1461                   |                           |                             | User Register 29 Data | Read Only |       |      |
| 1462                   |                           |                             | User Register 30 Data | Read Only |       |      |
| 1463                   | 41464                     | 9:253                       | User Register 31 Data | Read Only |       |      |

# NOTES:

- (1) If the record type is START, these are the maximum values during the start.
- (2) If the record type is START, these are the minimum values during the start.
- (3) If the record type is START, this is the  $I^2t$  used during the start.
- (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.
- (5) Undefined registers in this table read zero. Registers greater than 1463 return error.
- (6) Starting with revision 2.3, differential-module data replaces RTD module 3 data. Applies only to event records.
- (7) If an overload trip occurred, reset time is indicated. If in an overload condition and not tripped, trip time is indicated. If a start inhibit is active, time to inhibit removal is indicated. All other conditions indicate 0.
- (8) Trace Data are 16-bit raw values. These formulas convert the Trace Data to real values based on relay settings. These are already applied in the COMTRADE files so additional conversions are not required.  
 $I_a, I_b, I_c = \text{Trace Value} \times \text{CT Primary} \times 0.006285 \text{ A}$   
 $I_o = \text{Trace Value} \times \text{EFCT Primary} \times 0.00408 \text{ A}$   
1 PT:  $V_{ab}, V_{bc}, V_{ca} = \text{Trace Value} \times (V_{\text{primary}}/V_{\text{secondary}}) \times 0.00042636 \text{ kV}$   
{  $V_{bc}, V_{ca}$  are phase-shifted values derived from  $V_{ab}$  }  
2 PT:  $V_{ab}, V_{bc}, V_{ca} = \text{Trace Value} \times (V_{\text{primary}}/V_{\text{secondary}}) \times 0.00042636 \text{ kV}$   
{  $V_{ca}$  is calculated from  $V_{ab}$  and  $V_{bc}$  }  
3 PT:  $V_{ab}, V_{bc}, V_{ca} = \text{Trace Value} \times (V_{\text{primary}}/V_{\text{secondary}}) \times 0.00043358 \text{ kV}$   
{  $V_{ab}, V_{bc}, V_{ca}$  are calculated from  $V_{an}, V_{bn}, V_{cn}$  }
- (9) The following MPS-RTD error codes are supported:  
-100 = No RTD Sensor  
-90 = Open Sensor  
-80 = Shorted Sensor  
-70 = No Data/Module Communication Error

## APPENDIX F REGISTER FORMATS

| TYPE       | C TYPE | DESCRIPTION                                                        |
|------------|--------|--------------------------------------------------------------------|
| <b>T1</b>  | 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                                            |
| <b>T2</b>  | Long   | 32-Bit Integer                                                     |
|            |        | (High) Bits 31..16                                                 |
|            |        | (Low) Bits 15..0                                                   |
| <b>T3</b>  | Short  | 16-Bit Integer                                                     |
| <b>T4</b>  | Double | IEEE 64-Bit Floating-Point Number                                  |
|            |        | Bit 63: Sign                                                       |
|            |        | Bits 62..52: Exponent                                              |
|            |        | Bits 51..0: Mantissa                                               |
|            |        | Word 1 (Least Significant Word) ... Word 4 (Most Significant Word) |
| <b>T5</b>  |        | Reserved                                                           |
| <b>T6</b>  | Short  | Enable/Disable                                                     |
|            |        | 0: Enabled                                                         |
|            |        | 1: Disabled                                                        |
| <b>T9</b>  | Short  | Voltage-Connection Type                                            |
|            |        | 0: No Voltage Input                                                |
|            |        | 1: 1PT                                                             |
|            |        | 2: 2PT                                                             |
|            |        | 3: 3PT and Direct Connection                                       |
| <b>T10</b> | Short  | Frequency                                                          |
|            |        | 0: 50 Hz                                                           |
|            |        | 1: 60 Hz                                                           |
| <b>T11</b> | Short  | Starter Type                                                       |
|            |        | 0: Protection Only                                                 |
|            |        | 1: Full Voltage Non-Reversing                                      |
|            |        | 2: Adjustable-Speed Drive                                          |
|            |        | 3: Soft Start                                                      |
|            |        | 4: Full Voltage Reversing                                          |
|            |        | 5: Two Speed                                                       |
|            |        | 6: Reactor/Resistor Closed Transition                              |
|            |        | 7: Reactor/Resistor Open Transition                                |
|            |        | 8: Slip Ring                                                       |
|            |        | 9: Soft Start with Bypass                                          |
|            |        | 10: Part Winding                                                   |
|            |        | 11: Double Delta                                                   |
|            |        | 12: Autotransformer                                                |
|            |        | 13: Two Winding                                                    |
|            |        | 14: Wye Delta, Open Transition                                     |
|            |        | 15: Wye Delta, Closed Transition                                   |

