Instructions for FP-5000 Protective Relay

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1 PRODUCT OVERVIEW

1.1 General Description

The FP-5000 Protective Relay is a multi-function panel mounted, microprocessor-based relay, designed for both ANSI and IEC applications (Figure **1-1**). It is a self-contained device which operates from either AC or DC control power and provides true rms sensing of each phase and ground current. Only one relay is required per 3-phase circuit. Current, voltage, and operator-selectable protective functions are integral to each device.
The FP-5000 is designed to protect the mains, ties or feeders at any voltage level. It is primarily applied on medium voltage distribution circuits up to 69 kV. The FP-5000 monitors several primary and derived electrical parameters of the system.

1.2 Audience

The audience for this document is the Specifying or System Engineer, the operating personnel, and the troubleshooting personnel. This document will guide the system user to apply and program the FP-5000. The document will provide operating information, enabling the operating user to start and trip the breaker associated with the FP-5000. The operator can refer to this publication regarding any operation of the FP-5000. This document will also provide information to program the FP-5000 and use the troubleshooting features to collect and analyze historical, trending and oscillographic data.

1.3 Safety and Caution Notices/Disclaimers

This technical document is intended to cover most aspects associated with the installation, application, operation and maintenance of the Cutler-Hammer FP-5000 Protective Relay. It is provided as a guide for authorized and qualified personnel only in the selection and application of the FP-5000 Protective Relay. Please refer to the specific **WARNING** and **CAUTION** below before proceeding. If further information is required by the purchaser regarding a particular installation, application or maintenance activity, a Cutler-Hammer representative should be contacted. Technical Support is available 24 hours a day by phoning Cutler-Hammer Power Management Applications Support at 1-800-809-2772, Option 1.

See also 12.3, Getting help from Cutler-Hammer.

1.3.1 WARRANTY AND LIABILITY INFORMATION

⚠ CAUTION

NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OF MERCHANTABILITY, OR WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE, ARE MADE REGARDING THE INFORMATION, RECOMMENDATIONS AND DESCRIPTIONS CONTAINED HEREIN.

⚠ CAUTION

IN NO EVENT WILL CUTLER-HAMMER BE RESPONSIBLE TO THE PURCHASER OR USER IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGE OR LOSS WHATSOEVER, INCLUDING BUT NOT LIMITED TO DAMAGE OR LOSS OF USE OF EQUIPMENT, PLANT OR POWER SYSTEM, COST OF CAPITAL, LOSS OF POWER, ADDITIONAL EXPENSES IN THE USE OF EXISTING POWER FACILITIES, OR CLAIMS AGAINST THE PURCHASER OR USER BY ITS CUSTOMERS RESULTING FROM THE USE OF THE INFORMATION AND DESCRIPTIONS CONTAINED HEREIN.

⚠ CAUTION

ALL SAFETY CODES, SAFETY STANDARDS AND/OR REGULATIONS MUST BE STRICTLY OBSERVED IN THE INSTALLATION, OPERATION AND MAINTENANCE OF THIS DEVICE.

⚠ WARNING

THE WARNINGS AND CAUTIONS INCLUDED AS PART OF THE PROCEDURAL STEPS IN THIS DOCUMENT ARE FOR PERSONNEL SAFETY AND PROTECTION OF EQUIPMENT FROM DAMAGE. AN EXAMPLE OF A TYPICAL WARNING LABEL HEADING IS SHOWN ABOVE TO FAMILIARIZE PERSONNEL WITH THE STYLE OF PRESENTATION. THIS WILL HELP TO ENSURE THAT PERSONNEL ARE ALERT TO WARNINGS, WHICH MAY APPEAR THROUGHOUT THE DOCUMENT. IN ADDITION, CAUTIONS ARE ALL UPPERCASE AND BOLDFACE.

⚠ CAUTION

COMPLETELY READ AND UNDERSTAND THE MATERIAL PRESENTED IN THIS DOCUMENT BEFORE ATTEMPTING INSTALLATION, OPERATION OR APPLICATION OF THE EQUIPMENT. IN ADDITION, ONLY QUALIFIED PERSONS SHOULD BE PERMITTED TO PERFORM ANY WORK ASSOCIATED WITH THE EQUIPMENT. ANY WIRING INSTRUCTIONS PRESENTED IN THIS DOCUMENT MUST BE FOLLOWED PRECISELY. FAILURE TO DO SO COULD CAUSE PERMANENT EQUIPMENT DAMAGE.

⚠ WARNING

THE LOSS OF CONTROL VOLTAGE WILL CAUSE THE FP-5000 TO BE INOPERATIVE. IF AC CONTROL VOLTAGE IS USED, AN APPROPRIATE RELIABLE POWER SOURCE/SCHEME SHOULD BE SELECTED (POSSIBLY A UPS SYSTEM) TO SUPPLY POWER TO THE RELAY.

1.4 Referenced Documents

IMPACC Communications Standard, IL 17384

IEEE Standard Electrical Power System Device Function Numbers and Contact Designations, # C37.2-1996, ISBN 0-7381-0732-8 **Standard IEEE Device Numbers.**

1.5 Commercial and Trademarks

Acrobat™	Adobe Corporation
Explorer™	Microsoft Corporation
IMPACC™	Eaton/Cutler-Hammer
INCOM™	Eaton/Cutler-Hammer
IEEE™	Institute of Electrical and Electronic Engineers
PowerNet™	Eaton/Cutler-Hammer
PowerPort™	Eaton/Cutler-Hammer
Windows®	Microsoft Corporation

1.6 FP-5000 Hardware Resources and Description

The FP-5000 has four current measuring inputs, four voltage measuring inputs, eight contact inputs, seven contact output relays, communications, and a front panel user interface.

Based upon the firmware loaded into the flash memory of the FP-5000 and the customer settings entered manually through the front panel or through the RS-232 port using the PowerPort program, the microprocessor observes inputs, sets outputs, and stores data for user retrieval. The resources, the firmware, and the customer settings are the FP-5000.

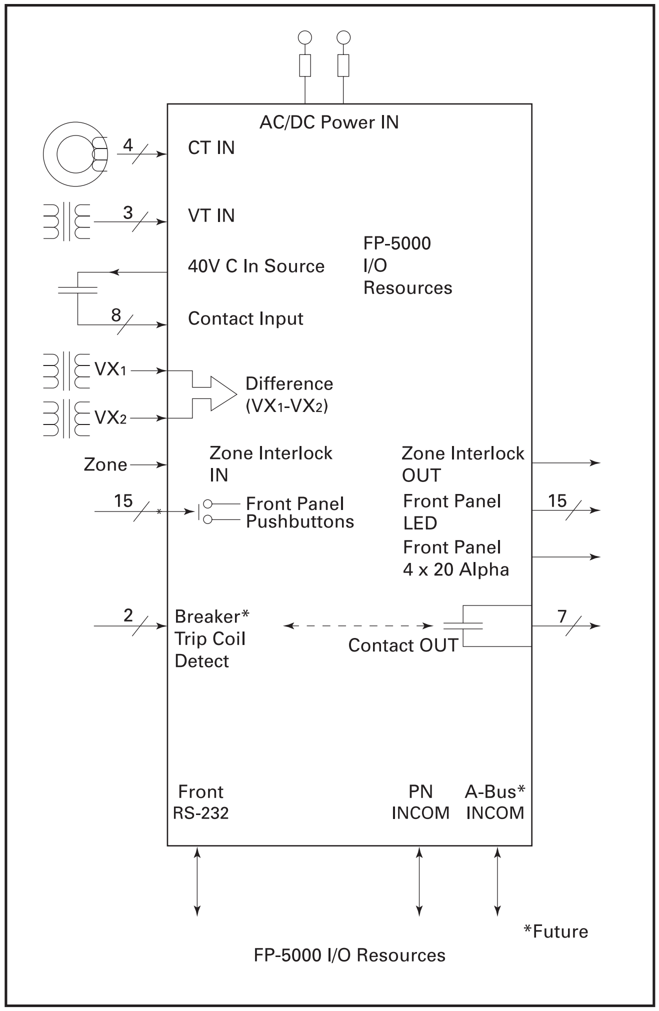


Figure 1-1. FP-5000 Resources

1.7 FP-5000 Features

The 10 Standard Curves referred to in the FP-5000 Features List are shown in Table 1.1 below. See examples of typical FP-5000 curves in the Appendix, 13.4, and Section 8.4.4.1.

Table 1.1 FP-5000 Curve Shapes

Thermal Curves	ANSI Curves (Per ANSI C37.112)	IEC Curves (Per IEC 255-3)
It	Moderately Inverse	IEC-A
I^2t	Very Inverse	IEC-B
I^4t	Extremely Inverse	IEC-C
Flat		

FP-5000 Features List

Protection Features

- Phase overcurrent
  - A. 2-stage instantaneous with timers (50P-1 & 50P-2)
  - B. Inverse time overcurrent (51P)
  - C. 10 standard curves
  - D. Reset
    1. Instantaneous
    2. Time Delay
    3. Calculated
- Independent measured ground or neutral overcurrent element
  - A. 2-stage instantaneous with timers (50X-1 & 50X-2)
  - B. Inverse time overcurrent (51X)
  - C. 10 standard & 3 user defined custom curves
  - D. Reset
    1. Instantaneous
    2. Time Delay
    3. Calculated
- Independent calculated ground or neutral overcurrent element
  - A. 2-stage instantaneous with timers (50R-1 & 50R-2)
  - B. Inverse time overcurrent (51R)
  - C. 10 standard curves
  - D. Reset
    1. Instantaneous
    2. Time Delay
    3. Calculated
- Breaker failure (50BF)
- Phase current unbalance and sequence protection (46)
- Phase voltage unbalance and sequence protection (47)
- Main 3-phase under/over voltage (27M1/59M1)
- Under/over frequency (81U/81O)
- Auxiliary single-phase under/over voltage (27A1/59A1)
- Power factor (55)
- Zone interlocking for bus protection (87B)
- Additional elements for alarming on:
  - A. Instantaneous overcurrent (50P-3, 50X-3, 50R-3)
  - B. Under/over voltage (27M-2/59M-2, 27A-2/59A-2)
  - C. Under/over frequency (81U-2, 810-2)
  - D. Current unbalance (46-2)
  - E. Voltage unbalance (47-2)

Metering Features

- Amps & amps demand
- Volts
- Volt-amps
- Watts & kw demand
- kwh, net kwh
- Vars & kvar demand
- Kvarh & net kvarh
- Power factor
- Frequency
- Min/max recording
- Trending (load profile over time)
- Current & voltage THD

Monitoring Features

- Trip coil
- Breaker wear (accumulated interrupted current)
- Oscillography (256 cycles total, up to 16 events)
- Trip data logs (up to 16 events)
- Sequence of events report (up to 100 events)
- Clock (1 ms time stamping)

Control Functions

- Remote open/close
- Local open/close
- Programmable I/O
- Programmable logic gates and timers
- Multiple setting groups (up to 4)

Mechanical Features

- Full drawout unit (automatic Ct shorts)
- Standard IQ Panel Cutout retrofit possible
- Outline Size is approximately 6.5" wide 10" high 7" deep
- Weight for outer case is 5.0 lbs, inner drawout 5.8 lbs. Approximate shipping weight is 16.5 lbs.

Design Features

- Password protected
- Data acquisition with necessary resolution and sampling frequency
  - A. 3-phase currents
  - B. Ground current
  - C. 3-phase voltages
  - D. Auxiliary voltage
  - E. rms values (current and voltages)
  - F. Power [real (W), reactive (VAR), apparent (VA)]
  - G. Power factor (apparent and displacement)

H. Frequency

I. Power and current demand

J. Min/max values

K. Energy

- Control power

  A. AC or DC control power (100–120V AC, 50/60 Hz, or 48–125V DC)

  B. Consult factory for availability of other voltage power supplies.

- Non-volatile memory for Settings, Waveforms, Sequence of Event Logs, Trip Logs and Trending
- Determine condition of acquired data relative to settings

  A. Current, voltage and frequency protection

- Monitoring and reporting of additional system information

  A. Oscillography

  B. Sequence of events recording

  C. Trip target data

  D. Real-time clock

  E. Breaker wear, trip coil

  F. Signal harmonic content

- Zone interlocking
- User access to processed data (through PowerNet and PowerPort)
- Meets ANSI, IEC, UL, CUL standards

Communication Features

- Local HMI
- Addressable
- Local Communication Port (RS-232 on 9-pin DIN)
- Remote communication ports

  A. Incom FSK

- Protocols

  A. INCOM/IMPACC Communications Standard, IL 17384 – Part A, version 3.0

Self-Test Features

- Hardware

  A. Processor integrity

  B. RAM

  C. PROM checksum

  D. Analog input circuitry

- Application

  A. Comparison of current flow with apparent state of breaker

  B. Comparison of apparent and set phase sequence

  C. Determination of correct voltage or current phasor relation-ships and/or balance

  D. Setting integrity

1.8 Ordering Information

The FP-5000 and a wide variety of related and support products may be obtained from Cutler-Hammer. Order information for the FP-5000 is:

Style Number	Catalog Number	Option Description
66D2041G01	FP5000-00	5A Ct 48 – 125V DC, 100 – 120V AC Power supply standard comm. board
66D2041G02	FP5100-00	1A Ct 48 – 125V DC, 100 – 120V AC Power supply standard comm. board
Renewal Parts		
66D2038G01	FP5000-00-IC	Relay Inner Chassis 5A
66D2038G02	FP5100-00-IC	Relay Inner Chassis 1A
66D2039G01	FP5XX0-OC	Outer Chassis for FP5XX0-00 IC

World-wide users may determine their Cutler-Hammer sales office by web browsing to:
http://www.ch.cutler-hammer.com/international/sales.html

In North America, web browse to:
http://www.ch.cutler-hammer.com/international/northamerica.html

In the USA or Canada, contact your Cutler-Hammer Sales office by calling 800-525-2000 for the location of your nearest sales office or click your location on the web map at:
http://www.ch.cutler-hammer.com/support/index.html

2 QUICK START

2.1 Introduction

The purpose of a Quick Start section is to provide a minimal overview of what it takes to operate the FP-5000. This perspective is useful as either providing the framework for learning the FP-5000 more thoroughly or for actually handling a simple application. The FP-5000 is approachable at a variety of levels. Significant results may be obtained with basic knowledge, yet the FP-5000 is powerful enough to handle the most difficult and involved of applications.

Use this Guide to begin performing basic metering functions quickly, without reviewing complete instructions provided in the User's Manual. To more fully understand the wide array of features offered by your FP-5000, it is strongly recommended that operators read the entire User's Manual. Following initial power-up of the FP-5000, the displayed "Meter Menu" values may not be what is anticipated for your specific system. The unit must first be programmed with "General Setup" information relating to your electrical system.

⚠ CAUTION

THE FP-5000 MUST BE SET FOR THE PARTICULAR APPLICATION BEFORE ENERGIZING THE ELECTRIC POWER SYSTEM.

2.2 Initial Checks

Your FP-5000 will either come pre-installed in a panel or as a separate FP-5000 component assembly package including an "Outer Chassis" assembly and an "Inner Chassis" assembly containing the major portion of the operating electronics. Follow Section 7 "Startup" if a review of the installation is required.

2.3 Standard Mounting

The FP-5000 is shipped with the Outer Enclosure assembled with a backing plate between the enclosure housing box and the front latching frame. This factory assembled outer chassis allows for panel thickness variations, minor panel distortions and has relaxed panel cutout tolerance requirements for easy faster panel mounting. The panel footprint outline is equivalent to the Cutler-Hammer DT3XXX and MP3XXX draw-out designs. However it differs from most Cutler-Hammer IQ style panel mounts in that:

- The panel cutout is slightly larger.
- The enclosure is mounted from the front user side of the panel.
- Four mounting studs/nuts are used for panel mounting instead of 10 mounting screws.

The standard panel cutout is shown in **Figure 2-1**.
Please refer to Section 6.1 for mounting details.
For IQ cutout retrofit see Section 6.2.

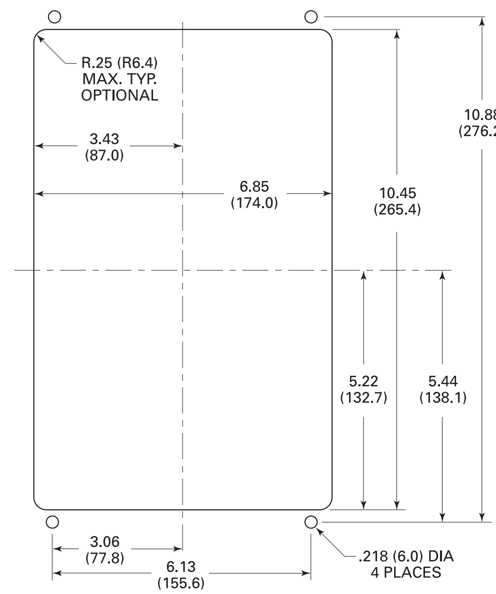


Figure 2-1. FP-5000 Standard Panel Cutout

2.4 Wiring

2.4.1 Powering the FP-5000

Power Supply control power is brought in on TB 101/102. Nominal input range is either:

- 100–120V AC
- 48–125V DC

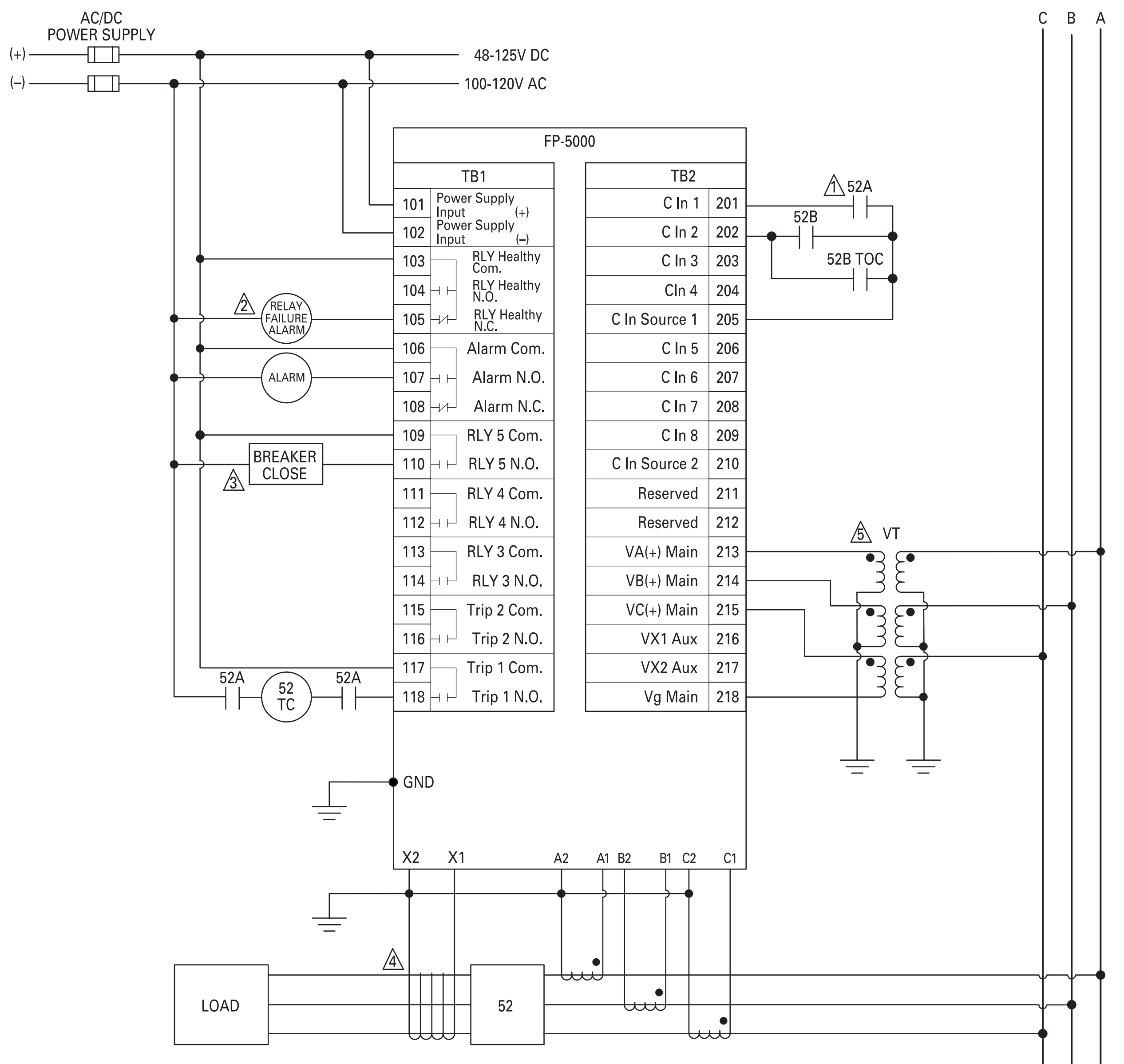
Terminal 101 is positive DC or Hot on AC with 102 being the common DC return or the AC neutral. With control power applied, the FP-5000 may be programmed and minimal functionality may be verified.

2.4.2 Typical Application Wiring

⚠ CAUTION

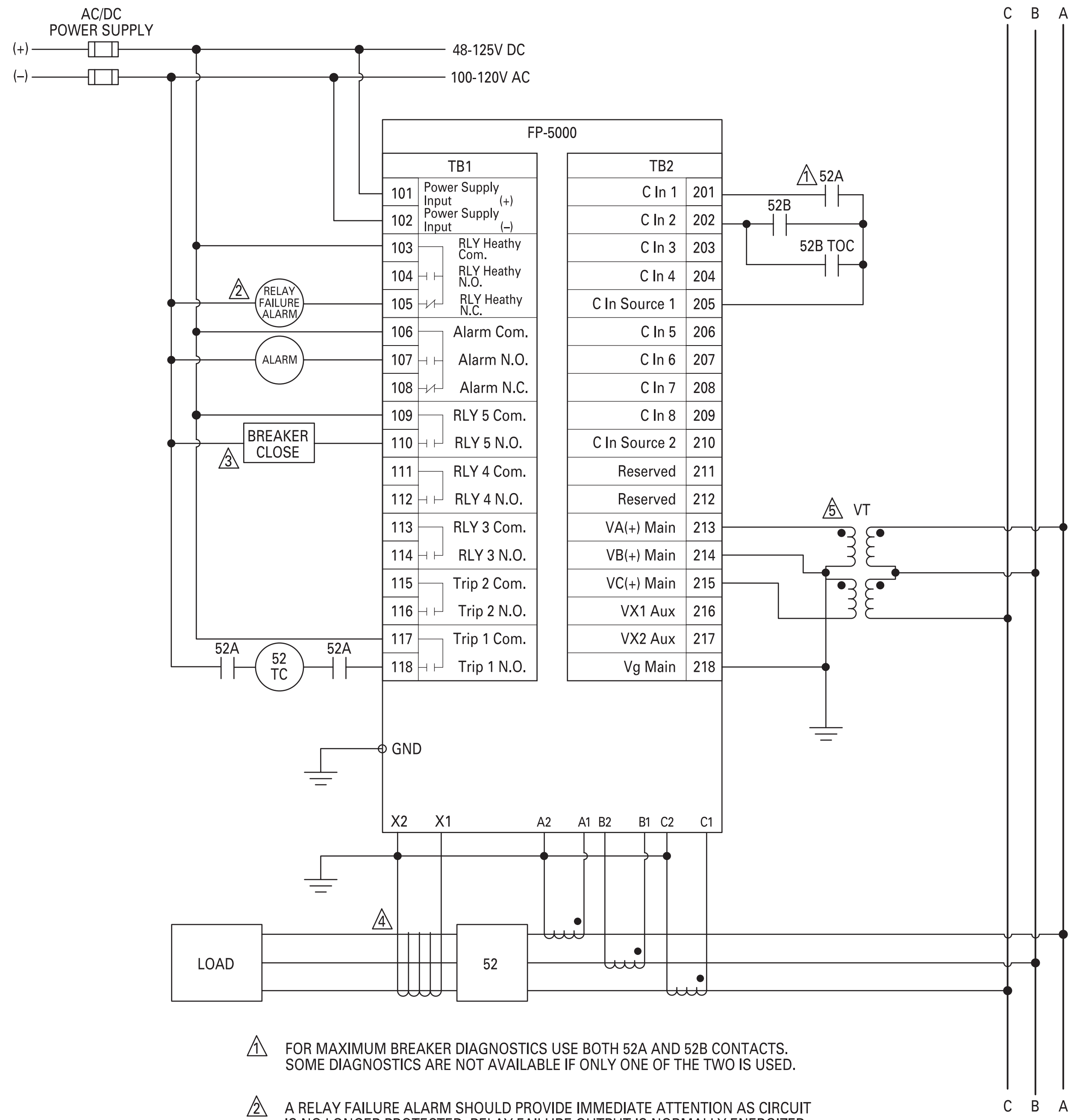
WIRING PROCEDURES MUST BE PERFORMED ONLY BY QUALIFIED PERSONNEL WHO ARE FAMILIAR WITH THE FP-5000 AND ITS ASSOCIATED ELECTRICAL EQUIPMENT. ENSURE THAT INCOMING POWER SOURCES ARE TURNED OFF AND LOCKED OUT PRIOR TO PERFORMING ANY ELECTRICAL WORK. FAILURE TO DO SO MAY RESULT IN SERIOUS INJURY OR EQUIPMENT DAMAGE.

Wiring installation for the FP-5000 must follow a suitable Wiring Plan Drawing and conform to applicable Federal, State and Local codes. Direct wires to the terminal blocks TB1 and TB2 must not be larger than AWG No. 14 (without spade lugs) and no smaller than 18 AWG. TB4 for the Ct connections can support 10 to 14 AWG. The lug screws of TB1, 2 and 4, are not captive and may be backed out entirely for the purpose of securing a ring terminal. The removable terminal plugs of TB3 can support direct connection of 14 to 20 AWG wires, however ferrules are recommended on the wire termination to minimize shorting of frayed wires. The following two figures, **Figure 2-2** and **Figure 2-3**, show typical wiring diagrams. Additional wiring diagrams are shown in Section 6.



1. FOR MAXIMUM BREAKER DIAGNOSTICS USE BOTH 52A AND 52B CONTACTS. SOME DIAGNOSTICS ARE NOT AVAILABLE IF ONLY ONE OF THE TWO IS USED.
2. A RELAY FAILURE ALARM SHOULD PROVIDE IMMEDIATE ATTENTION AS CIRCUIT IS NO LONGER PROTECTED. RELAY FAILURE OUTPUT IS NORMALLY ENERGIZED.
3. FP-5000 CAN INITIATE A BREAKER CLOSE VIA THE FRONT PANEL INTERFACE AND/OR REMOTE ACTIVATION THROUGH COMMUNICATION OR DISCRETE INPUT.
4. RESIDUAL CONNECTION MAY BE USED IN PLACE OF ZERO SEQUENCE CT.
5. DELTA OR OPEN DELTA PT CONNECTION MAY BE USED IN PLACE OF WYE-GROUND CONNECTION.

Figure 2-2. FP-5000 Simple Wye Connected Application



1 FOR MAXIMUM BREAKER DIAGNOSTICS USE BOTH 52A AND 52B CONTACTS. SOME DIAGNOSTICS ARE NOT AVAILABLE IF ONLY ONE OF THE TWO IS USED.

2 A RELAY FAILURE ALARM SHOULD PROVIDE IMMEDIATE ATTENTION AS CIRCUIT IS NO LONGER PROTECTED. RELAY FAILURE OUTPUT IS NORMALLY ENERGIZED.

3 FP-5000 CAN INITIATE A BREAKER CLOSE VIA THE FRONT PANEL INTERFACE AND/OR REMOTE ACTIVATION THROUGH COMMUNICATION OR DISCRETE INPUT.

4 RESIDUAL CONNECTION MAY BE USED IN PLACE OF ZERO SEQUENCE CT.

5 WYE-GROUND PT CONNECTION MAY BE USED IN PLACE OF DELTA OR OPEN DELTA CONNECTION.

Figure 2-3. FP-5000 Simple Open Delta Application

2.5 Introduction to Programming

The FP-5000 can be programmed using an HMI with PowerPort™ software through the RS-232 serial port or remotely via the rear INCOM PN using PowerNet. In addition, the FP-5000 may be programmed directly from the front panel. We will focus on direct programming from the front panel in this Quick Start Section. Programming is restricted to authorized users through password protection and through the physical restraint of a security door which may be sealed with a lead seal.

⚠ CAUTION

CHANGING THE SETTINGS OF THE FP-5000 WILL SUBSTANTIALLY IMPACT SYSTEM OPERATION. ONLY AUTHORIZED PERSONNEL WHO ALSO POSSESS THE PASSWORD MAY MAKE MODIFICATIONS TO THE FP-5000 SETTINGS.

2.5.1 Entering Set (Programming) Mode

Set

Lift the security door cover over the Set and Test buttons on the front panel and press the Set pushbutton. The Set LED (at the upper right corner of the Set pushbutton) will illuminate and the display will change to the Password request Window. Unauthorized programming is prevented by password protection and by means of the security door over the Set pushbutton, which may be secured with the lead seal, making apparent any programming access. Minimal programming will be described in this Quick Start section. Please refer to the complete programming instructions in Setting the FP-5000, Section 5.

2.5.2 Password

The Setting Mode from the Front Panel is password protected to prevent access by unauthorized users. In order to program the FP-5000, a Password must be entered in to access programming mode. Each Password is a 4-character alphanumeric value. The FP-5000 is shipped with the password protection effectively disabled, set to the default of '0000'. Entering Program Mode (or Test Mode) with acceptance of the default password is done by pressing the Enter button with the 4-asterisk Password display unchanged. Each character in the Password may be modified to any of the characters 0-9 and A-Z within program mode.

Password Window
[****]
Single Arrow For Bit
Dual Arrow for Value

Just press Enter, as the password is defaulted to 0, the unchanged state.

If a password has been previously programmed, use the and pushbuttons to select which of the 4 password characters to change, the and pushbuttons to change to the appropriate character in each location, and the pushbutton to enter the specified password.

Enter

⚠ CAUTION

KEEP YOUR PASSWORD SECRET AND RECORD IT IN A SAFE PLACE. IF THE PASSWORD IS LOST, A NEW PASSWORD MAY BE ENTERED DURING THE FIRST 2 MINUTES AFTER CONTROL POWER IS APPLIED TO THE FP-5000.

2.5.3 Navigation Within Settings Mode

The FP-5000 parameters that are set are either numeric or elements of a list.

Enter

Use the **Enter** pushbutton to select the settings category and value to update. Enter also verifies the updating of settings upon exiting Set mode.

Use the **Up** and **Down** pushbuttons to increment or decrement setting values one step at a time or to step forward and backward through a presented list of settings.

Use the **Page Up** and **Page Down** pushbuttons to increment or decrement setting values 10 times as fast as with the Up and Down pushbuttons, or to step forward or backward through a list of settings a page at a time.

Previous

Use the **Previous** pushbutton to back out of the settings menu. However, when the "Save Settings Window" appears, **Enter** must be pressed in order to accept and save your setting changes. If the **Previous** pushbutton is pressed, all your changes will be discarded. Numeric ranges are looped so that going past one end of an interval brings you to the beginning of the other end of the range for the setting. Similarly, lists are also looped.
Upon entry to the Set Function, the user will view the **Setting Main** Screen where the selections will be seen three at a time using the up and down navigation pushbuttons.

Setting Main
System Config
Protection
System Alarms
Logging
Contact Input CFG
Output Config
Programmable Logic
Clock
Communications
Change Password

We will only be concerned with System Config and Protection settings here.

Select the category and press the Enter pushbutton to proceed. The actual setting of values will be covered in Section 2.5.5.

2.5.4 Minimum Program Requirements

Default settings are provided to minimize the number of manual programming steps for typical applications. For more complex applications cases, the use of computer generated setting files simplifies the setting process. The user programs through the RS-232 front panel port by use of the PowerPort™ Windows® based or PowerNet™ Software program. This subject is treated more extensively later in the manual.

2.5.5 Functions Which Must be Programmed

The FP-5000 comes pre-configured with default or factory settings. The phase and ground overcurrent functions are the only protection functions enabled. All other protection functions are turned off and must be set to enable their operation. The I/O comes pre-configured as default from the factory for the most common applications. The I/O can be changed per the requirements of the user's application.

For now we assume that the default settings will be adequate except for the following list of functions, which the user must program in order to handle the specific characteristics of your system. Since only one protection setting Group is enabled, we need only program the one group of protection settings and the values necessary to define the proper operating environment of the FP-5000. Please refer to Table 2.1 Minimum List of Functions Which MUST be Programmed for those items.

Table 2.1 Minimum List of Functions Which MUST be Programmed

Setting	Default	Incr	Display	User Setting
System Configuration				
Frequency	60	List	50Hz, 60Hz	
Phase Sequence, “Phase Seq”	ABC	List	ABC, ACB	
Ct Connect	3-Wire	List	3-Wire, 4ct In, 4ct Ig	
Phase Ct Primary, “PH CT Pri”	500:Ct	1	Ct-6000:Ct, where Ct is 1 or 5 Amp based on CT board jumper	
Neutral Ct Primary, “NU CT Pri”	500:Ct	1	Ct-6000:Ct, where Ct is 1 or 5 Amp based on CT board jumper	
VT Connect	Wye	List	Wye, Delta	
Main VT Ratio, “Main VTR”	100	1	1-8000 Volt	
Aux VT Ratio, “Aux VTR”	100	1	1-8000 Volt	
TOC Reset Time, “TOC ResetT”	5	1	1-20 cycles	
Protection/Group 1				
Phase Overcurrent				
51P Ph TOC Shape	MOD	List	IT, I2T, I4T, FLAT, MOD, VERY, XTRM, IECA, IECB, IECC	
51P Ph TOC Reset	Calc	List	Inst, Calc, T Delay	
51P Ph TOC Pickup	1.00	0.01	0.10-4.00 p.u., “Disable”	
51P Ph TOC TIme Multi	1.00	0.01	0.05-10.00 p.u.	
50P1 Ph OC Pickup	2.00	0.01	0.10-20.00 p.u., “Disable”	
50P1 Ph OC Delay	0	1	0-9999 cycle	
50P2 Ph OC Pickup	3.00	0.01	0.10-20.00 p.u., “Disable”	
50P2 Ph OC Delay	15	1	0-9999 cycle	

Table 2.1 Minimum List of Functions Which MUST be Programmed (continued)

Setting	Default	Incr	Display	User Setting
IX Overcurrent				
51X Ix TOC Shape	XTRM	List	IT, I2T, 14T, FLAT, MOD, VERY, XTRM, IECA, IECB, IECC	
51X Ix TOC Reset	Calc	List	Inst, Calc, T Delay	
51X Ix TOC Pickup	0.50	0.01	0.10-4.00 p.u., “Disable”	
51X Ix TOC Time Multi	1.00	0.01	0.05-10.00 p.u.	
50X1 Ix OC Pickup	1.00	0.01	0.10-20.00 p.u., “Disable”	
50X2 Ix OC Delay	60	1	0-9999 cycle	
50X2 Ix OC Pickup	2.00	0.01	0.10-20.00 p.u., “Disable”	
50X2 Ix OC Delay	600	1	0-9999 cycle	
IR Residual Overcurrent				
51R Ir TOC Shape	XTRM	List	IT, I2T, 14T, FLAT, MOD, VERY, XTRM, IECA, IECB, IECC	
51R Ir TOC Reset	Inst	List	Inst, Calc, T Delay	
51R Ir TOC Pickup	0.1	0.01	0.10-4.00 p.u., “Disable”	
51R Ir TOC Time Multi	1.00	0.01	0.05-10.00 p.u.	
50R1 Ir OC Pickup	1.00	0.01	0.10-20.00 p.u., “Disable”	
50R1 Ir OC Delay	60	1	0-9999 cycle	
50R2 Ir OC Pickup	2.00	0.01	0.10-20.00 p.u., “Disable”	
50R2 Ir OC Delay	600	1	0-9999 cycle	

2.5.6 Default Settings

Please refer to the default settings as listed in Table 5.3 FP-5000 Setting Table. The default settings are those loaded into the program memory at the factory. Restoration to default settings can only be accomplished by deliberate user actions. No internal control action can cause the FP-5000 to reset itself to default settings. Restoring settings to factory defaults shown in Section 5.3 once alternative values are programmed involves one of three actions:

1. Manually input the default values for those changed through the Settings mode.

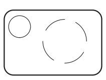
2. Completely restore to default settings through the Default Setting Control under the Status/Control mode function.

3. Execution of external communication commands. The user may also re-program individual settings or return all settings to default by INCOM Command(s) through either the rear INCOM port (J1), or through the front panel RS-232 Serial port. This functionality is incorporated into the Cutler-Hammer software that operates through these ports, for instance PowerNet or PowerPort.

We will emphasize restoring the defaults through No. 2 above, using the front panel capabilities of the FP-5000.

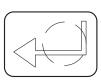
2.5.7 Restoring Default Settings

To assure a known starting point, unless you know that the FP-5000 is pre-programmed to the required settings, return the FP-5000 to its default programmed settings.

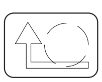


Status / Control

Press the **Status/Control** pushbutton to access the Default Setting Control.



Enter



Previous

After pressing **Status/Control**, select "Default Setting Ctr," and press the **Enter** pushbutton. Select "Load Default Setting" and press **Enter** again. The Password Window will appear to verify your authorization to make the desired change in settings back to the default values. After password entry, select "Load ALL Settings" and press **Enter**. A final verification display will enable you to accept the change by pressing **Enter** or cancel by using the **Previous** pushbutton.

2.5.8 Programming

Programming consists of selecting "System Config" or "Protection" from the "Setting Main" list. For the "System Config" items, simply scroll to the item, select with Enter, vary with Up/Down, and select with Enter. For "Protection," select "Setting Group 1" (the only default group enabled) and scroll to select the functions to be changed as for "System Config."

To save settings, press Previous until the screen requires Enter to Save or Previous to Cancel.

Update Settings?
ENTER to Save
Previous to Cancel
Reset to Exit Set

Press the key desired and this operation is completed.

2.6 Startup

Startup consists of programming the necessary operational parameters, verifying the operation of the FP-5000, checking the wiring, and verifying the reasonable operation of the system components before attempting to place the equipment into continuous service.

The programming should already be done by the time the FP-5000 is wired into a system and about to be Started Up and placed into service. Follow Section 7 for start procedures and refer to Section 6.3 for guidance in making connections during startup.

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3 SPECIFICATIONS

3.1 Table of Specifications

Note that accuracy specifications for the FP-5000 are for operation within the nominal frequency range of 50 Hz or 60 Hz at ± 5 Hz.
Unless stated otherwise, Operating Power Factor is “0.50 Lagging” to “Unity” to “0.50 Leading.”

Control Power: **TB101-102 (101 positive for DC)**

AC NominalVoltage	100 – 120V AC
AC Excursion Range	55 – 132V AC
AC Frequency Range	50/60 Hz nom. ± 5%
DC Nominal Voltage	48 – 125V DC
DC Excursion Range	38 – 150V DC
Interruption ride through time	5 Cycle Interruption of AC Supply at 120V AC 60 Hz Nominal
Power Consumption	20 VA max.

Current Transformer Inputs: **TB4 A, B, C, X**

	FP-5000-00	**FP-5100-00**
Nominal(I_{nom}):	5A	1A
Ct Rating: Steady state maximum transient	2 x I_{nom} = 10A 80 x I_{nom} = 400A for 1 sec.	3 X I_{nom}= 3A 100 X I_{nom} = 100A for 1 sec.
Ct Burdens	< 0.25 VA @ 5A (Nominal)	< 0.05 VA @ 1A (Nominal)

Contact Inputs: **TB201-204, 206-209, Source TB205, 210**

Number of contact inputs	Cin1 – Cin8
Rating	40V DC @ 2 mA/C In draw wetting voltage provided with internal return only

Voltage Transformer Inputs: **TB213-217, VA, VB, VC, VX1, VX2**

Nominal	0 – 120V AC Line to common
Operating Range	0 – 144V AC (+20%) Line to common
Internal Burden Loading	1 Meg Input Impedance
Reference	TB218, Vg internal 120 ohm PTC to chassis ground

Relay Output:

Number & type of output contacts	2 Form C, NO & NC TB103-105, 106-108 5 Form A, NO only TB109/110, 111/112, 113/114, 115/116, 117/118

Relay Output Contacts Rating:	**Both Form A & C**
Momentary	Make 30A AC/DC for 0.25 s. Break 0.5A @ 125V DC (resistive) Break 5A @ 120V AC
Continuous	5A @ 120/240V AC 5A @ 30V DC

IPONI Communications:	**TB3 J1**
Baud Rate	9600 Fixed
Max. distance	10,000 feet
Protocol	INCOM Slave
Media	Shielded Twisted pair - CH IMPCABLE; BELDEN 9463, 3072F
Signal lines	J1-1, J1-2 polarity not needed
Shield	J1-3 Filter referenced to chassis
DC input impedance	~2 ohms
AC input impedance @ 100 kHz	> 30k/100 ohms unterminated/terminated - Switch

Accessory Bus:	**TB3 J2, - FUTURE INTERFACE**
Baud Rate	9600 Fixed
Max. distance	10,000 feet
Protocol	INCOM
Media	Shielded Twisted pair - CH IMPCABLE: Belden 9463, 3072F
Signal lines	J2-1, 2-2 polarity not needed
Shield	J2-3 Filter referenced to chassis
DC input impedance	~2 ohms
AC Input impedance @ 100 kHz	> 100 ohms (permanent termination resistor)

Zone Interlock:	**TB3 J3**
Zone Out	J3-1 Open collector output ~ 4.5V to common
Zone In	J3-4, Approximately 300K ohms input impedance
Zone Common	J3-2, 3-5 internally connected
Zone Shield	J3-3 referenced direct to chassis – NOT REQUIRED
Cable	14-18 AWG Twisted Pair <250' between 1st and last unit

RS-232:	**Front temporary programming monitor port** **PowerPort Connection**
Baud Rate	38.4 kB, 19.2 kB, 9.6 kB
Connector	Standard 9-Pin D Subminiature, DCE Connection P2, 3, 5
Protocol	INCOM ASCII Slave
Cable	Shielded & restricted to < 3 meters in length

Metering Accuracy:

Input Signal Frequency necessary for accurate operation	60 Hz nominal, 57-63 Hz (5%) 50 Hz nominal, 47-53 Hz (5%)
Frequency Measurement Accuracy	+0.02 Hz
Clock Accuracy	Free running + 1 minute/month @ 25°C. Automatically updated by PowerNet host when present

Principal Parameters	Range	Accuracy
Current (Amps) Ia, Ib, Ic, Ir, Ix	0.02 to 20 per Unit	at < 2 • CT Rating: ±0.5% of CT Rating at > 2 • CT Rating: ±0.5% of Reading
Sequence Currents	0.02 to 20 per Unit	±1% of Nominal
Main Voltage (ϕϕ & ϕG)	0 to 160V	±0.5% of Nominal, ±0.2 V
Sequence Voltages	0 to 160V	±1% of Nominal
Aux Voltage	0 to 320V	±1% of Nominal
Phase Angle for I & V	0 to 360°	±1° at Nominal Voltage
System Frequency	45 to 65 Hz	±0.02 Hz
Amp Demand	0.02 to 20 per Unit	±0.5%
Watt Demand	0 to 4000 MW	±1.0% FS① for PF = Unity ±1.5% FS① for PF = -0.5 to 0.5
Watts	0 to 4000 MW	
Watt-hours	0 to 999,999 MWh	
Var Demand	0 to 4000 Mvar	±1.5% FS① for PF = -0.5 to 0.5
Vars	0 to 4000 Mvar	
Var-hours	0 to 999,999 Mvarh	
VA Demand	0 to 4000 MVA	±1% FS①
VA		0 to 4000 MVA
VA-hours	0 to 999,999 MVAh	
Apparent Power Factor	-1 to +1	±0.02, for Load Currents Above 20% Rated
Displacement Power Factor	-1 to +1	±0.02, for Load Currents Above 20% Rated
Total Harmonic Distortion	0 to 9999	±1%
Other Metering Accuracy	±1%	

Protective Function Pickup Accuracy

Trip Accuracy — Pickup and Trip Time Relative to Programmed:

Trip	Trip Description	Pickup Accuracy	Trip Time Accuracy
50X-1	Ground Trip (IX IOC)	±0.5%②	0 to + 2 Cycles or 0.1%, whichever is greater
50X-2	Ground Trip (IX IOC)	±0.5%②	0 to + 2 Cycles or 0.1%, whichever is greater
50R-1	Ground Trip Residual (IR IOC)	±3%③	0 to + 2 Cycles or 0.1%, whichever is greater
50R-2	Ground Trip Residual (IR IOC)	±3%③	0 to + 2 Cycles or 0.1%, whichever is greater
50P-1	Phase Trip (Ph IOC)	±0.5%②	0 to + 2 Cycles or 0.1%, whichever is greater
50P-2	Phase Trip (Ph IOC)	±0.5%②	0 to + 2 Cycles or 0.1%, whichever is greater
55A	Apparent PF Trip	±0.02	0 to + 0-1.2 Sec.
55D	Apparent PF Reset	±0.02	0 to + 0-1.2 Sec.
59M-1	Voltage Main Over	±0.5%④	0 to + 2 Cycles or 0.1%, whichever is greater
27M-1	Voltage Main Under	±0.5%④	0 to + 2 Cycles or 0.1%, whichever is greater
47-1	Voltage Unbalance	±1%④	0 to + 2 Cycles or 0.1%, whichever is greater
47-2A	Voltage Unbalance	±1%④	0 to + 2 Cycles or 0.1%, whichever is greater
46-1	Current Unbalance	±1%②	0 to + 2 Cycles or 0.1%, whichever is greater
46-2A	Current Unbalance	±1%②	0 to + 2 Cycles or 0.1%, whichever is greater
81O-1	Over Frequency	±0.02 Hz	0 to + 6 Cycles or 0.1%, whichever is greater
81U-1	Under Frequency	±0.02 Hz	0 to + 6 Cycles or 0.1%, whichever is greater
59A-1	Voltage Aux. Over	±0.5%④	0 to + 2 Cycles or 0.1%, whichever is greater
27A-1	Voltage Aux. Under	±0.5%④	0 to + 2 Cycles or 0.1%, whichever is greater

Time Overcurrent

51X	Ground Trip (IX TOC)	0.5%②	+3% or + 2 Cycles, whichever is greater
51P	Phase Trip (Ph TOC)	0.5%②	+3% or + 2 Cycles, whichever is greater
51R	Ground Trip Residual (IR TOC)	3%③	+3% or + 2 Cycles, whichever is greater

Common Mode Voltage Withstand **>1500 Vrms/1 minute, any port to chassis⑤**

Environmental Ratings:

Operating Temp	-40°C to +60°C (-40°F to +140°F).
Storage Temp	-40°C to +85°C(-40°F to +185°F).
Humidity	5% to 95% Relative Humidity (non-condensing)
Altitude	0 to 2500 meters above Mean Sea Level

Dimensions

Behind Panel:	
Height	6.7 in. (17.0 cm)
Width	5.3 in. (13.5 cm)
Depth	6.9 in. (17.75 cm)
In Front of Panel:	
Height	11.34 in. (28.9 cm)
Width	7.72 in. (19.7 cm)
Depth	0.80 in. (2.1 cm)
Weight:	
Drawout	5.8 lbs (2.6 Kg)
Enclosure	5.0 lbs (2.3 Kg)
Adapter Panel	1.3 lbs (.6 Kg)
Shipping	16.5 lbs (7.5 Kg)

① FS (Full Scale) = 3 • CT Rating • Nominal L-N Voltage.
② Minimum absolute tolerance of measured current is 0.5% of CT Rating.
③ Minimum absolute tolerance of residual current is 3% of CT Rating.
④ Minimum absolute tolerance of measured voltage is 0.5% of Nominal Voltage.
⑤ Note shield & VG exception details in Section 7 "Startup."

3.2 Standards Compliance

The FP-5000 complies with the following standards except where noted:

- ANSI/IEEE C37.90-1989, Standard for Relay Systems associated with electric power apparatus.
- UL/CUL-1053 Recognized – Ground Fault Sensing and Relaying Equipment File E154862:
  – FP5000-00 5A CT model only
  – FP5100-00 1A CT pending
- EMC Requirements:
  – ANSI C37.90.1 (1989) Surge withstand all ports
  – ANSI C37.90.2 (1995) RF withstand

Emissions (EN-50081-2):

- EN 50011 CISPR-11, Class A
- CFR 47 FCC Part 15 Subpart b Class A

Immunity (EN-61000-6-2):

- ENV 61000-4-2 ESD Immunity
- ENV 61000-4-3 RF Radiated Immunity
- ENV 61000-4-4 EFT Immunity
- EN 61000-4-5 Surge Withstand
- EN 61000-4-6 RF Conducted Immunity
- EN 61000-4-8 Power Frequency Magnetic Field Immunity
- EN 61000-4-11 Voltage Dips, Short Interruption and Voltage Variation Immunity

See Appendix Section 13.5 for compliance levels and related information.

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4 FRONT PANEL OPERATION

4.1 Description

The FP-5000 front panel is the local operator interface that provides a means to monitor, program and test the relay. It consists of a 4-line by 20-character vacuum fluorescent display, 6 display mode pushbuttons with integral LEDs, 9 status LEDs, 6 pushbuttons for display menu navigation, a Reset pushbutton, 2 pushbuttons for breaker control, DB-9 communication port, and a battery for trip indication. Each of these will be identified and described in the following sections.

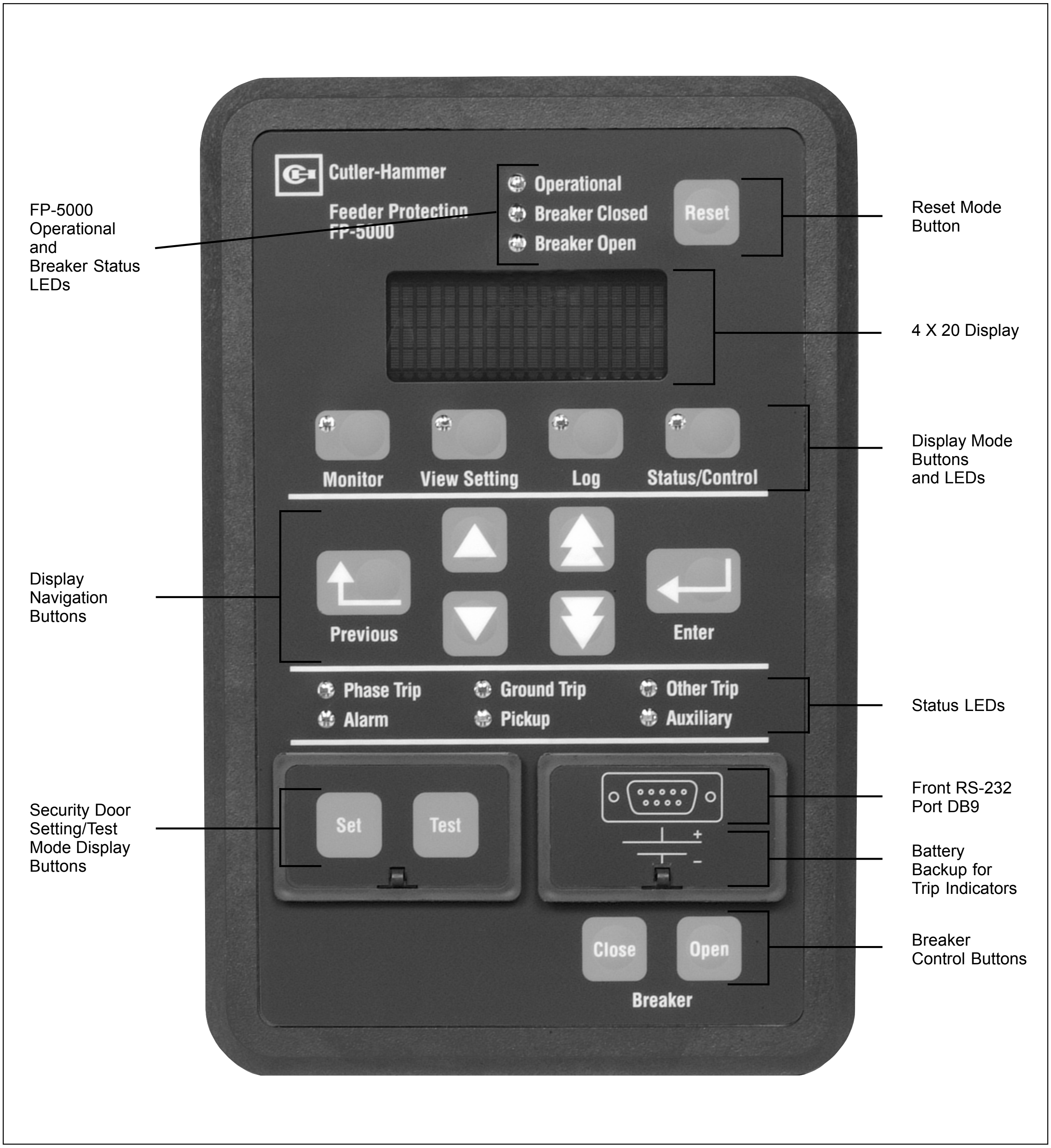


Figure 4-1. Panel

4.2 Display

4.2.1 Description

The display is a 4-line by 20-character vacuum fluorescent display. The first line of all display screens is reserved for the screen title. When the FP-5000 is first powered, the display lights and should display the system three-phase currents and voltages. This is called the default display screen shown below.

Note: Pushing the Reset pushbutton will default to the following screen.

Display 4.1 Default Display Screen

Currents/Voltages	
IA = <rms value>	**VA or VAB = <rms value>**
IB = <rms value>	**VB or VBC = <rms value>**
IC = <rms value>	**VC or VCA = <rms value>**

For all other display screens, the first column is reserved for the line pointer/selector. All display screen data fits within the allocated 3 lines by 20 columns.

4.2.2 Display Sleep Mode

When the unit sits idle for 15 minutes without any pushbuttons activated, the display goes into a "Sleep Mode," in which the screen goes blank. During this time, the unit is still in normal operating mode protecting and monitoring the system. Every 5 minutes thereafter, the message "**FP5000 Feeder Relay Push Any Button To Activate Display**" appears on the display for 30 seconds. This is a reminder of how to re-energize the display to the Default Display screen. When in this mode, the pushbuttons only activate the display, not the function of the pushbutton. The pushbutton must be pushed again, once the unit shows the Default Display screen, to do its pushbutton function.

4.2.3 Self Check Failure

Upon initialization, the FP-5000 performs a series of hardware and software checks to assure proper operation of the protective relay unit. These checks cover issues such as programming, memory and calibration of the unit. If a failure is detected then the FP-5000 operational LED will be out and the FP-5000 will display a warning or failure message. Table 12.1 "Self Test Displays and Status Flag" covers this topic.

4.2.4 FP-5000 Other Warning or Transient Messages

The FP-5000 has certain modes of operation and actions that may result in warning or error message. Table 4.2 and Table 12.2 list messages that may be encountered while programming. For example if you try to close the breaker that is already closed, the FP-5000 will display "Error – Breaker Closed."

Table 4.1 Transient Display Messages

"Display Message"	Display Mode	Cause
Functions Programmed to default. They can be viewed only. See System Config.	Flashing a few seconds in the setting-edit mode	When entering PLC, Cin and Cout in the setting-edit mode if they are disabled
Fault Test is Off!	5 seconds in Test mode	When stopping fault simulation if the test was complete
Zone Interlock Output is On	5 seconds in Test mode	When turning the Zone Interlock output on if it is on
Zone Interlock Output Is Off	5 seconds in Test mode	When turning the Zone Interlock output off if it is off

4.3 Pushbuttons

The front operations panel supports 15 membrane switch pushbuttons. Pressing any of the pushbuttons will initiate many of the FP-5000 functions and actions. This section gives a complete description of each pushbutton and its functions. The pushbuttons can be grouped logically into the 6 display modes, reset and breaker control.

1. Reset
2. Monitor
3. View Setting
4. Log
5. Status/Control
6. Set (Settings)
7. Test
8. Close Open Breaker

The center section consists of display navigation buttons:

1. Previous
2. Up/Down (single arrow)
3. Up/Down (double arrow)
4. Enter

"Reset" Pushbutton:

The "Reset"pushbutton performs many "Reset" functions, one of which resets the display to show the default rms current and voltage display screen from any display menu, when the relay is in normal monitoring mode.

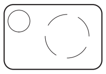
The FP-5000 has a "Reset" menu, which is accessed by pressing the "Reset" pushbutton when the unit is in normal monitoring mode. This menu allows the user to reset all of the relay functions: trips, alarms, peak current and power demands, min/max values, history log parameters, relays, and the data logger. There is no password protection for the reset functions. (See Display 4.2)

Display 4.2 Reset

Reset Main
Trip Alarm Bkr Lockout
Slow Bkr ALM Relay Peak Demand Values
Min/Max Values History Log Datalog
Energy Display Diag Warnings

By selecting a Reset sub-menu function listed above by using the Up/Down arrow and "Enter" pushbutton, the user can reset that function simply by pushing the "Enter" pushbutton again. The example below shows the "Trip Flag" sub-menu reset display screen.

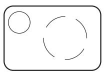
Reset Trip
Press ENTER To Confirm PREVIOUS To Cancel



Monitor

"Monitor" Pushbutton

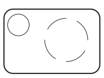
The "**Monitor**" pushbutton allows the user to go in to Monitor Mode and view all of the metered values of the FP-5000: Load parameters, Fundamental Phasors, Energy, Demand, and Minimum & Maximum values. These values include system power, currents & voltages, frequency, power factors, THD, current & voltage phasors, system demands, etc. Refer to Section 4.6 to see all parameters displayed while in Monitor Mode.



View Setting

"View Setting" Pushbutton

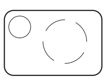
The "**View Setting**" pushbutton allows the user to go in to View Settings Mode and view all of the FP-5000 settings. It is important to note that pressing the "View Setting" pushbutton, the user can only go in and view the settings, not change the settings. Refer to Section 4.6 to see all settings displayed while in View Settings Mode. Refer to Section 5 for programming the settings.



Log

"Log" Pushbutton

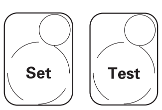
The "**Log**" pushbutton allows the user to go in to the Log Mode and view all of the data recorded by the FP-5000. The Log data consists of the Trip Log, Event Log and History Log. Refer to Section 4.6 to see all data displayed while in Log Mode.



Status / Control

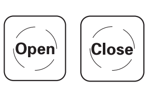
"Status/Control" Pushbutton

The "**Status/Control**" pushbutton allows the user to go in to the Status/Control Mode and view all of the status parameters and to set all of the control parameters of the FP-5000. The user can also view the Boot Code and Application Code versions by selecting the "Version" sub-menu. See Section 4.6 to see all status and control displays and options. Refer to Section 5 for programming the control options.



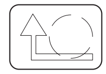
"Set" and "Test" Pushbuttons

The **"Set"** and **"Test"** pushbuttons are accessed via the security door at the bottom-left of the display panel. The **"Set"** pushbutton is used to enter the Setting Mode to program the settings. The **"Test"** pushbutton is used to enter the Test Mode to run self-tests and to exercise the outputs. See Section 5 Settings and Section 11 Testing for detailed information on setting and testing the FP-5000.



"Close" and "Open" Pushbuttons

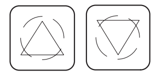
The **"Open"** and **"Close"** pushbuttons are used to initiate the breaker to **"open"** or **"close."** Once either of these pushbuttons is pressed, the user only has 10 seconds to confirm the open or close breaker action. See Section 8 for detailed information on breaker control. These buttons must be activated via settings to be operational. If disabled no operation of the breaker will occur.



Previous

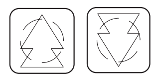
"Previous" Pushbutton

The "**Previous**" pushbutton allows the user to go to the previous menu. Once the user is in a "sub-menu," the user can push the "previous" pushbutton to revert back to the last display screen. It is also used when the user is updating settings to cancel out of saving the settings.

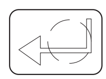


"Single and Double Up/Down Arrow" Pushbuttons

Both of these pushbuttons allow the user to scroll up and down the display menus. The single arrow pushbuttons "**Up,**" and "**Down,**" are used to scroll up and down the menu structure display selections one line at a time. They are also used to increment or decrement setting values one step at a time.



The double arrow pushbutton **"Page Up,"** and "**Page Down,**" pushbuttons scroll up and down the menu structure in page increments rather than in single line increments. They also increment or decrement setting values 10 times as fast as the Up and Down pushbuttons.



Enter

"Enter" Pushbutton

The "**Enter**" pushbutton allows the user to view the display menus, which are chosen by the up/down arrows. It also is used in the programming mode to change setting values and save the settings. Once a setting is chosen by the up/down arrows, the "**Enter**" pushbutton is used to enter that setting. If the **"Enter"** pushbutton is not pushed when changing a setting, that setting will not be changed.

4.4 RS-232 Communications Port / Front Panel Communication

The FP-5000 communications port (located on the bottom right of the front panel) is a straight through DB9 RS-232 communications port. It's used to view the status of the FP-5000 and to download setpoints via Cutler-Hammer's Power Port Communications software and a personal computer. PowerPort software can be obtained from the Cutler-Hammer internet site.

The FP-5000 transmits communications on pin 2 and it receives communications on pin 3, making it a Data Set or Data Communication Equipment (DSE/DCE) under the definitions of the RS-232 standard. The FP-5000 does not use the RS-232 hardware control lines. Although the FP-5000 operates with the "3-wire" connection, a standard off-the-shelf serial cable will allow communication. See **Figure 4-2** for the DB9 cable connections. An example of an off-the-shelf cable is the RadioShack®, 26-117B, Male DB9 to Female DB9 Shielded RS-232C Cable.

See Section 10 for a detailed description of the FP-5000 communications and the Cutler-Hammer PowerPort software.

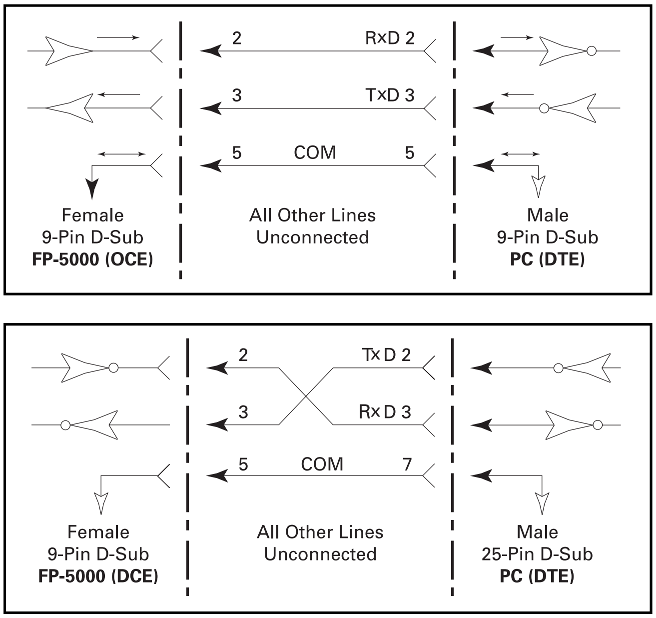


Figure 4-2. RS-232 Cable for 9- and 25-pin D-Subminiature Connectors

4.5 Battery for Trip Indication

Beneath the front panel communications port lays a receptacle for a lithium disc-style battery. The battery is used when there's a control power failure to latch the FP-5000 trip state and to operate the front panel trip LED. The FP-5000 can last 72 hours in this state on a completely charged lithium battery. When the FP-5000 is energized, the trip latch and LED indicators are powered by system power, preserving the batteries capacity.

