MPU-16A MANUAL

MOTOR PROTECTION UNIT

REVISION 13

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MOTOR PROTECTION UNIT

| MODE | VALUE |

C085

TRIP/ALARM ○
PROCESSOR ○
RUN

SET-POINT MODES
0 - I²T LIMIT (S @ 600%)
1 - OVERCURRENT (%)
2 - UNDERCURRENT (%)
3 - CURRENT UNBALANCE (%)
4 - TEMPERATURE (°C)
5 - EARTH FAULT (%)
6 - FULL-LOAD CURRENT (A)
7 - SERVICE FACTOR (%)

STATUS MODES
8 - PROGRAM
9 - AMMETER (A)
A - PEAK CURRENT (A)
b - CURRENT UNBALANCE (%)
C - TEMPERATURE (°C)
d - EARTH LEAKAGE (A)
E - PERCENT I²T
F - CT PRIMARY RATINGS (A)

RAMP ▲▼   MODE ▲▼   RESET   ALM S-PT ENTER VAL @ TRIP

STARTCO ENGINEERING LTD.   MPU – 16A

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1.   INTRODUCTION

1.1   GENERAL

Accuracy in design and improvements in materials have allowed designers to decrease the thermal mass and to increase the operating temperature of modern motors. The trend is to utilize the full capability of these motors in spite of the resulting decrease in their ability to tolerate overloads. The modelling technique used by the MPU-16A provides dynamic protection for a motor that is allowed to operate at its design limit.

1.2   FEATURES AND OPTIONS

— I^2t thermal-overload protection.
— Overcurrent protection.
— Undercurrent protection.
— Current-unbalance protection.
— Phase-reverse protection.
— Motor-temperature sensing and overtemperature protection.
— Earth-fault protection.
— Front-panel programming.
— Program-change lockout.
— Nonvolatile memory for programmed values and values-at-trip.
— Parameter-selectable, isolated analog output.
— Digital display of:
      Motor current
      Peak motor current
      Percent current modulation
      Percent current unbalance
      Motor temperature
      Earth-leakage current
      Percent I^2t
      Meter values-at-trip
      Minutes-to-reset
      CT-primary ratings
      Trip-and-alarm set points.
— Provision for 5-A or 1-A CT's.
— -40°C to 60°C operating temperature.
— Optional dc supply voltage.
— Optional electroluminescent backlit display.
— Optional remote-keypad input.
— Optional RS-485 communications interface.

1.3   ORDERING INFORMATION

— Determine MPU-16A model number from Table 1.
— Supplied with ICT-2, ICT-2 interconnection cable (6 m, 20 ft), and mounting hardware.
— Order window-type CT (EFCT-1, EFCT-2, or other) for zero-sequence earth-fault detection.
— Order TU-16 test unit for training or functional testing.

MPU-16A MODEL NUMBER

MPU-16A - P126 - P10 - 42 - 00

Mount
P   Panel
S   Surface

Supply Voltage
12   120 Vac
24   240 Vac
SW   Switch Selectable 120/240 Vac
AD   120/240 Vac/dc ⎤
D1   12 Vdc   ⎥ Note 3
D2   24 Vdc   ⎥
D4   48 Vdc   ⎦

Load Frequency
5   50 Hz (IEC Fusing)
6   60 Hz (CSA/UL Fusing)

Temperature-Sensor Input
P10 RTD 100-ohm Platinum
N10 RTD 100-ohm Nickel
N12 RTD 120-ohm Nickel
C01 RTD 10-ohm Copper
PTC PTC Thermistor

Signal-Output Configuration
42   4–20 mA Analog only
05   0–5 Vdc Analog only
01   0–10 Vdc Analog only
00   RS485 Communications Interface only
91   RS485 Communications Interface and 4-20 mA Analog Output,
       Output Parameter is CURRENT
92   RS485 Communications Interface and 4-20 mA Analog Output,
       Output Parameter is I²t
93   RS485 Communications Interface and 4-20 mA Analog Output,
       Output Parameter is EARTH LEAKAGE
94   RS485 Communications Interface and 4-20 mA Analog Output
       Output Parameter Is TEMPERATURE

Note 1
Note 2

Options
00   No options
01   Electroluminescent Backlit Display
02   Remote-Keypad Input
03   Electroluminescent Backlit Display and Remote-Keypad Input
10   RS-485 Communications Interface, A-B Protocol
11   RS-485 Communications Interface, Modicon Protocol
20   RS-485 Communications Interface c/w Data Logging, A-B Protocol
21   RS-485 Communications Interface c/w Data Logging, Modicon Protocol

Notes:
1. Panel mount only.
2. Communications protocol must be specified. See Options.
3. CSA certification pending.

TABLE 1

2. FRONT-PANEL ANNUNCIATION, INDICATION, AND PROGRAMMING

2.1 GENERAL (See Figure 1)

MPU-16A modes are listed on the front panel. Modes 0 to 5 are used to enter trip-and-alarm set points and to annunciate trips and alarms. Modes 6, 7, and F are used to enter motor full-load current, motor service factor, and CT-primary ratings. Mode 8 is used to select special functions. Modes 9, A, b, C, d, and E are used to display operating values and values-at-trip.

2.2 LIQUID-CRYSTAL DISPLAY

The left digit of the four-digit liquid-crystal display uses a hexadecimal format (0 to F) to indicate the mode displayed. The remaining digits (designated from left to right as value digits 1, 2, and 3) display set-point values, meter readings, and trip-and-alarm codes.

For value digits greater than 999, the last value digit is replaced by E to indicate an extended range. To obtain the actual value, multiply the reading by 100. For example, 30E is read as 3000.

2.3 KEYPAD

Four keypad switches provide the operator interface to the MPU-16A. Tactile-feedback switches are used to provide positive indication that switch contact has been made:

RAMP — This switch is used to adjust values in Modes 0 to 8 and F. Under normal operation this switch is inoperative. To make the RAMP switch operative, the program-change lockout must be defeated by connecting MPU-16A terminals 20 and 21. To change a set point, ENTER must be pressed within three seconds after RAMP is released. If ENTER is not pressed within three seconds, the display will return to its pre-adjusted value. One arrow up and two arrows down indicate that the RAMP switch is bidirectional. To ramp up: press and hold. To reverse: release, press again within one second and hold.

MODE — This switch is used to select the mode displayed. Bidirectional operation is the same as for RAMP.
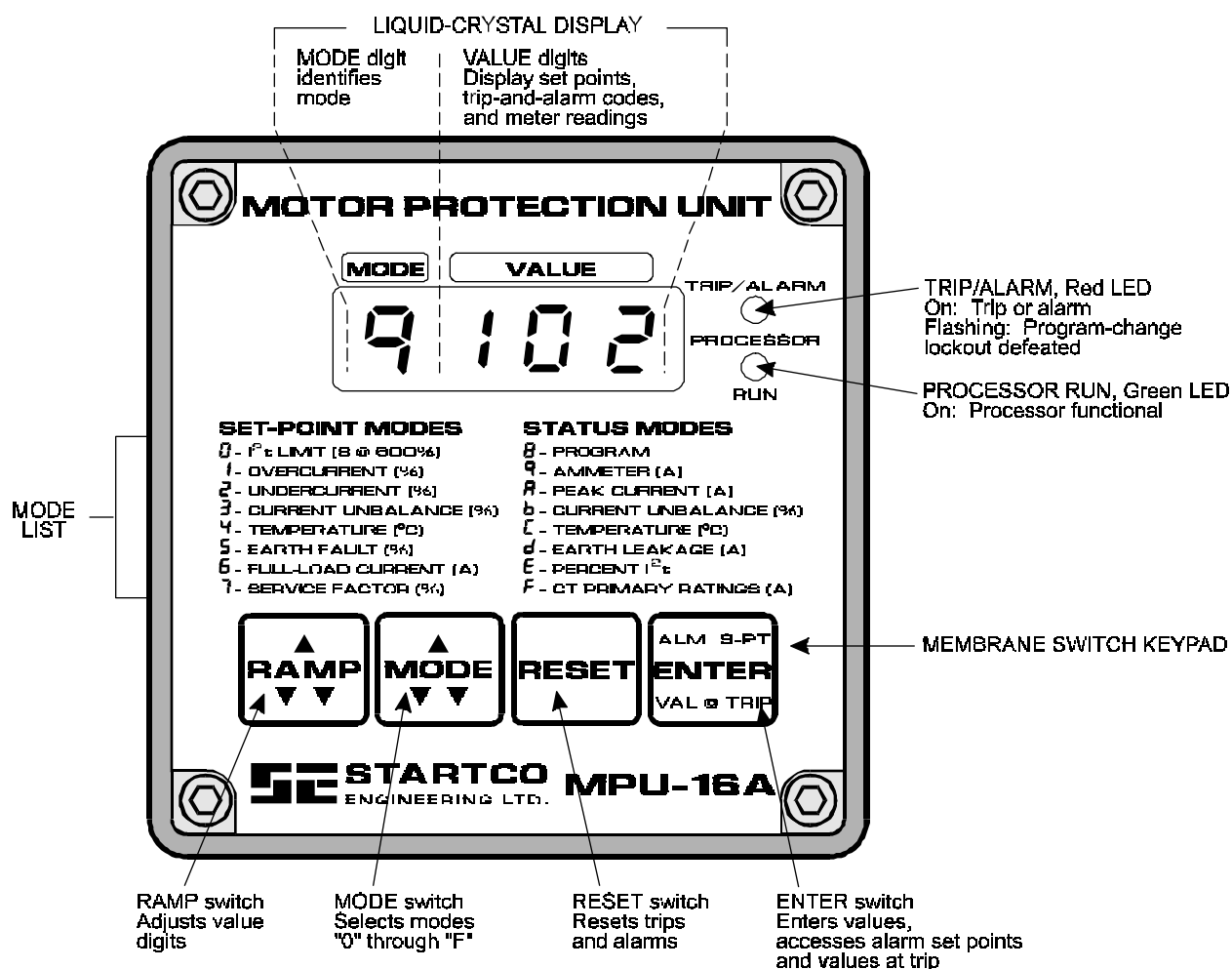
MPU-16A FRONT PANEL

FIGURE 1

RESET — This switch is used to reset trips and alarms. It is also used to display motor current in percent of full-load current (Mode 9), RTD peak temperature during the most-recent emergency thermal reset (Mode C), and time-to-reset (Mode E). It is used with ENTER to reset latched alarms, manually reset current modulation (Mode A), manually re-enable temperature protection after an emergency thermal reset (Mode 4), and initiate an emergency thermal reset (Mode E).

ENTER — This switch is used to enter values in Modes 0 to 8 and F, and to access a second level in all modes. Values can be entered only when the program-change lockout is defeated. This prevents unauthorized or unintentional program changes during normal operation. When the program-change lockout is defeated, the value displayed in Modes 0 to 8 or F will be entered if ENTER is pressed within three seconds after RAMP is released.

In Modes 0 to 5, 8, and F, the second-level set point will be displayed while ENTER is pressed. In Modes 9 and b to E, the value immediately prior to the most recent trip will be displayed while ENTER is pressed. In Modes 6, 7, and A, information specific to the mode will be displayed while ENTER is pressed. If the program-change lockout is defeated, the second level in Modes 0 to 5, 8, and F will remain displayed for three seconds after ENTER is released to allow RAMP to be pressed to initiate a second-level program change.

2.4 LED INDICATORS

The red TRIP/ALARM LED is on if a trip or alarm has occurred. It flashes when the program-change lockout is defeated (program enable active); however, ON has priority over FLASH. The green PROCESSOR-RUN LED is on when the processor is functional.

2.5 PROGRAMMING

The MPU-16A has individual trip-and-alarm control relays and all trip-and-alarm set points can be individually adjusted or deleted. At the top of each set-point range, the delete code "ddd" is displayed. If "ddd" is entered, the set point is deleted and the associated protection is disabled.

To enable program changes, the program-change lockout must be defeated by connecting MPU-16A terminals 20 and 21. Remove this connection when programming is completed. This will prevent unauthorized or unintentional program changes.

To program trip set points in Modes 0 to 5, and the first level of Modes 6, 7, 8, and F:
—   Press MODE to select the mode,
—   press RAMP to adjust, and within three seconds of release,
—   press ENTER.

To program alarm set points in Modes 0 to 5, and the second level of Modes 8 and F:
—   Press MODE to select the mode,
—   press ENTER, and within three seconds of release,
—   press RAMP to adjust, and within three seconds of release,
—   press ENTER.

All programmed values and values-at-trip are stored in a nonvolatile memory that retains its data indefinitely—even if supply voltage is lost. It is not necessary to reprogram the unit when supply voltage is restored.

2.6   TRIPS AND ALARMS

When a trip occurs:
—   The trip relay operates,
—   the red TRIP/ALARM LED comes ON,
—   the display automatically switches to the mode that initiated the trip, and
—   the mode digit is followed by a trip code.

With the exception of autoreset which can be enabled for Mode 0, all trips must be individually reset.

When an alarm occurs:
—   The alarm relay operates,
—   the red TRIP/ALARM LED comes ON, and
—   the display does not switch to the mode that initiated the alarm; however,
—   an alarm code is displayed if the mode that initiated the alarm is selected.

Unless latching alarms are selected in Mode 8, alarms automatically reset when conditions return to normal. See Section 3.10.2 and Table 3.

2.7   DEFAULT VALUES

A set of default values are preprogrammed at the factory. Default values are listed in their respective mode descriptions in Section 3.

To reload factory default values:
—   Remove the supply voltage,
—   connect MPU-16A terminals 20 and 21 to enable program changes, and
—   with RESET pressed, apply the supply voltage.

3. MODE DESCRIPTIONS

3.1 GENERAL

This section contains a description of each mode. It explains operational characteristics, describes special functions, and lists set-point ranges, display codes, and default values.

3.2 MODE 0 — I^2t LIMIT

This mode is used to enter overload-class set points and to annunciate overload alarms and trips.

