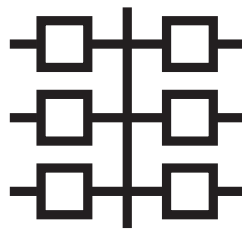




B-PRO

Bus Protection Relay

Model 8700/BUS



User Manual

**Version 2.1 Rev 1
D01908R02.11**

Preface

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Version Compatibility and Release History

This chart indicates the versions of *Offliner* Settings, RecordBase View and the User Manual which are compatible with different versions of B-PRO firmware.

RecordBase View and *Offliner* Settings are backward compatible with all earlier versions of records and setting files. You can use RecordBase View to view records produced by any version of B-PRO firmware and *Offliner* Settings can create and edit older setting file versions.

Minor releases (designated with a letter suffix - e.g. v1.1a) maintain the same compatibility as their base version. For example, B-PRO firmware v1.1b and *Offliner* Settings v1.1a are compatible.

B-PRO 8700/BUS Firmware/Software Compatibility Guide

| B-PRO Firmware | Record Version | Setting Version | Compatible <i>Offliner</i> Settings | Compatible RecordBase View |
|----------------|----------------|-----------------|-------------------------------------|----------------------------|
| v2.1a | 9 | 4 | v2.1 or greater | v1.5d or greater |
| v2.1 | 9 | 4 | v2.1 or greater | v1.5d or greater |
| v2.0 | 9 | 3 | v2.0 or greater | v1.5d or greater |
| v1.1 | 9 | 2 | v1.1 or greater | v1.4 or greater |
| v1.0 | 8 | 1 | v1.0 or greater | v1.1 or greater |

B-PRO 8700/BUS Firmware Revision History

| Date | Version | Changes from Previous Version |
|-------------|---------|--|
| 2007 Mar 14 | v2.1a | Improved 87B security |
| 2006 Jun 29 | v2.1 | Improved 87T target on wye-connected transformers Separated MVA settings for Bus 1 and Bus 2 Added invert switch on each digital control Extended transformer MVA setting range Increased external input glitch filter security Added support for a backup DNP SCADA Master |
| 2004 Jul 30 | v2.0 | Added multi bus differential zones (87B-1 and 87B-2). Added 30 virtual inputs for SCADA controls. Added swing recording. Added IO and IR recording to 87T. Extended Bus MVA setting range. |
| 2004 May 5 | v1.1c | Corrected SCADA protocol errors |

B-PRO 8700/BUS Firmware Revision History

| | | |
|-------------|-------|--|
| 2004 Mar 24 | v1.1b | Improved the Self Check algorithm to detect DC offset faster. Fixed reporting of time synchronization status in records. Fixed handling of user-specified IP addresses with leading zeros. |
| 2003 Jan 17 | v1.1a | PT Turns Ratio on the System Parameters screen expanded to allow a setting up to 10000:1. |
| 2002 Aug 08 | v1.1 | Add CT saturation detector. Standardized 51 IEEE parameters, user-defined directional characteristics. Increased 81 sensitivity for minimum time delay. |
| 2001 Mar 07 | v1.0 | First release. |

B-PRO 8700/BUS Offliner Settings Revision History

| Date | Offliner Settings Version | Changes from Previous Version |
|-------------|---------------------------|---|
| 2006 Jun 29 | v2.1 | Separated MVA settings for Bus 1 and Bus 2 Added invert switch on each digital control Extended transformer MVA setting range |
| 2004 Jul 30 | v2.0 | Added multi bus differential zones (87B-1 and 87B-2). Added 30 virtual inputs for SCADA. Added swing recording capability. Extended Bus MVA setting range. |
| 2003 Jan 17 | v1.1b | PT Turns Ratio on the System Parameters screen expanded to allow a setting up to 10000:1. |
| 2002 Sep 18 | v1.1a | Correct an error in ProLogic input list. |
| 2002 Aug 12 | v1.1 | Add CT saturation detector. Standardized 51 IEEE parameters, user-defined directional characteristics. |
| 2001 Mar 07 | v1.0 | First release. |

B-PRO 8700/BUS User Manual Revision History

| Date | Manual Version | Changes from Previous Version |
|-------------|----------------|---|
| 2007 Mar 14 | v2.1 Rev 1 | Update to include firmware v2.1a support |
| 2006 Jun 29 | v2.1 | Update to include firmware v2.1 support |
| 2004 Jul 30 | v2.0 Rev 1 | Update to include firmware v2.0 support |
| 2004 May 5 | v1.1 Rev 5 | Minor consistency improvements |
| 2004 Mar 24 | v1.1 Rev 4 | Update to include firmware v1.1b support. |

B-PRO 8700/BUS User Manual Revision History

| | | |
|-------------|------------|---|
| 2003 Oct 31 | v1.1 Rev 3 | Updated format of manual. |
| 2003 Jan 17 | v1.1 Rev 2 | PT Turns Ratio on the System Parameters screen expanded to allow a setting up to 10000:1. |
| 2002 Aug 12 | v1.1 | Update to include new functions. |
| 2001 Aug 14 | v1.0 Rev 2 | Update Setup and Communications. |
| 2001 Mar 07 | v1.0 | First release. |

Using This Guide

This user manual describes the installation and operation of the B-PRO bus protection relay user interface software. 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 |
|---|---|
| <i>Start>Settings>Control Panel</i> | Choose the Control Panel submenu in the Settings submenu on the Start menu. |
| Right-click | Click the right mouse button. |
| <i>Recordings</i> | Menu items and tabs are shown in italics. |
| service | User input or keystrokes are shown in bold. |
| Text boxes similar to this one | Relates important notes and information. |
| .. | Indicates more screens. |
|  | Indicates further drop-down menu, click to display list. |
|  | Indicates a warning. |

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1 Overview

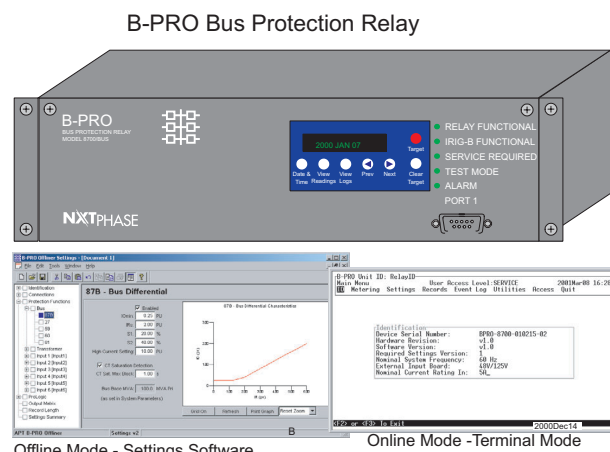
The B-PRO (model 8700/BUS) is a microprocessor-based relay providing bus differential protection, integrated breaker failure and overcurrent protection functions, metering, fault and swing oscillography.

B-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 B-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



The B-PRO relay provides differential protection (low-impedance) for the following types of bus configurations:

- 1 bus with up to six inputs and one set of voltage inputs (Figure 1.7).
- 1 transformer zone with 2 inputs.
- 2 differential zones, 1 for a bus and 1 for a transformer (Figure).
- 2 bus zones (Figure 1.9).

Backup feeder protection is provided for all inputs, regardless of which zone is selected, even if an input is not used in a differential zone.

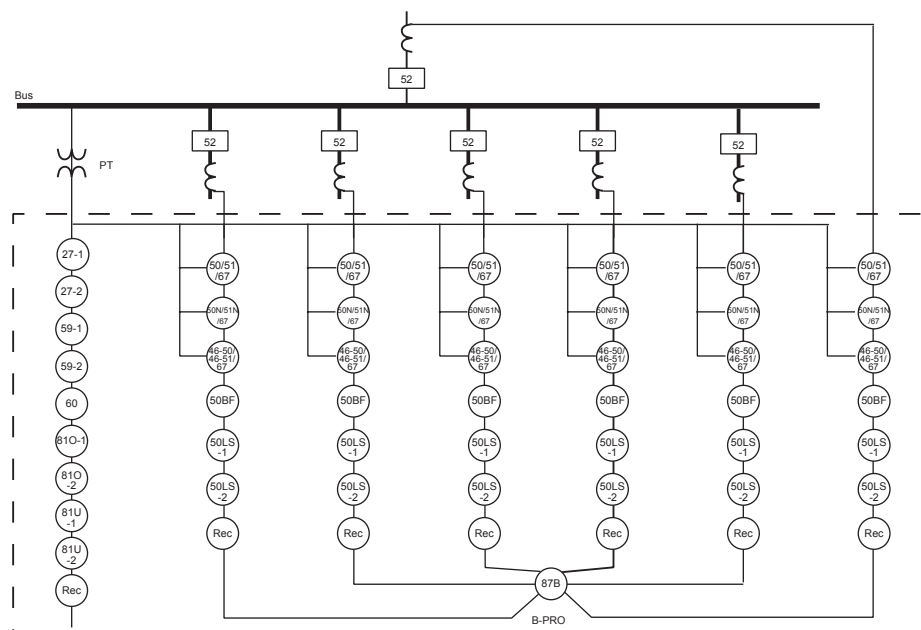


Figure 1.7: B-PRO Function Diagram (1 differential zone)

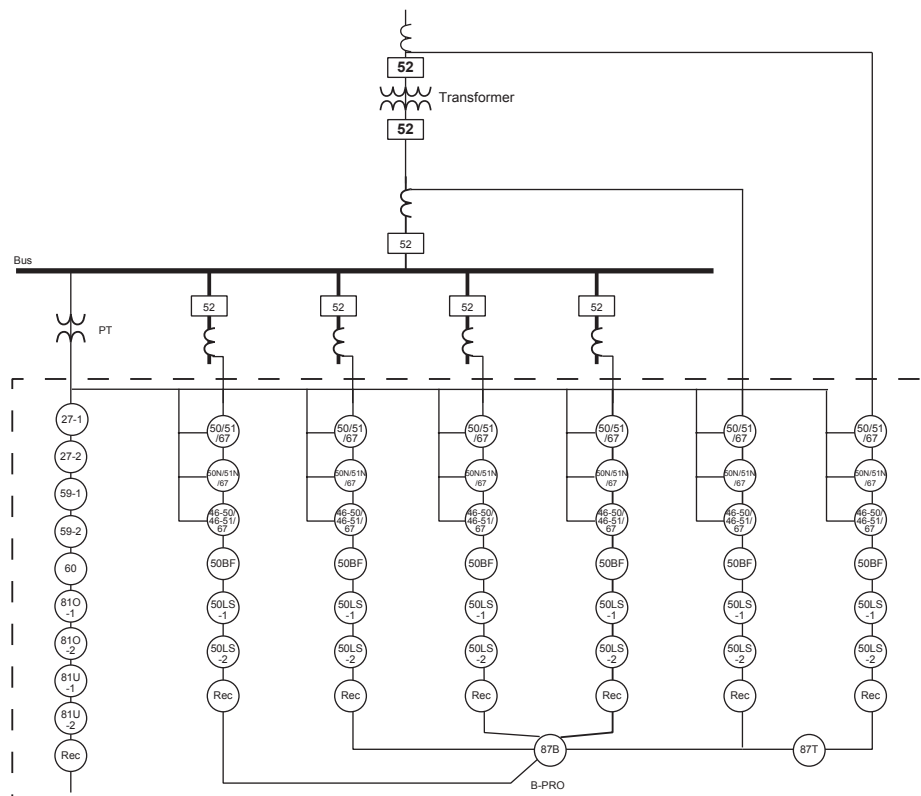


Figure 1.8: B-PRO Function Diagram (2 differential zones, 1 Bus & 1 Transformer)

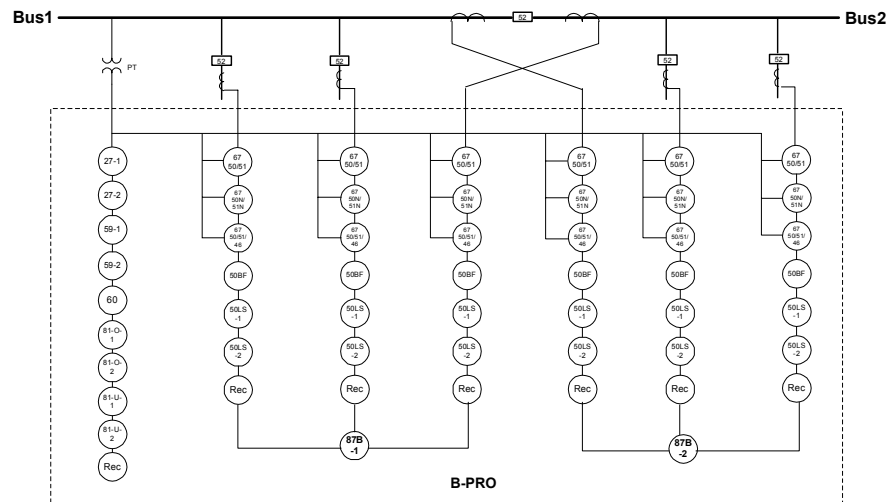
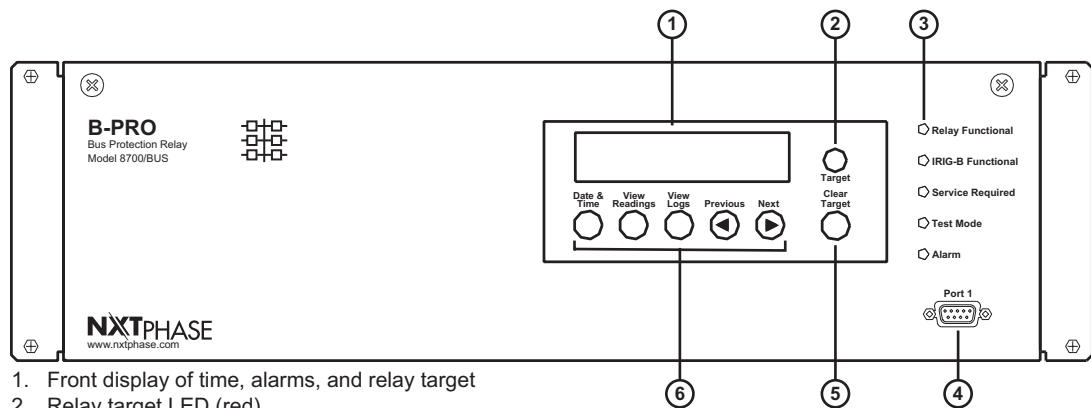


Figure 1.9: B-PRO Function Diagram (2 differential zones: Bus1 and Bus2)

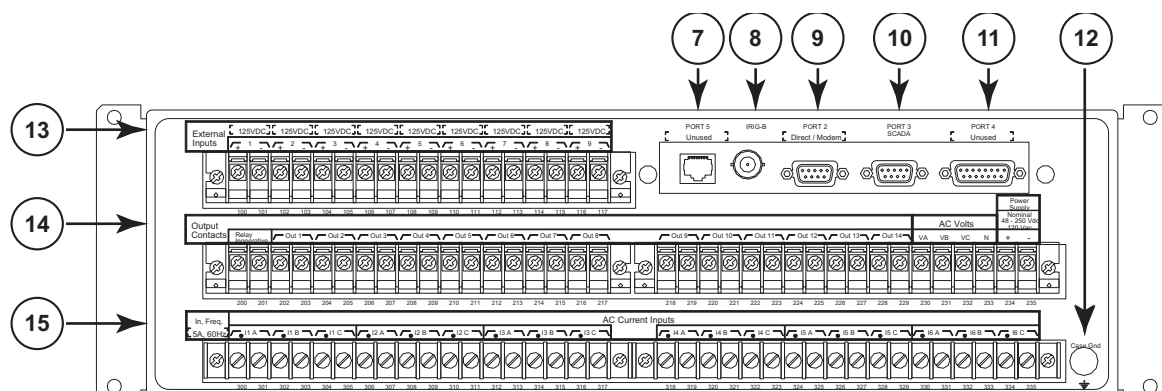
Front View



1. Front display of time, alarms, and relay target
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 1.10: B-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 inputs
14. This row contains 4 distinct areas from left to right:
 - Relay Inoperative contact
 - 14 programmable output contacts
 - 3 ac voltage inputs
 - power supply
15. 18 ac current inputs

Figure 1.11: B-PRO Back View

AC Current and Voltage Inputs

B-PRO is provided with terminal blocks for up to 18 ac currents and 3 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 B-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.

To prevent an external input from picking up on spurious voltage pulses, a software filter is applied to the input signals. The filter ignores logic high voltage levels that occur for less than 2 milliseconds. This was increased from 700 microseconds in firmware version 2.1.

Output Relay Contacts

The B-PRO relay has 14 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

B-PRO is available as a horizontal mount, for details see “Mechanical Drawings” in Appendix G.

B-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 to 250 Vdc, 120 Vac, 50/60 Hz. To protect against a 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 the station ground using the case-grounding terminal at the back of the relay, for details see for details see Figure 1.10: B-PRO Front 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 can enable or disable the IEEE 1344 extension in the terminal mode settings *Utilities>Setup>Time*. The enabled mode receives the year from the IRIG-B signal. Disable this setting, if the available IRIG-B signal has no year extension.

Communicating with the Relay (IED)

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

- 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

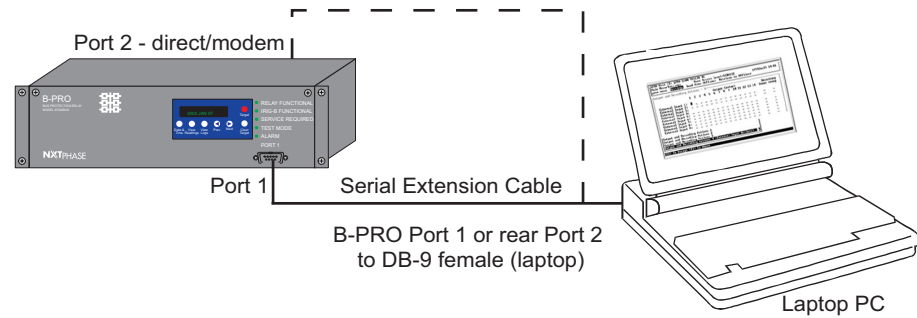


Figure 2.1: Direct Serial Link

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 SCADA Services" on page 2-8.

Modem Link - External

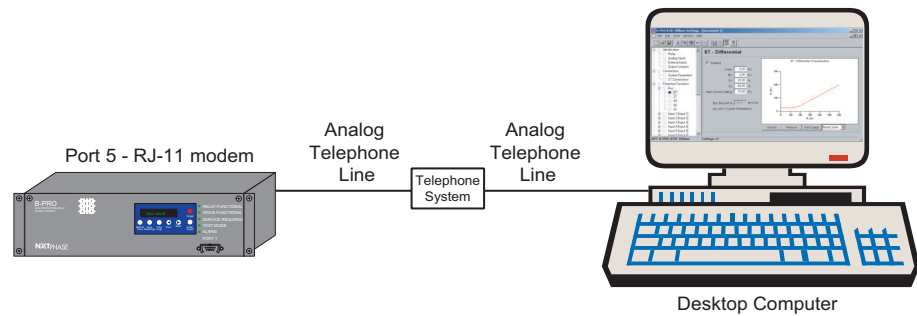


Figure 2.2: External Modem Link

Using an external modem, you can also access the relay's user interface through a telephone link between the relay and your computer.

Connect the serial port on the external modem to 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 NxtPhase 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.

You must appropriately configure the relay's Port 2 to work with a modem. Log into the relay through a direct serial link, go to the *Utilities>Setup>Ports* screen, and set *Port 2 Modem* option to *Yes*. Set the *Baud Rate* as high as possible — most modems handle 57,600 bps. The *Initialize* setting allows you to 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

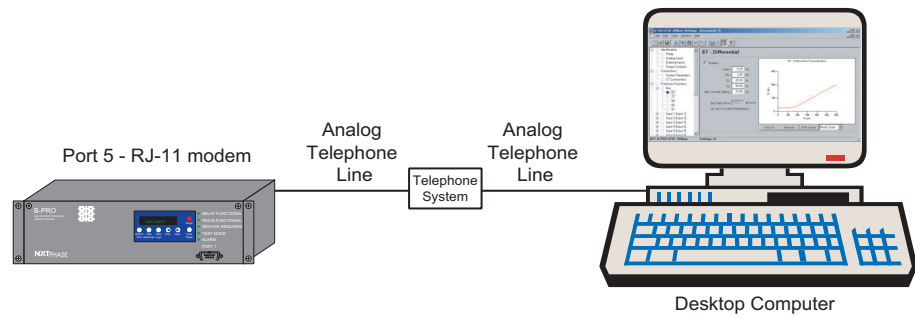


Figure 2.3: Internal Modem Link

Figure 2.4: Internal Modem Link

You can access the relay's user interface 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 is 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

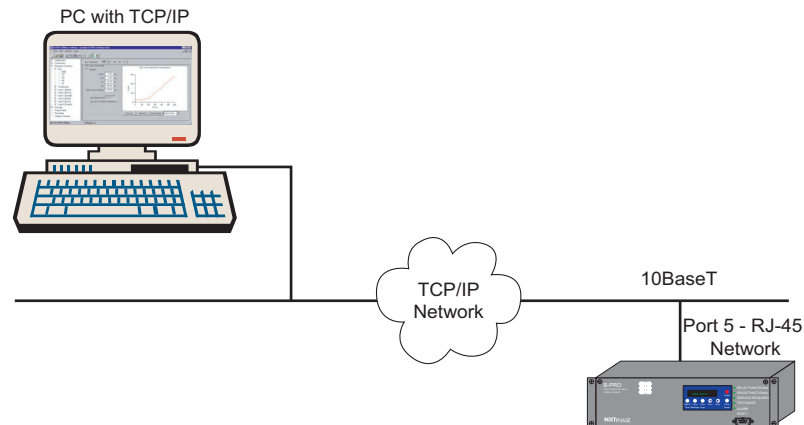


Figure 2.5: Network Link

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 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 |
| Emulation | VT100 |

| Terminal Program Setup | |
|------------------------|--|
| 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 a 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 B-PRO 8700 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)
'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 for logging in and running the user interface are given in “Terminal Mode” on page 3-4.

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 closes the interface and requires the next user to login 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) 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:

- 3 Access the relay's user interface through any of the available ports.
- 4 Login to the user interface and go to the *Utilities>Setup>Ports* menu, for details see "Terminal Mode" on page 3-4.
- 5 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 login to it.

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

- 1 From HyperTerminal bring up the *Properties* dialog box, 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 in "Modem Link - External" on page 2-3, except that you modify the Port 2 baud rate on the relay and the properties of the modem in HyperTerminal.

Accessing the 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 "Modbus RTU Communication Protocol" in Appendix E and "DNP3 Communication Protocol" in Appendix F.

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.

Ensure the Master IP Address is different from the relay's IP Address.

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 accessed 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: <ul style="list-style-type: none"> • User interface access through a direct serial connection. • User interface access through an external modem. The optional NxtPhase 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: <ul style="list-style-type: none"> • Used for user interface access through modem. When equipped with optional internal Ethernet card: <ul style="list-style-type: none"> • 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.

```
NxtPhase System Utility v1.3
NxtPhase
Customer support : (204) 477-0591, support@nxtphase.com

1 : Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : Restore ALL default settings, including calibration
5 : Restore only default configuration settings (channel definitions, device se)
6 : Restore only default system setup (ports, time settings)
7 : Force hardware reset
8 : View network statistics (if applicable)
9 : Monitor SCADA
10 : Enable/Disable Internal Modem (if one exists)
11 : Exit

Please enter a command:
[1-11] # _
```

| |
|---|
| 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. |

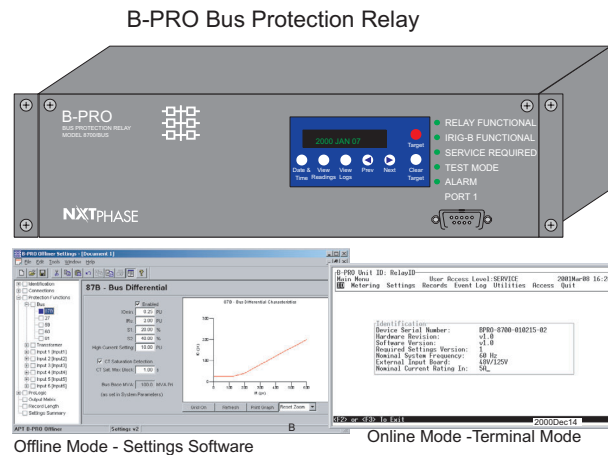
Firmware Update

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 B-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)



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 B-PRO:

- Front panel display
- Terminal Mode
- *Offliner* Settings software (Details in Chapter 5-1)

Front Panel Display

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

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

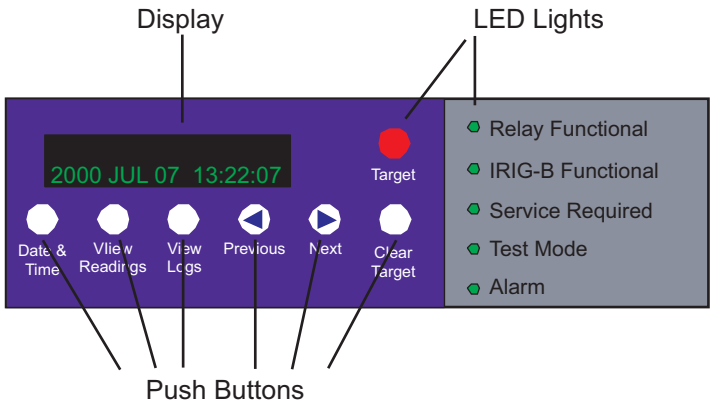


Figure 3.1: Front Panel Display

The front panel consists of a display, six LED lights and six push buttons.