A defective or discharged battery causes the loss of trip state visual LED indication during power loss conditions. A "Battery Test" button and a green "Battery Test Indicator" indicating LED are provided next to the lithium battery receptacle. Standard periodic maintenance should include pressing the Battery Test Button and noting that the "Battery Test Indicator" LED turns on, showing adequate operating capacity in the battery. Battery failure will not effect relay memory. The battery is for LED indication only.

See Section 2.6 Startup for initiating the battery into service and Section 11 for battery maintenance.

4.6 Display Modes

If System Voltage ("VT Connect") is set to a "Wye" Configuration: The default display screen will display the 3-phase voltages as line-neutral (L-N) voltages. The line-line (L-L) voltages can be viewed by going to the Monitor Mode selection screen and selecting "Load," then page down through the menu screen until the top line shows the "RMS L-L Voltages." The "RMS L-N Voltages" are shown on the next screen following the L-L voltages.

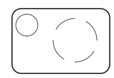
All parameters shown in (L-L) and (L-N) values in a "Wye" voltage ct configuration are:

- The rms System Voltages
- rms Average Voltages
- %THD
- Magnitude THD
- Voltage Phasors, Minimum and Maximum System Voltages

If System Voltage ("VT Connect") is set to a "Delta" Configuration: The default display screen will display the 3-phase voltages as line-line (L-L) voltages only. All other parameters will only be displayed in (L-L) values.

In addition to the default display screen and the display "sleep mode," there are eight FP-5000 display modes, each associated with a pushbutton on the front panel. The modes are Monitor, View Settings, Log, Status/Control, Set, Test, Reset and Close – Open Breaker. The Set and Test mode entry are restricted via a latched cover and password. The other modes are freely accessed and cannot change or cause operation of the relay.

4.6.1 Monitor



Monitor

The Monitor Mode is entered by pushing the "Monitor" pushbutton, which allows the user to view metered quantities (See Display 4.3). Note the possible selections are only viewable three lines at a time. The red LED in the upper left-hand portion of the pushbutton area will illuminate while the user is in the Monitor Mode.

Display 4.3 Monitor Mode

Metering Main
Load Fundamental Phasors Energy
Demand Minimum Maximum

Select one of the menu selections using the Up/Down or PgUp/PgDown pushbuttons and press the Enter pushbutton. This will enter you into the metering sub-menus to view any of the monitor displays of interest using the Up/Down, PgUp, or PgDown pushbuttons. Each box in the table shows one of the screens the user may select. The bullets below show all available monitoring data screens. Use the "Previous" pushbutton to return to the **Metering Main** in order to select another category of data screen.

The **Metering Main** menu provides easy access to the most common metering values. See the following:

- Current
- Voltage
- Power
- Energy
- Demand
- Power Factor
- Frequency
- THD

All values display the most recent measured and computed values of each system parameter. All the metering display information is also accessible through the communication port, which is described in detail in Section 10 Data Communications.

4.6.1.1 Selecting the "Load" Sub-menu

This sub-menu allows the user to view the following rms system parameters. (See Display Load Sub-menu 4.4) The FP-5000 calculates rms through the 15th harmonic. If Delta connected VTs are used then L-N voltages will not be displayed.

- rms Currents (IA, IB, IC, IX, IR)
- Average rms Current (I avg)
- % Current unbalance (% I2/I1)
- rms L-L Voltage (VAB, VBC, VCA)
- rms L-N Voltage (VA, VB, VC, VX)
- Average L-L Voltage (VLL Avg)
- Average L-N Voltage (VLN Avg)
- % Voltage Unbalance (% V2/V1)
- Power (Watt, Var, VA)
- Frequency
- Power Factor (App, Disp)
- %THD Current (IA, IB, IC)
- Magnitude THD Current (IA, IB, IC)
- % THD Voltage L-L Voltage (VAB, VBC, VCA)
- Magnitude THD L-L Voltage (VAB, VBC, VCA)
- % THD Voltage L-N Voltage (VA, VB, VC)
- Magnitude THD L-N Voltage (VA, VB, VC)

Display 4.4 Load Sub-menu

rms Phase Current	
IA	Magnitude
IB	Magnitude
IC	Magnitude

rms Current	
IX	Magnitude
IR	Magnitude

rms Average Current	
I Avg	Magnitude
% I2/I1	Magnitude

rms L-L Voltages	
VAB	Magnitude
VBC	Magnitude
VCA	Magnitude

rms L-N Voltages	
VA	Magnitude
VB	Magnitude
VC	Magnitude

rms Aux Voltage	
VX	Magnitude

rms Average Voltages	
V LL Avg	Magnitude
V LN Avg	Magnitude
% V2/V1	Magnitude

System Power	
M Watt	Magnitude
M var	Magnitude
M VA	Magnitude

System Freq / PF	
Freq (Hz)	
Dsp PF	Magnitude
Apt PF	Magnitude

% THD Currents	
IA	Percent
IB	Percent
IC	Percent

Mag THD Currents	
IA	Magnitude
IB	Magnitude
IC	Magnitude

Mag THD L-N Voltages	
VA	Magnitude
VB	Magnitude
VC	Magnitude

Mag THD L-L Voltages	
VAB	Magnitude
VBC	Magnitude
VCA	Magnitude

% THD L-N Voltages	
VA	Percent
VB	Percent
VC	Percent

% THD L-L Voltages	
VAB	Percent
VBC	Percent
VCA	Percent

Clock	
Time	HH:MM:SS
Date	MM/DD/YY

4.6.1.2 Selecting the "Fundamental Phasors" Sub-menu

This section allows the user to view the following fundamental Phasors for current and voltage. (See **Display 4.5**.)

Phasor Currents Magnitude and Angle (IA, IB, IC, IX, IR)
Sequence Currents Magnitude and Angle (3I0, I1, I2)

Phasor L-L Magnitude and Angle (VAB, VBC, VCA)
Phasor L-N Magnitude and Angle (VA, VB, VC, VX)
Sequence Voltage Magnitude and Angle (3V0, V1, V2)

Display 4.5 Fundamental Phasors Sub-menu

Current Phasors	
IA	Magnitude & ∠
IB	Magnitude & ∠
IC	Magnitude & ∠

Gnd Current Phasors	
IX	Magnitude & ∠
IR	Magnitude & ∠

Sequence Currents	
310	Magnitude & ∠
I1	Magnitude & ∠
I2	Magnitude & ∠

L-L Voltage Phasors	
VAB	Magnitude & ∠
VBC	Magnitude & ∠
VCA	Magnitude & ∠

L-N Voltage Phasors	
VA	Magnitude & ∠
VB	Magnitude & ∠
VC	Magnitude & ∠

Sequence Voltages	
3V0	Magnitude & ∠
V1	Magnitude & ∠
V2	Magnitude & ∠

Aux Voltage Phasor	
VX	Magnitude & ∠

4.6.1.3 Selecting the "Energy" Sub-menu

This section allows the user to view the following Energy parameters (See **Display 4.6**).

- Watt Energy Hours (Forward, Reverse, Net)
- Var Energy Hours (Lead, Lag, Net)
- VA Hours
- Start Date and Time stamp the Unit started measuring

Display 4.6 Energy Sub-menu

System Watt Hour	
Fwd kWh	Magnitude
Rev kWh	Magnitude
Net kWh	Magnitude

System var Hours	
Lead kvarh	Magnitude
Lag kvarh	Magnitude
Net kvarh	Magnitude

System VA Hours	
kVAh	Magnitude

Start Date	
Date	mm/dd/yy
Time	hh:mm:ss

The FP-5000 uses the positive sign convention for power measurement. A positive sign convention corresponds to:

- Inductive load = lagging power factor = positive Var and power factor values.
- Capacitive load = leading power factor = negative Var and power factor values.

Hence the Forward watt-hours and the Lagging Var-hours are positive, while the Reverse watt-hour and the Leading Var-hour displays represent negative values.

The Forward watt-hours, Reverse watt-hours, Leading Var-hours, Lagging Var-hours and VA-hours are all displayed as unsigned numbers. However, when the FP-5000 calculates the Net watt-hours and the Net Var-hours, the calculation is based on the sign convention, therefore the Net watt-hours and the Net Var-hours can be positive or negative values. Refer to the Power Quadrant diagram in **Figure 4.4**.

A lagging power factor is displayed as a positive value and a leading power factor is displayed as a negative value. The maximum power factor is the most lagging power factor value measured by the FP-5000 and the minimum power factor is the most leading power factor value measured. Two examples for min/max power factor values are shown in **Figure 4.3**.

The following examples define the sign convention for energy under various power flow conditions:

- Induction Motor Load (**Figures 4.4** and **4.5**)

  Typically when monitoring induction motor loads, the power flow is in Quadrant 4. The watts are positive and the power factor is lagging. By definition, the power factor and Vars are positive.

- Capacitive Load (**Figure 4.4**)

  When monitoring a capacitive load or a heavily excited synchronous motor, the power flow is in Quadrant 1. By definition, the power factor and Vars are negative.

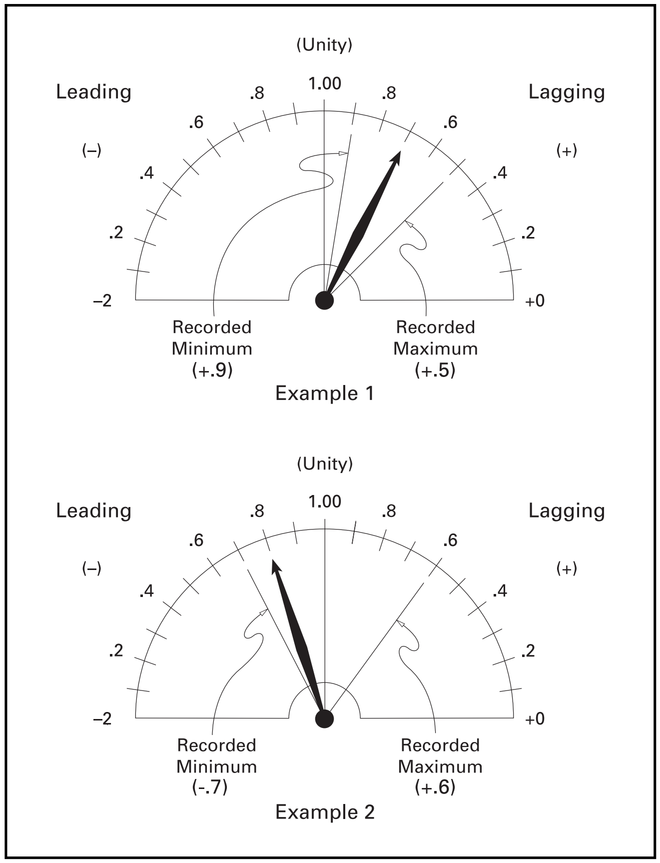


Figure 4-3. Power Factor Minimum/Maximum

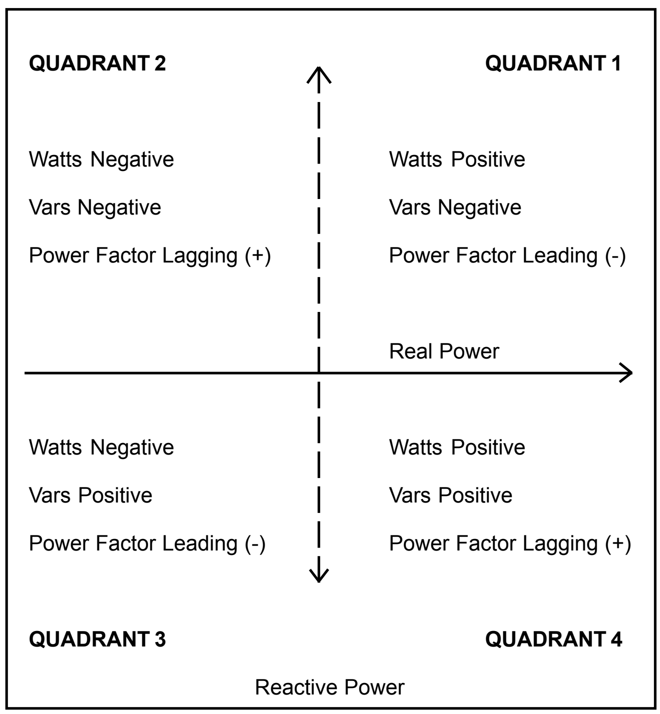


Figure 4-4. Power Quadrants

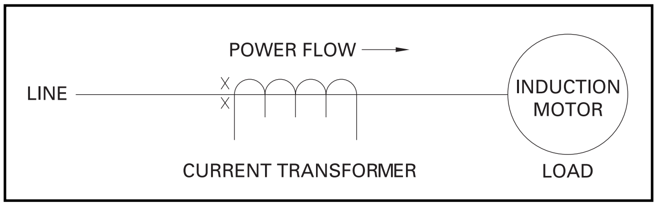


Figure 4-5. Induction Motor Load

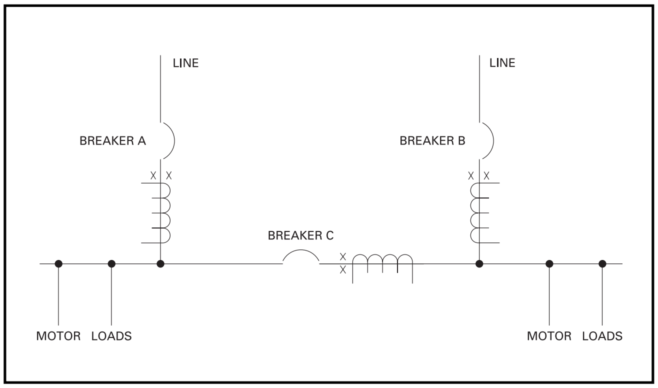


Figure 4-6. Power Distribution

- Power Distribution (**Figures 4.4** and **4.6**)

  Three conditions are typically encountered when monitoring power distribution systems as follows:

  1. Circuit breakers A and B are closed and C is open. Power flow is in Quadrant 4. The power factor and Vars are positive.
  2. Circuit breakers A and C are closed and B is open. Power flow for breakers A and C is in Quadrant 4. The power factor and Vars are positive.
  3. Circuit breakers B and C are closed and A is open. The power flow for breaker B is in Quadrant 4 and the metering conditions are the same as conditions 1 and 2. However, the power flow for breaker C is reversed and is in Quadrant 2.

The display units for Energy may be set to either kilo units or Mega units. The “Energy Unit” setting is changed in the “System Configuration” setting menu in the “Set” mode. The screen displays a 9-digit energy reading. Energy values roll over from 999,999,999 to 0.

4.6.1.4 Selecting the “Demand” Sub-menu

This menu allows the user to view the following Demand parameters (See **Display 4.7**).

- Current Demand (IA, IB, IC)
- Current Peak Demand (IA, IB, IC)
- Date and Time Stamp when Current Demand was last reset
- Power Demand (Watt, Var, VA)
- Power Peak Demand (Watt, Var, VA)
- Date and Time Stamp when Power Demand was last reset

Display 4.7 Demand Sub-menu

Current Demand	
IA Demand	Magnitude
IB Demand	Magnitude
IC Demand	Magnitude

Current Peak Demand	
IA Demand	Magnitude
IB Demand	Magnitude
IC Demand	Magnitude

I Demand Last Reset	
Date	mm/dd/yy
Time	hh:mm:ss

Power Demand	
M Watt	Magnitude
M Var	Magnitude
M VA	Magnitude

Power Peak Demand	
M Watt	Magnitude
M Var	Magnitude
M VA	Magnitude

P Demand Last Reset	
Date	mm/dd/yy
Time	hh:mm:ss

Current Demand Window (Fixed Window)

Current Demand is the average of system current over time, which can be set from 1 to 60 minutes. For example, if the range is set for 30 minutes, the FP-5000 calculates the average current over the past 30 minutes and updates the value every 30 minutes. The range can be selected from the Logging menu by pressing the “**Set**” pushbutton. Refer to Section 5 Settings of this manual for setting changes. The default setting for Current Demand window selection is 15 minutes.

Power Demand Window (Fixed or Slide)

In addition to the interval setting as in the Current Demand Window, the Power Demand window has an additional setting of **Fixed** or **Slide** window. The default setting for Power window is **Fixed**. If **Fixed** window is selected, the Demand will be calculated every fixed interval and updated every fixed interval. If the **Slide** window is selected, the Demand will be calculated every minute for the interval selected. For example, if the **Slide** window is selected and the interval is set to 30 minutes, the FP-5000 calculates and updates the average power for the past 30 minutes, every minute. Refer to Section 5 Settings of this manual for setting changes.

The FP-5000 also saves the peak demand values for current and power. The quantities represent the largest demand value since the demand values were last reset. Peak demands for current and system power are date and time stamped to the nearest second.

4.6.1.5 Selecting the “Minimum” Sub-menu

This menu allows the user to view the following system parameters. (See **Display 4.8** Minimum Sub-menu.)

- Minimum currents (IA, IB, IC, IX, IR)
- Minimum L-L Voltages (VAB, VBC, VCA)
- Minimum L-N Voltages (VA, VB, VC)
- Minimum Power (Watt, Var, VA)
- Minimum Frequency
- Minimum Power Factor (Apparent, Displacement)

Display 4.8 Minimum Sub-menu

Min <Variable>	
(Variable)	Magnitude
Date	mm/dd/yy
Time	hh:mm:ss

Min Rst Date & Time	
Date	mm/dd/yy
Time	hh:mm:ss

Table 4.2 Minimum Sub-menu

Where <Variable> (Variable) =

<IA Current>	(IA)
<IB Current>	(IB)
<IC Current>	(IC)
<IX Current>	(IX)
<IR Current>	(IR)
<VAB Voltage>	(VAB)
<VBC Voltage>	(VBC)
<VCA Voltage>	(VCA)
<VA Voltage>	(VA)
<VB Voltage>	(VB)
<VC Voltage>	(VC)
<System Watts>	(M Watts)
<System Vars>	(M VAR)
<System VA>	(MVA)
<Frequency>	(Freq)
<Apparent PF>	(Apt PF)
<Displacement PF>	(Disp PF)

The Date and Time Stamp is also recorded on the same page with the minimum value display for each parameter occurance.

The minimum values for each of the above parameters is compared to the last minimum value for that parameter every 32 cycles. If the new value is less than the last minimum, the value is updated. Power Factor Minimum is the most leading power factor value measured.

4.6.1.6 Selecting the “Maximum” Sub-menu

This menu allows the user to view the following system parameters. (See **Display 4.9** Maximum Sub-menu.)

- Maximum currents (IA, IB, IC, IX, IR)
- Maximum L-L Voltages (VAB, VBC, VCA)
- Maximum L-N Voltages (VA, VB, VC)
- Maximum Power (Watt, Var, VA)
- Maximum Frequency
- Maximum Power Factor (Apparent, Displacement)

Display 4.9 Maximum Sub-menu

Max <Variable>	
(Variable)	Magnitude
Date	mm/dd/yy
Time	hh:mm:ss

Min Rst Date & Time	
Date	mm/dd/yy
Time	hh:mm:ss

Table 4.3 Maximum Sub-menu

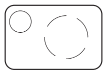
Where <Variable> (Variable) =

<IA Current>	(IA)
<IB Current>	(IB)
<IC Current>	(IC)
<IX Current>	(IX)
<IR Current>	(IR)
<VAB Voltage>	(VAB)
<VBC Voltage>	(VBC)
<VCA Voltage>	(VCA)
<VA Voltage>	(VA)
<VB Voltage>	(VB)
<VC Voltage>	(VC)
<System Watts>	(M Watts)
<System Vars>	(M VAR)
<System VA>	(M VA)
<Frequency>	(Freq)
<Apparent PF>	(Apt PF)
<Displacement PF>	(DisP PF)

The Date and Time Stamp is also recorded on the same page with the minimum value display for each parameter occurance.

The maximum values for each of the above parameters is compared to the last maximum value for that parameter every 32 cycles. If the new value is greater than the last maximum, the value is updated. Power Factor Maximum is the most lagging power factor value measured.

4.6.2 View Settings



View Setting

Press the “View Setting” pushbutton to view the existing settings in the FP-5000 program settings. The red LED in the upper left-hand portion of the pushbutton area will illuminate while you are in the View Setting Mode. Display 4.10 shows the options provided by pressing the “View Setting” pushbutton. Note that the possible selections are only viewable three at a time.

Going in to the “**View Settings Mode**” has no effect on the settings. The user cannot change the settings in this mode, it’s for viewing the settings only.

Display 4.10 View Settings “Main”

Setting Main
System Config Protection System Alarms
Logging Contact Input CFG Output CFG
Programmable Logic Communications

Select one of the Setting Main sub-menus using the Up/Down or PgUp/PgDown pushbuttons and press the “**Enter**” pushbutton. This will provide any of the monitor screens shown in the following Display. The data in the second column is an example value, please see Section 5 for all available settings of the FP-5000. Use the “**Previous**” pushbutton to return to the “**Setting Main**” screen to select another category of data screen. Note that the user can only view the settings three lines at a time on the display. Use the Up/Down pushbuttons to scroll through all of these settings.

Setting Main
> System Config Protection System Alarm

Display 4.11 View Settings

Display		**Display Meaning**
Frequency: Phase Seq: CT Connect:	60 ABC 3-wire	Frequency Phase Sequence Ct Connection
PH CT Ratio: IX CT Ratio: VT Connect:	500:5 500:5 Wye	Phase Ct ratio Ix Ct ratio Voltage Transformer Connection
Main VTR: Aux VTR: Prim Units:	100 100 No	Main Voltage Transformer Ratio Auxiliary Voltage Transformer Ratio Primary Units
I/O Config: Prog Logic: Remote Set:	Default Default Disable	Input/Output Configuration Programmable Logic Remote Set
Prg w/Bkr: Remote Bkr: # Set Grps:	Either Disable 1	Program With/Breaker Remote Breaker Number Setting Groups
Set Ctrl: Disarm Trip: Energy Unit:	Local Disable kWh	Set Control Disarm Trip Energy Unit
TOC Reset: Bkr Oper PB:	5 Disable	Time Overcurrent Adjust Time Breaker Operation Pushbutton

Protection

Display 4.12 View Settings

"Protection" Display:

Protection
Setting Group 1 Setting Group 2 Setting Group 3
Setting Group 4

"Setting Group 1" Display:

Setting Group 1
Phase Overcurrent IX Measured OC IR Residual OC
Unbalance Settings Main V Protection Aux V Protection
Freq. Protection Breaker Failure Power Factor
Zone Interlocking Alarms

* Note: The number of setting groups that are displayed is programmable as shown above in the Configuration Settings as "# Set Grps." The default # of setting groups is 1, so this "display" will normally only show "Setting Group 1." If "# Set Grps" is set to "4," then all four setting groups will be displayed as shown below. All four setting group's sub-menus display the same settings, therefore only one setting group is shown here.

"Phase Overcurrent" Display:

Phase Overcurrent
51P PH TOC Curve 51P PH TOC Setting 50P-1 PH IOC 1
50P-2 PH IOC 2

"51P PH TOC Curve" Display:

51P PH TOC Curve	
Shape:	MOD
Reset: Calc	
Direction:	Both

"51P PH TOC Setting" Display:

51P PH TOC Setting	
Pickup (pu):	1.00
Time Mult:	1.00

"50P-1 PH IOC 1" Display:

50P-1 PH IOC 1	
Pickup (pu):	2.00
Delay (c):	0
Direction:	Both

"50P-2 PH IOC 2" Display:

50P-2 PH IOC 2	
Pickup (pu):	3.00
Delay (c):	15
Direction:	Both

“IX Measured OC” Display:

IX Measured OC
51X IX TOC Curve 51X IX TOC Setting 50X-1 IX IOC 1
50X-2 IX IOC 2

“51X IX TOC Curve” Display:

51X IX TOC Curve	
Shape:	XTRM
Reset: Calc	
Direction:	Both

“51X IX TOC Setting” Display:

51X IX TOC Setting	
Pickup (pu):	1.00
Time Mult:	1.00

“50X-1 IX IOC 1” Display:

50X-1 IX IOC 1	
Pickup (pu):	2.00
Delay (c):	0
Direction:	Both

“50X-2 IX IOC 2” Display:

50X-2 IX IOC 2	
Pickup (pu):	3.00
Delay (c):	15
Direction:	Both

“IR Residual OC” Display:

IR Residual OC
51R IR TOC Curve 51R IR TOC Setting 50R-1 IR IOC 1
50R-2 IR IOC 2

“51R IR TOC Curve” Display:

51R IR TOC Curve	
Shape:	XTRM
Reset: Inst	
Direction:	Both

“51R IR TOC Setting” Display:

51R IR TOC Setting	
Pickup (pu):	0.10
Time Mult:	1.00

“50R-1 IR IOC 1” Display:

50R-1 IR IOC 1	
Pickup (pu):	1.00
Delay (c):	60
Direction:	Both

“50R-2 IR IOC 2” Display:

50R-2 IR IOC 2	
Pickup (pu):	2.00
Delay (c):	600
Direction:	Both

“Unbalance Settings” Display:

Unbalance Setting

47-1 Voltage Unbal
46-1 Current Unbal

“47-1 Voltage Unbal” Display:

47-1 Voltage Unbal

Threshold V:	Disable
% (V2/V1):	20
Delay (c):	600

“46-1 Current Unbal” Display:

46-1 Current Unbal

Threshold (pu):	Disable
% Unbal (I2/I1):	20
Delay (c):	600

“Main V Protection” Display:

Main V Protection

27M-1 Undervoltage
59M-1 Overvoltage

“27M-1 Undervoltage” Display:

27M-1 Undervoltage

Threshold V:	Disable
Delay:	1200

Note: M1 is for “Main 1” referring to protection metered by the Main Voltage transformer in the System Configuration.

“59M-1 Overvoltage” Display:

59M-1 Overvoltage

Threshold V:	Disable
Delay (c):	1200

“Aux V Protection” Display:

Aux V Protection

27A-1 Undervoltage
59A-1 Overvoltage

“27A-1 Undervoltage” Display:

27A-1 Undervoltage

Threshold V:	Disable
Delay (c):	1200

Note: A1 is for “Auxiliary 1” referring to voltage protection metered by the Auxiliary Voltage transformer in the System Configuration.

“59A-1 Overvoltage” Display:

59A-1 Overvoltage

Threshold V:	Disable
Delay (c):	1200

“Freq Protection” Display:

Freq Protection

81U-1 Underfreq
81O-1 Overfreq

“81U-1 Underfreq” Display:

81U-1 Underfreq

Threshold:	Disable
Delay (c):	60

“81O-1 Overfreq” Display:

81O-1 Overfreq

Threshold:	Disable
Delay (c):	60

“Breaker Failure” Display:

Breaker Failure

50BF Bkr Config
50BF Bkr Failure

“50BF Bkr Config” Display:

50BF Bkr Config

BF Config:	OFF

“50BF Bkr Failure” Display:

50BF Bkr Failure

IPh (pu):	Disable
IGnd (pu):	Disable
Delay (c):	0

“Power Factor” Display:

Power Factor

55A Apparent PF
55D Displacement PF

“55A Apparent PF” Display:

55A Apparent PF

Trigger PF:	Disable
Reset PF:	Disable
Delay (s):	0

“55D Displacement PF” Display:

55D Displacement PF

Trigger PF:	Disable
Reset PF:	DIsable
Delay (s):	0

“Zone Interlocking” Display:

Zone Interlocking

Zone Interlocking

“Zone Interlock” Display:

Zone Interlocking

Zone In:	Disable
Zone Out:	Disable

“50P-3 PH OC Alarm” Display:

50P-3 PH OC Alarm

Pickup: Disable
Delay: 0
Direction: Both

“50R-3 IR OC Alarm” Display:

50R-3 IR OC Alarm

Pickup: Disable
Delay: 0
Direction: Both

“47-2 V Unbal Alarm” Display:

47-2 V Unbal Alarm

Threshold: 50
% (V2/V1): 40
Delay: 60

“27-M2 Under V Alarm” Display:

27-M2 Under V Alarm

Threshold: Disable
Delay: 0

“27-A2 Under V Alarm” Display:

27-A2 Under V Alarm

Threshold: Disable
Delay: 0

“81U-2 Under Freq Al” Display:

81U-2 Under Freq Al

Threshold: Disable
Delay: 60

“Alarms” Display:

Alarms

50P-3 PH OC Alarm
50X-3 IX OC Alarm
50R-3 IR OC Alarm

46-2 I Unbal Alarm
47-2 V Unbal Alarm
59-M2 Over V Alarm

27-M2 Under V Alarm
59-A2 Over V Alarm
27-A2 Under V Alarm

81O-2 Over Freq Alm
81U-2 Under Freq Al

“50X-3 IX OC Alarm” Display:

50X-3 IX OC Alarm

Pickup: Disable
Delay: 0
Direction: Both

“46-2 I Unbal Alarm” Display:

46-2 I Unbal Alarm

Threshold: 0.10
% Unbal (I2/I1): 40
Delay: 60

“59-M2 Over V Alarm” Display:

59-M2 Over V Alarm

Threshold: Disable
Delay: 0

“59-A2 Over V Alarm” Display:

59-A2 Over V Alarm

Threshold: Disable
Delay: 0

“810-2 Over Freq Alarm” Display:

81O-2 Over Freq Alm

Threshold: Disable
Delay: 60

System Alarm

"Watt Power Alarm" Display:

Watt Power Alarm	
Units:	kW
Threshold:	Disable
Delay (m):	0

"VA Power Alarm" Display:

VA Power Alarm	
Units:	kVA
Threshold:	Disable
Delay (m):	0

"VAR Demand Alarm" Display:

VAR Demand Alarm	
Units:	kvar
Threshold:	Disable
Delay (m):	0

"Current Demand Alm" Display:

Current Demand Alm	
Threshold:	Disable
Delay (m):	0

"V THD Alarm" Display:

V THD Alarm	
Threshold:	Disable
Delay (s):	0

"System Alarm" Display:

System Alarms
Watt Power Alarm Var Power Alarm VA Power Alarm
Watt Demand Alm Var Demand Alm VA Demand Alm
Current Demand Alm I THD Alarm V THD Alarm
Breaker Alarm

"VAR Power Alarm" Display:

VAR Power Alarm	
Units:	kvar
Threshold:	Disable
Delay (m):	0

"Watt Demand Alarm" Display:

Watt Demand Alarm	
Units:	kW
Threshold:	Disable
Delay (m):	0

"VA Power Alarm" Display:

VA Power Alarm	
Units:	kVA
Threshold:	Disable
Delay (m):	0

"I THD Alarm" Display:

I THD Alarm	
Threshold:	Disable
Delay (s):	0

"Breaker Alarm" Display:

Breaker Alarm	
# Operations:	9999
Isum INTR Amp:	50000

Logging

"Current Demand" Display:

Current Demand	
Interval (m):	15

"Event Log Enable" Display:

Event Log Enable	
I Pickup:	Yes
V Pickup:	No
Freq Pickup:	No
PF Pickup:	No
Unbal Pickup:	No
SYSALM Pickup:	No
Cin1:	No
Cin2:	No
Cin3:	No
Cin4:	No
Cin5:	No
Cin6:	No
Cin7:	No
Cin8:	No
Comm.:	No

"Power Demand" Display:

Power Demand	
Window:	Fixed
Interval (m):	15

"Logging" Display:

Logging
Current Demand
Power Demand
Event Log Enable
Data Logger
Waveform Capture

"Datalogger" Display:

Datalogger	
Mode:	Cont.
Trigger:	Auto
Interval (s):	900
Value 1:	IA
Value 2:	IB
Value 3:	IC
Value 4:	IX
Value 5:	VA
Value 6:	VB
Value 7:	VC
Value 8:	VX

"Waveform Capture" Display:

Waveform Capture	
Records:	16 X 16
PreTrigger:	2
OSC Trigger	

OSC Trig Enable	
TRIP 2:	Overwrite
DV/VI:	Disable
Logic LG6:	Overwrite

OSC Trig Enable	
Cntrl PB:	Overwrite
Comm:	Overwrite

Contact Input CFG

"Contact Input CFG" Display:

Contact Input CFG	
Cin1:	52a
Cin2:	52b
Cin3:	BFI
Cin4:	Bkr Trouble
Cin5:	Remote Open
Cin6:	Remote Close
Cin7:	Remote Reset
Cin8:	user defined

BFI- "Breaker Fail Initiate"

Output relay CFG

“Output Trip1” Display:

Output Trip1	
Monitor:	On
Function:	OR
Dropout:	Off Delay
Off Delay (c):	5
IN1:	AllProt
IN2:	BreakerOpenBkr
IN3:	Unused
IN4:	Unused

“Output Trip2” Display:

Output Trip2	
Monitor:	Off
Function:	Disable
Dropout	Unlatched
Off Delay (c):	5
IN1:	Unused
IN2:	Unused
IN3:	Unused
IN4:	Unused

“Output Rly3” Display:

Output Rly3	
Function:	OR
Dropout:	Latched
Off Delay (c):	0
IN1:	Trip BF
IN2:	Unused
IN3:	Unused
IN4:	Unused

“Output Rly4” Display:

Output Rly4	
Function:	Disable
Dropout:	Unlatched
Off Delay (c):	0
IN1: Trip	Unused
IN2: Trip	Unused
IN3:	Unused
IN4: Breaker	All Alm

“Output Relay CFG” Display:

Output Relay CFG
Output Trip1
Output Trip2
Output Rly3
Output Rly4
Output Rly5
Output Alarm
Output Aux LED
Trip Indicator
Alarm Indicator
Pickup Indicator

“Output Rly5” Display:

Output Rly5	
Function:	OR
Dropout:	Off Delay
Off Delay (c):	1
IN1:	Breaker Close BK
IN2:	Unused
IN3:	Unused
IN4:	Unused

“Output Alarm” Display:

Output Gate Alarm	
Function:	OR
Dropout:	Unlatched
Off Delay (c):	0
IN1:	Trip AllProt
IN2:	Trip All Alm
IN3:	Sys Alm All Alm
IN4:	Breaker All Alm

“Output Aux LED” Display:

Output Aux LED	
Function:	OR
IN1:	Unused
IN2:	Unused
IN3:	Unused
IN4:	Unused

“Alarm Indicator” Display:

Alarm Indicator	
Dropout:	Latched
Trip1:	Disable
Trip2:	Disable
Rly3:	Disable
Rly4:	Disable
Rly5:	Disable
Alarm:	Enable
Rly Healthy:	Enable

“Trip Indicator” Display:

Trip Indicator	
Dropout:	Latched
Trip1:	Enable
Trip2:	Enable
Rly3:	Disable
Rly4:	Disable
Rly5:	Disable
Alarm:	Disable
Rly Healthy:	Disable

“Pickup Indicator” Display:

Pickup Indicator	
Dropout:	Unlatched
IOC:	Enable
TOC:	Enable
Volt:	Enable
OverFreq:	Enable
UnderFreq:	Enable
Unbalance:	Enable
Prot Alarm:	Disable

Programmable Logic

"Programmable Logic" Display:

Programmable Logic
Logic Gate 1 Logic Gate 2 Logic Gate 3
Logic Gate 4 Logic Gate 5 Logic Gate 6
Timer Gate 1 Timer Gate 2 Timer Gate 3
Timer Gate 4 Timer Gate 5 Timer Gate 6
Logic Latch 1 Logic Latch 2 Block 50X-1 IOC
Block 50X-2 IOC Block 50X-3 IOC Block 50R-1 IOC
Block 50R-2 IOC Block 50R-3 IOC Block 50P-1 IOC
Block 50P-2 IOC Block 50P-3 IOC Block 51P TOC
Block 51R TOC Block 51X TOC

"Logic Gate 1 through 6" Display:

Logic Gate 1 through 6	
Function:	Disable
Set Group:	1
IN1:	Unused
IN2:	Unused
IN3:	Unused
In4:	Unused

"Logic Latch 1 and 2" Display:

Logic Latch 1and 2	
Set Group:	1
SIn:	Unused
RIn:	Unused

"Timer Gate 1 through 6" Display:

Timer Gate 1 through 6	
Set Group:	1
In:	Unused
On Delay (c):	0
Off Delay (s):	0

"Block 50X1 through 3" Display:
"Block 50R1 through 3" Display:
"Block 50P1 through 3" Display:

"Block 51P" Display:
"Block 51R" Display:
"Block 51X" Display:

Block 50-51X,R,P	
Function:	Disable
Set Group:	1
In1:	Unused
In2:	Unused
In3:	Unused
In4:	Unused

Communications

“Communications” Display:

Communications
INCOM
Accessory Bus
RS232

“INCOM” Display:

INCOM	
Enable:	Yes
Address:	0x0001
Baud Rate:	9600

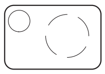
“Accessory Bus” Display:

Accessory Bus	
Address:	0x0001
Baud Rate:	9600

“RS232” Display:

RS232	
Baud Rate:	19200

4.6.3 Logs


Log

There are three types of logs: Trip, Event and History Log.

- The Trip Log provides details for the most recent 16 trip events.
- The Event Log is a sequence of events report for the last 100 events.
- The History Log provides a counter for number of operations and/or events.

See Section 12 for log details.

Press the “**Log**” pushbutton to go in to Log Mode and to view the FP-5000 Trip, Event and History Logs. The red LED in the upper left-hand portion of the pushbutton area will illuminate while you are in the Log Mode. The chart below shows the options provided by pressing the “**Log**” pushbutton.

Display 4.13 Log Main Menu

Log Main
Trip Log Event Log History Log

4.6.3.1 Trip Log

The Trip Log stores the trip information for the last 16 trip events. An example of the “Trip Log Display” showing two trip events is displayed below. The #1 event will always show the latest trip event. When the 16 trip event logs are filled, the FP-5000 will overwrite the oldest log.

Trip Log
1 50P IOC 1/19/01 2 Relay Test 10/25/00 3 0/0/00

By using the “Up/Down” pushbuttons, the user can select any trip event. Using the example above, the #1 event is an “instantaneous overcurrent” trip on phase that happened 1/19/01. By selecting this event with the Up/Down arrows and pushing the “**Enter**” pushbutton, the user can view additional information about the event. Display 4.14 is an example of the trip log information.

Display 4.14 Trip Log #1 Example Display

150P IOC 1/19/01	Display Meanings
Trip #: 2 Time: 13:36:06.109 Event #: 27	Trip # Time of trip Event #
Cause: 50P IOC Flt Type: AG Set Seq Num: 0	Cause of trip Fault Type Setting Sequence Number
WaveCap Index 34 ActiveSetGrp: 1 TripStatus: Processed	Waveform Capture Index Active Setting Group Trip Status
TOC Time MS NA Input Status Output Status	Time Overcurrent Trip Time Input Status Output Status
IOC Pickup Status V Ph Pickup Status TOC Pickup Status	Inverse Time Overcurrent Status Voltage Phase Pickup Status Time Overcurrent Pickup Status
Misc. Pickup Status OC Trip Status Misc. Trip Status	Miscellaneous Pickup Status Overcurrent Trip Status Miscellaneous Trip Status
Volt Trip Status Output Gate Status Logic Block Status	Voltage Trip Status Output Gate Status Logic Block Status
Logic Gate Status SYSALM Pickup SYSALM TimeOut	Logic Gate Status System Alarm Pickup System Alarm Timeout
Breaker Status OGx Input Settings OGx Input State	Breaker Status Output Gate Input Settings Output Gate Output Setting
Trip Test Status RMS Values V&I Phasors	Trip Test Status RMS Values of Voltages, Currents Voltage & Current Phasors

4.6.3.2 Event Log

The Event Log provides a time-stamped list of the most recent 100 events. Select “Event Log” in the Log menu to view these events. The logged events include pickup and dropout of protective or control functions, trip, change of state for contact input and outputs, and setting changes. The data logged for each event includes the event number, event I.D., a time stamp, and an optional 2 byte parameter. The user may disable logging of any event category except a trip or a self-test warning. By using the “Up/Down” pushbuttons, the user can select any event and retrieve its information. Refer to section 12.2.1 for more information on the Event Log.

4.6.3.3 History Log

The History Log provides the Total History Log and the Breaker History Log of FP-5000 trip events and breaker operations. This information is useful for breaker maintenance. See Displays 4.15 and 4.16 for History Log displays.

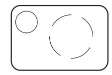
Display 4.15 Total History Log

Total History Log	Display Meanings
Operate Hours: # Power Up: # IOC Trips:	Number of house of operation. Number of times powered up. The number of instantaneous overcurrent trips.
# TOC Trips: # Unbal Trips: # Volt Trips:	The number of time overcurrent trips. The number of phase unbalance trips. The number of voltage related trips.
# Total Trips: # Bkr Ops: IA Accum:	The total number of trips. The number of breaker operations. Phase A accumulated interrupted amps.
IB Accum: IC Accum: RstTime:	Phase B accumulated interrupted amps. Phase C accumulated interrupted amps. The time stamp of the last History Log reset.
RstDate:	The date of the last History Log reset.

Display 4.16 Breaker History Log

Breaker History Log		Display Meanings
# Bkr Op: IA Accum: IB Accum:	0 0 0	The number of breaker operations. Phase A accumulated interrupted amps. Phase B accumulated interrupted amps.
IC Accum: RstTime: RstDate:	0 00:00:00 00/00/00mdy	Phase C accumulated interrupted amps. The time stamp of the last Breaker Log reset. The date of the last Breaker Log reset.

4.6.4 Status/Control



Status / Control

Press the "Status/Control" pushbutton to view all of the FP-5000 status and control parameters. The red LED in the upper left-hand portion of the pushbutton area will illuminate while you are in the Status/Control Mode. Display 4.17 shows the options displayed by activating the "Status/Control" pushbutton.

Display 4.17 Status/Control

Status/Control
Status Control Version
Copyright

By using the Up/Down pushbutton and scrolling down through the menus, the user can view additional information about the status of all inputs, outputs and control logic of the FP-5000 relay (see Display 4.18 below). "Version" display gives the user access to view the version of the product's boot code and application code.

Display 4.18 Status

Status
Self Test Status Active Set Group: 1 Input Status
Output Status Logic Status Pickup Status
Trip Status System Alarm Status Breaker Status

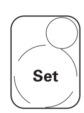
Control
Sel Active Set Grp Default Settings Trigger Datalogger
Trig Waveform Capt

Version Info
Boot Code Application

Copyright 2001
Eaton Corporation All Rights Reserved

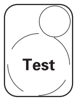
By selecting the "Control" sub-menu, the user can set the FP-5000 control parameters as shown in the "Control" display. See Section 5 for programming the control parameters.

4.6.5 Set



The "**Set**" pushbutton can be accessed through the security door on the front panel (See **Figure 4-1**). Once the "**Set**" pushbutton is activated, a password screen will show up on the display. The password must be entered to change the FP-5000 settings. To enter the password, use the "**single**" up/down arrow pushbutton to change the selected character of the password and use the "**double**" up/down arrow pushbutton to change the value of the character. Once the password is entered, the user must then press the "**Enter**" pushbutton to enter the password and to activivate the setting screens. See Section 5 for a complete description of the FP-5000 product settings.

4.6.6 Test



The “Test” pushbutton can be accessed through the security door on the front panel (see **Figure 4-1**). Once the “Test” pushbutton is activated, a password screen will show up on the display. The default password is “0000.” Press Enter to enter the “Test Mode.” The “Test Mode” allows the user to initiate current simulation tests, operate output relays, open or close the breaker, and test the Zone Interlocking outputs. See Section 11 for complete details on the “Test Mode” operation.

4.7 LEDs

The LEDs are used to indicate a number of functions, operations, and/or warnings of the FP-5000. Please refer to **Figure 4-1** for each LED location.

Operational LED
The Operational LED is a green flashing LED that flashes for a 1 second period, 50% duty cycle. It indicates that the FP-5000 is operational.

Breaker Closed LED
The red Breaker Closed LED indicates that the circuit breaker is closed based on the state of the 52a and 52b inputs.

Breaker Open LED
The green Breaker Open LED indicates that the circuit breaker is open based on the state of the 52a and 52b inputs.

Phase Trip LED
The red Phase Trip LED indicates that a phase overcurrent trip condition has occurred if the 50P-1, 50P-2, or 51P protective functions operate.

Ground Trip LED
The red Ground Trip LED indicates that a ground overcurrent trip condition has occurred if the 50X-1, 50X-2, 50R-1, 50R-2, 51X, or 51R protective functions operate.

Other Trip LED
The red Other Trip LED indicates that a trip condition other than phase or ground overcurrent has occurred.

Alarm LED
The red Alarm LED indicates that an alarm condition has occurred as programmed in the alarm indicator.

Pickup LED
The yellow Pickup LED indicates the presence of a pickup condition as programmed in the pickup indicator.

Auxiliary LED
The function of the yellow Auxiliary LED is user defined. The logic functions may be used to control the state of this LED, which is based on the state of the inputs programmed for the Aux LED output.

Set LED
The red set LED located at the right upper corner of the “Set” pushbutton indicates that the relay is in the program settings mode.

Test LED
The red test LED at the right upper corner of the “Test” pushbutton indicates that the relay is in the test mode. The test LED flashes while a fault simulation is in progress.

5 SETTING THE FP-5000

⚠ CAUTION

FP-5000 PROTECTIVE RELAY SETTINGS MUST BE PROGRAMMED BEFORE THE RELAY IS PUT INTO OPERATION. CARE MUST BE TAKEN WHEN PROGRAMMING THE FP-5000 WHILE THE BREAKER IS CLOSED AND CURRENT IS FLOWING. AN INCORRECT SETTING CONFIGURATION COULD CAUSE THE RELAY TO TRIP THE BREAKER WHEN SETTINGS ARE SAVED.

Introduction to Programming and the following specific details to become familiar with programming and setting the FP-5000.

Notes: 1. The relay leaves the manufacturing plant with default settings, many of which may be left unchanged. It is up to the user to program the settings into the FP-5000 for the intended application before the relay is put into service.

2. The Program Mode may be entered with the circuit breaker either open or closed or open only depending on how it is programmed in the System Configuration Settings. The relay comes from the factory in the “Either open or closed” program mode. The circuit breaker position is determined via the breaker “b” and/or breaker “a” contact. Refer to the typical wiring described in Section 6.

3. The settings that are changed during a programming session will not be saved unless the “Enter” pushbutton is pressed after the display shows “Update Setting? ENTER to save PREVIOUS to cancel RESET to Exit set.” To get the “Update Setting?” window to display, the user may 1.) Keep pressing the “Previous” pushbutton until the window appears, or 2.) Press any of the following pushbuttons while in the Set Mode: “Monitor”, “View Setting”, “Log”, or “Status/Control.”

4. The Set Mode may be exited, without saving any programmed settings, by pressing the “Reset” pushbutton at any time in the programming session. If there is no programming for 15 minutes the FP-5000 will automatically exit the setting mode and revert to the default operation.

⚠ CAUTION

THE ENTER PUSHBUTTON MUST BE PRESSED AND RELEASED AT THE “UPDATE SETTING?” WINDOW BEFORE EXITING THE SET MODE FOR THE CHANGED SETPOINTS TO BE SAVED.

5.1 Entering Set Mode

The “Set” pushbutton can be accessed through the security door on the front panel (See **Figure 4-1**). Push the ”Set” button to enter the Set Mode and begin programming the setpoints. Once the “Set” pushbutton is activated, a password screen will show up on the display. The FP-5000 is shipped with a default password “0000.” Every time the “Password Window” appears, the password is initialized to “0000.” If the password has not been changed or set then you simply press the Enter button to begin your programming session. If the password has been changed then you will need to enter the new password in order to begin your programming session. To enter the password, use the “single” up/down arrow pushbutton to change the selected character of the password and use the “double” up/down arrow pushbutton to change the value of the character. Once the password is entered, the user must then press the “Enter” pushbutton to enter the password and to activate the setting screens.

In addition to the front panel pushbutton access as described above, the FP-5000 settings can be programmed two other ways: 1) Via the front panel RS-232 communications port using the Cutler-Hammer PowerPort software, or 2) Via TB3 rear-access communications terminals using either Cutler-Hammer PowerNet or PowerPort software. An INCOM to RS-232 converter or a CONI card is required to access the rear communications port. See Data Communications Section 10 for more information on using PowerPort and PowerNet to program setpoints into the FP-5000.

The following sections describe all the FP-5000 settings and setting groups. A setting table is provided that includes all the settings as shown on the FP-5000 display, a short description, setting range, and factory default settings. **Only the “Configuration Settings” and “Protection Settings” need to be programmed for most power system feeder applications.** The table also includes a column, “Selected Value”, for the user to record settings.

5.2 FP-5000 Setting Flowchart

Below is a flowchart showing an example of how to program the protection settings. The display window shows 4 lines at a time, so use the up/down arrows to view all items in a menu.

```
Password Window
[****]
A Arrow      For Bit
Dual Arrow For Value
```

Access the "Set and Test" door in the lower left corner of the front panel and press the "Set" pushbutton to get into the password display window. The factory default password is 0000. A password of 0000 will always be accepted during the first 2 minutes after the FP-5000 is powered up. See Sec. 5.3.10 for changing password. Press "Enter" pushbutton to advance to next menu.

```
Setting Main
System Config
Protection
System Alarms
```

Select Protection settings using up/down arrows and press the "Enter" pushbutton to access the "Protection" settings.

```
Protection
Setting Group 1
```

Select Setting Group 1 settings using up/down arrows and press "Enter" pushbutton. If # of Set Grps is set to 4 in System Config, then 4 setting groups would be listed on the "Protection" display.

```
Setting Group 1
Phase Overcurrent
IX Measured OC
IR Residual OC
```

Select Phase Overcurrent to access the phase element protection settings.

```
Phase Overcurrent
51P PH TOC Curve
51P PH TOC Setting
50-1 PH IOC 1
```

Select the 51P PH TOC CURVE setting to access the Time Overcurrent curve settings.

```
51 PH TOC Curve
Shape:       MOD
Reset:       Calc
Direction:   Both
```

Press the "Enter" pushbutton to access the curve shape settings. Use up/down arrows to select curve shape. Press "Enter" to finish programming curve shape, then use up/down arrows to select Reset. Use "Enter" and up/down arrows to set all settings, then press the "Previous" pushbutton to return to Phase Overcurrent display window to change other settings.

Once all settings are changed, the user may back out of the setting menus by continually pressing the "Previous" pushbutton until the "Update Setting?" display window appears. Press "Enter" pushbutton to save settings, or press "Previous" to cancel. The user may abort setting entry at any time by pressing the "Reset" pushbutton.

5.3 FP-5000 Setting Table

NOTE: All voltage settings are in secondary units. All current settings are in per unit. All System settings are in primary units. Time delay setting is in cycles (c), seconds (s), or minutes (m).

Program Date:____________________ Control Schematic:____________________

FP-5000 Relay ID:____________________ Breaker ID:____________________

Work Order #:____________________ Line Protected:____________________

Table 5.1 System Config

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Frequency:	Nominal system operating frequency	50 Hz or 60 Hz	60		5.5.1
Phase Seq:	Nominal system phase sequence or rotation	ABC or ACB	ABC		5.5.1
Ct Connect:	Ct connect determines how residual current IR is calculated	3-wire, 4Ct In, 4Ct Ig	3-wire		5.5.1 8.2
	3-wire: 4th Ct is independent				
	4Ct In: 4-wire system with 4th Ct on neutral conductor				
	4Ct Ig: 4-wire system with 4th Ct on ground conductor				
PH Ct Ratio:	Ct ratio of the phase current Cts	I_{nom} to 6000 (Increments of I_{nom})	500:I_{nom}③		5.5.1
IX Ct Ratio:	Ct ratio of the fourth Ct	I_{nom} to 6000 (Increments of I_{nom})	500:I_{nom}③		5.5.1
VT Connect:	Voltage transformer connection	Wye or Delta	Wye		5.5.1 6.3.2
Main VTR:	Main voltage transformer ratio:1	1 to 8000 (Increments of 1)	100		5.5.1
Aux VTR:	Auxiliary voltage transformer ratio:1	1 to 8000 (Increments of 1)	100		5.5.1
Prim Units:	Selection of primary or secondary units of displayed values	Yes, No	No		5.5.1
I/O Config:	Default input/output configuration or customized input/output	Default or Custom ①	Default		5.5.1
Prog Logic:	Default or custom Programmable logic settings	Default or Custom ①	Default		5.5.1
Remote Set:	Enables or disables remote download setpoints capability from rear communication port	Enable or disable	Enable		5.5.1

Table 5.1 System Config (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Prg w/Bkr:	Program relay with breaker open or closed (requires 52a or 52b input)	Open or Either	Either		5.5.1
Remote Bkr:	Enable or disable remote breaker open/close control from rear comm port	Enable or disable	Disable		5.5.1
# Set Grps:	Select the max. number of different Protection Setting Groups	1, 2, 3, or 4 ①	1		5.5.1 9.7
Set Ctrl:	Select the means of control for selecting the active setting group	Local, Local+ Communications, Communications, Cin	Local		5.5.1 9.7
Disarm Ctrl:	Enable/disable of the Arm/Disarm control from the front panel “Test Mode” (Output Trip1 & Trip2 ONLY)	Enable or disable ②	Disable		5.5.1 11.2.5.1
Energy Unit:	This is the selection for “Energy Units” killo- or Mega- Watt-hours	kWh or MWh	kWh		5.5.1 4.6.1.3
TOC Reset T:	Time Overcurrent RESET Time Delay in cycles. Used when time option for reset is chosen	1 to 20 cycles ④ (Increments of 1)	5		5.5.1 5.5.2.1 8.3.2
Bkr Oper PB:	Front panel Breaker Open/Close pushbutton function Enable	Enable or disable	Disable		5.5.1

① This setting affects other settings. The user must save settings after changing this setting, which will take the user out of program mode. The user must then re-enter program mode to continue programming the remaining settings.
② If enabled, the user must go to the “Test Mode” by pressing the “test button”, select Arm/Disarm Trip, then select Arm Trip or Disarm Trip setting.
③ Ct secondary rating is automatically detected: I_{nom} = 1A or 5A.
④ This setting is the programmed time delay for the T Delay setting of the time overcurrent Reset setting. See TOC Curve settings for 51P, 51R, and 51X elements.

