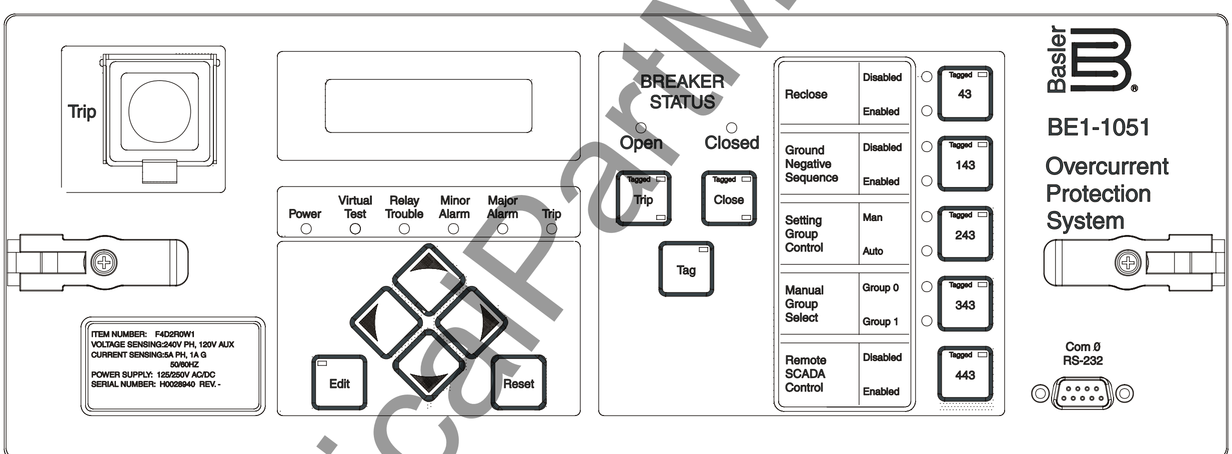
INSTRUCTION MANUAL

FOR

OVERCURRENT PROTECTION SYSTEM

BE1-1051



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INTRODUCTION

This instruction manual provides information about the operation and installation of the BE1-1051 Overcurrent 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 the user interface setup including ASCII communication and the human-machine interface (HMI).
- Installation procedures, dimension drawings, and connection diagrams.
- A summary of setting, metering, reporting, control, and miscellaneous commands.
- Testing and maintenance procedures.
- Description of BESTCOMS graphical user interface (GUI).
- Description and use 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 load encroachment guidelines.

Optional instruction manuals for the BE1-1051 include:

- Distributed Network Protocol (DNP) 3.0 (9334800992)
- Modbus™ (9334800991).

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 BE1-1051 hardware, firmware, and software. The corresponding revisions made to this instruction manual (9334800990) are also summarized. Revisions are listed in reverse chronological order.

BESTCOMS Software Version and Date	Change
2.05.00, 03/08	• Improved Settings Compare function. • Changed range of nominal frequency to 25-60 Hz on the *General Settings, Power System* screen. • Changed the x81 pickup setting range to 20-70 Hz.
2.04.01, 11/06	• Added DNP settings screen. • Added Settings Compare feature.
2.03.00, 07/06	• Added Option 2 to style number.
2.02.00, 06/05	• Added DSP setting on *General Operation, Power System* tab. • Enhanced 101 Logic Block diagram on *Virtual Switches, Breaker Control Switch & SCADA Cutoff* tab. • Enhanced features of the x43 & 101 *BESTlogic Function Element.* • Enhanced the x43 Logic Block diagram on *Virtual Switches, 43/143/243/343/443* tab.
2.01.01, 07/04	• Corrected 67N polarization problem when selecting VOIG. • Corrected problem of 47 pickup changing to Vpp while Vpn is selected.
2.01.00, 06/04	• Updated the *General Info* tab on the *General Operation* screen to support style options R and T (Ethernet Port Protocol). • Added ethernet communication pull-down menu that added Upload Settings to Device, Upload Security to Device, Download Settings from Device, Download Security from Device, and Set Date/Time selections. • Added *BESTNet Settings* screen with *General Settings* and *E-Mail* tabs. • Updated *BESTlogic Screen Function Blocks* tab to add E-mail 1 Trigger through E-mail 8 Trigger.
2.00.00, 08/02	• Initial release

Application Firmware Version and Date	Change
3.05.00, 03/08	• Added alternate DST (Daylight Saving Time) settings. • Improved x62 timer when changing setting groups. • Improved 25 Sync Check tripping. • Changed the frequency pickup of the 81 to function down to 20 Hz. • Changed settable default system frequency to support 25 to 60 Hz.
3.04.00, 08/06	• Added DNP settings.
3.03.00, 07/06	• Enhanced the front panel HMI to show fault report data. • Enhanced fault reports to show style and serial number information.

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Application Firmware Version and Date	Change
2.02.00, 05/05	• Added Digital Signal Processing setting for the Auxiliary Input to be measured as Fundamental or RMS. • Enhanced the x43 & 101 functions with a Trip, Reset, and Block input.
2.01.00, 05/04	• Added support for Ethernet Port Protocol options R and T to provide TCP/IP functionality. BESTNet functions (HTTP (Web page), DHCP, SMTP (E-mail), ASCII over TCP/IP, NTP, and GOOSE) were added over the TCP/IP ethernet interface. • Corrected DNP binary inputs 526, 257, and 278-284 mapping. • Improved SEF 50TN directional pickup accuracy. • Added frequency data to fault report and COMTRADE reports. • Corrected Reclosing Drive to Lockout and Lockout problem with /43. • Corrected problem with entering 27 inhibit voltage when VT ratio is > 1. • Corrected contact input recognition/debounce initialization. • Corrected display of Major, Minor, and Logic alarms in 2nd alarm displayed. • Corrected 60FL dropout upon a change to SG-NOM command.
2.00.05, 02/03	• Resolved an RTC overtemperature issue. • Resolved a situation that occasionally caused the relay to display an “Fatal EEPROM Error”, “Cal Defaults Loaded”, “and “Set Defaults Loaded”.
2.00.04, 01/03	• Improved performance of oscillography for extended fault conditions. • Added an “Error Pickup Condition” to the 27X element to prevent operation when changing pickup setting. • Resolved an “Out of Range” message when 10A (for 5A CTs) or 2A (for 1A CTs) was entered for 50BF phase and neutral fault detector pickup. • Fixed a minor problem with counting “new records” in the Sequence of Events report. • Improved distance to fault calculations for PICKUP events. • Enhanced fault reporting capability for close/pickup and close/trip events. • Improved performance of BLOCK and SLIDING BLOCK demand modes. • Added minimum voltage and current threshold for which real time metering angles will display. • Various DNP improvements. • Added sequence angles to fault records generated by a PICKUP event.
2.00.03, 11/02	• Improved firmware programming.
2.00.02, 10/02	• Improved reporting of “error pickup condition” when changing settings. • Corrected rebooting failures. • Improved distance to fault calculations.
2.00.01, 08/02	• Initial release

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Hardware Version and Date	Change
F, 06/07	• Improved CT terminal block.
D, 09/06	• Enhanced the I/O and digital boards to support either 7 inputs and 7 outputs or 8 inputs and 6 outputs. Refer to Section 1, *General Information, Model and Style Number Description,* for more information.
C, 06/04	• Added TCP/IP support and removed UCA2 support.
B, 12/02	• Updated firmware release versions 2.00.03 (1051 App), 2.01.05 (332 Boot), 2.00.02 (1051 Ethernet App), and 2.01.04 (360 Boot). Added for more versions of the front panel.
A, 09/02	• Made manufacturing changes to the main board by removing CGND net from J1. Moved J20 and J21 closer to the relays on the I/O board.
—, 08/02	• Initial release

Manual Revision and Date	Change
G, 03/08	• Added manual part number and revision to footers. • Corrected spec for case size in Section 1. • Changed 81 pickup range to 20-70 Hz in Sections 1 and 4. • Changed nominal frequency setting range to 25-60 Hz in Section 3. • Changed alarm output to be NC/NO in Figure 3-6. • Added *Settings Compare* in Section 6. • Updated Figures 12-9 and 12-10 to show alarm contact as NC/NO. • Added alternate DST commands in Sections 6, 11, and Appendix B.
F, 10/06	• Added Table 12-2 in Section 12, *Installation,* for reference when setting contact sensing jumpers.
E, 09/06	• Updated the 25 Sync-Check, 43, and 62 testing in Section 13, *Testing and Maintenance.*
D, 08/06	• Incorporated the *Addendum* from Rev C into this Rev D manual. • Added HMI layout in Section 10 for extended fault report data. • Added GOST-R and IRIG specs to Section 1. • Increased the 25 phase angle setting from 45 to 99. • Added *Targets as Displayed* table to Section 6. • Updated all BESTCOMS screen shots. • Added DNP settings information.
C, 05/05	• Added *Addendum* describing changes of the x43 and 101.

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Manual Revision and Date	Change
B, 06/04	• Added Section 15, *BESTNet Communication,* for the new optional web page enabled relay. • Revised Table 1-1, *Style Chart,* to add Ethernet Port Protocols R and T. • Added a description of Vnom and Inom under *Power System Settings* in Section 3. • Added Figure 4-63, *Overall Logic Diagram for Reclosing* to Section 14. • Removed Figure 14-27 since the x81 elements are now located in a single tab on the *Voltage Protection* screen in BESTCOMS. • Moved the *Contact Sensing Input Jumpers* subsection to the front of Section 12 and added a note that the relay is shipped with the jumpers in the low position. • Expanded trip characteristic constants to five significant digits in Table A-1, column B.
A, 02/04	• Added a discussion of directional element operating time to the sub-heading *67 Directional Overcurrent Element* in Section 4. • Added a discussion on *Switch Onto Fault Protection Logic (SOTF)* to Section 4. • Revised the discussion of calculating D_{max} in the subsection *Breaker Duty Monitoring* in Section 6. • Updated Figure 6-13, TCM with Other Devices. • Where appropriate, changed references of volatile memory to nonvolatile memory. • Included the SB-LOGIC command in Figure 7-2, BESTCOMS Function Blocks. • Updated Figure 8-1, BASIC-OC Logic Diagram and Figure 8-7, FDR-W-IL Logic Diagram, and Figure 8-12, BACKUP Logic Diagram. • Eliminated VO18 and VO19 from Table 8-29, POTT Virtual Output Logic. • Revised Figure 10-7, Protection Menu Branch Structure. • Revised Figure 12-10, Typical AC Connections. • Added several new screen shots to Section 14, BESTCOMS Software, to improve the reader's understanding of the BESTCOMS features. • Added Figure 12-32, BE1-1051 Main Board - Com 1 Jumper Locations. • Revised Figure A-17, 46 Time Characteristic Curve.
—, 06/02	• Initial release

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SECTION 1 • GENERAL INFORMATION

INTRODUCTION

The BE1-1051 Overcurrent Protection System is an economical, microprocessor based, multifunction relay that provides three-phase, ground, and negative-sequence directional overcurrent protection. The relay is available in a fully draw out MX case with configurations for horizontal 19" rack mount, horizontal panel mount, and vertical panel mount. BE1-1051 features include:

- Three-Phase Overcurrent Protection
- Neutral Overcurrent Protection
- Ground Overcurrent Protection
- Negative-Sequence Overcurrent Protection
- Metering Elements
- Communication
- Directional Overcurrent Protection
- Six Programmable Outputs
- Negative-Sequence Overvoltage Protection
- Four Setting Groups
- Virtual Lockout Protection
- Fuse Loss Detection
- Direct Access Virtual Control Panel
- Three-Phase Under/Overvoltage Protection
- Under/Overfrequency Protection
- Breaker Monitoring
- Breaker Failure Protection
- Automatic Reclosing
- Eight Programmable Contact Sensing Inputs
- One Fail Safe Alarm Output
- Overexcitation Protection
- Two General Purpose Logic Timers
- Sync-Check Function
- Web Page Over Ethernet (optional)

The BE1-1051 provides complete flexibility using Basler Electric's BESTlogic programmable logic. The relay provides six preprogrammed logic schemes and one user programmable logic scheme. The user programmable logic scheme along with the relay's programmable elements, inputs and outputs, allows for the flexibility required to configure unique protection and control schemes.

In addition to the programmable logic schemes, the BE1-1051 also provides a programmable liquid crystal display (LCD) and an optional Direct Access Virtual Control panel. The programmable LCD allows the relay to replace local indication and control devices such as panel meters, alarm annunciators, and control switches. The Direct Access Virtual Control panel eliminates panel switches by allowing access to virtual control switch functions at the push of a button.

BE1-1051 communications include three independent communication ports with protocol support for DNP 3.0 and MODBUS™. The relay also includes an optional ethernet port with TCP/IP ethernet protocol that allows high performance, peer-to-peer communications. The dual ethernet ports support both 10baseT and 10baseF formats.

Modbus™, DNP, TCP/IP, and other common protocols are also available. Available communication protocol instruction manuals include 9334800991 for Modbus™ and 9334800992 for DNP 3.0. For information about other protocols, consult your Basler Electric representative.

A simplified *"Getting Started"* procedure for BE1-1051 users is provided in Section 2, *Quick Start.*

FEATURES

The BE1-1051 relay includes many features for the protection, monitoring, and control of power system equipment. These features include protection and control elements, metering elements, and reporting and alarm functions. A highly flexible programmable logic system called BESTlogic allows the user to apply the available elements and functions with complete flexibility and customize the system to meet the requirements of the protected power system. Programmable I/O, extensive communication features, an advanced HMI (human-machine interface), and the optional Direct Access Virtual Control Panel facilitates the use of the BE1-1051's features.

Input and Output Functions

Input functions consist of power system measurement and contact sensing inputs. Programmable contact sensing outputs make up the output functions. Input and output functions are described in the following paragraphs.

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Voltage and Current Inputs

Three-phase currents and voltages are digitally sampled and the fundamental frequency 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, and watt/var metering. Neutral (residual) 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 first and third harmonic of the voltage source connected to the V_X Input. This capability is useful for ground fault protection or sync-check functions.

Each current sensing circuit is low burden and isolated. Neutral (residual) 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

Eight programmable Input Contacts, IN1 through IN8, with programmable signal conditioning provide a binary logic interface to the protection and control system. Each input contact and its label is programmable using BESTlogic. A user-meaningful label can be assigned to each input and to each state of the input to facilitate use in reporting functions.

Contact Outputs

Six programmable relay Output Contacts, OUT1 through OUT6, provide a binary logic interface to the protection and control system. OUT1 through OUT6 are driven by virtual outputs one through six. One programmable, fail-safe contact output, OUTA, provides an alarm output. OUTA is driven by Virtual Output A. Each output contact and its label is programmable using BESTlogic. A user-meaningful name can be assigned to each output and to each state of the output to facilitate its 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. In addition to the six relay output contacts and the alarm output, there are 11 other virtual outputs for use in programmable logic schemes.

Protection and Control Functions

Protection and control elements consist of the following:

- Directional Overcurrent Protection
- Directional Power Protection
- Permissive Pilot Logic
- Voltage Protection
- Frequency Protection
- Breaker Failure Protection
- SOTF (switch on to fault)
- General Purpose Logic Timers
- Fuse Loss Protection
- Lockout Protection
- Setting Groups
- Virtual Control Switches
- Multi-shot Recloser

The following paragraphs describe each protection and control function.

Directional Overcurrent Protection

Overcurrent protection is provided by six instantaneous overcurrent elements and four time-overcurrent elements. Digital signal processing filters out unwanted harmonic components while providing fast overcurrent response with limited transient overreach and over-travel. Each overcurrent function has a settable time delay.

Six instantaneous overcurrent elements are provided. There are two phase elements, 50TP and 150TP; two Neutral elements, 50TN and 150TN; and two Negative-Sequence elements, 50TQ and 150TQ.

Inverse time-overcurrent functions are provided for phase, neutral, and negative-sequence protection. A 51P phase element, 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

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programmable curve. Phase time overcurrent functions can be voltage restrained or controlled for generator backup applications.

An optional separate ground current input provides zero-sequence current polarization and/or ground overcurrent protection for a separate ground CT. Optionally, a SEF (sensitive earth fault) version of the separate ground CT is available.

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

Directional Power Protection

Two directional power elements are available, 32 and 132, and measure true power flow in the protected circuit. The measurement is calculated in three-phase watts and is adaptable for two element or three element response depending upon the primary voltage transformer connection.

Permissive Pilot Logic

The relay includes pilot tripping schemes, which provide improved protection for transmission lines with the aid of communications equipment. The schemes are:

- Permissive Overreaching Transferred Trip with hybrid logic scheme (POTT)
- Permissive Underreaching Transferred Trip (PUTT)

Voltage Protection

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

One phase undervoltage element, 27P, and one phase overvoltage element, 59P, provide over/undervoltage protection. Phase under/overvoltage protection can be set for one of three, two of three, or three of three logic allowing the relay to ignore single-phase faults unless directed otherwise. When a four-wire voltage transformer connection is used, under/overvoltage protection can be set for either phase-to-phase voltage or phase-to-neutral voltage.

One auxiliary undervoltage, 27X, and two auxiliary overvoltage elements, 59X and 159X, provide over/undervoltage protection. 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.

With the optional auxiliary voltage input connected to the bus, one sync-check element, 25, provides synchronism protection. Sync-check protection checks for phase angle difference, magnitude difference, frequency difference (slip), and if the three-phase VT frequency is greater than the auxiliary VT frequency. Two voltage monitor outputs, 25VM1 and 25VM2, provide independent dead/live voltage closing logic.

The 27P and 27X elements also include an undervoltage inhibit setting to prevent operation during complete loss of three-phase voltage as when switching.

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

Voltage transformer circuit monitoring (60FL) adds security by detecting problems in the voltage transformer sensing circuits and preventing misoperations of the 27P, 47, 59P, and the 51/27 function.

Frequency Protection

Six over/underfrequency protection elements are provided: 81, 181, 281, 381, 481, and 581.

Breaker Failure Protection

One breaker failure protection element, 50BF, provides programmable breaker failure protection.

General Purpose Logic Timers

Two general-purpose logic timers, 62 and 162, with 6 modes of operation are provided.

Lockout Protection

Two general-purpose lockout elements, 86 and 186, are provided. The state of these two elements is stored in nonvolatile memory.

Fuse Loss Protection

A Fuse Loss (60FL) element protects against false tripping due to a loss of voltage sensing.

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Setting Groups

Four setting groups allow adaptive relaying to be implemented to optimize BE1-1051 settings for various operating conditions. Automatic and external logic can be employed to select the active setting group.

Virtual Control Switches

BE1-1051 virtual control switches include one virtual breaker control switch and four 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 four virtual switches: 43, 143, 243, and 343. These virtual switches are accessed locally from the front panel human-machine interface (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.

The virtual switches and 101 can be accessed in three ways: From the HMI, from the communication ports, and from the optional Direct Access Virtual Control Panel. With the control panel option, the 101 and 43 switches can also be remotely tagged, i.e., red tag, blue tag, etc. via the communications channel.

Reclosing

A four-shot recloser with zone-sequence coordination and sequence-controlled protective element blocking functions is provided. The reclosing function also includes a separate pilot initiate and pilot close for high-speed trip and close applications.

Switch on to Fault

Switch on to fault (SOTF) protection provides high-speed non-directional tripping for a short period after the breaker is closed. This function provides line protection when conventional directional tripping is unavailable due to the absence of positive-sequence memory voltage.

Metering Functions

Metering is provided for all measured currents, voltages, and frequency and all derived neutral and negative-sequence currents and voltages. Three-phase watts, vars, and power factor metering is provided. Per-phase watts and vars metering is also provided when the voltage source connection is four wire (4W).

Reporting and Alarm Functions

Several reporting and alarm functions provide:

- Relay Identification
- Clock
- General Status Reporting
- Demand Reporting
- Breaker Monitoring
- Trip Circuit Monitoring
- Fault Reporting
- Sequence of Events Recorder
- Alarm Function
- Version Reporting

Relay Identification

Four 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 which relay is associated with which report. Examples of relay identification field uses are station name, circuit number, relay system, and purchase order.

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.

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.

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General Status Reporting

The BE1-1051 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. Demand registers are stored in nonvolatile memory. Demand recording functions record minimum and maximum voltage.

Optionally available is a 4,000-point data array. This allows the relay to record over 40 days of 15-minute demand data.

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). 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. Reports and events are stored in nonvolatile memory. The relay records and reports oscillography data in industry-standard IEEE, Comtrade 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 millisecond. 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. Report events are stored in nonvolatile memory.

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 ports.

BESTlogic Programmable Logic

Each BE1-1051 protection and control element is implemented in an independent function block. 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

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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 a person to tailor the relay functionality to match the needs of your operation's practices and power system requirements.

Application

The BE1-1051 provides six preprogrammed logic schemes that are designed to accommodate most common distribution or sub-transmission radial system overcurrent coordination schemes. A user-programmable logic scheme is also provided.

The BE1-1051 Overcurrent Protection System provides complete circuit protection with multiple overcurrent elements and is intended for use in any directional or non-directional overcurrent application.

Its unique capabilities make it ideally suited for applications where:

- Low burden is required to extend the linear range of CTs.
- High accuracy across a wide frequency range is desired for motor, generator, and generator step-up transformer protection or co-generation facilities.
- One relay provides the flexibility of wide settings ranges, multiple settings groups, and multiple coordination curves.
- A multifunction, multi-phase relay is desired for economical and space saving benefits. A single BE1-1051 provides all of the protection, local and remote indication, metering, and control required on a typical circuit.
- Directional control and fault locating are required.
- Overexcitation protection is required in transformer backup applications.
- Communication capability and protocol support is desired.
- The capabilities of a digital multifunction relay are required and drawout construction is desired.
- Bus protection is provided by a high-speed overcurrent-blocking scheme on the transformer bus mains instead of a bus differential circuit.
- Intelligent electronic devices (IEDs) capabilities decrease relay and equipment maintenance costs.
- Small relay size and limited behind-panel projection facilitates modernizing protection and control systems in existing substations.

Security

Security can be defined for three or four (with optional TCP/IP) 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 rear RS-232 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 BE1-1051 comes with a front panel display with six LED indicators for Power Supply Status, Virtual Test, 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:

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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.

An optional Direct Access Virtual Control panel can be provided to facilitate a system that is completely self-contained by eliminating panel switches.

ASCII Command Interface

Three independent, isolated communication ports provide access to all functions in the relay. COM0 is a 9-pin RS-232 port located on the front of the case. COM1 is a 9-pin RS-232 port located on the back of the case. COM2 is a 2-wire RS-485 port located on the back of the case. 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. For additional information, refer to Section 15, *BESTNet Communication, TCP/IP Communication.* A separate instruction manual is available for each optional protocol. Consult the product bulletin or the factory for availability of these options and instruction manuals.

Installation

The BE1-1051 is available in two, fully drawout, case styles; MX vertical can be mounted as an M1, M2, FT31, or an FT32; MX horizontal can be panel mounted or 19" rack mounted. Relay terminals are clearly marked on the rear panel.

Testing and Maintenance

Four testing methods are covered in this manual: acceptance testing, commissioning testing, periodic testing, and functional testing. The relay also provides a virtual testing function that allows the user to isolate a portion of the logic program and test it by using a set of switches.

BESTCOMS Software

BE1-1051 BESTCOMS is a 32-bit Windows® based graphical user interface (GUI). It provides the user with point and click capability for applying settings to the relay. This facilitates setting the relay by eliminating the need for the user to be thoroughly knowledgeable of the ASCII commands associated with the relay settings.

BESTNet Communication

BESTNet Communication provides additional BE1-1051 features if the relay is ordered with Ethernet Communication Protocol Options R or T (see Figure 1-1). 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 is used to view relay status, remotely.

MODEL AND STYLE NUMBER DESCRIPTION

The BE1-1051 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 BE1-1051 Relays. For example, if the style number were **E3N1R0N2C**, the device would have the following characteristics and features:

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BE1-1051 —

- (**E**) - 5 ampere nominal system with 5 ampere independent ground input
- (**3**) - Three-phase sensing
- (**N**) - Standard 6-button HMI with LCD display
- (**1**) - 48/125 Vac/Vdc power supply
- (**R**) - 19" horizontal rack mount, drawout case
- (**0**) - ASCII communication
- (**N**) - None
- (**2**) - 4,000 point Load Profile Demand Log
- (**C**) - 7 contact sensing inputs, 7 output contacts, and a N.C. Alarm contact

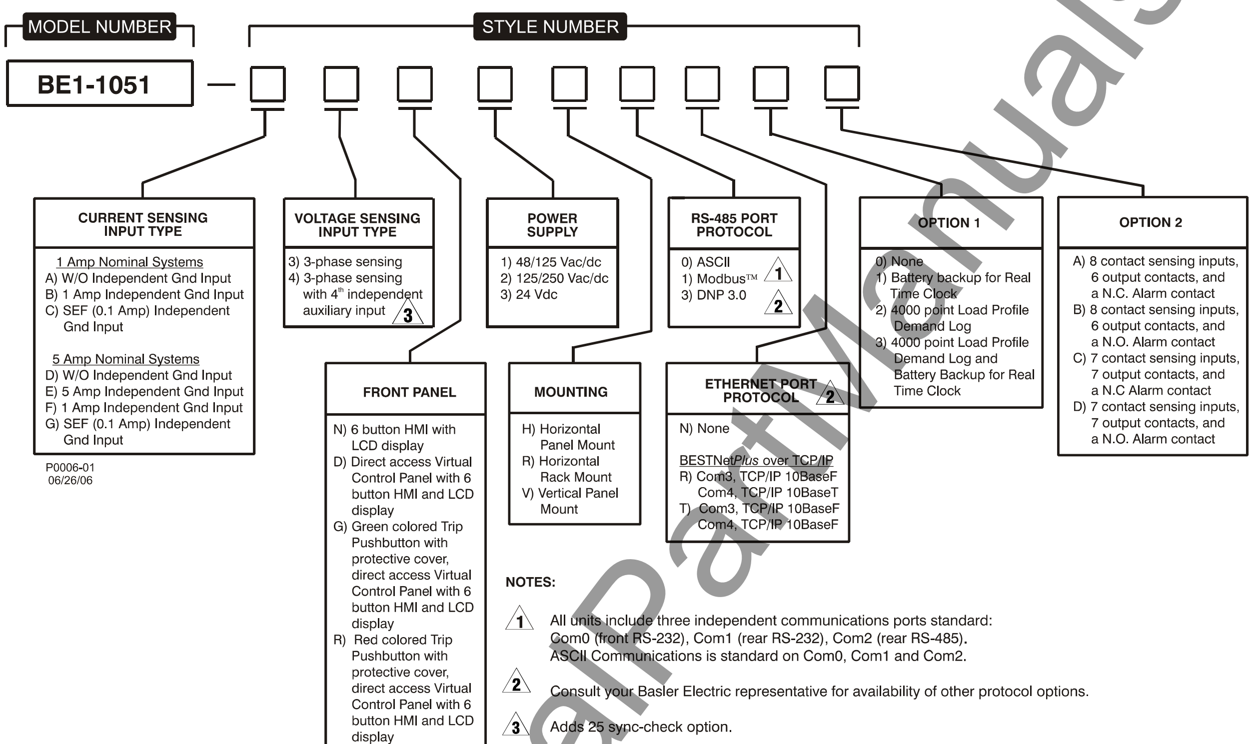

Figure 1-1. Style Chart

OPERATIONAL SPECIFICATIONS

BE1-1051 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
SEF:	0.01 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):	±0.5% of reading, ±1 least significant digit at 25°C
Temperature Dependence:	≤ ±0.02% per °C

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Metered Frequency Values and Accuracy

Frequency Range:	10 to 75 hertz
Accuracy:	±0.01 hertz
Minimum Frequency Tracking Voltage:	10 V rms

Calculated Values and Accuracy

Demand

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

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 CT:	1,000 GWh or 1,000 Gvarh
1 Ampere CT:	1,000 GWh or 1,000 Gvarh
Units of measure:	kilo, mega, giga
Rollover value of registers:	1,000 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: 9 3187 00 012 or Applied Power P/N: BM551902)

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Instantaneous Overcurrent Functions

Directional Control:	F = forward; R = reverse; N = none
Current Pickup Accuracy	
Phase & Neutral (50TP, 50TN, 150TP, 150TN)	
5 Ampere CT:	±2% or ±50 mA
1 Ampere CT:	±2% or ±10 mA
SEF:	±2.5% or ±2.5 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 (All 50 functions)	
5 Ampere CT:	0.5 to 150.0 A
1 Ampere CT:	0.1 to 30.0 A
SEF:	0.01 to 7.5 A
Settable Time Delay Characteristics	
Time Range:	0.00 to 60.0 seconds
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, and 50T/150T:	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, 51N, 151N)	
Dropout/pickup ratio:	95%
Pickup Accuracy	
5 Ampere CT:	±2% or ±50 mA
1 Ampere CT:	±2% or ±10 mA
SEF:	±2.5% or ±2.5 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:	0.50 to 16.0 A
1 Ampere CT:	0.10 to 3.2 A
SEF:	0.01 to 0.8 A
Directional Control:	F = forward; R = reverse; N = none

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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 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

Switch on to Fault Protection (SOTF)

Pickup	
5 Ampere CT:	0.5 to 150 A
1 Ampere CT:	0.1 to 30 A
Accuracy	
5 Ampere CT:	±2% or 0.05 A
1 Ampere CT:	±2% or 0.01 A
Hold Timer:	50 to 999 milliseconds
Accuracy:	±0.5% or ½ cycle

Directional Power (32, 132)

Pickup

5 Ampere CT:	1 to 6,000 watts, 3-phase
1 Ampere CT:	1 to 1,200 watts, 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

Setting Range:	0.05 to 600 seconds
Accuracy:	±0.5% of setting or ±2 cycles

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Volts/Hz (24)

Pickup: 0.5 to 6 V/Hz

Delay Time: Inverse Squared Curve

$$T_T = \frac{D_T}{(M-1)^2}$$

T_T = Time Trip

D_T = Time Dial

$$M = \frac{\text{Actual V/Hz}}{\text{Pickup V/Hz}}$$

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

T_R = Time to Reset

D_R = Time Dial, Reset

ET = Elapsed Time

FST = Full Scale Trip Time (T_T)

Phase Undervoltage Function (27P)

Pickup/Inhibit

Setting Range: 10 to 300 V

Accuracy: ±2% or 1 V

Time Delay

Setting Range: 0.050 to 600 seconds

Accuracy: ±0.5% or ±2 cycles

Auxiliary Undervoltage Function (27X)

Pickup/Inhibit

Setting Range: 1 to 150 V

Accuracy: ±2% or 1 V

Time Delay

Setting Range: 0.050 to 600 seconds

Accuracy: ±0.5% or ±1 cycle

Negative-Sequence Voltage Protection (47)

Pickup

Setting Range: 1.0 to 300 V_{L-N}

Accuracy: ±2% or 1 V

Time Delay

Setting Range: 0.050 to 600 seconds

Accuracy: ±0.5% or 2 cycles

Phase Overvoltage Function (59P)

Pickup

Setting Range: 10 to 300 V

Accuracy: ±2% or 1 V

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Time Delay	
Setting Range:	0.050 to 600 seconds
Accuracy:	±0.5% or ±1 cycle

Auxiliary Overvoltage Function (59X, 159X)

Pickup	
Setting Range:	1 to 150 V
Accuracy:	±2% or 1 V
Time Delay	
Setting Range:	0.050 to 600 seconds
Accuracy:	±0.5% or ±1 cycle

Frequency Function (81/181/281/381/481/581)

Pickup	
Setting Range:	20 to 70 Hz
Accuracy:	0.01 Hz
Time Delay	
Setting Range:	0 to 600 seconds
Accuracy:	±0.5% or 1 cycle (minimum trip is affected by 3 cycle security count)
Voltage Inhibit	
Setting Range:	15 to 300 V
Accuracy:	±2% or 1 volt

Breaker Fail Timer (50BF)

Fault Detect Pickup Range	
5 Ampere CT:	0.25 to 10 A
1 Ampere CT:	0.05 to 2.0 A
SEF:	0.01 to 0.05 A
Pickup Accuracy	
5 Ampere CT:	±2% or ±50 mA
1 Ampere CT:	±2% or ±10 mA
SEF:	±2.5% or ±2.5 mA
Delay Timer:	50 to 999 milliseconds
Accuracy:	±0.5% or ±½ cycles; whichever is greater plus 2 ¼ 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.
Control Timer:	50 to 999 milliseconds
Accuracy:	±0.5% or ±½ cycles

General Purpose Timers (62, 162)

Modes:	Pickup/Dropout, 1 Shot Nonretriggerable, 1 Shot Retriggerable, Oscillator, Integrating, Latch
Range:	0 to 9,999 seconds
Accuracy:	±0.5% or ±12 milliseconds

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Reclosing Timers (79)

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

Setting Range:	100 milliseconds to 600 seconds
Accuracy:	±0.5% or +1¾, -0 cycles, whichever is greater
79SCB Shots:	1 to 4

Sync-Check (25)

Delta Phase Angle:	1 to 99 degrees
Accuracy:	±0.50 degrees
Delta Voltage Magnitude:	1 to 20 V
Accuracy:	±2% or 1 Vac
Delta Frequency:	0.01 to 0.50 Hz
Accuracy:	±0.01 Hz

Sync-Check, Voltage Monitor (25VM)

Live/Dead voltage threshold:	10 to 150 V
Accuracy:	±2% or 1 Vac
Dropout Time delay:	0.050 to 60 seconds
Accuracy:	±0.5% or 2 cycles

VT Fuse Loss Detection (60FL)

Nominal Voltage:	50 to 250 V
5 Ampere CT:	0.5 to 10 A
1 Ampere CT:	0.1 to 2 A

Breaker Open/Dead Line Logic (52BT)

27P3PU V_{pp} Undervoltage:	10 to 300 V
Accuracy:	±2% or 1 V
52BD Recognition Dropout Time Delay:	16 to 999 milliseconds
Accuracy:	±0.5% or 1 cycle

Permissive Pilot Logic (P85)

P85RBD Reverse Block Dropout Delay:	16 to 999 milliseconds
Accuracy:	±0.5% or ½ cycle
P85EBD FWD TRIP Echo Block DO Delay:	16 to 999 milliseconds
Accuracy:	±0.5% or ½ cycle
P85ETDPU Echo Transmit Pickup Delay:	16 to 999 milliseconds
Accuracy:	±0.5% or ½ cycle
P85ETDUR Echo Transmit Duration:	16 to 999 milliseconds
Accuracy:	±0.5% or ½ cycle

Automatic Setting Group Characteristics

Number of Setting Groups:	4

Control Modes

Automatic:	Cold-Load Pickup, Dynamic Load or Unbalance, Recloser Shot, 60FL
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)

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Switch Timer

Range:	0 to 60 minutes with 1 minute increments where 0 = disabled
Accuracy:	±0.5% or ±2 seconds

GENERAL SPECIFICATIONS

AC Current Inputs

5 Ampere CT

Continuous Rating:	20 A
One Second Rating:	400 A
Begins to Clip (Saturate):	150 A
Burden:	<10 mΩ

1 Ampere CT

Continuous Rating:	4 A
One Second Rating:	80 A
Begins to Clip (Saturate):	30 A
Burden:	<22 mΩ

SEF

Continuous Rating:	4 A
One Second Rating:	80 A
Begins to Clip (Saturate):	7.5 A
Burden:	<22 mΩ

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

Sampling Rate:	16/cycle, adjusted to input frequency 10 to 75 Hz

Power Supply

Option 1

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

Option 2

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

Option 3

24 Vdc:	Input Voltage Range 17 to 32 Vdc

Frequency Range

Options 1 and 2 only:	40 to 70 Hz

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Burden

Options 1, 2, and 3: 16 watts

Output Contacts

Make and Carry for Tripping Duty: 30 A for 0.2 seconds per IEEE C37.90; 7A 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

48/125 Vac/Vdc Power Supply: 33/83 Vac/Vdc

125/250 Vac/Vdc Power Supply: 83/165 Vac/Vdc

24 Vdc Power Supply: 16 Vdc

Note: The above 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. Burden

Power Supply	Jumper Pins 1-2 (Low) Burden	Jumper Pins 2-3 (High) Burden
48/125 V	36 kΩ	94 kΩ
125/250 V	94 kΩ	185 kΩ
24 Vdc	15 kΩ	N/A

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: Non-linear, approximately 4kΩ at 3.5 Vdc, approximately 3 kΩ at 20 Vdc

Communication Ports

RS-232/RJ45

Response Time: Less than 100 milliseconds for metering and control functions

Baud Rate: 300 to 19200 baud

Ethernet

10BaseT: 10 mb/s, CAT 5 copper media

10BaseF: 10 mb/s, fiber optic media

Display

Type: Two line, 16 character alphanumeric LCD (liquid crystal display) with LED (light emitting diode) backlight

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Operating Temperature:	-40°C to 70°C (-40°F to 158°F) - The display contrast may be impaired at temperatures below -20°C (-4°F).

Isolation

2,000 Vac at 50/60 Hz in accordance with IEEE C37.90.

Surge Withstand Capability

<u>*Oscillatory*</u>

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

<u>*Fast Transient*</u>

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)

Type tested using a five-watt, hand-held transceiver in the ranges of 144 and 440 MHz with the antenna placed six inches from the relay. Qualified to C37.90.2-1995, *Standard For Withstand Capability Of Relay 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:	IEC 255-21-2, Class 1

Vibration

Qualification:	IEC 255-21-1, Class 1

Environment

<u>*Temperature*</u>

Operating Range:	-40°C to 70°C (-40°F to 158°F)
Storage Range:	-40°C to 70°C (-40°F to 158°F) ∗
	∗ Display is inoperative below -20°C (-4°F)

<u>*Humidity*</u>

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 No. POCC US.ME05.B03391; complies with the relevant standards of Gosstandart of Russia. Issued by accredited certification body POCC RU.0001.11ME05.

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Physical

Weight:	12. lbs (5.4 kg)

Case Configurations

M Horizontal:	Panel or 19" rack-mount, draw-out
M Vertical:	GE M1 and M2, FT31 and FT32 size, draw-out

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SECTION 2 • QUICK START

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SECTION 2 • QUICK START

GENERAL

This section provides an overview of the BE1-1051 Overcurrent Protection System. You should be familiar with the concepts behind the user interfaces and BESTlogic before you begin reading about the detailed BE1-1051 functions. Sections 3 through 6 in the Instruction Manual describe each function of the BE1-1051 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 BE1-1051 relay. Detailed information on the operation of the HMI (human-machine interface) 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 BE1-1051 relay. BESTCOMS for the BE1-1051 is provided free of charge with the BE1-1051. BESTCOMS operation is very transparent and contains 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 are set-up and used in the BE1-1051 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 BE1-1051 relay and include references to the following items. Note that **not** all items are appropriate for each function.

- HMI screens for setting the operational parameters.
- ASCII commands for setting the operational parameters.
- ASCII commands for setting up the BESTlogic required using the function 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 major categories: Input and output functions, protection and control functions, metering functions, and reporting and alarm functions. Detailed descriptions of each individual function, setup and use is 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.* For relays configured with optional ethernet enabled capabilities, refer to Section 15, *BESTNet Software.*

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

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BESTlogic

Each of the protection and control functions in the BE1-1051 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 BE1-1051 relay has all of the characteristics of a version of the BE1-51 overcurrent relay 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

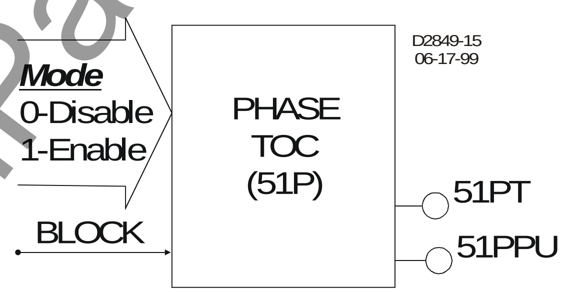

Figure 2-1. 51 Time Overcurrent Logic

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. The mode and the input logic. The mode is equivalent to deciding which devices you want to install in your protection and control scheme. You must then set the logic variables that will be connected to the inputs.

For example, the 51N function block has three modes (disabled, 3-phase summation ($3I_O$) 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 (3-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.

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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 BE1-1051, supports up to 18 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+BFRT 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 (+) BFRT (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 BE1-1051 relay: front panel HMI, ASCII communications, and BESTCOMS for BE1-1051. 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 BE1-1051 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 BE1-1051 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 4, *Protection and Control.* 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, and 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

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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 47 pickup and time delay settings of Setting Group 2 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*, passing the SETTING GROUP 1 branch (Screen 5.2) until the SETTING GROUP 2 branch (Screen 5.3) is reached.
4. From Screen 5.3, scroll down to the next level of detail which is the 24 SETTINGS (Screen 5.3.1).
5. Scroll *RIGHT* to the 47 SETTINGS (Screen 5.3.5) and then *DOWN* to reach the 47 pickup and time delay settings (Screen 5.3.4.1).

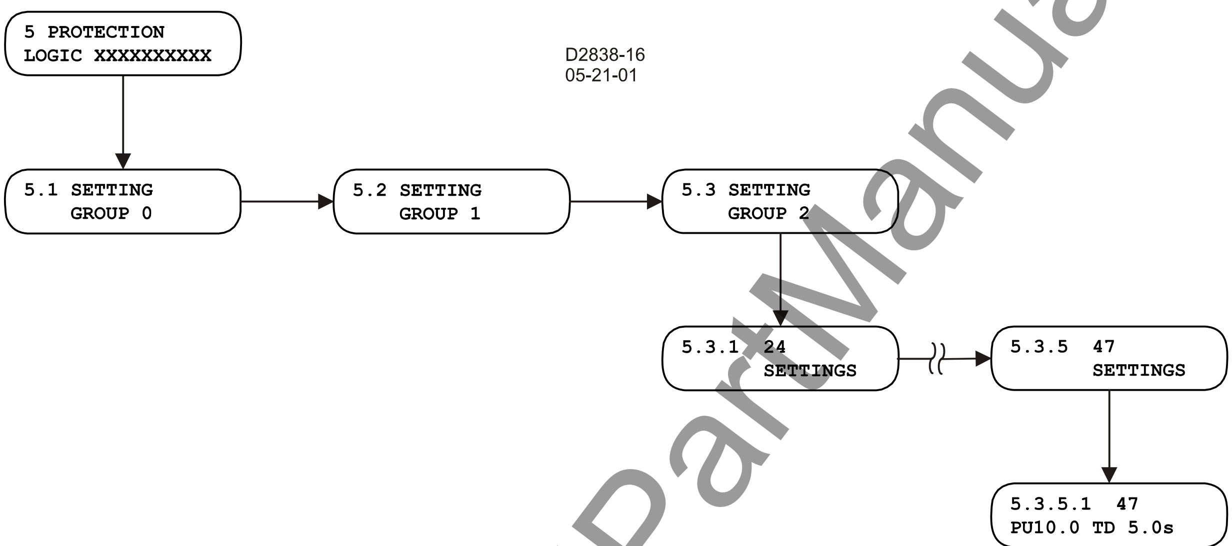

Figure 2-2. Menu Screens Numbering Example

ASCII Command Communications

The BE1-1051 relay has three independent communications ports for serial communications. A computer terminal or PC running a terminal emulation program such as Windows® HyperTerminal® can be connected to any of the three 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.

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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, 2, and 3 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 it's 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 BE1-1051 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, average, ground, 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 BE1-1051 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 BE1-1051, 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

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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/her 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 more information on BESTwave, contact your local sales representative or Basler Electric, Technical Support Services Department in Highland, Illinois.

GETTING STARTED

Refer to section 12, *Installation,* for typical external connection diagrams. 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 relay measures the A-phase, B-phase, and C-phase current magnitudes directly from the three current sensing inputs. When evaluating the negative sequence functions, the relay can be tested using a two-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.

Using a serial cable, connect a computer to the relay's front RS-232 port. Install BE1-1051 BESTCOMS according to the procedure given in Section 14, *BESTCOMS Software.* Once BESTCOMS is installed, apply power to the relay. From the Basler Electric program group on your windows *Start* menu, select BESTCOMS for BE1-1051 to start BESTCOMS. From the *RS-232 Communication* pull-down menu, select *Configure* and verify communication is configured correctly.

Once communication settings are correct, from the *RS-232 Communication* pull-down menu, select *Download Settings from Device.* See Figure 2-3. This command will transfer the relays current settings to the BESTCOMS software, allowing the settings to be viewed easily in a windows environment. Before continuing, select the *Save As* command from the *File* menu. The *File Properties* screen for the file you are saving will appear. Refer to Figure 2-4. Type in any comments about the file and select *OK.* The *Save As* dialog box will appear. Give the file a unique name that you will recognize at a later date and select *Save.* This action does not send the settings to the relay but rather saves them in a BESTCOMS settings file with a .bst extension. Once saved, the settings file may be retrieved, modified, and transmitted to the relay at any time.

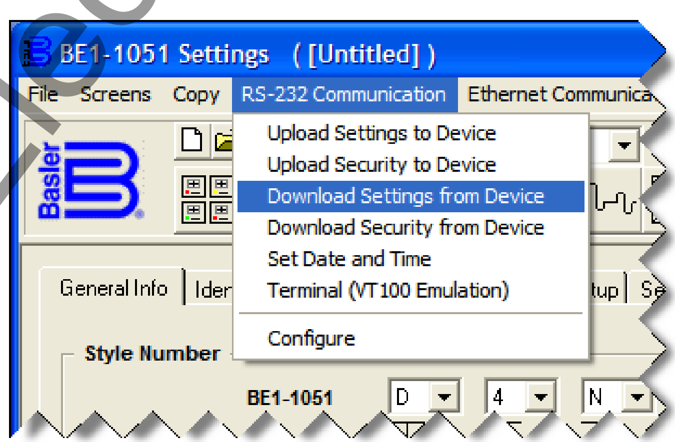

Figure 2-3. RS-232 Communication Pull-Down menu

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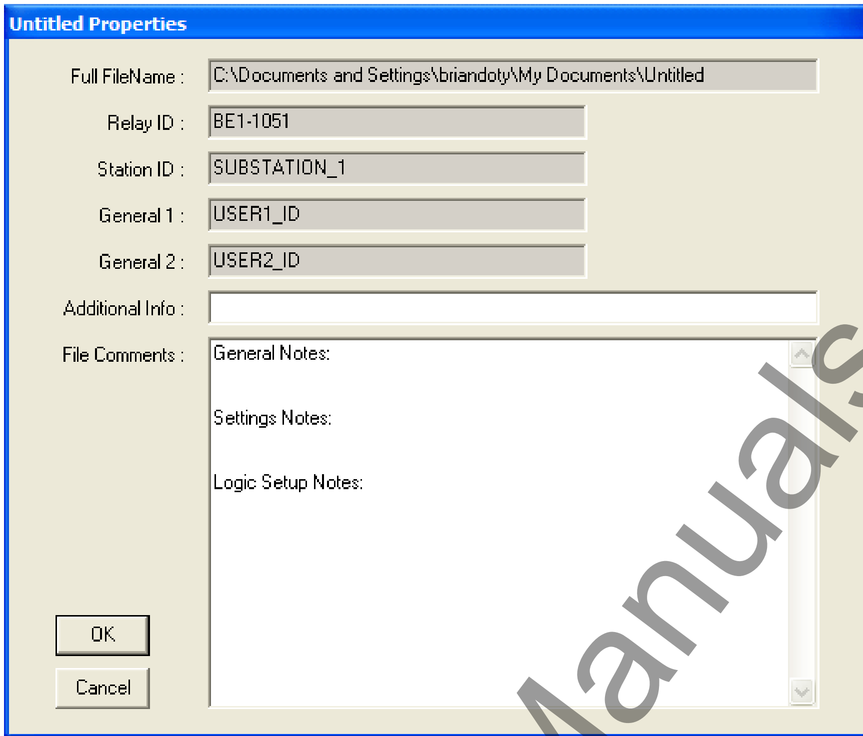

Figure 2-4. File Properties Screen

Entering Typical Settings

Time and date format can be changed by selecting *Reporting and Alarms* from the *Screens* menu. Select the time and date format for your application. To change the time and date, use the HMI display buttons to scroll over to Screen 4.5. Select the *Edit* button. The red LED in the button will light when you are in Edit mode. Use the *LEFT* and *RIGHT* arrows to move between hours, minutes, day, month, and year settings. Use the *UP* and *DOWN* arrow keys to change the settings. When finished editing, press the *Edit* button for the changes to take effect.

The BE1-1051 relay requires information on the nominal system frequency, current transformer (CT) ratio, and phase rotation for proper current measurement to occur. These settings can be made using BESTCOMS. Select *General Operation* from the *Screens* pull down menu. Then select the tab labeled *Power System.* Refer to Figure 2-5.

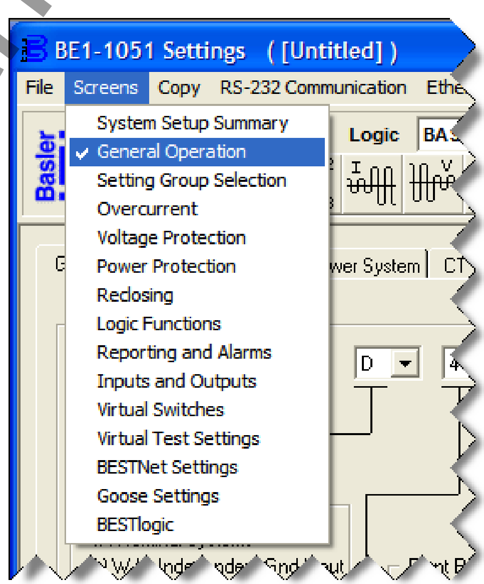

Figure 2-5. Screens Pull-Down Menu

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Using the pull-down menus and buttons located on the *Power System* tab, select the appropriate phase and neutral CT ratios, the system's nominal frequency, and the system's phase rotation. Refer to Figure 2-6.

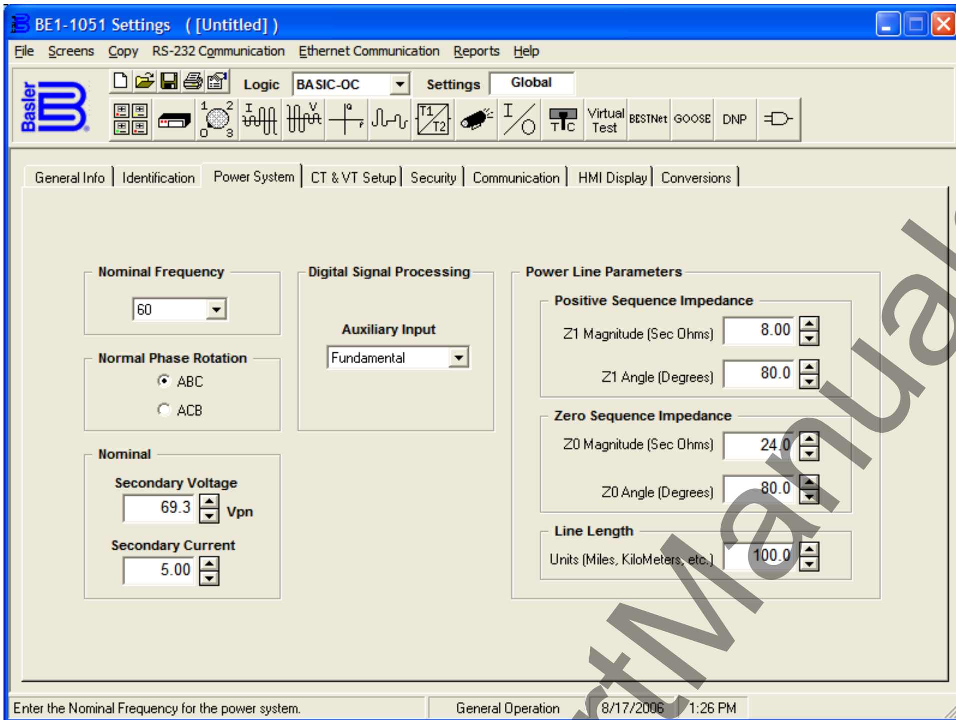

Figure 2-6. General Operation Screen, Power System Tab

From the *Screens* pull down men, select *Reporting and Alarms* and go to the *Demand* tab. Using the scrolling menus on the *Demand* tab, select the demand thresholds and their unit of measure. Refer to Section 6, *Reporting and Alarms,* for more details on demands.

Using the remaining screens and associated tabs make additional settings required for evaluation of the relay. Save the file. From the *RS-232 Communication* pull-down menu, select *Upload Settings to Device* to send the settings to the relay. The relay's inputs and outputs as well as targets, alarms, and current metering can be monitored from the *Metering* screen. To open the *Metering* screen select *Metering* from the *Reports* pull-down menu. To begin viewing the relays metered values, select the *Start Polling* button in the bottom right hand corner of the screen.

FAQ/TROUBLESHOOTING

Frequently Asked Questions

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 BE1-1051 style chart). See Section 12, *Installation,* for additional information.

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4.) Does the BE1-1051 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 BE1-1051 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 latch the relay outputs. 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 function is enabled.

6.) How many overcurrent elements does the BE1-1051 have available?

The BE1-1051 has six instantaneous overcurrent and four 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 from 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 BE1-1051 is a programmable device, what are the factory defaults?

The factory default logic is BASIC-OC 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 BE1-1051 have a battery installed as the back-up power source for the internal clock on loss of power?

No, the BE1-1051 does not have a battery installed as standard. A battery may be ordered as an option. The battery backup will maintain the clock for up to five years. Without the battery, the clock uses a capacitor as a backup power source during a loss of operating power and maintains the clock for at least eight hours. See Section 1, *General Information, Features, Reporting and Alarm Functions, Clock,* for additional information.

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: COM0, COM1, and COM2. The front panel HMI and RS-232 port are considered to be the same port and are designated COM0. The rear RS-232 port is designated as COM1 and the rear RS-485 port is designated as COM2. 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 (COM0). Access needs to be gained only when a write command to the BE1-1051 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

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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 expressions are 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 IRIG signal is demodulated (dc level-shifted digital signal).

13.) Can the IRIG signal be daisy-chained to multiple BE1-1051 units?

Yes, multiple BE1-1051 units can use the same IRIG-B input signal by daisy chaining the BE1-1051 inputs. The burden data is nonlinear, approximately 4 kilo-ohms at 3.5 Vdc and 3 kilo-ohms at 20 Vdc. See Section 6, *Reporting and Alarm Functions,* for additional information.

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

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 BE1-1051?

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 BE1-1051. (The version is provided on the *Identification* 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

BE1-1051 inputs consist of three-phase current inputs, an optional ground current input, three-phase voltage inputs, optional auxiliary voltage input and seven or eight contact sensing inputs depending on the style number. Six or seven general purpose output contacts depending on the style number and one dedicated, fail-safe alarm output make up the BE1-1051 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 BE1-1051 uses for calculating the power quantities.

POWER SYSTEM INPUTS

Power system inputs as described in the Introduction, are sampled 16 times per cycle by the BE1-1051. The BE1-1051 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 half cycle. If the applied voltage is greater than 10 volts, the BE1-1051 measures the frequency and varies the sampling rate to maintain 16 samples per cycle. Frequency compensation applies to all power system measurements. Power system inputs are broken down in the following paragraphs: *Current Measurement, Voltage Measurement, Frequency Measurement, Power Measurement, and Measurement Functions Setup.* The portion on *Power Measurement* discusses calculating power quantities.

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 16 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.

Neutral and Negative-Sequence Current

Neutral and negative-sequence components are measured 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 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 5 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 16 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

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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 BE1-1051 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.

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 BE1-1051 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 BE1-1051 varies the sampling rate to maintain 16 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 is set for 50 hertz or 60 hertz power systems. When the voltage is too low for reliable frequency measurement, the ADC defaults to operation at the nominal frequency setting.

Power Measurement

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

For four-wire VT connection:

$$WATTs_{3\Phi} = V_A I_A \cos(\Phi_A) + V_B I_B \cos(\Phi_B) + V_C I_C \cos(\Phi_C) \qquad \text{Equation 1}$$

$$VARs_{3\Phi} = V_A I_A \sin(\Phi_A) + V_B I_B \sin(\Phi_B) + V_C I_C \sin(\Phi_C) \qquad \text{Equation 2}$$

$$where: \Phi_x = \angle V_x - \angle I_x$$

For three-wire VT connection:

$$WATTs_{3\Phi} = V_{AB} I_A \cos(\Phi_A) + V_{CB} I_C \cos(\Phi_C) \qquad \text{Equation 3}$$

$$VARs_{3\Phi} = V_{AB} I_A \sin(\Phi_A) + V_{CB} I_C \sin(\Phi_C) \qquad \text{Equation 4}$$

$$where: \Phi_x = \angle V_{xy} - \angle I_x$$

For AN, BN, or CN VT connection:

$$WATTs_{3\Phi} = 3 \times V_x I_x \cos(\Phi_x) \qquad \text{Equation 5}$$

$$VARs_{3\Phi} = 3 \times V_x I_x \sin(\Phi_x) \qquad \text{Equation 6}$$

$$where: x = A, B, \text{ or } C \text{ based on sensing type and } \phi_x = \angle V_x - \angle I_x$$

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For AB, BC, or CA VT connection, with ABC phase-sequence:

$$WATTs_{3\Phi} = \sqrt{3} \times V_{xy} I_x \cos(\Phi - 30°) \qquad \textit{Equation 7}$$

$$VARs_{3\Phi} = \sqrt{3} \times V_{xy} I_x - \sin(\Phi - 30°) \qquad \textit{Equation 8}$$

$$where: x \text{ and } y = A, B, \text{or } C \text{ based on sensing type and } \phi = \angle V_{xy} - \angle I_x$$

For AB, BC, or CA VT connection, with ACB phase-sequence:

$$WATTs_{3\Phi} = \sqrt{3} \times V_{xy} I_x \cos(\Phi + 30°) \qquad \textit{Equation 9}$$

$$VARs_{3\Phi} = \sqrt{3} \times V_{xy} I_x - \sin(\Phi + 30°) \qquad \textit{Equation 10}$$

$$where: x \text{ and } y = A, B, \text{or } C \text{ based on sensing type and } \phi = \angle V_{xy} - \angle I_x$$

Measurement Functions Setup

The BE1-1051 requires information about the power system and its current and voltage transformers to provide metering, fault reporting, and protective relaying. This information is entered using BESTCOMS. Alternately, it may be entered at the human-machine interface (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, and SG-PHROT.

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.

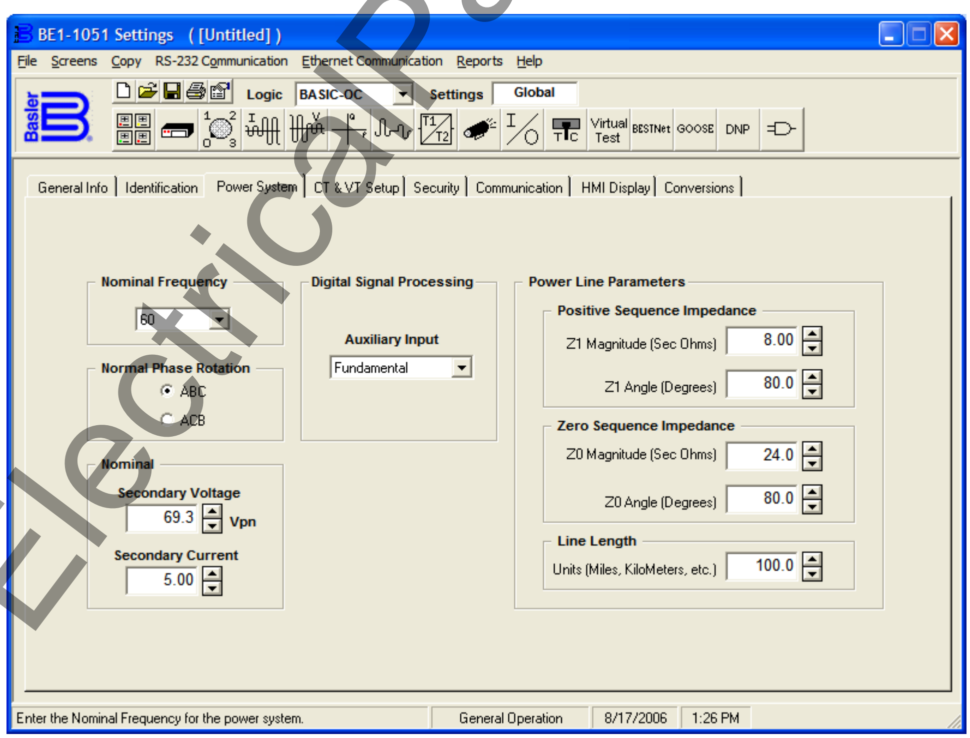

Figure 3-1. General Operation Screen, Power System Tab

Nominal Frequency can be set for 50 hertz or 60 hertz power systems. *Nominal Phase Rotation* can be set for either ABC rotation or ACB rotation.

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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 BE1-1051, 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.

The *Digital Signal Processing* setting governs how the Auxiliary Input quantity is measured. The two choices are *Fundamental* and *RMS*. Each setting causes the relay to respond differently. When set for *Fundamental,* a Fourier filter extracts the fundamental frequency component of the measured voltage. When set for *RMS,* the VX input and the 27X, 59X, and 159X elements measure and react to DC levels, which could then be used for any application requiring DC measurement.

Power Line Parameters are used by the directional overcurrent (67) element to provide directional supervision and control of the overcurrent tripping elements. To perform supervision of the overcurrent elements, the BE1-1051 requires information about the magnitude and angle of the *Positive-Sequence Impedance* and the *Zero-Sequence Impedance. Line Length* is also required. Refer to Table 3-1 for details on power system settings.

Table 3-1. Power System Settings

Function	Range	Increment	Unit of Measure	Default
Nominal Frequency	25 to 60	1	Hertz	60
Normal Phase Rotation	ABC, ACB	N/A	N/A	ABC
Nominal Secondary Voltage	50 to 250 0 = Disabled	0.1	Sec. Volts	69.3
Nominal Secondary Current	0.1 to 2 (1 A CTs)	0.01	Sec. Amps	1
	0.5 to 10 (5 A CTs)			5
Positive Sequence Impedance Z1 Magnitude (Sec Ohms)	0.05 to 200	0.05	Ohms	8
Positive Sequence Impedance Z1 Angle (Degrees)	0 to 90	1	Degrees	80
Zero Sequence Impedance Z0 Magnitude (Sec Ohms)	0.05 to 650	0.05	Ohms	24
Zero Sequence Impedance Z0 Angle (Degrees)	0 to 90	1	Degrees	80
Line Length Units (Miles, Kilometers, etc.)	0.01 to 650	0.01	Units	100

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CT & VT Settings

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

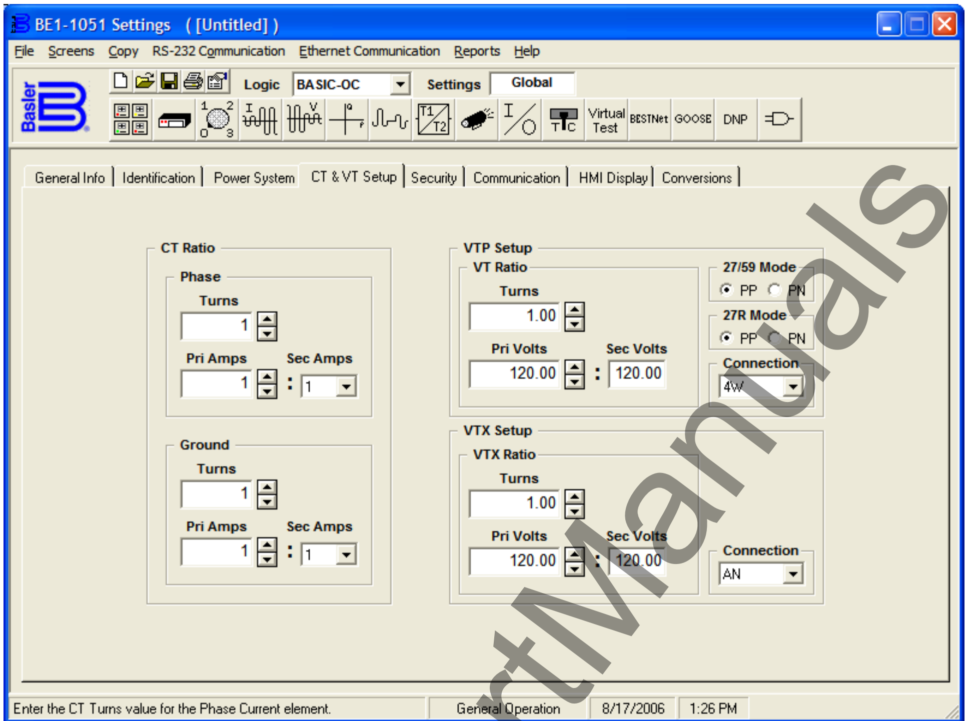

Figure 3-2. General Operation Screen, CT & VT Setup

CT Ratio. The BE1-1051 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 BE1-1051 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 3-2 lists the CT & VT settings.

Table 3-2. 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
VTP Ratio	1 to 10,000	0.01	Turns	1

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Function	Range	Increment	Unit of Measure	Default
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	AN

CONTACT SENSING INPUTS

BE1-1051 relays have seven or eight (depending on style number) contact sensing inputs to initiate BE1-1051 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 BE1-1051 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 13 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 3-3 for the control voltage ranges.

Table 3-3. Contact Sensing Turn-On Voltage

Nominal Control Voltage	Turn-On Voltage Range	
	Jumper Installed Pins 1-2 (Low Position)	**Jumper Installed Pins 2-3 (High Position)**
24 Vdc	13 – 19 Vdc	N/A
48/125 Vac or Vdc	26 – 38 Vac or Vdc	69 – 100 Vac or Vdc
125/250 Vac or Vdc	69 – 100 Vac or Vdc	138 – 200 Vac or Vdc

Each BE1-1051 is delivered with the contact-sensing jumpers installed on pins 1-2 for operation in the lower end of the control voltage range. If the contact sensing inputs are to be operated at the upper end of the control voltage range, the jumpers must be installed on pins 2-3. 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, IN4, IN5, IN6, IN7, and IN8. 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 16 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 milliseconds (1.3 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.

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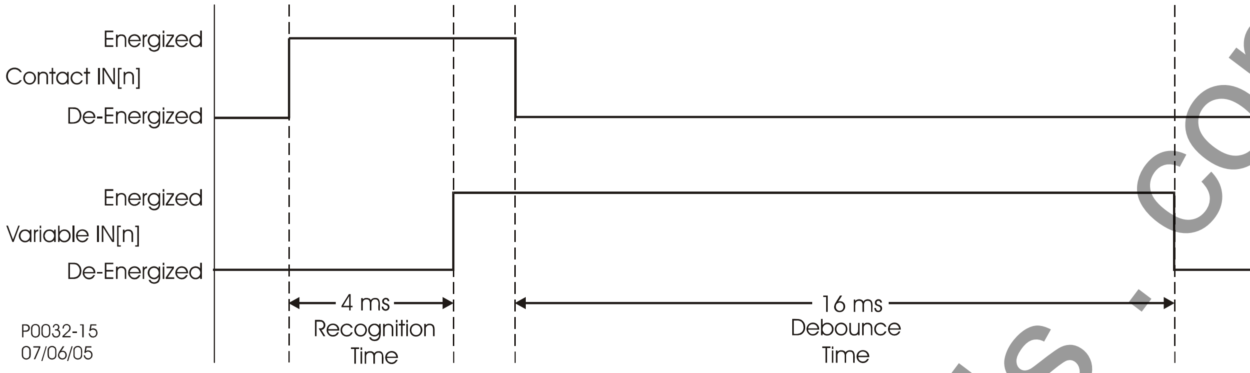

Figure 3-3. Digital Input Conditioning Timing Diagram

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.

<u>Setting the Digital Input Conditioning Function</u>

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 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 BE1-1051'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.

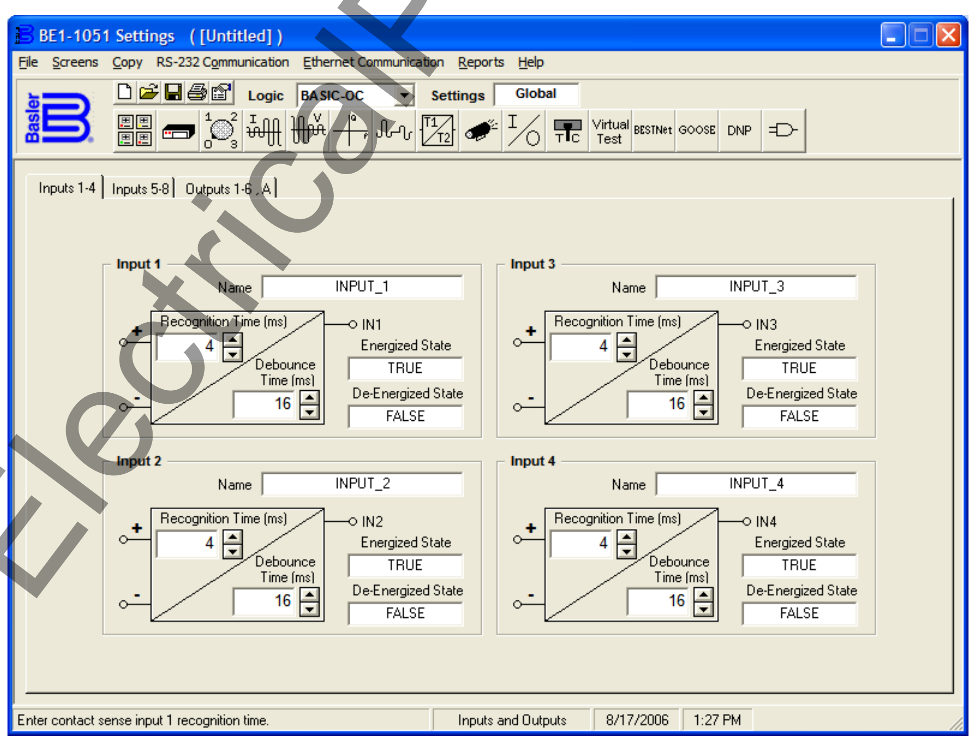

Figure 3-4. Inputs and Outputs Screen, Inputs 1-4 Tab

See Table 3-4 for a list of settings and their defaults.

