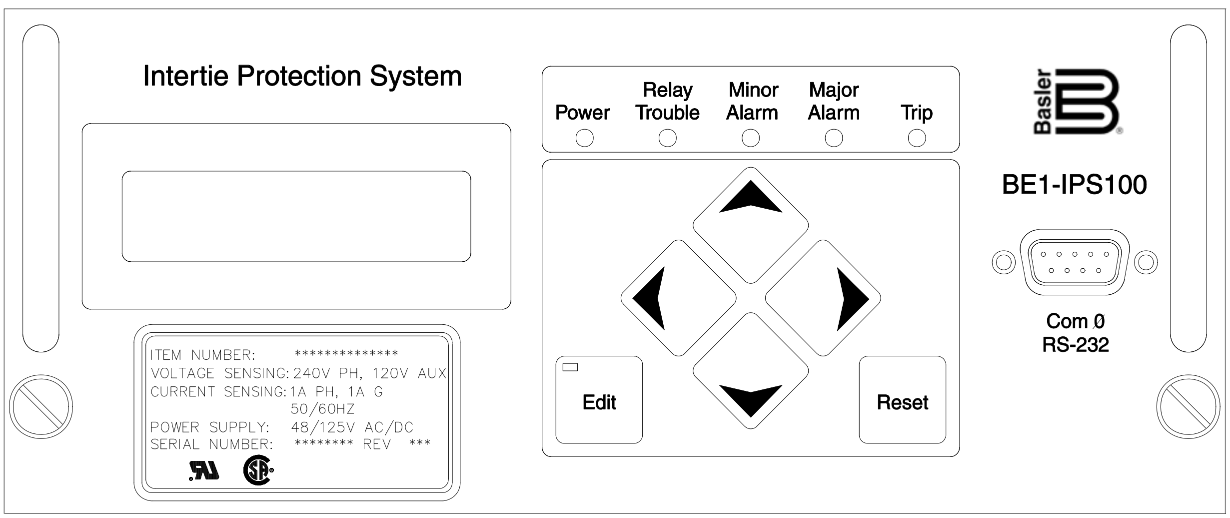
INSTRUCTION MANUAL

FOR

INTERTIE PROTECTION SYSTEM

BE1-IPS100



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INTRODUCTION

This instruction manual provides information about the operation and installation of the BE1-IPS100 Intertie Protection System. To accomplish this, the following information is provided:

- General information, specifications, and a *Quick Start* guide.
- Functional description and setting parameters for the inputs and outputs, protection and control functions, metering functions, and reporting and alarm functions.
- BESTlogic programmable logic design and programming.
- Documentation of the preprogrammed logic schemes and application tips.
- Description of security and user interface setup including ASCII communication and the human-machine interface (HMI).
- Installation procedures, dimension drawings, and connection diagrams.
- Description of the front panel HMI and the ASCII command interface with write access security procedures.
- A summary of setting, metering, reporting, control, and miscellaneous commands.
- Testing and maintenance procedures.
- Description of BESTCOMS graphical user interface (GUI).
- Description of BESTNet Communication for the optional web page enabled relay.
- Appendices containing time overcurrent characteristic curves, an ASCII command-HMI cross reference, terminal communication, and overexcitation (24) inverse time curves.

Optional instruction manuals for the BE1-IPS100 include:

- Distributed Network Protocol (DNP) 3.0 (9365900991)
- Modbus™ (9365900992).

WARNING!

To avoid personal injury or equipment damage, only qualified personnel should perform the procedures in this manual.

NOTE

Be sure that the relay is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the ground terminal on the rear of the unit case. When the relay is configured in a system with other devices, it is recommended to use a separate lead to the ground bus from each unit.

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It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Should further information be required, contact Basler Electric.

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REVISION HISTORY

The following information provides a historical summary of the changes made to the BE1-IPS100 hardware, firmware, and software. The corresponding revisions made to this instruction manual (9365900990) are also summarized. Revisions are listed in reverse chronological order.

BESTCOMS Software Version and Date	Change
2.05.01, 12/08	• Minor bug fix.
2.05.00, 05/08	• Changed nominal frequency range from 50-60 to 25-60 Hz. • Changed x81 pickup range from 40-70 to 20-70 Hz. • Added optional Ethernet communication.
2.04.00, 08/06	• Increased 25 delta angle upper limit to 99 degrees.
2.03.00, 01/06	• Added settings comparison feature. • Modified style chart illustration to show Case and Alarm Output option C (S1 case with normally-open alarm output) and G (H1 case with normally-open alarm output).
2.02.03, 12/04	• Enhanced BESTCOMS to pop up a message when trying to open a file created with a previous version of BESTCOMS. • Improved the controls on the 81 screen.
2.02.02, 09/04	• Changes to support product enhancements added in embedded firmware Version 1.04.01. • Updated pre-programmed logic scheme to IPS100-1547-C-BE. • Corrected the 25VM printout description for “Live Phase/Dead Aux” option. • Updated the default setting for SG-NOM voltage parameter. • Enhanced the printing capability of the comment field. • Added support for the International’s “,” decimal separator. • Added *System Summary* screen links to “jump” from the *Summary* screen to the *Settings* screen for selected items.
2.01.01, 11/03	• Updated 67N labels on the *Overcurrent* screen.
2.01.00, 10/03	• Made changes to support product enhancements added in Version 1.01.00 of the embedded firmware. • Added Double-Ended case style option. • Corrected the *DNP Setting* screen. • Corrected Printout Settings Instructions for S#-32 and S#-81INH settings. • Enhanced viewing capability of the BESTlogic Library. • Modified BESTCOMS to work with USB to Serial and Ethernet to Serial converters.
2.00.03, 04/03	• Corrected labels on the *151P Overcurrent* screen. • Corrected labels on the *System Summary* screen.
2.00.02, 03/03	• Initial release

Application Firmware Version and Date	Change
2.06.00, 12/08	• Added optional Ethernet communication.

Application Firmware Version and Date	Change
1.06.01, 12/08	• Corrected 81 ROC operation when negative sequence inhibit is not zero. • Increased immunity to noise when communicating via Modbus™.
1.06.00, 05/08	• Added alternate DST (Daylight Saving Time) settings. • Changed nominal frequency range from 50/60 to 25-60 Hz. • Changed x81 pickup range from 40-70 to 20-70 Hz. • Improved 25 Sync Check tripping. • Increased immunity to noise on IRIG input. • Improved x62 timer when changing setting groups.
1.05.01, 11/06	• Improved the Rate of Change mode of the 81 function. • Made the 1999 COMTRADE format compatible with BESTWAVE.
1.05.00, 07/06	• Increased 25 delta angle upper limit to 99 degrees. • Added additional fault report screens to the HMI. • Added style number and firmware version number to be displayed in the fault summary, fault directory, and sequence of events.
1.04.02, 12/04	• Improved COMTRADE Header files. • Enhanced 25 Sync Check function. • Improved 60FL function.
1.04.01, 09/04	• Added 32 Underpower capability to existing Directional Power elements. • Added Positive and Negative Rate of Change setting capability to the 81ROC element. • Added 81PU variable to all frequency elements. • Added adjustable angle of maximum torque for 67P & 67N separate from the power line parameters used for fault location. • Added an undervoltage inhibit setting to the 27P, 127P, and 27X elements. • Added mode selectable single phase tripping (1, 2, 3 of 3) to the x50TP elements. • Added positive-sequence current as a mode selection to the x50TQ element. • Added positive-sequence voltage and current to metered quantities. • Added phase angle to all metered voltage and current quantities. • Upgraded “3-wire” power calculation from a 2-watt meter method to 3-phase equations. • Added 3-phase load currents to single phase voltage power calculation. • Enhanced kWH and kVarH calculation and display to maintain full 32-bit resolution. • Enhanced preprogrammed logic scheme IPS100-1547-C-BE. • Improved performance of the fault recording function. • Improved performance of the 60FL function.
1.02.01, 12/03	• Corrected 3-wire, ACB rotation, Max Torque angle problem. • Enhanced COMTRADE config file time stamp calculation to improve accuracy for large frequency step changes.
1.02.00, 11/03	• Added Generator and Bus Frequency to the Fault Summary Report and COMTRADE files (Oscillography). • Updated COMTRADE format so that both ’91 and ’99 COMTRADE Standard files can be downloaded.

Application Firmware Version and Date	Change
1.01.00, 10/03	• Enhanced the performance of the Directional Power 32/132 function. • Improved performance of the Sync Check 25 function. • Corrected the 67N - IG, reversed polarizing problem.
1.00.00, 03/03	• Initial release

Hardware Version and Date	Change
P, 12/08	• Added an optional rear Ethernet port. • Upgraded RAM and flash memory. • Upgraded CPU. • Corresponds to version 2 firmware.
N, 12/08	• Release firmware version 1.06.01 and BESTCOMS version 2.05.01.
M, 12/08	• Improved overall keyboard manufacturability.
L, 10/08	• Increased spacing between the board-mounting bracket and trace near P7 and NC1 on analog board to prevent hipotting.
K, 08/08	• EEPROM replacement.
J, 05/08	• Released firmware version 1.06.00 and BESTCOMS version 2.05.00.
H, 04/08	• Improved contact-sensing circuit.
G, 07/07	• Improved CT terminal block.
F, 01/06	• Added normally-open alarm output for H1 case (style xxxxGxx) and S1 case (style xxxxCxx).
E, 12/05	• Revised power supplies.
D, 01/04	• Improved LCD display.
C, 12/03	• Relocated capacitors on cradle block/voltage board assembly to voltage board assembly only.
B, 10/03	• Added ground stud to the cradle. • Relocated jumper on analog board assembly.
A, 06/03	• Improved Trip Coil Monitor circuit.
—, 03/03	• Initial release (corresponds to version 1 firmware)

Manual Revision and Date	Change
F, 12/08	• Added Section 15, *BESTNet Communication.* • Added references to Ethernet and BESTNet throughout manual. • Added additional fault report screens to the HMI layout in Section 10, *Human-Machine Interface.* • Added style number and firmware version number as displayed in fault summary, fault directory, and sequence of events. • Added manual part number and revision to footers. • Added alternate DST (Daylight Saving Time) settings in Sections 6, 11, and Appendix B. • Updated Style Chart in Section 1. • Changed 81 pickup range from 40-70 to 20-70 Hz in Sections 1 and 4. • Changed nominal frequency settable range to 25-60 Hz in Section 3. • Updated Contact Sensing Input ranges and burden data for re-designed contact sense circuit. • Added BELARUS certification in Section 1.
E, 01/06	• Updated Figure 1-1 with revised style chart showing normally-open alarm output option. Where applicable, modified wording to describe normally-open alarm output. Where applicable, modified illustrations to show the alarm output as either normally closed or normally open. Updated the applicable BESTCOMS screen illustrations to show the updated style chart. • Added description of setting comparison feature to Section 14, *BESTCOMS Software.*
D, 10/05	• Updated BESTCOMS screen shots throughout manual with latest version of BESTCOMS. • Updated Appendix B, *Command Cross-Reference,* to show all commands. • Added examples to all commands in Section 11, *ASCII command Interface.* • Enhanced Note 3 on Figure 7-2 to clarify 151P. • Updated Figure 6-9, *Trip Circuit Monitor.* • Revised *Reclosing* in Section 4, *Protection and Control,* to be more informative. • Corrected Figures 4-5 and 4-7. • Added GOST-R certification in Section 1, *General Information.* • Added Frequency Range for power supply types in Section 1, *General Information.* • Added pickup and timing accuracies to the 32/132 specifications in Section 1.

Manual Revision and Date	Change
C, 09/04	• Revised *Nominal Secondary Voltage* and *Current Settings* on page 3-4. • Updated the *67 Directional Overcurrent Element,* which begins on page 4-18. • Added *Reclose Fail Timer* to page 4-51 under the discussion of the 79 element. • Updated the discussion of 60FL Element Blocking Settings on page 4-60. • Added and discussed *FP and FX* (page 6-30) under *Fault Summary Report Example.* • Revised the 79 element illustration in Figure 7-1, and the 24 and 25 element illustrations in Figure 7-2. • Revised Figures 8-2 and 8-3. • Updated the discussion of *Integration of Protection, Control, and I/O Elements* on page 8-5. • Updated Figure 7-9, *Protection Menu Branch Structure.*
B, 10/03	• Corrected voltage sensing terminal numbering error in Figure 12-13.
A, 09/03	• Updated the Style Chart (Figure 1-1) and General Specifications to add the S1 double-ended case. • On page 2-8, question #8, changed the default logic from BASIC-OC to IPS100-1547-A-BE. • On page 4-61, under 43 Virtual Selector Switches, changed the number of switches from five to two. • Updated the General Operation Screen, ID tab on pages 6-1 and 6-41. • Reconfigured Table 6-3, Logic Variable Status Report Format, to make it easier to read. • Added the 132 element to Figure 7-2. • Inserted a missing page (page 7-5) containing Output Logic Settings, along with Figure 7-4, Virtual Output Logic. • Revised Figure 12-14, Typical External DC Connections, to include terminals D19 and D20. • Added S1 case mounting information to page 12-16, Terminal Blocks. • In Figure 12-19, moved the reference to “minus 30 degrees” from illustration C to illustration D. • Added terminal labels to Figure 13-1, Rear Panel Terminal Connections (H1 Case). • Deleted erroneous numbers from the “Sensing Type” column of Tables 13-3, 13-7, 13-14, 13-15, 13-20, 13-24, 13-27, 13-100, 13-101, and 13-103 with “1 A” or “5 A”.
—, 02/03	• Initial release

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SECTION 1 • GENERAL INFORMATION

DESCRIPTION

The BE1-IPS100 Intertie Protection System is an economical, microprocessor based, multifunction system that is available in a drawout H1 (half-rack) or S1 package. BE1-IPS100 features include:

- Directional Three-Phase Overcurrent Protection
- Directional Ground Overcurrent Protection
- Directional Negative-Sequence Overcurrent Protection
- Directional Power Protection
- Control Protection
- Breaker Failure Protection
- Automatic Reclosing
- Voltage Protection
- Frequency Protection
- Breaker Monitoring
- Metering Functions
- Communication

BE1-IPS-100 relays have four programmable contact sensing inputs, five programmable outputs, and one alarm output. Outputs can be assigned to perform protection, control, or indicator operations through logical programming. For example, protection functions could be programmed to cause a protective trip. Control functions could be programmed to cause a manual trip, manual close, or automatic reclose. Indicators could be configured to annunciate relay failure, a settings group change, and others.

Protection scheme designers may select from a number of pre-programmed logic schemes that perform the most common protection and control requirements. Alternately, a custom scheme can be created using BESTlogic.

A simplified "How To Get Started" procedure for BE1-IPS100 users is provided in Section 2, *Quick Start*.

FEATURES

The BE1-IPS100 relay includes many features for the protection, monitoring, and control of power system equipment. These features include protection and control functions, metering functions, and reporting and alarm functions. A highly flexible programmable logic system called BESTlogic allows the user to apply the available functions with complete flexibility and customize the system to meet the requirements of the protected power system. Programmable I/O, extensive communication features, and an advanced human-machine interface (HMI) provide easy access to the features provided.

The following information summarizes the capabilities of this multifunction device. Each feature, along with how to set it up and how to use its outputs, is described in complete detail in the later sections of this manual.

Input and Output Functions

Input functions consist of Power System Measurement and Contact Sensing Inputs. Programmable contact outputs make up the output functions. Input and output functions are described in the following paragraphs.

Power System Measurement Functions

Three-phase currents and voltages are digitally sampled and the fundamental is extracted using a Discrete Fourier Transform (DFT) algorithm.

The voltage sensing circuits can be configured for single-phase, three wire, or four wire voltage transformer circuits. Voltage sensing circuitry provides voltage protection, frequency protection, polarizing, and watt/var metering. Neutral (residual), positive-sequence, and negative-sequence voltage magnitudes are derived from the three-phase voltages. Digital sampling of the measured frequency provides high accuracy at off-nominal values.

An auxiliary voltage sensing input provides protection capabilities for over/undervoltage monitoring of the fundamental and third harmonic of the VT source connected to the Vx input. This capability is useful for ground fault protection or sync-check functions.

Each current sensing circuit is low burden and isolated. Neutral (residual), positive-sequence, and negative-sequence current magnitudes are derived from the three-phase currents. An optional independent ground current input is available for direct measurement of the current in a transformer neutral, tertiary winding or flux balancing current transformer.

Contact Sensing Inputs

Four programmable contact sensing inputs (IN1, IN2, IN3, and IN4) with programmable signal conditioning provide a binary logic interface to the protection and control system. Each input function and label is programmable using BESTlogic. A user-meaningful label can be assigned to each input and to each state (open and closed) for use in reporting functions. Board mounted jumpers are provided for dual voltage ratings.

Contact Outputs

Five programmable general-purpose contact outputs (OUT1, OUT2, OUT3, OUT4, and OUT5) provide a binary logic interface to the protection and control system. One programmable, fail-safe contact output (OUTA) provides an alarm output. Each output function and label is programmable using BESTlogic. A user-meaningful name can be assigned to each output and to each state (open and closed) for use in reporting functions. Output logic can be overridden to open, close, or pulse each output contact for testing or control purposes. All output contacts are trip rated.

Protection and Control Functions

Protection functions consist of Overcurrent, Voltage, Frequency, Breaker Reclosing, Fuse Loss, Breaker Failure protection, and general-purpose logic timers. Setting Groups and Virtual Control Switches make up the control functions. The following paragraphs describe each protection and control function.

Directional Overcurrent Protection

Directional overcurrent protection is provided by six instantaneous overcurrent functions and five time overcurrent functions. Digital signal processing filters out unwanted harmonic components while providing fast overcurrent response with limited transient overreach and overtravel.

Each instantaneous overcurrent function has a settable time delay. Phase elements include 50TP and 150TP. Neutral elements include 50TN and 150TN. Negative-Sequence elements include 50TQ and 150TQ.

Inverse time overcurrent functions are provided for phase, neutral, and negative-sequence protection. A 51P and 151P phase elements, 51N and 151N neutral elements, and a 51Q negative-sequence element are provided. Time-overcurrent functions employ a dynamic integrating timing algorithm covering a range from pickup to 40 times pickup with selectable instantaneous or integrated reset characteristics. Time overcurrent curves conform to the IEEE PC37.112 document and include seven curves similar to Westinghouse/ABB CO curves, five curves similar to GE IAC curves, a fixed time curve, and a user programmable curve. Phase time-overcurrent functions can be voltage restrained or controlled for generator backup applications.

Each overcurrent element can be individually set for forward, reverse, or non-directional control.

Voltage Protection

One volts per hertz protective element provides overexcitation protection for a generator and/or transformer (24).

Two phase overvoltage and two phase undervoltage elements provide over/undervoltage protection (27P, 59P). Phase overvoltage/undervoltage protection can be set for one of three, two of three, or three of three logic. When a four-wire voltage transformer connection is used, over/undervoltage protection can be set for either phase-to-phase voltage or phase-to-neutral voltage. The 27 and 127P are equipped with an undervoltage inhibited feature.

Two auxiliary overvoltage and one auxiliary undervoltage element provides over/undervoltage protection (27X, 59X, 159X). Auxiliary voltage protection elements can be set to individually monitor the auxiliary voltage fundamental, third harmonic, or phase $3V_0$ voltages. Ground unbalance protection is provided when the optional auxiliary voltage input is connected to a source of $3V_0$ such as a broken delta VT. The 27X is equipped with an undervoltage inhibit feature.

With the optional auxiliary voltage input connected to the bus, one sync-check function provides synchronism protection (25). Sync-check protection checks for phase angle difference, magnitude difference, frequency difference (slip) and, optionally, if the three-phase VT frequency is greater than the auxiliary VT frequency. One voltage monitor output (25VM1) provides independent dead/live voltage closing logic.

One negative-sequence overvoltage element provides protection for phase unbalance or a reverse system phase-sequence (47).

Voltage transformer circuit monitoring adds security by detecting problems in the voltage transformer sensing circuits and preventing mis-operations of the 27P/127P, 47, 59P/159P, 67, and 51/27.

Directional Power Protection

Two directional power elements (32 and 132) are included in the BE1-IPS100 and can be set for forward or reverse, over or under power protection. The relay can be used for any application requiring directional power flow detection including intertie protection (interconnects between an electric utility and a source of non-utility generation). The power measurement algorithm is adapted as appropriate for any possible three-phase or single-phase voltage transformer connection. Directional power is calibrated on a three-phase basis regardless of the voltage transformer connection used. Directional Power Protection can be set for 1 of 3, 2 of 3, 3 of 3, or 3-phase trip logic.

Frequency Protection

There are six independent frequency elements. Each can be set for over, under, or rate of change (81R) frequency operation. Each can be individually set to monitor the frequency on the main three-phase voltage input or the VX input. Rate of change can be set to operate on positive, negative, or "either".

Breaker Failure Protection

One breaker failure protection block (BF) provides programmable breaker failure protection.

Fuse Loss Protection

A fuse loss function protects against false tripping due to a loss of voltage sensing.

General Purpose Logic Timers

Two general-purpose logic timers (62, 162) with six modes of operation are provided.

Setting Groups

Two setting groups allow adaptive relaying to be implemented to optimize BE1-IPS100 settings for various operating conditions. Automatic and external logic can be employed to select the active setting group.

Virtual Control Switches

BE1-IPS100 virtual control switches include one virtual breaker control switch and two virtual switches.

Trip and close control of a selected breaker can be controlled by the virtual breaker control switch (101). The virtual breaker control switch is accessed locally from the front panel human-machine interface (HMI) or remotely from the communication ports.

Additional control is provided by the two virtual switches: 43 and 143. These virtual switches are accessed locally from the front panel HMI or remotely from the communication ports. Virtual switches can be used to trip and close additional switches or breakers, or enable and disable certain functions.

Metering Functions

Metering is provided for all measured currents, voltages and frequency, and derived neutral, positive, and negative-sequence currents and voltages including angles. Three-phase watts, vars, and power factor are provided. Per phase watts and vars are also provided.

Reporting and Alarm Functions

Several reporting and alarm functions provide fault reporting, demand, breaker, and trip circuit monitoring as well as relay diagnostic and firmware information.

Energy Data Reporting

Energy information in the form of watt-hours and var-hours is measured and reported by the BE1-IPS100. Both positive and negative values are reported in three-phase, primary units.

Relay Identification

Two free-form fields are provided for the user to enter information to identify the relay. These fields are used by many of the reporting functions to identify the relay that the report is from. Examples of relay identification field uses are station name, circuit number, relay system, purchase order, and others.

Clock

A real-time clock is included with a capacitor backup and is available with an optional battery backup. Depending upon conditions, capacitor backup maintains timekeeping during an eight to 24 hour loss of operating power. Battery backup maintains timekeeping when operating power is removed for five years or longer.

IRIG

A standard IRIG input is provided for receiving time synchronization signals from a master clock. Automatic daylight saving time compensation can be enabled. Time reporting is settable for 12 or 24-hour format. The date can be formatted as mm/dd/yy or dd/mm/yy.

General Status Reporting

The BE1-IPS100 provides extensive general status reporting for monitoring, commissioning, and troubleshooting. Status reports are available from the front panel HMI or communication ports.

Demand Reporting

Ampere demand registers monitor phase A, B, C, Neutral, ±Power (kW), ±Reactive Power (kvar), and Negative-Sequence values. The demand interval and demand calculation method are independently settable for phase, neutral, and negative-sequence measurements. Demand reporting records today's peak, yesterday's peak, and peak since reset with time stamps for each register.

Breaker Monitoring

Breaker statistics are recorded for a single breaker. They include the number of operations, fault current interruption duty, and breaker time to trip. Each of these conditions can be set to trigger an alarm.

Trip Circuit Monitoring

A trip circuit monitor function is provided to monitor the trip circuit of a breaker or lockout relay for loss of voltage (fuse blown) or loss of continuity (trip coil open). The monitoring input is internally connected across OUT1. Additional trip or close circuit monitors can be implemented in BESTlogic using additional inputs, logic timers, and programmable logic alarms.

Fault Reporting

Fault reports consist of simple target information, fault summary reports, and detailed oscillography records to enable the user to retrieve information about disturbances in as much detail as is desired. The relay records and reports oscillography data in industry standard IEEE, Comrade format to allow using any fault analysis software. Basler Electric provides a Windows® based program called *BESTwave* that can read and plot binary or ASCII format files that are in the COMTRADE format.

Sequence of Events Recorder

A 255 event Sequence of Events Recorder (SER) is provided that records and time stamps all relay inputs and outputs as well as all alarm conditions monitored by the relay. Time stamp resolution is to the nearest half-cycle. I/O and Alarm reports can be extracted from the records as well as reports of events recorded during the time span associated with a specific fault report.

Alarm Function

Extensive self diagnostics will trigger a fatal relay trouble alarm if any of the relay core functions are adversely affected. Fatal relay trouble alarms are not programmable and are dedicated to the Alarm output (OUTA) and the front panel Relay Trouble LED. Additional relay trouble alarms and all other alarm functions are programmable for major or minor priority. Programmed alarms are indicated by major and minor alarm LEDs on the front panel. Major and minor alarm points can also be programmed to any output contact including OUTA. Over 20 alarm conditions are available to be monitored including user definable logic conditions using BESTlogic.

Active alarms can be read and reset from the front panel HMI or from the communication ports. A historical sequence of events report with time stamps lists when each alarm occurred and cleared. These reports are available through the communication ports.

Version Report

The version of the embedded software (firmware) is available from the front panel HMI or the communication ports. The unit serial number and style number is also available through the communication port.

BESTlogic Programmable Logic

Each BE1-IPS100 protection and control function is implemented in an independent function element. Every function block is equivalent to its single function, discrete device counterpart so it is immediately familiar to the protection engineer. Each independent function block has all of the inputs and outputs that the discrete component counterpart might have. Programming with BESTlogic is equivalent to choosing the devices required by your protection and control scheme and then drawing schematic diagrams to connect the inputs and outputs to obtain the desired operating logic.

Several preprogrammed logic schemes and a set of custom logic settings are provided. A preprogrammed scheme can be activated by merely selecting it. Custom logic settings allow you to tailor the relay functionality to match the needs of your operation's practices and power system requirements. The default logic scheme for the BE1-IPS100 is designed for intertie protection.

Write Access Security

Security can be defined for three distinct functional access areas: Settings, Reports, and Control. Each access area can be assigned its own password. A global password provides access to all three functional areas. Each of the four passwords can be unique or multiple access areas can share the same password.

A second dimension of security is provided by allowing the user to restrict access for any of the access areas to only specific communication ports. For example, you could set up security to deny access to control commands from the Ethernet port that is connected through a modem to a telephone line.

Security settings only affect write access. Read access is always available in any area through any port.

Human-Machine Interface (HMI)

Each BE1-IPS100 comes with a front panel display with five LED indicators for Power Supply Status, Relay Trouble Alarm, Minor Alarm, Major Alarm, and Trip. The lighted, liquid crystal display (LCD) allows the relay to replace local indication and control functions such as panel metering, alarm annunciation, and control switches. Four scrolling pushbuttons on the front panel provide a means to navigate through the menu tree. Edit and reset pushbuttons provide access to change parameters and reset targets, alarms, and other registers. In Edit mode, the scrolling pushbuttons provide data entry selections. Edit mode is indicated by an Edit LED on the *Edit* pushbutton.

The LCD has automatic priority logic to govern what is being displayed on the screen so that when an operator approaches, the information of most interest is automatically displayed without having to navigate the menu structure. The order of priorities is:

1. Recloser active
2. Targets
3. Alarms
4. Programmable automatic scrolling list

Up to 16 screens can be defined in the programmable, automatic scroll list.

Communication

Three independent, isolated communication ports provide access to all functions in the relay. COM 0 is a 9-pin RS-232 port located on the front of the case. COM 1 is located on the rear of the case and may be ordered as an Ethernet or RS-232 port. COM 2 is a two wire RS-485 port located on the back of the case. The optional rear Ethernet or RS-232 port is referred as COM 1 in the BESTCOMS *General Operation* screen, *Security* tab.

An ASCII command interface allows easy interaction with the relay, using standard, off the shelf communication software. The ASCII command interface is optimized to allow automation of the relay setting process. Settings files can be captured from the relay and edited using any software that supports the *.txt file format. These ASCII text files can then be used to set the relay using the send text file function of your communication software.

ASCII, Modbus™, and DNP 3.0 protocols are optionally available for the RS-485 communication port. A separate instruction manual is available for each available protocol. Consult the product bulletin or the factory for availability of these options and instruction manuals.

Ethernet information can be found in Section 15, *BESTNet Communication.*

PRIMARY APPLICATIONS

The BE1-IPS100 Intertie Protection System provides three phase, ground, and negative sequence overcurrent, voltage, and frequency protection and is intended for use in intertie applications covered by IEEE-P1547 or any directional or non-directional overcurrent application. Its unique capabilities make it ideally suited for applications with the following requirements:

- Intertie protection at the point of common coupling (PCC) between non-utility distributed generation (DG) and the electric utility/Area Electric Power System (Area EPS).
- Underfrequency load shed applications supervised or tripped directly by "true" Rate of Change frequency.
- Applications that require low burden to extend the linear range of CTs.
- Applications that require high accuracy across a wide frequency range such as for motor, generator, and generator step-up transformer protection or in co-generation facilities.
- Applications that require the flexibility provided by wide settings range, multiple setting groups, and multiple coordination curves in one unit.
- Applications that require the economy and space savings provided by a multifunction, multiphase unit. This one unit can provide all of the protection, control, metering, local, and remote indication functions required on a typical circuit.
- Applications that require directional control and fault locating.
- Transformer backup applications where overexcitation protection is required.
- Applications that require communications and protocol support.
- Applications where the capabilities of a digital multifunction relay are required yet draw out construction is also desirable.
- Applications where bus protection is provided by a high-speed overcurrent blocking scheme on the transformer bus mains instead of a dedicated bus differential circuit.
- Applications where the small size and limited behind-panel projection facilitates modernizing protection and control systems in existing substations.
- Applications using Ethernet communication, programmable email notifications, and live metering information via an embedded web server (with BESTNet option).
- Applications requiring Modbus™/TCP Ethernet communications (with Modbus™/TCP option).

MODEL AND STYLE NUMBER DESCRIPTION

General

The BE1-IPS100 relay electrical characteristics and operational features are defined by a combination of letters and numbers that make up the style number. The model number, together with the style number, describe the options included in a specific device and appear in the clear window on the front panel and on a sticker located inside the case. Upon receipt of a relay, be sure to check the style number against the requisition and the packing list to ensure that they agree.

Sample Style Number

Style number identification chart, Figure 1-1, defines the electrical characteristics and operational features included in BE1-IPS100 relays. For example, if the style number were **E4N1H0Y**, the device would have the following characteristics and features:

IPS-100 —

(**E**) **-** 5 ampere nominal system with 5 ampere independent ground input
(**4**) **-** Three-phase sensing with independent auxiliary input
(**N**) **-** H1 case; no cover is available
(**1**) **-** 48/125 Vac/Vdc power supply
(**H**) **-** H1 case and normally-closed alarm output contacts
(**0**) **-** ASCII over RS-485, no Ethernet
(**Y**) **-** 4,000 point Load Profile Demand Log

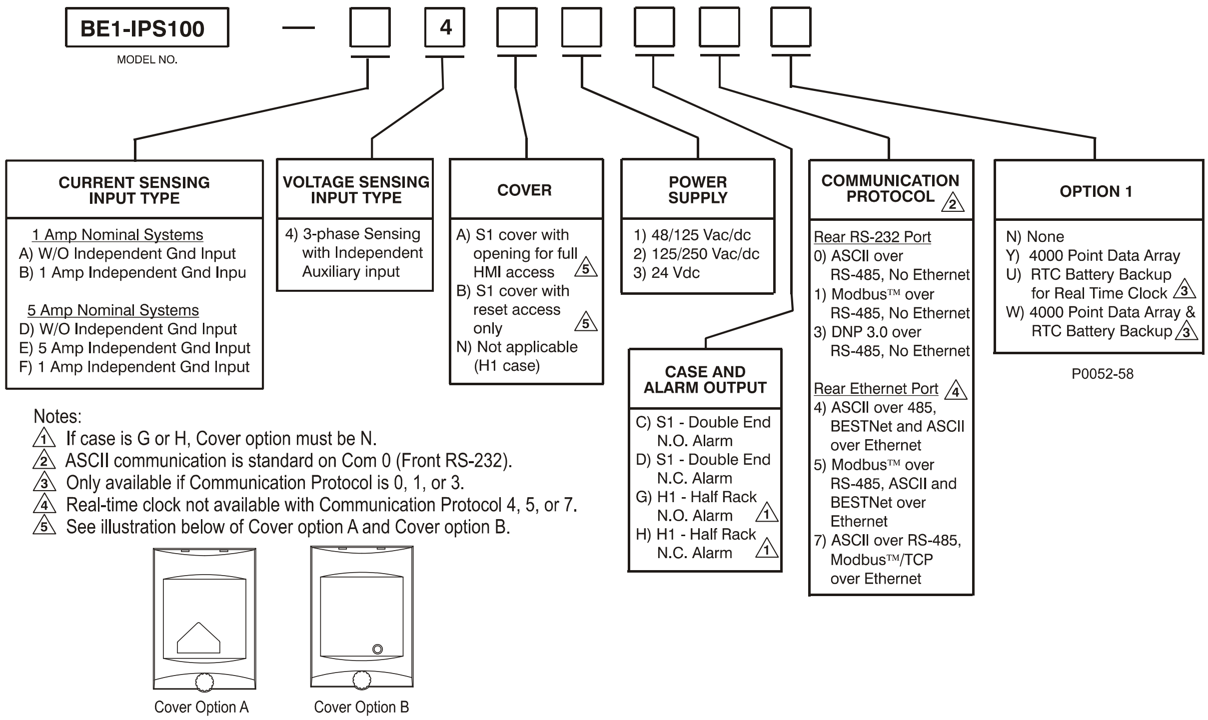

Figure 1-1. Style Chart

OPERATIONAL SPECIFICATIONS

BE1-IPS100 relays have the following features and capabilities.

Metered Current Values and Accuracy

Current Range:	
5 Aac Nominal:	0.5 to 15 Aac
1 Aac Nominal:	0.1 to 3.0 Aac
Accuracy:	±1% of reading, ±1 least significant digit at 25°C
Temperature Dependence:	≤ ±0.02% per °C

Metered Voltage Values and Accuracy

Voltage Range	
3-wire:	0 to 300 V_{L-L}
4-wire:	0 to 300 V_{L-L}
Accuracy (10 to 75 hertz)	
50 V to 300 V:	±0.5% of reading, ±1 least significant digit at 25°C
Temperature Dependence:	≤ ±0.02% per °C

Metered Frequency Values and Accuracy

Frequency Range:	10 to 75 hertz
Accuracy:	±0.01 hertz, ±1 least significant digit at 25°C
Sensing Input	
3-wire:	Phase A – B
4-wire:	Phase A – Neutral
Minimum Frequency Tracking Voltage:	10 V rms

Calculated Values and Accuracy

Demand

Range:	0.1 to 1.5 nominal
Type:	Exponential
Accuracy:	±1% of reading ±1 digit at 25°C
Temperature Dependence:	≤ ±0.02% per °C
Interval:	1 to 60 min

True Power

Range	
5 ampere CT:	–7,500 kW to +7,500 kW
1 ampere CT:	–1,500 kW to + 1,500 kW
Accuracy:	±1% at unity power factor

Reactive Power

Range	
5 ampere CT:	–7,500 kvar to +7,500 kvar
1 ampere CT:	–1,500 kvar to +1,500 kvar
Accuracy:	±1% at zero power factor

Energy Data Reporting

Range	
5 ampere unit:	1,000 GWh or 1,000 Gvarh
1 ampere unit:	1,000 GWh or 1,000 Gvarh
Units of measure:	kilo, mega, giga
Rollover value of registers:	1,000,000 GWh or 1,000 Gvarh
Accuracy:	±1% at unity power factor

Real-Time Clock

Accuracy:	1 second per day at 25°C (free running) or ±2 milliseconds (with IRIG synchronization)
Resolution:	1 millisecond
Date and Time Setting Provisions:	Front panel, communications port, and IRIG. Leap year and selectable daylight saving time correction provided.
Clock Power Supply Holdup	
Capacitor:	8 to 24 hours depending on conditions
Backup Battery (optional):	Greater than 5 years
Battery Type:	Lithium, 3.6 Vdc, 0.95 Ah (Basler Electric P/N: 9318700012 or Applied Power P/N: BM551902)

Instantaneous Overcurrent Functions

Current Pickup Accuracy

Phase & Neutral (50TP, 50TN, 150TP, 150TN)	
5 ampere CT:	±2% or ±50 mA
1 ampere CT:	±2% or ±10 mA
Dropout/pickup ratio:	95% or higher
Negative-Sequence (50TQ, 150TQ)	
5 ampere CT:	±3% or ±75 mA
1 ampere CT:	±3% or ±15 mA
Dropout/pickup ratio:	95% or higher

Current Pickup Ranges (50T, 150T)

5 ampere CT

Range:	0.5 to 150.0 A
Increment:	0.01 from 0.50 to 9.99 A 0.1 from 10.0 to 99.9 A 1.0 from 100 A to 150 A

1 ampere CT

Range:	0.1 to 30.0 A
Increment:	0.01 from 0.01 to 9.99 A 0.1 from 10.0 to 30.0 A

Settable Time Delay Characteristics (50T, 150T)

Definite time for any current exceeding pickup

Time Range:	0.00 to 60.0 s
Time Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 60 s

Timing Accuracy

50TP, 50TN, 150TP, 150TN:	±0.5% or ±½ cycle whichever is greater plus trip time for instantaneous response (0.0 setting)
50TQ, 150TQ:	±0.5% or ±1 cycle whichever is greater plus trip time for instantaneous response (0.0 setting)

Trip Time for 0.0 delay setting

50TP, 50TN, 150TP, 150TN:	2¼ cycles maximum for currents ≥ 5 times the pickup setting. Three cycles maximum for a current of 1.5 times pickup. Four cycles maximum for a current of 1.05 times the pickup setting.
50TQ, 150TQ:	3¼ cycles maximum for currents ≥ 5 times the pickup setting. Four cycles maximum for a current of 1.5 times pickup. Five cycles maximum for a current of 1.05 times the pickup setting.

Time Overcurrent Functions

Current Pickup Accuracy, Phase & Neutral (51P, 151P, 51N, 151N)

Dropout/pickup ratio:	95%
Pickup Accuracy	
5 ampere CT:	±2% or ±50 mA
1 ampere CT:	±2% or ±10 mA

Current Pickup Accuracy, Negative-Sequence (51Q)

Dropout/pickup ratio:	95%
Pickup Accuracy	
5 ampere CT:	±3% or ±75 mA
1 ampere CT:	±3% or ±15 mA

Current Input All 51 Functions

5 ampere CT

Range: 0.50 to 16.0 A	
Increment:	0.01 from 0.50 to 9.99 A 0.1 from 10.0 to 16.0 A

1 ampere CT

Range: 0.10 to 3.2 A	
Increment:	0.01 A

Time Current Characteristic Curves

Timing Accuracy (All 51 functions):	Within ±5% or ±1½ cycles whichever is greater for time dial settings greater than 0.1 and multiples of 2 to 40 times the pickup setting but not over 150 A for 5 A CT units or 30 A for 1 A CT units. See Appendix A, *Time Overcurrent Characteristic Curves*, for information on available timing curves.

51P Voltage Control (27R)

Control Modes:	Uncontrolled, voltage controlled, voltage restrained.
Control/Restraint Range:	30 - 250 V
Accuracy:	±2% or 1 V
Restrained Mode Characteristic:	See Figure 4-12, Section 4, *Protection and Control*.

Directional Element (67)

Modes:	Forward, Reverse, Non-directional
67P Polarization:	Positive-sequence with memory Negative-sequence
67Q Polarization:	Negative-sequence
67N Polarization:	Selectable any combination Zero-sequence voltage (requires 4W VT) Zero-sequence current (requires IG) Negative-sequence Continuous adjustable angle of maximum torque is 0 to 90 degrees

Directional Power (32, 132)

Modes:	Forward, Reverse, Over, Under
Pickup:	
5 A:	1 to 6,000 W, 3-phase
1 A:	1 to 1,200 W, 3-phase
Accuracy:	±3% of setting or ±2W, whichever is greater, at 1.0 PF. (The relay knows the phase relationship of V vs. I to within 0.5 deg when current is above 0.1A and voltage is above 5V. The power and var measurements at power factor other than 1.0 are affected accordingly.)
Time Delay:	0.05 to 600 seconds
Accuracy:	±0.5% of setting or ±2 cycles, whichever is greater

Volts/Hz (24)

Pickup

Range:	0.5 to 6 V/Hz
Accuracy:	±2%

Integrating Time Delay

Time Dial:	0.0 to 9.9
Reset Dial:	0.0 to 9.9
Accuracy:	5% or 4 cycles, whichever is greater

$$T_T = \frac{DT}{\left(\frac{V/HZ_{MEASURED}}{V/HZ_{NOMINAL}} - 1 \right)^n}$$

Time to Trip

$$T_R = D_R * \frac{E_T}{FST} * 100$$

Time to Reset

where:

T_T = Time to trip
T_R = Time to reset
D_T = Time dial trip
D_R = Time dial, reset
E_T = Elapsed time
n = Curve exponent (0.5, 1, 2)
FST = Full scale trip time (TT)
ET/FST = Fraction of total travel toward trip that integration had progressed to. (After a trip, this value will be equal to one.)

Definite Time Delay

Time Delay:	0.050 to 600 s
Accuracy:	5% or 4 cycles, whichever is greater

Phase Undervoltage Function (27P/127P)

Pickup/Inhibit

Setting Range:	10 to 300 V
Setting Increment:	0.1 from 0 to 99.9 V 1.0 from 100 to 150 V
Accuracy:	±2% or 1 V
Dropout/Pickup Ratio:	102%

Time Delay

Setting Range:	0.050 to 600 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 600 s
Accuracy:	±0.5% or ±1 cycle, whichever is greater

Auxiliary Undervoltage Function (27X)

Mode 1 = V_X, Mode 2 = $3V_0$, Mode 3 = V_X 3rd

Pickup/Inhibit

Setting Range:	1 to 150 V
Setting Increment:	0.1 from 0 to 99.9 V 1.0 from 100 to 150 V
Accuracy:	±2% or 1 V, whichever is greater
Dropout/Pickup Ratio:	102%

Time Delay

Setting Range:	0.050 to 600 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 600 s
Accuracy:	±0.5% or ±1 cycle, whichever is greater

Negative-Sequence Voltage Protection (47)

Pickup

Setting Range:	1.0 to 300 $V_{L\text{-}N}$
Setting Increment:	0.1 from 0 to 99.9 V 1.0 from 100 to 300 V
Accuracy:	±2% or 1 V
Dropout/Pickup Ratio:	98%

Time Delay

Setting Range:	0.050 to 600 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 600 s
Accuracy:	±0.5% or ±1 cycle, whichever is greater

Phase Overvoltage Function (59P/159P)

Pickup

Setting Range:	10 to 300 V
Setting Increment:	0.1 from 0 to 99.9 V 1.0 from 100 to 300 V
Accuracy:	±2% or 1 V
Dropout/Pickup Ratio:	98%

Time Delay

Setting Range:	0.050 to 600 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 60 s
Accuracy:	±0.5% or ±1 cycle, whichever is greater

Auxiliary Overvoltage Function (59X, 159X)

Mode 1 = V_X, Mode 2 = V_{3V0}, Mode 3 = V_X^{3rd}

Pickup

Setting Range:	1 to 150 V
Setting Increment:	0.1 from 0 to 99.9 V 1.0 from 100 to 300 V
Accuracy:	±2% or 1 V, whichever is greater
Dropout/Pickup Ratio:	98%

Time Delay

Setting Range:	0.050 to 600 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 60 s
Accuracy:	±0.5% or ±1 cycle, whichever is greater

Over/Under/ROC Frequency Function (81/181/281/381/481/581)

O/U

Range: 20 to 70 Hz	
Increment:	0.01 Hz
Accuracy:	0.01 Hz
Dropout:	0.02 Hz of pickup

ROC

Range:	0.2 to 20 Hz/sec (positive, negative or either)
Increment:	0.01 Hz/sec
Accuracy:	0.15 Hz/sec or ±2% of the setting, whichever is greater
Dropout:	±3% of pickup
Negative-Sequence Inhibit Range:	0 to 99% of nominal voltage
Increment:	1.0%
Accuracy:	±2% or 1 V
Over/Underfrequency Inhibit Range:	46 to 64 Hz
Increment:	0.01 Hz
Accuracy:	0.01 Hz

O/U/ROC

Time Delay Range:	0 to 600 s
Accuracy:	±0.5% or 1 cycle, whichever is greater (minimum trip is affected by 3 cycle security count)
Voltage Inhibit Range:	15 to 300 V
Increment:	0.1 from 0.1 to 99.9 V 1.0 from 100 to 150 V
Accuracy:	±2% or 1 volt, whichever is greater
Dropout:	95% of pickup

Breaker Fail Timer (50BF)

Current Detector Pickup:	Fixed at 0.5 A for 5 A unit, 0.1 A for 1 A unit
Current Detector Pickup Accuracy:	±10%
Delay Range:	50 to 999 ms
Increment:	1 ms
Reset Time:	Within 1¼ cycles of the current being removed
Timer Accuracy:	±0.5% or +1¼, -½ cycles, whichever is greater

General Purpose Timers (62, 162)

Modes:	Pickup/Dropout, 1 Shot Nonretriggerable, 1 Shot Retriggerable, Oscillator, Integrating, Latch
Range:	0 to 9,999 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 9,999 s
Accuracy:	±0.5% or ±3/4 cycles, whichever is greater

Reclosing Timers (79)

Reclose (791, 792, 793, 794), Reset (79R), Max Cycle (79M), Reclose Fail (79F)

Setting Range:	100 ms to 600 s
Increment:	1 ms from 0 to 999 ms 0.1 s from 1.0 to 9.9 s 1 s from 10 to 600 s 0.1 cycles from 6 to 36,000 cycles
Accuracy:	±0.5% or +1¾, -0 cycles, whichever is greater

Sync-Check (25)

Delta Phase Angle:	1 to 99°
Delta Voltage Magnitude:	1 to 20 V
Delta Frequency:	0.01 to 0.50 Hz

Sync-Check, Voltage Monitor (25VM)

Live voltage threshold:	10 to 150 V
Dead voltage threshold:	10 to 150 V
Dropout Time delay:	0.050 to 60 s
Logic:	Dead Phase/Dead Aux Dead Phase/ Live Aux Live Phase/ Dead Aux
Independent output:	25VM1

VT Fuse Loss Detection (60FL)

Time Delay:	Fixed at 50 ms

Automatic Setting Group Characteristics

Number of Setting Groups:	2

Control Modes

Automatic:	Cold-Load Pickup, Dynamic Load or Unbalance, Recloser Shot
External:	Discrete Input Logic, Binary Input Logic

Switch Level

Range:	0 to 150% of the Setting Group 0, monitored element setting
Accuracy:	±2% or ±50 mA (5 A), ±2% or ±10 mA (1 A)

Switch Timer

Range:	0 to 60 minutes with 1 minute increments where 0 = disabled
Accuracy:	±0.5% or ±2 s, whichever is greater

BESTlogic

Update Rate:	½ cycle

GENERAL SPECIFICATIONS

AC Current Inputs

5 Ampere CT

Continuous Rating:	20 A
One Second Rating:	400 A

For other current levels, use the formula: $I = (K/t)^{1/2}$ where t = time in seconds, K = 160,000 (all case styles).

Begins to Clip (Saturate):	150 A
Burden: Less than 10 milliohms	

1 Ampere CT

Continuous Rating:	4 A
One Second Rating:	80 A

For other current levels, use the following formula: $I = (K/t)^{½}$ where t = time in seconds, K = 90,000 (H1 case), K = 90,000 (S1 case).

Begins to Clip (Saturate):	30 A
Burden:	10 milliohms or less at 1 A

Phase AC Voltage Inputs

Continuous Rating:	300 V, Line to Line
One Second Rating:	600 V, Line to Neutral
Burden:	<1 VA @ 300 Vac

Auxiliary AC Voltage Inputs

Continuous Rating:	150 V, Line to Line
Fault Rating:	360 V, Line to Line
One Second Rating:	600 V, Line to Neutral
Burden:	<1 VA @ 150 Vac

Analog to Digital Converter

Type:	16-bit
Sampling Rate:	12 samples per cycle, adjusted to input frequency (10 to 75 Hz)

Power Supply

Option 1

48, 110, and 125 Vdc:	Range 35 to 150 Vdc
67, 110, and 120 Vac:	Range 55 to 135 Vac

Option 2

110, 125, and 250 Vdc:	Range 90 to 300 Vdc
110, 120, and 240 Vac:	Range 90 to 270 Vac

Option 3

24 Vdc:	Range 17 to 32 Vdc (down to 8 Vdc momentarily)

Frequency Range

Options 1 and 2 only:	40 to 70 Hz

Burden

Options 1, 2, and 3:	6 W continuous, 8 W maximum with all outputs energized

Output Contacts

Make and Carry for Tripping Duty:	30 A for 0.2 seconds per IEEE C37.90; 7 A continuous
Break Resistive or Inductive:	0.3 A at 125 or 250 Vdc (L/R = 0.04 maximum)

Control Inputs

Voltage Range: Same as control power

Turn-On Voltage

24 Vdc Power Supply: Approx. 5 Vdc

48/125 Vac/dc Power Supply: 26 to 100 Vac/dc ∗

125/250 Vac/dc Power Supply: 69 to 200 Vac/dc ∗

∗ Voltage ranges depend on Jumper configurations. See Section 3, *Input and Output Functions, Contact Sensing Inputs*.

Input Burden: Burden per contact for sensing depends on the power supply model and the input voltage. Table 1-1 provides appropriate burden specifications.

Table 1-1. Control Input Burden

Power Supply	Jumper Installed Burden	Jumper Not Installed Burden
24 Vdc	N/A	6 kΩ
48/125 Vac/dc	22 kΩ	53 kΩ
125/250 Vac/dc	66 kΩ	123 kΩ

IRIG

Supports IRIG Standard 200-98, Format B002

Input Signal: Demodulated (dc level-shifted digital signal)

Logic-High Voltage: 3.5 Vdc, minimum

Logic-Low Voltage: 0.5 Vdc, maximum

Input Voltage Range: ±20 Vdc, maximum

Resistance: Nonlinear, approximately 4 kΩ at 3.5 Vdc, approximately 3 kΩ at 20 Vdc

Contact Inputs Recognition Time

Programmable, 4 to 255 ms

NOTE

All timing specifications are for the worst-case response. This includes output contact operate times and standard BESTlogic operation timing but excludes input debounce timing and non-standard logic configurations. If a non-standard logic scheme involves feedback, then one or more BESTlogic update rate delays must be included to calculate the worst-case delay. An example of feedback is Virtual Outputs driving Function Block Inputs. For more information, see Section 7*, BESTlogic Programmable Logic*.

Communication Ports

Interface

Front RS-232: 300 to 19200 baud, 8N1 full duplex

Rear RS-232 (optional): 300 to 19200 baud, 8N1 full duplex

Rear RS-485: 300 to 19200 baud, 8N1 half duplex

Rear Ethernet (optional): IEEE 802.3 (10BaseT)

Response Time (RS-232): <100 ms for metering and control functions

Display

Type:	Two line, 16 character alphanumeric LCD (liquid crystal display) with LED (light emitting diode); backlight
Operating Temperature:	–40°C (–40°F) to +70°C (+158°F). Display contrast may be impaired at temperatures below –20°C (–4°F).

Isolation

Meets IEC 255-5 and exceeds IEEE C37.90 one minute dielectric test as follows:

All Circuits to Ground:	2,828 Vdc (excludes communication ports)
Resist isolation:	Currents are galvanically isolated; potentials are resistance isolated, 1.4 megohm to ground per terminal (A, B, C, N, $+V_X$, and $-V_X$).
Communication Ports to Ground:	500 Vdc
Input Circuits to Output Circuits:	2,000 Vac or 2,828 Vdc

Surge Withstand Capability

Oscillatory

Qualified to IEEE C37.90.1-1989 *Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems* (excluding communication ports).

Fast Transient

Qualified to IEEE C37.90.1-1989 *Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems* (excluding communication ports). (Excludes across open output contacts due to installed surge suppression components.)

Radio Frequency Interference (RFI)

Qualified to IEEE C37.90.2-1995 Standard for Withstand Capability of Relays Systems to Radiated Electromagnetic Interference from Transceivers.

Electrostatic Discharge (ESD)

Four kilovolts contact discharges and 8 kilovolts air discharges applied in accordance with Qualification EN61000-4-2.

Shock

Qualification:	Qualified to IEC 255-21-2, Class 1

Vibration

Qualification:	Qualified to IEC 255-21-1, Class 1

Environment

Temperature

Operating Temperature Range:	–40°C to 70°C (–40°F to 158°F) ∗
Storage Temperature Range:	–40°C to 70°C (–40°F to 158°F)
	∗ Display is inoperative below –20°C

Humidity

Qualified to IEC 68-2-38, 1st Edition 1974, *Basic Environmental Test Procedures, Part 2: Test Z/AD: Composite Temperature Humidity Cyclic Test.*

CE Qualified

This product meets or exceeds the standards required for distribution in the European Community.

UL Recognition

UL recognized per Standard 508, UL File Number E97033. Note: Output contacts are not UL recognized for voltages greater than 250 V.

CSA Certification

CSA certified per Standard CAN/CSA-C22.2 Number 14-M91, CSA File Number LR23131-140s. Note: Output contacts are not CSA certified for voltages greater than 250 V.

GOST-R Certification

GOST-R certified per the relevant standards of Gosstandart of Russia.

BELARUS Certification

Byelorussian certified.

Physical

Weight:	12.0 lb (5.4 kg) for H1 case
	12.8 lb (5.8 kg) for S1 case

Case Size

H1 Case (H x W x D)	
With Mounting Flanges:	10.5 x 3.47 x 9.1 in (267 x 88 x 231 mm)
Without Mounting Flanges:	8.50 x 3.47 x 9.1 in (216 x 88 x 231 mm)
S1 Case (H x W x D):	9.32 x 6.65 x 8.89 in (237 x 169 x 226 mm)

SECTION 2 • QUICK START

TABLE OF CONTENTS

Figures

Tables

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SECTION 2 • QUICK START

GENERAL

This section provides an overview of the BE1-IPS100 Intertie Protection System. You should be familiar with the concepts behind the user interfaces and BESTlogic before you begin reading about the detailed BE1-IPS100 functions. Sections 3 through 6 in the instruction manual describe each function of the BE1-IPS100 in detail.

The following information is intended to provide the reader with a basic understanding of the user interfaces and the security features provided in the BE1-IPS100 relay. Detailed information on the operation of the human-machine interface (HMI) can be found in Section 10, *Human-Machine Interface*, and the ASCII command communications in Section 11, *ASCII Command Interface*. BESTCOMS is a Windows® based software application that enhances communication between the PC user and the BE1-IPS100 relay. BESTCOMS for the BE1-IPS100 is provided free of charge with the BE1-IPS100. BESTCOMS operation is very transparent, and does contain a Windows® type help file for additional operational details.

Also covered in this section is an overview of BESTlogic, which is fundamental to how each of the protection and control functions is set-up and used in the BE1-IPS100 relay. Detailed information on using BESTlogic to design complete protection and control schemes for the protected circuit can be found in Section 7, *BESTlogic Programmable Logic*, and Section 8, *Application*.

Sections 3 through 6 describe each function provided in the BE1-IPS100 relay and include references to the following items. Note that **not** all items are appropriate for each function.

- Human-machine interface (HMI) screens for setting the operational parameters.
- BESTCOMS for setting the operational parameters.
- BESTCOMS for setting up the BESTlogic required for functions in your protection and control scheme.
- Outputs from the function such as alarm and BESTlogic variables or data reports.
- HMI screens for operation or interrogation of the outputs and reports provided by each function.
- ASCII commands for operation or interrogation of the outputs and reports provided by each function.

About This Manual

The various application functions provided by this multifunction relay are divided into four categories: input/output functions, protection and control functions, metering functions, and reporting and alarm functions. Detailed descriptions of each individual function, setup, and use are covered in the sections as shown in Table 2-1. Detailed information on using programmable logic to create your own protection and control scheme is described in Section 7, *BESTlogic Programmable Logic*. Section 15, *BESTNet Communication,* provides information on all of the device Ethernet features and capabilities. Browser screen shots of available web pages are illustrated and explained.

Table 2-1. Function Categories and Manual Sections Cross-Reference

Section Title	Section
Input and Output Functions	Section 3
Protection and Control	Section 4
Metering	Section 5
Reporting and Alarm Functions	Section 6
BESTlogic Programmable Logic	Section 7
Application	Section 8
BESTNet Communication	Section 15

BESTlogic

Each of the protection and control functions in the BE1-IPS100 is implemented as an independent function block that is equivalent to a single function, discrete device counterpart. Each independent function block has all of the inputs and outputs that the discrete component counterpart might have. Programming BESTlogic is equivalent to choosing the devices required by your protection and control scheme and drawing schematic diagrams to connect the inputs and outputs to obtain the desired operational logic. The concept is the same but the method is different in that you choose each function block by enabling it and use Boolean logic expressions to connect the inputs and outputs. The result is that in designing your system, you have even greater flexibility than you had using discrete devices. An added benefit is that you are not constrained by the flexibility limitations inherent in many multifunction relays.

One user programmable, custom logic scheme created by the user may be programmed and saved in memory. To save you time, several preprogrammed logic schemes have also been provided. Any of the preprogrammed schemes can be copied into the programmable logic settings without the user having to make any BESTlogic programming.

There are two types of BESTlogic settings: function block logic settings and output logic settings. These are described briefly in the following paragraphs. Detailed information on using BESTlogic to design complete protection and control schemes for the protected circuit can be found in Section 7, *BESTlogic Programmable Logic*, and Section 8, *Application*.

Characteristics of Protection and Control Function Blocks

As stated before, each function block is equivalent to a discrete device counterpart. For example, the phase time-overcurrent function block in the BE1-IPS100 relay has all of the characteristics of Basler BE1 relays with similar functionality. Figure 2-1 is a logic drawing showing the inputs and outputs.

One input:

- BLK (block 51P operation)

Two mode settings:

- Enable 51P operation
- Disable 51P operation

Two outputs:

- 51PT (51 Phase Trip)
- 51PPU (51 Phase Pickup)

Four operational settings:

- Pickup
- Time Delay
- Characteristic Curve
- Directional

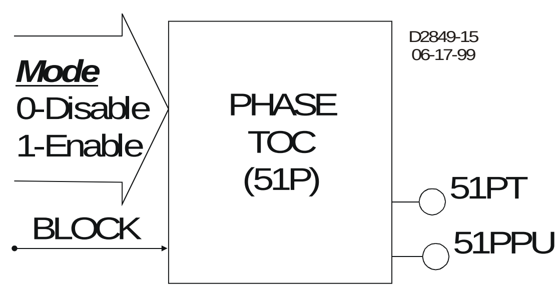

Figure 2-1. 51 Time Overcurrent Logic

Of the above characteristics, the four operational settings are not included in the logic settings. They are contained in the protection settings. This is an important distinction. Since changing logic settings is similar to rewiring a panel, the logic settings are separate and distinct from the operational settings such as pickups and time delays.

Function Block Logic Settings

To use a protection or control function block, there are two items that need to be set: *Mode* and *Input Logic*. The mode is equivalent to deciding which devices you want to install in your protection and control scheme. You then must set the logic variables that will be connected to the inputs.

For example, the 51N function block has three modes (disabled, three-phase summation (3Io), and ground), and one input, block (torque control). To use this function block, the logic setting command might be SL-51N=1,/IN2 for Set Logic-51N to be Mode 1 (three-phase and neutral) with the function blocked when Contact Sensing Input 2 is not (/) energized. Contact Sensing Input 2 would be wired to a ground relay enable switch.

As noted before, the protection settings for this function block, pickup, time dial, and curve must be set separately in the setting group settings. The setting might be S0-51N=6.5,2.1,S1R,F for Setting in group 0 - the 51N function = pickup at 6.5 amps with a time dial of 2.1 using curve S1 with an integrating Reset characteristic and set for Forward directional detection.

The 51N function block has two logic output variables, 51NT (Trip), and 51NPU (Picked Up). The combination of the logic settings and the operational settings for the function block govern how these variables respond to logic and current inputs.

Output Logic Settings

BESTlogic, as implemented in the BE1-IPS100, supports up to 16 output expressions. The output expressions are called virtual outputs to distinguish them from the physical output relays. VOA and VO1 through VO5 drive physical outputs OUTA (failsafe alarm output) and OUT1 through OUT5, respectively. The rest of the virtual outputs can be used for intermediate logic expressions.

For example, OUT 1 is wired to the trip bus of the circuit breaker. To set up the logic to trip the breaker, the BESTlogic setting command might be SL-VO1=VO11+101T+BFPU for Set Logic - Virtual Output 1 = to Virtual Output 11 (which is the intermediate logic expression for all of the function block tripping outputs) or (+) 101T (the trip output of the virtual breaker control switch) or (+) BFPU (the pickup output of the breaker failure function block that indicates that breaker failure has been initiated).

USER INTERFACES

Three user interfaces are provided for interacting with the BE1-IPS100 relay: front panel HMI, ASCII communications, and BESTCOMS for BE1-IPS100. The front panel HMI provides access to a subset of the total functionality of the device. ASCII communications provides access to all settings, controls, reports, and metering functions of the system. BESTCOMS for BE1-IPS100 is software used to quickly develop setting files, view metering data, and download reports in a user-friendly, Windows® based environment.

Front Panel HMI

The front panel HMI consists of a two line by 16 character LCD (liquid crystal display) with four scrolling pushbuttons, an edit pushbutton, and a reset pushbutton. The *EDIT* pushbutton includes an LED to indicate when edit mode is active. There are five other LEDs for indicating power supply status, relay trouble alarm status, programmable major and minor alarm status, and a multipurpose *Trip* LED that flashes to indicate that a protective element is picked up. The *Trip* LED lights continuously when the trip output is energized and seals in when a protective trip has occurred to indicate that target information is being displayed on the LCD. A complete description of the HMI is included in Section 10, *Human-Machine Interface*.

The BE1-IPS100 HMI is menu driven and organized into a menu tree structure with six branches. A complete menu tree description with displays is also provided in Section 10, *Human-Machine Interface*. A list of the menu branches and a brief description for scrolling through the menu is in the following paragraphs.

1. REPORT STATUS. Display and resetting of general status information such as targets, alarms, recloser status.
2. CONTROL. Operation of manual controls such as virtual switches, selection of active setting group, etc.
3. METERING. Display of real-time metering values.
4. REPORTS. Display and resetting of report information such as time and date, demand registers, breaker duty statistics, etc.
5. PROTECTION. Display and setting of protective function setting parameters such as logic scheme, pickups, time delays, etc.
6. GENERAL SETTINGS. Display and setting of non-protective function setting parameters such as communication, LCD contrast, and CT ratios.

Each screen is assigned a number in the HMI section. The number indicates the branch and level in the menu tree structure. Screen numbering helps you to keep track of where you are when you leave the menu tree top level. You view each branch of the menu tree by using the *RIGHT* and *LEFT* scrolling pushbuttons. To go to a level of greater detail, you use the *DOWN* scrolling pushbutton. Each time a lower level in a menu branch is reached, the screen number changes to reflect the lower level. The following paragraphs and Figure 2-2 illustrate how the display screens are numbered in the menu tree.

Viewing the 32R pickup and time delay settings of Setting Group 1 involves the following steps:

1. At the top level of the menu tree, use the *LEFT* or *RIGHT* scrolling pushbuttons to get to the PROTECTION logic branch (Screen 5).
2. Press the *DOWN* scrolling pushbutton to reach the SETTING GROUP level (Screen 5.1).
3. Scroll *RIGHT* to SETTING GROUP 1 branch (Screen 5.2).
4. From Screen 5.2, scroll down to the next level of detail which is the 24 SETTINGS (Screen 5.2.1).
5. Scroll right to the 32 SETTINGS (Screen 5.2.4) and then down to reach the 32R, U, pickup, and time delay settings (Screen 5.2.4.1).

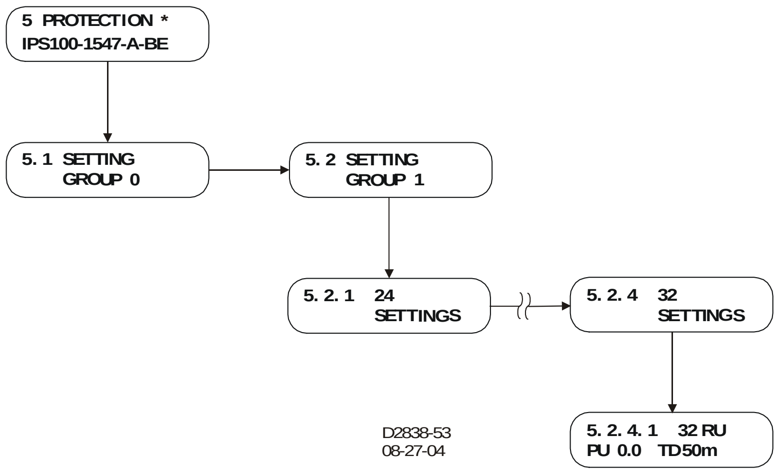

Figure 2-2. Menu Screens Numbering Example

ASCII Command Communications

The BE1-IPS100 relay has two independent communications ports for serial communications plus one optional rear Ethernet or RS-232 port. A computer terminal or PC running a terminal emulation program such as Windows® HyperTerminal® can be connected to any of the ports so that commands can be sent to the relay. Communication with the relay uses a simple ASCII command language. When a command is entered via a serial port, the relay responds with the appropriate action. ASCII command communication is designed for both human-to-machine interactions and batch download type operations. The following paragraphs briefly describe the command structure and discuss human-to-machine interactions and batch command text file operations. The operation of the ASCII commands is described in detail in Section 11, *ASCII Command Interface*.

Command Structure

An ASCII command consists of a command string made up of one or two letters followed by a hyphen and an object name. The first letter specifies the general command function and the second a sub-group. The object name is the specific function for which the command is intended. A command string entered alone is a read command. A command string followed by an equal sign and one or more parameters is a write command. The general command groups are organized into five major groups plus several miscellaneous commands. These commands are as follows:

C CONTROL. Commands to perform select before operate control actions such as tripping and closing the circuit breaker, changing the active setting group, etc. Subgroups include S for Select and O for Operate.

G GLOBAL. Perform global operations that do not fall into the other general groups such as password security. Subgroups include: S for security settings.

M METERING. Read all real time metering values. This general command group has no subgroups.

P PROGRAM. Subgroup command to read or program a setting.

R REPORTS. Read and reset reporting functions such as time and date, demand registers, breaker duty statistics, etc. Subgroups include: A for Alarm functions, B for Breaker monitoring functions, D for Demand recording functions, F for Fault summary reporting functions, G for General information, and S for sequence of events recorder functions.

S SETTINGS. Set all setting parameters that govern the functioning of the relay. Subgroups include: 0,1, for settings in setting groups, A for alarm settings, B for breaker monitoring settings, G for general settings, and L for logic settings.

MISCELLANEOUS. Miscellaneous commands include ACCESS, EXIT, and HELP.

Examples of object names would be 51N for the neutral inverse time overcurrent function or PIA for the A phase, peak current demand register.

For example, to check the 51N pickup setting in Setting Group 1, you would enter S1-51N for Setting, Group 1-51N. The relay would respond with the current pickup, time dial and curve settings for the 51N function. To edit these settings the same command would be used with an = followed by the new settings and the *ENTER* pushbutton. Note that its necessary to use the ACCESS and EXIT commands when using the write version of these commands.

ASCII Command Operations

Using ASCII commands, settings can be read and changed on a function-by-function basis. The mnemonic format of the commands helps you interact with the relay. It isn't necessary to remember all of the object names. Most commands don't require that you specify a complete object name. If the first two letters of a command are entered, the relay will respond with all applicable object names.

Example 1: Obtain a breaker operations count by entering RB (Report Breaker). The BE1-IPS100 responds with the operations counter value along with all other breaker report objects. If you know that the object name for the breaker operations counter is OPCNTR, you can enter RB-OPCNTR and read only the number of breaker operations.

Partial object names are also supported. This allows multiple objects to be read or reset at the same time.

Example 2: Read all peak-since-reset demand registers. Entering RD-PI (report demand - peak current) will return demand values and time stamps for phase A, B, C, neutral and negative-sequence current. To read only the neutral demand value, the full object name (RD-PIN) is entered. Entering RD-PI=0 resets all five of the peak-since-reset demand registers.

Batch Command Text File Operations

With a few exceptions, each function of the relay uses one command to set it and each setting command operates on all of the parameters required by that function. See the example mentioned previously in the paragraph titled *Command Structure*. This format results in a great many commands to fully set the relay. Also, the process of setting the relay does not use a prompting mode where the relay prompts you for each parameter in turn until you exit the setting process. For these reasons, a method for setting the relay using batch text files is recommended.

In batch download type operations, the user creates an ASCII text file of commands and sends it to the relay. To facilitate this process, the response from a multiple read command is output from the BE1-IPS100 in command format. So the user need only enter S for Set (with no subgroup) and the relay responds with all of the setting commands and their associated parameters. If the user enters S1 for Setting Group 1, the relay responds with all of the setting commands for setting group 1. The user can capture this response to a file, edit it using any ASCII text editor, and then send the file back to the relay. See Section 11, *ASCII Command Interface*, for a more detailed discussion of how to use ASCII text files for setting the relay.

BESTCOMS for BE1-IPS100, Graphical User Interface

Basler Electric's graphical user interface (GUI) software is an alternative method for quickly developing setting files in a user-friendly, Windows® based environment. Using the GUI, you may prepare setting files off-line (without being connected to the relay) and then upload the settings to the relay at your convenience. These settings include protection and control, operating and logic, breaker monitoring, metering, and fault recording. Engineering personnel can develop, test, and replicate the settings before exporting it to a file and transmitting the file to technical personnel in the field. On the field end, the technician simply imports the file into the BESTCOMS database and uploads the file to the relay where it is stored in nonvolatile memory.

The GUI also has the same preprogrammed logic schemes that are stored in the relay. This gives the engineer the option (off-line) of developing his setting file using a preprogrammed logic scheme, customizing a preprogrammed logic scheme, or building a scheme from scratch. Files may be exported from the GUI to a text editor where they can be reviewed or modified. The modified text file may then be uploaded to the relay. After it is uploaded to the relay, it can be brought into the GUI but it cannot be brought directly into the GUI from the text file. The GUI logic builder uses basic AND/OR gate logic combined with point and click variables to build the logic expressions. This reduces the design time and increases dependability.

The GUI also allows for downloading industry standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files may be accomplished using Basler Electric's BESTwave software. For more information on Basler Electric's Windows® based BESTCOMS (GUI) software, refer to Section 14, *BESTCOMS Software*. For information on BESTwave, contact your local sales representative or Basler Electric, Technical Support Services Department in Highland, Illinois.

GETTING STARTED

If your relay has Power Supply Option 1 or 2, it can be supplied by normal 120 Vac house power. These two power supply options (1 and 2) are the midrange and high range AC/DC power supplies. The contact sensing inputs are half-wave rectified, opto-isolators. The default contact recognition and debounce settings enable their use on ac signals as well as dc signals.

The BE1-IPS100 measures the A phase, B phase, and C phase current magnitudes and angles directly from the three current sensing inputs. The neutral, positive, and negative-sequence magnitudes and angles are calculated from the fundamental component of each of the three-phase currents. When evaluating the negative-sequence functions, the relay can be tested using a single-phase current source. To fully evaluate the operation of the relay in the power system, it is desirable to use a three-phase current source.

Connect a computer to the front RS-232 port (refer to Section 12, *Installation*, for connection diagrams). Apply power and Enter A= to gain setting access. Set the clock using the RG-TIME= and RG-DATE= commands. (Refer to Section 11, *ASCII Command Interface*, for additional information.)

Entering Test Settings

Enter SG (Setting General) to get a listing of the general setting commands with default parameters and put them in a text file as described previously in *Batch Command Text File Operations*. Then enter S0 (setting group 0) to get a listing of the group 0 protection setting commands with default parameters and put them in a text file also. With these two sub-groups of settings, you will not see the global security settings, user programmable BESTlogic settings, settings for protection Setting Groups 0 and 1, settings for alarm functions, and the settings for breaker monitoring functions.

Open the SG file in a text editor, change settings, as required and save the changes. For example:

- The ratios for the phase and neutral current transformers (CTP, CTG).
- The demand interval and CT circuit to monitor for the phase, neutral and negative-sequence currents (DIP, DIN, DIQ).
- The nominal system frequency (FREQ).
- The normal phase-sequence (ABC or ACB, nominal secondary voltage and current) for the system (PHROT).
- Open the S0 file in a text editor, change settings as required, and save the changes.

Do not forget to add E;Y (Exit; Save Settings? Yes) to the end of both files. Enter A= to gain setting access and then send each of these text files to the relay as described above under *Batch Command Text File Operations*.

As you gain knowledge of the relay, you can experiment with the rest of the settings. To set up a file with all user settings, enter S and the relay will respond with all settings in command format. For documentation, the user should use the Print command in BESTCOMS settings.

Default settings can be found several different ways. The default preprogrammed logic scheme is IPS100-1547-A-BE. Section 8, *Application*, lists all of the default logic settings for the default logic scheme. If you wanted to know the default logic setting for relay output 3 (VO3), you could look at the default listing and find that SL-VO3=51PT. Translated, this means that the setting, logic – Virtual Output 3 is TRUE (1) when the phase time-overcurrent element trips. You could also look in Section 4, *Protection and Control*, find the table for the logic settings. It lists the same information, but it lists the mode and block inputs separately. If you want to find the default settings for an input or output, look in Section 3, *Input and Output Functions*.

Checking the State of Inputs

You can review the state of the inputs through the front panel HMI, BESTCOMS metering screens, or the ASCII command interface. The front panel HMI displays the input status on Screen 1.5.1. A diagram showing all of the menu tree branches is located in Section 10, *Human-Machine Interface*. To get to this screen, press the *UP* scrolling pushbutton until you reach the top screen in the current branch. You know when you have reached the top screen because the screen stops changing when you press the *UP* scrolling pushbutton. From this position, press the *RIGHT* scrolling pushbutton until you have reached the screen titled, REPORT STATUS. From this position press the *DOWN* scrolling pushbutton one time (TARGETS) and press the *RIGHT* scrolling pushbutton three times. At this time, you should see the OPERATIONAL STATUS Screen. If you press the *DOWN* scrolling pushbutton from this screen, you should see the INPUTS Screen (IN 1234).

To check the state of the inputs using the ASCII command interface, type in the RG-STAT command and press enter. This command only reads the status of the inputs.

Testing

To determine if the relay is responding correctly to each test, the following commands are useful:

1. RG-TARG, (report general targets): reports the targets from the last fault.
2. RF, (report faults): reports a directory listing of the twelve fault summary reports. The fault summary reports are numbered from 1 to 255, then wrap around, and start over. RF-### reports the ### report.
3. RS-##, (report sequence of events record), ## events: reports the most recent ## changes of state in the protection and control logic.

FAQ/TROUBLESHOOTING

Frequently Asked Questions (FAQs)

1.) Why won't the *Trip* LED reset when I press the *Reset* key on the front panel?

The *Reset* key is context sensitive. To reset the *Trip* LED or the targets, the *Targets* screen must be displayed. To reset the alarms, the *Alarms* screen must be displayed.

2.) Is the power supply polarity sensitive?

No, the power supply will accept either an ac or dc voltage input. However, the contact sensing for the programmable inputs is polarity sensitive. Refer to Section 12, *Installation*, for typical interconnection diagrams.

3.) What voltage level is used to develop current flow through the contact sensing inputs?

Voltage level is dependent on the power supply option (called out in the BE1-IPS100 style chart). For additional information, see Figure 1-1 in Section 1, *General Information*, and Section 12, *Installation*.

4.) Does the BE1-IPS100 trip output contact latch after a fault?

The answer to the question is yes and no. In general, once the fault goes away the output contacts open. The BE1-IPS100 does offer an option to ensure that the contact will stay closed for at least 200 milliseconds. See Section 3, *Input and Output Functions,* for additional information on that function. But, BESTlogic can keep the relay outputs closed as long as power is applied. Refer to Section 8, *Application, Application Tips*, for additional information.

5.) Why won't a function work when I put in settings such as the pickup and time delays?

Make sure that the logic for the function is set to "Enable".

6.) How many overcurrent elements does the BE1-IPS100 have available?

The BE1-IPS100 has six instantaneous overcurrent and five time overcurrent elements. Just like any element each of these elements can be assigned to any output for building logic equations.

7.) Can I make logic settings at the front panel?

No, the front panel cannot program logic settings. Logic settings must be programmed using the ASCII command interface or BESTCOMS communication software.

8.) Since the BE1-IPS100 is a programmable device, what are the factory defaults?

The factory default logic is IPS100-1547-A-BE logic. Default settings are shown with each function in the instruction manual. For input or output default settings see Section 3, *Input and Output Functions*. For protection and control functions, see Section 4, *Protection and Control*.

9.) Does the BE1-IPS100 have a battery installed as the back-up power source for the internal clock on loss of power?

As an option, battery backup can be included. All relays come standard with a 12-hour ride-through capacitor.

10.) Why do I keep getting access conflict errors when I attempt communication with the relay?

If you try to gain access to more than one port at a time, an access conflict results. The relay has three communication ports: COM 0, COM 1, and COM 2. The front panel HMI and RS-232 port are considered to be the same port and are designated COM0. COM 1 is the optional rear Ethernet or RS-232 port. The rear RS-485 port is designated as COM 2. If access at the front panel HMI has been obtained, access cannot be gained at another port. The front RS-232 port can still be accessed because the HMI and front RS-232 port are considered to be the same port (COM 0). Access needs to be gained only when a write command to the BE1-IPS100 is required (control or setting change or report reset). When access is gained through a port, a five-minute timer starts counting down to zero. When port activity occurs, the timer resets to five minutes and resumes counting down. If no activity is seen for the duration of the five-minute timer, access is withdrawn and any unsaved changes are lost. When activity at a port is no longer required, access should be terminated with the Exit command. When using BESTCOMS, the Access and Exit commands are executed for you. Obtaining data or reports from the relay never requires password access.

11.) Why doesn't the Trip LED behave as expected when the relay picks up and trips? Why don't the targets work properly?

If a protective element is tripping at the desired level, but the targets and fault records aren't behaving as expected, two commands should be checked. The SG-TARG command needs the protective element (function) enabled so that targets are logged. The SG-TRIGGER command must be programmed with the correct pickup logic expression and trip logic expression to initiate fault records. Section 6, *Reporting and Alarm Functions, Fault Reporting*, for detailed information about programming these commands.

Trip LED behavior also depends on the pickup and trip expressions of the SG-TRIGGER command. When the SG-TRIGGER pickup expression is TRUE and the trip expression is FALSE, the Trip LED flashes. In other words, a flashing LED means that a protection element is in a picked up state and is timing toward a trip. When both the pickup and trip expression is TRUE, the Trip LED lights steadily. The Trip LED also lights steadily when neither expression is TRUE but latched targets exist. When resetting a target, the Trip LED will not turn off if the fault is still present. The truth table of Table 2-2 serves as an aid to interpreting Trip LED indications.

Table 2-2. Trip LED Truth Table

Trip	Pickup	Targets	Trip LED
No	No	No	Off
No	No	Yes	On
No	Yes	No	Flash
No	Yes	Yes	Flash
Yes	No	No	On
Yes	No	Yes	On
Yes	Yes	No	On
Yes	Yes	Yes	On

12.) Is the IRIG signal modulated or demodulated?

The BE1-IPS100 accepts an IRIG-B signal that is demodulated (dc level-shifted digital signal). See Section 1, *General Information, Operational Specifications*, for additional information.

13.) Can the IRIG signal be daisy-chained to multiple BE1-IPS100 units?

Yes, multiple BE1-IPS100 units can use the same IRIG-B input signal by daisy chaining the BE1-IPS100 inputs. The burden data is nonlinear, approximately 4 kilo-ohms at 3.5 Vdc and 3 kilo-ohms at 20 Vdc. See Section 1, *General Information, Operational Specifications*, and Section 3, *Input and Output Functions*, for additional information.

14.) How are reports and other information obtained from the relay saved in files for future use?

BESTCOMS can be used to capture records information. See Section 6, *Reporting and Alarm Functions, Fault Reporting, Fault Summary Reports*.

Also, any information reported by the relay can be transferred to a text file and saved for future use. Text received from the relay to your terminal emulation software can be selected and copied to the clipboard. The clipboard contents are pasted into any word processor such as Microsoft® Notepad and then saved with an appropriate file name.

You may also use your terminal emulation software to store reports in files as they are received from the relay. In BESTVIEW, this is accomplished by using the "log/open log file" function. In Microsoft® HyperTerminal, this function is available through the "capture text" feature. Microsoft® Windows® Terminal provides this function through the "received text file" feature.

15.) How can I check the version number of my BE1-IPS100?

The application version can be found in three different ways: One, use HMI, Screen 4.7. Two, use the RG-VER command with the ASCII command interface. Three, use BESTCOMS for BE1-IPS100. (The version is provided on the *General Information* tab of the *General Operation* screen.)

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SECTION 3 • INPUT AND OUTPUT FUNCTIONS

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SECTION 3 • INPUT AND OUTPUT FUNCTIONS

INTRODUCTION

BE1-IPS100 inputs consist of three-phase current inputs, an optional ground current input, three-phase voltage inputs, one auxiliary voltage input, and four contact sensing inputs. Five general-purpose output contacts and one dedicated, fail-safe alarm output make up the BE1-IPS100 outputs. Each input and output is isolated and terminated at separate terminal blocks. This section describes the function and setup of each input and output, and provides the equations that the BE1-IPS100 uses for calculating the power quantities.

POWER SYSTEM INPUTS

Power system inputs as described in the introduction, are sampled 12 times per cycle by the BE1-IPS100. The BE1-IPS100 measures the voltage and current from these samples and uses those measurements to calculate other quantities. Frequency is measured from a zero crossing detector. Measured inputs are then recorded every quarter cycle. If the applied voltage is greater than 10 volts, the BE1-IPS100 measures the frequency and varies the sampling rate to maintain 12 samples per cycle. Frequency compensation applies to all power system measurements. Power system inputs are broken down in the following paragraphs into Current Measurement, Voltage Measurement, Frequency Measurement, Power Measurement, and Measurement Functions Setup.

Current Measurement

Secondary current from power system equipment CTs is applied to current transformers inside the relay. These internal transformers provide isolation and step down the monitored current to levels compatible with relay circuitry. Secondary current from each internal CT is converted to a voltage signal and then filtered by an analog, low-pass, anti-aliasing filter.

Current Measurement Functions

Input waveforms are sampled by an analog-to-digital converter (ADC) at 12 samples per cycle. The relay extracts the magnitude and angle of the fundamental components of each three-phase current input and the magnitude and angle of the optional independent ground current input.

Positive, Neutral and Negative-Sequence Current Measurement

Positive, neutral and negative-sequence components are calculated from the fundamental component of the three-phase current inputs. The relay can be set to accommodate ABC or ACB phase-sequence when calculating the positive or negative-sequence component.

Fast-Dropout Current Detector

A separate, fast-dropout current measurement algorithm is used by the breaker failure function and the breaker trip-speed monitoring function. This measurement algorithm has a sensitivity of 10 percent of nominal rating and detects current interruption in the circuit breaker much more quickly than the regular current measurement functions. This measurement algorithm only monitors phase current.

Voltage Measurement

Three-phase voltage inputs are reduced to internal signal levels by a precision resistor divider network. If the relay is set for single-phase or four-wire VT operation, the measuring elements are configured in wye. If the relay is set for three-wire VT operation, the measuring elements are configured in delta.

Voltage Measurement Functions

Input waveforms are sampled by an analog-to-digital converter (ADC) at 12 samples per cycle. The relay extracts the magnitude and angle of the fundamental components of each three-phase voltage input and the magnitude of the optional auxiliary voltage input.

VT Connections

When four-wire VT connections are used, the relay measures the AN, BN, and CN voltages and calculates the phase voltage quantities. Overvoltage and undervoltage functions (27/59) can be set to operate on either the phase-to-neutral (PN) or phase-to-phase (PP) quantities. Three-wire VT connections limit 27/59 operation to PP quantities. When single-phase VT connections are used, the 27/59 elements operate as appropriate for the single-phase voltage applied.

Zero-Sequence Voltage

When four-wire VT connections are used, the BE1-IPS100 calculates the zero-sequence voltage ($3V_0$). Zero-sequence voltage measurement is not available when single-phase or three-wire VT connections are used. The 27X and 59X can be set to monitor the zero-sequence voltage.

Negative-Sequence (V_2) Voltage

Negative-sequence voltage is calculated from the fundamental component of the three-phase voltage inputs. It is only available on three-phase, three-wire, or three-phase, four-wire systems. V_2 is calibrated to the phase-to-neutral base. Negative-sequence measurements can accommodate either ABC or ACB phase-sequence.

Positive-Sequence (V_1) Voltage

Positive-sequence voltage is calculated from the fundamental component of the three-phase voltage inputs. It is only available on three-phase, three-wire, or three-phase, four-wire systems. V_1 is calibrated to the phase-to-neutral base. Positive-sequence measurements can accommodate either ABC or ACB phase-sequence.

Frequency Measurement

Power system frequency is monitored on the A-phase voltage input or the AB voltage input when in three-wire mode. When the applied voltage is greater than 10 volts, the BE1-IPS100 measures the frequency. The measured frequency is used by the 81 function and applies to all measurements and calculations.

Frequency Compensation

After measuring the frequency, the BE1-IPS100 varies the sampling rate to maintain 12 samples per cycle over a frequency of 10 to 75 hertz. If the voltage is too low for accurate frequency measurement or if the measured frequency is out of range, the ADC defaults to a sampling rate appropriate for the relay nominal frequency setting. The sampling rate is adjusted every 250 milliseconds.

Nominal Frequency

Nominal frequency (F_{nom}) can be set for 25 to 60 hertz power systems. When the voltage and current are too low for reliable frequency measurement, the ADC sample rate defaults to operation at the nominal frequency setting. Nominal frequency is also used in the volts/hertz (24) overexcitation calculation.

Power Measurement

The measured fundamental component of current and voltage as described previously in this section is used to calculate the power per the equations following:

For Sensing Type: Four-wire

$$Watts_A = V_{AN} I_A \cos(\phi_A) \qquad Watts_B = V_{BN} I_B \cos(\phi_B) \qquad Watts_C = V_{CN} I_C \cos(\phi_C)$$

$$Watts_{3\phi} = W_A + W_B + W_C$$

$$Vars_A = V_{AN} I_A \sin(\phi_A) \qquad Vars_B = V_{BN} I_B \sin(\phi_B) \qquad Vars_{CA} = V_{CN} I_C \sin(\phi_C)$$

$$Vars_{3\phi} = Vars_A + Vars_B + Vars_C$$

where: $\phi_P = \angle V_{PN} - \angle I_X$

For Sensing Type: Three-wire

In three-wire sensing mode, the equivalent LN voltages are determined from the LL voltages assuming $3V_0 = 0V$. This allows per phase watts and vars to be determine and provides improved accuracy over a 2-element method when zero-sequence current is present.

$$\hat{V}_{AN} = 1/3 \cdot (\hat{V}_{AB} - \hat{V}_{CA}) \qquad \hat{V}_{BN} = 1/3 \cdot (\hat{V}_{BC} - \hat{V}_{AB}) \qquad \hat{V}_{CN} = 1/3 \cdot (\hat{V}_{CA} - \hat{V}_{BC})$$

Using the computed PN voltages, watts and vars are then computed using the equations listed under four-wire sensing type, above.

For Single Phase Sensing Types: AN, BN, CN, AB, BC, CA

In single phase sensing mode, the unknown PN voltages are calculated. Assuming a balanced three-phase voltage is applied, the unknown PN voltages can be determined by scaling and rotating the measured voltage as follows:

ABC Rotation

AN Sensing: $V_{BN} = V_{AN} \cdot 1\angle -120°$ $\qquad V_{CN} = V_{AN} \cdot 1\angle 120°$

BN Sensing: $V_{AN} = V_{BN} \cdot 1\angle 120°$ $\qquad V_{CN} = V_{BN} \cdot 1\angle -120°$

CN Sensing: $V_{AN} = V_{CN} \cdot 1\angle -120°$ $\qquad V_{BN} = V_{CN} \cdot 1\angle 120°$

AB Sensing: $V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -30°$ $\qquad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -150°$ $\qquad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 90°$

BC Sensing: $V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 90°$ $\qquad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -30°$ $\qquad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -150°$

CA Sensing: $V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -150°$ $\qquad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 90°$ $\qquad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -30°$

ACB Rotation

AN Sensing: $V_{BN} = V_{AN} \cdot 1\angle 120°$ $\qquad V_{CN} = V_{AN} \cdot 1\angle -120°$

BN Sensing: $V_{AN} = V_{BN} \cdot 1\angle -120°$ $\qquad V_{CN} = V_{BN} \cdot 1\angle 120°$

CN Sensing: $V_{AN} = V_{CN} \cdot 1\angle 120°$ $\qquad V_{BN} = V_{CN} \cdot 1\angle -120°$

AB Sensing: $V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 30°$ $\qquad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 150°$ $\qquad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -90°$

BC Sensing: $V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -90°$ $\qquad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 30°$ $\qquad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 150°$

CA Sensing: $V_{AN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 150°$ $\qquad V_{BN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle -90°$ $\qquad V_{CN} = \frac{1}{\sqrt{3}} V_{AB} \cdot 1\angle 30°$

Using both the measured and calculated PN voltages, watts and vars are then computed using the equations listed under four-wire sensing type above.

Measurement Functions Setup

The BE1-IPS100 requires information about the power system and its current and voltage transformers to provide metering, fault reporting, fault location, and protective relaying. This information is entered using BESTCOMS. Alternately, it may be entered at the HMI (see Section 10, *Human-Machine Interface*) or through the communication port using the following ASCII commands: SG-CT, SG-VTP, SG-VTX, SG-FREQ, SG-NOM, SG-PHROT. The SG-LINE command for Power Line Parameters is found Section 6, *Reporting and Alarm Functions, Fault Reporting, Distance to Fault*. The SG-TORQ command for the Maximum Torque Angle setting (used by the directional overcurrent elements) is found in Section 4, *Protection and Control*, with the 67 polarizing information.

Power System Settings

To enter power system settings, select *General Operation* from the *Screens* pull-down menu. Then select the *Power System* tab. Refer to Figure 3-1.

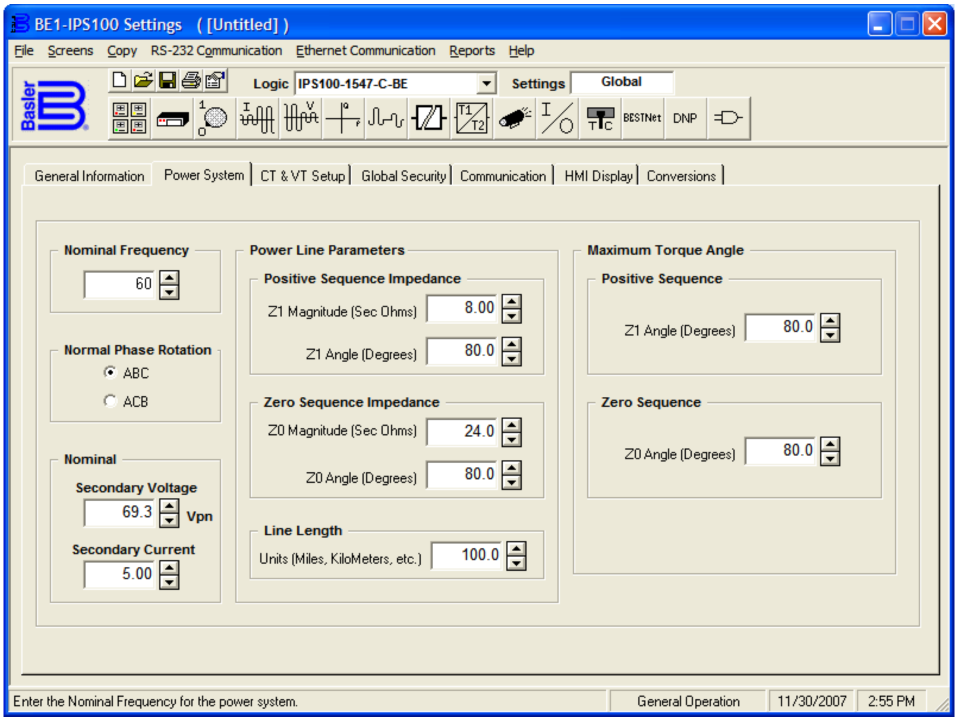

Figure 3-1. General Operation, Power System Tab

Use the pull down buttons and menus to make the power systems settings. *Nominal Frequency* can be set for 25 to 60 hertz power systems. *Nominal Phase Rotation* can be set for either ABC rotation or ACB rotation.

Nominal Secondary Voltage and Current Settings, V_{nom} and I_{nom}, are used by the 60FL function, directional calculations for the 67 elements, and DNP 3.0 analog event reporting functions. V_{nom} is also used in the volts/hertz (24) calculation, and I_{nom} is also used in the 46 time curve calculation (K factor) of the negative-sequence current (51Q) element.

Nominal Voltage (V_{nom}) is defined as the secondary phase-neutral voltage for all sensing connections. That is, even if the user has selected 3-wire, AB, BC, or CA phase-phase sensing connections, V_{nom} must be set for the phase-neutral equivalent. For example, if a 3-wire open delta voltage source with a phase-phase voltage rating of 120 volts is connected, the nominal voltage must be set at $120/\sqrt{3}$ or 69.3 volts. I_{nom} can be either the secondary rating of the CT (1 or 5 amp) or the secondary current allowed by the CT ratio.

In BESTCOMS for the BE1-IPS100, under *General Operation* screen *Power System* tab, are settings for Nominal Voltage and Current. Nominal Voltage (V_{nom}) is the nominal voltage rating corresponding to 1 pu volts and is configured as a phase-neutral secondary value.

Nominal Current (I_{nom}) is the nominal phase current rating for the system corresponding to 1 pu current and is configured in secondary amps. If 1 pu secondary current is unknown, then setting I_{nom} to the secondary CT rating (1 or 5 A) is acceptable for most applications. However, this could degrade the expectation (not accuracy) of the time curve for the 51Q element as I_{nom} is used to directly compute multiple of pickup (MOP) and time delay.

Power Line Parameters are used for fault location while Maximum Torque Angle (MTA) is used by the directional overcurrent (67) element to provide directional supervision of the overcurrent tripping elements. The MTA for the phase and ground polarizing elements is normally derived from the line impedance angles (power line parameters) but there are applications requiring MTA's different than the line impedance angles. For more information on setting MTA for different applications, see Section 4, *Protection and Control, Overcurrent Protection, 67 Directional Overcurrent Element*. For more information on Distance to Fault, see Section 6, *Reporting and Alarm Functions, Fault Reporting, Distance to Fault*.

CT & VT Settings

To enter current and power transformer settings, select *General Operations* from the *Screens* pull-down menu. Then select the *CT & VT Setup* tab. Refer to Figure 3-2.

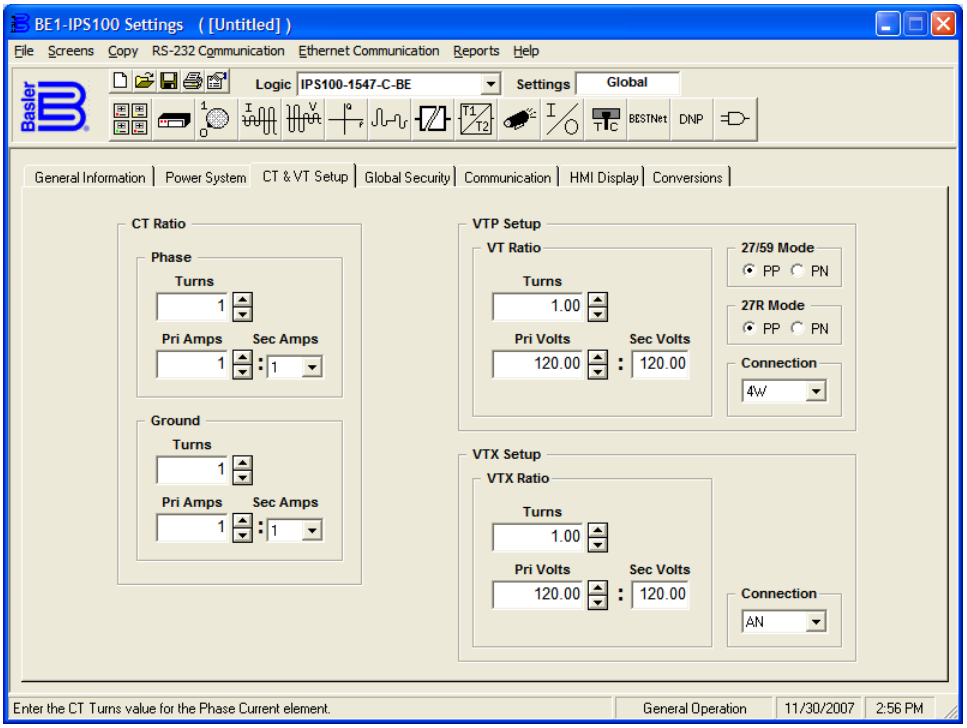

Figure 3-2. General Operation Screen, CT & VT Setup

CT Ratio. The BE1-IPS100 requires setting information on the CT ratio. These settings are used by the metering and fault reporting functions to display measured quantities in primary units. *Sec. Amps* is used to select secondary CT amps. *Pri Amps* will display the primary amps of the CT based on the number of turns. Either *Turns* or *Pri Amps* may be adjusted to achieve the desired turns ratio. Adjusting either will automatically change the value of the other.

VTP Setup, VT Ratio. The BE1-IPS100 requires setting information about the VT ratio, the VT connections, and the operating modes for the 27/59 and 51/27R functions. These settings are used by the metering and fault reporting functions to display measured quantities in primary units. The voltage input circuit settings also determine which power measurement calculations are used. Most of these connections such as 3W, 4W, AN, or AB are self-explanatory.

VTX Setup, VTX Ratio. The auxiliary voltage input (VX) connection can be set for any voltage combination VA, VB, VC, VAB, VBC, or VCA. When set for one of these voltages, the sync-check function can automatically compensate for the phase angle difference relative to the reference voltage measured at the three-phase voltage inputs. Alternately, the VX input connection can be set to GR. This setting is used when the VX input is connected to a source of ground unbalance voltage or residual voltage such as a generator grounding resistor, broken delta VT connection, or capacitor bank star point.

Table 3-1 lists the measurement function's settings.

Table 3-1. Measurement Functions Settings

Function	Range	Increment	Unit of Measure	Default
CT Ratio	1 to 50,000	1	Turns	1
CT Ratio, Independent Ground Input (optional)	1 to 50,000	1	Turns	1

Function	Range	Increment	Unit of Measure	Default
VTP Ratio	1 to 10,000	0.01	Turns	1
VTP Connection	3W, 4W, AN, BN, CN, AB, BC, CA	N/A	N/A	4W
27/59 Pickup Mode	PP (phase-to-phase) PN (phase-to-neutral)	N/A	N/A	PP
51/27R Pickup Mode	PP (phase-to-phase) PN (phase-to-neutral)	N/A	N/A	PP
VTX Ratio	1 to 10,000	0.01	Turns	1
VTX Connection	AN, BN, CN, AB, BC, CA, GR	N/A	N/A	4W
Nominal Frequency	25 to 60	1	Hertz	60
Nominal Volts	50 to 250 0 = Disabled	0.1	Sec. Volts	69.3
Nominal Amps	0.1 to 2 (1 A CTs)	0.01	Sec. Amps	1
	0.5 to 10 (5 A CTs)	0.01	Sec. Amps	5
Phase Rotation	ABC, ACB	N/A	N/A	ABC

CONTACT SENSING INPUTS

BE1-IPS100 relays have four contact sensing inputs to initiate BE1-IPS100 relay actions. These inputs are isolated and require an external wetting voltage. Nominal voltage(s) of the external dc source(s) must fall within the relay dc power supply input voltage range. To enhance user flexibility, the BE1-IPS100 relay uses wide-range AC/DC power supplies that cover several common control voltage ratings. To further enhance flexibility, the input circuits are designed to respond to voltages at the lower end of the control voltage range while not overheating at the high end of the control voltage range.

Energizing levels for the contact sensing inputs are jumper selectable for a minimum of approximately 5 Vdc for 24 Vdc nominal sensing voltages, 26 Vdc for 48 Vdc nominal sensing voltages, or 69 Vdc for 125 Vdc nominal sensing voltages. See Table 3-2 for the control voltage ranges.

Table 3-2. Contact Sensing Turn-On Voltage

Nominal Control Voltage	Contact Sensing Turn-On Voltage	
	Jumper Installed (Low Position)	Jumper Not Installed (High Position)
24 Vdc	N/A	Approx. 5 Vdc
48/125 Vac/dc	26 to 38 Vac/dc	69 to 100 Vac/dc
125/250 Vac/dc	69 to 100 Vac/dc	138 to 200 Vac/dc

Each BE1-IPS100 is delivered without the contact-sensing jumpers connected for operation in the higher end of the control voltage range. If the contact sensing inputs are to be operated at the lower end of the control voltage range, the jumpers must be installed. See Section 12, *Installation*, for details on how to set the jumper positions in the contact sensing input circuits.

The contact sensing inputs circuits are polarity sensitive. When an ac wetting voltage is applied, the input signal is half-wave rectified by the opto-isolator diodes. The contact sensing inputs drive BESTLOGIC variables IN1, IN2, IN3, and IN4. Each contact sensing input is completely programmable so meaningful labels can be assigned to each input and the logic-high and logic-low states. Section 7, *BESTLOGIC Programmable Logic*, provides more information about using contact sensing inputs in your programmable logic scheme.

Digital Input Conditioning Function

Status of the contact sensing inputs is checked 12 times per cycle. (See Figure 3-3.) When operating on a 60 hertz power system, the result is the input status being sampled every 1.4 milliseconds (1.6 milliseconds on 50 hertz systems). User-settable digital contact recognition and debounce timers condition the signals applied to the inputs. These parameters can be adjusted to obtain the optimum compromise between speed and security for a specific application. Digital input conditioning is evaluated every quarter cycle.

If the sampled status of a monitored contact is detected as energized for the recognition time, the logic variable changes from a de-energized (logic 0 or FALSE) state to an energized (logic 1 or TRUE) state. Once contact closure is recognized, the logic variable remains in the energized state until the sampled status of the monitored contact is detected to be de-energized for a period that is longer than the debounce time. At this point, the logic variable will change from an energized (logic 1 or TRUE) state to a de-energized (logic 0 or FALSE) state.

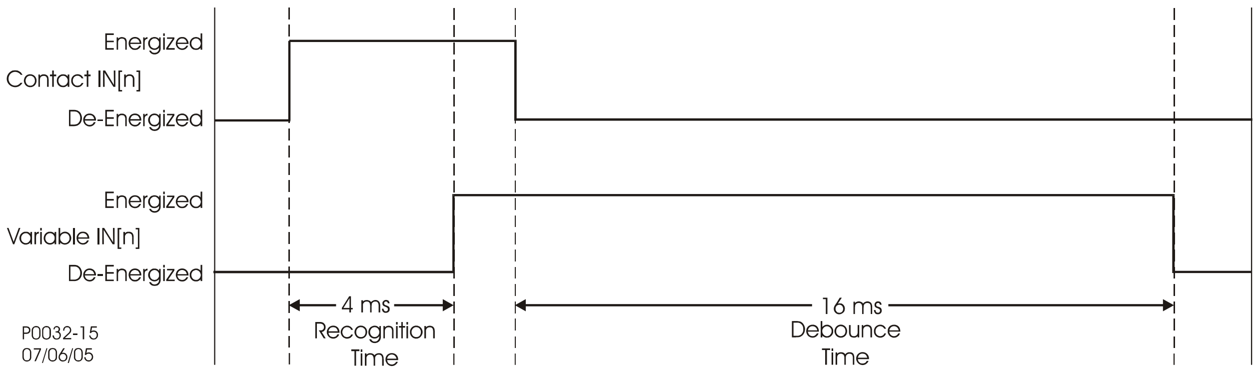

Figure 3-3. Digital Input Conditioning Timing Diagram

Setting the Digital Input Conditioning Function

Settings and labels for the digital input conditioning function are set using BESTCOMS. Alternately, settings may be made using the SG-IN ASCII Command.

Each of the four inputs has two settings and three labels. The settings are *Recognition Time* and *Debounce Time*. The labels include a label to describe the input, a label to describe the *Energized State*, and a label to describe the *De-Energized State*. Labels are used by the BE1-IPS100's reporting functions.

To edit the settings or labels, select *Inputs and Outputs* from the *Screens* pull-down menu. Then select the *Inputs 1-4* tab. Refer to Figure 3-4.

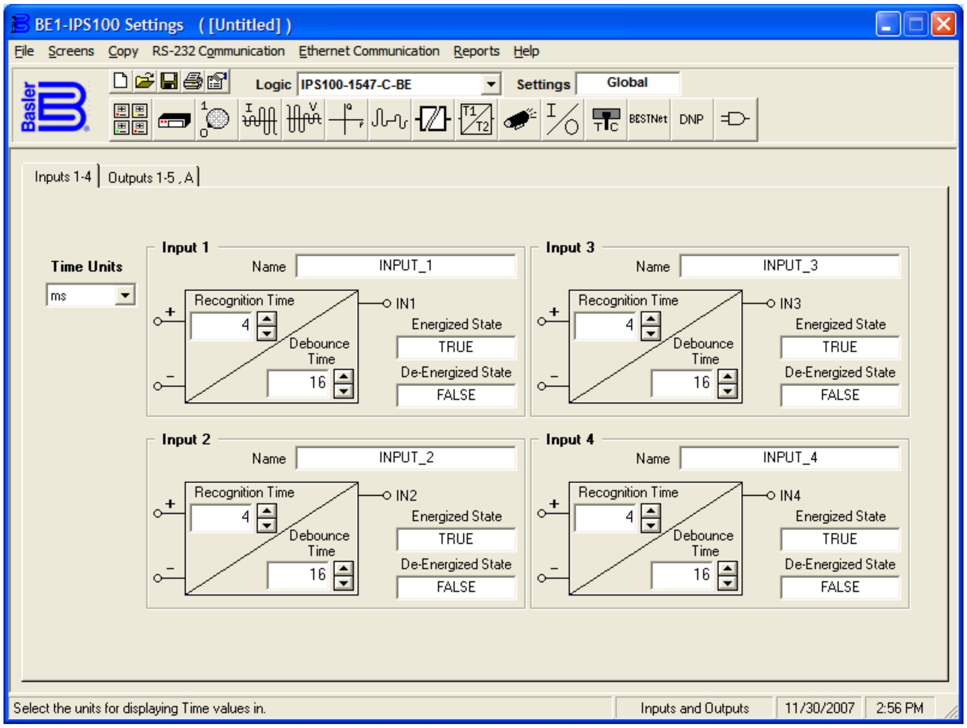

Figure 3-4. Inputs and Outputs Screen, Inputs 1-4 Tab

See Table 3-3 for a list of settings and their defaults.

Table 3-3. Digital Input Conditioning Settings

Setting	Range	Increment	Unit of Measure	Default
Recognition Time	4 to 255	1 ∗	Milliseconds	4
Debounce Time	4 to 255	1 ∗	Milliseconds	16
Time Units	Pull-down menu that selects the unit of measure for *Recognition Time* and *Debounce Time*. Units of measure available are: milliseconds (ms), seconds, minutes, and cycles. The default is milliseconds.			
Name	User programmable label for the input contact. Used by the reporting function to give meaningful identification to the input contact. This label may be up to 10 characters long.			
Energized State	User programmable label for the contact's energized state. Used by the reporting function to give meaningful identification to the state of the input contact. This label may be up to seven characters long.			
De-Energized State	User programmable label for the contact's de-energized state. Used by the reporting function to give meaningful identification to the state of the input contact. This label may be up to seven characters long.			

∗ Since the input conditioning function is evaluated every quarter cycle, the setting is internally rounded to the nearest multiple of 4.16 milliseconds (60 Hz systems) or 5 milliseconds (50 Hz systems).

If you are concerned about ac voltage being coupled into the contact sensing circuits, the recognition time can be set for greater than one-half of the power system cycle period. This will take advantage of the half-wave rectification provided by the input circuitry.

If an ac wetting voltage is used, the recognition time can be set to less than one-half of the power system cycle period and the debounce timer can be set to greater than one-half of the power system cycle period. The extended debounce time will keep the input energized during the negative half-cycle. The default settings of 4 and 16 milliseconds are compatible with ac wetting voltages.

Digital input conditioning settings may also be entered through the communication ports using the SG-IN (setting general-input) command.

Retrieving Input Status Information from the Relay

Input status is determined through BESTCOMS by selecting *Metering* from the *Reports* pull-down menu and selecting the *Start Polling* button in the lower right hand corner of the screen. Alternately, status can be determined through HMI Screen 1.5.1 or through the communication ports using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

OUTPUTS

BE1-IPS100 relays have five general-purpose output contacts (OUT1 through OUT5) and one fail-safe, normally open or closed (when de-energized), alarm output contact (OUTA). Each output is isolated and rated for tripping duty. OUT1 through OUT5 are Form A (normally open), and OUTA is Form B (normally closed) or Form A (normally open).The style number determines the type of alarm output contact. A trip coil monitoring circuit is hardwired across OUT1. See Section 6, *Reporting and Alarm Functions, Trip Circuit Monitoring*, for details.

Hardware Outputs and Virtual Outputs

Output contacts OUT1 through OUT5 and OUTA are driven by BESTlogic expressions for VO1 through VO5 (Virtual Outputs 1 through 5) and VOA (Virtual Output A). The use of each output contact is completely programmable so you can assign meaningful labels to each output and to the logic 0 and logic 1 states of each output. Section 7, *BESTlogic Programmable Logic*, has more information about programming output expressions in your programmable logic schemes.

A virtual output (VOn) exists only as a logical state inside the relay. A hardware output is a physical output relay contact. BESTlogic expressions for VO1 through VO5 (Virtual Outputs 1 through 5) and VOA (Virtual Output A) drive Output Contacts OUT1 through OUT5 and OUTA. The state of the output contacts can vary from the state of the output logic expressions for three reasons:

1. The relay trouble alarm disables all hardware outputs.
2. The programmable hold timer is active.
3. The select-before-operate function overrides a virtual output.
4.

Figure 3-5 shows a diagram of the output contact logic for the general-purpose output contacts. Figure 3-6 illustrates the output contact logic for the fail-safe alarm output contact.

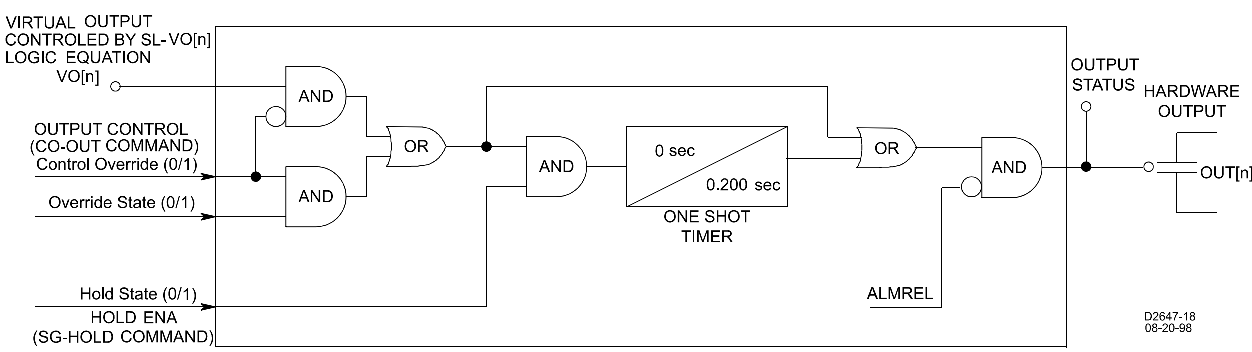

Figure 3-5. Output Logic, General Purpose Output Contacts

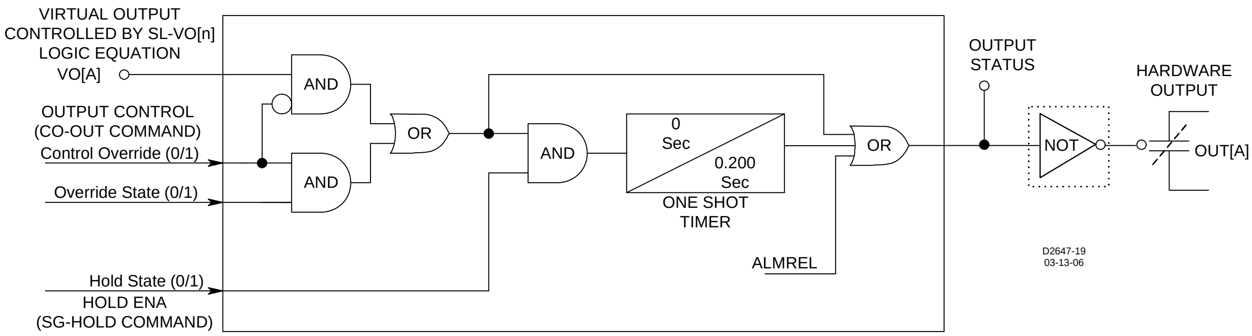

Figure 3-6. Output Logic, Fail-Safe Alarm Output Contact

Retrieving Output Status

Output status is determined through BESTCOMS by selecting *Metering* from the *Reports* pull-down menu and selecting the *Start Polling* button in the lower right hand corner of the screen. Alternately, status can be determined through the HMI Screen 1.5.2 and through the communication ports using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

Relay Trouble Alarm Disable

When the BE1-IPS100 self-diagnostics function detects a relay problem, an internal alarm condition (ALMREL) is set. This alarm condition disables the outputs and de-energizes the OUTA relay which, depending on the relay style, closes or opens the OUTA contacts. For more details about this function see Section 6, *Reporting and Alarm Functions, Alarms Function*.

Programmable Hold Timer

Historically, electromechanical relays have provided trip contact seal-in circuits. These seal-in circuits consisted of a dc coil in series with the relay trip contact and a seal-in contact in parallel with the trip contact. The seal-in feature serves several purposes for electromechanical relays. One purpose is to provide mechanical energy to drop the target. A second purpose is to carry the dc tripping current from the induction disk contact, which may not have significant closing torque for a low resistance connection. A third purpose is to prevent the relay contact from dropping out until the current has been interrupted by the 52a contacts in series with the trip coil. If the tripping contact opens before the dc current is interrupted, the contact may be damaged. Of the three items, only item three is an issue for electronic relays like the BE1-IPS100.

To prevent the output relay contacts from opening prematurely, a hold timer can hold the output contact closed for a minimum of 200 milliseconds. If seal-in logic with feedback from the breaker position logic is desired, the BESTlogic expression for the tripping output can be modified. This process is described in Section 7, *BESTlogic Programmable Logic, BESTlogic Application Tips*.

The hold timer can be enabled for each input using the SG-HOLD (setting general-hold) command. Hold timer settings are shown in Table 3-4.

To enable the hold timer using BESTCOMS, select *Inputs and Outputs* from the *Screens* menu, and select the *Outputs 1-5, A* tab. To enable the hold timer for a desired output, check the box labeled *Hold Attribute* by clicking in the box with the mouse pointer. Refer to Figure 3-7.

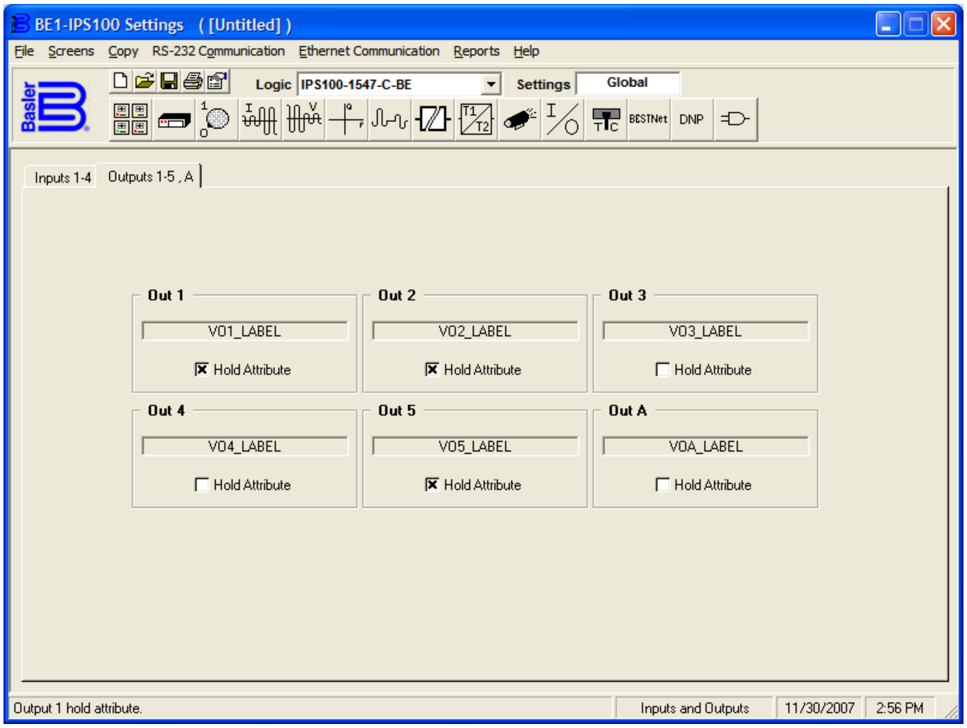

Figure 3-7. Inputs and Outputs Screen, Outputs 1-5, A Tab

Table 3-4 lists the default setting for the hold timer attribute. The Hold Attribute for OUT1, OUT2, and OUT5 is enabled.

Table 3-4. Hold Timer Settings

Setting	Range	Default
Output Hold Timer	0 = Disabled 1 = Enabled	OUTA = 0, OUT1 = 1, OUT2 = 1, OUT3 = 0, OUT4 = 0, OUT5 = 1

Output Logic Override Control

Each output contact can be controlled directly using the select-before-operate output control function. The virtual output logic expression that normally controls the state of an output contact can be overridden and the contact pulsed, held open, or held closed. This function is useful for testing purposes. An alarm point is available in the programmable alarm function for monitoring when the output logic has been overridden. See Section 6, *Reporting and Alarm Functions, Alarms Function*, for more information about programmable alarms. Write access to control functions is required before using the select-before-operate control functions through the HMI or ASCII command interface. It cannot be achieved using BESTCOMS.

Enabling Logic Override Control

By default, logic override control is disabled. Output logic override must be enabled before the control can be used. Enabling of the output logic override control is not possible at the front panel HMI. It can only be enabled through a communication port using the CS/CO-OUT=ena/dis (control select/control operate-output override=**ena**ble/**dis**able) command. The CS/CO-OUT command only enables or disables override control of the output logic; it doesn't enable or disable the outputs themselves.

Pulsing an Output Contact

Pulsing BE1-IPS100 outputs provides the same function as the push-to-energize feature of other Basler Electric solid-state relays. This feature is useful when testing the protection and control system. When pulsed, an output contact changes from the current state (as determined by the virtual output logic expression) to the opposite state for 200 milliseconds. After 200 milliseconds, the output contact is returned automatically to logic control.

Pulse override control is accessed at Screen 2.4.1 of the HMI by entering a P in the field for the output contact to be pulsed. Pulse control is accessed through a communication port by using the CS/CO-OUTn=P (control select/control operate-output contact n=pulse) command.

Holding an Output Contact Open or Closed

Outputs can be forced to a closed (logic 1 or TRUE) state or to an open (logic 0 or FALSE) state. This feature can be used to disable a contact during testing. Open or close logic override control is accessed at Screen 2.4.1 of the HMI by entering a 0 for open or 1 for closed in the field for the output contact to be controlled. Outputs are forced open or closed through a communication port by using the CS/CO-OUTn=P0/1 (control select/control operate-output contact n-0/1) command.

Returning an Output Contact to Logic Control

When the output logic has been overridden and the contact is held in an open or closed state, it is necessary to *manually* return the output to logic control. Outputs are returned to logic control through Screen 2.4.1 of the HMI. An L is entered in the field of the contact that is to be returned to logic control. Outputs are returned to logic control through a communication port by using the CS/CO-OUTn=L (control select/control operate-output contact n=logic control) command.

The output control commands require the use of select-before-operate logic. First, the command must be selected using the CS-OUT command. After the command is selected, there is a 30 second window during which the CO-OUT control command can be entered. The control selected and operation selected syntax must match exactly or the command will be blocked. If the operate command isn't entered within 30 seconds of the select command, the operate command will be blocked. An error message is returned when a control command is blocked.

Output control commands are acted on immediately except when the ENA and DIS modes are used. ENA and DIS output control command changes aren't executed until saved with the EXIT command. Output control status is saved in nonvolatile memory and is maintained when relay operating power is lost. All relay responses in the following examples and throughout the manual are printed in Courier New typeface.

CS/CO-OUT Command Examples:

1. Enable the output control feature.
   >CS-OUT=ENA
   `OUT=ENA SELECTED`
   >CO-OUT=ENA
   `OUT=ENA EXECUTED`
   >E *(exit)*
   `Save Changes (Y/N/C)?`
   >Y *(yes)*

2. Test all outputs by pulsing momentarily.
   >CS-OUT=P
   `OUT=P SELECTED`
   >CO-OUT=P
   `OUT=P EXECUTED`

3. Disable the trip output (OUT1) by holding it at logic 0.
   >CS-OUT1=0
   `OUT1=0 SELECTED`
   >CO-OUT1=0
   `OUT1=0 EXECUTED`

4. Return OUT1 to logic control.
   >CS-OUT1=L
   `OUT1=L SELECTED`
   >CO-OUT1=0
   `OUT1=L EXECUTED`

5. Disable the output control feature.
   >CS-OUT=DIS
   `OUT=DIS SELECTED`
   >CO-OUT=DIS
   `OUT=DIS EXECUTED`
   >E *(exit)*
   `Save Changes (Y/N/C)?`
   >Y *(yes)*

Retrieving Output Logic Override Status

The status of the output contact logic override control can be viewed at HMI Screen 1.5.3. It cannot be achieved using BESTCOMS. HMI Screen 2.4.1 is used for output control but can also display the current status. Output logic status can also be viewed using the RG-STAT (report general-status) command. An L indicates that the state of the output is controlled by logic. A 0 or 1 indicates that the logic has been overridden and the contact is held open (0) or closed (1) state. A P indicates that the contact is being pulsed and will return to logic control automatically. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

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SECTION 4 • PROTECTION AND CONTROL

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SECTION 4 • PROTECTION AND CONTROL

INTRODUCTION

The BE1-IPS100 Intertie Protection System provides the following functions that can be used to protect and control power system equipment.

BE1-IPS100 protection functions include:

- Volts per Hertz Overexcitation (24)
- Synchronism-check (25) including Conditional Voltage (25VM)
- Three-phase Undervoltage and Overvoltage (27P/127P and 59P/159P)
- Auxiliary Undervoltage and Overvoltage (27X and 59X/159X)
- Three-phase Directional Power (32/132)
- Negative-Sequence Overvoltage (47)
- Instantaneous Overcurrent with Settable Time Delay (50TP, 50TN, 50TQ, 150TP, 150TN, 150TQ)
- Time Overcurrent (51P, 51N, 51Q, 151P, 151N)
- Voltage Restraint for 51P Phase Time Overcurrent (27R) (One setting for 51P and 151P)
- VT Fuse Loss Detection (60FL)
- General Purpose Logic Timers (62, 162)
- Forward and Reverse Directional Control (671, 672, 670, 67I0)
- Overfrequency, Underfrequency, and Rate of Change Frequency (81, 181, 281, 381, 481, 581)
- Breaker Failure (50BF)

BE1-IPS100 control functions include:

- Four-shot Recloser (79) with zone-sequence coordination, sequence controlled blocking and reclose control of setting group.
- Virtual Selector Switches (43, 143)
- Virtual Breaker Control Switch (101)
- Trip Circuit Monitor (52TM)

Two setting groups allow coordination to be adapted for changes in operating conditions. Setting groups can be selected using programmable logic criteria.

Using Protection and Control Functions

Three steps must be taken before using a protection or control function.

1. The function logic must be enabled in the active logic scheme by the SL-<function> command.
2. Function inputs and outputs must be connected properly in a logic scheme.
3. Function characteristics or settings must be programmed and based on the specific application requirements.

If a preprogrammed logic scheme is used in a typical application, items 1 and 2 may be skipped. Most preprogrammed schemes are general in nature. Unneeded capabilities can be disabled by a setting of zero. For example, if the second neutral time overcurrent function is enabled but not needed, disable it by setting the 151N pickup setting to zero at the BESTCOMS screen or by using the ASCII command S#-151N=0,0,0.

More information about the individual function logic of item 1 is provided in this section. Information pertaining to items 2 and 3 is available in Section 7, *BESTlogic Programmable Logic*, Section 8, *Application*, and Section 14, *BESTCOMS Software*.

SETTING GROUPS

The BE1-IPS100 Intertie Protection System provides a normal setting group (SG0) and one auxiliary setting group (SG1). The auxiliary setting group allows for adapting the coordination settings to optimize them for a predictable situation. Sensitivity and time coordination settings can be adjusted to optimize sensitivity or clearing time based upon source conditions or to improve security during overload conditions. The possibilities for improving protection by eliminating compromises in coordination settings with adaptive setting groups is endless. Figure 4-1 shows the setting group control logic block.

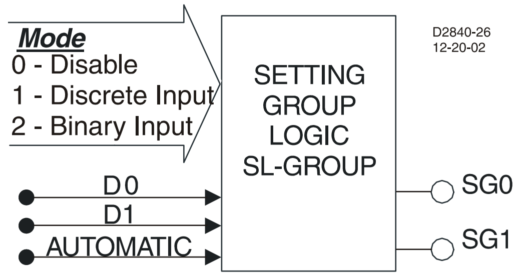

Figure 4-1. Setting Group Control Logic Block

The group of settings that is active at any point in time is controlled by the setting group control logic. This function logic allows for manual (logic) control. The function monitors logic inputs, D0 and D1 and changes the active setting group according to the status of these inputs. These inputs can be connected to logic expressions such as contact sensing inputs.

The function logic has two logic variable outputs, SG0 and SG1. The appropriate variable is asserted when each setting group is active. These logic variables can be used in programmable logic to modify the logic based upon which setting group is active. For example, it may be desirable for the 51P element to trip the low-side breaker through OUT2 under normal conditions but to trip the 86T lockout relay through OUT1 when in Setting Group 1. To accomplish this, the logic for OUT1 would include the term 51PTSG1 so that 51PT actuates only when SG1 is active.

The setting group control function logic also has an alarm output variable SGC (Setting Group Changed). This output is asserted whenever the BE1-IPS100 switches from one setting group to another. The SGC alarm bit is asserted for the SGCON time setting. This output can be used in the programmable alarms function if it is desired to monitor when the BE1-IPS100 changes to a new setting group. See Section 6, *Reporting and Alarm Functions, Alarms Function*, for more information on using alarm outputs.

The SGCON time setting also serves to provide anti-pump protection to prevent excessive changing between groups. Once a change in active group has been made, another change cannot take place for two times the SGCON setting.

The SGC ACTIVE alarm output is typically used to provide an external acknowledgment that a setting group change occurred. If SCADA (Supervisory Control and Data Acquisition) is used to change the active group, then this signal could be monitored to verify that the operation occurred. The SGC ACTIVE alarm output ON time is user programmable and should be set greater than the SCADA scan rate. This can be set through the BESTCOMS graphical user interface (GUI). Alternately, it can be set using the SG-SGCON (settings general–SGC Alarm on time) command.

When the BE1-IPS100 switches to a new setting group, all functions are reset and initialized with the new operating parameters. The settings change occurs instantaneously so at no time is the BE1-IPS100 off line. The active setting group is saved in nonvolatile memory so that the BE1-IPS100 will power up using the same setting group that was active when it was powered down. To prevent the BE1-IPS100 from changing settings while a fault condition is in process, setting group changes are blocked when the BE1-IPS100 is in a picked-up state. Since the BE1-IPS100 is completely programmable, the fault condition is defined by the pickup logic expression in the fault reporting functions. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information.

Selection of the active setting group provided by this function logic can also be overridden. When logic override is used, a setting group is made active and the BE1-IPS100 stays in that group regardless of the state of the manual logic control conditions.

BESTlogic Settings for Setting Group Control

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-2 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Setting Group Selection* function. To open the *BESTlogic Function Element* screen for *Setting Group Selection*, select *Setting Group Selection* from the *Screens* pull-down menu. Then select the *BESTlogic* button in the lower left hand corner of the screen. Alternately, settings may be made using the SL-GROUP ASCII command. At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

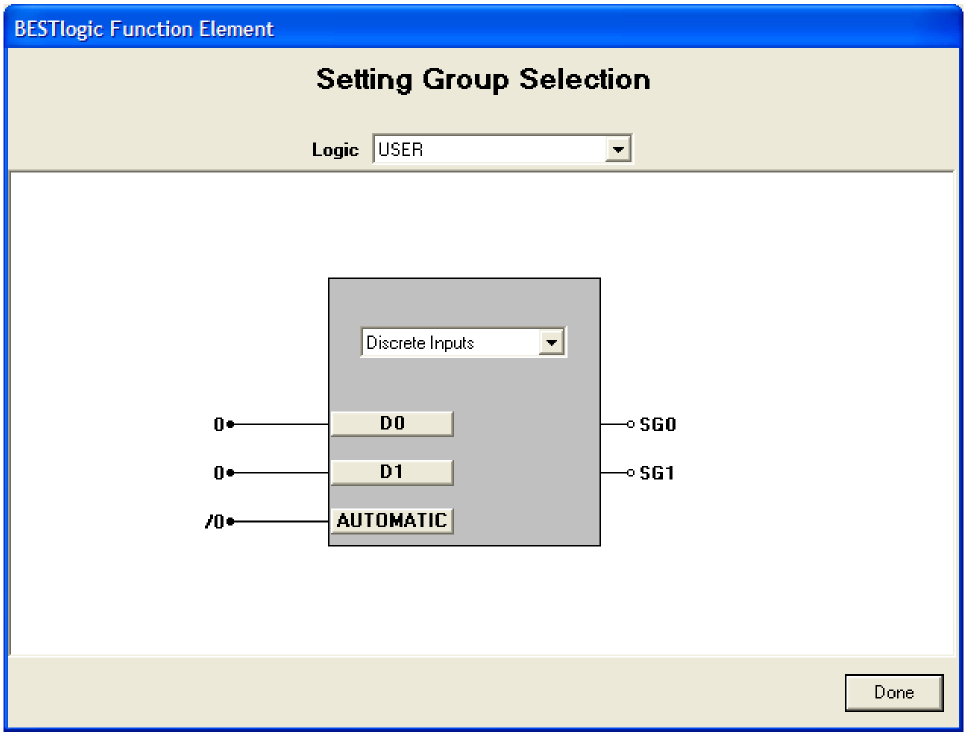

Figure 4-2. BESTlogic Function Element Screen, Setting Group Selection

Enable the *Setting Group Selection* function by selecting its mode of operation from the *Mode* pull-down menu. To connect the functions inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited. Table 4-1 summarizes the BESTlogic settings for Setting Group Control.

Table 4-1. BESTlogic Settings for Setting Group Control

Function	Range/Purpose	Default
Mode	0 = Disabled, 1 = Discrete Inputs, 2 = Binary Inputs (If Auto mode is desired, logic mode must be either 1 or 2.)	1 (Discrete Inputs)
D0	Logic expression. Meaning is dependent upon the Mode setting.	0
D1	Logic expression. Meaning is dependent upon the Mode setting.	0
Automatic	Logic Expression. When TRUE, automatic control is enabled and when FALSE, logic control is enabled.	/0

Example 1. Make the following settings to the setting group selection logic. Refer to Figure 4-2.

Mode: Discrete Inputs
D0: 0
D1: 0
AUTOMATIC: /0

Manual (logic) control reads the status of the logic inputs to the setting group control function block to determine what setting group should be active. **For the logic inputs to determine which setting group should be active, the AUTO input must be logic 0.** The function block logic mode setting determines how it reads these logic inputs. There are three possible logic modes as shown in Table 4-1.

When the setting group control function block is enabled for Mode 1, there is a direct correspondence between each discrete logic input and the setting group that will be selected. That is, asserting input D0 selects SG0 and asserting input D1 selects SG1. The active setting group latches in after the input is read so they can be pulsed. It is not necessary that the input be maintained. If one or more inputs are asserted at the same time, the numerically higher setting group will be activated. A pulse must be present for approximately one second for the setting group change to occur. After a setting group change occurs, no setting group change can occur within two times the SGC alarm on-time. Any pulses to the inputs will be ignored during that period.

Figure 4-3 shows an example of how the inputs are read when the setting group control function logic is enabled for Mode 1. Note that a pulse on the D1 input doesn't cause the setting group to change to SG1 because the AUTO input is active.

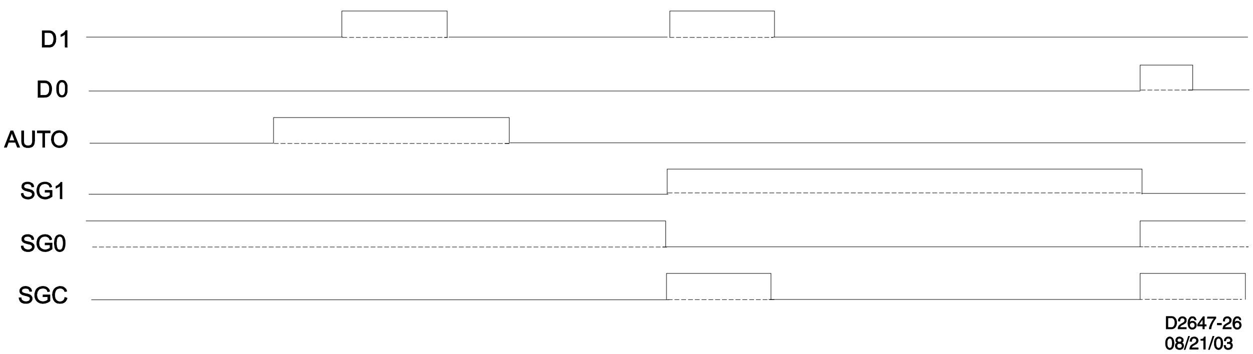

Figure 4-3. Input Control Mode 1

When the setting group control function block is enabled for Mode 2, inputs D0 and D1 are read as binary encoded (Table 4-2). A new coded input must be stable for approximately 1 second for the setting group change to occur. After a setting group change occurs, no setting group change can occur within two times the SGC alarm on time.

Table 4-2. Setting Group Binary Codes

Binary Code		Decimal Equivalent	Setting Group
D1	**D0**		
0	0	0	SG0
0	1	1	SG1

Automatic Setting Group Control

The relay has built in schemes that may be used to automatically change setting groups. One scheme is based on the history of the current in the relay. Another scheme is based upon the status of the reclose function (79) or fuse loss logic (60FL). To enable automatic change of setting groups, setting group control must be enabled and the <autologic> bit of SL-GROUP command must be a 1 and can be set as follows:

SL-GROUP = /0,,,,,/0.

When automatic control is enabled, it holds precedence over all manual logic control.

The automatic setting group control may be used to force the relay to change to settings that will automatically compensate for cold load pickup conditions. For instance, if the relay senses current drop below a very small amount for a period of time indicating an open breaker, then the relay may move to an alternate setting group that will allow for the large inrush of current the next time the load is energized. After current has returned to measurable levels for some period of time, the relay returns to the normal settings. Another application is to prevent the relay from seeing an overload condition as a fault. If the relay sees sustained high level phase or unbalance currents that are encroaching on normal trip levels (indicative of an overload or load imbalance rather than a fault), the relay may move to an alternate setting group that may accommodate the condition. The relay can be set to alarm for this condition using the programmable logic alarms.

The relay has the logic to automatically change setting groups based upon the status of the reclose function (79) or fuse loss (60FL). This scheme allows the relay to have fast and slow curves, for instance, when the user is applying automatic reclosing into a fault. On the first trip of a fault the relay may use a setting group with a fast overcurrent curve and/or a low set instantaneous setting, with the intent of tripping faster than downstream fuses. On subsequent trips, by monitoring the reclose step, the relay would be in an alternate setting group with a slower overcurrent response and/or a higher or no instantaneous trip with the intent of operating slower than downstream fuses.

The user should also be aware that the 79 function "Sequence Control Block" (79SCB) provides an alternate method to control relay operation based on the reclose status. See the 79 function description later in this section for additional details.

Automatic Control by Monitoring Line Current

The Setting Group 0 and 1 switch to and return settings determine how the function selects the active setting group when automatic selection is enabled.

Automatic control of the active setting group allows the relay to automatically change configuration for optimum protection based on the current system conditions. For example, in locations where seasonal variations can cause large variations in loading, the overcurrent protection can be set with sensitive settings during the majority of the time and switch to a setting group with lower sensitivity (higher pickups) during the few days of the year when the loading is at peak.

The relay will switch to a setting group when current rises above the "switch-to threshold" for the "switch-to time" and will return from the setting group when current falls below the "return threshold" for the "return time." However, if the "switch-to" threshold is 0 and a non-zero switch-to time is entered, then the relay changes to the indicated setting group and falls below 10% of nominal (0.5 A / 0.1 A for 5 A / 1 A nominal relays) after the switch-to time. This is used in the example application for cold load pickup, below.

If the monitored element is 60FL, 791, 792, 793, or 794, the switch-to time, switch-to threshold, return time, and return threshold are ignored and the setting group is based upon the status for the reclose step. This method of controlling setting groups will be covered further in the following paragraphs:

If a group's switch-to threshold is zero and the groups switch-to time delay is 0 and the monitored element is any overcurrent element (i.e., not 60FL, 791, 792, 793, or 794), then the relay will never automatically switch to that setting group.

There are five settings for each group that are used for automatic control. Each group has a *switch threshold* and time delay, a *return threshold* and time delay, and a monitored element. The *switch* and *return* thresholds are a percentage of the SG0 pickup setting for the monitored element. The monitored element can be any of the 51 protective functions. Thus, if you wish to switch settings based upon loading, you could set it to monitor 51P. If you wish to switch settings based upon unbalance, you could set it to monitor 51N, 151N, or 51Q. When the monitored element is 51P, any one phase must be above the *switch threshold* for the *switch to* time delay for the criteria to be met. All phases must be below the *return threshold* for the *return* time delay for the return criteria to be met.

This function can also be used to automatically change the active setting group for cold load pickup conditions. If the *switch threshold* for a group is set to 0%, the function will switch to that group when there is no current flow for the time delay period, indicating that the breaker is open or the circuit source is out of service. The threshold for this is 10% nominal rating of the relay current input.

Note the difference in operation when a switch-to threshold of 0% is used. For this setting the group is switched to when current falls below 0.5 A / 0.1 A (5 A / 1 A nominal). But when any other switch level is used, the switch occurs when current rises above the switch level.

When the *switch* criteria is met for more than one setting group at a time, the function will use the numerically higher of the enabled settings groups. If the switch to time delay setting is set to 0 for a setting group, automatic control for that group is disabled. If the return time delay setting is set to 0 for a setting group, automatic return for that group is disabled and the relay will remain in that settings group until returned manually by logic override control.

Group Control by Monitoring Reclose Status

The active setting group may also be controlled by the status of the reclose (79) function. Upon entering a reclose operation, as the relay steps through an automatic reclose operation, the relay may be instructed to change to an appropriate setting group using the command SP-GROUP[n] = ,,,,<791, 792, 793, or 794>. If the monitored element in the SP-GROUP command is 791, 792, 793, or 794, the switch-to time, switch-to threshold, return time, and return threshold are ignored.

When settings group changes are made via SP-GROUP[n] = ,,,,<791, 792, 793 or 794> the relay will stay in the last group changed to until the relay returns to reset condition. Upon return to reset condition, the relay restores Setting Group 0.

The points in the reclose process that the 791, 792, 793, and 794 setting causes a change to the desired setting group is when a) the referenced reclose occurs and b) after the breaker closes. For instance, SP-GROUP1 = ,,,,791 will cause the relay to change from Setting Group 0 to Setting Group 1 after the first reclose.

Example 1.

In most common practices, two setting groups are used for emulating a circuit recloser in a fuse saving scheme (a "fast" curve and a "slow" curve). The settings below call for using Setting Group 0 during normal operation, Setting Group 1 after reclose 2 and remain in Setting Group 1 until the breaker closed from lockout. The active group would return to group 0 when the recloser went to reset if any of the close operations prior to lockout was successful. Refer to Figure 4-4.

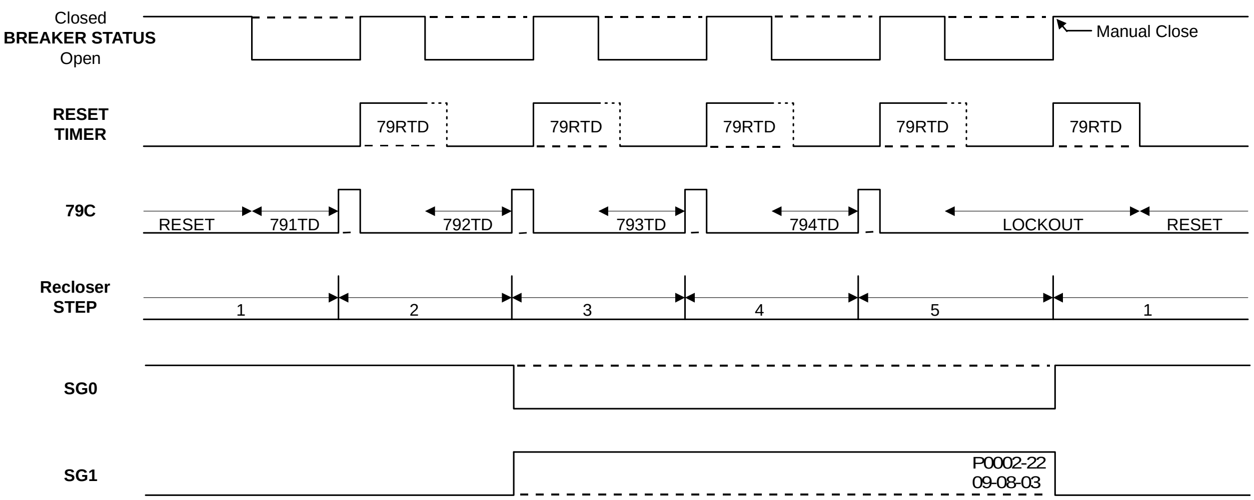

Figure 4-4. Example 1 - Change Group on Recloser Shot

<u>*Group Control by Monitoring Fuse Loss Status*</u>

The active setting group may also be controlled by the status of the fuse loss function (60FL). The relay may be instructed to change to Setting Group 1 using the command SP-GROUP1=....<60FL>. If the monitored element in the SP-GROUP command is 60FL, the switch-to threshold, return time, and return threshold are ignored.

When setting group changes are made via SP-GROUP1=,,,,<60FL>, the relay will stay in the last group changed until the relay returns to the reset condition. Upon return to the reset condition, the relay restores Setting Group 0.

Operating Settings for Setting Group Control

Operating settings are made using BESTCOMS. Figure 4-5 illustrates the BESTCOMS screen used to select operational settings for the *Setting Group Selection* function. To open the *Setting Group Selection* screen, select *Setting Group Selection* from the *Screens* pull-down menu. Alternately, settings may be made using the SP-GROUP ASCII command.

At the top left of the screen is a pull-down menu labeled Logic. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*. To the right of the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the elements settings apply to. Using the pull-down menus and buttons, make the application appropriate settings to the *Setting Group Selection* function. Table 4-3 summarizes the operating settings for Setting Group Control.

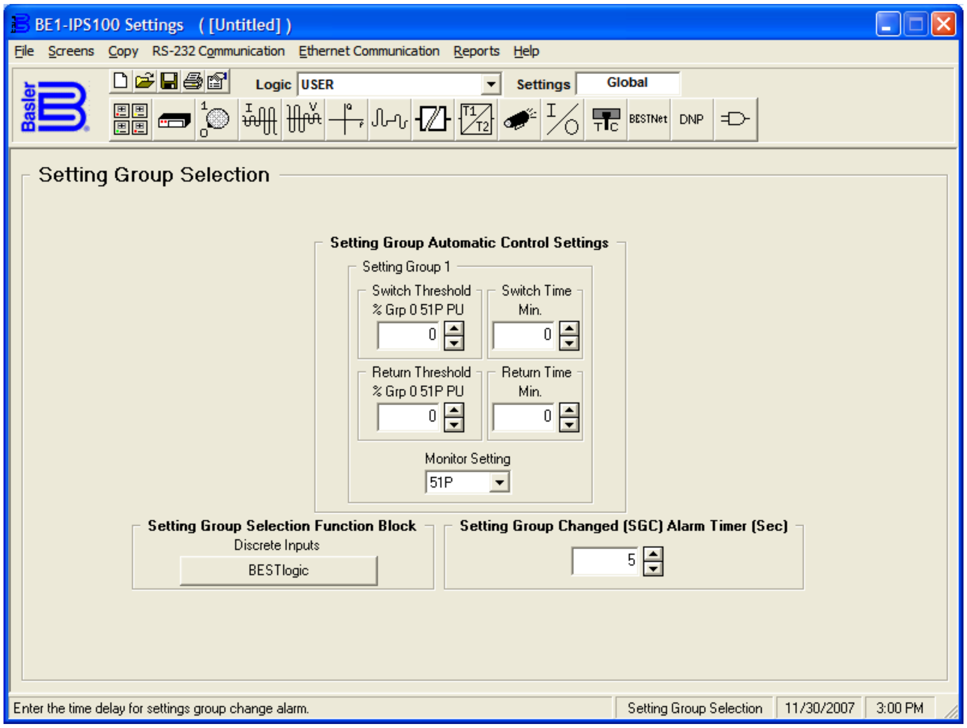

Figure 4-5. Setting Group Selection Screen

Table 4-3. Operating Settings for Setting Group Control

Setting	Range	Purpose	Default
Switch Time	1 to 60 0 = Disabled	Time in minutes that determines when a setting change occurs once the *Switch Threshold* setting is exceeded.	0
Switch Threshold	0 to 150	Percentage of the SG0 *Monitor Setting* that must be exceeded for a setting group change to occur.	0
Return Time	1 to 60 0 = Disabled	Time in minutes that determines when a return to SG0 will occur once the monitored current has decreased below the *Return Threshold* setting.	0
Return Threshold	0 to 150	Percentage of the SG0 *Monitor Setting* that the monitored current must decrease below in order for a return to SG0.	0
Monitor Setting	51P, 51N, 151N, 51Q, 60FL, 791, 792, 793, or 794	Determines when automatic setting group changes occur. Time overcurrent elements 51P, 51N, 151N, or 51Q can be selected so that setting group changes are based on load current. Recloser Shots 791, 792, 793, or 794 can be used to switch setting groups when the appropriate shot is reached in a reclosing sequence. Fuse Loss (60FL) can also be used to switch setting groups. If 60FL or one of the recloser shots is entered as the *Monitor Setting, the Switch Time, Switch Threshold, Return Time, and Return Threshold* parameters are not required.	51P
Setting Group Change (SGC) Alarm Timer	1 to 10 0 = Disabled	Measured in seconds, the SGC alarm timer sets the amount of time the alarm is on.	5

Logic Override of the Setting Group Control Function

Setting group selection can be overridden to allow manual setting group selection. Manual setting group control and selection is achieved through the human-machine interface (HMI) Screen 2.3.1 or by using the CS/CO-GROUP command. It cannot be achieved using BESTCOMS. The CS/CO-GROUP command uses select-before-operate logic. A setting group must be selected using the CS-GROUP command before the setting group is activated using the CO-GROUP command. The process of selecting and then placing a setting group in operation is summarized in the following two paragraphs:

Use the CS-GROUP command to select the desired setting group. After the CS-GROUP command is issued, there is a 30 second window during which the setting group can be activated using the CO-GROUP command.

Use the CO-GROUP command to activate the setting group already selected. The setting group activated with the CO-GROUP command must match the setting group selected with the CS-GROUP command. If the setting group specified in each command doesn't match or the CO-GROUP command isn't entered during the 30-second window, the CO-GROUP command is blocked and an error message is returned.

CS/CO-GROUP commands are executed without having to use the EXIT command to save setting changes.

When a setting group change is made, any subsequent setting change is blocked for two times the duration of the SGC alarm output time setting. Refer to the *Setting Groups* subsection for more information about SGC Alarm settings.

CS/CO-GROUP Command

Purpose: Read or change logic override settings for setting group selection.

Syntax: CS-GROUP[=<mode>]

Comments: mode =Setting Group 0, 1 or L. L returns group control to the automatic setting group logic. <mode> entry of CS-GROUP command and CO-GROUP command must match or setting group selection will be rejected. If more than 30 seconds elapse after issuing a CS-GROUP command, the CO-GROUP command will be rejected.

CS/CO-GROUP Command Examples:

Example 1. Read the current status of setting group override.

```
>CO-GROUP
L
```

Example 2. Override logic control and change the active setting group to SG1.

```
>A=password (Gains access)
>CS-GROUP=1
GROUP=1 SELECTED
>CO-GROUP=1
GROUP=1 EXECUTED
```

Example 3. Return control of the active setting group to the automatic setting group logic.

```
>CS-GROUP=L
GROUP=L SELECTED
>CO-GROUP=L
GROUP=L EXECUTED
>EXIT (Quits access)
```

Retrieving Setting Group Control Status from the Relay

The active setting group can be determined from HMI Screen 1.5.5 or by using the RG-STAT command. Section 6, *Reporting and Alarm Functions, General Status Reporting*, provides more information about determining the active setting group. The active group can also be determined using BESTCOMS *Metering* screen.

Logic override status can be determined from HMI Screen 2.3.1 or through the RG-STAT command. Section 6, *Reporting and Alarm Functions, General Status Reporting*, provides more information about determining logic override status. Logic override cannot be determined using BESTCOMS.

OVERCURRENT PROTECTION

The BE1-IPS100 includes instantaneous elements for Phase, Neutral or Ground, and Negative-Sequence as well as time overcurrent elements for Phase, Neutral or Ground, and Negative-Sequence.

50T - Instantaneous Overcurrent Protection with Settable Time Delay

There are two BESTlogic elements for phase (50TP and 150TP), two elements for ground (50TN and 150TN), and two elements for negative-sequence (50TQ and 150TQ) instantaneous overcurrent protection. The alphanumeric designation for each element contains the letter T to indicate that the element has an adjustable time delay. If an element has a time delay setting of zero, then that element will operate as an instantaneous overcurrent relay. Each element can also be set as either directional or non-directional. Refer to the paragraph, *67 - Directional Overcurrent*, for more information.

The 50TP, 50TN, and 50TQ instantaneous overcurrent elements are shown in Figure 4-6. The 150TP, 150TN, and 150TQ elements are identical to their counterparts. Each element has two logic outputs: Pickup (PU) and Trip (T).

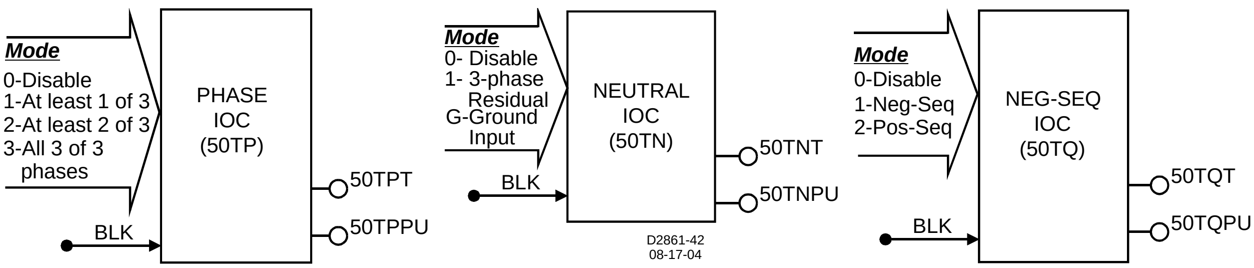

Figure 4-6. Instantaneous Overcurrent Logic Blocks

Each element has a *BLK* (Block) input that can be used to disable the function. A BESTlogic expression is used to define the *BLK* input. When this expression is TRUE, the element is disabled by forcing the outputs to logic zero and resetting the timers to zero. This feature functions in a similar way to a torque control contact of an electromechanical relay.

A Logic Mode input allows each instantaneous overcurrent element to be enabled or disabled. The phase elements 50TP and 150TP can be enabled for single phase or 3 phase tripping (Modes 1 of 3, 2 of 3, 3 of 3). The negative-sequence elements 50TQ and 150TQ can be enabled for negative-sequence operation, Mode 1; or positive-sequence operation, Mode 2. The ground elements, 50TN, and 150TN can be enabled to operate on calculated 3-phase Residual (3IO), Mode 1; or on measured ground current through the optional Ground Input, Mode G. See Mode selections in Figure 4-6. More information about logic mode selections is provided in the following *BESTlogic Settings for Instantaneous Overcurrent* subsection.

Each instantaneous overcurrent function has a pickup and time delay setting. When the measured current increases above the pickup threshold, the pickup output (PU) becomes TRUE and the timer starts. If the current stays above pickup for the duration of the time delay setting, the trip output (T) becomes TRUE. If the current decreases below the dropout ratio, which is 95 percent, the timer is reset to zero.

The phase overcurrent protective functions include three independent comparators and timers, one for each phase. When current increases above the pickup setting, the pickup output asserts. Mode selection determines how many phase pickups are required to define a TRIP condition. That is, if Mode 1 (1of 3) is selected, any one phase pickup output can generate a trip TRUE condition and the trip logic asserts. For Mode 2 (2 of 3), two-phase pickup outputs must be TRUE before the trip logic can assert, and for Mode 3, all three phase pickup outputs must be TRUE.

If the target is enabled for the element, the target reporting function will record a target for the appropriate phase when the protective function trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting. The overcurrent elements have adaptable targets. If one is set for directional control, it will report a 67 target. If one is set for non-directional controls it will report a 50 target. With the 50TQ set for "positive- sequence," the target response will be 50TP1 (1 for positive-sequence).

BESTlogic Settings for Instantaneous Overcurrent Protection

BESTlogic settings are made from the BESTlogic Function Element screen in BESTCOMS. Figure 4-7 illustrates the BESTCOMS screen used to select BESTlogic settings for the 50T and 150T elements. To open the *BESTlogic Function Element* screen, select *Overcurrent Protection* from the *Screens* pull-down menu. Then select the *50T* or *150T* Tab. Open the *BESTlogic Function Element* screen for the desired element by selecting the *BESTlogic* button corresponding with the desired element. Alternately, these settings can be made using the SL-50T and SL-150T ASCII commands.

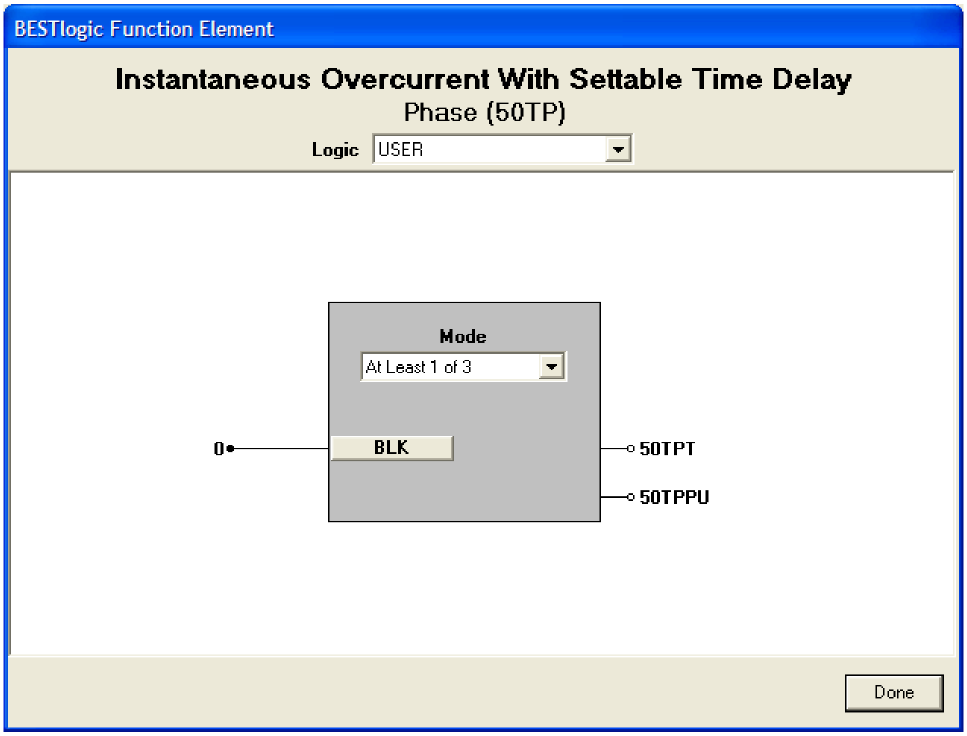

Figure 4-7. BESTlogic Function Element Screen, Neutral (50TN)

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the 50T or 150T function by selecting its mode of operation from the *Mode* pull-down menu. To connect the element's inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited. Tables 4-4, 4-5, and 4-6 summarize the BESTlogic Settings for the Phase, Neutral, and Negative-Sequence elements.

Table 4-4. BESTlogic Settings for 50TP/150TP Instantaneous Overcurrent Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = At least 1 of 3 2 = At least 2 of 3 3 = All 3 of 3 phases.	1
BLK	Logic expression that disables function when TRUE.	0

Table 4-5. BESTlogic Settings for 50TN/150TN Instantaneous Overcurrent Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = 3-phase residual (3IO) G = Ground input	1
BLK	Logic expression that disables function when TRUE.	0

Table 4-6. BESTlogic Settings for 50TQ/150TQ Instantaneous Overcurrent Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Negative-Sequence 2 = Positive-Sequence	1
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following settings to the 50TN element. Refer to Figure 4-7.
Mode: Three-phase Residual
BLK: 0

NOTE

If the BE1-IPS100 has 5 ampere phase inputs and a 1 ampere independent ground input, the valid pickup setting range of the neutral overcurrent functions will depend on the logic mode setting which designates whether the three-phase residual or the independent ground input is to be monitored. If changing logic schemes or settings causes a neutral overcurrent setting to be OUT OF RANGE, the out of range setting will be forced in-range by multiplying or dividing the current setting by 5.

Operating Settings for Instantaneous Overcurrent Protection

Operating settings for the 50T functions consist of *Pickup* and *Time* delay values. The *Pickup* value determines the level of current required for the element to start timing toward a trip. *Time* delays can be set in milliseconds, seconds, or cycles. The default is milliseconds if no unit of measure is specified. Minimum timing resolution is to the nearest one-quarter cycle. A time delay setting of zero makes the element instantaneous with no intentional time delay.

Operating settings are made using BESTCOMS. Figure 4-8 illustrates the BESTCOMS screen used to select operational settings for the 50T elements. To open the *BESTlogic Function Element* screen, select *Overcurrent Protection* from the *Screens* pull-down menu. Then select the *50T* tab. Alternately, settings may be made using S<g>-50T ASCII command or through HMI Screens 5.x.6.1 - 5.x.6.6 where x represents 1 (Setting Group 0) or 2 (Setting Group 1).

The default unit of measure for the *Pickup* setting is secondary amps. Primary amps (Pri Amps), per unit amps (Per U Amps), and percent amps (% Amps) can also be selected as the pickup setting unit of measure. The unit of measure for the *Time* setting that represents the element's time delay, defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

If time delay settings are made in cycles, they are converted to seconds or milliseconds (per the nominal frequency setting stored in EEPROM) before being stored and rounded to the nearest whole millisecond. See Section 3, *Input and Output Functions, Power System Inputs, Current Measurement*, for more information about this setting. If the nominal frequency setting is being changed from the default (60 hertz) and time delay settings are being set in cycles, the frequency setting should be entered and saved before making any time delay settings changes.

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the element's settings apply to.

Table 4-7 summarizes the operating settings for Instantaneous Overcurrent Protection.

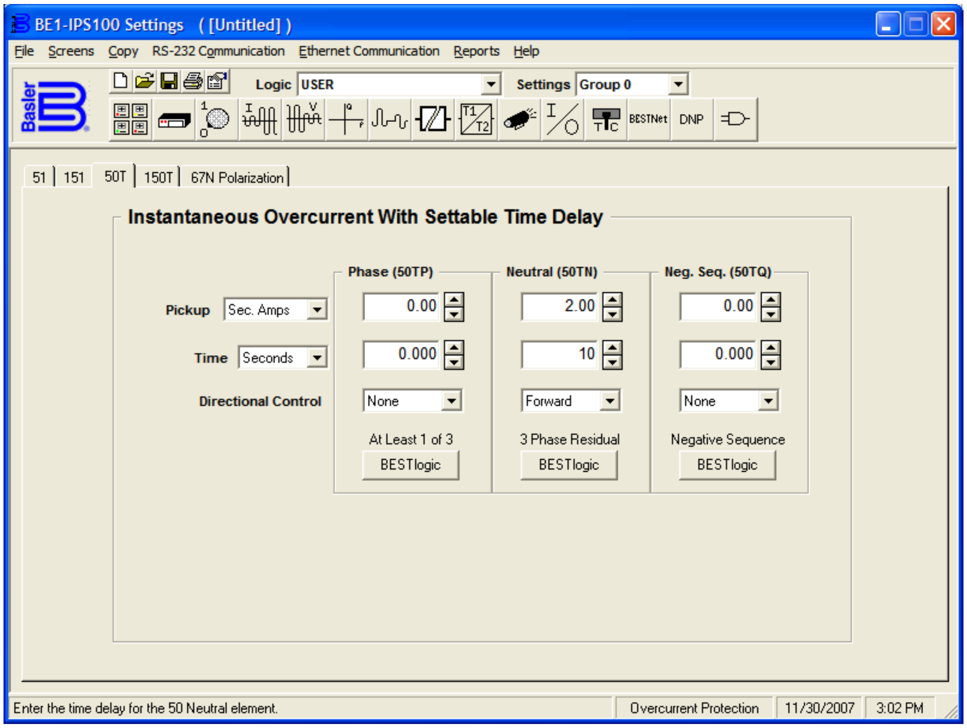

Figure 4-8. Overcurrent Protection Screen, 50T Tab

Table 4-7. Operating Settings for Instantaneous Overcurrent Protection

Setting	Range 1 A	Range 5 A	Increment	Unit of Measure	Default
Pickup	0 = Disabled 0.1 to 30	0 = Disabled 0.5 to 150	0.01 for 0.1 to 9.99 0.1 for 10.0 to 99.9 1.0 for 100 to 150	Secondary Amps	0
Time	0 to 999 milliseconds		1	Milliseconds	0
	0.1 to 60 seconds		0.1 for 0.1 to 9.9	Seconds	
			1.0 for 10 to 60	Seconds	
	0 to 3600 cycles (60 Hz)		∗	Cycles	
	0 to 2500 cycles (50 Hz)				
Direction	N = Non-directional F = Forward Directional R = Reverse Directional		N/A	N/A	N

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the front panel HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

Example 1. Make the following settings to the 50TN element. Refer to Figure 4-8.

Pickup: 2 secondary amps
Time: 10 seconds
Direction: Forward

<u>*Retrieving Instantaneous Overcurrent Protection Status from the Relay*</u>

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

51 - Time Overcurrent Protection

BE1-IPS100 relays have one element for phase which can be set for two pickup levels (51P and 151P) if 51P is set directional (emulating a second 51P element), two elements for neutral (51N and 151N), and one element for negative-sequence (51Q) inverse time overcurrent protection.

Operation on 151P settings is a function of the 51P operational setting. That is, 51P must be set for directional control to activate the 151P settings and, when activated, 151P will automatically "look" in the opposite direction of 51P. The 51P and 151P PU variables cannot operate simultaneously as there is only one phase overcurrent element. However, the single element can have two pickup settings that will respond to non-simultaneous faults, in front or behind the relay location. For example, if 51P is set forward, 151P will automatically look in the reverse direction and can have pickup, time dial, and curve settings separate from 51P. Conversely, if 51P is set reverse, 151P will automatically look in the forward direction with its own settings.

> **CAUTION**
>
> If 51P is set directional and a polarizing potential fuse blows (60FL), operation of the 51P is blocked. However, the 151P settings are allowed to operate as a non-directional overcurrent element providing a backup zone for such occurrences.

Figure 4-9 shows the 51P, 51N, and 51Q elements. The 151P and 151N elements are identical in configuration. Each element has two outputs: Pickup (PU) and Trip (T). A *BLK* (Block) logic input is provided to disable the function. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timers to zero. This feature operates in a similar manner to the torque control contact of an electromechanical relay.

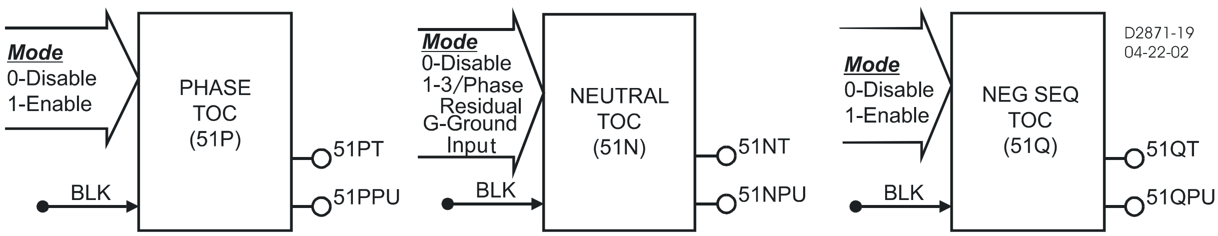

Figure 4-9. Time Overcurrent Logic Blocks

Each inverse time overcurrent function has a *Mode, Pickup, Time Dial, Curve setting,* and *Directional Control*. See Appendix A, *Time Overcurrent Characteristic Curves*, for details on each of the curves available. To make the protective element use integrated reset and emulate an electromechanical induction disk reset characteristic, the user can append an R to the selected time current characteristic curve designation. An available programmable curve can be used to create a custom curve by selecting coefficients in the inverse time characteristic equation.

When the measured current is above the pickup threshold, the pickup logic output is TRUE and inverse timing is started according to the selected characteristic. If the current stays above pickup until the element times out, the trip logic output becomes TRUE. If the current falls below the dropout ratio, which is 95 percent, the function will either reset instantaneously or begin timing to reset depending on the user's setting.

The phase overcurrent protective functions use the highest of the three measured phase currents. If the current is above the pickup setting for any one phase, the pickup logic output is asserted. If the trip condition is TRUE, the trip logic output is asserted.

If the target is enabled for an element, the target reporting function will record a target for all phases that are above pickup when the protective function trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more details on the target reporting function. The time overcurrent elements have adaptable targets. If one is set for directional control, it will report a 67T target. If one is set for non-directional control, it will report a 51 target.

BESTlogic Settings for Time Overcurrent Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-10 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Time Overcurrent* function.

To open the screen, select *Overcurrent Protection* from the *Screens* pull-down menu and select either *51* or *151* tab. Then select the *BESTlogic* button at the bottom of the screen that corresponds with the element to be modified. Alternately, settings may be made using the SL-51 and SL-151 ASCII commands.

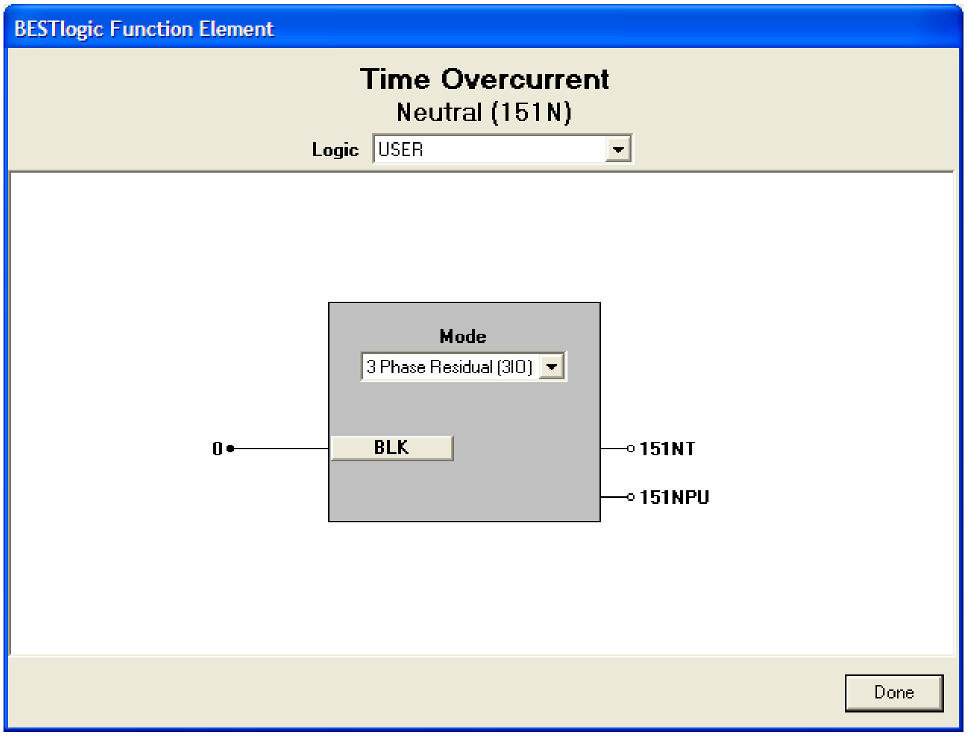

Figure 4-10. BESTlogic Function Element Screen, Neutral (151N)

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the *Time Overcurrent* function by selecting its mode of operation from the *Mode* pull-down menu. To connect the functions inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

The BESTlogic settings for Time Overcurrent Protection are provided in Table 4-8. These settings enable an element by attaching it to the CT input circuits and provide blocking control as determined by the logic expression assigned to the block input.

Table 4-8. BESTlogic Settings for Time Overcurrent Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled 1 = 3-phase residual (3IO) (51N, 151N only) G = Ground input (51N, 151N only)	1
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following settings to the 151N element using BESTCOMS. See Figure 4-10.

Mode: 3-phase residual (3I0) input

BLK: 0

Operating Settings for Time Overcurrent Protection

Operating settings are made using BESTCOMS. Figure 4-11 illustrates the BESTCOMS screen used to select operational settings for the *Time Overcurrent* element. To open the screen, select *Overcurrent Protection* from the *Screens* pull-down menu and select either *51* or *151* tab. Alternately, settings may be made using S<g>-51 and S<g>-151 ASCII commands or from the HMI Screens 5.x.7.1 through 5.x.7.5 where x equals 1 for Setting Group 0 and 2 for Setting Group 1.

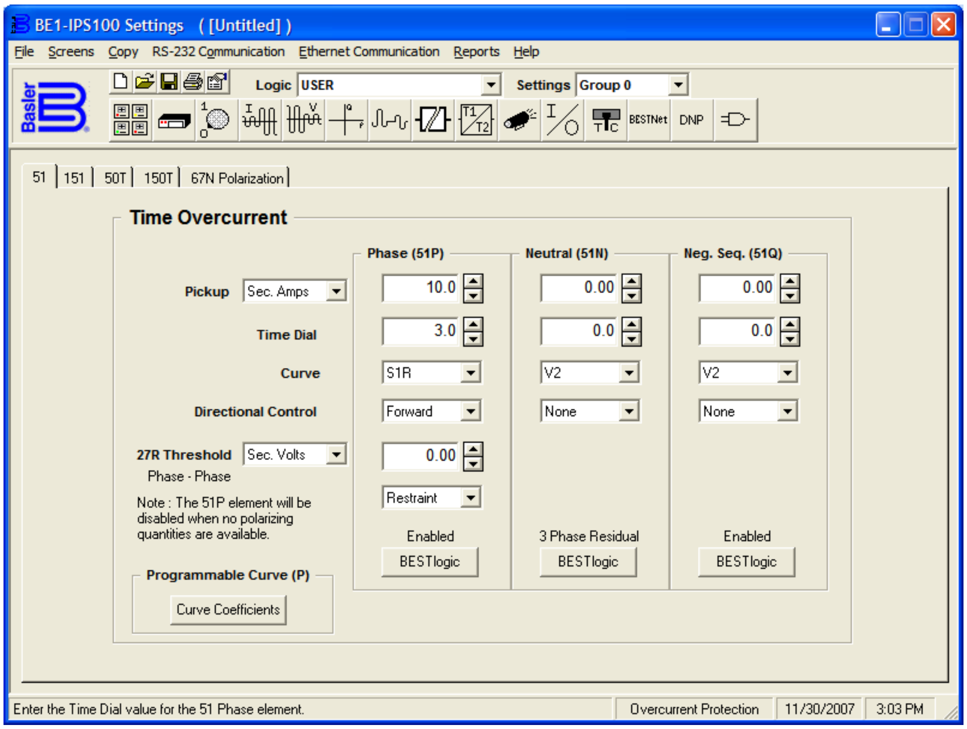

Figure 4-11. Time Overcurrent Protection Screen, 51 Tab

The default unit of measure for the *Pickup* setting is secondary amps. Primary amps (Pri Amps), per unit amps (Per U Amps), and percent amps (% Amps) can also be selected as the pickup setting unit of measure. The unit of measure for the *Time* setting that represents the element's time delay, defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the element's settings apply to.

Table 4-9 summarizes the operating settings for Time Overcurrent Protection.

Table 4-9. Operating Settings for Time Overcurrent Protection

Setting	Range		Increment	Unit of Measure	Default
	1 A	5 A			
Pickup	0 = Disabled 0.1 to 3.2	0 = Disabled 0.5 to 16	0.02 for 0.1 to 9.99 0.1 for 10.0 to 16.0	Secondary Amps	0
Time Dial	0.0 to 9.9 0.0 to 99 (46 only)		0.1	N/A	0
Curve	See Appendix A, *Table A-1*		N/A	N/A	V2
Direction	N = Nondirectional F = Forward Directional R = Reverse Directional		N/A	N/A	N

Example 1. Make the following settings to the Phase 51P time overcurrent element in BESTCOMS. Refer to Figure 4-11.

Pickup:	10 secondary amps
Time Dial:	3.0
Curve:	S1R
Direction:	Forward

Retrieving Time Overcurrent Protection Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

Voltage Restraint/Control for Time Overcurrent Protection

The 51P protection function can be set for voltage control or voltage restraint mode of operation (51V). This feature is used to allow increased overcurrent sensitivity while providing security from operation due to load current. This feature is also often used for generator backup protection to ensure delayed tripping during a short-circuit where the fault current contribution from the generator falls to a value close to the full-load rating of the generator.

When set for *Control* mode of operation, the phase overcurrent element is disabled until the measured voltage drops below the threshold. Thus, as long as the voltage on the appropriate phase is above the 27R threshold setting, the overcurrent element will be blocked. When set for this mode of operation, the 51P pickup setting is typically set near or below load current levels.

When set for *Restraint* mode of operation, the *pickup* of the phase overcurrent element is adjusted based upon the magnitude of the measured voltage. Figure 4-12 shows how the overcurrent pickup threshold setting is adjusted in response to the measured voltage level. Equation 4-1 determines the pickup level for the 51P elements when the measured voltage is between 25% and 100% of the 27R threshold setting. Below 25%, the pickup level stays at 25%. Above 100%, the pickup level stays at 100%. For example, if the 27R threshold is set for 120V and the measured voltage on the appropriate phase is 100V (83% of the 27R threshold setting), the overcurrent pickup level for that phase will be reduced to 83% of its setting. When set for this mode of operation, the 51P pickup setting is typically set above worst case, load current levels.

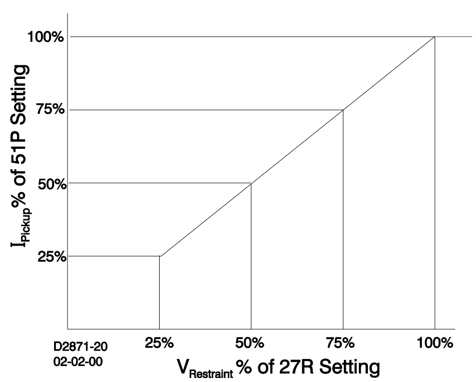

Figure 4-12. 51P Pickup Level Compensation

The 51/27R function can be set to monitor either Vpp or Vpn depending upon the VTP connection settings. See Section 3, *Input and Output Functions, Power System Inputs*, for more detail on how to set the VTP Connections. Table 4-10 shows which voltage measurements are used by each phase overcurrent element for each possible VTP connection and 51/27 voltage monitoring mode setting.

Table 4-10. VTP Connection Cross Reference

VTP Connection	51/27 Mode	51A	51B	51C
4W	Vpp	Vab	Vbc	Vca
4W	Vpn	Van	Vbn	Vcn
3W	Vpp	Vab	Vbc	Vca

VTP Connection	51/27 Mode	51A	51B	51C
AN	Vpn	Van	N/A	N/A
BN	Vpn	N/A	Vbn	N/A
CN	Vpn	N/A	N/A	Vcn
AB	Vpp	Vab	N/A	N/A
BC	Vpp	N/A	Vbc	N/A
CA	Vpp	N/A	N/A	Vca

When single-phase voltage sensing is used, only the overcurrent element on the phase with voltage magnitude information is affected by the 51/27R feature. Thus, in voltage control mode, the 51 elements on the two unmonitored phases will always be disabled. In voltage restraint mode, the 51 elements on the two unmonitored phases will not have their overcurrent pickup settings adjusted from 100%.

NOTE

For single-phase sensing, the unmonitored phase is not restrained or controlled. These phases are marked in the table by N/A (not applicable).

The VT fuse loss detection function (60FL) can also be set to supervise the 51/27R function. It is possible to set the 60FL function to automatically prevent mis-operation on loss of sensing voltage. When the 51/27R function is set for control and a 60FL condition is detected, the phase overcurrent elements will be disabled. When the 51/27R function is set for restraint and a 60FL condition is detected, the phase overcurrent elements will remain enabled but the pickup will not be adjusted from 100% of its setting. See the paragraph titled *Voltage Transformer Fuse Loss Detection*, later in this section for more information.

Operating Settings for Voltage Restraint/Control for Time Overcurrent Protection

See Figure 4-11 for setting the Time Overcurrent elements. Using the pull-down menus and buttons, make the appropriate settings to the *51P Voltage Restraint/Control* element. Table 4-11 summarizes the operating settings for Voltage Restraint/Control for Time Overcurrent.

Table 4-11. Operating Settings for Voltage Restraint/Control for Time Overcurrent Protection

Setting	Range	Increment	Unit of Measure	Default
Pickup	30 to 250, 0 = Disable	0.1 for 30 to 99, 1.0 for 100 to 250	Volts	0
Mode	C (control), R (restraint)	N/A	N/A	R

Pickup Threshold. A setting of zero disables voltage restraint/control and allows the 51P time overcurrent function to operate normally. When voltage restraint or control is desired, the pickup value can be set over a range of 30 to 250 volts. Setting curve coefficients is discussed later in this section.

Mode Setting (Mode). Two mode settings are available: Restraint and Control.

Restraint I. In Restraint mode, the 51P pickup level is reduced linearly when the sensing voltage decreases below the restraint pickup level. The 51P pickup level is determined by Equation 4-1.

$$\text{Actual Pickup Level} = \frac{\text{sensing voltage level}}{\text{restraint pickup setting}} \times \text{51P pickup setting}$$

Equation 4-1. Restraint Pickup Level

Control I. In Control Mode, pickup level is as selected by the 27R pickup setting.

Control or restraint operation can also be set by the S<g>-27R ASCII command.

Programmable Curves

Time current characteristics for trip and reset programmable curves are defined by Equation 4-2 and Equation 4-3 respectively. These equations comply with IEEE standard C37.112-1996. The curve specific coefficients are defined for the standard curves as listed in Appendix A, *Time Overcurrent Characteristic*

Curves. When time current characteristic curve P is selected, the coefficients used in the equation are those defined by the user. Definitions for these equations are provided in Table 4-12.

Equation 4-2. Time OC Characteristics for Trip

$$T_T = \frac{AD}{M^N - C} + BD + K$$

Equation 4-3. Time OC Characteristics for Reset

$$T_R = \frac{RD}{M^2 - 1}$$

Table 4-12. Definitions for Equations 4-2 and 4-3

Parameter	Description	Explanation
T_T	Time to trip	Time that the 51 function will take to time out and trip.
D	Time dial setting	Time dial setting for the 51 function.
M	Multiple of pickup	Measured current in multiples of pickup. The timing algorithm has a dynamic range of 0 to 40 times pickup.
A	Coefficient specific to selected curve	Affects the effective range of the time dial.
B	Coefficient specific to selected curve	Affects a constant term in the timing equation. Has greatest effect on curve shape at high multiples of tap.
C	Coefficient specific to selected curve	Affects the multiple of PU where the curve would approach infinity if allowed to continue below pickup. Has greatest effect on curve shape near pickup.
N	Exponent specific to selected curve	Affects how inverse the characteristics are. Has greatest effect on curve shape at low to medium multiples of tap.
K	Constant	Characteristic minimum delay term.
T_R	Time to reset	Relevant if 51 function is set for integrating reset.
R	Coefficient specific to selected curve	Affects the speed of reset when integrating reset is selected.

Setting Programmable Curves

Curve coefficients are entered using BESTCOMS. Alternately, curve coefficients can be entered using the SP-CURVE ASCII (Settings Protection-programmable curve) command. Table 4-13 lists the programmable curve settings.

Table 4-13. Programmable Time Current Characteristic Curve Coefficients

Setting	Range	Increment	Default
A Coefficient	0 to 600	0.0001	0.2663
B Coefficient	0 to 25	0.0001	0.0339
C Coefficient	0.0 to 1.0	0.0001	1.0000
N Coefficient	0.5 to 2.5	0.0001	1.2969
R Coefficient	0 to 30	0.0001	0.5000

Curve coefficients are entered by selecting the *Curve Coefficients* button on the *51* tab in the *Time Overcurrent* screen. (Refer to Figure 4-11.) The Curve Coefficients screen will appear (see Figure 4-13). Enter the calculated values for each constant and select *Done*.

Programmable curve coefficients can be entered regardless of the curve chosen for the protection element. However, the programmable curve will not be enabled until *P* is selected as the curve for the protective element.

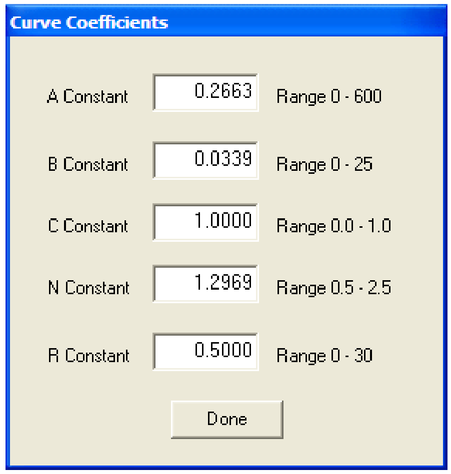

Figure 4-13. Curve Coefficients

<u>*46 Curve*</u>

The 46 curve is a special curve designed to emulate the I_2t withstand ratings of generators using what is frequently referred to as the generator's K factor. Do not confuse the 46 curve with the 46 element. The 46 curve was designed for use with the 46 function. But, in actuality, the 46 curve may be selected for use with the 51P, 51N, and 51Q protection functions as well (though in actual practice, it is doubted that this will be done very often).

To use the 46 curve, the user should determine the K factor of the generator and the continuous $(I_2)^2t$ rating of the generator (supplied by the manufacturer) and use this to set the time dial and pickup for the 46 curve by the process described in Appendix A, *Time Overcurrent Characteristic Curves*. The K factor is the time the generator can withstand 1 per unit I_2 where 1 pu is the relay setting for nominal current.