| TYPE       | C TYPE | DESCRIPTION                       |
|------------|--------|-----------------------------------|
| <b>T12</b> | Short  | Digital Input Function            |
|            |        | 0: Input Not Used                 |
|            |        | 1: Start 1 (N.O. Contact)         |
|            |        | 2: Start 2 (N.O. Contact)         |
|            |        | 3: Stop (N.C. Contact)            |
|            |        | 4: Starter RLYA Status            |
|            |        | 5: Starter RLYB Status            |
|            |        | 6: Starter RLYC Status            |
|            |        | 7: Starter RLYD Status            |
|            |        | 8: Interlock (N.C.)               |
|            |        | 9: Trip1 (N.C.)                   |
|            |        | 10: Reset (N.O.)                  |
|            |        | 11: Local Select -                |
|            |        | 12: Local Start1                  |
|            |        | 13: Local Start2                  |
|            |        | 14: 2-Wire Start1                 |
|            |        | 15: 2-Wire Start2                 |
|            |        | 16: FLA2 Select                   |
|            |        | 17: Limit1 Stop                   |
|            |        | 18: Limit2 Stop                   |
|            |        | 19: Reduced OC                    |
|            |        | 20: Local Select +                |
| <b>T13</b> | Short  | Relay Output Function             |
|            |        | 0: None                           |
|            |        | 1: Starter RLYA                   |
|            |        | 2: Starter RLYB                   |
|            |        | 3: Starter RLYC                   |
|            |        | 4: Starter RLYD                   |
|            |        | 5: Trip1                          |
|            |        | 6: Alarm1                         |
|            |        | 7: Trip 2                         |
|            |        | 8: Interlock                      |
|            |        | 9: Local                          |
|            |        | 10: Current Detected              |
|            |        | 11: Run Mode                      |
|            |        | 12: Starter Sequence Complete     |
|            |        | 13: Thermal Lockout/Start Inhibit |
|            |        | 14: None                          |
|            |        | 15: Watchdog                      |
|            |        | 16: Trip3                         |
|            |        | 17: Alarm2                        |
|            |        | 18: Alarm3                        |
|            |        | 19: Trip1 Pulse                   |
|            |        | 20: Reduced OC                    |
| <b>T14</b> | Short  | Relay Trip/Alarm Mode             |
|            |        | 0: Fail Safe                      |
|            |        | 1: Non Fail Safe                  |

| TYPE       | C TYPE | DESCRIPTION                  |
|------------|--------|------------------------------|
| <b>T15</b> | Short  | Analog Output Function       |
|            |        | 0: Phase Current             |
|            |        | 1: Earth Leakage             |
|            |        | 2: Thermal Capacity          |
|            |        | 3: Stator RTD                |
|            |        | 4: Bearing RTD               |
|            |        | 5: Load RTD                  |
|            |        | 6: Ambient RTD               |
|            |        | 7: Voltage                   |
|            |        | 8: Unbalance (I)             |
|            |        | 9: Power Factor              |
|            |        | 10: Real Power               |
|            |        | 11: Reactive Power           |
|            |        | 12: Apparent Power           |
|            |        | 13: Zero                     |
|            |        | 14: Full Scale               |
|            |        | 15: Speed                    |
|            |        | 16: Differential Current     |
| <b>T16</b> | Short  | Network Communication Type   |
|            |        | 0: None (Disabled)           |
|            |        | 1: A-B DF1                   |
|            |        | 2: Modbus RTU                |
|            |        | 3: AnyBus                    |
|            |        | 4: DeviceNet                 |
|            |        | 5: Modbus TCP                |
| <b>T17</b> | 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      |
| <b>T18</b> | Short  | Error Checking (AB DF1 Only) |
|            |        | 0: Not Selected              |
|            |        | 1: CRC Check                 |
|            |        | 2: BCC Check                 |
| <b>T19</b> | Short  | Number of RTD Modules        |
|            |        | 0: No RTD Module             |
|            |        | 1: 1 RTD Module              |
|            |        | 2: 2 RTD Modules             |
|            |        | 3: 3 RTD Modules             |
| <b>T20</b> | Short  | RTD Type                     |
|            |        | 0: Disable                   |
|            |        | 1: Platinum 100              |
|            |        | 2: Nickel 100                |
|            |        | 3: Nickel 120                |
|            |        | 4: Copper 10                 |

