ERL PHASE
Power Technologies Ltd

F-PRO

Feeder Protection Relay

Model 5100

User Manual

Version 2.0 Rev 4

Preface

Information in this document is subject to change without notice.

This manual is part of a complete set of product documentation that includes detailed drawings and operation. Users should evaluate the information in the context of the complete set of product documentation and their particular applications. ERLPhase assumes no liability for any incidental, indirect, or consequential damages arising from the use of this documentation.

While all information presented is believed to be reliable and in accordance with accepted engineering practices, ERLPhase makes no warranties as to the completeness of the information.

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Table of Contents

Version Descriptions

F-PRO Firmware Revision History		
Release Date	**Firmware Version**	**Changes from Previous Version**
2003 Jun 20	v2.0a	Fixed potential memory overflow while processing Event Log. Fixed unexpected unit restart under rare circumstances.
2002 Nov 22	v2.0	Added 10 Breaker Logic functions for breaker performance and I*I*t functions for breaker wear monitoring due to fault interruption. Added Demand, Peak Demand and Energy metering features. Added “BREAKER” user login option for the convenience of breaker monitoring for breaker maintenance personnel. Added 8 setting groups. Added 30 virtual inputs. Added 2 distance elements (device 21P-1 and 21P-2). Added rate of change detection in device 81. Made contact 12 available in the ProLogic and Breaker Logic input list. Made latched state of ProLogic persistent on power off and power on. Added auto save feature both in trend log and in event log. Added 3I0 metering both in the front LCD display and in the terminal UI metering screen.
2000 Nov 13	v1.0	First release.

F-PRO *Offliner* Settings Revision History		
Release Date	***Offliner* Settings Version**	**Changes from Previous Version**
2002 Nov 22	v2.0	Breaker Monitoring functions via Breaker Logic and I*I*t. Eight Setting groups with sixteen Group Logic statements per group. Reduced ProLogic from fifteen to ten logic statements New screen layout for product consistency
2000 Nov 13	v1.0	First release.

F-PRO User Manual Revision History		
Release Date	**Manual Version**	**Changes from Previous Version**
2008 Feb 29	v2.0 Rev 4	Branded to ERLPhase.
2003 Jun 20	v2.0 Rev 3	Update to Firmware v2.0a.
2002 Nov 22	v2.0	Incorporate new features.
2000 Nov 13	v1.0	First release.

Using This Guide

This User Manual describes the installation and operation of the F-PRO feeder protection relay. It is intended to support the first time user and clarify the details of the equipment.

The manual uses a number of conventions to denote special information:

Example	Describes
Start>Settings>Control Panel	Choose the Control Panel submenu in the Settings submenu on the Start menu.
Right-click	Click the right mouse button.
Recordings	Menu items and tabs are shown in italics.
service	User input or keystrokes are shown in bold.
Text boxes similar to this one	Relate important notes and information.
..	Indicates more screens.
▶	Indicates further drop-down menu, click to display list.
	Indicates a warning.

1 Overview

The F-PRO (model 5100) is a microprocessor-based relay providing comprehensive directional overcurrent protection, reclosing, metering, breaker monitoring and recording functions suitable for medium and low voltage lines.

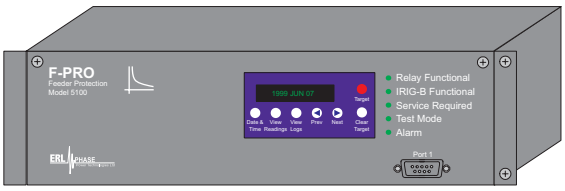
F-PRO has two working modes—online and offline. In the online mode you can use any communication software package (e.g. Procomm or HyperTerminal) to connect to the F-PRO using VT100 terminal emulation. In online mode you can:

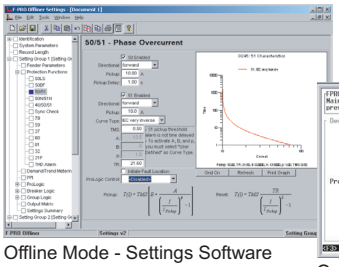
- change and review relay settings
- view event and metering information
- initiate and retrieve recordings, and retrieve settings

In offline mode you can use *Offliner* Settings and RecordBase View software to:

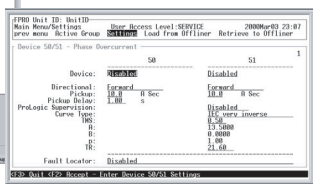
- create and review relay settings
- analyze fault waveforms
- store records

F-PRO Feeder Protection Relay





Offline Mode - Settings Software



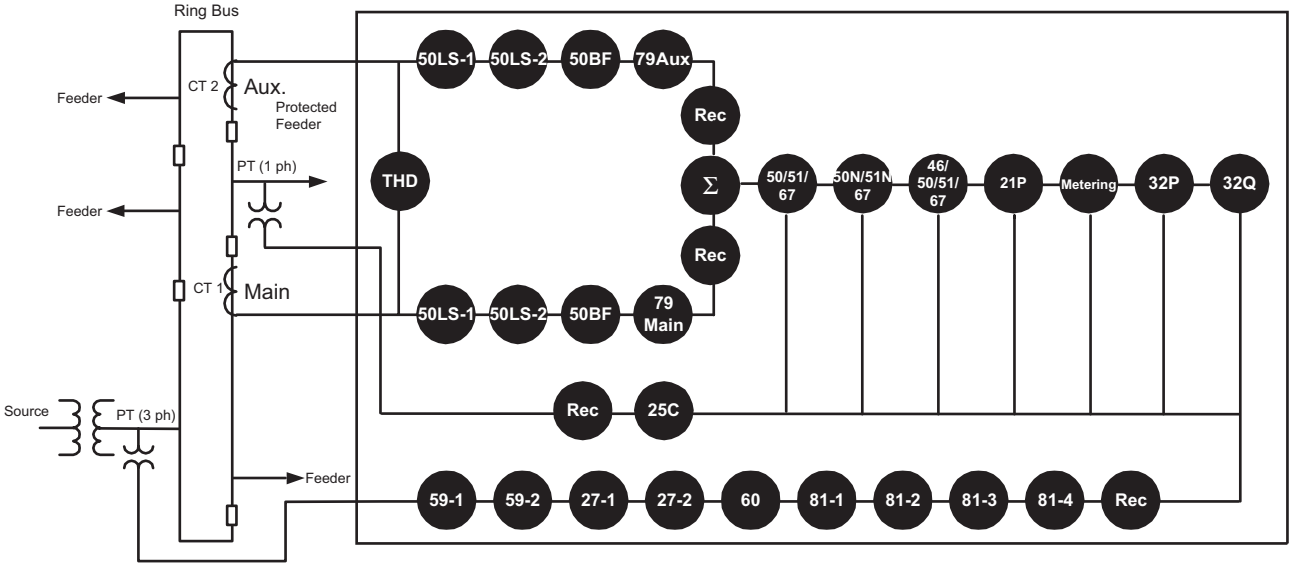
Online Mode - Terminal Mode

In addition to the protection functions F-PRO provides fault recording (96 sample/cycle) to facilitate analysis of the power system after a disturbance has taken place. The triggers for fault recording are established by programming the output matrix and allowing any internal relay function or any external input to initiate recording.

The primary protection provided is overcurrent based. A library for these overcurrent functions provides commonly used IEEE and IEC inverse curves. Because the curves are equation-driven, you can choose to enter an equation parameter directly, creating other overcurrent shapes as needed. All overcurrent functions are provided with directional control, if required, using the ERLPhase method of positive sequence control.

To provide a complete package of protection and control, F-PRO provides other functions such as:

- ring bus capability to protect and monitor lines connected to ring schemes Current inputs are labelled Main and Aux inputs to denote the breaker ring current inputs. Use F-PRO with straight single breaker line schemes by using the main current inputs
- breaker failure detection and monitoring
- 2 completely dedicated four shot reclosers devices 79 Main and 79 Aux to control line reclosing needs along with device 25C Sync Check/Dead Bus/ Dead Line supervision
- low set overcurrent functions for each breaker as well as for the summated line currents that include phase, neutral and negative sequence functions
- Watt, VAR flow detectors as well as undervoltage, overvoltage and over/ under frequency functions (Freq ROC) to provide protection for issues such as inter-tie protection needs
- ProLogic provide a flexible way to address special protection needs. Ten ProLogic statements are provided
- Breaker Logic, Group Logic, Demand Metering



Analog Inputs
4 Analog Voltages
1 Three-phase Input
1 Single-phase Input
6 Analog Currents
2 Three-phase Inputs

Outputs
12 Output Contacts
1 Relay Inoperative Alarm Contact

Inputs
9 External Inputs

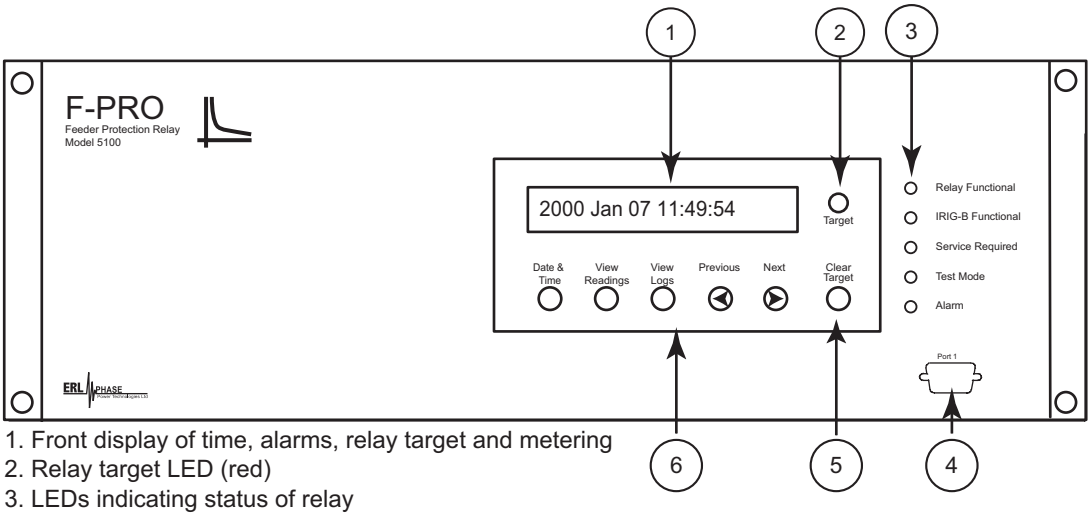
Trend Recording (Primary)
Real Power (MW In and Out)
Reactive Power (MVAR In and Out)
3 Phase Voltages (Va, Vb, Vc)
3 Phase Currents (Ia, Ib, Ic)
Real Energy (MWh In and Out)
Reactive Energy (MVARh In and Out)
THD Level (%)
System Frequency

Fault Recording
4 Voltages
6 Currents
97 Unique Events

Metering (Front Display)
Primary Pos. Sequence Volts, Amps, Primary Watts and VARs
Frequency
THD (Total Harmonic Distortion)
PF (Power Factor)
Primary Phase Voltage, Current, Phase Angle (A, B, C)
Peak Demand MW, MVAR In and Out Phase Currents
Energy Values MWh In and Out MVARh In and Out
3I0

Figure 1.1: F-PRO Line Diagram

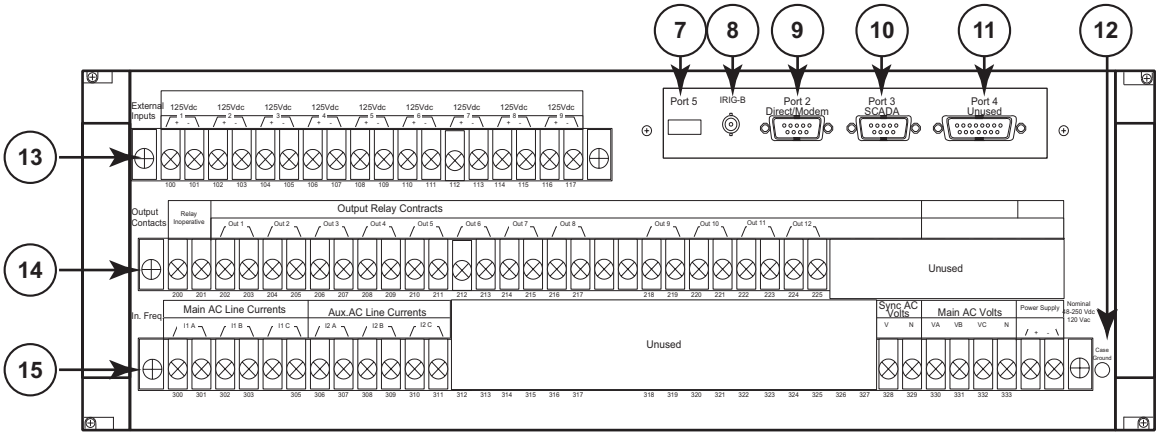
Front View



1. Front display of time, alarms, relay target and metering
2. Relay target LED (red)
3. LEDs indicating status of relay
4. Communications serial Port 1 for laptop computer
5. Clear target push button
6. Push buttons to manipulate information on LCD display

Figure 1.2: F-PRO Front View

Back View



7. Port 5 - 10BaseT Ethernet Port/Internal Modem (optional)
8. External clock, IRIG-B modulated or unmodulated
9. Port 2 - Direct/Modem RS-232 Port
10. Port 3 - SCADA
11. Port 4 - unused
12. Case ground
13. 9 programmable external inputs (1 to 9)
14. This row contains 2 distinct areas from left to right:
    12 programmable output relay contacts and relay inoperative contact
15. This row contains 3 distinct areas from left to right:
    6 ac current inputs
    4 ac voltage inputs
    Power supply

Figure 1.3: F-PRO Back View

AC Current and Voltage Inputs

F-PRO is provided with terminal blocks for up to 6 ac currents and 4 phase-to-neutral voltages.

Each of the current input circuits has polarity (•) marks.

A complete schematic of current and voltage circuits is shown, for details see "AC Schematic Drawing" in Appendix I and "DC Schematic Drawing" in Appendix J.

External Inputs

The F-PRO relay contains 9 programmable external inputs. External dc voltage of either 48/125 volts or 125/250 volts nominal are possible depending on the range provided.

Output Relay Contacts

The F-PRO relay has 12 output relay contacts. Each contact is programmable and has breaker tripping capability. All output contacts are isolated from each other. The output contacts are closed for a minimum of 100 ms after operation.

Relay Inoperative Alarm Output

If the relay is in self check program or becomes inoperative, then the Relay Inoperative Alarm output contact closes and all tripping functions are blocked.

Model Options/Ordering

F-PRO is available as a horizontal mount, for details see "Mechanical Drawings" in Appendix G.

F-PRO is available with an internal modem card or internal network card.

The CT inputs are 1 A nominal or 5 A nominal. The external inputs are 48/125 Vdc or 125/250 Vdc. The system base frequency is either 50 Hz or 60 Hz.

All of the above options must be specified at the time of ordering.

2 Setup and Communications

Power Supply

A wide range power supply is standard. The nominal operating range is 48–250 Vdc, 120 Vac, 50/60 Hz. To protect against possible short circuit in the supply use an inline fuse or circuit breaker with a 5 A rating. Make the chassis ground connection to ensure proper operation and safety.

There are no power switches on the relay. When the power supply is connected, the relay starts its initialization process and takes about 40 seconds to complete showing the green Relay Functional LED.

Case Grounding

You must ground the relay to station ground using the case-grounding terminal at the back of the relay, for details see Figure 1.3: F-PRO Back View on page 1-3.

WARNING!

To ensure safety and proper operation you must connect the relay to the station ground using the rear grounding terminal on the relay.

Ground the relay even when testing.

Do not rely on the rack mounting screws to provide case grounding.

IRIG-B Time Input

The relay is equipped to handle modulated or unmodulated GPS satellite time IRIG-B signals. The IRIG-B time signal is connected to the BNC connection on the back of the relay. When the IRIG-B signal is provided to the relay and is enabled in the settings through the user interface, the IRIG-B functional LED comes on and the relay clock is referenced to this signal. No settings are required to differentiate between modulated or unmodulated signals; this is automatically detected by the relay.

You enable or disable the IEEE 1344 extension in the terminal mode settings *Utilities>Setup>Time,* for details see "Utilities" on page 3-12. The enabled mode allows the year to be received from the IRIG-B signal. If the available IRIG-B signal has no year extension, this setting should be disabled.

Communicating with the Relay (IED)

You can connect to the relay to access its user interface and SCADA services:

- direct serial link (user interface and SCADA)
- external or internal modem link (user interface only)
- ethernet network link (user interface and SCADA)

Direct Serial Link

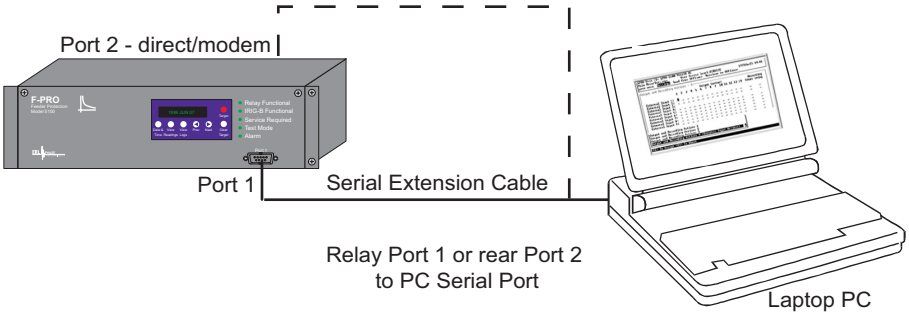


Figure 2.1: Direct Serial Link

The relay has three serial ports that provide direct access to its user interface and SCADA services.

All of the relay's serial ports (Ports 1, 2 and 3) are configured as EIA RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with a standard straight-through male-to-female serial cable, for pin-out, for details see "Communication Port Details" on page 2-9.

The relay's user interface is accessed through a standard VT-100 terminal emulation program running on a PC. To create a direct serial link between the relay and your computer, connect the serial cable (provided) between your computer's serial port and Port 1 on the relay's front panel. Port 2 on the relay's back panel can also be used for direct serial access, provided the port is not configured for modem use. When connected, run the terminal emulation software on your computer to establish the communication link, for details see "Using HyperTerminal to Access the Relay's User Interface" on page 2-5.

The relay's Modbus and DNP3 SCADA services can be accessed via a direct serial link to Port 3 on the relay's back panel, for details see "Accessing the Relay's SCADA Services" on page 2-8.

Modem Link - External

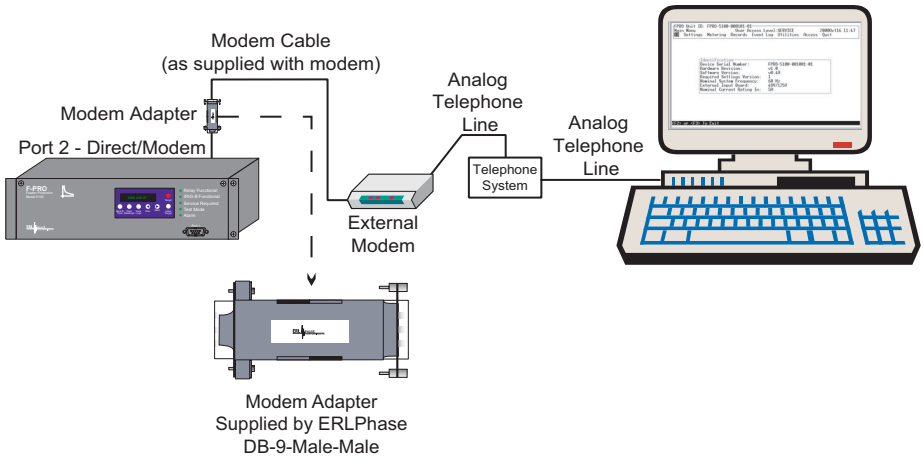


Figure 2.2: External Modem Link

The relay's user interface can also be accessed through a telephone link between the relay and your computer, using an external modem.

Connect the serial port on the external modem to the Port 2 on the relay's back panel. Both devices are configured as RS-232 DCE devices with female connectors, so the cable between the relay and the modem requires a crossover and a gender change. Alternatively, you can use the ERLPhase modem port adapter provided with the relay to make Port 2 appear the same as a PC's serial port. A standard modem-to-PC serial cable can then be used to connect the modem and the relay, for pin-out details see "Communication Port Details" on page 2-9.

Connect the modem to an analog telephone line or switch using a standard RJ-11 connector.

To work with a modem, the relay's Port 2 must be appropriately configured. Log into the relay through a direct serial link, go to the *Utilities>Setup>Ports* screen, and set the Port 2 *Modem* option to *Yes*. The *Baud Rate* should be set as high as possible - most modems will handle 57,600 bps. The *Initialize* setting lets you set the control codes sent to the modem at the start of each connection session. The factory defaults are: "M0S0=0&B1" for an external modem and "M0S0=0" for an internal modem.

Modem Link - Internal

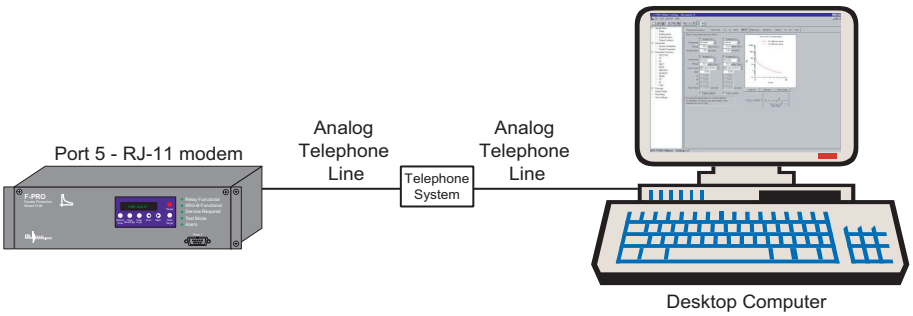


Figure 2.3: Internal Modem Link

The relay's user interface can also be accessed through a telephone link between the relay and your computer using an optional internal modem. If the modem has been installed, Port 5 on the rear panel will be labelled "INTERNAL MODEM."

Connect the relay's Port 5 to an analog telephone line or switch using a standard RJ-11 connector.

When an internal modem is installed, the relay's Port 2 is used to interface to the modem internally. Appropriate Port 2 settings are configured at the factory when the internal modem is installed. The factory defaults are: "M0S0=0&B1" for an external modem and "M0S0=0" for an internal modem.

Network Link

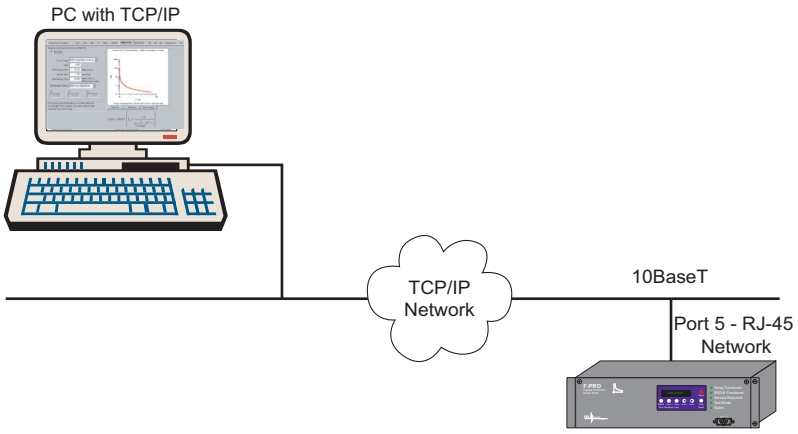


Figure 2.4: Network Link

You can access both the relay's user interface and DNP3 SCADA services simultaneously through the same network port with an optional Ethernet TCP/IP LAN link. If the Ethernet option has been installed, Port 5 on the rear panel will be labelled "NETWORK."

The user interface accessed through the LAN is the same as that available through a direct serial connection or a modem link, but requires the use of a Telnet client on your PC. The HyperTerminal program included with Microsoft Windows provides Telnet services. To select Telnet, go to HyperTerminal's Properties dialog box and set the *Connect Using* field to *TCP/IP (Winsock)*. If this option is not available in the pick list, you require a newer

version of HyperTerminal (v1.2 or greater). Alternatively, you can use any Telnet program that fully supports VT-100 terminal emulation and z-modem file transfer.

DNP3 SCADA services can also be accessed over the LAN, for details see “Accessing the Relay’s SCADA Services” on page 2-8.

Connect Port 5 to the Ethernet LAN using an appropriate 10BaseT cable with an RJ-45 connector. The relay supports 10 Mbit Ethernet, although a dual speed 10/100 Ethernet hub or switch can be used.

By default, the relay is assigned an IP address of 192.168.1.100. If this address is not suitable, it may be modified using the relay’s Maintenance Menu, for details see “Using HyperTerminal to Access the Relay’s User Interface” on page 2-5.

Using HyperTerminal to Access the Relay’s User Interface

Change settings, view measured values and retrieve data from the relay using its user interface. This section describes how to configure a standard Windows VT-100 terminal program on your PC for use with the relay.

The computer must be connected to the relay by one of its serial, modem or Ethernet communication ports, for details see “Communicating with the Relay (IED)” on page 2-2.

The relay user interface is accessed using a standard VT-100 terminal style program on your computer eliminating the need for specialized user interface software. Any terminal program that fully supports VT-100 emulation and provides z-modem file transfer services can be used. The HyperTerminal program included with Microsoft Windows is used here as an example.

Configure your terminal program as described in the table below and link it to the appropriate serial port, modem or TCP/IP socket on your computer.

Terminal Program Setup	
Baud rate	For a direct serial link, the baud rate must match that of the relay serial port. For a modem link, the baud rate refers only to the link between your computer and its own modem. Refer to “Setting the Baud Rate” on page 2-7 for further information
Data bits	8
Parity	None
Stop bits	1
Flow control	Hardware or Software. Hardware flow control is recommended. The relay automatically supports both on all its serial ports.
Function, arrow and control keys	Terminal keys

Terminal Program Setup	
Emulation	VT100
Font	Use a font that supports line drawing (e.g. Terminal or MS Line Draw). If the menu appears outlined in odd characters, the font you have selected is not supporting line drawing characters.

To initiate the connection with the relay, use HyperTerminal's *Call>Connect* function.

When the connection is established, press *Enter* in the terminal window to bring up the following login prompt:

```
---------- NxtPhase F-PRO 5100 Terminal User Interface login ----------


Log in using one of the following usernames:
  'view' - read-only access to settings and readings
  'change' - read/write access to settings and readings
  'service' - full access to all functions (Port 1 access only)
  'breaker' - access to breaker monitor menu
  'maintenance' - access to the maintenance menu
  'update' - to load a firmware update

Notes:
- Serial and modem connections have a 60 minute inactivity timeout
- Usernames and passwords are case sensitive

login:
```

Instructions on logging in and running the user interface are given in "Terminal Mode" on page 3-5.

If you see incorrect characters on a direct serial connection, it may mean there is a mismatch between the relay's baud rate and that of the PC.

Ending a User Interface Session

Use the *Quit* function in the relay's user menu to end a session. This will close the interface and require the next user to log in to the relay.

The relay automatically ends a session when it detects the disconnecting of a direct serial cable or a modem hang-up. For other types of connections (e.g. serial switches or Ethernet) you are advised to use the Quit function to ensure the interface is closed and login protection is activated.

Setting the Baud Rate

The baud rate of the relay's serial ports can be shown on the relay's front panel display. From the main *Date & Time* display, press the *Next* button.

Direct Serial Link

For a direct serial connection, both the relay and your computer must be set to the same baud rate.

To change the baud rate of a relay serial port:

1 Access the relay's user interface through any of the available ports

2 Log in to the user interface and go to the *Utilities>Setup>Ports* menu, for details see "Terminal Mode" on page 3-5.

3 Select the desired baud rate for the appropriate port by toggling through the options using the Space or Enter keys. Save the new setting with the F2 key. The message "New communications settings loaded" will appear.

The new baud rate will be used on that port the next time you log in to it.

To change the baud rate on your computer's serial port:

1 From within HyperTerminal, bring up the Properties dialogue, press the *Configure* button and set the baud rate field to the desired value.

2 Save the changes.

Modem Link

Unlike a direct serial link, the baud rates for a modem link do not have to be the same on your computer and on the relay. The modems automatically negotiate an optimal baud rate for their communication.

The baud rate set on the relay only affects the rate at which the relay communicates with the modem. Similarly, the baud rate set in HyperTerminal only affects the rate at which your computer communicates with its modem. Details on how to set these respective baud rates are described above, except that you modify the Port 2 baud rate on the relay and the properties of the modem in HyperTerminal.

Accessing the Relay's SCADA Services

The relay supports DNP3 (Level 2) and Modbus SCADA protocols as a standard feature on all relays. DNP3 is available through a direct serial link or the Ethernet LAN on top of either TCP or UDP protocols. The Modbus implementation supports both RTU (binary) or ASCII modes and is available through a direct serial link.

The relay's Port 3 is dedicated for use with Modbus or DNP3 serial protocols. Port 3 uses standard RS-232 signalling. An external RS-232<->RS-485 converter can also be used to connect to an RS-485 network.

For details on connecting to serial Port 3 see "Communicating with the Relay (IED)" on page 2-2 and "Communication Port Details" on page 2-9.

The DNP3 protocol can also be run across the optional Ethernet LAN. Both DNP over TCP and DNP over UDP are supported. For details on connecting to the Ethernet LAN see "Network Link" on page 2-4.

Complete details on the Modbus and DNP3 protocol services can be found in the Appendices, "Modbus RTU Communication Protocol" in Appendix E and "DNP3 Communication Protocol" in Appendix F respectively.

Protocol Selection

To select the desired SCADA protocol, login to the relay's user interface and access the *Utilities>Setup>SCADA* menu. Select the protocol and set the corresponding parameters.

> The DNP3 LAN/WAN - TCP and UDP options are only available if the unit has an optional Ethernet LAN port installed.

Communication Parameters

Port 3's communication parameters are set using the *Utilities>Setup>Ports* menu in relay's user interface. Both the baud rate and the parity bit can be configured. The number of data bits and stop bits are determined automatically by the selected SCADA protocol. Modbus ASCII uses 7 data bits. Modbus RTU and DNP Serial use 8 data bits. All protocols use 1 stop bit except in the case where either Modbus protocol is used with no parity; this uses 2 stop bits, as defined in the Modbus standard.

Diagnostics

Protocol monitor utilities are available to assist in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utilities can be access through the Maintenance user interface, for details see "Maintenance Menu" on page 2-12.

Communication Port Details

Port	Location	Function
1	Front Panel	RS-232 Data Communication Equipment (DCE) female DB9. Used for user interface access through a direct serial connection. Default Setting: 38,400 baud, 8 data bits, no parity, 1 stop bit.
2	Rear Panel	RS-232 DCE female DB9. Used for: • User interface access through a direct serial connection. • User interface access through an external modem. The optional ERLPhase Modem Adapter converts this port to a Data Terminal Equipment (DTE) to simplify connection to an external modem. Default Setting: 9,600 baud, 8 data bits, no parity, 1 stop bit. Port 2 is disabled if the relay is equipped with an internal modem (see Port 5).
3	Rear Panel	RS-232 DCE female DB9. Used for SCADA communication. Default Setting: 9,600 baud, 8 data bits, no parity, 1 stop bit.
4	Rear Panel	Not used
5	Rear Panel	RJ-11/RJ-45 receptacle. When equipped with optional internal modem: • Used for user interface access through modem. When equipped with optional internal Ethernet card: • User interface access. • DNP SCADA access. Default Ethernet IP address: 192.168.1.100.

Signal Name	Direction PC<-> Relay	Pin # on the Relay Port
DCD	←	1
RxD	←	2
TxD	→	3
DTR	→	4
Common		5
DSR	←	6
RTS	→	7
CTS	←	8
No connection		9

Notes:

- Relay is DCE, PC is DTE
- Pins 1 and 6 are tied together internal to the relay

Male DB-9 Cable End for Relay Port	Female DB-9 Cable End for Computer Port
Pin # on Cable	Pin # on Cable
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Signal Name	Direction Modem <-> Relay	Pin # on the Modem Adapter
DCD	→	1
RxD	→	2
TxD	←	3
DTR	←	4
Common		5
DSR	→	6
RTS	←	7
CTS	→	8
No connection		9

Notes:

- Relay (with modem adapter) is DTE, modem is DCE
- Pins 1 and 6 are tied together internal to the relay

Maintenance Menu

The relay has a Maintenance Menu that can be accessed by connection through a VT-100 terminal emulator (such as the HyperTerminal program that comes with MS Windows). Using either direct serial or modem connection:

1 Use the terminal program to connect to the serial port, either through direct serial link or modem.

2 Select *Enter*, the relay responds with a login prompt.

3 Login as “maintenance” in lower case.

A menu appears as below.

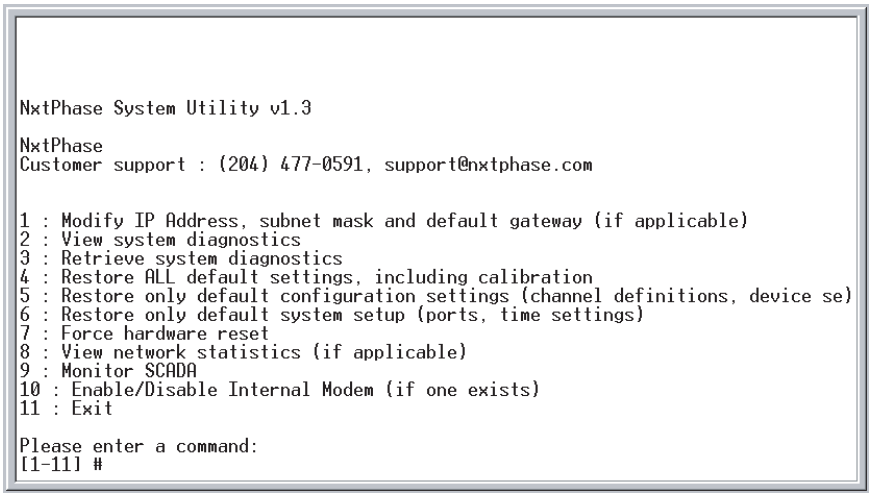


Figure 2.5: Maintenance Menu

Commands 1, 4, 5, 6, 7 and 10 are Port 1 access only.