Table 5.2 Protection

Setting Group ____					
Phase Overcurrent: Phase time overcurrent (51P) and instantaneous (50P-1 & 50P-2) protective device settings					
Display Setting	**Description**	**Setpoint Range/ Value Selection**	**Default Setting**	**Selected Value**	**Refer to Sec. #**
51P PH TOC Curve	Phase Time Overcurrent Curve Settings				5.5.2.1 8.3 13.4
Shape:	Select curve characteristic shape	IT, I2T, I4T, FLAT, MOD, VERY, XTRM, IECA, IECB, IECC	MOD		
Reset:	Select curve reset characteristics	Inst, Calc, T Delay	Calc		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
51P PH TOC Setting	Phase Time Overcurrent Pickup and Time Multiplier Settings				5.5.2.1 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 4.0 pu, or Disable (0.01 increments)	1.00		
Time Mult:	Select Time Multiplier	0.05 to 10.0 (.01 increments)	1.00		
50P-1 PH IOC 1	Phase Overcurrent Element #1 Setting				5.5.2.1 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, or Disable (0.01 increments)	2.00		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
50P-2 PH IOC 2	Phase Overcurrent Element #2 Setting				5.5.2.1 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, or Disable (0.01 increments)	3.00		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	15		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		

Table 5.2 IX Measured OC: Independent fourth Ct time overcurrent (51X) and instantaneous (50X-1 & 50X-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
51X IX TOC Curve	Fourth Ct Time Overcurrent Curve Setting (Uses gnd ct ratio)				5.5.2.2 8.3 13.4
Shape:	Select curve characteristic shape	IT, I2T, I4T, FLAT, MOD, VERY, XTRM, IECA, IECB, IECC	XTRM		
Reset:	Select curve reset characteristics	Inst, Calc, T Delay	Calc		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
51X IX TOC Setting	Fourth Ct Time Overcurrent Pickup and Time Multiplier Settings				5.5.2.2 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 4.0 pu, or Disable (0.01 increments)	0.50		
Time Mult:	Select time multiplier	0.05 to 10.0 (0.01 increments)	1.00		
50X-1 IX IOC 1	Fourth Ct Overcurrent Element #1 Setting				5.5.2.2 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, or Disable (0.01 increments)	1.00		
Delay (c):	Select delay time in cycles	0 to 9999 (1 cycle increments)	60		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
50X-1 IX IOC 2	Fourth Ct Overcurrent Element #2 Setting				5.5.2.2 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, or Disable (0.01 increments)	2.00		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	6.00		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		

Table 5.2 IR Residual OC: Calculated residual time overcurrent (51R) and instantaneous (50R-1 & 50R-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
51R IR TOC Curve	Calculated Residual Time	Overcurrent Curve Setting			5.5.2.3 8.3 13.4
Shape:	Select curve characteristic shape	IT, I2T, I4T, FLAT, MOD, VERY, XTRM, IECA, IECB, IECC	XTRM		
Reset:	Select curve reset characteristics	Inst, Calc, T Delay	Inst		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
51R IR TOC Setting	Calculated Residual Time Overcurrent Pickup and Time Multiplier Settings				5.5.2.3 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 4.0 pu, or Disable (0.01 increments)	0.10		
Time Mult:	Select time multiplier	0.05 to 10.0 (0.01 increments)	1.00		
50R-1 IR IOC 1	Calculated Residual Overcurrent Element #1 Setting				5.5.2.3 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, or Disable (0.01 increments)	1.00		
Delay (c):	Select delay time in cycles	0 to 9999 (1 cycle increments)	60		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
50R-1 IR IOC 2	Calculated Residual Overcurrent Element #2 Setting				5.5.2.3 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, or Disable (0.01 increments)	2.00		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	600		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		

Table 5.2 Unbalance Setting: Selects voltage (47-1) unbalance and current (46-1) unbalance device settings

47-1 Voltage Unbal	Voltage Unbalance Settings				5.5.2.4 8.6.1
Threshold:	Select magnitude of unbalance required (either V1 or V2)	1 to 100 volts, or Disable (1 volt increments)	Disable		
% (V2/V1):	Percent negative sequence (V2) divided by positive sequence (V1)	4 to 40 percent (1% increments)	20		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	600		

Table 5.2 Unbalance Setting (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
46-1 Current Unbal	Current Unbalance Settings				5.5.2.4 8.3.5
Threshold:	Select magnitude of unbalance required (either I1 or I2)	0.1 to 20.0, disable (0.01 pu increments)	Disable		
% (I2/I1):	Percent negative sequence (I2) divided by positive sequence (I1)	4 to 40 percent (1% increments)	20		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	600		

Table 5.2 Main V Protection: Selects undervoltage (27M-1) and overvoltage (59M-1) device settings

27M-1 Undervoltage	Main VT Undervoltage Settings				5.5.2.5 8.6.2
Threshold V:	Select magnitude of undervoltage required	10 to 150 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	1200		
59M-1 Overvoltage	Main VT Overvoltage Settings				5.5.2.5 8.6.2
Threshold V:	Select magnitude of overvoltage required	10 to 150 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	1200		

Table 5.2 Aux V Protection: Selects undervoltage (27A-1) and overvoltage (59A-1) device settings

27A-1 Undervoltage	Auxiliary VT Undervoltage Settings				5.5.2.5 8.6.2
Threshold V:	Select magnitude of undervoltage required	10 to 250 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	1200		
59A-1 Overvoltage	Auxiliary VT Overvoltage Settings				5.5.2.5 8.6.2
Threshold V:	Select magnitude of overvoltage required	10 to 250 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	1200		

Table 5.2 Freq Protection: Selects underfrequency (81U-1) and overfrequency (81O-1) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
81U-1 Underfreq	Underfrequency Settings				5.5.2.6 8.8
Threshold:	Select frequency threshold	45 to 65, disable (0.01 Hz increments)	Disable		
Delay (c):	Select delay time, which is based on power system frequency	0 to 9999 (1 cycle increments)	60		
81O-1 Overfreq	Overfrequency Settings				5.5.2.6 8.8
Threshold:	Select frequency threshold	45 to 65, disable (0.01 Hz increments)	Disable		
Delay (c):	Select delay time, which is based on power system frequency	0 to 9999 (1 cycle increments)	60		

Table 5.2 Breaker Failure: Selects breaker failure (50BF) device settings

50BF Bkr Config	Breaker Failure Configuration				5.5.2.7 8.9.5
BF Config:	Select how breaker failure is detected	off, internal, external, both	Off		
50BF Bkr Failure	Breaker Failure Settings				5.5.2.7 8.9.5
I Ph (pu):	Select phase current pickup in per unit values	0.1 to 5 pu, disable (0.01 increments)	Disable		
I Gnd (pu):	Select ground current pickup in per unit values	0.1 to 5 pu, disable (0.01 increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		

Table 5.2 Power Factor: Selects Apparent PF (55A) and Displacement PF (55D) device settings

55A Apparent PF	Apparent Power Factor Settings				5.5.2.8
Trigger PF:	Select power factor to trigger on	0.50 to 1.00 (lag), -0.50 to -0.99 (lead), disable (0.01 pu increments)	Disable		
Reset PF:	Select power factor to reset on	0.50 to 1.00 (lag), -0.50 to -0.99 (lead), disable (0.01 pu increments)	Disable		
Delay (s):	Select delay time in seconds	0 to 1000 seconds (1 second increments)	0		

Table 5.2 Power Factor (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
55D Displacement PF	Displacement Power Factor Settings				5.5.2.8
Trigger PF:	Select power factor to trigger on	0.50 to 1.00 (lag), -0.50 to -0.99 (lead), disable (0.01 pu increments)	Disable		5.5.2.8
Reset PF:	Select power factor to reset on	0.50 to 1.00 (lag), -0.50 to -0.99 (lead), disable (0.01 pu increments)	Disable		5.5.2.8
Delay (s):	Select delay time in seconds	0 to 1000 seconds (1 second increments)	0		5.5.2.8

Table 5.2 Zone Interlocking: Selects Zone In and Zone Out settings

Zone Interlocking	Zone Interlocking Settings				5.5.2.9 8.5
Zone in:	Select zone in function	Disable, Phase, Ground, Both	Disable		
Zone Out:	Select zone out function	Disable, Phase, Ground, Both	Disable		

Table 5.2 Alarms: Selects Alarms settings for all protection functions – 50P-3, 50X-3, 50R-3, 46-2, 47-2, 59-M2, 27M-2, 59A-2, 27A-2, 81O-2, and 81U-2

50P-3 PH IOC Alarm	Phase Overcurrent Alarm Setting				5.5.2.10 5.5.2.1 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, Disable (0.01 increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
50X-3 IX IOC Alarm	Fourth Ct Overcurrent Alarm Setting Alarm Setting				5.5.2.10 5.5.2.2 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, Disable (0.01 increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		
50R-3 IR IOC Alarm	Residual Time Overcurrent Alarm Setting				5.5.2.3 5.5.2.10 8.3
Pickup:	Select current pickup value in per unit values (x I_{nom})	0.1 to 20.0 pu, Disable (0.01 increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
Direction:	Directional control reserved for future use	(Fixed at Both)	Both		

Table 5.2 Alarms (continued)

Display Setting	Description	Setpoint range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
46-2 I Unbal Alarm	Current Unbalance Alarm Settings				5.5.2.10 5.5.2.4 8.3.5
Threshold:	Select magnitude of unbalance required (either I1 or I2)	0.1 to 20.0 pu, Disable (0.01 increments)	0.1		
% (I2/I1):	Percent negative sequence (I2) divided by positive sequencel (I1)	4 to 40 percent (1% increments)	40		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	60		
47-2 V Unbal Alarm	Voltage Unbalance Alarm Settings				5.5.2.10 5.5.2.4 8.6.1
Threshold:	Select magnitude of unbalance required (either V1 or V2)	1 to 100 volts, Disable (1 volt increments)	50		
% (V2/V1):	Percent negative sequence (V2) divided by positive sequence (V1)	4 to 40 percent (1% increments)	40		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	60		
59M-2 OV Alarm	Main VT Overvoltage Alarm Setting				5.5.2.10 5.5.2.5 8.6.2
Threshold V:	Select magnitude of overvoltage required	10 to 150 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
27M-2 UV Alarm	Main VT Undervoltage Alarm Setting				5.5.2.10 5.5.2.5 8.6.2
Threshold V:	Select magnitude of undervoltage required	10 to 150 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
59A-2 OV Alarm	Auxiliary VT Overvoltage Alarm Setting				5.5.2.10 5.5.2.5 8.6.2
Threshold V:	Select magnitude of overvoltage required	10 to 250 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
27A-2 UV Alarm	Auxiliary VT Undervoltage Alarm Setting				5.5.2.10 5.5.2.5 8.6.2
Threshold V:	Select magnitude of undervoltage required	10 to 250 volts, disable (1 volt increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		

Table 5.2 Alarms (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
81O-2 OF Alarm	Overfrequency Alarm Settings				5.5.2.10 5.5.2.6 8.8
Threshold:	Select threshold based on power system frequency	45 to 65 Hz, disable (0.01 increments)	Disable		
Delay (c):	Select delay time in cycles	0 to 9999 cycles (1 cycle increments)	0		
81U-2 UF Alarm	Underfrequency Alarm Settings				5.5.2.10 5.5.2.6 8.8
Threshold: Delay (c):	Select threshold based on power system frequency Select delay time in cycles (1 cycle increments)	45 to 65 Hz, disable (0.01 increments) 0 to 9999 cycles	Disable 0		

Table 5.3 System Alarms Phase time overcurrent (51P) and instantaneous (50P-1 & 50P-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Watt Power Alarm	System Watt Power Alarm Setting				5.5.3
Units:	Select units for watt power	kW or MW	kW		
Threshold:	Select magnitude threshold in primary units	1 to 40,000, Disable (increments of 1)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		
VAR Power Alarm	System VAR Power Alarm Setting				5.5.3
Units:	Select units for VAR power	kVAR or MVAR	kVAR		
Threshold:	Select magnitude threshold in primary units	1 to 40,000, Disable (increments of 1)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		
VA Power Alarm	System VA Power Alarm Setting				5.5.3
Units:	Select units for VA power	kVA or MVA	kVA		
Threshold:	Select magnitude threshold in primary units	1 to 40,000, Disable (increments of 1)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		
Watt Demand Alarm	System Watt Demand Alarm Setting				5.5.3
Units:	Select units for watt demand	kW or MW	kW		
Threshold:	Select magnitude threshold in primary units	1 to 40,000, Disable (increments of 1)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		
VAR Demand Alarm	System VAR Demand Alarm Setting				5.5.3
Units:	Select units for VAR demand	kVAR or MVAR	kVAR		
Threshold:	Select magnitude threshold in primary units	1 to 40,000, Disable (increments of 1)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		

Table 5.3 System Alarms (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
VA Demand Alarm	System VA Demand Alarm Setting				5.5.3
Units:	Select units for VA demand	kVA or MVA	kVA		
Threshold:	Select magnitude threshold in primary units	1 to 40,000, Disable (increments of 1)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		
Current Demand Alarm	System Current Demand Alarm Setting				5.5.3
Pickup:	Select pickup in primary units	10 to 10,000 amps, Disable (increments of 10)	Disable		
Delay (m):	Select delay time in minutes	0 to 60 minutes (increments of 1)	0		
I THD Alarm	System Current Total Harmonic Distortion Alarm Setting				5.5.3
Threshold:	Select magnitude of I THD in primary units	(Phase Ct Primary/100) to (Phase Ct Primary *10) [increments of Phase Ct Primary/100]	Disable		
Delay (m):	Select delay time in minutes	0 to 3600 seconds (increments of 1s)	0		
V THD Alarm	System Voltage Total Harmonic	Distortion Alarm Setting			5.5.3
Threshold:	Select magnitude of V THD in primary units	Main VTR/10 to Main VTR *10 (increments of Main VTR/100)	Disable		
Delay (m):	Select delay time in minutes	0 to 3600 seconds (increments of 1s)	0		
Breaker Alarm	Breaker alarm # of operations & sum of interrupting amps				5.5.3
# of Operation:	# of breaker operations based on the 52a and 52b contacts	1 to 9999 (increments of 1)	9999		
Isum INTR Amp:	Current sum of interrupting amps measured in kA^2	0 to 50,000 kA^2 seconds (increments of 1 kA^2s)	50,000		

Table 5.4 Logging Settings Phase time overcurrent (51P) and instantaneous (50P-1 & 50P-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Current Demand	Current Demand Logging Setting				5.5.4
Interval (m):	Select interval for taking current demand measurement in minutes	1 to 60 minutes (increments of 1)	15		5.5.4
Power Demand	Power Demand Logging Setting				5.5.4
Window:	Select type of power demand window	Fixed or Slide	Fixed		5.5.4
Interval (m):	Select interval for taking power demand measurement in minutes	1 to 60 minutes (increments of 1)	15		5.5.4
Event Log Enable	Event Log Settings for Pickups, Contact Inputs, and Communications				5.5.4 12.2.1
I Pickup:	Select I Pickup to be logged	No or Yes	Yes		
V Pickup:	Select V Pickup to be logged	No or Yes	No		
Freq Pickup:	Select Freq Pickup to be logged	No or Yes	No		
PF Pickup:	Select PF Pickup to be logged	No or Yes	No		
Unbal Pickup:	Select Unbal Pickup to be logged	No or Yes	No		
SYSALM Pickup:	Set system alarm pickup to be logged	No or Yes	No		
Cin 1:	Set Cin 1 event to be logged	No or Yes	No		
Cin 2:	Set Cin 2 event to be logged	No or Yes	No		
Cin 3:	Set Cin 3 event to be logged	No or Yes	No		
Cin 4:	Set Cin 4 event to be logged	No or Yes	No		
Cin 5:	Set Cin 5 event to be logged	No or Yes	No		
Cin 6:	Set Cin 6 event to be logged	No or Yes	No		
Cin 7:	Set Cin 7 event to be logged	No or Yes	No		
Cin 8:	Set Cin 8 event to be logged	No or Yes	No		
Comm.:	Set Comm event to be logged	No or Yes	No		

Table 5.4 Logging Settings (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Datalogger	Datalogger Settings				5.5.4 8.11
Mode:	Select mode of datalogger to be continuous (overwrites) or 1-pass	Cont. or 1-Pass	Cont.		
Trigger:	Select trigger type	Auto or manual	Auto		
Interval (s):	Select interval of datalogging in seconds	1 to 3600 seconds (increments of 1)	900		
Value 1:	Set Value 1 to be logged	IA, IB, IC, IX, IR, Iavg, I0, I1, I2, VA, VB, VC, VX, VLNavg, VAB, VBC, VCA, VLLavg, V0, V1, V2, Freq, W, VAR, VA, Dsp PF, App PF, IA Demand, IB Demand, IC Demand, W Demand, VAR Demand, VA Demand, Cin1, Cin2, Cin3, Cin4, Cin5, Cin6, Cin7, Cin8, LG1, LG2, LG3, LG4, LG5, LG6, TG1, TG2, TG3, TG4, TG5, TG6, IA THD, IB THD, IC THD, VA THD, VB THD, VC THD, VAB THD, VBC THD, VCA THD	Ia		
Value 2:	Set Value 2 to be logged		Ib		
Value 3:	Set Value 3 to be logged		Ic		
Value 4:	Set Value 4 to be logged		Ix		
Value 5:	Set Value 5 to be logged		Va		
Value 6:	Set Value 6 to be logged		Vb		
Value 7:	Set Value 7 to be logged		Vc		
Value 8:	Set Value 8 to be logged		Vx		
Waveform Capture	Waveform Capture Settings				5.5.4 8.10
Records:	Select size of the waveform capture using buffer x cycles	4x64, 8x32, 16x16 (buffer x cycles)	16x16		
PreTrigger:	Select # of cycles of preTrigger data	1 to 15 cycles (increments of 1)	2		
OSC Trigger TRIP2:	Select how to trigger waveform capture on Trip 2 operation	Disable, Overwrite, or Lock	Overwrite		
OSC Trigger dV/dI:	Select how to trigger waveform capture on a V or I disturbance	Disable, Overwrite, or Lock	Disable		
OSC Trigger Logic LG6:	Select how to trigger waveform capture on a LG6 logic operation	Disable, Overwrite, or Lock	Overwrite		
OSC Trigger Cntrl PB:	Select how to trigger waveform capture on pushbutton operation	Disable, Overwrite, or Lock	Overwrite		
OSC Trigger Comm:	Select how to trigger waveform capture on communication command	Disable, Overwrite, or Lock	Overwrite		

Table 5.5 Contact Input Configuration Settings Phase time overcurrent (51P) and instantaneous (50P-1 & 50P-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Contact input CFG	Contact Input Configuration Settings				5.5.5 9.1
Cin1:	Select Cin1 configuration	user defined, 52a, 52b, BFI, Bkr Trouble, Remote Open, Remote Close, Remote Reset, DatalogTrigger, Demand Sync, Select Set 1, Select Set 2	52a		
Cin2:	Select Cin2 configuration		52b		
Cin3:	Select Cin3 configuration		BFI		
Cin4:	Select Cin4 configuration		Bkr Trouble		
Cin5:	Select Cin5 configuration		Remote Open		
Cin6:	Select Cin6 configuration		Remote Close		
Cin7:	Select Cin7 configuration		Remote Reset		
Cin8:	Select Cin8 configuration		user defined		

Table 5.6 Output Configuration Settings Phase time overcurrent (51P) and instantaneous (50P-1 & 50P-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Output Trip1	Output Trip1 Relay Settings				5.5.6 9.2 9.6
Monitor:	Select "Breaker Trip" coil circuit monitoring to on or off	Off or On	On		
Function: for Output Trip1	Select logic output function NAND, Disable	OR, AND, NOR,	OR		
Dropout:	Select relay state after trip occurs	Latched, Unlatched, or Off Delay	Off Delay		
Off Delay (c):	Select delay for Trip Relay to dropout after trip event clears①	0 to 60 cycles (1 cycle increments)	5		
IN1:	Select logic input IN1 for Output Trip1	* See Logic Input Options Table 5.10	Trip AllProt		
IN2:	Select logic input IN2 for Output Trip1	* See Logic Input Options Table 5.10	Cntrl, OpenBkr		
IN3:	Select logic input IN3 for Output Trip1	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic input IN4 for Output Trip1	* See Logic Input Options Table 5.10	Unused		
Output Trip2	Output Trip2 Relay Settings				5.5.6 9.2 9.6
Monitor:	Select "Close" coil circuit monitoring to on or off	Off or On	Off		
Function: for Output Trip2	Select logic output function NAND, Disable	OR, AND, NOR,	Disabled		
Dropout:	Select relay state after trip occurs	Latched, Unlatched, or Off Delay	Unlatched		
Off Delay (c):	Select delay for Trip 2 Relay to dropout after trip event clears	0 to 60 cycles (1 cycle increments)	0		
IN1:	Select logic input IN1 for Output Trip2	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic input IN2 for Output Trip2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic input IN3 for Output Trip2	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic input IN4 for Output Trip2	* See Logic Input Options Table 5.10	Unused		

① This setting is only used if the "Dropout" setting is set to "Off Delay."

Table 5.6 Output Configuration Settings (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Output Rly3	Output Relay 3 Settings				5.5.6 9.2 9.6
Function:	Select logic output function for Output Rly3	OR, AND, NOR, NAND, Disable	OR		
Dropout: after trip occurs	Select relay state or Off Delay	Latched, Unlatched,	Latched		
Off Delay (C):	Select delay for Relay to dropout after trip event clears①	0 to 60 cycles (1 cycle increments)	0		
IN1:	Select logic input IN1 for Output Rly3	* See Logic Input Options Table 5.10	Trip, BF		
IN2:	Select logic input IN2 for Output Rly3	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic input IN3 for Output Rly3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic input IN4 for Output Rly3	* See Logic Input Options Table 5.10	Unused		
Output Rly4	Output Relay 4 Settings				5.5.6 9.2 9.6
Function:	Select logic output function for Output Rly4	OR, AND, NOR, NAND, Disable	Disabled		
Dropout:	Select relay state after trip occurs	Latched, Unlatched, or Off Delay	Unlatched		
Off Delay (C):	Select delay for Relay to dropout after trip event clears①	0 to 60 cycles (1 cycle increments)	0		
IN1:	Select logic input IN1 for Output Rly4	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic input IN2 for Output Rly4	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic input IN3 for Output Rly4	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic input IN4 for Output Rly4	* See Logic Input Options Table 5.10	Unused		

① This setting is only used if the "Dropout" setting is set to "Off Delay."

Table 5.6 Output Configuration Settings (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Output Rly5	Output Relay 5 Settings				5.5.6 9.2 9.6
Function:	Select logic output function for Output Rly5	OR, AND, NOR, NAND, Disable	OR		
Dropout:	Select relay state after trip occurs	Latched, Unlatched, or Off Delay	Off Delay		
Off Delay (C):	Select delay for relay to dropout after trip event clears①	0 to 60 cycles (1 cycle increments)	10		
IN1:	Select logic input IN1 for Output Rly5	* See Logic Input Options Table 5.10	Breaker, Close Bkr		
IN2:	Select logic input IN2 for Output Rly5	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic input IN3 for Output Rly5	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic input IN4 for Output Rly5	* See Logic Input Options Table 5.10	Unused		
Output Alarm	Output Alarm Relay Settings				5.5.6 9.2 9.6
Function:	Select logic output function for Output Alarm Relay	OR, AND, NOR, NAND, Disable	OR		
Dropout:	Select relay state after trip occurs	Latched, Unlatched, or Off Delay	Unlatched		
Off Delay (C):	Select delay for relay to dropout after trip event clears①	0 to 60 cycles (1 cycle increments)	0		
IN1:	Select logic input IN1 for Output Alarm Relay	* See Logic Input Options Table 5.10	Trip, All Prot		
IN2:	Select logic input IN2 for Output Alarm Relay	* See Logic Input Options Table 5.10	Trip, All Alm		
IN3:	Select logic input IN3 for Output Alarm Relay	* See Logic Input Options Table 5.10	Sys Alm, All Alm		
IN4:	Select logic input IN4 for Output Alarm Relay	* See Logic Input Options Table 5.10	Breaker, All Alm		
Output Aux LED	Output Auxiliary LED Settings				5.5.6 9.2 9.6
Function:	Select logic output function for Output Aux LED	OR, AND, NOR, NAND, Disable	OR		
IN1:	Select logic input IN1 for Output Aux LED	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic input IN2 for Output Aux LED	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic input IN3 for Output Aux LED	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic input IN4 for Output Aux LED	* See Logic Input Options Table 5.10	Unused		

① This setting is only used if the “Dropout” setting is set to “Off Delay.”

Table 5.6 Output Configuration Settings (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Trip Indicator	Output Trip Indicator Settings				5.5.6 9.2 9.6
Dropout:	Select trip indicator dropout	Latched or Unlatched	Latched		
Trip1:	Enable or disable Trip1 indicator	Disable or Enable	Enable		
Trip2:	Enable or disable Trip2 indicator	Disable or Enable	Enable		
Rly3:	Enable or disable Rly3 indicator	Disable or Enable	Disabled		
Rly4:	Enable or disable Rly4 indicator	Disable or Enable	Disabled		
Rly5:	Enable or disable Rly5 indicator	Disable or Enable	Disabled		
Alarm:	Enable or disable Alarm indicator	Disable or Enable	Disabled		
Healthy:	Enable or disable relay Healthy indicator	Disable or Enable	Disabled		
Alarm Indicator	Output Alarm Indicator Settings				5.5.6 9.2 9.6
Dropout:	Select trip indicator dropout	Latched or Unlatched	Latched		
Trip1:	Enable or disable Trip1 indicator	Disable or Enable	Disable		
Trip2:	Enable or disable Trip2 indicator	Disable or Enable	Disable		
Rly3:	Enable or disable Rly3 indicator	Disable or Enable	Disabled		
Rly4:	Enable or disable Rly4 indicator	Disable or Enable	Disabled		
Rly5:	Enable or disable Rly5 indicator	Disable or Enable	Disabled		
Alarm:	Enable or disable Alarm indicator	Disable or Enable	Enable		
Healthy:	Enable or disable relay Healthy indicator	Disable or Enable	Enable		
Pickup Indicator	Output Pickup Indicator Settings				5.5.6 9.2 9.6
Dropout:	Select pickup indicator dropout	Latched or Unlatched	Unlatched		
IOC:	Enable or disable IOC pickup indicator	Disable or Enable	Enable		
TOC:	Enable or disable TOC pickup indicator	Disable or Enable	Enable		
Volt:	Enable or disable voltage pickup indicator	Disable or Enable	Enable		
OverFreq:	Enable or disable overfrequency pickup indicator	Disable or Enable	Enable		
UnderFreq:	Enable or disable underfrequency pickup indicator	Disable or Enable	Enable		
Unbalance:	Enable or disable voltage/current unbalance pickup indicator	Disable or Enable	Enable		
Prot Alarm:	Enable or disable protection pickup indicator	Disable or Enable	Disabled		

Table 5.7 Programmable Logic Phase time overcurrent (51P) and instantaneous (50P-1 & 50P-2) device settings

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Logic Gate 1	Logic gate 1 Settings				5.5.7 9.3 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Logic Gate 2	Logic gate 2 Settings				5.5.7 9.3 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Logic Gate 3	Logic gate 3 Settings				5.5.7 9.3 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Logic Gate 4	Logic gate 4 Settings				5.5.7 9.3 9.7
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Logic Gate 5	Logic gate 5 Settings				5.5.7 9.3 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Logic Gate 6	Logic gate 6 Settings				5.5.7 9.3 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Timer Gate 1	Timer gate 1 Programmable Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for Timer gate to apply	1, 2, 3, 4 or All	1		
In:	Logic input	* See Logic Input Options Table 5.10	Unused		
On Delay (c):	Select timer gate on delay	0 to 9999 cycles (1 cycle increments)	0		
Off Delay (c):	Select timer gate off delay	0 to 9999 cycles (1 cycle increments)	0		
Timer Gate 2	Timer gate 2 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for Timer gate to apply	1, 2, 3, 4 or All	1		
In:	Logic input	* See Logic Input Options Table 5.20	Unused		
On Delay (c):	Select timer gate on delay	0 to 9999 cycles (1 cycle increments)	0		
Off Delay (c):	Select timer gate off delay	0 to 9999 cycles (1 cycle increments)	0		
Timer Gate 3	Timer gate 3 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for Timer gate to apply	1, 2, 3, 4 or All	1		
In:	Logic input	* See Logic Input Options Table 5.10	Unused		
On Delay (c):	Select timer gate on delay	0 to 9999 cycles (1 cycle increments)	0		
Off Delay (c):	Select timer gate off delay	0 to 9999 cycles (1 cycle increments)	0		
Timer Gate 4	Timer gate 4 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for Timer gate to apply	1, 2, 3, 4 or All	1		
In:	Logic input	* See Logic Input Options Table 5.10	Unused		
On Delay (c):	Select timer gate on delay	0 to 9999 cycles (1 cycle increments)	0		
Off Delay (c):	Select timer gate off delay	0 to 9999 cycles (1 cycle increments)	0		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Timer Gate 5	Timer gate 5 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for Timer gate to apply	1, 2, 3, 4 or All	1		
In:	Logic input	* See Logic Input Options Table 5.10	Unused		
On Delay (c):	Select timer gate on delay	0 to 9999 cycles (1 cycle increments)	0		
Off Delay (c):	Select timer gate off delay	0 to 9999 cycles (1 cycle increments)	0		
Timer Gate 6	Timer gate 6 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for Timer gate to apply	1, 2, 3, 4 or All	1		
In:	Logic input	* See Logic Input Options Table 5.10	Unused		
On Delay (c):	Select timer gate on delay	0 to 9999 cycles (1 cycle increments)	0		
Off Delay (c):	Select timer gate off delay	0 to 9999 cycles (1 cycle increments)	0		
Logic Latch 1	Logic Latch 1 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for logic latch to apply	1, 2, 3, 4 or All	1		
SIn:	Select logic input to set latch	* See Logic Input Options Table 5.10	Unused		
RIn:	Select logic input to reset latch	* See Logic Input Options Table 5.10	Unused		
Logic Latch 2	Logic Latch 2 Settings				5.5.7 9.3 9.6
Set Group:	Select protection setting group for logic latch to apply	1, 2, 3, 4 or All	1		
SIn:	Select logic input to set latch	* See Logic Input Options Table 5.10	Unused		
RIn:	Select logic input to reset latch	* See Logic Input Options Table 5.10	Unused		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Block 50X-1 IOC	Logic gate setting to block 50X-1 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 50X-2 IOC	Logic gate setting to block 50X-2 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 50X-3 IOC	Logic gate setting to block 50X-3 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Block 50R-1 IOC	Logic gate setting to block 50R-1 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 50R-2 IOC	Logic gate setting to block 50R-2 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 50R-3 IOC	Logic gate setting to block 50R-3 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Block 50P-1 IOC	Logic gate setting to block 50P-1 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 50P-2 IOC	Logic gate setting to block 50P-2 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2 Table 5.10	* See Logic Input Options	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 50P-3 IOC	Logic gate setting to block 50P-3 IOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		

Table 5.7 Programmable Logic (continued)

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Block 51P TOC	Logic gate setting to block 51P TOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 51R TOC	Logic gate setting to block 51R TOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		
Block 51X TOC	Logic gate setting to block 51X TOC operation				5.5.7 9.4 9.6
Function:	Select logic function to apply to logic gate	OR, AND, NOR, NAND, Disable	Disable		
Set Group:	Select protection setting group for logic gate to apply	1, 2, 3, 4 or All	1		
IN1:	Select logic type for logic input 1	* See Logic Input Options Table 5.10	Unused		
IN2:	Select logic type for logic input 2	* See Logic Input Options Table 5.10	Unused		
IN3:	Select logic type for logic input 3	* See Logic Input Options Table 5.10	Unused		
IN4:	Select logic type for logic input 4	* See Logic Input Options Table 5.10	Unused		

Table 5.8 Clock

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
Clock	Time and Date				5.5.8
Date mode:	Select date format	MM/DD/YY or DD/MM/YY	0		5.5.8
Time mode:	Select standard time or military time	12 or 24	12		5.5.8
Year:	Select year	0 to 99	0		5.5.8
Month:	Select month	1 to 12	1		5.5.8
Day:	Select Day	1 to 31	1		5.5.8
Hour:	Select hour (set in 24 hour mode)	0 to 23	0		5.5.8
Minute:	Select minute	0 to 59	0		5.5.8
Second:	Select Seconds	0 to 59	0		5.5.8
Update Clock!		Press the “Enter” pushbutton after setting clock to update the clock			

Table 5.9 Communications

Display Setting	Description	Setpoint Range/ Value Selection	Default Setting	Selected Value	Refer to Sec. #
INCOM	INCOM Communications Settings				5.5.9
Enable:	Enable INCOM communications	Yes or No	Yes		5.5.9
Address:	Select Communication address of FP5000	1 to 0xFFE (Hex Value - increments of 1)	1		5.5.9
Baud rate:	Baud rate fixed at 9600 baud	Fixed at 9600 Baud	9600		5.5.9
Accessory Bus	Accessory Bus Address and Baud rate setting				5.5.9
Address:	Select Communication address of FP5000	1 to 0xFFE (Hex Value - increments of 1)	2		5.5.9
Baud rate:	Baud rate fixed at 9600 baud	Fixed at 9600 Baud	9600		5.5.9
RS-232	RS-232 Baud Rate Setting				5.5.9
Baud rate:	Select baud rate for RS-232 communications	9600, 19200, or 38400 Baud	19200		5.5.9

5.4 Logic Input Settings

Table 5.10 Logic Input Setting Options

Logic Input (IN1, IN2, IN3, & IN4) Programming Option Settings: Logic input settings for the 8 logic categories		
Input Category	**“Available Setting Options”**	**Setpoint Range/ Value Selection**
Unused	Unused	Direct or Negated
Pickup	PH OC, G OC, IOC, TOC, OC, All Alm, Volt, Freq, AllProt, 50X-1, 50X-2, 50X-3, 50R-1, 50R-2, 50R-3, 50P-1, 50P-2, 50P-3, 51P, 51X, 51R, 59A-1, 59A-2, 27A-1, 27A-2, 59M-1, 59M-2, 27M-1, 27M-2, 46-1, 46-2, 47-1, 47-2, 81U-1, 81U-2, 81O-1, 81O-2, BF, 55A PF,	Direct or Negated
Trip	PH OC, G OC, IOC, TOC, OC, All Alm, Volt, Freq, AllProt, 50X-1, 50X-2, 50X-3, 50R-1, 50R-2, 50R-3, 50P-1, 50P-2, 50P-3, 51P, 51X, 51R, 59A-1, 59A-2, 27A-1, 27A-2, 59M-1, 59M-2, 27M-1, 27M-2, 46-1, 46-2, 47-1, 47-2, 81U-1, 81U-2, 81O-1, 81O-2, BF, 55A PF,	Direct or Negated
Logic	LG1, LG2, LG3, L54, LG5, LG6, TG1, TG2, TG3, TG4, TG5, TG6, Q1, or Q2	Direct or Negated
Inputs	Cin1, Cin2, Cin3, Cin4, Cin5, Cin6, Cin7, Cin8, or ZI In	Direct or Negated
SysAlm	Watt, VAR, VA, WattDmd, VARDmd, VADmd, CurDmd, V THD, I THD, BkrOps, Sum I, or AllAlm	Direct or Negated
Breaker	OpenBkr, CloseBkr, Open, Closed, BkrFail, SlowBkr, StateAlm, Mntr1Alm, Mntr2Alm or All Alm	Direct or Negated
Comm	Comm1, Comm2, Comm3 or Comm4	Direct or Negated

5.5 Setting Descriptions

This section discusses the settings in a little more detail than the settings table.

5.5.1 System Configuration Setting Descriptions (System Config)

The System Config settings contain all of the settings to configure the power system.

Frequency: Nominal system operating frequency.

Phase Seq: ABC or ACB system phase sequence or rotation.

Ct Connect: The “3-wire” setting should be used for three-phase, three-wire, medium voltage power systems. The “4Ct In” setting should be used on a three-phase, 4-wire system where a 4th Ct is connected in the neutral conductor on. The “4Ct Ig” should be used on a three-phase, 4-wire system when a zero-sequence ground Ct is used. See Section 8 for more information.

PH Ct Ratio: The primary connected current rating of the phase Cts. For example, set to 800 for phase Cts of 800:5.

IX Ct Ratio: The primary connected current rating for the fourth current input(usually for neutral or ground). If the ground measurement is taken from a residual phase connection then this setting will be the same as the Phase Ct Ratio setting above. If a zero sequence or ground Ct is used then the primary rating for that Ct will be used.

VT Connect: Voltage transformer connection – wye or “open” delta.

Main VTR: Main voltage transformer ratio to one. Example: 13.2 kV system, 120V VT – set Main VTR to 110 = (13200/120)

Aux VTR: Auxiliary voltage transformer ratio. See example above.

Prim Units: Selection of Primary units for metering voltage and current displayed values.

If setting is “Yes”, then all voltages and currents (including sequence voltages and currents) will be displayed in primary values, which are system values.

If setting is “No”, then all voltages and currents (including sequence voltages and currents) will be displayed in secondary values, which are the actual values measured at the FP-5000 inputs.

Power and energy readings are always in primary values.

I/O Config: The user may select either default input/output configuration or customized input/output configuration. The I/O refers to the contact inputs and output relays. Choosing customized I/O allows the user to freely program the contact inputs and relay outputs. See Table 5.16 Contact Input CFG and Output CFG settings and the following descriptions for more information. The unit is shipped from the factory with “I/O Config” set to default.

The I/O cannot be changed from the default setting unless this setting has been set to Custom I/O. A Default I/O setting will not give the user access to the configured I/O settings in the Set Mode. To view I/O configuration, the user will need to exit the Set Mode and enter the View Setting mode and scroll to the appropriate section. If the relay I/O has been customized, then selecting the “Default I/O” will change all the Custom I/O settings back to the factory default settings.

Changing this setting will immediately ask you to confirm and save the settings and will exit you out of the setting mode. You will need to enter back into the Set Mode to continue your programming session. Please note that all settings made prior to this point will be saved upon the confirmation to save the settings. This update is necessary for the relay to know if I/O configuration is permitted and to give access to these settings.

Prog Logic: The user may select either the default programmable logic or customized programmable logic settings. Choosing customized programmable logic allows the user to freely program all of the logic gates. See “Programmable Logic” Table 5.7 settings and in the descriptions below for more information. The unit is shipped from the factory with “Prog Logic” set to default.

The programmable logic cannot be changed from the default settings unless this setting has been set to Custom Programmable Logic. A Default programmable logic setting will not give the user access to the Programmable Logic settings in the Set Mode. To view programmable logic configuration, the user will need to exit the Set Mode and enter the View Setting mode and scroll to the appropriate section. If the relay programmable logic has been customized; then selecting the “Default Programmable Logic” will change all the Custom Programmable Logic settings back to the factory default settings.

Changing this setting will immediately ask you to confirm and save the settings and will exit you out of the setting mode. Please note that all settings made prior to this point will be saved upon the confirmation to save the settings. This update is necessary for the relay to know if Programmable Logic configuration is permitted and to give access to these settings.

Remote Set: This setting Enables or Disables the remote capability of downloading setpoints via the rear communication port using Cutler-Hammer’s PowerNet software. When enabled, the user can program and download settings to the relay through either the front RS-232 port or the rear communications port. If disabled, the settings can only be programmed into the unit via the front panel pushbuttons or the front RS-232 port.

Prg w/Bkr: This setting tells the relay if it can be programmed when the breaker is open only or if it can be programmed if the breaker is either opened or closed. When set to "Either", the user is permitted to program the relay when its associated breaker is in the open or closed position. If set to "Open", then the user may only program the relay when the breaker is in the "open" position. This is for security to prevent the user from changing settings and perhaps tripping the breaker while it is closed and carrying load.

The FP-5000 uses the "breaker a" and "breaker b" contacts to determine if the breaker is opened or closed. The FP-5000 may be configured to use only one auxiliary contact to determine breaker position. If no auxiliary contacts are used then the FP-5000 will not be able to determine breaker position and will allow programming at any time regardless of this setting. See Section 8 for more information on breaker logic.

Remote Bkr: If enabled, the user can remotely open and close the breaker via communications through the FP-5000. The FP-5000 is shipped with the "Remote Bkr" set to "disabled." This setting has no affect on the open and close operations through the contact inputs or the relay front panel open/close buttons.

 # Set Grps: This setting refers to the number of different Protection Setting Groups (1 to 4) that may be programmed into the FP-5000. Only one setting group can be used at a time, but up to four may be programmed.

Changing this setting will immediately ask you to confirm and save the settings and will exit you out of the setting mode. Please note that all settings made prior to this point will be saved upon confirmation to save settings. This update is necessary for the relay to provide access to the additional protection setting groups.

To view the active setting group, the user must press the "**Status/Control**" pushbutton to enter the Status/Control mode and select the "Status" sub-menu. The **"Status"** sub-menu is shown below. To change the active setting group, the user must press the "status/control" pushbutton to enter the "status/control" mode and select the "control" sub-menu.The user must select the "Sel Active Set Grp" sub-menu, then select the setting group desired to change the active setting group. To set the FP-5000 to its factory default settings see Section 5.3 for details.

Status
Status Test Status Active Set group: 1 Input Status

Set Ctrl: This setting allows the user to select the means of control for selecting the active setting group. The default setting is Local, which means the only way to change the active setting group is via the front panel in the **"Status/Control Mode."**

If it is set to **communications**, the active setting group can only be chosen via the C-H PowerPort or PowerNet software. Local + Comm setting means the user can change the active setting group either by the front panel or via software. If set to Cin, then the only way to change the active setting group is through a contact input, which the user would also have to program in the Contact input CFG settings.

To change the active setting group, the user must press the **"Status/Control"** pushbutton to enter the Status/Control mode and select the "Control" sub-menu. The user must select the "Sel Active Set Grp" sub-menu, then select the setting group desired to change the active setting group.

Control
Sel Active Set Grp Default Settings Trigger datalogger

Disarm Ctrl: If this setting is Enabled, the user has the ability to "arm" or "disarm" the output trip contacts by going into the Test Mode "Arm/Disarm Trip" sub-menu and selecting either Arm Trip or Disarm Trip.

This is a two-step process: 1.) The Disarm Ctrl setting must be enabled and 2.) The user must go into the Test Mode and select the "Arm/Disarm" sub-menu, then select Arm Trip or Disarm Trip.

If the Disarm Ctrl setting is set to Disabled, the user cannot select the Arm Trip or Disarm Trip in the "Arm/Disarm Trip" sub-menu. The message "Functions programmed to disable See System Config." will appear in the display window.

Energy Unit: This setting determines how the energy units are displayed. The selection is either kWh (kilowatt-hours) or MWh (megawatt-hours).

TOC Reset T: This is the Inverse Time Overcurrent Reset Time delay setting, which is used when "T Delay" is chosen for the reset of a 51 time overcurrent device in protection settings as described in Section 5.3.2. This time will apply to all of the 51P, 51X and 51R elements that have the selected "T Delay" for reset characteristics. Please refer to Section 5.3.2 for a complete description of the reset characteristics for the 51 TOC elements.

Bkr Oper PB: This setting allows the user to enable or disable the Breaker Open and Close pushbuttons on the front panel. The FP-5000 is shipped from the factory with the Bkr Oper PB set to "disabled."

5.5.2. Protection Settings

The Protection Settings include all of the FP-5000 protective device settings: 27, 46, 47, 50, 50BF, 51, 55A, 55D, 59, 81, zone interlocking, and protection alarm settings. The setting descriptions below will follow the order of the setting table. The FP-5000 may store four complete sets of Protection settings. Table 5.1 lists only settings for 1 setting group. Multiple copies of the Protection section from the table may be needed for a complete record.

To navigate to the individual protection settings you must select “Protection” from the Setting Main menu. If multiple setting groups have been selected then you must select which protection setting group you wish to set. You must now select the protection elements that you want to set and enter down to the set point page. To change an individual set point you must select the setting, press the enter button and change the set point to the desired setting. You must acknowledge the change by pressing the enter button again to return to the previous level. If you press the “Previous” button then the new setting will not be changed.

5.5.2.1 Phase Overcurrent Settings

51P PH TOC Curve:

This is the 51 device Phase Inverse Time Overcurrent Curve Setting. The user selects the characteristic *shape* and the *reset* characteristic of the TOC curve. The FP-5000 will have directional capability in the future. The direction setting is fixed at *Both*.

There are three families of TOC curves to choose from:

Thermal: Flat, It, I^2t, and I^4t

ANSI: Extremely Inverse, Very Inverse, and Moderately Inverse

IEC: IEC-A, IEC-B, and IEC-C

The TOC *reset* is a time overcurrent memory feature and has three setting choices:

Inst: Instantaneous reset: when the current drops below the pickup setting, the TOC time resets to zero within 2 cycles.

T Delay: Fixed time delay reset setting for the TOC curve. The time delay is set to the **TOC Reset T** setting of the System Configuration Settings. It will hold the time (“percent travel”), at the last value before the current drops below pickup, for the set time (TOC Reset T). If the current value goes above pickup before the reset time has expired then the relay will begin to accumulate time from its last value (percent travel).

“Percent Travel” refers to the percent of the time delay that the timer has accumulated. The time overcurrent time is dynamic. If the current changes it will change its trip times to the new value. Total trip time will be the time at which the accumulator reaches 100%. For example, if the current is at level 1 for 40% of the total trip time based on level 1 current then the accumulator will be at 40%. If the current now changes to level 2 with a new trip time, then the remaining trip time will be 60% of the new trip time. So the total trip time will be 40% of trip time t_1 plus 60% of trip time t_2. If the current was to drop below pickup for a time less than the TOC Reset T in between level 1 and level 2 currents, then the total trip time will include the time below pickup to the total trip time calculated. This feature could be beneficial to tripping for an arcing fault condition.

Calc: Calculated reset, which is defined by ANSI C37.112. This setting represents the electromechanical induction disk model and best integrates in a system utilizing E/M relays.

$T_{reset} = (t_r \times D) / [(I/I_{pu})^2 - 1]$ where t_r is a curve constant and D is the time multiplier. See Section 8 for more information.

Figure 5.1 provides a graphical representation of the three reset characteristics. The rms current value is the bottom square wave and assumes that the current level is either above or below the pickup setting for a period of time. The three curves above the current are the time values for the accumulator based on the three reset characteristic settings. The Instantaneous reset appears as a saw tooth and will not reach a trip time for this example. The T Delay setting holds the time fixed at last value for the specified reset time delay. This model will eventually accumulate enough time and trip provided the current is not below the pickup setting for a time greater than the reset time. The calculated reset option emulates the electromechanical disc action and will slowly reset over time to complete reset. This model will also trip in time.

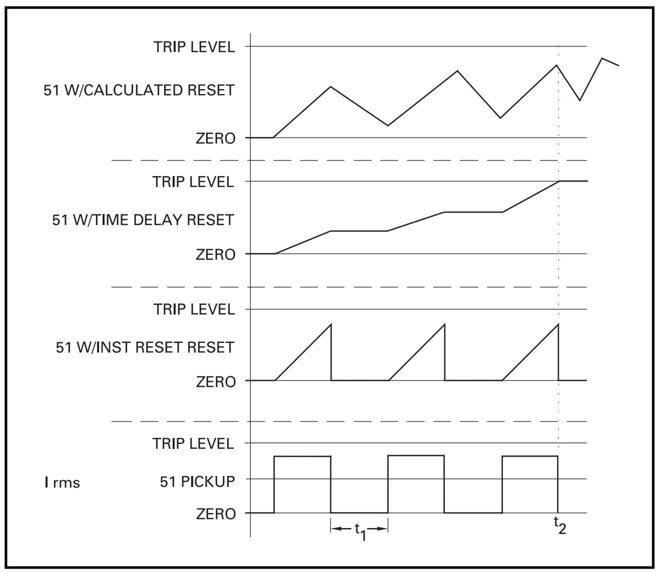


Figure 5-1. Graphical Representation of the TOC Reset T Setting

Time t_1, as shown, is less than the TOC Reset T time delay setting. If t_1 was greater than the TOC Reset T time delay setting, then the 51/w Time Delay Reset curve above would reset to zero.

51P PH TOC Setting

This includes the 51 device Phase Inverse Time Overcurrent pickup and time multiplier settings. A proper coordination study should be completed to determine the overcurrent pickup and time delay settings prior to commissioning the FP-5000 relay. The pickup setting (range: 0.1 to 4.0 per unit in 0.01 steps) is the overcurrent value in per unit at which the FP-5000 starts to time out to trip. To reference this setting to the Primary System Current simply multiply this setting by the Ct primary connected rating. For example, if the Ct is an 800/5 multi ratio Ct connected at 600/5, then a setting of 0.7 will represent a primary current pickup of 420A (0.7 times 600). In terms of the relay current used for bench testing, use the nominal current rating of the FP-5000 model, which is either 5A or 1A. So for a 5A version a setting of 0.7 will require 3.5A (0.7 times 5) relay current to operate.

To determine the pickup setting from the coordination study, simply divide the primary current value that you want the relay to trip at by the primary Ct rating. For example, if you want the relay to operate at 570A; set it to 0.95 per unit (570A divided by 600A).

The time multiplier setting (range: 0.05 to 10.0) sets the time portion of the TOC curve. Refer to Section 13 to view the Inverse Time Overcurrent Curves. The ANSI and IEC curves and multipliers are per their respective standards and definitions. The current scale along the x-axis is in terms of multiples of pickup (I/I_{pu}).

For the thermal curves, the current scale along the x-axis is in terms of I_{nom} (or Ct). The time multiplier is defined as the relay trip time at a current value equal to 3 times (I_{nom}) for phase and 1 times (I_{nom}) for ground. The relay trip times are dependent on the curve type selected. See Section 8 for curve equations and application of the protective curves and time multipliers.

50P-1 PH IOC 1 and 50P-2 PH IOC 2

These are the two 50 device phase instantaneous overcurrent settings, which are two independent elements. Both units have time delay settings available. One element could be used for a “Short Time” element (with a short time delay) and the other as “Instantaneous” element (with zero time delay) to improve flexibility and coordination of the OC curves. The pickup setting (range of 0.1 to 20.0 per unit in 0.01 steps). The time delay may be set from zero to 9999 cycles in 1 cycle steps. The cycle time is based on power system frequency. The direction setting (fixed at Both) is reserved for a future version release and operates the same as described above in the 51P PH TOC Settings.

5.5.2.2 IX Measured OC Settings

51X IX TOC Curve

This includes is the 51 device Inverse Time Overcurrent Curve Setting based on the measured fourth Ct input which is usually used for neutral or ground overcurrent protection. It is independent from the phase elements and may have its measurement from a ground Ct, neutral Ct or residual connection of the phase Cts for ground current measurement. The user selects the shape and the reset of the TOC curve. The direction setting is reserved for a future version and is fixed at Both. The available settings and setting ranges are the same as the 51P PH TOC settings described above.

51X IX TOC Setting

This is the 51 device Time Overcurrent pickup and time multiplier settings based on the measured fourth Ct input. The user selects the pickup and the time multiplier of the TOC curve. The available settings and setting ranges are the same as the 51P PH TOC Settings shown above. The pickup settings are in per unit and are based on the connected Ct ratio. If a ground Ct is used then the ratio may be different than the phase Ct ratio. If a residual ground current connection is used then the Ct ratio is the same as the phase Ct ratio.

50X-1 IX IOC 1 and 50X-2 IX IOC 2

These are the two 50 device IX instantaneous overcurrent settings, which are two independent elements. The settings operate the same as the 50P-1 PH OC 1 and 50P-2 PH OC 2 Settings.

5.5.2.3 IR Residual OC Settings

51R IR TOC Curve

This is the 51 device Residual Inverse Time Overcurrent Curve Setting, which is a residual ground overcurrent protection function. This is a calculated ground current from the sum of the measured phase currents. For a 3-phase, 3-wire system, this current is: IR = IA + IB + IC. This calculated value is affected by the Ct Connect Setting in the System Config. settings. In most applications this function is redundant to the 51X functions described above but does not require a ground current connection. The user selects the shape and the reset of the TOC curve. The direction setting is reserved for a future version and is fixed at Both. The available settings and setting ranges are the same as the 51P PH TOC settings.

51R IR TOC Setting

This is the 51 device setting Residual Inverse Time Overcurrent pickup and time multiplier settings. The user selects the pickup and the time multiplier of the TOC curve. The available settings and setting ranges are the same as the 51P PH TOC settings. The pickup settings are in per unit and are based on the connected phase Ct ratio.

50R-1 IR IOC 1 and 50R-2 IR IOC 2

These are the two 50 device residual IR instantaneous overcurrent settings, which are two independent elements. The settings operate the same as described in the 51P PH TOC settings. The pickup settings are in per unit and are based on the connected phase Ct ratio.

5.5.2.4 Unbalance Settings

47-1 Voltage Unbal

This is the 47 device Voltage Unbalance setting, which consists of the Threshold, %(V2/V1), and Delay settings. The voltage unbalance function is based on the Main VT system 3-phase voltages. The positive and negative sequence voltages are calculated from the 3-phase voltages.

The Threshold setting defines a minimum operating voltage magnitude of either V1 or V2 for the 47 function to operate, which ensures that the relay has a solid basis for initiating a voltage unbalance trip. This is a supervisory function and not a trip level.

The %(V2/V1) setting is the unbalance trip pickup setting. It is defined by the ratio of negative sequence voltage to positive sequence voltage (% Unbalance=V2/V1), or %(V2/V1) for ABC rotation and %(V1/V2) for ACB rotation. The FP-5000 will automatically select the correct ratio based on the Phase Sequence setting in the System Configuration group described above.

The time delay is a definite time delay adjustable from 0 to 9999 cycles in 1 cycle steps.

This function requires positive or negative sequence voltage magnitude above the threshold setting and the percentage voltage unbalance above the %(V2/V1) setting before allowing a voltage unbalance trip. Therefore, both the threshold and percent settings must be met for the specified Delay time setting before the relay initiates a trip for voltage unbalance.

The voltage unbalance pickup and trip functions are reset when the positive and negative sequence voltages V1 and V2 drop below the Threshold setting or (V2/V1) drops below the %(V2/V1) setting minus 1%.

46-1 Current Unbal

This is the 46 device Current Unbalance setting, which works similar to the 47 device Voltage Unbalance setting. The positive and negative sequence currents are calculated from the 3-phase currents.

The Threshold setting defines a minimum operating current magnitude of either I1 or I2 for the 46 function to operate, which insures that the relay has a solid basis for initiating a current unbalance trip. This is a supervisory function and not a trip level.

The %(I2/I1) setting is the unbalance trip pickup setting. It is defined by the ratio of negative sequence current to positive sequence current (% Unbalance=I2/I1), or %(I2/I1) for ABC rotation and %(I1/I2) for ACB rotation. The FP-5000 will automatically select the correct ratio based on the Phase Sequence setting in the System Configuration group described above.

The time delay is a definite time delay adjustable from 0 to 9999 cycles in 1 cycle steps.

This function requires positive or negative sequence current magnitude above the threshold setting and the percentage current unbalance above the %(I2/I1) setting before allowing a current unbalance trip. Therefore, both the threshold and percent settings must be met for the specified Delay time setting before the relay initiates a trip for current unbalance.

The current unbalance pickup and trip functions are reset when the positive and negative sequence current I1 and I2 drop below the Threshold setting or (I2/I1) drops below the %(I2/I1) setting minus 1%.

5.5.2.5 Voltage Protection Settings

27M-1 Undervoltage

This is the 27 device Undervoltage setting for the Main 3-phase VT. This function consists of a Threshold V and Delay setting. The Threshold V setting is the magnitude (10 to 150V in 1 volt steps) at which the undervoltage function operates. The Delay setting (0 to 9999 cycles in 1 cycle steps) is the time period an undervoltage must occur before the FP-5000 initiates a trip. This function will operate if any of the 3-phase voltages drop below the set point. This setting is based on line-to-line voltages for Delta configurations and line-to-neutral voltages for a Wye configuration.

The undervoltage pickup and trip functions are reset when the voltage raises above 102% of the undervoltage set threshold.

59M-1 Overvoltage

This is the 59 device Overvoltage setting for the Main VT. This function consists of a Threshold V and Delay setting. The Threshold V setting is the magnitude (10 to 150V in 1 volt steps) at which the overvoltage function operates. The Delay setting (0 to 9999 cycles in 1 cycle steps) is the time period an overvoltage must occur before the FP-5000 initiates a trip. This function will operate if any of the 3-phase voltages rise above the set point. This setting is based on line-to-line voltages for Delta configurations and line-to-neutral voltages for Wye connections.

The overvoltage pickup and trip functions are reset when the voltage drops below 98% of the overvoltage set threshold.

27A-1 Undervoltage

This is the 27 device Undervoltage setting for the Auxiliary VT. This device setting works exactly the same as the 27-M1 device above except it is a single-phase element only operating from the Auxiliary VT input.

Note: The expanded threshold V setting range (10–250V) is available for the Auxiliary Undervoltage setting.

59A-1 Overvoltage

This is the 59 device Overvoltage setting for the Auxiliary VT. This device setting works exactly the same as the 59M-1 device above, except it is a single-phase element only operating from from the Auxiliary VT input.

Note: The expanded threshold V setting range (10–250V) is available for the Auxiliary Overvoltage setting.

5.5.2.6 Frequency Protection Settings

81U-1 Underfreq

This is the 81U device Underfrequency setting. This function consists of a Threshold and Delay setting. The Threshold setting is the frequency (45-65 Hz in 0.01 Hz steps) below which the underfrequency function operates. The Delay setting (0 to 9999 cycles in 1-cycle steps) is the time period an underfrequency must occur before the FP-5000 initiates a trip.

The underfrequency pickup and trip functions are reset when the frequency raises above the underfrequency set threshold.

Note: Phase A voltage must be greater than 10V for this function to operate.

81O-1 Overfreq:

This is the 81O device Overfrequency setting. This function consists of a Threshold and Delay setting. The Threshold setting is the frequency (45-65 Hz in 0.01 Hz steps) above which the overfrequency function operates. The Delay setting (0 to 9999 cycles) is the time period an overfrequency must occur before the FP-5000 initiates a trip.

The overfrequency pickup and trip functions are reset when the frequency drops below the overfrequency set threshold.

Note: Phase A voltage must be greater than 10V for this function to operate.

5.5.2.7 Breaker Failure

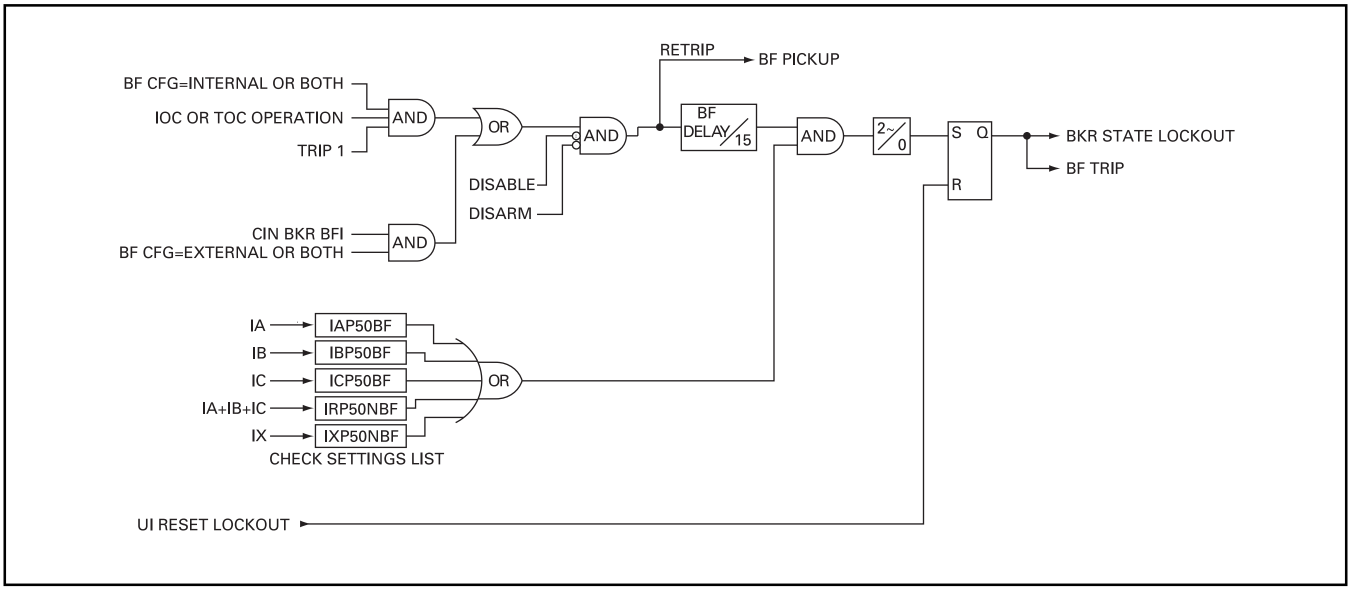


Figure 5-2. Breaker Failure Logic Diagram

50BF Bkr Config

This is the 50BF device Breaker Failure Configuration setting. The 50BF Bkr Config sets the conditions for the FP-5000 to detect a breaker failure condition. This function is only activated after initiation. The four 50BF Bkr Config setting descriptions are shown below:

50BF Bkr Config set to Off:	The 50BF device is turned off, so no breaker failure can be detected internally or externally.
50BF Bkr Config set to Internal:	The 50BF function will be initiated by an internal trip signal.
50BF Bkr Config set to External:	The 50BF function will be initiated by an external signal.
50BF Bkr Config set to Both:	The 50BF function will be initiated by either an internal or external trip signal.
50BF Bkr Failure:	This includes the 50BF device Breaker Failure setting, which is only applied if the 50BF Bkr Config setting is not set to “off.” The default configuration for the output logic maps the Breaker Failure trip (i.e. Breaker State Lockout) to output Relay 3 so that a separate lockout relay (device 86) can be used to provide backup tripping. The breaker failure function continues to monitor all phase currents after a trip is initiated by ether the FP-5000 or an external device. The breaker failure trip output operates if the phase or ground currents do not drop below the programmed I Ph (pu) or I Gnd (pu) setting levels within the breaker failure Delay time setting.

The I Ph (pu) is an independent overcurrent element monitoring the phase currents. It is recommended to set the level above maximum load currents even though the Breaker failure logic is only initiated upon a breaker trip signal.

The I Gnd (pu) is an independent ground overcurrent element that uses both the measured residual ground current (Ir) and the measured ground current (Ix). It is recommended to be set above any normal or expected rms ground currents.

5.5.2.8 Power Factor

55A Apparent PF and 55D Displacement PF

These are the two Power Factor protection settings: 55A device is the Apparent Power Factor setting and 55D device is the Displacement Power Factor setting. There are three settings, which are the same for the apparent and displacement power factor function:

Trigger PF: This setting is the apparent power factor that the FP-5000 will trip on.

Reset PF: This setting is the apparent power factor at which the FP-5000 will reset the apparent power factor function. It is like setting a hysterisis for the Trigger setting.

Delay: This setting defines the delay (in seconds) that the Trigger PF must be active before the FP-5000 will initiate a trip signal.

The Apparent Power Factor is computed by dividing real power (watts) by volt-amperes. The apparent power factor computation includes harmonics.

$$PF_{apparent} = \frac{\text{watt}}{\text{VA}}$$

The Displacement Power Factor is computed by dividing the fundamental watts by the fundamental volt-amperes as shown below. This definition is only valid at the system fundamental operating frequency. The Displacement Power Factor isolates the fundamental portion of the Power Factor from the effects of harmonics.

$$PF_{displacement} = \frac{\text{watt}}{\sqrt{(\text{watt}^2 + \text{var}^2)}}$$

New values of apparent and displacement power factor are computed every 32 cycles. The power factor function operates when the power factor is more lagging than the Trigger PF setting for the Power Factor Delay setting time. The function resets when the power factor is more leading than the Reset PF setting for the Power Factor Delay setting time.

5.5.2.9 Zone Interlocking

Zone Interlocking

The zone interlocking setting consists of settings to configure a Zone In and a Zone Out setting. Both Zone In and Zone Out settings can be set to Disable, Phase, Ground, or Both.

Disable – disables the zone function

Phase – defining the zone function to be a phase signal

Ground – defining the zone function to be a phase signal

Both – defining the zone function to be a phase or ground signal

See Section 8.5 for more information on zone interlocking.

5.5.2.10 Alarms

Protection Alarm Settings

A full set of protection alarm settings complement the protection elements for overcurrent, over/under voltage, unbalance and over/under frequency. They are designated as another protection element, for example 50P-3, and are programmed to the alarm output relay and alarm LED indication. The settings are similar to the protection settings described above. These elements may be used for alarm, tripping or logic functions. Custom programming of the output relay is required if the desired use is not as an alarm function.

5.5.3 System Alarm Settings

This setting menu contains the settings needed to configure all of the FP-5000 system alarm functions. Each alarm function can be disabled. The system alarms are programmed to the alarm output relay and alarm LED indication. These elements may be used for alarm, tripping or logic functions. The outputs will need to be configured if the desired use is not an alarm function. SYSALM pickup in the Event Log Enable settings must be set to "Yes" to enable logging of Pickup/ Dropout events related to system alarms.

Watt Power Alarm

Units: Sets the units for watts measurement (kW or MW).

Threshold: Sets the watts threshold level in units specified, at or above which the power pickup event occurs. After pickup, if the watts fall below the specified threshold, a power dropout event occurs.

Delay (m): Sets the number of minutes that the watts must remain at or above threshold, before the specified trip output occurs.

VAR Power Alarm

Units: Sets the units for VARS measurement (kVAR or MVAR).

Threshold: Sets the VARS threshold level in units specified, at or above which the power pickup event occurs. After pickup, if the VARS fall below the specified threshold, a power dropout event occurs.

Delay (m): Sets the number of minutes that the VARS must remain at or above threshold, before the specified trip output occurs.

VA Power Alarm

Units: Sets the units for VA measurement. (kVA or MVA).

Threshold: Sets the VA threshold level in units specified, at or above which the power pickup event occurs. After pickup, if the VA falls below the specified threshold, a power dropout event occurs.

Delay (m): Sets the number of minutes that the VA must remain at or above threshold, before the specified trip output occurs.

Watt Demand Alarm

Units: Sets the units for watts demand measurement. (kW or MW).

Threshold: Sets the watts demand threshold level in units specified, at or above which the power demand pickup occurs. After pickup, if the watt demand falls below the specified threshold, a power demand dropout event occurs. The demand interval is set in the Demand Setting section described later in this section.

Delay (m): Sets the number of minutes that the watt demand must remain at or above threshold, before the specified trip output occurs.

VAR Demand Alarm

Units: Sets the units for VARS demand measurement (kVAR or MVAR).

Threshold: Sets the VARS demand threshold level in units specified, at or above which the power demand pickup event occurs. After pickup, if the VARS demand falls below the specified threshold, a power demand dropout event occurs. The demand interval is set in the Demand Setting section described later in this section.

Delay (m): Sets the number of minutes that the var demand must remain at or above threshold, before the specified trip output occurs.

VA Demand Alarm

Units: Sets the units for VA demand measurement. (kVA or MVA).

Threshold: Sets the VA demand threshold level in units specified, at or above which the power demand pickup event occurs. After pickup, if the VA demand falls below the specified threshold, a power demand dropout event occurs. The demand interval is set in the Demand Setting section described later in this section.

Delay (m): Sets the number of minutes that the VA demand must remain at or above threshold, before the specified trip output occurs.

Current Demand Alarm

Pickup: Sets the current demand pickup level, at or above which the current pickup event occurs. After pickup, if the current demand falls below the specified pickup, a current demand dropout event occurs. The demand interval is set in the Demand Setting section described later in this section.

Delay (m): Sets the number of minutes that the current demand must remain at or above threshold, before the specified trip output occurs.

NOTE: Check the Demand Logging interval. The delay for alarm starts after the demand is logged, and the demand remains at or above threshold for the time specified in the setting delay for alarm. For example if the demand interval is set to 15 minutes and the delay for the demand alarm is set to 15 minutes, the system alarm pickup event occurs after 30 minutes.

I THD Alarm

Threshold: Sets the current THD magnitude threshold level, at or above which the current THD pickup event occurs. After pickup, if the current THD magnitude falls below the specified threshold, a current THD dropout event occurs.

Delay(s): Sets the number of seconds that the current THD magnitude must remain at or above threshold, before the specified trip output occurs.

V THD Alarm

Threshold: Sets the voltage THD magnitude threshold level, at or above which the voltage THD pickup event occurs. After pickup, if the voltage THD magnitude falls below the specified threshold, a voltage THD dropout event occurs.

Delay(s): Sets the number of seconds that the voltage THD magnitude must remain at or above threshold, before the specified trip output occurs.

Breaker Alarm

# of Operations: The FP-5000 counts the number of breaker operations. A breaker operation is counted when the breaker is opened after being closed for 3 cycles based on the state of the 52a and/or 52b contact inputs. This setting is used to provide a breaker alarm indication if the breaker is operated more than the specified settings. This counter is intended to be used for scheduling breaker maintenance after a number of operations.

Isum INTR Amp: In addition to counting the breaker operations, the FP-5000 records the interrupted current per phase and accumulates the total current interrupted on a per phase basis. If any of the accumulated interrupted phase currents exceeds this setpoint then an alarm and indication will occur. This accumulator is intended to be used for scheduling breaker maintenance after the accumulated interrupted current exceeds the setpoint.

5.5.4 Logging Settings

The following are setpoints needed to configure the Logging functions.

Current Demand

Interval (m): Sets the interval in number of minutes from 1 to 60 minutes in 1 minute intervals. After each specified interval, the average current for that period is calculated and updated.

Power Demand

Window: Sets the window to “Fixed” or “Slide.” If “Fixed” window is selected, after each specified interval, the average power for that period is calculated and updated. If “Slide” window is selected the average power is calculated and updated every minute for the interval specified. For example, if a 15-minute demand window is selected, the calculated demand is the average power during the last past 15 minutes, updated every minute.

Interval (m): Sets the interval in number of minutes from 1 to 60 minutes in 1 minute intervals. After each specified interval the average value of real, reactive and apparent power is calculated and updated.

Event Log Enable

These settings are used to define what pickup functions get recorded in the Event Log and can be used to prevent frequent and normal events from filling up the event log memory. The default setting for all settings under Event Log Enable is “No”, except for I Pickup.

I Pickup: Selecting “Yes” will enable specified current related pickup and dropout events to be logged.

V Pickup: Selecting “Yes” will enable specified voltage related pickup and dropout events to be logged.

Freq Pickup: Selecting “Yes” will enable specified frequency related pickup and dropout events to be logged.

PF Pickup: Selecting “Yes” will enable specified power factor related pickup and dropout events to be logged.

Unbal Pickup: Selecting “Yes” will enable specified current and voltage unbalance related pickup and dropout events to be logged.

SYSALM Pickup: Selecting “Yes” will enable specified system alarm related pickup and dropout events to be logged.

Cin 1-8: Each contact input can be individually set to either “Yes” or “No.” The contact inputs can be programmed to any input from the Contact Input CFG in the setting menu. See setting description of Contact Input CFG for details. Selecting “Yes” will enable specified Cin related pickup, output and dropout events to be logged.

Datalogger

Datalogger recorded information is only available through the communication interfaces but the settings can be done from the front panel.

Mode: Sets the mode for datalogging. If “1-Pass” is selected, the datalogger will stop collecting data after 1024 records are logged. The datalogger must be reset to restart data collection. If “Cont” is selected, the datalogger will continuously collect data and overwrite the oldest data.

Trigger: The trigger can be set to “Auto” or “Manual.” The manual Trigger is used to begin logging in the single-pass mode from a pushbutton, contact input, or communication command.

Note: 1-pass must be chosen to use data log in a manual mode.