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 where the LED is on. |
| 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: <ul style="list-style-type: none">• 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: <ul style="list-style-type: none">• Relay initialization on startup• 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. |

| | |
|--------|--|
| 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 <i>View Logs</i> button. |
| Target | Indicates that a fault has taken place. In the output matrix select which output contacts you want to activate when an alarm occurs. |

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 <i>Utilities>Setup>Time</i> 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 lines, for details see "Metering Data" on page 3-14. |
| View Logs | Pressing the View Logs button displays the target information, if a relay operation has occurred. |
| Previous/Next | Scroll through the menu by pressing Previous and Next. When the Date & Time is being displayed, pressing either of these buttons will display the Port 1 and Port 2 baud rates. |
| Clear Target | Use the Clear Target button to view all target information. When a fault takes place, the red target light appears. 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. |

Display

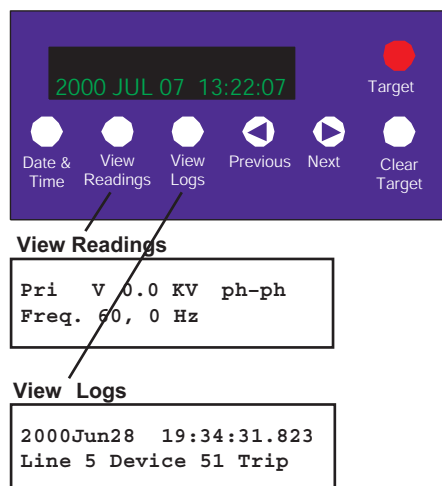


Figure 3.2: Display Examples

| Front Panel Display Messages |
|---|
| PRI V, Frequency |
| Va, Vb, Vc magnitude and angle of bus PT |
| Ia, Ib, Ic magnitude and angle of each CT input |
| P and Q of each line |
| Tripping device targets, times and dates |

For a detailed description of the metering data provided by the relay, see "Metering Data" on Page 3-14

Terminal Mode

The Terminal User Interface (TUI) is the main method of interaction between the relay and the user. From here the user can set the relay, load a setting file, view metering information, create and retrieve recordings, view logs, set-up system parameters and review system information. The following steps describe how to access the TUI.

Accessing TUI

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

- 2 When the 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 B-PRO 8700 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)
'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:

```

- 3 Login as one of **view**, **change** or **service** (lower case). These three login names provide differing levels of permission, for details see “Access Levels” on page 3-5. Maintenance and Update are explained in “Maintenance Menu” on page 2-12 and “Firmware Update” on page 2-13.

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.

- 4 If login is successful, the Main Menu appears:

```

B-PRO Unit ID: UnitID
Main Menu      User Access Level: VIEW      2004 Jun28 11:49
ID Settings  Metering  Records  Event Log  Utilities  Access  Quit

```

view, change or service
(depends on how you log in)

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. Also ensure that emulation is set to VT100 (not VT100J).

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.

Access Levels

The relay supports three 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, online readings and logs. List and retrieve records. At this level you cannot affect the operation of the controller. |
| 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 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

The menu tree consists of a series of sub-menus, which branch off from the Main Menu. For a map of the structure see "Terminal Mode Menus" on page 3-7. The features of the terminal mode screen are shown in Figure 3.3: "Terminal Mode Features", and explained below.

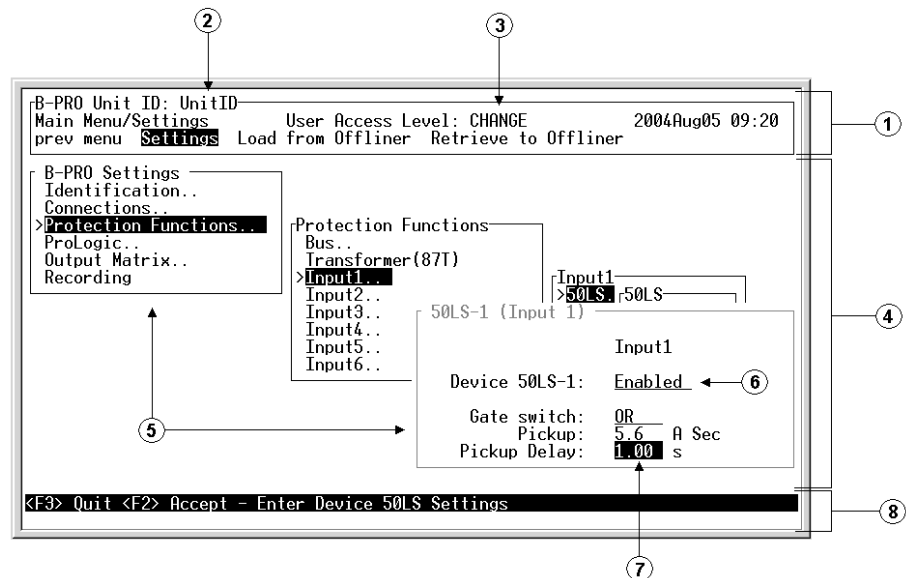


Figure 3.3: Terminal Mode Features

- 1 Main Menu Bar - This is where the menus are accessed. Use the right and left arrow keys to move the highlight. Items are selected using the <Enter> key. As a short-cut, use the first letter of the menu item to access it directly. The <Esc> key will take you back to the previous menu level.
- 2 Unit ID display - This is where the user-defined unit ID is displayed.
- 3 Access Level display - This is where the access level that you are logged in at is displayed.
- 4 Sub-Menu screen Area - This area is used when information is being displayed to or entered by the user.
- 5 Sub-Menu screens - There are two types, Intermediate and Data Entry/Display screens.
 - a. Intermediate screen - Used to navigate through menu system to the individual data entry/display screens. These screens are only used in the Settings>Settings menu. Use the arrow keys to move the highlight up, down, left or right through the screens. Items are selected using the <Enter> key. Using <F2> and <F3> will get you back to the Main Menu Bar. The difference is that <F2> will save settings and <F3> will not. The "." after an item means that there are more sub-menus. If not then the data entry/display screen for that menu item will be displayed.
 - b. Data Entry/Display screen - Used to display and/or change data. These screens can include a variety of information including settings, record lists, event logs, utility settings, etc. This also includes screens where commands are made, such as calibration, controlling output contacts, etc. Use the arrow keys to move the highlight up, down, left or right through the screens. Using <F2> or <F3> at this point will take you back to the previous inter-

mediate screen. The difference is that <F2> will save the changes that were made and <F3> will leave the data intact.

In Figure 3.3, the screens with the heading "B-PRO Settings" and "Protection Functions" are examples of intermediate screens and "50LS-1 (Input 1)" is an example of a Data Entry/Display screen

- 6 List - Used in Data Entry/Display screens. Toggles through a list of entries. Ex. Enabled/Disabled. Pressing the <Enter> key toggles forward through the list and the <Space Bar> toggles backwards through the list. For long lists such as those found in the ProLogic screen, a drop-down box will appear that displays multiple selections. In this case you can also use the up and down arrow keys to scroll through the list. Pressing <u> or <d> will scroll through the list up or down one page at a time. In all cases, press <F2> to accept the setting or <F3> to close the box with no changes.
- 7 Entry Box - Used in Data Entry/Display screens. Enter text or numbers, where appropriate.
- 8 Status Bar - Provides clues and information about entering data.

| Key | Function |
|-------------------------------|---|
| <F2> | Accept or Freeze or Execute |
| <F3> | Quit or Exit |
| <Esc> | Back to previous menu level |
| <Enter> | Select or toggle forward |
| <Space Bar> | Toggle backward |
| <Up>, <Down>, <Left>, <Right> | Moves the highlight in the direction specified by the key pressed |

Note: the mouse does not work in VT100 terminal mode.

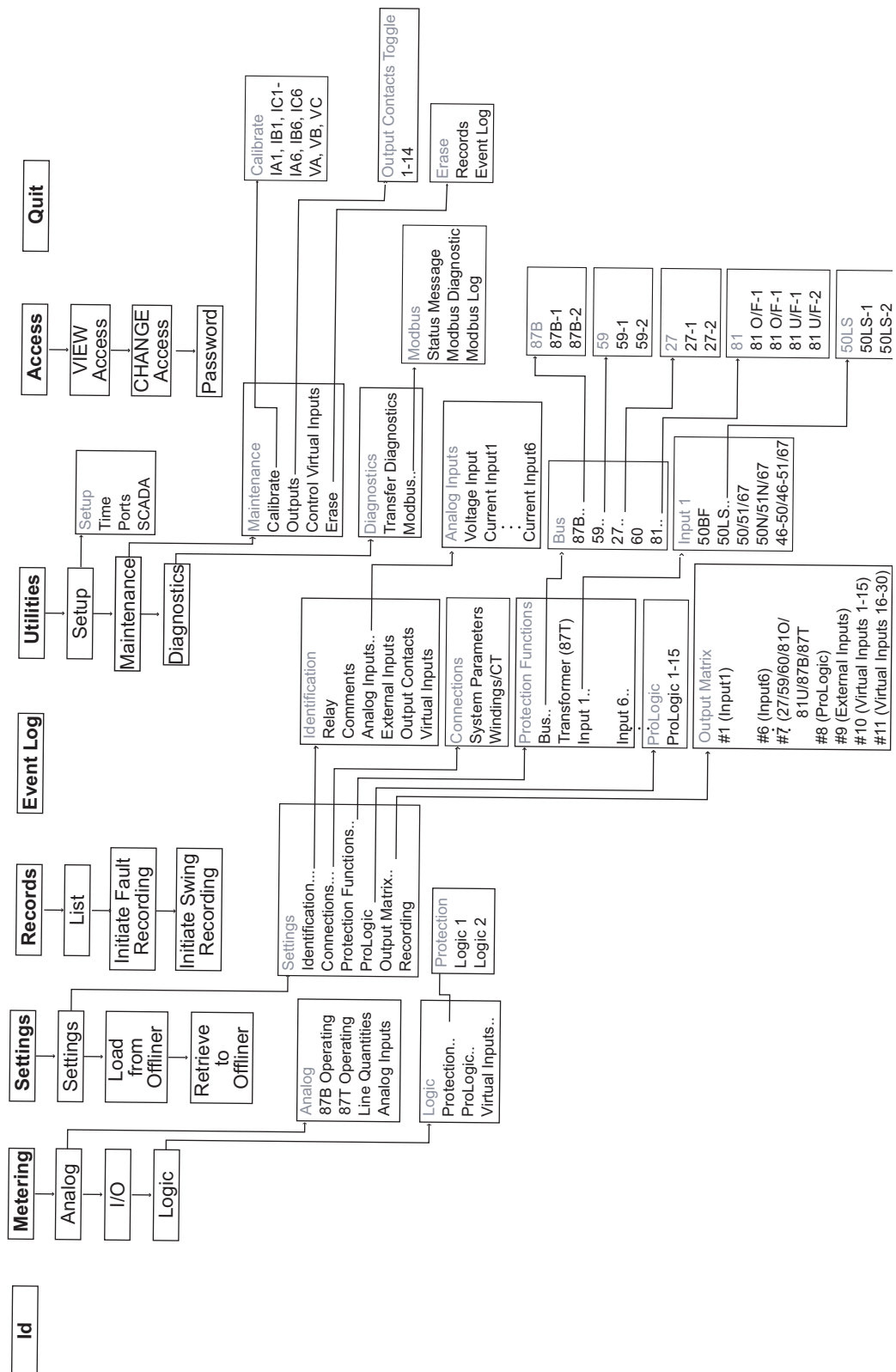


Figure 3.4: Terminal Mode Menus

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.

Metering

Submenus: Analog, I/O, Logic

| | |
|-----------------|---|
| Analog | |
| 87B Operating | Provides information about operating and restraint current for 87B-1 and 87B-2. |
| 87T Operating | Provides information about operating and restraint current for 87T. |
| Line Quantities | Provides primary MW and MVAR of each CT input. |
| Analog Inputs | Provides secondary values of the ac analog voltages and currents. |

| | |
|-----|--|
| I/O | |
| I/O | Displays the state of the external inputs and the output contacts. |

| | |
|-------------------|--|
| Logic | |
| Protection/Logic1 | Provides the present status of the internal logic states. |
| Protection/Logic2 | Provides the present status of the internal logic states. |
| ProLogic | Provides the present status of the ProLogic states. When a logic level becomes active, its state changes from low to high. |
| Virtual Inputs | Displays the state of the virtual inputs. |

Settings

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

Settings

Settings includes all the submenus pertaining to protection functions used to create a relay setting. When these settings are made or changed, you can load them into the relay allowing input of all settings information for the relay.

| | |
|---|---|
| Setting Submenus (Refer to Figure 3.4: "Terminal Mode Menus") | |
| Identification | These screens are where relay/station information can be entered, as well as names for the relay I/O. |
| Connections | These menus contain the settings that are used to define the primary system that is connected to the relay. Settings such as Bus Base MVA, Nominal Voltage Level are made in the System Parameters screen. The Windings/CT screen contains settings such as differential zone, CT ratio settings, transformer settings and digital control. |
| Protection Functions | These menus are used to make the individual settings for the various protection devices provided by the relay. Each of the sub menus above can be broken further into sub menus for the different protective zones available. |
| ProLogic | This where each ProLogic statement that is provided by the relay can be defined. There are 15 ProLogic statements available in the relay, so there are 15 screens. |

| | |
|---------------|--|
| Output Matrix | This is where the relay's protection devices, external inputs, virtual inputs, and ProLogics can be configured to close output contact(s) or trigger recordings. |
| Recording | This screen contains the settings for setting the length of fault and swing recording. |

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 B-PRO *Offliner* 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 B-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 B-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.

Records

Submenus - List, Fault Recording, Swing Recording.

Contains the means for initiating and examining recordings.

| | |
|-----------------|---------------------------|
| List | Lists all fault records. |
| Fault Recording | Creates one fault record. |
| Swing Recording | Creates one swing record. |

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. While viewing the Event Log, the event list must be manually refreshed in order to display new events. 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 21 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, reset and pulse virtual inputs. Pulse width is 1 second. Latched virtual inputs reset after pulse command has executed. Requires change or service access level. |
| Erase | Use submenus Records and Event Logs to erase these records from the relay memory. Requires change or service access level. |

| | |
|----------------------|---|
| Diagnostics | |
| Transfer Diagnostics | Transfers relay diagnostic file to the PC. The diagnostic file can be sent to NxtPhase 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, CHANGE Access, Password.

| | |
|----------|---|
| View | Changes the access level to view. Allows you read-only access to relay information. |
| Change | Changes the access level to change. Allows you to modify settings and delete records. |
| Password | Allows you to read and change passwords. Requires service access level. |

Quit

Selecting this option ends communication with the relay.

Metering Data

Front Panel Metering

The quantities provided on the front panel display include:

- Positive (primary) sequence L-L voltage
- Positive sequence frequency
- Phase to neutral bus voltage
- Inputs 1 to 6 A, B and C phase currents
- P and Q for each input

All quantities are in primary unless otherwise noted.

TUI Metering

The TUI provides the following metering quantities.

Analog/87B Operating

Provides the values of IO and IR for both the 87B-1 and 87B-2. It also displays the enabled/disabled status of the 87B-1 and 87B-2 protection functions. This screen is useful when testing.

Analog/87T Operating

Provides the values of IO and IR for both the 87T. It also displays the enabled/disabled status of the 87T protection function. This screen is useful when testing.

Analog/Line Quantities

Displays the P/Q information for each feeder, as well as the positive sequence L-L voltage and positive sequence frequency. All quantities are in primary values unless otherwise stated.

Analog/Analog Inputs

Displays all secondary values of the voltage and current inputs.

I/O

Displays the status of all external inputs and output contacts.

Logic/ProLogic

Displays the status of all ProLogic.

Logic/Protection/Logic 1

Displays the High/Low status of the 50LS, 50BF, 50/51/67, 50N/51N/67 and 46-50/46-51/67 for each input.

Logic/Protection/Logic 2

Displays the High/Low status of the 87B and 87T tripping/blocking/restraining functions, also including the 59, 27, 60 alarm, 81 High/Low status.

Logic/Protection/Virtual Inputs

Displays the status of all Virtual Inputs.

4 Protection Functions

Differential Zone Selection and CT Input Assignment

The B-PRO can be configured for a number of different differential zones. These zones are defined as:

- Bus1
- Bus1 and Transformer
- Transformer Only
- Bus1 and Bus2

Bus1 zone allows up to 6 current inputs to be used in the bus differential zone (87B-1). All CT's used for Bus Protection must be wired in wye.

Bus1 and Transformer zone allows up to 5 current inputs to be used for the bus zone and 2 inputs for the transformer zone. In this configuration, Input 5 is used for both the bus zone and the transformer zone. Inputs 1-4 are used for the bus zone. Input 6 is used for the transformer zone only. Inputs 1-5 must be wired in wye, but input 6 can be wired in wye or delta.

Transformer Only zone uses inputs 5 and 6 in the transformer differential zone (87T). Input 5 must be wired in wye, but input 6 can be wired in wye or delta.

Bus1 and Bus2 are used where 2 zones of bus differential protection are desired. In this case the maximum number of inputs that can be assigned to one zone is 4, with the minimum being 2. 87B-1 settings define the first differential zone and 87B-2 settings define the second.

In all cases, if a CT input will not be used, it should be set to "NC" or "not connected". This will remove this current input from any differential calculations. The CT input overcurrent functions and recording are still available.

Digital Control

Each CT input can be automatically excluded from all relaying, metering and recording functions based on the status of an associated external input. To set this feature, the Digital Control of the CT input must be enabled, the associated external input selected, and the state of "Exclude When" set. The CT input will be automatically excluded from all relaying, metering and recording functions when the status of the associated external input agrees with the "Exclude When" setting. This feature can be used to automatically adjust the CT inputs of a differential zone based on the changes in the bus configuration. The connections of "Exclude When" setting accommodates the use of "a" or "b" auxiliary contact as the digital control input.

Protection Function Descriptions

Bus Protection

87B-1 Bus Differential (Bus1 differential zone only)

Device 87B-1 is the main protection of the bus. It will operate for the internal faults and restraint for the external faults. Up to 6 CT inputs can be configured as the inputs of 87B-1 and controlled by external inputs. If external control is

enabled, and the corresponding external input is turned on, the ac analog current will be excluded from all relay metering and recording functions. There is no harmonic restraint provided for this function. Restraint quantities are summed; the magnitude sum is then divided by two. Operating quantities are summed vectors.

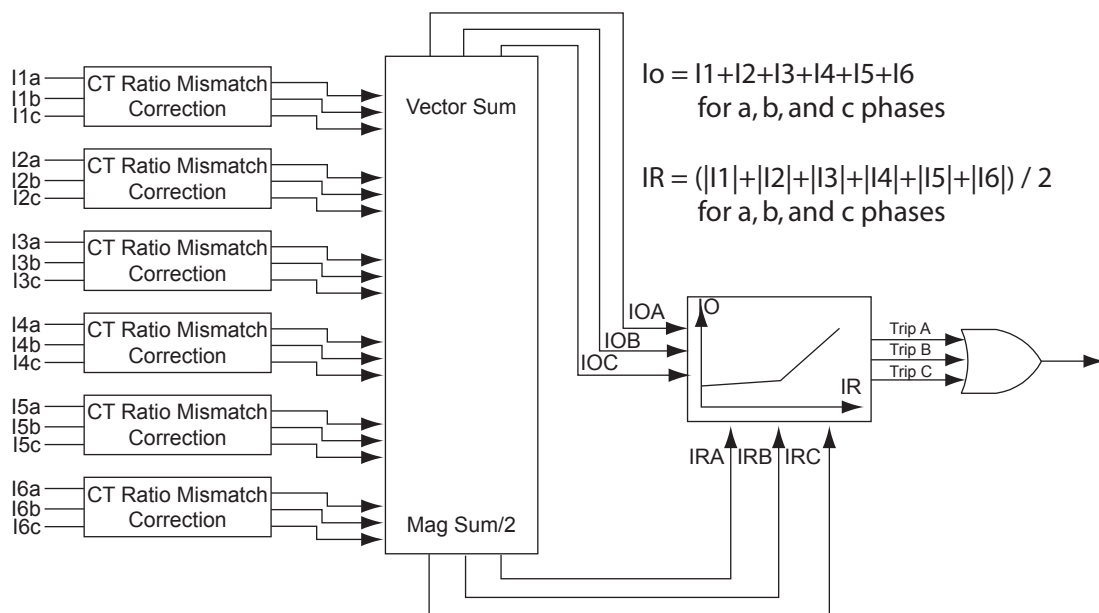


Figure 4.1: 87B-1 Bus Differential

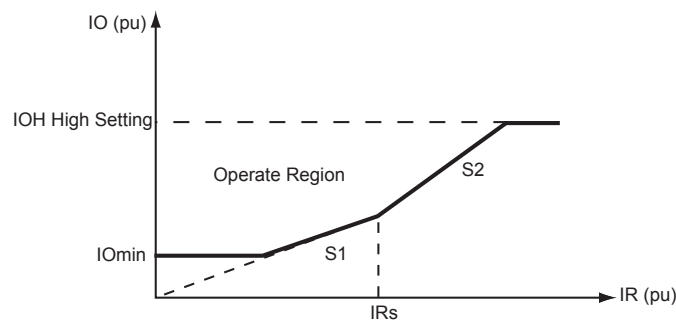


Figure 4.2: Bus Differential Characteristic

CT Saturation Detector

The B-PRO bus protection includes a significant improvement to the traditional two slope differential characteristic that provides immunity to CT mismatch and minimal CT saturation sensitivity for external faults. The CT saturation detector detects all CT saturation conditions for external faults and blocks the differential protection from operating.

The CT saturation detection and Trip-Blocking scheme are composed of two parts: the first part is to deal with the fast CT saturation, i.e. CT saturates in the first cycle after the fault occurs; the second part is to deal with the slow CT saturation, i.e. CT saturates after the first cycle.

Detection of Fast CT Saturation

Rather than examination of individual line fault currents for the presence of saturation, the detection method uses only IO and IR for its block/no-block decision. A novel algorithm (patent pending) has been developed to detect the fast CT saturation quickly, sensitively and accurately. The core of this algorithm is to check the phase relationship of dIO/dt and dIR/dt . For an internal fault, both IO and IR start to increase simultaneously and they are always kind of in phase. For an external fault, the phase dIO/dt is always lagging dIR/dt .

Detection of Slow CT Saturation

Sometimes CT does not saturate in the first cycle after the fault occurs due to the DC offset and the CT core remnant. Under these conditions, the algorithm described in above "Detection of Fast CT Saturation" could miss the detection of the changes of IR and IO, because of the limit of the sample window size in the DFT calculation. A "block zone" under the differential characteristic curve as shown in Figure 4.3 is defined to solve this.

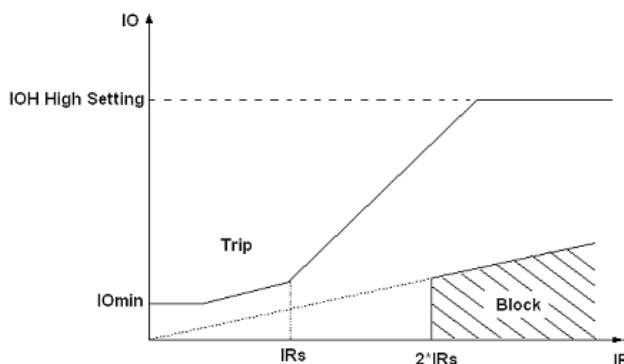


Figure 4.3: Detection of Slow CT Saturation

IRs is the setting parameter, which is normally set to be greater than the maximum bus transfer load. The block level is preset to 2 times of IRs for safety margin. The slope in the block zone is preset to 20% for safety margin to cover the maximum CT mismatch. Whenever the IO, IR trajectory is entered into the block zone, this algorithm for Slow CT Saturation Detection will set the block flag to block the differential element from tripping.

The CT saturation detector is simple to use and can be enabled or disabled. When enabled, you set a timer to control how long you want an external CT saturation condition to block the differential protection. Normally you would set this timer to be slightly longer than your maximum clearing time for an external fault.

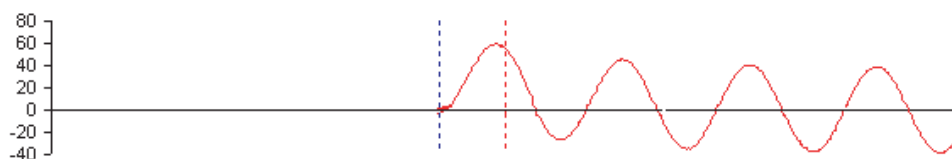


Figure 4.4: External Fault – Fully Offset Source Current

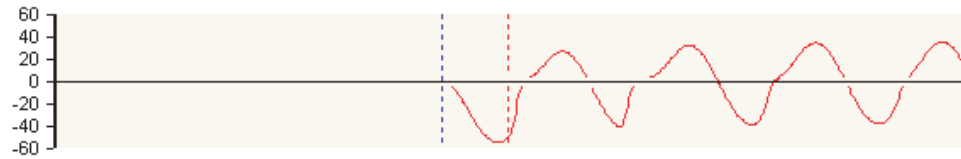


Figure 4.5: External Fault – CT Saturation

Additional Security

For additional security, some pickup delays are also applied to the differential protection function as described below.

IOmin and Slope1 (S1)

As shown in Figure 4.6, when the IO, IR trajectory enters into the trip zone from IOmin or slope1 region, a 6 ms (8 ms for 50Hz system) pickup delay is applied so as to be certain that the IO, IR trajectory has reliably come into the trip zone. To ensure the fast operating speed of 87B function for internal faults, IRs should be set to be greater than the maximum bus transfer load plus safety margin. The safety margin should be greater than S1/100 per unit. In this way, the IO, IR trajectories for internal faults are always entered into the trip zone from the IOmin and slope1 region rather than from the slope2 region under any pre-fault conditions.

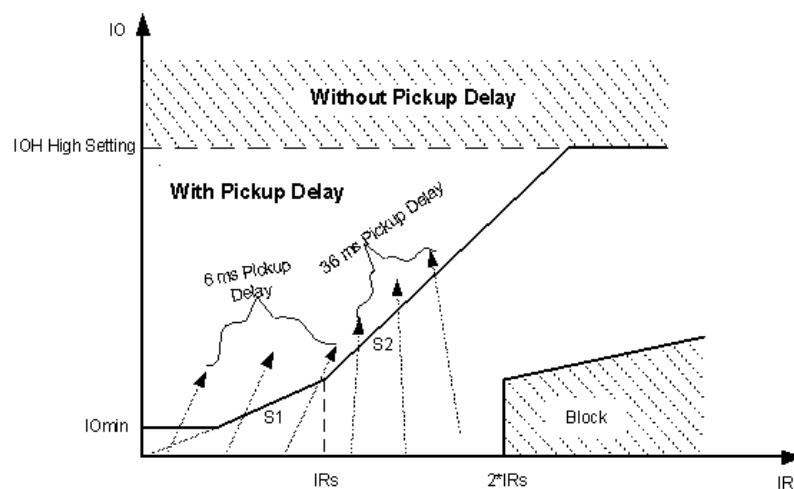


Figure 4.6: Pickup Delay for Additional Security

Slope2 (S2)

When a slow CT saturation occurs during an external fault as described in page 4-3, the IO, IR trajectory may enter the trip zone, but always from the slope2 region. In most cases when the slow CT saturation occurs, the IO, IR trajectory

will enter into the saturation block zone first so that the block flag will be set and 87B trip will be blocked accordingly. However, in some special situations when the fault current contains low AC current combined with high magnitude slow decaying DC current, the external fault current level may not be high enough to bring the IO, IR trajectory into the saturation block zone, but it might still bring the IO, IR trajectory into the trip zone from slope2 region for a short period of time (the CT recovers to normal quickly). In order to make the relay secure under these special situations, a 36 ms (45ms for 50Hz system) pickup delay is applied. As described before, this delay does not affect the operating speed for internal faults.

IOH High Setting

There is no any intentional delay as long as the IO exceeds the IOH setting threshold no matter where the IO, IR trajectory comes from. The purpose of the IOH zone is to clear the extremely severe bus internal faults as soon as possible

| | |
|--------------|--|
| IOmin | Minimum level that device 87 operates |
| IRs | Point of intersection between slope 1 and slope 2 of the characteristic |
| S1 | Slope of first part of characteristic meeting Io IOmin and slope 2 |
| S2 | Slope of second part of characteristic meeting slope 1 and high current unrestrained setting |
| IOH High Set | Heavy fault trip irrespective of restraint current. |

The differential relay setting parameters are defined in “Bus Differential Characteristic” on page 4-2, the restraint quantity for the bus differential is the sum of the restraint quantities divided by two.

| 87B Bus Differential | |
|-----------------------------|--|
| IOmin (pu) | $0.20 \text{ to } \text{Min} \left(\frac{IRs \times S1}{100}, 1.00 \right)$ |
| IRs (pu) | $\left(IOmin \times \frac{100}{S1} \right) \text{ to } 50.00$ |
| S1 (%) | $\left(IOmin \times \frac{100}{IRs} \right) \text{ to } \text{Min} (S2, 100)$ |
| S2 (%) | Max (S1, 30) to 200.00 |
| High Current Setting (pu) | $IOmin \times 3 \text{ to } 100.00$ |
| CT Saturation Detection | Enable/disable |
| CT Sat. Max Block (seconds) | 0.10 to 99.99 |

| | |
|--------------|--------------------------|
| Bus Base MVA | Set in System Parameters |
|--------------|--------------------------|

87B-2 Bus Differential

The 87B-2 is used to define the second bus differential zone. The 87B-2 is only available when the Differential Zone is selected as Bus1 and Bus2. Up to 4 CT inputs can be assigned to the 87B-2. The 87B-2 settings are the same as the 87B-1.

59 Overvoltage

Two sets of overvoltage protection elements are provided to monitor the bus voltage. The 59-1 and 59-2 functions are identical in terms of operation. Use the gate switch to select between an "AND" or an "OR" gate. Use an "AND" gate to detect 3-phase overvoltage condition; use an "OR" gate to detect any phase overvoltage condition. The definite time delay can be set to 0.0 for an instantaneous output.

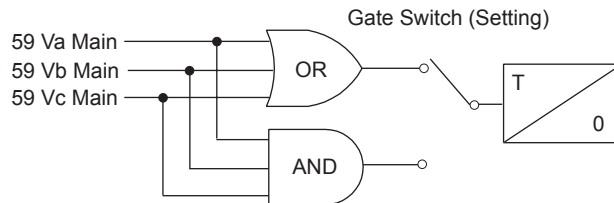


Figure 4.7: 59 Overvoltage

| 59 Overvoltage | |
|------------------------|---------------|
| Gate Switch | AND or OR |
| Pickup (Volts Sec.) | 60.0 to 138.0 |
| Pickup Delay (seconds) | 0.00 to 99.99 |

27 Undervoltage

Two sets of undervoltage protection elements are provided to monitor the bus voltage. The 27-1 and 27-2 functions are identical in terms of operation. Use the gate switch to select between an “AND” or an “OR” gate. Use an "AND" gate to detect 3-phase undervoltage condition; use an "OR" gate to detect any phase undervoltage condition. The definite time delay can be set to 0.0 for an instantaneous output.

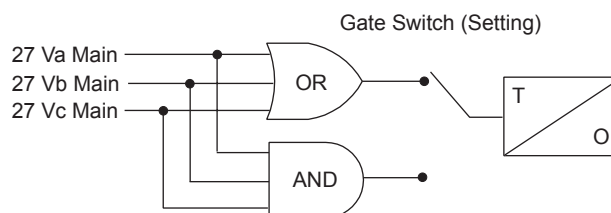


Figure 4.8: 27 Undervoltage

| 27 Undervoltage | |
|------------------------|---------------|
| Gate Switch | AND or OR |