67 - Directional Overcurrent Protection

The 67 element provides directional supervision for the overcurrent tripping elements. Two reference quantities for each polarizing method are compared to establish directional signals for controlling operation of the phase, ground, and negative-sequence overcurrent elements. Directionality is derived from a comparison between internally calculated sequence voltages V1, V2, V0 (magnitude and angle) and calculated values of I1, I2, 3I0, I0, (magnitude and angle) and measured IG (magnitude and angle). Regardless of fault direction, the angle of the sequence voltages and the ground current source will always be the same while the angle of the currents (I1, I2, 3I0/IN, I0, IG operate) will change based on the direction of fault current flow.

The polarization methods are as follows:

- Positive-Sequence Polarization – Forward is when the apparent Z_1 angle (angle of V_1/I_1) is equal to the positive-sequence maximum torque angle (MTA), ±90°.
- Negative-Sequence Polarization – Forward is when the apparent Z_2 angle (angle of V_2/I_2) is equal to the positive-sequence maximum torque angle (MTA), ±90°. (See Note 1.)
- Zero-Sequence Voltage Polarization – Forward is when the apparent Z_0 angle (angle of V_0/I_0) is equal to the positive-sequence maximum torque angle (MTA), ±90°. (See Note 1.) However, the relay has two forms of zero-sequence voltage available to it (calculated V_0 from the phase voltages or V_X from a broken delta VT) and two forms of zero-sequence current available to it (calculated I_0 from the phase currents or I_G from the relay's 4th CT input). This results in 4 options for zero-sequence voltage polarization:
    - Calculated V_0 verses calculated I_0
    - Calculated V_0 verses I_G
    - V_X verses calculated I_0
    - V_X verses I_G

    All four forms of zero-sequence voltage polarizations use the same MTA value.

- Zero-Sequence Current Polarization – Forward is when the phase angle of current in the optional ground CT input (IG) is in phase with the calculated I_0, ±90°.

Each of the four internal polarization methods has designated internal bits that are used in the relay for direction identification, one for forward direction and one for reverse direction. Combined, these eight bits are referred to as the directional status byte and are used to control the various overcurrent elements.

Note 1: For those highly interested readers, the negative and zero-sequence angle of max torque has a built in 180-degree phase shift that arises out of the calculation methods described at the bottom of this section.

Positive-Sequence Polarization. This is used to determine direction for three-phase faults. Under these conditions, very little negative or zero-sequence quantities are present, making the other polarization methods unreliable for this fault condition. For close-in faults the relay will also need to depend on memory voltage to determine direction (see below). Positive-sequence bits are used to supervise only the phase over current elements.

To provide memory, the positive-sequence voltage is stored continuously until a fault occurs. Memory voltage is used when the positive-sequence voltage falls below the minimum acceptable level of 12 volts. Due to minute errors in the sample rate and variations in the power system, the memory voltage becomes less accurate over time. Conservatively, the BE1-IPS100 can maintain memory voltage accuracy to less than 5° error for approximately one second. This should be adequate, as close in faults are expected to trip in very short time intervals. When using memory voltage polarization, the relay assumes nominal system frequency.

Negative-Sequence Polarization. This is used to test directionally for all fault types except three-phase faults. Negative-sequence bits are used to supervise phase, neutral and negative-sequence over current elements. With load flow and low fault currents, it is possible for the positive-sequence bits to be set at the same time negative-sequence bits are TRUE. Under these conditions, the negative-sequence bits have priority and the positive-sequence bits are cleared.

Zero-Sequence Voltage Polarization. This is used to test directionally for ground faults and is used to supervise only the neutral overcurrent elements (V0IN, V0IG, VXIN, VXIG). The neutral overcurrent elements can be set to operate on either calculated I_0 or independent ground input I_G. The four types of zero-sequence polarization methods were described above. Typical AC connections for external sources of V_0 (a broken delta VT) are provided in Section 12, *Installation*.

Zero-Sequence Current Polarization. This is also used to test directionally for ground faults and is used to supervise the neutral overcurrent elements.

Polarization Summary for tripping elements is as follows:

- Phase Element: Positive-Sequence; Negative-Sequence
- Negative-Sequence Element: Negative-Sequence
- Neutral Element: Negative-Sequence; Zero-Sequence Volt; Zero-Sequence Current

The neutral overcurrent elements can be supervised by various polarization methods using either or both zero-sequence and negative-sequence quantities. This is necessary depending on the application and fault conditions applied to relay. For example, negative-sequence polarizing can be used when zero-sequence mutual coupling effects cause zero-sequence polarizing elements to lose directionality. Also, high Z ground faults may cause values of zero-sequence voltage too low to measure during a fault, making zero-sequence polarization unreliable. A similar condition can occur with the negative-sequence voltage or current, although it is less likely. Under these conditions a user may need to use current polarization or dual polarization to provide reliable directional tripping.

Polarization Settings for Directional Overcurrent Protection

Polarization settings are made using BESTCOMS. Figure 4-14 illustrates the BESTCOMS screen used to select operational settings for the 67N element. To open the screen, select *Overcurrent Protection* from the *Screens* pull-down menu and select the *67N Polarization* tab. Alternately, settings may be made using the S#-67N ASCII command. To the right of the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the elements settings apply to.

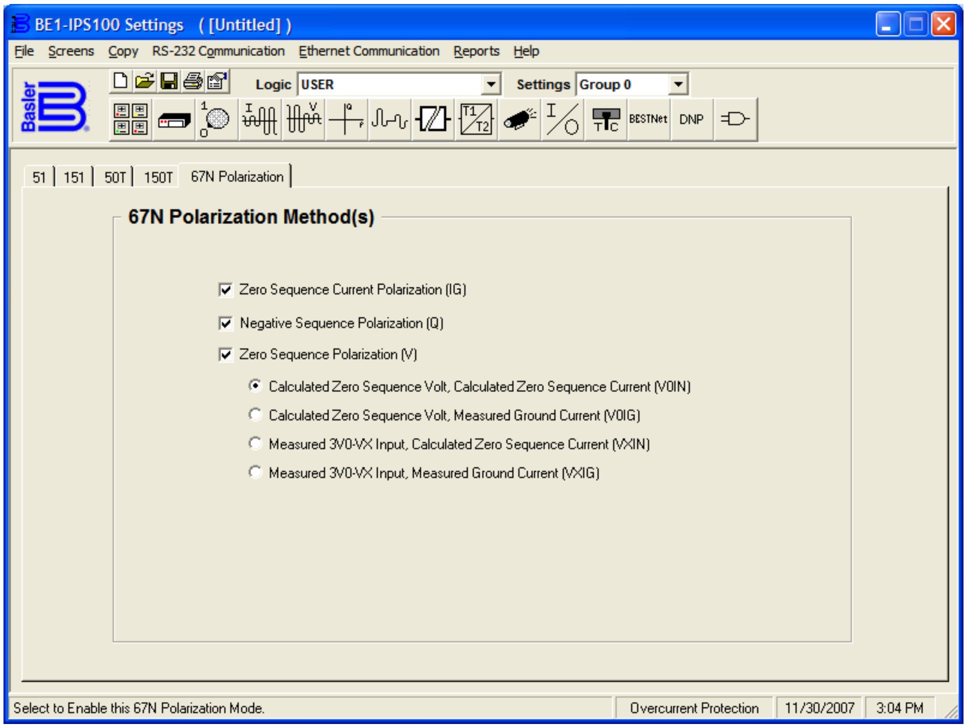

Figure 4-14. Overcurrent Protection Screen, 67N Polarization Tab

Table 4-14 summarizes the polarization settings for Directional Overcurrent Protection. In the table, Q represents negative-sequence polarization, V represents zero-sequence polarization, and I represents current polarization.

Table 4-14. Polarization Settings for Directional Overcurrent Protection

Setting	Range/Purpose		Default
Mode	QVI	= Use all three polarization methods for neutral elements.	QVI
	QV	= Use negative and zero-sequence polarization for neutral elements.	
	QI	= Use negative-sequence and current polarization for neutral elements.	
	VI	= Use zero-sequence and current polarization for neutral elements.	
	Q	= Use negative-sequence polarization for neutral elements.	
	V	= Use zero-sequence polarization for neutral elements.	
	I	= Use current polarization for neutral elements.	
Zero-Sequence Voltage Polarization Quantities	VOIN	= Calculated zero-sequence voltage is compared to calculated zero-sequence current.	VOIN
	VOIG	= Calculated zero-sequence voltage is compared to measured ground current on the independent ground CT input.	
	VXIN	= Measured 3V0 voltage on the auxiliary voltage input (VX) is compared to calculated zero-sequence current.	
	VXIG	= Measured 3V0 voltage on the auxiliary voltage input (VX) is compared to the measured ground current on the ground CT input (IG).	

Modes QVI, QV, QI, and VI are logical ORs of Modes Q, V, and I and are used to set up dual or possibly triple polarization techniques for the neutral elements. Thus, if more than one directional supervision element is enabled, any one can enable tripping if the appropriate forward or reverse directional decision is made.

Maximum Torque Angle and Directional Tests

The directional algorithm requires a user settable maximum torque angle (MTA). There is one MTA setting for positive and negative-sequence calculations, and a second setting for a zero-sequence MTA.

These settings are separate from the power line impedance parameters (used for distance to fault calculations) because some applications require a polarizing MTA different from the "distance to fault" line impedance angle. An entry for a negative-sequence MTA is not required since the relay uses the same MTA for Z2 and Z1 directional decisions.

Each MTA can be set over the range of 0 to 90 degrees (I lag E) in 0.1 degree steps. These parameters are inputted into the BE1-IPS100 using BESTCOMS *General Operation* screen, *Power System* tab, the SG-TORQ ASCII command or HMI Screens 6.3.13 and 6.3.14.

A fault current is considered to be in a forward direction when the sequence current, after being offset by the line angle, is in phase with the same sequence voltage. The forward direction zone extends for approximately ±90° from the nominal line angle. A similar argument applies for the reverse direction with the current 180° out of phase from the voltage. Z1's angle is used during positive and negative-sequence directional test. Likewise, Z0's angle is used during the zero-sequence directional test. Angle compensation is not required for current polarization since the polarizing quantity IG is inherently compensated.

Not forward does not necessarily imply reverse. Sufficient current and voltage must be present to declare direction. Internally, the BE1-IPS100 also uses several constant limits to determine if the system levels are adequate to perform reliable directional tests and set directional bits. See Table 4-15.

Table 4-15. Internal Constants

Internal Constant	Purpose	Value
Positive-Sequence Current	Minimum 3I1 current threshold for Positive-Sequence test.	0.50 A
Zero-Sequence Current	Minimum 3I0 current threshold for Current Polarization test.	0.25 A
Ground current (IG)	Minimum Ground (IG) current threshold for Current Polarization test.	0.50A
Negative-Sequence Voltage	Minimum V2 voltage threshold for Negative-Sequence test.	3.33% of V nominal
Zero-Sequence Voltage	Minimum V0 voltage threshold for Zero-Sequence test.	3.33% of V nominal
External Zero-Sequence Voltage (VX Input)	Minimum external 3V0 voltage threshold for Zero-Sequence test.	10% of V nominal
Negative-Sequence Ratio	Minimum ratio between 3I1 and 3I2 for Negative-Sequence test.	9%
Zero-Sequence Ratio	Minimum ratio between 3I1 and 3I0 for Zero-Sequence test is 9%.	9%

If the minimum levels are not met for a particular directional test, then the test is not run and the directional bits are cleared for that test. For instance, if 3I1 is less than 0.50 A, the positive-sequence test is skipped and the positive-sequence directional bits are cleared.

The Sequence Ratio refers to the minimum ratio required between the positive-sequence current and either the negative or zero-sequence current. A negative-sequence directional test would be allowed if the negative current were greater than 9% of the positive-sequence current. The same applies for the zero-sequence directional test.

The directional tests are also supervised by the loss of potential function 60FL. If the 60FL bit is TRUE, then voltage sensing was lost or is unreliable. Under this condition positive, negative and zero-sequence directional tests are disabled and their bits are cleared. Current polarization is not effected by the 60FL since it does not rely on voltage sensing.

The direction bits are updated once per ½ cycle. Under sudden current reversal conditions, depending on the change in magnitude of the forward current to reverse current, the DFT could require 1 cycle to determine polarity of the fault. Beyond this, the 50 element adds an additional ½ cycle delay when operating in direction mode for security, for an overall response time of a 50 element to sudden current reversal of approximately 2 cycles.

Theory of Using Sequence Impedances for Fault Direction

When using real world impedances in the Z_{ABC} domain, it is apparent that faulted phase voltage approaches zero as one gets closer to the fault and that the same phase's voltage becomes larger the closer one gets to the source. However, in the sequence domain (zero, positive, negative-sequence), 1) the above concept holds for positive-sequence voltage and current flow, but 2) for negative and zero-sequence current flow, the opposite condition occurs. Negative and zero-sequence voltage is highest at the fault location, and lowest at the source. This affects how the angle of maximum torque used in a 67 relay and protecting a 67 relay from operating for load flow.

For directional decisions, a relay is measuring the sequence impedance ($Z_{012}=V_{012}$ / I_{012}) and comparing the angle that it calculates to the angle of maximum torque with a window of ±90 degrees as forward (or reverse, depending on the relay setup). Suppose a radial single source condition exists relative to the relay location. The source impedance is Z_{Source} and the fault is downstream on a line of impedance Z_{Line}. Given a source voltage of V_{Source} and a fault current of I_{Relay} the local substation voltage will be shown in Equation 4-4.

$$\begin{bmatrix} V_{0,Relay} \\ V_{1,Relay} \\ V_{2,Relay} \end{bmatrix} = \begin{bmatrix} V_{0,Source} \\ V_{1,Source} \\ V_{2,Source} \end{bmatrix} - \begin{bmatrix} Z_{0,Source} & 0 & 0 \\ 0 & Z_{1,Source} & 0 \\ 0 & 0 & Z_{2,Source} \end{bmatrix} \begin{bmatrix} I_{0,Relay} \\ I_{1,Relay} \\ I_{2,Relay} \end{bmatrix}$$

Equation 4-4. Local Substation Voltage

Note this equation is true independent of the fault type or the faulted phase. For any fault type or faulted phase we will find some value for I_{012} and then whatever we find, we insert it into the equation above. Independent of however I_{012} works out, solving the above equation for impedance seen by the relay:

$$\begin{aligned} Z_{0,Relay} &= \frac{V_{0,Relay}}{I_{0,Relay}} = \frac{V_{0,Source}}{I_{0,Relay}} - Z_{0,Source} \\ Z_{1,Relay} &= \frac{V_{1,Relay}}{I_{1,Relay}} = \frac{V_{1,Source}}{I_{1,Relay}} - Z_{1,Source} \\ Z_{2,Relay} &= \frac{V_{2,Relay}}{I_{2,Relay}} = \frac{V_{2,Source}}{I_{2,Relay}} - Z_{2,Source} \end{aligned}$$

Equation 4-5. Impedance Seen by the Relay

If $V_{0,Source}$ and $V_{2,Source}$ are very small:

$$\begin{aligned} Z_{0,Relay} &\approx -Z_{0,Source} \\ Z_{2,Relay} &\approx -Z_{2,Source} \end{aligned}$$

Equation 4-6. Impedance with Small V_0 and V_2 Source Voltages

The calculations in the relay are aware of the negative factor in the above equation and hence a 180°-phase shift is buried in the equations inside the relay code so that a correct forward/reverse decision is made.

The positive-sequence impedance as seen by the relay is quite a bit more complicated since $V_{1,Source}$ is not negligible. One simple application to study is the three-phase fault and the B to C phase fault:

$$Z_{1,Relay,3phase} = \frac{V_{1,Source}}{\frac{V_{1,Source}}{Z_{1,Source} + Z_{1,Line}}} - Z_{1,Source} = Z_{1,Line}$$

$$Z_{1,Relay,BC} = \frac{V_{1,Source}}{\frac{V_{1,Source}}{Z_{1,Source} + Z_{1,Line} + Z_{2,Source} + Z_{2,Line}}} - Z_{1,Source} = Z_{1,Line} + Z_{2,Source} + Z_{2,Line}$$

Equation 4-7. Three-Phase/B to C-Phase Faults

Directional relaying of course, would not be of much value in a radial system, where all current flow will be forward. In two source systems, as shown in Figure 4-15, a profile of sequence voltages in the system will show V_0 and V_2 at either source will still be negligible in normal operation, and V_0 and V_2 only show up during fault conditions with their maximum value being at the fault location, with current flowing from X and Y in a current division rule applied to the symmetrical component network that represents the fault impedances and the fault type. Independent of the fault type and how the sequence currents divide in the system, the sequence voltages and hence sequence impedances measured by the relay will still be dependent on $V_{Relay}=V_{Source}$ - Z_{Source} I_{Source}. The relay will sense the zero and negative-sequence impedances in the opposite direction as the direction to the fault, looking back toward the source. But for the three-phase fault the relay will sense the positive-sequence impedance in the line between the relay and the fault location. The sensed zero-sequence current can be shifted notably when zero-sequence coupling between adjacent lines is involved. But since a large phase angle window of ±90° from the MTA is being utilized for directional decisions, the direction decision is not highly sensitive to zero-sequence coupling effects.

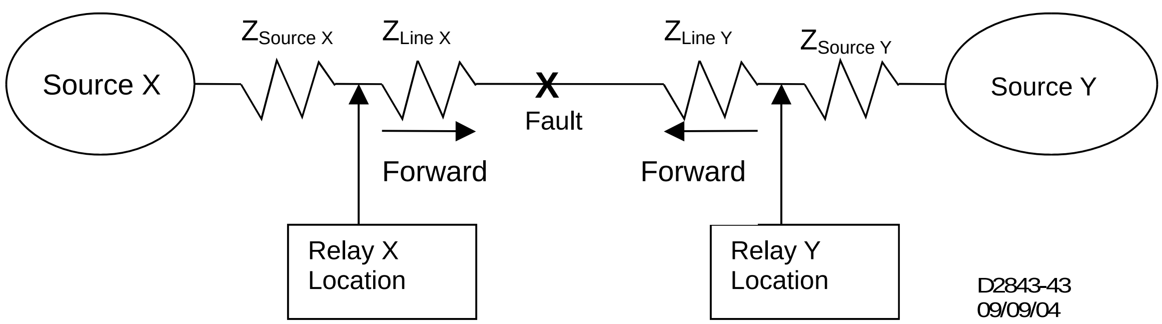

Figure 4-15. Directional Overcurrent Relaying

For more theory and mathematics of using sequence components for sensing direction to fault, see the paper, "*Directional Overcurrent Relaying in the DG Environment*" on the Basler Electric Web site (www.basler.com).

Negative-Sequence Overcurrent Protection

For years, protection engineers have enjoyed increased sensitivity to phase-to-ground unbalances with the application of ground relays. Ground relays can be set more sensitively than phase relays because a balanced load has no ground (3_{I0}) current component. The negative-sequence elements can provide similar increased sensitivity to phase-to-phase faults because a balanced load has no negative-sequence (I_2) current component.

<u>*Negative-Sequence Pickup Settings*</u>

A typical setting for the negative-sequence elements might be one-half the phase pickup setting in order to achieve equal sensitivity to phase-to-phase faults as three-phase faults. This number comes from the fact that the magnitude of the current for a phase-to-phase fault is √3/2 (87%) of the three-phase fault at the same location. This is illustrated in Figure 4-17.

The phase-to-phase fault is made up of both positive and negative-sequence components as shown in Figure 4-16 or a phase-to-phase fault, the magnitude of the negative-sequence component is 1/ 3 (58%) of the magnitude of the total phase current. When these two factors (√3/2 and 1/√3) are combined, the √3 factors cancel which leaves the one-half factor.

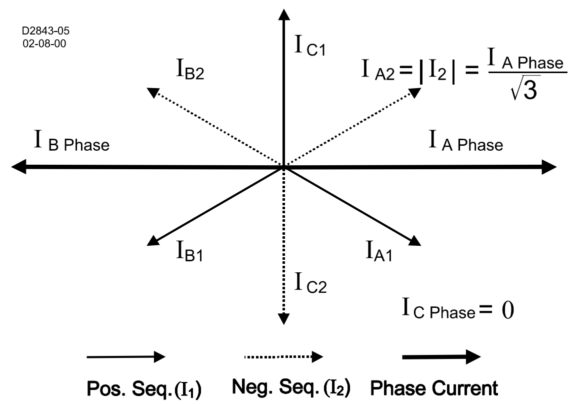

Figure 4-16. Sequence Components for an A-B Fault

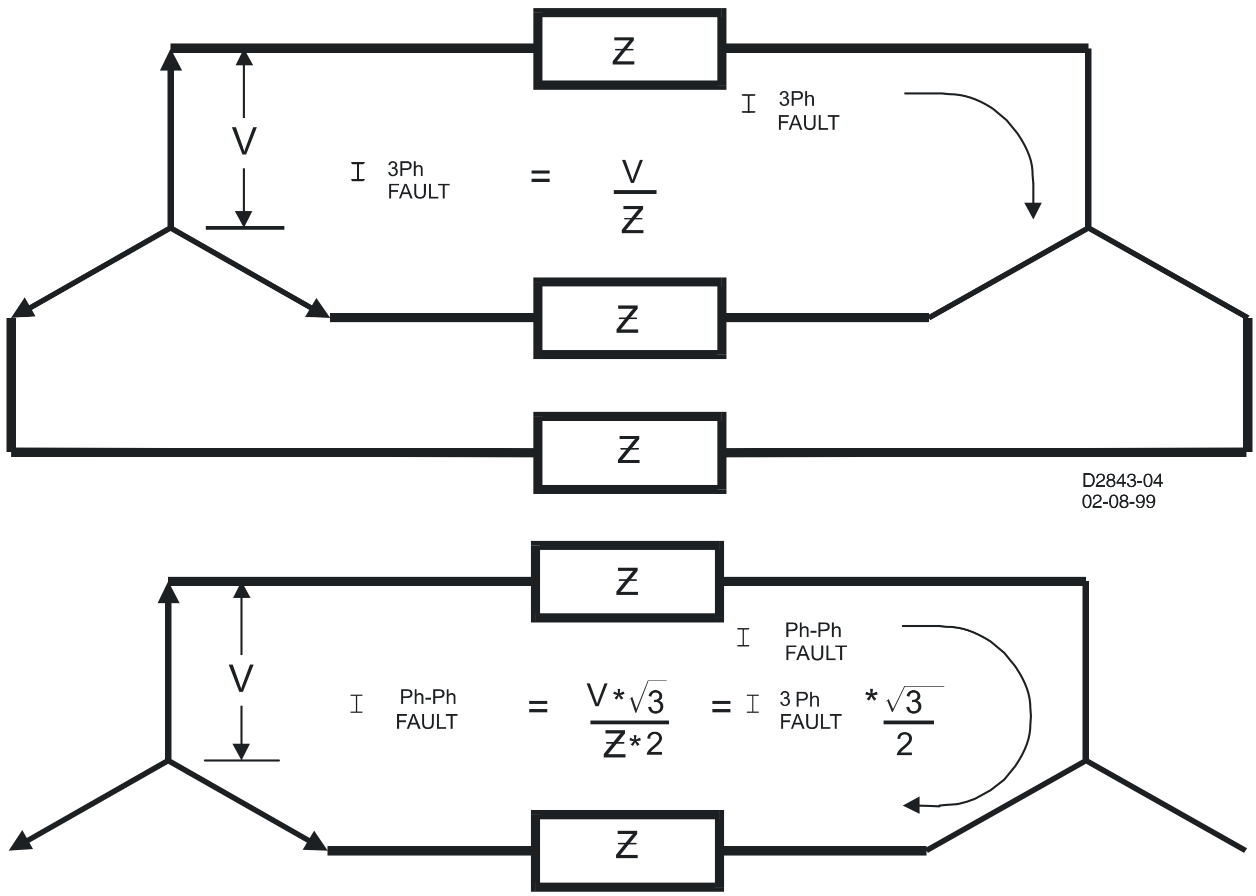

Figure 4-17. Phase-to-Phase Fault Magnitude

<u>*Negative-Sequence Coordination Settings*</u>

The 51Q settings should be checked for coordination with phase-only sensing devices such as downstream fuses and reclosers and/or ground relays. To plot the negative-sequence time current characteristics on the same plot for the phase devices, you need to multiply the negative-sequence element pickup value by the correct multiplier. The multiplier is the ratio of phase current to negative-sequence current for the fault type for which you are interested. To plot the negative-sequence time current characteristics on the same plot for the ground devices, you need to multiply the pickup value by the multiplier for phase-to-ground faults (see Table 4-16).

Table 4-16. Fault Type Multipliers

Fault Type	Multiplier
Ph-Ph	m = 1.732
Ph-Ph-G	m > 1.732
Ph-G	m = 3
3-phase	m = infinity

For example, a downstream phase 51 element has a pickup of 150 amperes. The upstream 51Q element has a pickup of 200 amperes. To check the coordination between these two elements for a phase-to-phase fault, the phase overcurrent element would be plotted normally with pickup at 150 amperes. The 51Q element would be shifted to the right by the appropriate factor m. Thus, the characteristic would be plotted on the coordination graph with pickup at: (200 amperes) ∗ 1.732 = 346 amperes.

Generally, for coordination with downstream phase overcurrent devices, phase-to-phase faults are the most critical to consider. All other fault types result in an equal or greater shift of the time current characteristic curve to the right on the plot.

Delta/Wye Transformer Application

Often, the phase relays on the delta side of a delta/wye transformer must provide backup protection for faults on the wye side. For faults not involving ground, this is not a problem since the phase relays will see 1.0 per unit fault current for three-phase faults and 2/√3 (1.15) per unit fault current for phase-to-phase faults. However, for faults involving ground, the sensitivity is reduced because the zero-sequence components are trapped in the delta not seen by the delta-side phase relays. The phase relays will see only 1/√3 (0.577) per unit current for phase-to-ground faults.

Negative-sequence overcurrent protection is immune to the effect caused by the zero-sequence trap and 30 degrees phase shift provided by the delta/wye transformer. For a phase-to-ground fault, the magnitude of the negative-sequence components is 1/3 the magnitude of the total fault current. On a per unit basis, this is true for the fault current on the delta side of the transformer as well. (The previous statement specifies per unit since the actual magnitudes will be adjusted by the inverse of the voltage ratio of the delta/wye transformer.) Thus, backup protection for phase-to-ground faults on the wye side of the transformer can be obtained by using negative-sequence overcurrent protection on the delta side with the pickup sensitivity set at 1/3 per unit of the magnitude of the phase-to-ground fault for which you wish to have backup protection.

Generator Application

Generators have a maximum continuous rating for negative-sequence current. This is typically given in terms of percent of stator rating. When using the 46 time current characteristic curve, the user should convert the I_2 rating data to actual secondary current at the relay. This value, plus some margin (if appropriate), should then be entered into the pickup setting. For example, generator ratings of 5 A of full-load current (at the relay terminals) and 10 percent continuous I_2, converts to 0.50 A. Therefore, the minimum pickup setting for the 46 curve should be set at a value below 0.50 A. Continuous I_2 ratings for generators are typically in the range of 3 to 15 percent of their full-load current rating.

POWER PROTECTION

32 - Directional Power Protection

There are two elements: 32 and 132. Figure 4-18 illustrates the inputs and outputs of the 32 directional power element. Element operation is described in the following paragraphs.

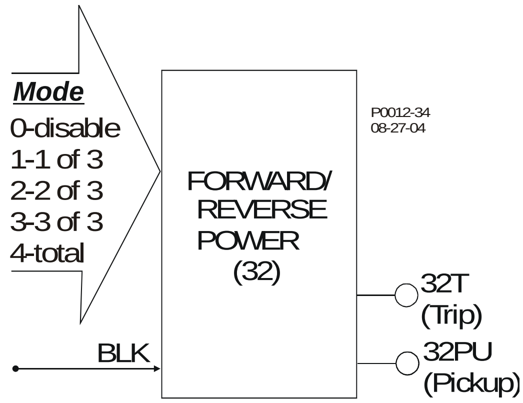

Figure 4-18. Directional Power Logic Block

The directional power element has two outputs: *32T* (Trip) and *32PU* (Pickup). When monitored power flow increases above or decreases below the pickup setting in the set direction (forward or reverse), the pickup element becomes TRUE and the function begins timing toward a trip. The trip output becomes TRUE when the element timer times out.

The *BLK* (Block) input is used to disable the 32 function. A BESTlogic expression defines how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timer to zero. This feature functions in a similar way to the torque control contact of an electromechanical relay.

The 32 and 132 elements are enabled or disabled by the *Mode* setting (see the Mode in Figure 4-18). Selecting Mode 0 disables the element and Modes 1 through 4 enable the element. Modes 1 though 3 are incremental power settings while Mode 4 is total power. In Mode 4, if total power is above or below pickup, and in the set direction, the element will pick up. In Modes 1, 2, or 3, a single-phase power pickup value is automatically calculated based on the three-phase power setting. If the single-phase power is above or below the calculated pickup value (1 of 3, 2 of 3, or 3 of 3) and in the set direction, the element will pick up. The element will remain in the picked-up condition until power flow falls below the dropout ratio of 95% of setting.

To further clarify the difference between Mode 3 (3 of 3) and Mode 4 (Total Power), assume that Mode 3 has been selected and the three-phase pickup setting is 30 watts. Therefore, the relay will pickup when **each** phase exceeds 10 watts (3-phase setting/3). Alternately, if two phases are 0 watts and the third phase is 50 watts, the relay **will not** pickup because two of the phases have not exceeded the single phase pickup threshold required for 3 of 3 operation. All three phases must exceed the single-phase pickup threshold for operation to occur. However, if the relay were set for Mode 4, the same power values previously mentioned would result in a pickup condition because "Total Power" (0 + 0 + 50 watts) exceeds the 3-phase pickup setting of 30 watts. For details on power calculations, refer to Section 3, *Input and Output Functions, Power System Inputs*.

In addition to exceeding the power pickup threshold, **direction** of power flow (Forward or Reverse) must match the directional setting to get a 32 or 132 operation. In the BE1-IPS100, the Forward and Reverse directions are defined by the polarity voltage and current connections to the relay as shown in Figure 4-19. Based on IEEE polarity convention, Forward Power is defined as Bus to Line and Reverse Power is defined as Line to Bus.

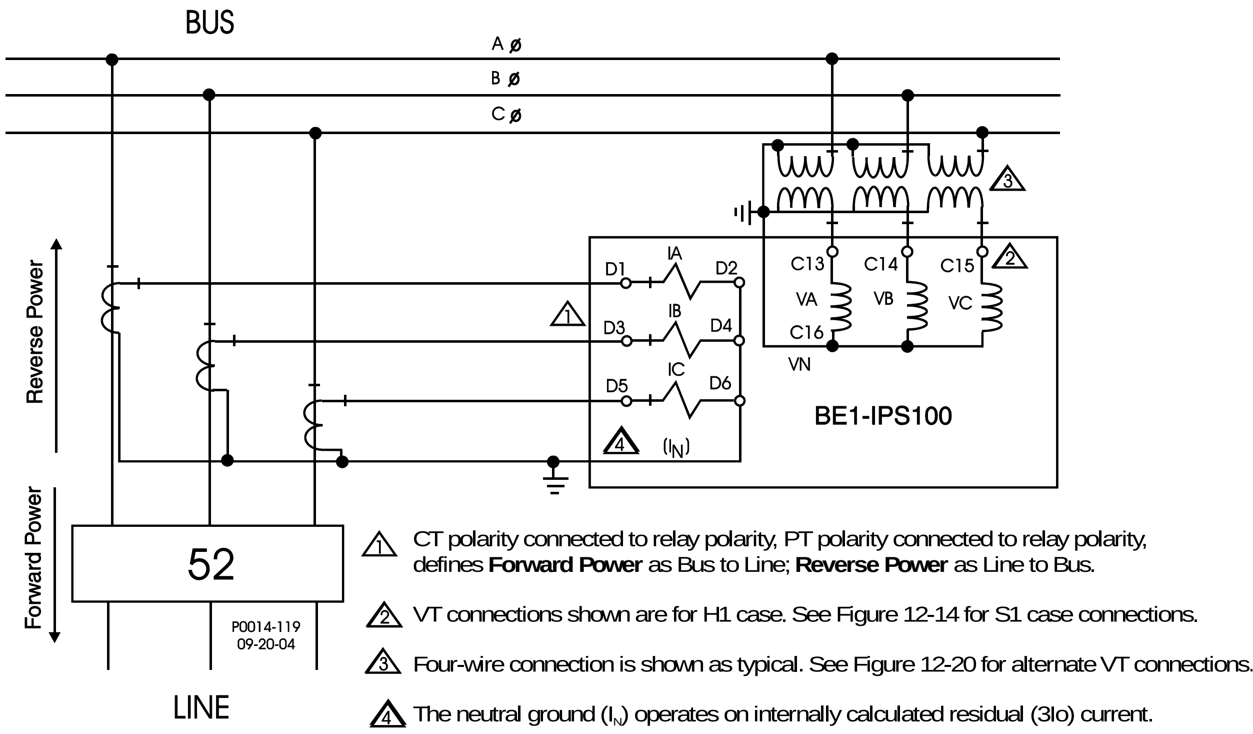

Figure 4-19. Reference for Forward and Reverse Directional Power

If the target is enabled for the element, the target reporting function will record a target when the protective function trip output is TRUE and the fault recording function trip logic expression is TRUE. Modes 1, 2, and 3, targets will be single phase (32A, 32B, 32C). Mode 4, Total Power, will target as 32ABC. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting.

Establishing Forward and Reverse Pickup Values

Three-phase power pickup settings for the 32 and 132 directional power elements are always positive regardless of directional setting. However, it is useful in understanding the element response to visualize the forward direction as positive power and the reverse direction as negative power, again, based on the connections shown in Figure 4-19. If we think in terms of a forward and reverse scale with zero in the middle as shown in Figure 4-20, positive and negative power flows relative to the forward and reverse directional setting. For example, assume an intertie application where the Area EPS (electric utility) requires the Local EPS (source of non-utility generation) to separate from the Area EPS (trip the intertie breaker) if **any** power flows towards the Area EPS. For illustrative purposes, assume that the BUS in Figure 4-19 is the Local EPS, 52 is the intertie breaker, and LINE is the Area EPS. Normal power flow is from the Area EPS to the Local EPS, which happens to be an industrial facility with local generation used for peak shaving.

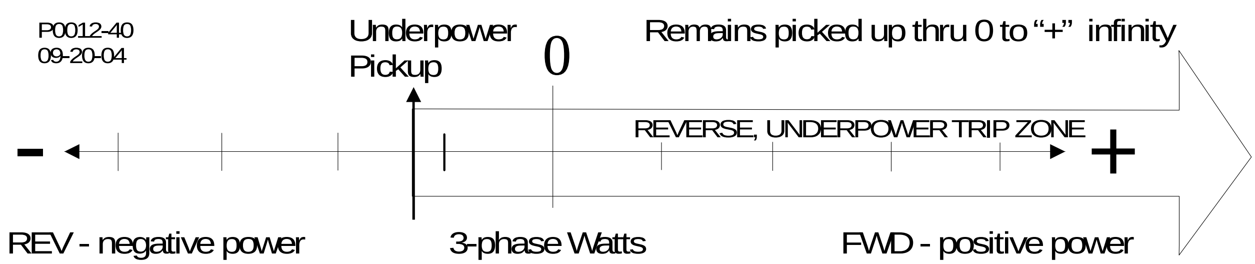

Figure 4-20. Forward and Reverse Pickup Values

Assuming polarity current and voltage connections as shown in Figure 4-19, forward power is defined as **into** the Area EPS and reverse power is defined as **into** the Local EPS. For this application, the 32 element should be set to trip for minimum underpower in the reverse direction (to the Local EPS). Therefore, the settings would be REV, Under and 1 watt 3-phase. To increase sensitivity, Mode selection should be "3 of 3" which requires each phase power to fall below 1/3 the 3-phase power setting or 0.33 watts. Assume that normal power absorbed by the load is 4 KW in the reverse or negative direction on our scale. If load is suddenly lost at the industrial plant while the peak shaving generation is running, power may, depending on the load to generation ratio, try to flow towards the Area EPS. What was a negative 4 kW passes through 0 watts on its way to some positive power level. But, in doing so, passes through the negative underpower trip threshold of REV, Under, 0.33 watts/phase, resulting in a 32 trip and opening of the intertie circuit breaker. From negative 0.33 to positive infinity, the 32 element remains in a picked up condition as shown in Figure 4-20. It is also a good idea to include some trip time delay to make sure the 32 element does not operate for a transient power condition.

BESTlogic Settings for Directional Power Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-21 illustrates the BESTCOMS screen used to select BESTlogic settings for the Directional Power element. To open the *BESTlogic Function Element* screen for *Directional Power*, select *Power Protection* from the *Screens* pull-down menu. Then select the *BESTlogic* button for the desired element. Alternately, settings may be made using SL-32 and SL-132 ASCII commands.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the BESTlogic function by selecting its mode of operation from the *Mode* pull-down menu. To connect the function/elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

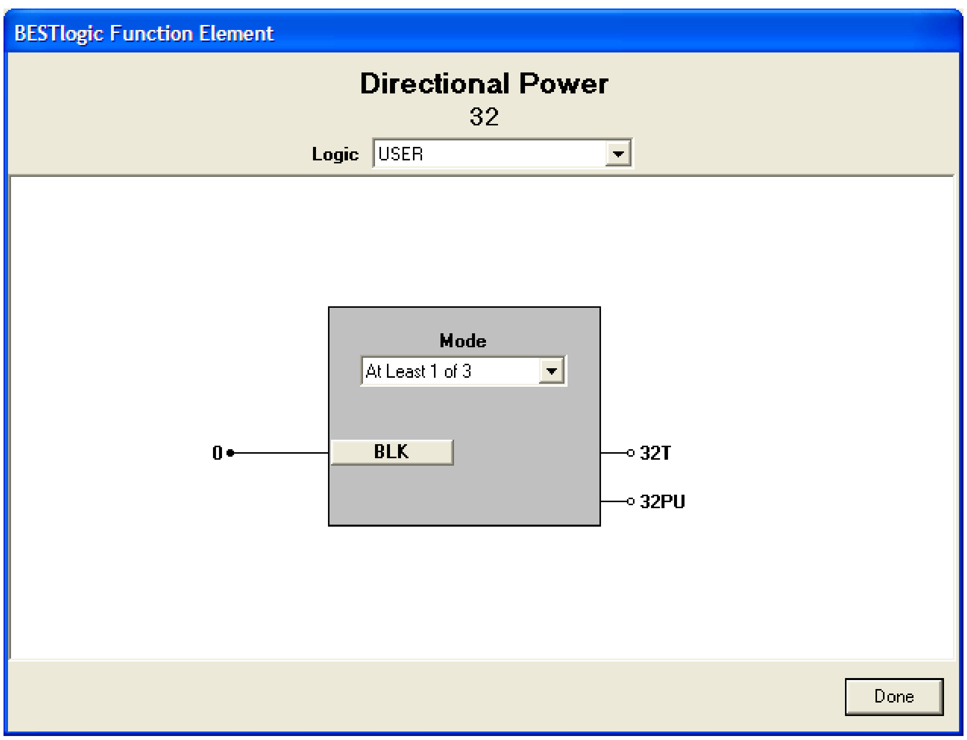

Figure 4-21. BESTlogic Function Element Screen, 32

Table 4-17 summarizes the BESTlogic settings for Directional Power Protection.

Table 4-17. BESTlogic Settings for Directional Power Protection

Function	Range/Purpose	Default
Mode	0 = Disable 1 = 1 of 3 2 = 2 of 3 3 = 3 of 3 4 = Total Power	4
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following BESTlogic settings to the directional power element. Refer to Figure 4-21.

Mode: At least 1 of 3

BLK: 0

<u>*Operating Settings for Directional Power*</u>

Operating settings are made using BESTCOMS. Figure 4-22 illustrates the BESTCOMS screen used to select operational settings for the directional power element. To open the *BESTlogic Function Element* screen for *Directional Power*, select *Power Protection* from the *Screens* pull-down menu. Alternately, settings may be made using S<g>-32 and S<g>-132 ASCII commands where g equals the setting group number or through HMI Screens 5.x.4.1 and 5.x.4.2 where x equals 1 (Setting Group 0) or 2 (Setting Group 1).

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the elements settings apply to.

The default unit of measure for the *Pickup* setting is secondary 3ϕ watts (Sec. 3ϕ Watts). Primary 3ϕ watts (Pri 3ϕ Watts), per unit 3ϕ watts (Per U 3ϕ Watts), and percent 3ϕ watts (% 3ϕ Watts) can also be selected as the pickup setting unit of measure. The unit of measure for the *Time* setting that represents the element's time delay defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

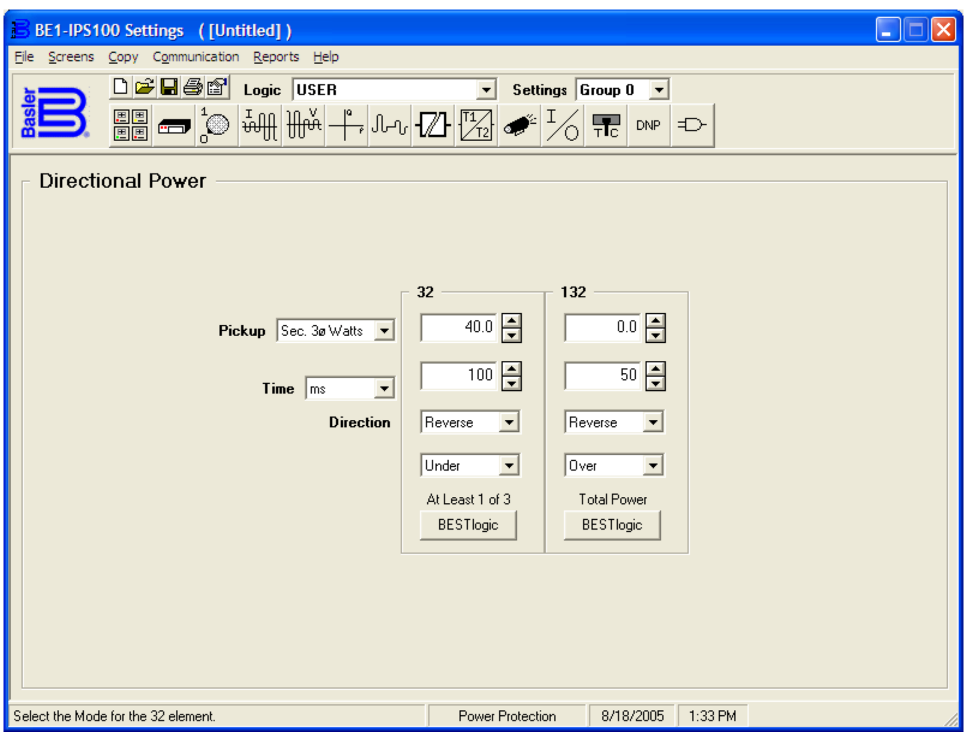

Figure 4-22. Power Protection (Directional Power) Screen

Using the pull-down menus and buttons, make the application appropriate settings to the directional power element. Table 4-18 summarizes the operating settings for Directional Power Protection.

Table 4-18. Operating Settings for Directional Power Protection

Setting	Range	Increment	Unit of Measure	Default
PU (pickup)	0 = Disabled 1 to 6000	0.1 / 1	Secondary Watts	0
TD (time delay)	0 to 999 milliseconds	1	Milliseconds	0
	0.0 to 600 seconds	0.1 for 0.1 to 9.9	Seconds	
		1.0 for 10 to 600	Seconds	
	3 to 36,000 cycles (60 Hz)	∗	Cycles	
	2.5 to 30,000 cycles (50 Hz)			
Mode	F = Forward R = Reverse	N/A	N/A	R
Power	Over, Under	N/A	N/A	Over

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

Example 1. Make the following operational settings to the 32 element. Refer to Figure 4-22.

Pickup: 40 secondary 3ϕ watts
Time: 100 ms
Direction: Reverse
Power: Under

Retrieving Directional Power Protection Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

VOLTAGE PROTECTION

BE1-IPS100 voltage protection includes elements for overexcitation, phase & auxiliary undervoltage, phase & auxiliary overvoltage, and negative-sequence overvoltage.

24 - Overexcitation Protection

Overexcitation occurs when a generator or transformer magnetic core becomes saturated. When this happens, stray flux is induced in non-laminated components, causing overheating. The BE1-IPS100 detects overexcitation conditions with a volts/hertz element that consists of one alarm setting, one integrating time characteristic with selectable exponents (3 sets of time curves), and two definite-time characteristics. This allows the user to individually select an inverse-time characteristic, a composite characteristic with inverse-time, and one or two definite-time elements, or a dual-level, definite-time element. The volts/hertz element has two outputs: *pickup* and *trip* as shown in Figure 4-23.

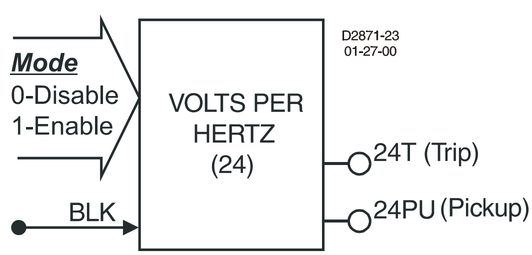

Figure 4-23. Volts per Hertz Overexcitation Logic Block

The integrating time characteristic closely approximates the heating characteristic of the protected equipment as overexcitation increases. A linear reset characteristic provides for the decreasing (cooling) condition.

The 24 element is enabled or disabled by the *Mode* input. Two modes are available. Selecting Mode 0 disables protection; Mode 1 enables the 24 element.

The *BLK* (Block) input is used to disable protection. A BESTlogic expression defines how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timers. This feature functions in a similar way to the torque control contact of an electromechanical relay.

Theory of Operation for Overexcitation Protection

V/Hz protection responds to the magnitude of voltage versus frequency where the measured voltage is phase-phase and includes the phase with the frequency measurement element. If monitored V/Hz is above a pickup setting, the pickup bit is asserted and integrating and/or definite time timers start timing towards trip. The trip output becomes TRUE when the first timer times out (integrating or definite time characteristic). If monitored V/Hz is above both the integrating and definite time pickup thresholds, the definite time delay has priority over the integrating time characteristic.

The pickup settings determine the V/Hz pickup level. The measured V/Hz is always calculated as the measured voltage divided by the sensed system frequency. The measured phase depends on the sensing voltage setting, SG-VTP. The 24 function monitors VAB for both 3-wire and 4-wire connections. Thus, setting is in VPP/Hz for VT connection = 3W, 4W, AB, BC, CA and VPN/Hz for VT connection = AN, BN, CN. For more information, refer to Section 3, *Input and Output Functions*.

Nominal voltage for the BE1-IPS100 is defined as a phase to neutral quantity. (Refer to Section 3, *Input and Output Functions*, for details). Nominal V/Hz depends on the sensing voltage (VT) connection, nominal voltage, and nominal frequency settings. Nominal V/Hz is calculated as the nominal voltage divided by nominal frequency. For VT connections equal to 3W, 4W, AB, BC, CA, the nominal voltage (phase-neutral value) must be converted to a phase-phase value by multiplying by the square root of 3. No additional conversion is required for VT connections equal to AN, BN, or CN.

For 3W, 4W, AB, BC, or CA phase to phase sensing connections:

$$\mathrm{V/Hz}_{\mathrm{Measured}} = \frac{\text{Measured V}_{\text{Phase-Phase}}}{\text{Measured Frequency}} \qquad \mathrm{V/Hz}_{\mathrm{Nominal}} = \frac{\mathrm{V}_{\mathrm{Nominal}} * \sqrt{3}}{\text{Nominal Frequency}}$$

Equation 4-8. Calculate V/Hz for 3W, 4W, AB, BC, or CA Connections

For AN, BN, or CN phase to neutral sensing connections:

$$\mathrm{V/Hz}_{\mathrm{Measured}} = \frac{\text{Measured V}_{\text{Phase-Neutral}}}{\text{Measured Frequency}} \qquad \mathrm{V/Hz}_{\mathrm{Nominal}} = \frac{\mathrm{V}_{\mathrm{Nominal}}}{\text{Nominal Frequency}}$$

Equation 4-9. Calculate V/Hz for AN, BN, or CN Connections

Equations 4-10 and 4-11 represent the trip time and reset time for a constant V/Hz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range. If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation 4-10 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

$$T_T = \frac{\mathrm{D_T}}{\left[\dfrac{\mathrm{V/Hz}_{\mathrm{Measured}}}{\mathrm{V/Hz}_{\mathrm{Nominal}}} - 1\right]^n}$$

Equation 4-10. Time to Trip

$$T_R = D_R * \frac{E_T}{FST} * 100$$

Equation 4-11. Time to Reset

where:

T_T = Time to trip

T_R = Time to reset

D_T = Time dial trip

D_R = Time dial, reset

E_T = Elapsed time

n = Curve exponent (0.5, 1, 2)

FST = Full scale trip time (T_T)

E_T/FST = Fraction of total travel toward trip that integration had progressed to. (After a trip, this value will be equal to one.)

When the measured V/Hz rises above a pickup threshold, the pickup element becomes TRUE and an integrating or definite time timer starts. If the V/Hz remains above the pickup threshold and the integration continues for the required time interval as defined by the equations shown above and the set time dial, the trip output becomes TRUE. But if the measured V/Hz condition falls below the pickup setting and integrating reset is chosen, the integrating trip timer will ramp down towards reset at a linear rate based on the reset time dial setting. See Appendix D, *Overexcitation (24) Inverse Time Curves*, for details on each of the available time curves.

If the target is enabled for the 24 element, the target reporting function will record a target when the trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting.

BESTlogic Settings for Overexcitation Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-24 illustrates the BESTCOMS screen used to select BESTlogic settings for the Overexcitation (24) element. To open the *BESTlogic Function Element* screen for *Overexcitation (24),* select *Voltage Protection* from the *Screens* pull-down menu and select the *24* tab. Then, select the *BESTlogic* button. Alternately, settings may be made using SL-24 ASCII command.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the BESTlogic function by selecting its mode of operation from the *Mode* pull-down menu. To connect the function/elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

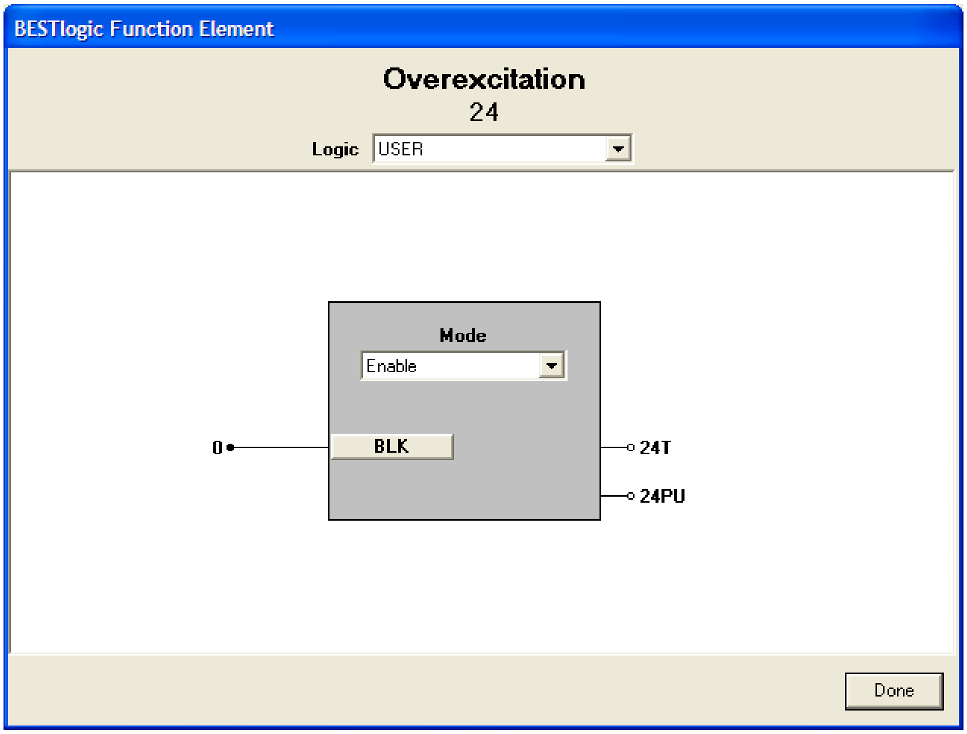

Figure 4-24. BESTlogic Function Element Screen, 24

Table 4-19 lists the BESTlogic settings for Overexcitation Protection.

Table 4-19. BESTlogic Settings for Overexcitation Protection

Function	Range/Purpose	Default
Mode	0 = Disable 1 = Enable	1
BLK	Logic expression that disables the function when TRUE.	0

Operating Settings for Overexcitation Protection

Operating settings for the 24 function consist of a pickup setting, a trip time dial, and a reset time dial. A pickup of 0 disables the element. The unit of measure is secondary VPP/Hz or VPN/Hz and depends on the SG-VTP setting. For more information, refer to Section 3, *Input and Output Functions, Power System Inputs*. Operating settings are made using BESTCOMS. Figure 4-25 illustrates the BESTCOMS screen used to select operational settings for the *Volts Per Hertz* element. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and select the *24* Tab. Alternately, settings can be made using the S<g>-24 and S<g>-24D commands or at the front panel HMI using Screen 5.x.1.1 where x equals 1 or 2, for Setting Group 0 or 1.

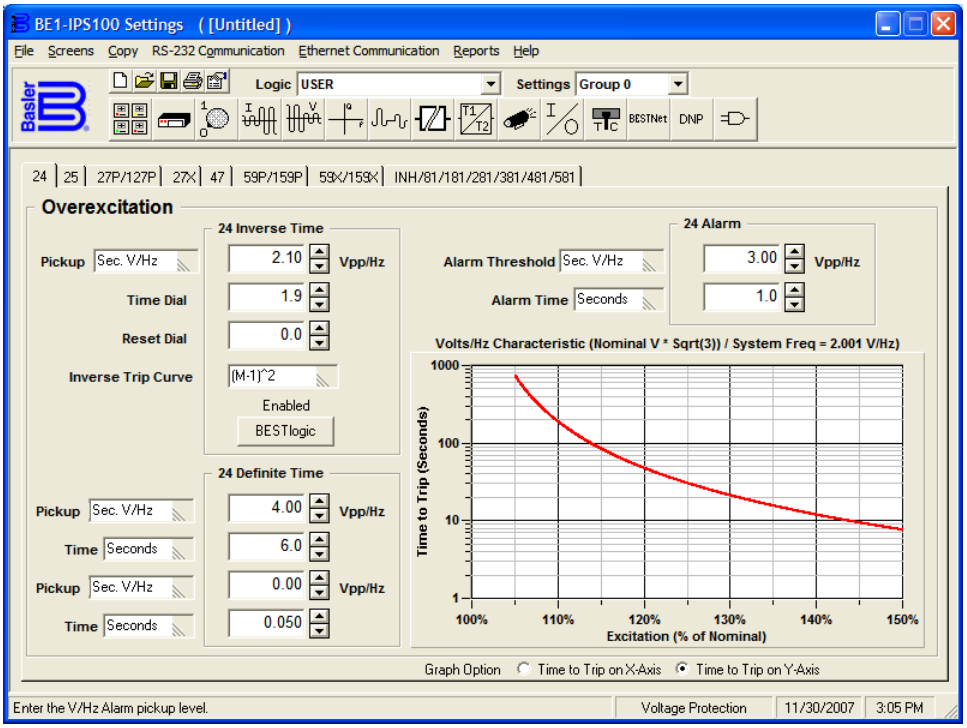

Figure 4-25. Voltage Protection Screen, 24 Tab

Table 4-20 lists the operating settings for Overexcitation Protection.

Table 4-20. Operating Settings for Overexcitation Protection

Setting	Range	Increment	Unit of Measure	Default
Integrating Pickup	0.5 to 6	0.1	Sec. V/Hz	0
Trip Time Dial	0 to 9.9	0.1	N/A	0
Reset Time Dial	0 to 9.9	0.1	N/A	0
Inverse Trip Curve	0.5, 1.0, 2.0	N/A	N/A	(M-1)^2
Definite Time Pickup #1	0.5 to 6	0.1	Sec. V/Hz	0
Definite Time Delay #1	0.050 to 600	3 digit resolution	Seconds	50 ms
Definite Time Pickup #2	0.5 to 6	0.1	Sec. V/Hz	0
Definite Time Delay #2	0.050 to 600	3 digit resolution	Seconds	50 ms

Programmable Alarm for Overexcitation Protection

A separate V/Hz alarm threshold and user adjustable time delay are included for indicating when overexcitation is occurring so that the operator can take corrective action before the 24 function trips. If the V/Hz level exceeds the alarm setting, a programmable alarm bit is set. See Section 6, *Reporting and Alarm Functions*, for more information. Settings for the alarm are made using BESTCOMS (Figure 4-25). Alternately, settings can be made with the SA-24 ASCII command. Table 4-21 lists the programmable alarm settings for Volts per Hertz Overexcitation. V/Hz alarm settings cannot be set through the HMI.

Table 4-21. Programmable Alarm Settings for Overexcitation Protection

Setting	Range	Increment	Unit of Measure	Default
Alarm Level	0.5 to 6	0.1	Sec. V/Hz	0
Alarm Time Delay	0.050 to 600	3 digit resolution	Seconds	0

<u>Settings Example for Volts per Hertz Overexcitation</u>

V/Hz tripping elements are used to de-energize a generator or transformer that is experiencing an overexcitation condition. Therefore, the manufacturer's overexcitation limit curves are required to establish optimum protection. Figures 4-26 and 4-27 show examples of a transformer and generator limit curve along with the optimum composite protection characteristic.

NOTE

Actual damage curves must be obtained from the equipment manufacturer for particular equipment to be protected.

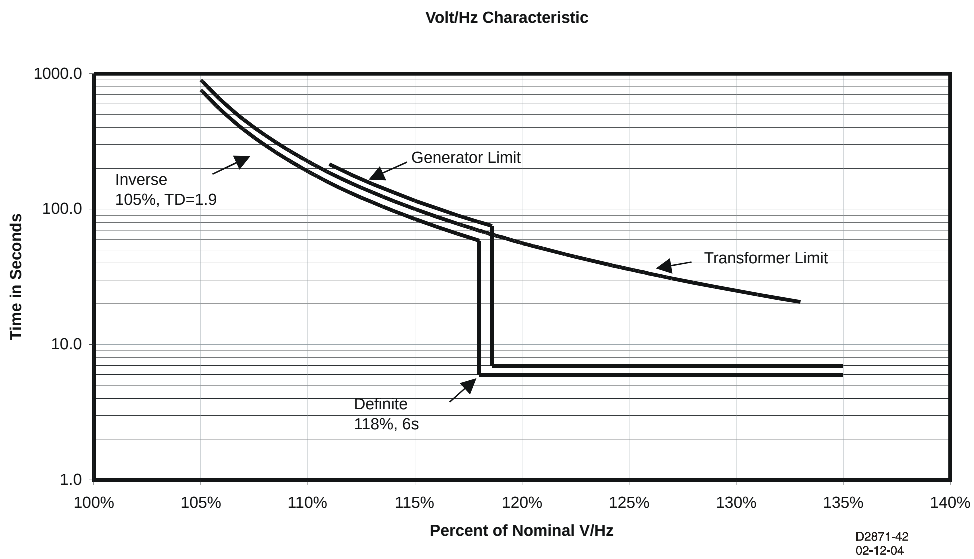

Figure 4-26. Time Shown on Vertical Axis

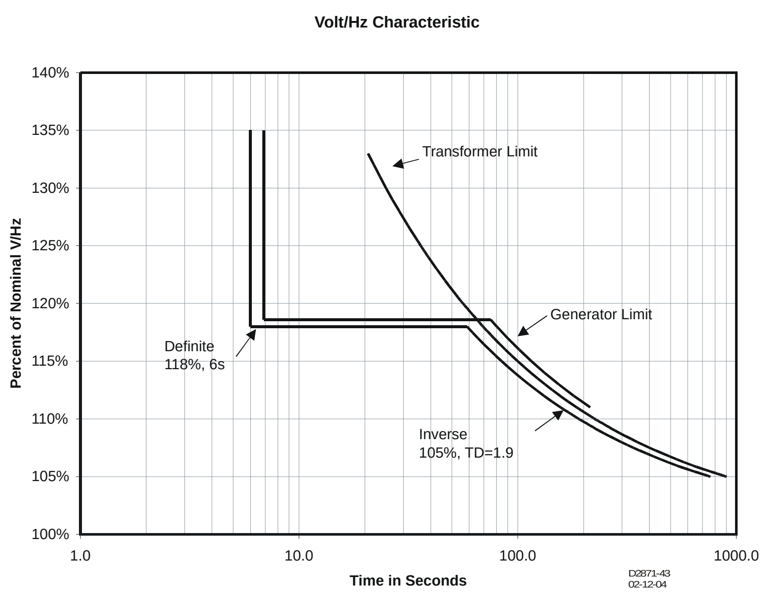

Figure 4-27. Time Shown on Horizontal Axis

Assuming a Vnom of 69.3 volts phase-neutral, 1 pu volts/hertz = (69.3 * √3) / 60 = 2.00. Using IEEE/C37.102, "*Guide for AC Generator Protection*" as a guide for setting overexcitation protection, the following example demonstrates how to set the BE1-IPS100 to provide a composite V/Hz characteristic for protection of a generator and a step-up transformer:

- Alarm = 105% @ 1 second time delay; V/Hz = 2 * 1.05 = 2.10
- Inverse time pickup = 105%; Time Dial = 1.9; Inverse Trip Curve = (M-1)^2; V/Hz = 2 * 1.05 = 2.10
- Definite Time #1 = 118% @ 6 seconds time delay; V/Hz = 1.18 * 2.0 = 2.36

In BESTCOMS, the 24 graphing capability can be used to verify the composite shape as shown in Figure 4-28. Secondary V/Hz is shown.

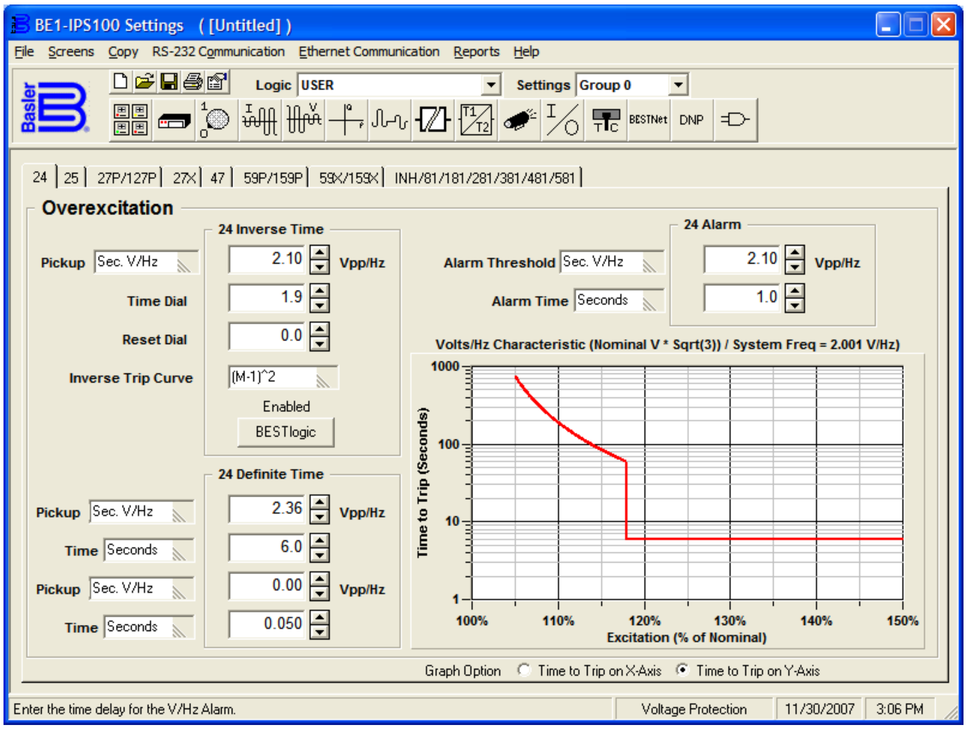

Figure 4-28. Voltage Protection Screen, Overexcitation (24) Tab

The reset rate is determined by the reset dial setting. A setting of 0.0 enables reset to be instantaneous. Using the inverse squared characteristic, assume a trip time dial setting 2.0 and a pickup multiple of 1.2. The total time to trip will be 50 seconds. If this exists for 30 seconds before being corrected (60% elapsed time), what would the total reset time be for a reset dial setting of 5? Based on the reset equation (Equation 4-12), the calculation will be:

$$T_R = D_R * \frac{E_T}{FST} * 100 \qquad\qquad T_R = 5.0 * \frac{30}{50} * 100 = 300 \text{ seconds}$$

Equation 4-12. Time to Reset

If the overexcitation condition returns prior to total reset (i.e., less than 300 seconds), timing resumes from that point at the inverse square rate. For example, if this condition recurs after 150 seconds or 50% of the total reset time, then trip time from the second event will start at 30% instead of 0%, therefore tripping in 70% or the original trip time or 35 seconds. Figure 4-29 illustrates the inverse time delay and reset time.

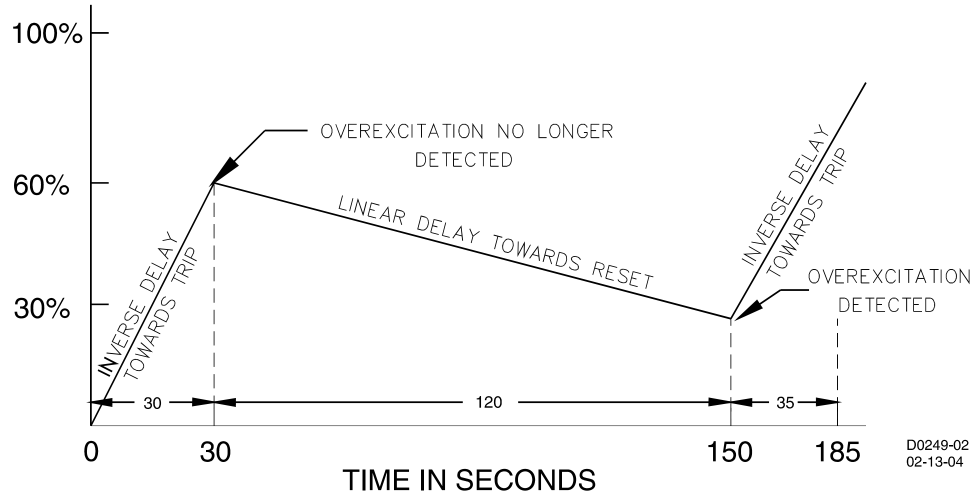

Figure 4-29. Inverse Time Delay and Reset Time

<u>*Retrieving Overexcitation Protection Status from the Relay*</u>

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

27P/59P - Phase Undervoltage/Overvoltage Protection

Figure 4-30 illustrates the Phase Undervoltage/Overvoltage Logic Blocks. The 127P phase undervoltage element and the 159P phase overvoltage element are identical in configuration.

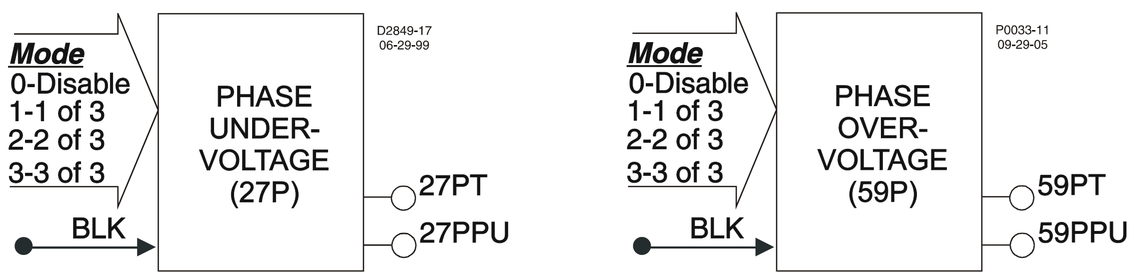

Figure 4-30. Phase Undervoltage/Overvoltage Logic Blocks

Each element has two logic outputs: *27PT* (Trip) and *27PPU* (Pickup). When the monitored voltage decreases below the undervoltage pickup setting (27P) or increases above the overvoltage pickup setting (59P), the pickup output becomes TRUE and the element starts timing toward a trip. The trip output becomes TRUE when the element timer times out. The *BLK* (Block) input is used to disable protection. A BESTlogic expression defines how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timer. This feature functions in a similar way to the torque control contact of an electromechanical relay.

An element is enabled or disabled by the *Mode* input. Any one of four modes is possible for the phase undervoltage and phase overvoltage elements. Selecting Mode 0 disables protection. Mode 1 activates protection when one of the three phases of voltage decreases below the pickup setting (27P) or increases above the pickup setting (59P). Mode 2 requires two of the three phases of voltage to be beyond the pickup setting. Mode 3 requires all three phases of voltage to be beyond the pickup setting. More information about logic mode selections is provided in the *BESTlogic Settings for Phase Undervoltage and Overvoltage* in this section.

The phase undervoltage and overvoltage protective functions each include a timer and three independent comparators, one for each phase. The 27P/59P functions can be set to monitor VPP or VPN. This is determined by the 27/59 mode parameter of the phase VT connections setting. For more information on the VTP setup for PP or PN voltage response, see Section 3, *Input and Output Functions, Power System Inputs, Voltage Measurement*.

If the 60FL element trip logic is TRUE, and V block is enabled for phase blocking (P), all functions that use the phase voltage are blocked. For more information on the 60FL function, see the paragraphs later in this section.

If the target is enabled for the element, the target reporting function will record a target for all phases that are picked up when the protective function trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting.

When undervoltage inhibit is selected, undervoltage sensing is disabled for any phase that falls below the inhibit threshold. Undervoltage inhibiting is disabled when the threshold is set to zero. Undervoltage inhibit is used to prevent undesired undervoltage tripping, such as when a loss of supply occurs.

BESTlogic Settings for Phase Undervoltage/Overvoltage Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-31 illustrates the BESTCOMS screen used to select BESTlogic settings for the Under and Overvoltage elements. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu, and select the *27P/127P* tab. Alternately, settings may be made using the SL-27P and SL-59P ASCII commands.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the element by selecting its mode of operation from the *Mode* pull-down menu. To connect the elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

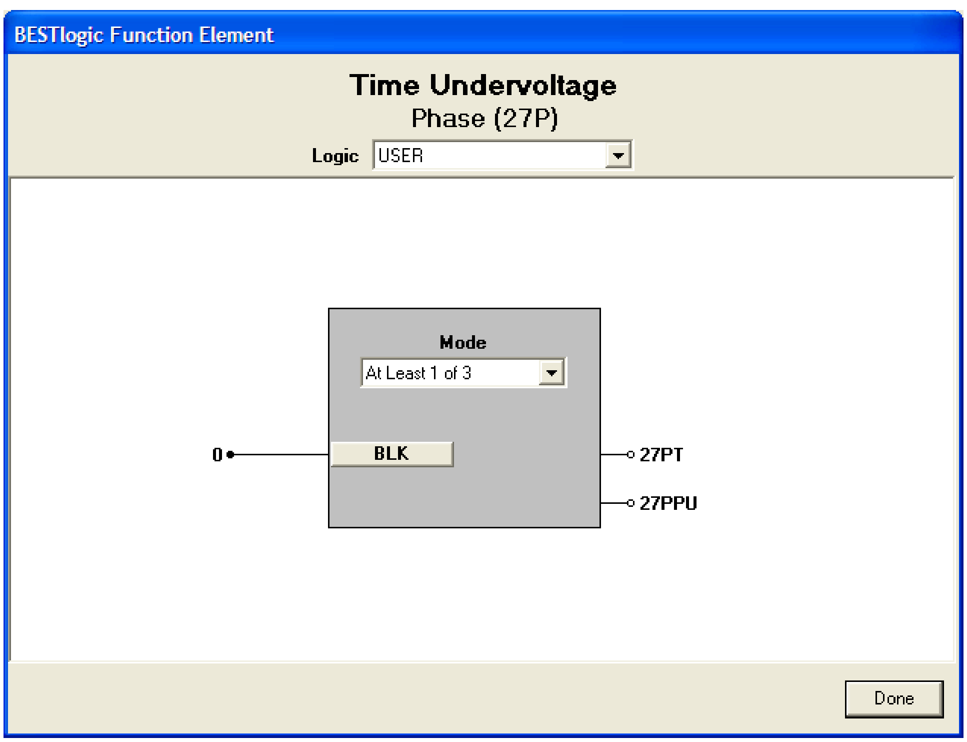

Figure 4-31. BESTlogic Function Element Screen, Phase (27P)

Table 4-22 summarizes the BESTlogic settings for Phase Undervoltage/Overvoltage Protection.

Table 4-22. BESTlogic settings for Phase Undervoltage/Overvoltage Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Undervoltage (27) or overvoltage (59) on one (or more) phases causes pickup. 2 = Undervoltage (27) or overvoltage (59) on two (or more) phases causes pickup. 3 = Undervoltage or overvoltage on all three phases causes pickup.	1
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following BESTlogic settings to the 27P element. Refer to Figure 4-31.

Mode: At least 1of 3 phases

BLK: 0

<u>*Operating Settings for Phase Undervoltage/Overvoltage Protection*</u>

Operating settings for the 27P and 59P functions consist of pickup and time delay values. The pickup value determines the level of voltage required for the element to start timing toward a trip. The time delay value determines the length of time between pickup and trip. Time delays can be set in milliseconds, seconds, or cycles. The default is milliseconds if no unit of measure is specified.

Operating settings are made using BESTCOMS. Figure 4-32 illustrates the BESTCOMS screen used to select operational settings for the undervoltage elements. The 59P/159P overvoltage elements are set in a similar manner. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and select the *27P/127P* or *59/159P* tab. Alternately, settings may be made using the S<g>-27P and S<g>-59P ASCII command or through the HMI using Screens 5.x.3.1 (27P) and 5.x.8.1 (59P), where x represents 1 (Setting Group 0) or 2 (Setting Group 1).

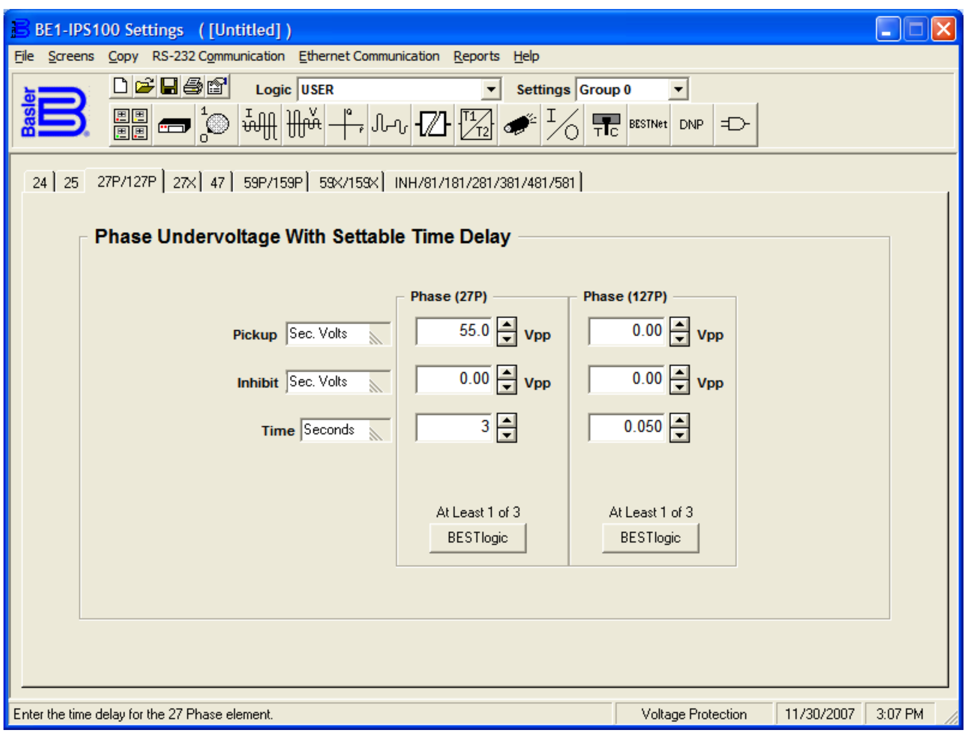

Figure 4-32. Voltage Protection Screen, 27P/127P Tab

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings.* The Settings menu is used to select the setting group that the elements settings apply to. The default unit of measure for the Pickup, Alarm Threshold, and Inhibit settings is secondary volts. Primary volts (Pri Volts), per unit volts (Per U Volts) and percent volts (% Volts) can also be selected as the *Pickup* setting unit of measure. The unit of measure for the *Time* setting that represents the element's time delay, defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

Operating settings for Phase Undervoltage/Overvoltage Protection are summarized in Table 4-23.

Table 4-23. Operating Settings for Phase Undervoltage/Overvoltage Protection

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 10 to 300	0.1 for 0 to 99.9 1.0 for 100 to 300	Secondary Volts †	0
Inhibit 27 only	0 = Disabled 10 to 300	0.1	Secondary Volts †	0
Time Delay	50 to 999 milliseconds	1	Milliseconds	50 ms
	1 to 600 seconds	0.1 for 1.0 to 9.9	Seconds	
		1.0 for 10 to 600	Seconds	
	3 to 36,000 cycles (60 Hz)	∗	Cycles	
	2.5 to 30,000 cycles (50 Hz)			

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the front panel HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

† Unit of measure is secondary VPP or secondary VPN depending on the VTP connection settings.

Time delay settings entered in cycles are converted to seconds or milliseconds (per the nominal frequency setting stored in EEPROM) before being stored. See Section 3, *Input and Output Functions, Power System Inputs*, *Voltage Measurement,* for more information about this setting. If the nominal frequency setting is being changed from the default (60 hertz) and time delay settings are being set in cycles, the frequency setting should be entered and saved before making any time delay settings changes.

Example 1. Make the following operating settings to the 27P element. Refer to Figure 4-30.

Pickup: 55 secondary volts

Time: 3 seconds

Retrieving Phase Undervoltage/Overvoltage Protection Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

27X/59X - Auxiliary Undervoltage/Overvoltage Protection

Figure 4-33 illustrates the inputs and outputs of the auxiliary under/overvoltage elements. Element operation is described in the following paragraphs.

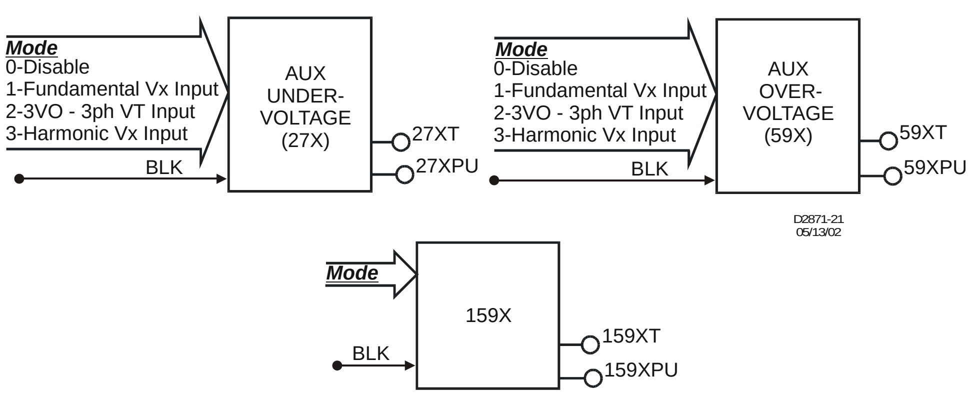

Figure 4-33. Auxiliary Undervoltage/Overvoltage Logic Blocks

The auxiliary elements have two outputs: 27/59XPU (pickup) and 27/59XT (trip). When the monitored voltage increases above the pickup setting, the pickup output becomes TRUE and the element starts timing toward a trip. The trip output becomes TRUE when the element timer times out.

The *BLK* (Block) input is used to disable protection. A BESTlogic expression defines how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timer. This feature functions in a similar way to the torque control contact of an electromechanical relay.

The 27X and the 59X elements are enabled or disabled by the *Mode* input. Four modes are available. Selecting Mode 0 disables protection. Modes 1, 2, or 3 enable the element as described in this section under *BESTlogic Settings for Auxiliary Undervoltage/Overvoltage*. The pickup setting determines the voltage pickup level of the element. The time delay setting controls how long it takes for the trip output to become TRUE after the pickup output becomes TRUE. When the monitored voltage increases above the pickup threshold, the pickup output becomes TRUE and the timer starts. If the voltage remains above the pickup threshold for the duration of the time delay setting, the trip output becomes TRUE. If the voltage decreases below the 59X dropout ratio of 98 percent or increases above the 27X dropout ratio of 100%, the timer is reset to zero.

If the 60FL element trip logic is TRUE and V block is enabled for 3VO blocking (N), the 27X/59X functions will be blocked if they are set to Mode 2. For more information on the 60FL function, see the paragraphs later in this section.

The 27X element is equipped with an undervoltage inhibit feature that monitors V_X input and is selectable for a Fundamental VX input or a 3VO - 3-phase VT input or a Harmonic V_X input. When undervoltage inhibit is selected, undervoltage sensing is disabled anytime the voltage falls below the inhibit threshold. Undervoltage inhibiting is disabled when the threshold is set to zero. Undervoltage inhibit is used to prevent undesired undervoltage tripping, such as when a loss of supply occurs.

If the target is enabled for the 59X element, the target reporting function will record a target when the trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting Functions*, for more information about targets.

BESTlogic Settings for Auxiliary Undervoltage/Overvoltage Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-34 illustrates the BESTCOMS screen used to select BESTlogic settings for the Undervoltage/Overvoltage element. (In this case, the auxiliary overvoltage element is shown.) To open the *BESTlogic Function Element* screen for Undervoltage/Overvoltage elements, select *Voltage Protection* from the *Screens* pull-down menu. Then select the *27X* or the *59X/159X* tab. Alternately, settings may be made using SL-59X, SL-159X, or SL-27X ASCII command.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the under/overvoltage function by selecting its mode of operation from the *Mode* pull-down menu. To connect the elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

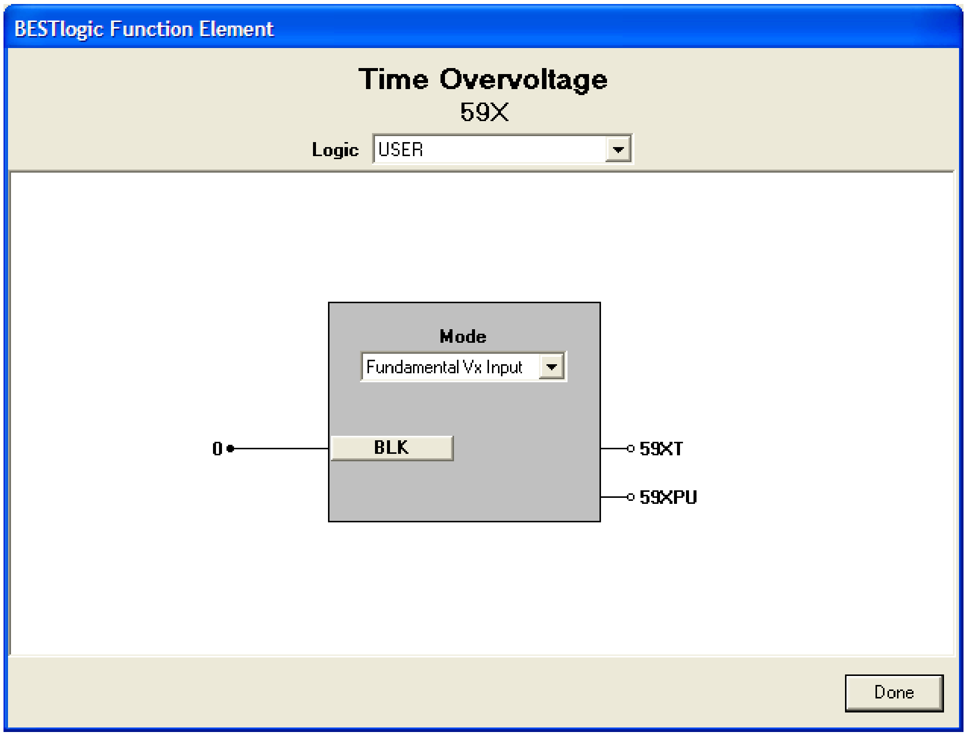

Figure 4-34. BESTlogic Function Element Screen, 59X

Table 4-24 summarizes the BESTlogic settings for Auxiliary Undervoltage/Overvoltage Protection.

Table 4-24. BESTlogic Settings for Auxiliary Undervoltage/Overvoltage Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Fundamental Vx Input 2 = 3Vo Phase Inputs ∗ 3 = 3rd Harmonic, Vx Input	0 for 27X 2 for 59X/159X
BLK	Logic expression that disables function when TRUE. A setting of 0 disables blocking.	0

∗ To use Mode 2, the VTP connection must be 4-wire. Optional Auxiliary Input must be present to use Mode 1 or Mode 3.

Example 1. Make the following settings to the 59X element. Refer to Figure 4-34.

Mode: Fundamental Vx Input

BLK: 0

Operating Settings for Auxiliary Undervoltage/Overvoltage Protection

Operating settings for the 27X and 59X functions consist of pickup and time delay values. The pickup value determines the level of voltage required for the element to start timing toward a trip. Unit of measure is secondary volts (PP or PN) and depends on the VTX setting see Table 4-25. For more information, refer to Section 3, *Input and Output Functions, Power System Inputs, Voltage Measurement*. The time delay value determines the length of time between pickup and trip. Time delays can be set in milliseconds, seconds, or cycles. The default is milliseconds if no unit of measure is specified.

Table 4-25. VTX Connection Settings

VTX Connection	Mode	Unit
AB, BC, CA	1 or 3	VPP
AN, BN, CN	1 or 3	VPN
GR	1 or 3	VPN
Don't care	2	VPN

Operating settings are made using BESTCOMS. Figure 4-35 illustrates the BESTCOMS screen used to select operational settings for the auxiliary Under/Overvoltage element. To open the *Voltage Protection* screen for Under/Overvoltage elements, select *Voltage Protection* from the *Screens* pull-down menu. Then select either the *27X* or the *59X/159X* tab. Alternately, settings may be made using the S<g>-59X, S<g>-159X, and S<g>-27X ASCII commands or through HMI Screens 5.x.3.3 (27x), 5.x.8.2 (59x), and 5.x.8.4 where x equals 1 (Setting Group 0) or 2 (Setting Group 1).

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The settings menu is used to select the setting group that the elements settings apply to.

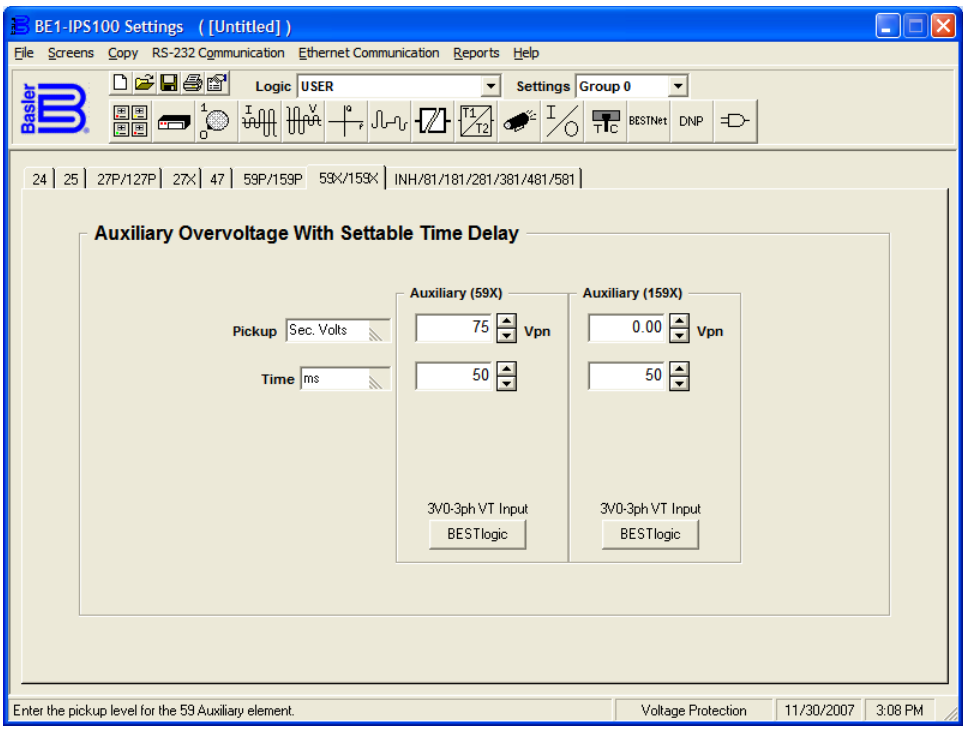

Figure 4-35. Voltage Protection Screen, 59X/159X Tab

Table 4-26 summarizes the operating settings for Auxiliary Undervoltage/Overvoltage Protection.

Table 4-26. Operating Settings for Auxiliary Undervoltage/Overvoltage Protection

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 1 to 150	0.1 for 0 to 99.9 1.0 for 100 to 150	Secondary Volts	0
Inhibit 27X only	0 = Disabled 1 to 150	0.1	Secondary Volts	0
Time Delay	50 to 999 milliseconds	1	Milliseconds	50 ms
	1 to 600 seconds	0.1 for 1.0 to 9.9	Seconds	
		1.0 for 10 to 600	Seconds	
	3 to 36,000 cycles (60 Hz)	∗	Cycles	
	2.5 to 30,000 cycles (50 Hz)			

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the front panel HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

Example 1. Make the following changes to the 59X element. Refer to Figure 4-35.

Pickup: 75 secondary volts
Time: 50 ms

Retrieving Auxiliary Undervoltage/Overvoltage Protection Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

47 - Negative-Sequence Overvoltage Protection

Figure 4-36 illustrates the inputs and outputs of the negative-sequence overvoltage element. Element operation is described in the following paragraphs. Negative-sequence overvoltage protection is not available if VTP connection is single-phase.

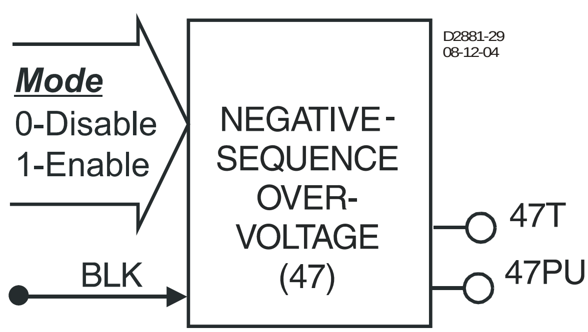

Figure 4-36. Negative-Sequence Overvoltage Logic Block

The negative-sequence overvoltage element has two outputs: *47PU* (pickup) and *47T* (trip). When the monitored negative-sequence voltage increases above the pickup setting, the pickup output becomes TRUE and the element starts timing toward a trip. The trip output becomes TRUE when the element timer times out.

The *BLK* (Block) input is used to disable protection. A BESTlogic expression defines how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timer. This feature functions in a similar way to the torque control contact of an electromechanical relay.

The 47 element is enabled or disabled by the *Mode* input. Two modes are available. Selecting Mode 0 disables protection. Mode 1 enables the 47 element. More information about logic mode selections is provided in the *BESTlogic Settings for Negative-Sequence Overvoltage* paragraphs.

The pickup setting determines the voltage pickup level of the element. Voltage pickup is based on PN. The time delay setting controls how long it takes for the trip output to become TRUE after the pickup output becomes TRUE. When the monitored voltage increases above the pickup threshold, the pickup output (47PU) becomes TRUE and the timer starts. If the voltage remains above the pickup threshold for the duration of the time delay setting, the trip output (47T) becomes TRUE. If the voltage decreases below the dropout ratio of 98 percent, the timer is reset to zero.

If the 60FL element trip logic is TRUE and V block is enabled for negative-sequence blocking <Q>, all functions that use the negative-sequence voltage (V_2) are blocked. For more information on the 60FL function, see the paragraphs later in this section.

If the target is enabled for the 47 element, the target reporting function will record a target when the trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting.

BESTlogic Settings for Negative-Sequence Overvoltage Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-37 illustrates the BESTCOMS screen used to select BESTlogic settings for the negative-sequence overvoltage function. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and then select the *47* Tab. Then select the *BESTlogic* button at the bottom of the screen. Alternately, settings may be made using the SL-47 ASCII command.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the negative-sequence overvoltage function by selecting its mode of operation from the *Mode* pull-down menu. To connect the elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

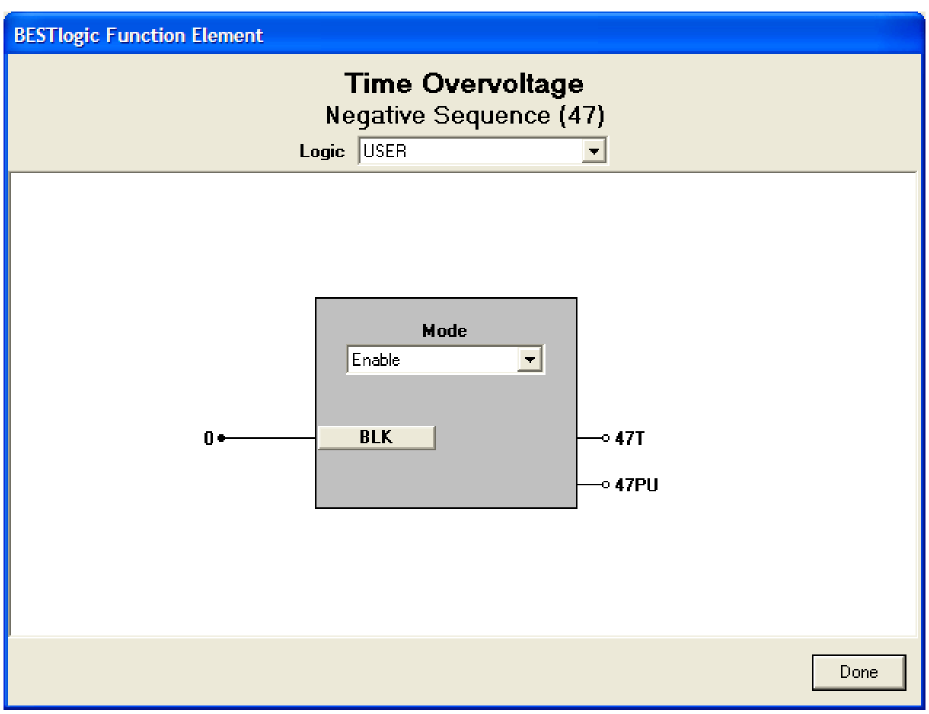

Figure 4-37. BESTlogic Function Element Screen, Negative Sequence (47)

Table 4-27 summarizes the BESTlogic settings for Negative-Sequence Overvoltage Protection.

Table 4-27. BESTlogic Settings for Negative-Sequence Overvoltage Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled	1
BLK	Logic expression that disables function when TRUE. A setting of 0 disables blocking.	0

Example 1. Make the following BESTlogic settings to the 47 element. Refer to Figure 4-37.
Mode: Enable
BLK: 0

Operating Settings for Negative-Sequence Overvoltage Protection

Operating settings are made using BESTCOMS. Figure 4-38 illustrates the BESTCOMS screen used to select operational settings for the negative-sequence overvoltage element. To open the screen select *Voltage Protection* from the *Screens* pull-down menu and then select the *47* tab. Alternately, settings maybe made using the S<g>-47 ASCII command or through the HMI interface using Screen 5.x.5.1 where x represents 1 (Setting Group 0) or 2 (Setting Group 1).

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the elements settings apply to.

The default unit of measure for the *Pickup* setting is secondary volts. Primary volts (Pri Volts), per unit volts (Per U Volts), and percent volts (% Volts) can also be selected as the pickup setting unit of measure. The unit of measure for the *Time* setting that represents the element's time delay, defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

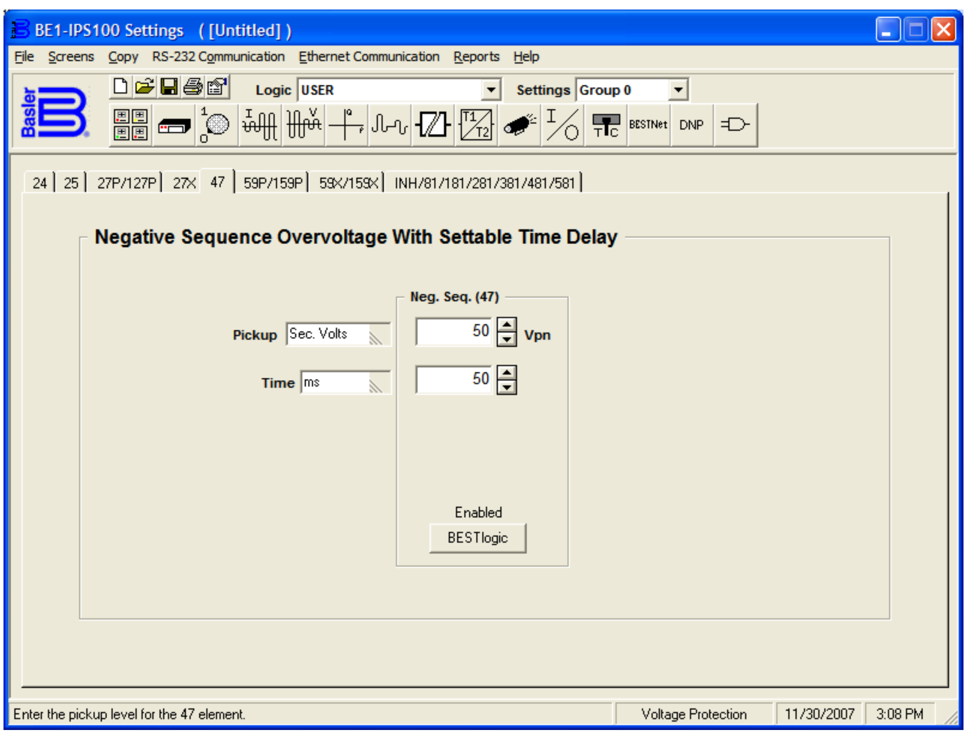

Figure 4-38. Voltage Protection Screen, 47 Tab

Table 4-28 summarizes operating settings for Negative-Sequence Overvoltage Protection.

Table 4-28. Operating Settings for Negative-Sequence Overvoltage Protection

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 10 to 300	0.1 for 0 to 99.9 1.0 for 100 to 300	Secondary Volts	0
Time Delay	50 to 999 milliseconds	1	Milliseconds	50 ms
	1 to 600 seconds	0.1 for 0.1 to 9.9	Seconds	
		1.0 for 10 to 600	Seconds	
	3 to 36,000 cycles (60 Hz)	∗	Cycles	
	2.5 to 30,000 cycles (50 Hz)			

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the front panel HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

Example 1. Make the following operational settings to the 47 element. Refer to Figure 4-38.

Pickup: 50 Vpn secondary volts
Time: 50 ms

Retrieving Negative-Sequence Overvoltage Protection Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

FREQUENCY PROTECTION

81 - Over/Under/Rate of Change Frequency Protection

BE1-IPS100 frequency protection consists of six independent elements that can be programmed for underfrequency, overfrequency, or rate of change (ROC) frequency protection. Under and over frequency protection can be used for load shedding or islanding detection such as when a source of distributed generation (DG) is suddenly separated or islanded from the electric utility. For this condition, frequency will quickly change from 60 Hz (except for the improbable case of a perfect load to generation match) making frequency measurement an excellent method for detecting an island condition. Rate of Change frequency provides a high-speed option for detecting islanding conditions. The element can be set to respond to positive ROC, negative ROC, or either. Again, when the DG is suddenly separated from the electric utility, the rate of frequency change will either increase or decrease rapidly. ROC protection provides high-speed detection of islanding situations under conditions that may not be detected by over/under frequency protection.

Each element has an adjustable frequency (Hz) or ROC frequency (Hz/Sec) setpoint and time delay. The 81 elements share a common undervoltage inhibit setting for under/over/ROC frequency applications. ROC applications also share a negative-sequence voltage inhibit which is used to prevent unwanted ROC operation during unbalanced faults and other system disturbances, and a high/low frequency limit that establishes a "window" for ROC operation. An over/under/ROC frequency element is shown in Figure 4-39. Power system frequency is measured on the A-phase voltage input for four-wire or single-phase connections or the AB voltage input when in three-wire mode. Power system frequency is measured on the optional auxiliary voltage input as well. When the applied voltage is greater than 10 volts, the BE1-IPS100 measures the frequency. The measured frequency is the average of two cycles of measurement.

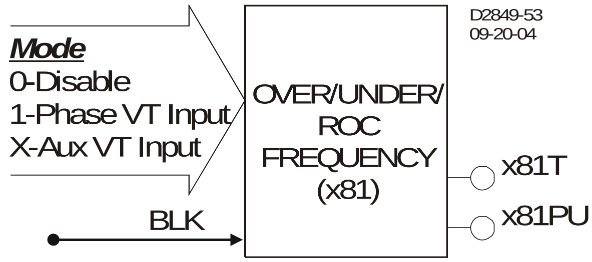

Figure 4-39. Over/Under/Rate of Change Frequency Logic Block

Frequency element designations are 81, 181, 281, 381, 481, and 581. Each of the six elements has identical inputs, outputs, and setting provisions as shown in Figure 4-39. An x81PU (pickup) and x81T (trip) are provided on each element. For over/under frequency applications, the pickup output becomes TRUE when the monitored frequency decreases below (81U) or increases above (81O) the pickup setting at which point the element starts timing toward a trip. The trip output becomes TRUE when the element's time delay setting has expired. If the pickup bit drops out before the timer expires, it resets and will start over on the next pickup. For ROC applications, the x81PU (pickup) becomes TRUE when the rate of frequency change (Hz/Sec) exceeds the pickup setting at which point the element starts timing toward a trip. Trip output becomes TRUE when the element's time delay has expired.

The *BLK* (Block) input is used to disable protection. A BESTlogic expression is used to define how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timer. This feature functions in a similar way to the torque control contact of an electromechanical relay.

An element is enabled or disabled by the *Mode* input. Three mode options are possible. Mode 0 disables protection, Mode 1 enables the element to monitor the frequency on the VTP input and mode X enables the element to monitor the frequency on the VTX input. Security of your load-shedding scheme can be enhanced by monitoring two independent VT circuits. See Section 8, *Application, Application Tips*, for more information. More information about logic mode selections is provided in the following *BESTlogic Settings for Under/Over/Rate of Change Frequency* paragraphs.

Pickup settings define the frequency or ROC frequency setpoint and time delay, and program the element for under/over/ROC frequency protection. The setpoint defines the value of frequency or ROC that will initiate action by an element. The time delay setting determines how long it takes for the trip output to become TRUE once the measured frequency or ROC reaches the setpoint. If three consecutive cycles of the measured frequency have decreased below, increased above, or exceeded the rate of change pickup threshold (x81PU) and the timer has timed out, the 81T will trip. If the timer has not timed out and the frequency or ROC remains in the pickup range for the remainder of the time delay, the 81T will also trip. If the monitored voltage decreases below the user-defined setpoint, over/under frequency protection is inhibited. In addition, for ROC applications, if the negative-sequence voltage (defined as a percentage of nominal voltage) exceeds a user-defined setpoint, or the measured frequency is outside the over/under user defined frequency limits (window), ROC protection is inhibited.

If the target is enabled for the element, the target reporting function will record a target for the appropriate element (x81) when the protective function trip output is TRUE and the fault recording function trip logic expression is TRUE. The target displayed on the HMI will be 81, 181, etc. Element settings determine if the x81 target is the result of an over, under, or rate of change operation. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting.

BESTlogic Settings for Over/Under/Rate of Change Frequency Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-40 illustrates the BESTCOMS screen used to select BESTlogic settings for the Over/Under/ROC Frequency element. To open the *BESTlogic Function Element* screen for Over/Under/ROC Frequency element, select *Voltage Protection* from the *Screens* pull-down menu and select the *INH/81/181/281/381/481/581* tab. Then select the *BESTlogic* button for the element to be programmed. Alternately, settings may be made using the SL-<x>81 ASCII command.

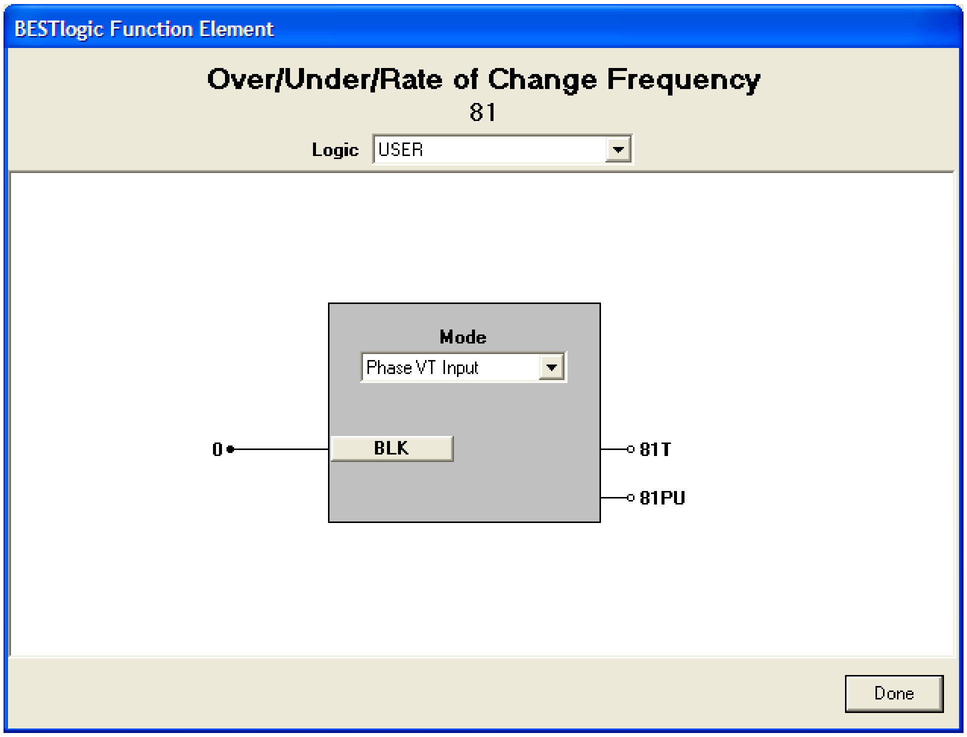

Figure 4-40. BESTlogic Function Element Screen, 81

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme <u>must</u> be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*. Enable the Over/Under/ROC Frequency function by selecting its mode of operation from the *Mode* pull-down menu. To connect the elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

BESTlogic settings for Over/Under/Rate of Change Frequency Protection are summarized in Table 4-29.

Table 4-29. BESTlogic Settings for Over/Under/Rate of Change Frequency Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled on VP Input X = Enabled on VX Input	1
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following BESTlogic settings to the 81 element. Refer to Figure 4-40.

Mode: Phase VT Input

BLK: 0

<u>*Operating Settings for Over/Under/Rate of Change Frequency Protection*</u>

Operating settings for the 81 elements consist of pickup values, time delay values, and a mode setting that defines whether an element provides under, over, or ROC frequency protection and is selectable from a pull-down menu under each element tab. The pickup value determines the value of frequency or ROC required for the element to start timing toward a trip. The time delay value determines the length of time between reaching the pickup value and tripping. Time delays can be set in milliseconds, seconds, or cycles. The default is milliseconds if no unit of measure is specified. Minimum timing resolution is two cycles. A time delay setting of zero makes the element instantaneous with no intentional time delay.

Operating settings are made using BESTCOMS. Figure 4-41 illustrates the BESTCOMS screen used to select operational settings for the Over/Under/ROC Frequency element. To open the *BESTlogic Function Element* screen for Over/Under/ROC Frequency element, select *Voltage Protection* from the *Screens* pull-down menu and select the *INH/81/181/281/381/481/581* tab. Alternately, settings may be made using the S<g>-<x>81 ASCII command or the HMI interface using Screens 5.x.12.1 through 5.x.12.8 where x equals the setting group number.

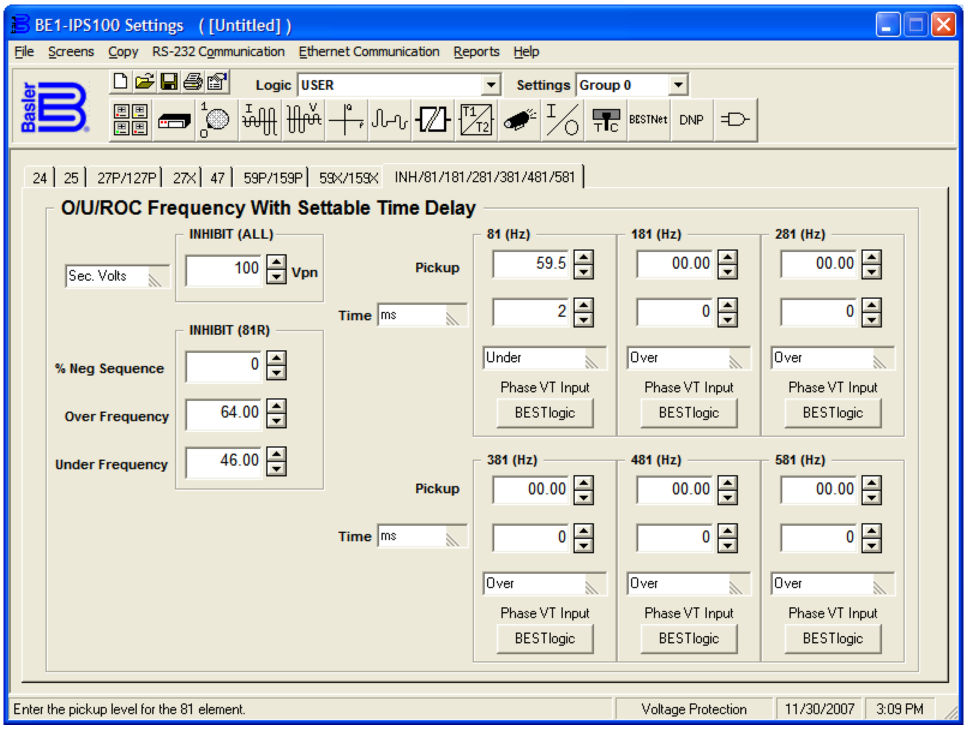

Figure 4-41. Voltage Protection Screen, INH/81/181/281/381/481/581 Tab

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the element's settings apply to.

Over/under/ROC frequency protection can be inhibited when the monitored voltage decreases below a user-defined level. The undervoltage inhibit level is set through BESTCOMS. Alternately it can be set using the S<g>-<x>81INH command where x equals nothing or one through five. Settings can also be made using HMI Screen 5.x.12.7. The voltage inhibit setting unit of measure depends upon the VTP and VTX connection settings. For 4-wire or PN connections, it is Sec VPN. For 3-wire or PP connections, it is Sec. VPP. ROC protection can be inhibited when the percentage of negative-sequence voltage exceeds a user defined level or when the system frequency is outside a user defined frequency window. If the negative-sequence inhibit is set to zero, the 81 ROC is operating all the time. If the negative-sequence inhibit is set to a value different from zero, the 81 ROC is NOT operating if the negative-sequence voltage is above the negative-sequence setting.

Table 4-30 summarizes the operating settings for Over/Under/Rate of Change Frequency Protection.

Table 4-30. Operating Settings for Over/Under/Rate of Change Frequency Protection

<table>
<tr><th>Setting</th><th>Range</th><th>Increment</th><th>Unit of Measure</th><th>Default</th></tr>
<tr><td>81 O/U Pickup</td><td>0 = Disabled
20 to 70 Hz</td><td>0.01</td><td>Hertz</td><td>0</td></tr>
<tr><td>81 ROC Pickup</td><td>0.20 to 20.0 Hz/sec.</td><td>0.01</td><td>Hertz/second</td><td>0</td></tr>
<tr><td rowspan="5">Time Delay</td><td>0 to 999 Milliseconds</td><td>1</td><td>Milliseconds</td><td rowspan="5">0</td></tr>
<tr><td rowspan="2">0.0 to 600 Seconds</td><td>0.1 for 0.1 to 9.9</td><td>Seconds</td></tr>
<tr><td>1.0 for 10 to 600</td><td>Seconds</td></tr>
<tr><td>3 to 36,000 cycles (60 Hz)</td><td rowspan="2">∗</td><td rowspan="2">Cycles</td></tr>
<tr><td>2.5 to 30,000 cycles (50 Hz)</td></tr>
<tr><td>Mode</td><td>O = Over
U = Under
R = Rate of Change
P = Positive ROC
N = Negative ROC</td><td>N/A</td><td>N/A</td><td>1</td></tr>
<tr><td>81 O/U/ROC Voltage Inhibit Level</td><td>0 = Disabled
15 to 150 Sec. Volts</td><td>0.1 for 15 to 99.9
1.0 for 100 to 150</td><td>Secondary Volts †</td><td>40</td></tr>
<tr><td>81 ROC Neg.-Seq. Voltage Inhibit Level</td><td>0 to 99% of nominal voltage</td><td>1%</td><td>Secondary Volts †</td><td>0</td></tr>
<tr><td>81 ROC Overfrequency Inhibit Level</td><td>46 to 64 Hz</td><td>0.01</td><td>Hertz</td><td>64</td></tr>
<tr><td>81 ROC Underfrequency Inhibit Level</td><td>46 to 64 Hz</td><td>0.01</td><td>Hertz</td><td>46</td></tr>
</table>

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the front panel HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

† Phase-to-phase and phase-to-neutral settings depend on the VTP and VTX connection settings.

The default unit of measure for the voltage and negative-sequence inhibit setting is secondary volts. Primary volt (Pri Volt), per unit volts (Per U Volts), and percent volts (% Volts) can also be selected as the pickup setting unit of measure. Over/underfrequency inhibit is in hertz. The unit of measure for the *Time* setting that represents the element's time delay, defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

Example 1. Make the following settings to the 81 element and to the inhibit function. See Figure 4-41.

Pickup Hertz:	59.5
Time:	2 ms
Mode:	Underfrequency
Voltage INHIBIT:	100 Vpn secondary volts

Retrieving Over/Under/Rate of Change Frequency Protection Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

BREAKER FAILURE PROTECTION

50BF - Breaker Failure Protection

BE1-IPS100 relays provide one function block for breaker failure protection. This function includes a timer and a current detector. Figure 4-42 shows the BF function block. The function block has two outputs BFPU (breaker failure pickup) and BFT (breaker failure trip).

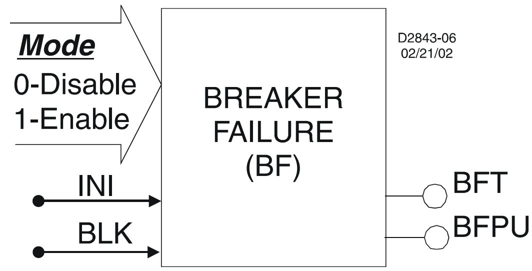

Figure 4-42. Breaker Failure Logic Block

An *INI* (Initiate) logic input is provided to start the breaker failure timer. When this expression is TRUE and current is flowing in the phase current input circuits, the breaker failure timer is started. Supervision of the initiate signal can be designed in BESTlogic. Once the breaker failure timer is started, the initiate signal does not have to remain TRUE.

A BESTlogic expression defines how the *BLK* (Block) input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timer to zero. For example, this may be an input wired to a test switch such that breaker failure protection is disabled when the primary protective elements are being tested to prevent inadvertent backup tripping during testing.

The breaker failure timer is stopped by the fast-dropout current detector function. See Section 3, *Input and Output Functions, Power System Inputs, Current Measurement*, for more details on this function. The fast-dropout current detector is designed to directly determine when the current in the poles of the breaker has been interrupted without having to wait for the fault current samples to clear the one-cycle filter time used by the normal current measurement function. This function has less than one cycle dropout time. The timer can also be stopped by the block logic input being asserted.

The current detector sensitivity is fixed at 10 percent of nominal. A traditional breaker failure relay includes a fault detector function that serves two independent purposes: *current detection* and *fault detection*. A current detector is generally included to stop breaker failure timing when it is determined that current flow in all poles of the breaker has stopped. The secondary function of a traditional fault detector is to provide an independent confirmation that a fault exists on the system and to increase security from mis-operation caused by an inadvertent initiate signal. To do this, a fault detector by definition *must* be set above load current which reduces its sensitivity as a current detector. Since this breaker failure timer is included in a multifunction protection system, fault detector supervision is not required.

If external relays are used to initiate the breaker failure timer, it may be desirable to include fault detector supervision of the initiate signal using an instantaneous overcurrent function in BESTlogic. For example, if it is desired that certain initiate signals be supervised by a fault detector, it is possible to *AND* them with one of the 50T protective functions using a virtual output expression. In other applications, it may be desirable to have breaker failure timing with no current detector supervision. In this case, one of the general-purpose logic timers (device 62) can be used as a breaker failure timer. See Section 8, *Application, Application Tips*, for more details on this application.

When the breaker failure timer is picked up, the BFPU logic output is TRUE. This output would typically be used as a re-trip signal to the protected breaker. This can provide an independent tripping signal to the breaker that may also open the breaker to prevent backup tripping.

If the current detector remains picked up for the duration of the breaker failure delay time, the BFT output is asserted. This output would normally be used to trip an 86F lockout relay, which will trip and prevent closing of adjacent breakers and/or key transfer trip transmitters.

If the target is enabled for the function block, the target reporting function will record a target when the protective function trip output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more details on the target reporting function.

An alarm variable is also provided in the programmable alarms function that can be used to indicate an alarm condition when the breaker failure protection trips. See Section 6, *Reporting and Alarm Functions, Alarms Function*, for more details on the alarm reporting function.

BESTlogic Settings for Breaker Failure Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-43 illustrates the BESTCOMS screen used to select BESTlogic settings for the breaker failure element. To open *BESTlogic Function Element* screen for the breaker failure element, select *Breaker Failure* from the *Screens* pull-down menu. Then select the button labeled *BESTlogic*. Alternately, settings may be made using the SL-50BF ASCII command.

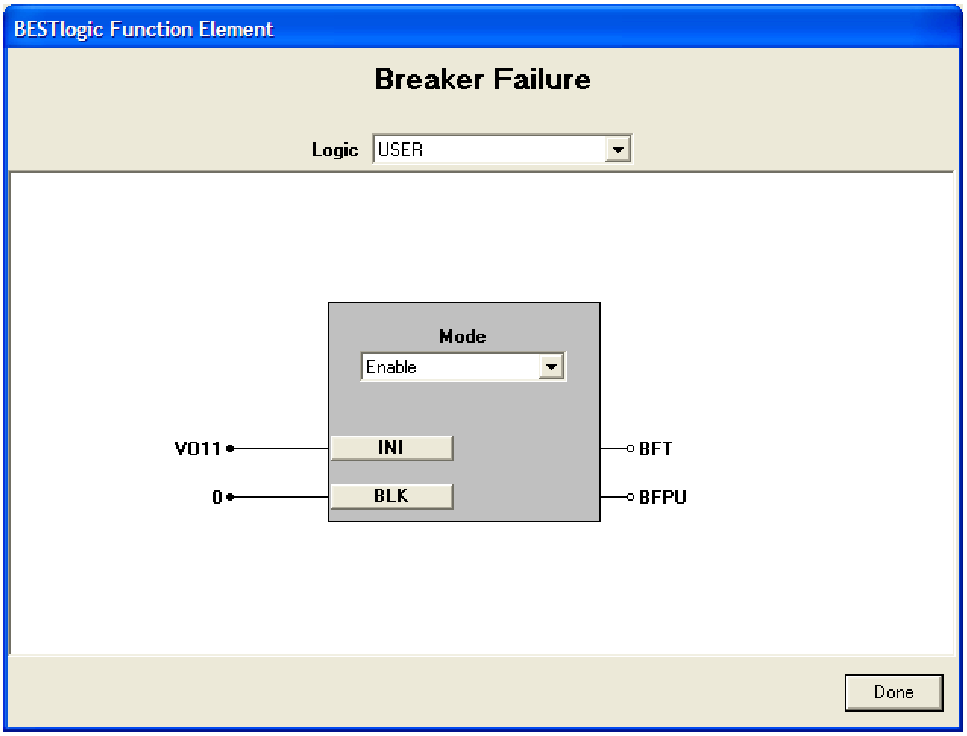

Figure 4-43. BESTlogic Function Element Screen, Breaker Failure

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the breaker failure function by selecting its mode of operation from the *Mode* pull-down menu. To connect the elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

Table 4-31 summarizes the BESTlogic settings for Breaker Failure Protection.

Table 4-31. BESTlogic Settings for Breaker Failure Protection

Function	Range/Purpose	Default
Mode	0 = Disabled, 1 = Enabled	0
INI	Logic expression that enables function when TRUE.	0
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following changes to the breaker failure element. Refer to Figure 4-41.

Mode: Enable
INI: VO11
BLK: 0

Operating Settings for Breaker Failure Protection

Operating settings are made using BESTCOMS. Figure 4-44 illustrates the BESTCOMS screen used to select operational settings for the breaker failure element. To open *BESTlogic Function Element* screen for the breaker failure element, select *Breaker Failure* from the *Screens* pull-down menu. Alternately, settings may be made using the SP-50BF ASCII command or through the HMI interface using Screen 5.3.1.1.

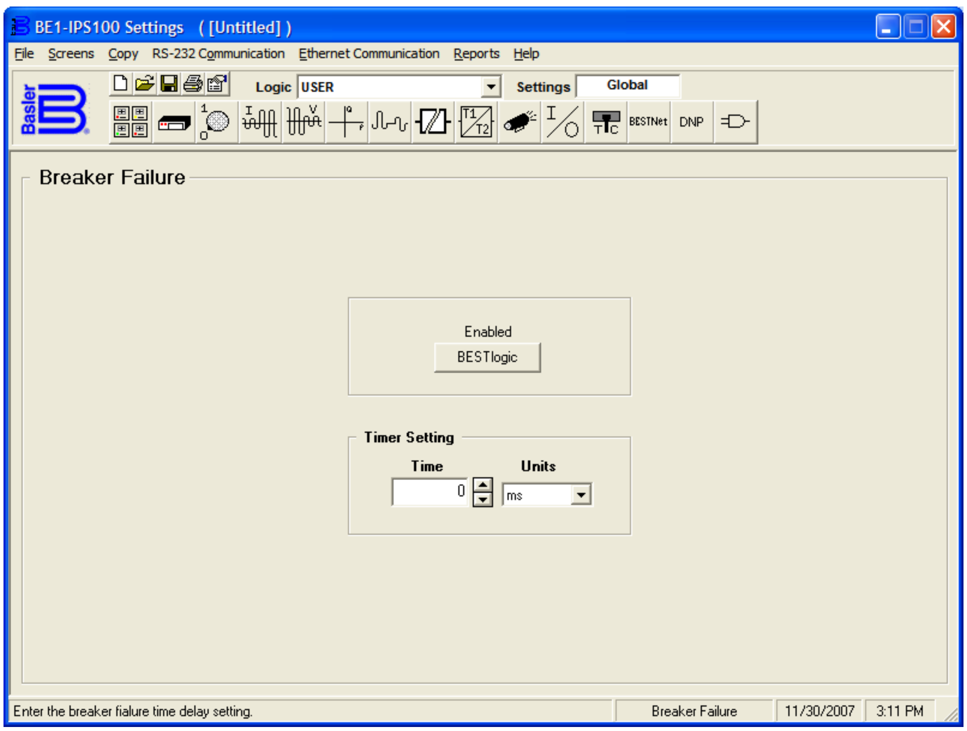

Figure 4-44. Breaker Failure Screen

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the elements settings apply to. Note that Breaker Failure settings are Global.

The default unit of measure for the *Pickup* setting is secondary amps. The unit of measure for the *Time* setting that represents the element's time delay, defaults to milliseconds. It is also selectable for seconds, minutes, and cycles.

Table 4-32 summarizes the operating settings for Breaker Failure Protection.

Table 4-32. Operating Settings for Breaker Failure Protection

Setting	Range	Increment	Unit of Measure	Default
Time	0 = Disabled	N/A	N/A	0
	50 to 999 ms	1 ms	Milliseconds	
	0.05 to 0.999 sec.	0.001 sec.	Seconds	
	0 to 59.96 (60 Hz) or 0 to 49.97 (50 Hz)	∗	Cycles	

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles from the front panel HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

Retrieving Breaker Failure Protection Status from the Relay

The status of each logic variable can be determined from the ASCII command interface using the RG-STAT (report general-status) or the RL (report logic) commands. Status can also be determined using BESTCOMS *Metering* screen. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

LOGIC TIMERS

62 - General Purpose Logic Timers

BE1-IPS100 relays provide two general-purpose logic timers, which are extremely versatile. Each can be set for one of five modes of operation to emulate virtually any type of timer. Each function block has one output (62 or 162) that is asserted when the timing criteria has been met according to the BESTlogic mode setting. Figure 4-45 shows the 62 function block as an example. Each mode of operation is described in detail in the following paragraphs.

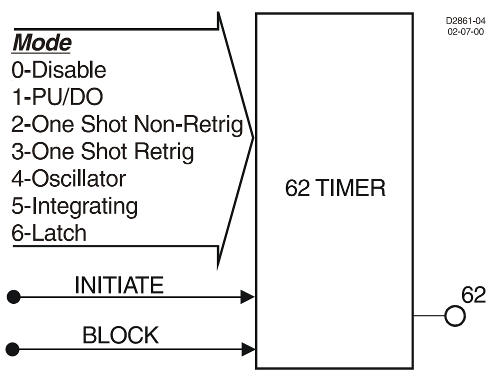

Figure 4-45. General Purpose Logic Timers Logic Block

An *INITIATE* logic input is provided to start the timing sequence.

A *BLOCK* logic input is provided to block operation of the timer. When this expression is TRUE, the function is disabled.

Each timer has a *T1* time setting and a *T2* time setting. The functioning of these settings is dependent upon the type of timer as specified by the mode setting in BESTlogic.

If the target is enabled for the function block, the target reporting function will record a target when the timer output is TRUE and the fault recording function trip logic expression is TRUE. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more details on the target reporting function.

Mode 1, PU/DO (Pickup/Dropout Timer)

The output will change to logic TRUE if the *INITIATE* input expression is TRUE for the duration of PICKUP time delay setting T1. See Figure 4-46. If the initiate expression toggles to FALSE before time T1, the T1 timer is reset. Once the output of the timer toggles to TRUE, the *INITIATE* input expression must be FALSE for the duration of DROPOUT time delay setting T2. If the *INITIATE* input expression toggles to TRUE before time T2, the output stays TRUE and the T2 timer is reset.

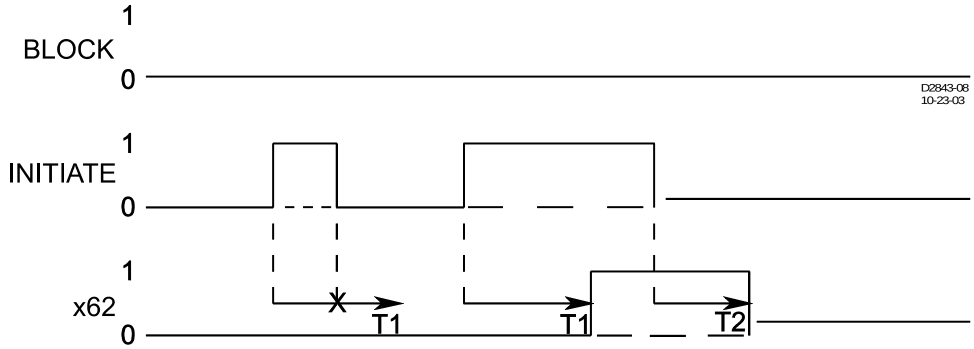

Figure 4-46. Mode 1, PU/DO (Pickup/Dropout Timer)

__Mode 2, One-Shot Nonretriggerable Timer__

The one-shot nonretriggerable timer starts its timing sequence when the *INITIATE* input expression changes from FALSE to TRUE. See Figure 4-47. The timer will time for DELAY time T1 and then the output will toggle to TRUE for DURATION time T2. Additional initiate input expression changes of state are ignored until the timing sequence has been completed. If the duration time (T2) is set to 0, this timer will not function. The timer will return to FALSE if the BLOCK input becomes TRUE.

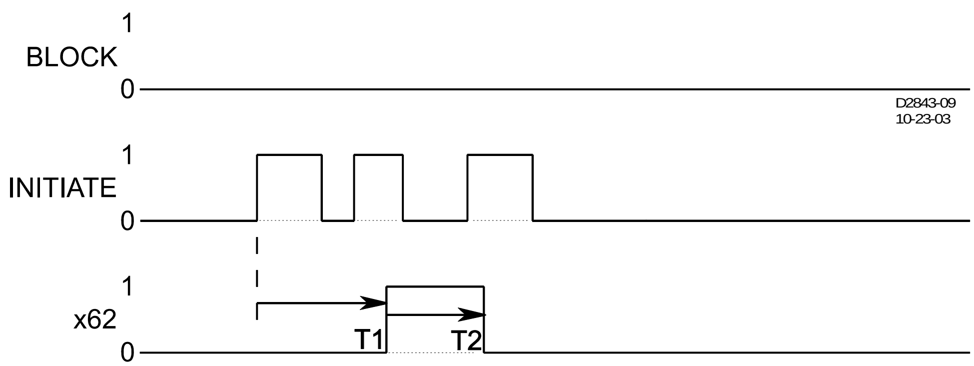

Figure 4-47. Mode 2, One-Shot Nonretriggerable Timer

__Mode 3, One-Shot Retriggerable Timer__

This mode of operation is similar to the one shot nonretriggerable mode, except that if a new FALSE-to-TRUE transition occurs on the *INITIATE* input expression, the output is forced to logic FALSE and the timing sequence is restarted. See Figure 4-48.

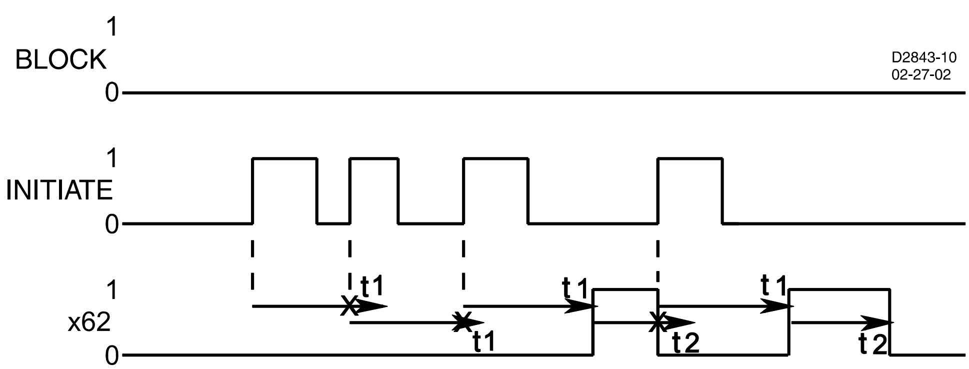

Figure 4-48. Mode 3, One Shot Retriggerable Timer

__Mode 4, Oscillator__

In this mode, the *INITIATE* input is ignored. See Figure 4-49. If the *BLOCK* input is FALSE, the output, x62, oscillates with an ON time of T1 and an OFF time of T2. When the *BLOCK* input is held TRUE, the oscillator stops and the output is held OFF.

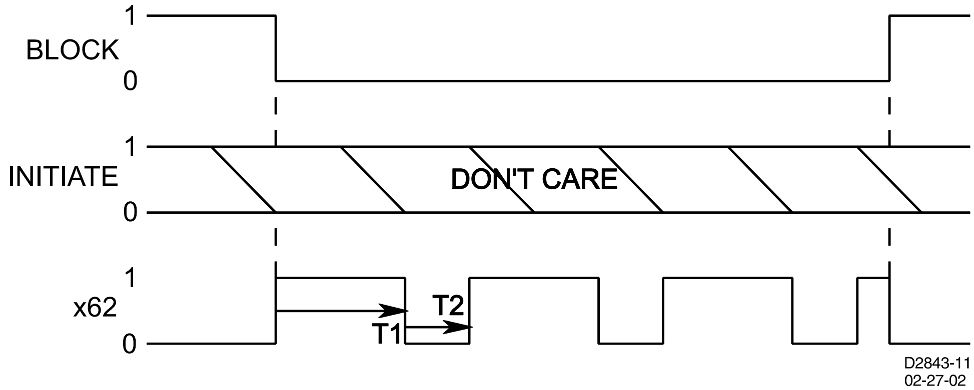

Figure 4-49. Mode 4, Oscillator

Mode 5, Integrating Timer

An integrating timer is similar to a pickup/dropout timer except that the PICKUP time T1 defines the rate that the timer integrates toward timing out and setting the output to TRUE. Conversely, the RESET time T2 defines the rate that the timer integrates toward dropout and resetting the output to FALSE. PICKUP time T1 defines the time delay for the output to change to TRUE if the initiate input becomes TRUE and stays TRUE. RESET time T2 defines the time delay for the output to change to FALSE if it is presently TRUE and the initiate input becomes FALSE and stays FALSE.

In the example shown in Figure 4-50, RESET time T2 is set to half of the PICKUP time T1 setting. The initiate input expression becomes TRUE and the timer starts integrating toward pickup. Prior to timing out, the initiate expression toggles to FALSE and the timer starts resetting at twice the rate as it was integrating toward time out. It stays FALSE long enough for the integrating timer to reset completely but then toggles back to TRUE and stays TRUE for the entire duration of time T1. At that point, the output of the timer is toggled to TRUE. Then at some time later, the initiate expression becomes FALSE and stays FALSE for the duration of RESET time T2. At that point, the output of the timer is toggled to FALSE.

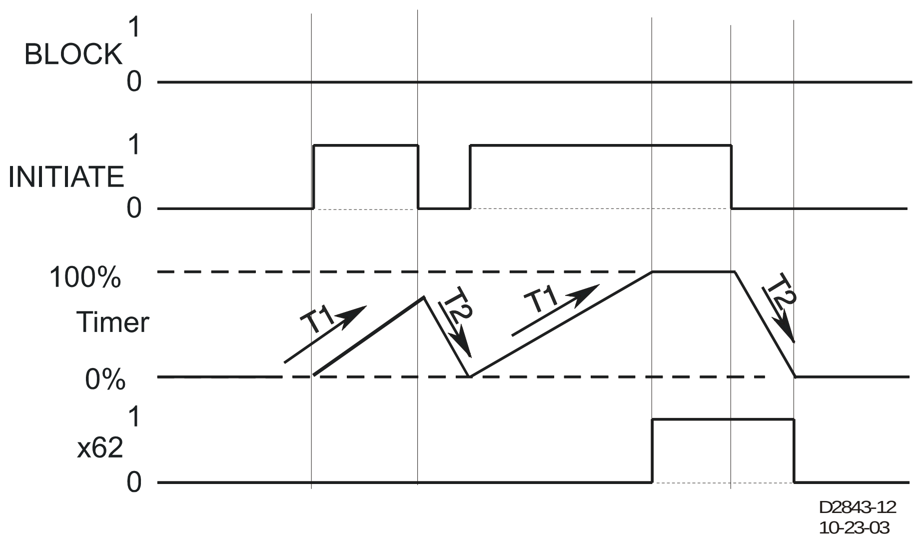

Figure 4-50. Mode 5, Integrating Timer

This type of timer is useful in applications where a monitored signal may be hovering at its threshold between on and off. For example, it is desired to take some action when current is above a certain level for a certain period of time. A 50T function could be used to monitor the current level. Thus, if the current level is near the threshold so that the *INITIATE* input toggles between TRUE and FALSE from time to time, the function will still time out as long as the time that it is TRUE is longer than the time that it is FALSE. With a simple pickup/dropout timer, the timing function would reset to zero and start over each time the initiate expression became FALSE.

Mode 6, Latch

A one shot timer starts its timing sequence when the *INITIATE* input expression changes from FALSE to TRUE. The timer will time for DELAY time T1 and then the output will latch TRUE. Additional *INITIATE* input expression changes of state are ignored. Time (T2) is ignored. Refer to Figure 4-51.

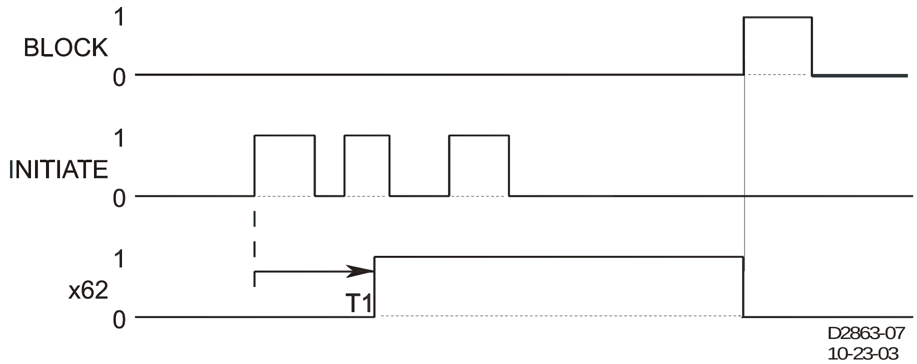

Figure 4-51. Mode 6, Latch

BESTlogic Settings for General Purpose Logic Timers

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-52 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Logic Timer* elements. To open the *BESTlogic Function Element* screen for *Logic Timer*, select *Logic Timers* from the *Screens* pull-down menu. Then select the *BESTlogic* button for either the 62 or the 162 element. Alternately, settings may be made using the SL-x62 ASCII command.

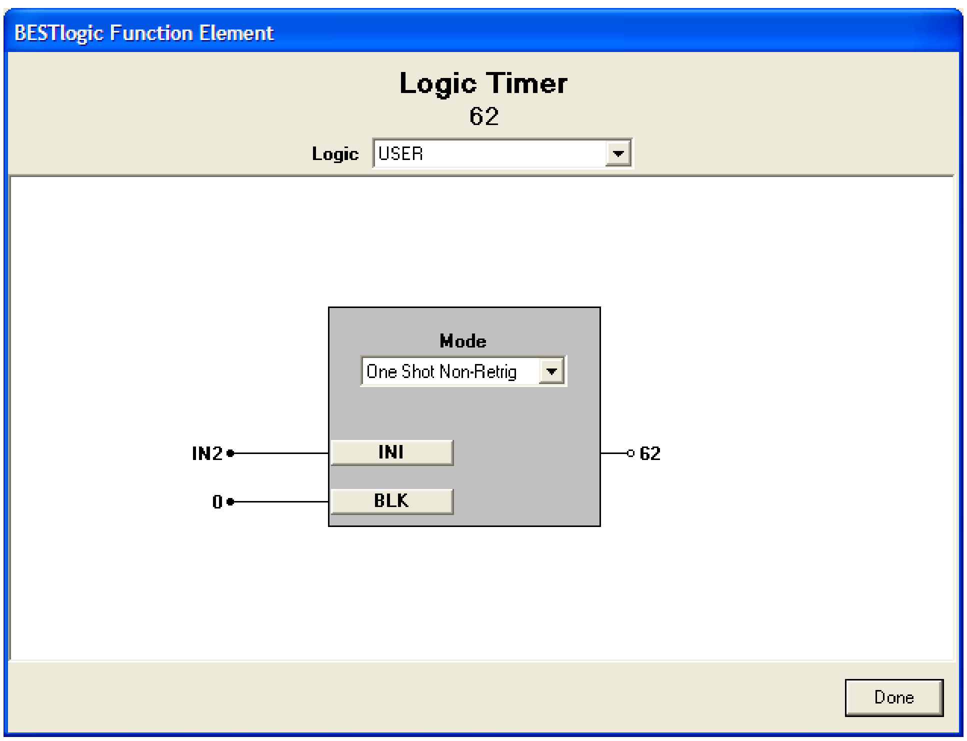

Figure 4-52. BESTlogic Function Element Screen, 62

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. User or custom logic must be selected on this menu in order to allow changes to the mode and inputs of the element. Enable the *Logic Timer* function by selecting its mode of operation from the *Mode* pull-down menu.

To connect the element's inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

Table 4-33 summarizes the BESTlogic settings for General Purpose Logic Timers.

Table 4-33. BESTlogic Settings for General Purpose Logic Timers

Function	Range/Purpose	Default
Logic Mode	0 = Disabled 1 = PU/DO 2 = One Shot Non-Retrig 3 = One Shot Retrig 4 = Oscillator 5 = Integrating 6 = Latch	0
INITIATE	Logic expression that initiates timing sequence.	0
BLOCK	Logic expression that disables function when TRUE.	0

Example 1. Make the following settings to the 62 Logic Timer. Figure 4-52 illustrates these settings.

Logic: User
Mode: One Shot Non-Retriggerable
INITIATE: IN2
BLOCK: 0

<u>*Operating Settings for General Purpose Logic Timers*</u>

Operating settings are made using BESTCOMS. Figure 4-53 illustrates the BESTCOMS screen used to select operational settings for the *Logic Timers* element. To open the *Logic Timers* screen, select *Logic Timers* from the *Screens* pull-down menu. Alternately, settings may be made using the S<g>-62/162 ASCII command or through the HMI interface using Screens 5.1.9.1 and 5.1.9.2.

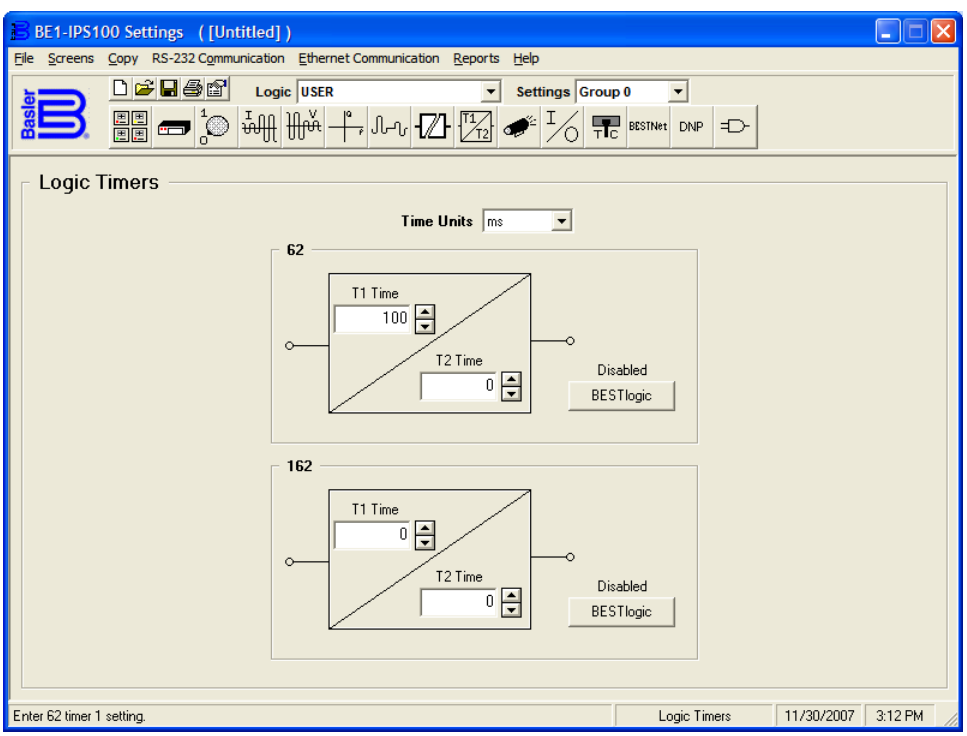

Figure 4-53. Logic Timers Screen

At the top left of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. User or custom logic <u>must</u> be selected on this menu in order to allow changes to be made to the mode and inputs of the element.

Beneath the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the element's settings apply to. See Section 7, *BESTlogic Programmable Logic, Logic Schemes*.

Using the pull-down menus and buttons, make the application appropriate settings to the *Logic Timers* element.

Table 4-34 summarizes the operating settings for General Purpose Logic Timers.

Table 4-34. Operating Settings for General Purpose Logic Timers

<table>
<tr><th>Setting</th><th>Range</th><th>Increment</th><th>Unit of Measure</th><th>Default</th></tr>
<tr><td rowspan="4">T1 Time,
T2 Time</td><td>0 to 999 ms</td><td>1</td><td>Milliseconds</td><td rowspan="4">0</td></tr>
<tr><td rowspan="2">0.1 to 9999 sec.</td><td>0.1 for 0.1 to 9.9 sec.</td><td rowspan="2">Seconds</td></tr>
<tr><td>1.0 for 10 to 9999 sec.</td></tr>
<tr><td>0 to 599,940 (60 Hz)
0 to 499,950 (50Hz)</td><td>∗</td><td>Cycles</td></tr>
</table>

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycles through the HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited to that appropriate for each of those units of measure.

Example 1. Make the following operating settings to the 62 element. Figure 4-53 illustrates these settings.

Logic: User
Setting: Group 0
Time units: ms
T1 Time: 100
T2 Time: 0

<u>*Retrieving General Purpose Logic Timers Status from the Relay*</u>

The status of each logic variable can be determined from the ASCII command interface by using the RG-STAT (report general-status) or the RL (report logic) commands. Status can also be determined using BESTCOMS *Metering* screen. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

RECLOSING

The BE1-IPS100 reclosing function provides up to four reclosing attempts that can be initiated by a protective trip or by one of the contact sensing inputs. The reclosers allow supervisory control and coordination of tripping and reclosing with other system devices. Any of the four recloser shots can be used to select a different setting group when the appropriate shot is reached in a reclosing sequence. This change in setting groups allows changing protection coordination during the reclosing sequence. For example, you could have a fast 51 curve on the first two trips in the reclosing sequence and then switch to a new group on the second reclose that uses a slow 51 curve. Detailed information about relay setting groups can be found earlier in this section under the heading of *Setting Groups.* Recloser function block inputs and outputs are shown in Figure 4-54 and are described in the following paragraphs. An overall logic diagram for the recloser function is shown in Figure 4-62.

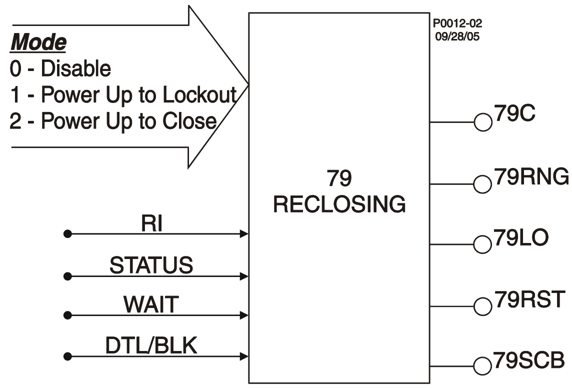

Figure 4-54. Reclosing Logic Block

Inputs and Outputs

Reclose Initiate (RI)

The *RI* input is used with the 52 status input to start the reclose timers at each step of the reclosing sequence. To start the automatic reclose timers, the *RI* input must be TRUE when the breaker status input indicates that the breaker has tripped. To ensure that the *RI* input is recognized, a recognition dropout timer holds the *RI* input TRUE for approximately 225 milliseconds after it goes to a FALSE state. This situation might occur if the *RI* is driven by the trip output of a protective function. As soon as the breaker opens, the protective function will drop out. The recognition dropout timer ensures that the *RI* signal will be recognized as TRUE even if the breaker status input is slow in indicating breaker opening. Figure 4-55 illustrates the recognition dropout logic and timing relationship.

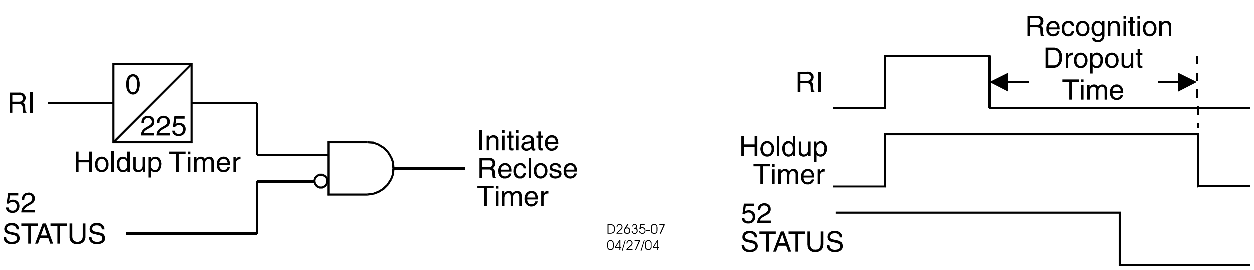

Figure 4-55. Recognition Dropout Timing

Breaker Status (STATUS)

This input is used to indicate to the recloser function block that the breaker is closed. A TRUE signal at this input indicates a closed breaker.

Reclose Wait (WAIT)

A TRUE signal at this input disables the reclosing function. In this condition, recloser timing is interrupted. When this input returns to a FALSE state, reclosing is enabled and recloser timing resumes.

Drive to Lockout/Block Recloser (DTL/BLK)

When TRUE, this input forces the reclosing function into the Lockout position. Lockout persists for the period defined by the Reset time after the *DTL/BLK* input becomes FALSE and the breaker is closed.

Close (79C)

The *79C* output becomes TRUE at the end of each reclose time delay and remains TRUE until the breaker closes. Any of the following conditions will cause the 79C output to become FALSE:

- The *STAT* input indicates that the breaker is closed.
- The reclose fail timer times out.
- The recloser goes to Lockout.
- The *WAIT logic is asserted.*

Recloser Running (79RNG)

The *79RNG* output is TRUE when the reclose is running (i.e., not in Reset or Lockout). This output is available to block the operation of a load tap changer on a substation transformer or voltage regulator during the fault clearing and restoration process.

Lockout (79LO)

This output is TRUE when the recloser is in the Lockout state. It remains TRUE until the recloser goes to the Reset state. The recloser will go to Lockout if any of the following conditions exist:

- More than the maximum number of programmed recloses is initiated before the recloser returns to the Reset state.
- The *DTL/BLK* input is TRUE.
- The Reclose Fail (79F) is TRUE.
- The maximum reclose cycle time is exceeded.

Reset Timer (79RST)

The 79RST output provides reset indication and is TRUE when the recloser is in the reset position.

Sequence Controlled Block (79SCB)

This output becomes TRUE when either the 52 status input OR the 79C input is TRUE AND the sequence operation (shot counter) matches one of the programmed steps of the S<g>-79SCB command. Figure 4-56 illustrates 79SCB logic.

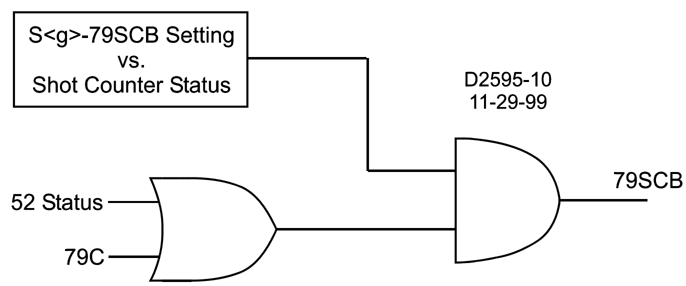

Figure 4-56. 79SCB Logic

BESTlogic Settings for Reclosing

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-57 illustrates the BESTCOMS screen used to select BESTlogic settings for the reclosing element. To open the *BESTlogic Function Element* screen for Reclosing (79), select *Reclosing* from the *Screens* pull-down menu. Alternately, settings may be made using the SL-79 ASCII command.

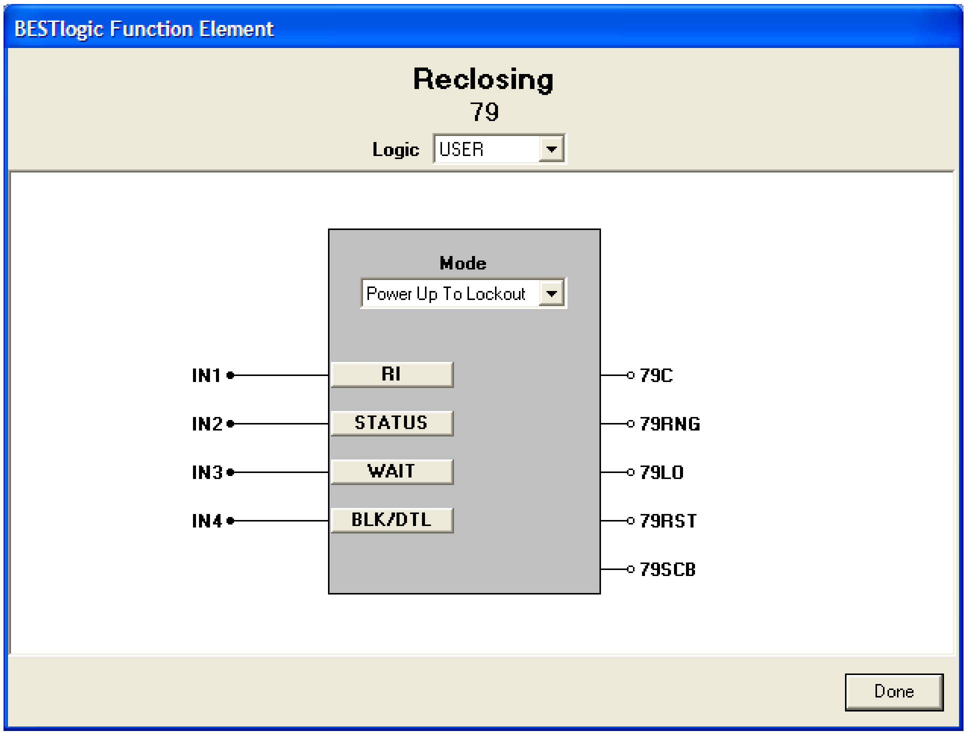

Figure 4-57. BESTlogic Function Element Screen, 79

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the reclosing function by selecting its mode of operation from the *Mode* pull-down menu. To connect the element's inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* after the settings have been completely edited.

Table 4-35 summarizes the BESTlogic settings for Reclosing.

Table 4-35. BESTlogic Settings for Reclosing

Function	Range/Purpose	Default
Mode	0 = Reclosing disabled 1 = Standard power-up operation. After power-up, the STATUS logic must be TRUE for the Reset time delay or the recloser automatically goes to Lockout. If the STATUS logic stays TRUE for reset time delay, the recloser goes to Reset. 2 = Power-up to close. If the recloser was in the Reset state when power was lost and when power is restored the STATUS logic is FALSE (breaker open) and the RI logic is TRUE, the recloser will initiate the first reclose operation. If the STATUS logic stays TRUE for the reset time delay, the recloser goes to Reset.	0
RI	OR logic term to initiate the operation of the reclosing function.	0
STATUS	OR logic term to indicate breaker status. TRUE/1 = closed, FALSE/0 = open.	0
WAIT	OR logic term to momentarily disable but not reset the recloser.	0
BLK/DTL	OR logic term to disable the recloser (drive to lockout).	0

Operating Settings for Reclosing

Operating settings are made using BESTCOMS. Figure 4-58 illustrates the BESTCOMS screen used to select operational settings for the reclosing element. To open the screen, select *Reclosing* from the *Screens* pull-down menu. Alternately, settings may be made using the S<g>-79 ASCII command.

Settings can also be made from the front panel HMI using Screens 5.x.11.1 through 5.x.11.5 where x equals 1 for Setting Group 0 and 2 for Setting Group 1.

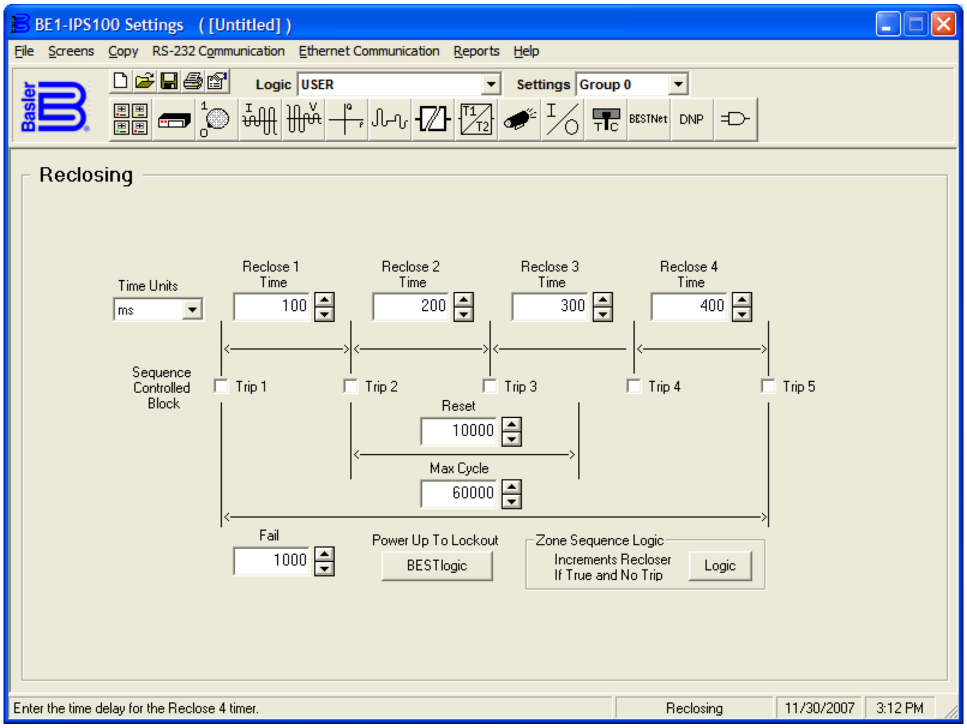

Figure 4-58. Reclosing Screen

At the top of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic setting can be changed. See Section 7, *BESTlogic Programmable Logic*. To the right of the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the element's settings apply to.

Selecting the time units selects the time measurement that applies to all of the reclosing timers, Reset timer, Max Cycle timer, and Reset Fail timer.

Using the pull-down menus and buttons, make the application appropriate settings to the reclosing function.

Table 4-36 summarizes the operating settings for Reclosing.

Table 4-36. Operating Settings for Reclosing

Setting	Range	Increment	Default
Time Delays	0.1 to 600 seconds	0.001 second (0 to 0.999 seconds) 0.1 second (1.0 to 9.9 seconds) 1 second (10 to 600 seconds) 0.1 cycles (6 to 36000 cycles)	791 = 0
			792 = 0
			793 = 0
			794 = 0
			79R = 10s
			79F = 1s
			79M = 60s

Setting	Range	Increment	Default
Step List	1. 79SCB TRUE during Reset and while timing to Reset after Lockout. 2. 79SCB TRUE when 79C is TRUE for first reclose and while timing to Reset after first reclose. 3. 79SCB TRUE when 79C is TRUE for second reclose and while timing to Reset after second reclose. 4. 79SCB TRUE when 79C is TRUE for third reclose and while timing to Reset after third reclose. 5. 79SCB TRUE when 79C is TRUE for fourth reclose and while timing to Reset after fourth reclose.		0

Reclosing Fail Timer (79F)

This timer begins when the 79C output becomes TRUE and continues counting until the *STATUS* input becomes TRUE. If the 79F timer times out, the recloser function is driven to lockout and the 79LO output becomes TRUE. The relay remains in Lockout until the breaker is manually closed and the *STATUS* input remains TRUE for the reset time. This setting can be changed on the *Reclosing* screen in BESTCOMS. See Figure 4-58.

Maximum Cycle Timer (MAX Cycle)

Max Cycle is the reclose maximum operation time. If a reclose operation is not completed before the maximum operate time expires, the recloser goes to *Lockout*. This timer limits the total fault clearing and restoration sequence to a definable period. The timer starts when the first trip command is issued from a protective element of the relay. The Max Cycle timer stops when the recloser is reset. If the total reclosing time between *Reset* states exceeds the maximum reclose cycle timer setting, the recloser will go *Lockout*. If the WAIT input goes high during the Max Cycle timing sequence, Max Cycle timing will “pause” until the WAIT input goes low. If not desired, the Max Cycle timer can be disabled by setting it at zero. This setting can be changed on the *Reclosing* screen in BESTCOMS. See Figure 4-58.

Sequence Controlled Blocking (SCB)

The 79SCB output is TRUE when the breaker is closed, the 79 close output (79C) is TRUE, and the reclose sequence step is enabled with a non-zero value. A 0 (zero) disables the 79SCB output. This setting can be changed on the *Reclosing* screen in BESTCOMS by checking the appropriate *Trip* box. See Figure 4-58.

Figure 4-59 shows a logic timing diagram showing all possible sequence controlled blocks enabled (TRUE). In Figure 4-60, 79RTD is the reclose reset time delay and 79#TD is the reclose time delay where # is the reclose shot number.

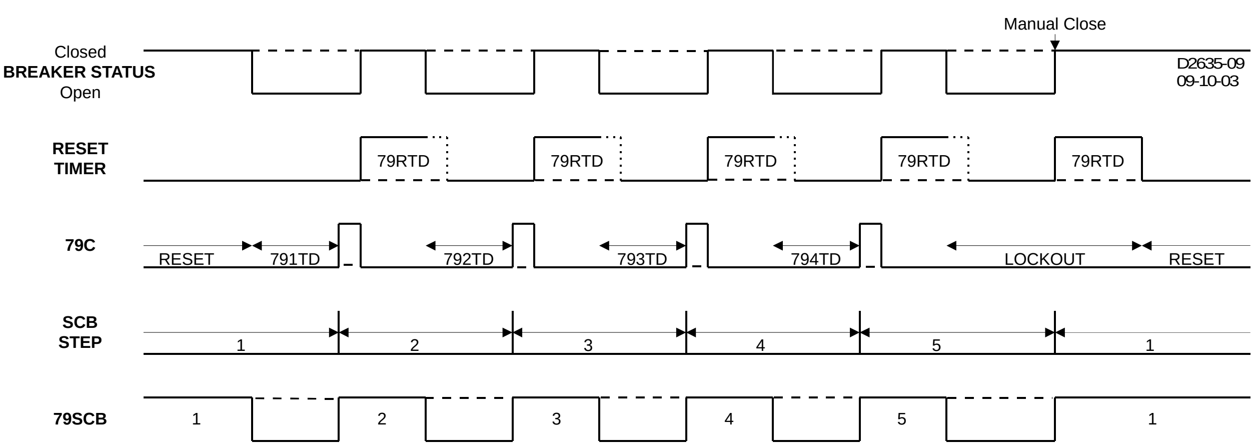

Figure 4-59. S#-79SCB=1/2/3/4/5 Logic Timing Diagram

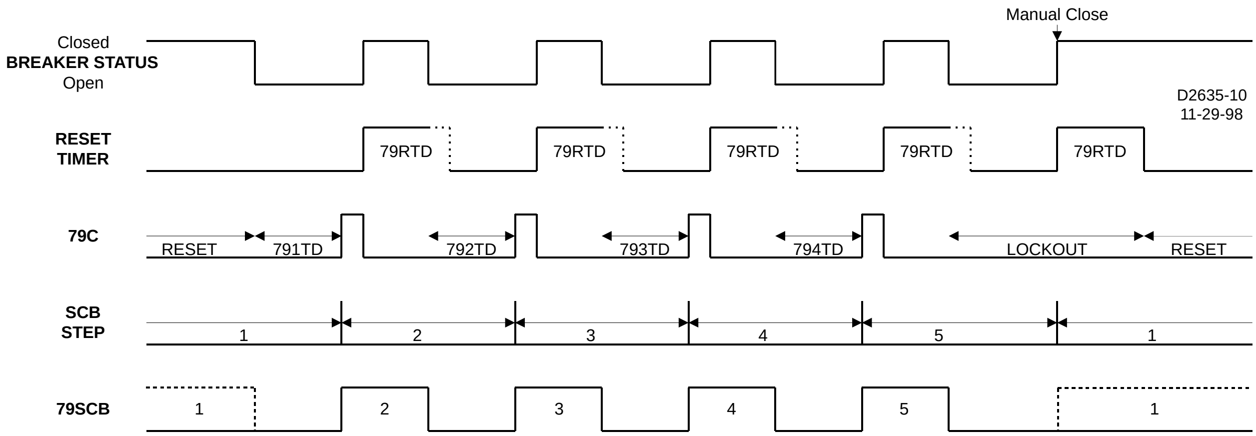

Figure 4-60. S#-79SCB=2/3/4/5 Logic Timing Diagram

Zone-Sequence Coordination

To coordinate tripping and reclosing sequences with downstream protective relays and reclosers, the BE1-IPS100 senses fault current from downstream faults when a user programmable logic, set by the SP-79ZONE command, picks up and then drops out without a trip output (defined with the SG-TRIGGER command) occurring. Typically, the low-set instantaneous pickup outputs (50TPPU and 50TNPU) or the time overcurrent pickup outputs (51PPU and 51NPU) are used for the zone sequence settings (SP-79ZONE=50TPPU+50TNPU or SP79ZONE=51PPU+51NPU).

If the upstream relay (BE1-IPS100) senses that a downstream device has interrupted fault current, the BE1-IPS100 will increment the trip/reclose sequence by one operation. This occurs because the BE1-IPS100 recognizes that a non-blocked low set (50TP or 50TN) element picked up and reset before timing out to trip.

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-61 illustrates the BESTCOMS screen used to select Zone Sequence Coordination Logic settings for the reclosing element. To open the *BESTlogic Function Element* screen for Reclosing (Zone Sequence Logic), select *Reclosing* from the *Screens* pull-down menu and click on the *Logic* button next to Zone Sequence Logic in the lower right corner of the screen. Alternately, settings may be made using the SP-79ZONE ASCII command.

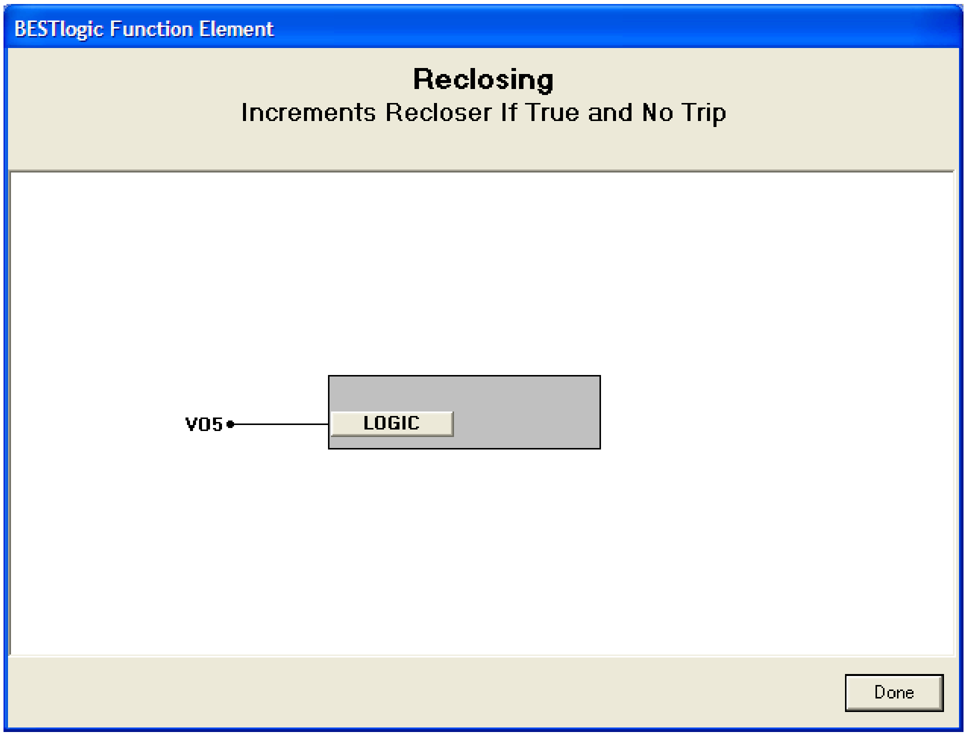

Figure 4-61. BESTlogic Function Element Screen, Reclosing (Zone Sequence Logic)

Table 4-37 summarizes the settings for Zone-Sequence Coordination.

Table 4-37. Settings for Zone-Sequence Coordination

Function	Range/Purpose
Zone Pickup Logic	The zone sequence pickup logic defines which logic elements should be considered zone sequence pickups. Only OR (+) logic can be used – no AND (∗) variables may be used.

Recloser zone-sequence coordination detects when a downstream recloser has cleared a fault and increments the upstream 79 automatic reclose count to maintain a consistent count with the other recloser. A fault is presumed cleared downstream when one or more protective functions pickup and dropout with no trip occurring. If the zone pickup logic becomes TRUE and then FALSE without a trip output operating, then the 79 automatic reclose counter should be incremented. The Max Cycle timer resets the shot counter.

Retrieving Reclosing Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

Figure 4-62 (next page) illustrates an overall logic diagram for Reclosing.

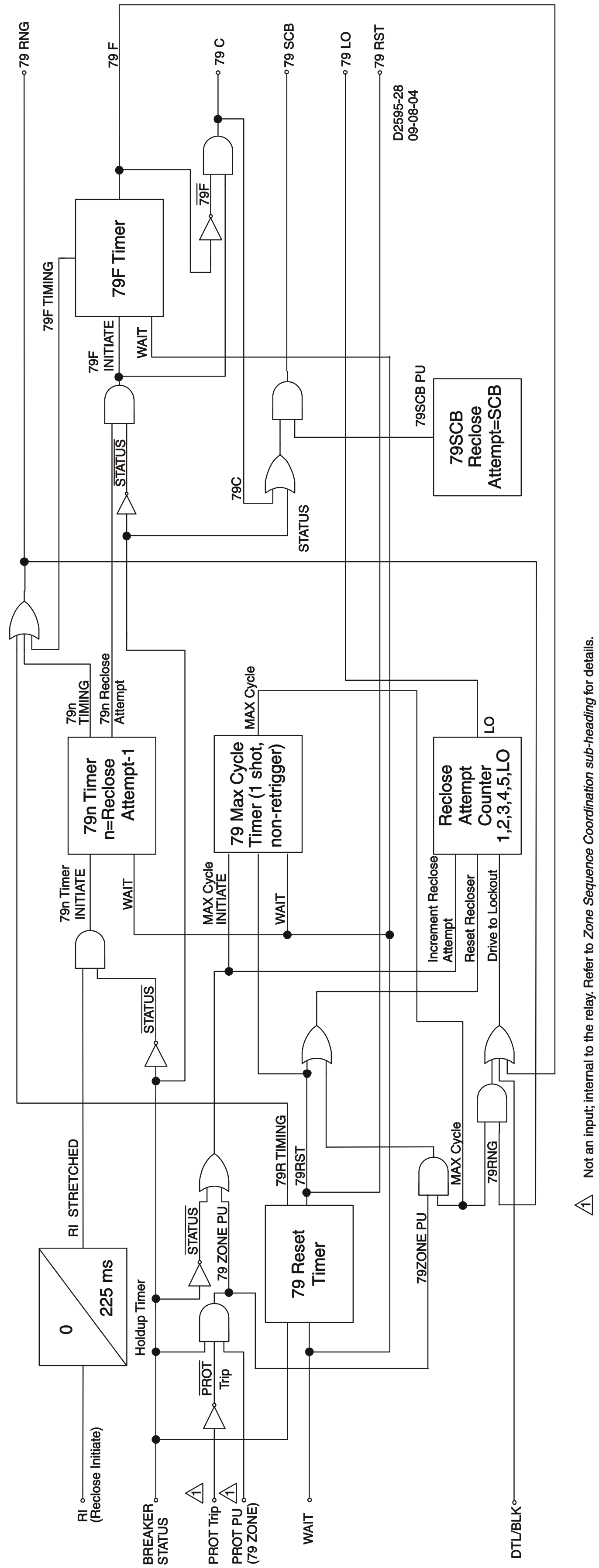

Figure 4-62. Overall Logic Diagram for Reclosing

SYNC-CHECK PROTECTION

25 - Sync-Check Protection

Figure 4-63 illustrates the inputs and outputs of the Sync-Check element. Element operation is described in the following paragraphs.

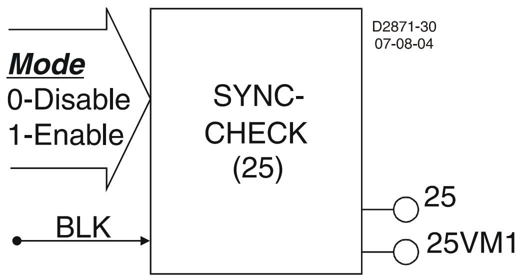

Figure 4-63. Sync-Check Logic Block

The Sync-Check element has two outputs: 25 and 25VM1. When monitored voltage between the systems as measured by the phase VTs and the auxiliary Vx input circuits meets angle, voltage and slip criteria, the 25 output becomes TRUE. 25VM1 is the voltage monitor output.

The *BLK* (Block) input is used to disable synchronism checking. A BESTlogic expression defines how the *BLK* input functions. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0. This feature functions in a similar way to the torque control contact of an electromechanical relay.

The 25 element is enabled or disabled by the mode input. Two modes are available. Selecting Mode 0 disables the 25 element and selecting Mode 1 enables the 25 element.

The 25 function module will change the 25 output to TRUE if the following conditions are met:

a) Phase angle between systems is less than setting.

b) Frequency error between systems is less than setting. As an additional parameter, the relay can be set to only allow generator frequency greater than bus frequency.

c) Voltage magnitude between systems is less than setting (the voltage used by the relay for this feature is a voltage magnitude measurement, not a voltage phasor measurement).

The BE1-IPS100 compares the VTP voltage magnitude and angle to the VTX voltage magnitude and angle to determine synchronism. Therefore, proper connection of the VT inputs is vital to the correct operation of the 25 function.

The relay automatically compensates for phase angle differences associated with the phase and auxiliary VT connections, including single-phase VTP connections. That is, for a VTP selection of phase to phase and a VTX selection of phase to neutral, the relay will automatically compensate for the 30-degree angle between the two voltage sources. **However, the relay does not scale for differences in magnitude between the applied voltages.** For example, if VTP = 4W (L-N) and VTX=AB (L-L), the angle is automatically compensated for. However, one of the input magnitudes needs to be scaled by SQRT (3) so that the magnitude of the compared voltages is equivalent under sync conditions. **Note:** The sync-check will not work if VTX connections are set for residual voltage input VTX=RG.

For clarification on single-phase VTP connections, refer to the interconnection diagrams shown in Section 12, *Installation*, of this manual. The single-phase parallel connections ensure that the zero-crossing circuit is always connected to the sensed circuit.

For single-phase sensing connections derived from a <u>phase-to-neutral</u> source:

H1 Case:	Terminals C13, C14, C15 (A, B, C) are connected in parallel. The single-phase signal is connected between the parallel group and C16 (N).
S1 Double-Ended Case:	Terminals C16, C15, C14 (A, B, C) are connected in parallel. The single-phase signal is connected between the parallel group and C13 (N).

For single-phase sensing connections derived from a <u>phase-to-phase</u> source:

H1 Case:	Terminals C14, C15, C16 (B, C, N) are connected in parallel. The single-phase signal is connected between C13 (A) and the parallel group (AB, BC, CA).

S1 Double-Ended Case: Terminals C15, C14, C13 (B, C, N) are connected in parallel. The single-phase signal is connected between C16 (A) and the parallel group (AB, BC, CA).

Also note that VM performs three of three testing for all connections. For 3W and 4W, phases A, B, and C are actually tested. For single-phase connections, the terminals are connected in parallel as described above and the single-phase is tested three times. This is implemented this way for convenience, allowing the exact same code for both conditions.

Measuring slip frequency directly allows the function to rapidly determine if systems are in synchronism and requires no timer or inherent delay (as compared to systems that check only that phase angle is held within a window for some stretch of time). The moment parameters a), b), and c) in the previous paragraph are met, the systems may be considered in synchronism and the output becomes TRUE. Refer to Section 5, *Metering*, for more information about slip frequency measurement.

NOTE

If the 60FL element logic is TRUE and V block is enabled for phase blocking (P), the 25 element will be blocked. For more information on the 60FL function, see *Voltage Transformer Fuse Loss Detection* later in Section 4.

BESTlogic Settings for Sync-Check Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-64 illustrates the BESTCOMS screen used to select BESTlogic settings for the Sync-Check element. To open the *BESTlogic Function Element* screen for the *Sync-Check* element, select *Voltage Protection* from the *Screens* pull-down menu. After selecting the *25* Tab, select the *BESTlogic* button. Alternately, settings may be made using SL-25 ASCII command.

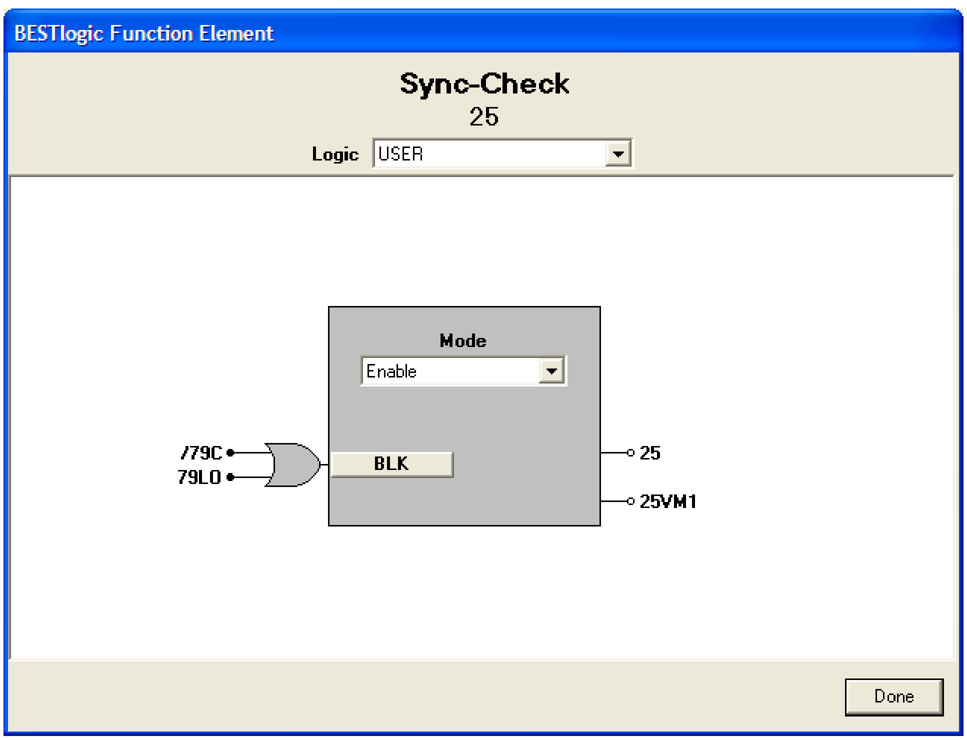

Figure 4-64. BESTlogic Function Element Screen, 25

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the Sync-Check function by selecting its mode of operation from the *Mode* pull-down menu. To connect the element's inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

Table 4-38 summarizes the BESTlogic settings for Sync-Check Protection.

Table 4-38. BESTlogic Settings for Sync-Check Protection

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled	0
BLK	Logic expression that disables function when TRUE. A setting of 0 disables blocking.	0

Example 1. Make the following BESTlogic settings to the Sync-Check element. Refer to Figure 4-64.

Mode: Enable

BLK: /79C OR 79LO

<u>*Operating Settings for Sync-Check Protection*</u>

Operating settings are made using BESTCOMS. Figure 4-65 illustrates the BESTCOMS screen used to select operational settings for the Sync-Check element. To open the *Voltage Protection* screen, select *Voltage Protection* from the *Screens* pull-down menu. Then select the *25* Tab. Alternately, settings may be made using the S<g>-25 ASCII command or through the HMI using Screens 5.x.2.1 through 5.x.2.4 where g equals the setting group number and x equals 1 (Setting Group 0) and 2 (Setting Group 1).

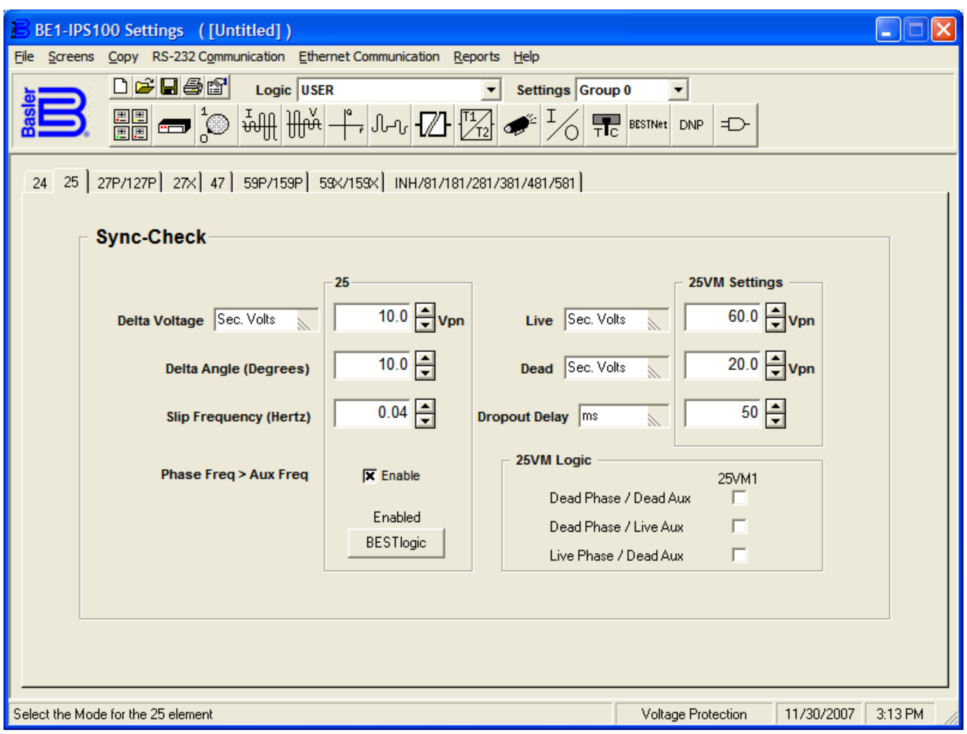

Figure 4-65. Voltage Protection Screen, 25 Tab

Beside the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The Settings menu is used to select the setting group that the elements settings apply to.

The default unit of measure for *Delta Voltage* is secondary volts (Sec. Volts). Primary volts (Pri Volts), per unit volts (Per U Volts), and percent volts (% Volts) can also be selected as the pickup setting unit of measure.

Table 4-39 summarizes the operating settings for Sync-Check Protection.

Table 4-39. Operating Settings for Sync-Check Protection

Setting	Range	Increment	Unit of Measure	Default
Delta Voltage	1 to 20	0.1	Secondary volts	1
Delta Angle	1 to 99	0.1	Degrees	10
Slip Frequency	0.01 to 0.5	0.01	Hertz	0.01
Phase Frequency > Aux Frequency	0 = Disabled 1 = Enabled	N/A	N/A	0

Example 1. Make the following operating settings to the Sync-Check element. Refer to Figure 4-65.

Delta Voltage: 10.0
Delta Angle: 10.0
Slip Frequency: 0.40
Phase Freq > Aux Freq: Enabled

<u>Retrieving Sync-Check Protection Status from the Relay</u>

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

25VM - Voltage Monitor

Operating settings for the 25VM are made on the *Voltage Protection* screen at the *25* tab. Refer to Figure 4-65. Settings can also be made with the S0-25VM ASCII command or on HMI Screens 5.x.2.2 – 5.x.2.4.

Table 4-40 summarizes the operating settings for Voltage Monitor.

Table 4-40. Operating Settings for Voltage Monitor

Setting	Range	Increment	Unit of Measure	Default
Live	10 to 150	0.1 for 10 to 100 1 for 100 to 150	Volts	60
Dead	10 to 150	0.1 for 10 to 100 1 for 100 to 150	Volts	20
Dropout Delay	50 to 60000	1 for 50 to 999 100 for 1000 to 9900 1000 for 10000 to 60000	Milliseconds	50 ms
	0.050 to 60	0.001 for 0.050 to 0.999 0.1 for 1.0 to 9.9 1 for 10 to 60	Seconds	
25VM1	0 = Disabled 1 – 3, 12, 13, 23, 123	N/A	N/A	0

The sync-check output, 25, only provides closing supervision for the live line/live bus condition. The voltage monitor function 25VM is provided for conditions where the bus and/or the line are dead. A live condition for either the VP or the VX is determined when the measured voltage on the respective input is above the measured voltage and below the DV threshold.

For the phase voltage input, if the connection is three phase, 3W or 4W, all three phases are tested and must be above the LV threshold for a live condition to be TRUE. Similarly, all three phases must be below the DV threshold for a dead condition to be TRUE.

