GE Industrial Systems

FM2

Feeder Manager 2

INSTRUCTION MANUAL

Firmware Revision: 1.1x
Software Revision: 1.0x

Manual P/N: 1601-0154-A2
Manual Order Code: GEK-106559A

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1 Introduction

Overview

Description

The FM2 combines control functions normally found in a low voltage power control center (PCC) with feeder protection. This compact, microprocessor-based device provides sophisticated control and protective relaying at significant cost savings over a PCC design using discrete devices.

Standard features in every FM2 simplify maintenance and plant expansion. One FM2 is required for every contactor/breaker unit in the PCC. The contactor can be energised and de-energised using the FM2's direct-wired inputs, or via the serial port.

Feeder protection is included for the basic causes of failure to prevent costly shutdowns. These include 3 phase thermal overload and earth fault protection.

A two wire RS485 Modbus protocol communications port is provided for high-speed communications with a complete line-up of PCCs. Any FM2 may be interrogated on demand, to determine both Actual and Setpoint operating parameters. Fast response time to a request for alarm or trip status makes real time control of a complete process possible. Statistical recording of running hours and number of contactor operations and trips assists with predictive maintenance scheduling.

Features

The FM2 has been developed with economy in mind. The customer is able to choose from different options to achieve maximum benefit from the relay when integrated into the process environment.

The basic FM2 comes with 3 phase thermal overload protection (49/51), earth fault protection (50G), six control inputs (Close A, Close B, Open, Test Mode, Contactor A status, and Contactor B status), 10 programmable inputs, two fixed outputs (relay A and relay B), and one programmable output relay. The following additional features are available:

- 20 × 2 alphanumeric display (Option PD)
- 1 additional electromechanical relay: ESD Relay
- programmable undervoltage reclose of feeders following an undervoltage condition
- diagnostics which includes pretrip data and historical statistics
- single phase voltage input which allows the FM2 to calculate and display kW and kWh

Ordering

Order Codes

TABLE 1–1: Selection Guide

	FM2	*	*	
Base Unit	FM2	|	|	Product Family
Model		712	|	120 V AC VT and switch input voltage
		722	|	240 V AC VT and switch input voltage
Mounting			PD	Panel mount with display
			C	Chassis mount (black box)

NOTE

All models contain three phase thermal overload protection (49/51), earth fault protection (50G), undervoltage reclose, current, voltage, power and energy metering, timers and counters, 6 control inputs (Close A, Close B, Open, Test Mode, Contactor A status, Contactor B Status), plus 10 programmable inputs, two output relays, one programmable relay, and ESD (emergency shutdown) relay. The relay unit can be powered up by 120/240 V AC, 50 or 60 Hz. The selection of control voltage shall be made by shifting the slide switch on back of the relay to the desired voltage.

MODEL:

- **712:** VT input and switch inputs are rated for 120 V AC, 50 or 60 Hz.
- **722:** VT input and switch inputs are rated for 240 V AC, 50 or 60 Hz.

MOUNTING:

- **Chassis mount:** “Black box” version of the FM2 mounted inside the PCC panel.
- **Panel mount and display:** Mounted on a panel with a 20 × 2 display, LEDs, and keypad.

Accessories

- **EnerVista FM2 setup software:** No-charge software package to aid in setting up FM2 operating parameters.
- **RS232/485:** RS232 to RS485 converter box designed for harsh industrial environments.
- **5 A Phase CT:** 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750, and 1000.
- **1 A Phase CT:** 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750, and 1000.
- **50:0.025 Earth Fault CT:** For sensitive earth fault detection on high resistance earthing systems.
- **Collar:** For reduced depth mounting.
- **Open key cover:** To prevent accidental pressing of the OPEN key.
- **Control key cover:** Full cover on control keys

Special Order

- **Mod 610:** provides protection in harsh environments

Specifications

FM2 Specifications

Design and specifications are subject to change without notice.

PHASE CURRENT INPUTS

Conversion: true RMS, sampling time of 12 samples/cycle for 50 Hz and 10 samples/cycle for 60 Hz

Range: 0.1 to 8 × **PHASE CT PRIMARY AMPS** setpoint

Full scale: 8 × **PHASE CT PRIMARY AMPS** setpoint

Accuracy: ±2% of **PHASE CT PRIMARY AMPS** setpoint or ±2% of reading, whichever is greater

EARTH FAULT CURRENT INPUT

Conversion: true RMS, sampling time of 12 samples/cycle for 50 Hz and 10 samples/cycle for 60 Hz

Range: 0.1 to 1.0 × **PHASE CT PRIMARY AMPS** setpoint (for 5 A secondary CT)
0.5 to 15.0 A (for 50:0.025 CT)

Full scale: 1.5 × **PHASE CT PRIMARY AMPS** (for 5 A secondary CT)
15 A (for 50:0.025 CT)

Accuracy:
5 A CT: ±2% of full scale
50:0.025 CT: ±0.10 A (0.0 to 3.99 A)
±0.20 A (4.00 to 15.00 A)

VOLTAGE INPUT / POWER READING

Conversion: true RMS, sampling time of 12 samples/cycle for 50 Hz and 10 samples/cycle for 60 Hz

Voltage full scale: 1.5 × VT Primary

Voltage accuracy: ±2% of VT Primary or ±2% of reading, whichever is greater

Power accuracy: ±5% of nominal or ±5% of reading, whichever is greater

Range: –12500 to 12500 kW

Nominal input voltage: 120 V AC or 240 V AC

Maximum input voltage:
150 V AC for FM-712-*-*
300 V AC for FM-722-*-*

VT burden: 0.01 VA

OVERLOAD CURVES

Trip time accuracy:
±200 ms up to 10 seconds
±2% of trip time over 10 seconds

Detection level: ±1% of primary CT amps

EARTH FAULT TRIP TIME

Accuracy: –0 ms / +50 ms,
0.0 = less than 50 ms

CURRENT IMBALANCE

Calculation Method:

if $I_{AV} \geq I_{FLC}$: Imbalance $= \frac{|I_M - I_{AV}|}{I_{AV}} \times 100\%$

if $I_{AV} < I_{FLC}$: Imbalance $= \frac{|I_M - I_{AV}|}{I_{FLC}} \times 100\%$

where: I_{AV} = average phase current
I_M = current in a phase with maximum deviation from I_{AV}
I_{FLC} = **FEEDER RATING** setpoint

COMMUNICATIONS

Type: RS485 2 wire, half duplex

Baud rate: 1200 to 19200 baud

Protocol: Modbus RTU

Functions: Read/write setpoints, Read coil status, Read actual values, Read device status, Execute commands, Loopback Test

DIGITAL INPUTS

Inputs: 6 fixed and 10 configurable inputs, optically isolated

Input type: dry contact

RELAY A & B AND ESD RELAY CONTACTS

Break:

VOLTAGE		BREAK
Resistive	30 V DC	10 A
	125 V DC	0.5 A
	250 V DC	0.3 A
Inductive (L/R = 7 ms)	30 V DC	5 A
	125 V DC	0.25 A
	250 V DC	0.15 A
Resistive	120 V AC	10 A
	240 V AC	
Inductive (PF = 0.4)	120 V AC	10 A
	225 V AC	8 A

Make/carry: 10 A continuous
30 A for 0.2 seconds

Configuration: Relay A and B: Form-A
ESD Relay: Form-C

Contact material: silver alloy (AgCdO)

Max. operating voltage: 280 V AC, 250 V DC

Maximum permissible load: 5 V DC, 100 mA

PROGRAMMABLE RELAY OUTPUT CONTACTS

Break:

VOLTAGE		BREAK
Resistive	30 V DC	5 A
	125 V DC	0.25 A
Inductive (L/R = 7 ms)	30 V DC	2.5 A
	125 V DC	0.1 A
Resistive	120 V AC	5 A
	240 V AC	
Inductive (PF = 0.4)	120 V AC	5 A
	225 V AC	3 A

Make/carry: 5 A continuous
15 A for 0.2 seconds

Configuration: dual Form C

Contact material: silver alloy (AgCdO)

Max. operating voltage: 280 V AC, 125 V DC

UNDERVOLTAGE/SUPPLY VOLTAGE

Undervoltage: 65% of nominal (120 V AC or 240 V AC)

Reclose: immediate reclose for maximum dip time of 0.1 to 0.5 seconds or OFF;

Delay 1 Reclose: delayed reclose for maximum dip time of 0.1 to 10.0 seconds or UNLIMITED

Delay 2 Reclose: delayed reclose for maximum dip time of 0.5 to 60.0 minutes or OFF

Delay reclose range: 0.2 to 300 seconds

Delay reclose accuracy: ±0.2 seconds

CT BURDEN

CT INPUT	CURRENT	BURDEN	
		VA	OHMS
1 A Phase CT	1 A	0.009	0.01
	5 A	0.2	
	20 A	3.5	
5 A Phase CT	5 A	0.04	0.002
	25 A	0.9	
	100 A	16	
5 A Earth Fault CT	5 A	0.04	0.002
	25 A	1.1	
	100 A	17	
50:0.025 Earth Fault CT	0.025 A	0.07	116
	0.1 A	1.19	119
	0.5 A	30.5	122

CT WITHSTAND

Phase CTs: 100 × CT for 1 sec.
40 × CT for 5 sec.
3 × CT continuous

Earth Fault CT: 100 × CT for 1 sec.
40 × CT for 5 sec.
3 × CT continuous

50:0.025A CT: 150 mA continuous
12 A for 3 cycles maximum

SUPPLY VOLTAGE

AC nominal: 120 V AC, range 108 to 135 V AC; 240 V AC, range 216 to 250 V AC

Frequency: 50/60 Hz

Power consumption: 25 VA (maximum)
7 VA (nominal)

TYPE TESTS

Transients: ANSI/IEEE C37.90.1 Oscillatory/Fast Risetime Transients; IEC 255-22-4 Electrical Fast Transient/Burst Requirements

Impulse: IEC 255-5 5 kV Impulse Voltage Test

RFI: IEC 255-22-3, 5 V/m with portable transmitter

Static: IEC 255-22-2 Electrostatic Discharge

Hi-Pot: 1500 V, 1 minute; all inputs > 30 V

ENVIRONMENT/GENERAL INFORMATION

Pollution degree: 2

Overvoltage category: 2

Insulation voltage: 300 V

Operating temperature range: 0°C to 60°C

Dust and moisture rating:
NEMA Type 12 and 12K

IP class: IEC 529 - IP30

PHYSICAL

Max. weight: 4 lbs. (1.8 kg)

Shipping box: 8.30" (211 mm) × 5.625" (143 mm) × 5.80" (147 mm)

FUSE

Type: 0.5 A; 250 V Fast Blow, High breaking capacity

INSTALLATION

Warning: HAZARD may result if the product is not used for its intended purpose

Ventilation requirements: None

Cleaning requirements: None

CERTIFICATION/COMPLIANCE

CE: IEC 61010-1

cULus: E83849 UL listed for the USA and Canada

NOTE **It is recommended that all FM2 relays are powered up at least once per year to avoid deterioration of electrolytic capacitors in the power supply.**

2 Installation

Mounting

Description

Cut the panel as shown below to mount the FM2. Use either #8-32 or #6 × ½" mounting screws provided to mount the FM2 to the panel.

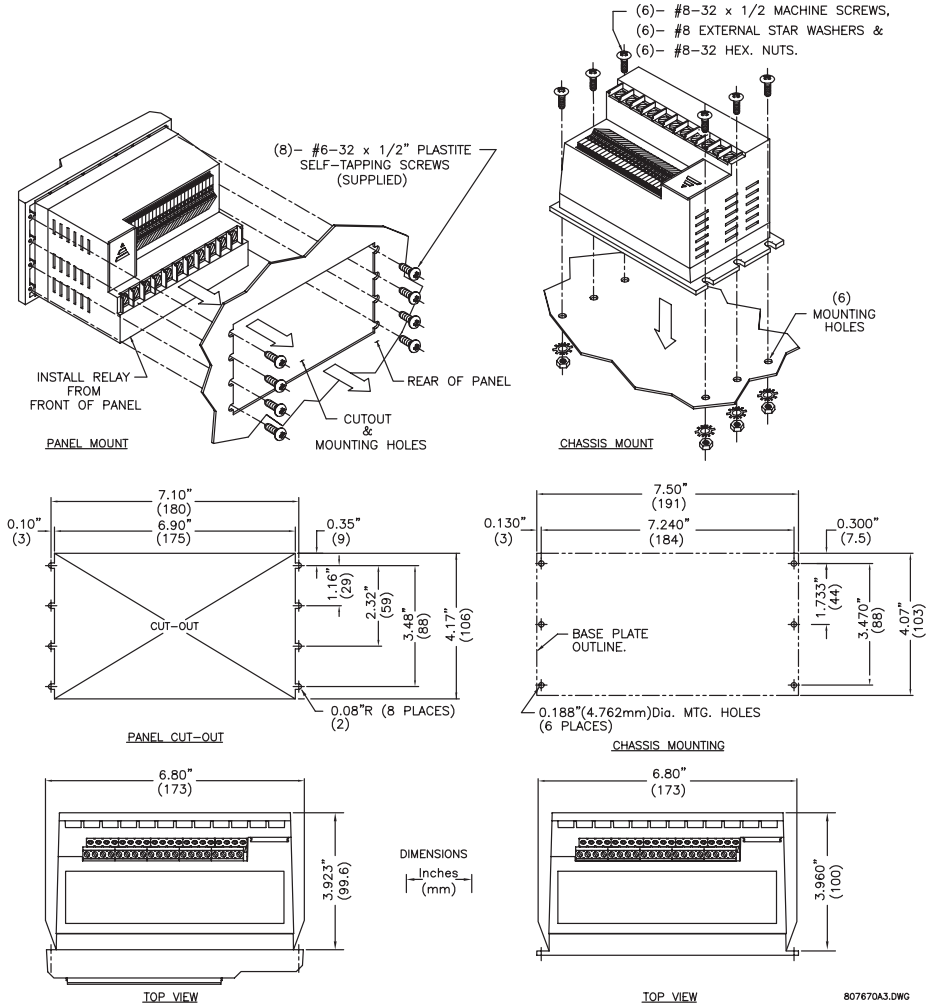


FIGURE 2–1: FM2 Mounting Instructions

The dimensions for the standard FM2 and the FM2 with reduced mounting collar are shown below:

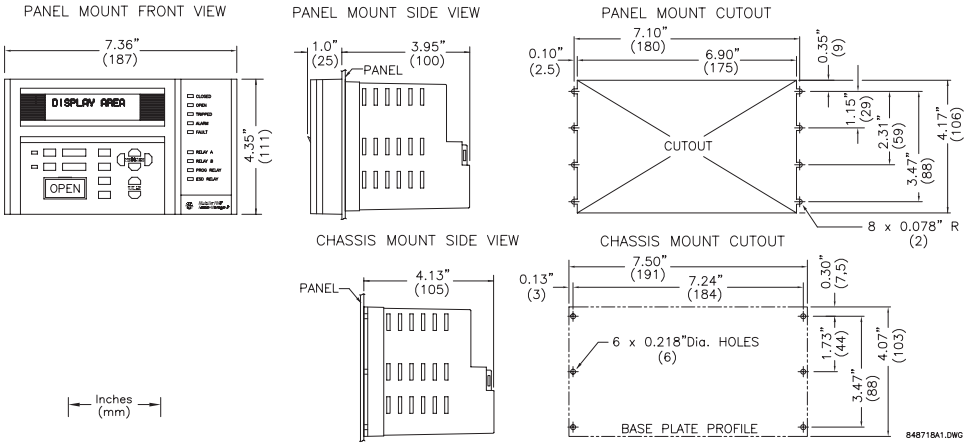


FIGURE 2–2: FM2 Dimensions

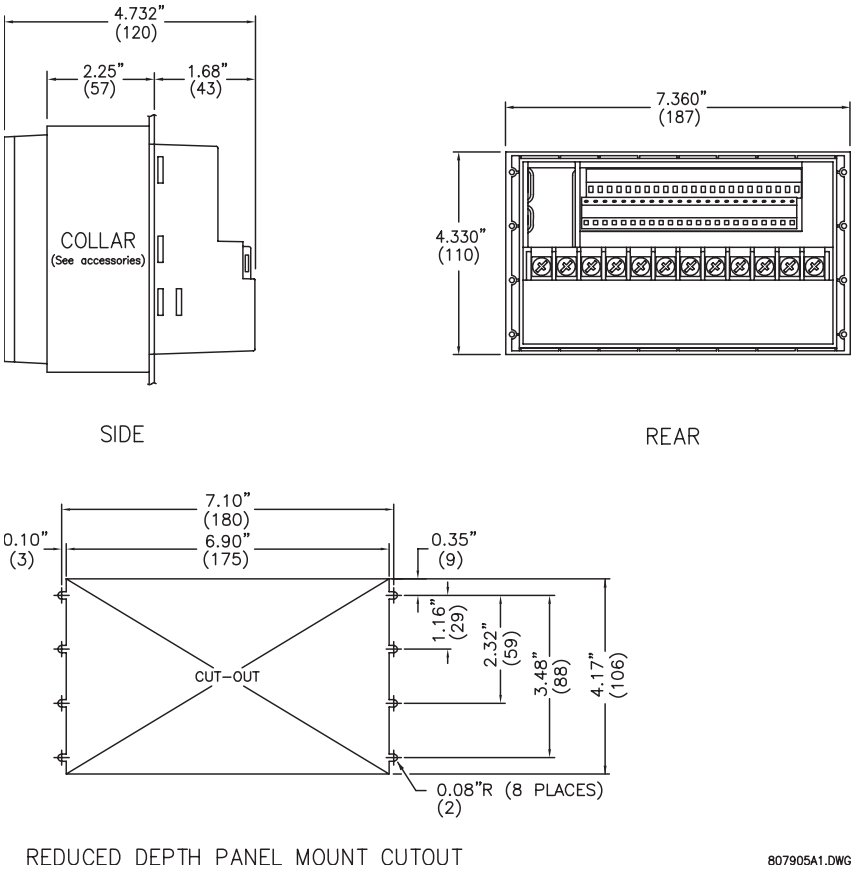
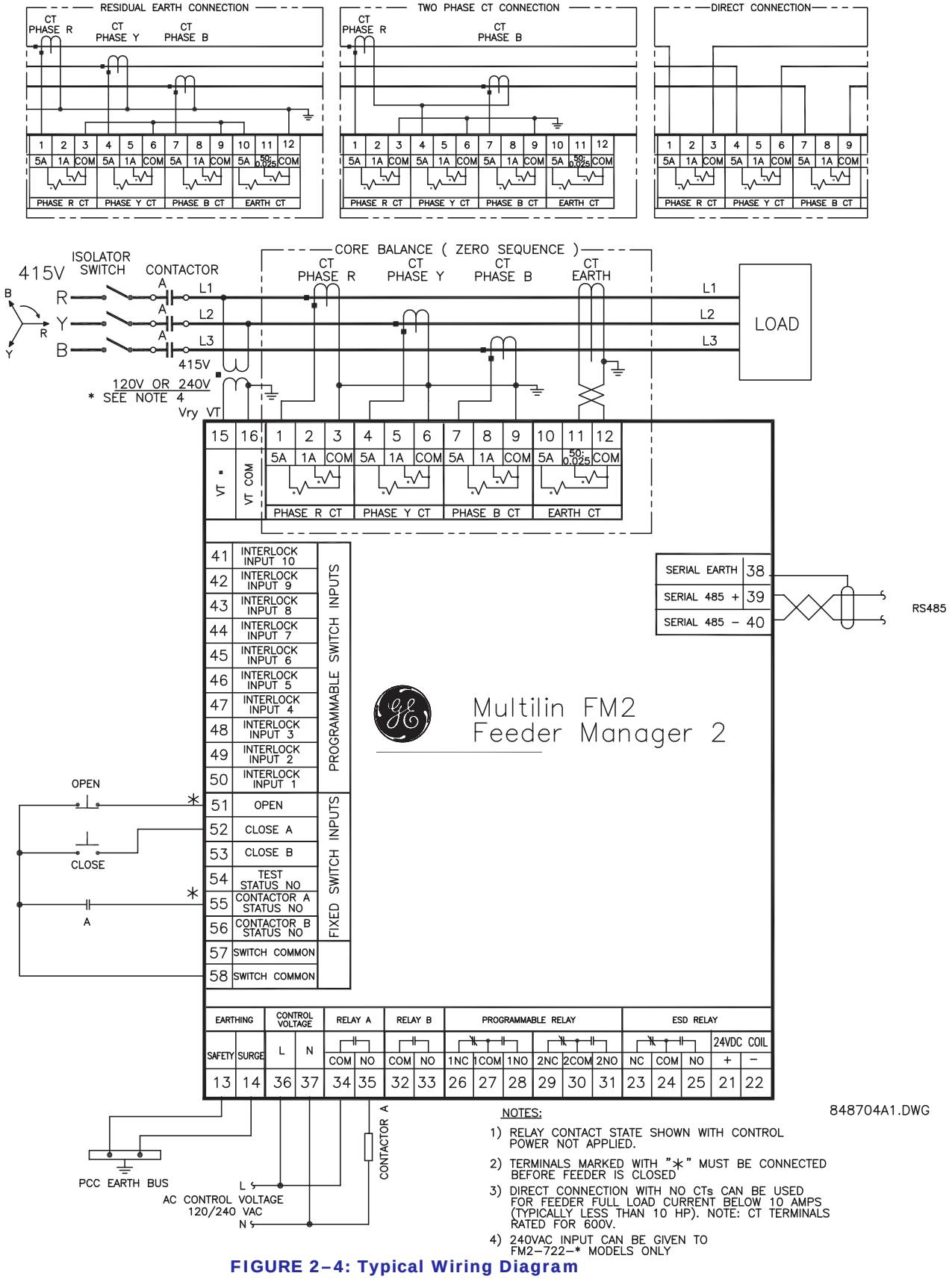


FIGURE 2–3: FM2 with Depth Reduction Collar Dimensions



NOTES:

1) RELAY CONTACT STATE SHOWN WITH CONTROL POWER NOT APPLIED.
2) TERMINALS MARKED WITH "*" MUST BE CONNECTED BEFORE FEEDER IS CLOSED
3) DIRECT CONNECTION WITH NO CTs CAN BE USED FOR FEEDER FULL LOAD CURRENT BELOW 10 AMPS (TYPICALLY LESS THAN 10 HP). NOTE: CT TERMINALS RATED FOR 600V.
4) 240VAC INPUT CAN BE GIVEN TO FM2–722–* MODELS ONLY

FIGURE 2–4: Typical Wiring Diagram

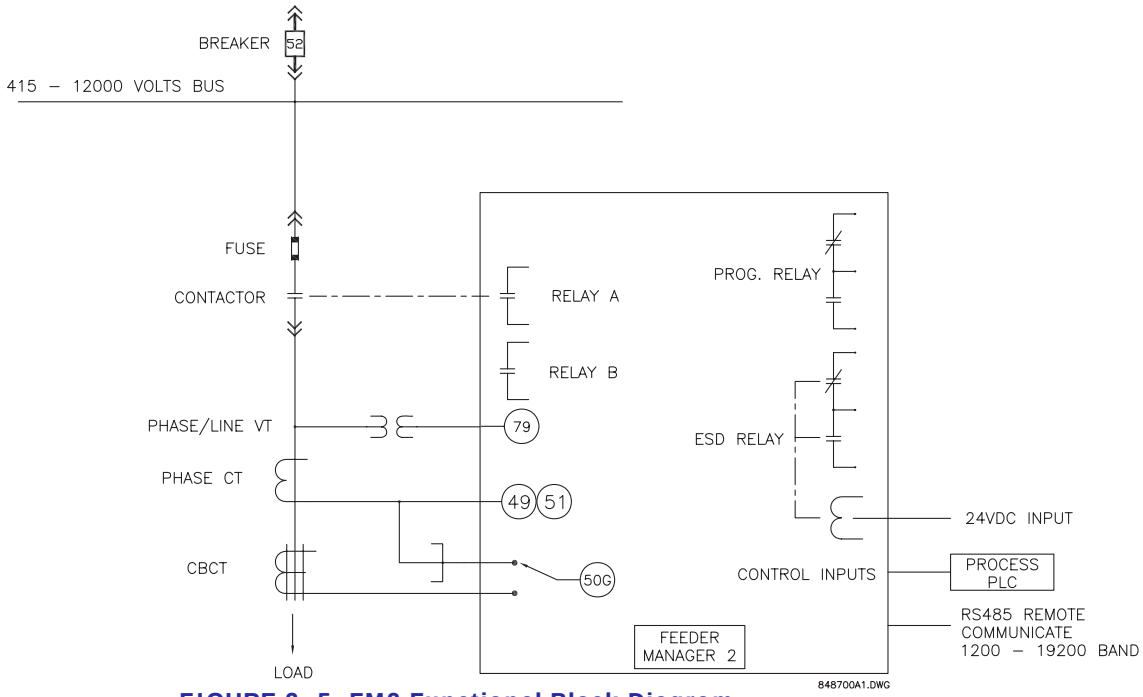


FIGURE 2–5: FM2 Functional Block Diagram

Inputs and Outputs

Phase CT Inputs

Both 5 A and 1 A current transformer secondaries are accommodated by the FM2. Each phase current input to the FM2 has 3 terminals: 5 A input, 1 A input, and the common input. For example, if the phase CTs are 200:5, connect phase R, Y, and B CT secondaries to terminals 1/3, 4/6, and 7/9, respectively. For load currents up to 10 A, the phase conductors can be directly connected to the FM2 with no phase CTs required providing that the voltage at the CT terminals does not exceed 600 V RMS.

CTs should be selected to be capable of supplying the required current to the total secondary load which includes the FM2 relay burden of 0.1 VA at rated secondary current and the connection wiring burden. The CT must not saturate under maximum current conditions which can be up to 8 times for a motor feeder (i.e. motor starting current can be 8 times motor full-load current).

Earth Fault CT Input

The earth fault CT has a 5 A input, a 50:0.025 input, and a common input. The 5 A input on the earth fault CT is used for 5 A secondary CTs or for residual connection of phase CTs. Residual earth fault protection provides a sensitivity of 10% of feeder Phase CT Primary. The 50:0.025 core balance (zero-sequence) CT input can be used for improved sensitivity when measuring the earth fault current.

NOTE

Care must be taken when turning ON the Earth Fault Trip feature. If the interrupting device (contactor or circuit breaker) is not rated to break earth fault current (low resistance or solidly earthed systems), the feature should be disabled. The 50:0.025 CT input is only recommended to be used on resistance earthed systems. Where the system is solidly earthed or high levels of current are to be detected use the 5 A earth fault input.

Supply Voltage

A supply voltage of 120/240 V AC, 50 or 60 Hz, is required to power the FM2. The label on the back of the unit will specify the voltage which has been internally set inside the FM2. To change the voltage setting, open the sliding door on the back of

the FM2 and locate the supply voltage selector slide switch. The selector slide switch has a label affixed to show the 120/240 V AC positions. Set the slide switch to the desired voltage.

Set the supply voltage slide switch to the desired voltage position before the unit is powered up. Improper setting could cause non-functioning or damage to the relay.

Surge Earthing

This is an additional earthing terminal provided for dissipating transient signals and surges. This must be connected by a thick wire or braid to the system earthing for reliable operation.

External Connections

Signal wiring is to box terminals that can accommodate wire as large as 12 gauge. CT connections are made using #8 screw ring terminals that can accept wire as large as 8 gauge. Consult the *Typical Wiring Diagram* on page 2–3. Other features can be wired as required.

ESD Coil

The ESD Relay can be externally energised by applying a 24 V DC signal to these terminals. Correct polarity is required (Terminal 21 = +24 V DC, Terminal 22 = 0 V DC). The ESD Relay is not directly operated by the FM2 via the front panel, PC software, or any logic.

Output Relays

There are up to 4 output relays on the FM2. Contact switching rating for the output relays as well can be found in *Specifications* on page 1–3.

- Relay A (34/35)
- Relay B (32/33)
- Programmable Relay (26/27/28, 29/30/31): field programmable
- ESD Relay (23/24/25): hard-wired 24 V DC coil

Switch Inputs

All switch inputs are opto-isolated and operate at a voltage of 120 V AC for 712 models and 240 V AC for 722 models. The switch will read closed when 120/240 V AC is applied to the switch terminal. This 120 V AC can be supplied from the switch common terminals (57, 58) or from an external source providing that the source is in phase with the supply voltage of the FM2.

SWITCH INPUT COMMON TERMINALS 57 AND 58 ARE LIVE 120 V AC.

Programmable Switch Inputs

These 10 inputs can be programmed to one of a number of different functions. Some of the available functions are: Setpoint Access, Lockout Reset, Plant Interlock, Auto Close, Remote Permissive, and Test. See the **S3 PROCESS ⇨⇩ CONFIGURABLE INPUTS** page for complete list of available functions.

Serial Communication Port

A serial port provides communication capabilities to the FM2. Multiple FM2s can be connected together with a 24 AWG stranded, shielded twisted pair with a characteristic impedance of 120 Ω such as Belden 9841 or equivalent. The total length of communications wiring should not exceed 1500 meters. Care should be used when routing the communications wiring to keep away from high power AC lines and other sources of electrical noise.

Correct polarity is essential for the communications port to operate. Terminal 39 (“+”) of every FM2 in a serial communication link must be connected together. Similarly, Terminal 40 (“–”) of every FM2 must also be connected together. The shield wire must be connected to Terminal 38 (485 SERIAL EARTHING) on every unit in the link to provide a common earthing potential for all units. Each relay should be “daisy chained” to the next one. Avoid star or stub connected configurations if possible to avoid potential communication problems.

A terminating resistor and capacitor network is required to prevent communication errors. Only the last FM2 and the master computer driver should have the terminating network to ensure proper matching. Using terminating resistors and capacitors on all the FM2s would load down the communication network while omitting them at the ends could cause reflections resulting in communication errors.

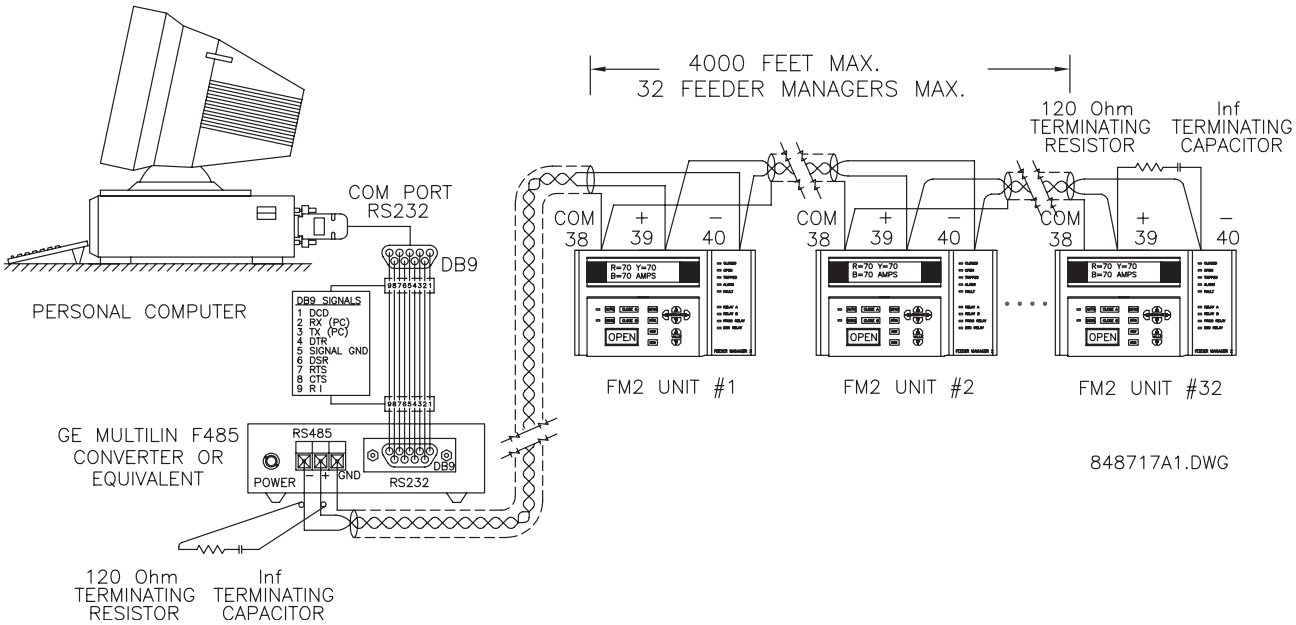


FIGURE 2–6: RS485 Termination

Open

When relay is used for contactor feeder, if this terminal is unhealthy, both output relays will open causing the contactor coils to de-energise. When relay is used for Circuit Breaker applications, if this terminal is de-energised then output relay A will open (if already in closed state) and output relay B will close. The Open input must be energised before the FM2 will process any close commands. Refer to Chapter 9: *Feeder Types* for additional details.

Close A/B

When relay is used for contactor feeder, either of the relays can be used for the feeder circuit. When the close input terminal is energised, the corresponding output relay will be energised. If relay is used for Circuit Breaker feeder, close B input is ignored and it doesn't perform any operation. Close inputs are usually momentary unless two-wire control is selected. Close A and B may also be initiated via the serial link. Refer to Chapter 9: *Feeder Types* for additional details.

Test Status N/O

This contact is used when control tests on the contactor/breaker are being performed. When the test switch input is healthy, the statistical counters are not incremented for any contactor/breaker operations.

Contactor Status

The FM2 **must** know the state of the contactor/breaker at all times in order to detect discrepancies in contactor/breaker close/open commands and also to display the state of the contactor/breaker. There are two contactor status inputs on the FM2, one for contactor A, the other for contactor B.

Auxiliary contacts mechanically linked to the contactor/breaker itself are used to feedback to the contactor status inputs. No status change following a “close” command indicates an open contactor control circuit and no status change following “open” command indicates a welded contactor. Appropriate messages and alarms are displayed for these conditions and the status can be read via the serial port.