In order to meet CSA, UL, and NEMA requirements, an overload relay set at 100% must ultimately trip when tested at 100% FLA, trip within 8 minutes when tested at 200% FLA, and trip within the number of seconds indicated by its class designation when tested at 600% FLA. The overload class for a MPU-16A is the time, in seconds, entered in Mode 0. The Mode-0 set point is determined by equating I^2t at 600% FLA to the allowable locked-rotor I^2t. For example, if locked-rotor current is 735% FLA and if allowable locked-rotor time is 20 seconds, the I^2t limit is:

$$6^2 \text{ x t} = 7.35^2 \text{ x } 20, \text{ and}$$
$$t = 30 \text{ seconds—this is the Mode-0 set point.}$$

Ultimate current is the minimum value of continuously applied current that will cause a relay to trip. For a MPU-16A, ultimate current is the product of FLA and service factor which are entered in Modes 6 and 7 respectively. With 26 service factors from 100% to 125%, and 45 classes from 1 s to 45 s, a total of 1170 cold curves are available. One of these cold curves is shown as the 0%-I^2t curve in Figure 2.

The 0%-I^2t curve is a maximum-time-to-trip curve for motor current above the ultimate current. Motor current in this range causes I^2t to tend toward a limit above the 100% trip level. Motor current below the ultimate current causes I^2t to tend toward a limit that is less than 100% as shown in the inset graph in Figure 2. In all cases, I^2t responds exponentially toward a final value. The time constant for this response is derived from entered service factor and I^2t-limit values so that I^2t continually tracks used thermal capacity in the motor. This dynamic modelling is operational with or without RTD compensation. If a motor is equipped with a RTD temperature sensor, the MPU-16A thermal model can compensate for high ambient temperature and loss of ventilation.
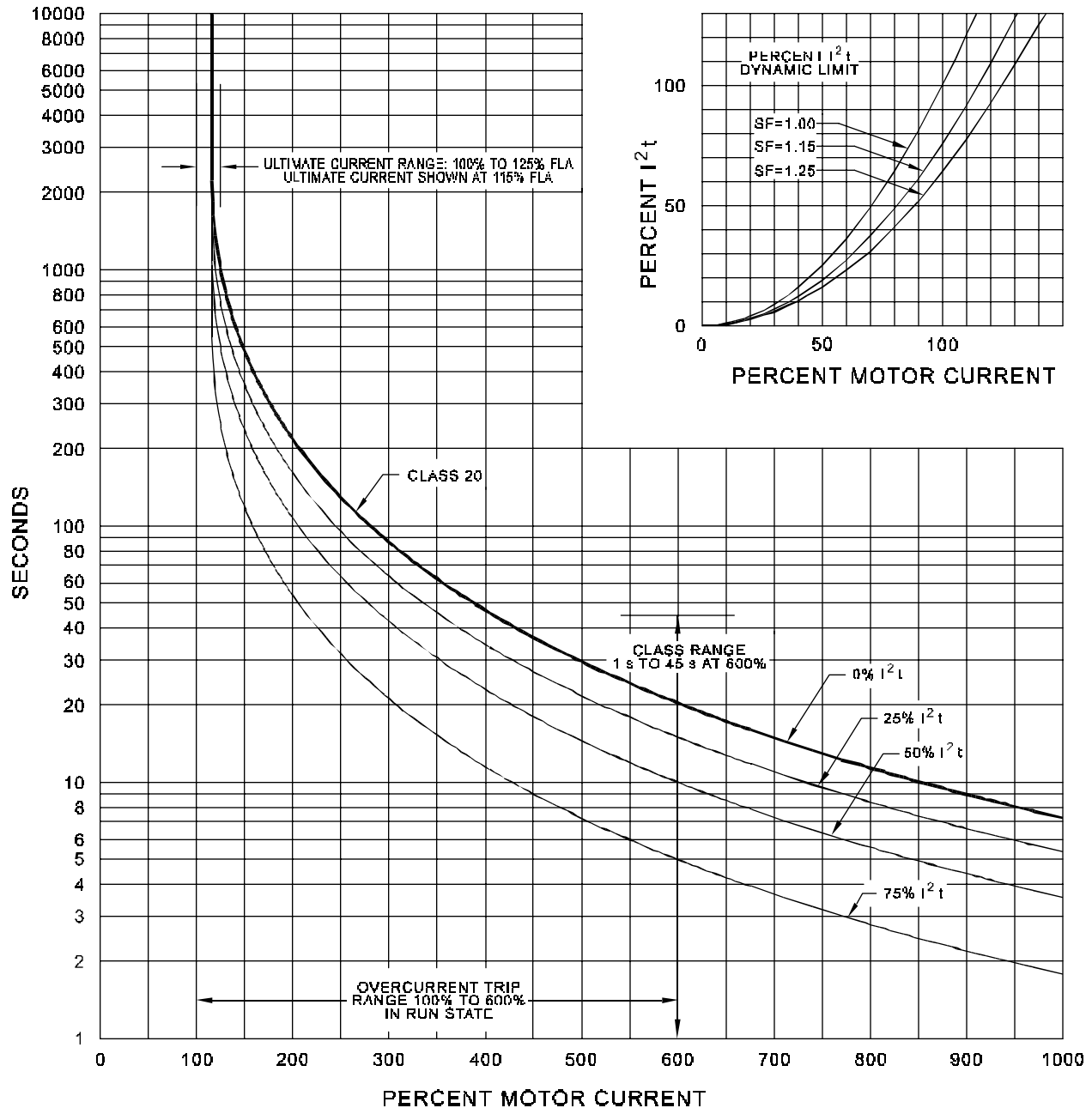
MPU-16A OVERLOAD CURVE

FIGURE 2

Used thermal capacity determines the time-to-trip for excursions above the ultimate current. For the Class-20, 1.15 service factor example shown in Figure 2, sustained operation at 100% FLA will cause I^2t to tend toward 75%. The time to trip for current above the ultimate current is reduced as shown by the 75%-I^2t curve.

The MPU-16A trips in Mode 0 when I^2t reaches 100%. It will not reset until I^2t has decreased to 30%. The time required for I^2t to decrease to 30% is a function of the time constant. For EMERGENCY THERMAL RESET, see Section 3.16. Percent I^2t and minutes-to-reset are displayed in Mode E. See Section 3.16. The MPU-16A can be programmed in Mode 8 to automatically reset when I^2t decreases to 30%. See Section 3.10.1 and Table 3.

As recommended by NEMA MG1-14.35 and MG1-20.56, the largest of the three phase-currents is used for the I^2t model to compensate for the additional heating caused by current unbalance.

```
Set-Point Range.................................. 1 s to 45 s @ 600% FLA
Set-Point Step Size .............................. 1 s
Display Codes:
        Trip........................................... 0FFF
        Alarm......................................... 0AAA*
        Set Point Deleted........................ 0ddd*
Default Values:
        Trip........................................... 10 s @ 600% FLA
        Alarm........................................ 9 s @ 600% FLA
```

* Alarm is on when $I^2t \geq$ (Alarm Set Point/Trip Set Point) x 100%. Deleting the TRIP function automatically deletes the ALARM function.

3.3 MODE 1 — OVERCURRENT

This mode is used to enter overcurrent set points and to annunciate overcurrent alarms and trips. Overcurrent protection is referred to as "jam" protection and it is active only after the motor is running. The MPU-16A considers the motor to be running when motor current remains between 10% and 125% FLA for more than 10 seconds.

An instantaneous short-circuit trip at 1200% FLA can be enabled in Mode 8. See Section 3.10.3 and Table 3. A short-circuit trip will occur within 10 ms in 11 of 15 occurrences and within 80 ms in 4 of 15 occurrences.

Set-Point Range.................................... 100% to 600% FLA
Set-Point Step Size .... 25% FLA
Trip-and-Alarm Times............................ 250 ± 125 ms
Alarm Hysteresis .... 5% FLA
Short-Circuit Trip Time........................... Instantaneous (45 ± 35 ms)
Display Codes:
      Trip.. 1FFF
      Alarm... 1AAA
      Set Point Deleted........................ 1ddd*
      Short-Circuit Trip......................... 1FSC
Default Values:
      Trip.. 300% FLA
      Alarm... 200% FLA

    *   Deleting the overcurrent trip does not disable the short-circuit trip.

3.4   MODE 2 — UNDERCURRENT

This mode is used to enter undercurrent set points and to annunciate undercurrent alarms and trips. Undercurrent protection is referred to as "loss-of-load" protection and it is active only after the motor is running. The MPU-16A considers the motor to be running when motor current remains between 10% and 125% FLA for more than 10 seconds. Alarms and/or trips occur when motor current decreases below the set points.

Set-Point Range.................................... 15% to 100% FLA
Set-Point Step Size .... 1% FLA
Trip Time... 5 s
Alarm Time.. 1 s
Alarm Hysteresis .... 2% FLA
Display Codes:
      Trip.. 2FFF
      Alarm... 2AAA
      Set Point Deleted........................ 2ddd
Default Values:
      Trip.. Deleted
      Alarm... Deleted

3.5 MODE 3 — CURRENT UNBALANCE

This mode is used to enter current-unbalance set points and to annunciate current-unbalance alarms and trips. Two equations are used to calculate current unbalance.

For $I_{max} \leq I_{FLA}$:

$$\text{Unbalance} = \left[(I_{max} - I_{min})/I_{FLA}\right] \times 100\% \qquad (3.1)$$

For $I_{max} > I_{FLA}$:

$$\text{Unbalance} = \left[(I_{max} - I_{min})/I_{max}\right] \times 100\% \qquad (3.2)$$

Where: I_{max} = maximum phase current
I_{min} = minimum phase current
I_{FLA} = full-load current

In addition to current-unbalance protection, phase-reverse protection is provided. Phase-reverse detection is active in the first three seconds of each start. This feature can be enabled and phase sequence selected in Mode 8. See Sections 3.10.6, 3.10.7, and Table 3.

Set-Point Range .... 5% to 75%
Set-Point Step Size 1%
Trip Time .... 5 s
Alarm Time .... 1 s
Alarm Hysteresis 2%
Phase-Reverse Trip Time .... 2.0 ± 1.2 s
Display Codes:
    Trip 3FFF
    Alarm 3AAA
    Set Point Deleted 3ddd*
    Trip on AbC Sequence 3AbC
    Trip on bAC Sequence 3bAC
Default Values:
    Trip 25%
    Alarm 15%

   *   Deleting the current-unbalance trip does not disable the phase-reverse trip.

3.6   MODE 4 — TEMPERATURE

This mode is used to enter temperature set points and to annunciate temperature alarms and trips. Rated winding temperature for a motor is the sum of ambient temperature, rated temperature rise, and an allowance for hot spots. The response of a temperature sensor embedded in a stator winding is too slow to protect a motor against most overload conditions; however, it will accurately indicate steady-state temperature and provide protection against loss of ventilation and high ambient temperature. If ambient temperature remains below 40°C and if there is no loss of ventilation, an accurate thermal model can provide protection against most overloads. If an embedded RTD temperature sensor is used to provide hot-motor compensation by adding a bias to the thermal model, then protection is extended to include overloads initiated when stator temperature is high. See Section 3.10.4 and Table 3. Only one sensor is required since the variation among sensors in the same motor is small compared to the temperature rise of the motor.

3.6.1 RTD

If an open-RTD or shorted-RTD sensor is detected, hot-motor compensation will automatically be disabled and an alarm code will be displayed. If a RTD is not connected, delete the Mode-4 set points to avoid an open-RTD alarm.

The temperature trip is disabled by an emergency thermal reset in Mode E, and 4Fdd is automatically displayed if the keypad has not been actuated in the previous 60 seconds. The Mode-4 trip is automatically re-enabled if the RTD temperature is decreasing and is 20°C below the trip set point. A Mode-4 trip can be manually re-enabled by simultaneously pressing ENTER and RESET.

Set-Point Range.................................... 50°C to 220°C
Set-Point Step Size .... 5°C
Trip-and-Alarm Times............................ 1 s
Alarm Hysteresis .... 3°C
Display Codes:
        Trip.. 4FFF
        Alarm.. 4AAA
        Open-RTD Alarm 4AA0
        Shorted-RTD Alarm..................... 4AA1
        Set Point Deleted........................ 4ddd
        Trip Disabled 4Fdd
Default Values:
        Trip.. 125°C
        Alarm.. 100°C

3.6.2 PTC

The actual set point is not important because trip temperature depends upon the Nominal Response Temperature (NRT) of the thermistor. The trip-and-alarm points are the same regardless of set-point values. It is recommended that the NRT value be entered for future reference.

As with the RTD, the temperature trip is disabled by an emergency thermal reset in Mode E, and 4Fdd is automatically displayed if the keypad has not been actuated in the previous 60 seconds. The Mode-4 trip is automatically re-enabled on a cooling transition through the NRT. A Mode-4 trip can be manually re-enabled by simultaneously pressing ENTER and RESET. Unlike the RTD, faulted-sensor detection is not provided and a trip will occur if the PTC opens.

```
Trip/Alarm Resistance ........................... 3300 ohms
Reset Resistance ................................. 2000 ohms
Display Codes:
        Trip........................................... 4FFF
        Alarm......................................... 4AAA
        Set Point Deleted........................ 4ddd
        Trip Disabled ............................. 4Fdd
Default Values:
        Trip........................................... 125°C
        Alarm........................................ 100°C
```

3.7   MODE 5 — EARTH FAULT

This mode is used to enter earth-fault set points and to annunciate earth-fault alarms and trips. Set points are expressed in percent of the earth-fault-CT-primary rating entered in the second level of Mode F.

Optional CT's (EFCT-1 or EFCT-2) with 5-A-primary ratings are available for sensitive earth-fault detection in applications where earth-fault current is less than 800 A and inrush current is less than 2.5 kA. If inrush current is greater than 1 kA but less than 2.5 kA, a flux conditioner should be used to prevent nuisance tripping. If earth-fault current is greater than 800 A, inrush current is greater than 2.5 kA, or if a trip level greater than 5 A is required, use a 5-A- or 1-A-secondary earth-fault CT that will not saturate at the prospective currents.

Earth-fault current can be derived from the phase currents by using the ICT-2 residual connection. See Section 5.5.2. When this connection is used, the primary rating of the phase CT's must be entered in both levels of Mode F. Due to CT errors, trip set points should be greater than 10% with the residual connection.

Earth-fault detection in a two-CT configuration requires an earth-fault CT. Do not use a residual-type connection with two phase-CT's because an earth fault in the derived phase will not be detected.

Four earth-fault-trip times are available. See Section 3.10.5 and Table 3. If instantaneous earth-fault trip is selected, the trip will occur in 10 ms or less in 11 of 15 occurrences and in 80 ms or less in 4 of 15 occurrences.