The function includes one independent output, 25VM1 as illustrated in Figure 4-66. The logic conditions are summarized in Table 4-41. Any combination of logic settings can be selected as shown in Table 4-41. When a logic condition is selected, it closes the respective switch in Figure 4-66 associated with each of the outputs. The two independent logic outputs might be used to set up different closing supervision criteria for automatic reclose versus manual close.

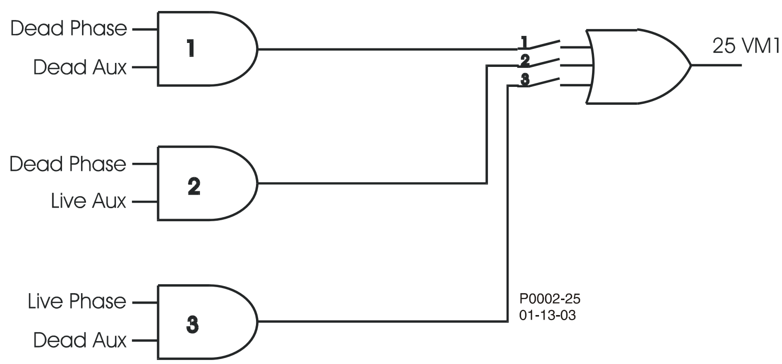

Figure 4-66. 25VM Logic

Table 4-41. Logic Settings for Voltage Monitor

Voltage Monitor Logic Condition	Logic Setting
Dead Phase and Dead Aux	1
Dead Phase and Live Aux	2
Live Phase and Dead Aux	3

Retrieving Voltage Monitor Status from the Relay

The status of each logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

VOLTAGE TRANSFORMER FUSE LOSS DETECTION

60FL - Fuse Loss Detection

BE1-IPS100 relays have one 60FL element that can be used to detect fuse loss or loss of potential in a three-phase system. The 60FL element is illustrated in Figure 4-67. When the element logic becomes TRUE, the 60FL logic output becomes TRUE. A logic diagram is shown in Figure 4-68. Logic parameters are shown in Table 4-42.

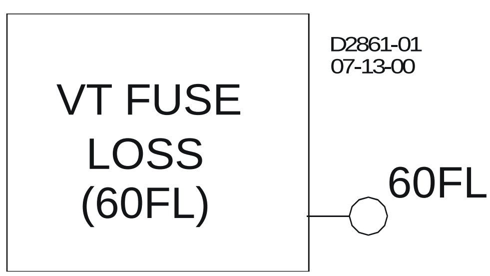

Figure 4-67. Fuse Loss Detection Logic Block

Trip Logic: 60FL Trip = (A * B * C * D * G) + (E * F * B * G) (See Table 4-42.)

Reset Logic: 60FL Reset = H * /K */L (See Table 4-42.)

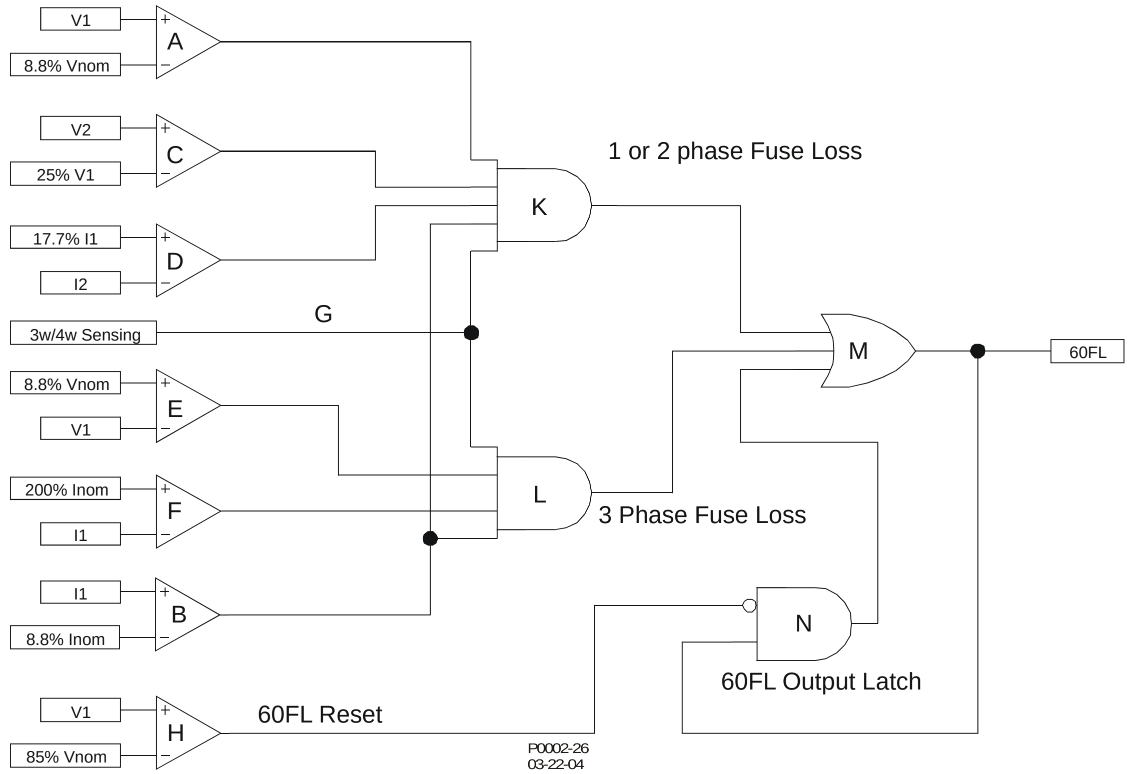

Figure 4-68. 60FL Element Logic

Table 4-42. 60FL Logic Parameters

Input	TRUE Condition
A	Positive-sequence volts greater than 8.8% of the nominal voltage; Detects minimum voltage is applied.
B	Positive-sequence amps greater than 8.8% of the nominal current; Detects minimum current is applied.
C	Negative-sequence volts greater than 25% of the pos-seq volts; Detects loss of 1 or 2 phase voltages.
D	Negative-sequence amps less than 17.7% of the pos-seq amps; Detects a normal current condition.
E	Positive-sequence volts less than 8.8% of the nominal voltage; Detects loss of 3-phase voltage.
F	Positive-sequence amps less than 200% of the nominal current; Detects a normal load current condition.
G	Three-wire or four-wire sensing selected.
H	Positive-sequence volts greater than 85% of nominal voltage; Detects a restored voltage condition.
K	(A * B * C * D * G); Detects when either one or two phases are lost.
L	(E * F * B * G); Detects when all three phases are lost.
M, N	Latches the 60FL output until the reset criteria is met.

Fuse Loss Detection Blocking Settings

The 60FL logic bit is always enabled regardless of the SP-60FL setting. User selectable block settings determine how certain (not all) current and voltage protective functions operate when a fuse loss condition exists (see Table 4-43). The I Block setting (51/27R) assumes that the voltage is VNOM when 60FL is TRUE because the voltage measurement is not present or is unreliable. If the input voltage is nominal, then voltage restraint and control have no effect. The V Block settings (P, N, Q) determine which voltage functions are blocked when the 60FL logic is TRUE.

Settings are made using BESTCOMS. Figure 4-69 illustrates the BESTCOMS screen used to select blocking settings for the 60FL element. Select *Reporting and Alarms* from the *Screens* pull-down menu and select the *VT Monitor* tab. Alternately, settings may be made using the SP-60FL ASCII command. See Section 11, *ASCII Command Interface, Command Summary, Protection Setting Commands,* for more information.

Table 4-43. 60FL Element Blocking Settings

Mode Input	Setting	Explanation	Default
I Block	DIS	When I Block is disabled, current tripping level is determined by the sensing voltage level (51/27R operates normally).	ENA
	ENA	When I Block is enabled and the 60FL logic is TRUE (voltage sensing is lost), the current tripping level is controlled by the 51P function and the 27R function is inhibited. When I Block is enabled and the 60FL logic is FALSE, the current tripping level is controlled by the 51/27R function.	
V Block	DIS	Phase (P), Neutral (N), and Negative-Sequence (Q) voltage functions are not automatically blocked when 60FL logic is TRUE.	PNQ
	P	All functions that use phase voltage are blocked when the 60FL logic is TRUE. (27P/127P, 59P/159P, and 25)	
	N	All functions that use 3-phase residual voltage ($3V_0$) measurements are blocked when the 60FL logic is TRUE. (27X, 59X, 159X, - Mode 2)	
	Q	All functions that use the negative-sequence voltage (V_2) measurement are blocked when the 60FL logic is TRUE. (47)	

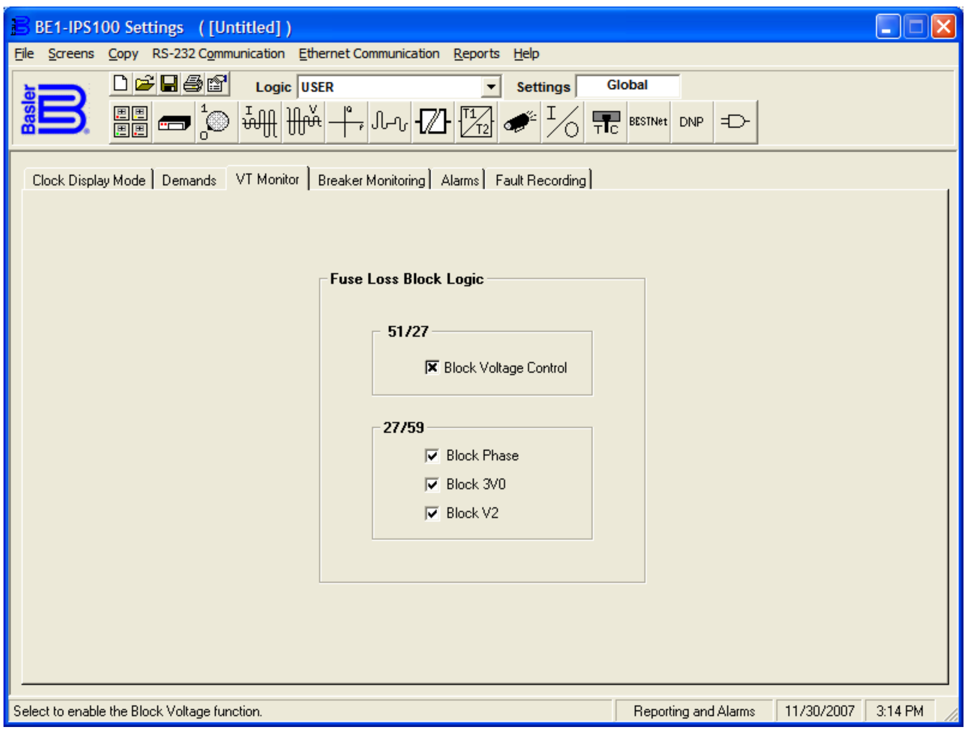

Figure 4-69. Reporting and Alarms Screen, VT Monitor Tab

The directional tests are also supervised by the loss of potential function 60FL. If the 60FL bit is TRUE, then voltage sensing was loss or is unreliable. Under this condition positive, negative, and zero-sequence directional tests are disabled and their bits are cleared. There is no user setting to enable or disabled this supervision. Current polarization is not effected by the 60FL since it does not rely on voltage sensing. Similarly, zero-sequence voltage polarization can only be performed if 3P4W sensing is selected. The following qualifiers are applied to the voltage polarized ground direction element based on the user selected input quantity:

V0IN inputs:

Test: 60FL=FALSE & 3P4W=TRUE & (IN > minimum) & (IN > I1*8%) & (V0 > minimum)

V0IG inputs:

Test: 60FL=FALSE & 3P4W=TRUE & (IG > minimum) & (V0 > minimum)

VXIN inputs:

Test: (IG > minimum) & (IN > I1*8%) & (VX > minimum)

VXIG inputs:

Test: (IG > minimum) & (VX > minimum)

I Block and V Block settings are made using the SP-60FL command.

The 60FL element detects fuse loss and loss of potential by using voltage and current thresholds that are expressed as a percentage of the nominal voltage and current values. See Section 3, *Input and Output Functions*, for information on changing the nominal voltage and current values using the SG-NOM command.

Retrieving Fuse Loss Detection Status from the Relay

The status of the logic variable can be determined through the ASCII command interface using the RG-STAT (report general-status) command. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status can also be determined using BESTCOMS *Metering* screen.

VIRTUAL SWITCHES

43 - Virtual Selector Switches

The BE1-IPS100 Intertie Protection System has two virtual selector switches that can provide manual control, locally and remotely, without using physical switches and/or interposing relays. Each virtual switch can be set for one of three modes of operation to emulate virtually any type of binary (two position) switch. An example would be an application that requires a ground cutoff switch. The traditional approach might be to install a switch on the panel and wire the output to a contact sensing input on the relay or in series with the ground trip output of the relay. Instead, a virtual switch can be used to reduce costs with the added benefit of being able to operate the switch both locally through the HMI and remotely from a substation computer or through a modem connection to a remote operator's console.

The state of the switches can be controlled from the optional HMI or ASCII command interface. Control actions can be set by the BESTlogic mode setting. When set for *On/Off/Pulse*, each switch can be controlled to open (logic 0), close (logic 1), or pulse such that the output toggles from its current state to the opposite state and then returns. Additional modes allow the switch operation to be restricted. In *On/Off*, the switch emulates a two-position selector switch, and only open and close commands are accepted. In *Off/Momentary On*, a momentary close, spring-return switch is emulated and only the pulse command is accepted. Because switch status information is saved in nonvolatile memory, the relay powers up with the switches in the same state as when the relay was powered down.

Each virtual selector switch element (see Figure 4-70) has one output: 43 or 143. The output is TRUE when the switch is in the closed state; the output is FALSE when the switch is the open state. Since both the output and the inverse of the output of these switches can be used as many times as desired in your programmable logic, they can emulate a switch with as many normally open and normally closed decks as desired.

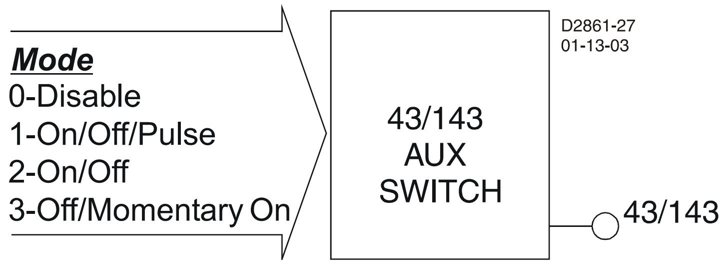

Figure 4-70. Virtual Selector Switches Logic Block

User specified labels could be assigned to each virtual switch and to both states of each switch. In the previous ground cutoff switch example, you might enable one of the switches in BESTlogic as Mode 2, ON/OFF and connect the output of that switch to the blocking input of the 59x protection element. This would disable the ground overvoltage protection when the switch is closed (logic 1) and enable it when the switch is open (logic 0). For the application, you might set the switch label to be 59N_CUTOFF (10 character maximum). The closed position on the switch might be labeled DISABLD (7 character maximum) and the open position might be labeled NORMAL. Section 7, *BESTlogic Programmable Logic*, has more details about setting user programmable names for programmable logic variables.

BESTlogic Settings for Virtual Selector Switches

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-71 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Virtual Switch* element. To open the *BESTlogic Function Element* screen for the *Virtual Switch* element, select *Virtual Switches* from the *Screens* pull-down menu. Then select the *BESTlogic* button for the virtual switch to be edited. Alternately, settings may be made using SL-43 or SL-143 ASCII commands.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic.* This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the Virtual Switch function by selecting its mode of operation from the *Mode* pull-down menu. Select *Done* when the settings have been completely edited.

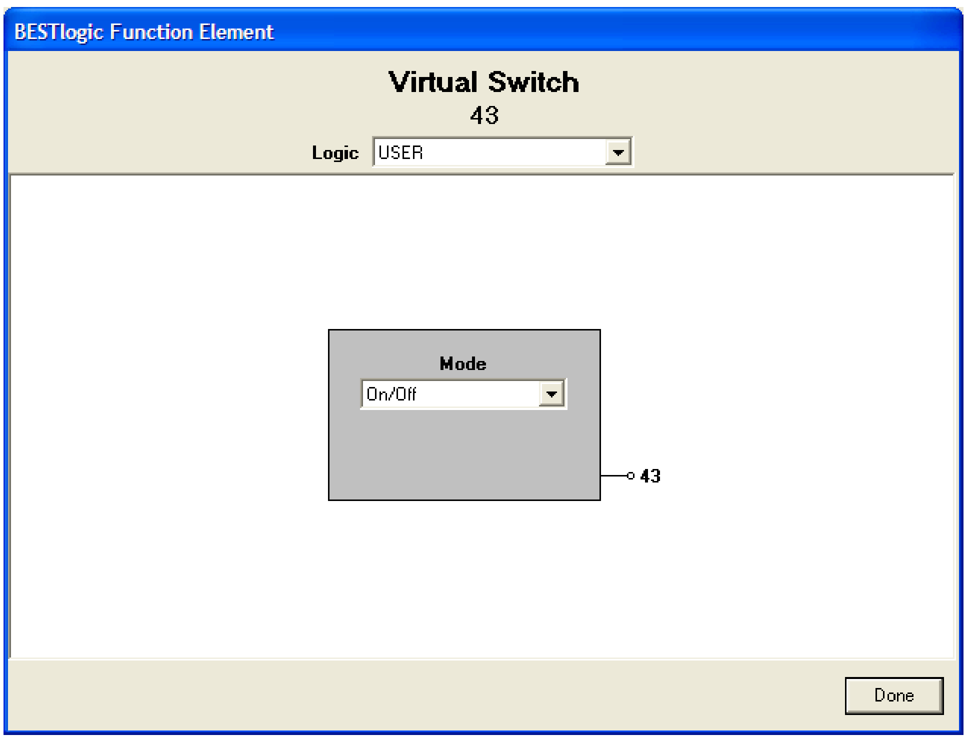

Figure 4-71. BESTlogic Function Element Screen, 43

Table 4-44 summarizes the BESTlogic settings for Virtual Selector Switches. These settings enable the x43 element by selecting the mode of operation. There are no logic inputs.

Table 4-44. BESTlogic Settings for Virtual Selector Switches

Function	Range/Purpose	Default
Mode	0 = Disabled 2 = On/Off 1 = On/Off/Pulse 3 = Off/Momentary On	0

Example 1. Make the following BESTlogic settings to the Virtual Switch function. See Figure 4-71.

Mode: On/Off

<u>Select Before Operate Control of Virtual Selector Switches</u>

The state of each virtual selector switch can be controlled at the HMI through Screens 2.1.1 and 2.1.2. Control is also possible through the ASCII command interface by using the select-before-operate commands CS-x43 (control select-virtual switch) and CO-x43 (operate select-virtual switch). A state change takes place immediately without having to execute an *Exit - Save* settings command.

CS/CO-x43 Command

Purpose: Select and operate the virtual selector switches.

Syntax: CS/CO-<x>43[=<Action>]

Comments: x = no entry for 43 or 1 for 143. Action = 0 to open the switch, 1 to close the switch, P to pulse the switch to the opposite state for 200 milliseconds and then automatically return to starting state.

The virtual switch control commands require the use of select-before-operate logic. First, the command must be selected using the CS-x43 command. After the select command is entered, there is a 30 second window during which the CO-x43 control command will be accepted. The control selected and the operation selected must match exactly or the operate command will be blocked. If the operate command is blocked, an error message is output.

CS/CO-x43 Command Examples:

Example 1. Read the current status of Virtual Switch 43.

```
>CO-43
0
```

Example 2. Momentarily toggle the state of Switch 43 to closed.

```
>CS-43=P
43=P SELECTED
>CO-43=P
43=P EXECUTED
```

Example 3. An example of an operate command not matching the select command.

```
>CO-143=1
ERROR:NO SELECT
```

<u>Retrieving Virtual Selector Switches Status from the Relay</u>

The state of each virtual selector switch can be determined from HMI Screen 1.5.4. This information is also available through the ASCII command interface by using the RG-STAT command and on BESTCOMS *Metering* screen. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

HMI Screens 2.1.1 and 2.1.2 provide switch control and can also display the current status of their respective switches. ASCII command CO-x43 returns the state of each virtual selector switch in a read-only mode. See the previous Example 1.

101 - Virtual Breaker Control Switch

The virtual breaker control switch (shown in Figure 4-72) provides manual control of a circuit breaker or switch without using physical switches and/or interposing relays. Both local and remote control is possible. A virtual switch can be used instead of a physical switch to reduce costs with the added benefit that the virtual switch can be operated both locally from the HMI and remotely from a substation computer or modem connection to an operator's console.

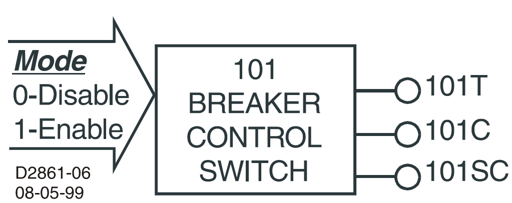

Figure 4-72. Virtual Breaker Control Switch Logic Block

The breaker control switch emulates a typical breaker control switch with a momentary close, spring return, trip contact (output 101T), a momentary close, spring return, close contact (output 101C), and a slip contact (output 101SC). The slip contact output retains the status of the last control action. That is, it is FALSE (open) in the after-trip state and TRUE (closed) in the after-close state. Figure 4-73 shows the state of the 101SC logic output with respect to the state of the 101T and 101C outputs.

When the virtual control switch is controlled to trip, the 101T output pulses TRUE (closed) for approximately 200 milliseconds and the 101SC output goes FALSE (open). When the virtual control switch is controlled to close, the 101SC output pulses TRUE (closed). The status of the slip contact output is saved to nonvolatile memory so that the relay will power up with the contact in the same state as when the relay was powered down.

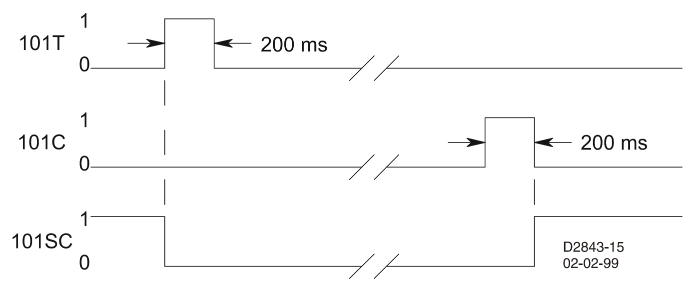

Figure 4-73. Virtual Breaker Control Switch State Diagram

BESTlogic Settings for Virtual Breaker Control Switch

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-74 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Breaker Control Switch* element. To open the *BESTlogic Function Element* screen for the *Virtual Switch* element, select *Virtual Switches* from the *Screens* pull-down menu. Then select the *BESTlogic* button for the virtual switch to be edited. Alternately, settings may be made using the SL-101 ASCII command.

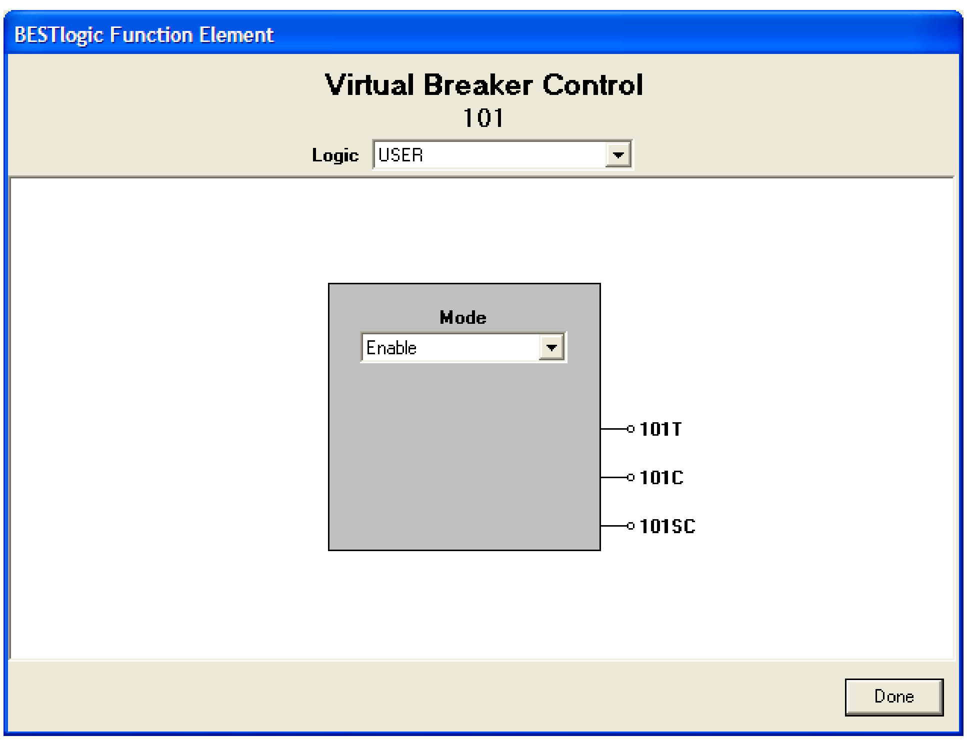

Figure 4-74. BESTlogic Function Element Screen, 101

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic.* This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

Enable the *Virtual Breaker Control* function by selecting its mode of operation from the *Mode* pull-down menu. Select *Done* when the settings have been completely edited.

Table 4-45 summarizes the BESTlogic settings for Virtual Breaker Control Switch.

Table 4-45. BESTlogic Settings for Virtual Breaker Control Switch

Function	Range/Purpose	Default
Mode	0 = Disable, 1 = Enable	0

Select Before Operate Control of Virtual Breaker Control Switch

The state of the virtual breaker control switch can be controlled at the HMI through Screen 2.2.1. Control is also possible through the ASCII command interface by using the select-before-operate commands CS-101 (control select-virtual control switch) and CO-101 (control operate-virtual controls switch). Control is not possible using BESTCOMS. A state change takes place immediately without having to execute an *Exit - Save* settings command.

CS/CO-101 Command

Purpose: Select and operate the virtual control switch.

Syntax: CS/CO-101=<action>

Comments: Action = T to pulse the 101T output; C to pulse the 101C output

The virtual breaker control switch commands require the use of select-before-operate logic. First, the command must be selected using the CS-101 command. After the select command is entered, there is a 30 second window during which the CO-101 control command will be accepted. The control selected and the operation selected must match exactly or the operate command will be blocked. If the operate command is blocked and error message is output.

CS/CO-101 Command Examples:

Example 1. Read the current status of the virtual control switch.

```
>CO-101
C
```

The returned setting indicates that the switch is in the after-close state.

Example 2. Trip the breaker by closing the trip output of the virtual control switch.

```
>CS-101=T
101=T SELECTED
>CO-101=T
101=T EXECUTED
```

Retrieving Virtual Breaker Control Switch Status from the Relay

The virtual breaker control switch state (after-trip or after-close) can be determined through the ASCII command interface by using the RG-STAT (reports general-status) command or on BESTCOMS *Metering* screen. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

HMI Screen 2.2.1 provides switch control and also displays the current status of the virtual breaker control switch (after-trip or after-close). As the previous Example 1 demonstrated, the state of the virtual breaker control switch can be determined using the CO-101 command in a read-only mode.

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SECTION 5 • METERING

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SECTION 5 • METERING

INTRODUCTION

The BE1-IPS100 Intertie Protection System measures the voltage and current inputs, displays those values in real time, records those values every ¼ second, and calculates other quantities from the measured inputs.

METERING FUNCTIONS

BE1-IPS100 metering functions include voltage, current, frequency, power factor, apparent power, reactive power, and true power. Metered values are viewed through any communication port using serial commands or at the front panel human-machine interface (HMI). Metering functions are summarized in the following paragraphs and in Table 5-2. For assistance with navigating through the HMI metering screens, refer to Section 10, *Human-Machine Interface*. For information on power, VA, and var calculations, refer to Section 3, *Input and Output Functions, Power System Inputs, Power Measurement*. Energy measurement is covered in Section 6, *Reporting and Alarm Functions*.

Auto Ranging

The BE1-IPS100 automatically scales metered values. Table 5-1 illustrates the ranges for each value metered.

Table 5-1. Auto Ranging Scales for Metered Values

Metered Value	Unit Display Ranges			
	Whole Units	**Kilo Units**	**Mega Units**	**Giga Units**
Current	0 A to 9,999 A	10 kA to 9,999 kA	10 MA	N/A
Voltage	0 V to 999 V	0 kV to 999 kV	N/A	N/A
Apparent Power	N/A	0 kVA to 000 kVA	1 MVA to 999 MVA	1 GVA to 1000 GVA
Reactive Power	N/A	0 kvar to 999 kvar	1 Mvar to 999 Mvar	1 Gvar to 1000 Gvar
True Power	N/A	0 kW to 999 kW	1 MW to 999 MW	1 GW to 1000 GW
Frequency	10 to 75 Hz	N/A	N/A	N/A

BESTCOMS Metering Screen

Metered values are viewed through the BESTCOMS *Metering* screen (see Figure 5-1). To open the *Metering* screen, select *Metering* from the *Reports* pull-down menu. To begin viewing metered values, select the *Start Polling* button in the bottom right of the screen.

Alternately, metering can be performed through the use of the ASCII command interface or HMI using Screens 3.1 through 3.11.

Refer to Table 5-2 for a list of ASCII commands and HMI Screens used for metering.

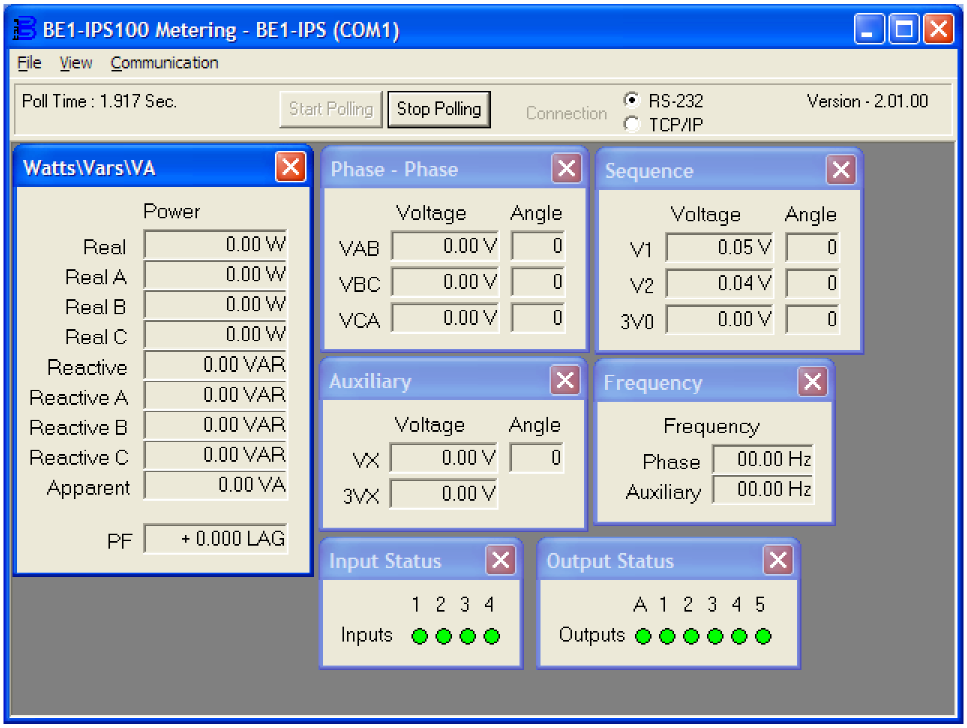


Figure 5-1. Metering - Watts/Vars/VA, Phase-Phase, Sequence, Auxiliary, Frequency, Input Status, Output Status

Other metering views can be selected from the *View* pull-down menu. These alternate views are shown in Figures 5-2 through 5-5.

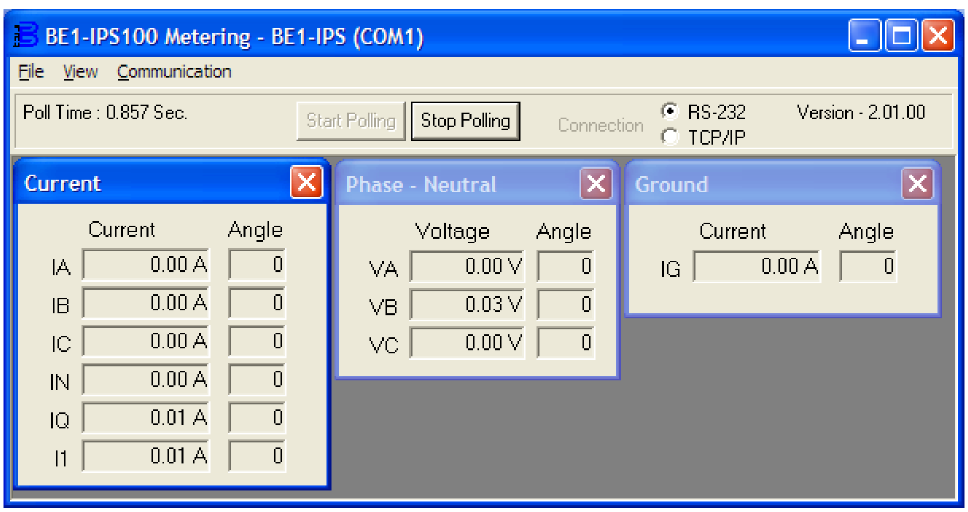


Figure 5-2. Metering - Current, Phase to Neutral, and Ground Views

Figure 5-3. Metering - Targets View

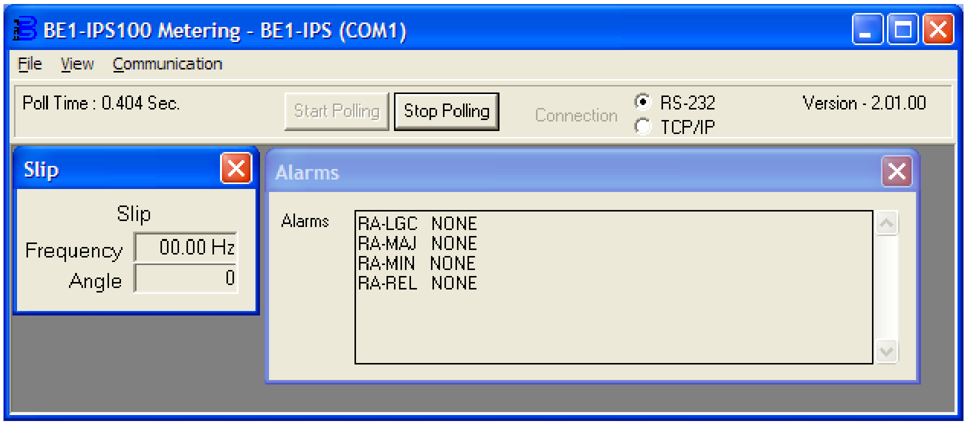


Figure 5-4. Metering - Slip and Alarms Views

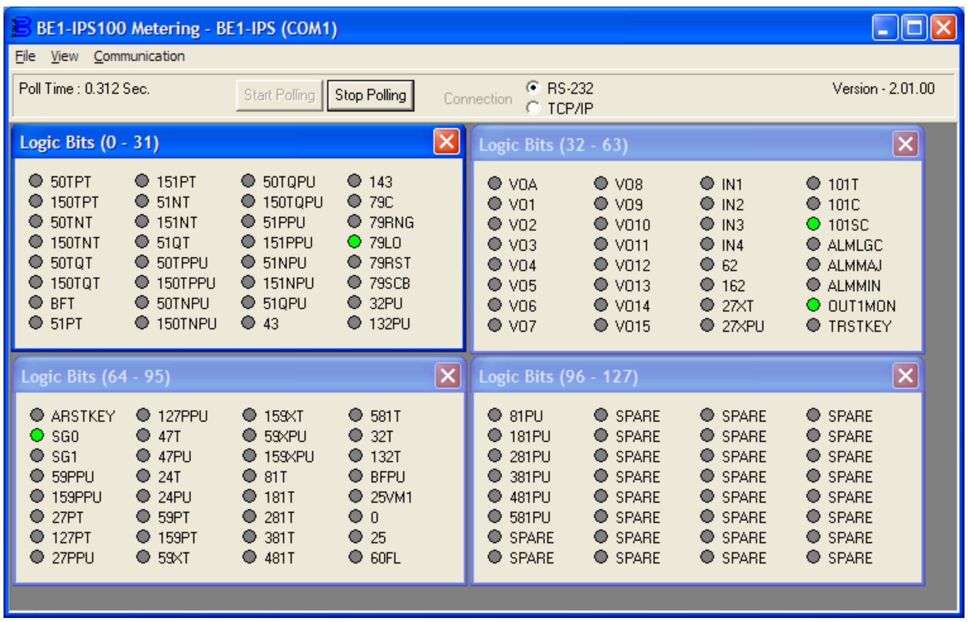


Figure 5-5. Metering - Logic Bits (0 – 31), (32 – 63), (64 – 95), and (96 – 127) Views

Table 5-2. ASCII Command and HMI Metering Cross-Reference

Metering Function	ASCII Command	HMI Screen
All metered values	M	3.1 – 3.11
Voltage, all values	M-V	3.1 – 3.4
Voltage, A-phase (phase angle)	M-VA	3.1 (3.1.1)
Voltage, B-phase (phase angle)	M-VB	3.1 (3.1.1)
Voltage, C-phase (phase angle)	M-VC	3.1 (3.1.1)
Voltage, A-phase to B-phase (phase angle)	M-VAB	3.2 (3.2.1)
Voltage, B-phase to C-phase (phase angle)	M-VBC	3.2 (3.2.1)
Voltage, A-phase to C-phase (phase angle)	M-VAC	3.2 (3.2.1)
Voltage, Auxiliary (phase angle)	M-VX	3.3 (3.3.1)
Voltage, 3RD Harmonic Auxiliary	M-V3X	3.3
Voltage, Positive-Sequence (phase angle)	M-V1	3.4 (3.4.1)
Voltage, Negative-Sequence (phase angle)	M-V2	3.4 (3.4.1)
Voltage, Zero-Sequence (phase angle)	M-3V0	3.4 (3.4.1)

Metering Function	ASCII Command	HMI Screen
Current, all values	M-I	3.5 – 3.7
Current, A-phase (phase angle)	M-IA	3.5 (3.5.1)
Current, B-phase (phase angle)	M-IB	3.5 (3.5.1)
Current, C-phase (phase angle)	M-IC	3.5 (3.5.1)
Current, Ground (phase angle)	M-IG	3.6 (3.6.1)
Current, Neutral (phase angle)	M-IN	3.7 (3.7.1)
Current, Positive-Sequence (phase angle)	M-I1	3.7 (3.7.1)
Current, Negative-Sequence (phase angle)	M-IQ	3.7 (3.7.1)
Power, True	M-WATT	3.8
Power, True, Three-phase	M-WATT3	3.8
Power, True, A-phase	M-WATTA	3.8.1
Power, True, B-phase	M-WATTB	3.8.2
Power, True, C-phase	M-WATTC	3.8.3
Power, Reactive	M-VAR	3.8
Power, Reactive, Three-phase	M-VAR3	3.8
Power, Reactive, A-phase	M-VARA	3.8.1
Power, Reactive, B-phase	M-VARB	3.8.2
Power, Reactive, C-phase	M-VARC	3.8.3
Power, Apparent (VA)	M-S	3.9
Power Factor	M-PF	3.9
Frequency	M-FREQ	3.10 – 3.11
Frequency, Phase	M-FREQP	3.10
Frequency, Auxiliary	M-FREQX	3.10
Frequency, Slip	M-FREQS	3.11
Metered sync angle between Phase and Aux inputs	M-SYNC	3.11

Voltage

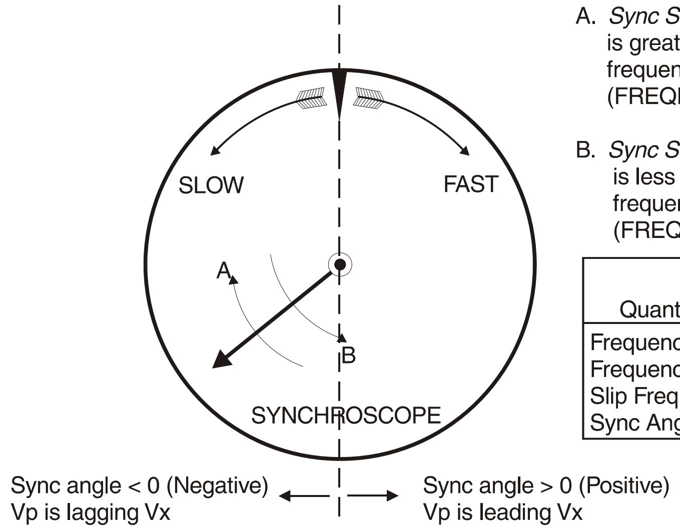
The BE1-IPS100 meters A-phase voltage, B-phase voltage, C-phase voltage, voltage across phases A and B, phases B and C, and phases A and C. Positive-sequence voltage, negative-sequence voltage, and three-phase zero-sequence (residual) voltage are also metered. The VTP connection determines what is measured. For the auxiliary voltage input, fundamental (Vx) and 3rd harmonic voltages (V3X) are measured.

Current

Metered current includes A-phase current, B-phase current, C-phase current, neutral three-phase zero-sequence current, and ground current. Other metered currents include positive-sequence current, negative-sequence current, and derived neutral current. All current measurements are auto ranging. Current is displayed in amps up to 9,999 A and then switches to kilo at 10.0 kA to 9,999 kA.

Frequency

Frequency is metered over a range of 10 to 75 hertz. If the measured frequency is outside this range, the nominal system frequency will be displayed. Frequency is sensed from A-phase to Neutral for four-wire sensing systems or from A-phase to B-phase for three-wire sensing systems. The frequency of auxiliary voltage VX is also measured. Refer to Figure 5-6.



A. *Sync Scope Fast.* When the phase frequency is greater than the auxiliary frequency, the slip frequency will be positive (FREQS > 0). (FREQP > FREQX = FREQS > 0)

B. *Sync Scope Slow.* When the phase frequency is less than the auxiliary frequency, the slip frequency will be negative (FREQS < 0) (FREQP < FREQX = FREQS < 0)

Quantity	ASCII Command	HMI Screen
Frequency VP	M-FREQP	3.10 PF
Frequency VX	M-FREQX	3.10 XF
Slip Frequency	M-FREQS	3.11 SLIP
Sync Angle	M-SYNC	3.11 ANG

P0002-01
6-18-00

Figure 5-6. Relationship of Slip Frequency and Sync Angle to Synchroscope

Power Factor

Three-phase power factor is metered over a range of maximum lagging (-0.00) to unity (1.00) to maximum leading (+0.00).

Apparent Power

Metered apparent power is displayed over a range of –7,500 kilovolt amperes to +7,500 kilovars on five-ampere nominal systems. One-ampere nominal systems meter reactive power over a range of –1,500 kilovars to +1,500 kilovars.

True Power

True power is metered over a range of –7,500 kilowatts to +7,500 kilowatts on five-ampere nominal systems. One-ampere nominal systems meter true power over a range of –1,500 watts to +1,500 watts.

Reactive Power

Reactive power is metered over a range of -7,500 kilovars to +7,500 kilovars on five ampere nominal systems. One ampere nominal systems meter reactive power over a range of -1,500 kilovars to +1,500 kilovars.

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SECTION 6 • REPORTING AND ALARM FUNCTIONS

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SECTION 6 • REPORTING AND ALARM FUNCTIONS

INTRODUCTION

This section describes all available reports from the BE1-IPS100 Intertie Protection System and how they are set and retrieved. All alarm functions are also described along with how major and minor alarms are programmed (or mapped).

RELAY IDENTIFIER INFORMATION

BE1-IPS100 relays have two relay Circuit Identification fields: *Relay ID* and *Station ID*. These fields are used in the header information lines of the Fault Reports, Oscillograph Records, and Sequence of Events Records.

Relay Circuit Identification settings are made using BESTCOMS. Figure 6-1 illustrates the BESTCOMS screen used to set *Relay ID* and *Station ID*. To open this screen, select *General Operation* from the *Screens* pull-down menu. Alternately, settings may be made using the SG-ID ASCII command.

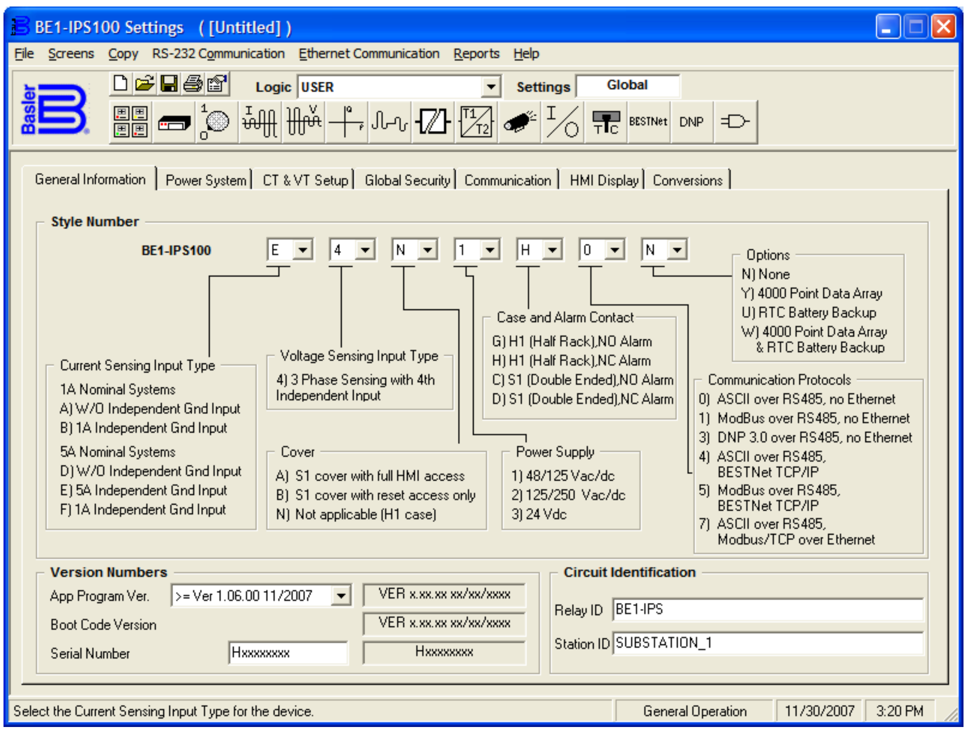

Figure 6-1. General Operation Screen, General Information Tab

To change these, delete the old label from the cell and type the new label. Identification settings are summarized in Table 6-1.

Table 6-1. Relay Circuit Identification Settings

Setting	Range	Default
Relay ID	1 to 30 alphanumeric characters ∗	BE1-IPS100
Station ID	1 to 30 alphanumeric characters ∗	SUBSTATION_1

∗ No spaces are allowed in labels; any spaces used in the labels are stripped when the label change is saved. Use the character "_" (Shift + Underscore) to create a break in characters. An example of this is "SUBSTATION_1".

CLOCK

The BE1-IPS100 provides a real-time clock with capacitor backup that is capable of operating the clock for up to eight hours after power is removed from the relay. The clock is used by the demand reporting function, the fault reporting function, the oscillograph recording function, and the sequence of events recorder function to time-stamp events. The clock function records the year in two-digit format.

Optionally, a backup battery may be installed. The battery will maintain the clock for up to five years. See Section 13, *Testing and Maintenance*, for maintenance of battery.

IRIG Port

IRIG time code signal connections are located on the rear panel. When a valid time code signal is detected at the port, it is used to synchronize the clock function. Note that the IRIG time code signal does not contain year information. For this reason, it is necessary to enter the date even when using an IRIG signal. Year information is stored in nonvolatile memory so that when operating power is restored after an outage and the clock is re-synchronized the current year is restored. When the clock rolls over to a new year, the year is automatically incremented in nonvolatile memory. An alarm bit is included in the programmable alarm function for loss of IRIG signal. The alarm point monitors for IRIG signal loss once a valid signal is detected at the IRIG port.

The IRIG input is fully isolated and accepts a demodulated (dc level-shifted) signal. The input signal must be 3.5 volts or higher to be recognized as a valid signal. Maximum input signal level is +10 to -10 volts (20 volt range). Input resistance is nonlinear and rated at 4 kΩ at 3.5 volts.

Setting the Clock Function

Time and date format settings are made using BESTCOMS. Figure 6-2 illustrates the BESTCOMS screen used to select time and date format settings. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Clock Display Mode* tab. Alternately, settings may be made using the SG-CLK ASCII command. Refer to Table 6-2, *Time and Date Format Settings*.

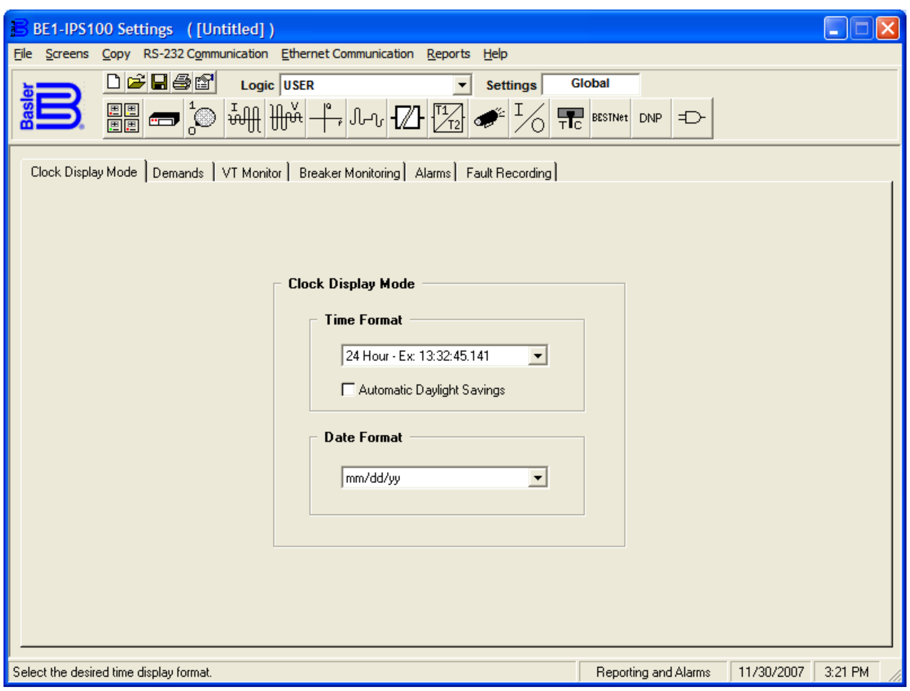

Figure 6-2. Reporting and Alarms Screen, Clock Display Mode Tab

Time and date reporting can be displayed in 12 or 24-hour format. When operating in the 12-hour format, the A.M./P.M. parameter is placed between the minutes and seconds parameters (10:24P23.004 indicates 10:24 in the evening). The default time format is 24 hours. Date reporting format can display the date in mm/dd/yy or dd/mm/yy format. The default date format is mm/dd/yy. The relay clock can also accommodate daylight saving time changes. Automatic daylight saving time adjustments are optional and are disabled by default.

Table 6-2. Time and Date Format Settings

Parameter	Range	Default
Time Format	12 (12 hour format) 24 (24 hour format)	24
Date Format	m (mm-dd-yy) d (dd-mm-yy)	M
Automatic Daylight Savings	0 (daylight saving time disabled) 1 (daylight saving time enabled)	0

Reading and Setting the Clock

Clock information can be viewed and set at the front panel human-machine interface (HMI) and through the communication ports using ASCII commands or BESTCOMS. Write access to reports is required to set the clock at the HMI and communication ports. An alarm point is provided in the programmable alarms to detect when the relay has powered up and the clock has not been set. Time and date information is read and set at HMI Screen 4.6, through the communication ports using the RG-DATE and RG-TIME ASCII commands, and through BESTCOMS by selecting the *Communication* pull-down menu and then selecting *Set Date and Time.*

Alternate DST (Daylight Saving Time) Settings

Alternate DST settings are necessary when not using a time zone in the United States. These settings can be adjusted only by using ASCII commands. They cannot be set with BESTCOMS or through the HMI.

The following serial commands must be entered in the order shown and all parameters must be entered in order for the alternate DST settings to function properly.

Select Floating Date or Fixed Date Configuration

SG-DST=1 (Floating Date) or 2 (Fixed Date)

Example: SG-DST=2 selects Fixed Date configuration

If using Floating Date Configuration

SG-DSTSTART=Mo,D,H,M,O and SG-DSTSTOP=Mo,D,H,M,O

Mo (Month) = 1 (January) to 12 (December)

D (Day of Week) = 0 (Sunday) to 6 (Saturday)

H (Hour) = 0 (12:00am) to 23 (11:00pm)

M (Minutes) = 0 to 59

O (Occurrence) = 1 (First D (Day) of the month) to 5 (Fifth D (Day) of the month)

Examples: SG-DSTSTART=5,3,2,15,3 is the 3rd Wednesday in May at 2:15am

SG-DSTSTOP=7,6,5,45,2 is the 2nd Saturday in July at 5:45am

If using Fixed Date Configuration

SG-DSTSTART=Mo,D,H,M,O and SG-DSTSTOP=Mo,D,H,M,O

Mo (Month) = 1 (January) to 12 (December)

D (Day of Month) = 1 to 31

H (Hour) = 0 (12:00am) to 23 (11:00pm)

M (Minutes) = 0 to 59

O (Occurrence) = 0 (Not used for Fixed Date configuration)

Examples: SG-DSTSTART=5,20,2,15,0 is May 20th at 2:15am

SG-DSTSTOP=7,10,15,30,0 is July 10th at 3:30pm

UTC (Coordinated Universal Time)

SG-UTC=M,R,B

M (Offset from UTC in Minutes) = -720 to 840

R (Reference Time) = 0 (Local) or 1 (UTC)

B (Bias: amount of minutes to adjust DST) = 0 to 300

Example: SG-UTC=0,0,60 for UTC offset of 0 minutes, local reference for the DST change, and adjustment amount of 60 minutes

The RG-DST command reports start and stop times and dates for daylight saving time referenced to local time. Refer to Section 11, *ASCII Command Interface,* for a list of all ASCII commands.

GENERAL STATUS REPORTING

BE1-IPS100 relays have extensive capabilities for reporting relay status. This is important for determining the health and status of the system for diagnostics and troubleshooting. Throughout this manual, reference is made to the RG-STAT (report general, status) report and the appropriate HMI screens for determining the status of various functions.

General Status Report

A General Status report is available through the communication ports using the RG-STAT command. This report lists all of the information required to determine the status of the relay. An example of a typical General Status report follows as well as a description of what each line represents. In the explanation of each line, cross-references are made to the corresponding HMI screens that contain that data.

>RG-STAT

```
INPUT(1234)         STATUS : 0000
OUTPUT(A12345)      STATUS : 000000
CO-OUT(A12345)      STATUS : LLLLLL
CO-43/143           STATUS : 00
CO-101(101SC)       STATUS : AFTER CLOSE(1)
CO-GROUP            STATUS : L
ACTIVE LOGIC        STATUS : IPS100-1547-C-BE
RECLOSER(79)        STATUS : LOCKOUT
LOGIC VAR( 0- 31)   STATUS : 00000000 00000000 00000000 00010000
LOGIC VAR(32- 63)   STATUS : 00000000 00000000 00000000 00100010
LOGIC VAR(64- 95)   STATUS : 01000000 00000000 00000000 00000000
LOGIC VAR(96-127)   STATUS : 00000000 00000000 00000000 00000000
ACTIVE GROUP        STATUS : 0
BREAKER(52)         STATUS : CLOSED
DIAG/ALARM          STATUS : 0 RELAY, 0 LOGIC, 0 MAJOR, 0 MINOR
```

Input (1234)

This line reports the status of contact sensing inputs IN1, IN2, IN3, and IN4. Input information is available at HMI Screen 1.5.1. “0” indicates a de-energized input and “1” indicates an energized input. See Section 3, *Input and Output Functions*, for more information about contact sensing input operation.

Output (A12345)

Output contact status for OUTA, OUT1, OUT2, OUT3, OUT4, and OUT5 is reported on this line. This information is also available at HMI Screen 1.5.2. “0” indicates a de-energized output and “1” indicates an energized output. More information about output contact operation is available in Section 3, *Input and Output Functions*.

CO-OUT (A12345)

This line reports the logic override of the output contacts. Logic override status is also reported at HMI Screen 1.5.3. Section 3, *Input and Output Functions*, provides more information about output logic override control.

<u>CO-43/143</u>

Virtual switch function status is reported on this line. This information is also available at HMI Screen 1.5.4. See Section 4, *Protection and Control*, *Virtual Switches,* for more information about virtual switch operation.

<u>CO-101 (101SC)</u>

This line reports the current status of the virtual breaker control switch slip contact output. More information about the virtual breaker control switch is available in Section 4, *Protection and Control, Virtual Switches*.

<u>CO-Group</u>

The logic override status of the setting group selection function is reported on this line. For more information about this function, refer to Section 4, *Protection and Control, Setting Groups*.

<u>Active Logic</u>

This line reports the name of the active logic scheme. The active logic scheme name can also be viewed at HMI Screen 5 and through the SL-N command. See Section 7, *BESTlogic Programmable Logic*, for more information about this function.

<u>Recloser (79)</u>

The status of the recloser is reported on this line. HMI Screen 1.1 also reports this information. More information about the recloser function is available in Section 4, *Protection and Control*.

<u>Logic Variables (00-31), (32-63), (64-95), and (96-127)</u>

These four lines report the status of each BESTlogic variable. These lines can be entered into Table 6-3 to determine the status of each logic variable. Section 7, *BESTlogic Programmable Logic*, provides more information about BESTlogic variables. This information is not available through the HMI.

Table 6-3. Logic Variable Status Report Format

50TPT	150TPT	50TNT	150TNT	50TQT	150TQT	BFT	51PT
00	01	02	03	04	05	06	07

151PT	51NT	151NT	51QT	50TPPU	150TPPU	50TNPU	150TNPU
08	09	10	11	12	13	14	15

50TQPU	150TQPU	51PPU	151PPU	51NPU	151NPU	51QPU	43
16	17	18	19	20	21	22	23

143	79C	79RNG	79LO	79RST	79SCB	32PU	132PU
24	25	26	27	28	29	30	31

VOA	VO1	VO2	VO3	VO4	VO5	VO6	VO7
32	33	34	35	36	37	38	39

VO8	VO9	VO10	VO11	VO12	VO13	VO14	VO15
40	41	42	43	44	45	46	47

IN1	IN2	IN3	IN4	62	162	27XT	27XPU
48	49	50	51	52	53	54	55

101T	101C	101SC	ALMLGC	ALMMAJ	ALMMIN	OUT1MON	TRSTKEY
56	57	58	59	60	61	62	63

ARSTKEY	SG0	SG1	59PPU	159PPU	27PT	127PT	27PPU
64	65	66	67	68	69	70	71

127PPU	47T	47PU	24T	24PU	59PT	159PT	59XT
72	73	74	75	76	77	78	79

159XT	59XPU	159XPU	81T	181T	281T	381T	481T
80	81	82	83	84	85	86	87

581T	32T	132T	BFPU	25VM1	LOGIC0	25	60FL
88	89	90	91	92	93	94	95

81PU	181PU	281PU	381PU	481PU	581PU	SPARE	SPARE
96	97	98	99	100	101	102	103

SPARE	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE
104	105	106	107	108	109	110	111

SPARE	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE
112	113	114	115	116	117	118	119

SPARE	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE	SPARE
120	121	122	123	124	125	126	127

Active Group

The active group is indicated on this line. HMI Screen 1.5.5 also provides this information. See Section 4, *Protection and Control,* for more information about setting groups.

Breaker (52)

This line reports the state of the breaker. This information is also available at HMI Screen 1.5.6. More information about breaker status is provided in the *Breaker Monitoring* subsection.

Diag/Alarm

This line reports the status of the Relay Trouble Alarm, Major Alarm, Minor Alarm, and Logic Alarm. The status of these alarms can be viewed at HMI Screen 1.3. Front panel LEDs also indicate the status of the Relay Trouble Alarm, Minor Alarm, and Major Alarm. Alarm status is also available through the communication ports. The SA-MIN command reports the Minor Alarm status, the SA-MAJ command reports the Major Alarm status, and the SA-LGC command reports the Logic Alarm status.

Other Report - General Commands

There are several other RG commands in addition to the RG-STAT command. These include RG-TIME, RG-DATE, RG-TARG, and RG-VER. These commands are covered in detail in respective paragraphs in this section. As with other commands, a combination read command is available to read several items in a group. If the command RG is entered by itself, the relay reports the time, date, target information, and other reports in the following example. RG-VER and RG-STAT commands have multiple line outputs and these are not read at the RG command.

ENERGY DATA

Energy information in the form of watthours and varhours is measured and reported by the BE1-IPS100. Both positive and negative values are reported in three-phase, primary units. Watthour and varhour values are calculated per minute as shown in Equation 6-1.

$$\frac{\text{Primary VT Ratio} \times \text{Primary CT Ratio}}{\text{60 minutes}} \times \text{Secondary watts or vars}$$

Equation 6-1. Energy Data Equation

Watt and var values are updated every 250 milliseconds and watthour and var-hour values are logged once every minute. Energy registers are stored in nonvolatile memory during every update.

Watthour values and varhour values can be read, reset, or changed through the HMI or communication ports. Watthour values can be accessed at the HMI through Screens 4.5.1 (positive values) and 4.5.2 (negative values). Varhour values can be accessed at the HMI through Screens 4.5.3 (positive values) and 4.5.4 (negative values). ASCII command RE-KWH (report energy-kilowatthours) gives access to both positive and negative watthour values. A lagging power factor load will report positive watts and positive vars.

ASCII command RE-KVAR (report energy - kilovarhours) gives access to both positive and negative varhour values.

Energy data is also available through the communication ports by using the RE (report energy) command. This read-only command returns both the watthours and varhours.

DEMAND FUNCTIONS

The demand reporting function continuously calculates demand values for the three-phase currents, three-phase power, three-phase reactive power, neutral current (three-phase residual 3IO), and negative-sequence current. Demand values are recorded with time stamps for Peak Since Reset, Yesterday's Peak, and Today's Peak. Programmable alarm points can be set to alarm if thresholds are exceeded for overload and unbalanced loading conditions.

Demand Reporting Settings

Demand reporting settings are made using BESTCOMS. Figure 6-3 illustrates the BESTCOMS screen used to select demand reporting settings. To open the screen shown in Figure 6-3, select *Reporting and Alarms*, from the *Screens* pull-down menu. Then select the *Demands* tab. Alternately, demand current settings may be made using the SG-DI ASCII command. Demand alarm thresholds for three-phase power and reactive power are set using the SA-DWATT and SA-DVAR commands. Demand reporting is setup using the SG-DI (setting general, demand interval) command.

Demand settings for current include columns labeled *Phase*, *Neutral*, and *Negative-Sequence*. Each of these columns has settings for *Interval (Minutes)* and *Current Threshold*. *Current Threshold* display units are selectable from a pull-down menu allowing the selection of *Sec. Amps, Pri. Amps, Per U Amps*, or *% Amps*. The default display unit is *Sec. Amps*.

Additionally, the *Phase* has adjustable forward and reverse watt threshold adjustments in secondary 3-phase, primary three-phase, per unit three-phase, and percent three-phase units. Likewise, var forward and reverse threshold is adjustable in a similar manner with secondary three-phase as the default unit of measurement for both watts and vars. Thresholds are set using the SA-DWATT and SA-DVAR commands.

Using the pull-down menus and buttons, make the application appropriate demand settings.

Demand reporting settings are summarized in Table 6-4.

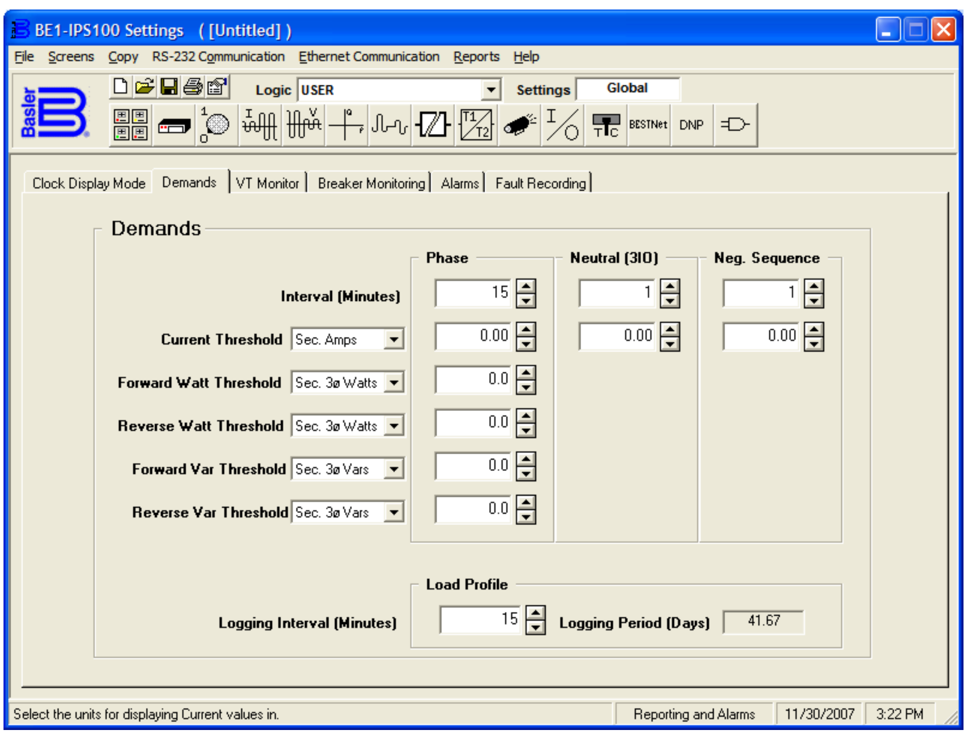

Figure 6-3. Reporting and Alarms Screen, Demands Tab

Table 6-4. Demand Settings for Current

Setting	Range	Increment	Unit of Measure	Default
Current Threshold Display Units	Sec. Amps, Pri. Amps, Per U Amps, % Amps	N/A	Amps	Sec. Amps
Current Threshold	.50 - 16.0 Sec. Amps	0.01	∗	0
Neutral Threshold	.50 - 16.0 Sec. Amps	0.01	∗	0
Negative-Sequence Threshold	.50 - 16.0 Sec. Amps	0.01	∗	0
Forward Watt Threshold Reverse Watt Threshold	0.0 - 8,500 Sec. Watts	0.1 for 0 to 99.9 1 for 100 to 8,500	Watts	0
Forward Var Threshold Reverse Var Threshold	0.0 - 8,500 Sec. Vars	0.1 for 0 to 99.9 1 for 100 to 8,500	Vars	0
Phase Current Logging Interval	0 - 60	1	Minutes	15
Current Logging Period (days)	2.78 - 166.67	2.78	Days	Set by Logging Interval

∗ Unit of measure is based on the threshold *Display Units* selection. The default is secondary amperes.

Retrieving Demand Reporting Information

Values and time stamps in the demand registers are reported in primary values. They can be read at the front panel HMI and through the communication ports.

Today's Peak, Yesterday's Peak, and Peak Since Reset demand values are accessed through HMI Screen 4.4, *DEMAND REPORTS*. Demand values viewed at the HMI can be reset by pressing the *Reset* key. When the *Reset* key is pressed, the viewed register value is set to zero and then updated on the next processing loop with the currently calculated demand value. No write access is needed to reset demand register values at the HMI. It is also possible to preset a value into the *Peak Since Demand* registers. This can be done by pressing the *Edit* key. Write access to the *Reports* functional area is required to preset values at the HMI.

Values and time stamps in the demand registers can also be read through the communication ports by using the RD (report demands) command.

Demand information specific to current, vars, or watts can be obtained by including an object name with the command function (R) and subgroup (D). Today's Peak, Yesterday's Peak and Peak Since reset information for current is available using the RD-TI, RD-YI, and RD-PI commands.

Today's Peak, Yesterday's Peak, and Peak Since Reset information for reactive power is available using the RD-TVAR, RD-YVAR, and RD-PVAR commands.

Today's Peak, Yesterday's Peak, and Peak Since Reset information for power is available using the RD-TWATT, RD-YWATT, and RD-PWATT commands.

Optional Load Profile Recording Function

Load profile recording is an optional selection when the BE1-IPS100 is ordered. This option (4000 Point Load Profile Demand Log or Y as the third character from the right in the style chart) uses a 4,000-point data array for data storage. Refer to Section 1, *General Information, Model, and Style Number Description*, for more information on optional selections. At the specified (programmed) interval, Load Profile takes the data from the demand calculation register and places it in a data array. If the programmed interval is set to 15 minutes, it will take 41 days and 16 hours to generate 4,000 entries. Load profile data is smoothed by the demand calculation function. If you made a step change in primary current, with the demand interval set for fifteen minutes, and the load profile recording interval set for one minute, it would take approximately fifteen minutes for the load (step change) to reach 90 percent of the final level. See the previous paragraphs in this section on *Demand Reporting* for information on calculation methods.

Setting the Load Profile Recording Function

For the load profile recording function to log data you must set the demand logging interval. This can be done in BESTCOMS. See Figure 6-3, *Reporting and Alarms Screen, Demands Tab*. Use the *Up/Down* arrows under *Load Profile* to make your setting in the range of one to sixty minutes. Alternately, settings can be made using the SG-LOG (setting general, logging interval) ASCII command. Table 6-4 lists the settings for the optional load profile recording.

Retrieving the Load Profile Recording Function

Load profile recorded data is reported by the ASCII command interface using the RD-LOG command. You may request the entire log or only a specific number of entries.

VT MONITOR FUNCTIONS

The VT Monitor reporting function allows the user to enable or disable *Fuse Loss Block Logic*. The *Block Voltage Control* box can be checked (enabled) or unchecked (disabled) for the 51/27 elements. Likewise, *Block Phase, Block 3V0*, and *Block V2* and each be independently checked (enabled) or unchecked (disabled) for the 27 and 59 elements. The default value for all of these logic functions is enabled.

Setting Fuse Loss Block Logic

Fuse Loss Block Logic settings can be made using BESTCOMS. Figure 6-4 illustrates the BESTCOMS screen used to select these reporting settings. To open the screen shown in Figure 6-4, select *Reporting and Alarms*, from the *Screens* pull-down menu. Then select the *VT Monitor* tab. Alternately, settings may be made using the SP-60FL ASCII command.

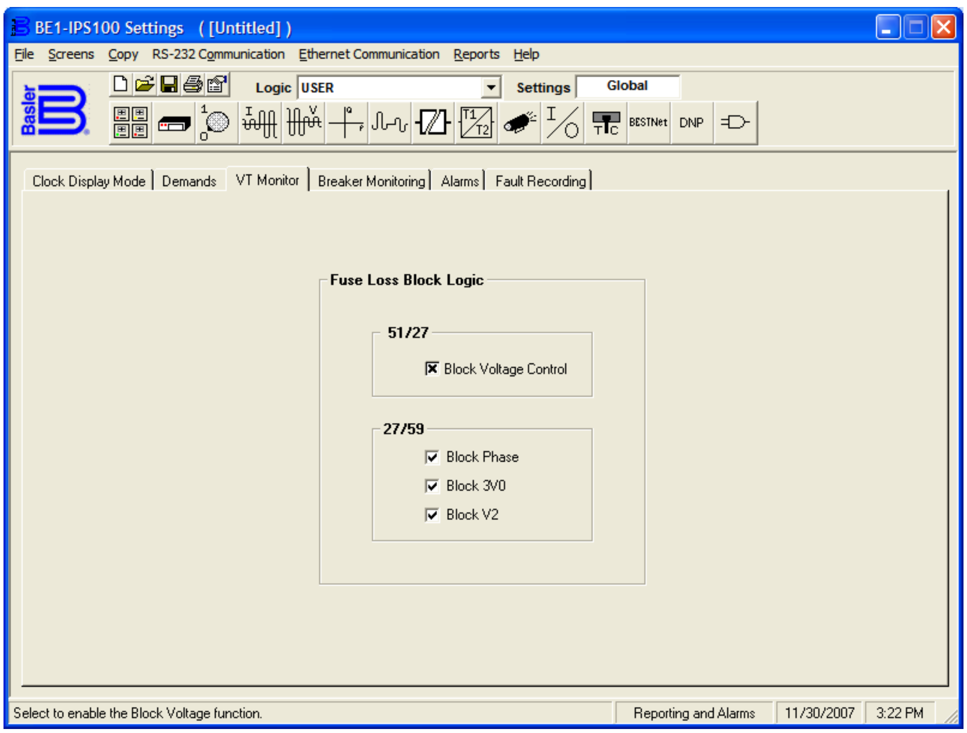

Figure 6-4. Reporting and Alarms Screen, VT Monitor Tab

BREAKER MONITORING

Breaker monitoring helps manage equipment inspection and maintenance expenses by providing extensive monitoring and alarms for the circuit breaker. Breaker monitoring functions include breaker status and operations counter reporting, fault current interruption duty monitoring and trip-speed monitoring. Each function can be set up as a programmable alarm. The *Alarms Function* sub-section has more information about the use of programmable alarms. The breaker trip circuit voltage and continuity monitor is a related function and is described in the *Trip Circuit Monitor* subsection.

Breaker Status Reporting

The breaker status monitoring function monitors the position of the breaker for reporting purposes. Opening breaker strokes are also counted and recorded in the breaker operations counter register. Circuit breaker status is also used by the breaker trip circuit voltage and continuity monitor. The *Trip Circuit Monitor* sub-section provides more details.

Setting the Breaker Status Reporting Function

Since the relay is completely programmable, it is necessary to program which logic variable will monitor breaker status. Breaker status is programmed using the *BESTlogic Function Element* screen in BESTCOMS. Figure 6-5 illustrates this screen. To open the *BESTlogic Function Element* screen for breaker status, select *Reporting and Alarms* from the *Screens* pull-down menu and choose the *Breaker Monitoring* tab. Then select the *Logic* button in the lower left hand corner of the screen and inside the box labeled, *Breaker Status Logic*. Alternately, settings may be made using the SB-LOGIC ASCII command.

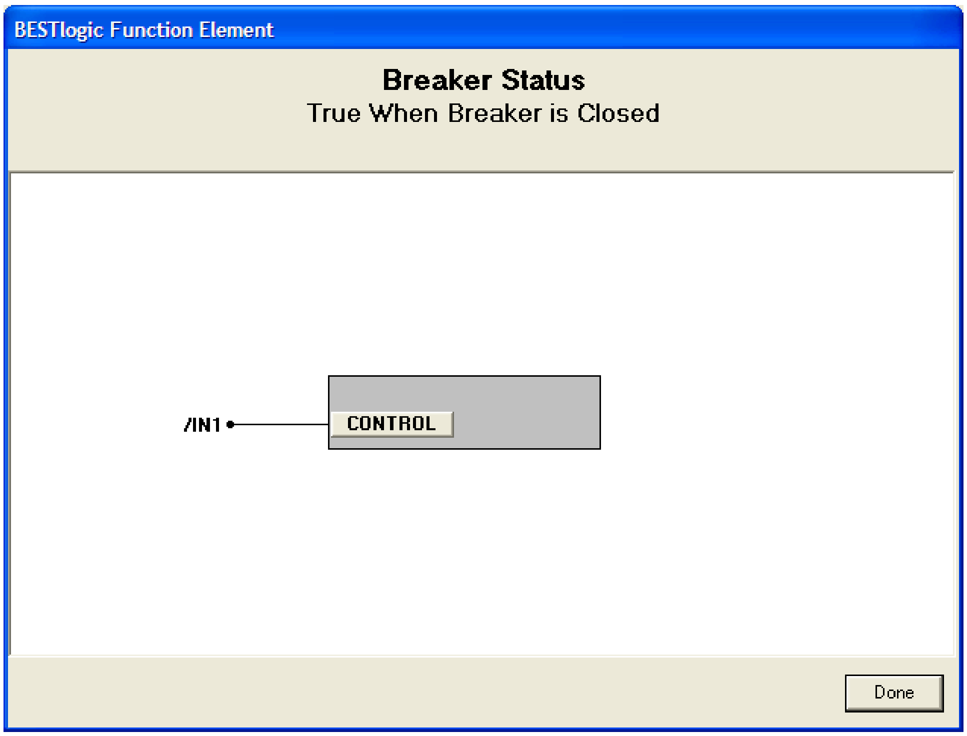

Figure 6-5. BESTlogic Function Element Screen, Breaker Status

To connect the Breaker Status's *CONTROL* input, select the *CONTROL* button. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

Table 6-5 lists the settings for the Breaker Status logic.

Table 6-5. Breaker Status Reporting BESTlogic Settings

Setting	Range/Purpose	Default
Breaker Closed Logic	OR logic expression that is TRUE when the breaker is closed (e.g., 52a logic).	/IN1

Example 1. Make the following settings to the Breaker Status logic. Refer to Figure 6-5.
CONTROL: /IN1

Retrieving Breaker Status and Operation Counter Information

Current breaker status can be read from HMI Screen 1.5.6 and through the communication ports using the RG-STAT command. The *General Status Reporting* subsection provides more information about this command.

The number of breaker operations can be read at HMI Screen 4.3.1. The counter value can be adjusted using the *Edit* key. This allows the relay counter value to be matched to an existing mechanical cyclometer on a breaker mechanism. Write access to the reports functions must be gained to edit this value at the HMI. Breaker operations can be read or set through the communication ports using the RB-OPCNTR (report breaker, operations counter) command.

The breaker operations counter can be monitored to give an alarm when the value exceeds a threshold. See *Breaker Alarms*, in this section for more information about this feature.

Breaker operations can also be read using the RB command. The RB command returns the number of breaker operations and breaker contact duty information.

Breaker duty monitoring is discussed in the following paragraphs.

Breaker Duty Monitoring

When the breaker opens, the current interrupted in each pole of the circuit breaker is accumulated by the breaker duty monitor. Breaker opening is defined by the breaker status monitoring function (SB-LOGIC). Figure 6-6 illustrates breaker status (SB-LOGIC) during a fault and protective trip. Table 6-6 serves as a legend for the call-outs of Figure 6-6.

Each time the breaker trips, the breaker duty monitor updates two sets of registers for each pole of the breaker. In the Accumulated `I` Duty registers, the breaker duty monitor adds the measured current in primary amperes. In the Accumulated `I2` Duty registers, the function adds the measured current squared in primary amperes. The user selects which of the two sets of duty registers are reported and monitored when setting up the breaker duty monitor.

Even though duty register values are calculated and stored in primary amperes or primary amperes-squared, the duty value is reported as a percent of maximum. The user sets the value that the relay will use for 100 percent duty (D_{MAX}). The value set for maximum duty is used directly for reporting the accumulated `I` Duty. The square of the value set for maximum duty is used for reporting the accumulated `I2` Duty.

Since the true measure of contact wear includes a factor for arcing time (t), an assumed arcing time for the breaker should be included when choosing the setting for 100 percent interruption duty (D_{MAX}).

When testing the relay by injecting currents into the relay, the values in the duty registers should be read and recorded prior to the start of testing. Once testing is complete and the relay is returned to service, the registers should be reset to the original pre-test values. A block accumulation logic input may be used when testing so that simulated breaker duty is not added to the duty registers. The *BLKBKR* logic function is an OR logic term (e.g., IN1 or VO7) which blocks the breaker monitoring logic when TRUE (1). *BLKBKR* is set to zero to disable blocking. When breaker monitoring is blocked (logic expression equals 1), breaker duty is not accumulated.

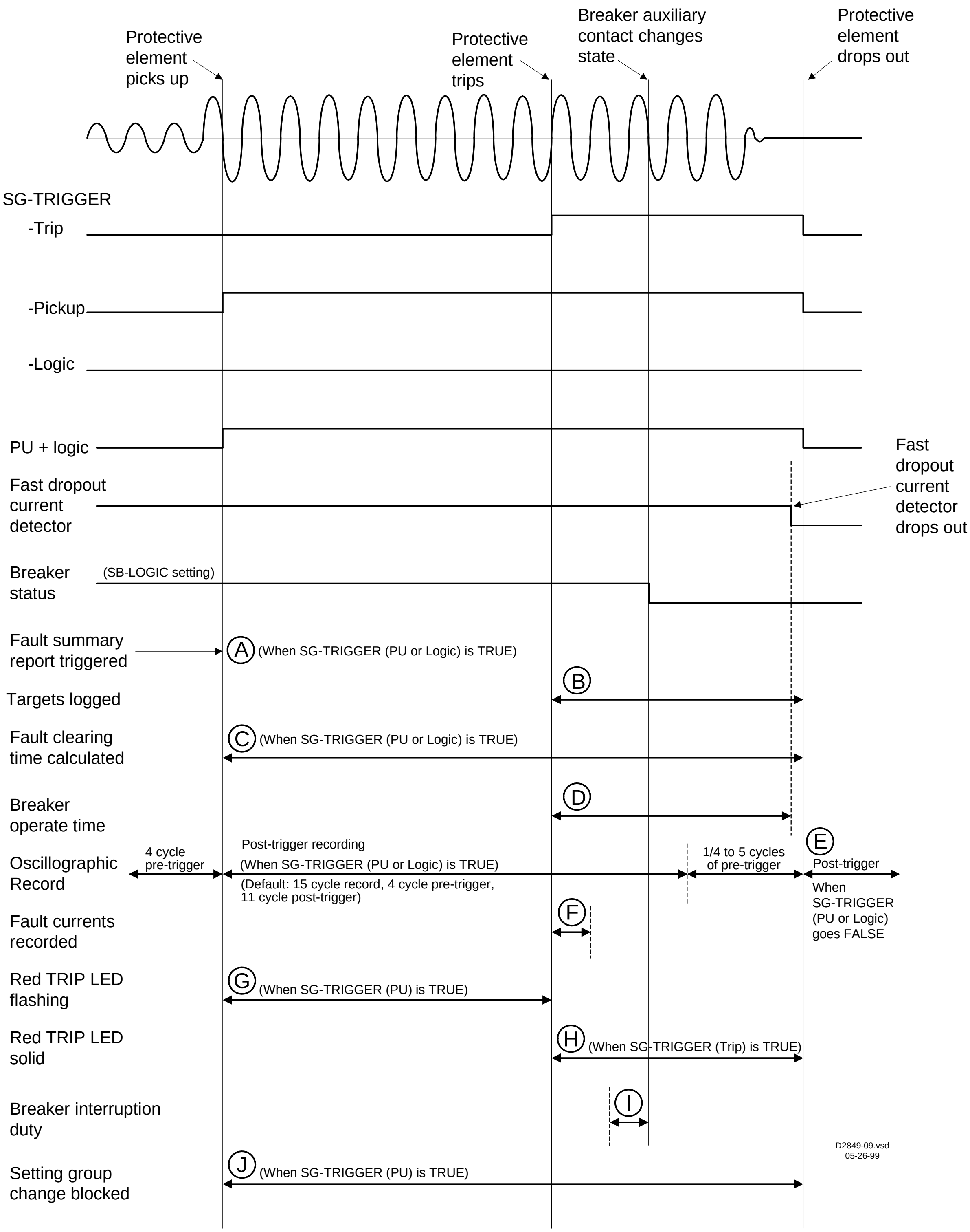

Figure 6-6. Protective Fault Analysis

Table 6-6. Legend for Figure 6-6

Locator	Description
A	A fault summary report and an oscillograph record are triggered when either the SG-TRIGGER pickup or logic expression becomes TRUE.
B	During the time that the SG-TRIGGER trip expression is TRUE, targets are logged from each of the protective functions that reach a trip state. If a protective function is not being used for tripping purposes, the associated target function can be disabled through the SG-TARG setting.
C	Fault clearing time is calculated as the duration of the time that either the SG-TRIGGER pickup or logic expression is TRUE.
D	Breaker operate time is calculated as the time from when the SG-TRIGGER trip expression becomes TRUE until the fast-dropout current detector senses that the breaker has successfully interrupted the current in all poles of the breaker.
E	A second oscillographic record is triggered to record the end of the fault if the SG-TRIGGER pickup or logic trigger expression remains in the TRUE state at the time that the first oscillographic record ends. This second record will have from ¼ to five cycles of pre-trigger data depending upon when both the SG-TRIGGER pickup and logic expressions become FALSE.
F	Recorded fault current, voltage, and distance magnitudes are displayed on the *Target* screen of the HMI. The same information including phase voltage frequency, auxiliary voltage frequency, and voltage and current angles are recorded in the Fault Summary Report. The magnitude, angle, and distance results are based on data captured two cycles after the trip output goes TRUE. This two-cycle delay allows the line transients to settle to provide more accurate data. The post fault current vectors are compared to pre-fault current vectors captured three cycles prior to protective pickup to perform distance calculations. If the SG_TRIGGER TRIP expression does not become TRUE, the fault was cleared by a down stream device. For these pickup-only events, fault current, voltage, angle, and distance recorded in the fault summary report will be for the power system cycle ending two cycles prior to the end of the fault record. This is also the case if the fault record was triggered through the ASCII command interface by the RF=TRIG command.
G	During the time that the SG-TRIGGER pickup expression is TRUE, the red Trip LED on the front panel flashes indicating that the relay is picked up.
H	During the time the SG-TRIGGER trip expression is TRUE, the red Trip LED on the front panel lights steadily indicating that the relay is in a tripped state. If targets have been logged for the fault, the Trip LED is sealed in until the targets have been reset.
I	Breaker operations and interruption duty functions are driven by the breaker status function. The operations counter is incremented on breaker opening. The magnitudes of the currents that are used for accumulating breaker duty are recorded for the power system cycle ending when the breaker status changes state. Thus, breaker duty is accumulated every time that the breaker opens even if it is not opening under fault.
J	Setting group changes are blocked when the SG-TRIGGER pickup expression is TRUE to prevent protective functions from being reinitialized with new operating parameters while a fault is occurring.

Setting the Breaker Duty Monitoring Function

Breaker Duty Monitoring settings are made using BESTCOMS. Figure 6-7 illustrates the BESTCOMS screen used to select settings for the Breaker Duty Monitoring function. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Breaker Monitoring* tab. Alternately, settings may be made using the SB-DUTY ASCII command.

At the top of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be selected on this menu in order to allow changes to be made to the mode and inputs of the element.

Using the pull-down menus and buttons, make the application appropriate settings to the Breaker Duty Monitoring function.

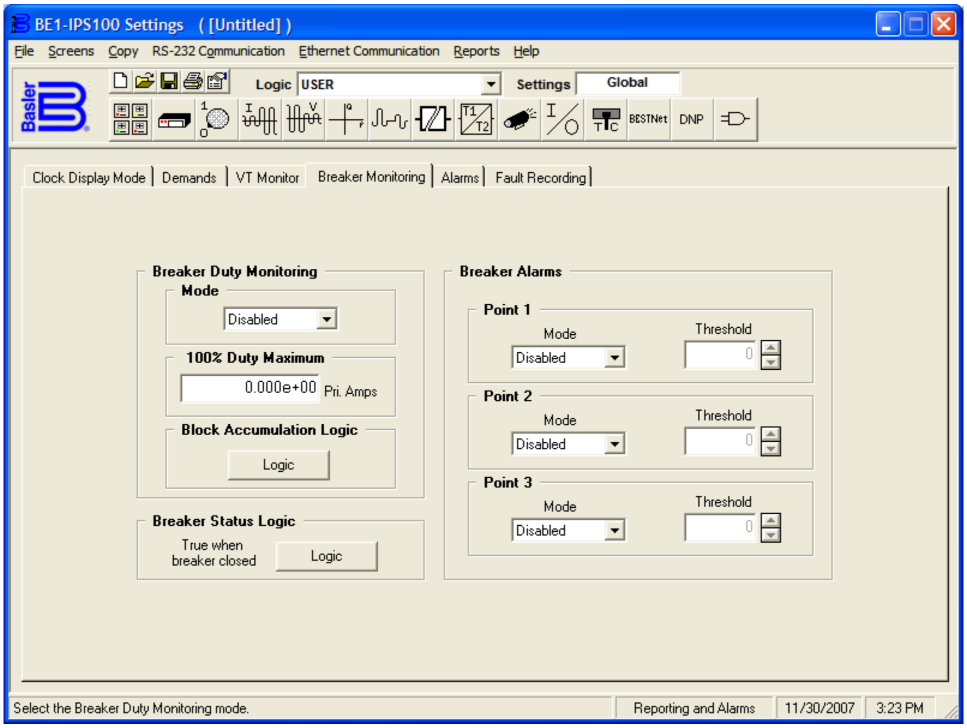

Figure 6-7. Reporting and Alarms Screen, Breaker Monitoring Tab

To connect the functions *BLOCK* logic input. Select the *Logic* button in the *Block Accumulation Logic* box. The *BESTlogic Function Element* screen for *Breaker Duty Monitoring* will appear. See Figure 6-8. Then select the *BLOCK* input button. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

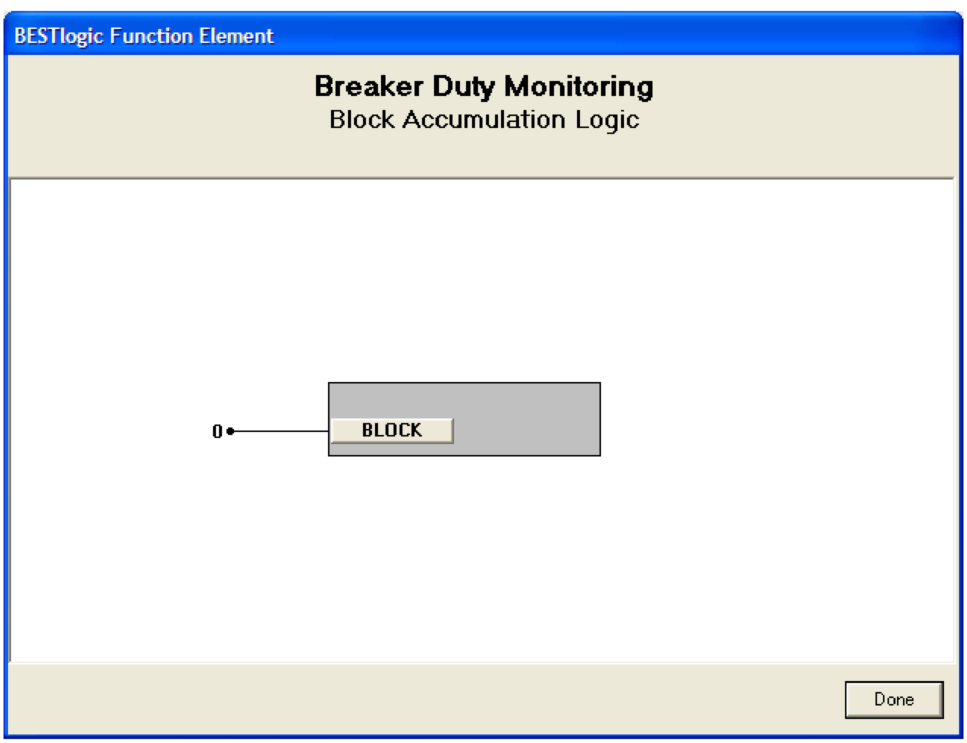

Figure 6-8. BESTlogic Function Element Screen, Breaker Duty Monitoring

Table 6-7 summarizes the Breaker Duty Monitoring settings.

Table 6-7. Breaker Duty Monitoring Settings

Function	Range/Purpose	Default
Mode	0 = Disabled, 1 = I (enabled), 2 = I^2 (enabled)	0
100% Duty Maximum	0 to 4.2e+7 The *100% Duty Maximum* parameter represents the maximum duty that the breaker contacts can withstand before needing service. *100% Duty Maximum* is programmed in primary amperes using exponential floating point format.	0
Block	OR logic term (e.g., IN1 or VO7) that blocks the breaker monitoring logic when TRUE (1). A setting of 0 disables blocking (breaker operations are no longer counted).	0

Example 1. Make the following settings to your Breaker Duty Monitoring Settings. Refer to Figures 6-7 and 6-8.

Exponent: 0
100% Duty Maximum: 0.000e+00
Block: 0

Retrieving Breaker Duty Information

Breaker duty values can be read at HMI Screen 4.3.2. Duty values can be changed by using the front panel *Edit* key. Write access to reports is required to edit breaker duty values. Duty values can also be read or changed through the communication ports using the RB-DUTY command.

Breaker Operate Time Monitoring

The breaker operate time monitor tracks the time from when a trip output occurs (defined by the TRIP logic expression) to when the fast dropout current detector observes that current is zero in all three breaker poles. This time is reported as a line in the Fault Summary Reports. See the *Fault Reporting* sub-section for more information about the TRIP logic expression and Fault Summary Reports.

Breaker operate time can be monitored to give an alarm when the value exceeds a threshold. The following *Breaker Alarms* sub-section provides more information about this feature.

Breaker Alarms

Three alarm points are included in the programmable alarms for checking breaker monitoring functions. Each alarm point can be programmed to monitor any of the three breaker monitoring functions, operations counter, interruption duty, or clearing time. An alarm threshold can be programmed to monitor each function. Alternately, three different thresholds can be programmed to monitor one of the monitored functions.

Breaker Alarms settings are made using BESTCOMS. Figure 6-7 illustrates the BESTCOMS screen used to select settings for the Breaker Alarms function. Alternately, settings may be made using the SB-BKR ASCII command.

At the top of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be selected on this menu in order to allow changes to be made to the mode and inputs of the function.

Using the pull-down menus and buttons, make the application appropriate settings to the Breaker Alarms function.

Table 6-8 summarizes the Breaker Alarms settings.

Table 6-8. Breaker Alarms Settings

Setting		Range/Purpose	Default
Mode		0 = Disabled 2 = Operations 1 = Duty 3 = Clearing Time	0
Threshold	Point 1 Mode	0 to 100 in percent, increment = 0.01	0
	Point 2 Mode	0 to 99,999 in operations, increment = 1	0
	Point 3 Mode	0, 20 to 1,000 in milliseconds (m), seconds (s), or cycles (c). Setting is reported in milliseconds if less than 1 seconds.	0

TRIP CIRCUIT MONITOR

The trip circuit monitor continually monitors the circuit breaker trip circuit for voltage and continuity. A closed breaker with no voltage detected across the trip contacts can indicate that a trip circuit fuse is open or there is a loss of continuity in the trip coil circuit. Breaker status (open or closed) is obtained through the breaker status reporting function (configured by the SB-LOGIC command).

The detector circuit used by the trip circuit monitor is hardwired across the OUT1 contact. This contact is used in all of the preprogrammed logic schemes as the main trip output. The detector circuit across OUT1 is not polarity sensitive because the optical isolator used for detecting continuity is connected across a full wave bridge. See Figure 6-9. The amount of current drawn through the optical isolator circuit depends on the total input impedance for each power supply voltage rating (see Table 6-9). Figure 6-10 illustrates typical trip circuit monitor connections for the BE1-IPS100.

If the breaker status reporting function detects a closed breaker and no trip circuit voltage is sensed by the trip circuit monitor after 500 milliseconds (coordination delay time), an alarm bit in the programmable alarms function is set (OUT1 CKT OPEN) and the OUT1MON BESTlogic variable is set to TRUE.

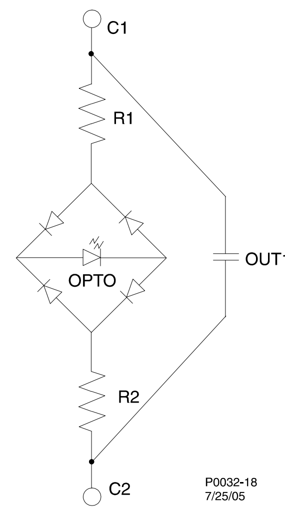

Figure 6-9.Trip Detector Circuit

Table 6-9. Current Draw for each Power Supply Voltage Rating

Power Supply Voltage Rating	R1 = R2 =	R Total	Optical Isolator	
			Off (55% V)	On (80% V)
24 Vdc	6.8 kΩ	14.6 kΩ	13.2 V (0.78 mA)	17.4 V (1.19 mA)
24/125 Vdc	18 kΩ	36 kΩ	26.4 V (0.68 mA)	38.4 V (1.02 mA)
125/250 Vdc	47 kΩ	94 kΩ	68.7 V (0.71 mA)	100 V (1.06 mA)

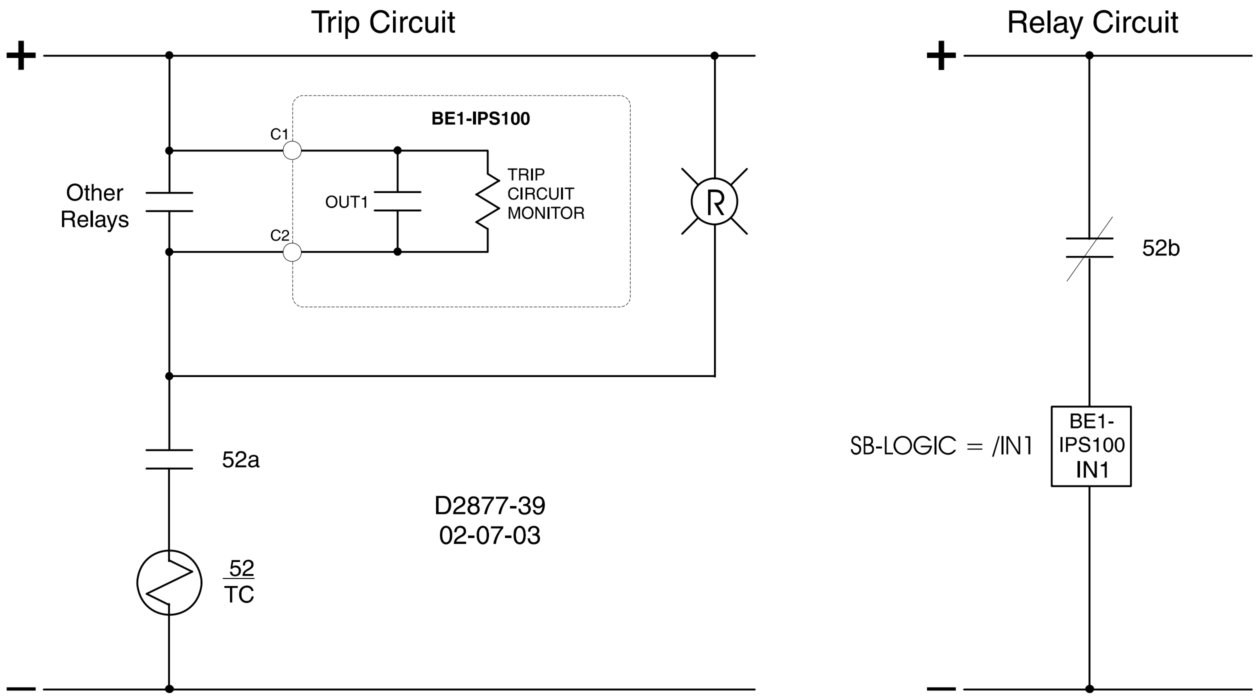

Figure 6-10. Trip Circuit Voltage and Continuity Monitor

CAUTION

Applications that place other device inputs in parallel with the breaker trip coil may not perform as desired. The connection of other devices in parallel with the trip coil causes a voltage divider to occur when the breaker or trip circuit is open. This may cause false tripping of the other devices and prevent the BE1-IPS100 trip circuit monitor from reliably detecting an open circuit. Contact Basler Electric for advice on this application.

The circuit monitor sensing element has the same rating as the power supply voltage. If the trip circuit voltage is significantly greater than the power supply voltage (for example, when using a capacitor trip device), the user should program the BE1-IPS100 to use one of the other output relays for tripping. In this situation, the trip circuit monitor function will not be available.

In Figure 6-11, a 62x auxiliary relay is shown. In this case, the impedance of the 62x coil is small compared to the impedance of the TCM circuit so the TCM optical isolator is always on and the TCM is always at logic 1. This prevents the TCM logic from working even if the trip coil is open. To prevent this problem, a diode was added as shown in Figure 6-11 to isolate the TCM circuit from the effects of 62X.

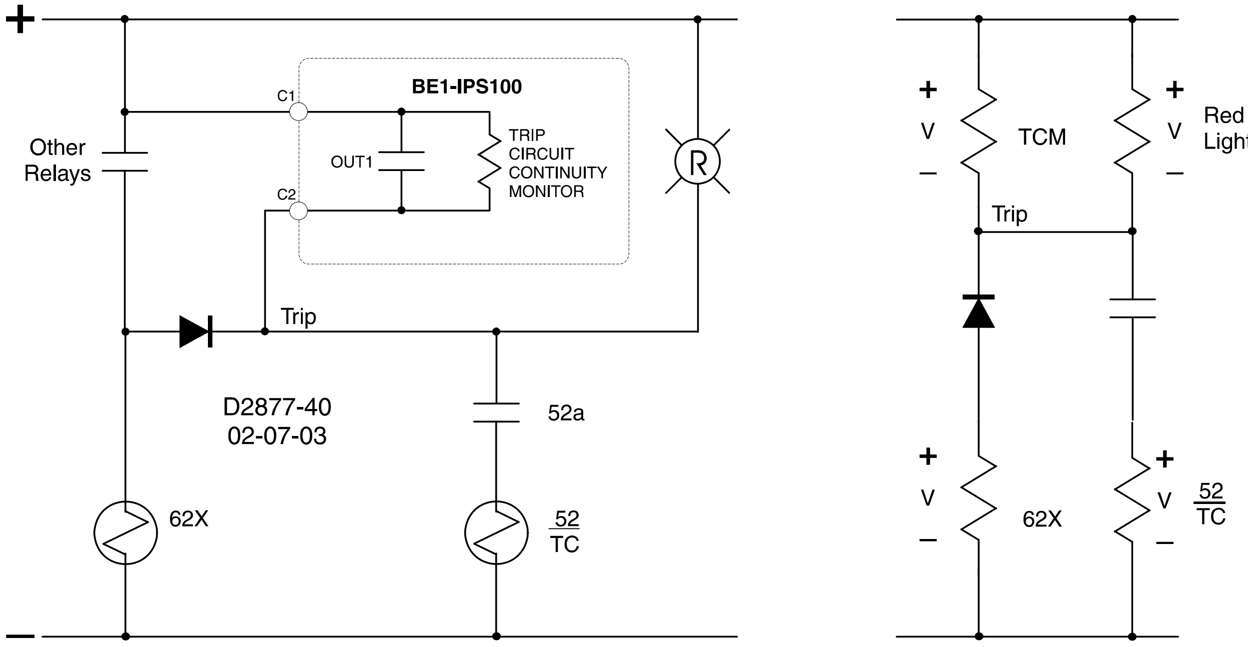

Figure 6-11. TCM with Other Devices

FAULT REPORTING

Fault Reporting Expressions and Settings

The fault reporting function records and reports information about faults that have been detected by the relay. The BE1-IPS100 provides many fault reporting features. These features include Fault Summary Reports, Sequence of Events Recorder Reports, Oscillographic Records, and Targets.

Logic expressions are used to define the three conditions for fault reporting. These conditions are Trip, Pickup, and Logic trigger. Figure 6-6 and Table 6-8 illustrate how each of these logic expressions is used by the various relay functions. Note that even though BESTlogic expressions are used to define these conditions, these expressions are not included here. Section 7, *BESTlogic Programmable Logic*, provides information about using BESTlogic to program the relay.

Trip

Trip expressions are used by the fault reporting function to start logging targets for an event and to record fault current magnitudes at the time of trip. The trip expression is used to illuminate the Trip LED on the HMI. The Trip LED will turn on and remain on as long as the trip expression is true. The Trip LED will remain on (or “sealed-in”) after the trip expression becomes false if targets are associated with the trip. The breaker monitoring function uses the trip expression to start counting the breaker operate time.

Pickup

Pickup expressions are used by the fault reporting function to time-stamp the fault summary record, time the length of the fault from pickup to dropout (fault clearing time), and to control the recording of oscillographic data. The pickup expression is used to flash, on and off, the Trip LED on the HMI. The Trip LED will continue to flash on and off as long as the pickup expression is true and the trip expression is not true. A pickup expression is also used by the setting group selection function to prevent a setting group change during a fault.

Logic

Logic trigger expressions allow the fault reporting function to be triggered even though the relay in not picked up. A logic trigger expression provides an input to the fault reporting function much as the pickup expression does. This logic expression is not used by the setting group selection or the HMI.

Fault Reporting Trigger Settings

Fault reporting trigger settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 6-12 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Fault Recording* function. To open the *BESTlogic Function Element* screen for *Fault Recording*, select *Reporting and Alarms* from the *Screens* pull-down menu. Select the *Fault Recording* tab. Then select the *Logic* button in the *Fault Recording* box in the upper left hand corner of the screen. Alternately, settings may be made using SG-TRIGGER ASCII command.

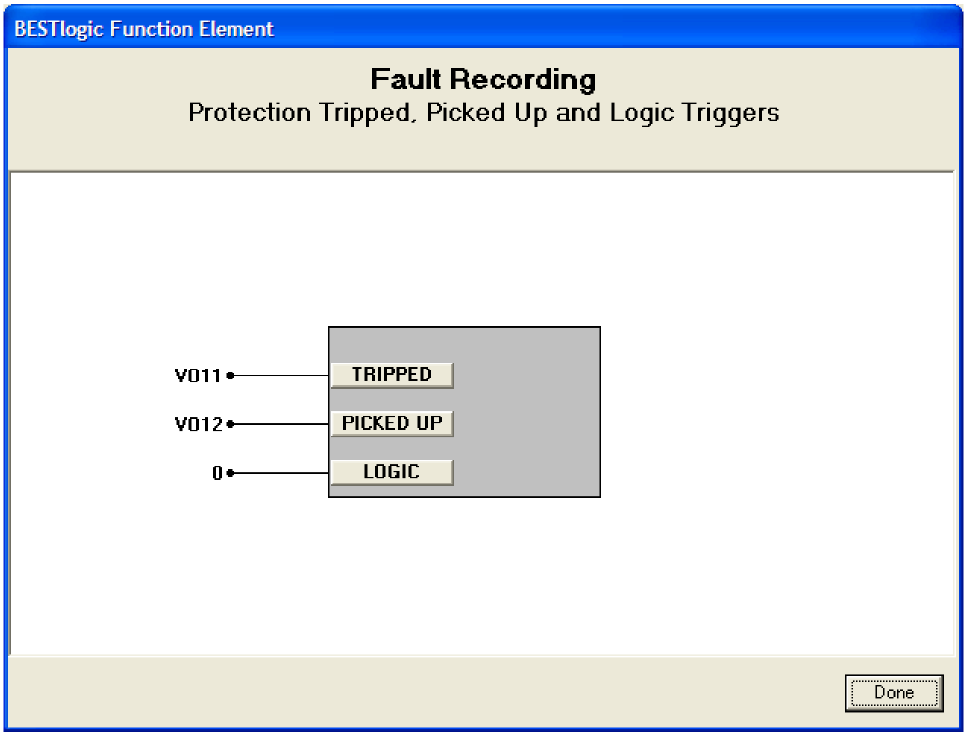

Figure 6-12. BESTlogic Function Element Screen, Fault Recording

To connect the function's inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited. Trigger settings for fault reports are made using the SG-TRIGGER (settings-general, trigger) command.

Table 6-10 lists the function's trigger settings.

Table 6-10. Fault Reporting Trigger Settings

Function	Purpose	Default
TRIPPED	Logic expression used to define Trip fault reporting condition. When this expression becomes TRUE (1), it triggers data recording and illuminates the Trip LED.	BFT+VO11
PICKED UP	Logic expression used to define Pickup fault reporting condition. When this expression becomes TRUE (1), it initiates the pickup timing sequence and the Trip LED will flash on and off.	BFPU+VO12
LOGIC	Logic expression used to define the trigger for fault reporting when relay is not picked up. When this expression is TRUE (1), fault reporting is triggered.	0

Example 1. Make the following BESTlogic settings to the Fault Recording function. See Figure 6-12.

Tripped: VO11
Picked up: VO12
Logic: 0

Targets

Each protective function (see Table 6-11) logs target information to the fault reporting function when a trip condition occurs and the trip output of the function block becomes TRUE (refer to Figure 6-6 and Table 6-6, call-out B). Target information can be viewed and reset at the HMI and through the communication ports.

Table 6-11. Protective Functions with Targets

Name	Protective Function	Target Default
51P	Phase Inverse Time Overcurrent	Enabled
51N	Neutral Inverse Time Overcurrent	Enabled
51Q	Negative-Sequence Inverse Time Overcurrent	Enabled
151P	Second Phase Time Overcurrent	Enabled
151N	Second Neutral Time Overcurrent	Enabled
50TP	Phase Instantaneous Overcurrent	Enabled
50TN	Neutral Instantaneous Overcurrent	Enabled
50TQ	Negative-Sequence Instantaneous Overcurrent	Enabled
150TP	Second Phase Instantaneous Overcurrent	Enabled
150TN	Second Neutral Instantaneous Overcurrent	Enabled
150TQ	Second Negative-Sequence Instantaneous Overcurrent	Enabled
81	Under/Overfrequency	Enabled
181	Second Under/Overfrequency	Enabled
281	Third Under/Overfrequency	Enabled
381	Fourth Under/Overfrequency	Enabled
481	Fifth Under/Overfrequency	Enabled
581	Sixth Under/Overfrequency	Enabled
59P	Phase Overvoltage	Enabled
159P	Second Phase Undervoltage	Enabled
59X	Auxiliary Overvoltage	Enabled
159X	Seconds Auxiliary Overvoltage	Enabled
47	Negative-Sequence Overvoltage	Enabled
27P	Phase Undervoltage	Enabled
127P	Second Phase Undervoltage	Enabled
27X	Auxiliary Undervoltage	Enabled
62	General Purpose Logic Timer	Disabled
162	Second General Purpose Logic Timer	Disabled
24	Volts per Hertz	Enabled
32	Directional Power	Enabled
132	Second Directional Power	Enabled
60FL	Fuse Loss Detection	Disabled
BF	Breaker Failure	Enabled

Target logging for a protective function can be disabled if the function is used in a supervisory or monitoring capacity. The following paragraphs describe how the relay is programmed to define which protective functions log targets.

Setting the Targets Function

Targets are enabled using the BESTCOMS screen shown in Figure 6-13. You can select which protective elements trigger a target and what type of logic condition will reset the targets. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Fault Recording* tab. Enable the targets by checking the appropriate boxes.

Alternately, targets can be enabled using the SG-TARG ASCII command. Using the SG-TARG command, you can select which protective elements trigger a target and what type of logic condition will reset the targets.

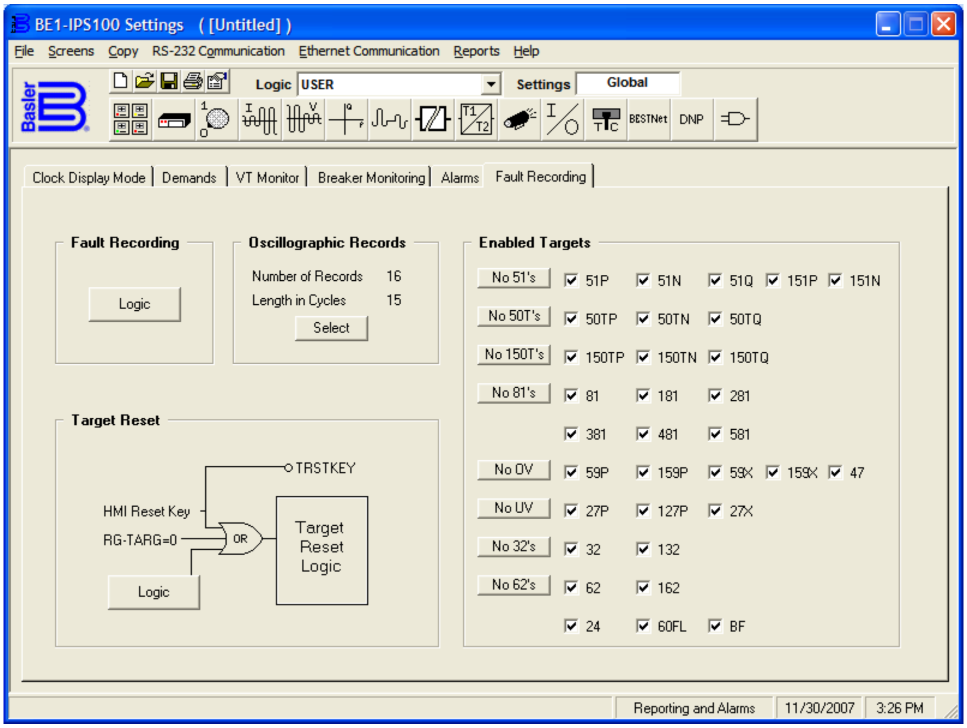

Figure 6-13. Reporting and Alarms, Fault Recording Tab

Target settings are summarized in Table 6-12.

Table 6-12. Target Settings

Function	Purpose
Enabled Targets	Specifies which protective elements will trigger a target. When the programmed protective element's BESTlogic expression is TRUE (1) and the trip output is TRUE (1), a trip event is recorded in the target log.
Target Reset Logic	Logic expression that will reset the targets when TRUE.

Retrieving and Resetting Target Information

Targets can be viewed at HMI Screen 1.2 and through the communication ports using the RG-TARG (report general, targets) command. The relay provides target information from the most recent trip event. Target information is specific to an event; it is not cumulative. Targets for previous events are recorded in the fault summary reports, which are described in the following subsection.

When a protective trip occurs and targets are logged, the HMI Trip LED seals-in and Screen 1.2 is automatically displayed. The LCD scrolls between the targets and the fault current magnitudes that were recorded during the fault. Pressing the HMI *Reset* key will clear these targets and the Trip LED. Password access is not required to reset targets at the HMI. See Figure 6-14.

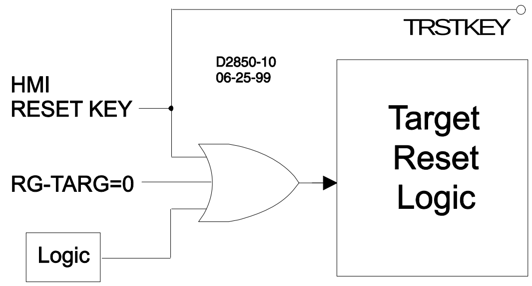

Figure 6-14. Target Reset Logic

A logic input can be used to reset the target. Using BESTCOMS, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select *Fault Recording* tab. The logic input can be connected by selecting the *Logic* button in the *Target Reset* pane. When the logic input becomes TRUE, the target is reset.

BESTCOMS can also be used to review targets and alarms after an operation by selecting *Metering* from the *Reports* pull-down menu. Using the *View* pull-down menu, select *Alarms Status* and *Targets Status.* These panes (Figure 6-15) will contain target and alarm information.

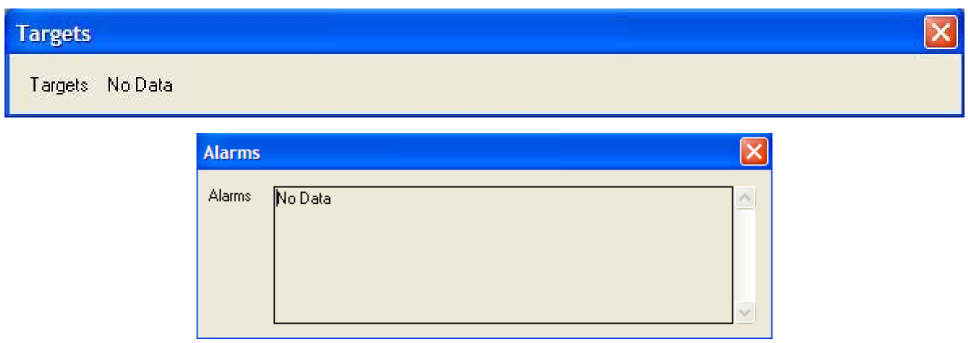

Figure 6-15. Targets and Alarms Status, BESTCOMS Metering Screen

Table 6-13 provides the possible targets that may be displayed on the *Metering* screen.

Table 6-13. Targets as Displayed

IEEE Device Number	Definition
24	Overexcitation
27/127 ABC	Phase Undervoltage
27BUS, 27N, 27-3BUS (27X fundamental, 3V0, 3rd harmonic)	Auxiliary Undervoltage
32/132	Directional Power
47	Negative-Sequence Voltage
50/150 ABC, Q or 1, N or G (Q can be set + or – Sequence.)	Instantaneous Overcurrents
51 ABC, Q, N or G; 151 ABC, N or G	Time Overcurrents
59/159 ABC	Phase Overvoltage
59/159BUS, 59N, 59-3BUS (59/159X fundamental, 3V0, 3rd harmonic)	Auxiliary Overvoltage
60FL	Fuse Loss
62/162	Logic Timers
67T ABC Q, N or G; 167T ABC, N or G	Directional Time Overcurrents
67/167 ABC, Q or 1, N or G (Q can be set + or – Sequence.)	Directional Instantaneous Overcurrents
81/181/281/381/481/581	Frequency
BF	Breaker Failure

The RG-TARG (report general-targets) command is used to read and reset targets through the communication ports.

Distance to Fault

The BE1-IPS100 calculates distance to fault each time a fault record is triggered. Distance to fault is calculated and displayed based on the power line parameters entered using BESTCOMS, the HMI, or with the SG-LINE command. Table 6-14 provides the power line operating settings.

Table 6-14. Power Line Operating Settings

Setting	Range	Increment	Unit of Measure	Default
Positive-Sequence Magnitude (Z1)	0.05 to 200	0.05	Ohms	8
Positive-Sequence Impedance Angle (A1)	0 to 90	1	Degrees	80
Zero-Sequence Magnitude (Z0)	0.05 to 650	0.05	Ohms	24
Zero-Sequence Impedance Angle (A0)	0 to 90	1	Degrees	80
Length of Power Line (LL)	0.01 to 650	0.01	Units	100

The command (SG-LINE) describes the power line parameters for which distance is to be computed over. The parameters should be entered in units per line length with line length being the actual length of the power line. Line length is entered as unit-less quantities and, therefore, can be entered in kilometers or miles. The distance results would, therefore, be in whatever units the line length represented.

Using BESTCOMS, power line parameters can be entered by selecting *General Operation* from the *Screens* pull-down menu. Then select the *Power System* tab (see Figure 6-16). Power line parameters such as *Positive-Sequence Impedance, Zero-Sequence Impedance,* and *Line Length* can be entered in the center pane under *Power Line Parameters*.

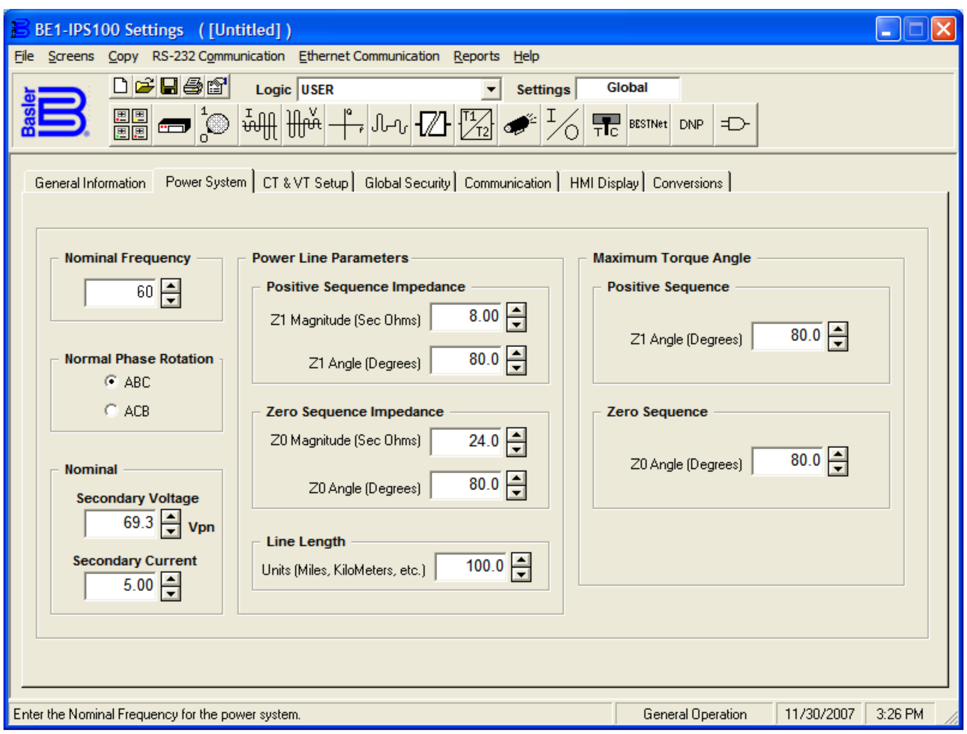

Figure 6-16. General Operation Screen, Power System Tab

The BE1-IPS100 calculates distance to fault each time a fault record is triggered. Refer to the fault record triggering logic command SG-TRIGGER for triggering details. Distance to fault is calculated and displayed based on the power line parameters. For more information on entering power line parameters, see Section 4, *Protection and Control*.

Note that both Z1-MAG and Z0-MAG are scaled by 10 times to represent the entire length of the power line. Since the units are in kilometers the distance results would also be in kilometers.

Distance calculations are preformed post-fault using vector data captured during the actual fault. Pre-fault current vectors are captured three cycles prior to pickup. Fault voltage and current vectors are captured two cycles after the trip command is issued. The two-cycle wait time allows line transients to settle to provide more accurate results.

To perform the actual distance calculation, the BE1-IPS100 first must determine the faulted phase. Faults can be categorized depending on the lines faulted. The various categories are LLL, LL, LLG, or LG where L = line and G = ground.

To determine the faulted phase, the fault vectors are compensated for load flow using the pre-fault data. Next, the compensated vectors are run through a series of sequence component comparisons. Once the faulted phase is determined, the fault data along with the line parameters are applied using the Takagi algorithm to determine the impedance of the faulted line. The impedance is divided by the impedance per unit length to determine the distance to fault. This method assumes the line is homogenous and that the line parameters do not change over the length specified. For a non-homogenous line, the distance would need to be manually corrected.

The distance to fault results are limited to ±300% of the specified line length. This limit prevents erroneous results from being displayed for non-over current type faults, such as over or under voltage faults. A computed value greater than maximum line length is reported as N/A (not applicable).

Fault Summary Reports

The BE1-IPS100 records information about faults and creates fault summary reports. A maximum of 16 fault summary reports are stored in the relay. The two most recent reports are stored in nonvolatile memory. When a new fault summary report is generated, the relay discards the oldest of the 16 events and replaces it with a new one. Each fault summary report is assigned a sequential number (from 1 to 255) by the relay. After event number 255 has been assigned, the numbering starts over at 1.

BE1-IPS100 relays generate three different fault summary reports. They are *Close, Trip*, and *Close Trip*. The *Close* report contains the data recorded by the relay when the breaker was closed. The *Trip* report contains the data recorded during the fault. The *Close Trip* report contains both sets of data.

BESTCOMS Fault Summary Report

To view fault reports using BESTCOMS, select *Oscillography Download* from the *Reports* pull-down menu. Then select *Serial Connection* or optional *Ethernet Connection.* A screen such as the one shown in Figure 6-17 will appear.

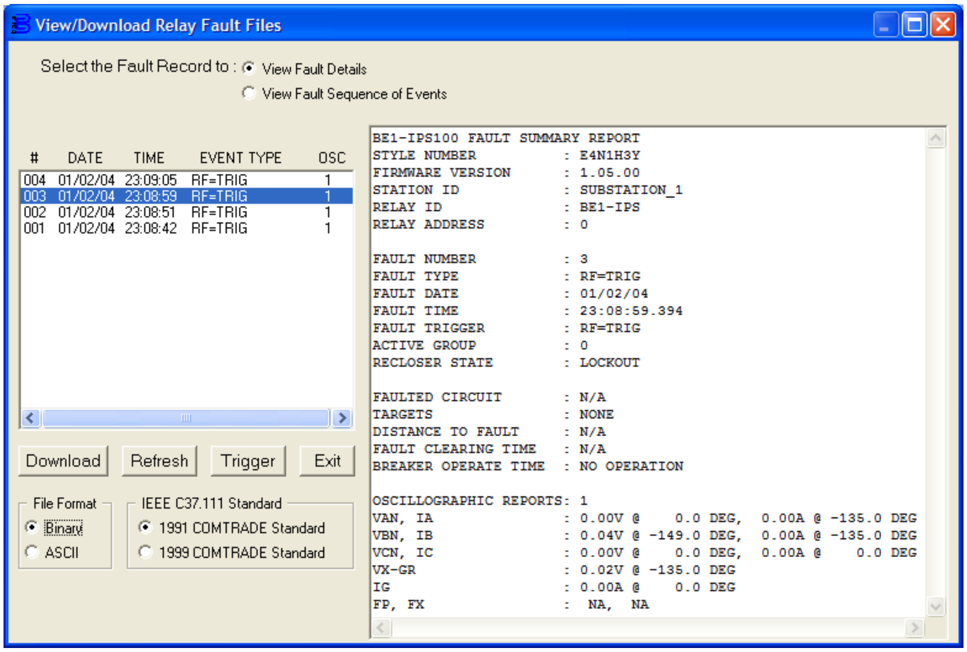

Figure 6-17. View/Download Relay Fault Files Screen

From this screen, you can *View Fault Details* or *View Fault Sequence of Events* by selecting your choice at the top of the screen and then highlighting the fault to be displayed. In Figure 6-17, fault 003 is highlighted.

The *Trigger* button allows a fault to be manually triggered. This can also be done using the SG-TRIGGER ASCII command.

The *Refresh* button is used to refresh the list of faults. The *Download* button will download the selected fault, storing it on the selected drive as either a binary or ASCII file, selected beneath the button.

<u>Fault Summary Report Example</u>

A fault summary report collects several items of information about a fault that can aid in determining why a fault occurred without having to sort through all of the detailed information available. The following example illustrates a typical fault summary report. Call-outs shown in the report are references to the legend of Table 6-6.

Fault Summary Report Example

>RF-4

```
BE1-IPS100 FAULT SUMMARY REPORT
STYLE NUMBER           : E4N1H3Y                              D2849-35
FIRMWARE VERSION       : 1.05.00                              09-05-06
STATION ID             : SUBSTATION_1
RELAY ID               : BE1-IPS
RELAY ADDRESS          : 0

FAULT NUMBER           : 4
FAULT TYPE             : TRIP
FAULT DATE             : 09/05/06          A
FAULT TIME             : 17:22:41.979
FAULT TRIGGER          : VO2.V010
ACTIVE GROUP           : 0
RECLOSER STATE         : OFF
                                            B
FAULTED CIRCUIT        : ABG
TARGETS                : 50TA,50TB
DISTANCE TO FAULT      : 7.81               F
FAULT CLEARING TIME    : 0.160 SEC          C
BREAKER OPERATE TIME   : 0.152 SEC          D

OSCILLOGRAPHIC REPORTS: 1                   E
VAN, IA                : 0.86KV @    0.0 DEG,   900A @ -56.5 DEG
VBN, IB                : 0.95KV @ -101.0 DEG,   945A @-166.4 DEG   F
VCN, IC                : 5.21KV @  149.0 DEG,   177A @ 125.8 DEG
VX-GR                  : 0.01KV @    0.2 DEG
IG                     : 9.85A  @   57.3 DEG
FP, FX                 : 60.00Hz,  60.00Hz
```

Style Number. This line reports the style number of the relay.

Firmware Version. This line reports the version of firmware that the relay holds.

Station ID and Relay ID. These lines report station and device identifier information as defined by the SG-ID command.

Relay Address. This line reports the communications port address that the report was requested from. The relay address number is assigned using the SG-COM command, described in Section 11, *ASCII Command Interface*.

Fault Number. This line reports the sequential number (from 1 to 255) assigned to the report by the BE1-IPS100.

Fault Type. This line reports the type of fault that occurred. There are five fault type categories:

- Trip: A fault was detected as defined by the pickup expression and the relay tripped to clear the fault.
- Pickup: A fault was detected as defined by the pickup expression but the relay never tripped indicating that the fault was cleared by another device.
- Logic: A fault report was recorded by the logic trigger expression but no fault was detected as defined by the pickup expression.
- Breaker Failure: A fault was detected as defined by the pickup expression and the breaker failure trip became TRUE before the fault was cleared.
- RF=TRIG: A fault report was recorded by the ASCII command interface.

Fault Date and Time. These lines report the date and time of the initial trigger of the event. This is based on either the pickup logic expression or the logic trigger expression becoming TRUE as defined by the SG-TRIGGER command. Refer to Figure 6-6 and Table 6-6, call-out A.

Fault Trigger. This line reports the logic variables in the pickup or logic trigger expressions that became TRUE to trigger the recording of the event.

Active Group. This line reports what setting group was active at the time that the fault occurred.

Recloser State. This line reports the state of the recloser shot counter prior to the fault that triggered the report.

Faulted Circuit. This line reports the faulted circuit such as phase-phase, phase-ground, etc.

Targets. This line reports the targets that were logged to the fault report between the time that the trip expression became TRUE until the end of the fault. Refer to Figure 6-6 and Table 6-6, call-out B.

Distance to Fault. This line reports the distance to the fault on the line. Units are the same as the units used to determine line length in SG-Line settings. Refer to Figure 6-6 and Table 6-6, call-out F.

Fault Clearing Time. This line reports the time from when the relay detected the fault until the relay detected that the fault had cleared. Refer to Figure 6-6 and Table 6-6, call-out C.

If the fault report was triggered by the RF-TRIG command, the recording of the report was terminated after 60 seconds and this line is reported as N/A.

If the pickup or logic expressions stay TRUE for more than 60 seconds, an alarm bit in the programmable alarm function is set and this line is reported as N/A. In this situation, the fault reporting functions (including targets) will not operate again until the pickup and logic trigger expressions return to a FALSE state to enable another trigger.

Breaker Operate Time. This line reports the breaker trip time from the breaker monitoring and alarm function. This is the time measured from when the breaker is tripped until the fast-dropout current detector function detects that the arc has been extinguished. Refer to Figure 6-6 and Table 6-6, call-out D.

Oscillographic Reports. This line reports the number of oscillographic records that are stored in memory for this fault report. Refer to Figure 6-6 and Table 6-6, call-out E. Recording of oscillographic records is described in the *Oscillographic Records* subsection.

IA, IB, IC, IG. These lines report the current magnitudes and angles measured two power system cycles immediately following the trip trigger. If the fault is cleared prior to the relay tripping, the recorded fault currents are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 6-6 and Table 6-6, call-out F.

VA, VB, VC, VX. These lines report the voltage magnitudes and angles measured two power system cycles immediately following the trip trigger. If the fault is cleared prior to the relay tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 6-6 and Table 6-6, call-out F.

FP and FX. This line reports the frequency for the phase voltage input and auxiliary voltage input measured immediately following the trip trigger. Refer to Figure 6-6 and Table 6-6, call-out F.

<u>Retrieving Fault Report Information from the Relay</u>

Fault Summary Directory Report. The fault reporting function provides a directory of fault summary reports that lists the number assigned to the fault summary report along with the date and time of the fault, the event type, and the total number of oscillography records stored in memory for that event. The event number is important because it is required to retrieve information about that event from the relay. This directory report can be accessed by using the RF command.

New Faults Counter. One line of the fault summary directory report contains the new faults counter. The new faults counter tracks how many new fault reports have been recorded since the new faults counter was reset to 0. This counter provides a way to check the fault information and then reset the new faults counter. Then, the next time that the relay is checked, it's easy to determine if any fault reports have been entered. Resetting the new faults counter is achieved using the RF-NEW=0 command. Write access to Reports must be gained to reset the new faults counter through the communication ports. The new faults counter can also be viewed at HMI Screen 4.1. The new faults counter cannot be reset at the HMI.

Fault Summary Reports. Individual fault summary reports can be retrieved using the RF-n command, where n represents the number assigned to the fault summary report. To obtain the most recent report, use RF-NEW. If additional detail is desired, Sequence of Events Recorder data and Oscillographic data can be obtained for the faults also. This is discussed in greater detail later in this section.

Oscillographic Records

<u>*Recording Oscillographic Records*</u>

The fault reporting function can record up to 16, *IEEE Standard Common Format for Transient Data Exchange* (COMTRADE) oscillographic records. Each time the fault reporting function starts recording a fault summary report, it freezes a 4 cycle pre-fault buffer. If the fault is not cleared within that time, the fault reporting function records a second oscillographic record. This second record captures the end of the fault. Oscillographic records are stored in volatile memory. As additional faults are recorded, the oldest records are overwritten. The relay has 240 cycles of memory. The SG-OSC setting sets the number of partitions and the length of the record is a function of the number of records. See Table 6-15.

If a second oscillographic record is required, the fault recording function will continue to record sample data in the second record with no gap. During this time, a 5-cycle buffer is being filled. If the fault is cleared within 5 cycles of the start of the second record, the record is terminated after it finished. If the fault does not clear in that period of time, the fault reporting function continues to save 5 cycles of sample data in its buffer until the fault is cleared. At that point, it freezes the 5-cycle buffer, providing 5 cycles of end of fault data.

Table 6-15. Possible Oscillographic Records

Number of Records	Length in Cycles
6	40
8	30
10	24
12	20
15	16
16	15

<u>*Oscillographic Records Settings*</u>

The oscillographic records settings can be programmed through BESTCOMS. To select the number of records, select *Reporting and Alarms* from the *<u>S</u>creens* pull-down menu. Select the *Fault Recording* tab and click the *Select* box in the *Oscillographic Records* pane. Make your selection as shown in Figure 6-18, *Oscillographic Records Selector*. Select *Done* once the setting has been made.

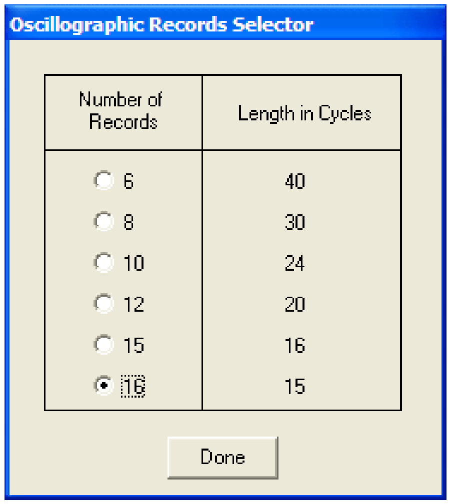

Figure 6-18. Oscillographic Records Selector

The oscillographic records settings can also be made using the SG-OSC (settings general, oscillography) ASCII command. See Table 6-16 for possible settings.

Table 6-16. Oscillographic Records Settings

Setting	Range	Default
Number of Records Saved	6, 8, 10, 12, 15, 16	16

Retrieving Oscillographic Records

The fault summary directory and the fault summary reports list the numbers assigned to each fault record and the number of oscillographic records associated with each fault. Oscillographic records can be retrieved using BESTCOMS. Alternately, oscillographic records can be retrieved using the RO ASCII command.

To download oscillographic records, select *Oscillography Download* from the *Reports* pull-down menu. Highlight the record to be downloaded and select either *ASCII* or *Binary* as the file type for download. Select the *Download* button.

Assume record 003 is selected for a binary download. When the *Download* button is selected, the *Browse for Folder* screen (Figure 6-19) appears. Select a location for the file to be stored or create a *New Folder* and press *OK*. The *Fault Record Filenames* screen (Figure 6-20) will appear. Type the base filename in the first row. The rest of the filenames will respond by changing to match the base filename. Select *OK* to save the file.

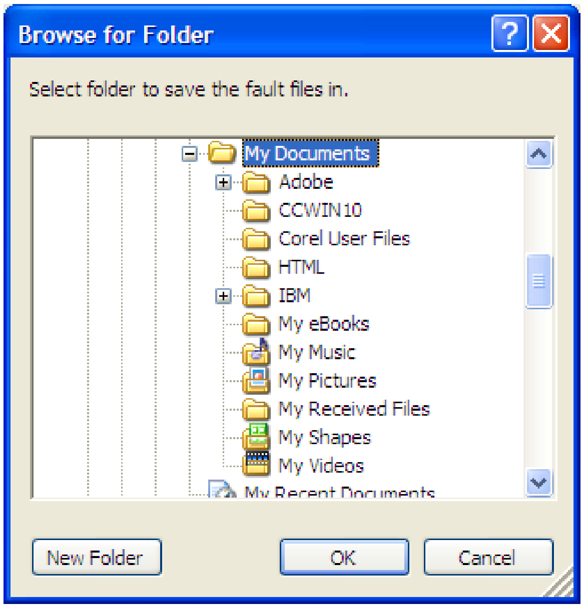

Figure 6-19. Browse for Folder Screen

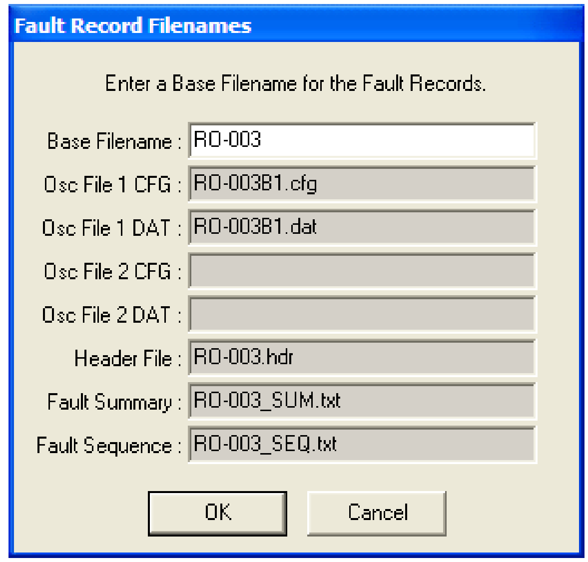

Figure 6-20. Fault Record Filenames

Only one oscillographic report file can be requested at a time. Reports are transmitted in COMTRADE format. A configuration file (CFG), a data file (DAT), or a header report (HDR) can be requested. Header files contain the fault summary report followed by all the pertinent settings that are associated with the requested fault record. These settings include the following:

- BESTlogic settings for User Programmable Logic Scheme.
- User Programmable Label settings, Global I/O settings.
- The protection setting group active during the fault.
- General protection settings.
- Fault reporting settings.
- Breaker monitoring settings.
- Alarm settings.

Files can be requested in ASCII or binary format but both file transfers use the same format. Binary file transfer is much faster and consumes less disk space. ASCII format data is human readable and can be analyzed by standard text editing software. Software for IBM compatible computers is available from Basler Electric to convert binary files to ASCII format. The download protocol may be either XMODEM or XMODEM CRC format. For ease of reference, the name of the downloaded file should be the same as the command.

SEQUENCE OF EVENTS RECORDER

A sequence of events recorder (SER) report is very useful in reconstructing the exact sequence and timing of events during a power disturbance or even normal system operations. The SER tracks over 100 data points by monitoring the internal and external status of the relay. Data points are scanned every quarter-cycle. All changes of state that occur during each scan are time tagged to 1 millisecond resolution. A total of 255 records are stored in volatile memory; when the SER memory becomes full, the oldest record is replaced by the latest one acquired.

The SER monitors the following points and conditions:

- Single-state events such as resetting demands or targets, changing settings, etc.
- Programmable logic variables
- Targets
- Relay trouble alarm variables
- Programmable alarm variables
- Output contact status
- Fault reporting trigger expressions

When a monitored event occurs or a monitored variable changes state, the SER logs the time and date of the event, the event or variable name, and the state that the variable changed to. For user-programmable logic variables (contact sensing inputs, virtual switches, and virtual outputs), the user-programmed variable name and state names are logged in the SER report instead of the generic variable name and state names. For more information, refer to Section 7, *BESTlogic Programmable Logic, User Input and Output Logic Variable Names.*

Retrieving SER Information Using BESTCOMS

To view SER information using BESTCOMS, select *Oscillography Download* from the *Reports* pull-down menu. Then select either *Serial Connection* or optional *Ethernet Connection.* A screen such as the one shown in Figure 6-21 will appear. Select *View Fault Sequence of Events* and highlight a fault record to view.

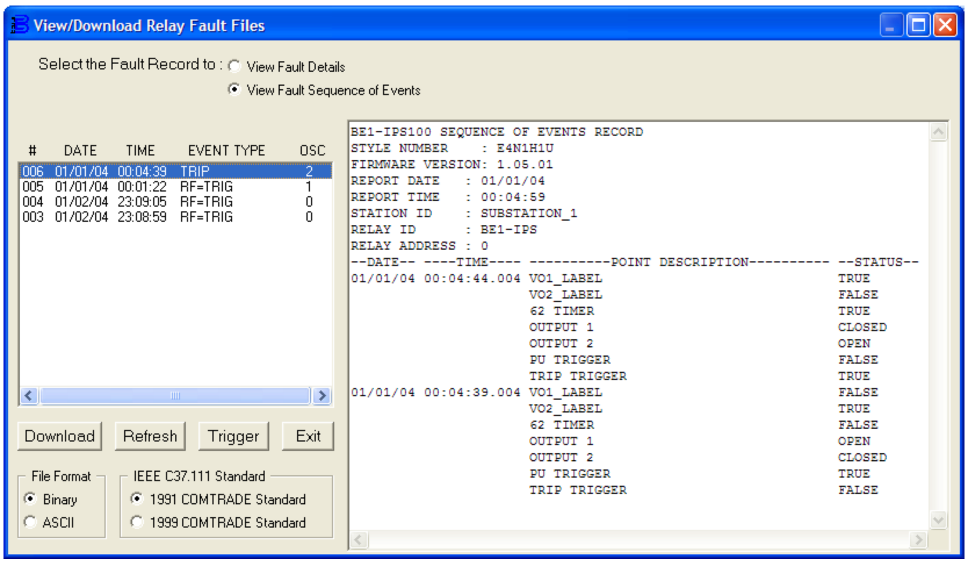

Figure 6-21. View/Download Relay Fault Files Screen

Retrieving SER Information Using ASCII Commands

SER information is retrieved through SER Directory Reports, the New Events Counter, and by obtaining specific SER Reports.

SER Directory Report

A directory report lists the number of events currently in memory and the time span that the events cover. Directory reports are accessed using the RS (report SER) command.

New Events Counter

The new events counter tracks how many new entries have been logged to the SER since the new events counter was reset to zero. After SER information is checked, the new events counter can be reset. Then, the next time that the relay is checked, it is easy to determine if there are new events that have not been evaluated. One line of an SER directory report contains the new events counter information. The new events counter is reset by obtaining write access to *Reports* and using the RS=0 command. The new events counter can be viewed but not reset at HMI Screen 4.2.

SER Report

A directory of SER reports can be obtained using the RS (report SER) command. Six sub-reports are available through the RS command: RS-n, RS-Fn, RS-ALM, RS-I/O, RS-LGC, and RS-NEW. These sub-reports give specific types of data without confusing the user with every internal state change and event occurrence. Each sub-report is defined in the following paragraphs:

1. RS-n (report SER, number of most recent events)

   Events are retrieved for the most recent entries. Entering RS-4 would view an SER report for the last four events.

2. RS-<n> (report SER, for Fault <event number>)

   Events are retrieved for the period of time specific to a fault event. The report includes all events within the time span of the fault plus one event before and after the fault. Entering RS-F9 views a SER report associated with fault record 9.

3. RS-ALM (report SER, alarm)

   This command retrieves all alarm events that exist since the last RS=0 command was issued. (RS=0 resets the new records counter to zero.) This information can also be obtained using the RA-SER command.

4. RS-IO (report SER, input/output)

   This command reports all input and output events since the last RS=0 command was issued. (RS=0 resets the new records counter to zero.)

5. RS-LGC (report SER, logic)

   A report is retrieved for all logic events since the last RS=0 command was issued. (RS=0 resets the new records counter to zero.)

6. RS-NEW (report SER, new events since RS=0 reset)

   Events are retrieved for the period of time covered by the New Events Counter register.

ALARMS FUNCTION

The alarms function monitors internal relay systems, external relay interfaces, and power system equipment. Alarm points are segregated into Relay Trouble Alarms and Programmable Alarms. Alarm point status is stored in nonvolatile memory and is retained when relay operating power is lost.

The ability to program the reporting and display of alarms along with the automatic display priority feature of the HMI gives the relay the functionality of a local and remote alarm annunciator. See Section 10, *Human-Machine Interface*, for more information on the automatic display priority logic.

Relay Trouble Alarms

All internal circuitry and software that affects how the relay functions is monitored by the continuous self-test diagnostics function of the relay trouble alarms. A detailed list of relay trouble alarms is provided in Table 6-17. If any one of these points asserts, the failsafe alarm output relay de-energizes and changes state of the OUTA contact, the HMI Relay Trouble LED lights, all output relays are disabled, logic variable ALMREL is set, and the relay is taken offline. The relay trouble alarms function is not programmable.

If you have a relay with a normally-closed alarm contact but require a normally-open contact, use BESTlogic to program the output logic. One of the output relays with normally open contacts (OUT1 through OUT5) can be programmed to be held closed. For example, to open OUT5 for indication of relay trouble, set the VO5 logic expression at /0 (SL-VO5=/0). A not zero setting is equal to logic 1. When the relay is fully functional, the OUT5 output contact is closed. Since all output relays are disabled when a relay trouble alarm exists, OUT5 opens when relay trouble occurs.

Table 6-17. Relay Trouble Alarms

I.D. #	Name	Description
1	RAM FAILURE	Static RAM read/write error.
2	ROM FAILURE	EPROM program memory checksum error.
3	UP FAILURE	Microprocessor exception or self-test error.
4	EEPROM FATAL ERROR	EEPROM read/write error.
5	ANALOG FAILURE	Analog to digital converter error.
6	CALIBRATION ERR	Relay not calibrated or calibration checksum error.
7	PWR SUPPLY ERR	Power supply out of tolerance.
8	WATCHDOG FAILURE	Microprocessor watchdog circuit timed out.
9	SET DEFLTS LOADED	Relay using setting defaults.
10	CAL DFLTS LOADED	Relay using calibration defaults.

Relay trouble alarms, except for CALIBRATION ERR, EEPROM FATAL ERR, SET DFLTS LOADED, and CALDFLTS LOADED indicate that the relay is not functional and causes the self-test diagnostics to force a microprocessor reset to try to correct the problem.

CALIBRATION ERR, EEPROM FATAL ERROR, or DFLTS LOADED errors indicate that the relay is functional but needs re-calibration or the settings reprogrammed.

Any relay trouble alarm will disable the protection functions, light the Relay Trouble LED, and place the output contacts in their normal, de-energized state. If a relay trouble (RA-REL) alarm is cleared by pressing the HMI *Reset* key while viewing Screen 1.3 or using the RA=0 or RA-REL=0 commands, then the relay will attempt to return back online by issuing a software reset. The relay resets by going through a full startup and initialization cycle. If no problems are detected, the relay returns online and enables protection.

Major, Minor, and Logic Programmable Alarms

The programmable alarms function covers all circuits monitored by the continuous self-test diagnostics function that do not affect the relay core functions. Alarm functions used to monitor the power system and equipment are also part of the programmable alarms. Table 6-18 provides a detailed list of all programmable alarms. The programmable alarm points can be prioritized into Major and Minor alarms using BESTCOMS. Major alarm points, when triggered, causes the HMI Major Alarm LED to light and the BESTlogic variable ALMMAJ to assert. Minor alarm points, when triggered, causes the HMI Minor Alarm LED to light and the BESTlogic variable ALMMIN to assert.

Any programmable alarm can also be used in programmable logic expressions without programming it to be reported by the programmable alarm reporting function. The ALMLGC variable is provided for this purpose. Programmable alarm variables can be masked to drive BESTlogic variable ALMLGC by using the SA-LGC command.

Table 6-18. Programmable Alarms

I.D. #	Name	Description
1	OUT1 CKT OPEN ∗	Trip circuit continuity and voltage monitor.
2	BKR FAIL ALARM	Breaker failure trip.
3	RECLOSER FAIL ∗	Reclose fail timer timed out before breaker closed.
4	RECLOSER LOCKOUT ∗	Recloser went through sequence without success.
5	BREAKER ALARM 1	Breaker Alarm 1 threshold (SA-BKR1 setting) exceeded.
6	BREAKER ALARM 2	Breaker Alarm 2 threshold (SA-BKR1 setting) exceeded.
7	BREAKER ALARM 3	Breaker Alarm 3 threshold (SA-BKR1 setting) exceeded.
8	P DEMAND ALARM ∗	Phase demand.
9	N DEMAND ALARM ∗	Neutral unbalance demand.
10	Q DEMAND ALARM ∗	Negative-sequence unbalance demand.
11	GROUP OVERRIDE ∗	Setting group control logic override.
12	SYS I/O ALARM	Excessive delay in HMI or serial communication operation.
13	COMM ERROR ALARM	Communication failure.
14	CLOCK ERROR ∗	Real-time clock not set.
15	uP RESET ALARM	Microprocessor has been reset.
16	SETTINGS CHANGE	Setting change made by user.
17	EE NONFATAL ERROR	EEPROM nonfatal recoverable error.
18	OUTPUT OVERRIDE ∗	One or more output contacts have logic override condition.
19	LOSS OF IRIGB	Loss of IRIG synchronization.
20	SGC ACTIVE ∗	Active setting group changed.
21	VO13_LABEL ∗	VO13 logic is TRUE (user programmable logic alarm).
22	VO14_LABEL ∗	VO14 logic is TRUE (user programmable logic alarm).
23	VO15_LABEL ∗	VO15 logic is TRUE (user programmable logic alarm).

I.D. #	Name	Description
24	FAULT REPORT TIMEOUT	TRUE if fault event trigger lasts longer than 60 seconds.
25	LOGIC = NONE ALARM	Active Logic=NONE.
26	VAR DEMAND ALARM ∗	Var demand maximum exceeded.
27	WATT DEMAND ALARM ∗	Watt demand maximum exceeded.
28	FREQ OUT OF RANGE ∗	Frequency out of range.
29	CHANGES LOST ALARM	Password access lost.
30	60 FL ALARM ∗	One or more phases of voltage lost.
31	V/Hz above Alarm Threshold	Trips at settable percentage of the pickup level.

∗ Alarms with an asterisk are non-latching. A non-latching alarm clears itself automatically when the alarm condition goes away. All other alarms are latching and must be manually reset by using the HMI *Reset* button or the RA=0 command.

Programming Alarm Priorities

Alarm settings include Major, Minor, and Logic alarm priorities, Demand alarm points, and the Breaker alarm points. Programming details for Demand alarm points is available in the *Demand Functions* subsection. Refer to the *Breaker Monitoring* subsection for details about programming Breaker alarm points. Major, Minor, and Logic programmable alarm settings are made using BESTCOMS. To select alarm priority, select *Reporting and Alarms* from the *Screens* pull-down menu. Select the *Alarms* tab. See Figure 6-22. Set the alarm point priority by checking the box or boxes to its right.

Alternately, settings for Major, Minor, and Logic alarms can be made using the SA-MAJ, SA-MIN, or SA-LGC ASCII commands. Refer to Section 11, *ASCII Command Interface, Command Summary, Alarm Setting Commands,* for complete command descriptions.

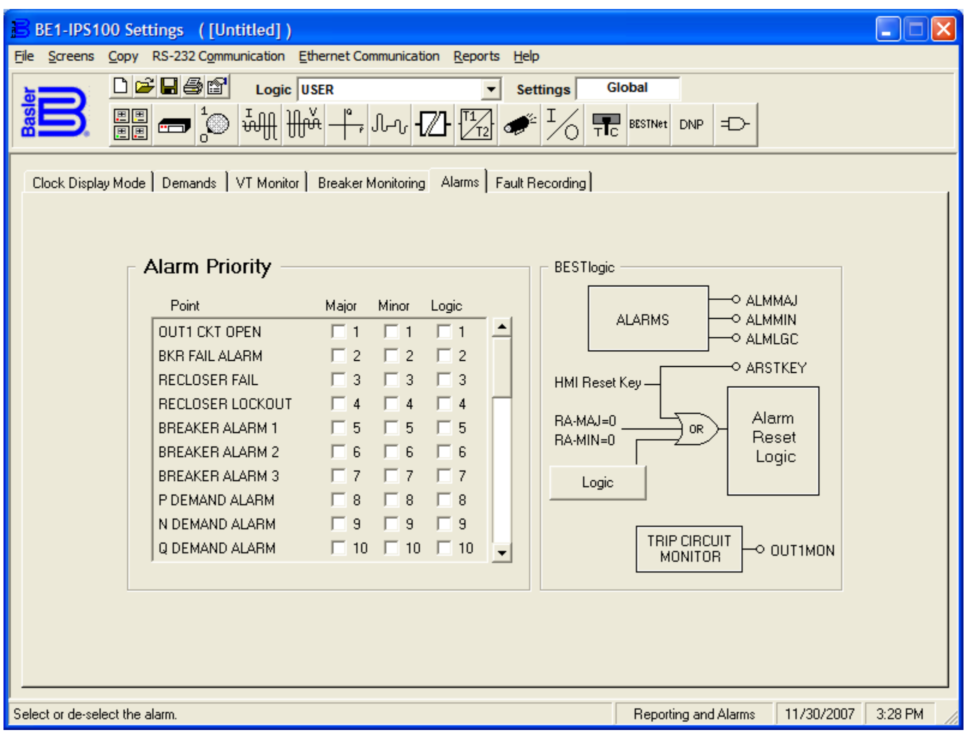

Figure 6-22. Reporting and Alarms Screen, Alarms Tab

Table 6-19 summarizes major, minor, and logic programmable alarm settings.

Table 6-19. Programmable Alarm Settings

Setting	Range/Purpose	Default
Major alarm points (drives Major Alarm LED and ALMMAJ logic variable).	List of alarm functions per Table 6-20.	25, 30
Minor alarm points (drives Minor Alarm LED and ALMMAJ logic variable).	List of alarm functions per Table 6-20.	29
Logic alarm points (drives ALMLGC logic variable).	List of alarm functions per Table 6-20.	0

<u>*Retrieving and Resetting Alarm Reports*</u>

When an alarm condition occurs, the appropriate front panel LED lights and HMI Screen 1.3 is displayed. (See Section 10, *Human-Machine Interface*, for more information about automatic display priority logic.) The HMI display scrolls between displaying all active alarm points. This includes alarms that are not programmable (relay trouble alarms). Any latched alarms that are not currently active can be reset by pressing the HMI *Reset* key. See Figure 6-23 for logic.

Logic variables for ALMMAJ, ALMMIN, and ALMLGC can also be set to operate any of the output contacts to give an indication that an alarm condition exists. Section 7, *BESTlogic Programmable Logic*, provides more details about this feature.

The status of the three front-panel LEDs (Relay Trouble, Minor Alarm, and Major Alarm) can be read through the communication ports by using the RG-STAT command. Alarm status is given in the DIAG/ALARM line of the General Status Report. Refer to the *General Status Reporting* subsection for more information about obtaining relay status with the RG-STAT command. Figure 6-23 shows the alarm reset logic.

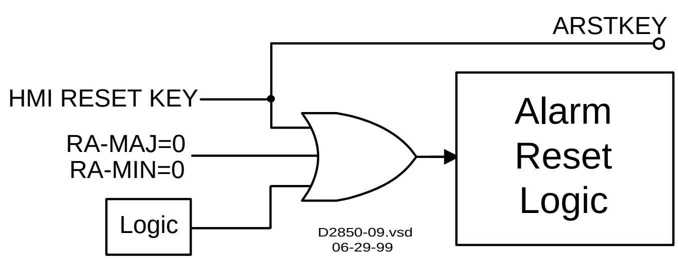

Figure 6-23. Alarm Reset Logic

The *Reset* key of the HMI is context sensitive. That is, the functionality depends upon what screen is currently being displayed. BESTlogic variable ARSTKEY takes advantage of this to allow the front panel *Reset* key to be used in the programmable logic scheme when *Alarms* screen 1.3 is active. An example of the use of this logic variable is to break the seal-in for a logic expression. The logic expression can be programmed so that the seal-in function uses VO13, VO14, or VO15. If the virtual output expression is included in one of the programmable alarm masks, the automatic display priority logic will cause the display to go to Alarms screen 1.3. When the HMI *Reset* key is pressed, the ARSTKEY logic variable is asserted and the logic expression seal-in is broken. See Section 8, *Application, Application Tips*, for more information. Pressing the HMI *Reset* key while the *Alarms* screen is displayed, will clear any latched alarms that are not currently active. Refer to Table 6-18 for a list of latching alarm points and self-clearing alarm points.

After an operation, alarms information can be viewed using BESTCOMS. Select *Metering* from the *Reports* pull-down menu. From the *View* pull-down menu, select *Alarms Status* (Figure 6-24).

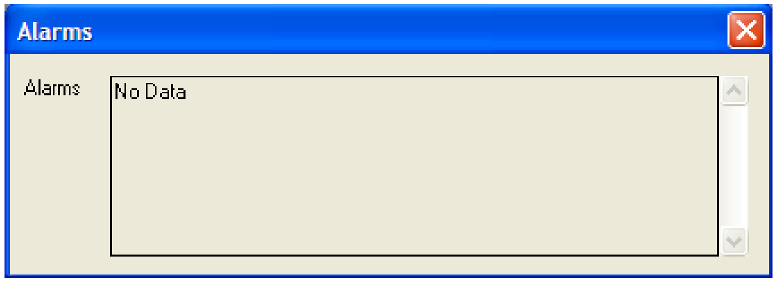

Figure 6-24. Alarms Status, Metering Screen

The RA (report alarms) command can be used to read detailed alarm reports and reset latched alarms.

Links between Programmable Alarms and BESTlogic

Several links between the programmable alarms and BESTlogic allow alarm functions to be used in the logic scheme and programmable logic functions to be used in the alarm reporting function.

Programmable Alarms Controlled by BESTlogic Elements

Virtual Outputs VO13, VO14, and VO15 are driven by BESTlogic expressions and are available in the programmable alarms function. These three virtual outputs have labels that can be assigned meaningful names. Then, when a logic condition that is used for an alarm exists, the label will be reported in the alarm reporting function.

Programmable Alarms Reset

Programmable alarms can be reset by any one of three methods:

- The programmable alarms reset logic expression becomes TRUE.
- Pressing the front panel *Reset* key when HMI Screen 1.3 is active.
- By connecting the alarms reset logic in BESTCOMS. Alternately, this can be done using the SA-RESET ASCII command.

To reset the alarms using BESTCOMS select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Alarms* tab. Select the *Logic* button in the *BESTlogic* box on the right side of the screen. Refer to Figure 6-22. The *BESTlogic Function Element* screen for *Alarm Reset Logic* will appear. See Figure 6-25.

To connect the function's input, select the *Reset* button in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

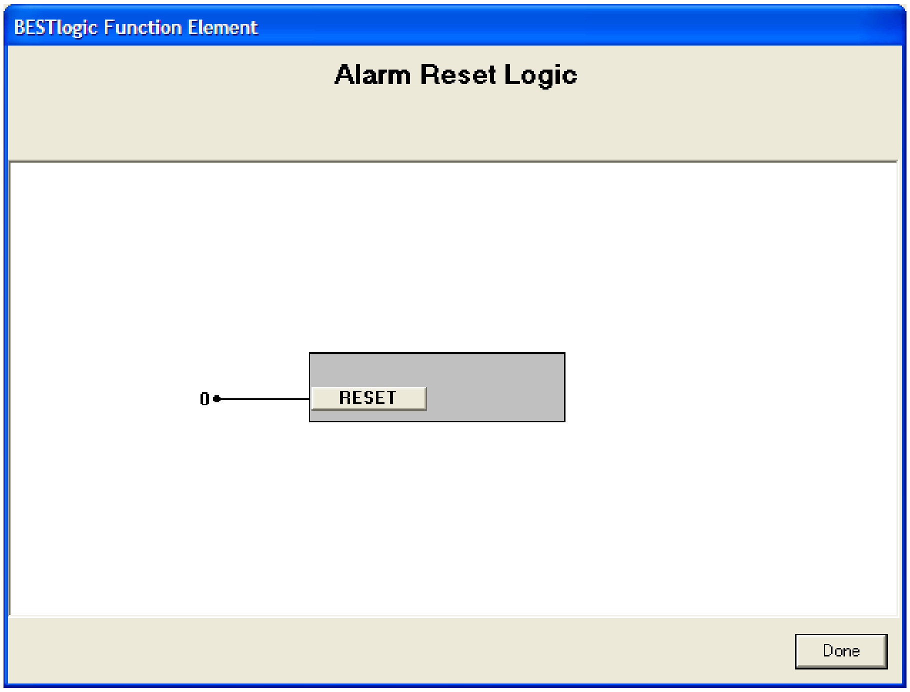

Figure 6-25. BESTlogic Function Element Screen, Alarm Reset Logic

<u>BESTlogic Elements Controlled by Programmable Alarms</u>

Major, Minor, and Logic programmable alarm settings drive BESTlogic variables ALMMAJ, ALMMIN, and ALMLGC. These variables can be used in logic expressions to control logic when the alarm is active. For example, these variables could be used to actuate an output relay to signal a SCADA RTU that an alarm condition exists.

HARDWARE AND SOFTWARE VERSION REPORTING

Hardware and software version reporting is used to determine what style chart selections are included in the relay, the relay serial number and the version of the embedded software (firmware).

Model (style) number serial number information is contained on the label on the front panel. Embedded software information can be obtained at HMI Screen 4.7. The information of Screen 4.7 is also displayed briefly when operating power is applied to the relay.

A software and hardware version report can be obtained through BESTCOMS. Alternately, it can be obtained using the RG-VER ASCII command.

To obtain the relay's version report through BESTCOMS, select *Download Settings from Device* from the *Communication* pull-down menu. Downloaded settings from the relay will overwrite any settings you have made in BESTCOMS; the relay will ask you to save your current file before continuing the download.

To view the version of the relay once the download is complete, select *General Operation* from the *Screens* pull-down menu. Then select the *General Information* tab. The *General Information* tab displays all of the style information about the relay. See Figure 6-26.

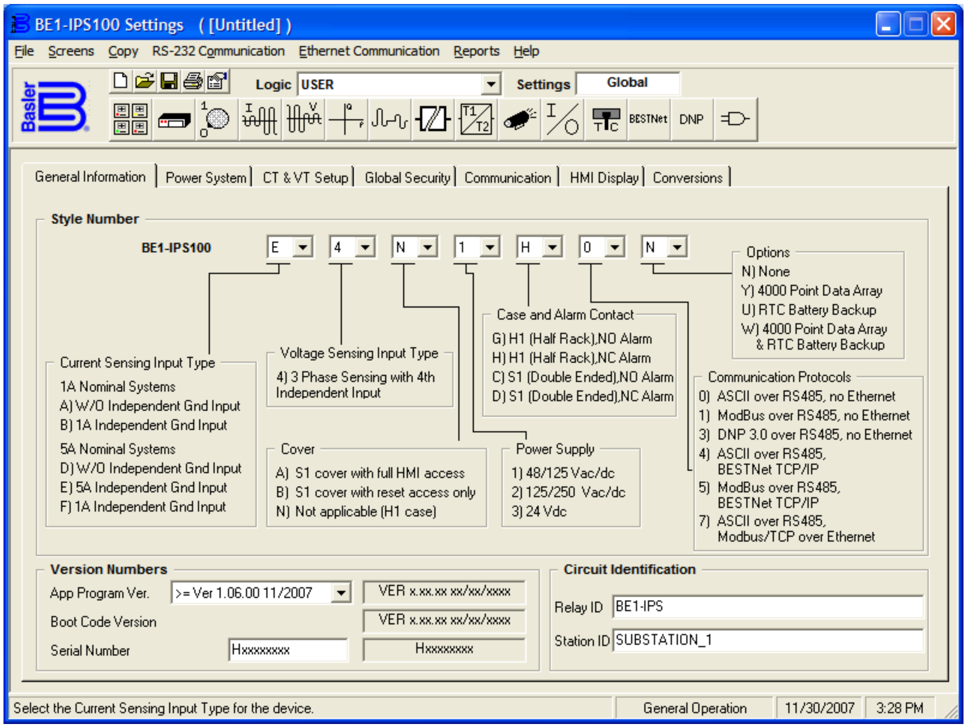

Figure 6-26. General Operation Screen, General Information Tab

SETTINGS COMPARE

BESTCOMS has the ability to compare two different settings files. To use this feature, pull down the *Reports* menu and select *Settings Compare*. The *BESTCOMS Settings Compare Setup* dialog box appears (Figure 6-27). Select the location of the first file to compare under *Left Settings Source* and select the location of the second file to compare under *Right Settings Source*. If you are comparing a settings file located on your PC hard drive or portable media, click the folder button and navigate to the file. If you want to compare settings downloaded from a unit, click the RS-232 button to set up the communication port and baud rate. Click the *Compare* button to compare the selected settings files.

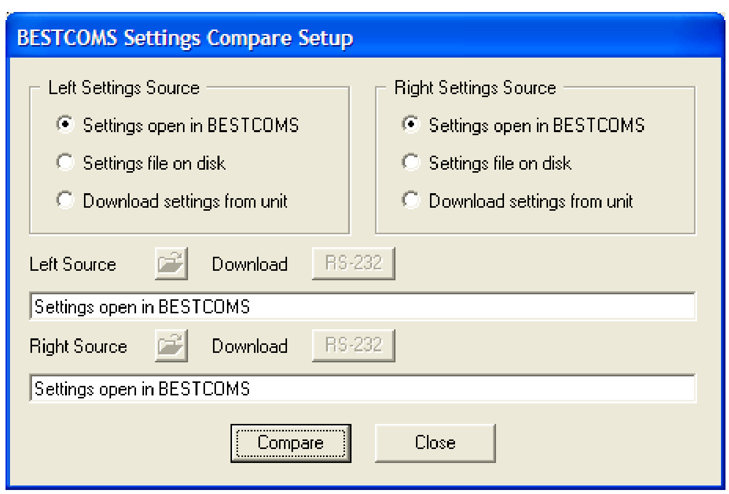

Figure 6-27. Settings Compare Setup

If there are any differences in the two files, a dialog box will appear and notify you that differences were found. The BESTCOMS Settings Compare dialog box (Figure 6-28) is displayed where you can view all settings (*Show All* button) or view only the differences (*Show Diffs* button).

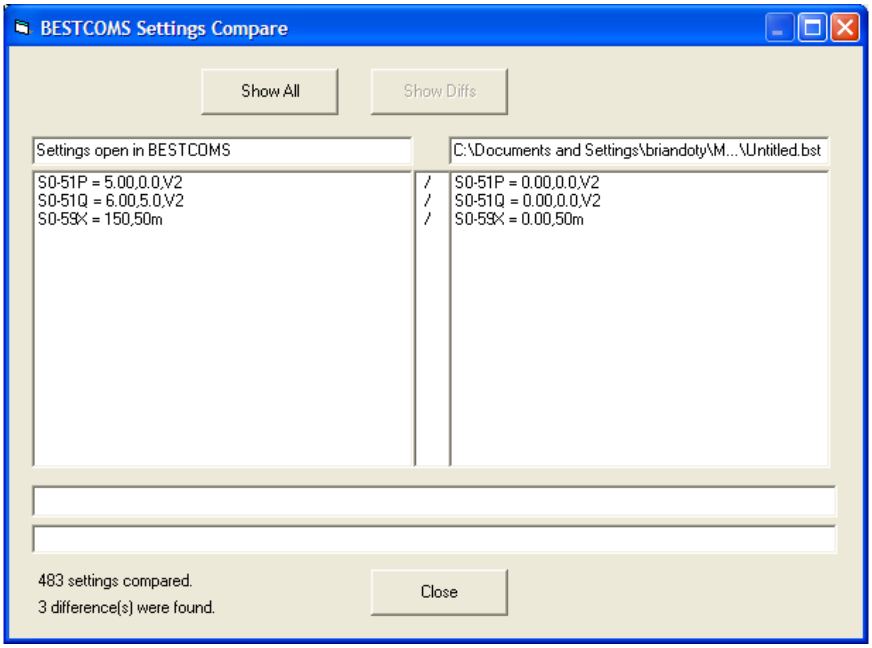

Figure 6-28. Settings Compare View

SECTION 7 • BESTLOGIC PROGRAMMABLE LOGIC

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SECTION 7 • BESTLOGIC PROGRAMMABLE LOGIC

INTRODUCTION

Multifunction relays such as the BE1-IPS100 Intertie Protection System are similar in nature to a panel of single-function protective relays. Both must be wired together with ancillary devices to operate as a complete protection and control system. In the single-function static and electromechanical environment, elementary diagrams and wiring diagrams provide direction for wiring protective elements, switches, meters, and indicator lights into a unique protection and control system. In the digital, multifunction environment, the process of wiring individual protection or control elements is replaced with the entry of logic settings. The process of creating a logic scheme is the digital equivalent of wiring a panel. It integrates the multifunction protection, control, and input/output elements into a unique protection and control system.

BESTlogic is a programming method used for managing the input, output, protection, control, monitoring, and reporting capabilities of Basler Electric's digital, multifunction, intertie protective relay systems. Each relay system has multiple, self-contained function blocks that have all of the inputs and outputs of its discrete component counterpart. Each independent function block interacts with control inputs, virtual outputs, and hardware outputs based on logic variables defined in equation form with BESTlogic. BESTlogic equations entered and saved in the relay system's nonvolatile memory integrate (electronically wire) the selected or enabled protection and control blocks with control inputs, virtual outputs, and hardware outputs. A group of logic equations defining the function of the multifunction relay is called a logic scheme.

Two preprogrammed logic schemes are stored in relay memory. Each scheme is configured for a typical protection application and virtually eliminates the need for "start-from-scratch" programming. Either of the two preprogrammed schemes can be copied and saved as the active logic. Preprogrammed logic schemes can also be copied and then customized to suit your application. Detailed information about preprogrammed logic schemes is provided later in this section.

BESTlogic is not used to define the operating settings (pickup thresholds and time delays) of the individual protection and control functions. Operating settings and logic settings are interdependent but separately programmed functions. Changing logic settings is similar to rewiring a panel and is separate and distinct from making the operating settings that control the pickup thresholds and time delays of a relay. Detailed information about operating settings is provided in Section 4, *Protection and Control*.

WORKING WITH PROGRAMMABLE LOGIC

BESTlogic uses two types of logic settings: output logic settings and function block logic settings. These two types of settings are discussed in the following subsections. Output logic settings are entered in equation form and control the hardware outputs of the relay. BESTlogic function blocks are illustrated in Figures 7-1 and 7-2 and are discussed in the following paragraphs.

Names assigned to inputs, outputs, timers, and protection and control elements represent the logic variables in the equations. Table 7-1 lists the logic variable names and descriptions.

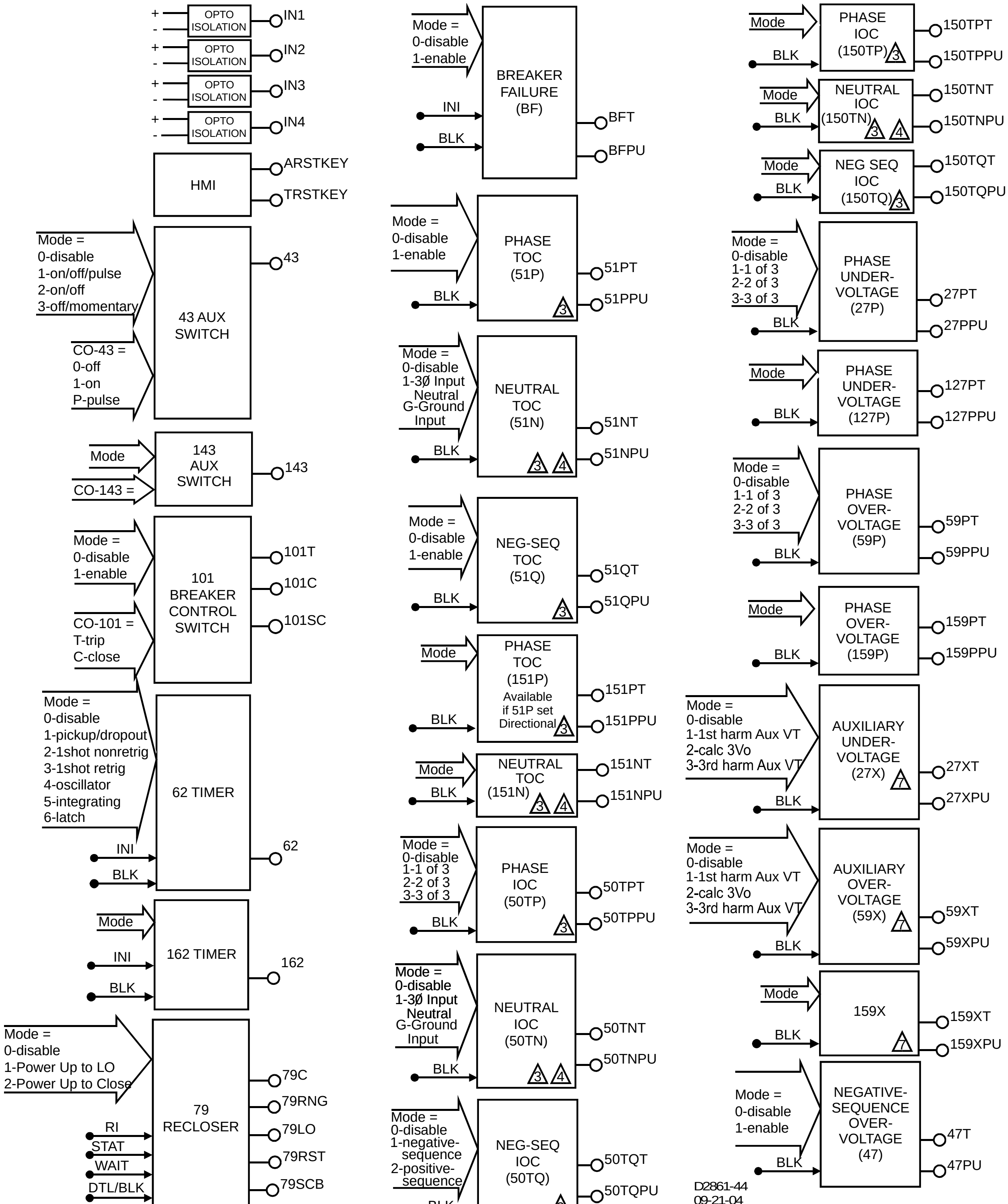

Figure 7-1. BESTlogic Function Blocks

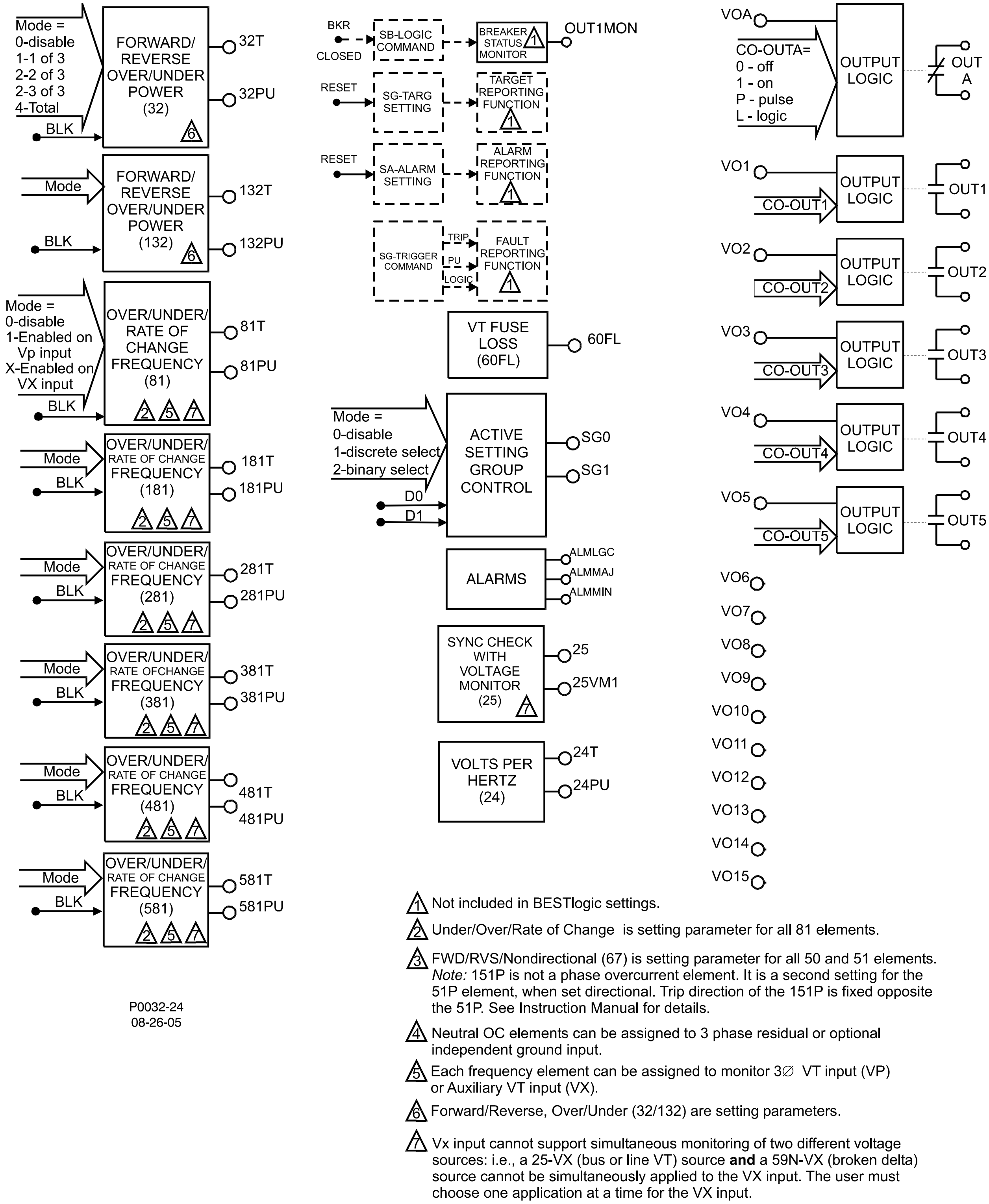

Figure 7-2. BESTlogic Function Blocks – Continued

Table 7-1. Logic Variable Names and Descriptions

Variable Name	Description	Variable Name	Description
Inputs and Outputs		47PU	47 Negative Sequence Picked Up
IN1-IN4	Inputs 1 through 4 Status	47T	47 Negative Sequence Tripped
VOA	Relay Trouble Alarm Output Status	**Over/Under Frequency**	
VO1-VO5	Virtual Outputs 1 through 5 (hardware outputs)	81T	81 Tripped
VO6-VO15	Virtual Outputs 6 through 15	181T	181 Tripped
Controls		281T	281 Tripped
TRSTKEY	HMI Target Reset Key	381T	381 Tripped
ARSTKEY	HMI Alarm Reset Key	481T	481 Tripped
101T	Virtual Breaker Control Switch Tripped	581T	581 Tripped
101C	Virtual Breaker Control Switch Closed	81PU	81 Picked Up
101SC	Virtual Breaker Control Switch Slip Contact	181PU	181 Picked Up
62	62 Timer Output	281PU	281 Picked Up
162	162 Timer Output	381PU	381 Picked Up
43	Virtual Switch 43 Output	481PU	481 Picked Up
143	Virtual Switch 143 Output	581PU	581 Picked Up
SG0	Setting Group 0 Active (default)	**Breaker Failure**	
SG1	Setting Group 1 Active	BFT	Breaker Failure Tripped
Alarms and Monitor		BFPU	Breaker Failure Picked Up
ALMLGC	Logic Alarm	**Instantaneous Overcurrent**	
ALMMAJ	Major Alarm	50TPT	50T Phase Tripped
ALMMIN	Minor Alarm	50TPPU	50T Phase Picked Up
OUT1MON	Output 1 Monitor (circuit continuity)	50TNT	50T Neutral Tripped
Reclosing		50TNPU	50T Neutral Picked Up
79C	79 Close Signal	50TQT	50T Negative-Sequence Tripped
79RNG	79 Running/Block Tap Changer	50TQPU	50T Negative-Sequence Picked Up
79LO	79 Lockout	150TPT	150T Phase Tripped
79RST	79 Reset	150TPPU	150T Phase Picked Up
79SCB	79 Sequence Control Block	150TNT	150T Neutral Tripped
Voltage		150TNPU	150T Neutral Picked Up
24T	24 Overexcitation Tripped	150TQT	150T Negative-Sequence Tripped
24PU	24 Overexcitation Picked Up	150TQPU	150T Negative-Sequence Picked Up
25	25 Sync-Check Output	**Time Overcurrent**	
25VM1	25 Voltage Monitor 1	51PT	51 Phase Tripped
27PT	27 Phase Undervoltage Tripped	51PPU	51 Phase Picked Up
27PPU	27 Phase Undervoltage Picked Up	51NT	51 Neutral Tripped
127PT	127 Phase Undervoltage Tripped	51NPU	51 Neutral Picked Up
127PPU	127 Phase Undervoltage Picked Up	51QT	51 Negative-Sequence Tripped
27XT	27 Auxiliary Undervoltage Tripped	51QPU	51 Negative-Sequence Picked Up
27XPU	27 Auxiliary Undervoltage Picked Up	151PT	151 Phase Tripped
59PT	59 Phase Overvoltage Tripped	151PPU	151 Phase Picked Up
59PPU	59 Phase Overvoltage Picked Up	151NT	151 Neutral Tripped
59XT	59 Auxiliary Overvoltage Tripped	151NPU	151 Neutral Picked Up
59XPU	59 Auxiliary Overvoltage Picked Up	**Fuse Loss**	
159PT	159 Phase Overvoltage Tripped	60FL	60 Loss of Potential Alarm
159PPU	159 Phase Overvoltage Picked Up		
159XT	159 Auxiliary Overvoltage Tripped		
159XPU	159 Auxiliary Overvoltage Picked Up		

Variable Name	Description	Variable Name	Description
Directional Power			
32T	32 Tripped	132T	132 Tripped
32PU	32 Picked Up	132PU	132 Picked Up

Function Block Logic Settings

Each BESTlogic function block is equivalent to its discrete device counterpart. For example, the Recloser Logic Function Block of Figure 7-3 has many of the characteristics of a BE1-79M Multiple Shot Reclosing Relay.

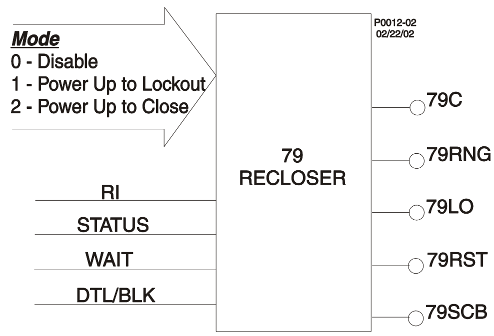

Figure 7-3. Recloser Element

Before using a protection or control function block, two items must be set: the *Mode* and the *Input Logic*. Setting the *Mode* is equivalent to deciding which protection or control functions will be used in a logic scheme. The *Input Logic* establishes control of a function block.

Mode and input logic information is contained in logic setting command strings. Depending on the command, the mode setting can either enable or disable a logic input or determine how a function block operates. Input logic defines which logic variables control or disable a logic function. An example of an input logic equation is SL-181=1,IN3+VO6. In this frequency logic command string, the 1 parameter indicates that the 181 function is enabled. The IN3+VO6 expression indicates that the 181 function is disabled when input 3 or virtual output 6 is TRUE.

The AND operator may not be applied to the terms of an input logic equation. Any number of variables or their inverse can be combined in a function block input logic expression. Section 4, *Protection and Control*, provides detailed information about setting the logic for each function block.

Output Logic Settings

Defining Output Operation

Output operation is defined by Boolean logic equations. Each variable in an equation corresponds to the current state (evaluated every quarter cycle) of an input, output, or timer. Figure 7-4 illustrates this relationship. Every quarter cycle, output expressions are evaluated as TRUE or FALSE. If a logic output that corresponds to a hardware output changes state, then the corresponding output relay contact also changes state.

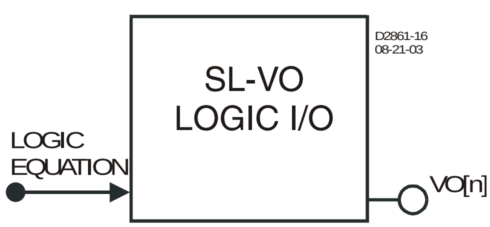

Figure 7-4. Virtual Output Logic

When the relay is powered up, all logic outputs are disabled and most variables (including virtual outputs) initialize as FALSE. Some variable states are stored in EEPROM and are restored to the last state prior to loss of power. These variables include 43/143,101SC, SG0, and SG1. All control commands, including logic override control, are also stored in EEPROM. If you override output logic and force an output to open, that condition will be maintained even if operating power is cycled.