Modify IP address	Modifies the LAN IP address when equipped with an optional internal 10BaseT Ethernet card.
View system diagnostic	Displays the internal status log.
Retrieve system diagnostics	Automatically packages up the internal status log plus setting and setup information and downloads it in compressed form to your computer. This file can then be sent to our customer support to help diagnose a problem.
Restore settings	Use this menu to force the system back to default values, if you suspect a problem due to the unit's settings, calibration and/or setup parameters.
Force hardware reset	Manually initiates a hardware reset. Note that the communication link is immediately lost and cannot be re-established until the unit completes its start-up.
View network statistics	View IP, TCP and UDP statistics when equipped with internal 10BaseT Ethernet card.
Monitor SCADA	Shows real time display of SCADA data.
Enable/disable Modem	Enables or disables the internal modem.

Firmware Update

The relay has an update login that can be accessed by a connection through a VT100 terminal emulator (such as HyperTerminal). This login is available only from Port 1.

1 Use the terminal program to connect to Port 1.

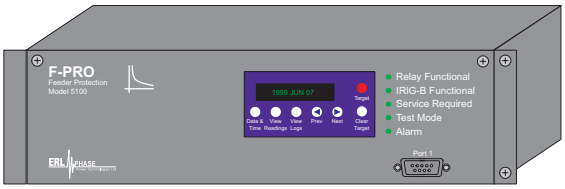
2 Select *Enter*, the terminal responds with a login prompt.

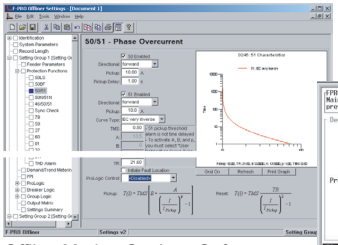
3 Login as **update** in lower case.

The firmware update is used to update the relay's software with maintenance or enhancement releases. Please see the F-PRO Firmware Update Procedure documentation that comes with the firmware update for instructions on how to update the firmware on the relay.

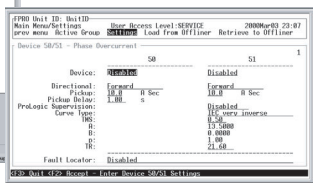
3 Using the IED (Getting Started)

F-PRO Feeder Protection Relay





Offline Mode - Settings Software



Online Mode - Terminal Mode

Start-up Sequence

The following initialization sequence takes place:

Test Mode—red LED on	2 seconds after power applied
Relay Functional—green LED on	5 seconds after power applied
Front Display—on	30 seconds after power applied
Test Mode—red LED off	40 seconds after power applied

When the relay is powered up, the normal sequence of LED operation is Test Mode followed by Relay Functional and IRIG-B Functional (if available), display on, then Test Mode off. The entire sequence takes about 40 seconds.

Ways to interface with F-PRO:

- Front panel display
- Terminal Mode
- *Offliner* Settings software

Front Panel Display

View or change settings using Terminal Mode or loading a setting file from *Offliner* Setting.

The front panel display is the fastest and easiest way of getting information from the relay.

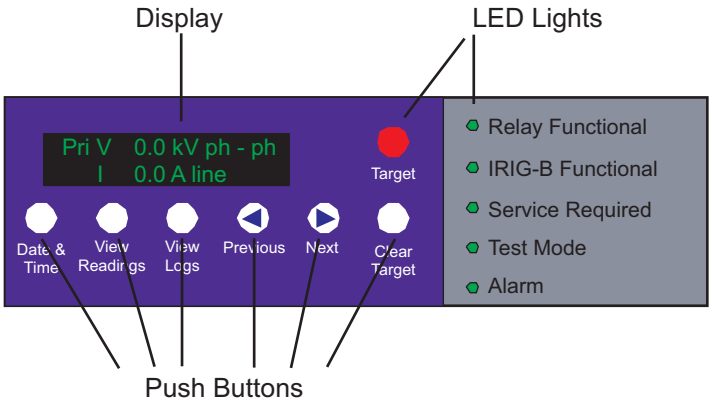


Figure 3.1: Front Panel Display

The line display, the six LED lights and the six push buttons provide selective information about the relay.

LED Lights

Relay Functional	Indicates when the relay is functional. When the Relay Functional green LED goes on, the rear Relay Inoperative contact changes to an open and the protective functions become functional.
IRIG-B Functional	Indicates the presence of a valid IRIG-B time signal.
Service Required	Indicates the relay needs service. This LED can be the same state as the Relay Functional LED or can be of the opposite state depending on the nature of the problem. The following items bring up this LED: • DSP failure - protection difficulties within the relay. • Communication failure within the relay. • Internal relay problems.
Test Mode	Occurs when the relay output contacts are intentionally blocked. Possible reasons are: • Relay initialization on start-up • User interface processor has reset and is being tested. You cannot communicate with the relay through the ports until the front display becomes active and the Test Mode LED goes out. Normally, the red Target LED remains off after this start-up unless the relay had unviewed target messages. Output contacts are controlled from the *Utilities* menu.

ALARM	Occurs when an enabled relay function picks up. The red Alarm LED should be off if there are no inputs to the relay. If the Alarm LED is on, check the event log messages on the front display by pressing the *View Logs* button.
Target	Indicates that a fault has taken place. An event message with date and time is presented in the display.

Push Buttons

Date &Time	Pressing the Date &Time button displays the date and time stored on the relay. If the time is incorrect, connect to a PC in Terminal Mode and go to *Utilities>Setup>Time* to make the change or connect to the IRIG-B plug at the back of the relay. The front display time and date is automatically updated. The green IRIG-B Functional LED comes on. The relay accepts either modulated or unmodulated IRIG-B signals automatically. Options using IRIG-B such as time skew for different time zones are available when you establish communication with the PC.
View Readings	Pressing the View Readings button obtains metering information about the feeder, for details see “Display” on page 3-4.
View Logs	Pressing the View Logs button displays the target information if a relay operation has occurred, for details see “Display” on page 3-4.
Previous/Next	Scroll through the menu by pressing Previous and Next.
Clear Target	When a fault takes place, the red target light appears. You can select a setting option to reset the target light after a short time delay. Use the Clear Target button to view all target information. If many faults have been stored, you may need to push this button several times. Clearing the target light does not clear the target information from the relay log. The relay holds all target messages during a power supply shutdown and restart. Pressing the Clear Target push button displays any targets not previously viewed on the front display and clears the Target LED after the last target has been viewed. Peak Demand Reset Energy Reset

Display

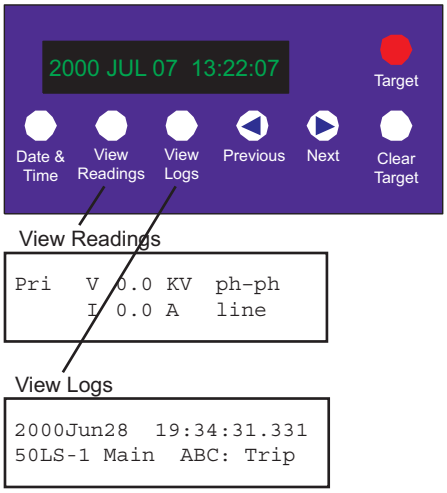


Figure 3.2: Line Display Examples

Line Display Messages
PRI V, I, P, Q
Va, Ia magnitude and angle
Vb, Ib magnitude and angle
Vc, Ic magnitude and angle
3IO magnitude and angle
Frequency and THD
Power Factor
Fault location, trip date and time of all functions involved.
Peak Demand
Energy In and Out

Terminal Mode

1 Establish terminal mode connection, for details see “Using HyperTerminal to Access the Relay’s User Interface” on page 2-5.

2 Login as one of **view, breaker, change** or **service** (lower case). These four login names provide differing levels of permission.

> The relay supports the optional use of passwords. A pop-up dialogue box appears after login has taken place.
>
> If you have forgotten the password, go to *Access>Passwords* in Terminal Mode, for details see “Passwords” on page 3-6.

3 When connection is established and the terminal mode program appears on your screen, the following prompt should appear. If it doesn’t appear, press *Enter*.

```
---------- NxtPhase F-PRO 5100 Terminal User Interface login ----------


Log in using one of the following usernames:
  'view' - read-only access to settings and readings
  'change' - read/write access to settings and readings
  'service' - full access to all functions (Port 1 access only)
  'breaker' - access to breaker monitor menu
  'maintenance' - access to the maintenance menu
  'update' - to load a firmware update

Notes:
- Serial and modem connections have a 60 minute inactivity timeout
- Usernames and passwords are case sensitive

login:
```

4 If login is successful, the Main Menu appears:

```
F-PRO Unit ID: Your ID entered earlier
Main Menu      User Access Level: VIEW       2000 Jun 08 11:53
ID  Settings  Metering  Records  Event Log  Utilities  Access  Quit
```

view, change or service

or

```
F-PRO Unit ID: Your ID entered earlier
Main Menu      User Access Level: BREAKER    2003 Jun 08 11:53
Breaker Log    Metering       Reset   Quit
```

Breaker

If the box around the menu does not appear as above, change the font in your terminal program to one that supports line draw characters, e.g. terminal fonts.

If there are incorrect characters in the display, improper line feeds or unerased portions, the baud rate is too high for the quality of the communication link. Use the *Utilities>Setup>Ports* menu to reduce the relay's baud rate. The new rate is in effect at the next connection.

The relay supports four user access levels that control what relay functions are available to you. The current access level is always shown in the centre of the Main Menu heading.

To change the Access Level either login again using the desired access level as your login name or use the *Main Menu>Access* menu.

Access	Level	Allowed actions
view	lowest	View settings, on-line readings and logs and to list and upload records. At this level you cannot affect the operation of the controller.
breaker	minimal	Do all of the above, plus reset breaker monitoring values. This level doesn't allow you to change settings.
change	middle	Do all of the above, plus change the settings and delete records.
service	highest	Do all of the above two categories, plus calibrate the analog inputs, manually control output auxiliary relays and modify passwords.

Service access is only available through a local, front port connection.

Passwords

Individual passwords for the view, breaker and change access levels are available to prevent or limit remote access to the relay. Passwords are not required for the service level. This level is only available at the front of the local relay through serial Port 1.

You can only change the passwords from the service level through the Access menu minimizing the chance that a password is changed casually and provides a means of resolving situations where a password has been forgotten.

Terminal Mode Menus

Use the right and left arrow keys and the enter key to move around in the terminal mode screen. The mouse does not work in VT100 terminal mode. Items from the menu are selected by moving the highlight to the desired item and activating it using the <Enter> key. As a short-cut, use the first letter of the menu item to access it directly.

Key	Function
<F2>	Accept or Freeze or Execute
<F3>	Quit or Exit
<F4>	Copy Group
<Esc>	Back to previous menu level

The menu tree consists of a series of sub-menus, for details see Figure 3.3: Terminal Mode Menus on page 3-8.

The Enter key allows you to toggle through a list of selections, i.e. enabled/disabled. The Enter key toggles forward through the list, while the space bar moves backward through the list. In this manner you do not have to scroll through the entire list to get back to a previous selection, you can use the space bar.

For certain lists a pick box appears when there is a long list of selections to chose from, for example, ProLogic inputs. You can scroll though these boxes with the arrow keys or the Enter key. Use the F2 key to make a selection or F3 to leave.

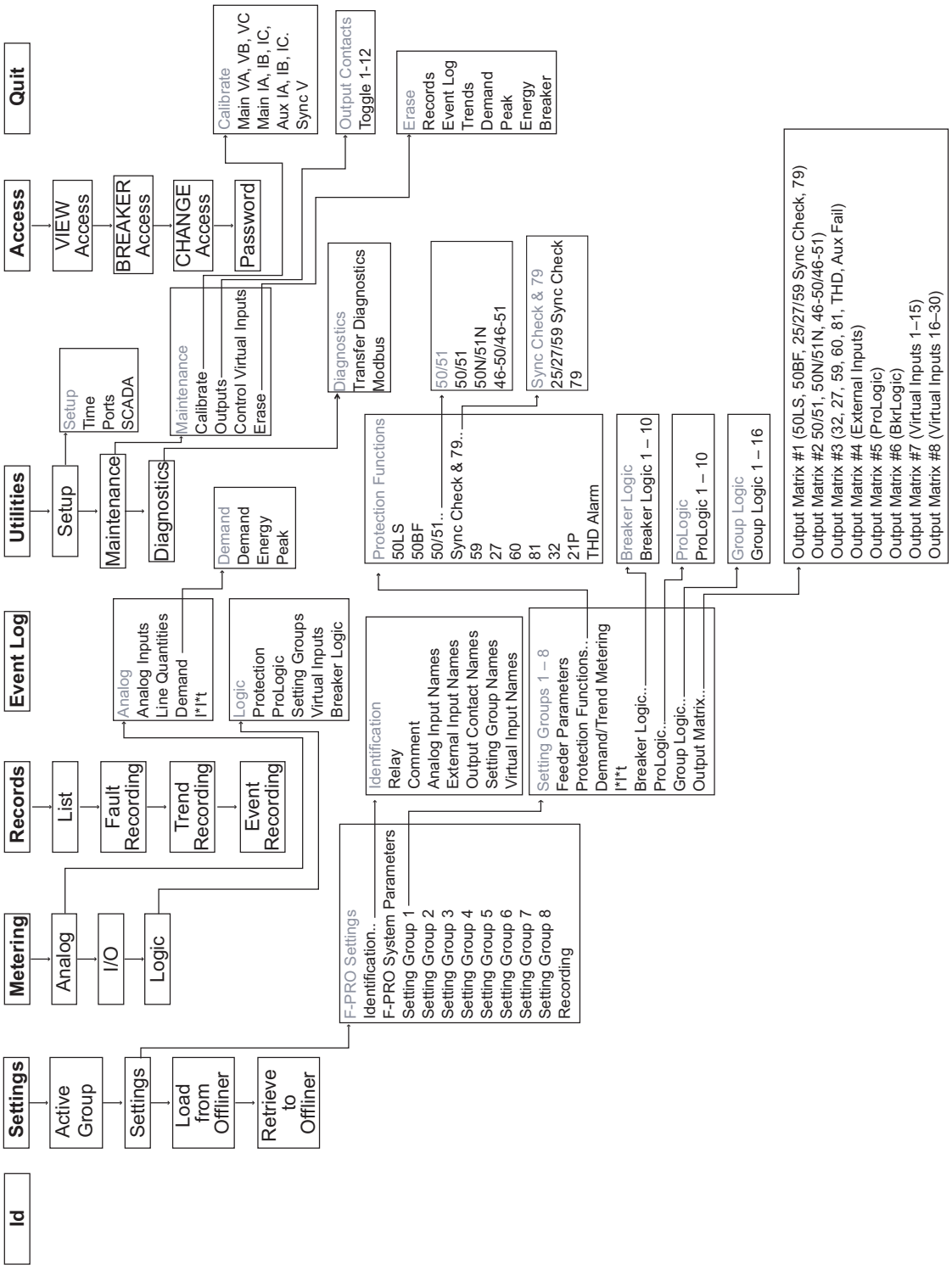


Figure 3.3: Terminal Mode Menus

View, Change or Service Login

The Main Menu display for view, change or service login is:

```
ID  Settings  Metering  Records  Event Log  Utilities  Access  Quit
```

ID

Provides the device serial number, software version, required settings version, nominal system values and external input board rating. There are no user settings here.

Settings

Submenus: Active Group, Settings, Load from *Offliner*, Retrieve to *Offliner*

Allows input of all the setting information for the relay. Includes all the submenus to change relay settings related to protection functions, when settings are changed they are not saved until you confirm the changes—Save and Load Setting Changes Now? [y/n].

Settings

Includes all the submenus to create a relay settings pertaining to protection functions. When these settings are made or changed, you can load them into the relay. Allows input of all settings information.

Settings submenus: Identification, F-PRO System Parameters, Setting Group 1 to 8, Recording.

Identification..	
Relay	Serial Number, Software Version, Relay ID, Line Name, Station Name, Station Number and Location.
Comments	Enter any appropriate comment.
Analog Input Names	Name inputs, Main VA, VB, VC, Main IA, IB, IC, Aux IA, IB, IC, Sync V.
External Inputs Names	Name external inputs 1 to 9.
Output Contact Names	Name auxiliary relay output contacts 1 to 12.
Setting Group Names	Name setting groups 1 to 8
Virtual Input Names	Name virtual inputs 1 to 30

The following characters are not allowed in the above setting parameters: “ ”, “\”, “/”, “:”, “*”, “?”, “|”, “"“, “<“, and “>”.

Load From *Offliner*

You can download the settings file into the relay using the terminal mode menu.

1 On the Window’s desktop, double-click F-PRO O*ffliner* Settings icon. The initial *Offliner* Settings screen appears.

2 Enter the required settings.

3 Save the settings to a file on your PC.

4 Start the Terminal Mode of F-PRO, login as **change** or **service,** then access the *Settings* menu and activate *Load from Offliner* function.

5 Reply *Yes* to the "Ready to load remote setting." prompt.

6 In your terminal program, initiate transfer of the setting file created in step 2 above. (For example, with Window's HyperTerminal, you would select *Transfer*, then *Send File*. Browse to find the file, then select *Open* and finally, *Send*.

7 When the file has been transferred, verified and loaded, a message "New settings loaded and secure" is displayed.

A "serial number discrepancy" message may appear. This is to ensure that you are aware of the exact relay to which the settings are being loaded. If this happens, check the relay serial number using the terminal mode ID menu item. Type this serial number into the F-PRO Serial No. box in the Identification tab display area of *Offliner* Settings. Alternately you may check the Ignore Serial Number check box to bypass serial number supervision.

Retrieve To *Offliner*

To transfer the relay's current settings to the PC do the following:

1 Navigate to *Settings>Retrieve To Offliner*.

2 Select *Enter.*

3 The relay asks you if you wish to continue. Select *Y* for yes.

4 The file is sent to the directory defined by the HyperTerminal menu *Transfer>Receive File*.

When using HyperTerminal use Z-modem (no crash recovery), files are received and auto incremented.

Metering

Submenus: Analog, I/O, Logic, for more details about metering see "Metering Data" on page 3-14.

Analog	
Analog Inputs	Provides secondary values of the ac analog voltages and currents.
Line Quantities	Provides primary voltage kV phase to phase of each line.
Demand	Demand Energy Peak
I*I*t	Displays the accumulated I*I*t value and I*I*t value for the last operation.
I/O	
	Displays the state of the external inputs and the output contacts.
Logic	

Protection	Protection Functions.
ProLogic	Provides the present status of the internal logic states. When a logic level becomes active, its state changes from low to high.
Setting Group	Displays current active Setting Group and Group Logic.
Virtual Inputs	Provides the present status of the virtual input logic states. When a logic level becomes active, its state changes from low to high.

Records

Submenus - List, Fault Recording, Trend Recording and Event Recording.

Contains the means for initiating and examining recordings.

List	Lists all records.
Fault Recording	Creates fault records.
Trend Recording	Creates trend records.
Event Recording	Creates event records.

Retrieve Records from the Relay

To retrieve records from the relay do the following:

1 Navigate to *Records>List* and press *Enter*; a records list appears.

2 Select *Records* using the space bar and select *R*. (You can also press *Enter* to retrieve a record directly.) The record will be saved in the directory specified by the terminal emulation program.

When using HyperTerminal if “Use receiving protocol:” is set to “Z modem with Crash Recovery”, file transfers are skipped by HyperTerminal if the record already exists in the downloads folder.

When using HyperTerminal use Z-modem (no crash recovery), files are received and auto incremented.

Delete Records from the Relay

To delete records from the relay do the following:

1 Navigate to *Records>List* and press *Enter*.

2 Select the records for deletion with the space bar and select *D*. The selected records will be deleted.

Event Log

The event log lists events stored in the relay. A complete list of the types of events logged is available, for details see “Event Messages” in Appendix D.

If an event triggered a record, then an (R) is displayed by the event.

Utilities

Sub-menus: Setup, Maintenance, Diagnostics.

Setup	
	Time - set manual time, IRIG-B skew control. Requires change or service access level.
	Ports - change Baud rates on communication ports. Requires change or service access level.
	SCADA – select which SCADA protocol (Modbus or DNP3) to run on the SCADA port. Configure parameters for the selected protocol such as address or timeout. Requires change or service access level.

Maintenance	
	Calibrate – calibrate all 10 analog ac. Requires service access level.
	Outputs – close and open output contacts independent of the associated relay functions. Requires service access level.
	Control Virtual Inputs – set, re-set and pulse virtual inputs. Pulse width is 1 second. Latched virtual inputs reset after pulse command has executed. Requires change or access level.
	Erase – use submenus Records and Event Logs to erase these records from the relay memory. Reset Demand Metering, I^2t and Breaker Logic counts. Requires change or service access level.

Diagnostics	
	Transfer Diagnostics – transfers relay diagnostic file to the PC. The diagnostic file can be sent to us for analysis.
	Modbus – allows Modbus Communications to enter its Diagnostic Mode. Follow directions on the screen. Programming done using the Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. G published by Modicon, Inc., dated November 1994. For details see “Modbus RTU Communication Protocol” in Appendix E.

Access Submenus: View Access, BREAKER Access, CHANGE Access, Password.

view	Changes the access level to view. Allows you read-only access to relay information.
breaker	Changes the access level to breaker.
change	Changes the access level to change. Allows you to modify settings and delete records.
service	Changes the access level to service. Allows you full access to calibration, manual control of the auxiliary relays and modification of passwords (available via local Port 1 connection only).
Passwords	Allows you to read and change passwords. Requires service access level.

Quit Selecting this option ends serial port communication with the relay.

Breaker Login

The Main Menu display for the breaker login is:

```
Breaker Log    Metering       Reset   Quit
```

Breaker Log The breaker log provides a log of breaker monitoring events.

Metering The metering quantities provided are breaker logic and I*I*t. For an explanation of those quantities see “Breaker Logic” on page 4-15 and “I*I*t” on page 4-16.

Reset Use Reset to preset/reset the breaker logic count and the I*I*t.

Quit Selecting this option ends serial port communication with the relay.

Metering Data

Front Panel Metering

The quantities provided on the front panel display include:

- Positive sequence L-L voltage
- Positive sequence line current
- Line MW, MVAR
- Positive sequence frequency
- THD
- Power Factor
- Primary line to neutral voltages and currents
- Primary 3IO current
- Peak MW In/Out, MVAR In/Out, Ia, Ib, Ic
- MWh In/Out
- MVARh In/Out

All quantities are in primary unless otherwise noted.

TUI Metering

The TUI provides the following metering quantities.

Analog/Analog Inputs

Displays all secondary values (magnitude and angle) of the voltage and current analog inputs.

Analog/Line Quantities

Displays the positive sequence L-L voltage, positive sequence line current, real and reactive power, positive sequence voltage frequency, THD, power factor and 3IO current. All values are in primary quantities. These are also available from the front panel.

Analog/Demand/Demand

Displays the current values of the demand metering quantities. Includes MW In/Out, MVAR In/Out, ABC phase voltages, ABC phase currents, frequency and THD, as well as, time of last reset.

Analog/Demand/Energy

Displays the current value of accumulated MWh and MVARh, as well as, the date of the last preset/reset.

Analog/Demand/Peak

Displays the peak value of the following quantities: MW In/Out, MVAR In/Out, ABC phase feeder currents, as well as the time of occurence.

Analog/I*I*t

Displays the valus of I^2t for the last breaker operation, the total accumulated I^2t, the last preset/reset I^2t value and the accumulated I^2t set limit for both the main and auxiliary breakers.

I/O

Displays the status of all external inputs and output contacts.

Logic/Protection

Displays the status of all internal logic, including alarm and trip states of all the relay elements.

Logic/ProLogic

Displays the status of all ProLogic.

Logic/Setting Groups

Displays the current active setting group as well as the current state of all the group logics.

Logic/Virtual Inputs

Displays the current state of all virtual inputs.

Logic/Breaker Logic

Displays the state of all breaker logics as well as the operation count. Also displays the last time the count was preset/reset.

4 Protection Functions and Specifications

Protection and Recording Functions

This section describes the equations and algorithms that define the F-PRO protection functions. The inverse time overcurrent functions have an alarm output where their pickup level has been exceeded. Devices 27, 59, 50LS, 50BF, 81, 50, 50N, 46050, 32 and ProLogic have user-settable intentional delay. When an alarm occurs, the front alarm LED turns on and an output contact closes, if you have selected this option in the output matrix settings. The alarm indication resets when the function is allowed to reset.

50/51/67 Phase Overcurrent

Phase Overcurrent provides protection to the line. You can define forward, reverse or non-directional control on either 50 or 51 functions.

You can apply inverse and instantaneous overcurrent protection on the line currents with this function. If ac current inputs are applied to the relay from ring bus breakers, this current is summated to represent the total line current and is used with this overcurrent function. You can set directional control of 50/51. If voltage is lost, the element becomes non-directional.

The fault location allows the function to initiate a fault location if it operates.

Device 51 provides three IEC inverse time curve types, three IEEE inverse time curve types of overcurrent protection and one user-defined curve. The equation and the parameters of Device 50/51/67 are listed below.

ProLogic control can be used to supervise the inverse time integration of the 51.

Table 4.1: IEC and IEEE Curves

#	Characteristic	A	B	p	TR
1	IEC Standard Inverse	0.14	0	0.02	13.50
2	IEC Very Inverse	13.5	0	1.0	47.30
3	IEC Extremely Inverse	80.0	0	2.0	80.00
4	IEEE Moderately Inverse	0.0103	0.0228	0.02	0.97
5	IEEE Very Inverse	3.922	0.0982	2.0	4.32
6	IEEE Extremely Inverse	5.64	0.0243	2.0	5.82
7	User-defined	0.001 to 100.0	0.0 to 10.0	0.01 to 10.0	0.1 to 100.0

* These constants are copied from the IEEE standards; they are not given in the IEC standard.

For I > pickup	For I < pickup
$T(I) = TMS\left[B + \frac{A}{\left(\frac{I}{Pickup}\right)^{p} - 1}\right]$	$T(I) = \left[\frac{TR}{\left(\frac{I}{Pickup}\right)^{2} - 1}\right]^{TMS}$

50/51 Phase Overcurrent	
50	Enable/disable
Directional	Forward, reverse, non-directional
Pickup	0.25 to 50.00 (5 A) 0.05 to 10.00 (1 A)
Pickup Delay	0.01 to 99.99 seconds 0.00 to 99.99 (non-directional)
51	Enable/disable
Directional	Forward, reverse, non-directional
Pickup	0.25 to 50.00 (5 A) 0.05 to 10.00 (1 A)
Curve Type	For details see “IEC and IEEE Curves” on page 4-1
TMS	0.01 to 10.00
A	0.0010 to 1000.0000
B	0.0000 to 10.0000
p	0.01 to 10.00
TR	0.10 to 100.00
Initiate Fault Location	Enable/disable
ProLogic Control	Enable/disable

50N/51N/67 Neutral Overcurrent

Neutral overcurrent provides protection for line-to-ground faults. You can define forward, reverse or non-directional control on either 50N or 51N functions. All the curve definitions are the same as the phase overcurrent except that this function uses 3I0 rather than phase current. The equation is:

For 3I0 > pickup	For 3I0 < pickup
$T(3I0) = TMS\left[A + \frac{B}{\left(\frac{3I0}{IPickup}\right)^{p} - 1}\right]$	$T(3I0) = TMS\left[\frac{TR}{\left(\frac{3IO}{IPickup}\right)^{2} - 1}\right]$

The Curve Type selection allows you to use a number of curves available in this menu. All of these curve types are generated by the equation shown at the bottom of the screen. If you choose a user-selectable curve, it can be created using the parameters A, B and p.

The characteristic of the overcurrent function can be rescaled by clicking on the characteristics using the right mouse key and by making a box around the area of interest. The characteristic can be printed by pressing the Print Graph option.

50N/51N Neutral Overcurrent	
50N	Enable/disable
Directional	Forward, reverse, non-directional
Pickup	0.25 to 50.00 (5 A) 0.05 to 10.00 (1 A)
Pickup Delay	0.01 to 99.99 seconds 0.00 to 99.99 (non-directional)
51N	Enable/disable
Directional	Forward, reverse, non-directional
Pickup	0.25 to 50.00 (5 A) 0.05 to 10.00 (1 A)
Curve Type	For details see “IEC and IEEE Curves” on page 4-1
TMS	0.01 to 10.00
A	0.0010 to 1000.0000
B	0.0000 to 10.0000
p	0.01 to 10.00
TR	0.10 to 100.00
Initiate Fault Location	Enable/disable
ProLogic Control	Enable/disable

46/50/51/67 Negative Sequence Overcurrent

Negative Sequence Overcurrent provides protection for any unbalanced faults. Functions 46-50/46-51/67 are similar to 50N/51N/67 except they use negative

sequence current to drive their algorithms. You can define forward, reverse or non-directional control on either 46-50 or 46-51 functions. All the curve definitions are the same as the Phase Overcurrent. The only difference is that this function uses the negative sequence current (I2) rather than phase current. The equation is:

For I_2 > pickup	For I_2 < pickup
$T(I2) = TMS\left[B + \frac{A}{\left(\frac{I2}{Pickup}\right)^{p} - 1}\right]$	$T(I2) = TMS\left[\frac{TR}{\left(\frac{I2}{Pickup}\right)^{2} - 1}\right]$

46-50/46-51N Negative Sequence Overcurrent	
46-50	Enable/disable
Directional	Forward, reverse, non-directional
Pickup	0.25 to 50.0 (5 A) 0.05 to 10.0 (1 A)
Pickup Delay	0.01 to 99.99 seconds 0.00 to 99.99 (non-directional)
46-51	Enable/disable
Directional	Forward, reverse, non-directional
Pickup	0.25 to 50.0 (5 A) 0.05 to 10.0 (1 A)
Curve Type	For details see “IEC and IEEE Curves” on page 4-1
TMS	0.01 to 10.00
A	0.0010 to 1000.0000
B	0.0000 to 10.0000
p	0.01 to 10.00
TR	0.10 to 100.00
Initiate Fault Location	Enable/disable
ProLogic Control	Enable/disable

50LS Low Set Overcurrent

F-PRO provides 2 sets of definite time delay overcurrent protection functions on each breaker: 50LS-1 Main, 50LS-2 Main, 50LS-1 Aux and 50LS-2 Aux. You can set the logic gate to either an AND or an OR gate to detect all 3 phases or any phase (of the 3 phases) overcurrent conditions. The definite time delay can be set to 0.0 for a instantaneous trip.

Auxiliary definite time delay functions are available to monitor main and auxiliary CT currents.

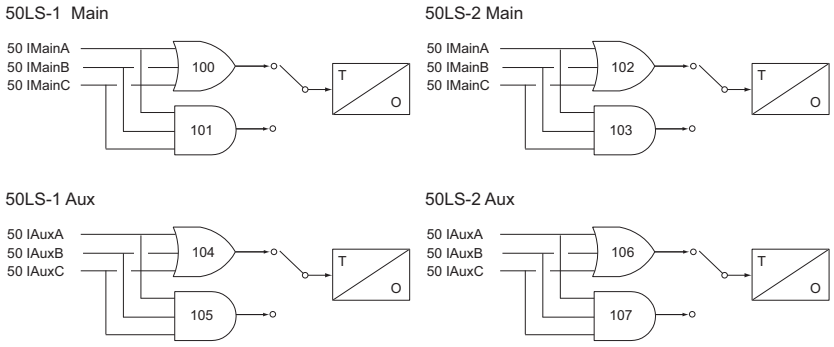


Figure 4.1: 50LS Low Set Overcurrent

50 Low Set Overcurrent	
50LS Main	Enable/disable
Pickup	0.1 to 50.0 amps (5 A) 0.02 to 10.00 amps (1 A)
Pickup Delay	0.00 to 99.99 seconds
50LS Aux	Enable/disable
Pickup	0.1 to 50.0 amps (5 A) 0.02 to 10.00 amps (1 A)
Pickup Delay	0.00 to 99.99 seconds

50BF Breaker Failure

There are two sets of breaker failure protection functions, 50BF Main and 50BF Auxiliary – one for each breaker. When breaker failure is initiated by a trip or other internal logic (user-settable through the output matrix) and the breaker current still exists, two timers (T1 and T2 – user-settable) are started. After these timers are timed out, and if the current still exists indicating a breaker failure, the output of this function is set high. Use the two outputs of this function to trip another trip coil or the next level of breakers, such as bus breakers. The breaker failure protection logic diagram is shown below. Phase current supervision is fixed at 4% of I nominal and is shown for a 5 A relay.

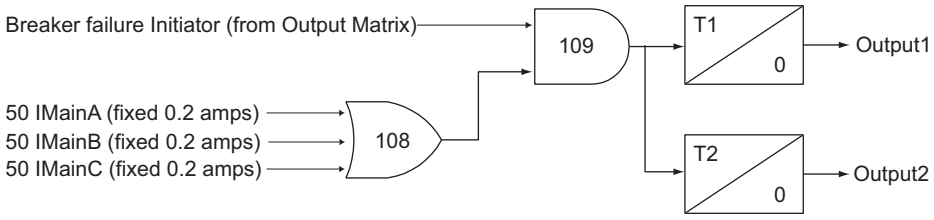


Figure 4.2: 50BF Main Breaker Failure

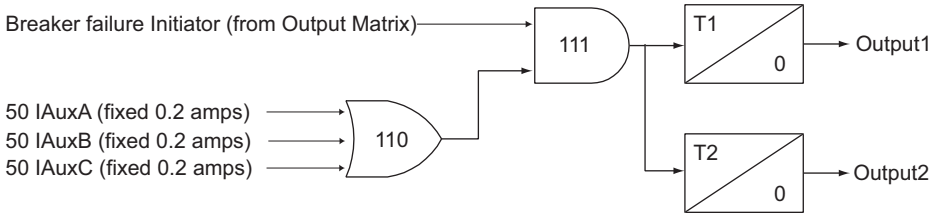


Figure 4.3: 50BF Aux Breaker Failure

50BF Breaker Failure	
Main	Enable/disable
Pickup Delay 1	0.01 to 99.99 seconds
Pickup Delay 2	0.01 to 99.99 seconds
Auxiliary	Enable/disable
Pickup Delay 1	0.01 to 99.99 seconds
Pickup Delay 2	0.01 to 99.99 seconds

Directional Element

The directional element of F-PRO uses the memory-polarized, voltage-based positive sequence impedance ($Z_{pos\ mem}$) to determine the fault direction.

This impedance is defined as:

$$Z_{posmem} = \frac{V_{posmem}}{I_{pos}}$$

where $V_{pos\ mem}$ is the memorized positive sequence voltage calculated from the polarization voltage signals, Figure 4.5: Effect of the Ring Filter on page 4-7, and I_{pos} is the positive sequence line current.