If the feeder contactor is externally energised, the FM2 will seal in the output relay and display an “EXTERNAL CLOSE” message. If the feeder contactor is externally de-energised, the FM2 will drop out the output relay and display an “EXTERNAL OPEN” message. Refer to *Circuit Breaker Feeder* on page 9–4 for additional details.

Switch Common

These two terminals serve as the common for all switches. The FM2 switch inputs operate at 120 VAC which is supplied from these terminals (for the FM2-722 models, external 240 V is required to energise the switch inputs).

Dielectric Strength Testing

It may be required to test a complete PCC with FM2s installed for dielectric strength. This is also known as “flash” or “hi-pot” testing. The FM2 is rated for 1500 V AC for 1 minute or 1800 V AC for 1 second isolation between switch inputs, relay outputs, VT voltage input, supply voltage inputs and earth terminal 13.

When performing dielectric tests, the connection to the surge earthing terminal (14) must be removed. A filter network is used on the AC input to filter out RF and EMI noise. The filter capacitors and transient absorbers could be damaged by the high voltages relative to earth surge on the AC input.

Under no circumstances should any inputs other than switches, relays, supply voltage, VT input, and CT inputs be dielectric tested.

3 Hardware

Faceplate Functions

Description

Once the FM2 has been wired and powered on, it is ready to be programmed for a specific application. Local programming is done using the front panel keypad and the 40 character alphanumeric display. Remote programming via the serial port is also possible using the EnerVista FM2 setup software.

Message Display

A 40-character display is used to communicate all information about the system to the user. Trip and alarm messages will automatically override the currently-displayed message. If no key is pressed for 2 minutes, a user-selected default message will be displayed. If the feeder is currently open, the Feeder Status message will be the default message. Once the feeder is closed, the user-selected message will appear.

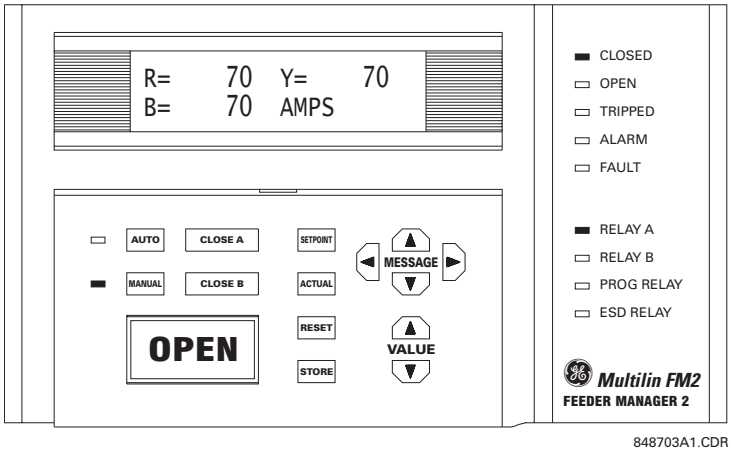


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FIGURE 3–1: Front Panel

Indicator LEDs

- **CLOSED**: The CLOSED indicator will be on when the following occurs:
  - For a contactor feeder: whenever the output relays A or B are closed and the contactor status inputs acknowledge the correct state.
  - For a circuit breaker feeder: whenever output relay A is closed and the contactor A status input acknowledges the correct state.

  Current flow does not affect the indicator for feeder status, only contactor status is monitored for the feeder status.

- **OPEN**: The OPEN indicator will be ON when the following occurs:
  - For a contactor feeder: if both the Contactor Status A and Contactor Status B inputs are unhealthy.
  - For a circuit breaker feeder: if the Contactor Status A input is unhealthy
- **TRIPPED**: If a trip condition causes the output relays to de-energise, this indicator will glow. As long as this indicator is on, the feeder cannot be closed. It is cleared using the reset key, lockout reset facility or serial port reset, dependent on the type of trip.
- **ALARM**: If an alarm condition is present this indicator will be ON. Use the **A2 ALARM DATA** actual values to view current alarm status.
- **FAULT**: If an internal fault within the FM2 is detected by self-checking, this indicator will be on. The FM2 must be replaced or repaired.
- **RELAY A**: If Output Relay A is energised, this indicator will be ON.
- **RELAY B**: If Output Relay B is energised, this indicator will be ON.
- **PROG RELAY**: If the Programmable Relay is ON, this indicator will be ON.
- **ESD RELAY**: If the ESD Relay is ON, this indicator will be ON.
- **AUTO**: If the FM2 is in Auto control mode or the Hard-Wired Auto mode, this indicator will be ON. In Auto mode the Close A / Close B switch inputs and CLOSE A/B keys are non-operational but serial port close commands are operational. In the Hard-wired Auto Mode, the Auto Close A and Auto Close B switch inputs are functional in conjunction with the Auto Permissive switch input. Serial, faceplate and remote closes are disabled. OPEN commands from any location are always operational.
- **MANUAL**: If the FM2 is in Manual control mode, this indicator will be on. In Manual mode the Close A / Close B switch inputs and CLOSE A / CLOSE B keys are operational but serial port close commands are ignored. All open commands are operational.

Keypad

Setpoints Key

The SETPOINT key allows the user to examine and alter all trip, alarm, and other FM2 setpoints. There are 6 pages of setpoints: configuration, protection, process, control, monitoring, and factory data.

This key displays the beginning of the next page of setpoints data. If actual values data is displayed while pressing the SETPOINT key, setpoints page S1 will appear:

```
■ SETPOINTS
■ S1 CONFIGURATION
```

This key can be pressed at any time to view FM2 setpoints. To scroll through the setpoint pages, press the SETPOINT key. To go from section to section within a page, press the MESSAGE UP / DOWN keys. To go from line to line within a section, press the MESSAGE LEFT / RIGHT keys.

To alter a setpoint, the VALUE UP / DOWN keys can be used. All setpoints can be incremented or decremented to pre-determined limits. When the desired value is reached, the STORE key must be used to save the new setpoint. If an altered setpoint is not stored, the previous value will still be in effect. All control and protection features continue to operate while setpoints data is displayed.

Actual Values Key

The ACTUAL key allows the user to examine all of the actual feeder operating parameters. There are 4 pages of actual values data: data, status, inputs, and statistics.

This key displays the beginning of the next page of actual values. If setpoints data is displayed while pressing the ACTUAL key, page A1 of actual values will be shown:

```
■ ACTUAL VALUES
■ A1 DATA
```

This key can be pressed at any time to view FM2 actual values. To scroll through the actual values pages, press the ACTUAL key. To go from section to section within a page, press the MESSAGE UP / DOWN keys. To go from line to line within a section, press the MESSAGE LEFT / RIGHT keys.

The VALUE UP / DOWN keys have no effect when actual values data is displayed.

Store Key

The STORE key allows the user to store new setpoints into the FM2 internal memory.

When this key is pressed the currently displayed setpoint will be stored in non-volatile memory and will immediately come into effect. When a Setpoint is stored, the following flash message will appear on the display:

```
NEW SETPOINT
STORED
```

The STORE key can be used only in setpoints mode to store new setpoints, or in actual values mode to select a new default message.

Open Key

The OPEN key will allow the user to open the breaker/contactor from the faceplate of the FM2. Pressing this key has the following effects:

- For contactor feeders: output relays A and B will de-energise, therefore dropping out the feeder contactor.
- For circuit breaker feeders: output relay B will energise, therefore tripping the feeder breaker.

The OPEN key is used to open the feeder circuit.

Reset Key

The RESET key allows the user to reset FM2 trips. Pressing this key will reset a tripped state on the FM2. A message indicating that a reset is not possible will be displayed if the condition causing the trip is still present.

The RESET key can be used to reset all trip conditions from the faceplate of the FM2, except for earth faults or thermal overloads. A Thermal Overload Trip can be assigned to the Lockout Reset feature on one of the programmable switch inputs for added safety. The factory default does not allow for the resetting of lockout trips using the front panel reset key.

Close A Key

The CLOSE A key can be used to close the feeder contactor/breaker. Pressing this key will cause Relay A to close.

The CLOSE A key is used to close the feeder/contactor from the faceplate of the FM2. Close A can also be initiated from the close switch inputs at the back of the FM2 or from the serial port.

Close B Key

The CLOSE B key can be used to close Relay B. For a contactor feeder, pressing this key will cause Relay B to close.

The CLOSE B key is used if Relay B is used to control the feeder contactor. It is used to close the feeder contactor from the faceplate of the FM2. Close B can also be initiated from the close switch input at the back of the FM2 or from the serial port.

Message Up/Down Keys

The MESSAGE UP / DOWN keys allow the user to move to the next or previous section of the currently selected page.

Pressing the MESSAGE DOWN key will cause the display to move to the next section of the current page. Pressing the MESSAGE UP key will cause the display to move to the previous section of the current page. Note: If either key is held for more than 1 sec-

ond, the next or previous sections will be selected at a fast rate. When the current display is at a page heading, the MESSAGE UP key has no effect. When the current display is at the end of the page, the MESSAGE DOWN key has no effect.

These keys are used to move through the sections of the currently selected page.

Message Left/Right Keys

The MESSAGE LEFT / RIGHT keys allow the user to scan the next or previous line of the currently selected section.

Pressing the MESSAGE RIGHT key displays the next line of the current section. Pressing the MESSAGE LEFT key displays the previous line of the current section. If either key is held for more than 1 second, the next or previous line will be selected at a faster rate. If the display shows a section heading, the MESSAGE LEFT key has no effect. If the message right key has no effect, the display is showing the last line of a section.

These keys are used to move through the lines of the currently selected section.

Value Up/Down Keys

The VALUE UP / DOWN keys allow the user to change setpoint values prior to pressing the STORE key.

Pressing the VALUE UP key will increment the currently displayed setpoint value. Pressing the VALUE DOWN key will decrement the currently displayed setpoint value. If the display shows an actual value, these keys will have no effect

These keys can be used any time to change the value of setpoint messages.

Auto/Manual Keys

The AUTO/MANUAL keys allow the user to toggle between the auto and manual mode of operation.

4 Software

Introduction

Overview

Although setpoints can be manually entered using the front panel keys, it is far more efficient and easier to use a computer to download values through the communications port. The no-charge EnerVista FM2 setup software included with the FM2 makes this a quick and convenient process. With the EnerVista FM2 setup software running on your PC, it is possible to:

- Program and modify setpoints
- Load/save setpoint files from/to disk
- Read actual values and monitor status
- Log data (trending)
- Get help on any topic

The EnerVista FM2 setup software allows immediate access to all the features of the FM2 through pull-down menus in the familiar Windows environment. The software can also run without a FM2 connected. This allows you to edit and save setpoint files for later use. If a FM2 is connected to a serial port on a computer and communication is enabled, the FM2 can be programmed from the setpoint screens. In addition, measured values, status and alarm messages can be displayed with the actual screens.

Hardware

Communications from the EnerVista FM2 setup software to the FM2 can be accomplished two ways: RS485 and Ethernet (requires the MultiNET adapter). The following figure illustrates typical connections for RS485 communications. For details on Ethernet communications, please see the MultiNET manual.

Installing the EnerVista FM2 setup software

The following minimum requirements must be met for the EnerVista FM2 setup software to operate on your computer.

- Microsoft Windows 95 or higher operating system
- 64 MB of RAM (256 MB recommended)
- Minimum of 50 MB hard disk space (200 MB recommended)

After ensuring these minimum requirements, use the following procedure to install the EnerVista FM2 setup software from the enclosed GE EnerVista CD.

1. Insert the GE EnerVista CD into your CD-ROM drive.
2. Click the **Install Now** button and follow the installation instructions to install the no-charge EnerVista software on the local PC.
3. When installation is complete, start the EnerVista Launchpad application.
4. Click the **IED Setup** section of the **Launch Pad** window.

5. In the EnerVista Launch Pad window, click the **Add Product** button and select the "FM2 Feeder Manager 2" from the Add Product window as shown below. Select the "Web" option to ensure the most recent software release, or select "CD" if you do not have a web connection, then click the **Check Now** button to list software items for the FM2.

6. EnerVista Launchpad will obtain the installation program from the Web or CD. Once the download is complete, double-click the installation program to install the EnerVista FM2 setup software.

7. The program will request the user to create a backup 3.5" floppy-disk set. If this is desired, click on the **Start Copying** button; otherwise, click on the **CONTINUE WITH FM2 VERSION 1.00 INSTALLATION** button.
8. Select the complete path, including the new directory name, where the EnerVista FM2 setup software will be installed.
9. Click on **Next** to begin the installation. The files will be installed in the directory indicated and the installation program will automatically create icons and add EnerVista FM2 setup software to the Windows start menu.
10. Click **Finish** to end the installation. The FM2 device will be added to the list of installed IEDs in the EnerVista Launchpad window, as shown below.

Configuring Serial Communications

Description

Before starting, verify that the serial cable is properly connected to the RS485 terminals on the back of the device. See *Hardware* on page 4–1 for connection details.

1. Install and start the latest version of the EnerVista FM2 setup software (available from the GE EnerVista CD). See the previous section for the installation procedure.
2. Click on the **Device Setup** button to open the Device Setup window and click the **Add Site** button to define a new site.
3. Enter the desired site name in the **Site Name** field. If desired, a short description of site can also be entered along with the display order of devices defined for the site. Click the **OK** button when complete.
4. The new site will appear in the upper-left list in the EnerVista FM2 setup software window.
5. Click the **Add Device** button to define the new device.
6. Enter the desired name in the **Device Name** field and a description (optional) of the site.
7. Select “Serial” from the Interface drop-down list. This will display a number of interface parameters that must be entered for proper RS232 functionality.

Enter the relay slave address and COM port values (from the **S1 FM2 CONFIGURATION ⇨⇩ COMMUNICATIONS** setpoints menu) in the Slave Address and COM Port fields.

Enter the physical communications parameters (baud rate and parity settings) in their respective fields.

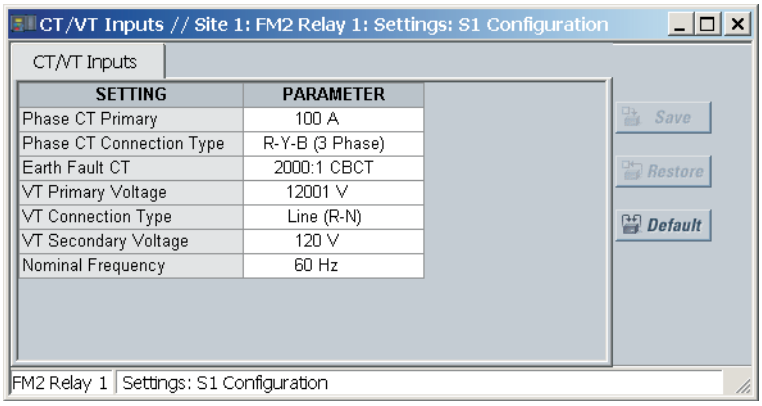
8. Click the **Read Order Code** button to connect to the FM2 device and upload the order code. If an communications error occurs, ensure that the FM2 serial communications values entered in the previous step correspond to the relay setting values.
9. Click **OK** when the relay order code has been received. The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista FM2 setup software window.
10. The FM2 Site Device has now been configured for serial communications.

Using the EnerVista FM2 setup software

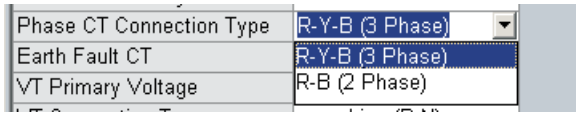
Entering Setpoints

The System Setup page will be used as an example to illustrate the entering of setpoints.

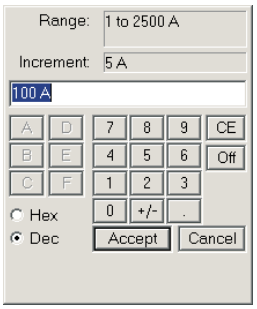
1. Select the **Setpoint > S1 Configuration > CT/VT Inputs** menu item. The following window will appear:



2. When a non-numeric setpoint such as **PHASE CT CONNECTION TYPE** is selected, the EnerVista FM2 setup software displays a drop-down menu:



3. When a numeric setpoint such as **PHASE CT PRIMARY** is selected, EnerVista FM2 setup software displays a keypad that allows the user to enter a value within the setpoint range displayed near the top of the keypad:



Click **Accept** to exit from the keypad and keep the new value. Click on **Cancel** to exit from the keypad and retain the old value.

4. In the Setpoint / System Setup dialog box, click on **Store** to save the values into the FM2. Click **OK** to accept any changes and exit the window. Click **Cancel** to retain previous values and exit.

Saving Setpoints To A File

It is important to save the current FM2 settings to a file on your PC. After the firmware has been upgraded, it may be required to load this file back into the FM2.

1. To save setpoints to a file, select the **File > Read Device Settings** menu item.
2. The EnerVista FM2 setup software will read the device settings and prompt the user to save the setpoints file. Select an appropriate name and location for the setpoint file and click **OK**.
3. The saved file will be added to the "Files" pane of the EnerVista FM2 setup software main window.

Loading Saved Setpoints

1. Select the previously saved setpoints file from the File pane of the EnerVista FM2 setup software main window.
2. Select the setpoint file to be loaded into the FM2 and click **OK**.
3. Select the **File > Edit Settings File Properties** menu item and change the file version of the setpoint file to match the firmware version of the FM2.
4. With the updated setpoint file selected in the File pane, select the **File > Write Settings to Device** menu item and select the target FM2 to receive the previously saved settings file.
5. A dialog box will appear to confirm the request to download setpoints. Click **Yes** to send the setpoints to the FM2 or **No** to end the process.

Viewing Actual Values

If a FM2 is connected to a computer via the serial port, any measured value, status and alarm information can be displayed. Use the Actual pull-down menu to select various measured value screens. Monitored values will be displayed and continuously updated.

Setpoint Files

To print and save all the setpoints to a file follow the steps outlined in *Saving Setpoints To A File* on page 4–5.

To load an existing setpoints file to a FM2 and/or send the setpoints to the FM2 follow the steps outlined in *Loading Saved Setpoints* on page 4–5.

Getting Help

A detailed Help file is included with the EnerVista FM2 setup software.

Select the **Help > Contents** menu item to obtain an explanation of any feature, specifications, setpoint, actual value, etc. Context-sensitive help can also be activated by clicking on the desired function.

For easy reference, any topic can be printed by selecting **File > Print Topic** item from the Help file menu bar.

Trending

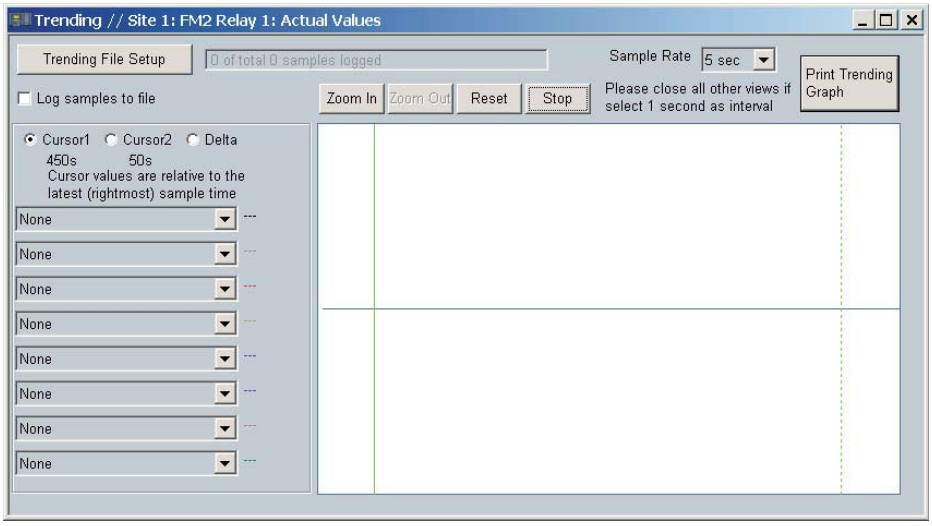
Description

The trending feature is used to sample and record up to eight actual values at an interval defined by the user. Several parameters can be trended and graphed at sampling periods ranging from 1 second up to 1 hour. The parameters which can be trended by the EnerVista FM2 setup software are:

- Phase Currents R, Y, and B, and Earth leakage current
- Imbalance phase current %
- VT Primary Voltage, Power (kW), Energy (kWhr)

The following procedure describes the trending function:

1. With the EnerVista FM2 setup software running and communications established, select the **Actual Values > Trending** menu item to open the trending window. The following window will appear.



2. To prepare for new trending, select **Stop** to stop the trending and **Reset** to clear the screen.
3. Select the graphs to be displayed through the pull-down menu beside each channel description.
4. Select the Sample Rate through the pull-down menu.
5. To save the information captured by trending, check the box beside **Log Samples to File** or click on **Trending File Setup**. The following dialog box will appear requesting for filename and path. The file is saved as a CSV (comma delimited values) file, which can be viewed and manipulated with compatible third-party software. Ensure that the sample rate not less than 5 seconds; otherwise, some data may not get written to the file.
6. To limit the size of the saved file, enter a number in the **Limit File Capacity To** box. The minimum number of samples is 1000. At a sampling rate of 5 seconds (or 1 sample every 5 seconds), the file will contain data collected during the past 5000 seconds. The EnerVista FM2 setup software will automatically estimate the size of the trending file.
7. Press **Run** to start the data logger. If the **Log Samples to File** item is selected, the EnerVista FM2 setup software will begin collecting data at the selected sampling rate and will display it on the screen. The data log will continue until the **Stop** button is pressed or until the selected number of samples is reached, whichever occurs first.

8. During the process of data logging, the trending screen appears as shown below.

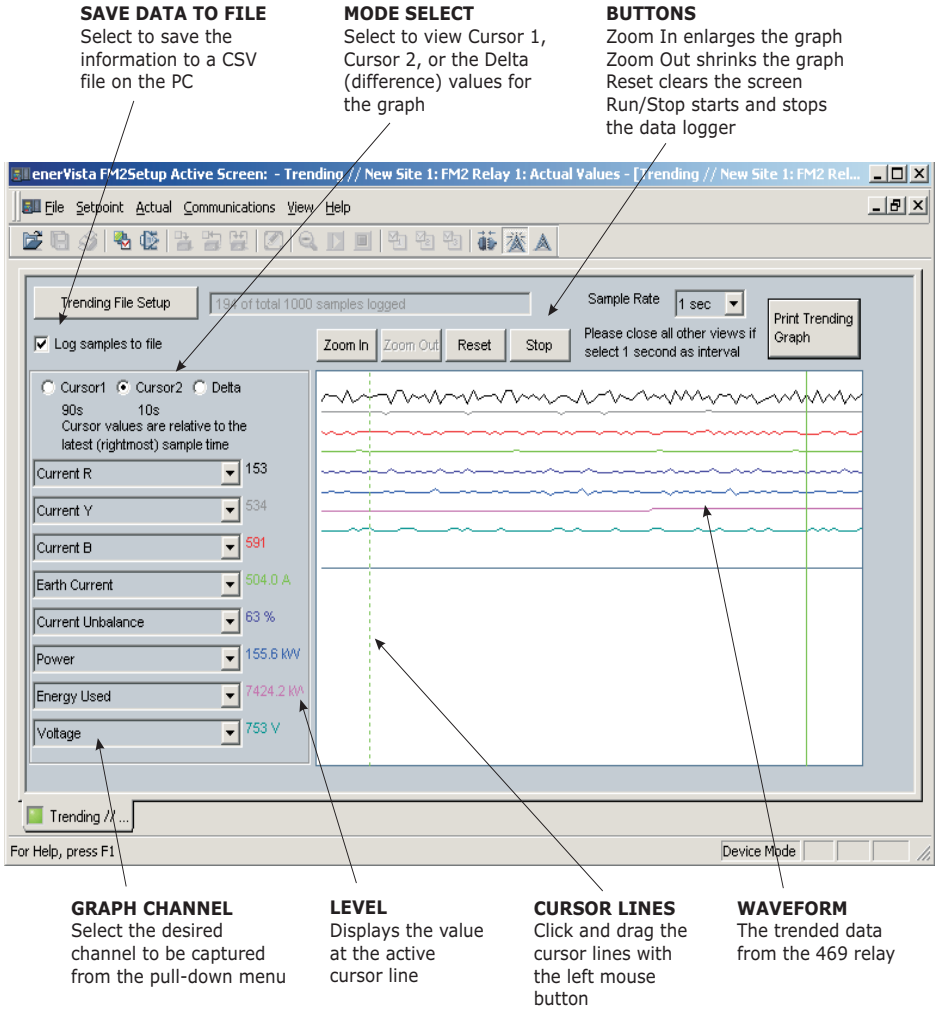


FIGURE 4–1: Trending Details

Upgrading Relay Firmware

Description

To upgrade the FM2 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the FM2 will have new firmware installed with the original setpoints.

The latest firmware files are available from the GE Multilin website at http://www.GEmultilin.com.

Saving Setpoints

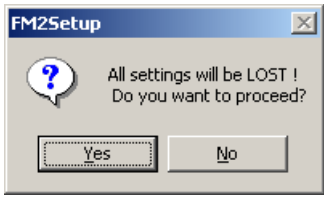
Before upgrading firmware, it is very important to save the current FM2 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the FM2.

Refer to *Saving Setpoints To A File* on page 4–5 for details on saving relay setpoints to a file.

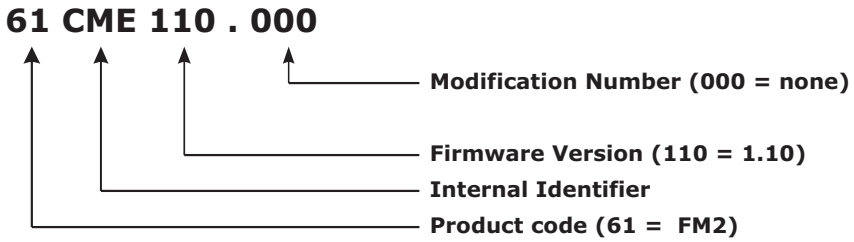
Loading New Firmware

Loading new firmware into the FM2 flash memory is accomplished as follows:

1. Connect the relay to the local PC and save the setpoints to a file as shown in *Saving Setpoints To A File* on page 4–5.
2. Select the **Commands > Update Firmware** menu item.
3. The following warning message will appear. Select **Yes** to proceed or **No** the cancel the process. *Do not proceed unless you have saved the current setpoints*.



4. The EnerVista FM2 setup software software will request the new firmware file. Locate the firmware file to load into the FM2. The firmware filename has the following format:



5. The EnerVista FM2 setup software software automatically lists all filenames beginning with '61'. Select the appropriate file and click **OK** to continue.
6. The software will prompt with another Upload Firmware Warning window. This will be the final chance to cancel the firmware upgrade before the flash memory is erased. Click **Yes** to continue or **No** to cancel the upgrade.
7. The EnerVista FM2 setup software software now prepares the FM2 to receive the new firmware file. The FM2 will display a message indicating that it is in Upload Mode. While the file is being loaded into the FM2, a status box appears indicating how much of the new firmware file has been transferred and how much is remaining, as well as the upgrade status. The entire transfer process takes approximately five minutes.
8. The EnerVista FM2 setup software software will notify the user when the FM2 has finished loading the file. Carefully read any displayed messages and click **OK** to return the main screen.

NOTE

Cycling power to the relay is highly recommended after a firmware upgrade.

After successfully updating the FM2 firmware, the relay will not be in service and will require setpoint programming. To communicate with the relay, the following settings will have to me manually programmed.

SLAVE ADDRESS
BAUD RATE

When communications is established, the saved setpoints must be reloaded back into the relay. See *Loading Saved Setpoints* on page 4–5 for details.

Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (i.e. default values, minimum/maximum values, data type, and item size) may change slightly from version to version of firmware.

The addresses are rearranged when new features are added or existing features are enhanced or modified. The **EEPROM DATA ERROR** message displayed after upgrading/downgrading the firmware is a resettable, self-test message intended to inform users that the Modbus addresses have changed with the upgraded firmware. This message does not signal any problems when appearing after firmware upgrades.

5 Setpoints

Overview

Setpoints Main Menu

The FM2 has a considerable number of programmable setpoints. These setpoints are grouped into six main pages with corresponding sub-pages as shown below. Each sub-page of setpoints (e.g. **S1 CONFIGURATION ⇩ COMMUNICATIONS**) has corresponding manual section which describes in detail the setpoints found on that page.

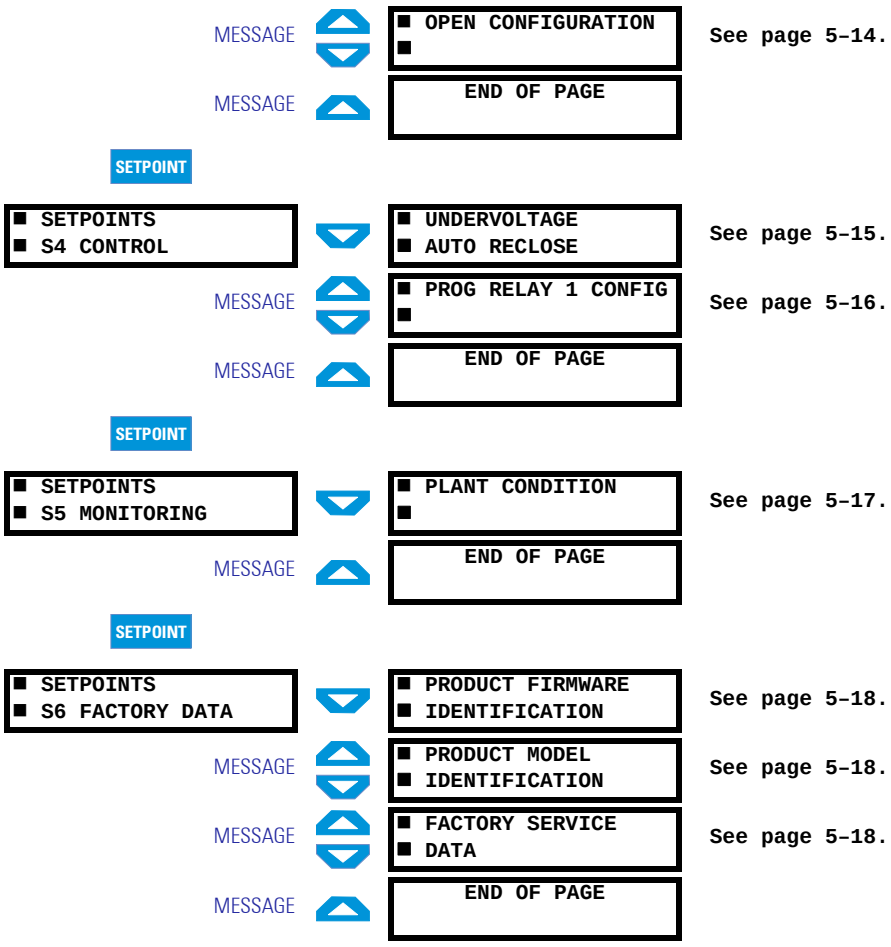
■ SETPOINTS ■ S1 CONFIGURATION	⇩	■ COMMUNICATIONS ■	See page 5–3.
	MESSAGE ⇩⇧	■ FEEDER ■ IDENTIFICATION	See page 5–4.
	MESSAGE ⇩⇧	■ FEEDER ■	See page 5–4.
	MESSAGE ⇩⇧	■ CT/VT INPUTS ■	See page 5–4.
	MESSAGE ⇩⇧	■ FAULT MODE ■	See page 5–5.
	MESSAGE ⇩⇧	■ STATISTICS ■	See page 5–5.
	MESSAGE ⇧	END OF PAGE	

SETPOINT

■ SETPOINTS ■ S2 PROTECTION	⇩	■ FEEDER PROTECTION ■ THERMAL	See page 5–10.
	MESSAGE ⇩⇧	■ FEEDER PROTECTION ■ EARTH FAULT	See page 5–10.
	MESSAGE ⇧	END OF PAGE	

SETPOINT

■ SETPOINTS ■ S3 PROCESS	⇩	■ CONFIGURABLE INPUTS ■	See page 5–11.
	MESSAGE ⇩⇧	■ PROCESS INTERLOCK ■ NAMES	See page 5–14.



Overview

By pressing the SETPOINT key, any of the relay setpoints may be viewed or altered. The setpoints are divided into six pages. Information about the feeder configuration and other connected devices is entered in **S1 CONFIGURATION**. Information for programming the protection features is located in **S2 PROTECTION**. Information describing the process control functions is in **S3 PROCESS**. Information for programming the control functions is in **S4 CONTROL**. Information to aid with contactor/breaker maintenance is contained in **S5 MONITORING**. Information about the internal configuration of the FM2 is contained in **S6 FACTORY DATA**.

To scroll through the setpoint pages, press the SETPOINT key. When this key is pressed for the first time the following message will appear on the display:

```
■ SETPOINTS
■ S1 CONFIGURATION
```

This is the first page of setpoints. The MESSAGE keys may be used to view all of the setpoints data.

The setpoint values themselves are changed with the VALUE keys. When a setpoint is adjusted to its proper value, the STORE key must be pressed to save the setpoint into non-volatile memory. Once the STORE key is pressed, the following flash message is displayed and the new setpoint value will be permanently saved.

```
NEW SETPOINT
STORED
```

WARNING

Setpoints may be changed while the feeder contactor/breaker is closed; however it is not recommended to change important protection parameters without first opening the feeder contactor/breaker.

Setpoints will remain stored indefinitely in the FM2 internal non-volatile memory even when control power to the unit is removed. Protection parameters are based on the entered data. This data must be complete and accurate for the given system for reliable protection of the feeder.

NOTE

All setpoint messages shown in this chapter reflect the factory default settings.