When the logic is running and logic expression SL-VO[n] is FALSE, then output VO[n] = 0. When the logic is running and logic expression SL-VO[n] is TRUE, then VO[n] = 1. Hardware outputs OUTA and OUT1 through OUT5 follow the corresponding logic outputs VOA and VO1 through VO5.

Logic equations are defined by logic variables, logic operators, and their position in an equation. The available logic operators include AND (∗), OR (+) and NOT (/). The NOT operator is applied to the variable immediately following the symbol (/). For virtual output equations, OR logic can be applied to any number of variables if no AND logic is used in the expression. Similarly, AND logic can be applied to any number of variables if no OR logic is used. Any number of NOT operators may be used. For complex expressions that use both AND and OR operators, OR logic is limited to four terms. Up to four AND terms with any number of variables can be ORed together. When the relay is processing a complex expression, it performs AND operations before performing OR operations.

Virtual and Hardware Outputs

A virtual output exists only as a logical state inside the relay. A hardware output is a physical relay contact that can be used for protection or control. Each BE1-IPS100 relay has five isolated, normally open (NO) output contacts (OUT1 – OUT5) and one isolated, normally closed (NC) alarm output (OUTA). Output contacts OUT1 through OUT5 are controlled by the status of the internal virtual logic signals VO1 through VO5. If VO[n] becomes TRUE, then the corresponding output relay OUT[n] energizes and closes the NO contacts. For the alarm output, if VOA becomes TRUE, the ALM output de-energizes and opens. More information about input and output functions is provided in Section 3, *Input and Output Functions*.

Hardware outputs can also be controlled by the CO-OUT (control operate, output) command. The CO-OUT command overrides control of logic outputs. Outputs may be pulsed or latched in a 0 or 1 state independently from the state of the virtual output logic. More information about overriding control of logic outputs is available in Section 3, *Input and Output Functions*.

BESTlogic Expression Builder

The *BESTlogic Expression Builder* is used to connect the inputs of the relay's function blocks, physical inputs and outputs, and virtual outputs. Using the *BESTlogic Expression Builder* is analogous to physically attaching wire between discrete relay terminals. The *BESTlogic Expression Builder* is opened each time the input of a BESTlogic function block is selected. Figure 7-5 illustrates the *BESTlogic Expression Builder* screen.

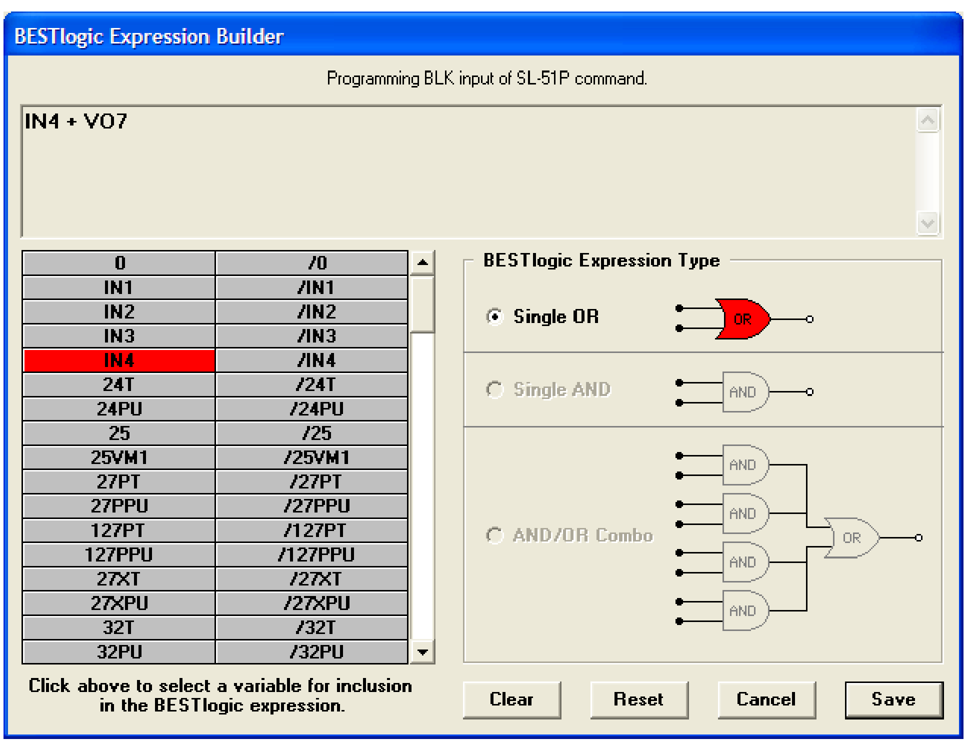

Figure 7-5. BESTlogic Expression Builder Screen

The *BESTlogic Expression Builder* provides a point and click interface that allows the selected input to be easily connected using a single OR gate, single AND gate, or an AND/OR combination. The usable list of inputs and outputs in the bottom left of the screen corresponds with the variable lists of Tables 7-1 and 7-2. Currently, the virtual outputs are the only functions that can use the single AND or AND/OR combination *BESTlogic Expression Type*.

The top of the screen displays the BESTlogic expression in a text window. Above the text window, the selected input and the associated ASCII command are displayed.

The *Clear* button will clear the expression to 0. The *Reset* button will reset the expression to its original state when the *BESTlogic Expression Builder* was first opened. The *Cancel* button resets the expression to its original state when the *BESTlogic Expression Builder* was first opened and returns the user to the previous screen. The *Save* button saves the expression shown in the text window and returns the user to the previous window.

LOGIC SCHEMES

A logic scheme is a group of logic variables written in equation form that defines the operation of a multi-function relay. Each logic scheme is given a unique name of one to eight alphanumeric characters. This gives you the ability to select a specific scheme and be confident that the selected scheme is in operation. Two logic schemes, IPS100-1547-A-BE and NONE, are configured for typical protection applications and are stored in nonvolatile memory. Only one of these logic schemes can be active at a given time. In most applications, preprogrammed logic schemes eliminate the need for custom programming. Preprogrammed logic schemes may provide more inputs, outputs, or features than are needed for a particular application. This is because the preprogrammed schemes are designed for a large number of applications with no special programming required. Unneeded inputs or outputs may be left open to disable a function or a function block can be disabled through operating settings. Unused current sensing inputs should be shorted to minimize noise pickup.

When a custom logic scheme is required, programming time can be reduced by copying a preprogrammed scheme into the active logic. The logic scheme can then be modified to meet the specific application.

The Active Logic Scheme

Digital, multifunction relays must have an active logic scheme in order to function. All Basler Electric multifunction relays are delivered with a default, active logic loaded into memory. The default, active logic scheme for the BE1-IPS100 is named IPS100-1547-A-BE. If the function block configuration and output logic of IPS100-1547-A-BE meets the requirements of your application, then only the operating settings (power system parameters and threshold settings) need to be adjusted before placing the relay in service.

NOTE

There has been a fundamental improvement to the way the user sets up BESTlogic in this device. In some prior implementations of BESTlogic, it was necessary to make a separate setting that determined whether the user's logic scheme or if one of the pre-programmed logic schemes was to be made active. This setting was made from the ASCII command interface using the SP-LOGIC (Set Protection Logic) command. **This setting has been eliminated.**

In the implementation of BESTlogic used in this relay, the logic scheme defined by the user's logic settings is always active. If the user wishes to use a preprogrammed logic scheme, he/she now copies it into his/her user logic settings. This process is accomplished from the ASCII command interface using the SL-N (Set Logic Name) command in this and previous BESTlogic implementations.

If a different preprogrammed logic scheme is required, it can be easily copied to active logic and used as is or customized to your specifications. To accomplish this, communication with the relay must be established. It is accomplished by connecting a computer to the front RS-232 port or optional rear Ethernet or RS-232 port.

Logic schemes can be selected from the logic select tab on the *BESTlogic* screen. To access this screen, select *BESTlogic* from the *Screens* pull-down menu. Then select the *Logic Select* tab. Select the desired logic scheme to *Copy to Active Logic* (Internal Logic). The active logic scheme is shown in the *Logic Name* box. In Figure 7-6, IPS100-1547-A-BE has been selected as the user logic.

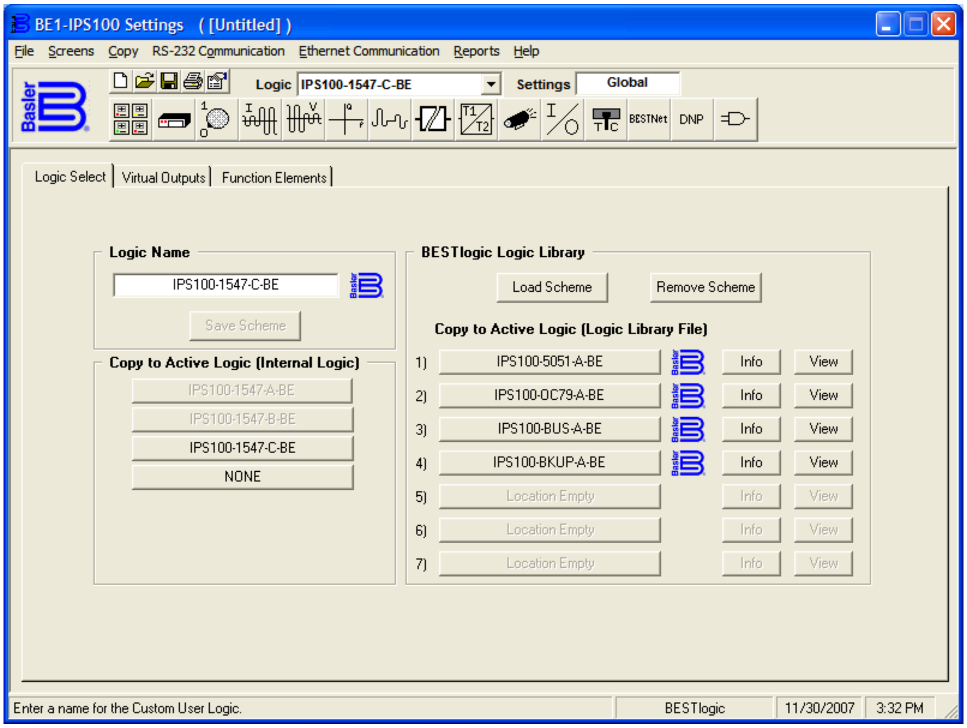

Figure 7-6. BESTlogic Screen, Logic Select Tab

CAUTION

Selecting a logic scheme to be active in BESTCOMS does not automatically make that scheme active in the relay. See the paragraphs later in this section titled, *Sending and Retrieving Relay Settings*.

Custom Logic Schemes

CAUTION

If "NONE" logic is selected, the protection elements are not connected to the virtual outputs or output relays and fault recording features including targets are not enabled.

A custom logic scheme can be created from scratch by copying NONE to *Logic Name* and then renaming the logic. A custom logic scheme can also be created by modifying a preprogrammed logic scheme after copying it to *Logic Name* and then renaming it. A preprogrammed logic scheme copied to *Logic Name* with no name change is treated as a read-only scheme and cannot have its logic expressions altered. Before modifying a logic scheme copied to *Logic Name*, the scheme must be assigned a unique name of one to eight alphanumeric characters. This scheme is then referred to as a custom or user programmable logic scheme because the variable expressions of the logic can be customized or created from scratch to suit the needs of an application. A custom logic scheme may be revised many times but only the most recent changes are saved to as the active (*Logic Name*) logic.

CAUTION

Always remove the relay from service prior to changing or modifying the active logic scheme. Attempting to modify a logic scheme while the relay is in service could generate unexpected or unwanted outputs.

Copying and Renaming Preprogrammed Logic Schemes

Copying a preprogrammed logic scheme to the active logic (*Logic Name*) and assigning a unique name is accomplished by selecting the desired logic scheme in BESTCOMS and then typing over the logic scheme's name. Changes are not activated until the new settings have been uploaded to the device.

Creating or Customizing a Logic Scheme

Before customizing a preprogrammed logic scheme, the scheme must be renamed. The following procedure outlines the process of customizing or creating a logic scheme:

Step 1. Copy the preprogrammed scheme.

Step 2. Rename the scheme with a unique, non-preprogrammed name.

Step 3. Using BESTCOMS, enable or disable the desired relay functions.

Step 4. Edit the logic expressions, as required.

Step 5. Save the changes. Refer to Section 14, *BESTCOMS Software*, for more information on how to save and export settings files.

Sending and Retrieving Relay Settings

Retrieving Relay Settings

To retrieve settings from the relay, the relay must be connected to a computer through a serial port. Once the necessary connections are made, settings can be downloaded from the relay by selecting *Download Settings from Device* on the *Communication* pull-down menu.

Sending Relay Settings

To send settings to the relay, the relay must be connected to a computer through a serial port. Once the necessary connections are made, settings can be uploaded to the relay by selecting *Upload Settings to Device* on the *Communication* pull-down menu.

Debugging the Logic Scheme

If there are problems with a customized logic scheme, the RG-STAT command can be used to check the status of all logic variables. More information about the RG-STAT command can be found in Section 6, *Reporting and Alarm Functions*.

USER INPUT AND OUTPUT LOGIC VARIABLE NAMES

Assigning meaningful names to the inputs and outputs makes sequential events reports easier to analyze. Input and output logic variable names are assigned by typing them into the appropriate text box on the related *BESTCOMS* screen. All of the BE1-IPS100's inputs, outputs, and 43 switches have labels that can be edited. Table 7-2 shows the range and purpose of each label. Alternately, labels may be edited using the SN ASCII command.

Table 7-2. Programmable Variable Name Setting

Settings	Range/Purpose	Default
Name/Label	1 to 10 characters. User name to replace <var> in the RS report.	INPUT_x SWITCH_x43 VOx_LABEL
True/Energized State	1 to 7 characters. Used to replace default labels.	TRUE
False/De-Energized State	1 to 7 characters. Used to replace default labels.	FALSE

BESTLOGIC APPLICATION TIPS

When designing a completely new logic scheme, logic evaluation order should be considered. Contact sensing inputs are evaluated first, then the function blocks, and then the virtual outputs. VO15 is evaluated first and VOA is evaluated last. If a virtual output is used in a logic expression to control another virtual output, the virtual output used in the expression should be numerically higher. Otherwise, a logic expression for a numerically smaller virtual output won't be available to a numerically higher virtual output until the next processing interval. Logic is evaluated every ¼ cycle.

When designing custom protection schemes, avoid confusion by maintaining consistency between input and output functions in the custom scheme and the preprogrammed schemes.

OUT1 through OUT5 have normally open contacts (coil is de-energized). Normally open contacts can be used as normally closed outputs by inverting the logic expressions that drive them. Inverting an output logic expression causes the coil to be energized with the contacts closed in the normal state. Caution should be taken with normally closed contact logic because there are no shorting bars to maintain the closed condition if the draw-out assembly is removed from the chassis. In applications where a normally closed output is needed even when the electronics are removed, a normally open contact from the relay can be used to drive a low-cost auxiliary relay. The normally closed output of the auxiliary relay will maintain the closed output when the draw-out assembly is removed from the case. Alternately, an external switch can be used to short across a normally closed relay output when the draw-out assembly is removed. Extra care is required to ensure that the switch is closed prior to removing the draw-out assembly and that the switch is open after the relay is placed back in service.

Several links between the programmable alarms function and BESTlogic programmable logic allow alarm functions to be used in a logic scheme and programmable logic functions to be used in the alarm reporting function.

Programmable alarm settings for Major, Minor, and Logic alarms drive BESTlogic variables ALMMAJ, ALMMIN, and ALMLGC. These variables can be used in logic expressions to control logic when an alarm is active.

Virtual outputs VO13, VO14, and VO15 are driven by BESTlogic expressions. These three logic variables are also available in the programmable alarm function. Virtual outputs can also be assigned user programmable labels (described previously). With this feature, a logic condition can be designed and used for an alarm. The virtual output label would then be reported in the Reporting and Alarm functions.

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SECTION 8 • APPLICATION

INTRODUCTION

This section discusses the application of the BE1-IPS100 Intertie Protection System using a preprogrammed logic scheme. The BE1-IPS100 has one embedded, default logic scheme (IPS100-1547-C-BE) as delivered from the factory. This scheme was developed based on the requirements of IEEE-P1547 Standard for Interconnecting Distributed Resources with Electric Power Systems. Also, California Rule 21 had a major influence on the development of this scheme. Other preprogrammed logic schemes such as Basic Overcurrent, Overcurrent with Reclosing, Feeder with Bus Interlocking, and Bus Protection are available on the Basler Website and included in *BESTCOMS*, Basler Electric's Windows based graphical user interface program. A description of each of those schemes follows the intertie protection discussion. The paragraphs on *Details of Preprogrammed Logic* describe the characteristics of the logic scheme and how they combine to create an Intertie Protection Scheme for application at the point of common coupling between a distributed generator and electric utility. This logic can also be used, with some modification, for feeder, transformer, bus, and generator protection. A detailed description of the preprogrammed scheme is also provided. This section concludes with tips on programming custom logic schemes to meet specific user applications.

This preprogrammed logic scheme is designed to take advantage of all the BE1-IPS100 protection capabilities. However, not all elements have to be set. The protection engineer can choose which elements receive operational settings or adapt the scheme to user specific needs by changing the protection and control elements and settings. In many cases, this eliminates the need to create a custom logic scheme from scratch.

Please note that this preprogrammed logic scheme also illustrates typical ways of using or controlling various functions. The user may choose to create a custom logic scheme by mixing preprogrammed logic with user defined logic. The logic also can be modified to incorporate some of the features described in the *Application Tips*, provided at the end of this section. The flexibility of BESTlogic in combination with easy to use BESTCOMS allows the engineer to quickly create a protection and control scheme that meets the exact requirements of the application.

> **CAUTION**
>
> If "NONE" logic is selected, the protection elements are not connected to the virtual outputs or output relays, and fault recording features including targets are not enabled. The user will have to program and enable these features and functions as part of building a custom logic scheme.

EXPLANATION OF TERMS

Understanding the following terms and definitions will help to clarify the application discussions that follow.

Area Electric Power System (Area EPS)

The electric utility to which the Distributed Generation is connected.

BESTlogic

Programming method for "electronically" wiring the Function Blocks (protection elements) together.

Distributed Generation (DG)

Electric generation facilities connected to an Area EPS through a PCC.

Function Block (Element)

Stand-alone protection or control function that is equivalent to the discrete component counterpart.

Point of Common Coupling (PCC)

The tie point between a source of non-utility generation and an electric utility. Also, may be the point where a Local EPS is connected to an Area EPS.

Local Electric Power System (Local EPS)

A power system contained entirely within a single premises or group of premises, i.e., industrial facility.

OVERVIEW OF PREPROGRAMMED INTERTIE PROTECTION LOGIC

The BE1-IPS100 has one preprogrammed logic scheme designed for intertie applications defined by IEEE-STANDARD 1547-2003 and California Rule 21 but can be easily modified for other applications such as feeder, bus, transformer, and generator protection. This logic scheme is comprised of two phase, ground and negative-sequence directional instantaneous overcurrent zones, and two phase and ground, and one negative-sequence directional time overcurrent zones. Network and conditional reclosing (25 and 25VM), breaker failure protection, over/under voltage phase protection, directional power, and over/under/rate of change frequency protection are also so included in this scheme. This scheme can be used in conjunction with other products to provide main-to-main protection.

IPS100-1547-C-BE preprogrammed logic scheme provides protection elements to cover all intertie needs defined by IEEE Standard 1547-2003 and gives the user a solid foundation for customizing the scheme for specific needs. More preprogrammed logic schemes for the BE1-IPS100 can be found in BESTCOMS and at the Basler Electric Web site (www.basler.com).

DETAILS OF PREPROGRAMMED INTERTIE PROTECTION LOGIC

The following paragraphs expand on the IPS100-1547-C-BE preprogrammed scheme. The application features of the logic scheme are broken down into their separate protection elements and described in detail. The integration of protection and control elements, and alarm elements are also described in detail. Although it is not discussed in each paragraph, the reader should be aware that the application of an independent, overlapping, backup zone of protection is recommended for a complete protection design.

The preprogrammed protection logic scheme begins with the application intent of the design. Next, the protection elements are discussed in detail, including CT connections and typical zone and reach information, followed by protection and control integration and alarm information specific to the preprogrammed design. Unique references for the scheme, including one-line and logic diagrams and program codes are included.

Preprogrammed logic can be a starting point or an ending point for the protection engineer depending on how closely the logic meets engineering requirements. The IPS100-1547-C-BE logic scheme was created by applications personnel from the utility industry and is easily modified to meet specific user needs. For applications assistance, contact your local Basler Electric representative.

IPS100-1547-C-BE LOGIC SCHEME (INTERTIE PROTECTION)

This logic scheme provides a directional time and instantaneous overcurrent zone of protection looking towards the electric utility, and the same looking towards the DR bus; a negative-sequence voltage element; phase and neutral over and under voltage elements; over, under and rate of change frequency elements; and directional power elements monitoring power at the point of common coupling.

Figure 8-1 is a one-line drawing and Figures 8-2 through 8-4 make up the logic drawings representing the logic settings and equations shown in Table 8-5. Table 8-5 is part of a setting printout that can be generated from BESTCOMS by using the Print command. These are the actual ASCII commands, settings and equations generated as a result of the selections made through the Windows based BESTCOMS interface program. The user can see the protection and control elements that are enabled (set to Mode 1) for this application and see how the elements are logically wired together (Boolean equations). If the user should decide to build on this scheme, all elements required for a modified application are available in BESTCOMS. For programming details, refer to *Application*, Section 7, *BESTlogic Programmable Logic,* and Section 14, *BESTCOMS Software*.

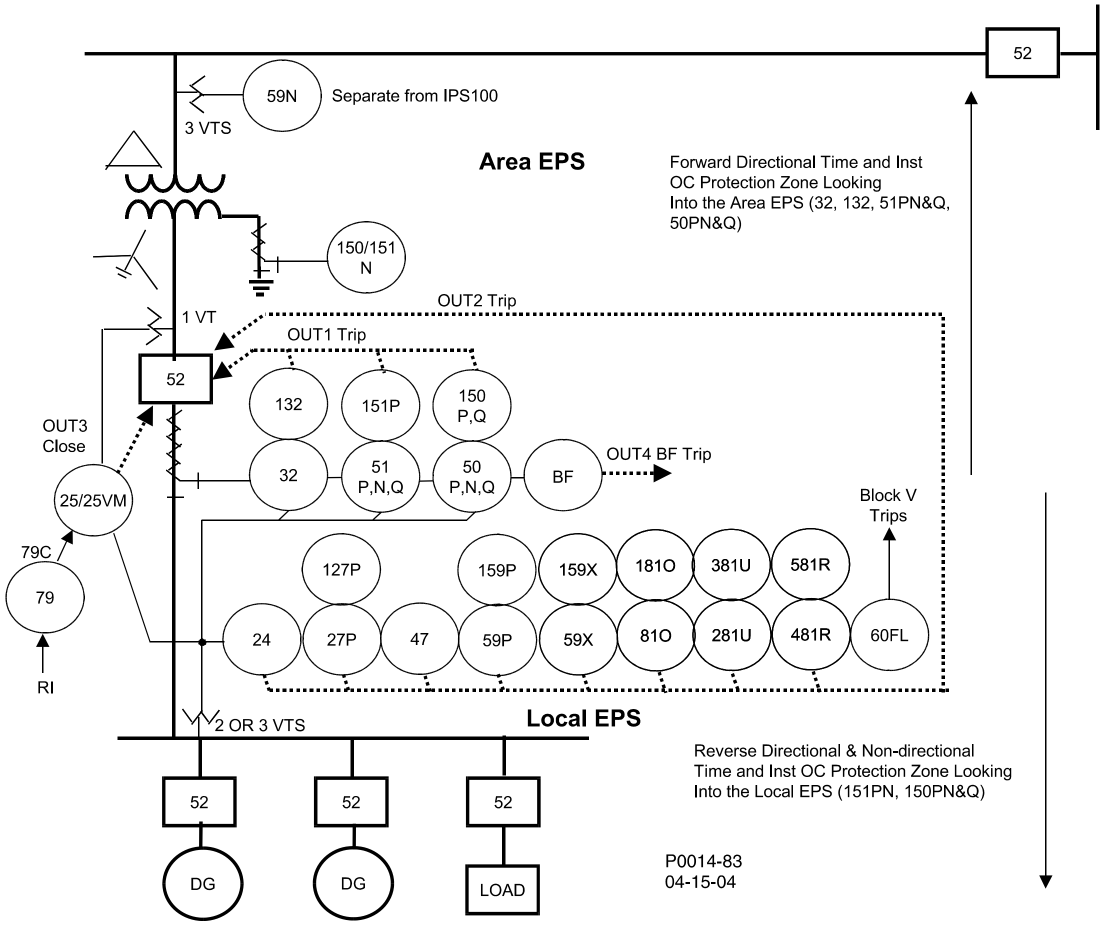

Figure 8-1. IPS100-1547-C-BE Protection One-line Diagram

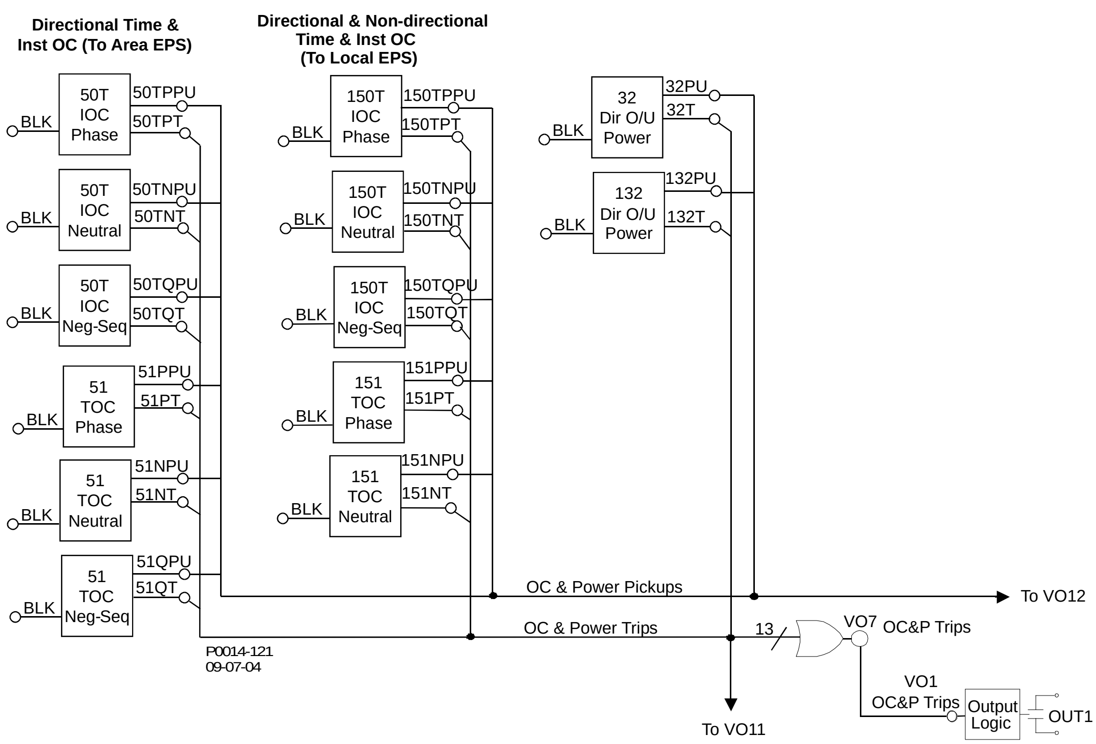

Figure 8-2. IPS100-1547-C-BE Logic Diagram – Figure 1 of 3

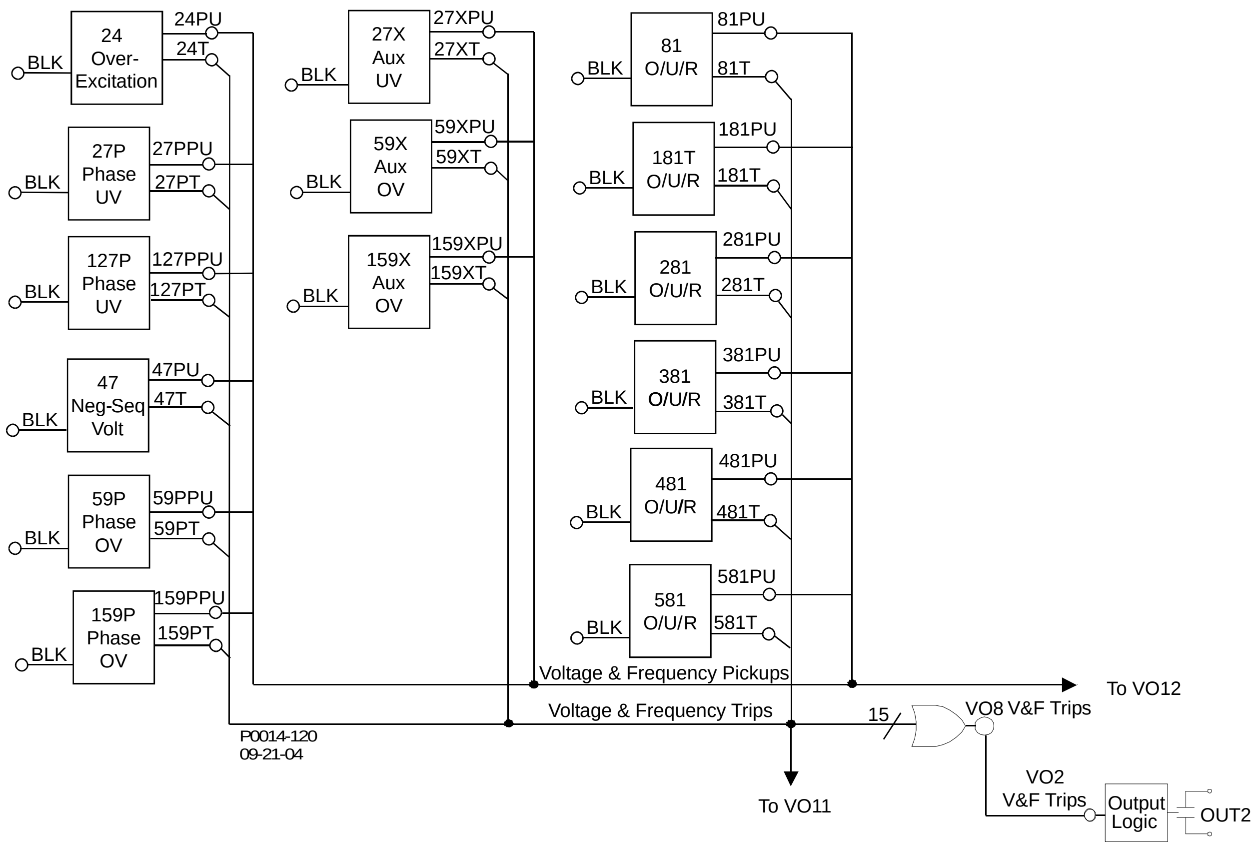

Figure 8-3. IPS100-1547-C-BE Logic Diagram – Figure 2 of 3

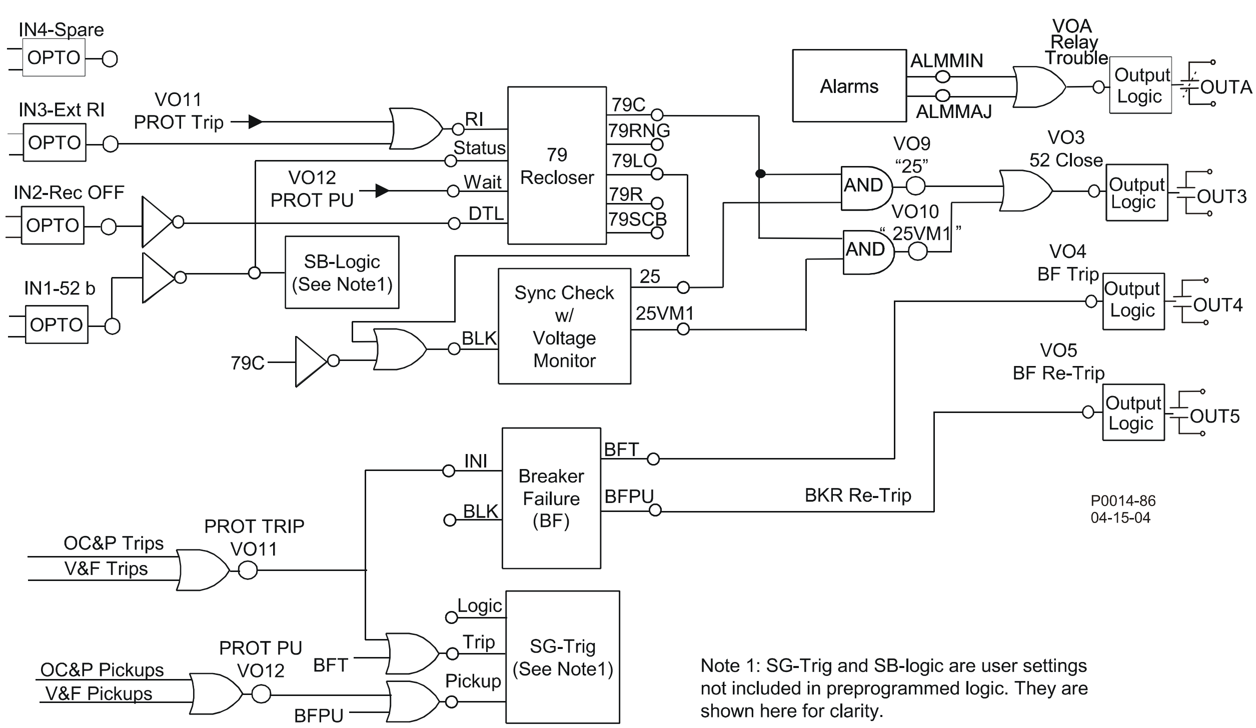

Figure 8-4. IPS100-1547-C-BE Logic Diagram – Figure 3 of 3

Protection Elements

Setting a protection element's pickup at zero will disable the element. To see which elements are enabled, select the *System Setup Summary* screen in BESTCOMS and note the color of the dot associated with each protection element. (Refer to the color legend on the *System Setup Summary* screen.) Each protection element in this preprogrammed logic scheme should be yellow or green depending on whether an operational setting has been applied.

Phase, neutral, and negative-sequence overcurrent elements are activated to provide a forward-looking directional (67) time (51P, N, Q), and inst (50P, N, Q) protection. Referring to Figure 8-1, the forward looking directional overcurrent zone of protection (into the transformer) is defined by the breaker CT and bus PT polarities and their connection to the appropriate polarity and non-polarity current and voltage terminals of the relay. The reverse looking directional (167) time (151P) and inst (150P/150Q) overcurrent zone of protection looks into the DR bus. Non-directional time (151N) and instantaneous (150N) overcurrents are applied for ground fault protection on low side of the transformer. Because the delta connected high side winding blocks zero-sequence current flow, directional ground overcurrent protection is not necessary. However, if the user elects to use direction control, note that forward direction is defined by the polarity current of the transformer neutral CT as compared to the bus VT polarity so all faults are either forward or reverse depending on CT and VT setup. Note that breaker failure protection (BF) is also provided for the intertie circuit breaker.

To ensure that voltage and frequency at the interconnect point are maintained within the limits established by the electric utility to which the DR is being connected, two over/undervoltage elements (27P/127P and 59P/159P), six over/under frequency elements (81o/u/r…581o/u/r) and one volts/hertz element (24) are provided. To ensure that power flow is in the direction established by the interconnect agreement, two over or under directional power elements (32 & 132) are provided and can be set for forward or reverse operation as defined by the PT and CT connection to the relay. Anti-islanding protection is also provided by the over/under voltage, over/under frequency elements, and directional power elements. In addition, the over/under frequency elements (81o/u/r…581o/u/r) can also be set for positive, negative, or "either" rate of change frequency to provide high-speed detection of loss of mains (anti-islanding) or for underfrequency load shed applications.

Sync-Check and Conditional Voltage Reclose

Provision for one sync check or conditional voltage reclose is provided in this logic scheme. With the reclose fail time set to zero, the Reclose Output (79C) is held indefinitely and Output 3 (Out3) effectively becomes a sync check contact.

Integration of Protection, Control, and I/O Elements

The logic settings in Table 8-5 include the logic equations that connect the various elements (electronic wiring) of the intertie protection scheme. Figures 8-2 through 8-4 show the logic drawings for the preprogrammed intertie protection scheme. Note that all overcurrent and power protection trips are connected to VO7. VO7 is connected to VO1, which, in turn, operates Output 1. Voltage and frequency trips are connected to VO8. VO8 is connected to VO2, which, in turn, operates Output 2. Output 3 is used for automatic reclosing of the intertie breaker. Output 5 operates when BFPU goes high and Output 4 operates when the 50BF timer expires (BFT) indicating that the breaker did not open when called on to trip.

Input 3 is used for external initiate of reclosing; Input 2 is connected to an external reclosing on/off switch, defeating automatic reclosing of the intertie logic scheme in the OFF position. Input 1 provides breaker position/status to the logic scheme.

Note that the Fault Recording Element (SG-Trigger Logic), which is used activate the pickup and trip LED, Targeting, and initiate recording of a disturbance (Fault Summary, Oscillography, and Sequence of Events), is fully integrated. All protection trip element outputs whether used or not are mapped to the fault recording TRIPPED input and all pickup element outputs whether used or not are mapped to the fault recording PICKED UP input. No user settings are required unless a LOGIC initiated record is required.

Alarms

Three logic variables drive the front panel alarm LEDs: Relay Trouble (ALMREL), Major Alarm (ALMMAJ), and Minor Alarm (ALMMIN). A fourth logic variable, Logic Alarm (ALMLGC), has no associated front panel LED. When the relay self-test detects a problem in the relay (ALMREL) as programmed for the intertie protection scheme, the Relay Trouble LED lights, Output A operates and all other outputs are disabled. When a major or minor alarm is detected, the associated LED lights. If the user chooses, Output A can also be set to operate for a major or a minor alarm.

> **NOTE**
>
> Tables 8-1 through 8-4 provide detailed logic definitions for the inputs, outputs, protection, and control elements. All inputs, logic blocks, and outputs available for use in the intertie preprogrammed logic are described in the following tables.

Table 8-1. Intertie Contact Sensing Inputs Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	Used for breaker status indication in SER reports and the 79 element. TRUE when breaker is closed.	BREAKER	CLOSED	OPEN
IN2	Used for turning off (defeating) automatic reclosing. Switch OFF removes voltage from IN2 (open contact). Therefore, /IN2 condition is TRUE.	REC_ON_OFF	ON	OFF
IN3	External initiate of automatic reclosing. TRUE when initiate is closed.	EXT_INI	EXT_INI	NORMAL
IN4	Spare	INPUT_4	CLOSED	OPEN

Table 8-2. Intertie Function Blocks Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	Used for detection of transformer overexcitation.	0	1 (enabled)
25	Blocked when 79C is FALSE (/79C) or when 79LO is TRUE.	/79C+79LO	1 (enabled)
27P	Used for phase undervoltage protection Level 1.	0	1 (1 of 3)
127P	Used for phase undervoltage protection Level 2.	0	1 (1 of 3)
27X	N/A	0	0 (disabled)
32	Used for directional power protection Level 1.	0	4 (Total Power)
132	Used for directional power protection Level 2.	0	4 (Total Power)
50TP	Used for instantaneous phase-overcurrent protection (1-3, 2-3, 3-3; Modes 1, 2, 3).	0	1 (1 of 3)
50TN	Used for instantaneous neutral-overcurrent protection.	0	1 (3-phase residual)
50TQ	Used for instantaneous negative-sequence overcurrent protection.	0	1 (Negative-Sequence)
150TP	Used for instantaneous phase-overcurrent protection (1-3, 2-3, 3-3; Modes 1, 2, 3).	0	3 (3 of 3)
150TN	Used for instantaneous neutral-overcurrent protection.	0	G (Ground Input)

Function	Purpose	BESTlogic Expression	Mode Setting
150TQ	Used for instantaneous positive-sequence overcurrent protection.	0	2 (Positive-Sequence)
51P	Used for timed phase-overcurrent protection.	0	1 (enabled)
51N	Used for timed neutral-overcurrent protection.	0	1 (3-phase residual)
51Q	Used for timed negative-sequence overcurrent protection.	0	1 (enabled)
151P	Used for timed phase-overcurrent protection (51P must be set for directional control).	0	1 (enabled)
151N	Used for timed neutral-overcurrent protection.	0	G (Ground Input)
47	Used for negative-sequence voltage protection.	0	1 (enabled)
59P	Used for phase-overvoltage protection Level 1.	0	1 (1 of 3)
159P	Used for phase-overvoltage protection Level 2.	0	1 (1 of 3)
59X	Used for 3V0 voltage detection Level 1.	0	2 (3V0-3ph VT Input)
159X	Used for 3V0 voltage detection Level 2.	0	2 (3V0-3ph VT Input)
62/162	N/A	0	0 (disabled)
79	*Reclose Initiate Logic:* Initiate when RI expression is TRUE.	VO11+IN3	1 (Power Up to Lockout)
	Breaker Statue Logic: Closed breaker is indicated when IN1 is de-energized.	/IN1	
	Wait Logic: Stop recloser timing when timing for a fault trip. TRUE when protection picked up expression is TRUE.	VO12	
	DTL/BLK Logic: Drive recloser to lockout when recloser DTL expression is TRUE or when /IN2 is TRUE (Rec Off).	/IN2	
BF	*Breaker Failure Initiate Logic:* Initiate breaker failure when breaker failure initiate expression is TRUE.	VO11	1 (enabled)
81	Underfrequency protection Level 1.	0	1 (Phase VT Input)
181	Underfrequency protection Level 2.	0	1 (Phase VT Input)
281	Overfrequency protection Level 1.	0	1 (Phase VT Input)
381	Overfrequency protection Level 2.	0	1 (Phase VT Input)
481	Rate of Change frequency protection Level 1.	0	1 (Phase VT Input)
581	Rate of Change frequency protection Level 2.	0	1 (Phase VT Input)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Inputs)
	Input 1 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Set to 1 (/0) to enable automatic selection. Manual selection is not used.	0	

Table 8-3. Intertie Virtual Switches Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	TRUE	FALSE
143	N/A	0 (disabled)	SWITCH_143	TRUE	FALSE
101	N/A	0 (disabled)	N/A	N/A	N/A

Table 8-4. Intertie Virtual Outputs Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Relay Trouble Alarm, Alarm Major, Alarm Minor	OUTA contact changes states when Relay Trouble, Major, or Minor Alarm is TRUE.	RELAY_TR	ACTIVE	NORMAL
BESTlogic Expression: VOA=ALMMAJ+ALMMIN					
VO1 (OUT1)	Breaker Trip Contact initiated by Overcurrent and Directional Power Trips.	OUT1 contact closes if any directional time OC (51/151P,N,Q), inst OC (50T/150TP,N,Q) or directional power (32/132) trip is TRUE.	DIR_BKR_TR	TRIP	NORMAL
BESTlogic Expression: VO1=VO7					
VO2 (OUT2)	Breaker Trip Contact initiated by Voltage and Frequency trips.	OUT2 contact closes if any voltage (24, 27P, 127P, 27X, 47, 59P, 159P, 59X, 159X) or frequency (81…581) trip is TRUE.	V&F_BKR_TR	TRIP	NORMAL
BESTlogic Expression: VO2=VO8					
VO3 (OUT3)	Breaker Reclosing.	OUT3 contact closes when VO9 (25) or VO10 (25VM1) is TRUE.	BKR_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO3=VO9+VO10					
VO4 (OUT4)	Breaker Failure Trip.	Trip backup if breaker protection times out.	BF_TRIP	TRIP	NORMAL
BESTlogic Expression: VO4=BFT					
VO5 (OUT5)	Breaker Re-Trip; Initiated from Breaker Failure PU.	OUT5 contact closes when BFPU is TRUE.	BKR_RETRIP	TRIP	NORMAL
BESTlogic Expression: VO5=BFPU					
VO6	N/A	N/A	VO6	TRUE	FALSE
BESTlogic Expression: VO6=0					
VO7	Overcurrent & Directional Power Trips.	VO7 is TRUE when any overcurrent or directional power element trips.	OC&P_TRIPS	TRIP	NORMAL
BESTlogic Expression: VO7=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+151PT+51NT+151NT+51QT+32T+132T					

Output	Purpose	Description	Label	State Labels	
				True	False
VO8	Voltage & Frequency Trips.	VO8 is TRUE when any voltage or frequency element trips.	V&F_TRIPS	TRIP	NORMAL
BESTlogic Expression: VO8=27XT+27PT+127PT+47T+24T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T					
VO9	Sync-Check Close.	79C is TRUE and 25 is TRUE.	SYNC_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO9=79C*25					
VO10	Conditional Voltage Close.	79C is TRUE and 25VM1 is TRUE.	VOLT_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO10=79C*25VM1					
VO11	Protective trip expression.	VO11 is TRUE when any OC & P or V & F protection element trips.	PROT_TRIP	TRIP	NORMAL
BESTlogic Expression: VO11=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+151PT+51NT+151NT+51QT+32T+132T+27XT+27PT+127PT+47T+24T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T					
VO12	Protective pickup expression.	VO12 is TRUE when any protection element picks up.	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+151PPU+51NPU+151NPU+51QPU+32PU+132PU+27XPU+59PPU+159PPU+27PPU+127PPU+47PU+24PU+59XPU+159XPU+81PU+181PU+281PU+381PU+481PU+581PU					
VO13	Alarm Mask 21.	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	Alarm Mask 22.	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	Alarm Mask 23.	N/A	VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					

Table 8-5. IPS100-1547-C-BE (Intertie Protection) Settings and Equations

```
SL-N=IPS100-1547-C-BE,BASLER
SL-50TP=1,0;    SL-50TN=1,0;    SL-50TQ=1,0
SL-150TP=3,0;   SL-150TN=G,0;   SL-150TQ=2,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
SL-151P=1,0
SL-151N=G,0
SL-24=1,0
SL-25=1,/79C+79LO
SL-27P=1,0;     SL-27X=0,0
SL-127P=1,0
SL-32=4,0
SL-132=4,0
SL-47=1,0
SL-59P=1,0;     SL-59X=2,0
SL-159P=1,0;    SL-159X=2,0
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SL-81=1,0
SL-181=1,0
SL-281=1,0
SL-381=1,0
SL-481=1,0
SL-581=1,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=1,VO11+IN3,/IN1,VO12,/IN2
SL-BF=1,VO11,0
SL-GROUP=1,0,0,/0
SL-43=0
SL-143=0
SL-101=0
SL-VOA=ALMMAJ+ALMMIN
SL-VO1=VO7
SL-VO2=VO8
SL-VO3=VO9+VO10
SL-VO4=BFT
SL-VO5=BFPU
SL-VO6=0
SL-VO7=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+151PT+51NT+151NT+51QT+32T+132T
SL-VO8=27XT+27PT+127PT+47T+24T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T
SL-VO9=79C*25
SL-VO10=79C*25VM1
SL-VO11=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+151PT+51NT+151NT+51QT+27XT+27PT+
127PT+47T+24T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T+32T+132T
SL-
VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+151PPU+51NPU+151NPU+51QPU+
32PU+132PU+27XPU+59PPU+159PPU+27PPU+127PPU+47PU+24PU+59XPU+159XPU+81PU+181PU+281PU+
381PU+481PU+581PU
SL-VO13=0
SL-VO14=0
SL-VO15=0
```

OVERVIEW OF ADDITIONAL PREPROGRAMMED LOGIC SCHEMES

The following preprogrammed logic schemes can be found in BESTCOMS for the BE1-IPS100 or at the Basler Electric Web site (www.basler.com).

IPS100-5051-A-BE (Basic Overcurrent Protection) Logic Scheme

This logic scheme provides basic time and instantaneous overcurrent protection. Included protective elements are phase, neutral, and negative-sequence overcurrent protection. Functions such as breaker failure, virtual breaker control, automatic reclosing, and protective voltage features are not enabled in this scheme. However, these features may be activated through BESTlogic.

IPS100-OC79-A-BE (Overcurrent Protection with Reclosing) Logic Scheme

This logic scheme provides time and both high-set and low-set instantaneous overcurrent elements for phase, neutral, and negative-sequence protection. Automatic reclosing is included and is initiated (RI) by a protective trip or by an external reclose initiate contact. Breaker failure, virtual breaker control, and protective voltage features are not activated in this scheme. However, these features may be activated through BESTlogic.

IPS100-BUS-A-BE (Bus Protection) Logic Scheme

This logic scheme is applied to a bus main breaker to provide primary bus overcurrent protection. It contains logic to interconnect with feeder protection schemes to provide high-speed overcurrent protection for the bus under normal conditions. It also contains logic to trip the feeder breakers when normal protection is out of service.

IPS100-BKUP-A-BE (Backup Protection) Logic Scheme

This logic scheme is applied to a bus main breaker to provide backup bus overcurrent protection as well as breaker failure protection for the bus breaker under normal conditions. It also provides primary bus overcurrent protection when the relay using BUS logic is providing feeder protection or when the primary bus relay is out of service.

DETAILS OF ADDITIONAL PREPROGRAMMED LOGIC SCHEMES

The following subsections describe each of the four additional preprogrammed logic schemes in detail. For each scheme, operation of the protection and control logic under normal conditions is described. The features of each logic scheme are broken down into functional groups and described in detail.

IPS100-5051-A-BE (BASIC OVERCURRENT) LOGIC SCHEME

This logic scheme is intended for applications requiring three-phase and neutral nondirectional overcurrent protection. While not as elaborate as the other preprogrammed schemes, this logic scheme provides an excellent base on which to create a custom scheme for a specific application.

Figure 8-5 shows a one-line drawing for the Basic Overcurrent logic scheme. A diagram of the logic is shown in Figure 8-6. The components of this logic scheme are summarized in Tables 8-6, 8-7, 8-8, and 8-9. The logic settings in Table 8-10 include the logic equations that connect the various elements (electronic wiring) of the basic overcurrent logic protection scheme.

Operation - Protection

The phase, neutral, and negative-sequence elements are activated to provide timed (51) and instantaneous (50) overcurrent protection in this scheme. A function block is disabled by setting the pickup set point at zero in each of the four setting groups. Virtual output VO11 is assigned for all protective trips. When VO11 becomes TRUE, OUT1 will operate and trip the breaker. Contact outputs OUT2, OUT3, OUT4, and OUT5 are designated to specific function blocks. OUT2 operates for instantaneous phase overcurrent conditions, OUT3 trips for timed phase overcurrent situations, OUT4 operates for instantaneous neutral and negative-sequence overcurrent conditions. And OUT5 operates for timed neutral and negative-sequence overcurrent conditions.

All contact sensing inputs are unassigned but IN1 is typically assigned to monitor breaker status (52b). Inputs IN2, IN3, and IN4 are available for user specified functions.

Voltage protection, frequency protection, automatic reclosing, breaker failure, breaker control, and virtual switches are not included in this logic scheme.

Operation - Setting Group Selection

A setting group can be selected automatically or by using the communication ports or the front panel human-machine interface (HMI). Automatic setting group changes are based on current level and duration. Automatic setting group changes for cold load pickup and/or dynamic setting adjustments are enabled by the SP-GROUP# command. Setting group changes initiated by contact sensing inputs are not accommodated in this scheme. But IN2, IN3, or IN4 can be programmed to provide this function.

Operation - Alarms

If the continuous self-test diagnostics of the relay detect an error, failsafe output contact OUTA will change states and the Relay Trouble LED of the HMI will light. OUTA will also change states if relay operating power is lost. More information about alarms is provided in Section 6, *Reporting and Alarm Functions*.

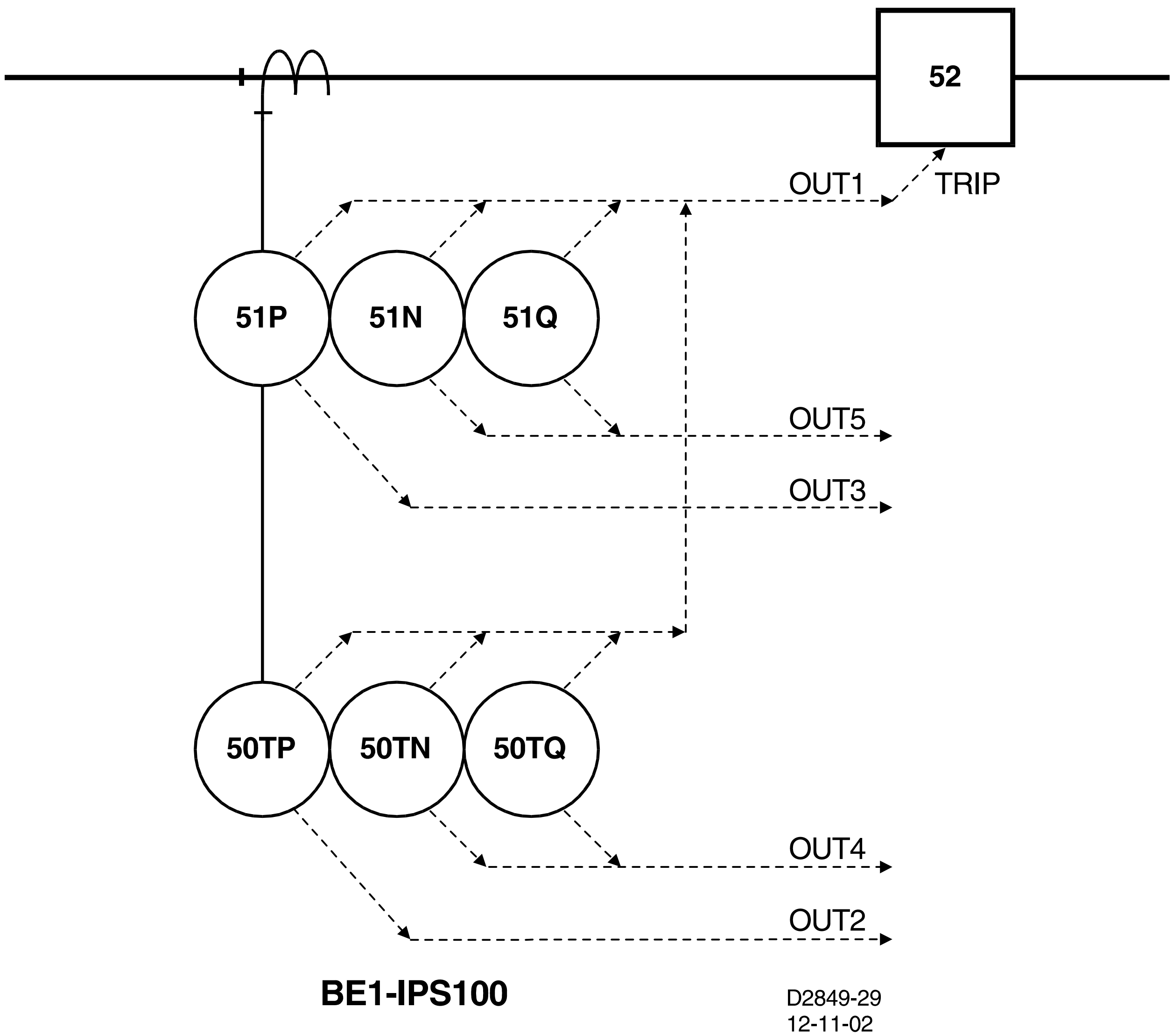

Figure 8-5. IPS100-5051-A-BE (Basic OC) One-Line Drawing

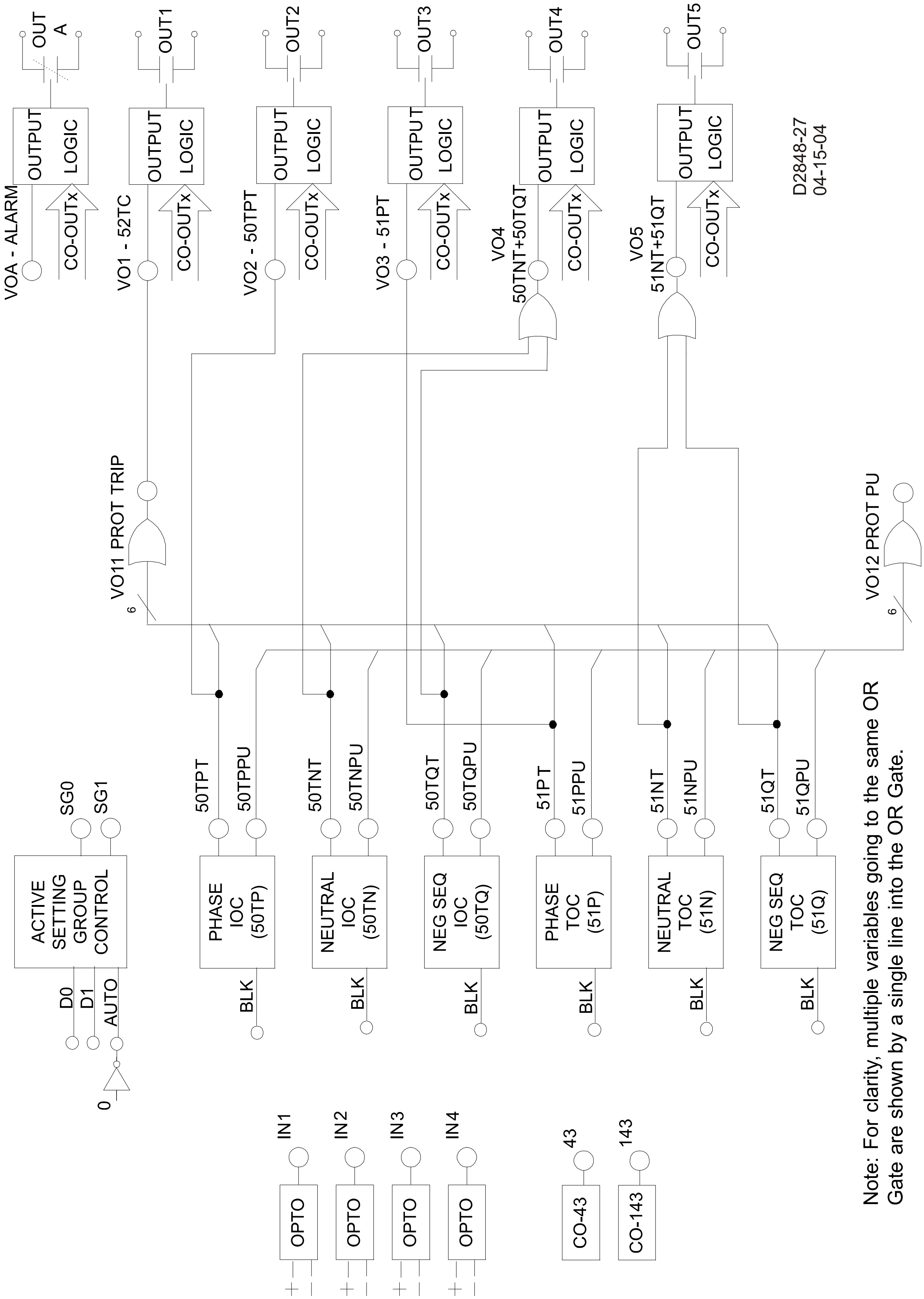

Figure 8-6. IPS100-5051-A-BE (Basic OC) Logic Diagram

Table 8-6. IPS100-5051-A-BE (Basic OC) Contact Sensing Inputs Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	Optional input used for breaker status indication in Sequence of Events Reporting. TRUE when breaker is open. Typically, IN1 is connected to the 52b contact of the breaker.	BREAKER	OPEN	CLOSED
IN2	N/A	INPUT_2	TRUE	FALSE
IN3	N/A	INPUT_3	TRUE	FALSE
IN4	N/A	INPUT_4	TRUE	FALSE

Table 8-7. IPS100-5051-A-BE (Basic OC) Function Blocks Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	N/A	0	0 (disabled)
25	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
127P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
50TP	Used for instantaneous phase-overcurrent protection.	0	1 (1 of 3)
50TN	Used for instantaneous neutral-overcurrent protection.	0	1 (3-phase residual)
50TQ	Used for instantaneous negative-sequence overcurrent protection.	0	1 (Negative-Sequence)
150TP	N/A	0	0 (disabled)
150TN	N/A	0	0 (disabled)
150TQ	N/A	0	0 (disabled)
51P	Used for timed phase-overcurrent protection.	0	1 (enabled)
51N	Used for timed neutral-overcurrent protection.	0	1 (3-phase residual)
51Q	Used for timed negative-sequence overcurrent protection.	0	1 (enabled)
151P	N/A	0	0 (disabled)
151N	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
59X	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)

Function	Purpose	BESTlogic Expression	Mode Setting
62/162	N/A	0	0 (disabled)
79	N/A	0	0 (disabled)
BF	N/A	0	0 (disabled)
81	N/A	0	0 (disabled)
181	N/A	0	0 (disabled)
281	N/A	0	0 (disabled)
381	N/A	0	0 (disabled)
481	N/A	0	0 (disabled)
581	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Inputs)
	Input 1 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Set to 1 (/0) to enable automatic selection. Manual selection is not used.	/0	

Table 8-8. IPS100-5051-A-BE (Basic OC) Virtual Switches Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	TRUE	FALSE
143	N/A	0 (disabled)	SWITCH_143	TRUE	FALSE
101	N/A	0 (disabled)	N/A	N/A	N/A

Table 8-9. IPS100-5051-A-BE (Basic OC) Virtual Outputs Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact changes states automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Contact.	Contact closes when protective trip expression is TRUE.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=VO11					
VO2 (OUT2)	Instantaneous Phase OC Auxiliary Contact.	Contact closes when instantaneous phase-overcurrent trip occurs.	50TP_TRIP	TRIP	NORMAL
BESTlogic Expression: VO2=50TPT					
VO3 (OUT3)	Timed Phase OC Auxiliary Contact.	Contact closes when timed phase-overcurrent trip occurs.	51P_TRIP	TRIP	NORMAL
BESTlogic Expression: VO3=51PT					

Output	Purpose	Description	Label	State Labels	
				True	False
VO4 (OUT4)	Instantaneous Neutral and Negative-Sequence OC.	Contact closes when instantaneous neutral or instantaneous negative-sequence overcurrent condition occurs.	INST_N&Q	TRIP	NORMAL
BESTlogic Expression: VO4=50TNT+50TQT					
VO5 (OUT5)	Timed Neutral and Negative-Sequence OC.	Contact closes when timed neutral or timed negative-sequence overcurrent condition exists.	51N&QTRP	TRIP	NORMAL
BESTlogic Expression: VO5=51NT+51QT					
VO6	N/A	N/A	VO6	TRUE	FALSE
BESTlogic Expression: VO6=0					
VO7	N/A	N/A	VO7	TRUE	FALSE
BESTlogic Expression: VO7=0					
VO8	N/A	N/A	VO8	TRUE	FALSE
BESTlogic Expression: VO8=0					
VO9	N/A	N/A	VO9	TRUE	FALSE
BESTlogic Expression: VO9=0					
VO10	N/A	N/A	VO10	TRUE	FALSE
BESTlogic Expression: VO10=0					
VO11	Protective Trip Expression.	TRUE when any 50 or 51 element times out.	PROT_TRIP	TRIP	NORMAL
BESTlogic Expression: VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT					
VO12	Protection Picked Up Expression.	TRUE when any 50 or 51 element picks up.	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU					
VO13	Alarm Mask 21.	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	Alarm Mask 22.	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	Alarm Mask 23.	N/A	VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					

Table 8-10. IPS100-5051-A-BE (Basic OC) Logic Settings and Equations

```
SL-N=IPS100-5051-A-BE,BASLER
SL-50TP=1,0;     SL-50TN=1,0;     SL-50TQ=1,0
SL-150TP=0,0;    SL-150TN=0,0;    SL-150TQ=0,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
```

```
SL-151P=0,0
SL-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0;        SL-27X=0,0
SL-127P=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0;        SL-59X=0,0
SL-159P=0,0;       SL-159X=0,0
SL-81=0,0
SL-181=0,0
SL-281=0,0
SL-381=0,0
SL-481=0,0
SL-581=0,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=0,0,0,0,0
SL-BF=0,0,0
SL-GROUP=1,0,0,/0
SL-43=0
SL-143=0
SL-101=0
SL-VOA=0
SL-VO1=VO11
SL-VO2=50TPT
SL-VO3=51PT
SL-VO4=50TNT+50TQT
SL-VO5=51NT+51QT
SL-VO6=0
SL-VO7=0
SL-VO8=0
SL-VO9=0
SL-VO10=0
SL-VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT
SL-VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU
SL-VO13=0
SL-VO14=0
SL-VO15=0
```

IPS100-OC79-A-BE (OVERCURRENT WITH RECLOSING) LOGIC SCHEME

This logic scheme is intended for feeder breaker applications where nondirectional overcurrent protection is required. Automatic reclosing is included and is initiated by a protective overcurrent trip or by an external contact to initiate reclosing (RI). Breaker failure and other control functions such as virtual switches are not provided in this scheme.

Figure 8-7 shows a one-line drawing for the OC-W-79 logic scheme. A diagram of the logic is shown in Figure 8-8. The components of OC with 79 logic are summarized in Tables 8-11, 8-12, 8-13, and 8-14. The logic settings in Table 8-15 include the logic equations that connect the various elements (electronic wiring) of the overcurrent with reclosing logic protection scheme.

Operation - Protection

All timed (51) and instantaneous (50, 150) overcurrent function blocks are included in this logic scheme. The overcurrent function block outputs are directed through VO11 to provide a protective trip signal at OUT1. Overcurrent elements intended for this scheme are phase (P), neutral (N), and negative-sequence (Q) protection. A function block is disabled by setting the pickup point at zero in each of the four setting groups.

The 150T function blocks are arranged as high-set instantaneous functions. When a 150T trip occurs, the recloser is driven to lockout. This scheme also allows the 50TN, 50TQ, 51N, and 51Q function blocks to be torque controlled by Contact Input IN4.

Operation - Reclosing

Reclosing logic in OC-W-79 uses a reclose initiate (RI) scheme where each step in the reclosing sequence is initiated by a protective trip or external initiate signal via IN3. Setting the first reclose time at zero in the four setting groups will disable the recloser. Reclosing can also be disabled by using IN2. Contact Input IN2 is connected to the drive to lockout (DTL) input of the recloser function block. In this scheme, enabling the recloser after a "one-shot" trip causes the recloser to be in lockout. When the breaker is manually closed, the relay will time out to a reset condition.

Recloser lockout also occurs if any of the 150TP/N/Q functions trips (typically used for high-set instantaneous protection). It should be noted that the 150TP/N/Q functions drive both the RI and the DTL inputs to the recloser function block. The DTL input takes priority over the RI input.

If zone-sequence control of the recloser is desired, a logic expression should be entered for the SP-79ZONE setting that will advance the recloser shot count when a fault is detected, regardless of whether the relay trips. This is typically the "Protection Picked Up" expression (VO12) in all of the preprogrammed schemes. Zone- sequence uses a BESTlogic expression but is not within the logic settings. Zone-sequence coordination may be enabled by the expression SP-79ZONE=VO12.

OC-W-79 logic provides for the recloser to torque control the 50TP/N/Q functions (typically used for low set instantaneous protection) during various steps in the reclosing sequence. Setting the recloser Sequence Controlled Blocking output in the four setting groups is done by using the S#-79SCB commands.

Recloser timing is stopped by the wait input if an overcurrent protection function block is picked up (VO12) and timing. This prevents the reset timer from resetting the reclose function for a situation where a 51 element is just above pickup and the time to trip is longer than the reset time.

Operation - Setting Group Selection

A setting group can be selected automatically or by using the communication ports or the front panel HMI. Automatic setting group changes are based on current level and duration. Automatic setting group changes for cold load pickup and/or dynamic setting adjustments are enabled by the SP-GROUP# command. Setting group changes initiated by contact sensing inputs are not accommodated in this scheme. But IN2, IN3, or IN4 can be programmed to provide this function.

Operation - Alarms

If the continuous self-test diagnostics of the relay detect an error, failsafe output contact OUTA will change states and the Relay Trouble LED of the HMI will light. OUTA will also change states if relay operating power is lost. More information about alarms is provided in Section 6, *Reporting and Alarm Functions*.

Outputs OUT4 and OUT5 are assigned to indicate user specified major or minor alarms. OUT4 indicates minor alarms and OUT5 indicates major alarms. The user has the ability to specify which alarms are announced as Major or Minor alarms. When an alarm is detected, the appropriate front panel LED will light to indicate the alarm. Note that some alarms are non-latching and will clear when the alarm condition goes away. Other alarms require a reset either by operating the front panel *Reset* pushbutton or by issuing ASCII commands through a communication port. More information about alarms is provided in Section 6, *Reporting and Alarm Functions*.

> **NOTE**
>
> When using OUT1 through OUT5 as alarm outputs, remember that these outputs do not have normally closed failsafe output contacts.

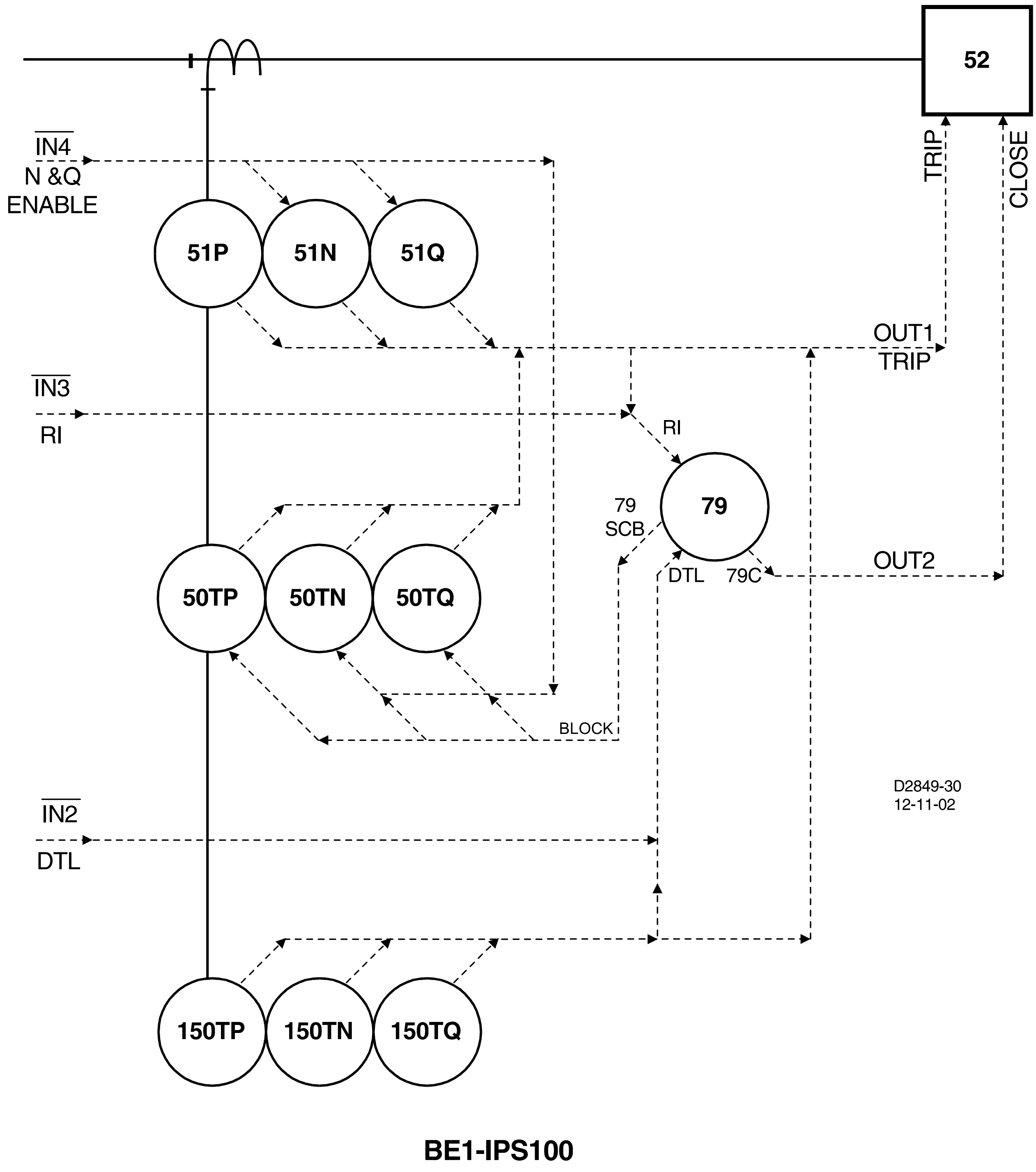

Figure 8-7. IPS100-OC79-A-BE OC with 79 One-Line Drawing

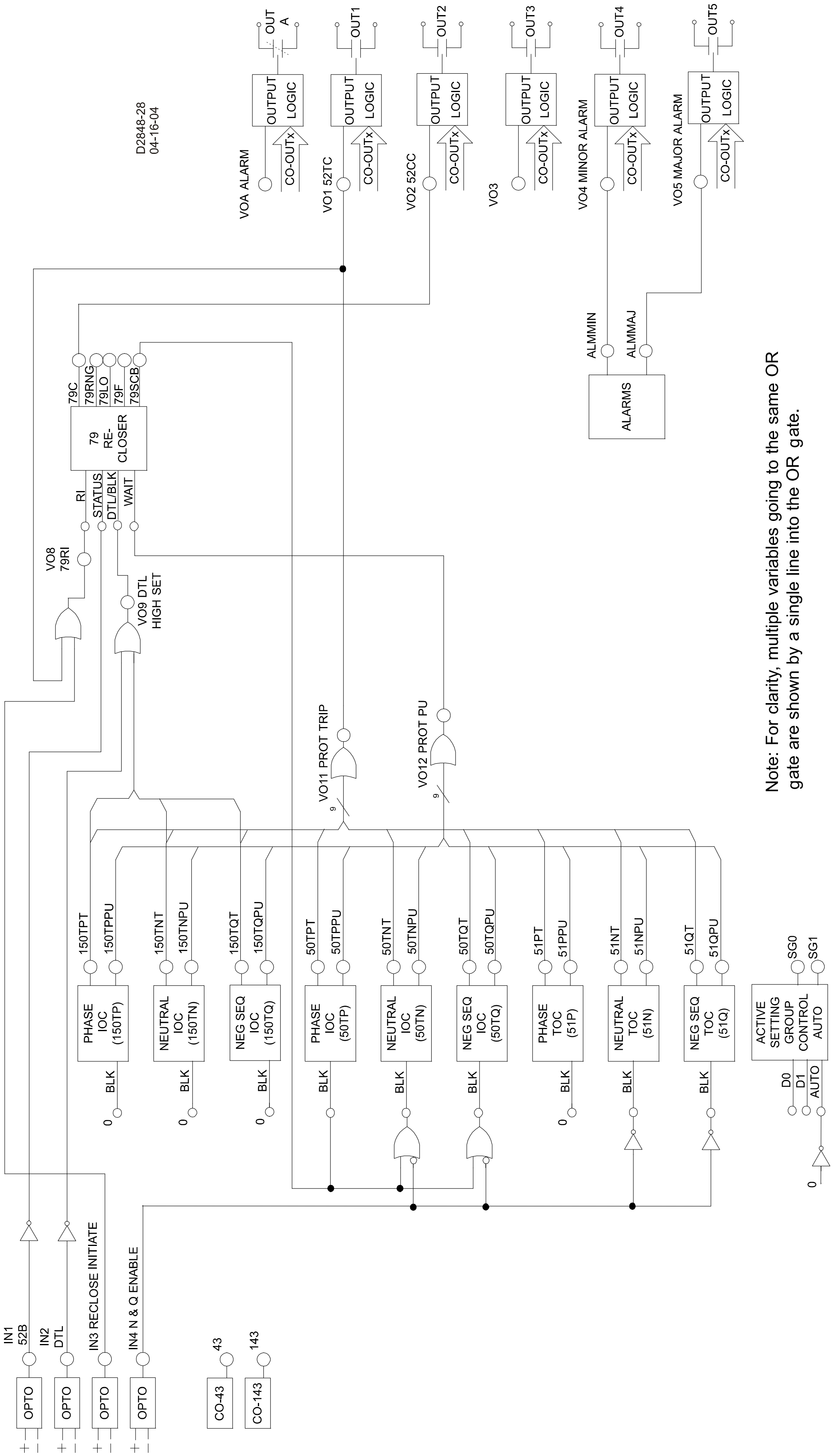

Figure 8-8. IPS100-OC79-A-BE OC with 79 Logic Diagram

Table 8-11. IPS100-OC79-A-BE OC with 79 Contact Sensing Inputs Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	52b breaker status (TRUE when breaker is open). Used for breaker status indication in Sequence of Events Reports, recloser control, and breaker monitoring.	BREAKER	OPEN	CLOSED
IN2	Reclosing Drive to Lockout. Drives recloser to lockout when de-energized. Can be used with an external switch to disable the recloser. If IN2 is not used, it must be strapped high to enable the recloser.	RCL_DTL	NORMAL	DTL
IN3	Reclosing initiate used to initiate reclosing by external protective relays.	RCL_INI	INI	NORMAL
IN4	When IN4 is energized, Neutral, Negative-Sequence, 50 and 51 protection is enabled. IN4 must be tied HIGH if this feature is not used.	N&Q_ENABLE	ENABLED	DISABLD

Table 8-12. IPS100-OC79-A-BE OC with 79 Function Blocks Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	N/A	0	0 (disabled)
25	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
127P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
50TP	Block when recloser sequence controlled blocking output is TRUE.	79SCB	1 (1 of 3)
50TN	Block when recloser sequence controlled blocking output is TRUE or when disabled by IN4.	79SCB+/IN4	1 (3-phase residual)
50TQ	Block when recloser sequence controlled blocking output is TRUE or when disabled by IN4.	79SCB+/IN4	1 (Negative-Sequence)
150TP	Used for high set.	0	0 (disabled)
150TN	Used for high set.	0	0 (disabled)
150TQ	Used for high set.	0	0 (disabled)
51P	N/A	0	1 (enabled)
51N	Block when disabled by IN4.	/IN4	1 (3-phase residual)
51Q	Block when disabled by IN4.	/IN4	1 (enabled)
151P	N/A	0	0 (disabled)
151N	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)

Function	Purpose	BESTlogic Expression	Mode Setting
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
59X	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
62/162	N/A	0	0 (disabled)
79	*Reclose Initiate Logic:* Initiate when Reclose Initiate Expression is TRUE.	VO8	1 (Power Up to Lockout)
	Breaker Status Logic: Closed breaker is indicated when IN1 is de-energized.	/IN1	
	Wait Logic: Stop recloser timing when timing for a fault trip. TRUE when protection picked up expression is TRUE.	VO12	
	DTL/BLK Logic: Drive recloser to lockout when recloser drive to lockout expression is TRUE.	VO9	
BF	N/A	0	0 (disabled)
81	N/A	0	0 (disabled)
181	N/A	0	0 (disabled)
281	N/A	0	0 (disabled)
381	N/A	0	0 (disabled)
481	N/A	0	0 (disabled)
581	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Inputs)
	Input 1 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Set to 1 (/0) to enable automatic selection. Manual selection is not used.	/0	

Table 8-13. IPS100-OC79-A-BE OC with 79 Virtual Switches Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	TRUE	FALSE
143	N/A	0 (disabled)	SWITCH_143	TRUE	FALSE
101	N/A	0 (disabled)	N/A	N/A	N/A

Table 8-14. IPS100-OC79-A-BE OC with 79 Virtual Outputs Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact changes states automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					

Output	Purpose	Description	Label	State Labels	
				True	False
VO1 (OUT1)	Breaker Trip Contact.	Contact closes when protective trip expression is TRUE.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=VO11					
VO2 (OUT2)	Breaker Close Contact.	Close breaker when recloser close output is TRUE.	BKR_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO2=79C					
VO3 (OUT3)	N/A	N/A	VO3	TRUE	FALSE
BESTlogic Expression: VO3=0					
VO4 (OUT4)	Minor Alarm.	Closes contact when Minor Alarm expression is TRUE.	ALMMIN	ACTIVE	NORMAL
BESTlogic Expression: VO4=ALMMIN					
VO5 (OUT5)	Major Alarm.	Closes contact when Major Alarm expression is TRUE.	ALMMAJ	ACTIVE	NORMAL
BESTlogic Expression: VO5=ALMMAJ					
VO6	N/A	N/A	VO6	TRUE	FALSE
BESTlogic Expression: VO6=0					
VO7	N/A	N/A	VO7	TRUE	FALSE
BESTlogic Expression: VO7=0					
VO8	Reclose Initiate.	TRUE when any protective element trips or when the external reclose initiate input is TRUE.	RCL_INI	INI	NORMAL
BESTlogic Expression: VO8=VO11+IN3					
VO9	Recloser Drive to Lockout.	Drive recloser to lockout if: IN2 is energized or the high-set instantaneous elements trip.	RCL_DTL	DTL	NORMAL
BESTlogic Expression: VO9=/IN2+150TPT+150TNT+150TQT					
VO10	N/A	N/A	VO10	TRUE	FALSE
BESTlogic Expression: VO10=0					
VO11	Protective Trip Expression.	TRUE when any 50, 150, or 51 element times out.	PROT_TRIP	TRIP	NORMAL
BESTlogic Expression: VO11=50TPT+50TNT+50TQT+150TPT+150TNT+150TQT+51PT+51NT+51QT					
VO12	Protection Picked Up Expression.	TRUE when any 50, 150, or 51 element picks up.	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+50TNPU+50TQPU+150TPPU+150TNPU+150TQPU+51PPU+51NPU+51QPU					
VO13	Alarm Mask 21.	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					

Output	Purpose	Description	Label	State Labels	
				True	False
VO14	Alarm Mask 22.	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	Alarm Mask 23.	N/A	VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					

Table 8-15. IPS100-OC79-A-BE OC with 79 Logic Settings and Equations

```
SL-N=IPS100-OC79-A-BE,BASLER
SL-50TP=1,79SCB;    SL-50TN=1,79SCB+/IN4;                SL-50TQ=1,79SCB+/IN4
SL-150TP=1,0;       SL-150TN=1,0;       SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,/IN4
SL-51Q=1,/IN4
SL-151P=0,0
SL-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0;         SL-27X=0,0
SL-127P=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0;         SL-59X=0,0
SL-159P=0,0;        SL-159X=0,0
SL-81=0,0
SL-181=0,0
SL-281=0,0
SL-381=0,0
SL-481=0,0
SL-581=0,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=1,VO8,/IN1,VO12,VO9
SL-BF=0,0,0
SL-GROUP=0,0,0,0
SL-43=0
SL-143=0
SL-101=0
SL-VOA=0
SL-VO1=VO11
SL-VO2=79C
SL-VO3=0
SL-VO4=ALMMIN
SL-VO5=ALMMAJ
SL-VO6=0
SL-VO7=0
SL-VO8=VO11+IN3
SL-VO9=150TPT+150TNT+150TQT+/IN2
SL-VO10=0
SL-VO11=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+51NT+51QT
SL-VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+51NPU+51QPU
SL-VO13=0
SL-VO14=0
SL-VO15=0
```

IPS100-BUS-A-BE AND IPS100-BKUP-A-BE (BUS AND BACKUP) LOGIC SCHEMES

Logic schemes Bus and Backup are intended for use on a bus main breaker and provide all overcurrent protection and control functions required for a typical bus main breaker in a nondirectional overcurrent protection application. When used with other programmable relays using the FDR-W-IL scheme, BUS and BACKUP logic provide complete overcurrent protection for the transformers, bus, and feeders in a radial system substation. Figure 8-9 illustrates how BUS and BACKUP relays are interconnected to achieve an integrated protection system.

Figure 8-9 shows a one-line drawing for the BUS logic scheme. A diagram of the BUS logic is shown in Figure 8-10. The components of BUS logic are summarized in Tables 8-16, 8-17, 8-18, and 8-19. The logic settings in Table 8-20 include the logic equations that connect the various elements (electronic wiring) of the of the BUS logic protection scheme.

Figure 8-11 shows a one-line drawing for the Backup logic scheme. A diagram of Backup logic is shown in Figure 8-12. The components of Backup logic are summarized in Tables 8-21, 8-22, 8-23, and 8-24. The logic settings in Table 8-25 include the logic equations that connect the various elements (electronic wiring) of the of the Backup logic protection scheme.

Normal Operation - Control

The virtual breaker control switch (101) is programmed to provide manual trip and close control of the breaker. Manual breaker control can be achieved by using the front panel HMI or by entering ASCII commands through the communication ports. Control functions of this logic scheme use both traditional contact sensing inputs and virtual switches. Virtual switches that are not needed may simply go unused. The contact sensing inputs can be freed up for other uses by utilizing the virtual switches for other control functions.

Normal Operation - Bus Protection

During normal operation, the primary task of the BUS relay is to provide high-speed fault protection (2 to 4 cycles coordination interval) and timed overload or high unbalanced load protection. The primary task of the BACKUP relay is to provide the BUS relay with backup support for bus faults with an 18 to 20 cycle coordination interval.

When any feeder relay overcurrent element is picked up and timing, OUT4 of the feeder relay closes. OUT4 is intended to be connected to IN2 of the upstream (primary) bus relay that is using BUS logic. When IN2 is energized, the bus relay 50T elements (2 to 4 cycle time delay) are blocked. If a fault occurs that is not on a feeder, then the bus relay 50T elements are not blocked. The bus relay 50T function blocks are set up to close OUT4 which will trip the bus breaker by an external bus lockout relay (86B). Because the BACKUP relay isn't blocked when a feeder relay picks up, its 50T elements are set with a time delay long enough to allow the feeder breaker to interrupt a fault. The BACKUP 50T elements are set up to trip the 86B relay via OUTA. If a bus-fault lockout relay isn't used, OUT4 can be wired in parallel with OUT1 to directly trip the bus breaker. The BUS and BACKUP 50T functions should be set with a higher pickup than the highest feeder instantaneous elements to ensure that they won't pickup before any feeder relay.

If there is a contingency problem such as a relay removed from service, 51 protection is still provided. The BUS and BACKUP 51 functions are enabled for tripping via OUT1. The 51 functions aren't blocked to allow clearing of a bus fault with a traditional coordination interval. When used to provide high-speed overcurrent protection for the substation bus, it is recommended that all 51 function timing curves be set for instantaneous reset.

Normal Operation - Setting Group Selection

For normal operation, the BUS and BACKUP relays use Setting Group 0. In Setting Group 0, the two relays will only trip the bus breaker. IN2 of the BACKUP relay identifies when a feeder relay is out of service. The BACKUP relay will close OUT3, which is connected to IN3 of the BUS relay. Both relays then switch to Setting Group 1. Binary coded setting group selection (Mode 2) is used to recognize the group setting state. When input D0 of the setting group selection function block is logic 1 (TRUE), it is interpreted as a binary 1 and causes the logic to switch to Setting Group 1.

When in Setting Group 1, the relays are operating in feeder relay backup mode. This expression is programmed to VO13 of the BUS relay, which drives alarm bit 21 in the programmable alarm mask. Alarm bit 21 can be masked to drive an alarm LED and alarm display screen to indicate when the BUS relay is in feeder backup mode. It can also be used to trip a feeder breaker instead of the bus breaker.

More information about setting group operation is provided in the Setting Group subsection of Section 4, *Protection and Control*.

Normal Operation - Alarms

If the continuous self-test diagnostics of the relay detect an error, failsafe output contact OUTA will change states and the Relay Trouble LED of the HMI will light. OUTA will also change states if relay operating power is lost. More information about alarms is provided in Section 6, *Reporting and Alarm Functions*.

Contingency Operation - Test Mode

The test mode is intended to increase the security of the protection and control system if external test switches are not installed on all outputs.

De-energizing IN4 or closing Virtual Switch 43 places the logic scheme in test mode. IN4 can be controlled by a panel mounted selector switch that is closed in the normal state and open in the test state. IN4 can also be controlled by a pole of a standard external test switch that is opened with the rest of the test switch poles. When test mode is activated in the BUS relay, external breaker failure initiate (BFI) via VO3 is inhibited. The BACKUP relay will block its own breaker failure function while test mode is enabled.

The logic for test mode drives VO15, which drives alarm bit 23 in the programmable alarm mask. Alarm bit 23 can be masked to drive an alarm LED and HMI alarm display screen to provide indication when the relay is in test mode.

Contingency Operation - Backup Protection for Bus Breaker Failure

Bus breaker-failure protection is provided by the main bus relay using the preprogrammed logic scheme BACKUP. OUT5 is configured as the breaker failure trip output. OUT5 can be wired to trip the upstream breaker, a bus breaker-failure lockout relay, or other lockout relays that trip the transformer high side such as the 86T transformer differential lockout relay.

Provision for external breaker failure initiation (BFI) is accommodated by IN3 of the BACKUP relay. The 150T function blocks provide fault detector supervision of IN3. The BACKUP logic scheme uses the pickup outputs of the 150TP/N/Q function blocks to drive the initiate input of the breaker failure function block. A maximum time delay setting for the 150TP/N/Q function blocks is needed to ensure that they don't trip and target. The breaker failure function block is also initiated by a protective trip (VO11). Keep in mind, if you are tripping for a bus fault via a lockout relay, the additional time delay of the lockout relay should be added to your breaker failure time delay setting.

The breaker failure function block has an independent fast dropout phase current detector that senses a breaker opening and stops timing. An open breaker is detected when the current drops below 10 percent of the nominal CT input (1 A or 5 A) for the relay.

A time delay setting of zero disables the BF function block. This permits the traditional radial system backup scheme of coordinated relays tripping different breakers.

Contingency Operation - Backup Protection for Backup Relay Out of Service

When the BACKUP relay is out of service, full high-speed bus fault protection and overload protection are provided by the BUS relay. Breaker failure protection is not provided during this double-contingency situation.

Contingency Operation - Backup Protection for Feeder Relay Out of Service

OUT3 of each feeder relay should be wired to an auxiliary transfer relay (83/Fn) with one normally open and one normally closed contact. Under normal conditions, OUT3 of a feeder relay is closed and the 83 auxiliary relay is picked up. When a relay is in test mode and out of service or withdrawn from its case, the 83 auxiliary relay will drop out.

The normally open contact (NO in shelf state) of the 83/Fn auxiliary relay is wired to IN2 of the BACKUP relay to signal the BUS and BACKUP relays to change to setting group 1. When setting group 1 is active, the BUS relay 50T and 51 overcurrent function blocks trip an auxiliary tripping relay (94/BU) via OUT5.

In setting group 1, the BACKUP relay 51 time settings must coordinate with the BUS relay 51 time dial settings. Since the feeder relays provide a blocking signal to the BUS relay upon pickup of the 51 function blocks, it isn't necessary for the 51 time dial settings of the BUS relay to coordinate with the feeder relays in setting group 1. Therefore, the 51 time dial settings of the BUS relay can be reduced in setting group 1 to provide the necessary coordination interval between the BUS relay and the BACKUP relay for this contingency. This minimizes the time delay that needs to be added to the BACKUP relay time dial settings and provides a greater opportunity to keep the setting below the transformer damage curve.

The tripping output of the 94/BU auxiliary relay and the normally closed contacts (form B) of the 83/Fn auxiliary relay are wired in series with the feeder breaker trip coil. This allows the 94/BU relay to trip the feeder breaker when the feeder relay is out of service.

When the BUS and BACKUP relays are in feeder relay backup mode, relay responses to the various faults are summarized in the following paragraphs:

- A feeder relay detecting a fault will send a blocking signal to the BUS relay to prevent it from issuing a high-speed trip. The 51 functions of the BUS and BACKUP relays are set to coordinate with each other and the feeder relays.
- An out of service feeder relay on a feeder with a fault will not send a blocking signal to the BUS relay so the BUS relay will trip the feeder breaker via the 94 and 83 relay contacts. Fault clearing occurs after the 2 to 4 cycle coordination interval set on the BUS relay 50T functions or after the BUS relay 51 time if the fault is further out. For this reason, the BACKUP relay 51 functions must be set to coordinate with the BUS relay in this setting group.
- A bus fault will cause the BUS relay to trip the feeder breaker with the relay out of service because no blocking signal will be sent by any of the feeder relays. Since this won't clear the fault, BACKUP relay will clear the fault with its 18 to 20 cycle coordination interval.

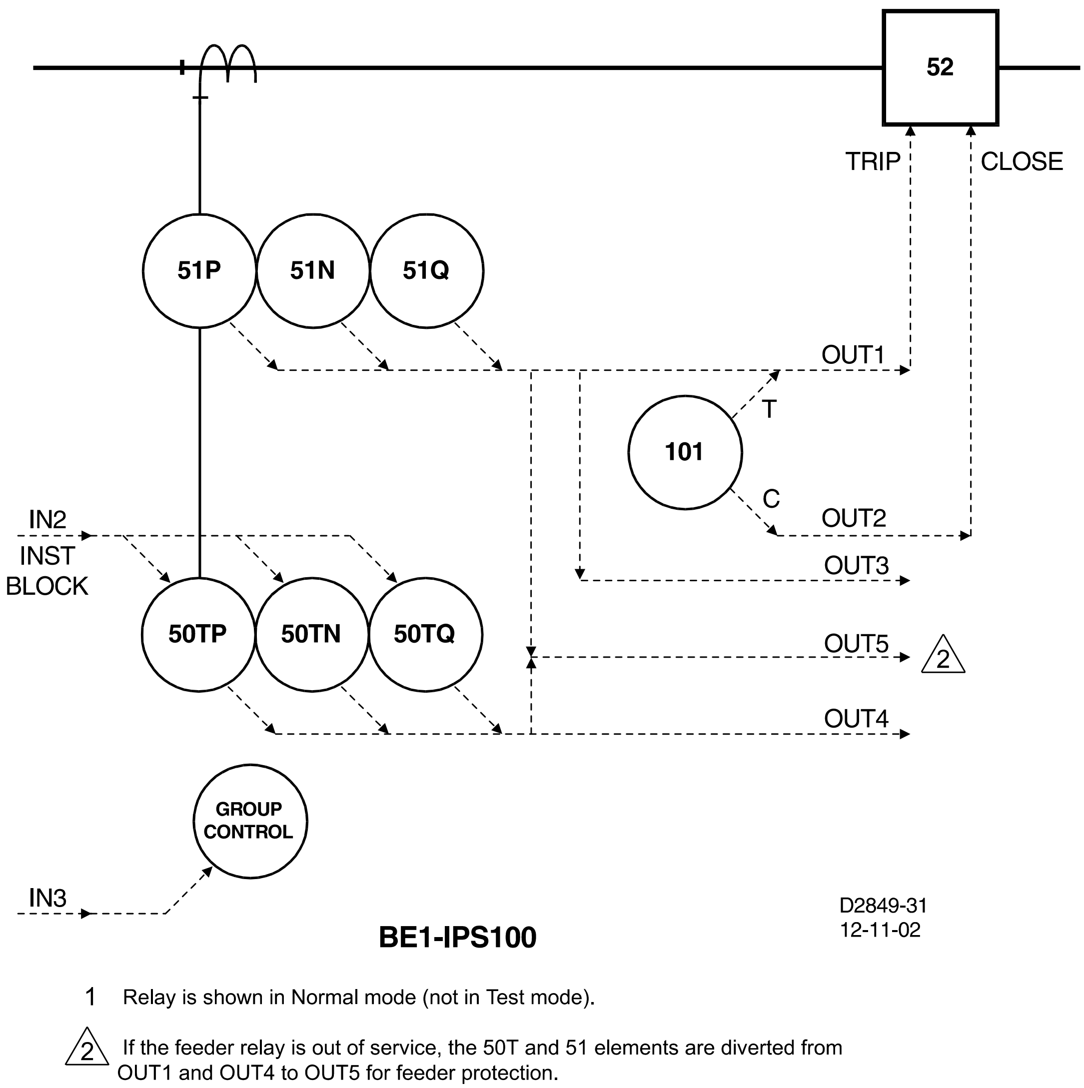

Figure 8-9. IPS100-BUS-A-BE (BUS) One-Line Drawing

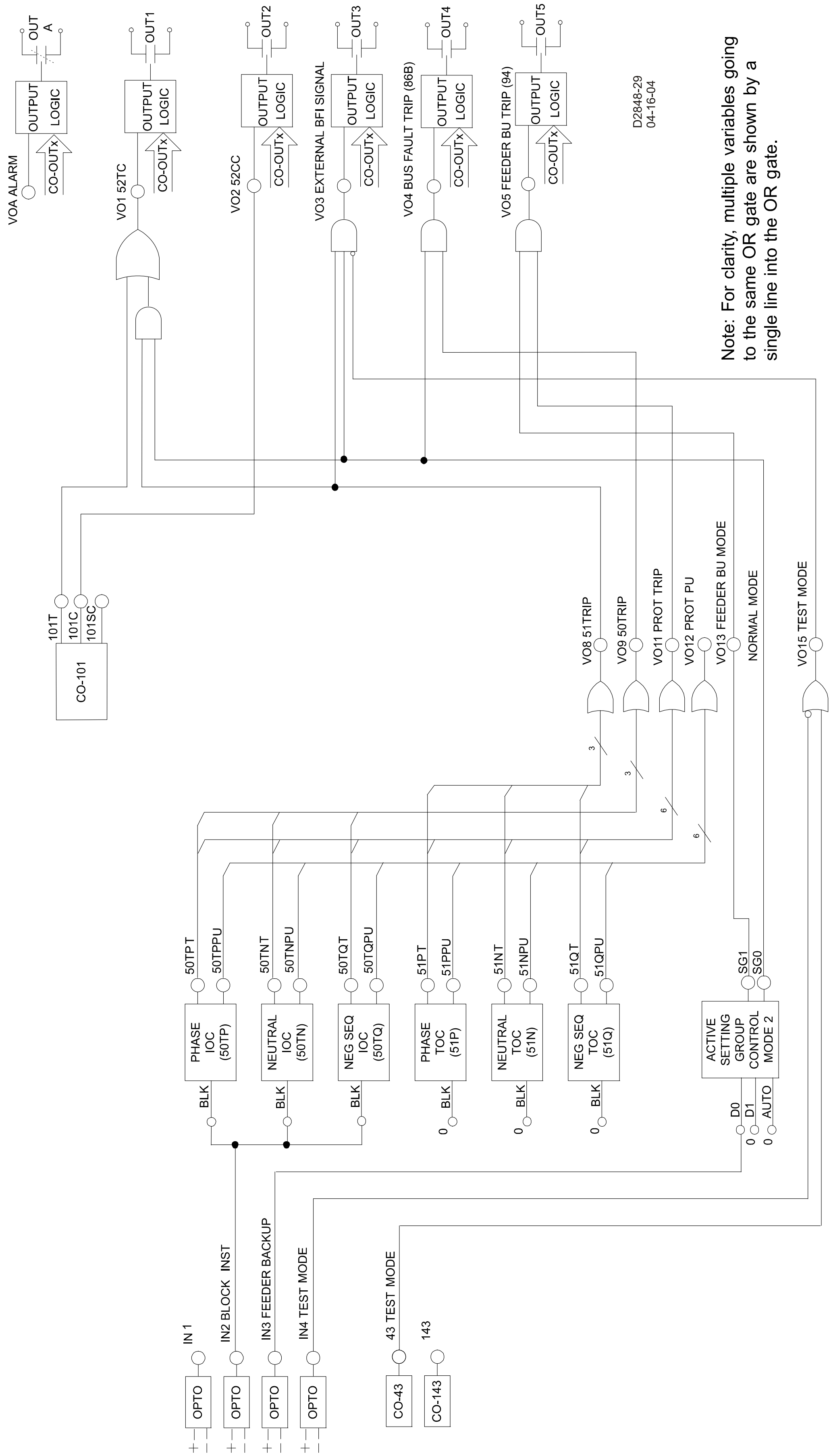

Figure 8-10. IPS100-BUS-A-BE (BUS) Logic Diagram

Table 8-16. IPS100-BUS-A-BE (BUS) Contact Sensing Inputs Logic

Input	Purpose	Name Label	State Labels	
			Energized	**De-Energized**
IN1	52b breaker status.	BREAKER	OPEN	CLOSED
IN2	Blocks instantaneous when feeder relay picks up.	FEEDER_PU	PICKUP	NORMAL
IN3	Signal from bus source relay using BACKUP logic that a feeder relay is out of service.	BACKUPMODE	BACKUP	NORMAL
IN4	Places the relay in Test mode so that all trips are rerouted to OUT1 when IN4 de-energizes.	TESTDISABL	NORMAL	TSTMODE

Table 8-17. IPS100-BUS-A-BE (BUS) Function Blocks Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	N/A	0	0 (disabled)
25	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
127P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
50TP	Inhibit when feeder fault is indicated by feeder relay pickup. Requires a 2 to 4 cycle coordination delay. Used for high-speed bus fault tripping or for feeder instantaneous tripping when in feeder backup mode.	IN2	1 (1 of 3)
50TN	Inhibit when feeder fault is indicated by feeder relay pickup. Requires a 2 to 4 cycle coordination delay. Used for high-speed bus fault tripping or for feeder instantaneous tripping when in feeder backup mode.	IN2	1 (3-phase residual)
50TQ	Inhibit when feeder fault is indicated by feeder relay pickup. Requires a 2 to 4 cycle coordination delay. Used for high-speed bus fault tripping or for feeder instantaneous tripping when in feeder backup mode.	IN2	1 (Negative-Sequence)
150TP	N/A	0	0 (disabled)
150TN	N/A	0	0 (disabled)
150TQ	N/A	0	0 (disabled)
51P	N/A	0	1 (enabled)
51N	N/A	0	1 (3-phase residual)
51Q	N/A	0	1 (enabled)
151P	N/A	0	0 (disabled)
151N	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)

Function	Purpose	BESTlogic Expression	Mode Setting
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
59X	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
62/162	N/A	0	0 (disabled)
79	N/A		0 (disabled)
BF	N/A	0	0 (disabled)
81	N/A	0	0 (disabled)
181	N/A	0	0 (disabled)
281	N/A	0	0 (disabled)
381	N/A	0	0 (disabled)
481	N/A	0	0 (disabled)
581	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* Switch to Setting Group 1 if feeder relay is out of service.	IN3	2 (Binary Inputs)
	Input 1 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Auto/Manual switch fixed in Manual position. No automatic selection. Selection by contact only.	0	

Table 8-18. IPS100-BUS-A-BE (BUS) Virtual Switches Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	Places the relay in Test mode and blocks BFI signal (VO3) to external Breaker Failure Relay.	2 (On/Off)	TESTENABLE	TSTMODE	NORMAL
143	N/A	0 (disabled)	SWITCH_143	TRUE	FALSE
101	N/A	1 (enabled)	N/A	N/A	N/A

Table 8-19. IPS100-BUS-A-BE (BUS) Virtual Outputs Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact changes states automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Bus Breaker Trip.	Trip for bus breaker virtual control switch trip OR for 51 trip when in Normal mode.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=101T+VO8*SG0					

Output	Purpose	Description	Label	State Labels	
				True	False
VO2 (OUT2)	Bus Breaker Close.	Close breaker when virtual breaker control switch is operated to close.	BKR_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO2=101C					
VO3 (OUT3)	External Breaker Failure Relay BFI.	Initiate external Breaker Failure Relay for Bus Timed-Overcurrent trip when in Normal mode.	EXT-BFI-03	BFI	NORMAL
BESTlogic Expression: VO3=VO8*SG0*/VO15					
VO4 (OUT4)	Bus Fault Trip (86B).	Trip bus breaker for bus faults (50TPT, 50TNT, or 50TQT) when in Normal.	BUS_TRIP	TRIP	NORMAL
BESTlogic Expression: VO4=VO9*SG0					
VO5 (OUT5)	Feeder Breaker Trip.	Trip feeder breaker via auxiliary relay (94) for timed (51) or instantaneous (50) trip when in Feeder Relay Backup mode.	FEEDER_TRIP	TRIP	NORMAL
BESTlogic Expression: VO5=VO11*SG1					
VO6	N/A	N/A	VO6	TRUE	FALSE
BESTlogic Expression: VO6=0					
VO7	N/A	N/A	VO7	TRUE	FALSE
BESTlogic Expression: VO7=0					
VO8	Time-Overcurrent Trip.	TRUE when any time overcurrent element trips.	51_TRIP	TRIP	NORMAL
BESTlogic Expression: VO8=51PT+51NT+51QT					
VO9	Instantaneous Overcurrent Trip.	TRUE when any instantaneous overcurrent element trips.	50_TRIP	TRIP	NORMAL
BESTlogic Expression: VO9=50TPT+50TNT+50TQT					
VO10	N/A	N/A	VO10	TRUE	FALSE
BESTlogic Expression: VO10=0					
VO11	Protective Trip Expression.	TRUE when any 50 or 51 element times out.	PROT_TRIP	TRIP	NORMAL
BESTlogic Expression: VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT					
VO12	Protection Picked Up Expression.	TRUE when any 50 or 51 element picks up.	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU					
VO13	Feeder Backup Mode Alarm.	TRUE when in Setting Group 1.	FEEDER_BU	BACKUP	NORMAL
BESTlogic Expression: VO13=SG1					
VO14	N/A	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					

Output	Purpose	Description	Label	State Labels	
				True	False
VO15	Test Mode.	Blocks the BFI signal (VO3) to an external breaker failure relay. TRUE when IN4 de-energizes or Virtual Switch 43 closes.	TEST_MODE	TEST	NORMAL
BESTlogic Expression: VO15=/IN4+43					

Table 8-20. IPS100-BUS-A-BE (BUS) Logic Settings and Equations

```
SL-N=IPS100-BUS-A-BE,BASLER
SL-50TP=1,IN2;    SL-50TN=1,IN2;    SL-50TQ=1,IN2
SL-150TP=0,0;    SL-150TN=0,0;    SL-150TQ=0,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
SL-151P=0,0
SL-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0;    SL-27X=0,0
SL-127P=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0;    SL-59X=0,0
SL-159P=0,0;    SL-159X=0,0
SL-81=0,0
SL-181=0,0
SL-281=0,0
SL-381=0,0
SL-481=0,0
SL-581=0,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=0,0,0,0,0
SL-BF=0,0,0
SL-GROUP=2,IN3,0,0
SL-43=2
SL-143=0
SL-101=1
SL-VOA=0
SL-VO1=101T+VO8*SG0
SL-VO2=101C
SL-VO3=VO8*/VO15*SG0
SL-VO4=VO9*SG0
SL-VO5=VO11*SG1
SL-VO6=0
SL-VO7=0
SL-VO8=51PT+51NT+51QT
SL-VO9=50TPT+50TNT+50TQT
SL-VO10=0
SL-VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT
SL-VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU
SL-VO13=SG1
SL-VO14=0
SL-VO15=43+/IN4
```

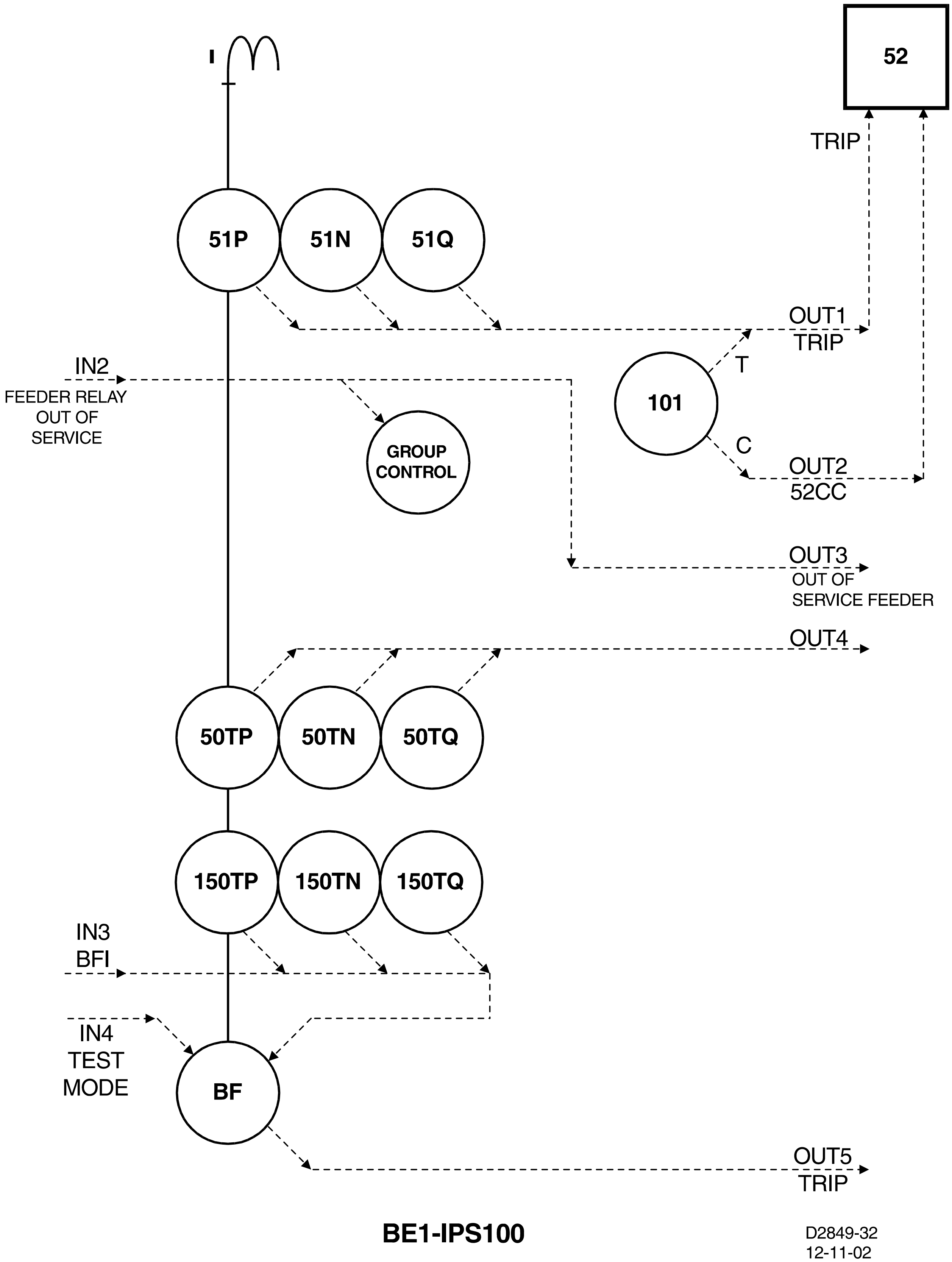

Figure 8-11. IPS100-BKUP-A-BE (Backup) One-Line Drawing

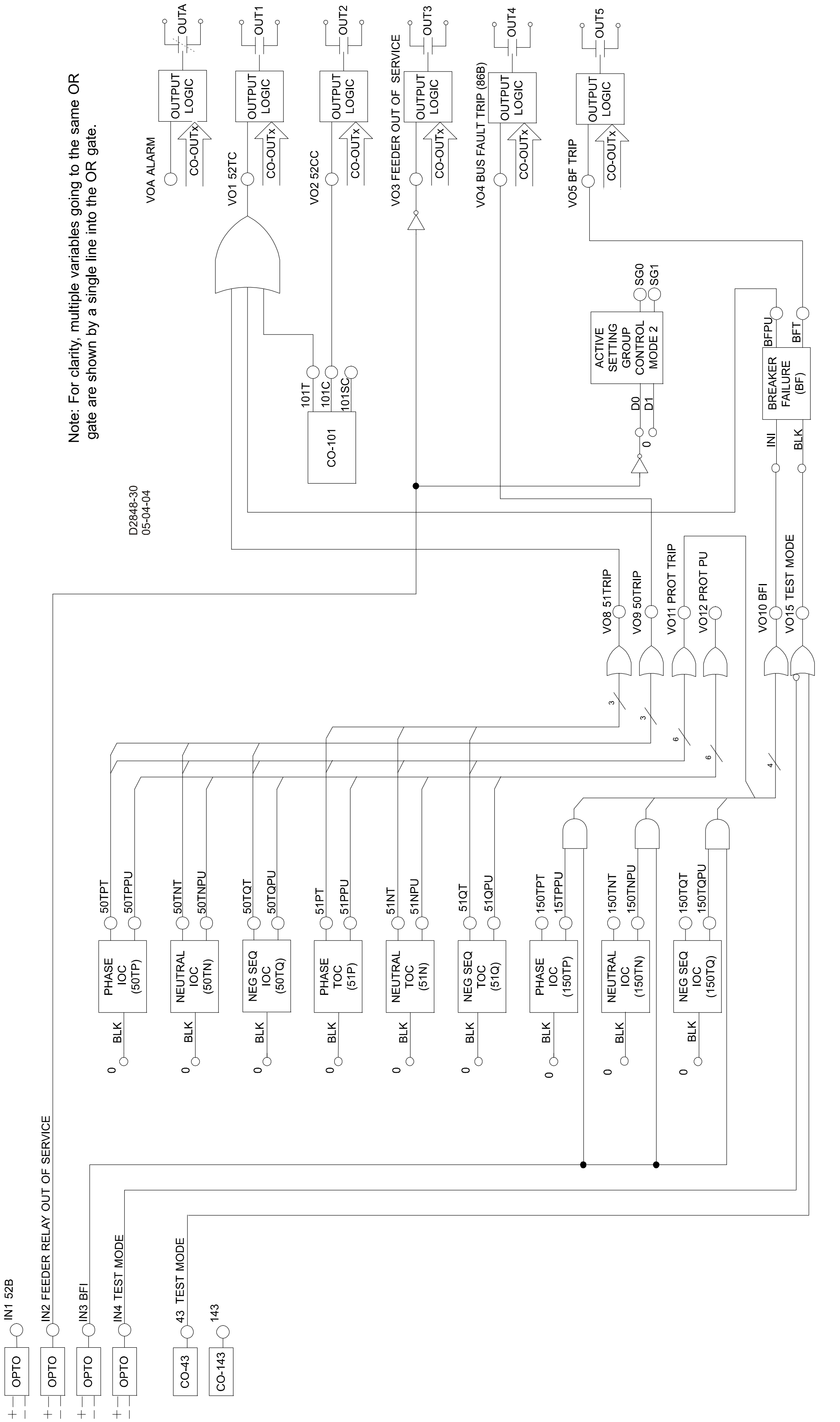

Figure 8-12. IPS100-BKUP-A-BE (Backup) Logic Diagram

Table 8-21. IPS100-BKUP-A-BE (Backup) Contact Sensing Inputs Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	52b breaker status.	BREAKER	OPEN	CLOSED
IN2	Places relay in feeder backup mode when out of service feeder relay is detected by open contact.	FEEDERS-OK	NORMAL	FDR_OOS
IN3	Initiates breaker failure (BFI) by external relays.	EXT-BFI	BFI-INI	NORMAL
IN4	Places the relay in test mode so that breaker failure is disabled when IN4 is de-energized.	TESTDISABL	NORMAL	TSTMODE

Table 8-22. IPS100-BKUP-A-BE (Backup) Function Blocks Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	N/A	0	0 (disabled)
25	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
127P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
50TP	Requires 18 – 20 cycle coordination delay since no blocking is provided for feeder relay pickup. Used for backup bus fault trip.	0	1 (1 of 3)
50TN	Requires 18 – 20 cycle coordination delay since no blocking is provided for feeder relay pickup. Used for backup bus fault trip.	0	1 (3-phase residual)
50TQ	Requires 18 – 20 cycle coordination delay since no blocking is provided for feeder relay pickup. Used for backup bus fault trip.	0	1 (Negative-Sequence)
150TP	Used for fault detector supervision of external BFI. Since this isn't used for tripping, the SG-TARG command should not be used to enable this function.	0	0 (disabled)
150TN	Used for fault detector supervision of external BFI. Since this isn't used for tripping, the SG-TARG command should not be used to enable this function.	0	0 (disabled)
150TQ	Used for fault detector supervision of external BFI. Since this isn't used for tripping, the SG-TARG command should not be used to enable this function.	0	0 (disabled)
51P	N/A	0	1 (enabled)
51N	N/A	0	1 (3-phase residual)
51Q	N/A	0	1 (enabled)
151P	N/A	0	0 (disabled)
151N	N/A	0	0 (disabled)

Function	Purpose	BESTlogic Expression	Mode Setting
47	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
59X	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
62/162	N/A	0	0 (disabled)
79	N/A	0	0 (disabled)
BF	*Breaker Failure Initiate Logic:* Initiate breaker failure when breaker failure initiate expression is TRUE.	VO10	1 (enabled)
	Block Input Logic: Block breaker failure protection when relay is in Test mode.	VO15	
81	N/A	0	0 (disabled)
181	N/A	0	0 (disabled)
281	N/A	0	0 (disabled)
381	N/A	0	0 (disabled)
481	N/A	0	0 (disabled)
581	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* Switch to Setting Group 1 if feeder relay is out of service.	IN3	2 (Binary Inputs)
	Input 1 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Auto/Manual switch fixed in Manual position. No automatic selection. Selection by contact only.	0	

Table 8-23. IPS100-BKUP-A-BE (Backup) Virtual Switches Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	Places the relay in Test mode so that breaker failure is disabled when IN4 is de-energized.	2 (On/Off)	TESTENABLE	TSTMODE	NORMAL
143	N/A	0 (disabled)	SWITCH_143	TRUE	FALSE
101	Allows breaker to be tripped or closed manually by the HMI or the ASCII command interface.	1 (enabled)	N/A	N/A	N/A

Table 8-24. IPS100-BKUP-A-BE (Backup) Virtual Outputs Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact changes states automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					

Output	Purpose	Description	Label	State Labels	
				True	**False**
VO1 (OUT1)	Bus Breaker Trip.	Trip for BACKUP breaker virtual control switch trip OR for 51 trip when in Normal mode.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=101T+VO8+BFPU					
VO2 (OUT2)	Bus Breaker Close.	Close breaker when virtual breaker control switch is operated to close.	BKR_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO2=101C					
VO3 (OUT3)	Feeder Relay Out of Service.	Signals a relay monitoring the bus source and using BUS logic that a feeder relay is out of service (indicated by open contact from feeder relays.)	BACKUPMODE	BACKUP	NORMAL
BESTlogic Expression: VO3=/IN2					
VO4 (OUT4)	Bus Fault Trip (86B).	Trip BUS breaker via lockout for bus faults (50T with 18-20 cycles delay).	BUS_TRIP	TRIP	NORMAL
BESTlogic Expression: VO4=VO9					
VO5 (OUT5)	Breaker Failure Trip.	Trip backup if breaker protection times out.	BKR_FAIL	TRIP	NORMAL
BESTlogic Expression: VO5=BFT					
VO6	N/A	N/A	VO6	TRUE	FALSE
BESTlogic Expression: VO6=0					
VO7	N/A	N/A	VO7	TRUE	FALSE
BESTlogic Expression: VO7=0					
VO8	Time-Overcurrent Trip.	TRUE when any time overcurrent element trips.	51_TRIP	TRIP	NORMAL
BESTlogic Expression: VO8=51PT+51NT+51QT					
VO9	Instantaneous Overcurrent Trip.	TRUE when any instantaneous overcurrent element trips.	50_TRIP	TRIP	NORMAL
BESTlogic Expression: VO9=50TPT+50TNT+50TQT					
VO10	Breaker Failure Initiate.	Initiate breaker failure timing when protective trip expression is TRUE or when external initiate contact is sensed and any of the fault detectors is picked up.	SUPV-BFI	BFI-INI	NORMAL
BESTlogic Expression: VO10=VO11+IN3*150TPPU+IN3*150TNPU+IN3*150TQPU					
VO11	Protective Trip Expression.	TRUE when any 50 or 51 element times out.	PROT_TRIP	TRIP	NORMAL
BESTlogic Expression: VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT					

Output	Purpose	Description	Label	State Labels	
				True	False
VO12	Protection Picked Up Expression.	TRUE when any 50 or 51 element picks up.	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU					
VO13	Alarm Mask 21.	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	Alarm Mask 22.	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	Test Mode.	Indicates that the relay is in Test mode and that breaker failure is disabled. TRUE if IN4 is de-energized or if Virtual Switch 43 is closed.	TEST_MODE	TEST	NORMAL
BESTlogic Expression: VO15=/IN4+43					

Table 8-25. IPS100-BKUP-A-BE (Backup) Logic Settings and Equations

```
SL-N=IPS100-BKUP-A-BE,BASLER
SL-50TP=1,0;    SL-50TN=1,0;    SL-50TQ=1,0
SL-150TP=1,0;    SL-150TN=1,0;    SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
SL-151P=0,0
SL-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0;    SL-27X=0,0
SL-127P=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0;    SL-59X=0,0
SL-159P=0,0;    SL-159X=0,0
SL-81=0,0
SL-181=0,0
SL-281=0,0
SL-381=0,0
SL-481=0,0
SL-581=0,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=0,0,0,0,0
SL-BF=1,VO10,VO15
SL-GROUP=2,/IN2,0,0
SL-43=2
SL-143=0
SL-101=1
SL-VOA=0
SL-VO1=VO8+101T+BFPU
SL-VO2=101C
SL-VO3=/IN2
SL-VO4=VO9
SL-VO5=BFT
```

```
SL-VO6=0
SL-VO7=0
SL-VO8=51PT+51NT+51QT
SL-VO9=50TPT+50TNT+50TQT
SL-VO10=VO11+150TPPU*IN3+150TNPU*IN3+150TQPU*IN3
SL-VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT
SL-VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU
SL-VO13=0
SL-VO14=0
SL-VO15=43+/IN4
```

MISCELLANEOUS LOGIC EXPRESSIONS

Several logic expression settings are classified as miscellaneous. That is, they are not included in the BESTlogic settings and are not set through the ASCII command interface using the SL (Set Logic) commands. Several of the reporting and alarm functions provided in the relay require programmable logic expressions to determine their functionality. These settings are included with the setup parameters related to each function. Table 8-26 cross-references the manual sections and setting commands associated with these non-BESTlogic logic settings.

Each of the pre-programmed logic schemes is designed to be compatible with the factory default logic expression settings for these reporting and alarm functions. However, when copying a pre-programmed scheme into your logic settings for modification, it is important to recognize that settings will not be copied in for these logic settings. These miscellaneous logic settings must be reviewed to ensure desired performance for these functions.

Table 8-26. Miscellaneous Logic Expressions

Command	Reference
SA-RESET	Section 6, *Reporting and Alarm Functions, Alarms Function*
SB-DUTY	Section 6, *Reporting and Alarm Functions, Breaker Monitoring*
SB-LOGIC	Section 6, *Reporting and Alarm Functions, Breaker Monitoring*
SG-TARG	Section 6, *Reporting and Alarm Functions, Fault Reporting*
SG-TRIGGER	Section 6, *Reporting and Alarm Functions, Fault Reporting*
SP-79ZONE	Section 4, *Protection and Control*

APPLICATION TIPS

Trip Circuit and Voltage Monitor

This application tip is intended for feeder applications using FDR-W-IL logic along with BUS and BACKUP schemes for protection.

OUT1 has a built-in trip circuit voltage and continuity monitor that drives logic variable OUT1MON. This variable can be used to improve breaker failure logic or to automatically enhance security during testing.

If the relay detects a loss of voltage or continuity in the breaker trip circuit, it's possible to reduce fault-clearing time by bypassing the breaker failure timer. Since feeder relay “Out of Service” and breaker failure is covered by different backup actions, it is desirable to reduce common mode failure mechanisms. It is recommended that the feeder breaker and feeder protection circuits be supplied by separate control power fuses or breakers. The equation for the breaker failure trip logic (VO5) can be modified by ORing the breaker failure initiate with the expression VO10*OUT1MON. VO10 is designated in the FDR-W-IL preprogrammed logic schemes as the breaker failure initiate expression. Example 1 shows how the BFT logic expression is modified. It's important that the breaker failure timer bypass logic also be disabled in test mode. Example 2 shows the expression for blocking the upstream instantaneous element. Figure 8-13 illustrates how the Trip Circuit Continuity Monitor can be used in breaker failure logic.

Example 1.

Breaker Failure Trip Expression: SL-VO5=BFT+VO10*OUT1MON*/VO15

Example 2.

Block Upstream Instantaneous Expression: SL-VO4=VO12*/VO5*/OUT1MON*/VO15

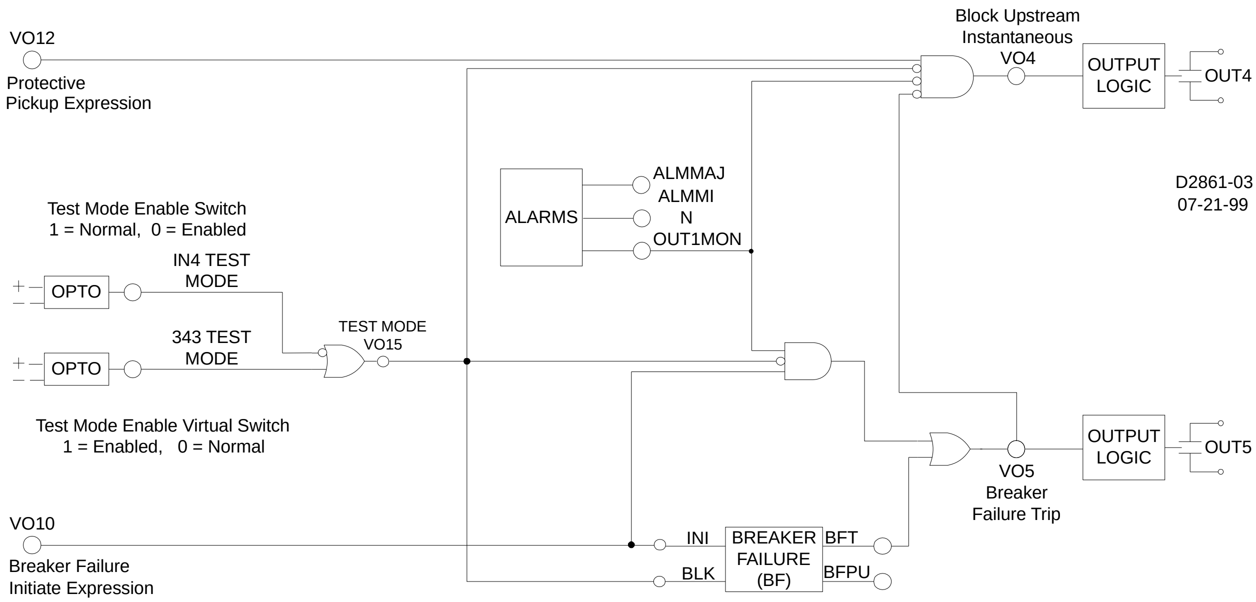

Figure 8-13. Trip Circuit Continuity and Voltage Monitor

Output Contact Latch Using the TRSTKEY Logic Variable

On occasion, an application will call for latching an output contact such as simulating a lockout (86) function. Each output contact of a Basler Electric relay can be set to latch by using an AND gate to seal the trip condition and the TRSTKEY logic variable to reset the latch.

As an example, assume a BE1-IPS100 is used for overcurrent protection of a radial transformer shown in Figure 8-14, Station One-line Drawing. The user wants to trip and lockout the high side circuit switcher for an overcurrent trip.

Referring to Figure 8-15, a 51 or 151 trip will cause VO11 to go high. This in turn causes VO14 to go high, sealing the inputs of VO3 and VO4 through AND gate VO7. This allows Output Contacts 3 and 4 to transition and remain in that state until the TRSTKEY variable is asserted. In this example, the circuit switcher will be tripped by Output 3 (simulating an 86 "a") and its close circuit disabled by Output 4 (simulating an 86 "b"). The HMI LCD display automatically goes to the *Target* screen per the automatic display priority function. When the operator presses the *Reset* key while the LCD display is on the *Target* screen (*Reset* key of the HMI is context sensitive), the TRSTKEY logic variable goes high breaking the VO7 seal in at which point Output 3 will open and Output 4 will close. Refer to Section 6, *Reporting and Alarm Functions, Fault Reporting, Targets*.

The data in Table 8-27 include the logic settings and equations for the ARSTKEY and TRSTKEY functions.

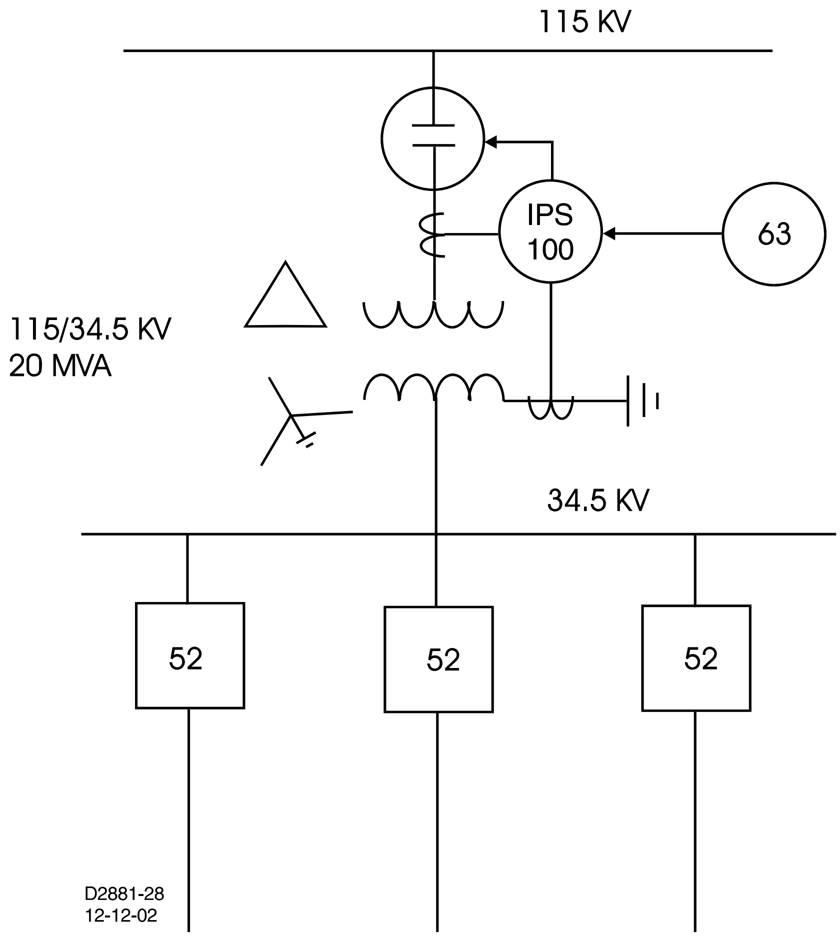

Figure 8-14. Station One-Line Drawing

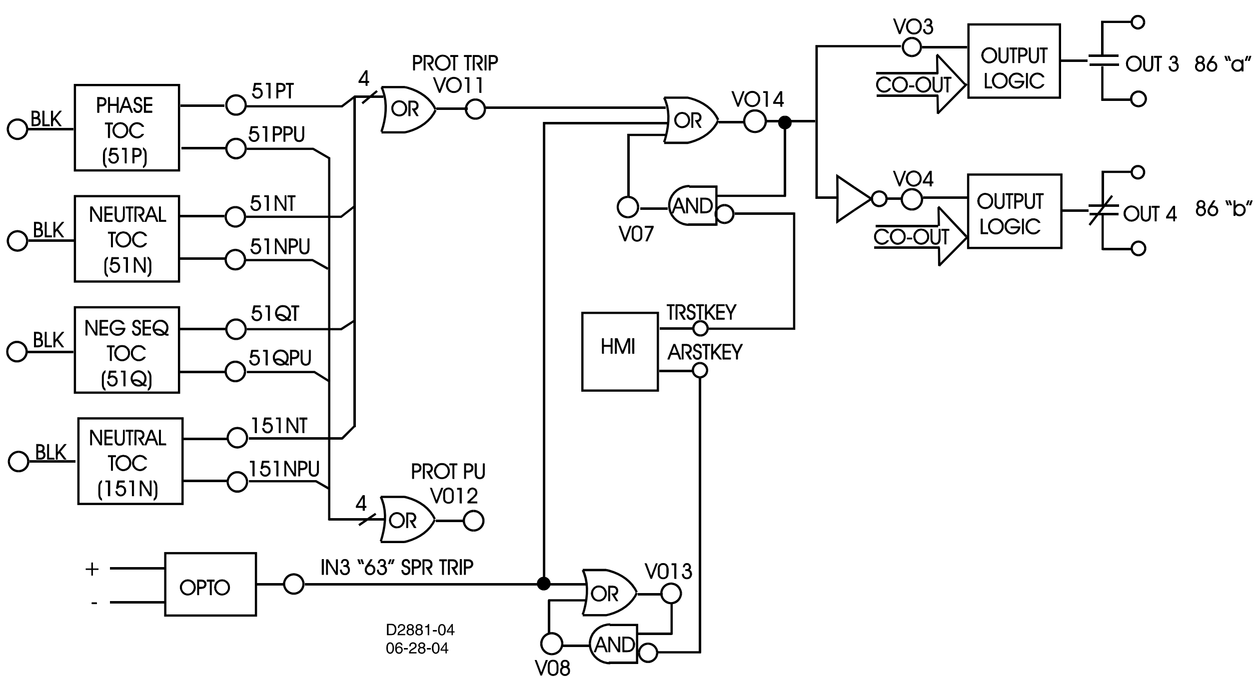

Figure 8-15. IPS100 Transformer Protection Output Latch, ARSTKEY and TRSTKEY

Table 8-27. ARSTKEY and TRSTKEY Logic Settings and Equations

```
SL-N=LATCH
SL-50TP=0,0;     SL-50TN=0,0;     SL-50TQ=0,0
SL-150TP=0,0;    SL-150TN=0,0;    SL-150TQ=0,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
SL-151N=G,0
SL-27P=0,0
SL-59P=0,0;      SL-59X=0,0
SL-47=0,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=0,0,0,0,0
SL-81=0,0
SL-181=0,0
SL-281=0,0
SL-381=0,0
SL-481=0,0
SL-581=0,0
SL-BF=0,0,0
SL-GROUP=0,0,0,0,0,0
SL-43=0
SL-143=0
SL-243=0
SL-343=0
SL-101=0
SL-VOA=0
SL-VO1=0
SL-VO2=0
SL-VO3=VO14
SL-VO4=/VO14
SL-VO5=0
SL-VO6=0
SL-VO7=VO14*/TRSTKEY
SL-VO8=VO13*/ARSTKEY
SL-VO9=0
SL-VO10=0
SL-VO11=51PT+51NT+51QT+151NT
SL-VO12=51PPU+51NPU+51QPU+151NPU
SL-VO13=IN3+VO8
SL-VO14=VO11+V07
SL-VO15=0
```

Alarm Latch and Pseudo Target Using the ARSTKEY Logic Variable

On occasion, the user may want the relay to annunciate and latch for a user defined condition originating internal or external to the relay. This is accomplished by using an AND gate to latch the condition through one of the relay's user defined alarms and the ARSTKEY logic variable to reset the latch. Virtual Outputs VO13, VO14, and VO15 can be programmed to alarm for any BESTlogic expression. Also, they can be assigned a user defined label up to a maximum of 10 characters that will be reported in the alarm reporting function and appear on the relay's HMI. In the following example, the user-defined alarm condition is defined as a "pseudo target" for an external trip function. Refer to the Section 6, *Reporting and Alarm Functions.*

Using the same transformer protection application as in the previous example, the user wants to trip and lockout the high side circuit switcher for a Sudden Pressure Relay trip. The user also wants a sealed annunciation on the HMI that reads "SPR_TRIP."

Referring to Figure 8-16, when the external sudden pressure relay trip contact connected to Input 3 closes, VO13 goes high, sealing the inputs of VO3 and VO4 through AND gate VO8. This allows Output Contacts 3 and 4 to transition and remain in that state until the ARSTKEY variable is asserted. The HMI LCD display automatically goes to the *Alarm* screen if VO13 is programmed as a major or minor alarm per the automatic display priority function. In this example, VO13 is programmed to be SN-VO13=SPR_TRIP and will display as such on the HMI when an SPR trip occurs. The trip and alarm (pseudo target) latch will remain until the *Reset* button on the front panel of the relay is pressed while the *Alarm* screen of the HMI, menu branch 1.3, is being displayed (*Reset* key of the HMI is context sensitive). Refer to Section 6, *Reporting and Alarm Functions, Alarms Function*, for details.

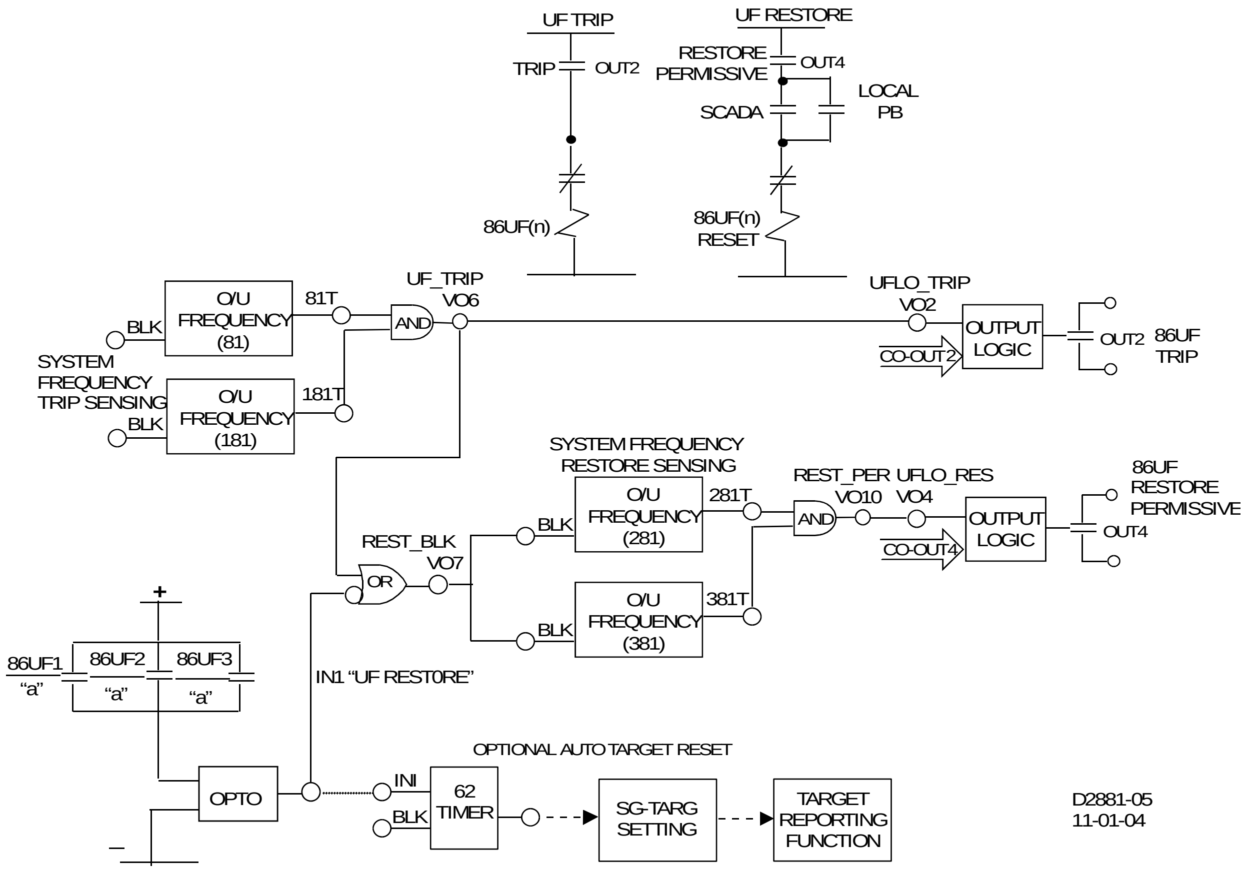

Figure 8-16. Underfrequency Load Shed Bus Level Application

Underfrequency Load Shedding with Restoration Permissive

Under frequency load shedding schemes are designed to operate when the load of a power region outpaces generation and begins to "drag" or slow system frequency. To save the system from total collapse, segregated blocks of load representing a percentage of the total power region load are set to trip at various levels of declining system frequency. For example, an electric utility determines that 30% of its load will have to be shed for a worst-case "load to generation" scenario. They decide to arrange the load in three blocks set to trip at under frequency levels of 59.7 Hz, 59.5 Hz, and 59.3 Hz. Load restoration is normally broken down into smaller blocks minimizing the impact of reapplying load to the system. Knowledge of local conditions or "restoration permissives" are normally included as part of the system restoration process.

Historically, under frequency load shedding schemes have been applied at the bus level. With the introduction of numeric, multifunction feeder protection relays, it has become more economical to apply underfrequency load shedding at the circuit level. Also, reliability increases as the user is no longer depending on a single relay to sense the under frequency condition. If the BE1-IPS100 is not available on every circuit or user philosophy requires a bus level installation, the BE1-IPS100 can also be applied for bus level under frequency protection.

The BE1-IPS100 also has an auxiliary voltage input that can be selected for the under frequency function. This allows the user to supply one under frequency element from a transmission or high side source and another element from a low side or distribution source. Output of the two elements is connected through an AND gate thus requiring both under frequency elements to pickup before providing a trip output. Dual source sensing helps to ensure operation for true system underfrequency events.

The following application tips detail examples of a "bus" and "circuit level" under frequency load shed scheme and restoration "permissive" using dual source sensing and the programming capabilities of the BE1-IPS100. (Single source sensing can also be used.) These schemes are easily customized to meet the user's specific requirements.

Bus Level Application

The following logic was designed to work with the preprogrammed BUS Logic Scheme described elsewhere in this section.

Referring to Figure 8-17, if sensing voltage is above the inhibit setting, and system frequency below the 81 and 181T setting, UF_TRIP, VO6 will go high. This in turn forces VO3 (UFLO_TRP) high, closing Output 3 Contact and tripping the user lockout(s) (86) devices and, in turn, tripping the associated breakers. When the "load condition" that caused the under frequency event has subsided, the system operator/dispatcher will initiate a remote restoration procedure. A "restoration permissive" from the BE1-IPS100 verifies that the following conditions are met prior to restoring load:

- The under frequency trip (81 and 181T) is no longer present.
- The 86UF(s) is/are tripped
- Sensing voltage is above the predetermined inhibit level.
- System Frequency is above the predetermined restore level (281 and 381T).

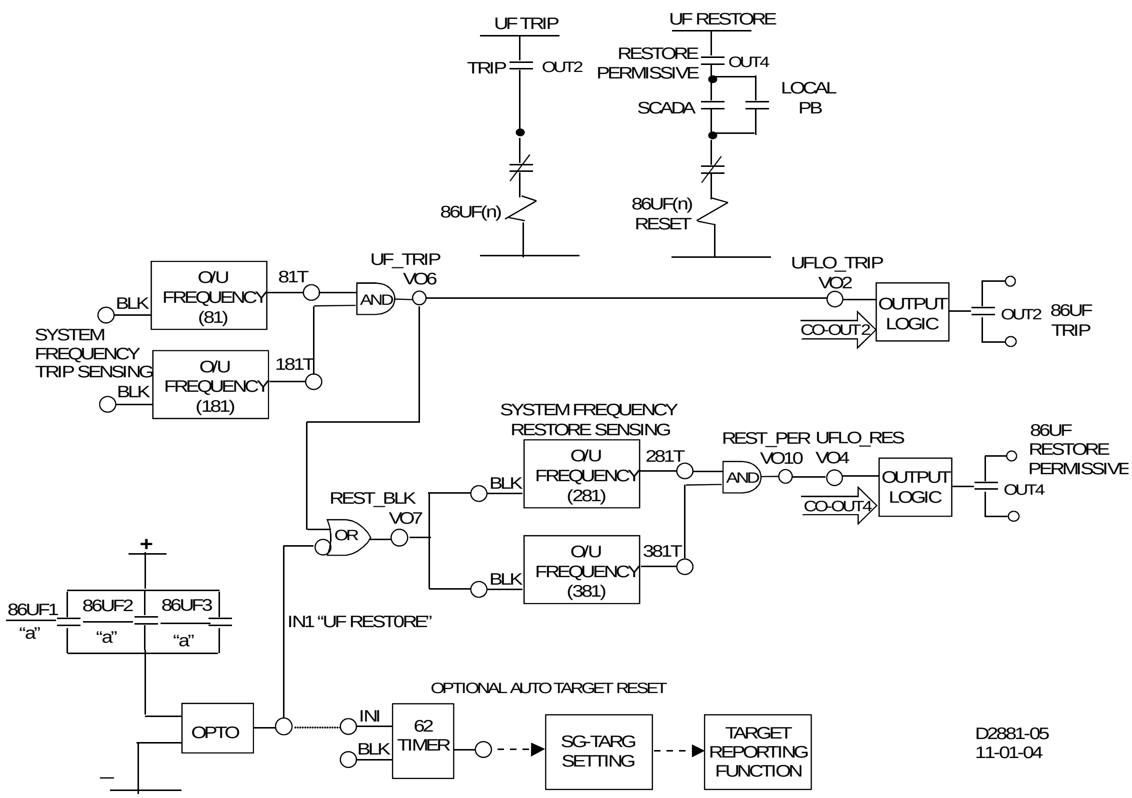

Figure 8-17. Underfrequency Load Shed, Circuit Level Application, Manual or Auto Close from SCADA or Local Restore

The first two conditions must be met to remove REST_BLK from the 281 and 381T overfrequency elements. Then, with sensing voltage above the inhibit setting of 281 and 381T and the system frequency above the 281 and 381T setting, VO10 (REST_PER) will go high forcing VO4, UFLO_RES high, closing Output Contact 4. As long as these conditions remain unchanged the Output Contact 4 will remain closed. When the last 86UF (electrical reset lockout relay) is reset, Input 1, UF_RESTORE will go low, blocking the 281 and 381T elements. Also, VO4 will go low, opening Output Contact 4, removing the 86UF Restore Permissive. The last 86UF to reset can initiate an optional "auto target reset circuit", thus eliminating the need for further operator input. A one-shot, non-retriggerable timer (62) initiated by the last lockout to reset (Input 1), is used to automatically reset the BE1-IPS100 targets and Trip LED via "logic" input to the Target Reset Logic. See Figure 6-14, *Target Reset Logic*, Section 6, *Reporting and Alarm Functions*.

Circuit Level Application - Manual and Auto Reclosing

The following logic was designed to work with the preprogrammed OC-W-79 Logic Scheme.

For the Bus Application, load restoration was accomplished by resetting the lockout relays (86UFs) and allowing the circuit reclosing relays to close the breaker and restore load. Using the Circuit Level Application, restoration can be accomplished by an automatic or manual closure of the breaker. Both methods are described in the following paragraphs.

Referring to Figure 8-17, if sensing voltage is above the inhibit setting of the under frequency elements 81 and 181T and system frequency is below the 81 and 181T setting, VO6, UF_TRIP goes high. This initiates the auto reclose sequence through VO8, RI and forces VO13 (UF_LO) high, closing and sealing the inputs to VO1 and VO3 through AND gate VO14 (LATCH). This allows the contacts of Output 3 and Output 4 to transition and remain in that state, simulating "a" and "b" contacts of an electrical reset lockout relay (86). The VO14 seal also removes the block input from the 281 and 381T overfrequency elements and either drives the 79 element to lockout (manual close) or puts a "wait" on 79 (auto close). The associated breaker will be tripped by Output 1 and the close circuit is disabled by Output 3. When the load condition that initiated the event has subsided, the system operator/dispatcher will initiate a remote restoration procedure. A "restoration permissive" from the BE1-IPS100 verifies that the following conditions are met prior to allowing closure of the breaker:

- Under frequency trip, 81T and 181T are no longer present.
- System frequency and voltage above the predetermined restore level (281 and 381T).
- The breaker is open.
- The VO14 latch circuit is high.

With VO7, PROT_RES high and the above conditions met, closure of the SCADA Restore contact forces VO10, REST_PER high, breaking the VO13/VO14 seal and resetting Output Contacts 1 and 3. If automatic reclosing is used, the "WAIT" input is removed and the reclosing element (79) closes the breaker after a predetermined time delay. If manual reclosing is used, the "DTL/BLK" input is removed and the breaker is ready to close SCADA or local close.

As with the Bus Level Application, an optional "auto target reset circuit" can be initiated, automatically resetting the BE1-IPS100 targets and Trip LED and eliminating the need for further operator input. A one-shot, non-retriggerable timer (62) initiated by VO10, REST_PER, is used to automatically reset the BE1-IPS100 targets and Trip LED via "logic" input to the Target Reset Logic. See Figure 6-14, *Target Reset Logic*, Section 6, *Reporting and Alarm Functions, Fault Reporting*.

Logic Equations and Settings, Underfrequency Load Shedding

Bus UF Load Shed

The following is an example of how to apply UF Load Shed logic at the Bus level. The logic can be applied in any number of ways including stand alone, to other preprogrammed schemes or completely customized by the user. Using BESTCOMS to modify and add to the logic is not only quick and easy but minimizes Input/Output "name" and "state" label changes. In this example, start with a renamed version of the BESTCOMS BUS logic scheme modified as follows:

SL-101=0
SL-V01=VO11*SG0
SN-IN1=UF-RESTORE,CLOSE,OPEN

Add the following UF logic to the modified BUS Logic Scheme:

SL-62=2, /IN1,0 (optional target reset)

SL-081=1,O
SL-181=1,O
SL-281=1,VO7
SL-381=1,VO7
SL-VO2=VO6
SL-VO4=VO10
SL-VO6=81T*181T
SL-VO7=VO6+/IN1
SL-VO10=281T*381T

Add +81T+181T to BUS SG-TRIG. Replace the ,0 with ,62 at the end of BUS SG-TARG.

The resulting BUS-UF setting logic is as follows:

SL-50TP=1,IN2; SL-50TN=1,IN2; SL-50TQ=1,IN2
SL-150TP=0,0; SL-150TN=0,0; SL-150TQ=0,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
SL-151N=0,0
SL-27P=0,0
SL-59P=0,0; SL-59X=0,0
SL-47=0,0
SL-62=2,/IN1,0
SL-162=0,0,0
SL-79=0,0,0,0,0
SL-81=1,0
SL-181=1,0
SL-281=1,VO7
SL-381=1,VO7
SL-481=0,0
SL-581=0,0
SL-BF=0,0,0
SL-GROUP=2,IN3,0,0,0,0
SL-43=0
SL-143=0
SL-243=0
SL-343=2
SL-101=0
SL-VOA=0
SL-VO1=VO11*SG0
SL-VO2=VO6
SL-VO3=VO8*/VO15*SG0
SL-VO4=VO10
SL-VO5=VO11*SG1
SL-VO6=81T*181T
SL-VO7=VO6+/IN1
SL-VO8=51PT+51NT+51QT
SL-VO9=50TPT+50TNT+50TQT
SL-VO10=281T*381T
SL-VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT
SL-VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU
SL-VO13=SG1
SL-VO14=0
SL-VO15=343+/IN4

Circuit UF Load Shed

The following is an example of how to apply UF Load Shed logic at the circuit or feeder level. The logic can be applied in any number of ways including stand alone, to other preprogrammed schemes, or completely customized by the user. Using BESTCOMS to modify and add to the logic is, not only quick and easy but minimizes Input/Output "name" and "state" label changes. In this example, start with a renamed version of the BESTCOMS 0C-W-79 logic scheme modified as follows:

SN-IN1=L_OR_S_RES,CLOSE,OPEN (Local or SCADA Restore)

Add the following Circuit UF logic to the modified OC-W-79 Logic Scheme:

SL-62=2,VO10,0 (optional target reset)
SL-79=1,VO8,/IN1,VO14,0
SL-081=1,O
SL-181=1,O
SL-281=1,VO14
SL-381=1,VO14
SL-VO1=VO13
SL-VO2=79C
SL-VO3=/VO13
SL-VO6=81T*181T
SL-VO7=281T*381T
SL-VO8=VO6
SL-VO10=/VO6*IN1*IN3*VO7
SL-VO13=VO6+VO14
SL-VO14=/VO10*VO13

Add +81T+181T to BUS SG-TRIG. Replace the ,0 with ,62 at the end of BUS SG-TARG.
The resulting OC-UF-79 setting logic is as follows:

SL-50TP=1,79SCB; SL-50TN=1,79SCB+/IN4; SL-50TQ=1,79SCB+/IN4
SL-150TP=1,0; SL-150TN=1,0; SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,/IN4
SL-51Q=1,/IN4
SL-151N=0,0
SL-27P=0,0
SL-59P=0,0; SL-59X=0,0
SL-47=0,0
SL-62=2,VO10,0
SL-162=0,0,0
SL-79=1,VO8,/IN1,VO12+VO14,150TPT+150TNT+150TQT+/IN2
SL-81=1,0
SL-181=1,0
SL-281=1,/VO14
SL-381=1,/VO14
SL-481=0,0
SL-581=0,0
SL-BF=0,0,0
SL-GROUP=1,0,0,0,0,/0
SL-43=0
SL-143=0
SL-243=0
SL-343=0
SL-101=0
SL-VOA=0
SL-VO1=VO11+VO13
SL-VO2=79C
SL-VO3=/VO13
SL-VO4=ALMMIN
SL-VO5=ALMMAJ
SL-VO6=81T*181T
SL-VO7=281T*381T
SL-VO8=VO6+VO11
SL-VO9=150TPT+150TNT+150TQT+/IN2

SL-VO10=/VO6*VO7*IN1*IN3
SL-VO11=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+51NT+51QT
SL-VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+51NPU+51QPU
SL-VO13=VO6+VO14
SL-VO14=/VO10*VO13
SL-VO15=0

Close Circuit Monitor

While a close circuit monitor is not included in any of the preprogrammed logic schemes, this function may be added by using a 62 function block and a contact sensing input (INX) to monitor the close circuit. The logic for the close circuit monitor is shown in Figure 8-18. The output of the 62 protection block will close the designated output contact (VOY) when an open breaker and open close circuit condition exists. The S<g>-62 command is used to provide a 500-millisecond time delay to inhibit the momentary alarm that will occur due to the timing differences between the two signals.

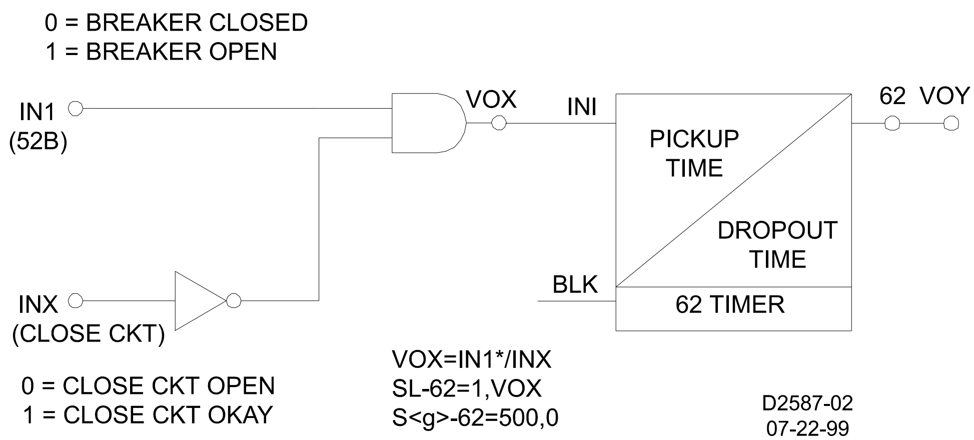

Figure 8-18. Close Circuit Monitor Logic

High-Speed Reclose

Each reclose time delay can be set as low as 100 milliseconds. If the application requires a reclose time delay of less than 250 milliseconds, it is recommended that the close logic expression be modified to prevent mis-coordination between the TRIP and CLOSE outputs.

A hold timer for each output relay is provided to hold the output closed for approximately 200 milliseconds. This prevents the relay contacts from opening before the breaker auxiliary contact interrupts the trip coil current. For high-speed reclosing, the hold timer must be disabled so that the output contact follows the VO1 output expression. To modify the logic, add the expression "reclose 79C AND NOT trip VO1" to the close logic. Examples 1 and 2 show a close expression and hold disable setting for high-speed reclosing. Figure 8-19 illustrates this high-speed reclose interlock logic scheme.

Example 1.
Close Expression: SL-VO2=79C*/VO1+101C

Example 2.
Hold Disable Setting: SG-HOLD1=0

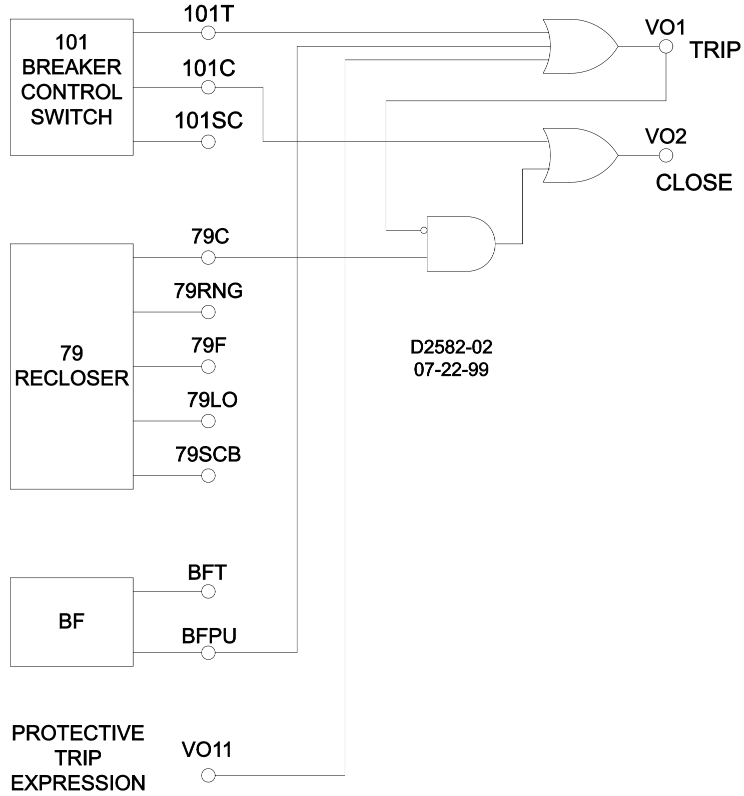

Figure 8-19. High-Speed Reclose Interlock Logic

Block Load Tap Changer

A block load tap changer output is not provided in any of the preprogrammed logic schemes. However, one of the output relays can be programmed to operate when the recloser is running (79RNG) and wired to energize a normally closed auxiliary relay. The 79RNG logic variable is high when any of the timers are timing and low when the reclosing function is in a lockout or reset state.

Block Neutral and Negative-Sequence Protection

The neutral and negative-sequence overcurrent elements provide greater sensitivity to unbalanced faults than the phase overcurrent elements because they can be set to pickup below balanced three-phase load. This can lead to a mis-operation during periods of load imbalance. The BE1-IPS100 provides a neutral and negative-sequence demand function that allows monitoring and alarming to prevent load imbalances. However, distribution systems with single-pole fault clearing and switching devices, or long single-phase laterals may have mis-operations during switching activities.

Preprogrammed logic scheme OC-W-79, OC-W-CTL, and FDR-W-IL accommodate the use of a cutoff switch to block the ground and negative-sequence 50T (used for low-set instantaneous) and the 51 (inverse time) function blocks during switching activities. This is the most conservative approach. You may wish to evaluate this strategy based on your system, operating practices and setting practices. For instance, on systems with wye-connected loads, the ground units are most sensitive to this situation. On systems with delta-connected loads, the negative-sequence units are most sensitive to this situation. It may not be necessary to block the instantaneous units if their settings prevent them from tripping for a switching imbalance.

To maintain proper coordination, the logic of the feeder relays (using FDR-W-IL logic) may be interconnected with the upstream bus relay to block the equivalent ground and/or negative-sequence function blocks in the upstream relay.

Setting Group Selection

The BE1-IPS100 Intertie Protection System provides multiple settings groups for adaptive relaying. The preprogrammed logic schemes barely tap the flexibility that is available. The following two examples illustrate how the settings groups can be adapted for different conditions and how different setting groups can be used to vary the system logic.

Example 1. Adapting the relay settings for different conditions:

In overcurrent protection systems, the source conditions can have a major impact on sensitivity, coordination intervals, and clearing times. Generally, the pickup and time dial settings are a compromise between a normal condition and a worst-case condition. Contact logic from the position of the source breakers can select which settings group is active. To achieve this, assign input D0 or D1 to a contact sensing input. Select binary coded setting group selection (Mode 2). If D0 is set, Group 0 will be selected when the input is off (binary code 00). Group 1 will be selected when the input is on (binary code 01). Similarly, if D1 is set, Group 2 will be selected when the input is on (binary coded 10).

This logic is useful in a situation where two transformers feed a single bus or two busses have a bus tie between them. The feeder and bus relays must be coordinated so that only one source is in service (bus tie open or one transformer out of service). However, when both sources are in service, such as when the bus tie is closed, each bus relay sees only half of the current for a fault. This results in poor sensitivity and slow clearing time for the bus relays.

Example 2. Adapting the logic in different setting groups:

The logic in most of the preprogrammed logic schemes can be varied in each of the different setting groups. This is accomplished by disabling functions by setting their primary settings at zero. It's also possible to perform more sophisticated modification of the logic in each of the different setting groups by using the active setting group logic variables SG0, SG1, SG2, and SG3 in the BESTlogic expressions.

Output Contact Seal-In

Trip contact seal-in circuits have historically been provided with electromechanical relays. These seal-in circuits consist of a dc coil in series with the relay trip contact and a seal-in contact in parallel with the trip contact. The seal-in feature serves several purposes for electromechanical relays:

1. It provides the mechanical energy to drop the target.
2. It carries the dc tripping current from the induction disk contact, which may not have significant closing torque for a low resistance connection.
3. It prevents the relay contact from dropping out until the current has been interrupted by the 52a contacts in series with trip coil.

The first two items aren't an issue for solid-state relays. But item three is significant.

To prevent the output relay contacts from opening prematurely, a 200 millisecond hold timer can be selected with the SG-HOLDn=1 command. Refer to Section 3, *Input and Output Functions, Outputs*, for more information about this feature. If desired, seal-in logic with feedback from the breaker position logic can be obtained by modifying the BESTlogic expression for the tripping output. To do this, set one of the general-purpose timers (62 or 162) for Mode 1 (Pickup/Dropout Timer). Set the timer logic so that it is initiated by the breaker position input, and set the timer for two cycles pickup and two cycles dropout. Then AND the timer output with the tripping output and OR it into the expression for the tripping output. The same can be done for the closing output. Figure 8-20 illustrates the seal-in logic diagram.

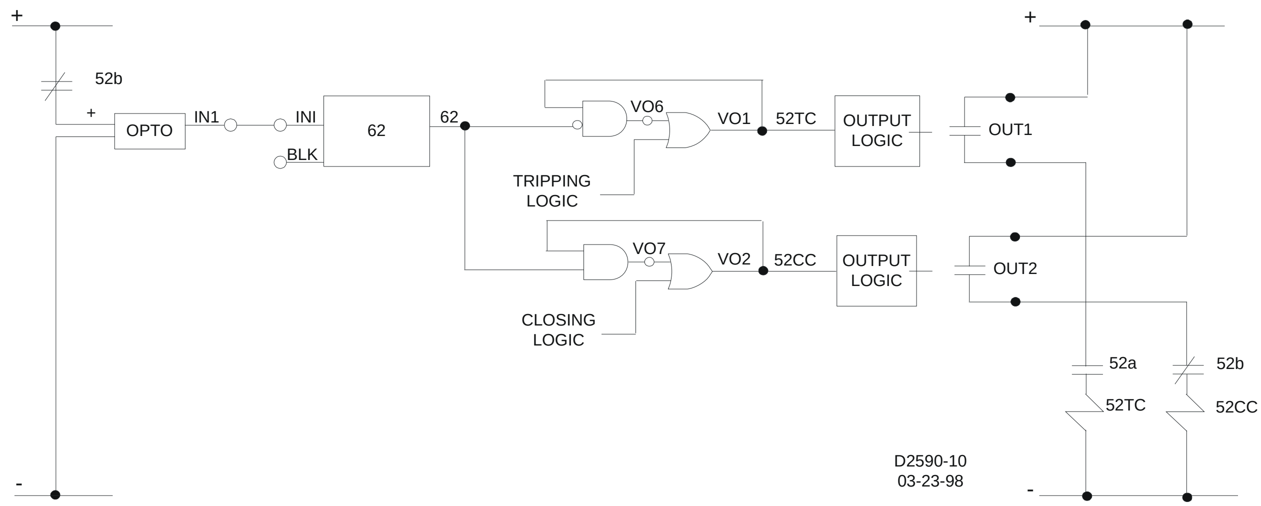

Figure 8-20. Output Seal-In Logic Diagram

> **NOTE**
> The following example is based on the FDR-W-IL Logic Scheme.

Example 1.

Turn off the hold timer for Output 1:	SG-HOLD1=0 SG-HOLD2=0
Set the timer logic:	SL-62=1,IN1,1,0
Set the pickup and dropout times:	S#-62=2c,2c
Set the output logic:	VO1=101T+BFPU+VO11+VO6 VO2=101C+79C+VO7 VO6=VO1*/162 VO7=VO2*62

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SECTION 9 • SECURITY

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SECTION 9 • SECURITY

INTRODUCTION

In this section, security, in the form of multilevel password protection, is discussed along with the information required for protecting specific function groups and user interface components against unauthorized access.

Passwords provide access security for three distinct functional access areas: Settings, Reports, and Control. Each functional area can be assigned a unique password or one password can be assigned to multiple areas. A global password is used to access all three of the functional areas. BE1-IPS100 passwords are not case sensitive; either lowercase or uppercase letters may be entered. Password security only limits write operations; passwords are never required to read information from any area.

Additional security is provided by controlling the functional areas that can be accessed from a particular communication port. For example, security can be configured so that access to Control commands from the optional rear Ethernet or RS-232 port (COM 1) is denied. Then, an attempt to issue a Control command through COM 1 will cause the relay to respond with an ACCESS DENIED and/or INVALID PASSWORD message. This will occur whether a valid password is entered or not. When configuring communication port access areas, you should be aware that the front RS-232 port (COM 0) and the front panel HMI are treated as the same port.

The communication ports and password parameters act as a two-dimensional control to limit changes. For a command to be accepted, the entered password must be correct and the command must be entered through a valid port. Only one password can be active at one time for any area or port. For example, if a user gains write access at the rear optional Ethernet or RS-232 port, then users at other areas (COM0, front panel HMI, and COM2) will not be able to gain write access until the user at the optional rear Ethernet or RS-232 port uses the EXIT command to release access control.

If a port holding access privileges sees no activity (command entered or HMI key pressed) for approximately five minutes, access privileges and any pending changes will be lost. This feature ensures that password protection cannot be accidentally left in a state where access privileges are enabled for one area and other areas locked out for an indefinite period.

If password protection is disabled, then entering **ACCESS=** followed by no password or any alphanumeric character string will obtain access to the unprotected area(s).

NOTE

For security reasons, all change passwords are disabled by default on the optional Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port.

Setting Password Protection

Password protection is configured for each access area port and communication port using BESTCOMS. Alternately, password protection can be configured using the GS-PW ASCII command.

To configure password protection using BESTCOMS, select *General Operation* from the *Screens* pull-down menu. Then select the *Global Security* tab. Refer to Figure 9-1.

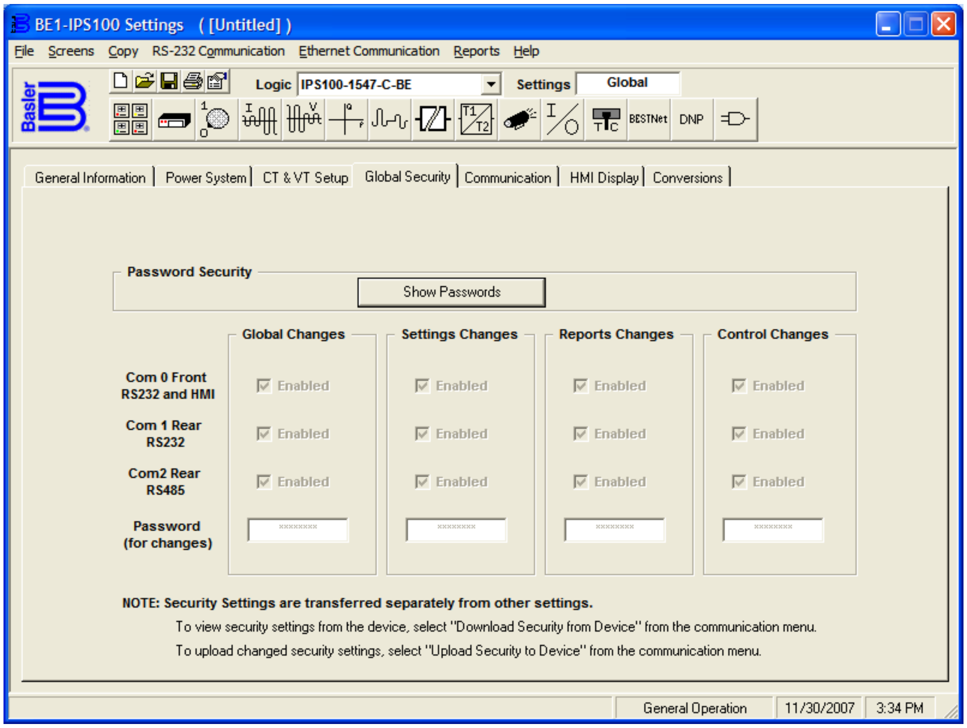

Figure 9-1. General Operation Screen, Global Security Tab

If a change is required and the *Password Security* box reads *Show Passwords*, press *Show Passwords*. Passwords may be entered in the text boxes for Global Access, Settings Access, Reports Access, and Control Access. See Figure 9-2. Each access level may be enabled (or not enabled) for COM 0 front RS-232 and HMI, optional rear Ethernet or RS-232 port (COM 1), and COM 2 rear RS-485. Access levels may also be enabled for multiple ports.

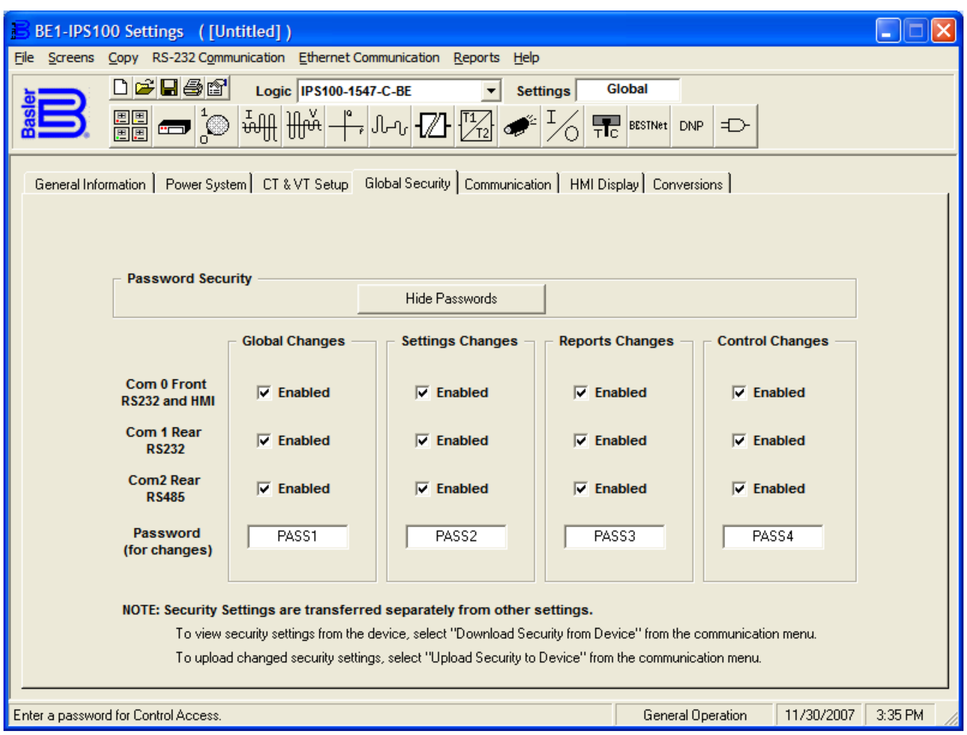

Figure 9-2. General Operation Screen, Global Security Tab with Passwords Shown

Table 9-1 lists password protection settings.

Table 9-1. Password Protection Settings

Setting	Range/Purpose
Password	User defined alphanumeric string with a maximum of 8 characters. A setting of 0 (zero) disables password protection.
Com ports	0 = Front RS-232 port 1 = Rear Ethernet or RS-232 port (optional) 2 = Rear RS-485 port

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SECTION 10 • HUMAN-MACHINE INTERFACE

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SECTION 10 • HUMAN-MACHINE INTERFACE

INTRODUCTION

This section describes the BE1-IPS100 Intertie Protection System human-machine interface (HMI) and illustrates the front panel display menu tree branches.

FRONT PANEL DISPLAY

Figure 10-1 shows the HMI components of a BE1-IPS100 in a “H1 (half-rack)” case. The locators and descriptions of Table 10-1 correspond to the locators shown in figure 10-1.

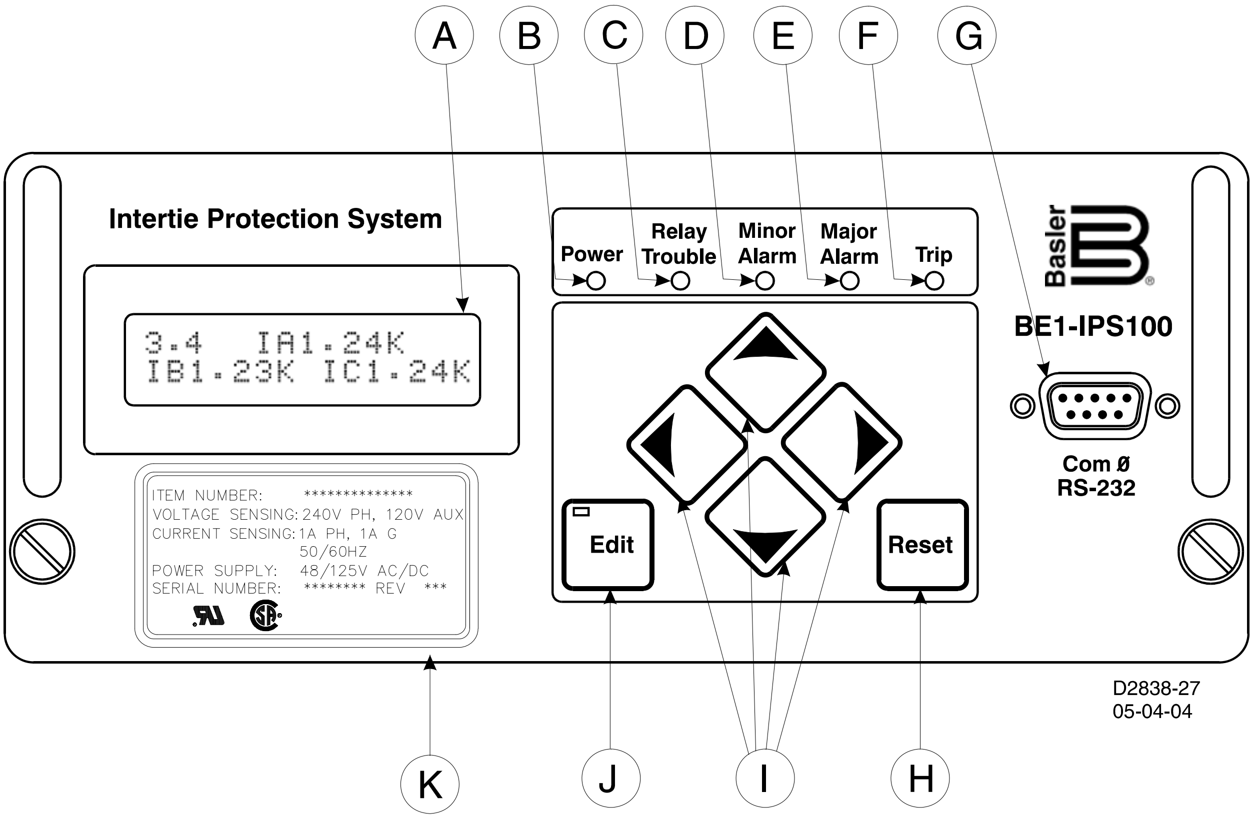

Figure 10-1. Front Panel

Table 10-1. Front Panel HMI Descriptions

Locator	Description
A	*Display* – Two line by 16-character liquid crystal display (LCD) with backlighting. The LCD is the primary source for obtaining information from the relay or when locally setting the relay. Information such as targets, metering values, demand values, communication parameters, the active logic scheme name, and diagnostic information is provided by the LCD. Information and settings are displayed in a menu with six branches. The *Menu Tree* subsection provides more information about the menu branches.
B	*Power Indicator* – This green LED lights when operating power is applied to the relay.
C	*Relay Trouble Indicator* – This red LED lights momentarily during start-up and lights continuously when a relay failure is detected. Section 6, *Reporting and Alarm Functions*, provides a complete description of all relay failure alarm diagnostics.

Locator	Description
D, E	*Minor Alarm, Major Alarm Indicators* – These red LEDs light to indicate that a programmable alarm has been set. Each indicator can be programmed to annunciate one or more conditions. Section 6, *Reporting and Alarm Functions*, provides detailed information about programming alarms.
F	*Trip Indicator* – A flashing Trip LED indicates that a protective element is picked up. A continuously lit LED indicates that a trip output is closed. This red LED is sealed in if a protective trip has occurred and targets are displayed.
G	*Communication Port 0* – This RS-232 serial port can be used to communicate with the relay using simple ASCII command language. A computer terminal or PC running terminal emulation software (such as Windows® HyperTerminal) is required to send commands to the relay or receive information from the relay.
H	*Reset Pushbutton* – Pushing this switch will reset the Trip LED, sealed-in Trip Targets, Peak Demand Currents, and Alarms.
I	*Scrolling Pushbuttons* – Use these four switches to navigate *(UP/DOWN/LEFT/RIGHT)* through the LCD's menu tree. When in Edit mode, the *LEFT* and *RIGHT* scrolling pushbuttons select the variable to be changed. The *UP* and *DOWN* scrolling pushbuttons change the variable.
J	*Edit Pushbutton* – Settings changes can be made at the front panel using this switch. When pushed, this switch lights to indicate that Edit mode is active. When you are finished making settings changes (using the scrolling pushbuttons) and the *Edit* switch is pressed again, the switch light turns off to indicate that your settings changes have been saved. If changes aren't completed and saved within five minutes, the relay will automatically exit the Edit mode without saving any changes.
K	*Identification Label* – This label lists the style number, serial number, sensing input current and voltage range and power supply input voltages.

Menu Tree

A menu tree with six branches can be accessed through the front panel controls and display. The *LEFT* and *RIGHT* scrolling pushbuttons are used to view each of the six branches. A greater level of detail in a menu branch is accessed using the *DOWN* scrolling pushbutton. Every display screen of the menu tree is numbered in the upper left hand corner. This number eases navigation below the top level of the menu tree by indicating the current branch and level in the menu tree structure. Each time a lower menu tree level is reached, another number is added to the screen number separated by a period. The *UP* scrolling pushbutton is used to return to the top of the menu branch.

The six branches of the menu tree are illustrated in Figure 10-2 and summarized in the following paragraphs.

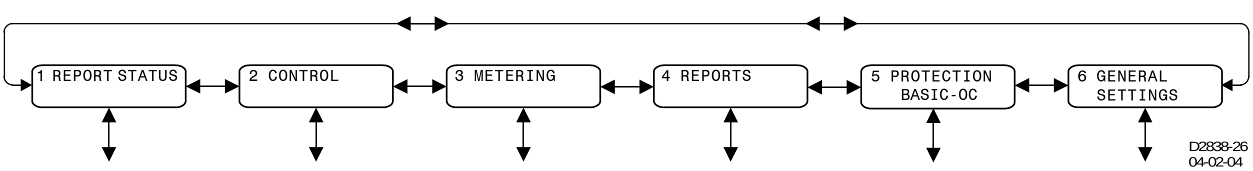

Figure 10-2. Menu Tree Branches

1. REPORT STATUS – Provides display and resetting of general status information such as targets, alarms, and recloser status. Figure 10-3 illustrates the structure of the Report Status menu branch.
2. CONTROL – Accesses control function operation of virtual switches, active setting group selection, and others. Control menu branch structure is illustrated in Figure 10-4.
3. METERING – Displays real time metering values. Figure 10-5 illustrates the structure of the Metering menu branch.
4. REPORTS – Provides display and resetting of report information such as time and date, demand registers, and breaker duty statistics. Reports menu branch structure is illustrated in Figures 10-6 and 10-7.
5. PROTECTION LOGIC – Provides display and setting of protective functions such as pickups and time delays. Figure 10-8 illustrates the structure of the Protection Logic menu branch.
6. GENERAL SETTINGS – Provides display and setting of relay configuration settings such as communication, LCD contrast, transformer ratios, and system frequency. General Settings menu branch structure is illustrated in Figure 10-9.