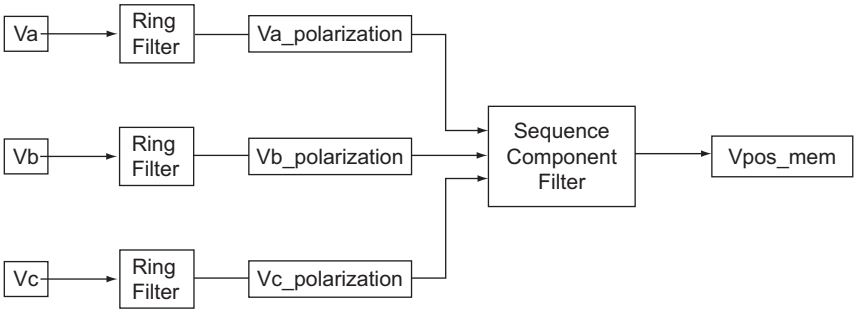


Figure 4.4: Vpos_mem Calculation

The effect of the Ring Filter (implemented in software) is to retain voltage information even if the voltage is severely depressed by a fault.

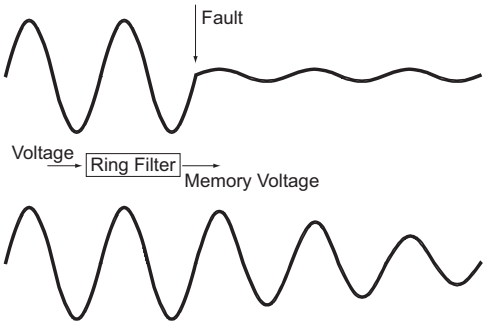


Figure 4.5: Effect of the Ring Filter

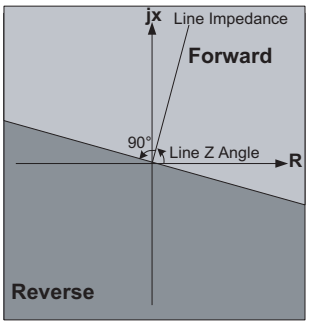


Figure 4.6: Directional Element

The principle of the directional element is shown above. If $Z_{pos\ mem}$ falls into the light gray area, Forward, it indicates a forward fault; and if it falls into the dark gray, Reverse area, a reverse fault is declared.

This directional element is used for directional overcurrent protection. No user settings are needed for this function.

Directional Control for Overcurrent Functions in F-PRO

The positive sequence memory voltage is also used to provide directional control to the overcurrent functions within the F-PRO relay. In this case, the positive sequence memory voltage and the positive sequence line current difference angles are compared to determine the directionality. For example, if the relay is set to directional mode, it allows the overcurrent function to operate if fault currents are towards the line and directions within 90 degrees of the line angle. For details see Figure 4.6: Directional Element on page 4-7.

For the directional control used on the overcurrent relays, a 30 cycle memory action is used on the positive sequence voltage. This memory action takes place only if a fault causes the positive sequence memory voltage to be above 2 volts secondary within the relay. If the positive sequence memory voltage goes below 2 volts, the directional control of the overcurrent reverts to a non directional characteristic, allowing it to operate and trip. For system faults that are not bolted three-phase faults that cause all phase-to-neutral voltages to go to zero, directional control are maintained because the positive sequence voltage does not go to zero.

25/27/59 Sync Check

The relay can bring in voltages from both line and bus PTs. The Sync Check function, if enabled, looks at the voltage steady state angle between the bus and the line PT voltage. If this angle is within a plus/minus specified value, (+/- 1 to 50 degree magnitude range of setting available), the function enables a definite time delay pickup (user-selectable 0 to 99.99 seconds) after which time an output is produced. The line sync reference voltage is taken from a bus and/or a line source; F-PRO uses one single-phase-to-neutral voltage. Settings within the relay allow the single-phase quantity to be offset from Phase A of the line PT by 0 to 330 degrees in 30 degree increments. The Dead Main Live Sync, Live Main Dead Sync and Dead Main Dead Sync logic functions can use fixed values of main and sync positive secondary voltages to determine the sync check condition. The voltage is fixed at 20 volts secondary, voltages below 20 volts are declared a dead state and voltages above 20 volts are declared a live state.

When enabled, this function checks that the voltage angle between the Main ac volts PT and bus sync ac volts PT voltages are within a specified value. Use this function to ensure that closing a line to a system results in acceptable power flow. The function uses three voltages from the Main PT and a single voltage from the Sync PT to make the angle measurement.

The dead main dead sync logic is based on fixed voltages less than 20 volt seconds. i.e. The line or bus is declared dead if its voltage is less than that value. The Sync PT Phase is settable in System Parameters from 0 to 330 degrees in steps of 30 degrees.

25/27/59 Sync Check	
25 Sync Check	Enable/disable
Maximum Voltage	60.0 to 138.0 volts secondary
Minimum Voltage	40.0 ≤ Minimum Voltage ≤ Maximum Voltage -0.1 ≤ 115 volts secondary
Angle Difference	1.0 to 50.0 degrees
Pickup Delay	0.00 to 99.99 seconds
Main/Aux	
Enable Dead Main Live Aux. (DMLA)	Enable/disable
Enable Live Main Dead Aux. (LMDA)	Enable/disable
Enable Dead Main Dead Aux. (DMDA)	Enable/disable

79Main/79Aux Recloser

F-PRO includes a four shots recloser with sync check supervision. After four tries, the recloser is locked out until the feeder returns to normal by manual operation. i.e. The feeder has been on with a load greater than the low set setting for a certain amount of time.

79Main and 79Aux are identical except the inputs are different. For device 79 initiate and block functions are defined in the output matrix.

Ring bus applications provide two separate reclosers.

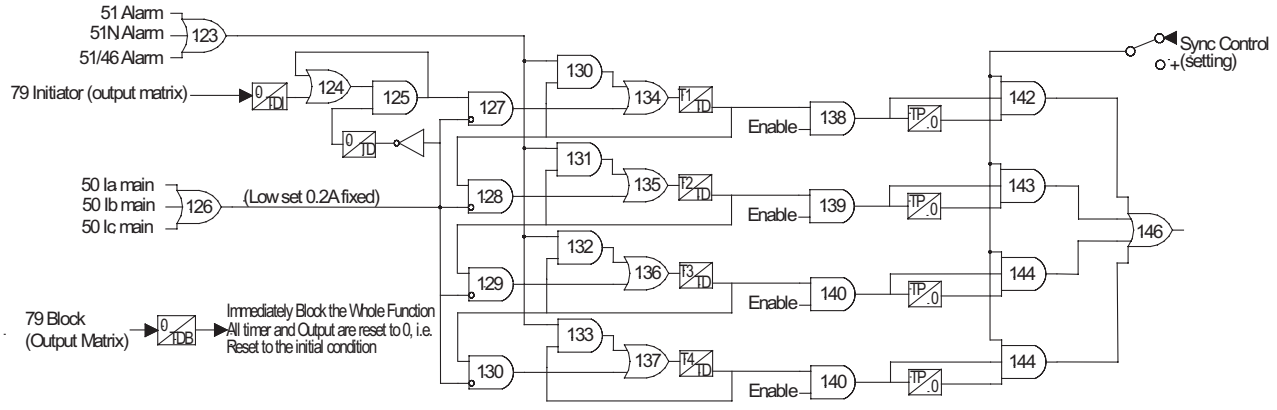


Figure 4.7: 79 Main Recloser

79 Recloser	
79 Recloser	Enable/disable
Number of Shots	1 to 4
First Reclose (T1)	0.02 to 99.99 seconds
Second Reclose (T2)	1.00 to 99.99 seconds
Third Reclose (T3)	1.00 to 99.99 seconds
Fourth Reclose (T4)	1.00 to 99.99 seconds
Close Time (Tp)	0.01 to 1.00 seconds
Lockout Time (TD)	0.00 to 99.99 seconds
Initial Reset (TDI)	0.00 to 99.99 seconds
Block Reset (TDB)	0.00 to 99.99 seconds
Sync Control Enabled	Enable/disable

59 Overvoltage

The F-PRO has a definite time delay main overvoltage function. This function looks at all three phase-to-neutral voltages to determine an overvoltage condition. The logic gate can be set to either AND or OR gate to detect all 3 phase or any phase (of the 3 phases) overvoltage conditions. The definite time delay can be set to 0.0 for a instantaneous trip.

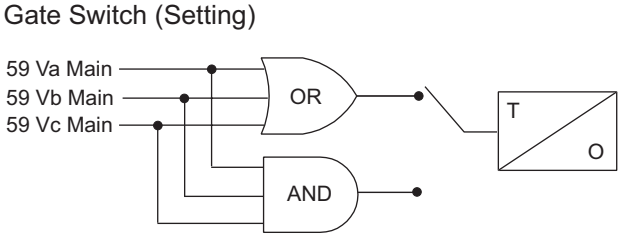


Figure 4.8: 59 Overvoltage

59 Overvoltage	
59-1	Enable/disable
Gate Switch	AND or OR
Pickup	1.0 to 138.0 volts
Pickup Delay	0.00 to 99.99 seconds
59-2	Enable/disable
Gate Switch	AND or OR
Pickup	1.0 to 138.0 volts
Pickup Delay	0.00 to 99.99 seconds

27 Undervoltage

The F-PRO has a definite time main undervoltage function. The function looks at the phase-to-neutral voltage of all three phases to make a determination of an undervoltage condition. The logic gate can be set to either AND or OR gate to detect all 3 phase or any phase (of the 3 phases) undervoltage conditions. The definite time delay can be set to 0.0 for a instantaneous trip.

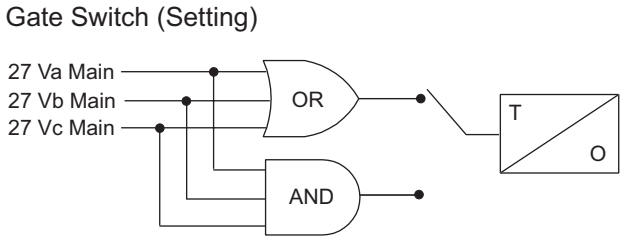


Figure 4.9: 27 Undervoltage

27 Undervoltage	
27-1	Enable/disable
Gate Switch	AND or OR
Pickup	1.0 to 120.0 volts
Pickup Delay	0.00 to 99.99 seconds
27-2	Enable/disable
Gate Switch	AND or OR
Pickup	1.0 to 120.0 volts
Pickup Delay	0.00 to 99.99 seconds

60 Loss of Potential

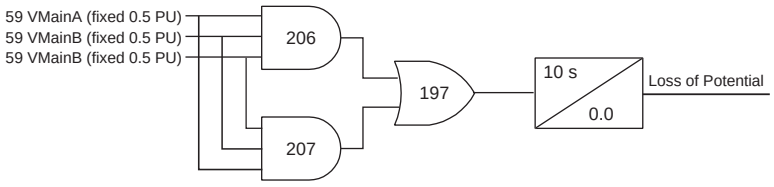


Figure 4.10: 60 Loss of Potential

This function detects the loss of potential from either one or two phases of a PT and issues an alarm.

60 Loss of Potential	Enable/disable
Pickup Delay	10.00 seconds fixed

81 Frequency

The relay has four frequency devices available. Each frequency element can be set to operate either at a fixed level of under-frequency, a fixed level of over-frequency or at a rate of change level (df/dt). The df/dt function can be set to operate for a positive rate of change or a negative rate of change. Each frequency element has a definite time delay setting to create a time delayed output. A fixed level of positive sequence voltage of 0.25 pu or 5 volts whichever is greater provides an undervoltage inhibit on each element.

Four frequency elements are provided, settable from over/under frequency, fixed level to rate of change.

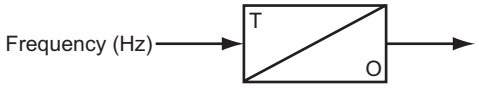


Figure 4.11: Frequency Fixed Level

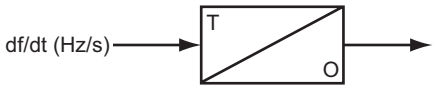


Figure 4.12: Frequency Rate of Change

81 Over/Under Frequency	
81-1	Disabled/Fixed Level/Rate of Change
Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)
81-2	Disabled/Fixed Level/Rate of Change
Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)
81-3	Disabled/Fixed Level/Rate of Change
Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)
81-4	Disabled/Fixed Level/Rate of Change
Pickup	50.000 to 59.995 or 60.005 to 70.000 (fixed level) -10.0 to -0.1 or 0.1 to 10.0 (rate of change)
Pickup Delay	0.05 to 99.99 seconds (fixed level) 0.20 to 99.99 seconds (rate of change)

32P/32Q Directional Power

F-PRO provides directional real power and reactive power protection. Set the pickup setting to a positive value (trip on forward power flow away from bus) or a negative value (trip on reverse power flow into bus).

You can set either a real (32P) and a reactive (32Q) direction. The values are set by specifying the pickup current. This value is set to positive values to detect power flow from the bus and to negative values to detect power flow into the bus.

32 Directional Power	
32P	Enable/disable
Pickup	[-15.00, -0.25] to [15.00, 0.25] A (real)
Pickup Delay	0.00 to 99.99 s
32Q	Enable/disable
Pickup	[-15.00, -0.25] to [15.00, 0.25] A (reactive)
Pickup Delay	0.00 to 99.99 s

21P Phase Distance

The relay has two mho phase distance elements. Each element includes a forward reach and delta current supervisor setting. The element output is only available as a ProLogic.

21 Phase Distance	
21P	Enable/disable
Forward Reach	0.05 to 66.00 ohms
Delta Current Supervision	0.2 to 50.0 A

THD Alarm

This function checks and picks the highest THD in any of the six current inputs (if ring bus configuration is enabled). It only checks the three main current inputs for highest THD, if ring bus configuration is disabled.

THD Alarm	
THD Alarm	Enable/disable
Pickup	5.0 to 100.0%

Fault Locator

When a fault occurs and the line trips, the fault locator calculates the fault type and the distance to the fault. This information is available from the front display of the relay or through terminal UI, or SCADA. Enable or disable the fault locator through 50/51, 50N/51N and 46/50/51 respectively. Define the functions initiating the fault location when setting.

ProLogic

ProLogic Control Statements

Using ProLogic, F-PRO can pick any of the protection functions or external inputs and place them into Boolean-like statements. ProLogic handles up to five functions to generate one ProLogic statement; ten statements are possible. The results from these statements are mapped to output contacts using the output matrix.

Special ProLogic inputs are:

- Output relay #12 as an input to ProLogic.

The ProLogic control statements are used to create Boolean-like logic. The F-PRO can use any of the protection functions or external inputs combined with logic gates to create a ProLogic control statement. The possible gates are AND, NAND, OR, NOR, XOR, NXOR, and LATCH. The control can be time delay pickup and or time delay dropout, and can drive the front panel target LED. Ten ProLogic control statements outputs are available and can be used in the output matrix to customize the relay to your specific needs. Inputs to ProLogic are all the elements plus previous ProLogic statements for logic nesting usage.

The example shows A to E inputs are status points of devices that are user-selectable. Each ProLogic output can be given a specific name, pickup and reset time delay.

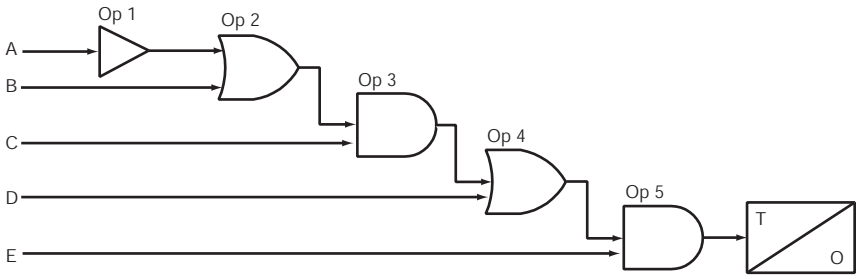


Figure 4.13: ProLogic

ProLogic Setting Functions	
Name	Give the ProLogic a meaningful name
Pickup Delay	Delay time from pickup to operate
Dropout Delay	Delay time from dropout to a ProLogic status of low
A, B, C, D, E	Relay elements as input statements
Operators	Boolean-type logic gates

Breaker Monitoring

The F-PRO breaker monitoring feature allows you to monitor the feeder breaker(s) in detail. An accumulated I*I*t function and ten user-definable logic statements can be used to determine the status of breaker wear and breaker performance.

Breaker monitoring can be configured for measuring the clearing time, mechanism time, trip coil energized time, operations count, fault operations or other user-defined conditions. Different users may require different feature sets to monitor the breaker. The breaker monitoring functions are realized through the Breaker Logic functions.

All associated breaker monitoring values are available in the terminal UI and SCADA interfaces. You can reset or preset all associated breaker monitoring values from the terminal UI interface. You can only reset all associated breaker monitoring values from the terminal SCADA interfaces.

Breaker Logic

The Breaker Logic function is similar to a ProLogic function, but includes some additional features specifically for breaker monitoring allowing different users to design their own breaker monitoring features by building different breaker logic statements. Breaker Logic has additional timers on every output of the logic statement, a total of four timers are available; a counter (including settable count limit) is available in the last logic gate position. The front panel Alarm LED can be enabled, and the logged message can be configured either when one of the four timers has expired or when the counter limit has been exceeded. A total of 10 Breaker Logic functions are available in the F-PRO.

The terminal UI and SCADA interfaces shows the status of each breaker logic and associated counter. The terminal UI also includes the time of last reset/preset.

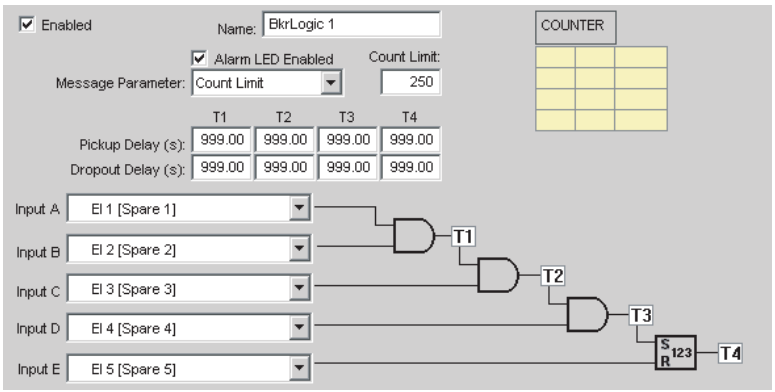


Figure 4.14: Breaker Logic

For examples of breaker condition monitoring using Breaker Logic see “Setting Examples” in Appendix L.

I*I*t

F-PRO has an accumulated I^2t function used for monitoring the wear of the breaker due to fault interruption. This function is available for both the main breaker and the auxiliary breaker. The I^2t value is accumulated for every operation and stored in the non-volatile memory; the write time interval will be 0.5 seconds. A fixed maximum write time of 20 seconds prevents the I^2t function from constantly writing to non-volatile memory. Therefore if the start signal is held on for longer than 20 seconds the accumulator will stop accumulating and stop writing to the flash memory. The output I^2t function will only be available in the event log, the output is not available in the output matrix or in the Pro-Logic input list.

The terminal UI and SCADA interfaces will show the accumulated value of each breaker I^2t function and value of last operation. The terminal UI will also include the time of last reset/preset.

The following figure shows the I^2t function's logic diagram. The accumulation is started when the trip coil of the breaker is energized (breaker starts to open), and will be stopped when the trip coil of the breaker is de-energized. The current that is used for accumulation is the maximum current among Phase A, B and C. An event message will be generated when the accumulated I^2t value is above the limit.

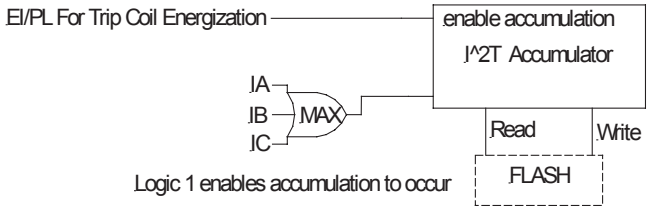


Figure 4.15: I*I*t

Demand Metering

The F-PRO has a demand metering feature which calculates the following quantities:

- 3 phase real power send (MW)
- 3 phase real power receive (MW)
- 3 phase reactive power send (MVAR)
- 3 phase reactive power receive (MVAR)
- A Phase Current (A Pri)
- B Phase Current (A Pri)
- C Phase Current (A Pri)
- A Phase Voltage (V Pri, L-N)
- B Phase Voltage (V Pri, L-N)
- C Phase Voltage (V Pri, L-N)
- Frequency (in Hz)
- THD (in%)

You can select from three calculation types, integrating, rolling and thermal. They are described in detail below.

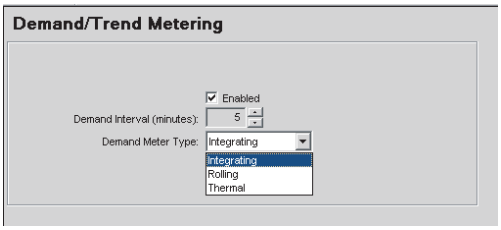


Figure 4.16: Integrating Demand Meter

Integrating demand meter is a linear average of the quantity over the demand interval. Each new value only becomes available at the end of each time interval. The average is calculated from samples taken every 0.5 seconds during the demand interval. Therefore, the equation for calculating what the demand quantity will be is based on the following equation:

New demand value = Sum of the samples during the demand interval / (120*Demand Interval Setting)

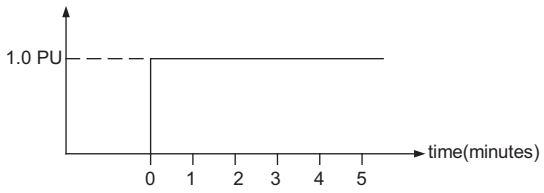


Figure 4.17: Step Power Input

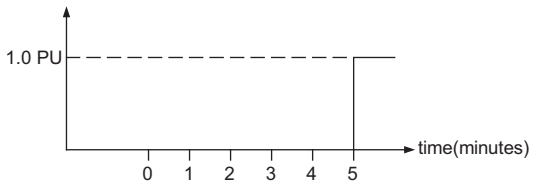


Figure 4.18: Integrating Demand Meter

Figure 4.17: Step Power Input on page 4-17 shows the input signal, which is a magnitude of zero and then suddenly goes to an instantaneous level of 1.0 per unit, i.e. a step change function.

Figure 4.18: Integrating Demand Meter on page 4-18 shows the integrating demand meter, i.e. the demand value will not be calculated or updated until the end of the demand interval (setting, it's 5 minutes for this example). The response for integrating demand meter is shown in the following table:

Time (min.)	1	2	3	4	5	6
Demand (% of Input)	0	0	0	0	100	100

Rolling Demand Meter

Rolling demand, also called “sliding window”, is a process by which intervals are divided into a fixed number of subintervals. Instead of calculating demand only at the end of each interval, the calculation is performed at the end of each subinterval, and totaled and averaged for the interval. The subinterval is 1 minute (fixed) in F-PRO relay. The calculation is the same as the Integrating Demand Meter.

Figure 4.19: Rolling Demand Meter on page 4-18 shows the rolling demand meter response to the input of Figure 4.17: Step Power Input on page 4-17. The demand value is calculated and updated on each subinterval (one minute). The average calculation is performed over the demand internal (setting, equal 5 minutes for this example). The response to the input shown in figure 1 for rolling demand meter is shown in the following table:

Time (min.)	1	2	3	4	5	6
Demand (% of Input)	20	40	60	80	100	100

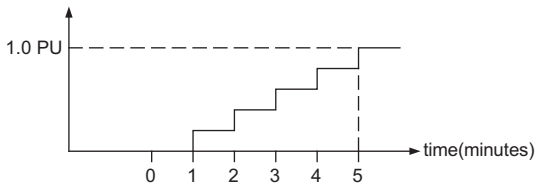


Figure 4.19: Rolling Demand Meter

Thermal Demand Meter

The thermal demand meter is described in this section. Again, use the step change power input from Figure 4.17: Step Power Input on page 4-17 as an example.

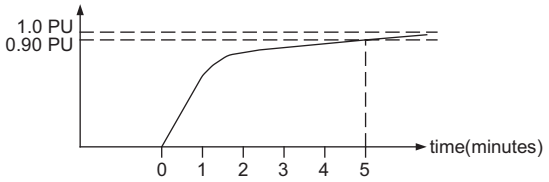


Figure 4.20: Thermal Demand

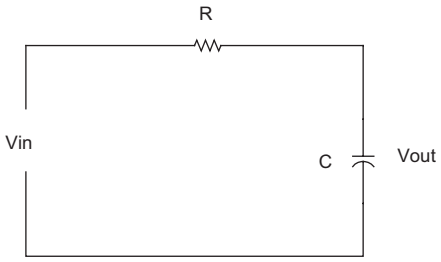


Figure 4.21: RC Circuit

Figure 4.20: Thermal Demand on page 4-19 shows the thermal model of demand calculation. It acts like a RC circuit as shown in Figure 4.21: RC Circuit on page 4-19. The output voltage will never reach the final value until the time goes to infinity, however, we define it in this way it will reach the 90% of the input when the elapsed time is equal to the Demand Interval (5 minutes for this example). The thermal demand will reach 99% of the input when the time is twice of the demand interval, as shown in the table below. The equation for this response is Vout = Vin*(1-e-t/τ), where τ is the time constant and it is equal to 2.17147241 minutes. The thermal demand meter data will be calculated and updated every half-second. The following table shows the response of the thermal demand.

Time (min.)	1	2	3	4	5	6	7	8	9	10
Demand (% of Input)	36.9	60.1	74.8	84.1	90	93.6	96	97.4	98.4	99

Peak Demand Quantities

Peak Demand quantities will be derived from the Demand/Trend quantities. A total of 7 Peak Demand Quantities will be metered:

- 3 Phase Real Power Out (MW)
- 3 Phase Real Power In (MW)
- 3 Phase Reactive Power Out (MVAR)
- 3 Phase Reactive Power In (MVAR)
- A Phase Feeder Current IA (A Pri)
- B Phase Feeder Current IB (A Pri)

- C Phase Feeder Current IC (A Pri)

The peak demand quantities are available from the front panel display, the TUI metering and SCADA. Peak Demand quantities can be reset from the front panel, TUI or SCADA. The peak value of the above quantities and the time of occurrence are displayed.

Accumulated Energy (kWh, kVARh metering)

For the accuracy and the consistency, the method of the energy calculation is the same regardless of the demand type. (rolling, integration, thermal). There are four accumulated energy quantities. They are:

- 3 Phase real energy OUT (MWh)
- 3 Phase real energy IN (MWh)
- 3 Phase reactive energy OUT (MVARh)
- 3 Phase reactive energy IN (MVARh)

The accumulated energy quantities are calculated by the integration of the average power over the elapsed time. This calculation is carried out once per minute, however the actual power is sampled every half second and averaged every minute (120 samples).

The accumulated energy quantities are stored in the non-volatile memory to avoid the data loss on power down.

When the accumulated energy quantities exceed 98000 MWh/MVARh they are reset to zero. A reset on one energy quantity will only reset it's own value, not the other energy quantities. All reset actions will be logged in the event log.

Group Logic

Group Logic Control Statements

The F-PRO relay has eight setting groups (SG). You can change all relay setting parameters except the physical connections such as input or output parameters in each setting group. Setting group changes are performed by using any one of the 16 available Group Logic statements per setting group. The Group Logic statements are similar to the ProLogic statements with the following exceptions—the sole function is to activate one of the eight setting groups and the processing is in a slower half second cycle. Group Logic input statements are driven from ProLogic, any external input, previous Group Logic statements or virtual inputs. Each Group Logic statement includes five inputs (with Boolean statements), one latch state and one pickup delay timer. The active setting group (ASG) is viewed from the Terminal Mode, the front panel or from a record stored by the relay (the active setting group is stored with the record).

Group Logic Processing

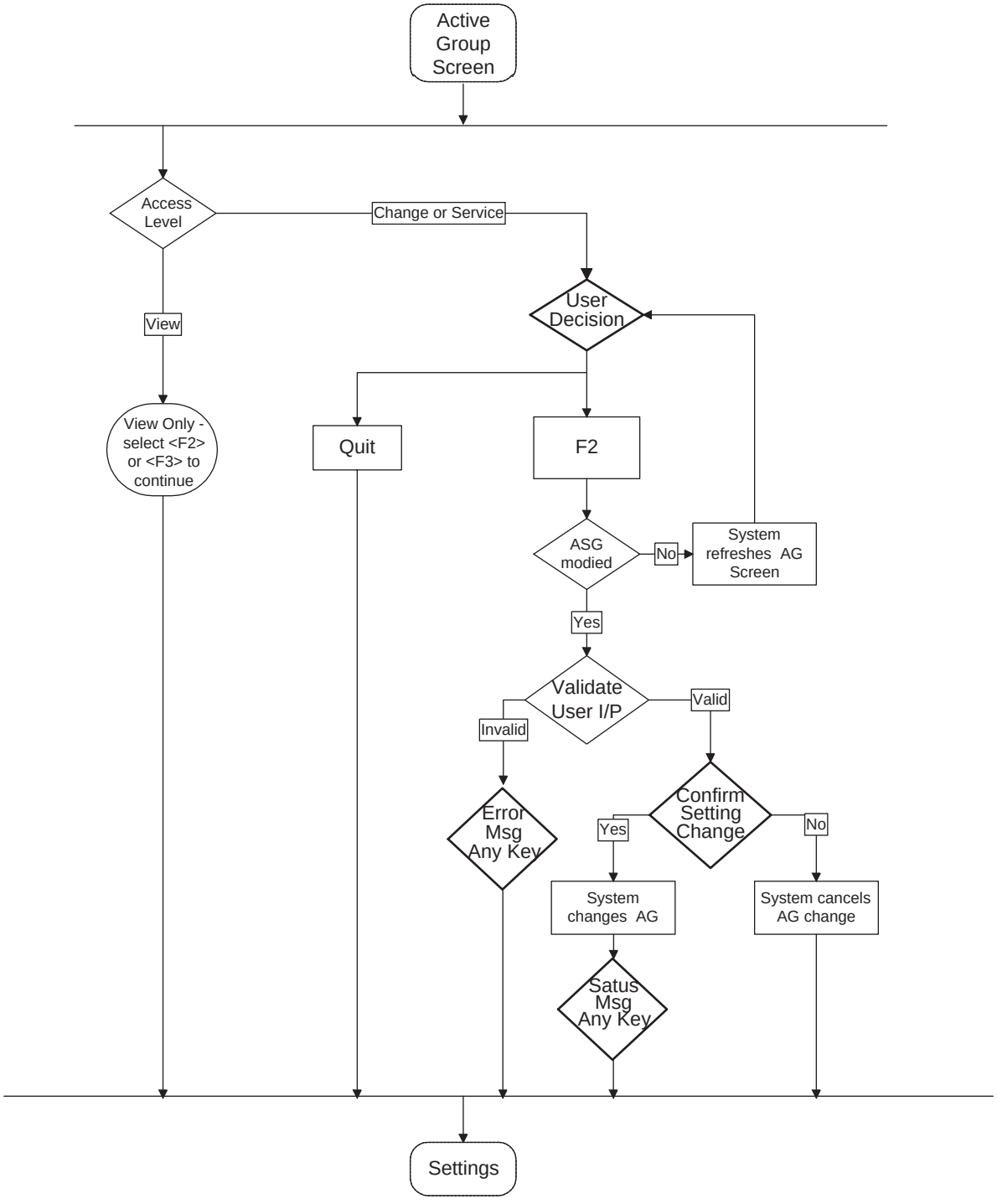
The sixteen Group Logic statements reside in a slower processing thread within the relay protection algorithms. The processing cycle happens once every half second (0.5 second). When using ProLogic statements remember that a latch or dropout timer should be used if the initiating condition does not last at least 0.5 seconds. In the example following, we will create a definite pulse length using ProLogic. For details see “F-PRO Setting Example” in Appendix L.

Default Setting Group

The relay uses Setting Group 1 as the factory default setting group and retains the current active setting group in memory. This allows the relay to use the last active setting group prior to interruption of relay power as the default setting group following power up.

Change Active Group

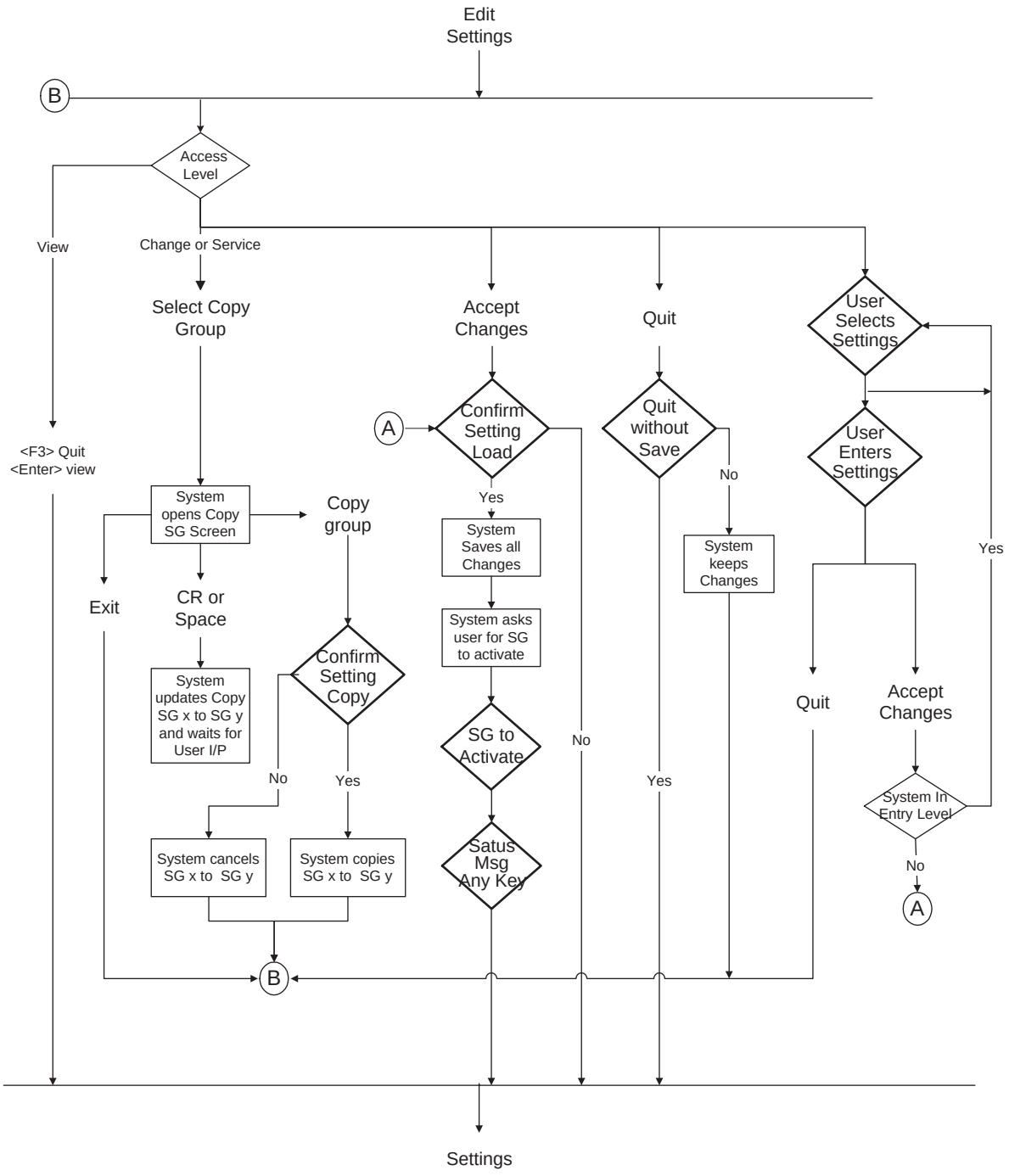
You can at any time change the active setting group. When you initiate a setting group change, this change takes precedence over an automatic setting group change. The terminal UI is used to change the active setting group. To view a snapshot of the group logic data select F2 prior to making any modification to the Active Setting Group input. The following is the flow of events that can occur in the Active Group Screen.