Interval(s): Sets the interval in seconds (1 to 3600 s in 1 s steps) for logging the specified data in the datalogger.

Value 1-8: Each Value (from 1 through 8) can be set to log monitored data from any of the following parameters: IA, IB, IC, IX, IR, Iavg, I0, I1, I2, VA, VB, VC, VX, VLNavg, VAB, VBC, VCA, VLLavg, V0, V1, V2, Freq, W, VAR, VA, Dsp PF, App PF, IA Demand, IB Demand, IC Demand, W Demand, var Demand, VA Demand, Cin1, Cin2, Cin3, Cin4, Cin5, Cin6, Cin7, Cin8, LG1, LG2, LG3, LG4, LG5, LG6, TG1, TG2, TG3, TG4, TG5, TG6, IA THD, IB THD, IC THD, VA THD, VB THD, VC THD, VAB THD, VBC THD, VCA THD.

Waveform Capture: Oscillographic waveform information is available only through the communication interfaces but setup and configuration may be done from the front panel. The FP-5000 can record 256 cycles of all 4 voltage and current waveforms at 32 samples per cycle.

Records: Sets the number of records and record size to store waveform capture data. Selection is either 16 records of 16 cycles each, 8 records of 32 cycles each or 4 records of 64 cycles each.

PreTrigger: Sets the number of cycles to record before trigger.

OSC Trigger: All parameters under OSC Trigger can be disabled.

Trip2: Sets the buffer to be overwritten or locked when Trip 2 output is activated. Locked will prevent the record triggered by this type of event from being overwritten.

dV/dI: Sets the buffer to be overwritten or locked. The dV/dI looks for approximately 17% change in either the voltage or current signals and can be used to record waveforms for any disturbance greater than 17%.

Logic LG6: Sets the buffer to be overwritten or locked when logic gate 6 is activated.

Cntrl PB: Sets the buffer to be overwritten or locked when the waveform capture is initiated manually from the front face plate of the FP-5000 relay. To initiate waveform capture from the relay, enter the Status/Control mode and select Control function. Select waveform capture and press the enter button.

Comm: Sets the buffer to be overwritten or locked when waveform capture is initiated through communications command.

Example of Waveform Capture with trigger options

Example 1: Set Trip2 in Out Relay Config. to any protection function. Set Trip2 under OSC Trigger in Waveform Capture to Overwrite. Any Trip2 event will trigger an oscillographic data capture and write the buffer with new data. This buffer can however be overwritten.

Example 2: Set Cntrl PB under OSC Trigger in Waveform Capture to Locked. Trigger oscillographic data capture by entering Trig Waveform Capture under Control in Status/Control from the front panel. The data will be captured in a buffer and then the buffer will be locked. This buffer cannot be overwritten.

5.5.5 Contact Input Configuration Settings (Contact input CFG)

These settings are directly linked to the I/O Configuration setting. The I/O Config setting in the System Config settings menu must be set to “custom” for the Contact input CFG settings to be configured by the user, otherwise the Contact input CFG settings are set to the default settings as shown in Section 5.6.

There are eight contact inputs (Cin1 to Cin8) that can be configured as inputs to pre-defined FP-5000 functions or for user-defined custom logic. The contact inputs are either on (external contact closed) or off (external contact open).

User Defined: This setting is user defined.

52a: Breaker contact 52a (Open/Trip) circuit breaker feedback.

52b: Breaker contact 52b (Close) circuit breaker feedback.

BFI: External Breaker Failure Initiation.

Bkr Trouble: Breaker Trouble

Remote Open: Remote Breaker Open

Remote Closed: Remote Breaker Closed

Remote Reset: Allows remote reset of the Trip and Alarm Relays and Indicators.

Datalog Trigger: Allows the datalogger to be triggered from external contact.

Demand Sync: Synchronize the Power and Current demand window.

5.5.6 Output Configuration Settings

These settings are directly linked to the I/O Configuration setting. The I/O Config setting in the System Config settings menu must be set to “custom” for the Output Config settings to be configured by the user, otherwise the Output Config settings are set to the default settings as shown in Section 5.6.

The output configuration settings consist of settings for five Form A output relays (Output Trip1, Output Trip2, Output Rly3, Output Rly4, Output Rly5), one Form C Output Alarm relay, the Auxiliary LED, and three indicators (Trip, Alarm, and Pickup). Output relays Trip1, Trip2, Rly3, Rly4, and Rly5 are rated for tripping per ANSI C37.90. The seven output logic gates control the seven outputs, listed above. Refer to Section 9.2 for more information about the output logic gates.

There is also another Form C Rly Healthy output relay, which is non-configurable. When the FP-5000 is energized, the Rly Healthy energizes after its self-test. This is to provide a fail-safe output contact meaning that the FP-5000 relay is functioning properly and is able to protect.

Each programmable output should be configured by the user for the desired application of the FP-5000. All of the settings to configure the outputs of the FP-5000 are shown below.

Output Trip1

This Form A relay output is intended to be the main trip relay to energize the “Breaker Trip” coil. The Trip1 relay is set per the settings described below.

Monitor: Set to On or Off. If set to “on”, the “Breaker Trip” coil circuit will be monitored by the FP-5000 for continuity through Output Trip1 relay. See Section 8.9 Breaker-Oriented Functions for more detailed information.

Function: Set to OR, AND, NOR, NAND, Disable. The Function setting defines the configuration of the output logic gate (with inputs IN1, IN2, IN3, and IN4) that energizes the Output Trip1 relay. The default setting is OR. See Section 9 for a description of the logic input settings.

Dropout: Set to Latched, Unlatched, or Off Delay. This setting refers to when Output Trip1 relay is de-energized after a trip event has occurred. The default setting is Off Delay.

Latched setting means that the Output Trip1 relay will stay latched until a “Reset” is initiated either manually, or remotely.

Unlatched setting means that the state of the Output Trip1 relay directly follows the state of the associated Output Logic gate. Example: If the FP-5000 trips on time overcurrent, then the Output Trip1 relay will stay energized until the sensed overcurrent drops below the hysteresis of the current pickup setting.

Off Delay means that the user can set a delay time during which the Output Trip1 relay would remain energized after a trip event has cleared. See Off Delay setting below.

Off Delay: Defines the time delay in cycles, which can be set from 0 to 60 cycles in 1 cycle increments. Default is set to 5 cycles.
Note: The user should consider the “breaker clearing time” when setting the Off Delay.

IN1, IN2, IN3, IN4: These settings define the logic inputs to the Output Logic gate associated with Output Trip1 relay. See Section 9.6 for a description of the logic input settings.

Output Trip2: The settings for this Form A relay output are set the same way as the Output Trip1 relay settings shown above. The only difference is the Monitor. If Monitor is set to “on”, the “Breaker Close” coil circuit will be monitored by the FP-5000 for continuity through Output Trip2 relay.

Output Rly3, Output Rly4, Output Rly5: The settings for these output relays are set the same way as the Output Trip1 relay settings shown above, except that these relays have no Monitor setting.

Output Alarm

The Output Alarm relay settings are set the same way as the Output Trip1 relay settings shown above, except that the alarm relay does not have a Monitor setting.

Output Aux LED

This setting determines what logic function controls the lighting of the yellow Auxiliary LED located on the front panel of the FP-5000. This setting contains the settings: Function, IN1, IN2, IN3, and IN4, which are set the same as the Output Trip1 settings shown above.

Trip Indicator

The trip indicator function reports the presence of a trip condition. This setting is programmed to operate based upon the operation of the output relays (Trip1, Trip2, Rly3, Rly4, Rly5, Alarm, and Healthy). This setting consists of the settings below.

Dropout: Set to Latched or Unlatched. This setting determines if the trip indicator stays active after a trip event clears.

Latched setting means that the Trip Indicator and the appropriate trip indicator LED lights on the front panel will stay latched until a “Reset” is initiated either manually or remotely.

Unlatched setting means that the state of the Trip Indicator directly follows the state of the associated output relay.

Trip1: Set to enable or disable.

Trip2: Set to enable or disable.

Rly3: Set to enable or disable.

Rly4: Set to enable or disable.

Rly5: Set to enable or disable.

Alarm: Set to enable or disable.

Healthy: Set to enable or disable. The indicator is active when the Healthy Alarm is de-energized to report a failure.

The default configuration sets the Dropout to “Latched” and enables the Trip Indication when Trip1 or Trip2 output relays are energized.

Alarm Indicator

The Alarm indicator function reports the presence of an alarm condition. This function is set the same way as the Trip Indicator. See Trip Indicator settings above. The default configuration sets the Dropout to Latched and enables the Alarm Indication when the Alarm Output relay is energized or the Relay Healthy output relay is de-energized.

Pickup Indicator

The Pickup Indication function reports a pickup of the programmed protective functions. The pickup indicator is active for the protective functions that are *enabled* in the settings.

Dropout: Set to Latched or Unlatched. This setting determines if the pickup indicator stays active after a pickup event. This Dropout setting works exactly the same as the Dropout setting in the Trip Indicator settings shown above.

IOC: Set to enable or disable.

TOC: Set to enable or disable.

Volt: Set to enable or disable.

OverFreq: Set to enable or disable.

UnderFreq: Set to enable or disable.

Unbalance: Set to enable or disable.

Prot Alarm: Set to enable or disable.

The default configuration sets the Dropout to Unlatched and enables all protective functions except the Prot Alarm setting.

See Section 9.2 for more information on configuring the outputs.

5.5.7 Programmable Logic Settings

The programmable logic settings consist of settings for six logic gates, six timer gates, two latches, twelve blocking gates, and seven output gates. The seven output gates (Output Trip1, Output Trip2, Rly3, Rly4, Rly5, Output Alarm, and Output Aux LED) are configured by the “Output Config” settings described previously, therefore they won”t be discussed in this section.

See Section 9, Programmable Logic Application, for detailed information about the logic functions. This section will only describe how to set the programmable logic settings. **Figure 5-3** Logic Setting Flowchart, on the following page, shows an example of how to program Logic Gate 1.

The **Figure 5-3** flowchart is an example of programming Logic Gate 1 to be a NAND gate of setting group 2 with IN1 “Trip G OC.”

1. Select programmable Logic from the “Setting Main” setting display menu and press “Enter PB.”
2. Select Logic Gate 1 press “Enter PB.”
3. Press “Enter PB” and choose Function to be NAND with up/down PBs, press “Enter PB.”
4. Select Set Group using up/down PBs, press “Enter PB”, choose Set Group to 2 using up/down PB”s, press “Enter PB.”
5. Select IN1 using up/down PBs, press “Enter PB.”
6. Select Trip using up/down PBs and press “Enter PB.”
7. Select G OC using up/down PBs and press “Enter PB.”
8. Select G OH to be Direct, then press “Enter PB”, which finishes Logic Gate 1 programming.

Press “Previous PB” to back out of Logic Gate 1 programming and return to “Programmable Logic” display to program other logic gates.

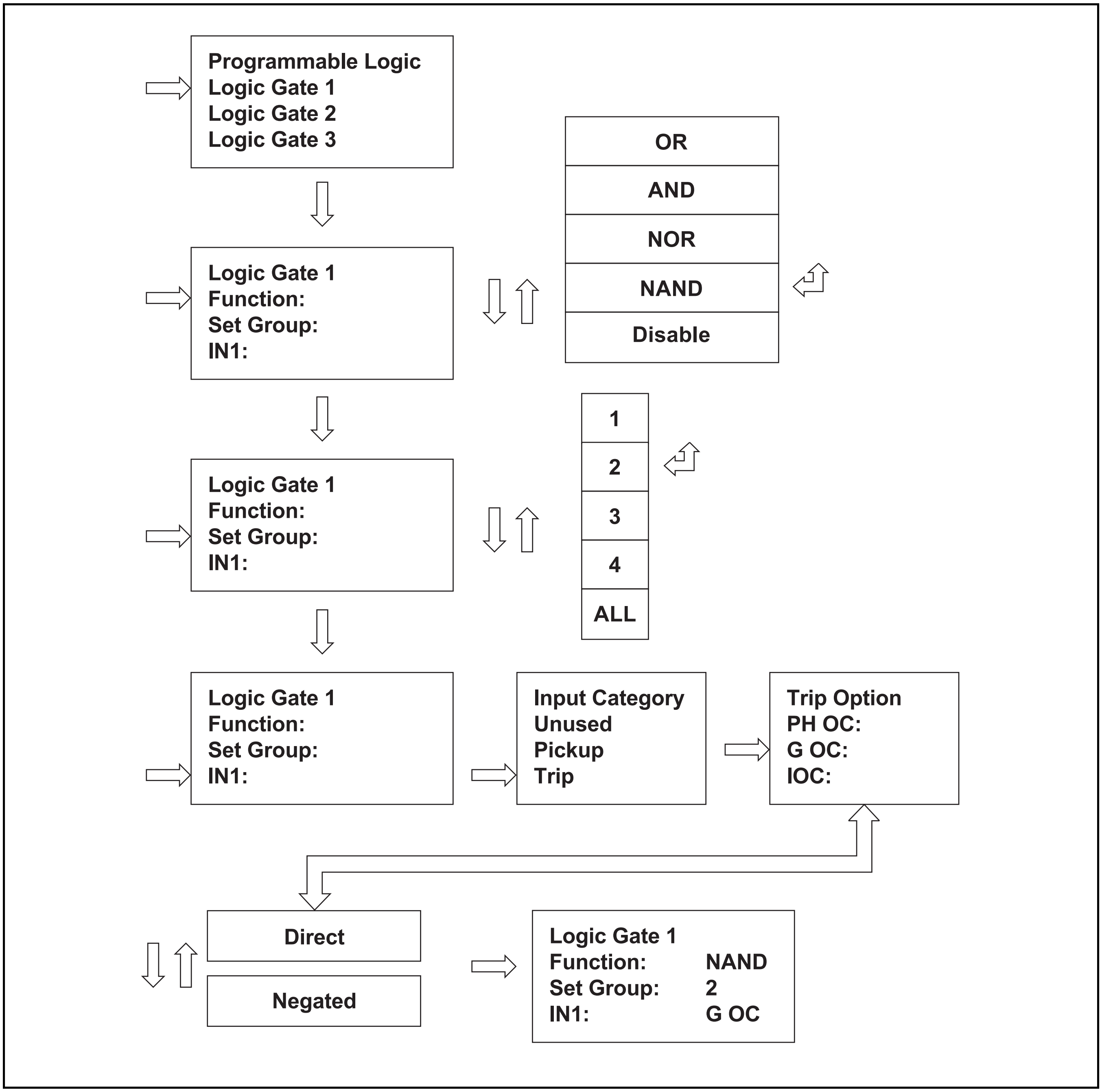


Figure 5-3. Logic Setting Flowchart

Logic Gates 1 through 6: All six logic gates contain the same settings as shown below.

Function: Set to OR, AND, NOR, NAND, Disable. The Function setting defines the output of the logic gates with inputs IN1, IN2, IN3, and IN4. The default setting is OR.

Setting Group: This setting defines the Setting Group for which the logic gate programming is active. This setting is also linked to the System Config settings, which is where the total number of settings groups (1 to 4) is programmed.

IN1, IN2, IN3, IN4: These settings define the logic inputs to Logic Gates 1 through 6. See the settings table and Section 9.6 for a complete description of the logic input settings.

Timer Gates 1 through 6: All six timer gates contain the same settings as shown below.

Setting Group: This setting defines the Setting Group for which the timer gate programming is active. This setting is also linked to the System Config settings, which is where the total number of settings groups (1 to 4) is programmed.

In: This setting defines the logic input to Timer Gates 1 through 6. See the settings table and Section 9 for a complete description of the logic input settings.

On Delay (c) : Sets the number of cycles the Timer Gate input must remain active before the Timer Gate output becomes active. See Section 9 for a detailed description of the logic settings.

Off Delay (c) : Sets the number of cycles the Timer Gate output will remain active after the Timer Gate input becomes inactive. The Off Delay has no affect unless the Timer Gate output is active when the input becomes inactive. See Section 9 for a detailed description of the logic settings.

Logic Latches 1 and 2: Both logic latches contain the same settings as shown below.

Setting Group: This setting defines the Setting Group for which the logic latch programming is active. This setting is also linked to the System Config settings, which is where the total number of settings groups (1 to 4) is programmed.

Set In: This setting defines the Set Input to the Logic Latch. The latch output goes active when the Set Input is active. The output remains latched in the active state until the Reset is activated. See the settings table and Section 9 for a complete description of the logic input settings.

Reset In: This setting defines the Reset Input to the Logic Latch. The latch output is reset when the Reset Input is active. If both the Set Input and Reset Input are active, the latch output is inactive. See the settings table and Section 9 for a complete description of the logic input settings.

Blocking Logic Gates for IOC and TOC: All 12 blocking logic gates contain the same settings as shown below. When the output of the blocking logic gate is active, operation of the associated IOC or TOC protection function is blocked. The IOC or TOC function will still pickup, but not trip.

Function: Set to OR, AND, NOR, NAND, Disable. The Function setting defines the output of the blocking logic gates with inputs IN1, IN2, IN3, and IN4. The default setting is Disable. See Section 9 for a detailed description of the logic settings.

Setting Group: This setting defines the Setting Group for which the logic gate programming is active. This setting is also linked to the System Config settings, which is where the total number of settings groups (1 to 4) is programmed.

IN1, IN2, IN3, IN4: These settings define the logic inputs to Logic Gates 1 through 6. See the settings table and Section 9 for a complete description of the logic input settings.

5.5.8 Clock Settings

Once the FP-5000 is properly installed, the real-time clock needs to be set, to get the right date and time for clock display, and all Metering and Logging date and time stamp values.

To set the clock, select the clock setting in the “Setting Main” display window. Configure the settings below to set the clock.

Date Mode: Sets the mode for the date used in all time stamp displays.

Time Mode: Sets the mode for the time used in all time stamp displays.

Year: Sets the current year for the real-time clock update.

Month: Sets the current month for the real-time clock update.

Day: Sets the current day for the real-time clock update.

Hour: Sets the current hour for the real-time clock update.

Minute: Sets the current minute for the real-time clock update.

Second: Sets the current second for the real-time clock update.

Update Clock: Pressing Enter updates the clock with the date and time specified above, with the message stating that the real-time clock was properly updated.

5.5.9 Communications Settings

To set the communications settings, select the Communications setting in the “Setting Main” display window. Configure the settings below to set the communications desired.

INCOM PN

Provides connection to the IMPACC network for communication over PowerNet. The standard IMPACC messages are supported.

Enable: Enables INCOM Communication.

Address: Sets the device address for INCOM communication.

Baud Rate: Sets the baud rate for INCOM communication. The baud rate is fixed at 9600 baud.

INCOM AB

Provides an additional INCOM channel for future expansion to interconnect function modules for analog and digital I/O accessories.

Address: Sets the device address for Communication through Accessory bus.

Baud Rate: Sets the baud rate for Accessory bus communication. The baud rate is fixed at 9600 baud.

RS-232

Provides connection to a personal computer for downloading code and/or downloading settings for FP-5000.

Baud Rate: Sets the baud rate for RS-232 communication.

5.5.10 Change Password

The factory default password is 0000. A password of 0000 will always be accepted during the first 2 minutes after the FP-5000 is powered up. This allows the user to enter a new password, in case the password is forgotten.

To change the password, select Change Password setting in the “Setting Main” display window. Use the single arrow up/down pushbuttons to move among the 4-character locations of the password and use the double arrow pushbuttons to change the value of the 4-character password. Zero through nine and A to Z are available for each password character.

If the user presses Enter for the password window without changing any password character the default password of 0 is accepted. The user can change the password to any non-zero values. However, if the user changes the password to any non-zero values, pressing Enter will not permit entry to the settings or the test functions. The correct password has to be entered.

The same password is valid for setting mode as well as the test mode.

The FP-5000 password is not valid for PowerNet. PowerNet has its own password scheme.

5.6 Default Settings

The Default Settings Table shows all of the System Configuration settings and the remaining settings that are enabled, or turned on, when the FP-5000 leaves the factory. If the user reverts back to the default settings at any time when the unit is installed in the field, the FP-5000 will revert back to the settings in this table.

Table 5.11 System Config

System Config	System Config Settings	Default Setting
	Frequency:	60
	Phase Seq:	ABC
	CT Connect:	3-wire
	PH CT Ratio:	500:5
	IX CT Ratio:	500:5
	VT Connect:	Wye
	Main VTR:	100
	Aux VTR:	100
	Prim Units:	No
	I/O Config:	Default
	Prog Logic:	Default
	Remote Set:	Enable
	Prg w/Bkr:	Either
	Remote Bkr:	Disable
	# Set Grps:	1
	Set Ctrl:	Local
	Disarm Ctrl:	Disable
	Energy Unit:	kWh
	TOC Reset T:	5
	Bkr Oper PB:	Disable

Table 5.12 Protection

Phase Overcurrent	PH Settings	Default Setting
51P PH TOC	Shape: Reset: Direction: Pickup: Time Mult:	MOD Calc Both 1.00 1.00
50P-1 PH OC 1	Pickup: Delay (c): Direction:	2.00 0 Both
50P-1 PH OC 2	Pickup: Delay (c): Direction:	3.00 15 Both
IX Overcurrent	**IX Settings**	**Default Setting**
51X PX TOC	Shape: Reset: Direction: Pickup: Time Mult:	XTRM Calc Both 0.50 1.00
50X-1 IX OC 1	Pickup: Delay (c): Direction:	1.00 60 Both
50X-1 IX OC 2	Pickup: Delay (c): Direction:	2.00 600 Both
IR Overcurrent	**IR Settings**	**Default Setting**
51R IR TOC	Shape: Reset: Direction: Pickup: Time Mult:	XTRM Inst Both 0.1 1.00
50R-1 IR OC 1	Pickup: Delay (c): Direction:	1.00 60 Both
50R-1 IR OC 2	Pickup: Delay (c): Direction:	2.00 600 Both
46-2 I Unbal Alarm	46-2 I Unbal Alarm Settings	Default Setting
	Threshold: % (I2/I1): Delay (c):	0.1 40 60
47-2 V Unbal Alarm	47-2 V Unbal Alarm Settings	Default Setting
	Threshold: % (V2/V1): Delay (c):	50 40 60

Table 5.13 System Alarms

Breaker Alarm	Breaker Alarm Settings	Default Setting
	# of Operation: Isum INTR Amp:	9999 50,000

Table 5.14 Logging Settings

Current Demand	Current Demand Settings	Default Setting
	Interval (m):	15
Power Demand	**Power Demand Settings**	**Default Setting**
	Window: Interval (m):	Fixed 15
Event Log Enable	**Event Log Enable Settings**	**Default Setting**
	I Pickup:	Yes
Data Logger	**Data Logger Settings**	**Default Setting**
	Mode: Trigger: Interval (s): Value 1: Value 2: Value 3: Value 4: Value 5: Value 6: Value 7: Value 8:	Cont. Auto 900 Ia Ib Ic Ix Va Vb Vc Vx
Waveform Capture	**Waveform Capture Settings**	**Default Setting**
	Records: PreTrigger: OSC Trigger TRIP2: OSC Trigger dV/dI: OSC Trigger Logic LG6: OSC Trigger Cntrl PB: OSC Trigger Comm:	16x16 2 Overwrite Disable Overwrite Overwrite Overwrite

Table 5.15 Contact Input CFG

Contact Input Config	Contact Input Config Settings	Default Setting
	Cin1: Cin2: Cin3: Cin4: Cin5: Cin6: Cin7: Cin8:	52a 52b BFI Bkr Trouble Remote Open Remote Close Remote Reset user defined

Table 5.16 Output Config

Output Trip1	**Output Trip1 Settings**	**Default Setting**
	Monitor: Function: Dropout: Off Delay (c): IN1: IN2:	On OR Off Delay 5 Trip AllProt Cntrl, OpenBkr
Output Rly3	**Output Rly3 Settings**	**Default Settings**
	Function: Dropout: IN2:	OR Latched Trip, BF
Output Rly5	**Output Rly5 Settings**	**Default Settings**
	Function: Dropout: Off Delay: IN1:	OR Off Delay 10 Breaker, Close Bkr
Output Alarm	**Output Alarm Settings**	**Default Settings**
	Function: Dropout: IN1: IN2: IN3: IN4:	OR Unlatched Trip, Allprot Trip, All Alarms SYSALM, All Breaker, All Alm
Trip Indicator	**Trip Indicator Settings**	**Default Setting**
	Dropout: Trip1: Trip2:	Latched Enable Enable
Alarm Indicator	**Alarm Indicator Settings**	**Default Setting**
	Dropout: Alarm Rly Healthy	Latched Enable Enable
Pickup Indicator	**Pickup Indicator Settings**	**Default Setting**
	Dropout: IOC: TOC: Volt: OverFreq: UnderFreq: Unbalance:	Unlatched Enable Enable Enable Enable Enable Enable

Table 5.17 Clock

Clock	Clock Settings	Default Setting
	Date mode: Time mode:	MM/DD/YY 12

Table 5.18 Communications

INCOM	INCOM Settings	Default Setting
	Enable: Address: Baud rate:	Yes 1 9600
Accessory Bus	**Accessory Bus Settings**	**Default Setting**
	Address: Baud rate:	2 9600
RS-232	**RS-232 Settings**	**Default Setting**
	Baud rate:	19200

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6 INSTALLATION AND WIRING

6.1 Mounting

The FP-5000 is shipped with the Outer Enclosure assembled with a backing plate between the enclosure housing box and the front latching frame. This factory assembled outer chassis allows for panel thickness variations, minor panel distortions and has relaxed panel cutout tolerance requirements for easy faster panel mounting. The panel footprint outline is equivalent to the Cutler-Hammer DT3XXX and MP3XXX draw-out designs. However it differs from most Cutler-Hammer IQ style panel mounts in that:

- The panel cut-out is slightly larger.
- The enclosure is mounted from the front user side of the panel.
- Four mounting studs/nuts are used for panel mounting.

The following paragraphs describe the mounting of the FP-5000 relay.

Mount the unit vertically on a flat panel. The location should be as free as possible of water, chemicals, dust, and excessive heat and vibration. The panel should protect the user from accidental contact with live terminals on the back of the FP-5000. A 1/8 inch steel panel or door, solidly grounded, is recommended.

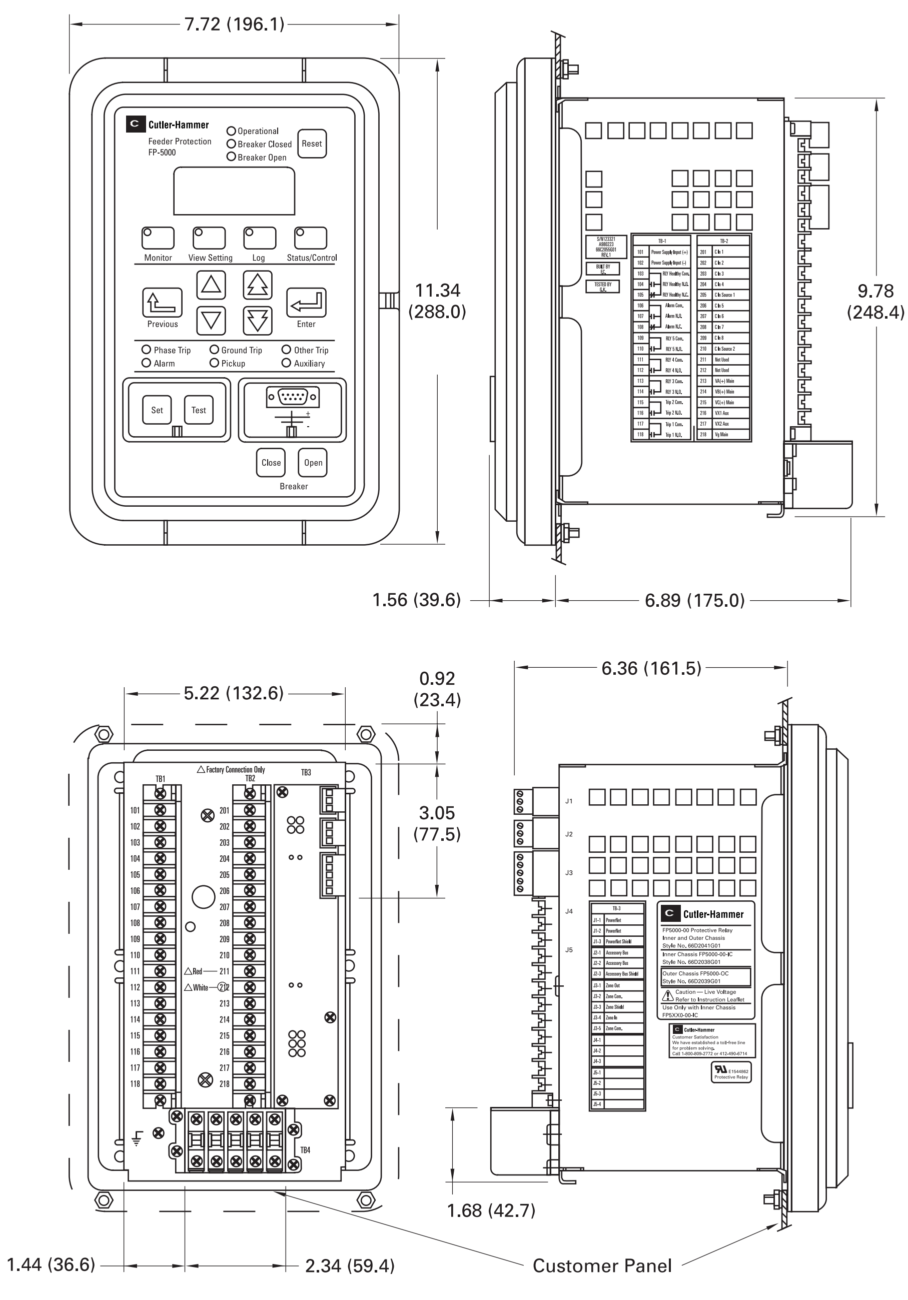


Figure 6-1. Panel Cutout and Mounting Holes

Before actually cutting the panel, check the required three-dimensional clearances for the FP-5000 case, particularly behind the panel. See dimensions in **Figure 6-1** and **Figure 6-2**. If mounting on a swinging door, check the swinging clearance of rear projections and wired connections.

Figure 6-2 shows dimensions for the panel cutout and mounting holes. Cutout tolerances and mounting screw hole placement are critical. In particular, the tolerance of the horizontal dimension between the center of the mounting holes and the vertical edge of the cutout must be between 0 and +0.050 in. (0.13 cm).

The Outer Chassis assembly is installed in the panel from the front, user side with the four mounting studs passing through the four panel mounting holes as shown in **Figure 6-2**. Secure the assembly from the inside of the panel with the four number 10 mounting nuts provided. Use moderate torque of ~ 10 inch pounds. The front latching frame and backing plate should be snug against the mounting panel. If it is not, inspect the installation for accuracy of the panel cutout and possible interference, correcting as necessary.

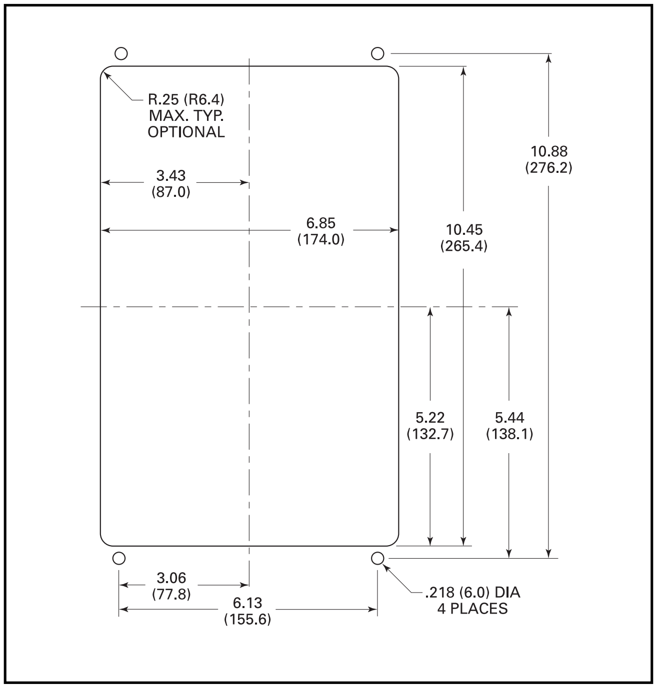


Figure 6-2. Panel Cutout and Mounting Holes

6.2 IQ Panel Cutout Retrofit

It is possible to retrofit the outer chassis to an existing IQ style panel cutout if the panel is guaranteed to be .125 inches thick and distortion free. Insure that there are no mechanical problems that could effect the overall mounting thickness of the outer chassis from the termination back to the front of the latching frame.

Given an acceptable, undistorted IQ cutout then the outer chassis must be disassembled to put the latching frame on the front and the outer chassis box on the back of the panel. The six mounting nuts on the plastic mounting frame should be removed, saved for reassembly, and the frame pulled from the outer chassis assembly. The back plate frame is removed leaving the back metal chassis box. This back plate is then not needed since the assembly panel is replacing it.

From the back of the panel pass the chassis box studs through the IQ panel cutout mounting holes, see **Figure 6-3**. From the front of the panel apply the latching frame onto the studs and replace the mounting nuts. Snug the nuts to get a hand free fit and inspect the opening. The IQ panel cutout should not project beyond the inside lip of the latching frame or it will hang up on the FP-5000 inner chassis slide guides. Note that there is some slop in the outer chassis mounting studs being size 8 and the panel holes being a size 10. By adjusting the fit on the panel the clearance may be removed or if necessary file the opening so that the inner chassis passes without interference. The inner chassis should slide in/out without binding and the face plate should lay evenly against the latching frame with little gap (~ .030 inches max). When finished follow the startup check out procedures outlined in Section 7 to ensure that the draw-out termination is engaged adequately.

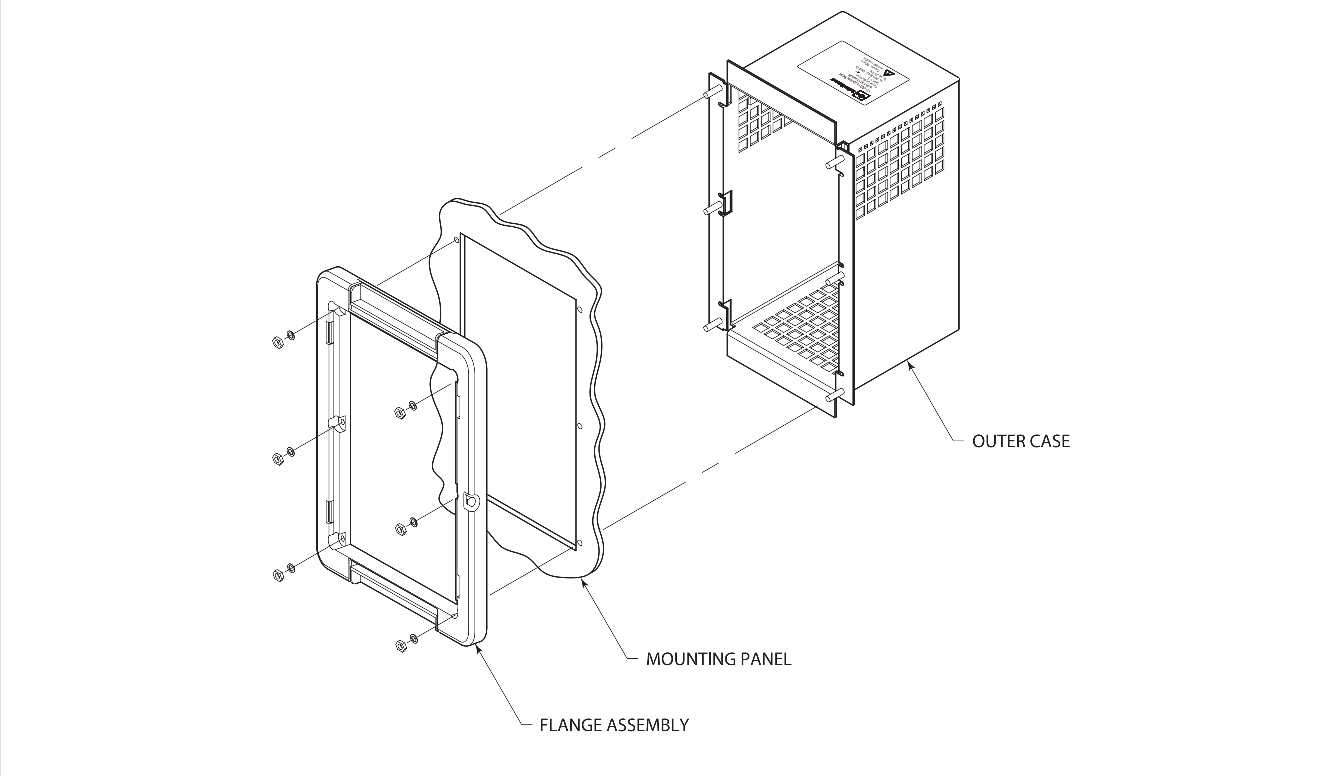


Figure 6-3. FP-5000 IQ Cutout Retrofit Mounting

6.3 Wiring – General

The main electrical interconnections are made from the rear of the outer case of the FP-5000. The mounting and wiring can be done with the inner chassis withdrawn from the outer case. Terminal lugs should be used to wire to the FP-5000. The terminal lugs are inserted by loosening the screws of the terminal blocks mounted on the rear of the outer case.

When routing wires between the FP-5000 and the associated machine or process equipment, follow these guidelines:

- Do not route the control wiring through the high voltage compartment of the gear in which the FP-5000 is mounted.
- Separate the lower voltage connections from the higher voltage (440V AC or higher) conductors as much as possible. In general, maintain a minimum distance of 1.5 feet (45 cm) between the two types.
- Any low voltage control wiring routed out of the cabinet should be at least #18 AWG stranded copper wire, AWG maximum.
- Any Ct wiring routed out of the cabinet should be at least #14 AWG stranded copper wire, 10 AWG maximum.
- Communications circuits may use thinner conductors, as recommended in installation literature for those circuits.

⚠ WARNING

BEFORE WORKING WITH THE WIRING, MAKE SURE POWER IS DISCONNECTED FROM THE FP-5000, AND ALL REMOTE CONNECTIONS INCLUDING CONTACT OUTPUT CONTROL CIRCUITS AND REMOTE INPUT CONTACTS. OTHERWISE, HAZARDOUS VOLTAGES COULD CAUSE INJURY OR DEATH. ALSO, UNEXPECTED CONTROL ACTION COULD INJURE PERSONNEL OR DESTROY EQUIPMENT.

Figure 6-5 shows FP-5000 rear terminal connections.

Connect ground terminal shown in lower left-hand corner of rear panel (see **Figure 6.4**) to the closest solid electrical-safety grounding point with a heavy wire or braid (#14 AWG or larger). Do not use a current-carrying or neutral conductor for this grounding.

6.3.1 Ct Wiring TB4

Carefully read the advice in Section 6.6.2 on choice of Ct ratios for a given particular application. An inappropriate Ct ratio will result in poor measurement accuracy and limited protection. More serious errors in ratio choice will make it impossible to set the relay properly.

Connect the phase and optional ground Cts as shown in **Figure 6-8**. Pay attention to the phase identification and sequence, and check for consistent polarity among the three phases. The FP-5000 unbalance protection will pick up and operate if two phases are swapped, or if the polarity of any Ct is reversed with respect to the other two. See **Figure 6-10** for other common wiring configurations such as 3-phase 3-wire, 3-phase 4-wire, 3-phase 3-wire with ground fault protection.

To minimize problems with Ct saturation during faults, keep the Ct wiring as short as possible and use very heavy wire. The total resistance of the connecting wire should not be much larger than the secondary resistance of the Ct itself. The FP-5000 presents very low burden.

Every phase and ground Ct circuit must have one and only one grounding point. **Figure 6-8** shows the common neutral connection of the three-phase Cts, and the ground fault Ct, connected at one point to a non-current-carrying ground. Do not use a neutral or current-carrying conductor for this grounding – the noise will disrupt FP-5000 measurements.

Residual connection of the phase Ct secondaries to form a ground current signal will not give sensitivity approaching that of the flux-canceling ground Ct.

6.3.2 VT Wiring TB2

Wiring of the VTs into the FP-5000 phase voltage input terminals can be achieved several ways. **Figure 6-8** gives a common example of the VT Wye wiring. In **Figure 6-9**, a Delta configuration is implemented using only two transformers, saving cost, weight and size. The transformer polarity indicated by polarity dots must be carefully considered when designing the VT into the system. It should be noted that the secondary side of the transformer center tap is tied to common, input VB (+) terminal 214, and VG terminal 218.

It should be noted that an FP-5000 can accommodate a reverse phase sequence providing that phase voltages and current are in sync. (See Section 5.)

⚠ CAUTION

TERMINAL TB218 VG IS INTERNALLY REFERENCED TO GROUND THROUGH A CONTROLLED IMPEDANCE TO THE FP-5000 CHASSIS. THE VOLTAGE TRANSFORMER SECONDARY RETURN MUST BE PROTECTIVE EARTH GROUNDED AND TB218 CONNECTED TO THIS RETURN. TB218 VG MUST NOT BE CONNECTED TO PHASE OR NEUTRAL CONNECTIONS.

6.3.3 Output Contact Wiring TB1

See Section 3 Specifications for ratings of output contacts, and check against controlled loads.

Figures 6-8 and **6-9** show typical connections of FP-5000 output relay contacts in control circuits. However, the outputs are completely programmable, so there can be numerous choices in selecting and using these outputs for tripping, alarming and auxiliary control.

The installation design engineer should refer to Sections 5 and 9 to understand the available output functions and programming options. It is recommended to record and confirm the settings, and also design a consistent connection of the contacts of the output relays to the control system.

6.3.4 Supply Wiring TB1

Refer to **Figure 6-8** or **6-9**. Connect terminals 101 and 102 to a source of control power rated at either 100 –120V AC or 48–125V DC. Nominal values other than these voltages are not acceptable. However, the FP-5000 is capable of handling depressions, dips, and limited sustained variations in the normal course of service. See Section 3 Specifications.

6.3.5 Contact Input Wiring TB2

The optically isolated contact inputs are “dry contact inputs.” The actuating or wetting voltage is provided by the FP-5000. Each input is activated by connecting it through an appropriate contact to the provided voltage. The return, common connection, or DC negative rail associated with the “wetting voltage” is internal only and is not provided to the user (See **Figure 6-9**). The wetting voltage and current requirements of the external contacts should be reviewed for compatibility with the FP-5000’s 40V DC source voltage and 2mA current draw. The particular contacts to be connected depend on the settings programmed in the FP-5000. There is a complete list of functions which can be assigned to each of these inputs.

The engineer designing the installation should study Sections 5 and 9 to understand and designate the use, if any, of the discrete contact-sensing inputs assigned to each input.

The discrete input circuits (Cin1 – Cin8) are totally isolated from the other circuits in the FP-5000. Supply or wetting voltages (40V DC) are located on terminals [C in source 1] and [C in source 2] (TB 205/210) and return is through each input. Wetting current is limited to ~2mA per input. There are no external connections for common or return for these circuits.

⚠ CAUTION

BEWARE OF LARGE SHUNT CAPACITANCE ACROSS CONTACTS OR IN SOLID-STATE RELAYS CONNECTED TO THE FP-5000 DISCRETE INPUTS. CHARGING CURRENT THROUGH THE CAPACITOR COULD CAUSE A FALSE INDICATION OF A CLOSED CONTACT. KEEP TOTAL CAPACITANCE BELOW 0.05 MICROFARADS.

6.3.6 Terminal Identification

This section offers a brief description of the terminals mounted on the rear of the outer case. The terminal designators are TB1, TB2, TB3, and Ct connector TB4. Refer to **Figure 6-4** and **6-5** FP-5000 Rear Terminal Designations.

Power Supply and Relay Contacts (TB1)

The power supply terminals are 101 and 102. There are 5 Form A normally open relays each with their own independent common, and 2 Form C normally open, normally closed relays each with their own independent common. These relays can be tested as well as reset when in the test mode as mentioned in Section 11.2.5.2. Refer to **Figure 6-4** FP-5000 Rear Connections and Table 3.1 Table of Specifications for relay terminal numbers and relay electrical characteristics.

Cin1 – Cin8 (TB2)

Terminals 201–210 of terminal block TB2 are used in programmable logic applications. Default settings are set at the factory to provide standard operational functions. **Cin1 – Cin8** are used as contact inputs when the “Contact Input” option category is selected. For more detailed information, refer to Section 9, “Programmable Logic Application.”

Reserved (TB2)

Terminals 211 and 212 are reserved for future design efforts. Do not connect circuits to these terminals.

VT Terminals (TB2)

Pins 213–218 are phase A, B, C, Auxiliary and ground voltage inputs from the VT (voltage transformer) module. The VT module is used to measure the line voltage and steps down the voltage to a smaller potential. It also provides isolation to the FP-5000 and from the voltage bus. **Figure 6-8** and **Figure 6-9** show Delta and Wye connected feeder protection, respectively.

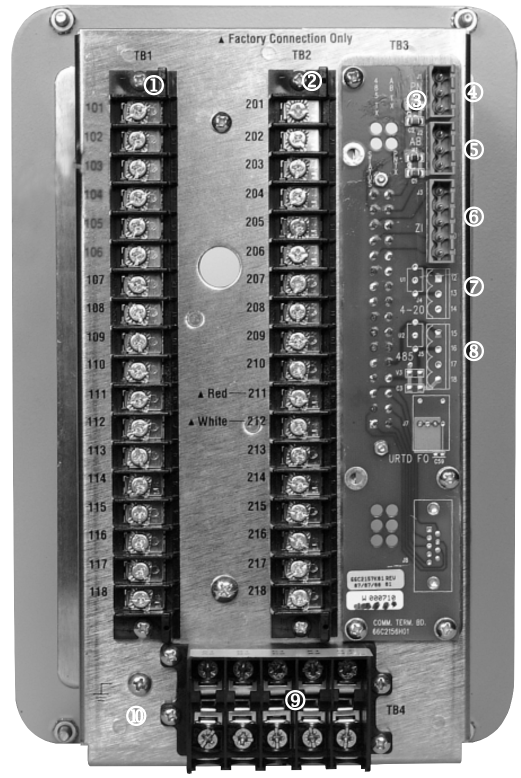
Note: Careful attention should be made to the phase wiring to avoid erroneous power and voltage indications as well as damage to the FP-5000.

Standard Communication Board TB3

There are three circuits on the “Standard communication” Terminal Block assembly TB3:

- J1 INCOM PN – is the connection of a PowerNet INCOM twisted pair communications interface. The connection is part of a daisy chained multi-point twisted pair interface. J1-1 and J1-2 are for the twisted pair connections and J1-3 for shield termination. The removable terminal plug can facilitate debug of the INCOM hardware interface. Switch selectable termination is located on the communication board of the inner chassis and can be accessed through an opening in the metal chassis with the draw-out removed. It is shipped open. Refer to Section 10 for INCOM wiring rules and details.
- J2 INCOM AB – this is an INCOM type interface reserved for future design features. The hardware is identical to J1 accept that there is a non-switch selectable 100 ohm termination resistor built in.
- J3 Zone Interlock – This is the termination for both the zone interlock Zone Out (J3-1) and Zone In (J3-4) circuits with duplicate J3-2 and J3-5 Zone com. connections, for Zone signal returns. The shield connection J3-3 is grounded to the chassis and is not needed for noise immunity. Twisted pair control wiring of 14-18 AWG is recommended.
- J4 and J5 are unpopulated future design options.

It is recommended that the wires terminated at TB3 be fitted on the end with ferrules to eliminate fray shorting and the cable stress released by strapping them to the back of the draw-out panel near the FP-5000.



① TB1
② TB2
③ TB3
④ J1
⑤ J2
⑥ J3
⑦ J4
⑧ J5
⑨ Ct Receptical
⑩ Protective Earth

Figure 6-4. FP-5000 Outer Chassis Rear Connections

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

TB-2	
201	C In 1
202	C In 2
203	C In 3
204	C In 4
205	C In Source 1
206	C In 5
207	C In 6
208	C In 7
209	C In 8
210	C In Source 2
211	Reserved
212	Reserved
213	VA(+) Main
214	VB(+) Main
215	VC(+) Main
216	VX1 Aux
217	VX2 Aux
218	Vg Main

TB-3	
J1-1	PowerNet
J1-2	PowerNet
J1-3	PowerNet Shield
J2-1	Accessory Bus
J2-2	Accessory Bus
J2-3	Accessory Bus Shield
J3-1	Zone Out
J3-2	Zone Com.
J3-3	Zone Shield
J3-4	Zone In
J3-5	Zone Com.
J4-1	
J4-2	
J4-3	
J5-1	
J5-2	
J5-3	
J5-4	

TB4				
A1	B1	C1	X1	N.C.
A2	B2	C2	X2	N.C.

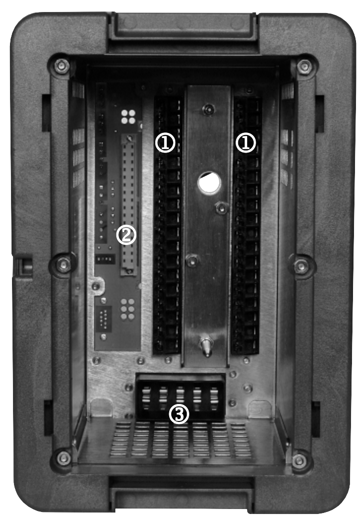
Figure 6-5. FP-5000 Rear Terminal Designations

6.4 Separated Draw-out Case Views with Internal Callouts

The FP-5000 assembly is shown in **Figure 6-6** prior to installation. The chassis is shown as it is when withdrawn from the case. When withdrawn, the make-before-break connectors within the case will provide a short accross the current transformers (Ct) inputs. This provides protection for the Cts in the event that the chassis is withdrawn while the current transformers are under power.

Figure 6-6. Case with Inner Chassis Withdrawn (Draw-out)

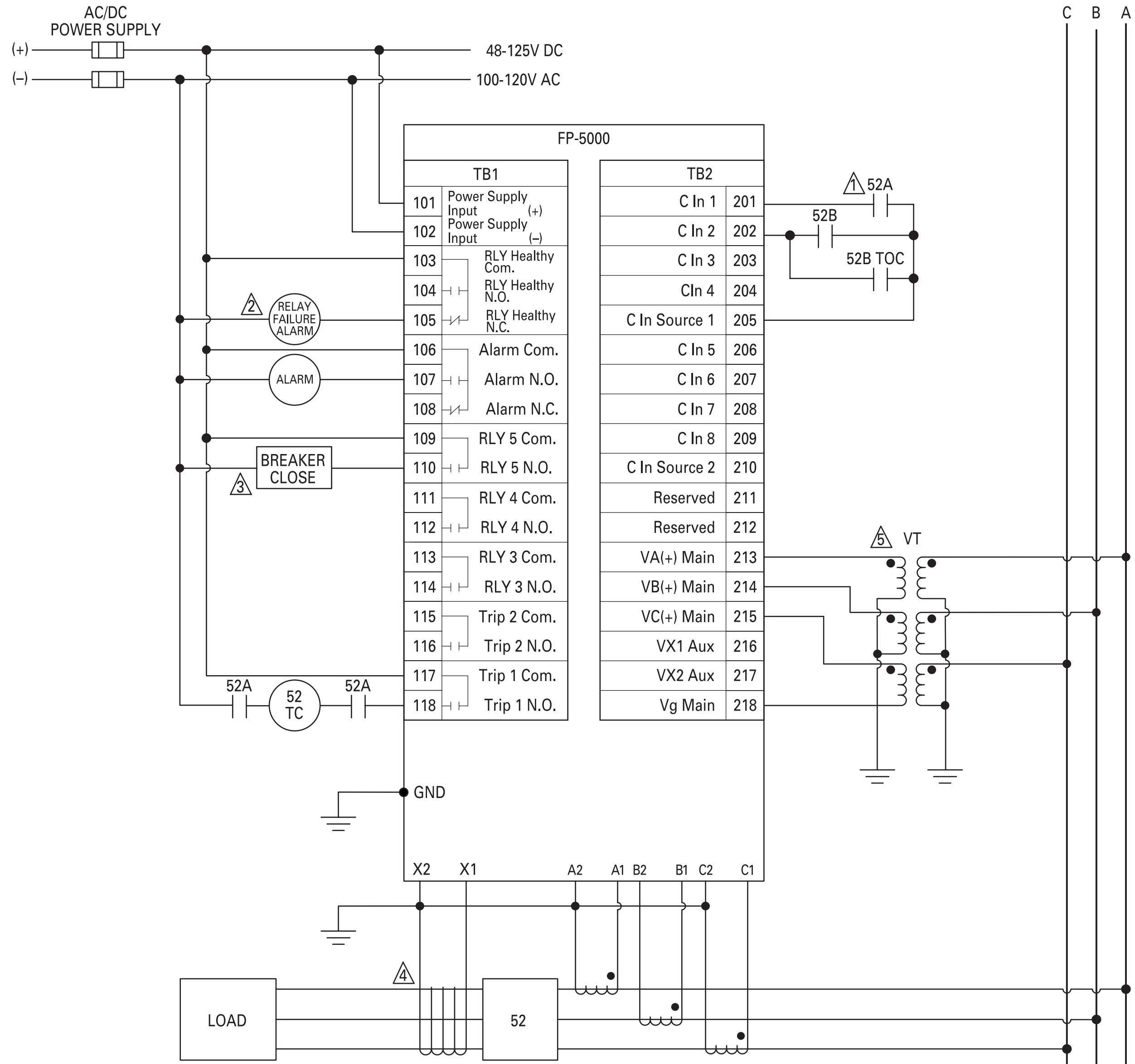
When removing the chassis from the case, care must be taken as many electronic components and circuits are exposed. Service personnel should use electrostatic wrist straps to avoid damage due to electrostatic discharge (ESD). Touching the metal chassis prior to handling may reduce the risk of damage due to ESD.



① Card Edge Connectors
② J Connector TB3
③ Current Connectors

Figure 6-7. Internal View of Case Connectors

Figure 6-7 provides a view of the case with the chassis fully withdrawn from the FP-5000 assembly. Several connectors can be seen in the rear of the enclosure. These connectors interface with their mating connectors of the Chassis. There are two card edge connectors, TB1 and TB2 (See **Figure 6-4** FP-5000 Rear Connections). TB1 connector is primarily used for the AC/DC power input and also relay contacts for relay RLY1 through RLY7, TB2 is used for the contact inputs and the phase voltage inputs. (See **Figure 6-5** Rear Terminal Designations.)



1. FOR MAXIMUM BREAKER DIAGNOSTICS USE BOTH 52A AND 52B CONTACTS. SOME DIAGNOSTICS ARE NOT AVAILABLE IF ONLY ONE OF THE TWO IS USED.

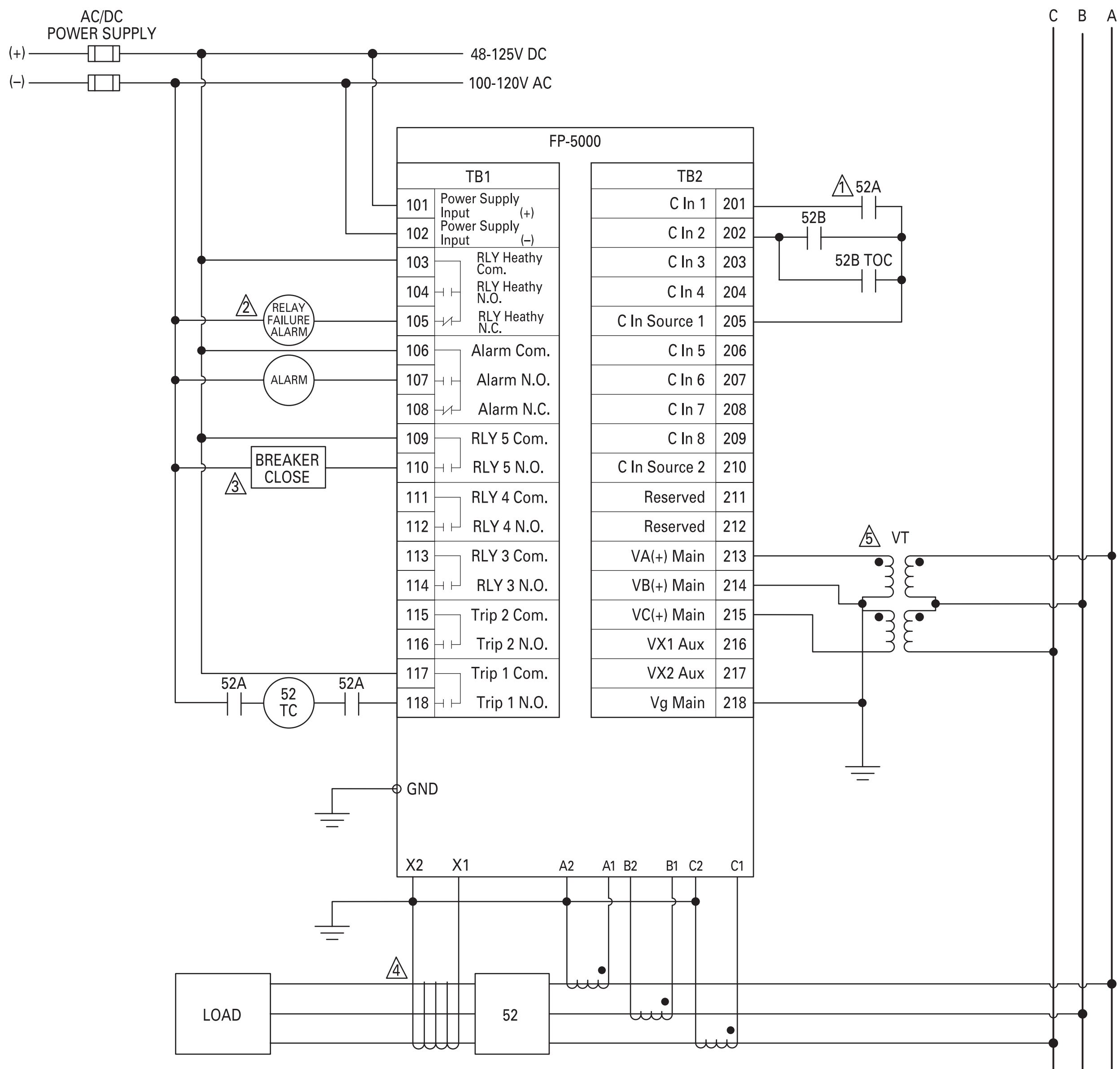
2. A RELAY FAILURE ALARM SHOULD PROVIDE IMMEDIATE ATTENTION AS CIRCUIT IS NO LONGER PROTECTED. RELAY FAILURE OUTPUT IS NORMALLY ENERGIZED.

3. FP-5000 CAN INITIATE A BREAKER CLOSE VIA THE FRONT PANEL INTERFACE AND/OR REMOTE ACTIVATION THROUGH COMMUNICATION OR DISCRETE INPUT.

4. RESIDUAL CONNECTION MAY BE USED IN PLACE OF ZERO SEQUENCE CT.

5. DELTA OR OPEN DELTA PT CONNECTION MAY BE USED IN PLACE OF WYE-GROUND CONNECTION.

Figure 6-8. Voltage Wye Input Wiring Options and Connection Schematics



1 FOR MAXIMUM BREAKER DIAGNOSTICS USE BOTH 52A AND 52B CONTACTS. SOME DIAGNOSTICS ARE NOT AVAILABLE IF ONLY ONE OF THE TWO IS USED.

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3 FP-5000 CAN INITIATE A BREAKER CLOSE VIA THE FRONT PANEL INTERFACE AND/OR REMOTE ACTIVATION THROUGH COMMUNICATION OR DISCRETE INPUT.

4 RESIDUAL CONNECTION MAY BE USED IN PLACE OF ZERO SEQUENCE CT.

5 WYE-GROUND PT CONNECTION MAY BE USED IN PLACE OF DELTA OR OPEN DELTA CONNECTION.

Figure 6-9. Voltage Delta Input Wiring Options and Connection Schematics

6.5 Draw-out Alarm

The draw-out alarm is implemented by use of the spare “N.C.” Ct terminals. When the relay chassis is inserted in the case, these contacts are open. When the relay chassis is removed from the case, these contacts close (self-shorting) thus providing an alarm. These are the only spare terminals and they have the desired characteristic of changing state mechanically when the relay chassis is withdrawn.

6.6 Zone Interlocking Connections

The zone interlocking connection between relays is done by means of a twisted shielded cable. Downstream Zone Interlock outputs may be paralleled from up to ten devices (FP-5000 or DT-3000 or a combination of both) for connection to upstream Zone Interlocked relays. See Section 8.5.

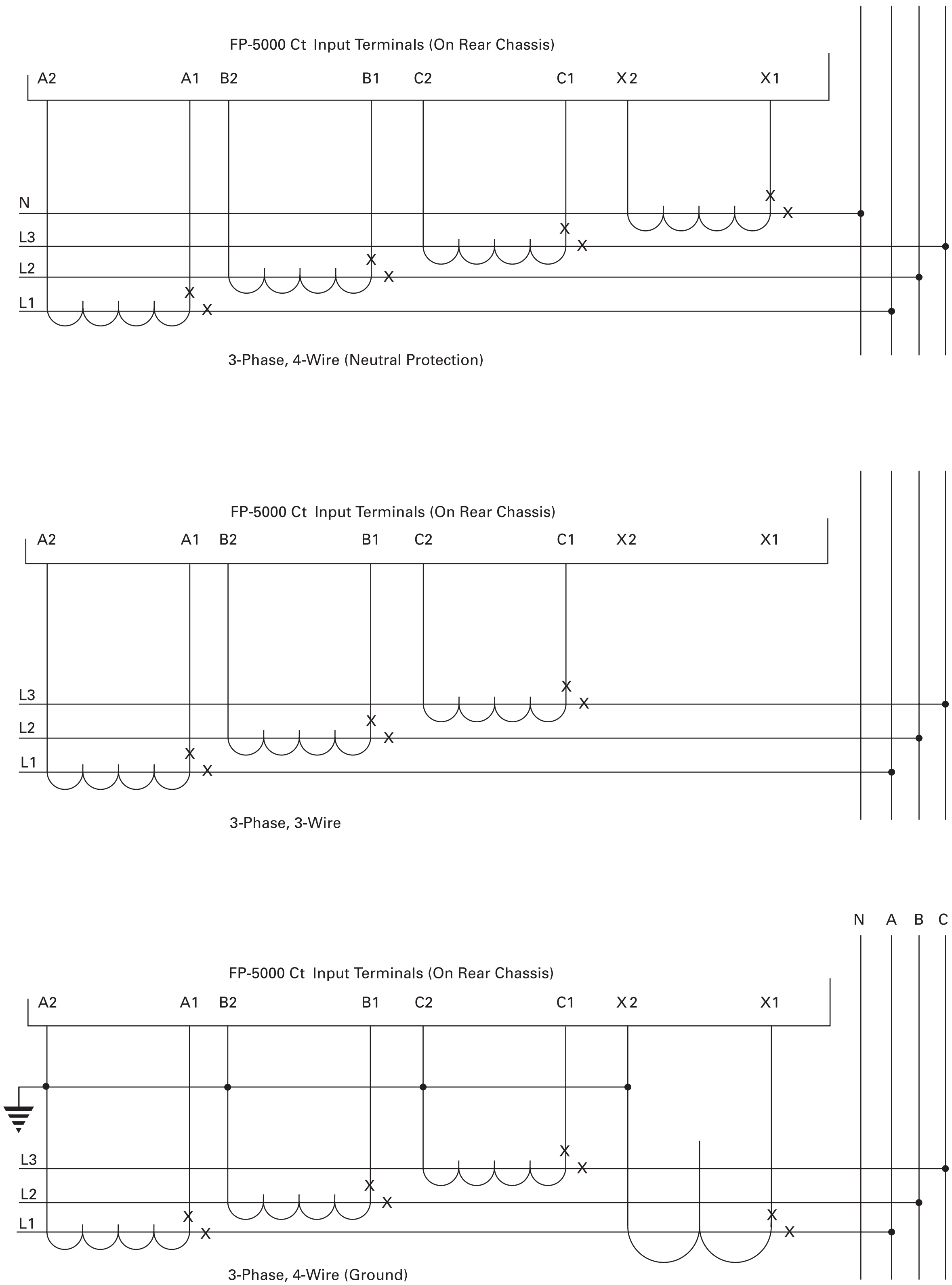

Figure 6-10. Common Ct Wiring Configurations

7 STARTUP

General — This section lists the procedure for applying power to an FP-5000 for the first time. Use it as a checklist to reduce the chance of skipping an item.