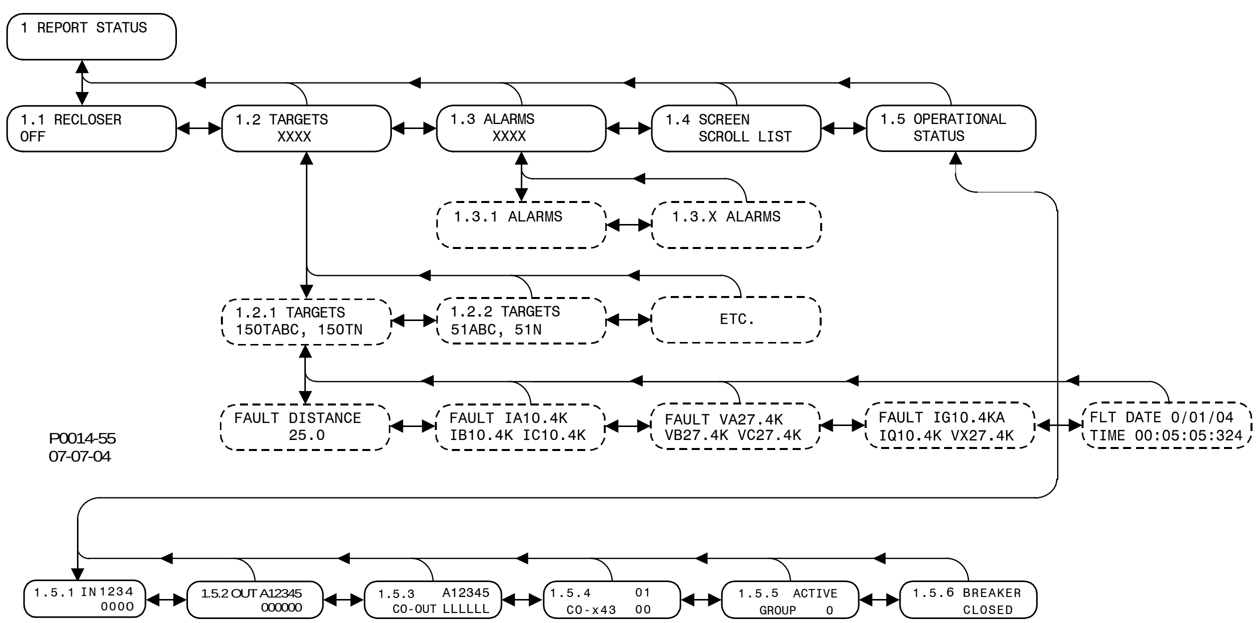

Figure 10-3. Report Status Menu Branch

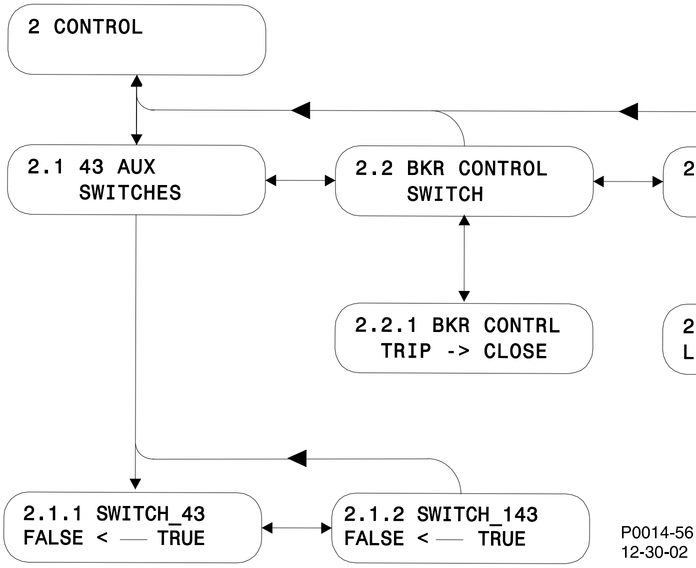

Figure 10-4. Control Menu Branch Structure

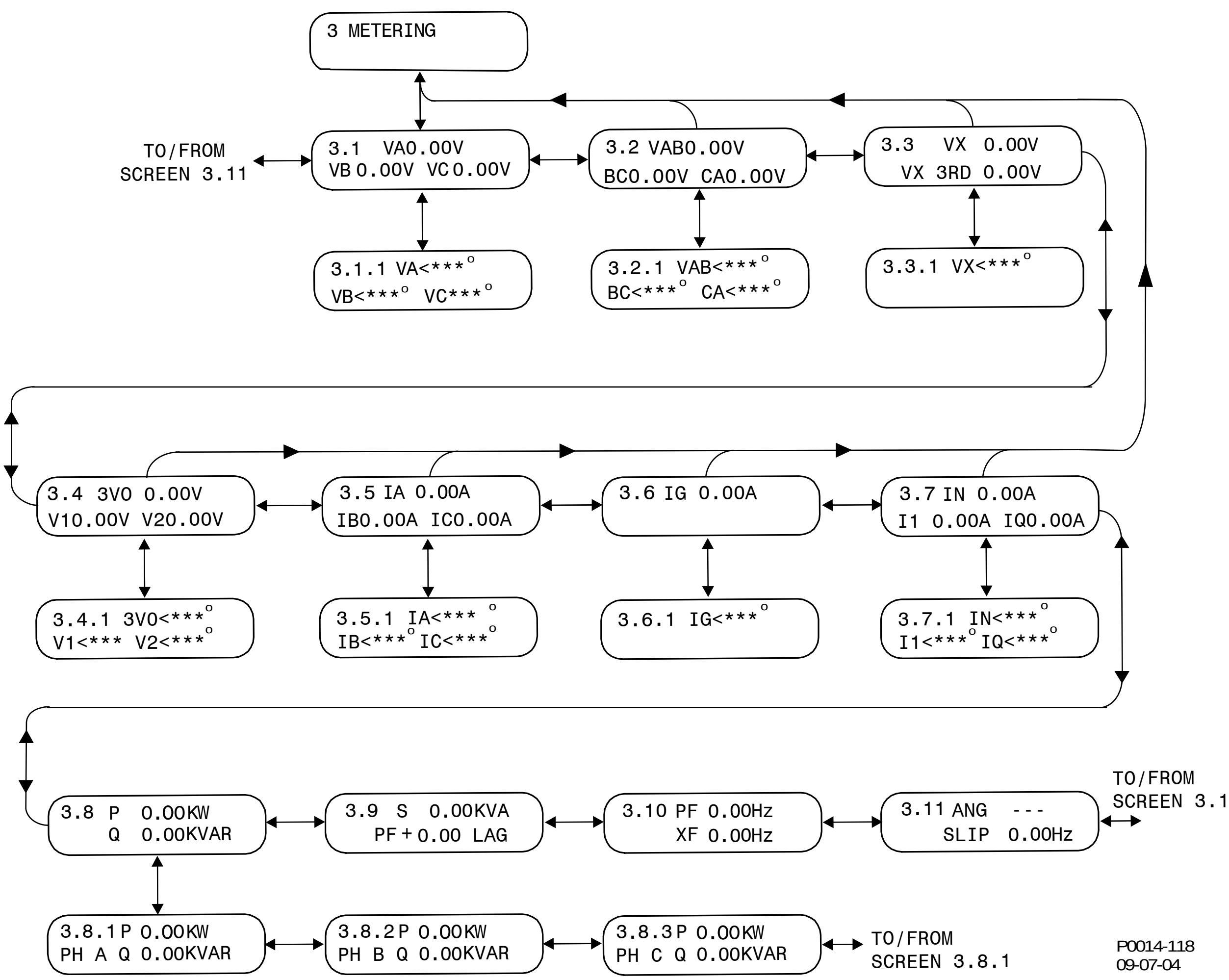

Figure 10-5. Metering Menu Branch Structure

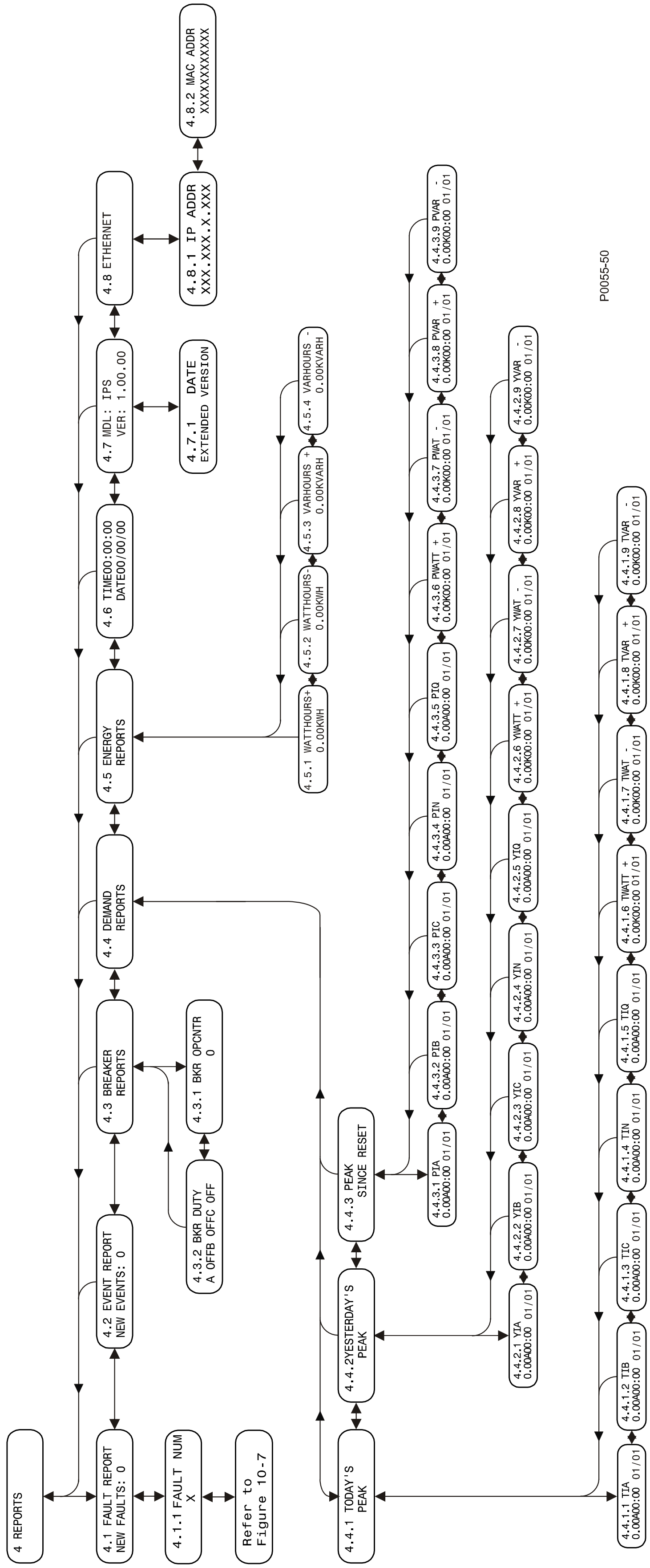

Figure 10-6. Reports Menu Branch Structure

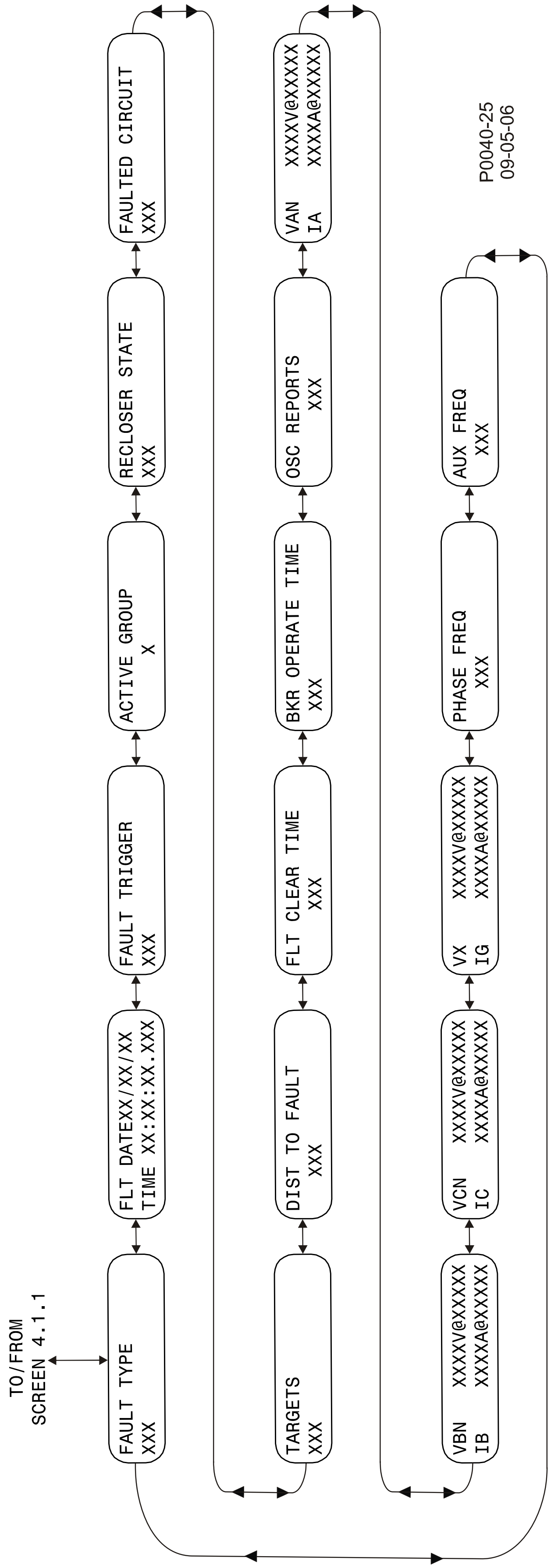

Figure 10-7. Reports Menu Branch Structure - Continued

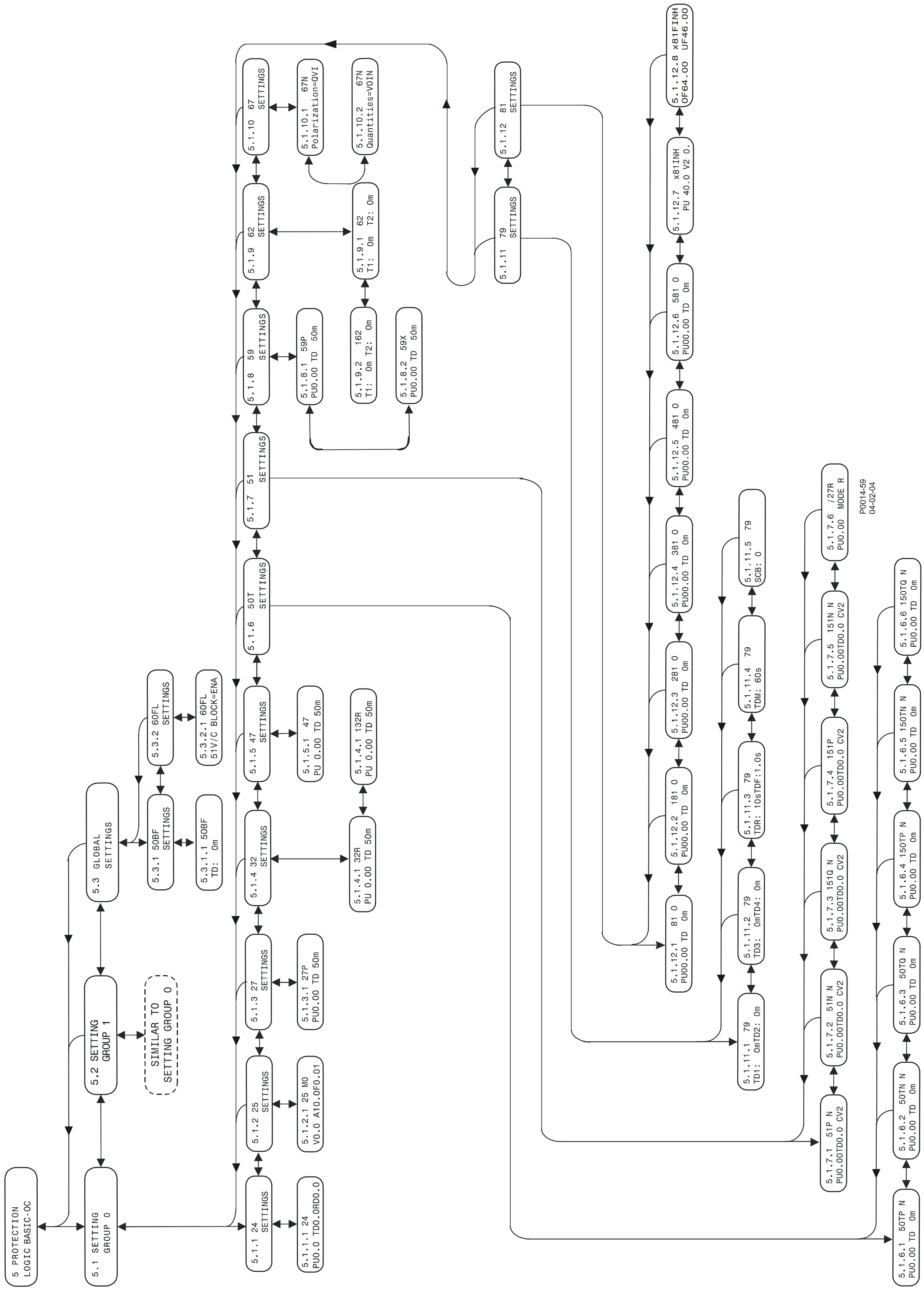

Figure 10-8. Protection Menu Branch Structure

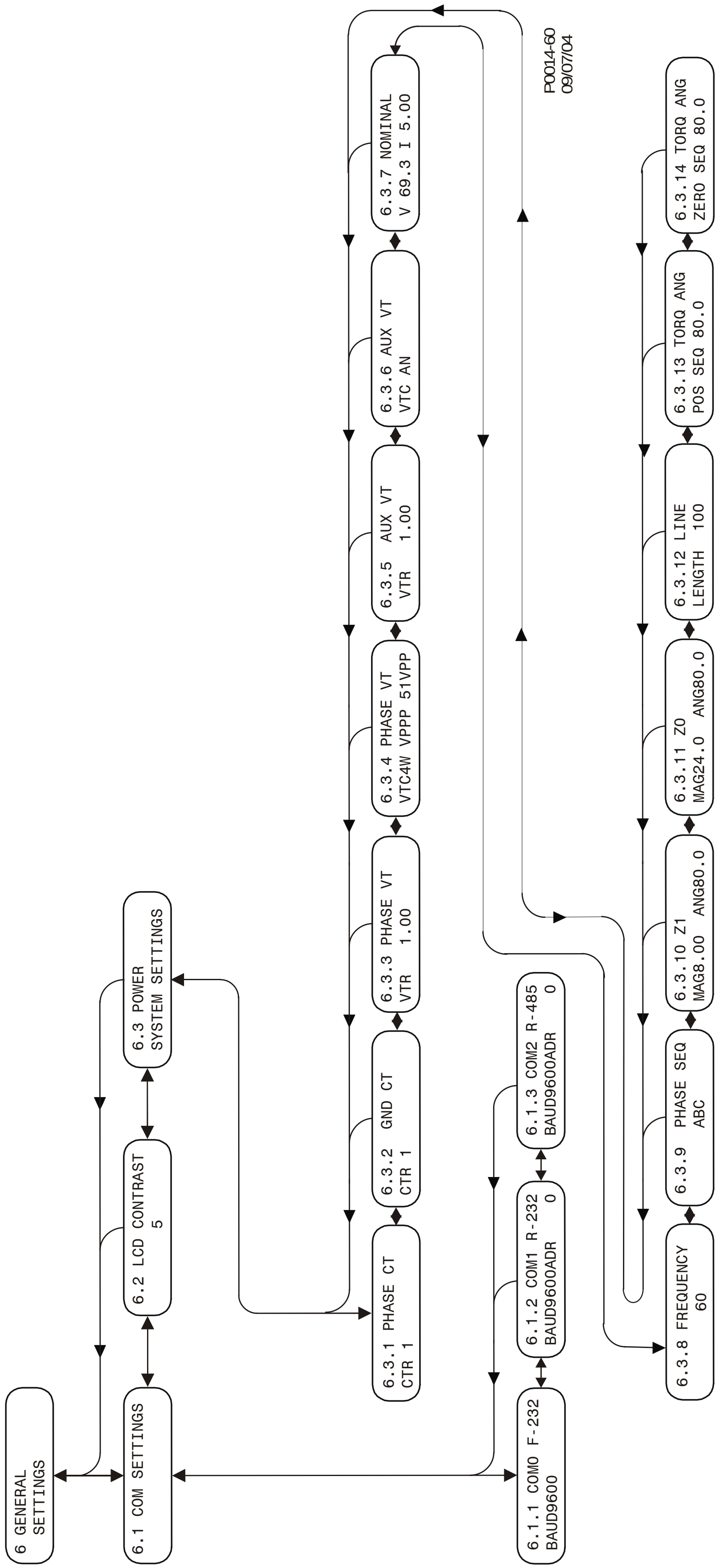

Figure 10-9. General Settings Menu Branch Structure

Automatic HMI Display Priorities

The *REPORT STATUS* screen (Menu Branch 1) provides fast and easy access to the most often used report and status data. Screens available under this menu heading report RECLOSER status, TARGET status, ALARM status, and OPERATIONAL status of inputs, outputs, controls, active setting group, and breaker state. In addition, up to 16 screens from anywhere in the menu system can be selected to be displayed in a screen scroll list.

If no front panel controls are operated for approximately five minutes, the relay automatically displays the highest priority *REPORT STATUS* screen. This keeps frequently viewed data on the displayed screen or at most, only a couple of keystrokes away. Automatic screen display follows the priority logic described in Table 10-2.

Table 10-2. Automatic Screen Display Priority

Priority	Priority Logic State	Screen	Displayed Data
1	Recloser (79) active	1.1	Recloser Status.
2	Targets active	1.2.x	Scrolling display of Target Elements and Fault Currents.
3	Alarms active	1.3.x	Scrolling display of Active Alarms.
4	Scrolling Screens active	1.4.x	Scrolling display of User Screens programmed with the SG-SCREEN command.
5	Scrolling Screens disabled	1.2	Default Target screen showing 'TARGETS NONE'.

If the recloser is inactive and no targets or alarms exist, the relay will scroll automatically through a maximum of 16 user programmable screens.

<u>*Setting the Screen Scroll List*</u>

To edit the automatic scrolling list using BESTCOMS, select *General Operation* from the *Screens* pull-down menu. Then select the *HMI Display* tab. Refer to Figure 10-10. The screen numbers listed exhibit the default scrolling list. The list of numbers on the right represents the screen numbers and the order in which they will be displayed when automatic scrolling begins. The number closest to the top will be displayed first. The four buttons on the screen can be used to add or remove screens from the list. They can also be used to change a selected screens position in the list.

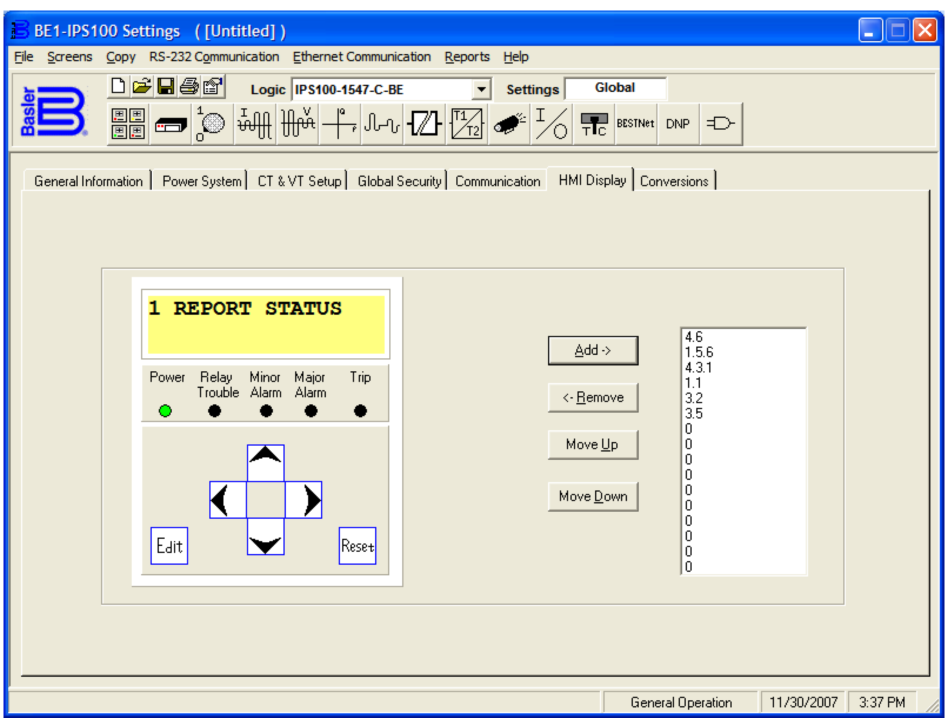

Figure 10-10. General Operation Screen, HMI Display Tab

To add a screen to the list, select the screen on the HMI simulation by clicking the mouse pointer on the arrows. Select the *Add->* button to add the screen to the list.

Alternately, these settings may be made using the SG-SCREEN ASCII command.

HMI OPERATIONS

The following paragraphs describe how the HMI is used to set and control relay functions.

Entering Settings

Settings for protection functions can be edited at menu branch 5, *PROTECTION LOGIC* of the HMI LCD. Settings for general and reporting functions can be edited from menu branch 6, *GENERAL SETTINGS*. To edit a setting using the manual scrolling pushbuttons, perform the following procedures:

1. Scroll to the screen that displays the function to be edited.
2. Press the *Edit* pushbutton to gain access. If password security has been initiated for settings, you will be prompted to enter the appropriate password. See the paragraphs, *Entering Passwords*, for details on entering passwords from the HMI. Once access has been gained, the EDIT LED will be lit and a cursor will appear in the first settings field on the screen.
3. Press the *UP* or *DOWN* scrolling key to select the desired setting. Some settings require entering a number, one character at a time. For example, to enter a 51 pickup as 7.3 amps, you would press the *UP* pushbutton until the 7 is showing. Then, press the *RIGHT* pushbutton to move the cursor over and press the *UP* pushbutton until the "." is showing. Then, press the *RIGHT* pushbutton to move the cursor over and press the *UP* pushbutton until the 3 is showing. Other settings require scrolling through a list of selections. For example, you would move the cursor over to the CRV field and then scroll through a list of available TCC curves.
4. Once all of the settings on the screen have been entered, press the *Edit* pushbutton a second time and the settings will be validated. If the settings are in range, the screen will flash **CHANGES SAVED** and the EDIT LED will go out. If you want to abort the edit session without changing any settings, press the *Reset* pushbutton before you press the *Edit* pushbutton the second time. The screen will flash **CHANGES LOST** and the EDIT LED will go out.

Performing Control Operations

Control operations can be executed at Menu Branch 2, *CONTROL* of the HMI LCD. These functions allow you to control the state of virtual switches, override logic and control the active setting group, and override the logic and control the state of output contacts. All of these functions work similarly to the process of entering settings in that you press the *Edit* pushbutton, use the *UP* and *DOWN* scroll pushbuttons to select the desired state and press the *Edit* pushbutton for the action to be executed.

Table 10-3 describes each of the call-outs shown on Figure 10-11. The user-programmable label for this switch is SWITCH_143. The TRUE (closed) state label has been set to TRUE. And, the FALSE (open) state label has been set to FALSE. The logical mode for this application would be set to Mode 2 (On/Off switch).

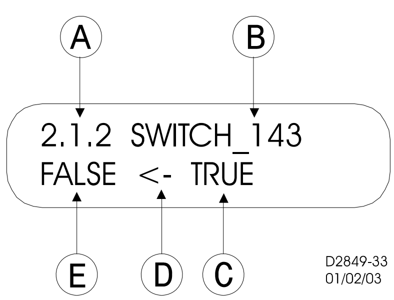

Figure 10-11. Virtual Control Switch 143 Screen

Table 10-3. Virtual Control Switches HMI Screen Indicators

Locator	Description
A	This is the screen number. It eases navigation by indicating the current branch and level in the menu tree structure.
B	User selectable label (meaningful name) for specific virtual switches. The switch label is set to 'SWITCH_143'.
C	User selectable label for the closed (1) state for Virtual Switch 143. The 'Switch 143' closed label is set to 'TRUE'.
D	An arrow icon indicates the current switch position (status). In Figure 10-11, the status is open (0), which is labeled 'FALSE'.
E	User selectable label for the open (0) state for Virtual Switch 143. The 'Switch 143' open label is set to 'FALSE'.

To operate the switch, you would use the following procedure:

1. Using the manual scrolling pushbuttons, scroll to Screen 2.1.2 (SWITCH_143). Or, if the screen has been placed in the automatic scroll list, simply wait for it to appear and press the *RIGHT* or *LEFT* scroll pushbutton to freeze the display.
2. Press the *Edit* pushbutton to gain access. If password security has been initiated for control functions, you will be prompted to enter the appropriate password. See the following sub-section *Entering Passwords*, for details on entering passwords at the HMI. Once access is gained to the control function, the EDIT LED will light and a cursor will appear in the action field.
3. Press the *UP* or *DOWN* scrolling key to select the desired action. The selections available depend on the logic mode setting for that switch. If it is set to Mode 1, the action choices are pulse or one of the two positions as defined by the user programmable state labels. If Mode 2 (ON/OFF switch) is selected, the choices for action are limited to one of the two positions. If Mode 3 (OFF/Momentary ON switch) is selected, the choice for action is limited to pulse.
4. Press the *Edit* pushbutton a second time and the switch will change to the selected position, the screen will flash **CHANGES SAVED** and the EDIT LED will go out. If you want to abort the editing session without changing any controls, press the *Reset* pushbutton before you press the *Edit* pushbutton the second time. The screen will flash **CHANGES LOST** and the EDIT LED will go out.

Resetting Functions

The *Reset* pushbutton is context sensitive. Its function is dependent upon the screen that is presently being displayed. For example, pressing the *Reset* key when the demand screen is displayed will reset the demands but will not reset the alarms. It is necessary to scroll through the menu tree to the *Alarm* screen to reset an alarm. You are not prompted for a password when using the *Reset* key.

There are two BESTlogic variables associated with the HMI *Reset* pushbutton. Logic variable TRSTKEY becomes TRUE when the *Reset* pushbutton is pressed while the *Target* screen is displayed. Logic variable ARSTKEY becomes TRUE when the *Reset* pushbutton is pressed while the *Alarm* screen is displayed. See Section 8, *Application, Application Tips*, for examples on the use of these variables.

Entering Passwords

If password security has been initiated for a function, the HMI will prompt you to enter a password when the *Edit* pushbutton is pressed. To gain access, you must enter the appropriate password. A field of eight asterisks appears with the cursor located under the leftmost character position. You can enter passwords by performing the following procedures:

1. Press the *UP* or *DOWN* scrolling pushbuttons until the proper first character of the password appears. Pressing *UP* scrolls through the alphabet and then the numbers in ascending order. Pressing *DOWN* scrolls through the numbers and then the alphabet in descending order.
2. Press the *RIGHT* scrolling pushbutton to move the cursor to the next character of the password and select the appropriate character.
3. Continue the process until the entire password has been spelled out. If the password is less than eight characters, leave the remaining asterisks in place instead of entering blanks.

4. Press the *Edit* pushbutton to enter the password. If the proper password has been entered, the screen will flash **ACCESS GRANTED**. If an incorrect password has been entered, the screen will flash **ACCESS DENIED** and the EDIT LED will go out.
5. Once you gain access, it remains in affect for five minutes after the last pushbutton has been pressed. As long as you continue to press the *Edit* key for a function for which you have gained access, the five-minute timer will be refreshed and you will not be prompted for a password.

SECTION 11 • ASCII COMMAND INTERFACE

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SECTION 11 • ASCII COMMAND INTERFACE

INTRODUCTION

Relay and power system information can be retrieved from a remote location using the ASCII command interface. The ASCII command interface is also used to enter settings, retrieve reports and metering information, and perform control operations. A communication port on the relay front panel provides a temporary, local interface for communication. Communication ports on the rear panel provide a permanent communication interface.

Front and rear panel communication ports can be connected to computers, terminals, serial printers, modems, and intermediate communication/control interfaces such as RS-232 serial multiplexors. BE1-IPS100 communication protocols support ASCII and binary data transmissions. ASCII data is used to send and receive human readable data and commands. Binary data is used for computer communication and transmission of raw oscillographic fault data if available.

DNP, Modbus™, and other common protocols are also available. Available communication protocol instruction manuals include 9365900991 for DNP 3.0 and 9365900992 for Modbus™. For information about other protocols, consult your Basler Electric representative. **Note:** ASCII commands, which support Ethernet-enabled relays, can be found in Section 15, *BESTNet Communication.*

NOTE

HyperTerminal as shipped with Windows® 98, either first or second edition, cannot be used for communications with the relay due to a problem introduced in the Windows® 98 version of HyperTerminal. The software bug is associated with the carriage return/line feed function when acting as a terminal emulator. An upgrade to HyperTerminal that fixes the problem is available from the Microsoft's source of HyperTerminal (Hilgraeve, Inc.) at www.hilgraeve.com. The upgrade is referred to as "HyperTerminal - Private Edition." Companies that download and use this software must review the terms and conditions associated with the use of the software.

SERIAL PORT

Communication connections consist of one front Data Communication Equipment (DCE) RS-232 port, one rear RS-485 port, rear IRIG port, and a rear optional RJ45 Ethernet port or RS-232 port (COM1). The BE1-IPS100 communication protocol is compatible with readily available modem/terminal software. If required, password protection provides security against unauthorized operation. Detailed information about making communication connections is provided in Section 12, *Installation*. Communications port setup is covered in this section. Security settings are covered in Section 9, *Security*.

RS-232 Ports

One female RS-232 (DB-9) connector is provided on the front panel and is designated COM0. A rear RS-232 (DB-9) connector is optional. Both support full-duplex operation.

RS-485 Port

RS-485 terminal block connections are located on the rear panel and designated COM2. This port supports half-duplex, multi-drop operation. Multi-drop operation is possible if a polling address is programmed for the port.

Ethernet Port

Optional Ethernet capability (COM1) is available. See Section 15, *BESTNet Communication.*

> **NOTE**
>
> For security reasons, all change passwords are disabled by default on the (optional) Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port. See Section 9, *Security, for details.*

ASCII COMMAND INTERFACE

A computer terminal or PC running terminal emulation software can be used at any of the three serial ports to send commands to the relay. Simple ASCII command language is used to communicate with the relay. When the relay receives a command, it responds with the appropriate action. ASCII commands can be used in human to machine interactions and in batch download type operations.

Command Structure

An ASCII command consists of a string made up of one or two letters followed by a hyphen and an object name:

xy-object name	
x	Specifies the general command function.
y	Specifies the command subgroup.
Object Name	Defines the specific object to which the command refers.

Examples of object names include 51N (neutral inverse time overcurrent function) and PIA (phase A peak current demand register). A command string entered by itself is a read command. A command string followed by an equal sign (=) and one or more parameters is a write command.

General command functions are organized into five major groups plus one group of miscellaneous commands.

CONTROL (C): Control commands perform select-before-operate control actions such as circuit breaker tripping and closing and active setting group changes. Subgroups include Select (S) and Operate (O).

GLOBAL (G): One Global command performs operations that don't fall into the other general groups. The command for reading and changing passwords (GS-PW) is the only global command available.

METERING (M): Commands in this group report all real-time metering values. No subgroup is used with metering commands.

REPORTS (R): Reports commands read and reset reporting functions such as time and date, demand registers and breaker duty statistics. Subgroups include Alarms (A), Breaker Monitoring (B), Demand Recording (D), Fault Summary Reporting (F), General Information (G), Sequence of Events Recorder (S), and Oscillography (O).

SETTINGS (S): This group contains all of the setting parameters that govern relay function. Subgroups include Setting Groups 0 and 1, Protection Settings (P) not in setting groups, Alarm Settings (A), Breaker Monitor Settings (B), General Settings (G), Logic Settings (L), and DNP Settings (DNP).

MISCELLANEOUS: Miscellaneous commands include Access, Exit, and Help. Note that only the first letter of these commands must be entered; entering the full command name is optional.

Using the ASCII Command Interface

Human to Machine ASCII Command Operations

Using ASCII commands, settings can be read and changed on a function-by-function basis. The mnemonic format of the commands helps you interact with the relay. It isn't necessary to remember all of the object names. Most commands don't require that you specify a complete object name. If the first two letters of a command are entered, the relay will respond with all applicable object names.

ASCII Command Examples:

Example 1. Obtain a breaker operations count by entering RB (Report Breaker). The BE1-IPS100 responds with the operations counter value along with all other breaker report objects. If you know that the object name for the breaker operations counter is OPCNTR, you can enter RB-OPCNTR and read only the number of breaker operations.

Partial object names are also supported. This allows multiple objects to be read or reset at the same time.

Example 2. Read all peak-since-reset demand current registers. Entering RD-PI (Report Demand - Peak Current (I)) will return demand values and time stamps for phase A, B, C, neutral, and negative sequence current. To read only the neutral demand value, the full object name (RD-PIN) is entered. Entering RD-PI=0 resets all five of the peak-since-reset current demand registers.

Command Text File Operations

In command text file operations, an ASCII text file of commands is created and sent to the relay. For example, the S command is used to retrieve a complete list of settings from the relay in ASCII command format. This list of commands is captured, saved to a file, edited with any ASCII text editor, and then uploaded to the relay. Because the number of relay settings is so large, loading settings with a text file is the preferred method of setting the BE1-IPS100.

Embedding Comments into ASCII Text Files

Adding comments to ASCII settings files is an easy way to organize and label your settings. A comment line is started with two forward slashes (//) followed by the comment text. When the relay encounters // in a text file, it ignores all following characters until the next carriage return or linefeed character.

Example of embedding comments in a settings file:

```
//Group0 is used during normal operation
>S0-50TP=7.50,0m;S0-50TN=2.5,0m . . .
//Group1 is used during cold load pickup
>S1-50TP=0,0m; S1-50TN=0,0m; S1-50TQ=0,0m
```

Miscellaneous Command Descriptions

HELP Command

The HELP (H) command provides general information on command syntax and functionality when the manual is not available. Entering HELP or H provides information about using the HELP command. HELP1 or H1 returns a complete list of relay commands. Entering HELP <cmd> where <cmd> is a specific command, returns information about the use and format of the command along with an example of how the command is used.

HELP Command

Purpose: Obtain help on command operation
Syntax: HELP {cmd} or H {cmd} for help on {cmd}, H1 for command list
Example: HELP, H1, H SG-COM

ACCESS Command

Before making settings changes through a communication port, the ACCESS command must be used to obtain programming access. Enter ACCESS=<password> to obtain access to change settings associated with the password. Different passwords give the ability or access to perform different operations. The relay will deny access if an invalid password is entered or if another user has already been granted programming access through another serial port or at the front panel. Only one user can have access at any one time.

Even if password protection is not used, it is still necessary to obtain access so that accidental changes are prevented. If password protection is disabled, then ACCESS= will be accepted in place of a password. The relay will respond with `ACCESS GRANTED: GLOBAL` if the command entered was received and executed. The relay will respond with an error message and a '?' if the command could not be executed.

The ACCESS (A) command and the EXIT (E) command are used to change relay settings, reset report registers, and enable control commands through a serial port. These commands prevent changes from being made concurrently from two areas. For example, a user cannot make changes through COM 0 at the same time a remote user is making changes through COM 2.

ACCESS Command

Purpose: Read/Set Access level in order to change settings

Syntax: ACCESS[={password}]

Example: ACCESS=IPS100

Comments: The ACCESS command must be used before any changes to settings can be made. Available ACCESS privileges are summarized in the following paragraphs.

READ-ONLY: This is the default access privilege when no passwords are active. Read-only access allows you to read settings and reports but not make settings changes.

PRIVILEGE G: GLOBAL ACCESS. Global access is obtained by password G (PWG). Global access permits entry of any command with no restrictions.

PRIVILEGE S: SETTING ACCESS. Setting access is obtained by password S (PWS). Setting access allows changes to any settings.

PRIVILEGE C: CONTROL ACCESS. Control access is obtained by password C (PWC). Control access enables relay control operations.

PRIVILEGE R: REPORT ACCESS. Report access is obtained by password R (PWR). Report access enables report operations to be performed.

An access privilege is obtained only when the appropriate password is entered. When a valid password is entered, the relay responds with the access privilege provided by the password entered. If an invalid password is entered, an error message is returned. If password protection is disabled in one or more privileges, then entering any string will provide access to the unprotected privileges.

Note: In examples throughout this manual, relay responses are printed in `Courier New` typeface.

ACCESS Command Examples:

Example 1. A valid password is entered.

>ACCESS=OPENUP

```
ACCESS GRANTED:    GLOBAL
```

Example 2. An invalid password is entered.

>ACCESS=POENUP

```
ACCESS DENIED
```

Example 3. The current access privilege is read.

>ACCESS

```
ACCESS:    GLOBAL
```

EXIT Command

After changes are made, the new data is saved or discarded using the EXIT command. Prior to saving or discarding any changes, you must confirm that you wish to exit the programming mode. There is three exit options: Y (yes), N (no), or C (continue).

EXIT Command

Purpose: Exit programming mode

Syntax: EXIT (Note: Relay will prompt for verification.)

Example: EXIT

Comments: It's important to make all programming changes before executing the EXIT command. This prevents a partial or incomplete protection scheme from being implemented.

When access privileges are obtained, all programming changes are made to a temporary, scratchpad copy of relay settings. These changes aren't saved to nonvolatile memory and initiated until the EXIT command is invoked and confirmed. After the EXIT command is entered, the relay prompts to confirm that the new data should be saved. Three options, Y, N, or C are available. Entering Y will save the data. If N is entered, the relay will clear the changes and resume operating with the old settings. Entering C will abort the EXIT command and allow programming to continue.

EXIT Command Example:	Release programming privileges and save settings changes.	
	>EXIT<CR>	
	`SAVE CHANGES (Y/N/C)?`	Prompt to save Yes, No, or Continue
	>Y<CR>	Confirmation to save changes
	`CHANGES SAVED`	Confirmation that changes were saved

Settings (S) Command Descriptions

Reading All Settings

All user programmable settings can be listed using the S command. This read-only command is useful for documenting relay status during installation. The settings retrieved by the S command can be saved to a standard text file and sent to another relay to be configured with the same settings. This type of settings transfer takes less than one minute.

S Command
Purpose: Read all relay setting parameters
Syntax: S
Example: S

The S command returns the values of relay setting parameters in the same form that they are programmed. It can be used at the end of a programming session to make a record of the relay settings. If saved in a file, the report can be sent to another BE1-IPS100 that will use the same settings. Because the report that is created is a set of commands, sending the report to a different relay re-programs that relay with the settings contained in the S report.

Reading Specific Groups of Settings

While the S command is useful for reading all relay settings, several commands are available to read specific groups of settings.

SA Command
Purpose: Read all alarm settings for Major and Minor alarms
Syntax: SA
Example: SA

SA Command Example:

Example 1. Read all alarm settings.

```
>SA
SA-BKR1=0,0;      SA-BKR2=0,0;      SA-BKR3=0,0
SA-DIP=0.00;      SA-DIN=0.00;      SA-DIQ=0.00
SA-DVAR=0.0,0.0
SA-DWATT=0.0,0.0
SA-24= 0
SA-LGC=0
SA-MAJ=25
SA-MIN=29
SA-RESET=0
```

SB Command

Purpose: Read all breaker settings
Syntax: SB
Example: SB

SB Command Example:

Example 1. Read all breaker settings.

```
>SB
SB-DUTY=0,0.000e+00
SB-LOGIC=/IN1
```

SG Command

Purpose: Read all general settings
Syntax: SG
Example: SG

SG Command Example:

Example 1. Obtain a report of all general settings.

```
>SG
SG-FREQ=60
SG-PHROT=ABC
SG-CTP=1; SG-CTG=1
SG-VTP= 1.00,4W,PP,PP
SG-VTX= 1.00,AN
SG-NOM= 120,5.00
SG-LINE=8.00,80.0,24.0,80.0, 100
SG-IN1= 4, 16; SG-IN2= 4, 16; SG-IN3= 4, 16; SG-IN4= 4, 16
SG-HOLDA=0; SG-HOLD1=1; SG-HOLD2=1; SG-HOLD3=0
SG-HOLD4=0; SG-HOLD5=1
SG-SGCON= 5
SG-DIP=15; SG-DIN= 1; SG-DIQ= 1
SG-LOG=15
SG-
TARG=24/27P/127P/27X/32/132/47/BF/50TP/150TP/50TN/150TN/50TQ/150TQ/51P/15
1P/59P/59X/159X/60FL/62/162/81/181/281/381/481/581/159P/51N/ 151N/51Q,0
SG-TRIGGER=VO11,VO12,0
SG-OSC=16
SG-ID=BE1-IPS,SUBSTATION_1
SG-CLK=M,24,0
SG-SCREEN1=4.6; SG-SCREEN2=1.5.6; SG-SCREEN3=4.3.1; SG-SCREEN4=1.1
SG-SCREEN5=3.2; SG-SCREEN6=3.5;   SG-SCREEN7=0;     SG-SCREEN8=0
SG-SCREEN9=0;   SG-SCREEN10=0;    SG-SCREEN11=0;    SG-SCREEN12=0
SG-SCREEN13=0;  SG-SCREEN14=0;    SG-SCREEN15=0;    SG-SCREEN16=0
SG-COM0=9600,A0,P0,R1,X1; SG-COM1=9600,A0,P0,R1,X1
SG-COM2=9600,A0,P0,R1,X0
```

SN Command

Purpose: Read/Set User Programmable Names
Syntax: SN[-{var}[={name},{TRUE label},{FALSE label}]
Example: SN or SN-VO1=TRIP,CLOSED,OPEN or SN-IN1=BREAKER,OPEN,CLOSED

SN Command Example:

Example 1. Read the programmed labels for the alarm output (OUTA).

```
>SN-VOA
SN-VOA=VOA_LBL,TRUE,FALSE
```

S<g> Command

Purpose: Read all Protection settings

Syntax: S{g} where g=setting group 0-1 or # for all groups

Example: S# or S0 or S1

S <g> Command Example:

Example 1. Obtain a list of settings for Setting Group 1.

```
>S1
S1-50TP=0.00, 0m,N
S1-50TN=0.00, 0m,N
S1-50TQ=0.00, 0m,N
S1-150TP=0.00, 0m,N
S1-150TN=0.00, 0m,N
S1-150TQ=0.00, 0m,N
S1-51P=0.00,0.0,V2,N
S1-51N=0.00,0.0,V2,N
S1-51Q=0.00,0.0,V2,N
S1-151P=0.00,0.0,V2
S1-151N=0.00,0.0,V2,N
S1-27R=0.00,R
S1-67N=QVI,V0IN
S1-24=0.0,0.0,0.0
S1-25=0.0,10.0,0.01,0
S1-25VM=60.0,20.0, 50m,DIS
S1-27P=0.00, 50m; S1-27X=0.00, 50m
S1-127P=0.00, 50m
S1-47=0.00, 50m
S1-59P=0.00, 50m; S1-59X=0.00, 50m
S1-159P=0.00, 50m; S1-159X=0.00, 50m
S1-81=00.00, 0m,O
S1-181=00.00, 0m,O
S1-281=00.00, 0m,O
S1-381=00.00, 0m,O
S1-481=00.00, 0m,O
S1-581=00.00, 0m,O
S1-81INH=40.0, 0,64.00,46.00
S1-32=0.0, 50m,R
S1-132=0.0, 50m,R
S1-62= 0m, 0m
S1-162= 0m, 0m
S1-791= 0m; S1-792= 0m; S1-793= 0m; S1-794= 0m
S1-79R= 10s; S1-79F=1.0s; S1-79M= 60s
S1-79SCB=0
SP-60FL=ENA,PNQ
SP-79ZONE=0
SP-BF= 0m
SP-CURVE= 0.2663, 0.0339, 1.0000, 1.2969, 0.5000
```

Reading Logic Settings

The SL command is used to view the names of available logic schemes in memory. It also will return all of the logic equations for a specific logic scheme.

SL Command

Purpose: Obtain Setting Logic Information

Syntax: SL:[{name}]

Example: SL, SL: or SL:BASIC-OC

Comments: No password access is required to read settings.

Entering SL by itself returns all of the logic equations associated with the active logic scheme including custom logic. Entering SL: returns the names of all available logic schemes. Entering SL:<name> returns all logic equations and settings for the named logic scheme.

SL Command Examples:

Example 1. Read the logic schemes available in memory.

>SL:

```
IPS100-1547-A-BE, IPS100-1547-A-BE, NONE
```

Example 2. Read all logic settings associated with the IPS100-1547-A-BE logic scheme.

>SL:IPS100-1547-A-BE

```
SL-N=IPS100-1547-A-BE,BASLER
SL-50TP=1,0; SL-50TN=1,0; SL-50TQ=1,0
SL-150TP=1,0; SL-150TN=1,0; SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,0
SL-51Q=1,0
SL-151P=1,0
SL-151N=1,0
SL-24=1,0
SL-25=1,/79C+79LO
SL-27P=1,0; SL-27X=0,0
SL-127P=1,0
SL-32=4,0
SL-132=4,0
SL-47=1,0
SL-59P=1,0; SL-59X=1,0
SL-159P=1,0; SL-159X=1,0
SL-81=1,0
SL-181=1,0
SL-281=1,0
SL-381=1,0
SL-481=1,0
SL-581=1,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=1,VO11+IN3,/IN1,VO12,/IN2
SL-BF=1,VO11,0
SL-GROUP=1,0,0,/0
SL-43=0
SL-143=0
SL-101=0
SL-VOA=ALMMAJ+ALMMIN
SL-VO1=VO7
SL-VO2=VO8
SL-VO3=VO9+VO10
SL-VO4=BFT
SL-VO5=BFPU
SL-VO6=0
```

```
SL-
VO7=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+151PT+51NT+151NT+
51QT+32T+132T
SL-
VO8=27XT+27PT+127PT+47T+24T+59PT+159PT+59XT+159XT+81T+181T+281T+3
81T+481T +581T
SL-VO9=79C*25
SL-VO10=79C*25VM1
SL-VO11=VO7+VO8
SL-
VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+151PPU+51
NPU+151NPU+51QPU+32PU+132PU+27XPU+59PPU+159PPU+27PPU+127PPU+47PU+
24PU+59XPU+159XPU
SL-VO13=0
SL-VO14=0
SL-VO15=0
```

Configuring the Serial Port Communication Protocol

The serial communication protocol is defined with the SG-COM command shown below.

SG-COM Command

Purpose: Read/Set serial communications protocol

Syntax: SG-COM[#[={baud},A{addr},P{pglen},R{reply ack},X{XON ena}]]

Example: SG-COM0=9600 or SG-COM1=9600,A0,P24,R1,X1

Comments: Password Access Privilege G or Privilege S required to change settings

= port number. (0 = Front RS-232, 1 = Rear RS-232 (optional), 2= Rear RS-485)

baud = baud rate (300/600/1200/2400/4800/9600/19K)

Ax = Address for polled operation where x = 0 (No polling) to 65534

Px = Page length (lines/pg) setting where x = 0 (No page mode) to 40

Rx = Reply acknowledgment level where x = 0 (disabled). 1 (enabled)

Xx = Xon/Xoff setting where X0 = handshake disabled, X1 = handshake enabled.

The following parameters pertain to relays using Modbus™ communication protocol at COM2:

MFx = Modbus extended precision format where x = 0 for floating point or 1 for triple precision

MPx = Modbus parity where x = N (None), O (Odd) and E (Even).

MRx = Modbus remote delay time where x = 10(ms) to 200(ms).

MSx = Modbus stop bit where x = 1 for one stop bit or 2 for two stop bits.

If a non-zero address is programmed in the 'A' parameter, then the relay will ignore all commands that are not preceded by its specific address. If an address of 0 is programmed, then the relay will respond with an error message for any command preceded by an address.

If polling software sends a command preceded by an address of 0, then that command will be treated as a global command. All relays will execute the command but no relay will respond to avoid bus contention.

NOTE: Polling is disabled on COM0 (Front RS-232), so an attempt to program an address other than A0 will cause an error message. The factory default settings are 9600, A0, P24, R1, X1 for COM 0 and COM 1 and 9600, A0, P0, R1, X0 for COM 2.

SG-COM Command Example:

Example 1. Program front port for 1200 baud

>SG-COM0=1200

Example 2. Read the protocol setting for the rear RS-485 port.

>SG-COM2

```
19K, A156,P0,R1,X0
```

Example 3. Read settings for all ports.

```
>SG-COM
SG-COM0=1200,P24,R1,X1
SG-COM1=9600,A0,P24,R1,X1
SG-COM2=19K,A156,P0,R1,X0
```

COMMAND SUMMARY

Miscellaneous Commands

ACCESS Command

Purpose: Read/Set Access level in order to change settings
Syntax: ACCESS[={password}]
Example: ACCESS=IPS100
Reference: Section 11, *ASCII Command Interface, Miscellaneous Command Descriptions*

EXIT Command

Purpose: Exit programming mode
Syntax: EXIT **Note:** Relay will prompt for verification
Example: EXIT
Reference: Section 11, *ASCII Command Interface, Miscellaneous Command Descriptions*

HELP Command

Purpose: Obtain help on command operation
Syntax: HELP {cmd} or H {cmd} for help on {cmd}, H1 for command list
Example: HELP, H1, H SG-COM
Reference: Section 11, *ASCII Command Interface, Miscellaneous Command Descriptions*

Metering Commands

M Command

Purpose: Read all metered values
Syntax: M
Example: M
Reference: Section 5, *Metering*

M-3V0 Command

Purpose: Read metered voltage (V) in primary units
Syntax: M-3V0
Example: M-3V0
Reference: Section 5, *Metering*

M-FAST Command

Purpose: Read fast metered values in primary units
Syntax: M-FAST[{xy}] where x=V,I,F,P,Q,S and y=P,L,S,1,2,3,4,G
Example: M-FAST,V or M-FAST,VP or M-FAST,I or M-FAST,L1
Reference: Section 5, *Metering*

M-FREQ Command

Purpose: Read metered frequency (F)
Syntax: M-FREQ[{source}] where source = P/X/S, Phase, Aux, Slip
Example: M-F or M-FREQ, M-FREQP, M-FREQX, M-FREQS
Reference: Section 5, *Metering*

M-I Command

Purpose:	Read metered current (I) in primary units
Syntax:	M-I[{phase}] where phase = A/B/C/N/Q/G
Example:	M-I or M-IA or M-IG
Reference:	Section 5, *Metering*

M-PF Command

Purpose:	Read metered 3 Phase Power Factor
Syntax:	M-PF
Example:	M-PF
Reference:	Section 5, *Metering*

M-S Command

Purpose:	Read metered 3 Phase VA in primary units
Syntax:	M-S
Example:	M-S
Reference:	Section 5, *Metering*

M-SYNC Command

Purpose:	Read metered sync angle between Phase & Aux inputs
Syntax:	M-SYNC
Example:	M-SYNC or M-SYN
Reference:	Section 5, *Metering*

M-V Command

Purpose:	Read metered voltage (V) in primary units
Syntax:	M-V[{phase}] where phase = A/B/C/AB/BC/CA/2
Example:	M-V or M-VA or M-VAB or M-V2
Reference:	Section 5, *Metering*

M-VAR Command

Purpose:	Read metered 3 Phase Vars in primary units
Syntax:	M-VAR[{phase}] where phase = 3/A/B/C
Example:	M-VAR or M-VAR3, M-VARA, M-VARB, or M-VARC
Reference:	Section 5, *Metering*

M-WATT Command

Purpose:	Read metered 3 Phase Watts (W) in primary units
Syntax:	M-WATT[{phase}] where phase = 3/A/B/C
Example:	M-WATT or M-WATT3, M-WATTA, M-WATTB, or M-WATTC
Reference:	Section 5, *Metering*

Control Commands

CO Command

Purpose:	Control Operation
Syntax:	CO-{control}[={mode}] where control=GROUP/OUT/x43/101 mode=0-1/L for GROUP, 0/1/P/L/ENA/DIS for OUT, 0/1/P for x43 and T/C for 101.
Example:	CO-GROUP=1 or CO-OUT1=1 or CO-43=P
Reference:	Section 3, *Input and Output Functions, Outputs* Section 4, *Protection and Control, Setting Groups* Section 4, *Protection and Control, Virtual Switches*

CS Command

Purpose: Control Selection

Syntax: CS-control[={mode}] where control=GROUP/OUT/x43/101
mode=0-1/L for GROUP, 0/1/P/L/ENA/DIS for OUT,
0/1/P for x43 and T/C for 101.

Example: CS-GROUP=1 or CS-OUT1=1 or CS-43=P

Reference: Section 3, *Input and Output Functions, Outputs*
Section 4, *Protection and Control, Setting Groups*
Section 4, *Protection and Control, Virtual Switches*

Report Commands

RA Command

Purpose: Report/Reset Alarm information

Syntax: RA[=0]

Example: RA

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-LGC Command

Purpose: Report/Reset Logic Alarm information

Syntax: RA-LGC[=0]

Example: RA-LGC

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-MAJ Command

Purpose: Report/Reset Major Alarm information

Syntax: RA-MAJ[=0]

Example: RA-MAJ

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-MIN Command

Purpose: Report/Reset Minor Alarm information

Syntax: RA-MIN[=0]

Example: RA-MIN

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-REL Command

Purpose: Report/Reset Relay Alarm information

Syntax: RA-REL[=0]

Example: RA-REL

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RB Command

Purpose: Read breaker status

Syntax: RB

Example: RB

Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

RB-DUTY Command

Purpose: Read/Set breaker contact Duty Log

Syntax: RB-DUTY[{phase}[={%duty}]] where %duty is % of dmax set with SB-DUTY

Example: RB-DUTYA or RB-DUTYB=50

Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

RB-OPCNTR Command

Purpose: Read/Set Breaker Operation Counter
Syntax: RB-OPCNTR[={#operations}]
Example: RB-OPCNTR=32 or RB-OPCNTR=652
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

RD Command

Purpose: Report all demand data
Syntax: RD
Example: RD
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-LOG Command

Purpose: Report load profile data
Syntax: RD-LOG,<n>
Example: RD-LOG,23 (view load profile record for last 23 records)
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-PI Command

Purpose: Read/Reset peak demand current (I)
Syntax: RD-PI[{p}[=0]] where p=A/B/C/N/Q
Example: RD-PI or RD-PIA or RD-PIN or RD-PI=0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-PVAR Command

Purpose: Read/Reset peak demand vars
Syntax: RD-PVAR[=0,0] - Fwd,Rev Var Flow
Example: RD-PVAR or RD-PVAR=0,0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-PWATT Command

Purpose: Read/Reset peak demand watts
Syntax: RD-PWATT[=0,0] - Fwd,Rev Power Flow
Example: RD-PWATT or RD-PWATT=0,0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TI Command

Purpose: Report today's demand current (I)
Syntax: RD-TI[{p}] where p=A/B/C/N/Q
Example: RD-TI or RD-TIA or RD-TIN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TVAR Command

Purpose: Report today's demand vars
Syntax: RD-TVAR
Example: RD-TVAR
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TWATT Command

Purpose: Report today's demand watts
Syntax: RD-TWATT
Example: RD-TWATT
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-YI Command

Purpose: Report yesterday's demand current (I)
Syntax: RD-YI[{p}] where p=A/B/C/N/Q
Example: RD-YI or RD-YIA or RD-YIN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-YVAR Command

Purpose: Report yesterday's demand vars
Syntax: RD-YVAR
Example: RD-YVAR
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-YWATT Command

Purpose: Report yesterday's demand watts
Syntax: RD-YWATT
Example: RD-YWATT
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RE Command

Purpose: Report all energy data
Syntax: RE
Example: RE
Reference: Section 6, *Reporting and Alarm Functions, General Status Reporting*

RE-KVARH Command

Purpose: Read/Reset/Preset 3 Phase kilovar-hours in primary units
Syntax: RE-KVARH[={pos_kvarh},{neg_kvarh}]
Example: RE-KVARH or RE-KVARH=100,10 or RE-KVARH=0,0
Reference: Section 6, *Reporting and Alarm Functions, General Status Reporting*

RE-KWH Command

Purpose: Read/Reset/Preset 3 Phase kilowatthours in primary units
Syntax: RE-KWH[={pos_kwh},{neg_kwh}]
Example: RE-KWH or RE-KWH=100,10 or RE-KWH=0,0
Reference: Section 6, *Reporting and Alarm Functions, General Status Reporting*

RF Command

Purpose: Read/Reset Fault Report Data
Syntax: RF[-n/NEW][=0/TRIG] where n=record # or NEW = new records
Example: RF (displays a directory of all fault reports in memory)
RF-23 (view summary report for fault record 23)
RF-NEW (view summary report for newest fault record since RF=0 reset)
RF=TRIG (Manually Trigger a fault record)
RF=0 (reset NEW fault counter)
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

RG Command

Purpose: Report General information
Syntax: RG
Example: RG
Reference: Section 6, *Reporting and Alarm Functions, Clock*
Section 6, *Reporting and Alarm Functions, Fault Reporting*

RG-DATE Command

Purpose: Report/Set Date
Syntax: RG-DATE[={M/D/Y}] or RG-DATE[={D-M-Y}]
Example: RG-DATE=12/31/96 or RG-DATE=31-12-96 (Format set by SG-CLK Command)
Reference: Section 6, *Reporting and Alarm Functions, Clock*

RG-DST Command

Purpose: Report start and stop times and dates for Daylight Saving Time referenced to local time.
Syntax: RG-DST
Example: RG-DST
Reference: Section 6, *Reporting and Alarm Functions, Clock*

RG-STAT Command

Purpose: Report relay status
Syntax: RG-STAT
Example: RG-STAT
Reference: Section 6, *Reporting and Alarm Functions, General Status Reporting*

RG-TARG Command

Purpose: Report/Reset Target status
Syntax: RG-TARG
Example: RG-TARG or RG-TARG=0
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

RG-TIME Command

Purpose: Report/Set Time
Syntax: RG-TIME[=hr:mn:sc] or RG-TIME[=hr:mn{f}sc]]
Example: RG-TIME=13:25:00 or RG-TIME=1:25P00 (Format(f) set by SG-CLK Command)
Reference: Section 6, *Reporting and Alarm Functions, Clock*

RG-VER Command

Purpose: Read Model #, Style #, Program Version, Serial #
Syntax: RG-VER
Example: RG-VER
Reference: Section 6, *Reporting and Alarm Functions, Hardware and Software Version Reporting*

RO Command

Purpose: Read Oscillographic COMTRADE .DAT/.CFG/.HDR Fault Report
Syntax: RO-nA/B[#].CFG/DAT/HDR where n=report number,A=ASCII/B=BINARY,#=OSC 1/2
Example: RO-3A1.CFG or RO-3A1.DAT or RO-5B2.CFG or RO-5B2.DAT or RO-5A.HDR
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

RS Command

Purpose: Read/Reset Sequence of Events Record Data
Syntax: RS[-n/Fn/ALM/IO/LGC/NEW][=0] where n=# of events and Fn=fault record #
Example: RS (displays a directory of all event records in memory)
RS-23 (view SER report for last 23 events)
RS-F12 (view SER report associated with fault record 12)
RS-ALM (view all SER report ALARM events since RS=0 reset)
RS-IO (view all SER report INPUT OUTPUT events since RS=0 reset)
RS-LGC (view all SER report LOGIC events since RS=0 reset)
RS-NEW (view all SER report events since RS=0 reset)
RS=0 (reset NEW records counter)
Reference: Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder*

Setting Command

S Command

Purpose: Read all relay setting parameters
Syntax: S
Example: S
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

Alarm Setting Commands

SA Command

Purpose: Read all alarm settings for Major and Minor alarms
Syntax: SA
Example: SA
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-24 Command

Purpose: Read/Set Volts Per Hertz alarm settings
Syntax: SA-24[={alarm level},{td(m)}] alarm level=volts per hertz
Example: SA-24 or SA-24=1.1,2000 or SA-24=1.08,500
Reference: Section 4, *Protection and Control, Voltage Protection*

SA-BKR Command

Purpose: Read/Set breaker alarm settings
Syntax: SA-BKR[n][={mode},{alarm limit}] where mode=0-3(disabled/%duty/#op/clr)
Example: SA-BKR or SA-BKR1=1,80 or SA-BKR2=2,250, or SA-BKR3=3,6c
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SA-DI Command

Purpose: Read/Set demand alarm settings
Syntax: SA-DI[p][={alarm level}] where p=P/N/Q, alarm level=Sec Amps
Example: SA-DI or SA-DIP=0 or SA-DIN=10
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SA-DVAR Command

Purpose: Read/Set Var demand alarm setting
Syntax: SA-DVAR[={fwd alm lvl},{rev alm lvl}] where alm lvl= FWD,REV Sec Vars
Example: SA-DVAR or SA-DVAR=0,0 or SA-DV=5000,1000
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SA-DWATT Command

Purpose: Read/Set Watt demand alarm setting
Syntax: SA-DWATT[={fwd alm lvl},{rev alm lvl}] where alm lvl= FWD,REV Sec Watts
Example: SA-DWATT or SA-DWATT=0,0 or SA-DW=5000,1000
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SA-LGC Command

Purpose: Read/Set logic alarm setting mask
Syntax: SA-LGC[={alarm num 1}[/{alarm num 2}]...[/{alarm num n}]]
Example: SA-LGC or SA-LGC=2/6/7/10/11
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-MAJ Command

Purpose: Read/Set major alarm setting mask
Syntax: SA-MAJ[={alarm num 1}[/{alarm num 2}]...[/{alarm num n}]]
Example: SA-MAJ or SA-MAJ=1/3/5/12
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-MIN Command

Purpose: Read/Set minor alarm setting mask
Syntax: SA-MIN[={alarm num 1}[/{alarm num 2}]...[/{alarm num n}]]
Example: SA-MIN or SA-MIN=2/6/7/10/11
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-RESET Command

Purpose: Read/Set Programmable Alarms Reset logic
Syntax: SA-RESET[={rst alm logic}]
Example: SA-RESET or SA-RESET=VO1
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

Breaker Monitor Setting Commands

SB Command

Purpose: Read all breaker settings
Syntax: SB
Example: SB
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SB-DUTY Command

Purpose: Read/Set Breaker Contact Duty where mode = 0/1/2 (disabled/I/I^2)
Syntax: SB-DUTY[={mode},{dmax},{BLKBKR logic}]
Example: SB-DUTY=1,60E3,IN5
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SB-LOGIC Command

Purpose: Read/Set Breaker Contact Logic
Syntax: SB-LOGIC[={breaker close logic}]
Example: SB-LOGIC=IN1 (IN1=52a) or SB-LOGIC=/IN2 (IN2=52b)
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

DNP Setting Commands

SDNP Command

Purpose: Read all Distributed Network Protocol (DNP) settings
Syntax: SDNP
Example: SDNP
Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

SDNP-AIDV Command

Purpose: Read/Set default(0) variation(1/2/3/4) for Analog Input static (obj 30) and/or Change Event object (obj 32).
Syntax: SDNP-AIDV[= {defVarObj30},{defVarObj32}]
Example: SDNP-AIDV= 4,2 means static AI 16-bit data without flag and change event AI 32-bit data without time.
Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

SDNP-DB Command

Purpose: Read/Set Analog Input event dead band for current, voltage and power points in DNP

Syntax: SDNP-DB[= {current dead band},{voltage dead band}, {power dead band}]
where dead band (xx.y) is % of nominal value, from 1.0 to 10.0 in steps of 0.1%. Default settings are: SDNP-DB= 2.5, 1, 2.5

Example: SDNP-DB= 1.5, 2.0 , 1.0

Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

SDNP-SFCNTR Command

Purpose: Read/Set scaling factor (SF) for breaker operations counter.

Syntax: SDNP-SFCNTR[= SF]
where scaling factor is from 0/1/2/3. Default setting is SDNP-SFCNTR=0.

Example: SDNP-SFPE= 1

Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

SDNP-SFIV Command

Purpose: Read/Set 4 scaling factors(SF): 2 for currents and 2 for voltages.

Syntax: SDNP-SFIV[= {SF of phase, N and Q currents },{ground current SF },
{SF of phase and line voltages},{ SF of auxilliary voltages}]
where scaling factor can be -2/-1/0/1/2/3
meaning data is scaled to be reported in the following physical units:
-2 for centiUnits / -1 in 0.1Unit /0 in Units (amps/volts)/ 1 in 10Units/
/ 2 in 100Units / 3 in kiloUnits(KA/KV).

Example: SDNP-SFIV=3,0,3,2

Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

SDNP-SFPE Command

Purpose: Read/Set power type,scaling factor (SF) for power and SF for energy.

Syntax: SDNP-SFPE[= {power secondary/primary },{power SF },{energy SF }]
where power type is S/P for secondary/primary,
power scaling factor is from -2/-1/0/1/2/3/4/5/6 ,
energy scaling factor is from 0/1/2/3/4/5/6/7/8/9 .

Example: SDNP-SFPE= P,3,6

Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

SDNP-SFT Command

Purpose: Read/Set scaling factors for time period and part2 of any time stamp.

Syntax: SDNP-SFT[={SF of time period},{SF of time stamp part 2}]
where scaling factor can be -3/-2/-1/0/1 meaning time is in the following physical units:millisec(-3) / 0.01 sec(-2) /
0.1 sec(-1) /1 sec (0)/ 10 sec (1). Defaults:SDNP-SFT=-3,-3

Example: SDNP-SFT= 0,1

Reference: *Distributed Network Protocol (DNP) manual for BE1-IPS100*

General Setting Commands

SG Command

Purpose: Read all general settings

Syntax: SG

Example: SG

Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

SG-CLK Command

Purpose: Read/Program format of date and time display
Syntax: SG-CLK[={date format(M/D)},{time format(12/24)},{dst enable(0/1)}]
Example: SG-CLK=D,12,1 or SG-CLK=M,24,0
Reference: Section 6, *Reporting and Alarm Functions, Clock*

SG-COM Command

Purpose: Read/Set serial communications protocol
Syntax: SG-COM[#[={baud},A{addr},P{pglen},R{reply ack},X{XON ena}]]
Example: SG-COM0=9600 or SG-COM1=9600,A0,P24,R1,X1
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions, Configuring the Serial Port Communication Protocol*

SG-CT Command

Purpose: Read/Set Phase/Neutral CT ratio
Syntax: SG-CT[t][={CTratio}] where t = P/G
Example: SG-CTP=80 or CTG=400:5 or CTG=400/5
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-DI Command

Purpose: Read/Set P(IA/IB/IC/VAR/WATT), N and Q demand interval
Syntax: SG-DI[p][={interval}] where p=P/N/Q, interval=0-60 (min)
Example: SG-DI or SG-DIP=15 or SG-DIN=1
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SG-DSP Command

Purpose: Read analog signal dsp filter type
Syntax: SG-DSP[P/N]   F=fundamental
Example: SG-DSP, SG-DSPP, SG-DSPN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SG-DST Command

Purpose: Read/Set Daylight Saving Time (DST) type
Syntax: SG-DST[=1/2] where 1 means floating date, and 2 means fixed date
Example: SG-DST, SG-DST=1, SG-DST=2
Reference: Section 6, *Reporting and Alarms Function, Clock*

SG-DSTSTART Command

Purpose: Read/Set settings for start of Daylight Saving Time
Syntax: SG-DSTSTART[={Mo,D,H,M,O}] where Mo=Month, D=Day of week (or month), H=Hour, M=Min, O=# of occurrence of 'D' in the month]
Example: SG-DSTSTART, SG-DSTSTART=3,1,2,0,1 (For 2AM Mar 1) or SG-DSTSTART=4,0,2,15,2 (For 2:15AM on 2nd Sunday in April)
Reference: Section 6, *Reporting and Alarms Function, Clock*

SG-DSTSTOP Command

Purpose: Read/Set settings for end of Daylight Saving Time
Syntax: SG-DSTSTOP[={Mo,D,H,M,O}] where Mo=Month, D=Day of week (or month), H=Hour, M=Min, O=# of occurrence of 'D' in the month]
Example: SG-DSTSTOP, SG-DSTSTOP=11,21,3,15,1 (For 3:15AM Nov. 21) or SG-DSTSTOP=11,2,23,20,1 (For 11:20AM on 1st Tue in Nov.)
Reference: Section 6, *Reporting and Alarms Function, Clock*

SG-EMAIL Command

Purpose: Read/Enter email logic
Syntax: SG-EMAIL[#[={email logic}]] where #=1-7
Example: SG-EMAIL1=VO1*VO2 or SG-EMAIL5=50TPT+50TPPU
Reference: Section 15, *BESTNet Communication, Unique ASCII Commands*

SG-FREQ Command

Purpose: Read/Enter power system Frequency
Syntax: SG-FREQ[={freq(HZ)}]
Example: SG-FREQ=60 or SG-FREQ=50
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-HOLD Command

Purpose: Read/Program Output Hold operation
Syntax: SG-HOLD[n][={1/0 hold ena}] where 1=TRUE, 0=FALSE
Example: SG-HOLD or SG-HOLD1=1 or SG-HOLD2=0
Reference: Section 3, *Input and Output Functions, Outputs*

SG-ID Command

Purpose: Read/Set relay ID and station ID used in reports
Syntax: SG-ID[={relayID(up to 30 char)},{StationID(up to 30 char)}]
Example: SG-ID=448,SUBSTATION3 or SG-ID=GEN3, POWERPOINT_SUBSTATION
Reference: Section 14, *BESTCOMS Software, Setting the Relay*

SG-IN Command

Purpose: Read/Set Input recognition/debounce
Syntax: SG-IN[#[={r(ms)},{db(ms)}]] where ms=1-255msec
Example: SG-IN or SG-IN3 or SG-IN3=4,16
Reference: Section 3, *Input and Output Functions, Contact Sensing Inputs*

SG-LINE Command

Purpose: Read/Set System Line parameters
Syntax: SG-LINE[={Z1},{A1},{Z0},{A0},{LL}] where Z1,Z0=impedance A1,A0=angle, LL=length
Example: SG-LINE or SG-LINE=8,80,24,80,100
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-LOG Command

Purpose: Read/Set load profile interval
Syntax: SG-LOG[={interval}] where interval is between 1 and 60 minutes
Example: SG-LOG or SG-LOG=15
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SG-NOM Command

Purpose: Read/Enter power system nominal Voltage & Current
Syntax: SG-NOM[={Nom Volts},{Nom Amps}]
Example: SG-NOM or SG-NOM=120,5 or SG-NOM=120,1
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-OSC Command

Purpose: Read/Set the number of oscillograph fault records saved
Syntax: SG-OSC[=6/8/10/12/15/16]
Example: SG-OSC or SG-OSC=6
Reference: Section 6, *Reporting and Alarm Functions, Oscillographic Records*

SG-PHROT Command

Purpose: Read/Set Phase Rotation setting
Syntax: SG-PHROT[={phase rotation}] ABC/ACB
Example: SG-PHROT or SG-PHROT=ABC or SG_PHROT=ACB
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-SCREEN Command

Purpose: Read/Set default screen(s)
Syntax: SG-SCREEN[n][={default screen number}]
Example: SG-SCREEN or SG-SCREEN1=2.2.1 or SG-SCREEN2=2.2.2
Reference: Section 10, *Human-Machine Interface, Front Panel Display*

SG-SGCON Command

Purpose: Read/Set SGC output on time
Syntax: SG-SGCON[={time}] where time is in (s)ec
Example: SG-SGCON or SG-SGCON=1S or SG-SGCON=5S
Reference: Section 4, *Protection and Control, Setting Groups*

SG-TARG Command

Purpose: Report/Enable Target List and Reset Target Logic
Syntax: SG-TARG[={x/x/..x},{rst TARG logic}] where x=27,47,50,51,59,81,181 etc.
Example: SG-TARG or SG-TARG=27/50/51N/59/81/281
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

SG-TORQ Command

Purpose: Read/Set Maximum Torq Angle for a fault parameters
Syntax: SG-TORQ[={A1},{A0}] where A1=Pos Seq angle, A0=Zero Seq angle
Example: SG-TORQ or SG-TORQ=80,80
Reference: Section 4, *Protection and Control, Overcurrent Protection, 67 Directional Overcurrent Element*

SG-TRIGGER Command

Purpose: Read/Set Trigger logic
Syntax: SG-TRIGGER[n][={TRIP trigger},{PU trigger},{LOGIC trigger}]
Example: SG-TRIGGER or SG-TRIGGER=VO1,VO2,IN4
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

SG-UTC Command

Purpose: Read/Set UTC information for Daylight Saving Time
Syntax: SG-UTC[=M,R,B] where M=Offset from UTC in minutes,R=Ref time: 0/1 for local/UTC, B=DSTBias: The amount in minutes to adjust DST
Example: SG-UTC, SG-UTC=60,0,60, or SG-UTC=-120,1,60, or local time is UTC-4:15 with UTC ref, bias is 120 min => SG-UTC=-255,1,120
Reference: Section 6, *Reporting and Alarm Functions, Clock*

SG-VTP Command

Purpose: Read/Set VT ratio, connection, 27/59 sensing mode, 51/27R sensing mode
Syntax: SG-VTP[={VT_ratio},{connection},{27/59mode},{51/27Rmode}]
Example: SG-VTP or VTP=10,4W,PN,PN or VTP=1200:120,3W,PP,PP or VTP=1200/120,AB
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-VTX Command

Purpose: Read/Set Aux VT ratio and connection
Syntax: SG-VTX[={VTratio},{connection}]
Example: SG-VTX or VTX=10,AB or VTX=1200:120,GR or VTX=1200/120,AN
Reference: Section 3, *Input and Output Functions, Power System Inputs*

Programmable Logic Setting Commands

SL Command

Purpose: Obtain Setting Logic Information
Syntax: SL:[{name}]
Example: SL, SL: or SL:BASIC-OC
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

SL-24 Command

Purpose: Read/Set Logic for 24 Function Modules
Syntax: SL-24[={mode},{BLK logic}]
Example: SL-24 or SL-24=1,0 or SL-24=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-25 Command

Purpose: Read/Set Logic for 25 Function Modules
Syntax: SL-25[={mode},{BLK logic}]
Example: SL-25 or SL-25=1,0 or SL-25=1,IN3
Reference: Section 4, *Protection and Control, Synchronism-Check Protection*

SL-27 Command

Purpose: Read/Set Logic for 27 Function Modules
Syntax: SL-{x}27[{p}[={mode},{BLK logic}]] where x=blank/1, p=P/X
Example: SL-27 or SL-27P=1,0 or SL-27X=3,0 or SL-127P=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-32 Command

Purpose: Read/Set Logic for 32 Function Modules
Syntax: SL-{x}32[={mode},{BLK logic}] where x=blank/1 and mode=0/1/2/3/4
Example: SL-32 or SL-32=1,0 or SL-132=3,IN3
Reference: Section 4, *Protection and Control, Directional Power Protection*

SL-43 Command

Purpose: Read/Set Logic for Virtual switch (x43)
Syntax: SL-{x}43[=mode] where x = blank/1/2/3, mode=0/1/2/3
Example: SL-43 or SL-43=0 or SL-143=1
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-47 Command

Purpose: Read/Set Logic for 47 Function Modules
Syntax: SL-47[={mode},{BLK logic}]
Example: SL-47 or SL-47=1,0 or SL-47=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-50T Command

Purpose: Read/Set Logic for x50 Function Modules
Syntax: SL-{x}50T[{p}[={mode},{BLK logic}]] where x = blank/1 and p = P/N/Q
Example: SL-50T or SL-50T=1,0 or SL-150TN=1,IN3
Reference: Section 4, *Protection and Control, Overcurrent Protection*

SL-51 Command

Purpose: Read/Set Logic for 51 Function Modules
Syntax: SL-51[{p}[={mode},{BLK logic}]] where p=P/N
Example: SL-51 or SL-51P=1,0 or SL-51N=1,IN3 or SL-151N=1,0
Reference: Section 4, *Protection and Control, Overcurrent Protection*

SL-51Q Command

Purpose: Read/Set Logic for 51Q Function Modules
Syntax: SL-51Q[={mode},{BLK logic}]
Example: SL-51Q or SL-51Q=1,0 or SL-51Q=1,IN3
Reference: Section 4, *Protection and Control, Overcurrent Protection*

SL-101 Command

Purpose: Read/Set Logic for Virtual Breaker switch (101)
Syntax: SL-101[=mode] where mode=0/1 (disabled/enabled)
Example: SL-101 or SL-101=0 or SL-101=1
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-59 Command

Purpose: Read/Set Logic for 59 Function Modules
Syntax: SL-59[{p}[={mode},{BLK logic}]] where p=P/X
Example: SL-59 or SL-59P=1,0 or SL-59X=2,0 or SL-159X=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-62 Command

Purpose: Read/Set Logic for 62 Function Modules
Syntax: SL-{x}62[={mode},{INI logic},{BLK logic}] where x=blank/1
Example: SL-62 or SL-62=1,VO10,0 or SL-162=2,VO9,VO8
Reference: Section 4, *Protection and Control, General Purpose Logic Timers*

SL-79 Command

Purpose: Read/Set for 79 Function
Syntax: SL-79[={mode},{RILogic},{STATUSLogic},{WAITLogic},{LOCKOUTLogic}]
Example: SL-79 or SL-79=1,VO1+IN4,/IN1,IN2,IN3
Reference: Section 4, *Protection and Control, Reclosing*

SL-81 Command

Purpose: Read/Set Logic for 81 Function Modules
Syntax: SL-{x}81[={mode},{BLK logic}] where mode=0/1/X, x=blank/1/2/3/4/5
Example: SL-81 or SL-81=1,0 or SL-81=X,0 or SL-181=1,IN3
Reference: Section 4, *Protection and Control, Frequency Protection*

SL-BF Command

Purpose: Read/Set Logic for Breaker Failure Function Modules
Syntax: SL-BF[{p}[={mode},{INI logic},{BLK logic}]]
Example: SL-BF or SL-BF=1,VO1,0 or SL-BF=1,VO1,IN1
Reference: Section 4, *Protection and Control, Breaker Failure Protection*

SL-GROUP Command

Purpose: Read/Set Logic for Setting Group Module
Syntax: SL-GROUP[={mode},{D0Logic},{D1Logic},{AUTOlogic}]
Example: SL-GROUP or SL-GROUP=1,0,IN3,0
Reference: Section 4, *Protection and Control, Setting Groups*

SL-N Command

Purpose: Read/Set Name of the custom logic
Syntax: SL-N[={name}]
Example: SL-N=IPSTEST
Reference: Section 7, *BESTlogic Programmable Logic, Logic Schemes*

SL-VO Command

Purpose: Read/Set Output Logic
Syntax: SL-VO[#[={Boolean equation}]]
Example: SL-VO or SL-VO1=50TPT+50TNT+51PT+51NT+101T
Reference: Section 7, *BESTlogic Programmable Logic, Working With Programmable Logic*

User Programmable Name Setting Command

SN Command

Purpose: Read/Set User Programmable Names
Syntax: SN[-{var}[={name},{TRUE label},{FALSE label}]
Example: SN or SN-VO1=TRIP,CLOSED,OPEN or SN-IN1=BREAKER,OPEN,CLOSED
Reference: Section 7, *BESTlogic Programmable Logic, User Input and Output Logic Variable Names*

Protection Setting Commands

S<g> Command

Purpose: Read all Protection settings
Syntax: S{g} where g=setting group 0-1 or # for all groups
Example: S# or S0 or S1
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

S<g>-24 Command

Purpose: Read/Set 24 pickup level, time delay, reset delay and curve
Syntax: S{g}-24[={pu(V/Hz)},{td},{rst},{crv}] where g=0,1
Example: S0-24 or S0-24=2.5,6.5,9.9,2 or S1-24=3,2.0,5.0,1
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-24D Command

Purpose: Read/Set 24 definite time pickup levels and time delays
Syntax: S{g}-24D[={pu1(V/Hz)},{td1},{pu2(V/Hz)},{td2}] where g=0,1
Example: S0-24D or S0-24D=1.1,6000,1.18,45000 or S1-24D=1.12,8000,1.20,60000
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-25 Command

Purpose: Read/Set 25 delta volts, phase angle, slip freq and mode
Syntax: S{g}-25[={Volts},{Ang},{Slip},{mode}] where g=0,1, mode=1-PF>XF, 0-PF<>XF
Example: S0-25 or S0-25=5,3,0.1,0 or S1-27=2,5,0.25,1
Reference: Section 4, *Protection and Control, Synchronism-Check Protection*

S<g>-25VM Command

Purpose: Read/Set 25VM live volts, dead volts, time delay, and VM1 logic
Syntax: S{g}-25VM[={LV},{DV},{td},{VM1}] where g=0,1, VM1=DIS/123
Example: S0-25VM or S0-25=80,20,100,123 S1-25VM=80,20,0.25,23
Reference: Section 4, *Protection and Control, Synchronism-Check Protection*

S<g>-27 Command

Purpose: Read/Set 27 pickup level, time delay, and inhibit level
Syntax: S{g}-{x}27{p}[={pu(V)},{td(m)},{inh(V)}] where x= blank/1, g=0,1, p=P,X
Example: S0-27P or S0-27P=100,10s,20, S0-27X=100,10s,20, S0-127P=80,5s,20
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-27R Command

Purpose: Read/Set (51)/27R control level and operating mode
Syntax: S{g}-27R[={pu(V)},{mode(m)}] where g=0,1, m=C-Control/R-Restraint
Example: S0-27R or S1-27R=100,C or S1-27=80,R
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-32 Command

Purpose: Read/Set 32 pickup level, time delay and mode
Syntax: S{g}-{x}32[={pu(W)},{td(m)},{F/R mode},{O/U Mode}] where g=0,1 and x=blank/1
Example: S0-32 or S1-32=100,0,R,O or S0-32=10,0,F,U or S1-132=1800,20,F,O
Reference: Section 4, *Protection and Control, Directional Power Protection*

S<g>-47 Command

Purpose: Read/Set 47 pickup level and time delay
Syntax: S{g}-47[={pu(V)},{td(m)}] where g=0,1
Example: S0-47 or S1-47=100,0
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-50T Command

Purpose: Read/Set 50T pickup level and time delay
Syntax: S{g}-{x}50T[{p}][={pu(A)},{td(m)},{dir}] where g=0,1, x=blank/1, and p=P/N/Q
Example: S0-50T or S1-50TP=25,0,N or S1-150TN=3,20,F
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-51 Command

Purpose: Read/Set 51 pickup level, time delay, curve, and direction
Syntax: S{g}-51[{p}][={pu(A)},{td(m)},{crv},{dir}] where g=0,1 and p=P/Q
Example: S0-51P or S0-51P=7.5,6.5,S1,N or S1-51Q=3,2.0,S1,F
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-51N Command

Purpose: Read/Set 51N pickup level, time delay and curve
Syntax: S{g}-{x}51N[={pu(A)},{td(m)},{crv},{dir}] where x=blank/1 and g=0,1
Example: S0-51N or S0-51N=7.5,6.5,S1,N or S1-151N=3,2.0,S1,F
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-59 Command

Purpose: Read/Set 59 pickup level and time delay
Syntax: S{g}-59[{p}][={pu(V)},{td(m)}] where g=0,1 and p=P/X
Example: S0-59P or S1-59P=100,0 or S1-59X=80,20 S1-159X=80,20
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-62 Command

Purpose: Read/Set 62 Time Delay
Syntax: S{g}-{x}62[={t1},{t2}] where g=0,1 & t suffix m=msec,s=sec,c=cycle
Example: S0-62=500m,200m or S0-62=0.5s,0.2s or S1-162=30c,12c
Reference: Section 4, *Protection and Control, General Purpose Logic Timers*

S<g>-67N Command

Purpose: Read/Set 67 Neutral Polarizing Mode and Quantities
Syntax: S{g}-67N[={mode},{quantity}] where g=0,1, mode=QVI/QV/QI/VI/Q/V/I
Example: S0-67N or S0-67N=QVI,V0IN or S1-67N=VI,VXIG or S1-67N=V,VXIG
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-79 Command

Purpose: Read/Set 79 Time Delay
Syntax: S{g}-79[#][={td}] where g=0,1 & t suffix m=msec,s=sec,c=cy
Example: S0-791=100m or S0-792=0.5s or S0-793=60c
Reference: Section 4, *Protection and Control, Reclosing*

S<g>-79SCB Command

Purpose: Read/Set 79 Sequence Controlled Block Output
Syntax: S{g}-79SCB[={step list}] where g=0,1
Example: S0-79SCB=2/4
Reference: Section 4, *Protection and Control, Reclosing*

S<g>-81 Command

Purpose: Read/Set 81 pickup level, time delay, and mode
Syntax: S{g}-{x}81[={pu(Hz)},{td(m)},{mode}] where g=0,1 and x=blank/1/2/3/4/5
Example: S0-81 or S0-81=59.00,6.5,U or S1-81=60.50,2.0,O or S1-81=0.2,0,R
Reference: Section 4, *Protection and Control, Frequency Protection*

S<g>-81INH Command

Purpose: Read/Set 81 Under Voltage Inhibit level
Syntax: S{g}-81INH[={pu(V)},{NegSeq(%)},{Over(Hz)},{Under(Hz)}] where g=0,1
Example: S0-81INH or S0-81INH=80,5,70,40 or S1-81INH=0,7,65,55
Reference: Section 4, *Protection and Control, Frequency Protection*

SP-60FL Command

Purpose: Read/Set 60 Fuse Loss Blocking
Syntax: SP-60FL[={I_Blk},{V_Blk}] I_Blk=ENA/DIS, V_Blk=DIS/PNQ/PN/PQ/NQ/P/N/Q
Example: SP-60FL or SP-60FL=ENA,PNQ or SP-60FL=DIS,DIS
Reference: Section 4, *Protection and Control, Voltage Transformer Fuse Loss Detection*

SP-BF Command

Purpose: Read/Set the Breaker Failure Timer Setting
Syntax: SP-BF[={time}[m/s/c]] where m=msec,s=sec,c=cycle
Example: SP-BF or SP-BF=50m or SP-BF=3c
Reference: Section 4, *Protection and Control, Breaker Failure Protection*

SP-CURVE Command

Purpose: Read/Set the user programmable 51 curve parameters
Syntax: SP-CURVE[={A},{B},{C},{N},{R}]
Example: SP-CURVE or SP-CURVE=1.0,0,0,2.5,0
Reference: Appendix A, *Time Overcurrent Characteristic Curves*

SP-GROUP Command

Purpose: Read/Program auxiliary setting group 1 operation
Syntax: SP-GROUP[{g}]=[{sw_time},{sw_level},{ret_time},{ret_level},{prot_ele}]
Example: SP-GROUP, SP-GROUP1=10,75,10,50,51P or SP-GROUP1=0,0,0,0,793
Reference: Section 4, *Protection and Control, Setting Groups*

SP-79ZONE Command

Purpose: Read/Set 79 Zone Sequence Logic
Syntax: SP-79ZONE[={zone pickup logic}]
Example: SP-79ZONE or SP-79ZONE=50TPPU+50TNPU
Reference: Section 4, *Protection and Control, Reclosing*

Global Commands

GS-PW Command

Purpose: Read/Set Password and password access port(s)
Syntax: GS-PW[{t}[={password},{com ports(0/1/2)}]] where t=G/S/C/R
Example: GS-PWG=TEST,0 or GS-PWS=XYZ,1/2
Reference: Section 9, *Security*

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SECTION 12 • INSTALLATION

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SECTION 12 • INSTALLATION

GENERAL

BE1-IPS100 Intertie Protection Systems are delivered with an instruction manual and BESTCOMS software in a sturdy carton to prevent shipping damage. Upon receipt of the relay, check the model and style number against the requisition and packaging list for agreement. If there is evidence of shipping damage, file a claim with the carrier and notify the Basler Electric Regional Sales Office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois.

If the BE1-IPS100 is not installed immediately, store it in the original shipping package in a moisture and dust free environment.

CONTACT SENSING INPUT JUMPERS

NOTE

The BE1-IPS100 relay are delivered with the input jumpers set to the HIGH position. Read the following paragraphs closely before placing the relay in service.

Four contact sensing inputs provide external stimulus to initiate BE1-IPS100 actions. An external wetting voltage is required for the contact sensing inputs. The nominal voltage level of the external dc source must comply with the dc power supply input voltage ranges listed in Section 1, *General Information, Specifications*. To enhance user flexibility, the BE1-IPS100 uses wide range AC/DC power supplies that cover several common control voltages. The contact sensing input circuits are designed to respond to voltages at the lower end of the control voltage range while not overheating at the high end of the range.

Energizing levels for the contact sensing inputs are jumper selectable for a minimum of approximately 5 Vdc for 24 Vdc nominal sensing voltages, 26 Vdc for 48 Vdc nominal sensing voltages, or 69 Vdc for 125 Vdc nominal sensing voltages. See Table 12-1 for the control voltage ranges.

Table 12-1. Contact Sensing Turn-On Voltage

Nominal Control Voltage	Contact Sensing Turn-On Voltage	
	Jumper Installed (Low Position)	**Jumper Not Installed (High Position)**
24 Vdc	N/A	Approx. 5 Vdc
48/125 Vac/dc	26 to 38 Vac/dc	69 to 100 Vac/dc
125/250 Vac/dc	69 to 100 Vac/dc	138 to 200 Vac/dc

Each BE1-IPS100 is delivered without the contact sensing jumpers installed for operation in the higher end of the control voltage range. If the contact sensing inputs are to be operated at the lower end of the control voltage range, the jumpers must be installed.

The following paragraphs describe how to locate and remove/change the contact sensing input jumpers:

1. Remove the drawout assembly by loosening the two thumbscrews and pulling the assembly out of the case. Observe all electrostatic discharge (ESD) precautions when handling the drawout assembly.
2. Locate the two jumper terminal blocks that are mounted on the Digital Circuit Board. The Digital Circuit Board is the middle board in the assembly and the jumper terminal blocks are located on the component side of the circuit board. Each terminal block has two sets pins. With the jumper as installed at the factory, one pin should be visible when viewed from the side of the unit. This configuration allows the inputs to operate at the higher end of the control voltage range. Figure 12-1 illustrates the location of the jumper terminal blocks as well as the position of a jumper placed in the high voltage position.

3. To select operation at the lower end of the control voltage range, install the jumper across the two pins. Use care when removing and installing each jumper so that no components are damaged.
4. When all jumpers are positioned for operation in the desired control voltage range, prepare to place the drawout assembly back into the case.
5. Align the drawout assembly with the case guides and slide the assembly into the case.
6. Tighten the screws.

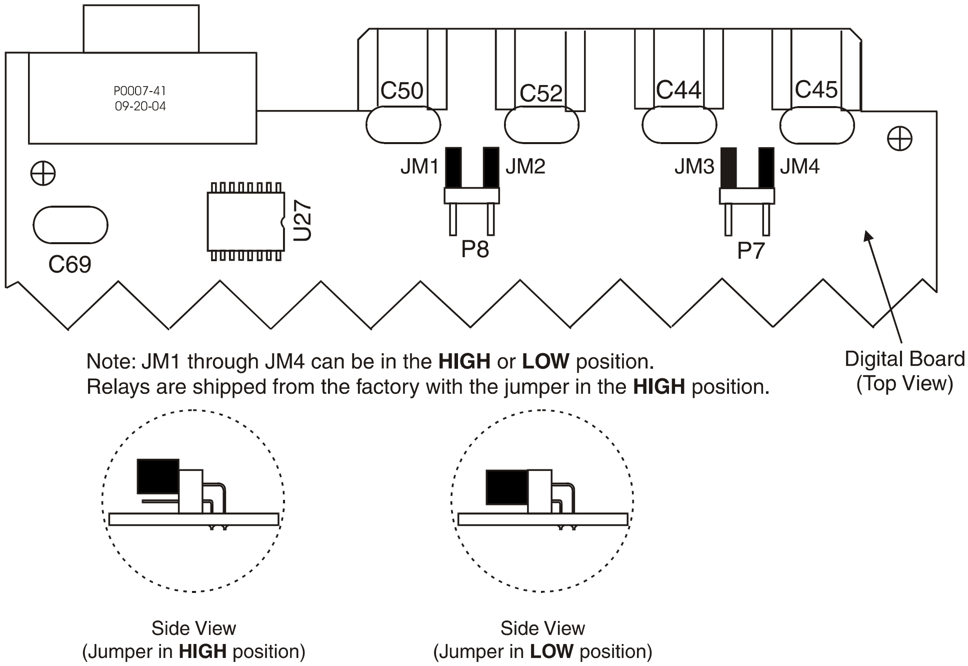


Figure 12-1. Contact Sensing Jumper Locations

REGISTRATION OF RELAY

End users are encouraged to register their relays with Basler Electric. A label on each relay directs users to complete registration on-line at http://www.basler.com/register. Registering your relays(s) with Basler Electric will give you Internet access to the latest BESTCOMS software and firmware updates for your devices. In addition, registration also allows Basler Electric to contact you if a problem is found in the design or manufacturing of our products that might affect you. The registration process only takes a few minutes. Please have the serial number(s) of your relay(s) available when registering.

MOUNTING

Basler numeric relays are supplied in fully-drawout, H1 or S1 cases that can be mounted at any convenient angle. The H1 case can be adapted to a panel or rack for single or double case mounting.

H1 Case Cutouts and Dimensions

H1 package dimensions are shown in Figure 12-2. Adapter bracket 9289924100 allows a single relay to be mounted in a 19-inch rack (see Figure 12-3). A second adapter bracket (9289929100) performs the same function but includes a cutout for an ABB FT switch (see Figure 12-4). Two escutcheon plates are available for panel mounting. Part number 9289900017 is used for panel mounting a single relay. Escutcheon plate 9289900016 is used to panel mount two dovetailed relays. Mounting plate cutout and drilling dimensions for a single H1 relay are shown in Figure 12-5. If a single H1 relay is to be panel mounted without an escutcheon plate, the cutout and drilling dimensions of Figure 12-6 should be used. Mounting plate cutout and drilling dimensions for two dovetailed H1 relays are shown in Figure 12-7. Figure 12-8 gives the cutout and drilling dimensions for panel mounting two dovetailed cases without an escutcheon plate.

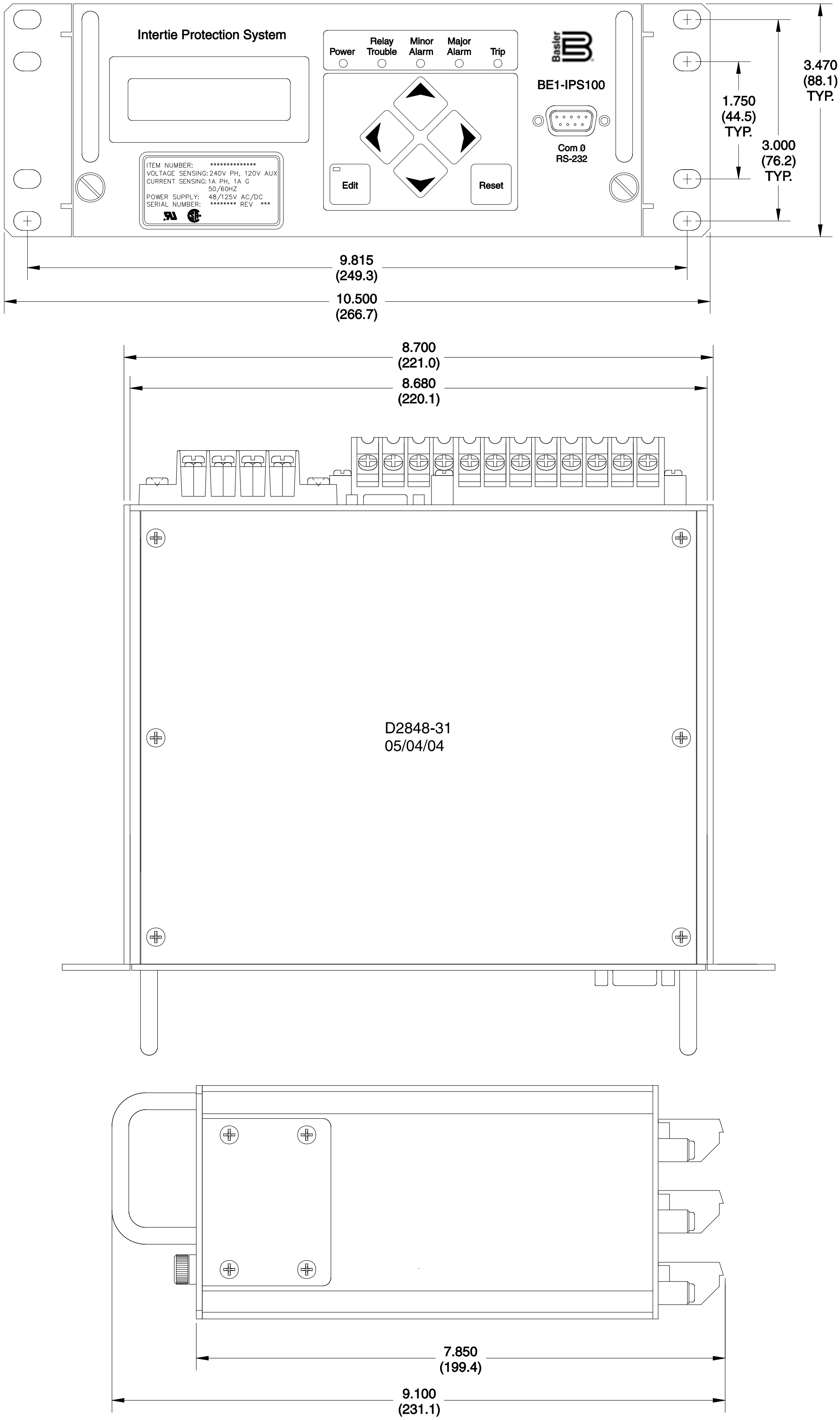


Figure 12-2. H1 Case Dimensions

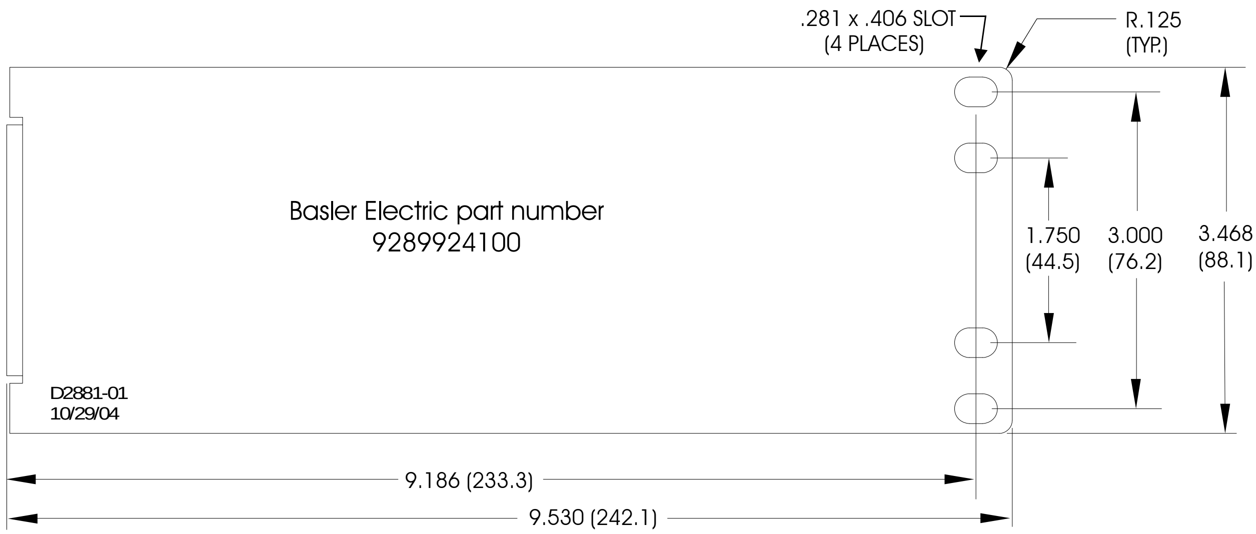


Figure 12-3. Adapter Bracket for Mounting a Single Relay in a 19-inch Rack

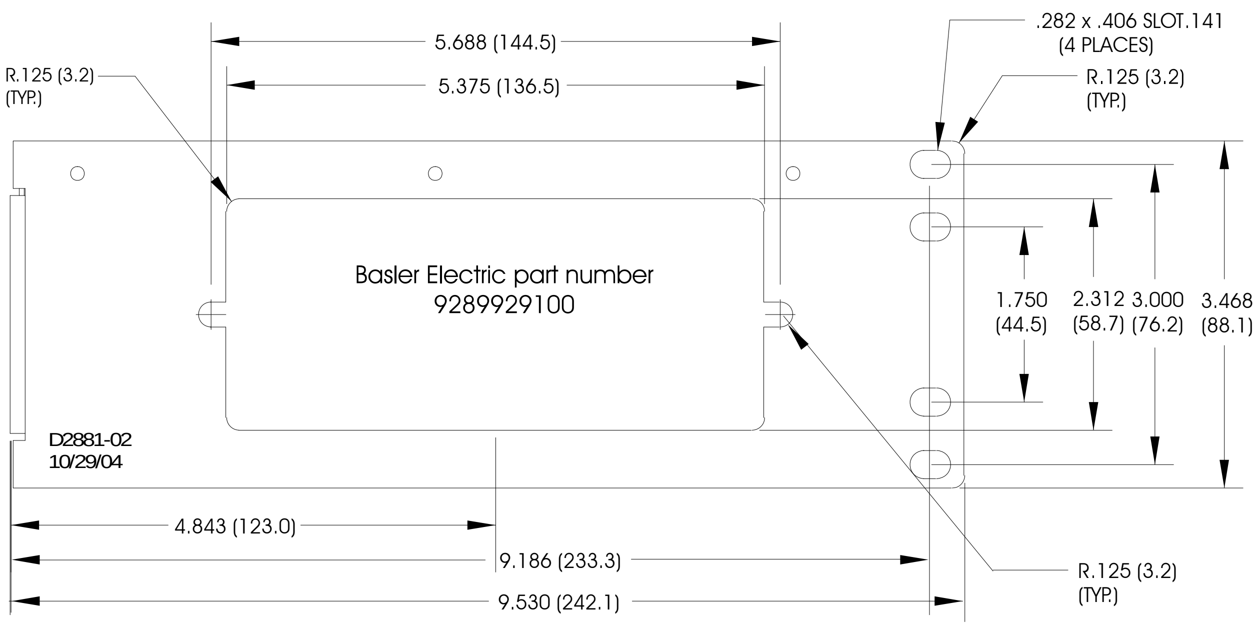
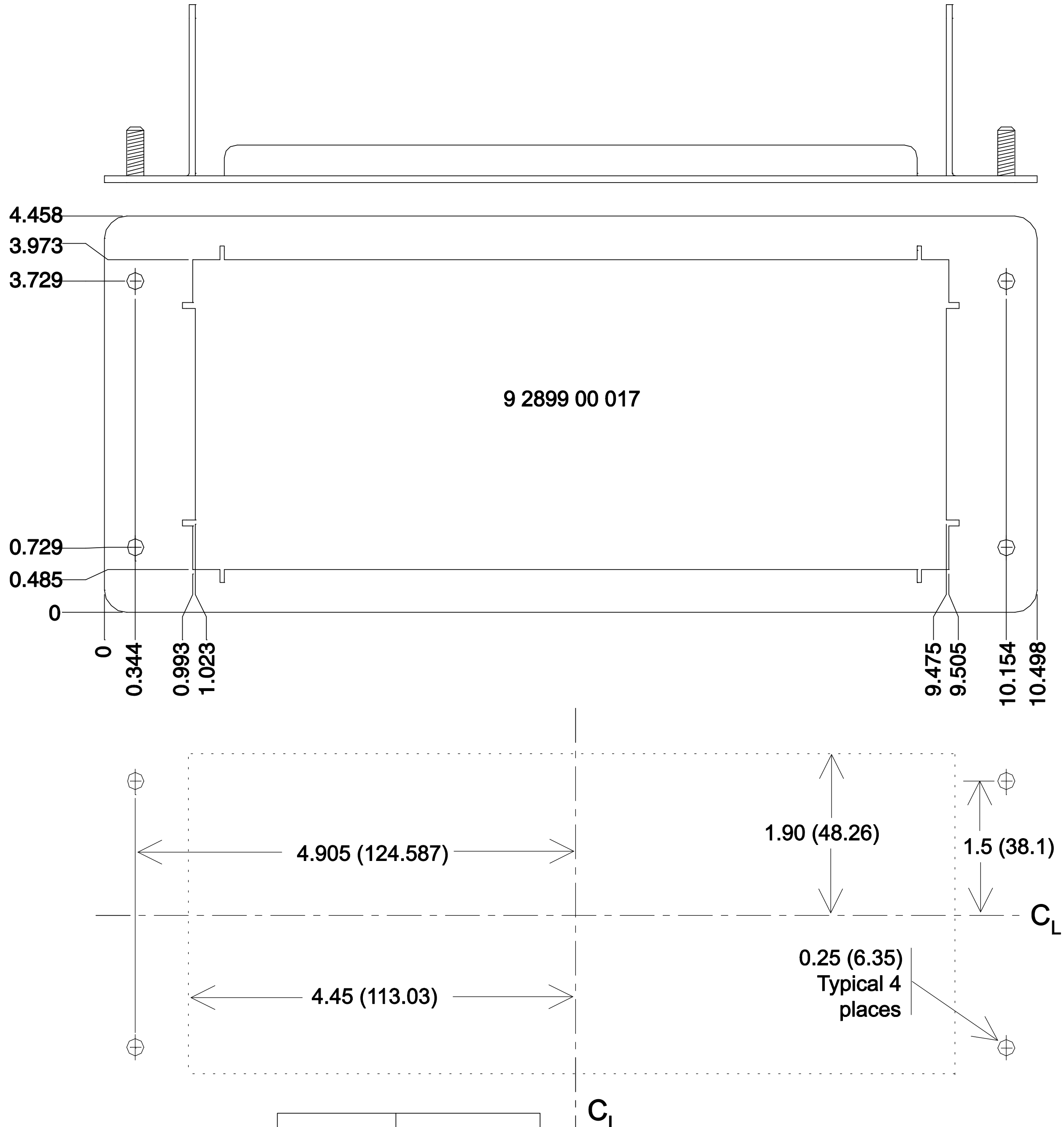


Figure 12-4. Adapter Bracket for 19-inch Rack Mount with ABB FT Cutout Switch



Inches	Millimeters
0	0
0.344	8.738
0.485	12.319
0.729	18.517
0.993	25.222
1.023	25.984
3.729	94.717
3.973	100.914
4.458	113.233
9.475	240.665
9.505	241.427
10.154	257.912
10.498	266.650

Figure 12-5. Single H1 Relay Escutcheon Plate and Cutout Dimensions

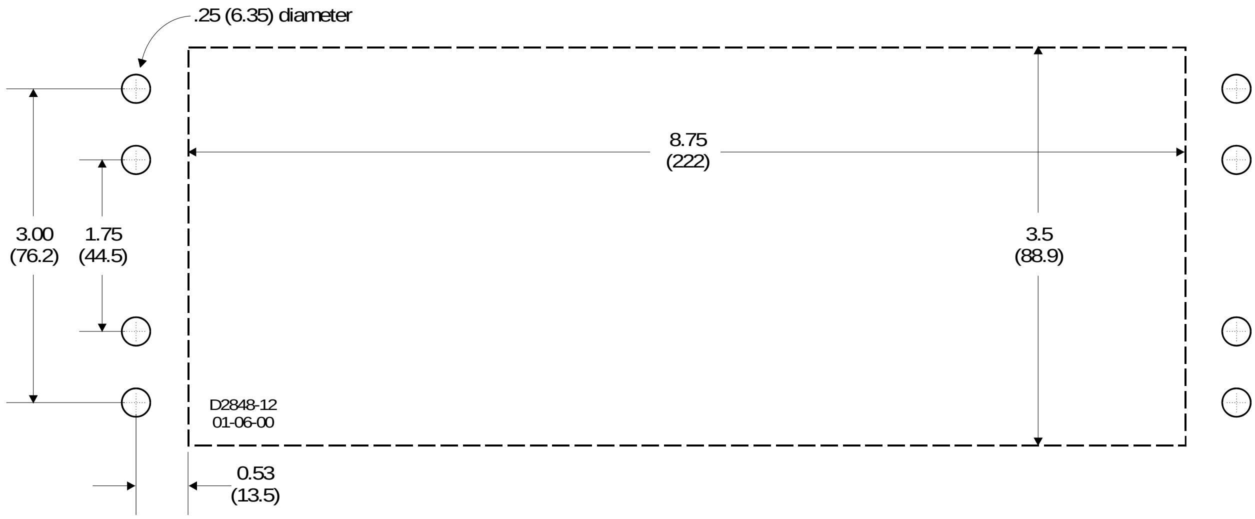


Figure 12-6. Single H1 Relay Mounting Dimensions for Panel Mounting without an Escutcheon Plate

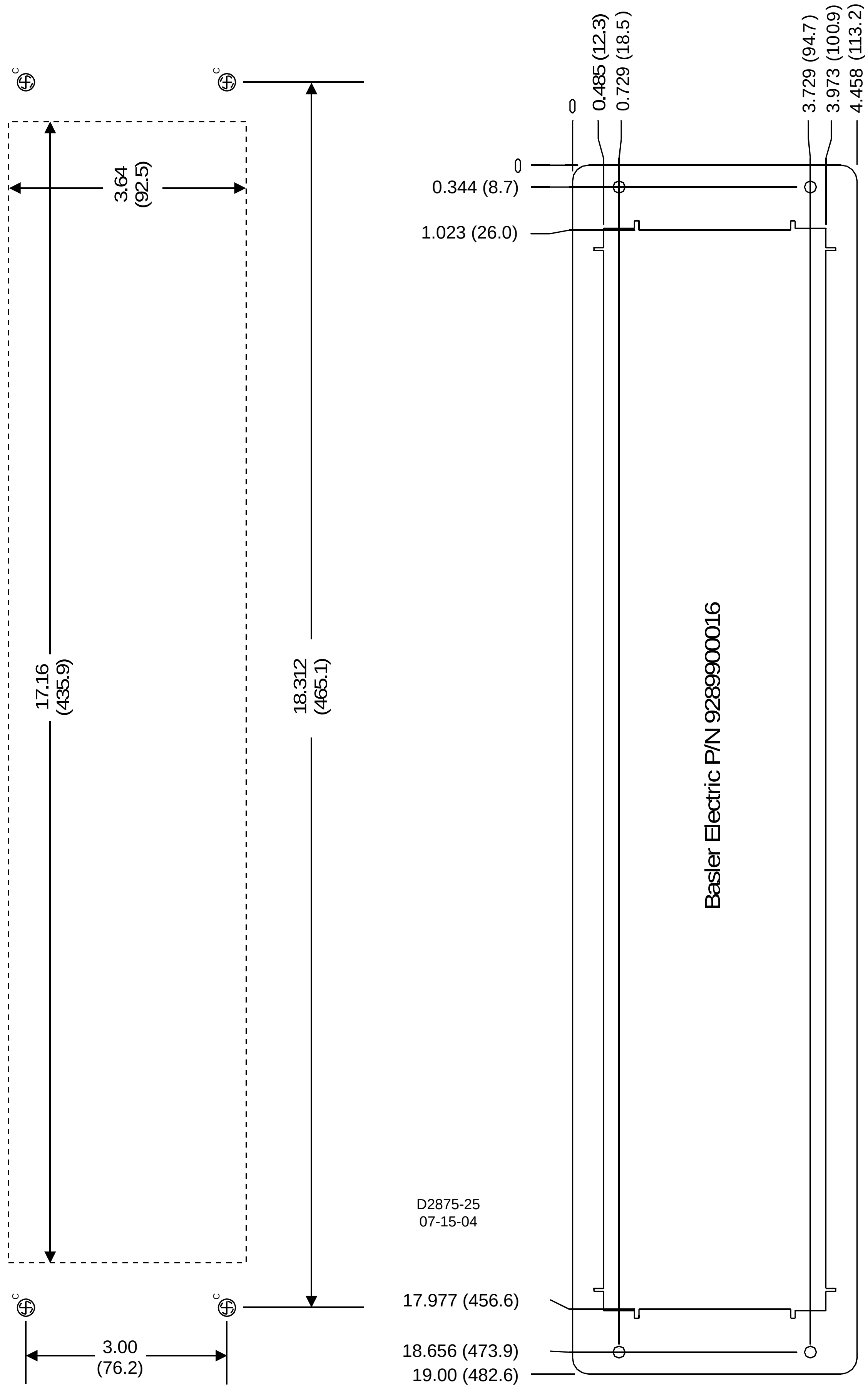


Figure 12-7. Dovetailed H1 Relay Escutcheon Plate and Cutout Dimensions

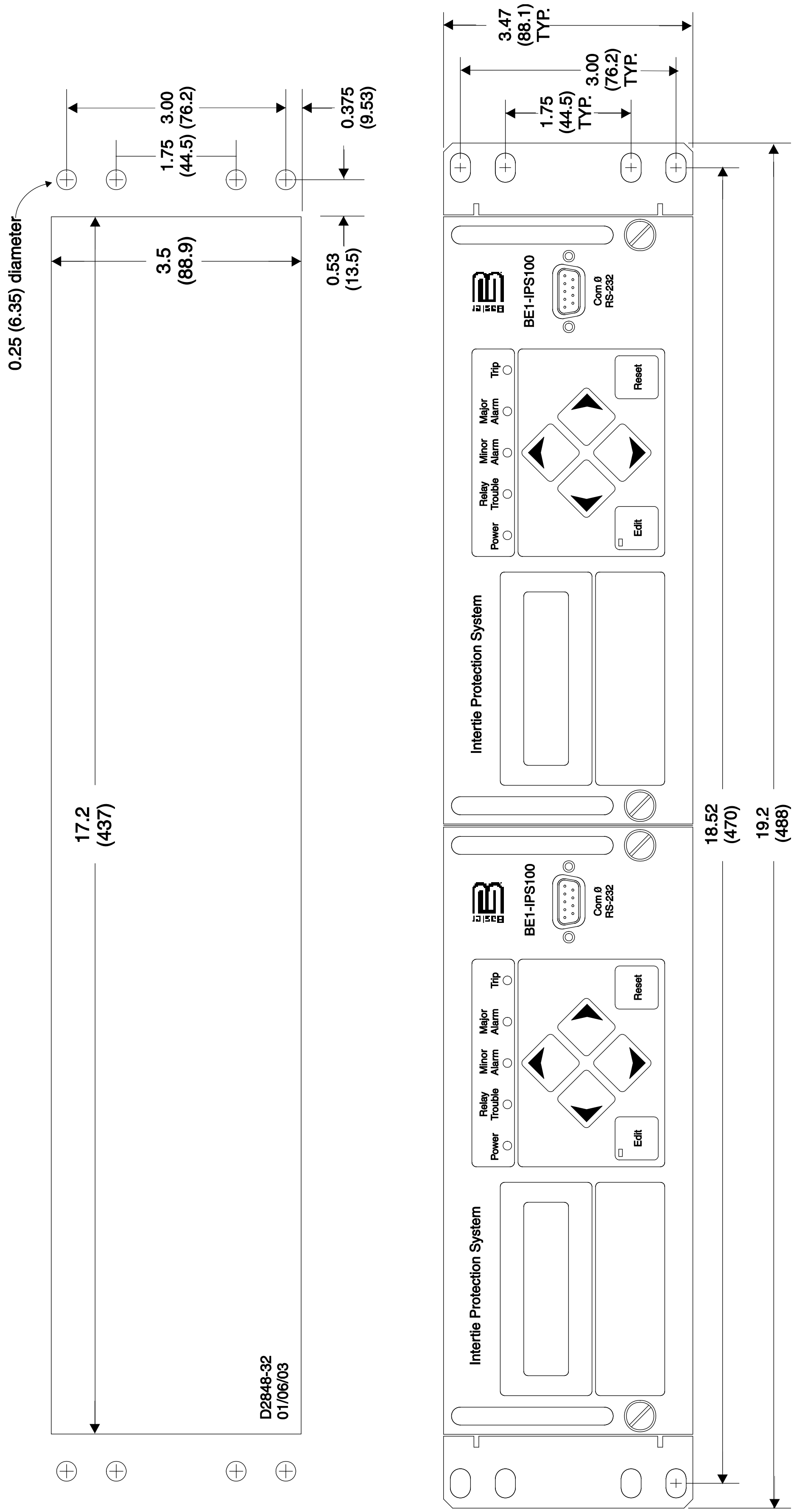


Figure 12-8. Mounting Dimensions for Panel Mounting Two H1 Relays without an Escutcheon Plate

S1 Case Cutouts and Dimensions

Refer to Figures 12-9 through 12-11 for relay outline dimensions and panel drilling diagrams.

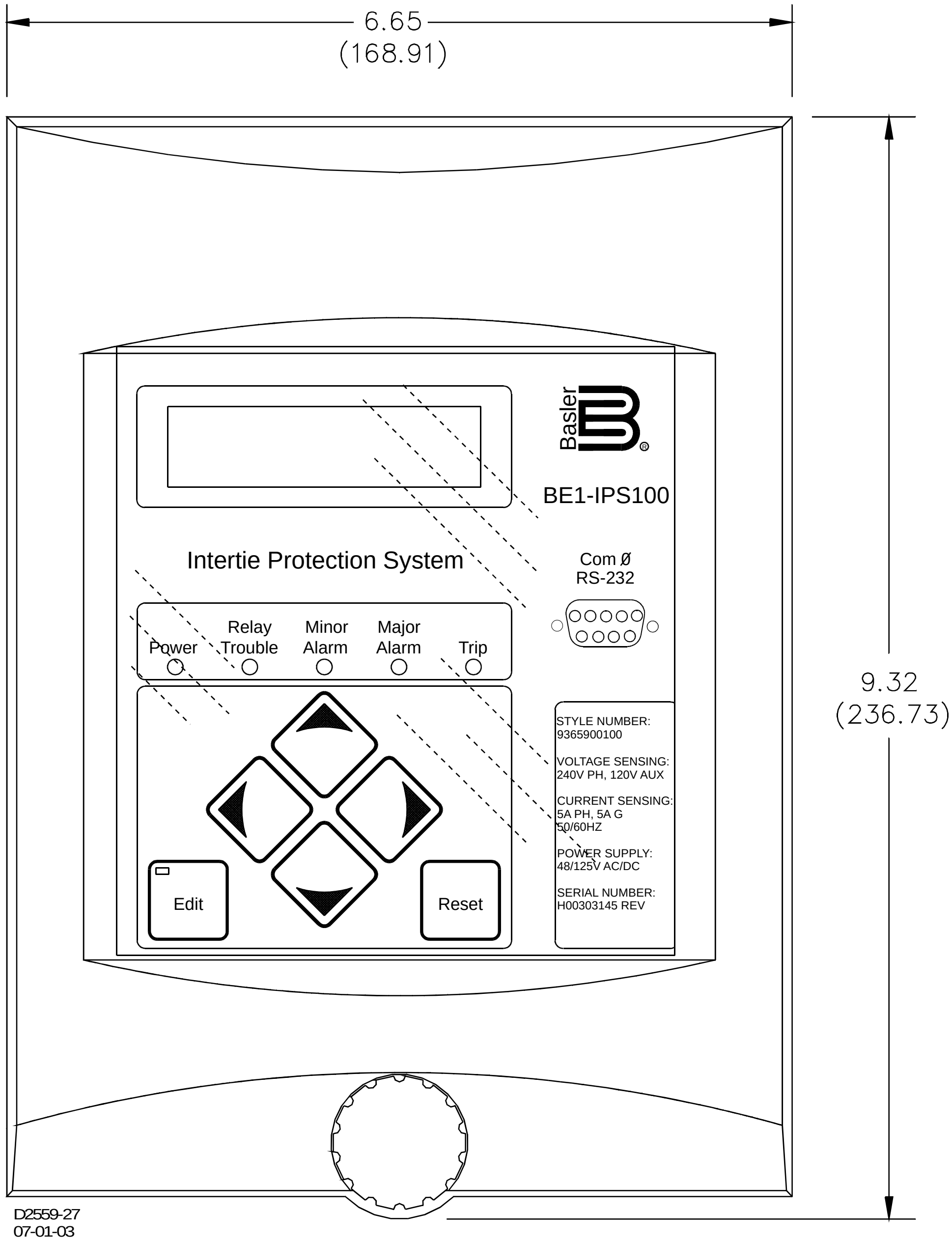


Figure 12-9. S1 Case, Outline Dimensions, Front View

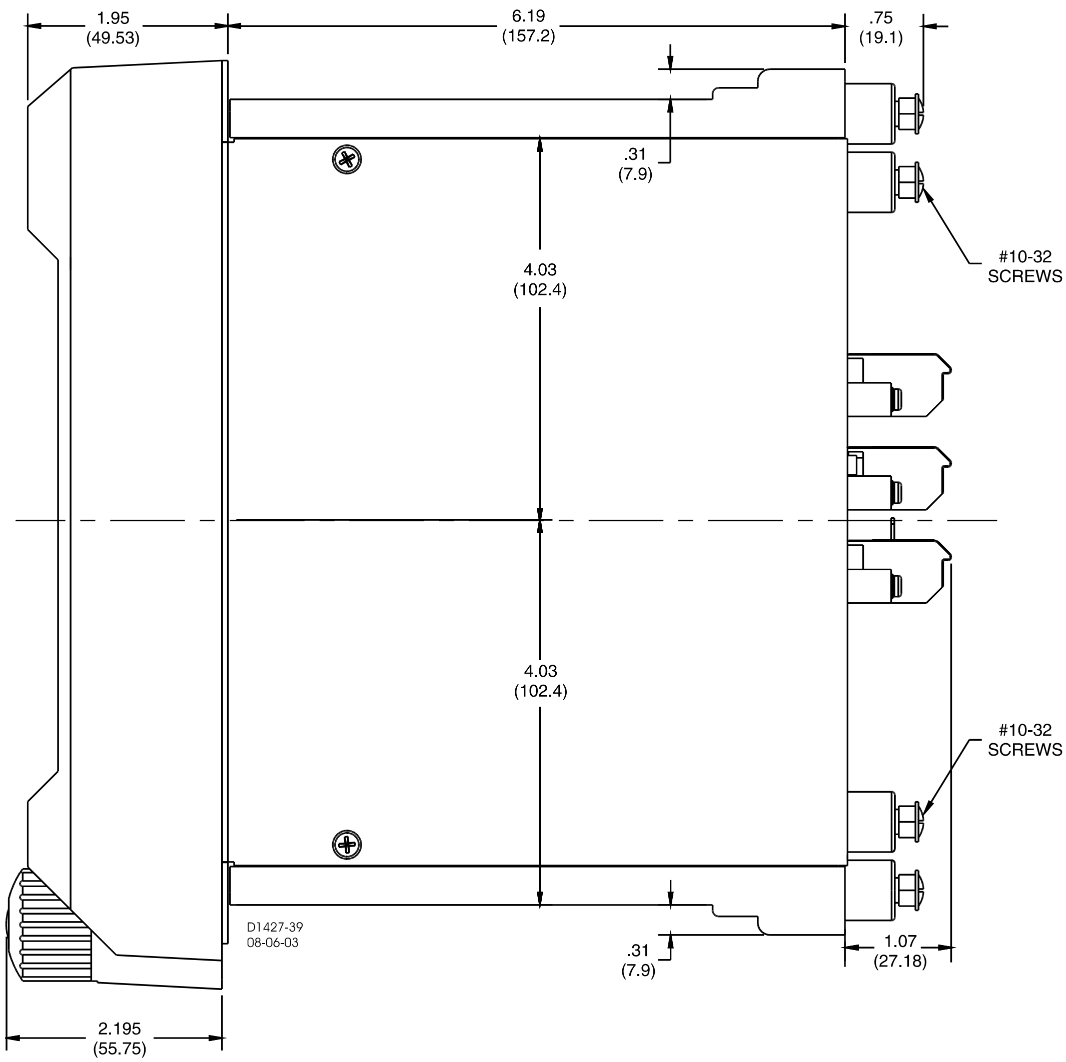


Figure 12-10. S1 Case, Double-Ended, Semi-Flush Mounting, Outline Dimensions, Side View

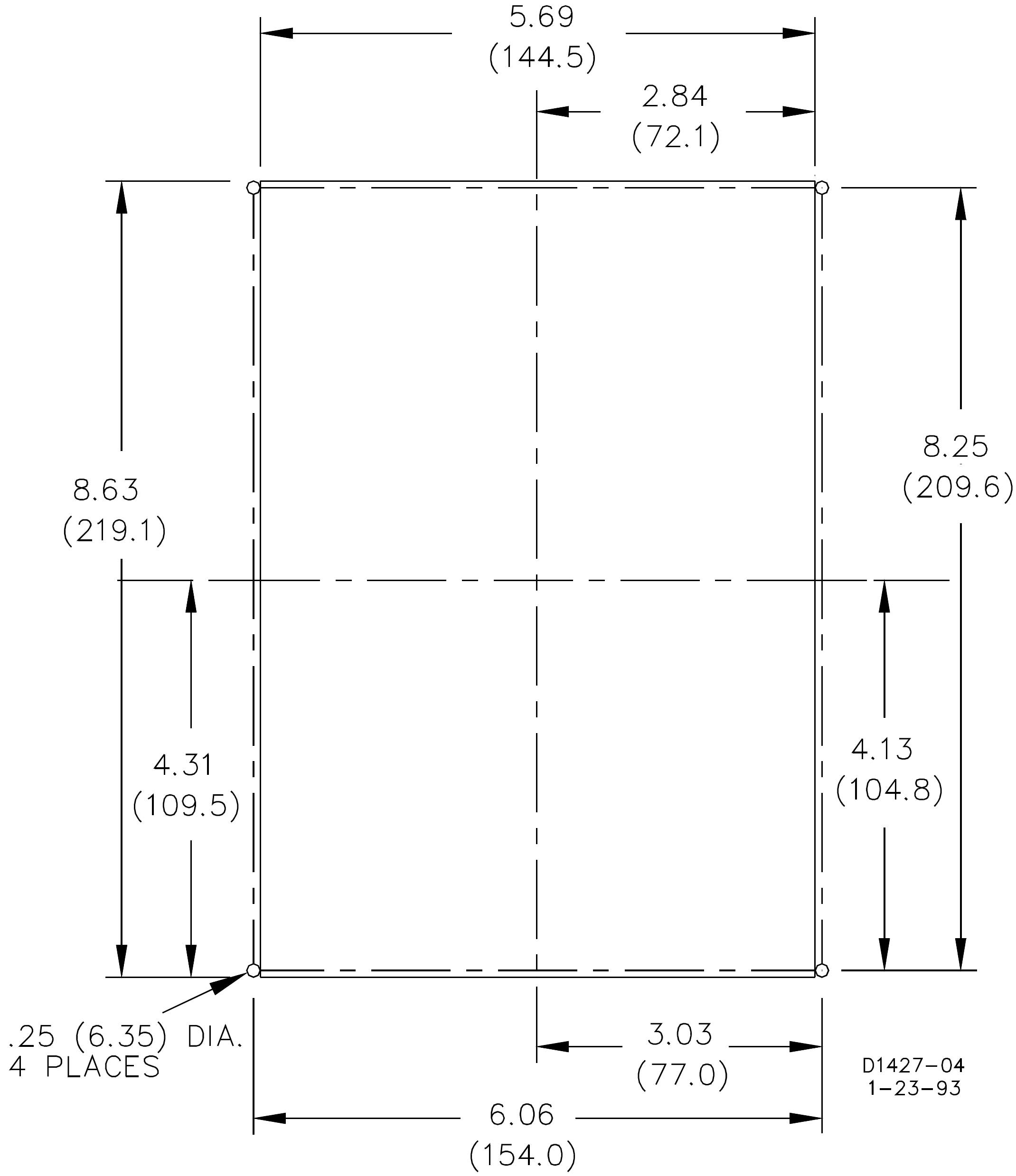


Figure 12-11. S1 Case, Panel Drilling Diagram, Semi-Flush Mounting

Dovetailing Procedure

Basler H1 cases can be interlocked by means of a tenon and mortise on the left and right sides of each case. The following paragraphs describe the procedure of dovetailing two cases. Figure 12-12 illustrates the process.

Step 1: Remove the draw-out assembly from each case by rotating the two captive, front panel screws counterclockwise and then sliding the assembly out of the case. Observe electrostatic discharge (ESD) precautions when handling the draw-out assemblies.

Step 2: Remove the mounting bracket from the side of each case where the two cases will mate. Each bracket is held in place by four Phillips screws.

Step 3: The rear panel must be removed from one of the cases in order for the two cases to be joined. On that panel, remove the Phillips screw from each corner of the rear panel except for the screw at the upper left-hand corner (when looking at the rear of the case). This screw is closest to Terminal Strip A.

Step 4: Turn the screw nearest to Terminal Strip A counterclockwise until the rear panel can be removed from the case. If you have difficulty removing this screw, use the alternate method described in Step 4a. Otherwise, proceed to Step 5.

Step 4a: Use a Torx® T15 driver to remove the two screws attaching Terminal Strip A to the rear panel. Remove the terminal strip and set it aside. Remove the remaining Phillips screw from the rear panel and set the rear panel aside.

Step 5: Arrange the two cases so that the rear dovetailed edge of the case without a rear panel is aligned with the front dovetailed edge of the case with the rear panel installed. Once the dovetails are aligned, slide the cases together.

Step 6: Position the rear panel on the case from which it was removed. Make sure that the panel orientation is correct. Perform Step 6a if Terminal Strip A *was not* removed during the disassembly process. Perform Step 6b if Terminal Strip A *was* removed during disassembly.

Step 6a: Position the rear panel over the case and align the screw closest to Terminal Strip A with its mating hole. Tighten the screw while maintaining proper alignment between the rear panel and case. Finish attaching the panel to the case by installing the remaining three Phillips screws. When installed, the rear panels prevent the two cases from sliding apart.

Step 6b: Align the rear panel with the case and install the four Phillips screws that hold the rear panel in place. Position Terminal Strip A in its panel opening and replace the two Torx® T15 screws. When installed, the rear panels prevent the two cases from sliding apart.

Step 7: Mount the case assembly in the desired rack or panel opening and reinstall the draw-out assembly in each case.

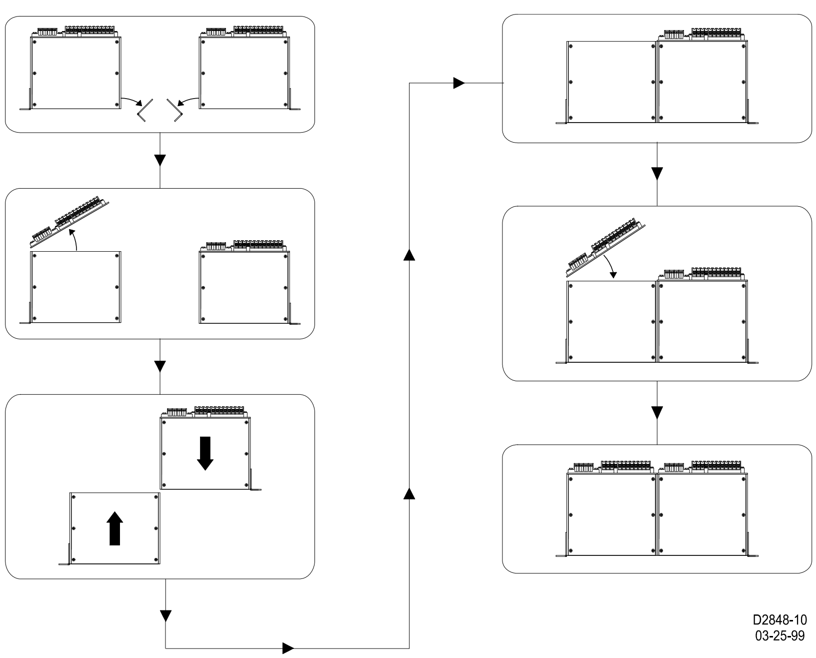


Figure 12-12. Dovetailing Procedure

RELAY CONNECTIONS

Connections to the relay are dependent on the application and logic scheme selected by the user. As a result, all of the relay's inputs and outputs may not be used for a given application. Before energizing a relay, make sure the connections match the options associated with the model and style number found on the relay nameplate. Refer to Figure 1-1, *Style Chart*, in Section 1, *General Information*, for available options. Be sure to use the correct input power for the specified power supply. Incorrect wiring may result in damage to the relay.

Figure 12-13 shows the rear-panel connections for an H1 style case and Figure 12-14 shows an S1 case.

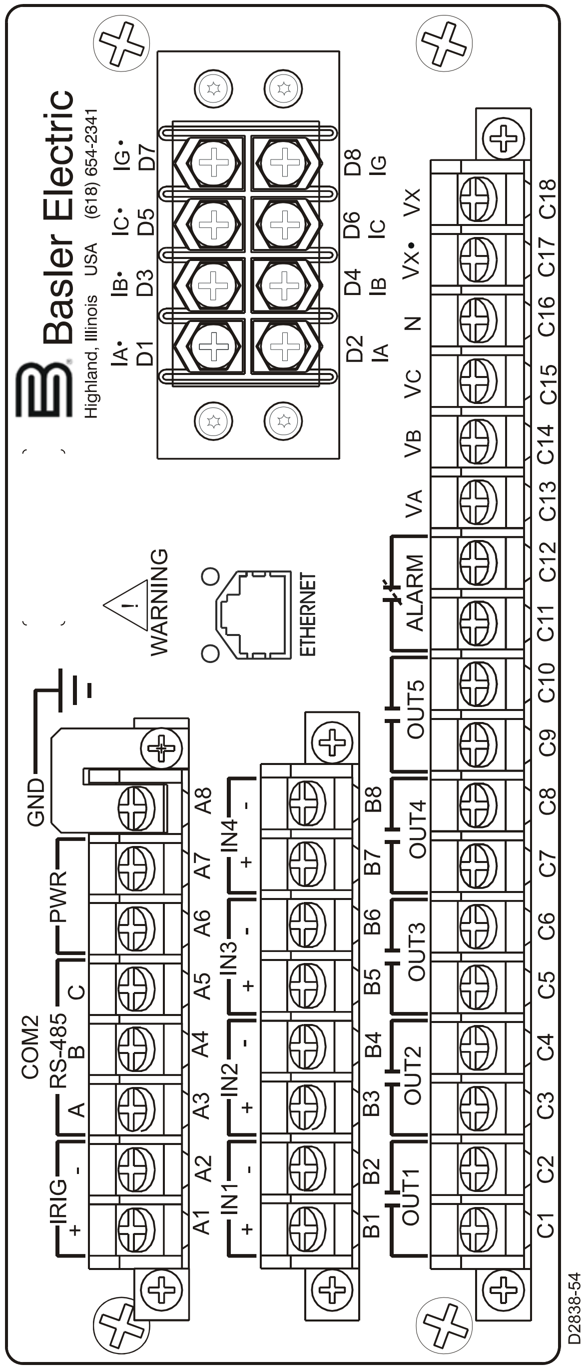
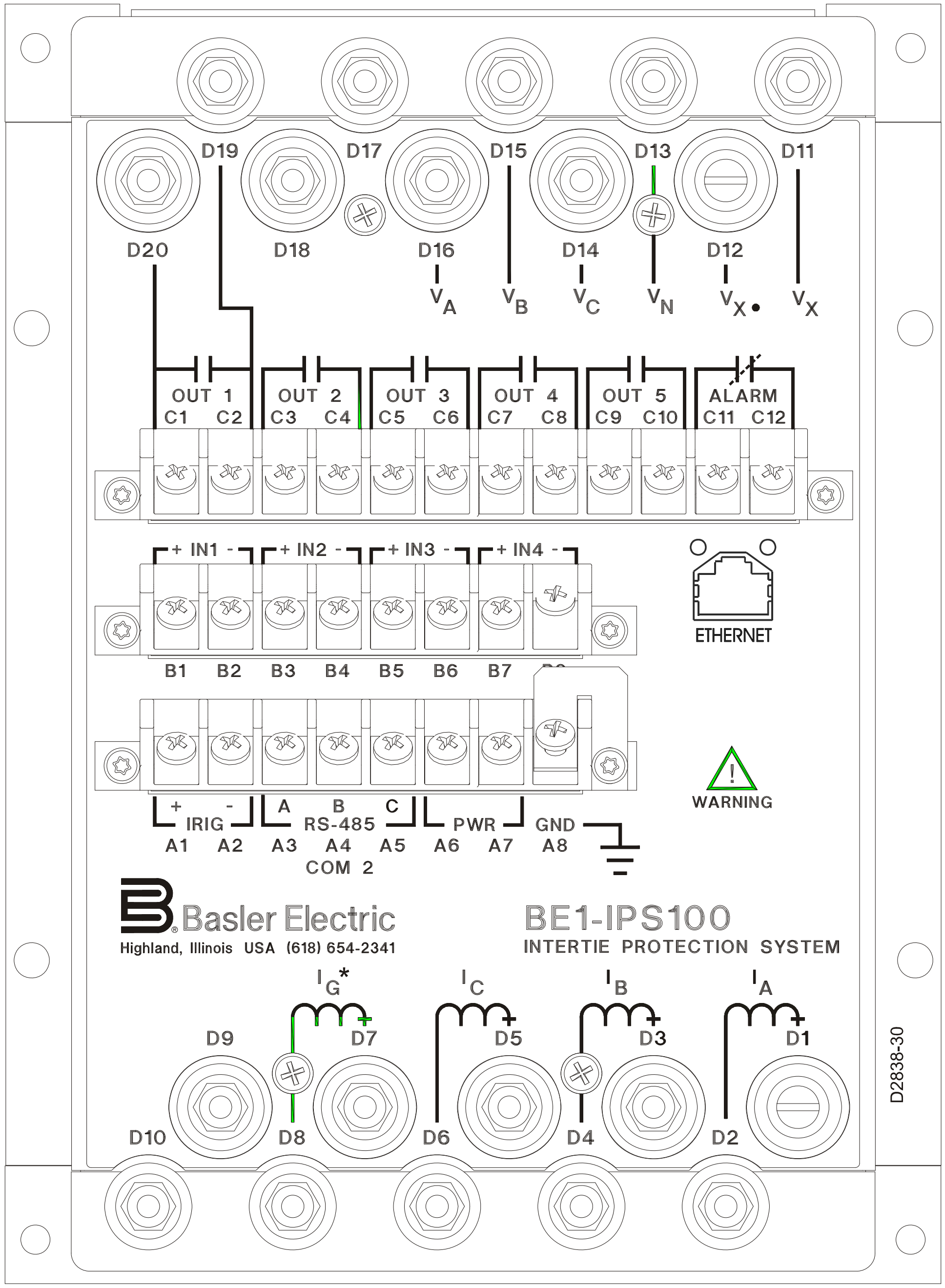


Figure 12-13. H1 Case Rear Panel Terminal Connections



* I_G INPUT IS OPTIONAL

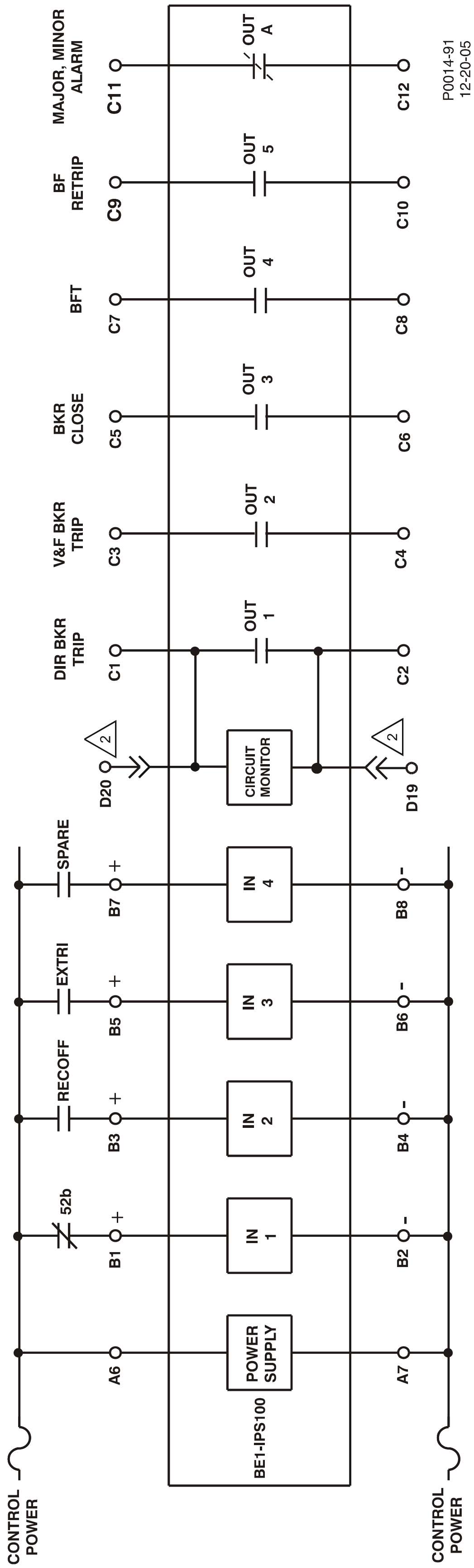
Figure 12-14. S1 Case Rear Terminal Connections

Typical DC and AC Connections

Typical external DC and AC connections for the BE1-IPS100 are shown in Figures 12-15 and 12-16.

NOTE

The relay should be hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the rear ground terminal of the relay case. When the relay is configured in a system with other protective devices, a separate ground bus lead is recommended for each relay.



NOTES: 1. Connections shown are for use with the BE1-IPS100-1547-C-BE pre-programmed logic scheme. This scheme provides intertie protection. All inputs and outputs are fully programmable using BESTlogic.

2 Additional output terminal connections D19 and D20 with test plug are available in S1 case, only.

Figure 12-15. Typical External DC Connections

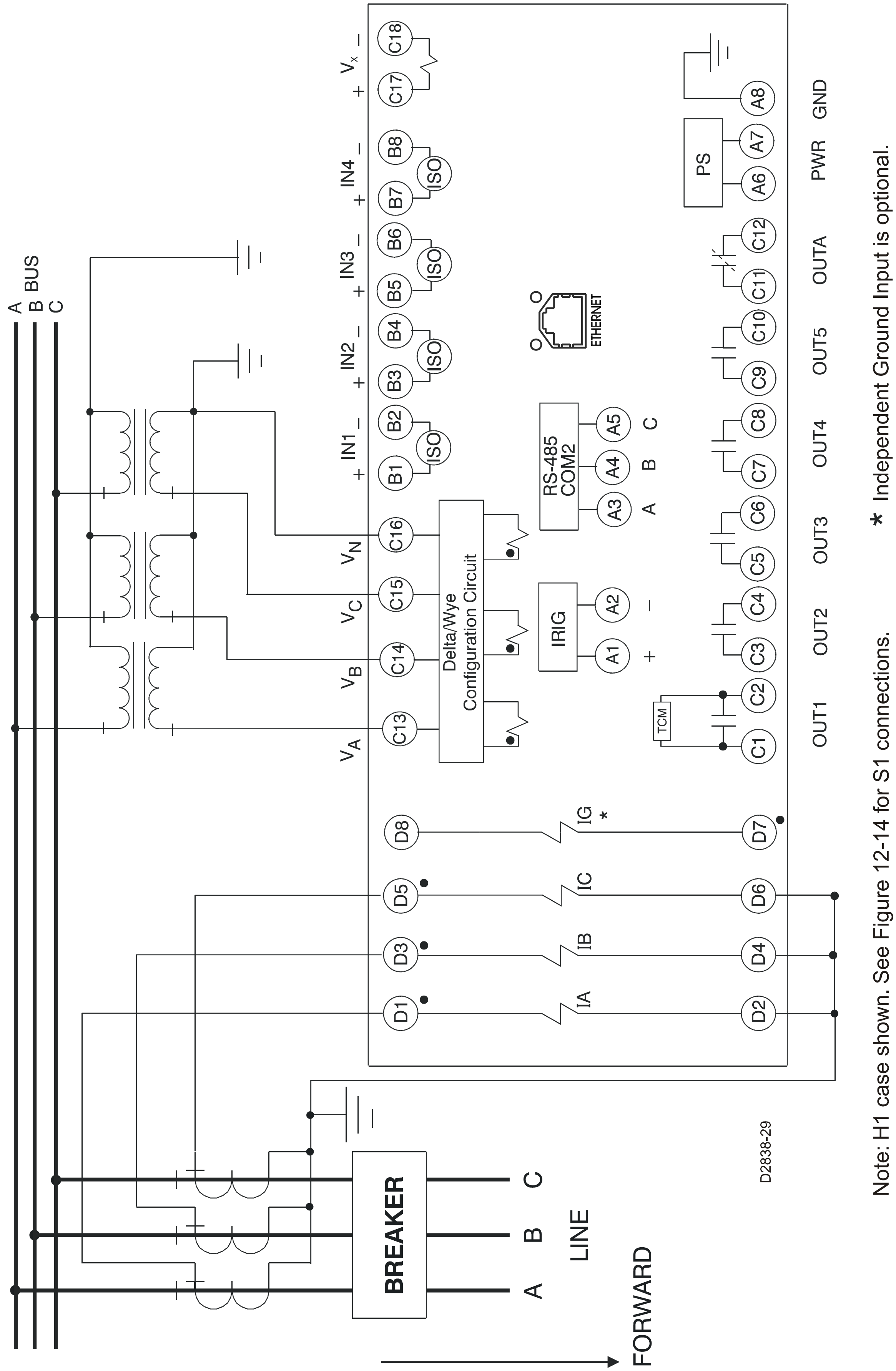


Figure 12-16. Typical AC Connections

Terminal Blocks

There are two sizes of terminal blocks used on the H1 case design, the current circuit block and the input-output blocks. The current circuit terminal block is the larger of the two types and uses 8/32 inch Phillips head screws with lock washers. The input-output block is the smaller of the two types and uses 6/32 inch slot or Phillips head screws with no washer. The S1 case design uses slotted 10-32 washerless pan-head screws for current and potential inputs. The input-output blocks are the same size as those incorporated in the H1 design and use 6/32 inch slot or Phillips head screws.

As stated, the current circuit terminal block on the H1 case uses 8/32 Phillips head screws with lock washers. The lock washer is an integral part of the current circuit wiring system and should not be removed. Without the lock washer, the 8-32 screw may bottom out preventing a tight fit against the lug (screw feels tight but lug may move under the screw head).

The maximum wire lug width accommodated by the current circuit terminal block on the H1 case is 0.344 inches (8.6 mm). The maximum wire lug width accommodated by the input-output block on the case is 0.320 inches (8.1 mm).

NOTE

Except as noted, connections to the relay should be made with a minimum wire size of 14 AWG.

CT Polarity

CT polarity is critical to the proper operation of the BE1-IPS100. The sidebar on the following page provides fundamental information on CT polarity and protective relays.

Sidebar. Current Circuit Polarity

By ANSI convention, current transformer polarity will face away from the protected winding of a transformer, motor, generator, or reactor, and away from the contacts in a circuit breaker. Therefore, primary current flow towards the winding or contacts (direction of protected zone) will result in a secondary current out X1, in phase with the primary (see Figures 12-17 and 12-18).

On occasion, however, protection engineers will run into situations where CT polarity is reversed for a specific application. That is, non-polarity of the CT secondary will be in phase with the primary current flow (Figure 12-19). For example, a transformer differential CT from a breaker with a different polarity convention such as low voltage switchgear, or a bus differential CT taken from the low side of a transformer.

Orientation of CT polarity relative to primary current flow establishes the secondary CT terminal that should be connected to polarity of the protective relay.

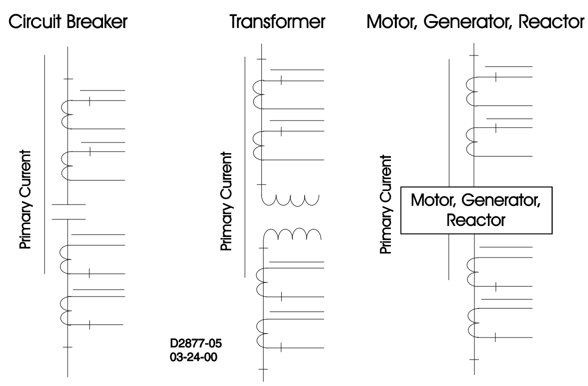


Figure 12-17. Standard CT Polarity

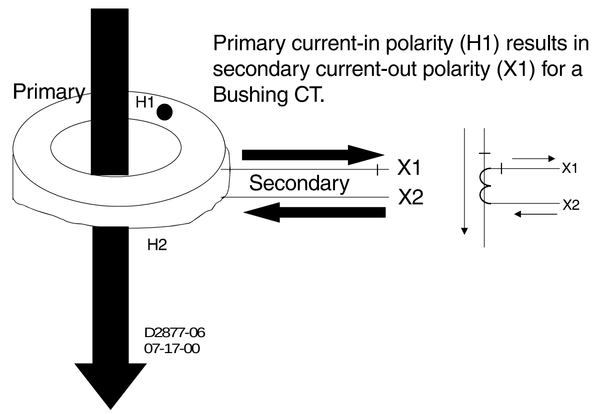


Figure 12-18. Current Transformer Action

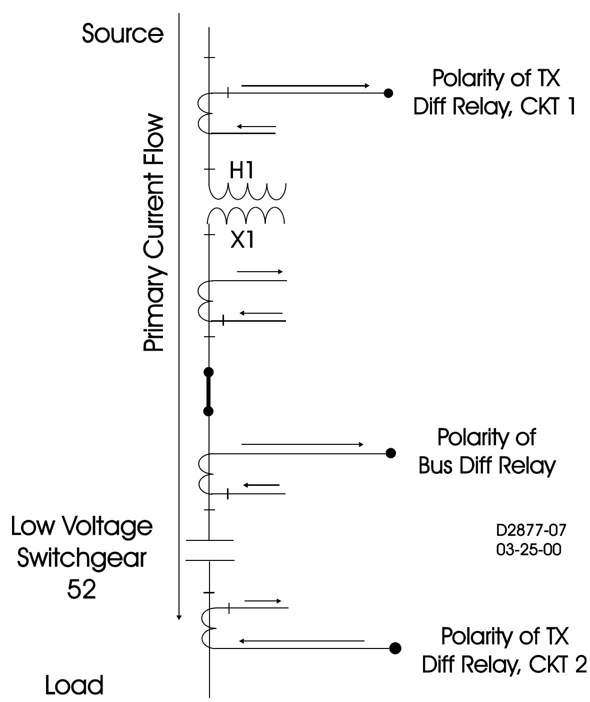


Figure 12-19. Example of Reversed CT Polarity

POWER SYSTEM APPLICATIONS

Figure 12-20 shows alternate VTP connections. Connections are shown for H1 case only. See Figure 12-14 for S1 case connections. Figures 12-21 through 12-31 are examples of the applications that can be served by the Basler Electric BE1-IPS100 Intertie Protection System. Many of these applications can be used in concert with other Basler numeric systems such as the BE1-851 Overcurrent Protection System, the BE1-951 Directional Overcurrent Protection System, the BE1-CDS220/240 Current Differential Protection Systems, or the BE1-GPS100 Generator Protection System. H1 case connections are shown throughout.

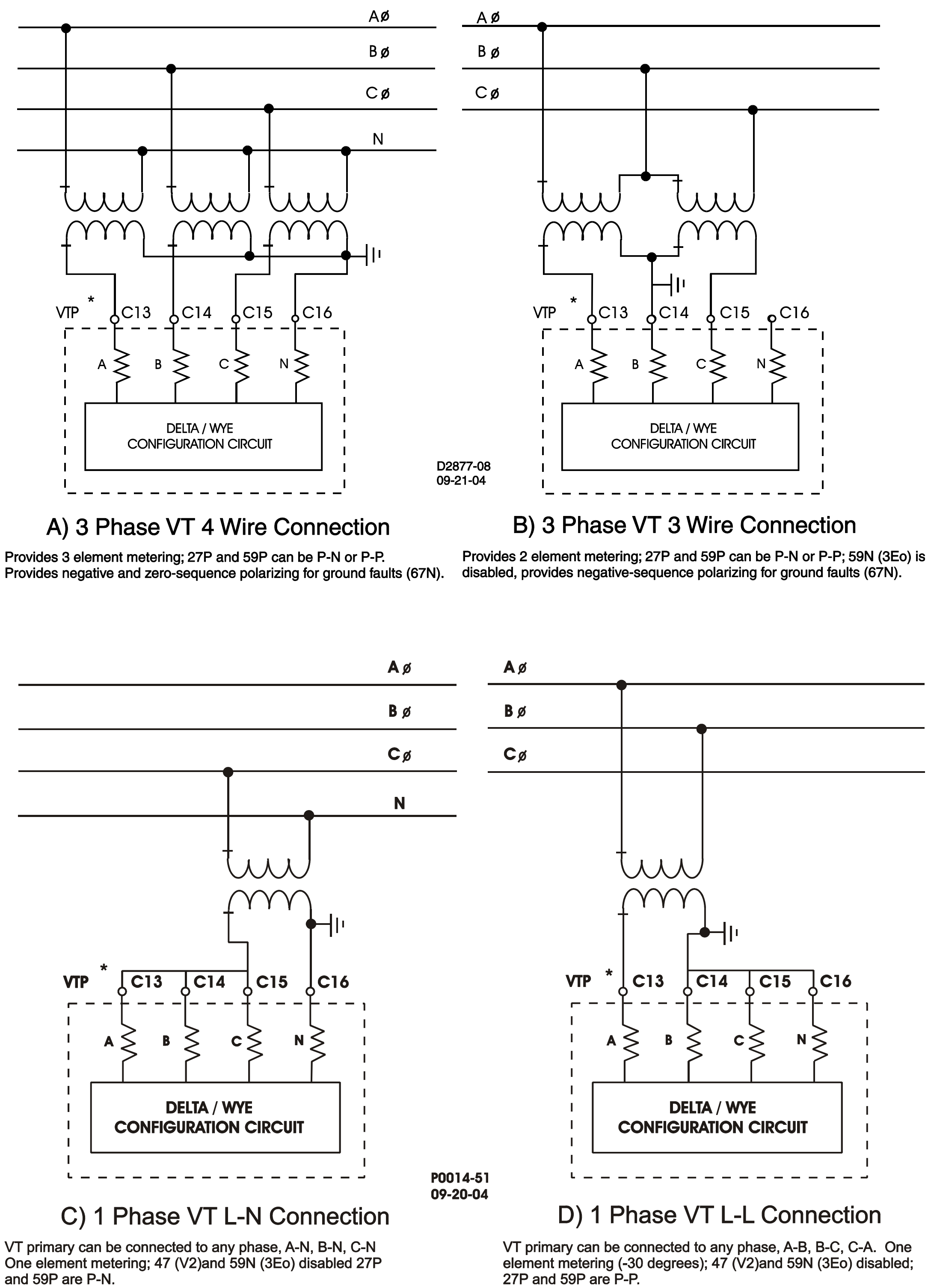
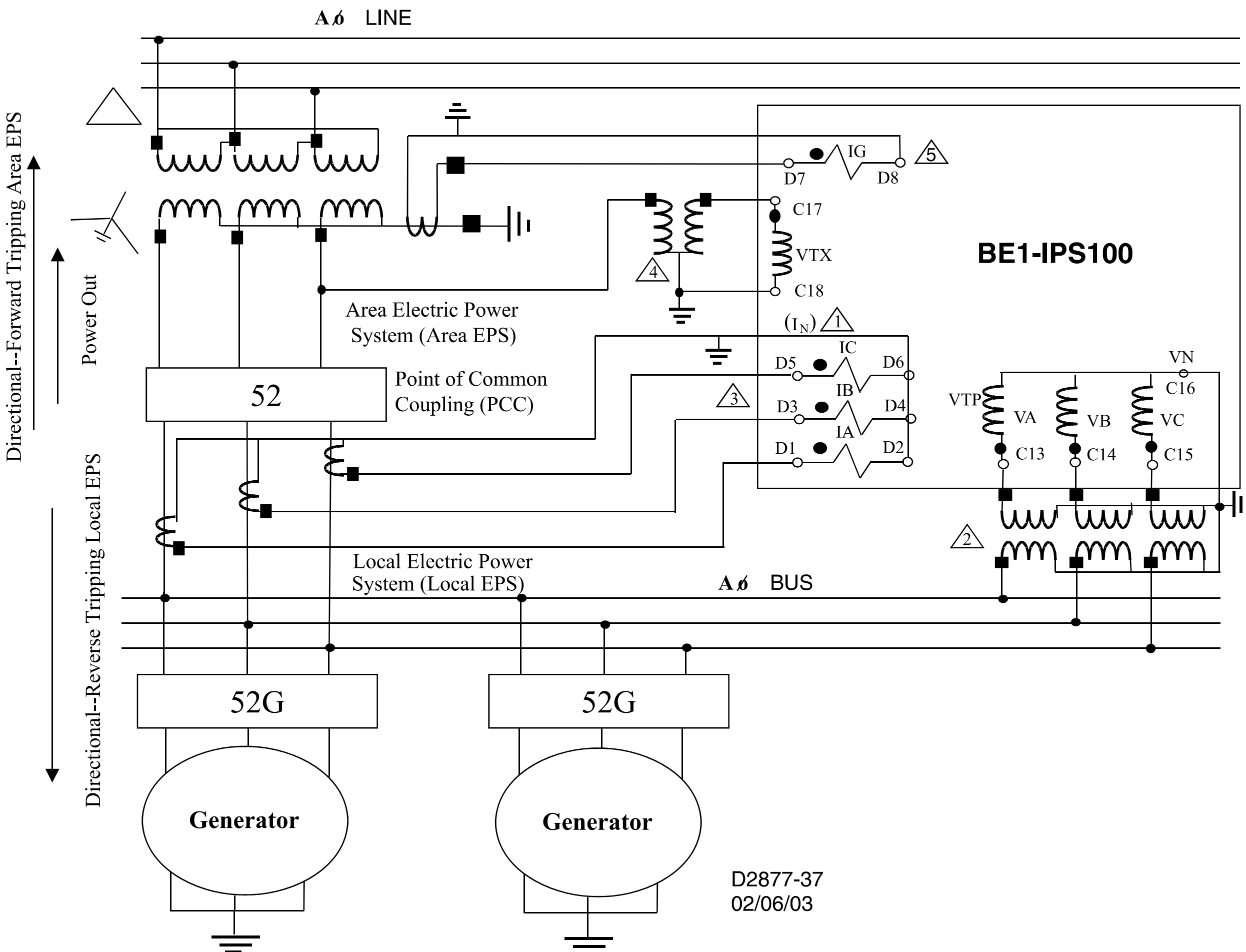


Figure 12-20. Three-Phase Voltage Sensing, Alternate VTP Inputs



Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

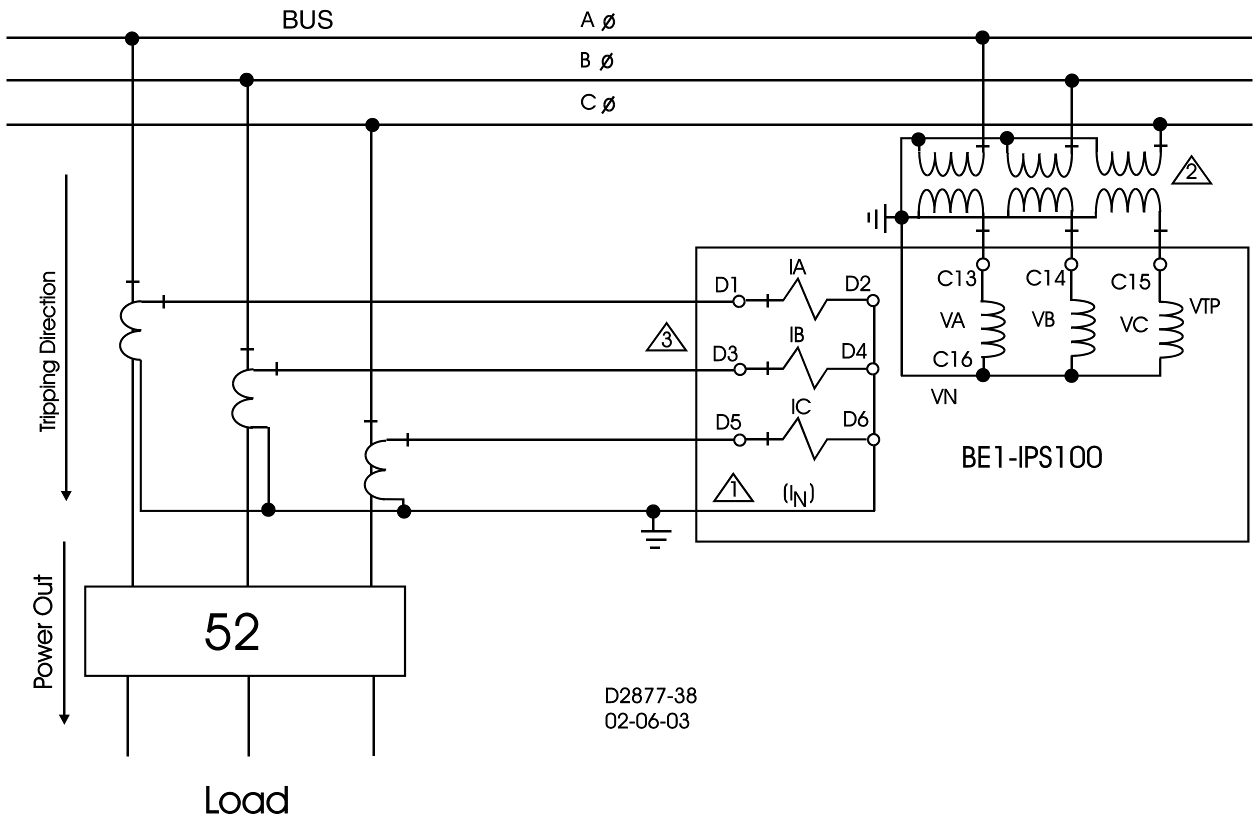
2. 4-wire connection is shown is typical. See Figure 12-20 for alternate VTP connections. The 4-wire connection provides negative and zero-sequence voltage polarizing for ground faults; 3-wire connection provides negative-sequence voltage polarizing.

3. CT polarity connected to relay polarity, power flow from Generator Bus to the Transformer is defined as power out and = "+" watts OC elements set for forward and reverse tripping.

4. VTX can be connected A-N, B-N, C-N or A-B, B-C, C-A. The relay automatically compensates for phase angle difference between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.

5. Optional Independent Ground Input (IG) connected to detect Low Side ground faults.

Figure 12-21. Intertie Protection with Forward & Reverse Directional Power & OC Looking into the Areas EPS & Local EPS



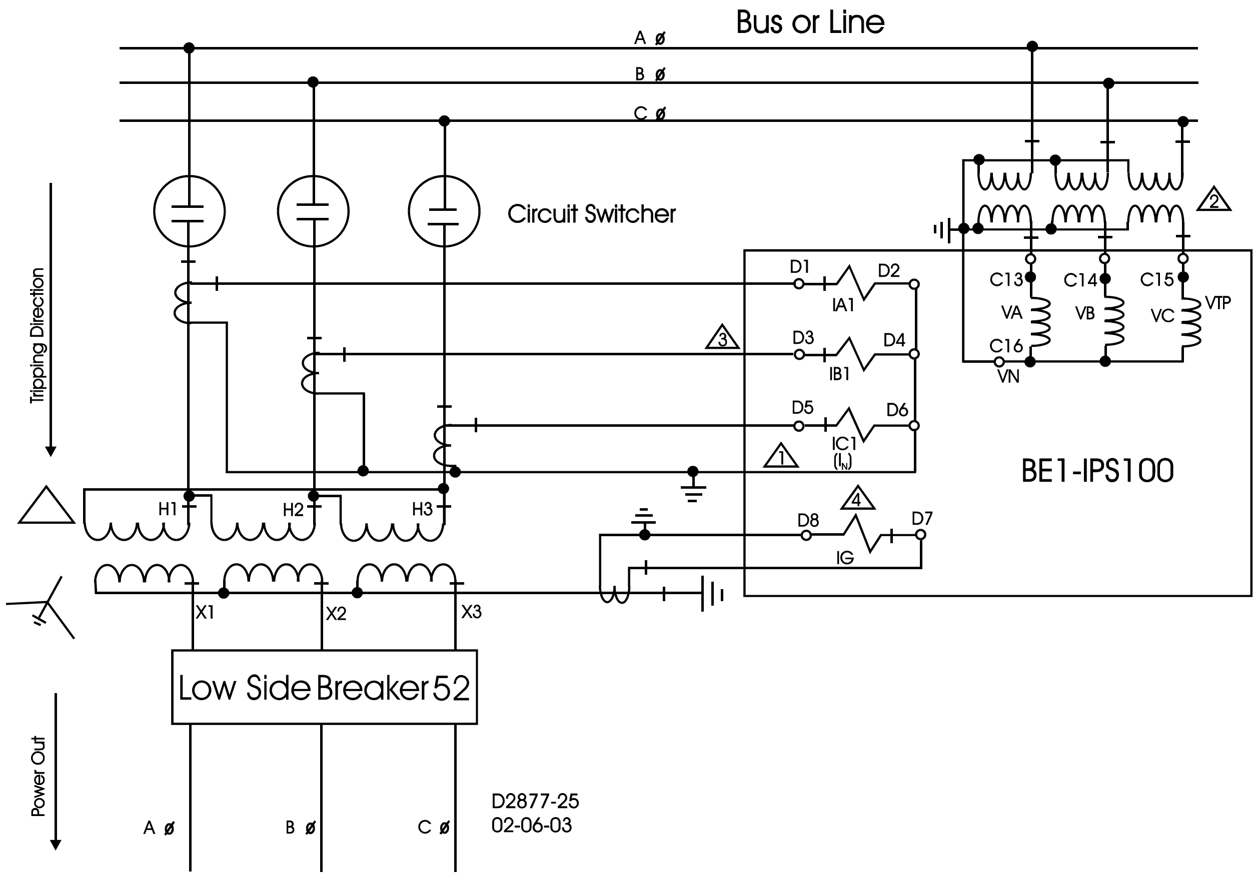
Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections.

3. CT polarity connected to relay polarity, power flow from Bus to Load defined as power out and = "+" watts.

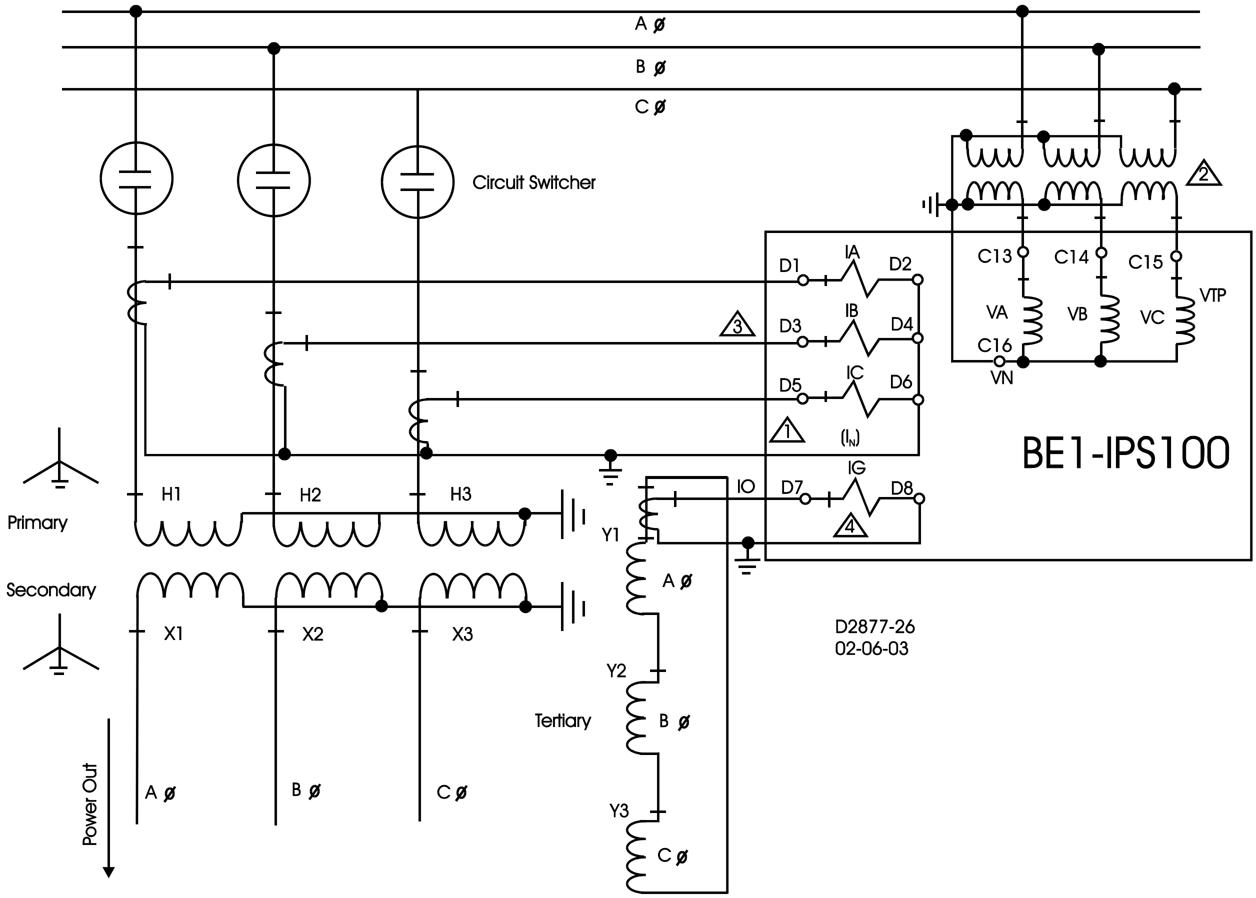
Figure 12-22. Overcurrent (OC) Protection of Typical Radial Loads - Distribution Circuit, Motor, or Reactor



Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.
2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections.
3. CT polarity connected to relay polarity, power flow from a High Side to Low Side defined as power out and = "+" watts.
4. Optional Independent Ground Input (IG) connected to detect Low Side ground faults.

Figure 12-23. OC Protection of a Delta-Wye Grounded Transformer (Radial Load) with Optional Independent Ground Input (IG) Connected for Low Side Ground Fault Protection



Notes: Δ

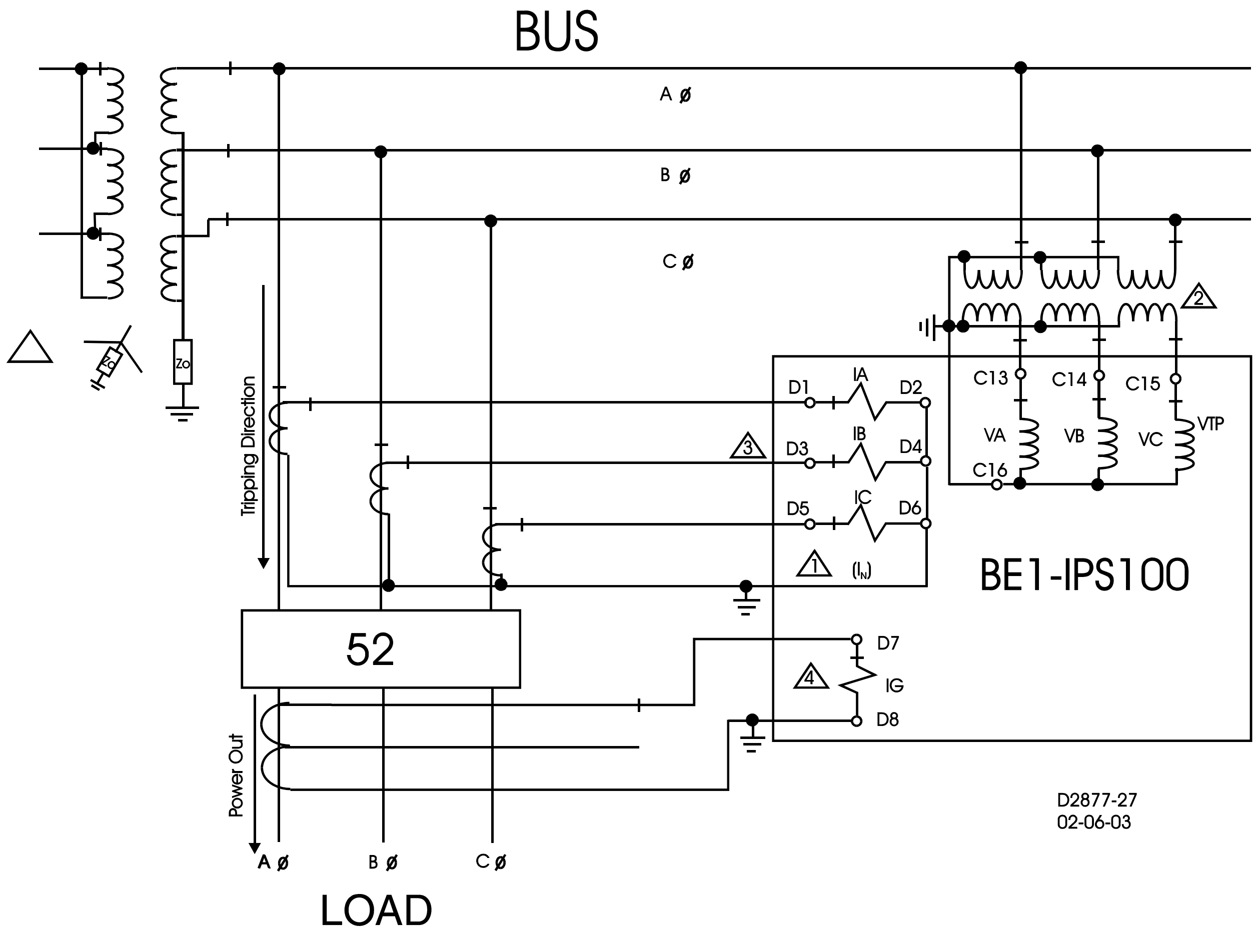
1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections.

3. CT polarity connected to relay polarity, power flow from High Side to Low Side defined as power out and = "+" watts.

4. Optional Independent Ground Input (IG) connected to one CT inside the delta to protect an unloaded tertiary winding and provide backup protection for system ground faults.

Figure 12-24. Backup OC Protection of a Three-winding Transformer with Optional Independent Ground Input (IG) Connected for Tertiary and System Ground Fault Protection



Notes: ∆

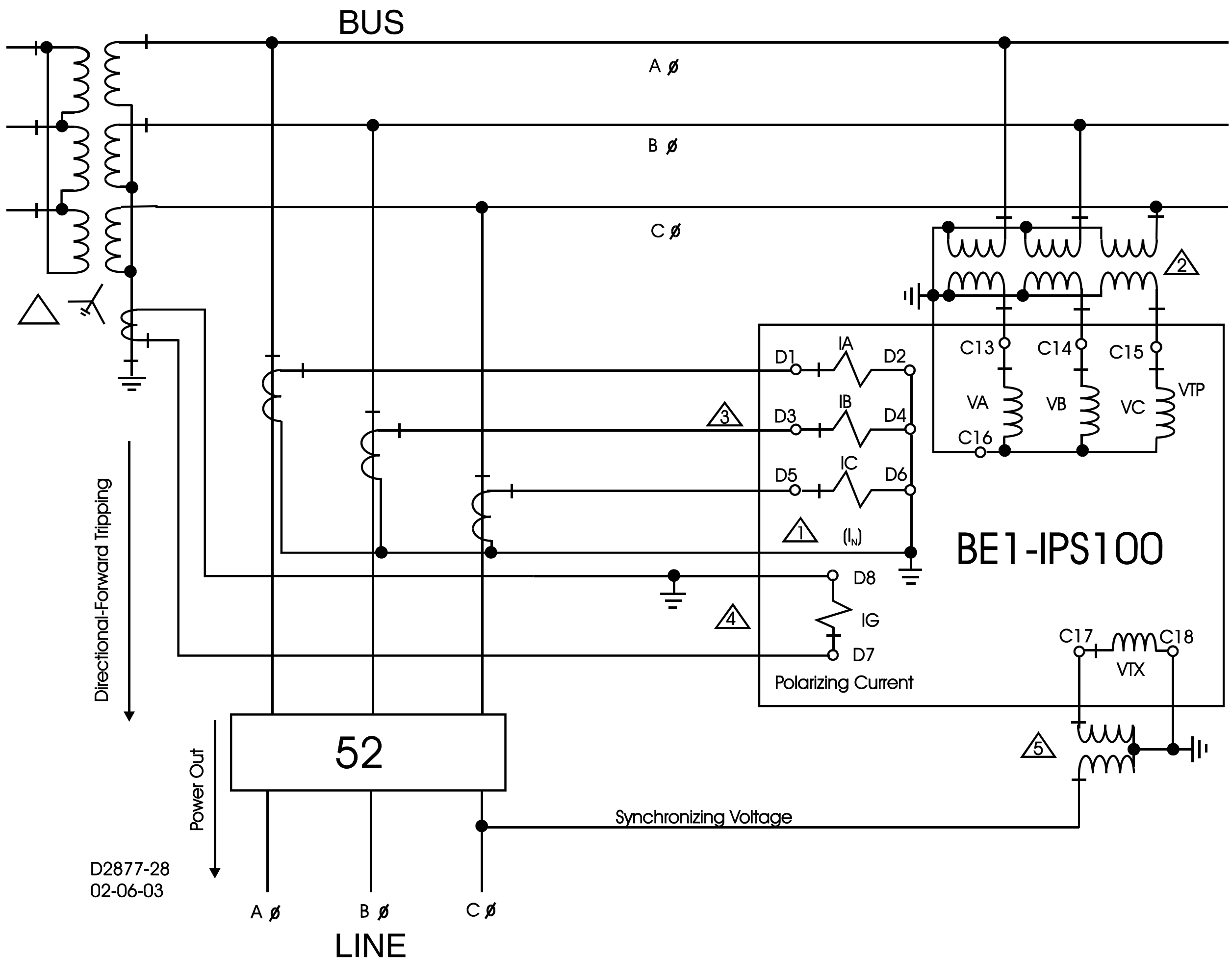
1. The neutral ground (IN) operates on internally calculated residual (3Io) current.

2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections.

3. CT polarity connected to relay polarity, power flow from Bus to Load defined as power out and = "+" watts.

4. Optional Independent Ground Input supplied by a core balance CT provides sensitive ground fault protection.

Figure 12-25. OC Protection of an Industrial Feeder (Radial Load) with Optional Independent Ground (IG) Connected to Core Balance CT for Sensitive Ground Fault Protection



Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

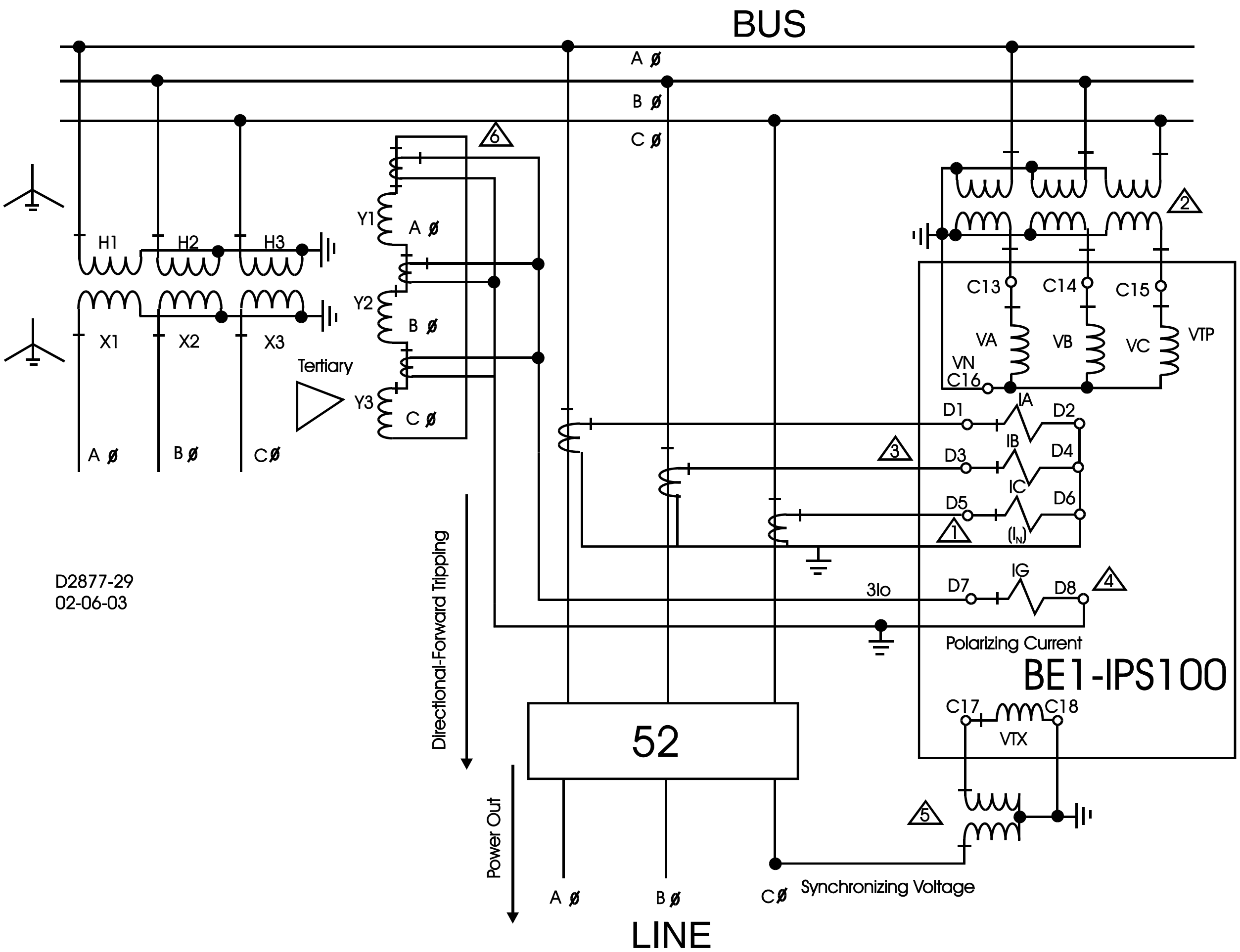
2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections. The 4-wire connection provides negative and zero sequence voltage polarizing for ground faults; 3-wire connection provides negative sequence voltage polarizing.

3. CT polarity connected to relay polarity, power flow from Bus to Line defined as power out and = "+" watts; OC elements set for forward trip.

4. Current polarizing input to IG provides zero sequence polarization for ground faults.

5. VTX can be connected A-N, B-N, C-N or A-B, B-C, C-A. The relay automatically compensates for phase angle differences between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.

Figure 12-26. Directional OC Protection with Reclosing of a Transmission Line (Zero Sequence Current Polarizing Source from Delta-Wye Transformer Connected to IG)



Notes:

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections. The 4-wire connection provides negative and zero sequence voltage polarizing for ground faults; 3-wire connection provides negative sequence voltage polarizing.