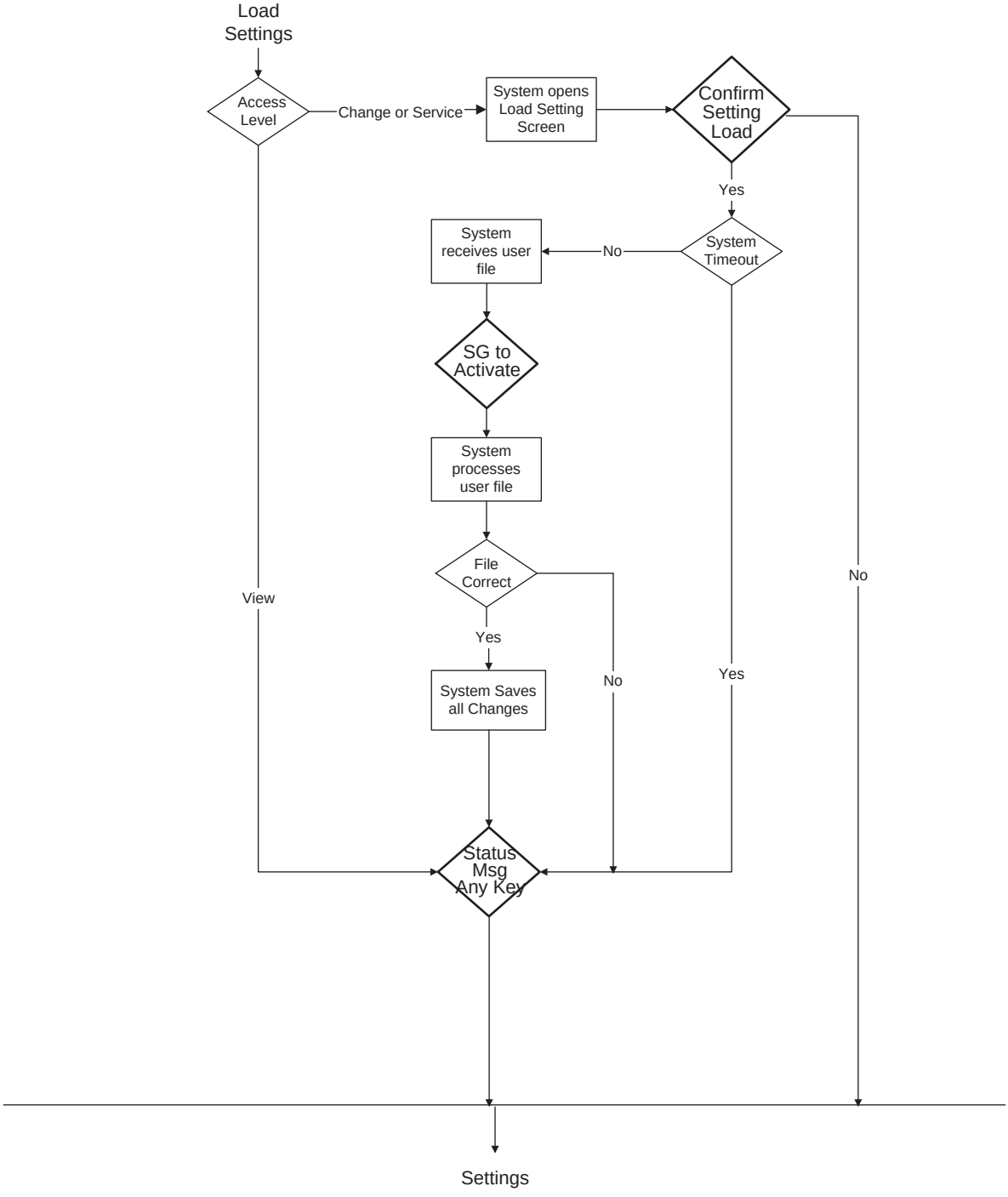
Settings Saved

You can change the active setting group while saving setting changes or loading settings from *Offliner*. The relay prompts you for a setting group to activate— you can keep the current setting group or switch to a new setting group following the settings save.

The following is the flow of events that can occur in the Editing Settings Screen.



The following is the flow of events that can occur in the Load Settings Screen.



Manual Settings Change

Relay configuration changes during a user-initiated manual setting; the change does not disrupt the relay protection functions. The relay logs an acceptance of the change request and puts the new setting file in service. When the new setting file is queued the relay loads the new setting configuration for protection functions to the protection processor. The relay loads the new name definitions for indication and recording functions to the interface processor. When the relay has completed loading the ancillary settings for indication purposes to the interface processor, an event is logged to show completion of the request. There is some lag time during the load request and the completion of the request where the interface processor associates ancillary functions with the previous setting file for approximately five seconds. The ancillary setting information includes channel or ProLogic and Group Logic statements names, front panel target light activation rules and record initiation rules.

The protection processor does not have any interruption in service.

Automatic Settings Change

Relay configuration changes during a relay-initiated setting; change does not disrupt the relay protection functions. Since the relay setting file does not change, the interface processor uses the new setting group ancillary setting information at the same time as the protection processor switches to the new setting group. An event is logged to show when the new setting group is in service.

Recording Functions

The F-PRO has recording and logging functions to allow you to analyze faults and to review the operation of the overall protection scheme.

Fault Recording

The F-PRO provides high quality fault recording, capturing input signal waveforms and external digital input states at a rate of 96 samples per cycle. Each record also contains the timing of the internal logic produced by the relay (e.g. 51 trip).

The quantities recorded are:

- 10 analog channels: 4 voltages and 6 currents @ 96 samples/cycle, up to the 25th harmonic frequency response
- 9 external digital inputs: @ 96 samples/cycle
- relay internal logic signals: @ 8 samples/cycle
- summation channels

Trend Recording

The trend recording provides continuous, slow-speed recording of P, Q, Energy, V, I, Freq. and THD of the feeder with an adjustable sample period from 5 to 60 minutes per sample. This same global trend sampling rate is applied to all the trend quantities. The relay stores a fixed number of samples. At the nominal sample period of 5 minutes per sample the F-PRO stores one month of trend records with automatic overwrite of the oldest.

Sample Interval	Trend Record Length
5 minute	30 days
10 minute	60 days
30 minute	180 days
60 minute	360 days

Record Initiation

Recording can be initiated automatically by the relay when a fault or abnormal condition is detected. You can set the relay to initiate a fault record upon activation of any of its trip or alarm functions or on assertion of any external digital inputs.

The assignment of fault record initiation to the various relay functions is done through the relay's Output Matrix settings.

A recording can also be initiated manually through the terminal user interface. The command *Initiate Fault Recording* is available under the *Records* menu.

Record Duration and Extension

The length of each record is determined by the Record Length setting. Fault record lengths can be set between 0.2 and 2.0 seconds. Pre-trigger times are fixed at 10 cycles for fault records and are included as part of the normal record length. A trend recording is for a 30 day period at one sample/5 minutes. You do not need triggers to create a trend record.

The F-PRO automatically extends a record as required to capture consecutive triggers that are close together. If a trigger occurs while a recording is in progress, the record is stretched to include the full post-trigger time of subsequent triggers, up to a maximum length—2.0 seconds for fault records. If a trigger occurs before the end of a record caused by a previous trigger, but too late to allow sufficient post-trigger time in a maximum extended record, a new overlapping record is created.

The normal record lengths settings are accessible under the *Recording* heading of the relay settings, and can be set from either the terminal user interface or the *Offliner* Settings software.

Event Recording

The event recording provides permanent storage of the event log. An event record can be created automatically or manually. When the event auto save is enabled an event record is created approximately every 230 events.

A recording can also be initiated manually through the terminal user interface. The command *Initiate Event Recording* is available under the *Records* menu.

Record Storage

The F-PRO compresses records on the fly, achieving a typical lossless compression rate of 4:1. As a result, the F-PRO can store up to 30 seconds of fault recordings and a minimum of 30 days of trend recordings in non-volatile storage. If the storage is full, new records automatically overwrite the oldest, ensuring that the recording function is always available.

Retrieval and Analysis

A listing of stored records is available through the terminal user interface under the *Records* menu. The listing provides the means to transfer records to a connected PC and to delete them from storage.

Example:

```
FPRO-2100-990726-04-2000-06-09 13.17.16.000(Fault)
```

Records are named by combining the Relay ID setting with the date and time of the initiating record trigger. In the record list, the record type (fault or swing) is shown.

To delete a record from storage, use the up/down cursor keys to select the record, then press <*D*>. You can also do group deleting and group transferring.

To select multiple records:

1 Select a record.

2 Press the spacebar - a asterisk will appear to the left of the record to indicate it is selected.

3 Continue selecting and pressing the spacebar until all desired records are selected.

4 Press <*D*>. A message asks “Delete all selected files?” shown above. Select *Y* for Yes and the files are deleted.

To transfer a record to your PC, use the up/down cursor keys to select the record, then press *r*. The record is automatically transferred to your PC using the PC terminal program's z-modem file transfer protocol. The record is placed in your terminal program's default to receive the directory which was set before transfer to an appropriate directory. (e.g. Windows Hyperterm's default receive directory is set through the its Transfer menu). When transferred, the record name remains unchanged and the file extension indicates the record type: ".fpr" for fault, ".fpe" and ".fpt" for trend.

When the transfer has taken place, you can choose to delete the record or leave a copy on the relay.

Logging Functions

Event Log

The F-PRO maintains a log of events in a 250 entry circular log. Each entry contains the time of the event plus an event description.

Logged events include trips, alarms, external input assertions plus internal events such as setting changes. Fault location and classification information is included in event messages where appropriate. For example, the event log entry for a device trip might be:

2000 Nov 21, 15:34:19.832 : 51 ABC 112.3 km: Trip.

The event log can be viewed in two ways:

Front Panel	The front panel display shows events in abbreviated form (Trip and Alarm events only).
Terminal User Interface	The full event log is available through the Event Log menu of the terminal user interface.

This display is a snapshot of the event list which must be manually refreshed to display new events that occur while the display is up.

There is a list of the F-PRO event messages. For details see "Event Messages" in Appendix D.

5 *Offliner* Settings Software

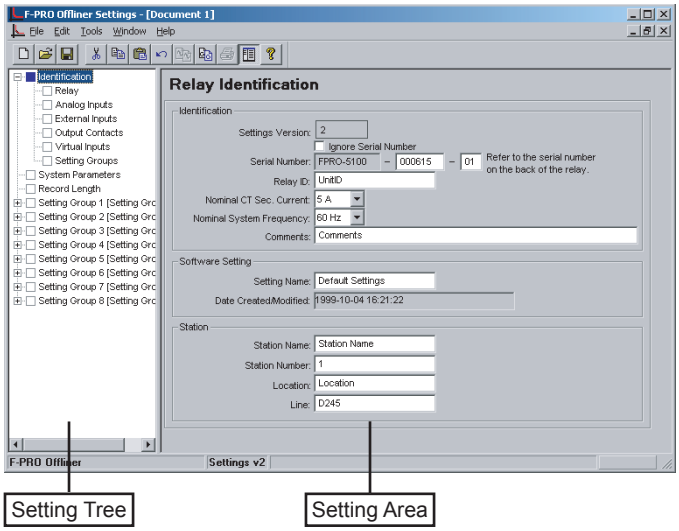


Figure 5.1: Opening Screen

Introduction

Use the *Offliner* Settings software to create relay settings on a PC. *Offliner* Settings provides an easy way to view and manipulate settings.

PC System Requirements

Hardware

The minimum hardware requirements are:

- Pentium processor
- 64 MB of available RAM
- 100 MB of available hard-disk space recommended
- VGA monitor
- CD-ROM drive
- Serial communication port

Operating System

The following software must be installed and functional prior to installing *Offliner* and RecordBase View software:

- Microsoft Windows 95, 98, ME, NT 4.0, 2000 or XP

Installing PC Software

Insert the CD-ROM in your drive. The CD-ROM should open automatically. If the CD-ROM does not open automatically, go to Windows Explorer and find the CD-ROM (usually on D drive). Open the F-PRO.exe file to launch the CD-ROM.

To install the software on your computer, click the desired item on the screen. The installation program launches automatically. Installation may take a few minutes to start.

To view the F-PRO User Manual you must have Adobe Acrobat on your computer. If you need a copy, download a copy by clicking on Download Adobe Acrobat.

Offliner Features

The *Offliner* software includes the following menu and system tool bar.

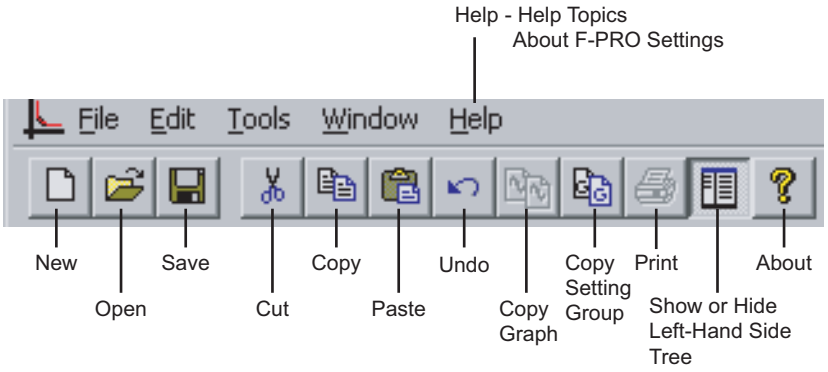


Figure 5.2: Top Tool Bar

Tool Bar	
Windows Menu	
Icon	Restore, minimize, close.
File	New, open, close, save, save as, print setup.
Edit	Undo, cut, copy, paste.
Tools	Display and print only enabled protection devices.
Window	Cascade, tile, arrange icons.
Help	Help Topics, About F-PRO Settings.
Settings Program Icons	
New	Create new default settings file.
Open	Open any valid settings file.
Save	Save current settings file.

Cut	Edit function.
Copy	Edit function.
Paste	Edit function.
Undo	Edit function.
Copy Graph	Copy to clipboard.
Copy Setting Group	Copy from Setting Group X to Setting Group Y.
Print	Print from Output Matrix, any graph or Settings Summary.
Show or Hide Left-Hand Side Tree	Show or Hide Left-Hand Side Tree
About	Version number.

Graphing Protection Functions

Grid On/Grid Off

The graph can be viewed with the grid on or off by clicking the Grid On or Grid Off button. A right-click on the trace of the curve gives you the x and y coordinates.

Print Graph

To print a particular graph, click the *Print Graph* button.

Zoom on Graphs

Graphs can be zoomed to bring portions of the traces into clearer display. Left-click on any graph and drag to form a small box around the graph area. When you release the mouse, the trace assumes a new Zoom position determined by the area of the zoom coordinates.

To undo the zoom on the graph, click the Refresh button.

Handling Backward Compatibility

Offliner Settings displays the version number in the second pane on the bottom status bar. The settings version is a whole number (v1, v2, v3, v4, etc.).

The *Offliner* Settings is backward compatible. Open and edit older settings files and convert older settings files to a newer version. *Offliner* Settings handles forward conversion only; it converts an older setting file to a newer setting file.

Converting a Settings File

1 Open the setting file you wish to convert.

2 In the *File* menu, select *Convert to...* and then select the *version x* (where x is the newer version). A dialog box pops up prompting *Offliner* for a new file name. Use either the same file name or enter a new file name. The conversion process inserts default values for any newly added devices in the new setting file. When the conversion is complete, *Offliner* Settings displays the new file.

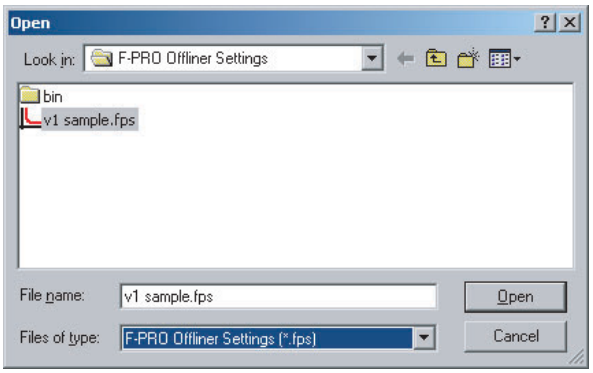


Figure 5.3: Converting Setting Files

Sending a New Setting File to the Relay

1 Make sure the settings version and the serial number of the relay in the setting file match. The relay will reject the setting file if either the serial number or the settings version do not match.

> A "serial number discrepancy" message may appear. This is to ensure that you are aware of the exact relay in which settings are to be loaded. If this happens, check the relay serial number using the terminal mode ID menu item. Type this serial number into the F-PRO Serial No. box in the Identification tab display area of *Offliner* Settings. Alternately you may check the Ignore Serial Number check box to bypass serial number supervision.

2 Check the serial number and the settings version of the relay, for details see "ID" on page 3-9. The Device Serial Number and Required Settings Version on the Identification screen indicate the serial number and the settings version of the relay.

Creating a Setting File from an Older Version

1 *Offliner* Settings displays a default setting file on start up showing the settings version in the bottom status bar. As an example F-PRO *Offliner* is shipped with a set of default sample files of older settings versions. The sample file is "v1 sample.fps". The sample file contains default values of an older settings version. For a new installation these sample files are placed in the default directory C:\Program Files\NxtPhase\F-PRO Offliner Settings, or you can choose the path during the *Offliner* software installation. If an older version of F-PRO *Offliner* was previously installed on your PC, then the default directory may be C:\Program Files\APT\F-PRO Offliner Settings.

2 Open a sample file of the desired version. Use *File/Save As* to save the sample file to a new file name. Then edit the setting file and the serial number, save it and load it into the relay.

RecordBase View Software

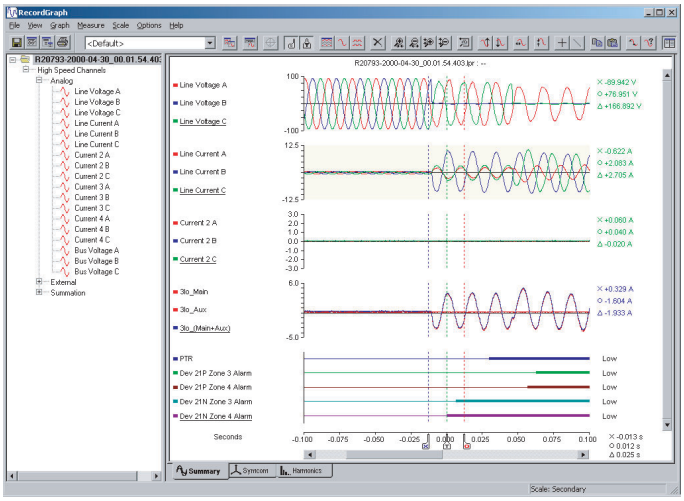


Figure 5.4: RecordBase View

Use RecordBase View to analyze the records from a relay.

1 Set the receive directory on your terminal program to point to a convenient directory on your PC's hard disk or network. For example with Windows HyperTerminal, select *Transfer>Receive File* to set the receive directory.

2 Select one or more records on the relay using the *List* function in the Terminal Mode's *Records* menu.

3 Initiate transfer of the selected records by selecting *R* on the keyboard.

4 Start the RecordBase View program and use the *File>Open* menu command to open the downloaded record files located in the receive directory specified in step 1.

For further instructions refer to the RecordBase View Manual at the back of the printed version of this manual.

Main Branches from the Tree View

Identification

The first screen presents all the menu items in the left menu tree. Access the menu items by clicking on item on the left menu tree.

Relay

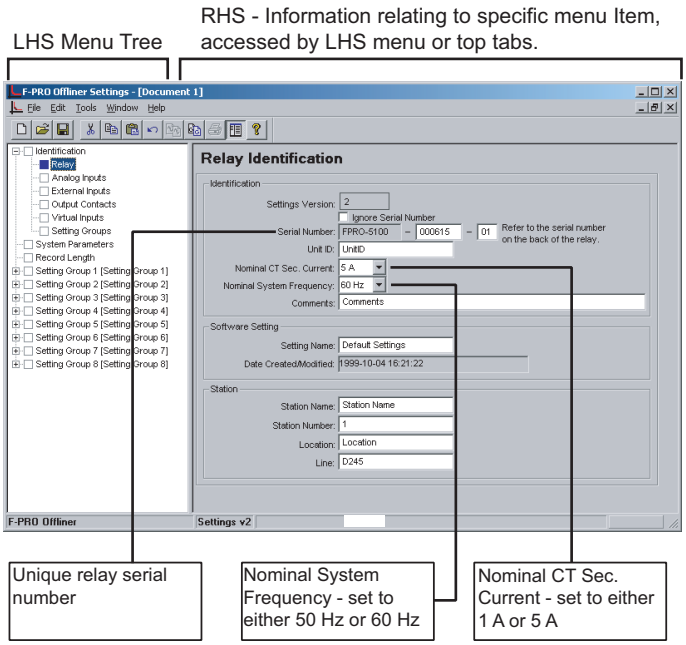


Figure 5.5: Identification

Identification	
Settings Version	Indicates the settings version number, fixed.
Ignore Serial Number	Bypass serial number check, if enabled.
Serial Number	Available at back of each relay.
Unit ID	User-defined up to 20 characters.
Nominal CT Format	5 A or 1 A
Nominal System Frequency	60 Hz or 50 Hz
Comments	User-defined up to 20 characters.
Setting Software	
Setting Name	User-defined up to 20 characters.
Date Created/Modified	Indicates the last time settings were entered.
Station	
Station Name	User-defined up to 20 characters.
Station Number	User-defined up to 20 characters.
Location	User-defined up to 20 characters.
Line	User-defined up to 20 characters.

Important Note

Nominal CT Sec. Current can be set to either 5 A or 1 A.

Nominal System Frequency can be set to either 60 Hz or 50 Hz.

Ensure setting selection matches that of target F-PRO.

The serial number of the relay must match the one in the setting file, or the setting will be rejected by the relay. This feature ensures that the correct setting file is applied to the right relay.

In Settings Version 2 or greater you can choose to ignore the serial number enforcement in the identification screen. The relay only checks for proper relay type and setting version if the ignore serial number has been chosen, requires relay firmware version 2.0 or greater.

Analog Inputs

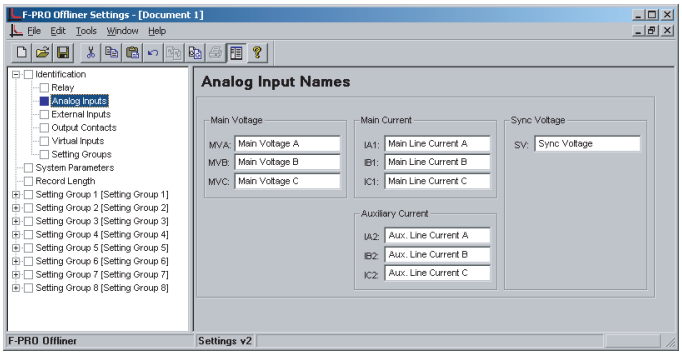


Figure 5.6: Analog Inputs

Analog Inputs screen identifies all the ac voltage and current inputs to the relay. These names appear in any fault disturbance records the F-PRO produces.

Analog Inputs	
Main Voltage	MVA, MVB, MVC
Main Current	IA1, IB1, IC1
Aux. Current	IA2, IB2, IC2
Sync Voltage	SV

External Inputs

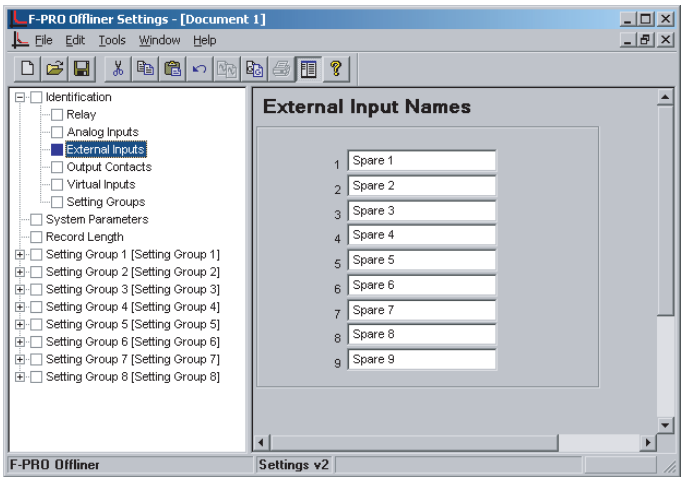


Figure 5.7: External Inputs

The External Inputs screen allows you to define meaningful names for nine external inputs.

External Input Names	
1 to 9	User-defined

Output Contacts

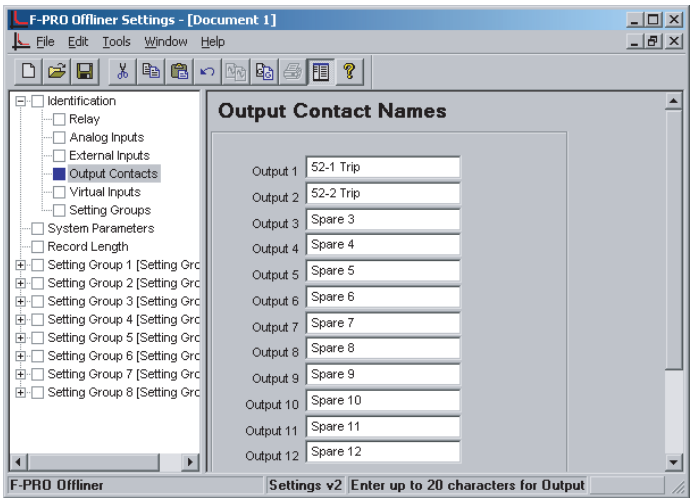


Figure 5.8: Output Contacts

The Output Contact Names screen allows you to define meaningful names to the 12 output contacts.

Output Contact Names	
Outputs 1 to 12	User-defined

Virtual Inputs

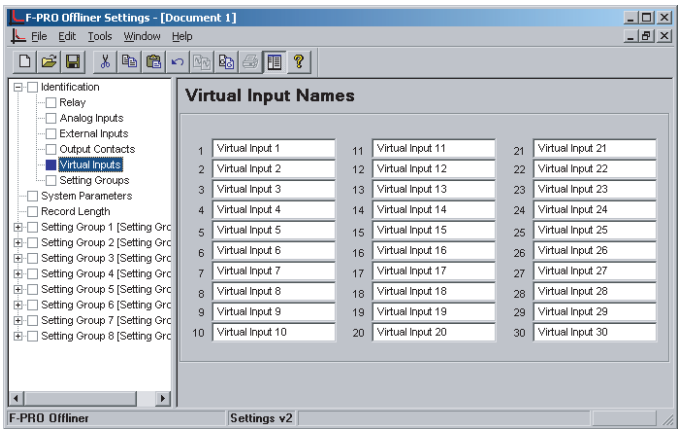


Figure 5.9: Virtual Inputs

Virtual Inputs	
Virtual Inputs 1 to 30	User-defined

The relay can control its internal functions and connected devices both locally and remotely. Thirty general purpose logic points are accessible via DNP3 and the terminal UI. The 30 virtual inputs are individually controlled and include a set, reset and pulse function. The latch state is retained during setting changes and relay power down conditions. The 30 virtual inputs conform to DNP3 standards. Use the DNP3 functions such as SBO (select before operate), Direct Operate, or Direct Operate with no acknowledge to control virtual inputs.

Use virtual inputs to:

- control circuit breakers
- enable or disable reclosing
- enable or disable under-frequency load shedding
- change setting groups
- provide interlocking between local/remote supervisory control

Setting Groups

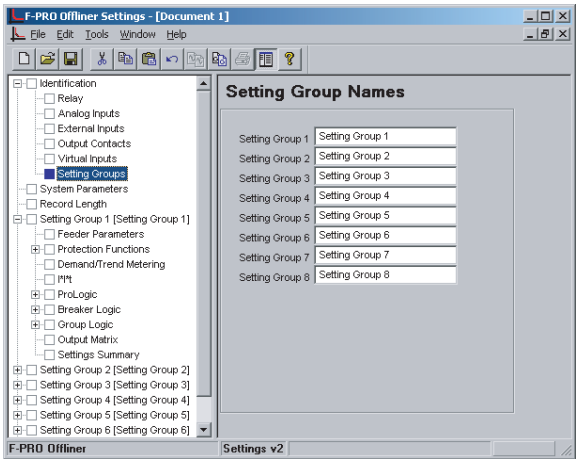


Figure 5.10: Setting Groups

The Setting Group Names screen allows you to define meaningful names to the 8 setting groups.

Setting Groups	
Setting Groups 1 to 8	User-defined

System Parameters

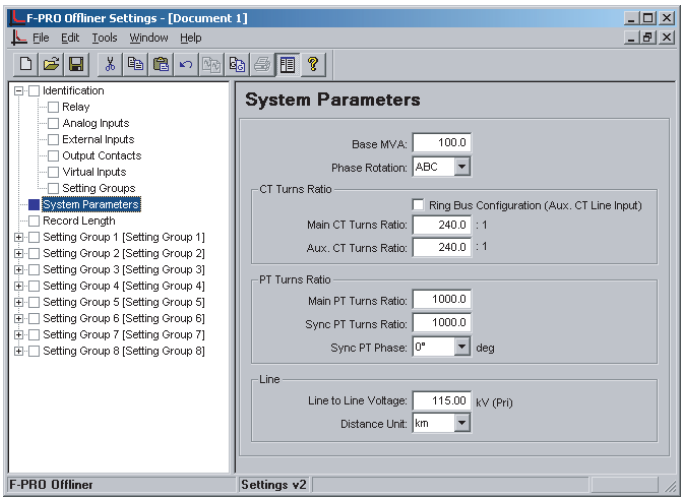


Figure 5.11: System Parameters

System Parameters	
Base MVA	1.0 to 1000.0 MVA (primary)
Phase Rotation	ABC or ACB
CT Turns Ratio	
Ring Bus Configuration (Aux CT Line Input)	Enable/disable
Main CT Turns Ratio	1.0 to 10000.0
Aux CT Turns Ratio	1.0 to 10000.0
PT Turns Ratio	
Main PT Turns Ratio	1.0 to 10000.0
Sync PT Turns Ratio	1.0 to 10000.0
Sync PT Phase	0 to 330 degrees
Line	
Line to Line Voltage	1.00 to 500.00 kV (Primary)
Distance Units	km or miles

Base MVA

The base MVA is used for recording purposes.

CT Turns Ratio and PT Turns Ratio

The CT and PT ratios are specified for the analog inputs. All CT and PT ratios are specified with a ratio relative to one (i.e. X amps to 1A). The line protection uses the main current and the main voltage to operate. When two sets of CTs (main and auxiliary) are used as line current input (e.g. ring bus application), you must enable the ring bus configuration parameter to inform the relay. If enabled, the currents from the two sets of CTs are added to the relay to form the line current. F-PRO uses ac volts from the main PTs for its protections and for the metering functions. A single phase voltage from the bus is connected to sync ac volts to provide voltage for sync checking capability.

Record Length

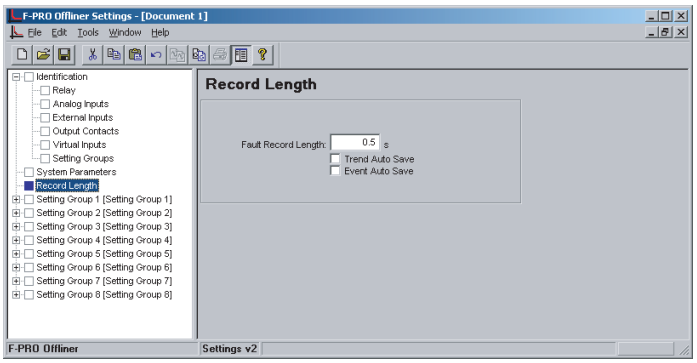


Figure 5.12: Record Length

Record Length	
Fault Record Length	0.2 to 2.0 seconds
Trend Auto Save	Enable/disable
Event Auto Save	Enable/disable

The relay has recording and logging functions to analyze faults and to review the operation of the overall protection scheme.

This item identifies the amount of time that each fault record. Prefault is fixed at 10 cycles.

Setting Groups

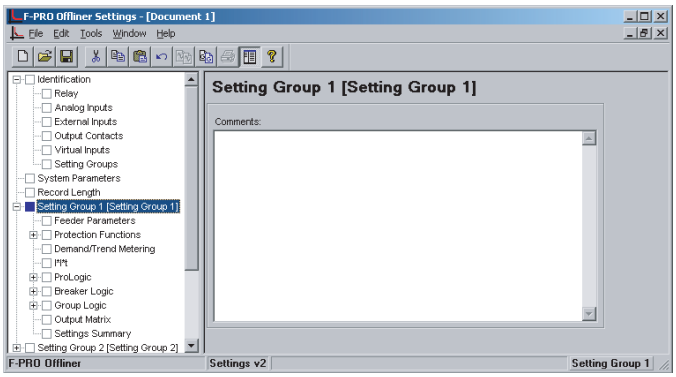


Figure 5.13: Setting Groups Comments

The relay has eight setting groups (1 to 8). You can change all relay setting parameters except the physical connections such as input or output parameters in each setting group. Use any one of the 16 available Group Logic Statements per setting group to perform Setting Group changes. The Group Logic statements are similar to the ProLogic statements with the following exceptions, the sole function is to activate one of the eight setting groups and the processing is in a slower half second cycle. Group Logic inputs statements can be driven from ProLogic, any external input, previous Group Logic statements or virtual inputs. Each Group Logic statement includes five inputs (with Boolean statements), one latch state and one pickup delay timer. View the active setting group from the Terminal Mode, from the front panel or from a record stored by the relay (the active setting group is stored with the record).