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Table 3-4. 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 16 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

BE1-1051 relays have five or six (depending on style number) general-purpose SPST output contacts (OUT1, 2, 3, 4, 5, 7), one SPDT output contact (OUT6), and one fail-safe, alarm output contact (OUTA), which can be normally closed or normally open, depending on style number. Each output is isolated and rated for tripping duty. OUT1, 2, 3, 4, 5, and 7 are Form A (normally open) and OUTA is either Form A or B (normally open or closed depending on style number). Since OUT6 has SPDT contacts, it is both Form A and B.

Hardware Outputs and Virtual Outputs

Output contacts OUT1 through OUT7 and OUTA are driven by BESTlogic expressions for VO1 through VO7 (Virtual Outputs 1 through 7) 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 VO7 (Virtual Outputs 1 through 7) and VOA (Virtual Output A) drive Output Contacts OUT1 through OUT7 and OUTA. The state of the output contacts can vary from the state of the output logic expressions for three reasons:

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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.

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.

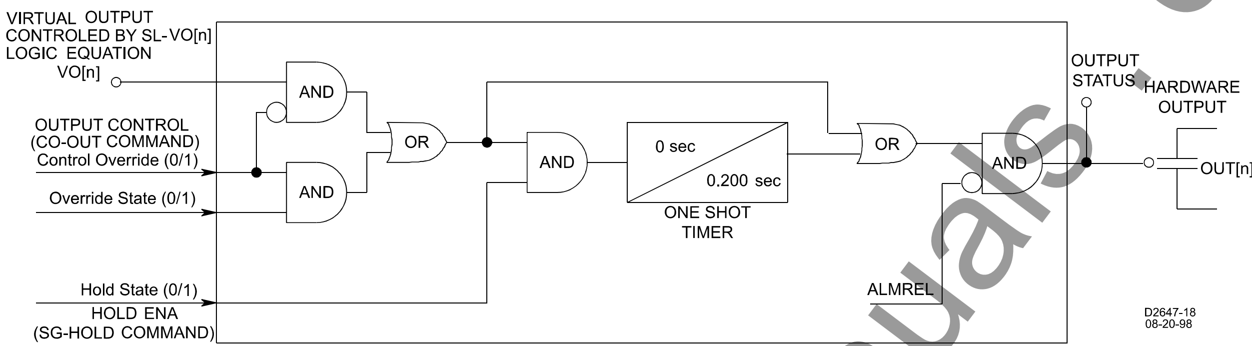

Figure 3-5. Output Logic, General Purpose Output Contacts

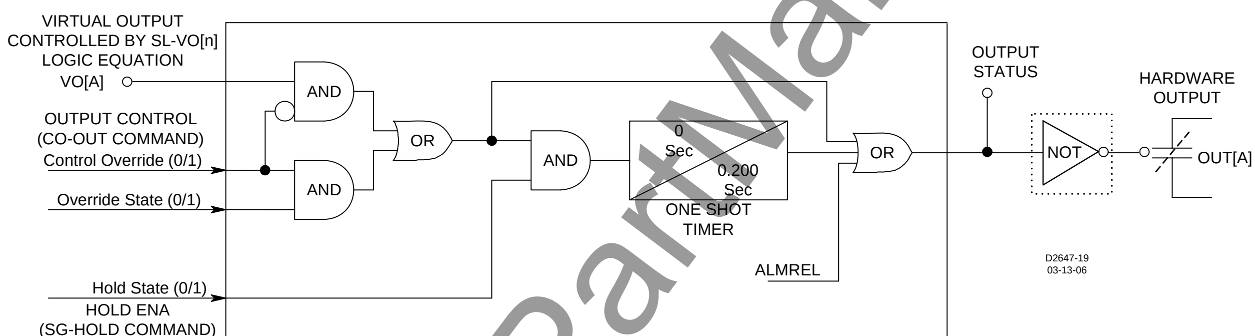

Figure 3-6. Output Logic, Fail-Safe Alarm Output Contact

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 BE1-1051 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 BE1-1051.

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

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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 3-5.

To enable the hold timer using BESTCOMS, select *Inputs and Outputs* from the *Screens* menu, and select the *Outputs 1-7* 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.

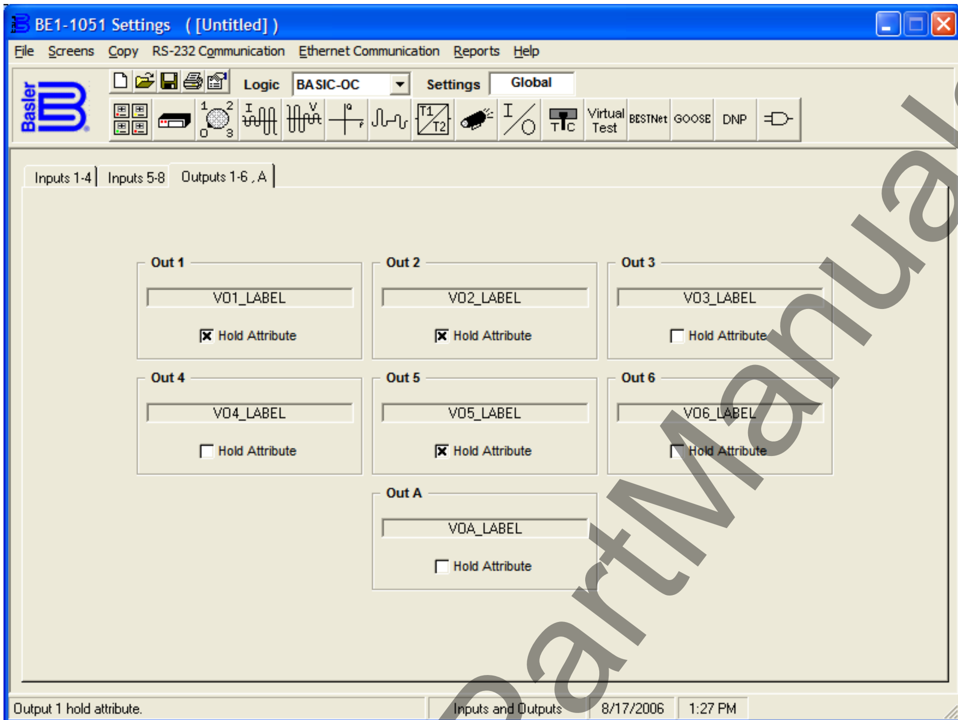

Figure 3-7. Inputs and Outputs Screen, Outputs 1-7 Tab

Table 3-5 lists the default setting for the hold timer attribute. The Hold Attribute for OUT1, OUT2, and OUT5 is enabled.

Table 3-5. 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, OUT6 = 0, OUT7 = 0

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 possible through the front panel HMI on Screen 2.4.1 or it can 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.

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Pulsing an Output Contact

Pulsing BE1-1051 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 2.4.2 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 2.4.2 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 2.4.2 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.

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`

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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)*

<u>*Retrieving Output Logic Override Status*</u>

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 2.4.2 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 BE1-1051 provides many functions that can be used to protect and control power system equipment in and around a protected zone.

BE1-1051 protection functions include:

- Instantaneous Overcurrent w/ Settable Time Delay (50TP, 50TN, 50TQ, 150TP, 150TN, 150TQ)
- Time Overcurrent (51P, 51N, 151N, 51Q, 51LE)
- Voltage Restraint for 51P Phase Time Overcurrent (27R)
- Directional Control (67P, 67N, 67Q)
- Undervoltage and Overvoltage (27P and 59P)
- Auxiliary Undervoltage and Overvoltage (27X and 59X/159X)
- Negative-Sequence Overvoltage (47)
- Directional Power (32/132)
- Overfrequency and Underfrequency (81, 181, 281, 381, 481, 581)
- Breaker Failure (BF)
- VT Fuse Loss Detection (60FL)
- General Purpose Logic Timers (62, 162)
- Overexcitation, Volts per Hertz (24)
- Sync-check (25)
- Permissive Pilot (P85)
- Switch On To Fault (SOTF)
- Breaker Open/Dead Line Logic (52BT)

BE1-1051 control functions include:

- Four-shot recloser (79)
- Virtual Selector Switches (43, 143, 243, 343, 443)
- Virtual Breaker Control Switch (101)
- Virtual Lockout Protection (86, 186)

Four 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 at zero (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*, and Section 8, *Application.*

SETTING GROUPS

The BE1-1051 provides a normal setting group (SG0) and three auxiliary setting groups (SG1, SG2, and SG3). 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. The possibilities for improving protection by eliminating compromises in coordination settings with adaptive setting groups are endless. Figure 4-1 shows the setting group control logic block.

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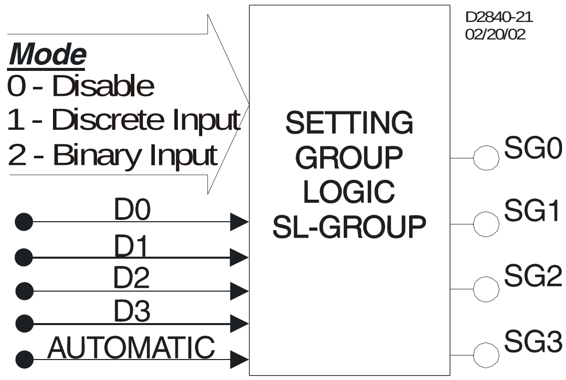

Figure 4-1. Setting Group Control Logic Block

The group of settings that are 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, D1, D2, and D3 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 four logic variable outputs, SG0, SG1, SG2, and SG3. 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 3. To accomplish this, the logic for OUT1 would include the term 51PT SG3 so that 51PT actuates only when SG3 is active.

The setting group control function logic also has an alarm output variable SGC (Setting Group Changed). This output is asserted whenever the BE1-1051 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 BE1-1051 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 BE1-1051 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 BE1-1051 off line. The active setting group is saved in nonvolatile memory so that the BE1-1051 will power up using the same setting group that was used when it was powered down. To prevent the BE1-1051 from changing settings while a fault condition is in process, setting group changes are blocked when the BE1-1051 is in a picked-up state. Since the BE1-1051 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 BE1-1051 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. The BESTCOMS screen used to select BESTlogic settings for the *Settings Group Selection* function is illustrated in Figure 4-2. 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.

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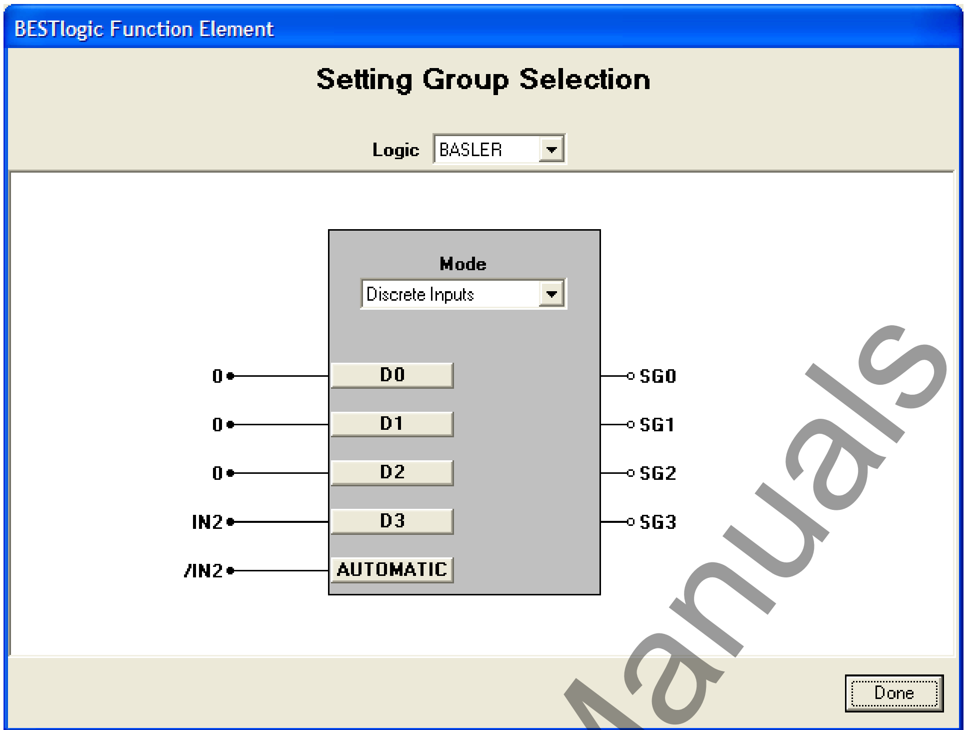

Figure 4-2. BESTlogic Function Element Screen, Setting Group Selection

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 *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
D2	Logic expression. Meaning is dependent upon the Mode setting.	0
D3	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

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

Mode:	Discrete Inputs
D0:	0
D1:	0
D2:	0
D3:	IN2
AUTOMATIC:	/IN2

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, asserting input D1 selects SG1, etc. 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 D3 input while D0 is also active doesn't cause a setting group change to SG3 because the AUTO input is active.

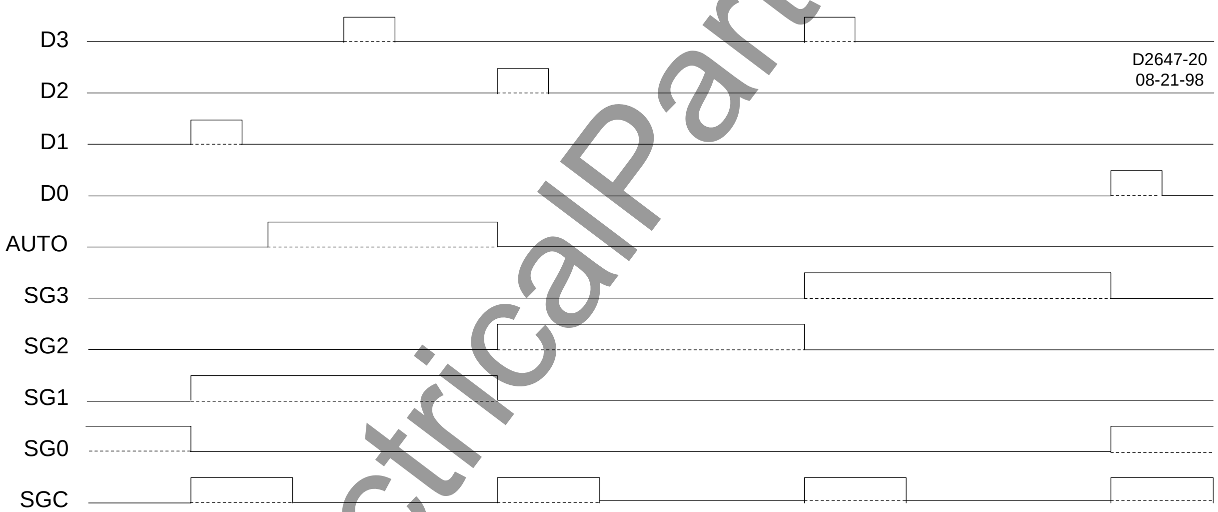

Figure 4-3. Input Control Mode 1

When the setting group control function block is enabled for Mode 2, inputs D0 and D1 are read as binary encoded (Table 4-2). Inputs D2 and D3 are ignored. 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.

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Table 4-2. Setting Group Binary Codes

Binary Code		Decimal Equivalent	Setting Group
D1	**D0**		
0	0	0	SG0
0	1	1	SG1
1	0	2	SG2
1	1	3	SG3

When using control Mode 2, the active setting group is controlled by a binary signal applied to discrete inputs D0 and D1. This requires separate logic equations for only D0 and D1 if all setting groups are to be used. Figure 4-4 shows how the active setting group follows the binary sum of the D0 and D1 inputs except when blocked by the AUTO input. Note that a pulse on the D1 input while D0 is also active doesn't cause a setting change to SG3 because the AUTO input is active.

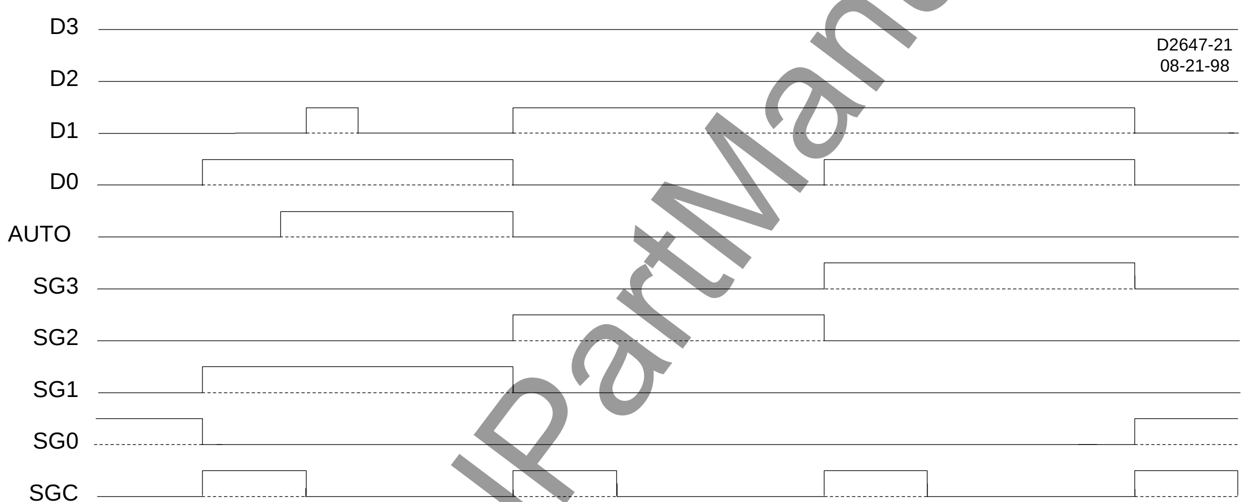

Figure 4-4. Input Control Mode 2

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). 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 had 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). 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

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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 1, 2, and 3 *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 791, 792, 793, 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 below.

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 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 to* threshold and time delay, a *return* threshold and time delay, and a monitored element. The *switch to* 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 to* 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.

Figure 4-5 shows an example of using the automatic setting group selection settings to change settings groups based upon loading. Note that the AUTO input must be at a TRUE logic state in order to allow the automatic logic to operate. At time = 0, current begins to increase. When current reaches 75 percent of pickup, Setting Group 2 begins timing (30 minutes). When current reaches 90 percent of pickup, Setting Group 3 begins timing (5 minutes). After 5 minutes, at time = 37, with the current still above Setting Group 3 threshold, Setting Group 3 becomes active and the setting group change output pulses. At time = 55, Setting Group 2 timer times out but no setting group change occurs because a higher setting group takes precedence. The faint dashed line for SG2, between time = 55 and 75 shows that Setting Group 2 would be active except for Setting Group 3. Current decreases to 75 percent at time = 70 and Setting Group 3 *return* timer begins timing. Current varies but stays below 75 percent for 5 minutes and at time = 75, Setting Group 2 becomes active and the setting change output pulses. After 20 minutes, Setting Group 0 becomes active and the setting change output pulses.

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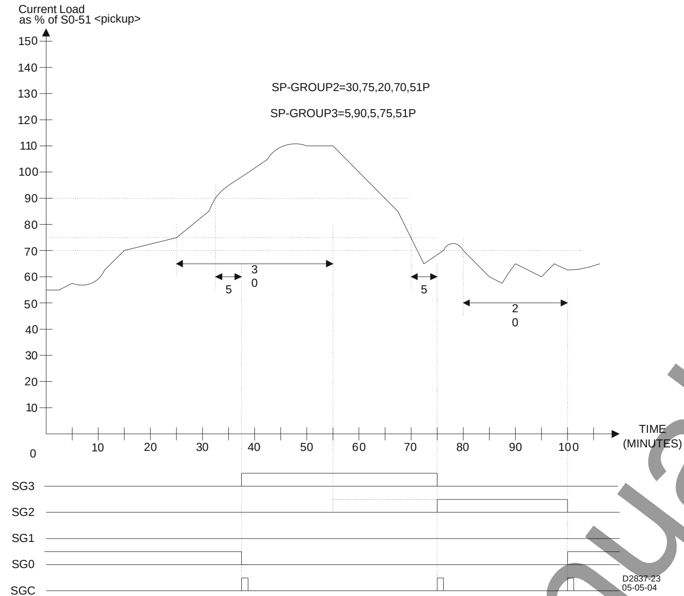

Figure 4-5. Automatic Operation Based on Load Change

This function can also be used to automatically change the active setting group for cold load pickup conditions. If the *switch to* 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.

Figure 4-6 shows how the active setting group follows the load current and time delay settings for Setting Group 1. Note that the AUTO input must be at a TRUE (1) logic state in order to allow the automatic logic to operate. When the breaker opens, the load current falls to zero at time = 15 minutes. After 10 minutes, Setting Group 1 becomes active and the setting group change output pulses TRUE. When the breaker is closed at time = 40 minutes, load current increases to approximately 90 percent of pickup. As the load current decreases to 50 percent of pickup, the Setting Group 1 *return* timer begins timing. After ten minutes, Setting Group 1 output goes FALSE, the setting group returns to Setting Group 0 and the setting group change output pulses TRUE.

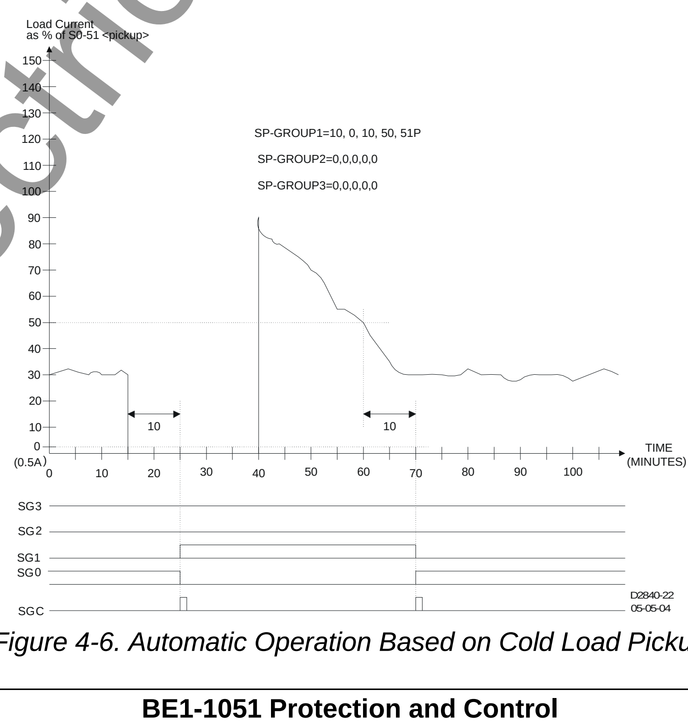

Figure 4-6. Automatic Operation Based on Cold Load Pickup

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When the *switch to* 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 till the relay returns to reset condition. Upon return to reset condition, the relay restores Setting Group 0. The settings group changes via SP-GROUP[n] = ,,,,<791, 792, 793 794> can only raise setting a group number. For instance, one cannot have reclose 1 change to Setting Group 2 and then reclose 2 change to Setting Group 1. When reclose 2 occurs, the relay will remain in Setting Group 2.

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, but not until the relay senses the breaker has actually closed. This may be best understood by examining the diagram in the following example.

Example 1:

In most common practices, only two setting groups would be used for emulating 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 Setting Group 0 when the recloser went to reset if any of the close operations prior to lockout was successful. Setting Groups 2 and 3 are not used (the 51P element is monitored by settings, but the switch-to threshold and switch-to time delay are zero, so a switch to Setting Group 2 or 3 never occurs). Refer to Figure 4-7.

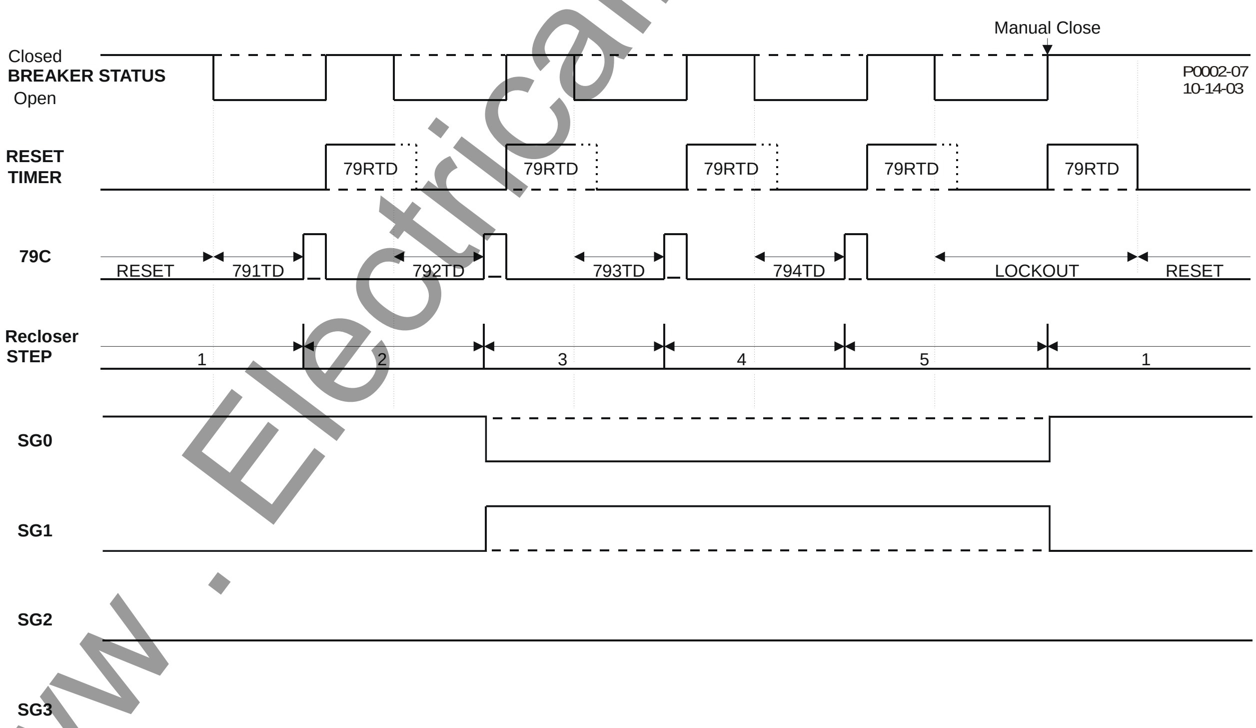

Figure 4-7. Example 1, Change Group on Recloser Shot

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Example 2:

This example illustrates an error in setting the automatic group control. As mentioned above, the settings group changes via SP-GROUP parameter <prot_ele> = 791, 792, 793, or 794 can only raise the setting group number. For example, the following would change to Setting Group 3 after reclose shot 1 and the setting group would remain in Setting Group 3 until RESET is reached or breaker closed from lockout, at which time the setting group returns to Setting Group 0. The relay would never use Setting Group 1 or 2. Refer to Figure 4-8.

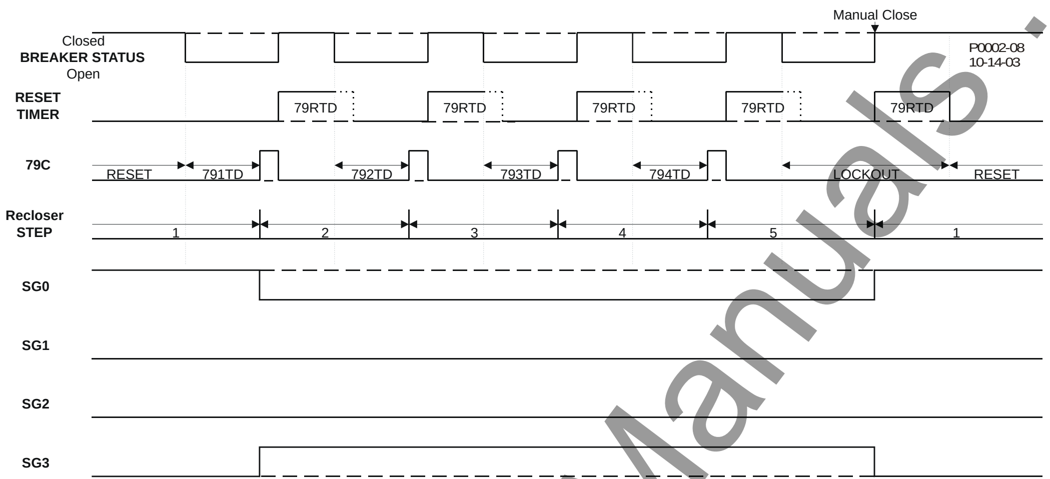

Figure 4-8. Example 2, Error in Setting Group Control by Recloser Shot

Example 3:

When a relay reclose operation reaches a lockout condition, the user may want a special setting group to be enabled before the next manual close. The following settings would be one way of handling this condition. With these settings, in normal operation the relay is in Setting Group 0. After the first and subsequent recloses, the relay would use Setting Group 1. Upon reaching a lockout condition, the automatic mode is disabled, manual logic control takes over, and the relay begins to use Setting Group 2. Once the breaker is closed, the relay will be in Setting Group 2 until the recloser times to reset. At that time, automatic group control is restored and the active group will return to Setting Group 0. An alternative method to get into Setting Group 2 for this scenario would be to use the cold load pickup feature for Setting Group 2 as described in the previous section. Refer to Figure 4-9.

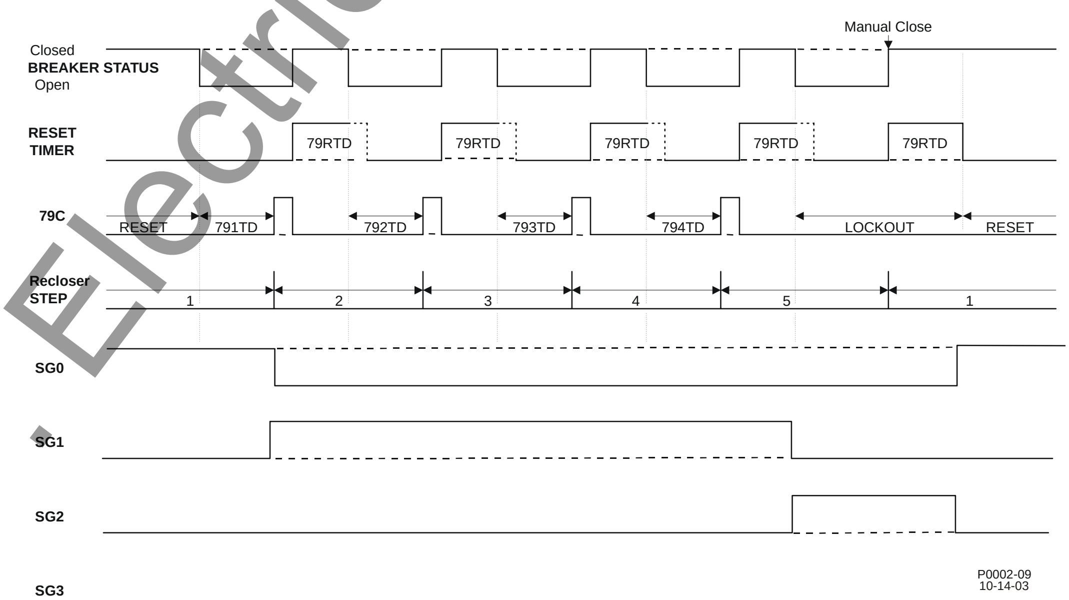

Figure 4-9. Example 3, Using 79LO Logic to Modify Group Control

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Group Control by Monitoring Fuse Loss Status

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 an appropriate Setting Group using the command SP-GROUP[n]= ,,,,<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-GROUP[n]= ,,,,<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 4-10 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.

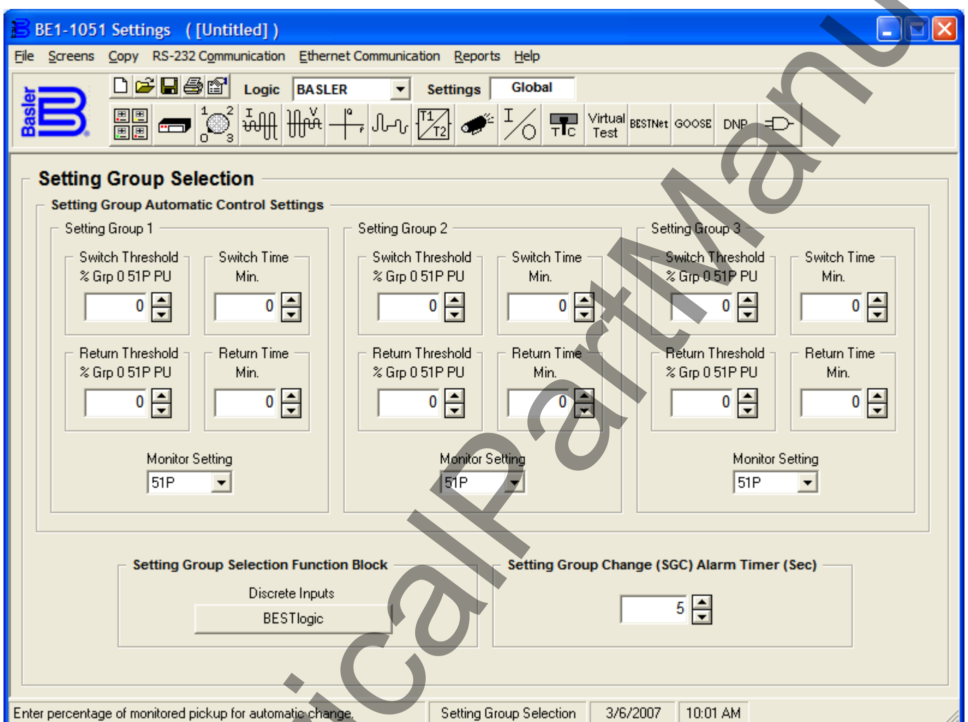

Figure 4-10. Setting Group Selection Screen

At the top center 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 function's modes of operation.

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Table 4-3. Automatic Setting Group Control Settings

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, 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

A transfer to cold load pickup settings (SG1) occurs when the current monitored by the SG0 51P element is at zero for 30 minutes. A return to SG0 settings happens when the monitored current increases to 75 percent of the SG0 51P pickup setting for 15 minutes.

A transfer to unbalance overload settings (SG2) occurs when the monitored current increases above 75 percent of the SG0 51N pickup setting for 5 minutes. Control will return to SG0 when the current decreases below 70 percent of the SG0 51N pickup setting for 5 minutes.

SG3 settings are activated whenever the recloser reaches shot 3 in a reclosing sequence. Note that the *Switch Time, Switch Threshold, Return Time, and Return Threshold* settings are reported as 0 when 791, 792, 793, or 794 is entered for the *Monitor Setting* parameter, as discussed below.

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 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.

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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: GROUP[=<mode>]

Comments: mode = Setting Group 0, 1, 2, 3, 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.

```
>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
```

Retrieving Setting Group Control Status from the Relay

The active setting group can be determined from HMI Screen 1.5.6 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 cannot be determined using BESTCOMS.

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 BE1-1051 includes instantaneous elements for Phase, Neutral, 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 nondirectional. Refer to the paragraph, *67 Directional Overcurrent*, for more information.

The 50TP, 50TN, and 50TQ instantaneous overcurrent elements are shown in Figure 4-11. The 150TP, 150TN, and 150TQ elements are identical to their counterparts. Each element has two logic outputs: Pickup (PU) and Trip (T).

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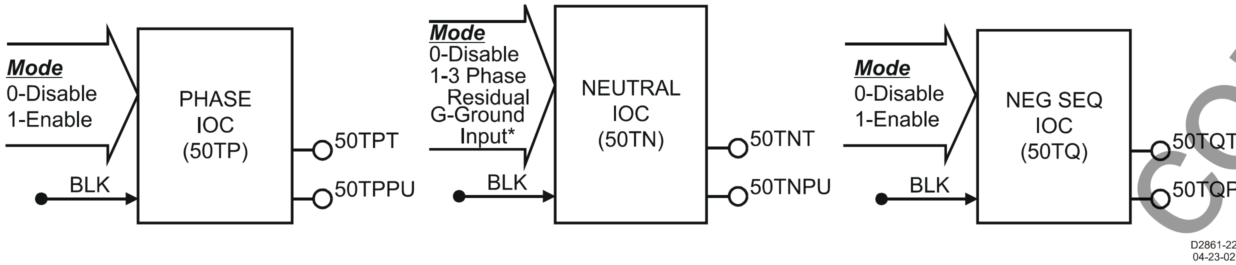

Figure 4-11. Instantaneous Overcurrent Logic Blocks

Each element has a block logic *(BLK)* 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 electro mechanical relay.

A Logic Mode input allows each instantaneous overcurrent element to be enabled or disabled. The ground elements, 50TN and 150TN, have additional mode selections. Element operation can be based on calculated three-phase 3I0 current values (Mode 1) or on measured ground current through the optional independent ground CT input (Mode G). More information about logic mode selection 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. If the current increases above the pickup setting for any one phase, the pickup output asserts. If the trip condition is TRUE for any one phase, the trip logic output asserts.

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 (67A, B, C, N or G). If one is set for non-directional control it will report a 50 target.

BESTlogic Settings for Instantaneous Overcurrent

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-12 illustrates the BESTCOMS screen used to select BESTlogic settings for the 50T and 150T elements (the Neutral 50TN element is shown). To open the *BESTlogic Function Element* screen, select *Overcurrent* 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.

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.

Table 4-4 summarizes the BESTlogic settings for the Phase, Neutral, and Negative-Sequence elements.

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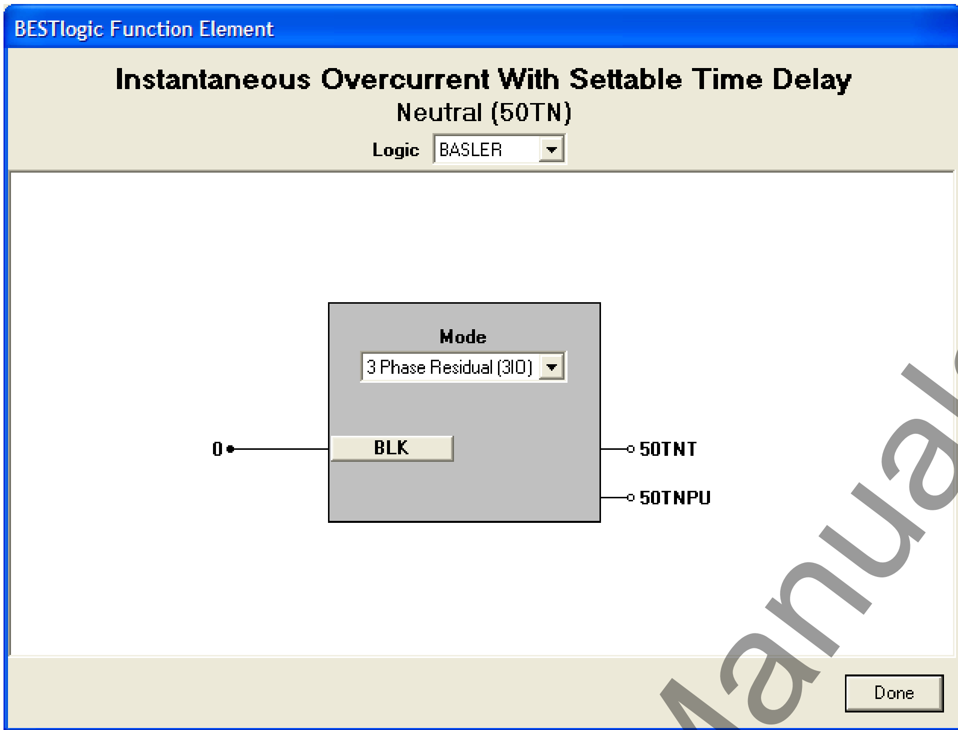

Figure 4-12. BESTlogic Function Element Screen, Neutral (50TN)

Table 4-4. BESTlogic Settings for Instantaneous Overcurrent

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled (x50TP and x50TQ) 1 = 3-phase input neutral (x50TN only) G = Ground input (x50TN only)	1
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following settings to the 50TN element. Refer to Figure 4-12.

Mode: 3 Phase Residual
BLK: 0

NOTE

If the BE1-1051 has 5 ampere phase inputs and a 1 ampere independent ground input or SEF 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 (3I0) 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 or 20 (SEF).

<u>*Operating Settings for Instantaneous Overcurrent*</u>

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.

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Operating settings are made using BESTCOMS. Figure 4-13 illustrates the BESTCOMS screen used to select operational settings for the 50T elements. To open the screen, select *Overcurrent* 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.7.1 - 5.x.7.6 where x equals 1 for Setting Group 0, 2 for Setting Group 1, 3 for Setting Group 2, and 4 for Setting Group 3.

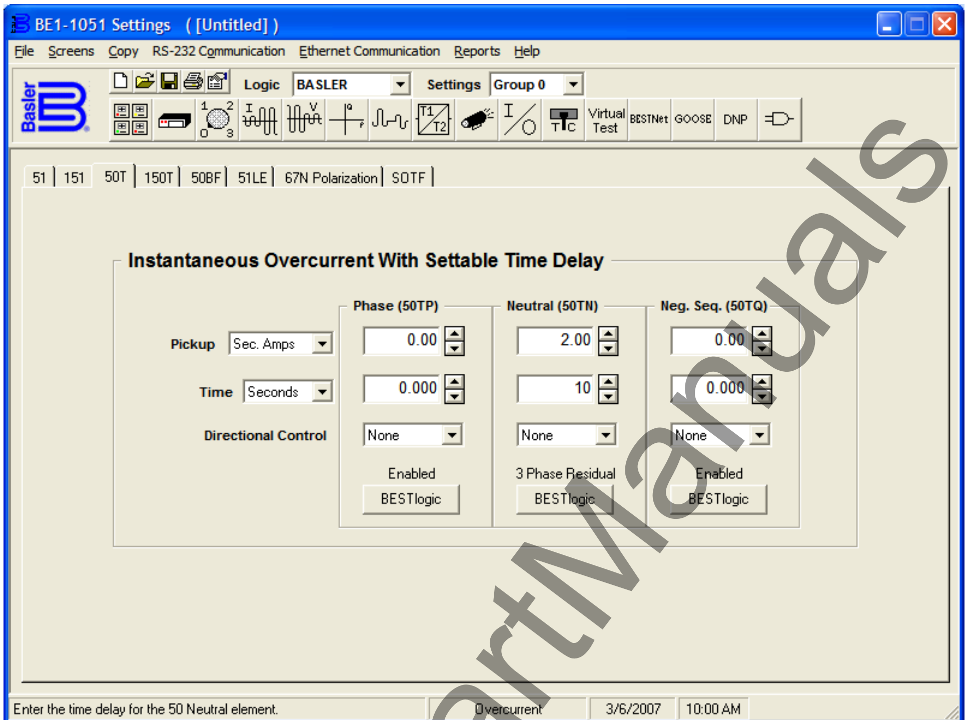

Figure 4-13. Overcurrent Screen, 50T Tab

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.

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 elements settings apply to.

Table 4-5 summarizes the operating settings for instantaneous overcurrent.

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Table 4-5. Operating Settings for Instantaneous Overcurrent

Setting	Range			Increment	Unit of Measure	Default
	SEF	1 A	5 A			
Pickup	0 = Disabled 0.01 to 7.5	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 = Nondirectional 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 4-13.

Pickup: 2 secondary amps
Time: 10 seconds

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. 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.

51 - Time Overcurrent Protection

BE1-1051 relays have one element for phase (51P), two elements for neutral (51N and 151N), and one element for negative-sequence (51Q) inverse time overcurrent protection. Figure 4-14 shows the 51 elements. The 151N element is identical in configuration. Each element has two outputs: Pickup (PU) and Trip (T). A block logic *(BLK)* 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.

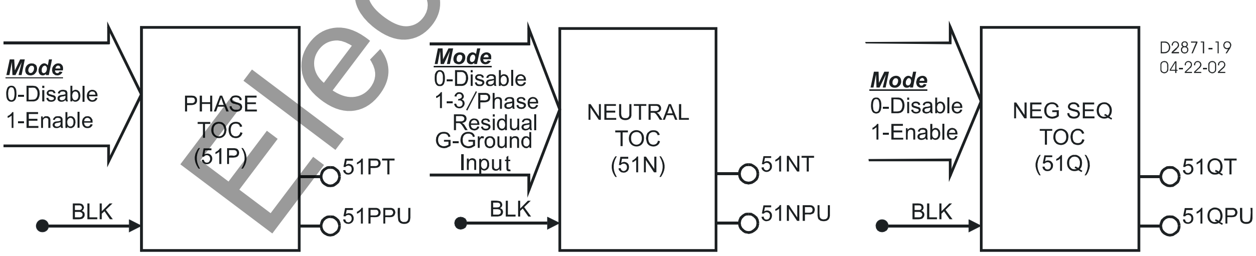

Figure 4-14. Time Overcurrent Logic Blocks

Each inverse time overcurrent function has a mode, pickup, time dial, and curve setting. 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.

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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 (67TA, B, C, N, or G). If one is set for non-directional control, it will report a 51 target.

BESTlogic Settings for Time Overcurrent

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-15 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Time Overcurrent* function (the 151N logic is shown). To open the screen, select *Overcurrent* from the *Screens* pull-down menu and select either the *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.

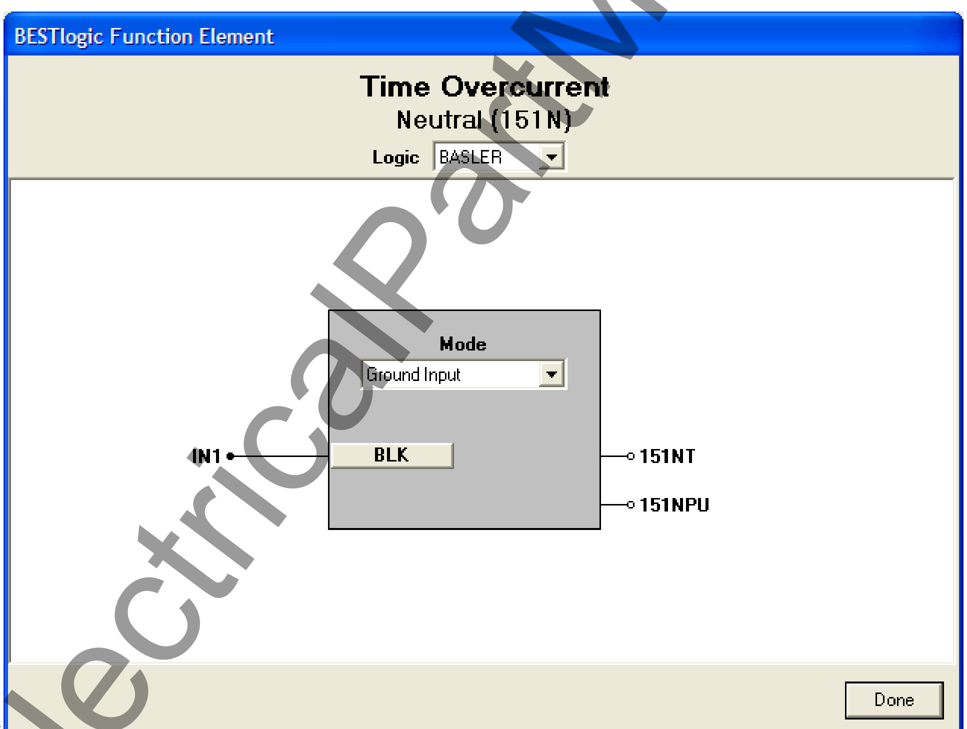

Figure 4-15. BESTlogic Function Element Screen, Neutral (151N)

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

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BESTlogic Expression Builder, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

The BESTlogic settings for Time Overcurrent are provided in Table 4-6. 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 4-6. BESTlogic Settings for Time Overcurrent

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled 1 = 3-phase input neutral (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. Refer to Figure 4-15.

Mode: Ground Input

BLK: IN1

<u>*Operating Settings for Time Overcurrent*</u>

Operating settings are made using BESTCOMS. Figure 4-16 illustrates the BESTCOMS screen used to select operational settings for the *Time Overcurrent* element (the 51 element is shown). To open the screen, select *Overcurrent* 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.8.1 through 5.x.8.5 where x equals 1 for Setting Group 0, 2 for Setting Group 1, 3 for Setting Group 2, and 4 for Setting Group 3.

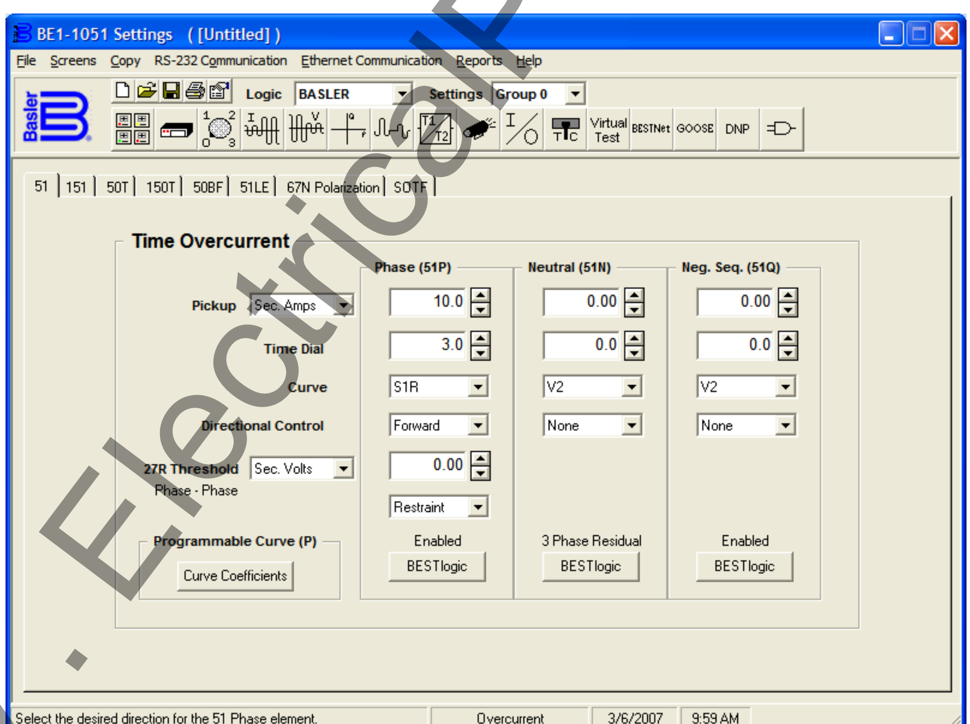

Figure 4-16. Overcurrent Screen, 51 Tab

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

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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 elements settings apply to.

Using the pull-down menus and buttons, make the application appropriate settings to the *Time Overcurrent* function. The *27R* element is explained later in this section.

Table 4-7 summarizes the operating settings for Time Overcurrent.

Table 4-7. Operating Settings for Time Overcurrent

Setting	Range			Increment	Unit of Measure	Default
	SEF	1 A	5 A			
Pickup	0 = Disabled 0.01 to 0.8	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 changes to the 51P Time Overcurrent element in BESTCOMS. Refer to Figure 4-16.

Pickup: 10 secondary amps
Time Dial: 3.0
Curve: S1R
Directional Control: Forward

Retrieving Time Overcurrent 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 cannot be determined by using BESTCOMS.

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 4-17 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.

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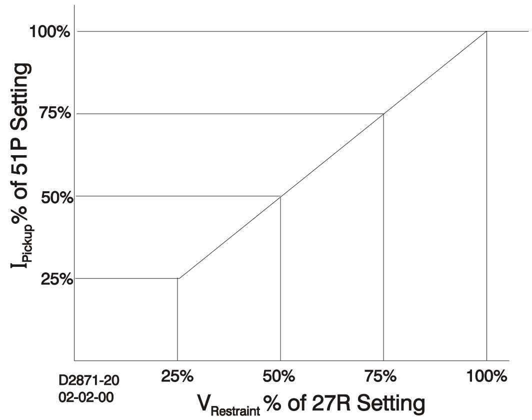

Figure 4-17. 51P Pickup Level Compensation

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 4-8 shows which voltage measurements are used by each phase overcurrent element for each possible VTP connection and 51/27 voltage monitoring mode setting.

Table 4-8. 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
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

NOTE

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

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%.

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 misoperation 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

Operating settings are made using BESTCOMS. Figure 4-16 illustrates the BESTCOMS screen used to select operational settings for the *Time Overcurrent* element. To open the screen, select *Overcurrent* from the *Screens* pull-down menu and select the *51* tab. Alternately, settings may be made using S<g>-27R ASCII commands or from the HMI Screen 5.x.8.5 where x equals 1 for Setting Group 0, 2 for Setting Group 1, 3 for Setting Group 2, and 4 for Setting Group 3.

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The default unit of measure for the *Pickup Threshold* setting is secondary amps. Secondary amps (Sec Amps), per unit amps (Per U Amps), and percent amps (% Amps) can also be selected as the pickup setting unit of measure.

At the top center 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 *Voltage Restraint* element. Table 4-9 summarizes the function's modes of operation.

Table 4-9. Operating Settings for Voltage Restraint/Control for Time Overcurrent

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 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 4-10.

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

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

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Table 4-10. 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.

<u>*Setting Programmable Curves*</u>

Curve coefficients are entered using the SP-CURVE (Settings Protection-programmable curve) command. Table 4-11 lists the programmable curve settings.

Table 4-11. 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 can also be entered using BESTCOMS. Select the *Curve Coefficients* button on the *51* tab in the *Overcurrent* screen (refer to Figure 4-16). The *Curve Coefficients* screen will appear. See Figure 4-18. 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.

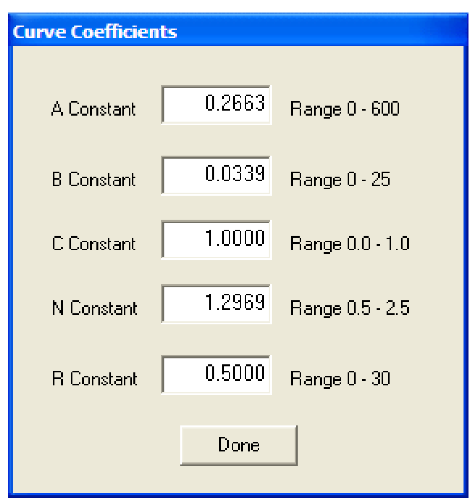

Figure 4-18. Curve Coefficients Screen

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46 Curve

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, 151N, 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.

51LE - Load Encroachment

BE1-1051 relays provide load encroachment that increases the sensitivity of the pickup setting for the 51P function. Load encroachment allows the 51P function to distinguish between overload and fault conditions. It does this by monitoring load current. An overload current is indicated by a relatively low multiple of pickup current and the load is fairly well balanced. Unbalanced loads usually indicate a fault.

Operating Settings for Load Encroachment

Operating settings are made using BESTCOMS. Figure 4-19 illustrates the BESTCOMS screen used to select operational settings for the load encroachment function. To open the screen, select *Overcurrent* from the *Screens* pull-down menu. Then select the *51LE* tab.

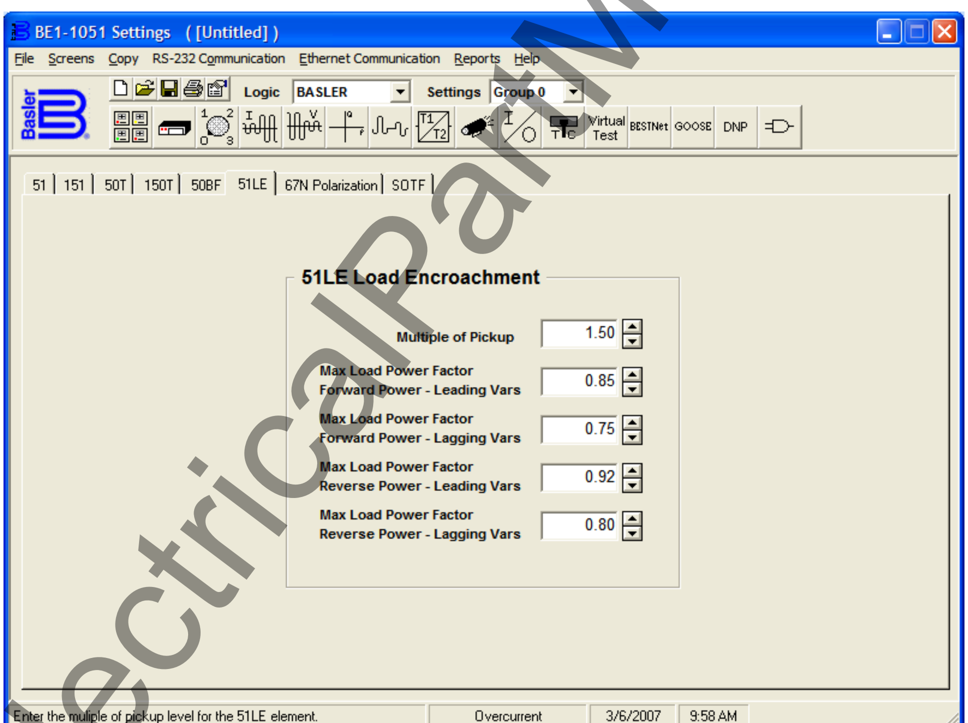

Figure 4-19. Overcurrent Screen, 51LE Tab

At the top center 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 *Load Encroachment* function. Table 4-12 summarizes the function's modes of operation.

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Table 4-12. Operating Settings for the 51LE Function

Function	Purpose	Range	Increment	Default
Multiple of Pickup	Multiplies the 51P pickup by a number between 1 and 2.	1 to 2	0.01	0
Max Load Power Factor Forward Power - Leading Vars	Representation of maximum load power factor angle in the forward power flow, leading vars case. This number is treated as negative internally.	0 to 1	0.01	0
Max Load Power Factor Forward Power - Lagging Vars	Representation of maximum load power factor angle in the forward power flow, lagging vars case. This number is treated as positive internally.	0 to 1	0.01	0
Max Load Power Factor Reverse Power - Leading Vars	Representation of maximum load power factor angle in the reverse power flow, leading vars case. This number is treated as positive internally.	0 to 1	0.01	0
Max Load Power Factor Reverse Power - Lagging Vars	Representation of maximum load power factor angle in the reverse power flow, lagging vars case. This number is treated as negative internally.	0 to 1	0.01	0

Example. Assume the following setting and perform the necessary following calculations:

51P (Pickup):	100 A Primary
51LE Multiple of Pickup:	1.5
Max load power factor forward power - leading vars (FPLD):	0.85
Max load power factor forward power - lagging vars (FPLG):	0.75
Max load power factor reverse power - leading vars (RPLD):	0.92
Max load power factor reverse power - lagging vars (RPLG):	0.80
Typical Load Power Factor:	0.85 Lag
Typical Fault Current Angle:	-75°

Current Angle Represented by FPLD: COS^{-1} (.85) = 31.8° I leads V forward power
Current Angle Represented by FPLG: COS^{-1} (.75) = 41.4° I lags V forward power
Current Angle Represented by RPLD: COS^{-1} (.92) = 23.1° I leads V reverse power
Current Angle Represented by RPLG: COS^{-1} (.80) = 36.9° I lags V reverse power

Angle represented by load power factor: COS^{-1} (.85) = 31.8° I lag forward power

Reference voltage angle: 0

The 51P setting with the region defined by FPLD, FPLG, RPLD, and RPLG is:

51P x Multiple of Pickup or 100 x 1.5 = 150 A

Figure 4-20 illustrates this example.

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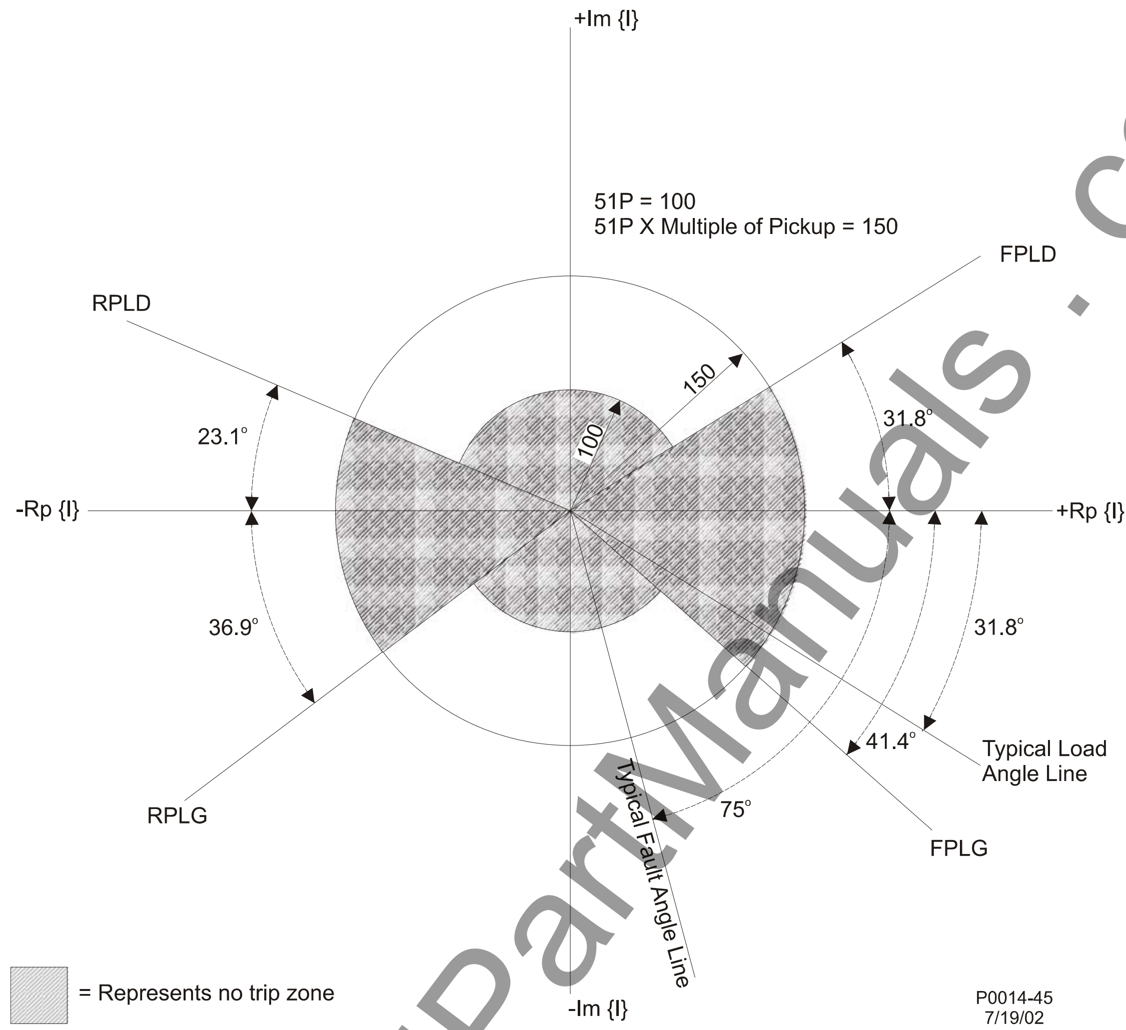

Figure 4-20. 51LE Tripping Diagram

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.

Excluding the angle associated with line impedances Z1, Z2, and Z0, consider the following: Standing at the bus and looking at a typical 4 wire power system, the angle difference between the positive-sequence voltage and positive-sequence current for 3-phase faults is 0 degrees while an angle difference of 180 degrees exist between negative-sequence voltage and current (for all fault types except 3-phase) and zero-sequence voltage and current (for ground faults). To establish a simple, consistent methodology for providing a forward or reverse directional decision in the BE1-1051, an internal “angle adjustment factor” of 180 degrees was included in the V2 and V0 voltage calculations. As a result, an in-phase condition (0 degrees) between the positive, negative and zero-sequence component voltages and currents will result in “forward fault detection” and out-of-phase conditions (180 degrees) result in “reverse fault detection.” Of course, the actual angle is that of the Z1/Z2 and Z0 impedance angle which is covered later. For zero-sequence current polarizing, a true angle difference of 0 degrees exists between the measured zero-sequence current source (IG) and the internally calculated 3IO reference value IN. Forward or reverse declarations are relative to the polarity connections of the relay’s current and potential circuits. Typical AC connections are provided in Section 12, *Installation*.

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Internal Polarization Methods

Each of the four internal polarization methods has designated bits: 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. The polarization methods are as follows:

- Positive-Sequence Polarization – Compares the angle and minimum magnitudes of V1 and I1.
- Negative-Sequence Polarization – Compares the angle and minimum magnitudes of V2 and I2.
- Zero-Sequence Voltage Polarization – Compares the angle and minimum magnitude of the internally calculated V0 to 3I0/IN or IG, or compares an external source of 3V0 to 3I0/IN or IG.
- Zero-Sequence Current Polarization – Compares optional ground CT input (IG) to 3I0/IN.

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 BE1-1051 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.

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 3I0 or independent ground input IG. When an external source of 3V0 is used as the polarizing reference (VX input), the same "angle adjustment factor" as described for V0 and V2 is applied. Typical AC connections for external sources of 3V0 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 the 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 to be too low to measure during a fault, making zero-sequence polarization unreliable. A similar condition can occur with the negative-sequence voltage, although it is less likely. Under these conditions a user may need to use current polarization or dual polarization to provide reliable directional tripping.

Polarizing Settings for 67N Directional Overcurrent Element

Polarization settings are made using BESTCOMS. Figure 4-21 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 element's settings apply to.

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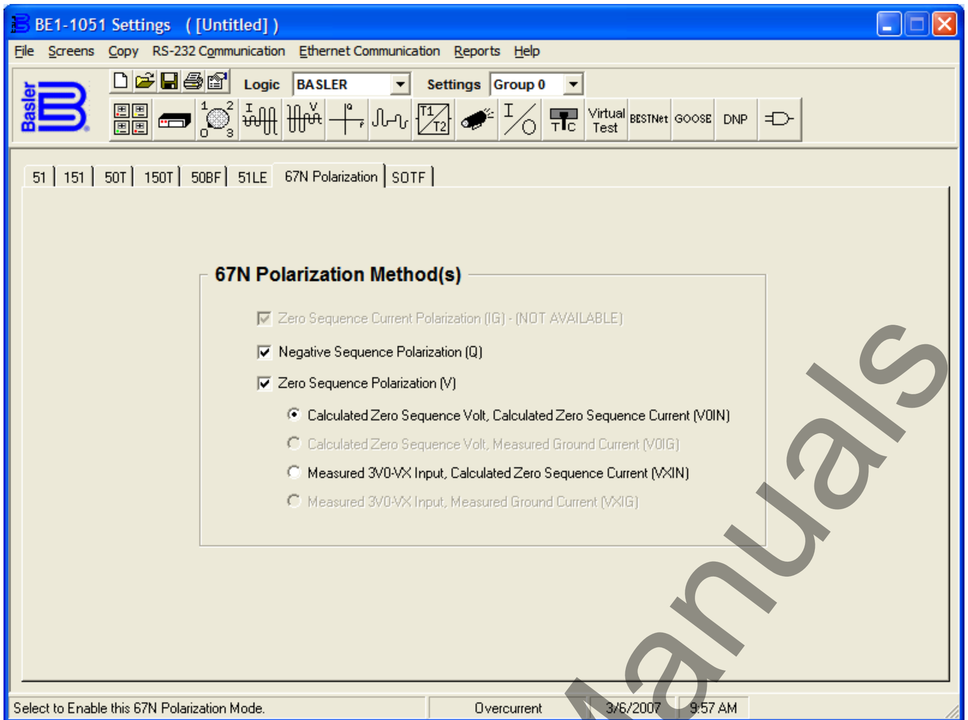

Figure 4-21. Overcurrent Protection Screen, 67N Polarization Tab

Table 4-13 summarizes the polarization settings for Directional Overcurrent. In the table, Q represents negative-sequence polarization, V represents zero-sequence polarization, and I represents current polarization.

Table 4-13. Polarization Settings for Directional Overcurrent

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 OR's of modes Q, V, and I and are used to setup 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.

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The directional algorithm requires the power line impedance parameters. These parameters are input into the BE1-1051 using BESTCOMS, the SG-LINE ASCII command or HMI Screens 6.3.10 through 6.3.12.

Table 4-14 provides the power line impedance settings.

Table 4-14. Power Line Impedance 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

Only the angle parameters are used in determining the fault direction. The other parameters are used for fault location as described in Section 6, *Reporting and Alarm Functions, Fault Reporting*. An entry for Z2 negative-sequence impedance is not required since Z2 and Z1 are considered to be equal. These angles represent the line angle present between the sequence voltage and current if a fault has occurred on the power line.

A fault current is considered to be in a forward direction when the current, after being offset by the line angle, is in phase with the 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.

Internally, the BE1-1051 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 clear 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

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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 affected by the 60FL since it does not rely on voltage sensing.

The direction bits are updated once per ½ cycle. Under sudden reversal conditions, depending on the change in magnitude of the forward current to reverse current, the DFT could require 1 cycle to determine the 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 a sudden current reversal of approximately 2 cycles.

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 (3I0) 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.

Negative-Sequence Pickup Settings

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 4-22.