Set-Point Range................................... 1% to 100% of Earth-Fault-
                                                     CT-Primary Rating
Set-Point Step Size............................... 1%
Instantaneous Trip Time........................ 45 ± 35 ms
Trip Delays.. 0.25, 0.5, or 1.0 ± 0.1 s
Alarm Time... 250 ± 125 ms
Display Codes:
       Trip.. 5FFF
       Alarm... 5AAA
       Set Point Deleted........................ 5ddd
Default Values:
       Trip.. 40%
       Alarm... 20%

3.8   MODE 6 — FULL-LOAD CURRENT

This mode is used to enter the full-load current (FLA) of the motor and to indicate the firmware revision level. FLA range is a function of the phase-CT-primary rating entered in Mode F. It is necessary to enter the CT rating in Mode F before FLA is entered in Mode 6 because Mode 6 is set to the minimum value of the FLA range when the CT rating is entered. The firmware revision level is displayed by pressing ENTER.

Set-Point Range................................... 9 A to 800 A
Set-Point Step Size............................... 1 A
FLA Range.. 0.45 to 0.93 x Phase-CT-Primary Rating
Default Value .... 100 A

3.9 MODE 7 — SERVICE FACTOR

This mode is used to enter the service factor and to indicate the hardware configuration. Service factor is the factor by which the ultimate-trip current exceeds the full-load current entered in Mode 6. The hardware configuration code is displayed by pressing ENTER. See Table 2.

Set-Point Range.................................... 100% to 125%
Set-Point Step Size 1%
Default Value 100%

HARDWARE CONFIGURATIONS

DISPLAY CODE	TEMP SENSOR OPTION
7008	Platinum
7009	Nickel
700A	PTC
700C	Copper

TABLE 2

3.10 MODE 8 — PROGRAM (See Tables 3 & 4)

This mode is used to select special program options. Any combination in Tables 3 and 4 can be selected by entering the appropriate hexadecimal numbers in Mode 8 in the same way that trip-and-alarm set points are entered in Modes 0 to 5.

Default Values:
Table 3 8000
Table 4 8000

3.10.1 AUTORESET

When autoreset is ON, a Mode-0 trip will automatically reset when I^2t decreases to 30%. See Section 3.2.

Default... OFF

3.10.2 ALARM LATCH

When the alarm latch is ON, all alarms that occur in Modes 0 to 5 will latch and must be individually reset. To reset a latched alarm, use MODE to select the alarm and press ENTER and RESET simultaneously.
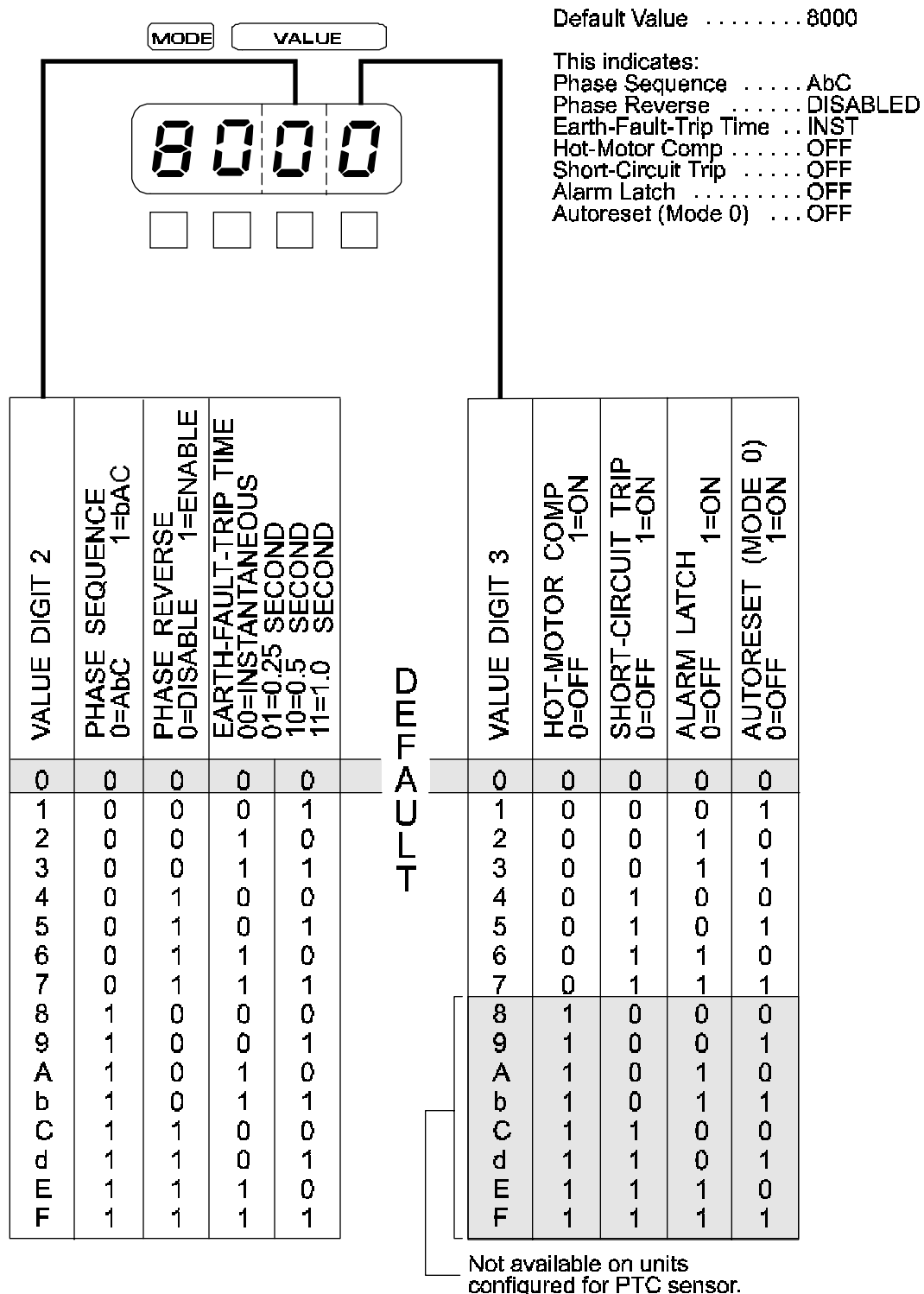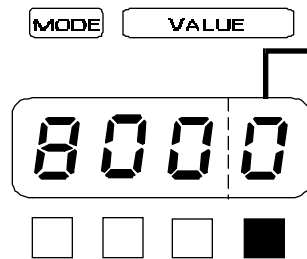
Default... OFF

MODE 8 — PROGRAM

[MODE] [VALUE]

```
8000
```

Default Value 8000

This indicates:
Phase Sequence . . . . . AbC
Phase Reverse . . . . . . DISABLED
Earth-Fault-Trip Time . . INST
Hot-Motor Comp . . . . . . OFF
Short-Circuit Trip . . . . . OFF
Alarm Latch . . . . OFF
Autoreset (Mode 0) . . . OFF

VALUE DIGIT 2	PHASE SEQUENCE 0=AbC 1=bAC	PHASE REVERSE 0=DISABLE 1=ENABLE	EARTH-FAULT-TRIP TIME 00=INSTANTANEOUS 01=0.25 SECOND 10=0.5 SECOND 11=1.0 SECOND	
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
b	1	0	1	1
C	1	1	0	0
d	1	1	0	1
E	1	1	1	0
F	1	1	1	1

DEFAULT

VALUE DIGIT 3	HOT-MOTOR COMP 0=OFF 1=ON	SHORT-CIRCUIT TRIP 0=OFF 1=ON	ALARM LATCH 0=OFF 1=ON	AUTORESET (MODE 0) 0=OFF 1=ON
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
b	1	0	1	1
C	1	1	0	0
d	1	1	0	1
E	1	1	1	0
F	1	1	1	1

Not available on units configured for PTC sensor.

TABLE 3

MODE 8 — PROGRAM
(2nd Level Without Communications Interface)

Default Value 8000

This Indicates:
Trip Relay. . . . . .Fail Safe
Alarm Relay . . . . .Fail Safe
Analog-Output Parameter. . .Current

D E F A U L T	VALUE DIGIT 3	TRIP RELAY	ALARM RELAY	ANALOG-OUTPUT PARAMETER (MODE 9) (MODE E) (MODE C) (MODE d) 00=CURRENT 01=I²t 10=TEMPERATURE 11=EARTH LEAKAGE	
	0	0	0	0	0
	1	0	0	0	1
	2	0	0	1	0
	3	0	0	1	1
	4	0	1	0	0
	5	0	1	0	1
	6	0	1	1	0
	7	0	1	1	1
	8	1	0	0	0
	9	1	0	0	1
	A	1	0	1	0
	b	1	0	1	1
	C	1	1	0	0
	d	1	1	0	1
	E	1	1	1	0
	F	1	1	1	1

Column headers: RELAY OPERATING MODE 0=FAIL SAFE 1=NON FAIL SAFE; FULL SCALE 1.25 x FLA / 100% / 200°C / 100%

NOTE:

Not applicable to units with RS-485 communications interface. See MPU-16A RS-485 Communications Interface Manuals.

TABLE 4

3.10.3 SHORT-CIRCUIT TRIP

The instantaneous short-circuit trip at 1200% FLA should not be enabled unless the interrupting capacity of the interrupting device is rated for the available fault level. If short-circuit trip is enabled, phase CT's must be selected so that motor FLA is between 45% and 75% of the phase-CT-primary rating. See Sections 3.3 and 3.17.

Default.. OFF

3.10.4 HOT-MOTOR COMPENSATION (RTD Only)

The MPU-16A's thermal model assumes a 40°C ambient temperature and it calculates a thermal time constant from the programmed values of service factor and I^2t limit. It is important that actual motor values be used so that the model can track motor temperature. If the model time constant is too short, premature trips can occur and premature resets will be allowed. If the model time constant is too long, motor temperature can be excessive before a trip occurs.

When hot-motor compensation is ON, motor temperature measured by the RTD can bias the thermal model. This bias provides protection against high ambient temperature, loss of ventilation, or premature reset. With hot-motor compensation, the minimum percent I^2t value is:

$$\frac{\text{Measured Temp (°C)} - 40\text{°C}}{\text{Temperature Trip Set Point (°C)} - 40\text{°C}} \times 100\%$$

Hot-motor compensation is disabled if the Mode-4-trip set point is deleted, if an open-RTD or shorted-RTD sensor is detected, or if the Mode-4 trip is disabled by an emergency thermal reset. See Sections 3.6 and 3.16.

Hot-motor compensation cannot be selected on units configured for PTC-thermistor temperature sensors.

Default.. OFF

3.10.5 EARTH-FAULT TRIP DELAY

Four earth-fault-trip times (instantaneous, 0.25 s, 0.5 s, or 1.0 s) are available. See Section 3.7.

Default.. Instantaneous

3.10.6 PHASE REVERSE

If phase-reverse protection is enabled, phase sequence will be checked during the first three seconds of each start. See Section 3.5.

Default... Disabled

3.10.7 PHASE SEQUENCE

If phase-reverse protection is enabled, select sequence AbC or bAC. See Section 3.5.

Default... AbC

3.10.8 ANALOG-OUTPUT PARAMETER

For units without RS-485 communication interface, one of the following parameters can be directed to the isolated analog output:

Current (Mode 9)......................... 0 to 125% FLA
I^2t (Mode E)................................ 0 to 100%
Temperature (Mode C)................ 0 to 200°C
Earth Leakage (Mode d)............. 0 to 100%

Default... Current

3.10.9 RELAY OPERATING MODE

Each output-relay driver can be independently operated in a fail-safe or non-fail-safe mode. In the fail-safe mode, the output relays are energized when supply voltage is on and the unit is not in a trip-or-alarm condition. The output relays are de-energized if supply voltage is off or if a trip-or-alarm condition occurs. MPU-16A labelling shows the relays de-energized. In the non-fail-safe mode, the output relays are energized only during a trip-or-alarm condition.

Default Values:
Trip Relay .... Fail Safe
Alarm Relay .... Fail Safe

3.11 MODE 9 — AMMETER

This mode is used to display the largest of the three phase-currents. Mode 9 is automatically displayed when supply voltage is applied. For currents above 999 A, the last value digit is replaced by E to indicate an extended range. To obtain the actual value, multiply the reading by 100. For example, 30E is read as 3000 A.

Motor current as a percentage of full-load current is displayed by pressing RESET. The pre-trip ammeter value can be recalled by pressing ENTER.

Range.. 0 to 10 x FLA
Resolution.. 1 A for I < 1000 A
100 A for I ≥ 1000 A
Accuracy.. ± 0.3% Full Scale or
± 3% Reading

See Technical Specifications in Section 7 for metering accuracy vs ICT interconnection cable length.

3.12 MODE A — PEAK CURRENT / % CURRENT MODULATION

This mode is used to display the maximum phase current measured since the previous reset in Mode A. The extended-range notation applies for values above 999 A. See Section 2.2. Unlike the ammeter, the peak-reading ammeter is operational only after the motor is running. The MPU-16A considers the motor to be running when motor current remains between 10% and 125% FLA for more than 10 seconds.

Mode A is also used to display percent current modulation. Reciprocating loads can produce pulsating motor currents. These pulsating currents can be considered to be amplitude-modulated current waveforms.

NEMA MG1-20.82 defines percent modulation as:

$$\%Mod = [\text{Peak Variation} / (1.414 \times FLA)] \times 100\% \qquad (3.3)$$

Peak percent modulation for the present run cycle can be displayed in Mode A by pressing ENTER. It is automatically reset each time the motor stops and can be manually reset by simultaneously pressing ENTER and RESET.

Peak Current:
    Range.. 0 to 6 x FLA
    Resolution .... 1 A for I < 1000 A,
    100 A for I ≥ 1000 A
Percent Modulation:
    Range.. 0 to 100%
    Resolution 1%

3.13   MODE b — CURRENT-UNBALANCE DISPLAY

This mode is used to display percent current unbalance. The unbalance value is calculated using equations 3.1 and 3.2. See Section 3.5.

The pre-trip current unbalance value can be recalled by pressing ENTER.