Abbreviations

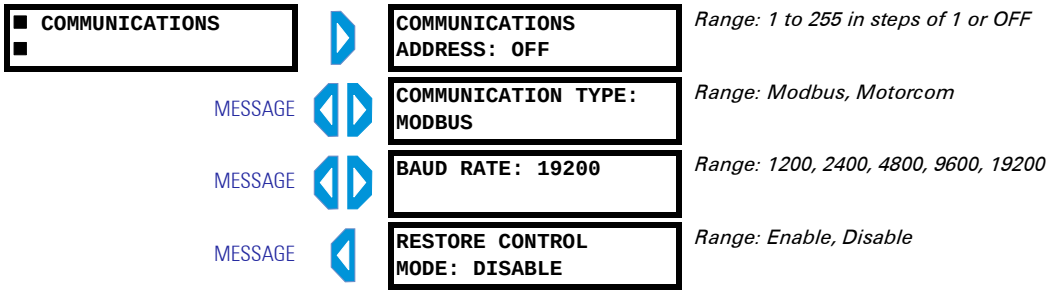
The following abbreviations are used in the messages in the setpoints pages.

- A, AMPS: Amperes
- CBCT: Core Balance Current Transformer
- COM, COMM, COMMS: Communication
- CT: Current Transformer
- FLC: Full Load Current (Feeder Rating)
- E/F: Earth Fault
- Hz: Hertz
- KOHMS: kΩ
- MAX: Maximum
- MIN: Minimum
- PROG: Programmable
- SEC, s: Seconds
- UV: Undervoltage
- VT: Voltage Transformer

S1 Configuration

Communications

PATH: SETPOINTS ⇩ S1 CONFIGURATION ⇨ COMMUNICATIONS

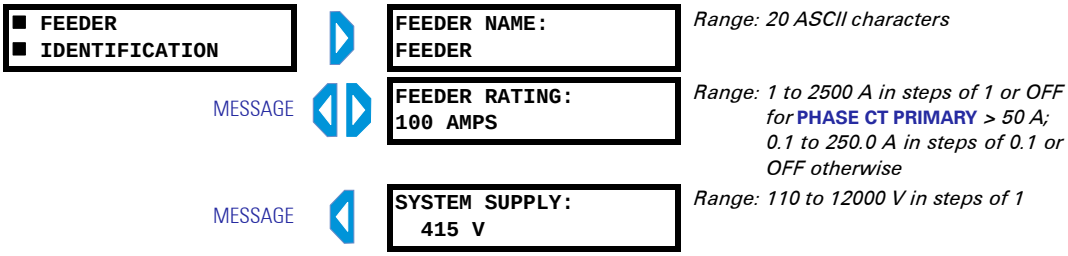


Each FM2 relay on the same serial communication network must have a unique address in the range of 1 to 255. Computer software driving the serial network must be configured to recognise each separate address.

The communications protocol used with the FM2 is selected via the **COMMUNICATIONS TYPE** setpoint. The **BAUD RATE** setpoint selects the data transfer rate for Modbus serial communications. The **RESTORE CONTROL MODE** setpoint overrides a serial 'Local Control Disable' command.

Feeder Identification

PATH: SETPOINTS ⇩ S1 CONFIGURATION ⇨⇨ FEEDER IDENTIFICATION



Range: 20 ASCII characters

Range: 1 to 2500 A in steps of 1 or OFF for PHASE CT PRIMARY > 50 A; 0.1 to 250.0 A in steps of 0.1 or OFF otherwise

Range: 110 to 12000 V in steps of 1

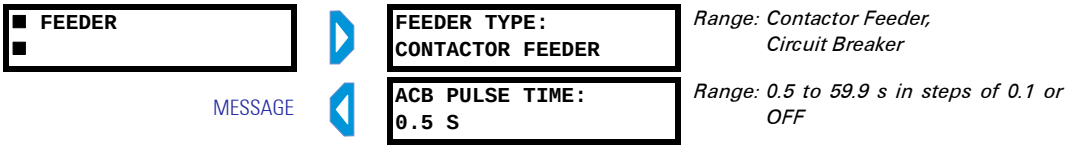
The feeder name that will appear in the A1 DATA ⇩ FEEDER DATA ⇨ FEEDER STATUS actual value message is entered via the FEEDER NAME setpoint.

Enter the full-load current of the feeder in FEEDER RATING. This rating is used for thermal overload and earth fault protection. When configuring through software, a value of 2501 A (or 250.1 A) indicates "OFF".

The SYSTEM SUPPLY setpoint indicates the system supply voltage on this line. This setpoint is for reference only and does not affect operation of the FM2 relay.

Feeder

PATH: SETPOINTS ⇩ S1 CONFIGURATION ⇨⇨⇨ FEEDER



Range: Contactor Feeder, Circuit Breaker

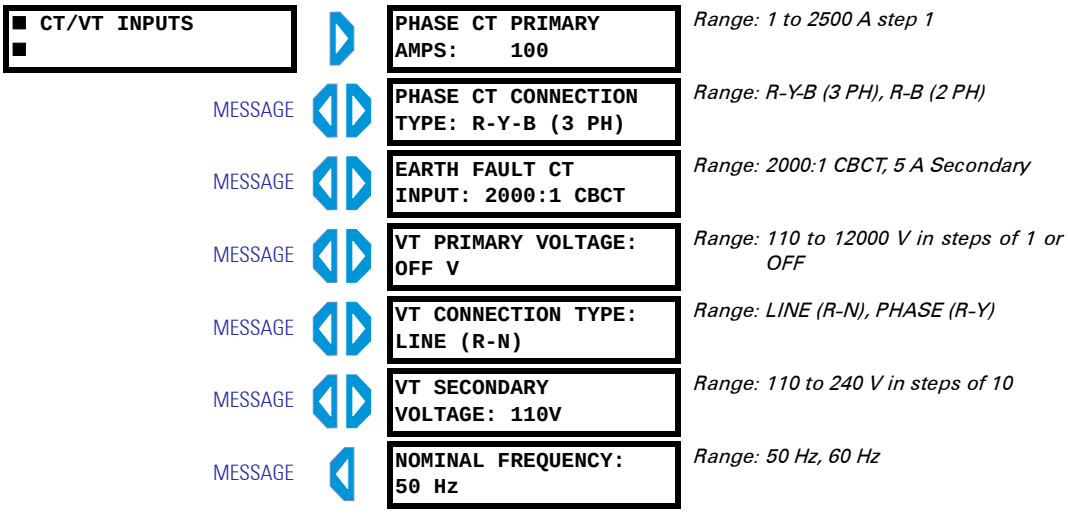
Range: 0.5 to 59.9 s in steps of 0.1 or OFF

The FEEDER TYPE setting selects the type of power switching device used for the feeder. This determines the control logic used for output relay A and B operation. The ACB PULSE TIME setpoint is applicable if the FEEDER TYPE is selected as "Circuit Breaker". Set the pulse time for breaker close and open commands. Refer to *Feeder Types* on page 9–1 for details on feeder operation.

If the ACB PULSE TIME is set to "OFF", a maximum pulse time of 60.0 seconds is set in the relay. When configuring through software, a value of 60.0 s indicates "OFF".

CT/VT Inputs

PATH: SETPOINTS ⇩ S1 CONFIGURATION ⇨⇨⇨⇨ CT/VT INPUTS



Range: 1 to 2500 A step 1

Range: R-Y-B (3 PH), R-B (2 PH)

Range: 2000:1 CBCT, 5 A Secondary

Range: 110 to 12000 V in steps of 1 or OFF

Range: LINE (R-N), PHASE (R-Y)

Range: 110 to 240 V in steps of 10

Range: 50 Hz, 60 Hz

Enter the phase CT rated primary current with PHASE CT PRIMARY AMPS. For example, if the phase CTs are rated 500:5, enter "500". The CT secondary must be connected to the correct input, i.e. 1 A or 5 A. Select the PHASE CT CONNECTION TYPE as per actual CT connections.

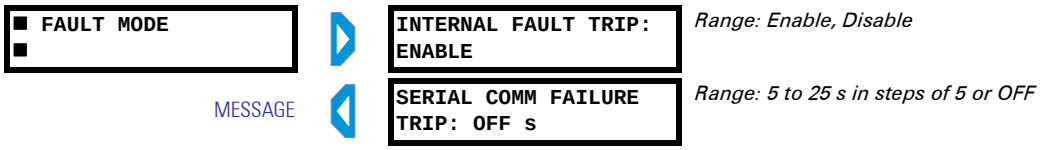
Enter the earth fault sensing CT used for the **EARTH FAULT CT INPUT** setting. This value is either sensitive 2000:1 core-balanced earth fault CT or 5 A Secondary for residual earth fault current sensing from the 5 A phase CT secondaries.

The **VT PRIMARY VOLTAGE** setting enables/disables the voltage/power features and sets VT primary volts. The **VT CONNECTION TYPE** setting appears only if the VT **PRIMARY VOLTAGE** setpoint is not set to "OFF"; enter the VT connection type, either Line R-N (V_{rn}) or Phase R-Y (V_{ry}). The **VT SECONDARY VOLTAGE** setting appears only if **VT PRIMARY VOLTAGE** is not "OFF". The setting range is 110 to 240 V. When configuring through software, a value of 12001 V for **VT PRIMARY VOLTAGE** indicates "OFF".

Enter the system frequency for the **NOMINAL FREQUENCY** setting.

Fault Mode

PATH: SETPOINTS ⇩ S1 CONFIGURATION ⇨⇨⇨⇨⇨ FAULT MODE

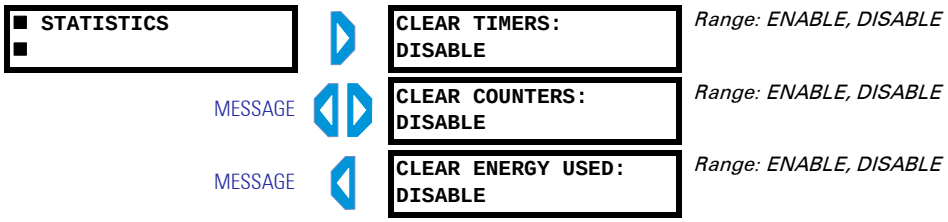


An internal fault during self-checking will cause an alarm. Since operation may be erratic depending on the fault condition, it may be desirable to trip the feeder by setting the **INTERNAL FAULT TRIP** setpoint to "Enable". The FM2 continues to supply the feeder with an internal fault present if set to "Disable".

If using serial communications to control a process with several feeders working together, it may be desirable to shut down the feeder if communication control is lost. When no activity occurs on the communications port for 5 to 25 seconds, the relay will trip if the **SERIAL COMM FAILURE TRIP** setpoint is enabled. When configuring through software, a value of 30 s indicates "OFF".

Statistics

PATH: SETPOINTS ⇩ S1 CONFIGURATION ⇨⇨⇨⇨⇨ STATISTICS



Enabling and storing the **CLEAR TIMERS** setpoint clears the operating time, the operating time since last closed, and the opened time timers (see **A4 STATISTICS ⇩ TIMERS**). Enabling and storing the **CLEAR COUNTERS** setpoint clears the number of operations and trip counters values (see **A4 STATISTICS ⇩⇩ COUNTERS**). Enabling and storing the **CLEAR ENERGY USED** setpoint clears the energy used (kWhr) values seen on page **A1 DATA ⇩ FEEDER**.

S2 Protection

IEC Overload Curves

The relay offers three standard curves defined in IEC 255-4 and British Standard BS142. These are defined as IEC Curve A, IEC Curve B, and IEC Curve C. The formulas for these curves are:

$$T = M \times \left(\frac{K}{(I / I_{pu})^{E} - 1} \right) \qquad \textbf{(EQ 5.1)}$$

where T is the trip time in seconds, M is the curve multiplier, I is the input current, I_{pickup} is the feeder rating, and K and E are constants.

TABLE 5–1: IEC (BS) Inverse Time Curve Constants

IEC (BS) Curve Shape	K	E
IEC Curve A (BS142)	0.140	0.020
IEC Curve B (BS142)	13.500	1.000
IEC Curve C (BS142)	80.000	2.000

TABLE 5–2: IEC Curve Trip Times (in seconds)

Multiplier (TDM)	Current (I / I_{pickup})									
	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
IEC Curve A										
0.05	0.860	0.501	0.315	0.249	0.214	0.192	0.176	0.165	0.156	0.149
0.10	1.719	1.003	0.630	0.498	0.428	0.384	0.353	0.330	0.312	0.297
0.20	3.439	2.006	1.260	0.996	0.856	0.767	0.706	0.659	0.623	0.594
0.40	6.878	4.012	2.521	1.992	1.712	1.535	1.411	1.319	1.247	1.188
0.60	10.317	6.017	3.781	2.988	2.568	2.302	2.117	1.978	1.870	1.782
0.80	13.755	8.023	5.042	3.984	3.424	3.070	2.822	2.637	2.493	2.376
1.00	17.194	10.029	6.302	4.980	4.280	3.837	3.528	3.297	3.116	2.971
IEC Curve B										
0.05	1.350	0.675	0.338	0.225	0.169	0.135	0.113	0.096	0.084	0.075
0.10	2.700	1.350	0.675	0.450	0.338	0.270	0.225	0.193	0.169	0.150
0.20	5.400	2.700	1.350	0.900	0.675	0.540	0.450	0.386	0.338	0.300
0.40	10.800	5.400	2.700	1.800	1.350	1.080	0.900	0.771	0.675	0.600
0.60	16.200	8.100	4.050	2.700	2.025	1.620	1.350	1.157	1.013	0.900
0.80	21.600	10.800	5.400	3.600	2.700	2.160	1.800	1.543	1.350	1.200
1.00	27.000	13.500	6.750	4.500	3.375	2.700	2.250	1.929	1.688	1.500
IEC Curve C										
0.05	3.200	1.333	0.500	0.267	0.167	0.114	0.083	0.063	0.050	0.040
0.10	6.400	2.667	1.000	0.533	0.333	0.229	0.167	0.127	0.100	0.081
0.20	12.800	5.333	2.000	1.067	0.667	0.457	0.333	0.254	0.200	0.162
0.40	25.600	10.667	4.000	2.133	1.333	0.914	0.667	0.508	0.400	0.323
0.60	38.400	16.000	6.000	3.200	2.000	1.371	1.000	0.762	0.600	0.485
0.80	51.200	21.333	8.000	4.267	2.667	1.829	1.333	1.016	0.800	0.646
1.00	64.000	26.667	10.000	5.333	3.333	2.286	1.667	1.270	1.000	0.808

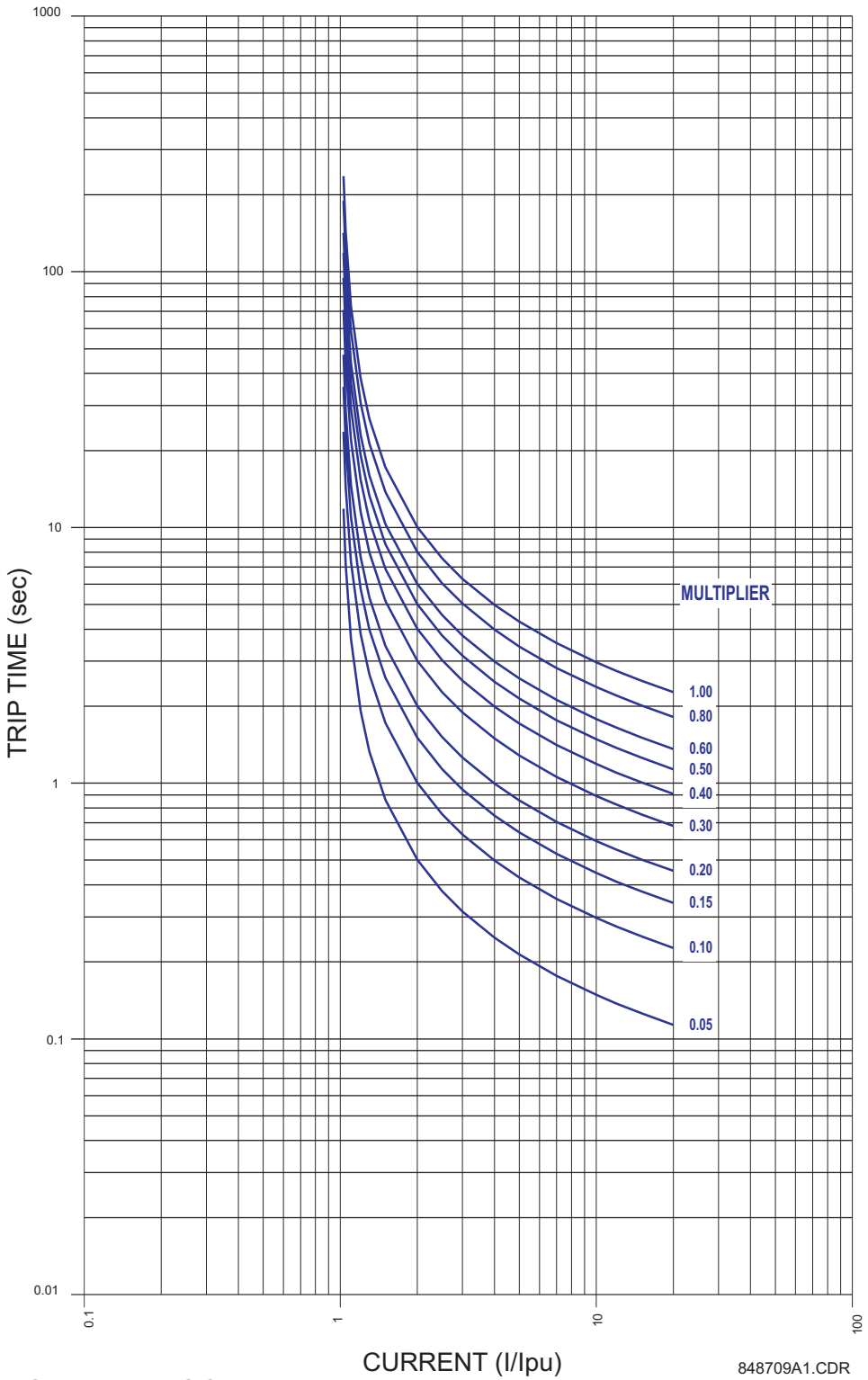


FIGURE 5–1: IEC Curve A

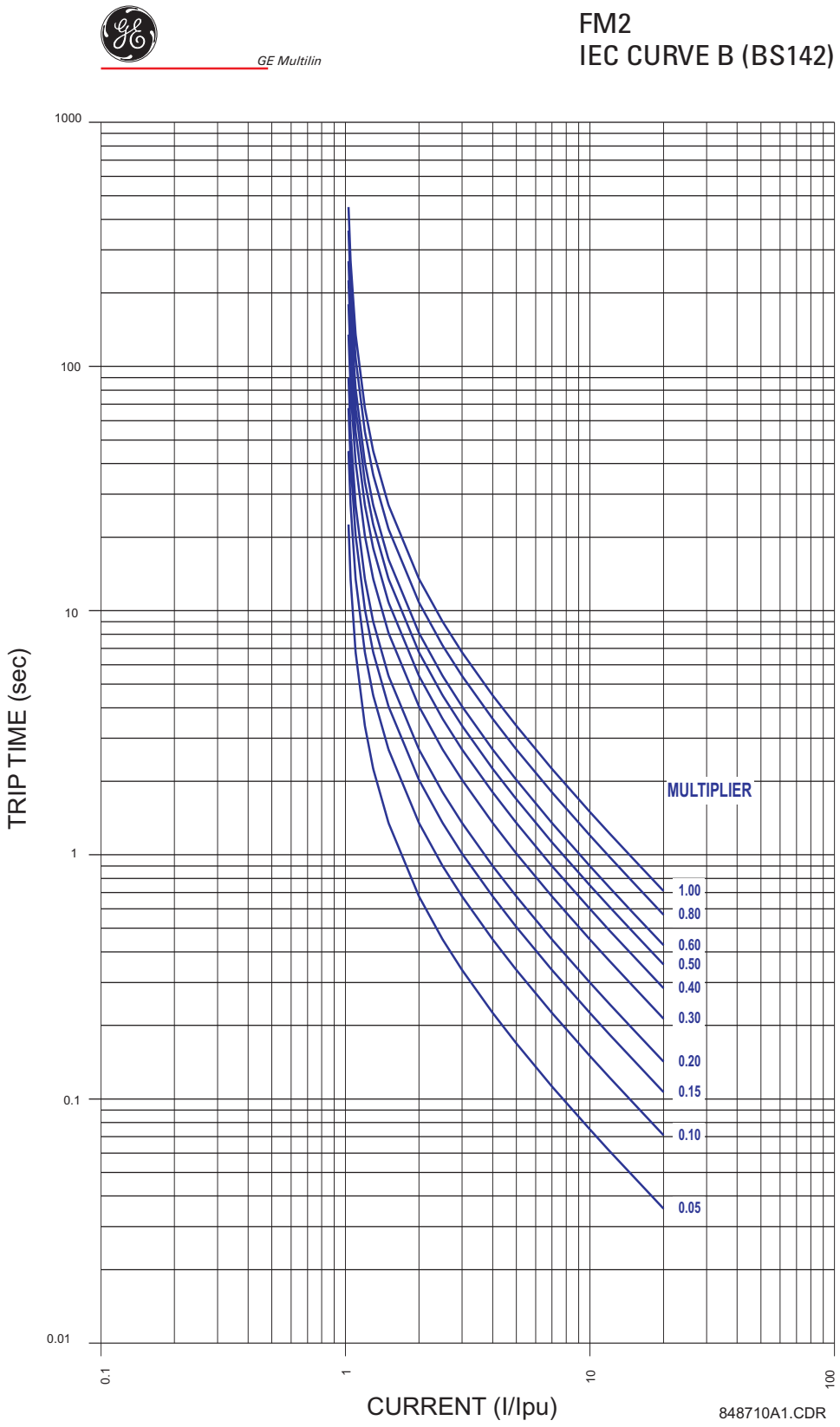


FIGURE 5–2: IEC Curve B

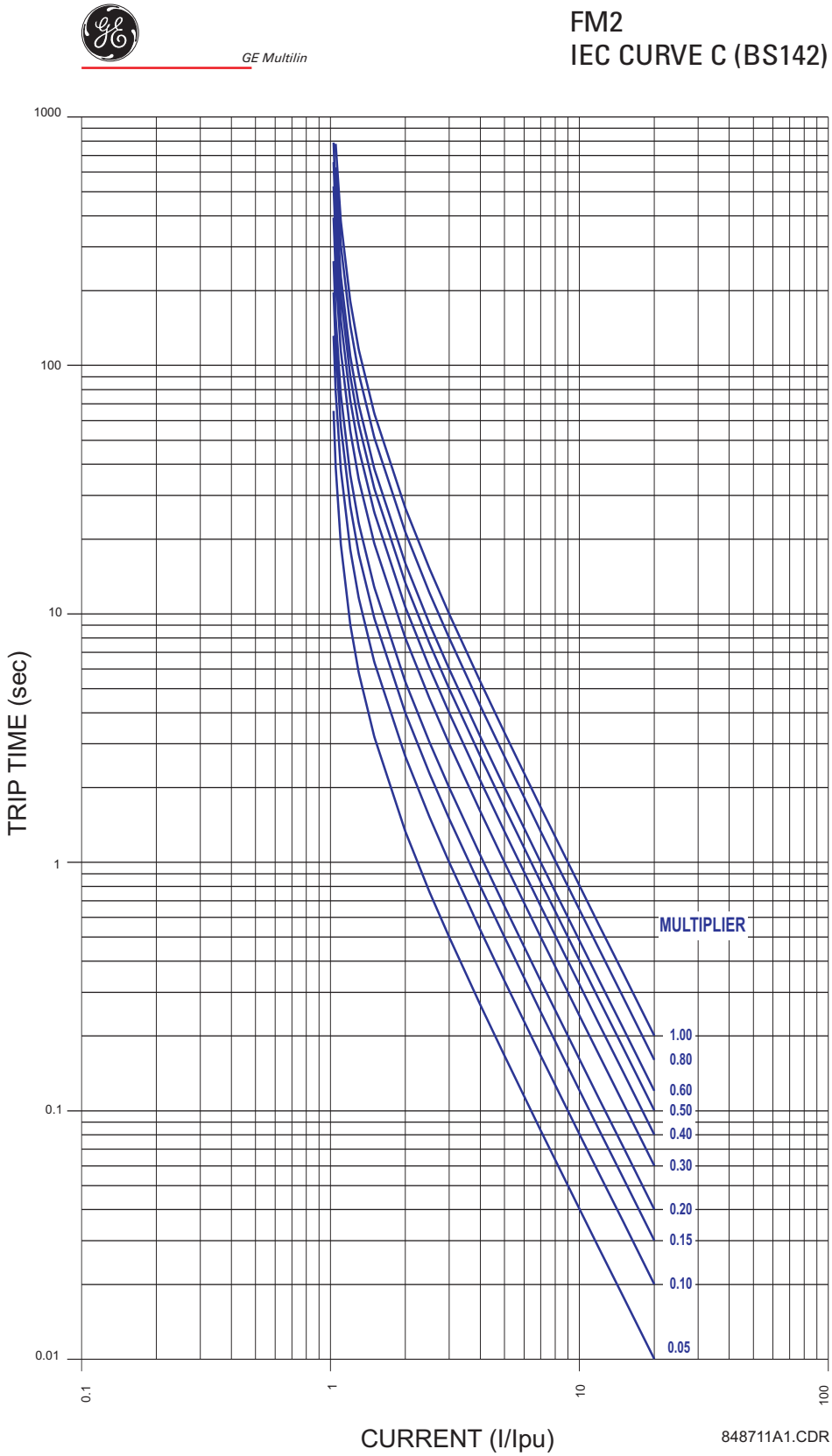
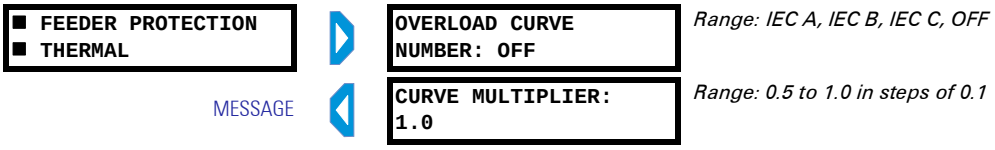


FIGURE 5–3: IEC Curve C

Thermal Protection

PATH: SETPOINTS ⇩⇩ S2 PROTECTION ⇨ FEEDER PROTECTION THERMAL

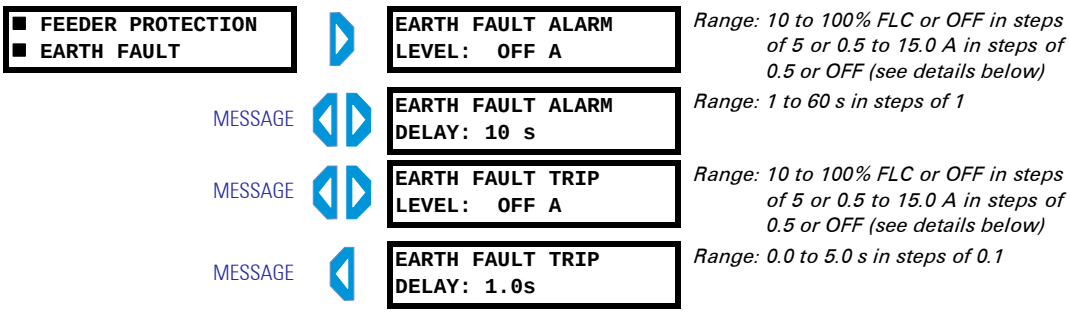


Set the **OVERLOAD CURVE NUMBER** to "OFF" to disable the thermal protection function. Select one of the curves to enable the function. Refer to *IEC Overload Curves* on page 5–6 for details on the IEC curves.

This **CURVE MULTIPLIER** setpoint allows shifting of the selected base curve in the vertical time direction. Unlike the electromechanical time dial equivalent, trip times are directly proportional to the value of the time multiplier setpoint. For example, all trip times for a multiplier of 0.5 are 0.5 times the multiplier 1 or base curve values.

Earth Fault Protection

PATH: SETPOINTS ⇩⇩ S2 PROTECTION ⇨⇨ FEEDER PROTECTION EARTH FAULT



WARNING

Care must be taken when turning ON the Earth Fault Trip feature. If the interrupting device (contactor or circuit breaker) is not rated to break earth fault current (low resistance or solidly earthed systems), the feature should be disabled. Alternately, the feature may be assigned to the programmable relay and connected such that it trips an upstream device that is capable of breaking the fault current. Be aware that the FM2 will energise the programmable relay and de-energise relay A at the same time when the earth fault trip occurs. Unless a contactor trip delay setting has been chosen (see PROG RELAY 1 CONFIG for details).

Set the **EARTH FAULT ALARM LEVEL** to some arbitrary amount below the **EARTH FAULT TRIP LEVEL** to get an early warning of insulation breakdown. For maximum sensitivity, the value selected should be just high enough to prevent nuisance alarms. If the **EARTH FAULT CT INPUT** is set to "5 A Secondary", the level is calculated as a percentage of the **FEEDER RATING** setting; if the **EARTH FAULT CT INPUT** is set to "2000:1 CBCT", the level is calculated in amps. When configuring through software, a value of 101% or 15.5 A for **EARTH FAULT ALARM LEVEL** indicates "OFF".

For residual CT connection, the earth fault trip and alarm levels are set as a percentage of full-load current (feeder rating). For example, given the following:

feeder rating = 250 A
CT primary = 500 A
earth fault alarm level = 25 A
earth fault trip level = 50 A

the relay settings are calculated as shown below.

$$\text{EARTH FAULT ALARM LEVEL} = \frac{25}{\text{feeder rating}} \times 100 = \frac{25}{250} \times 100 = 10\%\ \text{FLC} \quad \textbf{(EQ 5.2)}$$

$$\text{EARTH FAULT TRIP LEVEL} = \frac{50}{\text{feeder rating}} \times 100 = \frac{25}{250} \times 100 = 20\%\ \text{FLC} \quad \textbf{(EQ 5.3)}$$

If the earth current is equal to or above the **EARTH FAULT ALARM LEVEL** setpoint value and remains this way for the time delay programmed in **EARTH FAULT ALARM DELAY**, the alarm relay will activate and the EARTH ALARM message will be displayed.

Some leakage current will always flow between the three phases and earth due to capacitance, insulation, resistance, etc. On resistance limited earth systems, the value selected must be below the maximum resistance limited current that can flow or a trip will never occur. If no optimum value is known, monitor actual leakage current then enter a current somewhat above this value. Earth fault trips at a later time would indicate a deterioration in the system and insulation integrity should be verified. Persistent, high values of leakage current pose a threat to personnel and equipment and should not be left unchecked. If the **EARTH FAULT CT INPUT** is "5 A Secondary", the level is calculated as a percentage of the **FEEDER RATING** setting; if the **EARTH FAULT CT INPUT** is "2000:1 CBCT", the level is calculated in amps.

If the earth fault current is equal to or greater than the **EARTH FAULT TRIP LEVEL** value and remains this way for the **EARTH FAULT TRIP DELAY** time delay, the trip relay will activate and the CAUSE OF TRIP: EARTH FAULT message is displayed.

S3 Process

Configurable Inputs

PATH: SETPOINTS ⇩⇩⇩ S3 PROCESS ⇨ CONFIGURABLE INPUTS

```
■ CONFIGURABLE INPUTS
■
```

```
INTERLOCK INPUT 1:
NOT USED
```

Range: Not Used, Process Interlock A to J, Plant Interlock, Lockout Reset, Setpoint Access, Auto Permissive, Auto Close A, Auto Close B, Reset Emergency Open Trip, Two Wire Control, Test, Remote Permissive, Serial Permissive, Open A, Open B, Non-lockout Reset, Local Isolator, Switch Input Monitor

MESSAGE

```
STARTUP OVERRIDE
DELAY:  0 s  IL1
```

Range: 0 to 125 s in steps of 1 or OFF

MESSAGE

```
RUNNING OVERRIDE
DELAY:  0 s
```

Range: 0 to 125 s in steps of 1 or OFF

MESSAGE

```
OPERATION:
INTERLOCK STOP
```

Range: Interlock Stop, Latched Trip

MESSAGE

```
INSTANTANEOUS ALARM:
DISABLE
```

Range: Enable, Disable

MESSAGE

```
TEST MODE:
DISABLE
```

Range: Enable, Disable

NOTE

Interlock input functions are active when the applicable switch input is closed and energised. The first five messages are repeated for all ten interlock outputs.

The FM2 has 10 configurable switch inputs. Each input can have one of many functions assigned to it. Once a function is assigned to one Interlock input, that function cannot be assigned to any other Interlock input. The Interlock functions are:

- **NOT USED:** This is stored if this Interlock switch input is not used.
- **PROCESS INTERLOCK A(J):** The Process Interlock functions are used to provide time dependent trip/alarm/stop features based on a switch input. This function is used together with the **STARTUP OVERRIDE DELAY**, **RUNNING OVERRIDE DELAY**, **OPERATION**, and **INSTANTANEOUS ALARM** setpoints. The **STARTUP OVERRIDE DELAY** setpoint sets the amount of time that the Process Interlock switch can remain open after the feeder is closed. If the switch remains unhealthy for

longer than this time, a Process Interlock Trip will occur. If the **STARTUP OVERRIDE DELAY** is set to "0", the Process Interlock switch must be healthy in order for the FM2 to allow the feeder to close. If the **STARTUP OVERRIDE DELAY** is set to "OFF" this timer is disabled. The **RUNNING OVERRIDE DELAY** setpoint sets the amount of time that the Process interlock switch can be unhealthy during normal operation. If the Process Interlock switch goes unhealthy after a feeder close and remains unhealthy for longer than the **RUNNING OVERRIDE DELAY**, a Process Interlock Trip will occur. If the **RUNNING OVERRIDE DELAY** is set to "OFF", and the Process Interlock switch goes unhealthy after the feeder is in normal operation, no Process Interlock Trip or Process Interlock Stop will occur. The **OPERATION** setpoint determines whether the Process Interlock feature is a Process Interlock Trip (reset required to reclose the feeder) or a Process Interlock Stop (no reset required). The **INSTANTANEOUS ALARM** setpoint is used to create an alarm whenever the Process Interlock switch is unhealthy. There is no time delay associated with this alarm feature.

When configuring through software, a value of 126 s for the **STARTUP OVERRIDE DELAY** and **RUNNING OVERRIDE DELAY** indicates "OFF".