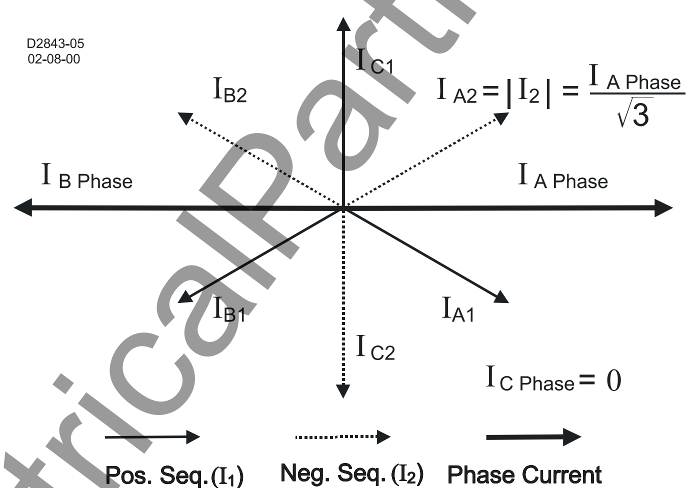

Figure 4-22. Sequence Components for an A-B Fault

The phase-to-phase fault is made up of both positive and negative-sequence components as shown in Figure 4-23. For 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.

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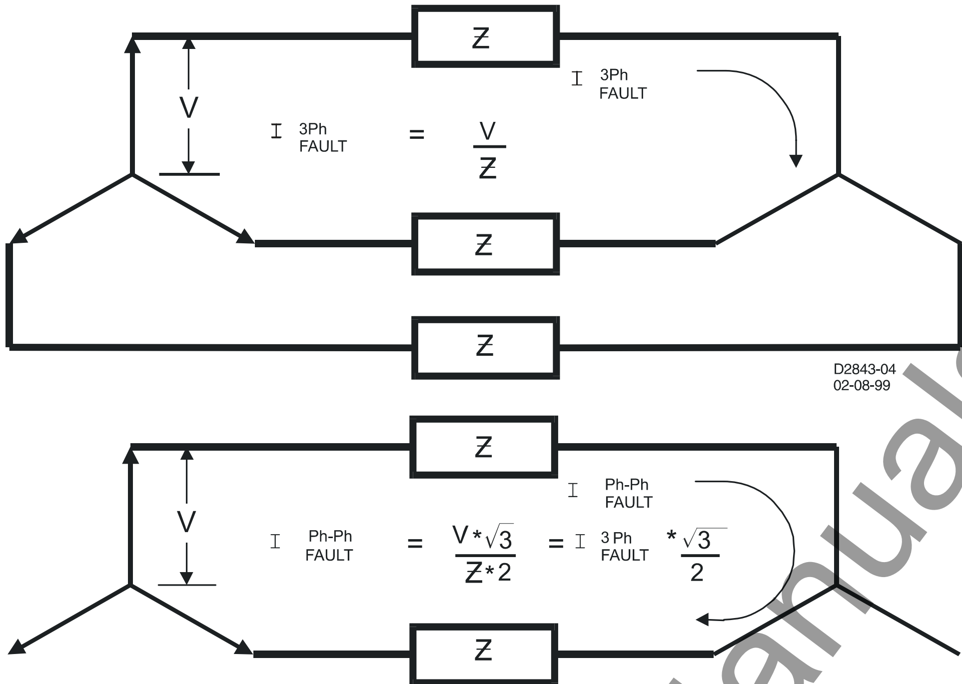

Figure 4-23. Phase-to-Phase Fault Magnitude

<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 (see Table 4-16). 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.

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.

<u>*Delta/Wye Transformer Application*</u>

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 $2/\sqrt{3}$ (1.15) per unit fault current for phase-to-phase faults. However, for faults involving ground, the sensitivity is reduced because the zero-sequence

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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 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 0.5 A. Therefore, the minimum pickup setting for the 46 curve should be set at a value below 0.50 A. Continuous $(I_2)^2$ ratings for generators are typically in the range of 3 to 15 percent of their full-load current rating.

SOTF - Switch on to Fault Logic

SOTF logic (Figure 4-24) provides tripping in the event that the breaker is closed into an existing zero-voltage, bolted three-phase fault, such as that which occurs if the grounds were left on the line following maintenance. Using distance protection alone is not always possible if the line side VTs are used since pre-fault voltage is not present in the distance element memory circuit. An instantaneous high set, non-directional phase overcurrent element is set to trip in the SOTF trip logic. The SOTF function is only active for a preset (user selectable "Hold Timer") amount of time following breaker closure, and is then defeated. A typical *Hold Timer* setting is 12 cycles or 200 milliseconds. Referring to Figure 4-24, the *Tripping* input is commonly programmed with Zone 2/Level 2 overreaching instantaneous elements to cover beyond 50TPPU reach.

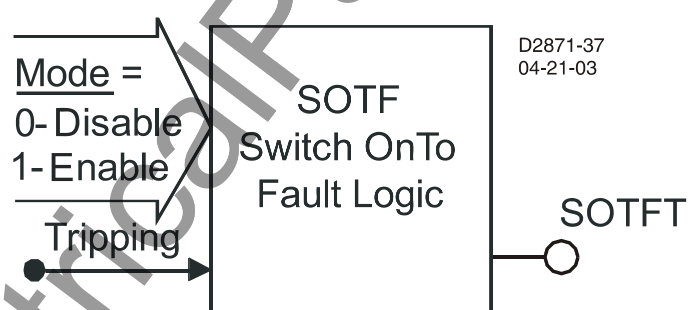

Figure 4-24. SOTF Element

BESTlogic Settings for SOTF

The logic settings for the SOTF element are provided in Table 4-17. These settings enable the element by attaching it to one of the CT input circuits and provide initiate and blocking control as determined by the logic expressions assigned to those inputs.

Table 4-17. BESTlogic Settings for SOTF

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Enabled	1
EXT TRIP	Additional Tripping Elements.	0
BLK	Logic expression that disables function when TRUE.	0

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BESTlogic settings can be made using BESTCOMS. Select Overcurrent for the Screens pull-down menu and then select the SOTF tab. Click on the BESTlogic button. Figure 4-25 will appear.

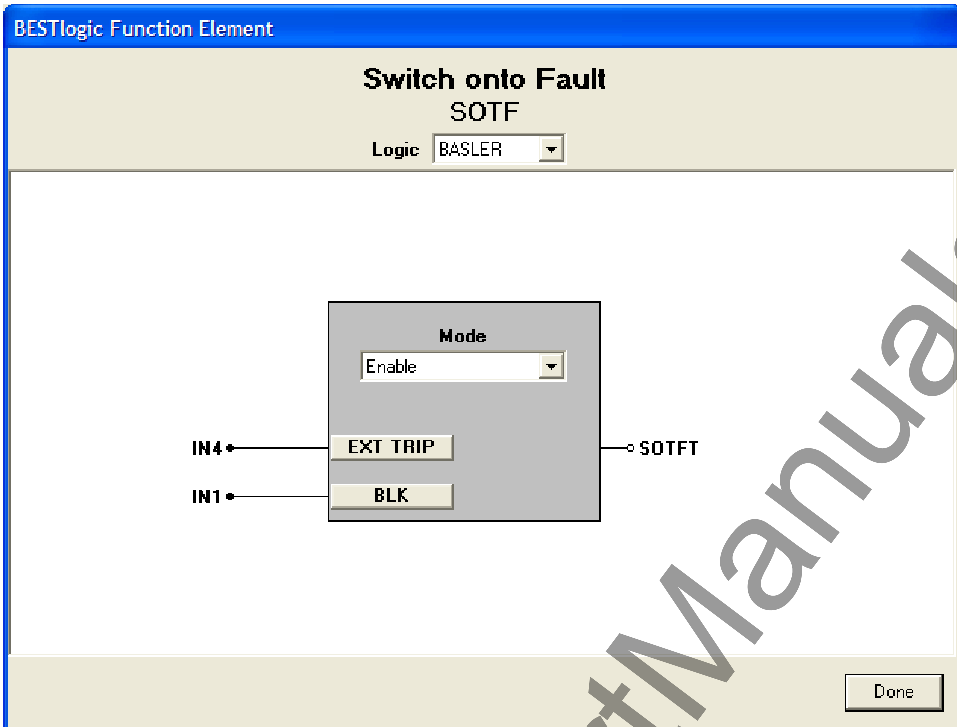

Figure 4-25. BESTlogic Function Element Screen for SOTF

<u>*Operating Settings for SOTF*</u>

The operating parameter settings for the SOTF element are listed in Table 4-18. The time delay can be set in milliseconds, seconds, or cycles. The default is milliseconds if no unit of measure is specified. The minimum resolution of the timing is to the nearest ¼ cycle. A time delay setting of 0 makes the element instantaneous with no intentional time delay.

Table 4-18. Operating Settings for SOTF

Setting	Range		Increment	Unit of Measure	Default
	1 A	5 A			
Phase Inst. OC PU	0.10 to 30	0.5 to 150	0.02 for 1 A CTs 0.1 for 5 A CTs	Secondary Amps	0
Hold Timer	50 to 999		1	Milliseconds	0 (Disabled)
	0.05 to 0.999		0.001	Seconds	
	3 to 59.94 (60 Hz) or 2.5 to 49.95 (50 Hz)		∗	Cycles	

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycle from the front panel HMI. All time delays can be entered to the nearest 0.01 cycle 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.

SOTF settings can be entered through BESTCOMS (see Figure 4-26) or at the HMI Screen 5.x.16.1. Alternately the Sx-SOTF ASCII command may be used, where x = 0 for setting group 1, 1 for setting group 2, 2 for setting group 3, or 3 for setting group 4.

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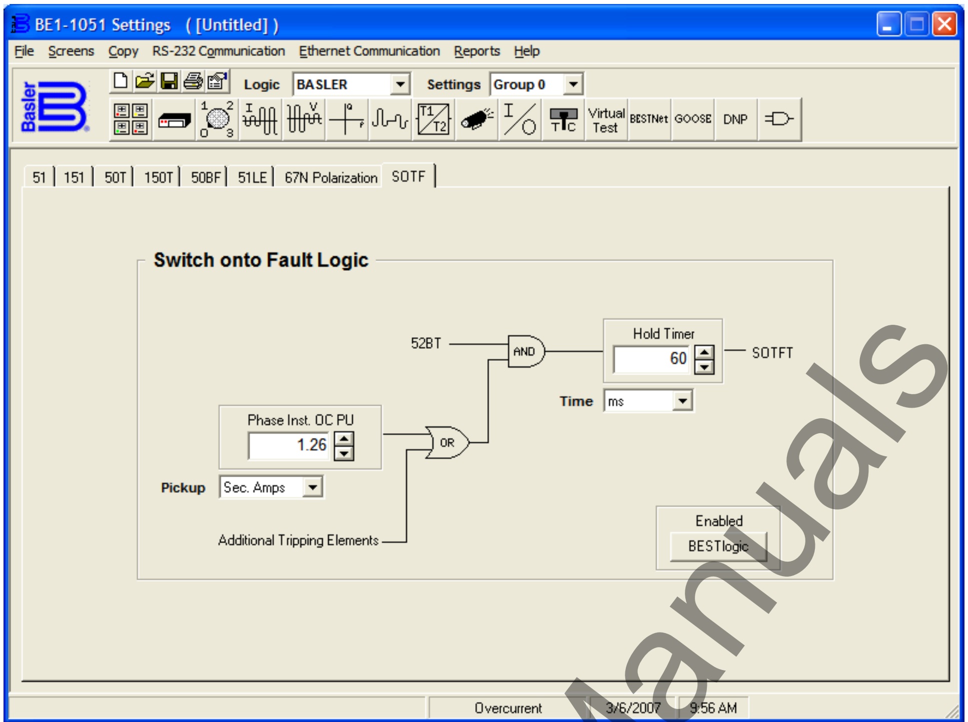

Figure 4-26. Overcurrent Screen, SOTF Tab

DIRECTIONAL POWER PROTECTION

32 - Directional Power Protection

Figure 4-27 illustrates the inputs and outputs of the Directional Power element. The BE1-1051 provides two such elements: 32 and 132. Element operation is described in the following paragraphs.

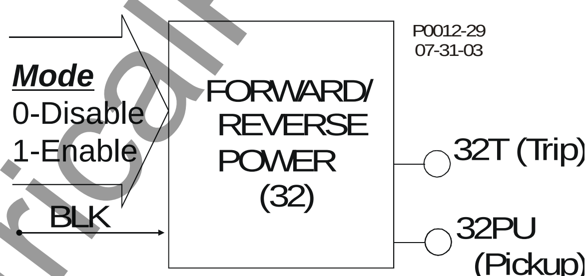

Figure 4-27. Directional Power Logic Block

The Directional Overpower element has two outputs: *32PU* (pickup) and *32T* (trip). When monitored power flow increases above 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 block *(BLK)* 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 element is enabled or disabled by the *Mode* input. Two modes are available. Selecting Mode 0 disables the element; Mode 1 enables the element.

The 32 element monitors three-phase power and compares it to the setting point. If total power is above the set point in the set direction, the element will pick up. The element may be set as forward or reverse sensing. The element will remain in the picked-up condition until power flow falls below the dropout ratio of 95% of setting. The element is always calibrated to the equivalent three-phase power, even if the

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connection is single-phase. For more information on the calibration and power calculations, refer to Section 3, *Input and Output Functions, Power System Inputs*.

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. See Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more information about target reporting.

BESTlogic Settings for Directional Power

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-28 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.

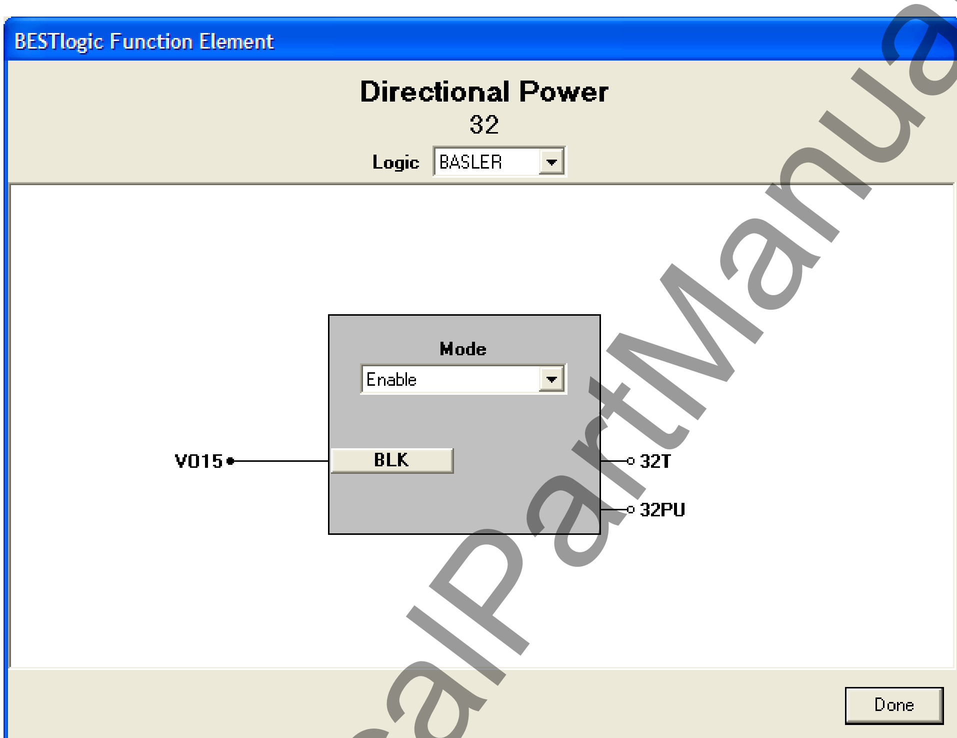

Figure 4-28. BESTlogic Function Element Screen, 32

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.

Table 4-19 summarizes the BESTlogic settings for Directional Power.

Table 4-19. BESTlogic Settings for Directional Power

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

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Example 1. Make the following BESTlogic settings to the directional power element. Refer to Figure 4-28.

Mode: Enable
BLK: VO15

Operating Settings for Directional Power

Operating settings are made using BESTCOMS. Figure 4-29 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 the HMI interface using Screens 5.x.4.1 and 5.x.4.2 where x equals the setting group number.

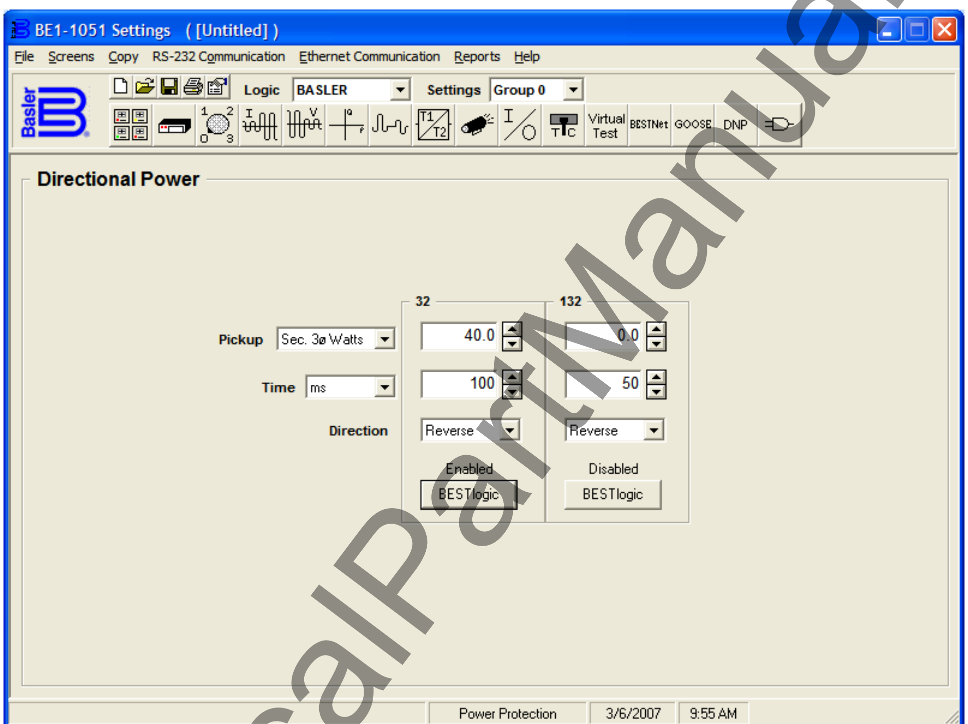

Figure 4-29. Power Protection (Directional Power) Screen

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.

The default unit of measure for the Pickup setting is secondary 3-phase watts (Sec. 3∅ Watts). Primary 3-phase watts (Pri 3∅ Watts), per unit 3-phase watts (Per U 3∅ Watts), and percent 3-phase watts (% 3∅ 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.

Using the pull-down menus and buttons, make the application appropriate settings to the directional power element.

Table 4-20 summarizes the operating settings for Directional Power.

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Table 4-20. Operating Settings for Directional Power

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 1 – 6000 5 A CTs 1 - 1200 1 A CTs	0.1 for 1 to 100 1 for 100 to 6000/1200	Secondary Watts	0
Time	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)			
Direction	F = Forward R = Reverse	N/A	N/A	R

∗ 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 4-29.

Pickup: 40 secondary 3∅ watts
Time: 100 ms
Direction: Reverse

Retrieving Directional Power 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 cannot be determined by using BESTCOMS.

VOLTAGE PROTECTION

BE1-1051 voltage protection includes elements for overexcitation, phase undervoltage, phase overvoltage, auxiliary overvoltage, auxiliary undervoltage, and negative-sequence overvoltage.

24 - Volts per Hertz Overexcitation Protection

Figure 4-30 illustrates the inputs and outputs of the Volts per Hertz element. Element operation is described in the following paragraphs.

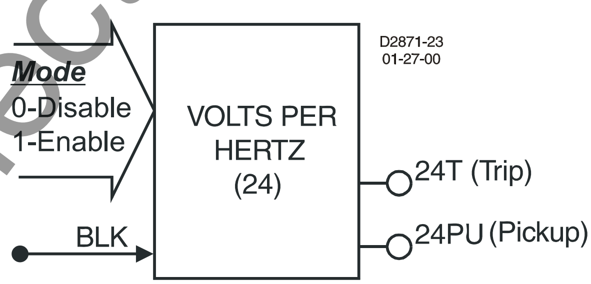

Figure 4-30. Volts per Hertz Overexcitation Logic Block

The volts/hertz element has two outputs: *24T* (trip) and *24PU* (pickup). When monitored Volts per Hertz 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 block *(BLK)* 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

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resetting the timer. This feature functions in a similar way to the torque control contact of an electromechanical relay.

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 pickup setting determines the volts per hertz pickup level. The measured volts per hertz is always calculated as the measured phase to phase voltage divided by the sensed system frequency and is dependent upon VTP connection. When the measured volts per hertz rises above the pickup threshold, the pickup element becomes TRUE and the integrating timer starts. If the volts per hertz remains above the pickup threshold and the integration continues for the required time interval as defined by the equations below and the set time dial, the trip output becomes TRUE.

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.

The timer for the 24 element is an integrating timer with a variety of time dials and either an instantaneous reset or a time delayed integrating reset. Equations 4-4 and 4-5 represent the trip time and reset time for a constant volts per hertz level.

$$T_T = \frac{D_T}{(M-1)^2}$$

Equation 4-4. Time to Trip

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

Equation 4-5. 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
- M = Multiples of pickup = (measured V/Hz) divided by (V/Hz PU setting)
- 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.)

Figure 4-31 shows trip time for various time dials and multiples of pickup.

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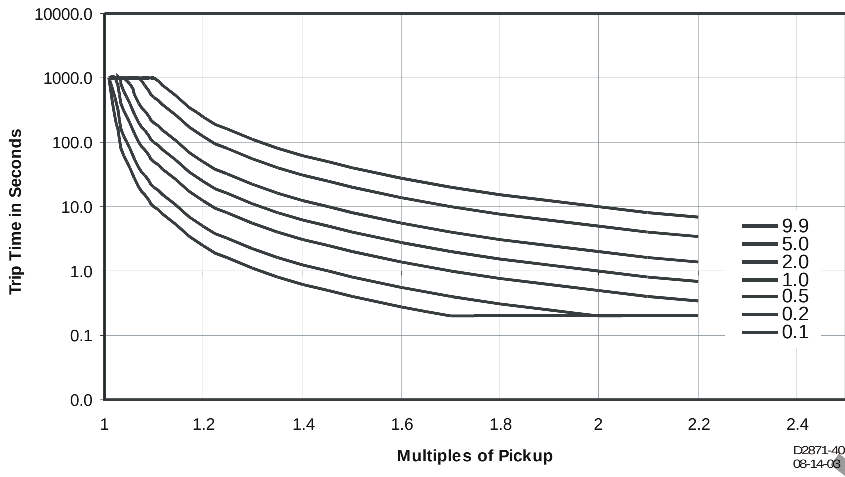

Figure 4-31. Trip Time for Various Time Dials and Multiples of Pickup

BESTlogic Settings for Volts per Hertz Overexcitation

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-32 illustrates the BESTCOMS screen used to select BESTlogic settings for the overexcitation element. To open the screen, 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 the SL-24 ASCII command.

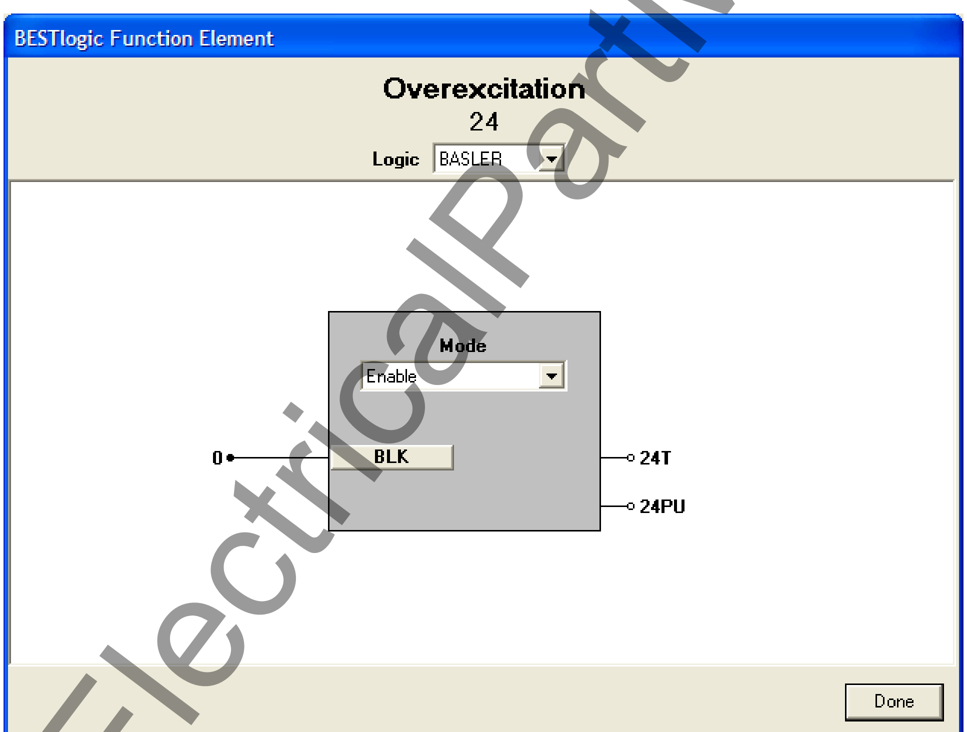

Figure 4-32. BESTlogic Function Element Screen, 24

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 overexcitation 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

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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 4-21 lists the BESTlogic settings for Volts per Hertz Overexcitation.

Table 4-21. BESTlogic Settings for Volts per Hertz Overexcitation

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

<u>Operating Settings Volts per Hertz Overexcitation</u>

Operating settings for the 24 function consist of a pickup setting, a trip time dial, a reset time dial, and an alarm threshold. A pickup of 0 disables the element. The unit of measure is secondary (Sec) 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 4-33 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 may be made using S<g>-24 and SA-24 ASCII command or through HMI Screen 5.x.1.1 where x represents the number of the setting group.

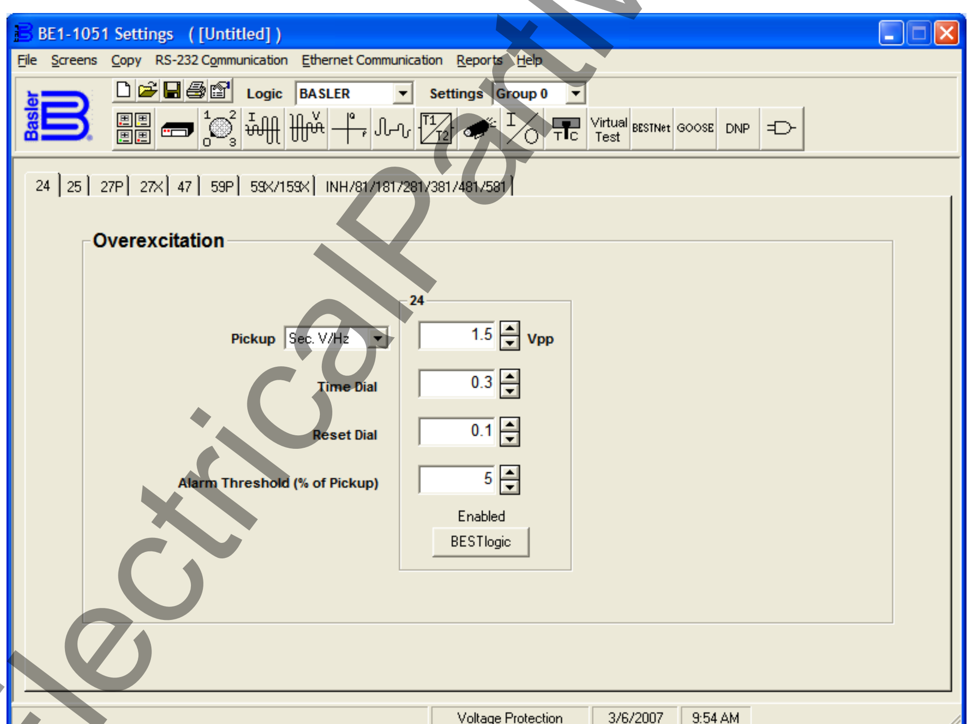

Figure 4-33. Voltage Protection Screen, 24 Tab

The default unit of measure for the *Pickup* setting is secondary V/Hz amps. Primary V/Hz (Pri V/Hz), per unit V/Hz (Per U V/Hz), and percent V/Hz (%V/Hz) 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 elements settings apply to.

Using the pull-down menus and buttons, make the application appropriate settings to the Volts per Hertz element.

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Table 4-22 lists the operating settings for Volts per Hertz Overexcitation.

Table 4-22. Operating Settings for Volts per Hertz Overexcitation

Setting	Range	Increment	Unit of Measure	Default
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

Programmable Alarm for Volts per Hertz Overexcitation

The Volts per Hertz function also has a settable alarm feature. If the Volts per Hertz level reaches a settable percentage of the pickup level (0 to 120%), a programmable alarm bit is set. See Section 6, *Reporting and Alarm Functions*, for more information. The setting for the alarm is via the SA-24 command. Table 4-23 lists the programmable alarm settings for Volts per Hertz Overexcitation.

Table 4-23. Programmable Alarm Settings for Volts per Hertz Overexcitation

Setting	Range	Increment	Unit of Measure	Default
Alarm Level	0 to 120	1	% of pickup level	0

Retrieving Volts per Hertz Overexcitation 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 cannot be determined by using BESTCOMS.

27P/59P - Phase Undervoltage/Overvoltage Protection

Figure 4-34 illustrates the Phase Undervoltage/Overvoltage Logic Blocks.

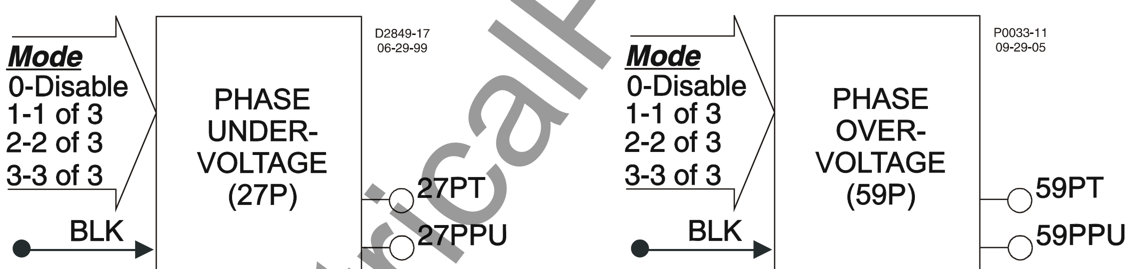

Figure 4-34. Phase Undervoltage/Overvoltage Logic Blocks

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

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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

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-35 illustrates the BESTCOMS screen used to select BESTlogic settings for the Undervoltage element. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and select the *27P* tab. Then select the *BESTlogic* button. BESTlogic settings for the Overvoltage element are found by navigating to the *59P* tab and selecting the *BESTlogic* button. Alternately, settings may be made using the SL-27P and SL-59P ASCII commands.

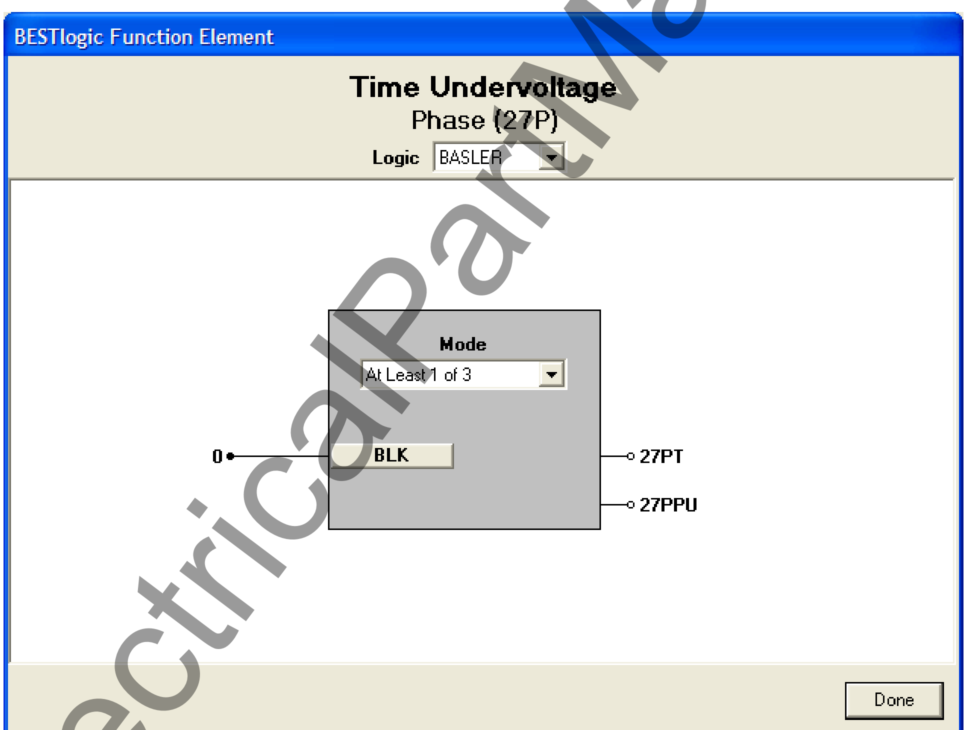

Figure 4-35. BESTlogic Function Element Screen, Phase (27P)

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.

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

Table 4-24. BESTlogic settings for Phase Undervoltage/Overvoltage

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 4-35.

Mode: At least 1of 3 phases

BLK: 0

<u>Operating Settings for Phase Undervoltage/Overvoltage</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 4-36 illustrates the BESTCOMS screen used to select operational settings for the undervoltage element. The 59P overvoltage element is set in a similar manner. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and select the *27P* 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.10.1 (59P), where x represents 1 (Setting Group 0), 2 (Setting Group 1), 3 (Setting Group 2), or 4 (Setting Group 3).

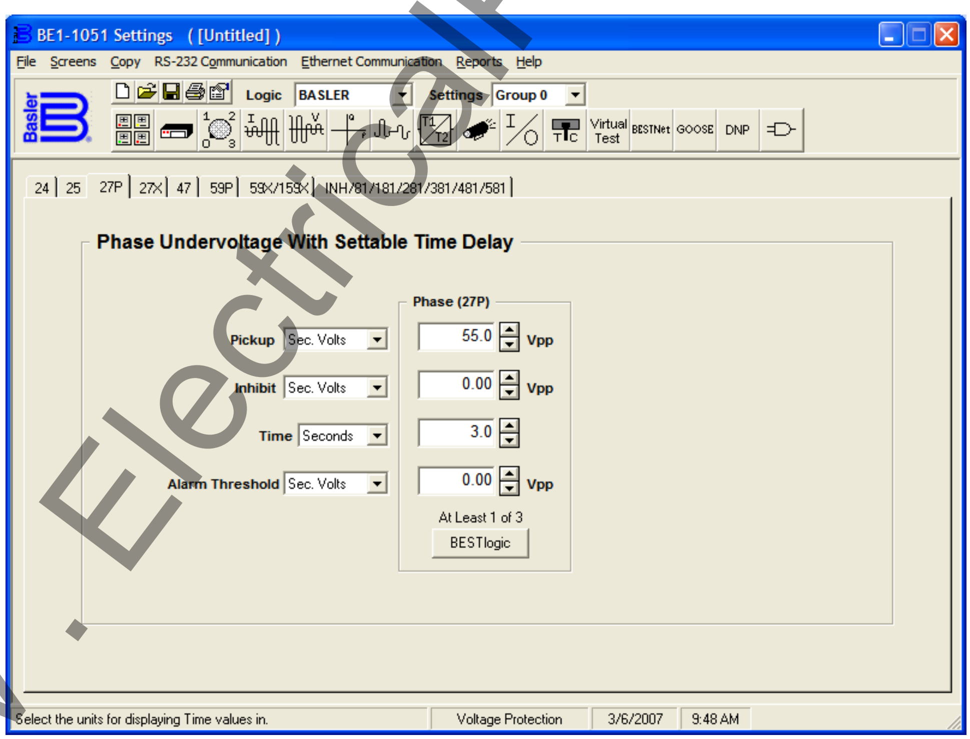

Figure 4-36. Voltage Protection Screen, 27P Tab

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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 are summarized in Table 4-25.

Table 4-25. Operating Settings for Phase Undervoltage/Overvoltage

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 4-36.

Pickup: 55 secondary volts

Time: 3 seconds

<u>*Retrieving Phase Undervoltage/Overvoltage 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 cannot be determined by using BESTCOMS.

27X/59X - Auxiliary Undervoltage/Overvoltage Protection

Figure 4-37 illustrates the inputs and outputs of the auxiliary under/overvoltage elements. Element operation is described in the following paragraphs.

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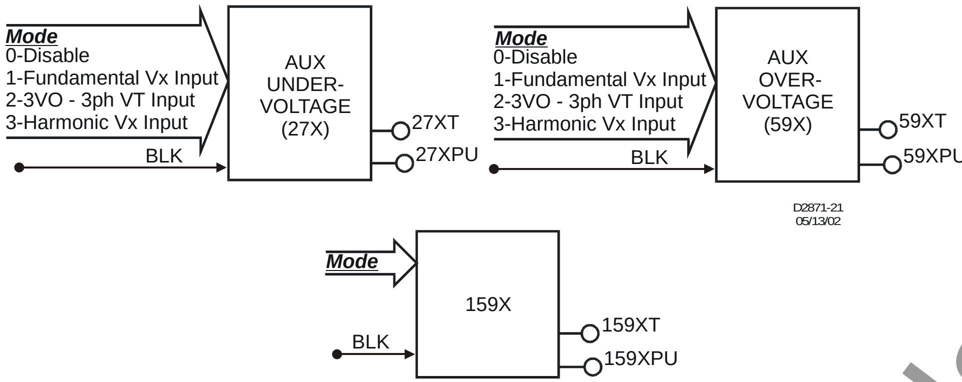

Figure 4-37. Auxiliary Undervoltage/Overvoltage Logic Blocks

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 27X/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.

<u>BESTlogic Settings for Auxiliary Undervoltage/Overvoltage</u>

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-38 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.

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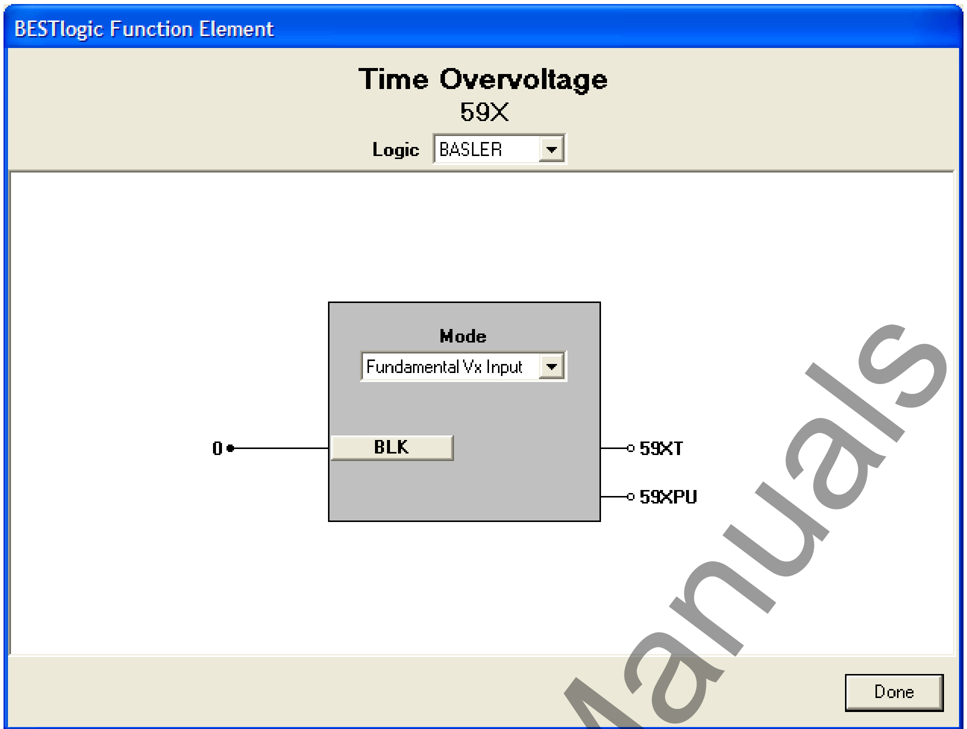

Figure 4-38. BESTlogic Function Element Screen, 59X

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.

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

Table 4-26. BESTlogic Settings for Auxiliary Undervoltage/Overvoltage

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Fundamental Vx Input 2 = 3Vo Phase Inputs ∗ 3 = 3rd Harmonic, Vx Input	0
BLK	Logic expression that disables function when TRUE.	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 4-38.
Mode: Fundamental Vx Input
BLK: 0

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Operating Settings for Auxiliary Undervoltage/Overvoltage

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 4-27. 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 4-27. 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 4-39 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.10.2 (59x), and 5.x.10.3 (159X) where x equals 1 (Setting Group 0), 2 (Setting Group 1), 3 (Setting Group 2), or 4 (Setting Group 3).

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.

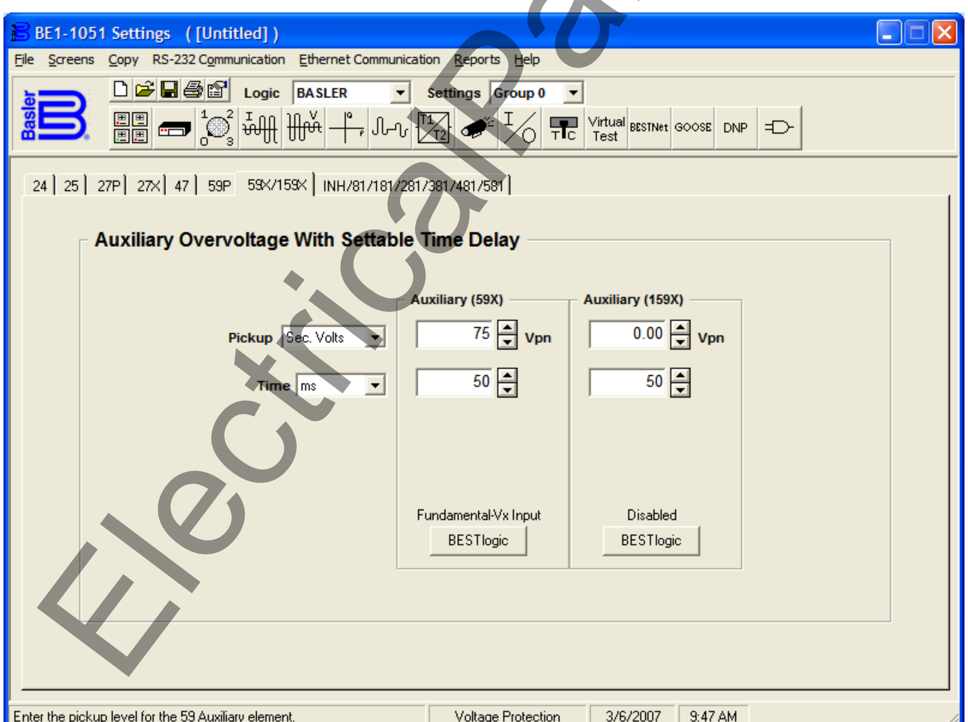

Figure 4-39. Voltage Protection Screen, 59X/159X Tab

Table 4-28 summarizes the operating settings for Auxiliary Undervoltage/Overvoltage.

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Table 4-28. Operating Settings for Auxiliary Undervoltage/Overvoltage

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	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 4-39.

Pickup: 75 secondary volts
Time: 50 ms

Retrieving Auxiliary Undervoltage/Overvoltage 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 cannot be determined by using BESTCOMS.

47 - Negative-Sequence Overvoltage Protection

Figure 4-40 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.

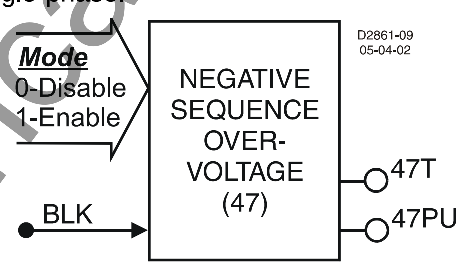

Figure 4-40. Negative-Sequence Overvoltage Logic Block

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 Block *(BLK)* 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

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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

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-41 illustrates the BESTCOMS screen used to select BESTlogic settings for the Negative-Sequence Overvoltage with Settable Time Delay 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.

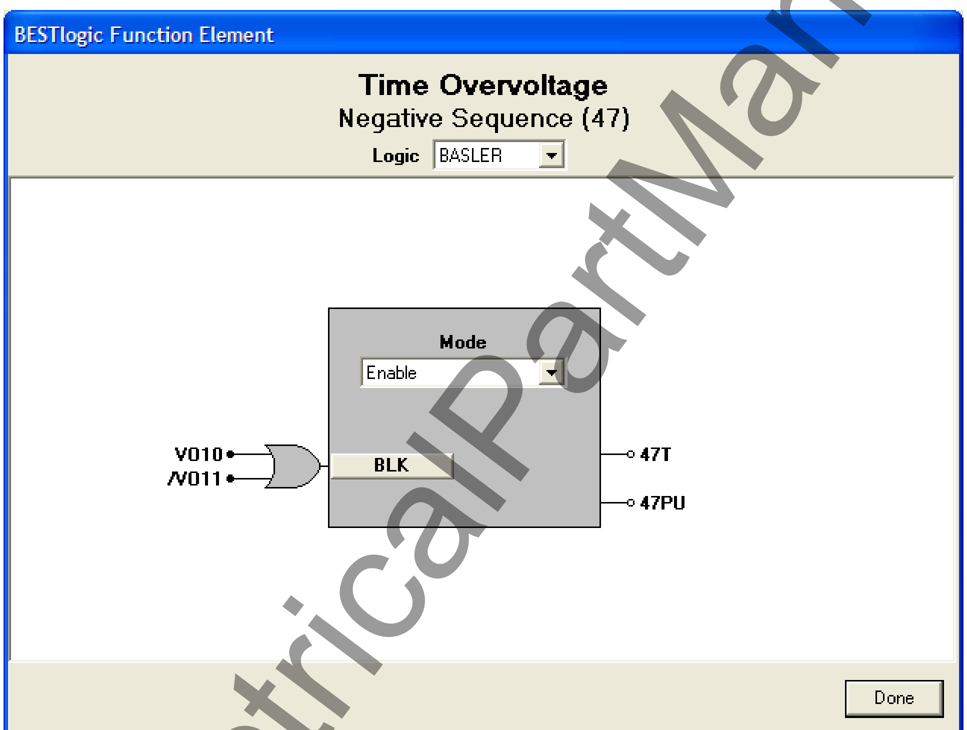

Figure 4-41. BESTlogic Function Element Screen, Negative Sequence (47)

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 with Settable Time Delay 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 Negative-Sequence Overvoltage are summarized in Table 4-29.

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Table 4-29. BESTlogic Settings for Negative-Sequence Overvoltage

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

<u>*Operating Settings for Negative-Sequence Overvoltage*</u>

Operating settings are made using BESTCOMS. Figure 4-42 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 the number of the setting group.

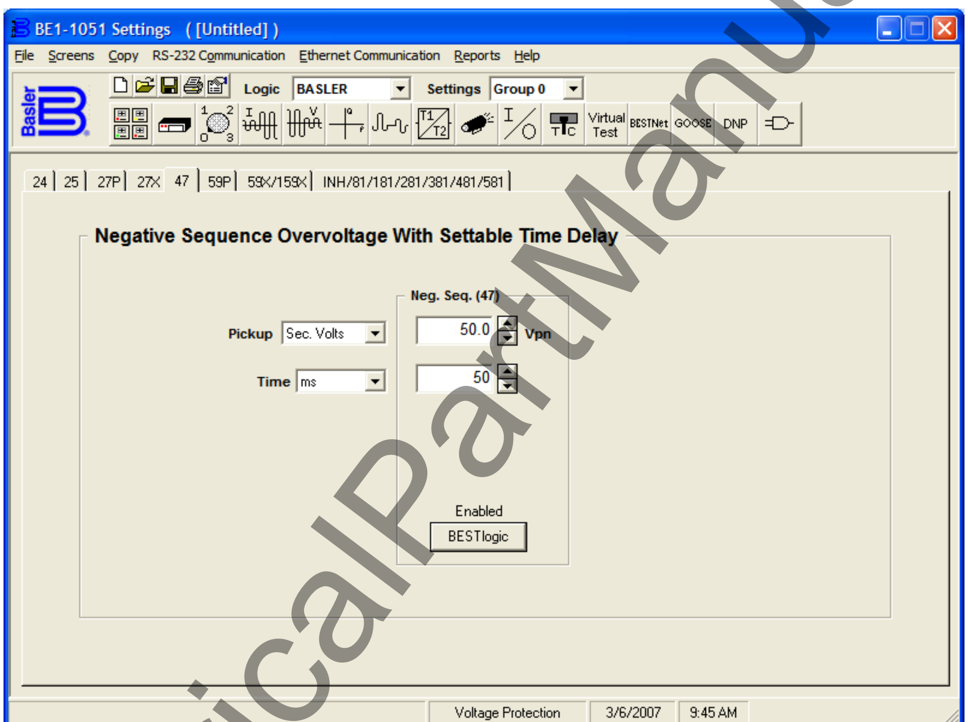

Figure 4-42. Voltage Protection Screen, 47 Tab

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* 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.

Using the pull-down menus and buttons, make the application appropriate settings to the negative-sequence overvoltage element.

Operating settings for Negative-Sequence Overvoltage are summarized in Table 4-30.

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Table 4-30. Operating Settings for Negative-Sequence Overvoltage

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 1 to 300	0.1 for 1 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 4-42.

Pickup: 50 Vpn secondary volts

Time: 50 ms

Retrieving Negative-Sequence Overvoltage 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 cannot be determined by using BESTCOMS.

FREQUENCY PROTECTION

81 - Over/Underfrequency Protection

BE1-1051 frequency protection consists of six independent elements that can be programmed for underfrequency or overfrequency protection. Each element has an adjustable frequency setpoint and time delay. The 81 elements share a common undervoltage inhibit setting. An over/underfrequency element is shown in Figure 4-43. 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 BE1-1051 measures the frequency. The measured frequency is the average of two cycles of measurement.

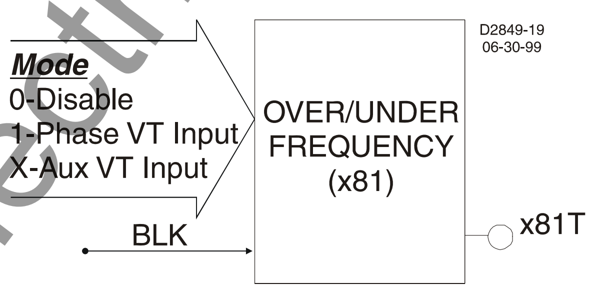

Figure 4-43. Over/Underfrequency Logic Block

Frequency element designations are 81, 181, 281, 381, 481, and 581. Each of the six elements has identical inputs, outputs, and setting provisions. Figure 4-43 illustrates the inputs and output of a frequency element. A trip output (x81T) is provided on each element. The trip output becomes TRUE when the monitored frequency decreases below (81U) or increases above (81O) the pickup setting and the element timer times out.

The block *(BLK)* 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

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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 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 Tips*, for more information. More information about logic mode selections is provided in the following *BESTlogic Settings for Over/Underfrequency* paragraphs.

Pickup settings define the frequency setpoint and time delay and program the element for underfrequency or overfrequency protection. The frequency setpoint defines the value of frequency 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 reaches the frequency setpoint. If three consecutive cycles of the measured frequency have either decreased (81U) below or increased (81O) above the pickup threshold and the timer has timed out, then the 81T will trip. If the timer has not timed out and the frequency remains in the pickup range for the remainder of the time delay, the 81T will trip. If the monitored voltage decreases below the user-defined setpoint, frequency protection is inhibited.

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.

<u>BESTlogic Settings for Over/Underfrequency</u>

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-44 illustrates the BESTCOMS screen used to select BESTlogic settings for the 81 Over/Underfrequency element. To open the *BESTlogic Function Element* screen for Over/Underfrequency element, select *Voltage Protection* from the *<u>S</u>creens* pull-down menu and select either 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.

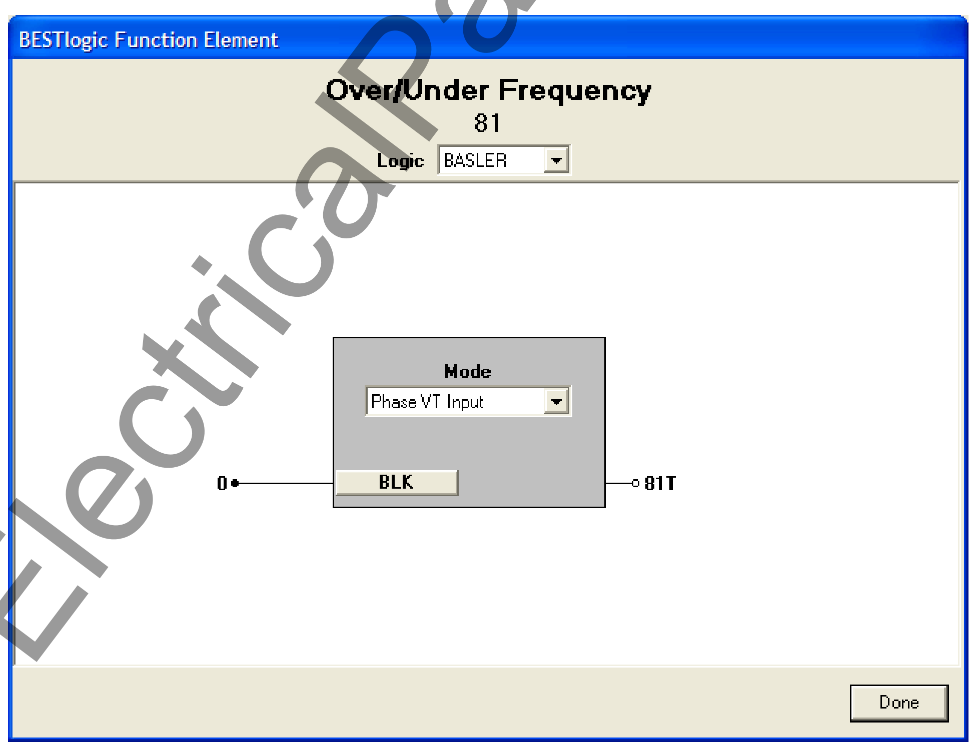

Figure 4-44. BESTlogic Function Element, 81

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*.

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Enable the Over / Underfrequency 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/Underfrequency are summarized in Table 4-31.

Table 4-31. BESTlogic Settings for Over/Underfrequency

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

Example 1. Make the following BESTlogic settings to the 81 element. Refer to Figure 4-44.

Mode: Phase VT Input

BLK: 0

Operating Settings for Over/Underfrequency

Operating settings for the 81 elements consist of pickup values, time delay values, and a mode setting that defines whether an element provides underfrequency or overfrequency protection. The pickup value determines the value of frequency 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 4-45 illustrates the BESTCOMS tab used to select operational settings for the six Over/Underfrequency elements. To open the *BESTlogic Function Element* screen for Over/Underfrequency 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.14.1 through 5.x.14.6 where x equals the setting group number.

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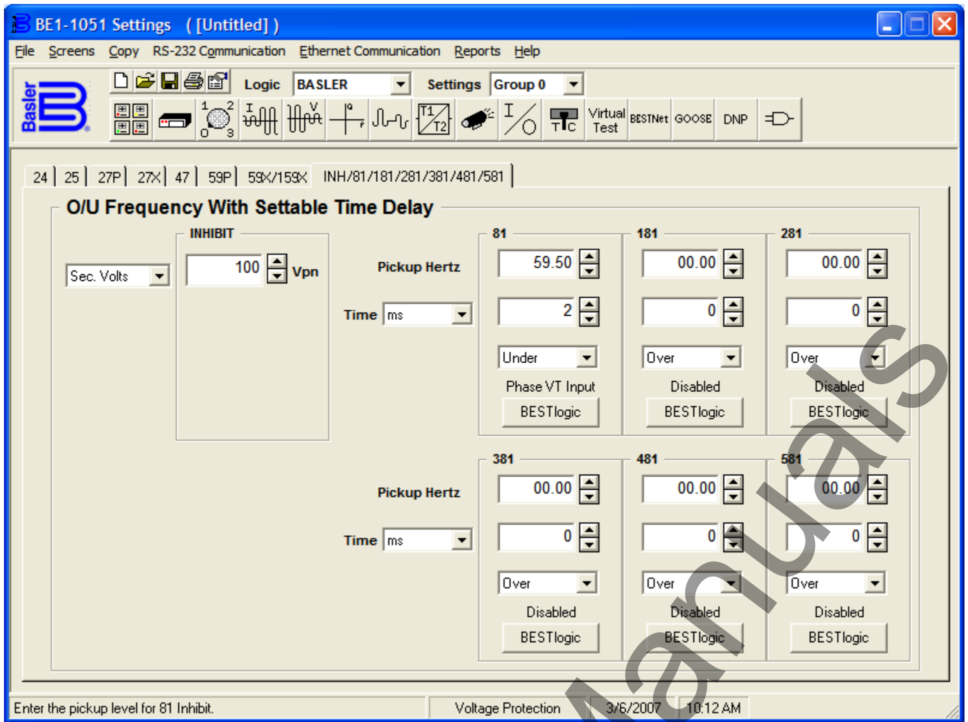

Figure 4-45. Voltage Protection Screen, INH/81/181 Tab

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.

Using the pull-down menus and buttons, make the application appropriate settings to the over/underfrequency element.

Frequency protection can be inhibited when the monitored voltage decreases below a user-defined level. The undervoltage inhibit level is set using the S<g>-81INH command or Screen 5.x.14.7 of the front panel HMI.

The voltage inhibit setting unit of measure depends upon the VTP and VTX connection settings. For 4-wire or PN connections it is secondary VPN. For 3-wire or PP connections it is secondary VPP.

Operating settings for Over/Underfrequency are summarized in Table 4-32.

Table 4-32. Operating Settings for Over/Underfrequency

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 20 to 70	0.01	Hertz	0
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	O = Overfrequency U = Underfrequency	N/A	N/A	0
Inhibit Level	0 = Disabled (functions enabled for all voltage levels) 15 to 150	0.1 for 15 – 99.9 1.0 for 100 - 150	Secondary Volts †	40

∗ 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

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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 Inhibit 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.

Example 1. Make the following settings to the 81 element and to the Inhibit function. Refer to Figure 4-45.

Pickup hertz: 59.5
Time: 2 ms
Mode: Under
Inhibit: 100 Vpn secondary volts

Retrieving Over/Underfrequency 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 cannot be determined by using BESTCOMS.

BREAKER FAILURE PROTECTION

50BF - Breaker Failure Protection

BE1-1051 relays provide one independent breaker failure protection. Figure 4-46 shows the breaker failure function block which has two outputs, *BFRT* (Breaker Failure Retrip) and *BFT* (Breaker Failure Trip) which is TRUE after the breaker failure *Delay Timer* has timed out. The *BFIALM* (Breaker Failure Initiate Alarm) occurs if the *Control Timer* has expired (closing the window of breaker failure opportunity), there is no *BLK* (block input), and the BFI50 (internal protection element) is still calling for a trip.

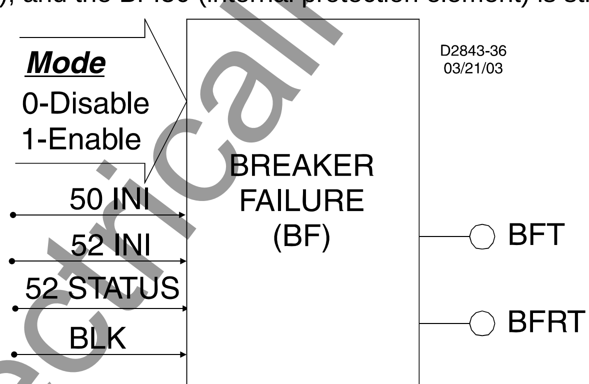

Figure 4-46. Breaker Failure Logic Block

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 *Delay 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 a less than one cycle dropout time. The *Delay Timer* can also be stopped by the *BLK* (Block) logic input being asserted.

Upon sensing *50 INI* transition from 0 to 1 state, a *Control Timer* seals in the *50 INI* signal for the duration of the *Control Timer* setting. If the *Control Timer* expires and the *50 INI* signal is still present, a *BFIALM*

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(Breaker Failure Initiate Alarm) signal will occur. The *Control Timer* serves the purpose to improve security by presenting a window of opportunity for the breaker failure element to operate. It improves dependability by sealing in the initiate to prevent stopping breaker failure timing if the tripping relay drops out prematurely. A *Control Timer* setting of zero shall disable the control timer seal in function allowing the *Control Timer* to follow the *50 INI* input.

Phase and ground input fault detectors are provided to monitor current. At least one of these four fault detectors must be picked up to start the breaker failure *Delay Timer*. See Section 12, *Installation*, for a 3-line current connection diagram. The ground input fault detector setting is ignored by the relay if the style number does not support it.

The current detector logic is TRUE if the current has been interrupted and is used to stop the BF timer. The I = 0 algorithm looks at the sample data directly and does not rely upon the 1 cycle phasor estimation calculation. It rejects dc tail-off by looking for the characteristic exponential decay. Current shall be declared interrupted when the current in all three phases is below 5% nominal or if the current is decaying exponentially. Only the three phase currents shall be monitored by this function.

Logic to start the breaker failure timing via the *52 INI* input is provided with breaker status supervision. Both the *52 STATUS* and the *52 INI* have to be TRUE for a *52 INI* to cause a trip condition. A breaker status logic input monitors the breaker state.

The breaker failure timer is initiated by the either the *52 INI* or the *50 INI*. When both signals are in the zero state the breaker failure *Delay Timer* will be stopped. When the breaker failure *Delay Timer* is actively timing, the *BFRT* (Breaker Failure Retrip) output shall be TRUE. When the breaker failure *Delay Timer* times out, the *BFT* output shall be TRUE. A block input is provided to disable the function and reset the timers to zero.

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.

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

BESTlogic Settings for Breaker Failure

BESTlogic settings are made from the *BESTlogic Function Element* Screen in BESTCOMS. Figure 4-47 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 *Overcurrent* from the *Screens* pull-down menu. Then select the button labeled *BESTlogic*. Alternately, settings may be made using the SL-50BF ASCII command.

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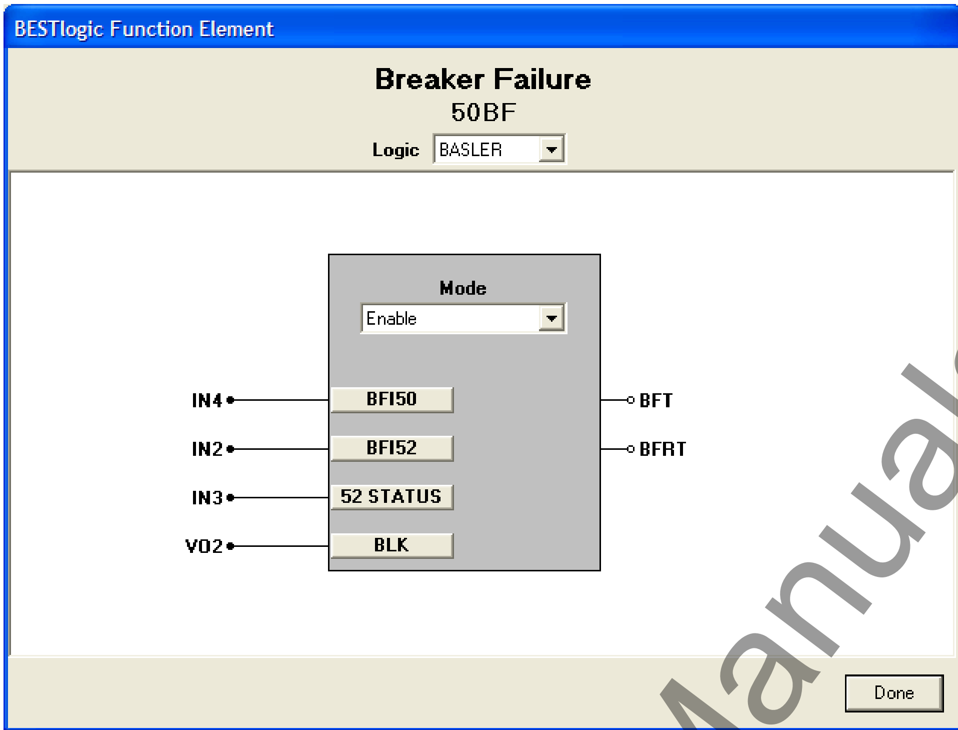

Figure 4-47. BESTlogic Function Element Screen, 50BF

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 4-33 summarizes the BESTlogic settings for Breaker Failure.

Table 4-33. BESTlogic Settings for Breaker Failure

Function	Range/Purpose	Default
Mode	0 = Disable, 1 = Enable	0
BFI50	Logic expression that starts the breaker failure timer when TRUE.	0
BFI52	Logic expression that starts the breaker failure timer when TRUE.	0
52 STATUS	Monitors the breaker state.	0
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following changes to the Breaker Failure element. Refer to Figure 4-47.

Mode:	Enable
50 INI:	IN4
52 INI:	IN2
52 STATUS:	IN3
BLK:	VO2

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Operating Settings for Breaker Failure

Operating settings are made using BESTCOMS. Figure 4-48 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 S0-x50BF (where x = blank, 1, 2, or 3) ASCII command or through the optional HMI interface using Screens 5.x.6.1 and 5.x.6.2 where x equals the number of the setting group.

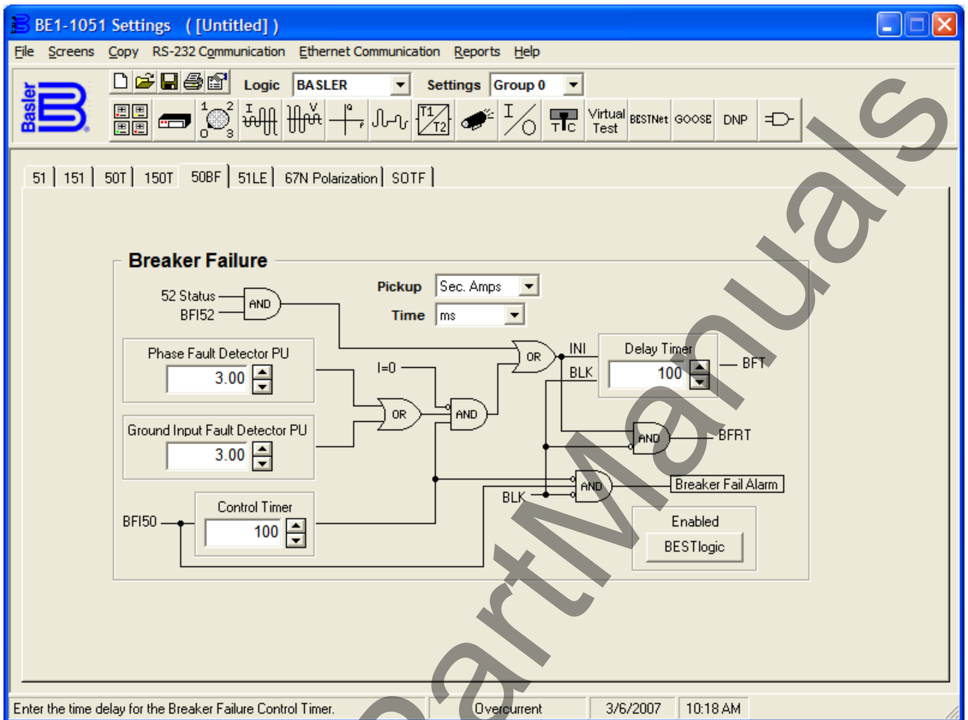

Figure 4-48. Breaker Failure Screen, 50BF Tab

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* 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 4-34 summarizes the operating settings for Breaker Failure.

Table 4-34. Operating Settings for Breaker Failure

Setting	Range	Increment	Unit of Measure	Default
Pickup	Sec. Amps, Pri. Amps, Per. U. Amps, % Amps	N/A	N/A	Sec. Amps
Time	Milliseconds, Seconds, Minutes, Cycles	N/A	N/A	Milliseconds
Phase Fault Detector PU	5A CT: 0.5 A to 10.00 A 1A CT: 0.1 A to 2.00 A	0.01 A	(See Pickup)	0.00
Ground Input Fault Detector PU	5A CT: 0.5 A to 10.00 A 1A CT: 0.1 A to 2.00 A SEF: 0.01 A to 0.50 A	0.01 A	(See Pickup)	0.00
Delay Timer	0 = Disabled	N/A	N/A	0
	50 to 999 ms	1 m	Milliseconds	
	0.05 to 0.999 seconds	0.1 sec	Seconds	
	3 to 59.96 (60 Hz) or 2.5 to 49.97 (50 Hz)	*	Cycles	

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Setting	Range	Increment	Unit of Measure	Default
Control Timer	0 = Disabled	N/A	N/A	0
	50 to 999 ms	1 m	Milliseconds	
	0.05 to 0.999 seconds	0.1 sec	Seconds	
	3 to 59.94 (60 Hz) or 2.5 to 49.95 (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.

Example 1. Make the following operational settings to the breaker failure element. See Figure 4-48.

Pickup:	secondary amps
Time:	ms
Phase Fault Detector PU:	3.00
Ground Input Fault Detector PU:	3.00
Control Timer:	100
Delay Timer:	100

Retrieving Breaker Failure 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. Logic status cannot be determined using BESTCOMS. See Section 6, *Reporting and Alarm Functions, General Status Reporting,* for more information.

LOGIC TIMERS

62 - General Purpose Logic Timers

BE1-1051 relays provide two general-purpose logic timers, which are extremely versatile. Each can be set for one of six 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 4-49 shows the 62 function block as an example. Each mode of operation is described in detail in the following paragraphs.