| Pickup (Volts Sec.) | 1.0 to 120.0 |
| Pickup Delay (seconds) | 0.00 to 99.99 |

60 Loss of Potential

This protection is to detect the loss of potential from either one or two phases, and issue an alarm.

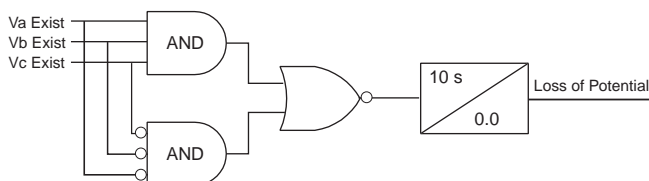


Figure 4.9: 60 Loss of Potential

Where $Va_Exist = 1$ if $Va > 0.5$ pu, similar for Vb_Exist and Vc_Exist . Pickup time (= 10.0 seconds) and drop-out time (= 0.0 seconds) are fixed parameters. 1.0 pu is calculated as:

$$V_{pusec} = \frac{\text{Bus Voltage (Pri)}}{\sqrt{3} \times (\text{PT Turns Ratio})}$$

| 60 Loss of Potential | |
|----------------------|--------------------|
| Pickup Delay | 10 seconds (fixed) |

81 Over/Under Frequency

The relay provides two sets of over frequency protection elements to monitor the bus frequency. The 81 O/F-1 and 81 O/F-2 functions are identical in terms of operation. Any positive sequence overfrequency condition produces an output. Undervoltage inhibit is provided and fixed at 0.25 pu of nominal system voltage.

The relay provides two sets of under frequency protection elements to monitor the bus frequency. The 81 U/F-1 and 81 U/F-2 functions are identical in terms of operation. Any positive sequence underfrequency condition produces an output. Undervoltage inhibit is provided and fixed at 0.25 pu of nominal system voltage.

The 81 frequency elements operate and produce an output using a definite time delay function. The overall time delay will be the user setting, an additional inherent delay from 1.25 cycles to 1.75 cycles, and an additional ± 3 ms operate time for the output contact. The element will have a total operate time of under 5 cycles when set to the minimum time delay setting of 0.05 seconds.

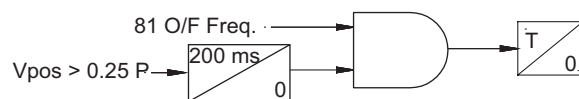


Figure 4.10: 81 O/F Over Frequency

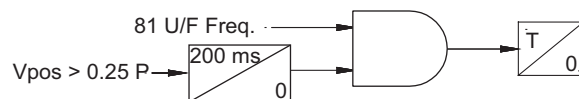


Figure 4.11: 81 U/F Under Frequency

| 81 Over/Under Frequency | |
|-------------------------|---|
| Pickup (Hz) | 60.0 to 70.0 / 50.0 to 60.0 (60 Hz) 50.0 to 60.0 / 40.0 to 50.0 (50 Hz) |
| Pickup Delay (seconds) | 0.05 to 99.99 (inherent delay of 1.25 to 1.75 cycles, depending on frequency step change) |

Transformer Protection

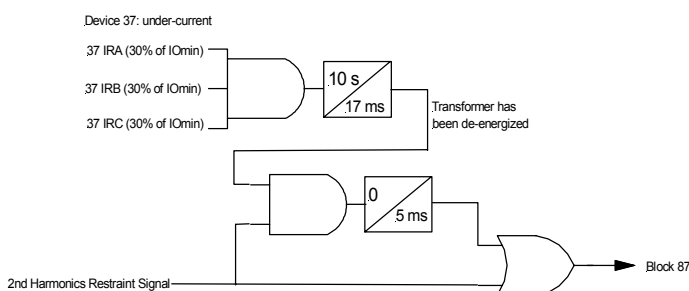
87T Transformer Differential

Device 87T is the differential protection for the transformer zone. It can be used when the differential zone is selected as Bus1 & Transformer or Transformer Only. The device operates for internal faults and provides restraint for external faults, transformer energization or transformer over excitation conditions. CT input 5 and CT input 6 are dedicated for the differential device when 2 differential zones (bus and transformer) are selected, or if only 1 differential zone (transformer) is selected. If external control is enabled, and asserted, the ac analog current will be excluded from all relay, metering and recording functions.

Restraint quantities are summed; the magnitude sum is then divided by two. Operating quantities are summed vectors.

Device 87T has 2nd and 5th harmonic blocking, each element is set independent of each other. If an input phase current is less than 5% of I nominal, this current will not be used for the 2nd and 5th harmonic blocking calculation. For a 5A relay this equals 0.25A.

As shown below, the 2nd harmonics restraint signal is stretched for 5ms in the first cycle on transformer energization to prevent the 2nd harmonics restraint signal from any possible momentary reset due to the current signal transition in the first cycle. Note that this logic only becomes active when the transformer has been de-energized or very lightly loaded (the restraint current is less than 30% of IOmin setting)



| | |
|--------------|--|
| IOmin | Minimum level that device 87 operates |
| IRs | Point of intersection between slope 1 and slope 2 of the characteristic |
| S1 | Slope of first part of characteristic meeting IO min and slope 2 |
| S2 | Slope of second part of characteristic meeting slope 1 and high current unrestrained setting |
| I2 | Ratio of 2nd harmonic current to fundamental, used to provide energizing harmonic restraint |
| I5 | Ratio of 5th harmonic current to fundamental, used to provide restraint on over excitation |
| IOH High Set | Unrestrained high set overcurrent, operates if a heavy fault occurs on the transformer irrespective of restraint |

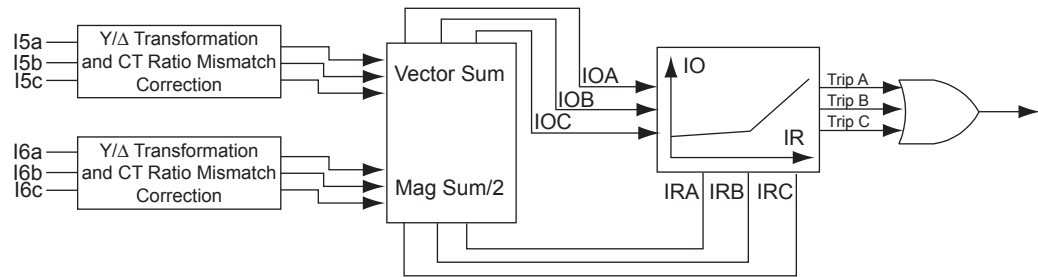


Figure 4.12: 87T Transformer Differential

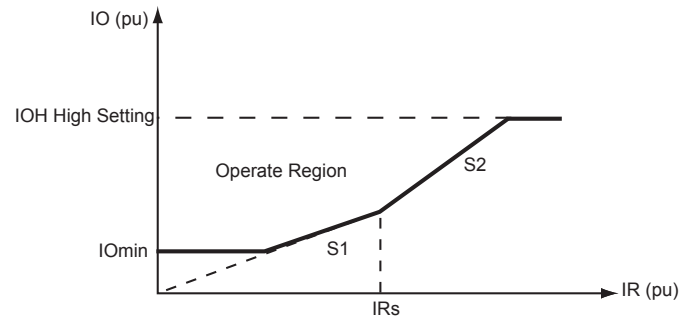


Figure 4.13: Transformer Differential Protection Characteristic

| 87T Transformer Differential | |
|---|--|
| IOmin (pu) | $0.2 \text{ to } \left(\frac{IRs \times S1}{100} \right)$ |
| IRs (pu) | $\left(IOmin \times \frac{100}{S1} \right) \text{ to } 50.00$ |
| S1 (%) | $\left(IOmin \times \frac{100}{IRs} \right) \text{ to } \text{Min} (S2, 100)$ |
| S2 (%) | Max (S1, 30) to 200.00 |
| High Current Setting (pu) | $IOmin \times 3 \text{ to } 100.00$ |
| I _{2nd} /I _{fund} Ratio | 0.05 to 1.00 |
| I _{5th} Restraint Enabled | Enable/disable |
| I _{5th} /I _{fund} Ratio | 0.05 to 1.00 |
| Transformer Base MVA | Set in Winding/CT Connections |

Inputs 1 to 6
Protection

50LS Low Set

Two sets of definite time delay overcurrent protection functions on each CT input provide non-directional current detection. The 50LS-1 and 50LS-2 functions are identical in terms of operation. Use the gate switch to select between an “AND” gate or an “OR” gate. Use an "AND" gate to detect 3-phase overcurrent condition; use an "OR" gate to detect any phase overcurrent condition. The definite time delay can be set to 0.0 for a instantaneous output.

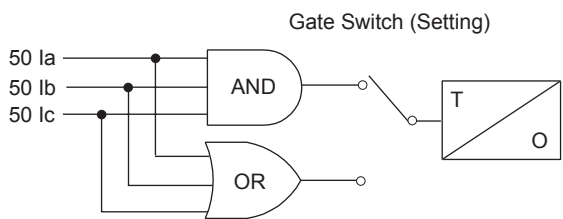


Figure 4.14: 50LS Low Set

| 50LS Low Set Overcurrent | |
|--------------------------|--|
| Gate Switch | AND or OR |
| Pickup (Amps Sec.) | 0.1 to 50.0 (5A) 0.02 to 10.00 (1A) |
| Pickup Delay (seconds) | 0.00 to 99.99 |

50BF Breaker Failure

Breaker failure protection function is used to detect breaker failures and react correspondingly. This function is provided on all the current inputs. When breaker failure is initiated by a trip (user-settable: include 87B-1, 87B-2, 87T, ProLogic, External Input or its own O/C functions) and the breaker current still exists, two timers (T1 and T2, user settable) will be started. After these timers are timed out, if the current still exists (which indicates breaker failure), the output of this function will be set high.

The two outputs of this function can be used to trip another trip coil or the next level of breakers, such as bus breakers. For example set T1 to 10 ms and T2 to 200 ms, and then use the output of T1 to send a trip to the associated circuit breaker before sending the output of T2 to the bus or transformer protection. If the output of T1 tripped the circuit breaker before T2 timed out the current input would dropout and you would not clear the whole transformer or bus zone.

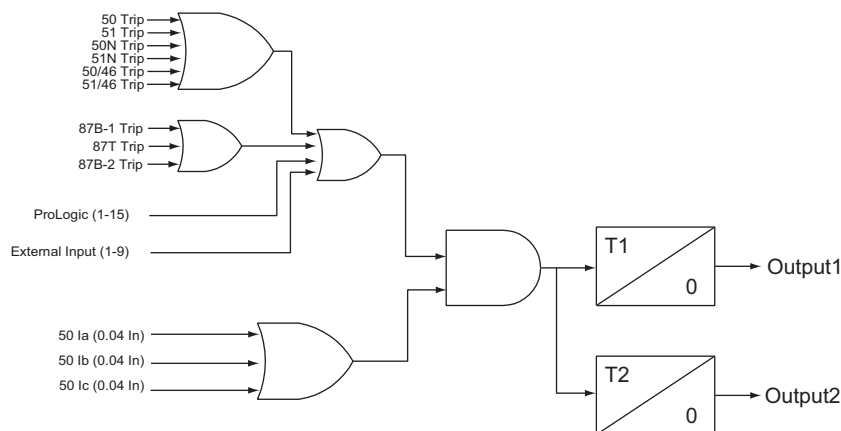


Figure 4.15: 50BF Breaker Failure

| 50BF Breaker Fail | |
|---|--------------------------------------|
| Breaker Failure Initiated by 87B-1 | Enable/disable |
| Breaker Failure Initiated by 87B-2 | Enable/disable |
| Breaker Failure Initiated by 87T | Enable/disable |
| Breaker Failure Initiated by ProLogic | ProLogic 1 to ProLogic 15 |
| Breaker Failure Initiated by External Input | External Input 1 to External Input 9 |
| Pickup Delay 1 (seconds) | 0.01 to 99.99 |
| Pickup Delay 2 (seconds) | 0.01 to 99.99 |

67 Directional Element

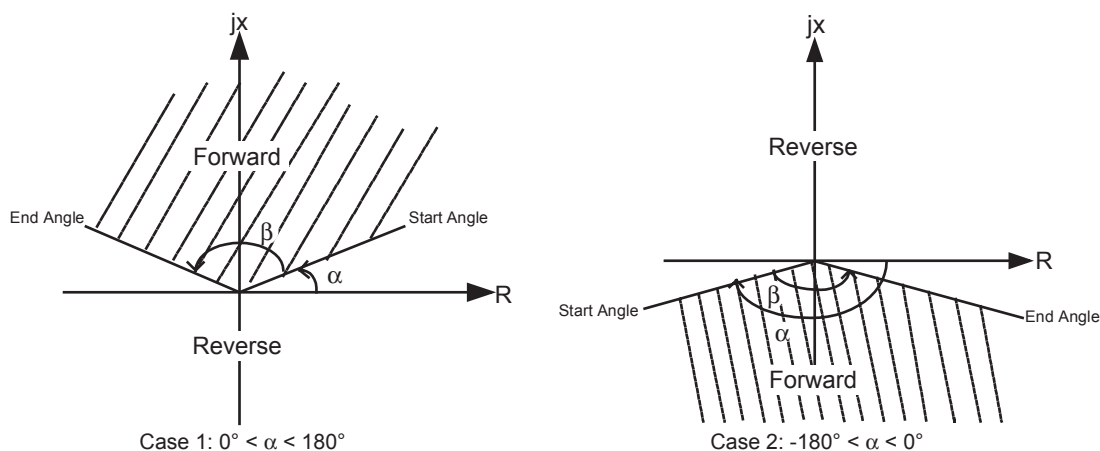


Figure 4.16: 67 Directional Element

Two user-defined parameters, Alpha (-179.9° to 180.0°) and Beta (0.1° to 360.0°), set in the system parameters setting area, define the directional element where Alpha is the start angle and Beta is the angle range (always positive), i.e. the end angle is Alpha + Beta. The forward direction is defined in the region where the line originates, the start angle, and rotates anti-clockwise completing at the end angle. for details see Figure 4.16: 67 Directional Element on page 4-13 illustrates the definition of the directional element. You can flexibly define the forward trip region by setting Alpha and Beta properly based on your needs.

When Beta is set to 360° the forward trip region becomes the whole complex range ($R + jX$), making the element fully non-directional, i.e. the fault is always declared as a forward fault even if the actual fault is not a forward fault.

Positive sequence memory voltage (V_{posMem}) and positive sequence current (I_{pos}) are used to decide the directionality of the fault, i.e. if the calculated positive sequence impedance through V_{posMem} and I_{pos} falls into the forward trip region as shown above, the fault is declared as a forward fault.

50/51/67 Phase Overcurrent

Phase overcurrent provides backup protection to the differential protection. This function operates on fundamental quantities of the highest phase current of the 3 phases. Two sets of phase time overcurrent protection functions on each CT input provide directional or non-directional current detection. There is a definite time overcurrent element (50) and an inverse time overcurrent element (51). You can configure both 50 and 51 to be non-directional, forward direction, or reverse direction sensitive. You can also configure both 50 and 51 outputs to initiate the 50BF protection element. Device 51 provides three pre-defined IEEE, three IEC inverse time curves, and one user-defined curve. The equation and the parameters of device 51 are listed below. You can select the user-defined curve type and the parameters in the equation are settable otherwise they are fixed and determined by the curve type.

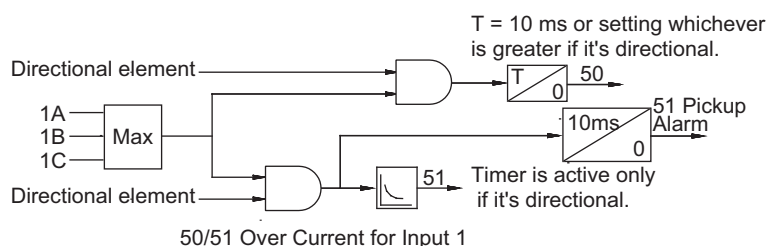


Figure 4.17: 50/51/67 Phase Overcurrent

When the threshold for pickup of the relay is exceeded, the function 51 alarm will pickup indicating the relay has commenced timing.

Table 4.1: IEC and IEEE Curves

| # | Characteristic | A | B | p | tr |
|---|-------------------------|------------------|------------------|--------------|----------------|
| 1 | IEC Standard Inverse | 0.14 | 0 | 0.02 | 13.5 |
| 2 | IEC Very Inverse | 13.5 | 0 | 1.0 | 47.3 |
| 3 | IEC Extremely Inverse | 80.0 | 0 | 2.0 | 80.0 |
| 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 | 0.0010 to 1000.0 | 0.0000 to 10.000 | 0.01 to 10.0 | 0.10 to 100.00 |

Pickup: For $I > \text{Pickup}$

$$T(I) = TMS \left(B + \frac{A}{\left(\frac{I}{\text{Pickup}} \right)^p - 1} \right)$$

Reset: For $I < \text{Pickup}$

$$T(I) = \left(\frac{TR}{\left(\frac{I}{\text{Pickup}} \right)^2 - 1} \right) TMS$$

| | |
|------------------------------|--|
| 50/51/67 Phase Overcurrent | |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5A) 0.1 to 10.0 (1A) |
| Pickup Delay | 0.00 to 99.99 |
| 50 Breaker Failure Initiated | enabled or disabled |
| 51 Enabled | enabled or disabled |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5A) 0.1 to 10.0 (1A) |
| Curve Type | For details see Table 4.1: IEC and IEEE Curves on page 4-14. |
| 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 | 0.01 to 100.00 |
| 51 Breaker Failure Initiated | enabled or disabled |

50N/51N/67 Neutral Overcurrent

Neutral Overcurrent provides protection for phase to ground faults. This function operates fundamental $3I_0$ quantities. Two sets of neutral time overcurrent protection functions on each CT input provide directional or non-directional current detection. There is a definite time overcurrent element (50N) and an inverse time overcurrent element (51N). You can configure both 50N and 51N to be non-directional, forward direction, or reverse direction sensitive. You can also configure both 50N and 51N outputs to initiate the 50BF protection element. Device 51N provides three predefined IEEE, three IEC inverse time curves, and one user-defined curve. The equation and the parameters of device 51N are listed below. You can select the user-defined curve type and the parameters in the equation are settable otherwise they are fixed and determined by the curve type.

| 50N/51N/67 Neutral Overcurrent | |
|--------------------------------|--|
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5A) 0.1 to 10.0 (1A) |
| Pickup Delay | 0.00 to 99.99 |
| 50N Breaker Failure Initiated | enabled or disabled |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5A) 0.1 to 10.0 (1A) |
| Curve Type | For details see Table 4.1: IEC and IEEE Curves on page 4-14. |
| TMS | 0.01 to 10.00 |
| A | 0.0010 to 1000.0000 |
| B | 0.0000 to 10.0000 |
| ρ | 0.01 to 10.00 |
| TR | 0.01 to 100.00 |
| 51N Breaker Failure Initiated | enabled or disabled |

Pickup: For $I > \text{Pickup}$

$$T(I) = TMS \left(B + \frac{A}{\left(\frac{3I_0}{\text{Pickup}} \right)^p - 1} \right)$$

Reset: For $I < \text{Pickup}$

$$T(I) = \left(\frac{TR}{\left(\frac{3Io}{\text{Pickup}} \right)^2 - 1} \right) TMS$$

46-50/46-51/67 Negative Sequence Overcurrent

Negative Sequence Overcurrent provides further protection for any unbalanced faults. This function operates fundamental I₂ quantities. Two sets of negative sequence time overcurrent protection functions on each CT input provide directional or non-directional current detection. There is a definite time overcurrent element (46-50) and an inverse time overcurrent element (46-51). You can configure both 46-50 and 46-51 to be non-directional, forward direction, or reverse direction sensitive. You can also configure both 46-50 and 46-51 outputs to initiate the 50BF protection element. Device 46-51 provides three predefined IEEE, three IEC inverse time curves, and one user-defined curve. The equation and the parameters of device 46-51 are listed below. You can select the user-defined curve type and the parameters in the equation are settable otherwise they are fixed and determined by the curve type.

| 46-50/46-51/67 Negative Sequence Overcurrent | |
|--|--|
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5A) 0.1 to 10.0 (1A) |
| Pickup Delay | 0.00 to 99.99 |
| 46-50 Breaker Failure Initiated | enabled or disabled |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5A) 0.1 to 10.0 (1A) |
| Curve Type | For details see Table 4.1: IEC and IEEE Curves on page 4-14. |
| 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 | 0.01 to 100.00 |
| 46-51 Breaker Failure Initiated | enabled or disabled |

Pickup: For $I > \text{Pickup}$

$$T(I) = TMS \left(B + \frac{A}{\left(\frac{I_2}{\text{Pickup}} \right)^p - 1} \right)$$

Reset: For $I < \text{Pickup}$

$$T(I) = \left(\frac{TR}{\left(\frac{I2}{\text{Pickup}} \right)^2 - 1} \right) TMS$$

ProLogic

The ProLogic control statements are used to create Boolean-like logic. The B-PRO can use any of the protection functions, external inputs or virtual inputs combined with logic gates to create a ProLogic control statement. The output of a ProLogic statement can be nested in another ProLogic statement, so long as the ProLogic output that is to be nested is of lower order than the one in which it is to be nested. For example, ProLogic 5 can be used in ProLogic 7 but not vice-versa.

The possible gates are AND, NAND, OR, NOR, XOR, XNOR, and LATCH. The control can be time delay pickup and or time delay dropout, and can drive the front panel target LED. 15 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 can be all the elements, previous ProLogic statements for logic nesting usage, as well as External and Virtual Inputs.

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 rest time delay.

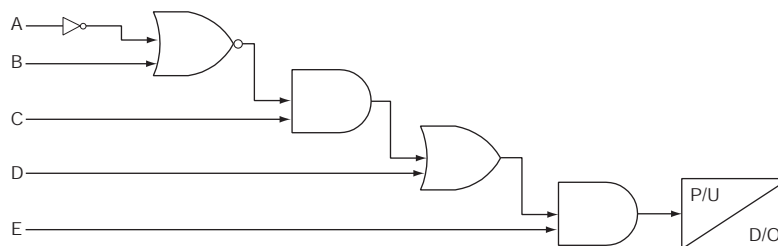


Figure 4.18: ProLogic

| 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 |

Recording Functions

The relay has recording and logging functions to aid with the analysis of faults, and the overall performance of your protection scheme.

Fault Recording

The relay provides DFR-quality fault recording, capturing input signal waveforms and external 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. Device 87B-1 trip). Obtain this information by uploading the records from the relay via the terminal mode file transfer process and view them with RecordBase View software.

The quantities recorded are:

- 21 analog channels (3 voltages and 18 currents, in secondary volts and amperes respectively) @ 96 samples/cycle
- 9 operational currents and 9 restraint currents @ 8 samples/cycle (87B-1, 87B-2, 87T IO+IR)
- 9 external inputs @ 96 samples/cycle
- relay internal logic signals @ 8 samples/cycle, including virtual inputs
- 15 ProLogic signals @ 8 samples/cycle.

Parameters that are user-selectable with respect to recording faults:

- Record length (0.2–2.0 seconds => 12 – 120 cycles @ 60 Hz Base) with automatic extension to capture successive triggers
- Recorder triggering by any internal logic or external input signal

Swing Recording

The B-PRO records dynamic system responses allowing you to analyze system stability and to provide a larger context for fault analysis. Swing records contain positive sequence phasor measurements and system frequency calculated at a rate of 1 phasor per cycle. Swing records can extend to 3 minutes in duration.

The quantities recorded are:

- Positive sequence impedance (magnitude)
- Positive sequence voltage (magnitude)
- Positive sequence current (magnitude)
- 3-Phase Vars (reactive power)
- 3-Phase Watts (real power)
- Positive sequence frequency

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 on activation of any of its trip or alarm functions or on assertion of any external 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 commands *Fault Recording* and *Swing Recording* are available under the *Records* menu.

A swing record can take a couple of minutes to produce due to the long post-trigger time.

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; swing record lengths can be set between 30 and 120 seconds. Pre-trigger times are fixed at 10 cycles for fault records and 30 seconds for swing records and are included as part of the normal record length.

The B-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; 180 seconds for swing 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.

Record Storage

The B-PRO compresses records on the fly, achieving a typical lossless compression rate of 4:1. As a result, the B-PRO can store up to 30 seconds of fault recordings and up to 24 minutes of swing recordings in non-volatile storage. If the storage is full, new records automatically overwrite the oldest, ensuring that the recording function is always available.

Record Retrieval and Deletion

A listing of stored records is available through the terminal user interface under the *Records>List* menu. The listing transfers records to a connected PC and deletes them from storage.

Example:

BPRO-8700-010306-04-2002-05-15 13.17.16.000(Fault)

Records are named by combining the Unit ID setting with the date and time of the initiating record trigger. The record list shows the record type (fault).

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

To select multiple records:

- 1 Select a record.
- 2 Press the space bar, a asterisk appears to the left of the record to indicate it is selected.
- 3 Continue selecting and pressing the space bar until all desired records are selected.
- 4 Select *<D>*. A message asks “Delete all selected files?”. 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 select *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. (e.g. Windows HyperTerminal'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: ".bpr" for transient. When the transfer has taken place, you can delete the record or leave a copy on the relay.

Event Log

The relay 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. Phase 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 on ABC Trip

The event log can be viewed in three 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. |
| SCADA | The protocols included in the B-PRO allow all the SCADA master access to the event data from the relay (Trip and Alarm events only). |

5 Offliner Settings Software

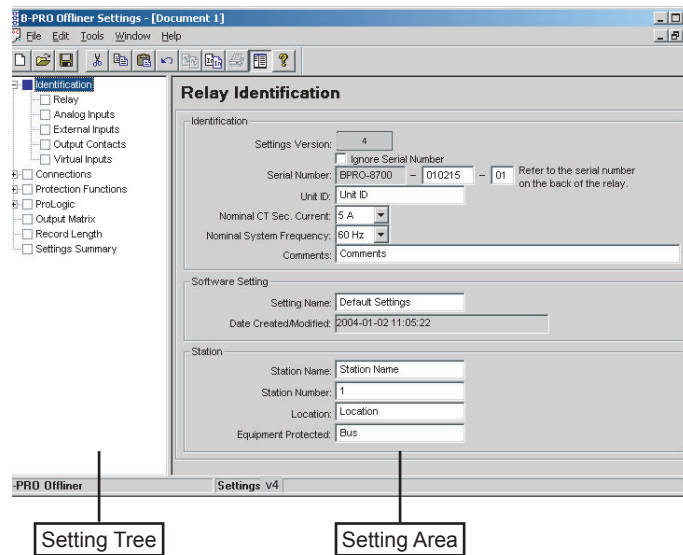


Figure 5.1: Opening Screen

Introduction

Use the *Offliner* Settings software to create relay settings on a PC. *Offliner* provides an easy way to view and manipulate settings. *Offliner* supports all firmware versions and has the capability to convert older setting versions into newer ones.

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 B-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 B-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

Menu and Toolbar

The *Offliner* software includes the following menu and system tool bar. Figure 5.2: "Top Tool Bar" describes the details.

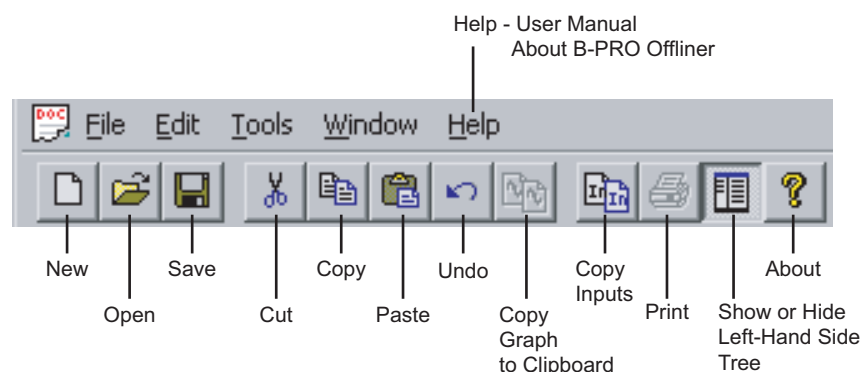


Figure 5.2: Top Tool Bar

| Windows Menu | | |
|----------------------|----------|--|
| Windows Menu | Sub Menu | Comment |
| Document Menu (Icon) | Restore | Restores active window to previous size |
| | Move | Allows user to move active window |