Feeder Parameters

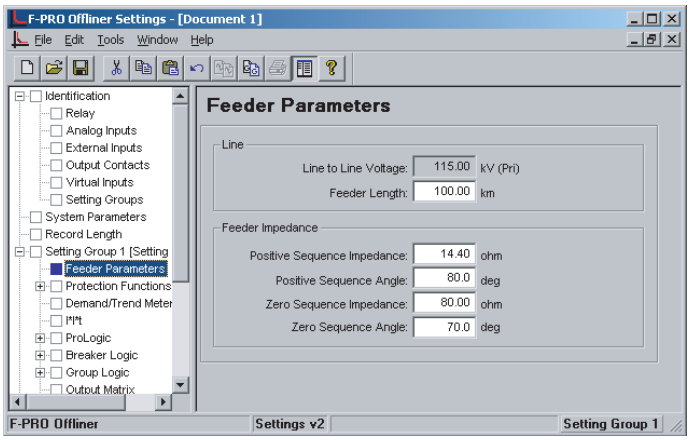


Figure 5.14: Feeder Parameters

Feeder Parameters	
Line	
Line to Line Voltage	Fixed (from System Parameters)

Feeder Length	1.0 to 1000.0 km or 0.62 to 621.37 miles
Feeder Impedance	
Positive Sequence Impedance	0.05 to 66.00 ohms
Positive Sequence Angle	25.0 to 89.0 degrees
Zero Sequence Impedance	0.05 to 200.00 ohms
Zero Sequence Angle	25.0 to 89.0 degrees

Feeder Parameters permit a parameter entry related to the line voltage, CT ratio, PT ratio, line length, line secondary positive and zero sequence impedance. The relay internally calculates Ko from these values.

Feeder parameters are entered in secondary quantities.

Protection Functions

For detailed descriptions of the protection functions see “Protection Functions and Specifications” on page 4-1.

Demand/Trend Metering

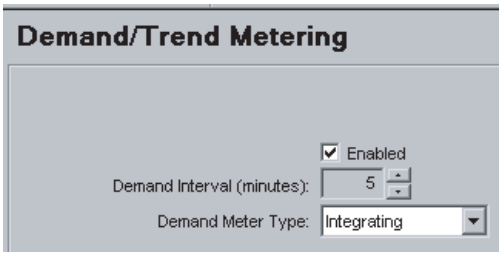


Figure 5.15: Demand/Trend Metering

Demand/Trend Metering	
Demand/Trend Metering	Enable/disable
Demand Interval (minutes)	5 to 60 minutes with increments of 5
Demand Meter Type	Integrating, rolling or thermal

I*I*t

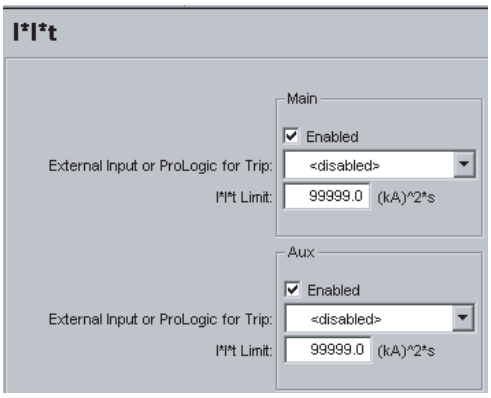


Figure 5.16: I*I*t

I*I*t	
Main	Enable/disable
External Input or ProLogic for Trip	Disable or External Input or ProLogic
I*I*t Limit	0.1 to 99999.0 $(KA)^2.s$
Aux	Enable/disable
External Input or ProLogic for Trip	Disable or External Input or ProLogic
I*I*t Limit	0.1 to 99999.0 $(KA)^2.s$

ProLogic

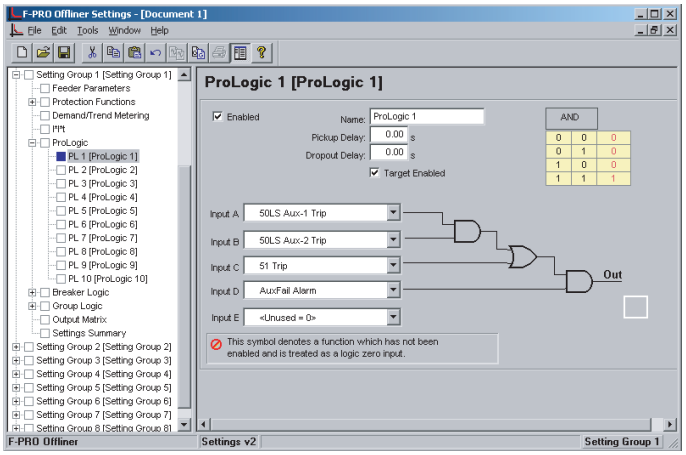


Figure 5.17: ProLogic

Apply ProLogic to multiple inputs to create an output based on qualified inputs. ProLogic enables up to 10 ProLogic control statements and programs those logics to output contacts. You can name the function being created and set a pickup and dropout delay. Start with input A by selecting any of the relay functions using the list for up to 5 possible inputs. Put these inputs into AND/OR, NAND/NOR and exclusive logics and latches by clicking on the gate. Invert the input by clicking on the input line.

The output of ProLogic 1 can be nested into ProLogic 2 and so forth. If desired you can illuminate the front target LED on operation of this function by enabling this feature. The operation of the ProLogic statements are logged on the events listing. This logic shows on the view fault records.

Breaker Logic

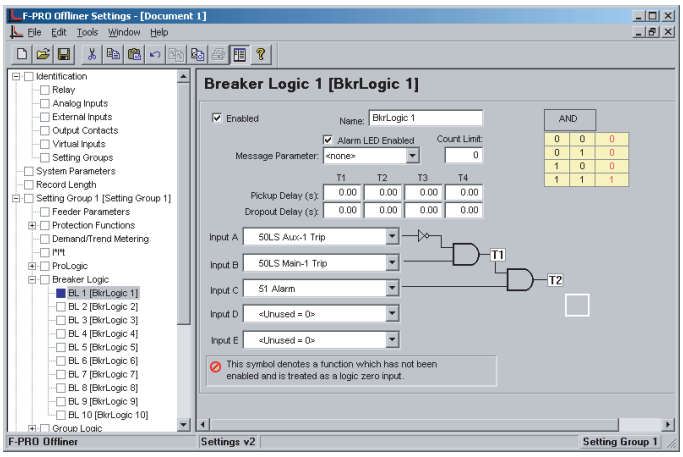


Figure 5.18: Breaker Logic

Group Logic

The sixteen Group Logic statements reside in a slower processing thread within the relay protection algorithms. The processing cycle happens once every half second (0.5 s). When using ProLogic statements you must keep in mind that a latch or dropout timer should be used if the initiating condition does not last at least 0.5 seconds.

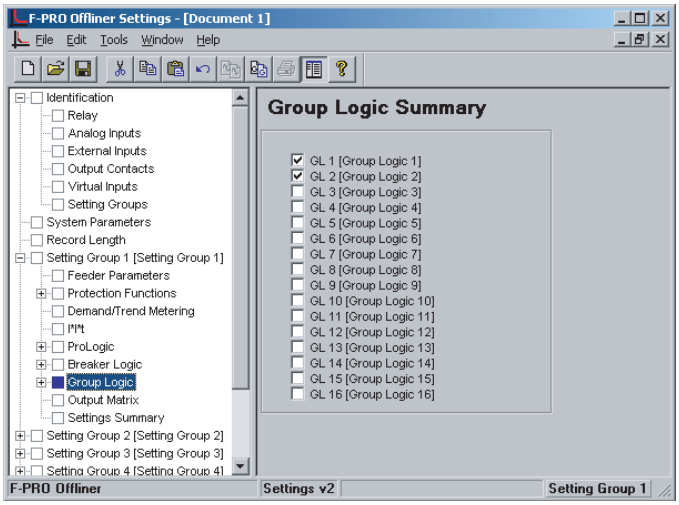


Figure 5.19: Group Logic

Output Matrix

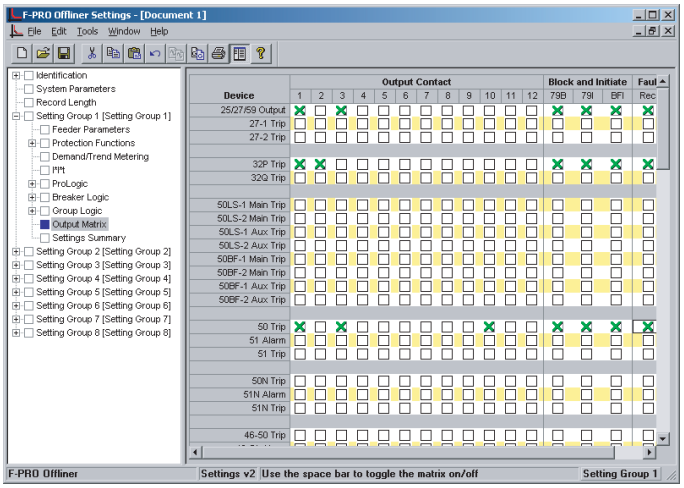


Figure 5.20: Output Matrix 1

The output contact matrix determines which function initiates which output relay. All output relays have a fixed 0.1 second stretch time. Functions can also initiate fault recording, recloser blocking, recloser initiation and/or breaker failure initiation.

> For a particular function to operate correctly, it must be enabled and must also have its logic output assigned to at least one output contact if it is involved in a tripping function.

Print the entire output matrix by selecting *File>Print Summary*. This printout is produced on two pages.

Settings Summary

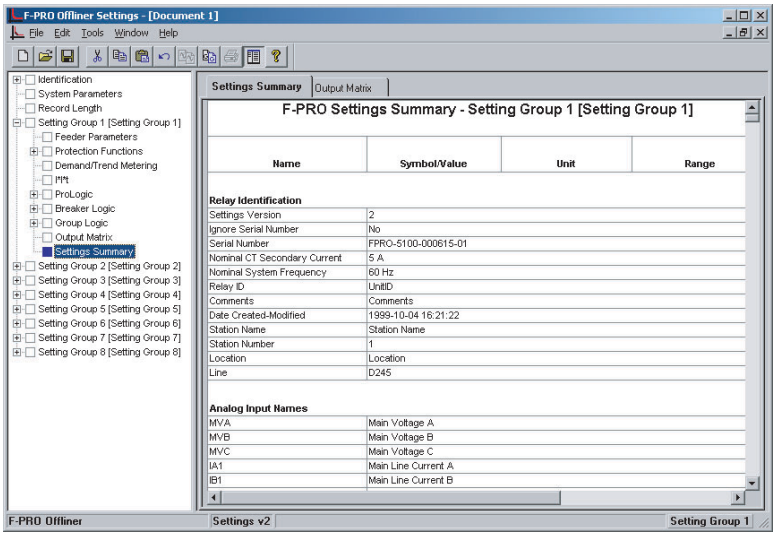


Figure 5.21: Settings Summary

Select *Settings Summary* to view and print the relay settings in text form. For details see “IED Settings and Ranges” in Appendix B.

Settings From a Record

The settings on the relay at the time of a recording are included in every record and can be viewed through the RecordBase View analysis software. While viewing a recording in RecordBase View, select the *View Setting* button to display the settings. RecordBase View will automatically launch F-PRO *Offliner* to display the settings in summary form.

If the record contains Setting Groups, the *Offliner* displays all Setting Groups in the summary. Bold text in the tree view indicates an active Setting Group (the Setting Group used at the time the record was captured). The setting summary is read-only. To edit the setting file associated with the summary, you must use *File/Save As* to save the summary to a file. Then close the summary screen and open the setting file for editing.

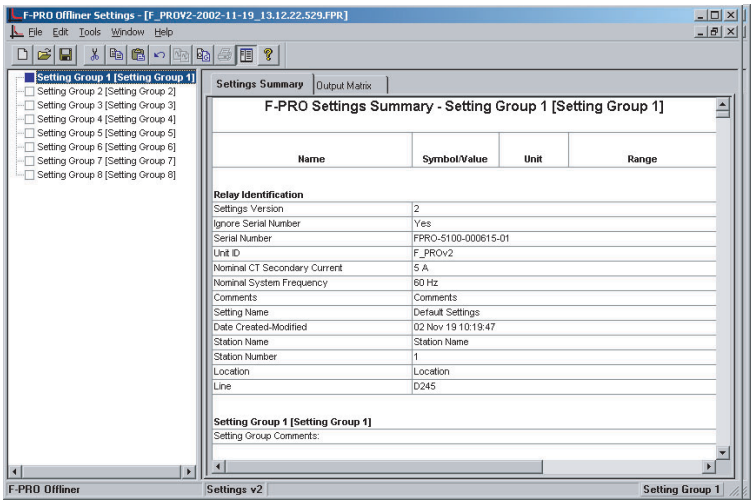


Figure 5.22: View Setting Summary in RecordBase View

6 Testing the F-PRO Functions

Testing is required to determine if your relay performs correctly after the settings are complete or to determine verification of relay settings needed. In most cases a simple test using three voltage sources and three current sources is adequate.

Calibration

The relay is calibrated when it leaves the factory; but if component changes are made within the relay, you may need to do a re-calibration.

> Establish the accuracy of equipment used to calibrate the relay before a new calibration is attempted. A source quality of 0.5% or better is required.

To perform a calibration, you must be logged into the relay in Terminal Mode at the Service access level. Select *Utilities>Maintenance>Calibrate*. The Calibrate menu leads you through every analog input and prompts you to apply the appropriate quantity.

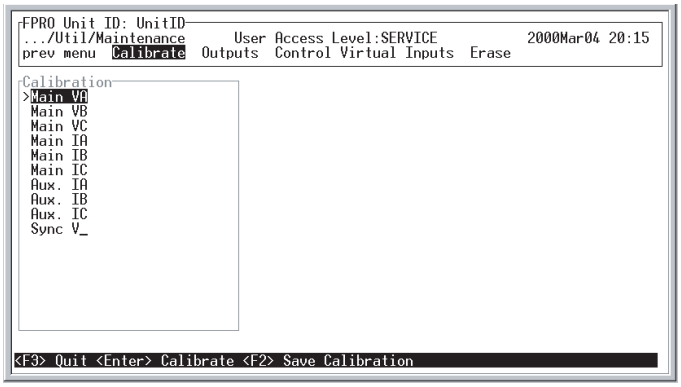


Figure 6.1: Enter actual applied signal level

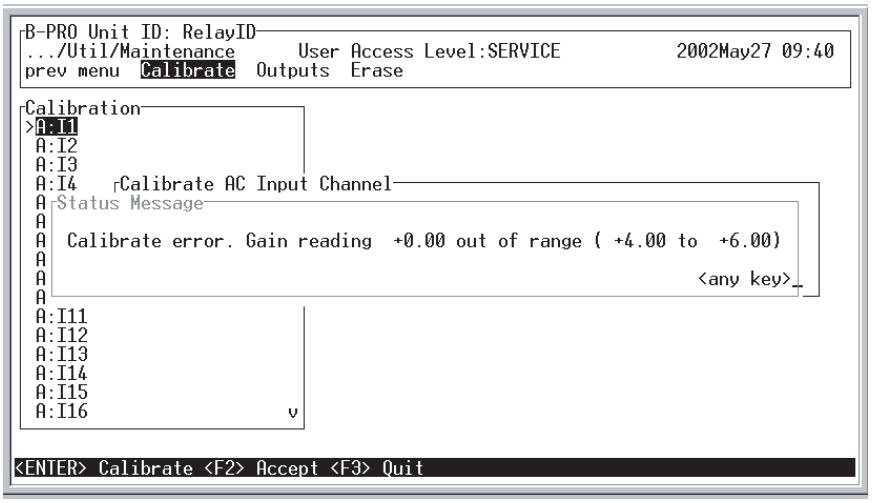


Figure 6.2: Calibration error - out of range

For example, when you select voltage VA for calibration, a prompt appears which asks you which quantity the relay should try to calibrate. If a 66 volt phase-to-neutral quantity is applied to the back VA terminals, 66.0 volts would be indicated as the desired calibration.

In a similar way, you are prompted to go through all ac analog quantities and provide the information about the injected calibration quantities. You must have a test source to perform the function. Only the magnitude of the analog input requires calibration, not the angle.

When an input analog channel is calibrated, verify the quantity measured by selecting the *Metering* menu and the *Analog Quantity* submenu. The VA of the ac voltage input is used as a reference quantity by your relay. Therefore, if it is absent, there is not a locked, valid relationship among all of the analog quantities.

Testing the External Inputs

To test the external inputs, the relay is connected to a laptop in the Terminal Mode, in service level, in the I/O sub-menu. This screen displays the status of the Event Input and the Output Contacts. Placing a voltage of 125 Vdc nom. (150 V maximum) to each of the external inputs in turns causes the input to change from Low to High status. These inputs are polarity sensitive. This screen has a 0.5 second update rate.

Testing the Output Relay Contacts

The output relays are tested to verify their integrity using the terminal mode Utilities menu and the Output Contacts sub-menu. At this stage the output contacts can be closed by pressing Enter key. This toggles the output contact from Open to Closed. Pressing the Enter key again toggles the contact status to Open again. The output contact status is verified using an ohmmeter. When you exit this sub-menu, all contact status reverts to the open position.

7 Installation

Physical Mounting

Standard 3U

The relay is 3 rack units or 5.25 inches high and approximately 12.25 inches deep. The standard relay is designed for a 19-inch rack. A complete mechanical drawing is shown, for details see “Mechanical Drawings” in Appendix G.

To install the relay you need the following:

- 19 inch rack
- 4 - #10 screws

AC and DC Wiring

For details see “AC Schematic Drawing” in Appendix I and “DC Schematic Drawing” in Appendix J.

Communication Wiring

EIA-232

All of the relay’s serial ports (Ports 1, 2 and 3) are configured as EIA RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with a standard straight-through male-to-female serial cable for pin-out, for details see “Communication Port Details” on page 2-9.

Ethernet/Modem

The relay has an RJ-45 receptacle for accepting a 10BaseT Ethernet connector or an RJ-11 connector.

IRIG-B Wiring

The IRIG-B connector on the back of the relay is BNC type.

Appendix A IED Specifications

Model 5100 Specifications

Item	Quantity/Specs	Note
General:		
Nominal Frequency	50 or 60 Hz	Including relay output operation
Sampling Rate	96 samples/cycle	Records up to 25th harmonic
Power Supply	Nominal Range: 48–250 Vdc, 120 Vac Full Operating Range: 40–300 Vdc	
Memory	Settings and records are stored in non-volatile memory	Records are stored in a circular buffer
Protection Functions:		
IEEE Dev. 50LS, 50BF, 50/51/67, 50N/51N/67, 46/50/51/67, 25/27/59, 27, 32, 59, 60, 79, 81, 21P,THD Alarm.	Feeder protection takes in 6 currents and 4 voltages.	10 ProLogic statements provide flexible solutions. 10 Breaker Logic statements provide flexible breaker condition monitoring.
Recording:		
Fault	96 s/c oscillography of all analog and external input channels. Capacity: up to 15 x 2 second records	Records up to the 25th harmonic. Viewing software provides waveform, symmetrical components and harmonic analysis.
Trend	MW In and Out, MVAR In and Out, I, V, PF, Frequency, THD. Capacity: 30 to 360 days	Available in front panel and SCADA ports as metering quantities.
Events	250 events	Circular event log
A/D Resolution	13 bits, 8192 counts full scale, peak to peak.	
Input & Output:		
Analog Input Channels	10 (6 currents, 4 voltages)	Rating: In = 5 A or 1 A, Vn = 69 V Continuous: 3x In, 2x Vn One Second: 20x In without distortion One Minute: 3x Vn, once per hour
Sampling Resolution	12 bits plus sign, amplitude measurement accuracy: ± 0.5% for 54 to 66 Hz	
Burden	ac input voltage: < 0.15 VA @ 67 V, ac input current: ≤ 0.50 VA @ 5 A	
Analog Input Sampling	Sample rate: 96 samples/cycle for recording, 8x/cycle for protection.	
External Inputs	9 isolated inputs.	Optional 48 to 125 or 125 to 250 Vdc nominal, externally wetted.
Burden	Burden resistance: > 10 k ohms	
Isolation	Internal optical isolation	

Model 5100 Specifications

Sample Rate	1 ms resolution.	
Output Relays (contacts)	12 programmable outputs	12 relay trip, 1 relay inoperative Make: 30 A as per IEEE C37.90 Carry: 8 A Break: 0.9 A at 125 Vdc 0.35 A at 250 Vdc
Interface & Communication:		
Front Display	2 lines x 24 characters, fluorescent	Exceptional visibility in all ambient light conditions.
Front Panel Indicators	6 LEDs	Target, Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm.
Serial	Front and rear RS-232 ports to 57.6 K baud	Rear port can support an external modem
Internal Modem	33.6 Kbps, V.32 bis	Optional internal modem
Network	10 Base T Ethernet port	Optional Ethernet card
SCADA Interface	DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Time Sync	IRIG-B, BNC connector	Modulated or unmodulated, auto-detect
Self Checking/Relay Inoperative	1 contact	Closed when relay inoperative.
Terminal User Interface	VT100 terminal emulation	Accessible via serial, modem or network interface.
Environmental:		
Ambient Temperature Range	-40°C to 85°C	IEC 60068-2-1/IEC 60068-2-2
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs, external inputs, output contacts – 1.5 kV, 50/60 Hz, 1 minute.	IEC 60255-5
Electrical Fast Fault		ANSI/IEEE C37.90.1 - 1989
Oscillatory Fault		ANSI/IEEE C37.90.1 - 1989
RFI Susceptibility		ANSI/IEEE C37.90.2, IEC 255-22-3
Shock and Bump		IEC 60255-21-2 Class 1
Sinusoidal Vibration	10Hz to 150Hz, 0.15mm or 20m/s^2, 10 sweep cycles	IEC 60068-2-6
Physical:		
Weight	11.1kg	24.47 lbs
Dimensions	13.3 cm	3U high, 5.25"
	48.3 cm rack mount	19" rack mount
	30.5 cm deep	12" deep

Model 5100 Specifications

Time Synchronization and Accuracy		
External Time Source	The F-PRO relay is synchronized using IRIG-B input (modulated or unmodulated) auto-detect.	Free Running Accuracy: In the absence of an external time source, the relay maintains time with a maximum ±15 minutes drift per year over the full operating temperature range, and maximum ±90 seconds drift per year at a constant temperature of 25°C. The relay can detect loss or re-establishment of external time source and automatically switch between internal and external time.
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external).	
Overall F-PRO Accuracies		
Current	±2.5% of inputs from 0.1 to 1.0 x nominal current (In)	
	1.0% of inputs from 1.0 to 20.0 x nominal current (In)	
Voltage	1.0% of inputs from 0.01 to 2.00 x nominal voltage (Vn)	
Impedance	±5.0% of set value from 0.05 to 66.00 ohms secondary (0.25 to 330.00 ohms secondary, 1 Amp nominal)	
Directional Phase Angle	±2.0° of set value of Positive Sequence Line Angle value from 25.0° to 89.0°	
Frequency Elements	±0.001 Hz (fixed level)	
	±0.05 Hz/s (df/dt)	
Sync Check Element	±0.2 degrees	
Timers	±2.5 ms of set value plus 1.00 to 1.50 cycles of inherent delay	
Inverse Overcurrent Times	±2.5% or ±1 cycle of selected curve	
Definite Overcurrent Timers	±2.5% or ±1 cycle non-directional	
	±2.5% or ±1.5 cycle directional	
Frequency Timers	±2.5% of set value plus 1.25 cycles to 1.75 cycles of inherent delay (fixed level)	
	at 2x pickup, error <40 ms at 0.1 Hz/s above pickup, error <100 ms	
Burden	AC Voltage Inputs, < 0.15 VA @ 69 volts	
	AC Current Inputs, ≤ 0.5 VA @ 5 amps	

Distance Element Operating Time Curves at Nominal Frequency

Figure B.1: F-PRO Phase Mho Operating Times Phase-to-Phase Fault shows the operating times for the F-PRO Relay distance elements.

The diagrams show operating times at each test point including output contact operate time.

Faults were applied at a location representing a percentage of the Zone 1 relay reach setting.

Tests were performed for source impedance ratios (SIR) of 0.1, 1.0, 10.0, and 30.0.

No pre-fault load current or fault resistance was included. Operating times are the same for both 50 Hz and 60 Hz.

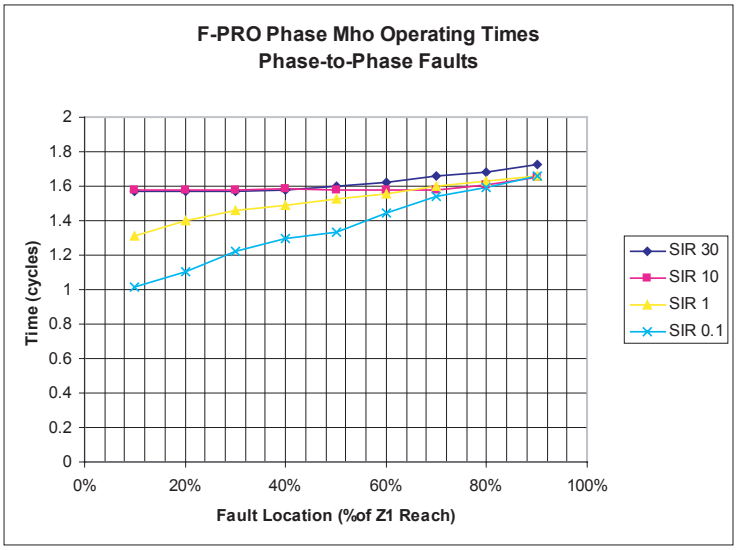


Figure B.1: F-PRO Phase Mho Operating Times Phase-to-Phase Fault

Frequency Element Operating Time Curves

Figure B.2: Time delay Error at .2 Seconds, Figure B.3: Time Delay Error at 1 Second and Figure B.4: Time Delay Error at 10 Seconds show operating times for the F-PRO frequency rate of change elements at different time delay settings and rate of change settings.

The diagrams show operating times at each test point including output contact operate time. Operating times are the same for both 50 Hz and 60 Hz.

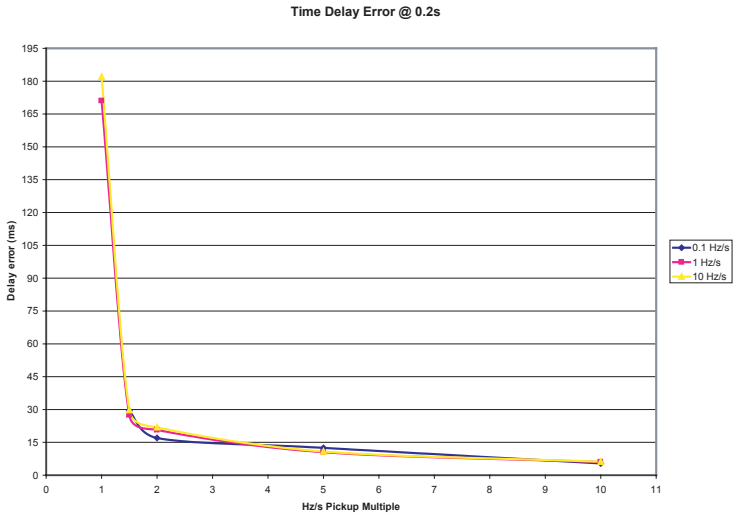


Figure B.2: Time delay Error at .2 Seconds

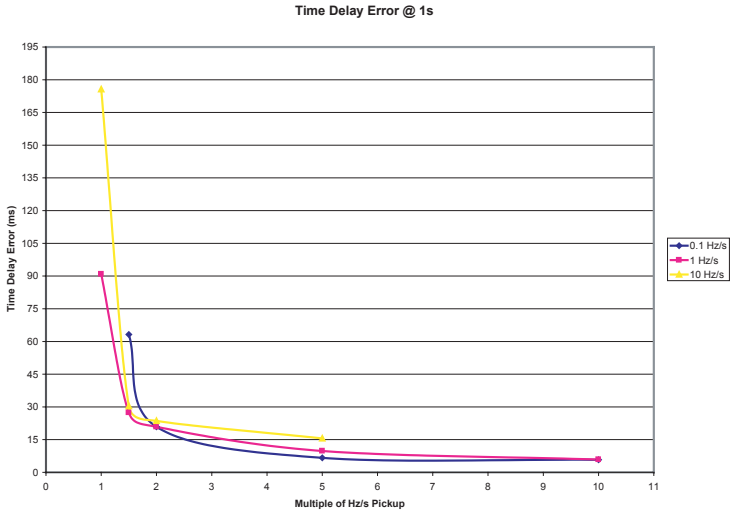


Figure B.3: Time Delay Error at 1 Second

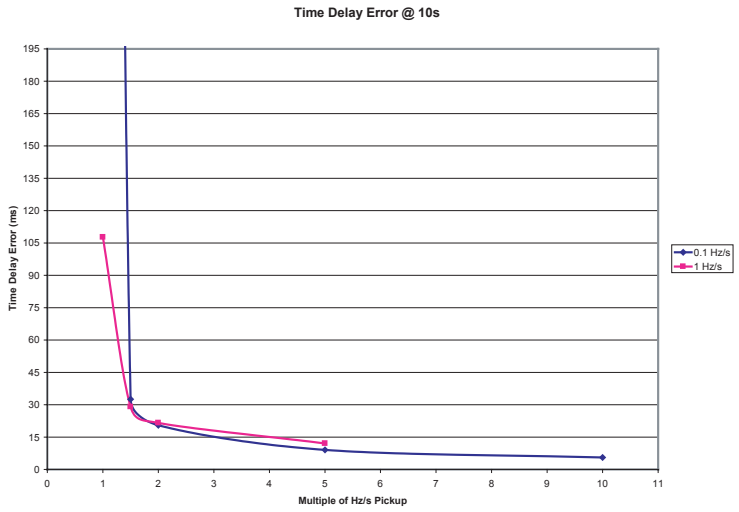


Figure B.4: Time Delay Error at 10 Seconds

Appendix B IED Settings and Ranges

When a setting has been completed in the F-PRO Offliner Settings software, it can be printed along with the ranges available for these settings. This is a view only option, that is, if you want to change settings you must go back into the settings portion dealing with that setting to make changes. The summary is however, a quick way of having a look at all the settings in a very compact form.

The top part of the settings summary identifies the date that the settings were done, the relay identification, the station that the relay is applied and the location.

The setting summary provides a list of all the current and voltage analog input quantity names used for line protection and used for recording. External Inputs and Output contact names are also identified on this summary.