⚠ DANGER

ONLY QUALIFIED PERSONNEL FAMILIAR WITH THE FP-5000, THE BREAKER, AND ITS ASSOCIATED MECHANICAL EQUIPMENT, SHOULD PERFORM THESE STARTUP PROCEDURES. FAILURE TO COMPLY CAN RESULT IN SERIOUS OR FATAL INJURY AND/OR EQUIPMENT DAMAGE.

⚠ CAUTION

NEVER HIGH POT THE FP-5000 CIRCUITS BEYOND 1500VRMS/1 MIN. DO NOT USE A MEGGER®, HI-POT, OR OTHER HIGH VOLTAGE INSULATION TESTER ON THE FP-5000 TERMINALS, IT HAS BEEN FACTORY TESTED, AND FIELD TESTING MAY CAUSE UNNECESSARY STRESS. REMOVE THE FP-5000 INNER CHASSIS WHEN TESTING THE PROTECTIVE RELAY SYSTEM.

⚠ CAUTION

DO NOT USE A MEGGER®, HI-POT, OR OTHERWISE HIGH VOLTAGE TO TEST THE FOLLOWING TERMINALS OR POINTS:
- **TB3 - J1-3 SHIELD – IS BONDED TO HOUSING (FILTER CLAMP)**
- **TB3 - J2-3 SHIELD – IS BONDED TO HOUSING (FILTER CLAMP)**
- **TB3 - J3-5 SHIELD – IS BONDED TO HOUSING (DIRECT GROUND)**
- **TB2 - 218 VG (REF.) – IS BONDED TO HOUSING (FILTER CLAMP)**
- **FRONT RS-232 PROGRAMMING PORT SHELL – IS BONDED TO HOUSING (DIRECT GROUND)**

Startup consists of Programming the necessary operational parameters, verifying the operation of the FP-5000, checking the wiring, and verifying the reasonable operation of the system components before attempting to place the equipment into continuous service.

The programming should already be done before FP-5000 is placed into service. Protection parameters may be reviewed in the View Settings mode or adjusted in the Set Mode.

Refer to wiring **Figures 2-2** and **2-3** and **Figure 6-5** on terminal definitions, Section 3 “Specifications” for nominal ratings during startup.

7.1 Power-Off Checks

With the incoming AC distribution power locked off and after all sources of power to the FP-5000 are de-energized, including control system battery, check the wiring for conformance to the wiring plan developed for the application.

- Verify that the Ct secondary current rating and the FP-5000 Ct input rating style agree (either 5A or 1A). See Section 1.8 Ordering Information for catalog number identification.
- Verify that the Voltage Inputs are referenced to Voltage transformers where the common is earth ground. TB2 Terminal 218 “Vg” is internally bonded within the FP-5000 to protective earth and can not be connected to neutral or a phase reference.

⚠ WARNING

VOLTAGE TRANSFORMERS ARE OFTEN CONNECTED “UPSTREAM” FROM THE BREAKER CIRCUIT MONITORED AND SO MAY BE DIFFICULT TO DISENGAGE.

7.2 Initial Control Power-On Checks

- All power sources should be disconnected as described in Section 7.1.
- Disable all trip and control circuits.
- Disconnect and insulate the breaker trip coil load leads from any of the trip relay terminals, typically Relay1 and Relay2 on TB1 terminals 116 and 118, to prevent breaker from energizing during most of this testing.
- Disconnect and insulate any control circuit loads connected to the remaining control relays on the FP-5000.
- Verify FP-5000 power supply control power:
  - Disconnect the AC or DC control power lead to terminals TB101(+).
  - Connect a voltmeter to the circuit that fed TB101 and the return on TB102.
  - Energize the FP-5000 power supply power source and monitor the voltage.
  - Make sure that it is within nominal specifications:
  - Battery system 48 – 125V DC or control power transformer 100 – 120V AC.
  - De-energize the power supply source.
- Verify trip relay control voltage:
  - Connect a voltmeter between each trip relay breaker trip coil load wire just disconnected from terminal 116 or 118, and the other meter lead to the control power source (TB115/117).
  - Energize the trip coil source power.
  - Measure the voltage and ensure that it is within the FP-5000 trip relay nominal specifications.
  - De-energize the control power and troubleshoot as necessary.
- Verify the FP-5000 Relay Health Alarm, Breaker Alarm and any other auxiliary FP-5000 relay control circuit in the same manner as the trip relay circuits.

7.3 Check with FP-5000 Powered

- All relay loads should remain disconnected.
- Reconnect the FP-5000 power supply connection TB101 and energize the source.
- The FP-5000 should initialize and display the default Metering Screen, the operational LED should be blinking at 1 Hz.
- Examine the Self-Test flags by navigating to the status/control mode and select Self-Test. Refer to Section 12.1.3 Self Test Failure Indication for detailed description and possible action.
- If previously programmed, then the setpoints should be verified against a system drawing for this application.
  - Section 5 can aid in understanding the setpoint configuration.
  - Note that PowerNet or PowerPort PC software can be used to record setpoint files.
  - Confirm that correct active setting group is selected.
- If the setpoint status is not as desired then it can be initialized to the default by navigating to the status/control mode, -> Control, ->Default Settings and then select “load Default values.”

⚠ CAUTION

DO NOT ATTEMPT TO ENTER SETTING VALUES WITHOUT USING THE APPROPRIATE SET POINT RECORD SHEET. IMPROPER OPERATION AND/OR PERSONAL INJURY COULD RESULT IF THIS PROCEDURE IS NOT FOLLOWED.

- The real time clock should be set. It can be viewed under monitor/ load and page up. If it needs to be adjusted then navigate to the Setting mode/Clock menu and adjust.
- The history, trip, and data logs should be cleared. Navigate to the reset mode and select the appropriate function to clear.
- The functioning of the Contact Inputs should be verified. The functioning of the inputs can be verified.
  - Verify that there is ~ 40V DC between the Contact Input source TB 205 or 210 and open Contact Inputs 1 – 8 (TB201-204 and 206-209).
  - For applications where the initial state is to have the Contact Inputs off they can be forced on. With a wire strap attached to either TB205 or 210, touch each of the Contact inputs 1 – 8 in order while monitoring the status. Navigate to Status/Control ->Status -> Input Status ->Input Status -> view Cin1 – Cin8.
  - If the default contact input configuration is used, then the state of the 52a and 52b inputs should be confirmed. The Breaker Open LED should be on. If not or if the Breaker Closed LED is on while the breaker is open, a wiring error has occurred. To make sure that the 52a and 52b contact inputs are not in the same state, examine breaker status flags in the status/control mode and make sure that the “Bkr State Alarm” is off.
- If the Zone Interlock In is connected, ensure that the input is off. Navigate to Status/Control -> Status, -> Input Status, -> Zone Int In: to check the state.
- Any Trip or Alarm indications should be investigated and eliminated before continuing.
- Verify that the Relay output contacts are in the expected state. An ohm meter can be used to determine if they are open = high impedance (> 1Meg ohm) or closed = low impedance, (< ~ 1 ohm). In the case of the Trip Relay contacts, the open circuit impedance is equal to the monitor circuit impedance of ~ 44K-ohm.
- If the status is what is expected, secure all power sources and reconnect the wiring to the contact inputs. Otherwise troubleshoot the FP-5000 wiring.
- Turn the relay power source(s) back on.
- Verify the Trip Monitor status. Navigate to Status/Control -> Status, -> Input Status, -> Trip 1(2) Monitor: to check status. See Section 11.2.3.4 Testing Trip Monitors.
  - If there is adequate voltage across trip relay 1 or 2 and the relay is open then the status should read “On.” A voltmeter across the relay contacts can be used to verify if the source and load are properly connected and the source energized. Note: The trip monitor circuit requires at least 38V DC to detect the presence of a source. AC detection operates well below 55V AC.
  - If the relay is closed or if the control power source and or wiring is compromised then the status should read “Off.”
- Verify that the healthy relay is in the energized state. Removing power to the FP-5000 power supply should disengage the healthy relay, closing the NC contacts TB105 which should drive an Alarm indicator.

⚠ WARNING

IT IS VERY IMPORTANT THAT AN ALARM ANNUNCIATION IS DRIVEN FROM THE FP-5000 HEALTHY RELAY THAT REQUIRES IMMEDIATE ATTENTION WHEN TRIPPED, SINCE THIS MEANS THAT THE FP-5000 IS NO LONGER PROTECTING THE CIRCUIT AND THE SYSTEM SHOULD BE SERVICED.

- Verify the functioning of the INCOM PowerNet communications if used.
  - Make sure that the FP-5000 INCOM slave address is unique and matches the system drawings. The programmed address can be checked under the “View Setting” mode and modified under the “Setting” mode.
  - Verify that the FP-5000 is communicating over the INCOM network by getting confirmation of the device at the master polling device. Visit the PowerNet or other INCOM master client and check the monitoring displays for the particular FP-5000. Confirm that you are viewing displays for the correct relay. Disconnecting and reconnecting the network connector is a simple way to check this.
  - The INCOM PN Transmit LED, viewed through the back chassis TB3, will light if a response is sent by the FP-5000 to a valid INCOM command reception.
- Testing of Relay circuits – each relay 1 – 6 can be forced in test mode to operate and can be opened under the reset mode and the associated circuitry evaluated.

⚠ WARNING

OPERATING THE CONTROL RELAYS MANUALY SHOULD ONLY BE DONE IF THE RESULT OF ENGAGING EACH CIRCUIT LOAD CAN BE DONE SAFELY.

7.4 Voltage Checks

The voltage inputs should be checked prior to closing the breaker. The voltage inputs should be confirmed by looking at either the phasor voltage angles or looking at the voltage sequential components to make sure that the phase rotation and polarity is being measured properly.

7.5 Draw-Out Checks

The draw-out design consists of an “outer chassis,” which is mounted into the distribution gear or control panel and then wired into the system. The operational electronic hardware is assembled into a separable “inner chassis,” which may be inserted or withdrawn for quick replacement. The inner chassis makes electrical contact with the wired outer chassis by means of engaging contacts in the back of the case. The contacts providing the current transformer signals short upon withdrawal of the chassis (make-before-break). The remaining contacts remain or become open.

The outer chassis frame has provisions for a wire seal loop that must be cleared for extraction of the inner chassis. Once this impediment is removed, the top and bottom handles must be depressed simultaneously to release internal latches and pull out the inner chassis. It is suggested that an individual’s thumbs be placed against the outer chassis frame while the fingers grasp the front overlay bezel using the finger hold space provided by the release depression. Hot removal and replacement of the inner chassis on activated circuits is possible. However depending on the design of the alarm circuit the healthy alarm may be engaged.

On removal of the inner chassis verify that all the Ct connections have shorted. Inspect for obvious damage to the connectors both in the Outer Chassis and at the rear of the Inner Chassis. Carefully re-insert the chassis, being careful to engage the latches at the sides into the slots. As the inner chassis is pushed into the outer chassis the outer frame will capture the latches causing the release handles to pop in and out. When the outer chassis is fully inserted it should be ~ flush with the outer chassis mounting frame. Verify that the FP-5000 energizes and proper metering display is activated.

7.6 Trip Test with Built-in Function

The FP-5000 has a self-test function, which allows voltages and currents, both rms and phasor values, to be applied to the internal firmware in a simulation process. The unit can be placed in a trip or no trip mode to verify coordination trip times, demonstrate tripping and indicate trip times under user selected overload conditions. Refer to Section 11.2.5.1.

7.7 Checks After Closing the Breaker

⚠ CAUTION

IT IS POSSIBLE TO GET A TRIP ON THE INITIAL CLOSING OF THE BREAKER DUE TO MIS-PROGRAMMING AND WIRING PROBLEMS AND ALL PRECAUTIONS SHOULD BE TAKEN IN ANTICIPATION OF A TRIP EVENT.

⚠ CAUTION

THE BREAKER CONTROL CIRCUIT IS TO BE RECONNECTED. AT THIS TIME THE LOAD(S) ASSOCIATED WITH THE APPLICATION MAY BE STARTED. IT IS IMPORTANT TO ENSURE THAT ALL SAFETY PRECAUTIONS ASSOCIATED WITH THE LOAD EQUIPMENT AND THE ASSOCIATED MECHANISM BE TAKEN. FAILURE TO DO SO CAN RESULT IN SERIOUS OR FATAL INJURY AND/OR EQUIPMENT DAMAGE.

- Disconnect all control power from the system.
- Reconnect the breaker lead to FP-5000 trip relay terminals 116 and 118.
- Clear away any loose or foreign objects.
- Clear all personnel from the area of the breaker and loads.
- Turn on all control power.
- Make sure the FP-5000 green Operational LED is flashing on and off, and that the display shows the normal Currents/Voltages values.
- Follow any startup procedures for the load equipment.
- Close the breaker, the external Start Switch or contacts.
- Using the information supplied by the application engineer or equipment manufacturer, verify that the breaker is operating properly and the load is energized.
- With a load on the breaker, use a clamp-on type ammeter to measure the AC current on each of the line phases.
- Verify that the IA, IB, and IC currents as indicated by the FP-5000 on the Default Monitor Page are within about 5% of the ammeter values.
- Verify the voltage and current phase rotation and the polarity of the wiring for correctness.
- If the Cts are far from the optimum ratio, errors may be larger. This test is intended to show incorrectly set Ct ratios or faulty wiring, rather than precision of measurements.
- If the IX Ct is connected, check the magnitude of IX. Consider the cause of any anomalies. For instance, if ground current is being measured, investigate the cause of any abnormal ground leakage current flow.
- If a PowerNet data communications host is connected, upload an oscillographic sample of the operating currents and voltages. Review for inconsistencies or problems.

- It is wise to verify the ability of the FP-5000 to open the breaker and trip the load. The easiest way is by remote trip, via remote trip contact or data communications. Many other internal functions can be manipulated to force a relay trip.
- Verify if the 52a and/or 52b contacts are used and the Breaker Closed LED lights.
- Verify that the trip coil monitor function is reading trickle current around trip 1 relay.
- Verify the phasor angles have correct polarity between voltage and current inputs.

8 APPLICATION AND SETTINGS

8.1 Over-all Measuring Principles of the FP-5000

8.1.1 Analog Input Sample Processing

The four current (I_A, I_B, I_C, I_X) and four voltage (V_A, V_B, V_C, V_X) inputs are sampled 32 times per cycle. The residual current, I_R, is computed from the phase currents during each update. The definition of I_R is dependent upon the System Configuration setting for the Ct Connection. Diagrams of the system configurations and definitions of I_R are included in Section 8.2, Ct Connection Options, below.

For most protection purposes, the values of voltage and current are updated every frequency cycle. In the case of instantaneous overcurrent protection (50X and 50P) the values are updated every half cycle.

For the monitoring function, values are the sums of one cycle rms values averaged over 32 cycles. The averaged rms quantities provide stable values of current and voltage for display on the front panel. The phase angle for voltages and currents is computed from the one-cycle voltage and current phasor values every 32 cycles for updating the current phasor angle displays.

8.1.2 Frequency Measurement

The line frequency is obtained through the measurement of the period of the phase A voltage. The frequency measurement is used to determine the dynamic sampling rate of all other voltage and current inputs. A system configuration setting is used to declare the nominal frequency as 50 or 60 Hz, and this frequency will be used for sampling in the case where phase A voltage is unavailable.

8.1.3 Discrete Input Sampling

The eight discrete contact inputs Cin1 – Cin8 and the zone interlocking input states are declared every cycle.

8.2 Ct Connection Options

The Current Transformers may be connected in several ways, and the specified configuration affects the way system measurements are made and results computed.

The computation of the residual current I_R, is dependent on the System Configuration setting for the Ct Connection. The configurations resulting from the three setting options are shown as well as the calculated I_R residual current.

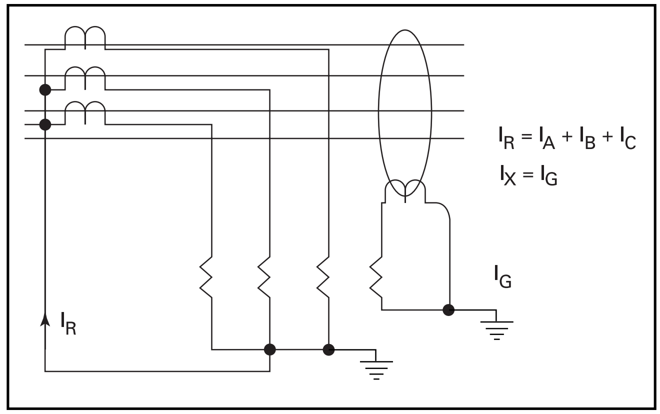

Figure 8-1. Three-Wire Ct Connection

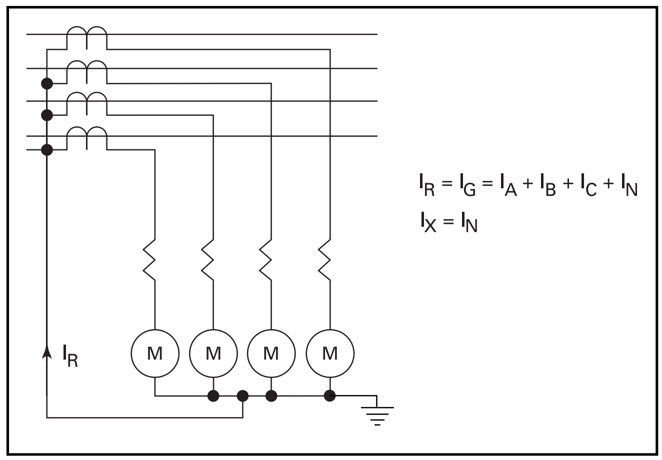

Figure 8-2. Four-Wire with IN Ct

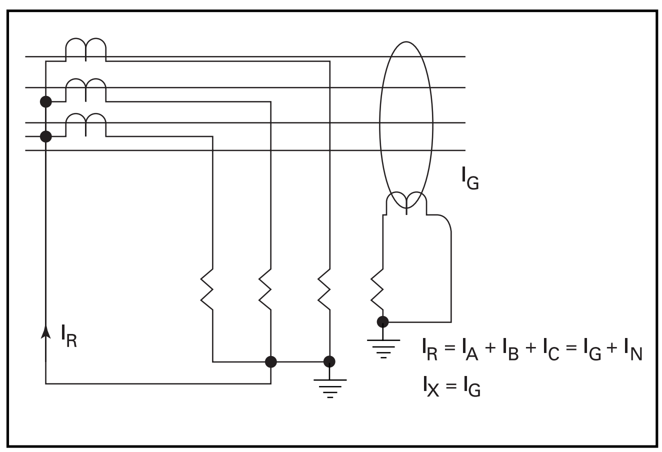

Figure 8-3. Four-Wire with IG Ct

8.3 Overcurrent Functions – Instantaneous and Time

8.3.1 Instantaneous

The Instantaneous Trip occurs when any of the phase currents exceeds the pickup current defined by the user. That is:

$$I_{phase} > I_{pick\ up}$$

Instantaneous Trip may be set for a delay from zero (0) to 9999 cycles after the pickup current is exceeded. Since the current is evaluated twice per cycle, the initiation of the trip action begins within a cycle for a setting of 0. Completion of the trip depends upon the usual electromechanical contact output delays in the FP-5000 (included in specification of trip time accuracy) and in the time for the breaker to open. The FP-5000 provides two timed or instantaneous phase trip functions: 50P1 and 50P2. One of the trip functions can be used as a truly instantaneous with zero delay while the other can be used as a short delay function.

8.3.2 Inverse Time-Overcurrent Protection (51)

Three families of curves provide inverse time overcurrent protection. The three families are: Thermal, ANSI and IEC curves. The FP-5000 provides 10 standard Time overcurrent curves: Flat, It, I^2t, and I^4t for Thermal; Extremely Inverse, Very Inverse and Moderately Inverse for ANSI; and IEC-C, IEC-B and IEC-A for IEC.

Thermal

Thermal curves include It, I^2t, I^4t and FLAT, and are defined by the following equation:

$$T = \frac{5 \cdot D \cdot K^M}{\left(\frac{I}{I_{nom}}\right)^M}$$

T = Trip Time in Seconds
D = Time Multiplier Setting
M = Slope (0=FLAT, 1= It, $2=I^2t$, $4=I^4t$)
K = 3 for Phase, 1 for Ground
I_{nom} = Nominal Current either 5 or 1 A
I = Measured Current

ANSI & IEC

The ANSI Moderately Inverse, Very Inverse and Extremely Inverse curves are defined by ANSI C37.112. The IEC curves are defined by IEC 255-3. The ANSI and IEC families of curves are defined by the same equation and differ only in the selection of constants A, B and P as contained in Table 8.1. The trip time, T, in seconds is defined by the following equation:

$$T = D \cdot \left[\frac{A}{\left(\frac{I}{I_{pu}}\right)^P - 1} + B\right]$$

T = Trip Time in seconds
D = Time Multiplier Setting
I_{pu} = Pickup Current Setting
I = Measured Current
A, B, P = Constants

Reset

The reset function describes what occurs to the accumulated tally of the TOC function if the current goes below pickup. The accumulated tally is similar to how far an induction disk has traveled if an electromechanical relay was being used. The time delayed reset function provides improved coordination with electromechanical and other relays. The reset function is very important if the breaker recloses quickly after tripping. The FP-5000 allows a choice of three different reset functions:

Instantaneous Reset – If the current is less than the programmed pickup current, the accumulated memory is erased.

Time Delay – This is exactly like the instantaneous reset except the current must be below pickup for the set number of cycles before the accumulated memory is removed.

Calculated – For the thermal curves, the following reset time is given to zero the accumulated memory:

$$t(I) = -5 \cdot D \cdot K^2$$

t = Time to Reset Accumulated Memory
D = Time Multiplier Setting
K = 1 for Ground, 3 for Phase

Notice that the reset time is independent of the magnitude of the current as long as the current magnitude is below pickup.

The reset function for the ANSI and IEC curves are given in the following equations defined in ANSI C37.112. The constant t_r is defined in Table 8.1.

$$T_{reset} = \frac{t_r \cdot D}{\left(\frac{I}{I_{pu}}\right)^2 - 1}$$

Gr = See Table 8.1
D = Time Multiplier Setting
I = Measured Current
I_{pu} = Pickup Current Setting

The constants for the indicated curve equations are contained in Table 8.1.

Table 8.1 Constants for Inverse Time Overcurrent Curves

CALCULATED CURVES				
Curve Type	**P**	**A**	**B**	**t_r**
ANSI/IEEE				
Moderately Inverse	0.02	0.0515	0.114	4.85
Very Inverse	2	19.61	0.491	21.6
Extremely Inverse	2	28.2	0.1217	29.1
IEC①				
IEC-A	0.02	0.14	0	0.14
IEC-B	1	13.5	0	13.5
IEC-C	2	80	0	80

① FP-5000 does not directly provide IEC-D, IEC-E and IEC-F curves. In the latest IEC standard, IEC-D, IEC-E and IEC-F are the same as ANSI Moderately Inverse, Very Inverse and Extremely Inverse, respectively.

8.3.3 Curve Shapes

The FP-5000 Protective Relay provides circuit breakers with an extensive degree of selective coordination potential, and permits curve shaping over a wide range. The available pickup settings, which are inverse time overcurrent time multiplier settings, and inverse time overcurrent (phase and ground) curve selections are addressed with respect to their effect on the resultant characteristic curve described above. The operating characteristics of the relay are graphically represented by time-current characteristic curves shown in **Figure 8-4**, below.

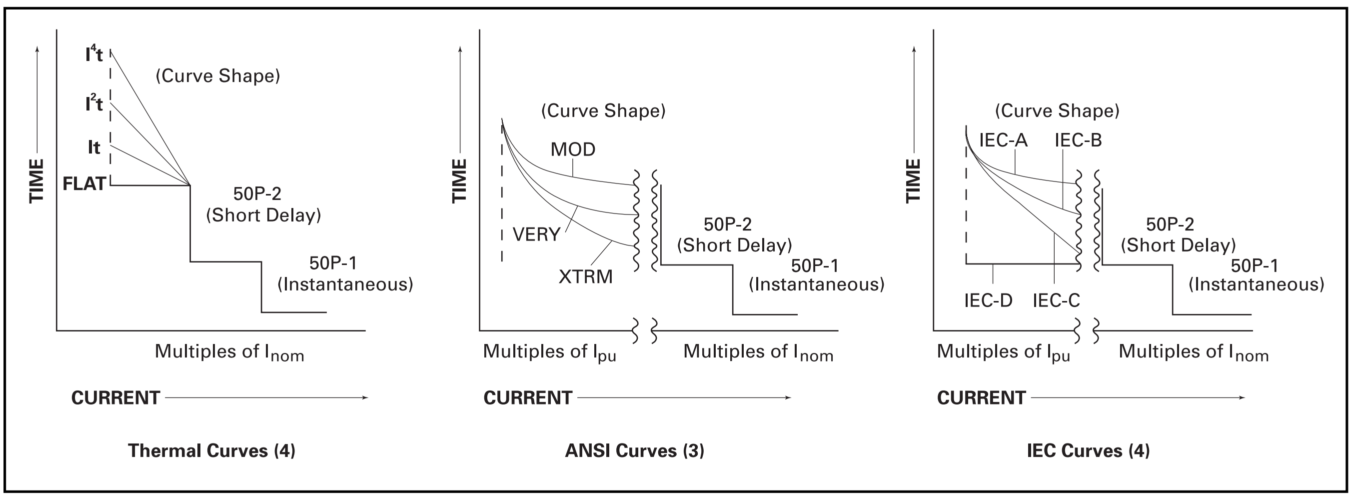

Figure 8-4. FP-5000 Time-Current Characteristic Curves

⚠ NOTICE

AS SHOWN IN FIGURE 8.4, THE ANSI AND IEC "CURVE SHAPES" ARE IN TERMS OF MULTIPLES OF I_{PU}(PICKUP CURRENT OF THE CT PRIMARY), WHEREAS, "SHORT DELAY" AND "INSTANTANEOUS" ARE IN TERMS OF MULTIPLES OF I_{NOM} (5A OR 1A SECONDARY OF CT CURRENT). THE THERMAL CURVE IS REPRESENTED IN TERMS OF MULTIPLES OF I_{NOM} FOR ITS CURVE SHAPE, SHORT DELAY AND INSTANTANEOUS SETTINGS. THIS MUST BE CONSIDERED IN THE COORDINATION STUDY AND IN THE PROGRAMMING OF THE FP-5000 PROTECTIVE RELAY.

The ANSI curves are defined by ANSI C37.112, and IEC curves are defined by IEC 255-3. These curve shapes combined with the customized capability of the short delay and instantaneous functions allow for very versatile coordinated protection schemes. The thermal curve shape is also customized by the user for any desired type of coordinated protection scheme.

These curves show how and when a particular relay will act for given values of time and current. The more versatile the relay, the easier it is to accomplish close coordination and achieve optimum protection. Since the FP-5000 Protective Relay is very versatile, the makeup of a typical curve is presented for clarification.

For the sake of simplification, the curve discussion will center on a single line curve. Keep in mind, however, that a characteristic curve in reality is represented by a band of minimum and maximum values, not a line (**Figure 8-5**, Sample Electronic Trip Curves, below). Minimum and maximum values are generally the result of manufacturing tolerances for components and the relay's accuracy. Any expected value of tripping current or time could be the nominal value anticipated within a plus or minus tolerance. The tolerances are usually stated in terms of the relay's accuracy and frequently highlighted on the actual working curves. Accuracy is stated in terms of a plus or minus percentage and represents a permitted fluctuation on either side of the nominal tripping point for a family of relays, like the FP-5000.

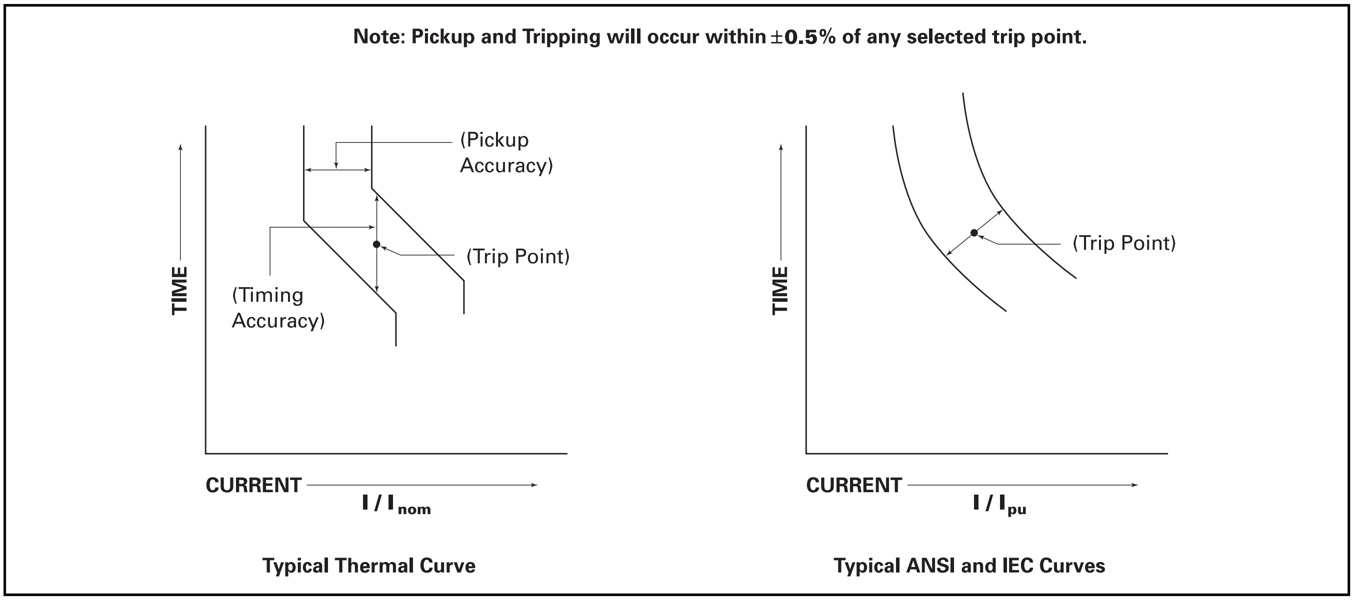

Figure 8-5. Sample Electronic Trip Curves

Adjustability

The adjustability of the relay permits movement of its characteristic curve or parts of the curve. This movement can be done in both a horizontal and vertical direction on the time current grid. The actual shape of the curve can be changed along with the curve movement. This adjustability permits distinct curves to be established to match the electrical protection to the application. (**Figure 8-6** through **Figure 8-11.**) Horizontal movement of the ANSI and IEC curve shapes is controlled by changing the pickup setting. Changing the pickup setting of the thermal curves moves the point at which the relay starts to time out along the curve shape.

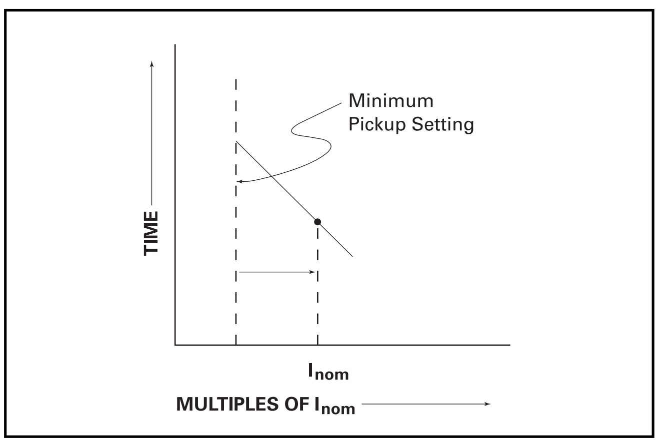

Figure 8-6. Typical Inverse Time Overcurrent Pickup Horizontal Movement

Nominal Current

The nominal primary current I_{nom}, as measured by the FP-5000, is established by the ratio of the selected current transformers. This ratio must by set via the programming of the relay under “System Config” in the Setting Main menu. These settings must agree with the current transformers to which the relay is connected. Therefore, I_{nom} is established by the current transformer ratio used and becomes the primary scale factor for the trip functions and readouts.

Before proceeding with the curve explanation, it should be noted that combining functional capabilities, such as inverse time overcurrent, short delay and instantaneous, is a coordination activity. The effects of one group of settings on another should be understood in order to determine if the results are acceptable under all foreseeable circumstances. This helps to avoid unexpected operations or non-operations in the future. Keep in mind that the FP-5000 operates its trip/alarm algorithms simultaneously and independently. If any one of the algorithms detects a trip condition, the FP-5000 will trip, even though the user may expect one of the other trip curves (algorithms) to prevail. For instance, if the Inverse Time Overcurrent calculation results in a time which is less than the 50P-2 trip time, the FP-5000 will trip; it will not cease ITOC evaluation within the operative domain of the 50P-2 evaluation. (See **Figure 8-7**.) The shaded portion of the curve illustrates the ITOC value less than the 50P-2 Delay time. For the FP-5000, the ITOC time will prevail. The programmable logic may be configured to prevent tripping in this region if desired.

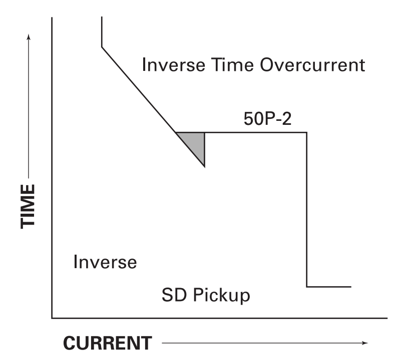

Figure 8-7. Typical Curve with I²t Shape

Inverse Time Overcurrent Protection

Inverse time overcurrent protection consists of a curve shape, pickup setting, and an inverse time multiplier setting. The inverse time overcurrent function offers 10 possible curve shape types as previously described (**Figure 8-4** and Table 8.1). When programming the FP-5000, this will be the first choice to make. The curve shape and its effect on the characteristic curve will be covered with the time multiplier explanations.

The pickup setting establishes the current level pickup at which the relay’s inverse time overcurrent tripping function begins timing. If, after a predetermined amount of time, the current condition that started the timing process still exists, the inverse time overcurrent function operates and the relay’s trip relay is energized. Pickup settings can be adjusted from 0.10 to 4.00 times I_{nom}. **Figure 8-6** graphically illustrates how the beginning of the Thermal Inverse Time Overcurrent Pickup portion of the overall curve can be moved horizontally on the time current grid by means of the pickup settings. The Inverse Time Overcurrent Pickup is represented by the dotted lines, while the rest of the curve is represented by a solid line.

The Time Multiplier setting is used to select a predetermined amount of time a sustained overload condition will be carried before the breaker trips. For the Thermal Curves, a setting is entered by determining the trip time needed at a 3 X I_{nom} overcurrent for phase faults and I_{nom} for ground faults. This value is then divided by 5. For the ANSI and IEC curves, this represents a pure multiplication of the curve as viewed in Section 8.3.2. A wide range of time settings are available for curve shape selection. As Time Multiplier settings are varied, the Time Multiplier portion of the overall curve is moved vertically up or down on the time current grid. This movement is also independent of the other portions of the curve. **Figure 8-8** graphically illustrates the vertical time line movement with an I²t curve shape selection. Similar movement occurs for the remaining curve shapes.

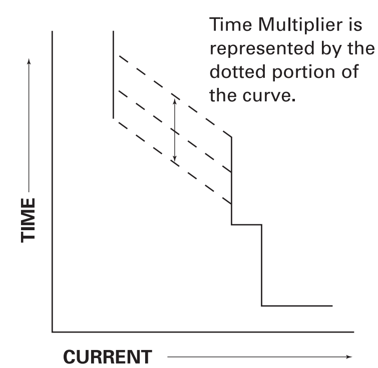

Figure 8-8. Typical Time Multiplier Adjustment (I²t Response)

Timed Overcurrent Protection

Two timed overcurrent functions are provided each for phase I_a, I_b, I_c, I_x and I_r. The pairs are: [50P1, 50P2], [50X1, 50X2] and [50R1, 50R2]. If desired they may be used for the traditional Instantaneous Overcurrent function and the Short Time Delay Overcurrent function. Instantaneous, is achieved by setting the time delay to zero. In most cases the number 1 overcurrent function is set as the instantaneous, and the number 2 as the short delay. However, the setting ranges are identical for the two sets of curves, and they may be set as the user desires.

Instantaneous Protection

Instantaneous (short circuit) protection reacts to high level fault currents. The 50P pickup settings establish the current level at which the FP-5000 picks up on an instantaneous fault. An optional time delay may be programmed for coordination purposes.

If an Instantaneous Setting other than “Disable” is selected, the instantaneous portion of the overall curve can be moved independently in a horizontal direction. **Figure 8-9** graphically illustrates this horizontal movement.

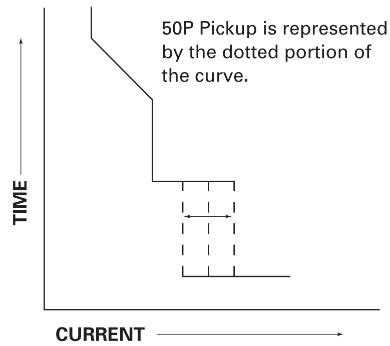

Figure 8-9. 50P (Instantaneous) Setting Adjustment

Ground Fault Protection

The ground fault protection function can be a composite of the ground:

1. Inverse time overcurrent curve shape pickup and time.

2. 50X-2 and 50R-2 (Short delay) pickup and time.

3. 50X-1 and 50R-1(Instantaneous) pickup.

Its curve shape is independent of the phase curve. The inverse time overcurrent time multiplier values for the ground function of the thermal curves are for (1 x I_n) while the phase function is (3 x I_n). Movement of the pickup portion of the curve in a horizontal direction and the time portion of the curve in a vertical direction is similar to phase inverse time overcurrent, short delay and instantaneous functions as previously described. Therefore, the ground fault curve movement is not graphically illustrated. When programming ground fault protection, keep in mind that if “Disable” is selected, the ground fault protection is disabled.

8.3.5 Negative Sequence Current Protection (46)

The FP-5000 provides monitoring and protection based on the percent of current unbalance or negative sequence. The presence of negative sequence current identifies either a phase unbalance in the voltage magnitude or reverse phase rotation condition. The positive and negative sequence currents are calculated from the three phase currents. The % unbalance is the ratio of negative sequence current to positive sequence current (%Unbalance = I_2 / I_1). A current unbalance pickup occurs when I_2 / I_1 exceeds the IUB % Unbalance setting, and I_1 or I_2 magnitude exceeds the IUB Threshold setting. The Current Unbalance trip is set when the pickup condition exists for the delay time specified. The current unbalance pickup and trip is reset when the positive sequence current drops below the IUB Threshold setting or I_2 / I_1 drops below the IUB % Unbalance setting minus 1%. The settings associated with voltage unbalance or negative sequence voltage protection are listed in Table 8.2.

Table 8.2 Negative Sequence Current Protection Settings

Parameter	Range	Step
46-1 IUB Threshold	0.10 to 20 pu, Disabled	0.01 pu
46-1 IUB % Unbalance	4% to 40%	1%
46-1 IUB Delay	0 to 9999 Cycles	1 Cycle
46-2 IUB Threshold	0.10 to 20 pu, Disabled	0.01 pu
46-2 IUB % Unbalance	4% to 40%	1%
46-2 IUB Delay	0 to 9999 Cycles	1 Cycle

8.4 Curve Overlapping Issues

Several calculations are performed simultaneously for the determination of trip and alarm conditions. Each of these trip and alarm criteria are considered independently of each other. Whichever condition occurs first will cause the fault with no additional coordination between the processes.

8.5 Zone Interlocking Behavior and Application

To minimize damage to the system, faults should be cleared as quickly as possible. Zone interlocking provides this capability better than a system with only selective coordination. Zone interlocking functions must be programmed (see Section 5.5.2.9) before they can be used. By default the function is disabled.

The zone interlocking protection scheme provides a way for a protective device to determine if a device, in a downstream zone, picks up a fault and is taking action. With this information, the protective device can immediately trip if no other device is taking action or use its programmed time delay if another device is taking action.

8.5.1 Compatible Zone Interlock Devices

The Cutler-Hammer FP-5000 and DT-3000 protective relays support the zone interlocking function and are compatible with each other. Refer to the DT-3000 instruction book (I.B. 17555) for details on the DT-3000 implementation of the zone interlocking function.

8.5.2 Connection Rules

Zone interlocking information is passed on a two-wire Twisted pair communication pair, see Section 6.11, for complete wiring details. All devices in the same zone wire their zone-out terminals (J3-1 and J3-2) in parallel see **Figure 8-10**. Zone Interlocking Example with FP-5000 and DT-3000. This daisy chained wire pair is then connected to the upstream zone protection device zone-in terminal (J3-4 and J3-2). Up to 10 devices can have their zone-out terminals wired in parallel. Only one device, in the upstream zone should have these wires connected to its zone-in terminals.

Any downstream device can drive the daisy chained wire pair active, signaling that the device is going to take action. In this case the upstream device will not trip immediately but will use the programmed time delay.

8.5.3 Operation (see Figure 8-10).

In general, if configured, the zone-out signal in a FP-5000 is driven when the protective device is picked up on an Instantaneous Over Current (IOC) or Inverse Time Over Current (TOC).

In particular, if the Zone Out setpoint is “Phase” then any phase current IOC or TOC pickup will activate the zone out signal. Ground or residual current IOC or TOC will not activate the signal.

If the Zone Out setpoint is “Ground” then any ground or residual current IOC or TOC will cause activation of zone-out signal. Phase current IOC or TOC will not activate the signal.

If the Zone Out setpoint is “Both” then phase, ground and residual currents over the IOC or TOC pickup levels will cause the zone-out signal to activate.

If the Zone Out setpoint is set to “Disable” then the zone-out signal will not activate.

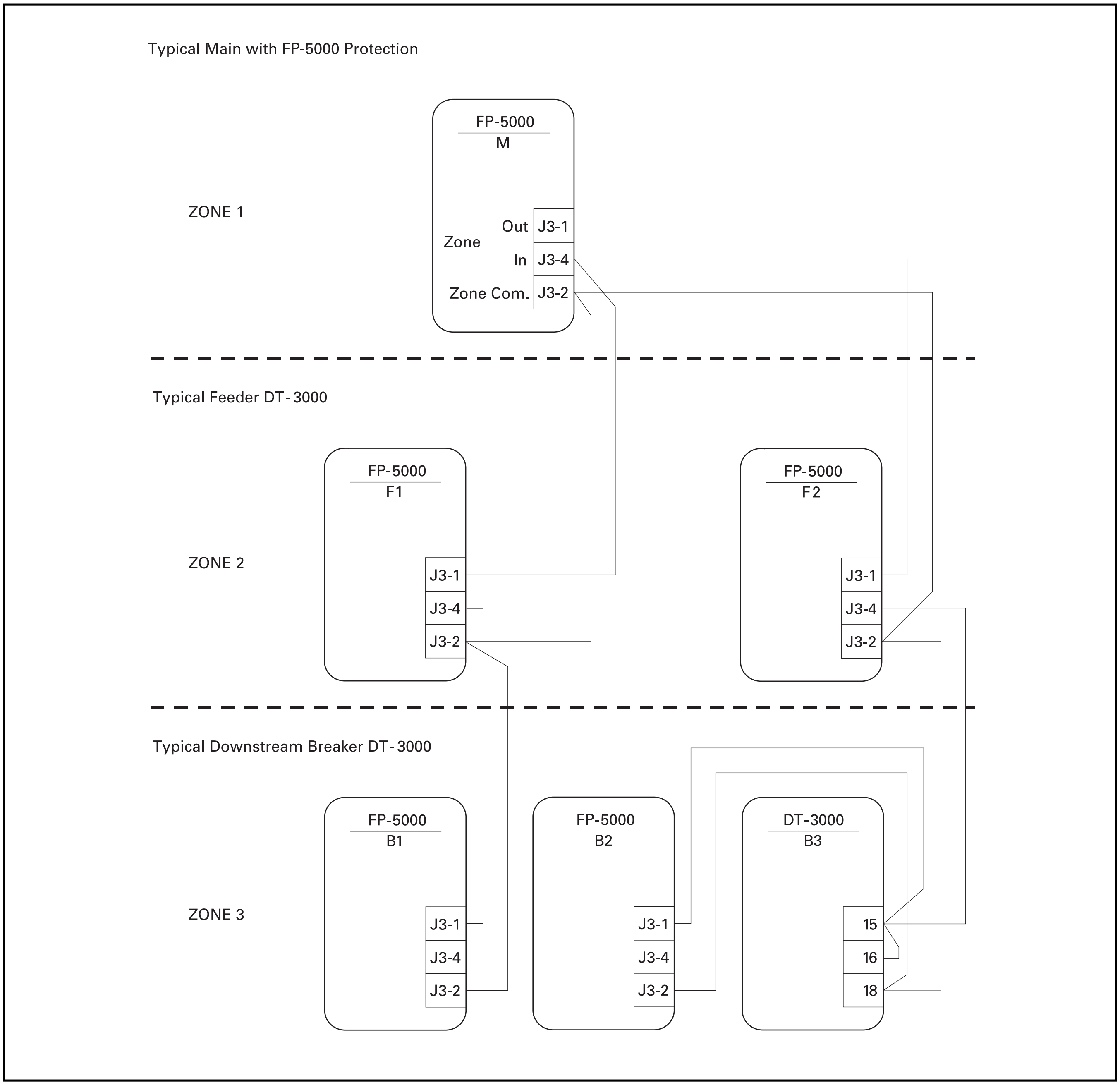

Figure 8-10. Zone Interlocking Example with FP-5000 and DT-3000

In general, if the Zone Interlocking Input is enabled, the absence of a zone-in signal active, and an IOC or TOC pickup occurs, an immediate trip will occur. The immediate trip has a 3-cycle pickup delay to make sure the downstream devices have a chance to activate the zone interlock signal. If the zone-in signal is active, then the programmed delay time is used.

If the Zone In setpoint is set to “Phase” then any phase current above of the IOC pickup or **1.5 times** the TOC pickup will cause an immediate trip in the absence of an active zone-in signal. Ground or residual current IOC or TOC will not cause an immediate trip. The 1.5 time multiplier is used so that a low level current overload does not cause an immediate trip. If the zone-in signal is active then the programmed delay time is used.

If the Zone In setpoint is set to “Ground” then any ground or residual current above the IOC pickup or the TOC pickup will cause an immediate trip in the absence of an active zone-in signal. Phase current IOC or TOC will not cause an immediate trip. If the zone-in signal is active then the programmed delay time is used.

In the case that the breaker that is taking action fails to open the circuit, the zone-out signal is removed in one of two ways:

1. If the breaker fail function is active then the zone out signal is immediately removed. See Section 5 Programming on page 5-1 and Section 8.9 Breaker-Oriented Functions.

2. If the protective relay has operated but the current is still sensed, the zone-out signal is removed 10 cycles after the operation.

8.6 Voltage Functions and Protection

8.6.1 Negative Sequence Voltage Protection (47)

The FP-5000 provides monitoring and protection based on the percent of voltage unbalance or negative sequence voltage. The presence of negative sequence voltage identifies either a phase unbalance or reverse phase rotation condition. The positive and negative sequence voltages are calculated from the three phase voltages. The % unbalance is the ratio of negative sequence voltage to positive sequence voltage (%Unbalance = V_2/V_1). A voltage unbalance pickup occurs when V_2/V_1 exceeds the VUB % Unbalance setting and the V_1 or the V_2 magnitude exceeds the VUB Threshold setting. The Voltage Unbalance trip is set when the pickup condition exists for the delay time specified. The voltage unbalance pickup and trip is reset when the positive sequence voltage drops below the VUB Threshold setting or V_2/V_1 drops below the VUB % Unbalance setting minus 1%.

The settings associated with voltage unbalance or negative sequence voltage protection are listed in Table 8.3 below.

Table 8.3 Negative Sequence Voltage Protection

Parameter	Range	Step
47-1 VUB Threshold	1 to 100V, Disabled	1 V
47-1 VUB % Unbalance	4% to 40%	1%
47-1 VUB Delay	0 to 9999 Cycles	1 Cycle
47-2 VUB Threshold	1 to 100V, Disabled	1 V
47-2 VUB % Unbalance	4% to 40%	1%
47-2 VUB Delay	0 to 9999 Cycles	1 Cycle

8.6.2 Undervoltage (27) and Overvoltage (59) Protection

Separate undervoltage and overvoltage protective elements are provided for the main voltage inputs (V_A, V_B, V_C) and the auxiliary voltage input (V_X). Two elements are provided for each function so alarm and trip levels can be set independently. Each of the voltage protection functions has a Threshold and a Delay setting. The optional time delay is provided for coordination with other devices.

An overvoltage pickup occurs when the measured voltage exceeds the OV Threshold setting. The overvoltage trip flag is set when the voltage exceeds the threshold setting for the delay time specified. The overvoltage pickup and trip is reset when the voltage drops below 98% of the OV Threshold setting.

An undervoltage pickup occurs when the measured voltage drops below the UV Threshold setting. The undervoltage trip is set when the voltage stays below the threshold setting for the delay time specified. The undervoltage pickup and trip is reset when the voltage raises above 102% of the UV Threshold setting.

The Main OV and UV Pickup and Delay settings apply to all three phase voltages, V_A, V_B and V_C.

The settings for the voltage protection functions are shown in Table 8.4.

Table 8.4 Voltage Protection Settings

Parameter	Range	Step
59-M1 Main Overvoltage Threshold	10 to 150V, Disabled	1V
59-M1 Main Overvoltage Delay	0 to 9999 Cycles	1 Cycle
59-M2 Main Overvoltage Threshold	10 to 150V, Disabled	1V
59-M2 Main Overvoltage Delay	0 to 9999 Cycles	1 Cycle
27-M1 Main Undervoltage Threshold	10 to 150V, Disabled	1 V
27-M1 Main Undervoltage Delay	0 to 9999 Cycles	1 Cycle
27-M2 Main Undervoltage Threshold	10 to 150V, Disabled	1 V
27-M2 Main Undervoltage Delay	0 to 9999 Cycles	1 Cycle
59-A1 Auxiliary Overvoltage Threshold	10 to 250V, Disabled	1V
59-A1 Auxiliary Overvoltage Delay	0 to 9999 Cycles	1 Cycle
59-A2 Auxiliary Overvoltage Threshold	10 to 250V, Disabled	1V
59-A2 Auxiliary Overvoltage Delay	0 to 9999 Cycles	1 Cycle
27-A1 Auxiliary Undervoltage Threshold	10 to 250V, Disabled	1 V
27-A1 Auxiliary Undervoltage Delay	0 to 9999 Cycles	1 Cycle
27-A2 Auxiliary Undervoltage Threshold	10 to 250V, Disabled	1 V
27-A2 Auxiliary Undervoltage Delay	0 to 9999 Cycles	1 Cycle

8.7 Wye versus Delta Voltage Transformers

The FP-5000 requires setting of system configuration parameters for proper operation of all system functions (see programming Section 5.1). All voltage settings are based on the VT input configuration. Both wye (ϕ - G) and Delta (ϕ - ϕ) voltage connections are supported. For wye-connected systems, the voltage settings are based on phase-to-ground voltages. Voltage settings are based on phase-to-phase voltages for delta-connected systems.

8.8 Frequency Protection (81)

The FP-5000 includes protective functions for detecting under-frequency and over-frequency conditions. Two elements are provided for each function so alarm and trip levels can be set independently. Each of the frequency protection functions has a Threshold and a Delay setting. The time delay is provided for coordination with other devices. If the voltage on phase A drops below 10 volts, the under-frequency and over-frequency functions are disabled.

An over-frequency pickup occurs when the measured frequency exceeds the over-frequency Threshold setting. The over-frequency trip is set when the over-frequency condition exists for the delay time specified. The over-frequency pickup and trip are reset when the frequency drops below the over-frequency Threshold setting.

An under-frequency pickup occurs when the measured frequency drops below the under-frequency Threshold setting. The under-frequency trip is set when the under-frequency condition exists for the delay time specified. The under-frequency pickup and trip is reset when the frequency raises above the under-frequency Threshold setting.

The settings for the over-frequency and under-frequency functions are shown in Section 5, Programming and are repeated in Table 8.5.

Table 8.5 Frequency Protection Settings

Parameter	Range	Step
81U-1 Under Frequency Threshold	45 to 65 Hz, Disabled	0.1 Hz
81U-1 Under Frequency Time Delay	0 to 9999 Cycles	1 Cycle
81O-1 Over Frequency Threshold	45 to 65 Hz, Disabled	0.1 Hz
81O-1 Over Frequency Time Delay	0 to 9999 Cycles	1 Cycle
81U-2 Under Frequency Threshold	45 to 65 Hz, Disabled	0.1 Hz
81U-2 Under Frequency Time Delay	0 to 9999 Cycles	1 Cycle
81O-2 Over Frequency Threshold	45 to 65 Hz, Disabled	0.1 Hz
81O-2 Over Frequency Time Delay	0 to 9999 Cycles	1 Cycle

8.9 Breaker-Oriented Functions

8.9.1 Breaker State

Circuit breakers typically have both a 52a contact and a 52b contact. The FP-5000 reports breaker state based on either one or both of these inputs. It is recommended that both be used. When both are used the FP-5000 can alarm if a conflict between the two signals exists (see Breaker State Alarm below). By default, Contact Input 1 is configured as 52a and Contact Input 2 as 52b, but any of the eight contact inputs can be configured as inputs to read the 52a or 52b breaker contact outputs. Never configure more than one input to be 52a or 52b.

When the breaker is closed, the 52a breaker contact output is closed and the 52b breaker output is open.

When the breaker is open, the 52a breaker contact output is open and the 52b breaker output is closed.

The "Breaker Closed" and "Breaker Open" LEDs on the front face panel are only operational if at least one contact input is programmed to be 52a or 52b. The "Breaker Closed" LED will light when the 52a contact input is on and/or the 52b contact is off. The "Breaker Open" LED will light when the 52a contact input is off and/or the 52b contact is on.

8.9.2 Breaker Close

The FP-5000 has been designed to issue a close breaker signal from one of its programmable contact outputs. The default configuration maps the Close Breaker function to contact output relay 5. This relay can be made to operate for 45 line cycles when commanded, giving a pulsed on function. The Close Breaker function can be initiated from four different sources:

- Front panel Close Breaker pushbutton, if enabled by System Configuration "Bkr Operation PB" setting (see Section 5).
- Test menu Close Breaker function.
- Communication Close Breaker command, if enabled by System Configuration "Remote Bkr" setting (see Section 5).
- Contact input programmed to Remote Close.

By using the FP-5000 to close the breaker, the following advantages of built-in logic are obtained:

- Close signal is prevented after breaker failure (see 8.9.5 Breaker Failure).
- Close signal is prevented while the FP-5000 Trip 1 output relay is active.
- Closed signal is prevented if the configured input Breaker Trouble is active (see 8.9.7 Breaker Trouble).
- Closed signal is prevented if the breaker is already in the closed state.
- Closed signal is prevented if the open signal is being requested.
- A slow breaker alarm is raised if the breaker closes too slowly (see 8.9.8 Slow Breaker Time).
- If the faceplate pushbutton is used, a warning message is given if already in the closed state or a breaker state alarm (see 8.9.6 Breaker State Alarm) is active, or a slow breaker alarm (see 8.9.8 Slow Breaker Time) is active.

8.9.3 Breaker Open

The FP-5000 has been designed to issue an open breaker signal from one of its programmable contact outputs. The default configuration maps the Open Breaker function to contact output relay Trip 1. This relay can be made to operate for 30 line cycles after the removal of the opening signal. The Open Breaker function can be initiated from different sources:

- Front panel Open Breaker pushbutton, if enabled by System Configuration "Bkr Operation PB" setting (see Section 4.2).
- Test menu Open Breaker function.
- Communication Open Breaker command, if enabled by System Configuration "Remote Bkr" setting (see Section 4.2).
- Contact input programmed to Remote Open.

By using the FP-5000 to open the breaker, the following advantages of built-in logic are obtained:

- A slow breaker alarm is raised if the breaker opens too slowly (see 8.9.8 Slow Breaker Time).
- If the faceplate pushbutton is used, a warning message is given if already in the open state or a breaker state alarm (see 8.9.6 Breaker State Alarm) is active, or a slow breaker alarm (see 8.9.8 Slow Breaker Time) is active.

8.9.4 Breaker Trip and Open Coil Supervision

The FP-5000 includes optional Trip Coil Supervision on the Trip 1 output relay and Close Coil Supervision on the Trip 2 output relay. When the coil supervision alarm activates, it indicates wiring to a coil or the coil itself has an electrical open circuit.

In the case of Trip Coil Supervision, a trickle current is sensed across the Trip 1 relay output contacts whenever the breaker state is closed and the Trip 1 relay is open. Since the state of the breaker must be known, this function is operational only if at least one contact input is configured as 52a or 52b. In addition, the Trip 1 relay Monitor setting must be set to "On" and one of the inputs set to "Breaker, OpenBkr" (see Section 4.2). By default, if this alarm should occur the alarm contact output relay will close.

⚠ WARNING

IF THE TRIP 1 MONITOR ALARM IS ACTIVE, THIS IS AN INDICATION THAT THE TRIP CIRCUIT MIGHT NOT BE ABLE TO OPEN THE BREAKER IF A FAULT SHOULD OCCUR. IMMEDIATE INVESTIGATION OF THE CIRCUIT SHOULD BE PERFORMED.

In the case of Close Coil Supervision, a trickle current is sensed across the Trip 2 relay output contacts whenever the breaker state is open and the Trip 2 relay is open. Since the state of the breaker must be known this function is operational only if at least one contact input is configured as 52a or 52b. In addition, the Trip 2 relay Monitor setting must be set to "On" and one of the inputs set to "Breaker, CloseBkr" (see Section 4.2). By default, if this alarm should occur the alarm contact output relay will close. If the Trip 2 Monitor Alarm is active, this is an indication that the close breaker circuit might not be able to close the breaker, if so desired.

8.9.5 Breaker Failure (50BF)

The FP-5000 Breaker Failure function provides the option of local tripping when a BFI Contact Input is detected and optional output relay operation if local breaker failure is detected.

Table 8.6 lists the relevant setpoints to the breaker fail functions see programming Section 5.1.

Table 8.6 Breaker Failure Settings

Parameter	Range	Step
Breaker Failure Configuration	Off, Int, Ext, Both	
BF Phase Current	0.1 to 5 x Ct Rating, Disable	0.01 x Ct Rating
BF Ground Current	0.1 to 5 x Ct Rating, Disable	0.01 x Ct Rating
Breaker Failure Delay Time	0 to 9999 Cycles	1 Cycle
Contact Input X Configuration	BFI	
Output Gate Rly X	Trip, BF	

If the Breaker Failure Configuration is programmed to Off then no Breaker Failure function is possible. The default configuration for Breaker Failure Configuration is Off.

If the Breaker Failure Configuration is set to “Int”; if an IOC or TOC phase, ground, or residual trip operation occurs; if after Breaker Failure Delay Time cycles the current is above BF Phase or BF Ground current limits — then the Breaker Failure (BF) Trip indication is given as well as the Breaker Failure Lockout indication. If BF Trip is true then a programmed contact output relay will activate. By default Output Gate Relay 3 is programmed for this function. When the Breaker Failure Lockout is true then the FP-5000 close command is locked out until reset. Reset is accomplished with a special reset command in the reset menu different from the trip reset.

If the Breaker Failure Configuration is set to “Ext” and if a contact input is configured to be “BFI” and is true, then a breaker failure pickup initiates a trip operation without delay. If after Breaker Failure Delay cycles, the current is above BF Phase or BF Ground current limits, then the Breaker Failure (BF) Trip indication is given along with the BF lockout indication. By default, contact input 3 is configured to BFI. Reset is accomplished with a special reset command in the reset menu different from the trip reset.

It can be seen that a downstream device might use the Breaker Failure Configuration “Int” to issue a breaker failure event, and use the “Ext” setting in an upstream breaker to immediately trip upon downstream breaker failure.

If the Breaker Failure Configuration is set to “Both” then both “Int” and “Ext” function operate independently as explained above.

8.9.6 Breaker State Alarm

The Breaker State Alarm reports contact disagreement if both 52a and 52b remain in the same state for more than 30 cycles. By default, the alarm contact output relay will close.

8.9.7 Breaker Trouble

Any of the eight contact inputs (Cin1 – Cin8) can be configured as Breaker Trouble. Contact input 4 is so configured by default. If external logic determines that the breaker has failed in some way then it can activate this contact input. If this input is true and the FP-5000 gives the command to close the breaker then the closed breaker command will be locked out until the signal goes to the inactive state.

8.9.8 Slow Breaker Time

If the FP-5000 is used to issue the close and open breaker signal to the breaker, and if at least 52a or 52b is configured to a contact input then the Slow Breaker Time Monitoring is activated. If a breaker close command is issued from one of the FP-5000 output relays, the state of the breaker is monitored to see how long it takes for the 52a to activate or the 52b to deactivate. If it takes more than 40 cycles for the breaker to change to the closed state, the slow breaker time alarm is raised. By default the alarm contact output relay will close.

Likewise if the open command is given and the breaker takes more than 15 line cycles to change to the open state the slow breaker time alarm is raised. By default the alarm contact output relay will close.

8.10 Setting Up Oscillographic Data Capture

The FP-5000 can capture oscillographic waveforms based on a number of triggers. This function is useful to capture waveform data during faults and abnormal events for later analysis. The oscillographic data can be viewed using the Cutler-Hammer PowerNet software package equipped with the NPWAVEFORM component. All four voltage, and four current inputs are captured when a trigger occurs and are available for display. The waveform data consists of 32 samples a cycle. Table 8.7 list the setpoints used for setting up the oscillographic data waveform capture function.