| | Size | Allows user to resize active window |
| | Minimize | Makes the active window as small as possible |
| | Maximize | Makes the active window as large as possible |
| | Close | Closes the active Offliner setting document |
| | Next | Switches to the next open Offliner setting file, if more than setting file is being edited |

| | | |
|----------------|----------------------------|---|
| File Menu | New | Opens up a default setting file of the most recent setting version |
| | Open | Open an existing setting file |
| | Close | Closes the active Offliner setting document |
| | Save | Saves the active setting file |
| | Save As | Saves the active setting file with a new name or location |
| | Convert to Newer | Convert an older setting version to a newer version. |
| | Print | Prints graphs or setting summary depending on active screen |
| | Print Preview | Provides a print preview of the setting summary |
| | Print Setup | Changes printers or print options |
| | 1-6 | The six most recently accessed setting files |
| | Exit | Quits the program |
| Edit Menu | Undo | Undo last action |
| | Cut | Cut the selection |
| | Copy | Copy the selection |
| | Paste | Insert clipboard contents |
| | Copy Graph | Copy the graph for the active screen to the clipboard |
| | Copy Inputs | Brings up the Copy Inputs dialog box |
| Tools | Options | Displays the Options Dialog Box |
| Window | Cascade | Cascades all open windows |
| | Tile | Tiles all open windows |
| | Hide/Show Tree | If this option is checked then the LHS Tree view will be hidden |
| | 1-9, More Windows | Allows access to all open Offliner setting files. The active document will have a check beside it |
| Help | User Manual | Displays the user manual |
| | About Offliner | Displays the Offliner version |
| Toolbar | | |
| New | Create a new document. | Create a new document of the most recent setting version |
| Open | Open an existing document. | Open an existing document |
| Save | Save the active document. | Save the active document |
| Cut | Cut the selection. | Cut selection |

| | | |
|--------------------|------------------------------|---|
| Copy | Copy the selection. | Copy the selection |
| Paste | Insert clipboard contents. | Insert clipboard contents |
| Undo | Copy graph to clipboard. | Undo last action |
| Copy Graph | | Copy the graph for the active scene to the clipboard |
| Copy Inputs | Copy inputs. | Brings up the Copy Inputs dialog box |
| Show/Hide LHS Tree | | If this option is checked then the LHS Tree view will be hidden |
| Print | Print active document. | Prints Graphs or the setting summary, depending on which seen is selected |
| About | Display program information. | Displays the Offliner version |

Graphing Protection Function Characteristics

For the devices that have characteristics such as the 51 and 87, graphs have been provided to aid in selecting settings. See Figure Figure 5.3: "87 Differential Slope Characteristic" and Figure Figure 5.4: "51 Inverse Time Overcurrent Characteristic" for examples of these graphs. The graph features are described below. Note that the protection function must be enabled in order to have it's characteristic displayed.

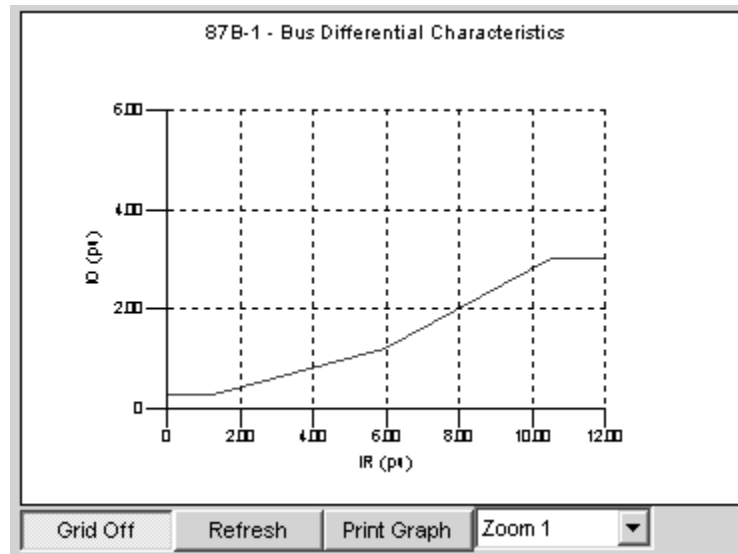


Figure 5.3: 87 Differential Slope Characteristic

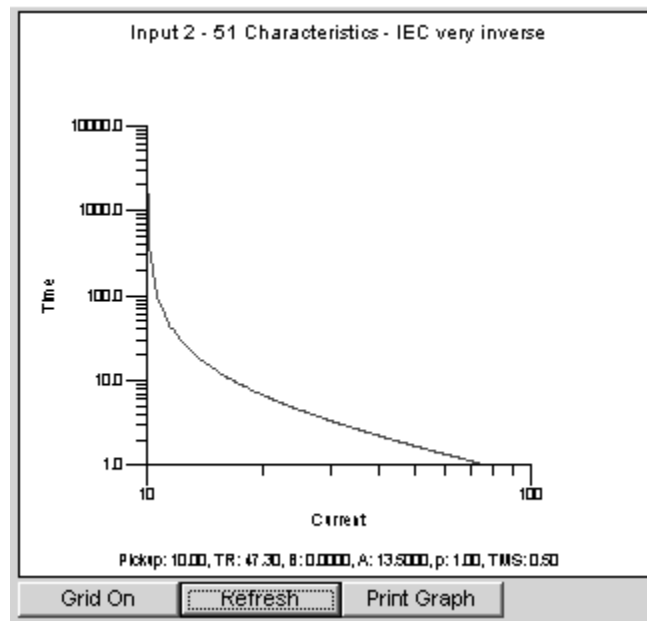


Figure 5.4: 51 Inverse Time Overcurrent Characteristic

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.

Refresh

This button will manually refresh the graph if it has been zoomed.

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.

Displaying Co-ordinates

At any time you may right-click on the graph to display the co-ordinates of the point you selected.

Copying Input Protection

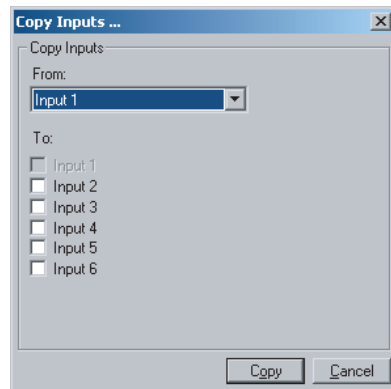


Figure 5.5: Copy Input Protection Functions

This feature allows the backup feeder protection that is provided for each input to be copied from one input to another. All the settings are duplicated exactly, including the output matrix. This is useful when you want to set each CT connection with the same protection characteristics.

This feature will copy all settings including the output matrix.

Main Branches from the Tree View

This section will describe the tree view, which provides access to the various setting screens. This section will not describe individual settings, but will provide a general description of where to find the individual settings. For a detailed description of the individual settings, see Chapter 4.

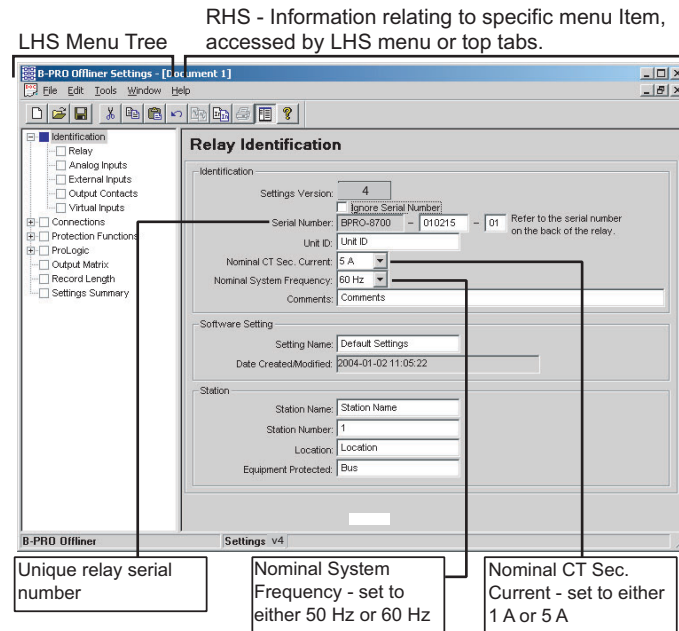


Figure 5.6: Relay Identification

In the LHS Menu Tree there are a series of menu headings that may have sub menus associated with them. Figure Figure 5.6: "Relay Identification" shows the LHS tree view. Clicking on an item in the left hand side tree view will display its corresponding menu in the RHS view. Similarly, you can use the arrow keys to scroll through the menu tree.

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.

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.

Identification

Sub Menus

Relay, Analog Inputs, External Inputs, Output Contacts, Virtual Inputs.

These screens are where relay/station information can be entered, names for the relay I/O and model specific options such as nominal CT current and system frequency can be entered.

Connections**Sub Menus**

System Parameters and Winding/CT

These menus contain the settings that are used to define the primary system that is connected to the relay. Settings such as Bus Base MVA, Nominal Voltage Level are made in the System Parameters screen. The Windings/CT screen contains settings such as differential zone, CT ratio settings, transformer settings and digital control.

Protection Functions**Sub Menus**

Bus, Transformer, Inputs 1-6

These menus are used to make the individual settings for the various protection devices provided by the relay. Each of the sub menus above can be broken further into sub menus for the different protective zones available. Note that selecting the Protection Functions item in the LHS tree view will display the Protection Summary screen in the RHS Tree view. This screen will display the enabled/disabled status of all devices in the relay, and will also allow these devices to be enabled/disabled.

Bus Sub Menu

This sub menu contains the settings for the devices that are in the Bus Zone. These functions are the 87B-1, 87B-2 and the voltage devices, 27, 59, 60, and 81.

Transformer Sub Menu

This sub menu contains only one item, the 87T settings. This is the only device that is provided for the transformer protection zone.

Inputs 1-6 Sub Menus

These menus are where the settings for the backup feeder protection are located. Inputs 1-6 are identical and include menus for 50LS, 50BF, 50/51/67, 50N/51N/67 and 46-50/46-51/67 settings.

ProLogic**Sub Menus**

ProLogic 1 - ProLogic 15

This where each ProLogic statement that is provided by the relay can be defined. There are 15 ProLogic statements available in the relay, so there are 15 screens. Similar to the Protection Functions menu, selecting ProLogic in the LHS tree view will bring up the ProLogic Summary screen, which displays the enabled/disabled status of all ProLogic. You can also enable or disable any ProLogic from this screen. This unique ProLogic name is also displayed on this screen, in brackets next to the generic ProLogic name.

Output Matrix

This is where the relay's protection devices, external inputs, virtual inputs, and ProLogics can be configured to close output contact(s) or trigger recordings.

Record Length

This screen contains the settings for setting the length of fault and swing recording.

Settings Summary

This menu provides a read-only list of all the relay's settings. The setting names, values, units and ranges are displayed. For the Protection devices, you can use the "display and print only enabled protection devices" option from the Tools menu to shorten the summary such that if a device is not enabled, its settings will be hidden, except that the enabled setting will be displayed. This is convenient if you are not using all of the available devices.

Offliner Keyboard Shortcuts

The following table lists the keyboard shortcuts that Offliner provides.

| | |
|----------|--|
| Ctrl+N | Opens up a default setting file of the most recent setting version |
| Ctrl+O | Open an existing setting file |
| Ctrl+S | Saves the active setting file |
| Ctrl+Z | Undo |
| Ctrl+X | Cut |
| Ctrl+C | Copy |
| Ctrl+V | Paste |
| Ctrl+F4 | Closes the active Offliner setting document |
| Ctrl+F6 | Switches to the next open Offliner setting file, if more than one setting file is being edited |
| F6 | Toggles between the LHS Tree view and HRS screen |
| F10, Alt | Enables menu keyboard short-cuts |
| F1 | Displays the user manual |

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 Newer...* 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.

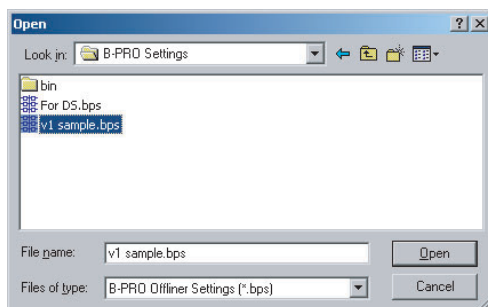


Figure 5.7: Converting Setting Files

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 B-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 3-10. 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 B-PRO *Offliner* is shipped with a set of default sample files of older settings versions. These sample files are “v1 sample.bps”, “v2 sample.bps”, “v3 sample.bps”, etc. Each 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\B-PRO Offliner Settings, or you can choose the path during the *Offliner* software installation. If an older version of B-PRO *Offliner* was previously installed on your PC, then the default directory may be C:\Program Files\APT\B-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

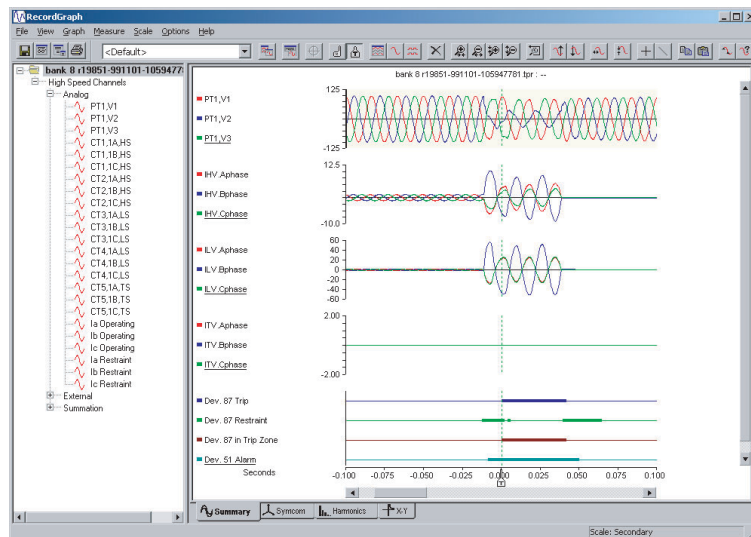


Figure 5.8: RecordBase View

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.

6 Testing the B-PRO Functions

You can set Nominal CT Secondary Current to either 5 A or 1 A and Nominal System Frequency to either 60 Hz or 50 Hz. This example is set to 5 A/60 Hz.

Relay testing is required to determine if B-PRO 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. Testing the bus differential element requires up to six sets of three phase current sources when used in full capability. Use all the available metering functions during testing to verify issues such as polarities of voltage and current signals.

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.

Before you begin a new calibration, establish the accuracy of the equipment being used.

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

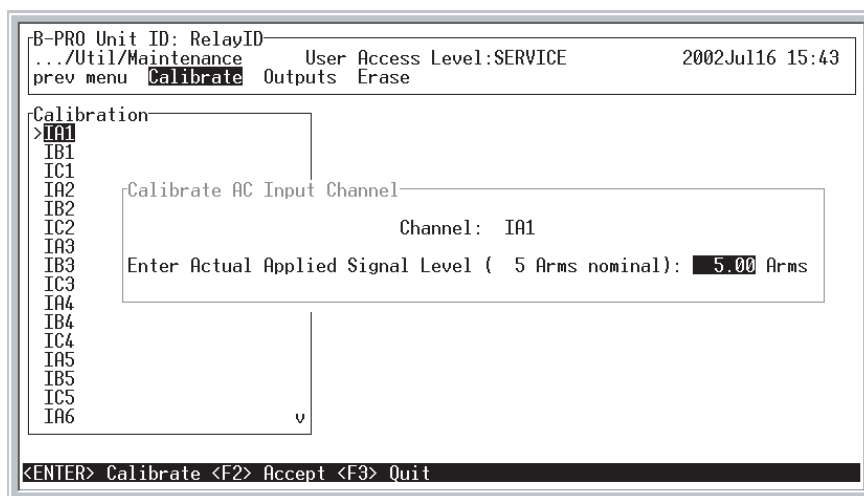


Figure 6.1: Enter actual applied signal level

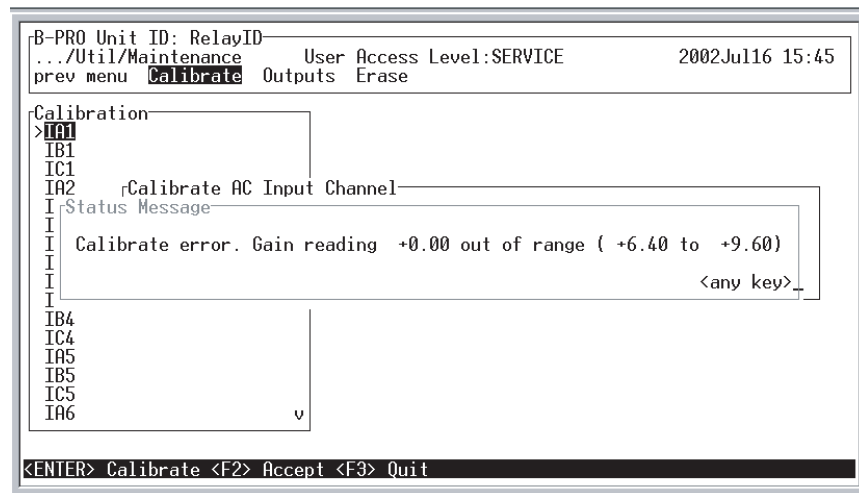


Figure 6.2: Calibration error - out of range

For example when you select voltage V_A 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 V_A terminals, 66.0 volts would be indicated as the desired calibration.

In a similar way, you are prompted to go through all 21 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, the quantity measured you can verify it by selecting the *Metering* menu and the *Analog Quantity* submenu. V_A of the ac voltage input is used as a reference quantity by B-PRO. 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, connect the relay to a laptop in *Terminal Mode*, *Service level*>*Metering*>*I/O*. This screen displays the status of the Inputs and Output Contacts. Placing a voltage of 125 Vdc nominal, (150 V maximum), to each of the external inputs in turn causes the input to change from Low to High status. These inputs are polarity sensitive and this screen has a 0.5 seconds update rate. The inputs should reset when the dc voltage drops below about 80 volts. Testing requires application of a correct voltage polarity.

Testing the Output Relay Contacts

Test the output relays to verify their integrity using the *Utilities*>*Maintenance*>*Outputs*. The output contacts are closed by pressing the *Enter* key. Toggles the output contacts from open to closed by pressing the *Enter* key. Verify the output contact status using an ohmmeter. When you exit this sub-menu, all contact status reverts to the open position

Testing the Inverse Time Overcurrent Function

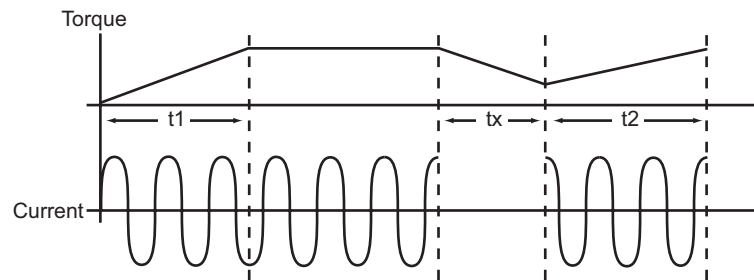
Test function 51 by injecting current into the relay. The setting pickup of function 51 is done on a secondary current basis.

The equation for the IEEE overheating curves is displayed in the B-PRO *Offliner* Settings program and can be used to determine how long it takes to operate the overcurrent function for a given input current. The overcurrent curve function is equation-driven and uses fixed constants to generate the operation curves. See “50/51/67 Phase Overcurrent” on page 4-14 for details on the equations and constants.

Test the 51 reset time by using the following example and equations. Use your test software to setup an appropriate test sequence and measure time t_1 , t_x and t_2 to determine the relay’s performance with your setting parameters.

Equation 1

$$T(I) = TMS \left[\frac{TR}{\left(\frac{I}{Pickup} \right)^2 - 1} \right]$$



If $(t_x > t_{(I)})$ then $t_2 = t_1$

$$t_2 = \frac{t_x}{t_m} \cdot t_1$$

Where t_I equals the time to operate for the applied current and t_m equals the value of solving *Equation 1*.

Testing the Loss of Potential Function

There are no user settings for device 60. If one or two of the AC voltages go below 0.5 per unit or below 33.2 volt-seconds an ac Loss Of Potential alarm will take place after a definite 10 second delay. This can be tested by dropping all combinations of one and two voltages and waiting 10 seconds

Some Additional Points to Consider

In all of the test cases, B-PRO can be set to trigger a transient fault record. Once this is done, the fault record can be viewed, as can the point where the operation point crosses into the trip region. Also, any combination of injected currents can be performed to test all the functions of the relay. That is, the differential function between HV and LV can be performed. A test using all 15 currents could be performed. This presumes that fifteen synchronized currents are available. A verification of operate IO and restraint IR quantities is possible through the TERMINAL MODE by selecting the OPERATING QUANTITIES sub-menu. This screen indicates the current pu quantity relationship within the relay.

Most protection functions also have pickup level outputs available. These can be programmed to produce outputs by enabling them in the OUTPUT MATRIX screens. These functions can be useful during testing, especially time delayed functions where the user is trying to determine where the function is starting to pickup.

| | | | |
|--|---------------|---------------------------|-------------------------------|
| B-PRO Unit ID: UnitID | | | |
| .../Metering/Analog | | User Access Level: CHANGE | 2004Aug05 10:19 |
| prev menu | 87B Operating | 87T Operating | Line Quantities Analog Inputs |
| 87B Operating | | | |
| Bus Differential (87B-1) | A Phase | B Phase | C Phase |
| Operating Current, IO (pu) | 0.0 | 0.0 | 0.0 |
| Restraint Current, IR (pu) | 0.0 | 0.0 | 0.0 |
| 87B-1 Function Enabled | | | |
| Bus Differential (87B-2) | A Phase | B Phase | C Phase |
| Operating Current, IO (pu) | 0.0 | 0.0 | 0.0 |
| Restraint Current, IR (pu) | 0.0 | 0.0 | 0.0 |
| 87B-2 Function Enabled | | | |
| Note: 1 pu = 50.0 MVA for both 87B-1 and 87B-2 | | | |
| <F3> Quit <F2> Freeze | | | |

Figure 6.3: Operating Quantities

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

The relay’s three 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 details see “Communication Port Details” on page 2-9.

An adapter is available for connecting an external modem to Port 2. For details, see “Modem Link - External” on page 2-3.

RJ-45

The relay may have an optional internal modem or an optional internal 10BaseT Ethernet port. Connection to either of these is via the relay’s Port 5 RJ-45 receptacle. Labeling above the port will indicate which option, if any, has been installed.

IRIG-B Wiring

The relay accepts both modulated and unmodulated IRIG-B standard time signals with or without the IEEE 1344 extensions. The IRIG-B connector on the back of the relay is BNC type.

Appendix A IED Specifications

| B-PRO Model 8700/BUS Specification | | |
|--|---|--|
| Item | Quantity/Specs | Note |
| General: | | |
| Nominal Frequency | 50 or 60 Hz | |
| Operate Time | 8–20 ms for 87B function 12–24 ms for 87T function | Including relay output operation. |
| Sampling Rate | 96 samples/cycle for recording 8 samples/cycle for protection | |
| Power Supply | Nominal Range: 48–250 Vdc, 120 Vac Full Operating Range: 40–300 Vdc | Battery load is 50 watts or 50VA AC current. |
| Memory | Settings and records are stored in non-volatile memory. | Records are stored in a circular buffer. |
| Protection Functions: | | |
| IEEE Dev. 87B, 59, 27, 60, 81, 87T, 50LS, 50BF, 50/51/67, 50N/51N/67, 46-50/46-51/67 | 2 differential zones (bus and transformer, or Bus1 and Bus2) and overcurrent protection on each line. | 15 ProLogic statements provide flexible solutions. |
| 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. |
| Dynamic Swing | 1 s/c phasor measurements of line positive sequence V and I plus frequency Capacity: up to 15 x 3 minute records | |
| A/D Resolution | 13 bits, 8192 counts full scale, peak–peak. | |
| Events | 250 | |
| Input and Output: | | |
| Analog Input Channels | 18 currents and 3 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/hour |
| Sampling Resolution | 12 bits plus sign, amplitude measurement accuracy: $\pm 0.5\%$ for 54 to 66 Hz | |
| Burden (Analog Inputs) | 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. | |

| B-PRO Model 8700/BUS Specification | | |
|---|---|---|
| External Inputs | 9 isolated inputs. | Optional 48–125 or 125–250 Vdc nominal, externally wetted. |
| Burden | Burden resistance: > 10 k ohms | |
| Isolation | Internal optical isolation | |
| External Input Sampling | Sample rate: 96 samples/cycle for recording, 8x/cycle for protection | |
| Output Relays (contacts) | 14 programmable outputs plus relay inoperative contact | Make: 30 A as per IEEE C37.90 Carry: 8 A Break: 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive |
| 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 User Interface | 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 Transient | | ANSI/IEEE C37.90.1 - 1989 |
| Oscillatory Transient | | 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: | | |

| B-PRO Model 8700/BUS Specification | | |
|---|--|--|
| Weight | 11.52 kg | 25.40 lbs |
| Dimensions | 13.3 cm | 3U high, 5.25" |
| | 48.3 cm rack mount | 19" rack mount |
| | 30.5 cm deep | 12" deep |
| Mounting | Horizontal | |
| Time Synchronization and Accuracy: | | |
| External Time Source | The B-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 B-PRO Accuracies: | | |
| Current | $\pm 2.5\%$ of inputs from 0.1 to 1.0 x nominal current (I_n) | |
| | $\pm 1.0\%$ of inputs from 1.0 to 20.0 x nominal current (I_n) | |
| Voltage | $\pm 1.0\%$ of inputs from 0.01 to 2.0 x nominal voltage (V_n) | |
| Timers | ± 3 ms of set value | |
| Inverse Overcurrent Times | $\pm 2.5\%$ or ± 1 cycle of selected curve | |
| Definite Overcurrent Times | $\pm 2.5\%$ or ± 1 cycle non-directional | |
| | $\pm 2.5\%$ or ± 1.5 cycle directional | |
| Frequency Timers | ± 3 ms of set value plus 1.25 cycles to 1.75 cycles of inherent delay | |
| Burden | AC Voltage Inputs, < 0.15 VA @ 69 volts | |
| | AC Current Inputs, < 0.50 VA @ 5 amps | |

Appendix B IED Settings and Ranges

When a setting has been completed in the B-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 the user wants to change settings they 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.

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|---------------------|------|-------|
| Name | Symbol/Value | Unit | Range |
| Relay Identification | | | |
| Settings Version | 4 | | |
| Ignore Serial Number | No | | |
| Serial Number | BPRO-8700-010215-01 | | |
| Nominal CT Secondary Current | 5 A | | |
| Nominal System Frequency | 60 Hz | | |
| Relay ID | RelayID | | |
| Comments | Comments | | |
| Date Created-Modified | 2002-06-21 14:10:22 | | |
| Station Name | Station Name | | |
| Station Number | 1 | | |
| Location | Location | | |
| Equipment Protected | Bus | | |
| Analog Input Names | | | |
| Voltage Input Name | BUS PT 1 | | |
| VA | Voltage A | | |
| VB | Voltage B | | |
| VC | Voltage C | | |
| Input 1 | Input1 | | |
| IA1 | Input1 Current A | | |
| IB1 | Input1 Current B | | |
| IC1 | Input1 Current C | | |
| Input 2 | Input2 | | |
| IA2 | Input2 Current A | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------------|--|--|
| IB2 | Input2 Current B | | |
| IC2 | Input2 Current C | | |
| Input 3 | Input3 | | |
| IA3 | Input3 Current A | | |
| IB3 | Input3 Current B | | |
| IC3 | Input3 Current C | | |