Range.. 0 to 100%
Resolution... 1%

3.14   MODE C — TEMPERATURE DISPLAY

This mode is used to display RTD temperature or PTC-thermistor status. If the unit is configured for a RTD sensor, Mode C will display temperature in °C. If the unit is configured for a PTC thermistor, Mode C will display 0 to 10 when the sensor temperature is below the NRT (R < 2000 ohms) and 200 to 255 (R > 3300 ohms) when the sensor temperature is above the NRT.

The pre-trip value can be recalled by pressing ENTER.

An emergency thermal reset will temporarily disable the Mode-4 trip. The peak value reached while the Mode-4 trip was disabled can be displayed by pressing RESET. The peak temperature reached will be in °C if the unit is configured for a RTD; however, a unit configured for a PTC will display the PTC trip indication if the NRT has been exceeded. Peak values are not saved if control power is lost.

RTD:
Range....................................... 0 to 255°C
Resolution .... 1°C
Accuracy.................................... ± 2°C
Sensor-Open Indication .... 255°C
Sensor-Short Indication............... 255°C

PTC:
Trip Indication .... 200 to 255
Reset Indication .... 0 to 10

3.15   MODE d — EARTH LEAKAGE

This mode is used to display earth-leakage current. The extended-range notation applies in Mode d.

The pre-trip earth-leakage value can be recalled by pressing ENTER.

Range.. 0 to 1.25 x EF-CT-Primary Rating
Accuracy .... ± 3% EF-CT-Primary Rating
Resolution With:
    EFCT-1 or EFCT-2...................... 0.02 A
    5-A- or 1-A-Secondary CT .... 1 A for I < 1000 A,
                                        100 A for I $\geq$ 1000 A

3.16 MODE E — PERCENT I^2t / TIME-TO-RESET / EMERGENCY THERMAL RESET

This mode is used to display percent I^2t which is a measure of used thermal capacity. See Section 3.2. If the increase in I^2t during a typical start is known, the value in Mode E will indicate if sufficient thermal capacity is available to start a hot motor.

Mode E is also used to display time in minutes until a Mode-0 reset will be allowed if a Mode-0 trip has occurred. Reset time is a function of the time constant. Reset time is displayed when RESET is pressed; however, the reset time can be longer than the value displayed if hot-motor compensation is enabled. See Section 3.10.4.

EMERGENCY THERMAL RESET will reduce I^2t to 0%, reset Mode 0, and temporarily disable Mode 4 and hot-motor compensation. For EMERGENCY THERMAL RESET:

— Defeat program-change lockout by connecting MPU-16A terminals 20 and 21,
— select Mode E, and
— press ENTER and RESET simultaneously.

The pre-trip percent I^2t value can be recalled by pressing ENTER.

Percent I^2t:
    Range.. 0 to 100%
    Resolution 1%
    Trip Value.................................. 100%
    Reset Value 30%

Time-to-Reset:
    Range.. 0 to 85 minutes
    Resolution .... 1 minute

- - - CAUTION - - -

USE OF EMERGENCY THERMAL RESET CAN RESULT IN MOTOR DAMAGE.

3.17   MODE F — CT-PRIMARY RATINGS

This mode is used to enter phase-CT- and earth-fault-CT-primary ratings in the same way that trip-and-alarm set points are entered. Mode-F set points change in 5-A or 50-A increments and all four digits display the CT-primary rating when a set point is being adjusted. When a new rating is entered, the display returns to the three-value-digit format and the extended-range notation applies for values above 999 A. See Section 2.2.

Phase CT's should be selected so that motor full-load current is approximately 70% of the primary rating. The FLA programming range in Mode 6 is 45% to 93% of the phase-CT-primary rating. If short-circuit trip is enabled, phase CT's must be selected so that motor FLA is between 45% and 75% of the phase-CT-primary rating. Mode F must be programmed before Mode 6 because Mode 6 is set to the bottom of the FLA range when the phase-CT-primary rating is entered.

The primary rating for the EFCT-1 and EFCT-2 is 5 A. If a 5-A- or 1-A-secondary earth-fault CT is used, the primary rating of the earth-fault CT must be entered. If the residual connection is used, enter the primary rating of the phase CT's in both levels of Mode F.

All programmed values and values-at-trip are stored in nonvolatile memory. When data are retrieved from this memory, error-detection techniques check for corrupted data. If data are suspect, the unit will trip, "FbAd" will be displayed, and default values will be loaded. If "FbAd" is displayed, defeat the program-change lockout, reprogram the unit, and reset Mode F.

Phase-CT-Primary Ratings .... 20 A to 1200 A in 5-A increments
Earth-Fault-CT-Primary Ratings:
      EFCT-1 and EFCT-2 .... 5 A
      5-A- or 1-A-Secondary CT .... 50 A to 2000 A in 50-A increments
Display Codes:
      Invalid Data Trip .... FbAd
Default Values:
      Phase-CT-Primary Rating............ 150 A
      Earth-Fault-CT-Primary Rating.... 5 A

4. SETUP

4.1 GENERAL

This section contains information to assist in selecting CT ratios and set-point values.

To enable program changes, the program-change lockout must be defeated by connecting MPU-16A terminals 20 and 21. See Section 5.4.7. All values entered should be recorded on the reference value label provided.

4.2 PHASE-CT SELECTION (Mode F)

Select the primary rating of the phase CT's between 1.07 and 2.22 x motor FLA. If short-circuit trip is to be used, the primary rating of the phase CT's must be between 1.33 and 2.22 x motor FLA. Enter the phase-CT-primary rating in Mode F.

4.3 EARTH-FAULT-CT SELECTION (Mode F, 2nd Level)

Earth-fault protection is low-level protection. High-level faults must be cleared by fuses or by circuit breakers which limit the energy let-through to a fault. In a solidly-grounded installation, select an earth-fault CT that will not saturate below the operating value of the high-level devices and enter the CT-primary rating in the second level of Mode F.

Optional CT's (EFCT-1 or EFCT-2) with 5-A-primary ratings are available for sensitive earth-fault detection in applications where earth-fault current is less than 800 A and inrush current is less than 2.5 kA. If inrush current is greater than 1 kA but less than 2.5 kA, a flux conditioner should be used to prevent nuisance tripping. If earth-fault current is greater than 800 A, inrush current is greater than 2.5 kA, or if a trip level greater than 5 A is required, use a 5-A- or 1-A-secondary earth-fault CT that will not saturate at the prospective currents.

The residual connection can be used if earth-fault set points are greater than 10% of the primary rating of the phase CT's. If the residual connection is used, enter the primary rating of the phase CT's in both levels of Mode F.

4.4 I^2t Limit (Mode 0)

Use locked-rotor data for the motor to determine the Mode-0 set point. For example, if locked-rotor current is 735% FLA and if allowable locked-rotor time is 20 seconds, the I^2t limit is:

6^2 x t = 7.5^2 x 20, and
t = 30 seconds—this is the Mode-0 set point.

Enter "030" as the trip set point. If alarm indication is required, enter an alarm set point that is a percentage of the trip set point. For this example, an alarm at 90% I^2t requires an alarm set point at 0.9 x 30 = 27 seconds.

4.5   TRIP-AND-ALARM SET POINTS (Modes 1 to 5)

Enter trip-and-alarm set points for Modes 1 to 5:
—   Overcurrent, or "jam", protection should be set below the current at which breakdown torque occurs.
—   If loss-of-load protection is required, undercurrent should be set between the no-load current and the minimum operating current.
—   A voltage unbalance of 1% can produce as much as 10% current unbalance. Observe current unbalance in Mode b to determine if set points less than the default values can be used.
—   Select temperature set points according to the insulation class of the motor. Class-B insulation is rated at 130°C (40°C ambient + 80°C rise + 10°C hot-spot allowance). Class-F insulation is rated at 155°C (40°C ambient + 105°C rise + 10°C hot-spot allowance). Trip temperature should be at least 5°C below the rated temperature of the insulation. Alarm temperature should be at least 5°C below the trip temperature.
—   Earth-fault set points require coordination with upstream devices.

If specific data are not available for trip-and-alarm set-point selection, initially use the default values and observe meter values to determine operating set points.

4.6   FULL-LOAD CURRENT (Mode 6)

Enter motor full-load current in Mode 6. The phase-CT-primary rating <u>must</u> be entered in Mode F before motor full-load current is entered in Mode 6.

4.7   SERVICE FACTOR (Mode 7)

Service factor is the factor by which the ultimate-trip current exceeds full-load current. Most electrical codes allow set-points up to 115% and 125% for motors with service factors of 1.0 and 1.15 respectively.

4.8   PROGRAM (Mode 8)

Using Tables 3 and 4, select the functions required and enter the appropriate codes in Mode 8.

5. INSTALLATION

5.1 GENERAL

A basic motor-protection system consists of a MPU-16A motor protection unit, an ICT-2 interface CT, and three customer-supplied phase CT's. An ICT-1 is available to replace the ICT-2 in special CT-ratio applications. To utilize temperature sensing, the motor must be equipped with a RTD or PTC sensor. An earth-fault CT is usually required for earth-fault detection.

5.2 COMPONENT MOUNTING

5.2.1 PANEL-MOUNT CONFIGURATION

Outline dimensions and mounting details for the panel-mount MPU-16A are shown in Figure 3. The MPU-16A mounts in a 92-mm (3.62-in) square cutout (1/4 DIN) and is secured to the panel by the panel-mount clamp. To mount the MPU-16A, insert it through the panel cutout and slip the panel-mount clamp over the MPU-16A body. Slide the clamp forward until the latch tabs snap into the mating holes. Lock the unit in place by tightening the four clamp screws against the mounting panel.

- - - CAUTION - - -

OVER TIGHTENING THE CLAMP SCREWS WILL DEFORM THE CLAMP AND CAUSE THE LATCH TABS TO RELEASE.

5.2.2 SURFACE-MOUNT CONFIGURATION

Outline dimensions and mounting details for the surface-mount MPU-16A are shown in Figure 4. Mount the MPU-16A using M4 (No. 8) screws and external-tooth lockwashers. Surface-mount MPU-16A's have panel-mount-clamp latch holes and are supplied with panel-mount clamps and hole plugs. This allows surface-mount units to be panel mounted as described in Section 5.2.1; however, 100-mm (3.94-in) mounting centres cannot be maintained. If the unit is surface mounted, insert hole plugs in the latch holes.

5.2.3 ICT-2 INTERFACE CT

Outline dimensions and mounting details for the ICT-2 interface CT are shown in Figure 5. Locate the ICT-2 near the phase CT's.

5.2.4 EFCT-1 AND EFCT-2 EARTH-FAULT CT'S

Outline dimensions and mounting details for the EFCT-1 and EFCT-2 earth-fault CT's are shown in Figures 6 and 7.

TOP

SIDE

FRONT

REAR

LATCH TAB

CLAMP SCREWS

PANEL-MOUNT CLAMP

PANEL THICKNESS
1.6 (0.06) TO 4.8 (0.19)

81.1
(3.59)

157.5
(6.20)

96.0
(3.78)

96.0
(3.78)

MPU-16A

92.0
(3.62)

92.0
(3.62)

R=4.8 (0.19)
MAXIMUM

100.0
(3.94)
MINIMUM

100.0
(3.94)
MINIMUM

NOTES:

1. DIMENSIONS IN MILLIMETRES (INCHES).

2. SWITCHABLE SUPPLY SHOWN ON REAR VIEW.

PANEL CUTOUT DETAIL

PANEL-MOUNT MPU-16A OUTLINE AND MOUNTING DETAILS

FIGURE 3

MOUNTING PLATE

HOLE PLUGS

15/.9
(6.22)

8.0
(0.32)

TOP

SIDE

96.0
(3.78)

16.6
(0.65)

122.0
(4.80)

96.0
(3.78)

MPU-16A

FRONT

6-32 x 0.375
FLAT HEAD SCREW

REAR

19.0
(0.75)

9.9
(0.39)

76.2
(3.00)

5.0
(0.20)

19.0
(0.75)

(NOTE 3)

112.0
(4.41)

25.4
(1.00)

(NOTE 3)

M4 OR 8-32 TAP

NOTES:

1. DIMENSIONS IN MILLIMETRES (INCHES).

2. MOUNTING SCREWS: M4 x 10 OR
   8-32 x 0.375 PAN HEAD.

3. MINIMUM CLEARANCE TO ADJACENT
   OBJECTS.

4. SWITCHABLE SUPPLY SHOWN ON REAR
   VIEW.

MOUNTING DETAIL

SURFACE-MOUNT MPU-16A OUTLINE AND MOUNTING DETAILS

FIGURE 4
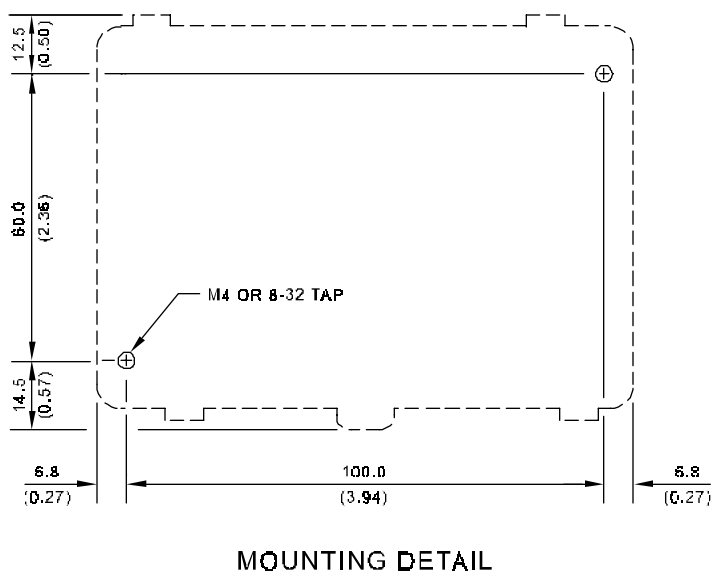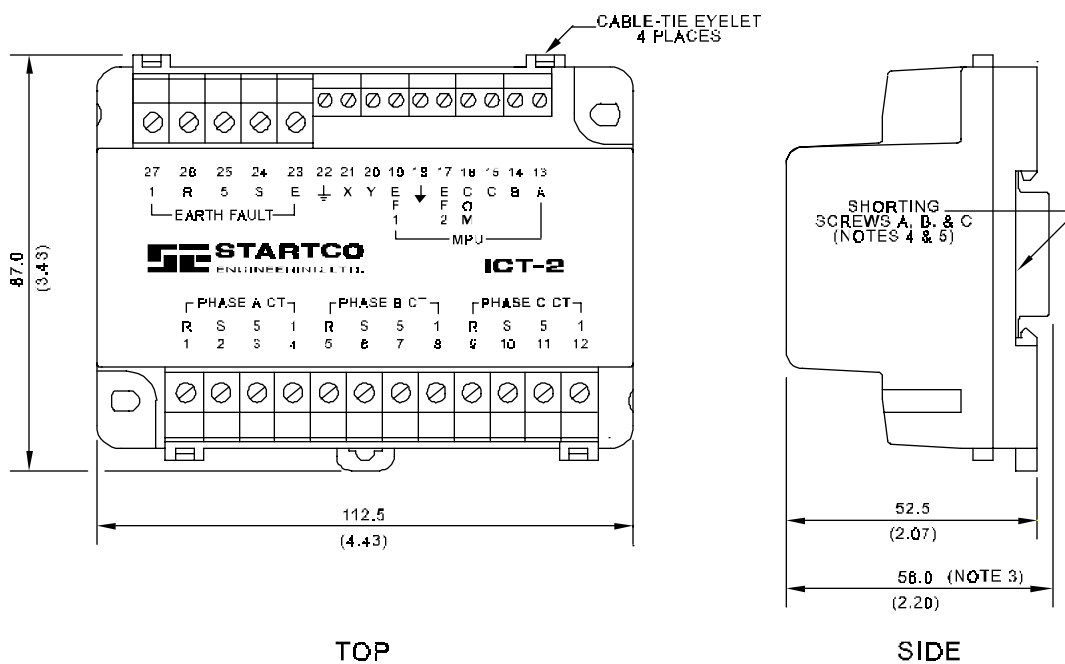
NOTES:

1. DIMENSIONS IN MILLIMETRES (INCHES).

2. MOUNTING SCREWS: M4 x 20 OR 8-32 x 0.875.

3. OVERALL HEIGHT WHEN MOUNTED ON DIN EN50022 35-mm x 7.5-mm TOP-HAT RAIL.

4. SHORTING SCREWS ARE ACCESSIBLE FROM BOTTOM OF ICT-2.

5. SHORTING SCREWS: 6-32 x 0.375 NICKEL-PLATED-BRASS BINDING HEAD. DO NOT SUBSTITUTE.

ICT-2 OUTLINE AND MOUNTING DETAILS

FIGURE 5

TOP

MOUNTING DETAIL

FRONT

SIDE
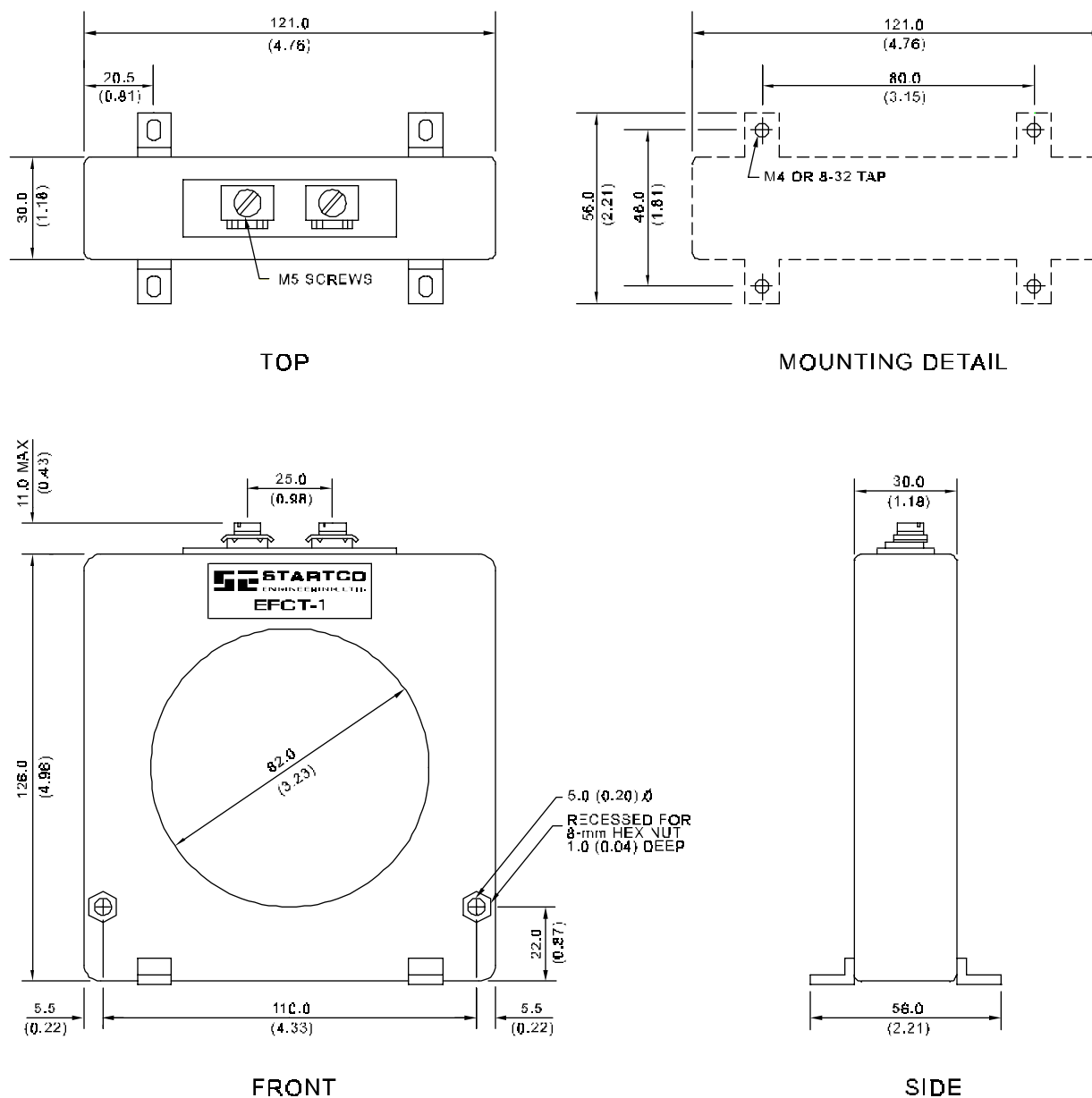
NOTES:

1. DIMENSIONS IN MILLIMETRES (INCHES).
2. MOUNTING SCREWS: M4 x 12 OR 8-32 x 0.50.

EFCT-1 OUTLINE AND MOUNTING DETAILS

FIGURE 6

215.0
(8.46)

64.0
(2.52)

31.0
(1.22)

M5 SCREWS

TOP

215.0
(8.46)

162.0
(6.38)

52.3
(2.06)

M4 OR 8-32 TAP

MOUNTING DETAIL

25.0
(0.98)

236 MAX
(9.29)

155.0
(6.10)

5.0 (0.20) DIA

60.0
(2.36)

8.5
(0.33)

198.0
(7.80)

8.5
(0.33)

FRONT

31.0
(1.22)

215.0
(8.46)

SIDE
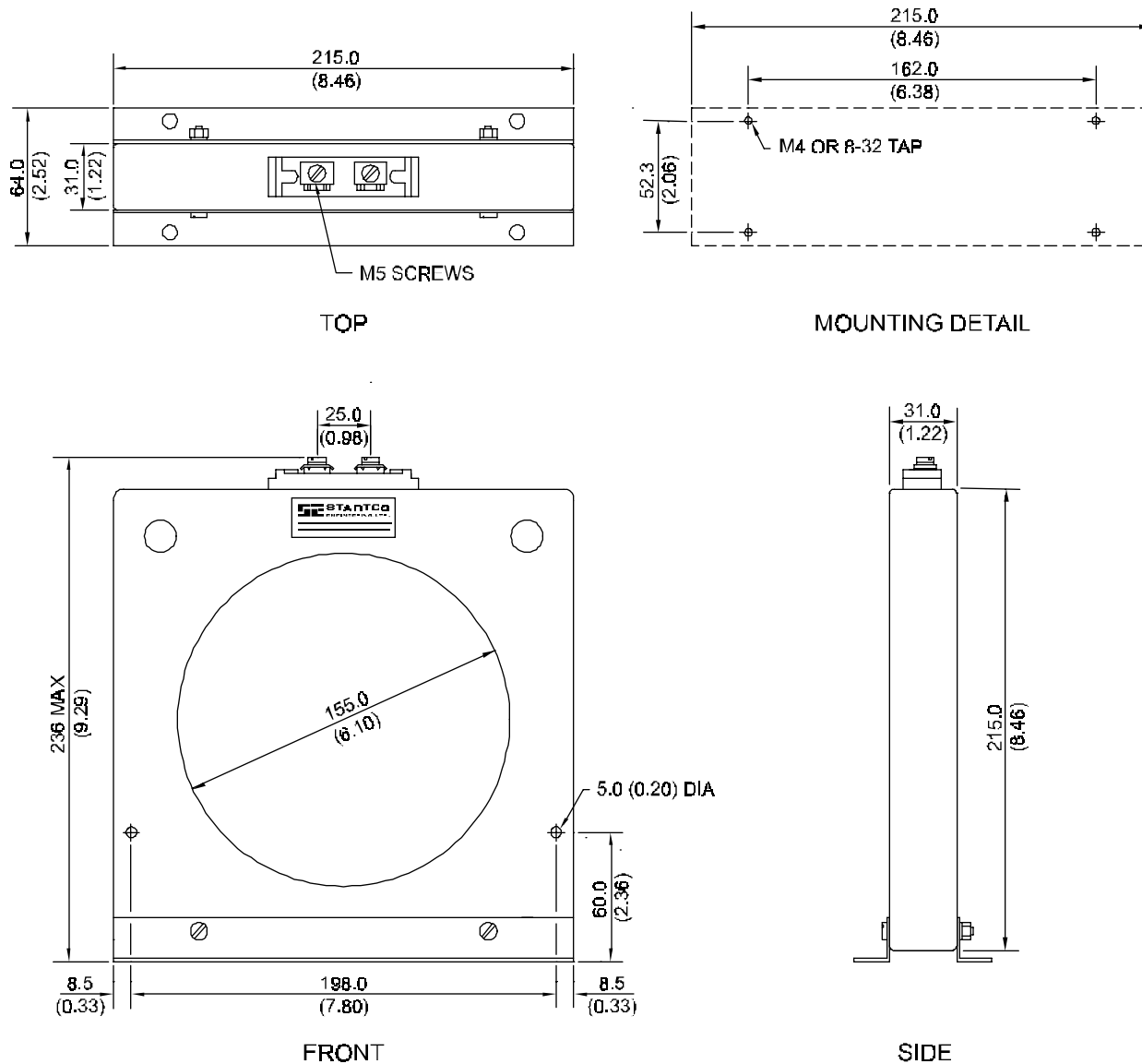
NOTES:

1.   DIMENSIONS IN MILLIMETRES (INCHES).

2.   MOUNTING SCREWS: M4 x 12 OR 8-32 x 0.50.

EFCT-2 OUTLINE AND MOUNTING DETAILS

FIGURE 7

5.3 SHIELDED CABLES

Motor protection equipment must operate in electrically noisy environments. Use shielded, twisted cables for all low-level signals to minimize electrostatic and electromagnetic coupling. The shield must enclose the signal conductors as completely as possible and the shield must have only one connection to ground.

Input-cable shields from the ICT-2, the temperature sensor, and the remote program-enable switch must be grounded at the MPU-16A end only. Analog- and communications-output cables should be grounded at the receiver end only.

Terminate foil-shielded input cables as shown in Figure 8:

1. Strip 150 mm (6") of outer jacket from the cable.

2. Peel and strip the foil shield from the drain and insulated wires.

3. Trim the insulated wires to 50 mm (2"), and strip 6 mm (1/4") of insulation from each wire. Leave the drain wire full length.

4. Connect the insulated wires to the terminal block.

5. Group the drain wires from all shielded input cables and twist them together. Trim the drain wires to length and attach the crimp-type ground lug provided. For panel-mount units, fasten the lug with the shield screw. For surface-mount units, install the lug between the screw head and the lockwasher on one of the MPU-16A mounting screws.

6. Repeat steps 1 and 2 at the other end of the cable. Cut off the drain wire and use heat-shrink sleeving or tape to insulate the shield from ground.

Terminate output cables in the same manner. Ground the drain wires at the receiver ends only.