| TYPE       | C TYPE | DESCRIPTION                                                                                           |
|------------|--------|-------------------------------------------------------------------------------------------------------|
| <b>T21</b> | Short  | RTD Function                                                                                          |
|            |        | 0: Stator                                                                                             |
|            |        | 1: Bearing                                                                                            |
|            |        | 2: Load                                                                                               |
|            |        | 3: Ambient                                                                                            |
|            |        | 4: Stator Voting                                                                                      |
|            |        | 5: Bearing Voting                                                                                     |
|            |        | 6: Load Voting                                                                                        |
|            |        | 7: Ambient Voting                                                                                     |
| <b>T22</b> | 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".                                          |
| <b>T23</b> | Long   | Date                                                                                                  |
|            |        | Bits 31..16: Year in Binary                                                                           |
|            |        | Bits 15..8: 1-12 Months in Binary                                                                     |
|            |        | Bits 7..0: 1-31 days in Binary                                                                        |
| <b>T24</b> | 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                                                       |
| <b>T25</b> | Short  | Starts per Hour                                                                                       |
|            |        | 0: 1 Start per Hour                                                                                   |
|            |        | 1: 2 Starts per Hour                                                                                  |
|            |        | 2: 3 Starts per Hour                                                                                  |
|            |        | 3: 4 Starts per Hour                                                                                  |
|            |        | 4: 5 Starts per Hour                                                                                  |
|            |        | 5: 6 Starts per Hour                                                                                  |
|            |        | 6: 7 Starts per Hour                                                                                  |
|            |        | 7: 8 Starts per Hour                                                                                  |
|            |        | 8: 9 Starts per Hour                                                                                  |
|            |        | 9: 10 Starts per Hour                                                                                 |

| TYPE | C TYPE | DESCRIPTION                      |
|------|--------|----------------------------------|
| T26  | Short  | Trigger Source                   |
|      |        | 0: Empty Record                  |
|      |        | 1: Trip Record                   |
|      |        | 2: Start Record                  |
|      |        | 3: ETR Record                    |
| T27  | Short  | Message Code                     |
|      |        | 0: Main Overcurrent Trip         |
|      |        | 1: Auxiliary Overcurrent Trip    |
|      |        | 2: Overload Trip                 |
|      |        | 3: Overload Alarm                |
|      |        | 4: Earth-Fault Trip              |
|      |        | 5: Earth-Fault Alarm             |
|      |        | 6: Current-Unbalance Trip        |
|      |        | 7: Current-Unbalance Alarm       |
|      |        | 8: Voltage-Unbalance Trip        |
|      |        | 9: Voltage-Unbalance Alarm       |
|      |        | 10: Jam Trip                     |
|      |        | 11: Jam Alarm                    |
|      |        | 12: Undercurrent Trip            |
|      |        | 13: Undercurrent Alarm           |
|      |        | 14: Overvoltage Trip             |
|      |        | 15: Overvoltage Alarm            |
|      |        | 16: Undervoltage Trip            |
|      |        | 17: Undervoltage Alarm           |
|      |        | 18: Analog-Input-High Trip       |
|      |        | 19: Analog-Input-High Alarm      |
|      |        | 20: Analog-Input-Low Trip        |
|      |        | 21: Analog-Input-Low Alarm       |
|      |        | 22: PTC Temperature Trip         |
|      |        | 23: PTC Temperature Alarm        |
|      |        | 24: Phase-Loss (Current) Trip    |
|      |        | 25: Phase-Reverse (Current) Trip |
|      |        | 26: Phase-Loss (Voltage) Trip    |
|      |        | 27: Phase-Reverse (Voltage) Trip |
|      |        | 28: Underspeed Trip              |
|      |        | 29: Relay-Status Trip            |
|      |        | 30: Digital 1 Trip               |
|      |        | 31: Digital 2 Trip               |
|      |        | 32: Digital 3 Trip               |
|      |        | 33: Digital 4 Trip               |
|      |        | 34: Digital 5 Trip               |
|      |        | 35: Digital 6 Trip               |
|      |        | 36: Digital 7 Trip               |
|      |        | 37: RTD Module 1 INP 1 Trip      |
|      |        | 38: RTD Module 1 INP 1 Alarm     |
|      |        | 39: RTD Module 1 INP 2 Trip      |
|      |        | 40: RTD Module 1 INP 2 Alarm     |