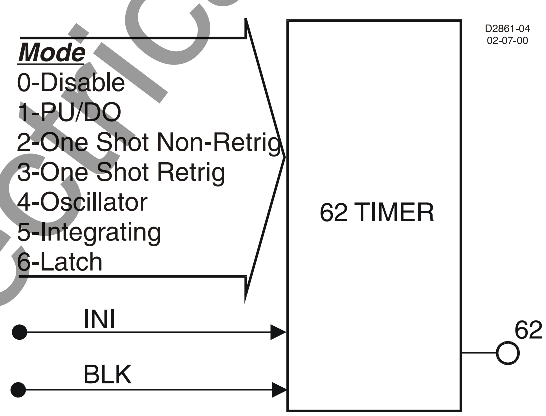

Figure 4-49. General Purpose Logic Timers Logic Block

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

A *BLK* 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.

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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 4-50. 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.

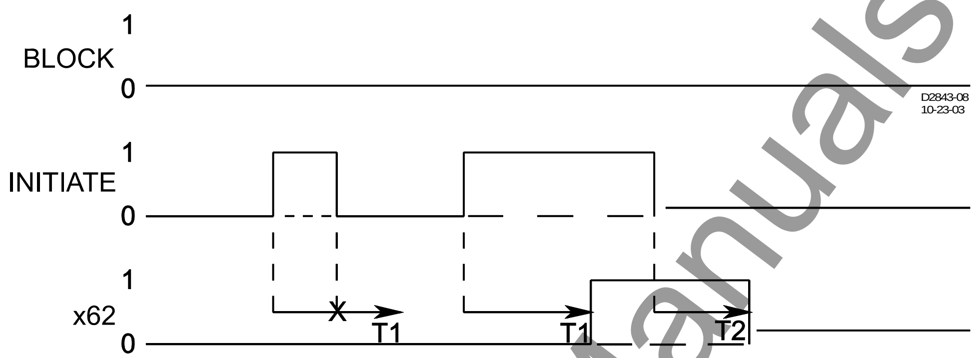

Figure 4-50. Mode 1, PU/DO (Pickup/Dropout Timer)

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 4-51. 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.

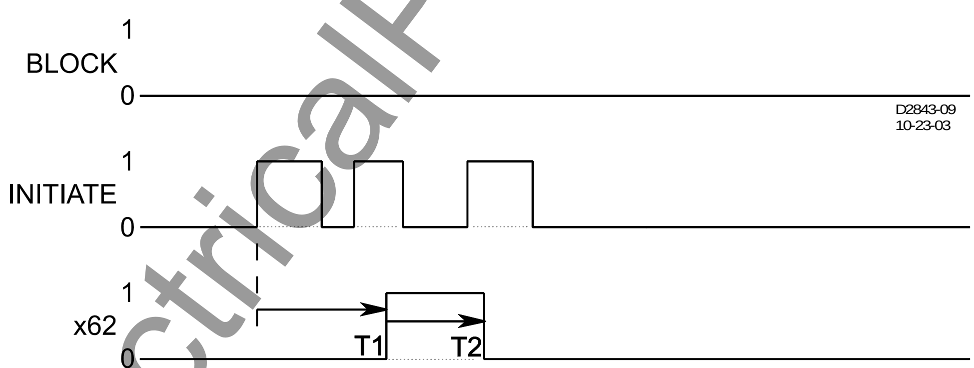

Figure 4-51. Mode 2, One-Shot Nonretriggerable Timer

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 4-52.

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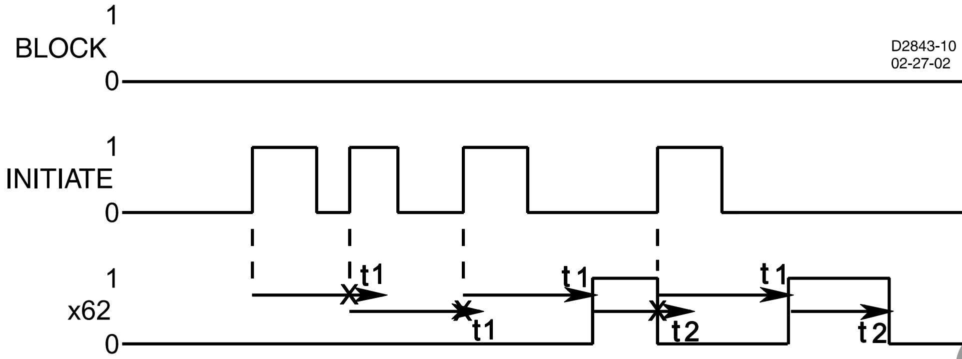

Figure 4-52. Mode 3, One Shot Retriggerable Timer

Mode 4, Oscillator

In this mode, the *INITIATE* input is ignored. See Figure 4-53. 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.

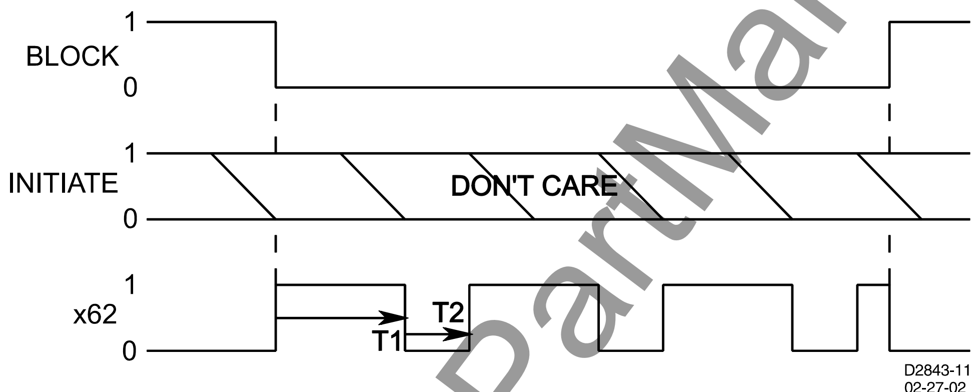

Figure 4-53. Mode 4, Oscillator

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 4-54, 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.

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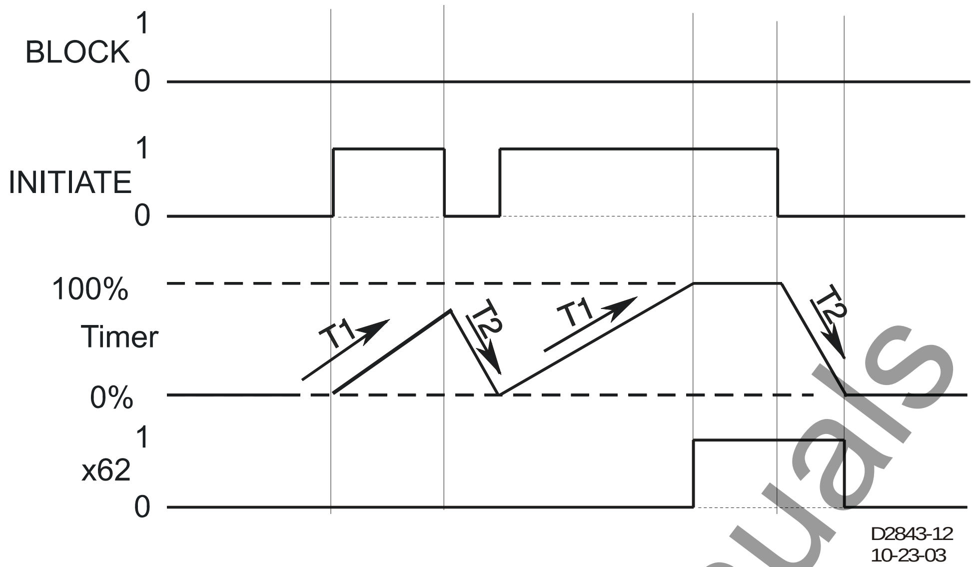

Figure 4-54. Mode 5, Integrating Timer

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 4-55.

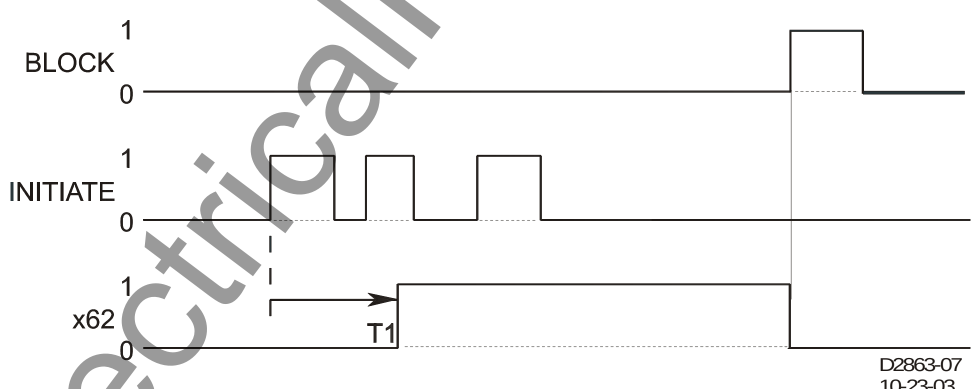

Figure 4-55. Mode 6, Latch

BESTlogic Settings for General Purpose Logic Timers

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-56 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 Functions* 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.

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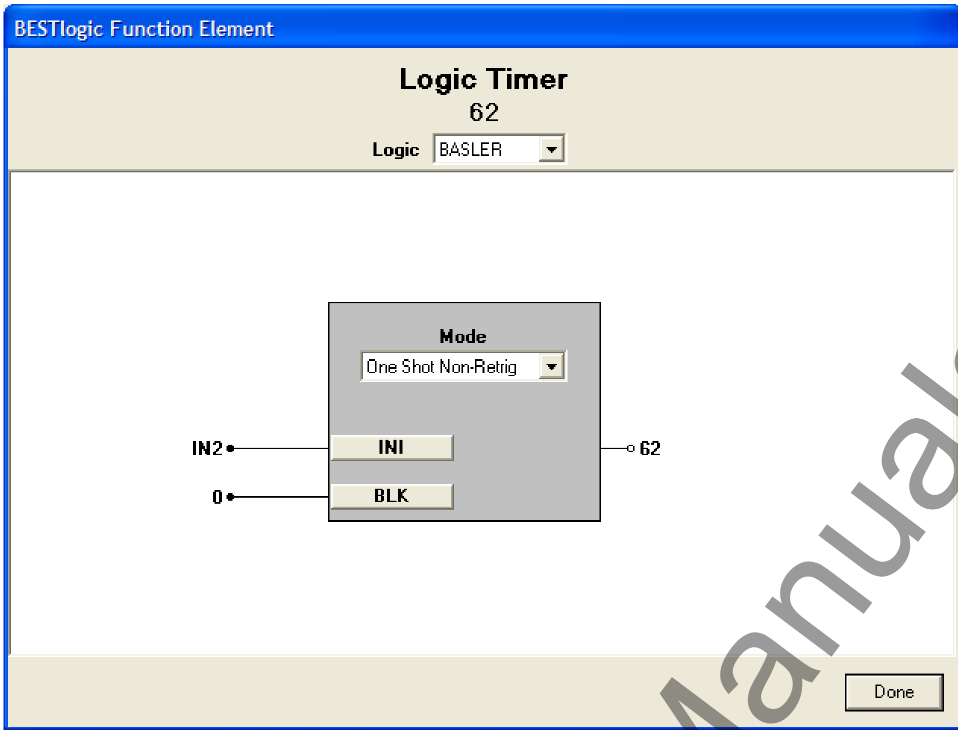

Figure 4-56. BESTlogic Function Element Screen, 62

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 4-35 summarizes the BESTlogic settings for General Purpose Logic Timers.

Table 4-35. BESTlogic Settings for General Purpose Logic Timers

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = PU/DO 2 = One Shot Non-Retrig 3 = One Shot Retrig 4 = Oscillator 5 = Integrating 6 = Latch	0
INI	Logic expression that initiates timing sequence.	0
BLK	Logic expression that disables function when TRUE.	0

Example 1. Make the following settings to the 62 Logic Timer. Figure 4-56 illustrates these settings.

Logic: User
Mode: One Shot Non-Retriggerable
INITIATE: IN2
BLOCK: 0

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<u>Operating Settings for General Purpose Logic Timers</u>

Operating settings are made using BESTCOMS. Figure 4-57 illustrates the BESTCOMS screen used to select operational settings for the *Logic Timers* element. To open the *Logic Timers* screen, select *Logic Functions* from the *<u>S</u>creens* pull-down menu. Alternately, settings may be made using the S<g>-62/162 ASCII command or through the HMI interface using Screens 5.1.11.1 and 5.1.11.2.

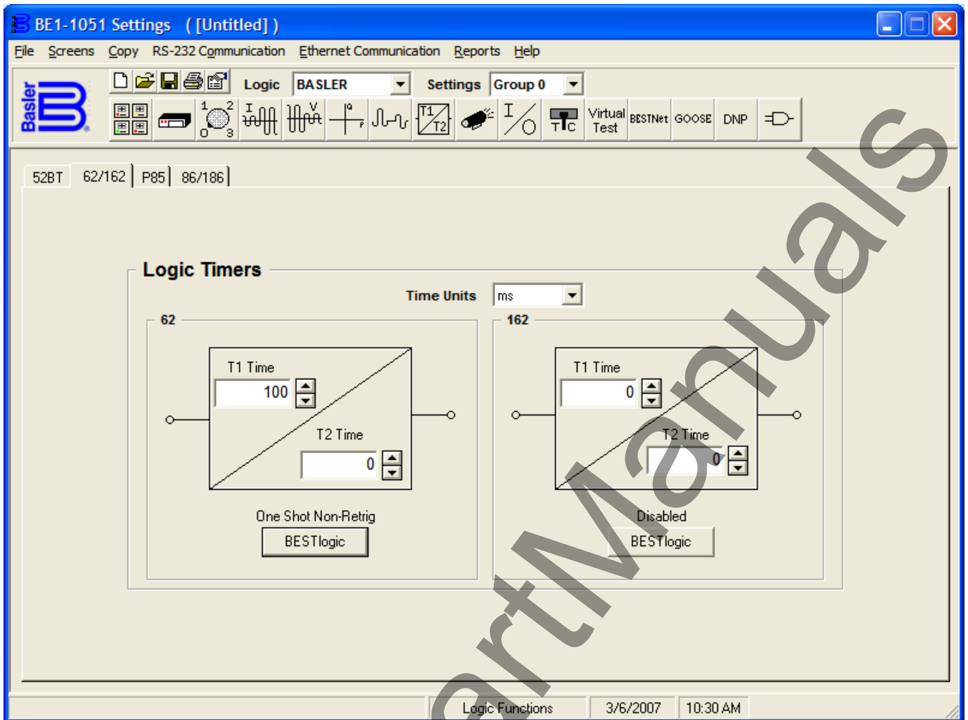

Figure 4-57. Logic Timers Screen

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 4-36 summarizes the operating settings for General Purpose Logic Timers.

Table 4-36. Operating Settings for General Purpose Logic Timers

Setting	Range	Increment	Unit of Measure	Default
T1 Time, T2 Time	0 to 999 ms	1	Milliseconds	0
	0.1 to 9999 sec.	0.1 for 0.1 to 9.9 sec.	Seconds	
		1.0 for 10 to 9999 sec.		
	0 to 599,940 (60 Hz) 0 to 499,950 (50Hz)	*	Cycles	

* 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.

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Example 1. Make the following operating settings to the 62 element. Figure 4-57 illustrates these settings.

T1 Time: 100 ms

T2 Time: 0

Retrieving General Purpose Logic Timers Status from the Relay

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 BE1-1051 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 4-58 and are described in the following paragraphs. An overall logic diagram for the recloser function is shown in Figure 4-66.

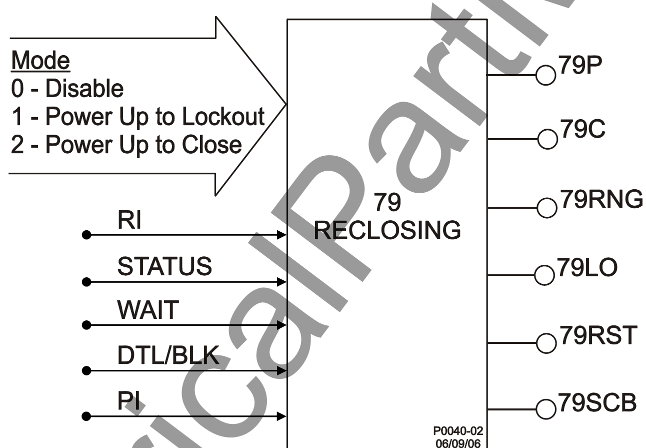

Figure 4-58. Reclosing Logic Block

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 4-59 illustrates the recognition dropout logic and timing relationship.

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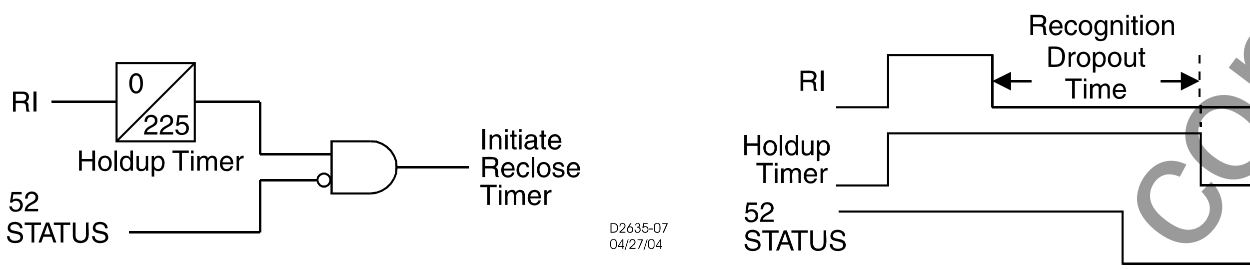

Figure 4-59. Recognition Dropout Timing

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.

Pilot Initiate (PI) and Pilot Reclose (79P)

If the recloser is in the reset state upon receiving a pilot initiate *(PI)* input signal, the reclose logic issues a pilot reclose output *(79P)* after the programmed time delay. The initiate logic shall be held for 100 milliseconds in order to assure that it will be there when the STATUS input and the *PI* input are compared. If the recloser is in the reset state and the *PI* and *RI* inputs are received simultaneously with the breaker status open, the *79P* timer shall be initiated instead of the 791 timer. After the *79P* shot, only the *RI* input is monitored to start the delayed reclosing sequence if the 52 status input indicates that the breaker opened before the reset time has expired.

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 Control 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 4-60 illustrates 79SCB logic.

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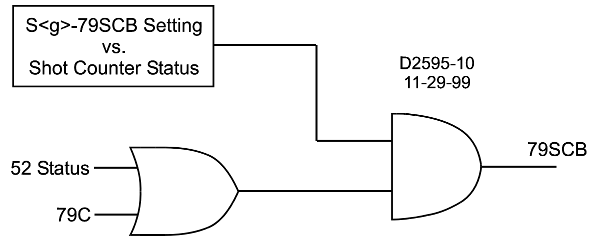

Figure 4-60. 79SCB Logic

BESTlogic Settings for Reclosing

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-61 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.

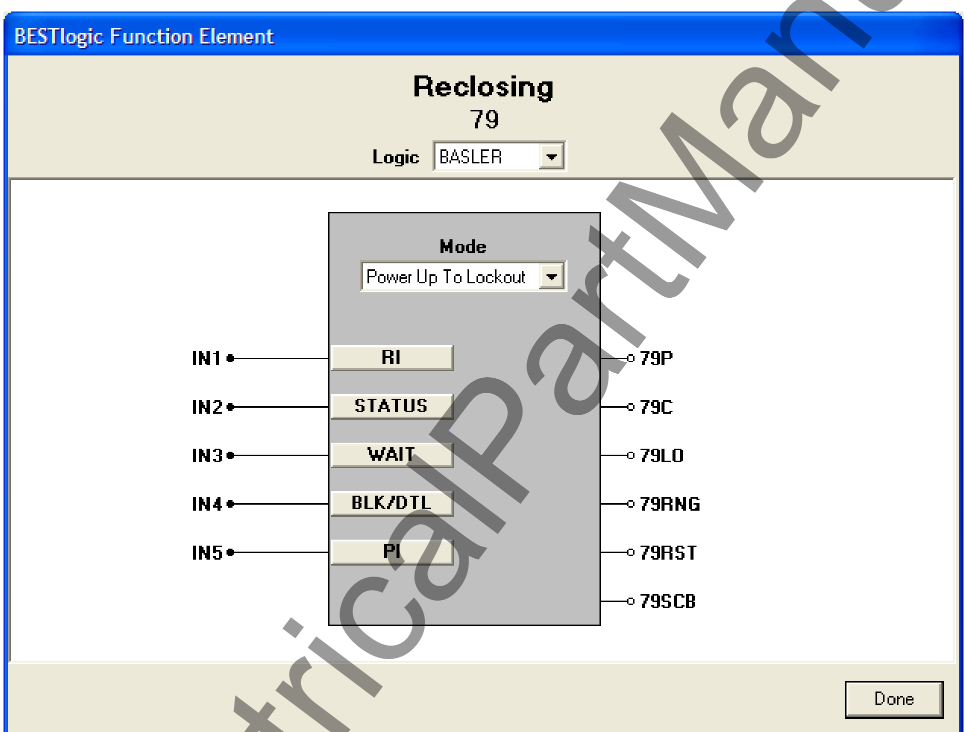

Figure 4-61. BESTlogic Function Element Screen, 79

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 4-37 summarizes the BESTlogic settings for Reclosing.

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Table 4-37. 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
PI	OR logic term to initiate the operation of the pilot reclosing function.	0

Operating Settings for Reclosing

Operating settings are made using BESTCOMS. Figure 4-62 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.13.1 through 5.x.13.5 where x equals 1 for Setting Group 0, 2 for Setting Group 1, 3 for Setting Group 2, and 4 for Setting Group 3.

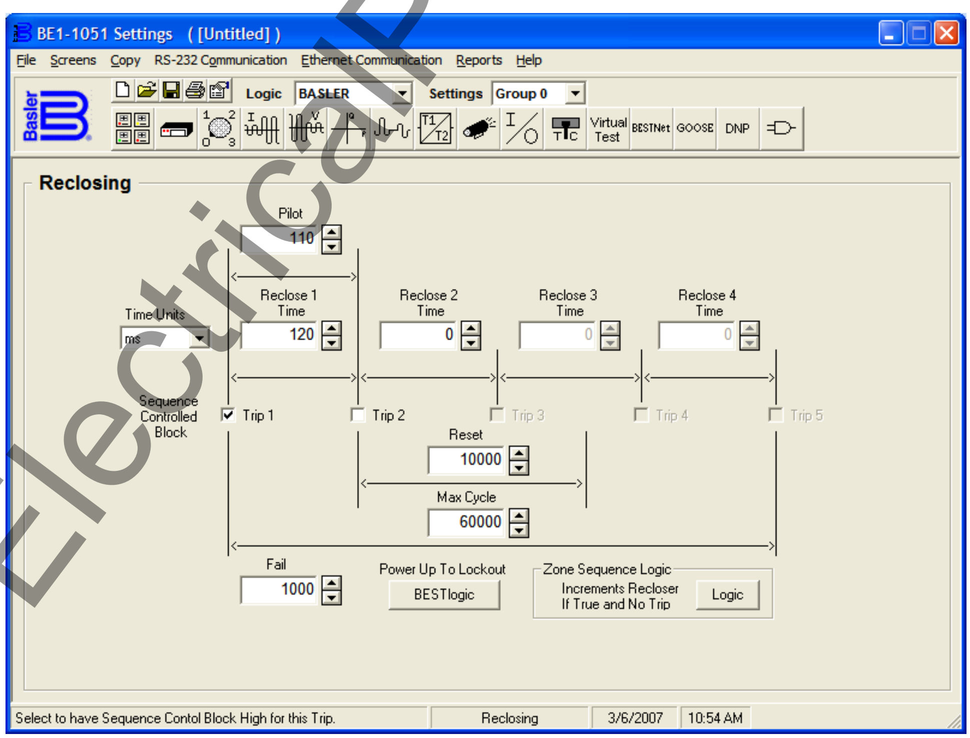

Figure 4-62. Reclosing Screen

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

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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 4-38 summarizes the operating settings for Reclosing.

Table 4-38. Operating Settings for Reclosing

Setting	Range	Increment	Default
Reclose 1 - 4 Time Pilot Time	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)	Pilot = 0 791 = 0 792 = 0 793 = 0 794 = 0 79R = 10s 79F = 1s 79M = 60s
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

<u>*Reclosing Fail Timer (79F)*</u>

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 4-62.

<u>*Maximum Cycle Timer (MAX Cycle)*</u>

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 4-62.

<u>*Sequence Controlled Blocking (SCB)*</u>

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 in the S#-79SCB command. A 0 (zero) disables the 79SCB output. This setting can be changed on the *Reclosing* screen in BESTCOMS. See Figure 4-62.

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Figure 4-63 shows a logic timing diagram showing all possible sequence control blocks enabled (TRUE). In Figure 4-64, 79RTD is the reclose reset time delay and 79#TD is the reclose time delay where # is the reclose shot number.

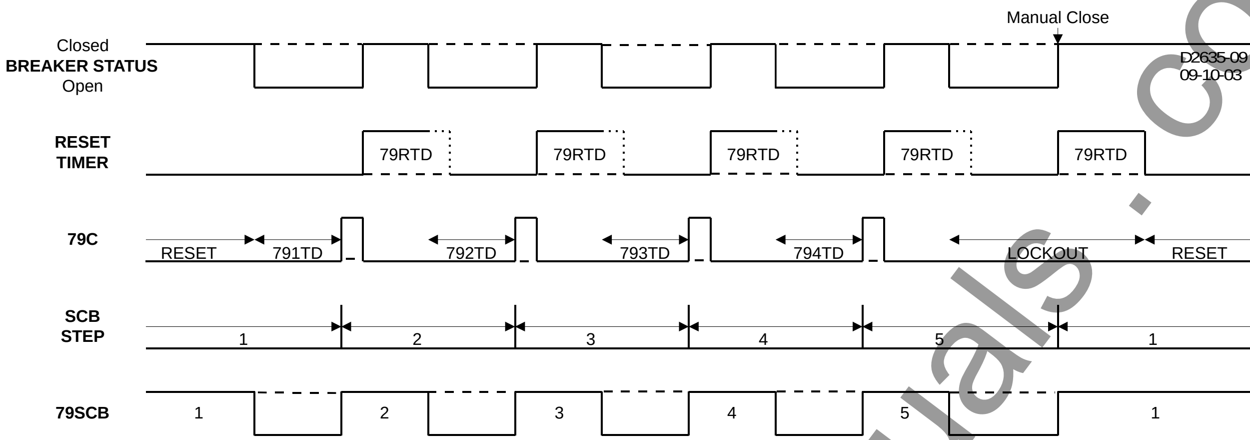

Figure 4-63. S#-79SCB=1/2/3/4/5 Logic Timing Diagram

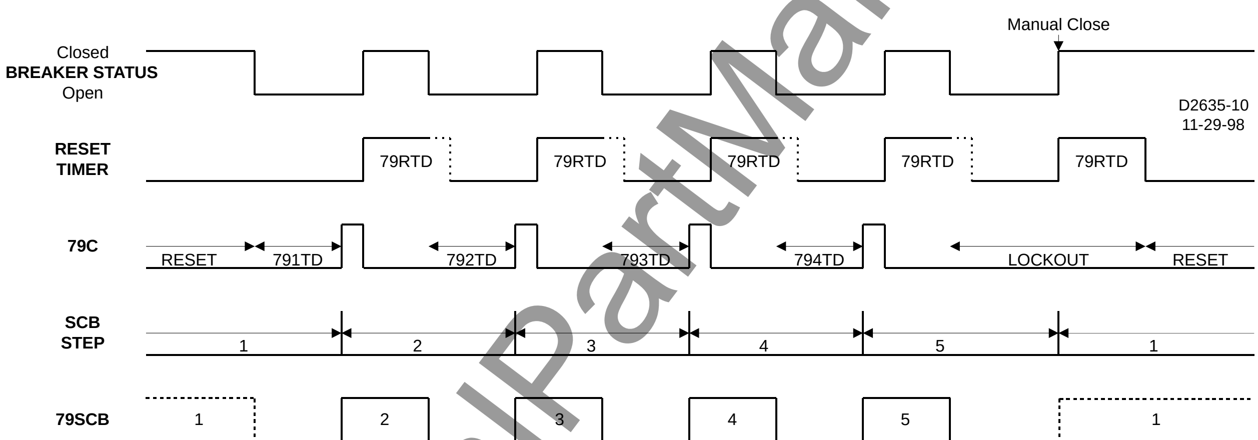

Figure 4-64. S#-79SCB=2/3/4/5 Logic Timing Diagram

Zone-Sequence Coordination

To coordinate tripping and reclosing sequences with downstream protective relays and reclosers, the BE1-1051 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 (BE1-1051) senses that a downstream device has interrupted fault current, the BE1-1051 will increment the trip/reclose sequence by one operation. This occurs because the BE1-1051 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 4-65 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.

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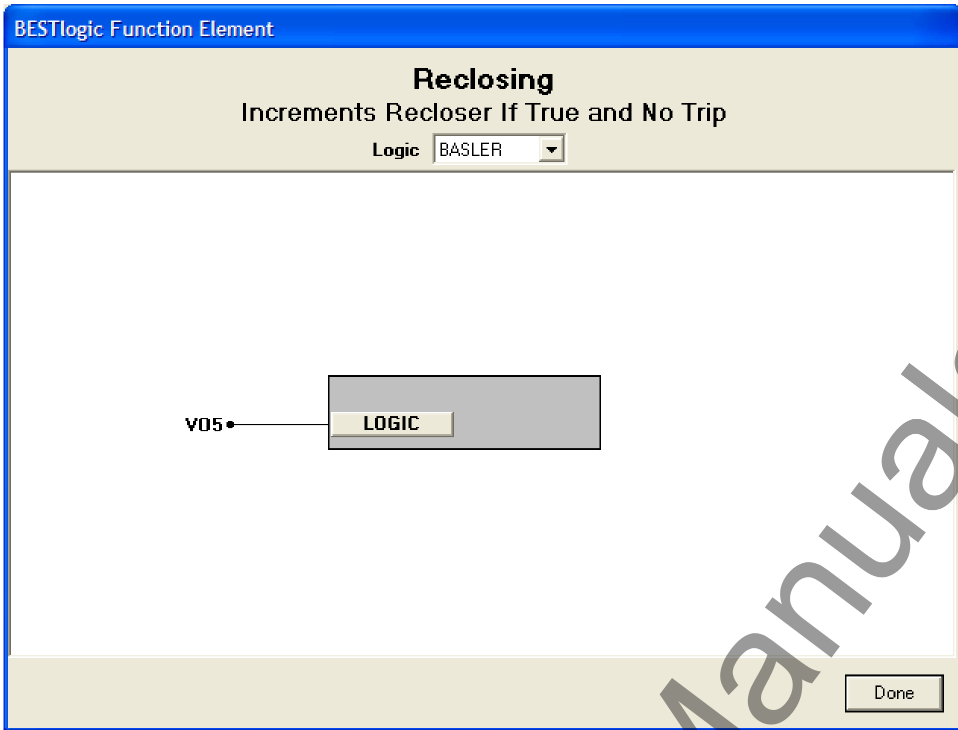

Figure 4-65. BESTlogic Function Element Screen, Reclosing (Zone Sequence Logic)

Table 4-39 summarizes the zone sequence coordination settings.

Table 4-39. Zone-Sequence Coordination Settings

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.

Figure 4-66 illustrates an overall logic diagram for the recloser function.

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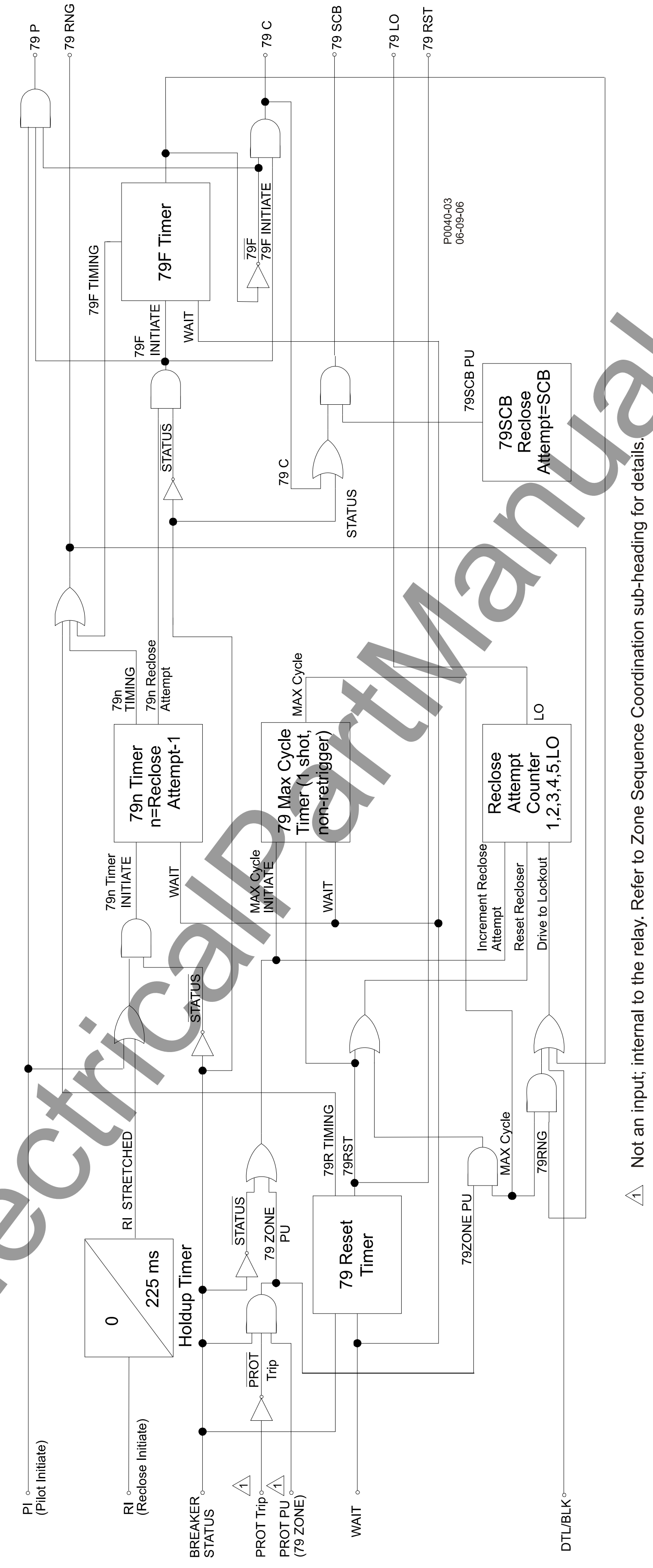

Figure 4-66. Overall Logic Diagram for Reclosing

25 - Synchronism-Check Protection

Figure 4-67 illustrates the inputs and outputs of the Sync-Check element. Element operation is described in the following paragraphs.

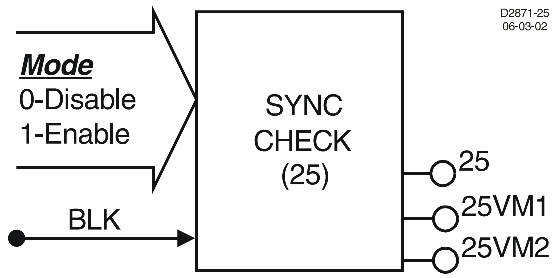

Figure 4-67. Sync-Check Element

The Sync-Check element has three outputs: 25, 25VM1, and 25VM2. 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 and 25VM2 are the voltage monitor outputs.

The Block *(BLK)* input is used to disable Sync-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; 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, but the slip rate must be greater than 0.010 Hz for sync to occur.
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 BE1-1051 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.** Delta V is a single-phase test only. For 3W VTP connection, the relay compares V_{AB}, to V_X. For 4W VTP connection, it compares V_{AN} to V_X and for single-phase sensing the relay compares the applied phase to V_X. 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 V_{AN} on the phase must be equal V_{AB} applied to the VX input 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:

Terminals B1, B2, B3 (A, B, C) are connected in parallel. The single-phase signal is connected between the parallel group and B4 (N).

For single-phase sensing connections derived from a <u>phase-to-phase</u> source:

Terminals B2, B3, B4 (B, C, N) are connected in parallel. The single-phase signal is connected between B1 (A) and the parallel group (AB, BC, CA).

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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, Frequency*, 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 Synchronism-Check

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-68 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. Then select the *BESTlogic* button. Alternately, settings may be made using SL-25 ASCII command.

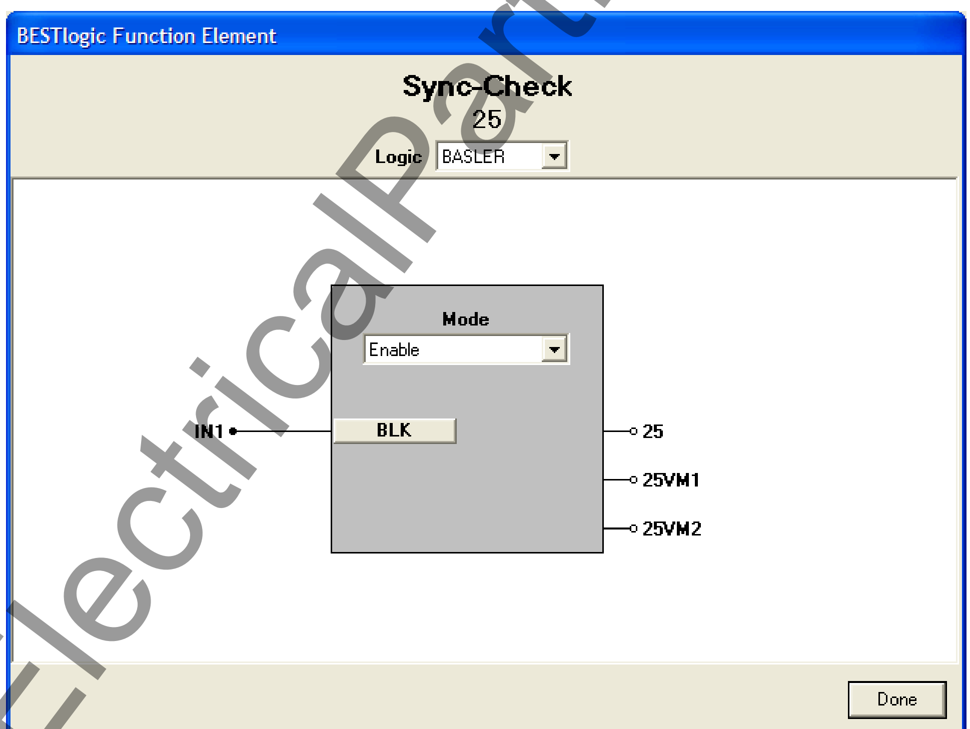

Figure 4-68. BESTlogic Function Element Screen, 25

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

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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 4-40 summarizes the BESTlogic settings for Synchronism-Check.

Table 4-40. BESTlogic Settings for Synchronism-Check

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 4-68.

Mode: Enable

BLK: IN1

<u>*Operating Settings for Synchronism-Check*</u>

Operating settings are made using BESTCOMS. Figure 4-69 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. 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 and x equals the setting group number.

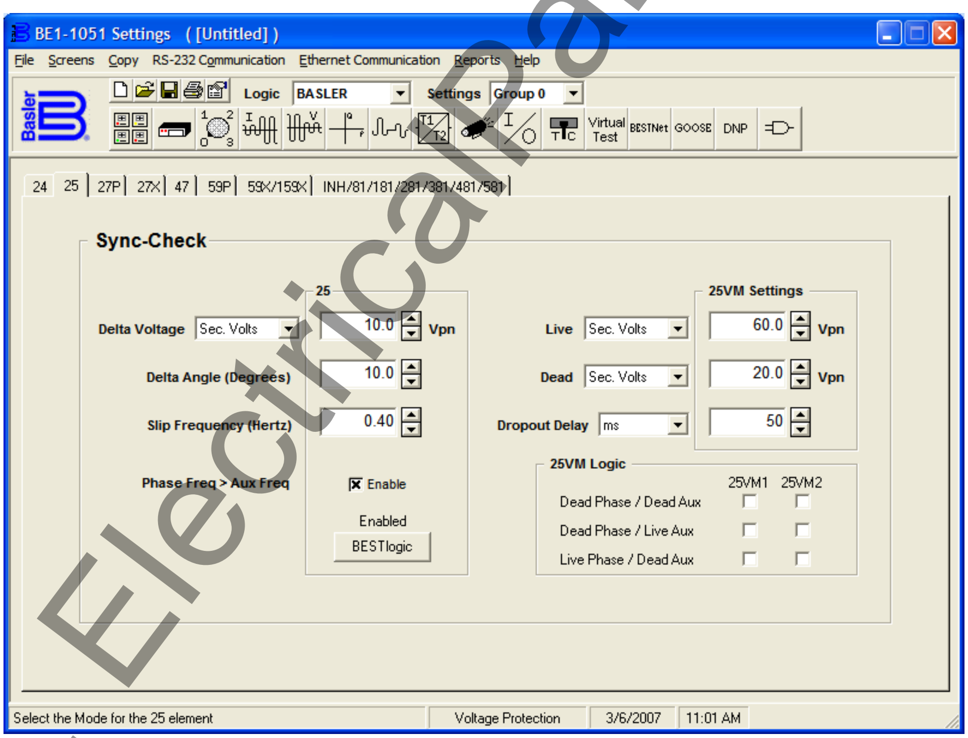

Figure 4-69. Voltage Protection Screen, 25 Tab

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.

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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.

Using the pull-down menus and buttons, make the application appropriate settings to the Sync-Check element.

Table 4-41 summarizes the operating settings for Synchronism-Check.

Table 4-41. Operating Settings for Synchronism-Check

Setting	Range	Increment	Unit of Measure	Default
Delta V Max	1 - 20	0.1	Secondary Volts	1
Delta Angle Max	1 - 99	0.1	Degrees	10
Delta Freq. Max	0.01 – 0.5	0.01	Hertz	0.01
Gen Frequency > Bus 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 4-69.

Delta Voltage:	10.0 Vpn
Delta Angle:	10.0 degrees
Slip Frequency:	0.40
Phase Freq > Aux Freq:	Enabled

25VM - Voltage Monitor

Operating settings for the 25VM are made on the *Voltage Protection Screen, 25* tab. Refer to Figure 4-69.

Table 4-42 summarizes the operating settings for Voltage Monitor.

Table 4-42. Operating Settings for Voltage Monitor

Setting	Range	Increment	Unit of Measure	Default
Live	10 – 150	0.1 for 10 to 100 1 for 100 to 150	Volts	60
Dead	10 – 150	0.1 for 10 to 100 1 for 100 to 150	Volts	20
Dropout Delay	50 - 60000	1 for 50 to 999 100 for 1000 to 9900 1000 for 10000 to 60000	Milliseconds	50 ms
	0.050 - 60	0.001 for 0.050 to 0.999 0.1 for 1.0 to 9.9 1 for 10 to 60	Seconds	
VM1	0 = Disabled 1 – 3, 12, 13, 23, 123	N/A	N/A	0
VM2	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 LV threshold or is 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.

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The function includes two independent outputs, 25VM1, and 25VM2 as illustrated in Figure 4-70. The logic conditions are summarized in Table 4-43. Any combination of logic settings can be selected. When a logic condition is selected, it closes the respective switch in Figure 4-70 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 used, for example.

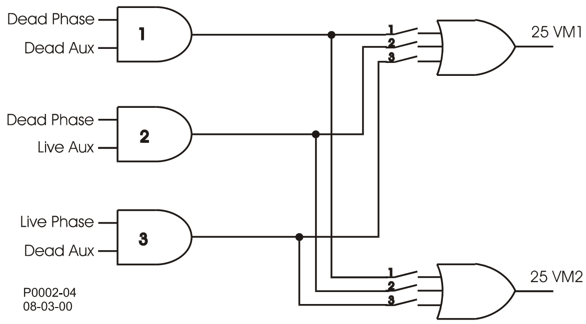

Figure 4-70. 25VM Logic

Table 4-43. Voltage Monitor Logic Settings

Voltage Monitor Logic Condition	Logic Setting
Dead Phase and Dead Aux	1
Dead Phase and Live Aux	2
Live Phase and Dead Aux	3

VOLTAGE TRANSFORMER FUSE LOSS DETECTION

60FL - Fuse Loss Detection

BE1-1051 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 4-71. When the element logic becomes TRUE, the 60FL logic output becomes TRUE. A logic diagram is shown in Figure 4-72 and the 60FL logic parameters are found in Table 4-44.

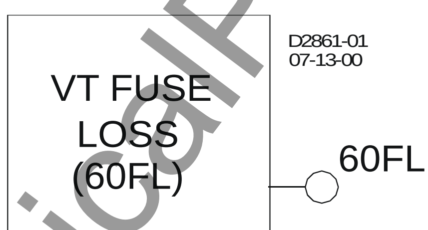

Figure 4-71. 60FL Element

Trip Logic: 60FL Trip = (A * B * C * D * G) + (E * F * B * G) (See Table 4-44.)
Reset Logic: 60FL Reset = H * /K */L (See Table 4-44.)

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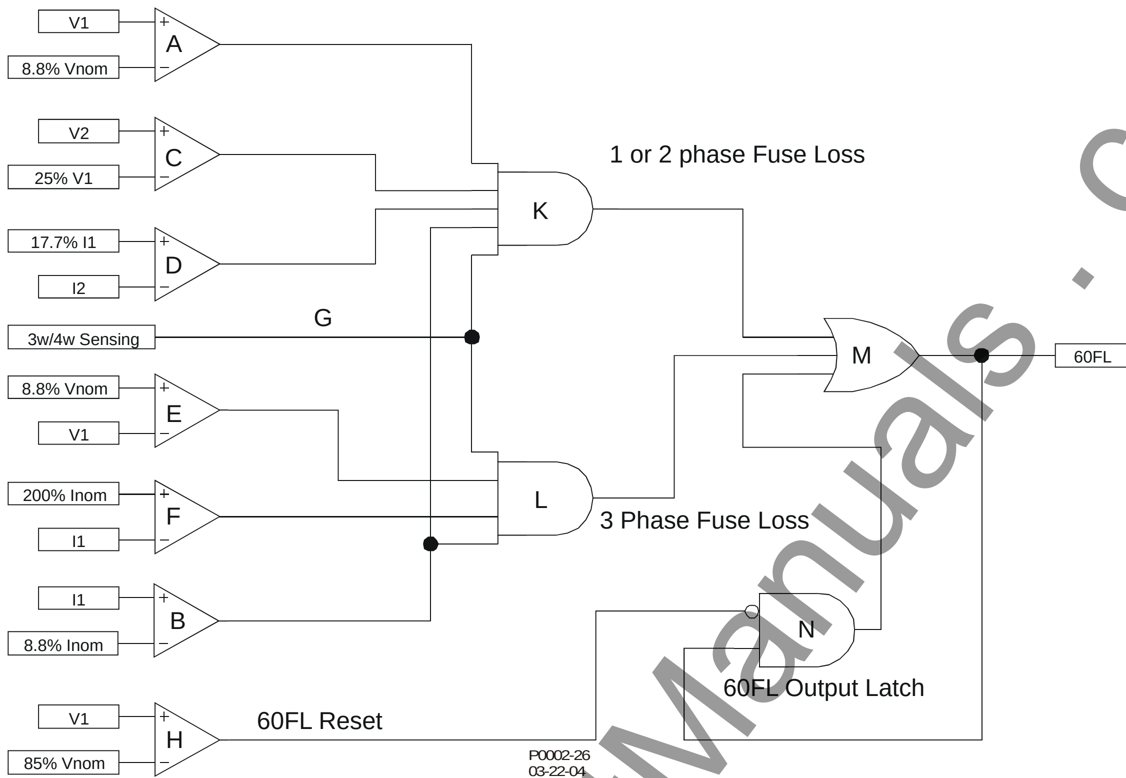

Figure 4-72. 60FL Element Logic

Table 4-44. 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 are 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 4-45). The I Block setting (51/27R) assumes that the voltage is V_{nom} 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 setting (P, N, Q) determines which voltage functions are blocked when the 60FL logic is TRUE.

Settings are made using BESTCOMS. Figure 4-73 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.

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Table 4-45. 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, 59P, 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)	

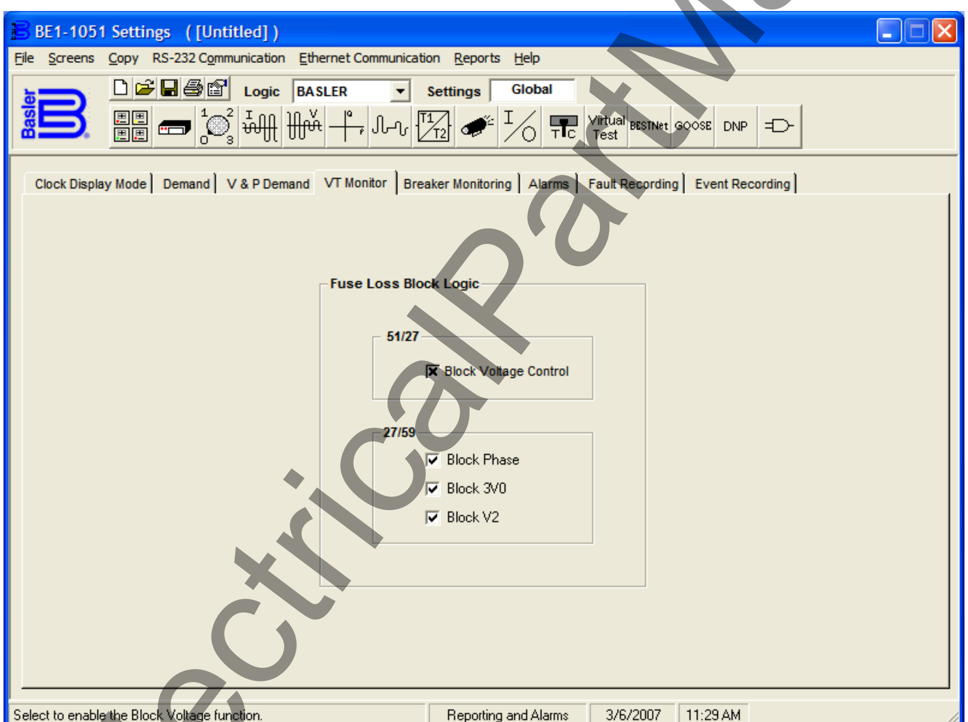

Figure 4-73. Reporting and Alarms Screen, VT Monitor Tab

The directional tests are also supervised by the loss of potential function 60FL. If the 60FL bit is TRUE, then voltage sensing was lost 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 disable this supervision. Current polarization is not affected 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:

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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.

BREAKER OPEN/DEAD LINE LOGIC

52BT - Breaker Open/Dead Line Logic

Some of the BE1-1051's main and supplementary functions require information about the position of the circuit breaker to operate optimally. Some of these functions are:

1. Short time inhibition of the Quad Ground distance elements for possible pole disagreement during breaker closure.
2. Switch onto fault logic implementation.
3. Echo and weak feed schemes validation.
4. Supervision of reclosing function.

In addition to circuit breaker status, the 52BT element provides Dead Line and Live Line recognition by use of measured quantities from the line CTs and VTs installed on the line side of the breaker.

The element consists of a three-phase undervoltage detector, a 52 status input, and an output from the fast dropout current detector used in the breaker failure logic. The output of the logic is conditioned through a user settable dropout recognition timer (instantaneous pickup, time delay dropout).

Referring to Figure 4-74, the user cn individually enable each condition or both can be enabled at the same time with the two conditions ORed together. If the breaker position path is enabled, a combination of breaker position and zero current detection cause 52BT output to go high. If the voltage detection path is enabled, a combination three-phase voltage below a user settable threshold and zero current detection cause 52BT to go high. When the breaker is closed, the dropout recognition timer must time out before 52BT goes low to qualify the circuit breaker closure.

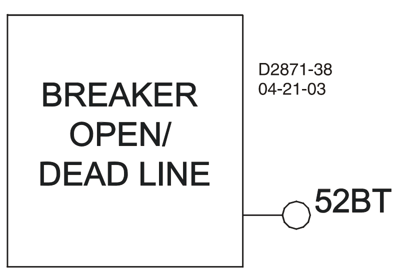

Figure 4-74. 52BT Logic Block

<u>BESTlogic Settings for 52BT</u>

The BESTlogic settings for the 52BT element are provided in Table 4-46.

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Table 4-46. BESTlogic Settings for 52BT

Function	Range/Purpose	Default
52 Status	0 = Disable, 1 = Enable	0
27 3P Undervoltage	0 = Disable, 1 = Enable	0

BESTlogic settings can be made from BESTCOMS. At the *Screens* drop-down menu, select *Logic Functions* and the *52BT* tab (Figure 4-75). Select *Enable* or *Disable* for each of the two functions.

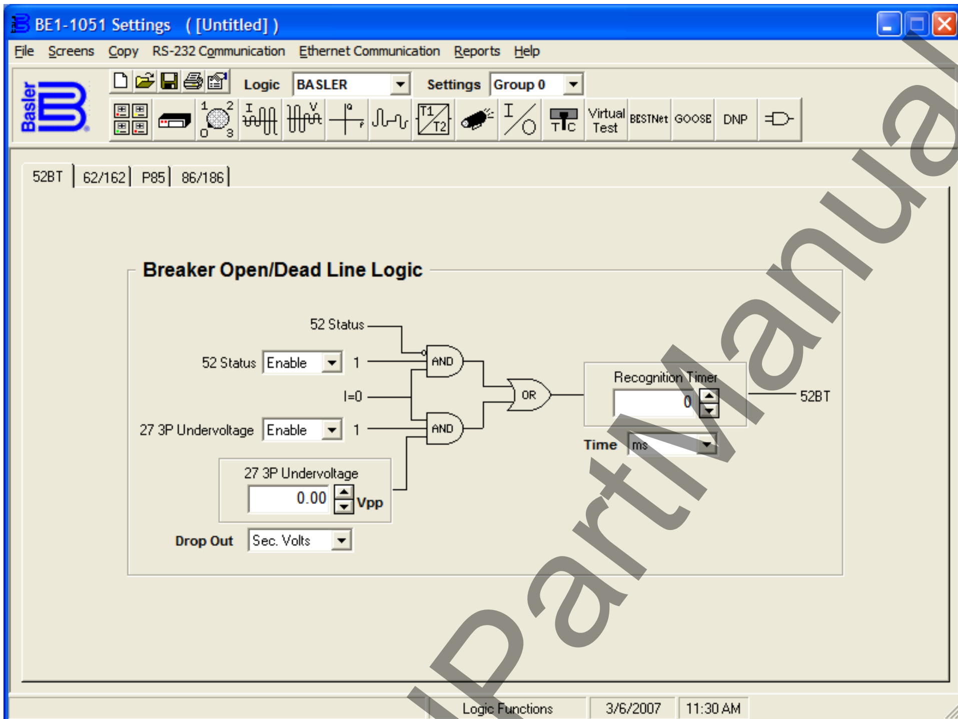

Figure 4-75. Logic Functions Screen, 52BT Tab

<u>*Operating Settings for 52BT*</u>

The operating settings for the 52BT element are listed in Table 4-47. The time delay can be set in milliseconds, seconds, or cycles. The default is milliseconds if no unit of measure is specified. The minimum resolution of the timing is to the nearest ¼ cycle. A time delay setting of 0 makes the element instantaneous with no intentional time delay.

If the time delay settings are made in cycles, they are converted to seconds or milliseconds before being stored. This conversion is based on the nominal frequency setting stored in EEPROM. See Section 3, Input and Output Functions, Power System Inputs, for more information on this setting. If the user is changing the nominal frequency setting from the default (60 Hz) and setting the time delays in cycles, the frequency setting should be entered and saved to EEPROM first by entering E;Y.

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Table 4-47. Operating Settings for 52BT

Setting	Range	Increment	Unit of Measure	Default
27P3 Undervoltage	0 = Disabled 10 to 300	0.1	Volts	0
Recognition Timer	0 = Instantaneous	N/A	N/A	0
	16 to 999	1	Milliseconds	
	0.016 to 0.999	0.1	Seconds	
	0.96 to 59.94 (60 Hz) 0.80 to 49.95 (50 Hz)	∗	Cycles	

∗ Time delays less than 10 cycles can be entered to the nearest 0.1 cycle from the front panel HMI. All time delays can be entered to the nearest 0.01 cycle 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.

52BT operating settings can be entered through BESTCOMS (Figure 4-75) or at the HMI Screen 5.x.9.1 and 5.x.9.2, where x = 1 for setting group 0, 2 for setting group 1, 3 for setting group 2, or 4 for setting group 3.

Retrieving 52BT Logic Output 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. See Section 6, *Reporting and Alarm Functions, General Status Reporting,* for more information.

PERMISSIVE PILOT LOGIC

P85 - Permissive Pilot Logic

The overcurrent based permissive pilot logic provides high speed, end to end clearing of faults on networked transmission and sub-transmission lines when a communications channel is available. It is designed such that it can operate as Permissive Underreaching Transfer Trip (PUTT) or Permissive Overreaching Transfer Trip (POTT) or Direct Underreaching Transfer Trip (DUTT) by simply changing the setup parameters on the input functions connected to it. The functions control communications aided tripping for the local line terminal and communications transmitter keying for the remote line terminal.

A permissive scheme works on the principle that if the local line terminal sees the fault in the forward direction, it keys permission to the remote terminal. At each terminal, the relay determines that it can trip if it sees the fault in the forward direction and it has received permission from the remote end. There are modifications required with this scheme to handle the case where there is a weak source (or no source) behind one terminal to allow tripping of the weak feed terminal and transmitter keying for the strong feed terminal (echo trip/echo key). There are also modifications required to prevent mis-operation if there is a current reversal when there is a fault in an adjacent line section.

Referring to Figure 4-76, the P85 function has a logic input *(FWD TRIP)* that defines when a fault is determined to be in a forward direction. The function has a logic input *(REV TBLK)* that defines when a fault is determined to be in a reverse direction. The function has a logic input expression *(85RX)* that defines when a permissive signal is being received from the remote line terminal. The function has a logic input expression *(WFC)* that defines when a weak feed condition may be occurring. The function also monitors the breaker open/deadline logic *(52BT)* that allows the user to define when the breaker is open and/or the line is dead. This logic is also used by the "switch on to fault" function. See Section 8, *Application,* for tips on using the P85 function.

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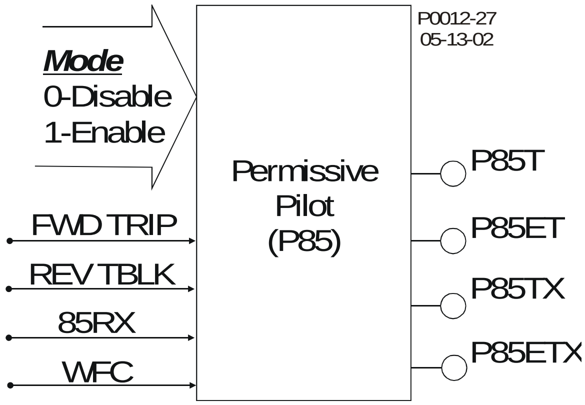

Figure 4-76. Permissive Pilot Logic Block

Permissive Pilot Trip (P85T)

This output occurs if *FWD TRIP* and *85RX* are TRUE. This is supervised by the *REV TBLK* and not 52BT function with a time delay dropout timer. If either of these signals has not been FALSE for a user definable period of time, the *P85T* output is blocked. The time delay dropout of the *REV TBLK* or 52BT prevents mis-operation for current reversal.

Permissive Pilot Echo Trip with Weak Feed Suppression (P85ET)

This output is TRUE when the *P85ETX* echo transmit is true and the breaker is closed and the *WFC* logic input is TRUE. This will allow tripping the weak feed terminal in an echo TX condition. The *WFC* logic would ordinarily be detected by the 59X element set to monitor 3V0 or low voltage on all three phases as detected by the 27P element. The breaker open/deadline logic also effects determination of Echo Trip. If the WFC logic input is not connected to anything, *P85ET* will be disabled and it will be necessary for the *FWD TRIP* elements to pickup when current redistributes after the strong feed terminal opens or the breaker will remain closed which may be desirable if the system is operating radial at the time of the event. If it is desired for *P85ET* to trip the local terminal for every Echo TX condition, the *WFC* logic could be strapped high by setting it to /0.

Refer to Section 8, Application*, Communications Assisted Protection Schemes,* for additional information.

Permissive Pilot Transmit (P85TX)

This output shall be true if *FWD TRIP* is TRUE. This is supervised by the *REV TBLK* and not 52BT function with a time delay dropout timer. If either of these signals has not been FALSE for a user definable period of time, the *P85TX* is blocked. *P85TX* is also TRUE if the Permissive Pilot Echo Transmit *(P85ETX)* logic is TRUE.

Permissive Pilot Echo Transmit (P85ETX)

If *85RX* is TRUE and the *FWD TRIP* and *REV TBLK* inputs are FALSE, the Echo *Transmit Pick Up Delay* timer will be started. If this condition remains TRUE for the delay setting, a *Echo Transmit Duration Timer* duration timer shall hold this condition for the duration time setting. The output of this timer is supervised by the *REV TBLK* and not 52BT function with time delay dropout. The 52BT allows echo transmit (TX) when the local breaker is open. The time delay dropout of *REV TBLK* is to prevent echo transmit for current reversal. A *Forward Trip Echo Block Delay Timer* time also serves to stretch the FWD TRIP signal to prevent the *P85ETX* logic from operating if there is a *FWD TRIP* condition.

BESTlogic Settings for Permissive Pilot Logic

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-77 illustrates the BESTCOMS Screen used to select BESTlogic settings for the Permissive Pilot logic. To open the screen, select *Logic Functions* from the *Screens* pull-down menu and select *P85*. Then select the BESTlogic button in the lower portion of the screen. Alternately, settings may be made using the SL-P85 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.*

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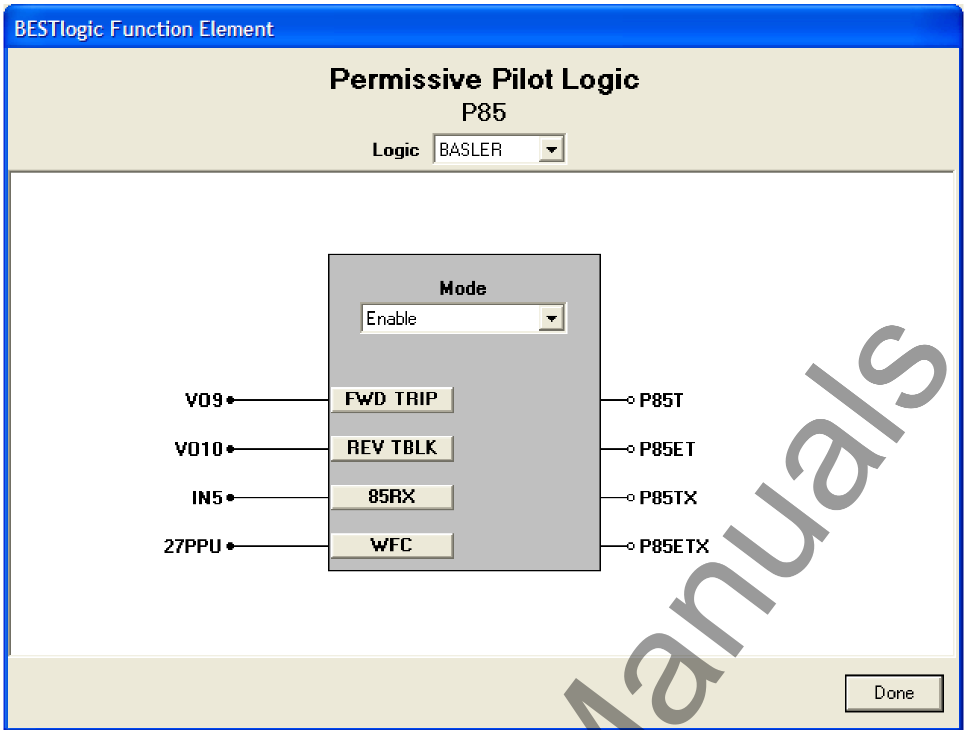

Figure 4-77. BESTlogic Function Element Screen, Permissive Pilot Logic

Enable the Permissive Pilot Logic 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 4-48 summarizes the BESTlogic settings for Permissive Pilot Logic.

Table 4-48. BESTlogic Settings for Permissive Pilot Logic

Setting	Range/Purpose	Default
Mode	0 = Disable, 1 = Enable	0
FWD TRIP	Input that defines to the P85 element when a fault is in the forward direction.	0
REV TBLK	Input that defines to the P85 element when a fault is in the reverse direction.	0
85RX	Input that defines to the P85 element when a permissive signal is being received from the remote line terminal.	0
WFC	Input that defines to the P85 element when a weak feed condition is occurring.	0

Example. Make the following BESTlogic settings to the Permissive Pilot Logic. Refer to Figure 4-77.

Mode:	Enable
FWD TRIP:	VO9
REV TBLK:	VO10
85RX:	IN5
WFC:	27PPU

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Operating Settings for Permissive Pilot Logic

Operating settings are made using BESTCOMS. Figure 4-78 illustrates the BESTCOMS screen used to select operational settings for the Permissive Pilot Logic. To open the screen, select *Logic Functions* from the *Screens* pull-down menu and select *P85*. Alternately, settings may be made using S<g>-P85 ASCII command or through the HMI interface using Screens 5.x.15.1 and 5.x.15.2 where x represents the setting group number.

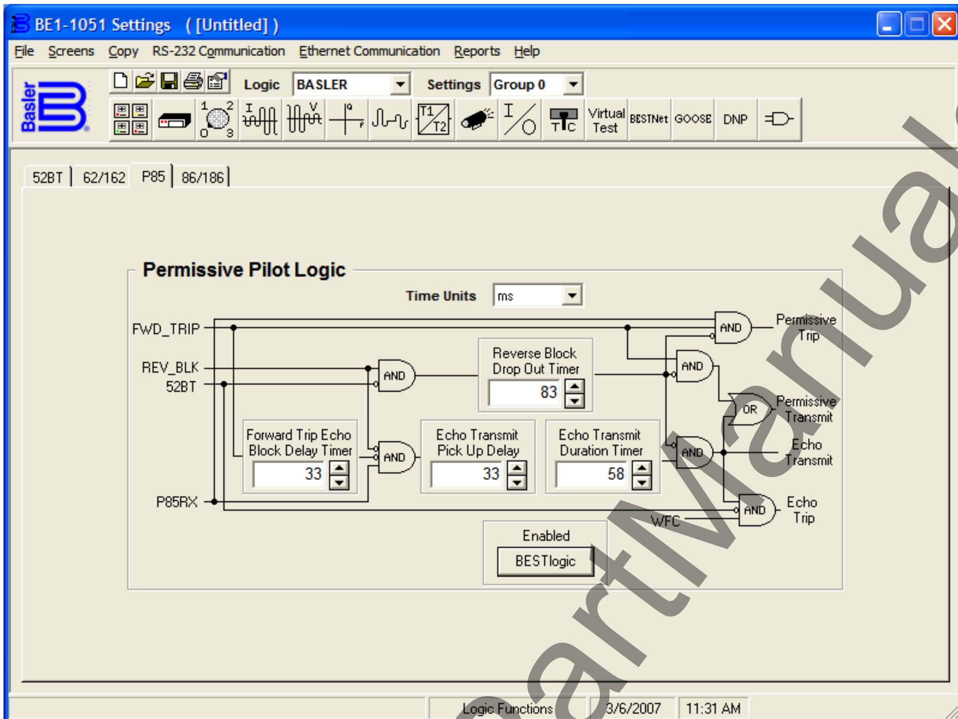

Figure 4-78. Logic Functions Screen, P85 Tab

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.

Using the pull-down menus and buttons, make the application appropriate settings to the Permissive Pilot Logic.

Table 4-49 summarizes the operating settings for Permissive Pilot Logic.

Table 4-49. Operating Settings for Permissive Pilot Logic

Settings	Purpose	Range	Unit of Measure	Default
Time Units	Set the unit of measure for the time delays	ms, seconds, minutes, cycles	N/A	ms
Reverse Block Dropout Timer	Input Delay Timers	16 to 999	Milliseconds	0
Forward Trip Echo Block Delay Timer		16 to 999	Milliseconds	0
Echo Transmit Pickup Delay		16 to 999	Milliseconds	0
Echo Transmit		16 to 999	Milliseconds	0

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Example. Make the following operating settings to the Permissive Pilot Logic. Refer to Figure 4-78.

Time Units:	ms
Reverse Block Dropout Timer:	83 ms
Forward Trip Echo Block Delay Timer:	33 ms
Echo Transmit Pickup Delay:	33 ms
Echo Transmit Duration Timer:	58 ms

Retrieving Permissive Pilot Logic 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 cannot be determined by using BESTCOMS.

VIRTUAL LOCKOUT PROTECTION

86 - Virtual Lockout Protection

BE1-1051 virtual lockout protection consists of two protection elements: 86 and 186. The element can be enabled or disabled using the *Mode* input. In addition to the *Mode* input, the 86 element also has a *Trip* input and *Reset* input. All three of these inputs are BESTlogic programmable. See Figure 4-79.