NOTE

The names of the Process Interlock features can be changed to any 20 ASCII character sequence. See *Process Interlock Names* on page 5–14 for additional details.

- **PLANT INTERLOCK:** This function is used to provide a switch input trip feature. When this switch is unhealthy a Plant Interlock Trip will occur. The Plant Interlock Trip is automatically cleared when the Plant Interlock switch goes healthy.
- **LOCKOUT RESET:** This function is used to provide a separate reset facility for lockout trips (i.e. Thermal Overload and Earth Fault). These trips are considered to be more serious than other FM2 trips. When used, this switch will reset Thermal Overload Trips (regardless of Lockout Time) and Earth Fault Trips only. All other trips must be reset using the RESET key.
- **SETPOINT ACCESS:** This function is used to provide security against unauthorised changing of FM2 setpoints. When this switch is unhealthy setpoints cannot be changed from the FM2 keypad. When this switch is healthy setpoints can be changed from the keypad. If this feature is not used, setpoints can always be changed from the keypad.
- **AUTO PERMISSIVE:** This function is used together with the Auto Close A/B functions. If the Auto Permissive Switch is healthy, close commands can come from the Auto Close A/B switches. When the Auto Permissive Switch is unhealthy the Auto Close A/B switches are ignored. When the Auto Permissive Switch is healthy, close commands via the Close A and B switch inputs and from the faceplate are blocked.
- **AUTO CLOSE A:** This function is used in conjunction with the Auto Permissive function described above. When the Auto Permissive switch is healthy, the Auto Close A switch can be used to close the feeder.
- **AUTO CLOSE B:** This function is used together with the Auto Permissive function. When the Auto Permissive switch is healthy, the Auto Close B switch can be used to close the feeder contactor B in applications where Relay B is used.
- **RESET EMERGENCY OPEN TRIP:** This function is used when a separate Emergency Open Trip Reset switch is required. When this switch is healthy and an Emergency Open Trip is present, the trip will be reset.
- **TWO WIRE CONTROL:** This function is used to switch from normal pulsed three-wire close/open control to maintained two-wire close/open control. For contactor feeders, when this switch is healthy, close commands (Close A/B switch inputs, Auto Close A/B switch inputs) must be maintained in the closed state for the FM2 to keep the feeder contactor closed. When the Close input is opened, the FM2 sees this as an OPEN command and both output relays will open. For a breaker feeder, when this switch is healthy, close commands (Close A switch input, Auto Close switch input) must be maintained in the closed state for the FM2 to keep the breaker feeder closed. When the Close input is opened,

the FM2 sees this as an OPEN command and will open the breaker by closing Relay B.

This is useful in applications with limit switches, PLC control, or Hand/Off/Auto control.

- **TEST:** This function is used to create a Test switch facility. When the Test input is healthy statistical counters (see actual values **A4 STATISTICS ⇨⇨ COUNTERS**) are not incremented. This is used when control tests on the contactor/breaker are being performed and counters should not be updated.

  If the feeder is closed and the switch becomes unhealthy, this function will issue a command to open the feeder.

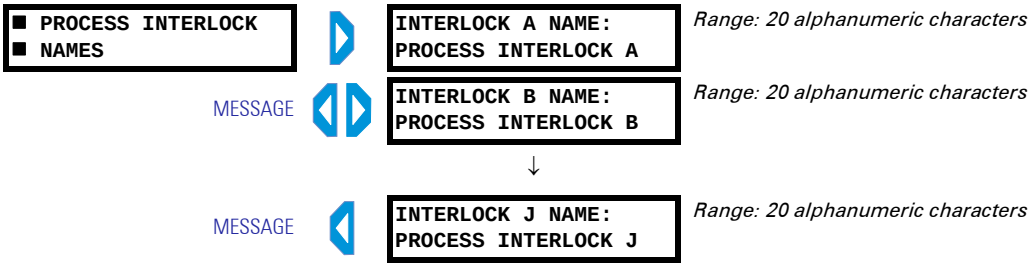
NOTE

- **REMOTE PERMISSIVE:** This function provides a means to interlock between the keypad CLOSE keys and the Close A / B switch inputs. When a Remote Permissive switch is not used both of these close command sources will operate when the FM2 is in Manual mode (Manual LED on). If the Remote Permissive switch is healthy, the Close A / B switch inputs are functional but the CLOSE keys are disabled. When the Remote Permissive switch is unhealthy, the CLOSE keys are functional but the Close A / B switch inputs are disabled. Note: Auto mode or Hardwired Auto mode (Auto LED on) disables both the Close A / B switches and the CLOSE keys.
- **OPEN A:** This function is used for end of travel applications. When an interlock configured for Open A opens the corresponding output relay will open. When the Open A input is open the feeder cannot be closed using Close A commands or switch inputs.
- **OPEN B:** This function is used for end of travel applications. When an interlock configured for Open B opens the corresponding output relay will open. When the Open B input is open the feeder cannot be closed using Close B commands or switch inputs.
- **SWITCH INPUT MONITOR**: When assigned, the application of the switch input monitor feature requires an input to be permanently wired closed via a hardware jumper. When the Switch Input Monitor feature is assigned to an Interlock, the FM2 continually reads the switches as it normally would and then checks the switch monitor input to check if it is still healthy. If so, the FM2 updates the switch data with the new switch read and performs any necessary functions. If not, the FM2 assumes the unit is in an undervoltage situation and disregards the switch data until the Switch Input Monitor becomes healthy again. This feature improves the reliability of the Undervoltage Reclose element to successfully close the feeder under very specific voltage dips and durations (approximately 56 to 62% of nominal 100 ms duration).
- **LOCAL ISOLATOR**: The local isolator NO auxiliary contacts are used to prevent feeder closing in the event of the Local Isolator being in the “open” position. To prevent closing, the FM2 produces a trip when the Local Isolator input is open. A Local Isolator Trip is automatically reset when the Local Isolator is reclosed.
- **NON-LOCKOUT RESET**: This function provides a separate reset facility for non-lockout trips (i.e. trips other than Earth Fault and Thermal Overload).
- **SERIAL PERMISSIVE**: This function provides a facility to override the keypad auto/manual keys. When this switch is healthy, the FM2 is forced to the auto serial mode (Auto LED on). When the switch is unhealthy, the FM2 reverts to the mode present before the switch was closed (manual mode with Manual LED on or hand-wired auto mode with Auto LED on).

The **TEST MODE** setting is used with the “TEST” function for interlock inputs. With **TEST MODE** set as “Enabled”, the feeder status is changed to test mode. When enabled, the relay will not allow any setting changes from the keypad. To return the relay to normal mode, one of the configurable inputs must be programmed to “Setpoint Access” and should be healthy.

Process Interlock Names

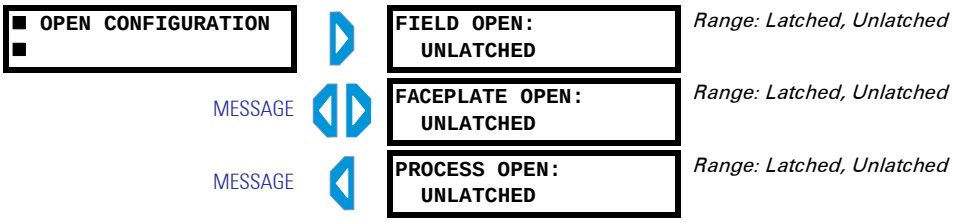
PATH: SETPOINTS ⇩⇩⇩ S3 PROCESS ⇨⇨ PROCESS INTERLOCK NAMES



The FM2 allows programming of user-defined names for the process interlock functions. To store a name, use the VALUE keys to change the cursor to the desired letter or number. Press the STORE key. This stores the character and moves the cursor to the next position. Repeat until the entire message has been entered. A space can be used to replace characters if no new character is required. If the cursor is at the end of the message, pressing STORE wraps around to the first position. This message now appears on any actual values message relating to Process Interlock A.

Open Configuration

PATH: SETPOINTS ⇩⇩⇩ S3 PROCESS ⇨⇨⇨ OPEN CONFIGURATION



If the FM2 detects that either Contactor Status A or Contactor Status B has become unhealthy without receiving a Open command, an External Open sequence has occurred. If the **FIELD OPEN** setpoint is set to "Unlatched" the **EXTERNAL OPEN** message will be displayed. If the **FIELD OPEN** setpoint is set to "Latched", the FM2 will initiate an Emergency Open Trip. This trip condition must be reset before the feeder can be reclosed.

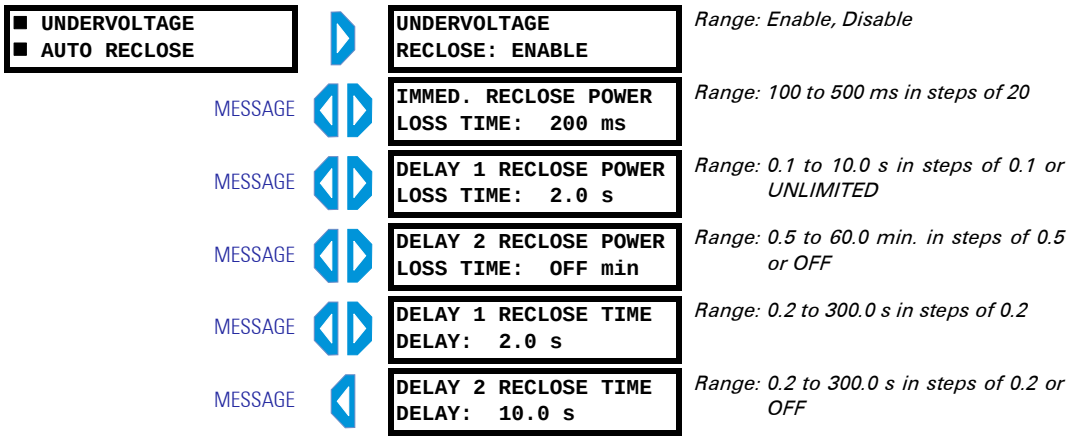
When the **FACEPLATE OPEN** setpoint is "Latched", pressing the OPEN button causes a latched trip. Pressing RESET allows the feeder to reclose. If the FM2 is receiving a constant close signal, the feeder will close as soon as reset is pressed.

When the **PROCESS OPEN** setpoint is "Latched", a momentary opening of a contact connected to Terminal 51 will cause a latched trip condition. Pressing the reset key will allow the feeder to close. If the FM2 is receiving a constant close signal the feeder will close as soon as reset is pressed.

S4 Control

Undervoltage Autoreclose

PATH: SETPOINTS ⇩⇩⇩⇩ S4 CONTROL ⇨ UNDERVOLTAGE AUTO RECLOSE



It is possible to reclose the feeder after a momentary power loss if this feature is enabled. When the control voltage (derived from the incoming feeder supply) drops below the dropout voltage, both output relays are de-energised. Voltage thresholds for the two internally set control voltage levels are 80 V for 120 V control voltage and 150 V for 240 V control voltage. At nominal voltage, the FM2 rides through a power outage less than 135 ms (varies according to the number of output relays energised at the time of power failure). Critical data is saved to E^2PROM at this time. A power outage that exceeds the FM2 ride-through initialises a backup timer that continues to run without power for approximately 1 hour. Once control power is restored, the FM2 can take up to 300 ms to initialise; this time includes the initializing of the microprocessor, variables in the code, the determination that a reclose is required, and the closure of the internal output relay. The reaction time of the output relay will be in addition to the 300 ms power-up time. If control voltage is restored within the **IMMED. RECLOSE POWER LOSS TIME** (0.1 to 0.5 seconds), the feeder will be reclosed immediately.

If the supply is restored after the **IMMED. RECLOSE POWER LOSS TIME** but before the **DELAY 1 RECLOSE POWER LOSS TIME**, the feeder will be reclosed after the **DELAY 1 RECLOSE TIME DELAY**. If a delayed reclose is always required, set the **DELAY 1 RECLOSE POWER LOSS TIME** to "Unlimited".

If the supply is restored after the **DELAY 1 RECLOSE POWER LOSS TIME** and before the **DELAY 2 RECLOSE POWER LOSS TIME**, the feeder will be reclosed after the **DELAY 2 RECLOSE TIME DELAY**. Set the **DELAY 2 RECLOSE POWER LOSS TIME** to "OFF" if this feature is not required.

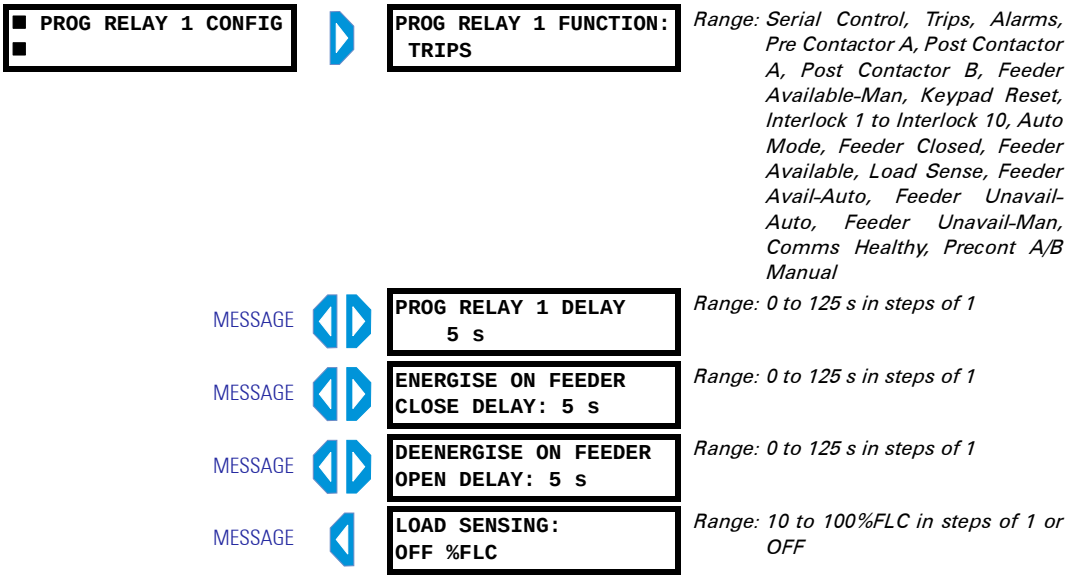
The **IMMED. RECLOSE POWER LOSS TIME**, **DELAY 1 RECLOSE POWER LOSS TIME**, and **DELAY 1 RECLOSE POWER LOSS TIME** are measured by the FM2 backup processor, not the time the AC power has been off.

NOTE

When configuring through software, a value of 10.1 s for the **DELAY 1 RECLOSE POWER LOSS TIME** indicates "UNLIMITED", a value of 60.5 min. for the **DELAY 1 RECLOSE POWER LOSS TIME** indicates "OFF", and a value of 300.2 s for the **DELAY 2 RECLOSE TIME DELAY** indicates "OFF".

Prog Relay 1 Config

PATH: SETPOINTS ⇩⇩⇩⇩ S4 CONTROL ⇨⇨ PROG RELAY 1 CONFIG



The FM2 has one auxiliary programmable output relay. This output can be assigned via the **PROG RELAY 1 CONFIG** setpoint to any of the following functions. The dual form "C" Programmable Relay 1 can be configured to activate on various conditions as described below.

- **SERIAL CONTROL**: Programmable Relay 1 can be energised/de-energised via the serial port.
- **TRIPS**: The Programmable Relay 1 will be energised when the FM2 is tripped. Resetting the FM2 will de-energise Programmable Relay 1.
- **ALARMS**: The Programmable Relay 1 will be energised while any alarm is present.
- **PRE CONTACTOR A**: The Programmable Relay 1 will energise when the FM2 receives a close command. Relay A will close after the delay specified in the **PROG RELAY 1 DELAY** setpoint. The Programmable Relay 1 will de-energise after Relay A is open.
- **PRE CONTACTOR A/B MAN**: The Programmable Relay 1 will energise when the FM2 receives a Close A / B command from the keypad. Relay A/B will close after the delay specified in the **PROG RELAY 1 DELAY** setpoint. The Programmable Relay will de-energise when Relay A/B energises.
- **POST CONTACTOR A**: The Programmable Relay 1 will energise after Relay A in the time specified by the **PROG RELAY 1 DELAY** setpoint. The Programmable Relay 1 will de-energise when Relay A de-energises.
- **POST CONTACTOR B**: The Programmable Relay 1 will energise after Relay B in the time specified by the **PROG RELAY 1 DELAY** setpoint. The Programmable Relay 1 will de-energise when Relay B de-energises.
- **FEEDER AVAILABLE MANUAL**: When the Feeder Status message indicates that the feeder can be closed manually, the Programmable Relay 1 will be energised. Any other Feeder Status indication will cause the Programmable Relay 1 to be de-energised.
- **KEYPAD RESET**: Programmable Relay 1 will energise while the RESET key is pressed.
- **INTERLOCK 1 to 10**: Programmable Relay 1 will energise while the corresponding Interlock 1 to 10 switch inputs are closed.
- **AUTO MODE**: Programmable Relay 1 will energise when the Auto LED is on.

- **FEEDER CLOSED**: Programmable Relay 1 will energise while the feeder is closed, in conjunction with the **ENERGISE FEEDER ON CLOSE DELAY** and **DE-ENERGISE FEEDER ON CLOSE DELAY** setpoints.
- **FEEDER AVAILABLE AUTO**: This Programmable Relay function will activate the Programmable Relay when the feeder is available to close in Auto Mode.
- **FEEDER UNAVAILABLE AUTO**: This Programmable Relay function will activate the Programmable Relay when the feeder is not available to close in Auto Mode.
- **FEEDER AVAILABLE MAN:** This Programmable Relay function will activate the Programmable Relay when the feeder is available to close in Manual mode.
- **FEEDER UNAVAILABLE MAN:** This Programmable Relay function will activate the Programmable Relay when the feeder is not available to close in Manual mode.
- **COMMS HEALTHY**: This Programmable Relay function will activate the Programmable Relay when the relay serial communication port is healthy.
- **LOAD SENSE**: This Programmable Relay function will activate the Programmable Relay when one of the phase current is greater than the **LOAD SENSING** setpoint.

The **PROG RELAY 1 DELAY** setpoint provides a delayed energization of Programmable Relay 1 when “Pre Contactor A”, “Post Contactor A”, “Post Contactor B”, or “Precont A/B Manual” is selected as the **PROG RELAY 1 FUNCTION**.

The **ENERGISE ON FEEDER CLOSE DELAY** setpoint provides a delayed energization of the Programmable Relay 1 when “Feeder Closed” is selected as the **PROG RELAY 1 FUNCTION**. The Programmable Relay 1 energises after this time delay on the occurrence of a feeder close. Likewise, the **DE-ENERGISE ON FEEDER CLOSE DELAY** setpoint provides a delayed de-energization of the Programmable Relay 1 when “Feeder Closed” is selected as the **PROG RELAY 1 FUNCTION**. Programmable Relay 1 will de-energise after this time delay on the occurrence of a feeder open.

The **LOAD SENSING** setpoint determines the operating level for the load sensing function when “Load Sense” is selected as the **PROG RELAY 1 FUNCTION**. When configuring through software, a value of 101%FLC indicates “OFF”.

S5 Monitoring

Plant Condition

PATH: SETPOINTS ⇩⇩⇩⇩⇩ S5 MONITORING ⇨ PLANT CONDITION

```
■ PLANT CONDITION
■
```

⇨

```
CONTACTOR INSPECTION
  OFF x 1000 OPS
```

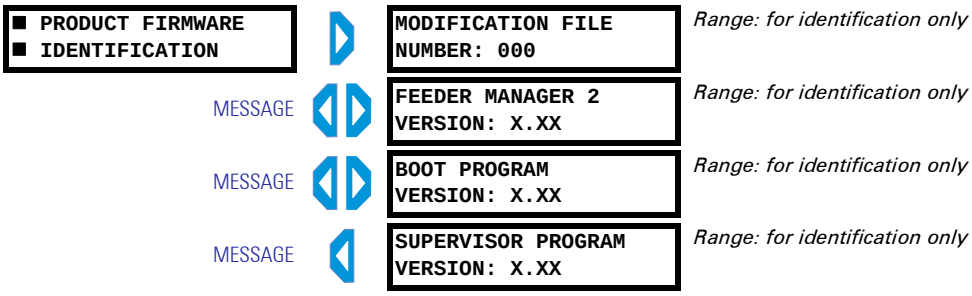
Range: 50000 to 10000000 operations in steps of 10000 or OFF

Enter the interval at which the contactor/breaker contacts must be inspected for wear. When the **NUMBER OF OPERATIONS** counter exceeds this setpoint a Contactor Inspection Interval Alarm is generated. Use the **S1 CONFIGURATION ⇨⇨⇨⇨⇨⇨ STATISTICS ⇨⇨ CLEAR COUNTERS** setpoint to clear the **NUMBER OF OPERATIONS** counter. If this feature is not required set this setpoint to “OFF”. When configuring through software, a value of 10010 × 1000 ops indicates “OFF”.

S6 Factory Data

Product Firmware

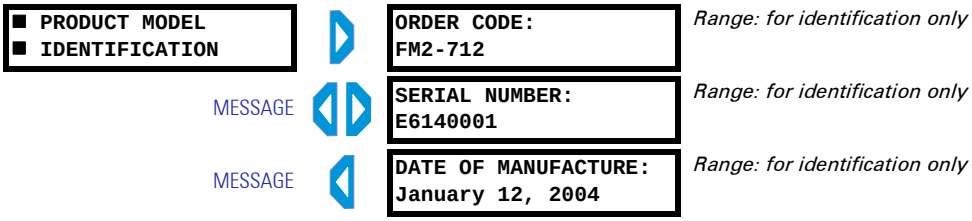
PATH: SETPOINTS ⇩⇩⇩⇩⇩⇩ S6 FACTORY DATA ⇨ PRODUCT FIRMWARE IDENTIFICATION



The firmware, boot program, supervisor program, and hardware revisions are displayed here. If the FM2 has been modified so that it is no longer a standard model, a modification number will be displayed in the **MODIFICATION FILE NUMBER** message.

Product Model

PATH: SETPOINTS ⇩⇩⇩⇩⇩⇩ S6 FACTORY DATA ⇨⇨ PRODUCT MODEL IDENTIFICATION



The FM2 order code, serial number, and date of manufacture are displayed here.

Factory Service Data

PATH: SETPOINTS ⇩⇩⇩⇩⇩⇩ S6 FACTORY DATA ⇨⇨⇨ FACTORY SERVICE DATA

This menu is for use by GE Multilin personnel for testing and calibration purposes.

6 Monitoring

Actual Values Viewing

Actual Values Menu

■ ACTUAL VALUES
■ A1 DATA

▼ ■ FEEDER DATA ■ — See page 6–3.

MESSAGE ▲ END OF PAGE

ACTUAL

■ ACTUAL VALUES
■ A2 STATUS

▼ ■ TRIP DATA ■ — See page 6–4.

MESSAGE ▲▼ ■ ALARM DATA ■ — See page 6–5.

MESSAGE ▲▼ ■ FEEDER STATUS ■ — See page 6–6.

MESSAGE ▲ END OF PAGE

ACTUAL

■ ACTUAL VALUES
■ A3 INPUTS

▼ ■ INPUT CONTACTS STATUS ■ — See page 6–7.

MESSAGE ▲ END OF PAGE

ACTUAL

■ ACTUAL VALUES
■ A4 STATISTICS

▼ ■ TIMERS ■ — See page 6–7.

MESSAGE ▲▼ ■ COUNTERS ■ — See page 6–8.

MESSAGE ▲ END OF PAGE

Description

Any measured value can be displayed on demand using the ACTUAL and MESSAGE keys. Press the ACTUAL key to select the actual values, then the MESSAGE DOWN key to select the beginning of a new page of monitored values. These are grouped as follows: A1 Data, A2 Status, A3 Inputs, and A4 Statistics. Use the MESSAGE keys to move between actual value messages. A detailed description of each displayed message in these groups is given in the sections that follow.

Default Message Selection

One default message can be selected to view when the feeder is closed and the FM2 is left unattended. If no keys are pressed for 2 minutes and the feeder is closed, then the currently displayed message will automatically be overwritten by the default message. Alarm and trip messages will override default message display. Any Actual Value can be selected as a default message.

To select a default message, use the MESSAGE keys to display any actual values message to be displayed. Press the STORE key twice in rapid succession. The display will read:

```
NEW DEFAULT LINE
SELECTED
```

To delete the default message and select a new default message, use the ACTUAL and MESSAGE keys to display the desired new default message. Press the STORE key twice in rapid succession. The display will prompt:

```
NEW DEFAULT LINE
SELECTED
```

The new default message is now stored.

Abbreviations

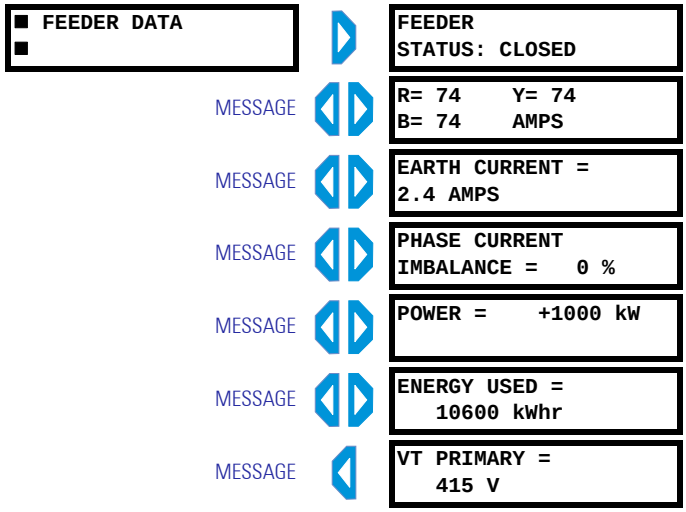
The following abbreviations are used in the actual values messages.

- A, AMPS: amperes
- kW: kilowatts
- kWhr: kilowatt-hours
- MIN: minutes
- N/O: normally open
- O/L: overload
- s: seconds

A1 Data

Feeder Data

PATH: ACTUAL VALUES ⇩ A1 DATA ⇨ FEEDER DATA



This **FEEDER STATUS** value indicates the name and status of the feeder. The top line of the display (20 characters) can be programmed to a user defined alphanumeric name. The second line indicates feeder status. The following list shows the possible feeder status indications:

- *Unavailable*: There is at least one condition present that is preventing close commands from operating. Possible conditions are: a trip is present, the OPEN key is being pressed, the Open Switch input is open, one of the Process Interlock switches is open or an undervoltage delayed reclose is in progress.
- *Available-Auto*: Close commands from the serial port or the Auto Close A / Auto Close B interlock switch inputs will be performed. Close commands from the Close A / Close B switch inputs and the CLOSE keys will be ignored.
- *Available-Manual*: Close commands from the Close A / Close B switch inputs and/or the CLOSE keys will be performed. Close commands from the serial port and Auto Close A / Auto Close B switch inputs will be ignored.
- *Closed*: At least one contactor output relay is closed.

The actual RMS current in each phase (R, Y, and B) is displayed in amps. The **EARTH CURRENT** value displays the earth fault leakage current flowing from any phase to earth in amps.

The **PHASE CURRENT IMBALANCE** value displays the percentage imbalance in the feeder phase currents. The imbalance is calculated as shown in *Specifications* on page 1–3.

The **POWER** value displays the three phase power, calculated using phase A current and voltage V_{rn} or V_{ry}. The **ENERGY USED** value displays the total accumulated energy used since last cleared and is updated once every minute. The **VT PRIMARY** value displays the voltage present at the primary of the VT. The last three values appear only if the **VT PRIMARY** setpoint is programmed.

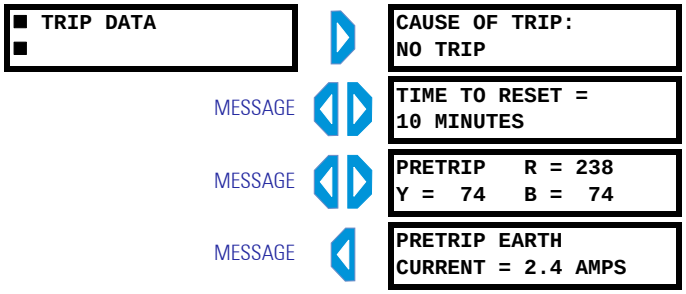
NOTE

Power and energy used values are not displayed if the **PHASE CT PRIMARY** setting is greater than 1000.

A2 Status

Trip Data

PATH: ACTUAL VALUES ⇩⇩ A2 STATUS ⇨ TRIP DATA



The **CAUSE OF TRIP** value displays the cause of the current trip. If no trip is present, the display indicates "NO TRIP". When a trip occurs, the cause of trip message will override the currently selected default message. The possible causes of trip are: Thermal Overload, Earth Fault, Plant Interlock, Local Isolator, Serial Comms Failure, Internal Fault, Emergency Open, and Process Interlock A to J.

The **TIME TO RESET** actual value is visible only when a Thermal Overload Trip is present and indicates the time remaining before the thermal overload trip can be reset. The Lockout Reset Interlock can be used to override this time.

The thermal capacity value will decrease exponentially and an overload trip can normally be reset when the thermal capacity values decreases to 15%. The relay uses a cooling time constant of 6 minutes for calculating time to reset the overload trip.

The time to reach 15% thermal capacity used can be calculated by:

$$15 = |100| \times e^{-t/T} \Rightarrow 0.15 = e^{-t/T} \Rightarrow \frac{t}{T} = -\ln(0.15) \Rightarrow t = -T\ln(0.15)$$
$$\Rightarrow t = 11.4 \text{ minutes} \qquad \textbf{(EQ 6.1)}$$

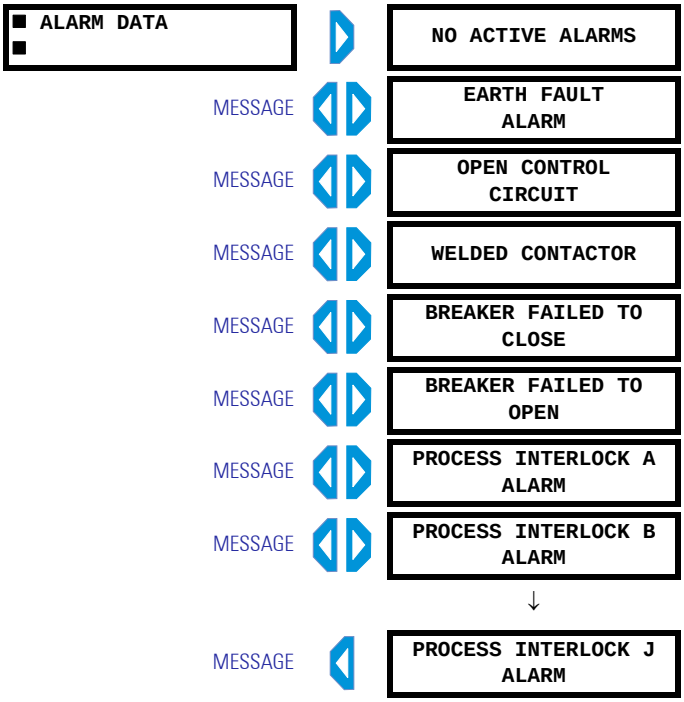
The **PRETRIP R, Y, B** value displays the feeder phase current flowing at the time of trip. The **PRETRIP EARTH CURRENT** displays the earth leakage current that was flowing from any phase to earth at the time of trip.

NOTE

Pretrip values for current related trips are stored in the EEPROM at the time of trip. This enables the FM2 to "remember" pretrip values if power is removed. This feature is enabled for thermal overload and earth fault trips. When a trip not listed above occurs and power is removed, the FM2 displays zero for pretrip values.

Alarm Data

PATH: ACTUAL VALUES ⇩⇩ A2 STATUS ⇨⇨ ALARM DATA

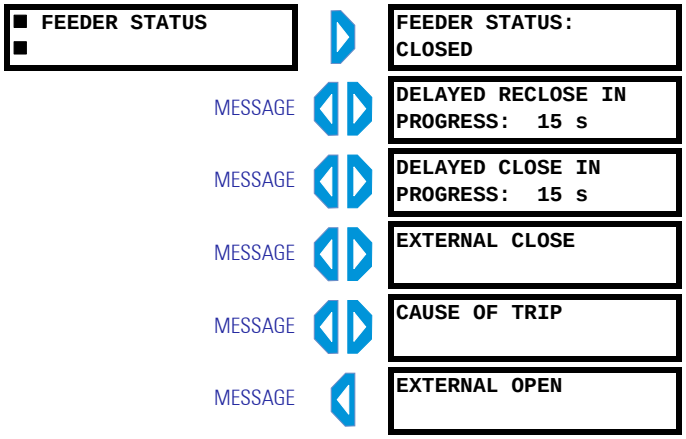


Any alarm conditions that are currently active will be displayed. This could be one or more of the following:

- **NO ACTIVE ALARMS**: This message is displayed only when there are no alarms currently active. If at least one alarm has occurred, the most recent alarm message will override the currently selected default message and this message will not be displayed.
- **EARTH FAULT ALARM**: The earth fault current has exceeded Earth Fault Alarm Level for the Earth Fault Alarm Time Delay.
- **OPEN CONTROL CIRCUIT**: While performing a close, the FM2 did not see a change in contactor status (open to closed) within 0.25 second of energizing the output relay.
- **WELDED CONTACTOR**: While performing an open, the FM2 did not see a change in contactor status (closed to open) within 0.25 second of de-energizing the output relay.
- **BREAKER FAILED TO CLOSE**: This message is displayed while performing a close for circuit breaker feeders, if the FM2 did not detect a change in breaker status within 0.25 second of a close command.
- **BREAKER FAILED TO OPEN**: This message is displayed while performing an open for circuit breaker feeders, if the FM2 did not detect a change in breaker status within 0.25 second of a trip or open command.
- **PROCESS INTERLOCK A(J) ALARM**: An open Process Interlock A(J) switch input has been detected.