| TYPE | C TYPE | DESCRIPTION                  |
|------|--------|------------------------------|
|      |        | 41: RTD Module 1 INP 3 Trip  |
|      |        | 42: RTD Module 1 INP 3 Alarm |
|      |        | 43: RTD Module 1 INP 4 Trip  |
|      |        | 44: RTD Module 1 INP 4 Alarm |
|      |        | 45: RTD Module 1 INP 5 Trip  |
|      |        | 46: RTD Module 1 INP 5 Alarm |
|      |        | 47: RTD Module 1 INP 6 Trip  |
|      |        | 48: RTD Module 1 INP 6 Alarm |
|      |        | 49: RTD Module 1 INP 7 Trip  |
|      |        | 50: RTD Module 1 INP 7 Alarm |
|      |        | 51: RTD Module 1 INP 8 Trip  |
|      |        | 52: RTD Module 1 INP 8 Alarm |
|      |        | 53: RTD Module 2 INP 1 Trip  |
|      |        | 54: RTD Module 2 INP 1 Alarm |
|      |        | 55: RTD Module 2 INP 2 Trip  |
|      |        | 56: RTD Module 2 INP 2 Alarm |
|      |        | 57: RTD Module 2 INP 3 Trip  |
|      |        | 58: RTD Module 2 INP 3 Alarm |
|      |        | 59: RTD Module 2 INP 4 Trip  |
|      |        | 60: RTD Module 2 INP 4 Alarm |
|      |        | 61: RTD Module 2 INP 5 Trip  |
|      |        | 62: RTD Module 2 INP 5 Alarm |
|      |        | 63: RTD Module 2 INP 6 Trip  |
|      |        | 64: RTD Module 2 INP 6 Alarm |
|      |        | 65: RTD Module 2 INP 7 Trip  |
|      |        | 66: RTD Module 2 INP 7 Alarm |
|      |        | 67: RTD Module 2 INP 8 Trip  |
|      |        | 68: RTD Module 2 INP 8 Alarm |
|      |        | 69: RTD Module 3 INP 1 Trip  |
|      |        | 70: RTD Module 3 INP 1 Alarm |
|      |        | 71: RTD Module 3 INP 2 Trip  |
|      |        | 72: RTD Module 3 INP 2 Alarm |
|      |        | 73: RTD Module 3 INP 3 Trip  |
|      |        | 74: RTD Module 3 INP 3 Alarm |
|      |        | 75: RTD Module 3 INP 4 Trip  |
|      |        | 76: RTD Module 3 INP 4 Alarm |
|      |        | 77: RTD Module 3 INP 5 Trip  |
|      |        | 78: RTD Module 3 INP 5 Alarm |
|      |        | 79: RTD Module 3 INP 6 Trip  |
|      |        | 80: RTD Module 3 INP 6 Alarm |
|      |        | 81: RTD Module 3 INP 7 Trip  |
|      |        | 82: RTD Module 3 INP 7 Alarm |
|      |        | 83: RTD Module 3 INP 8 Trip  |
|      |        | 84: RTD Module 3 INP 8 Alarm |
|      |        | 85: RTD Module 1 Comm Trip   |
|      |        | 86: RTD Module 1 Comm Alarm  |
|      |        | 87: RTD Module 2 Comm Trip   |
|      |        | 88: RTD Module 2 Comm Alarm  |