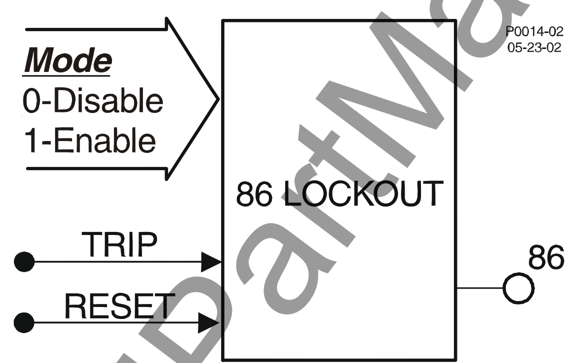

Figure 4-79. Virtual Lockout Logic Block

When the *Trip* input is asserted the output of the function becomes TRUE. When the *Reset* input is asserted the output becomes FALSE. If for some reason both inputs are asserted at the same time, the *Trip* input will have priority and drive the functions output TRUE. The state of the function is stored in nonvolatile memory.

BESTlogic Settings for Virtual Lockout

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-80 illustrates the BESTCOMS screen used to select BESTlogic settings for the lockout protection element. To open the *BESTlogic Function Element* screen for logic timers, select *Logic Functions* from the *Screens* pull-down menu and select the *86/186* tab. Then select the *BESTlogic* button for the element to be changed. Alternately, settings may be made using SL-86 and SL-186 ASCII command.

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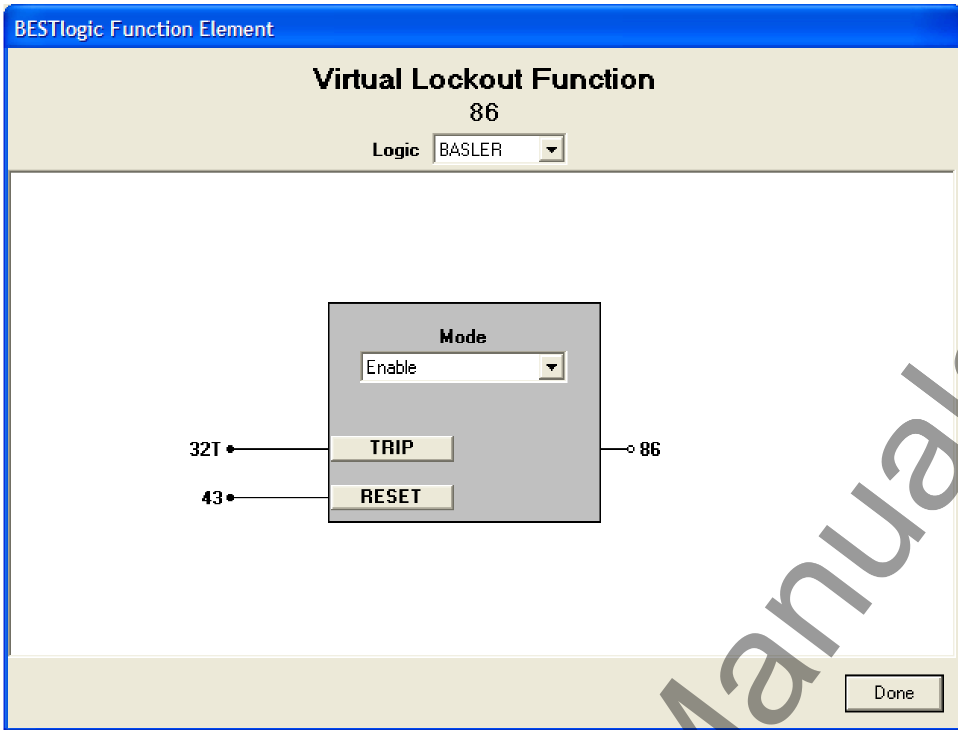

Figure 4-80. BESTlogic Function Element Screen, Virtual Lockout Function

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 lockout protection element 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 4-50 summarizes the BESTlogic settings for Virtual Lockout.

Table 4-50. BESTlogic Settings for Virtual Lockout

Function	Range/Purpose	Default
Mode	0 = Disable 1 = Enable	0
Trip	Logic expression that determines when and how the element will trip.	0
Reset	Logic expression that determines when and how the element will be reset.	0

Example 1. Make the following BESTlogic settings to the lockout function. Refer to Figure 4-80.

Mode: Enable
Trip: 32T
Reset: 43

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Retrieving Virtual Lockout 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 or through HMI Screen 1.5.5. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information. The status cannot be determined by using BESTCOMS.

VIRTUAL SWITCHES

43 - Virtual Selector Switches

BE1-1051 Overcurrent Protection Systems have five 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.

The breaker control switch contains three inputs to the function. The *TRIP* input is used to set the state of the 101 to TRIP (open) and the *RESET* input is used to set the state of the 101 to RESET (closed). The block input *(BLK)* prevents operation of the *TRIP* and *RESET* inputs from any source and holds them in their current state.

Each virtual selector switch element (see Figure 4-81) has one output: 43/143/243/343/443. 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.

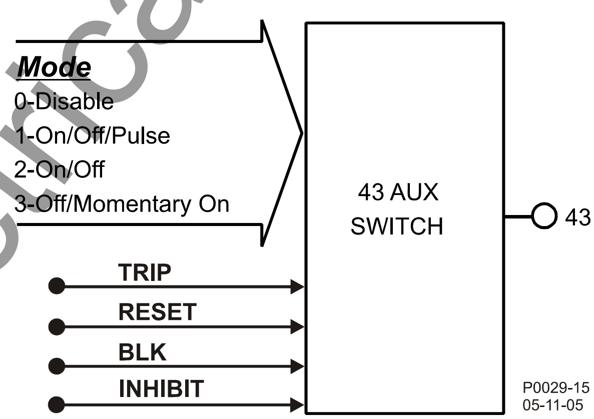

Figure 4-81.Virtual Selector Switch Logic Block

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.

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BESTlogic Settings for Virtual Selector Switches

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-82 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, SL-143, SL-243, SL-343, or SL-443 ASCII commands.

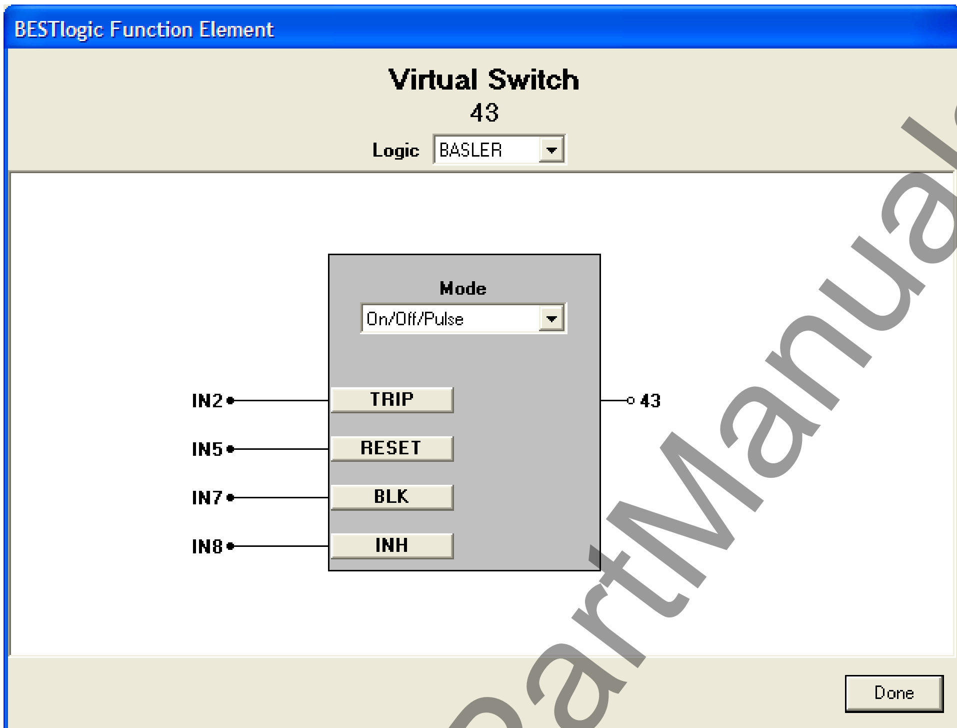

Figure 4-82. BESTlogic Function Element Screen, Virtual Switch

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.

Table 4-51 summarizes the BESTlogic settings for Virtual Selector Switches.

Table 4-51. BESTlogic Settings for Virtual Selector Switches

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = On/Off/Pulse 2 = On/Off 3 = Off/Momentary On	0
Trip Logic	Input that sets the state of the x43 to TRIP (closed).	0
Reset Logic	Input that sets the state of the x43 to RESET (open).	0
Block Logic	This input prevents operation of the *TRIP* and *RESET* inputs from any source and holds them in their current state.	0
Inhibit Logic	This input inhibits the front panel switch from functioning.	0

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Example 1. Make the following BESTlogic settings to the Virtual Switch function. Refer to Figure 4-82.

Mode: On/Off/Pulse
Trip: IN2
Reset: IN5
BLK: IN7
INH: IN8

Select Before Operate Control of Virtual Selector Switches

The state of each virtual selector switch can be controlled at the HMI through Screens 2.1.1 through 2.1.5. 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.

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.

>CS-443=P
`443=P SELECTED`
>CO-743=1
`ERROR:NO SELECT`

Retrieving Virtual Selector Switch Status Information from the Relay

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. This information is not available through BESTCOMS. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

HMI Screens 2.1.1 through 2.1.5 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.

Virtual Selector Switch Tagging (BESTlogic Settings)

BE1-1051 Virtual Switches provide tagging for each switch to indicate that the switch function is, or may be, under revision. Each switch has two tagging modes, *Informational* and *Blocking*. When in *Informational* mode, the switch will still be operational when tagged. When in the *Blocking* mode, the switch will not be operational when tagged.

A tagged switch is indicated by an illuminated LED on the operational virtual control panel. Alternately, tagged switches can be indicated by running a general status report using the RG-STAT ASCII command.

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-83 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Virtual Switch Tag* function. To open the *BESTlogic Function Element* screen for the *Virtual Switch* element, select *Virtual Switches*

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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-43TAG, SL-143TAG, SL-243TAG, SL-343TAG or SL-443TAG ASCII commands.

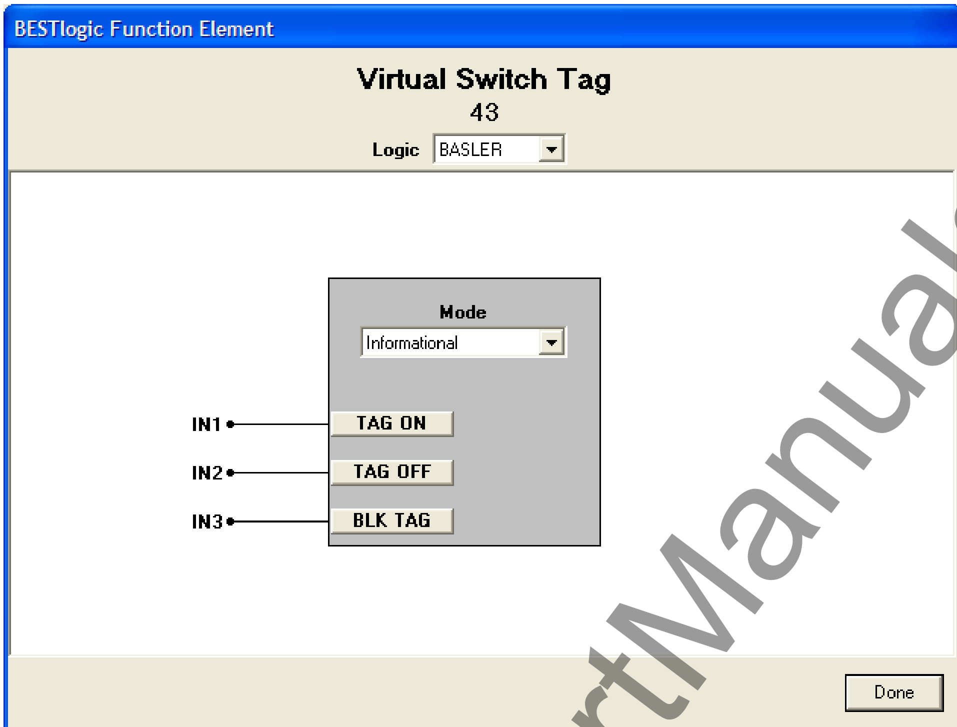

Figure 4-83. BESTlogic Function Element Screen, Virtual Switch Tag

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 Tag* 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 4-52 summarizes the function's operating settings.

Table 4-52. BESTlogic Settings for Virtual Switch Tag

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = Informational: When selected, the switch is tagged to indicate future changes. 2 = Blocking: When selected, the switch is tagged and unusable.	0
TAG On	When this input is toggled TRUE, the switch is tagged.	0
TAG Off	When this input is toggled TRUE, the tag is removed from the switch.	0
BLK TAG	When this input is TRUE, the *TAG ON* and *TAG OFF* inputs are blocked and therefore held in their current states.	0

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Example 1. Make the following settings to the Virtual Switch Tagging function. Refer to Figure 4-83.

Mode: Informational
TAG ON: IN1
TAG OFF: IN2
BLK TAG: IN3

101- Virtual Breaker Control Switch

The virtual breaker control switch (shown in Figure 4-84) 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.

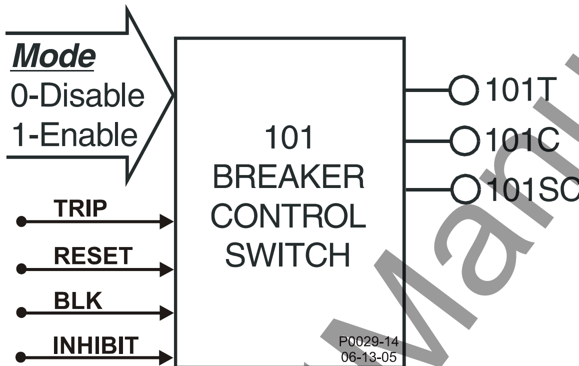

Figure 4-84. Virtual Breaker Control Switch

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 4-85 shows the state of the *101SC* logic output with respect to the state of the *101T* and *101C* outputs.

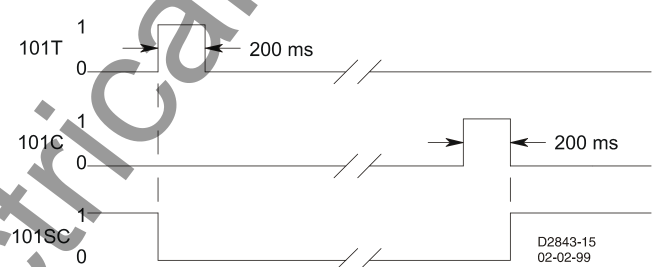

Figure 4-85. Virtual Breaker Control Switch State Diagram

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.

The breaker control switch also contains four inputs to the function. The *TRIP* input is used to set the state of the 101 to TRIP (open) and the *RESET* input is used to set the state of the 101 to RESET (closed). The block input *(BLK)* prevents operation of the TRIP and RESET inputs from any source and holds them in their current state. The *INHIBIT* input prevents the front panel input from functioning when asserted.

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BESTlogic Settings for Virtual Breaker Control Switch

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-86 illustrates the BESTCOMS screen used to select BESTlogic settings for the Breaker Control Switch element. To open the *BESTlogic Function Element* screen for the Breaker Control Switch element, select *Virtual Switches* from the *Screens* pull-down menu and select the *Breaker Control Switch & SCADA Cutoff* tab. Then select the *BESTlogic* button for the virtual switch to be edited. Alternately, settings may be made using the SL-101 ASCII command.

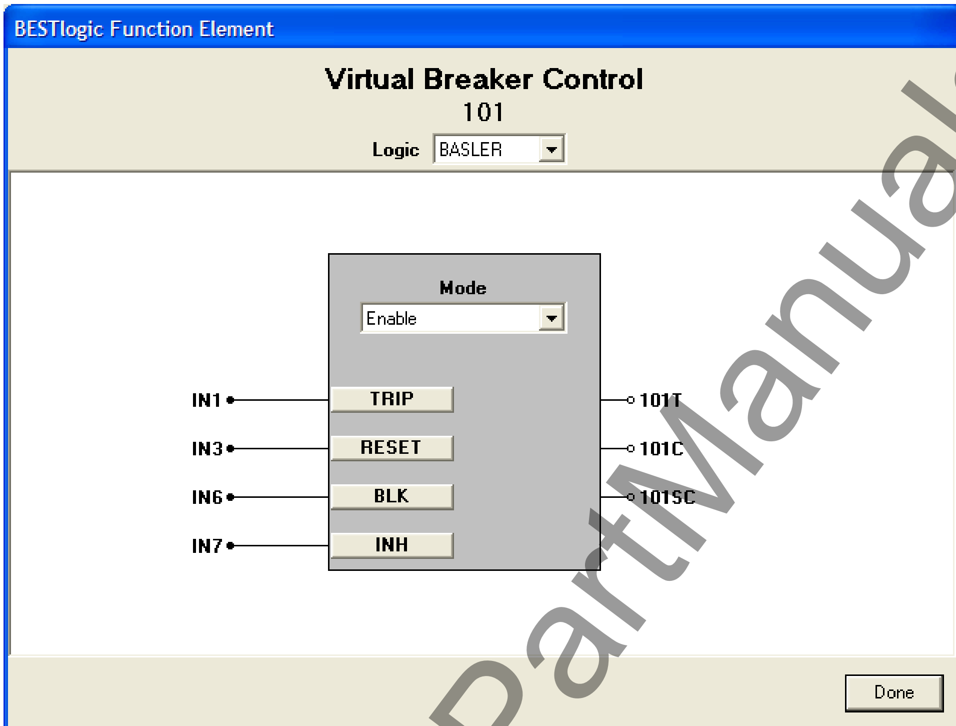

Figure 4-86. BESTlogic Function Element Screen, Virtual Breaker Control

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 4-53 summarizes the element's operating modes.

Table 4-53. 101 Virtual Selector Switch BESTlogic Settings

Function	Range/Purpose	Default
Mode	0 = Disabled, 1 = Enabled	0
TRIP	Input that sets the state of the 101 to TRIP (open).	0
RESET	Input that sets the state of the 101 to RESET (closed).	0
BLK	This input prevents operation of the TRIP and RESET inputs from any source and holds them in their current state.	0
INHIBIT	This input inhibits the front panel switch from functioning.	0

Select Before Operate Control of Virtual Breaker Control Switch

The state of each virtual selector 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-

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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: Control Selection
Syntax : CS/CO-control[={mode}] where control=GROUP/OUT/x43/x43TAG/101/VTS
Example: CS/CO-GROUP=2, CS-OUT1=1, CS-43=P, CS-43TAG=1, CS-101=T or CS-VTS=2

The virtual switch control 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 Information from the Relay

The virtual 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. Status cannot be retrieved using BESTCOMS. 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 control switches (after-trip or after-close). As the previous Example 1 demonstrated, the state of each virtual selector 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 BE1-1051 measures the voltage and current inputs, displays those values in real time, records those values every one-quarter second, and calculates other quantities from the measured inputs.

METERING FUNCTIONS

BE1-1051 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 5-1. 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 Calculations.* Energy measurement is covered in Section 6, *Reporting and Alarm Functions.*

Metered values are viewed through the BESTCOMS *Metering* screen. Figure 5-1 illustrates the *Metering* screen. 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 accomplished through the communication port using ASCII commands or at the front panel HMI. For assistance navigating the HMI, refer to Section 10, *Human-Machine Interface,* for details on navigating the HMI Metering screens. Alternately, metering can be performed through the ASCII command interface or the HMI using Screens 3.1 through 3.12. Refer to Table 5-1 for a list of ASCII commands used for metering.

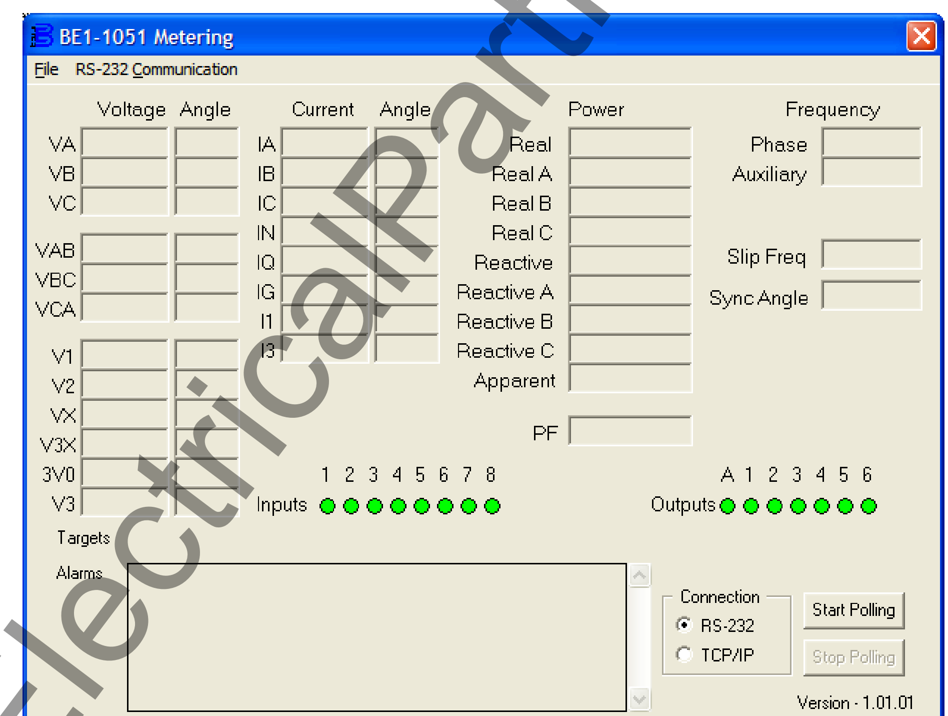

Figure 5-1. Reports, Metering Screen

Table 5-1. Metering Functions Summary

Metering Function	Serial Command	HMI Screen
All metered values	M	N/A
Voltage, all values	M-V	N/A
Voltage, A-phase	M-VA	3.1
Voltage, B-phase	M-VB	3.1

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Metering Function	Serial Command	HMI Screen
Voltage, C-phase	M-VC	3.1
Voltage, A-phase to B-phase	M-VAB	3.3
Voltage, B-phase to C-phase	M-VBC	3.3
Voltage, C-phase to A-phase	M-VCA	3.3
Voltage, Positive-Sequence	M-V1	3.5
Voltage, Negative-Sequence	M-V2	3.5
Voltage, Auxiliary	M-VX	3.4
Voltage, 3rd Harmonic Auxiliary	M-V3X	3.4
Voltage, Zero-Sequence	M-V3V0	3.5
Voltage, Three-phase Average	M-V3	3.2
Current, all values	M-I	N/A
Current, A-phase	M-IA	3.6
Current, B-phase	M-IB	3.6
Current, C-phase	M-IC	3.6
Current, Neutral	M-IN	3.8
Current, Negative-Sequence	M-IQ	3.8
Current, Ground	M-IG	3.7
Current, Positive-Sequence	M-I1	3.8
Current, Three-phase	M-I3	3.7
Power, True	M-WATT	N/A
Power, True, Three-phase	M-WATT3	3.9
Power, True, A-phase	M-WATTA	3.9.1
Power, True, B-phase	M-WATTB	3.9.2
Power, True, C-phase	M-WATTC	3.9.3
Power, Reactive	M-VAR	N/A
Power, Reactive, Three-phase	M-VAR3	3.9
Power, Reactive, A-phase	M-VARA	3.9.1
Power, Reactive, B-phase	M-VARB	3.9.2
Power, Reactive, C-phase	M-VARC	3.9.3
Power, Apparent (VA)	M-S	3.10
Power Factor	M-PF	3.10
Frequency	M-FREQ	N/A
Frequency, Phase	M-FREQP	3.11
Frequency, Auxiliary	M-FREQX	3.11
Frequency, Slip	M-FREQS	3.12
Metered sync angle between Phase and Aux inputs.	M-SYNC	3.12

The BE1-1051 provides primary and secondary metering that is selectable only through the HMI interface, Screen 3. Selecting the relay for primary metering will cause the relay to display metered values for the primary winding of the system CT. Selecting the relay for secondary metering will cause the relay to display metered values for the secondary winding, or the relay side, of the CT. To select the type of metering using the HMI, go to Screen 3 and press the Edit button. The LED in the Edit button will illuminate to indicate the unit is in the edit mode. Use the UP and DOWN buttons to select between primary and secondary metering. Press the Edit button when finished to save your changes. Information about the CT ratio must be entered in the relay for primary metering to be accurate.

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Voltage

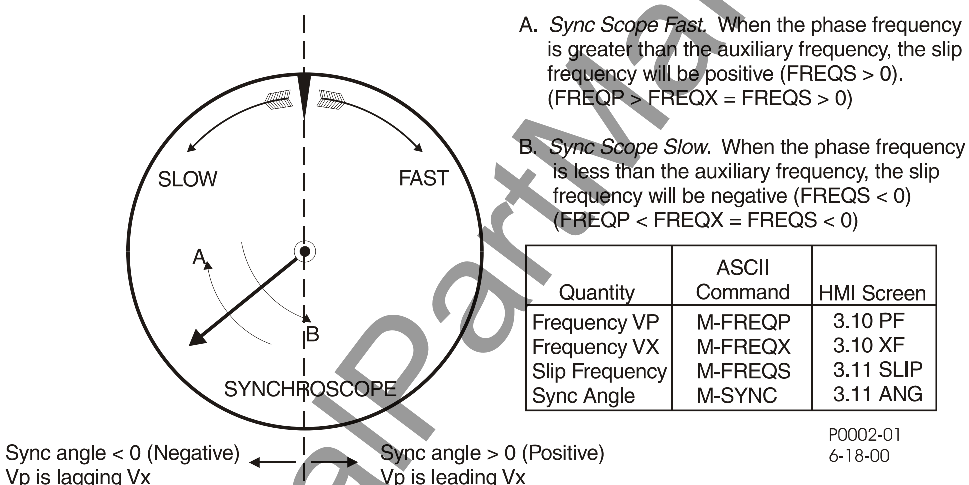
The BE1-1051 meters A-phase voltage, B-phase voltage, C-phase voltage, voltage across phases A and B, phases B and C, and phases A and C. Negative-sequence voltage and three-phase zero-sequence (residual) voltage is also metered. In addition, metered voltages also include positive-sequence voltage, three-phase average voltage, auxiliary voltage, and auxiliary 3rd harmonic voltage. The VTP connection determines what is measured.

Current

Metered current includes A-phase current, B-phase current, C-phase current, neutral three-phase zero-sequence current, and ground current. Metered current also includes positive-sequence current and 3-phase average current. Other metered currents include 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. Refer to Figure 5-2.



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

Figure 5-2. 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 kilovoltamperes to +7,500 kilovoltamperes on five ampere nominal systems. One ampere nominal systems meter apparent power over a range of -1,500 kilovars to +1,500 kilovars.

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.

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.

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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 BE1-1051 relay 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

BE1-1051 relays have four relay Circuit Identification fields: *Relay ID*, *Station ID*, *General 1*, and *General 2*. These fields are used in the header information lines of the Fault Reports, the Oscillograph Records, and the Sequence of Events Records.

Relay *Circuit Identification* settings are made using BESTCOMS. Figure 6-1 illustrates the BESTCOMS screen used to set *Relay ID*, *Station ID*, *General 1*, and *General 2*. To open this screen, select *General Operation* from the *Screens* pull-down menu. Alternately, settings may be made using the SG-ID ASCII command.

In Figure 6-1, the circuit identification labels indicate the default labels. To change these, delete the old label from the cell and type the new label. Identification settings are summarized in Table 6-1.

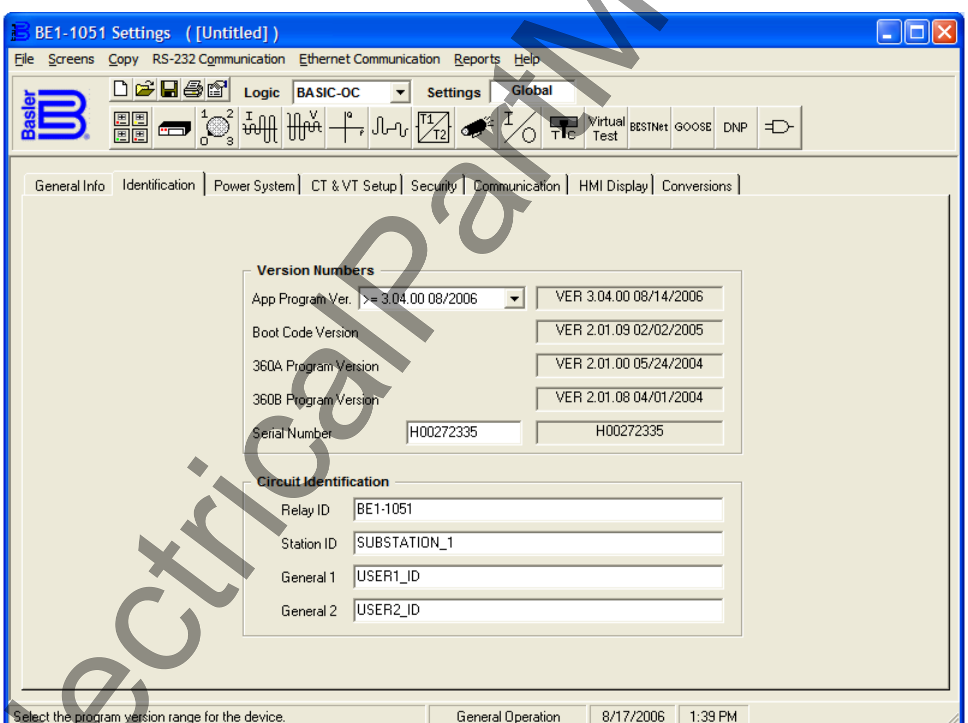

Figure 6-1. General Operation Screen, Identifications Tab.

Table 6-1. Relay Circuit Identification Settings

Setting	Range	Default
Relay ID	1 to 30 alphanumeric characters ∗	BE1-1051
Station ID	1 to 30 alphanumeric characters ∗	SUBSTATION_1
General 1	1 to 30 alphanumeric characters ∗	USER1_ID
General 2	1 to 30 alphanumeric characters ∗	USER2_ID

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∗ 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_ID".

CLOCK

The BE1-1051 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 battery backup may be installed. The battery will maintain the clock for up to five years.

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 kilo-ohms 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 in Figure 6-2, 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.

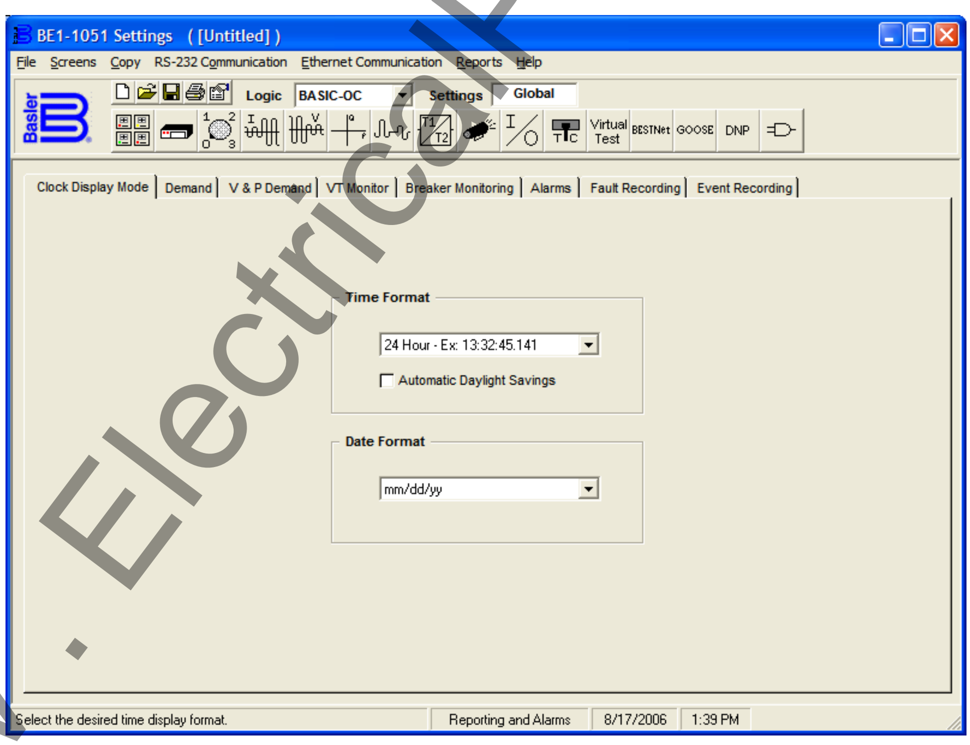

Figure 6-2. Reporting and Alarms Screen, Clock Display Mode Tab

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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. Refer to Table 6-2, *Time and Date Format Settings*.

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 read and set at the front panel human-machine interface (HMI) and through the communication ports. 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. Time and date information is read and programmed through the communication ports using the RG-DATE and RG-TIME ASCII commands.

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)

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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

BE1-1051 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(12345678)   STATUS : 00000000
OUTPUT(A123456)   STATUS : 0000000
CO-OUT(A123456)   STATUS : DISABLED
CO-x43 (43-443)   STATUS : 00000
CO-x43TAG(43-443) STATUS : 00000
CO-101(101SC)     STATUS : AFTER CLOSE(1)
CO-101 TAG        STATUS : 0
CO-GROUP          STATUS : DISABLED
VTS CONTROL       STATUS : DISABLED
BLK COM CTRL(012) STATUS : DISABLED
86 186            STATUS : DISABLED DISABLED
ACTIVE LOGIC      STATUS : TEST
RECLOSER(79)      STATUS : OFF
LOGIC VAR(00-31)  STATUS : 00000000 00000000 00000000 00000000
LOGIC VAR(32-63)  STATUS : 00000000 00000000 00000000 00001000
LOGIC VAR(64-95)  STATUS : 00000000 00000000 00000000 00000000
LOGIC VAR(96-127) STATUS : 00000000 00000000 00000000 00001000
ACTIVE GROUP      STATUS : 0
BREAKER(52)       STATUS : CLOSED
DIAG/ALARM        STATUS : 0 RELAY, 0 LOGIC, 0 MAJOR, 0 MINOR
```

INPUT (1234567(8))

This line reports the status of contact sensing inputs one through seven (or eight depending on style number). Input information is available at HMI Screen 1.5.1. A 0 indicates a de-energized input and a 1 indicates an energized input. See Section 3, *Input and Output Functions,* for more information about contact sensing input operation.

OUTPUT (A123456(7))

Current output contact status is reported on this line. This information is also available at HMI Screen 1.5.2. A 0 indicates a de-energized output and a 1 indicates an energized output. More information about output contact operation is available in Section 3, *Input and Output Functions.*

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CO-OUT (A123456(7))

This line reports the logic override of the output contacts. Logic override status is reported at HMI Screen 1.5.3 and through the CO-OUT command. Section 3, Input and Output Functions, provides more information about output logic override control.

CO-x (43-443)

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,* for more information about virtual switch operation.

CO-x43TAG (43-443) STATUS

Virtual switch tagging is reported on this line. This information is also available at the optional Direct Access Virtual Control Panel. The LEDs labeled Tagged will be illuminated to indicate the tagging state of the switch.

CO-101 (101SC)

This line reports the 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.*

CO-Group

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.*

VTS CONTROL STATUS

This line reports the status of the virtual test switch, indicating the switch's mode of operation. See Section 13, *Testing and Maintenance,* for more information on using the virtual test switch.

BLK COM CTRL (012)

This line reports the status of the COM port Block feature.

86, 186

This line reports the status of the virtual lockout function. The virtual lockout function operating mode can also be viewed through the HMI at Screen 1.5.5. See Section 4, *Protection and Control,* for more information.

ACTIVE LOGIC

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.

RECLOSER (79)

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.*

LOGIC VAR (00-31), LOGIC VAR (32-63), LOGIC VAR (64-95), and LOGIC VAR (96-127)

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.

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Table 6-3. Logic Variable Status Report Format

50TPT	150TPT	50TNT	150TNT	50TQT	150TQT	BFT	51PT	51NT	151NT	51QT	50TPPU	150TPPU	50TNPU	150TNPU	50TQPU	150TQPU	BFRT	51PPU	51NPU	151NPU	51QPU	86	186	52BT	79P	79C	79RNG	79LO	79RSY	79SCB	0
00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

VOA	VO1	VO2	VO3	VO4	VO5	VO6	VO7	VO8	VO9	VO10	VO11	VO12	VO13	VO14	VO15	VO16	VO17	IN1	IN2	IN3	IN4	IN5	IN6	IN7	IN8	101T	101C	101SC	ALMLGC	ALMMAJ	ALMMIN
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63

32T	132T	32PU	132PU	VTS	27PT	27XT	27PPU	27XPU	47T	47PU	24T	24PU	59PT	159XT	59XT	59PPU	159XPU	59XPU	81T	181T	281T	381T	481T	581T	CKTMON	62	162	25VM1	25VM2	25	60FL
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95

VIN1	VIN2	VIN3	VIN4	VIN5	VIN6	VIN7	VIN8	VIN9	VIN10	VIN11	VIN12	VIN13	VIN14	VIN15	VIN16	ARSTKEY	TRSTKEY	43	143	243	343	443	P85ET	P85ETX	P85TX	P85T	SOTF	SG0	SG1	SG2	SG3
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127

BREAKER (52)

This line reports the state of the breaker. This information is also available at HMI Screen 1.5.7. More information about breaker status is provided in the Breaker Monitoring sub-section.

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

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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 BE1-1051. 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.

$$\frac{\text{Primary VT Ratio} \times \text{Primary CT Ratio}}{60 \text{ minutes}} \times \text{Secondary watts or vars}$$

Equation 6-1. Energy Data Equation

Watt and var values are updated every 250 milliseconds and watthour and varhour 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 (3-phase residual 3I0), 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 Calculation

Thermal Demand Calculation Method

The demand reporting function incorporates an algorithm to digitally simulate a thermal or exponential response. Thermal demand values are computed by an exponential algorithm with the demand interval or response period defined as the time taken by the meter to reach 90 percent of the final value for a step change in the current being measured. The demand interval and monitored CT can be set independently for the phase, neutral, and negative-sequence demand calculations.

Block Demand Calculation Method

The block demand method calculates the average value of the measured current for the time interval set by the demand reporting function. This value remains constant and is stored in registers and reported for the duration of the following time interval. At the end of the time interval, the calculated average for the previous time interval is again stored in registers and reported for the duration of the following time interval. If you have set a 15-minute time interval and block demand calculation, the reported value for 15 minutes is the average value of the measured current for the previous 15 minutes.

Sliding Block Demand Calculation Method

Sliding block demand method calculates the average value of the measured current for the time interval set by the demand reporting function. This value is stored in registers and reported for one minute. After one minute has elapsed, the sliding block demand method again calculates the average value of the measured current for the set time interval including the most recent minute. This value is updated each minute.

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An algorithm in the demand reporting function digitally simulates a thermal or exponential response. Demand values are computed by an exponential algorithm with the demand interval or response period defined as the time taken by the meter to reach 90 percent of the final value for a step change in the current being measured. Demand interval can be set independently for the phase, neutral, and negative-sequence demand calculations. The reactive power and power demand intervals always match the phase demand interval setting.

Each time that the value in the current demand register is updated, it is compared to the values stored in the Peak Since Reset and the Today's Peak registers. If the new demand is greater, the new value and time stamp is entered into the appropriate registers. In addition, the demand reporting function keeps an additional set of registers for Yesterday's Peak. Each day at midnight, the demand reporting function replaces the values and time stamps stored in Yesterday's Peak registers with the values and time stamps from Today's Peak registers. It then starts recording new information in Today's Peak registers. Demand registers are stored in volatile memory.

Today's Peak and Yesterday's Peak registers are read-only. Values in the Peak Since Reset registers can be reset to zero or preset to a predetermined value. For example, if some loads will be switched to remove a feeder from service and you do not want the abnormal loading to affect the Peak Since Reset register values, these values can be read prior to switching the loads. Once the abnormal loading condition has passed, the registers can be reset to the original values.

Demand Reporting

Setting Demand Current Reporting

Demand reporting settings for current 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 *Demand* tab. Alternately, settings may be made using the SG-DI and SA-DI ASCII commands.

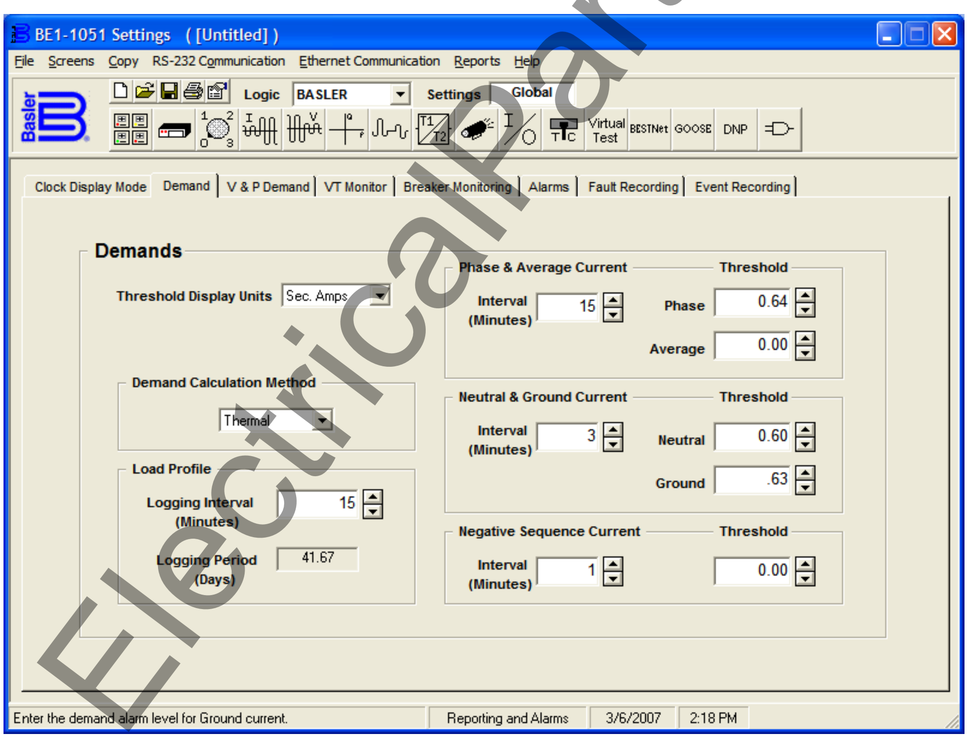

Figure 6-3. Reporting and Alarms Screen, Demand Tab

Demand settings for current include *Phase & Average Current, Neutral & Ground Current,* and *Negative-Sequence Current.* Each group has settings *for Interval (Minutes)* and *Threshold*. Demand *Threshold Display Units* are selectable from a pull-down menu for *Sec. Amps, Pri. Amps, Per U Amps* and *% Amps.* The default display unit is *Sec. Amps.*

The programmable demand alarm includes alarm points for monitoring phase demand thresholds for phase overload alarms, and neutral and negative-sequence demand thresholds for unbalanced loading

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alarms. Each time the current demand register is updated, the register value is compared to the corresponding demand alarm threshold. If a threshold is exceeded, the alarm point is set. The *Alarm Functions* subsection provides more information about using the programmable alarms reporting function.

Using the pull-down menus and buttons, make the application appropriate demand settings. Demand alarm thresholds for current are set using the SA-DI (setting alarm, demand current) command. Demand reporting is setup using the SG-DI (setting general, demand interval) command. Demand reporting settings are summarized in Table 6-4.

Table 6-4. Demand Settings for Current

Setting	Range	Increment	Unit of Measure	Default
Threshold Display Units	Sec. Amps, Pri. Amps, Per U Amps, % Amps	N/A	N/A	Sec. Amps
Demand Calculation Method	Thermal, Block, Sliding Block	N/A	N/A	Thermal
Phase & Average Current Interval	0 to 60	1	Minutes	15
Phase Threshold	0.50 Sec. Amps to 16.0 Sec. Amps	0.01	∗	0
Average Threshold	0.50 Sec. Amps to 16.0 Sec. Amps	0.01	∗	0
Neutral & Ground Current Interval	0 to 60	1	Minutes	15
Neutral Threshold	0.50 Sec. Amps to 16.0 Sec. Amps (5A) 0.10A to 3.2A (1A)	0.01	∗	0
Ground Threshold	0.50 Sec. Amps to 16.0 Sec. Amps 0.01A to 0.8A (SEF)	0.01	∗	0
Negative-Sequence Current Interval	0 to 60	1	Minutes	15
Negative-Sequence Threshold	0.50 Sec. Amps to 16.0 Sec. Amps	0.01	∗	0
Load Profile Logging Interval	1 to 60	1	Minutes	15

∗ Unit of measure is based on the Threshold Display Units selection. The default is secondary amps.

Example 1. Make the following settings to the demand function. Refer to Figure 6-3.

Threshold Display Units: Sec. Amps
Demand Calculation Method: Thermal
Logging Interval (Minutes): 15
Phase & Average Current Interval (Minutes): 15
Phase Threshold: 0.64
Average Threshold: 0
Neutral & Ground Current Interval (Minutes): 3
Neutral Threshold: 0.60
Ground Threshold: 0.63
Negative-Sequence Current Interval (Minutes): 1
Negative-Sequence Threshold: 0

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Setting Demand Power and Voltage Reporting

Demand reporting settings for power and voltage are made using BESTCOMS. Figure 6-4 illustrates the BESTCOMS screen used to select demand reporting settings. To open the screen shown in Figure 6-4, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *V & P Demand* tab. Alternately, settings may be made using the SG-DI and SA-DV ASCII commands.

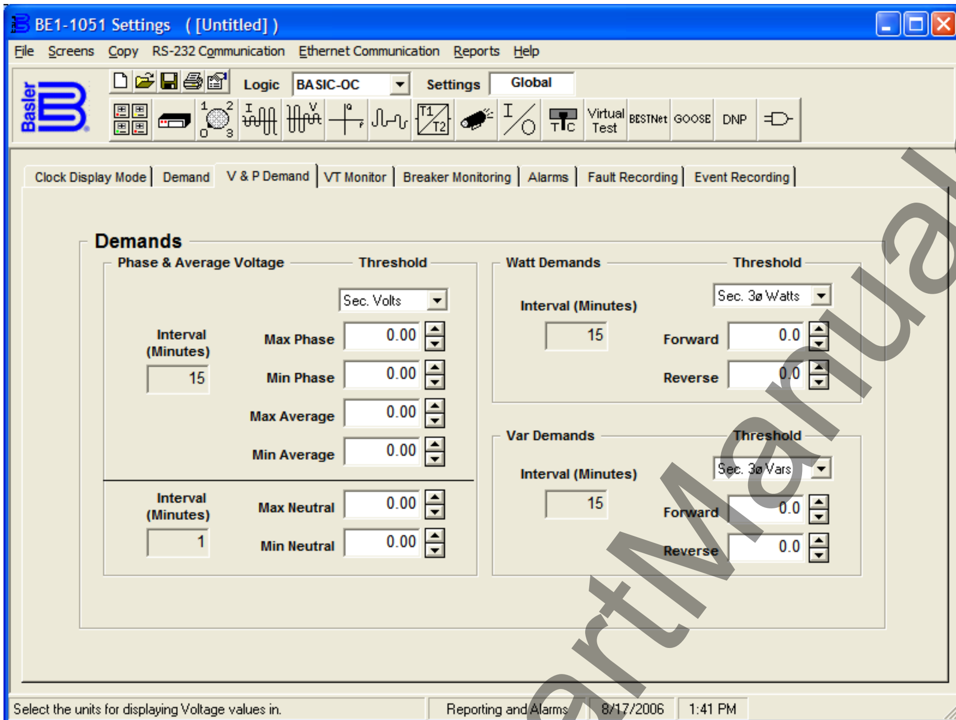

Figure 6-4. Reporting and Alarms Screen, V & P Demand Tab

Demand settings for power and voltage include *Phase & Average Voltage, Watt Demands,* and *Var Demands.* Each group has settings for *Threshold. Demand Threshold Display Units* are selectable from a pull-down menu for *Sec. Amps, Pri. Amps, Per U Amps,* and *% Amps.* The default display unit is secondary amps.

The programmable demand alarm includes alarm points for monitoring phase demand thresholds for phase overload alarms, and neutral and negative-sequence demand thresholds for unbalanced loading alarms. Each time the current demand register is updated, the register value is compared to the corresponding demand alarm threshold. If a threshold is exceeded, the alarm point is set. The *Alarm Functions* subsection provides more information about using the programmable alarms reporting function.

Demand reporting is set up using the SG-DI (setting general, demand interval) command. Demand reporting settings are summarized in Table 6-5.

Table 6-5. Demand Settings for Voltage and Power

Setting	Range	Increment	Unit of Measure	Default
Max Phase Threshold	10 Sec. Volts to 300 Sec. Volts	0.1 for 10 to 99.9 1 for 100 to 300	*	0
Min Phase Threshold	10 Sec. Volts to 300 Sec. Volts	0.1 for 10 to 99.9 1 for 100 to 300	*	0
Max Average Threshold	10 Sec. Volts to 300 Sec. Volts	0.1 for 10 to 99.9 1 for 100 to 300	*	0
Min Average Threshold	10 Sec. Volts to 300 Sec. Volts	0.1 for 10 to 99.9 1 for 100 to 300	*	0

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Setting	Range	Increment	Unit of Measure	Default
Max Neutral Threshold	10 Sec. Volts to 150 Sec. Volts	0.1 for 10 to 99.9 1 for 100 to 150	∗	0
Min Neutral Threshold	10 Sec. Volts to 150 Sec. Volts	0.1 for 10 to 99.9 1 for 100 to 150	∗	0
Forward Watt Threshold	10 Sec. 3Ø Watts to 8500 Sec. 3Ø Watts	0.1 for 0 to 99.9 1 for 100 to 8500	∗	0
Reverse Watt Threshold	10 Sec. 3Ø Watts to 8500 Sec. 3Ø Watts	0.1 for 0 to 99.9 1 for 100 to 8500	∗	0
Forward Var Threshold	10 Sec. 3Ø Vars to 8500 Sec. 3Ø Vars	0.1 for 0 to 99.9 1 for 100 to 8500	∗	0
Reverse Var Threshold	10 Sec. 3Ø Vars to 8500 Sec. 3Ø Vars	0.1 for 0 to 99.9 1 for 100 to 8500	∗	0

∗ Selectable from the BESTCOMS screen. The default unit of measure is displayed in the range column.

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 voltage, 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.

Overload and Unbalance Alarms

The programmable demand alarm includes alarm points for monitoring phase demand thresholds for phase overload alarms, and neutral and negative-sequence demand thresholds for unbalanced loading alarms. Alarm points for three-phase power and three-phase reactive power are also included. Each time the current demand register is updated, the register value is compared to the corresponding demand alarm threshold. If a threshold is exceeded, the alarm point is set. The *Alarms Function* subsection provides more information about using the programmable alarms reporting function.

Demand alarm thresholds for current are set using the SA-DI (setting alarm, demand current) command. Table 6-6 summarizes the demand alarm settings.

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Table 6-6. Demand Alarm Settings

Setting Alarm Level	Range	Increment	Unit of Measure	Default
Alarm Level	0 = Disabled 0.1 - 3.2 (1 A units) 0.5 - 16.0 (5 A units)	0.01 for 0.1 to 9.99 0.1 for 10.0 to 16.0	Secondary Amps	0
Fwd alm lvl (watts)	0 = Disabled 1 - 8,500	1	Secondary Watts	
Rev alm lvl (watts)				
Fwd alm lvl (vars)			Secondary Vars	
Rev alm lvl (vars)				

Demand alarm thresholds for three-phase power and reactive power are set using the SA-DWATT and SA-DVAR commands. Demand alarm settings for power are summarized in Table 6-6.

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. 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.

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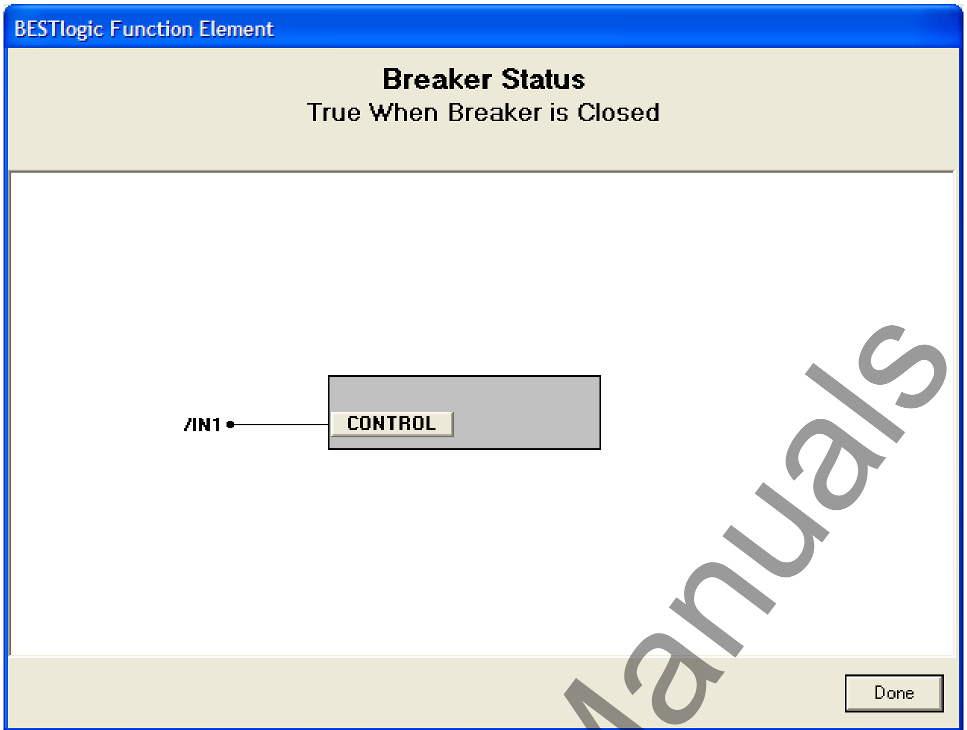

Figure 6-5. BESTlogic Function Element Screen, Breaker Status

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 6-7 lists the settings for the Breaker Status logic.

Table 6-7. Breaker Status Reporting BESTlogic Settings

Setting	Range/Purpose	Default
Breaker Status 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 1.5.7 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.

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Breaker Duty Monitoring

When the breaker opens, the N^{th} power of 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 6-8 serves as a legend for the call-outs of Figure 6-6.

The relay sums the N^{th} power of the currents that are interrupted and will set the breaker duty alarm when the sum exceeds the N^{th} power of the maximum breaker duty (D_{max}) setting. The user must enter a value for N and a value for D_{max}.

To determine N and D_{max}, the user needs to find two measurements of allowable breaker wear. These levels would typically be the maximum number of operations at load level currents and the maximum number of operations at maximum fault rating.

Point 1; # Ops @ $_{\text{Imax load}}$

Point 2; # Ops @ $_{\text{Imax fault}}$

To determine the breaker wear exponent N, using the above data points as an example, apply this equation:

$$N = \frac{\log\left(\frac{\#\text{Ops}@\text{I}_{\text{max load}}}{\#\text{Ops}@\text{I}_{\text{max fault}}}\right)}{\log\left(\frac{\text{I}_{\text{max fault}}}{\text{I}_{\text{max load}}}\right)}$$

Equation 6-2. Breaker Wear Exponent N

N can be any value from 1 to 3.

Using values for $_{\text{Imax load}}$ and $_{\text{Imax fault}}$ in primary amperes (the relay multiplies by the CTR before doing calculations), the value for maximum breaker duty, D_{max}, is calculated from either of these two equations:

$$D_{\text{max}} = \left(\left(\text{I}_{\text{max load}}\right)^{N} \bullet \#\text{Ops}@\text{I}_{\text{max load}}\right)^{I/N}$$

$$D_{\text{max}} = \left(\left(\text{I}_{\text{max fault}}\right)^{N} \bullet \#\text{Ops}@\text{I}_{\text{max fault}}\right)^{I/N}$$

Equation 6-3. Determining D_{max}

Both of the last two equations should yield the same value for 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.

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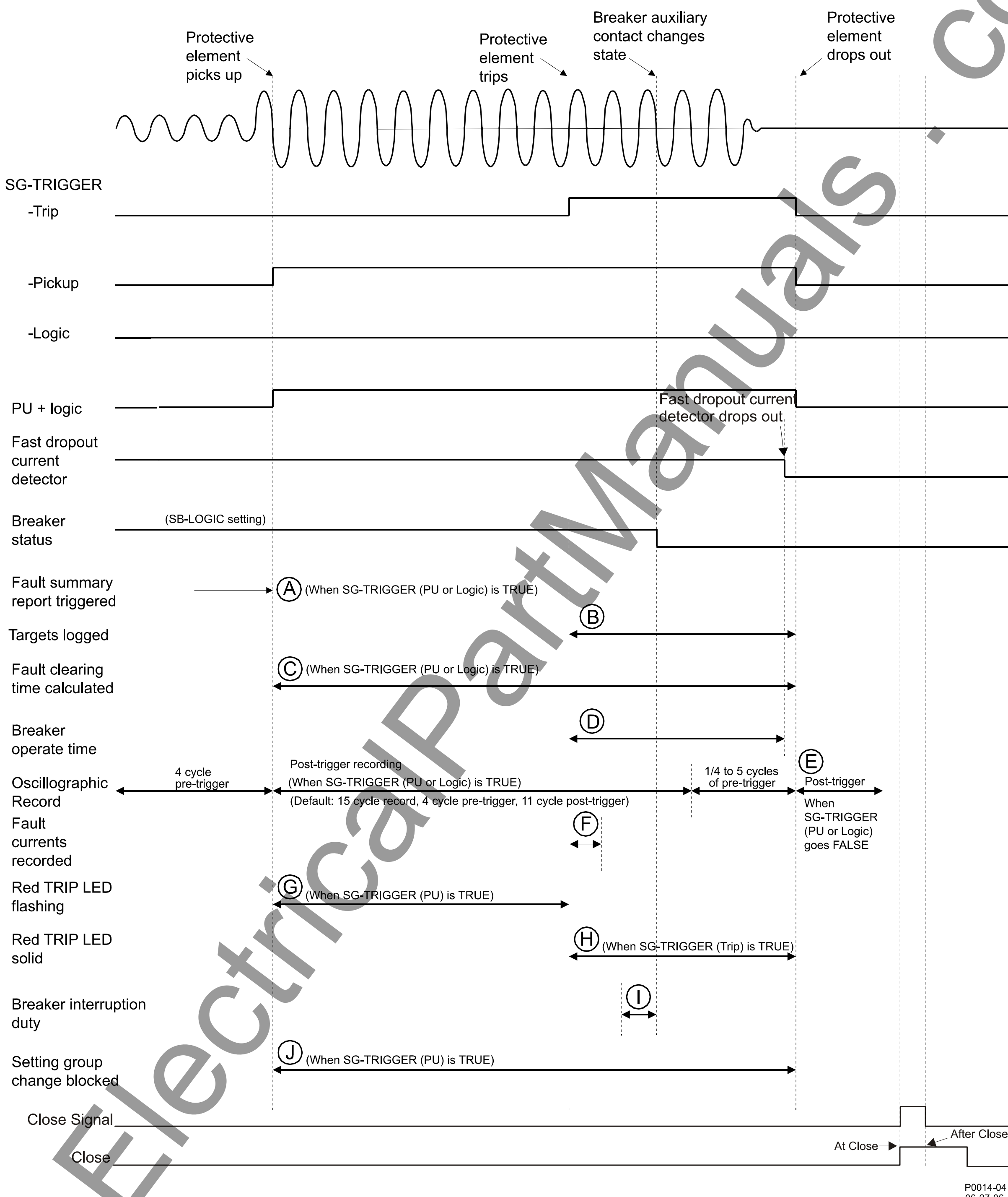

Figure 6-6. Protective Fault Analysis

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Table 6-8. 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. Select *Reporting and Alarms* from the *Screens* pull-down menu and 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. Table 6-9 summarizes the Breaker Duty Monitoring settings.

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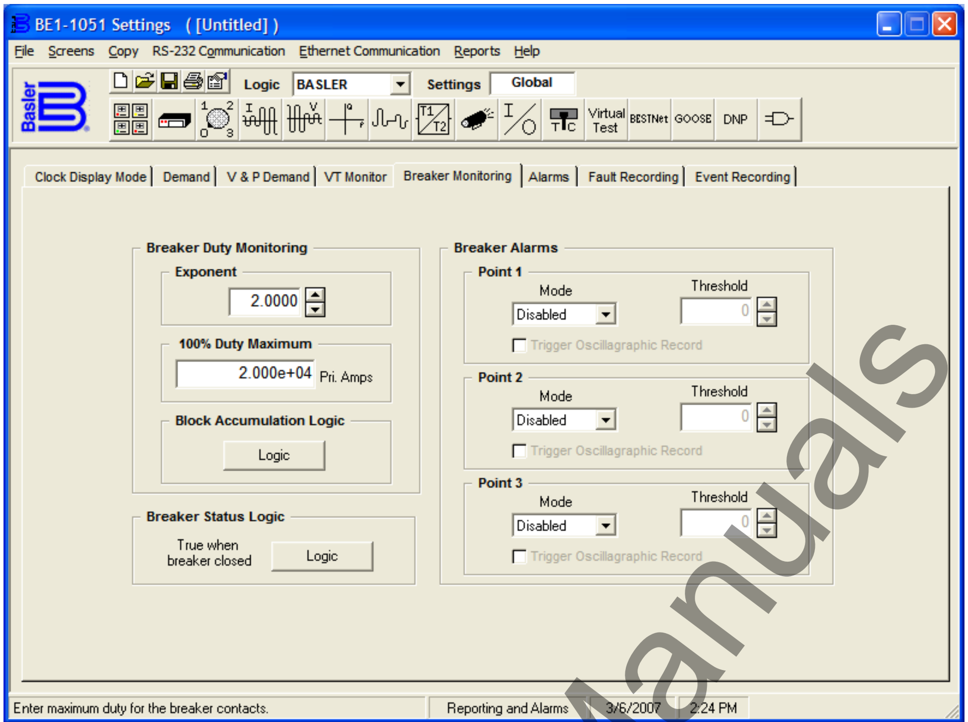

Figure 6-7. Reporting and Alarms Screen, Breaker Monitoring Tab

Table 6-9. Breaker Duty Monitoring Settings

Setting	Range/Purpose	Default
Exponent	1 to 3 in increments of 0.0001 (0 = breaker monitoring disabled)	0.0000
100% Duty Maximum	Maximum duty the breaker contacts can withstand before they need service. DMAX is programmed in primary amperes using exponential floating-point format. The maximum DMAX setting is 4.2e+7.	0.000e+00
Block	Logic expression. Logic OR term which blocks the breaker duty accumulation when TRUE (1).	0

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.

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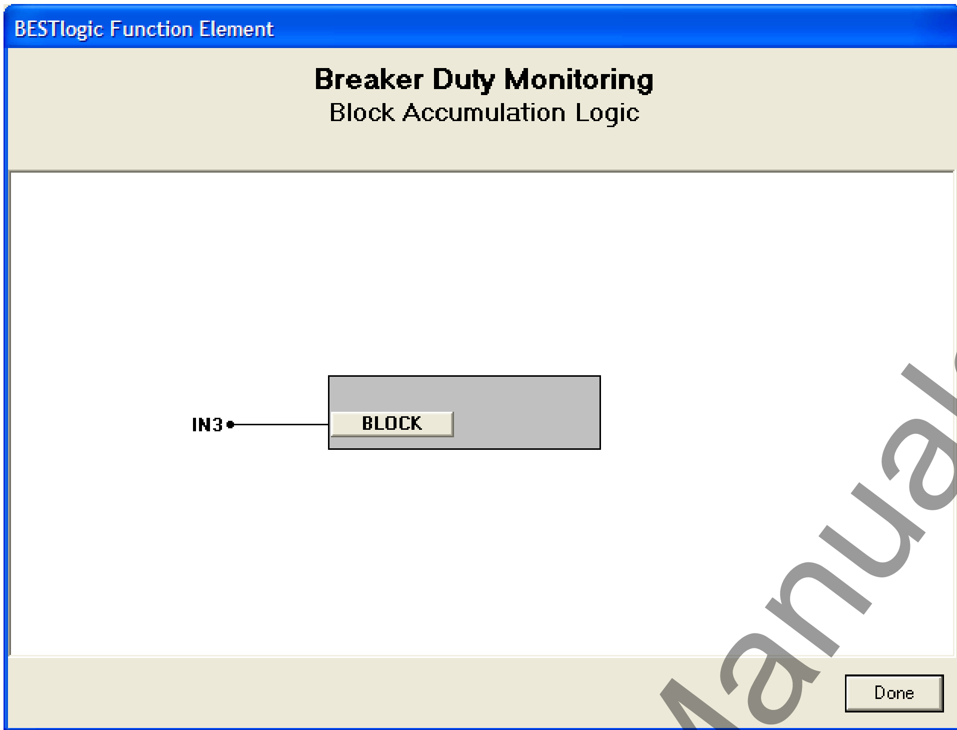

Figure 6-8. BESTlogic Function Element Screen, Breaker Duty Monitoring

Example 1. Make the following settings to Breaker Duty Monitoring. Refer to Figures 6-7 and 6-8 and Table 6-9.

Exponent:	2.0000
100% Duty Maximum:	2.000e+04
BLOCK:	IN3

<u>Retrieving Breaker Duty Information</u>

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.

<u>Breaker Operate Time Monitoring</u>

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 also illustrates the BESTCOMS screen used to select settings for the Breaker Alarms function. Select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Breaker Monitoring* tab. Alternately, settings may be made using the SB-BKR ASCII command.

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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 6-10 summarizes the Breaker Alarms settings.

Table 6-10. Breaker Alarms Settings

Setting		Range/Purpose	Default
Mode		0 = Disabled 1 = Duty 2 = Operations 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
Trigger Oscillographic Record		When checked, an oscillographic record is triggered when the alarm threshold is exceeded.	0

Optional Load Profile Recording

Load profile recording is an optional selection when the BE1-1051 is ordered. This option (4,000 Point Load Profile Demand Log) 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. Using the Thermal Demand Calculation Method as an example, 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 *Demand Calculation* earlier in this section for information on calculation methods.

Setting the Load Profile Recording Function

Operating settings are made using BESTCOMS. Figure 6-9 illustrates the BESTCOMS screen used to select operational settings for the Load Profile function. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Demand* tab. Alternately, settings may be made using SG-LOG ASCII command.

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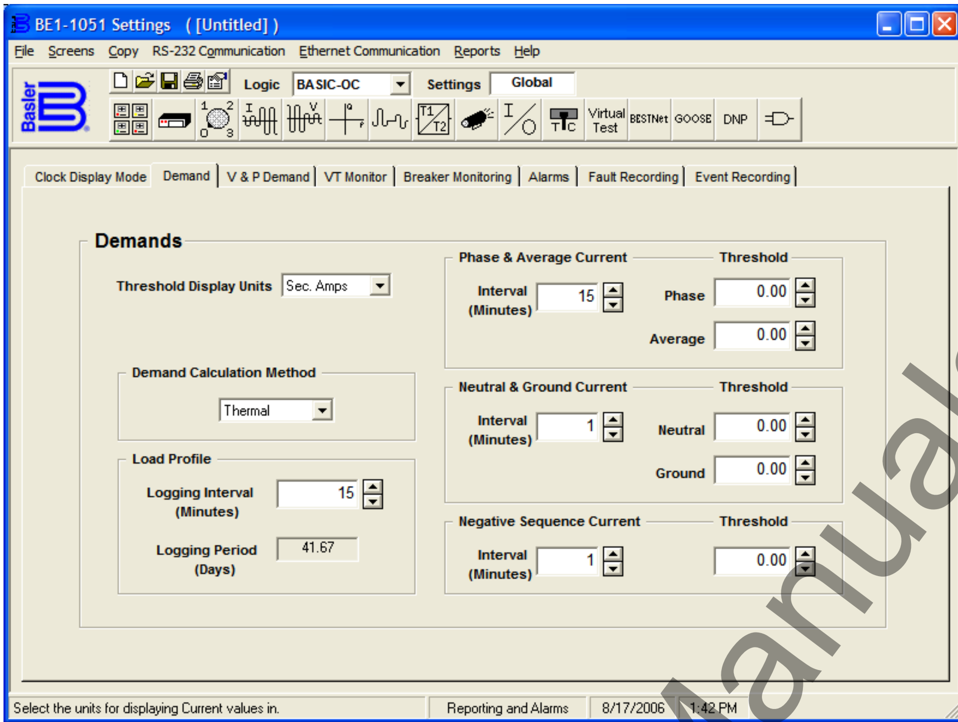

Figure 6-9. Reporting and Alarms Screen, Demand Tab

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 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.

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.

Using the pull-down menus and buttons, make the application appropriate settings to the Load Profile function.

Table 6-11 summarizes the function/element's modes of operation.

Table 6-11. Load Profile Recording Settings

Function	Range	Increment	Unit of Measure	Default
Demand Log Interval	1 to 60	1	Minutes	15
Demand Calculation Method	Thermal, Block, Sliding Block	N/A	N/A	Thermal

Retrieving the Load Profile Recording Function

Recorded load-profile 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.

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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 trip circuit monitor function obtains the breaker status from a programmable setting, which is set using the <status> parameter in the SL-CKTMON command. The detector circuit used by the trip circuit monitoring function is programmable using the <monitor> parameter in the SL-CKTMON command. The input circuit draws less than two milliamperes of current through the trip coil when the breaker is closed. Figure 6-10 shows the trip circuit monitor logic.

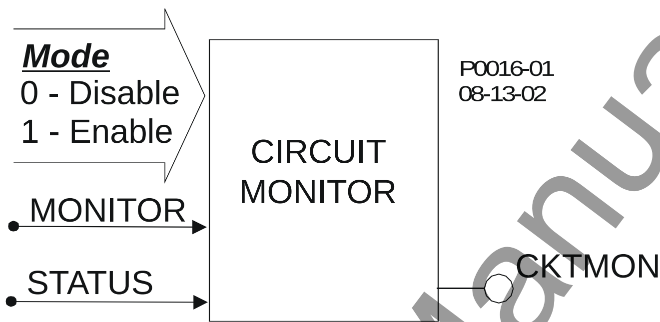

Figure 6-10. Trip Circuit Monitor Logic

The user is to provide jumper wires from the output contacts to the input contacts used for the circuit monitor.

If the relay detects that the breaker is closed and no voltage is sensed in the trip circuit after the appropriate coordination time delay (approximately 500 milliseconds), the relay sets an alarm bit in the programmable alarms function and sets the CKTMON BESTlogic logic variable to TRUE.

Figure 6-11 shows a typical connection diagram for the circuit monitor. Also, see Section 8, *Application, Application Tips,* for instructions on how to program a close-circuit monitoring function in BESTlogic. In this example, OUT1 is tripping the Circuit Breaker Trip Coil (52TC), IN6 is monitoring the Trip Circuit voltage and IN1 is monitoring the Circuit Breaker 52B status.

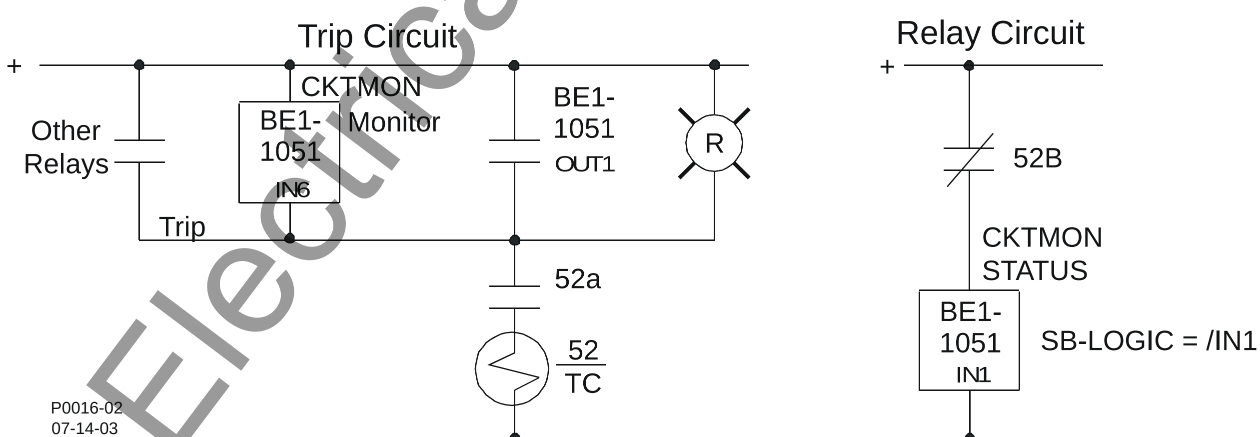

Figure 6-11. Sample Trip Circuit Voltage and Continuity Monitor

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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. (Figure 6-12 shows a schematic representation of the equivalent circuit.) This may cause false tripping of the other devices and prevent the BE1-1051 trip circuit monitor from reliably detecting an open circuit. Contact Basler Electric for advice on using 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 trip circuit monitor function should not be used.

In Figure 6-12, a 62x auxiliary relay is shown. In this case, the impedance of the 62x coil is small compared to the impedance of the Trip Circuit Monitor circuit so the Trip Circuit Monitor is always at logic 1. This prevents the Trip Circuit Monitor logic from working, even if the trip coil is open. Normally, when redundant systems are used, each relay system is on an individual circuit and the sensing input for each relay system is isolated from the tripping circuit.

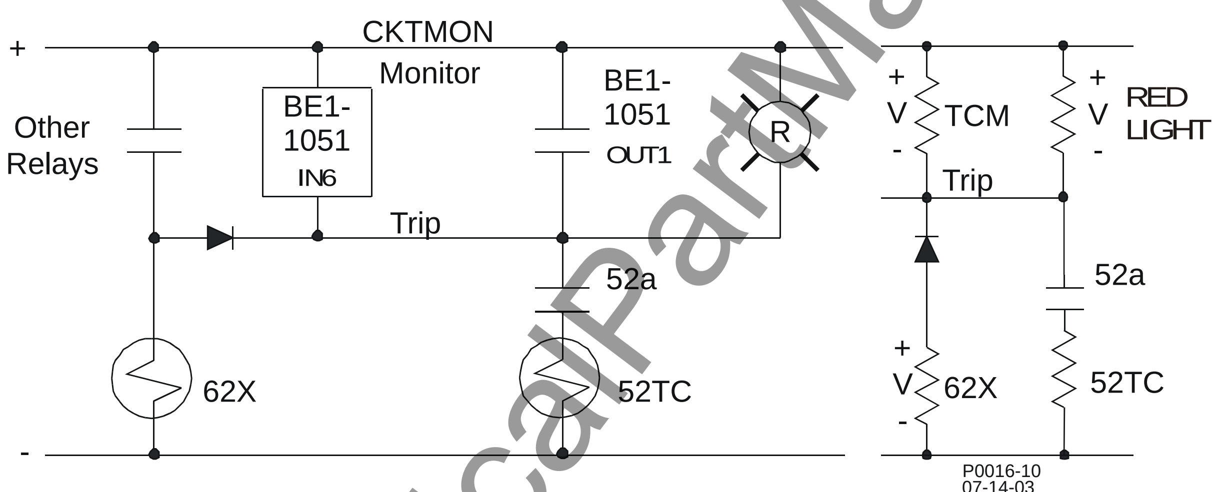

Figure 6-12. TCM with Other Devices

In Figures 6-13 and 6-14, a possible trip and close circuit monitor is shown. With a virtual output, it would be possible to determine that there is a problem, just not exactly which circuit. The logic is further described in the next section. The use of a sequence of events report would aid in determining the problem circuit.

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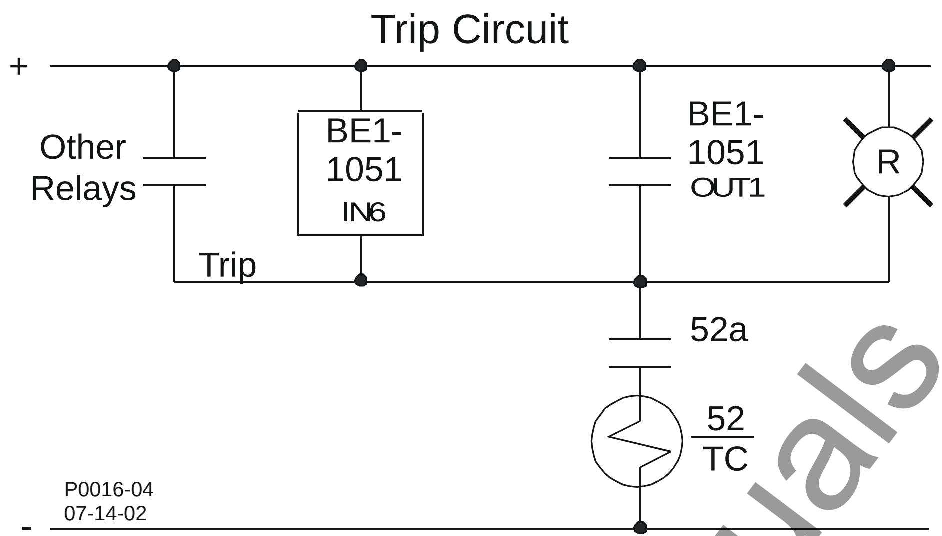

Figure 6-13. Trip Circuit

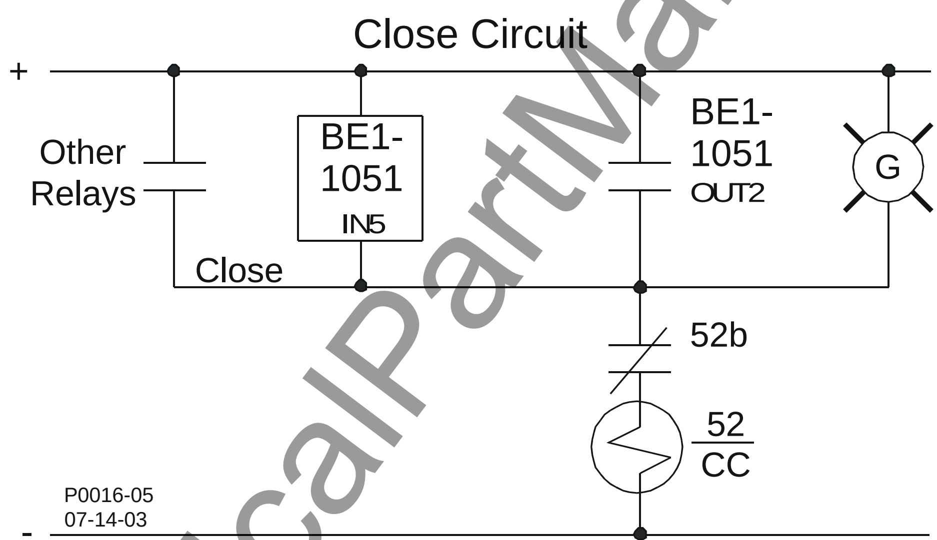

Figure 6-14. Close Circuit

BESTlogic Settings for Trip Circuit Monitor

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 6-15 illustrates the BESTCOMS screen used to select BESTlogic settings for the Trip Circuit Monitor. To open the screen shown in Figure 6-15, select *Reporting and Alarms* from the *Screens* pull-down menu and select the *Alarms* tab. Then select the *BESTlogic* button at the bottom of the screen and next to the box labeled *Circuit Monitor.* Alternately, settings may be made using the SL-CKTMON ASCII command.

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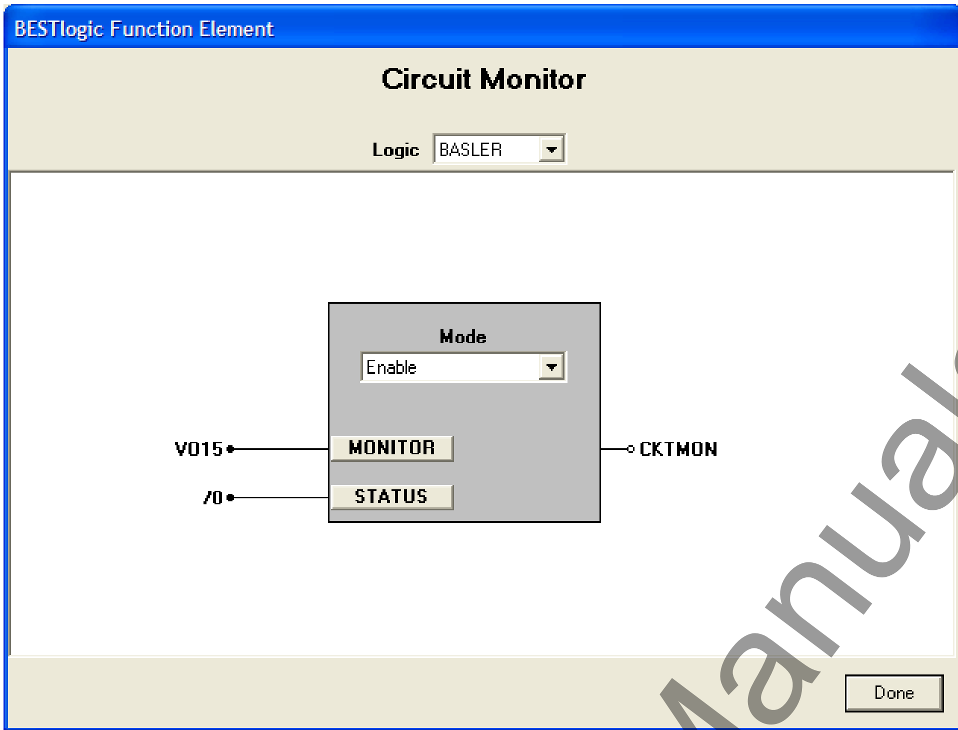

Figure 6-15. BESTlogic Function Element Screen, Circuit Monitor

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 Trip Circuit Monitor 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 6-12 summarizes the Trip Circuit Monitor's modes of operation.

Table 6-12. Trip Circuit Monitor Function Settings

Settings	Range/Purpose	Default
Mode	0 = Disabled, 1 = Enabled	0
Monitor	Logic expression for the input circuit monitoring the trip circuit.	0
Status	Logic OR expression that is TRUE when the breaker is closed.	0

Example 1. In the circuit illustrated in Figure 6-15 (for Figures 6-13 and 6-14), the Trip Circuit Monitor would always be active. It will alarm for a trip or close circuit problem, but will not identify the exact problem circuit. Note that the following logic expression represents Virtual Output 15 (VO15) in the example. The first half of the expression represents a trip and the second half a close.

VO15 = (IN6 • /IN1) + (IN5 • IN1)

FAULT REPORTING

The fault reporting function records and reports information about faults that have been detected by the relay. The BE1-1051 provides many fault reporting features. These features include Fault Summary Reports, Sequence of Events Recorder Reports, Oscillographic Records, and Targets.

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Conditions for Fault Reporting

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 are 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 the fault current magnitudes at the time of trip. The HMI uses the trip expression to seal-in the Trip LED. 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 oscillograph data. The HMI uses the pickup expression to control the flashing of the Trip LED. 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 6-16 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 the SG-TRIGGER ASCII command.

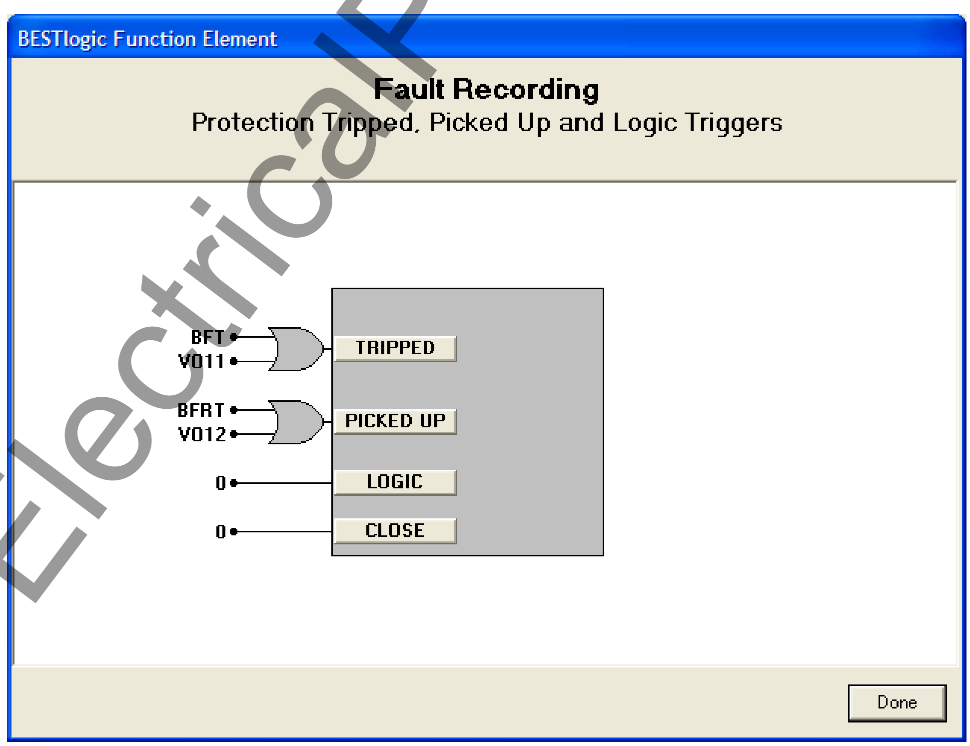

Figure 6-16. BESTlogic Function Element Screen, Fault Recording

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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 6-13 lists the function's settings.

Table 6-13. 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.	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.	BFRT+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
CLOSE	Logic expression used to define the trigger for close reporting. When this expression is TRUE (1), close reporting is triggered.	0

Example 1. Make the following BESTlogic settings to the Fault Recording function. Refer to Figure 6-16.

TRIPPED: VO11+BFT
PICKED UP: VO12+BFRT
LOGIC: 0
CLOSE: 0

Targets

Each protective function (see Table 6-14) 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 6-8, call-out B). Target information can be viewed and reset at the HMI and through the communication ports.

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.

Table 6-14. 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
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

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Name	Protective Function	Target Default
81	Under/Over Frequency	Enabled
181	Second Under/Over Frequency	Enabled
281	Third Under/Over Frequency	Enabled
381	Fourth Under/Over Frequency	Enabled
481	Fifth Under/Over Frequency	Enabled
581	Sixth Under/Over Frequency	Enabled
59P	Phase Overvoltage	Enabled
59X	Auxiliary Overvoltage	Enabled
159X	Second Auxiliary Overvoltage	Enabled
47	Negative-Sequence Overvoltage	Enabled
27P	Phase Undervoltage	Enabled
27X	Auxiliary Undervoltage	Enabled
62	General Purpose Logic Timer	Enabled
162	Second General Purpose Logic Timer	Enabled
24	Volts per Hertz	Enabled
32	Directional Power	Enabled
132	Second Directional Power	Enabled
60FL	Fuse Loss Detection	Enabled
BF	Breaker Failure	Enabled
52BT	Breaker Trouble	Enabled
SOTF	Switch on to Fault	Enabled
P85	Permissive Pilot	Enabled
P85E	Permissive Pilot Echo	Enabled

Setting the Targets Function

Targets are enabled using the BESTCOMS screen shown in Figure 6-17. 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 and enable the targets by checking the appropriate boxes. Alternately, targets can be enabled using the SG-TARG ASCII command.

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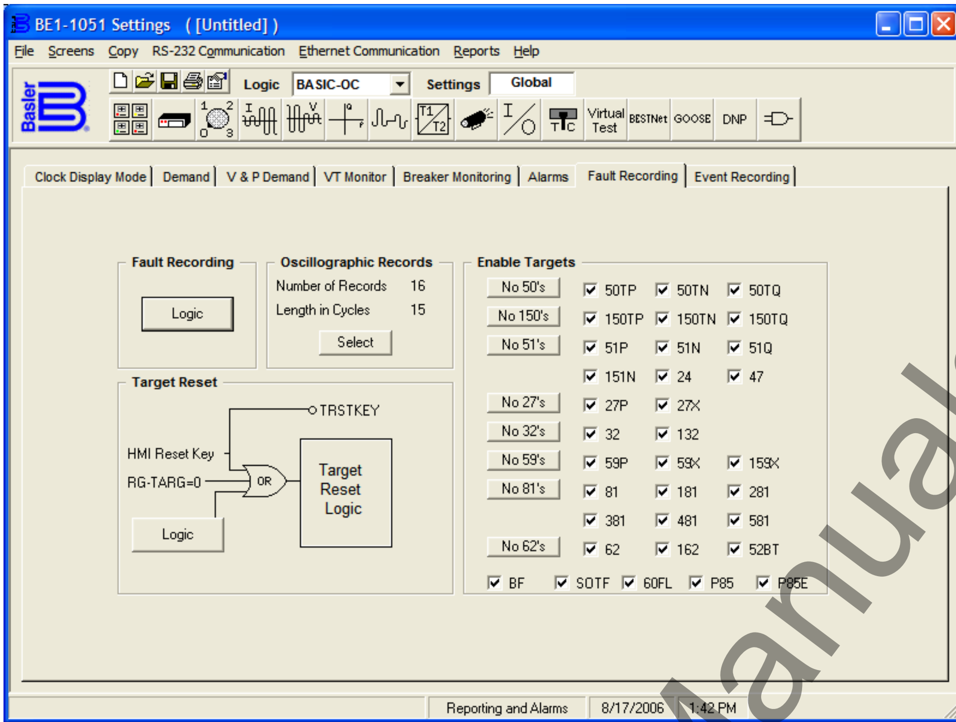

Figure 6-17. Reporting and Alarms Screen, Fault Recording Tab

Retrieving 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 and voltage 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 6-18.

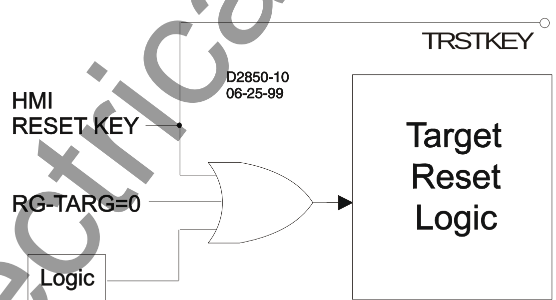

Figure 6-18. Target Reset Logic

A logic input can be used to reset the target. Using BESTCOMS, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *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 after an operation by selecting *Metering* from the *Reports* pull-down menu. Targets are shown on the *Metering* screen. Refer to Figure 6-19.

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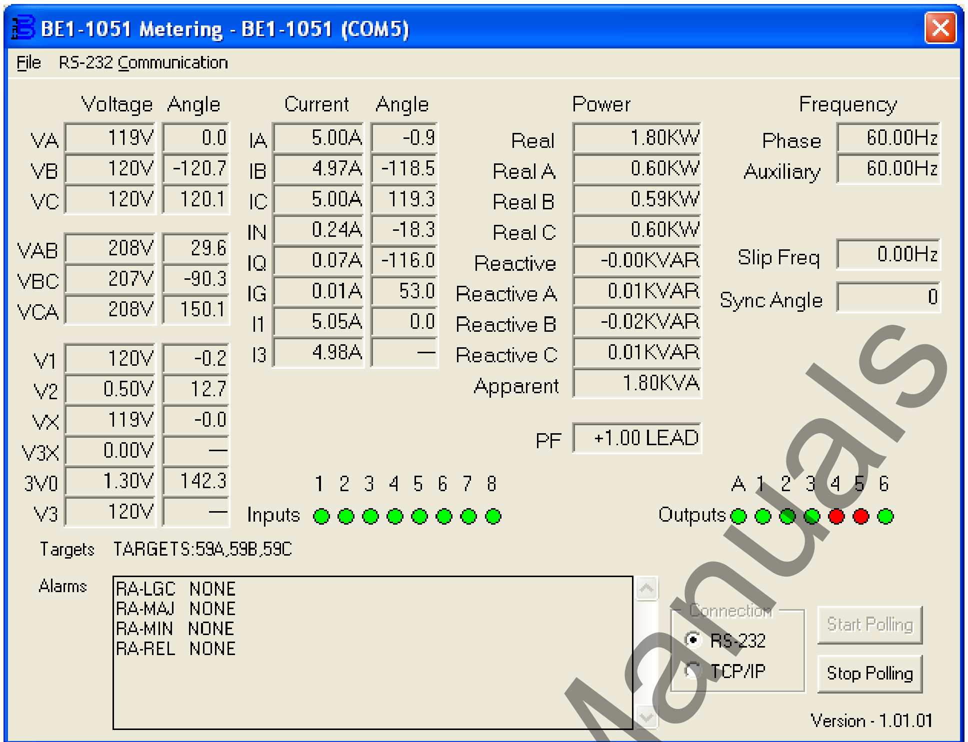

Figure 6-19. Metering Screen

Table 6-15 provides the possible targets, which may be displayed in the *Metering* screen.

Table 6-15. Targets as Displayed

IEEE Device Number	Definition
24	Overexcitation
27 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	Instantaneous Overcurrents
51 ABC, Q, N or G; 151 ABC, N or G	Time Overcurrents
52BT	Breaker Trouble
59 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	Directional Instantaneous Overcurrents
81/181/281/381/481/581	Frequency
BF	Breaker Failure
P85 / P85E	Permissive Pilot / Pilot Echo
SOTF	Switch on to Fault

The RG-TARG (report general-targets) command is used to read and reset targets through the communication ports.

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Distance to Fault

The BE1-1051 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 6-16 provides the power line operating settings.

Table 6-16. 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 6-20). 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*.

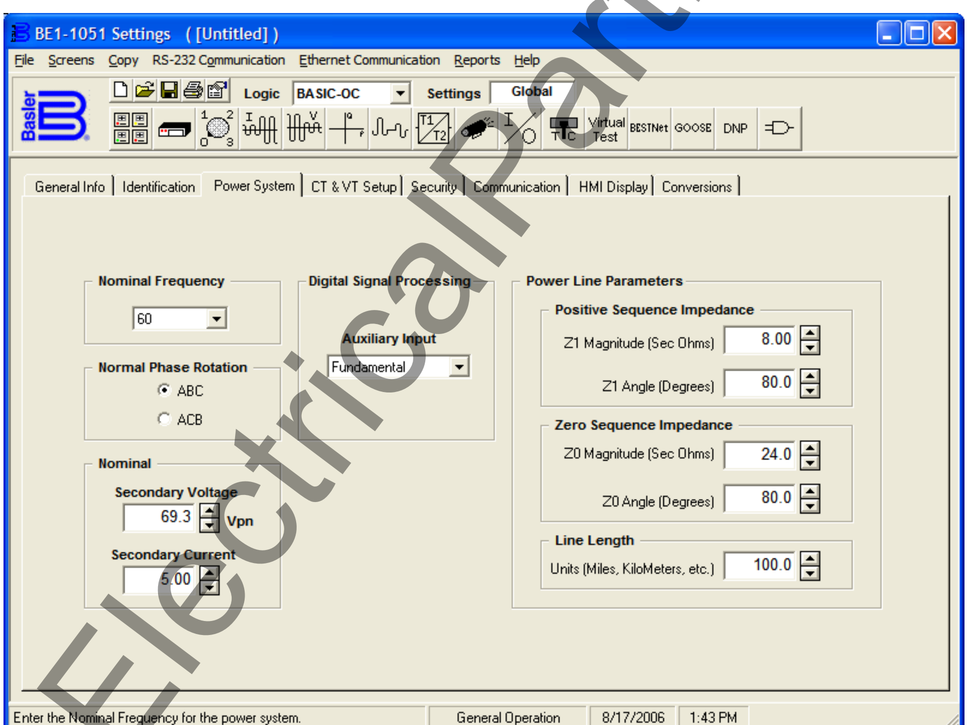

Figure 6-20. General Operation Screen, Power System Tab

The BE1-1051 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 3, *Input and Output Functions.*

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.

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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 BE1-1051 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 is used to prevent 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 BE1-1051 records information about faults and creates fault summary reports. A maximum of 16 fault summary reports are stored in the relay. All 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 fault number 255 has been assigned, the numbering starts over at 1.

BE1-1051 relays generate nine different fault types. They are BKR FAIL, PICKUP, TRIP, LOGIC, RF-TRIG, CLOSE, CLOSE/PICKUP, CLOSE/TRIP, and BKR ALRM TRIP.

<u>*BESTCOMS Fault Summary Report*</u>

To view fault reports using BESTCOMS, select *Oscillography Download* from the *Reports* pull-down menu. A screen such as the one shown in Figure 6-21 will appear.

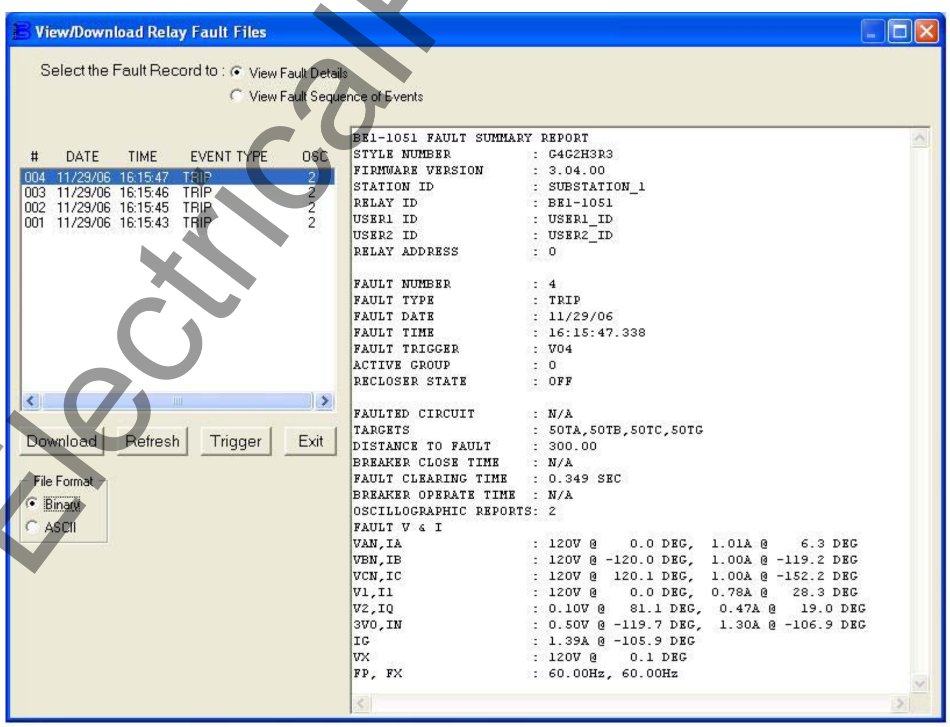

Figure 6-21. View/Download Relay Fault Files Screen

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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 6-21, fault 028 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 6-8.

Fault Summary Report Example:

```
BE1-1051 FAULT SUMMARY REPORT
STYLE NUMBER           : B4G2V1N1
FIRMWARE VERSION       : 3.04.00
STATION ID             : SUBSTATION_1
RELAY ID               : BE1-1051
USER1 ID               : USER1_ID
USER2 ID               : USER2_ID
RELAY ADDRESS          : 0

FAULT NUMBER           : 49
FAULT TYPE             : TRIP
FAULT DATE             : 08/17/06          <- A
FAULT TIME             : 10:31:06.164      <- A
FAULT TRIGGER          : V011,V012
ACTIVE GROUP           : 0
RECLOSER STATE         : OFF

FAULTED CIRCUIT        : AG
TARGETS                : 50TB,50TC,60FL    <- B
DISTANCE TO FAULT      : -15.68
BREAKER CLOSE TIME     : N/A
FAULT CLEARING TIME    : 1.241 SEC         <- C
BREAKER OPERATE TIME   : 1.241 SEC         <- D
OSCILLOGRAPHIC REPORTS: 2                  <- E
FAULT V & I                                                        ┐
VAN,IA                 : 100V @    0.0 DEG,  1.00A @    1.2 DEG    │
VBN,IB                 : 100V @ -120.1 DEG,  1.00A @ -119.0 DEG    │
VCN,IC                 : 100V @  120.1 DEG,  1.00A @  120.8 DEG    │
V1,I1                  : 99.6V @    0.0 DEG,  1.01A @    1.0 DEG   │
V2,IQ                  : 0.10V @   -1.4 DEG,  0.00A @  160.2 DEG   ├─ F
3V0,IN                 : 0.30V @ -136.4 DEG,  0.00A @   70.2 DEG   │
IG                     : 0.00A @  -64.8 DEG                        │
VX                     : 100V @    0.1 DEG                         │
FP, FX                 : 60.00Hz, 60.00Hz                          ┘
```

P0040-06
08-17-06

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, Relay ID, User1 ID, and *User2 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 BE1-1051.

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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 fault. 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 6-8, 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 fault.

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 6-8, 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 6-8, call-out F.

Breaker Close Time. This line reports the time from Reclose Output until Breaker status change.

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 6-8, 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 6-8, 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 6-8; call-out E. Recording of oscillographic records is described in the Oscillographic Records subsection.

IA, IB, IC, I1, IQ, IN, 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 6-8, call-out F.

VA, VB, VC, V1, V2, 3V0, 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 6-8, 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 6-8, 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

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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 is 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 detail later in this section.

Oscillographic Records

Recording Oscillographic Records

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 6-17.

Table 6-17. Possible Oscillographic Records

Number of Records	Length in Cycles
6	40
8	30
10	24
12	20
15	16
16	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, 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.

Oscillographic Records Settings

The oscillographic records settings can be programmed through BESTCOMS. To select the number of records, select *Reporting and Alarms* from the *Screens* 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 6-22, *Oscillographic Records Selector.* Select *Done* once the setting has been made.

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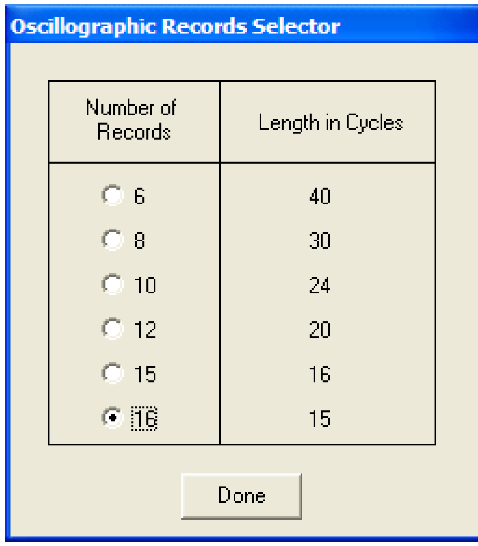

Figure 6-22. Oscillographic Records Selector Screen

The oscillographic records settings can also be made using the SG-OSC (settings general, oscillography) ASCII command. See Table 6-18 for possible settings.

Table 6-18. Recording Oscillographic Records Settings

Setting	Range	Default
Number of Records Saved	6, 8, 10, 12, 15, 16	16

<u>Retrieving Oscillographic Records</u>

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 6-23) appears. Select a location for the file to be stored or create a *New Folder* and press *OK.* The *Fault Record Filenames* screen (Figure 6-24) 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.

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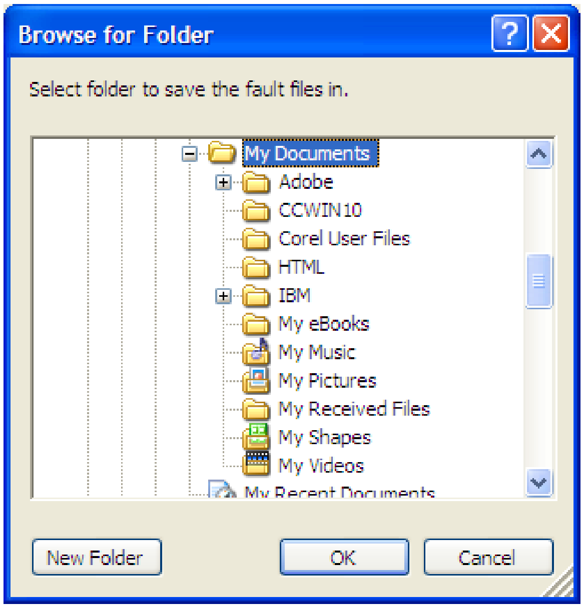

Figure 6-23. Browse for Folder Screen

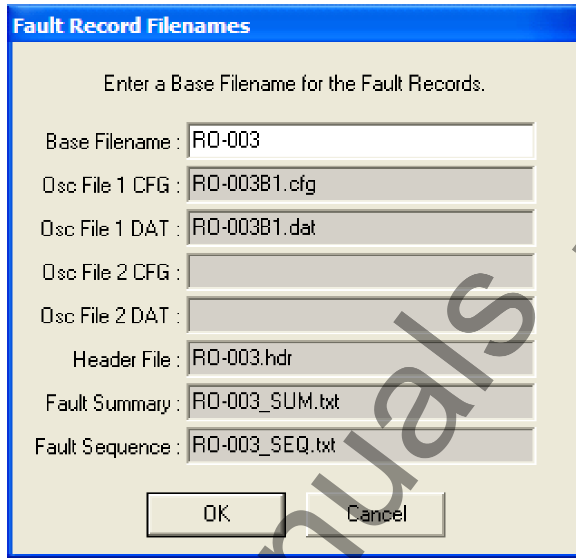

Figure 6-24. Fault Record Filenames

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.

An oscillographic record is triggered when the *PICKED UP* or *LOGIC* expressions defined by the *FAULT RECORDING* logic becomes TRUE. The oscillographic record will contain 3 cycles of pre-trigger data and 8 cycles of post-trigger data. Twelve samples will be stored every cycle. Each sample will contain 16-bit A/D values for all 4 analog channels (IA, IB, IC, and IN) and a 1 or 0 for each of the 64 digital channels. The digital channels are updated every ¼ cycle but recorded every 1/24 cycle. If the fault is not cleared by the end of the record, then a second oscillographic report will be triggered as soon as the first ends. The first report will cover the initiation of the fault (start fault) and the second report will cover the breaker operate time (end fault).

Configuration and data files can be downloaded using any standard communications program. The download protocol may be XMODEM or XMODEM CRC format. For ease of reference, use the command name for the name of the downloaded file.

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

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resolution. 255 changes 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 6-25 will appear. Select *View Fault Sequence of Events* and highlight a fault record to view.

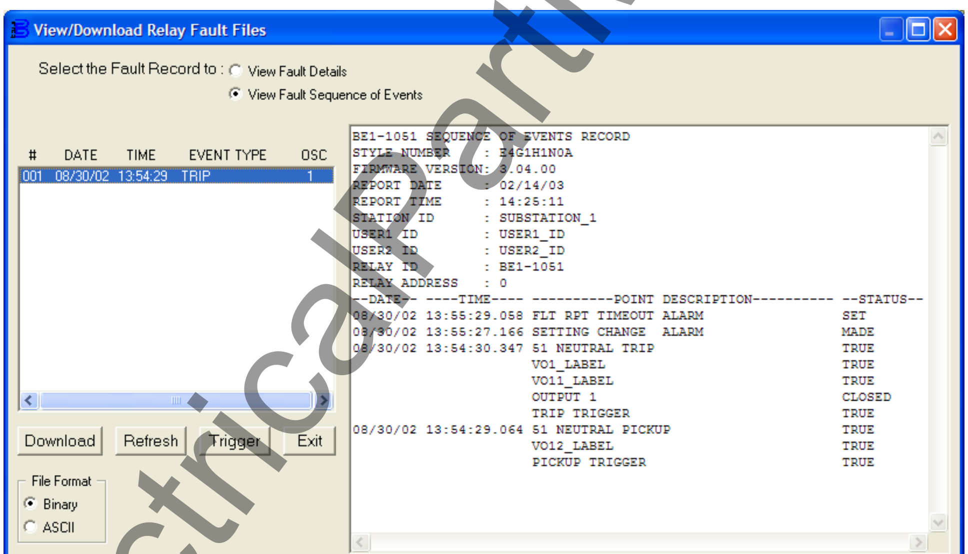

Figure 6-25. View/Download Relay Fault Files Screen

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.

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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-F<n> (report SER, for Fault <event number>)

   Events are retrieved for the period 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-I/O (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 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 6-19. If any one of these points asserts, the failsafe alarm output relay de-energizes and closes or opens 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 6-19. Relay Trouble Alarms

I.D. #	Name	Description
1	RAM FAILURE	Static RAM read/write error.
2	ROM FAILURE	EPROM program memory checksum error.

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I.D. #	Name	Description
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 6-20 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 6-20. Programmable Alarms

I.D. #	Name	Description
1	OUTPUT CIRCUIT OPEN ∗	Trip circuit continuity and voltage monitor.
2	BKR FAIL ALARM	Breaker Failure Initiate > Control Time.
3	RECLOSE FAIL ALARM ∗	Reclose fail timer timed out before breaker closed.
4	RECLOSER LOCK OUT ∗	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	IP DEMAND ALARM ∗	Phase demand.
9	IN DEMAND ALARM ∗	Neutral unbalance demand.
10	IQ DEMAND ALARM ∗	Negative-sequence unbalance demand.
11	GROUP OVERRIDE ∗	Setting group control logic override.
12	SYS I/O DELAY	Excessive delay in HMI or serial communication operation.
13	COMM ERROR ALARM	Communication failure.

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I.D. #	Name	Description
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	IRIG SYNC LOST	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).
24	FLT RPT TIMEOUT	TRUE if fault event trigger lasts longer than 60 seconds.
25	LOGIC = NONE	Active Logic=NONE.
26	VAR POS DEMAND ∗	Var demand maximum exceeded.
27	WATT FWD DEMAND ∗	Watt demand maximum exceeded.
28	FREQ OUT OF RANGE ∗	Frequency out of range.
29	CHANGES LOST ALARM	Password access lost.
30	60 FUSE LOSS ∗	One or more phases of voltage lost.
31	VOLTS PER HERTZ ∗	Trips at settable percentage of the pickup level.
32	27 UNDER VOLTAGE ∗	Instantaneous undervoltage alarm.
33	59 OVER VOLTAGE ∗	Instantaneous overvoltage alarm.
34	VIRTUAL TEST ON ∗	Virtual test mode enabled.
35	VAR NEG DEMAND ∗	Negative direction VAR flow threshold exceeded.
36	WATT REV DEMAND ∗	Reverse direction WATT flow threshold exceeded.
37	IG DEMAND ALARM ∗	Excessive Ground Current threshold exceeded.
38	IAVG DEMAND ALARM ∗	Excessive Average Phase Current threshold exceeded.
39	VP MAX DEMAND ALARM ∗	Phase voltage maximum threshold exceeded.
40	VP MIN DEMAND ALARM ∗	Phase voltage minimum threshold exceeded.
41	VAVG MAX DEMAND ∗	Average Phase voltage maximum threshold exceeded.
42	VAVG MIN DEMAND ∗	Average Phase voltage minimum threshold exceeded.
43	VN MAX DEMAND ALARM ∗	Neutral voltage maximum threshold exceeded.
44	VN MIN DEMAND ALARM ∗	Neutral voltage minimum threshold exceeded.
45	COM BOARD SYNC LOST ∗	Optional Com board lost sync with main board processor.
46	COM BOARD INIT ERROR ∗	Optional Com board did not initialize on power up.

∗ 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 6-26. Set the alarm point priority by checking the box or boxes to its right.

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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.

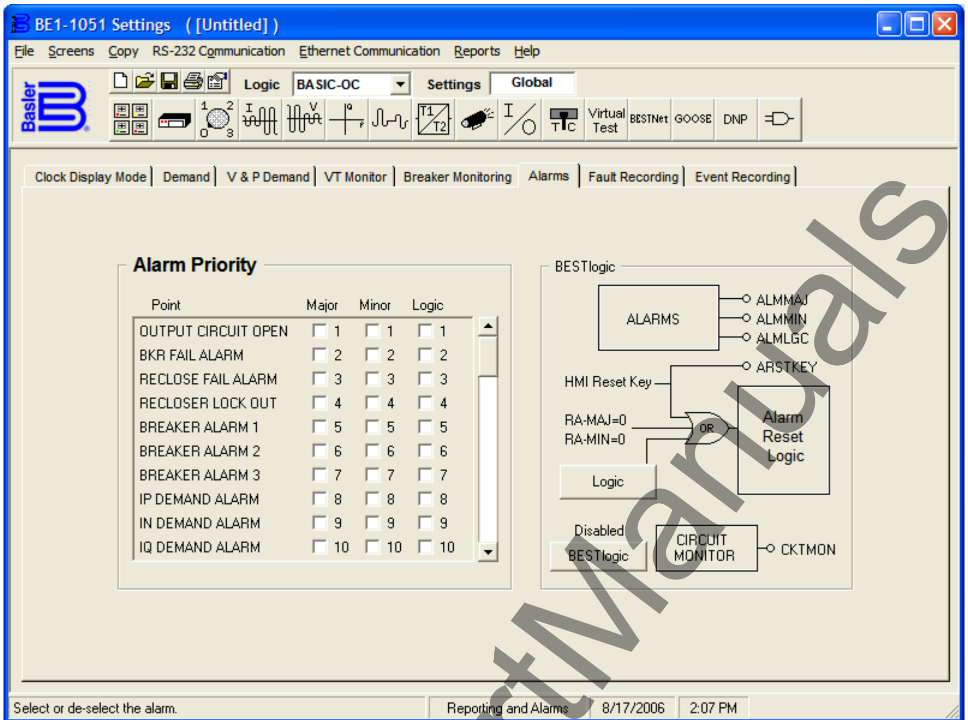

Figure 6-26. Reporting and Alarms Screen, Alarms Tab

Table 6-21 summarizes major, minor, and logic programmable alarm settings.

Table 6-21. 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 6-22 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 6-27 shows the alarm reset logic.

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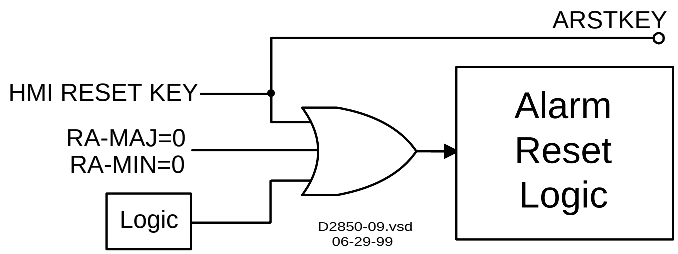

Figure 6-27. Alarm Reset Logic

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 6-20 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. Alarms are shown on the Metering screen. See Figure 6-28.

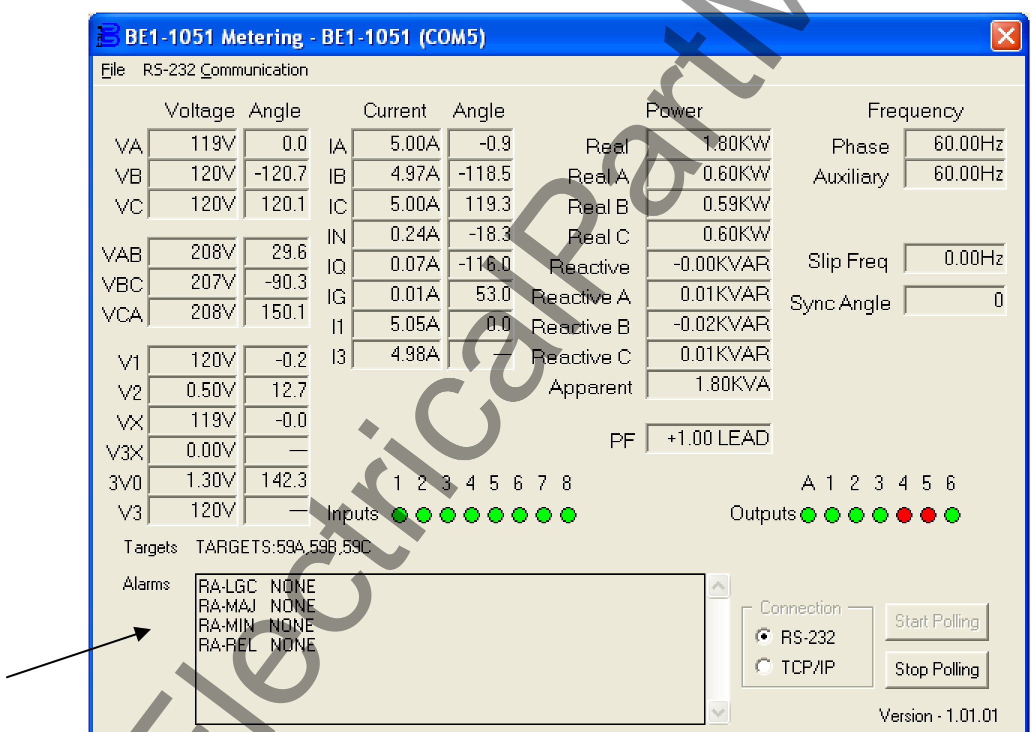

Figure 6-28. Metering Screen

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

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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 6-26. The *BESTlogic Function Element* screen for *Alarm Reset Logic* will appear. See Figure 6-29.

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.

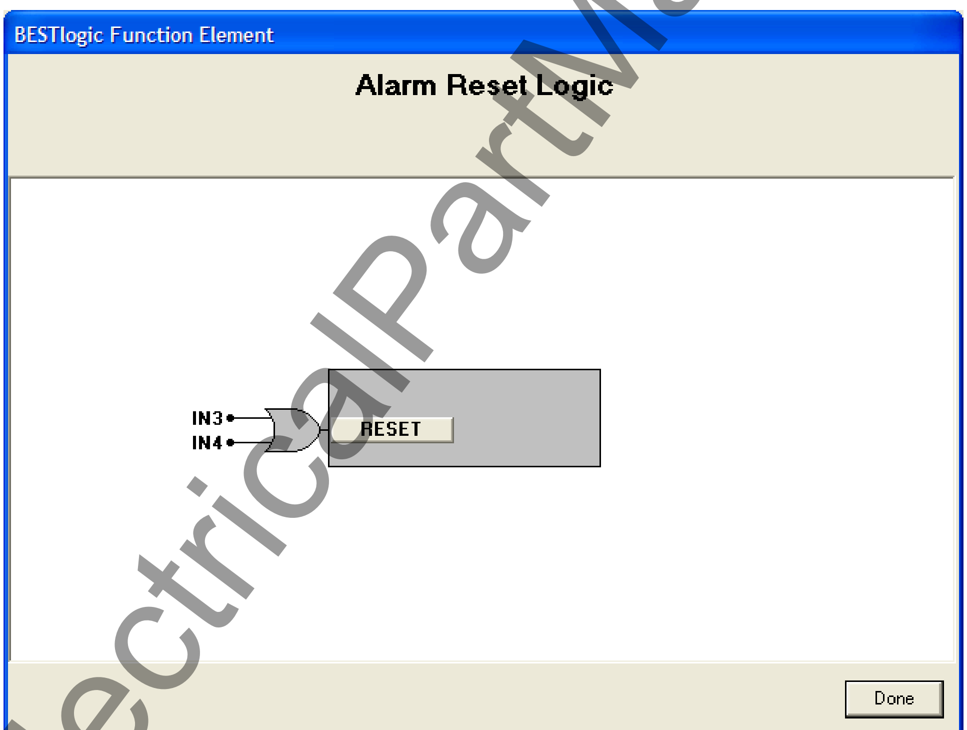

Figure 6-29. BESTlogic Function Element Screen, Alarm Reset Logic

BESTlogic Elements Controlled by Programmable Alarms

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.

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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).

Style and 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 *Communications* 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 *Identification* tab (Figure 6-30).

The *General Info* tab (Figure 6-31) displays all of the style information about the relay.

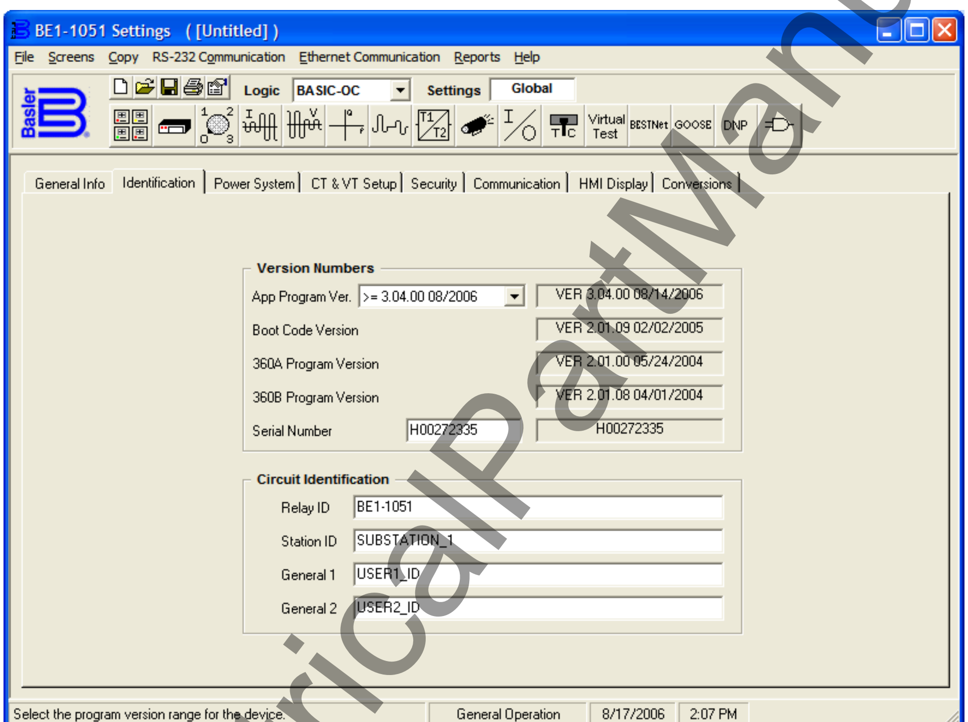

Figure 6-30. General Operation Screen, Identification Tab

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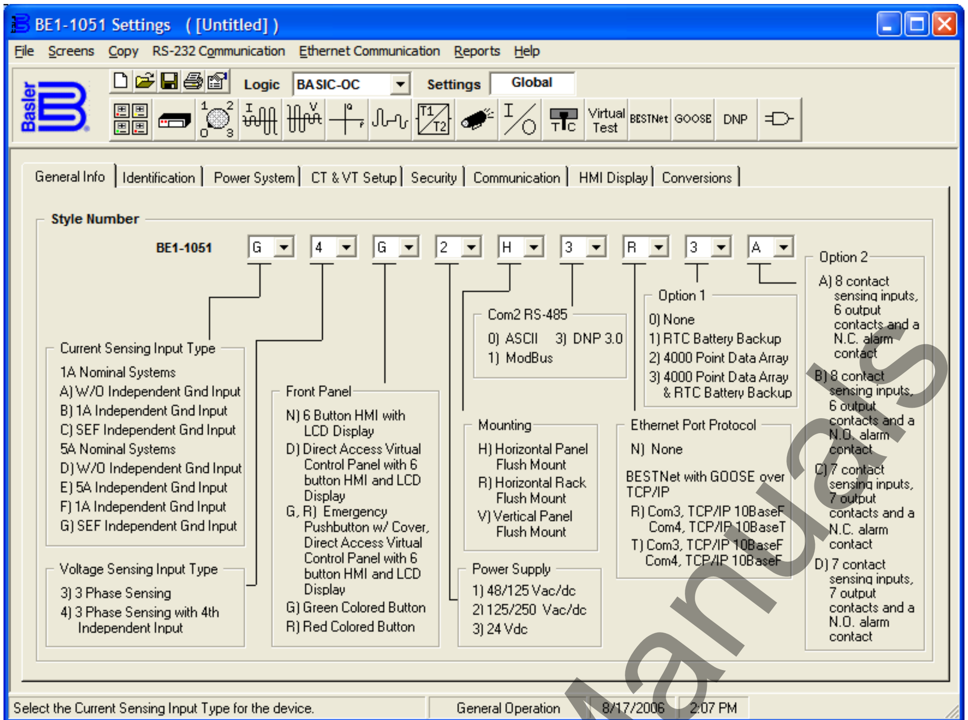

Figure 6-31. General Operation Screen, General Info Tab

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. See Figure 6-32. 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 on disk*, click on the folder box and browse for the file. If you wish to *Download settings from unit* to compare, click on the RS-232 box to setup the *Com Port* and *Baud Rate*. Click on the *Compare* box to compare the settings files that you have selected.

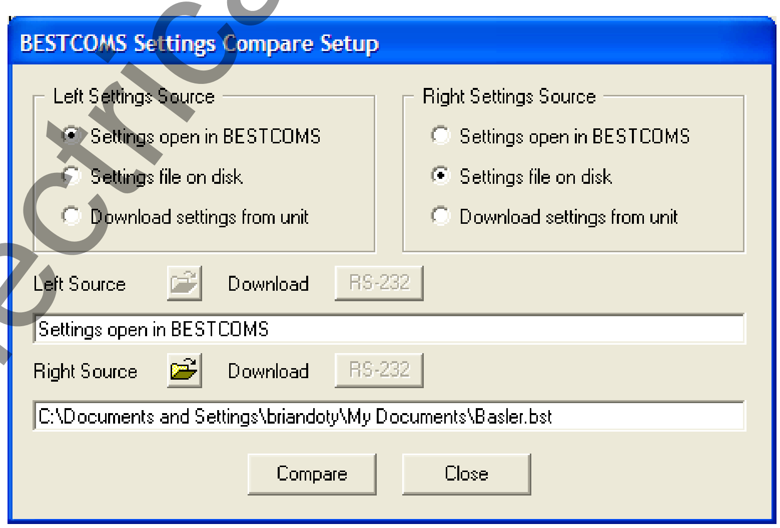

Figure 6-32. BESTCOMS Settings Compare Setup Dialog Box

If there are any differences in the two files, a dialog box will pop up notifying you that *Differences Are Found*. The *BESTCOMS Settings Compare* dialog box pops up (Figure 6-33) where you can select to *Show All* or *Show Diffs*.

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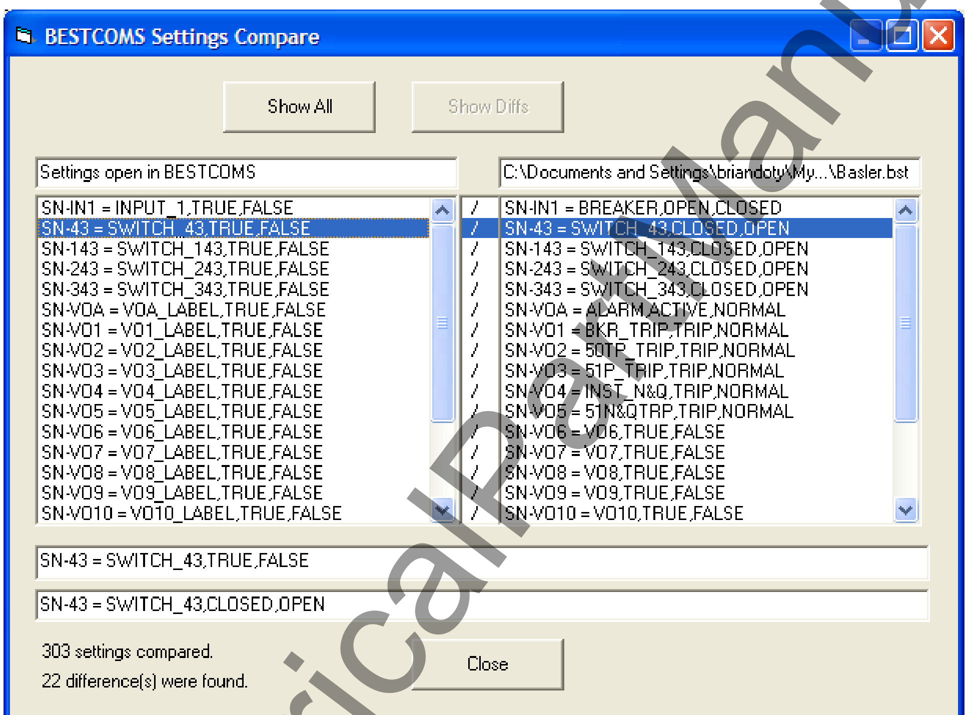

Figure 6-33. BESTCOMS Settings Compare Dialog Box

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SECTION 7 • BESTLOGIC PROGRAMMABLE LOGIC

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SECTION 7 • BESTLOGIC PROGRAMMABLE LOGIC

INTRODUCTION

Multifunction relays 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, 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.

Several 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. Any of the 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.

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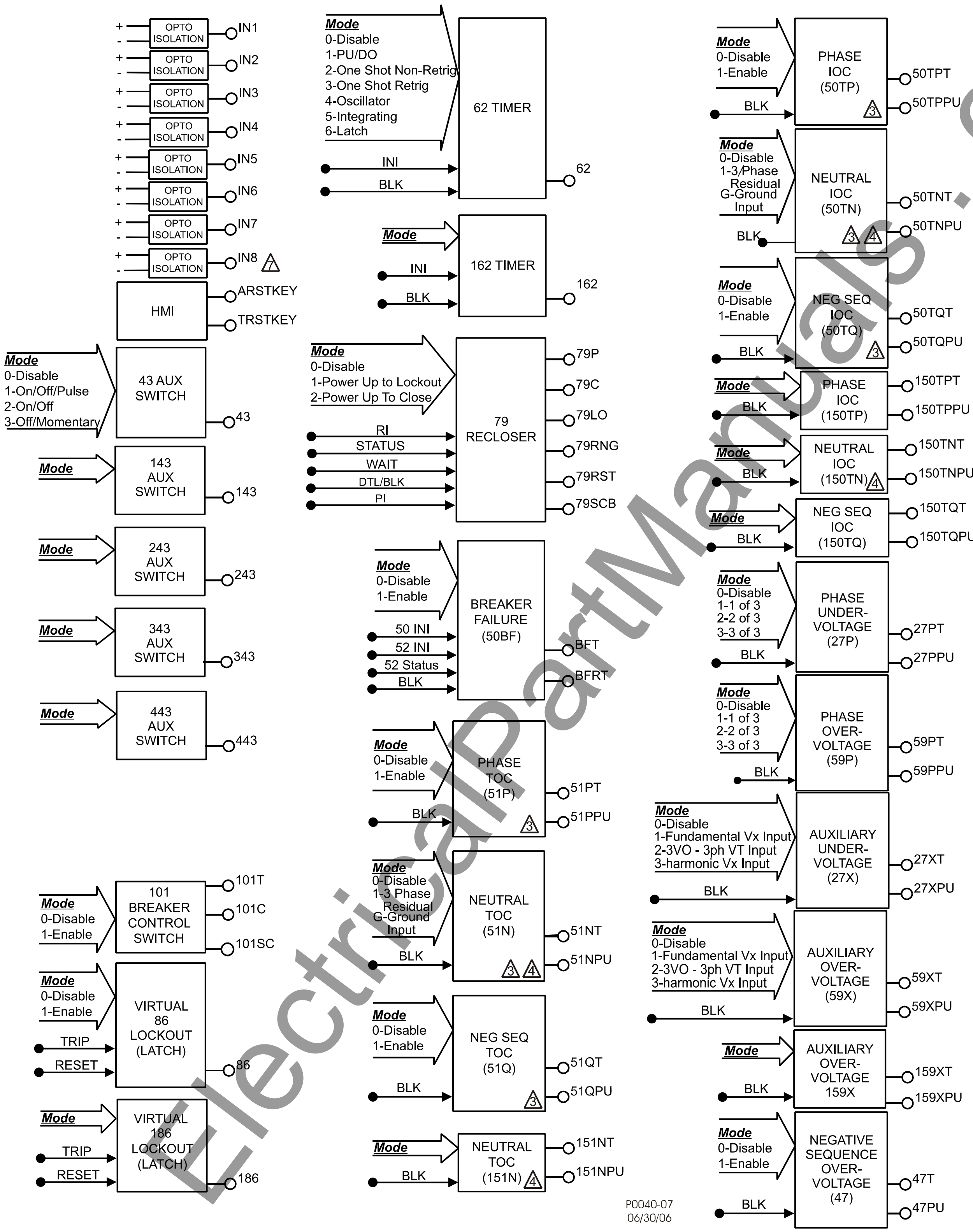

Figure 7-1. BESTlogic Function Blocks – Page 1

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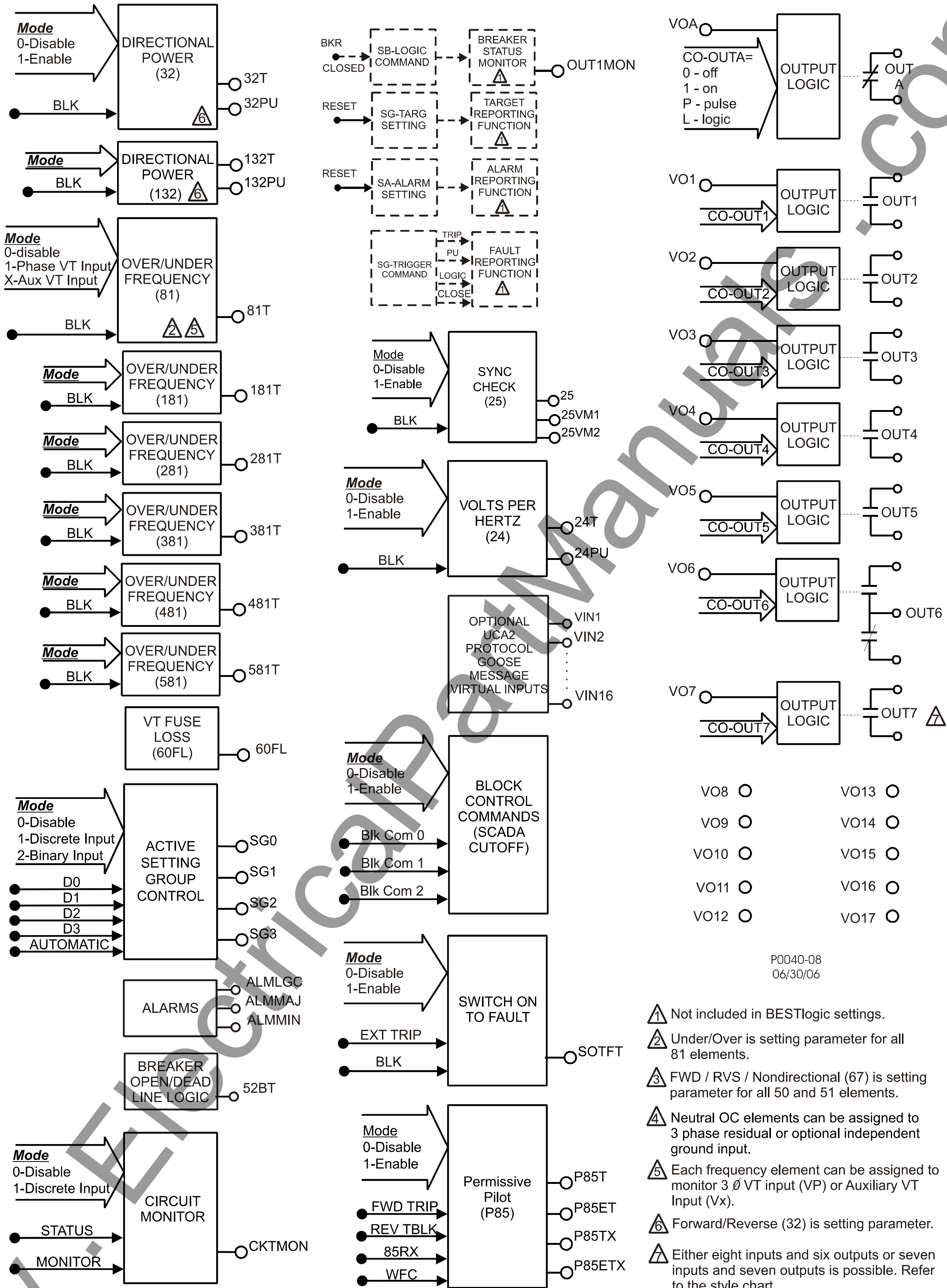

Figure 7-2. BESTlogic Function Blocks – Page 2

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Table 7-1. Logic Variable Names and Descriptions

Variable Name	Description	Variable Name	Description
Inputs and Outputs		**Lockout Protection**	
IN1-IN8	Inputs 1 - 8 Status	86	86 Output
VIN1-VIN16	Virtual Inputs 1 - 16	186	186 Output
VOA	Virtual Output – OUTA	**Voltage**	
VO1-VO7	Virtual Outputs 1 - 7 (hardware outputs)	24T	24 Overexcitation Tripped
VO8-VO17	Virtual Outputs 8 - 17	24PU	24 Overexcitation Picked Up
Controls		25	25 Sync-Check Output
TRSTKEY	HMI Target Reset Key	25VM1	25 Voltage Monitor 1 Output
ARSTKEY	HMI Alarm Reset Key	25VM2	25 Voltage Monitor 2 Output
101T	Virtual Breaker Control Switch Tripped	27PT	27 Phase Undervoltage Tripped
101C	Virtual Breaker Control Switch Close	27PPU	27 Phase Undervoltage Picked Up
101SC	Virtual Breaker Control Switch Slip Contact	27XT	27 Auxiliary Undervoltage Tripped
62	62 Timer Output	27XPU	27 Auxiliary Undervoltage Picked Up
162	162 Timer Output	47T	47 Negative-Sequence Tripped
43	Virtual Switch 43 Output	47PU	47 Negative-Sequence Picked Up
143	Virtual Switch 143 Output	59PT	59 Phase Overvoltage Tripped
243	Virtual Switch 243 Output	59PPU	59 Phase Overvoltage Picked Up
343	Virtual Switch 343 Output	59XT	59 Auxiliary Overvoltage Tripped
443	Virtual Switch 443 Output	59XPU	59 Auxiliary Overvoltage Picked Up
SG0	Setting Group 0 Active (default)	159XT	159 Auxiliary Overvoltage Tripped
SG1	Setting Group 1 Active	159XPU	159 Auxiliary Overvoltage Picked Up
SG2	Setting Group 2 Active	**Over/Under Frequency**	
SG3	Setting Group 3 Active	81T	81 Tripped
Alarm and Monitor		181T	181 Tripped
ALMLGC	Logic Alarm	281T	281 Tripped
ALMMAJ	Major Alarm	381T	381 Tripped
ALMMIN	Minor Alarm	481T	481 Tripped
CKTMON	Output 1 Monitor (circuit continuity)	581T	581 Tripped
Reclosing		**Directional Power**	
79C	79 Close Signal	32T	32 Tripped
79RNG	79 Running/Block Tap Changer	32PU	32 Picked Up
79LO	79 Lockout	132T	132 Tripped
79RST	79 Reset	132PU	132 Picked Up
79P	79 Pilot Reclose	**Time Overcurrent**	
79SCB	79 Sequence Control Block	51PT	51 Phase Overcurrent Tripped
Breaker Failure		51PPU	51 Phase Overcurrent Picked Up
52BT	Breaker Open/Dead Line Logic	51NT	51 Neutral Overcurrent Tripped
BFT	Breaker Failure Tripped	51NPU	51 Neutral Overcurrent Picked Up
BFRT	Breaker Failure Retrip	151NT	151 Neutral Overcurrent Tripped
SOTF	Switch On To Fault	151NPU	151 Neutral Overcurrent Picked Up
Fuse Loss		51QT	51 Negative-Sequence Overcurrent Tripped
60FL	60 Loss of Potential Alarm	51QPU	51 Negative-Sequence Overcurrent Picked Up
Permissive Pilot		**Instantaneous Overcurrent**	
P85T	Permissive Pilot Trip	50TPT	50T Phase Tripped
P85TX	Permissive Pilot Transmit	50TPPU	50T Phase Picked Up
P85ETX	Permissive Pilot Echo Transmit	150TPT	150T Phase Tripped
P85ET	Permissive Pilot Echo Trip	150TPPU	150T Phase Picked Up

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Table 7-2. Logic Variable Names and Descriptions (continued)

Variable Name	Description	Variable Name	Description
50TNT	50T Neutral Tripped	50TQT	50T Negative-Sequence Tripped
50TNPU	50T Neutral Picked Up	50TQPU	50T Negative-Sequence Picked Up
150TNT	150T Neutral Tripped	150TQT	150T Negative-Sequence Tripped
150TNPU	150T Neutral Picked Up	150TQPU	150T Negative-Sequence Picked Up

Function Block Logic Settings

Each BESTlogic function block is equivalent to its discrete device counterpart. For example, the Reclosing logic function block of Figure 7-3 has many of the characteristics of a BE1-79M Multiple Shot Reclosing Relay.

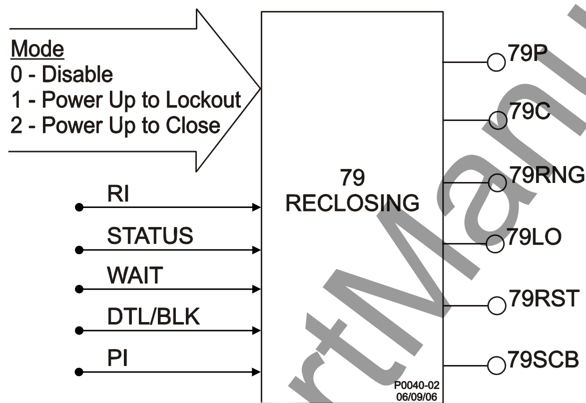

Figure 7-3. Reclosing Logic Block

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 are 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 logic output that corresponds to a hardware output changes state, then the corresponding output relay contact also changes state.

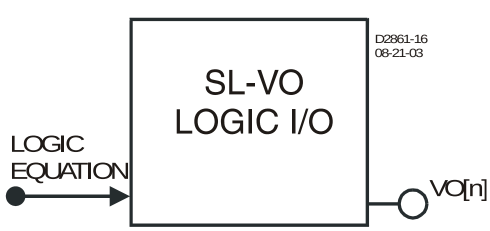

Figure 7-4. Virtual Output Logic

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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 43/143/243/343/443,101SC, and SG0 through SG3. 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 OUT7 follow the corresponding logic outputs VOA and VO1 through VO7.

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 BE1-1051 relay has five or six (depending on style number) isolated, normally open (NO) output contacts (OUT1 – OUT5, OUT7), one SPDT output contact (OUT6), and one isolated, normally closed (NC) or normally open (NO) (depending on style number) alarm output (OUTA). Output contacts OUT1 through OUT6(7) are controlled by the status of the internal virtual logic signals VO1 through VO6(7). If VO[n] becomes TRUE, then the corresponding output relay OUT[n] energizes and changes the state of the contacts. For the alarm output, if VOA becomes TRUE, the ALM output de-energizes and changes state depending on style number. 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.

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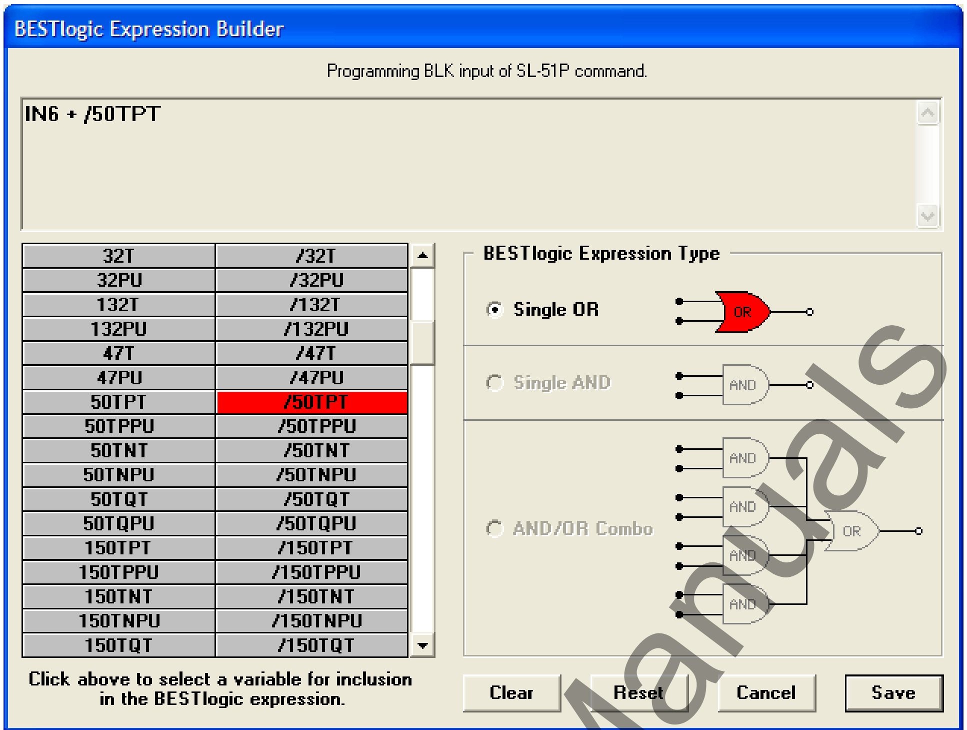

Figure 7-5. BESTlogic Expression Builder Screen

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. Six logic schemes configured for typical protection applications 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

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scheme for the BE1-1051 is named BASIC-OC. If the function block configuration and output logic of BASIC-OC 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 now copies it into his 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 or rear 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 User logic. The active logic scheme is shown in the *User* box. In Figure 7-6, *BASIC-OC* has been selected to user logic.

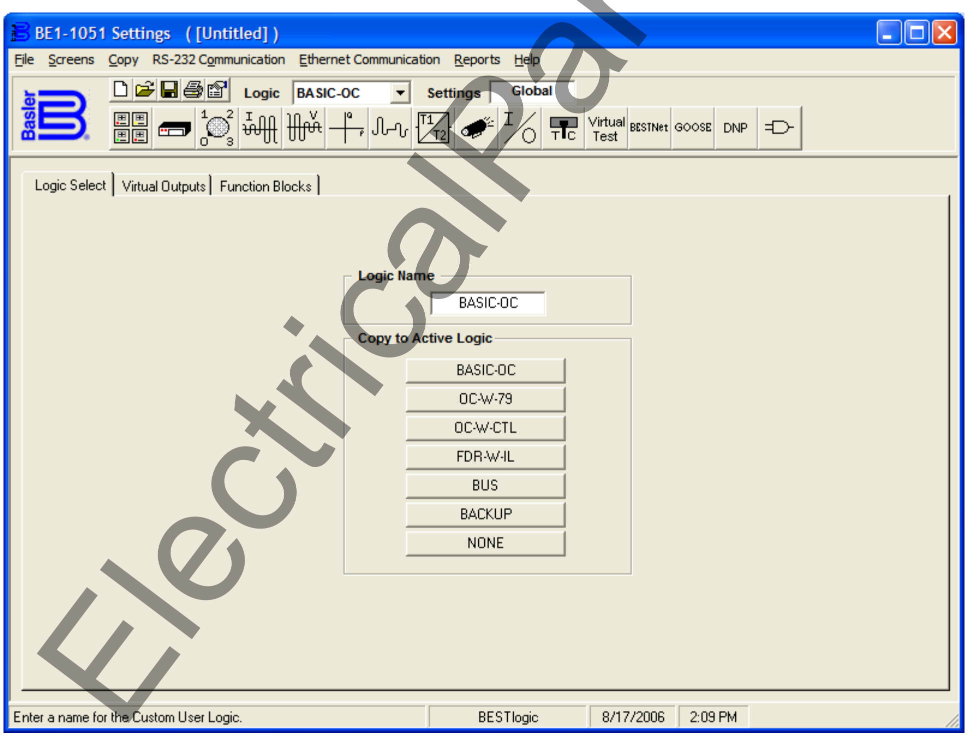

Figure 7-6. BESTlogic Screen, Logic Select Tab

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> **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 active logic and then renaming the logic. A custom logic scheme can also be created by modifying any one of the preprogrammed logic schemes after copying it to active logic and renaming. Preprogrammed logic schemes copied to active logic with no name change are read-only schemes and cannot have their logic expressions altered. Before modifying a logic scheme copied to active logic, 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 active logic.

Copying and Renaming Preprogrammed Logic Schemes

> **CAUTION**
> Always remove the relay from service prior to changing or modifying the active logic scheme. Attempting a logic scheme change while the relay is in service could generate unexpected or unwanted outputs.

Copying a preprogrammed logic scheme to the active logic 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. Use BESTCOMS to 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.

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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 BE1-1051's inputs, outputs, and 43 switches have labels that can be edited. Table 7-3 shows the range and purpose of each label. Alternately, labels may be edited using the SN ASCII command.

Table 7-3. Programmable Variable Name Setting

Settings	Range/Purpose	Default
Name/Label	1 to 16 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. VO17 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 will not be available to a numerically higher virtual output until the next processing interval. Logic is evaluated every quarter cycle.

When designing custom protection schemes, avoid confusion by maintaining consistency between input and output functions in the custom and preprogrammed schemes.

OUT1 through OUT5 and OUT7 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.

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Virtual Outputs VO8 to VO17 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 alarm reporting function.

> **NOTE**
>
> Either eight inputs and 6 outputs or seven inputs and seven outputs are possible. Refer to the style chart for more information.

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SECTION 8 • APPLICATION

INTRODUCTION

This section discusses application of the BE1-1051 Overcurrent Protection System using the preprogrammed logic schemes. The *Details of Preprogrammed Logic Schemes* subsection describes the characteristics of each logic scheme and how they combine to create an Overcurrent Protection System for a radial system substation. A detailed description of each preprogrammed scheme is also provided. This section concludes with application tips for programming a custom logic scheme to meet the requirements of your application.

The preprogrammed logic schemes are designed to accommodate most common distribution or sub-transmission radial system overcurrent coordination schemes. The protection engineer can choose a logic scheme that most closely meets his application practices and adapt it by changing the function block operation and settings. This eliminates the need to create a custom logic scheme.

It should be noted that each 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 the logic from several of the preprogrammed schemes. The logic can also be modified to incorporate some of the features described in the application tips provided at the end of this section. The flexibility of BESTlogic allows the protection engineer to create a custom scheme that exactly meets the 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

The following paragraphs define terms that are used in the logic scheme discussions of this section.

Function Block - A stand-alone protection or control function that is equivalent to its discrete component counterpart.

Torque Control - Blocks the start of an overcurrent function block. The pickup and trip outputs are held at zero and the timing function is inhibited. This is in contrast to merely blocking the trip output. Torque control applies to all overcurrent function blocks including those that don't emulate induction disk type (51) relays.

Virtual Switches - Logic switches that emulate traditional switches used on relay and control panels. Examples of these switches are breaker control switches (101) and selector switches (43). Virtual switches can be operated via communication commands or the front panel human-machine interface (HMI). Operation of a virtual switch can be disabled if the switch won't be used in a preprogrammed logic scheme that includes the switch. Password protection is also available for the virtual switches.

Radial System - A system where the loads are fed from only one source at a time.

OVERVIEW OF PREPROGRAMMED LOGIC SCHEMES

Six preprogrammed logic schemes are available. A brief description of each preprogrammed logic scheme is provided in the following paragraphs. More detailed information about these schemes is provided in *Details of Preprogrammed Logic Schemes*.

NOTE

It is possible for the BE1-1051 to have either 6 hardware outputs and 8 inputs or 7 hardware outputs and 7 inputs. Refer to the *Style Chart* in Section 1 for more information.

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BASIC-OC Logic Scheme (Basic Overcurrent Protection)

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.

OC-W-79 Logic Scheme (Overcurrent Protection with Reclosing)

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.

OC-W-CTL Logic Scheme (Overcurrent Protection with Control)

This logic scheme is similar to OC-W-79 but has the added ability to manually open and close the breaker by using the virtual breaker control switch (101). Breaker failure and voltage protection features are not included in this scheme. However, these features may be activated through BESTlogic.

FDR-W-IL Logic Scheme (Feeder Protection with Interlock)

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. The breaker may be manually opened or closed via the virtual breaker control switch (101). Protective voltage features are not enabled in this scheme. However, these features may be activated through BESTlogic. Interlock logic allows for bus overcurrent backup of feeder relays and allows for fast bus overcurrent protection.

BUS Logic Scheme

This logic scheme is applied to a bus main relay to provide primary bus overcurrent protection. It contains logic to interconnect with the feeder logic scheme (FDR-W-IL) to provide high-speed overcurrent protection for the bus under normal conditions. It also contains logic to trip the feeder breakers while the feeder relays using FDR-W-IL logic scheme are out of service.

BACKUP Logic Scheme

This logic scheme is applied to a bus main relay 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 PREPROGRAMMED LOGIC SCHEMES

The following subsections describe each of the six 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. In addition, FDR-W-IL, BUS, and BACKUP logic schemes also provide a discussion of how various contingencies are covered between these logic schemes.

NOTE

Name Labels are limited to sixteen characters and *State Labels* are limited to seven characters.

BASIC-OC LOGIC SCHEME

Logic scheme BASIC-OC 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.

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The components of BASIC-OC logic are summarized in Tables 8-1, 8-2, 8-3, and 8-4. Figure 8-1 shows a one-line drawing for the BASIC-OC logic scheme. A diagram of BASIC-OC logic is shown in Figure 8-2.

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, IN4, IN5, IN6, IN7, and IN8 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 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, IN4, IN5, IN6, IN7, or IN8 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*.

Table 8-1. BASIC-OC Contact Sensing Input 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
IN5	N/A	INPUT_5	TRUE	FALSE
IN6	N/A	INPUT_6	TRUE	FALSE
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

Table 8-2. BASIC-OC Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
50TP	Used for instantaneous phase overcurrent protection.	0	1 (enabled)
50TN	Used for instantaneous neutral overcurrent protection.	0	1 (3 Phase Residual)
50TQ	Used for instantaneous negative-sequence overcurrent protection.	0	1 (enabled)

Function	Purpose	BESTlogic Expression	Mode Setting
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)
151N	N/A	0	0 (disabled)
24	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)
25	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)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
79	N/A	0	0 (disabled)
50BF	N/A	0	0 (disabled)
62	N/A	0	0 (disabled)
162	N/A	0	0 (disabled)
86	N/A	0	0 (disabled)
186	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Input Selection)
	Input 1 Logic: No manual selection logic is used.	0	
	Input 2 Logic: No manual selection logic is used.	0	
	Input 3 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Set to 1 (/0) to enable automatic selection. No manual selection is used.	/0	

Table 8-3. BASIC-OC Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	CLOSED	OPEN
143	N/A	0 (disabled)	SWITCH_143	CLOSED	OPEN
243	N/A	0 (disabled)	SWITCH_243	CLOSED	OPEN
343	N/A	0 (disabled)	SWITCH_343	CLOSED	OPEN
443	N/A	0 (disabled)	SWITCH_443	CLOSED	FALSE
101	N/A	0 (disabled)	N/A	N/A	N/A

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Table 8-4. BASIC-OC Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact changes state automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Output.	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					
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 (OUT6)	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_TRP	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	N/A	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	N/A	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO15	N/A	N/A	VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					
VO16	N/A	N/A	VO16	TRUE	FALSE
BESTlogic Expression: VO16=0					
VO17	N/A	N/A	VO17	TRUE	FALSE
BESTlogic Expression: VO17=0					

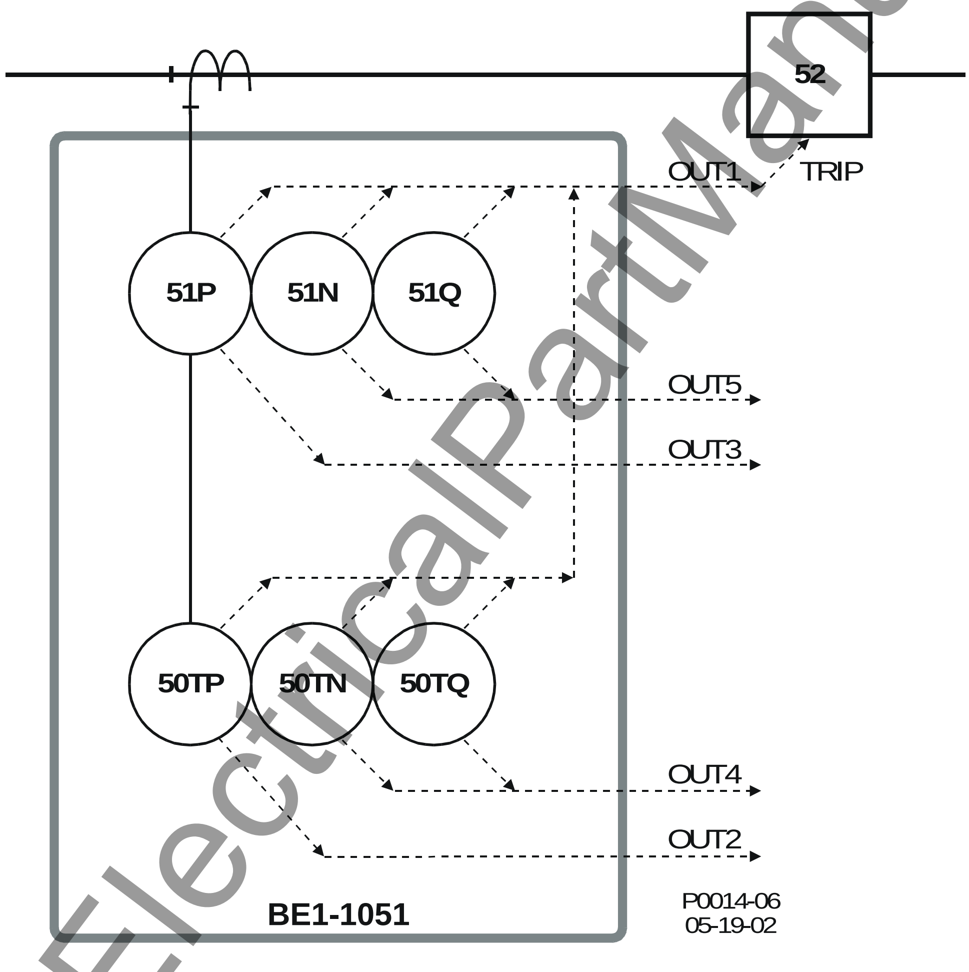

Figure 8-1. BASIC-OC One-Line Drawing

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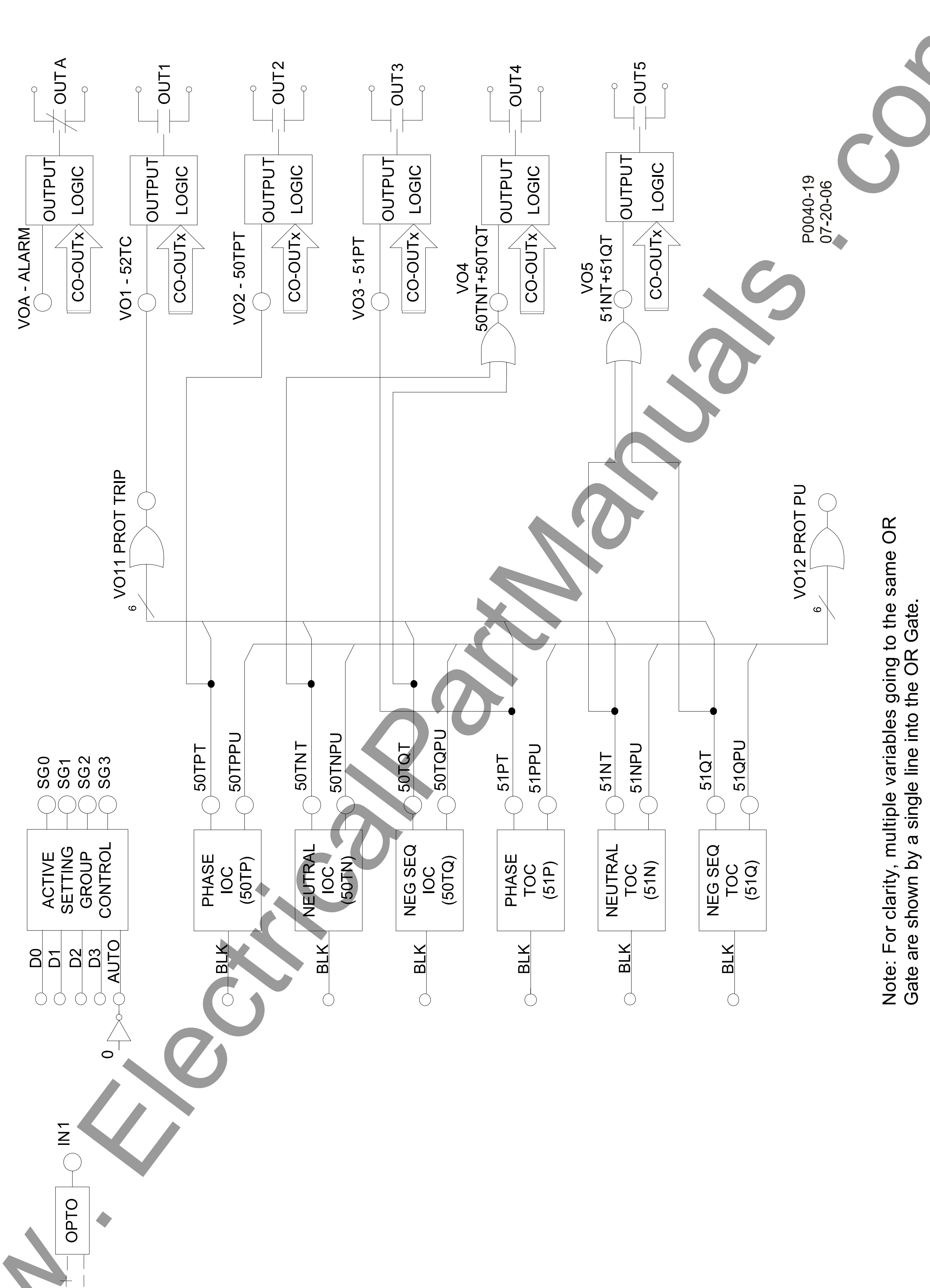

Figure 8-2. BASIC-OC Logic Diagram

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BASIC-OC Logic Settings and Equations

SL-50BF=0,0,0,0,0
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-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0; SL-27X=0,0
SL-32=1,0
SL-132=1,0
SL-47=0,0
SL-59P=0,0; SL-59X=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=0,0,0,0,0,0
SL-P85=0,0,0,0,0
SL-86=0,0,0
SL-186=0,0,0
SL-GROUP=1,0,0,0,0,/0
SL-43=0,0,0,0,0
SL-143=0,0,0,0,0
SL-243=0,0,0,0,0
SL-343=0,0,0,0,0
SL-443=0,0,0,0,0
SL-43TAG=0,0,0,0
SL-143TAG=0,0,0,0
SL-243TAG=0,0,0,0
SL-343TAG=0,0,0,0
SL-443TAG=0,0,0,0
SL-101=0,0,0,0,0
SL-CKTMON=0,0,0
SL-CTRL=0,0,0,0
SL-SOTF=0,0,0
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
SL-VO16=0
SL-VO17=0

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OC-W-79 LOGIC SCHEME

Logic scheme OC-W-79 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.

The components of OC-W-79 logic are summarized in Tables 8-5, 8-6, 8-7, and 8-8. Figure 8-3 shows a one-line drawing for the OC-W-79 logic scheme. A diagram of OC-W-79 logic is shown in Figure 8-4.

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 IN3 or virtual switch 243.

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 state and the Relay Trouble LED of the HMI will light. OUTA will also change state 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

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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.

Table 8-5. OC-W-79 Contact Sensing Input Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	51b 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 are enabled. IN4 must be tied HIGH if this feature is not used.	N&Q_ENABLE	ENABLED	DISABLD
IN5	N/A	INPUT_5	TRUE	FALSE
IN6	N/A	INPUT_6	TRUE	FALSE
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

Table 8-6. OC-W-79 Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
50TP	Block when recloser sequence controlled blocking output is TRUE.	79SCB	1 (enabled)
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 (enabled)
150TP	Used for high set.	0	1 (enabled)
150TN	Used for high set.	0	1 (3 Phase Residual)
150TQ	Used for high set.	0	1 (enabled)
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)
151N	N/A	0	0 (disabled)
24	N/A	0	0 (disabled)

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Function	Purpose	BESTlogic Expression	Mode Setting
27P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)