Feeder Status

PATH: ACTUAL VALUES ⇨⇩ A2 STATUS ⇨⇨⇨ FEEDER STATUS



The **FEEDER STATUS** value has the same possible values as the **A1 DATA** ⇩ **FEEDER DATA** ⇨ **FEEDER STATUS** message. Refer to *Feeder Data* on page 6–3 for details.

The **DELAYED RECLOSE IN PROGRESS** value will appear if a delayed undervoltage reclose is in progress. The displayed time indicates the time remaining until the close sequence will begin. The **DELAYED CLOSE IN PROGRESS** value will appear if a close is in progress. This occurs if one of the programmable relays is set to Pre Contactor A OR B operation. The displayed time indicates the time remaining until Relay A energises.

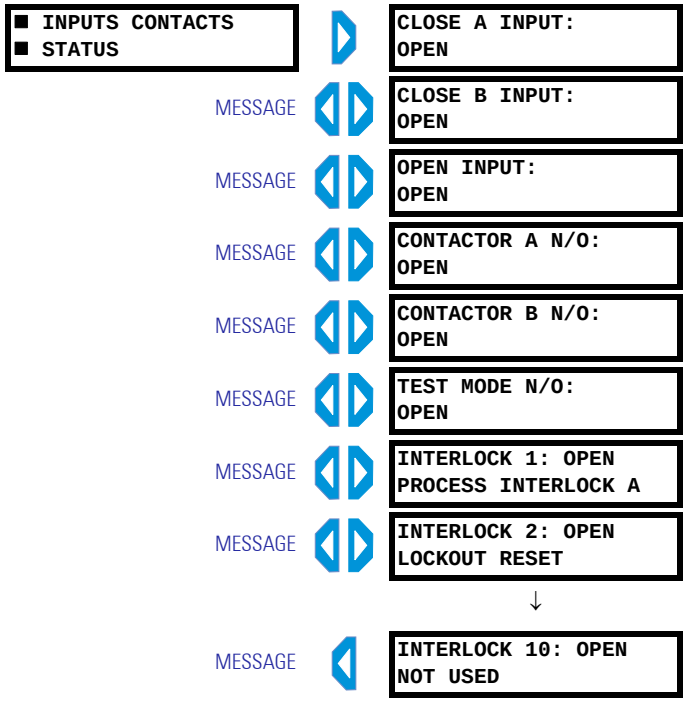
The **EXTERNAL CLOSE** value will appear if the contactor/breaker closed without receiving a close command from the FM2. The FM2 will close the corresponding output relay to seal in the contactor. The **EXTERNAL OPEN** value indicates that the open operation was caused externally to the FM2, i.e. The Relay A input status changed from close to open.

The **CAUSE OF TRIP** value indicates the cause of the current trip condition.

A3 Inputs

Input Contacts Status

PATH: ACTUAL VALUES ⇩⇩⇩ A3 INPUTS ⇨ INPUT CONTACTS STATUS



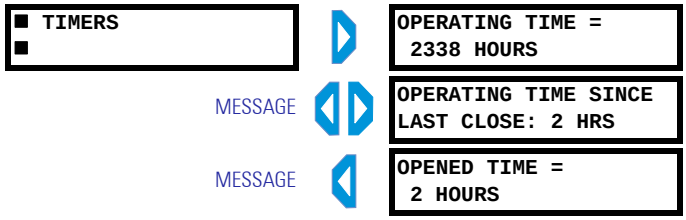
The status of various input contacts are shown in this menu. A value of “CLOSED” indicates the corresponding switch is closed, and a value of “OPEN” indicates the corresponding switch is open.

The **INTERLOCK 1(10)** messages also indicated the function assigned (if any) to the corresponding interlock on the second line.

A4 Statistics

Timers

PATH: ACTUAL VALUES ⇩⇩⇩⇩ A4 STATISTICS ⇨ TIMERS

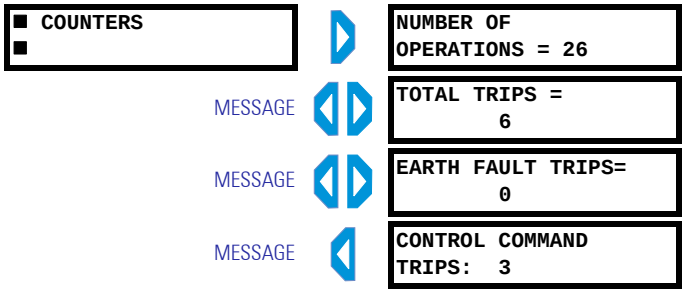


The total accumulated time the feeder has been operating is indicated by the **OPERATING TIME**.

This non-accumulated time the feeder has been in operation since last close is indicated by the **OP TIME SINCE LAST CLOSE**. This value clears to zero once the feeder has opened. The non-accumulated feeder open time indicated by the **OPENED TIME**. This is the amount of time that the feeder has been open since the last time it was in operation. This value clears to zero the next time the feeder is closed.

Counters

PATH: ACTUAL VALUES ⇩⇩⇩⇩ A4 STATISTICS ⇨⇨ COUNTERS



The total number of contactor/breaker operations is indicated by the **NUMBER OF OPERATIONS** actual value. When the FM2 receives feedback into the contactor status input to confirm that one of the contactors/breaker has closed, this counter will increment.

When the FM2 trips for any reason, the **TOTAL TRIPS** value is incremented. It is the sum of all of the individual causes of trip. When a earth fault trip occurs, the **EARTH FAULT TRIPS** value is incremented. If a control trip occurs (i.e. Plant Interlock, Local Isolator, etc.), the **CONTROL COMMAND TRIPS** value is incremented.

7 Communications

FM2 Modbus Protocol

Overview

The FM2 implements a subset of the Modicon Modbus RTU serial communication standard. The Modbus protocol is hardware-independent. That is, the physical layer can be any of a variety of standard hardware configurations. This includes RS232, RS422, RS485, fibre optics, etc. Modbus is a single master / multiple slave type of protocol suitable for a multi-drop configuration as provided by RS485 hardware. The FM2 Modbus implementation employs two-wire RS485 hardware. Using RS485, up to 32 FM2s can be daisy-chained together on a single communication channel.

The FM2 is always a Modbus slave. They can not be programmed as Modbus masters. Computers or PLCs are commonly programmed as masters.

Modbus protocol exists in two versions: Remote Terminal Unit (RTU, binary) and ASCII. Only the RTU version is supported by the FM2. Both monitoring and control are possible using read and write register commands. Other commands are supported to provide additional functions.

Electrical Interface

The hardware or electrical interface in the FM2 is two-wire RS485. In a two-wire link, data is transmitted and received over the same two wires. Although RS485 two wire communication is bi-directional, the data is never transmitted and received at the same time. This means that the data flow is half duplex.

RS485 lines should be connected in a daisy-chain configuration with terminating networks installed at each end of the link (i.e. at the master end and the slave farthest from the master). The terminating network should consist of a 120 Ω resistor in series with a 1 nF ceramic capacitor when used with Belden 9841 RS485 wire. Use shielded wire to minimise noise. The shield should be connected to all of the FM2s as well as the master, then earthed at one location only. This keeps the earth potential at the same level for all of the devices on the serial link.

NOTE

Polarity is important in RS485 communications. The '+' (positive) terminals of every device must be connected together.

See *FIGURE 2–6: RS485 Termination* on page 2–6 for additional information.

Data Frame Format and Data Rate

One data frame of an asynchronous transmission to or from a FM2 typically consists of 1 start bit, 8 data bits, and 1 stop bit. This produces a 10 bit data frame. This is important for transmission through modems at high bit rates (11 bit data frames are not supported by Hayes modems at bit rates of greater than 300 bps). The FM2 has the capability of adding an odd or even parity bit if necessary.

Modbus protocol can be implemented at any standard communication speed. The FM2 supports operation at 1200, 2400, 4800, 9600, 19200, and 57600 baud.

Data Packet Format

A complete request/response sequence consists of the following bytes (transmitted as separate data frames):

Master Request Transmission:

SLAVE ADDRESS: 1 byte
FUNCTION CODE: 1 byte
DATA: variable number of bytes depending on FUNCTION CODE
CRC: 2 bytes

Slave Response Transmission:

SLAVE ADDRESS: 1 byte
FUNCTION CODE: 1 byte
DATA: variable number of bytes depending on FUNCTION CODE
CRC: 2 bytes

- **SLAVE ADDRESS**: This is the first byte of every transmission. This byte represents the user-assigned address of the slave device that is to receive the message sent by the master. Each slave device must be assigned a unique address and only the addressed slave will respond to a transmission that starts with its address. In a master request transmission the slave address represents the address of the slave to which the request is being sent. In a slave response transmission the slave address represents the address of the slave that is sending the response.

A master transmission with a slave address of 0 indicates a broadcast command. Broadcast commands can be used only in certain situations; see *Applications* on page 7–9 for details.

- **FUNCTION CODE**: This is the second byte of every transmission. Modbus defines function codes of 1 to 127. The FM2 implements some of these functions. See *FM2 Supported Functions* on page 7–3 details of the supported function codes. In a master request transmission the function code tells the slave what action to perform. In a slave response transmission the function code tells the master what function was performed as requested. If the high order bit of the function code sent from the slave is a 1 (i.e. if the function code is > 127) then the slave did not perform the function as requested and is sending an error or exception response.
- **DATA**: This will be a variable number of bytes depending on the function code. This may be actual values, setpoints, or addresses sent by the master to the slave or by the slave to the master. See *FM2 Supported Functions* on page 7–3 for a description of the supported functions and the data required for each.
- **CRC**: This is a two byte error checking code.

Error Checking

The RTU version of Modbus includes a two byte CRC-16 (16 bit cyclic redundancy check) with every transmission. The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (1100000000000101B). The 16-bit remainder of the division is appended to the end of the transmission, MSByte first. The resulting message including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred.

If a FM2 Modbus slave device receives a transmission in which an error is indicated by the CRC-16 calculation, the slave device will not respond to the transmission. A CRC-16 error indicates than one or more bytes of the transmission were received incorrectly and thus the entire transmission should be ignored in order to avoid the FM2 performing any incorrect operation.

The CRC-16 calculation is an industry standard method used for error detection. An algorithm is included here to assist programmers in situations where no standard CRC-16 calculation routines are available.

CRC-16 Algorithm

Once the following algorithm is complete, the working register "A" will contain the CRC value to be transmitted. Note that this algorithm requires the characteristic polynomial to be reverse bit ordered. The MSBit of the characteristic polynomial is dropped since it does not affect the value of the remainder. The following symbols are used in the algorithm:

-->: data transfer;
A: 16-bit working register;
AL: low order byte of A;
AH: high order byte of A;
CRC: 16-bit CRC-16 value;
i and j: loop counters;
(+): logical exclusive-OR operator;
Di: i-th data byte (i = 0 to N – 1);
G: 16-bit characteristic polynomial = 1010000000000001 with MSbit dropped and bit order reversed;
shr(x): shift right (the LSbit of the low order byte of x shifts into a carry flag, a '0' is shifted into the MSbit of the high order byte of x, all other bits shift right one location

The algorithm is shown below:

```
1. FFFF hex --> A
2. 0 --> i
3. 0 --> j
4. Di (+) AL --> AL
5. j + 1 --> j
6. shr(A)
7. is there a carry?  No: go to 8; Yes: G (+) A --> A
8. is j = 8?  No: go to 5; Yes: go to 9.
9. i + 1 --> i
10. is i = N?  No: go to 3; Yes: go to 11.
11. A --> CRC
```

Timing

Data packet synchronization is maintained by timing constraints. The receiving device must measure the time between the reception of characters. If 3.5 character times elapse without a new character or completion of the packet, then the communication link must be reset (i.e. all slaves start listening for a new transmission from the master). Thus at 9600 baud a delay of greater than $3.5 \times 1 / 9600 \times 10 = 3.65$ ms will reset the communication link.

Modbus Functions

FM2 Supported Functions

The following functions are supported by the FM2:

- Function Code 01 - Read Coil Status
- Function Code 03 - Read Setpoints and Actual Values
- Function Code 04 - Read Setpoints and Actual Values
- Function Code 05 - Execute Operation
- Function Code 06 - Store Single Setpoint
- Function Code 07 - Read Device Status
- Function Code 08 - Loopback Test
- Function Code 10 - Store Multiple Setpoints

Function Code 01h

Modbus implementation: Read Coil Status
FM2 implementation: Read Last Command Operation

This function code allows the master to read back which command operation was last performed using Modbus function code 05: force single coil/execute operation. Upon request of coil/operation status, the FM2 will set a bit corresponding to the last operation performed. The operation commands are in the Modbus Data Formats table under code F22.

NOTE

Operation 0 will be set (1) if no operations have been performed since the FM2 has been powered up.

For example, a request slave 17 to respond with status of 6 operations, starting at operation 10, after performing command operation 13 (Manual Inhibit). For this example the data definition is as follows:

Data 1 = 08 (hex):	0	0	0	0	1	0	0	0
Command operation number:	N/A	N/A	15	14	13	12	11	10

The master/slave packet format is shown below:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	01	read last command operation
Operation Starting Address	2	00 0A	start at operation 10
Operations to Read	2	00 06	read 6 operations
CRC	2	9E 9A	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	01	read last command operation
Byte Count	1	01	6 operations = 6 bits only one byte is required
Data 1 (see definition above)	1	08	bit corresponding to command 13
CRC	2	54 8E	CRC error code

Function Code 03h

Modbus implementation: Read Holding Registers
FM2 implementation: Read Setpoints and Actual Values

For the FM2 implementation of Modbus, this command can be used to read any setpoints ('holding registers') or actual values ('input registers'). Holding and input registers are 16 bit (two byte) values transmitted high order byte first. Thus all FM2 setpoints and actual values are sent as two bytes. The maximum number of registers that can be read in one transmission is 125. This function code is identical to function code 04.

The slave response to this function code is the slave address, function code, a count of the number of data bytes to follow, the data itself and the CRC. Each data item is sent as a two byte number with the high order byte sent first.

For example, consider a request for slave 17 to respond with 3 registers starting at address 006B. For this example the register data in these addresses is as follows:

Address	Data
006B	022B
006C	0000
006D	0064

The master/slave packets have the following format:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	03	read registers
Data Starting Address	2	00 6B	data starting at 006B
Number of Setpoints	2	00 03	3 registers = 6 bytes total
CRC	2	76 87	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	03	read registers
Byte Count	1	06	3 registers = 6 bytes total
Data 1 (see definition above)	2	02 2B	value in address 006B
Data 2 (see definition above)	2	00 00	value in address 006C
Data 3 (see definition above)	2	00 64	value in address 006D
CRC	2	C8 BA	CRC error code

Function Code 04h

Modbus Implementation: Read Input Registers
FM2 implementation: Read Setpoints and Actual Values

For the FM2 implementation of Modbus, this command can be used to read any setpoints ('holding registers') or actual values ('input registers'). Holding and input registers are 16-bit (two byte) values transmitted high order byte first. Thus all FM2 setpoints and actual values are sent as two bytes. The maximum number of registers that can be read in one transmission is 125. This function code is identical to function code 03.

The slave response to this function code is the slave address, function code, a count of the data bytes to follow, the data itself and the CRC. Each data item is sent as a two byte number with the high order byte sent first.

For example, request slave 17 to respond with 1 register starting at address 0008. For this example the value in this register (0008) is 0000.

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	04	read registers
Data Starting Address	2	00 08	data starting at 0008
Number of Actual Values	2	00 01	1 register = 2 bytes
CRC	2	B2 98	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	04	read registers
Byte Count	1	02	1 registers = 2 bytes total
Data (see definition above)	2	00 00	value in address 0008
CRC	2	78 F3	CRC error code

Function Code 05h

Modbus Implementation: Force Single Coil
FM2 Implementation: Execute Operation

This function code allows the master to request a FM2 to perform specific command operations. The commands supported by the FM2 are listed in *Applications* on page 7–9.

For example, to request slave 17 to execute operation code 1 (reset), we have the following master/slave packet format:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	05	execute operation
Operation Code	2	00 01	operation code 1
Code Value	2	FF 00	perform function
CRC	2	DF 6A	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	05	execute operation
Operation Code	1	00 01	operation code 1 (reset)
Code Value	2	FF 00	perform reset
CRC	2	DF 6A	CRC error code

The commands that can be performed by the FM2 using function code 05 can also be initiated by using function code 10. See *Function Code 10h* on page 7–8 for an example of performing commands using function code 10.

Function Code 06h

Modbus Implementation: Preset Single Register
FM2 Implementation: Store Single Setpoint

This command allows the master to store a single setpoint into the memory of a FM2. The slave response to this function code is to echo the entire master transmission.

For example, request slave 17 to store the value 01F4 in setpoint address 1020. After the transmission in this example is complete, setpoints address 1020 will contain the value 01F4. The master/slave packet format is shown below:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	06	store single setpoint
Data Starting Address	2	10 20	setpoint address 1020
Data	2	01 F4	data for address 1020
CRC	2	8E 47	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	06	store single setpoint
Data Starting Address	1	10 20	setpoint address 1020
Data	2	01 F4	data in address 1020
CRC	2	8E 47	CRC error code

Function Code 07h

Modbus Implementation: Read Exception Status
FM2 Implementation: Read Device Status

This is a function used to quickly read the status of a selected device. A short message length allows for rapid reading of status. The status byte returned will have individual bits set to 1 or 0 depending on the status of the slave device. For this example, consider the following FM2 general status byte:

LSBit:	B0: Alarm condition = 1
	B1: Trip condition = 1
	B2: Internal fault = 1
	B3: Auto mode selected = 1
	B4: Contactor A N/O (input closed = 1, open = 0)
	B5: Contactor B N/O (input closed = 1, open = 0)
	B6: Programmable Relay 1 Status
MSBit:	B7: ESD Relay Status

The master/slave packets have the following format:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	07	read device status
CRC	2	4C 22	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	07	read device status
Device Status (see above)	1	2C	status = 00101100b
CRC	2	22 28	CRC error code

Function Code 08h

Modbus Implementation: Loopback Test
FM2 Implementation: Loopback Test

This function is used to test the integrity of the communication link. The FM2 will echo the request.

For example, consider a loopback test from slave 17:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	08	loopback test
Diagnostic Code	2	00 00	must be 0000h
Data	2	00 00	must be 0000h
CRC	2	E2 9B	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	08	loopback test
Diagnostic Code	2	00 00	must be 0000h
Data	2	00 00	must be 0000h
CRC	2	E2 9B	CRC error code

Function Code 10h

Modbus Implementation: Preset Multiple Registers
FM2 Implementation: Store Multiple Setpoints

This function code allows multiple setpoints to be stored into the FM2 memory. Modbus "registers" are 16-bit (two byte) values transmitted high order byte first. Thus all FM2 setpoints are sent as two bytes. The maximum number of setpoints that can be stored in one transmission is dependent on the slave device. Modbus allows up to a maximum of 60 holding registers to be stored. The FM2 response to this function code is to echo the slave address, function code, starting address, the number of setpoints stored, and the CRC.

Consider a request for slave 17 to store the value 01F4 to setpoint address 1020 and the value 2710 to setpoint address 1021. After the transmission in this example is complete, FM2 slave 17 will have the following setpoints information stored:

Address	Data
1020	01F4
1021	2710

The master/slave packets have the following format:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	10	store setpoints
Data Starting Address	2	10 20	setpoint address 1028h
Number of Setpoints	2	00 02	2 setpoints = 4 bytes total
Byte Count	1	04	4 bytes of data
Data 1	2	01 F4	data for address 1020h
Data 2	2	27 10	data for address 1021h
CRC	2	32 85	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	10	store setpoints
Data Starting Address	2	10 20	setpoint address 1020h
Number of Setpoints	2	00 02	2 setpoints
CRC	2	46 52	CRC error code

Error Responses

When a FM2 detects an error other than a CRC error, a response will be sent to the master. The MSBit of the function code byte will be set to 1 (i.e. the function code from the slave is equal to the function code sent from the master plus 128). The following byte will be an exception code indicating the type of error that occurred.

Transmissions received from the master with CRC errors will be ignored by the FM2. The slave response to an error (other than CRC error) will be:

SLAVE ADDRESS: 1 byte
FUNCTION CODE: 1 byte (with MSbit set to 1)
EXCEPTION CODE: 1 byte
CRC: 2 bytes

The FM2 implements the following exception response codes.

- 01 - ILLEGAL FUNCTION: The function code transmitted is not one of the functions supported by the FM2.
- 02 - ILLEGAL DATA ADDRESS: The address referenced in the data field transmitted by the master is not an allowable address for the FM2.
- 03 - ILLEGAL DATA VALUE: The value referenced in the data field transmitted by the master is not within range for the selected data address.

Applications

Performing Commands with Function Code 10h

Commands can be performed using function code 16 as well as function code 5. When using Function Code 16, the Command Function register must be written with a value of 5. The Command Operation register must be written with a valid command operation number. The Command Data registers must be written with valid data; this is dependent upon the command operation.

The commands supported by the FM2 are listed in *Data Formats* on page 7–21 under code F22.

For example, consider a request for slave 17 to perform command operation 1 (RESET): The master/slave packets have the following format:

Master Transmission	Bytes	Example	Description
Slave Address	1	11	message for slave 17
Function Code	1	10	store multiple setpoints
Data Starting Address	2	11 60	setpoint address 1160h
Number of Setpoints	2	00 02	2 setpoints = 4 bytes total
Byte Count	1	04	4 bytes of data
Data 1	2	00 05	data for address 1160h
Data 2	2	00 01	data for address 1161h
CRC	2	B0 D6	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	11	message from slave 17
Function Code	1	10	store multiple setpoints
Data Starting Address	2	11 60	setpoint address 1160h
Number of Setpoints	2	00 02	2 setpoints
CRC	2	46 7A	CRC error code

Storing Communications Addresses via the Broadcast Command

The default setting for the communications address from the factory and after a 'Setpoint Dump' is off. The communication speed and parity default settings are 9600 baud, no parity. We have provided a facility to store the communications address to any FM2 without using the keypad and display (typically chassis mount FM2s).

Make sure the master is transmitting to the FM2 at 9600 baud, no parity. After installing the FM2 and ensuring communications is hooked up, cycle control voltage to the FM2 you wish to set the address for. This will allow you to send a broadcast command with the new communications address for the FM2. The address must be set within 2 minutes of cycling power. Once the new address is stored or the 2 minutes have elapsed, the FM2 will ignore all further attempts at changing the communications address unless power is cycled again. The address is changed using a broadcast command to communications address 0 and a command function code.

For example, to store communications address 25 to a new FM2 without a display, we have the following master/slave packet format. The master/slave packets have the following format:

Master Transmission	Bytes	Example	Description
Slave Address	1	00	broadcast command, all units
Function Code	1	10	store setpoints
Data Starting Address	2	11 60	setpoint address 1160h
Number of Setpoints	2	00 03	3 setpoints = 6 bytes total
Byte Count	1	06	6 bytes of data
Data 1	2	00 05	data for address 1160h
Data 2	2	00 10	data for address 1161h
Data 3	2	00 19	data for address 1162h
CRC	2	BB 8C	CRC error code

Slave Response	Bytes	Example	Description
Slave Address	1	00	message from slave
Function Code	1	10	store setpoints
Data Starting Address	2	11 60	setpoint address 1160h
Number of Setpoints	2	00 03	3 setpoints
CRC	2	84 FB	CRC error code

Memory Map

Description

The data stored in the FM2 is grouped into two areas: setpoints and actual values. Setpoints can be read and written by a master computer. Actual values can be read only. All setpoints and actual values are stored as two byte values. That is, each register address is the address of a two byte value. Addresses are listed in hexadecimal. Data values (setpoint ranges, increments, factory values) are in decimal.

TABLE 7–1: Modbus Memory Map (Sheet 1 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
Actual Values (Input Registers) Addresses - 0000-0FFF									
PRODUCT ID	30001	0	0000	GE Product Device Code	---	---	---	F1	61
	30002	1	0001	Hardware Version Code	---	---	---	F4	current version
	30003	2	0002	Main Software Version Code	---	---	---	F1	current version
	30004	3	0003	Modification File Number	---	---	---	F1	mod. file no.
	30005	4	0004	Boot Software Version Code	---	---	---	F1	current version
	30006	5	0005	Supervisor Processor Version Code	---	---	---	F1	current version
	30007	6	0006	...Reserved...	...	...	...	...	...
	30008	7	0007	Serial Number char. 1 and 2	---	---	ASCII	F10	char. 1 and 2
	30009	8	0008	Serial Number char. 3 and 4	---	---	ASCII	F10	char. 1 and 2
	30010	9	0009	Serial Number char. 5 and 6	---	---	ASCII	F10	char. 1 and 2
	30011	10	000A	Serial Number char. 7 and 8	---	---	ASCII	F10	char. 1 and 2
	30012	11	000B	Manufacture Month/day	---	---	---	F33	manuf. mo./day
	30013	12	000C	Manufacture year	---	---	---	F34	manuf. year
	30014	13	000D	...Reserved...	...	...	...	...	...
	30015	14	000E	Display Processor F/W Version Code				F1	current version
	30016	15	000F	...Reserved...	...	...	...	...	...
STATUS	30017	16	0010	Switch Input Status	---	---	---	F100	N/A
	30018	17	0011	LED Status Flags 1	---	---	---	F101	N/A
	30019	18	0012	LED Status Flags 2	---	---	---	F102	N/A
	30020	19	0013	Operation Status Flags	---	---	---	F103	N/A
	30021	20	0014	General Alarm Active Status Flags 1	---	---	---	F104	N/A
	30022	21	0015	General Alarm Active Status Flags 2	---	---	---	F105	N/A
	30023	22	0016	Interlock Alarm Active Status Flags	---	---	---	F106	N/A
	30024	23	0017	General Alarm Pickup Status Flags 1	---	---	---	F104	N/A
	30025	24	0018	General Alarm Pickup Status Flags 2	---	---	---	F105	N/A
	30026	25	0019	Interlock Alarm Pickup Status Flags	---	---	---	F106	N/A
	30027	26	001A	Interlock Close Block Status Flags	---	---	---	F106	N/A
	30028	27	001B	Trip Active Status Flags 1	---	---	---	F107	N/A
	30029	28	001C	Trip Active Status Flags 2	---	---	---	F108	N/A
	30030	29	001D	Trip Pickup Status Flags 1	---	---	---	F107	N/A
	30031	30	001E	Trip Pickup Status Flags 2	---	---	---	F108	N/A
	30032	31	001F	Close Status Flags	---	---	---	F109	N/A
	30033	32	0020	Speed Status Flags	---	---	---	F110	N/A
	30034	33	0021	Interlock Open	---	---	---	F5	N/A
	30035	34	0022	Command Mode	---	---	---	F6	N/A
	30036	35	0023	Feeder Status	---	---	---	F7	N/A
	30037	36	0024	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30048	47	002F	...Reserved...	...	...	...	...	...

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 2 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
FEEDER DATA	30049	48	0030	Phase Current Scale Factor	---	---	---	F1	N/A
	30050	49	0031	Phase R Current	---	---	**	F1	N/A
	30051	50	0032	Phase Y Current	---	---	**	F1	N/A
	30052	51	0033	Phase B Current	---	---	**	F1	N/A
	30053	52	0034	Earth Current	---	---	0.1 x A	F1	N/A
	30054	53	0035	Feeder Load	---	---	%FLC	F1	N/A
	30055	54	0036	Thermal Capacity	---	---	%	F1	N/A
	30056	55	0037	Current Imbalance	---	---	%	F1	N/A
	30057	56	0038	...Reserved...	...	...	...	...	...
	30058	57	0039	...Reserved...	...	...	...	...	...
	30059	58	003A	...Reserved...	...	...	...	...	...
	30060	59	003B	Power - high order	---	---	0.1 x kW	F3	N/A
	30061	60	003C	Power - low order	---	---	0.1 x kW	F3	N/A
	30062	61	003D	Power (scaled)	---	---	kW	F21	N/A
	30063	62	003E	Energy Used - high order	---	---	0.1 xkWh	F2	N/A
	30064	63	003F	Energy Used - low order	---	---	0.1 xkWh	F2	N/A
	30065	64	0040	Voltage	---	---	V	F1	N/A
	30066	65	0041	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30080	79	004F	...Reserved...	...	...	...	...	...
TRIP DATA	30081	80	0050	Cause of Trip	---	---	---	F9	N/A
	30082	81	0051	Time to Reset	---	---	min.	F1	N/A
	30083	82	0052	Pre Trip Phase R Current	---	---	**	F1	N/A
	30084	83	0053	Pre Trip Phase Y Current	---	---	**	F1	N/A
	30085	84	0054	Pre Trip Phase B Current	---	---	**	F1	N/A
	30086	85	0055	Pre Trip Earth Current	---	---	0.1 x A	F1	N/A
	30087	86	0056	...Reserved...	...	...	...	...	...
	30088	87	0057	...Reserved...	...	...	...	...	...
MAINTEN-ANCE TIMERS	30089	88	0058	Operating Time	---	---	hr.	F1	0
	30090	89	0059	Opened Time	---	---	hr.	F1	0
	30091	90	005A	Operating Time Since Last Close	---	---	hr.	F1	0
	30092	91	005B	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30110	109	006D	...Reserved...	...	...	...	...	...
MAINTEN-ANCE COUNTERS	30097	96	0060	Number of Operations - high order	---	---	---	F2	0
	30098	97	0061	Number of Operations - low order	---	---	---	F2	0
	30099	98	0062	Total Trips	---	---	---	F1	0
	30100	99	0063	...Reserved...	...	...	...	...	...
	30101	100	0064	...Reserved...	...	...	...	...	...
	30102	101	0065	Earth Fault Trips	---	---	---	F1	0
	30103	102	0066	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30107	106	006A	...Reserved...	...	...	...	...	...
	30108	107	006B	Control Command Trips	---	---	---	F1	0
	30109	108	006C	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30112	111	006F	...Reserved...	...	...	...	...	...

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 3 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
TIMERS	30113	112	0070	Undervoltage Reclose Timer	---	---	0.1 x s	F1	N/A
	30114	113	0071	Programmable Relay Timer	---	---	s	F1	N/A
	30115	114	0072	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30128	127	007F	...Reserved...	...	...	...	...	...
DEBUG DATA	30129	128	0080	ADC Reference	---	---	---	F1	N/A
	30130	129	0081	...Reserved...	...	...	...	...	...
	30131	130	0082	Power Loss Fine Time	---	---	10 ms	F1	N/A
	30132	131	0083	Power Loss Coarse Time	---	---	0.1 min	F1	N/A
	30133	132	0084	Current key press	---	---	---	F24	N/A
	30134	133	0085	...Reserved...	...	...	...	...	...
	30135	134	0086	Phase R Current (fast update)	---	---	**	F1	N/A
	30136	135	0087	Phase Y Current (fast update)	---	---	**	F1	N/A
	30137	136	0088	Phase B Current (fast update)	---	---	**	F1	N/A
	30138	137	0089	Earth Current (fast update)	---	---	0.1 x A	F1	N/A
	30139	138	008A	Voltage (fast update)	---	---	V	F1	N/A
	30140	139	008B	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30144	143	008F	...Reserved...	...	...	...	...	...
	30145	144	0090	Message Buffer characters 1 and 2	---	---	ASCII	F10	N/A
	30146	145	0091	Message Buffer characters 3 and 4	---	---	ASCII	F10	N/A
	30147	146	0092	Message Buffer characters 5 and 6	---	---	ASCII	F10	N/A
	30148	147	0093	Message Buffer characters 7 and 8	---	---	ASCII	F10	N/A
	30149	148	0094	Message Buffer characters 9 and 10	---	---	ASCII	F10	N/A
	30150	149	0095	Msg. Buffer characters 11 and 12	---	---	ASCII	F10	N/A
	30151	150	0096	Msg. Buffer characters 13 and 14	---	---	ASCII	F10	N/A
	30152	151	0097	Msg. Buffer characters 15 and 16	---	---	ASCII	F10	N/A
	30153	152	0098	Msg. Buffer characters 17 and 18	---	---	ASCII	F10	N/A
	30154	153	0099	Msg. Buffer characters 19 and 20	---	---	ASCII	F10	N/A
	30155	154	009A	Msg. Buffer characters 21 and 22	---	---	ASCII	F10	N/A
	30156	155	009B	Msg. Buffer characters 23 and 24	---	---	ASCII	F10	N/A
	30157	156	009C	Msg. Buffer characters 25 and 26	---	---	ASCII	F10	N/A
	30158	157	009D	Msg. Buffer characters 27 and 28	---	---	ASCII	F10	N/A
	30159	158	009E	Msg. Buffer characters 29 and 30	---	---	ASCII	F10	N/A
	30160	159	009F	Msg. Buffer characters 31 and 32	---	---	ASCII	F10	N/A
	30161	160	00A0	Msg. Buffer characters 33 and 34	---	---	ASCII	F10	N/A
	30162	161	00A1	Msg. Buffer characters 35 and 36	---	---	ASCII	F10	N/A
	30163	162	00A2	Msg. Buffer characters 37 and 38	---	---	ASCII	F10	N/A
	30164	163	00A3	Msg. Buffer characters 39 and 40	---	---	ASCII	F10	N/A
	30165	164	00A4	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30256	255	00FF	...Reserved...	...	...	...	...	...
USER DEFINED DATA	30257	256	0100	User Definable Data 0000					
	30258	257	0101	User Definable Data 0001					
	30259	258	0102	User Definable Data 0002					
	30260	259	0103	User Definable Data 0003					
	30261	260	0104	User Definable Data 0004					
	30262	261	0105	User Definable Data 0005					
	30263	262	0106	User Definable Data 0006					
	30264	263	0107	User Definable Data 0007					

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 4 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
USER DEFINED DATA con't	30265	264	0108	User Definable Data 0008					
	30266	265	0109	User Definable Data 0009					
	30267	266	010A	User Definable Data 000A					
	30268	267	010B	User Definable Data 000B					
	30269	268	010C	User Definable Data 000C					
	30270	269	010D	User Definable Data 000D					
	30271	270	010E	User Definable Data 000E					
	30272	271	010F	User Definable Data 000F					
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	30376	375	0177	User Definable Data 0077					
Setpoint Values (Holding Registers) Addresses - 1000-1FFF									
FEEDER ID	44097	4096	1000	Feeder Name characters 1 and 2	32-127	1	ASCII	F10	"MO"
	44098	4097	1001	Feeder Name characters 3 and 4	32-127	1	ASCII	F10	"TO"
	44099	4098	1002	Feeder Name characters 5 and 6	32-127	1	ASCII	F10	"R "
	44100	4099	1003	Feeder Name characters 7 and 8	32-127	1	ASCII	F10	" "
	44101	4100	1004	Feeder Name characters 9 and 10	32-127	1	ASCII	F10	" "
	44102	4101	1005	Feeder Name characters 11 and 12	32-127	1	ASCII	F10	" "
	44103	4102	1006	Feeder Name characters 13 and 14	32-127	1	ASCII	F10	" "
	44104	4103	1007	Feeder Name characters 15 and 16	32-127	1	ASCII	F10	" "
	44105	4104	1008	Feeder Name characters 17 and 18	32-127	1	ASCII	F10	" "
	44106	4105	1009	Feeder Name characters 19 and 20	32-127	1	ASCII	F10	" "
	44107	4106	100A	Feeder Rating	1-2501	1	A	F1*	100
	44108	4107	100B	...Reserved...	...	...	...	...	...
	44109	4108	100C	System Supply Voltage	110-12000	1	V	F1	415
	44110	4109	100D	...Reserved...	...	...	...	...	...
	44111	4110	100E	...Reserved...	...	...	...	...	...
	44112	4111	100F	...Reserved...	...	...	...	...	...
	44113	4112	1010	Feeder Type	2-8	---	---	F11	2 = Contactor
	44114	4113	1011	...Reserved...	...	...	...	...	...
	44115	4114	1012	ACB Pulse Time	5-600	5	0.1 x s	F1*	5 = 0.5 s
	44116	4114	1013	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44128	4127	101F	...Reserved...	...	...	...	...	...
CT/VT INPUTS	44129	4128	1020	Phase CT Primary	1-2500	1	A	F1†	100
	44130	4129	1021	...Reserved...	...	...	...	...	...
	44131	4130	1022	Phase CT Connection Type	0-1	1	---	F12	0 = 3 CTs
	44132	4131	1023	Earth Fault CT Input	0-1	1	---	F13	0=50:0.025
	44133	4132	1024	VT Primary Voltage	110-12001	1	---	F1*	12001 = OFF
	44134	4133	1025	VT Connection Type	0-1	1	---	F15	0= Phase (A-N)
	44135	4134	1026	VT Secondary Voltage	110-240	10	V	F1	110
	44136	4135	1027	Nominal Frequency	50-60	10	Hz	F1	50
	44137	4136	1028	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44144	4143	102F	...Reserved...	...	...	...	...	...
FAULT MODE	44145	4144	1030	Internal Fault Trip	0-1	1	---	F14	1 = ENABLE
	44146	4145	1031	Serial Comms Failure Trip	5-30	5	---	F1*	30 = OFF
	44147	4146	1032	Serial Comms Failure Alarm	5-30	5	---	F1*	30 = OFF
	44148	4147	1033	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44152	4151	1037	...Reserved...	...	...	...	...	...