Table 8.7 Waveform Capture Setpoints

Parameter	Range	Units
Records	4 X 64, 8 X 32, 16 X 16	# of Waveforms X # of Cycles Recorded
Pre-Trigger	1 – 15	Line Cycles
OSC Trigger	Trip 2, dV/dI, Logic LG6, Cntrl PB, Comm	Disable, Overwrite, Lock

The Records setpoint defines how many sets of all inputs can be captured per the number of cycles recorded. By default, 16 waveform sets will be available with a recorded length of 16 line cycles long. A smaller number of waveform sets can be selected allowing for a longer recording time of 32 or 64 cycles. In all cases each cycle of data contains 32 data points.

The Pre-Trigger setpoint defines the number of cycles captured and recorded before the defined trigger event. The pre-trigger applies to all waveform sets captured. By default 2 cycles will be recorded before the trigger event, and 14 cycles after the trigger event.

The OSC Trigger describes the events that can cause a trigger of the waveform capture. Each event is described as:

- Trip 1 relay closing – this is by default and cannot be turned off.
- Trip 2 relay closing.
- dV/dI disturbance detection – All eight voltage and current inputs are converted to real and imaginary phasor quantity each cycle. If the latest cycle real or imaginary phasor quantity has changed + 12.5% from the previous cycle value, and if a voltage value is greater than 5 volts or if a current value is greater than .5 per unit than a waveform trigger occurs.
- Logic LG6 – Logic Gate 6 (See Section 9 Programmable Logic, and Section 5 Table 5.7 for LG6 programming) is used to cause a waveform trigger. This logic gate can be used to trigger on any combination of trip, pickup and alarm events. It is a powerful selection tool to make sure that only the waveforms needed are captured.
- Cntrl PB – This enables a waveform trigger from the front face-plate of the FP-5000. The menu selection can be found by pressing the “Status/Control” button, selecting control and pressing enter, selecting “Trig Waveform Capt” and pressing enter, and pressing enter a second time. This trigger is useful to test the waveform capture system.
- Comm – This enables waveform triggering through external communication means.

Each trigger described above can be set to one of three settings: Disable, Overwrite and Lock. If programmed as “Disable” then the waveform trigger cannot occur. If programmed as “Overwrite” or “Lock”, when the trigger event occurs, a new waveform will be captured if space is available. The FP-5000 will use the programmed number of record space (16, 8 or 4 records) in the following order:

1. If a waveform record space is empty it will be used. A space is empty when no waveform has ever been written to it or the previous waveform was cleared after being downloaded over the communication channel.
2. If a waveform record was recorded with an “Overwrite” trigger then the oldest overwrite record will be written over.
3. If a waveform record has been recorded due to a “Lock” trigger event then no other waveform capture can overwrite this record until it has been downloaded over the communications channel. The Trip 1 event is always a “Lock” trigger.

If all the previously recorded waveforms are locked then the new waveform capture is lost. All new capture will be lost until waveforms are downloaded.

8.11 Data Logging Functions

The FP-5000 can capture selected measured data at selected periodic intervals of time. This function is useful to capture trends over longer periods of time. Up to 1024 sets of measured data can be recorded. The logged data can be viewed using the Cutler-Hammer PowerNet software package equipped with the NPMONITOR component. Eight different measured data parameters will be recorded at the programmed interval.

Table 8.8 lists the setpoints used for setting up the data logging function.

Table 8.8 Data Logging Setpoints

Parameter	Range	Units
Mode	Cont., 1-Pass	
Trigger	Auto, Manual	
Interval(s)	1-3600	Seconds
Value 1 – Value 8	See text description below	

The Mode setpoint will determine if the recording of data wraps around to the oldest recorded values or stops recording after all 1024 data records are taken. If the setpoint is Cont the data wraps around and is continuously recorded. If the setpoint is 1-Pass then the data is recorded 1024 times at the programmed interval and then stops.

The Trigger setpoint determines what will start the data logging process. If set to Auto then upon saving and exiting the program mode the data logging will begin. If Manual is selected then any one of the following events will cause the data logging function to start:

- Contact Input – One of the contact inputs can be configured to Data log Trigger, when this input becomes true the data logging function is started.
- Control Pushbutton – A data logging function is started from the FP-5000 front faceplate. This can be accomplished by pushing the “Status/Control” button, selecting Control and pressing enter, selecting Trigger Datalogger and pressing enter, and pressing enter a second time. This function is useful for testing the data logging function.
- Communication Channel – Using external communications channel to initiate the data logging function.

The Interval setpoint determines how often data will be recorded. This parameter along with the knowledge that the data will be sampled a maximum of 1024 times sets the period of time that the logging will take place without loss of information. If set to 1 second, the total time of recording of data without loss is 17 minutes and 4 seconds. If set to 3600 seconds, the total time of recording of data without loss is 42 days, 16 hours.

The Value setpoints, eight in all, describe what data values are recorded at each interval. Eight data measurements can be selected from the following:

- All current inputs (IA, IB, IC, IX, IR, Iavg).
- All current sequential components (I0, I1, I2).
- All phase current demand (IA Demand, IB Demand, IC Demand).
- All phase current Total Harmonic Distortion (IA THD, IB THD, IC THD).
- All Wye voltage inputs (VA, VB, VC, VLNavg,). Use only if voltage connection is Wye.
- All phase-to-phase voltage inputs (VAB, VBC, VCA, VLLavg).
- Auxiliary voltage (VX).
- All voltage sequential components (V0, V1, V2).
- All Wye voltage Total Harmonic Distortion (VA THD, VB THD, VC THD). Use only if voltage connection is Wye.
- All Delta Voltage Total Harmonic Distortion (VAB THD, VBC THD, VCA THD). Use only if voltage connection is Delta.

- All power measurements (W, var, VA).
- All power demand measurements (W, var, VA).
- All power factor measurements (Dsp PF, App PF).
- The voltage frequency.
- All contact inputs (Cin1 – Cin8).
- All logic block outputs (LB1 – LB6).
- All timer block outputs (TB1 – TB6).

If the data logger is programmed to 1-Pass then a trigger will not be recognized until the data logger is reset. The data logger can have its data reset in one of the following ways:

- Front Panel Reset – Press the reset button until the “Reset Main” menu is displayed, select “Datalog Trigger” and press enter, press enter again.
- Communication – A reset is performed through an external communication command being given.

9 PROGRAMMABLE LOGIC APPLICATION

The FP-5000 Protective Relay includes programmable logic for programming inputs, outputs, blocking of protective functions, and custom logic functions in the relay. The logic provides control of the output relays based on the state of the contact inputs, protective function pickup, protective function operation, breaker state, system alarms, and internal logic.

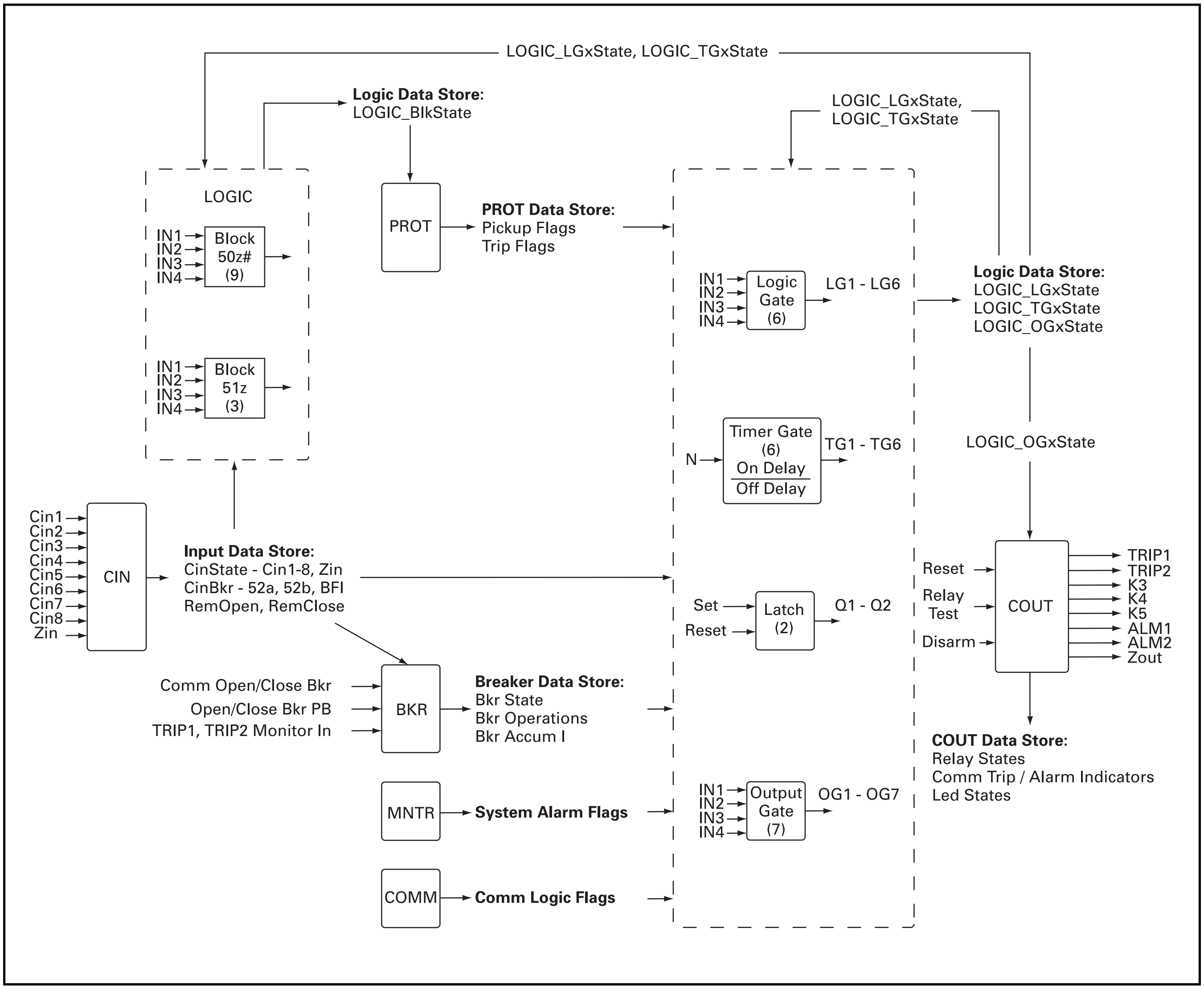

Figure 9-1. Overall Logic Diagram

9.1 Contact Inputs

The FP-5000 is equipped with eight optically isolated inputs that may be configured as inputs to pre-defined FP-5000 functions or for custom logic applications. The contact inputs are either ON (external contact closed) or OFF (external contact open). They are “debounced” for one power line cycle to prevent false operation from transient signals. Because of the debouncing, signals are not processed until the input remains stable for one cycle.

The contact inputs are designed to be activated by connecting the “C In Source” voltage on terminal block TB2 to the desired inputs through a dry contact, typically an external switch, pushbutton, or relay contact. See Section 6.2.5.

The contact inputs can be configured as circuit breaker logic inputs, Remote Reset, Setting Group Selection, Datalogger Trigger, Demand Sync, or for user-defined logic functions. The contact inputs can also be programmed as an input to any logic gate. The logic gates provide blocking of the protective functions, operation of the output relays, and provisions for custom logic. The Contact Input setting options are shown below. With the exception of the user-defined option, each function can be programmed to only one contact input.

- 52a
- 52b
- Breaker Failure Initiate (BFI)
- Breaker Trouble
- Remote Open
- Remote Close
- Remote Reset
- Datalogger Trigger
- Demand Sync
- Setting Group 1
- Setting Group 2
- User Defined

The FP-5000 is shipped from the factory with default settings for the Contact Inputs. It is necessary to change the System Configuration setting (activated by the “Set” pushbutton) “I/O Config” from “Default” to “Custom” to change the programmed function of the inputs. The eight inputs are pre-defined with the following default functions when the input configuration is set to default.

Cin1	52a (Open/Trip) Circuit Breaker Feedback
Cin2	52b (Close) Circuit Breaker Feedback
Cin3	BFI, External Breaker Failure Initiation
Cin4	Breaker Trouble
Cin5	Remote Breaker Open (If Enabled in Settings)
Cin6	Remote Breaker Close (If Enabled in Settings)
Cin7	Remote FP-5000 Reset
Cin8	User Defined

9.2 Output Relays

The FP-5000 is equipped with seven electromechanical output relays. The relays include five Form A output relays (Trip1, Trip2, Rly3, Rly4, Rly5), one Form C Alarm output relay, and a Form C Relay Healthy Alarm relay. The functionality of the Relay Healthy alarm is fixed. The functionality of the remaining six relays is programmed via the “Output Config” setting sub-menu (activated by the “Set” pushbutton). A 4-input logic gate is associated with each of these six outputs. Each output of the logic gate can be configured as an AND, OR, NAND, or NOR gate. The relays are energized based on the output logic gate programming and de-energized based on the dropout setting.

Output relay operation may be programmed as Latched, Unlatched, or Off Delay. The output relay is energized when any of the features programmed to the Output Logic Gate operate. A description of the dropout for each mode of operation follows:

Unlatched	When configured for Unlatched operation, the state of the output relay directly follows the output state of the associated Output Logic Gate. The output relay remains in the energized state until all features programmed to operate the relay return to the non-operated state.
Off Delay	When configured for Off Delay operation, the output relay remains energized for an additional Off Delay time after the Logic Gate output clears. The output relay remains energized until all features programmed to operate the relay return to the non-operated state and the number of cycles specified in the Off Delay setpoint has expired. The off-delay timer is started when all features programmed to operate the relay return to the non-operated state.
Latched	With the dropout set to Latched, a reset signal is required to de-energize the output relay. The Trip1, Trip2, and Alarm output relays are de-energized by a reset from the front panel Reset Trip, the Remote Reset contact input, or a communication Remote Reset command. The six programmable relays may be de-energized by a reset from the front panel Reset Relay menu or a communication Deactivate Relay command. This mode is used to provide a “lockout” function or for operations that must be acknowledged.

The FP-5000 provides optional Trip Coil Supervision of the Trip1 output relay and Close Coil Supervision of the Trip2 output relay. The coil monitoring functions are enabled in the “Output Config” setting menu (activated by the “Set” pushbutton) for the Trip1 and Trip2 relays.

The FP-5000 is shipped from the factory with default settings for the Outputs. It will be necessary to change the System Configuration setting “I/O Config” from “Default” to “Custom” to change the programmed function of the outputs. See Default settings in Table 9.1.

Table 9.1 Output Configuration Default Relay Settings

Output	Gate	Function	Inputs	Dropout
Trip 1 Relay	OG1	OR	Any Protection Trip, Open Breaker	5-cycle Off Delay
Trip 2 Relay	OG2	Disabled	unused	
Relay 3	OG3	OR	Breaker Failure Trip	Latched
Relay 4	OG4	Disabled	unused	
Relay 5	OG5	OR	Close Breaker	10-cycle Off Delay
Alarm Relay	OG6	OR	Any Protection Trip, Any Alarm Trip, Any System Alarm, Any Breaker Alarm	Latched
Healthy Relay	N/A		Not Programmable	

In addition to the output relays, the Auxiliary LED and the Pickup, Trip and Alarm Indicators are also programmable. The programming for the Auxiliary LED uses the same type of Output Logic Gate (OG7) as the output relays. The Trip and Alarm Indicators are programmed as the OR of the seven output relays. Each of the output relays is enabled or disabled from inclusion in the OR function. See **Figure 9-2** Trip and Alarm Indicator/Pickup Indicator.

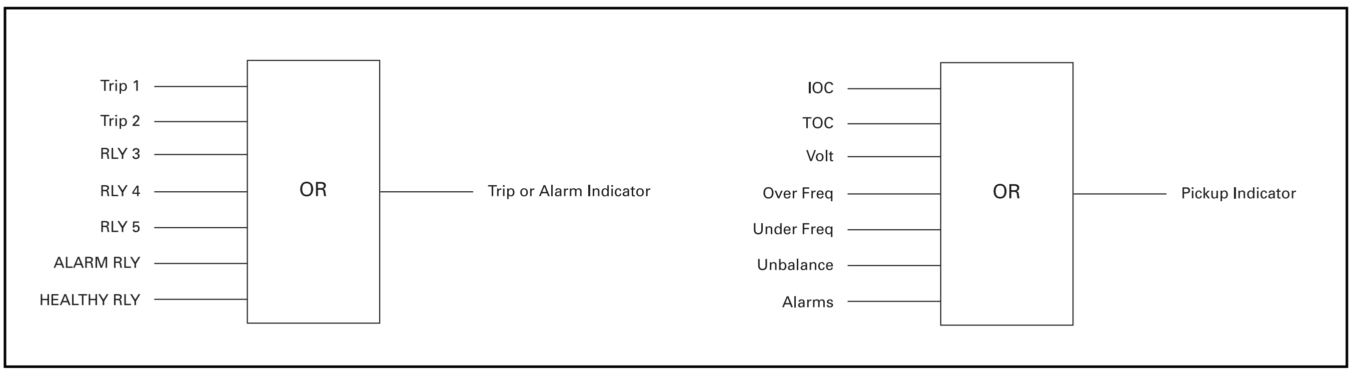

Figure 9-2. Trip and Alarm Indicator/Pickup Indicator

The Pickup Indicator is programmed as the OR of the protective functions. Each of the protective categories IOC, TOC, Voltage, Over Frequency, Under Frequency, Unbalance, and Protection Alarms is enabled or disabled from inclusion in the OR function. The dropout of the Trip, Alarm and Pickup Indicators can be set to latched or unlatched operation. See Default settings in Table 9.2.

Table 9.2 Output Configuration Default Indicator Settings

Output	Gate	Function	Inputs	Dropout
Auxiliary LED	OG7	OR	unused	
Trip Indicator	N/A	OR	Trip 1, Trip 2	Latched
Alarm Indicator	N/A	OR	Alarm Relay, Healthy Relay Dropout	Latched
Pickup Indicator	N/A	OR	IOC, TOC, Voltage, Frequency, Unbalance	Unlatched

Note: Relay K7 is always Relay Healthy. It is energized when all internal diagnostics pass, and de-energized when any diagnostic warning or failure is detected.

9.2.1 Relay Test

The FP-5000 has provisions for testing the output relays individually or as a group. From the front panel Test menu, use the Operate Relays and Reset Relays menu functions to energize and de-energize the relays. The same functionality is provided via the communication interface. When a relay is energized using the Relay Test function, it will remain energized until it is de-energized through the Reset menu, Test menu or Remote Reset.

9.2.2 Disarm Trip

The FP-5000 relay can be disarmed to prevent operation of the Trip 1 and Trip 2 output relays during testing. When the Disarm Control System Configuration setting is Enabled (activated by the “Set” pushbutton), the user can Disarm tripping using the Test menu Arm/ Disarm Trip function (activated by the “Test” pushbutton). The Relay Healthy Alarm is de-energized when tripping is disarmed.

9.3 Programmable Logic Elements

The FP-5000 provides programmable logic for programming custom functions. The Programmable Logic functions include 12 blocking gates for the overcurrent protective functions, six logic gates, six timer gates, two latches, and seven output gates. The basic logic element for the blocking gates, logic gates, and output gates is a 4-input logic gate that can be configured as Disabled, or as an AND, OR, NAND, or NOR function. Each logic gate accepts up to four inputs, which can be entered directly or negated. The following table shows the output of each function for any combination of inputs.

Table 9.3 Logic Functions

Inputs				Outputs			
IN1	**IN2**	**IN3**	**IN4**	**OR**	**AND**	**NOR**	**NAND**
0	0	0	0	0	0	1	1
0	0	0	1	1	0	0	1
0	0	1	0	1	0	0	1
0	0	1	1	1	0	0	1
0	1	0	0	1	0	0	1
0	1	0	1	1	0	0	1
0	1	1	0	1	0	0	1
0	1	1	1	1	0	0	1
1	0	0	0	1	0	0	1
1	0	0	1	1	0	0	1
1	0	1	0	1	0	0	1
1	0	1	1	1	0	0	1
1	1	0	0	1	0	0	1
1	1	0	1	1	0	0	1
1	1	1	0	1	0	0	1
1	1	1	1	1	1	0	0

Each timer gate has a single input and a single output with internal on-delay and off-delay timers. The setting range on the timers is 0 to 9999 cycles with 1-cycle resolution. The latches include a set input and a reset input. The reset input has the highest priority. If both the set and reset inputs are active, the latch output is inactive. A diagram of each logic gate is shown in **Figure 9-3** Programmable Logic Elements.

A programmable logic gate or timer gate output may be connected to other timer or logic gates, used to trigger waveform capture (Logic Gate 6), or tied to an output gate to control an output relay.

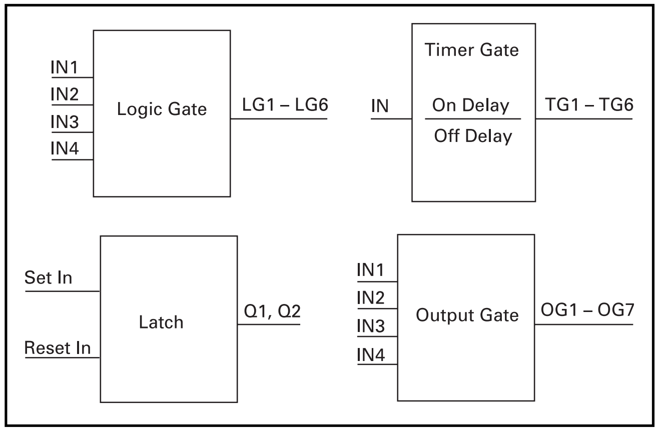

Figure 9-3. Programmable Logic Elements

The default settings for the input and output functions are defined in the previous sections. The default settings for the remaining logic functions are disabled or unused. User Defined logic may only be entered under the Set Mode if the “Prog Logic” setting in the System Configuration menu is changed from Default to Custom.

If a diagnostic failure is detected, the protective functions and logic functions are disabled and the Relay Healthy Alarm relay is de-energized. The other relays will not change state.

9.4 Trip and Alarm Blocking

The FP-5000 has blocking logic functions to block operation of the overcurrent protective functions. A Blocking logic gate is provided for each of the nine instantaneous overcurrent and three inverse-time overcurrent protective functions. They are: 50X-1, 50X-2, 50X-3, 50R-1, 50R-2, 50R-3, 50P-1, 50P-2, 50P-3, 51P, 51R, 51X. Each logic gate can be configured as Disabled or as an AND, OR, NAND, or NOR function. Each logic gate accepts up to four inputs, which can be entered directly or negated.

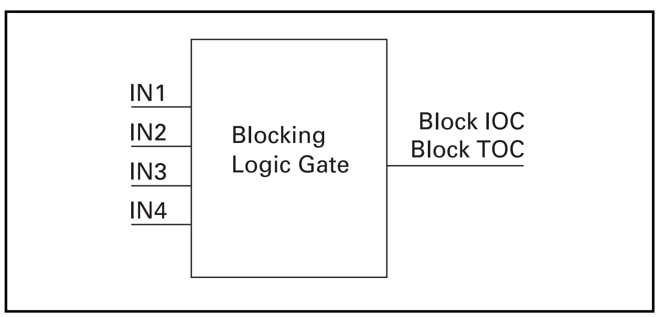

Figure 9-4. Blocking Logic Gate

9.5 Logic Operation by the FP-5000

From the internal operation of the FP-5000, the pickup and operation state of protective functions, system alarms, and breaker logic are set as operation dictates and as described in other sections of this manual (e.g. Inverse Time Overcurrent Pickup). The FP-5000 maintains a "Data Store" or image of the state of the outputs from each function. The FP-5000 uses the value from the Data Store, according to what the user has specified in the Setting Mode, to determine the output state of each logic element. The user has a selection of logical elements available that are connected together by the use of programming references within the "Set Mode" rather than with wires. The various logic gates and other logical elements are "connected" together using symbolic references within the "Set Mode."

The logical elements are:

- Eight electrically isolated contact inputs (Cin1 – Cin8).
- A Zone Interlock input (Zin).
- Six flexible logic gates (LG1 – LG6).
- Six timer gates with programmable on delay and/or programmable off delay (TG1 – TG6).
- Logic latches (Q1 – Q2).
- System status associated with Pickup and Timeout of protective functions, operation of Monitoring Mode System Alarms, Breaker monitoring and control, and communication logic states.
- Seven flexible Output logic gates (OGI – OG7).

The FP-5000 functions are processed in the following order to ensure proper and predictable operation of the logic functions.

1. One cycle values for rms and phasor quantities are computed.
2. The Contact Input states are read.
3. Logic Blocking Gate functions.
4. Protection functions.
5. Breaker monitoring and control functions.
6. Logic Gate, Timer Gate, and Latch functions LG1 – LG6, then TG1 – TG6, then Q1 – Q2.
7. Logic Output Gate functions OG1 – OG7.
8. Output Relay logic routine.

Remember the programmed logic is evaluated sequentially, one element at a time. Consequently, if this is not taken into account, the user may encounter unexpected logic operation.

9.6 Programming Logic Functions

Some settings will so substantially change the structure of programming that they force the user to make a choice to save immediately and re-enter Set Mode in order to continue. The System Configuration settings that permit Custom programming of the I/O Configuration and Programmable Logic fall into this category.

Programming logic consists of picking the logic gates as in any logic design and connecting them together. Instead of signals, "Data Stores" record the state of each of the important system parameters as of the last determination or sampling. Instead of wires, logical name references direct the FP-5000 code to obtain the logic input from a particular Data Store. The computed outputs of the logic elements are also saved. The stored results may be directed to additional logic gate inputs until an output is directed to an output gate. Thus, the user specified (or default) logic results in a relay contact closing or opening.

Programming of the logic functions is accomplished by selecting an input category and element for each logic gate input. Input categories include Unused, Pickup, Trip, Logic, Inputs, System Alarms, Breaker Control, and Communications. The Pickup and Trip input categories include selection of individual or groups of protective functions. The System Alarm category provides selection of power, demand, THD, and breaker operation functions. The Input category provides selection of one of the eight contact inputs. The communications category provides selection of any of the four communications logic and states the user may set true or false through the communication channel. Table 9.4 shows the elements available for each input category.

Table 9.4 Logic Elements Input Options

Input Category	Elements
Unused	
Pickup	Ph OC, Gnd OC, IOC, TOC, OC, All Alarm, Voltage, Frequency, All Protection, 50X-1, 50X-2, 50X-3, 50R-1, 50R-2, 50R-3, 50P-1, 50P-2, 50P-3, 51P, 51X, 51R, 59-A1, 59-A2, 27-A1, 27-A2, 59-M1, 59-M2, 27-M1, 27-M2, 46-1, 46-2, 47-1, 47-2, 81U-1, 81U-2, 81O-1, 81O-2, BF, 55A PF, 55D PF
Trip	Ph OC, Gnd OC, IOC, TOC, OC, All Alarm, Voltage, Frequency, All Protection, 50X-1, 50X-2, 50X-3, 50R-1, 50R-2, 50R-3, 50P-1, 50P-2, 50P-3, 51P, 51X, 51R, 59-A1, 59-A2, 27-A1, 27-A2, 59-M1, 59-M2, 27-M1, 27-M2, 46-1, 46-2, 47-1, 47-2, 81U-1, 81U-2, 81O-1, 81O-2, BF, 55A PF, 55D PF, PhZone, GndZone
Logic	LG1, LG2, LG3, LG4, LG5, LG6, TG1, TG2, TG3, TG4, TG5, TG6, Q1, Q2
Inputs	Cin1, Cin2, Cin3, Cin4, Cin5, Cin6, Cin7, Cin8, Zone Interlock In
System Alarm	Watt, VAR, VA, Watt Demand, VAR Demand, VA Demand, Current Demand, V THD, I THD, Breaker Operations Count, Accumulated Interrupted Current, All System Alarms
Breaker Control	Open Breaker, Close Breaker, Breaker State Open, Breaker State Closed, Breaker Fail, Slow Breaker, Breaker State Alarm, Trip 1 Monitor Alarm, Trip 2 Monitor Alarm, All Breaker Alarms
Communications	Comm1, Comm2, Comm3, Comm4

The pickup and trip input categories provide selection of predefined groups of protective functions. The definition of the individual elements included in each group are shown in Table 9.5 Logic Input Group Definitions.

Table 9.5 Logic Input Group Definitions

Group	Individual Elements
Ph OC	50P-1, 50P-2, 51P
Gnd OC	50X-1, 50X-2, 50R-1, 50R-2, 51X, 51R
IOC	50X-1, 50X-2, 50R-1, 50R-2, 50P-1, 50P-2
TOC	51X, 51R, 51P
OC	50X-1, 50X-2, 50R-1, 50R-2, 50P-1, 50P-2, 51X, 51R, 51P
All Alarm	50X-3, 50R-3, 50P-3, 59-A2, 27-A2, 59-M2, 27-M2, 46-2, 47-2, 81U-2, 81O-2
Voltage	59-A1, 27-A1, 59-M1, 27-M1
Frequency	81U-1, 81O-1
All Protection	50X-1, 50X-2, 50R-1, 50R-2, 50P-1, 50P-2, 51X, 51R, 51P, 59-A1, 27-A1, 59-M1, 27-M1, 46-1, 47-1, 81U-1, BF Pickup, Zone Gnd, Zone Phase

9.6.1 Example of Use

A simple example of the logic will illustrate the principles of programming a logic diagram. This example shows how to add a “High Load Alarm” function to the FP-5000.

- Set the 50P-3 Phase IOC Alarm Pickup to 85% of the 51P TOC Pickup setting. Go to “Set Mode” Protection ⇨ Protection Setting Group1 ⇨ Alarms ⇨ 50P-3 PH IOC Alarm ⇨ Pickup and enter a value of 0.85.
- Use programmable logic to turn on the Auxiliary LED and energize Output Relay 4.
- Require the 50P-3 function pickup to be present for 1 second to prevent spurious operation.
- Maintain the output signal for 5 seconds after the current drops below the pickup level.
- Add an external switch to Contact Input 8 to enable or disable the High Load Alarm at the user’s discretion.

A Timer Gate has an On Delay and/or an Off Delay that can be set for up to 9999 cycles (166 minutes at 60 Hz). Use 60 cycles for an On Delay of 1 second and 300 cycles for an Off Delay of 5 seconds. Figure 9-5 is an implementation of the “High Load Alarm.”

The logic functions are programmed as follows from the main settings menu:

- Programmable Logic ⇨
  Logic Gate1 ⇨ Function: AND
  IN1: Input CIn8
  IN2: Pickup 50P-3
- Programmable Logic ⇨
  Timer Gate1 ⇨ In: Logic LG1
  On Delay (c): 60
  Off Delay (c): 300
- Output Config ⇨
  Output Rly4 ⇨ Function: OR
  IN1: Logic TGI
- Output Config ⇨
  Output Aux LED ⇨ Function: OR
  IN1: Logic TGI

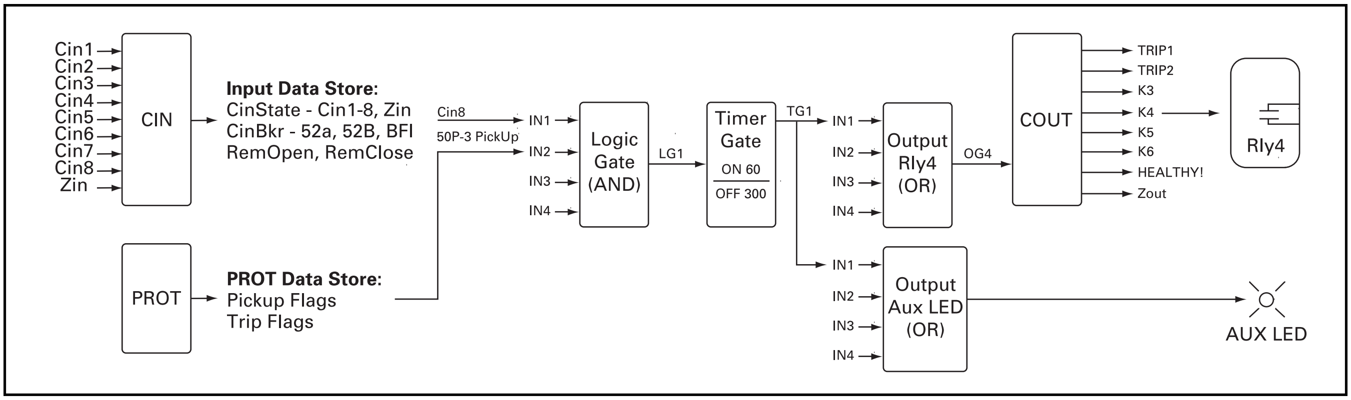

Figure 9-5. Logic Example

9.7 Use of Multiple Setting Groups

The FP-5000 contains multiple setting groups for adapting to different operating situations. Selection of the active setting group can be either automatic or manual. Automatic setting group selection can be initiated by a contact input or via communications. Manual setting group selection at the front panel is provided for applications where different settings are required based on maintenance needs or seasonal power requirements. A system configuration setting provides selection of the control mechanism for selecting the active setting group.

The setting for Control of Multiple Setpoint Groups has four options: Contact Input, Comm, Local and Local+Comm. The reason for providing multiple setpoint groups is to permit a quick change of settings and to minimize the risk of changing settings. Changing the active setpoint group is a sub-menu option of the Status/Control mode on the user interface if the Multiple Setpoint Group Control is set to Local. Access is not limited by the security door or password protection, as switching between the four logic schemes is considered part of normal operation. The active setpoint group will also be displayed using the Status/Control mode on the user interface.

- If the Multiple Setpoint Group Control is set to Contact Input, the contact inputs are defined in the Contact Input setting section. One or two contact inputs can control the setpoint group selection. If only one is used, the input selects between group 1 (Cin = Sel Set1 = 0) and group 2 (Cin = Sel Set1 = 1). If two contact inputs are used, the combination of the two contact inputs provides selection of group 1 (00), group 2 (01), group 3 (10), or group 4 (11).
- If the Multiple Setpoint Group Control is set to Local, the active setpoint group is selected using a sub-menu option of the Status/ Control mode PB on the user interface.
- If the Multiple Setpoint Group Control is set to Remote, the active setpoint group is selected using a PowerNet slave action command (3 D 0).
- If the Multiple Setpoint Group Control is set to Local+Remote, the active setpoint group is selected using either a sub-menu option of the Status/Control PB or the PowerNet slave action command (3 D 0). The active setpoint group is the group that was selected last.

Logic gate outputs can be enabled for one setting group or for all setting groups.

9.8 Default Settings

If no programming steps are taken, the inputs and outputs will have default settings that are likely to satisfy the majority of user applications with no setting changes required. Attempts to program the inputs, outputs, or any logic will be prevented until the user changes the System Configuration settings for I/O Config or Prog Logic from Default to Custom. Attempting to access Contact input CFG or Output Config within the Set or Programming mode when I/O Config is Default will result in a few seconds of the display.

Functions Programmed To Default. They can be viewed only. See System Config.

Attempting to access Programmable Logic settings when Prog Logic is set to Default will result in the same message.

10 DATA COMMUNICATIONS

10.1 Overview of Ports

The FP-5000 is designed to provide several communication options. The major options are single-point RS-232 and 2-wire INCOM Local Area Network (LAN). This section describes these two communication ports and the two major software packages which make use of these ports to interface with the FP-5000. One additional software package, the FlashLoader, is treated in Section 12 Troubleshooting. That program updates the firmware, an infrequent event which is not part of the day-to-day operation of the FP-5000.

10.1.1 Handling of Multiple Communication Hosts

The FP-5000 is designed to handle simultaneous communications with the front and rear communications channels. Monitoring functions can occur in parallel, however service routines like setpoint download or control functions will be handled on a "first come – first serve" basis. Whichever port starts first will lock the other port out until finished.

10.1.2 INCOM Network Information and Wiring

The following simplified rules apply given a system consisting of a single daisy chained main cable link between master and slave devices. For more complex considerations, including star configurations or systems containing old and new INCOM slave devices, please refer to the IMPACC Wiring Specification 17513 available on the Cutler-Hammer web site.

- The maximum system capacity is 10,000 feet of communications cable and 1000 slave devices.
- The main cable link must be terminated at each end by a ½ W, 100 ohm carbon resistor.
- Non-terminated taps, up to 200 feet in length, off the main link are permitted, but add to the total cable length.
- Terminals 1 and 2 of the INCOM J1 or J2 terminal plugs are for the twisted pair conductors, terminal 3 is for the shield. The polarity of the twisted pair is not important. Note: It is highly recommended that ferrules be used to dress the ends of the cable leads to minimize frayed connections and add stress release.
- Always follow the National Electrical and local codes for cable routing.
- When leaving a building, lightening surge protection is required. Phoenix Contact Plugtrab is recommended. This two-piece design absorbs 0.5 db of signal strength (reduces cable length maximum by ~ 250ft. per protector.):
  - Base UFBK-BE #27 83 09 5
  - Plug UFBK-M-2-PE-24DC-ST #28 17 05 5
- The twisted pair cable must be one of the following:
  - CH IMPCABLE – 600V AWM, 300V CM, 90C (attenuation1.6 db/1 K')
  - Belden 3072F – 600V TC, 75C (attenuation 2.0 db/1 K')
  - Belden 9463 family (many variations are available) or equivalent

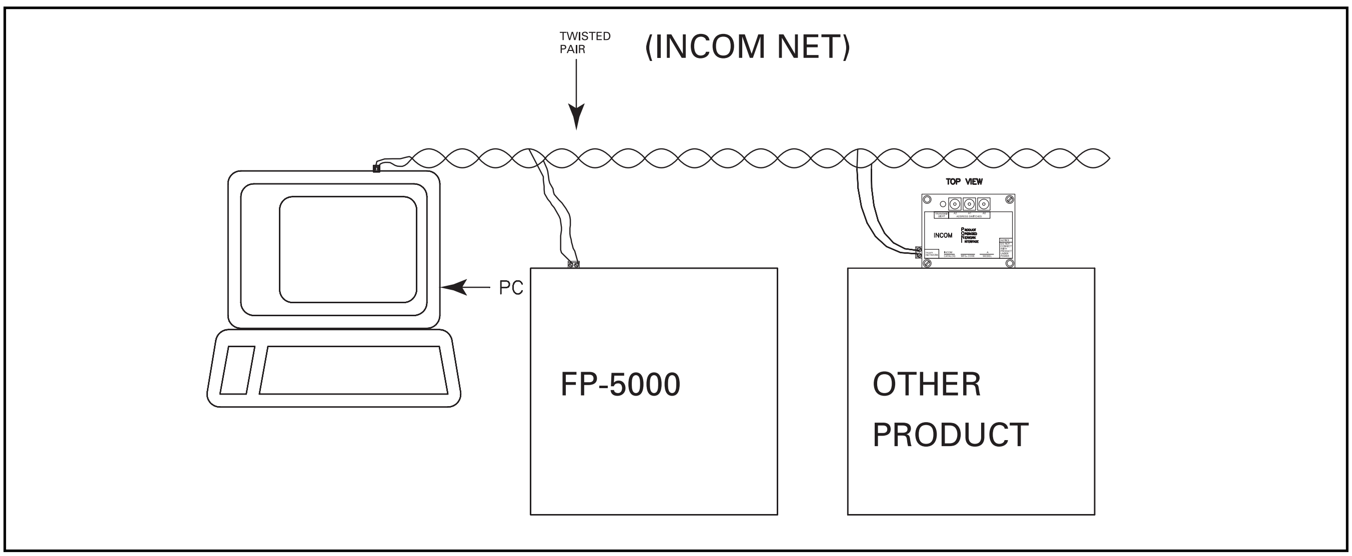

Figure 10-1. INCOM Network Connection

10.1.3 Front RS-232 Port Connection

The Front Panel RS-232 port provides the user convenient PC or lap-top access to the data and update features of the FP-5000. The user may access all the data measured and calculated, program and retrieve settings, invoke or monitor logging or data capture activity, and update firmware through the Front Panel RS-232 port.

The FP-5000 places its transmit onto pin 2 and its receive onto pin 3, making it a Data Set or Data Communication Equipment (DSE or DCE) interface under the definitions of the RS-232 standard. PCs are generally defaulted to Data Terminal (DTE), which allows them to connect directly to a Data Set with straight-through wiring. Note that the FP-5000 communicates through a 9-pin D-Subminiature Connector, whereas a PC RS-232 connector may be either a 9-pin or a 25-pin D-Subminiature Connector. The "straight-through" wiring for a 9-pin to 9-pin cable is not the case for a 9-pin to 25-pin cable. (See **Figure 10-2**.) The wire names are related to the Data Terminal end, thus RS-232 output of the FP-5000 is connected to the Receive line, and its RS-232 input is connected to the Transmit line.

The FP-5000 uses none of the RS-232 hardware control lines. Although the FP-5000 operates with the "3-wire" connection shown in **Figure 10-2**, a standard off-the-shelf serial cable will allow communication. An example of an easily available and acceptable cable is the RadioShack®, 26-117B, Male DB9 to Female DB9 Shield RS-232C Cable. This cable connects 1-1, 2-2, ..., 9-9. That is, the cable is connected "straight-through."

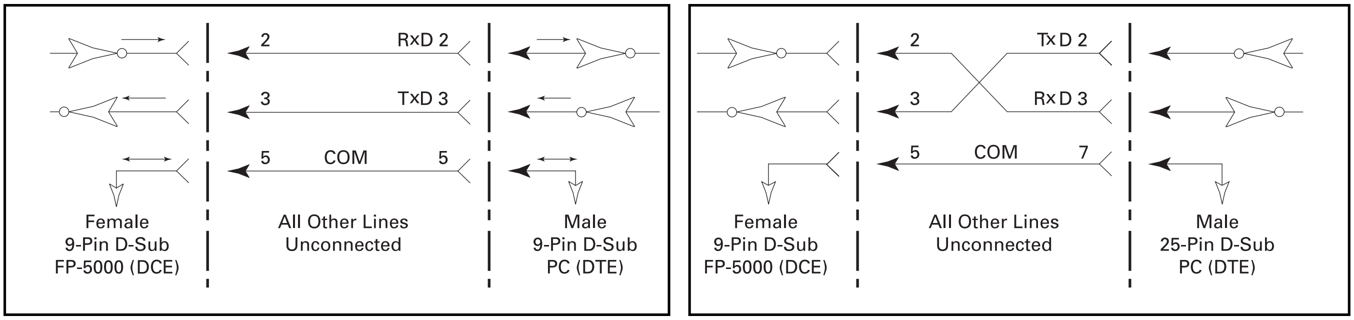

Figure 10-2. RS-232 Cable for 9- and 25-pin D-Subminiature Connectors

10.2 PowerPort Software

Please refer to publication, **IL 17B.01.T.E**, PowerPort™ 1.0 User's Guide. The objective of this section is to provide a brief overview of obtaining, installing, invoking and using the PowerPort software. Much of the functionality for the FP-5000 will be evident from the menus and the Help Function. However, the User's Guide will provide additional information.

PowerPort is a portable, scaled-down version of the flexible and powerful PowerNet Power Management Software. PowerNet communicates with multiple Cutler-Hammer devices over an INCOM™ network, whereas PowerPort communicates with one device at a time via a direct connection using the RS-232 ASCII version of the INCOM protocol. With PowerPort installed on a PC, the user may program the settings of the FP-5000 and retrieve any of the data generated and stored by the FP-5000. PowerPort provides no-cost PC-aided access to the features of the FP-5000.

10.2.1 Obtaining PowerPort

PowerPort may be obtained over the Internet from the Cutler-Hammer web site at no charge. Browse to the Cutler-Hammer web site at **http://www.ch.cutler-hammer.com** and follow the "**Power Management Products**" link. You will find several web pages dedicated to free software and downloadable data.

Prior to downloading PowerPort, you must register as a User, effectively joining PMUG (Power Management Users Group). Anyone may do this at no cost.

10.2.2 Installing PowerPort

Download the PowerPort software, noting the location (path) to which your browser downloads the module. Double click on the downloaded file using Windows® Explorer™. Follow the instructions provided by the installation sotware, and PowerPort installs within a few minutes.

You must install on a PC running the Windows 98, NT, or 2000 operating system. PowerPort is not available for non-PC capatible computers. PowerPort will not install on a PC with PowerNet already installed. PowerPort requires an IP address, though it doesn't use it. If you don't have an established IP address (i.e. you are not on a network), you must create one in order for PowerPort to work.

10.2.3 Running PowerPort

Connect your PC to the front panel RS-232 connector on the front panel of the FP-5000 using a standard DTE to DSE cable. The FP-5000 front panel RS-232 connector is wired as a 9-socket (Female) Data Set (DSE) D-Subminiature under the RS-232 standard. Typical PCs are wired as a 9-pin (Male) Data Terminal (DTE) under the RS-232 standard. Sometimes PCs might have a 25-position D-Subminiature connector. In the case of the 9-position configuration, an off-the-shelf Male DB9 to Female DB9 "straight-through" connection cable will work properly, even though only the Transmit, Receive and common wires are required. (The front panel RS-232 connector uses a 3-wire connection, not relying on the hardware handshaking lines.) (An example of an easily available and acceptable cable is the RadioShack, 26-117B, Male DB9 to Female DB9 Shielded RS-232C Cable.)

Note the baud rate setting for the FP-5000 (see in View Settings mode), and the baud rate of the running PowerPort program must be set to the same baud rate in order to communicate. Before attempting to go on-line with the FP-5000, set the baud rate and other communications parameters for the running PowerPort software to match the settings of the FP-5000. Consider using the highest baud rate of 38.4K baud to minimize data transfer times. Since the default baud of the FP-5000 is 19.2K baud, this entails changing program setting manually from the front panel of the FP-5000 prior to serial data operation.

Start PowerPort by selecting it from the Windows Start Menu. **The program may be run off-line, not connected to an FP-5000 if desired.**

In order to change anything in the FP-5000, the user must be **logged on** and **on-line**. After installation, the password is **ADMIN**. When logged on, the password should be changed to assure that unauthorized users will not use this program installation to change the programming of the FP-5000.

⚠ CAUTION

KEEP YOUR PASSWORD SECRET AND RECORD IT IN A SAFE PLACE. IF THE PASSWORD IS LOST, A NEW PASSWORD MAY BE ENTERED DURING THE FIRST 2 MINUTES AFTER CONTROL POWER IS APPLIED TO THE FP-5000.

10.2.4 What PowerPort Can Do

Off-line, an existing file of FP-5000 settings may be reviewed, printed, revised and resaved. Also, a new file of FP-5000 settings may be created starting from a template file provided with the default settings.

On-line, not logged on, the real-time operating data of the FP-5000 may be observed. Settings may also be observed or retrieved and saved to the PC.

On-line and logged on, the FP-5000 may be controlled and the settings may be updated in addition to all the functions above.

10.2.5 Quitting PowerPort

You may go on-line or off-line repeatedly, however, once logged on, you may not log off except when quitting the program.

Quitting is done in the standard manner for all Windows programs. After quitting, disconnect the serial cable, and the FP-5000 will continue to operate in whichever mode it was last set.

10.3 INCOM PowerNet Software

Cutler-Hammer PowerNet is the most recent and most comprehensive software tool for integrating and managing Cutler-Hammer Power Management relays and meters. It is the successor to IMPACC. Please refer to the manual accompanying the PowerNet software for installation, configuration and use of this software. It is not the intent of this manual to describe the complete operation of PowerNet, but rather to familiarize the user with its use to enhance FP-5000 operation.

A wide variety of descriptive material is available on PowerNet from the Cutler-Hammer web site. Browse to the Cutler-Hammer web site at **http://www.ch.cutler-hammer.com** and follow the "**Power Management Products**" link. A number of documents in Adobe Acrobat™ format (.pdf) which fully describes the PowerNet software, features and use may be downloaded. The **free** Adobe Acrobat Reader (for viewing and printing the document files) is available for download from **http://www.adobe.com.**

10.4 PowerNet Functions

10.4.1 What is PowerNet Software?

PowerNet is Cutler-Hammer's system of integrated metering, protection and control devices. PowerNet Software is the suite of software applications that allows you to monitor device data, physically control devices, collect information, compile information, and generate reports.

10.4.2 Distributed Client/Server Architecture

PowerNet Software uses distributed client/server architecture. The individual applications act as clients, sending control commands and requests for information to NetPower DeviceServers. Upon receiving a request from a PowerNet Software application, or based on pre-configured parameters, NetPower DeviceServers communicate with devices to either acquire data or control devices.

The distributed architecture of PowerNet Software allows you to run different applications on one or more computers at the same time. You can also run multiple copies of some applications on different computers, simultaneously. In addition, applications can be run at a remote, networked location (via an intranet or the Internet).

10.4.3 Licensing

PowerNet Software uses a floating license system to license the PowerNet Software applications. Each copy of a PowerNet Software application requires a license to run it.

10.4.4 PowerNet Software Applications

PowerNet Software is comprised of NetPower DeviceServers that communicate with devices to either acquire data or control devices, and applications that allow you to communicate with the NetPower DeviceServer. Some of the applications allow you to generate reports and bills, based on data collected from devices.

10.4.5 Core Components

The core components are (in most cases) the minimum set of components PowerNet Software requires to run. They include the following:

- NetPower DeviceServer
- NetPower Configurator
- PowerNet Tools
- NetPower License Manager

NetPower DeviceServer

NetPower DeviceServer is a server on a PowerNet Software client/server system. It polls for IMPACC device status and data, and transmits information (device control, setpoints, etc.) from applications to specific devices. In addition, NetPower DeviceServer can also act as a Modbus slave.

NetPower Configurator

NetPower Configurator serves as either an on-line or off-line configuration tool to configure any number of NetPower DeviceServers making up a PowerNet Software system.

You can also use NetPower Configurator to perform security administration. NetPower Configurator allows you to assign a unique user ID and password for each PowerNet Software user, designate the functions that each user can access, and add and delete NetPower DeviceServers to and from a PowerNet Domain.

PowerNet Tools

PowerNet Tools is a PowerNet application designed to automatically merge the device energy, trend, alarm and event data collected by multiple NetPower DeviceServers into a central database. PowerNet Tools is also used to archive central databases.

NetPower License Manager

NetPower License Manager is the PowerNet Software application that controls and manages the floating licenses. NetPower License Manager monitors how many purchased licenses for an application are available for check out, which computer licenses have been checked out, and the current status of each license.

10.4.6 Optional Components

There are several additional applications you can add to the core to customize the PowerNet Software system to your needs. They include the following:

- NetPower DDE Server
- NetPower Bill
- NetPower Trend
- NetPower Modbus Tools
- NetPower Monitor
- NetPower Waveform
- NetPower Setpoints & Trip Curve
- NetPower OPC Server
- NetPower Event Viewer
- Power Pager
- NetPower DDE Logger
- NetPower Integrator

NetPower DDE Server

DDE (Dynamic Data Exchange) is a communication protocol supported within the Microsoft® Windows® operating environment that allows cooperating Windows applications to share information. DDE implements a client/server relationship between concurrently running applications.

NetPower DDE Server is the PowerNet Software application that acts as a DDE server to other DDE clients. NetPower DDE Server accepts requests from DDE clients, then relays the requests to the NetPower DeviceServer (or DeviceServers), using PowerNet Protocol. When the NetPower DDE Server receives device data from a NetPower DeviceServer, it uses the DDE link to send device data back to the DDE clients.

NetPower Bill

NetPower Bill is a billing software package that generates bills for energy consumers based on energy provider metrics (such as rate schedules, rate periods and seasons) and energy user profile information (such as group charges, individual charges, and individual billing formulas).

NetPower Trend

NetPower Trend is a PowerNet Software application that graphically displays energy data collected by the NetPower DeviceServer. NetPower Trend plots energy utilization (by kilowatt-hours) or demand (by kilowatts) over time. NetPower Trend can plot energy profiles of loads or combinations of loads, which you can then save for viewing at a later time.

NetPower Modbus Tools

NetPower Modbus Tools is a PowerNet Software application that is used to define Modbus register mapping in NetPower DeviceServers. A NetPower DeviceServer serves as an interface between a Modbus Master and IMPACC devices, and supports a subset of the standard Modbus serial protocol communication.

NetPower Monitor

NetPower Monitor is a PowerNet Software application used to monitor and control devices on NetPower DeviceServers. With NetPower Monitor, you can view all the detailed device information, as well as a summary view of current and energy information and device alarm information.

NetPower Waveform

NetPower Waveform is the PowerNet Software application that allows you to command certain IMPACC devices to capture waveform data, to upload the waveform data from devices to a file, and to view a graphical representation of waveform data.

NetPower Setpoints & Trip Curve

NetPower Setpoints & Trip Curve is a tool that allows you to view setpoint data for each device connected to a NetPower DeviceServer, change setpoint data for a device, and view the trip curve for a device.

NetPower OPC Server

OPC (OLE Process Control) is an industry standard protocol for communicating with multiple data sources, such as devices on a factory floor or a database in a control room. OPC is supported by Microsoft Windows. NetPower OPC Server acts as an interface between the OPC protocol and the PowerNet protocol, enabling Windows applications to receive data dynamically from IMPACC devices and issue device commands. Windows applications act as clients, sending and receiving data to and from the NetPower OPC Server using the OPC protocol.

NetPower Event Viewer

NetPower Event Viewer is a PowerNet software application used to view historical information collected by NetPower DeviceServers, and merged into databases with PowerNet Tools.

Power Pager

Power Pager is a PowerNet Software application that allows any pager to be configured and alerted when a value obtained through Dynamic Data Exchange (DDE) violates a set of defined conditions. If an on-alert condition occurs, Power Pager automatically dials the configured pagers.

NetPower DDE Energy Logger

NetPower DDE Energy Logger is the PowerNet Software application that facilitates logging of energy usage data from alternate sources. NetPower DDE Energy Logger uses DDE connectivity to gather and integrate energy data from third-party sources into the PowerNet System. The NetPower DDE Energy Logger application utilizes the industry standard Dynamic Data Exchange (DDE) protocol to exchange information with a target DDE Server.

11 TESTING AND MAINTENANCE

11.1 Overview of Testing and Maintenance

The FP-5000 is designed to be a self-contained and maintenance-free unit. The printed circuit boards and related assemblies are calibrated and conformally coated at the factory; no field calibration is required. They are intended to be serviced by factory trained personnel only. The draw-out design allows for user hot swap out of the inner chassis if a failure is detected without disturbing the field circuit connections to the outer chassis. The outer chassis provides shorting contacts for the current monitor inputs preventing breaks in the power distribution current loop monitoring circuits. No external shorting terminals are necessary.

The FP-5000 uses a multi-functional microprocessor, and an Analog-to-Digital converter to monitor current and voltage inputs. The microprocessor also monitors all external digital and analog inputs. The microprocessor performs self-tests on power up initialization and periodically, while powered, and will report abnormalities if detected. Normal operation of the unit with source power applied, is demonstrated by a flashing operational LED, an engaged Healthy relay, along with normal communications and user interface functions. The installer should verify proper operation and circuit connections by noting normal input levels relative to field circuit status.

The user interface can be used to perform verification. Alternatively, Cutler-Hammer software products can facilitate verification of the FP-5000 operation. Either the RS-232 communications port on the front panel, or the INCOM PowerNet communications port can be used for communications as well as other functional testing. See Section 11.2.2 for more details. Use the following procedures for bench testing, or for verification of inputs. It is recommended this be done on a periodic basis.

11.2 Verifying the Product Hardware

The product hardware can be verified using the self-test feature described in Section 11.3, in-service monitoring of the FP-5000 under normal operating conditions, or bench testing by injecting currents and voltages into the various inputs. This section will discuss in-service monitoring and injection testing methods.

11.2.1 In-service Monitoring

In-service monitoring refers to observing the unit under normal operating conditions within the power system. The normal load currents, system voltages, rms auxiliary voltage, system power, frequency and power factor, % THD currents, as well as the system clock should be periodically read from the FP-5000 monitor menu.

The “Operational” LED on the top center of the front nameplate is the first indicator that should be verified. A blinking 1 Hz LED signifies the microprocessor is executing its protection routine. A solid LED signifies a product failure. If the LED is out, this could also signify product failure or it may just indicate lack of adequate power to TB101 and TB102.

Secondly, the Healthy Alarm relay should be used to indicate the FP-5000 health status. This relay is energized when the FP-5000 is powered-up and protection is active. If the power source goes out or if the FP-5000 senses an internal error this relay will open. This is a Form C relay and the NO contact can be used, for example, to drive an “all ok” light indicator while the NC contact can alarm an enunciator.

The following features should be verified:

- Load conditions should be verified and recorded for future reference.
- Zone interlock inputs. These should be verified to ensure proper system coordination.
- Proper operation of output relays.
- Coil monitors and breaker status (52a and 52b).
- “Breaker control” operation can be performed but will interrupt the system power. This feature will remotely close and open the circuit breaker.
- Setpoints. Compare to setting record.

The setpoints should be verified by comparing to the system setting records. The FP-5000 settings can be verified in the self-test mode by selecting “disarmed” and performing a test. Otherwise, the test feature can be used in the armed mode where the user can expect to trip and interrupt power downstream of the breaker.

11.2.2 Verification of Communications Ports

INCOM wiring rules are covered in Section 10. Ensure that proper connections and terminations are being followed. A red transmit LED can be viewed at the back of the outer chassis at the top of TB3. It lights only when responding to a valid INCOM command to its programmed address. If the unit under test is connected to Cutler-Hammer’s PowerNet Systems software, normal communications can be verified in a number of ways:

- Active monitor screens are an obvious indication of a proper link. If the communications is compromised then an alarm will be logged.
- An INCOM communications statistics buffer can be accessed to determine the link quality. Use this information to determine the quality of the link. Refer to your PowerNet manual for details. An occasional error is acceptable, excessive errors can indicate a problem either in the product or in the twisted pair interface in general.

Make certain when configuring PowerNet that the baud rate and INCOM address of the FP-5000 corresponds to the PowerNet configuration. The FP-5000 supports 9600 baud FSK mode only. If a connection is made through the RS-232 connector on the front panel, Cutler-Hammer’s PowerPort software can be used for configuration as well as RS-232 communications verification. Make certain that the baud rate of the computer running PowerPort has the baud rate set to the baud rate setting of the FP-5000 RS-232 port. You may select a baud rate of 9600, 19200, or 38400. See Section 10 for more details.

The INCOM Accessory Buss port TB3 J2 is a future interface that is not currently operational.

11.2.3 Bench Testing

Bench testing may be done prior to installation to test for coordination and many other features provided by the FP-5000. Current injection can be performed using commercially available power test sets such as: Omicron®, AVO®, or Doble®. These sources provide accurate current and voltage signals and can be used to simulate actual load conditions.

Note that these are typically three-phase sources and so the Auxiliary 4th Current Transformer, TB4 X1 and X2, will have to be accommodated by running in series with another phase or looked at separately from the main three phases. The same holds for the auxiliary voltage taps VX1 Aux. and VX2 Aux. The examples that follow will focus on phase testing but can be applied to the auxiliary circuits as well.

11.2.3.1 Verifying Current and Voltage Inputs

Using a current source provides a three-phase input current to the current transformer input terminals (TB4). See Section 6 for phase identification and wiring tips. Also provide a three-phase voltage input to the unit under test. Refer to the FP-5000 time current curves. Set the unit's setpoints as desired and note the expected trip time as indicated on the trip curve. Apply the test current and note the start time. Select the "Monitor" button on the front panel and verify the proper current and voltage inputs. Polarity and phasing of the currents and voltages must be considered. Next, note the trip time of the trip coil. The FP-5000 should trip within the time indicated on the time current curves. For tolerances see the Table of Specifications in Section 3.1.

11.2.3.2 Verify Zone Interlock

Connect the contact of the Zone Interlock output to the contact of the Zone Interlock input. Verify settings, input current and expected trip times as mentioned above in Section 11.2.3.1. In the View Settings menu, verify the Zone Interlock is enabled. Test the unit by applying current as in the test in 11.2.3.1. Trip times should be as indicated in Table specification. Remove the short from Zone Interlock Out to Zone Interlock In. Repeat the previous test. The trip times should be much faster (around .050 seconds).

The Zone Interlock output can be checked through the use of the "Test Zone Interlock" menu item from the test menu. A simple voltmeter can be used for this test. This function is available under the bottom lower protective cover labeled "Set" and "Test." This function is found under Test/Test Zone Interlock menu. You will have a choice of "Turn on ZI Output" or "Reset ZI Output." Move cursor and press Enter to select either mode. Using a voltmeter, measure the voltage on TB3 connector J3-1 and J3-2. A voltage of 4.5 to 5.0 volts should be measured when on and then near zero when off.

11.2.3.3 Testing Over-voltage and Under-voltage Protection

Under the View Settings menu, find the setting of both the under-voltage and over-voltage protection. If the settings are not as desired then modify it in the setting's menu under Protection/Main V Protection. Set the under-voltage to 60 volts and then the over-voltage to 120 volts, both with no delay. Starting with 100 volts, apply the test voltage to the voltage input terminals TB2 213-215. Decrease the voltage input to just below 60V and the unit should trip on under-voltage, raise the voltage to just over 120V and the FP-5000 should trip on over-voltage as expected.

11.2.3.4 Testing Trip Monitors

The trip monitor feature status can be viewed under the "Status/Control" menu - Input status/Trip # Monitor. The trip monitor circuits can be tested on the bench by simply applying a fused AC voltage source and series load across the trip relay contacts TB117 and 118 or TB115 and 116 – see **Figure 11.1**. The fuse and load should limit current to stay within the relay rating in case the relay contacts are engaged. A 120V AC indicator lamp can serve this purpose. With the trip relay open, apply the 120V source to trip relay 1. The Trip 1 monitor display should indicate the "on" status. Remove the source or close the relay and the status should indicate "off." Repeat this procedure for the Trip 2 relay.

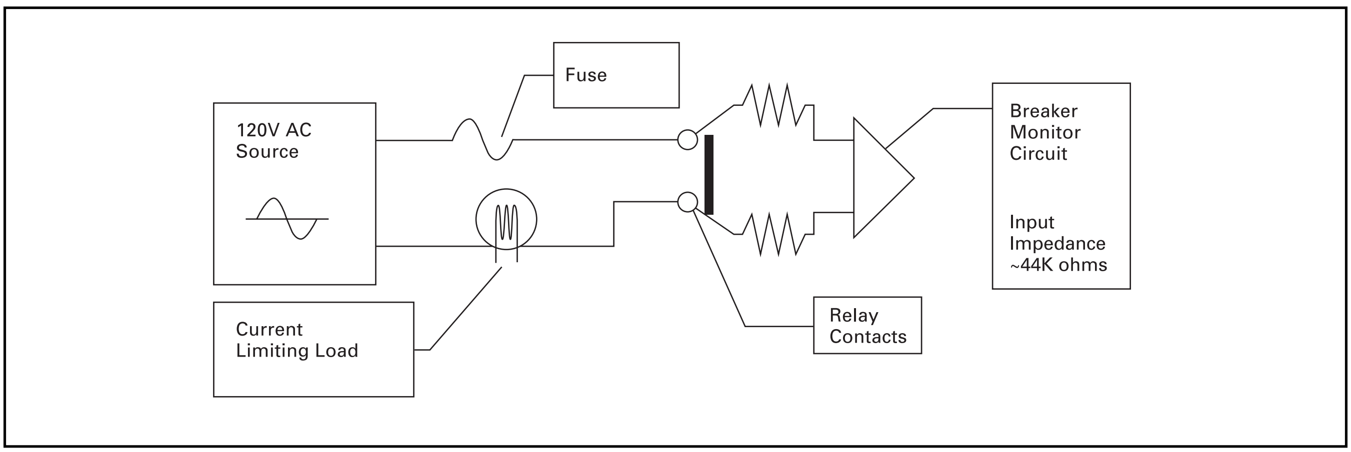

Figure 11-1. Testing Trip Monitors

11.2.4 Self Test Status

The FP-5000 Feeder Protection Relay performs a self-test of the microprocessor and supporting hardware such as memory and analog circuitry. To view the results, select the Status/Control menu then Status/Self Test Status. See the troubleshooting Section 12.1.3 “Self Test Status Indication” for a detailed description of each function.