25	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)
32	N/A	0	0 (disabled)
132	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	
	Block/Drive to Lockout Logic: Drive recloser to lockout when recloser drive to lockout expression is TRUE.	VO9	
	Pilot Initiate (PI) Logic: If the recloser is in the reset state upon receiving a *Pilot Initiate* input signal, the reclose logic issues a pilot reclose output (79P) after the programmed time delay.	0	
50BF	N/A	0	0 (disabled)
62	N/A	0	0 (disabled)
162	N/A	0	0 (disabled)
86	N/A	0	0 (disabled)
186	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Input Selection)
	Input 1 Logic: No manual selection logic is used.	0	
	Input 2 Logic: No manual selection logic is used.	0	
	Input 3 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Set to 1 (/0) to enable automatic selection. No manual selection is used.	/0	

Table 8-7. OC-W-79 Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	CLOSED	OPEN
143	N/A	0 (disabled)	SWITCH_143	CLOSED	OPEN
243	N/A	0 (disabled)	SWITCH_243	CLOSED	OPEN
343	N/A	0 (disabled)	SWITCH_343	CLOSED	OPEN
443	N/A	0 (disabled)	SWITCH_443	CLOSED	FALSE
101	N/A	0 (disabled)	N/A	N/A	N/A

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Table 8-8. OC-W-79 Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Output.	Trip breaker 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 (OUT6)	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=150TPT+150TNT+150TQT+/IN2					
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_TRP	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	N/A	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO14	N/A	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	N/A	N/A	VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					
VO16	N/A	N/A	VO16	TRUE	FALSE
BESTlogic Expression: VO16=0					
VO17	N/A	N/A	VO17	TRUE	FALSE
BESTlogic Expression: VO17=0					

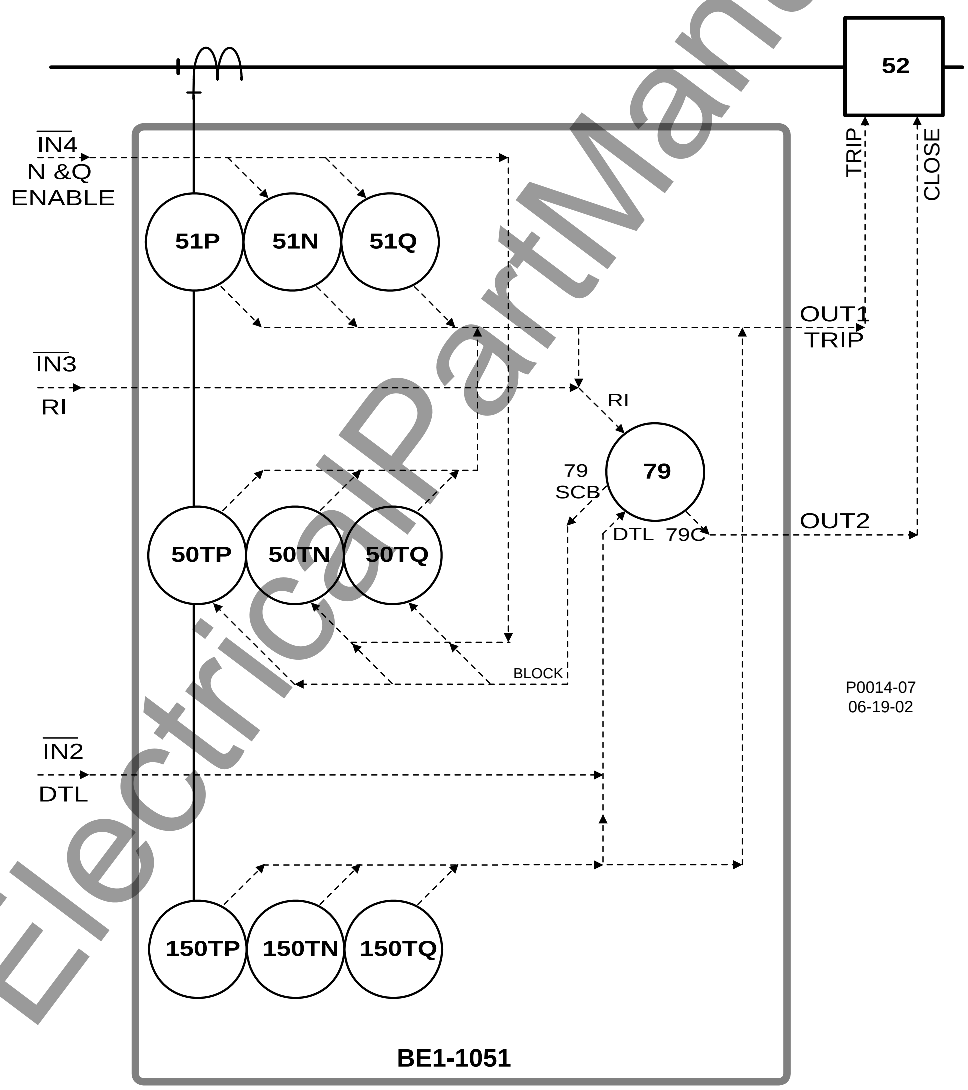

Figure 8-3. OC-W-79 One-Line Drawing

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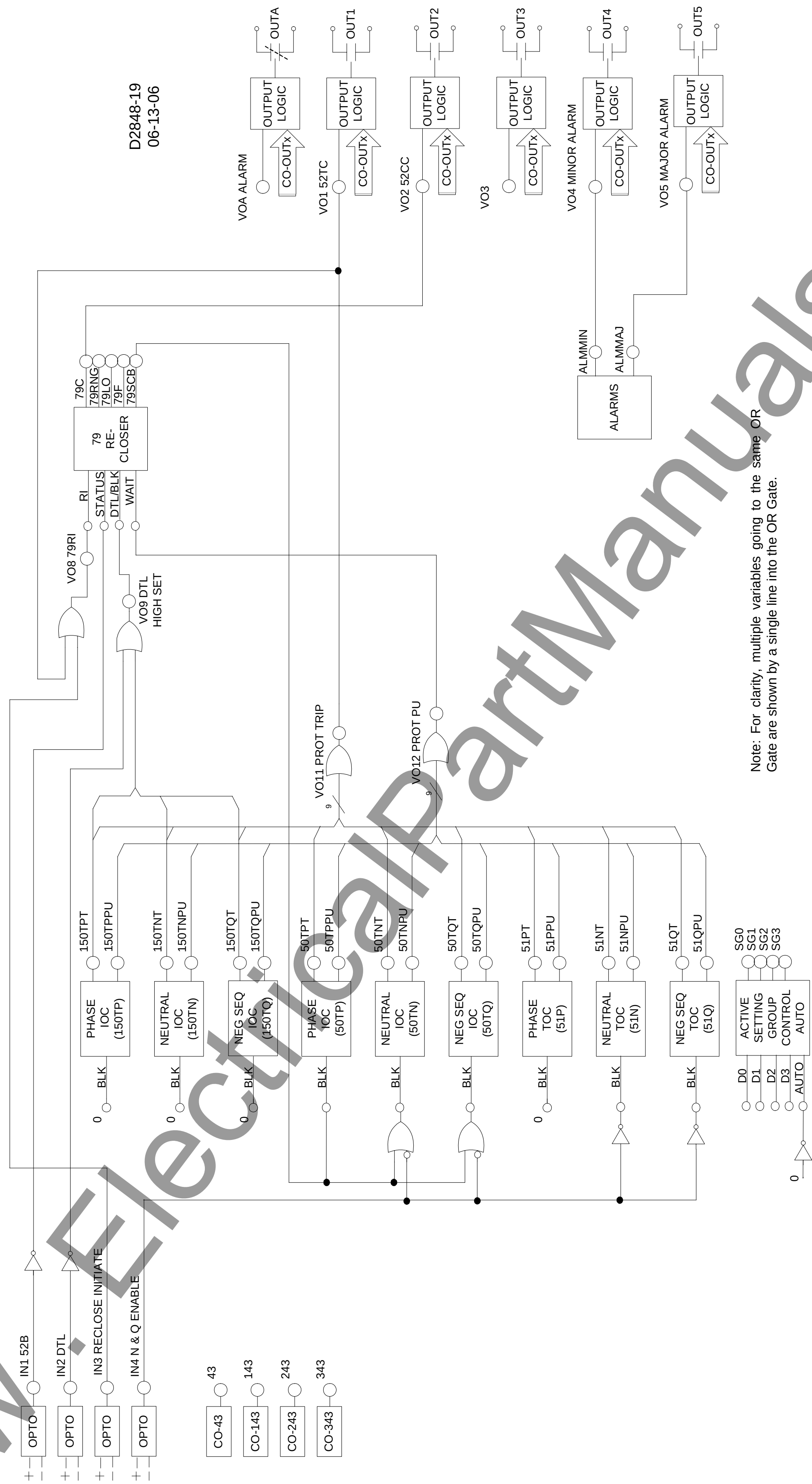

Figure 8-4. OC-W-79 Logic Diagram

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OC-W-79 Logic Settings and Equations (Overcurrent with Reclosing)

SL-N=OC-W-79
SL-50BF=0,0,0,0,0
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-24=0,0
SL-25=0,0
SL-27P=0,0; SL-27X=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0; SL-59X=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,VO9,0
SL-P85=0,0,0,0,0
SL-86=0,0,0
SL-186=0,0,0
SL-GROUP=1,0,0,0,0,0
SL-43=0,0,0,0,0
SL-143=0,0,0,0,0
SL-243=0,0,0,0,0
SL-343=0,0,0,0,0
SL-443=0,0,0,0,0
SL-43TAG=0,0,0,0
SL-143TAG=0,0,0,0
SL-243TAG=0,0,0,0
SL-343TAG=0,0,0,0
SL-443TAG=0,0,0,0
SL-101=0,0,0,0,0
SL-CKTMON=0,0,0
SL-CTRL=0,0,0,0
SL-SOTF=0,0,0
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
SL-VO16=0
SL-VO17=0

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OC-W-CTL LOGIC SCHEME

Logic scheme OC-W-CTL is intended for use on feeder breakers. This scheme provides overcurrent protection, breaker failure protection, reclosing, and the control functions required for typical feeders in non-directional overcurrent protection applications.
In OC-W-CTL, automatic reclosing uses a recluse initiate scheme and is initiated by a protective trip or by an external reclose initiate (RI) contact.

The components of OC-W-CTL logic are summarized in Tables 8-9, 8-10, 8-11, and 8-12. Figure 8-5 shows a one-line drawing for the OC-W-CTL logic scheme. A diagram of OC-W-CTL logic is shown in Figure 8-6.

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.

Operation - Protection

All overcurrent function blocks are enabled in this scheme. These functions include timed (51) and instantaneous (50, 150) overcurrent protection. 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 tripped, these functions drive the recloser to lockout. This scheme also allows the 50TN, 50TQ, 51N, and 51Q function blocks to be torque controlled by using either IN3 or Virtual Switch 243.

Operation - Reclosing

OC-W-CTL logic 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 setting at zero in each of the four setting groups will disable the recloser function block. Reclosing can also be disabled by energizing IN2, which is connected to the drive to lockout (DTL) input of the recloser function block. When the breaker is manually closed, the relay will time out to a reset condition.

Drive to lockout also occurs if any of the 150TP, N, or Q functions trip (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.

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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.

Table 8-9. OC-W-CTL Contact Sensing Input Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	51b 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 are enabled. IN4 must be tied HIGH if this feature is not used.	N&Q_ENABLE	ENABLED	DISABLD
IN5	N/A	INPUT_5	TRUE	FALSE
IN6	N/A	INPUT_6	TRUE	FALSE
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

Table 8-10. OC-W-CTL Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
50TP	Block when recloser sequence controlled blocking output is TRUE.	79SCB	1 (enabled)
50TN	Block when recloser sequence controlled blocking output is TRUE or when disabled by IN4 or virtual switch 243.	79SCB+/IN4+243	1 (3 Phase Residual)

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Function	Purpose	BESTlogic Expression	Mode Setting
50TQ	Block when recloser sequence controlled blocking output is TRUE or when disabled by IN4 or virtual switch 243.	79SCB+/IN4+243	1 (enabled)
150TP	Used for high set.	0	1 (enabled)
150TN	Used for high set.	0	1 (3 Phase Residual)
150TQ	Used for high set.	0	1 (enabled)
51P	N/A	0	1 (enabled)
51N	Block when disabled by IN4 or virtual switch 243.	/IN4+243	1 (3 Phase Residual)
51Q	Block when disabled by IN4 or virtual switch 243.	/IN4+243	1 (enabled)
151N	N/A	0	0 (disabled)
24	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)
25	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)
32	N/A	0	0 (disabled)
132	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	
	Block/Drive to Lockout Logic: Drive recloser to lockout when recloser drive to lockout expression is TRUE.	VO9	
	Pilot Initiate (PI) Logic: If the recloser is in the reset state upon receiving a *Pilot Initiate* input signal, the reclose logic issues a pilot reclose output (79P) after the programmed time delay.	0	
50BF	N/A	0	0 (disabled)
62	N/A	0	0 (disabled)
162	N/A	0	0 (disabled)

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Function	Purpose	BESTlogic Expression	Mode Setting
86	N/A	0	0 (disabled)
186	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Input Selection)
	Input 1 Logic: No manual selection logic is used.	0	
	Input 2 Logic: No manual selection logic is used.	0	
	Input 3 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Disable automatic selection when Virtual Switch 43 is in the Manual position.	/43	

Table 8-11. OC-W-CTL Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	Auto/Manual switch for automatic setting group change logic.	2 (On/Off)	SETGRP_MAN	MANUAL	AUTO
143	Disable recloser when virtual switch is closed.	2 (On/Off)	RCL_DISABL	DISABLD	ENABLED
243	Disable neutral and negative sequence, 50 and 51 protection when virtual switch is closed.	2 (On/Off)	N&Q_DISABL	DISABLD	ENABLED
343	N/A	0 (disabled)	SWITCH_343	CLOSED	OPEN
443	N/A	0 (disabled)	SWITCH_443	CLOSED	FALSE
101	Allows breaker to be tripped or closed manually from the HMI or ASCII interface.	1 (enabled)	N/A	N/A	N/A

Table 8-12. OC-W_CTL Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Contact.	Trip breaker when protective trip expression is TRUE or when virtual breaker control switch is operated to trip.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=VO11+101T					
VO2 (OUT2)	Breaker Close Contact.	Close breaker when recloser initiates breaker close command or when virtual breaker control switch operates.	BKR_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO2=79C+101C					

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Output	Purpose	Description	Label	State Labels	
				True	False
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 (OUT6)	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=150TPT+150TNT+150TQT+143+/IN2					
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_TRP	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	N/A	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	N/A	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	N/A	N/A	VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO16	N/A	N/A	VO16	TRUE	FALSE
BESTlogic Expression: VO16=0					
VO17	N/A	N/A	VO17	TRUE	FALSE
BESTlogic Expression: VO17=0					

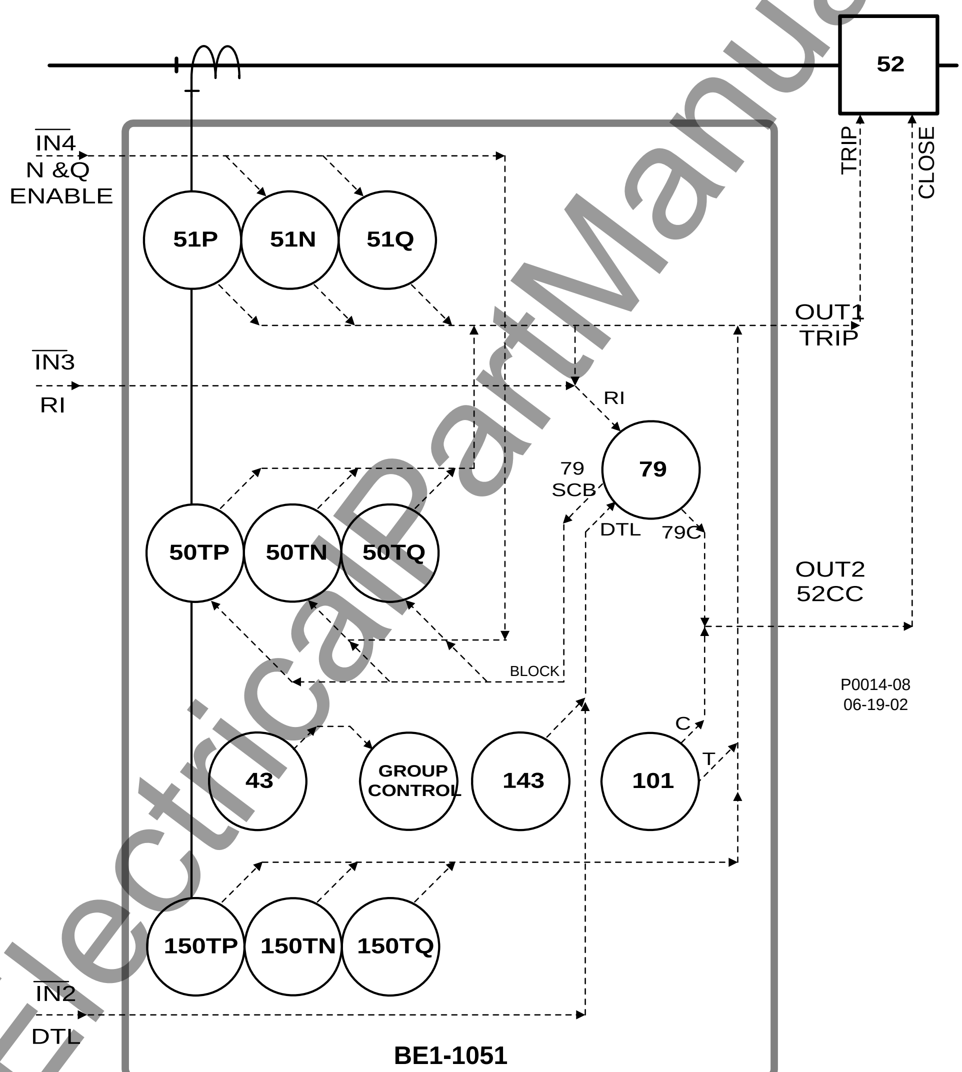

Figure 8-5. OC-W-CTL One-Line Diagram

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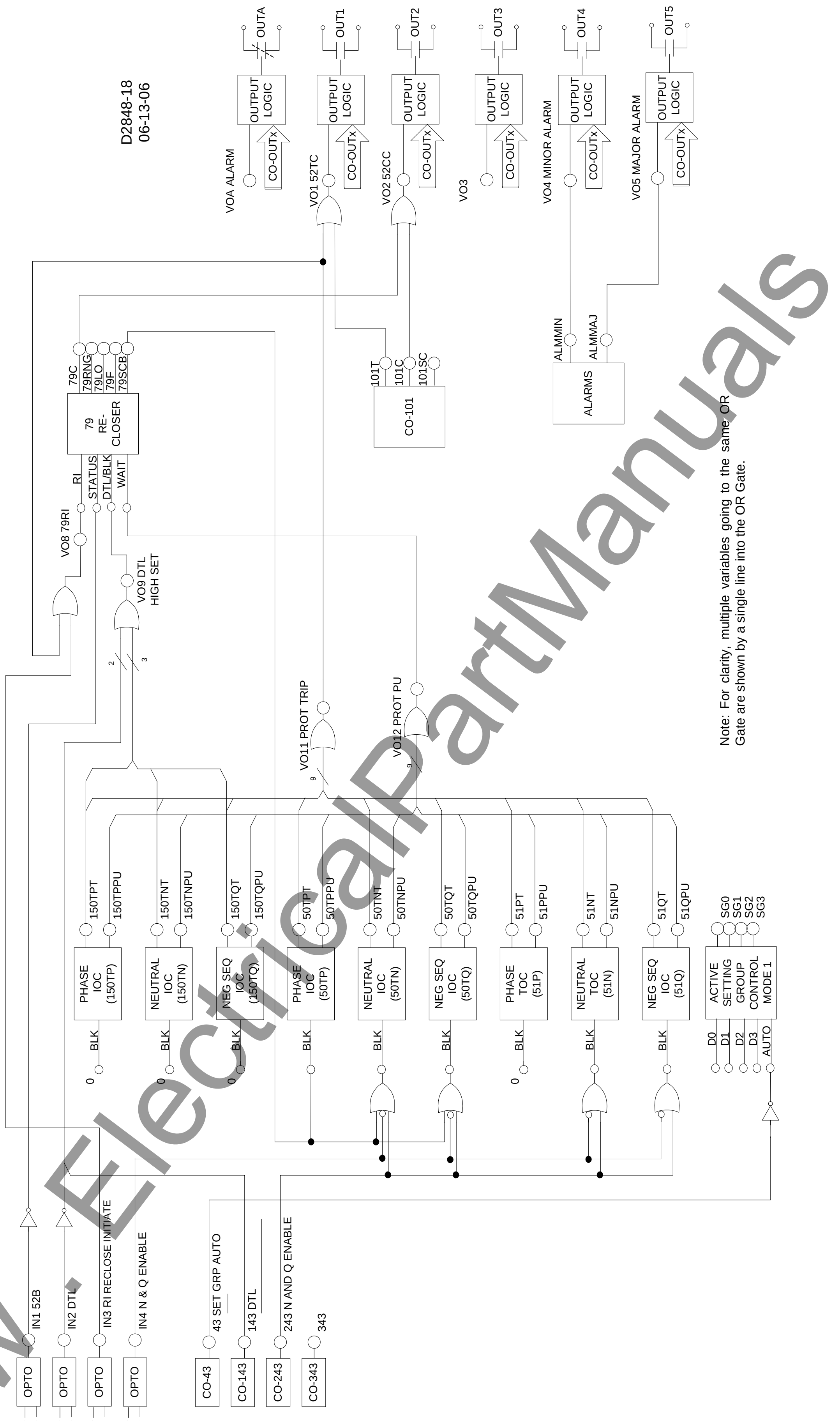

Figure 8-6. OC-W-CTL Logic Diagram

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OC-W-CTL Logic Settings and Equations

SL-N=OC-W-CTL
SL-50BF=0,0,0,0,0
SL-50TP=1,79SCB; SL-50TN=1,79SCB+/IN4+243; SL-50TQ=1,79SCB+/IN4+243
SL-150TP=1,0; SL-150TN=1,0; SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,/IN4+243
SL-51Q=1,/IN4+243
SL-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0; SL-27X=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0; SL-59X=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,VO9,0
SL-P85=0,0,0,0,0
SL-86=0,0,0
SL-186=0,0,0
SL-GROUP=1,0,0,0,0,/43
SL-43=2,0,0,0,0
SL-143=2,0,0,0,0
SL-243=2,0,0,0,0
SL-343=0,0,0,0,0
SL-443=0,0,0,0,0
SL-43TAG=0,0,0,0
SL-143TAG=0,0,0,0
SL-243TAG=0,0,0,0
SL-343TAG=0,0,0,0
SL-443TAG=0,0,0,0
SL-101=1,0,0,0,0
SL-CKTMON=0,0,0
SL-CTRL=0,0,0,0
SL-SOTF=0,0,0
SL-VOA=0
SL-VO1=VO11+101T
SL-VO2=79C+101C
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+143
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
SL-VO16=0
SL-VO17=0

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FDR-W-IL LOGIC SCHEME

Logic scheme FDR-W-IL is intended for use on feeder breakers to provide overcurrent protection, breaker failure protection, reclosing, and control functions required for typical feeders in nondirectional overcurrent protection applications. When used with other programmable relays using BUS and BACKUP logic schemes, FDR-W-IL logic provides protection when the feeder relay is out of service. Basler Electric protective relays that incorporate a BUS and BACKUP logic scheme are the BE1-851 Overcurrent Protection System, the BE1-851E Enhanced Overcurrent Protection System, the BE1-951 Overcurrent Protection System, the BE1-1051 Overcurrent Protection System, the BE1-CDS220/240 Current Differential Systems, and the BE1-IPS100 Intertie Protection System. Complete overcurrent protection for the transformers, bus, and feeders in radial system substation applications can be achieved by combining these devices.

The components of FDR-W-IL logic are summarized in Tables 8-13, 8-14, 8-15, and 8-16. Figure 8-7 shows a one-line drawing for the FDR-W-IL logic scheme. A diagram of FDR-W-IL logic is shown in Figure 8-8.

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 - Protection

All timed and instantaneous overcurrent function blocks are enabled in this scheme. Overcurrent function blocks are directed through VO11 to provide a protective trip signal at OUT1. The breaker failure function will also re-trip OUT1 once picked up via BFRT.

The 150T function blocks are arranged as high-set instantaneous functions that drive the recloser to lockout when they trip. Each overcurrent function block can be disabled individually by a pickup setting of 0 in each of the four setting groups. This scheme also allows the 50TN, 50TQ, 51N, and 51Q function blocks to be torque controlled by using either IN3 or virtual switch 243.

Normal Operation - Reclosing

FDR-W-IL reclosing logic uses a reclose initiate (RI) scheme where each step in the reclosing sequence is initiated by a protective trip.

Setting the first reclose time at zero will disable the recloser function block. Reclosing can also be disabled by either IN2 or Virtual Switch 143, which 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 will cause the recloser to be in lockout. When the breaker is manually closed, the relay will time out to a reset condition.

Drive to lockout also occurs if any of the 150TP/N/Q functions (typically used for high-set instantaneous protection) trip or a breaker failure trip (BFT) occurs. 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, which is VO12 in all preprogrammed logic 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.

FDR-W-IL 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. The recloser sequence-controlled blocking output is set in the four setting groups using the S#-79SCB commands.

Recloser timing is stopped by the wait input if an overcurrent protection function block is picked up 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.

Initiation of the recloser function block by external relaying is not accommodated in this logic scheme.

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Normal 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. Automatic setting group change logic can be enabled by Virtual Switch 43.

Normal Operation - Bus Protection

When any of the feeder relay overcurrent function blocks are picked up, OUT4 closes. The signal from OUT4 is intended for connection to IN2 of an upstream BE1-1051 using BUS logic. When the upstream relay recognizes an external contact closure on IN2, the upstream relay will block its 50T elements that are set to trip the bus breaker or bus lockout relay (OUT3 of BUS relay). If the fault is not on a feeder, the 50T elements of the bus relay are not blocked. Bus relay 50T elements are typically set with a 2 to 4 cycle time delay to provide a minimal coordination interval for the feeder relay OUT4 to close. Should there be a problem with the blocking logic, the bus relay 51 functions are not blocked to allow bus fault clearing 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 - 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

Test mode is intended to increase the security of the feeder protection and control system if external test switches aren't installed on all outputs. When the relay is out of service for testing, the breaker failure, automatic reclosing, and block upstream instantaneous functions are disabled. Backup by the upstream relay is enabled. See the *Bus and Backup Logic Schemes* subsection for more details.

De-energizing IN4 or closing virtual switch 343 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.

The logic for test mode drives virtual output 15 (VO15), which is alarm bit 23 in the programmable alarm mask. If desired, it can be masked to drive an alarm LED to provide indication when the relay is in test mode.

Contingency Operation - Backup Protection for Feeder Breaker Failure

OUT5 is configured as the breaker failure trip output and can be wired to trip the bus breaker or a lockout relay. The breaker failure pickup (BFRT) output trips the feeder breaker directly via OUT1 to provide a breaker re-trip signal for additional security.

Initiation of the BF function block by external relays is not accommodated in this scheme. The breaker failure function block is initiated by a protective trip (VO11). This function block has an independent fast dropout phase current detector that detects a breaker opening and stops timing. An open breaker is detected when the current decreases below 10 percent of the nominal CT input (1 A or 5 A).

A time delay setting of zero will disable the breaker failure function block. This permits the traditional radial system backup scheme of coordinated relays tripping different breakers.

The FDR-W-IL logic scheme will prevent OUT4 (Block Upstream Instantaneous Trip) from energizing when a breaker failure trip (BFT) occurs. This allows the BUS relay to trip the bus breaker through its own 50T elements if a direct trip from the feeder relay is not desired. Then, fault clearing time on the circuit with the failed breaker will be determined by the feeder relay breaker failure time (or bus relay 50T time, whichever is greater) instead of the bus relay 51 time. Note that this approach is limited by the sensitivity constraints of the bus relay.

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Contingency Operation - Backup Protection for Feeder Relay Out-of-Service

When the feeder relay is out of service, OUT3 opens to signal the upstream relays providing backup protection. OUT3 operates in a failsafe mode; the output is closed during normal operation and open when the feeder relay is out of service. This feature provides backup mode signaling when the feeder relay is extracted from the case.

Backup for relay failure can be implemented using the BUS and BACKUP preprogrammed logic schemes. These schemes are described in detail in the *Bus and Backup Logic Schemes* subsection.

Table 8-13. FDR-W-IL Contact Sensing Input Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	51b breaker status.	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	Enable neutral and negative sequence, 50, and 51 protection when IN3 is energized.	N&Q_ENABLE	ENABLED	DISABLD
IN4	When IN4 is de-energized, the relay is placed in Test mode and reclosing and breaker failure are disabled.	TESTDISABL	NORMAL	TSTMODE
IN5	N/A	INPUT_5	TRUE	FALSE
IN6	N/A	INPUT_6	TRUE	FALSE
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

Table 8-14. FDR-W-IL Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
50TP	Block when recloser sequence controlled blocking output is TRUE.	79SCB	1 (enabled)
50TN	Block when recloser sequence controlled blocking output is TRUE or when disabled by IN3 or virtual switch 243.	79SCB+/IN3+243	1 (3 Phase Residual)
50TQ	Block when recloser sequence controlled blocking output is TRUE or when disabled by IN3 or virtual switch 243.	79SCB+/IN3+243	1 (enabled)
150TP	N/A	0	1 (enabled)
150TN	N/A	0	1 (3 Phase Residual)
150TQ	N/A	0	1 (enabled)
51P	N/A	0	1 (enabled)
51N	Block when disabled by IN3 or virtual switch 243.	/IN3+243	1 (3 Phase Residual)
51Q	Block when disabled by IN3 or virtual switch 243.	/IN3+243	1 (enabled)
151N	N/A	0	0 (disabled)
24	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)

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Function	Purpose	BESTlogic Expression	Mode Setting
27X	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)
25	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)
32	N/A	0	0 (disabled)
132	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	
	Block/Drive to Lockout Logic: Drive recloser to lockout when recloser drive to lockout expression is TRUE.	VO9+VO15	
	Pilot Initiate (PI) Logic: If the recloser is in the reset state upon receiving a *Pilot Initiate* input signal, the reclose logic issues a pilot reclose output (79P) after the programmed time delay.	0	
50BF	Breaker Failure timer starts when all 3 of the following occur: • Phase or neutral fault detect threshold is exceeded. • There is a protective relay trip input *(BFI50 Logic)*. • The 3-phase current detector senses current above 5% of nominal.	VO10	1 (enabled)
	BLK Logic: Disabled the 50BF function when TRUE.	VO15	
62	N/A	0	0 (disabled)
162	N/A	0	0 (disabled)
86	N/A	0	0 (disabled)
186	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Input Selection)
	Input 1 Logic: No manual selection logic is used.	0	
	Input 2 Logic: No manual selection logic is used.	0	
	Input 3 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Disable automatic selection when Virtual Switch 43 is in the Manual position.	/43	

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Table 8-15. FDR-W-IL Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	Auto/Manual switch for automatic setting group change logic.	2 (On/Off)	SETGRP_MAN	MANUAL	AUTO
143	Disable recloser when virtual switch is closed.	2 (On/Off)	RCL_DISABL	DISABLD	ENABLED
243	Disable neutral and negative sequence, 50, and 51 protection when virtual switch is closed.	2 (On/Off)	N&Q_DISABL	DISABLD	ENABLED
343	Places the relay in Test mode so that breaker failure is disabled when virtual switch is closed.	2 (On/Off)	SWITCH_343	TRUE	FALSE
443	N/A	2 (On/Off)	SWITCH_443	CLOSED	FALSE
101	Allows breaker to be tripped or closed manually from the HMI or ASCII interface.	1 (enabled)	N/A	N/A	N/A

Table 8-16. FDR-W-IL Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Contact.	Trip breaker when protective trip expression is TRUE or when breaker is initiated or when virtual breaker control switch is operated to trip.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=VO11+101T+BFRT					
VO2 (OUT2)	Breaker Close Contact.	Close breaker when recloser close output is TRUE or when virtual breaker control switch is operated to close.	BKR_CLOSE	CLOSE	NORMAL
BESTlogic Expression: VO2=79C+101C					
VO3 (OUT3)	Relay Backup Enable.	Output is held closed when relay is in service but is in Test mode or in Relay Failure mode.	IN_SERVICE	NORMAL	BACKUP
BESTlogic Expression: VO3=/VO15					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO4 (OUT4)	Block Upstream Instantaneous Elements.	Upstream instantaneous elements are blocked when relay is picked up for high-speed bus overcurrent protection. Blocks upstream instantaneous elements when the protective pickup expression is TRUE, the relay is not in Test mode and the breaker has not failed.	BLK_UPSTRM	BLOCKED	NORMAL
BESTlogic Expression: VO4=VO12+/VO5*/VO15					
VO5 (OUT5)	Breaker Failure Trip.	Trip backup if breaker protection times out.	BKR_FAIL	TRIP	NORMAL
BESTlogic Expression: VO5=BFT					
VO6 (OUT6)	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.	RCL_INI	INI	NORMAL
BESTlogic Expression: VO8=VO11					
VO9	Recloser Drive to Lockout.	Drive recloser to lockout if: IN2 is de-energized, Virtual Switch 143 is closed, the breaker fails, or the high set instantaneous elements trip.	RCL_DTL	DTL	NORMAL
BESTlogic Expression: VO9=150TPT+150TNT+150TQT+143+/IN2+VO5					
VO10	Breaker Failure Initiate.	Initiate breaker failure timing when protective trip expression is TRUE.	BFI	INI	NORMAL
BESTlogic Expression: VO10=VO11					
VO11	Protective Trip Expression.	TRUE when any 50, 150, or 51 element times out.	PROT_TRP	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	N/A	N/A	VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	N/A	N/A	VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO15	Alarm Mask 23.	Indicates that the relay is in Test mode and that the breaker failure is disabled. TRUE if IN4 is de-energized or if virtual switch 343 is closed.	TEST_MODE	TEST	NORMAL
BESTlogic Expression: VO15=343+/IN4					
VO16	N/A	N/A	VO16	TRUE	FALSE
BESTlogic Expression: VO16=0					
VO17	N/A	N/A	VO17	TRUE	FALSE
BESTlogic Expression: VO17=0					

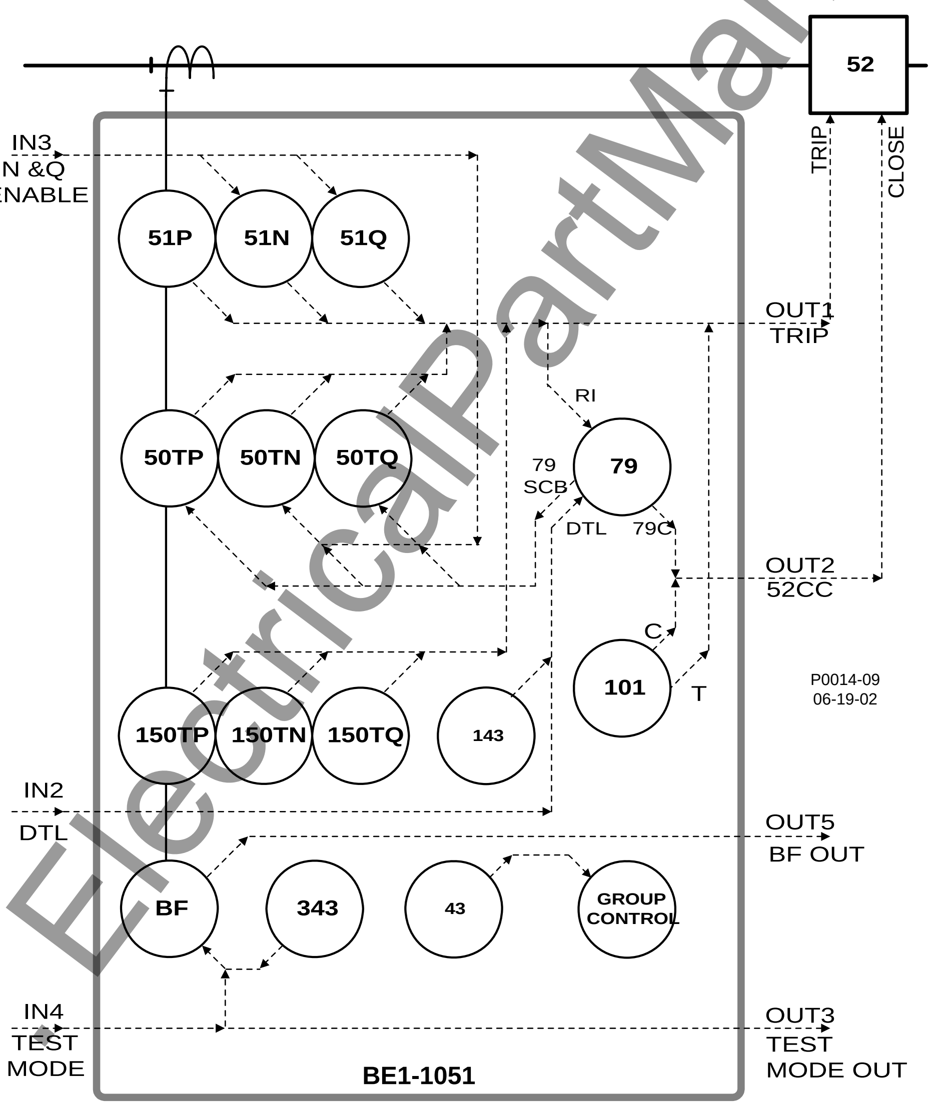

Figure 8-7. FDR-W-IL One-Line Diagram

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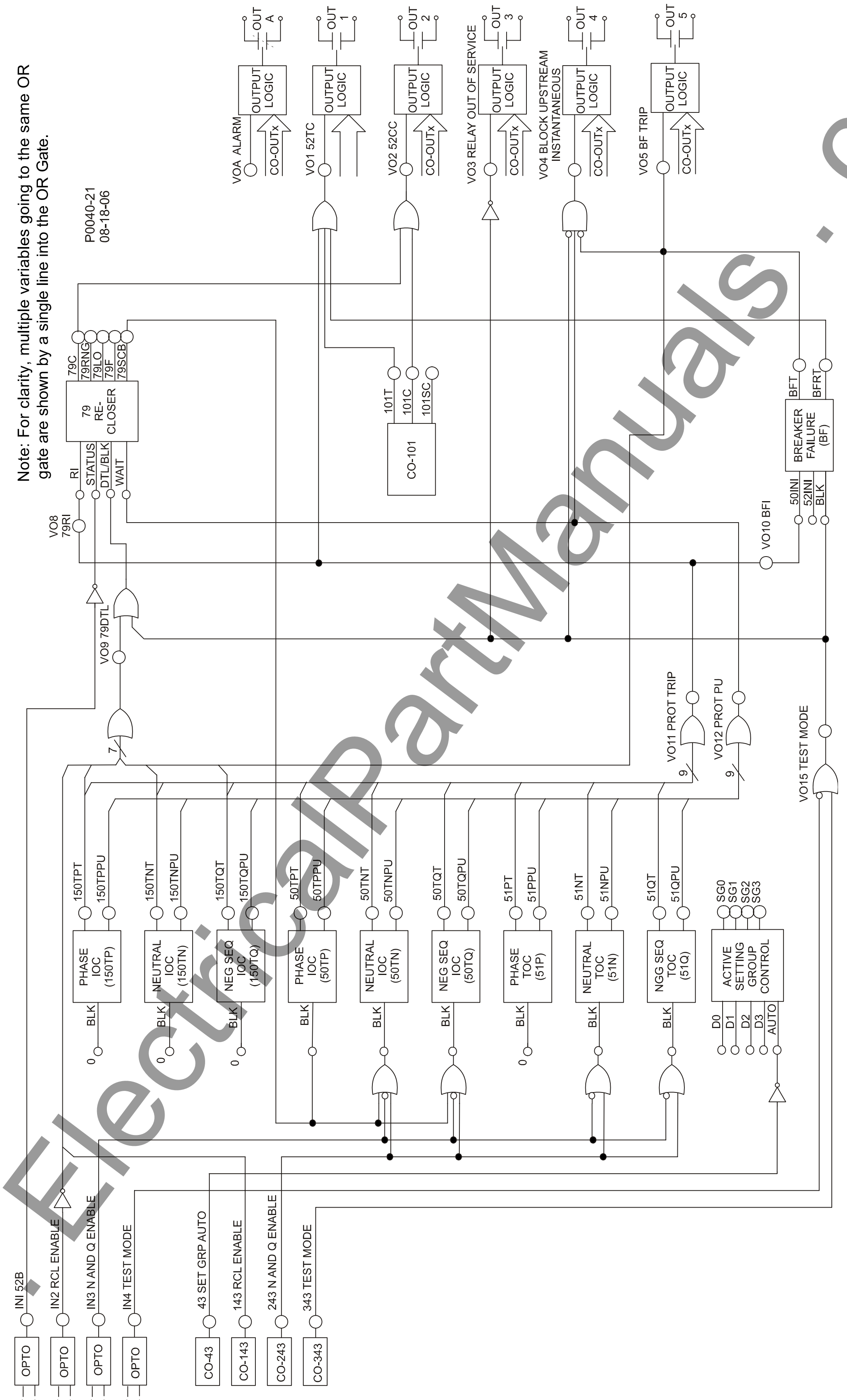

Figure 8-8. FDR-W-IL Logic Diagram

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FDR-W-IL Logic Settings and Equations

SL-N=FDR-W-IL
SL-50BF=1,VO10,0,0,VO15
SL-50TP=1,79SCB; SL-50TN=1,/79SCB+/IN3+243; SL-50TQ=1,79SCB+/IN3+243
SL-150TP=1,0; SL-150TN=1,0; SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,/IN3+243
SL-51Q=1,/IN3+243
SL-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0; SL-27X=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0; SL-59X=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+VO15,0
SL-P85=0,0,0,0,0
SL-86=0,0,0
SL-186=0,0,0
SL-GROUP=1,0,0,0,0,/43
SL-43=2,0,0,0,0
SL-143=2,0,0,0,0
SL-243=2,0,0,0,0
SL-343=2,0,0,0,0
SL-443=2,0,0,0,0
SL-43TAG=0,0,0,0
SL-143TAG=0,0,0,0
SL-243TAG=0,0,0,0
SL-343TAG=0,0,0,0
SL-443TAG=0,0,0,0
SL-101=1,0,0,0,0
SL-CKTMON=0,0,0
SL-CTRL=0,0,0,0
SL-SOTF=0,0,0
SL-VOA=0
SL-VO1=BFRT+VO11+101T
SL-VO2=79C+101C
SL-VO3=/VO15
SL-VO4=/VO5*VO12*/VO15
SL-VO5=BFT
SL-VO6=0
SL-VO7=0
SL-VO8=VO11
SL-VO9=150TPT+150TNT+150TQT+VO5+/IN2+143
SL-VO10=VO11
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=/IN4+343
SL-VO16=0
SL-VO17=0

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BUS AND BACKUP LOGIC SCHEMES

Logic schemes BUS and BACKUP are intended for use on a bus main breaker and they 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.

Interconnection of a relay using FDR-W-IL logic with relays using BUS and BACKUP logic provides complete backup protection (except for reclosing) for the feeder relays if they are out of service for testing or maintenance. Figure 8-9 illustrates how FDR-W-IL, BUS, and BACKUP relays are interconnected to achieve this integrated protection system.

The components of BUS logic are summarized in Tables 8-17, 8-18, 8-19, and 8-20. Figure 8-10 shows a one-line drawing for the BUS logic scheme. A diagram of BUS logic is shown in Figure 8-11.

The components of BACKUP logic are summarized in Tables 8-21, 8-22, 8-23, and 8-24. Figure 8-12 shows a one-line drawing for the BACKUP logic scheme. A diagram of BACKUP logic is shown in Figure 8-13.

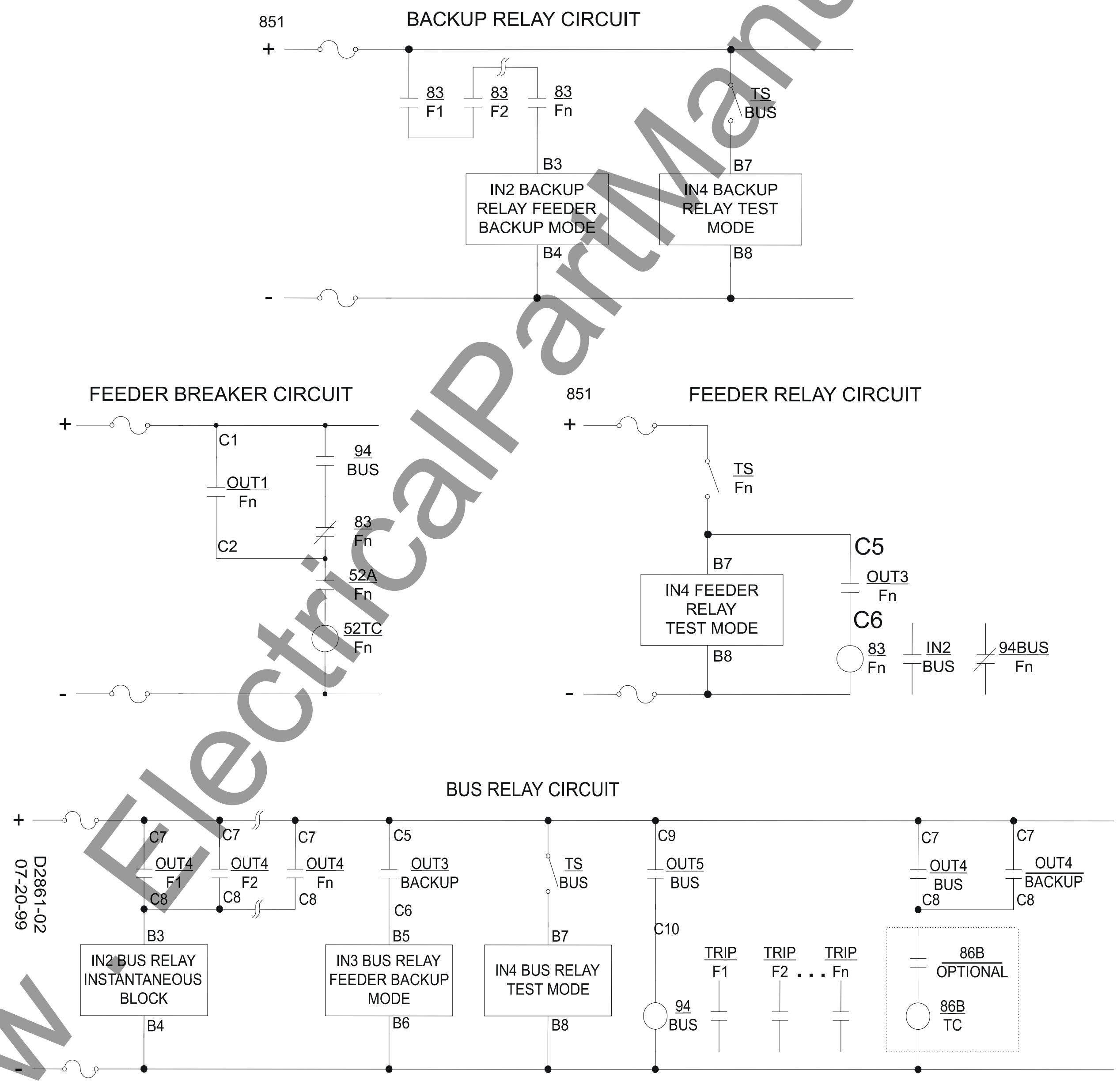

Figure 8-9. Device Interconnection for Integrated Protection System

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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 close OUT4 that 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 that drives alarm bit 21 in the programmable alarm mask. Alarm bit 21 can be masked to drive an alarm LED and Alarm 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 343 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

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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 *Alarms* 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

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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, the BACKUP relay will clear the fault with its 18 to 20-cycle coordination interval.

Table 8-17. BUS Contact Sensing Input Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	51b 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
IN5	N/A	INPUT_5	TRUE	FALSE
IN6	N/A	INPUT_6	TRUE	FALSE
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

Table 8-18. BUS Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
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 (enabled)
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 (enabled)
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)
151N	N/A	0	0 (disabled)
24	N/A	0	0 (disabled)

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Function	Purpose	BESTlogic Expression	Mode Setting
27P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)
25	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)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
79	N/A	0	0 (disabled)
50BF	N/A	0	0 (disabled)
62	N/A	0	0 (disabled)
162	N/A	0	0 (disabled)
86	N/A	0	0 (disabled)
186	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* Switch to Setting Group 1 if feeder relay is out of service.	IN3	2 (Binary Coded Selection)
	Input 1 Logic: N/A	0	
	Input 2 Logic: N/A	0	
	Input 3 Logic: N/A	0	
	Auto/Manual Logic: Auto/Manual switch fixed in Manual position. No automatic selection. Selection by contact sensing only.	0	

Table 8-19. BUS Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	CLOSED	OPEN
143	N/A	0 (disabled)	SWITCH_143	CLOSED	OPEN
243	N/A	0 (disabled)	SWITCH_243	CLOSED	OPEN
343	Places the relay in Test mode and blocks BFI signal (VO3) to external Breaker Failure Relay.	2 (On/Off)	TESTENABLE	TSTMODE	NORMAL

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				State Labels	
443	N/A	0 (disabled)	SWITCH_443	TSTMODE	FALSE
101	Allows breaker to be tripped or closed manually from the HMI or ASCII interface.	1 (enabled)	N/A	N/A	N/A

Table 8-20. BUS Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) 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					
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+/VO15*SG0					
VO4 (OUT4)	Bus Fault Trip (86B).	Trip bus breaker for bus faults (50TPT, 50TNT, or 50TQT) when in Normal mode.	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_TRP	TRIP	NORMAL
BESTlogic Expression: VO5=VO11*SG1					
VO6 (OUT6)	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					

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Output	Purpose	Description	Label	State Labels	
				True	False
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_TRP	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					
VO15	Test Mode.	Blocks the BFI signal (VO3) to an external breaker failure relay. TRUE when IN4 de-energizes or Virtual Switch 343 closes.	TEST_MODE	TEST	NORMAL
BESTlogic Expression: VO15=343+/IN4					
VO16	N/A	N/A	VO16	TRUE	FALSE
BESTlogic Expression: VO16=0					
VO17	N/A	N/A	VO17	TRUE	FALSE
BESTlogic Expression: VO17=0					

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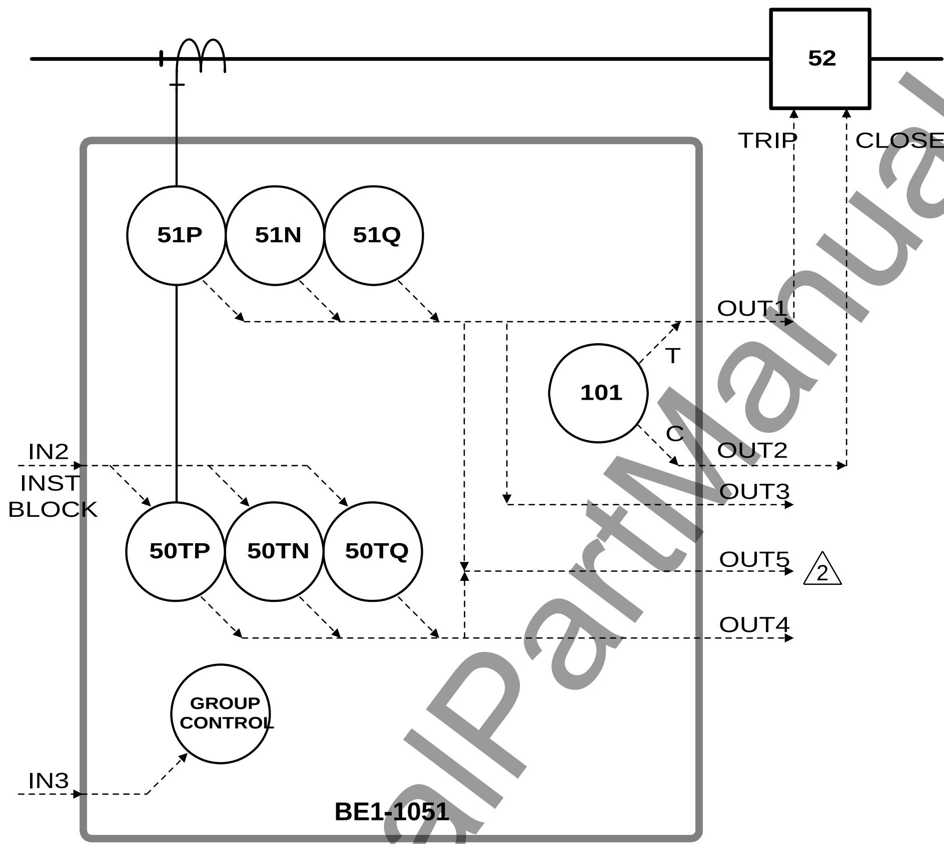

1 Relay is shown in Normal mode (not in Test mode).

2 If the feeder relay is out of service, the 50T and 51 elements are diverted from OUT1 and OUT4 to OUT5 for feeder protection.

Figure 8-10. BUS One-Line Diagram

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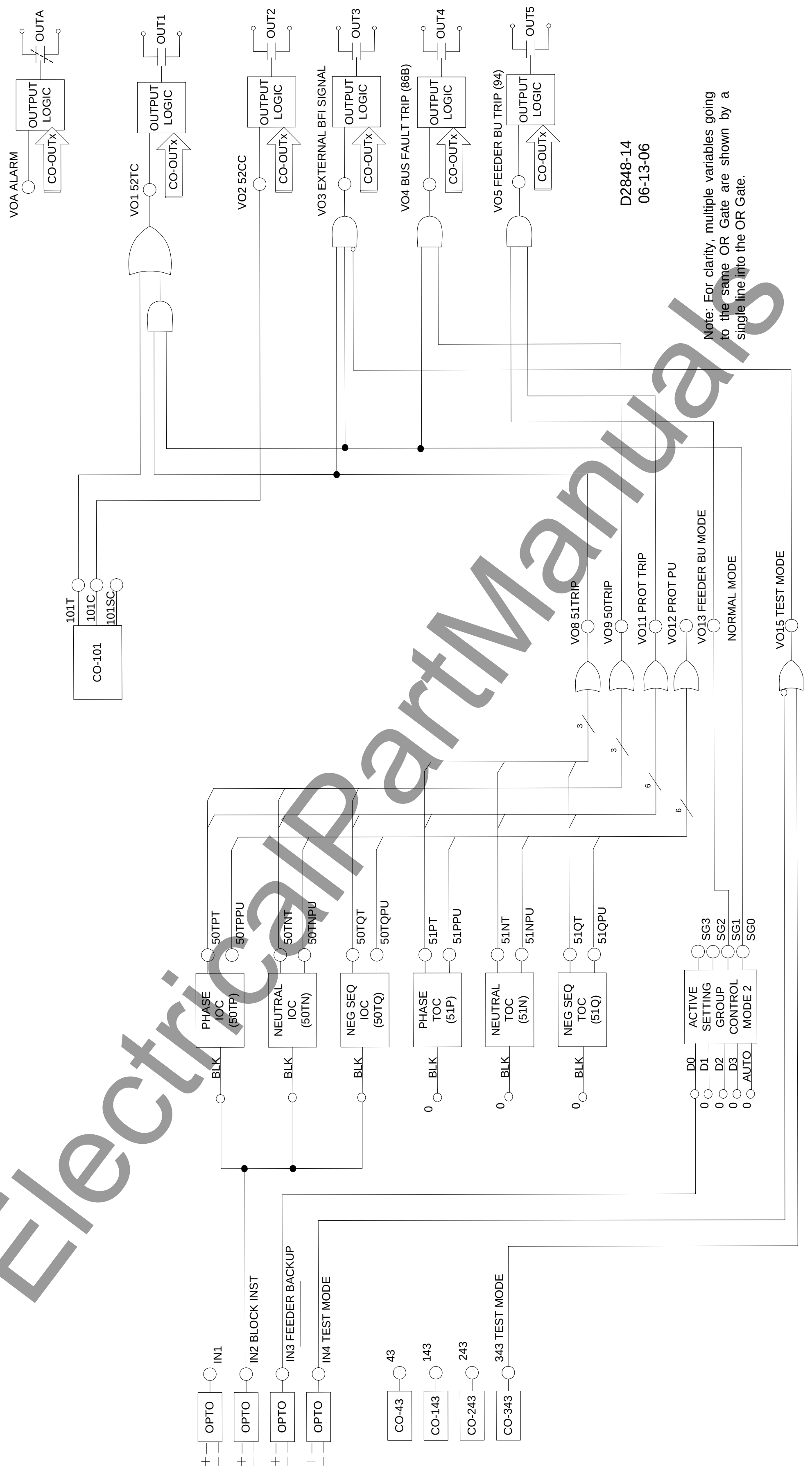

Figure 8-11. BUS Logic Diagram

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BUS Logic Settings and Equations

SL-N=BUS
SL-50BF=0,0,0,0,0
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-24=0,0
SL-25=0,0
SL-27P=0,0; SL-27X=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0; SL-59X=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=0,0,0,0,0,0
SL-P85=0,0,0,0,0
SL-86=0,0,0
SL-186=0,0,0
SL-GROUP=2,IN3,0,0,0,0
SL-43=0,0,0,0,0
SL-143=0,0,0,0,0
SL-243=0,0,0,0,0
SL-343=2,0,0,0,0
SL-443=0,0,0,0,0
SL-43TAG=0,0,0,0
SL-143TAG=0,0,0,0
SL-243TAG=0,0,0,0
SL-343TAG=0,0,0,0
SL-443TAG=0,0,0,0
SL-101=1,0,0,0,0
SL-CKTMON=0,0,0
SL-CTRL=0,0,0,0
SL-SOTF=0,0,0
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=/IN4+343
SL-VO16=0
SL-VO17=0

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Table 8-21. BACKUP Contact Sensing Input Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	51b 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
IN5	N/A	INPUT_5	TRUE	FALSE
IN6	N/A	INPUT_6	TRUE	FALSE
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

Table 8-22. BACKUP Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
50TP	Requires 18-20 cycle coordination delay since no blocking is provided for feeder relay pickup. Used for backup bus fault trip.	0	1 (enabled)
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 (enabled)
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	1 (enabled)
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	1 (enabled)
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	1 (enabled)
51P	N/A	0	1 (enabled)
51N	N/A	0	1 (3 Phase Residual)
51Q	N/A	0	1 (enabled)
151N	N/A	0	0 (disabled)
24	N/A	0	0 (disabled)
27P	N/A	0	0 (disabled)
27X	N/A	0	0 (disabled)
59P	N/A	0	0 (disabled)
159P	N/A	0	0 (disabled)
159X	N/A	0	0 (disabled)
47	N/A	0	0 (disabled)

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Function	Purpose	BESTlogic Expression	Mode Setting
25	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)
32	N/A	0	0 (disabled)
132	N/A	0	0 (disabled)
79	N/A	0	0 (disabled)
50BF	Breaker Failure timer starts when all 3 of the following occur: • Phase or neutral fault detect threshold is exceeded. • There is a protective relay trip input *(BFI50 Logic)*. • The 3-phase current detector senses current above 5% of nominal.	VO10	1 (enabled)
	BLK Logic: Disabled the 50BF function when TRUE.	VO15	