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Relay Identification			
Settings Version	2		
Ignore Serial Number	No		
Serial Number	FPRO-5100-000615-01		
Unit ID	UnitID		
Nominal CT Secondary Current	5 A		
Nominal System Frequency	60 Hz		
Comments	Comments		
Setting Name	Default Settings		
Date Created-Modified	1999-10-04 16:21:22		
Station Name	Station Name		
Station Number	1		
Location	Location		
Line	D245		
Setting Group 1 [Setting Group 1]			
Setting Group Comments:			
Analog Input Names			
MVA	Main Voltage A		
MVB	Main Voltage B		
MVC	Main Voltage C		
IA1	Main Line Current A		
IB1	Main Line Current B		
IC1	Main Line Current C		
IA2	Aux. Line Current A		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
IB2	Aux. Line Current B		
IC2	Aux. Line Current C		
SV (Sync Voltage)	Sync Voltage		
External Input Names			
1	Spare 1		
2	Spare 2		
3	Spare 3		
4	Spare 4		
5	Spare 5		
6	Spare 6		
7	Spare 7		
8	Spare 8		
9	Spare 9		
Output Contact Names			
Output 1	Spare 1		
Output 2	Spare 2		
Output 3	Spare 3		
Output 4	Spare 4		
Output 5	Spare 5		
Output 6	Spare 6		
Output 7	Spare 7		
Output 8	Spare 8		
Output 9	Spare 9		
Output 10	Spare 10		
Output 11	Spare 11		
Output 12	Spare 12		
Virtual Input Names			
VI 1	Virtual Input 1		
VI 2	Virtual Input 2		
VI 3	Virtual Input 3		
VI 4	Virtual Input 4		
VI 5	Virtual Input 5		
VI 6	Virtual Input 6		
VI 7	Virtual Input 7		
VI 8	Virtual Input 8		
VI 9	Virtual Input 9		
VI 10	Virtual Input 10		
VI 11	Virtual Input 11		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
VI 12	Virtual Input 12		
VI 13	Virtual Input 13		
VI 14	Virtual Input 14		
VI 15	Virtual Input 15		
VI 16	Virtual Input 16		
VI 17	Virtual Input 17		
VI 18	Virtual Input 18		
VI 19	Virtual Input 19		
VI 20	Virtual Input 20		
VI 21	Virtual Input 21		
VI 22	Virtual Input 22		
VI 23	Virtual Input 23		
VI 24	Virtual Input 24		
VI 25	Virtual Input 25		
VI 26	Virtual Input 26		
VI 27	Virtual Input 27		
VI 28	Virtual Input 28		
VI 29	Virtual Input 29		
VI 30	Virtual Input 30		
Setting Group Names			
Setting Group 1	Setting Group 1		
Setting Group 2	Setting Group 2		
Setting Group 3	Setting Group 3		
Setting Group 4	Setting Group 4		
Setting Group 5	Setting Group 5		
Setting Group 6	Setting Group 6		
Setting Group 7	Setting Group 7		
Setting Group 8	Setting Group 8		
System Parameters			
Base MVA	100.0	MVA Pri	1.0 to 1000.0
Phase Rotation	ABC		
Ring Bus Configuration (Aux CT Line Input)	Disabled		
Main CT Turns Ratio	240.0	:1	1.0 to 10000.0
Aux CT Turns Ratio	240.0	:1	1.0 to 10000.0
Main PT Turns Ratio	1000.0	:1	1.0 to 10000.0
Sync PT Turns Ratio	1000.0		1.0 to 10000.0
Sync PT Phase	0° degrees		
Line to Line Voltage	115.00	kV	1.00 to 500.00

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Distance Unit Selection	km		
Record Length			
Fault Record Length	0.5	seconds	0.2 to 2.0
Trend Auto Save	Disabled		
Event Auto Save	Disabled		
Feeder Parameters			
Feeder Length	100.00	km	1.00 to 1000.00
Positive Sequence Impedance	14.40	ohms	0.05 to 66.00
Positive Sequence Angle	80.0	degrees	25.0 to 89.0
Zero Sequence Impedance	80.00	ohms	0.05 to 200.00
Zero Sequence Angle	70.0	degrees	25.0 to 89.0
Protection Functions			
50LS-1 Main	Enabled		
50LS-1 Aux	Enabled		
50LS-2 Main	Enabled		
50LS-2 Aux	Enabled		
50BF Main	Enabled		
50BF Aux	Disabled		
50	Enabled		
51	Enabled		
50N	Enabled		
51N	Enabled		
46-50	Enabled		
46-51	Enabled		
25 Sync Check	Enabled		
25 Dead Main Live Sync	Enabled		
25 Live Main Dead Sync	Enabled		
25 Dead Main Dead sync	Enabled		
79 Main	Enabled		
79 Aux	Enabled		
59-1	Enabled		
59-2	Enabled		
27-1	Enabled		
27-2	Enabled		
60	Enabled		
81-1	Disabled		
81-2	Disabled		
81-3	Disabled		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
81-4	Disabled		
32 P	Enabled		
32 Q	Enabled		
21P-1	Enabled		
21P-2	Enabled		
THD	Enabled		
50LS - Low Set Overcurrent			
50LS-1 Main	Enabled		
Gate Switch	OR		
Pickup	10.0	amperes	0.1 to 50.0
Pickup Delay	0.00	seconds	0.00 to 99.99
50LS-2 Main	Enabled		
Gate Switch	OR		
Pickup	10.0	amperes	0.1 to 50.0
Pickup Delay	0.00	seconds	0.00 to 99.99
50LS-1 Aux	Enabled		
Gate Switch	OR		
Pickup	10.0	amperes	0.1 to 50.0
Pickup Delay	0.00	seconds	0.00 to 99.99
50LS-2 Aux	Enabled		
Gate Switch	OR		
Pickup	10.0	amperes	0.1 to 50.0
Pickup Delay	0.00	seconds	0.00 to 99.99
50BF - Breaker Failure			
50BF Main	Enabled		
Pickup Delay 1	0.50	seconds	0.01 to 99.99
Pickup Delay 2	1.50	seconds	0.01 to 99.99
50BF Aux	Disabled		
Pickup Delay 1	0.50	seconds	0.01 to 99.99
Pickup Delay 2	1.50	seconds	0.01 to 99.99
50/51 - Phase Overcurrent			
50	Enabled		
Directional Control	forward		
Pickup	10.00	amperes	0.25 to 50.00
Pickup Delay	1.00	seconds	0.01 to 99.99
51	Enabled		
Directional Control	forward		
Pickup	10.00	amperes	0.25 to 50.00

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Curve Type	User defined		
TMS	0.50	-	0.01 to 10.00
A	13.5000	-	0.0010 to 100.0
B	0.0000	-	0.0 to 10.0
p	1.00	-	0.01 to 10.0
TR	21.60	-	0.10 to 100.0
Initiate Fault Location	Enabled		
ProLogic Control	Disabled		
50N/51N - Neutral Overcurrent			
50N	Enabled		
Directional Control	forward		
Pickup	10.00	amperes	0.25 to 50.00
Pickup Delay	1.00	seconds	0.01 to 99.99
51N	Enabled		
Directional Control	forward		
Pickup	10.00	amperes	0.25 to 50.00
Curve Type	IEC very inverse		
TMS	0.50	-	0.01 to 10.00
A	13.5	-	-
B	0.0	-	-
p	1.0	-	-
TR	21.60	-	-
Initiate Fault Location	Enabled		
ProLogic Control	Disabled		
46/50/51 - Negative Sequence Overcurrent			
46-50	Enabled		
Directional Control	forward		
Pickup	10.00	amperes	0.25 to 50.00
Pickup Delay	1.00	seconds	0.01 to 99.99
46-51	Enabled		
Directional Control	forward		
Pickup	10.00	amperes	0.25 to 50.00
Curve Type	IEC very inverse		
TMS	0.50	-	0.01 to 10.00
A	13.5	-	-
B	0.0	-	-
p	1.0	-	-
TR	21.60	-	-

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Initiate Fault Location	Disabled		
ProLogic Control	Disabled		
25/27/59 - Sync Check			
25 Sync Check	Enabled		
Maximum Voltage	70.0	volts	60.0 to 138.0
Minimum Voltage	60.0	volts	40.0 to 69.9
Angle Difference	20.0	degrees	1.0 to 50.0
Pickup Delay	0.02	seconds	0.00 to 99.99
Dead Main Live Sync (DMLS)	Enabled		
Live Main Dead Sync (LMDS)	Enabled		
Dead Main Dead Sync (DMDS)	Enabled		
79 - Recloser			
Main	Enabled		
Number of Shots	4		
First Reclose (T1)	1.00	seconds	0.02 to 99.99
Second Reclose (T2)	5.00	seconds	1.00 to 99.99
Third Reclose (T3)	10.00	seconds	1.00 to 99.99
Fourth Reclose (T4)	20.00	seconds	1.00 to 99.99
Close Time (Tp)	0.20	seconds	0.01 to 1.00
Lockout Reset (Td)	25.00	seconds	0.00 to 99.99
Initiate Reset (TDI)	1.00	seconds	0.00 to 99.99
Block Reset (TDB)	0.50	seconds	0.00 to 99.99
Sync Control	Disabled		
Aux	Enabled		
Number of Shots	4		
First Reclose (T1)	1.00	seconds	0.02 to 99.99
Second Reclose (T2)	5.00	seconds	1.00 to 99.99
Third Reclose (T3)	10.00	seconds	1.00 to 99.99
Fourth Reclose (T4)	20.00	seconds	1.00 to 99.99
Close Time (Tp)	0.20	seconds	0.01 to 1.00
Lockout Reset (Td)	25.00	seconds	0.00 to 99.99
Initiate Reset (TDI)	1.00	seconds	0.00 to 99.99
Block Reset (TDB)	0.50	seconds	0.00 to 99.99
Sync Control	Disabled		
59 - Overvoltage			
59-1	Enabled		
Gate Switch	OR		
Pickup	70.0	volts	1.0 to 138.0

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Pickup Delay	1.00	seconds	0.00 to 99.99
59-2	Enabled		
Gate Switch	OR		
Pickup	70.0	volts	1.0 to 138.0
Pickup Delay	1.00	seconds	0.00 to 99.99
27 - Undervoltage			
27-1	Enabled		
Gate Switch	OR		
Pickup	20.0	volts	1.0 to 120.0
Pickup Delay	1.00	seconds	0.00 to 99.99
27-2	Enabled		
Gate Switch	OR		
Pickup	20.0	volts	1.0 to 120.0
Pickup Delay	1.00	seconds	0.00 to 99.99
60 - Loss of Potential Alarm			
60	Enabled		
81 - Over/Under Frequency			
81-1	Disabled		
Pickup	60.005	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	seconds	0.05 to 99.99
81-2	Disabled		
Pickup	60.005	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	seconds	0.05 to 99.99
81-3	Disabled		
Pickup	59.995	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	seconds	0.05 to 99.99
81-4	Disabled		
Pickup	59.995	Hz	[50.000, 59.995] or [60.005, 70.000]
Pickup Delay	2.00	seconds	0.05 to 99.99
32 - Directional Power			
32P	Enabled		
Pickup	3.00	amperes	[-15.00, -0.25] or [0.25, 15.00]

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Pickup Delay	2.00	seconds	0.00 to 99.99
32Q	Enabled		
Pickup	3.00	amperes	[-15.00, -0.25] or [0.25, 15.00]
Pickup Delay	2.00	seconds	0.00 to 99.99
21P - Phase Distance			
21P-1	Enabled		
Forward Reach	10.00	ohms	0.05 to 66.00
Delta Current Supervision	0.2	amperes	0.2 to 50.0
21P-2	Enabled		
Forward Reach	10.00	ohms	0.05 to 66.00
Delta Current Supervision	0.2	amperes	0.2 to 50.0
THD - Total Harmonic Distortion			
THD	Enabled		
Pickup	10.0	%	5.0 to 100.0
Demand Metering			
Demand Metering	Disabled		
Demand Interval	5	minutes	5 to 60
Demand Meter Type	Integrating		
I*I*t			
I*I*t Main	Disabled		
External Input or ProLogic for Trip	<disabled>		
I*I*t Limit	99999.0	(kA)^2*s	0.1 to 99999.0
I*I*t Aux	Disabled		
External Input or ProLogic for Trip	<disabled>		
I*I*t Limit	99999.0	(kA)^2*s	0.1 to 99999.0
PL 1 [ProLogic 1]			
ProLogic 1	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Operator 5			
Input E	<Unused = 0>		
PL 2 [ProLogic 2]			
ProLogic 2	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 3 [ProLogic 3]			
ProLogic 3	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 4 [ProLogic 4]			
ProLogic 4	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 5 [ProLogic 5]			
ProLogic 5	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 6 [ProLogic 6]			
ProLogic 6	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input E	<Unused = 0>		
PL 7 [ProLogic 7]			
ProLogic 7	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 8 [ProLogic 8]			
ProLogic 8	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 9 [ProLogic 9]			
ProLogic 9	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
PL 10 [ProLogic 10]			
ProLogic 10	Disabled		
Target	Enabled		
Pickup Delay	0.00	seconds	0.00 to 999.00
Dropout Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 1 [BkrLogic 1]			
BkrLogic 1	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 2 [BkrLogic 2]			
BkrLogic 2	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 3 [BkrLogic 3]			
BkrLogic 3	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 4 [BkrLogic 4]			
BkrLogic 4	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input E	<Unused = 0>		
Breaker Logic 5 [BkrLogic 5]			
BkrLogic 5	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 6 [BkrLogic 6]			
BkrLogic 6	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 7 [BkrLogic 7]			
BkrLogic 7	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 8 [BkrLogic 8]			
BkrLogic 8	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 9 [BkrLogic 9]			
BkrLogic 9	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Operator 5			
Input E	<Unused = 0>		
Breaker Logic 10 [BkrLogic 10]			
BkrLogic 10	Disabled		
Alarm LED	Enabled		
Message Parameter	<none>		
Count Limit	0	-	0 to 99999
Pickup Delay (T1)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T1)	0.00	seconds	0.00 to 999.00
Pickup Delay (T2)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T2)	0.00	seconds	0.00 to 999.00
Pickup Delay (T3)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T3)	0.00	seconds	0.00 to 999.00
Pickup Delay (T4)	0.00	seconds	0.00 to 999.00
Drop Out Delay (T4)	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 1 [Group Logic 1]			
Group Logic 1	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input E	<Unused = 0>		
Group Logic 2 [Group Logic 2]			
Group Logic 2	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 3 [Group Logic 3]			
Group Logic 3	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 4 [Group Logic 4]			
Group Logic 4	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 5 [Group Logic 5]			
Group Logic 5	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 6 [Group Logic 6]			
Group Logic 6	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 7 [Group Logic 7]			
Group Logic 7	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 8 [Group Logic 8]			
Group Logic 8	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 9 [Group Logic 9]			
Group Logic 9	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 10 [Group Logic 10]			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Group Logic 10	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 11 [Group Logic 11]			
Group Logic 11	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 12 [Group Logic 12]			
Group Logic 12	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 13 [Group Logic 13]			
Group Logic 13	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 14 [Group Logic 14]			
Group Logic 14	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 15 [Group Logic 15]			
Group Logic 15	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			

F-PRO Settings Summary - Setting Group 1 [Setting Group 1]			
Name	**Symbol/Value**	**Unit**	**Range**
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		
Group Logic 16 [Group Logic 16]			
Group Logic 16	Disabled		
Setting Group to Activate	<none>		
Pickup Delay	0.00	seconds	0.00 to 999.00
Operator 1			
Input A	<Unused = 0>		
Operator 2			
Input B	<Unused = 0>		
Operator 3			
Input C	<Unused = 0>		
Operator 4			
Input D	<Unused = 0>		
Operator 5			
Input E	<Unused = 0>		

Appendix C Hardware Description

External Input and Comm Board

The F-PRO relay has 9 channels of external input provided by the External Input and Comm Board. Inputs are optically isolated, factory pre-set to the customer's requested voltage level. Two dual-range user-selectable external-input voltage-level model of the External Input and Comm Board are available. This allows you to select between 48 Vdc and 125 Vdc or 125 Vdc and 250 Vdc (nominal) on a per-input basis.

The External Input and Comm Board also provides the relay with two rear-panel RS-232 ports, IRIG-B time synchronization input, and optional network or telephone connection. The RS-232 ports are female DB-9S connectors, IRIG-B is a male BNC, and network or telephone is a female RJ-45 modular jack.

Relay Output Board

The Relay Output Board provides 12 normally open contact outputs for relaying, alarms and control, 1 normally closed output contact for indicating proper relay operation.

Power Supply Board

The power supply operates from 40 to 300 Vdc or 120 Vac +- 20% at 50/60 Hz. This wide operating range provides easier installation by eliminating power supply ordering options.

AC Analog Input Board

The AC Analog Input Board has 6 current transformer inputs and 4 potential transformer inputs. On-board anti-aliasing filters provide accurate and secure digitization of the ac input signals.

Main Processor Board (MPB)

The MPB has analog data acquisition, high-speed digital signal processing for triggering and data conversion, communications and interface logic to perform the core functions of the relay.

The Digital Signal Processor (DSP) on the MPB performs the protective relaying functions of the relay separate from the 486 CPU. It has its own flash memory and self-checking for fully independent operation.

The Main Processor Board has:

- 24 channels of high-speed 12 bit-plus-sign analog-to-digital conversion
- Re-programmable flash memory for the DSP, allows independent relay operation and field software upgrades. Settings are stored in non-volatile memory.
- Floating point DSP for fast capture and manipulation of data
- Standard RS-232 serial communications ports
- High speed link between DSP and 486 processors
- Time synchronism processor with automatic detection of modulated and unmodulated IRIG-B
- Sophisticated fault detection and "watchdog" recovery hardware

486 CPU Board

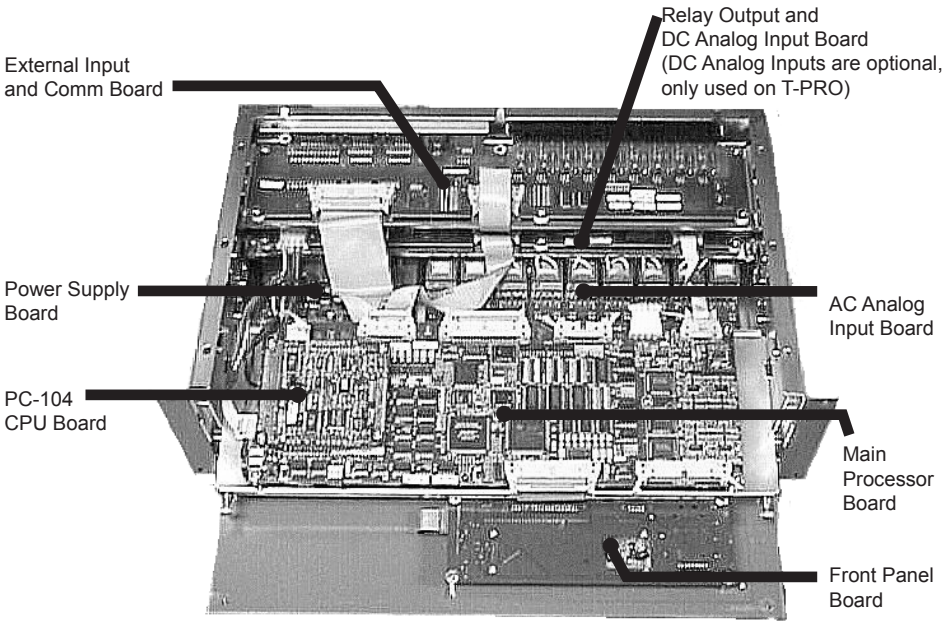
A 486-class CPU provides data storage, information management, housekeeping, and communications for the relay. The 486 runs a real-time operating system optimized for high speed, high precision computing. The 486 provides

sophisticated facilities for communications and field software updates. Local and wide area networking is supported by providing the relay with a path to future networking capability.

A highly reliable solid-state flash disk on the CPU board provides the operating software for the 486, and stores the relay's recordings.

Front Panel Board

The Front Panel Board provides visual indication of the status of the relay, an alphanumeric display and keypad for system monitoring, and a front-panel RS-232 port.

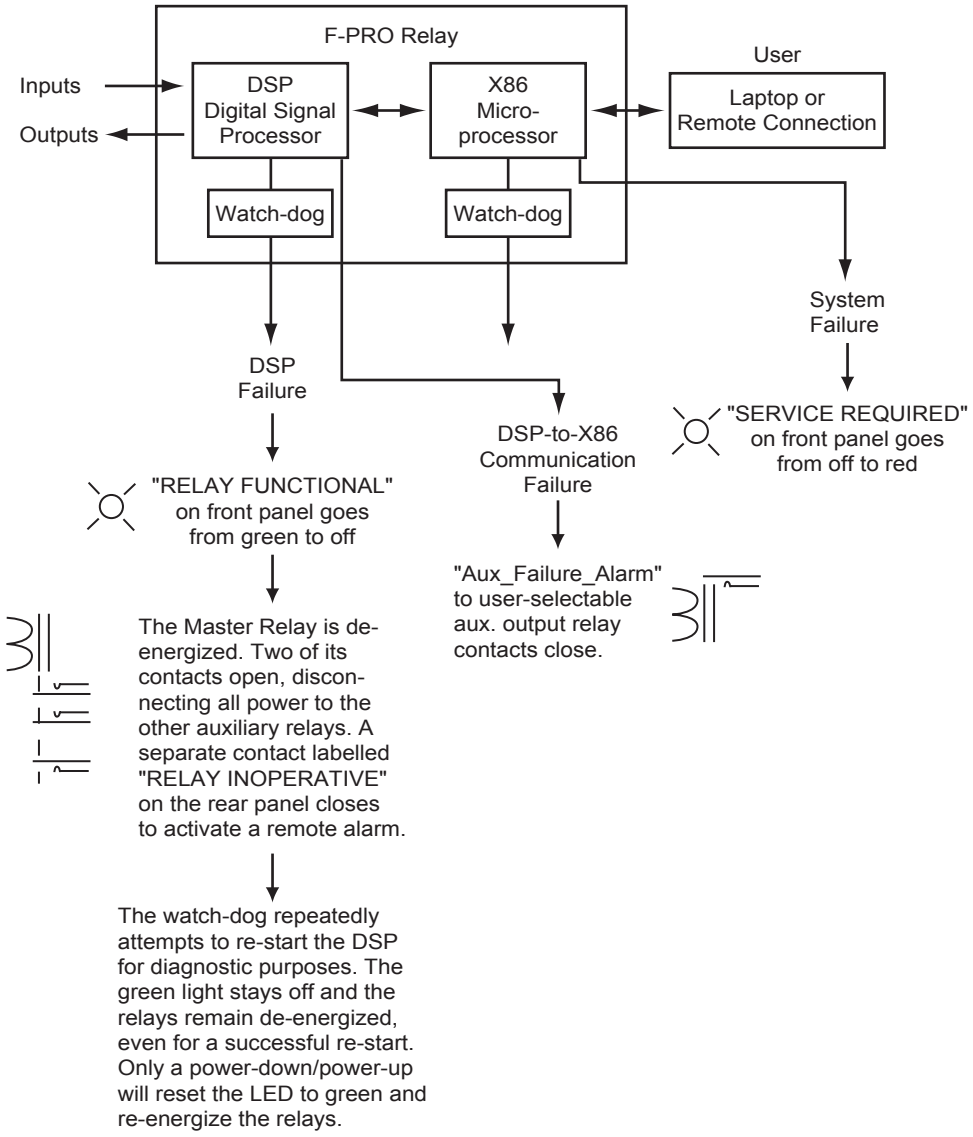


Appendix D Event Messages

F-PRO Event Messages	
Event Log Message	**Notes**
50LS-1 Main ABC:Trip	The possible phase information will be: • A • B • C • N • AB • BC • CA • ABC
50LS-2 Main ABC:Trip	
50LS-1 Aux ABC:Trip	
50LS-2 Aux ABC:Trip	
50BF-1 Main ABC:Trip	
50BF-2 Main ABC:Trip	
50BF-1 Aux ABC:Trip	
50BF-2 Aux ABC:Trip	
51 ABC 1234.5km:Alarm	Fault Location will be included if enabled The possible phase information will be: • A • B • C • N • AB • BC • CA • ABC
50 ABC 1234.5km:Trip	
51 ABC 1234.5km:Trip	
51N 1234.5km:Alarm	Fault Location will be included if enabled
50N 1234.5km:Trip	
51N 1234.5km:Trip	
46-51 1234.5km:Alarm	
46-50 1234.5km:Trip	
46-51 1234.5km:Trip	
252759 Sync Check: High	
79 Initiated: High	Recloser is initiated.
79 Main Lockout: High	Recloser shot count has expired and reclosing attempts are blocked.
79 Aux Lockout: High	Recloser shot count has expired and reclosing attempts are blocked.
79 Main Reclose: shot n	Recloser Main circuit breaker close attempt where n equals the shot count.
79 Aux Reclose: shot n	Recloser Aux. circuit breaker close attempt where n equals the shot count.
79 Block: High	Recloser is blocked by an external signal.

F-PRO Event Messages	
59-1 ABC:Trip	The possible phase information will be: • A • B • C • N • AB • BC • CA • ABC
59-2 ABC:Trip	
27-1 ABC:Trip	
27-2 ABC:Trip	
60 LOP ABC:Alarm	
32P ABC:Trip	
32Q ABC:Trip	
81-1: Trip	
81-2: Trip	
81-3: Trip	
81-4: Trip	
THD Alarm:High	
ProLogic Name: PL*n*	ProLogic outputs names are user-assigned Where n = 1-10
Extern Input Name: EI*n*	External input names are user-assigned Where n = 1-9
BkrLogic Name *msgParam*:BLn	Breaker Logic outputs names are user-assigned Where msgParam = none, timers 1 to 4, or count limit Where n = 1-10
BkrLogic Name Upper Limit Reset:(*msgParam*)BLn	Breaker Logic outputs names are user-assigned Where msgParam = count limit Where n = 1-10
BkrLogic Name Input Reset:(*msgParam*-BLn	
I*I*t Main Limit:99999.0	
I*I*t Aux Limit:99999.0	
MWh IN Count Rollover Reset:9800	
MWh OUT Count Rollover Reset:9800	
MVARh IN Count Rollover Reset:9800	
MVARh OUT Count Rollover Reset:9800	
New Settings loaded, Active group n.	Where n = 1-8
Manual Settings Load request, activate SGn	Manual or user-initiated settings change.
Manual Settings Load request completed	Completion of user-initiated settings change.
Changed Active Group from x to y Logic n	This happens when relay changes setting group. Automatic group logic initiated setting group change
User changed Active Group from x to y	This happens when the relay changes setting group. User-initiated setting group change
Unit Recalibrated	
Unit restarted	
User logged In	

Details of Failure Modes



Note: For either of the above cases the DSP controller functions continue with normal auxiliary relay outputs, provided that DSP failure has not occurred.

Appendix E Modbus RTU Communication Protocol

The SCADA port supports DNP3 and Modicon Modbus protocols. All metering values available through the terminal user interface are also available via the Modbus protocol. Additionally, the Modbus protocol support the reading of the unit time and time of the readings and provides access to trip and alarm events, include fault location information.

A “Hold Readings” function is available to freeze all metering readings into a snapshot (see Force Single Coil function, address 0).

Read Coil Status (Function Code 01)

Channel	Address	Value	
Hold Readings	1	0: Readings not held	1: Readings held
Reserved	257	Reserved	Reserved
Output Contact 1	513	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 2	514	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 3	515	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 4	516	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 5	517	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 6	518	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 7	519	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 8	520	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 9	521	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 10	522	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 11	523	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 12	524	0: Contact Open (inactive)	1: Contact Closed (active)
50LS-1 Main Trip	769	0: Off (inactive)	1: On (active)
50LS-2 Main Trip	770	0: Off (inactive)	1: On (active)
50LS-1 Aux Trip	771	0: Off (inactive)	1: On (active)
50LS-2 Aux Trip	772	0: Off (inactive)	1: On (active)
50BF-1 Main Trip	773	0: Off (inactive)	1: On (active)
50BF-2 Main Trip	774	0: Off (inactive)	1: On (active)
50BF-1 Aux Trip	775	0: Off (inactive)	1: On (active)
50BF-2 Aux Trip	776	0: Off (inactive)	1: On (active)
25/27/59 Sync Check	777	0: Off (inactive)	1: On (active)
79 Main Reclose	778	0: Off (inactive)	1: On (active)
79 Aux Reclose	779	0: Off (inactive)	1: On (active)

Read Coil Status (Function Code 01)			
Channel	**Address**	**Value**	
50 Trip	780	0: Off (inactive)	1: On (active)
51 Alarm	781	0: Off (inactive)	1: On (active)
51 Trip	782	0: Off (inactive)	1: On (active)
50N Trip	783	0: Off (inactive)	1: On (active)
51N Alarm	784	0: Off (inactive)	1: On (active)
51N Trip	785	0: Off (inactive)	1: On (active)
46-50 Trip	786	0: Off (inactive)	1: On (active)
46-51 Alarm	787	0: Off (inactive)	1: On (active)
46-51 Trip	788	0: Off (inactive)	1: On (active)
32P Trip	789	0: Off (inactive)	1: On (active)
32Q Trip	790	0: Off (inactive)	1: On (active)
59-1 Trip	791	0: Off (inactive)	1: On (active)
59-2 Trip	792	0: Off (inactive)	1: On (active)
27-1 Trip	793	0: Off (inactive)	1: On (active)
27-2 Trip	794	0: Off (inactive)	1: On (active)
60 Alarm	795	0: Off (inactive)	1: On (active)
81-1 Trip	796	0: Off (inactive)	1: On (active)
81-2 Trip	797	0: Off (inactive)	1: On (active)
81-3 Trip	798	0: Off (inactive)	1: On (active)
81-4 Trip	799	0: Off (inactive)	1: On (active)
THD Alarm	800	0: Off (inactive)	1: On (active)
Auxillary Alarm	801	0: Off (inactive)	1: On (active)
ProLogic 1	802	0: Off (inactive)	1: On (active)
ProLogic 2	803	0: Off (inactive)	1: On (active)
ProLogic 3	804	0: Off (inactive)	1: On (active)
ProLogic 4	805	0: Off (inactive)	1: On (active)
ProLogic 5	806	0: Off (inactive)	1: On (active)
ProLogic 6	807	0: Off (inactive)	1: On (active)
ProLogic 7	808	0: Off (inactive)	1: On (active)
ProLogic 8	809	0: Off (inactive)	1: On (active)
ProLogic 9	810	0: Off (inactive)	1: On (active)
ProLogic 10	811	0: Off (inactive)	1: On (active)
Breaker Logic 1	812	0: Off (inactive)	1: On (active)
Breaker Logic 2	813	0: Off (inactive)	1: On (active)
Breaker Logic 3	814	0: Off (inactive)	1: On (active)
Breaker Logic 4	815	0: Off (inactive)	1: On (active)
Breaker Logic 5	816	0: Off (inactive)	1: On (active)

Read Coil Status (Function Code 01)			
Channel	**Address**	**Value**	
Breaker Logic 6	817	0: Off (inactive)	1: On (active)
Breaker Logic 7	818	0: Off (inactive)	1: On (active)
Breaker Logic 8	819	0: Off (inactive)	1: On (active)
Breaker Logic 9	820	0: Off (inactive)	1: On (active)
Breaker Logic 10	821	0: Off (inactive)	1: On (active)
79 Initialize	822	0: Off (inactive)	1: On (active)
79 Block	823	0: Off (inactive)	1: On (active)
79 Main Lockout	824	0: Off (inactive)	1: On (active)
79 Aux Lockout	825	0: Off (inactive)	1: On (active)
50BF Initiate	826	0: Off (inactive)	1: On (active)
Group Logic 1	827	0: Off (inactive)	1: On (active)
Group Logic 2	828	0: Off (inactive)	1: On (active)
Group Logic 3	829	0: Off (inactive)	1: On (active)
Group Logic 4	830	0: Off (inactive)	1: On (active)
Group Logic 5	831	0: Off (inactive)	1: On (active)
Group Logic 6	832	0: Off (inactive)	1: On (active)
Group Logic 7	833	0: Off (inactive)	1: On (active)
Group Logic 8	834	0: Off (inactive)	1: On (active)
Group Logic 9	835	0: Off (inactive)	1: On (active)
Group Logic 10	836	0: Off (inactive)	1: On (active)
Group Logic 11	837	0: Off (inactive)	1: On (active)
Group Logic 12	838	0: Off (inactive)	1: On (active)
Group Logic 13	839	0: Off (inactive)	1: On (active)
Group Logic 14	840	0: Off (inactive)	1: On (active)
Group Logic 15	841	0: Off (inactive)	1: On (active)
Group Logic 16	842	0: Off (inactive)	1: On (active)

Read Input Status (Function Code 02)			
Channel	**Address**	**Value**	
External Input 1	10001	0: Off (inactive)	1: On (active)
External Input 2	10002	0: Off (inactive)	1: On (active)
External Input 3	10003	0: Off (inactive)	1: On (active)
External Input 4	10004	0: Off (inactive)	1: On (active)
External Input 5	10005	0: Off (inactive)	1: On (active)
External Input 6	10006	0: Off (inactive)	1: On (active)
External Input 7	10007	0: Off (inactive)	1: On (active)
External Input 8	10008	0: Off (inactive)	1: On (active)
External Input 9	10009	0: Off (inactive)	1: On (active)

Read Input Status (Function Code 02)			
External Input 1 Change of state latch	10257	0: Off (inactive)	1: On (active)
External Input 2 Change of state latch	10258	0: Off (inactive)	1: On (active)
External Input 3 Change of state latch	10259	0: Off (inactive)	1: On (active)
External Input 4 Change of state latch	10260	0: Off (inactive)	1: On (active)
External Input 5 Change of state latch	10261	0: Off (inactive)	1: On (active)
External Input 6 Change of state latch	10262	0: Off (inactive)	1: On (active)
External Input 7 Change of state latch	10263	0: Off (inactive)	1: On (active)
External Input 8 Change of state latch	10264	0: Off (inactive)	1: On (active)
External Input 9 Change of state latch	10265	0: Off (inactive)	1: On (active)
Virtual Input 1	10513	0: Off (inactive)	1: On (active)
Virtual Input 2	10514	0: Off (inactive)	1: On (active)
Virtual Input 3	10515	0: Off (inactive)	1: On (active)
Virtual Input 4	10516	0: Off (inactive)	1: On (active)
Virtual Input 5	10517	0: Off (inactive)	1: On (active)
Virtual Input 6	10518	0: Off (inactive)	1: On (active)
Virtual Input 7	10519	0: Off (inactive)	1: On (active)
Virtual Input 8	10520	0: Off (inactive)	1: On (active)
Virtual Input 9	10521	0: Off (inactive)	1: On (active)
Virtual Input 10	10522	0: Off (inactive)	1: On (active)
Virtual Input 11	10523	0: Off (inactive)	1: On (active)
Virtual Input 12	10524	0: Off (inactive)	1: On (active)
Virtual Input 13	10525	0: Off (inactive)	1: On (active)
Virtual Input 14	10526	0: Off (inactive)	1: On (active)
Virtual Input 15	10527	0: Off (inactive)	1: On (active)
Virtual Input 16	10528	0: Off (inactive)	1: On (active)
Virtual Input 17	10529	0: Off (inactive)	1: On (active)
Virtual Input 18	10530	0: Off (inactive)	1: On (active)
Virtual Input 19	10531	0: Off (inactive)	1: On (active)
Virtual Input 20	10532	0: Off (inactive)	1: On (active)
Virtual Input 21	10533	0: Off (inactive)	1: On (active)
Virtual Input 22	10534	0: Off (inactive)	1: On (active)
Virtual Input 23	10535	0: Off (inactive)	1: On (active)
Virtual Input 24	10536	0: Off (inactive)	1: On (active)
Virtual Input 25	10537	0: Off (inactive)	1: On (active)
Virtual Input 26	10538	0: Off (inactive)	1: On (active)
Virtual Input 27	10539	0: Off (inactive)	1: On (active)
Virtual Input 28	10540	0: Off (inactive)	1: On (active)
Virtual Input 29	10541	0: Off (inactive)	1: On (active)
Virtual Input 30	10542	0: Off (inactive)	1: On (active)

Read Holding Registers (Function Code 03)			
Channel		**Units**	**Scale**
F-PRO Clock Time (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds Now	40001	0-999	1
Seconds Now	40002	0-59	1
Minutes Now	40003	0-59	1

Read Holding Registers (Function Code 03)			
Channel		**Units**	**Scale**
Hours Now	40004	0-23	1
Day of Year Now	40005	1-365 (up to 366 if leap year)	1
Years since 1900	40006	90-137	1
Sync'd to IRIG-B	40007	0: No 1: Yes	1
Time of Acquisition (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds Now	40008	0-999	1
Seconds Now	40009	0-59	1
Minutes Now	40010	0-59	1
Hours Now	40011	0-23	1
Day of Year Now	40012	1-365 (up to 366 if leap year)	1
Years since 1900	40013	90-137	1
Sync'd to IRIG-B	40014	0: No 1: Yes	1
Milliseconds Now	40015	2's complement half hours, North America is negative	1

Channel	Address	Units	Scale
Main Va Magnitude	40257	kV	10
Main Va Angle	40258	degrees	10
Main Vb Magnitude	40259	kV	10
Main Vb Angle	40260	degrees	10
Main Vc Magnitude	40261	kV	10
Main Vc Angle	40262	degrees	10
Main Ia Magnitude	40263	A	1
Main Ia Angle	40264	degrees	10
Main Ib Magnitude	40265	A	1
Main Ib Angle	40266	degrees	10
Main Ic Magnitude	40267	A	1
Main Ic Angle	40268	degrees	10
Aux Ia Magnitude	40269	A	1
Aux Ia Angle	40270	degrees	10
Aux Ib Magnitude	40271	A	1
Aux Ib Angle	40272	degrees	10
Aux Ic Magnitude	40273	A	1
Aux Ic Angle	40274	degrees	10
Line Ia Magnitude	40275	A	1

Channel	Address	Units	Scale
Line Ia Angle	40276	degrees	10
Line Ib Magnitude	40277	A	1
Line Ib Angle	40278	degrees	10
Line Ic Magnitude	40279	A	1
Line Ic Angle	40280	degrees	10
Sync V Magnitude	40281	A	0
Sync V Angle	40282	degrees	10
Real Power (P)	40283	MW	10
Reactive Power (Q)	40284	MVAR	10
Pos Seq Voltage	40285	kV	10
Pos Seq Current	40286	A	1
Frequency	40287	Hz	100
THD	40288	%	100
Active Setting Group Numbers	40289		
Demand Real Power Out	40290	MW	10
Demand Real Power In	40291	MW	10
Demand Reactive Power In	40292	MVAR	10
Demand Reactive Power Out	40293	MVAR	10
Demand A-Phase Voltage	40294	kV	10
Demand B-Phase Voltage	40295	kV	10
Demand C-Phase Voltage	40296	kV	10
Demand A-Phase Current	40297	A	1
Demand B-Phase Current	40298	A	1
Demand A-Phase Current	40299	A	1
Demand System Frequency	40300	Hz	300
Demand Maximum THD along all current	40301	%	100
3-phase MWh Out	40302	MWh	0.333
3-phase MWh In	40303	MWh	0.333
3-phase MVARh Out	40304	MVARh	0.333
3-phase MVARh In	40305	MVARh	0.333
BkrLogic 1 Count	40306		1
BkrLogic 2 Count	40307		1
BkrLogic 3 Count	40308		1
BkrLogic 4 Count	40309		1
BkrLogic 5 Count	40310		1
BkrLogic 6 Count	40311		1
BkrLogic 7 Count	40312		1
BkrLogic 8 Count	40313		1

Channel	Address	Units	Scale
BkrLogic 9 Count	40314		1
BkrLogic 10 Count	40315		1
I^2t Main Accumulated	40316		1
I^2t Main for last operation	40317		10
I^2t Aux Accumulated	40318		1
I^2t Aux or last operation	40319		10

Read Input Register (Function Code 04)
No input registers supported. Response fron IED indicates “ILLEGAL FUNCTION.”