| TYPE       | C TYPE | DESCRIPTION                                               |
|------------|--------|-----------------------------------------------------------|
|            |        | 89: RTD Module 3 Comm Trip                                |
|            |        | 90: RTD Module 3 Comm Alarm                               |
|            |        | 91: RTD Sensor-Failure Trip                               |
|            |        | 92: RTD Sensor-Failure Alarm                              |
|            |        | 93: Thermal Lockout                                       |
|            |        | 94: All Defaults Loaded                                   |
|            |        | 95: Non-Volatile Memory (NV) Enumeration Error            |
|            |        | 96: NV Numeric Error                                      |
|            |        | 97: NV String Error                                       |
|            |        | 98: NV Event-Record Error                                 |
|            |        | 99: NV Used Thermal Capacity Error                        |
|            |        | 100: Starter Trip                                         |
|            |        | 101: Display Communications Trip                          |
|            |        | 102: Diagnostic Error                                     |
|            |        | 103: Trip Caused By STOP                                  |
|            |        | 104: Network-Communications Trip                          |
|            |        | 105: Network-Communications Alarm                         |
|            |        | 106: PF Quadrant 4 Trip                                   |
|            |        | 107: PF Quadrant 4 Alarm                                  |
|            |        | 108: Underfrequency Trip                                  |
|            |        | 109: Underfrequency Alarm                                 |
|            |        | 110: Overfrequency Trip                                   |
|            |        | 111: Overfrequency Alarm                                  |
|            |        | 112: PF Quadrant 3 Trip                                   |
|            |        | 113: PF Quadrant 3 Alarm                                  |
|            |        | 114: Phase-Reverse Alarm (Current)                        |
|            |        | 115: Phase-Reverse Alarm (Voltage)                        |
|            |        | 116: Starts per Hour Trip                                 |
|            |        | 117: Starts per Hour Alarm                                |
|            |        | 118 to 127: Reserved                                      |
|            |        | 128: Differential Communication Trip                      |
|            |        | 129: Differential Communication Alarm                     |
|            |        | 130: Differential Trip                                    |
|            |        | 131: Differential Alarm                                   |
|            |        | 132: Reduced Overcurrent Trip                             |
|            |        | 133: Underpower Trip                                      |
|            |        | 134: Underpower Alarm                                     |
|            |        | 135: Reversepower Trip                                    |
|            |        | 136: Reversepower Alarm                                   |
|            |        | 252: ETR Request <sup>(2)</sup>                           |
|            |        | 253: Normal Start <sup>(2)</sup>                          |
|            |        | 254: Incomplete Start <sup>(2)</sup>                      |
|            |        | 255: No Trip or Alarm                                     |
| <b>T28</b> | Short  | Motor Status                                              |
|            |        | Bit0: 1 = Motor current > Current threshold               |
|            |        | Bit1: 1 = Motor in Run Mode                               |
|            |        | Bit2: 1 = Motor at Full Speed (Based on Tach Information) |

| TYPE       | C TYPE | DESCRIPTION                                      |
|------------|--------|--------------------------------------------------|
|            |        | Bit3: 1 = Motor Current > 125% FLA               |
|            |        | Bit4: 1 = Temperature Set Point Bypassed         |
|            |        | Bit5: 1 = Reduced Overcurrent Operational        |
| <b>T29</b> | Short  | Starter Sequencer Status                         |
|            |        | 1: Start1                                        |
|            |        | 2: Run1                                          |
|            |        | 3: Start2                                        |
|            |        | 4: Run2                                          |
|            |        | 5: Stop                                          |
|            |        | 6: Backspin Timer On                             |
| <b>T30</b> | Short  | Trip and Alarm Summary                           |
|            |        | Bit0: 1 = Trip1 or Trip3                         |
|            |        | Bit1: 1 = Alarm1, Alarm2, or Alarm3              |
|            |        | Bit2: 1 = Trip2                                  |
|            |        | Bit3: 1 = Interlocks Not Valid                   |
|            |        | Bit4: 1 = $I^2t > I^2t$ Inhibit Level            |
|            |        | Bit5: 1 = Stops Active (STOP is Pressed)         |
| <b>T31</b> | 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. |
| <b>T32</b> | Short  | Record_Head points to the next free record.      |
|            |        | Subtract 1 to obtain last record.                |
|            |        | Range is 0 to 63.                                |
| <b>T33</b> | Short  | Thermal Model Type                               |
|            |        | 0: NEMA                                          |
|            |        | 1: K-Factor                                      |
| <b>T34</b> | Short  | 4-20 mA Analog Input Type                        |
|            |        | 0: Metering Only                                 |
|            |        | 1: Generic 4-20 mA                               |
|            |        | 2: ASD Sync                                      |
|            |        | 3: Motor Speed                                   |
| <b>T35</b> | Short  | Digital Input Status                             |
|            |        | Bit0: 1 = Digital Input 1 Valid                  |
|            |        | Bit1: 1 = Digital Input 2 Valid                  |
|            |        | Bit2: 1 = Digital Input 3 Valid                  |
|            |        | Bit3: 1 = Digital Input 4 Valid                  |
|            |        | Bit4: 1 = Digital Input 5 Valid                  |
|            |        | Bit5: 1 = Digital Input 6 Valid                  |
|            |        | Bit6: 1 = Digital Input 7 Valid                  |
| <b>T36</b> | Short  | Relay Output Status                              |
|            |        | Bit0: 1 = Relay 1 Energized                      |
|            |        | Bit1: 1 = Relay 2 Energized                      |