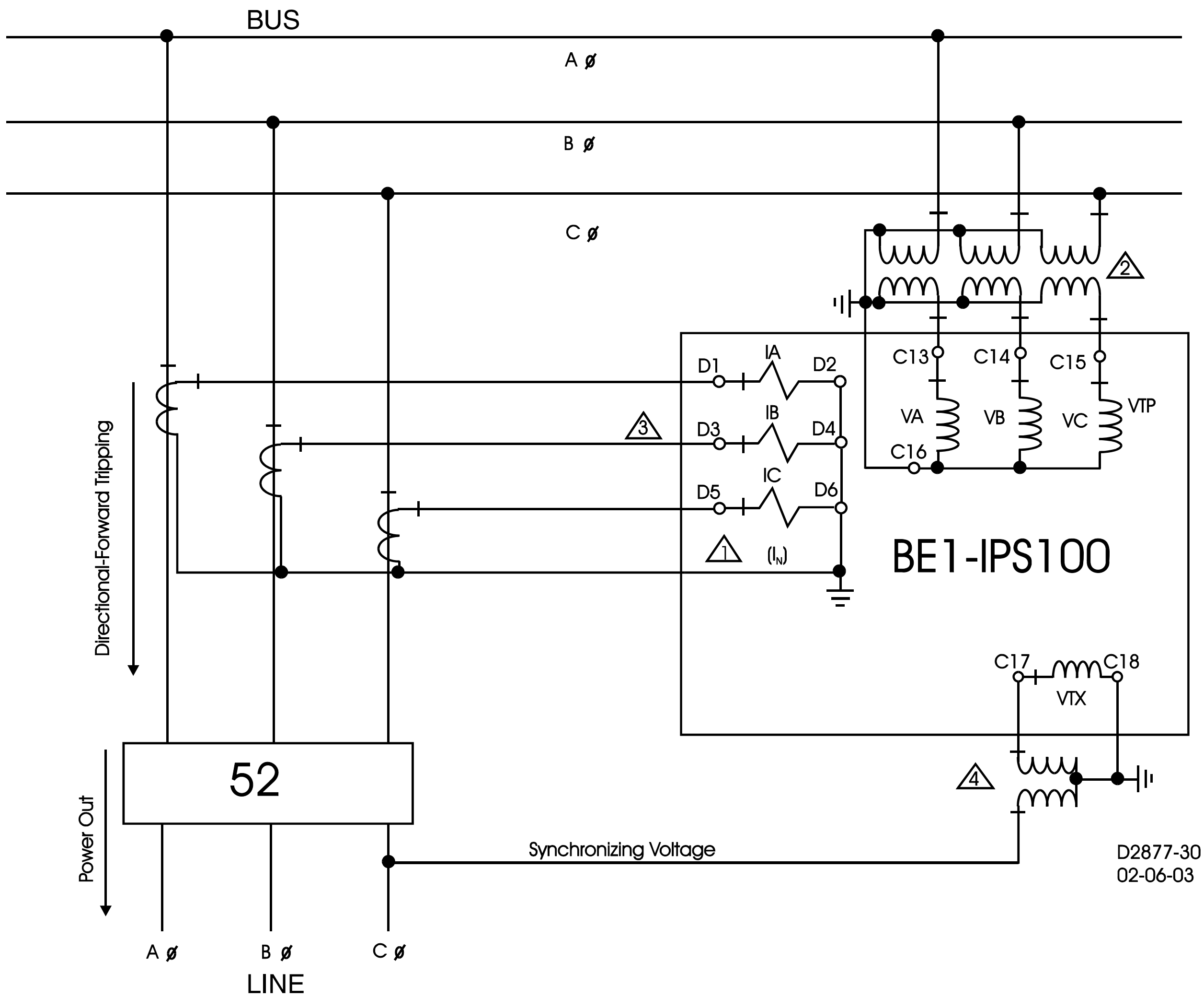
3. CT polarity connected to relay polarity, power flow from Bus to Line defined as power out and = "+" watts; OC elements set for forward trip.

4. Current polarizing input to IG provides zero-sequence polarization for ground faults.

5. VTX can be connected A-N, B-N, C-N or A-B, B-C, C-A. The relay automatically compensates for phase angle differences between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.

6. When tertiary is loaded, use 3 CT's inside Delta ($3I_o$). When tertiary is unloaded, only 1 CT (I_o) is required.

Figure 12-27. Directional OC Protection with Reclosing of a Transmission Line (Zero Sequence Current Polarizing Source from Delta Tertiary Connected to IG)



Notes: Δ

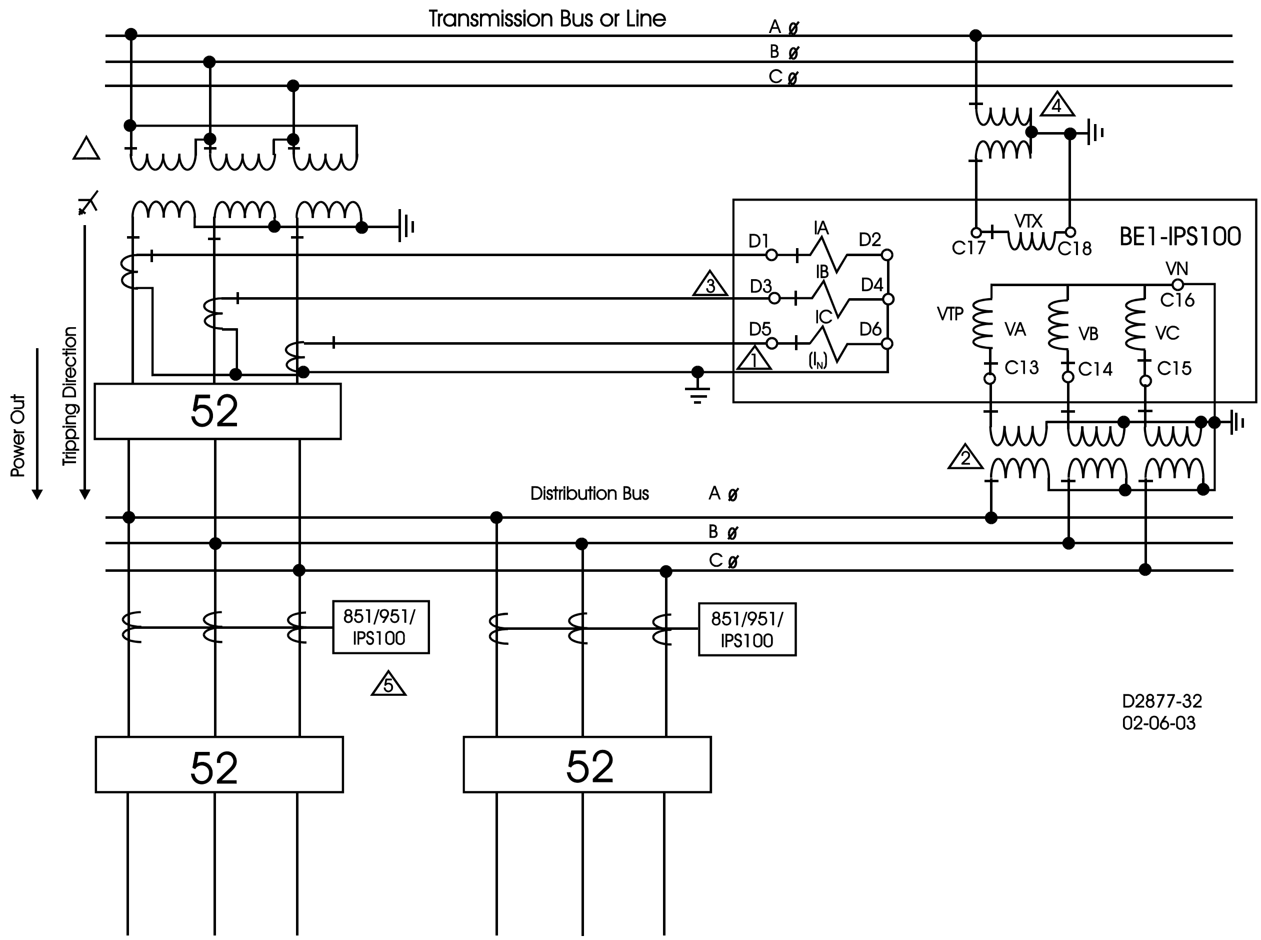
1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections. The 4-wire connection provides negative and zero sequence voltage polarizing for ground faults; 3-wire connection provides negative sequence voltage polarizing.

3. CT polarity connected to relay polarity, power flow from Bus to Line defined as power out and = "+" watts; OC elements set for forward trip.

4. VTX can be connected A-N, B-N, C-N or A-B, B-C, C-A. The relay automatically compensates for phase angle differences between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.

Figure 12-28. Directional OC Protection with Reclosing of a Transmission Line (Potential Polarized)



Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

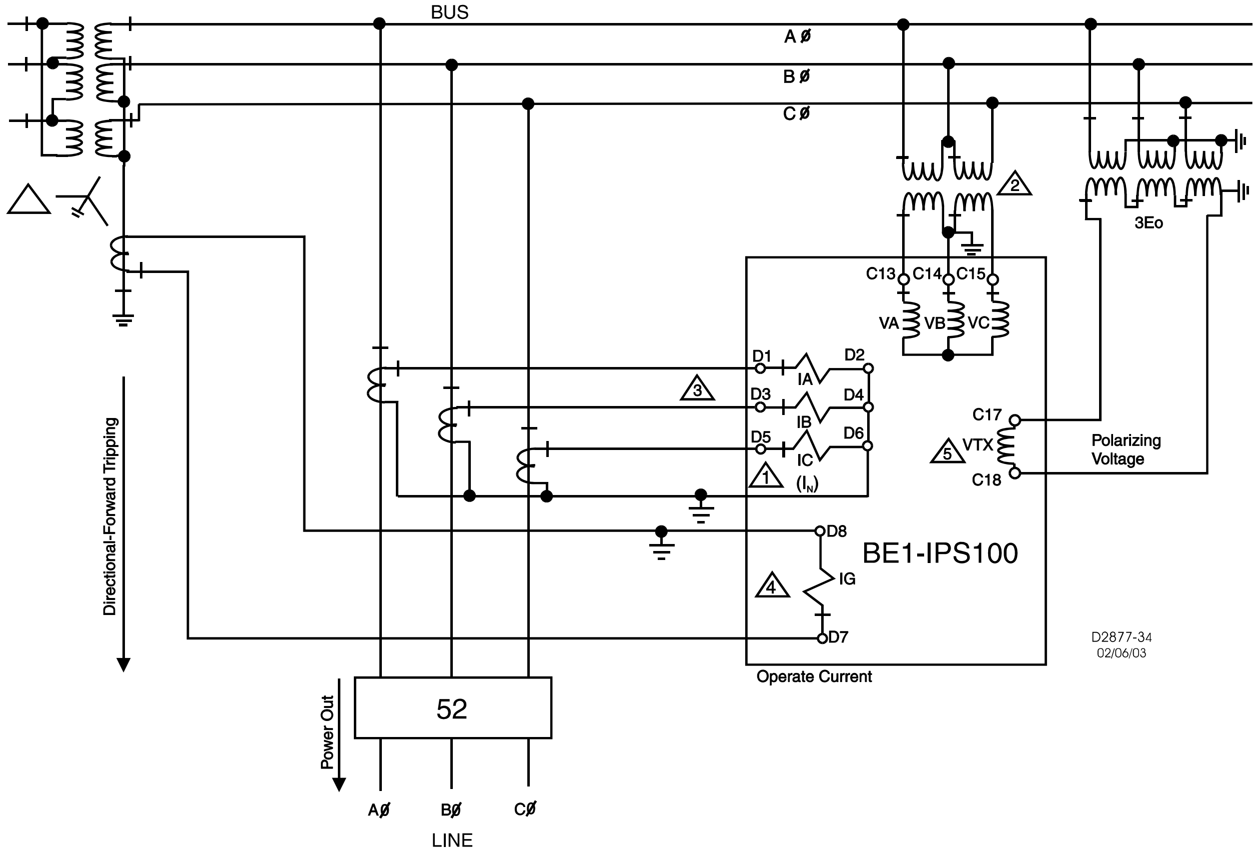
2. 4-wire connection is shown as typical. See Figure 12-20 for alternate VTP connections. Note that the 81 voltage inhibit function for 4-wire and single-phase L-N systems monitor A-N voltage. 3-wire and single-phase L-L systems monitor A-B voltage.

3. CT polarity connected to relay polarity, power flow from Transformer Low Side to Distribution Bus defined as power out and = "+" watts.

4. VTX can be connected A-N, B-N, C-N or A-B, B-C, C-A. For VTP connection shown, VTX input can be A-N, B-N, or C-N. If a 3-wire VTP system is connected, use A-B, B-C, or C-A for VTX input. Voltage magnitude between VTX and VTP must be matched external to the relay.

5. A BE1-851, BE1-951, or BE1-IPS100 is required on each circuit to implement a high-speed bus interlocking scheme.

Figure 12-29. Dual Voltage Source UF Load Shed Using Optional VTX Input; OC Bus Protection (Including High Speed Bus Interlocking)



Notes:

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current.

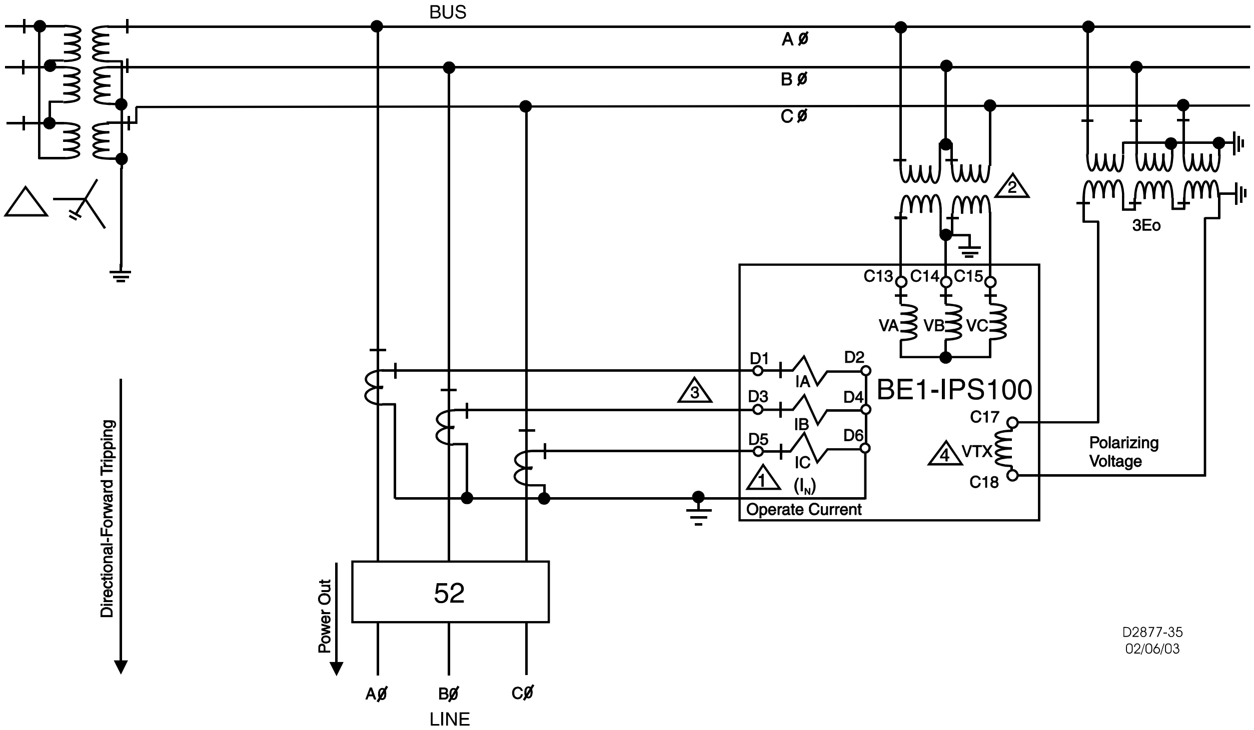
2. 3-wire connection is shown. See Figure 12-20 for alternate VTP connections. The 4-wire connection provides negative sequence and, if selected (V0IN or V0IG), zero sequence voltage polarizing for ground faults; 3-wire connection provides negative sequence voltage polarizing.

3. CT polarity connected to relay polarity, power flow from Bus to Line defined as power out and = "+" watts; OC elements set for forward trip.

4. IG input is ground fault operating quantity compared VX polarizing input (VXIG).

5. VTX connected to external source of $3E_0$ polarizing voltage.

Figure 12-30. Directional Ground OC Protection Using External Source of Zero-Sequence Polarizing Voltage (VX) Compared to Ground Current (IG) Up the Neutral of a Delta-Wye Grounded Transformer



Notes: ∆

1. The neutral ground (I_N) operates on internally calculated residual ($3I_o$) current (VXIN).

2. 3-wire connection is shown. See Figure 12-20 for alternate VTP connections. A 4-wire connection provides negative sequence and, if selected, zero-sequence voltage polarizing (V0IN or V0IG) for ground faults; 3-wire connection provides negative-sequence voltage polarizing.

3. CT polarity connected to relay polarity, power flow from Bus to Line defined as power out and = "+" watts; OC elements set for forward trip.

4. VT connected to external source of $3E_0$ polarizing voltage.

Figure 12-31. Directional Ground OC Protection Using External Source of Zero-Sequence Polarizing Voltage (VX) Compared to Calculated Residual (3IO) (IN)

SETTINGS

Settings for your application need to be entered and confirmed before placing the relay in service. Register settings such as breaker operations and breaker duty can be entered to match the current state of your system.

PREPARING THE RELAY FOR SERVICE

Basler microprocessor-based protection systems are similar in nature to a panel of electromechanical or solid-state component relays. Both must be wired together with inputs and outputs, and have operating settings applied. Logic settings determine which protection elements are electronically wired to the inputs and outputs of the device. Operating settings determine the pickup thresholds and time delays.

The logic and operating settings should be tested by applying actual inputs and operating quantities and verifying proper output response. For more details, refer to Section 13, *Testing and Maintenance*. All of the following connections and functions should be verified during commissioning tests:

- Proper connection and sensing of current and voltage signals
- Input and output contact connections
- I/O sensing versus virtual sensing
- Settings validation
- Proper operation of equipment (main or auxiliary)
- Proper alarming (to SCADA) and/or targeting

Refer to Section 7, *BESTlogic Programmable Logic*, for information about customizing preprogrammed logic and creating user-defined logic, and Section 8, *Application*, for information about the application of preprogrammed logic schemes.

COMMUNICATIONS CONNECTIONS

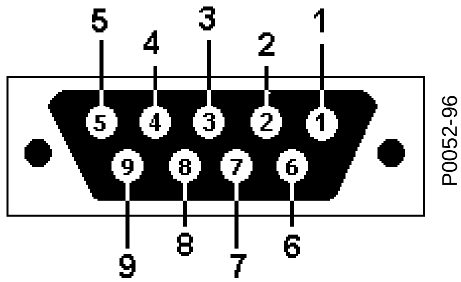
The following paragraphs describe the communication connections for the BE1-IPS100. Section 11, *ASCII Command Interface*, provides information about using the relay communication interface and lists all communication commands along with a description and the syntax for each command.

RS-232 Connections

Front and optional rear panel RS-232 connectors are Data Communication Equipment (DCE) DB-9 female connectors. Connector pin numbers, functions, names, and signal directions are shown in Table 12-2 and Figure 12-32. RS-232 cable connection diagrams are provided in Figures 12-33 through 12-36. Optional Clear to Send (CTS) and Request to Send (RTS) connections are required only if hardware handshaking is enabled.

Table 12-2. RS-232 Pinouts (COM0 and Optional COM1)

Name	Function	Name	Direction
1	Shield	----	N/A
2	Transmit Data	(TXD)	From relay
3	Receive Data	(RXD)	Into relay
4	N/C	----	N/A
5	Signal Ground	(GND)	N/A
6	N/C	----	N/A
7	N/C	----	N/A
8	N/C	----	N/A
9	N/C	----	N/A



(BE1-IPS100)

View looking into **female** connector

Figure 12-32. RS-232 Pin-outs

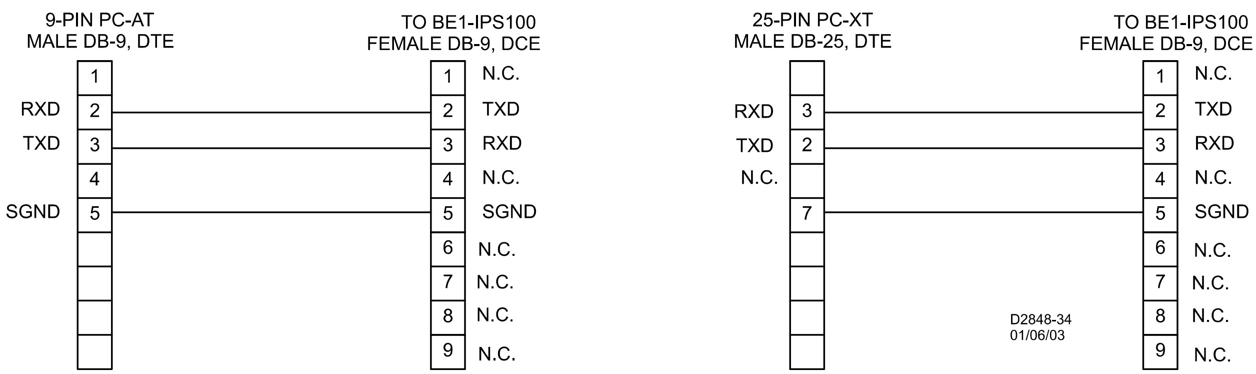


Figure 12-33. Personal Computer to BE1-IPS100

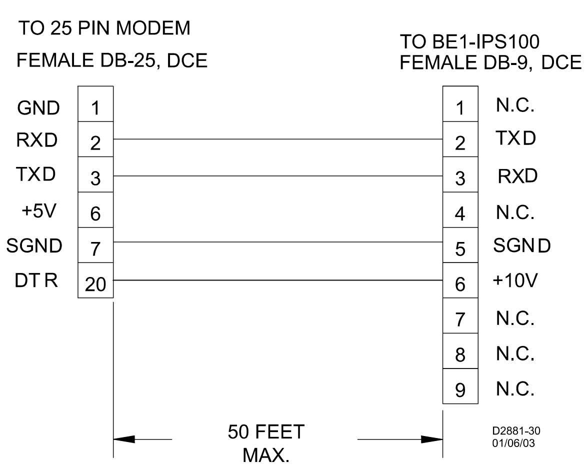


Figure 12-34. Modem to BE1-IPS100

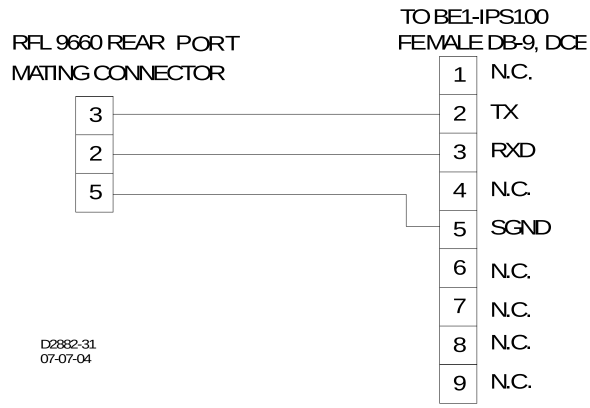


Figure 12-35. RFL9660 Protective Relay Switch to BE1-IPS100 Cable

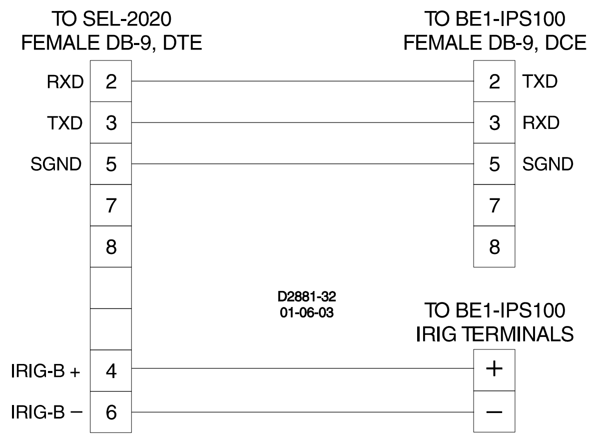


Figure 12-36. SEL 2020 to BE1-IPS100

RS-485 Connections

RS-485 connections are made at a three-position terminal block connector that mates with a standard communication cable. A twisted pair cable is recommended. Connector pin numbers, functions, names, and signal directions are shown in Table 12-3. An RS-485 connection diagram is provided in Figure 12-37.

Table 12-3. RS-485 Pinouts (COM2)

Terminal	Function	Name	Direction
A	Send/Receive A	(SDA/RDA)	In/Out
B	Send/Receive B	(SDB/RDB)	In/Out
C	Signal Ground	(GND)	N/A

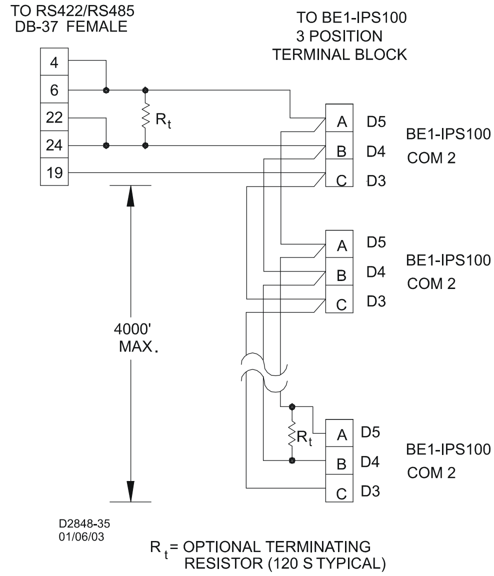


Figure 12-37. RS-485 DB-37 to BE1-IPS100

Ethernet Connections

BE1-IPS100 relays with style numbers xxxxx4x, xxxxx5x, and xxxxx7x have a rear-panel Ethernet port that communicates using ASCII commands. The 10BaseT port is an eight-pin RJ-45 connector that connects to Cat 5 / Cat 5e shielded twisted pair wire media. Be sure to disconnect the Ethernet cable before removing the BE1-IPS100 relay assembly from the draw-out case.

NOTE

For security reasons, all change passwords are disabled by default on the optional Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port. See Section 9, *Security,* for details.

ASCII Command Communication

ASCII communication byte-framing parameters are fixed at 8 data bits, no parity, and 1 stop bit. Additional ASCII communication protocol parameters are settable. Baud rate and address are settable from the ASCII command interface using the SG-COM command. These parameters can also be set at human-machine interface (HMI) Screen 6.1.x. Several additional settings are available to further customize ASCII communications. These settings are described Section 9, *Security*. Additional parameters for Page Length, Reply Acknowledge, and Software Handshaking can be changed only through the ASCII command interface using the SG-COM command.

IRIG Input and Connections

The IRIG input is fully isolated and supports IRIG Standard 200-98, Format B002. The demodulated (dc level-shifted) input signal must be 3.5 volts or higher to be recognized as a high logic level. The maximum acceptable input voltage range is +10 volts or -10 volts (a 20-volt range). Input burden is nonlinear and rated at approximately 4 kΩ at 3.5 Vdc and approximately 3 kΩ at 20 Vdc.

IRIG connections are located on a terminal block shared with the RS-485 and input power terminals. Terminal designations and functions are shown in Table 12-4.

Table 12-4. IRIG Terminal Assignments

Terminal	Function
A1	(+) Signal
A2	(-) Reference

SECTION 13 • TESTING AND MAINTENANCE

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SECTION 13 • TESTING AND MAINTENANCE

GENERAL

The need to test protective relays to confirm performance as designed by relay manufacturers has always existed. However, numeric relay design is changing the industry testing paradigms that have been in use since the first protective relay was built. Each time a fault occurs, the numeric protection system is tested, and as a result of its fault and event recording capability, the test is also documented. In the unlikely event of a protection system problem, continuous monitoring along with remote communications capability provide for removing the affected relay from service, auto switching to backup systems, and immediate notification of a manned facility. These features have virtually eliminated the need for periodic maintenance. Simple acceptance tests that verify the integrity of the relays measuring circuits and commissioning tests that verify the relays "electronic wiring" (control logic) are Basler Electric's recommended pre-installation tests.

This section provides guidelines for performing these tests and others. It also provides guidelines for care, handling, and troubleshooting of the BE1-IPS100 relay. For assistance in conducting relay self-tests and troubleshooting using internal diagnostics, contact Basler Electric Technical Support Services.

TESTING PHILOSOPHIES

Testing is generally divided into the following categories:

- Acceptance
- Commissioning
- Periodic (user scheduled maintenance)
- Functional

While all types of tests may be performed, all users do not generally perform them. Likewise, the degree to which you will conduct each type of test depends on need, economics, and perceived system value.

Acceptance Testing

Acceptance testing is intended to confirm that a particular relay delivered to a customer meets published specifications. Because this is a numerical relay whose characteristics are defined by software, Basler Electric does not require the user to test each operational setting in the relay. Successful completion of the Acceptance Test verifies proper response of the relay's input and output circuits as well as its response to all external sensing input quantities (voltage, current, frequency).

Basler Electric performs detailed acceptance testing on all devices to verify all functions meet published specifications. All products are packaged and shipped with the strictest of standards. The BE1-IPS100 relay is a microprocessor-based relay whose operating characteristics will not change over time. The relay will also not experience any change in operating characteristics during transit. However, it remains material that the user perform these acceptance tests to verify the device has not suffered any degradation in transit. Basler Electric warrants all products against any decay in performance outside of the published specified tolerances that result from problems created during transit.

Commissioning Testing

Commissioning testing verifies all physical connections and functional aspects of the protective relay for a new installation. This includes a thorough review and documentation of the operational settings to verify that the users calculated values match the actual values on each enabled protection element of the relay. All of the following connections or functions can be verified during commissioning tests:

- Proper connection and sensing of current and voltage signals as applicable
- Connections of I/O contacts
- I/O sensing versus virtual sensing
- Setting validation
- Proper operation of equipment (main or auxiliary)
- Proper alarming (to SCADA) and/or targeting

Periodic Testing

Periodic testing can be performed at regularly scheduled intervals or upon an indication of problems or questionable operations within the relay. Verifying the integrity of the relay's performance, short of playback of recorded events, may be necessary by performing certain tests similar to those accomplished in the acceptance tests. Verification that the relay is measuring signals faithfully, that relay logic is appropriate, and, that protective elements and equipment (main or auxiliary) operate correctly, are goals that can be achieved during this type of testing.

Basler Electric recommends that all captured fault records and sequence of event records be analyzed and kept on file as in-service periodic test results for this particular device. This is an indication that all protective elements and the associated equipment are operating satisfactorily.

It is not the intent of this manual to elaborate on every conceivable test possible since this would encroach on individual preferences, techniques, and philosophies. It is the intent to pursue relevant testing methods to verify this relay meets published design specifications and applicability.

Functional Testing

Functional (or application) testing is significantly more comprehensive in nature and is intended to test suitability for a particular application. Functional testing also provides a means to familiarize the user with the logic and operation of this device. Test setups are generally more involved and often times include ancillary equipment beyond voltage or current source type equipment. While economics may at times prohibit full functional testing, it is recommended that some application testing be performed when published specifications lack appropriate detail to satisfy application testing requirements.

Basler Electric performs a thorough and comprehensive functional test of all relays before shipping. This ensures that this device is within specified tolerances, measures accurately, and operates correctly as designed.

TESTING AND TROUBLESHOOTING AIDS

Under test or in-service, the BE1-IPS100 provides several ways to check operations, targets, or events. A continuous self-test monitors the system health and status. The most basic reporting function is targets. Targets may be viewed through ASCII command interface or through the front panel human-machine interface (HMI). Fault Summary Reports, Sequence of Events Recorder (SER) Reports, and Oscillographic Records yield more detail.

Each time a system disturbance occurs in or around this relay zone of protection, it is a test of the relay performance during the fault. If a questionable operation results in the need for troubleshooting, you have several ways in which to troubleshoot the relay, the installation, and the overall application.

Performance Testing

Performance testing can be accomplished through the capture and playback of system fault records. In actual applications, this type of test realizes further confirmation of faithful relay responses during system disturbances. For specific power system disturbances, relays can be to subject to a re-creation of captured events with the aide of equipment capable of replicating COMTRADE record files. In these instances, there is significant merit in testing relays in this manner to assess relay performance. Correct response of relay action in a performance test is supplemental verification of the conclusions drawn from functional (or application) tests.

This type of testing verifies not only whether or not the device operated correctly for a particular system disturbance but also offers additional confirmation of your protection philosophy in this application. It is beyond the scope of this manual to develop performance tests for this device. For assistance in developing these types of tests, please consult Basler Electric and your test equipment.

Relay Self-Test

All internal circuitry and software that affect the relay core functionality are monitored by the continuous self-test diagnostics. For specific relay trouble alarms, the self-test diagnostics force the microprocessor to reset and try to correct the problem. If unsuccessful, OUTA operates, the Relay Trouble LED on the front panel turns on, all of the output relays are disabled, internal logic Point ALMREL is set, and the relay is taken off line. For more information on self-test diagnostics and relay trouble alarms, see Section 6, *Reporting and Alarm Functions, Alarms Function*.

Status Reporting Features

General status reporting is available through the ASCII command interface using the RG-STAT (report general, status) command. This report assembles all of the information required to determine the relay status. For more information on general status reporting, see Section 6, *Reporting and Alarm Functions, General Status Reporting, General Status Report.*

Fault reporting and target data is dependent on the proper setting of trip, pickup, and logic trigger expressions (via the SG-TRIGGER command) and the assignment of protective elements to be logged as targets (via the SG-TARG command).

While the design of the relay facilitates obtaining and verifying targets and event data, it is not always necessary to utilize the relay functions to determine if the device operated while testing. You may simply use an ohmmeter or continuity tester to monitor the output contact status.

The following is a summary of ASCII commands where target and event data may be viewed:

- RF provides a directory of fault summary reports in memory
- RF-# provides a summary report giving targets, timing and event data
- RG-TARG provides target data only
- RS provides a summary of sequence of events records
- RS-F# provides a detailed SER report for the selected fault event number
- RS-# provides a detailed SER report on the last numbered events

For more information on human-machine interface (HMI) menu trees, see Section 10, *Human-Machine Interface*. Also, much of this information can be accessed through BESTCOMS. See Section 14, *BESTCOMS Software*, for details.

Event Reporting Features

The SER function of the relay records protective element output changes, overcurrent element pickup or dropout, input/output contact state changes, logic triggers, setting group changes, and setting changes. For more information on event reporting, see Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder*.

The following summarizes the reporting capabilities of the relay through the front panel HMI:

- Trip LED (Flashing): flashes during pickup of protective elements based on the pickup logic expression set in the SG-TRIGGER command.
- Trip LED (sealed-in): stays lit after trip logic becomes TRUE based on the trip logic expression set in the SG-TRIGGER command.
- TARGETS, Screen 1.2: Provides target data.
- ALARMS, Screen 1.3: Provides alarm data (including BKR FAIL, REC FAIL and REC LO).
- FAULT REPORTS, Screen 4.1: Indicates new fault reports
- EVENT REPORT, Screen 4.2: Gives the number of new events logged by the SER since the last new counter reset (executed only by the RS=0 command). Events must be viewed using the RS and RS# commands listed in the previous paragraph.

ACCEPTANCE TESTING

Although Basler Electric performs detailed acceptance testing on all new relays, it is generally recommended that you perform each of the following acceptance test steps before installation. Performing these steps tests each function of the BE1-IPS100 relay to validate that the relay was manufactured properly and that no degradation of performance occurred as a result of shipping. ASCII communication is discussed throughout this section but BESTCOMS can also be used for the majority of settings and tests. See Section 14, *BESTCOMS Software*, for details.

Test Equipment

Suitable test equipment requires a minimum of two current source elements, two voltage source elements, and a contact wetting voltage. Test equipment should also have the capability of varying the frequency and the angle of the voltage and current sources.

NOTE

Test connections referred to in this section are for an H1 style case relay. Refer to Figure 13-1 (H1 case) for terminal locations. If testing a relay in an S1 case, modify the current and potential test connections according to the terminal locations shown in Figure 13-2 (S1 case).

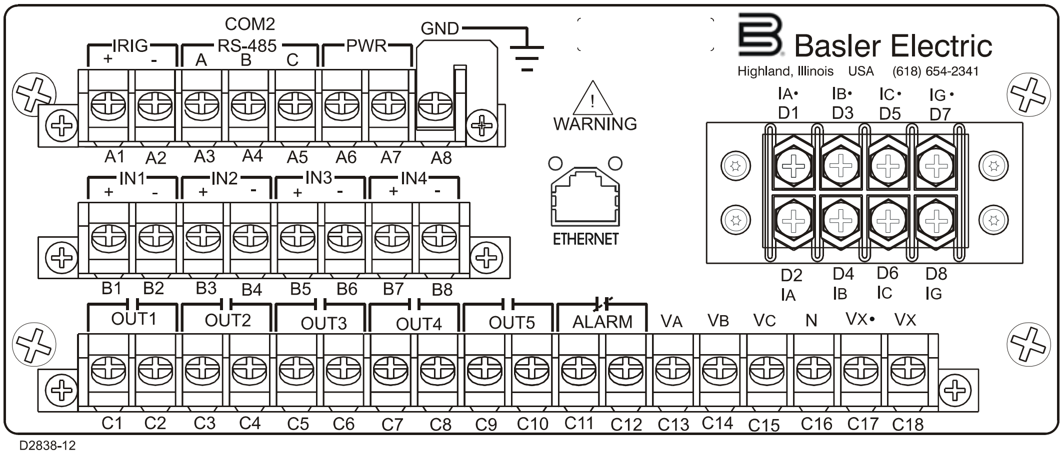
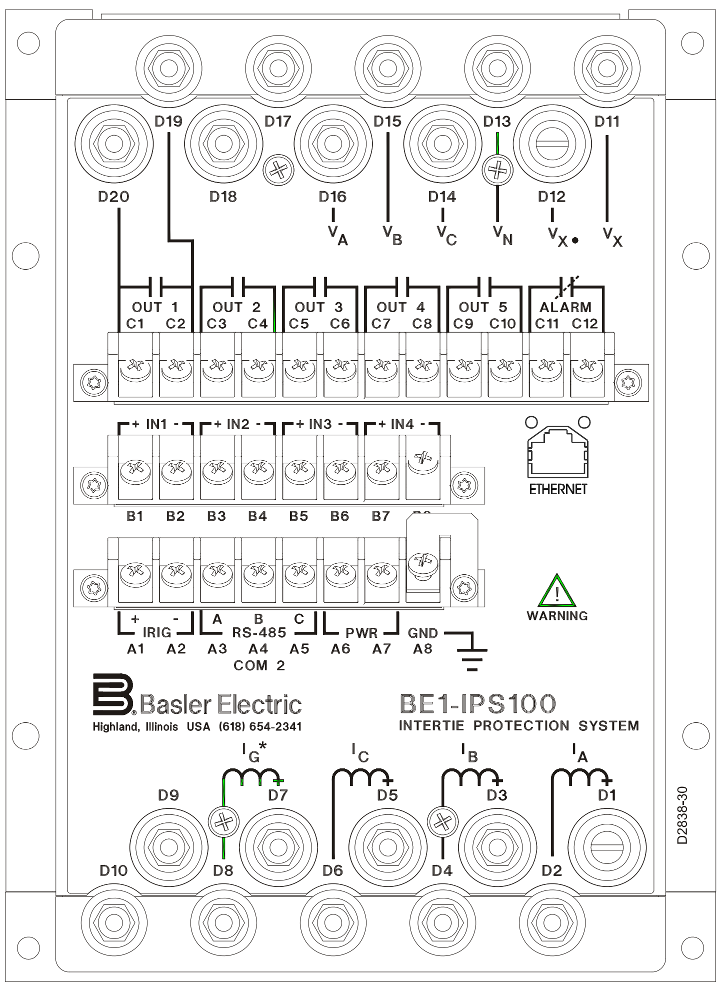


Figure 13-1. Rear Panel Terminal Connections (H1 Case)



* I_G INPUT IS OPTIONAL

Figure 13-2. Rear Panel Terminal Connections (S1 Case)

Power Up

Purpose: To verify that the relay performs the power-up sequence.

Step 1: Apply voltage to the input power Terminals A6 and A7. Table 13-1 shows the appropriate input voltage for each relay style.

Table 13-1. Input Voltages

Style Number	Voltage Input
IPS-100-xxN1Hxx	48/125 Vac/dc
IPS-100-xxN2Hxx	125/250 Vac/dc
IPS-100-xxN3Hxx	24 Vdc

Step 2: Verify that the Power LED is on and that characters are displayed on the HMI display. Upon power-up, the relay will perform a brief self-test.

During this brief test, all front panel LEDs flash momentarily, the display indicates each step of the self-test, the relay model, the software version, and then the default display screen. Contact Basler Electric, Technical Support Services if anything appears out of the ordinary or if an LCD error message appears.

Communications

Purpose: To verify that the BE1-IPS100 relay communicates through all ports.

Reference Commands: ACCESS, EXIT

To communicate with the BE1-IPS100 through any of the three ports, use a terminal emulation program such as BESTCOMS - Basler Terminal running on a personal computer (PC) with a serial port that is suitable for communications. The relay communication default settings are:

- Baud Rate = 9,600 bps
- Data Bits = 8
- Stop Bit =1
- Parity = None
- Flow Control = Xon/Xoff

Set Up the Relay to Communicate with the PC

Step 1: Depress the *Up* arrow pushbutton on the front panel HMI until the top level of the menu tree is reached. Depress the *Left/Right* arrow pushbuttons until Screen 6, *General Settings*, appears. Next, depress the *Down* arrow pushbutton twice to get to Screen 6.1.1, *COM0 F-232*. This screen displays the baud rate for the front panel communication port (COM 0). Verify that the baud rate is 9,600 bps (9.6 Kbps).

Step 2: Connect the serial cable between the PC and the front RS-232 port on the relay.

Step 3: Initiate the communication program for your computer.

Step 4: Transmit the command ACCESS= (you may use the shortcut keystrokes and just enter a=).

RESULT: The relay should respond with `ACCESS GRANTED: GLOBAL`.

Step 5: Transmit EXIT.

Step 6: Repeat Steps 1, 2, and 3 for the optional rear RS-232 port (COM 1).

Step 7: Connect the male end of the terminal cable to the RS-232 port on a RS-232/485 converter box. Connect the RS-485 output of the converter box to the relay RS-485 terminals and repeat Steps 1, 2, and 3.

Style Number and Serial Number Verification

Purpose: To verify that the BE1-IPS100 relay model number, style number and current software program version matches the unit and unit labels.

Reference Commands: RG-VER

Step 1: Through any communications port, transmit the command RG-VER. The BE1-IPS100 relay should respond with the model number, style number, application program version and date, boot program version and date, the relay serial number, and Ethernet information (for style numbers xxxxx4x and xxxxx5x). Verify that all reported data is current, appropriate and matches the label on the relay front panel.

IRIG Verification (if used)

Purpose: To verify that the BE1-IPS100 relay acquires and updates IRIG time and date information.

Reference Commands: RG-DATE, RG-TIME

Step 1: Connect a suitable IRIG source to relay Terminals A1 and A2.

Step 2: Upon receiving the IRIG signal, the relay clock will be updated with the current time, day, and month. Verify this at Screen 4.6 on the front panel HMI or by sending the RG-TIME and RG-DATE commands to the relay through any communications port.

Contact Sensing Inputs

Purpose: To verify that the BE1-IPS100 relay senses hardware input and output status.

Reference Commands: ACCESS, CO-OUT, CS-OUT, EXIT, RG-STAT

Step 1: Apply an external voltage source within the range of the voltages listed in Table 13-2 to Contact Sensing Inputs IN1, IN2, IN3, and IN4.

Table 13-2. Contact Sensing Turn-On Voltage

Nominal Control Voltage	Contact Sensing Turn-On Voltage	
	Jumper Installed (Low Position)	Jumper Not Installed (High Position)
24 Vdc	N/A	Approx. 5 Vdc
48/125 Vac/dc	26 to 38 Vac/dc	69 to 100 Vac/dc
125/250 Vac/dc	69 to 100 Vac/dc	138 to 200 Vac/dc

Step 2: To verify that all inputs have been detected, transmit the command RG-STAT to retrieve INPUT (1234) information. Input status can also be viewed at HMI Screen 1.4.1.

Control Outputs

Step 1: Transmit the commands ACCESS=, CS-OUT=ENA, CO-OUT=ENA, EXIT, and YES to enable the output control override capability of the relay in order to pulse each output contact.

Step 2: From the HMI keypad, navigate to Screen (Output Control Override) to override control of the outputs via the keypad.

Step 3: Once you have accessed the screen, press the *Edit* pushbutton to enable the override function (Step 1 enables logic override, pressing the *Edit* pushbutton enables selecting the control action). Select an output to override by using the *LEFT/RIGHT* arrow pushbuttons. Once selected, use the *UP/DOWN* arrow pushbuttons to choose the type of action (P, 1, or 0) for the selected output contact. Select the pulse (P) action for the alarm contact (A). Pressing the *Edit* pushbutton again will force the alarm output contact action.

Step 4: Verify that the sequence of events recorder logged the events by sending the command RS-2 to the relay (requesting the last two events it logged). The close-open pulse action should be listed as two separate events.

Step 5: Repeat Step 3 for all desired output contacts and verify that the sequence of events recorder logged the events.

Step 6: Transmit the commands CS-OUT=DIS, CO-OUT=DIS, EXIT, and YES to disable the output control override capability of the relay.

Current Circuit Verification

For all tests in this section, ASCII metering commands, HMI Metering, and the Metering Screen of BESTCOMS include angles for each current and voltage quantity. The zero reference for current and voltage angle measurement is based on the following:

- When voltage and current are applied to the relay, VAN is the 0° reference for all other angle measurements.
- In the absence of VAN, the positive-sequence voltage V1 is the 0° reference for all other angle measurements.
- In the absence of all phase voltages, the A-phase current IA is the 0° reference for all other angle measurements.
- In the absence of all phase voltages and IA current, IB and IC will still read an angle but with no fixed angle reference.

For example, in a 3-phase 4-wire system, ABC rotation at unity power factor, the three-phase to neutral voltage angles will be displayed as 0°, 240°, and 120°. The phase currents will be in phase with the phase to neutral voltages or 0°, 240°, and 120°, and IA will lag VAB voltage by 30°.

Step 1: To verify IN, I1, and IQ, connect an ac current source to Terminals D1 and D2.

Step 2: Apply the appropriate current values in Table 13-3 to the relay. Measured IN should correspond to values in Table 13-3 while IQ (negative-sequence current I2) and positive-sequence current, I1, should be 1/3 the applied value ±1.5%. (For example, if the applied value equals 2 amps, IQ and I1 = 2/3 = 0.667 amps ±1.5% or ±.01 amps.) Verify current measuring accuracy by transmitting the M command to the relay for each applied current value. HMI Screen 3.7 also can be used to verify the IN, I1, and IQ current measurements.

Table 13-3. Current Circuit Verification Values

Sensing Type	Applied Current	Measured Current	
		Lower Limit	**Upper Limit**
1 A	0.25 amps	0.2475 A	0.2525 A
	1 amps	0.99 A	1.01 A
	2 amps	1.98 A	2.02 A
	3 amps	2.97 A	3.03 A
	4 amps	3.96 A	4.04 A
5 A	1 amps	0.99 A	1.01 A
	5 amps	4.95 A	5.05 A
	10 amps	9.90 A	10.10 A
	15 amps	14.85 A	15.15 A
	20 amps	19.80 A	20.20 A

Step 3: To verify IP and IG, connect a suitably sized jumper wire across relay Terminals D2 and D3, D4 and D5, and D6 and D7. Apply an ac current source to Terminals D1 and D8.

Step 4: Apply the appropriate current values in Table 13-3 to the relay. Verify current measuring accuracy by transmitting the M command to the relay for each applied current value. HMI Screens 3.5 and 3.6 also can be used to verify current measurements. Screen 3.7, IN, will read 3 times the phase value.

Step 5: Leave current circuit connected and de-energized. These test connections will be used later when verifying power readings.

Three-Phase Voltage Circuit Verification

Step 1: Connect an ac voltage source at nominal frequency between relay Terminals C13 (A-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by transmitting the M command to the relay. Readings should be: M-VA = 100 volts, M-VAB = 100 volts, M-VCA = 100 volts, M-3V0 = 100 volts, M-V2 = 33.4 volts (applied divided by 3), and M-

V1 = 33.4 volts (applied divided by 3) all at ±1.0%. HMI Screens 3.1, 3.2, and 3.4 can also be monitored to verify voltage measurements.

Step 2: Connect an ac voltage source at nominal frequency between relay Terminals C14 (B-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by transmitting the M command to the relay. Readings should be: M-VB = 100 volts, M-VAB = 100 volts, M-VBC = 100 volts, M-3V0 = 100 volts, M-V2 = 33.4 volts (applied divided by 3), and M-V1 = 33.4 volts (applied divided by 3), all at ±1.0%. HMI Screens 3.1, 3.2, and 3.4 can also be monitored to verify voltage measurements.

Step 3: Connect an ac voltage source at nominal frequency between relay Terminals C15 (C-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by transmitting the M command to the relay. Readings should be: M-VC = 100 volts, M-VBC = 100 volts, M-VCA = 100 volts, M-3V0 = 100 volts, M-V2 = 33.4 volts (applied divided by 3), and M-V1 = 33.4 volts (applied divided by 3), all at ±1.0%. HMI Screens 3.1, 3.2, and 3.4 can also be monitored to verify voltage measurements.

Step 4: Connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Connect an ac voltage source at nominal frequency to the three jumpered terminals and the Neutral Terminal (C16).

Step 5: Apply the voltage values listed in Table 13-4 and verify voltage measuring accuracy by transmitting the M command to the relay. HMI Screen 3.1 can also be monitored to verify voltage measurements or the *Metering* screen of BESTCOMS.

Table 13-4. Voltage Circuit Verification Values

Applied Voltage	Measured Voltage	
	Lower Limit	**Upper Limit**
80 volts	79.2 V	80.8 V
100 volts	99.0 V	101.0 V
120 volts	118.8 V	121.2 V
140 volts	138.6 V	141.4 V
160 volts	156.8 V	163.2 V

Power Reading Verification

Step 1: Use the same voltage connections as in the previous test, polarity voltage jumpered to C13, 14, and 15, neutral tied to C16. Use the same current connection as in Steps 3 and 4 of *Current Circuit Verification*; that is, polarity current in 1 out 8 with 2 and 3, 4 and 5, 6 and 7 jumpered together.

NOTE

Power readings in this procedure are based on a 5-amp relay; for 1-amp values, divide by 5.

Step 2: Apply 100 volts at angle 0 degrees and 1 or 5 amps (depending on the current rating) at angle 0 degrees to the relay. Verify the accuracy of the power reading by transmitting the M command to the relay. Power should be 1.5 kw ±1.0% and reactive should read near 0 vars. BESTCOMS *Metering* or the HMI Screen 3.8 can also be monitored to verify power and reactive readings. The apparent power should be 1.5 kVA ±1.0% at unity power factor. Apparent power can also be viewed on HMI Screen 3.9.

Step 3: Reverse the current polarity and apply the same values as in Step 2. Note that the power reading is -1.5 kW, which indicates "power in" to the zone being protected.

Step 4: Return the current polarity back to Step 1 position. Apply 100 volts at angle 0 degrees and 5 amps at angle -90 degrees (I lag E by 90 degrees) to the relay and verify reactive power accuracy by transmitting the M command to the relay. Power should be nearly 0 kw and reactive should read 1.5 kvar ±1.0%. BESTCOMS *Metering* or HMI Screen 3.8 can also be monitored to verify power and reactive values. Apparent power and power factor can also be viewed on HMI Screen 3.9. Note power factor reads near 0 with a negative sign indicating a lagging power factor angle.

Step 5: Reverse the current polarity and apply the same values as in Step 4. Note that the reactive power reading is -1.5 kvar which indicates reactive power in to the device being protected. Also note that the power factor angle is near 0 with a positive sign indicating a leading power factor angle.

Step 6: Repeat Steps 2 and 4 for current values of 10 and 20 amps. Corresponding power reading should be 3 kW/kvar and 6 kW / kvar ±1.0%.

Auxiliary Voltage Input Verification - VX and VX 3rd (Fundamental and Third Harmonic)

Step 1: Connect relay Terminals C17 (polarity) and C18 to a 60 hertz ac voltage source.

Step 2: Apply the voltage values listed in Table 13-5 and verify voltage-measuring accuracy by transmitting the M-V command to the relay. BESTCOMS Metering or HMI Screens 3.3 can also be monitored to verify VX voltage measurements.

Step 3: Connect relay Terminals C17 (polarity) and C18 to a 180 hertz (third harmonic) ac voltage source.

Step 4: Apply the voltage values listed in Table 13-5 and verify voltage-measuring accuracy by transmitting the M command to the relay. BESTCOMS Metering or HMI Screen 3.3 can also be monitored to verify VX voltage measurements.

Table 13-5. Aux Voltage Circuit Verification VX & VX 3rd Values

Applied Voltage	Measured Voltage	
	Lower Limit	Upper Limit
5 volts	4.95 V	5.05 V
20 volts	19.8 V	20.2 V
60 volts	59.4 V	60.6 V
80 volts	79.2 V	80.8 V
120 volts	118.8 V	121.2 V

Line and Bus Angle, Frequency, and Slip Verification

- Connect relay Terminals C13 (polarity) and C16 (A to Neutral of the three-phase voltage input) to a 60-hertz ac voltage source (line voltage).
- Connect relay Terminals C17 (polarity) and C18 (auxiliary voltage input) to a second 60-hertz ac voltage source (bus voltage).
- Apply 115 volts at 0 degrees and 60 hertz to both sources. Verify the measuring accuracy of the line and bus frequency, angle between the two voltages and slip frequency by transmitting the M command to the relay. HMI Screens 3.10 and 3.11 can also be monitored to verify the measurements.
- Vary the angle of the line voltage and verify the measured angle as in Step 3. Polarity of the angle measurement is relative to the angle of the line voltage. That is, if the line voltage lags the bus voltage by 30 degrees, the sign of the angle will be negative or -30 degrees. When the line voltage leads, the angle has no sign and is assumed to be positive.
- Return the line voltage angle to 0 degrees. Vary the frequency of the line voltage and verify the measured slip as in Step 3. (Note that the angle shown on HMI Screen 3.11 is continuously changing as a result of slip between the two systems. This is normal). Polarity of the slip frequency is relative to the frequency of the line. That is, if the line frequency is 58 hertz and the bus frequency is 60 hertz, the slip frequency is -2. As soon as the line frequency rises above 60 hertz, slip frequency has no sign and is assumed to be positive.

COMMISSIONING TESTING

Because the commissioning of this relay may be a new installation or a retrofit, special precautions should be taken to ensure that all tests are performed with safety as the utmost concern. Any CT circuit signals that are routed through this device as part of a protection scheme including discrete relays or as a stand-alone device should be shorted and isolated from this relay during these tests until the final instrument transformer current circuit check.

If this relay is being installed in an existing installation, please be aware of the equipment monitoring features of this device, especially if the monitoring logic will be utilized. Please make note of any pretest operation levels, duty levels, etc. on existing equipment (e.g., breakers or transformers). As the user, you may make the determination of what values the relay should have as initial monitoring values when the relay is placed in service.

Also, please be aware that because of the multi-function nature of the BE1-IPS100 relay, it may on occasion be necessary to temporarily disable some of the protective elements while testing the relay to facilitate isolated testing of individual functions. Always remember to enable these functions before placing the relay in service.

To assist you in the commissioning testing of this relay, you may at any time refer to Section 6, *Reporting and Alarm Functions*, for various means of reporting status, alarms, and targets.

Please refer to the other sections of this instruction manual for assistance on any particular functions of the relay. If you require further assistance, contact Basler Electric field application personnel or the factory.

Digital I/O Connection Verification

Contact Sensing Inputs

Purpose: To verify contact sensing input label assignments and recognition and debounce settings.

Reference Commands: SN-IN, SG-IN

Step 1: Transmit the SN-IN1 command to verify the Input 1 user-defined name, Energized State label, and De-Energized State label.

Step 2: Repeat Step 1 for each of the remaining contact sensing inputs. Add the number of an input to the SN-IN command to check that input's name and labels.

Step 3: Verify the recognition and debounce settings for each contact sensing input by using the SG-IN command. When the SG-IN command is transmitted, the relay responds with the recognition and debounce settings for each input. Reported settings use the format SG-IN#=recognition, debounce.

Step 4: Transmit the RG_STAT command to the relay or use HMI Screen 1.4.1 to verify the status of Input 1. Transmit the RS-NEW=0 command to the relay. From the actual field device, energize (or de-energize) the specific contact that supplies relay Input 1. While maintaining contact position, verify that Input 1 has changed state by transmitting the RG-STAT command or using HMI Screen 1.4.1. Return the field contact to its original state, verifying that Input 1 returns to its original state. Transmit the RS-NEW command to the relay and review the event record associated with the field contact change.

Step 5: Repeat Step 4 for each connected input.

Output Contacts

Purpose: To verify output contact settings and output contact logic settings.

Reference Commands: SN-VO, SL-VO, SG-HOLD

Step 1: Transmit the SN-VOA command to verify the Virtual Output A user-defined name, TRUE label, and FALSE label.

Step 2: Repeat Step 1 for Virtual Outputs 1 through 15. Add the number of an output to the SN-VO command to check that output's name and labels.

Step 3: Transmit the SL-VO command to obtain a list of all virtual outputs and their Boolean logic equations. Verify that the desired virtual output equations match the reported equations.

Step 4: Verify the programmable hold timer setting for each hardware output by transmitting the command SG-HOLD. The output hold timer setting for each output is reported as enabled (1) or disabled (0).

Step 5: Verify the output contact activity by viewing the sequence of events reports with the RS-### command.

Step 6: Use the procedure outlined under "*Acceptance Tests, Control Outputs*" to actuate selected output contacts (V01 through V05) and actually trip or close the connected field device (circuit breaker, lockout, etc.). Use the same procedure to verify that operation of the Alarm Output Relay (V0A) initiates the appropriate alarm response.

Virtual Selector Switches

Purpose: To verify the operation, labels, and logic settings of the 43 switches.

Reference Commands: SN-43, SL-43, RG-43STAT, RG-STAT, CS/CO-43

Step 1: Transmit the SN-43 command to verify the Virtual Selector Switch 43 name, TRUE label, and FALSE label. This information is reported using the format SN-x43=name, TRUE label, FALSE label.

Step 2: Repeat Step 1 for Virtual Selector Switch 143. Use the number of a switch in the SN-43 command to retrieve name and label information for that switch.

Step 3: Use the SL-x43 command to obtain the logic setting of Virtual Switches 143. Logic settings for virtual switches can also be obtained by using the SL command or by viewing optional HMI Screens \CTRL\43\143. Verify that the desired virtual selector switch setting matches the reported setting.

Step 4: Transmit the RG-43STAT command to obtain the position of the eight virtual selector switches. Alternately, the virtual selector switch positions can be obtained through the RG-STAT command or HMI Screen 1.5.4.

Step 5: Obtain write access to the relay by using the ACCESS= command. For each virtual selector switch enabled in your logic scheme, change the switch position by entering CS-x43=1 (TRUE), 0 (FALSE) or P (Pulse) followed by CO-x43=1,0 or P. The syntax of the CS-x43 and CO-x43 commands must match or the CO-x43 command won't be executed.

Step 6: Verify each switch position change by using the CO-x43 command or through HMI Screen 1.5.4.

Step 7: Return each Virtual Selector Switch to the original position by repeating Step 5.

Step 8: Verify the 43 Switch activity by viewing the sequence of events reports with the RS-### command.

Virtual Control Switch

Purpose: To verify the operation and logic setting for the 101 Switch.

Reference Commands: SB-LOGIC, SL-101, RG-101STAT, RG-STAT, CS/CO-101

Step 1: Verify the breaker label and breaker-closed logic expression with the SB-LOGIC command.

Step 2: Use the SL-101 command to read the logic mode of the 101 Switch. The switch is either enabled (1) or disabled (0).

Step 3: Obtain the virtual control switch status by using the RG-101STAT or RG-STAT commands.

Step 4: Transmit the command ACCESS= to obtain write access to the relay. Change the switch position by entering CS-101=T (trip) or C (close) followed by CO-101=T (trip) or C (close). The syntax of the CS-101 and CO-101 commands must match or the CO-101 command won't be executed.

Step 5: Confirm the switch position change with the RG-101STAT or RG-STAT commands.

Step 6: Repeat Step 4 to return the 101 Switch to the desired position for your application.

Step 7: Verify the 101 Switch activity by viewing the sequence of events reports with the RS-### command.

Protection and Control Function Verification

Before placing the relay in service, the user should ensure that all system ac and dc connections are correct, that the relay functions as intended with user settings applied, and that all equipment external to the relay operates as intended. All connected or monitored inputs and outputs, and polarity and phase rotation of ac connections should be tested. Verify that:

- Power supply and contact wetting voltages are correct.
- User desired protection and control functions are enabled and connected to the correct CT and VT input circuits.
- The programmable logic settings (electronic wiring) provide the proper interconnection of these functions with the I/O of the relay.
- Each protection function has the desired operational set points.

Simple user designed fault tests should be used to verify that the operational settings are correct, that the proper output relays are actuated, and proper targeting occurs. (Refer to Figures 13-1 or 13-2 for terminal locations.) It is not necessary to test every protection element, timer, and function in these tests.

Use of the fault and event recording capability of the relay will aid in the verification of the protection and control logic. Transmit the RS command to retrieve all SER records or RS-n to get a specific operation. Also, it is helpful to transmit RS-NEW=0 prior to starting a test. This allows the user to review only those operations recorded since the last RS-NEW was initiated. Replace the S with F and use the same commands for fault records. Refer to Section 6, *Reporting and Alarm Functions*, for more detail.

Please be aware that because of the multi-function nature of the BE1-IPS100 relay, it may be necessary to disable protection elements or change setting logic to verify a specific function. To guard against placing the relay in service with unwanted operational or logic settings, it is good practice to save a copy of the original setting file before the testing process begins. When testing is complete, compare the copy of the saved settings to the actual relay settings as a final verification.

To accomplish this, transmit the S command to the relay or use BESTCOMS, *File, Export to Text.* This command generates all logic and operational settings that are on the relay. Copy the data to a text editor such as Notepad and print it out. This along with the user's logic diagram provides a complete picture of the relay's protection and control capability. The logic and operational settings of the protection and control functions should be examined to determine:

- The mode setting for the function so that you know what the relay is supposed to do.
- Which virtual output logic expressions contain the logic variables that represent the output contacts for protection function being tested.
- The input logic expressions for the function under test (especially the block input because it renders the function disabled if the block input is asserted).
- That the operational pickup and dropout threshold values and time delays agree with the user's calculated values.
- That the fault reporting settings are set so the relay properly indicates pickup and trip states and records targets. These settings are set from the ASCII command interface using the SG-TRIGGER and SG-TARG setting commands. Refer to Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more details.

Verify Other Set Points as Appropriate

Consult *Functional Testing* found later in this section for guidelines on testing and verifying set points of other protection and control functions.

Reporting and Alarm Functions

Just prior to placing the relay in service, the following reporting and alarm functions should be reset and/or verified. For details on how to use the HMI or the ASCII command interface to enter or edit relay operating values, see Sections 10 and 11, respectively. BESTCOMS can also be used for many of the functions. See Section 14*, BESTCOMS Software*, for details.

<u>*Clock Display*</u>

Set the real time clock to the current date and time. If an IRIG input is used, day and time are automatically synched to the IRIG source but note that the IRIG time code signal does not contain the current year information thus necessitating the entry of the year.

Reference Commands: RG-TIME, RG-DATE

Reference: HMI Screen 1.4.6 and Section 6, *Reporting and Alarm Functions, Clock*, for setting details.

<u>Energy Data and Demand</u>

Read, change, or reset KWH and KVARH records. If the Demand Functions feature of the relay is enabled, use the following to reset the peak current, watt and var demand registers to "0" or a pre-existing value.

Reference Commands: RE, RD, RD-<pp>

Reference: HMI Screens 4.4.1.x, 4.4.2.x, 4.4.3.x, and Section 6, *Reporting and Alarm Functions, Energy Data and Demand Functions*, for setting details.

<u>Breaker Monitoring</u>

If the Breaker Monitoring features of the relay are enabled, use the following to reset the counter and the duty registers to "0" or a pre-existing value.

Reference Commands: RB-OPCNTR, RB-DUTY

Reference: HMI Screens: 4.3.1 and Section 6, *Reporting and Alarm Functions, Breaker Monitoring*, for setting details.

<u>Relay Trouble Alarms</u>

Reset and verify that the relay trouble alarm is not illuminated. If required, alarm information can be read by transmitting the RA or RG-STAT commands. To attempt clearing a Relay Trouble Alarm, first gain write access to the reporting functions ("R" password) and initiate the RA=0 or RA-REL=0 commands or press the *RESET* key from the STAT\ALARMS\ALARM Screen on the HMI. Refer to Section 6, *Reporting and Alarm Functions, Relay Trouble Alarms*, for setting details.

<u>Major/Minor/Logic Programmable Alarms</u>

Reset and verify that the programmable alarms, Major, Minor, and Logic, as set to meet user needs verify that they are not illuminated or asserted. If required, alarm information can be read by transmitting the RA or RG-STAT commands. To reset a Major/Minor/Logic Alarm, first gain write access to the reporting functions ("R" password) and initiate the RA=0 or RA-MAJ/MIN/LGC=0 commands or by pressing the *RESET* key from a STAT\ALARMS\DET Screen on the HMI.

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function, Major, Minor, and Logic Programmable Alarms*, for setting details.

<u>Targets</u>

Reset and verify that there is no target information. Targets are reset from HMI Screen 1.2, \STATS\TARGETS by pressing the *Reset* key or gaining write access to the reporting functions ("R" password) and transmitting RG-TARG=0. Relay target information can be read either from HMI Screen 1.1.1, \STATS\TARGETS or by transmitting the RG-TARG command.

Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting, Targets*, for setting details.

<u>Fault Summary Reports</u>

Reset "new" fault summary directory records to "0" by first gaining write access to the reporting functions ("R" password), and transmitting the RF-NEW=0 command. Verify that new faults is "0" by transmitting the RF command.

Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting, Fault Summary Reports*, for setting details.

<u>Sequence of Events Recorder (SER)</u>

Reset the "new" SER records counter to "0" by first gaining write access to the reporting functions ("R" password), and transmitting the RS-NEW=0 command two times. Verify that new records is "0" by transmitting the RS command.

Reference: Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder Function*, for setting details.

<u>Just Prior to Energizing - Report Documentation</u>

After completing the previous steps, capture and save a General Status Report by transmitting the RG-STAT command. This report should be kept in the permanent record file of the device so the data can be used for comparison in future maintenance procedures.

Also, save the entire settings record for future reference by transmitting the "S" command. Use this record during the maintenance cycle or during the analysis of an operation to verify that the “as found" settings are exactly as left during the commissioning process.

Reference: Section 6, *Reporting and Alarm Functions, General Status Reporting*, for details.

In Service Readings

Just after energizing the equipment, transmit the "M" command to the relay. Use this record to review the following:

- M-I and M-V to verify VT and CT ratios.
- Polarity of M-WATT and M-VAR readings to verify polarity of VT and CT connections.
- M-IQ and M-V2 to verify proper phase sequence connections.
- M-SYNC to verify proper phase relationship of VP and VX.
- Anything else that the user might find helpful.

Save this record along with the RG-STAT record mentioned earlier for future reference.

PERIODIC TESTING

Because the BE1-IPS100 has extensive internal test capabilities, periodic testing of the protection system can be greatly reduced. Relay operating characteristics are a function of programming instructions that do not drift over time. Thus, the user may wish to verify items that the relay's self-testing features cannot completely determine. Periodic testing might consist of the following settings and function checks:

- Verify that the set points that were proven during commissioning have not been changed.
- Verify that the inputs and outputs are interfacing properly with the rest of the protection and control system.
- Verify that the power system analog parameters used by the protection and control functions are being measured accurately.

Settings Verification

Verification of the relay digital I/O connections can be accomplished in different ways. The method used depends on your preferences and practices. You might choose to use either of the following two methods:

- Repeat the digital I/O connection and label verification under commissioning tests.
- Monitor SER, Status, and Fault reports for proper sensing of digital signals and proper output tripping during normal operation.

NOTE

In redundant protection systems where multiple relays will trip a given breaker or other device for a fault, fault record monitoring may not indicate a failed output contact. The relay may report that it energized an output when tripping was actually accomplished by the redundant relay. In this situation, testing the contact is recommended.

Analog Circuit Verification

Verification of relay analog measurement circuits can be accomplished in multiple ways and depends on your preferences and practices. Either of the two following methods might be used:

- Repeat the acceptance tests by injecting test quantities into the relay.
- Use the relay metering functions to compare the relay's measurements with those made by similar devices that are measuring the same signals. Redundant relays or metering devices can provide this independent conformation of measured signals. If the relay is connected to an integration system, this verification can even be automated and done on a semi-continuous basis.

> **NOTE**
>
> If verifying the analog measurement circuits by comparison to independent devices is used, you should ensure that the two devices use similar measurement algorithms. For example, the measurements of a fundamental sensing relay cannot be compared with the measurements of an RMS sensing device.

MAINTENANCE OF BACKUP BATTERY FOR REAL TIME CLOCK

The backup battery for the real time clock is an optional feature available in Basler Electric BE1-IPS100 numeric products. A 3.6 V, 0.95 Ah lithium battery is used to maintain clock function during extended loss of power supply voltage (over eight hours). In mobile substation and generator applications, the primary battery system that supplies the relay power supply may be disconnected for extended periods (weeks, months) between uses. Without battery backup for the real time clock, clock functions would cease after eight hours (capacitor backup).

The backup battery should be replaced after five years of operation. The recommended battery is a lithium 3.6V, 0.95 Ah battery (Basler P/N: 9 3187 00 012; Applied Power P/N: BM551902). Use the following instructions to replace the battery.

To Replace Battery in H1 Case

Step 1: Remove the unit from the case.

Step 2: Disconnect the battery cable from the connector on the right side of the unit. See Figure 13-3. **Caution:** Be sure that all static body charges are neutralized before touching the PC board.

Step 3: The battery is located on the left side of the case. See Figure 13-3. Using a 5/16" nut driver, remove the nut holding the battery strap in place. Then remove the old battery, being careful not to hang the leads on the PC board components. Consult your local ordinance for proper battery disposal.

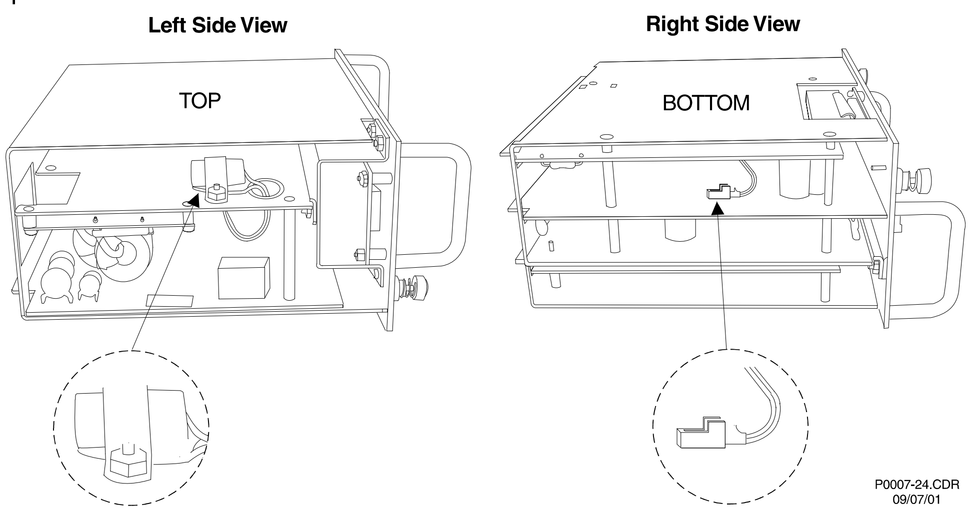


Figure 13-3. Backup Battery Location

Step 4: Insert the new battery by carefully feeding the leads through the hole in the aluminum plate and sliding them between the PC boards. Plug the new battery into the connector as shown in Figure 13-3.

> **WARNING!**
>
> Do not short-circuit, reverse battery polarity, or attempt to recharge the battery.

Step 5: Place the battery under the battery strap and replace the nut. Put the unit back into the case.

To Replace Battery in S1 Case

Step 1: Remove the unit from the case.

Step 2: Remove the front panel from the unit by removing the four screws located in the upper, lower, left, and right hand corners. The battery will be attached to the back side of the panel, using a strap similar to what is shown for the H1 case in Figure 13-3.

Step 3: Disconnect the battery cable from the connector on the right side of the unit. **Caution:** Be sure that all static body charges are neutralized before touching the PC board.

Step 4: Using a 5/16" nut driver, remove the nut holding the battery strap in place. Then remove the old battery, being careful not to hang the leads on the PC board components. Consult your local ordinance for proper battery disposal.

WARNING!

Do not short-circuit, reverse battery polarity, or attempt to recharge the battery.

Step 5: Insert the new battery and connect the lead to the connector the old battery had been connected.

Step 6: Place the battery under the battery strap and replace the nut. Put the unit back into the case.

CARE AND HANDLING

The BE1-IPS100 can be fully drawn out of the case. When the drawout assembly is removed, the current transformer input circuits are automatically shorted by the case. The case contains no components that are likely to require service; all critical components are contained in the drawout assembly. When removing the drawout assembly from the case, care should be taken to prevent electrostatic discharge (ESD) and mechanical damage.

There is no need to disturb the circuit interconnections within the drawout assembly. Repair of the drawout assembly by replacement of individual circuit boards is not recommended. The printed circuit boards are constructed using surface-mount technology and are not intended to be field serviceable.

If a relay failure occurs in a critical application without sufficient redundancy, protection can be restored by inserting a spare relay in the mounted and wired case of the relay requiring service. The drawout assembly requiring service can then be returned to the factory in the case from the spare relay. If a spare case isn't available, care should be used when packing the drawout assembly for shipment. Use antistatic packing material that prevents mechanical damage during transit.

Before returning the drawout assembly for repair, contact the Basler Electric, Technical Services Department at 618-654-2341 for a return authorization number.

UPDATING FIRMWARE AND SOFTWARE

Future enhancements to relay functionality may make a firmware update desirable. Enhancements to relay firmware typically coincide with enhancements to BESTCOMS software for that relay. When a relay is updated with the latest version of firmware, the latest version of BESTCOMS software should also be obtained.

Updating Relay Firmware

If a firmware upgrade is desired, you may request a CD-ROM containing the latest firmware or download the firmware from the Basler Electric website. Direct your web browser to http://www.basler.com/BE1_Firm/ and complete the online form to request a CD-ROM containing the latest firmware or a password for downloading firmware from the Basler Electric web site.

Once the appropriate firmware is obtained, it can be uploaded to a relay using the BESTload software utility provided on the CD-ROM originally supplied with the relay.

Updating BESTCOMS Software

Firmware enhancements often include the addition of relay settings or the modification of existing settings. BESTCOMS software is revised to accommodate the new or changed settings. When firmware is updated, the latest version of BESTCOMS should also be obtained. If a CD-ROM containing firmware was obtained from Basler Electric, then that CD-ROM will also contain the corresponding version of

BESTCOMS software. BESTCOMS can also be downloaded from the Basler Electric web site (http://www.basler.com). An online form can be completed to obtain a password for downloading BESTCOMS from the Basler Electric web site.

FUNCTIONAL TESTING

> **NOTE**
>
> Functional testing is not required for this device. It is necessary only when performing a comprehensive assessment to determine suitability for an application.

Functional testing is a way to assess this relay's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that your relay measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the relay is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Support Services Department.

Test connections referred to in this section are for an H1 case relay. Refer to Figure 13-1 (H1 case) for terminal locations. If testing a relay in an S1 case, modify the current and potential test connections according to the terminal locations shown in Figure 13-2 (S1 case).

The "access command" (A=) and the "exit with save commands" (E and Yes) are shown in the initial logic setup table found in each test section. In order to include multiple test settings in each operational setting table. The "ACCESS" and "EXIT WITH SAVE" commands are not included. However, "ACCESS" and "EXIT WITH SAVE" are required each time a logic or operational setting is changed.

To accelerate the testing process, two protection elements may have the same setting and are tested at the same time but with different outputs. During the pickup/dropout test, one of the elements could pick up slightly ahead of the other, resulting in only one target being displayed. At some point in the test, apply 110% of the pickup value and verify that both targets display. Reset targets prior to each test by pressing the HMI *RESET* key.

Instantaneous Overcurrent (50T)

50TP/150TP and TN (Calculated 3Io) Pickup and Dropout Verification

Purpose: To verify the accuracy of the operation of the 50/150TP and TN (3Io) elements.

Reference Commands: SL-50T/150T, SL-GROUP, SL-VO

Step 1: Connect a current source to Terminals D1 and D2 (A-phase). Refer to Figure 13-1 for terminal locations. An ohmmeter or continuity tester may be used to monitor output contact status.

Step 2: Prepare the 50T/150T elements for testing by transmitting the commands in Table 13-6 to the relay. Reset targets. Note that 50/150TP can be set for 1 of 3, 2 of 3, or 3 of 3 tripping, test is conducted on 1 of 3.

Table 13-6. 50TP and 50TN Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with logic=none settings.
Y	Confirm overwrite.
SL-N=PU50	Sets PU50 as custom logic name.
SL-50TP=1,0; SL-50TN=1,0	Enables 50TP and 50TN (3Io), and disables blocking.
SL-VO1=50TPT	Enables OUT1 to close for 50TP trip.
SL-VO2=50TNT	Enables OUT2 to close for 50TN trip.

Command	Purpose
SG-CT=1	Sets P, N CT ratio at 1:1
SG- TRIG=50TPT+50TNT, 50TPPU+50TNPU,0	Enable 50TPT or 50TNT to log and trigger fault recording.
SG-TARG=50T/150T	Enables 50T/150T targets.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-7 as a guide, transmit the low range setting commands (minimum pickup setting) for your sensing input type.

Step 4: Slowly increase the A-phase current until OUT1 closes. Verify that pickup occurs within the specified accuracy listed in Table 13-8. Slowly decrease the applied current until OUT1 opens. Dropout should occur at 93 to 97 percent of pickup.

Step 5: Repeat Step 4 while monitoring OUT2 (50TN enabled for 3Io). Verify 50TA and 50TN targets on the HMI.

Step 6: Repeat Steps 4 and 5 for the middle and high range pickup settings for your sensing input type.

Table 13-7. 50T and 150T Pickup Settings

Current Sensing Input Type	Ranges	Pickup Settings Commands		Purpose
		Phase	Neutral	
5 A	Low	S0-50TP=0.5,0,N	S0-50TN=0.5,0,N	Sets 50T PU at 0.5 A, TD = 0, non-directional.
	Middle	S0-50TP=5.0,0,N	S0-50TN=5.0,0,N	Sets 50T PU at 5.0 A, TD = 0, non-directional.
	High	S0-50TP=25.0,0,N	S0-50TN=25.0,0,N	Sets 50T PU at 25.0 A, TD = 0, non-directional.
1 A	Low	S0-50TP=0.1,0,N	S0-50TN=0.1,0,N	Sets 50T PU at 0.1 A, TD = 0, non-directional.
	Middle	S0-50TP=1.0,0,N	S0-50TN=1.0,0,N	Sets 50T PU at 1.0 A, TD = 0, non-directional.
	High	S0-50TP=5.0,0,N	S0-50TN=5.0,0,N	Sets 50T PU at 5.0 A, TD = 0, non-directional.

Table 13-8. 50T/150T Element Accuracy

Sensing Type	Pickup Accuracy
A or B (1 A)	±2% or ±10mA
D, E, or F (5 A)	±2% or ±50mA

Step 7: (Optional.) Repeat Steps 3 through 6 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).

Step 8: (Optional.) Repeat Steps 1 through 7 for the 150T elements. Overwrite the 50T commands entered in Step 2 with the commands of Table 13-9.

Table 13-9. 150TP and 150TN Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-150TP=1,0; SL-150TN=1,0	Enables 150TP and 150TN, disables blocking.
SL-VO1=150TPT	Enables OUT1 to close for 150TP trip.

Command	Purpose
SL-VO2=150TNT	Enables OUT2 to close for 150TN trip.
SG-TRIGGER=150TPT+150TNT, 150TPPU+150TNPU,0	Enable 150TPT or 150TNT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 9: (Optional.) Repeat Steps 1 through 8 for the 50T and 150T elements in Setting Group 1. Before testing settings in other setting groups, a setting group must be selected using the CS/CO-GROUP commands. To activate Setting Group 1, CS-GROUP=1 would be entered to select Setting Group 1 and CO-GROUP=1 would be entered to make Setting Group 1 active.

Also, the pickup settings made in Step 3 (Table 13-7) must be changed to specify the setting group being tested. To test settings in Group 1, replace the 0 in the S0-x50 commands with a 1 (S1-x50).

50TP/150TP and TN (Calculated 3Io) Time Delay Verification

Step 1: Connect a current source to Terminals D1 and D2 (A-phase). Refer to Figure 13-1 for terminal locations.

Step 2: Prepare the 50T/150T elements for testing by transmitting the commands in Table 13-10 to the relay.

Table 13-10. 50TP and 50TN Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=TD50	Sets TD50 as custom logic name.
SL-50TP=1,0; SL-50TN=1,0	Enables 50TP and 50TN (3Io), and disables blocking.
SL-VO1=50TPT	Enables OUT1 to close for 50TP trip.
SL-VO2=50TNT	Enables OUT2 to close for 50TN trip.
SG-CT=1	Sets P, N CT ratio at 1:1
SG-TRIG=50TPT+50TNT, 50TPPU+50TNPU,0	Enable 50TPT or 50TNT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-11, transmit the first column of setting commands.

Table 13-11. 50T/150T Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-50TP=0.5,2S	S0-50TP=0.5,5S	S0-50TP=0.5,10S	Sets 50TP TD.
S0-50TN=0.5,2S	S0-50TN=0.5,5S	S0-50TN=0.5,10S	Sets 50TN TD.

Step 4: Step the applied A-phase current to .55 amps (for 1 amp CT circuit divide by 5). Measure the time delay and verify the accuracy of the 50TP time delay setting, OUT1, and 50TN, OUT2. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 5: Repeat Steps 2 and 3 for the middle and higher time delay settings in Table 13-11.

Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals D3 and D4), phase C (Terminals D5 and D6).

Step 7: (Optional.) Repeat Steps 1 through 6 for the 150T elements. Overwrite the 50T commands entered in Step 2 with the commands of Table 13-12.

Table 13-12. 150TP and 150TN Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-150T=1,0; SL-150TN=1,0	Enables 150TP and 150TN, disables blocking.
SL-VO1=150TPT	Enables OUT1 to close for 150TP trip.
SL-VO2=150TNT	Enables OUT2 to close for 150TN trip.
SG-TRIGGER=150TPT+150TNT, 150TPPU+150TNPU,0	Enable 150TPT or 150TNT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 8: (Optional.) Repeat Steps 1 through 7 for the 50T and 150T elements in Setting Group 1. Before testing settings in other setting groups, a setting group must be selected using the CS/CO-GROUP commands. To activate Setting Group 1, CS-GROUP=1 would be entered to select Setting Group 1 and CO-GROUP=1 would be entered to make Setting Group 1 active.

Also, the pickup settings made in Step 3 (Table 13-11) must be changed to specify the setting group being tested. To test settings in Group 1, replace the 0 in the S0-x50 commands with a 1 (S1-x50).

50TQ/150TQ Pickup and Dropout Verification

Purpose: To verify the operation of the 50TQ and 150TQ elements.

Reference Commands: SL-50T/150T

Step 1: Connect a current source to Terminals D1 and D2 (A-phase).

Step 2: Prepare the 50TQ and 150TQ elements for testing by transmitting the commands in Table 13-13 to the relay. Reset targets.

Table 13-13. 50TQ Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=Q50	Sets Q50 as custom logic name.
SL-50TQ=1,0	Enables 50TQ, disables blocking.
SL-VO1=50TQT	Enables OUT1 to close for 50TQ trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIGGER=50TQT,50TQPU,0	Enable 50TQT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-14, transmit the first row of setting commands for your sensing input type.

Table 13-14. 50TQ Pickup Settings

Sensing Type	Command	Purpose
1 A	S0-50TQ=0.1,0,N	Sets 50TQ pickup at 0.1 A, TD = 0, non-directional.
	S0-50TQ=1.0,0,N	Sets 50TQ pickup at 1.0 A, TD = 0, non-directional.
	S0-50TQ=5.0,0,N	Sets 50TQ pickup at 5.0 A, TD = 0, non-directional.
5 A	S0-50TQ=0.5,0,N	Sets 50TQ pickup at 0.5 A, TD = 0, non-directional.
	S0-50TQ=5.0,0,N	Sets 50TQ pickup at 0.5 A, TD = 0, non-directional.
	S0-50TQ=10.0,0,N	Sets 50TQ pickup at 10.0 A, TD = 0, non-directional.

For a single-phase input test, I_2 = Ia ÷ 3. Therefore, the relay should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for an a 1 A relay with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.

Step 4: Slowly ramp up A-phase current until OUT1 closes. Verify that pickup occurred within the specified accuracy of the relay (5 A sensing: ±3 percent or ±75 mA, 1 A sensing: ±3 percent or ±15 mA). Table 13-15 provides the upper and lower limits for the specified tests.

Table 13-15. 50TQ/150TQ Pickup Values

Sensing Type	Pickup Setting	Lower Limit	Upper Limit
1 A	S0-50TQ=0.1,0	0.225 A	0.375 A
	S0-50TQ=1.0,0	2.91 A	3.09 A
	S0-50TQ=5.0,0	14.55 A	15.45 A
5 A	S0-50TQ=0.5,0	1.425 A	1.575 A
	S0-50TQ=5.0,0	14.55 A	15.45 A
	S0-50TQ=10.0,0	29.1 A	30.1 A

Step 5: After pickup occurs, slowly ramp the current down until OUT1 opens. Verify that dropout occurred as specified (95 percent, ±2 percent). Verify 50TQ target on the HMI.

Step 6: Repeat Steps 3, 4, and 5, applying all Table 13-15 values that apply to your sensing input type.

Step 7: (Optional.) Repeat Steps 3 through 6 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).

Step 8: (Optional.) Repeat Steps 1 through 7 for the 150TQ elements. Use Table 13-16 as a reference when substituting the commands used in Step 1.

Table 13-16. 150TQ Pickup Test Commands

Replace These Commands	With These Commands
SL-50TQ=1,0	SL-150TQ=1,0
SL-VO1=50TQT	SL-VO1=150TQT
SG-TRIG=50TQT,50TQPU,0	SG-TRIG=150TQT,150TQPU,0

Step 9: (Optional.) Repeat Steps 1 through 8 for the 50TQ and 150TQ elements in Setting Group 1.

Step 10: (Optional.) Repeat Steps 1 through 8 for the 50TQ and 150TQ elements set for positive-sequence Mode 2.

50TQ/150TQ Time Delay Verification

Step 1: Connect a current source to Terminals D1 and D2 (A-phase).

Step 2: Prepare the 50TQ and 150TQ elements for testing by transmitting the commands in Table 13-17 to the relay.

Table 13-17. 50TQ/150TQ Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=Q50	Sets Q50 as custom logic name.
SL-50TQ=1,0	Enables 50TQ, disables blocking.
SL-150TQ=1,0	Enables 150TQ, disables blocking.
SL-VO1=50TQT	Enables OUT1 to close for 50TQ trip.
SL-VO2=150TQT	Enables OUT2 to close for 150TQ trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIGGER=50TQT+50TQPU, 150TQT+150TQPU,0	Enable 50TQT and 150TQT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-18, transmit the first column of setting commands for your sensing input type (substitute 0.1 for 1 amp CT).

Table 13-18. 50TQ/150TQ Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-50TQ=0.5,2S	S0-50TQ=0.5,5S	S0-50TQ=0.5,10S	Sets 50TQ TD.

For a single-phase input test, I_2 = Ia ÷ 3. Therefore, the relay should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for a 1-amp relay with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.

Step 4: Step the applied A-phase current to 110% of pickup. Measure the time delay and verify the accuracy of the 50TQ time delay setting, OUT1, and 150TQ, OUT2. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 5: Repeat Step 2 and 3 for the middle and higher time delay settings in Table 13-18.

Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals D3 and D4), phase C (Terminals D5 and D6).

Step 7: (Optional.) Repeat Steps 1 through 6 for Setting Group 1.

Step 8: (Optional.) Repeat Steps 1 through 8 for the 50TQ and 150TQ elements set for positive-sequence Mode 2.

50TN/150TN (Independent Ground Input IG) Pickup and Dropout Verification

Purpose: To verify the operation of the 50TN and 150TN elements for IG input.

Reference Commands: SL-50TN/150TN

Step 1: Connect a current source to Terminals D7 and D8 (IG).

Step 2: Prepare the 50TN and 150TN elements for testing by transmitting the commands in Table 13-19 to the relay. Reset targets.

Table 13-19. 50TN/150TN Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=50/150TN	Sets 50/150TN as custom logic name.
SL-50TN=G,0	Enables 50TN, disables blocking.
SL-150TN=G,0	Enables 150TN, disables blocking.
SL-VO1=50TNT	Enables OUT1 to close for 50TN trip.
SL-VO2=150TNT	Enables OUT2 to close for 150TN trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIGGER=50TNT+50TNPU, 150TNT+150TNPU,0	Enable 50TNT and 150TNT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-20, transmit the first row of setting commands for your sensing input type.

Table 13-20. 50TN/150TN Pickup Settings

Sensing Type	Command	Purpose
1 A	S0-50TN=0.1,0,N;S0-150TN=0.1,0,N	Sets 50TN and 150TN pickup at 0.1 A, TD = 0, non-directional.
	S0-50TN=1.0,0,N;S0-150TN=1.0,0,N	Sets 50TN and 150TN pickup at 1.0 A, TD = 0, non-directional.
	S0-50TN=5.0,0,N;S0-150TN=5.0,0,N	Sets 50TN and 150TN pickup at 5.0 A, TD = 0, non-directional.
5 A	S0-50TN=0.5,0,N;S0-150TN=0.5,0,N	Sets 50TN and 150TN pickup at 0.5 A, TD = 0, non-directional.
	S0-50TN=5.0,0,N;S0-150TN=5.0,0,N	Sets 50TN and 150TN pickup at 5.0 A, TD = 0, non-directional.
	S0-50TN=10.0,0,N;S0-150TN=10.0,0,N	Sets 50TN and 150TN pickup at 10.0 A, TD = 0, non-directional.

Step 4: Slowly increase the IG current until OUT1 closes. Verify that pickup occurs within the specified accuracy listed in Table 13-21. Slowly decrease the applied current until OUT1 opens. Dropout should occur at 93 to 97 percent of pickup.

Step 5: Repeat Step 4 while monitoring OUT2 (150TN). Verify 50TG and 150TG targets on the HMI. Verify the pickup accuracy of the middle and upper pickup settings.

Table 13-21. 50TN/150TN Element Accuracy

Sensing Type	Pickup Accuracy
A or B (1 A)	±2% or ±10mA
D, E, or F (5 A)	±2% or ±50mA

Step 6: (Optional.) Repeat Steps 1 through 5 for the 50TN and 150TN elements in Setting Group 1.

50/150TN (Independent Ground Input IG) Time Delay Verification

Step 1: Prepare the 50TN and 150TN elements for testing by transmitting the commands in Table 13-19 to the relay.

Step 2: Using Table 13-22, transmit the first column of setting commands for your sensing input type (5 A is shown).

Table 13-22. 50TN/150TN Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	**5 Second TD**	**10 Second TD**	
S0-50TN=0.5,2S	S0-50TN=0.5,5S	S0-50TN=0.5,10S	Sets 50TN TD.
S0-150TN=0.5,2S	S0-150TN=0.5,5S	S0-150TN=0.5,10S	Sets 150TN TD.

Step 3: With the current source still connected to Terminals D7 and D8 (IG), step the applied current to .55 amps (for 1 amp CT circuit divide by 5). Measure the time delay and verify the accuracy of the 50TN time delay setting, OUT1, and 150TN, OUT2. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 4: Repeat Steps 2 and 3 for the middle and higher time delay settings in Table 13-22.

Step 5: (Optional.) Repeat Steps 1 through 4 for Setting Group 1.

Time Overcurrent (51)

Timing Verification

Purpose: To verify the timing operation of the 51 and 151 elements.

Reference Commands: SL-51PNQ/151P/151N, S<g>-51P/151P

Step 1: Prepare the 51 element for testing by transmitting the commands in Table 13-23 to the relay.

Table 13-23. 51P/51N/51Q Timing Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=PU51	Sets PU51 as custom logic name.
SL-51P=1,0	Enables 51P, disables blocking.
SL-51N=1,0	Enables 51N, disables blocking.
SL-51Q=1,0	Enables 51Q, disables blocking.
SL-VO1=51PT	Enables OUT1 to close for 51P trip.
SL-VO2=51NT	Enables OUT2 to close for 51N trip.
SL-VO3=51QT	Enables OUT3 to close for 51Q trip.
SG-CT=1	Sets CT ratio at 1.
SG- TRIG=51PT+51NT+51QT, 51PPU+51NPU+51QPU,0	Enable 51PT, 51NT, or 51QT to log and trigger fault recording.
SG-TARG=51	Enables 51P, 51N, and 51Q targets.
EXIT;Y	Exit and save settings.

Step 2: Transmit the appropriate commands in Table 13-24 for your sensing input type.

Table 13-24. 51P/51N/51Q Time Delay Settings

Sensing Type	Phase Commands	Neutral Commands	Negative-Sequence Commands
1 A	S0-51P=0.1,0.5,I2,N	S0-51N=0.1,0.5,I2,N	S0-51Q=0.1,0.5,I2,N
5 A	S0-51P=0.5,0.5,I2,N	S0-51N=0.5,0.5,I2,N	S0-51Q=0.5,0.5,I2,N

Step 3: Connect a current source to relay Terminals D1 and D2 (A-phase). Using the values listed in Table 13-25 (table value x3 for 51Q), apply the appropriate current values and measure the time between the application of current and the closure of OUT1, OUT2, and OUT3. Verify that the relay performs within the specified limits.

Table 13-25. 51P/51N/51Q Timing Values

Sensing Type	Time Dial	Applied Current	Relay Trip Limits	
			Lower Limit	Upper Limit
1 A	0.5	0.15 A	0.748 sec	0.827 sec
		0.50 A	0.190 sec	0.240 sec
		2.5 A	0.100 sec	0.150 sec
	5	0.15 A	7.244 sec	8.007 sec
		0.50 A	1.798 sec	1.988 sec
		2.5 A	0.944 sec	1.044 sec
	9.9	0.15 A	14.318 sec	15.825 sec
		0.50 A	3.535 sec	3.907 sec
		2.5 A	1.844 sec	2.038 sec
5 A	0.5	2.5 A	0.190 sec	0.240 sec
		12.5 A	0.100 sec	0.150 sec
	5	0.75 A	7.244 sec	8.007 sec
		2.5 A	1.798 sec	1.988 sec
		12.5 A	0.944 sec	1.044 sec
	9.9	0.75 A	14.318 sec	15.825 sec
		2.5 A	3.535 sec	3.907 sec
		12.5 A	1.844 sec	2.038 sec

Step 4: Repeat Steps 2 and 3 for all of the current and time dial settings for your current sensing type.

Step 5: (Optional.) Repeat Steps 2 through 4 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).

Step 6: (Optional.) Using ASCII commands, substitute 151 for any 51 logic or setting commands in each test.

<u>*Pickup and Dropout Verification*</u>

Purpose: To verify the pickup accuracy of the 51P, 51N, 151P, 151N, and 51Q elements.

Reference Commands: SL-51P, SL-151P, SL-51N, SL-51Q, SL-151N, SL-GROUP, SL-VO

Step 1: Connect a current source to Terminals D1 and D2 (A-phase). Refer to Figures 13-1 or 13-2 for terminal locations. An ohmmeter or continuity tester may be used to monitor output contact status.

Step 2: To prepare the 51P, 51N, and 51Q elements for testing, transmit the commands in Table 13-26 to the relay. Reset targets.

Table 13-26. 51P/51N/51Q Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=PU51	Sets PU51 as custom logic name.
SL-51P=1,0	Enables 51P and disables blocking.
SL-51N=1,0	Enables 51N and disables blocking.
SL-51Q=1,0	Enables 51Q and disables blocking.
SL-VO1=51PT	Enables OUT1 to close for 51PT trip.
SL-VO2=51NT	Enables OUT2 to close for 51NT trip.
SL-VO3=51QT	Enables OUT3 to close for 51QT trip.
SG-CT=1	Sets P, N CT ratio at 1:1
SG-TRIGGER=51PT+51NT+51QT, 51PPU+51NPU+51QPU,0	Enable 51PT, 51NT, or 51QT to log and trigger fault recording.
SG-TARG=51	Enables 51P, 51N, and 51Q targets.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-27 as a guide, transmit the first row of setting commands (minimum pickup setting) for your sensing type.

Table 13-27. 51P/51N/51Q Pickup Settings

Sensing Type	Pickup Settings			Purpose
	Phase	Neutral	Neg.-Sequence	
5 A	S0-51P=0.5,0,I2,N	S0-51N=0.5,0,I2,N	S0-51Q=0.5,0,I2,N	Sets 51PNQ PU at 0.5 A.
	S0-51P=5.0,0,I2,N	S0-51N=5.0,0,I2,N	S0-51Q=5.0,0,I2,N	Sets 51PNQ PU at 5.0 A.
	S0-51P=25,0,I2,N	S0-51N=25,0,I2,N	S0-51Q=25,0,I2,N	Sets 51PNQ PU at 25 A.
1 A	S0-51P=0.1,0,I2,N	S0-51N=0.1,0,I2,N	S0-51Q=0.1,0,I2,N	Sets 51PNQ PU at 0.1 A.
	S0-51P=1.0,0,I2,N	S0-51N=1.0,0,I2,N	S0-51Q=1.0,0,I2,N	Sets 51PNQ PU at 1.0 A.
	S0-51P=5.0,0,I2,N	S0-51N=5.0,0,I2,N	S0-51Q=5.0,0,I2,N	Sets 51PNQ PU at 5.0 A.

Step 4: Slowly increase the A-phase current until OUT1 (51P pickup indicator) closes. Verify that pickup occurs within the specified accuracy listed in Table 13-28. Slowly decrease the applied current until OUT1 opens. Dropout should occur at 93 to 97 percent of pickup. Verify 51A and 51N targets on the HMI. Repeat Step 4 while monitoring OUT2 (51N). Verify the pickup and dropout accuracy of the middle and upper pickup settings for your sensing type.

Table 13-28. 51P/51N Element Accuracy

Sensing Type	Pickup Accuracy
A or B (1 A)	±2% or ±10mA
D, E, or F (5 A)	±2% or ±50mA

Step 5: Slowly increase the A-phase current until OUT3 (51Q pickup indicator) closes (3 x A-phase value). Verify that pickup occurs within the specified accuracy listed in Table 13-29. Slowly decrease the applied current until OUT3 opens. Dropout should occur at 93 to 97 percent of

pickup. Verify the 51Q target on the HMI. Verify the pickup accuracy of the middle and upper pickup settings for your sensing type.

Table 13-29. 51Q Element Accuracy

Sensing Type	Pickup Accuracy
A or B (1 A)	±3% or ±15mA
D, E, or F (5 A)	±3% or ±75mA

Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6). To test independent ground input IG, gain access and transmit SL-51N=G,0 exit and save. Apply test current to Terminals D7 and D8 while monitoring OUT2 and repeat Step 4. Verify 51G target on the HMI.

Step 7: (Optional.) Repeat Steps 1 through 4 and Step 6, IG input, for the 151N element. Overwrite the 51 commands entered in Step 2 with the commands of Table 13-30.

Table 13-30. 151N Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-151N=G,0	Enables 151N, disables blocking.
SL-VO2=151NT	Enables OUT2 to close for 151N trip.
SG-TRIGGER=151NT,151NPU,0	Enable 151NT or 151NPU to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 8: (Optional.) Repeat Steps 1 through 7 for the 51P, 151P, 51N, and 151N elements in Setting Group 1. Before testing settings in other setting groups, a setting group must be selected using the CS/CO-GROUP commands. To activate Setting Group 1, CS-GROUP=1 would be entered to select Setting Group 1 and CO-GROUP=1 would be entered to make Setting Group 1 active. Also, the pickup settings made in Step 3 (Table 13-27) must be changed to specify the setting group being tested. To test settings in Group 1, replace the 0 in the S0-x51 commands with a 1 (S1-x51).

Voltage Restraint/Control Time Overcurrent

Purpose: To verify the operating accuracy of the 27R (Restraint and Control) for the phase time overcurrent function.

Reference Commands: S<g>-27R, SL-51, RG-STAT

51/27R-Voltage "Control" Pickup and Dropout Verification

Step 1: To prepare the 51P element for testing, transmit the commands in Table 13-31 to the relay. Reset targets.

Table 13-31. 51P Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=51/27R/C	Sets custom logic name.
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
SL-51P=1,0	Enables 51P and disables blocking.
SL-VO1=51PT	Enables OUT1 to close for 51PT trip.

Command	Purpose
SG-CT=1	Sets P, N CT ratio at 1:1
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-32 as a guide, transmit the 51/27R setting commands to the relay.

Table 13-32. 51/27R Settings

Operating Settings	Purpose
S0-51P=2.0,0,V2,N	Sets 51P PU at 2 amps, TD = 0, Time Curve = V2, non-directional.
S0-27R=100,C	Set 27R to 100 volts, 51P to Voltage Control.

Step 3: Connect and apply 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on users nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figure 13-1 for terminal locations.

Step 4: Apply 2 amps of A-phase current and slowly reduce A-phase voltage until OUT1 closes. Increase A-phase voltage until OUT1 just drops out. Pickup will occur within ±2% or 1 volt of the of the 27R voltage setting. Dropout will occur at 102% to 103% or actual pickup.

Step 5: Repeat Steps 2 and 3 for B-phase current (D3 and D4) while varying B-phase voltage and C-phase current (D5 and D6) while varying C-phase voltage.

Step 6: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.

51/27R-Voltage "Restraint" Pickup and Dropout Verification

Step 1: Using Table 13-33 as a guide, transmit the 51/27R setting commands to the relay.

Table 13-33. 51/27R Settings

Operating Settings	Purpose
S0-51P=2.0,0,V2,N	Sets 51P PU at 2 amps, TD = 0, Time Curve = V2, non-directional.
S0-27R=100,R	Set 27R to 100 volts, 51P to Voltage Restraint.

Step 2: Connect and apply 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on users nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figure 13-1 for terminal locations.

Step 3: Adjust the A-phase voltage to VR setting (100 volts). Apply and slowly increase A-phase current until OUT1 closes. Decrease A-phase current until OUT1 just drops out. Pickup will occur within ±2 percent of the 51P pickup setting. Dropout will occur at 93% to 97% of actual pickup.

Step 4: Adjust the A-phase voltage to ½ VR setting (50 volts). Apply and slowly increase A-phase current until OUT1 closes. Decrease A-phase current until OUT1 just drops out. Pickup will occur at ½ the 51P pickup setting (1 amp ±2%). Dropout will occur at 93% to 97% of actual pickup. See Instruction Manual Section 4, *Protection and Control*, *Overcurrent Protection, Voltage Restraint/Control for Phase Time Overcurrent Function*, for a graphical explanation of 51P pickup level compensation.

Step 5: Repeat Steps 2 and 3 for B-phase current (D3 and D4) while varying B-phase voltage, and C-phase current (D5 and D6) while varying C-phase voltage.

Step 6: (Optional.) Repeat Steps 1 through 5 for Setting Group 1.

Directional Overcurrent (67)

Purpose: To verify the operating accuracy of the 67 Directional Overcurrent function.

Reference Commands: SG-LINE, SL-50/51, S0-67, R.-STAT

Step 1: To prepare the 50TP,N, and Q elements for directional testing, transmit the commands in Table 13-34 to the relay. Reset targets. Note that SG-TORQ

Table 13-34. 50TP/50TN/50TQ Directional Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
SG-VTX=1,AN	Set auxiliary voltage parameters.
SL-N=67	Sets custom logic name.
SL-50TP=1,0	Enables 50TP and disables blocking.
SL-50TN=1,0	Enables 50TN and disables blocking.
SL-50TQ=1,0	Enables 50TQ and disables blocking.
SL-VO1=50TPT	Enables OUT1 to close for 50TPT trip.
SL-VO2=50TNT	Enables OUT2 to close for 50TNT trip.
SL-VO3=50TQT	Enables OUT3 to close for 50TQT trip.
SG-TRIG=50TPT+50TNT+50TQT, 50TPPU+50TNPU+50TQPU,0	Enable 50TP, 50NT, or 50QT to log and trigger fault recording.
SG-CT=1	Sets P, N CT ratio at 1:1
SG-TORQ=80,80	Set Pos, Neg, and Zero Max Torque Angle.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-35 as a guide, transmit the 67 setting commands to the relay. Prior to each directional test, reset the relay targets (HMI screen) from the previous test. Max Torque Angle setting, SG-TORQ for positive/negative, and zero sequence impedance angle is continuously adjustable between 0 and 90°, the default setting of 80° is used in the test example.

Table 13-35. 67P-50TP Operational Settings

Operating Settings	Purpose
S0-67=Q	Sets 67N to Negative-Sequence Polarizing.
S0-50TP=2.5,0,F	Sets 50TP at 2.5 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TN=0,0,F	Sets 50TN at 0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TQ=0,0,F	Sets 50TQ at 0 amps, 0 Time Delay, Forward Tripping Direction.

Positive-Sequence Voltage Polarizing, Phase Overcurrent Elements

Step 3: Connect and apply a 120 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Apply 0 amps A-phase current at an angle of 80 degrees I lag E (positive-sequence line angle) and slowly increase the current until OUT1 closes. Decrease A-phase current until OUT1 just drops out. Pickup will occur within ±2 percent of the 50TP pickup setting. Dropout will occur at 93% to 97% of actual pickup. Verify 67A target on the HMI.

Step 5: With three-phase voltage still applied, increase the A-phase current until OUT1 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree positive-sequence line angle. Verify that OUT1 opens at approximately 170 degrees I lag E and 350 degrees I lag E. Out1 should remain closed from 170 through 80 to 350 degrees I lag E (defined as forward trip direction).

Negative-Sequence Voltage Polarizing, Phase Overcurrent Elements

Step 6: Apply a 120 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.4 to verify that negative-sequence voltage is greater than 1 volt.

Step 7: Apply 0 amp A-phase current at an angle of 80 degrees I lag E (same as positive-sequence line angle) and slowly increase the current until OUT1 closes. Decrease A-phase current until OUT1 just drops out. Pickup will occur within ±2 percent of the 50TP pickup setting. Dropout will occur at 93% to 97% of actual pickup. Verify 67A target on the HMI.

Step 8: With the same voltage still applied, increase the A-phase current until OUT1 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree positive-sequence line angle. Verify that OUT1 opens at approximately 170 degrees I lag E and 350 degrees I lag E. Out1 should remain closed from 170 through 80 to 350 degrees I lag E (defined as forward trip direction).

Negative-Sequence Voltage Polarizing, Negative-Sequence Overcurrent Elements

Step 9: Using Table 13-36 as a guide, transmit the 67 setting commands to the relay.

Table 13-36. 67P-50TQ Operational Settings

Operating Settings	Purpose
S0-50TP=0,0,F	Sets 50TP at 0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TN=0,0,F	Sets 50TN at 0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TQ=0.5,0,F	Sets 50TQ at 0.5 amps, 0 Time Delay, Forward Tripping Direction.

Step 10: Apply a 120 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.4 to verify that negative-sequence voltage is greater than 1 volt.

Step 11: Apply 0 amp A-phase current at an angle of 80 degrees I lag E (same as positive-sequence line angle) and slowly increase the current until OUT3 closes (Negative-Sequence Pickup current will be approximately 1/3 the applied A-phase current value). Decrease A-phase current until OUT3 just drops out. Pickup will occur within ±2 percent of the 50TQ pickup setting. Dropout will occur at 93% to 97% of actual pickup. Verify the 67Q target on the HMI.

Step 12: With the same voltage still applied, increase the A-phase current until OUT3 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree positive-sequence line angle. Verify that OUT3 opens at approximately 170 degrees I lag E and 350 degrees I lag E. OUT3 should remain closed from 170 through 80 to 350 degrees I lag E (defined as forward trip direction).

Step 13: (Optional.) Repeat Steps 3 through 12 for B-phase current (D3 and D4) and C-phase current (D5 and D6). Reduce the corresponding B-phase and C-phase voltage for negative-sequence tests.

Negative-Sequence Voltage Polarizing, Ground Overcurrent Elements

Step 14: Using Table 13-37 as a guide, transmit the 67 setting commands to the relay.

Table 13-37. 67N (Q pol)-50TN Operational Settings

Operating Settings	Purpose
S0-50TP=0,0,F	Sets 50TP at 0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TN=2.0,0,F	Sets 50TN at 2.0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TQ=0,0,F	Sets 50TQ at 0 amps, 0 Time Delay, Forward Tripping Direction.

Step 15: Apply a 120 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.4 to verify that negative-sequence voltage is greater than 1 volt.

Step 16: Apply 0 amp A-phase current at an angle of 80 degrees I lag E (same as positive-sequence line angle) and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within ±2 percent of the 50TN pickup setting. Dropout will occur at 93% to 97% of actual pickup. Verify the 67N target on the HMI.

Step 17: With the same voltage still applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree positive-sequence line angle. Verify that OUT2 opens at approximately 170 degrees I lag E and 350 degrees I lag E. OUT2 should remain closed from 170 through 80 to 350 degrees I lag E (defined as forward trip direction).

Zero-Sequence Voltage Polarizing, Ground Overcurrent Elements

Step 18: Using Table 13-38 as a guide, transmit the 67 setting commands to the relay.

Table 13-38. 67N (Vo pol)-50TN Operational Settings

Operating Settings	Purpose
S0-67=V,VOIN	Sets 67N to Zero-Sequence Voltage Polarizing. V0IN compares calculated V0 to calculated 3I0 (IN).
S0-50TP=0,0,F	Sets 50TP at 0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TN=2.0,0,F	Sets 50TN at 2.0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TQ=0,0,F	Sets 50TQ at 0 amps, 0 Time Delay, Forward Tripping Direction.

Step 19: Apply a 120 Vac, three-phase voltage source at nominal frequency to terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI screen 3.4 to verify that the zero sequence voltage is greater than 1 volt.

Step 20: Apply 0 amp A-phase current at an angle of 80 degrees I lag E (zero sequence line angle) and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within ±2 percent of the 50TN (calculated 3I0) pickup setting. Dropout will occur at 93 to 97% of actual pickup. Verify the 67N target on the HMI.

Step 21: With the same voltage still applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 80-degree zero sequence line angle. Verify that OUT2 opens at approximately 170 degrees I lag E and 350 degrees I lag E. OUT2 should remain closed from 170 through 80 to 350 degrees I lag E (defined as forward trip direction). Steps 18 through 21 verify polarizing reference quantities V0IN, with 50TN set to operate for IN (calculated 3I0) as per Table 13-34 (SL-50TN=1,0). The 50TN element can also be set to operate for measured ground current IG (optional IG input) while still being polarized by V0IN. To verify, connect A-phase current in series with IG current. That is, polarity current should go in D1 out D2, in D7 out D8. Repeat Steps 19 through 21 with 50TN set for IG operate (SL-50TN=2, 0). Verify the 67G target on the HMI.

Step 22: Transmit S0-67=V,V0IG. The polarizing reference quantities are V0 compared to IG measured. This compares calculated V0 to measured IG (independent ground input). Repeat Steps 19 through 21 with A-phase current connected in series with IG current. That is, polarity current should go in D1 out D2, in D7 out D8.Verify the 67G target on the HMI. Note that 50TN can also be set to operate for calculated IN (3I0) while still being polarized by V0IG. Verify operation by repeating Steps 19 through 21 with 50TN set for IN operate (SL-50TN=1, 0). Verify the 67N target on the HMI.

Step 23: Transmit S0-67=V, VXIG and set SL-50TN=2,0. The polarizing reference quantities are an external source of 3V0 applied at the VX input compared to measured IG (independent ground input). Apply polarity of a single-phase voltage source (30 Vac at nominal frequency) to terminal C17 and non-polarity to C18 at an angle of 180 degrees I lag E. An angle of 180 degrees is used to simulate a broken delta voltage where polarity to non-polarity is 180 degrees out of phase with, for example, the A-phase current during an A-phase to ground fault. The relay internally compensates for the 180 degree phase difference such that polarity voltage from the broken delta source connected to polarity of the relay results in a 0 degree condition for a Forward fault. To verify, connect A-phase current in series with IG current. That is, polarity current should go in D1 out D2, in D7 out D8. Repeat Steps 20 and 21 with 50TN set for IG operate (SL-50TN=2,0). Verify the 67G target on the HMI. Note that 50TN can also be set to operate for calculated IN (3I0) while still being polarized by VXIG. Verify operation by repeating Steps 20 and 21 with 50TN set for IN operate (SL-50TN=1, 0). Verify the 67N target on the HMI.

Step 24: Transmit S0-67=V,VXIN. The polarizing reference quantities are an external source of 3V0 applied at the VX input compared to the calculated IN (3I0) quantity. Apply polarity of a single-phase voltage source (30 Vac at nominal frequency) to terminal C17 and non-polarity to C18 at an angle of 180 degrees I lag E. An angle of 180 degrees is used to simulate a broken delta voltage where polarity to non-polarity is 180 degrees out of phase with, for example, the A-phase current during an A-phase to ground fault. The relay internally compensates for the 180 degree phase difference such that polarity voltage from the broken delta source connected to polarity of the relay results in a 0 degree condition for a Forward fault. To verify, connect A-phase current in series with IG current (if option is available). That is, polarity current should go in D1 out D2 and in D7 out D8 if IG option is available. Repeat Steps 20 and 21 with 50TN set for IN operate (SL-50TN=1, 0). Verify the 67N target on the HMI. Note that 50TN can also be set to operate for measured independent ground (IG) while still being polarized by VXIN. Verify operation by repeating Steps 20 and 21 with 50TN set for IN operate (SL-50TN=1, 0). Verify the 67N target on the HMI.

Step 25: Repeat Steps 3 through 24 for "Reverse Polarization." Relay operation will occur 180 degrees away from the Positive and Negative Sequence line angle (both at 80 degrees or 260 degrees I lags E in our example). Verify that the output contacts remain closed from 170 through 260 to 350 degrees I lags E.

Step 26: (Optional.) Repeat Steps 3 through 25 for 150TNQ, 51TNQ, and 151N. Setup commands and associated operational setting Tables must be modified accordingly, i.e. all "50" entries would change to "150" and so on.

Step 27: (Optional.) Repeat Steps 3 through 25 for Setting Group 1.

__Zero-Sequence Current Polarization__

Use setup commands in Table 13-34. Using Table 13-39 as a guide, transmit the 67 setting commands to the relay.

Table 13-39. 67N (Io pol)-50TN Operational Settings

Operating Settings	Purpose
S0-67=I	Sets 67N to Zero-Sequence Current Polarizing.
S0-50TP=0,0,F	Sets 50TP at 0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TN=2.0,0,F	Sets 50TN at 2.0 amps, 0 Time Delay, Forward Tripping Direction.
S0-50TQ=0,0,F	Sets 50TN at 0 amps, 0 Time Delay, Forward Tripping Direction.

Step 1: Apply 2 amps ac current at 0 degrees to the independent ground input IG, terminals D7 (polarity) and D8 (non-polarity). No ac voltage is required for this test.

Step 2: From a second current source, apply 0 amp A-phase current at an angle of 0 degrees and slowly increase the current until OUT2 closes. Decrease A-phase current until OUT2 just drops out. Pickup will occur within ±2 percent of the 50TN pickup setting. Dropout will occur at 93 to 97% of actual pickup. Verify the 67N target on the HMI.

Step 3: With the same polarizing current applied, increase the A-phase current until OUT2 closes. Swing the angle of the applied current +90 degrees and -90 degrees away from the 0. Verify that OUT2 opens at approximately 90 degrees I lag E and 270 degrees I lag E. OUT2 should remain closed from 90 through 0 to 270 degrees I lag E (defined as forward trip direction).

Step 4: Repeat Steps 1 through 4 for "Reverse Polarization by transmitting the "R" command in the operational setting, i.e. S0-50TP=2.5,0,R". Relay operation will occur at 180 degrees I lag E. Swing the angle of the applied current +90 degrees and -90 degrees away from the 180 degrees. Verify that OUT2 opens at approximately 90 degrees I lag E and 270 degrees I lag E. OUT2 should remain closed from 90 through 180 to 270 degrees I lag E (defined as reverse trip direction).

Step 5: (Optional.) Repeat Steps 1 through 5 for 150TN, 51N, and 151N. Setup commands in Table 13-34 and operational settings in Table 13-39 must be modified accordingly, i.e. all "50" entries would change to "150" and so on.

Step 6: (Optional.) Repeat Steps 1 through 5 for Setting Group 1.

Directional Over/Under Power (32)

Purpose: To verify the operating accuracy of the forward and reverse 32/132 function.

Reference Commands: SG-LINE, SL-32/132, S0-32/132, RG-STAT

Step 1: To prepare the 32 element for directional testing, transmit the commands in Table 13-40 to the relay. Use the same procedure for testing the 132 element. There are four enable modes for the 32 elements 1 of 3, 2 of 3, 3 of 3, and Total Power (Modes 1, 2, 3, and 4). The following test uses Single Phase Tripping (1 of 3) Mode 1. Regardless of mode, the element is set for 3-phase power. Single-phase modes automatically operate at the 3-phase setting divided by the appropriate mode. Optionally, the user can test Modes 2, 3, and 4 but they are not shown. Consult Section 4, *Protection and Control, Directional Power*, for operating details.

Table 13-40. 32 Directional Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=32_132	Sets custom logic name.
SL-32=1,0	Enables 32 and disables blocking.
SL-132=1,0	Enables 32 and disables blocking.
SL-VO1=32PU+132PU	Enables OUT1 to close for 32 or 132 pickup.
SL-VO2=32T+132T	Enables OUT2 to close for 32 or 132 trip.
SG-TRIG=VO2,VO1,0	Enable 32T and 132T to log and trigger fault recording.
SG-TARG=32/132	Enables 32 and 132 targets.
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
SG-CT=1	Sets P, N CT ratio at 1:1
EXIT;Y	Exit and save settings.

Forward Tripping Direction (Overpower)

Step 1: Using Table 13-41 as a guide, transmit the 32 setting commands to the relay. Prior to each directional test, reset the relay targets (HMI Screen) from the previous test.

Table 13-41. 32 Operational Settings

Operating Settings	Purpose
S0-32=500,50ms,F,O	Sets 32 to 500 watts, TD = 50ms, Fwd Trip Direction, Overpower.
S0-32=1000,50ms,F,O	Sets 32 to 1000 watts, TD = 50ms, Fwd Trip Direction, Overpower.
S0-32=2000,50ms,F,O	Sets 32 to 2000 watts, TD = 50ms, Fwd Trip Direction, Overpower.

Step 2: Connect and apply a 100 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 3: Apply 0 amp A-phase current at an angle of 0 degrees I lag E and slowly increase the current until OUT1 closes. Decrease A-phase current until OUT1 just drops out. Pickup will occur within ±2 percent of the 3-phase 32 pickup setting divided by 3 (500 watts = 5 amps, 100 volts, 0 degrees lag E)/3. See Section 4, *Protection and Control, Directional Power*, for details on single phase and total power operation. Dropout will occur at 93% to 97% of actual pickup. Verify 32 target on the HMI.

Step 4: With the relay picked up (OUT1 closed), change the angle of the applied current to 180 degrees lag E and verify that OUT1 opens. This verifies that the 32 function is operating in the forward trip direction and not in the reverse direction.

Step 5: Repeat Steps 1 through 4 for the middle and upper settings in Table 13-41.

Step 6: (Optional.) Repeat Steps 1 through 5 for B-phase and C-phase currents. (Consult Section 4 for operating details).

Step 7: (Optional.) Repeat Steps 1 through 6 using “132” in place of “32”.

Step 8: (Optional.) Repeat Steps 1 through 7 for Setting Group 1.

Reverse Tripping Direction (Overpower)

Step 1: Using Table 13-42 as a guide, transmit the 32 setting commands to the relay. Prior to each test, reset the relay targets (HMI Screen) from the previous test.

Table 13-42. 32 Operational Settings

Operating Settings	Purpose
S0-32=500,50ms,R,O	Sets 32 to 500 watts, TD = 50ms, Rev Trip Direction, Overpower.

Step 2: Connect and apply a 100 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 3: Apply 0 amp A-phase current at an angle of 180 degrees I lag E and slowly increase the current until OUT1 closes (1/3 of the 3-phase setting). Decrease A-phase current until OUT1 just drops out. Pickup will occur within ±2 percent of the 32 pickup setting (500 watts = 5 amps, 100 volts, 180 degrees I lag E)/3. Dropout will occur at 93% to 97% of actual pickup. Verify 32 target on the HMI.

Step 4: With the relay picked up (OUT1 closed), change the angle of the applied current to 0 degrees I lag E and verify that OUT1 opens. This verifies that the 32 function is operating in the reverse trip direction and not in the forward direction.

Step 5: (Optional.) Repeat Steps 1 through 4 for B-phase and C-phase currents. (Consult Section 4 for operating details).

Step 6: (Optional.) Repeat Steps 1 through 6 using “132” in place of “32”.

Step 7: (Optional.) Repeat Steps 1 through 7 for Setting Group 1.

Forward Tripping Direction (Underpower)

Step 1: Using Table 13-43 as a guide, transmit the 32 setting commands to the relay. Prior to each directional test, reset the relay targets (HMI Screen) from the previous test.

Table 13-43. 32 Operational Settings

Operating Settings	Purpose
S0-32=500,50ms,F,U	Sets 32 to 500 watts, TD = 50ms, Fwd Trip Direction, Underpower.
S0-32=250,50ms,F,U	Sets 32 to 250 watts, TD = 50ms, Fwd Trip Direction, Underpower.
S0-32=50,50ms,F,U	Sets 32 to 50 watts, TD = 50ms, Fwd Trip Direction, Underpower.

Step 2: Connect and apply a 100 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations. Note that Out1 is closed with no current applied.

Step 3: Apply 4 amps A-phase current at an angle of 0 degrees I lag E noting that OUT1 drops out. Slowly decrease the current until OUT1 closes (1/3 of the 3-phase setting). Increase A-phase current until OUT1 just drops out. Under power pickup will occur within ±2 percent of the 32 pickup setting (500 watts = 5 amps, 100 volts, 0 degrees I lag E)/3. Dropout will occur at 93% to 97% of actual pickup. Verify 32 target on the HMI.

Step 4: With the relay picked up (OUT1 closed), change the angle of the applied current to 180 degrees lag E and verify that OUT1 opens. This verifies that the 32 function is operating in the forward trip direction and not in the reverse direction.

Step 5: Repeat Steps 1 through 4 for the middle and upper settings in Table 13-43.

Step 6: (Optional.) Repeat Steps 1 through 5 for B-phase and C-phase currents. (Consult Section 4 for operating details.)

Step 7: (Optional.) Repeat Steps 1 through 6 using “132” in place of “32”.

Step 8: (Optional.) Repeat Steps 1 through 7 for Setting Group 1.

Reverse Tripping Direction (Underpower)

Step 1: Using Table 13-44 as a guide, transmit the 32 setting commands to the relay. Prior to each test, reset the relay targets (HMI Screen) from the previous test.

Table 13-44. 32 Operational Settings

Operating Settings	Purpose
S0-32=500,50ms,R,U	Sets 32 to 500 watts, TD = 50ms, Rev Trip Direction, Underpower.

Step 2: Connect and apply a 100 Vac, three-phase voltage source at nominal frequency to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Connect a variable ac current source to Terminals D1 (A-phase polarity) and D2 (A-phase non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 3: Apply 4 amps A-phase current at an angle of 180 degrees I lag E noting that OUT1 drops out. Slowly decrease the current until OUT1 closes (1/3 of the 3-phase setting). Increase A-phase current until OUT1 just drops out. Pickup will occur within ±2 percent of the 32 pickup setting (500 watts = 5 amps, 100 volts, 180 degrees I lag E)/3. Dropout will occur at 93% to 97% of actual pickup. Verify 32 target on the HMI.

Step 4: With the relay picked up (OUT1 closed), change the angle of the applied current to 0 degrees I lag E and verify that OUT1 opens. This verifies that the 32 function is operating in the reverse trip direction and not in the forward direction.

Step 5: (Optional.) Repeat Steps 1 through 4 for B-phase and C-phase currents. (Consult Section 4 for operating details.)

Step 6: (Optional.) Repeat Steps 1 through 5 using “132” in place of “32”.

Step 7: (Optional.) Repeat Steps 1 through 6 for Setting Group 1.

Volts per Hertz Overexcitation (24)

Purpose: To verify the operating accuracy of the 24 protection element.

Reference Commands: SL-24, SL-VO, SL-GROUP, RG-STAT

Overexcitation, Volts/Hertz Alarm, Integrating Time and Definite Time Pickup Verification

The BE1-IPS100 detects overexcitation conditions with a volts/hertz element that consist of one alarm setting, one integrating time characteristic with selectable exponents (3 sets of time curves as shown in Appendix D, *Overexcitation (24) Inverse Time Curves*), and two definite time characteristics. Note that V/Hz nominal is 69.3 volts (phase to neutral) x square root 3/60 Hz, or 2.001. That is, at nominal voltage and frequency (60 Hz system) 1 pu V/Hz = 2.001.

Step 1: Prepare the 24 pickup function for testing by transmitting the commands in Table 13-45 to the relay. Reset targets.

Table 13-45. V/Hz Alarm, Integrating Time, and Definite Time Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=24	Sets 24 as custom logic name.
SG-VTP=1,4W,PN,PN	Sets VT phase voltage parameters.
SG-NOM=69.3,5.00	Set nominal voltage to 69.3 P to N.
SA-MAJ=31	Enables Major Alarm Light for 24 alarm.
SL-24=1,0	Enables 24, disables blocking.
SL-VO1=24T	Enables OUT1 to close for 24 trip.
SG-TRIG=24T,24PU,0	Enables 24 to log and trigger fault recording.
SG-TARG=24	Enables 24 target.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-46 as a guide, transmit the setting commands to the relay.

Table 13-46. Alarm, Integrating Time, and Definite Time Pickup Settings (Step 2)

Overexcitation Settings	Purpose
Pickup	
SA-24=2.05,0.0	Sets 24 Alarm at 1.025% of nominal (2.05 V/Hz), Time Delay = 0.
S0-24=2.1,0.0,0.0,2.0	Sets 24 Integrating PU at 1.05% of nominal (2.10 V/Hz), Trip Time Dial = 0, Reset Time Dial = 0, Time Curve Exponent = 2.
S0-24D=0.0,50ms,0.0,50ms	Sets 24 Definite Time, Pickups at 0 and Definite Time, Time Delay at minimum.

Step 3: Prepare to monitor the operation of the 24 Alarm and Trip functions. Alarm operation can be verified by monitoring the Major Alarm LED on the relay's front panel. Operation of 24T by can be verified by monitoring OUT1.

Step 4: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 5: Apply A-phase voltage at nominal frequency and slowly increase until the Major Alarm LED lights (V/H PU x Freq x % Alarm = PU). Pickup should occur within ±2 percent or 1 volt of the

Alarm setting. Continue increasing the A-phase voltage until OUT1 closes (V/H Trip x Freq = PU). Pickup should occur within ±2 percent or 1 volt of the Trip pickup setting. Slowly decrease the A-phase voltage until OUT1 opens. Dropout should occur at 95% or higher of the of the actual pickup value for both Trip and Alarm.

Step 6: Verify the 24 target on the HMI.

Step 7: (Optional.) Repeat Steps 2 through 6 for higher and lower alarm and trip pickup settings.

Step 8: (Optional.) Repeat Steps 2 through 6 for frequencies other than nominal.

Step 9: (Optional.) Repeat Steps 2 through 8 for the B-phase and C-phase voltage inputs.

Step 10: (Optional.) Repeat Steps 2 through 9 for Setting Group 1.

Step 11: Using Table 13-47 as a guide, transmit the setting commands to the relay.

Table 13-47. Alarm, Integrating Time, and Definite Time Pickup Settings (Step 11)

Overexcitation Settings	**Purpose**
Pickup	
SA-24=0,0.0	Sets 24 Alarm = 0, Time Delay = 0.
S0-24=0.0,0.0,0.0,2.0	Sets 24 Integrating PU =0, Trip Time Dial = 0, Reset Time Dial = 0, Time Curve Exponent = 2.
S0-24D=2.36,50ms,0.0,50ms	Sets the first 24 Definite Time Pickup at 118% of nominal (2.36 V/Hz) and Definite Time Delay at minimum. Set second 24 Definite Time Pickup = 0 and Definite Time Delay at minimum.

Step 12: Repeat Steps 2 through 10 for the first definite time pickup.

Step 13: Using Table 13-47 as a guide, set first definite time setting to 0 and second to 2.36 V/Hz.

Step 14: Repeat Steps 2 through 10 for the second definite time delay.

Overexcitation, Volts/Hertz Integrating Trip Time Verification

The following test uses the (M-1)^2 time curve.

Step 1: Using Table 13-48 as a guide, transmit the setting commands to the relay.

Table 13-48. V/Hz Trip Time Settings

Settings	**Purpose**
S0-24=2.1,0.5,0.0,2.0	Sets integrating 24 PU at 1.05% of nominal (2.10 V/Hz), Trip Time Dial = 0.5, Reset Time Dial = 0, Time Curve Exponent = 2.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figures 13-1 and 13-2 for terminal locations.

Step 3: All integrating timing tests are based on % of nominal Volts/Hertz (1 PU value). Refer to Appendix D of the BE1-IPS100 instruction manual for time curves. Apply A-phase voltage at nominal frequency and a value of voltage that equals the V/Hz % of nominal shown in Table 13-49 for Time Dial 0.5. Measure the time between the application of voltage and the closure of OUT1. Verify that the relay operates within ±5% of the values shown in Table 13-49.

Table 13-49. V/Hz Trip Times

Percent of Nominal V/Hz	**Time Dial 0.5**	**Time Dial 1.0**	**Time Dial 2.0**
110%	50 seconds	100 seconds	200 seconds
120%	12.5 seconds	25 seconds	50 seconds
140%	3.1 seconds	6.3 seconds	12.5 seconds

Step 4: Repeat the test for Time Dial 1.0 and 2.0.

Step 5: (Optional.) Repeat Steps 2 through 4 for the B-phase and C-phase voltage inputs.

Step 6: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.

Overexcitation, Volts/Hertz Linear Reset Time Verification

The following reset time test is an approximation. For a more precise test, use a computer driven test set and the integration time equations found in Section 4, *Protection and Control, Voltage Protection, 24 Element*, or Appendix D, *Overexcitation (24) Inverse Time Curves*.

Step 1: Using Table 13-50 as a guide, transmit the setting commands to the relay.

Table 13-50. V/Hz Reset Time Pickup Settings

Setting	Purpose
S0-24=2.1,0.5,0.2,2.0	Sets 24 PU at 1.05% of nominal (2.10 V/Hz), Trip Time Dial = 0.5, Reset Time Dial = 0.2, Time Curve Exponent = 2.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 3: Apply A-phase voltage at nominal frequency and a value of voltage that equals the V/Hz % of nominal shown in Table 13-51. Measure the time between the application of voltage and the closure of OUT1 (12.5 seconds). Remove the test voltage and reapply after 5 seconds has elapsed.

With a Reset Time Dial setting of 0.2, the total time to reset, after trip is removed, will be approximately 10 seconds. (See Section 4, *Protection and Control, Voltage Protection*, for more details.) Reapplying the test voltage after 5 seconds will yield a trip time of approximately ½ its original value or 6.25 seconds for Trip Time Dial 0.5 verifying that the reset time delay is working.

Table 13-51. V/Hz Reset Time

Percent of Nominal V/Hz	Time Dial 0.5	Time Dial 1.0	Time Dial 2.0
120%	12.5 seconds	25 seconds	50 seconds

Step 4: Repeat Step 3 for Trip Time Dial 1.0 and 2.0 (½ trip time is approximately 12.5 seconds for Time Dial 1.0, and 25 seconds for Time Dial 2.0. (Still reapply voltage after 5 seconds as reset time dial is still 0.2.)

Step 5: (Optional.) Repeat Steps 2 through 4 for the B-phase and C-phase voltage inputs.

Step 6: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.

Overexcitation, Volts/Hertz Definite Time (24D)Trip Time Verification

Step 1: Using Table 13-52 as a guide, transmit the setting commands to the relay.

Table 13-52. Definite Time V/Hz Trip Time Settings

Settings	Purpose
S0-24D=2.36,50ms,0.0,50ms	Sets the first 24 definite pickup at 118% of nominal (2.36 V/Hz) and definite time delay at minimum. Sets second pickup at 0 and time delay at minimum.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 3: Definite timing tests are based on % of nominal Volts/Hertz (1 PU value). Apply A-phase voltage at nominal frequency and a value of voltage that equals the V/Hz % of nominal shown in Table 13-53 (118% or 2.36 V/Hz). Measure the time between the application of voltage and the closure of OUT1. Verify that the relay operates within ±0.5% or 1 cycle, whichever is greater, for the TD settings shown in Table 13-53.

Table 13-53. Definite Time (24D) V/Hz Trip Times

Percent of Nominal V/Hz	Time Dial 0.5	Time Dial 1.0	Time Dial 2.0
118%	0.50 seconds	5 seconds	20 seconds

Step 4: (Optional.) Repeat Steps 2 through 4 for the B-phase and C-phase voltage inputs.

Step 5: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.

Step 6: Set first definite time pickup setting to 0 and set the second definite time pickup setting to 2.36 V/Hz.

Step 7: Repeat Steps 2 through 5 for the second definite time function.

Phase and Auxiliary Undervoltage/Overvoltage (27/59)

Purpose: To verify the operating accuracy of the 27P/127P/27X and 59P/159P/59X/159X protection elements.

Reference Commands: SL-27P/127P/27X, SL-59P/159P/59X/159X, SL-VO, SL-GROUP, RG-STAT

Phase Undervoltage and Overvoltage Pickup Verification

Step 1: Prepare the 27P and 59P pickup functions for testing by transmitting the commands in Table 13-54 to the relay. Reset targets. Follow the same procedure for the 127P/159P except for the 27/127 under voltage inhibit pickup test.

Table 13-54. 27P and 59P Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=27_59	Sets 27_59 as custom logic name.
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
SA-MAJ=0	Disables Major Alarm.
SL-27P=1,0	Enables 27P, disables blocking.
SL-59P=1,0	Enables 59P, disables blocking.
SL-VO1=27PT+59PT	Enables OUT1 to close for 27P or 59P trip.
SG-TRIG=27PT+59PT, 27PPU+59PPU,0	Enables 27P and 59P to log and trigger fault record.
SG-TARG=27/59/127/159	Enables 27, 59, 127, and 159 targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-55 as a guide, transmit the first row of setting commands (highest 27P PU, lowest 59P PU) to the relay.

Table 13-55. 27P and 59P Pickup Settings

Phase Pickup Settings		Purpose
Undervoltage	Overvoltage	
S0-27P=96,50ms	S0-59P=132,50ms	Sets 27P PU at 96 V, 59P at 132 V, TD at min
S0-27P=84,50ms	S0-59P=144,50ms	Sets 27P PU at 84 V, 59P at 144 V, TD at min
S0-27P=72,50ms	S0-59P=156,50ms	Sets 27P PU at 72 V, 59P at 156 V, TD at min

Step 3: Prepare to monitor the 27P and 59P function operation. Operation can be verified by monitoring Out 1.

Step 4: Connect and apply a 120 Vac, three-phase voltage source to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 5: Slowly decrease the A-phase voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the 27P pickup setting. Slowly increase the A-phase voltage until OUT1 opens. Dropout should occur between 102 and 103 percent of the actual pickup value. Verify the 27A target and the HMI. Reset the target.

Step 6: Continue increasing the A-phase voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the 59P pickup setting. Slowly reduce the A-phase voltage until OUT1 opens. Dropout should occur between 97 and 98 percent of the actual pickup value. Verify 59A target on the HMI.

Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings listed in Table 13-55.

Step 8: (Optional.) Repeat Steps 2 through 7 for the B-phase and C-phase voltage inputs.

Step 9: (Optional.) Repeat Steps 2 through 8 for Setting Group 1.

27/127 Phase Undervoltage Inhibit Pickup Test

Step 10: Using Table 13-56 as a guide, transmit the setting commands to the relay.

Table 13-56. 27P UV Inhibit Pickup Settings

Phase Inhibit Pickup Settings	Purpose
Undervoltage	
S0-27P=96,50ms,50	Sets 27P PU at 96 V, Time Dial at minimum, UV Inhibit at 50 V.

Step 11: Using the same test connections as Step 4 above, slowly decrease the A-phase voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the 27P pickup setting.

Step 12: Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ±3 percent of 50 V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ±5 percent of inhibit pickup.

Step 13: (Optional.) Repeat Steps 1 and 2 for 127P.

Step 14: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

Phase Undervoltage and Overvoltage Timing Verification

Step 1: Using Table 13-57 as a guide, transmit the first row of setting commands to the relay.

Table 13-57. 27P and 59P Pickup and Time Delay Settings

Phase Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27P=72,2s	S0-59P=156,2s	Sets 27P PU at 72 V, 59P at 156 V, TD at 2 sec
S0-27P=,5s	S0-59P=,5s	Sets 27P PU at 72 V, 59P at 156 V, TD at 5 sec
S0-27P=,10s	S0-59P=,10s	Sets 27P PU at 72 V, 59P at 156 V, TD at 10 sec

Step 2: Prepare to monitor the 27P and 59P timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a 120 Vac, three-phase voltage source to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Step the A-phase voltage down to 68 volts. Measure the time delay and verify the accuracy of the 27P time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 5: Step the A-phase voltage up to 165 volts. Measure the time delay and verify the accuracy of the 59P time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-57.

Step 7: (Optional.) Repeat Steps 2 through 6 for the B-phase and C-phase voltage inputs.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

<u>Auxiliary Undervoltage and Overvoltage Pickup Verification (3E0 VT Input)</u>

Step 1: Prepare the 27X and 59X/159X pickup function for testing by transmitting the commands in Table 13-58 to the relay. Reset targets.

Table 13-58. 27X and 59X/159X Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=27X/59/159X	Sets 27X/59/159X as custom logic name.
SL-47=0	Disables 47.
SL-27X=2,0	Enables 27X (3E0), disables blocking.
SL-59X=2,0	Enables 59X, disables blocking.
SL-159X=2,0	Enables 159X, disables blocking.
SL-VO1=27XT+59XT	Enables OUT1 to close for 27X and 59X trip.
SL-VO2=159XT	Enables OUT2 to close for 159X trip.
SG-TRIG=27XT+59XT+159XT, 27XPU+59XPU+159XPU,0	Enable 27XT, 59XT, or 159XT to log and trigger fault recording.
SG-TARG=27X/59X/159X	Enables 27X, 59X, and 159X targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-59 as a guide, transmit the first row of setting commands (highest 27X PU, highest 59XPU/159XPU) to the relay.

Table 13-59. 27X and 59X/159X Pickup Settings (3V0)

Pickup Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=50,50ms,0	S0-59X/159X=60,50ms	Sets 27X PU at 50 V, 59X/159X at 60 V, TD at min, UV Inhibit disabled.
S0-27X=20,50ms,0	S0-59X/159X=30,50ms	Sets 27X PU at 20 V, 59X/159X at 30 V, TD at min, UV Inhibit disabled.
S0-27X=5,50ms,0	S0-59X/159X=10,50ms	Sets 27X PU at 5 V, 59X/159X at 10 V, TD at min, UV Inhibit disabled.

Step 3: Prepare to monitor the 59X/159X function operation. Operation can be verified by monitoring OUT1 (OUT2 for 159X).

Step 4: Connect and apply a single-phase, 55 Vac voltage source to Terminals C13 (polarity) and C16 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 5: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the 27X pickup setting. Slowly increase the voltage until OUT1 opens. Dropout should occur between 102% and 103% of the actual pickup value. Verify the 27N target on the HMI and reset.

Step 6: Continue increasing the voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Slowly reduce the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Verify the 59N target on the HMI.

Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings in Table 13-59.

Step 8: (Optional.) Repeat Steps 2 through 7 for the B-phase and C-phase voltage inputs.

Step 9: (Optional.) Repeat Steps 2 through 8 for Setting Group 1.

27X Auxiliary Undervoltage Inhibit Pickup Test (3V0)

Step 1: Using Table 13-60 as a guide, transmit the setting commands to the relay.

Table 13-60. 27X UV Inhibit Pickup Settings

Phase Inhibit Pickup Settings	Purpose
Undervoltage	
S0-27X=96,50ms,50	Sets 27X PU at 96 V, Time Dial at minimum, UV Inhibit at 50V.

Step 2: Using the same test connections as Step 4 above, slowly decrease the A-phase voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the 27X pickup setting.

Step 3: Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ±3 percent of 50V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ±5 percent of inhibit pickup.

Step 4: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Timing Verification (3V0 VT Input)

Step 1: Using Table 13-61as a guide, transmit the first row of setting commands to the relay.

Table 13-61. 27X and 59X/159X Pickup and Time Delay Settings (3V0)

Pickup Settings		Purpose
Undervoltage	**Overvoltage**	
S0-27X=10,2S,0	S0-59X/159X=30,2S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 2 sec, UV Inhibit disabled.
S0-27X=,5S	S0-59X/159X=,5S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 5 sec.
S0-27X=,10S	S0-59X/159X=,10S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 10 sec.

Step 2: Prepare to monitor the 27X and 59X/159X timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a single-phase, 20 Vac to Terminals C13 (polarity) and C16 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Step the voltage down to 5 volts. Measure the time delay and verify the accuracy of the 27X time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 5: Step the voltage up to 35 volts. Measure the time delay and verify the accuracy of the 59X/159X time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-61.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Pickup Verification (Fundamental Vx Input)

Step 1: Prepare the 27X and 59X/159X pickup functions for testing by transmitting the commands in Table 13-62 to the relay. Reset targets.

Table 13-62. 27X and 59X/159X Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=27X_59X/159X	Sets 27X_59X/159X as custom logic name.
SG-VTX=1,AN	Set auxiliary voltage parameters.
SL-27X=1,0	Enables 27X, disables blocking.
SL-59X/159X=1,0	Enables 59X and 159X, disables blocking.
SL-VO1=27XT+59XT+159XT	Enables OUT1 to close for 27X, 59X, or 159X trip.
SG-TRIG=27XT+59XT+159XT, 27XPU+59XPU+159XPU	Enables 27XT, 59XT, or 159XT to log and trigger fault recording.
SG-TARG=27X/59X/159X	Enables 27X, 59X, and 159X targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-63 as a guide, transmit the first row of setting commands (highest 27X PU, lowest 59XPU/159XPU) to the relay.

Table 13-63. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=70,50ms,0	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min, UV Inhibit disabled.
S0-27X=60,50ms,0	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min, UV Inhibit disabled.
S0-27X=50,50ms,0	S0-59X159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min, UV Inhibit disabled.

Step 3: Prepare to monitor the 27X and 59X/159X function operation. Operation can be verified by monitoring OUT1.

Step 4: Connect and apply a single-phase, 80 Vac voltage source to VX Input, Terminals C17 (polarity) and C18 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 5: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Slowly increase the voltage until OUT1 opens. Dropout should occur between 102% and 103% of the actual pickup value. Verify the 27 bus target on the HMI and reset.

Step 6: Continue to increase the voltage until out1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Slowly reduce the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Verify the 59 Bus target on the HMI.

Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings listed in Table 13-63.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

27X Auxiliary Undervoltage Inhibit Pickup Test (Fundamental VX Test)

Step 1: Using Table 13-64 as a guide, transmit the first row of setting commands to the relay.

Table 13-64. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	**Overvoltage**	
S0-27X=70,50ms,50	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min, UV Inhibit at 50V.
S0-27X=60,50ms,50	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min, UV Inhibit at 50V.
S0-27X=50,50ms,50	S0-59X159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min, UV Inhibit at 50V.

Step 2: Prepare to monitor the 27X and 59X/159X function operation. Operation can be verified by monitoring OUT1.

Step 3: Connect and apply a single-phase, 80 Vac voltage source to VX Input, Terminals C17 (polarity) and C18 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ±3 percent of 50V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ±5 percent of inhibit pickup.

Step 5: (Optional.) Repeat Steps 1 through 4 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Timing Verification (Fundamental Vx Input)

Step 1: Using Table 13-65 as a guide, transmit the first row of setting commands to the relay.

Table 13-65. 27X and 59X/159X Pickup and Time Delay Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	**Overvoltage**	
S0-27X=50,2S,0	S0-59X/159X=110,2S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 2 sec, UV Inhibit disabled.
S0-27X=,5S	S0-59X/159X=,5S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 5 sec.
S0-27X=,10S	S0-59X159X=,10S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 10 sec.

Step 2: Prepare to monitor the 27X and 59X/159X timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a single-phase, 80 Vac voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Step the voltage down to 45 volts. Measure the time delay and verify the accuracy of the 27X time delay setting. Timing accuracy is ±5% or ±3 cycles of the time delay setting.

Step 5: Step the voltage up to 115 volts. Measure the time delay and verify the accuracy of the 59X/159X time delay setting. Timing accuracy is ±5% or ±3 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-68.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Pickup Verification (3rd Harmonic Vx Input)

Step 1: Prepare the 27X and 59X/159X pickup functions for testing by transmitting the commands in Table 13-66 to the relay. Reset targets.

Table 13-66. 27X and 59X/159X Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=27X_59X/159X	Sets 27X_59X/159X as custom logic name.
SG-VTX=1,AN	Set auxiliary voltage parameters.
SL-27X=3,0	Enables 27X, disables blocking.
SL-59X/159X=3,0	Enables 59X/159X, disables blocking.
SL-VO1=27XT+59XT+159XT	Enables OUT1 to close for 27X, 59X, or 159X trip.
SG-TRIG=27XT+59XT+159XT, 27XPU+59XPU+159XPU,0	Enables 27XT, 59XT, or 159XT to log and trigger fault recording.
SG-TARG=27X/59X/159X	Enables 27X, 59X, and 159X targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-67 as a guide (same values as the fundamental test but at 3rd harmonic frequency), transmit the first row of setting commands (highest 27X PU, lowest 59XPU/159X PU) to the relay.

Table 13-67. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=70,50ms,0	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min, UV Inhibit disabled.
S0-27X=60,50ms,0	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min, UV Inhibit disabled.
S0-27X=50,50ms,0	S0-59X159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min, UV Inhibit disabled.

Step 3: Prepare to monitor the 27X and 59X/159X function operation. Operation can be verified by monitoring OUT1.

Step 4: Connect and apply a single-phase, 80 Vac, 3rd harmonic voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 5: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Slowly increase the voltage until OUT1 opens. Dropout should occur between 102% and 103% of the actual pickup value. Verify the 27-3 Bus target on the HMI.

Step 6: Continue to increase voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Slowly reduce the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value.

Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings listed in Table 13-67. Verify the 59-3 Bus target on the HMI.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

UV Inhibit for 27X (3rd Harmonic VX Input)

Step 1: Using Table 13-68 as a guide, transmit the setting commands to the relay.

Table 13-68. UV Inhibit for 27X (3rd Harmonic VX Input) Pickup Settings

Phase Inhibit Pickup Settings	Purpose
Undervoltage	
S0-27X=96,50ms,50	Sets 27X PU at 96 V, Time Dial at minimum, UV Inhibit at 50V.

Step 2: Connect and apply a single-phase, 80 Vac, 3rd harmonic voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 3: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ±3 percent of 50V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ±5 percent of inhibit pickup.

Step 4: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Timing Verification (3rd Harmonic VX Input)

Step 1: Using Table 13-69 as a guide (same values as the fundamental test but at 3rd harmonic frequency), transmit the first row of setting commands to the relay.

Table 13-69. 27X and 59X/159X Pickup and Time Delay Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	**Overvoltage**	
S0-27X=50,2S,0	S0-59X/159X=110,2S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 2 sec, UV Inhibit disabled.
S0-27X=,5S	S0-59X/159X=,5S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 5 sec.
S0-27X=,10S	S0-59X159X=,10S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 10 sec.

Step 2: Prepare to monitor the 27X and 59X/159X timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a single-phase, 80 Vac, 3rd harmonic voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Step the voltage down to 45 volts. Measure the time delay and verify the accuracy of the 27X time delay setting. Timing accuracy is ±5% or ±3 cycles of the time delay setting.

Step 5: Step the voltage up to 115 volts. Measure the time delay and verify the accuracy of the 59X/159X time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-69.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Negative-Sequence Voltage (47)

Purpose: To verify the operating accuracy of the 47 protection element.

Reference Commands: SL-47, SL-VO, SL-GROUP, RG-STAT

Negative-Sequence Voltage Pickup Verification

Step 1: Prepare the 47 pickup function for testing by transmitting the commands in Table 13-70 to the relay. Reset targets.

Table 13-70. 47 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=47	Sets 47 as custom logic name.
SL-27P=0	Disables 27P.
SL-59P=0	Disables 59P.
SL-47=1,0	Enables 47, disables blocking.
SP-60FL=ENA,PN	Removes 60FL block from 47 element.
SL-VO1=47T	Enables OUT1 to close for 47 trip.
SG-TRIG=47T,47PU,0	Enables 47 to log and trigger fault recording.
SG-TARG=47	Enables 47 target.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-71 as a guide, transmit the first row of setting commands to the relay.

Table 13-71. 47 Pickup Settings

Pickup Settings (Negative-Sequence Voltage)	Purpose
S0-47=24,50ms	Sets 47 PU at 24 V, Time Delay at minimum.
S0-47=30,50ms	Sets 47 PU at 30 V, Time Delay at minimum.
S0-47=36,50ms	Sets 47 PU at 36 V, Time Delay at minimum.

Step 3: Prepare to monitor 47 function operation. Operation can be verified by monitoring OUT1.

Step 4: Connect and apply a 50 Vac, single-phase voltage source to Terminals C13 (A-phase) and C16 (neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 5: Negative-sequence voltage is 1/3 the phase voltage, therefore for a V2 setting of 24 volts, the applied phase voltage will be 24 x 3 or 72 volts. Slowly increase the A-phase voltage until OUT1 closes. Pickup should occur within ±2 percent or 1 volt of the pickup setting. Slowly decrease the A-phase voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Verify the 47 target on the HMI.

Step 6: Verify the pickup and dropout accuracy of the middle and upper 47 pickup settings.

Step 7: (Optional.) Repeat Steps 2 through 6 for the B-phase and C-phase voltage inputs.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

Negative-Sequence Voltage Timing Verification

Step 1: Using Table 13-72 as a guide, transmit the first row of setting commands to the relay.

Table 13-72. 47 Pickup and Time Delay Settings

Pickup and Time Delay Settings	Purpose
S0-47=36,2S	Sets 47 PU at 36 V, Time Dial at 2 seconds
S0-47=,5S	Sets 47 PU at 36 V, Time Dial at 5 seconds
S0-47=,10S	Sets 47 PU at 36 V, Time Dial at 10 seconds

Step 2: Prepare to monitor the 47 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a 100 Vac, single-phase voltage source to Terminals C13 (A-phase) and C16 (neutral). Refer to Figures 13-1 or 13-2 for terminal locations.

Step 4: Step the A-phase voltage up to 115 volts. Measure the time delay and verify the accuracy of the 47 time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 5: Repeat Step 5 for the middle and upper time delay settings of Table 13-72.

Step 6: (Optional.) Repeat Steps 2 through 5 for the B-phase and C-phase voltage inputs.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Over/Underfrequency (81)

Purpose: To verify the operating accuracy of the 81/181/281/381/481/581 protection elements.

Reference Commands: SL-x81, SL-VO, S<g>-x81, S<g>-81INH

Note: Testing the 81 Rate of Change (ROC) mode requires a voltage source capable of smoothly sweeping the frequency of the applied voltage for a variable positive and negative rate of change. Frequency step change at 1ms intervals (maximum) is required to support the accuracy requirement of the element.

Over/Underfrequency Pickup Verification

Step 1: Prepare the x81 pickup functions for pickup testing by transmitting the commands in Table 13-73 to the relay.

Table 13-73. x81 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=FREQTEST	Sets FREQTEST as custom logic name.
SL-81=1,0	Enables 81, disables blocking.
SL-181=1,0	Enables 181, disables blocking.
SL-281=1,0	Enables 281, disables blocking.
SL-381=1,0	Enables 381, disables blocking.
SL-481=1,0	Enables 481, disables blocking.
SL-581=1,0	Enables 581, disables blocking.
SL-VO1=81T+581T	Enables OUT1 to close for 81 or 581 trip.
SL-VO2=181T	Enables OUT2 to close for 181 trip.
SL-VO3=281T	Enables OUT3 to close for 281 trip.
SL-VO4=381T	Enables OUT4 to close for 381 trip.
SL-VO5=481T	Enables OUT5 to close for 481 trip.
SG-TARG=81/181/281/381/481/581	Enables 81, 181, 281, 381, 481, and 581 targets.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands in Table 13-74 to the relay. These commands set the voltage inhibit value, pickup value, and operating mode (Underfrequency, Overfrequency or ROC) for each of the x81 functions.

Table 13-74. x81 Pickup and Mode Settings

Pickup and Mode Settings	Purpose
S0-81INH=40,0,64,46	Set PU = 40V, V2 = 0%, OF = 64 Hz, UF = 46 Hz.
S0-81=42,0,U	Sets 81 PU at 42 Hz, Underfrequency.
S0-181=46,0,U	Sets 181 PU at 46 Hz, Underfrequency.
S0-281=48,0,U	Sets 281 PU at 48 Hz, Underfrequency.
S0-381=65,0,O	Sets 381 PU at 65 Hz, Overfrequency.
S0-481=67,0,O	Sets 481 PU at 67 Hz, Overfrequency.
S0-581=69,0,O	Sets 581 PU at 69 Hz, Overfrequency.

Step 3: Prepare to monitor x81 function operation. Operation can be verified by monitoring the programmed output contacts or HMI Screen 1.5.2.

Step 4: Connect and apply a 120 Vac, 60-hertz voltage source to Terminals C13 (A-phase) and C16 (neutral).

Step 5: Slowly decrease the frequency of the applied voltage until OUT3 (281) closes. Pickup should occur within ±0.01 hertz of the pickup setting. Slowly increase the frequency until OUT3 opens. Dropout should occur at 0.02 hertz above or below the pickup setting.

Step 6: Lower the frequency until OUT3 again closes. Lower the source voltage until OUT3 drops out (under voltage inhibit level), raise the voltage until OUT3 picks up. Pickup should occur ±2% of the voltage inhibit setting and drop out at 95% of pickup.

Step 7: Repeat Step 5 for the 181 (OUT2) and 81 (OUT1) functions.

Step 8: Repeat Step 4.

Step 9: Slowly increase the frequency of the applied voltage until OUT4 (381) closes. Pickup should occur within ±0.01 hertz of the pickup setting. Slowly decrease the frequency until OUT4 opens. Dropout should occur at 0.02 hertz above or below the pickup setting.

Step 10: Repeat Step 5 for the 481 (OUT5) and 581 (OUT1) functions.

Step 11: In Table 13-73, change SL-81 through 581 = 2,0 and transmit to the relay.

Step 12: Connect and apply, 120 Vac, 60Hz voltage source to Vx Input C17 and C18.

Step 13: Repeat Steps 5 through 9.

Step 14: (Optional.) Repeat Steps 1 through 11 for Setting Group 1.

Time Delay Verification

Step 1: Prepare the x81 functions for time delay testing by transmitting the commands in Table 13-73 to the relay. Next, transmit the commands in the first column (2 second TD) of Table 13-75 to the relay. Commands entered in Tables 13-74 should be retained for this test.

Table 13-75. x81 Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-81=,2S	S0-81=,5S	S0-81=,10S	Sets 81 TD.
S0-181=,2S	S0-181=,5S	S0-181=,10S	Sets 181 TD.
S0-281=,2S	S0-281=,5S	S0-281=,10S	Sets 281 TD.
S0-381=,2S	S0-381=,5S	S0-381=,10S	Sets 381 TD.
S0-481=,2S	S0-481=,5S	S0-481=,10S	Sets 481 TD.
S0-581=,2S	S0-581=,5S	S0-581=,10S	Sets 581 TD.

Step 2: Prepare to monitor the x81 timings. Timing accuracy is verified by measuring the elapsed time between a frequency change and programmed output closing.

Step 3: Connect and apply a 120 Vac, 60-hertz voltage source to Terminals C13 (A-phase) and C16 (neutral).

Step 4: Step the frequency of the applied voltage down from 60 hertz to a value below the 281 underfrequency setting. Measure the time delay and verify the accuracy of the 281 time delay setting. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.

Step 5: Repeat Step 4 for the 181 (OUT2) and 81 (OUT1) elements.

Step 6: Step the frequency of the applied voltage up from 60 hertz to a value above the 381 overfrequency setting. Measure the time delay and verify the accuracy of the 281 time delay setting. Timing accuracy is ±5% or ±3 cycles of the time delay setting.

Step 7: Repeat Step 6 for the 481 (OUT5) and 581 (OUT1) elements.

Step 8: Transmit the commands in the second column (5 second TD) of Table 13-75 to the relay.

Step 9: Repeat Steps 2 through 7 with a time delay setting of 5 seconds.

Step 10: Transmit the commands in the third column (10 second TD) of Table 13-75 to the relay.

Step 11: Repeat Steps 2 through 7 with a time delay setting of 10 seconds.

Step 12: Repeat Steps 4 through 11 for Vx Inputs C17 and C18 (change SL command to 2,0).

Step 13: (Optional.) Repeat Steps 1 through 11 for Setting Group 1.

Rate of Change (ROC) Frequency Pickup Verification

Step 1: Prepare the x81 pickup functions for ROC pickup testing by transmitting the commands in Table 13-76 to the relay.

Table 13-76. x81 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=FREQTEST	Sets FREQTEST as custom logic name.
SL-81=1,0	Enables 81, disables blocking.
SL-181=1,0	Enables 181, disables blocking.
SL-281=1,0	Enables 281, disables blocking.
SL-VO1=81T	Enables OUT1 to close for 81 trip.
SL-VO2=181T	Enables OUT2 to close for 181 trip.
SL-VO3=281T	Enables OUT3 to close for 281 trip.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands in Table 13-77 to the relay. These commands set the voltage inhibit value, pickup value, and operating mode (Underfrequency, Overfrequency, or ROC) for each of the x81 functions.

Table 13-77. x81 ROC Inhibit, Pickup, and Mode Setting

Pickup and Mode Settings	Purpose
S0-81INH=40,0,64,46	Set PU = 40V, V2 = 0%, OF = 64 Hz, UF = 46 Hz.
S0-81=10,0,R	Sets 81R PU at 10 Hz/sec ROC frequency.
S0-181=5,0,R	Sets 181R PU at 5 Hz/sec ROC frequency.
S0-281=2,0,R	Sets 281R PU at 2 Hz/sec ROC frequency.

Step 3: Prepare to monitor x81 function operation. Operation can be verified by monitoring the programmed output contacts or HMI Screen 1.5.2.

Step 4: Connect a 120 Vac voltage source capable of smoothly sweeping the frequency from 35 Hz to 75 Hz to Terminals C13 (A-phase) and C16 (neutral).

Step 5: Set the ramp rate at 0.001 seconds/step (max level, lower if possible) and set the total number steps at 1000 (one second total for the sweep test).

Step 6: Set the frequency range of the sweep (ramp) for 55.0 to 64.7 Hz. This equates to a ROC of 9.7 Hz/sec (3.0% below the 10.0Hz/sec pickup setting).

Step 7: Initiate the sweep (ramp) which simultaneously applies voltage to the relay and note that there is no operation of OUT1.

Step 8: Increase the rate of change in increments of 1% (9.8, 9.9 Hz/sec) up to 9.9 Hz/sec and 0.5% thereafter until OUT1 operates. Pickup accuracy is ±2% of setting or ±0.15 Hz/sec, whichever is greater.

Step 9: Repeat Steps 3 through 7 with the pickup value set at 5 Hz/sec and monitoring OUT2. Begin the test by applying a rate of change value 6% below pickup (4.7 Hz/sec or a frequency sweep range of 57 to 61.7 Hz). Increase the rate of change in 1% increments until the OUT2 operates. Pickup accuracy is ±2% of setting or ±0.15 Hz/sec, whichever is greater.

Step 10: Repeat Steps 3 through 7 with the pickup value set at 2 Hz/sec. Begin the test by applying a rate of change value 8% below pickup (1.84 Hz/sec or a frequency sweep range of 59 to 60.84 Hz). Increase the rate of change in 1% increments until the OUT3 operates. Pickup accuracy is ±2% of setting or ±0.15 Hz/sec, whichever is greater.

Step 11: Optionally, repeat Steps 2 through 10 for SO-381, 481, and 581.

Step 12: Optionally, repeat Steps 2 through 11 for Setting Group 1.

Step 13: Optionally, repeat Steps 2 through 12 for POS ROC. Additionally, verify that a sweep from a high to low frequency does not cause an operation.

Step 14: Optionally, repeat Steps 2 through 12 for NEG ROC by reversing the sweep rate from high to low to simulate negative rate of change. Additionally, verify that a sweep from a low to high frequency does not cause an operation.

ROC Time Delay Verification

Time delay verification is not necessary for the ROC mode as the same timers are used as in the over/under frequency timing tests. Timing starts when 81T goes high whether the cause is over, under, or rate of change.

ROC Inhibit Quantities

Operation in the rate of change mode can be inhibited by sensing voltage, negative-sequence voltage, and frequency limits or range, the latter of which creates a "frequency window" of operation. The sensing voltage inhibit is the same feature used for the over/under frequency elements and has already been tested. The following tests verify the negative-sequence and frequency limit inhibits.

Prepare the x81 pickup functions for ROC pickup testing by transmitting the commands in Table 13-78 to the relay.

Table 13-78. x81 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=INHTEST	Sets INHTEST as custom logic name.
SL-81=1,0	Enables 81, disables blocking.
SL-VO1=81T	Enables OUT1 to close for 81 trip.
EXIT;Y	Exit and save settings.

Step 1: Transmit the commands in Table 13-79 to the relay. These commands set the voltage inhibit value, pickup value, and operating mode (Underfrequency, Overfrequency or ROC) for each of the x81 functions.

Table 13-79. x81 ROC Inhibit, Pickup, and Mode Setting

Pickup and Mode Settings	Purpose
S0-81INH=40,20,64,46	Set PU = 40V, V2 = 20%, OF = 64 Hz, UF = 46 Hz.
S0-81=2,0,R	Sets 81R PU at 2 Hz/sec ROC frequency.

Step 2: To test the negative-sequence inhibit function, connect a three-phase voltage source with 120 degrees between phases. The negative-sequence quantity is based on phase to neutral nominal voltage (69.3 or 120). The negative-sequence inhibit setting is a percent of nominal voltage. Assuming a 4 wire connection and a nominal voltage of 120 volts phase to neutral, 208 phase to phase, a 20% of nominal setting equates to a negative-sequence voltage of 24 volts.

Step 3: Set the rate of change (sweep or ramp) for 3 Hz/second (relay set to trip at 2 Hz/sec), initiate the sweep and note that OUT1 operates. While monitoring Metering Screens 3.x.x of the BE1-IPS100, reduce the C phase voltage to 55 volts and note the negative-sequence voltage. Continue to reduce the C phase voltage in 1 volt increments repeating the sweep test after each reduction until OUT1 **does not** operate. Inhibit should occur at 24 volts negative-sequence (Metering Screen 3.x.x). Negative-Sequence Inhibit pickup accuracy is ±.5% or ±1 V, whichever is greater.

Step 4: Transmit the commands in Table 13-80 to the relay. These commands set the voltage inhibit value, pickup value and operating mode (Underfrequency, Overfrequency or ROC) for each of the x81 functions.

Table 13-80. x81 ROC Inhibit, Pickup, and Mode Setting

Pickup and Mode Settings	Purpose
S0-81INH=40,0,64,46	Set PU = 40V, V2 = 0%, OF = 64 Hz, UF = 46 Hz.
S0-81=2,0,R	Sets 81R PU at 2 Hz/sec ROC frequency.

Step 5: To test the frequency limit inhibit function, connect a 120 Vac voltage source capable of smoothly sweeping the frequency from 35 Hz to 75 Hz to Terminals C13 (A-phase) and C16 (neutral). With a ROC setting of 2 Hz/sec, initiate a 3 Hz/sec sweep (frequency range set 60 Hz to 57 Hz) and note that OUT1 operates.

Step 6: Modify the OF and UF limit of Table 13-80 to OF-59.7 and UF-59.5. Repeat Step 5 and note that OUT1 does not operate. Pickup accuracy for over and underfrequency limit is ±0.01 Hz.

Synchronism Check (25)

Purpose: To verify the operation of the Sync Check (25) function.

Reference Commands: SL-25, SL-V0.

<u>*25VM - VTP and VTX Live Voltage, Dead Voltage Pickup Test*</u>

Step 1: Prepare the 25 function block for testing by transmitting the commands in Table 13-81 to the relay.

Table 13-81. Sync-Check Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=25	Sets 25 as custom logic name.

Command	Purpose
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
SG-VTX=1,AN	Set VT auxiliary voltage parameters.
SL-25=1,0	Enable 25 function.
SL-VO1=25VM1	Enables OUT1 to close for 25VM1.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-82 as a guide, transmit the setting commands to the relay.

Table 13-82. Sync-Check Voltage Monitor Pickup Settings

Sync Check VM Pickup Settings	Purpose
S0-25VM=95,55,0,123	Sets LV = 95, DV = 55, TD = 50, VM1 = 123.

Step 3: Prepare to monitor the 25VM function operation. Operation can be verified by monitoring OUT1.

Step 4: Connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a single phase, 0 Vac, 50 or 60 hertz ac voltage source (Line VTP) to the three jumpered terminals and the neutral Terminal (C16).

Step 5: OUT1 should be closed. Slowly increase the line voltage until OUT1 opens (55 volts). Dropout should occur within ±2% or 1 volt of the Dead Voltage setting. Lower the voltage until OUT1 closes. Pickup should be between 97% to 98% of the actual dropout value. Increase the voltage until OUT1 opens. Continue to increase the voltage until OUT1 closes (95 volts). Pickup should occur within ±2% or 1 volt of the hot voltage setting. Lower the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Remove voltage source 1.

Step 6: Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to relay Terminals C17 (polarity) and C18 (non-polarity). Apply 0 Vac.

Step 7: Output 1 should be closed. Slowly increase the Auxiliary voltage until OUT1 opens (55 volts). Dropout should occur within ±2 percent or 1 volt of the Dead Voltage setting. Lower the voltage until OUT1 closes. Pickup should be between 97 to 98% of the actual dropout value. Increase the voltage until OUT1 opens. Continue to increase the voltage until OUT1 closes (95 volts). Pickup should occur within ±2 percent or 1 volt of the Hot Voltage setting. Lower the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

25VM Live/Dead Dropout Timing Verification

Step 1: Using Table 13-83 as a guide, transmit the setting commands to the relay.

Table 13-83. Sync Check 25VM Live/Dead Dropout Time Settings

Sync Check VM Time Settings	Purpose
S0-25VM=95,55,50ms,123	Sets LV = 95, DV = 55, TD = min, VM1 = 123.
S0-25VM=95,55,2S,123	Sets LV = 95, DV = 55, TD = 2 sec, VM1 = 123.
S0-25VM=95,55,5S,123	Sets LV = 95, DV = 55, TD = 5 sec, VM1 = 123.

Step 2: Prepare to monitor the 25VM Hot/Dead timing. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 opening.

Step 3: Connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a 50 Vac, 50 or 60 hertz ac voltage source (Line VTP) to the three jumpered terminals and the neutral Terminal (C16).

Step 4: Step the voltage up to 60 volts. Measure the time delay and verify the accuracy of the dead dropout time delay setting. Timing accuracy is ±5% or ±3 cycles of the time delay setting.

Step 5: Set the ac voltage at 100 volts. Step the voltage down to 90 volts. Measure the time delay and verify the accuracy of the Live dropout delay setting. Timing accuracy is ±5% or ±3 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-83.

Step 7: Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to relay Terminals C17 (polarity) and C18 (non-polarity). Repeat Steps 2 through 6.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

25VM1 Output Test

Step 1: With no voltage applied to either the Line or Auxiliary voltage sources, OUT1 should be closed. This verifies the DEAD-LINE, DEAD AUX output of 25VM1.

Step 2: Apply 0 volts ac to the line voltage input (VTP). OUT1 contact should be closed. Output 1 will open as the voltage is increased above the DEAD-LINE setting and close again when voltage exceeds the LIVE-LINE setting. This verifies the LIVE-LINE, DEAD-AUX output of 25VM1. Remove voltage source 1.

Step 3: Apply 0 volts ac to the Auxiliary Voltage Input (VTX). OUT1 contact should be closed. Output 1 will open as the voltage is increased above the DEAD-LINE setting and close again when voltage exceeds the LIVE-LINE setting. This verifies the DEAD-LINE, LIVE-AUX output of 25VM1.

Step 4: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

25 Sync-Check Verification

Step 1: Transmit SL-VO1=25;EXIT;Y to the relay.

Step 2: Using Table 13-84 as a guide, transmit the setting commands to the relay.

Table 13-84. Sync-Check Settings

Sync Check Settings	Purpose
S0-25=10,10,0.3,0	Sets Delta V, angle, delta slip, and GF>BF mode.

Step 3: Prepare to monitor the 25 function operation. Operation can be verified by monitoring OUT 1.

Step 4: As in the previous test, connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Line VTP) to the three jumpered terminals and the neutral Terminal (C16).

Step 5: Apply a second 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Auxiliary VTX) to C17 and C18. OUT1 should close verifying the 25 output for a Delta Angle of 0 degrees, 0 Delta V and 0 Delta Frequency (Slip).

Step 6: Decrease the Auxiliary voltage input (VTX) until OUT1 opens. Slowly increase the voltage until OUT1 closes. Pickup should occur within ±2% of the Delta V setting. Dropout should occur at 97% to 98% of actual pickup.

Step 7: Repeat Step 6 for the Line voltage input (VTP). Return voltage inputs to 120 Vac, 50 or 60 hertz, 0 degrees.

Step 8: Swing the angle between voltage source 1 and 2 until the OUT1 opens. Slowly decrease the angle until OUT1 closes. Pickup should occur within ±2° of the Delta Angle setting on the leading and lagging side of 0 degrees. Dropout should occur at 97% to 98% of actual pickup. Return Delta Angle to 0 degrees.

Step 9: With the Auxiliary Voltage set at nominal frequency, step change the frequency of the Line voltage input by -0.25 hertz (59.75 on a 60 hertz relay). Note that OUT1 is closing and opening based on a slip rate of 0.25 hertz. Decrease the frequency until OUT1 stays open. Slowly increase the frequency until OUT1 begins to cycle (closed/open). Cycling pickup should occur within ±2% of the Delta Slip setting. Also check on the fast side (60.25 for a 60 hertz relay).

Step 10: Repeat Step 9 for the Auxiliary Voltage input.

Step 11: (Optional.) Repeat Steps 4 through 10 for Setting Group 1.

Breaker Failure (BF)

Purpose: To verify the operation of the breaker failure (BF) function.

Reference Commands: SL-BF, SP-BF

Step 1: Prepare the BF function block for testing by transmitting the commands in Table 13-85 to the relay.

Table 13-85. BF Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=BF	Sets BF as custom logic name.
SL-BF=1,IN4,/IN3	Enables BF, IN4 initiate, /IN3 block.
SP-BF=50m	Set BF time delay at minimum.
SL-VO1=BFT	Enables OUT1 to close for BF trip.
SL-VO2=BFPU	Enables OUT2 to close for BF pickup.
SG-CT=1	Sets P, N CT ratio at 1:1
SG-TRIGGER=BFT,BFPU,0	Enable BFT to log and trigger fault recording.
SG-TARG=BF	Enables BF target.
EXIT;Y	Exit and save settings.

Step 2: Energize relay Inputs IN3 and IN4. This enables the BF logic and BF initiate. The BF current detector pickup setting is a fixed value that is determined by the relay current sensing type. Table 13-86 lists the pickup setting for each current sensing type.

Table 13-86. BF Current Detector Pickup Settings

Sensing Type	Pickup Setting
A or B (1 A)	0.1 A
D, E, or F (5 A)	0.5 A

Step 3: Connect a current source to Terminals D1 and D2 (A-phase input). Slowly increase the current applied to the A-phase input until OUT2 (and subsequently OUT1) closes. Compare the applied current to the current values listed in Table 13-87. Verify that pickup occurred between the lower and upper limits for your relay.

Table 13-87. BF Pickup Limits

Sensing Type	Lower PU Limit	Upper Pickup Limit
A or B (1 A)	0.09 A	0.11 A
D, E, or F (5 A)	0.45 A	0.55 A

Step 4: Transmit the commands in Table 13-88 to set the BF time delay.

Table 13-88. BF Time Delay Commands

Command	Purpose
A=	Gains write access.
SP-BF=100m	Set BF time delay at 100 milliseconds.
EXIT;Y	Exit and save settings.

Step 5: Verify the BF time delay by applying the pickup current obtained in Step 3 for the duration given in the following steps:

A. Apply pickup current to phase A for 4 cycles (67 ms at 60 Hz). No trip should occur.

B. Apply pickup current to phase A for 5 cycles (83 ms at 60 Hz). No trip should occur.

C. Apply pickup current to phase A for 7 cycles (117 ms at 60 Hz). A BF trip should occur. Use the RS-LGC command to retrieve an SER report and verify that a BF trip was logged 100 milliseconds ±5% (+11/4, -1/4) after application of pickup current.

Step 6: (Optional.) De-energize relay Input IN3. This will block the breaker fail logic and cause OUT1 and OUT2 to open. Verify that relay outputs OUT1 and OUT2 remain open (BF element does not operate) even though pickup current is applied. De-energize IN3 and verify that OUT2 (and subsequently OUT1) closes. Remove current from phase A.

Step 7: (Optional.) Apply pickup current to phase A. OUT2 and OUT1 should close. De-energize IN4 and verify that OUT1 and OUT2 open. Remove current from phase A.

Step 8: Energize IN4 and apply 0.7 A of current to the phase A current input and measure the time between the application of current and OUT1 closing. OUT2 should have closed immediately when current was applied. Verify that the BF Timer operated within the specified accuracy of ±5% or +11/4, -1/4 cycles, whichever is greater.

Step 9: (Optional.) Repeat Steps 3 through 8 for the phase B and phase C elements.

Virtual Switches (43)

Purpose: To verify operation of the 43/143 virtual switches.

Reference Commands: SL-43/143, CS/CO-43/143

To test virtual switches, we verify each mode of operation but you do not have to verify both of the virtual switches. In your testing, you may use either of the switches, as desired. If you give an invalid command such as CS-143=1/CO-143=1 when Switch 143 is programmed for Mode 3 operation, the relay will reject the command and return an INVALID PARAMETER message through the ASCII command interface. For more information about virtual switch operation, see Section 4, *Protection and Control, Virtual Switches*. You may verify operation of virtual switches by monitoring the programmed output contacts, HMI Screen 1.5.4, or by using the RS-LGC command to retrieve logic variable data from the SER. You also may use the RG-STAT command. See Section 6, *Reporting and Alarm Functions*, for more information about reports.

Mode 1 - On/Off/Pulse

Step 1: Prepare the x43 virtual switch for Mode 1 testing by transmitting the commands in Table 13-89.

Table 13-89. x43 Mode 1 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=MODE1	Sets MODE1 as custom logic name.
SL-43=1	Sets 43 for Mode 1 operation.
SL-VO1=43	Enables OUT1 operation.
EXIT;Y	Exit and save settings.

Step 2: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester may be used to monitor the contact status of OUT1.

Step 3: Transmit the commands in Table 13-90 to the relay. These commands change the state of the 43 Switch to On. Result: OUT1 contact closes and remains closed.

Table 13-90. x43 Mode 1 On Commands

Command	Purpose
A=	Gains write access.
CS-43=1	Selects 43 for On operation.
CO-43=1	Executes 43 for On operation.

Step 4: Transmit the commands in Table 13-91 to the relay. These commands change the state of the 43 Switch to off. It isn't necessary to gain access for the following steps unless the write access timer expires. Result: OUT1 contact opens and remains open.

Table 13-91. x43 Mode 1 Off Commands

Command	Purpose
A=	Gains write access.
CS-43=0	Selects 43 for Off operation.
CO-43=0	Executes 43 for Off operation.

Step 5: Transmit the commands in Table 13-92. These commands pulse the 43 Switch on and off once. Result: OUT1 contact closes for 200 milliseconds and returns to the open state.

Table 13-92. x43 Mode 1 Pulse Commands

Command	Purpose
A=	Gains write access.
CS-43=P	Selects 43 for Pulse operation.
CO-43=P	Executes 43 for Pulse operation.

<u>Mode 2 - On/Off</u>

Step 1: Prepare for Mode 2 testing by transmitting the commands in Table 13-93 to the relay.

Table 13-93. x43 Mode 2 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=MODE2	Sets MODE2 as custom logic name.
SL-143=2	Sets 143 Switch for Mode 2 operation.
SL-VO1=143	Enables OUT1 to close for 143.
EXIT;Y	Exit and save setting

Step 2: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester may be used to monitor the contact status of OUT1.

Step 3: Transmit the commands in Table 13-94 to the relay. These commands change the state of the 43 Switch to On. Result: OUT1 contact closes and remains closed.

Table 13-94. x43 Mode 2 On Commands

Command	Purpose
A=	Gains write access.
CS-143=1	Selects 143 for On operation.
CO-143=1	Executes 143 for On operation.

Step 4: Transmit the commands in Table 13-95 to the relay. These commands change the state of the 143 Switch to Off. It isn't necessary to gain access for the following steps unless the write access timer expires.

Table 13-95. x43 Mode 2 Off Commands

Command	Purpose
A=	Gains write access.
CS-143=0	Selects 143 for Off operation.
CO-143=0	Executes 143 for Off operation.

Mode 3 - Pulse

Step 1: Prepare for Mode 3 testing by transmitting the commands in Table 13-96 to the relay.

Table 13-96. x43 Mode 3 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=MODE3	Sets MODE3 as custom logic name.
SL-143=3	Sets 143 switch for Mode 3 operation.
SL-VO1=143	Enables OUT1 to close for 143.
EXIT;Y	Exit and save settings.

Step 2: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester may be used to monitor the contact status of OUT1.

Step 3: Transmit the commands in Table 13-97 to the relay. These commands pulse the 143 Switch On and Off once. Result: OUT1 contact closes for 200 milliseconds and returns to the open state.

Table 13-97. x43 Mode 3 Pulse Commands

Command	Purpose
A=	Gains write access.
CS-143=P	Selects 143 for Pulse operation.
CO-143=P	Executes 143 for Pulse operation.

Virtual Breaker Control Switch (101)

Purpose: To verify 101 Virtual Breaker Control Switch operation.

Reference Commands: SL-101, CS/CO-101C, CS/CO-101T

Step 1: Prepare the 101 Virtual Breaker Control Switch for testing by transmitting the commands in Table 13-98 to the relay.

Table 13-98. 101 Virtual Breaker Control Switch Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=S101	Sets S101 as custom logic name.
SL-101=1	Enables 101 Switch.
SL-VO1=101T	Enables OUT1 to close when 101T is TRUE.
SL-VO2=101C	Enables OUT2 to close when 101C is TRUE.
SL-VO3=101SC	Enables OUT3 to close when 101SC is TRUE.
EXIT;Y	Exit and save settings.

Step 2: Prepare to monitor the 101 Virtual Breaker Control Switch operation. Operation can be verified by monitoring the programmed output contacts, HMI Screen 2.2.1 or by using RG-STAT command. See Section 6, *Reporting and Alarm Functions*, for more information.

Step 3: Transmit the commands in Table 13-99 to the relay. These commands place the 101 Switch in the trip position. Result: OUT1 closes for 200 milliseconds and returns to the open state. OUT3 opens (trip state) and remains open.

Table 13-99. 101 Virtual Breaker Control Switch Trip Test Commands

Command	Purpose
A=	Gains write access.
CS-101T=T	Selects 101T for Trip operation.
CO-101T=T	Executes 101T for Trip operation.

Step 4: Transmit the commands in Table 13-100 to the relay. These commands place the 101 Switch in the closed state. Result: OUT2 closes for 200 milliseconds and returns to the open state. OUT3 closes (close state) and remains closed.

Table 13-100. 101 Virtual Breaker Control Switch Close Test Commands

Command	Purpose
A=	Gains write access.
CS-101C=C	Selects 101C for Close operation.
CO-101C=C	Executes 101C for Close operation.

Logic Timer (62)

Purpose: To verify the operation of the 62/162 Timer elements.

Reference Commands: SL-62/162, S<g>-62/162, RS-LGC

> **NOTE**
>
> In these tests, the relay's virtual switches (x43) are used to initiate the 62/162 Timers. See Section 4, *Protection and Control, Virtual Switches*, for detailed information about x43 Switch operation.

Mode 1 - Pickup/Dropout

Step 1: Prepare the 62 timer for Mode 1 testing by transmitting the commands in Table 13-101 to the relay.

Table 13-101. x62 Mode 1 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T62	Sets T62 as custom logic name.
SL-43=2	Enables 43 Switch ON/OFF mode.
SN-43=62_INI,PU,DO	Name switch to make SER report easier to read.
SL-62=1,43	Enables 62 PU/DO mode, 43 initiate, no blocking.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands in Table 13-102 to set the 62 function pickup and dropout time.

Table 13-102. x62 Mode 1 Pickup and Dropout Settings

Command	Purpose
A=	Gains write access.
S#-62=400m,2000m	Sets 62 pickup at 400 milliseconds, dropout at 2,000 milliseconds.
EXIT;Y	Exit and save settings.

Step 3: Transmit the commands in Table 13-103 to the relay. These commands will initiate the 62 Timer by changing the 43 Switch state to closed (logic 1). Once initiated, the 62 Timer will force an output based on the 400-millisecond pickup time setting.

Table 13-103. x62 Mode 1 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-43=1	Selects 43 for On operation.
CO-43=1	Executes 43 for On operation.

Step 4: Transmit the commands in Table 13-104 to the relay. These commands will remove the initiate input from the 62 Timer by changing the 43 Switch state to open (logic 0).

Table 13-104. x62 Mode 1 Timer Initiate Removal Commands

Command	Purpose
A=	Gains write access.
CS-43=0	Selects 43 for Off operation.
CO-43=0	Executes 43 for Off operation.

Step 5: Use the RS-LGC command to retrieve logic variable data from the SER. Verify that the 43 Switch change to a closed state was logged and approximately 400 milliseconds later, the 62 Timer picked up. Then, some time later, the 43 Switch change to an open state was logged and the 62 Timer dropped out approximately 2,000 milliseconds later. The state of the 43 switches in the SER report use the programmable name parameters applied to the switch. Figure 13-4 illustrates the timing relationship of the 43 Switch and 62 Timer.

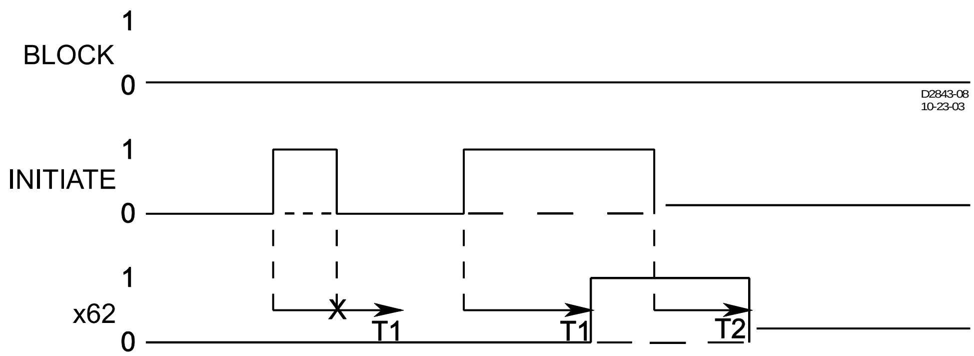


Figure 13-4. x62 Mode 1 (Pickup/Dropout) Timing Example

Mode 2 - One-Shot Nonretriggerable

Step 1: Prepare the 162 Timer for Mode 2 testing by transmitting the commands in Table 13-105 to the relay.