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 5 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
FEEDER PROTEC-TION THERMAL	44153	4152	1038	...Reserved...	...	...	...	...	...
	44154	4153	1039	...Reserved...	...	...	...	...	...
	44155	4154	103A	Overload Curve Number	0-3	1	---	F28	0
	44156	4155	103B	...Reserved...	...	...	...	...	...
	44157	4156	103C	...Reserved...	...	...	...	...	...
	44158	4157	103D	...Reserved...	...	...	...	...	...
	44159	4158	103E	...Reserved...	...	...	...	...	...
	44160	4159	103F	Curve Multiplier	5-10	1	0.1	F1	10 = 1.0
FEEDER PROTEC-TION EARTH FAULT	44161	4160	1040	Earth Fault Alarm Level (5 A CT)	10-105	5	% FLC	F1*	65535 = OFF
	44162	4161	1041	Earth Fault Alarm Level (50:0.025 CT)	5-155	5	0.1 x A	F1*	65535 = OFF
	44163	4162	1042	Earth Fault Alarm Delay	1-60	1	s	F1	10
	44164	4163	1043	Earth Fault Trip Level (residual)	10-105	5	% FLC	F1*	65535 = OFF
	44165	4164	1044	Earth Fault Trip Level (50:0.025 CT)	5-155	5	0.1 x A	F1*	65535 = OFF
	44166	4165	1045	Earth Fault Trip Delay	0-50	1	0.1 x s	F1	10 = 1.0
	44167	4166	1046	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44192	4191	105F	...Reserved...	...	...	...	...	...
CONFIG. INPUTS	44193	4192	1060	Interlock Input 1 Function	0-27	1	---	F17	0 = NOT USED
	44194	4193	1061	Startup Override Delay	0-126	1	s	F1*	0
	44195	4194	1062	Running Override Delay	0-126	1	s	F1*	0
	44196	4195	1063	Operation	0-1	1	---	F18	0 = IL STOP
	44197	4196	1064	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44198	4197	1065	...Reserved...	...	...	...	...	...
	44199	4198	1066	...Reserved...	...	...	...	...	...
	44200	4199	1067	...Reserved...	...	...	...	...	...
	44201	4200	1068	Interlock Input 2 Function	0-27	1	---	F17	0 = NOT USED
	44202	4201	1069	Startup Override Delay	0-126	1	s	F1*	0
	44203	4202	106A	Running Override Delay	0-126	1	s	F1*	0
	44204	4203	106B	Operation	0-1	1	---	F18	0 = IL STOP
	44205	4204	106C	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44206	4205	106D	...Reserved...	...	...	...	...	...
	44207	4206	106E	...Reserved...	...	...	...	...	...
	44208	4207	106F	...Reserved...	...	...	...	...	...
	44209	4208	1070	Interlock Input 3 Function	0-27	1	---	F17	0 = NOT USED
	44210	4209	1071	Startup Override Delay	0-126	1	s	F1*	0
	44211	4210	1072	Running Override Delay	0-126	1	s	F1*	0
	44212	4211	1073	Operation	0-1	1	---	F18	0 = IL STOP
	44213	4212	1074	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44214	4213	1075	...Reserved...	...	...	...	...	...
	44215	4214	1076	...Reserved...	...	...	...	...	...
	44216	4215	1077	...Reserved...	...	...	...	...	...
	44217	4216	1078	Interlock Input 4 Function	0-27	1	---	F17	0 = NOT USED
	44218	4217	1079	Startup Override Delay	0-126	1	s	F1*	0
	44219	4218	107A	Running Override Delay	0-126	1	s	F1*	0
	44220	4219	107B	Operation	0-1	1	---	F18	0 = IL STOP
	44221	4220	107C	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44222	4221	107D	...Reserved...	...	...	...	...	...
	44223	4222	107E	...Reserved...	...	...	...	...	...
	44224	4223	107F	...Reserved...	...	...	...	...	...
	44225	4224	1080	Interlock Input 5 Function	0-27	1	---	F17	0 = NOT USED

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 6 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
CONFIG. INPUTS con't	44226	4225	1081	Startup Override Delay	0-126	1	s	F1*	0
	44227	4226	1082	Running Override Delay	0-126	1	s	F1*	0
	44228	4227	1083	Operation	0-1	1	---	F18	0 = IL STOP
	44229	4228	1084	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44230	4229	1085	...Reserved...	...	...	...	...	...
	44231	4230	1086	...Reserved...	...	...	...	...	...
	44232	4231	1087	...Reserved...	...	...	...	...	...
	44233	4232	1088	Interlock Input 6 Function	0-27	1	---	F17	0 = NOT USED
	44234	4233	1089	Startup Override Delay	0-126	1	s	F1 *	0
	44235	4234	108A	Running Override Delay	0-126	1	s	F1*	0
	44236	4235	108B	Operation	0-1	1	---	F18	0 = IL STOP
	44237	4236	108C	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44238	4237	108D	...Reserved...	...	...	...	...	...
	44239	4238	108E	...Reserved...	...	...	...	...	...
	44240	4239	108F	...Reserved...	...	...	...	...	...
	44241	4240	1090	Interlock Input 7 Function	0-27	1	---	F17	0 = NOT USED
	44242	4241	1091	Startup Override Delay	0-126	1	s	F1*	0
	44243	4242	1092	Running Override Delay	0-126	1	s	F1*	0
	44244	4243	1093	Operation	0-1	1	---	F18	0 = IL STOP
	44245	4244	1094	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44246	4245	1095	...Reserved...	...	...	...	...	...
	44247	4246	1096	...Reserved...	...	...	...	...	...
	44248	4247	1097	...Reserved...	...	...	...	...	...
	44249	4248	1098	Interlock Input 8 Function	0-27	1	---	F17	0 = NOT USED
	44250	4249	1099	Startup Override Delay	0-126	1	s	F1*	0
	44251	4250	109A	Running Override Delay	0-126	1	s	F1*	0
	44252	4251	109B	Operation	0-1	1	---	F18	0 = IL STOP
	44253	4252	109C	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44254	4253	109D	...Reserved...	...	...	...	...	...
	44255	4254	109E	...Reserved...	...	...	...	...	...
	44256	4255	109F	...Reserved...	...	...	...	...	...
	44257	4256	10A0	Interlock Input 9 Function	0-27	1	---	F17	0 = NOT USED
	44258	4257	10A1	Startup Override Delay	0-126	1	s	F1*	0
	44259	4258	10A2	Running Override Delay	0-126	1	s	F1*	0
	44260	4259	10A3	Operation	0-1	1	---	F18	0 = IL STOP
	44261	4260	10A4	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44262	4261	10A5	...Reserved...	...	...	...	...	...
	44263	4262	10A6	...Reserved...	...	...	...	...	...
	44264	4263	10A7	...Reserved...	...	...	...	...	...
	44265	4264	10A8	Interlock Input 10 Function	0-27	1	---	F17	0 = NOT USED
	44266	4265	10A9	Startup Override Delay	0-126	1	s	F1*	0
	44267	4266	10AA	Running Override Delay	0-126	1	s	F1*	0
	44268	4267	10AB	Operation	0-1	1	---	F18	0 = IL STOP
	44269	4268	10AC	Instantaneous Alarm	0-1	1	---	F14	0 = DISABLE
	44270	4269	10AD	...Reserved...	...	...	...	...	...
	44271	4270	10AE	...Reserved...	...	...	...	...	...
	44272	4271	10AF	...Reserved...	...	...	...	...	...

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 7 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
PROCESS INTERLOCK NAMES	44273	4272	10B0	Process Intlk A Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44274	4273	10B1	Process Intlk A Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44275	4274	10B2	Process Intlk A Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44276	4275	10B3	Process Intlk A Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44277	4276	10B4	Process Intlk A Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44278	4277	10B5	Process Intlk A Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44279	4278	10B6	Process Intlk A Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44280	4279	10B7	Process Intlk A Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44281	4280	10B8	Process Intlk A Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44282	4281	10B9	Process Intlk A Name chars 19 and 20	32-127	1	ASCII	F10	"A "
	44283	4282	10BA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44288	4287	10BF	...Reserved...	...	...	...	...	...
	44289	4288	10C0	Process Intlk B Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44290	4289	10C1	Process Intlk B Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44291	4290	10C2	Process Intlk B Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44292	4291	10C3	Process Intlk B Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44293	4292	10C4	Process Intlk B Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44294	4293	10C5	Process Intlk B Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44295	4294	10C6	Process Intlk B Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44296	4295	10C7	Process Intlk B Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44297	4296	10C8	Process Intlk B Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44298	4297	10C9	Process Intlk B Name chars 19 and 20	32-127	1	ASCII	F10	"B "
	44299	4298	10CA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44304	4303	10CF	...Reserved...	...	...	...	...	...
	44305	4304	10D0	Process Intlk C Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44306	4305	10D1	Process Intlk C Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44307	4306	10D2	Process Intlk C Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44308	4307	10D3	Process Intlk C Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44309	4308	10D4	Process Intlk C Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44310	4309	10D5	Process Intlk C Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44311	4310	10D6	Process Intlk C Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44312	4311	10D7	Process Intlk C Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44313	4312	10D8	Process Intlk C Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44314	4313	10D9	Process Intlk C Name chars 19 and 20	32-127	1	ASCII	F10	"C "
	44315	4314	10DA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44320	4319	10DF	...Reserved...	...	...	...	...	...
	44321	4320	10E0	Process Intlk D Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44322	4321	10E1	Process Intlk D Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44323	4322	10E2	Process Intlk D Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44324	4323	10E3	Process Intlk D Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44325	4324	10E4	Process Intlk D Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44326	4325	10E5	Process Intlk D Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44327	4326	10E6	Process Intlk D Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44328	4327	10E7	Process Intlk D Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44329	4328	10E8	Process Intlk D Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44330	4329	10E9	Process Intlk D Name chars 19 and 20	32-127	1	ASCII	F10	"D "

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 8 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
	44331	4330	10EA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44336	4335	10EF	...Reserved...	...	...	...	...	...
FIELD OPEN	44337	4336	10F0	Field Open Mode	0-1		---	F19	0=Unlatched
	44338	4337	10F1	ESD Open Mode	0-1		---	F19	0=Unlatched
	44339	4338	10F2	Faceplate Open	0-1		---	F19	0=Unlatched
	44340	4339	10F3	Process Open	0-1		---	F19	0=Unlatched
	44341	4340	10F4	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44384	4383	111F	...Reserved...	...	...	...	...	...
UNDER-VOLTAGE AUTO RECLOSE	44385	4384	1120	Undervoltage Reclose	0-1	1	---	F14	1 = ENABLE
	44386	4385	1121	Immediate Reclose Power Loss Time	100-520	20	ms	F1*	200
	44387	4386	1122	Delay 1 Reclose Power Loss Time	1-101	1	0.1 x s	F1***	20 = 2.0 s
	44388	4387	1123	Delay 1 Reclose Time Delay	2-3000	2	0.1 x s	F1	20 = 2.0 s
	44389	4388	1124	Delay 2 Reclose Power Loss Time	5-605	5	0.1 x min	F1*	65535 = OFF
	44390	4389	1125	Delay 2 Reclose Time Delay	2-3002	2	0.1 x s	F1*	65535 = OFF
	44391	4390	1126	...Reserved...	...	...	...	...	...
	44392	4391	1127	...Reserved...	...	...	...	...	...
PROGRA-MMABLE RELAY	44393	4392	1128	Programmable Relay 1 Function	0-33	1	---	F20	1 = TRIPS
	44394	4393	1129	Programmable Relay 1 Delay	0-125	1	s	F1	5
	44395	4394	112A	Energise on Feeder Close Delay	0-125	1	s	F1	5
	44396	4395	112B	De-Energise on Feeder Open Delay	0-125	1	s	F1	5
	44397	4396	112C	Load Sensing	10-101	1	%FLC	F1*	65535 = OFF
	44398	4397	112D	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44401	4400	1130	...Reserved...	...	...	...	...	...
MONITOR-ING	44402	4401	1131	Contactor Inspection Interval	50-10010	10	× 1000 op	F1*	65535 = OFF
	44403	4402	1132	...Reserved...	...	...	...	...	...
				↓	↓	↓	↓	↓	↓
	44408	4407	1137	...Reserved...	...	...	...	...	...
FACTORY SERVICE	44409	4408	1138	Reset Lockout Using RESET Key	0-1	1	---	F14	1 = ENABLE
COMMS	44410	4409	1139	Modbus Baud Rate	0-4	1	---	F25	4 = 19200
FACTORY SERVICE	44411	4410	113A	Manual/Auto Keys	0-1	1	---	F14	1 = Enable
	44412	4411	113B	Close A Key	0-1	1	---	F14	1 = Enable
	44413	4412	113C	Close B Key	0-1	1	---	F14	1 = Enable
	44414	4413	113D	Close Switch Input	0-1	1	---	F14	1 = Enable
UV	44415	4414	113E	Undervoltage Pickup Level	300-950	1	---	F1	900
	44416	4415	113F	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44424	4423	1147	...Reserved...	...	...	...	...	...
FLASH MESSAGE	44425	4424	1148	Flash message characters 1 and 2	32-255	1	ASCII	F10	" "
	44426	4425	1149	Flash message characters 3 and 4	32-255	1	ASCII	F10	" "
	44427	4426	114A	Flash message characters 5 and 6	32-255	1	ASCII	F10	" "
	44428	4427	114B	Flash message characters 7 and 8	32-255	1	ASCII	F10	" "
	44429	4428	114C	Flash message characters 9 and 10	32-255	1	ASCII	F10	" "
	44430	4429	114D	Flash message characters 11 and 12	32-255	1	ASCII	F10	" "
	44431	4430	114E	Flash message characters 13 and 14	32-255	1	ASCII	F10	" "
	44432	4431	114F	Flash message characters 15 and 16	32-255	1	ASCII	F10	" "
	44433	4432	1150	Flash message characters 17 and 18	32-255	1	ASCII	F10	" "

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
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~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 9 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
FLASH MESSAGE continued	44434	4433	1151	Flash message characters 19 and 20	32-255	1	ASCII	F10	" "
	44435	4434	1152	Flash message characters 21 and 22	32-255	1	ASCII	F10	" "
	44436	4435	1153	Flash message characters 23 and 24	32-255	1	ASCII	F10	" "
	44437	4436	1154	Flash message characters 25 and 26	32-255	1	ASCII	F10	" "
	44438	4437	1155	Flash message characters 27 and 28	32-255	1	ASCII	F10	" "
	44439	4438	1156	Flash message characters 29 and 30	32-255	1	ASCII	F10	" "
	44440	4439	1157	Flash message characters 31 and 32	32-255	1	ASCII	F10	" "
	44441	4440	1158	Flash message characters 33 and 34	32-255	1	ASCII	F10	" "
	44442	4441	1159	Flash message characters 35 and 36	32-255	1	ASCII	F10	" "
	44443	4442	115A	Flash message characters 37 and 38	32-255	1	ASCII	F10	" "
	44444	4443	115B	Flash message characters 39 and 40	32-255	1	ASCII	F10	" "
	44445	4444	115C	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44448	4447	115F	...Reserved...	...	...	...	...	...
COM-MANDS	44449	4448	1160	Command Function Code	5	---	---	F1	5
	44450	4449	1161	Command Operation Code	1-32	1	---	F22	0
	44451	4450	1162	Command Data 1	0-65535	1	---	F1/F23/F26	0
	44452	4451	1163	Command Data 2	0-65535	1	---	F1	0
	44453	4452	1164	Command Data 3	0-65535	1	---	F1	0
	44454	4453	1165	Command Data 4	0-65535	1	---	F1	0
	44455	4454	1166	Command Data 5	0-65535	1	---	F1	0
	44456	4455	1167	Command Data 6	0-65535	1	---	F1	0
	44457	4456	1168	Command Data 7	0-65535	1	---	F1	0
	44458	4457	1169	Command Data 8	0-65535	1	---	F1	0
	44459	4458	116A	Command Data 9	0-65535	1	---	F1	0
	44460	4459	116B	Command Data 10	0-65535	1	---	F1	0
	44461	4460	116C	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44464	4463	116F	...Reserved...	...	...	...	...	...
PROCESS INTERLOCK NAMES	44465	4464	1170	Process Intlk E Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44466	4465	1171	Process Intlk E Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44467	4466	1172	Process Intlk E Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44468	4467	1173	Process Intlk E Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44469	4468	1174	Process Intlk E Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44470	4469	1175	Process Intlk E Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44471	4470	1176	Process Intlk E Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44472	4471	1177	Process Intlk E Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44473	4472	1178	Process Intlk E Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44474	4460	116C	Process Intlk E Name chars 19 and 20	32-127	1	ASCII	F10	"E "
	44475	4461	116D	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44480	4479	117F	...Reserved...	...	...	...	...	...
	44481	4480	1180	Process Intlk F Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44482	4481	1181	Process Intlk F Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44483	4482	1182	Process Intlk F Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44484	4483	1183	Process Intlk F Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44485	4484	1184	Process Intlk F Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44486	4485	1185	Process Intlk F Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44487	4486	1186	Process Intlk F Name chars 13 and 14	32-127	1	ASCII	F10	"RL"

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 10 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
PROCESS INTERLOCK NAMES continued	44488	4487	1187	Process Intlk F Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44489	4488	1188	Process Intlk F Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44490	4489	1189	Process Intlk F Name chars 19 and 20	32-127	1	ASCII	F10	"F "
	44491	4490	118A	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44496	4495	118F	...Reserved...	...	...	...	...	...
	44497	4496	1190	Process Intlk G Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44498	4497	1191	Process Intlk G Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44499	4498	1192	Process Intlk G Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44500	4499	1193	Process Intlk G Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44501	4500	1194	Process Intlk G Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44502	4501	1195	Process Intlk G Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44503	4502	1196	Process Intlk G Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44504	4503	1197	Process Intlk G Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44505	4504	1198	Process Intlk G Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44506	4505	1199	Process Intlk G Name chars 19 and 20	32-127	1	ASCII	F10	"G "
	44507	4506	119A	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44512	4511	119F	...Reserved...	...	...	...	...	...
	44513	4512	11A0	Process Intlk H Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44514	4513	11A1	Process Intlk H Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44515	4514	11A2	Process Intlk H Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44516	4515	11A3	Process Intlk H Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44517	4516	11A4	Process Intlk H Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44518	4517	11A5	Process Intlk H Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44519	4518	11A6	Process Intlk H Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44520	4519	11A7	Process Intlk H Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44521	4520	11A8	Process Intlk H Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44522	4521	11A9	Process Intlk H Name chars 19 and 20	32-127	1	ASCII	F10	"H "
	44523	4522	11AA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44528	4527	11AF	...Reserved...	...	...	...	...	...
	44529	4528	11B0	Process Intlk I Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44530	4529	11B1	Process Intlk I Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44531	4530	11B2	Process Intlk I Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44532	4531	11B3	Process Intlk I Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44533	4532	11B4	Process Intlk I Name chars 9 and 10	32-127	1	ASCII	F10	"IN"
	44534	4533	11B5	Process Intlk I Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44535	4534	11B6	Process Intlk I Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44536	4535	11B7	Process Intlk I Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44537	4536	11B8	Process Intlk I Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44538	4537	11B9	Process Intlk I Name chars 19 and 20	32-127	1	ASCII	F10	"I "
	44538	4538	11BA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44544	4543	11BF	...Reserved...	...	...	...	...	...
	44545	4544	11C0	Process Intlk J Name chars 1 and 2	32-127	1	ASCII	F10	"PR"
	44546	4545	11C1	Process Intlk J Name chars 3 and 4	32-127	1	ASCII	F10	"OC"
	44547	4546	11C2	Process Intlk J Name chars 5 and 6	32-127	1	ASCII	F10	"ES"
	44548	4547	11C3	Process Intlk J Name chars 7 and 8	32-127	1	ASCII	F10	"S "
	44549	4548	11C4	Process Intlk J Name chars 9 and 10	32-127	1	ASCII	F10	"IN"

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

TABLE 7–1: Modbus Memory Map (Sheet 11 of 11)

Group	Mod-icon	Address		Description	Range	Step Value	Units / Scale	For-mat	Default Value
		Dec	Hex						
PROCESS INTERLOCK NAMES continued	44550	4549	11C5	Process Intlk J Name chars 11 and 12	32-127	1	ASCII	F10	"TE"
	44551	4550	11C6	Process Intlk J Name chars 13 and 14	32-127	1	ASCII	F10	"RL"
	44552	4551	11C7	Process Intlk J Name chars 15 and 16	32-127	1	ASCII	F10	"OC"
	44553	4552	11C8	Process Intlk J Name chars 17 and 18	32-127	1	ASCII	F10	"K "
	44554	4553	11C9	Process Intlk J Name chars 19 and 20	32-127	1	ASCII	F10	"J "
	44555	4554	11CA	...Reserved...	...	...	...	...	...
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44736	4735	127F	...Reserved...	...	...	...	...	...
USER-DEFINED MEMORY	44737	4736	1280	Address - User Definable Data 0100	0-12FF	1	---	F1	0
	44738	4737	1281	Address - User Definable Data 0101	0-12FF	1	---	F1	0
	44739	4738	1282	Address - User Definable Data 0102	0-12FF	1	---	F1	0
	44740	4739	1283	Address - User Definable Data 0103	0-12FF	1	---	F1	0
	↓	↓	↓	↓	↓	↓	↓	↓	↓
	44856	4855	12F7	Address - User Definable Data 0177	0-12FF	1	---	F1	0

Notes: * – Maximum setpoint value and 65535 represent OFF; ** – 1/Phase Current Scale Factor x A
*** – 101 represents unlimited; † – Minimum setpoint value represents OFF
†† – This register is only applicable to units with the VFD display
~* – 0.1 x A when Hi resolution mode is disabled; 0.01 x A when enabled

Data Formats

TABLE 7–2: Data Formats (Sheet 1 of 8)

Code	Description	Bitmask
F1	**Unsigned Integer: Numerical Data**	FFFF
F2	**Unsigned Long Integer: Numerical Data**	FFFFFFFF
F3	**Signed Long Integer: Numerical Data**	FFFFFFFF
F4	**Hardware Version Code**	---
	1 = A	---
	↓	↓
	26 = Z	---
F5	**Unsigned Integer: Interlock Open**	FFFF
	0 = No Interlock Open	---
	1 = Interlock A Open	---
	2 = Interlock B Open	---
	3 = Interlock C Open	---
	4 = Interlock D Open	---
	5 = External Open	---
	6 = ESD Open	---
	7 = Interlock E Open	---
	8 = Interlock F Open	---
	9 = Interlock G Open	---
	10 = Interlock H Open	---
	11 = Interlock I Open	---
	12 = Interlock J Open	---
F6	**Unsigned Integer: Command Mode**	FFFF
	0 = Manual	---
	1 = Auto	---
	2 = Manual Inhibit	---
	3 = Manual and Auto	---
	4 = Hard-Wire Auto	---

TABLE 7–2: Data Formats (Sheet 2 of 8)

Code	Description	Bitmask
F7	**Unsigned Integer - Feeder Status**	FFFF
	0 = Unavailable	---
	1 = Available - Auto	---
	2 = Available - Manual	---
	3 = Available (Manual and Auto)	---
	4 = Closed	---
	5 = ESD Trip/Open (Mod)	---
	6 = Test Mode	---
F9	Unsigned Integer - Cause of Trip	FFFF
	0 = No Trip	---
	1 = Process Interlock A	---
	2 = Process Interlock B	---
	3 = Process Interlock C	---
	4 = Process Interlock D	---
	5 = Faceplate Open	---
	6 = Process Open	---
	11 = Overload	---
	15 = Earth Fault	---
	17 = ESD Open	---
	18 = Local Isolator	---
	19 = Serial Comm Failure	---
	20 = Internal Fault	---
	22 = Emergency Open	---
	26 = Plant Interlock	---
	27 = Process Interlock E	---
	28 = Process Interlock F	---
	29 = Process Interlock G	---
	30 = Process Interlock H	---
	31 = Process Interlock I	---
	32 = Process Interlock J	---

TABLE 7–2: Data Formats (Sheet 3 of 8)

Code	Description	Bitmask
F10	**Two ASCII Characters**	FFFF
	32 to 127 = ASCII Character	7F00
	32 to 127 = ASCII Character	007F
F11	**Unsigned Integer: Feeder Type**	FFFF
	2 = Contactor Feeder	---
	8 = Circuit Breaker	---
F12	**Unsigned Integer: Phase CT Connection**	FFFF
	0 = 3 CTs (R-Y-B)	
	1 = 2 CTs (R-B)	
F13	**Unsigned Integer - Earth Fault CT Type**	FFFF
	0 = 2000:1 CBCT	---
	1 = 5 A Secondary	---
F14	**Unsigned Integer: Enable/Disable**	FFFF
	0 = Disable	---
	1 = Enable	---
F15	**Unsigned Integer: VT Connection Type**	FFFF
	0 = Line (R-N)	---
	1 = Phase (R-Y)	---
F16	**Unsigned Integer: Manual/Auto**	FFFF
	0 = Manual	---
	1 = Auto	---
F17	**Interlock Input Function**	FFFF
	0 = Not Used	---
	1 = Process Interlock A	---
	2 = Process Interlock B	---
	3 = Process Interlock C	---
	4 = Process Interlock D	---
	5 = Plant Interlock	---
	6 = Lockout Reset	---
	7 = Setpoint Access	---
	8 = Auto Permissive	---
	9 = Auto Close A	---
	10 = Auto Close B	---
	11 = Reset Emergency Open Trip	---
	12 = Reserved	---
	13 = Two Wire Control	---
	14 = Test Switch	---
	15 = Remote Permissive	---
	16 = Serial Permissive	---
	17 = Non-Lockout Reset	---
	18 = Process Interlock E	---
	19 = Process Interlock F	---
	20 = Process Interlock G	---
	21 = Process Interlock H	---
	22 = Process Interlock I	---
	23 = Process Interlock J	---
	24 = Open A	---

TABLE 7–2: Data Formats (Sheet 4 of 8)

Code	Description	Bitmask
F17 ctd.	25 = Open B	---
	26 = Local Isolator	---
	27 = Switch Input Monitor	---
F18	**Unsigned Integer: Interlock Stop / Latched Trip**	FFFF
	0 = Interlock Stop	---
	1 = Latched Trip	---
F19	**Unsigned Integer: Unlatched / Latched**	FFFF
	0 = Unlatched	---
	1 = Latched	---
F20	**Unsigned Integer: Programmable Relay**	FFFF
	0 = Serial Control	---
	1 = Trips	---
	2 = Alarms	---
	3 = Pre Contactor A	---
	4 = Post Contactor A	---
	5 = Post Contactor B	---
	6 = Feeder Available Manual	---
	7 = Reserved	---
	8 = Reserved	---
	9 = Reserved	---
	10 = Keypad Reset	---
	11 = Interlock 1	---
	12 = Interlock 2	---
	13 = Interlock 3	---
	14 = Interlock 4	---
	15 = Interlock 5	---
	16 = Interlock 6	---
	17 = Interlock 7	---
	18 = Interlock 8	---
	19 = Interlock 9	---
	20 = Interlock 10	---
	21 = Auto Mode	---
	22 = Feeder Closed	---
	23 = Feeder Available	---
	24 = Feeder Unavailable Auto	---
	25 = Feeder Unavailable Manual	---
	26 = Feeder Available Auto	---
	27 = Load Sense	---
	28 = Comms Healthy	---
	29 = Pre-Cont. A/B Manual	---
F21	**Signed Integer**	FFFF
F22	**Command**	FFFF
	1 = Reset	---
	2 = Lockout Reset	---
	3 = Open	---
	4 = Close A	---
	5 = Close B	---
	6 = Prog. Relay 1 = On	---

TABLE 7–2: Data Formats (Sheet 5 of 8)

Code	Description	Bitmask
F22 ctd.	7 = Prog. Relay 1 = Off	---
	8 = Clear Maintenance Timers	---
	9 = Clear Maintenance Counters	---
	10 = Clear Energy Data	---
	11 = Display Message	---
	12 = Simulate Keypress	---
	13 = Manual Inhibit	---
	14 = Manual Restore	---
	15 = Not used	---
	16 = Store New Address	---
	17 = Upload Mode Entry 2	---
	18 = Upload Mode Entry 1	---
	19 = Reload Factory Setpoints 2	---
	20 = Reload Factory Setpoints 1	---
	21 = Test Relays & LEDs	---
F23	**Unsigned Integer: Keypress Simulation**	FFFF
	0x3100 = SETPOINT	---
	0x3200 = ACTUAL	---
	0x3300 = RESET	---
	0x3400 = STORE	---
	0x3500 = MESSAGE UP	---
	0x3600 = MESSAGE DN	---
	0x3700 = MESSAGE LEFT	---
	0x3800 = MESSAGE RT	---
	0x3900 = VALUE UP	---
	0x6100 = VALUE DOWN	---
F24	**Unsigned Integer: Current key press**	FFFF
	0000 = no key	---
	FE01 = AUTO	---
	FE02 = MANUAL	---
	FE04 = CLOSE A	---
	FE08 = CLOSE B	---
	FD01 = OPEN 1	---
	FD02 = OPEN 2	---
	FD04 = RESET	---
	FD08 = STORE	---
	FB01 = SETPOINT	---
	FB02 = ACTUAL	---
	FB04 = MESSAGE UP	---
	FB08 = MESSAGE DOWN	---
	F701 = MESSAGE LEFT	---
	F702 = MESSAGE RIGHT	---
	F704 = VALUE UP	---
	F708 = VALUE DOWN	---
F25	Unsigned Integer: Modbus Baud Rate	FFFF
	0 = 1200	---
	1 = 2400	---
	2 = 4800	---
	3 = 9600	---
	4 = 19200	---

TABLE 7–2: Data Formats (Sheet 6 of 8)

Code	Description	Bitmask
F26	**Unsigned Integer: Relay / LED Test Data**	FFFF
	0 = Normal operation	---
	1 = Relay A On	---
	2 = Relay B On	---
	3 = Prog. Relay On	---
	4 = ESD Relay On	---
	5 = All Relays On	---
	6 = Closed LED On	---
	7 = Open LED On	---
	8 = Tripped LED On	---
	9 = Alarm LED On	---
	10 = Fault LED On	---
	11 = Auto LED On	---
	12 = Manual LED On	---
	13 = All LEDs On	---
	14 = Flash Voltage On	---
F28	**Unsigned Integer: Overload Curve**	FFFF
	0 = OFF	---
	1 = IEC A	---
	2 = IEC B	---
	3 = IEC C	---
F33	**Manufacture Month / Day**	FFFF
	Month: 1 = January, 2 = February...12 = December	---
	Day: 1 to 31 in steps of 1	---
F34	**Manufacture Year: Unsigned Integer**	FFFF
	Year: 1995, 1996	---
F35	**Unsigned Integer: CT Connection Type**	FFFF
	0 = 3 CTs (R-Y-B)	---
	1 = 2 CTs (R and B)	---
F36	**Simulated Switch State**	FFFF
	0 = OPEN	---
	1 = CLOSED	---
F100	**Switch Input Status:**	FFFF
	Interlock Input 1	0001
	Interlock Input 2	0002
	Interlock Input 3	0004
	Interlock Input 4	0008
	Interlock Input 5	0010
	Interlock Input 6	0020
	Interlock Input 7	0040
	Interlock Input 8	0080
	Interlock Input 9	0100
	Interlock Input 10	0200
	Open	0400
	Close A	0800
	Close B	1000
	Test Mode	2000
	Contactor A N/O	4000
	Contactor B N/O	8000

TABLE 7–2: Data Formats (Sheet 7 of 8)

Code	Description	Bitmask
F101	**LED Status Flags 1**	FFFF
	Closed	0001
	Open	0002
	Tripped	0004
	Alarm	0008
	Fault	0010
	Test 1	0020
	Test 2	0040
F102	**LED Status Flags 2**	FFFF
	Relay A	0001
	Relay B	0002
	Programmable Relay	0004
	ESD Relay	0008
	Auto	0010
	Manual	0020
	Beeper	0040
	VFD/LCD test mode	0080
F103	**Operation Status**	FFFF
	External Close	0001
	External Open	0002
	ESD Open	0004
F104	**Alarm Status Flags 1**	FFFF
	Earth Fault Alarm	0040
	Contactor Inspection Interval Exceeded Alarm	0400
	Internal Fault Alarm	1000
F105	**Alarm Status Flags 2**	FFFF
	Open Control Circuit / Breaker Failed to Close	0001
	Welded Contactor / Breaker Failed to Open	0002
F106	**Interlock Flags**	FFFF
	Not Used	0001
	Process Interlock A	0002
	Process Interlock B	0004
	Process Interlock C	0008
	Process Interlock D	0010
	Process Interlock E	0020
	Process Interlock F	0040
	Process Interlock G	0080
	Process Interlock H	0100
	Process Interlock I	0200
	Process Interlock J	0400
F107	**Trip Flags 1**	FFFF
	Earth Fault	0001
	Overload	0002
	Local Isolator	0400
	Plant Interlock	0800
	Serial Communication Failure	1000
	Internal Fault	2000
	Emergency Open	4000
	ESD Open (Mod)	8000

TABLE 7–2: Data Formats (Sheet 8 of 8)

Code	Description	Bitmask
F108	**Trip Flags 2**	FFFF
	Process Interlock A	0001
	Process Interlock B	0002
	Process Interlock C	0004
	Process Interlock D	0008
	Process Interlock E	0080
	Process Interlock F	0100
	Process Interlock G	0200
	Process Interlock H	0400
	Process Interlock I	0800
	Process Interlock J	1000
F109	**Open/Close Flags**	FFFF
	Two Wire Open requested	0002
	Undervoltage Reclose in Progress	0004
F112	**Internal Fault Error Code**	FFFF
	ADC Reference out of Range	0001
	HC705 Processor not Responding	0002
	Switch Input Circuit Fault	0004
	HC705 processor MOR byte not programmed	0008
F113	Unsigned Integer: Auto Mode Definition	FFFF
	0 = Serial	---
	1 = Hard-Wire	---

8 Testing

Injection Testing

Primary Injection Testing

Prior to FM2 commissioning, complete system operation can be verified by injecting current through the phase and earth fault CTs. To accomplish this, a current injection test set is required.