| TYPE       | C TYPE | DESCRIPTION                              |
|------------|--------|------------------------------------------|
|            |        | Bit2: 1 = Relay 3 Energized              |
|            |        | Bit3: 1 = Relay 4 Energized              |
|            |        | Bit4: 1 = Relay 5 Energized              |
| <b>T37</b> | Short  | MPS Command                              |
|            |        | 0: Stop                                  |
|            |        | 1: Start 1                               |
|            |        | 2: Start 2                               |
|            |        | 3: Reset Trips                           |
|            |        | 4: Set Real-Time Clock                   |
|            |        | 5: Clear Data-Logging Records            |
|            |        | 6: Clear Trip Counters                   |
|            |        | 7: Not Used                              |
|            |        | 8: Clear Running Hours                   |
|            |        | 9: Emergency Thermal Reset               |
|            |        | 10: Select Local Control                 |
|            |        | 11: De-select Local Control              |
|            |        | 12: Re-enable Temperature Protection     |
|            |        | 13: Start Time                           |
| <b>T38</b> | Short  | Overload Reset Type                      |
|            |        | 0: Normal                                |
|            |        | 1: Auto Reset                            |
|            |        | 2: Multiple-Motor Sequence               |
| <b>T39</b> | Short  | Language                                 |
|            |        | 0: English                               |
|            |        | 1: Spanish (Not supported at this time.) |
|            |        | 2: French (Not supported at this time.)  |
| <b>T40</b> | Short  | Number of OPI's                          |
|            |        | 0: 1 OPI                                 |
|            |        | 1: 2 OPI's                               |
|            |        | 2: 3 OPI's                               |
| <b>T41</b> | Short  | Starter Transfer Type                    |
|            |        | 0: Time Transfer                         |
|            |        | 1: Current Transfer                      |
| <b>T42</b> | Short  | Trip Action                              |
|            |        | 0: Disabled                              |
|            |        | 1: Trip1                                 |
|            |        | 2: Trip2                                 |
|            |        | 3: Trip3                                 |
|            |        | 4: Trip1 & Trip2                         |
|            |        | 5: Trip1 & Trip3                         |
|            |        | 6: Trip1 & Trip2 & Trip3                 |
|            |        | 7: Trip2 & Trip3                         |
| <b>T43</b> | Short  | Alarm Action                             |
|            |        | 0: Disabled                              |
|            |        | 1: Alarm1                                |
|            |        | 2: Alarm2                                |
|            |        | 3: Alarm3                                |
|            |        | 4: Alarm1 & Alarm2                       |

| TYPE        | C TYPE | DESCRIPTION                      |
|-------------|--------|----------------------------------|
|             |        | 5: Alarm1 & Alarm3               |
|             |        | 6: Alarm1 & Alarm2 & Alarm3      |
|             |        | 7: Alarm2 & Alarm3               |
| <b>T82</b>  | 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: 0x36 Extended Motor Starter 2 |
|             |        | 6: 0x64 Status/Meters/RTDs       |
|             |        | 7: 0x65 Status/Meters            |
|             |        | 8: 0x66 Status                   |
|             |        | 9: User Registers                |
| <b>T83</b>  | Short  | DeviceNet Consuming Instance     |
|             |        | 0: None                          |
|             |        | 1: 0x02 Basic Overload           |
|             |        | 2: 0x03 Basic Motor Starter      |
|             |        | 3: 0x04 Extended Contactor       |
|             |        | 4: 0x05 Extended Motor Starter   |
| <b>T107</b> | Short  | Trace Channel Selection          |
|             |        | 0: I <sub>a</sub>                |
|             |        | 1: I <sub>b</sub>                |
|             |        | 2: I <sub>c</sub>                |
|             |        | 3: I <sub>0</sub>                |
|             |        | 4: VA                            |
|             |        | 5: VB                            |
|             |        | 6: VC                            |