| Input 4 | Input4 | | |
| IA4 | Input4 Current A | | |
| IB4 | Input4 Current B | | |
| IC4 | Input4 Current C | | |
| Input 5 | Input5 | | |
| IA5 | Input5 Current A | | |
| IB5 | Input5 Current B | | |
| IC5 | Input5 Current C | | |
| Input 6 | Input6 | | |
| IA6 | Input6 Current A | | |
| IB6 | Input6 Current B | | |
| IC6 | Input6 Current C | | |
| External Input Names | | | |
| 1 | EI Spare 1 | | |
| 2 | EI Spare 2 | | |
| 3 | EI Spare 3 | | |
| 4 | EI Spare 4 | | |
| 5 | EI Spare 5 | | |
| 6 | EI Spare 6 | | |
| 7 | EI Spare 7 | | |
| 8 | EI Spare 8 | | |
| 9 | EI Spare 9 | | |
| Output Contact Names | | | |
| Output 1 | Out Spare 1 | | |
| Output 2 | Out Spare 2 | | |
| Output 3 | Out Spare 3 | | |
| Output 4 | Out Spare 4 | | |
| Output 5 | Out Spare 5 | | |
| Output 6 | Out Spare 6 | | |
| Output 7 | Out Spare 7 | | |
| Output 8 | Out Spare 8 | | |
| Output 9 | Out Spare 9 | | |
| Output 10 | Out Spare 10 | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|-----------------------|-------------|-----------------|
| Output 11 | Out Spare 11 | | |
| Output 12 | Out Spare 12 | | |
| Output 13 | Out Spare 13 | | |
| Output 14 | Out Spare 14 | | |
| System Parameters | | | |
| Bus 1 MVA | 100.0 | MVA Primary | 1.0 to 1000.0 |
| Bus 2 MVA | 100.0 | MVA Primary | 1.0 to 1000.0 |
| Bus Voltage | 230.0 | kV Primary | 1.0 to 1000.0 |
| PT Turns Ratio | 10000.0 | :1 | 1.0 to 10000.0 |
| Phase Rotation | ABC | | |
| Directional Control Alpha | 0.0 | degrees | -179.9 to 180.0 |
| Directional Control Beta | 180.0 | degrees | 0.1 to 360.0 |
| Winding/CT Connections | | | |
| Differential Zone | Bus only | | |
| Bus side: | | | |
| Voltage | 230.0 | kV Primary | 1.0 to 1000.0 |
| Connection | Y | | |
| Phase | 0° degree ref (fixed) | | |
| Non-Bus side: | | | |
| Voltage | 115.0 | kV Primary | 1.0 to 1000.0 |
| Connection | Y | | |
| Phase | 0° | | |
| Transformer 3 Phase MVA | 60.0 | MVA Primary | 1.0 to 2000.0 |
| CT Connections | | | |
| Input 1 [Input1] | | | |
| Connect to | Bus | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100.0 | :1 | - |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 2 [Input2] | | | |
| Connect to | Bus | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100.0 | :1 | - |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|----|---|
| Exclude When | High | | |
| Input 3 [Input3] | | | |
| Connect to | Bus | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100.0 | :1 | - |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 4 [Input4] | | | |
| Connect to | Bus | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100.0 | :1 | - |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 5 [Input5] | | | |
| Connect to | Bus | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100.0 | :1 | - |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 6 [Input6] | | | |
| Connect to | Bus | | |
| CT Connection | Y | | |
| CT Phase | 0° | | |
| CT Turns Ratio (to 1) | 100.0 | :1 | - |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Protection Summary | | | |
| 87B | Enabled | | |
| 87T | Disabled | | |
| 60 | Enabled | | |
| 27-1 | Enabled | | |
| 27-2 | Enabled | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|----------|--|--|
| 59-1 | Enabled | | |
| 59-2 | Enabled | | |
| 81 O/F-1 | Enabled | | |
| 81 O/F-2 | Enabled | | |
| 81 U/F-1 | Enabled | | |
| 81 U/F-2 | Enabled | | |
| Input 1 [Input1] Protection | | | |
| 50BF | Enabled | | |
| 50LS-1 | Enabled | | |
| 50LS-2 | Enabled | | |
| 50 | Enabled | | |
| 51 | Enabled | | |
| 50N | Enabled | | |
| 51N | Enabled | | |
| 46-50 | Enabled | | |
| 46-51 | Enabled | | |
| Input 2 [Input2] Protection | | | |
| 50BF | Disabled | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 3 [Input3] Protection | | | |
| 50BF | Disabled | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 4 [Input4] Protection | | | |
| 50BF | Disabled | | |
| 50LS-1 | Disabled | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|----------|-------|-----------------|
| 50LS-2 | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 5 [Input5] Protection | | | |
| 50BF | Disabled | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 6 [Input6] Protection | | | |
| 50BF | Disabled | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| 87B-1 - Bus Differential | | | |
| 87B-1 | Enabled | | |
| IOmin | 0.25 | p. u. | 0.20 to 0.40 |
| IRs | 2.00 | p. u. | 1.25 to 50.00 |
| S1 | 20.00 | % | 12.50 to 40.00 |
| S2 | 40.00 | % | 30.00 to 200.00 |
| High Curr. Setting | 10.00 | p. u. | 0.75 to 100.00 |
| CT Saturation Detection | Disabled | | |
| CT Saturation Max Block | 1.00 | - | 0.10 to 99.99 |
| 87B-2 - Bus Differential | | | |
| 87B-2 | Enabled | | |
| IOmin | 0.25 | p. u. | 0.20 to 0.40 |

| Settings Summary - B-PRO 8700 | | | |
|--|----------|---------|-----------------|
| IRs | 2.00 | p. u. | 1.25 to 50.00 |
| S1 | 20.00 | % | 12.50 to 40.00 |
| S2 | 40.00 | % | 30.00 to 200.00 |
| High Curr. Setting | 10.00 | p. u. | 0.75 to 100.00 |
| CT Saturation Detection | Disabled | | |
| CT Saturation Max Block | 1.00 | - | 0.10 to 99.99 |
| 87T - Transformer Differential | | | |
| 87T | Disabled | | |
| IOmin | 0.25 | p. u. | 0.10 to 0.40 |
| IRs | 2.00 | p. u. | 1.25 to 50.00 |
| S1 | 20.00 | % | 12.50 to 40.00 |
| S2 | 40.00 | % | 30.00 to 200.00 |
| High Curr. Setting | 10.00 | p. u. | 0.75 to 100.00 |
| I _{2nd} / I _{fund} Ratio | 0.20 | - | 0.05 to 1.00 |
| I _{5th} Harmonic Restraint | Disabled | | |
| I _{5th} / I _{fund} Ratio | 0.20 | - | 0.05 to 1.00 |
| 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 |
| 59 - Overvoltage | | | |
| 59-1 | Enabled | | |
| Gate Switch | OR | | |
| Pickup | 70.0 | volts | 60.0 to 140.0 |
| Pick-up Delay | 1.00 | seconds | 0.00 to 99.99 |
| 59-2 | Enabled | | |
| Gate Switch | OR | | |
| Pickup | 70.0 | volts | 60.0 to 140.0 |
| Pickup Delay | 1.00 | seconds | 0.00 to 99.99 |
| 60 - Loss of Potential Alarm | | | |
| 60 | Enabled | | |
| 81 - Over-Frequency | | | |
| 81 O/F-1 | Enabled | | |
| Pickup | 61.00 | Hz | 60.00 to 70.00 |

| Settings Summary - B-PRO 8700 | | | |
|--|----------|---------|----------------|
| Pickup Delay | 2.00 | seconds | 0.05 to 99.99 |
| 81 O/F-2 | Enabled | | |
| Pickup | 62.00 | Hz | 60.00 to 70.00 |
| Pickup Delay | 2.00 | seconds | 0.05 to 99.99 |
| 81 - Under-Frequency | | | |
| 81 U/F-1 | Enabled | | |
| Pickup | 59.50 | Hz | 50.00 to 60.00 |
| Pickup Delay | 2.00 | seconds | 0.05 to 99.99 |
| 81 U/F-2 | Enabled | | |
| Pickup | 59.00 | Hz | 50.00 to 60.00 |
| Pickup Delay | 2.00 | seconds | 0.05 to 99.99 |
| Input 1 [Input1], 50BF - Breaker Failure | | | |
| 50BF | Enabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.50 | seconds | 0.01 to 99.99 |
| Pickup Delay 2 | 1.50 | seconds | 0.01 to 99.99 |
| Input 1 [Input1], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Enabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| 50LS-2 | Enabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| Input 1 [Input1], 50/51/67 - Phase Overcurrent | | | |
| 50 | Enabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Enabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 1 [Input1], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Enabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Enabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 1 [Input1], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Enabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Enabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 2 [Input2], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.50 | seconds | 0.01 to 99.99 |
| Pickup Delay 2 | 1.50 | seconds | 0.01 to 99.99 |
| Input 2 [Input2], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| Input 2 [Input2], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 2 [Input2], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 2 [Input2], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 3 [Input3], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.50 | seconds | 0.01 to 99.99 |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| Pickup Delay 2 | 1.50 | seconds | 0.01 to 99.99 |
| Input 3 [Input3], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| Input 3 [Input3], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 3 [Input3], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 3 [Input3], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 4 [Input4], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.50 | seconds | 0.01 to 99.99 |
| Pickup Delay 2 | 1.50 | seconds | 0.01 to 99.99 |
| Input 4 [Input4], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| 50LS-2 | | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| Input 4 [Input4], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 4 [Input4], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 4 [Input4], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 5 [Input5], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.50 | seconds | 0.01 to 99.99 |
| Pickup Delay 2 | 1.50 | seconds | 0.01 to 99.99 |
| Input 5 [Input5], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| Input 5 [Input5], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 5 [Input5], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 5 [Input5], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|---------------|
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 6 [Input6], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.50 | seconds | 0.01 to 99.99 |
| Pickup Delay 2 | 1.50 | seconds | 0.01 to 99.99 |
| Input 6 [Input6], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1.0 | amperes | 0.1 to 50.0 |
| Pickup Delay | 0.00 | seconds | 0.00 to 99.99 |
| Input 6 [Input6], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 6 [Input6], 50N/51N/67 - Neutral Overcurrent | | | |

| Settings Summary - B-PRO 8700 | | | |
|--|------------------|---------|----------------|
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Input 6 [Input6], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Pickup Delay | 1.00 | amperes | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10.0 | amperes | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0.0 | - | - |
| p | 1.0 | - | - |
| TR | 47.30 | - | - |
| TMS | 0.50 | - | 0.01 to 10.00 |
| Record Length | | | |
| Fault Record Length | 0.5 | seconds | 0.2 to 2.0 |
| 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 |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|---------|----------------|
| Operator 1 | | | |
| Input A | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|---------|----------------|
| Input E | <Not Used> | | |
| 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 | | | |
| Input A | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|---------|----------------|
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| PL 9 [ProLogic 9] | | | |
| ProLogic 9 | Disabled | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|---------|----------------|
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| PL 11 [ProLogic 11] | | | |
| ProLogic 11 | 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|---------|----------------|
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| PL 12 [ProLogic 12] | | | |
| ProLogic 12 | 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| PL 13 [ProLogic 13] | | | |
| ProLogic 13 | 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| PL 14 [ProLogic 14] | | | |
| ProLogic 14 | Disabled | | |
| Target | Enabled | | |
| Pickup Delay | 0.00 | seconds | 0.00 to 999.00 |
| Dropout Delay | 0.00 | seconds | 0.00 to 999.00 |

| Settings Summary - B-PRO 8700 | | | |
|-------------------------------|------------|---------|----------------|
| Operator 1 | | | |
| Input A | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |
| PL 15 [ProLogic 15] | | | |
| ProLogic 15 | 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 | <Not Used> | | |
| Operator 2 | | | |
| Input B | <Not Used> | | |
| Operator 3 | | | |
| Input C | <Not Used> | | |
| Operator 4 | | | |
| Input D | <Not Used> | | |
| Operator 5 | | | |
| Input E | <Not Used> | | |

Appendix C Hardware Description

The B-PRO is a complete bus and transformer protection relay package designed and manufactured with high quality features and components.

External Input and Comm Board

The B-PRO relay has 9 channels of external input provided by the External Input and Comm Board. Inputs are optically isolated, factory preset 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 B-PRO 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. A high-speed DSP communications port is also provided as a DB-15S, for future use.

Relay Output Board

The Relay Output Board provides 14 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 \pm 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 18 current transformer inputs and 3 potential transformer inputs for ac current and voltage 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 B-PRO relay.

The Digital Signal Processor (DSP) on a MPB performs the protective relaying functions of the B-PRO, 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 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

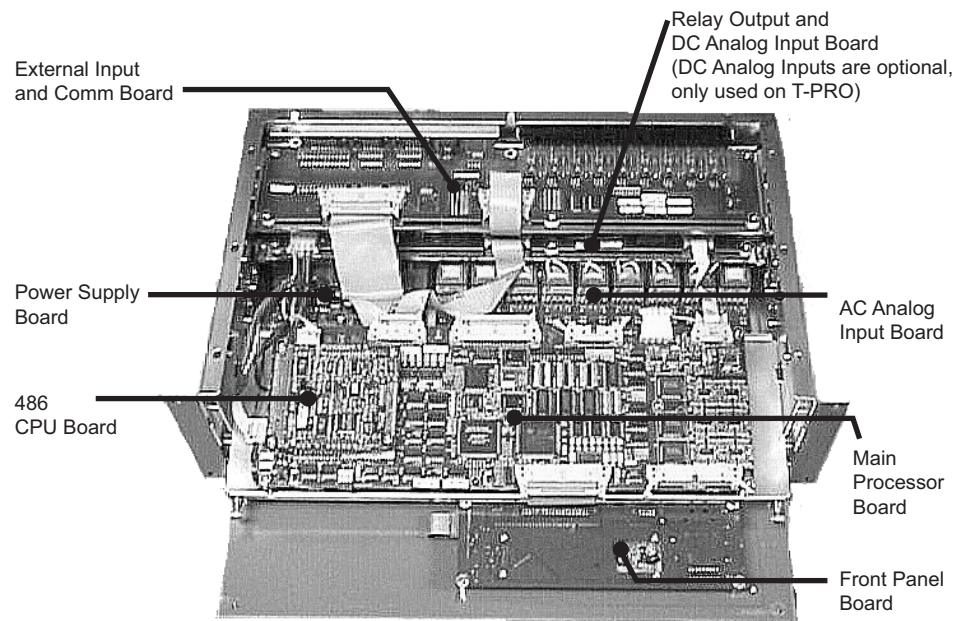
486 CPU Board

A 486-class CPU with 16 MB of RAM provides data storage, information management, housekeeping, and communications for the B-PRO. 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 B-PRO 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 B-PRO's recordings.

Front Panel Board

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

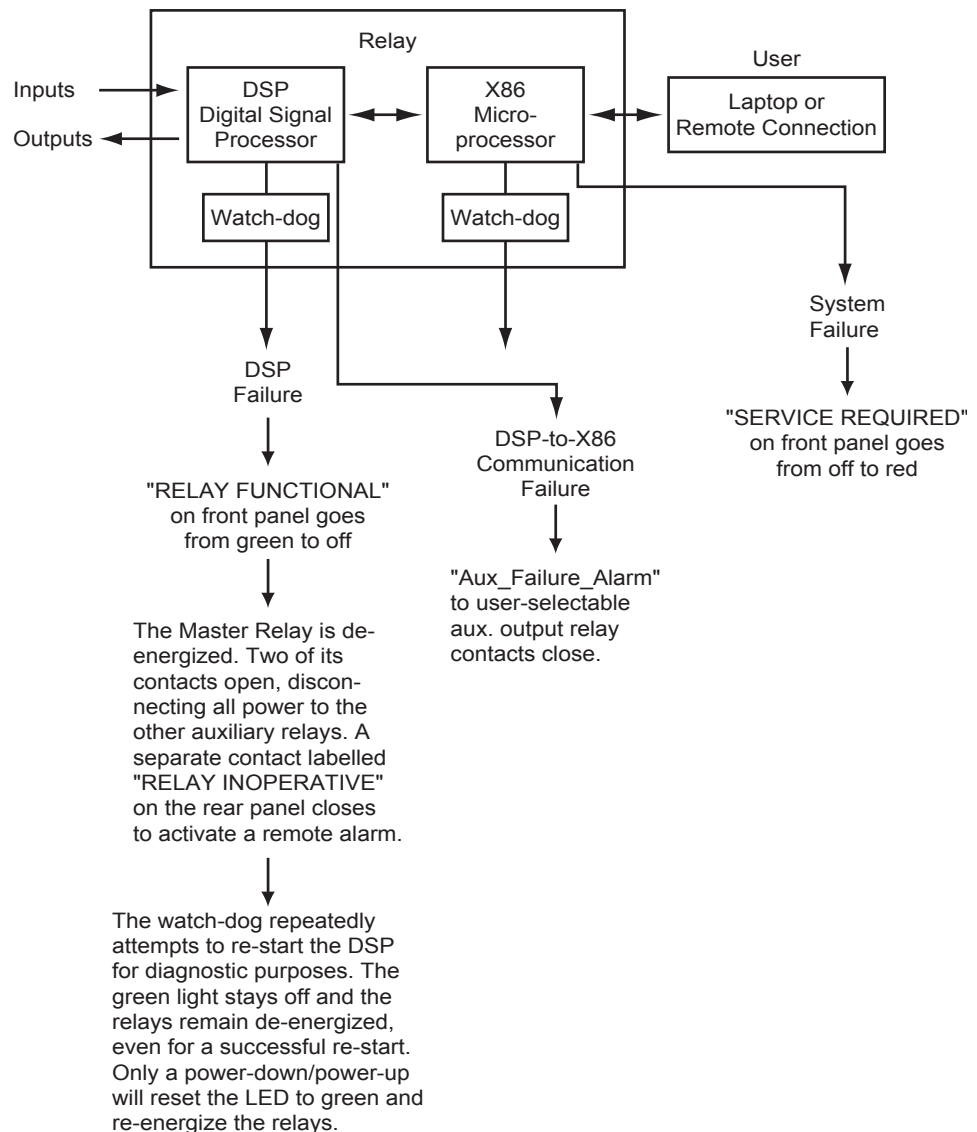


Appendix D Event Messages

| B-PRO Event Messages | |
|-------------------------------------|--|
| Event Message | Notes |
| (Input Name) 50LS-1 ABC High | The possible phase information will be A, B, C, AB, BC, CA, ABC |
| (Input Name) 50LS-2 ABC High | |
| (Input Name) 50BF-1 ABC Trip | |
| (Input Name) 50BF-2 ABC Trip | |
| (Input Name) 50 on ABC Trip | |
| (Input Name) 51 on ABC Alarm | |
| (Input Name) 51 on ABC Trip | |
| (Input Name) 50N Trip | |
| (Input Name) 51N Alarm | |
| (Input Name) 51N Trip | |
| (Input Name) 46-50 Trip | |
| (Input Name) 46-51 Alarm | |
| (Input Name) 46-51 Trip | |
| 87T Trip (IOH) on ABC | The possible phase information will be A, B, C, AB, BC, CA, ABC. (IOH) will be added into the message if the setting has been exceeded |
| 87B-1 Trip (IOH) on ABC | |
| 87B-2 Trip (IOH) on ABC | |
| 87B-1 Block via CT Sat | |
| 87B-2 Block via CT Sat | |
| 59 O/V-1 on ABC: Trip | The possible phase information will be A, B, C, AB, BC, CA, ABC |
| 59 O/V-2 on ABC: Trip | |
| 27 U/V-1 on ABC: Trip | |
| 27 U/V-2 on ABC: Trip | |
| 60 on phase ABC: Alarm | |
| 81 O/F-1 Trip | |
| 81 O/F-2 Trip | |
| 81 U/F-1 Trip | |
| 81 U/F-2 Trip | |
| (ProLogic Name): PL (1–15) | ProLogic names are user-defined |
| (Ext. Input Name): EI (1–9): status | External input names are user-defined. Status can be "High" or "low" |

| | |
|--|---|
| (Virtual Inputs Name): VI (1-30): status | Virtual input names are user-defined. Status can be "High" or "low" |
| Self Check: DC Ch.n: Alarm | Continuous dc level on Ch. n, where n=1 to 18. |
| Self Check: DC Alarm Reset | Continuous dc level, condition has reset. |
| Self Check: DC Ch. n: O/P Block | Continuous dc level on Ch. n, where n=1 to 18. Relay is blocked. |
| New Setting Loaded | |
| Manual Settings Load request | Manual or user-initiated settings change |
| Manual Settings Load request completed | Completion of user-initiated settings 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 or Self Check Fail: Block has not occurred.

Self Check Fail due to DC Offset Detector

The DSP has an algorithm that detects continuous dc levels on the analog inputs and initiates alarms and relay output contact blocking when the measured dc level exceeds the Alarm or Block level. The Alarm level is intended to provide an early indication of a problem. The Block level blocks the relay from false-tripping by preventing any output contact from closing. The Relay Functional LED turns off, but the protection functions will operate normally, with the exception that the output contacts will not be allowed to close. The Relay Inoperative contact will close for a Block condition. The following table describes all the Alarm/Block indication functions

| Action | Condition | |
|----------------------------------|-----------|-------|
| | Alarm | Block |
| Relay Functional LED off | | X |
| Service Required LED on | X | X |
| Self Check Fail Signal high | X | X |
| Relay Inoperative Contact closed | | X |
| Output Contacts held open | | X |
| Event Log Message | X | X |
| Status available through SCADA | X | X |

The Self Check Fail signal, which is available in the Output Matrix, TUI metering and SCADA, can be used to signal an alarm. Note that if this signal is mapped to an output contact, the contact which it is mapped to will only be closed for an alarm condition. If the relay is in the Block condition, the Relay Inoperative contact must be used to signal an alarm.

The status of the Self Check Fail is available through the SCADA services provided by the B-PRO. The digital signal Self Check Fail will indicate that DSP has detected a continuous dc level and the analog metering value Self Check Fail Parameter is used to indicate which condition, Alarm or Block. The failure types and which analog values they are associated with are described in the table below. Both signals are available in DNP and Modbus.

| Point Value | Condition |
|-------------|----------------------------|
| 0 | Normal |
| 1 | Alarm |
| 2 | Block |
| 3 | Alarm has evolved to block |

The Alarm condition is allowed to reset if the continuous dc level drops below the pickup level. The Block condition has no reset level. If power is cycled to the relay it will go into its normal state until the continuous dc level is detected again.

Note: Self Check Fail appears as "Aux. Failure Alarm" in the settings versions before v2.

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 | 00001 | 0: Readings not held | 1: Readings held |
| Reserved | 00257 | Reserved | Reserved |
| Output Contact 1 | 00513 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 2 | 00514 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 3 | 00515 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 4 | 00516 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 5 | 00517 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 6 | 00518 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 7 | 00519 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 8 | 00520 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 9 | 00521 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 10 | 00522 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 11 | 00523 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 12 | 00524 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 13 | 00525 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 14 | 00526 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Input 1 5LS-1 Output | 00769 | 0: Off (inactive) | 1: On (active) |
| Input 1 50LS-2 Output | 00770 | 0: Off (inactive) | 1: On (active) |
| Input 1 50BF-1 Trip | 00771 | 0: Off (inactive) | 1: On (active) |
| Input 1 50BF-2 Trip | 00772 | 0: Off (inactive) | 1: On (active) |
| Input 1 50 Trip | 00773 | 0: Off (inactive) | 1: On (active) |
| Input 1 51 Alarm | 00774 | 0: Off (inactive) | 1: On (active) |
| Input 1 51 Trip | 00775 | 0: Off (inactive) | 1: On (active) |
| Input 1 50N Trip | 00776 | 0: Off (inactive) | 1: On (active) |
| Input 1 51N Alarm | 00777 | 0: Off (inactive) | 1: On (active) |
| Input 1 51N Trip | 00778 | 0: Off (inactive) | 1: On (active) |

| Read Coil Status (Function Code 01) | | | |
|-------------------------------------|-------|-------------------|----------------|
| Input 1 46-50 Trip | 00779 | 0: Off (inactive) | 1: On (active) |
| Input 1 46-51 Alarm | 00780 | 0: Off (inactive) | 1: On (active) |
| Input 1 46-51 Trip | 00781 | 0: Off (inactive) | 1: On (active) |
| Input 2 5LS-1 Output | 00782 | 0: Off (inactive) | 1: On (active) |
| Input 2 50LS-2 Output | 00783 | 0: Off (inactive) | 1: On (active) |
| Input 2 50BF-1 Trip | 00784 | 0: Off (inactive) | 1: On (active) |
| Input 2 50BF-2 Trip | 00785 | 0: Off (inactive) | 1: On (active) |
| Input 2 50 Trip | 00786 | 0: Off (inactive) | 1: On (active) |
| Input 2 51 Alarm | 00787 | 0: Off (inactive) | 1: On (active) |
| Input 2 51 Trip | 00788 | 0: Off (inactive) | 1: On (active) |
| Input 2 50N Trip | 00789 | 0: Off (inactive) | 1: On (active) |
| Input 2 51N Alarm | 00790 | 0: Off (inactive) | 1: On (active) |
| Input 2 51N Trip | 00791 | 0: Off (inactive) | 1: On (active) |
| Input 2 46-50 Trip | 00792 | 0: Off (inactive) | 1: On (active) |
| Input 2 46-51 Alarm | 00793 | 0: Off (inactive) | 1: On (active) |
| Input 2 46-51 Trip | 00794 | 0: Off (inactive) | 1: On (active) |