Force Single Coil (Function Code 05)			
Only the “hold readings” coil can be forced. When active, this coil locks all coil, input and holding register readings simultaneously at their present values. When inactive, coil, input and holding register values will read their most recently available state.			
Channel	**Type**	**Address**	**Value**
Hold Readings	Read/Write	01	0000: Readings update normally (inactive) FF00: Hold readings (active)
Energy Reset		257	
Reset Breaker Logic 1		258	
Reset Breaker Logic 2		259	
Reset Breaker Logic 3		260	
Reset Breaker Logic 4		261	
Reset Breaker Logic 5		262	
Reset Breaker Logic 6		263	
Reset Breaker Logic 7		264	
Reset Breaker Logic 8		265	
Reset Breaker Logic 9		266	
Reset Breaker Logic 10		267	
I^2t Main Reset		268	
I^2t Aux Reset		269	
Demand Reset		270	
Peak Demand Reset		271	

Preset Single Register (Function Code 06)			
Channel	**Address**	**Value**	**Scaled Up By**
Event Message Control (See below for details of use)			
Refresh event list	40513	No data required	N/A
Acknowledge the current event and get the next event	40514	No data required	N/A

Get the next event (without acknowl-edge)	40515	No data required	N/A

Diagnostic Subfunctions (Function Code 08)	
Return Query Data (Subfunction 00)	This provides an echo of the submitted message.
Restart Comm. Option (Subfunction 01)	This restarts the Modbus communications process.
Force Listen Only Mode (Subfunction 04)	No response is returned. IED enters “Listen Only” mode. This mode can only be exited by the “Restart Comm. Option” com-mand.

Report Slave ID (Function Code 17/0x11)			
A fixed response is returned by the IED, including system model, version and issue numbers.			
Channel	**Type**	**Bytes**	**Value**
Model Number	Read Only	0 and 1	0 x 13EC = 5100 decimal
Version Number	Read Only	2 and 3	Version number
Issue Number	Read Only	4 and 5	Issue number

- The F-PRO IED model number is 5100.
- Version and issue will each be positive integers, say X and Y.
- The F-PRO is defined as “Model 5100, Version X Issue B”

Accessing F-PRO Event Information	
All F-PRO detector event messages displayed in the Event Log are available via Modbus. This includes fault location information. The following controls are available.	
Refresh Event List	(Function Code 6, address 40513): Fetches the latest events from the F-PRO's event log and makes them available for Modbus access. The most recent event becomes the current event available for reading.
Acknowledge Current Event and Get Next Event	(Function Code 6, address 40514): Clears the current event from the read registers and places the next event into them. An acknowledged event is no longer available for reading.
Get Next Event	(Function Code 6, address 40515): Places the next event in the read registers without acknowledging the current event. The current event will reappear in the list when Refresh Event List is used.
Size of Current Event Mes-sage	(Function Code 3, address 40516): Indicates the number of 16 bit registers used to contain the current event. Event data is stored with two characters per register. A reading of zero indi-cates that there are no unacknowledged events available in the current set. (NB. The Refresh Event List function can be used to check for new events that have occurred since the last Refresh Event List.)
	(Function Code 3, address 40517): Identifies fault location events. These events are identified by “FL” in this register. Non-fault location events contain “ ” in this location.

Read Event Message	(Function Code 3, addresses 40518 - 40576): Contains the current event message. Two ASCII characters are packed into each 16 bit register. All unused registers in the set are set to 0.

Register	**Value**	**Meaning**	
	High Byte	Low Byte	
40516	0x00	0x1B	Event text size = 27 (0x1B hex)
40517	0x46	0x4C	‘FL’ - Fault locator event
40518	0x32	0x30	‘2’, ‘0’
40519	0x30	0x30	‘0’, ‘0’
40520	0x53	0x65	‘S’, ‘e’
40521	0x70	0x32	‘p’, ‘2’
40522	0x31	0x20	‘1’, ‘ ’
40523	0x32	0x30	‘2’, ‘0’
40524	0x3A	0x31	‘:’, ‘1’
40525	0x36	0x3A	‘6’, ‘:’
40526	0x31	0x36	‘1’, ‘6’
40527	0x2E	0x39	‘.’, ‘9’
40528	0x36	0x36	‘6’, ‘6’
40529	0x20	0x3A	‘ ’, ‘:’
40530	0x20	0x35	‘ ’, ‘5’
40531	0x30	0x2D	‘ 0’, ‘-’
40532	0x31	0x20	‘1’, ‘ ‘
40533	0x54	0x72	‘T’, ‘r’
40534	0x69	0x70	‘i’, ‘p’
40535	0x20	0x41	‘ ’, ‘A’
40536	0x42	0x20	‘B’, ‘ ‘
40537	0x31	0x2E	‘1’, ‘.’
40538	0x30	0x6B	‘0 ’, ‘k’
40539	0x6D	0x0	‘m’, ‘ ’

Appendix F DNP3 Communication Protocol

Device Profile

Vendor Name: ERLPhase Corporation			Device Name: Relay Model #	
Highest DNP Level Supported: For Requests: 2 For Responses: 2			Device Function: _ Master x Slave	
Maximum Data Link Frame Size (octets): Transmitted: 292 Received: 292			Maximum Application Fragme Size (octets): Transmitted: 2048 Received: 2048	
Maximum Data Link Re-tries: _ None x Fixed at 3 _ Configurable, range __ to __			Maximum Application Layer Re-tries: x None _ Configurable, range __ to __	
Requires Data Link Layer Confirmation: _ Never _ Always _ Sometimes x Configurable, either always or never			Requires Application Layer Confirmation: _ Never _ Always (not recommended) x When reporting Event Data (Slave) x When sending multi-fragment responses (Slave) _ Sometimes _ Configurable	
Timeouts (in seconds) while waiting for:				
Data Link Confirm	__None	x Fixed at 2	__Variable	__Configurable
Complete Application Fragment	x None	__Fixed at 2	__Variable	__Configurable
Application Confirm	__None	x Fixed at 5	__Variable	__Configurable
Complete Application Response	x None	__Fixed at 2	__Variable	__Configurable
Others_____				
Select to execute delay	__None	x Fixed at 10	__Variable	__Configurable
Sends/Executes Control Operations:				
WRITE Binary Outputs	x Never	__Always	__Sometimes	__Configurable
SELECT/OPERATE	__Never	x Always	__Sometimes	__Configurable
DIRECT OPERATE	__Never	x Always	__Sometimes	__Configurable
DIRECT OPERATE No ACK	__Never	x Always	__Sometimes	__Configurable
Count > 1	x Never	__Always	__Sometimes	__Configurable
Pulse On	__Never	x Always	__Sometimes	__Configurable
Pulse Off	x Never	__Always	__Sometimes	__Configurable
Latch On	__Never	x Always	__Sometimes	__Configurable
Latch Off	__Never	x Always	__Sometimes	__Configurable
Queue	x Never	__Always	__Sometimes	__Configurable
Clear Queue	x Never	__Always	__Sometimes	__Configurable
Maximum number of control objects per request: 16				
Notes: Control Trip/Close - Code Combination supported: Latch On/NUL Latch Off/NUL Pulse On/NUL (Pulse duration fixed at 1 s)				
Report Binary Input Change Events when no specific variation requested: __Never __Only time-tagged x Only non-time-tagged _ Configurable to send both, one or the other			Reports time-tagged Binary Input Change Events when no specific variation requested __Never x Binary Input Change with Time _ Binary Input Change with Relative Time _ Configurable	
Sends Unsolicited Response: x Never _ Configurable _Only certain objects _ Sometimes _ ENABLE/DISABLE UNSOLICITED Function codes supported			Sends Static Data in Unsolicited Responses: x Never _ When Device Restarts _ When Status Flags Change No other options are permitted.	
Default Counter Object/Variation: x No Counter Reported _ Configurable			Counters Roll Over at: x No Counters Reported _ Configurable	

_ Default Object _____ _ Default Variation _____ _ Point-by-point list attached	_ 16 Bits _ 32 Bits _ Other Value _____ _ Point-by-point list attached

Implementation Table

Object			Request		Response	
Grp	**Var**	**Description**	**Function Code**	**Qualifier Codes (hex)**	**Function Code**	**Qualifier Codes (hex)**
1	0	Binary Input - All Variations	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x00
1	1	Binary Input (default)	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x00
1	2	Binary Input with Status	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x00
2	0	Binary Input Change - All Variations	1 (read)	0x06, 0x07, 0x08	129 (response)	0x17
2	1	Binary Input Change without Time	1 (read)	0x06, 0x07, 0x08	129 (response)	0x17
2	2	Binary Input Change with Time (default)	1 (read)	0x06, 0x07, 0x08	129 (response)	0x17
2	3	Binary Input Change with Relative Time	1 (read)	0x06, 0x07, 0x08	129 (response)	0x17
10	0	Binary Output - All Variations	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x00
10	2	Binary Output Status (default)	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x00
12	1	Control Relay Output Block	3 (select), 4 (operate), 5 (direct op) 6 (direct op, no ack)	0x00, 0x01, 0x07, 0x08, 0x17, 0x18	129 (response)	echo of request
30	0	Analog Input - All Variations	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x01
30	1	32-bit Analog Input	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x01
30	2	16-bit Analog Input	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x01
30	3	32-bit Analog Input without flag	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x01
30	4	16-bit Analog Input without flag (default)	1 (read)	0x00, 0x01, 0x06, 0x07, 0x08, 0x17, 0x28	129 (response)	0x01
32	0	Analog Input Change Event - All Variations	1 (read)	0x06, 0x07, 0x08	129 (response)	0x28
32	1	Analog Input Change Event - 32-bit without Time	1 (read)	0x06, 0x07, 0x08	129 (response)	0x28
32	2	Analog Input Change Event - 16-bit without Time (default)	1 (read)	0x06, 0x07, 0x08	129 (response)	0x28
32	3	Analog Input Change Event - 32-bit with Time	1 (read)	0x06, 0x07, 0x08	129 (response)	0x28
32	4	Analog Input Change Event - 16-bit with Time	1 (read)	0x06, 0x07, 0x08	129 (response)	0x28
51	1	Time and Data CTO			129 (response)	0x07, quantity=1
52	1	Time Delay Coarse			129 (response)	0x07, quantity=1
60	1	Class 0 Data	1 (read)	0x06		
60	2	Class 1 Data	1 (read)	0x06, 0x07, 0x08		

Object			Request		Response	
60	3	Class 2 Data	1 (read)	0x06, 0x07, 0x08		
80	1	Internal Indications	2 (write)	0x00, index=7		
110	0	Octet String	1 (read)	0x06	129 (response)	0x07
111	0	Octet String Change Event	1 (read)	0x06	129 (response)	0x07
		No Object	14 (warm restart)			

Point List

Binary Inputs (Obj 1, 2)		
	Static Points	**Change Event Points**
Object Group	1	2
Object Variation	1 – Binary Input (default)	1 – Binary Input Change without Time
	2 – Binary Input with Status	1 – Binary Input Change with Time (default)
		3 – Binary Input Change with Relative Time
Class	0	1
Note: Binary inputs are scanned with 1 ms resolution.		
Change Event Buffer Size		100

Name	Point Index	Change Event Class
External Input 1	0	1
External Input 2	1	1
External Input 3	2	1
External Input 4	3	1
External Input 5	4	1
External Input 6	5	1
External Input 7	6	1
External Input 8	7	1
External Input 9	8	1

Binary Outputs (Obj 10, 12)		
	Static Points	**Control Points**

Binary Outputs (Obj 10, 12)		
Object Group	10	12
Object Variation	2 – Binary Output Status (default)	1 – Control Relay Output Block
Class	0	Not Applicable
Note: Binary outputs are scanned with 500 ms resolution.		
No change buffer		

Name	Point Index	Change Event Class	Object Group
Output Contact 1	0	N/A	
Output Contact 2	1	N/A	
Output Contact 3	2	N/A	
Output Contact 4	3	N/A	
Output Contact 5	4	N/A	
Output Contact 6	5	N/A	
Output Contact 7	6	N/A	
Output Contact 8	7	N/A	
Output Contact 9	8	N/A	
Output Contact 10	9	N/A	
Output Contact 11	10	N/A	
Output Contact 12	11	N/A	
50LS-1 Main Trip	12	N/A	
50LS-2 Main Trip	13	N/A	
50LS-1 Aux Trip	14	N/A	
50LS-2 Aux Trip	15	N/A	
50BF-1 Main Trip	16	N/A	
50BF-2 Main Trip	17	N/A	
50BF-1 Aux Trip	18	N/A	
50BF-2 Aux Trip	19	N/A	
25/27/59 Output	20	N/A	
79 Main Output	21	N/A	
79 Aux Output	22	N/A	
50 Trip	23	N/A	
51 Alarm	24	N/A	
51 Trip	25	N/A	
50N Trip	26	N/A	
51N Alarm	27	N/A	
51N Trip	28	N/A	
46-50 Trip	29	N/A	
46-51 Alarm	30	N/A	
46-51 Trip	31	N/A	
32P Trip	32	N/A	
32Q Trip	33	N/A	
59 1 Trip	34	N/A	
59 2 Trip	35	N/A	

Name	Point Index	Change Event Class	Object Group
27 1 Trip	36	N/A	
27-2 Trip	37	N/A	
60 Alarm	38	N/A	
81-1 Trip	39	N/A	
81-2 Trip	40	N/A	
81-3 Trip	41	N/A	
81-4 Trip	42	N/A	
THD Alarm	43	N/A	
Auxillary Alarm	44	N/A	
ProLogic 1	45	N/A	
ProLogic 2	46	N/A	
ProLogic 3	47	N/A	
ProLogic 4	48	N/A	
ProLogic 5	49	N/A	
ProLogic 6	50	N/A	
ProLogic 7	51	N/A	
ProLogic 8	52	N/A	
ProLogic 9	53	N/A	
ProLogic 10	54	N/A	
Breaker Logic 1	55	N/A	
Breaker Logic 2	56	N/A	
Breaker Logic 3	57	N/A	
Breaker Logic 4	58	N/A	
Breaker Logic 5	59	N/A	
Breaker Logic 6	60	N/A	
Breaker Logic 7	61	N/A	
Breaker Logic 8	62	N/A	
Breaker Logic 9	63	N/A	
Breaker Logic 10	64	N/A	
79 Initialize	65	N/A	
79 Block	66	N/A	
79 Main Lockout	67	N/A	
79 Aux Lockout	68	N/A	
50BF Initiate	69	N/A	
Group Logic 1	70	N/A	10
Group Logic 2	71	N/A	10
Group Logic 3	72	N/A	10

Name	Point Index	Change Event Class	Object Group
Group Logic 4	73	N/A	10
Group Logic 5	74	N/A	10
Group Logic 6	75	N/A	10
Group Logic 7	76	N/A	10
Group Logic 8	77	N/A	10
Group Logic 9	78	N/A	10
Group Logic 10	79	N/A	10
Group Logic 11	80	N/A	10
Group Logic 12	81	N/A	v
Group Logic 13	82	N/A	10
Group Logic 14	83	N/A	10
Group Logic 15	84	N/A	10
Group Logic 16	85	N/A	10
Virtual Input 1	86	N/A	10, 12
Virtual Input 2	87	N/A	10, 12
Virtual Input 3	88	N/A	10, 12
Virtual Input 4	89	N/A	10, 12
Virtual Input 5	90	N/A	10, 12
Virtual Input 6	91	N/A	10, 12
Virtual Input 7	92	N/A	10, 12
Virtual Input 8	93	N/A	10, 12
Virtual Input 9	94	N/A	10, 12
Virtual Input 10	95	N/A	10, 12
Virtual Input 11	96	N/A	10, 12
Virtual Input 12	97	N/A	10, 12
Virtual Input 13	98	N/A	10, 12
Virtual Input 14	99	N/A	10, 12
Virtual Input 15	100	N/A	10, 12
Virtual Input 16	101	N/A	10, 12
Virtual Input 17	102	N/A	10, 12
Virtual Input 18	103	N/A	10, 12
Virtual Input 19	104	N/A	10, 12
Virtual Input 20	105	N/A	10, 12
Virtual Input 21	106	N/A	10, 12
Virtual Input 22	107	N/A	10, 12
Virtual Input 23	108	N/A	10, 12
Virtual Input 24	109	N/A	10, 12

Name	Point Index	Change Event Class	Object Group
Virtual Input 25	110	N/A	10, 12
Virtual Input 26	111	N/A	10, 12
Virtual Input 27	112	N/A	10, 12
Virtual Input 28	113	N/A	10, 12
Virtual Input 29	114	N/A	10, 12
Virtual Input 30	115	N/A	10, 12
I*I*t Main Breaker Reset	116	N/A	10, 12
I*I*t Aux Breaker Reset	117	N/A	10, 12
Reset Energy	118	N/A	10, 12
Reset Breaker Logic 1	119	N/A	10, 12
Reset Breaker Logic 2	120	N/A	10, 12
Reset Breaker Logic 3	121	N/A	10, 12
Reset Breaker Logic 4	122	N/A	10, 12
Reset Breaker Logic 5	123	N/A	10, 12
Reset Breaker Logic 6	124	N/A	10, 12
Reset Breaker Logic 7	125	N/A	10, 12
Reset Breaker Logic 8	126	N/A	10, 12
Reset Breaker Logic 9	127	N/A	10, 12
Reset Breaker Logic 10	128	N/A	10, 12
Demand Reset	129	N/A	10, 12
Peak Demand Reset	130	N/A	12

Analog Inputs (Obj 30, 31)		
	Static Points	**Change Event Points**
Object Group	30	32
Object Variation	1 - 32-bit Analog Input	1 - Analog Input Change - 32-bit without Time
	2 - 16-bit Analog Input	2 - Analog Input Change - 16-bit without Time (default)
	3 - 32-bit Analog Input without flag	3 - Analog Input Change - 32-bit with Time
	4 - 16-bit Analog Input without flag (default)	4 - Analog Input Change - 16-bit with Time
Class	0	2
Note: Analog Inputs are scanned with 500 ms resolution. Note: Nominal is based on 69 V secondary voltage * PT ratio for voltage channels, and either 1A or 5A secondary current * CT ratio for current channels dependent upon the format of CT installed in the F-PRO.		
Change Event Buffer Size		100

Name	Point Index	Units	Scale	Change Event Class	Deadband
Main Va-Mag	0	kV	10	2	2% nominal
Main Va-Ang	1	degrees	10	2	0.5 degrees
Main Vb-Mag	2	kV	10	2	2% nominal
Main Vb-Ang	3	degrees	10	2	0.5 degrees
Main Vc-Mag	4	kV	10	2	2% nominal
Main Vc-Ang	5	degrees	10	2	0.5 degrees
Main Ia-Mag	6	A	1	2	2% nominal
Main Ia-Ang	7	degrees	10	2	0.5 degrees
Main Ib-Mag	8	A	1	2	2% nominal
Main Ib-Ang	9	degrees	10	2	0.5 degrees
Main Ic-Mag	10	A	1	2	2% nominal
Main Ic-Ang	11	degrees	10	2	0.5 degrees
Aux Ia-Mag	12	A	1	2	2% nominal
Aux Ia-Ang	13	degrees	10	2	0.5 degrees
Aux Ib-Mag	14	A	1	2	2% nominal
Aux Ib-Ang	15	degrees	10	2	0.5 degrees
Aux Ic-Mag	16	A	1	2	2% nominal
Aux Ic-Ang	17	degrees	10	2	0.5 degrees
Line Ia-Mag	18	A	1	2	2% nominal
Line Ia-Ang	19	degrees	10	2	0.5 degrees
Line Ib-Mag	20	A	1	2	2% nominal
Line Ib-Ang	21	degrees	10	2	0.5 degrees
Line Ic-Mag	22	A	1	2	2% nominal
Line Ic-Ang	23	degrees	10	2	0.5 degrees
Sync V-Mag	24	kV	10	2	2% nominal
Sync V-Ang	25	degrees	10	2	0.5 degrees
Real Power (P)	26	MW	10	2	4% nominal
Reactive Power (Q)	27	MVAR	10	2	4% nominal
Pos Seq Voltage	28	kV	10	2	2% nominal
Pos Seq Current	29	A	1	2	2% nominal
Frequency	30	Hz	100	2	0.05 Hz
THD	31	%	100	2	0.25%
Active Setting Group Number	32		1	2	1
Demand Real Power Out	33	MW	10	2	0.5
Demand Real Power In	34	MW	10	2	0.5
Demand Reactive Power Out	35	MVAR	10	2	0.5

Name	Point Index	Units	Scale	Change Event Class	Deadband
Demand Reactive Power In	36	MVAR	10	2	0.5
Demand A-phase Voltage	37	kV	10	2	2% nominal
Demand B-phase Voltage	38	kV	10	2	2% nominal
Demand C-phase Voltage	39	kV	10	2	2% nominal
Demand A-phase Current	40	A	1	2	2% nominal
Demand B-phase Current	41	A	1	2	2% nominal
Demand C-phase Current	42	A	1	2	2% nominal
Demand System Frequency	43	Hz	300	2	0.05 Hz
Demand Maximum THD among all current	44	%	100	2	0.25%
3-phase MWh Out	45	MWh	1/3	2	0.5
3-phase MWh In	46	MWh	1/3	2	0.5
3-phase MVARh Out	47	MVARh	1/3	2	0.5
3-phase MVARh In	48	MVARh	1/3	2	0.5
BkrLogic 1 Count	49		1	2	1
BkrLogic 2 Count	50		1	2	1
BkrLogic 3 Count	51		1	2	1
BkrLogic 4 Count	52		1	2	1
BkrLogic 5 Count	53		1	2	1
BkrLogic 6 Count	54		1	2	1
BkrLogic 7 Count	55		1	2	1
BkrLogic 8 Count	56		1	2	1
BkrLogic 9 Count	57		1	2	1
BkrLogic 10 Count	58		1	2	1
I^2t Main Accumulated	59		1	2	1
I^2t Main for last operation	60		10	2	1
I^2t Aux Accumulated	61		1	2	1
I^2t Aux for last operation	62		10	2	1

Object 110, 111 - Octet String for Event Log access

Object 110 and Object 111 are Octet String objects used to provide access to the Event Log text of the F-PRO. These objects are described in Technical Bulletin 9701-004.zip_71 available from the DNP user group web page (www.dnp.org). Object 110 always contains the most recent event in the F-PRO. Object 111 is the corresponding change event object. As stated in the DNP technical bulletin, the variation of the response object represents the length of the string. The string represents the ASCII values of the event text. The first 2 characters in the string can be used to quickly identify fault location events. Fault locator events begin with the characters “FL” (0x46, 0x44 hex).

The following example shows a fault distance event returned through either of the octet string objects.

DNP Example: Event Message

"FL2000Sep21 20:16:16.966 : 50-1 Trip AB 1.0km"

DNP Octet string object contents:					
0x46	0x4C	0x32	0x30	0x30	0x30
0x53	0x65	0x70	0x32	0x31	0x20
0x32	0x30	0x3A	0x31	0x36	0x3A
0x31	0x36	0x2E	0x39	0x36	0x36
0x20	0x3A	0x20	0x35	0x30	0x2D
0x31	0x20	0x54	0x72	0x69	0x70
0x20	0x41	0x42	0x20	0x31	0x2E
0x30	0x6B	0x6D			