Operation of the entire FM2 control/protection system, except the phase and earth fault CTs, can be checked by applying input signals to the FM2 from a secondary injection test set as described in this chapter.

Secondary Injection Testing

A simple, three-phase secondary injection test circuit is shown below. Tests should be performed to verify correct operation and wiring. All functions are firmware driven and this testing is required only to verify correct firmware/hardware interaction.

The tests described in this chapter can be repeated and modified using setpoints and current levels more closely suited to the actual installation.

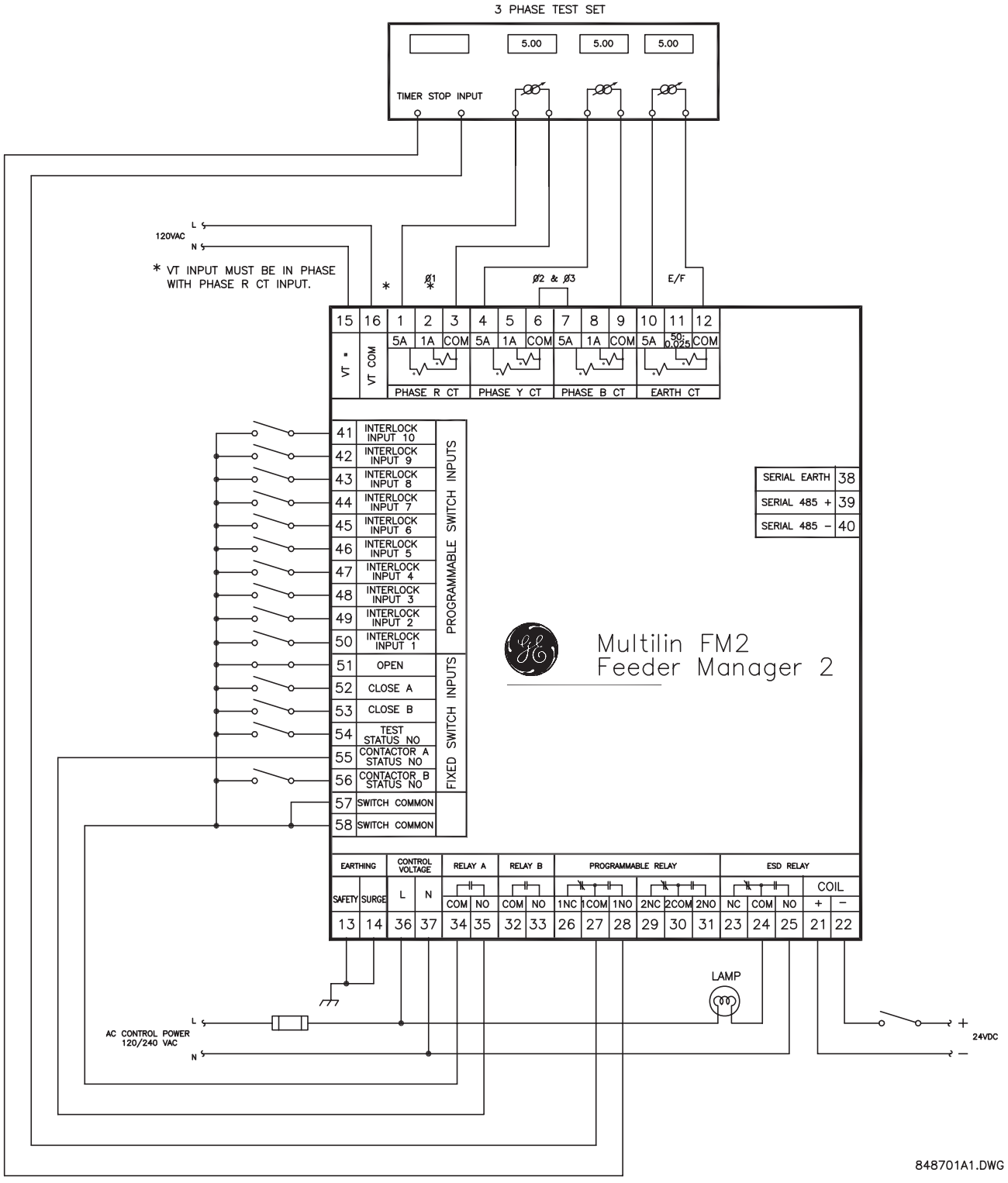

FIGURE 8–1: Secondary Injection Test Setup

Functional Tests

Phase Current Functions

Any phase current protection is based on the ability of the FM2 to read phase input currents accurately.

Make the following settings changes:

S1 CONFIGURATION ⇩⇩ **FEEDER IDENTIFICATION** ⇨⇨ **FEEDER RATING** = "100 A"
S1 CONFIGURATION ⇩⇩⇩ **FEEDER** ⇨ **FEEDER TYPE** = "CONTACTOR FEEDER"
S1 CONFIGURATION ⇩⇩⇩⇩ **CT/VT INPUTS** ⇨ **PHASE CT PRIMARY AMPS** = "100"

To determine if the relay is reading the proper input current values, inject different phase currents into the CT inputs and view the current readings in **A1 DATA** ⇩ **FEEDER DATA**. The displayed current should be equal to the actual injected current multiplied by the CT ratio.

Phase current values will be displayed even if the feeder status is open; that is, Relay A has not been activated by a close command. Very low currents are displayed as "0 A".

Once the accuracy of the phase CT inputs has been established, various phase alarm and trip condition tests can be performed by altering setpoints and injected phase currents.

To simulate an overload condition, make the following changes in the **S2 PROTECTION** ⇩ **FEEDER PROTECTION THERMAL** menu:

OVERLOAD CURVE NUMBER = "IEC A"
CURVE MULTIPLIER = "1.0"

Set the **FEEDER RATING** to "50 A". Close the Close A input and note that the CLOSED LED goes on. Inject a current of 10 A into all three phases. The relay will display a current value of:

$$\text{displayed current} = \text{injected current} \times \frac{100}{5} = 10\ \text{A} \times \frac{100}{5} = 200\ \text{A} \qquad \textbf{(EQ 8.1)}$$

This represents four times the phase **FEEDER RATING** setpoint. Therefore, based on a 400% overload and an IEC A curve, Relay A will change state 4.980 seconds after the overload is first applied. When this occurs, the Closed LED turns off and the Tripped and Open LEDs are lit.

Make the following setting change to operate the Programmable Relay on any trip

S4 CONTROL ⇩⇩ **PROG RELAY 1 CONFIG** ⇨ **PROG RELAY 1 FUNCTION** = "TRIPS"

To reset the thermal overload and earth fault trips, make the following setting change:

S3 PROCESS ⇩ **CONFIGURABLE INPUTS** ⇨ **INTERLOCK INPUT 1** = "LOCKOUT RESET"

Close the interlock 1 switch to reset the trip.

Earth Fault Current Functions

Test the Earth Fault CT (Secondary / 2000:1) in a similar manner to phase currents for accuracy at various injected current levels. To check alarm and trip levels, make the following settings changes.

In the **S1 CONFIGURATION** ⇩⇩⇩⇩ **CT/VT INPUTS** setpoints page, change:

EARTH FAULT CT INPUT = "5 A Secondary"

In the **S1 CONFIGURATION** ⇩⇩ **FEEDER IDENTIFICATION** setpoints page, change:

FEEDER RATING = "100 A"

In the **S2 PROTECTION** ⇩⇩ **FEEDER PROTECTION EARTH FAULT** setpoints page, change:

EARTH FAULT ALARM LEVEL = "40 %FLC"
EARTH FAULT TRIP LEVEL = "80 %FLC"

While displaying the **A1 DATA** ⇩ **FEEDER DATA** ⇨⇨⇨ **EARTH CURRENT** actual value, begin injecting current into the 5 A Earth Fault CT input. The Alarm LED lights at 40 A corresponding to the 40% FLC alarm setting. Change the display back to **EARTH CUR-**

RENT and continue increasing injected secondary current. When the measured Earth Current reaches 80 A, a Earth Fault Trip occurs. This trip causes the FM2 to change its indicators and output relay status. The Closed LED turns off, the Tripped and Open LEDs turn on, and Relay A de-energises. The FM2 displays a Earth Fault Trip message. Turn the Earth Fault current off and close the Interlock 1 switch to reset the trip.

Input Functions

Operation of each FM2 switch input can be verified on the display. Go to **A3 INPUTS ⇩ INPUT CONTACT STATUS** and using the MESSAGE LEFT/RIGHT keys, view the status of each input one at a time. Open and close each switch input and note that the display reflects the present status of the input terminals. The status is shown as either OPEN or CLOSED.

Power Fail Test

To test the Power Fail circuit, connect the supply voltage to the FM2 through a variac and begin decreasing control voltage. When the control voltage drops below 80 V for 120 V AC input or 150 V for 240 V AC input, the fault light comes on and the FM2 ceases to operate. The FM2 has insufficient voltage to continue accurately monitoring the feeder. All output relays will change to their power off state. Decrease control voltage to zero and then return voltage to its normal operating level. Verify that the FM2 resumes its normal operation. Check the power fail memory circuit by verifying that setpoints and statistical data have not been altered.

9 Feeder Types

Contactor Type

Description

This PCC circuit uses contactors as a power-switching device in the feeder. When the close button is pressed the 1M coil is picked up, closing the contactor and is sealed in by 1M contact. When the open button is pressed the 1M coil is dropped out and feeder opens.

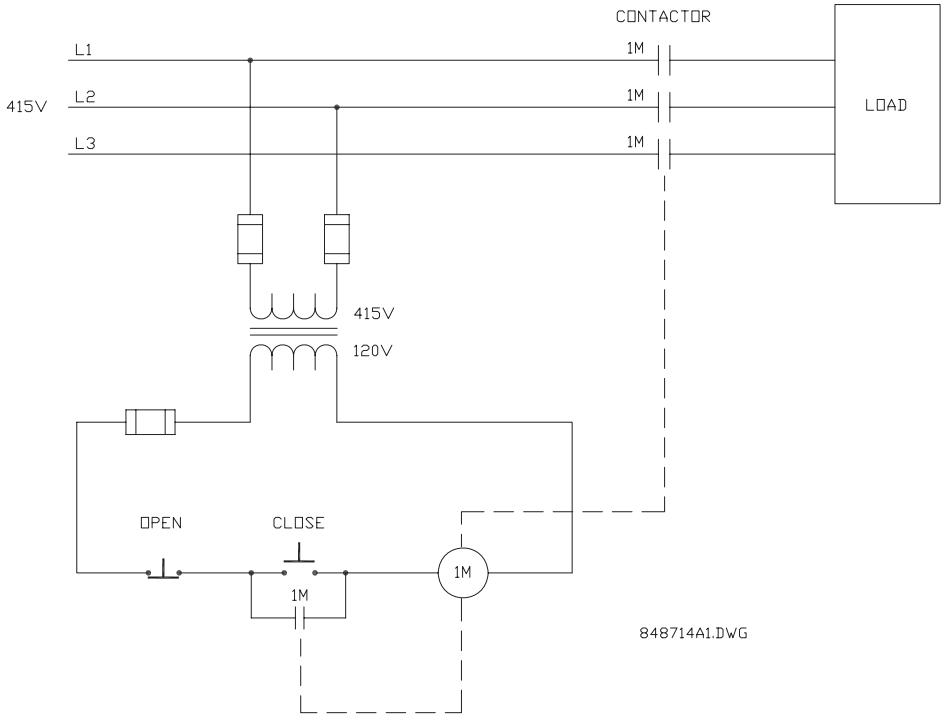

FIGURE 9–1: Feeder with Contactor

To program the FM2 for contactor feeder, set **S1 CONFIGURATION ⇩⇩⇩ FEEDER ⇨ FEEDER TYPE** to “CONTACTOR FEEDER”.

FM2 Sequences for Contactor A

Either of the output relays can be used for contactor switching. The sequences for contactor A are shown below.

To CLOSE:

1. Close A signal received by the FM2 (serial, switch input or faceplate).
2. Close and maintain Relay A. The feeder is now closed.

To OPEN/TRIP:

1. Open signal received or trip occurs.
2. Open output Relay A. The feeder is now open

When the power to the FM2 is interrupted, Relay A de-energises, causing it to open and open the feeder. The FM2 can only be wired for fail-safe operation. If feedback is not received from the 1M contact to the Contactor A Status N.O. input on the FM2 within 0.25 second of closing Relay A, an Open Control Circuit alarm occurs. This causes Relay A to open. If feedback remains at the Contactor A Status N.O. input for more than 0.25 second after opening Relay A, a Welded Contactor alarm occurs. The Close B signal opens Relay A and closes Relay B.

FM2 Sequences for Contactor B

The sequences for contactor B are shown below.

To CLOSE:

1. Close B signal received by the FM2 (serial, switch input or faceplate).
2. Close and maintain Relay B. The feeder is now closed.

To OPEN/TRIP:

1. Open signal received or trip occurs.
2. Open Relay B. The feeder is now open

When the power to the FM2 is interrupted, Relay B de-energises, causing it to open and open the feeder. The FM2 can only be wired for fail-safe operation. If feedback is not received from the 1M contact to the Contactor B Status N.O. input on the FM2 within 0.25 second of closing Relay B, an Open Control Circuit alarm occurs. This causes the Relay B to open. If feedback remains at the Contactor B Status N.O. input for more than 0.25 second after opening Relay By, a Welded Contactor alarm occurs. The Close A signal opens Relay B and closes Relay A.

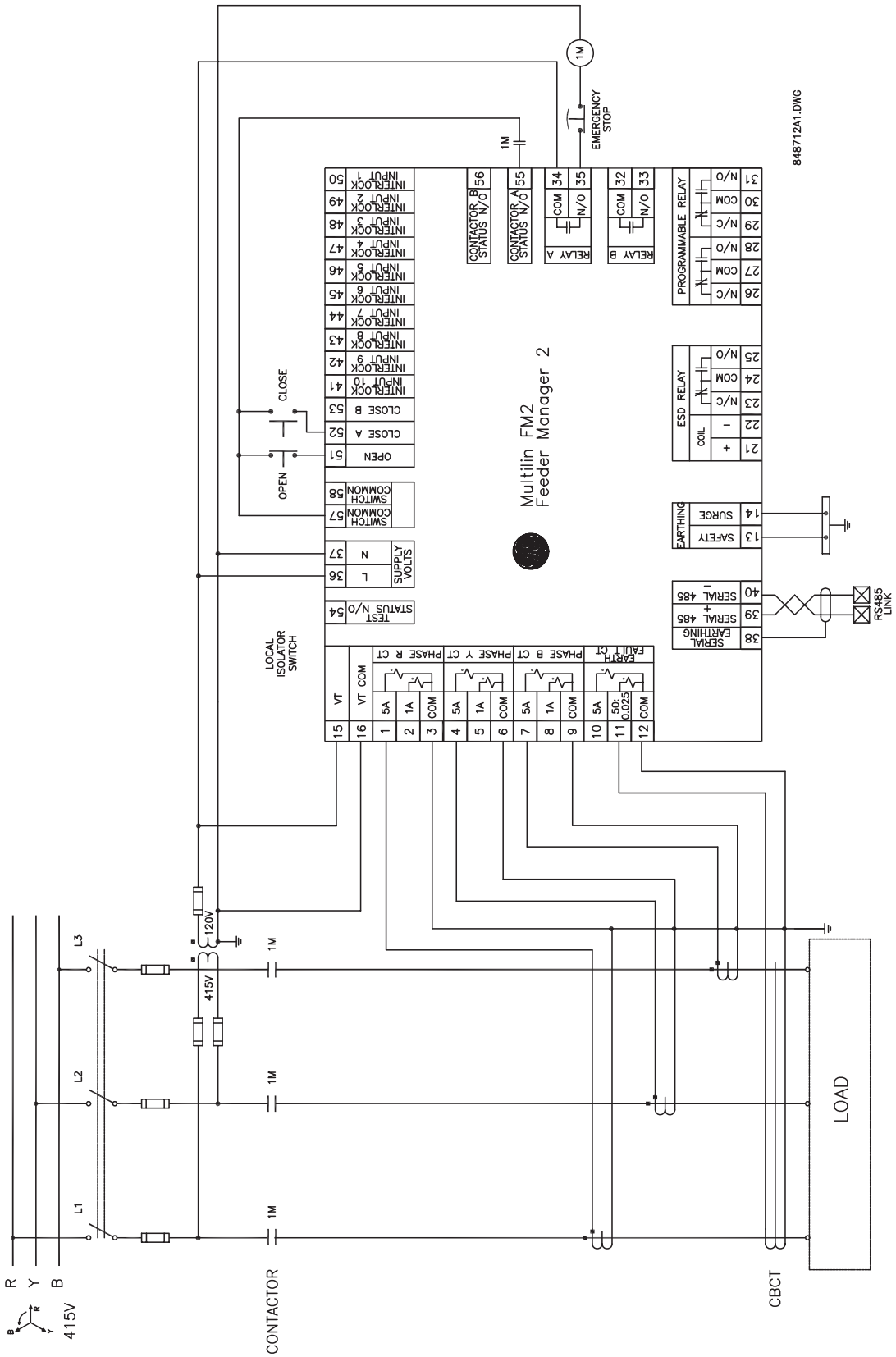

FIGURE 9–2: Contactor Feeder Wiring Diagram

Circuit Breaker Feeder

Description

This PCC circuit uses circuit breaker as a power-switching device in the feeder. When the close button is pressed the closing coil is picked up, closes the circuit breaker. Once the breaker is closed, the 52b breaker N/C contact opens and stops the current flowing into the closing coil circuit. When the open button is pressed the breaker trip coil energises & opens the circuit breaker. Once the breaker is opened, the breaker N/O contact (52a) opens and stops the current flowing into the trip coil circuit.

WARNING

The FM2 can be used for breaker feeders only if the breaker has built-in trip units.

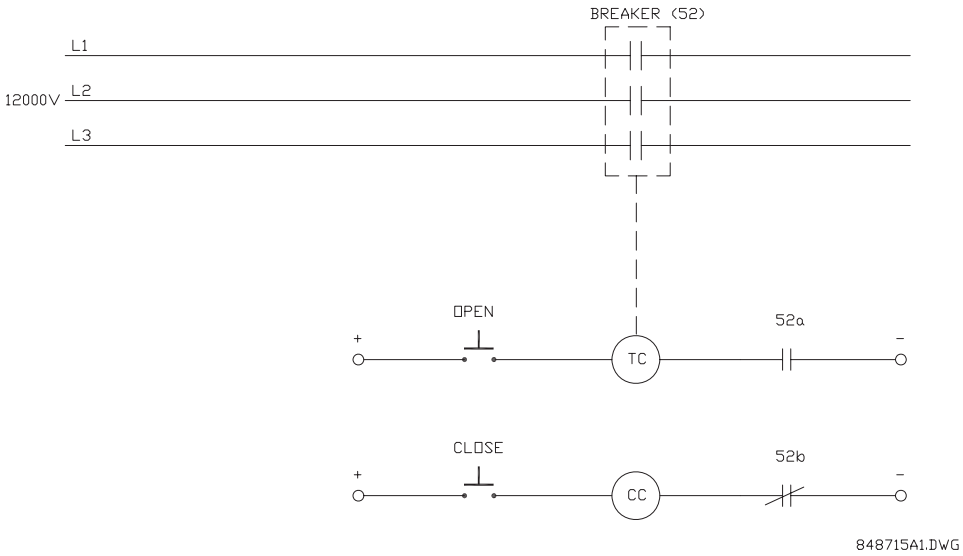

FIGURE 9–3: Feeder with Circuit Breaker

To program the FM2 for circuit breaker feeder, make the following changes in the **S1 CONFIGURATION** ⇨⇩ **FEEDER** menu:

FEEDER TYPE = "CIRCUIT BREAKER"
ACB PULSE TIME = "0.5 s"

FM2 Sequences

To CLOSE:

1. Close A signal received by the FM2 (serial, switch input or faceplate).
2. Closes and maintains Relay A for the set duration of circuit breaker pulse time.
3. The Circuit breaker is now closed

To OPEN/TRIP:

1. Open signal received or trip occurs.
2. Closes and maintains Relay B for the set CB pulse time and energises trip coil
3. The Feeder is now open.
4. If FM2 receives Open signal within CB pulse time after Close signal, Relay A is opened and Relay B is closed for the set CB pulse time.

If feedback is not received from the breaker contact to the Contactor A Status N.O. input on the FM2 within 0.25 second of closing Relay A, a Breaker Failed To Close alarm occurs. This causes Relay A to open. If feedback remains at the Contactor A Status N.O. input for more than 0.25 second after closing Relay B, a Breaker Failed To Open alarm occurs. The Close B signal is non-operative in a breaker type feeder.

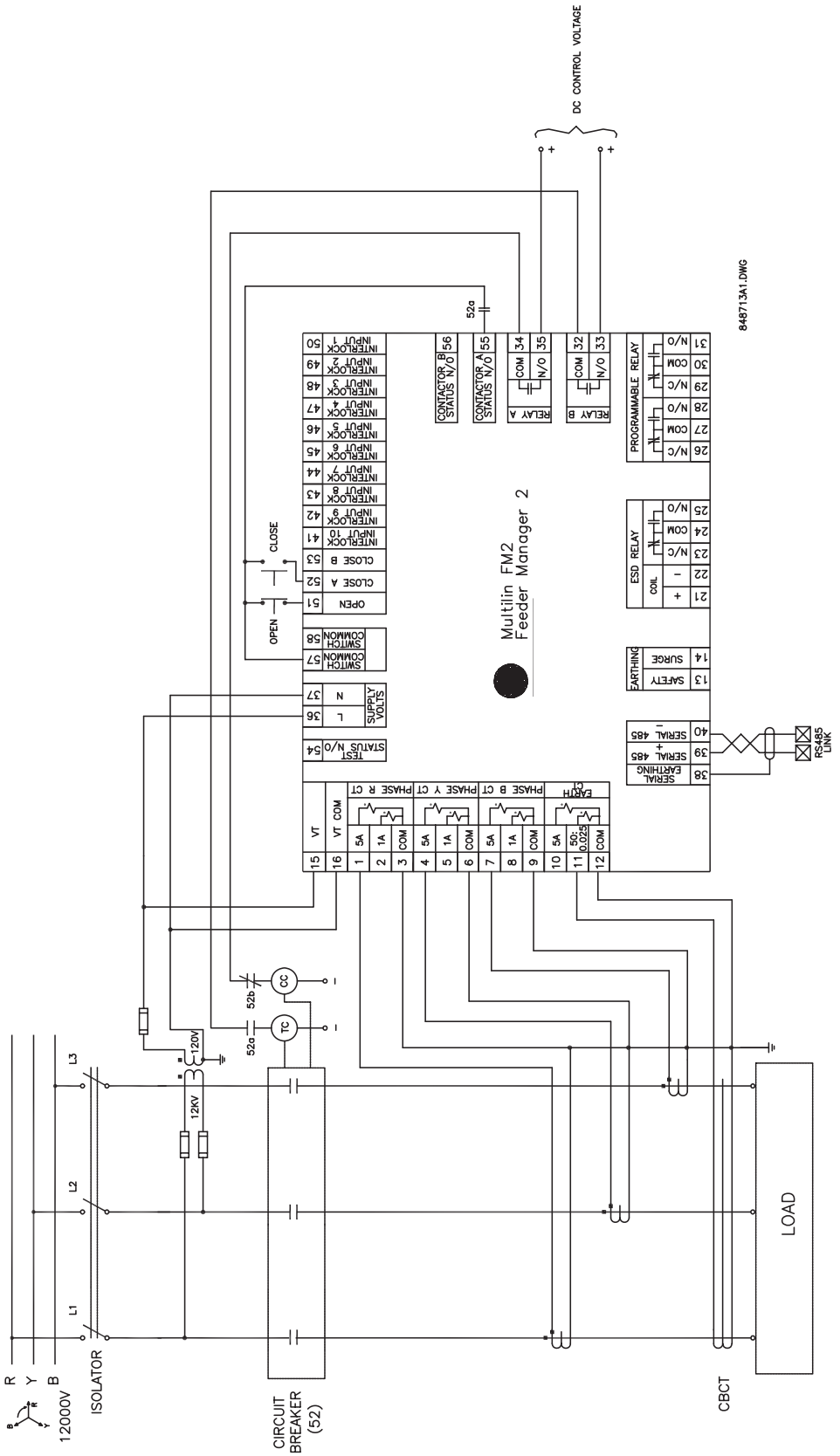

FIGURE 9–4: Circuit Breaker Feeder Wiring Diagram

10 Control Wire

Two Wire Control

Description

This control scheme is used when a feeder is directly controlled by a PLC contact. When the PLC contact is closed the feeder is closed. When the PLC contact opens the feeder opens.

To program the FM2 for two-wire control, make the following setpoint changes in the menu:

S3 PROCESS ⇩ CONFIGURABLE INPUTS ⇨ INTERLOCK INPUT 1: "TWO WIRE CONTROL"
S3 PROCESS ⇩⇩⇩ OPEN CONFIGURATION ⇨⇨ FACEPLATE OPEN: "LATCHED"

NOTE

The **INTERLOCK INPUT 1** setpoint was chosen to match the wiring diagram provided. Any of the available Interlocks 1 through 10 could be programmed for "TWO WIRE CONTROL".

Control Operation

CLOSE:

- Close command received (switch input) and maintained.

OPEN:

- Close command removed.
- Pressing the OPEN key causes a latched trip. The feeder cannot be reclosed until the RESET key is pressed.

Terminal 51 (Open input) must be closed to allow a close. The FM2 display will read "Feeder Status Unavailable" when the open input is open.

If feedback is not received by the Contactor A relay Status N.O. inputs within 0.25 second of closing Relay A, an Open Control Circuit alarm will occur. This will cause Relay A to open.

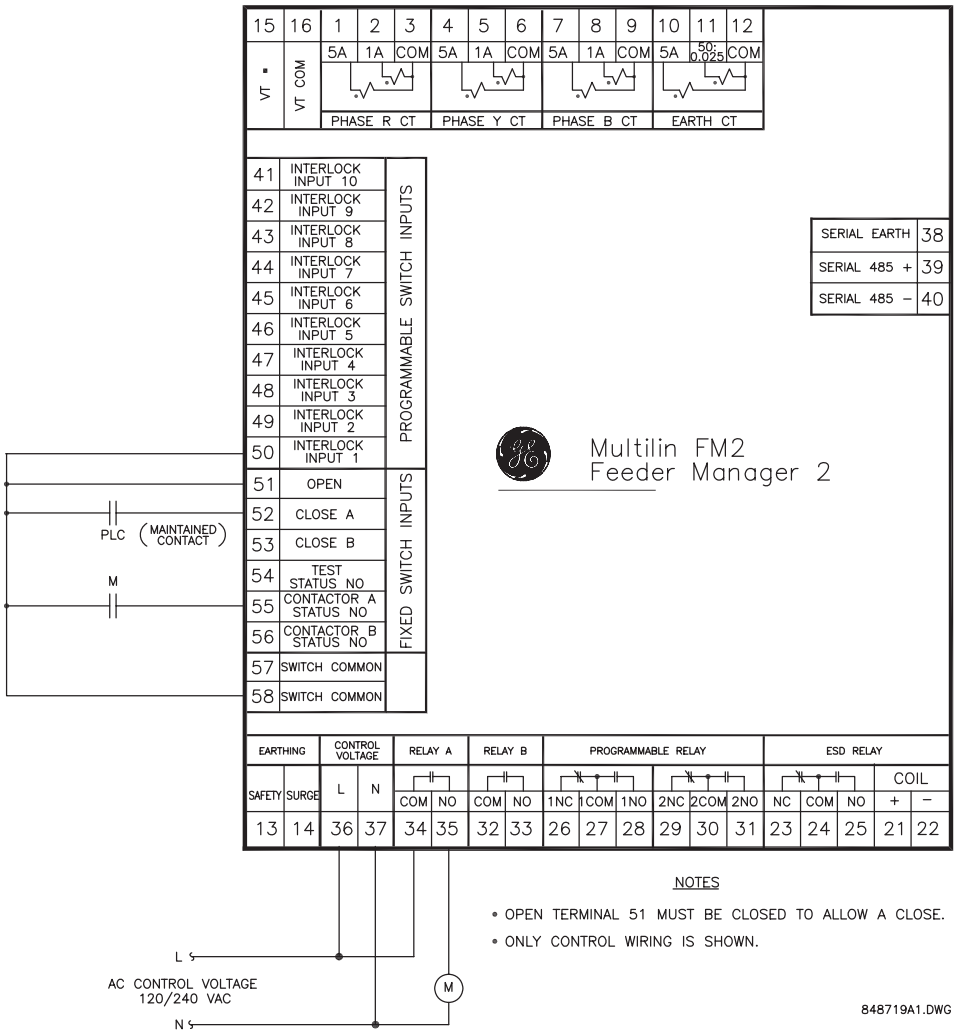

FIGURE 10–1: Two Wire Control

Hand/Off/Auto Configuration

2-Wire Hand / 2-Wire Auto Description

This control scheme is used when it is desirable to control the feeder manually and automatically. In the Hand position, the feeder is energised immediately. In the auto position, the feeder is energised by the maintained PLC contact. When the PLC contact opens, the feeder opens.

To program the FM2 for two-wire hand / two-wire auto control, set:

S3 PROCESS ⇩ CONFIGURABLE INPUTS ⇨ INTERLOCK INPUT 1: "TWO WIRE CONTROL"
S3 PROCESS ⇩⇩⇩ OPEN CONFIGURATION ⇨⇨ FACEPLATE OPEN: "LATCHED"

NOTE

The **INTERLOCK INPUT 1** setpoint was chosen to match the wiring diagram provided. Any of the available Interlocks 1 through 10 could be programmed for "TWO WIRE CONTROL".

2-Wire Hand / 2-Wire Auto Control Operation

HAND:

- In the hand position, the feeder will close.

- Pressing the OPEN key causes a latched trip. The feeder cannot be reclosed until the RESET key is pressed.

OFF:

- In the off position, the feeder will open.

AUTO:

- In the auto position, the feeder is available to close.
- When the PLC contact closes, the feeder closes.
- When the PLC contact opens, the feeder opens.
- Pressing the OPEN key causes a latched trip. The feeder cannot be reclosed until the RESET key is pressed.

Terminal 51 (Open input) must be closed to allow a close. The FM2 display will read "Feeder Status Unavailable" when the open input is open.

If feedback is not received by the Contactor A Status N.O. input within 0.25 second of closing Relay A, an Open Control Circuit alarm will occur. This causes Relay A to open.

In the case of a Faceplate Open trip, the close signal to Terminal 52 should be removed if reclosing is not desired. When the RESET key is pressed on the FM2, the feeder will be reclosed based on Terminal 52.