| Input 3 5LS-1 Output | 00795 | 0: Off (inactive) | 1: On (active) |
| Input 3 50LS-2 Output | 00796 | 0: Off (inactive) | 1: On (active) |
| Input 3 50BF-1 Trip | 00797 | 0: Off (inactive) | 1: On (active) |
| Input 3 50BF-2 Trip | 00798 | 0: Off (inactive) | 1: On (active) |
| Input 3 50 Trip | 00799 | 0: Off (inactive) | 1: On (active) |
| Input 3 51 Alarm | 00800 | 0: Off (inactive) | 1: On (active) |
| Input 3 51 Trip | 00801 | 0: Off (inactive) | 1: On (active) |
| Input 3 50N Trip | 00802 | 0: Off (inactive) | 1: On (active) |
| Input 3 51N Alarm | 00803 | 0: Off (inactive) | 1: On (active) |
| Input 3 51N Trip | 00804 | 0: Off (inactive) | 1: On (active) |
| Input 3 46-50 Trip | 00805 | 0: Off (inactive) | 1: On (active) |
| Input 3 46-51 Alarm | 00806 | 0: Off (inactive) | 1: On (active) |
| Input 3 46-51 Trip | 00807 | 0: Off (inactive) | 1: On (active) |
| Input 4 5LS-1 Output | 00808 | 0: Off (inactive) | 1: On (active) |
| Input 4 50LS-2 Output | 00809 | 0: Off (inactive) | 1: On (active) |
| Input 4 50BF-1 Trip | 00810 | 0: Off (inactive) | 1: On (active) |
| Input 4 50BF-2 Trip | 00811 | 0: Off (inactive) | 1: On (active) |
| Input 4 50 Trip | 00812 | 0: Off (inactive) | 1: On (active) |
| Input 4 51 Alarm | 00813 | 0: Off (inactive) | 1: On (active) |
| Input 4 51 Trip | 00814 | 0: Off (inactive) | 1: On (active) |
| Input 4 50N Trip | 00815 | 0: Off (inactive) | 1: On (active) |
| Input 4 51N Alarm | 00816 | 0: Off (inactive) | 1: On (active) |
| Input 4 51N Trip | 00817 | 0: Off (inactive) | 1: On (active) |

| Read Coil Status (Function Code 01) | | | |
|-------------------------------------|-------|-------------------|----------------|
| Input 4 46-50 Trip | 00818 | 0: Off (inactive) | 1: On (active) |
| Input 4 46-51 Alarm | 00819 | 0: Off (inactive) | 1: On (active) |
| Input 4 46-51 Trip | 00820 | 0: Off (inactive) | 1: On (active) |
| Input 5 5LS-1 Output | 00821 | 0: Off (inactive) | 1: On (active) |
| Input 5 50LS-2 Output | 00822 | 0: Off (inactive) | 1: On (active) |
| Input 5 50BF-1 Trip | 00823 | 0: Off (inactive) | 1: On (active) |
| Input 5 50BF-2 Trip | 00824 | 0: Off (inactive) | 1: On (active) |
| Input 5 50 Trip | 00825 | 0: Off (inactive) | 1: On (active) |
| Input 5 51 Alarm | 00826 | 0: Off (inactive) | 1: On (active) |
| Input 5 51 Trip | 00827 | 0: Off (inactive) | 1: On (active) |
| Input 5 50N Trip | 00828 | 0: Off (inactive) | 1: On (active) |
| Input 5 51N Alarm | 00829 | 0: Off (inactive) | 1: On (active) |
| Input 5 51N Trip | 00830 | 0: Off (inactive) | 1: On (active) |
| Input 5 46-50 Trip | 00831 | 0: Off (inactive) | 1: On (active) |
| Input 5 46-51 Alarm | 00832 | 0: Off (inactive) | 1: On (active) |
| Input 5 46-51 Trip | 00833 | 0: Off (inactive) | 1: On (active) |
| Input 6 5LS-1 Output | 00834 | 0: Off (inactive) | 1: On (active) |
| Input 6 50LS-2 Output | 00835 | 0: Off (inactive) | 1: On (active) |
| Input 6 50BF-1 Trip | 00836 | 0: Off (inactive) | 1: On (active) |
| Input 6 50BF-2 Trip | 00837 | 0: Off (inactive) | 1: On (active) |
| Input 6 50 Trip | 00838 | 0: Off (inactive) | 1: On (active) |
| Input 6 51 Alarm | 00839 | 0: Off (inactive) | 1: On (active) |
| Input 6 51 Trip | 00840 | 0: Off (inactive) | 1: On (active) |
| Input 6 50N Trip | 00841 | 0: Off (inactive) | 1: On (active) |
| Input 6 51N Alarm | 00842 | 0: Off (inactive) | 1: On (active) |
| Input 6 51N Trip | 00843 | 0: Off (inactive) | 1: On (active) |
| Input 6 46-50 Trip | 00844 | 0: Off (inactive) | 1: On (active) |
| Input 6 46-51 Alarm | 00845 | 0: Off (inactive) | 1: On (active) |
| Input 6 46-51 Trip | 00846 | 0: Off (inactive) | 1: On (active) |
| 87T Trip | 00847 | 0: Off (inactive) | 1: On (active) |
| 87B-1 Trip | 00848 | 0: Off (inactive) | 1: On (active) |
| 59-1 Trip | 00849 | 0: Off (inactive) | 1: On (active) |
| 59-2 Trip | 00850 | 0: Off (inactive) | 1: On (active) |
| 27-1 Trip | 00851 | 0: Off (inactive) | 1: On (active) |
| 27-2 Trip | 00852 | 0: Off (inactive) | 1: On (active) |
| 60 Alarm | 00853 | 0: Off (inactive) | 1: On (active) |
| 81O-1 Trip | 00854 | 0: Off (inactive) | 1: On (active) |
| 81O-2 Trip | 00855 | 0: Off (inactive) | 1: On (active) |
| 81U-1 Trip | 00856 | 0: Off (inactive) | 1: On (active) |

| Read Coil Status (Function Code 01) | | | |
|-------------------------------------|-------|-------------------|----------------|
| 81U-2 Trip | 00857 | 0: Off (inactive) | 1: On (active) |
| Self Check Fail | 00858 | 0: Off (inactive) | 1: On (active) |
| ProLogic 1 | 00859 | 0: Off (inactive) | 1: On (active) |
| ProLogic 2 | 00860 | 0: Off (inactive) | 1: On (active) |
| ProLogic 3 | 00861 | 0: Off (inactive) | 1: On (active) |
| ProLogic 4 | 00862 | 0: Off (inactive) | 1: On (active) |
| ProLogic 5 | 00863 | 0: Off (inactive) | 1: On (active) |
| ProLogic 6 | 00864 | 0: Off (inactive) | 1: On (active) |
| ProLogic 7 | 00865 | 0: Off (inactive) | 1: On (active) |
| ProLogic 8 | 00866 | 0: Off (inactive) | 1: On (active) |
| ProLogic 9 | 00867 | 0: Off (inactive) | 1: On (active) |
| ProLogic 10 | 00868 | 0: Off (inactive) | 1: On (active) |
| ProLogic 11 | 00869 | 0: Off (inactive) | 1: On (active) |
| ProLogic 12 | 00870 | 0: Off (inactive) | 1: On (active) |
| ProLogic 13 | 00871 | 0: Off (inactive) | 1: On (active) |
| ProLogic 14 | 00872 | 0: Off (inactive) | 1: On (active) |
| ProLogic 15 | 00873 | 0: Off (inactive) | 1: On (active) |
| 87T Restraint | 00874 | 0: Off (inactive) | 1: On (active) |
| 87T Fast Trip | 00875 | 0: Off (inactive) | 1: On (active) |
| 87B-1 Fast Trip | 00876 | 0: Off (inactive) | 1: On (active) |
| 87B-1 Block via Saturation | 00877 | 0: Off (inactive) | 1: On (active) |
| 87B-2 Trip | 00878 | 0: Off (inactive) | 1: On (active) |
| 87B-2 Fast Trip | 00879 | 0: Off (inactive) | 1: On (active) |
| 87B-2 Block via Saturation | 00880 | 0: Off (inactive) | 1: On (active) |

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

| Read Holding Registers (Function Code 03) | | | |
|--|---------|--|-------|
| Channel | Address | Units | Scale |
| B-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 |
| 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 |
| Offset of UTC to IED local time. | 40015 | 2's complement half hours, North America is negative | 1 |
| VA Magnitude | 40257 | KV | 10 |
| VA Angle | 40258 | Degrees | 10 |
| VB Magnitude | 40259 | KV | 10 |
| VB Angle | 40260 | Degrees | 10 |
| VC Magnitude | 40261 | KV | 10 |
| VC Angle | 40262 | Degrees | 10 |
| I1A Magnitude | 40263 | A | 1 |
| I1A Angle | 40264 | Degrees | 10 |
| I1B Magnitude | 40265 | A | 1 |
| I1B Angle | 40266 | Degrees | 10 |
| I1C Magnitude | 40267 | A | 1 |
| I1C Angle | 40268 | Degrees | 10 |
| I2A Magnitude | 40269 | A | 1 |
| I2A Angle | 40270 | Degrees | 10 |
| I2B Magnitude | 40271 | A | 1 |
| I2B Angle | 40272 | Degrees | 10 |
| I2C Magnitude | 40273 | A | 1 |
| I2C Angle | 40274 | Degrees | 10 |
| I3A Magnitude | 40275 | A | 1 |

| Read Holding Registers (Function Code 03) | | | |
|---|-------|---------|----|
| I3A Angle | 40276 | Degrees | 10 |
| I3B Magnitude | 40277 | A | 1 |
| I3B Angle | 40278 | Degrees | 10 |
| I3C Magnitude | 40279 | A | 1 |
| I3C Angle | 40280 | Degrees | 10 |
| I4A Magnitude | 40281 | A | 1 |
| I4A Angle | 40282 | Degrees | 10 |
| I4B Magnitude | 40283 | A | 1 |
| I4B Angle | 40284 | Degrees | 10 |
| I4C Magnitude | 40285 | A | 1 |
| I4C Angle | 40286 | Degrees | 10 |
| I5A Magnitude | 40287 | A | 1 |
| I5A Angle | 40288 | Degrees | 10 |
| I5B Magnitude | 40289 | A | 1 |
| I5B Angle | 40290 | Degrees | 10 |
| I5C Magnitude | 40291 | A | 1 |
| I5C Angle | 40292 | Degrees | 10 |
| I6A Magnitude | 40293 | A | 1 |
| I6A Angle | 40294 | Degrees | 10 |
| I6B Magnitude | 40295 | A | 1 |
| I6B Angle | 40296 | Degrees | 10 |
| I6C Magnitude | 40297 | A | 1 |
| I6C Angle | 40298 | Degrees | 10 |
| Transformer IA Operating | 40299 | A | 1 |
| Transformer IB Operating | 40300 | A | 1 |
| Transformer IC Operating | 40301 | A | 1 |
| Transformer IA Restraint | 40302 | A | 1 |
| Transformer IB Restraint | 40303 | A | 1 |
| Transformer IC Restraint | 40304 | A | 1 |
| Bus IA Operating | 40305 | A | 1 |
| Bus IB Operating | 40306 | A | 1 |
| Bus IC Operating | 40307 | A | 1 |
| Bus IA Restraint | 40308 | A | 1 |
| Bus IB Restraint | 40309 | A | 1 |
| Bus IC Restraint | 40310 | A | 1 |
| Input 1 P | 40311 | MW | 10 |
| Input 1 Q | 40312 | MVARs | 10 |
| Input 2 P | 40313 | MW | 10 |
| Input 2 Q | 40314 | MVARs | 10 |

| Read Holding Registers (Function Code 03) | | | |
|---|-------|-------|-----|
| Input 3 P | 40315 | MW | 10 |
| Input 3 Q | 40316 | MVARS | 10 |
| Input 4 P | 40317 | MW | 10 |
| Input 4 Q | 40318 | MVARS | 10 |
| Input 5 P | 40319 | MW | 10 |
| Input 5 Q | 40320 | MVARS | 10 |
| Input 6 P | 40321 | MW | 10 |
| Input 6 Q | 40322 | MVARS | 10 |
| Positive Sequence V | 40323 | kV | 10 |
| Frequency | 40324 | Hz | 100 |
| 87B-2 IA Operating | 40325 | A | 1 |
| 87B-2 IB Operating | 40326 | A | 1 |
| 87B-2 IC Operating | 40327 | A | 1 |
| 87B-2 IA Restraint | 40328 | A | 1 |
| 87B-2 IB Restraint | 40329 | A | 1 |
| 87B-2 IC Restraint | 40330 | A | 1 |
| Self Check Fail Parameter | 40331 | N/A | 1 |

| Read Input Register (Function Code 04) |
|---|
| No input registers supported. Response from 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) |

| 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 acknowledge) | 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" command. |

| 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 | 21FC = 8700 decimal |
| Version Number | Read Only | 2 and 3 | Version number |
| Issue Number | Read Only | 4 and 5 | Issue number |

- The B-PRO IED model number is 8700/BUS.
- Version and issue will each be positive integers, say X and Y.
- The B-PRO is defined as “Model 8700/BUS, Version X Issue Y”

| Accessing B-PRO Event Information | |
|--|--|
| All B-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 B-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 Message | (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 indicates 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.) |
| Read Event Message | (Function Code 3, addresses 40517 - 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. |

Modbus Event Message Example

"2002May15 16:45:07.848: 27-1 (U/V) on ABC: Trip"

| Register | Value | | Meaning |
|----------|-----------|----------|---------------------------------|
| | High Byte | Low Byte | |
| 40516 | 0x00 | 0x19 | Event text size = 25 (0x19 hex) |
| 40517 | 0x20 | 0x20 | '<sp>', '<sp>' |
| 40518 | 0x32 | 0x30 | '2', '0' |
| 40519 | 0x30 | 0x32 | '0', '2' |
| 40520 | 0x40 | 0x61 | 'M', 'a' |
| 40521 | 0x79 | 0x31 | 'y', '1' |
| 40522 | 0x35 | 0x20 | '5', '<sp>' |
| 40523 | 0x31 | 0x36 | '1', '6' |
| 40524 | 0x3A | 0x34 | ':', '4' |
| 40525 | 0x35 | 0x3A | '5', ':' |
| 40526 | 0x30 | 0x37 | '0', '7' |
| 40527 | 0x2E | 0x38 | ':', '8' |
| 40528 | 0x34 | 0x38 | '4', '8' |
| 40529 | 0x20 | 0x3A | '<sp>', ':' |
| 40530 | 0x20 | 0x32 | '<sp>', '2' |
| 40531 | 0x37 | 0x2D | '7', '-' |
| 40532 | 0x31 | 0x20 | '1', '<sp>' |
| 40533 | 0x28 | 0x55 | '(', 'U' |
| 40534 | 0x2F | 0x56 | '/', 'V' |
| 40535 | 0x29 | 0x20 | ')', '<sp>' |
| 40536 | 0x6F | 0x6E | 'o', 'n' |
| 40537 | 0x20 | 0x41 | '<sp>', 'A' |
| 40538 | 0x42 | 0x43 | 'B', 'C' |
| 40539 | 0x3A | 0x20 | ':', '<sp>' |
| 40540 | 0x54 | 0x72 | 'T', 'r' |
| 40541 | 0x69 | 0x70 | 'i', 'p' |

Appendix F DNP3 Communication Protocol

Device Profile

The DNP3 SCADA protocol is available through a direct serial link (Port 3) or the Ethernet LAN over the TCP or UDP protocols (network card required). All metering values available through the terminal user interface are available by DNP3 protocol. Included are the device profile, implementation table and the point list for the DNP3 protocol.

| | |
|---|--|
| Vendor Name: NxtPhase 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 Frame 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 Complete Application Fragment x None __Fixed at 2 Application Confirm __None x Fixed at 5 Complete Application Response x None __Fixed at 2 Others _____ Select to execute delay __None x Fixed at 10 | |
| Sends/Executes Control Operations: WRITE Binary Outputs x Never __Always SELECT/OPERATE __Never x Always DIRECT OPERATE __Never x Always DIRECT OPERATE No ACK __Never x Always Count > 1 x Never __Always Pulse On __Never x Always Pulse Off x Never __Always Latch On __Never x Always Latch Off __Never x Always Queue x Never __Always Clear Queue x Never __Always 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 | Sends Static Data in Unsolicited Responses: x Never _ When Device Restarts |

| | |
|---|---|
| _ Only certain objects _ Sometimes _ ENABLE/DISABLE UNSOLICITED Function codes supported | _ When Status Flags Change No other options are permitted. |
| Default Counter Object/Variation: x No Counter Reported _ Configurable _ Default Object _____ _ Default Variation _____ _ Point-by-point list attached | Counters Roll Over at: x No Counters Reported _ Configurable _ 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 | | |
| 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 |

| Binary Inputs | 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 |
| Virtual Input #1 | 9 | 1 |
| Virtual Input #2 | 10 | 1 |
| Virtual Input #3 | 11 | 1 |
| Virtual Input #4 | 12 | 1 |
| Virtual Input #5 | 13 | 1 |
| Virtual Input #6 | 14 | 1 |
| Virtual Input #7 | 15 | 1 |

| | | |
|-------------------|----|---|
| Virtual Input #8 | 16 | 1 |
| Virtual Input #9 | 17 | 1 |
| Virtual Input #10 | 18 | 1 |
| Virtual Input #11 | 19 | 1 |
| Virtual Input #12 | 20 | 1 |
| Virtual Input #13 | 21 | 1 |
| Virtual Input #14 | 22 | 1 |
| Virtual Input #15 | 23 | 1 |
| Virtual Input #16 | 24 | 1 |
| Virtual Input #17 | 25 | 1 |
| Virtual Input #18 | 26 | 1 |
| Virtual Input #19 | 27 | 1 |
| Virtual Input #20 | 28 | 1 |
| Virtual Input #21 | 29 | 1 |
| Virtual Input #22 | 30 | 1 |
| Virtual Input #23 | 31 | 1 |
| Virtual Input #24 | 32 | 1 |
| Virtual Input #25 | 33 | 1 |
| Virtual Input #26 | 34 | 1 |
| Virtual Input #27 | 35 | 1 |
| Virtual Input #28 | 36 | 1 |
| Virtual Input #29 | 37 | 1 |
| Virtual Input #30 | 38 | 1 |

| Binary Outputs (Obj 10) | | |
|--|------------------------------------|---------------------|
| | Static Points | Change Event Points |
| Object Group | 10 | Not Applicable |
| Object Variation | 2 – Binary Output Status (default) | Not Applicable |
| Class | 0 | Not Applicable |
| Note: Binary outputs are scanned with 500 ms resolution. | | |
| No change buffer | | |

| Binary Outputs | Point Index | Change Event Class | Object Group |
|-----------------------|-------------|--------------------|--------------|
| Output Contact 1 | 0 | N/A | 10 |
| Output Contact 2 | 1 | N/A | 10 |
| Output Contact 3 | 2 | N/A | 10 |
| Output Contact 4 | 3 | N/A | 10 |
| Output Contact 5 | 4 | N/A | 10 |
| Output Contact 6 | 5 | N/A | 10 |
| Output Contact 7 | 6 | N/A | 10 |
| Output Contact 8 | 7 | N/A | 10 |
| Output Contact 9 | 8 | N/A | 10 |
| Output Contact 10 | 9 | N/A | 10 |
| Output Contact 11 | 10 | N/A | 10 |
| Output Contact 12 | 11 | N/A | 10 |
| Output Contact 13 | 12 | N/A | 10 |
| Output Contact 14 | 13 | N/A | 10 |
| Input 1 5LS-1 Output | 14 | N/A | 10 |
| Input 1 50LS-2 Output | 15 | N/A | 10 |
| Input 1 50BF-1 Trip | 16 | N/A | 10 |
| Input 1 50BF-2 Trip | 17 | N/A | 10 |
| Input 1 50 Trip | 18 | N/A | 10 |
| Input 1 51 Alarm | 19 | N/A | 10 |
| Input 1 51 Trip | 20 | N/A | 10 |
| Input 1 50N Trip | 21 | N/A | 10 |
| Input 1 51N Alarm | 22 | N/A | 10 |
| Input 1 51N Trip | 23 | N/A | 10 |
| Input 1 46-50 Trip | 24 | N/A | 10 |
| Input 1 46-51 Alarm | 25 | N/A | 10 |
| Input 1 46-51 Trip | 26 | N/A | 10 |
| Input 2 5LS-1 Output | 27 | N/A | 10 |
| Input 2 50LS-2 Output | 28 | N/A | 10 |
| Input 2 50BF-1 Trip | 29 | N/A | 10 |
| Input 2 50BF-2 Trip | 30 | N/A | 10 |
| Input 2 50 Trip | 31 | N/A | 10 |
| Input 2 51 Alarm | 32 | N/A | 10 |
| Input 2 51 Trip | 33 | N/A | 10 |
| Input 2 50N Trip | 34 | N/A | 10 |
| Input 2 51N Alarm | 35 | N/A | 10 |
| Input 2 51N Trip | 36 | N/A | 10 |

| Binary Outputs | Point Index | Change Event Class | Object Group |
|-----------------------|-------------|--------------------|--------------|
| Input 2 46-50 Trip | 37 | N/A | 10 |
| Input 2 46-51 Alarm | 38 | N/A | 10 |
| Input 2 46-51 Trip | 39 | N/A | 10 |
| Input 3 5LS-1 Output | 40 | N/A | 10 |
| Input 3 50LS-2 Output | 41 | N/A | 10 |
| Input 3 50BF-1 Trip | 42 | N/A | 10 |
| Input 3 50BF-2 Trip | 43 | N/A | 10 |
| Input 3 50 Trip | 44 | N/A | 10 |
| Input 3 51 Alarm | 45 | N/A | 10 |
| Input 3 51 Trip | 46 | N/A | 10 |
| Input 3 50N Trip | 47 | N/A | 10 |
| Input 3 51N Alarm | 48 | N/A | 10 |
| Input 3 51N Trip | 49 | N/A | 10 |
| Input 3 46-50 Trip | 50 | N/A | 10 |
| Input 3 46-51 Alarm | 51 | N/A | 10 |
| Input 3 46-51 Trip | 52 | N/A | 10 |
| Input 4 5LS-1 Output | 53 | N/A | 10 |
| Input 4 50LS-2 Output | 54 | N/A | 10 |
| Input 4 50BF-1 Trip | 55 | N/A | 10 |
| Input 4 50BF-2 Trip | 56 | N/A | 10 |
| Input 4 50 Trip | 57 | N/A | 10 |
| Input 4 51 Alarm | 58 | N/A | 10 |
| Input 4 51 Trip | 59 | N/A | 10 |
| Input 4 50N Trip | 60 | N/A | 10 |
| Input 4 51N Alarm | 61 | N/A | 10 |
| Input 4 51N Trip | 62 | N/A | 10 |
| Input 4 46-50 Trip | 63 | N/A | 10 |
| Input 4 46-51 Alarm | 64 | N/A | 10 |
| Input 4 46-51 Trip | 65 | N/A | 10 |
| Input 5 5LS-1 Output | 66 | N/A | 10 |
| Input 5 50LS-2 Output | 67 | N/A | 10 |
| Input 5 50BF-1 Trip | 68 | N/A | 10 |
| Input 5 50BF-2 Trip | 69 | N/A | 10 |
| Input 5 50 Trip | 70 | N/A | 10 |
| Input 5 51 Alarm | 71 | N/A | 10 |
| Input 5 51 Trip | 72 | N/A | 10 |
| Input 5 50N Trip | 73 | N/A | 10 |
| Input 5 51N Alarm | 74 | N/A | 10 |
| Input 5 51N Trip | 75 | N/A | 10 |

| Binary Outputs | Point Index | Change Event Class | Object Group |
|-----------------------|-------------|--------------------|--------------|
| Input 5 46-50 Trip | 76 | N/A | 10 |
| Input 5 46-51 Alarm | 77 | N/A | 10 |
| Input 5 46-51 Trip | 78 | N/A | 10 |
| Input 6 5LS-1 Output | 79 | N/A | 10 |
| Input 6 50LS-2 Output | 80 | N/A | 10 |
| Input 6 50BF-1 Trip | 81 | N/A | 10 |
| Input 6 50BF-2 Trip | 82 | N/A | 10 |
| Input 6 50 Trip | 83 | N/A | 10 |
| Input 6 51 Alarm | 84 | N/A | 10 |
| Input 6 51 Trip | 85 | N/A | 10 |
| Input 6 50N Trip | 86 | N/A | 10 |
| Input 6 51N Alarm | 87 | N/A | 10 |
| Input 6 51N Trip | 88 | N/A | 10 |
| Input 6 46-50 Trip | 89 | N/A | 10 |
| Input 6 46-51 Alarm | 90 | N/A | 10 |
| Input 6 46-51 Trip | 91 | N/A | 10 |
| 87T Trip | 92 | N/A | 10 |
| 87B Trip | 93 | N/A | 10 |
| 59 1 Trip | 94 | N/A | 10 |
| 59 2 Trip | 95 | N/A | 10 |
| 27 1 Trip | 96 | N/A | 10 |
| 27 2 Trip | 97 | N/A | 10 |
| 60 Alarm | 98 | N/A | 10 |
| 81O 1 Trip | 99 | N/A | 10 |
| 81O 2 Trip | 100 | N/A | 10 |
| 81U 1 Trip | 101 | N/A | 10 |
| 81U 2 Trip | 102 | N/A | 10 |
| Self Check Fail | 103 | N/A | 10 |
| ProLogic 1 | 104 | N/A | 10 |
| ProLogic 2 | 105 | N/A | 10 |
| ProLogic 3 | 106 | N/A | 10 |
| ProLogic 4 | 107 | N/A | 10 |
| ProLogic 5 | 108 | N/A | 10 |
| ProLogic 6 | 109 | N/A | 10 |
| ProLogic 7 | 110 | N/A | 10 |
| ProLogic 8 | 111 | N/A | 10 |
| ProLogic 9 | 112 | N/A | 10 |
| ProLogic 10 | 113 | N/A | 10 |
| ProLogic 11 | 114 | N/A | 10 |

| Binary Outputs | Point Index | Change Event Class | Object Group |
|----------------------------|-------------|--------------------|--------------|
| ProLogic 12 | 115 | N/A | 10 |
| ProLogic 13 | 116 | N/A | 10 |
| ProLogic 14 | 117 | N/A | 10 |
| ProLogic 15 | 118 | N/A | 10 |
| 87T Restraint | 119 | N/A | 10 |
| 87T Fast Trip | 120 | N/A | 10 |
| 87B-1 Fast Trip | 121 | N/A | 10 |
| 87B-1 Block via Saturation | 122 | N/A | 10 |
| 87B-2 Trip | 123 | N/A | 10 |
| 87B-2 Fast Trip | 124 | N/A | 10 |
| 87B-2 Block via Saturation | 125 | N/A | 10 |
| Virtual Input #1 | 126 | N/A | 10, 12 |
| Virtual Input #2 | 127 | N/A | 10, 12 |
| Virtual Input #3 | 128 | N/A | 10, 12 |
| Virtual Input #4 | 129 | N/A | 10, 12 |
| Virtual Input #5 | 130 | N/A | 10, 12 |
| Virtual Input #6 | 131 | N/A | 10, 12 |
| Virtual Input #7 | 132 | N/A | 10, 12 |
| Virtual Input #8 | 133 | N/A | 10, 12 |
| Virtual Input #9 | 134 | N/A | 10, 12 |
| Virtual Input #10 | 135 | N/A | 10, 12 |
| Virtual Input #11 | 136 | N/A | 10, 12 |
| Virtual Input #12 | 137 | N/A | 10, 12 |
| Virtual Input #13 | 138 | N/A | 10, 12 |
| Virtual Input #14 | 139 | N/A | 10, 12 |
| Virtual Input #15 | 140 | N/A | 10, 12 |
| Virtual Input #16 | 141 | N/A | 10, 12 |
| Virtual Input #17 | 142 | N/A | 10, 12 |
| Virtual Input #18 | 143 | N/A | 10, 12 |
| Virtual Input #19 | 144 | N/A | 10, 12 |
| Virtual Input #20 | 145 | N/A | 10, 12 |
| Virtual Input #21 | 146 | N/A | 10, 12 |
| Virtual Input #22 | 147 | N/A | 10, 12 |
| Virtual Input #23 | 148 | N/A | 10, 12 |
| Virtual Input #24 | 149 | N/A | 10, 12 |
| Virtual Input #25 | 150 | N/A | 10, 12 |
| Virtual Input #26 | 151 | N/A | 10, 12 |
| Virtual Input #27 | 152 | N/A | 10, 12 |