Appendix G Mechanical Drawings

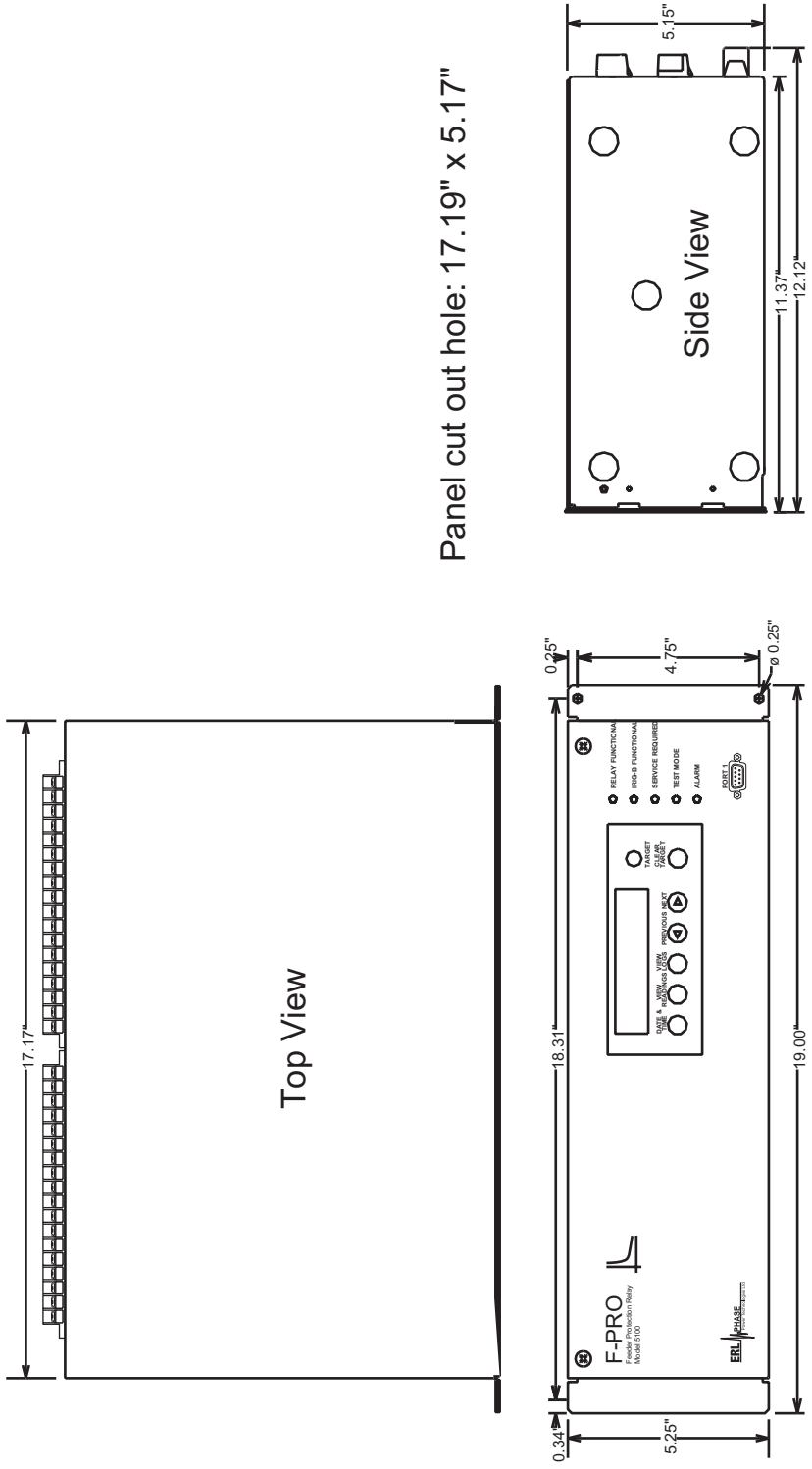


Figure A.3: Mechanical Drawing

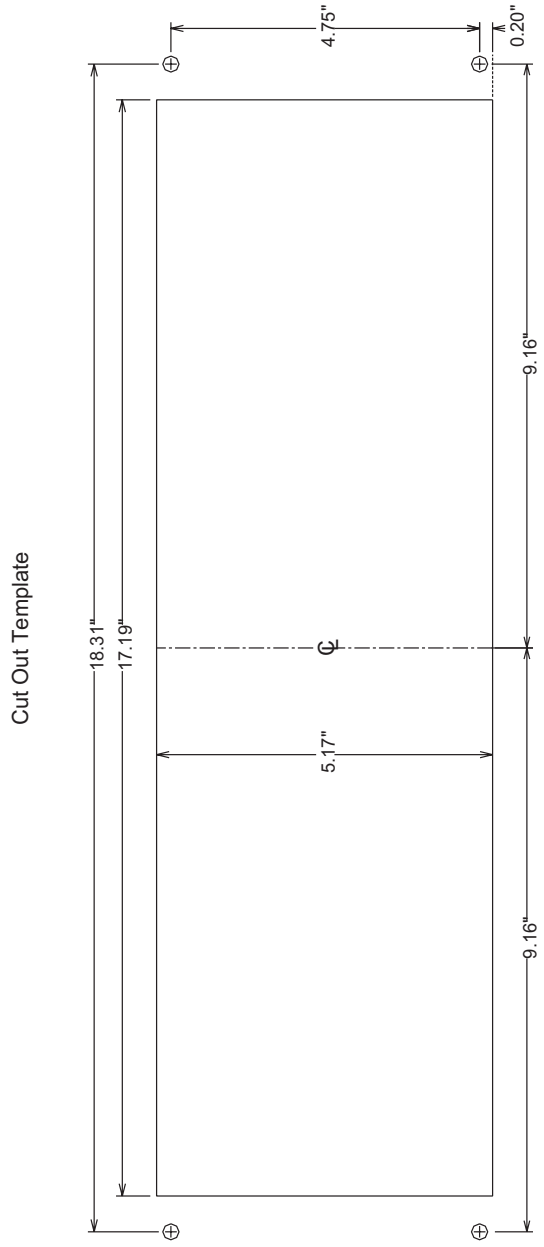


Figure A.4: Cut-out Template

Appendix H Rear Panel Drawings

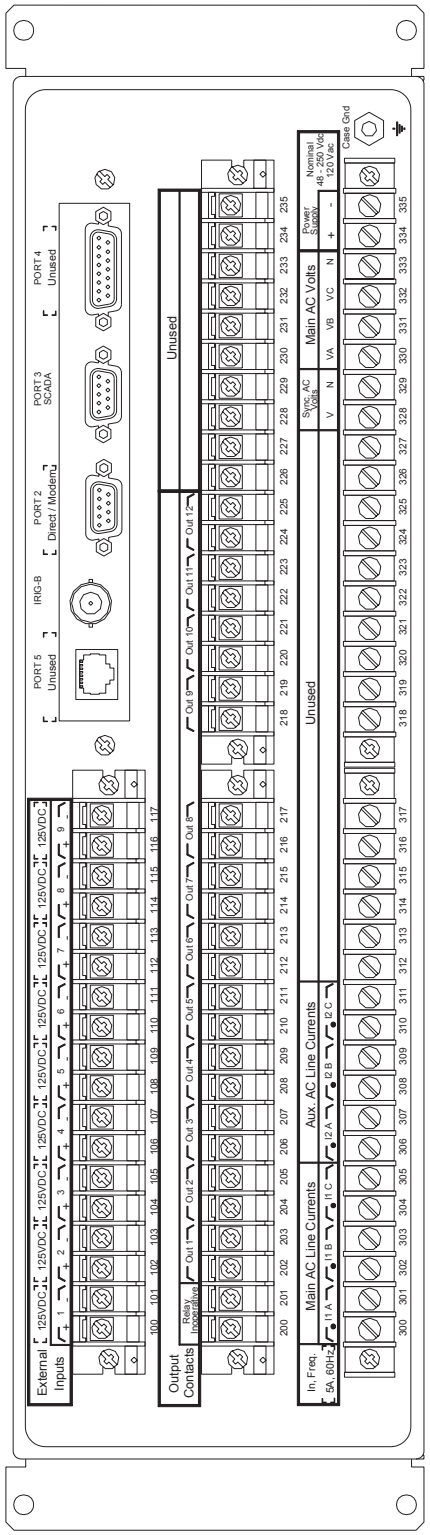


Figure A.5: Rear Panel

Appendix I AC Schematic Drawing

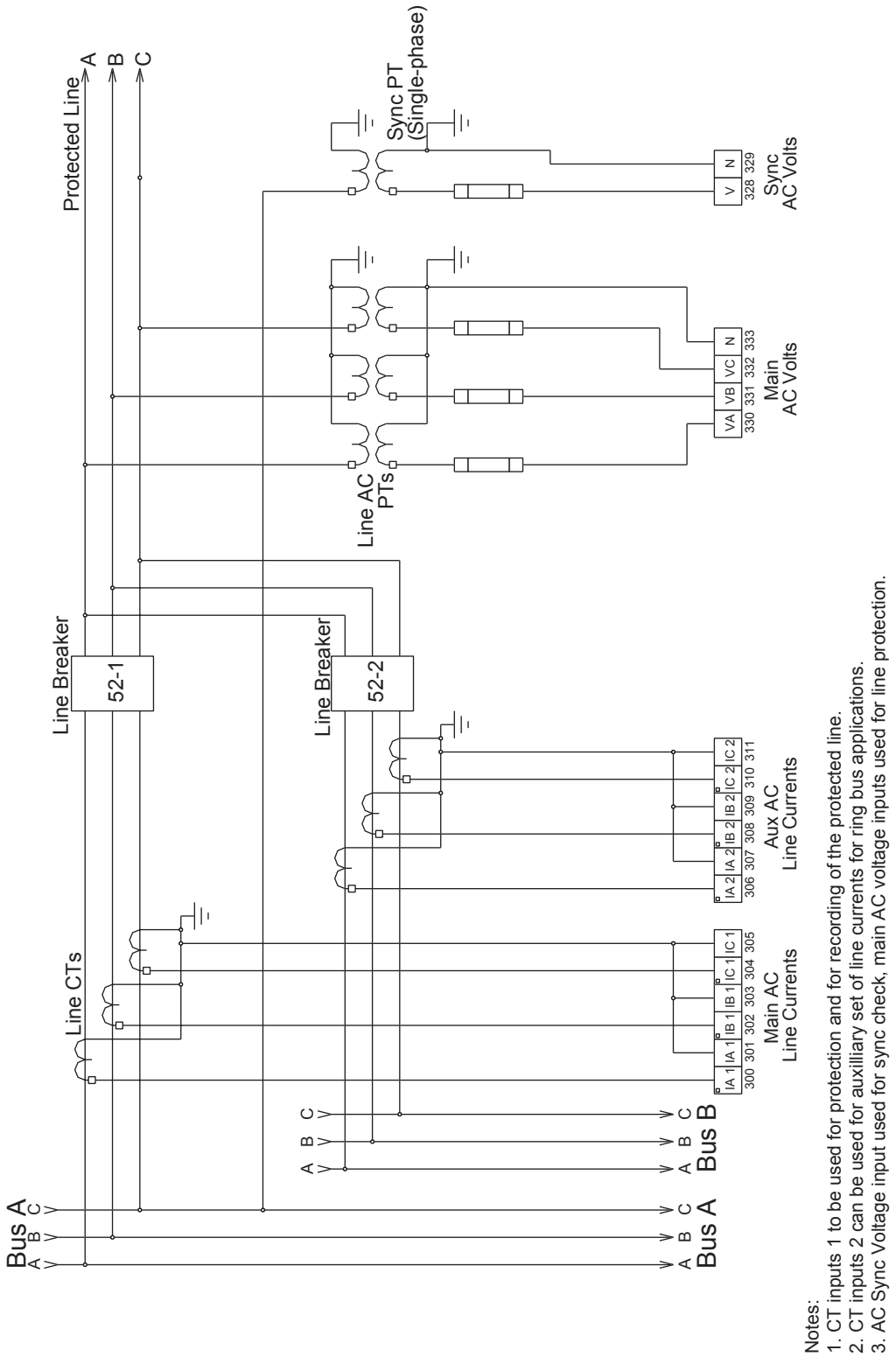
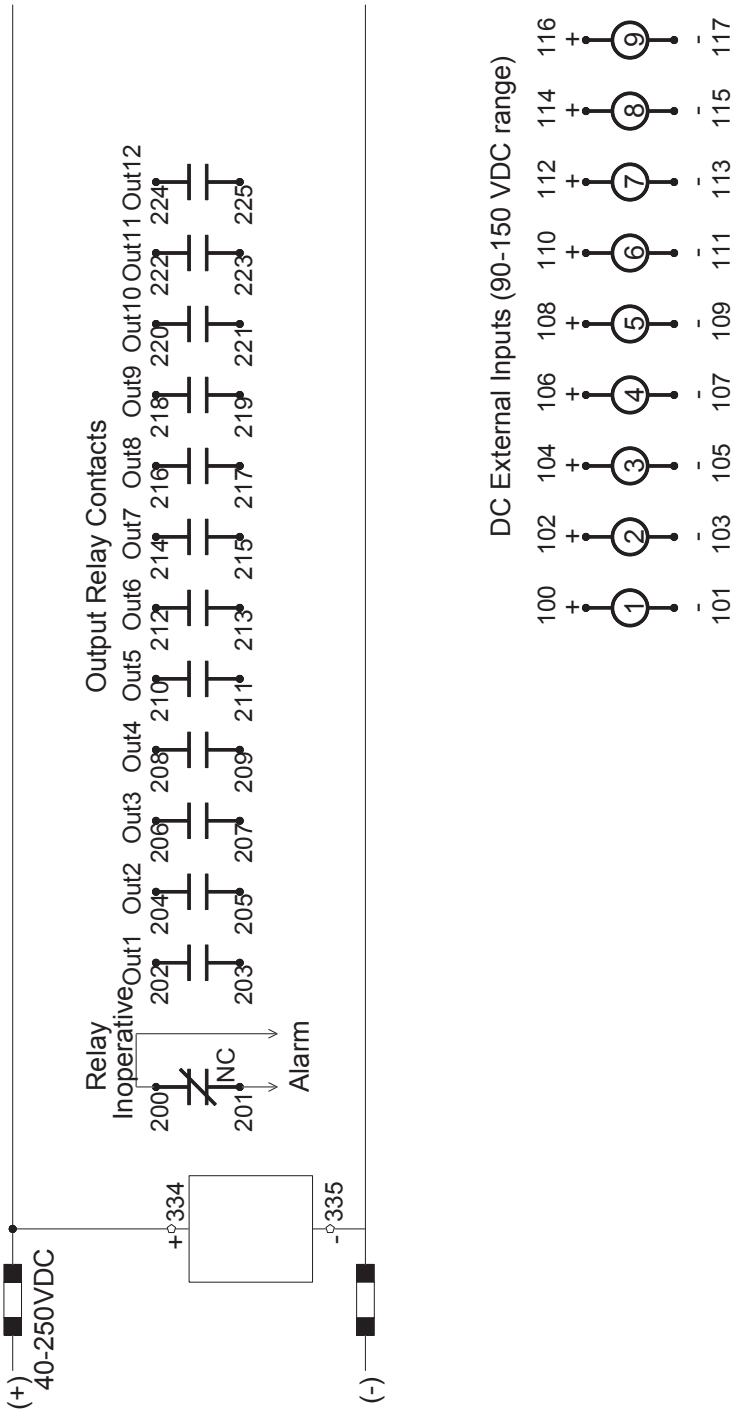


Figure A.6: F-PRO AC Schematic

Appendix J DC Schematic Drawing



Notes:
1. IRIG-B and comm ports shown separately on F-PRO rear panel layout drawing # 371003.
2. All output relays can be programmed to operate on any relay function.
3. All outputs are rated tripping duty, interrupting via breaker aux "a" contact.

Figure A.7: F-PRO DC Schematic

Appendix K Function Logic Diagram

Diagram in plastic sleeve.

Appendix L F-PRO Setting Example

Protection, Timers and I/O Status

The relay does not block any protection functions or external inputs during the setting save or active group change, but the external output contacts are reset for one cycle.

The relay applies the setting parameters, resets all protection functions, resets all timers and continues to process the protection algorithms but does not apply any action to the output contacts for one cycle. For close-in (heavy) fault conditions that occur at the time of a setting change the relay performance has a maximum increase in output delay of one cycle. For light fault conditions the relay performance does not have a noticeable change. There is normally a one cycle decision making process. The relay algorithms have been processing and when the one cycle blocking ends and the contacts are closed immediately (+3ms hardware delay).

Latch Status

The relay does not reset any ProLogic, Group Logic or Virtual Input latch functions during the setting save or active group change. Retaining latch status allows the relay continuous access to specific latched logic states. This is useful when the relay has ProLogic, Group Logic or Virtual Input functions used to block protection or ancillary functions for specific operating conditions.

Event Status Reset

The relay resets all the events that are currently high and reports states of all the events that remain high after a setting change.

Viewing Active Setting Group

To view the active setting group and status of the group logic functions in real time via the terminal UI, enter the *Metering/Logic/Setting Group* menu choice. To view a snapshot of the group logic data, enter the *Settings/Active Group* menu choice.

Front Panel Active Setting Group

View the active setting group with the relay front panel display. There is no capability to change active setting group with the front panel. The front panel displays two lines of data, the first line contains the “Active Setting Group: x”, where x is the current setting group and flashes. The second line of data displays the user-defined setting name for the current setting group.

To view the active setting group press the *Previous* or *Next* buttons to cycle through the time/date indication and the serial port settings.

Flash Memory Write

The flash memory on the main processor board is capable of approximately one hundred thousand erases. The retention of the active setting group causes 2 bytes to be written to a memory block in the flash. Each memory block writes about 65 Kbytes before an erase is performed on the flash memory. An average of 14 setting group changes per day for the 25 year life of a relay results in the flash memory being erased only four times. Latch states from ProLogic and Group Logic also performs writes to the flash memory increasing the number of erases performed on the flash.

Setting Examples

Breaker Monitor Examples Using Breaker Logic

Clearing Time Monitoring

Definition – The breaker clearing time is the elapsed time from trip coil energized until last phase current is zero.

Desired Behavior – Alarm if the elapsed time is greater than the Clearing Time Pickup Threshold (T1) and the current flowing through the breaker had dropped below the 50LS setting. The logged event message includes the actual clearing time (Timer 1 accumulated run time). When the final output goes high, the run time associated with all the timers is available and can be recorded in the event log. The message parameter setting is used to define the event log message.

The Alarm LED Enabled setting is used to tell the F-PRO to turn on the front panel led. In this example a latch gate is used to keep the alarm condition present until Virtual Input 1 is pulsed high. An alternative setting could be applied where no latch gate is used and T2 drop out timer is set for creating the desired Alarm pulse width.

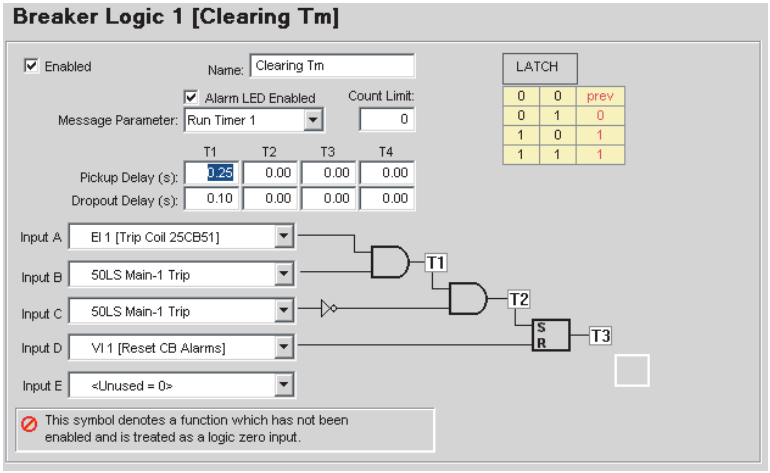


Figure A.8: Breaker Logic 1

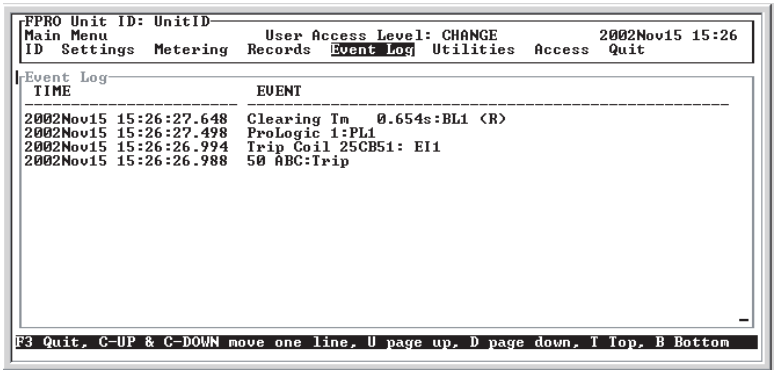


Figure A.9: Event Log

Operations Count Monitoring

Definition – The breaker operations count since last reset/preset.

Desired Behavior – Alarm if the counter is greater than the Count Limit Pick-up. Timer T1 pickup delay is used to provide a de-bounce time for the circuit breaker 52a contact. Timer T2 drop out delay is set to one second, for creating the desired Alarm pulse width.

The message parameter setting is used to define the event log message.

The Alarm LED Enabled setting is used to tell the F-PRO to turn on the front panel led. In this example T2 drop out timer is set for creating the desired Alarm pulse width. An alternative setting could be applied with a latch gate to keep the alarm condition present until Virtual Input 1 is pulsed high.

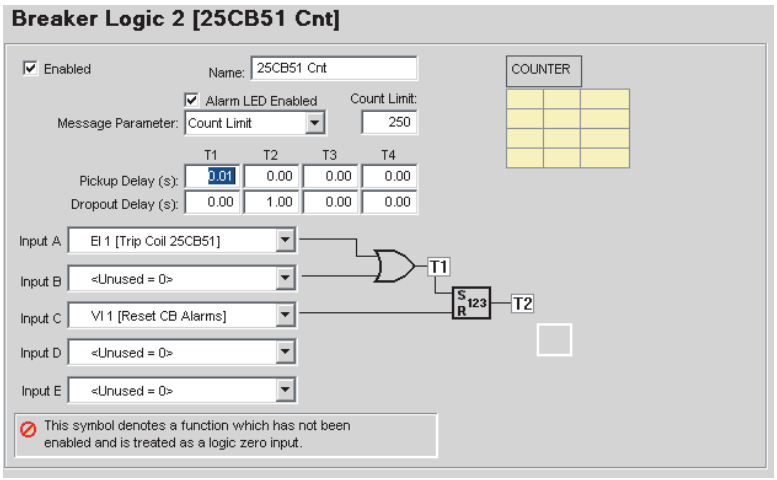


Figure A.10: Breaker Logic 2

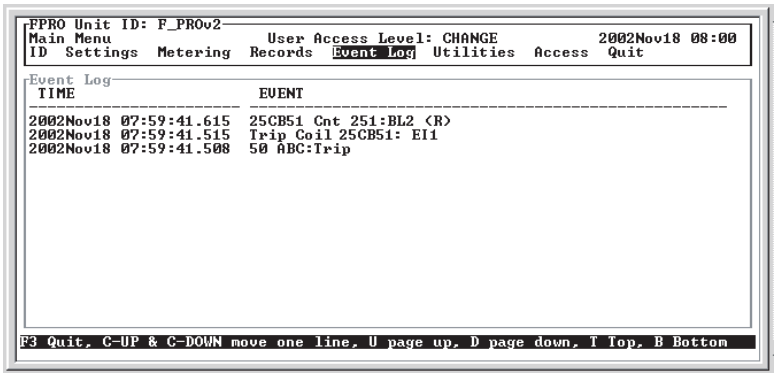


Figure A.11: Event Log

Re-Strike Monitoring

Definition – The fault current appears through the breaker within a set time after fault clearing.

Desired Behavior – Alarm if the fault current appears quicker than the settling time as defined by timer T1 drop out delay, after fault clearing has taken place. Timer T2 drop out delay is set to one second, for creating the desired Alarm pulse width. The message parameter setting is used to define the event log message, this example you do not need any additional information to be included with the event message therefore the message parameter setting equals none.

The Alarm LED Enabled setting is used to tell the F-PRO to turn on the front panel led. In this example T2 drop out timer is set for creating the desired Alarm pulse width. An alternative setting could be applied with a latch gate to keep the alarm condition present until Virtual Input 1 is pulsed high.

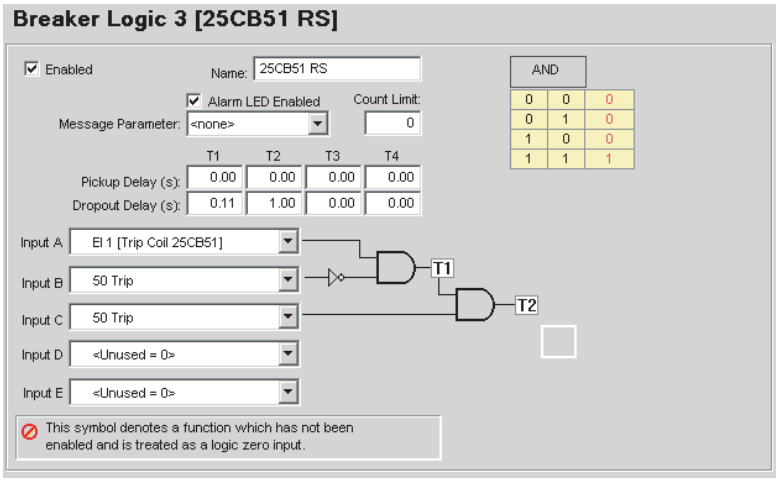


Figure A.12: Breaker Logic 3

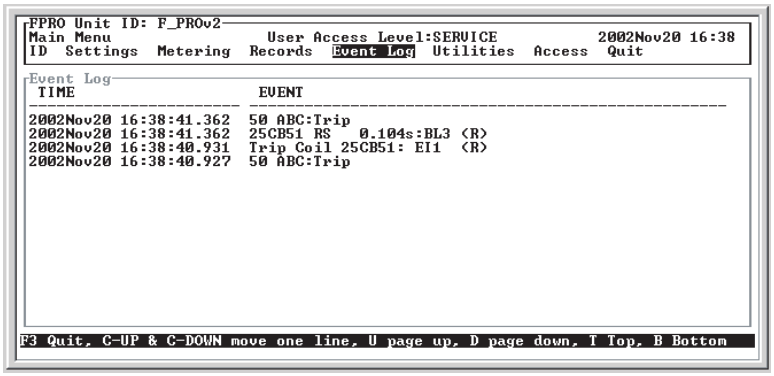


Figure A.13: Event Log

Switching Setting Groups

You can program a total of sixteen Group Logic statements per setting group to cause a setting change from one group to another. Create settings using the *Offliner* setting software or by using the Terminal Mode.

An example of pulsing an external input and an example of a solid initiate to activate setting group changes are shown below.

Using One External Input to Toggle Setting Group

Use one external input connected to a SCADA output contact to toggle between two or more setting groups. In this example we connect external input one (EI 1) to the SCADA control output contact and switch between group one and group two. If you wanted to switch through all setting groups, group logic two would switch to setting group three, and so forth. If the contact input to switch setting groups becomes welded shut or the SCADA system has a problem, the relay will only switch to the new logic and stay in that logic until the input has been de-energized for the ProLogic pickup delay, which was set to 10 seconds.

Setting Group 1 – Logic Statements

When setting group one becomes active either through a setting group change or is the default group after relay power up, ProLogic 9 becomes high after the 10.00 second delay, if EI 1 is low. ProLogic 9 is set for a 0.26 second dropout time; to be used with ProLogic 10 dropout timer allowing for the slower processing thread where Group Logic is processed and providing a definite timed pulse to the group logic.

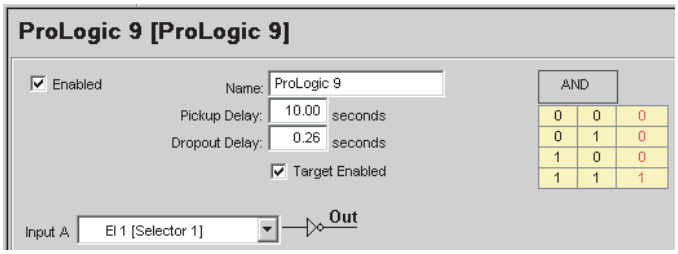


Figure A.14: ProLogic 9

Prologic 10 has no intentional delay and becomes high for the combined drop-out time of ProLogic 9 and 10 equalling 0.52 seconds.

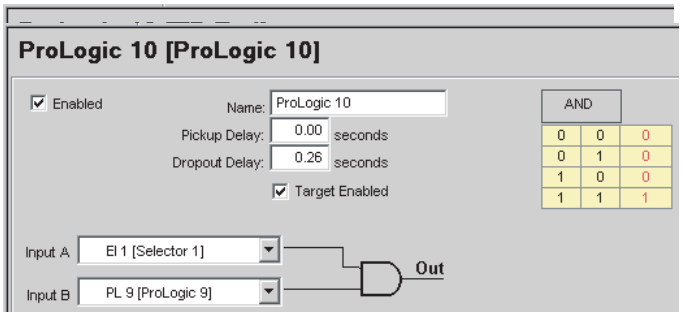


Figure A.15: ProLogic 10

Group Logic 1 is used to switch to the new setting group; there is no intentional delay. You can also provide four additional logic inputs to be used to provide qualifiers before switching setting groups. The example uses a ProLogic statement and an external input as qualifiers, see example "Using ProLogic to Qualify Group Logic Statements" on page Appendix L-11.

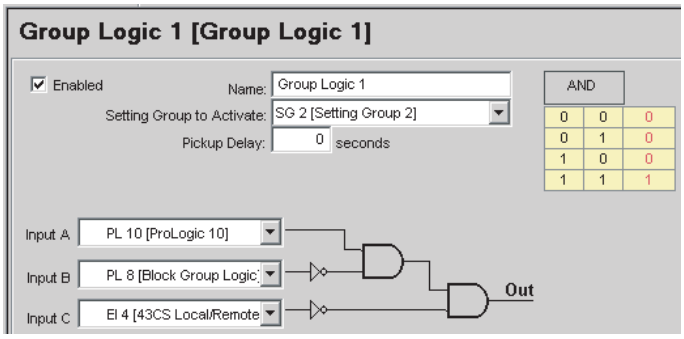


Figure A.16: Group Logic 1

Setting Group 2 – Logic Statements

When setting group two becomes active either through a setting group change or is the default group after relay power up, ProLogic 9 becomes high after the 10.00 second delay, if external input one is low. The example shows ProLogic 9 set for a 0.26 second dropout time to be used with ProLogic 10 dropout timer allowing for the slower processing thread where Group Logic is processed and providing a definite timed pulse to the group logic.

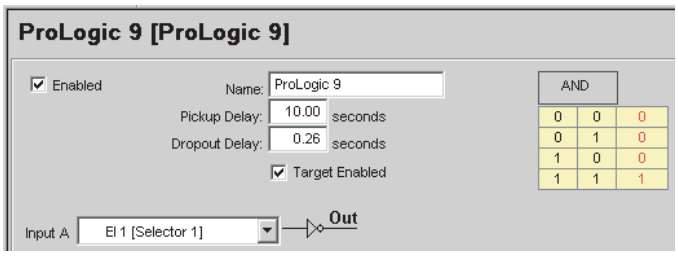


Figure A.17: ProLogic 9

Prologic 10 has no intentional delay and becomes high for the combined drop-out time of ProLogic 9 and 10 equalling 0.52 seconds.

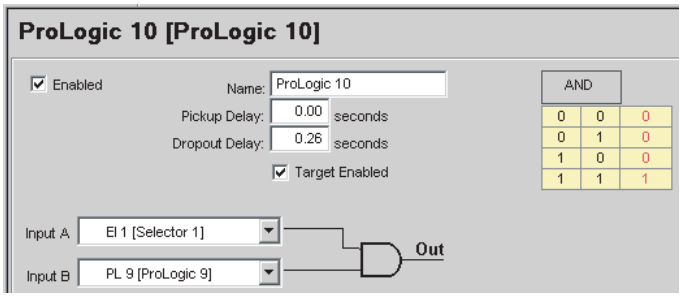


Figure A.18: ProLogic 10

Group Logic 1 is used to switch to the new setting group; there is no intentional delay.

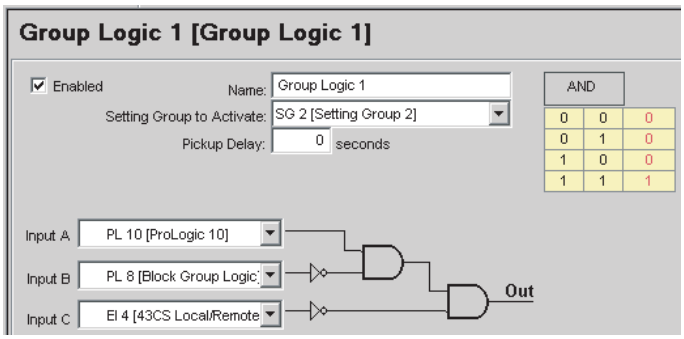


Figure A.19: Group Logic 1

Using Three External Inputs to Toggle Setting Group

Three external inputs connected to an eight position selector switch. The output contact is used to build a truth table to toggle between eight setting groups. In this example we connect EI 1, EI 2, and EI 3 to the selector switch output contacts.

Selector Switch	Input States			Setting Group to Activate
	EI 3	EI 2	EI 1	
1	0	0	0	Setting Group 1
2	0	0	1	Setting Group 2
3	0	1	0	Setting Group 3
4	0	1	1	Setting Group 4
5	1	0	0	Setting Group 5
6	1	0	1	Setting Group 6
7	1	1	0	Setting Group 7

Selector Switch	Input States			Setting Group to Activate
8	1	1	1	Setting Group 8

Setting Group 1…8 – Logic Statements

The following Group Logic statements are entered into each of the eight setting groups.

When the selector switch is rotated to the appropriate position the corresponding setting group becomes active. Each setting group logic can have a specific time delay pickup setting. You can also provide two additional logic inputs in each statement to be used to provide qualifiers before switching setting groups. We are using a ProLogic statement and an external input as qualifiers. For details see "Using ProLogic to Qualify Group Logic Statements" on page Appendix L-11.

EI 1 low, EI 2 low, and EI 3 low

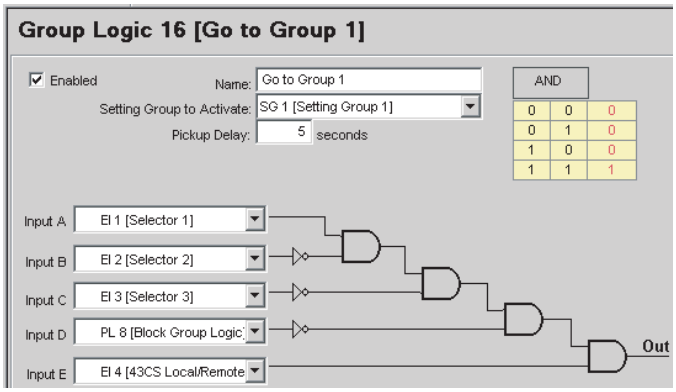


Figure A.20: Group Logic 16

EI 1 high, EI 2 low, and EI 3 low

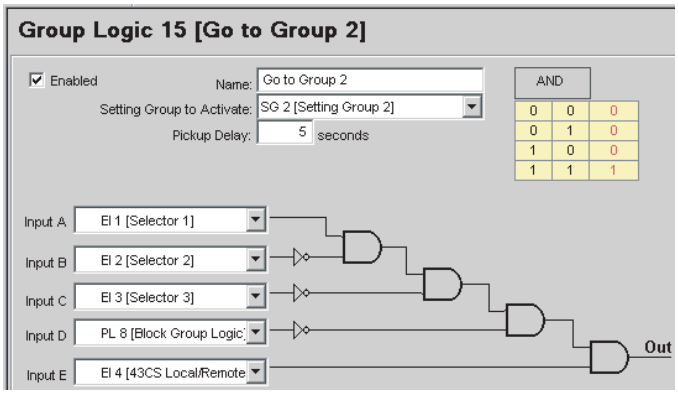


Figure A.21: Group Logic 15

EI 1 low, EI 2 high, and EI 3 low

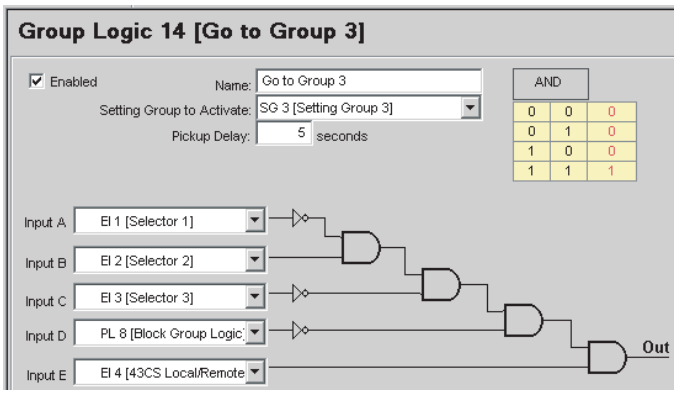


Figure A.22: Group Logic 14

EI 1 high, EI 2 high, and EI 3 low

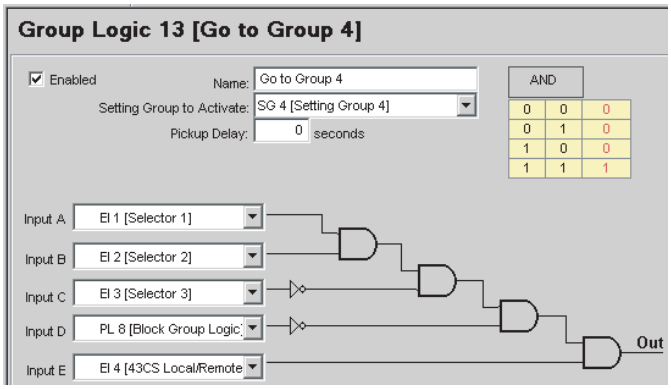


Figure A.23: Group Logic 13

EI 1 low, EI 2 low, and EI 3 high

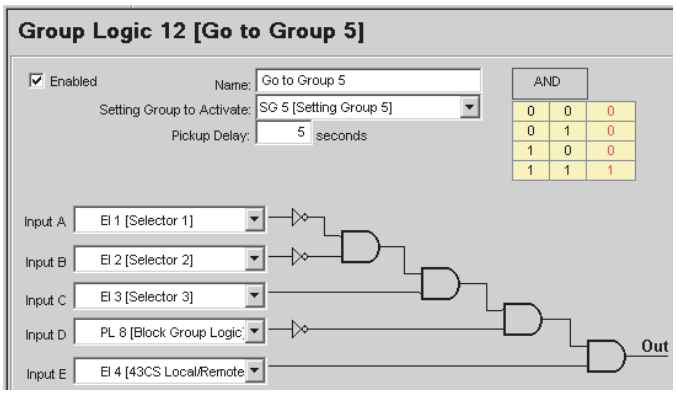


Figure A.24: Group Logic 12

EI 1 high, EI 2 low, and EI 3 high

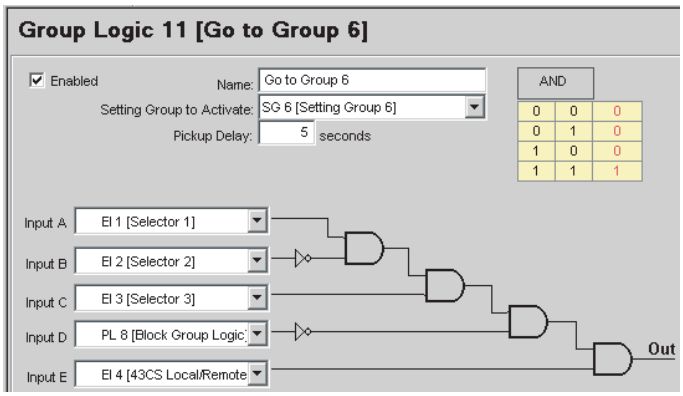


Figure A.25: Group Logic 11

EI 1 low, EI 2 high, and EI 3 high

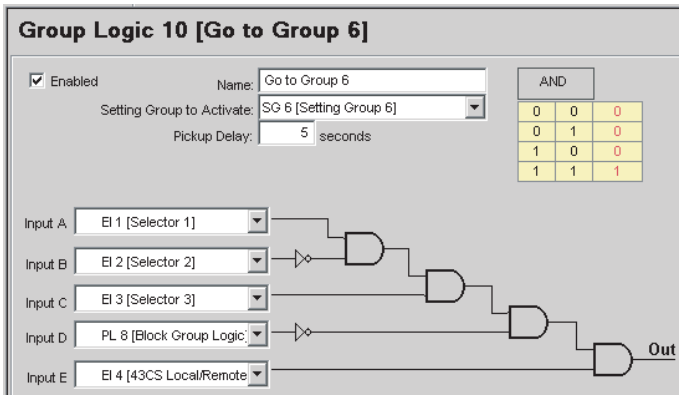


Figure A.26: Group Logic 10

EI 1 high, EI 2 high, and EI 3 high

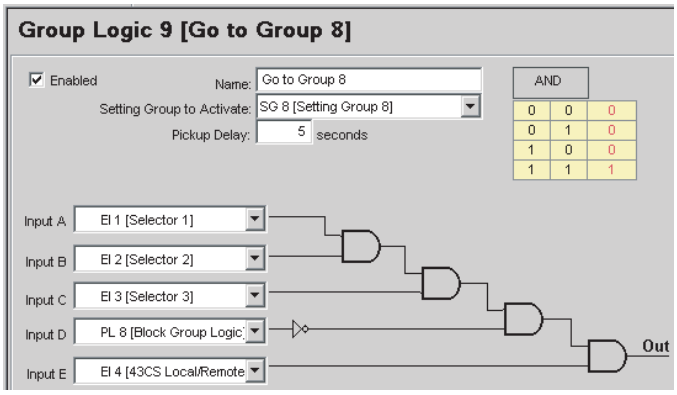


Figure A.27: Group Logic 9

Using ProLogic to Qualify Group Logic Statements

You can select from any available ProLogic inputs to make specific blocking logic to be used as a qualifier for any group logic decisions. In this example we use either the 50 or 50N elements to drive the Block Group Logic statement. There is no intentional pickup delay and 0.5 second drop-out delay to hold the block on after the block condition has reset

.

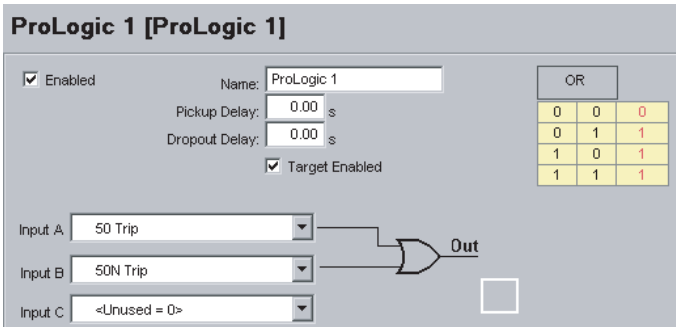


Figure A.28: ProLogic 8

Index

Software Installation Instructions

The CD-ROM contains software and the User Manual for the F-PRO Feeder Protection Relay.

Software is installed directly from the CD-ROM to a Windows PC.

The CD-ROM contains the following:

- F-PRO *Offliner* Settings: Offline settings program for the F-PRO relay
- F-PRO Firmware: Firmware and installation instructions.
- F-PRO User Manual: F-PRO manual in PDF format

To Install Software on your Computer

Insert the CD-ROM in your drive. The CD-ROM should open automatically. If the CD-ROM does not open automatically, go to Windows Explorer and find the CD-ROM (usually on D drive). Open the F-PRO.exe file to launch the CD-ROM.

To install the software on your computer, click the desired item on the screen. The installation program launches automatically. Installation may take a few minutes to start.

To view the F-PRO User Manual you must have Adobe Acrobat on your computer. If you need a copy, download a copy by clicking on Download Adobe Acrobat.