11.2.5 Test Menu

Tests performed under the test menu allow the user to perform fault simulations and control the state of relays 1 – 6. To access the test menu functions, lift the protective cover labeled “Set” and “Test”, press the “**Test**” button, and enter the unit’s password.

11.2.5.1 Fault Simulation

The FP-5000 has a self-test function, which allows voltages and currents, both rms and phasor values, to be applied to the internal firmware in a simulation process. The unit can be placed in a trip or no trip mode to verify coordination trip times, demonstrate tripping and indicate trip times under user-selected overload conditions. The various functions that can be checked are:

- Overvoltage
- Undervoltage
- Unbalanced voltage
- Instantaneous overcurrent
- Inverse time overcurrent
- Unbalance current protection

Once the desired protection settings have been programmed, the “Test” function can be used as follows:

- If a non-trip test is desired, the user must disarm tripping. The first step is to enable the “Disarm Control” setting in the “**Set**” mode “System Config” setting menu. Then, the “Arm/Disarm Trip” selection can be made from the test menu.
- Press the “**Test**” button. Enter the unit’s password, then select “Fault Simulation” under the test menu.
- Enter the phasor values of voltages (line-to-neutral for a Wye connection or line-to-line for a Delta connection) and phasor currents. Refer to the FP-5000 protection settings to determine appropriate values for testing. Select the “Fault V&I Phasors” menu item and select the VA Phasor. Input the desired VA magnitude from 0 to 150V and the angle. Press “**Enter**” and then press “**Previous.**” Repeat these steps to set the remaining voltages and currents to the desired test values, then press “**Previous**” to return to the “Fault Simulation” menu.
- Using the down arrow key, select “Max Time (s):”. Enter the maximum test time, in seconds (up to 600 seconds = 10 minutes), that the simulation will be allowed to run without a trip condition.
- Scroll down to the “Start Simulation!” menu selection. Press “**Enter**” to begin the simulation.
- Once the simulation is started and before a trip occurs, the “**Monitor**” screens can be used to view the measured values of the simulated voltages and currents.
- When a trip occurs, the front panel “**Log**” screens can be used to view the cause of the trip and the voltages, currents and internal flags at the time of trip.
- The time to trip can be viewed by re-entering the front panel “**Test**” function Fault Simulation/Stop Simulation, which includes a screen showing the Simulation status, including the elapsed time in cycles.

The power and energy calculations continue to be based on the measured current and voltage inputs, not the simulation values. The fault simulation is aborted and normal protection is resumed if measured currents go above 0.1 per unit.

11.2.5.2 Operate Relays

Note that the Healthy Relay cannot be overwritten. To test the Healthy Relay, cycle power and the contacts should follow. To test relays 1 – 6, lift the protective cover labeled “**Set**” and “**Test.**” Press the “**Test**” button. Enter the unit’s password, then scroll down to “Operate Relays” using the single arrow down key. The following procedure will test relay 3 in this example. Scroll down using the single arrow key to “Operate Rly3” and press “**Enter**”, then “**Enter**” once again to confirm. With an ohmmeter measure between pins 113 and 114 of connector TB1 to verify that Relay 3 is closed. The resistance should be close to zero ohms. Now press the “**Previous**” button to return to the test menu. Scroll down to “Reset Relays” and press “**Enter.**” Scroll down using the single down arrow key to “Reset Rly3.” Press “**Enter**” and “**Enter**” again to confirm. Measure between pins 113 and 114 of connector TB1 again. The ohmmeter should read a high resistance or O.L. for an open circuit. This exercise can be performed on all relays listed in the “Operate Relays” menu.

Note: Trip 1 & 2 relays have approximately 44K across the open contacts as part of the monitor circuit.

11.3 Cleaning Instructions

Never clean the FP-5000 with the system or FP-5000 power energized. Clean only with a dry, clean cloth. Do not use water or solvents of any kind.

11.4 Trip Battery Check

The battery backed trip circuit latch is sourced by a user-accessible disc/button type battery located under the bottom right hand cover shared with the PowerPort RS-232 interface. Testing is accomplished by pushing the test button to the left of the battery holder with or without the FP-5000 powered. If the green LED indicator above the battery holder does not light then the battery has expired or has been installed upside down. Proper orientation is depicted on the front of the battery cover door. The battery can easily be replaced with a 2032 (20X3.2 mm) 200 mAhr, 3.0V lithium button cell.

Installing the battery into a powered FP-5000 is normal acceptable maintenance and will insure proper trip LED status. When power is removed the battery maintains the trip status latch and drives the appropriate LED. This will occur even with the inner case removed from the outer chassis. A fresh battery will last a minimum of 72 hours.

If the battery is installed with the FP-5000 power off (for at least ten seconds) then all three trip indicator LEDs, phase, ground, or other trip, in the center of the user interface will flash at 1 Hz regardless of the actual trip status. This may be a useful test if the integrity of the LED indicators is in question. Restore power to the FP-5000 and the proper trip status should be restored.

11.5 Power-up LED Indicator Status

Upon power-up of the FP-5000, all 13 LEDs on the user interface overlay and the four communication board LEDs viewed through holes at the top of TB3 will light for ~ 1 second. If an LED fails to light, this indicates there is an internal failure of the LED or related circuitry, and the inner chassis is suspect and should be replaced or returned for service. The Trip Battery test LED is a separate circuit and does not light on power up, only when the pushbutton is pushed.

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12 TROUBLESHOOTING

There are two aspects to troubleshooting:

1. Failures in the system being protected.
2. Failures of the FP-5000 relay.

The FP-5000 can be programmed to record data during system faults, which can be analyzed to determine the cause of faults. The FP-5000 continuously determines its own ability to function, if any internal failures are detected the FP-5000 can raise an alarm. For information on troubleshooting the FP-5000 relay failures see Section 12.1. For information on troubleshooting the circuit the FP-5000 is protecting, see Section 12.2.

The FP-5000 firmware can be revised in the field by using a PC and the front mounted serial port on the FP-5000 Section 12.4 covers the procedures for upgrading the firmware in the field.

12.1 Troubleshooting the Relay

The FP-5000 performs a great many self-checks on a continuous basis to warn the operating personnel of impending or actual failure, and allowing steps to be taken to minimize the impact of such failure. Some internal failures will not effect the ability of the FP-5000 to protect the circuit while others will. Detected failures of the FP-5000 will cause the relay healthy contact output to de-energize, see Section 12.1.1. All FP-5000 failures will cause the Alarm LED on the front panel to light, and the condition to be reported over the INCOM communication network usually displayed in the PowerNet application software. The front display will also indicate failures and is described in Section 12.1.3.

12.1.1 Relay Healthy Output

The relay healthy alarm is a crucial part of notification for relay failure. This contact output is energized during normal operation, when no warnings or failures are present. The relay healthy contact output is a Form C relay. Typically the normally closed contacts are used and wired to an alarm that is guaranteed to get immediate attention. If an FP-5000 relay self diagnostic failure is detected, the relay healthy alarm will be de-energized and the alarm will be sounded. In the case of a catastrophic failure of the FP-5000 or its control power supply, the normally closed relay will cause an alarm whenever power is removed from the relay healthy contact output.

⚠ WARNING

FAILURE TO UTILIZE THE RELAY HEALTHY CONTACT OUTPUT IN A MANNER THAT WILL BRING IMMEDIATE ATTENTION IF DE-ENERGIZED CAN RESULT IN A FAILURE TO PROTECT THE CIRCUIT FOR EXTENDED PERIODS OF TIME.

12.1.2 Failures That Disable Protection

In the case that an FP-5000 critical failure is detected, the protection functions of the FP-5000 are disabled, and all output relays except relay healthy will remain in their current state. The relay healthy output will be de-energized as described in Section 12.1.1. Protection is disabled so that a false trip operation will not occur. If it is desired to trip the breaker upon FP-5000 failure then the relay healthy alarm should be connected to the breaker trip coil in parallel with the trip output contact. Table 12.1, under the “Protection” column, shows what diagnostic test failures will cause protection to be disabled.

12.1.3 Self Test Failure indication

When a diagnostic self test indicates a failure, an error message is displayed instead of the default metering display, and the Healthy Relay (K7) is de-energized, no longer indicating proper operation. All other display screens operate normally to permit display of diagnostic information during troubleshooting. The screen saver is disabled when a warning or failure message is displayed. If more than one warning or failure condition exists, the FP-5000 scrolls through the multiple error messages. Table 12.1, under the “Display” column, shows all possible displays.

A group of status flags are given in the Status/Control mode that describes the current results of diagnostic self tests. To view these status flags press the Status/Control button, select “Status” and press enter, select “Self Test Status” and press enter, use the arrow keys to scroll through the list. Table 12.1, under the “Status Flag” column, lists all of the self test status flags.

Table 12.1 Self Test Displays and Status Flag

Display	Status Flag	Protection	Description	Recommended Action
Boot Code CheckSum Error	Boot Code	Disabled	The boot code firmware has been corrupted	The circuit is not protected, replace FP-5000 immediately Possible Flash reload
Application Code Checksum Error	Firmware	Disabled	The application code firmware has been corrupted	The circuit is not protected, replace FP-5000 immediately Possible Flash FW reload
RAM Failure at 0X——-	External RAM	Disabled	A portion of external RAM cannot be read or written	The circuit is not protected, replace FP-5000 immediately
RAM Failure at 0X——-	Internal RAM	Disabled	A portion of the RAM internal to the microprocessor cannot be read or written	The circuit is not protected, replace FP-5000 immediately
Protection Disabled Analog Input Failure	Analog Input	Disabled	The analog input has failed to respond or has read a reference input incorrectly	The circuit is not protected, replace FP-5000 immediately
Protection Disabled Setting Failure	Settings	Disabled	If Fail, the setpoints have been corrupted	The circuit is not protected, replace FP-5000 immediately
Display Warning	Display	Enabled	The display content could not be verified	Replace FP-5000 at the earliest convenience
Protection Disabled Relay Not Calibrated	Calibrated	Disabled	At power up, the calibration constants are corrupted	The circuit is not protected, replace FP-5000 immediately
Nonvolatile Memory Battery Warning	RAM Battery	Enabled	The NVRAM battery is failing	If needed, store all log and history data before power down. This can be done with the PowerNet application software. Contact factory for replacement instructions.
Real-Time Clock Warning	Clock	Enabled	The real time clock has malfunctioned	Check the clock for proper time and future time keeping. If in error, replace at the earliest convenience.
EEPROM Warning	EEPROM	Enabled	The EEPROM cannot be read or written	Replace the FP-5000 at the earliest convenience. It is possible that the FP-5000 will fail to protect the circuit the next time powered up.

Table 12.1 Self Test Displays and Status Flag – continued

Display	Status Flag	Protection	Description	Recommended Action
Protection Disabled Calibrate Failure	Calibration	Disabled	The calibration constants have been corrupted	The circuit is not protected, replace FP-5000 immediately.
Setting Warning	—	Enabled	A recoverable corruption of the setpoints has occurred	Check the settings in the FP-5000, making corrections if needed. If this warning repeats then replace the FP-5000.
Test in Progress	—	Disabled	A test simulation has begun	To stop the test, press the Test button, select Fault Simulation, and select Stop Simulation.
Calibrate Warning	—	Enabled	A recoverable corruption of the calibration setpoints has occurred	Check the accuracy of the voltage current input measurement. If this warning repeats then replace the FP-5000.
EEPROM Write Warning	—	Enabled	The EEPROM has been written to a large number of times and is in danger of wearing out	Call the factory, for troubleshooting help.
EEPROM Write Lockout	—	Enabled	Because the EEPROM has been written to a large number of times no more writes are permitted	Call the factory, for troubleshooting help.
Relay Tripping Disarmed	—	Disabled	The Disarmed function has been activated	The Disarmed feature can be turned off by pressing the “Test” pushbutton selecting Arm/Disarm Trip, and selecting Arm Trip.

12.1.4 Transient Messages

The following display messages replace the normal display for the indicated time duration or until a pushbutton is pressed. The messages are in response to transient conditions as described in Table 12.2

Table 12.2 FP-5000 Transient Messages

Condition	Display Message Text	Duration
Display if current is sensed during fault simulation	“Fault Test Aborted”	5 seconds
Open breaker pushbutton with breaker open	“Error: Breaker Open”	5 seconds
Close breaker pushbutton with breaker closed	“Error: Breaker Closed”	5 seconds
Update clock	“Clock Update Confirmed”	5 seconds
Display if “Set” pushbutton is pressed while a remote setting download is in progress	“Remote Setting Change in Progress”	5 seconds
Displayed when a download of settings occur	Remote Download Settings …	1 second
Settings are saved and being processed	“Saving Settings To EEPROM in Progress”	1 second

12.2 Troubleshooting the Protected Circuit

The FP-5000 contains information that can be used to discover the nature of power distribution faults which is contained in the Event log, Trip log, History log, and waveform capture. In addition, the FP-5000 can be useful in detecting problems with the breaker and current and voltage transformers.

12.2.1 Event Log

The Event log contains a chronological list of events that the FP-5000 has observed. It is similar to an operation log where all events are recorded as they happen. This data is very useful to see the order of events that have occurred during a fault and is also useful for later analysis.

If a trip, or alarm LED indication is present the Event log is useful to explain the action behind the LED indication.

The FP-5000 records 100 Event logs in a circular buffer before writing over the oldest log. The logs are numbered with the most recent event marked by an index of 1 to the oldest event marked with an index of 100. As new logs are entered, the index numbers are automatically changed to keep the newest log at index 1. The oldest event, previously number 100, is discarded as a new event is logged.

After pressing the "Log" pushbutton and selecting the "Event Log" the indexed list of events are given. Each event has an index number (the list always starts with 1), followed by a title (all possible titles are described in Table12.3), and the date that the event occurred. The ability to log a pickup of protection functions, the changing of input states, and the changing of a communication driven logic variable must be enabled by programming setpoints (see Section 5). The ability to ignore particular types of events is given so that events that occur often will not fill the event log.

Table 12.3 Possible Titles

Event Title Name	Event Title Description
General	Contains general events
Pickup	Pickup of any active protection function that is programmed to be logged
Dropout	Dropout of any active protection function that is programmed to be logged
Operate	The operation of any protective function that is programmed to be logged
Input	Changing state of any contact input that is programmed to be logged
Output	Changing state of any contact output
Breaker	Breaker state changes and related breaker alarms
Comm	Changing state of a communication driven logic variable
Self Test	Self test diagnostic alarms, and going in and out of test mode

Each line of the event log, containing the log index, title and date, can be selected using the single or double arrow pushbuttons and entered by pressing the Enter pushbutton. The information displayed for every event includes the title, and time the event occurred, along with the cause of the event, and a value (see Table 12.4 through Table 12.11 for a list of all event causes, with displayed values). This value in many cases can be selected with the single arrow pushbutton and pushing the Enter pushbutton to reveal a group of status indicators that were true at the time of the event logged.

The General events pertain to the powering, programming, triggering and resetting of the FP-5000. These events are always logged, no programming is necessary. The General events are shown in Table 12.4.

Table 12.4 Event General Cause Table

Cause	Cause Description	Value Given
PwrOn	The FP-5000 is powered on	No value associated with this cause
PwrOff	The FP-5000 is powered off	No value associated with this cause
FltPwrOp	Transition to Fault Powered Operation	No value associated with this cause
SetChange	The program settings are changed and saved	The Setpoint Sequence number
PRSetGrpCh	The protection active setting group is changed	The new active setting group number (#1 - #4)
SetRTC	The real time clock is set to a new date/time	No value associated with this cause
Trig Wfm Capt	The trigger for a waveform capture is activated	The event that has caused the trigger – dV/dI, Logic, PB, Comm
Rst Trip/Alm	A reset of the trip or alarm is performed	No value associated with this cause
Reset Energy	The energy values are reset	No value associated with this cause
RstCurPKDmd	The current peak demand values are reset	No value associated with this cause
RstPwrPKDmd	The power peak demand values are reset	No value associated with this cause
RstMinMax	The min and max values are reset	No value associated with this cause
RstHistLog	The history log has been reset	No value associated with this cause
ClrDataLogger	The data logger saved data is cleared	No value associated with this cause
Default Set	The setpoints are returned to the default settings	The Setpoint Sequence number

Every pickup and dropout of an enabled protection function can be logged in the Event log. Each class of pickups must be programmed to be logged (see Section 5). Observing pickups in the Event log can show if a current or voltage transient is causing a pickup. Most values given with each log can be accessed by selecting the line immediately below the Cause and pressing Enter. The information given is a series of status flags that show the state of that status at the time of the event. Table 12.5 shows all the possible event causes that are a pickup or a dropout of a protective function.

12.5 Event Pickup, or Dropout Cause Table

Cause	Cause Description	Value Given
50P IOC	Phase Instantaneous Over Current is picked up or dropped out	IOC Pickup Status – contains status flags that describe the state of all possible IOC pickups
50X IOC	IX (ground) Instantaneous Over Current is picked up or dropped out	IOC Pickup Status – contains status flags that describe the state of all possible IOC pickups
50R IOC	IR Residual Instantaneous Over Current is picked up or dropped out	IOC Pickup Status – contains status flags that describe the state of all possible IOC pickups
51P TOC	Phase Time Over Current is picked up or dropped out	TOC Pickup Status – contains the status flags that describe the state of all possible TOC pickups
51X TOC	IX (ground) Time Over Current has picked up or dropped out	TOC Pickup Status – contains the status flags that describe the state of all possible TOC pickups
51R TOC	IR Residual Time Over Current has picked up or dropped out	TOC Pickup Status – contains the status flags that describe the state of all possible TOC pickups
59M OV	Main Phase Over Voltage has picked up or dropped out	Voltage Pickup Status – contains the status flags that describe all under and over voltage pickups
27M UV	Main Phase Under Voltage has picked up or dropped out	Voltage Pickup Status – contains the status flags that describe all under and over voltage pickups

Table 12.5 Event Pickup, or Dropout Cause Table — continued

Cause	Cause Description	Value Given
59A OV	Auxiliary Over Voltage has picked up or dropped out	Voltage Pickup Status – contains the status flags that describe all under and over voltage pickups
27A UV	Auxiliary Under Voltage has picked up or dropped out	Voltage Pickup Status – contains the status flags that describe all under and over voltage pickups
46 Iunbal	Phase Current Unbalance has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
47 Vunbal	Phase Voltage Unbalance has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
81 UF	Under Frequency has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
81 OF	Over Frequency has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
BF	Breaker Failure has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
55A PF	Apparent Power Factor has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
55D PF	Displacement Power Factor has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
Zin Trip	Zone Interlock Trip has picked up or dropped out	Miscellaneous Pickup Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking pickups
PwrAlm	The system alarm for Watt, VA, or VAR has picked up or dropped out	System Alarm Pickup Status – contains the status flags for all system alarms
PwrDmdAlm	The system alarm for Watt demand, VA demand, or VAR demand has picked up or dropped out	System Alarm Pickup Status – contains the status flags for all system alarm pickups
CurDmdAlm	The system alarm for Current Demand has picked up or dropped out	System Alarm Pickup Status – contains the status flags for all system alarm pickups
THD CurAlm	The system alarm for Current Total Harmonic Distortion has picked up or dropped out	System Alarm Pickup Status – contains the status flags for all system alarm pickups
THD VolAlm	The system alarm for Voltage Total Harmonic Distortion has picked up or dropped out	System Alarm Pickup Status – contains the status flags for all system alarm pickups

Every time a protective function operates, it is recorded in the Event log, by default and no extra programming is needed. Note, most values given with each log can be accessed by selecting the line immediately below the Cause and pressing Enter. The information given is a group of status flag states at the time of the event. Table 12.6 shows all of the protective operations that can be logged in the Event log.

Table 12.6 Event Operate Cause Table

Cause	Cause Description	Value Given
50P IOC	Phase Instantaneous Over Current has operated	OC Trip Status – contains status flags that describe the state of all possible IOC and TOC trip functions
50X IOC	IX (ground) Instantaneous Over Current has operated	OC Trip Status – contains status flags that describe the state of all possible IOC and TOC trip functions
50R IOC	IR Residual Instantaneous Over Current has operated	OC Trip Status – contains status flags that describe the state of all possible IOC and TOC trip functions
51P TOC	Phase Time Over Current has operated	OC Trip Status – contains status flags that describe the state of all possible IOC and TOC trip functions
51X TOC	IX (ground) Time Over Current has operated	OC Trip Status – contains status flags that describe the state of all possible IOC and TOC trip functions
51R TOC	IR Residual Time Over Current has operated	OC Trip Status – contains status flags that describe the state of all possible IOC and TOC trip functions
59M OV	Main Phase Over Voltage has operated	Voltage Trip Status – contains the status flags that describe all under and over voltage trips
27M UV	Main Phase Under Voltage has operated	Voltage Pickup Status – contains the status flags that describe all under and over voltage trips
59A OV	Auxiliary Over Voltage has operated	Voltage Pickup Status – contains the status flags that describe all under and over voltage trips
27A UV	Auxiliary Under Voltage has operated	Voltage Pickup Status – contains the status flags that describe all under and over voltage trips
46 Iunbal	Phase Current Unbalance has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
47 Vunbal	Phase Voltage Unbalance has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
81 UF	Under Frequency has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
81 OF	Over Frequency has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
BF	Breaker Failure has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips

Table 12.6 Event Operate Cause Table — continued

Cause	Cause Description	Value Given
55A PF	Apparent Power Factor has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
55D PF	Displacement Power Factor has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
Zin Trip	Zone Interlock Trip has operated	Miscellaneous Trip Status – contains the status flags that describe all unbalance, frequency, breaker failure, power factor, and zone interlocking trips
PwrAlm	The system alarm for Watt, VA, or VAR has operated	System Alarm Timeout Status – contains the status flags for all system alarm timeouts
PwrDmdAlm	The system alarm for Watt demand, VA demand, or VAR demand has operated	System Alarm Timeout Status – contains the status flags for all system alarm timeouts
CurDmdAlm	The system alarm for Current Demand has operated	System Alarm Timeout Status – contains the status flags for all system alarm timeouts
THD CurAlm	The system alarm for Current Total Harmonic Distortion has operated	System Alarm Timeout Status – contains the status flags for all system alarm timeouts
THD VolAlm	The system alarm for Voltage Total Harmonic Distortion has operated	System Alarm Timeout Status – contains the status flags for all system alarm timeouts
BrkOpAlm	Breaker Operation Alarm, the number of breaker operations has exceeded the programmed limit	System Alarm Timeout Status – contains the status flags for all system alarm timeouts
AccuCurAlm	Accumulated Current Alarm, the accumulated interrupted current the breaker has opened has exceeded the programmed limit	System Alarm Timeout Status – contains the status flags for all system alarm timouts

Any contact input state change can be logged in the Event log if so programmed. Each input can be logged or not logged according to the program settings (see Section 5). The value given for each event is: Active for an input transition of low to high, or inactive for an input transition of high to low. Table 12.7 summarizes the contact input causes for an event log.

Table 12.7 Event Input Cause Table

Cause	Cause Description	Value Given
Cin1State Alt	Contact Input 1 State changed	Active or Inactive
Cin2State Alt	Contact Input 2 State changed	Active or Inactive
Cin3State Alt	Contact Input 3 State changed	Active or Inactive
Cin4State Alt	Contact Input 4 State changed	Active or Inactive
Cin5State Alt	Contact Input 5 State changed	Active or Inactive
Cin6State Alt	Contact Input 6 State changed	Active or Inactive
Cin7State Alt	Contact Input 7 State changed	Active or Inactive
Cin8State Alt	Contact Input 8 State changed	Active or Inactive

All contact output changes will be logged in the event log and no programming is necessary. If more than one relay changes state at exactly the same time because of a single causal event activating more than one relay, only one log is entered into the event log. Table 12.8 summarizes all output event causes that will be logged.

Table 12.8 Event Output Cause Table

Cause	Cause Description	Value Given
Relay Changed	One of the first 6 relays – Trip 1, Trip 2, Rly3, Rly4, Rly5, or Alarm – has changed state	Output Status – contains the status flag for all contact outputs
Healthy State	The Relay Healthy contact output has changed state	Output Status – contains the status flag for all contact outputs

Breaker commands that come through the FP-5000, breaker state changes and breaker alarms are all logged automatically in the event log. Table 12.9 shows all possible causes for breaker event logs.

Table 12.9 Event Breaker Cause Table

Cause	Cause Description	Value Given
Open Breaker	An Open Breaker command is given remotely or through the front panel pushbutton	Breaker Status – contains all the flags related to the breaker
Close Breaker	A Close Breaker command is given remotely or through the front panel pushbutton	Breaker Status – contains all the flags related to the breaker
Bkr Opened	The Breaker State is determined to be Opened	Breaker Status – contains all the flags related to the breaker
Bkr Closed	The Breaker State is determined to be Closed	Breaker Status – contains all the flags related to the breaker
Bkr Lockout	The Breaker has failed to break the current in the programmed amount of time	Breaker Status – contains all the flags related to the breaker
Bkr Time Alm	The Breaker has taken more than 40 cycles to close or more than 30 cycles to open	Breaker Status – contains all the flags related to the breaker
Bkr State Alm	There is a state disagreement between the 52A and 52B contact inputs.	Breaker Status – contains all the flags related to the breaker
Trip1 Mntr Alm	The Breaker is determined to be in the closed state and no trickle open (trip) coil current is sensed around the Trip 1 contact output	Breaker Status – contains all the flags related to the breaker
Trip2 Mntr Alm	The Breaker is determined to be in the open state and no trickle close coil current is sensed around the Trip 2 contact output	Breaker Status – contains all the flags related to the breaker

Whenever the communication variable input changes, if so programmed, it will be logged in the event log.
Table 12.10 shows the cause for this event log.

Table 12.10 Event Communication Cause Table

Cause	Cause Description	Value Given
CommLogic Alt	Communication Logic variable has changed state	Communication Logic Status – contains all 4 communication logic variable states

As described in Section 12.1, the FP-5000 does a series of self diagnostic checking. If any self test should fail, the event is logged automatically in the event log. See Table 12.11 for a complete list of self test event causes.

Table 12.11 Self Test Event Cause Table

Cause	Cause Description	Value Given
Bt Flash Err	Boot Flash Checksum Failure	No value associated with this cause
ProgFlash Err	Program Flash Checksum Failure	No value associated with this cause
Ext RAM Fail	External RAM Error	Bad RAM Address
TPU RAM Fail	Internal TPU RAM Error	Bad Internal TPU RAM Address
Analog In Err	Analog to digital conversion error	No value associated with this cause
Set Warning error has occurred	A recoverable Settings (setpoint)	No value associated with this cause
Set Failure error has occurred	A non-recoverable Settings (setpoint)	No value associated with this cause
Display Warn	Display Warning – read back test failed	No value associated with this cause
RelNotCalibra	No Calibration constants are present	No value associated with this cause
RAM Batt Warn	The non-volatile RAM Battery is low	No value associated with this cause
Clock Warning	The real time clock has failed	No value associated with this cause
Test Mode	The Test Mode has been entered or exited	Enter or Exit
EEPROM Warning	The EEPROM has failed	No value associated with this cause
CalibrateWarn	A recoverable Calibration error has occurred	No value associated with this cause
CalibrateFail	A non-recoverable Calibration error has occurred	No value associated with this cause

12.2.2 Trip Log

The trip log contains detailed information on the last 16 trips. An event is considered a trip if it causes either, or both, Trip 1 and Trip 2 to activate. The trip log gives detailed information on the state of all I/O, the state of all pickups and operations of protective functions, and the state of all voltages and currents at the time of trip. The trip log is useful in determining how, why, and when a trip operation has occurred.

Each set of trip data recorded in the log is numbered from 1 to 16. The most recent trip event is always denoted number 1, the oldest number 16. Once 16 trips are recorded, and a new trip occurs, the oldest trip is discarded as the new trip is recorded.

Every time the Trip 1 or Trip 2 relay activates, the display immediately goes to the Trip Log page (unless the user is changing the settings). On this page is a list of trip events starting with number 1 and going to 16. Each line of the trip log will contain the index number (1-16), the cause of the event and the date the event occurred. The majority of the time the Trip 1 or Trip 2 output contacts are programmed to activate on protective function operation. In this case the cause of the trip is logged into the title of the trip log entry. On occasion one of the trip relays will be programmed to operate on other events, like contact input change for example. A summary of all causes used in the trip log is in Table 12.12.

Table 12.12 Trip Log Cause of Trip Table

Cause of Trip	Cause Description
27A UV	An Auxiliary Under Voltage operation
27M UV	A Main Under Voltage operation
46 Iunbal	A phase current Unbalance operation
47 Vunbal	A main voltage Unbalance operation
50P IOC	A Phase current Instantaneous Over Current operation
50R IOC	A Residual current Instantaneous Over Current operation
50X IOC	An IX (ground) current Instantaneous Over Current operation
51P TOC	A Phase current Time Over Current operation
51R TOC	A Residual current Time Over Current operation
51X TOC	An IX (ground) current Time Over Current operation
55A PF	An Apparent Power Factor operation
55D PF	A Displacement Power Factor operation
59A OV	An Auxiliary Over Voltage operation
59M OV	A Main Over Voltage operation
81 OF	An Over Frequency operation
81 UF	An Under Frequency operation
AccuCurAlm	An Accumulated interrupted Current Alarm
BF	A Breaker Failure operation
Bkr Closed an operation	A Closed Breaker state has caused
Bkr Open	An Open Breaker state has caused an operation
BkrAlm	A Breaker Alarm (breaker state, breaker time, close or open coil supervision) operation
BkrFailalm	A Breaker Failure Alarm operation
BrkOpAlm	A number of Breaker Operations Alarm operation
Close Bkr an operation	A Close Breaker signal has caused
COMM	A Communication command has caused an operation
ContactIn	A programmed Contact Input has caused an operation
CurDmdAlm	A Current Demand Alarm operation
Gnd Zint	A Ground current Zone Interlock operation
Logic	A programmed logic gate has caused an operation
Open Bkr	An Open Breaker signal has caused an operation
Ph Zint	A Phase current Zone Interlock operation
Pickup	A Pickup of a protective function has caused an operation
PwrAlm	A Power (Watt, var or VA) Alarm operation
PwrDmdAlm	A Power Demand (Watt, var or VA) Alarm operation
RLY Test	A Relay test has caused an operation
THD CurAlm	A THD Current Alarm operation
THD VolAlm	A THD Voltage Alarm operation
Zin Trip	A Zone Interlock operation

Note: The “Cause of Trip” is reported as “Logic” if the output Gate Fuction is set to AND, NOR, or NAND.

From the main page of the trip log any one record of an event can be chosen. Simply move the arrow using the arrow pushbuttons to the event you would like more detail on and then press Enter.

Each individual record has many lines of information. Table 12.13 shows what information is included in every line. Some lines contain another level of information that can be accessed by using the arrow keys to select the line and then pressing Enter. All such lines in the trip log are asterisked in Table 12.13.

Table 12.13 Trip Log Record Line-by-Line

Line	Display	Description
1	Trip #	Unique number assigned to every trip event sequentially. The numbers rolls over after 65,535.
2	Time HH:MM:SS:mmm	The time of the event displayed in hours, minutes, seconds, and milliseconds. The hours will be in 24-hour mode or 12-hour mode with an AM – PM designation according to the programmed setpoint.
3	Event #	The event number is a unique number given for each log in the event log. The event number is a reference to the event log of the trip relay activating. This is useful to synchronize the event log to the trip log.
4	Cause	The cause of the trip relay activation is given and is detailed in Table 12.11.
5	Flt Type	Fault type details the phases or ground channel that has caused the fault. Fault type will only have value for current TOC, IOC protective functions, and the main under and over voltage protective functions.
6	Set Seq Num	The setting sequence number is a unique number given when new setpoints are saved. It is a way of identifying which setpoints were in use at the time of the trip.
7	WaveCap Index	The waveform capture index is a unique number that is assigned to every waveform capture operation. A waveform is automatically captured every time the Trip1 relay activates, and can be programmed to capture a waveform when the Trip2 relay activates.
8	ActiveSetGrp	Active Setting Group in effect when the trip occurred.
9	Trip Statu	Trip Status – shows if the FP-5000 has fully processed the trip data.
10	TOCTime ms	The Time Over Current trip time, that is the time from the TOC pickup to the trip in milliseconds.
11	Input Status *	A group of status flags detailing the state of the discrete inputs at the time of the trip.
12	Output Status *	A group of status flags detailing the state of the discrete outputs at the time of the trip.
13	IOC Pickup Status *	A group of status flags detailing the state of all the Instantaneous Over Current protective function pickups at the time of the trip.
14	V PH Pickup Status *	A group of status flags detailing the state of all the phase voltage protective function pickups at the time of the trip.
15	TOC Pickup Status *	A group of status flags detailing the state of all the Time Over Current protective function pickups at the time of the trip.
16	Misc. Pickup Status *	A group of status flags detailing miscellaneous protective function pickups at the time of the trip.
17	OC Trip Status *	A group of status flags detailing Over Current protective function operations at the time of the trip.
18	Misc. Trip Status *	A group of status flags detailing miscellaneous protective function operations at the time of the trip.
19	Volt Trip Status *	A group of status flags detailing voltage protective function operations at the time of the trip.

Table 12.12 Trip Log Record Line-by-Line — continued

Line	Display	Description
20	Output Gate Status *	A group of status flags detailing the state of the logic output gate driving each output relay as well as the state of auxiliary LED at the time of the trip.
21	Logic Block Status *	A group of status flags detailing the logical state of the programmable blocking gates output at the time of the trip.
22	Logic Gate Status *	A group of status flags detailing the logical state of the programmable logic gates and timing gates at the time of the trip.
23	SYSALM Pickup *	A group of status flags detailing the system alarm pickups at the time of the trip.
24	SYSALM Timeout *	A group of status flags detailing the system alarm timeouts at the time of the trip.
25	Breaker Status *	A group of status flags detailing the breaker state and associated alarms at the time of the trip.
26	Ogx Input Settings *	Shows the program settings of the inputs on the output logic gate that has driven either Trip 1 or Trip 2 to the active state at the time of the trip. This can identify which trip relay has activated.
27	Ogx Input State *	Shows the state of each logic input on the output logic gate that has driven either Trip 1 or Trip 2 to the active state.
28	Trip Test Status *	A group of status flags that shows if any output relay or zone interlock output has been forced to the active state through the test function.
29	rms Values *	Show the rms values of currents and voltages, as well as the frequency, current unbalance, and voltage unbalance at the time of the trip.
30	V&I Phasors *	Shows the fundamental voltage and current phasors with magnitude and relative phase angle.

* Indicates information available by selecting the line and pressing Enter.

12.2.3 History Log

The history log records statistics that can be gathered over time. It is therefore useful in detecting chronic problems that occur over time. In addition it keeps track of the number of operations and accumulated interrupted amps, that can indicate if the breaker needs maintenance. Each history log has a date-times stamp to indicate when the data was last reset. Each history log can be reset by pressing the reset button until the reset menu appears, then selecting History Log and then choosing the correct history log to be reset. See Section 4.13 for more information on the history log.

12.2.4 Using Waveform Data

Waveforms of all current and voltage phases are available through the PowerNet application software. The trigger of the waveform is automatic when the Trip 1 relay output contact activates. Using a logging setting (see setpoint Section 5) the waveform capture can also be triggered on the activation of the Trip 2 relay. See applications Section 8.10 and Section 5 for more information on how to set up the waveform capture.

12.2.5 Detection of Breaker Failures

The FP-5000 can detect failures in the breaker that can be useful in troubleshooting the system. Detectable failures include:

- Breaker failure to interrupt fault current
- Slow breaker operation time
- Breaker state alarm due to conflicting 52a and 52b contact inputs
- Open circuit detection on the trip or open coil circuit, and the close coil circuit

Please see application Section 8.9 and setting Section 5 for more details.

12.2.6 Detection of Failed Current or Voltage Transformer

The loss of the ability to read a phase voltage or current can be detected by using the 46 current unbalance and 47 voltage unbalance protection alarm functions (see Section 5). If a current or voltage transformer circuit should fail then a large unbalance of 50% will be detected and an alarm can be raised.

12.3 Getting Help from Cutler-Hammer

For help, contact:
Cutler-Hammer
Power Management Products Center
240 Vista Park Drive
Pittsburgh, PA 15205

Or phone Cutler-Hammer
Power Management Applications Support at:
1-800-809-2772, Option 1

Or browse to the Cutler-Hammer web site at:
http://www.ch.cutler-hammer.com, and follow the “Power Management Products” link and then the “contact us” link.

Technical personnel are available on a 24-hour basis with standard support from 7:00 AM to 5:45 PM Eastern Time and emergency hours from 5:45 PM to 7:00 AM Eastern Time weekdays. Holidays and weekends are emergency hours.

12.4 Firmware Upgrading

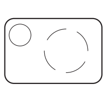
Cutler-Hammer will occasionally upgrade the firmware of the FP-5000 for the purpose of enhancing functionality or for other quality improvements. For this purpose, firmware is upgraded through the Cutler-Hammer FP-5000 FlashLoader program, along with a downloadable code file with a name such as, fp5kapp.s19 (example), which contains a representation of the firmware. This “S-Record” file contains all the information necessary to upgrade your FP-5000 firmware. The FlashLoader program must be installed on your PC, and your PC must have RS-232 serial communication capability. The “S-Record” file must be in one of the disk data paths accessible to your PC. Requirements for your PC are Windows® 95 version 2 or newer, 3 meg space on your hard drive and at least a 486 Intel™ processor.

12.4.1 FlashLoader Installation

There are a variety of formats in which you might obtain the FlashLoader installation files, such as by CD, floppy disks, or Internet download. Contact your Cutler-Hammer sales office or your Cutler-Hammer technical support team for assistance. Identify the location of the provided Setup.exe program in the source provided. Double-click on the file using Widows®
Explorer™, and follow the installation instructions.

12.4.2 Preparation for Downloading with FlashLoader

Make sure that the FP-5000 is active and not in stand-by mode. If the display is blank, press any key to activate the unit. Start the FlashLoader program on your PC and follow the instructions. The operation of the program is self explanatory, however the following description will enhance the user’s understanding of this program.



View Setting

Verify the Baud rate setting for the front panel RS-232 port. The setting may be viewed by pressing the **View Setting** button, selecting Communications, RS-232, and reading the Baud rate. The default Baud rate for the FP-5000 is 19,200. The default Baud rate setting for the FlashLoader is 9600. In order to decrease the download time, consider setting both to 38,400. Set the FP-5000 Baud rate setting before starting the FlashLoader.

Connect your PC to the front panel RS-232 connector on the front panel of the FP-5000 using a standard DTE to DSE cable. The FP-5000 front panel RS-232 connector is wired as a 9-socket (Female) Data Set (DSE) D-Subminiature under the RS-232 standard. Typical PCs are wired as a 9-pin (Male) Data Terminal (DTE) under the RS-232 standard. Sometimes PCs might have a 25-position D-Subminiature connector. In the case of the 9-position configuration, an off-the-shelf Male DB9 to Female DB9 “straight through” connection cable will work properly, even though only the Transmit, Receive, and common wires are required. (The front panel RS-232 connector uses a 3-wire connection, not relying on the hardware handshaking lines.)

Place the provided “S-Record” file into an accessible data path, preferably loading it onto a convenient place on your hard drive to minimize access time during the download process.

⚠ CAUTION

VERIFY THAT YOU HAVE THE PROPER S-RECORD FILE BEFORE ERASING THE FLASH MEMORY IN YOUR FP-5000. ONCE THE FLASH MEMORY HAS BEEN ERASED, FURTHER OPERATION OF THE FP-5000 WILL BE IMPOSSIBLE UNTIL A PROPER S-RECORD FILE IS DOWNLOADED. ONE MEANS OF ASSURANCE IS TO VERIFY THE DATE AND SIZE OF THE FILE WITH REPRESENTATIVES OF CUTLER-HAMMER BEFORE PROCEEDING.

12.4.3 Running the FlashLoader Program

Using Windows® Explorer™, double-click on the FlashLoader.exe program installed in the previous section.

If you expect to run the FlashLoader program frequently, you might wish to provide a link icon on the desk-top or in an appropriate group on the start-up menu by right clicking on the file name in Explorer™ and selecting “Create Shortcut.” Drag the shortcut to the desired group or to the desktop.

12.4.4 Initializing the FlashLoader

The FlashLoader starts up displaying the Com Port Configuration Frame. Select the Comm Port and the baud rate to which the FP-5000 is set. To speed up programming time, it is recommended to select the FP-5000 RS-232 baud rate to 38.4 K baud. To avoid port conflicts it is also recommended to close other programs that effect serial comm port communications. Then click the “OK” button initializing the relay to respond. If the relay has not responded in 5 seconds, a message will appear indicating the possible causes. Once the cause has been resolved, the operator can reinitialize the Flashloader program so that the relay will respond to the request. (See **Figure12-1**.) When communications have been established this window will close and a communications window will appear. (See **Figure 12-2**.) You will then be prompted to open the “S-Record File” from the file menu.

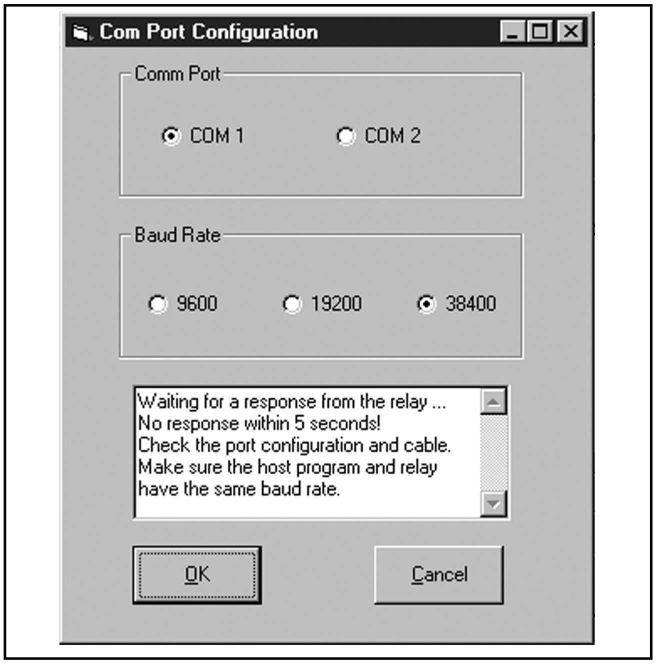


Figure 12-1. Flash Programmer Com Port Configuration

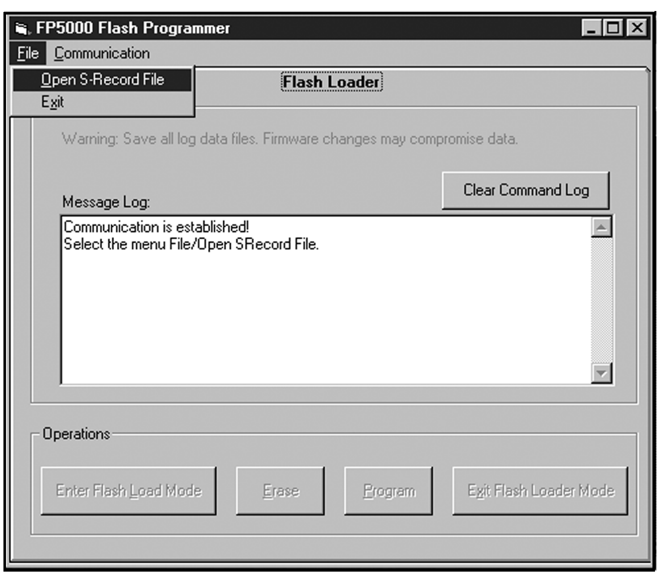


Figure 12-2. Flash Programmer

Once the S-Record File has been selected, a message will be displayed to “Click Browse to get the S-Record file.” (See **Figure 12-3**.) Click the Browse button and a file similar to “Fp5kapp.s19” (as an example) will appear. (See **Figure 12-4**.)

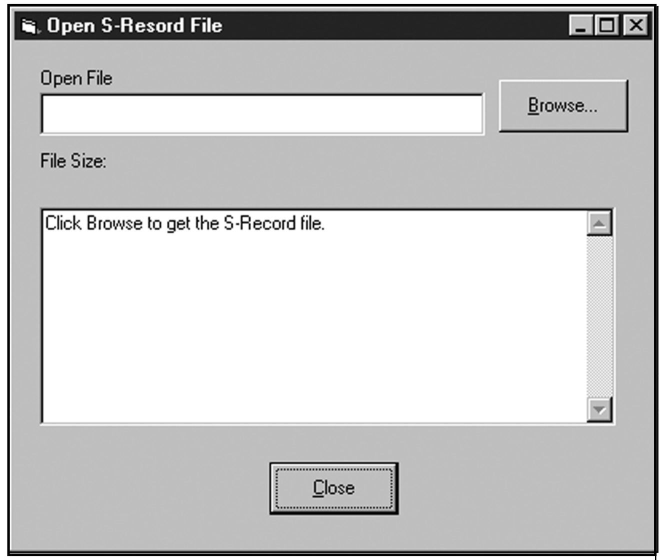


Figure 12-3. Flash Loader Open S-Record File

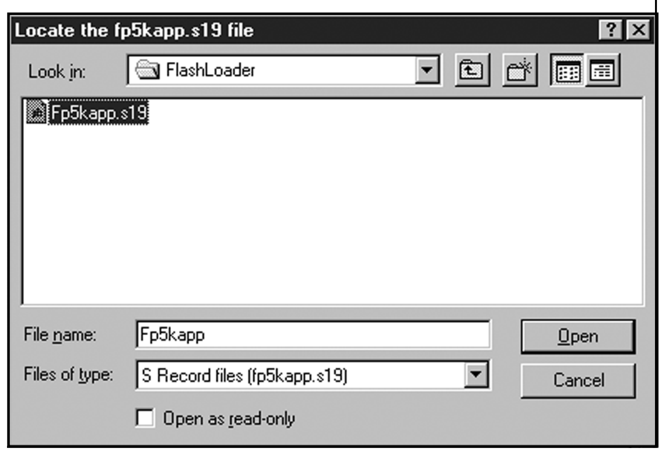


Figure 12-4. Flash Loader

Open the selected file. Once this has been accomplished this screen will automatically close and the next screen will appear asking the user to verify the selected file. (See **Figure 12-5**.) If verify is selected (highly recommended) a message will appear at the bottom of the screen stating that "Verifying is in progress." (See **Figure 12-6**.) This should take anywhere between 10 to 60 seconds depending on the file size. Once this has been completed the screen will automatically close and the next screen will appear. If close is selected the screen will automatically close and the next screen will appear.

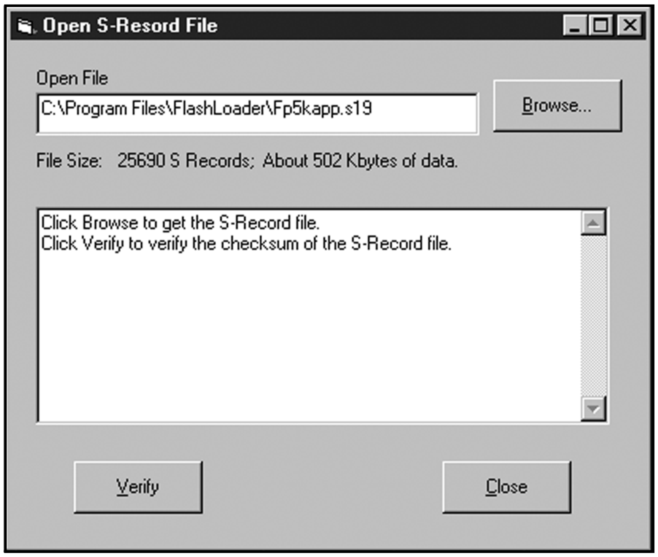


Figure 12-5. Open S-Record File

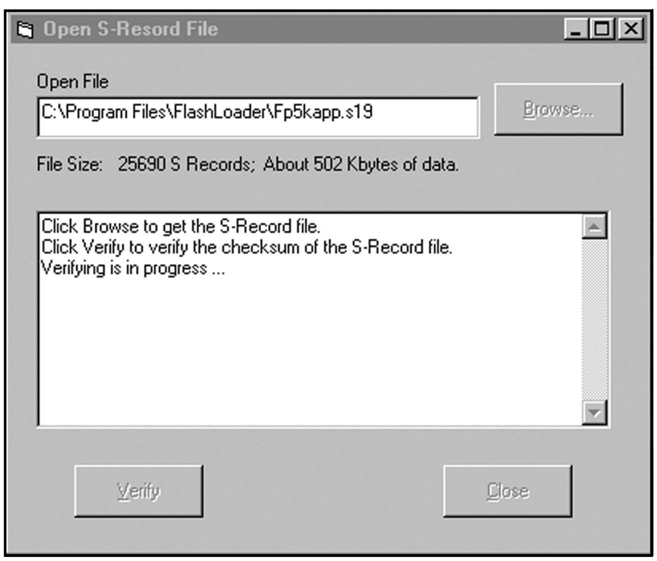


Figure 12-6. Open S-Record File

The next screen will prompt the user to Enter-Flash-Load-Mode. (See **Figure 12-7**.) Clicking on the "Enter Flash Mode" pushbutton will prompt the user to Erase or Program the FP-5000, and will switch the relay from normal mode to flash load mode. Note that the Erase, Program and Exit Flash Loader pushbuttons are now activated. (See **Figure 12-8**.)

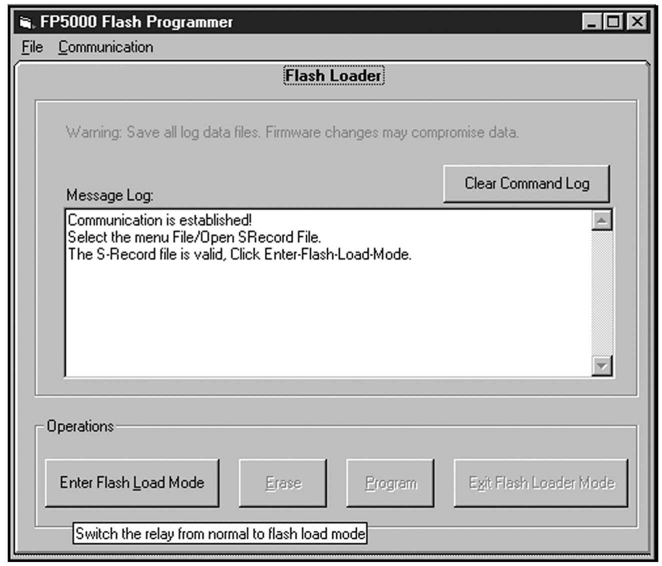


Figure 12-7. Flash Programmer

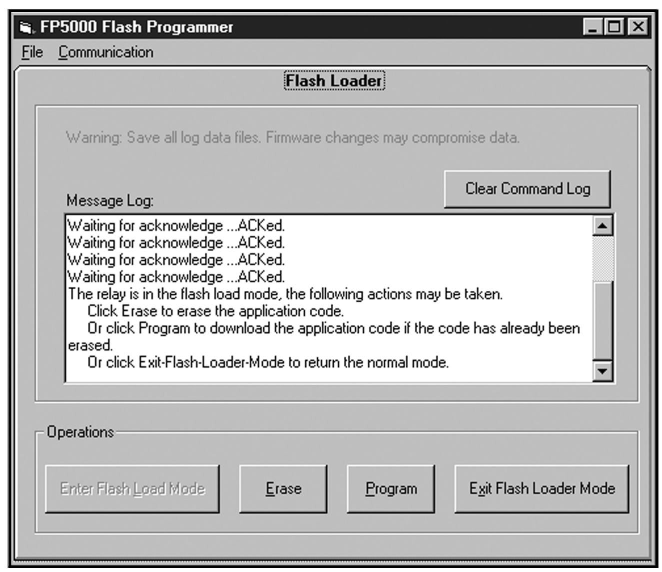


Figure 12-8. Flash Programmer

Figure 12-8. Flash Programmer

The recommended procedure is to first erase the memory by pushing the “Erase” button. A message will be displayed stating that “Erasing in progress.” (See **Figure 12-9**.) The FP-5000 will display “Flash Loader Mode – Erase in progress.” This process takes approximately 20 seconds to several minutes to complete depending on the size of the program. When completed, a message will appear on the screen “Erased properly.” (See **Figure 12-10**.) The FP-5000 will display Flash Loader Mode “App code erased.”

If a user chooses not to erase the FP-5000 and proceed with the program downloading, the FP-5000 will not allow the new program to be entered unless the memory has been erased. Screen messages will appear instructing the user how to proceed. If the user selects “Exit Flash Loader” the program is aborted. If the user selects “Program” the unit will begin to program if its memory has been erased. If the memory has not been erased a message will appear instructing the user to erase before programming.

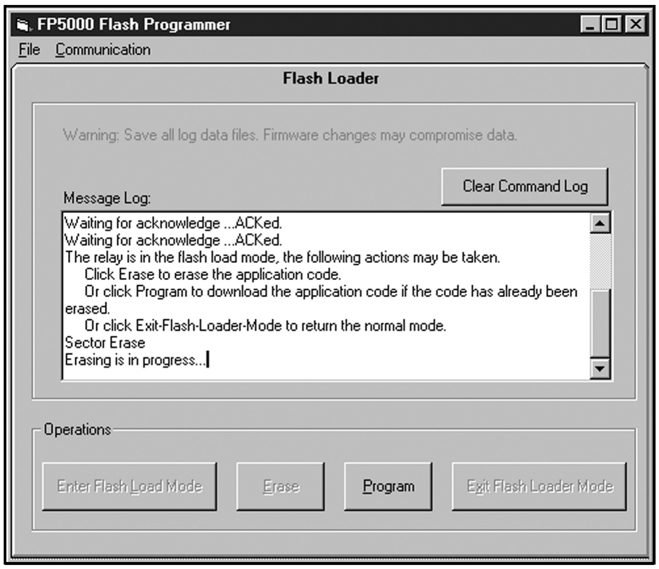


Figure 12-9. Flash Programmer

Figure 12-10. Flash Programmer

The user can now push the Program button to start downloading the application code process. A new screen will appear with instructions to “Click Program to download the application code.” (See **Figure 12-11**.) The FP-5000 will display Flash Loader Mode “BlankCheck Pass.” A % complete bar will appear at the bottom of the screen. Pressing the Program button will begin downloading the new application code and begin to fill the % complete bar from left to right indicating the status of the programming process. (See **Figure 12-12**.) The FP-5000 will display Flash Loader Mode “Program in progress.”

If the user chooses to abort the programming he can do so at any time. He must then push the close button, which will activate the previous screen. The user can then choose to erase which will then allow him to reprogram or exit the program. Using the close button will close the program, and display the screen as shown in **Figure 12-10**. The user can either exit the FlashLoader Program or continue.

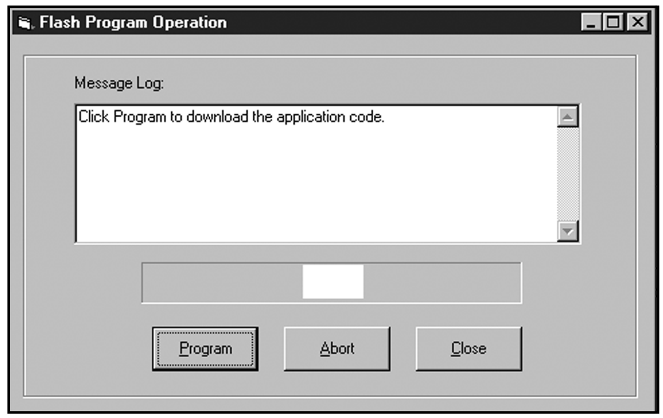


Figure 12-11. Flash Program Operation

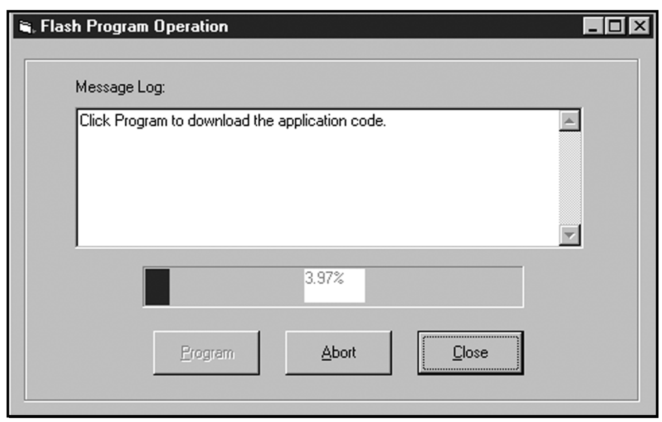


Figure 12-12. Flash Program Operation

Once the program has been loaded the user will be instructed to exit the flash load mode by pushing the “Exit Flash Loader Mode.” (See **Figure 12-13**.) The FP-5000 will display Flash Loader Mode “Program Complete Exit FL Load Mode.” Once this has been completed the screen will prompt the user to force the relay to run in normal mode. This is accomplished by clicking on “File” then “Exit” to exit the Flash Loader program thus returning the FP-5000 to its normal state. (See **Figure 12-14**.)

If there is a message displayed on the FP-5000 that “App checksum fail Enter FL Load Mode to erase or program” the user will have to go back and erase the FP-5000 and reprogram following the above steps.

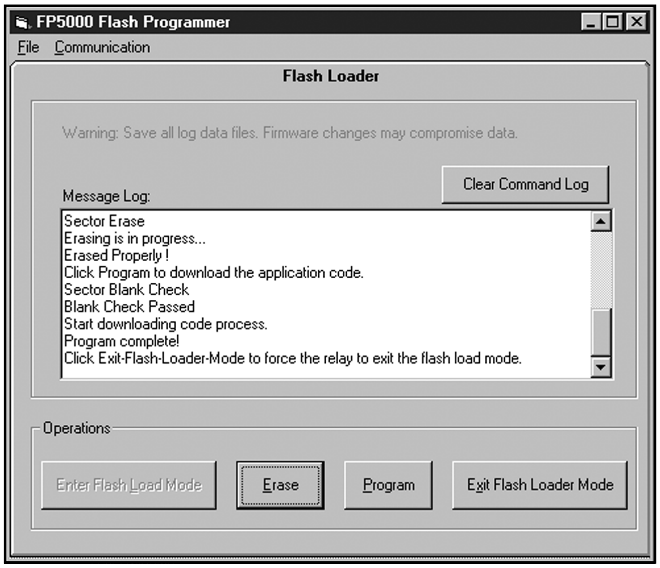


Figure 12-13. Flash Programmer

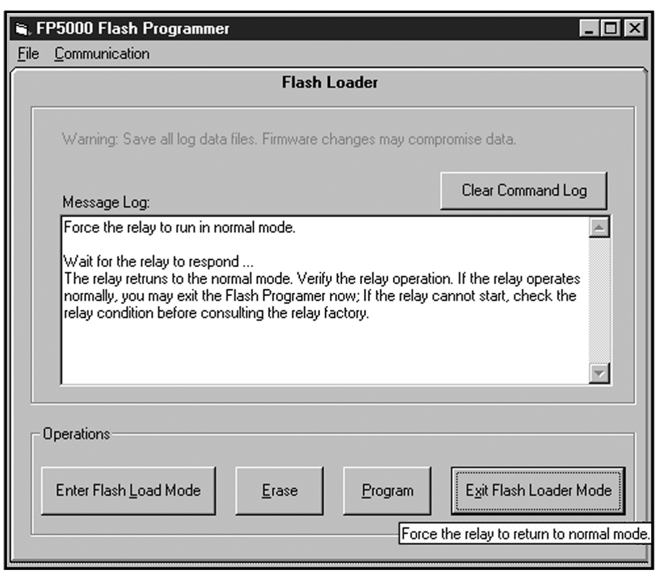


Figure 12-14. Flash Programmer

13 APPENDIX

13.1 Glossary

The following acronyms, abbreviations and definitions are used throughout this document.

Algorithms	A set of rules or equations by which a value is calculated or a relay strategy is implemented by the FP-5000 processor.
ADC	Analog-to-Digital Converter.
ADT	Adjustable Definite Time is the time value provided by the user as fixed reset delay independent of current.
Analog Signal	Currents and voltages are analog signals.
Apparent Power Factor	Real power (watts) divided by volt-amperes (using the true rms values).
ASCII	American Standard Code for Information Interchange. Code with one byte per character used for alphanumerics.
AWG	American Wire Gauge. Standard wire-cross section area.
BFI	External Breaker Fault Initiation.
Bit	Binary digit either 1 or 0. The smallest unit of information handled by a computer.
CBEMA	This is defined as the ratio of the crest factor of a pure sine wave to the actual application crest factor.
CH	Cutler-Hammer
Click	To quickly press and release the mouse button without moving the mouse.
COM1	Serial communication port 1 on a PC.
COM2	Serial communication port 2 on a PC.
Crest Factor	The crest factor is the ratio of the peak value to the rms value. It is equal to 1.414 for a pure sine wave.
Ct	Current Transformer.
DAS	Data Acquisition System.
Digital Signal	Digital inputs, such as on or off switches.
Displacement Power Factor	Fundamental watts divided by fundamental volt-amperes. This definition is valid only for the system fundamental operating frequency.
Double-Click	To quickly press and release the mouse button twice on a PC.
Drag	To press and hold down the mouse button while you move the mouse on a PC.
FSK	Frequency Shift Keying is encoding typically used by a MODEM.
HMI	Human Machine Interface is also called MMI or Man Machine Interface.
Ia, Ib, Ic	Phase currents for phases a, b, and c respectively.
Icon	A picture on a computer screen representing an application.
IMPACC™	Standard Cutler-Hammer Integrated Monitoring, Protection, And Control Communications protocol definition for communication on the INCOM network.
Inom	Nominal Current for context rating of the FP-5000 (1 amp or 5 amp).
INCOM™	Cutler-Hammer INdustrial COMmunications network.