Table 13-105. x62 Mode 2 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T162	Sets T162 as custom logic name.
SL-162=2,143,0	Enables 162 1-shot, nonretriggerable mode, 143 initiate, no blocking.
SL-143=3	Enables 143 Switch momentary pulse mode.
SN-143=162_INI,INI,NORMAL	Name Switch 143 to make SER report easier to read.
S0-162=400m,20s	Sets 162 delay at 400 milliseconds. Sets 162 dropout at 20 seconds.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands of Table 13-106 to the relay. These commands supply the 162 Timer with a momentary initiate input by pulsing the 143 Switch from a FALSE state to a TRUE state and then back to a FALSE state. You may view the state changes of the 143 Switch at Screen 1.5.4 of the front panel HMI.

NOTE

The 143 Switch action is performed twice in this test. To illustrate the action of the timer mode, the commands of Table 13-106 should be executed as quickly as possible. Ideally, this test should be repeated within 20 seconds. If this is a problem, try extending the dropout timer setting to 30 seconds.

Table 13-106. x62 Mode 2 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-143=P	Selects 143 for pulse F-T-F operation.
CO-143=P	Executes 143 pulse F-T-F operation.
CS-143=P	Selects 143 for pulse F-T-F operation.
CO-143=P	Executes 143 pulse F-T-F operation.
EXIT	Exit select and operate mode.

Step 3: Use the RS-LGC command to retrieve logic variable data from the SER. Verify that a 143 FALSE-TRUE-FALSE pulse action was logged and that approximately 400 milliseconds after the initial 143 FALSE-TRUE-FALSE initiate signal action, the 162 Timer output went TRUE. Then, approximately 20 seconds later, duration Timer T2 expired and the timer output went FALSE despite a second 143 FALSE to TRUE initiate signal while the duration timer was active. Figure 13-5 illustrates the timing relationship of the 143 Switch and x62 Timer.

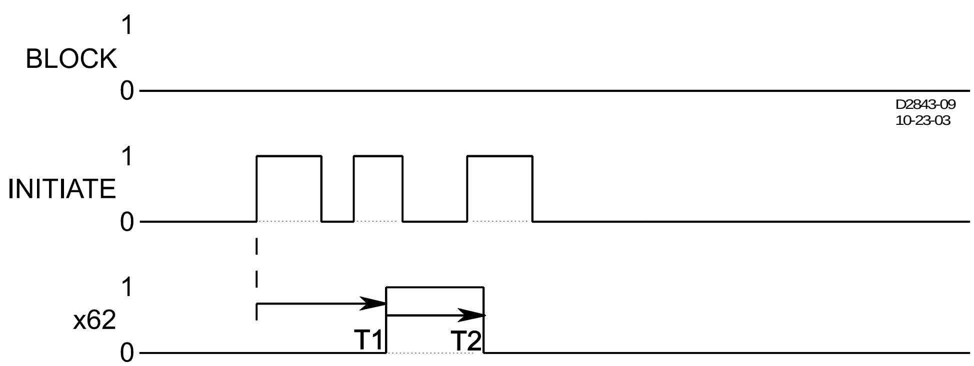


Figure 13-5. Mode 2 and x62 Timer Relationship Example

Mode 3 - One-Shot Retriggerable

Step 1: Prepare the 62 Timer for Mode 3 testing by transmitting the commands in Table 13-107.

Table 13-107. x62 Mode 3 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T62	Sets T62 as custom logic name.
SL-62=3,43,0	Enables 62 one-shot, retriggerable mode, 43 initiate, no blocking.
SL-43=3	Enables 43 Switch momentary pulse mode.

Command	Purpose
SN-43=62_INI,INI,NORMAL	Name Switch 43 to make SER easier to read.
S0-62=15s,20s	Sets 62 delay at 15 seconds. Sets 62 dropout at 20 seconds.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands of Table 13-108 to the relay. These commands supply the 62 Timer with a momentary initiate input by pulsing the 43 Switch from FALSE to TRUE and then back to FALSE. You may view the state changes of the 43 Switch at Screen 1.5.4 of the front panel HMI.

NOTE

The 43 Switch action is performed three times in this test. To illustrate the action of the timer mode, the second 43 Switch action should be executed as quickly as possible (within the 15 second duration of the pickup time delay). Perform the third 43 Switch action after at least 15 seconds (the pickup timer setting) have elapsed but before the 20 second dropout time delay expires. This will illustrate the action of the timer mode. The time delay settings may be increased if difficulty is encountered with repeating the 43 Switch actions.

Table 13-108. x62 Mode 3 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-43=P	Selects 43 for pulse F-T-F operation.
CO-43=P	Executes 43 pulse F-T-F operation.
CS-43=P	Selects 43 for pulse F-T-F operation.
CO-43=P	Executes 43 pulse F-T-F operation.
Wait at least 15 seconds (but no longer than 35 seconds) to execute next commands.	
CS-43=P	Selects 43 for pulse F-T-F operation.
CO-43=P	Executes 43 pulse F-T-F operation.
EXIT	Exit select and operate mode.

Step 3: Use the RS-LGC command to obtain an SER report and verify that the following actions were logged. These events are illustrated in the timing diagram of Figure 13-6.

Approximately 15 seconds after the second 43 FALSE to TRUE initiate signal, the 62 Timer output went TRUE. The timer output went FALSE when the third FALSE to TRUE initiate signal forced the 62 Timer (T1) to restart.

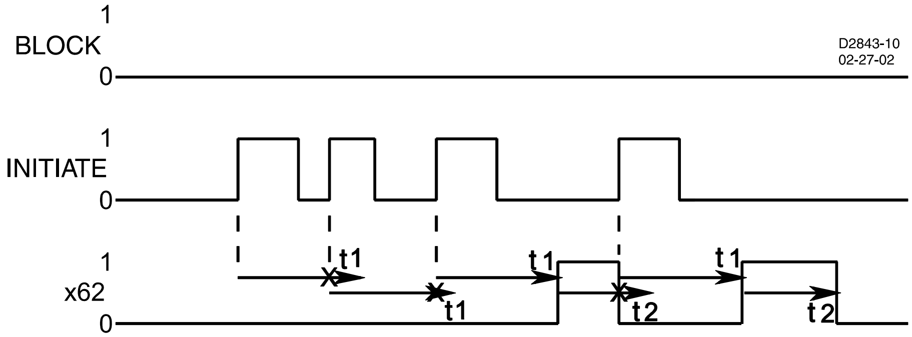


Figure 13-6. Mode 3 (One-Shot Retriggerable) Timing Example

Mode 4 - Oscillator

Because this operating mode is not intended for general use, no testing procedure is available. Information about Mode 4 is available in Section 4, *Protection and Control, General Purpose Logic Timers*.

Mode 5 - Integrating

Step 1: Prepare the 62 Timer for Mode 5 testing by transmitting the commands in Table 13-109.

Table 13-109. x62 Mode 5 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T62	Sets T62 as custom logic name.
SL-43=2	Enables 43 Switch ON/OFF mode.
SN-43=62_INI,PU,DO	Name Switch 43 to make SER easier to read.
SL-62=5,43,0	Enables 62 integrating mode, 43 initiate, no blocking.
S0-62=15s,5s	Sets T1 at 15 seconds. Sets T2 at 5 seconds.
EXIT;Y	Exit and save settings.

NOTE

The CS and CO commands of Table 13-101 are performed three times. Follow the timing sequence to illustrate timer mode action. The time delay settings may be increased if difficulty is encountered with repeating the 43 Switch actions.

Step 2: Transmit the commands of Table 13-110 to the relay. These commands supply a block input to the 62 Timer by changing the 43 Switch state to TRUE.

Table 13-110. x62 Mode 5 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-43=1	Selects 43 for TRUE operation.
CO-43=1	Executes 43 TRUE operation.
Wait no longer than 10 seconds to interrupt the T1 timer.	

Command	Purpose
CS-43=0	Selects 43 for FALSE operation.
CO-43=0	Executes 43 FALSE operation.
Wait at least 5 seconds for the T2 timer to reset.	
CS-43=0	Selects 43 for FALSE operation.
CO-43=0	Executes 43 FALSE operation.
Wait at least 20 seconds to allow the T1 timer to elapse.	
EXIT	Exit the select and operate mode.

Step 3: Use the RS-LGC command to obtain an SER report and verify that the following actions were logged. These events are illustrated in the timing diagram of Figure 13-7.

Timer T1 failed to time out in the first 43 Switch action (TRUE).

Timer T2 timed out after the second 43 Switch action (FALSE).

Timer T1 timed out and the 62 Timer output went TRUE.

Timer T2 timed out and the 62 Timer output returned to a FALSE state.

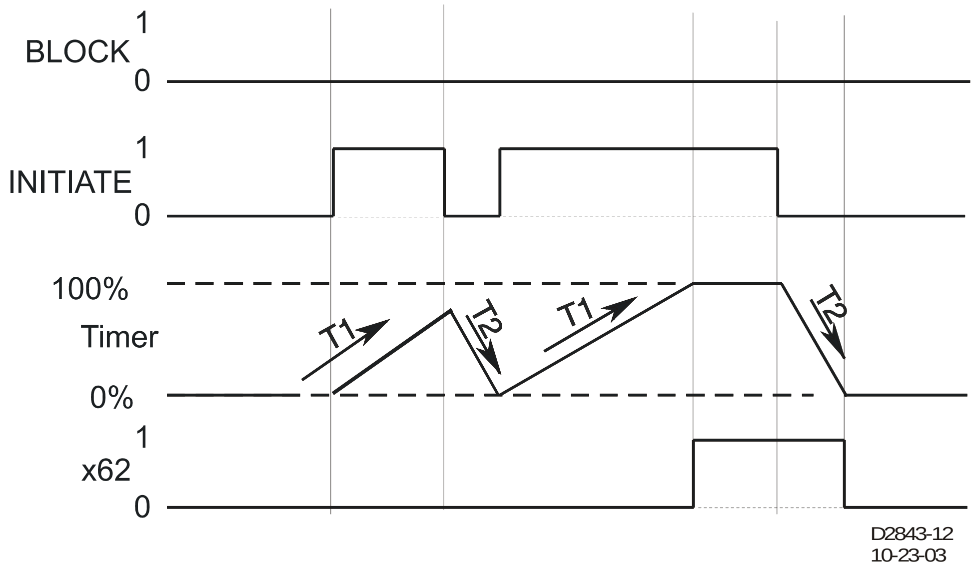


Figure 13-7. Mode 5 (Integrating Timer) Timing Example

Step 4: (Optional.) Repeat the 62 Timer tests for Modes 1, 2, 3, and 5 for Setting Group 1.

Mode 6 - Latch

Step 1: Prepare for Mode 6 logic timer testing by transmitting the commands in Table 13-111 to the relay.

Table 13-111. x62 Mode 6 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T62	Sets T62 as custom logic name.
SL-43=1	Enables 43 Switch pulse mode.
SL-143=1	Enables 143 Switch pulse mode.
SN-43=62_INI	Name Switch 43 to make SER report easier to read.

Command	Purpose
SN-143=62_RES	Name Switch 143 to make SER report easier to read.
SL-62=6,43,143	Enables 62 latch mode, 43 initiate, 143 blocking.
S0-62=30s	Sets T1 at 30 seconds.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands in Table 13-112 to the relay. These commands supply a latch input to the 62 Timer by changing the 43 Switch state to TRUE. By changing the BLK input (143 Switch) to TRUE, these commands supply a reset command, also.

NOTE

The CS and CO commands of Table 13-112 are performed twice in this test. Follow the timing sequence to illustrate time mode action. The time delay settings may be increased if difficulty is encountered with repeating the 43 and 143 Switch actions.

Table 13-112. x62 Mode 6 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-43=P	Selects 43 for pulse operation.
CO-43=P	Executes 43 pulse operation.
Execute the following commands in less than 30 seconds.	
CS-43=P	Selects 43 for pulse operation.
CO-43=P	Executes 43 pulse operation.
Wait at least 30 seconds (total elapsed time) to initiate the block command.	
CS-143=P	Selects 143 for pulse operation.
CO-143=P	Executes 143 pulse operation.
EXIT	Exit the select and operate mode.

Step 3: Use the RS-LGC command to obtain an SER report and verify that the following actions were logged. These events are illustrated in the timing diagram of Figure 13-8.

Timer T1 continued to time out after the first 43 Switch action. (TRUE).

Timer T1 timed out and the 62 Timer output went TRUE 30 seconds after 43 Switch action. (TRUE). Timer output 62 returned to a FALSE state with the 143 Switch action (TRUE).

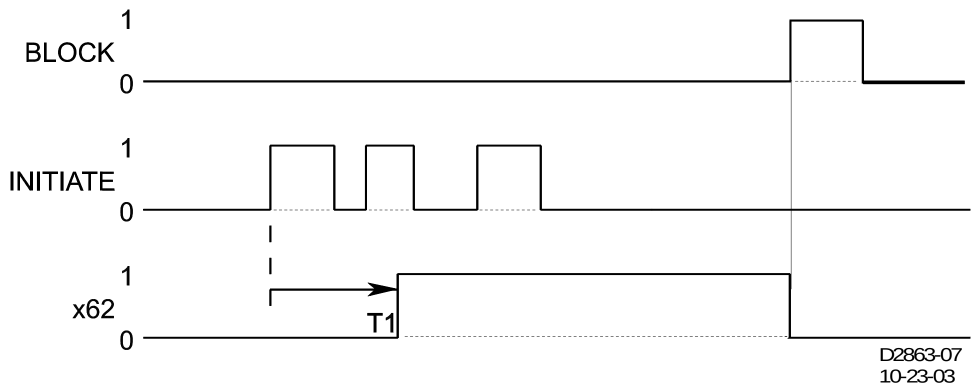


Figure 13-8. x62 Mode 6 (Latch) Timing Example

Step 4: (Optional.) Repeat the 62 Timer tests for Modes 1, 2, 3, and 5 for Setting Group 1.

Automatic Setting Group Change

Purpose: To verify the operation of the automatic setting group change function.

Reference Commands: SL-GROUP, SG-SGCON, SP-GROUP, CS/CO-GROUP, SL-51, S<g>-51

Automatic Change

Step 1: Connect a current source to Terminals D1 and D2 (A-phase input).

Step 2: Prepare the automatic setting group change function for testing by transmitting the commands in Table 13-113 to the relay.

Table 13-113. Automatic Setting Group Change Function Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=ASG	Name custom logic for this test.
SL-GROUP=1,43,143,INI	Sets logic mode to discrete selection with virtual switch and contact input control.
SL-51P=1,0	Enables 51P, disables blocking.
SG-SGCON=1S	Sets SGC on-time at 1 seconds.
SL-VO1=SG1	Closes OUT1 when SG1 is active.
SG-CTP=1	Sets the phase CT ratio at 1.
SG-TRIGGER=51PT,51PPU,0	Enable 51PT to log and trigger fault recording.
SL-43=3	Enables 43 Switch OFF/momentary ON mode.
SL-143=3	Enables 143 Switch OFF/momentary ON mode.
SN-43=MAN_SEL,GRP0,NORMAL	Assigns 43 Switch labels.
SN-143=MAN_SEL,GRP1,NORMAL	Assigns 143 Switch labels.
SN-IN1=MAN_SEL,AUTO,MANUAL	Assigns IN1 Switch labels.
SP-GROUP1=1,75,1,70,51P	SG1 ts = 1 min @ 75%, tr = 1 min @ 70% of SG0 51P setting.
EXIT;Y	Exit and save settings.

Step 3: Select automatic setting group control by energizing Input IN1.

Step 4: Gain write access and transmit the appropriate setting commands in Table 13-114 to the relay. Remember to save your setting changes with the EXIT;Y commands. An ohmmeter or continuity tester may be used to monitor the output contacts (OUT1, OUT2, OUT3) status.

Table 13-114. 51P Element Pickup Settings

Sensing Type	Command	Comments
1 A	S0-51P=1.0,5.0,I2	pu = 1.0, td = 5, curve = I2
	S0-51P=1.5,5.0,I2	pu = 1.5, td = 5, curve = I2
	S0-51P=1.8,5.0,I2	pu = 1.8, td = 5, curve = I2
	S0-51P=2.2,5.0,I2	pu = 2.2, td = 5, curve = I2
5 A	S0-51P=5.0,5.0,I2	pu = 5.0, td = 5, curve = I2
	S0-51P=7.5,5.0,I2	pu = 7.5, td = 5, curve = I2
	S0-51P=9.0,5.0,I2	pu = 9.0, td = 5, curve = I2
	S0-51P=10.5,5.0,I2	pu = 10.5, td = 5, curve = I2

Step 5: Using the values listed in Table 13-115, apply current to the A-phase current input. Begin at the starting point and then step the current up to just slightly above the low limit for the amount of time listed. If the active setting group does not change, step the current up to just below the high limit for the duration indicated. The setting group should change should occur between the low and high limits. Verify that the change occurred within the time limits programmed at an accuracy of ±5 percent or ±2 seconds, whichever is greater. Step the current up to each new level and verify the setting group change and pickup accuracy.

Table 13-115. Setting Group Change Example Accuracy Limits – Increasing Current

Sensing Type	Current Limit		Time	Comments
	Low	High		
1 A	0.5	0.5		Starting point 50% pickup.
	0.735	0.765	> 1 min	Switch to SG1 (75% SG0 51P).
5 A	2.5	2.5		Starting point 50% pickup.
	3.675	3.825	> 1 min	Switch to SG1 (75% SG0 51P).

Step 6: Transmit the select and operate commands in Table 13-116 to the relay.

Table 13-116. Automatic Setting Group Control Selection

Command	Purpose
A=	Gains write access.
CS-143=1	Selects 143 for TRUE operation.
CO-143=1	Executes 143 TRUE operation.
EXIT	Exit select and operate mode.

Step 7: Begin stepping down the current from one level to the next as shown in Table 13-117. First, step the current down to just below the high limit for the amount of time listed. If the active setting group does not change, step the current down to just above the low limit for the duration indicated. This will verify the accuracy of the pickup. Continue stepping the current down to each new level.

Table 13-117. Setting Group Change Example Accuracy Limits – Decreasing Current

Sensing Type	**Current Limit**		**Time**	**Comments**
	Low	**High**		
	0.867	0.833	> 1 min	Switch to SG1 (85% SG0 51P).
	0.714	0.686	> 1 min	Switch to SG0 (70% SG0 51P).
	4.335	4.165	> 1 min	Switch to SG1 (85% SG0 51P).
	3.57	3.43	> 1 min	Switch to SG0 (70% SG0 51P).

Step 8: Remove the current from Phase A, Terminals D1 and D2.

Step 9: Using the RS-LGC command to retrieve logic variable data from the SER, verify that the following actions were logged:

- Verify that all setting group changes were logged.
- Verify that VO1 went TRUE and closed relay output OUT1 when SG1 became the active setting group.
- Verify the events that occurred in reverse order when the current was being stepped down.

Manual Change - Mode 1

Manual Change Mode 1 test procedures are a continuation of the automatic test procedures. Do not change the logic or settings except for those in Step 1 and subsequent.

Step 1: De-energize IN1 and verify that VO1 goes TRUE and closes OUT1 when SG1 becomes the active setting group.

Step 2: Transmit the select and operate commands in Table 13-118 to the relay.

Table 13-118. Manual Setting Group Control Selection

Command	**Purpose**
A=	Gains write access.
CS-143=0	Selects 143 for FALSE operation.
CO-143=0	Executes 143 FALSE operation.
CS-43=1	Selects 43 for TRUE operation.
CO-43=1	Executes 43 TRUE operation.
CS-43=0	Selects 43 for FALSE operation.
CO-43=0	Executes 43 FALSE operation.
EXIT	Exit select and operate mode.

Step 3: Use the RS-LGC command to retrieve logic variable data from the SER. Verify that the setting group change actions were logged.

Manual Change - Mode 2

Manual Change Mode 2 test procedures are a continuation of the Mode 1 test procedures. Do not change the logic or settings except for those in Step 1 and subsequent.

Step 1: Transmit the commands in Table 13-119 to the relay. These commands set up the relay for binary setting group control selection.

Table 13-119. Binary Group Control Selection Setup

Command	Purpose
A=	Gains write access.
SL-GROUP=2,43,0,143	Configures the setting group control function as binary coded selection. D0 logic = 43, D1 logic = 0, Auto logic = 143
SL-43=2	Sets 43 to On/Off mode.
EXIT;Y	Exit and save settings.

Step 2: Transmit the select and operate commands in Table 13-120 to the relay. For more information on setting group selection, see Section 4, *Protection and Control, Setting Groups*.

Table 13-120. Binary Group control Select and Operate Commands

Command	Purpose
A=	Gains write access.
CS-43=0	Selects 43 for FALSE operation.
CO-43=0	Executes 43 FALSE operation.
EXIT	Exit select and operate mode.

Step 3: Verify that VO1 goes FALSE and opens OUT1 when SG0 becomes the active setting group.

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DESCRIPTION

BESTCOMS is a Windows® based program that runs on an IBM compatible computer and provides a user friendly, graphical user interface (GUI) for use with Basler Electric communicating products. BESTCOMS is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMS provides the user with a point and click means for setting and monitoring the in-service relay or relays under test. The point and click method provides an efficient, fast setup for configuring one or several relays. This software is provided free with every BE1-IPS100 Intertie Protection System.

INTRODUCTION

A primary advantage of the 32-bit BESTCOMS is that an actual unit (i.e., operating transmission protection system) is not required to perform any or all settings and adjustments for any preprogrammed scheme. Nor is it needed to create a custom scheme complete with settings and adjustments. Also, BESTCOMS is identical within all of the Basler Electric Numerical Systems except for differences inherit in the individual systems. This means that once you become familiar with a BESTCOMS for one system, you are also familiar with BESTCOMS for all of the systems.

Using the BESTCOMS GUI, you may prepare setting files off-line (without being connected to the relay) and then upload the settings to the relay at your convenience. These settings include protection and control, operating and logic, breaker monitoring, metering, and fault recording. Engineering personnel can develop, test, and replicate the settings before exporting them to a file and transmitting the file to technical personnel in the field. In the field, the technician simply imports the file into the BESTCOMS database and uploads the file to the relay where it is stored in nonvolatile memory. (See the paragraphs on *File Management* later in this manual for more information on saving, uploading, and downloading files.)

The BESTCOMS GUI also has the same preprogrammed logic schemes that are stored in the relay. This gives the engineer the option (off-line) of developing his/her setting file using a preprogrammed logic scheme, customizing a preprogrammed logic scheme, or building a unique scheme from scratch. Files may be exported from the GUI to a text editor where they can be reviewed or modified. The modified text file may then be uploaded to the relay. After it is uploaded to the relay, it can be brought into the GUI but it cannot be brought directly into the GUI from the text file. The GUI logic builder uses basic AND/OR gate logic combined with point and click variables to build the logic expressions. This reduces the design time and increases dependability.

The BESTCOMS GUI also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files may be accomplished using Basler Electric's BESTwave software. For more information on Basler Electric's Windows® based BESTwave software, contact your local sales representative or Basler Electric, Technical Support Services Department in Highland, Illinois.

This section provides an introduction to all of the screens in the BE1-IPS100 Intertie Protection System with their field layouts and typical entries. Common program activities such as applying settings, modifying logic, and setting up password security are discussed. These discussions are application oriented. We explore how the activity or task can be performed using an appropriate BE1-IPS100 BESTCOMS screen.

BESTCOMS screens are similar to most Windows® based GUI screens. You may immediately notice common features such as the pull-down menu, toolbar, icons, and help prompts when the mouse pointer is paused over an icon. Some of these features are shown in Figure 14-1. If the Navigation Bar has a right and left arrow at the extreme right hand side of the screen, clicking on these arrows will shift the Navigation Bar to allow access to all of the icons on the bar. Like most computer programs, there is often more than one way to perform an activity or task. These various methods are discussed in the following paragraphs in conjunction with the appropriate BESTCOMS screen.

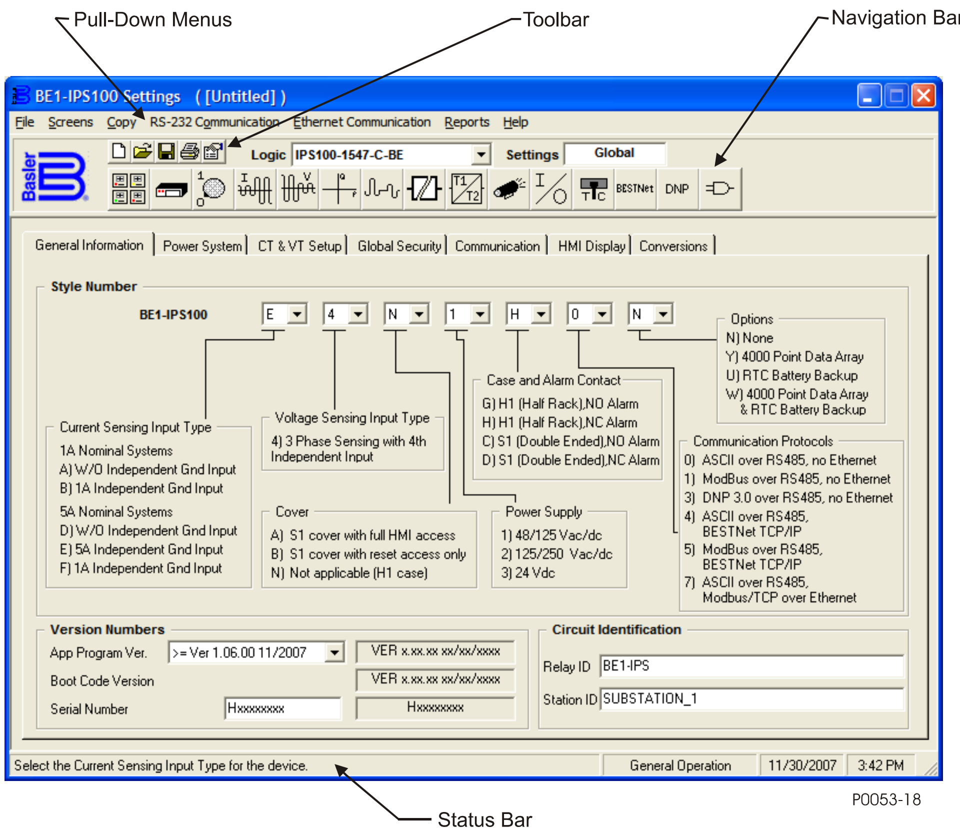


Figure 14-1. Typical User Interface Components

INSTALLATION

BESTCOMS for BE1-IPS100 software contains a setup utility that installs the program on your PC. (This is typical for all of the BE1 numerical systems.) When it installs the program, an uninstall icon (in the Control Panel, Add/Remove Programs feature) is created that you may use to uninstall (remove) the program from your PC. The minimum recommended operating requirements are listed in the following paragraph.

PC Requirements

- 486DX2-100-MHz or higher processor
- 20 megabytes (MB) of RAM
- Microsoft® Windows® 2000/XP/Vista
- 7 MB of hard disk space
- CD-ROM drive for installation
- One available serial port
- One Ethernet port (optional Ethernet-enabled relay)

Installing the Program on Your PC Using Microsoft® Windows®

1. Insert the CD in the PC CD-ROM drive.
2. When the *Setup and Documentation CD* menu appears, click the install button for the BESTCOMS PC Program. The setup utility automatically installs “BESTCOMS for BE1-IPS100” on your PC.

When BESTCOMS installation is complete, a Basler Electric folder is added to the Windows® program menu. This folder is accessed by clicking the Start button and Programs and then Basler Electric. The *Basler Electric* folder contains an icon for the “BESTCOMS for BE1-IPS100” program.

Connecting the PC to the Relay

Remember, you do not have to have a unit connected to the PC to operate BESTCOMS and program settings. If you have an actual unit, connect a communication cable between the front RS-232 communication port on the BE1-IPS100 front panel and an appropriate communication port on the PC.

UPDATING BESTCOMS SOFTWARE

Future enhancements to relay functionality may make firmware update desirable. Enhancements to relay firmware typically coincide with enhancements to BESTCOMS software for that relay. When a relay is updated with the latest version of firmware, the latest version of BESTCOMS should also be obtained.

If you obtained a CD-ROM containing firmware from Basler Electric, then that CD-ROM will also contain the corresponding version of BESTCOMS software. BESTCOMS can also be downloaded from the Basler Electric web site (http://www.basler.com). An outline form can be completed to obtain a password for downloading BESTCOMS from the Basler Electric web site.

STARTING BESTCOMS

Start BESTCOMS

Start BESTCOMS by clicking the *Start* button, *Programs*, *Basler Electric*, and then the *BESTCOMS for BE1-IPS100* icon. At startup, a splash screen with the program title and version number is displayed for a brief time (Figure 14-2). After the splash screen clears, you can see the initial screen - the *System Setup Summary* screen. (This is the same process if you do or do not have a unit connected to your PC.)

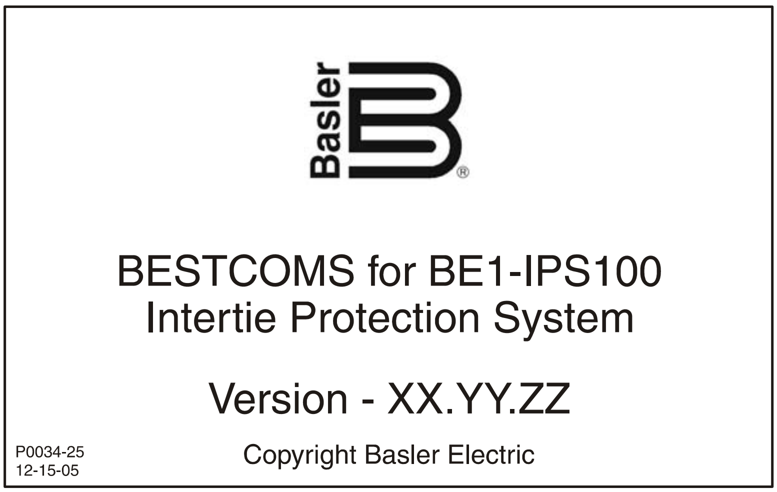
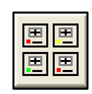


Figure 14-2. BESTCOMS Splash Screen

System Setup Summary Screen



If you are at another BESTCOMS screen such as *Overcurrent Protection* and want to go to this screen, you may use the *Screens* pull-down menu or click on the *System Setup Summary* icon as is shown at the right margin of this paragraph. This screen has two areas or folder tabs (like paper file folder tabs) to the screen (see Figure 14-3). The first tab is *Protection and Control* and the second tab is *Reporting and Alarms*.

This screen gives you an overview of the system setup. When the screen is first displayed, the *Protection and Control* tab is in the foreground and the *Reporting and Alarms* tab is in the background. You may select either of these tabs and bring that tab and information into the foreground.

Protection and Control

Look in the lower, right-hand corner for the legend. This legend provides interpretation for the various indicated colors. Any protection and control function or element may be enabled or disabled and the current state is indicated by the associated color. If the function is enabled, the color is green. If the function is **only** disabled by a setting (such as zero), the color is yellow. If the function is **only** disabled by logic, the color is blue. If the function is disabled by **both** a setting and logic, the color is gray.

If a function has variations such as 27X or 59X, which has three modes (fundamental, three-phase residual and third harmonic) and none of these modes are enabled, a tilde (~) is displayed.

In addition to the functional status, *Group Selection* is displayed and the names are shown for the displayed and active logic and the virtual switches.

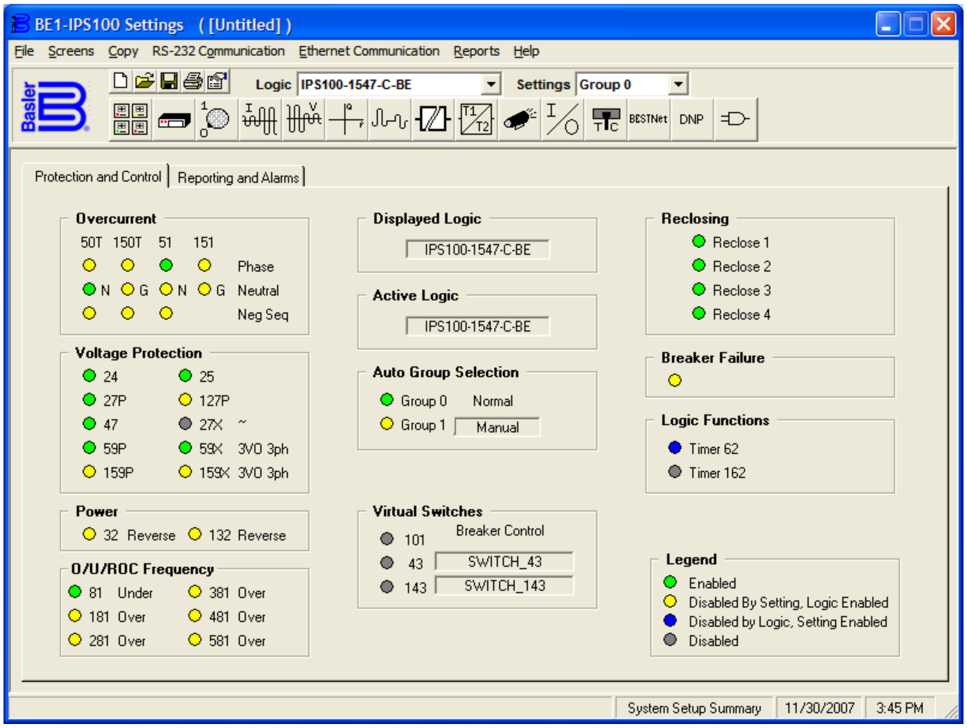


Figure 14-3. System Setup Summary Screen, Protection and Control Tab

Reporting and Alarms

This second tab of the *System Setup Summary* screen (Figure 14-4) provides the remaining summary information for the relay in regard to monitoring, metering, and alarms. Again, a legend for the color-coding of relay status is provided in the lower right side of the screen.

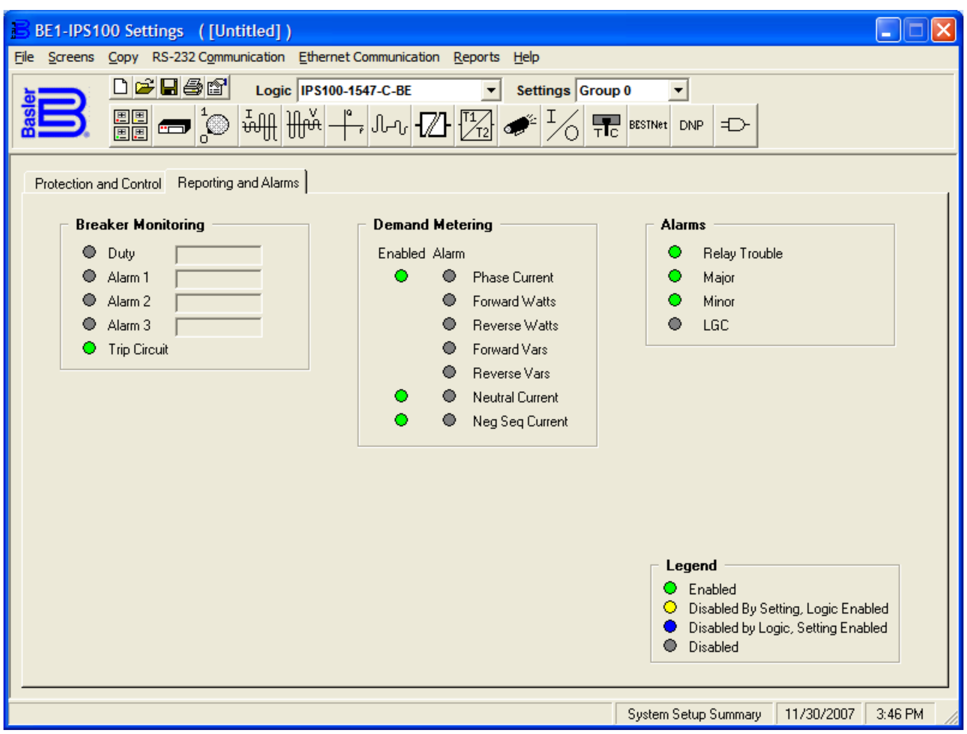


Figure 14-4. System Setup Summary Screen, Reporting and Alarms Tab

CONFIGURING THE PC

If you have an actual BE1-IPS100 relay, configure your PC to match the BE1-IPS100 configuration. To do this, pull down the *Communication* menu in the pull-down menu and select *Configure*. Now, match the communication configuration in the BE1-IPS100 relay. You may select *Terminal (VT100 Emulation)* and go directly to that communication protocol. You must close *Terminal Mode* before you can use BESTCOMS again. If you are comfortable using ASCII commands, the *Terminal Mode* is an easy method for checking the actual settings or status of the relay when you are in doubt about an action to take in BESTCOMS. ASCII commands are available in Section 11, *ASCII Command Interface*.

SETTING THE RELAY

To set the relay, we will discuss the contents of each of the screens for BESTCOMS for the BE1-IPS100. The *System Setup Summary* screen was discussed in previous paragraphs. We begin with the assumption that you have started BESTCOMS, connected the PC to the relay, and configured your PC to the relay. If the default settings are active in your relay, you will have to change the logic to clear the Major alarm or disable the Logic = None Alarm under *Alarm Priority* in *Reporting and Alarms, Alarms*. This section describes BESTCOMS features as they occur and not on a priority (perform this setting first) basis. For information on how to select or name the active logic, see the paragraphs on *BESTlogic.*

Select Logic Scheme for Display

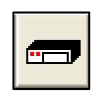
In Figure 14-4, below the pull-down Menu bar, there is a pull-down arrow for the *Logic* window in the Toolbar row. To select a preprogrammed scheme, pull down this menu and click on the desired scheme. When you do, the selected logic name is displayed in the *Logic* window and the *System Setup Summary* screen displays what results would be if that scheme were active. It does not make it the active screen. You select custom and preprogrammed logic schemes using the *BESTlogic* screen. (See additional paragraphs in this section.)

Settings Display and Selection

Immediately to the right of the *Logic* window is a *Settings* window. A pull-down menu is shown and provides for Group 0 or 1 selection. An example of this is the *Overcurrent Protection* screen. Pull down the *Screens* menu and select *Overcurrent Protection*. When you do, the *Settings* window display changes to the *Group* pull-down menu. If you wanted the specific setting change that you were about to make to affect the Group 1 settings, select Group 1.

General Operation Screen

Pull-down the *Screens* menu and select *General Operation* or click on the General Operation icon, which is shown at the right margin of this paragraph. This screen has seven folder tabs. The first tab is *General Information* (Figure 14-5).



General Information

The *General Information* tab allows you to fill in the style number of the relay, which is available from the label on the relay front panel. You can also enter the serial number of the relay and software application version information. Additionally, you may enter the name of the substation and the feeders so that the relay reports have some form of installation-specific identification.

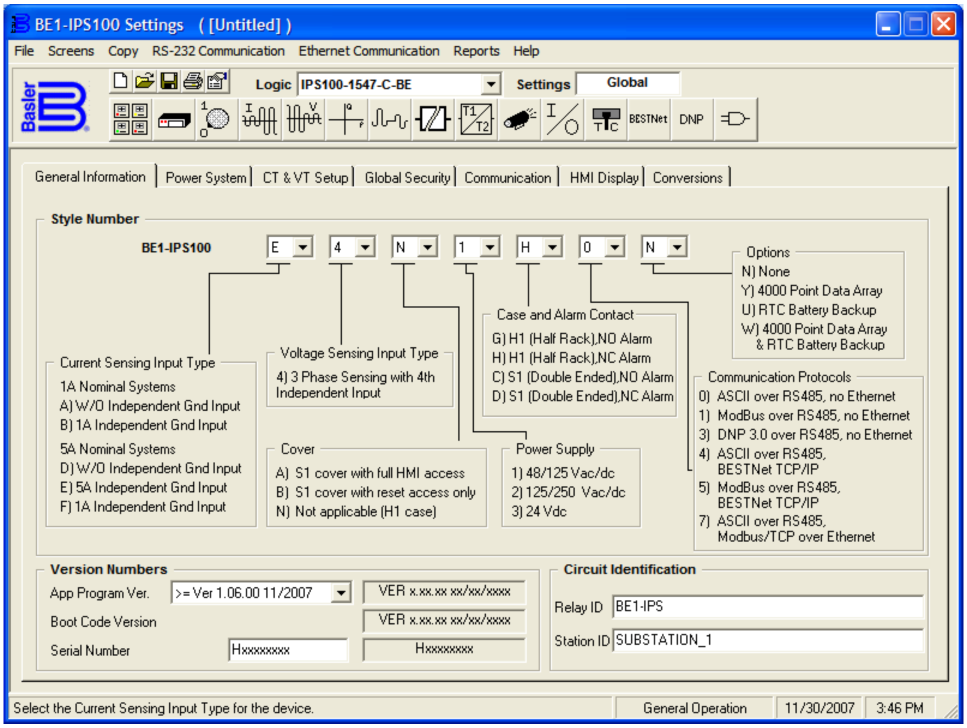


Figure 14-5. General Operation Screen, General Information Tab

Power System

This tab (Figure 14-6) allows you to enter the frequency, phase rotation, nominal CT secondary voltage and current, and power line parameters. If the phase rotation entry is not correct, it will cause problems in several areas including metering values and targets. Power line parameters are necessary for line protection. In other words, you must make entries in these fields in order for the BE1-IPS100 protection elements to function properly. These symmetrical component sequence quantities are entered to provide immediate reference information for settings of the protection elements in the BE1-IPS100 relay. Distance to fault calculation accuracy is also dependent on the power line parameters entered in this screen.

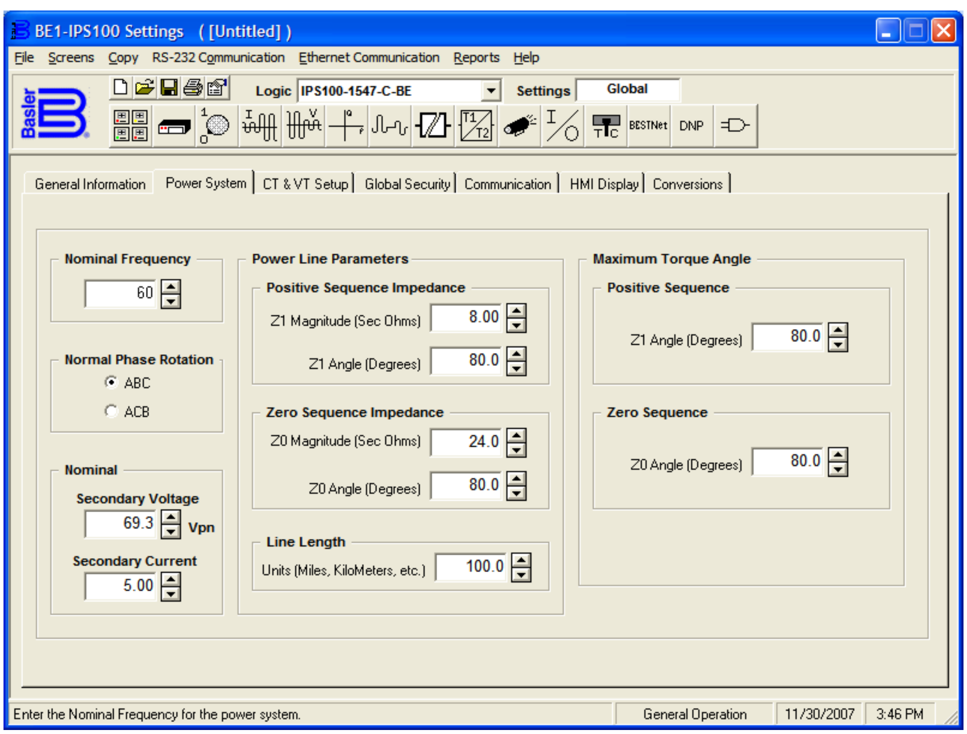


Figure 14-6. General Operation Screen, Power System Tab

CT & VTP Setup

This tab (Figure 14-7) allows you to enter the CT ratios and set up the VT parameters. These entries affect every function that relies on voltage and current measurements and calculations derived from those measurements. Click the up or down arrows to adjust the CT Phase Turns Ratio. Once you enter the CT Ratio, Phase Turns value, the primary amperes value is entered for you. For example, if you entered 240 for the Turns value and the secondary nominal current input is 1, the primary amperes value becomes 240. If you change the secondary nominal current input to 5, the primary amperes value becomes 1,200. The CT Ground Ratio is set in the same manner and again the primary amperes value is automatically set.

The VTP Setup is very similar. You may click once in an entry window and select the entire value entered. If you are making an entry in the window, clicking once locates the cursor in the entry and clicking twice selects the entire value entered. Over- and undervoltage modes can be set to operate on either the phase-to-phase (PP) or phase-to-neutral (PN) quantities. Click on the appropriate button to select the quantity required. Pull down the connection menu and select the appropriate Connection for phase voltage input. Perform these same steps for the VTX Setup if the auxiliary voltage input is valid.

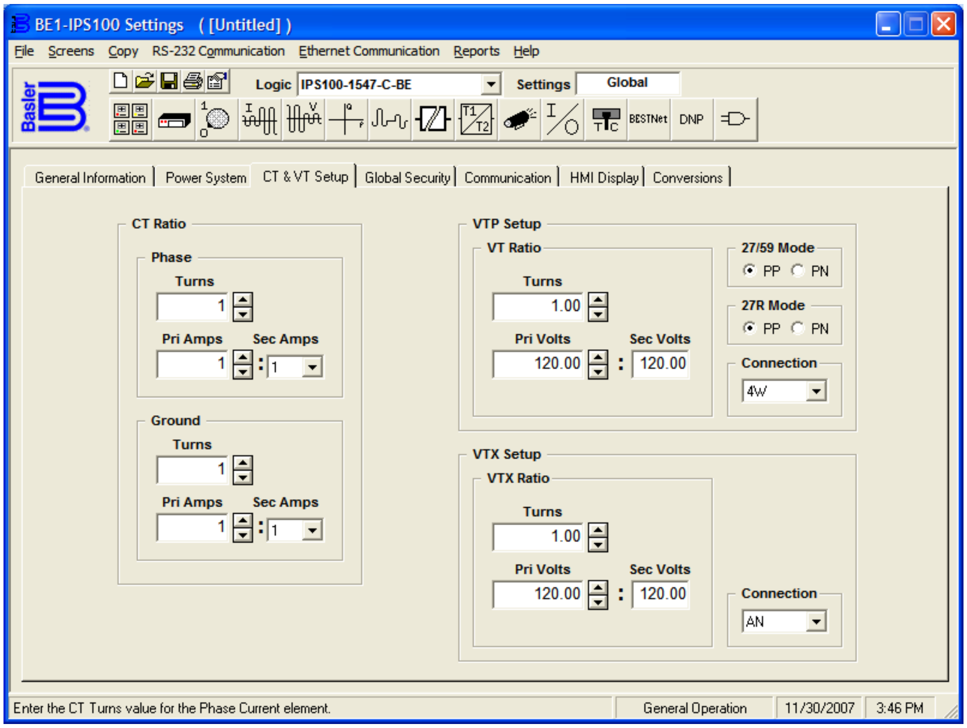


Figure 14-7. General Operation Screen, CT & VT Setup Tab

Global Security

Each of three communication ports and the three functional areas (Settings, Reports, and Control) has password security. See Figure 14-8. This allows the user to customize password protection for any and all ports. For example, you could allow technicians to have global access (sometimes called a fourth level of access) to all three functional areas via the front port. You could also restrict the rear port, which is connected to a modem to read-only access.

If you select *Show Passwords* and the default passwords have not been changed, all four passwords appear and can be changed. If the Global Access password has been changed, a dialog box appears explaining that you must enter the Global Access password to enable viewing and editing the existing passwords. After entering the global password, the passwords and enable boxes appear. You may then make changes in any and all areas. Clicking a box for a specific communication port toggles the functional area for that port either ON or OFF. Notice that the front panel human-machine interface (HMI) and communications port zero are combined and considered as one. **Note:** By default, all modes of access are disabled on the optional rear Ethernet port (COM1). Read access is always enabled.

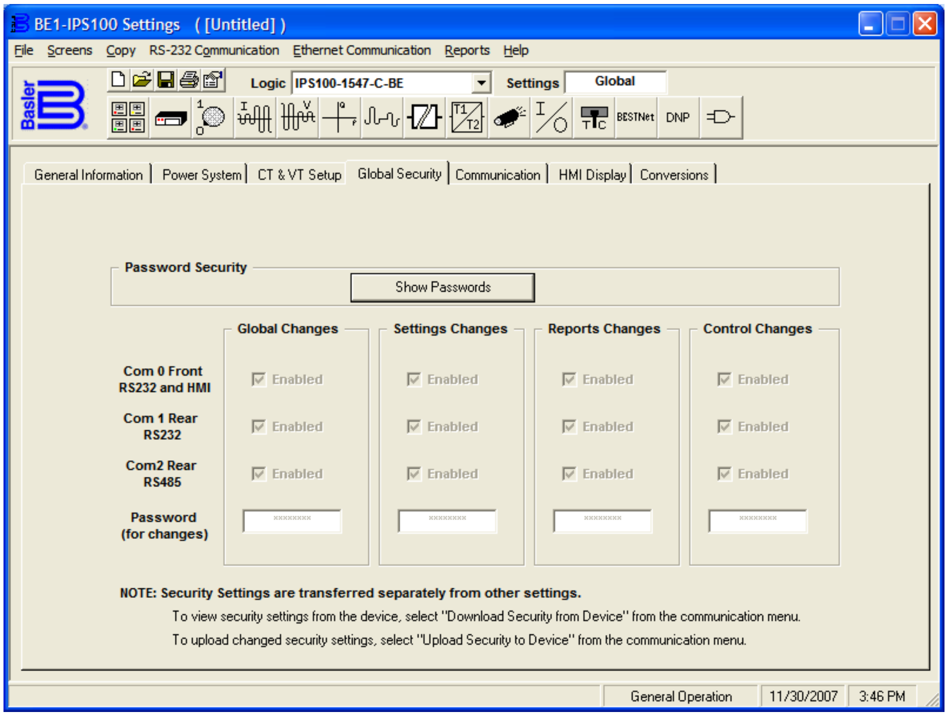


Figure 14-8. General Operation Screen, Global Security Tab

Communication

This tab, Figure 14-9, allows the user to set or change communication port settings. *Baud Rate* has the pull-down menu. *Reply and Handshaking* are either enabled or disabled, and *Page Length* can be stepped up or down one page at a time using the up or down arrow button. *Address* can be stepped up or down to change the address except for *Com Port 0 Front*. This address is always A0 and cannot be changed. If the relay has Modbus™, an additional panel appears on the *General Operation, Communication Screen*. This panel allows the user to select the *Precision Format, Parity, Remote Delay Time,* and *Stop Bits*. For more information on these parameters, see the appropriate Modbus™ instruction manual.

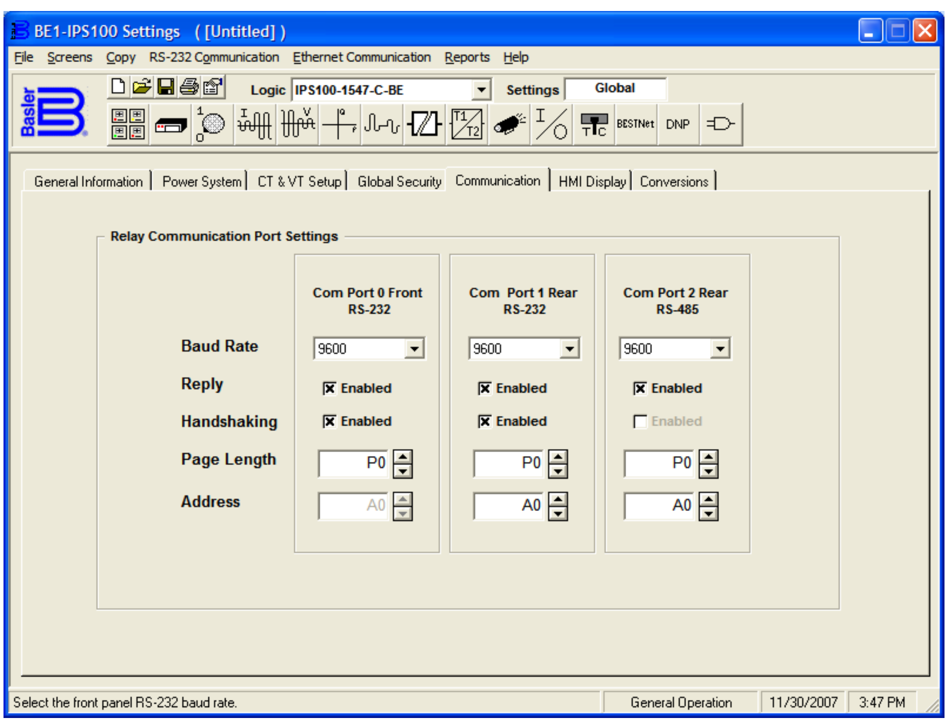


Figure 14-9. General Operation Screen, Communication Tab

HMI Display

This tab (Figure 14-10) allows the user to view what would be shown on the BE1-IPS100's HMI display as the *UP, DOWN, LEFT,* and *RIGHT* push buttons are clicked. These displays are similar to Figures 10-2 through 10-9 in Section 10, Human-Machine Interface. Notice, too, that the corresponding screen number is shown in the right pane. The user is also able to change the screen scroll list from the right pane. Be aware that only the code for the latest version of BESTCOMS is contained within BESTCOMS. If you have an earlier version of the embedded firmware in your relay and select information on the *General Information* tab under *General Operation* screen, you might select a screen scroll item in BESTCOMS that is not available in the relay. If you do, you will immediately get an error code.

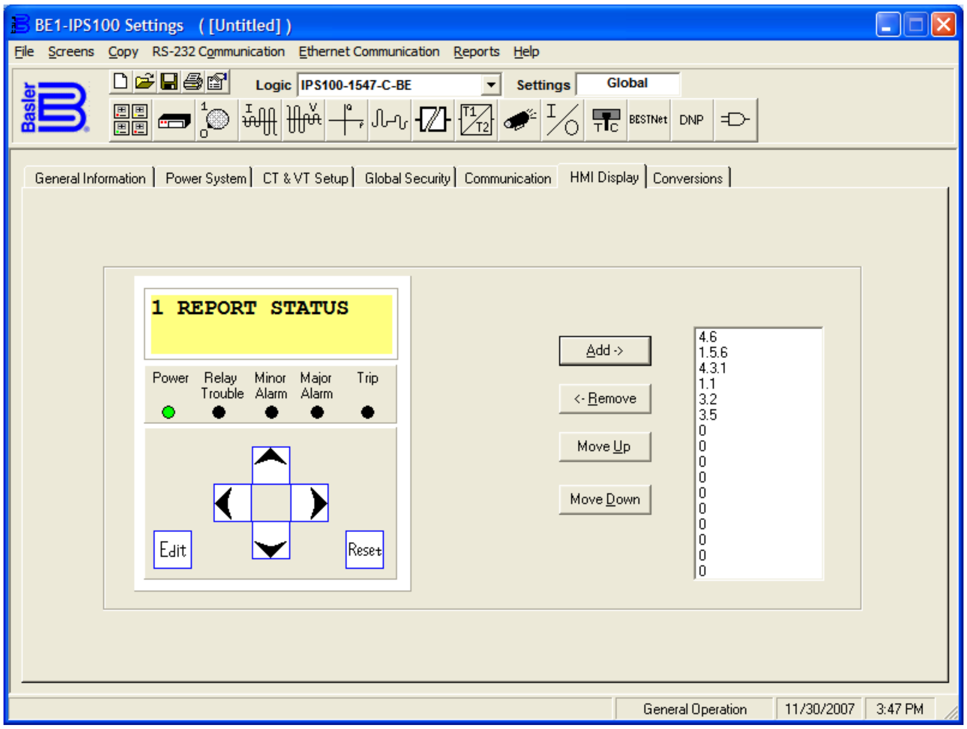


Figure 14-10. General Operation Screen, HMI Display Tab

Conversions

The *Conversions* tab brings up the screen that allows entries in per unit quantities. See Figure 14-11. The per unit conversion for the settings involves entries for the Base quantities. When you are entering settings later on, you can select primary current values, secondary current values, percent, or per unit values. If you are using percent or per unit, then you have to enter the *Conversion* screen field values regarding three-phase, phase-to-phase, and phase-to-neutral base quantities. If the settings are entered in terms of primary or secondary current values, you do not need to enter this information.

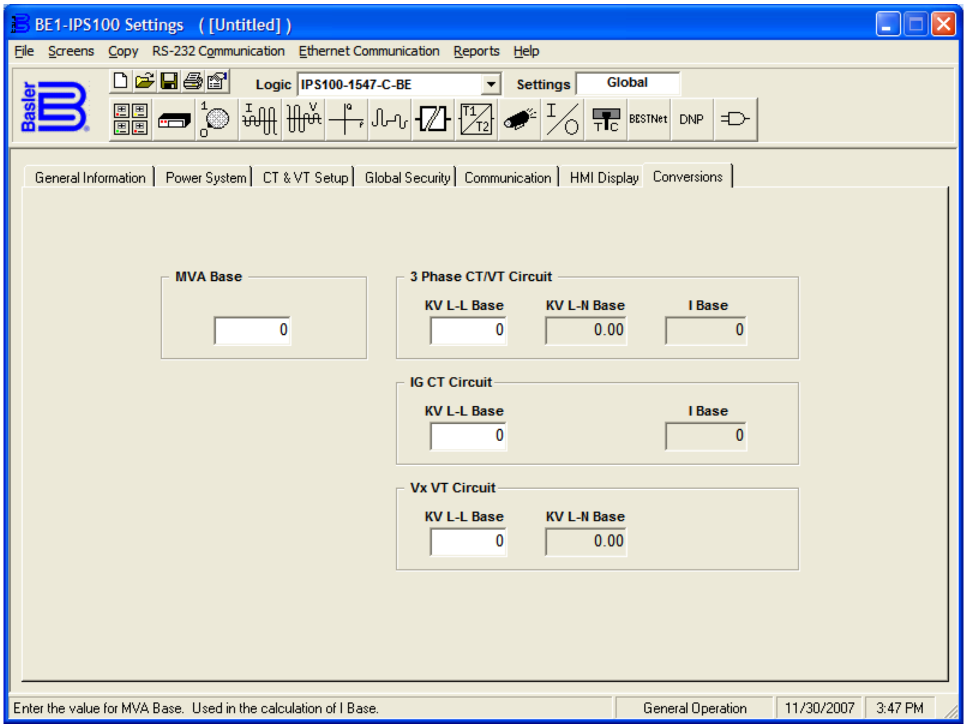
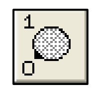


Figure 14-11. General Operation Screen, Conversions Tab

Setting Group Selection

Pull down the *Screens* menu and select *Setting Group Selection* or click on the *Setting Group Selection* icon, which is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *Setting Group Selection* (Figure 14-12).



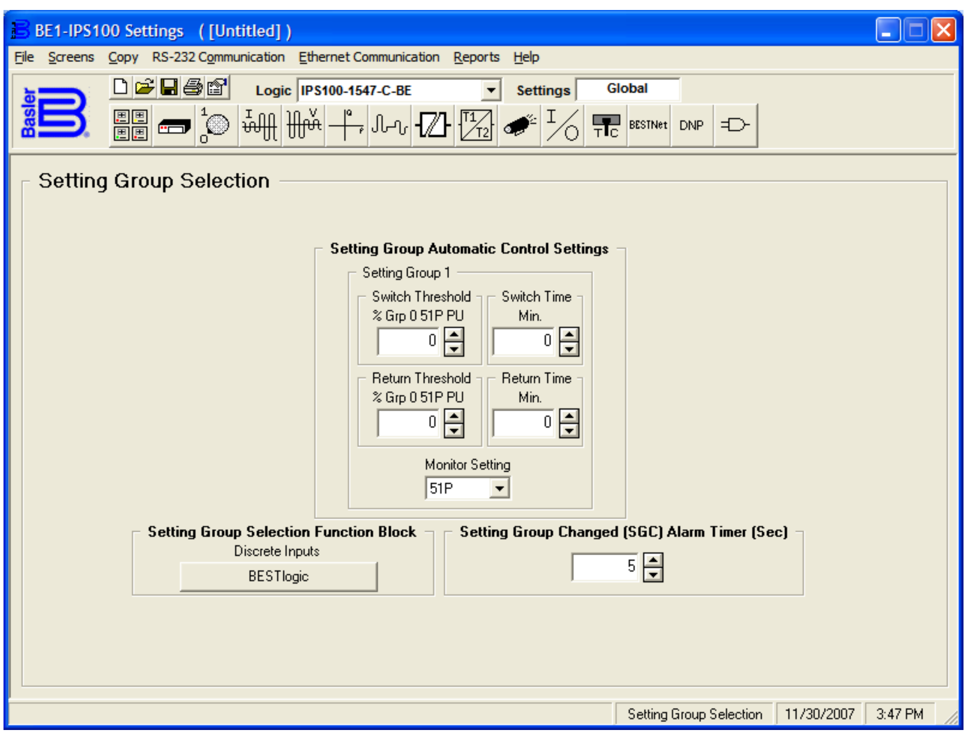


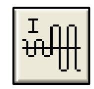
Figure 14-12. Setting Group Selection Screen

Setting group selection involves programming the relay to automatically select one group out of two protective element setting groups in response to system conditions. When the system is normal, the default or normal group is 0. Auxiliary setting groups allow adapting the coordination settings to optimize them for a predictable situation. Sensitivity and time coordination settings can be adjusted to optimize sensitivity or clearing time based upon source conditions or to improve security during overload conditions. In the center of Figure 14-12, there is a *Monitor Setting* window for Group 1. This field allows you to select which element controls that specific group selection. The *Switch Threshold* sets the level for the monitored element and the *Switch Time* sets the time delay (in minutes) to prevent the group change from changing the instant that the monitored element exceeds the *Switch Threshold* setting. *Return Threshold* and *Return Time* does the same thing for changing back to the previous group.

You do not have to depend only on monitored conditions to change the group selection. The active Setting Group can be controlled at any point in time by the setting group control logic. (Refer to Section 4, *Protection and Control*, for more information on setting groups.) The setting group control also has an alarm output variable SGC (Setting Group Changed). This output is asserted whenever the BE1-IPS100 switches from one setting group to another. The alarm bit is asserted for the SGCON time setting. You can click in the *Setting Group Change (SGC) Alarm Timer (Sec)* field and set the SGCON time setting. Or, use the *UP* and *DOWN* arrows to adjust the SGCON time setting.

Overcurrent Protection

Pull down the *Screens* menu and select *Overcurrent Protection* or click on the *Overcurrent Protection* icon, which is shown at the right margin of this paragraph. This screen has five folder tabs and the first tab is *51* (Figure 14-13).



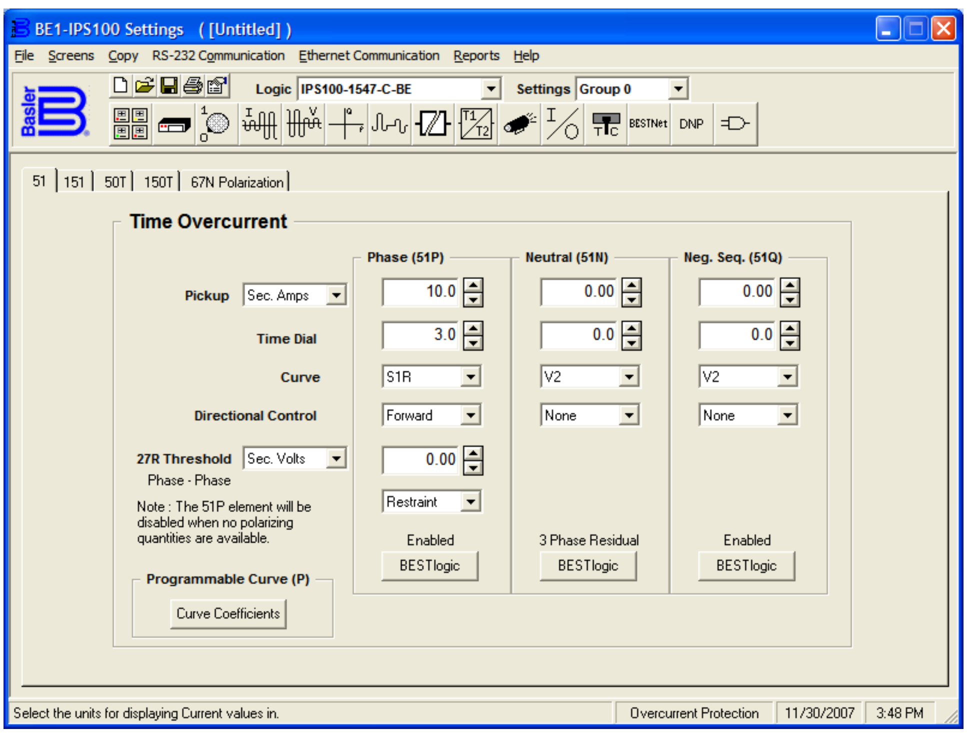


Figure 14-13. Overcurrent Protection Screen, 51 Tab (Time Overcurrent)

<u>*51 and 151 (Time Overcurrent)*</u>

This tab (Figure 14-13) allows you to enter the settings for the time overcurrent elements. BE1-IPS100 relays have five time overcurrent elements (three with the 51 element and two with the 151 element). The pull down *Pickup* menu allows you to select the relative pickup quantity. As the default, BE1-IPS100 relays measure the current input in secondary amperes. If you want to use primary current, per unit or percent amperes, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Settings for *Time Dial*, *Curve* (time characteristic curve), and *Direction Control* are conventional settings. If you want to change the characteristic curve constants, select the *Curve Coefficients* and a dialog box opens for those entries. Select the *BESTlogic* box at the bottom of the *Phase (51P)* column. The status of the logic is shown above the *BESTlogic* box. A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices. The 151 element is adjusted in a similar fashion to the 51 element.

50T and 150T (Instantaneous Overcurrent with Settable Time Delay)

The BE1-IPS100 relay has six instantaneous elements (three with the 50T element and three with the 150T element). See Figure 14-14 for the 50T element. The tabs for the instantaneous elements are almost identical to the *51/151* tabs. The settable time delay is the primary difference. To change the time delay, click the *Time* menu *Down* arrow and select your preferred unit of measure (milliseconds, minutes, or cycles). Then change the time for the appropriate phase, neutral, or negative-sequence element. The 150T element is set in a fashion similar to the 50T element.

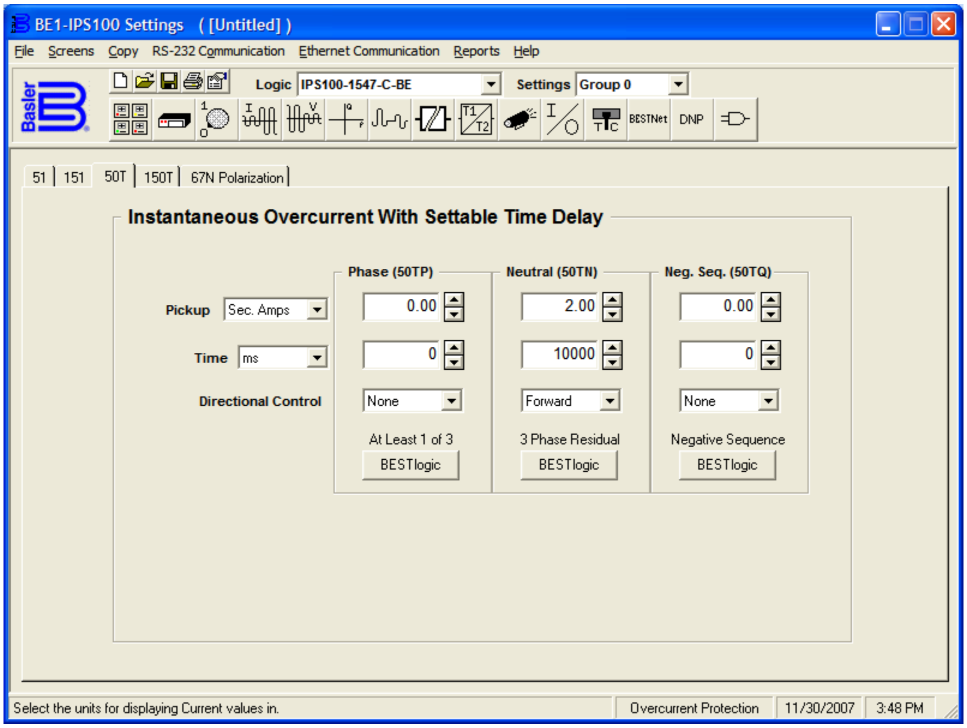


Figure 14-14. Overcurrent Protection Screen, 50T Tab (Instantaneous Overcurrent)

67N Polarization

The methods of polarization, such as Negative-Sequence Polarization (Q) or Zero-Sequence Polarization (V), can be set by using this tab. See Figure 14-15. If Zero-Sequence Polarization is chosen, there are additional settings that may be selected.

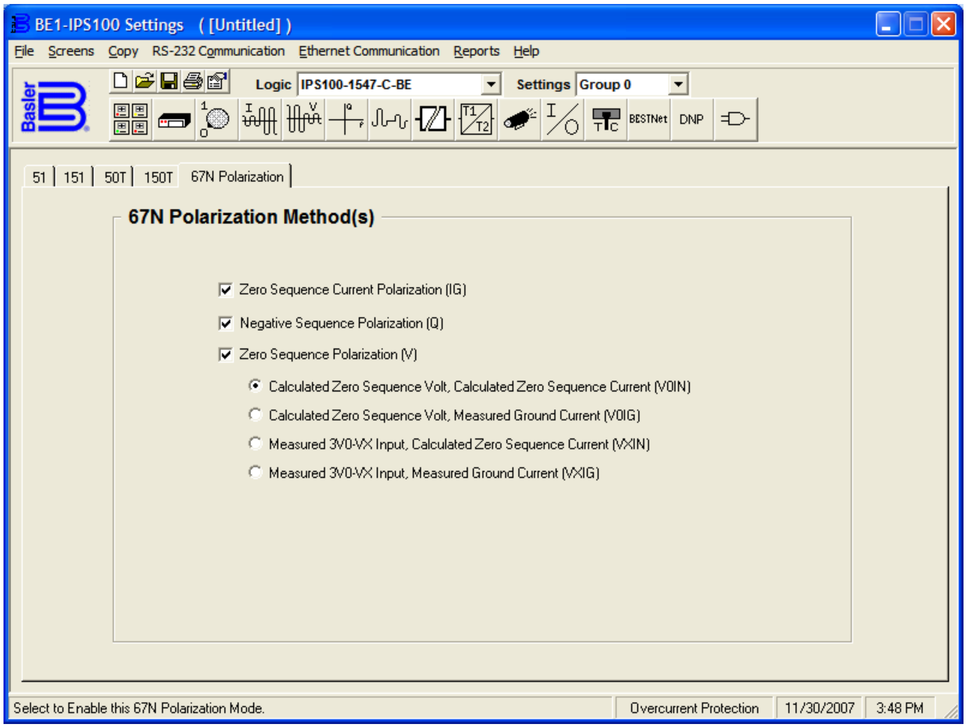
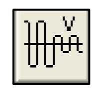


Figure 14-15. Overcurrent Protection Screen, 67N Polarization Tab

Voltage Protection

Pull down the *Screens* menu and select *Voltage Protection* or click on the *Voltage Protection* icon, which is shown at the right margin of this paragraph. This screen has nine folder tabs and the first tab is *24* (Overexcitation) (see Figure 14-16). Many of the settings for voltage protection are identical or similar to those settings in overcurrent protection. These settings explanations are not repeated.



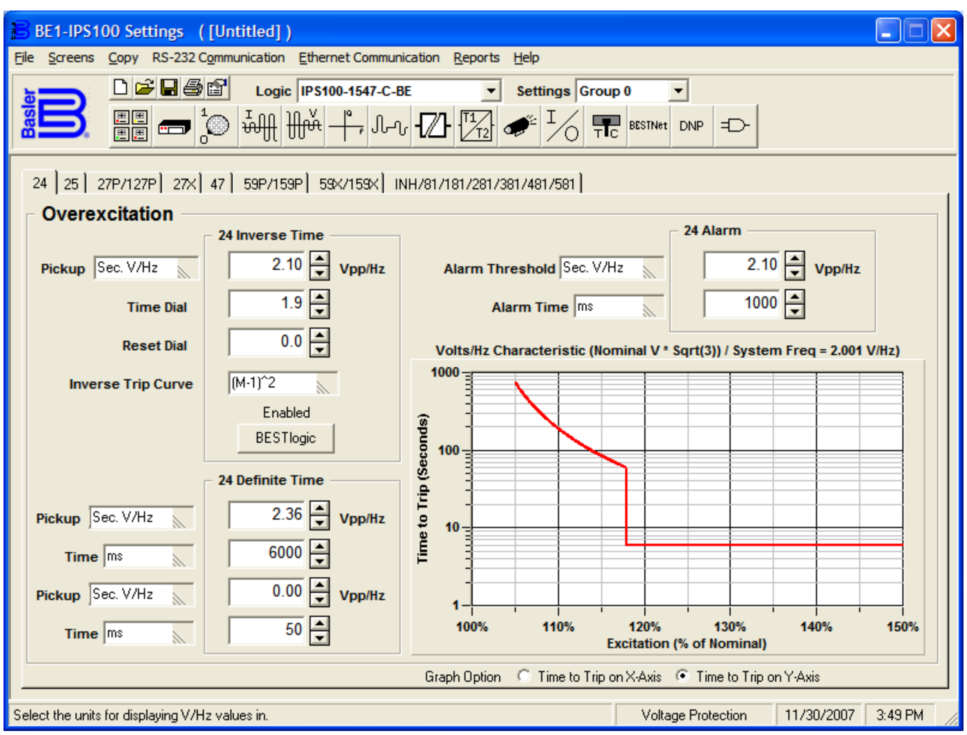


Figure 14-16. Voltage Protection Screen, 24 Tab (Overexcitation)

24 (Overexcitation)

This tab (Figure 14-16) allows you to make the settings for the volts/hertz element. The pull down *Pickup* menu allows you to select the relative pickup quantity. The BE1-IPS100 relay measures the voltage input in secondary voltage. If you want to use primary volts, per unit volts or percent volts, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Whatever the measurement, the method is displayed besides the settings e.g., V_{PP} (voltage, phase-to-phase). Settings for trip *Time Dial* and *Reset Dial* can be adjusted. The *Alarm Threshold* (percent of pickup) can also be adjusted.

Select the *BESTlogic* box at the bottom of the *24 Inverse Time* column. The status of the logic is shown above the *BESTlogic* box. A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices.

25 (Sync-Check)

This tab (Figure 14-17) allows you to make the settings for the sync-check monitor element. The pull down *Delta Voltage* menu allows you to select the relative pickup quantity. The BE1-IPS100 relay measures the voltage input in secondary voltage. If you want to use primary volts, per unit volts, or percent volts, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Whatever the measurement, the method is displayed besides the settings, e.g., V_{PN} (voltage, phase-to-neutral). Settings for *Delta Angle* (Degrees) and *Slip Frequency* (Hertz) are conventional settings. If you want the 25 phase input frequency to be greater than the auxiliary input frequency during sync-check, click the *Enable* box on the screen.

Set the 25VM *Live* and *Dead* threshold levels. Set the *Dropout Delay* (time delay between sensing dropout and clearing VM1 logic bit) unit of measure and value. Select the 25VM Logic that will set the VM1 logic bits.

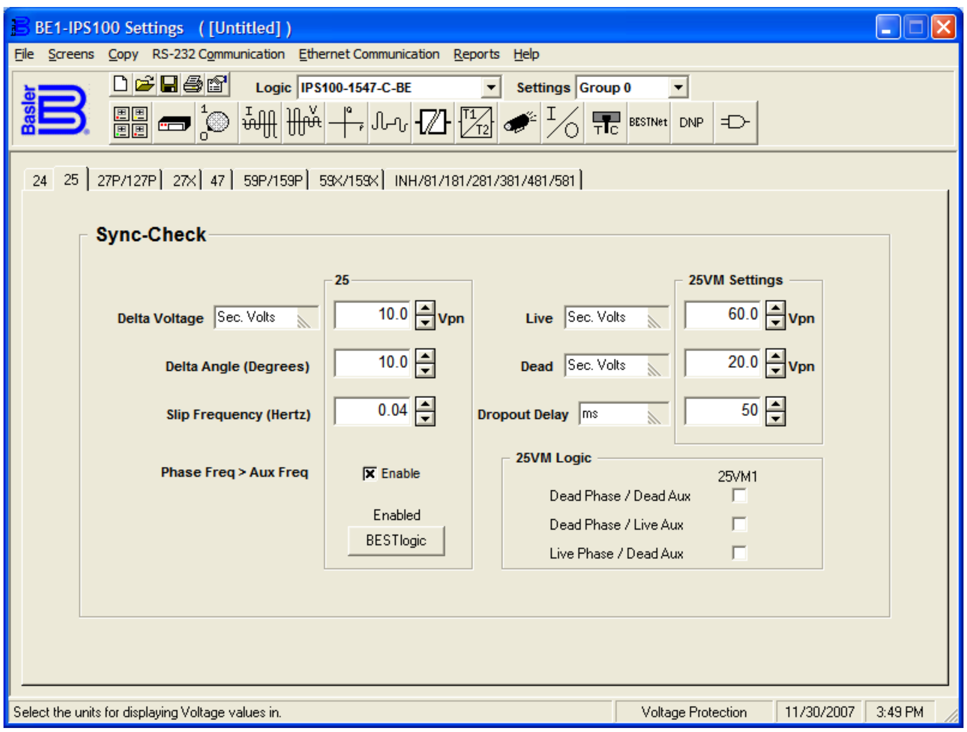


Figure 14-17. Voltage Protection Screen, 25 Tab (Sync-Check)

27P/127P (Phase Undervoltage)

This tab (Figure 14-18) is the *Phase Undervoltage with Settable Time Delay*. The pull down *Pickup* menu allows you to select the relative pickup quantity. The BE1-IPS100 relay measures the voltage input in secondary voltage. If you want to use primary volts, per unit volts or percent volts, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Whatever the measurement, the method is displayed besides the settings, e.g., V_{PP} (voltage, phase-to-phase). Select the Time delay unit of measure and the value for the 27P and 127P elements. Select the *BESTlogic* box at the bottom of the Phase (27P) or

Phase (127P) columns. The status of the logic is shown above the *BESTlogic* box. A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices.

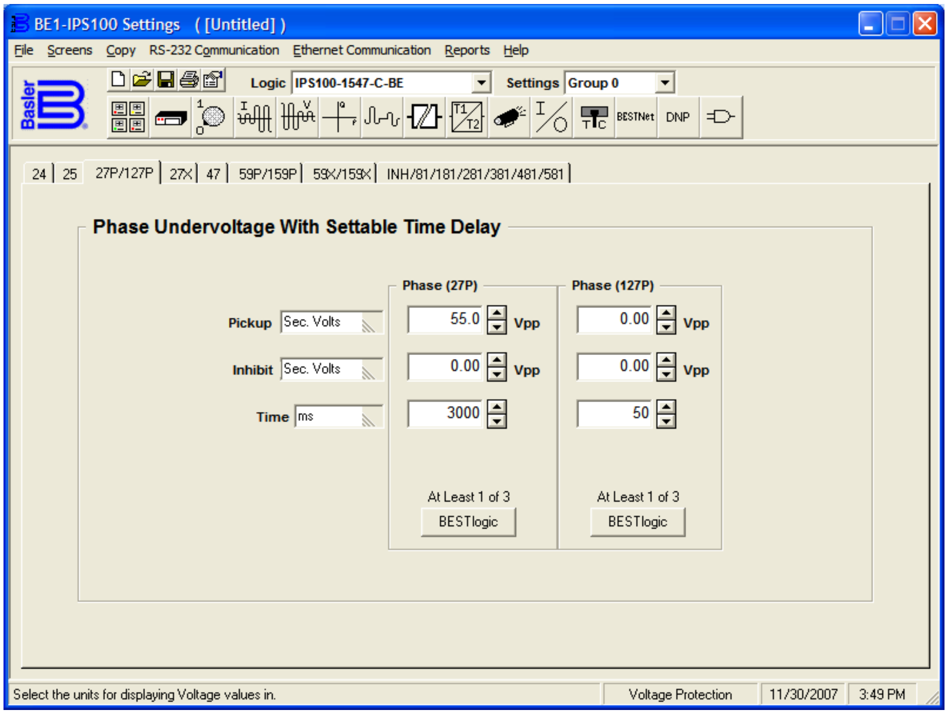


Figure 14-18. Voltage Protection Screen, 27P/127P Tab (Phase Undervoltage)

27X (Auxiliary Undervoltage)

This tab (Figure 14-19) is the *Auxiliary Undervoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those of the 27P/127P elements above.

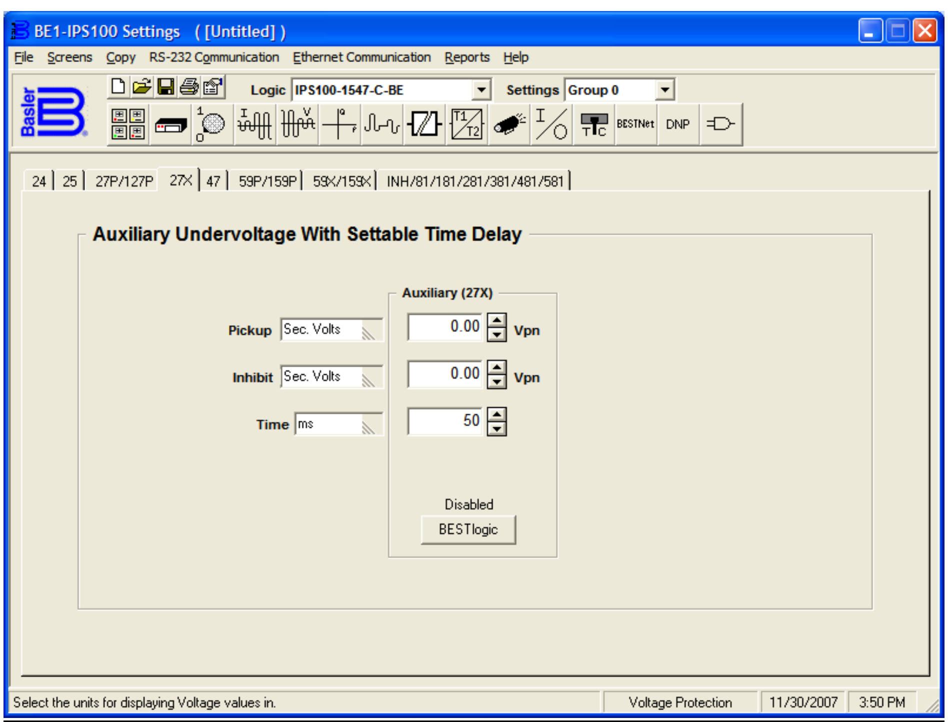


Figure 14-19. Voltage Protection Screen, 27X Tab (Auxiliary Undervoltage)

47 (Neg.-Seq. Overvoltage)

This tab (Figure 14-20) is the *Negative-Sequence Overvoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those of the 27P/127P elements above.

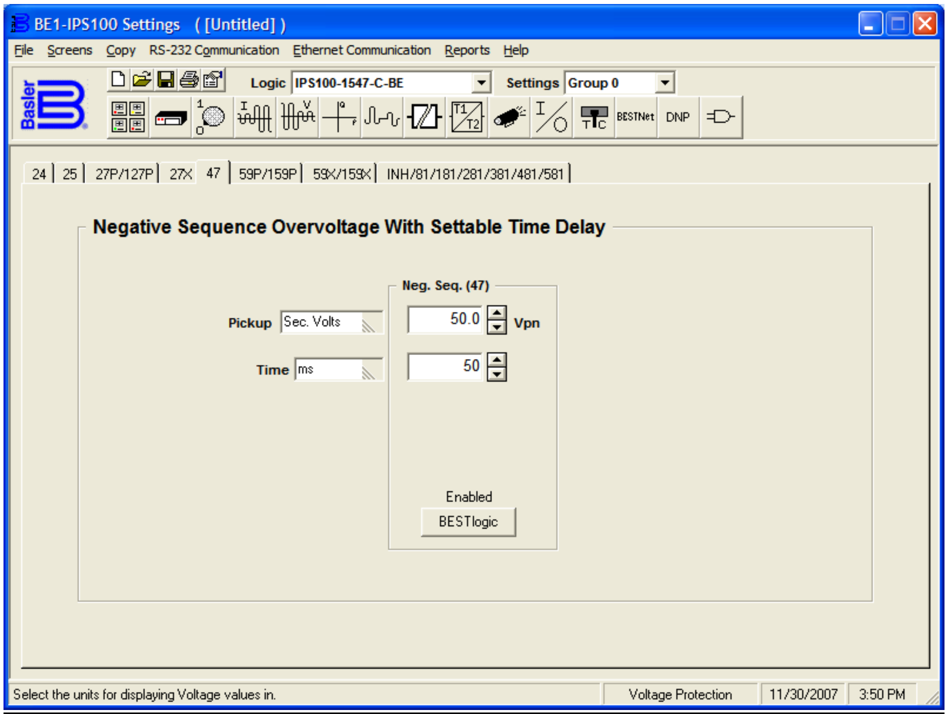


Figure 14-20. Voltage Protection Screen, 47 Tab (Neg.-Seq. Overvoltage)

59P/159P (Phase Overvoltage)

This tab (Figure 14-21) is the *Phase Overvoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those settings of the 27P/127P elements above.

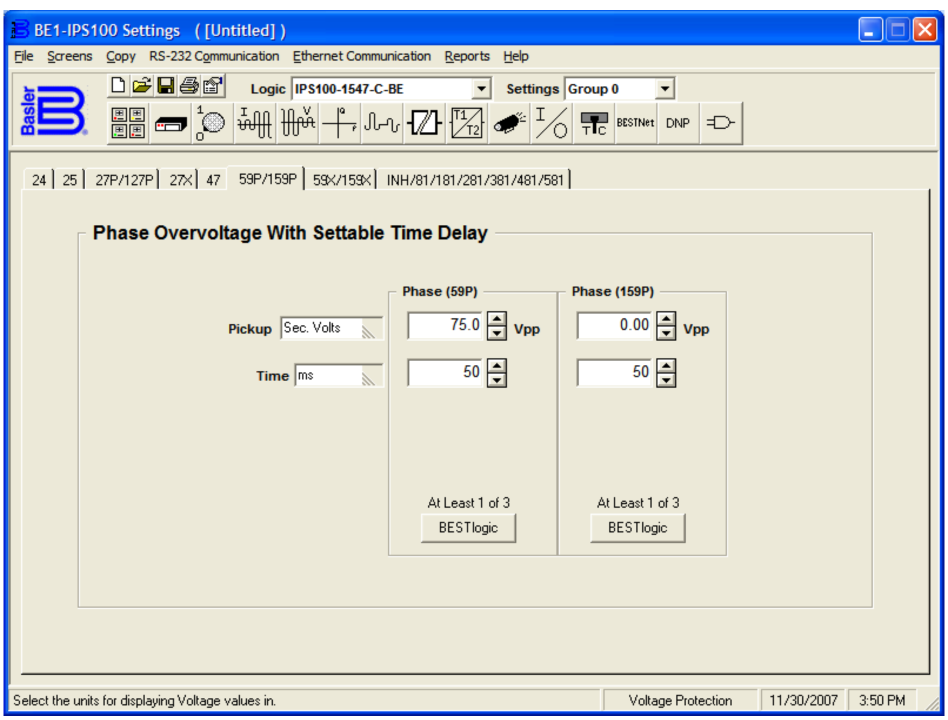


Figure 14-21. Voltage Protection Screen, 59P/159P Tab (Phase Overvoltage)

59X/159X (Auxiliary Overvoltage)

This tab (Figure 14-22) is the *Auxiliary Overvoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those settings of the 27P/127P elements above.

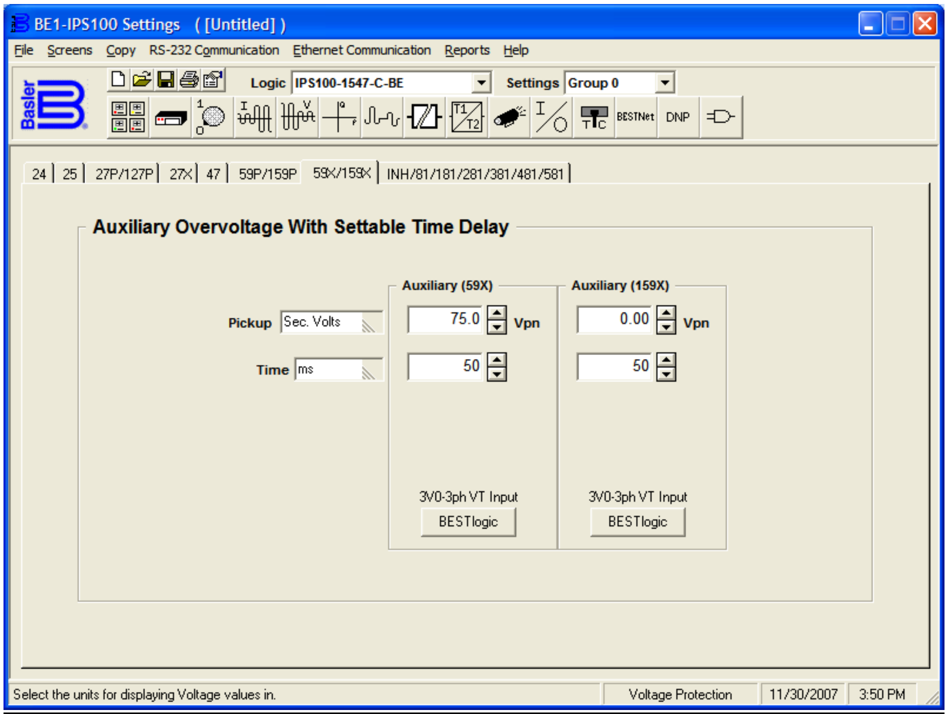


Figure 14-22. Voltage Protection Screen, 59X/159X Tab (Auxiliary Overvoltage)

INH/81/181/281/381/481/581 (Over/Under Frequency)

This tab (Figure 14-23) is the *O/U (over/under)/Rate of Change (ROC) Frequency with Settable Time Delay*. Changing the settings for these elements are identical or similar to those settings of the 27P/127P elements above.

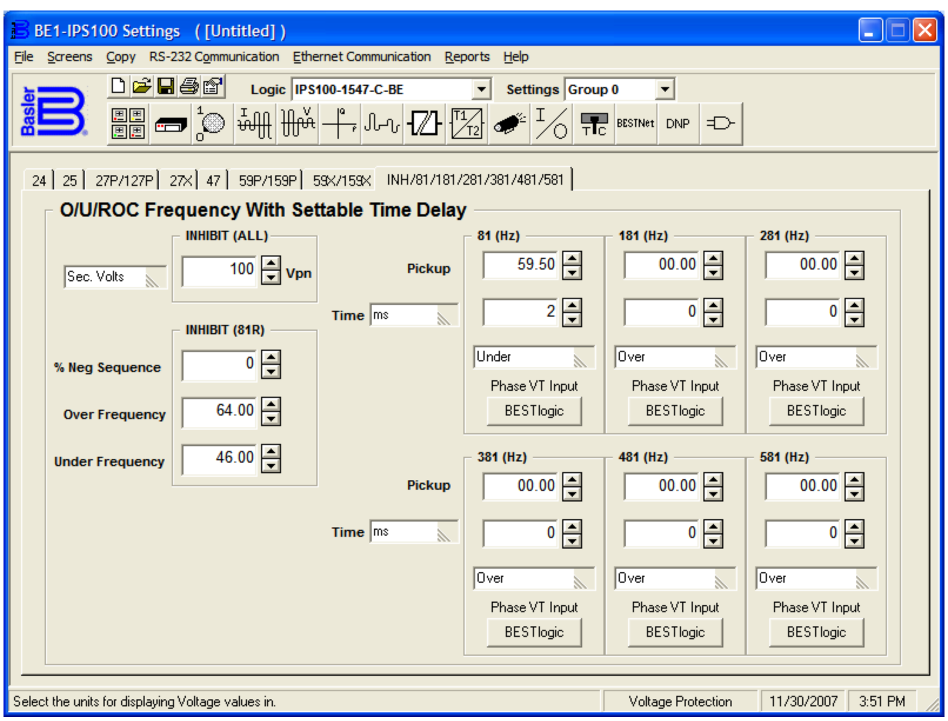
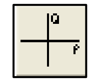


Figure 14-23. Voltage Protection Screen, INH/81/181/281/381/481/581 Tab (Over/Under Frequency)

Power Protection (Directional Power)



Pull down the *Screens* menu and select *Power Protection* or click on *the Power Protection* icon, which is shown at the right margin of this paragraph. This screen (Figure 14-24) has no folder tabs and is labeled *Directional Power*. The pull down pickup menu allows you to select the relative pickup quantity. The BE1-IPS100 relay measures directional power input in secondary three-phase current. If you want to use primary three phase watts, per unit three phase watts or percent three phase watts, you must select it and coordinate the settings in *CT & VT Setup* and *Conversions.* Select the Time delay unit of measure (milliseconds, seconds, or minutes) and set the value for the 32 and 132 elements. If *Cycles* is selected, the range is from 3.00 to 36,000.00 cycles. Click the arrow near *Direction* to obtain a menu for choosing *Forward* or *Reverse*.

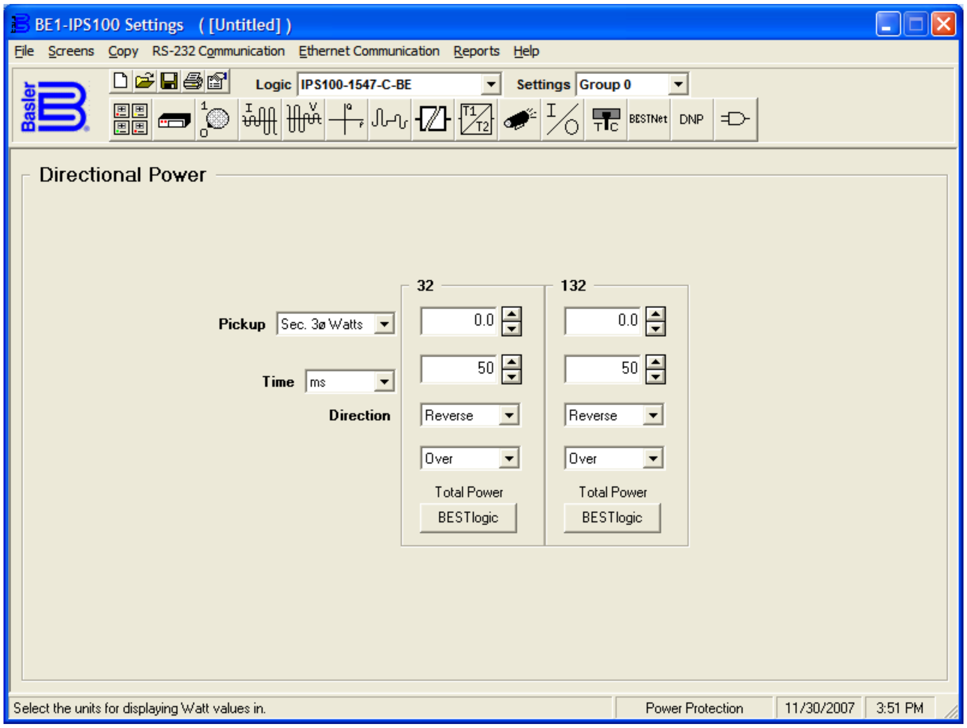
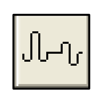


Figure 14-24. Power Protection (Directional Power) Screen

Select the *BESTlogic* box at the bottom of the 32 or 132 columns. The status of the logic is shown above the *BESTlogic* box. A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices.

Reclosing



Pull down the *Screens* menu and select *Reclosing* or click on the *Reclosing* icon, which is shown at the right margin of this paragraph. This screen (Figure 14-25) has no folder tabs and is labeled *Reclosing*.

The reclosing function provides up to four reclosing attempts that can be initiated by a protective trip or by one of the contact sensing inputs. To set the actual reclose sequence, first pull down the *Time Units* menu box and set the units (milliseconds, seconds, minutes, or cycles) for time measurement. Notice that when the Reclose 1 Time setting is zero, the Sequence Controlled Block (SCB), Trip 1 is grayed out. Set the Reclose 1 Time for the first reclose time (other than zero) and the SCB window is now available. After entering a value, proceed to enter the reclose times for the remaining three reclose attempts. The total time for all reclose attempts is cumulative. For example, the second reclose attempt is the sum of Reclose 1 Time and Reclose 2 Time. Reclose three total time would be the sum of the reclose time for three, two, and one. If you want to block the instantaneous or any other protection element during reclose, check the *Sequence Controlled Block* window or windows. If the 79C or 52 status is TRUE, and the SCB is enabled (checked) for the next reclose attempt, the 79 SCB output becomes TRUE and the output logic can be used to block the instantaneous element.

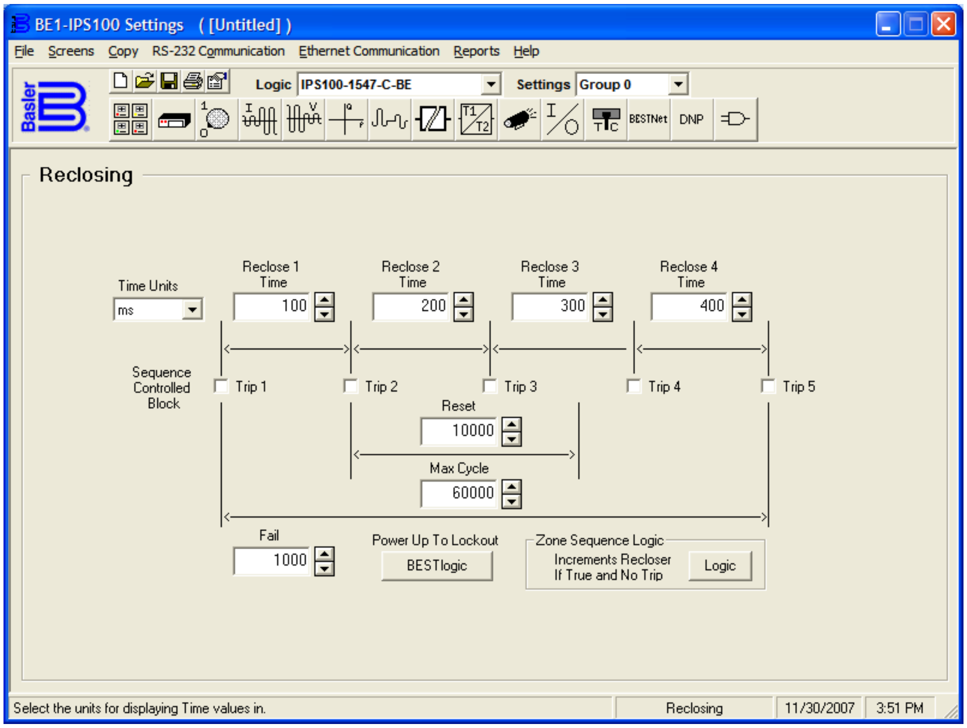


Figure 14-25. Reclosing Screen

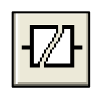
Set the Reset time using the same unit of measure that was used for the reclosing attempts. Reset time is how long you want the relay to remain reset before the relay returns to the initial state. Its range is from 0.100 to 600 seconds.

Set the maximum cycle time. Maximum cycle (Max Cycle) time limits the duration of a reclosing sequence as determined from sequence initiation to automatic relay reset or lockout. Its range is also 0.100 to 600 seconds.

Logic settings for the 79 reclosing function can be made by clicking on the *BESTlogic* button. With your custom logic selected, select the mode and other input logic by using the *Mode* pull-down menu and click on the logic inputs to set the logic.

To set the zone-sequence coordination, click on the *Zone Sequence Logic* button. When the *Reclosing* dialog box opens, click on the logic diagram and set the logic.

Breaker Failure



Pull down the *Screens* menu and select *Breaker Failure* or click on the *Breaker Failure* icon, which is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *Breaker Failure* (see Figure 14-26). The breaker failure function includes a timer and a current detector. The unit of measurement can be set for milliseconds, seconds, or minutes. The acceptable range is 0.050 to 0.999 seconds. The timer can also be set for cycles. If used, the acceptable range is from 3.00 to 59.94 cycles.

Logic settings for the breaker failure function can be made by clicking on the *BESTlogic* button. With your custom logic selected, select the mode and other input logic by using the *Mode* pull-down menu and click on the logic inputs to set the logic.

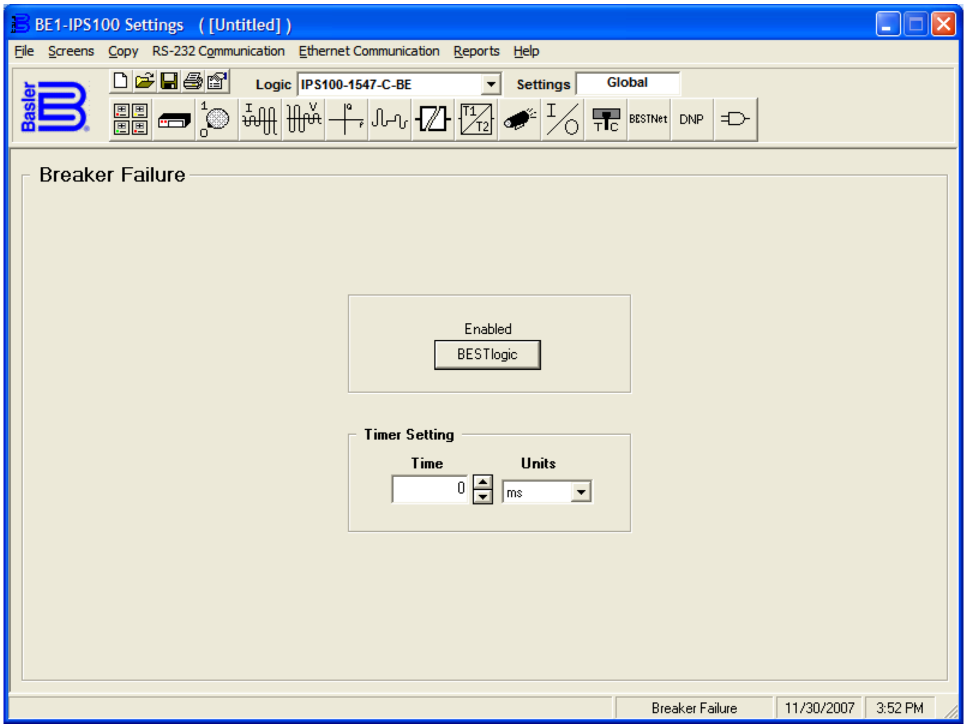
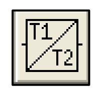


Figure 14-26. Breaker Failure Screen

Logic Timers



Pull down the *Screens* menu and select *Logic Timers* or click on the *Logic Timers* icon, which is shown at the right margin of this paragraph. This screen has no folder tabs and the screen is labeled *Logic Timers* (see Figure 14-27).

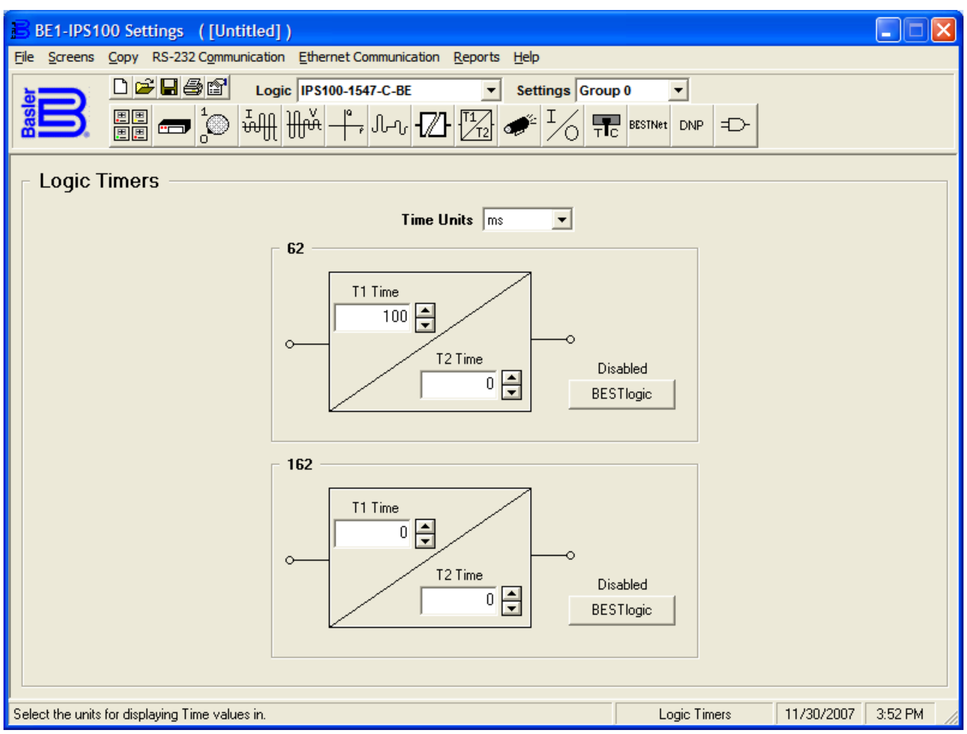


Figure 14-27. Logic Timers Screen

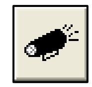
62/162 (Logic Timers)

Logic timers, 62 and 162, are general-purpose timers with six operating modes. Each operating mode has a T1 and T2 setting. The function of these settings depends on the type of timer (mode) selected. For a description of the setting functions, see Section 4, *Protection and Control, General Purpose Logic Timers*.

The unit of measurement can be set for milliseconds, seconds, or minutes. The acceptable range is 0.00 to 9,999 seconds. The timer can also be set for cycles. If used, the acceptable range is from 0.00 to 599,940 cycles.

Logic settings for the logic timers can be made by clicking on the *BESTlogic* button and with your custom logic selected, use the *Mode* pull-down menu and select one of the six timer modes or disable the logic timers. Select other input logic by clicking on the logic inputs to set the logic.

Reporting and Alarms



Pull down the *Screens* menu and select *Reporting and Alarms* or click on the *Reporting and Alarms* icon, which is shown at the right margin of this paragraph. This screen has six folder tabs and the first tab is *Clock Display Mode* (Figure 14-28).

Clock Display Mode

Use the *Time Format* and *Date Format* pull-down menus to set the current time and date in the preferred format. See Figure 14-28. Daylight savings time can be automatically adjusted if the appropriate check box is checked. Likewise, select the preferred method for displaying month, date, and year from the two choices provided.

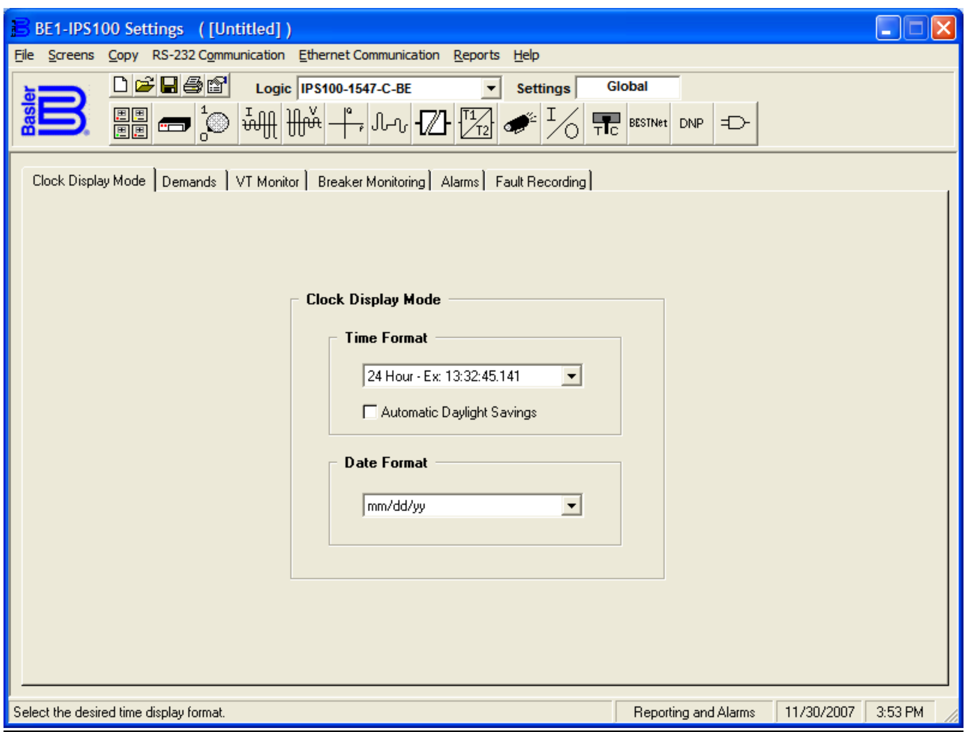


Figure 14-28. Reporting and Alarms Screen, Clock Display Mode Tab

Demands

Demand intervals can be set independently for the phase, neutral, and negative-sequence demand calculations. See Figure 14-29. Click in the phase, neutral, or negative-sequence field and enter the time or adjust the time by using the appropriate up or down arrow buttons. Use the pull-down menus to set the unit of measure for each threshold setting. The demand value is shown in each field as the data is metered.

Load profile is an optional function and is not available on some units. This option uses a 4,000-point data array for data storage. At the *Load Profile Logging Interval (Minutes)*, the data in the demand calculation registers is copied and stored in the data array. The period of time required to generate 4,000 entries is shown in the *Logging Period (Days)* field. To set the *Logging Interval (Minutes)*, click in the field and enter the time or adjust the time by using the appropriate up or down arrow buttons.

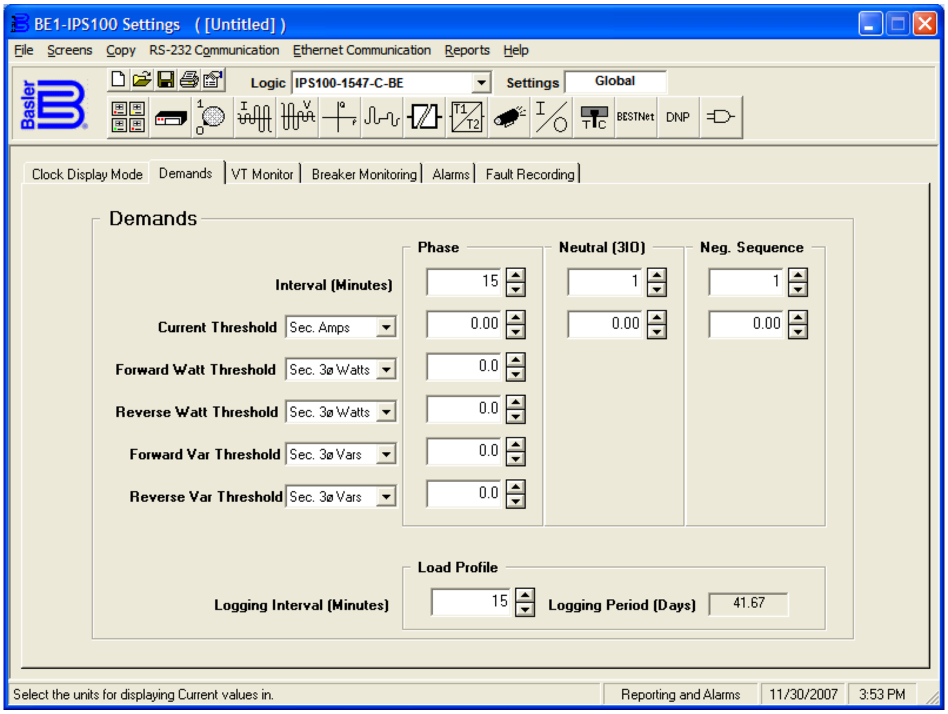


Figure 14-29. Reporting and Alarms Screen, Demands Tab

<u>*VT Monitor*</u>

Fuse loss block logic can prevent mis-operation on loss of sensing voltage. See Figure 14-30. This can be applied on both the 51/27R (voltage control and restraint) and 27/59 functions.

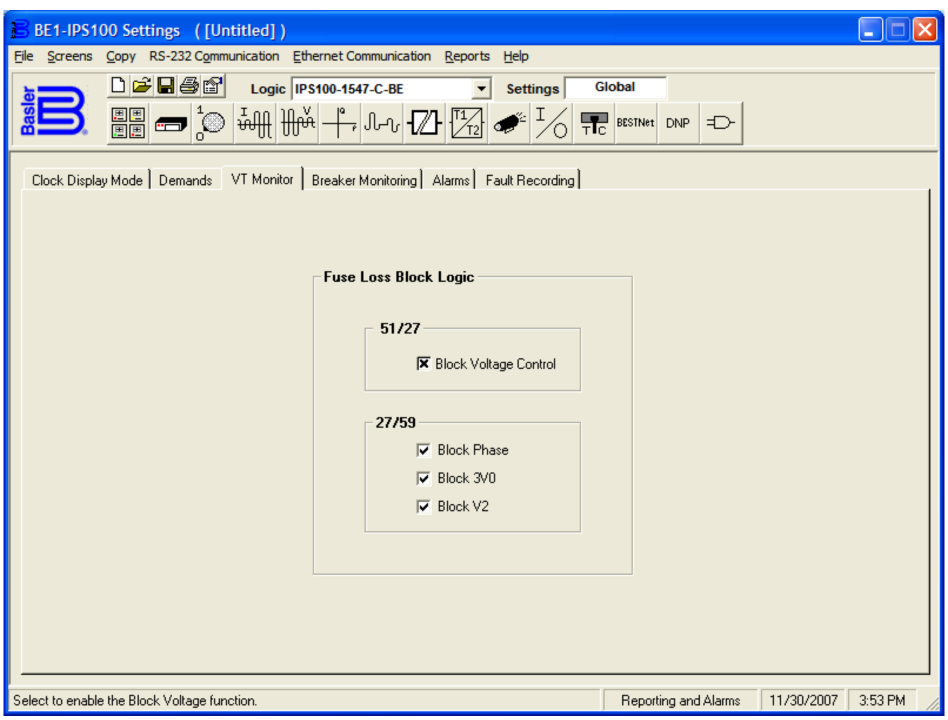


Figure 14-30. Reporting and Alarms Screen, VT Monitor Tab

When the 51/27R function is set for control and a 60FL condition is detected, the phase overcurrent elements will be disabled if you place an x in the *51/27 Block Voltage Control* field by clicking in the field. If the 51/27R function is set for restraint and a 60FL condition is detected, the phase overcurrent elements will remain enabled and the pickup setting is not adjusted from 100% of the setting.

If the *27/59, Block Phase* is enabled with a check mark in the field and a 60FL condition is detected, all functions that use the phase voltage are blocked. If the *27/59, Block 3V0* is enabled with a check mark in the field and a 60FL condition is detected, all functions that use the auxiliary over/undervoltage (27X/59X) functions with Mode 2 selected are blocked. If the *27/59, Block V2* is enabled with a check mark in the field and a 60FL condition is detected, all functions that use the negative-sequence voltage are blocked.

Breaker Monitoring

Each time the breaker trips, the breaker duty monitor updates two sets of registers for each pole of the breaker. See Figure 14-31. This function selects which of the two sets of duty registers are reported and monitored, sets the existing values and programs the function logic.

Use the *Breaker Duty Monitoring* pull-down menu to select the operating *Mode*. Click in the field for *100% Duty Maximum* and set the value. Logic settings for the *Block Accumulation Logic* can be made by clicking on the logic button and, with your custom logic selected, selecting the block accumulation logic.

Because the relay is completely programmable, it is necessary to program which logic variable monitors breaker status (how the relay knows when the breaker is closed). Set the *Breaker Status Logic* by clicking on the logic button and, with your custom logic selected, selecting the control logic.

Three breaker alarm points are programmable for checking breaker monitoring functions. Each alarm point can be programmed to monitor any of the three breaker monitoring functions or all three alarm points can be programmed to monitor one function and alarm at various threshold levels. Use the pull-down menu for *Point 1* and select the preferred breaker monitoring mode (*Disabled, Operations*, or *Clearing Time*). With the *Mode* set, the *Threshold* field is viable and has a zero threshold. Use the keyboard to enter the threshold value or the appropriate (*UP* or *DOWN*) arrow buttons. Repeat the procedure for *Breaker Alarm Points 2* and *3*.

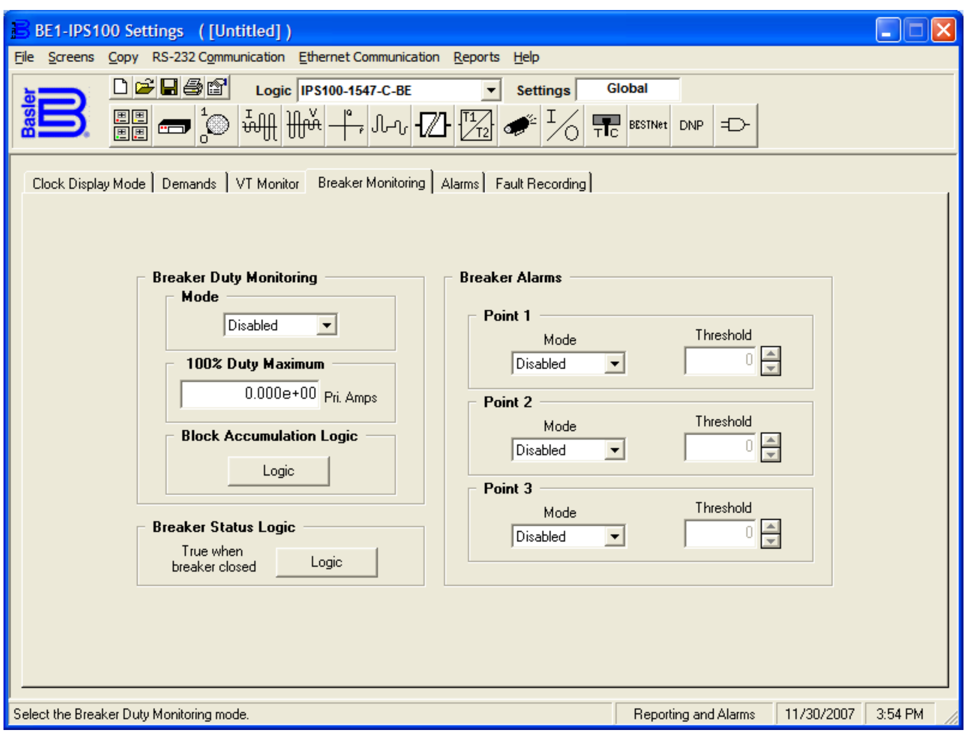


Figure 14-31. Reporting and Alarms Screen, Breaker Monitoring Tab

Alarms

BE1-IPS100 relays have 33 programmable alarm points. See Figure 14-32. These points are for the monitored power system, associated equipment and non-core circuits, and functions in the relay. Each of these alarm points can be programmed to assert the Major, Minor, or Logic Alarms when an alarm point is activated. To program an alarm point, find the point in the *Alarm Priority* list and then click on the appropriate field under the Major, Minor, or Logic Alarm.

Logic settings for the *Alarm Reset Logic* can be made by clicking on the *BESTlogic* logic button and then clicking on the reset input. Other logic blocks shown under BESTlogic on the *Alarms* tab are shown for reference only. There is no interaction available.

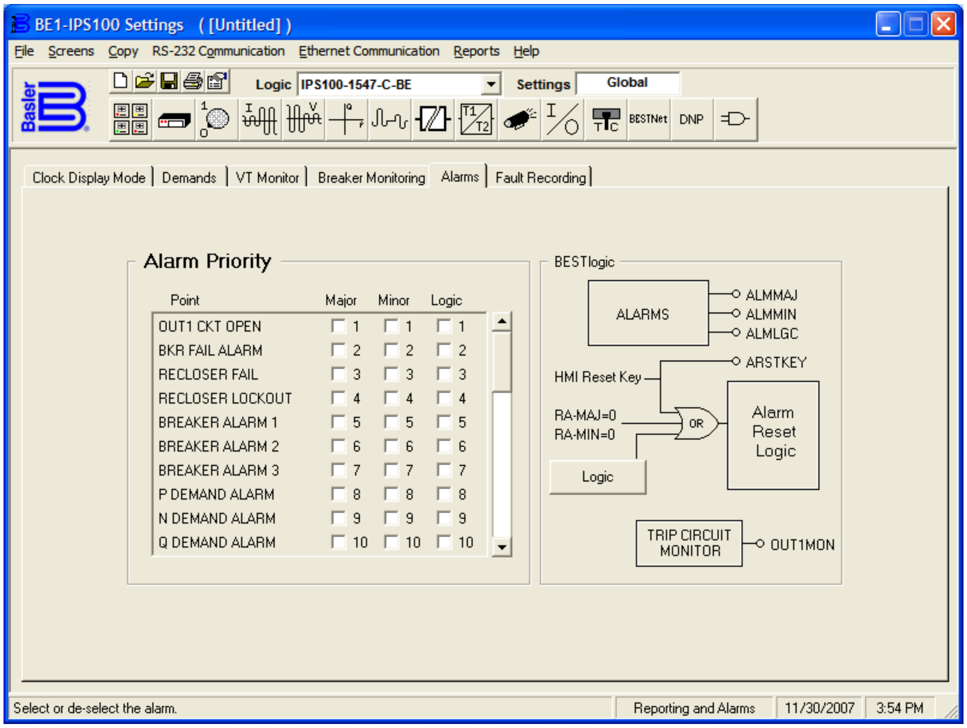


Figure 14-32. Reporting and Alarms Screen, Alarms Tab

Fault Recording

Logic expressions define the three conditions that determine when a fault has occurred. See Figure 14-33. When a fault is detected by the relay, the relay records (stores in memory) data about the fault. The three conditions that determine a fault are Trip, Pickup, and Logic Trigger. To define these conditions, click on *Fault Recording, Logic* box. Then click on *Tripped, Picked Up*, and *Logic*, in turn, and program the inputs that define each condition. You may clear existing programming by clicking on the *Clear* button or clicking on each individual variable.

The fault recording function can record up to 16 oscillographic records in volatile memory. Because there is only a specific amount of memory available, as additional faults are recorded, the oldest records are overwritten. Each record can record only a limited number of data cycles. If you have less than 16 records, you can have more than 15 cycles of data per record. To select the number of cycles of data and number of records, click on the *Oscillographic Records, Select* button and click on the number of records that you want to record.

Logic settings for the *Target Reset Logic* can be made by clicking on the *Target Reset - Logic* button and then clicking on the *Reset* input. Other logic blocks shown under BESTlogic on the *Alarms* tab are shown for reference only. There is no interaction available.

Any protective function, except 62, 162, and 60FL, that has a trip will set a target because these functions have the targets enabled on the *Fault Recording* tab. If you are using a protective function in a supervisory capacity and do not want to set a target when the protective function trips, disable that target by clicking on the specific target. If you want to disable all of the targets for a function such as the inverse time overcurrent functions, click on the No 51's button on the left side of the *Enabled Targets* pane.

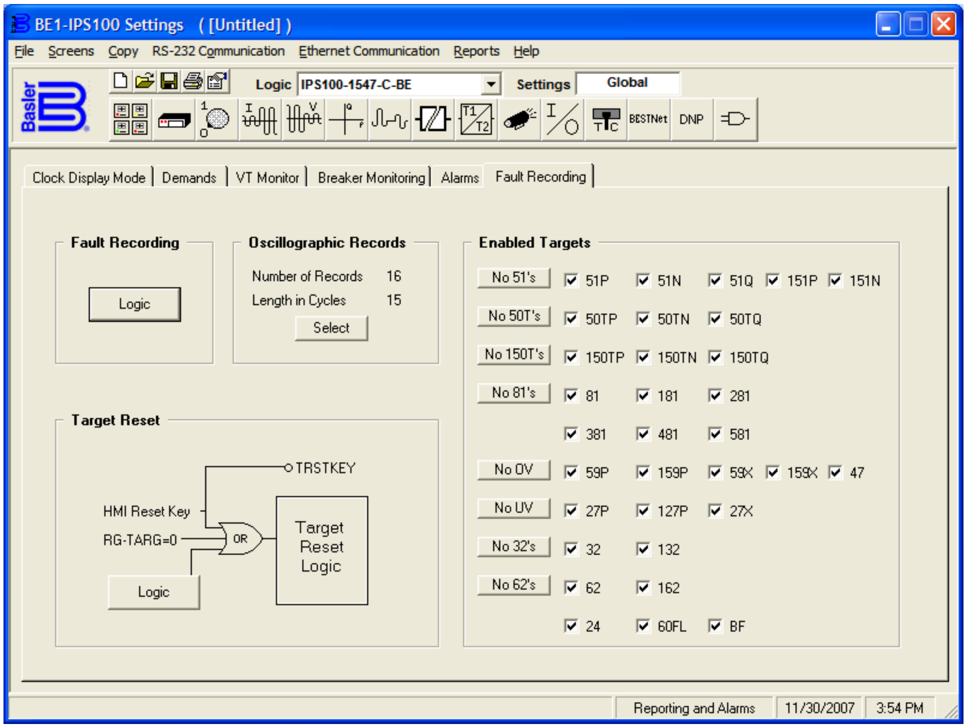
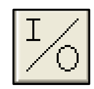


Figure 14-33. Reporting and Alarms Screen, Fault Recording Tab

Inputs and Outputs

Pull down the *Screens* menu and select *Inputs and Outputs* or click on the *Inputs and Outputs* icon, which is shown at the right margin of this paragraph. This screen has two folder tabs and the first tab (Figure 14-34) is labeled *Inputs 1 - 4*.



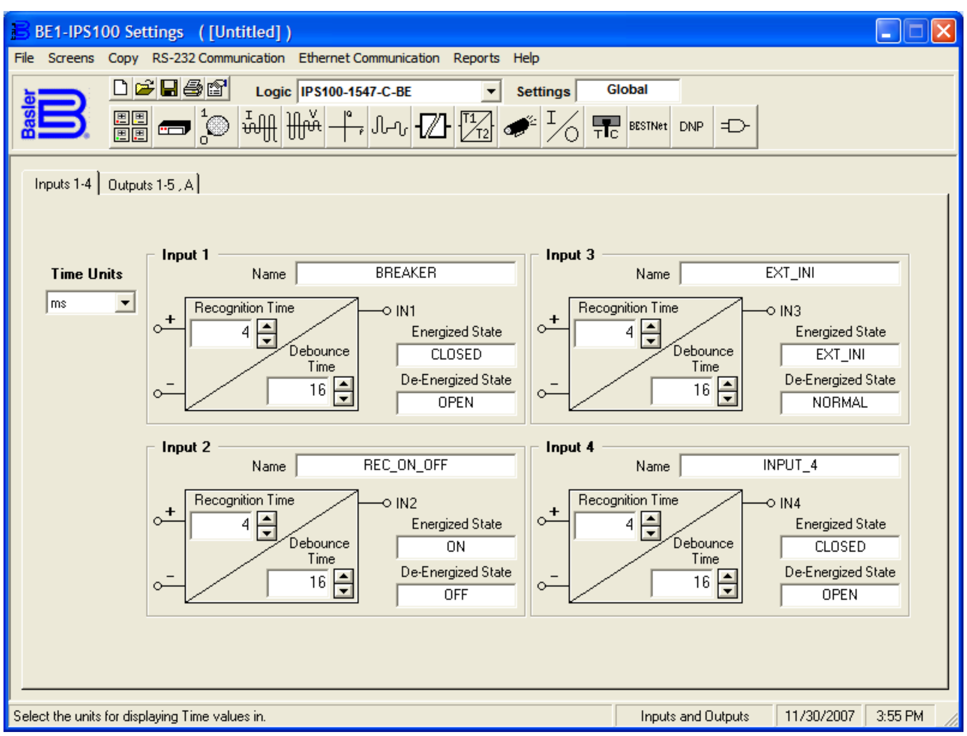


Figure 14-34. Inputs and Outputs Screen, Inputs 1-4 Tab

Inputs 1 - 4

The first tab (Figure 14-34) allows setting the four programmable inputs available in the BE1-IPS100 relay. To program how long the Input 1 contact must be closed to be recognized as closed, first, pull down the *Time Units* menu, and set the units for the appropriate time measurement. Then in the Input 1 pane, enter the new value for *Recognition Time* or use the appropriate up or down arrow buttons to set the new value. To program how long the Input 1 contact must be open to be recognized as open, enter the new value in Input 1, *Debounce Time* box or use the appropriate up or down arrow buttons to set the new value.

You can assign a meaningful name to each input. This makes sequential events reports easier to analyze. To assign a meaningful name to Input 1, click in the *Name* field and enter the new name. To change the label for the *Energized State*, click on the *Energized State* field and enter the new name. To change the label for the *De-Energized State*, click on the *De-Energized State* field and enter the new name. The remaining three inputs have the same functions.

Outputs 1 - 5, A

On this tab (Figure 14-35), the only feature that you may change is to select the programmable hold attribute. To select the hold attribute (contacts remain closed for 200 milliseconds) for any output, click on the *Hold Attribute* field for that output. To change the label for any of the virtual outputs, see the paragraphs on *BESTlogic, Virtual Outputs*, later in this manual.

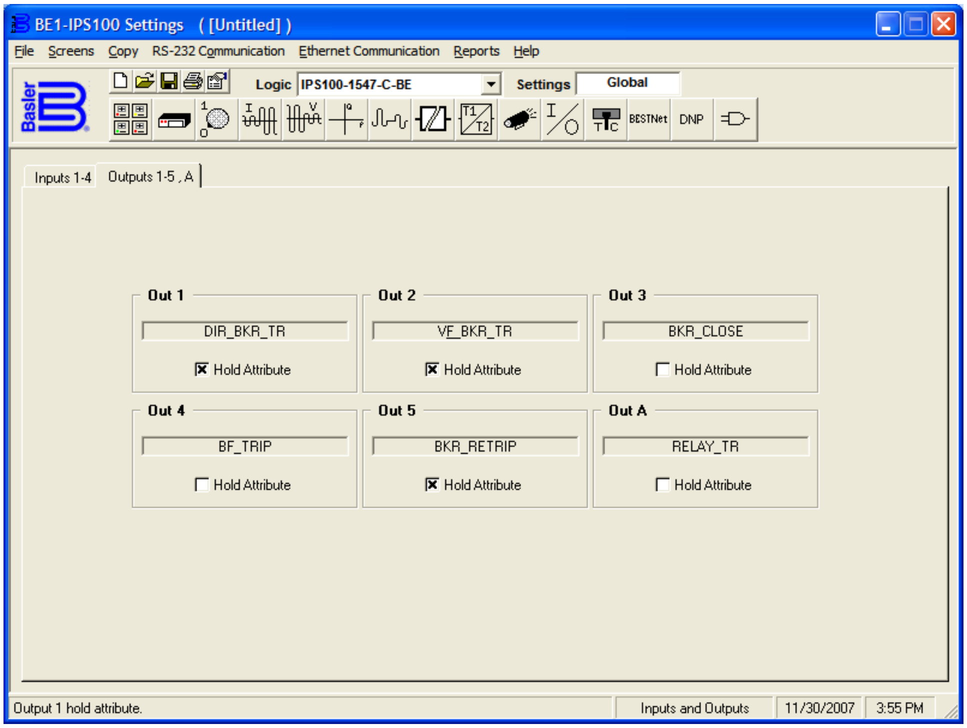
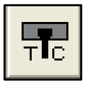


Figure 14-35. Inputs and Outputs Screen, Outputs 1-5, A Tab

Virtual Switches

Pull down the *Screens* menu and select *Virtual Switches* or click on the *Virtual Switches* icon, which is shown at the right margin of this paragraph. This screen (Figure 14-36) has no folder tabs and is labeled *Virtual Switches*.



Virtual Switches (x43 & 101)

You can assign a meaningful name or label to each of the two virtual switches (Figure 14-36). This makes sequential events reports easier to analyze. To assign a meaningful label to Virtual Switch 43, click in the *Label* field and enter the new name. To change the label for the *True State*, click on the *True State* field and enter the new name. To change the label for the *False State*, click on the *False State* field and enter the new name.

The mode logic setting for Virtual Switch 43 can be made by clicking on the *BESTlogic* button and, with your custom logic selected, select the mode logic by using the *Mode* pull-down menu. The 143 Virtual Switch has the same functions.

The Virtual Breaker Control Switch (101) provides manual control of a circuit breaker or switch without using physical switches and/or interposing relays. The mode logic setting for Virtual Breaker Control Switch 101 can be made by clicking on its associated *BESTlogic* button and, with your custom logic selected, select the mode logic by using the *Mode* pull-down menu. Trip outputs include Trip, Close, and Slip Contact.

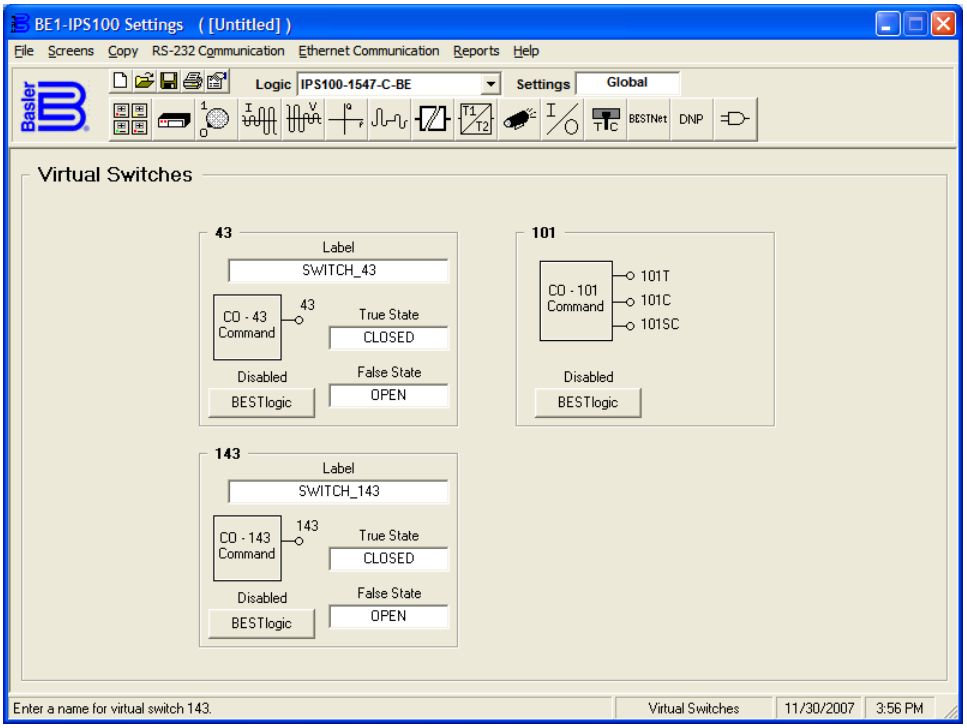
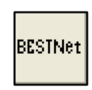


Figure 14-36. Virtual Switches Screen

BESTNet Settings



Pull down the *Screens* menu and select *BESTNet Settings* or click on the BESTNet icon that is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *BESTNet Settings* (Figure 14-37).

Com protocol 4 or 5 must be ordered with your relay. For detailed information regarding the *BESTNet Settings* screen, refer to Section 15, *BESTNet Communication.*

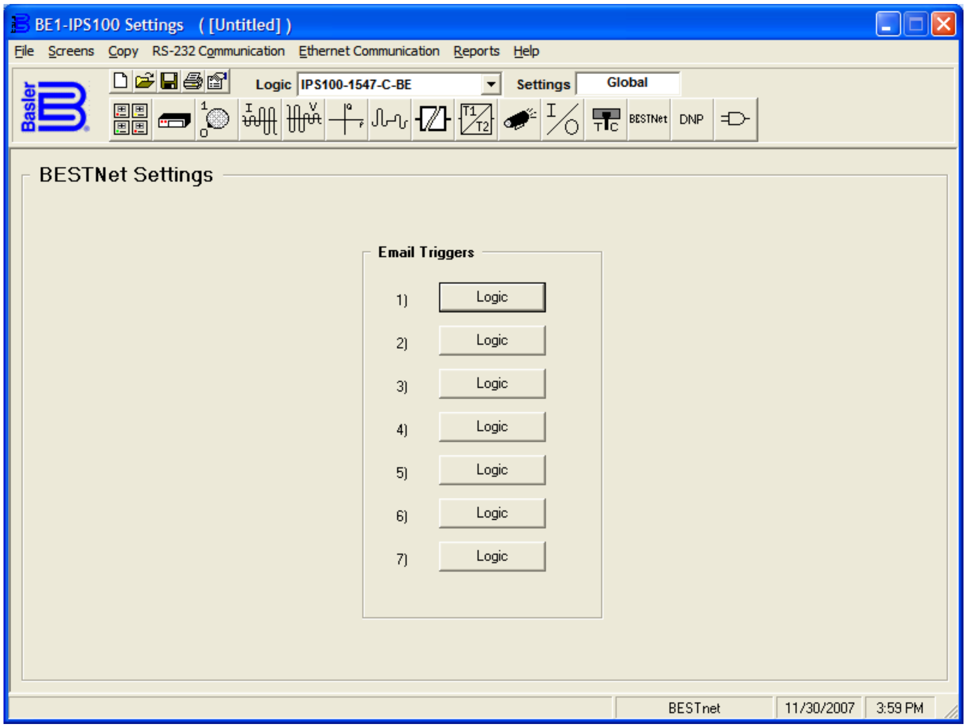
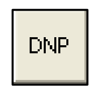


Figure 14-37. BESTNet Settings Screen

DNP Settings

Pull down the *Screens* menu and select *DNP Settings* or click on the *DNP Settings* icon, which is shown at the right margin of this paragraph. This screen has two folder tabs and the first tab (Figure 14-38) is labeled *DNP Settings*.



DNP Settings

This tab is used to set the possible number of analog input events. A 16-bit analog input can have up to 32,767 input points while a 32-bit analog input can have up to 2,147,483,647 input points. Selecting with *Flag* or *Time* will include a date/time stamp to the events. The left panel allows a user to set the *Static Input Object 30* as well as the *Change Event Object 32*.

The right pane allows the user to set the *Current, Voltage*, and *Power Dead Band*. The range is from 1 to 10 and represents a percentage of the nominal value. This setting, in effect, is a method to reduce the amount of data received when polling. For example, if nominal voltage was 120 Vac and the *Voltage Dead Band* was set at 10, then polling would only return data over for voltages below 108 or above 132.

For additional information, refer to Basler Electric Instruction Manual 9365900991, Section 5, *DNP V3.00 Point List, Analog Inputs*.

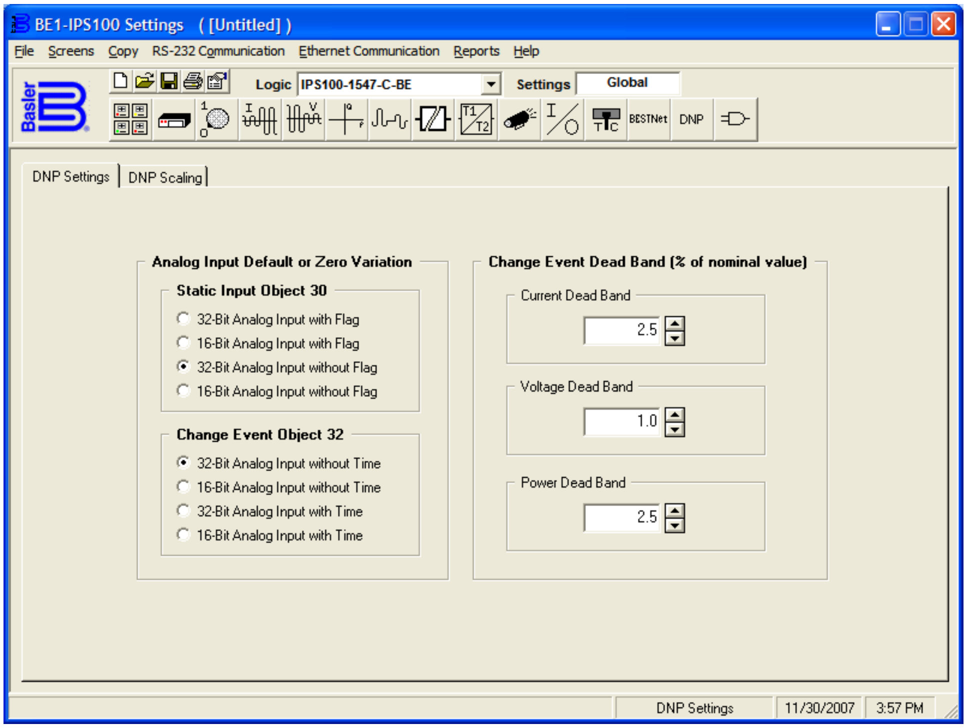


Figure 14-38. DNP Settings Screen, DNP Settings Tab

<u>*DNP Scaling*</u>

This tab (Figure 14-39) allows the user to set the scale for current, voltage, power, and energy units in the left panes. And it allows the setting of scale for time, internal time stamps, and the breaker operation counter in the right panes. A legend is provided to define the various metric units available. Returns when polling will include two significant places to the right of the decimal point. Default values were chosen to represent reasonable scales in many typical applications.

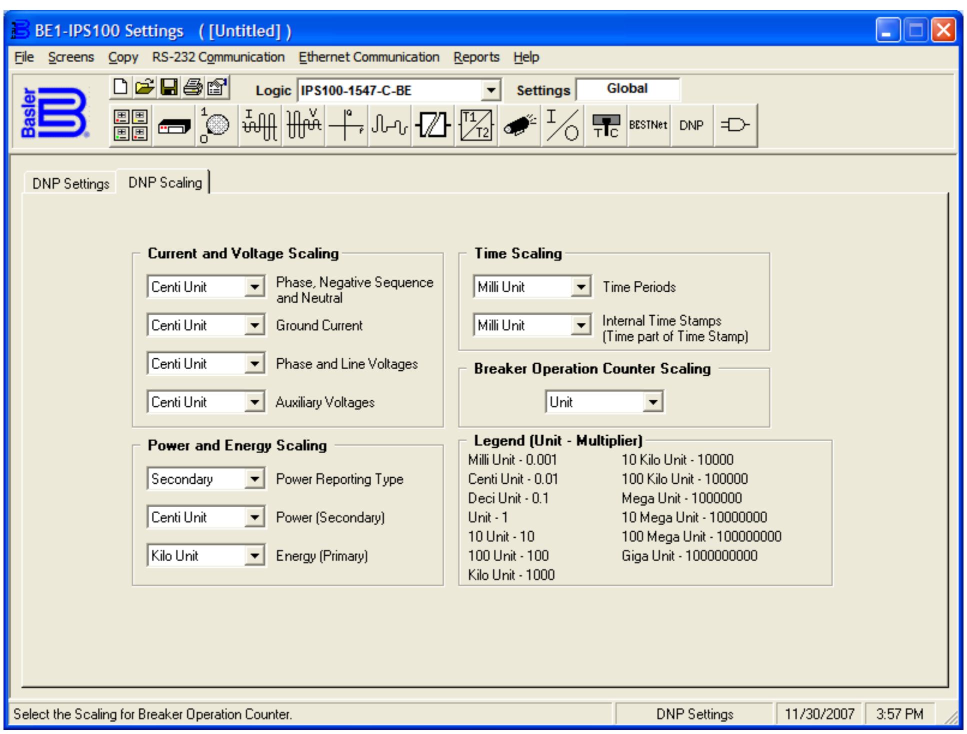
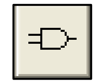


Figure 14-39. DNP Settings Screen, DNP Scaling Tab

BESTlogic



Pull down the *Screens* menu and select *BESTlogic* or click on the *BESTlogic* icon, which is shown at the right margin of this paragraph. This screen has three folder tabs and the first tab (Figure 14-40) is labeled *Logic Select*.

Logic Select

This tab (Figure 14-40) allows you to select one of the preprogrammed logic schemes and copy that scheme to the active logic. You may then keep the preprogrammed logic but are not allowed to change anything in the scheme. You must rename that logic to a custom name and then make changes as you desire. Click on the logic to be copied to the active logic. Two check boxes allow you include appropriate variable names and include appropriate logic expressions for *Breaker Status* and *Fault Recording*. A box appears requiring that you okay the replacement of all settings. Click *OK* to close the dialog box and then type in your customized logic name.

With the *BESTlogic Logic Library*, you can *Load Scheme* or *Remove Scheme.* You may also *Copy to Active Logic*.

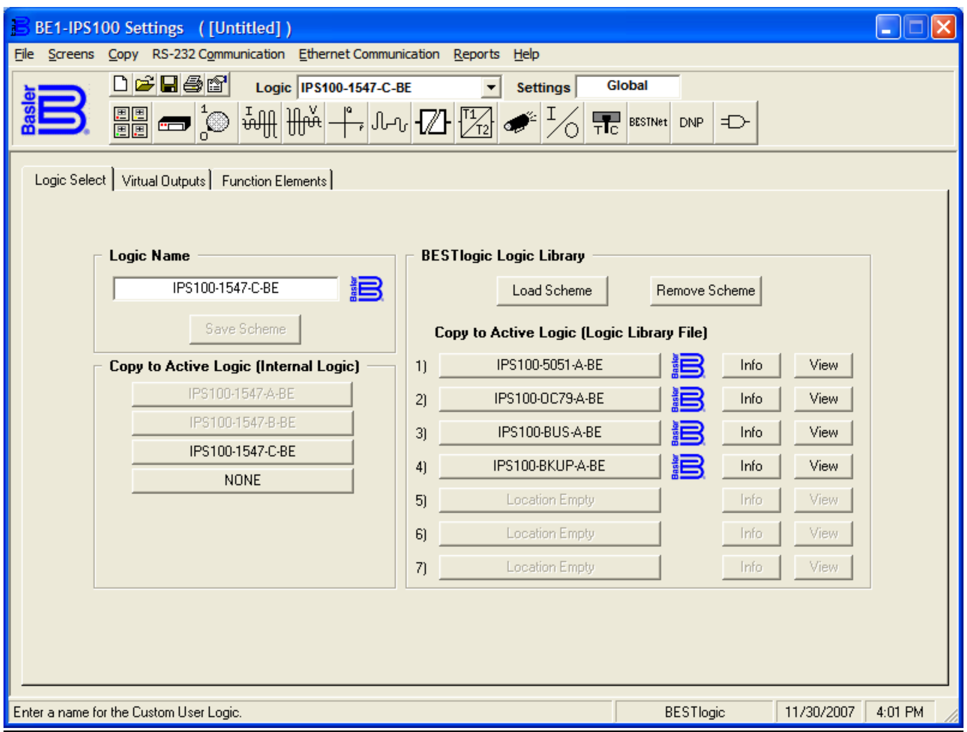


Figure 14-40. BESTlogic Screen, Logic Select Tab

Virtual Outputs

You can assign a meaningful name or label to each virtual output. See Figure 14-41. This makes sequential events reports easier to analyze. To assign a meaningful label to virtual output VO6, for example, click in the *Label* field and enter the new name. To change the label for the *TRUE* state, click on the *True State* field and enter the new name. To change the label for the *FALSE* state, click on the *False State* field and enter the new name. To change the logic associated with VO6, click on the *BESTlogic* button associated with VO6. Click on the logic input and program the logic variables that define VO6. You may clear existing programming by clicking on the button or clicking on each individual variable. The other 15 virtual outputs have the same function.

VO6 through VO15 do not have actual hardware output contacts. Only VOA and VO1 through VO5 have hardware output contacts.

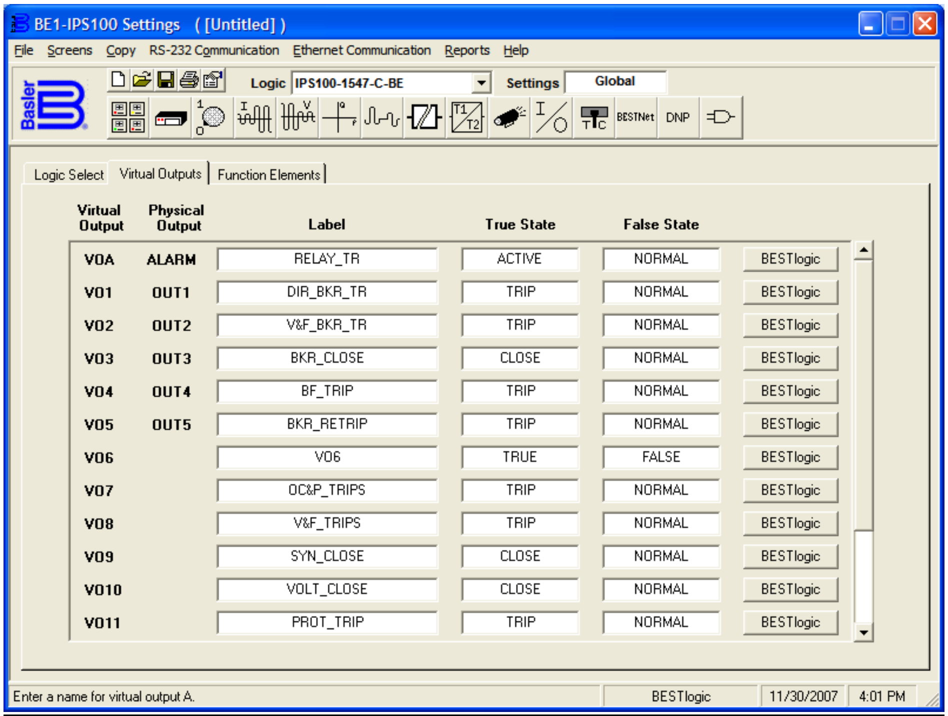


Figure 14-41. BESTlogic Screen, Virtual Outputs Tab

Function Elements

Not all of the logic functions have *BESTlogic* labeled on the button. See Figure 14-42. If the logic function is labeled Logic and not *BESTlogic*, the ASCII command for the function is not prefixed with SL-. For example: Breaker Status is a function of breaker monitoring and the ASCII command is SB-LOGIC for Setting, Breaker-Logic. To program a logic function, find the logic function in the list and click on the associated *BESTlogic* or *Logic* button. The *BESTlogic Function Element* dialog box opens with the available programming. If the *Mode* pull-down menu is available, select the appropriate mode. Click on the logic inputs and program the appropriate logic.

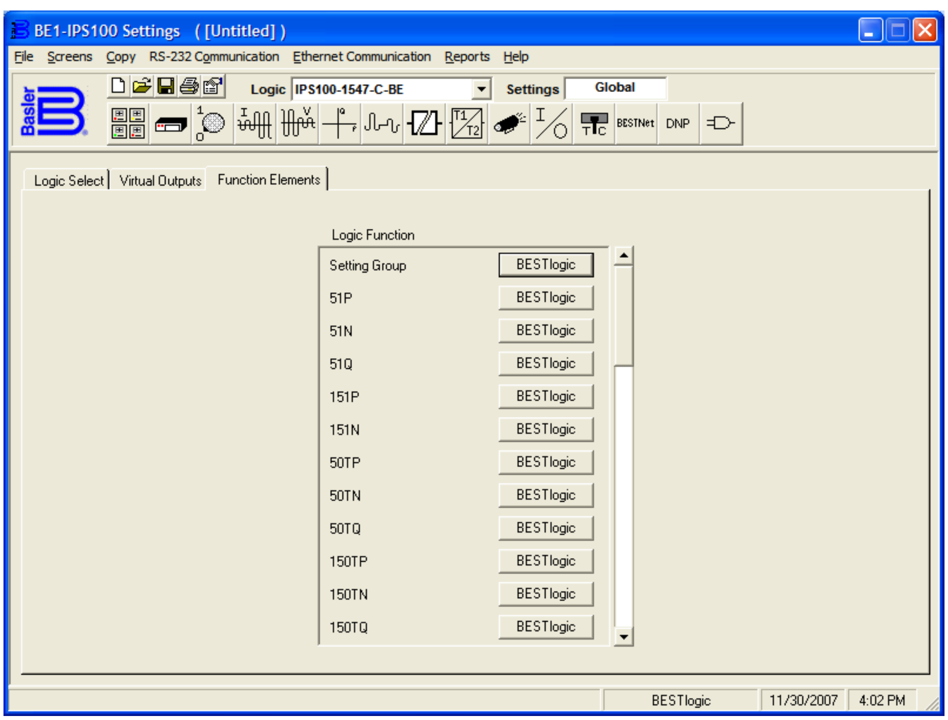


Figure 14-42. BESTlogic Screen, Function Elements Tab

COPYING SETTINGS FROM GROUP TO GROUP

There are a lot of settings in any BE1-IPS100 numerical systems product but the differences between Group 0 and Group 1 settings may be minimal. With BESTCOMS, there is a convenient way to copy settings from Group 0 to Group 1. Then, you only have to change the settings that are different. Pull down the *Copy* menu (see Figure 14-43) from the pull-down menu. There is only one choice, From *Group to Group*. When you select this choice, a dialog box opens (Figure 14-44) allowing you to select which group you wish to copy. After making your selection and clicking *OK*, the copy routine commences followed by another dialog box informing you that the copy routine is complete. Now, change those settings that are different.

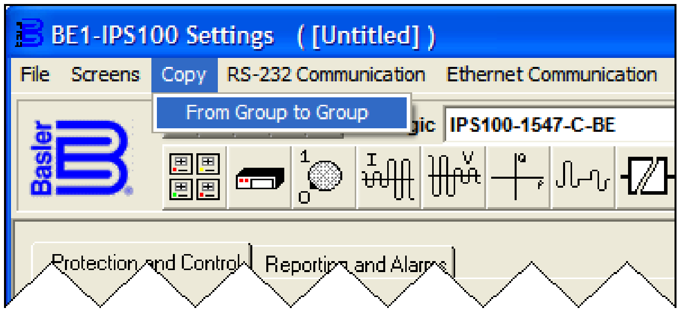


Figure 14-43. Copy From Group to Group Drop-Down Menu

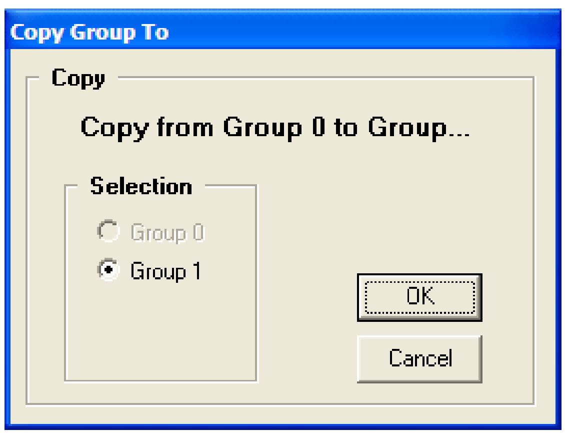


Figure 14-44. Copy Group To Dialog Box

DOWNLOADING OSCILLOGRAPHY FILES

To download an oscillography file, pull down the *Reports* menu (see Figure 14-45) from the pull-down menu and select *Oscillography Download* and then either *Serial Connection* or *Ethernet Connection.* When you select this choice, you may get a communication error if you are not configured to an actual relay. If you have communication with the relay, a dialog box opens (Figure 14-46) allowing you to *View/Download Relay Fault Files*. If there have been no fault events triggered, you may create one by clicking on the *Trigger* button in the *View/Download Relay Fault Files* dialog box.

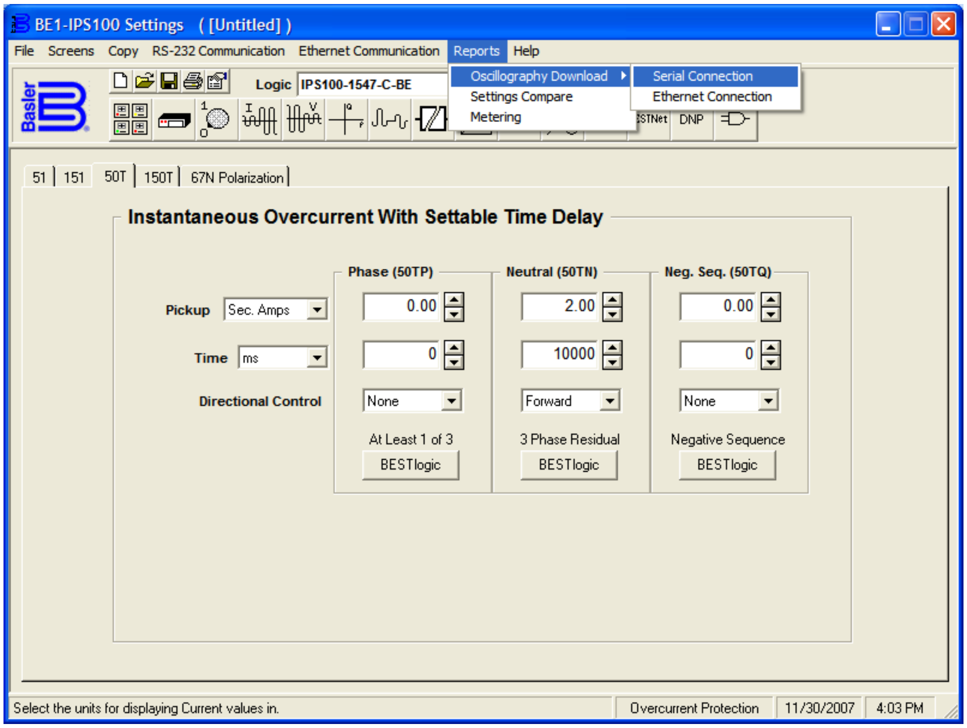


Figure 14-45. Oscillography Download Drop-Down Menu

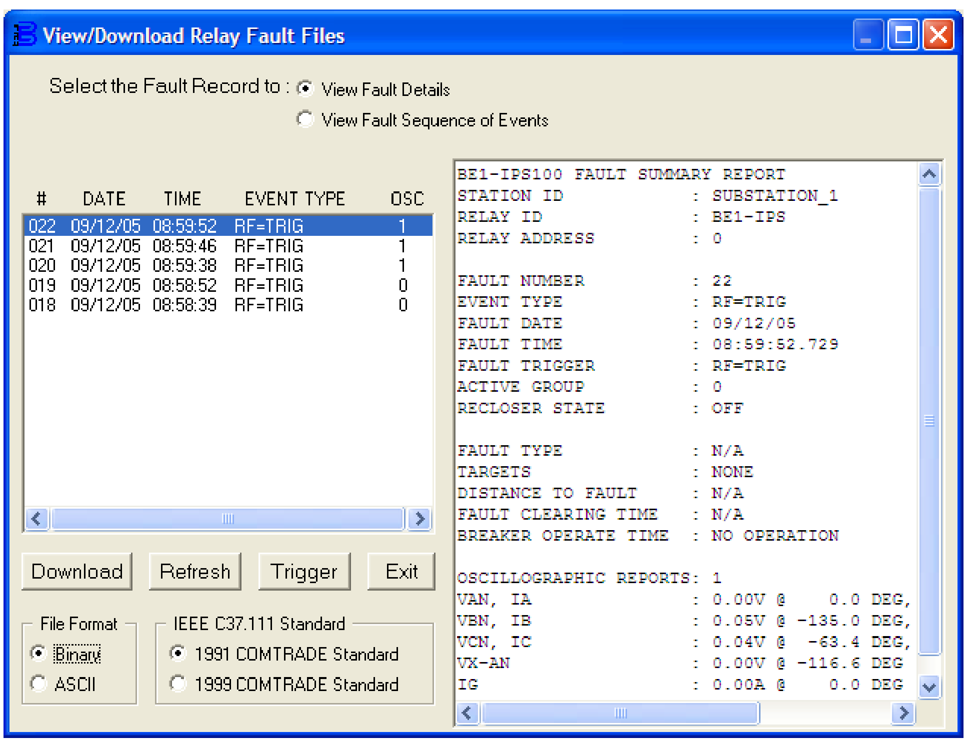


Figure 14-46. View/Download Relay Fault Files Screen

View Fault Details

To view the fault record details, select an event by clicking on the event number or anywhere on the event line. The event grays-out while the information is being retrieved from the relay. View the fault details in the associated window.

View Fault Sequence of Events

To view the fault record sequence of events, click on the radio button by the *View Fault Sequence of Events*. View the fault sequence of events in the associated window.

Download Oscillography File

To download an oscillography file, select the type of file to download: *Binary* or *ASCII* and *1991* or *1999 Comtrade Format*. Click on the *Download* button in the *View/Download Relay Fault Files* dialog box. Use normal Windows® techniques to select the computer folder that is to receive the download file. You may create a new folder at this time by clicking on the *New Folder* button. Okay the file save and the *Fault Record Filenames* dialog box opens. Use the default *Base Filename* or enter a new file name. As you change the file name, the names for the *Header File, Fault Sequence*, and *Fault Summary* also change automatically. *OK* the file names and then exit the dialog box. You have now downloaded the oscillography file. You may view this oscillography file using *Basler Electric's BESTwave* software.

METERING

To observe the system metering, pull down the *Reports* menu from the pull-down menu and select *Metering*. When the *Metering* dialog box (Figure 14-47) opens, click on the *Start Polling* button. If BESTCOMS is not configured to the relay communication settings, you will receive a Communications Error. The *Metering* dialog box has two pull-down menus: *File* and *Communication*. To configure communication with the relay, pull down the *Communication* menu and select *Configure*. Choose the *Com Port* and *Baud Rate*, as required. If you have communication with the relay, click on the *Start Polling Button*. Metering values are displayed in the various screen windows. If you select *Configure* with polling in progress, you will get the *Polling Active* dialog box. You must stop polling before you can change configuration. To stop polling, click on the *Stop Polling* button. To exit, pull down the *File* menu and select *Exit*. You may also use the Windows® techniques and click on the close icon (X) in the upper right-hand corner of the *Metering* dialog box.

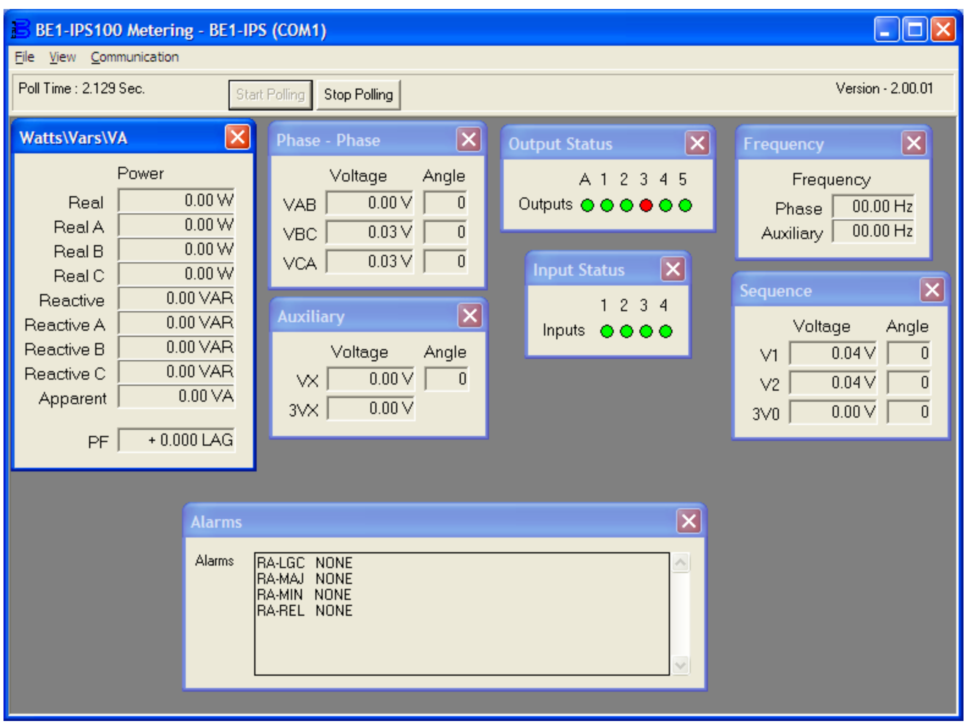


Figure 14-47. Metering from Reports Pull-Down Menu

FILE MANAGEMENT

In these paragraphs, file management describes saving, opening, uploading, downloading, and printing settings files.

Saving a Settings File

If you change any settings in the active custom logic scheme and try to exit BESTCOMS, the dialog box shown in Figure 14-48 appears. If you choose *Yes*, a file properties dialog box appears. The file properties dialog box also appears if you pull down the file menu and choose *Save* or *Save As*. The lines of information that are grayed-out are automatically entered based on the file name and relay identifier information command (SG-ID). You may enter up to 50 characters in the *Additional Info:* field and 2,500 characters in the *File Comments* field. When you okay the dialog box, you are given an opportunity to name the file and select the path. Clicking on *Save* completes the saving of a settings file.

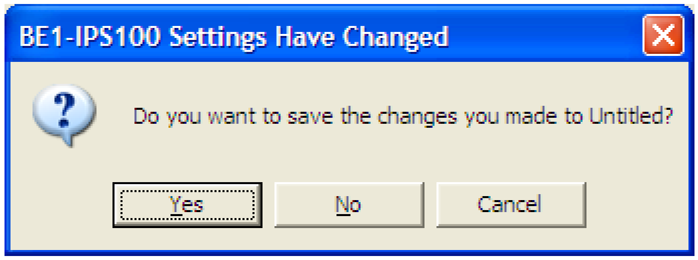


Figure 14-48. Settings Have Changed Dialog Box

Opening a Settings File

To open a settings file into BESTCOMS, pull down the *File* menu and choose *Open*. If the settings in your BESTCOMS have changed, a dialog box will open asking you if want to save the current settings changes. You may choose *Yes* or *No*. After you have taken the required action to save or not save the current settings, the *Open* dialog box appears. This dialog box allows you to use normal Windows® techniques to select the file that you want to open. Select the file and open it and the file settings have been brought into BESTCOMS.

Uploading a Settings File

To upload a settings file to the BE1-IPS100 relay, you must first open the file through BESTCOMS or create the file using BESTCOMS. Then pull down the *Communication* menu or the *Ethernet Communication* menu and select *Upload Settings to Device.* You are prompted to enter the password. If the password is correct, the upload begins and the percent complete loading bar is shown. At upload completion, you are asked if you want to save the settings and make them active. After replying, you are informed of the status: Yes - settings are saved or No - settings are discarded. If you would like to view the file names as they are uploaded, pull down the *Communication* menu and select *Configure*. When the *Configure Communication Port* dialog box opens, click the *On* button for *Show Commands During Data Transfer* and then click *OK*. Now, during data transfer, you will see two screens (*Sending* and *Status*) and the percent complete loading bar. If a data transfer error occurs, you can briefly see the error notification in the *Status* window. The file settings will not be uploaded and the changes discarded. You may then scroll through the *Status* window until you find the error notification. Click on the error notification and the data file that transferred in error is shown in the *Sending* window.

Downloading a Settings File

To download a settings file from a BE1-IPS100 relay, you must pull down the *Communication* menu or the *Ethernet Communication* menu and select *Download Settings from Device*. If the settings in your BESTCOMS have changed, a dialog box will open asking you if want to save the current settings changes. You may choose *Yes* or *No*. After you have taken the required action to save or not save the current settings, the downloading is executed.

Printing a Settings File

To print a settings file, pull down the *File* menu and select *Print*. A dialog box, *Print BE1-IPS100 Settings File* opens with the settings file shown and typical Windows® choices to setup the page and the printer. Execute these commands, as necessary, and then select *Print*.

You may also export the settings file to a text file. Pull down the *File* menu and select *Export to Text*. A dialog box, *Export to Text File* opens with the settings file shown. Execute the *OK* command and then use normal Windows® techniques to select the path. Execute the *Save* command and you now have a text file of your BESTCOMS settings.

SETTINGS COMPARE

BESTCOMS has the ability to compare two different settings files. To use this feature, pull down the *Reports* menu and select *Settings Compare*. The *BESTCOMS Settings Compare Setup* dialog box appears (Figure 14-49). Select the location of the first file to compare under *Left Settings Source* and select the location of the second file to compare under *Right Settings Source*. If you are comparing a settings file located on your PC hard drive or portable media, click the folder button and navigate to the file. If you want to compare settings downloaded from a unit, click the RS-232 button to set up the communication port and baud rate. Click the *Compare* button to compare the selected settings files.

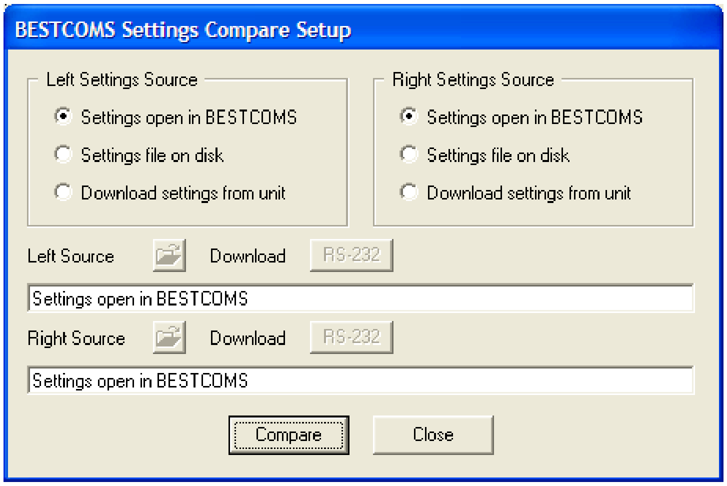


Figure 14-49. Settings Compare Setup

If there are any differences in the two files, a dialog box will appear and notify you that differences were found. The BESTCOMS Settings Compare dialog box (Figure 14-50) is displayed where you can view all settings (*Show All* button) or view only the differences (*Show Diffs* button).

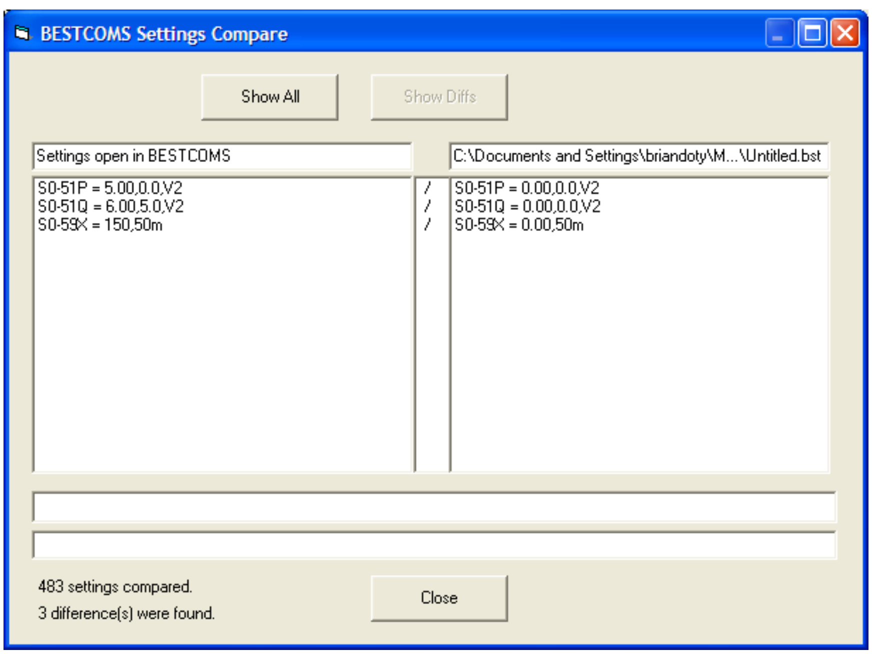


Figure 14-50. Settings Compare View

BESTPrint

BESTPrint, which is included on the CD-ROM provided with the BE1-IPS100, will preview and print Basler Electric relay settings files. This is via graphic representations similar to what is seen in the BESTCOMS software application. BESTPrint will only read the settings files and document the information. It will not write or change any settings in the settings file (*.bst) at this time.

Profile files for each device are needed to print documentation for that particular device. New and updated profiles will be available from Basler Electric. One new set of profiles and their support files will be the optimum way to acquire additional printing of more devices or updated settings files.

For additional information, see the help files in the BESTPrint application.

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SECTION 15 • BESTNet COMMUNICATION

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SECTION 15 • BESTNet COMMUNICATION

INTRODUCTION

The BESTNet Communication package provides additional BE1-IPS100 features if the relay is ordered with one of the BESTNet Protocol Options (Refer to Section 1, *General Information*). By using the user's TCP/IP network, remote access via Ethernet provides a new and unique method of monitoring, controlling, and coordinating protection and control functions. A web browser such as Microsoft® Internet Explorer is used to view relay status remotely. The BESTNet over Ethernet option provides the following capabilities:

- Viewing relay status and real time metering using easy to use web pages as the graphical user interface.
- Operational parameters can be set using BESTCOMS for BE1-IPS100 Software over the Ethernet port interface.
- ASCII commands can be sent via a TCP/IP terminal or Telnet program. For example, ASCII commands can be sent to set up the BESTlogic required to use user-established protection and control schemes over the BESTNet Ethernet interface.
- Outputs from the relay such as alarms and BESTlogic variables or data reports can be viewed.
- Alarms can be configured to send e-mail messages to alert interested parties when a particular condition occurs.

NOTE

For security reasons, all change passwords are disabled by default on the (optional) Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port. Refer to Section 9, *Security.*

INSTALLATION

BESTNet is part of the BE1-IPS100 firmware and part of the BESTCOMS software for the BE1-IPS100. (See Section 14, *BESTCOMS Software*, for BESTCOMS installation instructions.) The Basler Electric Device Discovery component is an aid to initial configuration and is contained in BESTCOMS. Once network parameters such as the static IP address are set, this configuration will not have to be run again.

NOTE

The use of dynamically assigned IP addresses (default) will require the Device Discovery component to be used each time BESTCOMS is started in order to find BE1-IPS100 relays on the local area network (LAN).

Configuring the BE-IPS100 for Ethernet

BE1-IPS100 Ethernet options are set through a configuration applet that is stored in the BE1-IPS100. This configuration applet is loaded into the PC on demand, and is not part of the BESTCOMS software for the BE1-IPS100.

To configure the BE1-IPS100 BESTNet features, follow the steps outlined below:

1. Ensure that the PC has an Ethernet port, a recent version of Microsoft Internet Explorer, and a Java™ Runtime Environment installed.

NOTE

A Java™ Runtime Environment is required for proper operation of the BE1-IPS100 configuration applet and web pages. Once the BE1-IPS100 is configured, Java™ is not required to receive e-mail alerts from the BE1-IPS100 or to use BESTCOMS over Ethernet, but is required to view web page data.

2. Insure that the PC has a current version of BESTCOMS for BE1-IPS100 Software installed. BESTCOMS for BE1-IPS100 Software is included on the BESTCOMS for BE1-IPS100 Software CDROM, and is available for download from the Basler Electric web site.
3. Connect the PC to the same LAN as the BE1-IPS100, or connect the PC directly to the BE1-IPS100 through a hub, or with a Category 5 (Cat-5) crossover cable.
4. If you already know the IP address of the BE1-IPS100, skip to the next step. To scan the network for connected BE1-IPS100 relays, launch BESTCOMS, click on the "Ethernet Communications" menu, and select "Download Settings From Device". When the Device Selection Dialog appears, select "Scan for Connected Devices" and note the IP address of the device of interest. (See Figures 15-10 and 15-11.) If no devices are found, insure that the BE1-IPS100 is on the same subnet, that all cables are connected, or that the direct connection cable is a CAT5 crossover cable, as appropriate.
5. Launch an Internet Explorer window and type the following URL, substituting the IP address of the BE1-IPS100 for the zeros shown below:

http://000.000.000.000/FS/WEB/config.htm

6. If the computer has a compatible Java™ Runtime installed, the screen shown in Figure 15-1 should appear.

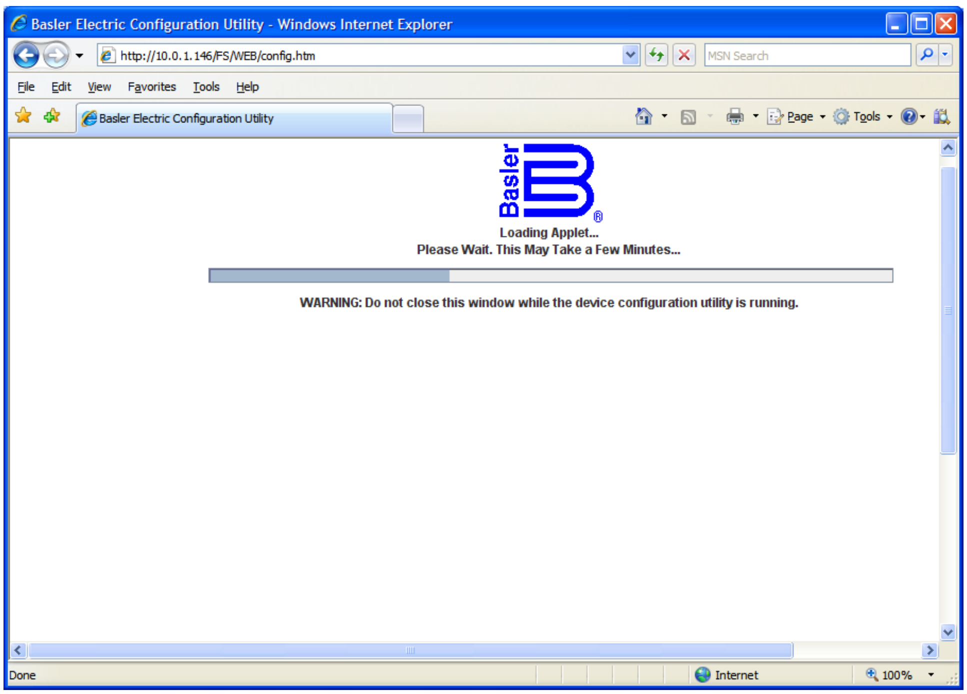


Figure 15-1. Launch Screen for BESTNet Configuration Applet (Internet Explorer)

7. Once the configuration applet is loaded, its window should appear (Figure 15-2).
8. Prior to changing any configuration parameters, verify, by serial number, that the relay being configured is the correct one.
9. Step through the Network, HTTP Security and E-mail Alerts screens and set as desired (see the following paragraphs for details). Save or cancel the changes, as required, with the appropriate screen buttons.

> **NOTE**
>
> E-mail alerts are triggered by BESTlogic equations that are configured under the *BESTNet* section of BESTCOMS software. E-mail alerts will not function unless BOTH the configuration applet AND the BESTNet e-mail equations are set.

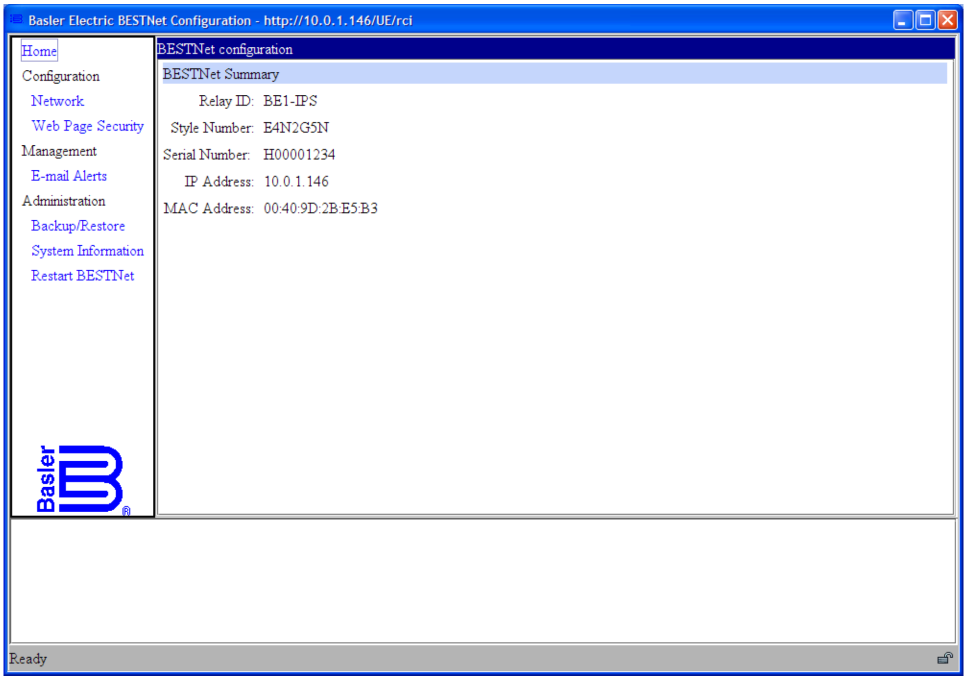


Figure 15-2. BESTNet Configuration Applet

CONFIGURATION SCREENS

The BESTNet Configuration Applet has seven screens of information and settings, as described in the following paragraphs.

Home

Purpose: Provides general identifying information about the BE1-IPS100. This screen should be used to verify that the correct relay device has been selected prior to making any configuration changes. The *Home Configuration* screen is shown in Figure 15-3. Information provided on the *Home Configuration* screen is described in Table 15-1.

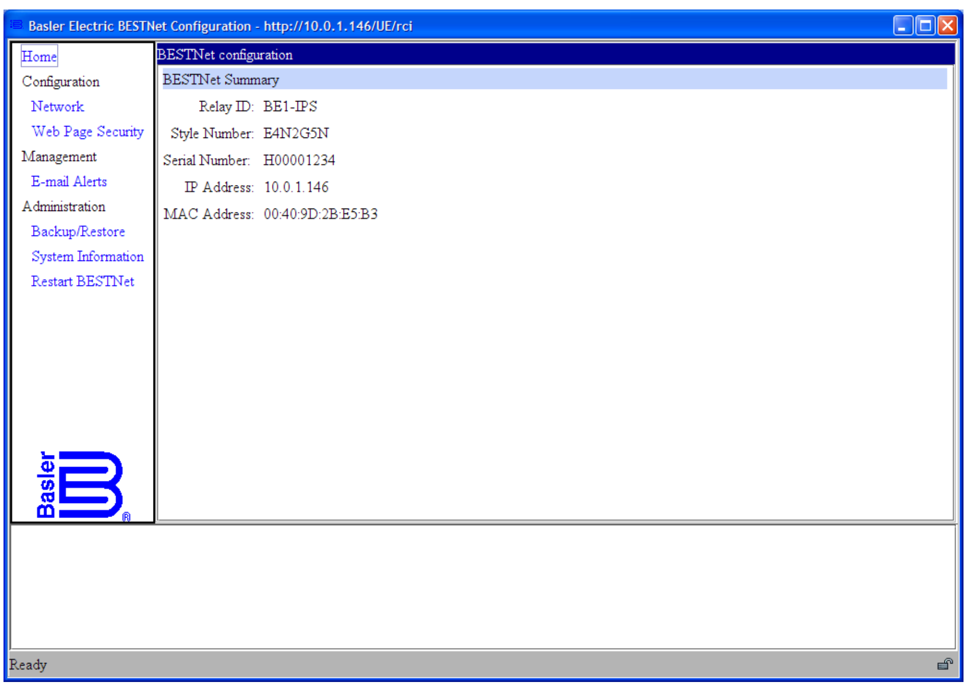


Figure 15-3. Home Configuration Screen

Table 15-1. Home Configuration Screen Settings and Information

Information	Value	Function
Model	"BE1-IPS100"	Indicates the type of BESTNet relay. This value is factory-assigned and cannot be changed.
Relay ID	Programmable text string	This string can contain up to 30 alphanumeric characters and is programmed through BESTCOMS or an ASCII command. It can be used to provide information about the location and function of each BE1-IPS100. It is helpful (but not required) for each BE1-IPS100 to be programmed with a unique relay ID.
Style Number	7-character, alphanumeric string	Describes the features and functions included in a particular BE1-IPS100 relay. Refer to the relay style chart or BESTCOMS software for the meaning of each style chart character. The style number is not unique to each BE1-IPS100. This value is factory assigned and cannot be changed by the user.
Serial Number	9-character string	A unique serial number is assigned to each BE1-IPS100 relay. The serial number is printed on a label attached to the relay and provides a way to ensure that the relay data being viewed is for the correct relay. The serial number is factory assigned and cannot be changed.
IP Address	IP address of the BE1-IPS100 is in dotted decimal notation (0.0.0.0)	The internet protocol address of the BE1-IPS100. This address is required for BE1-IPS100 communication with BESTCOMS, Internet Explorer, or any other application. It can be set manually through the Network screen of the BESTNet configuration applet, or can be automatically assigned by a DHCP server.
MAC Address	6-byte hexadecimal value	Globally unique identifier assigned to each Ethernet Media Access Controller. This value is factory assigned and cannot be changed by the user.