5.4 MPU-16A CONNECTIONS

All connections to the MPU-16A are made through two plug-in, wire-clamping terminal blocks. Each terminal will accept one No. 14 AWG conductor. The supply-voltage terminal block has a keying pin blocking terminal 9 so that supply voltage cannot be accidentally applied to the signal terminals. See Figures 9 and 10 for typical connections and control circuits.

a) OUTER JACKET REMOVED AND FOIL SHIELD PEELED

FOIL SHIELD

BARE DRAIN WIRE

INSULATED
SIGNAL CONDUCTORS

150 mm
(6 in)
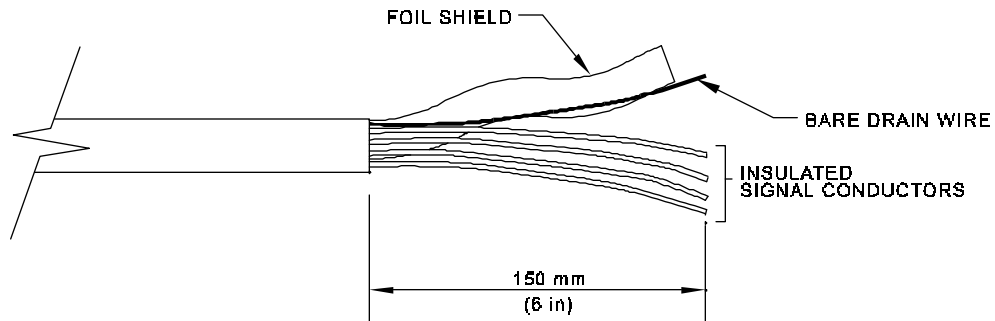
b) CONDUCTORS PREPARED FOR TERMINATION

FOIL SHIELD REMOVED

SLEEVE IF NECESSARY TO PREVENT
CONTACT WITH OTHER CONDUCTORS

DRAIN WIRE
FULL LENGTH

6 mm
(0.25 in)

50 mm
(2 in)

SHIELD-GROUND END

SHIELD AND DRAIN WIRE
CUT OFF AT JACKET EDGE

HEAT-SHRINK SLEEVING OR TAPE TO
PREVENT SHIELD CONTACT WITH GROUND
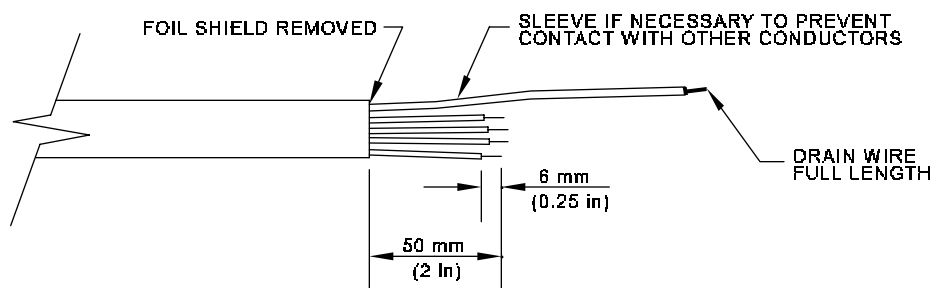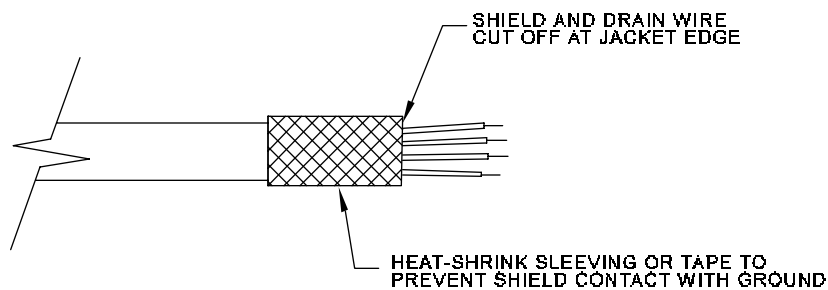
UNGROUNDED END

SHIELDED-CABLE PREPARATION

FIGURE 8
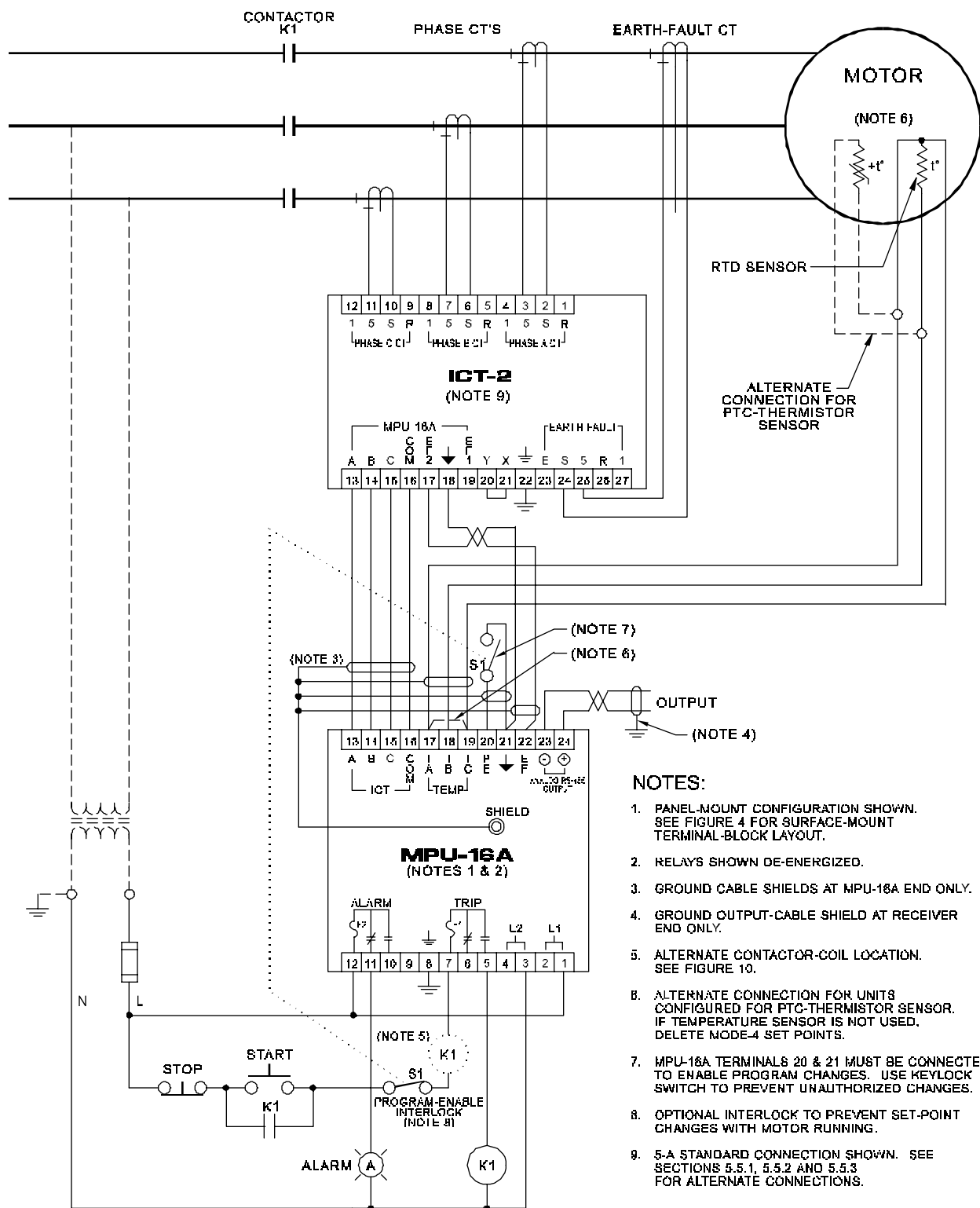
TYPICAL MPU-16A CONNECTION DIAGRAM

FIGURE 9

ALTERNATE COIL CIRCUIT FOR PLC STATUS INPUT

ALTERNATE COIL CIRCUIT FOR TRIP CONTACTS BETWEEN COIL AND NEUTRAL

TYPICAL CONTROL CIRCUITS

FIGURE 10

5.4.1 ICT-2 INTERCONNECTION CABLE

Connect the MPU-16A to the ICT-2 with the interconnection cable supplied. See Figures 12 and 13. Prepare the shielded-conductor groups as outlined in Section 5.3. The following colour code is recommended:

A	Black	Shielded-Group 1
B	White	
C	Red	
COM	Green	
EF(1,2)	Blue	Shielded-Group 2
	Brown	

Ground the cable shields at the MPU-16A only.

5.4.2 POWER SUPPLY

The MPU-16A power supply is protected by a time-delay fuse, F3, which is externally accessible only on units with SW, D1, D2, and D4 power-supplies. SW units are supplied with fuses for 120-Vac operation. D1, D2, and D4 units are fused for 12, 24, and 48 Vdc operation respectively. All other units are internally fused for the supply indicated on the MPU-16A nameplate. See Section 7 for recommended F3 fuses.

Derive supply voltage from the line side of the motor starter or from an independent source. Connect supply voltage to terminals 1 and 3 (L1 and L2) as shown in Figure 9. In 120-Vac systems, L2 is usually designated as the neutral conductor. Direct-current power supplies use L1 for the positive terminal and L2 for the negative terminal. Ground terminal 8.

5.4.3 TRIP-RELAY CONTACTS

A set of Form C relay contacts are provided for use in a contactor- or breaker-control circuit. These contacts are designated TRIP and are available at terminals 5, 6, and 7. The trip contacts are rated 8 A resistive at 250 Vac and are protected by an 8-A fuse, F1. Three typical contactor control circuits are shown in Figure 10. The trip relay is shown de-energized.

5.4.4 ALARM-RELAY CONTACTS

A set of Form C relay contacts are provided for use in an indication or supervisory-control circuit. These contacts are designated ALARM and are available at terminals 10, 11, and 12. The alarm contacts are rated 8 A resistive at 250 Vac and are protected by an 8-A fuse, F2. The alarm relay is shown de-energized.

NOTE: USE No. 14 AWG CONDUCTORS FOR SUPPLY-VOLTAGE AND OUTPUT-RELAY CONNECTIONS.

5.4.5 RTD TEMPERATURE SENSOR

The MPU-16A nameplate indicates the RTD sensor type that the temperature circuit is configured for. Lead compensation requires equal lead resistances. Use shielded, three-conductor, No. 16 AWG to No. 22 AWG cable to connect the RTD sensor to terminals 17, 18, and 19 as shown in Figure 9. Ground the cable shield at the MPU-16A only.

The MPU-16A indicates an alarm if the RTD opens or shorts. Delete temperature sensing in Mode 4 if a RTD is not connected.

5.4.6 PTC THERMISTOR TEMPERATURE SENSOR

The MPU-16A nameplate indicates if the temperature circuit is configured for a PTC thermistor. Use No. 16 AWG to No. 22 AWG cable to connect the PTC thermistor to terminals 17 and 18. Install a jumper between terminals 17 and 19 as shown in Figure 9. If shielded cable is used, ground the shield at the MPU-16A only.

A PTC thermistor switches from a low resistance to a high resistance above its Nominal Response Temperature (NRT). Consequently, shorted-sensor and open-sensor detection is not provided. If the unit is configured for a PTC thermistor and if a thermistor is not used, delete temperature sensing in Mode 4.

5.4.7 PROGRAM-CHANGE LOCKOUT

As explained in Sections 2.3 and 2.5, program-change lockout prevents unauthorized or unintentional changes. It is recommended that a keylock switch be connected to MPU-16A terminals 20 and 21 to allow programming. To prevent program changes while the motor is running, use a two-pole keylock switch as an interlock as shown in Figures 9 and 10. If the switch is mounted more than 1 m (3 ft) from the MPU-16A, use shielded cable and ground the shield at the MPU-16A end only.

5.4.8 ANALOG OUTPUT

An isolated analog output is available at terminals 23 and 24. Terminal 23 is negative. Use shielded cable and ground the cable shield at the receiver.

5.4.9 COMMUNICATIONS INTERFACE

The optional RS-485 communications interface replaces the analog output at terminals 23 and 24. See communications interface manuals.

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5.5   ICT-2 CONNECTIONS

The MPU-16A uses an ICT-2 interface CT to simplify wiring and to minimize CT burden.   The ICT-2 contains four signal-conditioning interface transformers which are interconnected as shown in Figure 11. These transformers isolate the MPU-16A from the phase and earth-fault CT's. Also, they eliminate the need for CT shorting contacts when the MPU-16A is disconnected. Phase-CT and earth-fault-CT secondaries can be simultaneously grounded through terminal 22 and a jumper to terminal 20.   For in-line applications, the CT secondaries can be isolated by removing shorting screws A, B, and C through holes in the bottom of the ICT-2. See Figure 5.

5.5.1 STANDARD CONNECTION

Standard connections with three, phase CT's and an earth-fault CT are shown in Figure 12. Dotted lines indicate 1-A-CT connections. Use shielded cable for EFCT-1 connections. Ensure that only current-carrying phase conductors pass through the earth-fault CT window and that ground conductors do not. For applications where the CT secondaries must be grounded at another location, remove shorting screws A, B, and C.

5.5.2 RESIDUAL EARTH-FAULT CONNECTION

The residual earth-fault connection is shown in Figure 13a. Dotted lines indicate 1-A-CT connections. Use three identical phase CT's for this connection.

5.5.3 TWO-CT CONNECTION

The two-CT connection is shown in Figures 13b and 13c. Dotted lines indicate 1-A-CT connections.   Since this connection derives the current in the unmonitored phase, this connection should be used only in retrofit applications where it is not possible to install a third phase CT.

5.6   CABLE RESTRAINT

All conductors should be restrained within 100 mm (4") of the terminal blocks as shown in Figure 14. Three sizes of adjustable "P" clips are provided for this purpose. For surface-mounted units, restrain the conductors by fastening the "P" clips to the mounting surface. For panel-mounted units, secure the "P" clips to the MPU-16A rear panel. Secure cables to the ICT-2 using the cable-tie eyelets and the cable ties provided.