IP Address	A 32-bit number containing both a subnet address and a host address that identify a device in a network.
IR	Residual ground current calculated for the three phases, Ia + Ib +Ic, is a calculated value not measured directly. It will be different on a 4-wire system.
IOC	Instantaneous Over Current protective function; The IOC functions have an optional time delay for coordination with other relays.
IX	Current measured by a fourth system current transformer. This could be a physical ground measurement from a residual current connection of the phase Cts.
LAN	Local Area Network.
Left Mouse Button	The primary mouse button, unless you have configured your mouse differently. When instructed to click on an item, point to it and press the left mouse button.
List Box	A box on a pop-up screen that displays information, allowing you to scroll through or select its contents.
Modbus protocol	A popular industrial communication protocol.
MODEM	Modulator/Demodulator – encodes and decodes data stream, typically for transmission over telephone lines.
Mouse	A hand-held pointer that attaches to your computer. The mouse displays on the computer screen as an arrow. By moving the mouse and clicking the mouse buttons, you can perform and select various operations.
PC	Personal Computer based upon the Intel™ processor family.
Phase Reversal	When any two phases become reversed.
Phase Unbalance	Deviation of the percentage of nominal line voltage between any two phases.
Point	To position the pointer so that it is resting on the desired item on the screen.
Pointer	The hollow white arrow that you can move around the screen using the mouse.
Pop-Up Screens	A screen that displays access to a PC program function, prompting you to enter additional information.
Power Flow	Power Flow is the direction of power flow for each harmonic, and is defined as the sign of WATTS = [Id*Vd + Iq*Vq] for that harmonic. Thus, a positive power flow is power into the load, and a negative power flow is power being generated by the load. Power should be greater than 2% of the full load to be sure the result has significance. Zero power should default to a positive power flow.
Reactive Power (VARs)	Reactive power or energy associated with the displacement power factor is power factor correctable (Volt-Amperes Reactive). It is sometimes referred to as the "Q" or "Q-Hours." Calculation of the "Q" will use the technique of multiplying voltage samples by the associated current samples taken 90° earlier. Thus, a leading power factor will follow the convention of being positive.
Real Power (Watts)	Real power is computed by summing the product of the individual current and voltage readings over one cycle.
Right Mouse Button	The secondary mouse button, unless you have configured your mouse differently. Use the right mouse button only when specifically instructed to do so.
rms	The rms value of a quantity X follows the standard definition of: With sufficient sampling, harmonics will be included in the rms values.
RS-232	A standard that defines the electrical characteristics of a widely-used serial communication link.
T/H	Track and Hold.

THD	Total Harmonic Distortion is the ratio of the rms of the harmonic content to the rms value of the fundamental quantity, expressed as a percent of the fundamental where n is the highest harmonic value available.
TOC	Time Over Current protective function – typically Inverse Time.
VA, VB, VC	Phase voltages for phases a, b, and c respectively.
VAB, VBC, VCA	Line-to-line voltage between phase a & b, phase b & c, phase c & a respectively.
VT	Voltage Transformer.
VX	Voltage measured on differential voltage input (VX1-VX2)
Waveform data	The numeric oscillographic values that may be captured. These values can be retrieved by PowerNet or PowerPort.
Window	An area of the computer screen that displays an application.

13.2 Display Abbreviations

Apt	Apparent
Aux	Auxiliary
Dsp	Displacement
Config	Configuration
Ctr	Control or counter depending on context
Fwd	Forward
L-N	Line to neutral
L-L	Line to line
Mag	Magnitude
Rev	Reverse
OC	Over current
Rst	Reset
rms	Root means square
Varh	Var-hour
Wh	Watt-hour

13.3 Standard IEEE Device Numbers

Standard IEEE Device Numbers for power devices are covered under IEEE document, IEEE Standard Electrical Power System Device Function Numbers and Contact Designations, # C37.2-1996, ISBN 0-7381-0732-8.

Some typical device numbers are used frequently within this document and throughout Cutler-Hammer's product and other documentation. For a complete list, please see the IEEE document referenced above.

Device Number	Description (Function)	
27.	**Undervoltage Relay**	Relay that operates when the voltage drops below a programmed value.
46.	**Reverse-Phase, or Phase-Balance, Current Relay**	Relay which functions when the polyphase currents are of reverse-phase sequence, or when the polyphase currents are unbalanced or contain negative phase-sequence components above a given amount.
47.	**Phase-Sequence Voltage Relay**	Functions upon a predetermined value of polyphase voltage in the desired phase sequence.
50.	**Instantaneous Overcurrent, or Rate-of-Rise Relay**	Relay that functions instantaneously on an excessive value of current, or on an excessive rate of current rise, thus indicating a fault in the apparatus or circuit being protected.
51.	**AC Time Over Current Relay**	Relay with either a definite or inverse time characteristic that functions when the current in an AC circuit exceeds a predetermined value.
52.	**AC Circuit Breaker**	Device that is used to close and interrupt an AC power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.
55.	**Power Factor Relay**	Relay that operates when the power factor in an AC circuit rises above or below a predetermined value.
59.	**Overvoltage Relay**	Relay that operates when the voltage rises above a programmed value.
81.	**Frequency Relay**	Relay that operates when the frequency falls outside a programmed range.

13.4 Time-Current Curves

A variety of inverse time overcurrent curves for the FP-5000 are shown in this section.

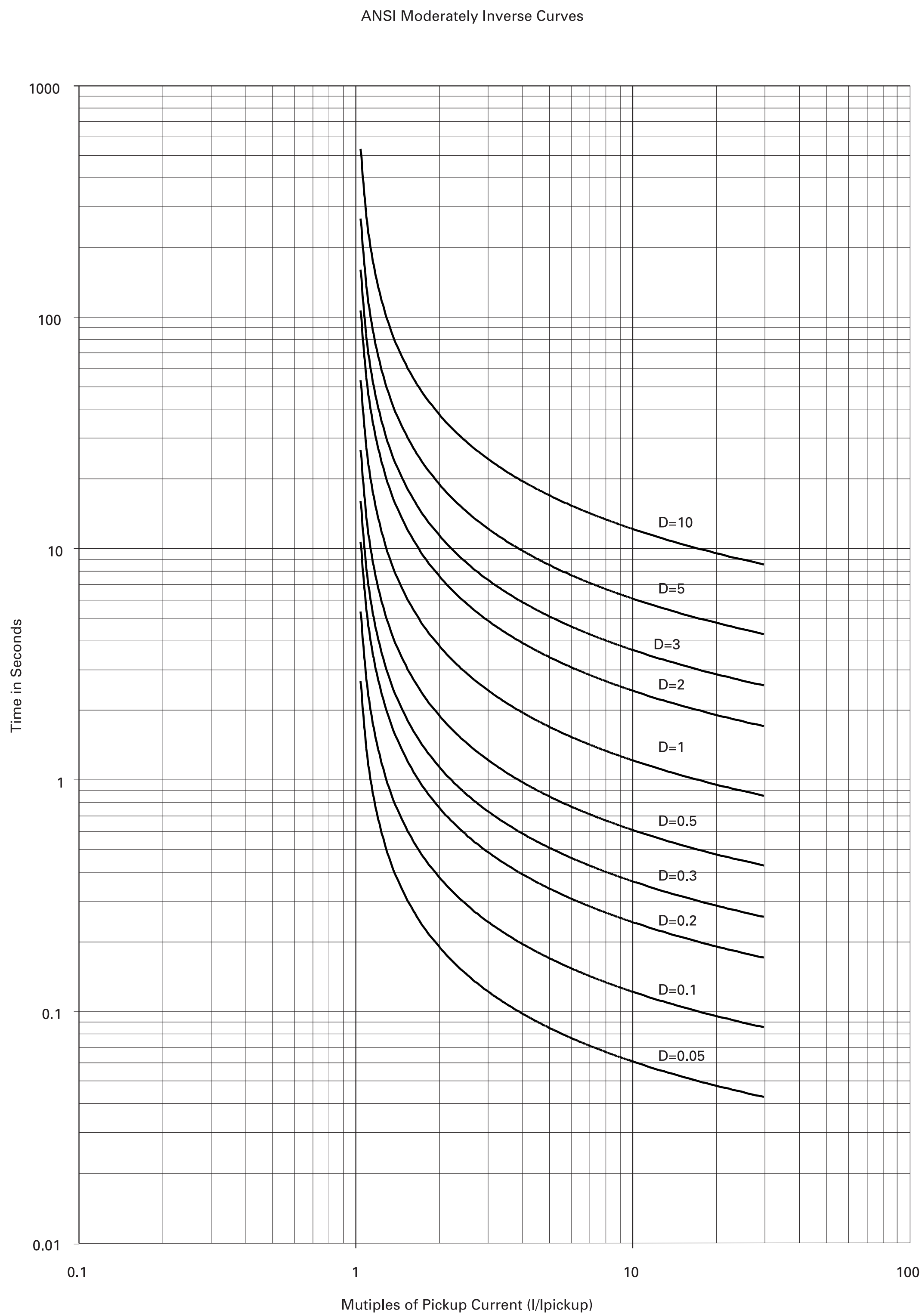


Figure 13-1. ANSI Moderately Inverse

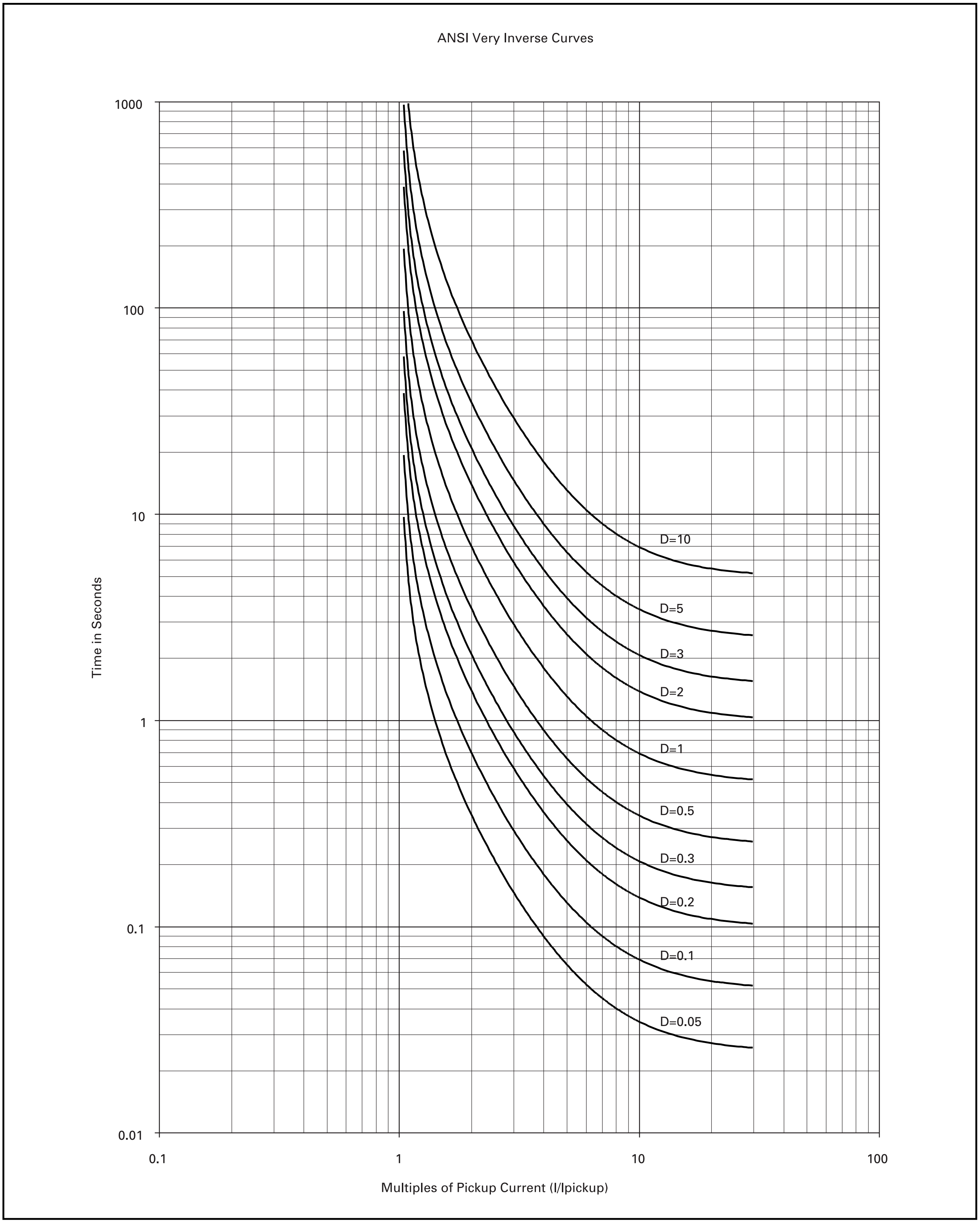


Figure 13-2. ANSI Very Inverse

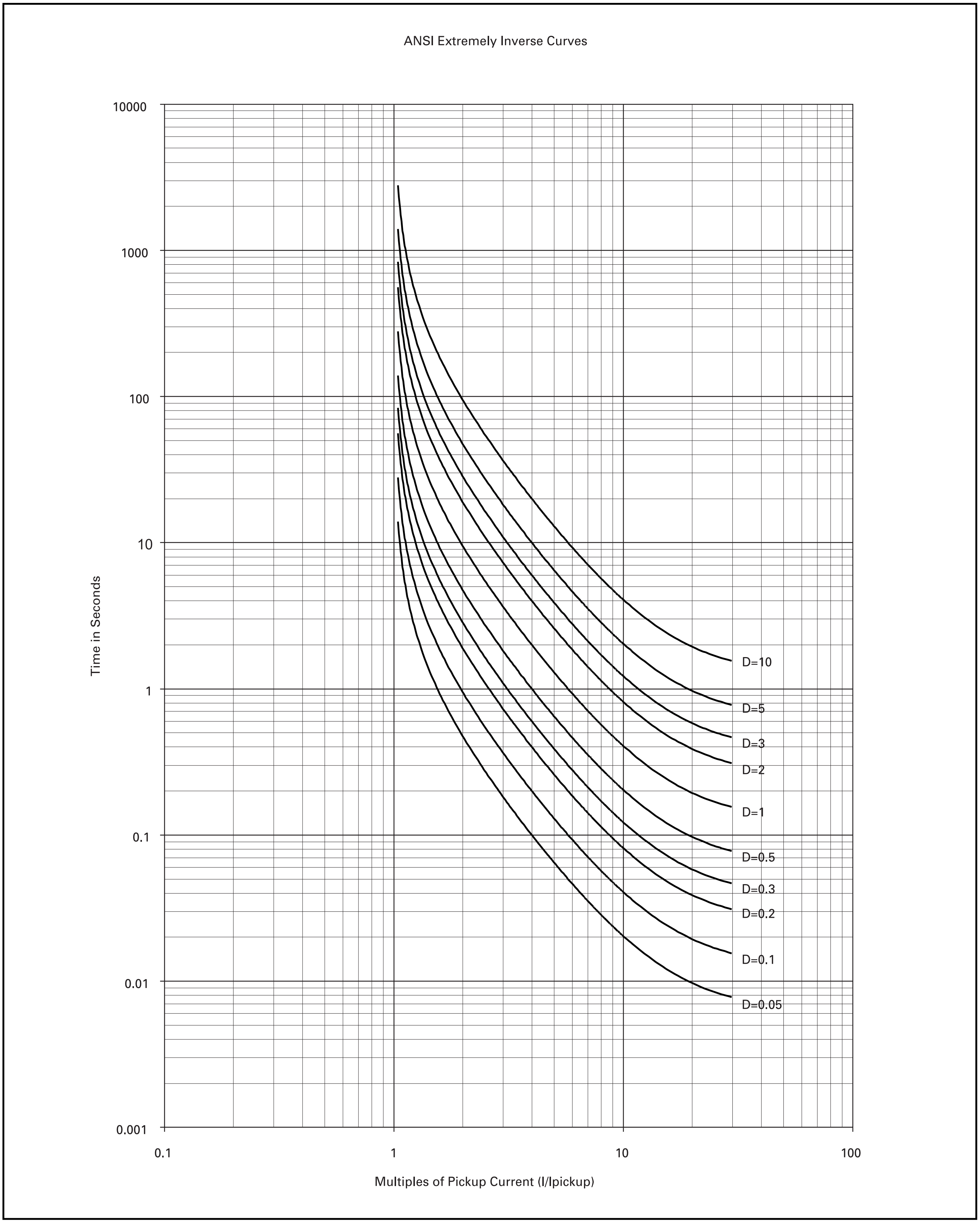


Figure 13-3. ANSI Extremely Inverse

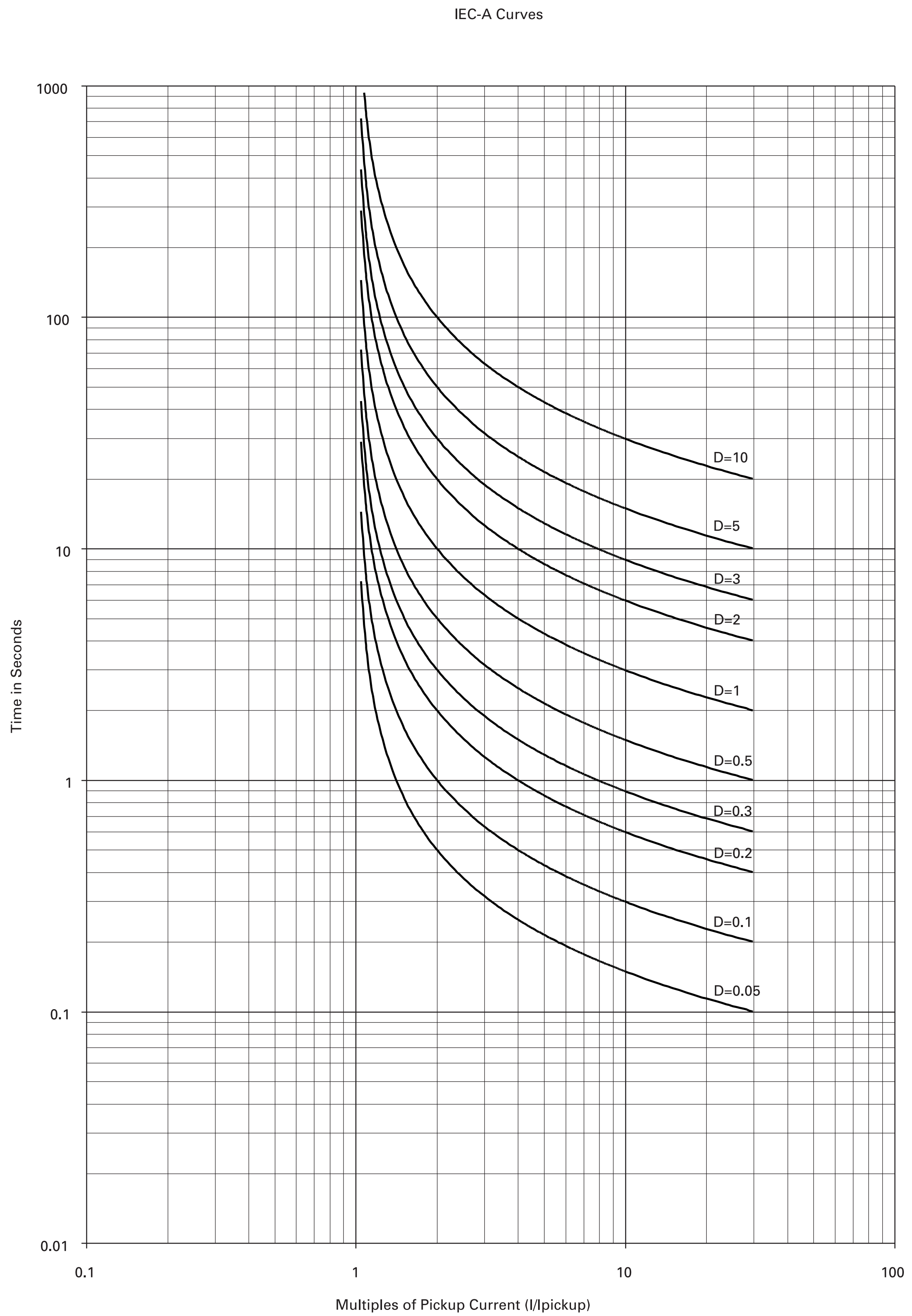


Figure 13-4. IEC - A

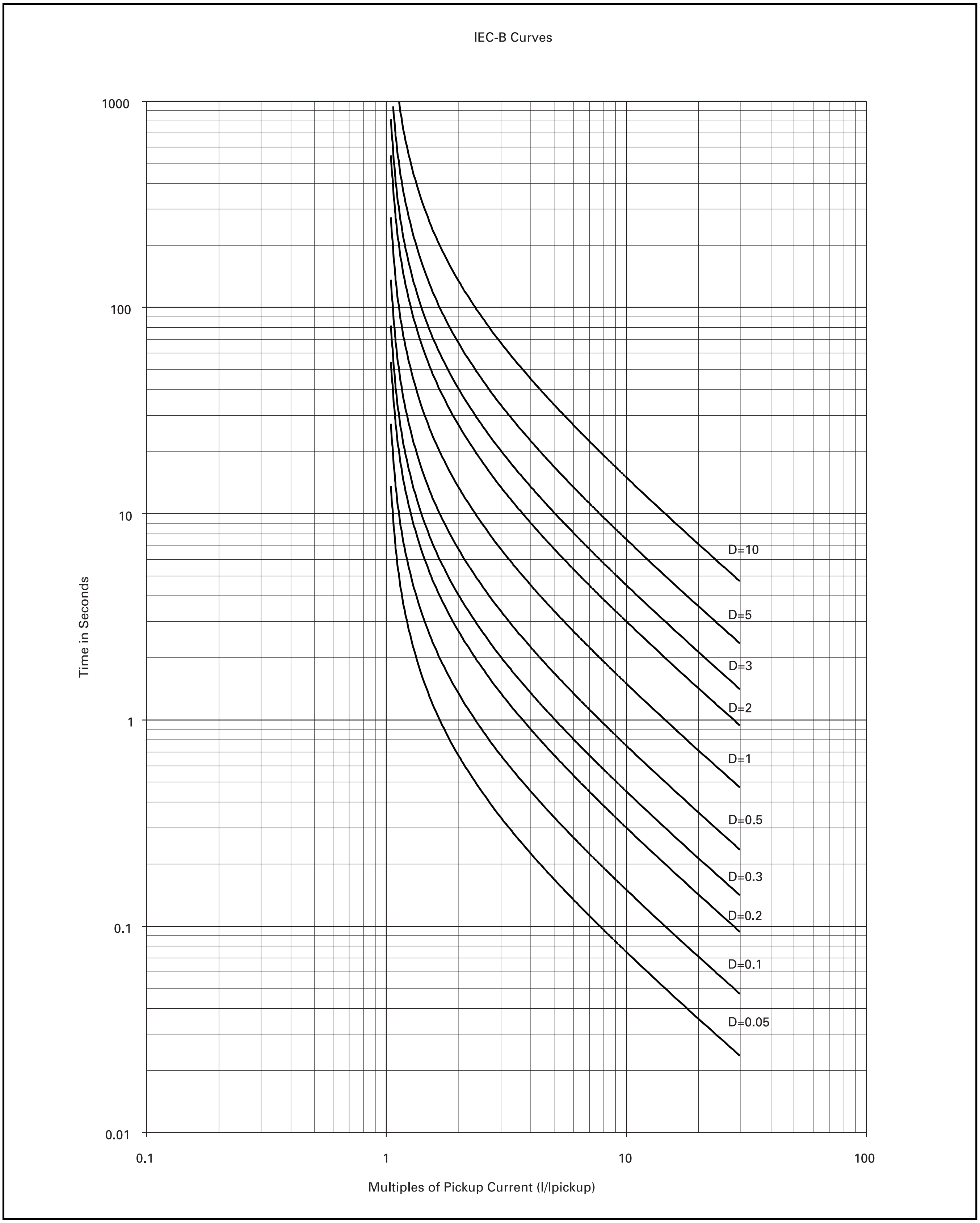


Figure 13-5. IEC - B

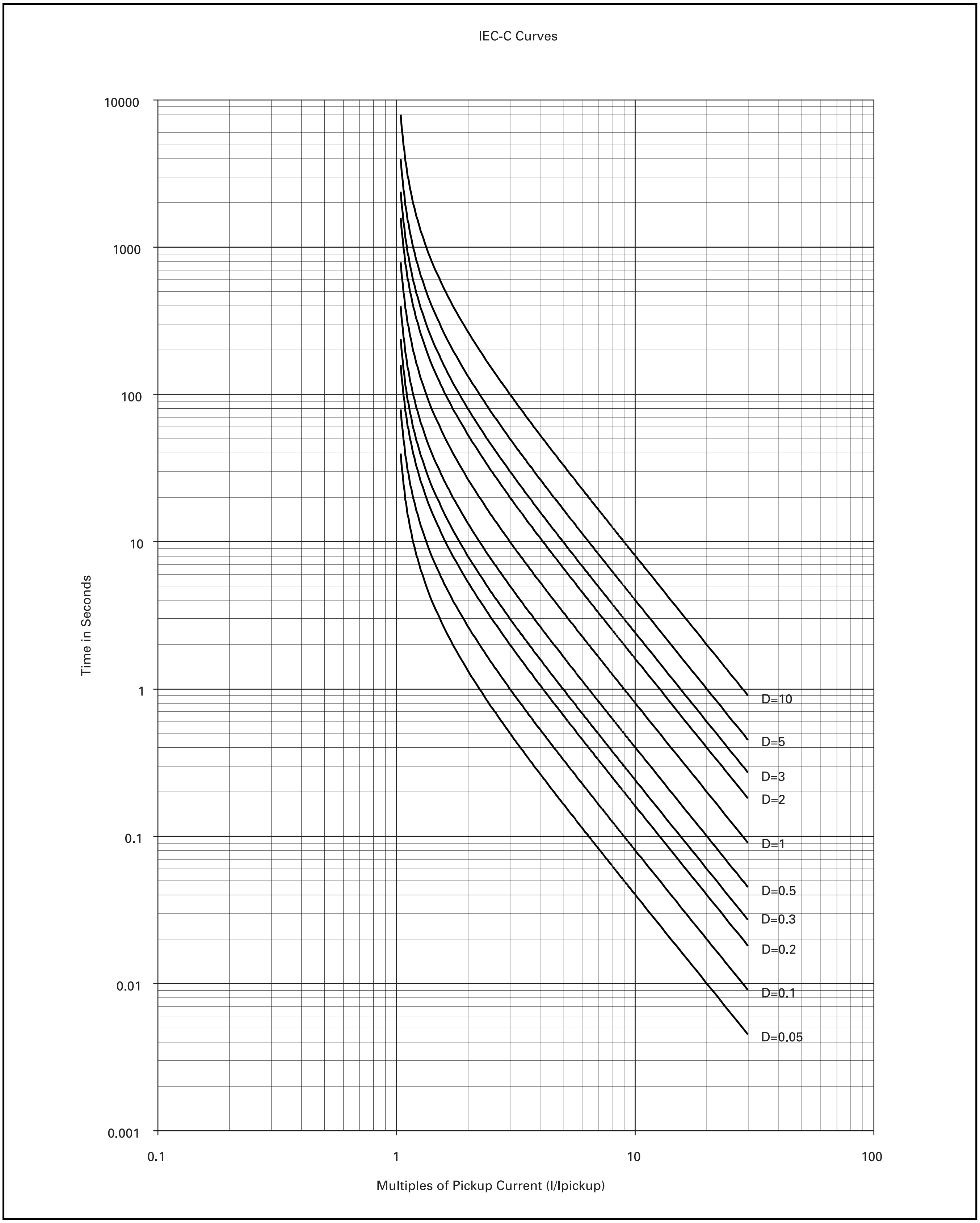


Figure 13-6. IEC - C

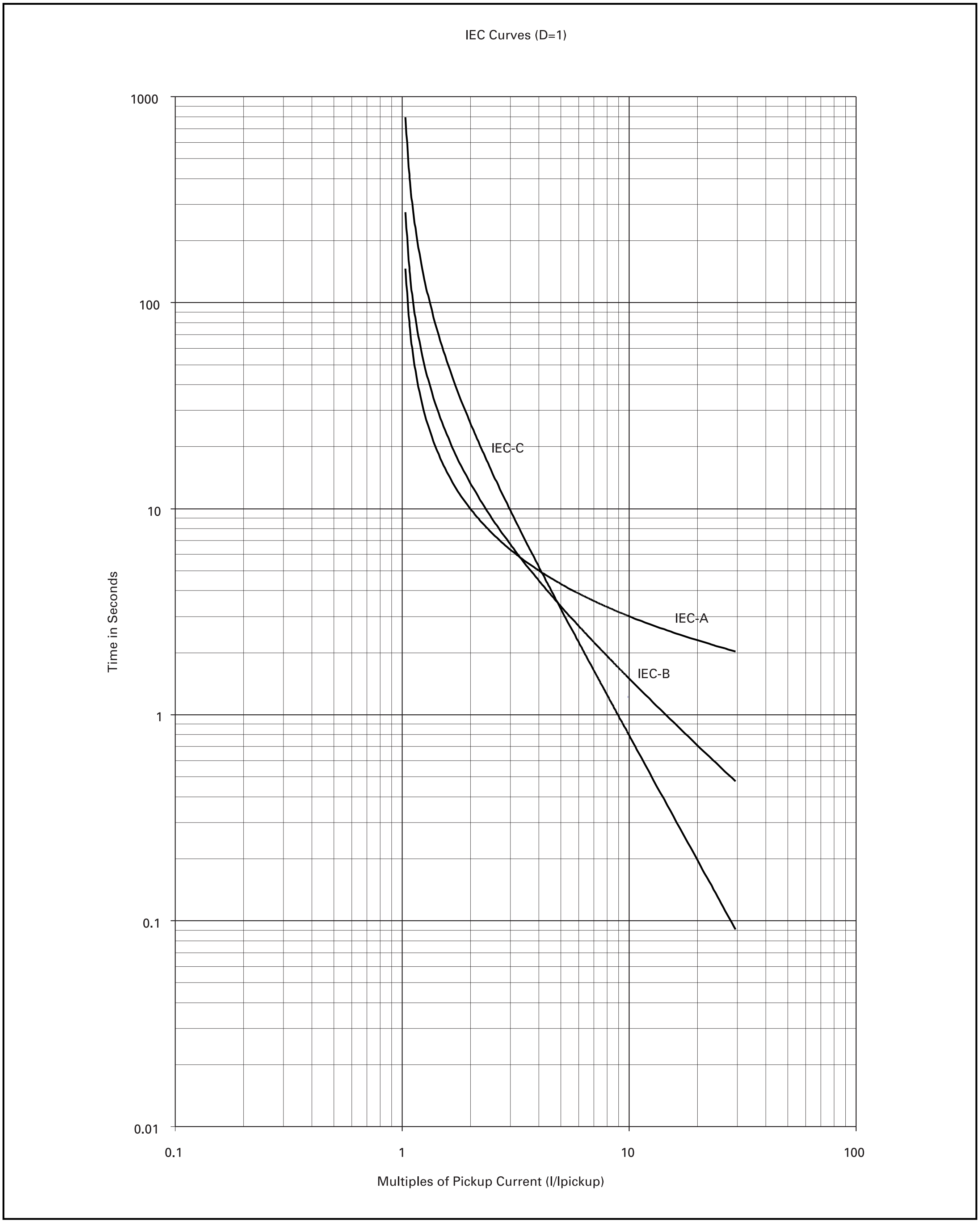


Figure 13-7. IEC

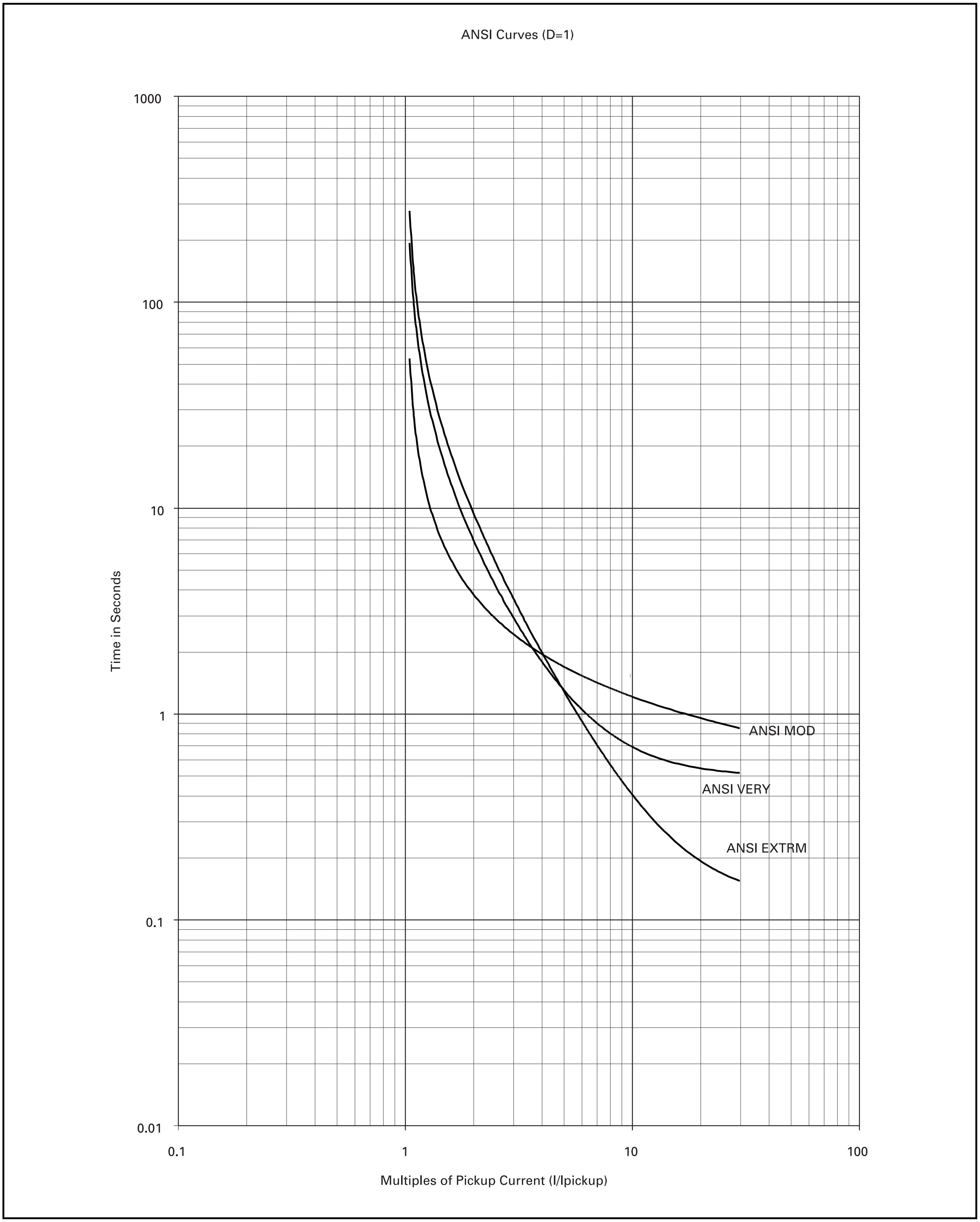


Figure 13-8. ANSI

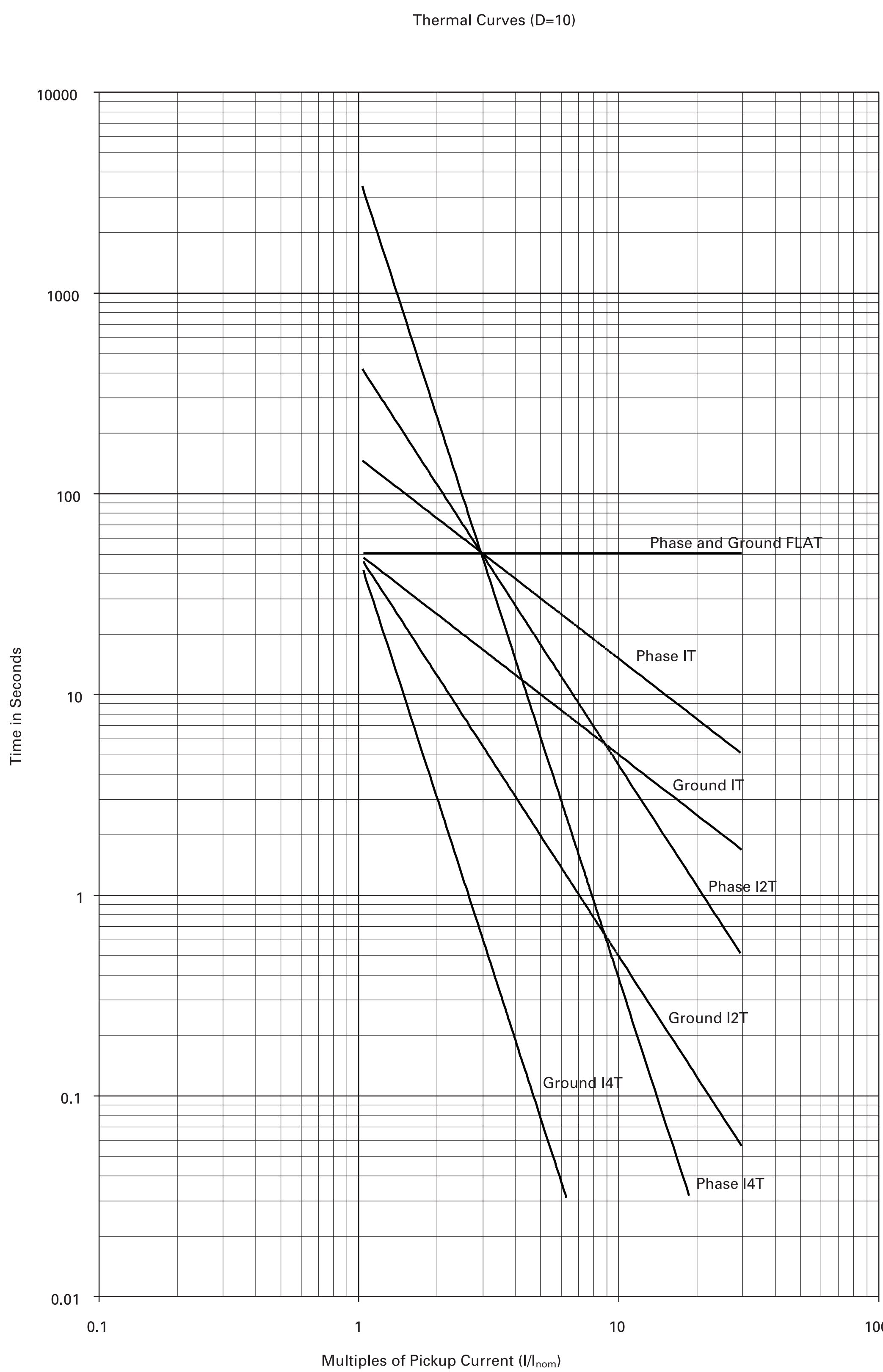


Figure 13-9. Thermal

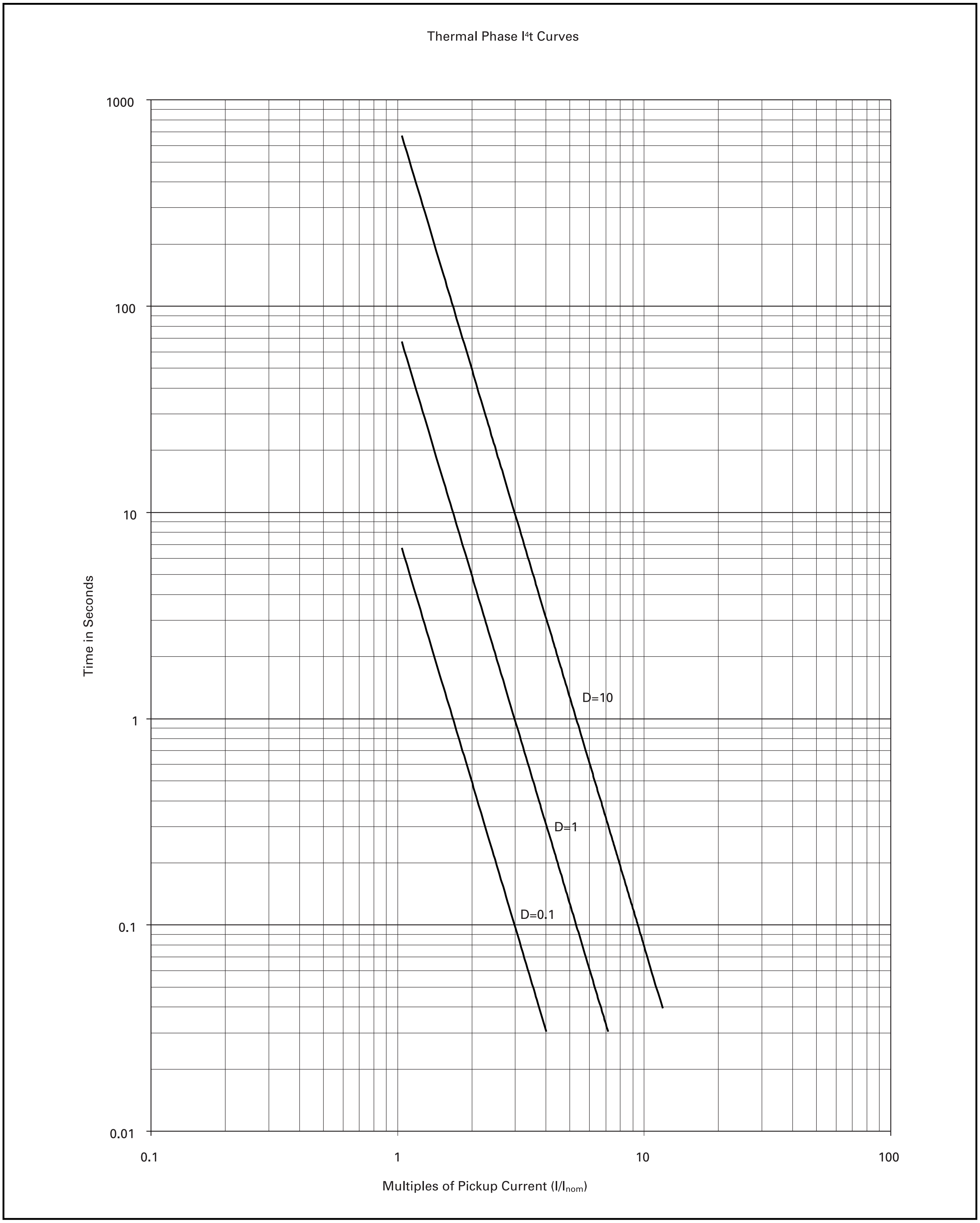


Figure 13-10. Phase I^4t

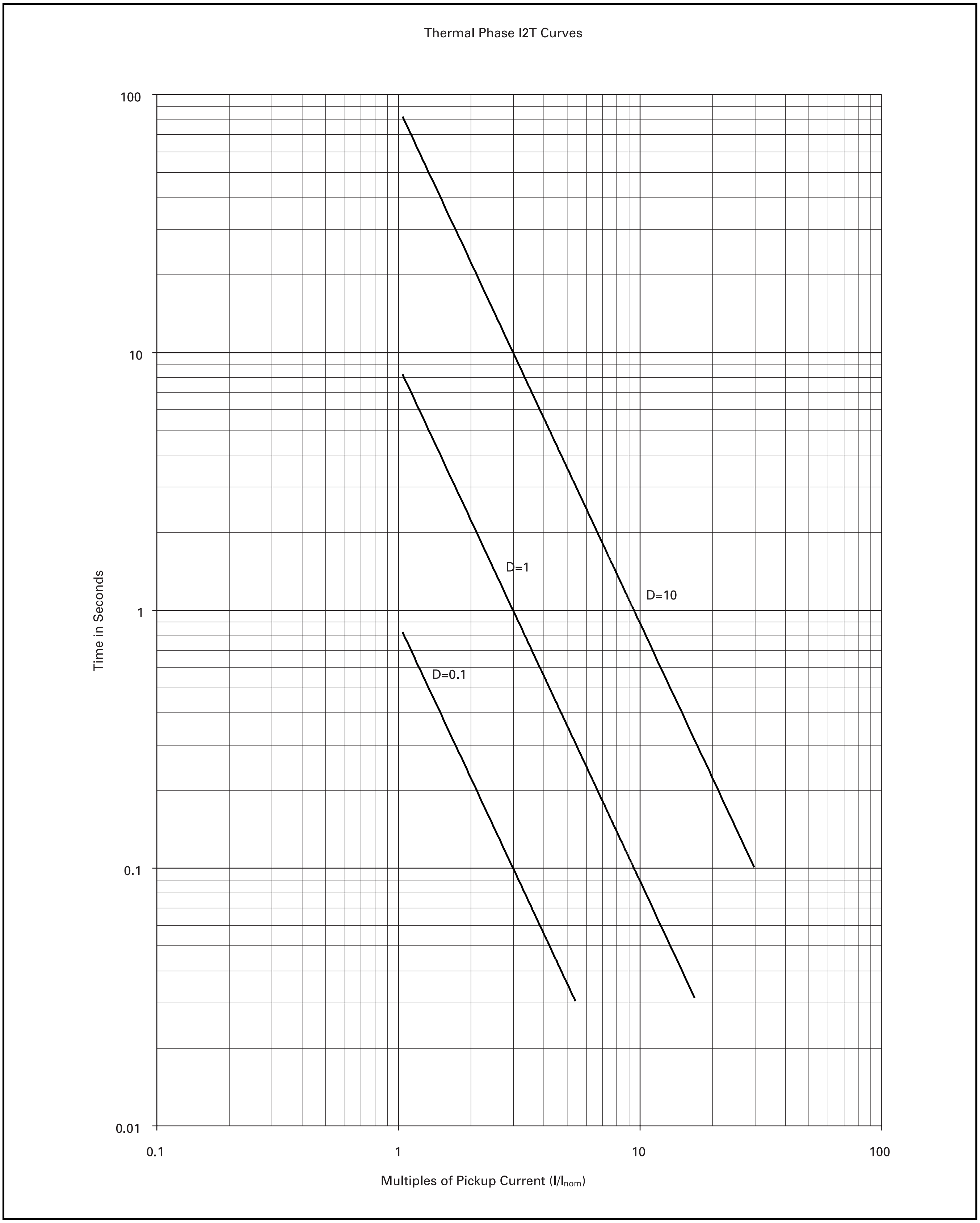


Figure 13-11. Phase I²t

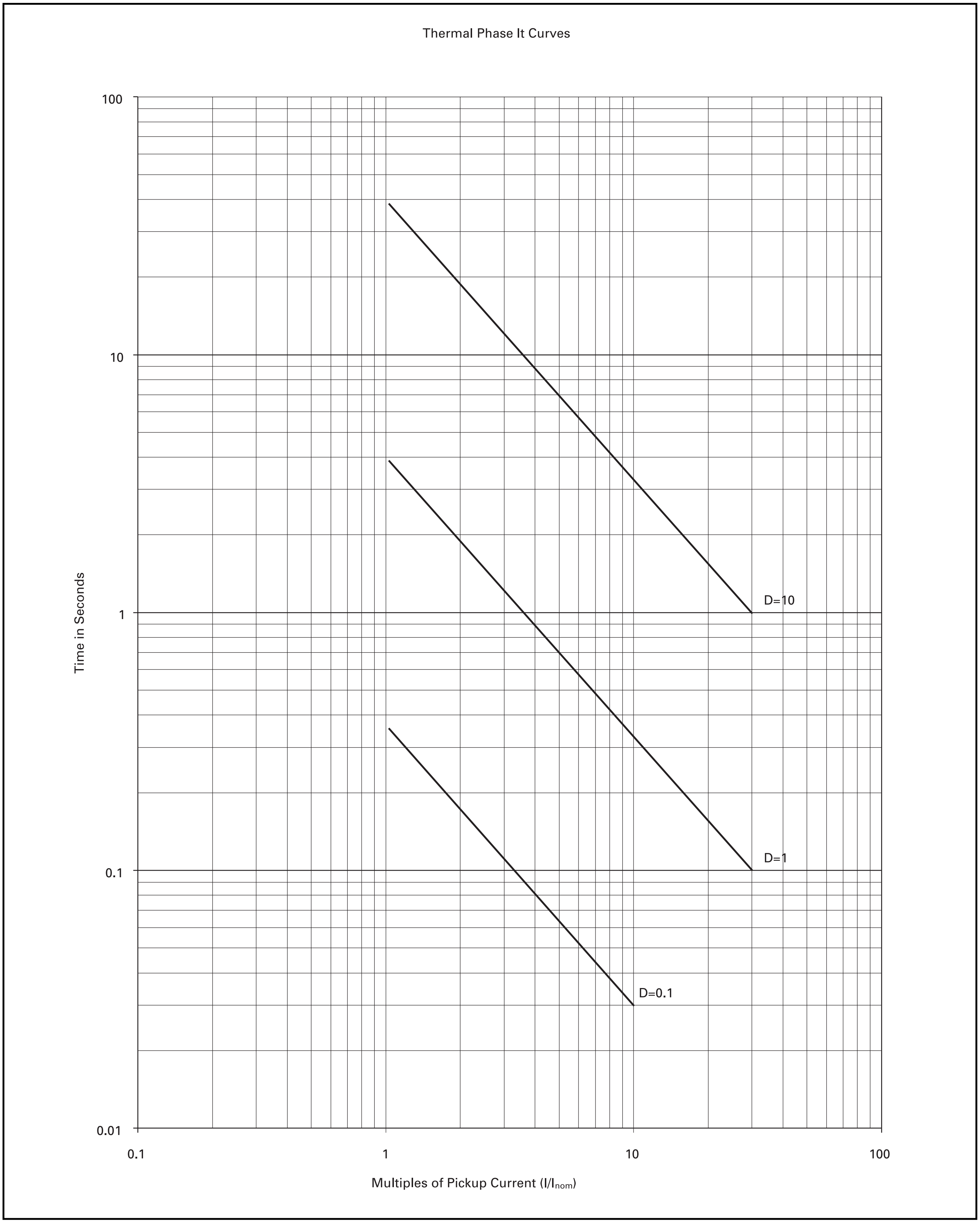


Figure 13-12. Phase It

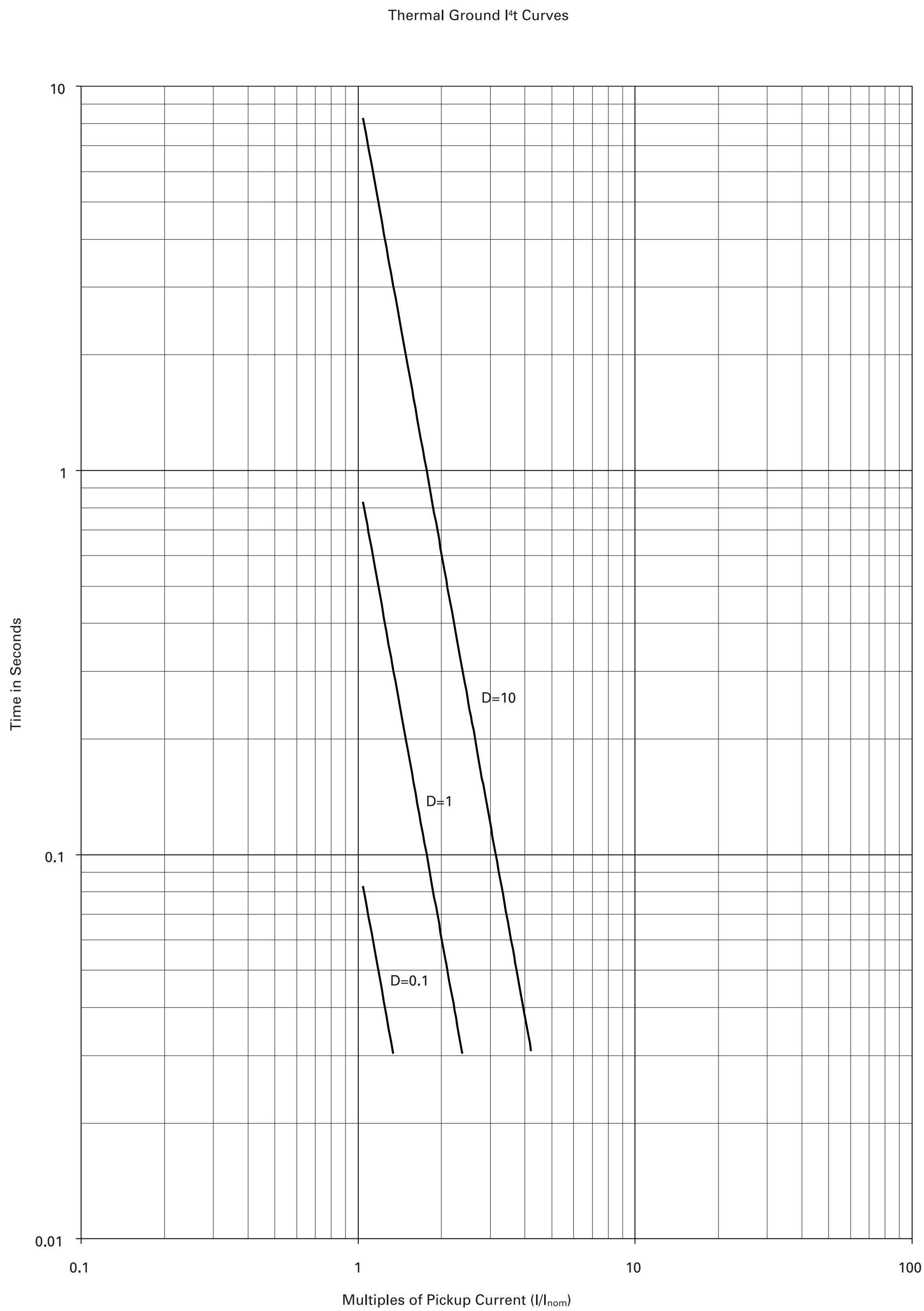


Figure 13-13. Phase 12 I^4t

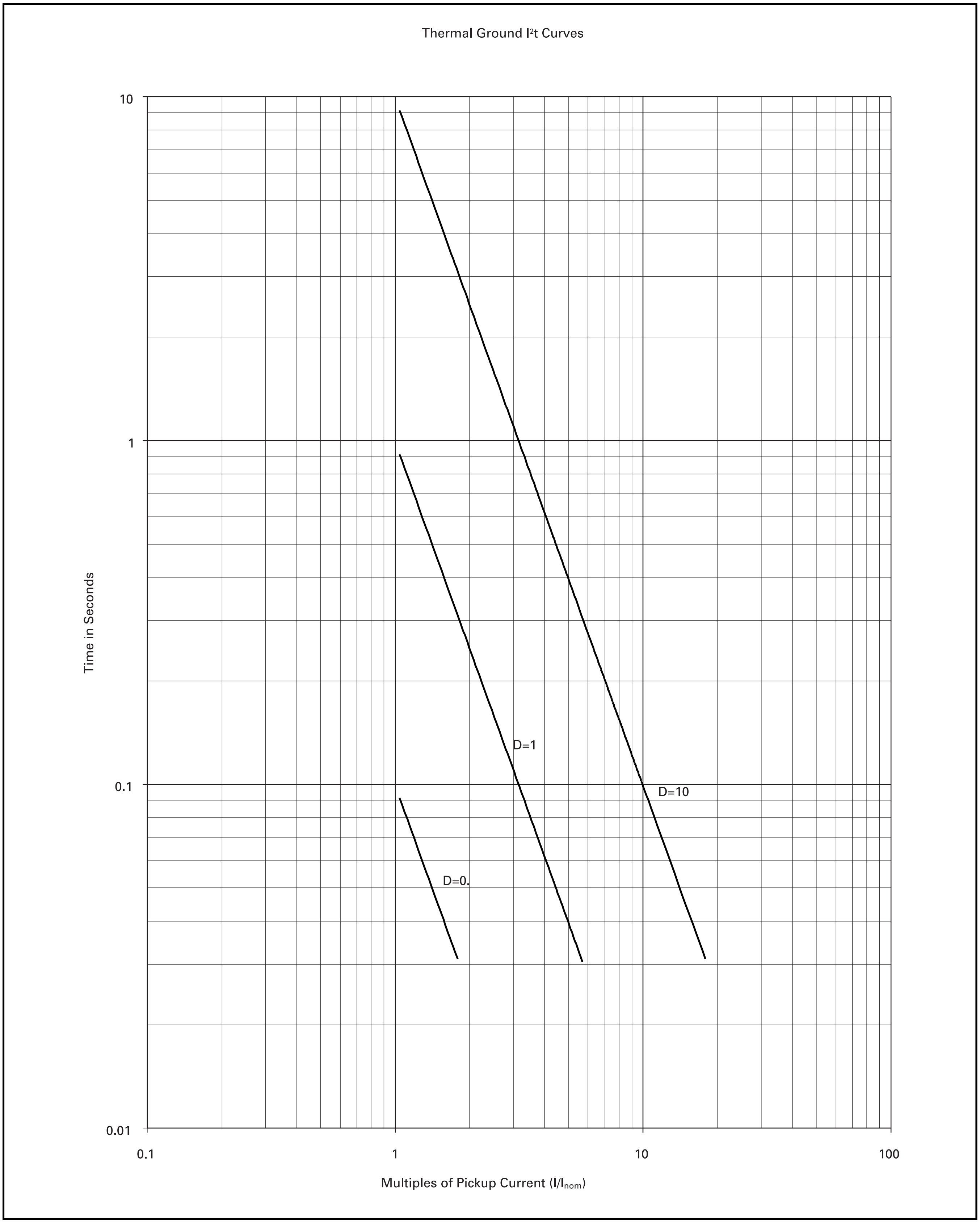


Figure 13-14. Phase I²t

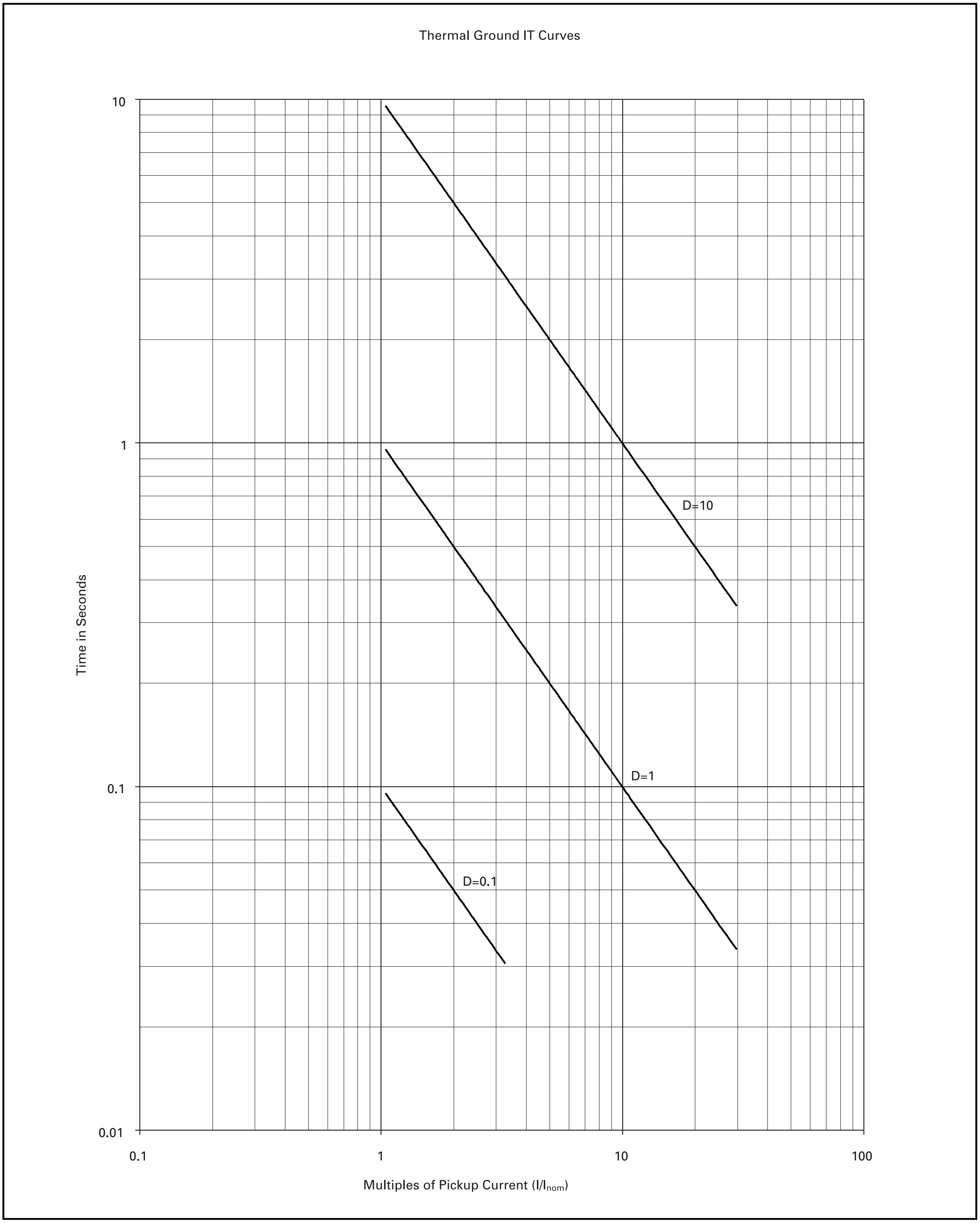


Figure 13-15. Ground IT

13.5 Standards Compliance

The following table shows the standards to which the FP-5000 complies and, where appropriate, the rating achieved under the standard's categories. Note that, in most cases, the performance levels exceed the levels given. This table is not a maximum performance specification, rather it shows compliance to published numbers in the standards.

NORTH AMERICAN STANDARDS

ANSI/IEEE	
ANSI/IEEE C37.90-1989	Performance Standard for Relay Systems associated with electric power apparatus
ANSI C37.90.1 (1989) Surge Withstand Capability	
Oscillatory Surge Wave Compliance (OSWC)	2.5 kV
Fast Transient Surge Wave Compliance (FTSWC)	4.0 kV
ANSI C37.90.2 (1995) RF radiated immunity	
RF Radiation Withstand	to > 35 V/M; 27 - 1000 MHz
UL/CUL	FP-5000 UL Compliance is covered under UL File Number E154862 Catalog # FP-5000-00 5 Amp Version only, FP5100-00 1 Amp version pending
UL-1053	Ground Fault Interruption (GFI) for Protective Relaying (PR) Equipment Performance - FP-5000-00 5 Amp version only, FP-5100-00 1 Amp version pending
UL-508	Spacing of conductors, Safety, Fire
FCC	
CFR 47 FCC Part 15 Subpart b Class A	EMF radiation limitation

EUROPEAN STANDARDS

Emissions	
EN-50081-2	
EN 50011 CISPR-11, Class A	
Immunity EN-61000-6-2 (1999)	
IEC 61000-4-2 ESD Immunity	Electrostatic discharge, 8/6 kV; Air/Contact
IEC 61000-4-3 RF Radiated Immunity	RF Radiation, 10 V/M 80-1000 MHz (1kHz 80% Amplitude Modulation)
IEC 61000-4-4 EFT/Burst Immunity	Electrical Fast Transient, 4/2 kV; CM/DM
IEC 61000-4-5 Surge Immunity	Surge, 2/1kV; CM/DM
IEC 61000-4-6 RF Conducted Immunity	RF Conductive, 10 Vo; 0.150-80 MHz
IEC 61000-4-8 Power Frequency Magnetic Field Immunity	Magnetic Field, 50/60 Hz 30 A/m
IEC 61000-4-11 Voltage Variation Immunity test	Voltage dips, 30% reduction, 0.5 periods; 60% reduction 5/50 periods. Voltage Interruption 95% reduction 250 periods

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