**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 MPS REVISION HISTORY

### G.1 MPS-CTU REVISION HISTORY

| MANUAL<br>RELEASE DATE | MANUAL<br>REVISION | HARDWARE<br>REVISION <sup>(1)</sup><br>(REVISION NUMBER<br>ON PRODUCT LABEL) | FIRMWARE REVISION                                            |
|------------------------|--------------------|------------------------------------------------------------------------------|--------------------------------------------------------------|
| February 21, 2017      | 6-F-022117         | 02C                                                                          | 3.40                                                         |
| March 1, 2016          | 6-E-030116         |                                                                              |                                                              |
| June 8, 2015           | 6-D-060815         |                                                                              | 3.30                                                         |
| January 15, 2015       | 6-C-011515         | 02C <sup>(2)</sup>                                                           | 3.21                                                         |
| June 19, 2014          | 6-B-061914         | 02C                                                                          | 3.20                                                         |
| February 14, 2014      | 6-A-101813         | 01J<br>02C                                                                   | 3.15                                                         |
| October 18, 2013       |                    | 02B                                                                          |                                                              |
| November 2012          |                    | 02A                                                                          | 3.14                                                         |
| October 2012           |                    | 02                                                                           | 3.13                                                         |
| January 2012           |                    |                                                                              | 3.11                                                         |
| April 2010             |                    | 01H                                                                          | 3.05<br>3.04<br>3.03<br>3.02<br>3.01<br>3.00<br>2.90<br>2.80 |

<sup>(1)</sup> At time of release.

<sup>(2)</sup> Hardware Update R also released.

### MANUAL REVISION HISTORY

#### REVISION 6-F-022117

##### SECTION 9

UL certification updated.

#### REVISION 6-E-030116

##### SECTION 3

Section 3.2.1.2 updated.

##### SECTION 5

I<sub>p</sub> Threshold setpoint added to Sections 5.8, 5.19, and 5.20.

##### SECTION 9

RCM Certification added.

##### APPENDIX A

System Config menu updated.

##### APPENDIX B

I<sub>p</sub> Threshold setpoint added.

##### APPENDIX E

MPS registers 220 and 221 added.

#### REVISION 6-D-060815

##### SECTION 4

RTD protection updated in Section 4.4.

##### SECTION 5

Section 5.24 updated.

**APPENDIX A**

RTD temperature menu updated.

**APPENDIX B**

RTD modules updated.

**APPENDIX E**

MPS registers 548 and 549 added.

**REVISION 6-C-011515**

**SECTION 2**

Figs. 2.8, 2.9, 2.10, and 2.11 updated.

**SECTION 5**

OPI menu updated in Section 5.24.

**REVISION 6-B-061914**

**SECTION 1**

Underpower and reversepower features added.

**SECTION 5**

Underpower (5.17) and reversepower (5.18) sections added.

**SECTION 9**

Terminal torque specification added.

Direct connection (Note 5) updated in Section 9.4.

**APPENDIX A**

Underpower and reversepower trip and alarm access added to messages and protection menus.

**APPENDIX B**

Underpower and reversepower protection set points added.

**APPENDIX E**

Underpower and reversepower added to communication database table.

**APPENDIX F**

Underpower and reversepower added to register formats table.

**REVISION 6-A-101813**

**SECTION 1**

Faceplate updated.

Series 2 features added.

**HARDWARE REVISION HISTORY**

**HARDWARE UPDATE R**

Updated opto-coupler relay drive circuit.

Updated non-volatile and RTC battery.

Update R can only be combined with hardware revisions older than 01J and 02C. It will be indicated with an "Update R" label on the serial number label.

**HARDWARE REVISION 02C**

Updated opto-coupler relay drive circuit.

Updated non-volatile and RTC battery.

**HARDWARE REVISION 02B**

Power Supply: Power factor correction update.

Analog Module: ADC package changed.

**HARDWARE REVISION 02A**

Analog Module: Improved accuracy.

**HARDWARE REVISION 02**

Processor Module memory size increased.

Rev 02 required to enable waveform capture functionality.