Network

Purpose: Allows configuration of the BE1-IPS100 relay IP address and other parameters that may be required on the network to which the BE1-IPS100 is connected. Consult your network administrator for the appropriate values for these settings. Incorrect *Network Configuration* screen settings can prevent BE1-IPS100 network access, or create problems on the network to which it is connected.

Network Configuration screen settings are summarized in Table 15-2. The *Network Configuration* screen is shown in Figure 15-4.

Table 15-2. Network Configuration Screen Settings and Information

Setting	Value	Function
Access relay data over network	Unchecked/Checked	An unchecked box disables ASCII, BESTCOMS, and web page data communication over TCP. A checked box enables ASCII, BESTCOMS, and web page data communication over TCP. This setting does not affect EMAIL ALERTS. EMAIL ALERTS must be enabled or disabled by the ENABLE SENDING EMAIL ALERTS setting.
Select method to assign IP address	Obtain automatically using DHCP	This setting allows a DCHP server on your network to assign network parameters (such as IP address) to the relay automatically. A DHCP server is required if this option is selected. If this option is used, the BE1-IPS100 IP address may change from time to time. BESTCOMS includes a Discovery function that will detect BESTNet relays and display their IP addresses.
	Use the following IP address	This setting allows a static IP address to be assigned to the relay, as well as a subnet mask and default gateway. For more information, see the following settings in this table.

Setting	Value	Function
The following settings are enabled only when USE THE FOLLOWING IP ADRESS setting is selected.		
IP Address	IP address to be assigned to a BE1-IPS100	This is the IP address, expressed in dotted decimal notation (0.0.0.0), that users enter to access this relay on the network. Consult your network administrator for the appropriate value to use in this field.
Subnet Mask	Subnet mask to be assigned to a BE1-IPS100	This is the subnet mask, expressed in dotted decimal notation (0.0.0.0), of the subnet of the network to which the BE1-IPS100 is connected. Consult your network administrator for the appropriate value to use in this field.
Default Gateway	IP address of the default gateway server	This is the IP address, expressed in dotted decimal notation (0.0.0.0), of the gateway used to access the BE1-IPS100. If no gateway is used, this value should be set at 0.0.0.0. Consult your network administrator for the appropriate value to use in this field.

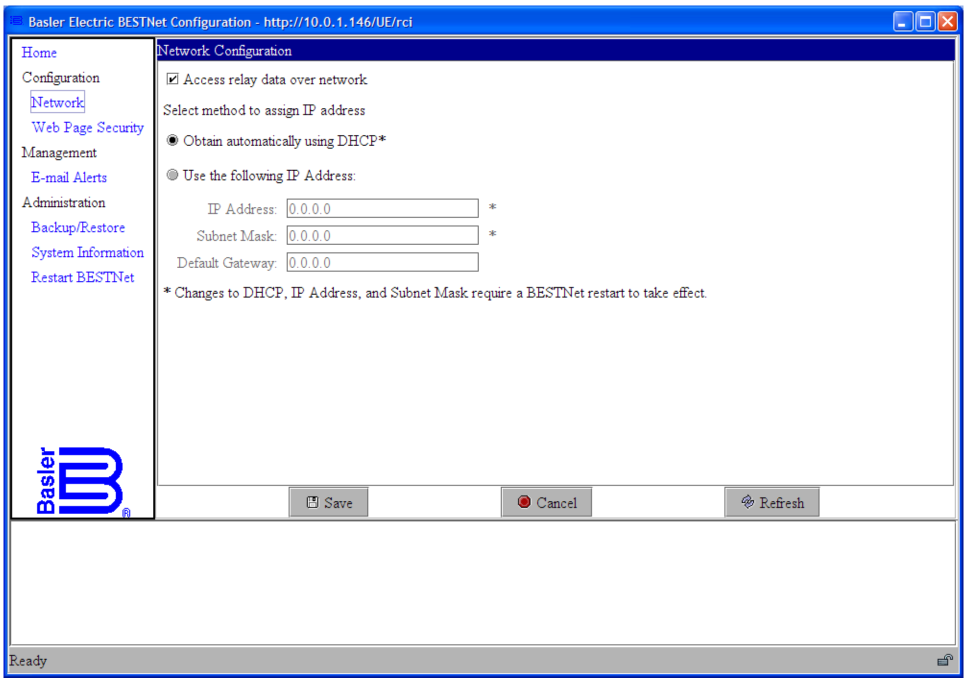


Figure 15-4. Network Configuration Screen

Web Page Security

Purpose: Provide security to prevent unauthorized changes to BESTNet configuration.

> **NOTE**
>
> Web page security ONLY protects against changes to the BESTNet configuration. It DOES NOT prevent changes to relay settings over Ethernet. To add password control for setting changes, use the *Global Security* tab in BESTCOMS to select password(s) for the COM1 Ethernet port.

By entering a username and password on this screen, a login will be required to make future changes to the BESTNet configuration.

NOTE

BEFORE saving the username and password, make a written note of these values! Once the values are saved, the user name and password will be required for all future changes, including disabling security.

Web Page Security Configuration screen settings are shown in Figure 15-5 and described in Table 15-3.

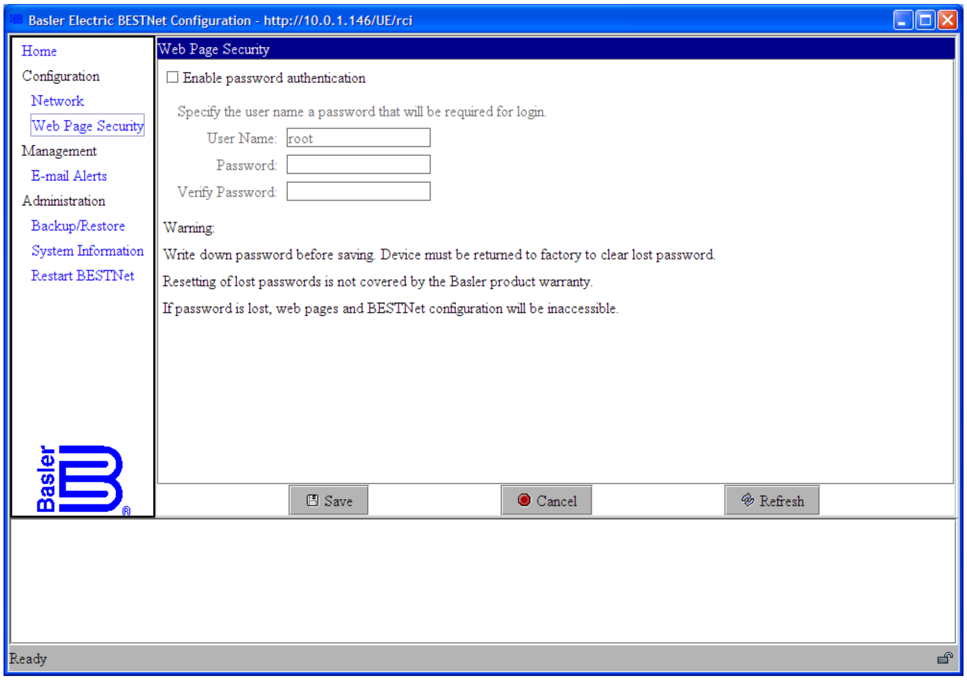


Figure 15-5. Web Page Security Configuration Screen

Table 15-3. Web Page Security Configuration Screen Settings and Information

Setting	Value	Function
Enable password authentication	Unchecked	Disables password authentication of web pages
	Checked	Requires entry of a password before allowing web page viewing
The remaining settings are enabled only when the ENABLE PASSWORD AUTHENTICATION setting is checked.		
User Name	User name required for access	A user name must be entered to allow future changes to BESTNet configuration. Both a user name and password are required to gain access.
Password	Password required for access	A password must be entered to allow future changes to BESTNet configuration. Both a user name and password are required to gain access.
Verify Password	Second entry of password required for confirmation of access privilege	The correct password must be reentered in this field to ensure that an entry error was not made. If the PASSWORD and VERIFY PASSWORD fields do not match, an error will be generated and the security settings will not be saved.

E-Mail Alerts

Purpose: Configure the parameters for E-mail Alerts. E-mail alerts allow a BESTlogic equation to cause an e-mail message to be sent to a predetermined e-mail address and carbon-copied (CC) to a second e-mail address. The subject line of the e-mail message can be programmed to indicate the type of event that triggered the e-mail.

Settings allow a trigger interval time delay to be added to prevent multiple e-mails from being sent when a trigger is being sent repeatedly. Separate settings allow "reminder" e-mails to be sent periodically if a trigger remains active for an extended period. Care must be taken with these settings to ensure that recipients are not "flooded" with e-mails.

NOTE

E-mail alerts are triggered by BESTlogic equations that are configured in the BESTNet section of BESTCOMS. E-mail alerts will not function unless BOTH the configuration applet AND the BESTNet e-mail equations are set.

E-mail Alerts Configuration screen settings are shown in Figure 15-6 and described in Table 15-4.

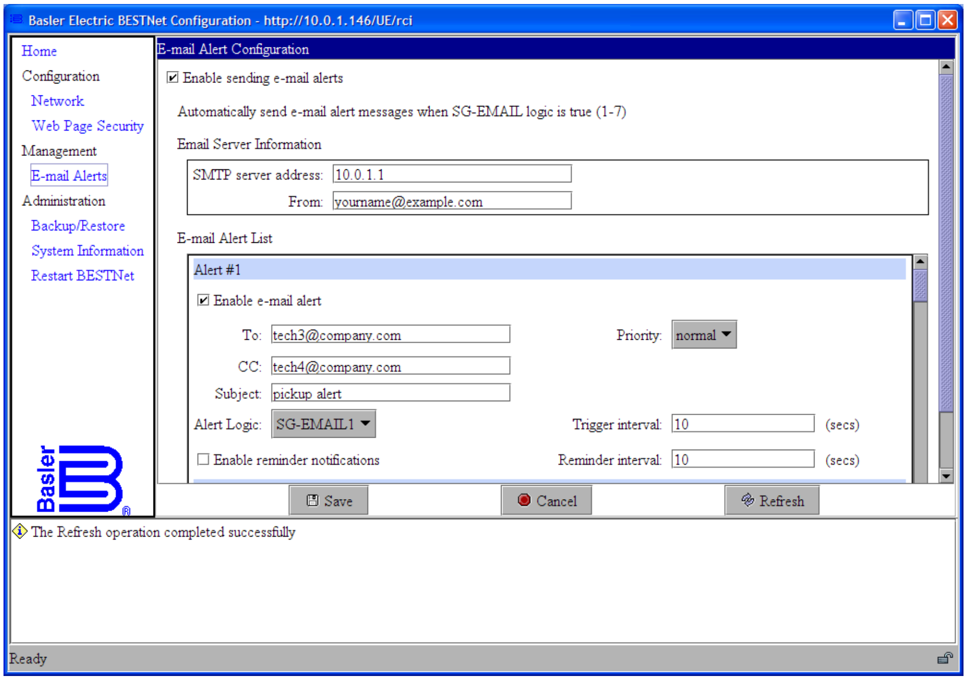


Figure 15-6. E-mail Alerts Configuration Screen

Table 15-4. E-mail Alerts Configuration Screen Settings and Information

Setting	Value	Function
Enable sending e-mail alerts	Unchecked	Disables sending of any e-mail alerts
	Checked	Enables sending of e-mail alerts
SMTP Server Address	IP address of an SMTP server	This setting field contains the IP address, in dotted decimal notation (0.0.0.0), of an SMTP server accessible by the BE1-IPS100. This server must not require authentication.
From	Any e-mail address with a valid format	This e-mail address will show in the From field of e-mails sent by the BE1-IPS100. It cannot contain spaces or punctuation other than an underscore (_). It must contain one ampersand (@).
The remaining settings are repeated for each of the 10 programmable alerts.		
Enable e-mail alert	Unchecked	Disables sending of this e-mail alert
	Checked	Enables sending of this e-mail alert
To	Any e-mail address with a valid format	When the ALERT LOGIC condition becomes true, this is the address that the BE1-IPS100 attempts to send an e-mail message to. The address cannot contain spaces or punctuation other than an underscore (_). It must contain one ampersand (@).

Setting	Value	Function
CC	Any e-mail address with a valid format	When the ALERT LOGIC condition becomes true, this is the address that the BE1-IPS100 attempts to send a carbon copy e-mail message to. The address cannot contain spaces or punctuation other than an underscore (_). It must contain one ampersand (@).
Subject	Text string , up to 63 characters	This string is placed in the subject line of the e-mail message and contains user-defined text that describes the type of error indicated by the selected ALERT LOGIC equation. Subject line examples are “Overcurrent Trip” and “Breaker Close”.
Priority	Normal	Sends e-mail with normal priority
	High	Sends e-mail with high priority. (The effect of this setting depends on the recipient’s e-mail application.)
Alert Logic	SG-EMAIL1, SG-EMAIL2 . . . SG-EMAIL7	This setting selects which BESTNet logic equation will cause e-mail message(s) to be sent by the BE1-IPS100 relay. The BESTNet logic equations are defined in BESTCOMS.
Trigger Interval	0 to 99,999 seconds	Minimum time to detect a true ALERT LOGIC condition. A setting other than zero causes the BE1-IPS100 to wait the specified time before sending another e-mail message for additional occurrences of the same trigger.
Enable Reminder Notifications	Unchecked	Send only one alert e-mail per trigger.
	Checked	Send e-mails periodically for as long as the ALERT LOGIC remains true.
Reminder Interval	0 to 99,999 seconds	Repetition interval for reminder e-mails, if enabled. A value of zero is NOT recommended and will send many e-mails per second while the ALERT LOGIC is true.

Backup/Restore

Purpose: Allows BESTNet configuration to be saved in a file on the PC or loaded from a file. This is useful for saving a configuration before making a change, or for copying a configuration from one BE1-IPS100 to another.

> **NOTE**
>
> This file will contain only settings saved by the BESTNet configuration applet. To save all settings from a BE1-IPS100, save the BESTNet settings with this function, then use BESTCOMS to save the protection settings to a .BST file. These two files together will contain all configuration information for a BE1-IPS100 relay.

Backup/Restore Configuration screen settings are shown in Figure 15-7 and described in Table 15-5.

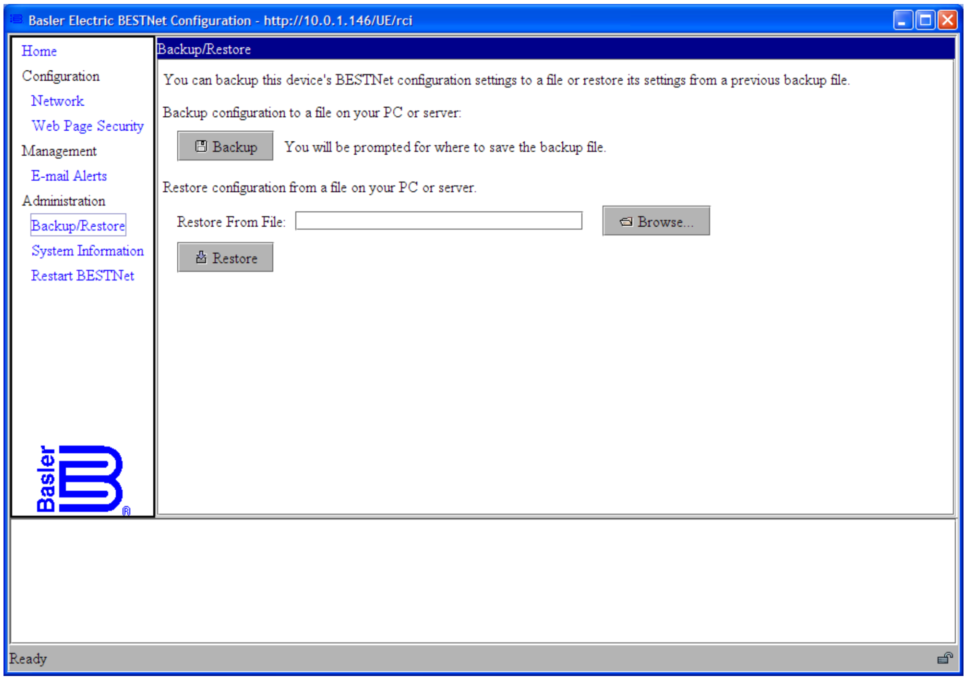


Figure 15-7. Backup/Restore Configuration Screen

Table 15-5. Backup/Restore Configuration Screen Settings and Information

Information	Value	Function
BACKUP Button	Click to activate	Click the BACKUP button to save all BESTNet settings. A dialog box will appear and allow you to select a location and file name on your PC. Click the BACKUP button in the dialog box to save BESTNet settings in a file. Clicking this button DOES NOT save ANY relay protection or configuration settings!
Restore From File	File path string	Enter a valid path to a previously saved BESTNet backup file.
BROWSE Button	Click to activate	A dialog box will appear and allow you to select a location and file name or an existing backup file on your PC. Click the BACKUP button in the dialog box to save BESTNet settings in a file.
RESTORE Button	Click to activate	After selecting a file with the BROWSE button, click the RESTORE button to open the selected file and restore the settings from that file into the BESTNet subsystem. All currently active BESTNet settings will be lost and replaced with the settings from the file.

System Information

Purpose: Provides detailed technical information about the configuration and status of the BESTNet Ethernet subsystem in the BE1-IPS100 Relay. This information is not generally required, but may be useful for troubleshooting.

The *System Information Configuration* Screen is shown in Figure 15-8.

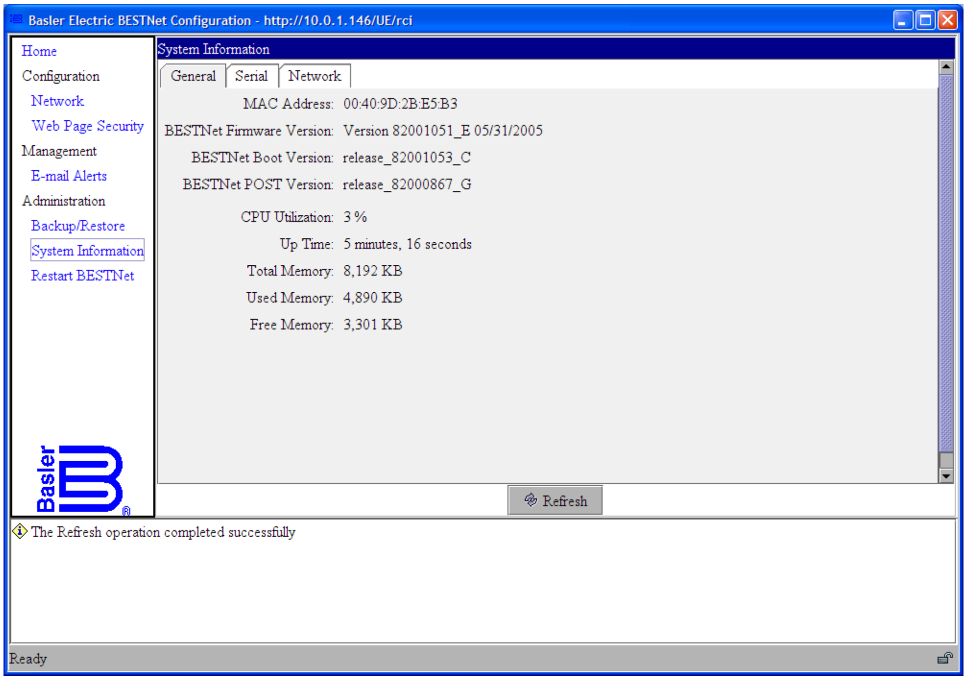


Figure 15-8. System Information Configuration Screen

Information Available from the System Information Configuration Screen

General: Provides information about the firmware installed in the BESTNet subsystem, as well as statistics about how long the BESTNet subsystem has been running and CPU and memory utilization information.

Serial: Provides information about how much data has flowed between the BESTNet subsystem and the BE1-IPS100 protection processor.

Network: Provides information about how much data has flowed between the BESTNet subsystem and Ethernet clients accessing data on the BE1-IPS100 relay.

Restart BESTNet

Purpose: Resets the BESTNet subsystem and processor. This is required for new NETWORK setting changes to take effect. Restarting BESTNet does not affect any protection settings or data.

Restart BESTNet Configuration Screen settings are shown in Figure 15-9 and described in Table 15-6.

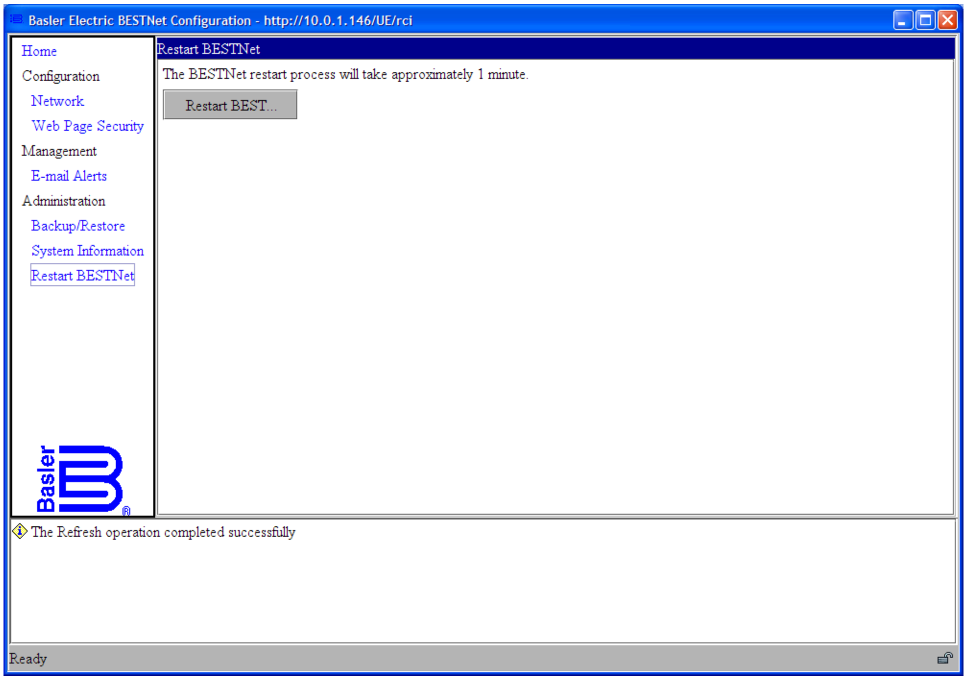


Figure 15-9. Restart BESTNet Configuration Screen

Table 15-6. Restart BESTNet Configuration Screen Settings and Information

Information	Value	Function
RESTART BESTNet Button	Click to activate	Clicking this button generates a prompt which allows you to restart the BE1-IPS100 BESTNet subsystem. This restart terminates all Ethernet connections and reinitializes the BESTNet processor. It is necessary to restart BESTNet after changing network parameters.

CONFIGURING BESTCOMS FOR ETHERNET

Connect your PC and the BE1-IPS100 Intertie Protection System to the TCP/IP LAN or intranet. An Ethernet port is provided on the back of the relay. Start BESTCOMS as described in Section 14, *BESTCOMS Software*.

Identifying the IP Address

To identify an unknown IP address, click the *Ethernet Communication* pull-down menu (available on any BESTCOMS screen) and select *Download Settings from Device.* This will display the screen shown in Figure 15-10. Click the *Scan for Connected Devices* button. Immediately, the *Basler Electric Device Discovery* (configuration utility) program will run and reflect the IP Address and Relay ID of BE1-IPS100 relays on the same LAN (as shown in Figure 15-11). (Note that all BE1-IPS100 Ethernet-enabled relays on the same subnet will be displayed. So, you may have to confirm the correct IP address with your network administrator.) On the *BE1-IPS100 Device Discovery* screen, click the *Add* button to add the second device to the list of known BE1-IPS100 relays. Click *Connect* to connect without adding the device to the list. Note this IP address since it can be used to access the web pages of the BE1-IPS100 with BESTNet.

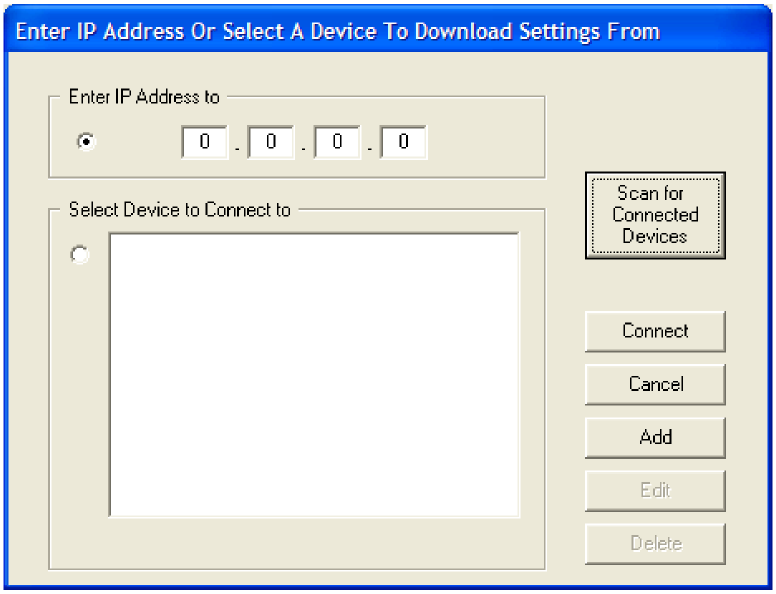


Figure 15-10. BE1-IPS100 Device List Window

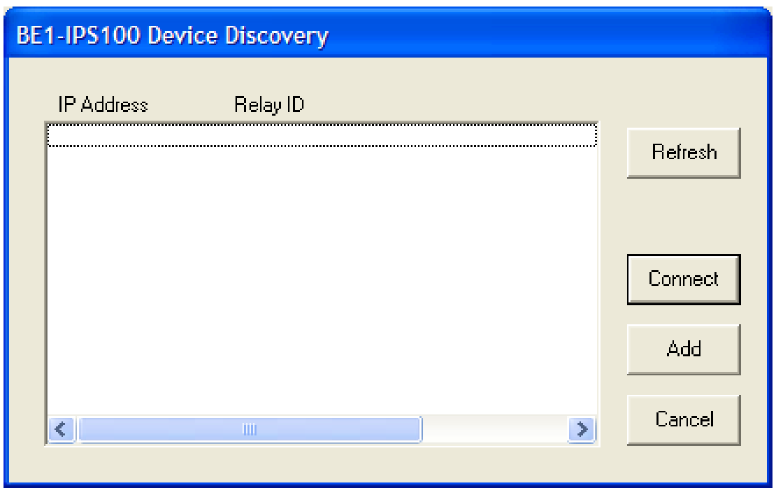


Figure 15-11. BE1-IPS100 Device Discovery Results Window

VIEWING WEB PAGES

Status Web Page

Using the PC, start your web browser and enter the IP address, determined by the Device Discovery utility, in the browser URL Block (Address Bar) and press *Enter.* The *BE1-IPS100 Digital Protection Relay Status* web page will appear (Figure 15-12).

This home page provides overall status information of the relay and of the network. Current data is presented each time the web page is refreshed. A web page is refreshed manually by pressing the keyboard F5 button or clicking the *Refresh* button in Microsoft Internet Explorer. A web page is refreshed continuously if the *Start Polling* button is clicked. The *General Status* and *System Info* panes provide the most important information from the protection and control relays. This web page is created by the BE1-IPS100 relay and provides the following "read-only" information.

- General Status
    - Relay Trouble
    - Major Alarm
    - Minor Alarm
    - Logic Alarm
    - Targets
    - Breaker

    - Recloser (status)
- System Info
    - Relay ID
    - Station ID

- Networking Settings
    - MAC (address)
    - E-mail (server)
    - DHCP (mode)
    - IP Address
    - IP Subnet Mask
    - IP Gateway

- Version Info
    - Model Number
    - Style Number
    - App Program (firmware version)
    - Boot Program (firmware version)
    - Serial Number

None of the above settings can be changed from within the web page but some can be changed through the BE1-IPS100 front panel human-machine interface (HMI) or through a PC using BESTCOMS. Refer to other sections in the instruction manual for details. Network settings can be changed by the company network administrator or through BESTCOMS as was discussed previously in this section. The *Status* web page is also the location from which other web-based features are launched, as is discussed in the following paragraphs.

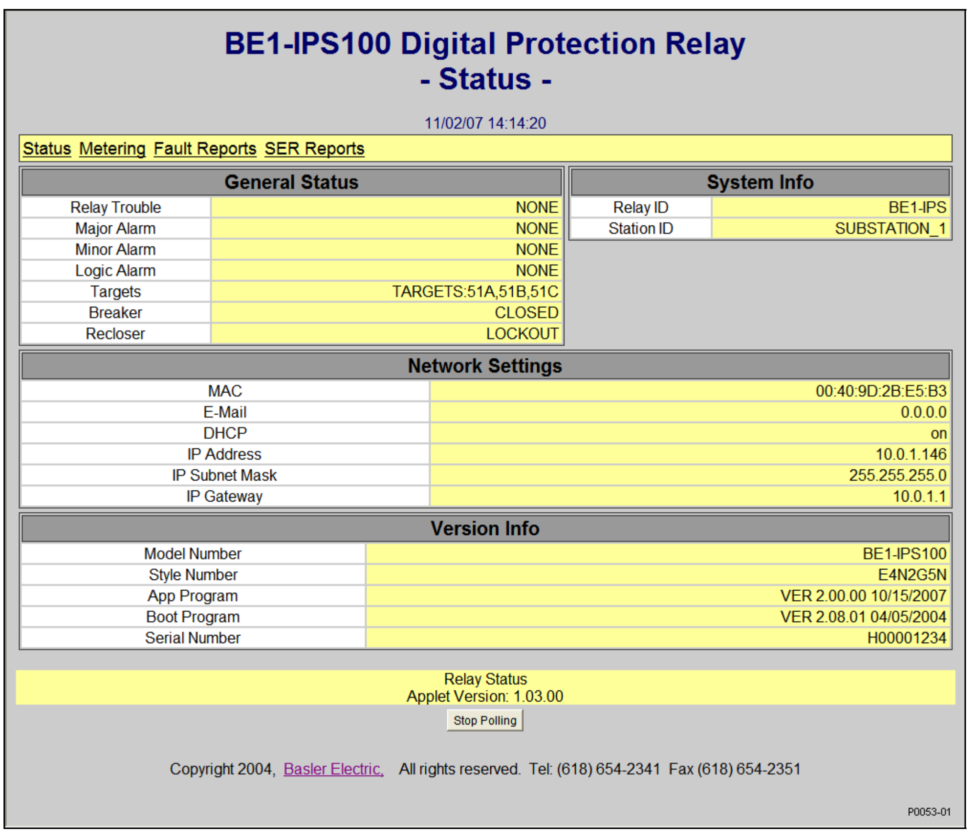
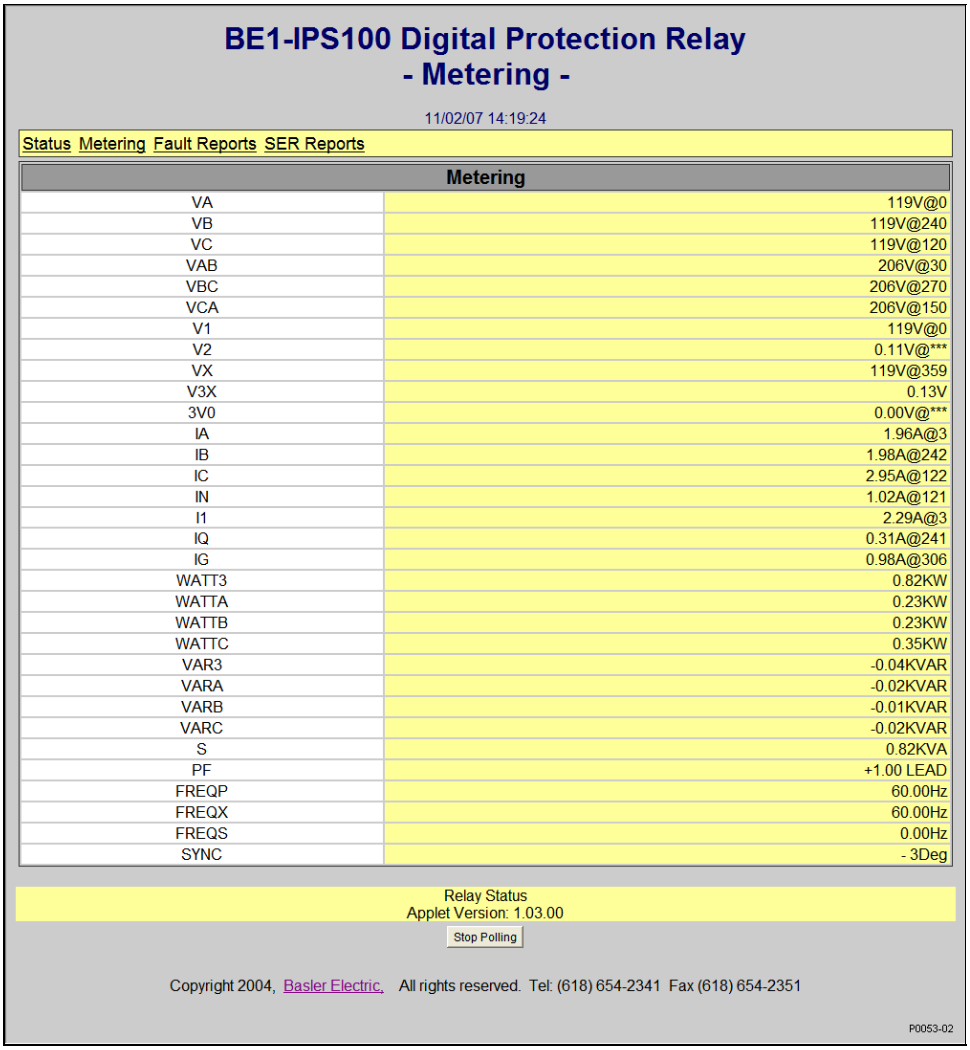


Figure 15-12. BE1-IPS100 Status Web Page

Metering Web Page

From the *Status* web page (home page) click the *Metering* hyperlink below and to the left of the page title. The *BE1-IPS100 Digital Protection Relay Metering* web page will appear as illustrated in Figure 15-13. Click the *Start Polling* button at the bottom of the page, and real-time, read-only metering information will appear. If you wish to freeze the information, click the *Stop Polling* (start/stop toggle) button. If desired, you may save a copy of the screen shot (by pressing the keyboard *Alt* and *Print Screen* keys) and pasting the image in another application for analysis. Note, too, that the relay date and time information is shown at the top of the *Metering* web page. For more information on metering, see Section 5, *Metering*, and Section 14, *BESTCOMS Software*, *Metering*. Click the *Back* button on your browser to return to the *Status* (home) web page.



BE1-IPS100 Digital Protection Relay
- Metering -

11/02/07 14:19:24

Status Metering Fault Reports SER Reports

Metering	
VA	119V@0
VB	119V@240
VC	119V@120
VAB	206V@30
VBC	206V@270
VCA	206V@150
V1	119V@0
V2	0.11V@***
VX	119V@359
V3X	0.13V
3V0	0.00V@***
IA	1.96A@3
IB	1.98A@242
IC	2.95A@122
IN	1.02A@121
I1	2.29A@3
IQ	0.31A@241
IG	0.98A@306
WATT3	0.82KW
WATTA	0.23KW
WATTB	0.23KW
WATTC	0.35KW
VAR3	-0.04KVAR
VARA	-0.02KVAR
VARB	-0.01KVAR
VARC	-0.02KVAR
S	0.82KVA
PF	+1.00 LEAD
FREQP	60.00Hz
FREQX	60.00Hz
FREQS	0.00Hz
SYNC	- 3Deg

Relay Status
Applet Version: 1.03.00

Stop Polling

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P0053-02

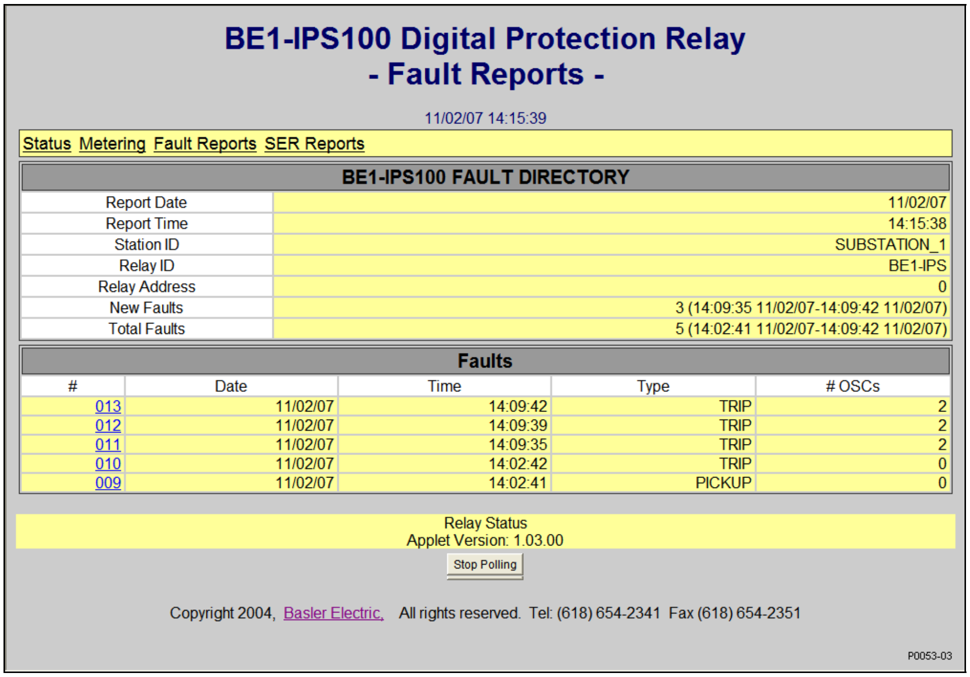
Figure 15-13. BE1-IPS100 Metering Web Page

Fault Reports Web Page

From the *Status* web page (home page) click the *Fault Reports* hyperlink below and to the left of the page title. The *BE1-IPS100 Digital Protection Relay Fault Reports* web page will appear as illustrated in Figure 15-14. The web page shows general information about the relay at the top, including the number of faults recorded and the time range during which they occurred. Below that is a list of faults, with the highest numbered faults appearing at the top. The date, time, type and number of oscillographic recordings is shown for each fault.

For a more detailed fault summary of a particular fault, click on the fault number hyperlink to show the *Fault Summary Reports* web page.

Click the web browser's *Back* button to return to the *Status* (home) web page.



BE1-IPS100 Digital Protection Relay
- Fault Reports -

11/02/07 14:15:39

Status Metering Fault Reports SER Reports

BE1-IPS100 FAULT DIRECTORY	
Report Date	11/02/07
Report Time	14:15:38
Station ID	SUBSTATION_1
Relay ID	BE1-IPS
Relay Address	0
New Faults	3 (14:09:35 11/02/07-14:09:42 11/02/07)
Total Faults	5 (14:02:41 11/02/07-14:09:42 11/02/07)

Faults

#	Date	Time	Type	# OSCs
013	11/02/07	14:09:42	TRIP	2
012	11/02/07	14:09:39	TRIP	2
011	11/02/07	14:09:35	TRIP	2
010	11/02/07	14:02:42	TRIP	0
009	11/02/07	14:02:41	PICKUP	0

Relay Status
Applet Version: 1.03.00

Stop Polling

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P0053-03

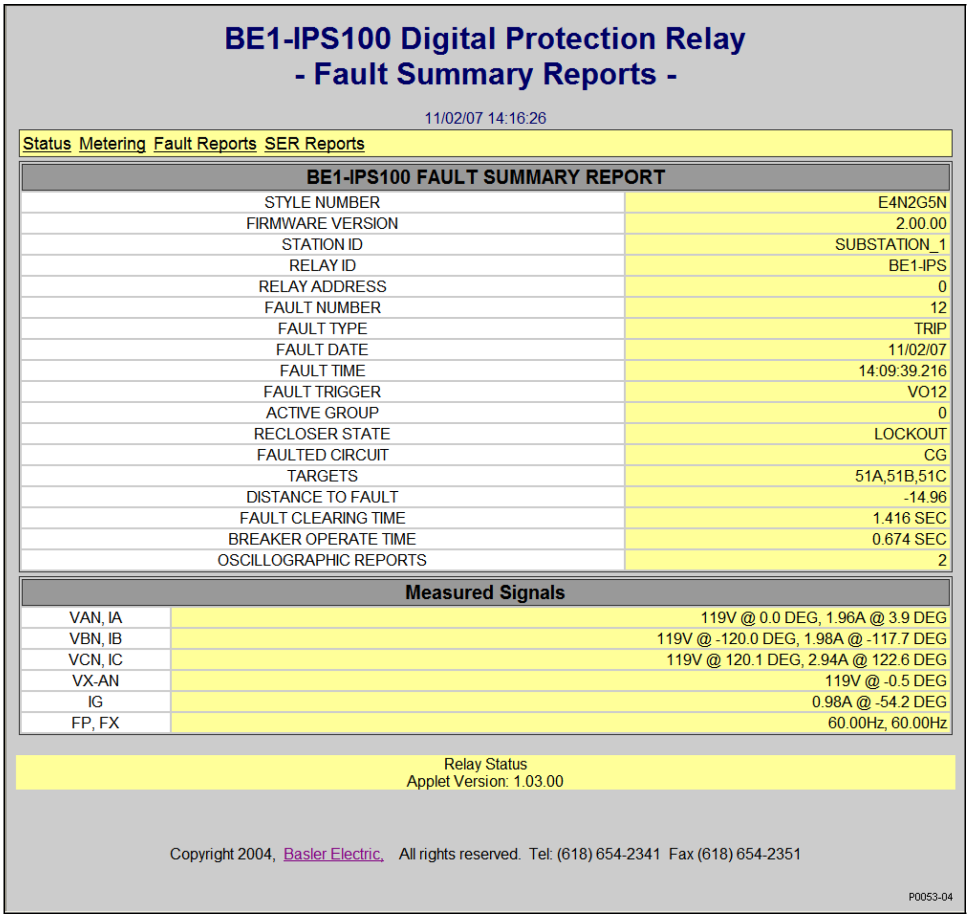
Figure 15-14. BE1-IPS100 Fault Reports Web Page

Fault Summary Reports Web Page

From the *Fault Reports* web page click the fault number hyperlink at the left of the row of interest. The *BE1-IPS100 Digital Protection Relay Fault Summary Reports* web page will appear as illustrated in Figure 15-15. This web page shows details from the selected fault summary report. General information about the fault is at the top of the page, including relay information, date, time, type, trigger, targets, and fault clearing and operate time (if applicable), as well as number of oscillographic recordings.

At the bottom under *Measured Signals,* the measured values for that fault are shown as magnitudes with angles for each measured analog quantity.

Click the *Back* button on the browser to return to the *Fault Reports* (list) web page.



BE1-IPS100 Digital Protection Relay
- Fault Summary Reports -

11/02/07 14:16:26

Status Metering Fault Reports SER Reports

BE1-IPS100 FAULT SUMMARY REPORT	
STYLE NUMBER	E4N2G5N
FIRMWARE VERSION	2.00.00
STATION ID	SUBSTATION_1
RELAY ID	BE1-IPS
RELAY ADDRESS	0
FAULT NUMBER	12
FAULT TYPE	TRIP
FAULT DATE	11/02/07
FAULT TIME	14:09:39.216
FAULT TRIGGER	VO12
ACTIVE GROUP	0
RECLOSER STATE	LOCKOUT
FAULTED CIRCUIT	CG
TARGETS	51A,51B,51C
DISTANCE TO FAULT	-14.96
FAULT CLEARING TIME	1.416 SEC
BREAKER OPERATE TIME	0.674 SEC
OSCILLOGRAPHIC REPORTS	2

Measured Signals	
VAN, IA	119V @ 0.0 DEG, 1.96A @ 3.9 DEG
VBN, IB	119V @ -120.0 DEG, 1.98A @ -117.7 DEG
VCN, IC	119V @ 120.1 DEG, 2.94A @ 122.6 DEG
VX-AN	119V @ -0.5 DEG
IG	0.98A @ -54.2 DEG
FP, FX	60.00Hz, 60.00Hz

Relay Status
Applet Version: 1.03.00

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P0053-04

Figure 15-15. BE1-IPS100 Fault Summary Reports Web Page

SER Reports Webpage

From the *Status* web page (home page) click the *SER Reports* hyperlink below and to the left of the page title. The *BE1-IPS100 Digital Protection Relay SER Reports* webpage will appear as illustrated in Figure 15-16. The upper portion of this webpage shows the *Sequence of Events Directory.* The lower portion shows the *Sequence of Events* details.

Click the web browser's *Back* button to return to the *Status* (home) web page.

BE1-IPS100 Digital Protection Relay
- SER Reports -

11/02/07 14:17:45

Status Metering Fault Reports SER Reports

BE1-IPS100 SEQUENCE OF EVENTS DIRECTORY	
Report Date	11/02/07
Report Time	14:17:35
Station ID	SUBSTATION_1
Relay ID	BE1-IPS
Relay Address	0
New Records	25 (14:08:29.723 11/02/07 - 14:11:39.834 11/02/07)
Total Records	31 (00:00:00.012 01/01/07 - 14:11:39.834 11/02/07)

Show all records

Sequence of Events

Date	Time	Point Description	Status
11/02/07	14:11:39.834	SETTING CHANGE ALARM	MADE
11/02/07	14:09:45.582	FREQ RANGE ALARM	SET
11/02/07	14:09:45.516	51 PHASE ABC TRIP 51 PHASE PICKUP VO1_LABEL VO7_LABEL VO11_LABEL VO12_LABEL OUTPUT 1 PU TRIGGER TRIP TRIGGER	FALSE FALSE FALSE FALSE FALSE FALSE OPEN FALSE FALSE
11/02/07	14:09:43.716	51 PHASE ABC TRIP VO1_LABEL VO7_LABEL VO11_LABEL OUTPUT 1 TRIP TRIGGER	TRUE TRUE TRUE TRUE CLOSED TRUE
11/02/07	14:09:43.032	FREQ RANGE ALARM	RESET
11/02/07	14:09:42.982	51 PHASE PICKUP VO12_LABEL PU TRIGGER	TRUE TRUE TRUE
11/02/07	14:09:40.682	FREQ RANGE ALARM	SET
11/02/07	14:09:40.632	51 PHASE C TRIP 51 PHASE PICKUP VO1_LABEL VO7_LABEL VO11_LABEL VO12_LABEL OUTPUT 1 PU TRIGGER TRIP TRIGGER	FALSE FALSE FALSE FALSE FALSE FALSE OPEN FALSE FALSE
11/02/07	14:09:40.616	51 PHASE AB TRIP	FALSE
11/02/07	14:09:39.933	51 PHASE ABC TRIP VO1_LABEL VO7_LABEL VO11_LABEL OUTPUT 1 TRIP TRIGGER	TRUE TRUE TRUE TRUE CLOSED TRUE
11/02/07	14:09:39.283	FREQ RANGE ALARM	RESET
11/02/07	14:09:39.216	51 PHASE PICKUP VO12_LABEL PU TRIGGER	TRUE TRUE TRUE
11/02/07	14:09:36.983	FREQ RANGE ALARM	SET
11/02/07	14:09:36.950	51 PHASE ABC TRIP 51 PHASE PICKUP VO1_LABEL VO7_LABEL VO11_LABEL VO12_LABEL OUTPUT 1 PU TRIGGER TRIP TRIGGER	FALSE FALSE FALSE FALSE FALSE FALSE OPEN FALSE FALSE
11/02/07	14:09:35.783	51 PHASE ABC TRIP VO1_LABEL VO7_LABEL VO11_LABEL OUTPUT 1 TRIP TRIGGER	TRUE TRUE TRUE TRUE CLOSED TRUE
11/02/07	14:09:35.083	FREQ RANGE ALARM	RESET
11/02/07	14:09:35.066	51 PHASE PICKUP VO12_LABEL PU TRIGGER	TRUE TRUE TRUE
11/02/07	14:08:33.606	RELAY TROUBLE ALARM RESET	

Relay Status
Applet Version: 1.03.00

Stop Polling

P0053-05

Figure 15-16. BE1-IPS100 SER Reports Web Page

E-MAIL ALERTS

The BE1-IPS100 relay with the BESTNet option can provide status alerts via e-mail. Any system or device capable of receiving electronic-mail (e-mail) can be the recipient of these alerts.

Configuring the E-mail Alerts Function

In order to use e-mail alerts, the BE1-IPS100 must be purchased with Communications Protocol option 4 or 5. Refer to Section 1 for the BE1-IPS100 style chart, Figure 1-1. Likewise, option 4 or 5 must be entered as part of the style number in BESTCOMS. (See Section 14, *BESTCOMS Software.)*

Configuring BE1-IPS100 e-mail alerts involves two steps. Both steps must be executed in order for e-mail alerts to function properly.

Step 1. The BESTlogic equations must be set using the BESTNet tab in BESTCOMS.

First, go to the *BESTNet Settings* Screen in BESTCOMS (Figure 15-17). This screen is used for setting e-mail triggers. A maximum of seven alerts can be set.

Click the *Logic* button for the desired trigger and the *BESTlogic Function Element* screen (Figure 15-18) will appear. To select the desired inputs, click the *TRIGGER* button. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then select the BESTlogic variable to be connected to the input. (It is suggested that only one variable be selected.) Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the BESTlogic Expression Builder, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

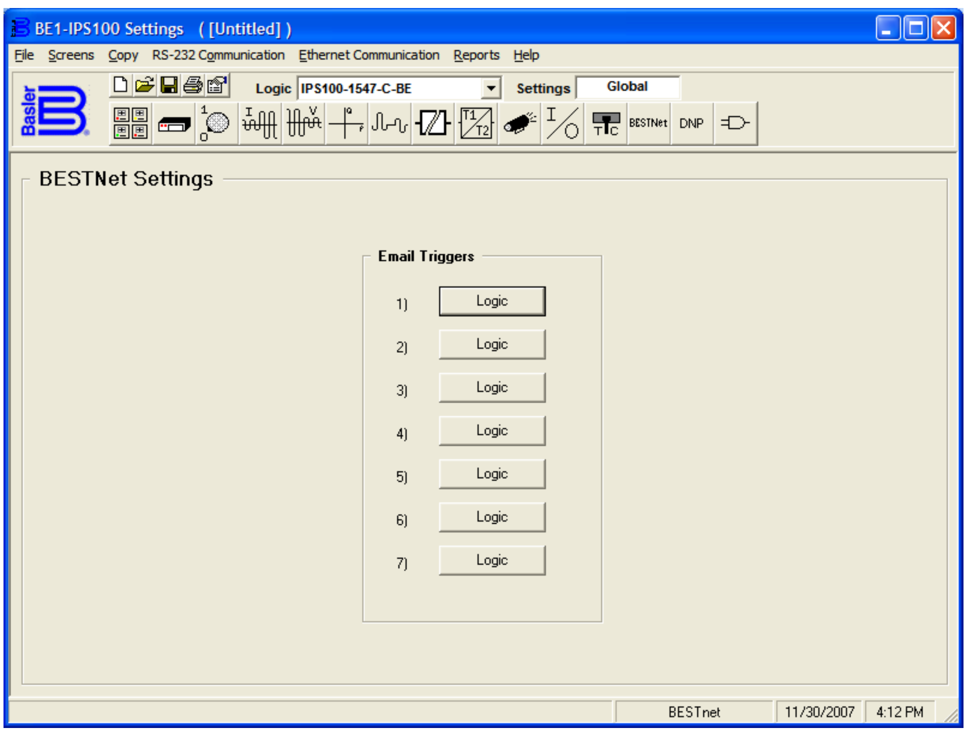

Figure 15-17. BESTNet Settings Screen

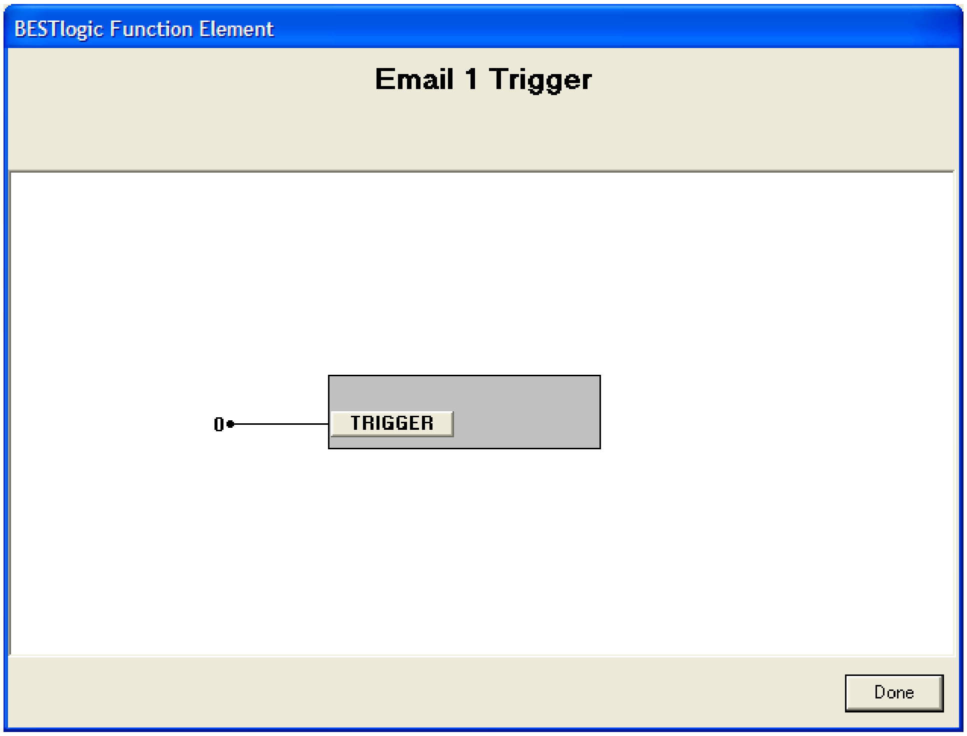

Figure 15-18. BESTlogic Function Element Screen, E-mail 1 Trigger

Step 2. The e-mail addresses, subject, etc. must be set and the appropriate e-mail alerts enabled using the BESTNet configuration applet, which is accessed with a web browser. (See *Configuring the BE1-IPS100 for Ethernet*.)

The *To: CC:* (carbon copy) and *Subject:* may be set just like an ordinary E-mail. It is suggested that the subject be tailored to match the type of trigger conditions. The functionality of E-mail 2 through 7 is the same as for E-mail 1, just described.

TCP/IP ASCII COMMUNICATION

TCP/IP ASCII communication allows a BE1-IPS100 relay Ethernet connection for the purpose of issuing ASCII commands and receiving responses. The commands and responses are identical to those available on the serial communication ports, and described in Section 11, *ASCII Command Interface*.

A TCP/IP ASCII session can be started in most versions of Microsoft Windows using the built-in Telnet application.

To be able to use Telnet to change parameters on a Basler Electric BE1-IPS100 relay, the user must have security access through the rear Ethernet port (COM1). This can be achieved by setting the GS-PW ASCII command to enable area 1 (see Section 9, *Security*) or by selecting the appropriate COM1 rear Ethernet check box or boxes in BESTCOMS as shown in Figure 15-19. **Note:** These changes can only be made using a serial (RS-232 or RS-485) connection. Attempts to enable changes for COM1 (Ethernet) will be rejected. See Section 9, *Security,* for details.

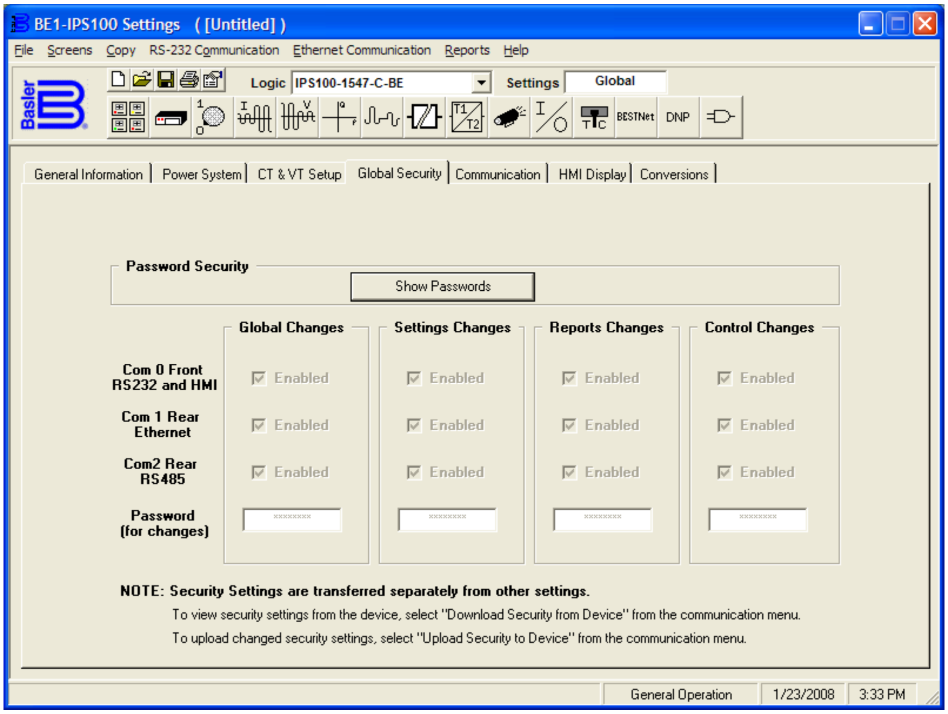

Figure 15-19. General Operation Screen, Global Security Tab

The Telnet application is normally located in the C:\Windows\System32 folder in the Microsoft Windows® operating system and can be accessed through the *Run* command of the Windows® *Start* menu. Since there is usually a search path defined for the System32 folder, it is usually not necessary to type the full path. To get help on the Telnet command, type telnet/? at a command prompt.

To access the BE1-IPS100 using Telnet, you must know the IP address of the BE1-IPS100. Refer to the paragraphs under *Identifying the IP Address* for information about determining the IP address.

The main syntax for the Telnet command is:

telnet [host IP Address] [port #]

NOTE
The Telnet access port for all BE1-IPS100 relays is 2101. This port number will be required any time a program wishes to establish a TCP/IP ASCII session with a BE1-IPS100 relay.

Telnet Command Example

Telnet into a BE1-IPS100 relay with an IP Address of 10.0.1.122.

Open the Windows *Command Prompt* window (Figure 15-20) or Windows *Run* box (Figure 15-21) and type **telnet 10.0.1.122 2101** and press *Enter.* The *Command Prompt* window will display a blinking cursor.

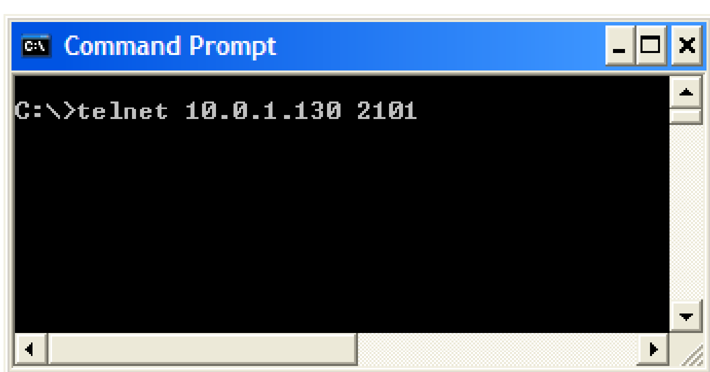

Figure 15-20. Windows Command Prompt Window

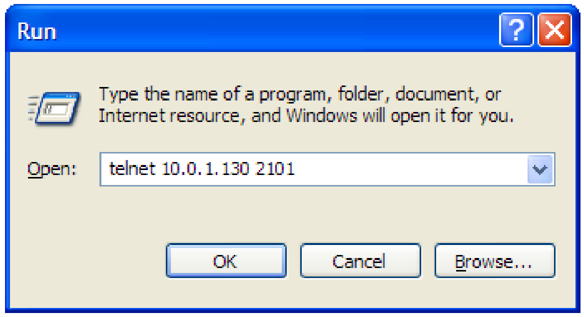

Figure 15-21. Windows Run Box

Type an ASCII command, such as RG-VER, and press Enter to verify that you have made the Telnet connection. See Figure 15-22.

Figure 15-22. Telnet Session Command and Relay Response

Once the Telnet connection is verified, you can type any BE1-IPS100 ASCII command to see settings, reports, or status information.

NOTE
The Telnet application may not echo your typed entries.

To close the Telnet connection, type **Ctrl** + **]** and then type *quit.* You can also exit the Telnet connection by clicking the *X* button in the upper right corner of the Telnet session window.

ETHERNET PORTS

An Ethernet port is available as an option and communicates using ASCII commands (relay style XXXXX4X or XXXXX5X).

The 10BaseT port is an eight-pin RJ-45 connector that connects to 10/100 megabit Category 5 copper wire media.

UNIQUE ASCII COMMANDS

SG-EMAIL Command

Purpose: Read/Set E-mail parameters where n is 1 to 7.
Syntax: SG-EMAIL[n][={e-mail logic}]
Comments: Sets up to seven different e-mail triggers which will automatically send e-mail messages when the trigger logic becomes TRUE. The following parameters are required:

[n] E-mail number 1 to 7.
{logic} This is an OR-only BESTlogic equation that when TRUE triggers the sending of an e-mail message. A entry into the sequence of event record will be logged for each e-mail message triggered.

SG-EMAIL Command Example

1. Set e-mail #2 logic to VO3, where SL-VO3=50TPT.
   >SG-EMAIL2=VO3

TROUBLESHOOTING GUIDE

For LAN Connections

Requirements

- Standard Cat 5 or Cat 5e cable less than 100 meters (328 feet) in length.
- For BESTCOMS to be able to detect the relay(s) with the scan function, the PC and relay must be on the same side of a single router (i.e., on the same network segment).
- If DHCP is not used, consult your network administrator for a static IP address, subnet mask and default gateway, appropriate for your network.
- To use e-mail alerts, an SMTP server that does not require a login (by clients on the network) must be accessible by the relay. Consult your network administrator.

Troubleshooting Suggestions

- When configuring the relay for Ethernet, the first time the configuration applet is run, you may get a security warning asking if you trust the signed applet distributed by Basler Electric. Clicking *Yes* will allow the process to continue.
- If DHCP is being used, Ethernet cable should be connected to the relay before applying power. If the Ethernet cable is connected after powering up relay, it may take a long time for the IP address to be assigned by the DHCP server. You can force this process to happen by cycling relay power while the Ethernet cable is connected.
- If some commands work and some do not, the security settings for COM1 may be set to the default state which allows reading parameters via Ethernet but prevents writing. These settings can be changed from BESTCOMS but ONLY via an RS-232 connection to the relay. For security reasons, the Ethernet port cannot be used to turn on Ethernet write options.
- Only one user can be polling the relay at a time. If another user is using the Ethernet connection, you must wait until their session is complete.

For Direct Connections (PC to Relay without a LAN)

Requirements

- A special Ethernet crossover/cross wired Cat 5 or Cat 5e cable less than 100 meters should be used. A standard Ethernet cable **will not work** for a back-to-back PC connection (i.e., directly connected without a hub/switch/router) to a relay.
- If the relay is set for DHCP, then the PC must also be set for DHCP.

Troubleshooting Suggestions

- E-mail alerts will not work on a direct PC-to-relay connection.
- On some computers, particularly those with older Windows® operating systems, it may be necessary to release/renew the DHCP connection on the PC to get it to the default subnet that matches the relay. This can be done with the ipconfig.exe or winipconfig.exe (Windows® ME, 98 or 95, only) application provided with Windows®.
- If the direct connection is not working, try using a hub, switch, router, or LAN to verify that the PC and relay are communicating. In this case, do not use crossover cable(s).
- If some commands work and some do not, the security settings for COM1 may be set to the default state which allows reading parameters via Ethernet but prevents writing. These settings can be changed from BESTCOMS but ONLY via a RS-232 connection to the relay. For security reasons, the Ethernet port cannot be used to turn on Ethernet write options.
- If the scan function of BESTCOMS shows an address of 0.0.0.0 when the relay is set to DHCP, the communications processor of the relay is still being initialized. Wait 30 seconds and then try "*Scan for Connected Devices*" or "*Refresh*" again.

- If the scan function in BESTCOMS shows the relay but no other Ethernet functions work, then it may be necessary to set the static IP address of the PC to the same IP address shown in BESTCOMS. But, change the part after the last period to a different number and change the subnet mask to 255.255.255.0.

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APPENDIX A • TIME OVERCURRENT CHARACTERISTIC CURVES

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APPENDIX A • TIME OVERCURRENT CHARACTERISTIC CURVES

GENERAL

Basler Electric inverse time overcurrent systems (ANSI Device 51) provide time/current characteristic curves that very closely emulate most of the common electro-mechanical, induction disk relays that were manufactured in North America. To further improve proper relay coordination, selection of integrated reset or instantaneous reset characteristics is also provided.

CURVE SPECIFICATIONS

Timing Accuracy (All 51 Functions): Within ±5% or ±1½ cycles, whichever is greater, for time dial settings greater than 0.1 and multiples of 2 to 40 times the pickup setting but not over 150 A for 5 A CT units or 30 A for 1 A CT units.

Sixteen inverse time functions, one fixed time function, and one programmable time function can be selected. Characteristic curves for the inverse and definite time functions are defined by the following equations and comply with IEEE C37.112 - 1996.

$$T_T = \frac{A \cdot D}{M^N - C} + B \cdot D + K \qquad \textit{Equation A-1}$$

$$T_R = \frac{R \cdot D}{\left| M^2 - 1 \right|} \qquad \textit{Equation A-2}$$

T_T = Time to trip when $M \geq 1$

T_R = Time to reset if relay is set for integrating reset when $M < 1$. Otherwise, reset is 50 milliseconds or less

D = TIME DIAL setting (0.0 to 9.9)

M = Multiple of PICKUP setting (0 to 40)

A, B, C, N, K = Constants for the particular curve

R = Constant defining the reset time.

Table A-1 lists time characteristic curve constants. See Figures A-1 through A-17 for graphs of the characteristics.

Table A-1. 51P, 51N, and 51Q Time Characteristic Curve Constants

Curve Selection	Curve Name	Trip Characteristic Constants §					Reset †
		A	B	C	N	K	R
S1	S, S1, Short Inverse	0.2663	0.03393	1.0000	1.2969	0.0280	0.5000
S2	S2, Short Inverse	0.0286	0.02080	1.0000	0.9844	0.0280	0.0940
L1	L, L1, Long Inverse	5.6143	2.18592	1.0000	1.0000	0.0280	15.750
L2	L2, Long Inverse	2.3955	0.00000	1.0000	0.3125	0.0280	7.8001
D	D, Definite Time	0.4797	0.21359	1.0000	1.5625	0.0280	0.8750
M	M, Moderately Inverse	0.3022	0.12840	1.0000	0.5000	0.0280	1.7500
I1	I, I1, Inverse Time	8.9341	0.17966	1.0000	2.0938	0.0280	9.0000
I2	I2, Inverse Time	0.2747	0.10426	1.0000	0.4375	0.0280	0.8868
V1	V, V1, Very Inverse	5.4678	0.10814	1.0000	2.0469	0.0280	5.5000
V2	V2, Very Inverse	4.4309	0.09910	1.0000	1.9531	0.0280	5.8231
E1	E, E1, Extremely Inverse	7.7624	0.02758	1.0000	2.0938	0.0280	7.7500
E2	E2, Extremely Inverse	4.9883	0.01290	1.0000	2.0469	0.0280	4.7742
A	A, Standard Inverse	0.01414	0.00000	1.0000	0.0200	0.0280	2.0000
B	B, Very Inverse (I^2t)	1.4636	0.00000	1.0000	1.0469	0.0280	3.2500
C	C, Extremely Inverse (I^2t)	8.2506	0.00000	1.0000	2.0469	0.0280	8.0000
G	G, Long Time Inverse (I^2t)	12.1212	0.00000	1.0000	1.0000	0.0280	29.0000
F	Fixed Time ∗	0.0000	1.00000	0.0000	0.0000	0.0280	1.0000
P	Programmable	0 to 600	0 to 25	0 to 1	0.5 to 2.5	0.0280	0 to 30
46	Neg.-Seq. Overcurrent	‡	0	0	2	0.0280	100

∗ Curve F has a fixed delay of one second times the Time Dial setting.

† For integrated reset, append **R** to the curve name. For example, curve **S1** has instantaneous reset. Curve **S1R** has integrated reset.

‡ Constant A is variable for the 46 curve and is determined, as necessary, based on system full-load current setting, minimum pickup, and K factor settings.

§ The programmable curve allows for four significant digits after the decimal place for every variable.

TIME OVERCURRENT CHARACTERISTIC CURVE GRAPHS

Figures A-1 through A-16 illustrate the characteristic curves of the BE1-IPS100 relay. Table A-2 cross-references each curve to existing electromechanical relay characteristics. Equivalent time dial settings were calculated at a value of five times pickup.

Table A-2. Characteristic Curve Cross-Reference

Curve	Curve Name	Similar To
S1	S, S1, Short Inverse	ABB CO-2
S2	S2, Short Inverse	GE IAC-55
L1	L, L1, Long Inverse	ABB CO-5
L2	L2, Long Inverse	GE IAC-66
D	D, Definite Time	ABB CO-6
M	M, Moderately Inverse	ABB CO-7
I1	I, I1, Inverse Time	ABB CO-8
I2	I2, Inverse Time	GE IAC-51
V1	V, V1, Very Inverse	ABB CO-9
V2	V2, Very Inverse	GE IAC-53
E1	E, E1, Extremely Inverse	ABB CO-11
E2	E2, Extremely Inverse	GE IAC-77
A	A, Standard Inverse	BS, IEC Standard Inverse
B	B, Very Inverse (I^2t)	BS, IEC Very Inverse (I^2t)
C	C, Extremely Inverse (I^2t)	BS, IEC Extremely Inverse (I^2t)
G	G, Long Time Inverse (I^2t)	BS, IEC Long Time Inverse (I^2t)
F	Fixed Time	N/A
P	Programmable	N/A

Time Dial Setting Cross-Reference

Although the time characteristic curve shapes have been optimized for each relay, time dial settings of Basler Electric relays are not identical to the settings of electromechanical induction disk overcurrent relays. Table A-3 helps you convert the time dial settings of induction disk relays to the equivalent setting for Basler Electric relays. Enter time dial settings using BESTCOMS, S<g>-51P/51N/51Q/151P/151N ASCII commands, or human-machine interface (HMI) Screens 5.x.7.1 (51P), 5.x.7.2 (51N), 5.x.7.3 (51Q), 5.x.7.4 (151P), and 5.x.7.5 (151N). For more information, refer to Section 4, *Protection and Control, Overcurrent Protection, 51 - Time Overcurrent Protection*.

Using Table A-3

Cross-reference table values were obtained by inspection of published electromechanical time current characteristic curves. The time delay for a current of five times tap was entered into the time dial calculator function for each time dial setting. The equivalent Basler Electric time dial setting was then entered into the cross-reference table.

If your electromechanical relay time dial setting is between the values provided in the table, it will be necessary to interpolate (estimate the correct intermediate value) between the electromechanical setting and the Basler Electric setting.

Basler Electric relays have a maximum time dial setting of 9.9. The Basler Electric equivalent time dial setting for the electromechanical maximum setting is provided in the cross-reference table even if it exceeds 9.9. This allows interpolation as noted above.

Basler Electric time current characteristics are determined by a linear mathematical equation. The induction disk of an electromechanical relay has a certain degree of non linearity due to inertial and friction effects. For this reason, even though every effort has been made to provide characteristic curves with minimum deviation from the published electromechanical curves, slight deviations can exist between them.

In applications where the time coordination between curves is extremely close, we recommend that you choose the optimal time dial setting by inspection of the coordination study. In applications where coordination is tight, it is recommended that you retrofit your circuits with Basler Electric electronic relays to ensure high timing accuracy.

Table A-3. Time Dial Setting Cross-Reference

Curve	Equivalent To	Electromechanical Relay Time Dial Setting											
		0.5	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**
		Basler Electric Equivalent Time Dial Setting											
S, S1	ABB CO-2	0.3	0.8	1.7	2.4	3.4	4.2	5.0	5.8	6.7	7.7	8.6	9.7
L, L1	ABB CO-5	0.4	0.8	1.5	2.3	3.3	4.2	5.0	6.0	7.0	7.8	8.8	9.9
D	ABB CO-6	0.5	1.1	2.0	2.9	3.7	4.5	5.0	5.9	7.2	8.0	8.9	10.1
M	ABB CO-7	0.4	0.8	1.7	2.5	3.3	4.3	5.3	6.1	7.0	8.0	9.0	9.8
I, I1	ABB CO-8	0.3	0.7	1.5	2.3	3.2	4.0	5.0	5.8	6.8	7.6	8.7	10.0
V, V1	ABB CO-9	0.3	0.7	1.4	2.1	3.0	3.9	4.8	5.7	6.7	7.8	8.7	9.6
E, E1	ABB CO-11	0.3	0.7	1.5	2.4	3.2	4.2	5.0	5.7	6.6	7.8	8.5	10.3
I2	GE IAC-51	0.6	1.0	1.9	2.7	3.7	4.8	5.7	6.8	8.0	9.3	10.6	N/A
V2	GE IAC-53	0.4	0.8	1.6	2.4	3.4	4.3	5.1	6.3	7.2	8.4	9.6	N/A
S2	GE IAC-55	0.2	1.0	2.0	3.1	4.0	4.9	6.1	7.2	8.1	8.9	9.8	N/A
L2	GE IAC-66	0.4	0.9	1.8	2.7	3.9	4.9	6.3	7.2	8.5	9.7	10.9	N/A
E2	GE IAC-77	0.5	1.0	1.9	2.7	3.5	4.3	5.2	6.2	7.4	8.2	9.9	N/A

THE 46 CURVE

The 46 curve (Figure A-17) is a special curve designed to emulate the $(I_2)^2$ t withstand ratings of generators using what is frequently referred to as the generator K factor.

The 46 Curve Characteristics

46 Pickup Current

Generators have a maximum continuous rating for negative sequence current. This is typically expressed as a percent of stator rating. When using the 46 curve, the user should convert the continuous I^2 rating data to actual secondary current at the relay. This value (plus some margin, if appropriate) should be entered as the pickup setting. For example, if a generator’s rated full-load current is 5 amperes, a pu setting of 0.5 A would allow 10% continuous I_2.

46 Time Dial (= Generator K factor)

The amount of time that a generator can withstand a given level of unbalance is defined by Equation A-3.

$$t = \frac{K}{(I_2)^2} \qquad \textit{Equation A-3}$$

The K factor gives the time that a generator can withstand 1 per unit negative sequence current. For example, with a K factor of 20, since $(I_2)^2$ becomes 1 at 1 per unit of current, the generator can withstand the condition for 20 seconds. Typical values for generator K factors are in the 2 to 40 range. The relay uses the “nominal current” setting of the relay (front panel Screen 6.3.7 or via the SG-NOM command) to determine what corresponds to 1 per unit current in the generator.

When curve 46 is selected, the relay changes the range of the allowed time dial to 1 to 99 (instead of the time dial range of 0.1 to 9.9 for all the other curves). The user should enter the “K” factor of the generator into the time dial field.

Relay Equation

When the 46 function is used, the relay uses the K factor (i.e., 46 time dial setting), 46 minimum pickup setting and generator full-load current to create a constant Z (see Equation A-4).

$$Z = 46 \text{ Time Dial} \left(\frac{I_{\text{Nom Setting}}}{46 \text{ Pickup Setting}} \right)^2$$

Equation A-4

The time to trip equation used in the relay is:

$$T_T = \frac{Z}{M^2} + 0.028 \text{ seconds}$$

Equation A-5

where

$$M = \frac{\text{Measured } I_2}{46 \text{ Pickup Setting}}$$

Equation A-6

which, when M > 1, reduces to:

$$T_T = 46 \text{ Time Dial} \left(\frac{I_{\text{Nom Setting}}}{I_2 \text{ Measured}} \right)^2$$

Equation A-7

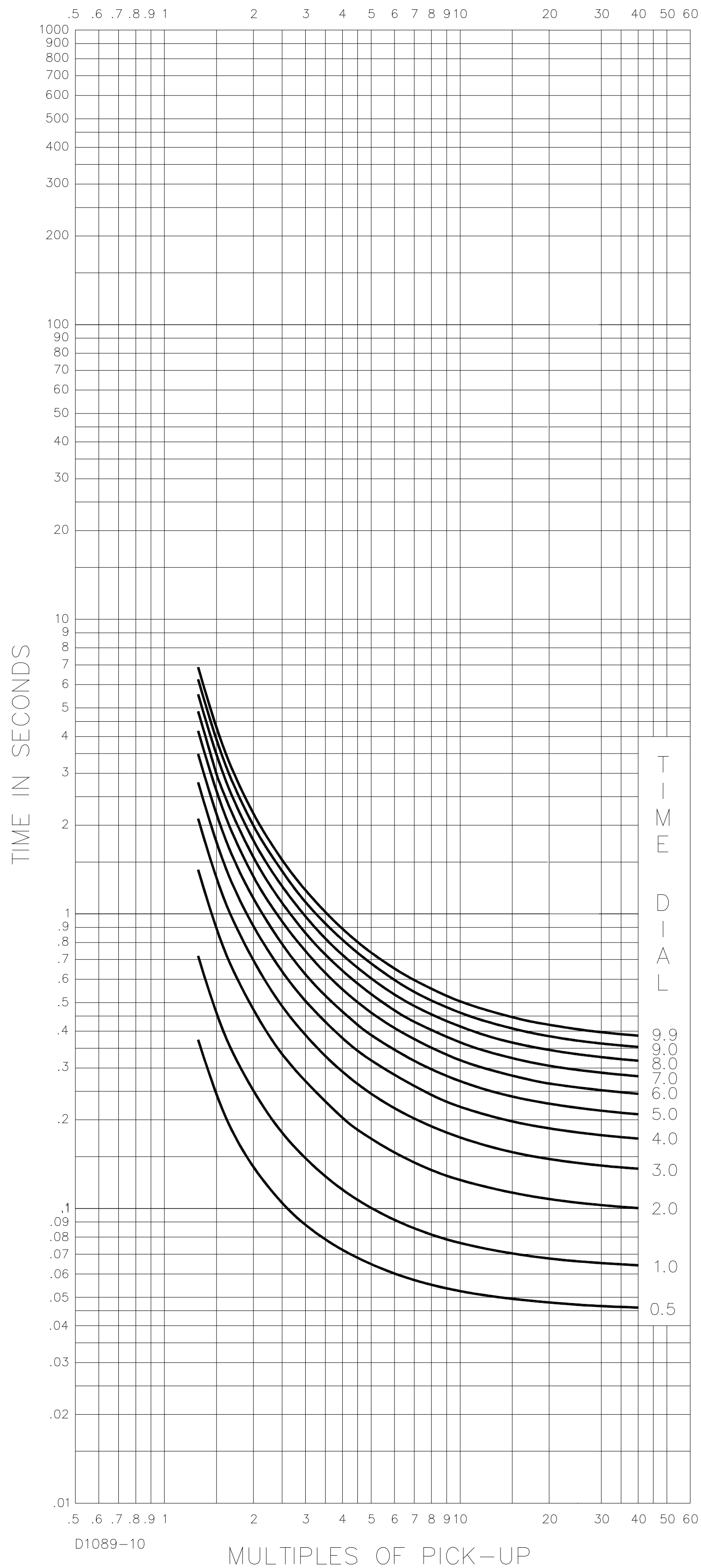


Figure A-1. Time Characteristic Curve S, S1, Short Inverse (Similar to ABB CO-2)

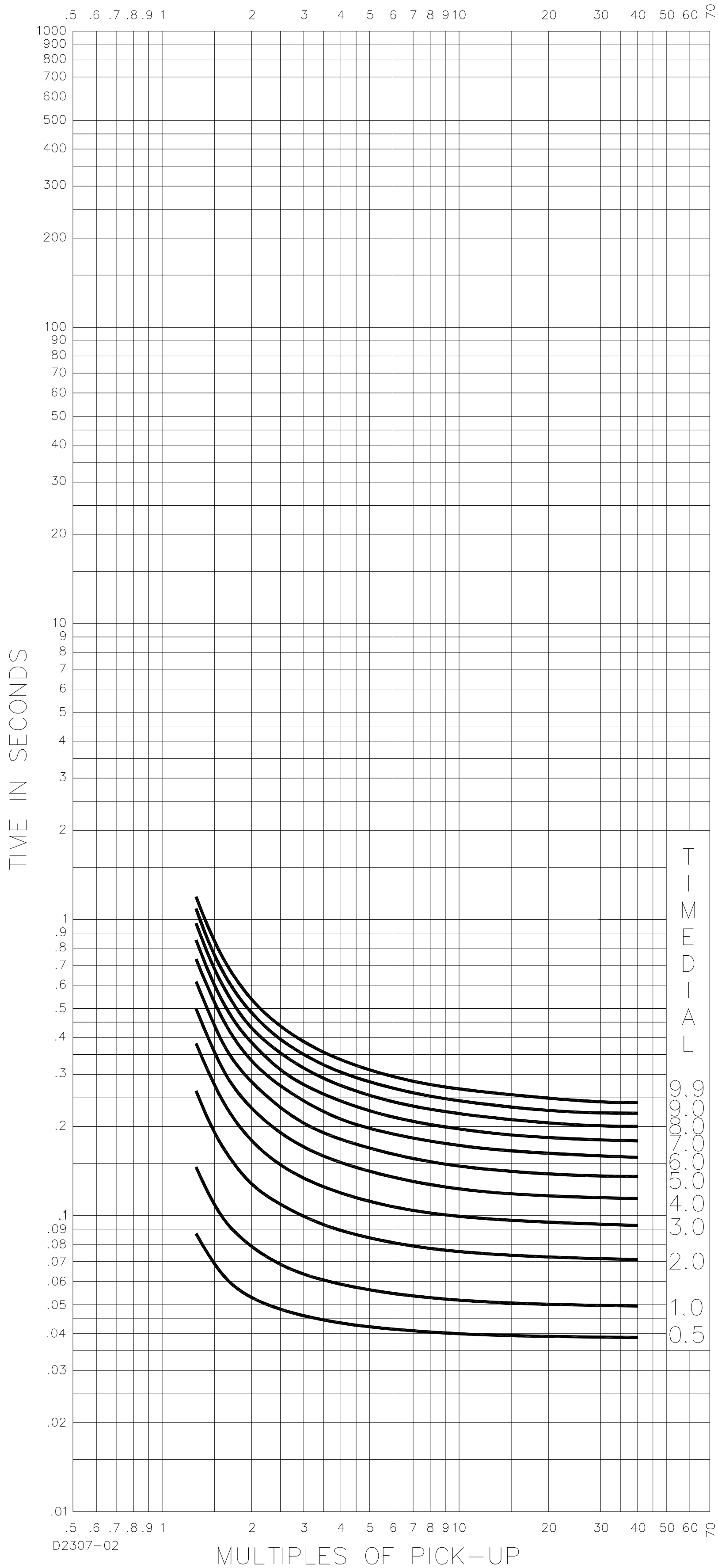


Figure A-2. Time Characteristic Curve S2, Short Inverse (Similar To GE IAC-55)

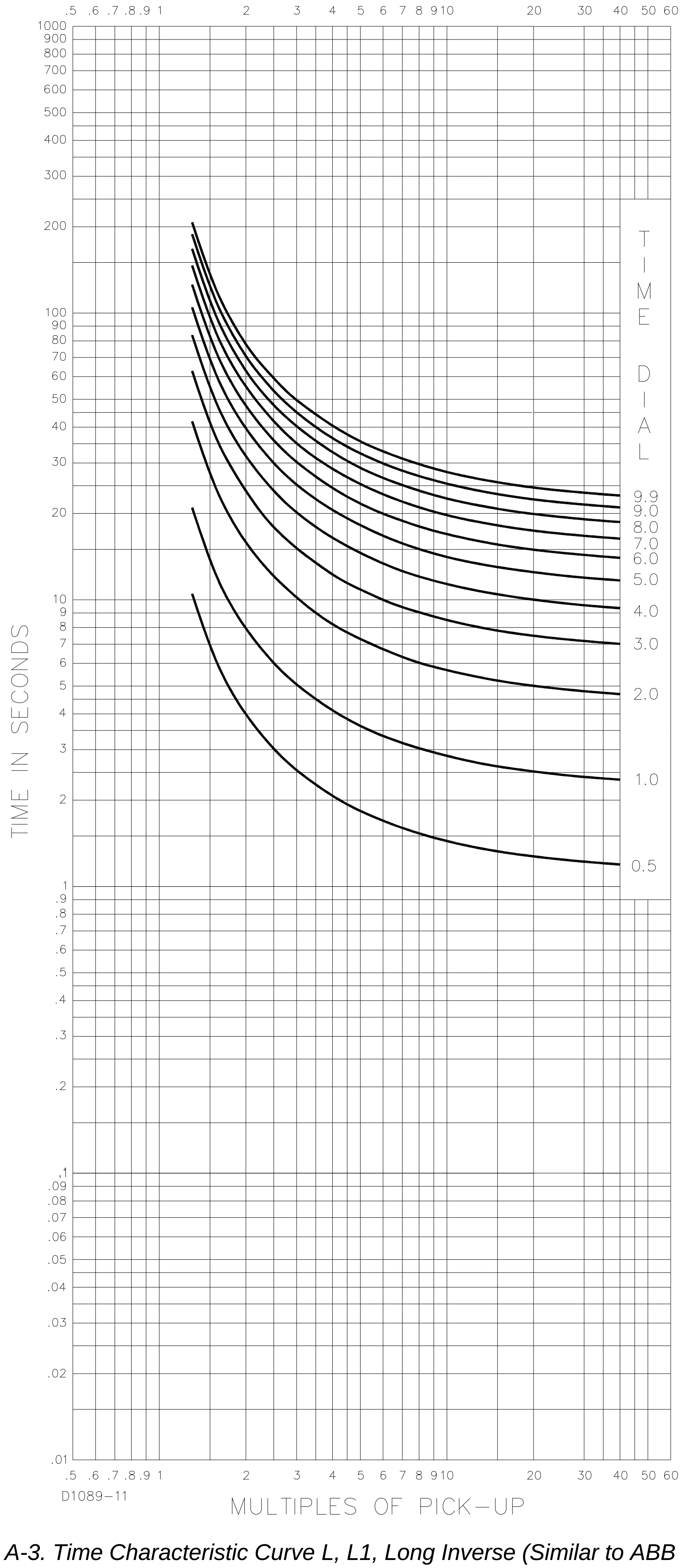


Figure A-3. Time Characteristic Curve L, L1, Long Inverse (Similar to ABB CO-5)

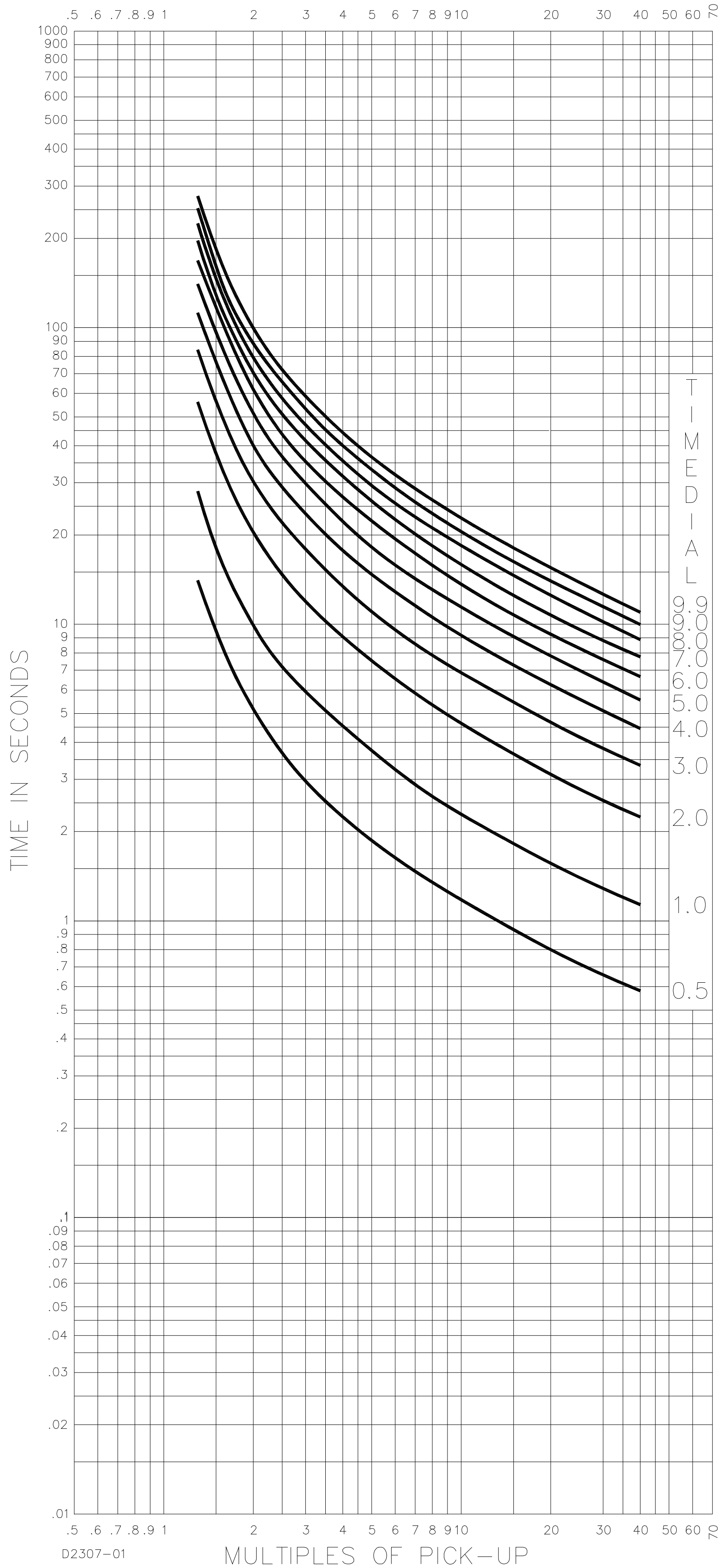


Figure A-4. Time Characteristic Curve L2, Long Inverse (Similar To GE IAC-66)

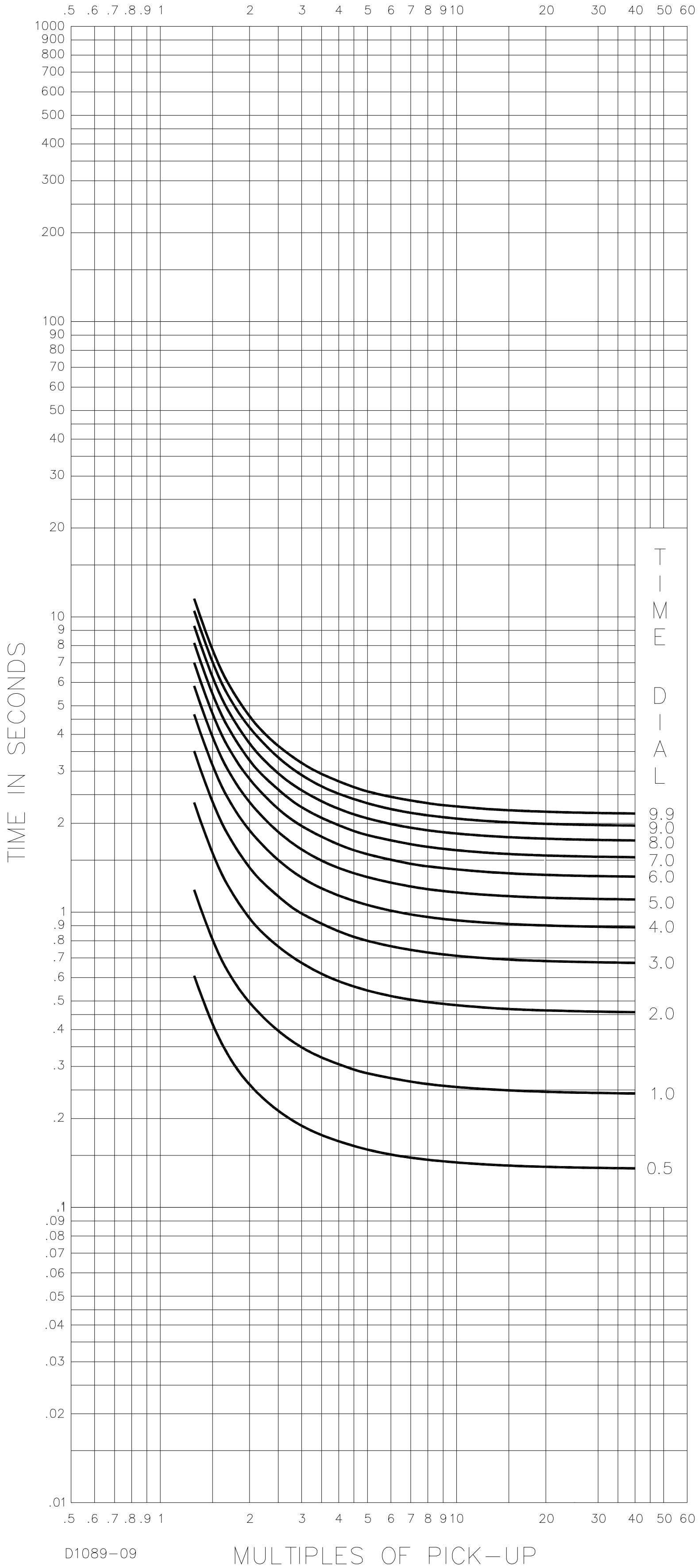


Figure A-5. Time Characteristic Curve D, Definite Time (Similar To ABB CO-6)

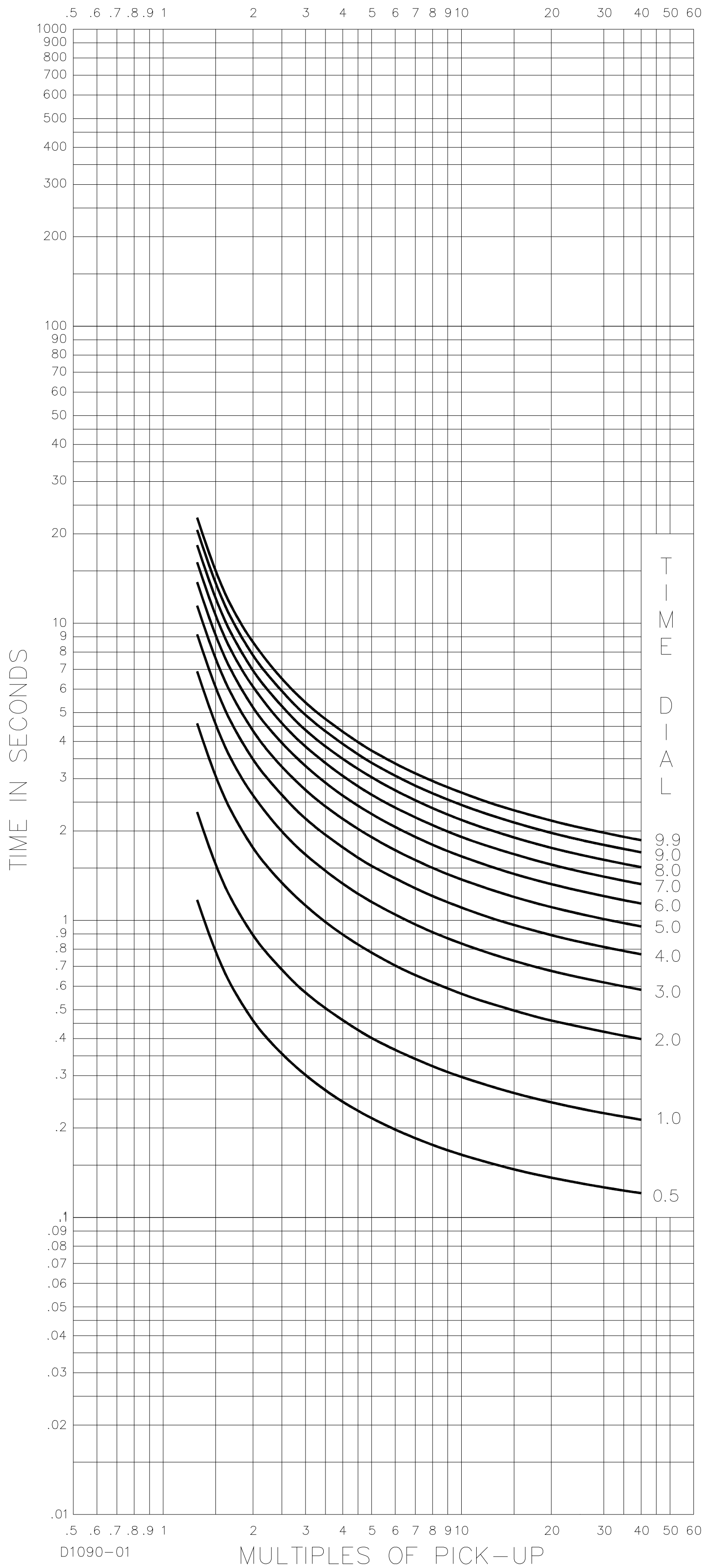


Figure A-6. Time Characteristic Curve M, Moderately Inverse (Similar to ABB CO-7)

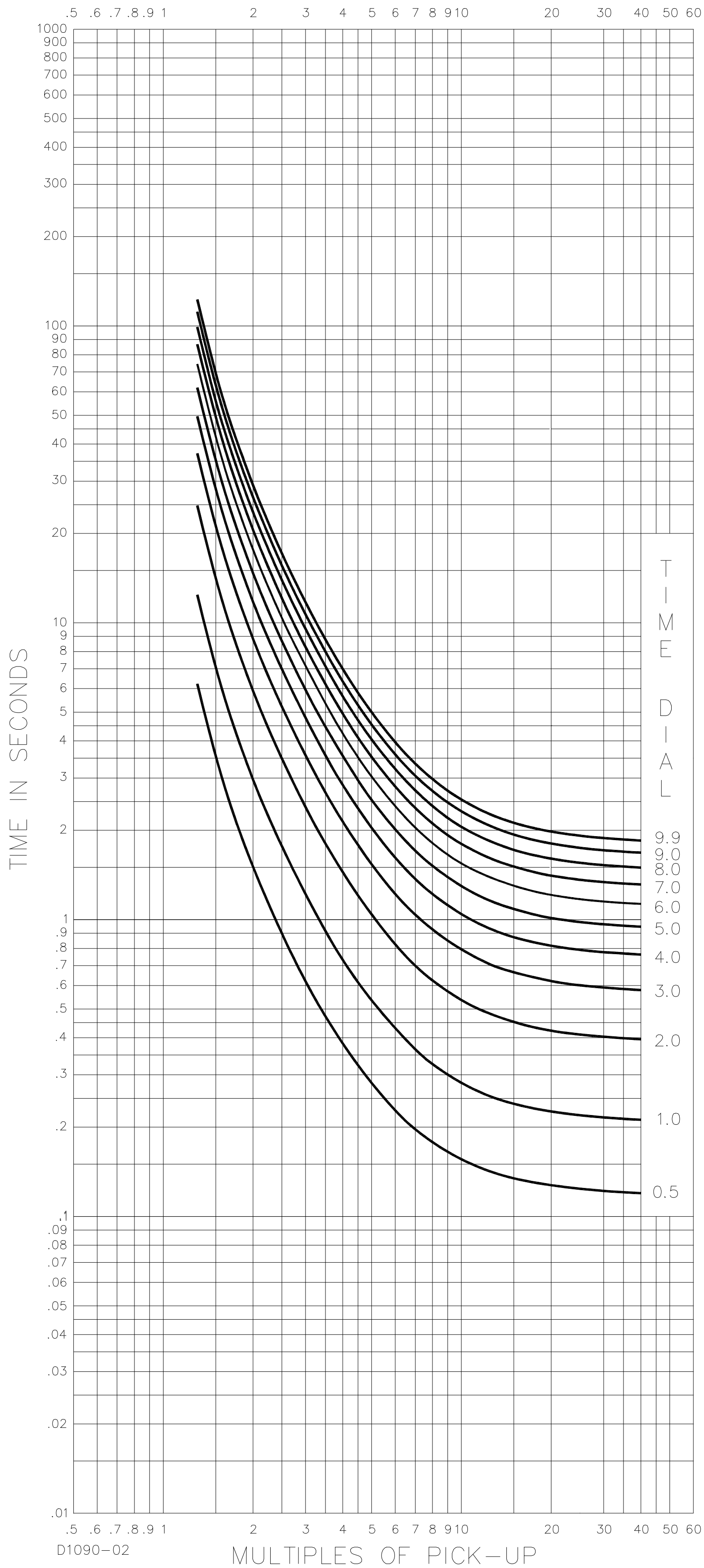


Figure A-7. Time Characteristic Curve I, I1, Inverse Time (Similar to ABB CO-8)

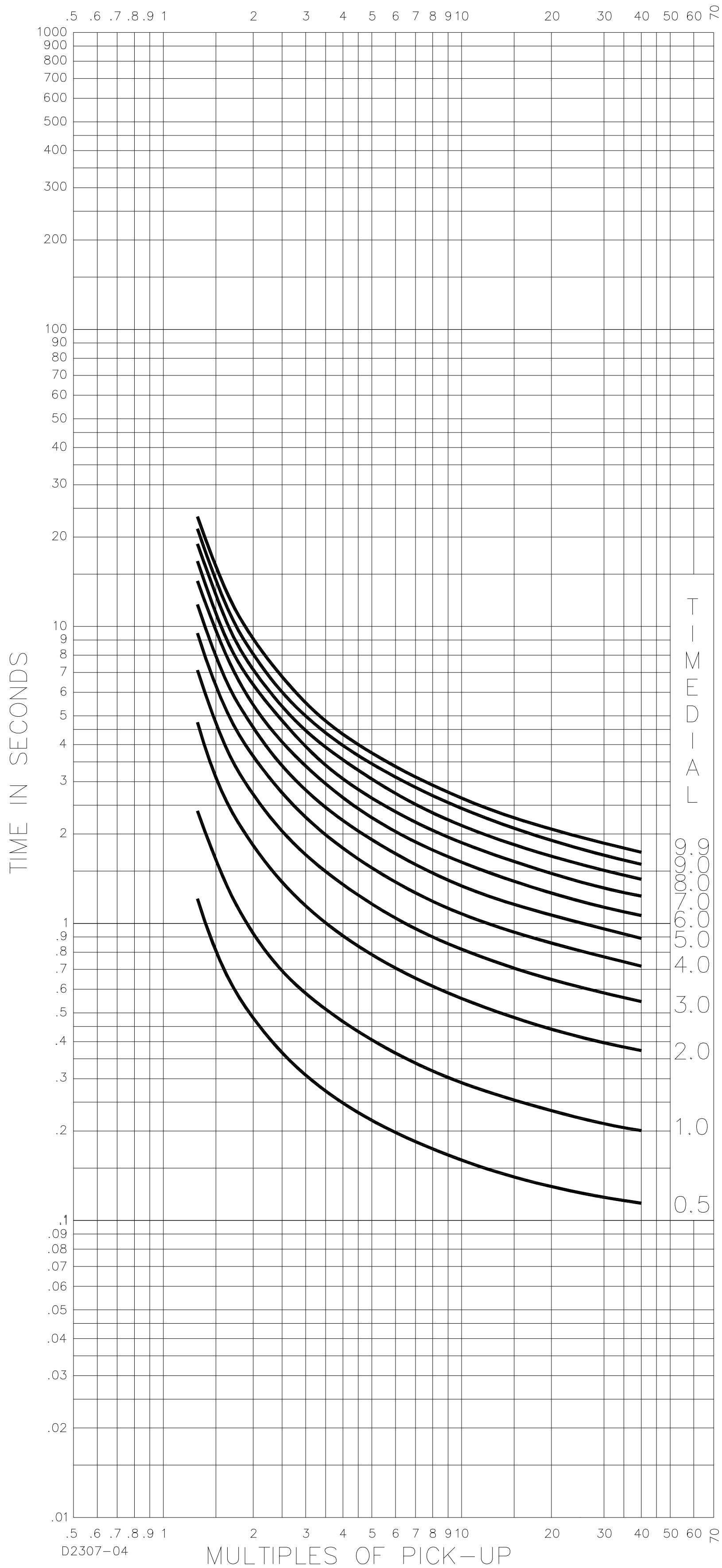


Figure A-8. Time Characteristic Curve I2, Inverse Time (Similar to GE IAC-51)

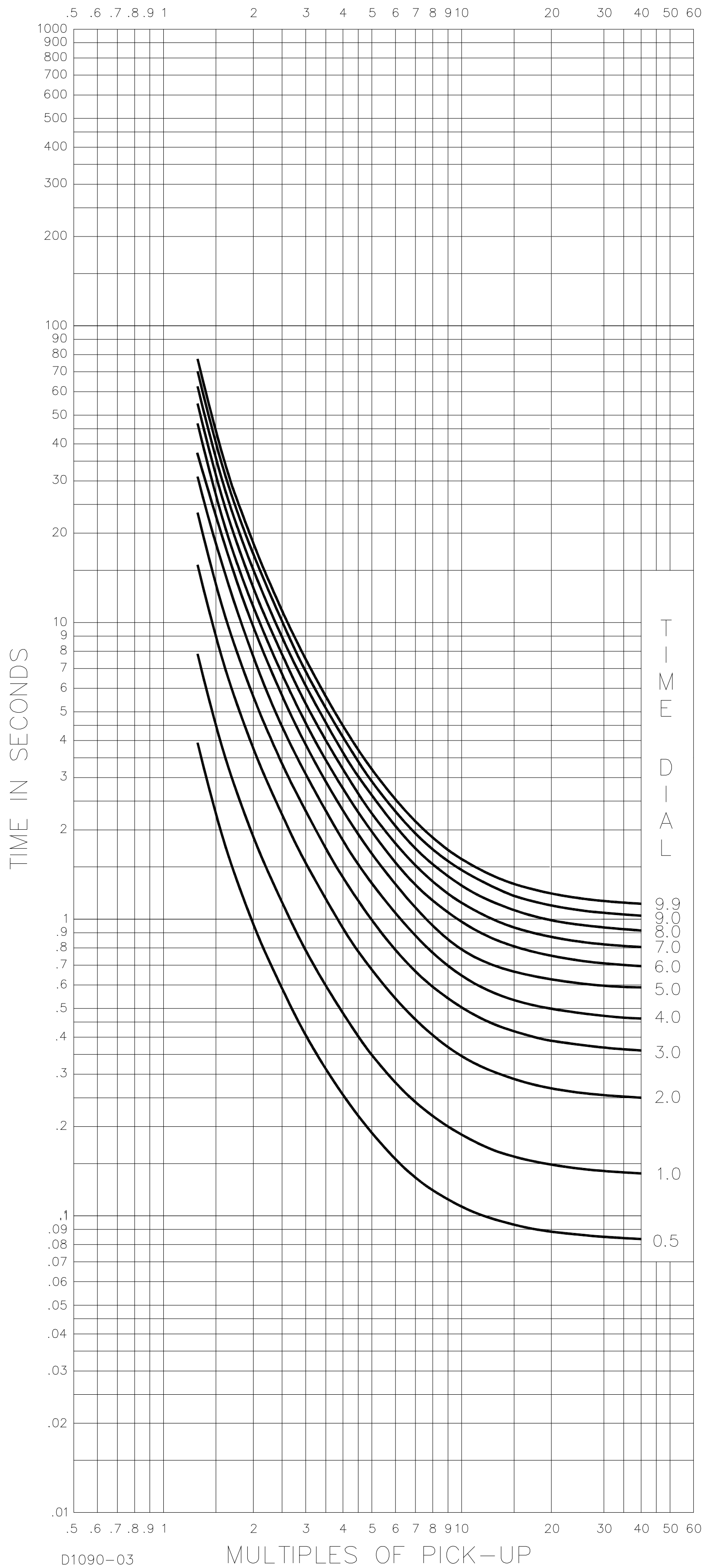


Figure A-9. Time Characteristic Curve V, V1, Very Inverse (Similar to ABB CO-9)

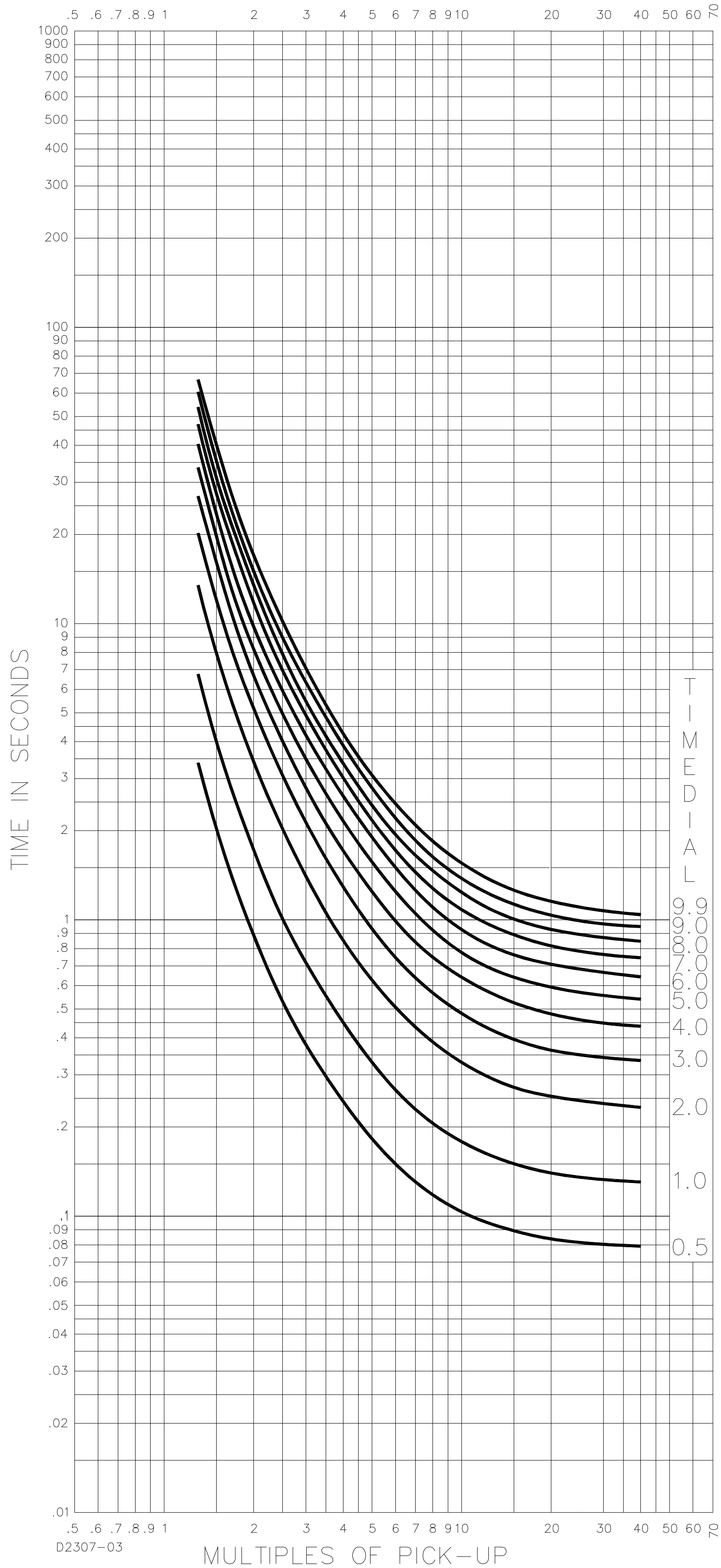


Figure A-10. Time Characteristic Curve V2, Very Inverse (Similar to GE IAC-53)

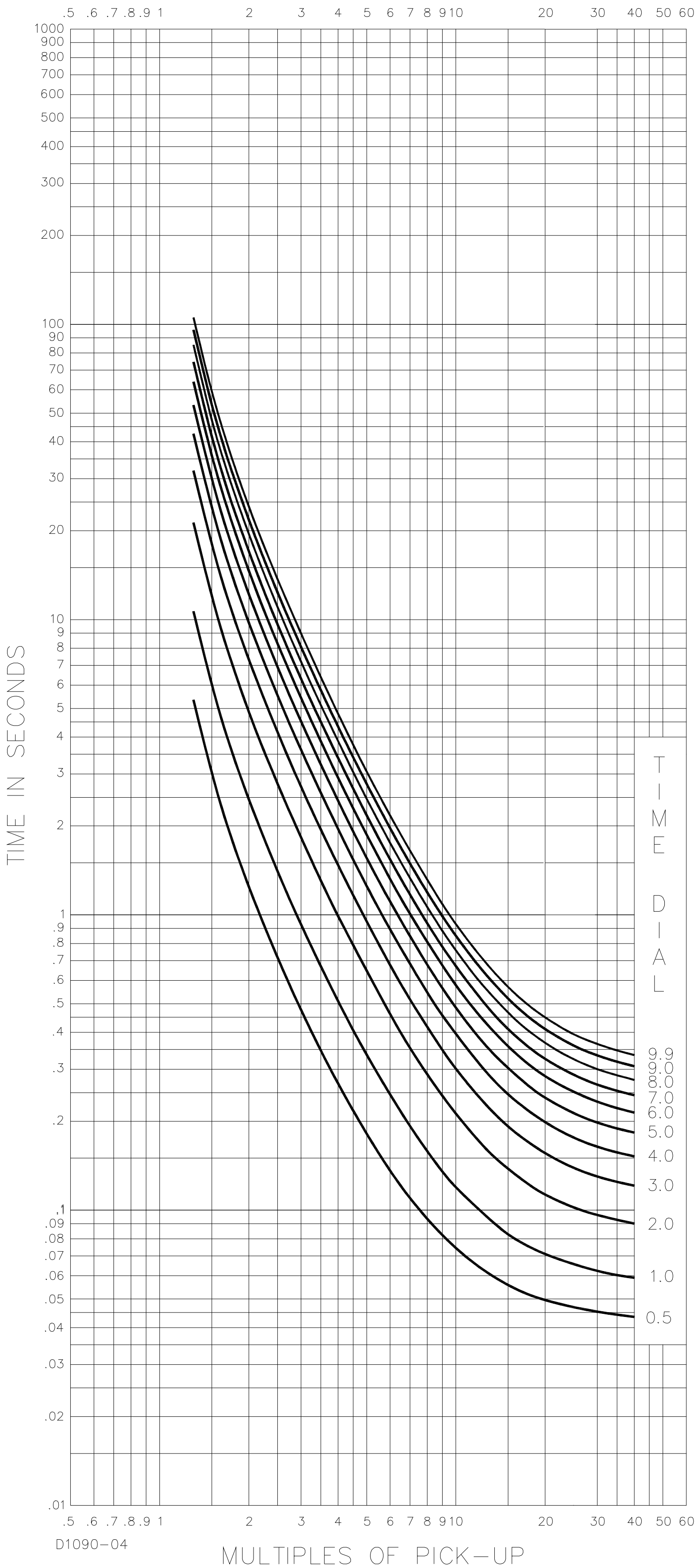


Figure A-11. Time Characteristic Curve E, E1, Extremely Inverse, (Similar to ABB CO-11)

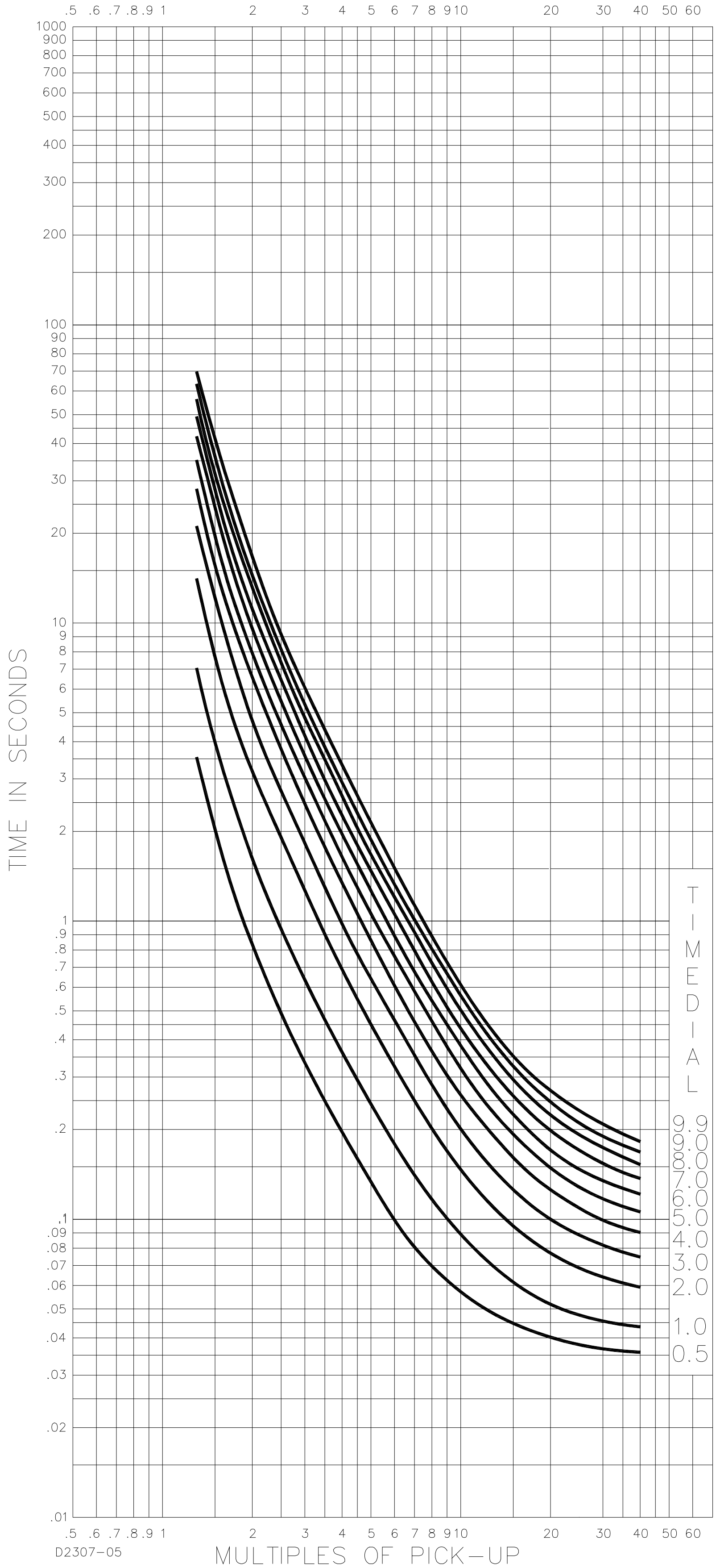


Figure A-12. Time Characteristic Curve E2, Extremely Inverse (Similar to GE IAC-77)

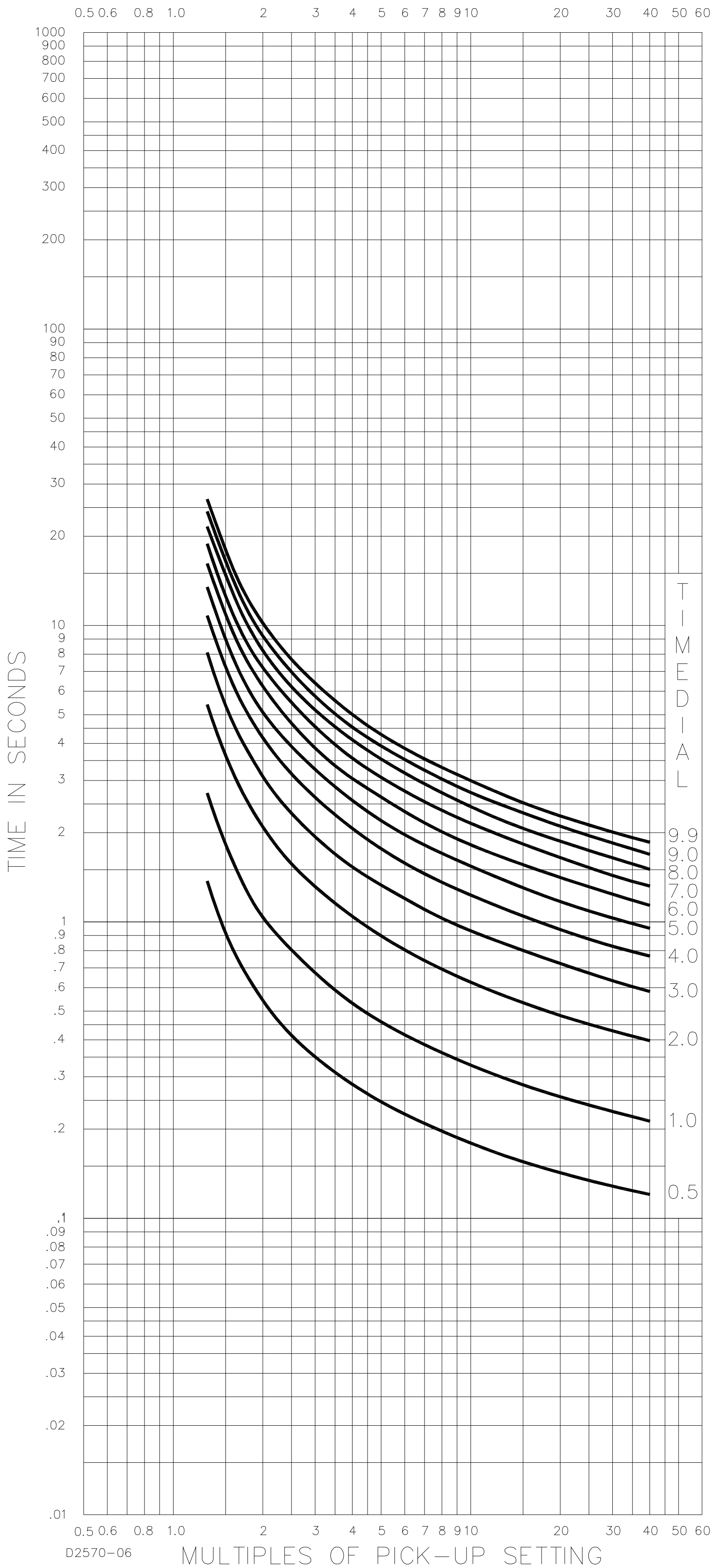


Figure A-13. Time Characteristic Curve A, Standard Inverse

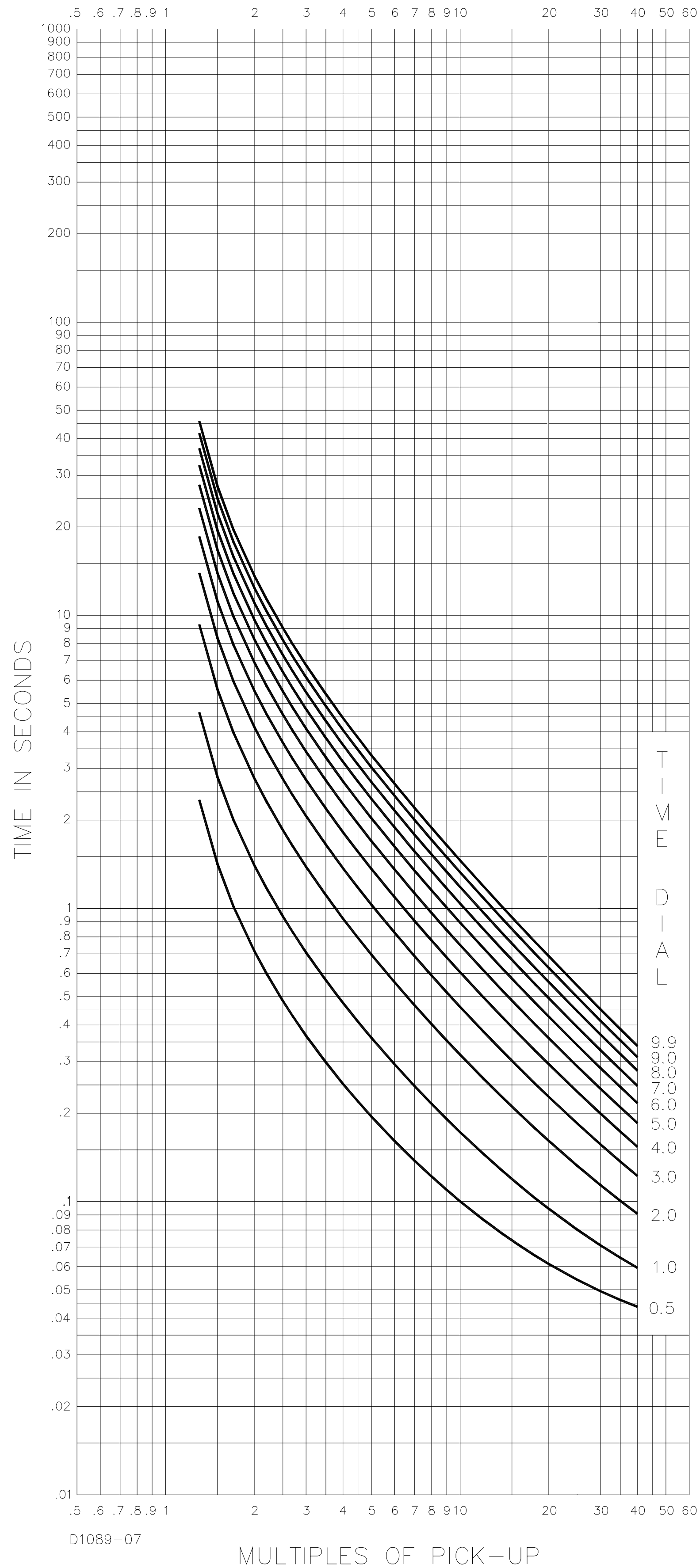


Figure A-14. Time Characteristic Curve B, Very Inverse

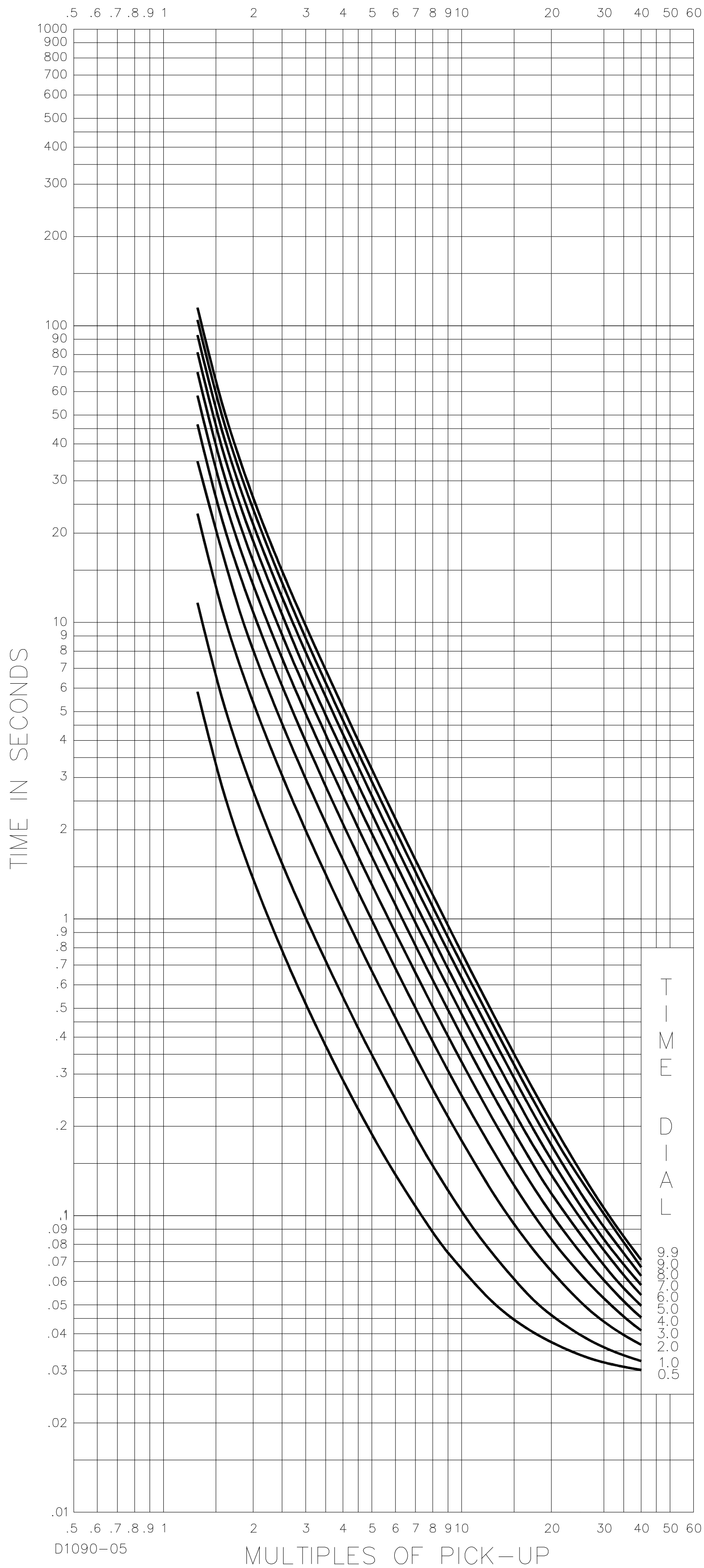


Figure A-15. Time Characteristic Curve C, Extremely Inverse

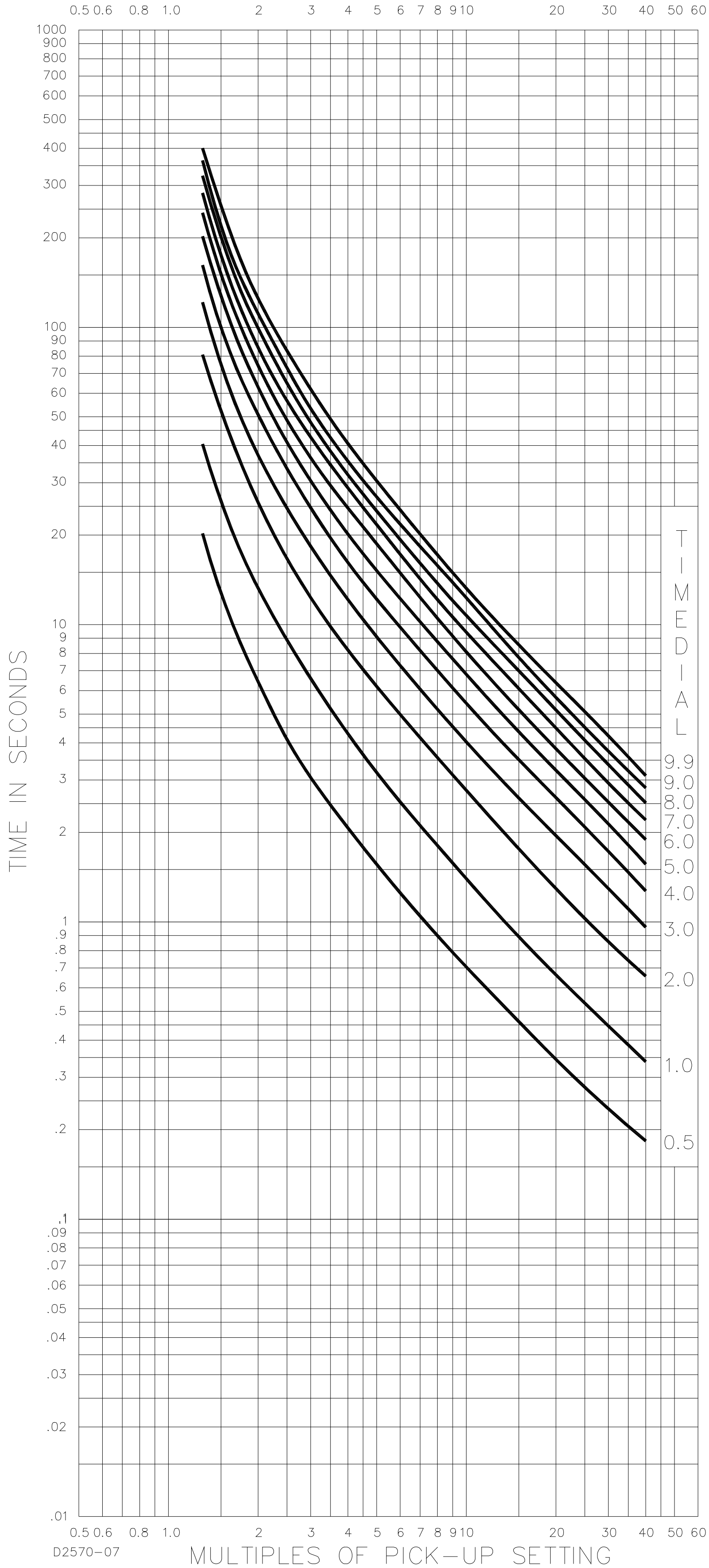
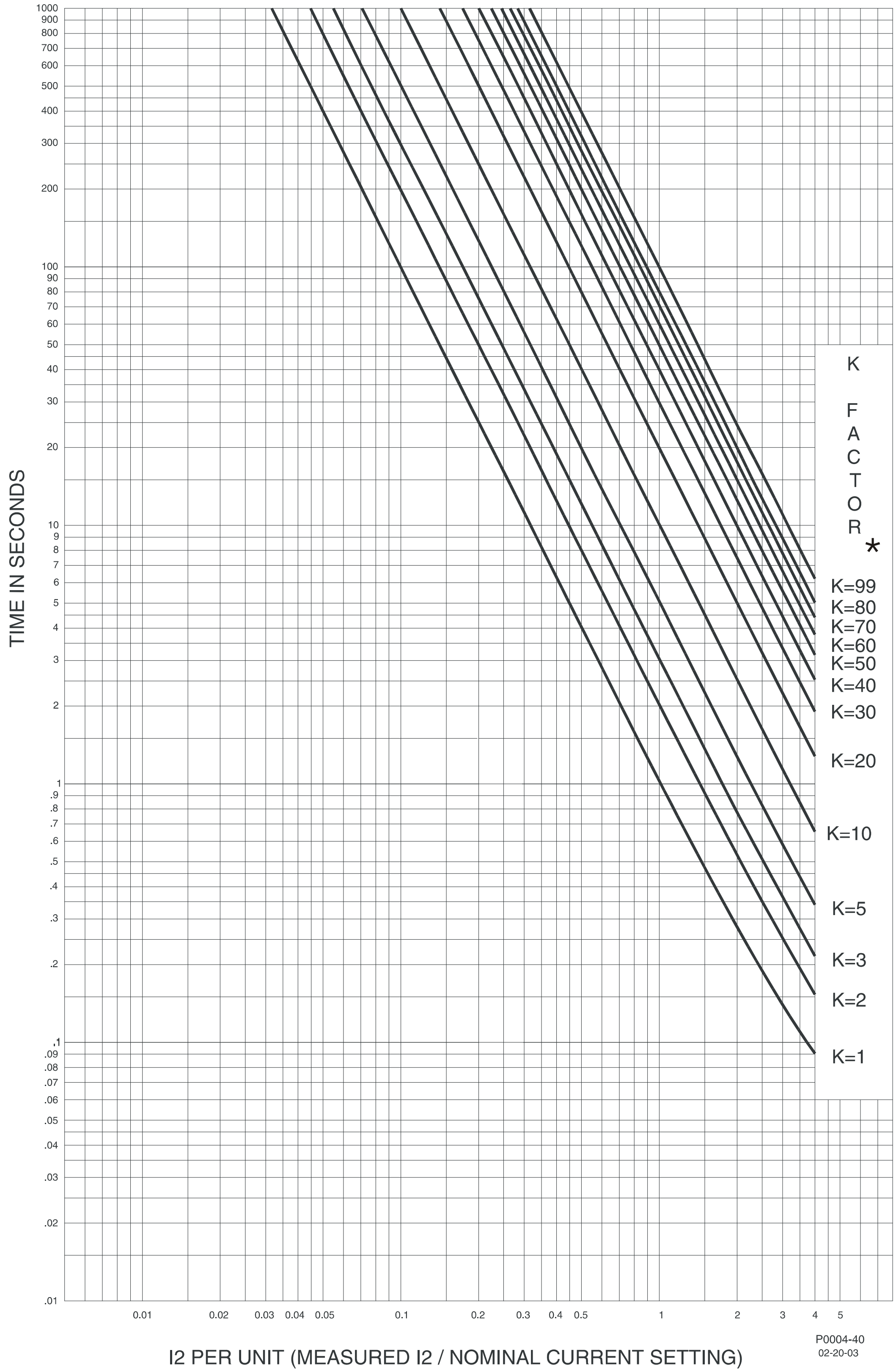


Figure A-16. Time Characteristic Curve G, Long Time Inverse



* The K factor is the time that a generator can withstand 1 per-unit I2, where 1 pu is the user's setting for full-load current.

Figure A-17. 46 Time Characteristic Curve

NOTE: Curves are shown as extending farther to the left than they will in practice. Curves stop at pickup level. For example, if the user selects 5A FLC and a pickup setting of 0.5A, the per-unit pickup is 0.1A. The relay will not pick up at less than 0.1 pu I2 for these settings.

APPENDIX B • COMMAND CROSS-REFERENCE

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Tables

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APPENDIX B • COMMAND CROSS-REFERENCE

INTRODUCTION

This appendix lists all ASCII commands, command syntax, brief command descriptions, and any corresponding HMI screens. Commands are organized by function in the following groups and tables:

- Miscellaneous (Table B-1)
- Metering (Table B-2)
- Control (Table B-3)
- Report (Table B-4)
- Setting (Table B-5)
- Alarm (Table B-6)
- General (Table B-7)
- Breaker Monitoring (Table B-8)
- Programmable Logic (Table B-9)
- User Programmable Name (Table B-10)
- Protection (Table B-11)
- Global (Table B-12)
- DNP (Table B-13)

An entry of x in the HMI Screen column represents multiple entry possibilities such as 0 or 1 for setting groups and 43 or 143 for virtual switches.

Table B-1. Miscellaneous Commands

ASCII Command	Function	HMI Screen
ACCESS[=<password>]	Read/Set access level in order to change settings.	N/A
EXIT	Exit programming mode.	N/A
HELP <cmd> or H <cmd>	Obtain help with command operation.	N/A

Table B-2. Metering Commands

ASCII Command	Function	HMI Screen
M	Read all metered values.	N/A
M-FAST[,<x>,<y>]	Read fast metered values.	N/A
M-FREQ	Read metered frequency.	3.10
M-I[<phase>]	Read metered current in primary unit.	3.5 - 3.7
M-PF	Read metered three-phase power factor.	3.9
M-S	Read metered three-phase VA in primary units.	3.9
M-SYNC	Read metered sync angle between phase and aux inputs.	3.11
M-V[<phase>]	Read metered voltage in primary units.	3.1 - 3.3
M-VAR	Read metered three-phase vars in primary units.	3.8, 3.81 - 3.83
M-3V0	Read calculated neutral voltage.	3.4
M-WATT or M-W	Read metered three-phase watts in primary units.	3.8, 3.81 - 3.83

Table B-3. Control Commands

ASCII Command	Function	HMI Screen
CO-<control>[=<mode>]	Control operation.	N/A
CS-<control>[=<mode>]	Control selection.	N/A
CS/CO-x43	Control virtual switches.	2.1.1 - 2.1.2
CS/CO-101	Control breaker control switch.	2.2.1

ASCII Command	Function	HMI Screen
CS/CO-GROUP	Control group.	2.3.1
CS/CO-OUTn	Control output n.	2.4.1

Table B-4. Report Commands

ASCII Command	Function	HMI Screen
RA[=0]	Report/Reset alarm information.	1.3
RA-LGC[=0]	Report/Reset logic alarm information.	N/A
RA-MAJ[=0]	Report/Reset major alarm information.	N/A
RA-MIN[=0]	Report/Reset minor alarm information.	N/A
RA-REL[=0]	Report/Reset relay alarm information.	N/A
RB	Read breaker status.	1.5.7
RB-DUTY[<phase>[=%duty>]	Read/Set breaker contact duty log.	4.3.2
RB-OPCNTR[=<#operations>]	Read/Set breaker operation counter.	4.3.1
RD	Report all demand data.	N/A
RD-PI<p>[=0]	Read/Reset peak demand current.	4.4.3.1 - 4.4.3.5
RD-PVAR[=0]	Read/Reset peak demand vars.	4.4.3.8 (+) 4.4.3.9 (-)
RD-PWATT[=0]	Read/Reset peak demand watts.	4.4.3.6 (+) 4.4.3.7 (-)
RD-TI[<p>]	Report today’s demand current.	4.4.1.1 - 4.4.1.5
RD-TVAR	Report today’s demand vars.	4.4.1.8 (+) 4.4.1.9 (-)
RD-TWATT	Report today’s demand watts.	4.4.1.6 (+) 4.4.1.7 (-)
RD-YI[<p>]	Report yesterday’s demand current.	4.4.2.1 - 4.4.2.5
RD-YVAR	Report yesterday’s demand vars.	4.4.2.8 (+) 4.4.2.9 (-)
RD-YWATT	Report yesterday’s demand watts.	4.4.2.6 (+) 4.4.2.7 (-)
RE	Report all energy data.	N/A
RE-KVARH[=0]	Read/Reset three-phase varhours.	4.5.3 (+) 4.5.4 (-)
RE-KWH[=0]	Read/Reset three-phase watthour.	4.5.1 (+) 4.5.2 (-)
RF[-n/NEW][=0/TRIG]	Read/Reset fault report data.	N/A
RG	Report general information.	N/A
RG-DATE[={M/D/Y}] or RG-DATE[={D-M-Y}]	Read/Set date.	4.6
RG-DST	Report Start/Stop Times and Dates for Daylight Savings Time referenced to local time.	N/A
RG-STAT	Report relay status.	N/A
RG-TARG[=0]	Report/Reset target status.	1.2
RG-TIME[=hr:mn:sc] or RG-TIME[=hr:mn<f>sc]	Report/Set time.	4.6
RG-VER	Read program version, model number, style number, and serial number.	4.7
RO-nA/B[#].CFG/DAT	Read oscillographic COMTRADE fault report.	N/A

ASCII Command	Function	HMI Screen
RS[-n/Fn/ALM/IO/LGC/NEW][=0]	Read/Reset Sequence of Events Record Data.	N/A

Table B-5. Setting Command

ASCII Command	Function	HMI Screen
S	Read all relay setting parameters.	N/A

Table B-6. Alarm Setting Commands

ASCII Command	Function	HMI Screen
SA	Read all major and minor alarm setting.	N/A
SA-24[=<alarm level>,time delay>]	Read/Set Volts Per Hertz alarm settings.	N/A
SA-BKR<n>[=<mode>,<alarm limit>]	Read/Set breaker alarm settings.	N/A
SA-DI<p>[=<alarm level>]	Read/Set demand alarm settings.	N/A
SA-DVAR[=<alarm level>,<alarm level>]	Read/Set var demand alarm setting.	N/A
SA-DWATT[=<alarm level>,<alarm level>]	Read/Set watt demand alarm setting.	N/A
SA-LGC[=<alarm num 1>[/<alarm num 2>]…[<alarm num n>]]	Read/Set logic alarm setting mask.	N/A
SA-MIN[=<alarm num 1>[/<alarm num 2>]…[<alarm num n>]]	Read/Set minor alarm setting mask.	N/A
SA-MAJ[=<alarm num 1>[/<alarm num 2>]…[<alarm num n>]]	Read/Set major alarm setting mask.	N/A
SA-RESET[=<rst alm logic>]	Read/Set programmable alarms reset logic.	N/A

Table B-7. General Setting Commands

ASCII Command	Function	HMI Screen
SG	Read all general settings.	N/A
SG-CLK[=<date format(M/D)>,<time format(12/24)>]	Read/Program time and date format.	N/A
SG-COM<#>[=<baud>,A<addr>,P<pglen>, R<reply ack>,X<XON ena>]	Read/Set serial communication protocol.	6.1.1, 6.1.3
SG-CT<x>[=<CT ratio>]	Read/Set Phase/Neutral CT ratio.	6.3.1 - 6.3.2
SG-DI<x>[=<interval>]	Read/Set P(IA/IB/IC/var/watt), N and Q demand interval.	N/A
SG-DSP[P/N]	Read analog signal dsp filter type.	N/A
SG-DST[=1/2]	Read/Set Daylight Saving Time type.	N/A
SG-DSTSTART[={Mo,D,H,M,O}]	Read/Set settings for start of Daylight Saving Time.	N/A
SG-DSTSTOP[={Mo,D,H,M,O}]	Read/Set settings for end of Daylight Saving Time.	N/A
SG-EMAIL[#[={email logic}]]	Read/Enter email logic.	N/A
SG-FREQ[=<freq(Hz)>]	Read/Enter power system frequency.	6.3.8
SG-HOLD<x>[=<1/0 hold ena>]	Read/Program output hold operation.	N/A
SG-ID[=<relayID>,<stationID>]	Read/Set relay ID and station ID used in reports.	N/A
SG-IN<x>[=<Recognition Time>,<Debounce Time>]	Read/Set input recognition/debounce.	N/A
SG-LINE[=<Z1>,<A1>,<Z0>,<A0>,<line length>]	Read/Set System Line parameters.	N/A
SG-LOG[=<interval>]	Read/Set load profile interval.	N/A
SG-NOM[=<nom volts>,<nom amps>]	Read/Set nominal voltage and current.	6.3.7

ASCII Command	Function	HMI Screen
SG-OSC[=<# records saved>]	Read/Set the number of oscillographic fault records saved.	N/A
SG-PHROT[=<phase rotation>]	Read/Set phase rotation setting.	6.3.9
SG-SCREEN<x>[=<default screen number>]	Read/Set default screen(s).	N/A
SG-SGCON[=<time>]	Read/Set SGC output time.	N/A
SG-TARG[=<x/x/…x>,<rst TARG logic>]	Report/Enable Target list and Reset Target logic.	N/A
SG-TORQ[=<Pos.-Seq. angle>,<Zero-Seq. angle>]	Read/Set Maximum Torq Angle.	N/A
SG-TRIGGER<x>[=<TRIPtrigger>,<Putrigger>, <LOGICtrigger>]	Read/Set trigger logic.	N/A
SG-UTC[=M,R,B]	Read/Set UTC information for Daylight Saving Time.	N/A
SG-VTP[=<VT ratio>,<connection>, <27/59 mode>,<51/27R mode>]	Read/Set VT ratio, connection, and 27/59 pickup mode.	6.3.3 - 6.3.4
SG-VTX[=<VT_ratio>,<connection>]	Read/Set Aux. VT ratio and connection.	6.3.5 - 6.3.6

Table B-8. Breaker Monitoring and Setting Commands

ASCII Command	Function	HMI Screen
SB	Read all breaker settings.	N/A
SB-DUTY[=<mode>,<DMAX>]	Read/Set breaker contact duty.	N/A
SB-LOGIC[=<breaker close logic>]	Read/Set breaker contact logic.	N/A

Table B-9. Programmable Logic Setting Commands

ASCII Command	Function	HMI Screen
SL[:<name>]	Obtain setting logic information.	N/A
SL-24[=<mode>,<BLK logic>]	Read/Set logic for 24 function modules.	N/A
SL-25[=<mode>,<BLK logic>]	Read/Set logic for 25 function modules.	N/A
SL-<x>27<p>[=<mode>,<BLK logic>]	Read/Set logic for 27 function modules.	N/A
SL-<x>32[=<mode>,<BLK logic>]	Read/Set logic for 32 function modules.	N/A
SL-47[=<mode>,<BLK logic>]	Read/Set logic for 47 function modules.	N/A
SL-<x>50T<p>[=<mode>,<BLK logic>]	Read/Set logic for 50 function modules.	N/A
SL-<x>51<p>[=<mode>,<BLK logic>]	Read/Set logic for 51 function modules.	N/A
SL-<x>59<p>[=<mode>,<BLK logic>]	Read/Set logic for 59 function modules.	N/A
SL-<x>62[=<mode>,<INI logic>,<BLK logic>]	Read/Set logic for 62 function modules.	N/A
SL-79[={mode},{RI logic},{STATUS logic}, {WAIT logic},{LOCKOUT logic}]	Read/Set logic for 79 function.	N/A
SL-<x>81[=<mode>,<BLK logic>]	Read/Set logic for 81 function modules.	N/A
SL-BF<x>[=<mode>,<INI logic>,<BLK logic>]	Read/Set logic for breaker failure function modules.	N/A
SL-GROUP[=<mode>,<D0 logic>,<D1 logic>,<automatic>]	Read/Set logic for setting group module.	N/A
SL-N[=<name>]	Read, set, or copy the name of the custom logic.	N/A
SL-VO<x>[=<Boolean equation>]	Read/Set output logic.	N/A
SL-<x>43[=<mode>]	Read/Set logic for Virtual Switches.	N/A
SL-101[=<mode>]	Read/Set logic for Virtual Breaker Control Switch.	N/A

Table B-10. User Programmable Name Setting Command

ASCII Command	Function	HMI Screen
SN[-<var>[=<name>,<TRUE label>,<FALSE label>]]	Read/Set user programmable names.	N/A

Table B-11. Protection Setting Commands

ASCII Command	Function	HMI Screen
S<g>	Read all protection settings.	N/A
S<g>-24[=<Pickup>,<Time Delay>,<Reset Time>,<Curve>]	Read/Set 24 pickup level, time delay, and reset delay.	5.x.1.1
S<g>-25[=<volts>,<ang>,<slip>,<mode>]	Read/Set 25 delta volts, phase angle, slip frequency, and mode.	5.x.2.1
S<g>-25VM[=<live volts>,<dead volts>,<time dial>,<logic condition>]	Read/Set 25VM pickups, time delay, and logic condition.	5.x.2.2 - 5.x.2.4
S<g>-<x>27<p>[=<Pickup>,<Time Delay>]	Read/Set 27 pickup level, time delay, and mode.	5.x.3.1 - 5.x.3.3
S<g>-27R[=<Pickup>,<mode>]	Read/Set (51)/27R control level and operating mode.	5.x.7.6
S<g>-<x>32[=<Pickup>,<Time Delay>,<Direction>,<Power>]	Read/Set 32 pickup level, time delay, and direction.	5.x.4.1 - 5.x.4.2
S<g>-47[=<Pickup>,<Time Delay>]	Read/Set 47 pickup level and time delay.	5.x.5.1
S<g>-<x>50T<p>[=<Pickup>,<Time Delay>]	Read/Set 50T pickup level and time delay.	5.x.6.1 - 5.x.6.6
S<g>-<x>51<p>[=<Pickup>,<Time Delay>,<Curve>]	Read/Set 51 pickup level, time delay, and curve.	5.x.7.1 - 5.x.7.5
S<g>-<x>59<p>[=<Pickup>,<Time Delay>]	Read/Set 59 pickup level, time delay, and mode.	5.x.8.1 - 5.x.8.4
S<g>-<x>62[=<T1>,<T2>]	Read/Set 62 time delay.	5.x.9.1 - 5.x.9.2
S<g>-67N[=<Mode>,<Quantity>]	Read/Set 67 Neutral Polarizing Mode and Quantities.	5.x.10.1 - 5.x.10.2
S<g>-79<x>[=<Time Delay>]	Read/Set 79 time delay.	5.x.11.1 - 5.x.11.4
S<g>-79SCB[=<step list>]	Read/Set 79 Sequence Controlled Block output.	5.x.11.5
S<g>-<x>81[=<Pickup>,<Time Delay>,<mode>]	Read/Set 81 pickup level, time delay, and mode.	5.x.12.1 - 5.x 12.6
S<g>-81INH[=<Pickup>]	Read/Set 81 undervoltage inhibit level.	5.x.12.7 - 5.x.12.8
SP-60FL[=<I_Blk>,<V_Blk>]	Read/Set loss of potential pickup setting.	5.3.2.1 - 5.3.2.2
SP-BF[<time>[m/s/c]]	Read/Set the breaker failure timer setting.	5.3.1.1
SP-CURVE[=<A>,<B>,<C>,<N>,<R>]	Read/Set the user programmable 51 curve parameters.	N/A
SP-GROUP<x>[=<switch time>,<switch level>,<return time>,<return level>,<protection element>]	Read/Program auxiliary setting group 1 operation.	N/A
SP-79ZONE[=<Zone Pickup Logic>]	Read/Set Zone Sequence Pickup Logic.	N/A

Table B-12. Global Setting Command

ASCII Command	Function	HMI Screen
GS-PW<t>[=<password>,<com ports(0/1/2)>]	Read or change a password.	N/A

Table B-13. DNP Setting Commands

ASCII Command	Function	HMI Screen
SDNP	Read all Distributed Network Protocol (DNP) settings.	N/A
SDNP-AIDV[=<defVarObj30>,<defVarObj32>]	Read/Set default variation for Analog Input static and/or Change Event logic.	N/A
SDNP-DB[=current dead band>,<voltage dead band>,<power dead band>]	Read/Set Analog Input event dead band for current, voltage, and power points.	N/A
SDNP-SFCNTR[=<scaling factor>]	Read/Set scaling factor for breaker operations counter.	N/A
SDNP-SFIV[=<SF of P,N,Q elements>,<SF of Ground Current>,<SF of Phase and Line Voltages>,<SF of Auxiliary Voltages>]	Read/Set scaling factors for currents and voltages.	N/A
SDNP-SFPE[=<power sec./pri.>,<power SF>,<energy SF>]	Read/Set power type, scaling factor (SF) for power and SF for energy.	N/A
SDNP-SFT[=<SF of time period>,<SF of time stamp part 2>]	Read/Set scaling factors for time period and part 2 of any time stamp.	N/A

APPENDIX C • TERMINAL COMMUNICATION

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Figures

Tables

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APPENDIX C • TERMINAL COMMUNICATION

WINDOWS® 2000/XP

HyperTerminal (provided with Windows® 2000/XP) or other stand-alone software can be used to communicate with a BE1-IPS100 relay. The following instructions are used for configuring HyperTerminal in Windows® 2000/XP to communicate with your BE1-IPS100 relay. The configuration of other stand-alone software is similar.

Step 1: Click Start: Highlight Programs, Accessories, Communication, HyperTerminal.

Step 2: Click HyperTerminal to open the folder.

Step 3: Select the file or icon labeled Hypertrm or Hypertrm.exe. Once the program has started, you will be presented with a series of dialog boxes.

Step 4: Dialog Box: Connection Description

a. Type the desired file name, for example, BE1-IPS100. See Figure C-1.

b. Click "OK".

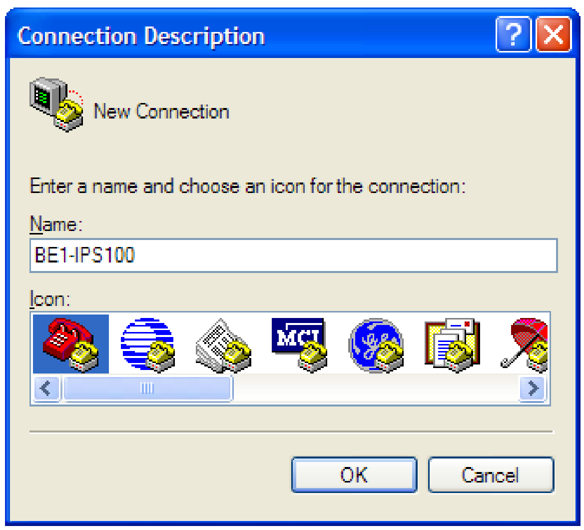

Figure C-1. Connection Description Dialog Box

Step 5: Dialog Box: Connect To

a. Click the Connect using: drop-down menu. See Figure C-2.

Select COMx, where x is the port you are using on your computer.

b. Click "OK".

Figure C-2. Connect To Dialog Box

Step 6: Dialog Box: COMx Properties

a. Make the following selections using Figure C-3 as a guide:

Set the bits per second setting so that it matches the setting of the relay. The default baud rate of the relay is 9,600.

Set the Data bits at 8.

Set the Parity to None.

Set the Stop bits at 1.

Set Flow control to Xon/Xoff.

b. Click "OK". This creates an icon with the file name entered in Step 4 and places it in the HyperTerminal folder. Future communication sessions can then be started by clicking the appropriate icon.

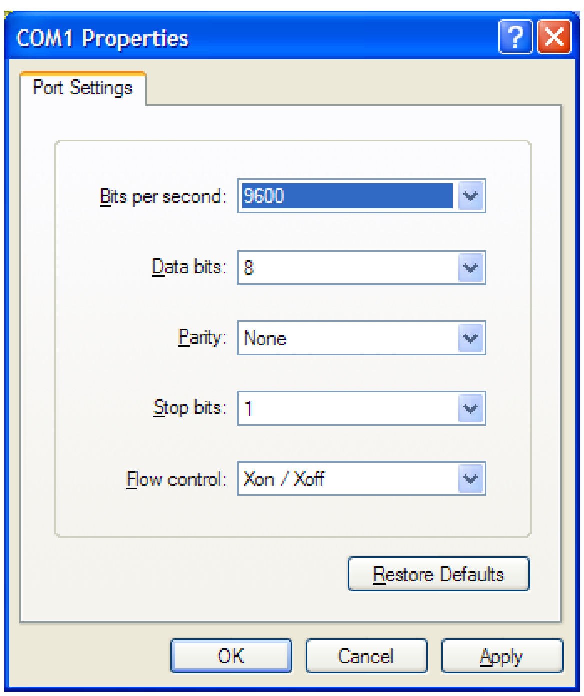

Figure C-3. COM Properties Dialog Box

Step 7: Click File/Properties on the menu bar. Click the Settings tab.

a. Make the following selections using Figure C-4 as a guide:
   Check the Terminal Keys radio button.
   Select VT-100 emulation.
   Set Backscroll buffer lines to the maximum setting of 500.

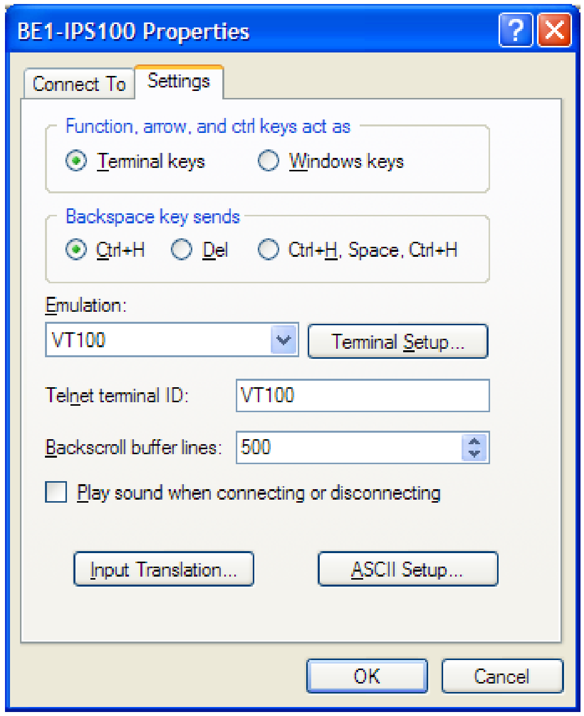

Figure C-4. Properties, Settings Tab

b. Click the ASCII Setup button. Make the following selections using Figure C-5 as a guide:
   ASCII Sending
   Place a check at Send line ends…
   Place a check at Echo typed characters…
   Select a Line delay setting of 100 to 200 milliseconds.
   Set the Character delay setting to 0 milliseconds.
   ASCII Receiving
   Disable Append line feeds…by leaving the box unchecked.
   Disable Force incoming… by leaving the box unchecked.
   Place a check at Wrap lines…

c. Click "OK".

d. Click "OK".

Step 8: Click File and click Save.

NOTE
Settings changes do not become active until the settings are saved.

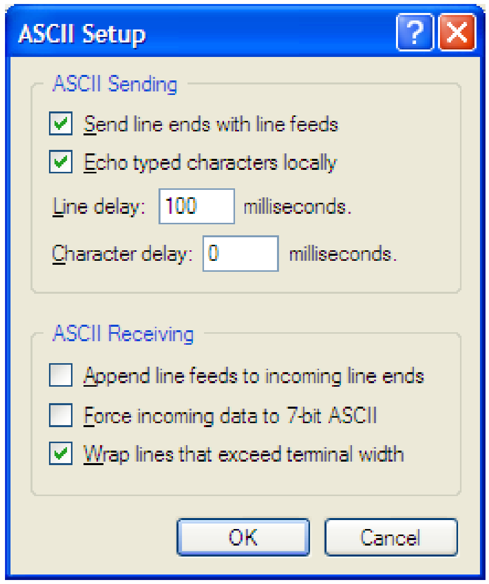

Figure C-5. ASCII Setup Dialog Box

Step 9: HyperTerminal is now ready to communicate with the relay. Table C-1 describes the required connection for each RS-232 port.

Table C-1. RS-232 Communication Ports

Connection	Type
Front Port	9-pin female DCE
PC to Front RS-232 port cable	Straight
Rear Port	9-pin female DCE
PC to Rear RS-232 port cable	Straight

WINDOWS® VISTA

HyperTerminal is not provided with Windows® Vista. Stand-alone software from other vendors can be used to communicate with a BE1-IPS100 relay. The configuration of stand-alone software is similar to that of HyperTerminal.

APPENDIX D • OVEREXCITATION (24) INVERSE TIME CURVES

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Equations

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APPENDIX D • OVEREXCITATION (24) INVERSE TIME CURVES

GENERAL

This appendix contains the inverse time curves for the overexcitation element (24). Equations D-1 and D-2 represent the trip time and reset time for constant volts per hertz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range.

CURVE SPECIFICATIONS

If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation D-1 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

$$T_T \frac{D_T}{\left(\frac{V/Hz\,\mathrm{Measured}}{V/Hz\,\mathrm{Nominal}} - 1\right)^n}$$

Equation D-1, Time to Trip

$$T_R = D_R * \frac{E_T}{FST}$$

Equation D-2, Time to Reset

where:

T_T	= Time to trip
T_R	= Time to reset
D_T	= Time dial trip
D_R	= Time dial, reset
E_T	= Elapsed time
n	= Curve exponent (0.5, 1, 2)
FST	= Full scale trip time (T_T)
E_T/FST	= Fraction of total travel toward trip that integration had progressed to. (After a trip, this value will be equal to one.)

When the measured V/Hz rises above a pickup threshold, the pickup element becomes TRUE and an integrating or definite time timer starts. If the V/Hz remains above the pickup threshold and the integration continues for the required time interval as defined by the equations shown above and the set time dial, the trip output becomes TRUE. If the measured V/Hz drops below pickup before timeout to trip, either an instantaneous or a time delayed integrating reset can be selected.

The following sets of curves (Figures D-1 through D-6) are shown first with the time axis on the vertical and then on the horizontal for ease of use.

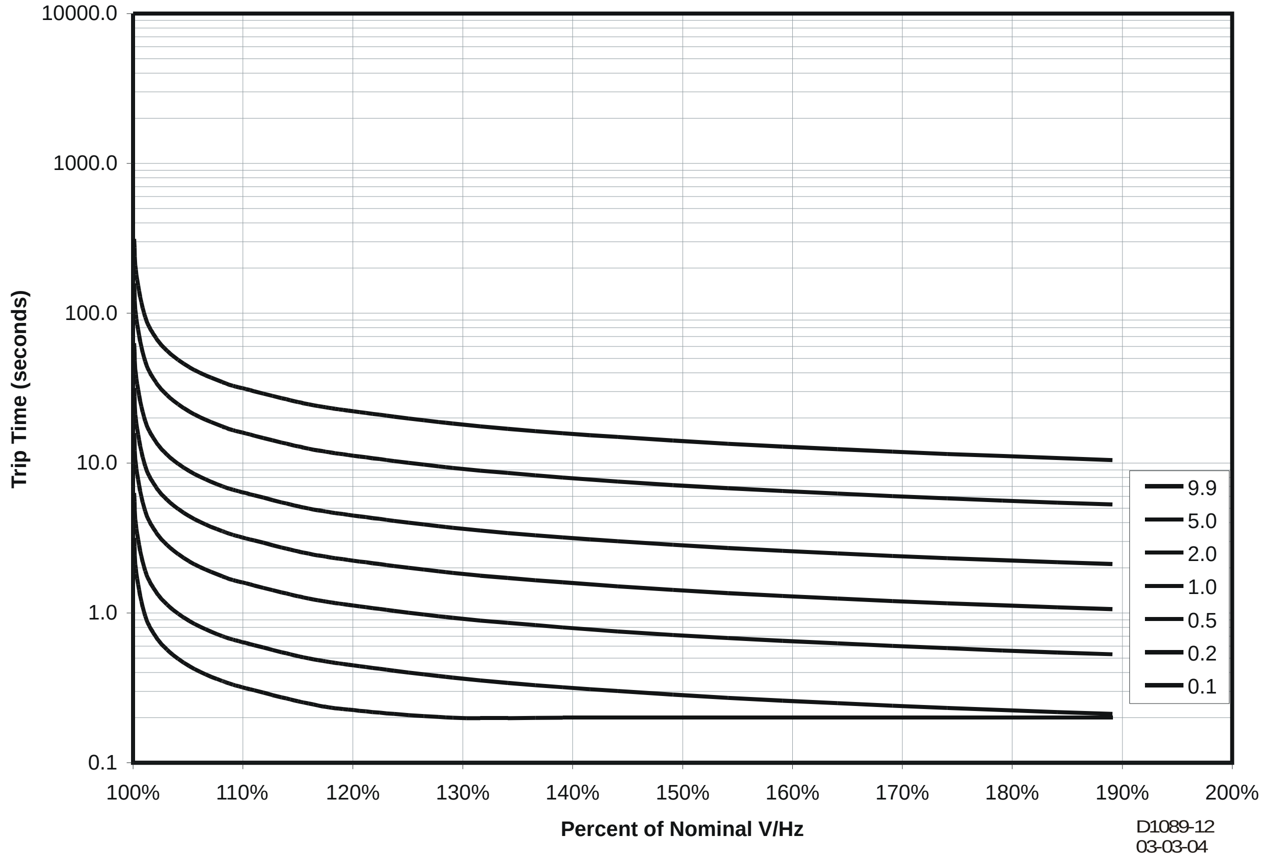

Figure D-1. V/Hz Characteristic (M-1)^0.5 – Time on Vertical Axis

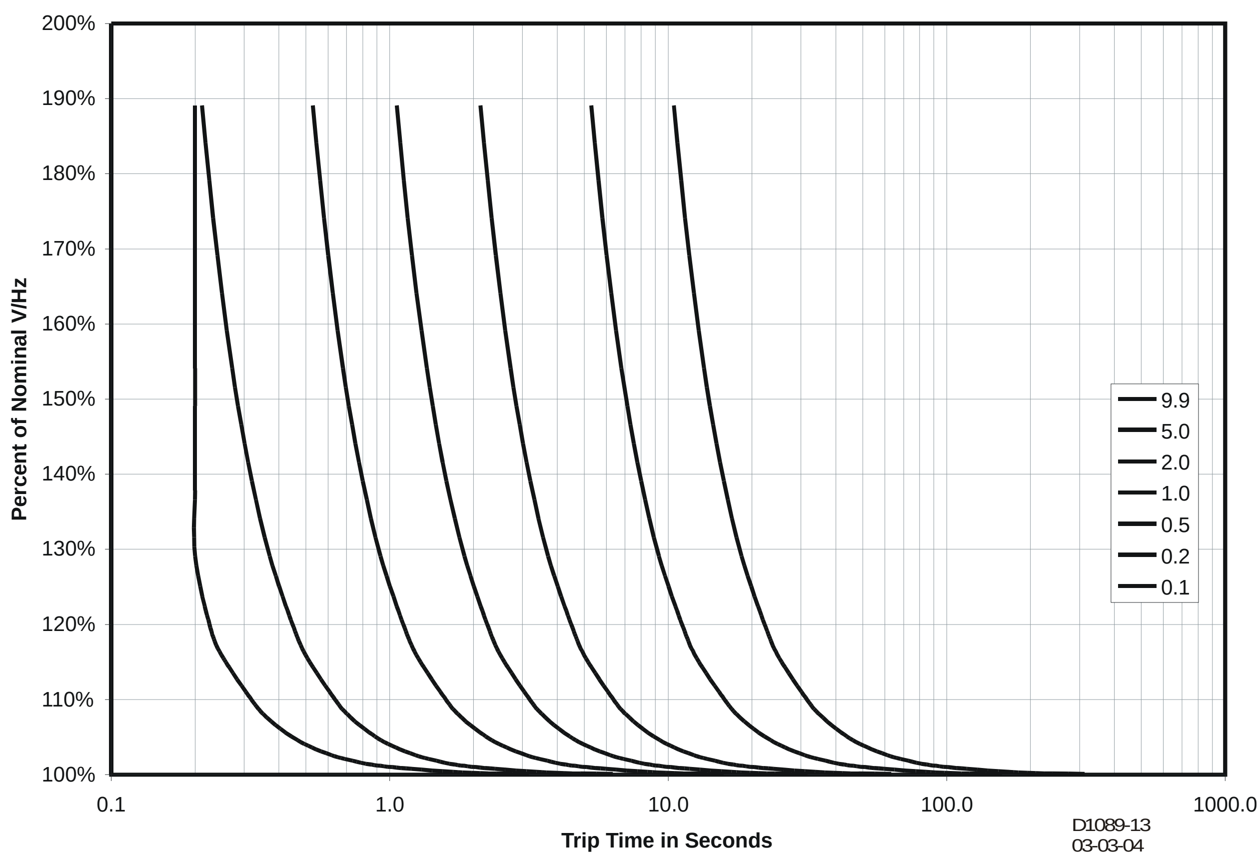

Figure D-2. V/Hz Characteristic (M-1)^0.5 – Time on Horizontal Axis

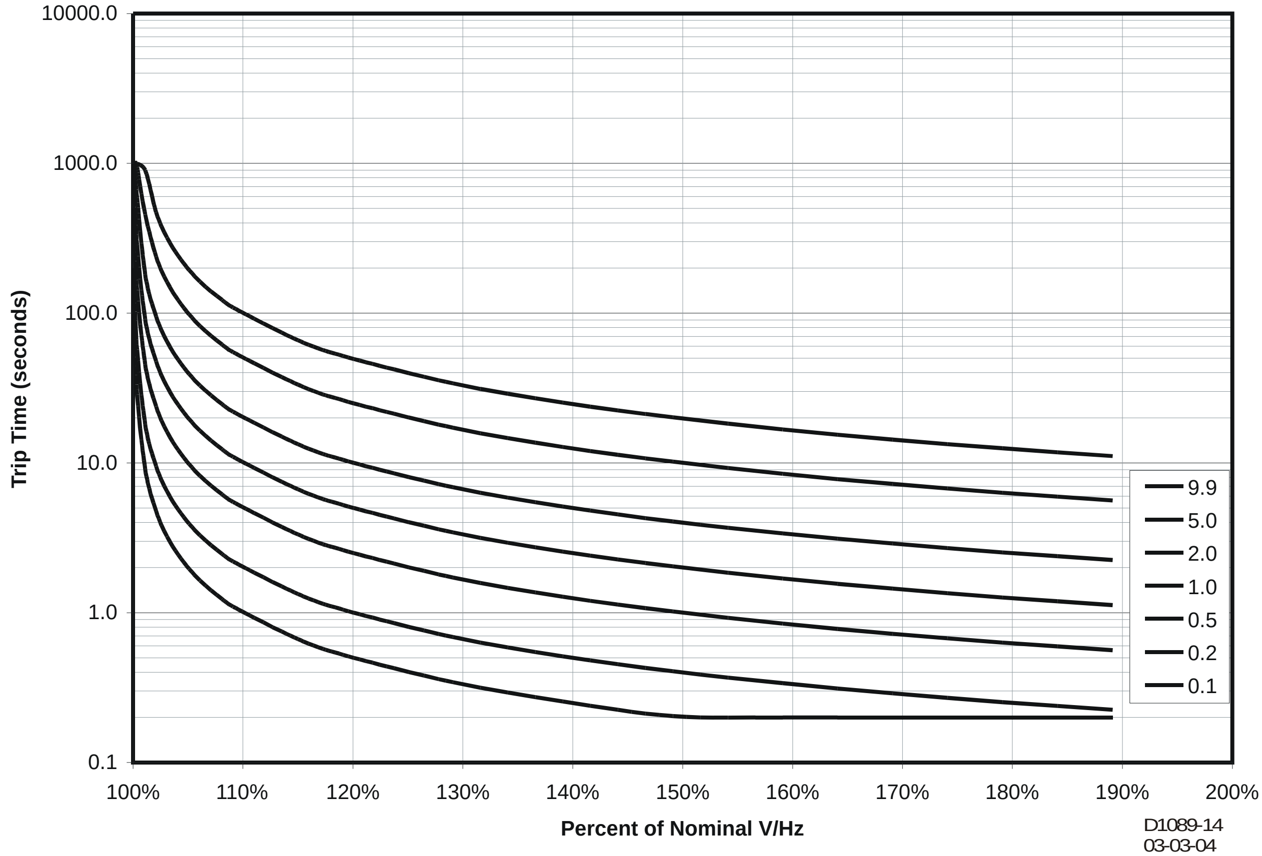

Figure D-3. V/Hz Characteristic (M-1)^1 – Time on Vertical Axis

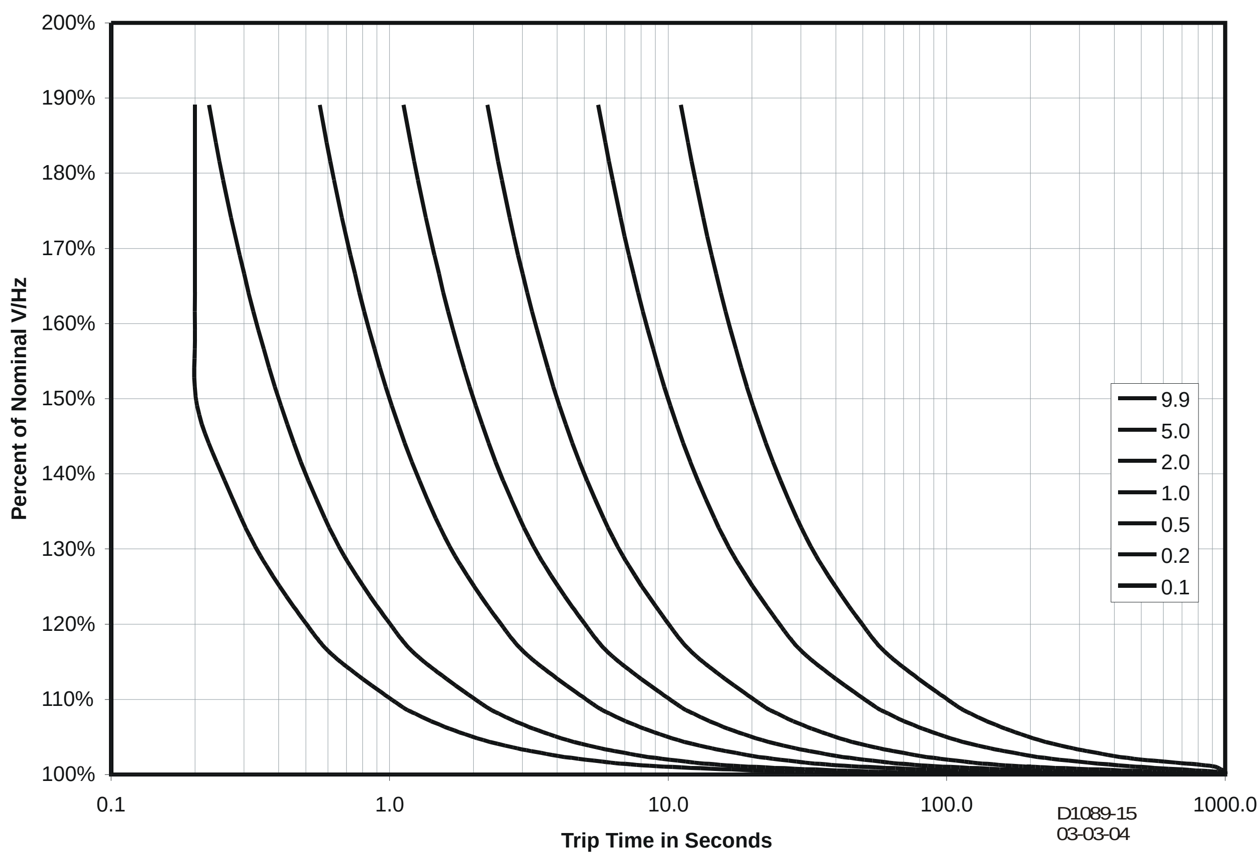

Figure D-4. V/Hz Characteristic (M-1)^1 – Time on Horizontal Axis

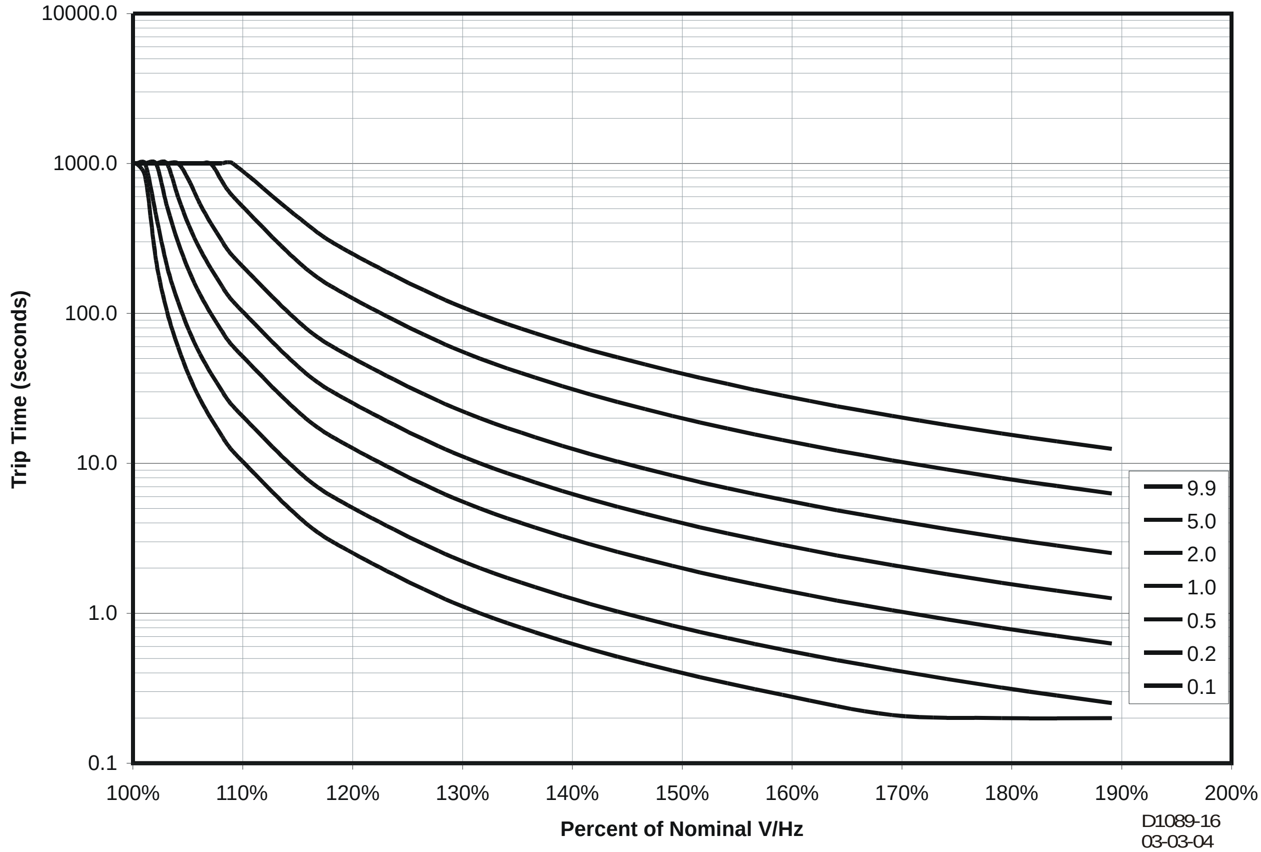

Figure D-5. V/Hz Characteristic (M-1)^2 – Time on Vertical Axis

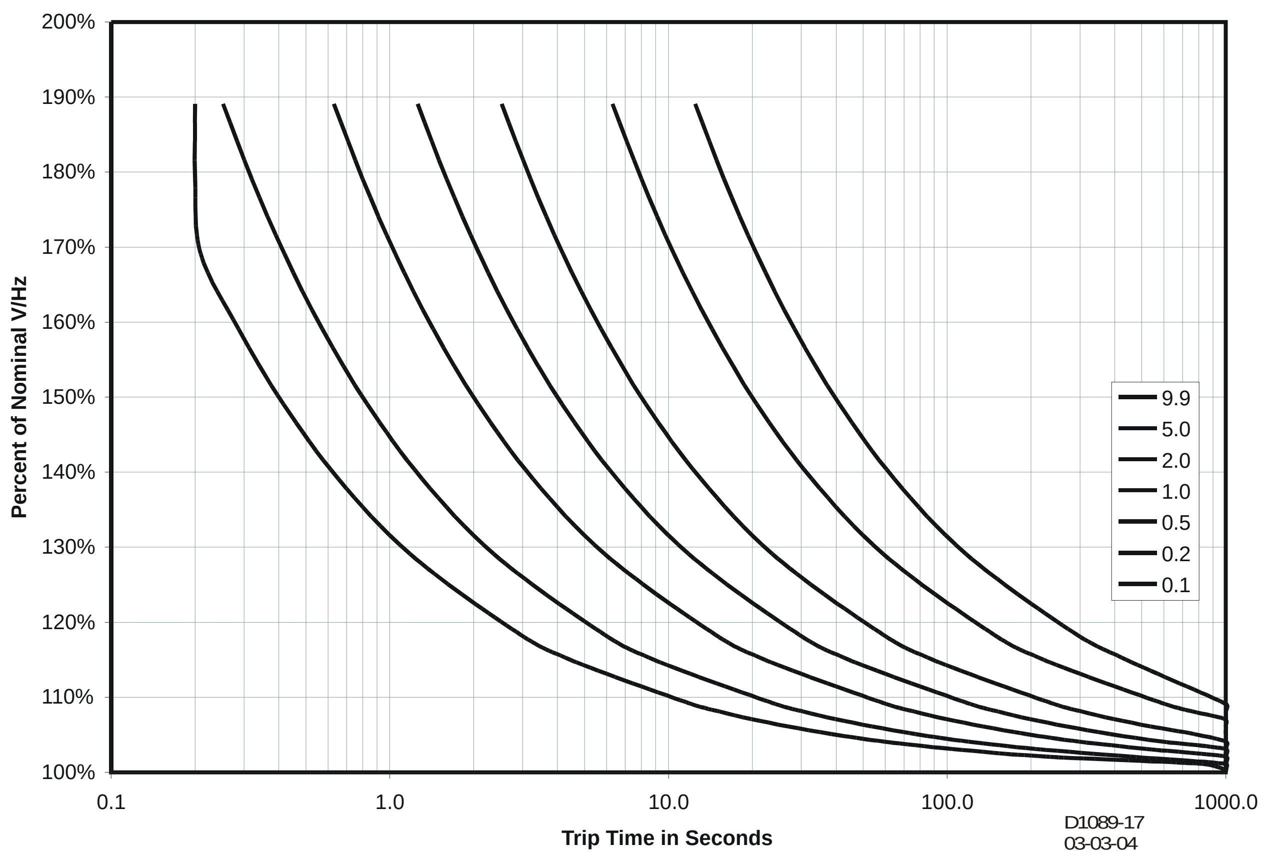

Figure D-6. V/Hz Characteristic (M-1)^2 – Time on Horizontal Axis

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