Pub. MPU-16A-M, November, 1997

Downloaded from the Internet, see Disclaimer.
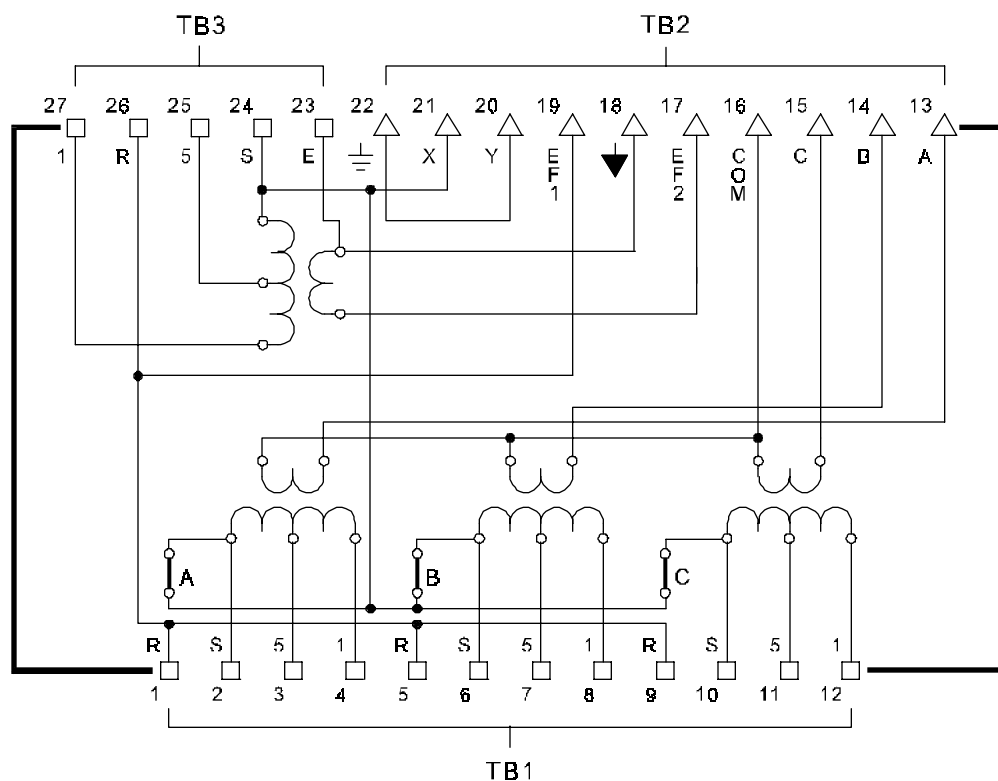
NOTES:

1. REMOVE SHORTING SCREWS A, B, AND C TO ISOLATE PHASE-CT AND EARTH-FAULT-CT SECONDARIES FOR IN-LINE APPLICATIONS.

2. SHORTING SCREWS A, B, AND C: 6-32 x 0.375 NICKEL-PLATED-BRASS BINDING HEAD. DO NOT SUBSTITUTE.

3. SHORTING SCREWS A, B, AND C MUST NOT BE REMOVED FOR RESIDUAL OR TWO-CT CONNECTIONS.

4. EACH TERMINAL ON TB1 AND TB3 WILL ACCEPT ONE NO. 10 AWG CONDUCTOR.

ICT-2 SCHEMATIC

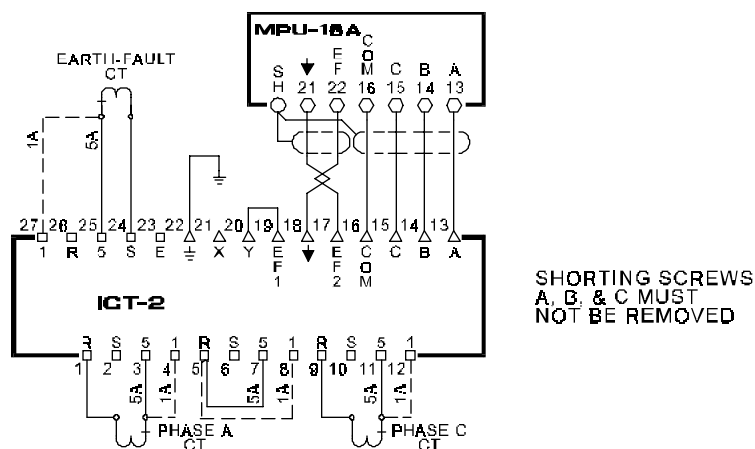**FIGURE 11**

a) STANDARD CONNECTION
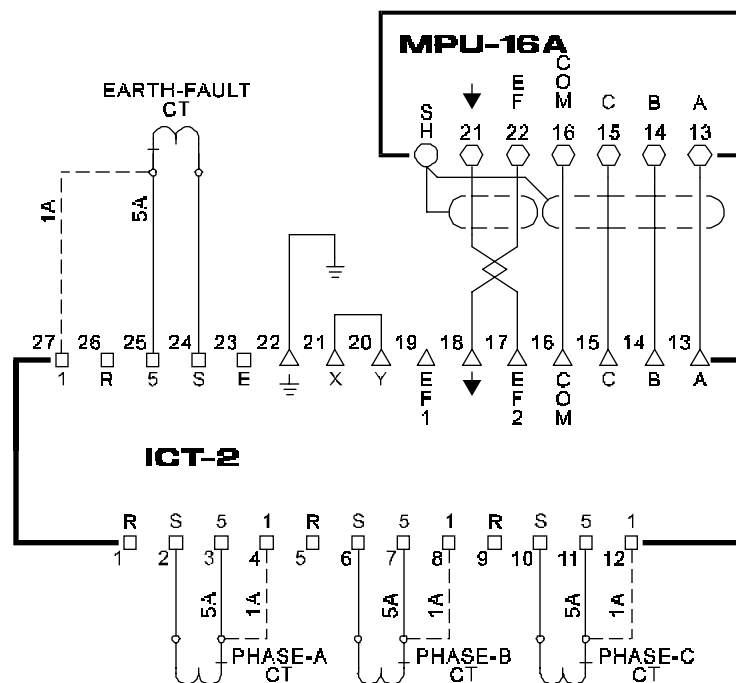
b) STANDARD CONNECTION WITH EFCT
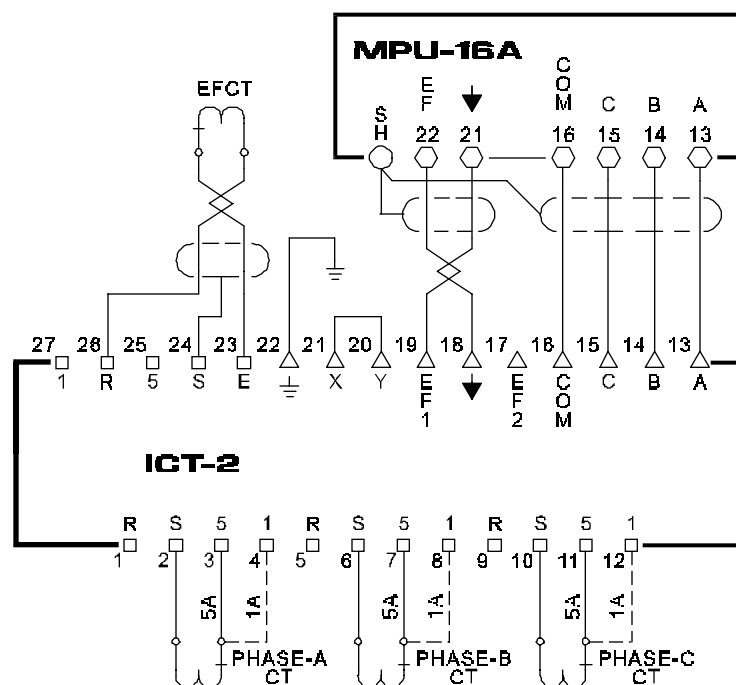
ICT-2 STANDARD CONNECTIONS

FIGURE 12

a) RESIDUAL CONNECTION
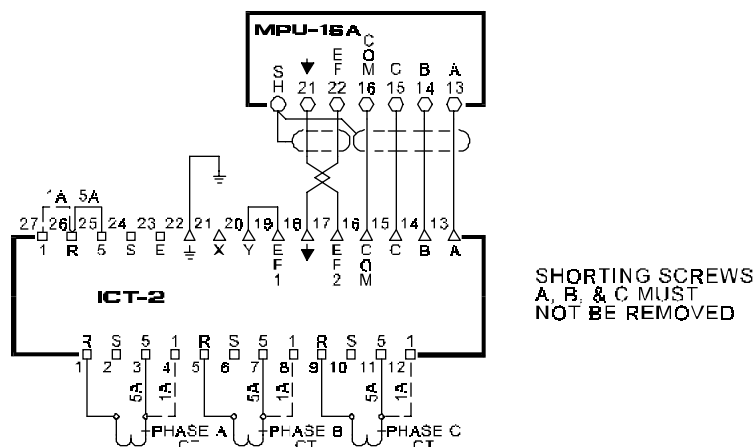
b) TWO-CT CONNECTION

c) TWO-CT CONNECTION WITH EFCT-1
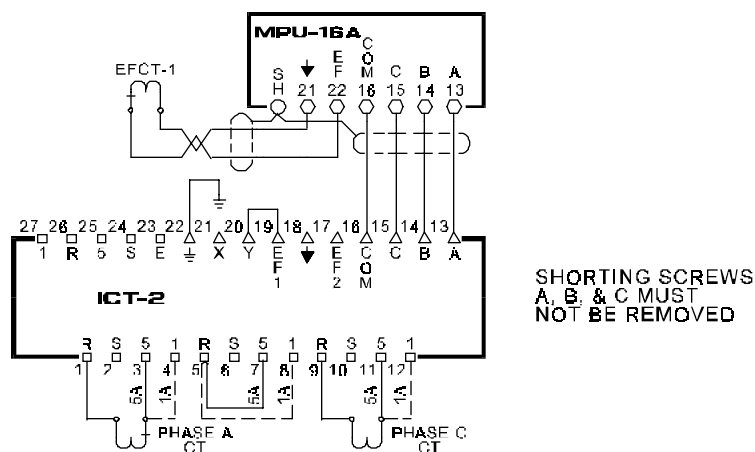
OTHER ICT-2 CONNECTIONS

FIGURE 13

a) SURFACE MOUNT

"P" CLIP SCREWED TO
MOUNTING PANEL

GROUND LUG

MPU-16A

b) PANEL MOUNT

6-32 x 0.375
BINDING-HEAD SCREW

SHIELD

GROUND LUG

SHIELD-GROUND
TERMINAL

ADJUSTABLE "P" CLIP
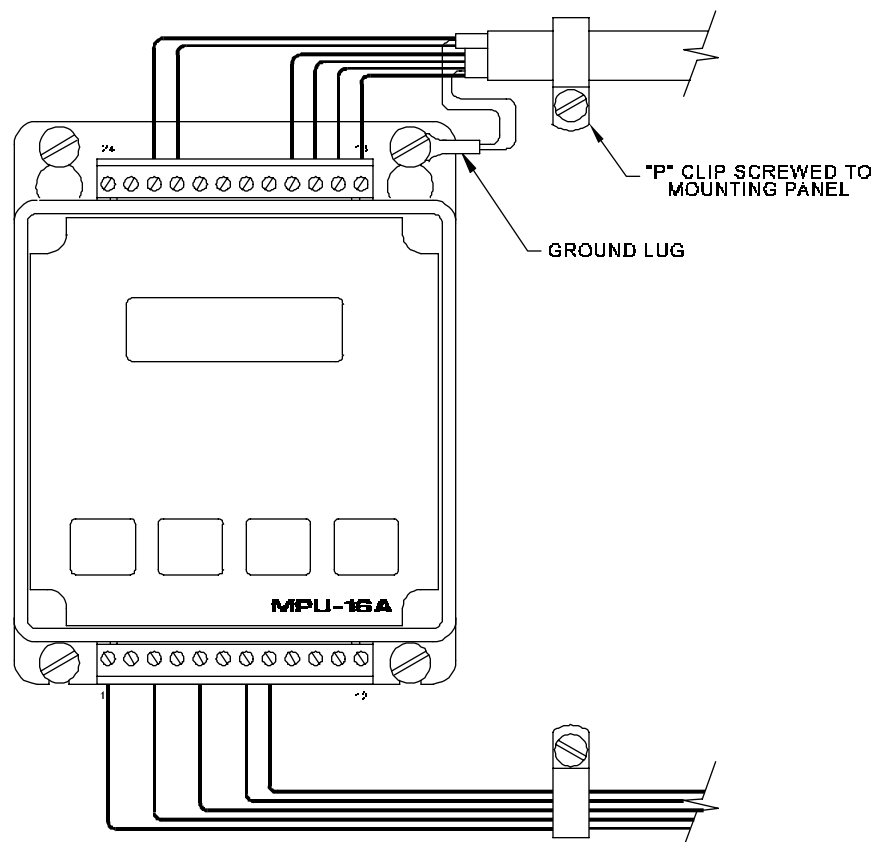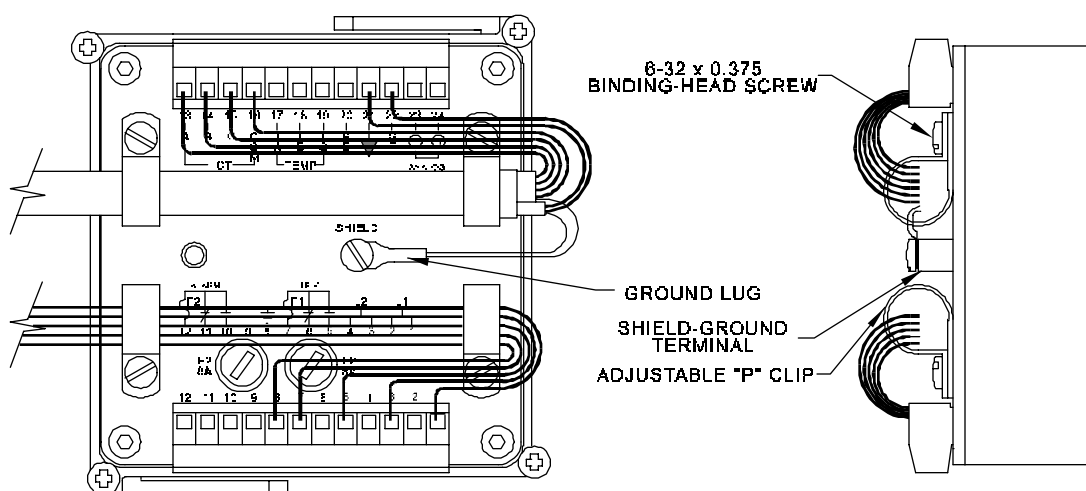
CABLE TERMINATION AND RESTRAINT

FIGURE 14

6. THEORY OF OPERATION

6.1 GENERAL (See Figure 15)

A basic MPU-16A consists of a display module, a power-supply module, a processor module, and an analog module. The display module is a "motherboard" for the other modules.

6.2 DISPLAY MODULE

The display module has two functions. It is the operator interface and it provides the main bus network for the system. The display module contains the LCD, LCD driver, LED indicators, and bus connectors. The power-supply, processor, analog, and option modules plug into the bus connectors. A sealed-membrane-switch keypad containing four switches and an ESD shield also connect to the bus. A direct-drive LCD allows operation to -40°C.

6.3 POWER-SUPPLY MODULE

A transformer-isolated power supply provides 5, 12, and 20 Vdc for the other modules. The transformer primary can be connected for 120- or 240-Vac operation. A dc-to-dc converter is used for 120/240-Vac/dc operation or for 12-, 24-, or 48-Vdc operation. The power-supply module also contains the trip-and-alarm relays.

6.4 PROCESSOR MODULE

The processor module contains the CMOS 6805 microprocessor, EPROM memory, nonvolatile EEPROM memory, and watchdog circuit.

The EEPROM memory provides 64, 8-bit memory locations to store programmed values and values-at-trip. When supply voltage is lost, a power-fail circuit generates an interrupt and data are written into the EEPROM memory. Hysteresis in the power-fail circuit ensures that the MPU-16A will not attempt to operate unless the supply voltage is within specifications.