| Virtual Input #28 | 153 | N/A | 10, 12 |

| Binary Outputs | Point Index | Change Event Class | Object Group |
|-------------------|-------------|--------------------|--------------|
| Virtual Input #29 | 154 | N/A | 10, 12 |
| Virtual Input #30 | 155 | N/A | 10, 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 B-PRO. | | |

| Analog Inputs | Point Index | Units | Scale | Change Event Class | Deadband |
|---------------|-------------|---------|-------|--------------------|-------------|
| VA Magnitude | 0 | kV | 10 | 2 | 2% Nominal |
| VA Angle | 1 | Degrees | 10 | 2 | 0.5 Degrees |
| VB Magnitude | 2 | kV | 10 | 2 | 2% Nominal |
| VB Angle | 3 | Degrees | 10 | 2 | 0.5 Degrees |
| VC Magnitude | 4 | kV | 10 | 2 | 2% Nominal |
| VC Angle | 5 | Degrees | 10 | 2 | 0.5 Degrees |
| I1A Magnitude | 6 | A | 1 | 2 | 2% Nominal |
| I1A Angle | 7 | Degrees | 10 | 2 | 0.5 Degrees |
| I1B Magnitude | 8 | A | 1 | 2 | 2% Nominal |
| I1B Angle | 9 | Degrees | 10 | 2 | 0.5 Degrees |
| I1C Magnitude | 10 | A | 1 | 2 | 2% Nominal |
| I1C Angle | 11 | Degrees | 10 | 2 | 0.5 Degrees |
| I2A Magnitude | 12 | A | 1 | 2 | 2% Nominal |
| I2A Angle | 13 | Degrees | 10 | 2 | 0.5 Degrees |
| I2B Magnitude | 14 | A | 1 | 2 | 2% Nominal |
| I2B Angle | 15 | Degrees | 10 | 2 | 0.5 Degrees |
| I2C Magnitude | 16 | A | 1 | 2 | 2% Nominal |
| I2C Angle | 17 | Degrees | 10 | 2 | 0.5 Degrees |
| I3A Magnitude | 18 | A | 1 | 2 | 2% Nominal |
| I3A Angle | 19 | Degrees | 10 | 2 | 0.5 Degrees |
| I3B Magnitude | 20 | A | 1 | 2 | 2% Nominal |
| I3B Angle | 21 | Degrees | 10 | 2 | 0.5 Degrees |
| I3C Magnitude | 22 | A | 1 | 2 | 2% Nominal |
| I3C Angle | 23 | Degrees | 10 | 2 | 0.5 Degrees |
| I4A Magnitude | 24 | A | 1 | 2 | 2% Nominal |
| I4A Angle | 25 | Degrees | 10 | 2 | 0.5 Degrees |
| I4B Magnitude | 26 | A | 1 | 2 | 2% Nominal |
| I4B Angle | 27 | Degrees | 10 | 2 | 0.5 Degrees |
| I4C Magnitude | 28 | A | 1 | 2 | 2% Nominal |
| I4C Angle | 29 | Degrees | 10 | 2 | 0.5 Degrees |
| I5A Magnitude | 30 | A | 1 | 2 | 2% Nominal |
| I5A Angle | 31 | Degrees | 10 | 2 | 0.5 Degrees |
| I5B Magnitude | 32 | A | 1 | 2 | 2% Nominal |
| I5B Angle | 33 | Degrees | 10 | 2 | 0.5 Degrees |
| I5C Magnitude | 34 | A | 1 | 2 | 2% Nominal |
| I5C Angle | 35 | Degrees | 10 | 2 | 0.5 Degrees |
| I6A Magnitude | 36 | A | 1 | 2 | 2% Nominal |

| Analog Inputs | Point Index | Units | Scale | Change Event Class | Deadband |
|---------------------------|-------------|---------|-------|--------------------|-------------|
| I6A Angle | 37 | Degrees | 10 | 2 | 0.5 Degrees |
| I6B Magnitude | 38 | A | 1 | 2 | 2% Nominal |
| I6B Angle | 39 | Degrees | 10 | 2 | 0.5 Degrees |
| I6C Magnitude | 40 | A | 1 | 2 | 2% Nominal |
| I6C Angle | 41 | Degrees | 10 | 2 | 0.5 Degrees |
| Transformer IA Operating | 42 | A | 1 | 2 | 2% Nominal |
| Transformer IB Operating | 43 | A | 1 | 2 | 2% Nominal |
| Transformer IC Operating | 44 | A | 1 | 2 | 2% Nominal |
| Transformer IA Restraint | 45 | A | 1 | 2 | 2% Nominal |
| Transformer IB Restraint | 46 | A | 1 | 2 | 2% Nominal |
| Transformer IC Restraint | 47 | A | 1 | 2 | 2% Nominal |
| Bus IA Operating | 48 | A | 1 | 2 | 2% Nominal |
| Bus IB Operating | 49 | A | 1 | 2 | 2% Nominal |
| Bus IC Operating | 50 | A | 1 | 2 | 2% Nominal |
| Bus IA Restraint | 51 | A | 1 | 2 | 2% Nominal |
| Bus IB Restraint | 52 | A | 1 | 2 | 2% Nominal |
| Bus IC Restraint | 53 | A | 1 | 2 | 2% Nominal |
| Input 1 P | 54 | MW | 10 | 2 | 1.0 MW |
| Input 1 Q | 55 | MVAR | 10 | 2 | 0.5 MVAR |
| Input 2 P | 56 | MW | 10 | 2 | 1.0 MW |
| Input 2 Q | 57 | MVAR | 10 | 2 | 0.5 MVAR |
| Input 3 P | 58 | MW | 10 | 2 | 1.0 MW |
| Input 3 Q | 59 | MVAR | 10 | 2 | 0.5 MVAR |
| Input 4 P | 60 | MW | 10 | 2 | 1.0 MW |
| Input 4 Q | 61 | MVAR | 10 | 2 | 0.5 MVAR |
| Input 5 P | 62 | MW | 10 | 2 | 1.0 MW |
| Input 5 Q | 63 | MVAR | 10 | 2 | 0.5 MVAR |
| Input 6 P | 64 | MW | 10 | 2 | 1.0 MW |
| Input 6 Q | 65 | MVAR | 10 | 2 | 0.5 MVAR |
| Positive Sequence V | 66 | KV | 10 | 2 | 2% Nominal |
| Frequency | 67 | Hz | 100 | 2 | 0.05 Hz |
| 87B-2 IA Operating | 68 | A | 1 | 2 | 2% Nominal |
| 87B-2 IB Operating | 69 | A | 1 | 2 | 2% Nominal |
| 87B-2 IC Operating | 70 | A | 1 | 2 | 2% Nominal |
| 87B-2 IA Restraint | 71 | A | 1 | 2 | 2% Nominal |
| 87B-2 IB Restraint | 72 | A | 1 | 2 | 2% Nominal |
| 87B-2 IC Restraint | 73 | A | 1 | 2 | 2% Nominal |
| Self Check Fail Parameter | 74 | N/A | 1 | 2 | 0.5 |

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 B-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 B-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 following example shows an event returned through either of the octet string objects.

DNP Example: Event Message

| |
|---|
| “ 1999Dec08 07:27:55.248 : 27-2 (U/V) on ABC: Trip” |
|---|

| DNP Octet string object contents: | | | | |
|-----------------------------------|------|------|------|------|
| 0x20 | 0x20 | 0x31 | 0x39 | 0x39 |
| 0x39 | 0x44 | 0x65 | 0x63 | 0x30 |
| 0x38 | 0x20 | 0x30 | 0x37 | 0x3A |
| 0x32 | 0x37 | 0x3A | 0x35 | 0x35 |
| 0x2E | 0x32 | 0x34 | 0x38 | 0x20 |
| 0x3A | 0x20 | 0x32 | 0x37 | 0x2D |
| 0x32 | 0x20 | 0x28 | 0x55 | 0x2F |
| 0x56 | 0x29 | 0x20 | 0x6F | 0x6E |
| 0x20 | 0x41 | 0x42 | 0x43 | 0x3A |
| 0x20 | 0x54 | 0x72 | 0x69 | 0x70 |

Appendix G Mechanical Drawings

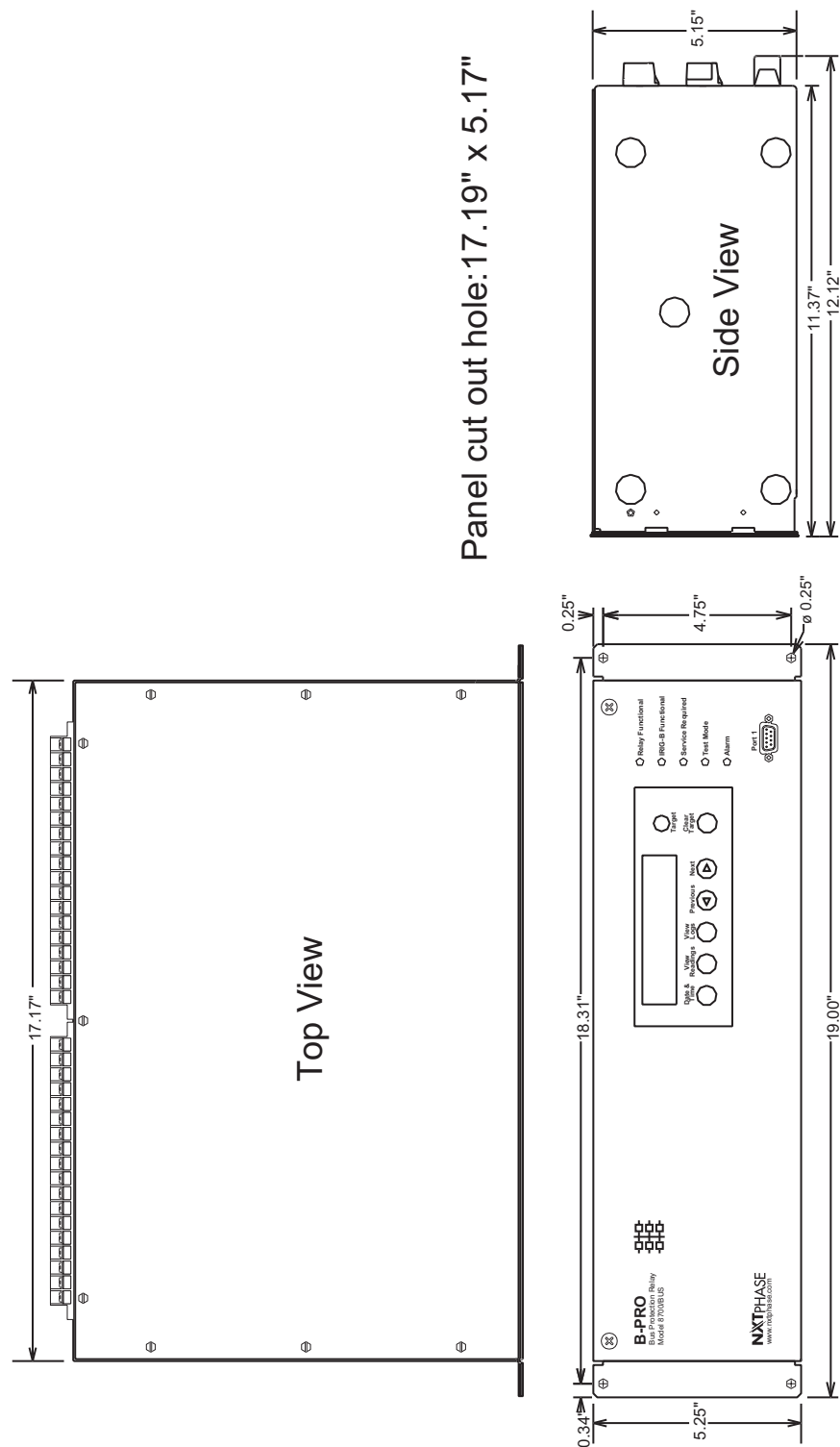


Figure G.1: Mechanical Drawing

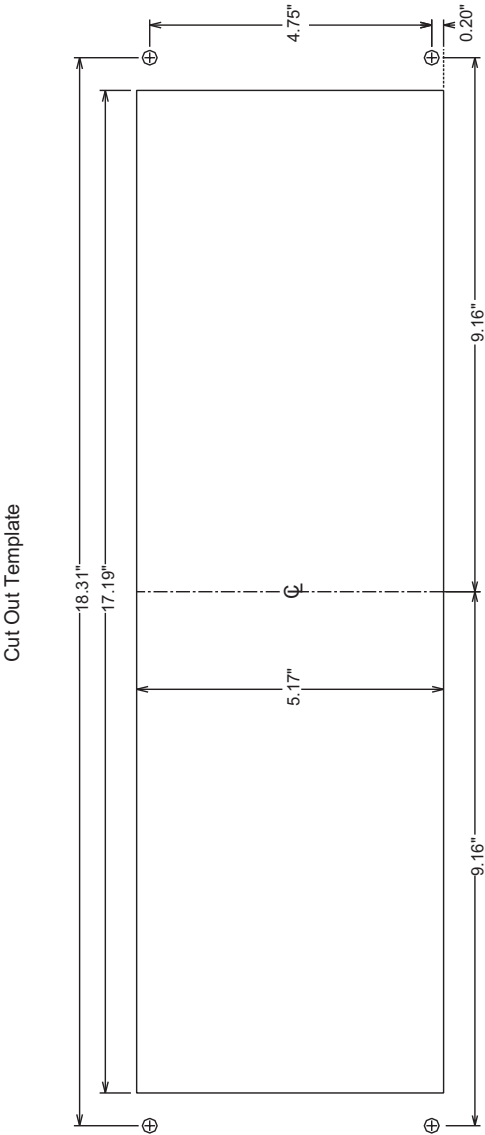


Figure G.2: Cut-out Template

Appendix H Rear Panel Drawings

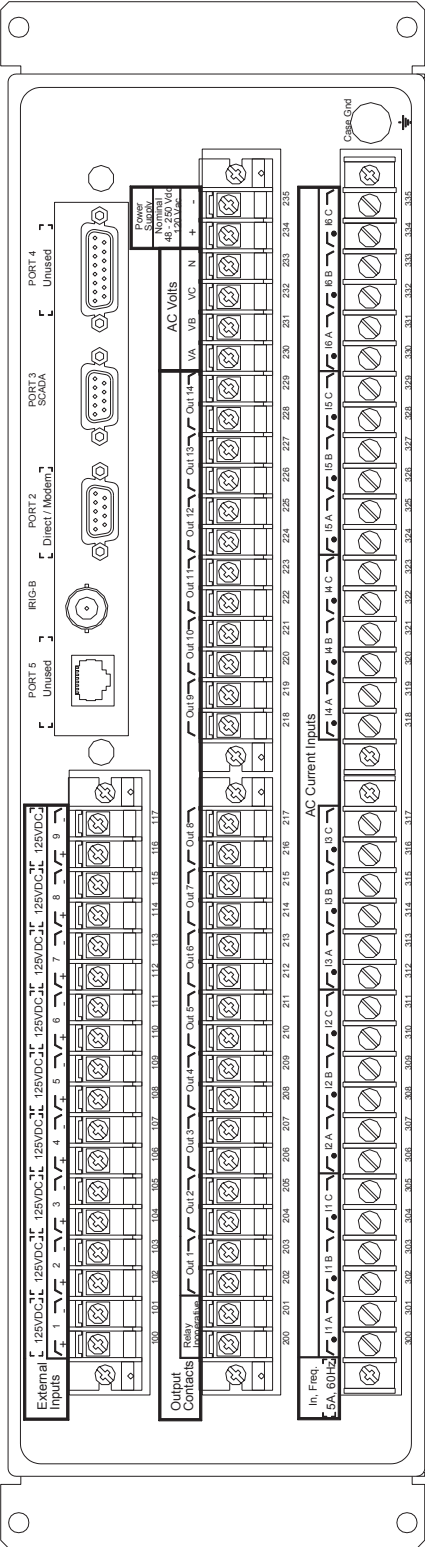


Figure H.1: Rear Panel

Appendix I AC Schematic Drawing

AC schematic using bus differential only

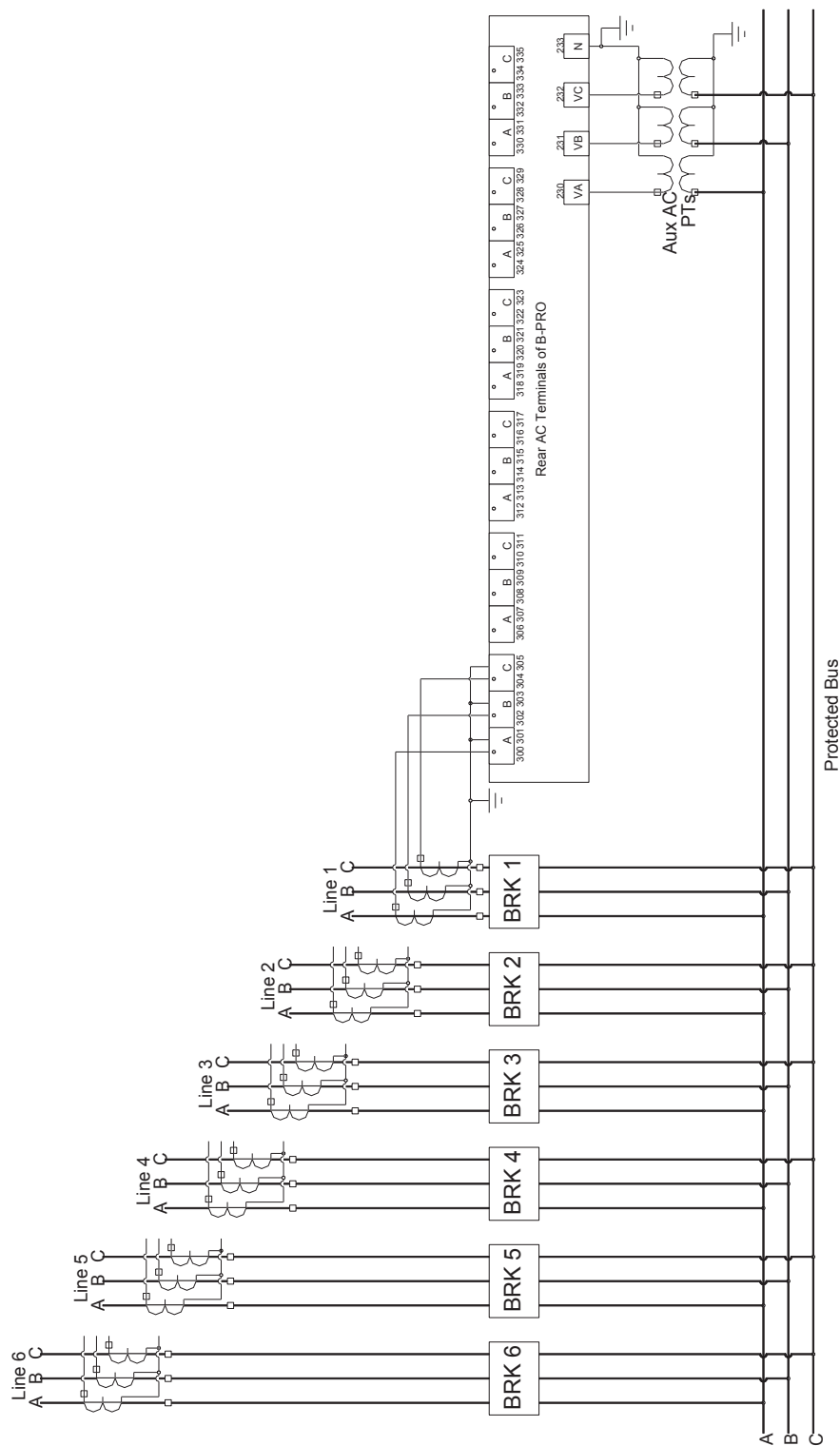


Figure I.1: AC Schematic (bus differential)

- Notes:
1. All CT's on lines connected GRD WYE.
 2. Lines 2 to 6 connected similarly to line 1.

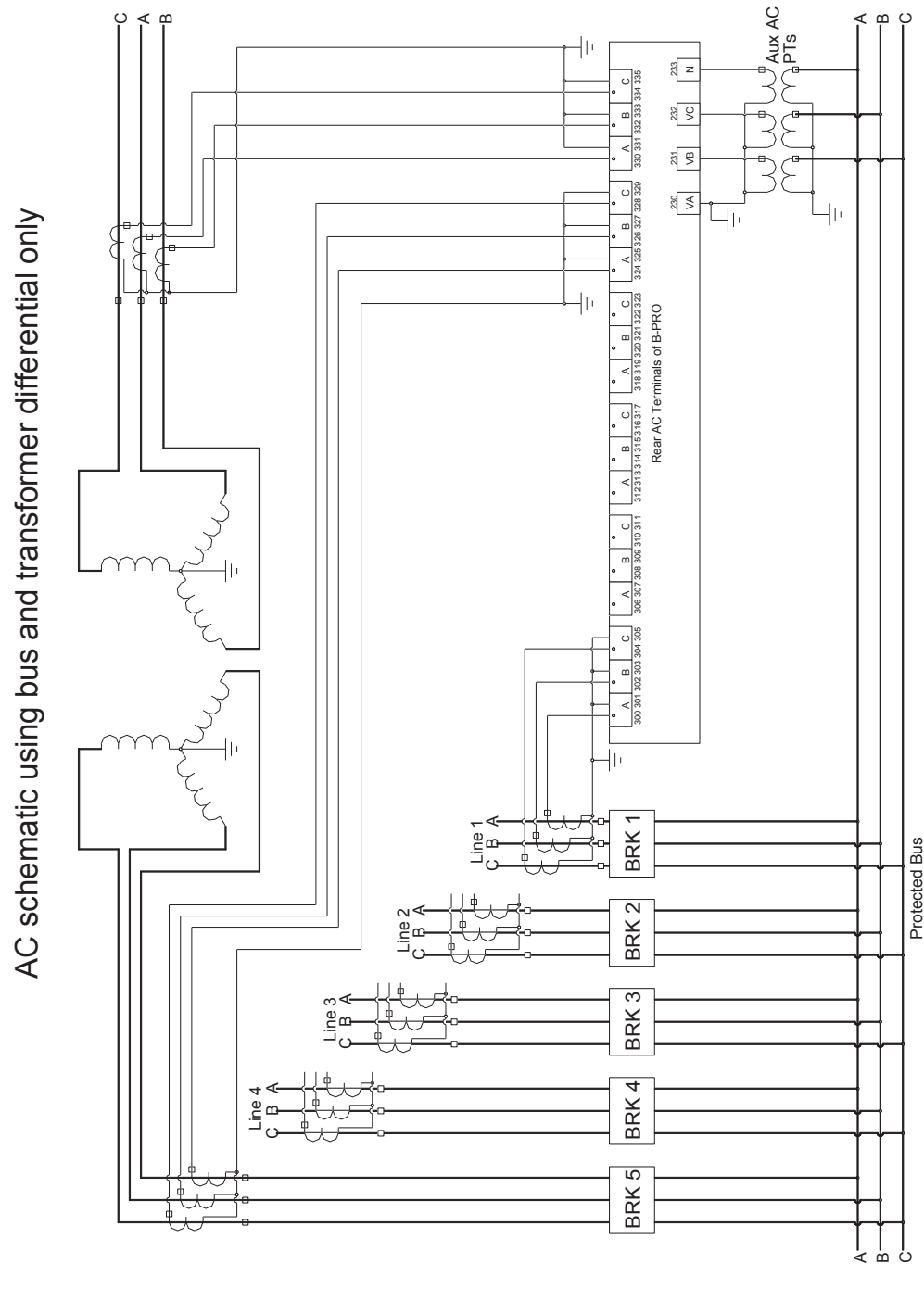


Figure I.2: AC Schematic (bus and transformer differential)

Appendix J DC Schematic Drawing

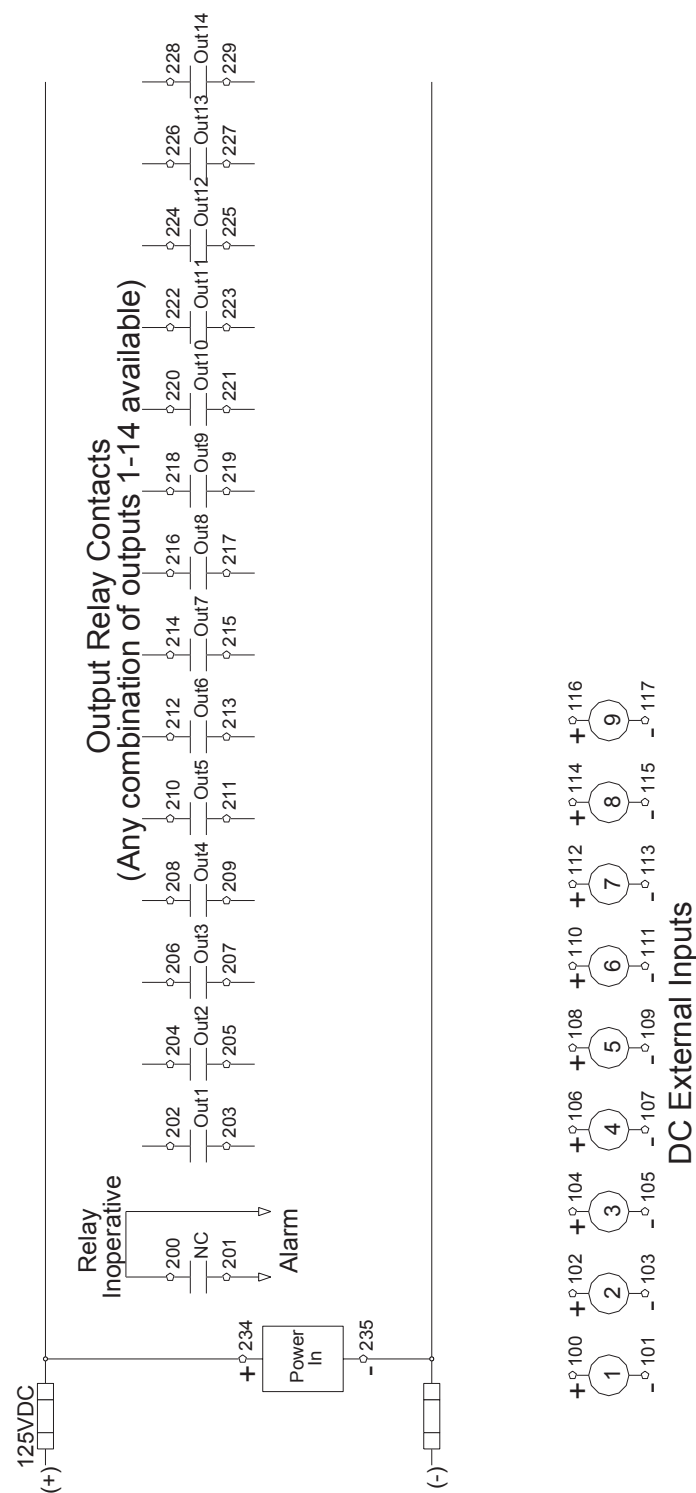


Figure J.1: DC Schematic

- Notes:
- 1. IRIG-B and comm ports shown separately on B-PRO rear panel layout drawing # 670003
 - 2. All output relays are N.O. and can be programmed to operate on any relay function.
 - 3. All outputs are rated tripping duty, interrupting via breaker aux "a" contact
 - 4. DC External Inputs are available for 48/125VDC or 125/250VDC ranges.

Appendix K Bus Differential Function Setting Examples

Introduction

The B-PRO Bus Protection Relay provides low-impedance differential protection for transmission and distribution buses, for up to 6 three-phase inputs. The B-PRO is a per-unit based relay, meaning all secondary currents entering the relay are converted to per-unit values for protection calculations. Choosing the correct per-unit base for the current permits the development of standard protection settings that work for most bus protection applications. The resulting settings method only requires 2 calculations to implement.

The settings described in this technical note will provide a good balance between dependability and security of the protection system. This method also assumes the CTs have burdens within their ratings, and that the measured secondary current by the CTs is between 0.2 A and 15 A secondary.

Bus Differential (87B-1 and 87B-2 Protection Function Characteristic

The operating characteristic of the 87B function is shown in Figure 1. I_{Omin} is the minimum operating current for fault detection. I_{Rs} is the setting for the breakpoint between the region of slope S1 and the region of slope S2. I_{Rs} is normally used as the upper limit of the load range, or the protection zone used to detect bus faults during normal load conditions. The S2 region is therefore used for protection during through-fault events, where CT measurement errors can be quite large. The High Current Setting is an unrestrained differential element. Settings are described more completely in the B-PRO instruction manual.

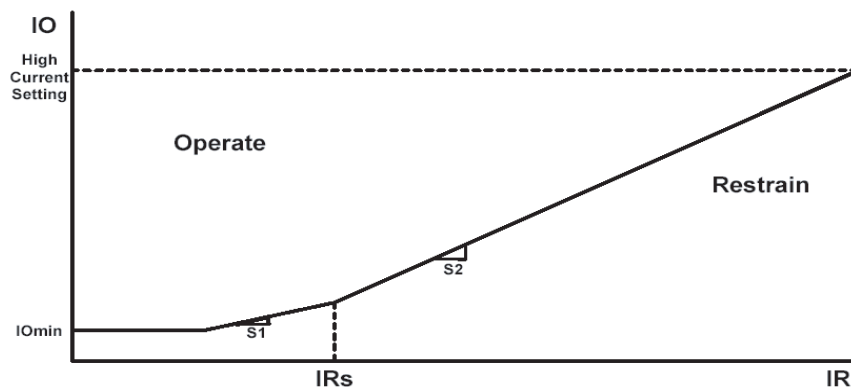


Figure K.1: 87B Operating Characteristic

In addition to this operating characteristic, the B-PRO includes a CT Saturation Detection algorithm that correctly identifies CT saturation due to external faults, and blocks the differential element from tripping.

While performing setting calculations for the B-PRO, the IO operate current is calculated by the equation:

$$IO = \left| \vec{I1} + \vec{I2} + \vec{I3} + \vec{I4} + \vec{I5} + \vec{I6} \right| A_{per\ unit}$$

The restraint current IR calculation is:

$$IR = \frac{\left| \vec{I1} \right| + \left| \vec{I2} \right| + \left| \vec{I3} \right| + \left| \vec{I4} \right| + \left| \vec{I5} \right| + \left| \vec{I6} \right|}{2} A_{per\ unit}$$

Settings Philosophy

The recommended settings method described in this technical note is simple: choose the MVA Base setting of the relay such that the maximum bus transfer load current is equal to the IRs setting in per-unit current. All other settings are related to the per-unit base current. The preferred setting for IRs is 2 per-unit, but there are some applications where a higher value is required. This method ensures that IRs is the upper limit setting for the load range, provides dependability for normal operating conditions, and provides adequate security for through-fault events.

The basic settings philosophy is to make sure operating and restraint current values (during normal operating conditions) fall in the load range. This means the S1 range accommodates the actual operating current, accounting for the maximum CT measurement error under any load condition. External fault conditions will be in the S2 or High Current range of the characteristic. Figure 2 describes recommended settings for most bus differential applications.

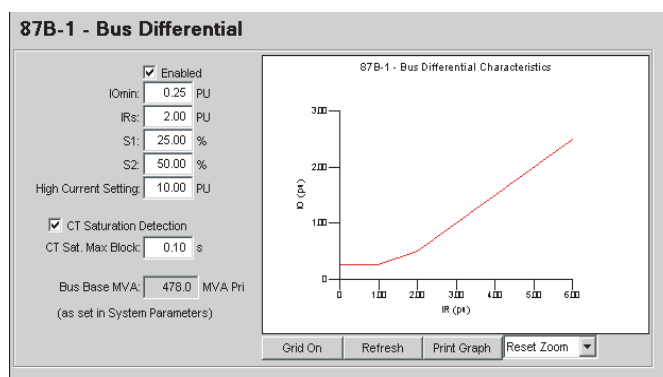


Figure K.2: 87B-1 settings

Settings Method

The clearest way to understand the proposed bus differential settings method is through a specific example. Figure 3 illustrates normal load conditions.

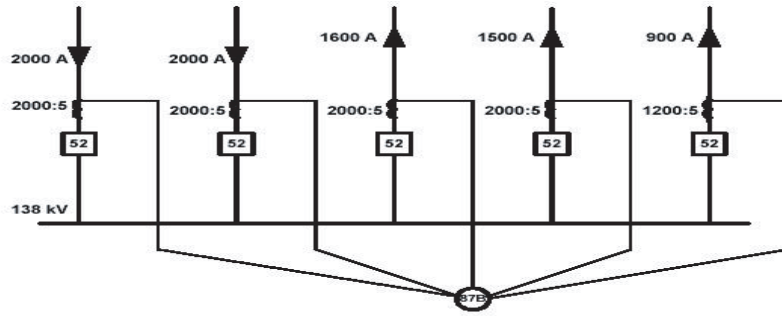


Figure K.3: Bus transfer load

Settings are developed using simple steps:

1. Enter Winding/CT connection information
2. Determine the maximum bus transfer current
3. Choose a value for IRs
4. Calculate the Bus Base MVA
5. Determine the CT Saturation Block Timer
6. Enter settings in the B-PRO

1. Enter Winding/CT Connection Information

Enter Winding and CT connection information to match the specific bus protection application, as in the example of Figure 4.

Winding/CT Connections

Differential Zones:

- ☒ Bus1
- ☐ Transformer
- ☐ Bus1 and Transformer
- ☐ Bus1 and Bus2

Transformer 3 Phase Capacity (MVA Pri):

Bus Side: 230.0
Non-bus Side: 115.0

Voltage (kV Pri): 230.0
Connection: Y
Phase (deg): 0° (ref)

CT Phase (deg): 0°
CT Turns Ratio (to 1): 60.0

| Current Inputs | Connect To | CT Connection | CT Phase (deg) | CT Turns Ratio (to 1) | Digital Control | External Input |
|----------------|------------|---------------|----------------|-----------------------|-------------------------------------|----------------|
| 1 [Input1] | Bus1 | Y | 0 | 400.0 | <input checked="" type="checkbox"/> | <Not Used> |
| 2 [Input2] | Bus1 | Y | 0 | 400.0 | <input checked="" type="checkbox"/> | <Not Used> |
| 3 [Input3] | Bus1 | Y | 0 | 400.0 | <input checked="" type="checkbox"/> | <Not Used> |
| 4 [Input4] | Bus1 | Y | 0 | 400.0 | <input checked="" type="checkbox"/> | <Not Used> |
| 5 [Input5] | Bus1 | Y | 0 | 240.0 | <input checked="" type="checkbox"/> | <Not Used> |
| 6 [Input6] | NC | Y | 0° | 100.0 | <input checked="" type="checkbox"/> | <Not Used> |

Figure K.4: Winding/CT Connections Settings

2. Determine the Maximum Bus Transfer Current

The maximum bus transfer current is going to be based on the CT primary ratings. For the example of Figure 3, there are many load flow configurations possible, but it is not possible to exceed an inflow of 4000 A_{pri} without exceeding at least one CT rating. Therefore, 4000 A_{pri} is the maximum bus transfer condition for this bus. It is possible, of course, for the maximum bus transfer current to be smaller than the rating limits of the CTs due to other system constraints.

3. Choose a Value for IRs

The IRs setting determines the break point between the slope S1 and slope S2. The IRs setting is also the upper limit of the load range of the B-PRO. For this recommended settings method, the maximum bus transfer current is equal to IRs in per-unit current. The preferred setting for IRs is 2 per-unit, which will work for most applications, but IRs can be any whole number 2 or greater. This method ensures the IR restraint current of the B-PRO for maximum bus transfer current is always within the upper limit of the load range.

4. Calculate the Bus Base MVA

The B-PRO does not have an explicit setting for the current base, but calculates the current base from the Bus Voltage and Bus Base MVA settings. Therefore, choosing the base current requires calculating the Bus Base MVA.

$$\text{Bus Base MVA} = \sqrt{3} \times \text{Bus Voltage} \times \text{Base Current}$$

$$\text{Maximum bus transfer current} = \text{IRs}$$

$$\text{Base Current} = \frac{\text{Maximum bus transfer current (A}_{pri})}{\text{IRs (A}_{per\ unit})}$$

For the configuration of Figure 3, the maximum bus transfer current = 4000A, and IRs = 2 per-unit

$$\text{Base Current} = \frac{4000 \text{ A}_{pri}}{2 \text{ A}_{per\ unit}} = 2000 \text{ A}$$

$$\text{Bus Base MVA} = \sqrt{3} \times 138 \text{ kV} \times 2000 \text{ A} = 478 \text{ MVA}$$

Enter this amount as a relay setting in System Parameters, as illustrated in Figure 5.

| System Parameters | | |
|----------------------------|--------|---------|
| Bus Base MVA: | 478.0 | MVA Pri |
| Bus Voltage: | 138.0 | kV Pri |
| PT Turns Ratio: | 2000.0 | :1 |
| Phase Rotation: | ABC | |
| Directional Control Alpha: | 0.0 | deg |
| Directional Control Beta: | 180.0 | deg |

Figure K.5: System Parameters settings

The maximum relay setting for the Bus Base MVA in the B-PRO is 10000 MVA. If the calculated Bus Base MVA exceeds this value, choose the next higher whole number value for IRs (3 per-unit in this example), and re-calculate the Bus Base MVA.

5. Determine the CT Saturation Block Timer

The settings method used assumes the CT Saturation Detector is enabled. When an external fault occurs on a feeder, it can look like an internal fault if the feeder CTs saturate sufficiently. The "saturation detection algorithm" detects this condition and blocks tripping. It does not block tripping for CT saturation during an internal fault.

Once the CT Saturation Detector has identified a CT saturation condition, the 87B function is blocked from tripping until the CT Saturation Max Block timer expires. This setting should be greater than the slowest fault clearing time for any of the feeders connected to the bus. A typical clearing time is 5 cycles, or 2 cycles to recognize the fault and 3 cycles for the circuit breaker to open. The minimum setting of 0.10 seconds provides some safety margin.

6. Enter Settings in the B-PRO

The un-restrained differential High Current Setting should be set at 5 x IRs. For this example, $5 \times 2 = 10$ per-unit. I_{omin} is set at 0.25 per-unit, other than for applications with widely diverse CT ratios. S1 is recommended to be at 25%, and S2 at 50%, as shown in Figure 2.

To help determine whether any CT saturation will occur for any of the external fault conditions, use NxtPhase CT Saturation Program located on the CD provided with the relay.

Widely Diverse CT Ratios

"Widely diverse CT ratios" differ by more than 5-to-1 (for example, 1200:5 and 8000:5). With widely diverse CT ratios, there is a possibility of false tripping under light load conditions. Consider a case such as Figure 6: Widely diverse CT ratios

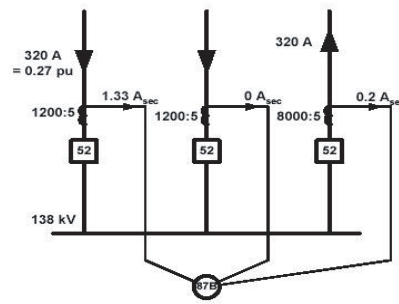


Figure K.6: Widely diverse CT ratios

Assume that the base current is chosen in the same way described by this Technical Note. Thus the *maximum bus transfer current* through this bus is 2400 A, and the *base current* for the bus differential protection is $2400 \text{ A} / 2 = 1200 \text{ A}$. When the secondary current of a nominally 5A CT is as small as 0.2 A, there is a possibility that the current may be interpreted as close to zero amps due to CT error and A-to-D conversion error. Assuming the worst case, 0.2 amps is interpreted as zero amps by the relay.

Then, for this light load condition the operating current, I_O , is perceived as $320 - 0 = 320$ primary amps. On a 1200 A base this is 0.27 per-unit, which is above the recommended setting for I_{Omin} , namely 0.25 per-unit. For this case, it is recommended to set I_{Omin} to 0.4 per-unit in order to prevent possible false tripping of the bus.

Appendix L Analog Phase Shift Table

| +30°(-330°) Shift | +60°(-300°) Shift |
|------------------------------------|------------------------------------|
| $I_A = \frac{I_a - I_b}{\sqrt{3}}$ | $I_A = \frac{I_a - 2I_b + I_c}{3}$ |
| $I_B = \frac{I_b - I_c}{\sqrt{3}}$ | $I_B = \frac{I_b - 2I_c + I_a}{3}$ |
| $I_C = \frac{I_c - I_a}{\sqrt{3}}$ | $I_C = \frac{I_c - 2I_a + I_b}{3}$ |

| +90°(-270°) Shift | +120°(-240°) Shift |
|------------------------------------|------------------------------------|
| $I_A = \frac{I_c - I_b}{\sqrt{3}}$ | $I_A = \frac{2I_c - I_a - I_b}{3}$ |
| $I_B = \frac{I_a - I_c}{\sqrt{3}}$ | $I_B = \frac{2I_a - I_b - I_c}{3}$ |
| $I_C = \frac{Ib - Ia}{\sqrt{3}}$ | $I_C = \frac{2Ib - I_c - I_a}{3}$ |

| +150°(-210°) Shift | -30°(+330°) Shift |
|------------------------------------|------------------------------------|
| $I_A = \frac{I_c - I_a}{\sqrt{3}}$ | $I_A = \frac{I_a - I_c}{\sqrt{3}}$ |
| $I_B = \frac{Ia - Ib}{\sqrt{3}}$ | $I_B = \frac{Ib - Ia}{\sqrt{3}}$ |
| $I_C = \frac{Ib - Ic}{\sqrt{3}}$ | $I_C = \frac{Ic - Ib}{\sqrt{3}}$ |

| -60°(+300°) Shift | -90°(+270°) Shift |
|------------------------------------|------------------------------------|
| $I_A = \frac{I_a - 2I_c + I_b}{3}$ | $I_A = \frac{I_b - I_c}{\sqrt{3}}$ |
| $I_B = \frac{I_b - 2I_a + I_c}{3}$ | $I_B = \frac{I_c - I_a}{\sqrt{3}}$ |
| $I_C = \frac{I_c - 2I_b + I_a}{3}$ | $I_C = \frac{I_a - I_b}{\sqrt{3}}$ |

| -120°(+240°) Shift | -150°(+210°) Shift |
|------------------------------------|------------------------------------|
| $I_A = \frac{2I_b - I_c - I_a}{3}$ | $I_A = \frac{I_b - I_a}{\sqrt{3}}$ |
| $I_B = \frac{2I_c - I_a - I_b}{3}$ | $I_B = \frac{I_c - I_b}{\sqrt{3}}$ |
| $I_C = \frac{2I_a - I_b - I_c}{3}$ | $I_C = \frac{I_a - I_c}{\sqrt{3}}$ |

| 0° Shift | ±180° Shift |
|------------------------------------|------------------------------------|
| $I_A = \frac{2I_a - I_b - I_c}{3}$ | $I_A = \frac{I_c - 2I_a + I_b}{3}$ |
| $I_B = \frac{2I_b - I_c - I_a}{3}$ | $I_B = \frac{I_a - 2I_b + I_c}{3}$ |
| $I_C = \frac{2I_c - I_a - I_b}{3}$ | $I_C = \frac{I_b - 2I_c + I_a}{3}$ |

Appendix M Function Logic Diagram

Diagram in plastic sleeve.

Appendix N How to Start the CT Saturation Calculator

The CT Saturation Calculator will assist you with setting the B-PRO relay. This program is a Microsoft Excel spreadsheet. It is available from the downloads page on NxtPhase's Website (www.nxtphase.com/sub-downloads.htm). The CT Saturation Calculator tool is also included on the B-PRO software CD.

Run from the CD

- 1 Insert the B-PRO CD into your CD-ROM drive.
- 2 If the CD does not open automatically, browse the CD and locate the "CD.exe" file in the root of the CD. Double-click on the file to run it.
- 3 Select either the text "B-PRO Bus Protection", located below the image of the relay, or the "B-PRO" text in the upper right hand corner of the start page.
- 4 Select the text "Install CT Saturation Software". This will launch Microsoft Excel either directly or from within your default WEB browser. Refer to the instructions at the top of the spreadsheet for further descriptions.

Copy to your hard drive

- 1 Use Windows File Manager to copy "CT_Sat.xls" from the B-PRO CD to a directory on your local hard drive.
- 2 When you need to access the program either double-click on the file or launch Microsoft Excel and use the standard "File" "Open" menu items to start the spreadsheet. You can also create a short cut icon on your desktop to run the CT program for your convenience.

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Software Installation Instructions

The CD-ROM contains software and the User Manual for the B-PRO Bus Protection Relay.

Software is installed directly from the CD-ROM to a Windows PC. Alternatively, you can create installation diskettes to install software on computers without a CD-ROM drive.

The CD-ROM contains the following:

- B-PRO *Offliner* Settings: Offliner settings program for the B-PRO relay
- B-PRO Firmware: Firmware and installation instructions.
- B-PRO User Manual: B-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 CD.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 B-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.