**HARDWARE REVISION 01J**

Updated opto-coupler relay drive circuit.

Updated non-volatile and RTC battery.

**HARDWARE REVISION 01H**

Power supply updated.

## **FIRMWARE REVISION HISTORY**

### **FIRMWARE REVISION 3.40**

Added  $I_p$  Threshold setpoint.  
Integrated  $I_p$  Threshold within current unbalance and power factor protective functions.

### **FIRMWARE REVISION 3.30**

Added RTD Temperature Trip Action, Alarm Action, and ability to meter temperature information.

### **FIRMWARE REVISION 3.21**

Underspeed protection can now be enabled after a motor start.

### **FIRMWARE REVISION 3.20**

Underpower and Reversepower protection added.  
Loss of network comms time increased to 10 s.  
RTD temperature trip now occurs when temperature is equal to or greater.

### **FIRMWARE REVISION 3.15**

HMC Compensation limit is set to 0.9 (90%).  
Added feature to initiate MPS upgrade mode using OPI.

### **FIRMWARE REVISION 3.14**

Fixed RTD reading for unused RTDs.

### **FIRMWARE REVISION 3.13**

Fixed EtherNet/IP issue with Exp Msg.

### **FIRMWARE REVISION 3.11**

Waveform capture added and RTD voting added.

### **FIRMWARE REVISION 3.05**

DeviceNet I/O Assembly Tx queue size increased to prevent loss of data (only an issue with Assembly 0x64).

### **FIRMWARE REVISION 3.04**

Added Default Gateway to Ethernet settings group.

### **FIRMWARE REVISION 3.03**

Corrected OPI flashing problem.

### **FIRMWARE REVISION 3.02**

Added delay in EtherNet/IP communications to improve performance during high-bandwidth communication.

### **FIRMWARE REVISION 3.01**

Added Starts Remaining to communications.  
Added Time Remaining until Start Inhibit Removal to communications.

### **FIRMWARE REVISION 3.00**

Added Starts Remaining to meter values.  
Added Time Remaining until a start is available to the meter values.

### **FIRMWARE REVISION 2.90**

Added analog-output filter.

### **FIRMWARE REVISION 2.80**

Added digital input selection "Local Select +".  
Added OPI start-source selection to LOCAL mode.  
Increased tach gear-tooth number to 120.

## G.2 MPS-OPI REVISION HISTORY

| MANUAL<br>RELEASE DATE | MANUAL<br>REVISION | HARDWARE REVISION<br>(REVISION NUMBER<br>ON PRODUCT LABEL) | FIRMWARE REVISION |
|------------------------|--------------------|------------------------------------------------------------|-------------------|
| January 15, 2015       | 6-C-011515         | 03A                                                        | 1.60              |
| June 19, 2014          | 6-B-061914         |                                                            |                   |
| October 18, 2013       | 6-A-101813         |                                                            |                   |
| May 2007               |                    |                                                            |                   |

### HARDWARE REVISION HISTORY

#### HARDWARE REVISION 03A

Display update.

### FIRMWARE REVISION HISTORY

#### FIRMWARE REVISION 1.60

Firmware update to support new display and equivalent LCD version.

## G.3 MPS-RTD REVISION HISTORY

| MANUAL<br>RELEASE DATE | MANUAL<br>REVISION | PRODUCT REVISION<br>(REVISION NUMBER ON PRODUCT LABEL) |
|------------------------|--------------------|--------------------------------------------------------|
| January 15, 2015       | 6-C-011515         | 02                                                     |
| June 19, 2014          | 6-B-061914         |                                                        |
| October 18, 2013       | 6-A-101813         |                                                        |
| December 2006          |                    |                                                        |

### PRODUCT REVISION HISTORY

#### PRODUCT REVISION 02

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

## G.4 MPS-DIF REVISION HISTORY

| MANUAL<br>RELEASE DATE | MANUAL<br>REVISION | PRODUCT REVISION<br>(REVISION NUMBER ON PRODUCT LABEL) |
|------------------------|--------------------|--------------------------------------------------------|
| January 15, 2015       | 6-C-011515         | 01                                                     |
| June 19, 2014          | 6-B-061914         |                                                        |
| October 18, 2013       | 6-A-101813         |                                                        |
| November 2007          |                    |                                                        |

### PRODUCT REVISION HISTORY

#### PRODUCT REVISION 01

Initial Release.