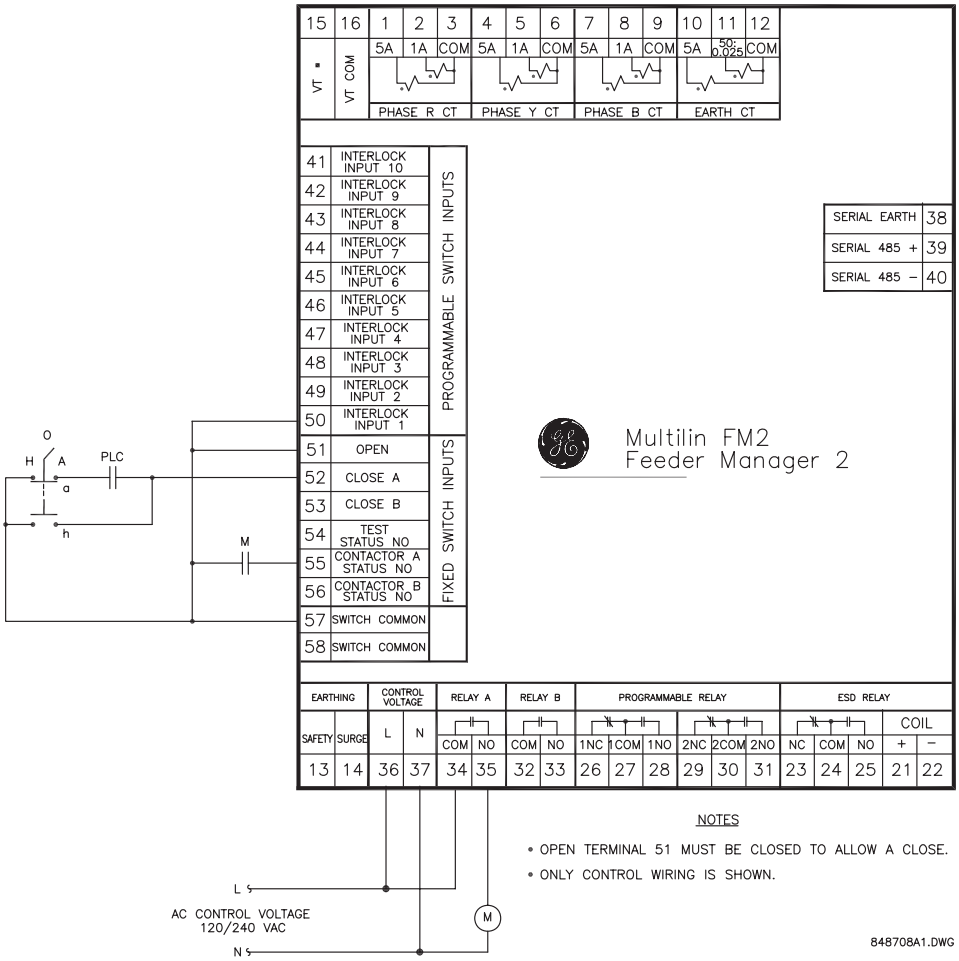

FIGURE 10–2: HOA Two-Wire Hand / Two-Wire Auto

3-Wire Hand / 2-Wire Auto Description

This control scheme is used when it is desirable to control the feeder manually and automatically. In the Hand position, the feeder is energised via the CLOSE button and de-energised via the OPEN button. In the auto position, the feeder is energised by the maintained PLC contact. When the PLC contact opens, the feeder opens.

To program the FM2 for three-wire hand / two-wire auto control, set:

S3 PROCESS ⇩ CONFIGURABLE INPUTS ⇨ INTERLOCK INPUT 1: "TWO WIRE CONTROL"
S3 PROCESS ⇩⇩⇩ OPEN CONFIGURATION ⇨⇨ FACEPLATE OPEN: "LATCHED"

NOTE

The **INTERLOCK INPUT 1** setpoint was chosen to match the wiring diagram provided. Any of the available Interlocks 1 through 10 could be programmed for "TWO WIRE CONTROL".

3-Wire Hand / 2-Wire Auto Control Operation

HAND:

- In the hand position, the feeder is available to close.
- When the CLOSE button is pressed, the feeder will close.
- When the OPEN button is pressed, the feeder will open.
- Pressing the OPEN key causes a latched trip. The feeder cannot be reclosed until the RESET key is pressed.

OFF:

In the off position, the feeder will open.

AUTO:

- In the auto position, the feeder is available to close.
- When the PLC contact closes the feeder closes.
- When the PLC contact opens the feeder opens.
- When the faceplate OPEN key is pressed, it causes a latched trip. The feeder cannot be reclosed until reset is pressed.

Terminal 51 (Open input) must be closed to allow a close. The FM2 display will read "Feeder Unavailable" when the open input is open.

If feedback is not received by the Contactor A Status N.O. input within 0.25 second of closing Relay A, an Open Control Circuit alarm will occur. This will cause Relay A to open.

In the auto position the OPEN pushbutton at the feeder control **will not OPEN** the feeder.

In the case of a faceplate open trip, the close signal to Terminal 52 should be removed if reclosing is not desired. When the RESET key is pressed on the FM2, the feeder will be reclosed based on Terminal 52.

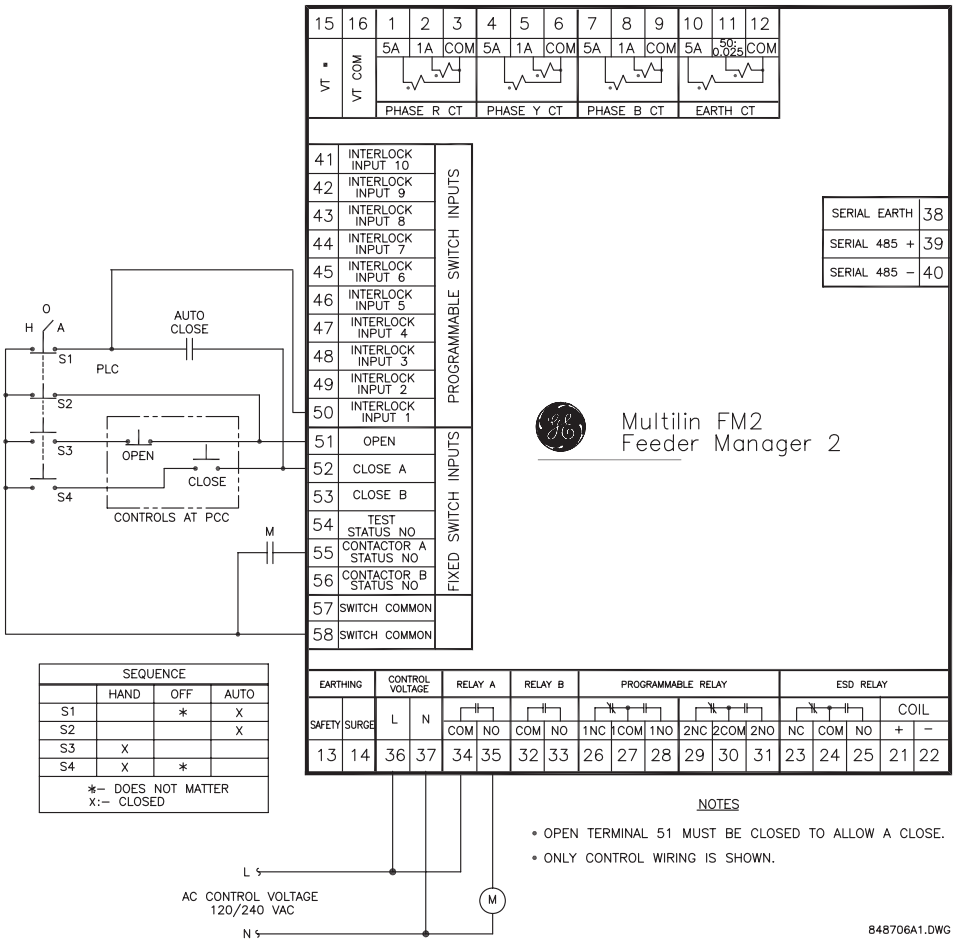

FIGURE 10–3: HOA Three Wire Hand / Two Wire Auto

3 Wire Hand / 3 Wire Auto Description

This control scheme is used when it is desirable to control the feeder manually and automatically. In the Hand position, the feeder is energised via the CLOSE button and de-energised via the OPEN button. In the auto position, the feeder is energised automatically when the PLC1 contact is pulsed closed. When the PLC2 contact is pulsed open, the feeder opens.

To program the FM2 for three-wire hand / two-wire auto control, set the FM2 to the default settings.

3 Wire Hand / 3 Wire Auto Control Operation

HAND:

- In the hand position, the feeder is available to close.
- When the CLOSE button is pressed, the feeder closes.
- When the OPEN button is pressed, the feeder opens.

OFF:

- In the off position, the feeder will open.

AUTO:

- In the auto position, the feeder is available to close.
- When the PLC contact is pulsed closed, the feeder closes.
- When the PLC contact is pulsed open, the feeder opens.
- When the OPEN button is pressed, the feeder opens.

Terminal 51 (Open input) must be closed to allow a close. The FM2 display will read "Feeder Status Unavailable" when the open input is open.

If feedback is not received by the Contactor A Status N.O. input within 0.25 second of closing Relay A, an Open Control Circuit alarm will occur. This will cause Relay A to open.

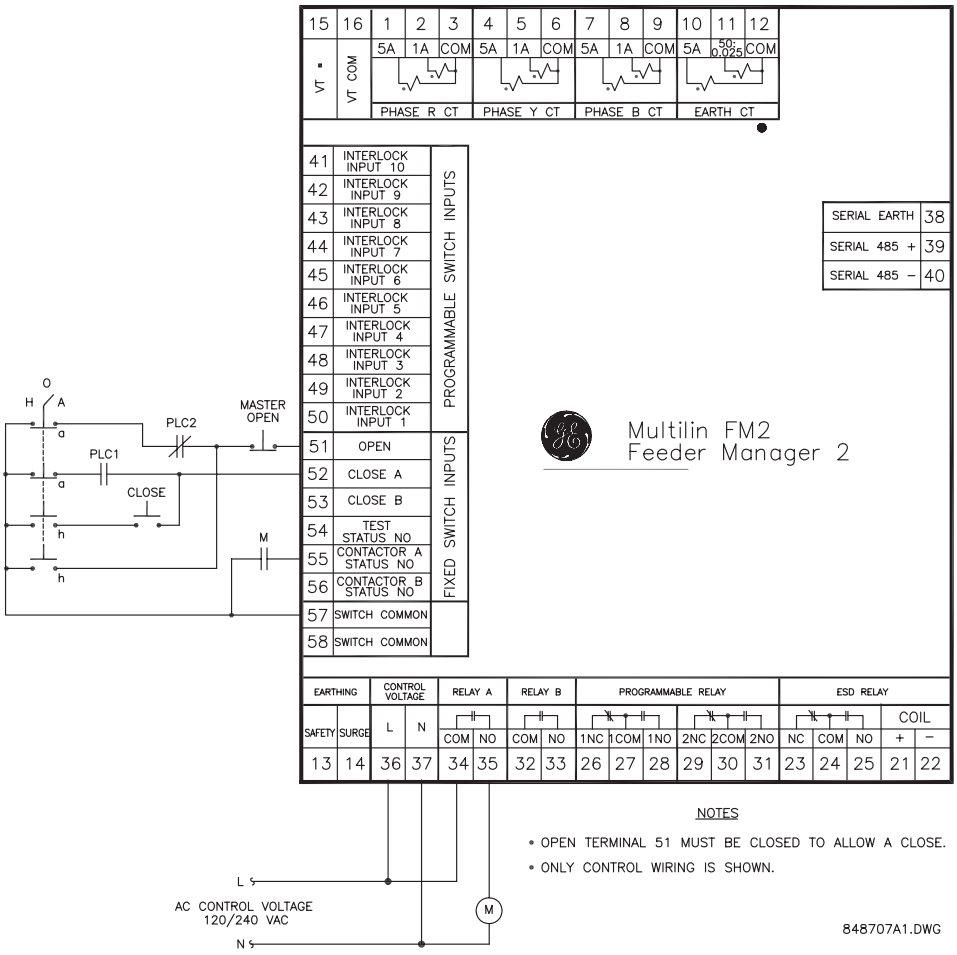

FIGURE 10–4: HOA Three Wire Hand / Three Wire Auto

Hand/Auto Configuration

3-Wire Hand / 2-Wire Auto

This control scheme is used when it is desirable to control the feeder manually and automatically. In the Hand position the feeder is energised via the CLOSE button and de-energised via the OPEN button. In the auto position the feeder is energised automatically by the maintained PLC contact. When the PLC contact opens, the feeder opens.

To program the FM2 for three-wire hand / two-wire auto control (hand/auto configuration), make the following setpoint changes.

In the **S3 PROCESS ⇨ CONFIGURABLE INPUTS** menu, set:

INTERLOCK INPUT 1 = "TWO WIRE CONTROL"
INTERLOCK INPUT 2 = "AUTO PERMISSIVE"
INTERLOCK INPUT 3 = "AUTO CLOSE A"

In the **S3 PROCESS ⇨⇨⇨ OPEN CONFIGURATION** menu, set:

FACEPLATE OPEN = "LATCHED"
PROCESS OPEN = "LATCHED"

NOTE

The **INTERLOCK INPUT 1(3)** setpoints were chosen to match the wiring diagram provided. Any of the available Interlocks 1 through 10 could be programmed for "TWO WIRE CONTROL", "AUTO-PERMISSIVE", or "AUTO CLOSE A".

Control Operation

HAND:

- In the hand position, the feeder is available to close.
- When the CLOSE button is pressed, the feeder closes.
- When the OPEN button or faceplate OPEN key is pressed, the feeder opens and a latched trip is generated. The feeder cannot be reclosed until RESET is pressed.

AUTO:

- In the auto position, the feeder is available to close.
- When the PLC contact closes, the feeder closes.
- When the PLC contact opens, the feeder opens.
- When the faceplate OPEN key is pressed, it causes a latched trip. The feeder cannot be reclosed until RESET is pressed.
- Close commands from the faceplate, serial port and terminals 52 and 53 are blocked.

Terminal 51 (Open input) must be closed to allow a close. The FM2 display will read "Feeder Unavailable" when the open input is open.

If feedback is not received by the Contactor A Status N.O. input within 0.25 second of closing Relay A, an Open Control Circuit alarm will occur. This will cause Relay A to open.

In the case of a faceplate *or* process open trip, the close signal to Terminal 52 should be removed if reclosing is not desired. When the FM2 RESET key is pressed, the feeder will be reclosed based on Terminal 52.

The OPEN button at the feeder control remains active in the auto mode.

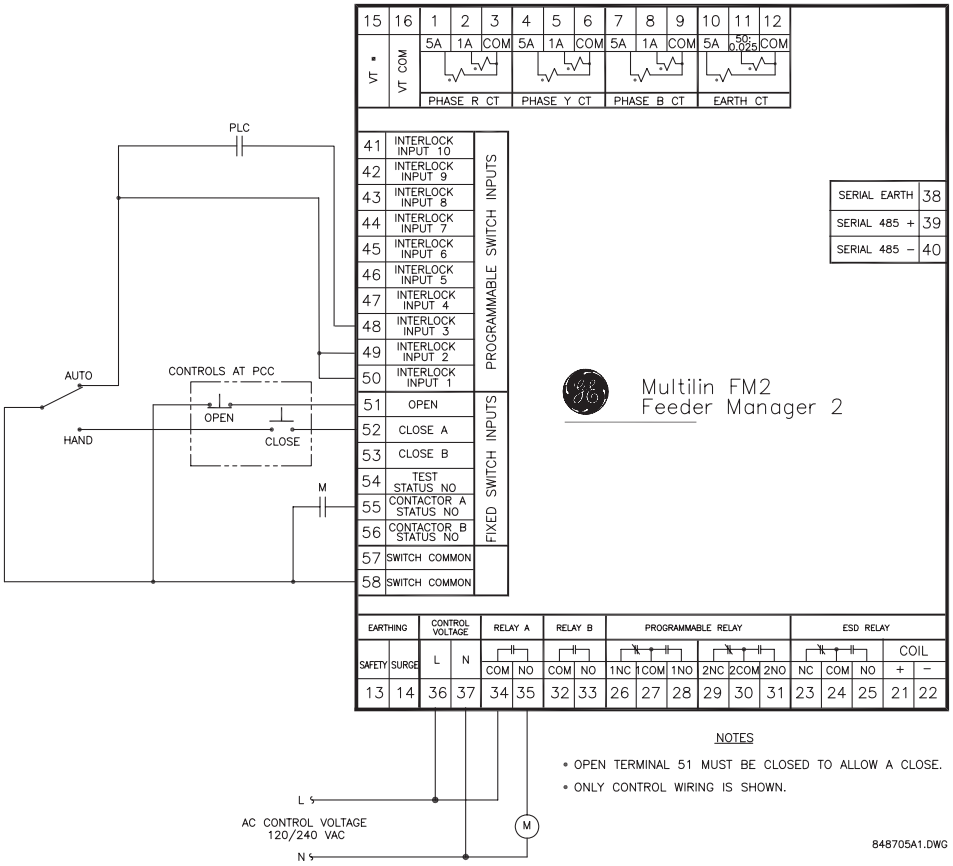

FIGURE 10–5: HA Three Wire Hand / Two Wire Auto

Appendix

Frequently Asked Questions

Questions and Answers

Listed below are some of the more frequently asked questions by FM2 users. The list includes questions asked by consultants before the FM2 has even been specified to the end user and after the FM2 is installed and controlling a feeder.

Q **Does the FM2 support ladder logic as in a PLC?**

A No. The FM2 switch inputs do not allow total programmability as in PLCs; however, it does have a range of over 25 different dedicated functions that can be assigned for typical applications. These functions come complete with built in timers if necessary for that particular function. For example: Auto Permissive and Auto Close for PLC hard wired control, Two Wire Control for PLC close, Process Interlocks with starting and running override timers for pressure and flow monitoring.

Q **After wiring the FM2 into the control circuit, it remains UNAVAILABLE for closes. What does this mean?**

A Three conditions can cause the FM2 to remain UNAVAILABLE for closes:

1. The FM2 has tripped on a trip condition
2. The Open switch input (Terminal 51) is not energised.
3. If a Process Interlock function is assigned to one of the configurable switch inputs and the startup override is set to 0 seconds, the FM2 will remain unavailable until that switch input is energised.

Q **When a close is attempted, the feeder closes for a second then shuts off. The FM2 displays an OPEN CONTROL CIRCUIT alarm. What is the problem?**

A The FM2 must see feedback from the Contactor A or, if used, Contactor B within 0.25 second of the FM2 closing the contactor or the FM2 will open the feeder as it assumes that there is a problem in the circuitry for the feeder contactor coil. The feedback from the contactors go to the status inputs (terminals 15 & 16) of the FM2. NOTE: This condition will result in the toggling of the feeder contactor when the FM2 is in the Two Wire mode as there can be a constant close signal from the two wire device. Use the Open Control Circuit trip feature to prevent the toggling of the feeder contactor.

Q: After connecting the FM2 through an interface device to a PLC network, communications to the FM2 cannot be established. What is the problem?

A: Verify the following:

1. If master is communicating with Modbus® RTU protocol.
2. The wiring between the interface device and the FM2.
3. The FM2 communications address.
4. The master polling address.
5. The FM2 baud rate
6. The master baud rate.
7. The master parity settings.

If the problem persists, call GE Multilin for technical support.

Q: Can the FM2 interface with an external analog device?

A: No. The FM2 does not contain any analog inputs to monitor an external transducer.

Q: Can the FM2 be used on medium voltage feeders?

A: Yes. The FM2 was designed specifically for the medium voltage market (up to 12000 V). However, the protection features offered in the FM2 are typically not advanced enough for phase faults. The power measuring will accommodate up to 12000 V systems.

Q: Can the control transformer in the PCC be used for the VT input on the FM2 as well as for control voltage?

A: Yes, provided that control transformer secondary voltage is 110 to 120 V for the FM2-712 model, or 220 to 240 V for the FM2-722 model, corresponding to the **VT SECONDARY VOLTAGE** setpoint.

Q: Can the CLOSE keys on the faceplate of the FM2 be disabled?

A: Yes. One of the configurable switch inputs can be configured to Remote Permissive and a jumper placed from Switch Common to permanently energise that switch input. This will allow closes from the switch inputs of the FM2 only, when in the Manual mode.

DOs and DON'Ts Checklist

For proper and reliable operation of the GE Multilin FM2 Feeder Manager 2, it is imperative that the steps, recommendations and practices listed below be adhered to at all times. This DO's and DON'Ts checklist has been compiled as a result of years of trouble free operation by a variety of GE Multilin products.

FM2 Earthing

Users are requested to earth terminals 13 (safety earthing) and 14 (filter earthing) directly to the EARTH BUS using a heavy gauge wire or braided cable. Terminals 13 and 14 will accept up to #12 AWG wire. These terminals must be earthed for proper filtering of noise, and protection against transient conditions.

Earthing of Phase and Earth Fault CTs

All external phase CT and earth fault CT secondary windings must be earthed to the EARTH BUS to keep the potential difference to a minimum. If the CT secondary windings are not earthed, capacitive coupling could allow the CT secondary voltage to float up to the voltage of the mains. This is a serious safety hazard. Note that Terminal 12 of the External Earth CT is internally earthed; therefore, do not earth terminal 11 since the Earth CT signal would then be shunted.

It is also recommended that, in addition to the solid earthing of the earth fault CT described above, a shielded twisted pair cable be employed when using the GE Multilin 50:0.025 earth CT. The reasoning behind this recommendation is that the 50:0.025 earth CTs are typically used on high resistance earthed systems where the fault currents are limited to less than 200 A. The alarm and trip levels on these systems are usually between 0.5 A and 15.0 A. This equates to a secondary current of 0.25 mA to 7.5 mA. Due to the very low levels that must be monitored by the FM2, any noise picked up by these secondary wires must be kept to a minimum.

RS485 Communications Port

The FM2 interfaces with PCs, PLCs, and DCSs using the Modicon Modbus RTU protocol. The FM2 supports Modbus function codes 01, 03, 04, 05, 06, 07, 08, and 16. The communications port is a very important part of the FM2's process and control applications. The port allows reading and writing of data as well as full control to close and open the feeder from a remote location. For these reasons, proper wiring practices are critical.

- A shielded, twisted pair cable, such as 24 gauge Belden 9841 (120 Ω characteristic impedance) or equivalent, **MUST** be used for the communications link. The cable should be routed away from all power carrying cables, such as the feeder mains, power supply wiring, CT wiring and noisy contactors or breakers.
- When using the GE Multilin 232/485 converter box at the MASTER, **GE Multilin recommends placing no more than 32 GE Multilin devices** on the same data link which should be of **no greater length than 1500 m**. The devices on the data link should be daisy chained for reliable operation. Star or stub connections are **not recommended**. If more than 32 devices are required to go onto the data link, or the distance must be greater than 1500 m, consult the EIA 485 standard for more details on specific calculations. Another way to increase the number of units on the data link or the transmission length is to utilise a RS485 Repeater.
- The **shields** of the cable should be daisy-chained to all of the FM2 serial commons (Terminal 38) and earthed **at the MASTER only.** This provides a common reference for all of the devices on the data link, as well as, earthing the data link without creating the potential for earth loops. The potential difference between the FM2 safety earth (terminal 14) and the FM2 serial common (Terminal 38) **should not** exceed 36 V.
- A terminating network consisting of a 120 Ω / 0.25 W resistor in series with a 1 nF / 50 V general purpose mono ceramic or equivalent capacitor **MUST** be placed across the positive and negative terminals at both ends of the data link (terminals 39 and 40 on the FM2). This is to provide the 200 mV separation between the +ve and –ve terminals of the device, as well as to eliminate any reflected signals and ringing.

Switch Inputs

The FM2 has 16 switch inputs that operate on 120 V AC for the FM2-712 models and 240 V AC for the FM2-722 models.

Terminals 57 and 58 are live at 120 V AC!

WARNING

An external source can be used to supply the circuitry into the FM2 switch inputs providing that the external source is *in phase* with the control voltage of the FM2. The FM2 switches the inputs on and off internally, to minimise power consumption, at a frequency determined by the control voltage. If the external source is not in phase with the control voltage to the FM2, the timing will be off which could cause errors when reading the switch inputs. If an external source is used to supply the control signals to the FM2 switch inputs, the source should be fused to protect against fault conditions in the circuitry.

Open Switch Input

The Open switch input on the FM2 **MUST** be energised before the FM2 is available to perform a close. If the contactor is being energised and de-energised externally to the FM2, this terminal will need a jumper from terminal 57 or 58 before the FM2 will seal in Relay A.

Contactor Status Feedback

The FM2 **MUST** see feedback from Contactor A and Contactor B auxiliary contacts into the applicable status switch inputs (Terminals 55 and 56) within 0.25 second of closing the output relays (A/B). If this feedback is not received, the FM2 will open the output relay instead of sealing it in, and will alarm with an Open Control Circuit.

CT Isolation

FM2 CT Withstand

When is withstand important?

Withstand is important when the phase or earth fault CT has the capability of driving a large amount of current into the interposing CTs in the relay. This typically occurs on retrofit installations when the CTs are not sized to the burden of the relay. New electronic relays have typically low burdens, while the older electromechanical relays have typically high burdens (e.g. 1 Ω).

For high current earth faults, the system will be either low resistance or solidly earthed. The limiting factor that determines the amount of earth fault current that can flow in these types of systems is the capacity of the source. Withstand is not important for earth fault on high resistance earthing systems. On these systems, a resistor makes the connection from source to earth at the source (generator, transformer). The resistor value is chosen such that in the event of a earth fault, the current that flows is limited to a low value, typically 5, 10, or 20 A.

Since the potential for very large faults exists (earth faults on high resistance earthed systems excluded), the fault must be cleared as quickly as possible.

NOTE

Care must he taken to ensure that the interrupting device is capable of interrupting the potential fault. If not, some other method of interrupting the fault should be used, and the feature in question should be disabled (e.g. a fused contactor relies on fuses to interrupt large faults).

CT Size and Saturation

How do I know how much current my CTs can output?

CT characteristics may be acquired by one of two methods.

The rating (as per ANSI/IEEE C57.13.1) for relaying class CTs may be given in a format such as these: 2.5C100, 10T200, T100, 10C50, or C200. The number preceding the letter represents the maximum ratio correction; no number in this position implies that the CT accuracy remains within a 10% ratio correction from 0 to 20 times rating. The letter is an indication of the CT type. A 'C' (formerly L) represents a CT with a low leakage flux in the core where there is no appreciable effect on the ratio when used within the limits dictated by the class and rating. The 'C' stands for

calculated; the actual ratio correction should be different from the calculated ratio correction by no more than 1%. A 'C' type CT is typically a bushing, window, or bar type CT with uniformly distributed windings. A 'T' (formerly H) represents a CT with a high leakage flux in the core where there is significant effect on CT performance. The 'T' stands for test; since the ratio correction is unpredictable, it is to be determined by test. A 'T' type CT is typically primary wound with unevenly distributed windings. The subsequent number specifies the **secondary terminal voltage** that may be delivered by the full winding at 20 times rated secondary current without exceeding the ratio correction specified by the first number of the rating. (Example: a 10C100 can develop 100 V at 20 × 5A, therefore an appropriate external burden would be 1 Ω or less to allow 20 times rated secondary current with less than 10% ratio correction). Note that the voltage rating is at the secondary terminals of the CT and the internal voltage drop across the secondary resistance must be accounted for in the design of the CT. There are seven voltage ratings: 10, 20, 50, 100, 200, 400, and 800. If a CT comes close to a higher rating, but does not meet or exceed it, then the CT must be rated to the lower value.

The curve below represents a typical excitation curve for a CT. The Y-axis represents secondary exciting voltage; the X-axis represents the secondary exciting current. When the CT secondary exciting voltage level is picked off the graph, the corresponding secondary exciting current is the amount of current required to excite the core of the CT. With respect to the ideal CT that conforms perfectly to its ratio, the exciting current could be considered loss.

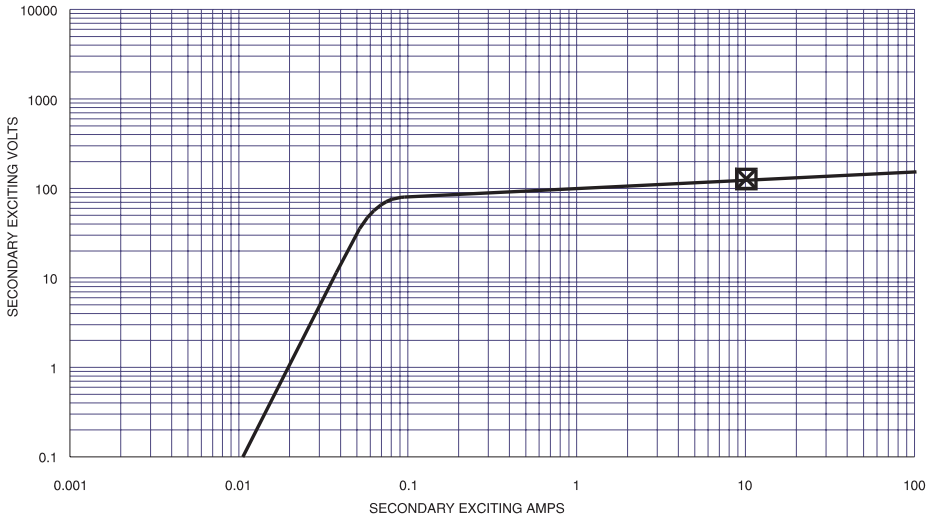

FIGURE A–1: Excitation Curves

For a Protection Class CT with a 5A secondary and maximum 10% ratio error correction, it is probable that the design point for 20 times rated secondary will be at or slightly lower than the 10 A secondary exciting current point (10% of 20□× 5 A). To design such that the 20 times rated secondary current is in the linear region would be more expensive.

In order to determine how much current CTs can output, the secondary resistance of the CTs is required. This resistance will be part of the equation as far as limiting the current flow. This is determined by the maximum voltage that may be developed by the CT secondary divided by the entire secondary resistance, CT secondary resistance included.

The easiest method of evaluating a CT is by the Excitation Curves Method, as illustrated by the curves shown below. The Y-axis represents secondary exciting voltage; the X-axis represents the secondary exciting current. These curves may be obtained from the CT manufacturer, or by experimentation (see ANSI/IEEE C57.13.1 for procedures). The curves illustrate the values of secondary volts for which the output of the CT will be linear. The desired operating secondary voltage is below the kneepoint (A or B on the graph (ANSI or IEC respectively) or just slightly

above it, staying within 10% CT ratio error correction at 20 times rating. Using this information, it is important to recognise that the secondary exciting voltage is the total voltage that the CT can develop at the secondary. In this case, that voltage will drop across the secondary winding resistance as well as any load that is applied to the unit. Therefore, the secondary winding resistance must always be included with the excitation curves, or the information is incomplete.

A curve with a knee at 100 V for example could drive a total burden of:

$$\frac{100\ V}{20 \times 5\ A} = 1\ \Omega \qquad \textbf{(EQ A.1)}$$

Evaluation of CT performance is best determined from the excitation curves. They present the complete story and eliminate any guess work. Most CT manufacturers will provide excitation curves upon request.

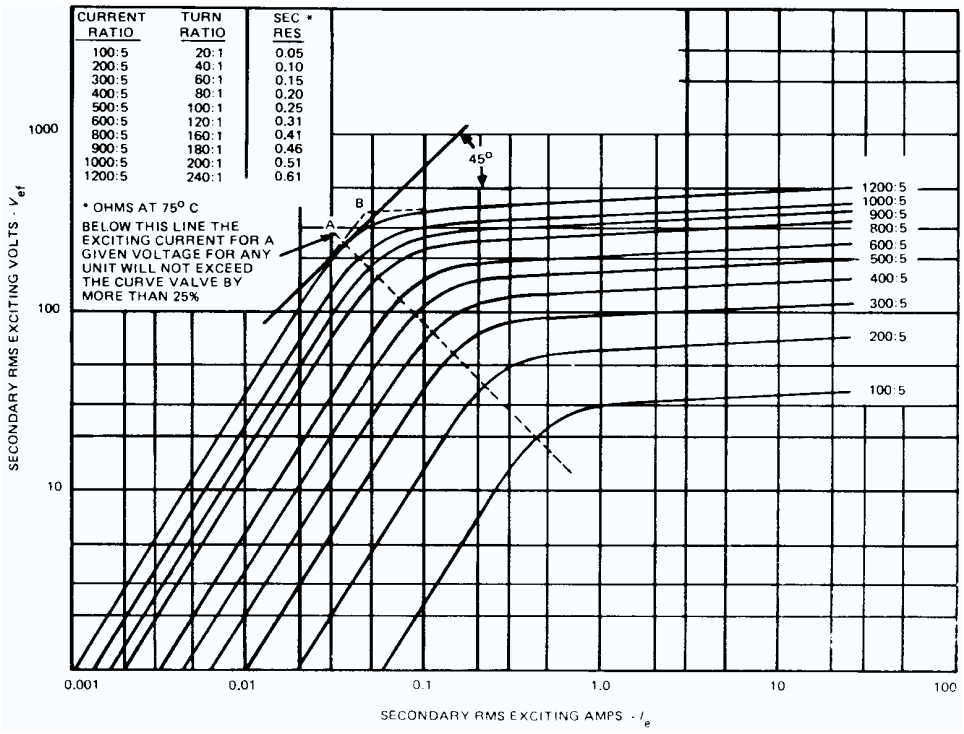

FIGURE A–2: Excitation Curves Method

Revision History

Release Dates

TABLE A–1: Release Dates

MANUAL	GE PART NO.	FM2 REVISION	RELEASE DATE
GEK-106559	1601-0154-A1	1.0x	June 4, 2004
GEK-106559A	1601-0154-A2	1.1x	Aug 3, 2005

GE Multilin Warranty

Warranty Statement

General Electric Multilin (GE Multilin) warrants each device it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the device providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorised service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any device which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorised factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a device malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

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