The watchdog connected to the CPU reset line will reset the CPU if a watchdog pulse has not been detected for 0.25 second. The watchdog prevents changes to the EEPROM contents until the CPU is reset. If the CPU does not reset, the relay lock-out circuit is set and the green PROCESSOR-RUN LED is turned off. When the relay lock-out circuit is set, the trip-and-alarm relays are de-energized.
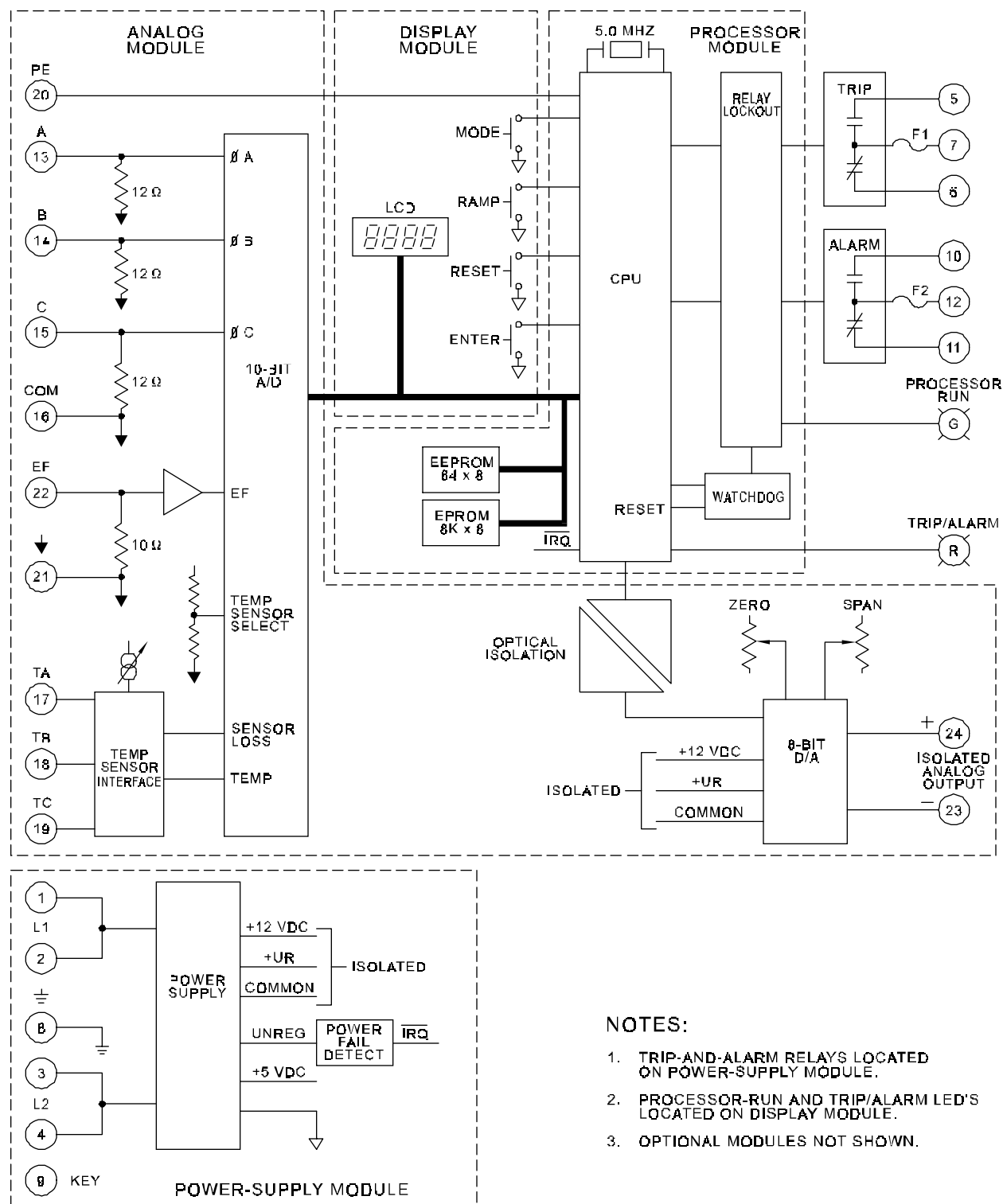
MPU-16A FUNCTIONAL BLOCK DIAGRAM

FIGURE 15

6.5   ANALOG MODULE

The analog module contains input circuits for phase current, temperature, and earth-leakage current. It also contains an eight-channel, multiplexed, ten-bit, A/D converter and an isolated analog-output circuit. All inputs and outputs have MOV protection against electrical transients.

The RTD temperature measurement circuit uses current sources to provide RTD lead compensation. Digital linearization is provided for nickel RTD's.

Serial data are transferred to the isolated analog-output circuit through a dual-channel optical isolator. The analog signal is scaled and buffered to provide the required current or voltage output.

6.6   OPTION MODULES

A 50-pin bus connector on the display module accepts a backlighting, remote input, or RS-485 communications interface module.

6.7   FIRMWARE

The MPU-16A completes four program scans per second. In 60-Hz applications, each scan has an eleven-cycle sampling interval followed by a four-cycle calculation interval. In each sampling interval, the multiplexed A/D converter obtains 960 samples of the earth-fault and phase-current signals.   The multiplexer sequences these four signals so that each measurement is a digital integration of 240 samples uniformly spaced throughout the sampling interval. This technique eliminates nuisance phase-unbalance trips on modulating or rapidly-changing loads.

In order to provide instantaneous short-circuit and earth-fault trips, each current sample is compared to its trip value. If four samples in one sampling interval exceed the trip value, a trip will result.

All other data and I/O are processed, and all time delays are initiated during the four-cycle calculation interval.

7. TECHNICAL SPECIFICATIONS

SPECIFICATIONS APPLY TO FIXED-FREQUENCY APPLICATIONS.

Supply:
    AC (supply voltage codes: 12, 24, SW, and AD*):
        120/240 Vac, 50/60 ± 1 Hz ..... 10 VA
        Maximum Continuous .... 135/265 Vac
        Minimum Continuous .... 85/170 Vac
        Power-up Voltage .... 100/200 Vac
    DC (supply voltage code: AD): *
        100 to 240 Vdc...................... 10 W
        Maximum Continuous .... 340 Vdc
        Minimum Continuous .... 90 Vdc
    DC (supply voltage codes: D1, D2, and D4): *
        12, 24, or 48 Vdc................... 10 W
        Maximum Continuous .... +50%
        Minimum Continuous .... -25%
    Fuse (F3).................................. See Fuse-Selection Chart

Interface-CT Inputs:
    Thermal Withstand
      Continuous .... 5 x CT-Secondary Rating
      1-Second .... 80 x CT-Secondary Rating
    Burden .... < 0.01 Ω

Metering Accuracy vs ICT Interconnection Cable Length:

No. 22 AWG	No. 18 AWG	Accuracy
< 18 m (60 ft)	< 45 m (150 ft)	± 3%
< 30 m (100 ft)	< 75 m (250 ft)	± 4%
> 30 m (100 ft)	> 75 m (250 ft)	± 5%

Temperature Input:

    3-Wire RTD:

	100-Ω Platinum DIN 43760	100-Ω Nickel	120-Ω Nickel	10-Ω Copper
100°C Calibration (Ω)	138.5	167.2	200.6	12.9
Sensor Current (mA)	3.9	2.6	2.0	3.8
Lead Compensation (Ω)	< 50	< 50	< 50	< 25
Shorted-RTD Alarm (Ω)	< 20	< 40	< 55	< 2

* CSA certification pending on AD, D1, D2, and D4.

PTC Thermistor:
    Cold Resistance........................ 1500 Ω max
    Trip Level................................. 3300 Ω
    Reset Level.............................. 2000 Ω
    Sensor Current .... 0.6 mA

Output Relays:
    Contact Rating........................... 8 A Resistive, 250 Vac or
                                24 Vdc. B300 Pilot Duty
                                  0.25 hp @ 120 Vac
    Contact Configuration .... Form C
    Fuse Rating (F1 & F2) .... 8 A, 250 Vac
    Fuse Type .... See Fuse-Selection Chart

Analog Output:
    Parameter................................. 0 to 125% FLA,
                                    0 to 100% I^2t,
                                    0 to 200°C, or
                                    0 to 100% Earth Leakage
    Drive:
     4—20 mA................................. 700 Ω max
     0—5 Vdc.................................. 25 mA max
     0—10 Vdc................................ 25 mA max
    Isolation to Ground .... 300 Vac Continuous
    Dielectric Strength .... 1500 Vac
    Resolution .... ± 1% Full Scale

Accuracies:
    Ammeter Accuracy .... ± 0.3% Full Scale or
                                      ± 3% Reading [1, 2]
    Earth-Leakage Accuracy .... ± 3% EF-CT-Primary Rating [2]
    RTD Temperature Accuracy .... ± 2°C

      [1] Ammeter Full Scale = 10 x FLA
      [2] Interface-CT accuracy included

Environment:
    Operating Temperature............... -40°C to 60°C
    Storage Temperature .... -55°C to 80°C

Terminal Block Ratings:
    MPU-16A .... 10 A, 300 Vac, No. 14 AWG
    ICT-2, CT Inputs .... 25 A, 500 Vac, No. 10 AWG

Certification .... CSA NRTL/C
                                                    (Canada & USA)

Compliance:
    Impulse Voltage Withstand to IEC 255-4,
     Appendix E, Class III
    High-Frequency Disturbance to IEC 255-4,
     Appendix E, Class III
    Dielectric to IEC 255-5, Clause 6
    Insulation Resistance to IEC 255-5, Clause 7

Fuse-Selection Chart:

FUSE	HZ	VOLTAGE	RATING	DESCRIPTION
F1, F2	60	120/240	8 A, 250 Vac	¼" x 1 ¼" CSA/UL Normal
	50			IEC 127/I F Quick Acting
F3	60	120	100 mA, 250 Vac	¼" x 1¼" CSA/UL Time Delay
		240	62 mA, 250 Vac	
SW	50	120	160 mA, 250 Vac	IEC 127/III T Time Lag
		240	80 mA, 250 Vac	
F3		12 Vdc	2 A, 250 Vac	¼" x 1 ¼" CSA/UL Time Delay
D1				5 x 20 mm IEC 127/III TD
F3		24 Vdc	1 A, 250 Vac	¼" x 1 ¼" CSA/UL Time Delay
D2				5 x 20 mm IEC 127/III TD
F3		48 Vdc	0.5 A 250 Vac	¼" x 1 ¼" CSA/UL Time Delay
D4				5 x 20 mm IEC 127/III TD

All specifications are subject to change without notice.

MPU-16A MANUAL COMPATIBILITY

Startco Engineering Ltd. constantly strives to improve its products. These product improvements are upwardly compatible so that a unit can be replaced by a unit of more recent manufacture. As features or enhancements are incorporated, the manual is revised to reflect the changes made. It is important that the manual revision corresponds to both the MPU-16A revision level and the firmware revision level. Consult Table 5 to determine the correct manual for a particular MPU-16A.

MANUAL REVISION LEVELS

REVISION LEVELS					COMMENTS
MPU-16A		FIRMWARE		MANUAL	
60 Hz	50 Hz	60 Hz	50 Hz		
0	50	0	50	0, 1	Initial release.
1	51	1	51	1	Decimal-point driver revised.
2	52	2	52	2, 3	Range change, Modes 6 & F.
3	53	3	53	3	EFCT-1 trip range increased.
4	54	4	54	4, 5	Emergency thermal reset revised.
5	55	5	55	5	Phase-reverse delay changed.
6	56	6	56	6,7	EF-CT ratio selection, non-fail-safe relay selection, display and input operations released.
7	57	6	56	7	Processor module revision. Manual sections 1 through 4 rewritten.
8	58	8	58	8	Mode-F set point firmware revision.
9	59	100	150	9	ICT-2 released, processor module revised, and manual rewritten.
10	60	101	151	10	RS-485 program option change.
10	60	101	151	10A	Minor manual changes.
11	61	102	152	11	Phase sequence firmware revision.
11	61	102	152	12	Manual changes, EFCT-2 added.
13	63	104	154	13	Manual changes, dc power supply added.

TABLE 5

The MPU-16A revision level is shown on its nameplate and the firmware revision level is accessed by selecting Mode 6 and pressing ENTER. The manual revision level is listed on the manual title page.

WARRANTY

The Startco Engineering MPU-16A motor protection unit is warranted to be free from defects in material and workmanship for a period of 12 months from installation, or 18 months from date of invoice, whichever comes first. Startco Engineering Ltd. will (at Startco's option) repair, replace, or refund the original purchase price of a unit which is determined by Startco to be defective if it is returned to Startco, prepaid, within the warranty period. This warranty does not apply to any motor protection unit which has been subjected to misuse, negligence, or accident, or has been misapplied, modified, or improperly installed.

The foregoing provisions are the sole obligation of Startco Engineering Ltd. and exclude all other warranties or guarantees. No warranty or representation is to be taken to have been given or implied from anything said or written in the negotiations between the customer and Startco Engineering Ltd., or their respective representatives, prior to the granting of this warranty, and any statutory or other warranty or condition, expressed or implied, as to the state, quality, or fitness of the goods subject to this warranty is hereby expressly excluded. No agent, distributor, or employee is authorized to extend or enlarge upon this warranty by any verbal or written statement or advertisement.

Under no circumstances shall Startco Engineering Ltd. be liable to the customer or to any person for injury to person, or damage to or loss of property or value caused by unit malfunction, misapplication, modification, or adjustment. Under no circumstances shall Startco Engineering Ltd. be liable for any incidental, consequential, or special damages, losses or expenses in connection with the use of, or inability to use the product for any purpose whatsoever. Disclaimers apply both during and after the term of this warranty.

- -

MPU-16A WARRANTY REGISTRATION

Completed warranty registration must be returned within 30 days of purchase.

MODEL NO. MPU-16A _____   SERIAL NO._____

PURCHASED FROM _____

PURCHASE DATE _____   INSTALLATION DATE _____

PURCHASED BY _____

ADDRESS _____

CITY _____   PROV. OR STATE _____

POSTAL OR ZIP CODE _____   SIGNATURE _____

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