62	N/A	0	0 (disabled)
162	N/A	0	0 (disabled)
86	N/A	0	0 (disabled)
186	N/A	0	0 (disabled)
GROUP	*Input 0 Logic:* Switch to Setting Group 1 if feeder relay is out of service.	IN3	2 (Binary Coded Selection)
	Input 1 Logic: N/A	0	
	Input 2 Logic: N/A	0	
	Input 3 Logic: N/A	0	
	Auto/Manual Logic: Auto/Manual switch fixed in Manual position. No automatic selection. Selection by contact sensing only.	0	

Table 8-23. BACKUP Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	CLOSED	OPEN
143	N/A	0 (disabled)	SWITCH_143	CLOSED	OPEN
243	N/A	0 (disabled)	SWITCH_243	CLOSED	OPEN
343	Places the relay in Test mode so that breaker failure is disabled when IN4 is de-energized.	2 (On/Off)	TESTENABLE	TSTMODE	NORMAL
443	N/A	0 (disabled)	SWITCH_443	TSTMODE	FALSE
101	Allows breaker to be tripped or closed manually from the HMI or ASCII interface.	1 (enabled)	N/A	N/A	N/A

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Table 8-24. BACKUP Virtual Output Logic

Output	Purpose	Description	Label	State Labels True	State Labels False
VOA (OUTA)	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
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+BFRT					
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 (OUT6)	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					

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Output	Purpose	Description	Label	State Labels	
				True	False
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*150TNPU+IN3*150TNPU+IN3*150TQPU					
VO11	Protective Trip Expression.	TRUE when any 50 or 51 element times out.	PROT_TRP	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					
VO15	Alarm Mask 23.	Indicates that the relay is in Test mode and that breaker failure is disabled. TRUE if IN4 is de-energized or if Virtual Switch 343 is closed.	TEST_MODE	TEST	NORMAL
BESTlogic Expression: VO15=343+/IN4					
VO16	N/A	N/A	VO16	TRUE	FALSE
BESTlogic Expression: VO16=0					
VO17	N/A	N/A	VO17	TRUE	FALSE
BESTlogic Expression: VO17=0					

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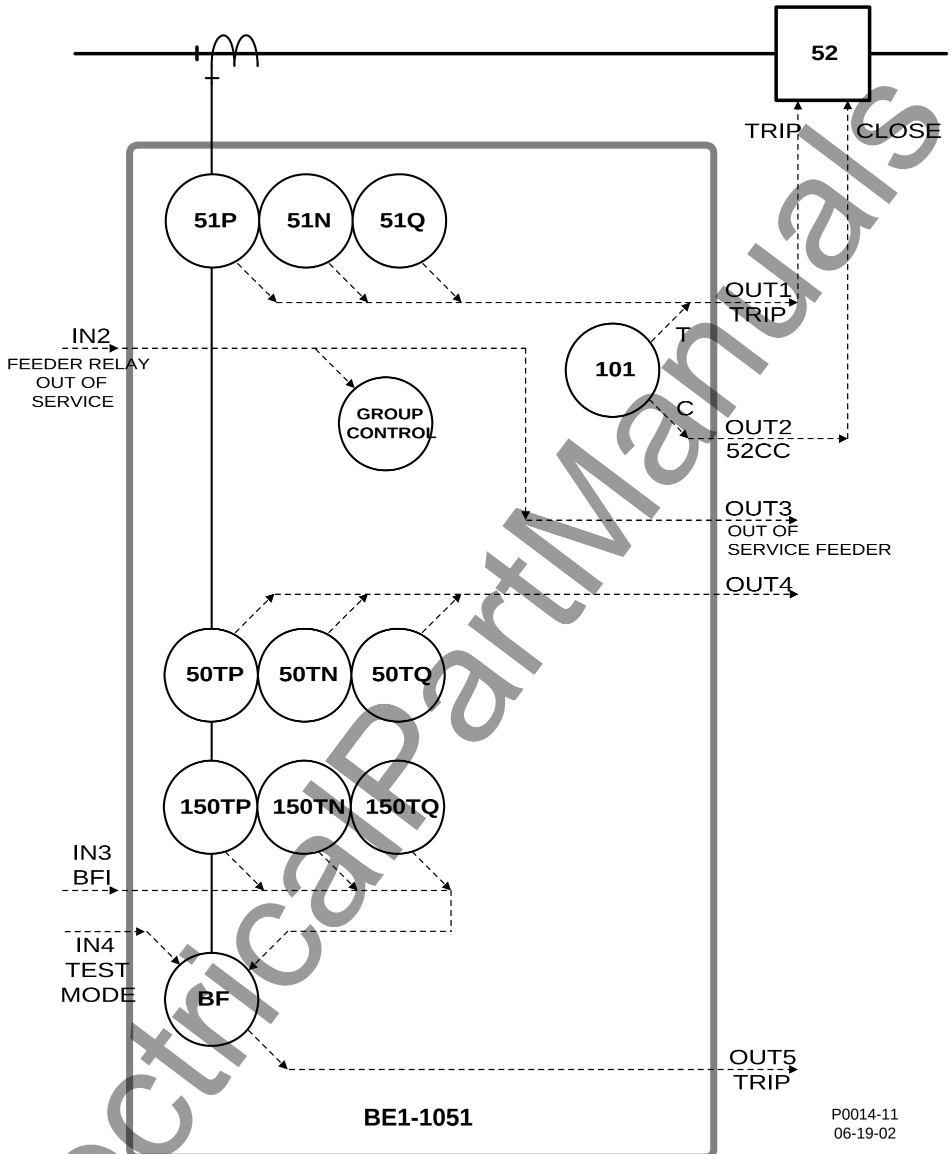

Figure 8-12. BACKUP One-Line Diagram

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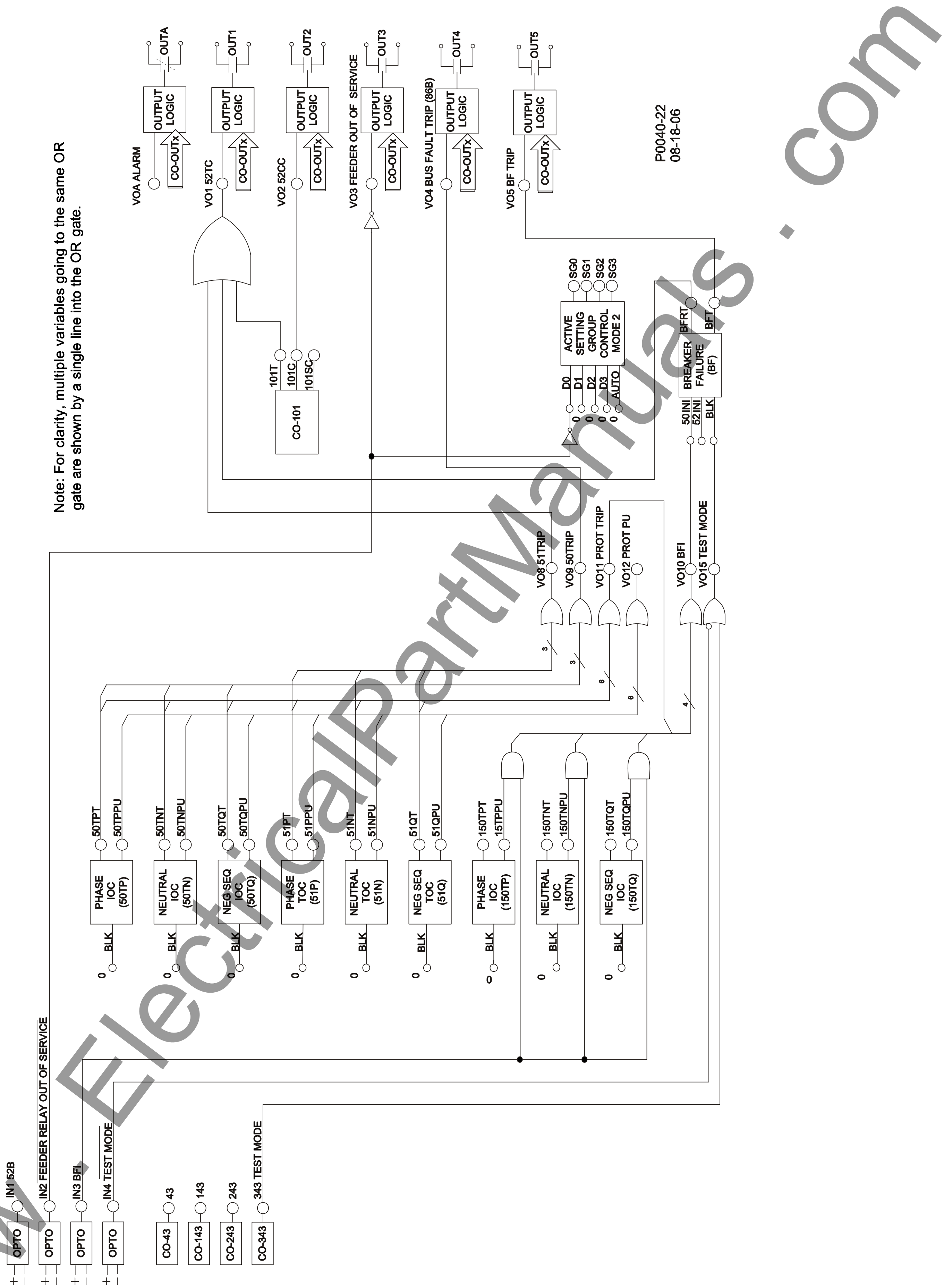

Figure 8-13. BACKUP Logic Diagram

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BACKUP Logic Settings and Equations

SL-N=BACKUP
SL-50BF=1,VO10,0,0,VO15
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-151N=0,0
SL-24=0,0
SL-25=0,0
SL-27P=0,0; SL-27X=0,0
SL-32=0,0
SL-132=0,0
SL-47=0,0
SL-59P=0,0; SL-59X=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=0,0,0,0,0,0
SL-P85=0,0,0,0,0
SL-86=0,0,0
SL-186=0,0,0
SL-GROUP=2,/IN2,0,0,0,0
SL-43=0,0,0,0,0
SL-143=0,0,0,0,0
SL-243=0,0,0,0,0
SL-343=2,0,0,0,0
SL-443=0,0,0,0,0
SL-43TAG=0,0,0,0
SL-143TAG=0,0,0,0
SL-243TAG=0,0,0,0
SL-343TAG=0,0,0,0
SL-443TAG=0,0,0,0
SL-101=1,0,0,0,0
SL-CKTMON=0,0,0
SL-CTRL=0,0,0,0
SL-SOTF=0,0,0
SL-VOA=0
SL-VO1=BFRT+VO8+101T
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=/IN4+343
SL-VO16=0
SL-VO17=0

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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 associated with each function. Table 8-25 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 8-25. 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*

COMMUNICATIONS ASSISTED PROTECTION SCHEMES

The BE1-1051 in combination with suitable transfer trip communications equipment can provide high-speed pilot protection for network distribution, sub-transmission, and transmission facilities. Communications assisted protection schemes such as Direct Underreaching Transfer Trip (DUTT), Permissive Overreaching Transfer Trip (POTT), and Permissive Underreaching Transfer Trip (PUTT) can be accommodated. The POTT example that follows provides the protection engineer with a foundation logic scheme that can be adapted for most communications assisted protection schemes by changing function block operation and settings.

It should be noted that the example logic scheme illustrates typical ways of using or controlling various functions. The user may choose to create a custom logic scheme by mixing logic from several of the preprogrammed schemes and this example. The flexibility of BESTlogic allows the protection engineer to create a custom scheme that exactly meets the requirements of the application.

Explanation of Terms

The following paragraphs define terms that are used in the POTT logic scheme example:

Backup Zone

The protected zone of a relay that is not the primary protection. It is usually time delayed as with 2ND and 3rd zone distance or overreaching directional time overcurrents. The backup zone usually results in the removal of more system elements than required by the operation of the primary zone of protection.

Blocking Signal

A logic signal that is transmitted in a pilot scheme to prevent tripping.

Function Block

A stand-alone protection or control function that is equivalent to its discrete component counterpart.

Network System

A transmission or distribution power system where the loads are fed from more than one source at the same time.

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Permissive

Pertaining to a scheme requiring permission to trip from a remote terminal, usually in the form of a pilot signal.

Primary Zone

The protected zone of a relay that is the primary protection. It is usually a high speed overreaching zone that provides simultaneous tripping of all line terminals and requires a permissive signal to prevent over tripping. The primary zone usually results in the removal of only the affected line and is normally followed by a high speed reclose.

Pilot Communications Scheme

A protection scheme involving relays at two or more substations that share data or logic status via a communication channel to improve tripping speed and/or coordination.

Switch Onto Fault Protection

This provides tripping in the event that the breaker is closed into a zero-voltage bolted fault (no voltage memory in protective relays) such as occurs if the safety grounds were left on the line following maintenance.

Transfer Trip

The sending of a TRIP signal via a communication channel to a remote line terminal.

Virtual Switches

Logic switches that emulate traditional switches used on relay and control panels. Examples of these switches are breaker control switches (101) and selector switches (43). Virtual switches can be operated via communication commands or the front panel HMI. Operation of a virtual switch can be disabled if the switch won't be used in a preprogrammed logic scheme that includes the switch. Password protection is also available for the virtual switches.

POTT LOGIC SCHEME

The POTT (Permissive Over Reaching Transfer Trip for overcurrent) Logic Scheme includes Weak Feed, Echo, and Current Reversal features. Directional overreaching instantaneous phase, ground, and negative-sequence elements are used for permissive tripping and blocking. Non-pilot, overreaching, directional time-overcurrrent elements are used for time delay backup protection. A suitable frequency-shift keying (FSK) transfer trip transceiver is required at both ends of the protected line.

This scheme is designed for 3-pole tripping and reclosing. Pilot reclosing, network reclosing (25 and 25VM), breaker failure protection, and switch on to fault (SOTF) protection are also so included in the scheme.

The following sub-sections describe the POTT Logic Scheme in detail. Refer to Section 4, *Protection and Control,* for internal logic descriptions of P85, SOTF, 50BF, and 52BT.

General

POTT is defined as permissive overreaching transfer trip scheme with non-pilot overreaching backup. The main application of this scheme is to provide primary and backup protection of network transmission facilities. An overreaching zone and P85 logic from the BE1-1051 are used in conjunction with suitable transfer trip communications equipment to provide high-speed pilot protection. Additionally, an overreaching non-pilot zone is used for backup protection. This scheme is ideally suited for applications where the cost associated with separate manufacturers' systems for primary and backup protection cannot be justified. This scheme can also be used to provide primary and backup protection of sub-transmission and network distribution facilities. For further information on the application of Permissive Overreaching Transfer Trip protection, consult the *IEEE Guide for Protective Relay Applications to Transmission Lines, IEEE Std C37.113-1999.*

The BE1-1051 used in this scheme has 3 independent levels of phase, ground, and negative-sequence directional overcurrent protection that can be set forward or reverse looking and has selectable polarizing quantities that include positive, negative, and zero-sequence voltage polarizing as well and zero-sequence current polarization.

Permissive Pilot Logic (P85) of the BE1-1051 is used in conjunction with phase, ground and negative-sequence overreaching zones and an external communications channel (FSK transfer trip equipment).

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This combination provides for a Permissive Overreaching Transfer Trip (POTT) scheme which is the subject of this logic scheme. A Non-pilot overreaching zone of the BE1-1051 is used to provide time delay backup protection. See Section 4, *Protection and Control,* for a detailed logic description.

A "switch on to fault" function is provided for applications where the 3-phase voltage for the BE1-1051 is derived from the line side of a circuit breaker. This element provides high-speed non-directional overcurrent protection for faults that occur when the breaker is first closed and no "memory voltage" is available to polarize the distance or directional OC elements. The element is only active for a preset (user selectable) amount of time after the breaker is closed, and is then defeated. See Section 4, *Protection and Control,* for a detailed logic description.

Breaker Failure protection is provided and includes security features such as a control timer, built in phase and ground OC fault detectors, and a fast reset 3-phase level detector. Breaker failure initiate can be derived from the internal BE1-1051 protection elements or externally through one of the relay's optically isolated inputs. At the same time the breaker failure timer starts, a circuit breaker re-trip signal is provided. The re-trip signal allows the user to apply a trip signal to the circuit breaker through an alternate path and possibly prevent a breaker failure operation. See Section 4, *Protection and Control,* for a detailed logic description.

The components of POTT logic are summarized in Tables 8-26, 8-27, 8-28, and 8-29. Diagrams of POTT logic are shown in Figures 8-14 and 8-15. Figure 8-16 shows a protection one-line drawing for the POTT logic scheme and Figure 8-17 shows a system one-line drawing of the application.

Pilot Tripping

Referring to the logic diagram, there are two independent paths for tripping. One path includes the high-speed pilot trip and the other includes the time delay non-pilot trip. Switch on to fault (SOTF) is also a high-speed trip but is "logically" isolated from the other trip to prevent it (SOTFT) from initiating an automatic circuit breaker reclose.

Trip outputs from the overreaching instantaneous directional overcurrents 150TP, N and Q provide the "Forward Trip" (FWD_TRIP) input for Permissive Pilot Logic (P85). This in conjunction with the receipt of a remotely initiated Transfer Trip Signal (P85RX) allows for a pilot trip output (P85T). At the same time, assuming there is no reverse block input (RVS_BLK), the P85 element provides an output (P85TX) that initiates a permissive transfer trip signal to the remote terminal. The receipt of this signal by the remote BE1-1051 P85 element will provide a remote pilot trip (P85T) output and trip the remote circuit breaker at the same time the local breaker is tripping.

High-speed pilot trips are connected to the external circuit breaker trip bus via Output 1 of the BE1-1051. The permissive transfer trip signal (P85X) is connected to a FSK transfer trip transmitter via Output 2. The output relays of the BE1-1051 are high-speed in that, upon initiation, they can close their contacts in ¼ cycle.

Pilot Block (Reverse Block)

The overreaching (forward looking) pilot tripping protection zone will see faults on the adjacent line. Therefore, a method for blocking trip for these faults must be employed. To accomplish this, protection elements of the BE1-1051 are set to identify this condition and provide the P85 element with a blocking input.

The reverse block input is derived from a second set of overreaching instantaneous directional overcurrents 50TP, N, and Q set to look in the reverse direction or behind the local terminal. Trip outputs from these elements provide the reverse blocking input (RVS_BLK) to the P85 element. This input blocks local and remote pilot tripping because the fault is not in the "tripping zone" as defined by the forward looking protection elements at both ends of the line.

To prevent unwanted operation of the overreaching tripping zones during current reversals, a reverse block dropout timer is included in the P85 logic. Depending on system flows during and after an external fault is cleared, the overreaching tripping elements may suddenly see enough current to trip. To prevent operation of the trip elements when the block input is removed, the reverse block dropout timer maintains the block condition for the duration of its timer setting. If the condition still exists after the dropout time has expired, both ends of the line are allowed to function as normal. A typical setting for the reverse block dropout timer is five cycles.

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Echo Transmit

A means must be provided to key the transmitter at an open breaker if tripping is to be initiated for faults seen by the remote terminal. To cover this situation, an Echo Transmit output is provided by the P85 element of the BE1-1051. The P85 element monitors the circuit breaker and determines when it is open. At the same time, the P85 element makes sure that no input signals from the forward or reverse protection elements are present. With these conditions met, and the receipt of a remote transfer trip signal by P85RX, the P85 element provides an echo transit output. As a result, an echo transmit signal is returned to the remote terminal where the closed breaker is allowed to trip and clear the fault via a pilot trip (P85T).

To insure proper coordination of the echo transmit feature with permissive receive, two timers are included in the P85 element. The first is an Echo Transmit Pickup Delay timer (Time Delay Pickup) which establishes the minimum time that a permissive signal must be received before initiating an echo transmit. The second timer, Echo Transmit Duration Timer, ensures sure that the signal is maintained for a fixed period of time after the initiate goes away (Time Delay Dropout). Typical setting for the Echo Transmit Pickup Delay timer is 2 cycles. The Echo Transmit Duration timer is typically set at 3.5 cycles.

When faults are cleared, the forward trip input immediately resets. To prevent an unwanted echo transmit during the transition between fault detect and non-fault detect, a Forward Trip Echo Block delay timer is used. When the forward trip input to the P85 element resets, the echo block time delay dropout timer is initiated and maintains a forward trip signal to the echo transmit circuit for the duration of the dropout timer setting, thus preventing operation of echo transmit.

Weak Feed Condition

There are applications where one end of a line has no or only a weak fault current source. Directional overcurrent protection at that end of the line cannot pickup and therefore cannot issue a trip command to the local breaker nor send any permissive signal to the remote end. For this condition, not even the strong source breaker could be tripped because no permissive signal would be received. This is known as a "Weak Feed Condition (WFC)."

For this condition, the BE1-1051 P85 element has a WFC input that is actuated by a phase undervoltage (27P) or residual voltage (59X). That is, under fault conditions, only a small voltage will appear at the weak-feed end of the line. Voltage collapse on the weak source end of the line is the result of high source impedance and is much more likely than on the strong source end of the line. This collapse is predictable and voltage elements can be set to detect the condition.

With no forward or reverse fault detect input signal at the P85 element, and receipt of a transfer trip signal from the remote end, and a "WFC" input, an "Echo Trip" output is initiated to trip the weak source breaker. At the same time, an echo transmit output is provided so that the remote terminal can also trip.

Non-Pilot Tripping (Backup)

Time delay non-pilot trips are provided by overreaching inverse time directional overcurrent elements 51P, N, and Q. These elements are set to see the remote end of adjacent lines to provide time delay overlapping backup protection. Intentional time delay is required for each of these elements so they coordinate with adjacent line protection schemes. High-speed and time delay trips are connected to the external circuit breaker trip bus via Output 1 of the BE1-1051.

Switch On To Fault Tripping

This logic provides tripping in the event that the breaker is closed into an existing zero-voltage bolted three-phase fault, such as occurs if the grounds were left on the line following maintenance. Using directional overcurrent alone is not always possible if the line side VT's are used since prefault voltage is not present at the distance element memory circuit. The SOFT function is only active for a preset (user selectable "Hold Timer") amount of time following breaker closure and is then defeated. A typical Hold Timer setting is 12 cycles or 200 ms.

Breaker Failure Tripping

In this example, High Speed and Time Delay Trips initiate breaker failure. Phase and Ground fault detectors internal to the 50BF element insure that fault current is flowing before allowing a breaker failure sequence to commence. For added security, a control timer (user settable) is included to supervise the breaker failure function. The control timer is used to create a "time window" during which a breaker failure operation can occur. Once that time has expired, a breaker failure operation can not occur until the initiate is removed. At the same time the breaker failure timer is started, a breaker "re-trip" output is generated

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from the 50BF element to try and trip the breaker one more time through a different path. A fast reset, 3-phase level detector insures timely shutdown of the breaker failure timer for a normal fault clearing operations. Breaker failure trip is connected to an external lockout device (86) via Output 4 of the BE1-1051 and breaker re-trip is connected to an alternate circuit breaker trip path via Output 5.

Reclosing

Referring to the logic diagram, there are two independent Reclose Initiate Paths for this application. Trips that are defined as high-speed (except SOTF) initiate reclose through the Pilot Initiate (PI) input of the Reclosing (79) element. Time delay trips and all but the initial HS trip, initiate reclose through the Reclose Initiate input of the 79 element. In this logic example, pilot initiate is intended to generate an "Instantaneous Reclose" (79P) after a high-speed trip. Therefore, the pilot time setting is minimum or 0.1 seconds (6 cycles). This reclose has no condition other than breaker status and pilot initiate.

The reclose initiate path (RI) is used to provide up to three time delay recloses (79C) in this application. The recloses are conditional in that circuit breaker reclose attempts are made only after satisfying an angle difference setting between a hot bus and a hot line (Sync Check 25), or satisfying specific voltage conditions selected by the user (Voltage Check 25VM HB-DL, DB-HL, DB-DL). Externally initiated recloses (PI or RI) are made possible through use of the relay's optically isolated inputs IN3 and IN4. Reclose attempts are applied to the external circuit breaker close path via Output 3 of the BE1-1051.

Alarms

If the continuous self-test diagnostics of the relay detect an error, failsafe output contact OUTA will close and the Relay Trouble LED of the HMI will light. OUTA will also close if relay operating power is lost. More information about alarms is provided in Section 6, *Reporting and Alarm Functions.*

Output OUT6 which has a normally open and normally closed contact is assigned to indicate user specified Major or Minor 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.*

Table 8-26. POTT Contact Sensing Input Logic

Input	Purpose	Name Label	State Labels	
			Energized	De-Energized
IN1	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	Reclosing Drive to Lockout. Drives recloser to lockout when external switch is turned off. Contact from external switch must be closed in the Off position, open in the On.	REC_OFF	OFF	ON
IN3	External time delay reclose initiate. TRUE when RI is high.	EXT_RI	ACTIVE	NORMAL
IN4	N/A	INPUT_4	TRUE	FALSE
IN5	Transfer trip receive.	TT_REC	TT_REC	NORMAL
IN6	Pilot Trip OFF. Blocks Pilot Trip when external switch is OFF. Contact from external switch must be closed in the Off position, open in the On.	PILT_OFF	OFF	ON
IN7	N/A	INPUT_7	TRUE	FALSE
IN8	N/A	INPUT_8	TRUE	FALSE

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Table 8-27. POTT Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
67PT	Directional timed phase overcurrent protection, overreaching non-pilot.	0	1 (enabled)
67NT	Directional timed neutral overcurrent protection, overreaching non-pilot.	0	1 (enabled)
67QT	Directional timed negative-sequence overcurrent protection, overreaching non-pilot.	0	1 (enabled)
167PT	Directional instantaneous phase overcurrent protection, underreaching non-pilot.	0	1 (enabled)
167NT	Directional instantaneous neutral overcurrent protection, underreaching non-pilot.	0	1 (enabled)
167QT	Directional instantaneous negative-sequence overcurrent protection, underreaching non-pilot.	0	1 (enabled)
267PT	Directional instantaneous phase overcurrent protection, pilot overreaching forward trip supervision.	0	1 (enabled)
267NT	Directional instantaneous neutral overcurrent protection, pilot overreaching forward trip supervision.	0	1 (enabled)
267QT	Directional instantaneous negative-sequence overcurrent protection, pilot overreaching forward trip supervision.	0	1 (enabled)
25	Sync check and voltage conditions.	0	1 (enabled)
27P	Weak Feed Condition.	0	1 (enabled)
79	*Reclose Initiate Logic:* Initiate when Reclose Initiate Expression is TRUE.	VO7+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	
	Block/Drive to Lockout Logic: Drive recloser to lockout when recloser drive to lockout expression is TRUE.	IN2	
	Pilot Initiate (PI) Logic: If the recloser is in the reset state upon receiving a *Pilot Initiate* input signal, the reclose logic issues a pilot reclose output (79P) after the programmed time delay.	0	
50BF	Breaker Failure timer starts when all 3 of the following occur: • Phase or neutral fault detect threshold is exceeded. • There is a protective relay trip input *(BFI50 Logic)*. • The 3-phase current detector senses current above 5% of nominal.	VO10	1 (enabled)
	BLK Logic: Disabled the 50BF function when TRUE.	VO15	
52BT	Used by SOTF for recognition that breaker is closed AND fault current is flowing.	0	1 (enabled) for breaker status; 0 (disabled) for 27 3P

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Function	Purpose	BESTlogic Expression	Mode Setting
P85	*FWD Trip Logic:* Forward Trip Supervision.	VO9	1 (enabled)
	REV TBLK Logic: Reverse Block Supervision.	VO10	
	85RX Logic: Transfer Trip Receive.	IN5	
	WFC Logic: Weak Feed Condition.	27PPU	
SOTF	Used for switch on to fault protection.	0	1 (enabled)
GROUP	*Input 0 Logic:* No manual selection logic is used.	0	1 (Discrete Input Selection)
	Input 1 Logic: No manual selection logic is used.	0	
	Input 2 Logic: No manual selection logic is used.	0	
	Input 3 Logic: No manual selection logic is used.	0	
	Auto/Manual Logic: Disable automatic selection when set to 0. Set to 1 to enable automatic selection.	/0	

Table 8-28. POTT Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				True	False
43	N/A	0 (disabled)	SWITCH_43	CLOSED	OPEN
143	N/A	0 (disabled)	SWITCH_143	CLOSED	OPEN
243	N/A	0 (disabled)	SWITCH_243	CLOSED	OPEN
343	N/A	0 (disabled)	SWITCH_343	CLOSED	OPEN
443	N/A	0 (disabled)	SWITCH_443	CLOSED	OPEN
101	N/A	0 (disabled)	N/A	N/A	N/A

Table 8-29. POTT Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				True	False
VOA (OUTA)	Alarm Output Contact.	Alarm contact closes/opens (refer to style number) automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Contact.	Contact closes when VO15 or SOTFT or VO13 or P85ET is TRUE.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=VO13+VO15+SOTFT+P85ET					
VO2 (OUT2)	Key Transfer Trip Transmitter.	Contact closes when P85TX or P85ETX logic expression is TRUE.	TT_TX	TRANS	NORMAL
BESTlogic Expression: VO2=P85TX+P85ETX					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO3 (OUT3)	Breaker Close Contact.	Close breaker when Pilot or 25 or 25VM are TRUE.	BKR_CLO	CLOSE	NORMAL
BESTlogic Expression: VO3=79P+VO16+VO17					
VO4 (OUT4)	Breaker Failure Trip.	Local backup protection if primary does not clear a fault. Based on breaker position and fault detector picked up. Contact closes when BFT is TRUE.	BF_TRIP	TRIP	NORMAL
BESTlogic Expression: VO4=BFT					
VO5 (OUT5)	Breaker Failure Re-Trip.	Final attempt to trip breaker through different path, prior to BFT. Contact closes when BFRT is TRUE.	BF_RTRP	TRIP	NORMAL
BESTlogic Expression: VO5=BFRT					
VO6 (OUT6)	Alarms.	Contact closes or opens for Minor or Major alarms.	MIN_MAJ	ACTIVE	NORMAL
BESTlogic Expression: VO6=ALMMAJ+ALMMIN					
VO7	High Speed Reclose Initiate (PI).	TRUE when any HS protective element trips or when the external pilot initiate input is TRUE.	PI_INI	PI_INI	NORMAL
BESTlogic Expression: VO7=IN4+VO10					
VO8	Time Delay Reclose Initiate (RI).	TRUE when any TD protective element trips or when the external reclose initiate input is TRUE, or HS protective element trip after first PI reclose.	RI_INI	RI_INI	NORMAL
BESTlogic Expression: VO8=IN3+VO7+VO9					
VO9	Pilot Forward Trip Supervision.	TRUE when any forward Overreaching Pilot protective element trip is TRUE.	PORFFD	TRIP	NORMAL
BESTlogic Expression: VO9=150TPT+150TNT+150TQT					
VO10	Pilot Reverse Block Supervision.	TRUE when either reverse Overreaching Pilot protective element trip is TRUE.	PORRFD	TRIP	NORMAL
BESTlogic Expression: VO10=50TPT+50TNT+50TQT					
VO11	Protective trip.	TRUE when any protective element trips. (Input to SB Logic tripped.)	PRT_TRP	TRIP	NORMAL
BESTlogic Expression: VO11=BFT+P85T+P85ET+SOFT+VO15					

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Output	Purpose	Description	Label	State Labels	
				True	False
VO12	Protection Picked Up.	TRUE when any protective element picks up. (Input to SB Logic Pickup.)	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+50TNPU+50TQPU+150TPPU+150TNPU+150TQPU+51PPU+51NPU+51QPU+27PPU+BFT+SOTFT+IN5+VO9+VO10					
VO13	Pilot Trip.	TRUE when P85T picks up.	PILOT_TR	TRIP	NORMAL
BESTlogic Expression: VO13=P85T					
VO14	Alarm when HS trip OFF.	TRUE when IN6 is high.	HST_OFF	OFF	NORMAL
BESTlogic Expression: VO14=IN6					
VO15	Non-Pilot Trip.	TRUE when non-pilot Ov Re TD protective elements are picked up.	NON_PIL	TRIP	NORMAL
BESTlogic Expression: VO15=51PT+51NT+51QT					
VO16	Synch Check Close.	TRUE when 25 and 79C are TRUE.	25_CLOSE	ACTIVE	NORMAL
BESTlogic Expression: VO16=25+79C					
VO17	Voltage Condition Close.	TRUE when 25VM and 79C are TRUE.	25VM_CL	ACTIVE	NORMAL
BESTlogic Expression: VO17=25VM+79C					

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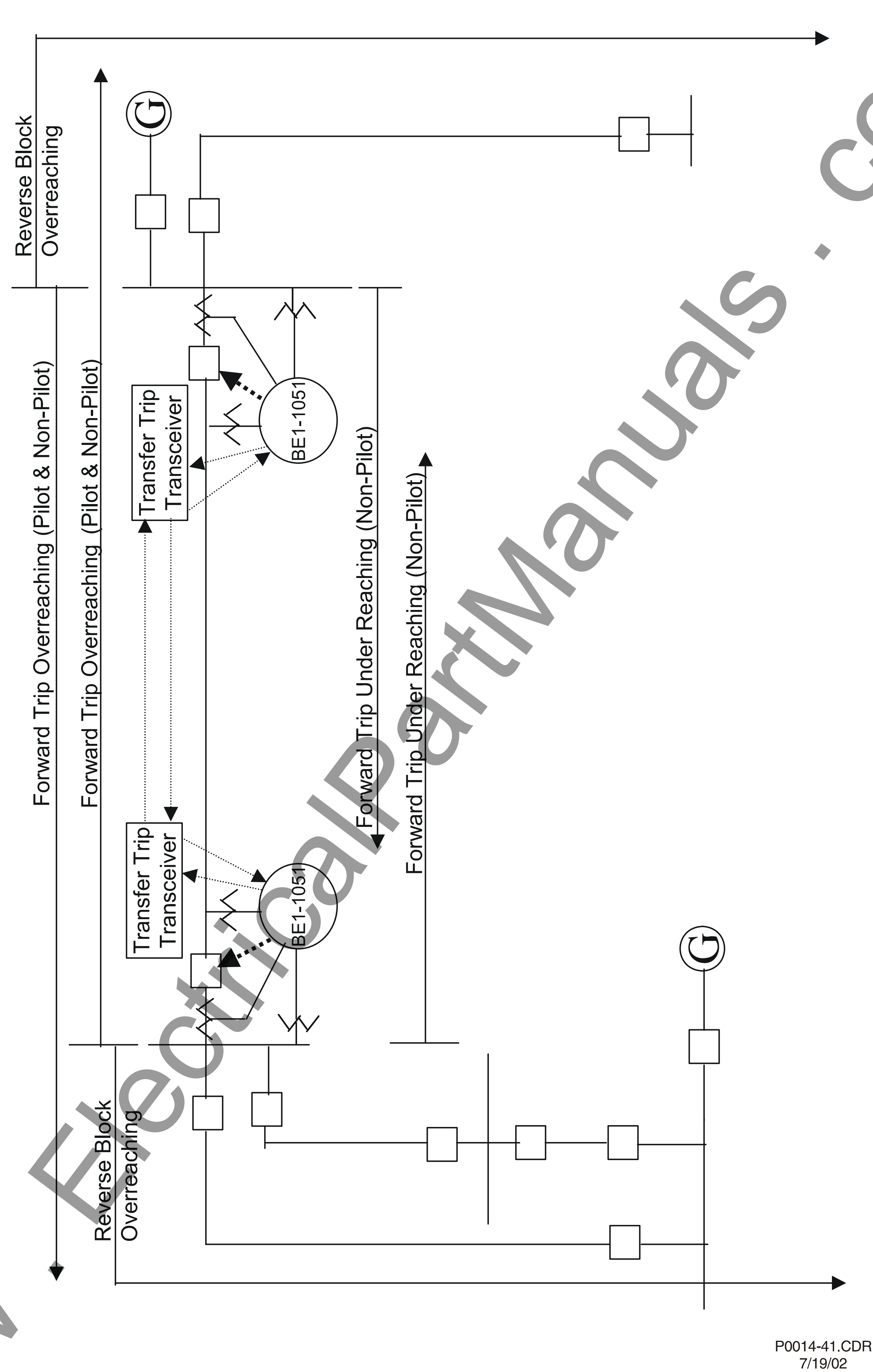

Figure 8-14. Permissive Overreaching Transfer Trip (POTT) with Non-Pilot Overreaching Backup

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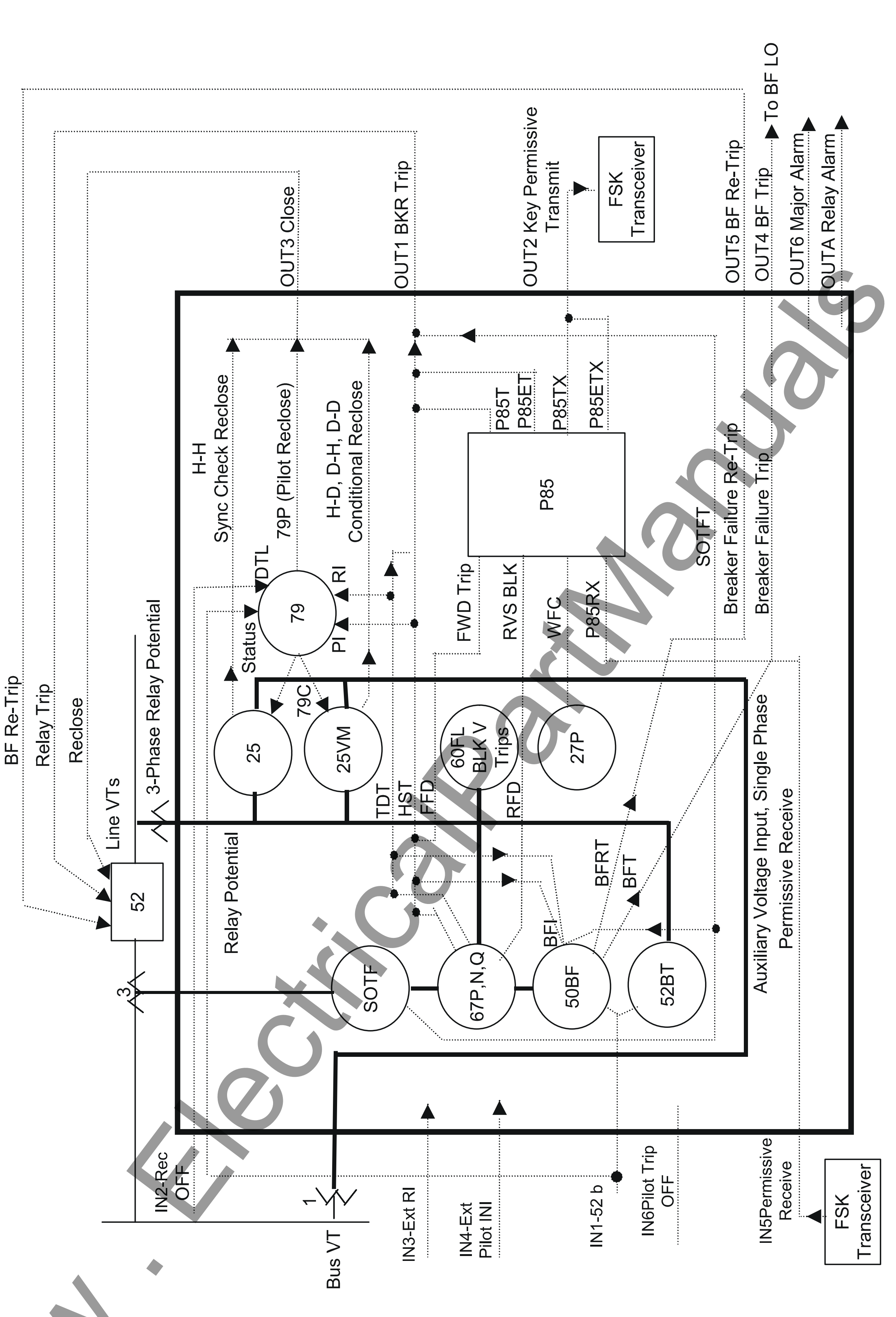

Figure 8-15. Permissive Overreaching Transfer Trip (POTT) with Non-Pilot Overreaching Backup

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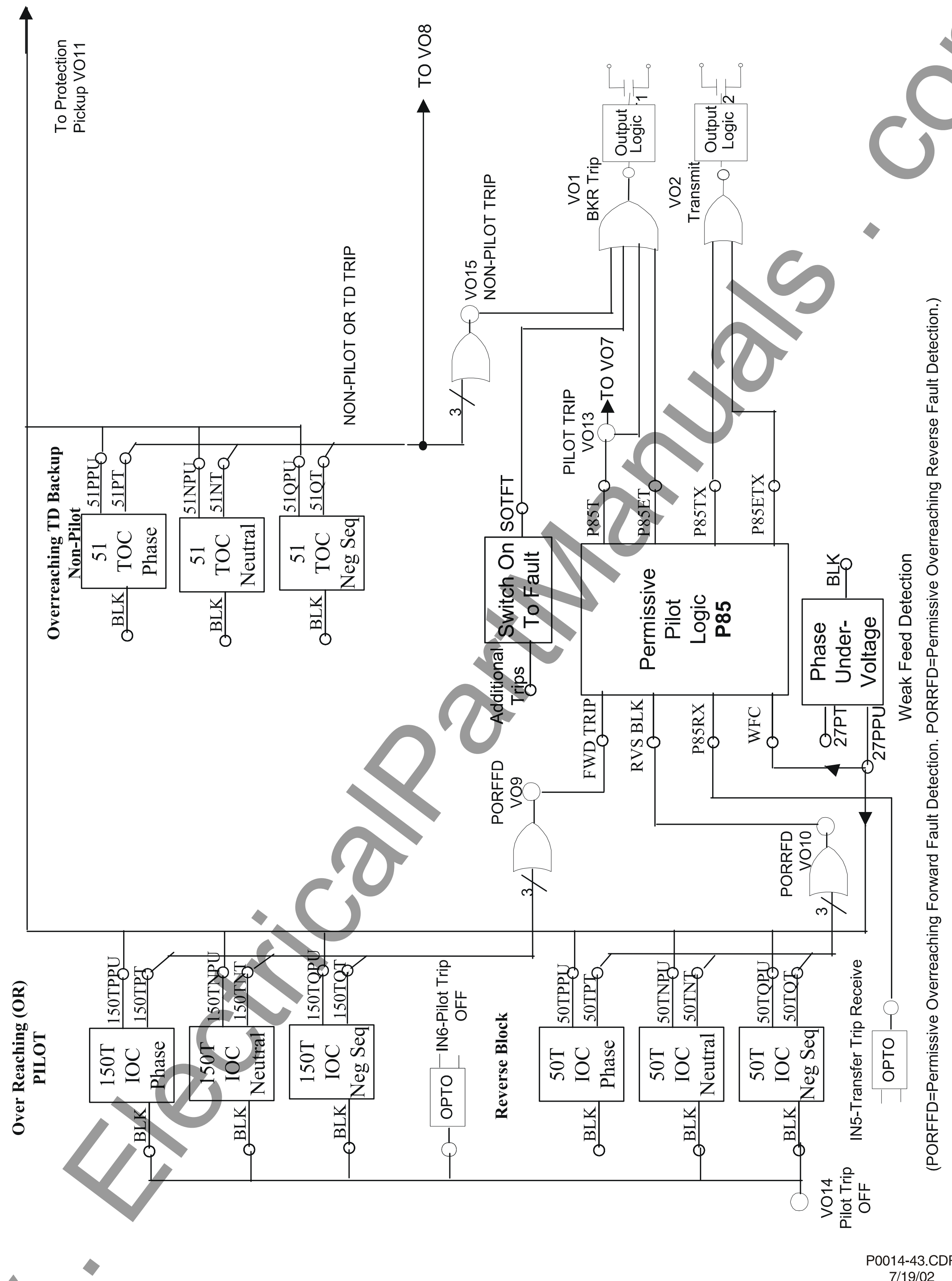

Figure 8-16. Permissive Overreaching Transfer Trip (POTT)
with Non-Pilot Overreaching Backup (1 of 2)

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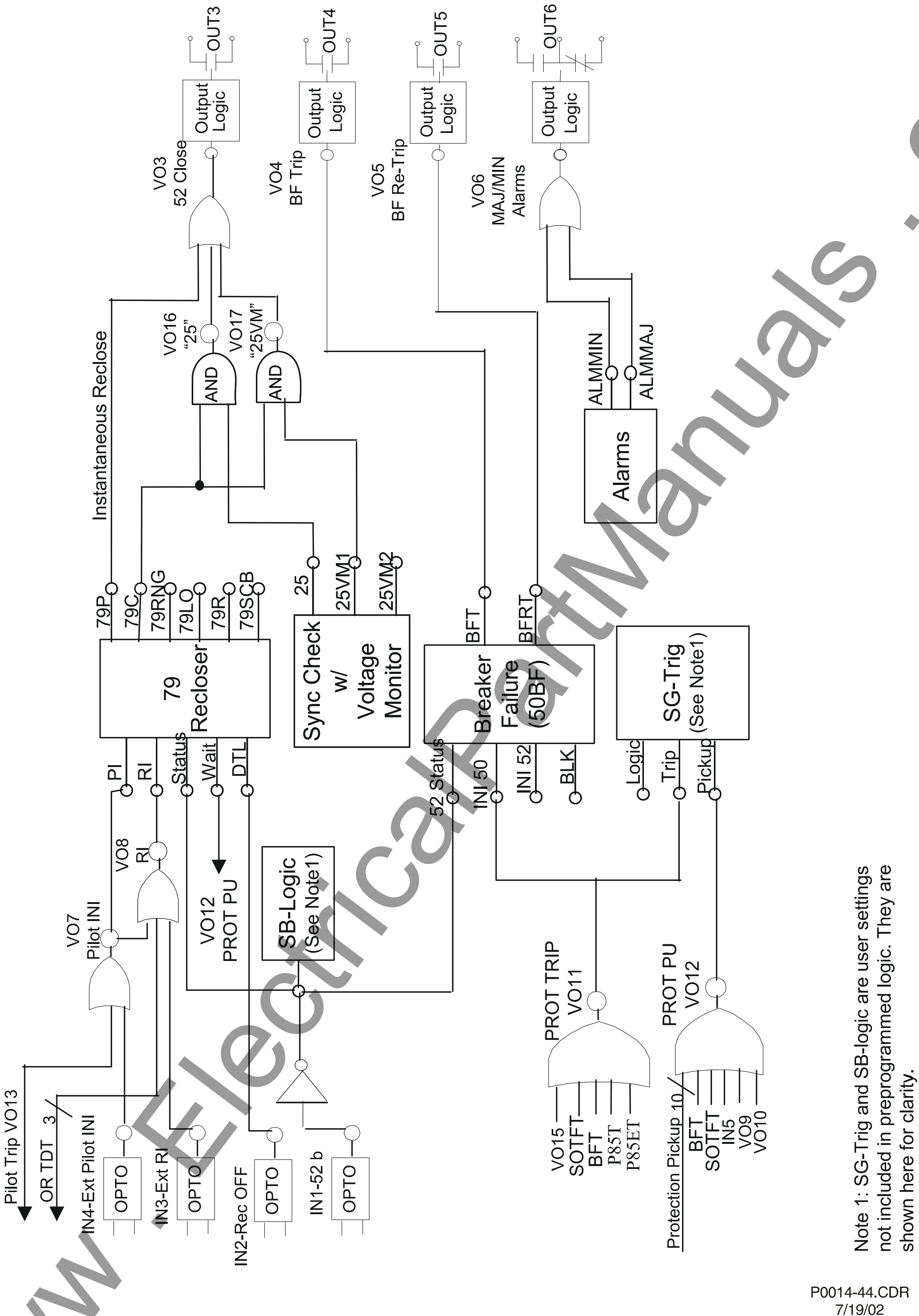

Figure 8-17. Permissive Overreaching Transfer Trip (POTT) with Non-Pilot Overreaching Backup (2 of 2)

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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 are 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 8-18 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

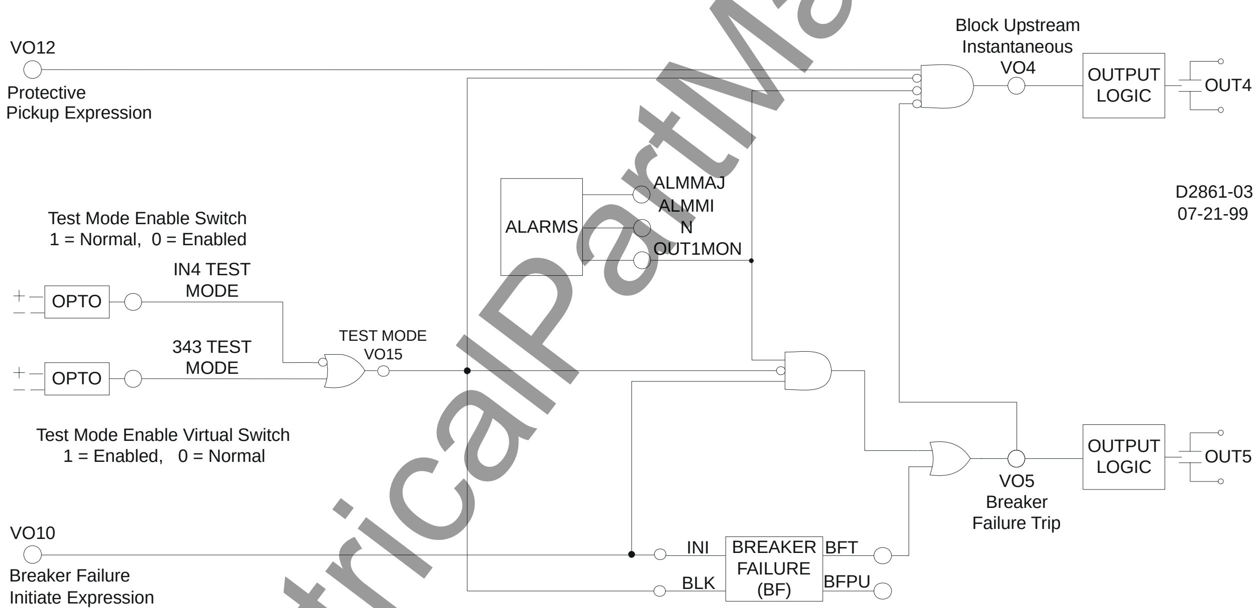

Figure 8-18. Trip Circuit Continuity and Voltage Monitor

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 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 BE1-1051 is used for overcurrent protection of a radial transformer shown in Figure 8-19, *Station One-Line Drawing*. The user wants to trip and lockout the high side circuit switcher for an overcurrent trip.

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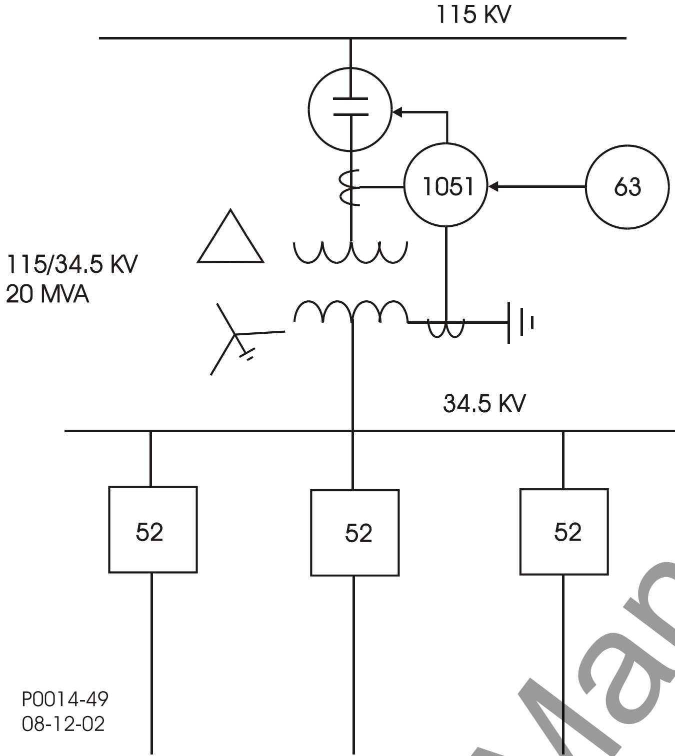

Figure 8-19. Station One-Line Drawing

Referring to Figure 8-20, a 51 or 151 trip will causeVO11 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 *Targets* screen per the automatic display priority function. When the operator presses the reset key while the LCD display is on the *Targets* 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*.

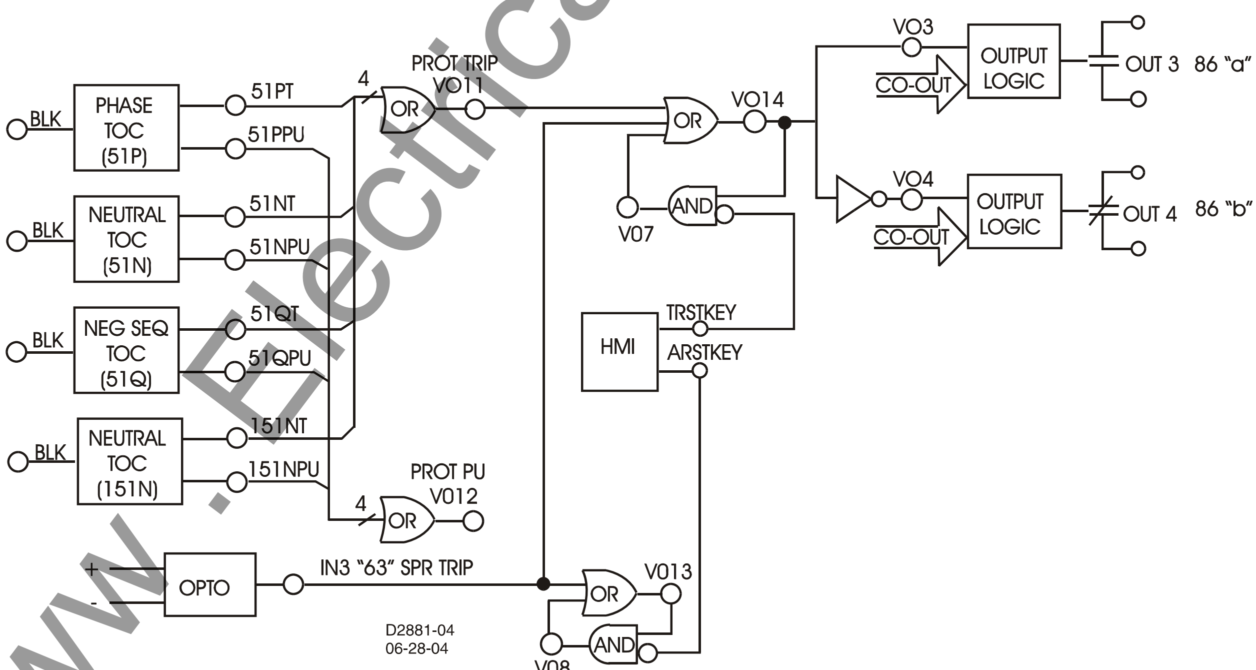

Figure 8-20. Transformer Protection Output Latch, ARSTKEY and TRSTKEY

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Logic Settings and Equations for ARSTKEY and TRSTKEY

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=0,0,0,0,0,0
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-50BF=0,0,0,0,0
SL-GROUP=0,0,0,0,0,0
SL-43=0
SL-143=0
SL-243=0
SL-343=0
SL-443=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+VO7
SL-VO15=0
SL-VO16=0
SL-VO17=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*.

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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 8-20, 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 *Alarms* 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 *Alarms* 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.

Under Frequency 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 under frequency 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 BE1-1051 is not available on every circuit or user philosophy requires a bus level installation, the BE1-1051 can also be applied for bus level under frequency protection.

The BE1-1051 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 BE1-1051 (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 in Section 8, *Application*.

Referring to Figure 8-21, 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 BE1-1051 verifies that the following conditions are met prior to restoring load:

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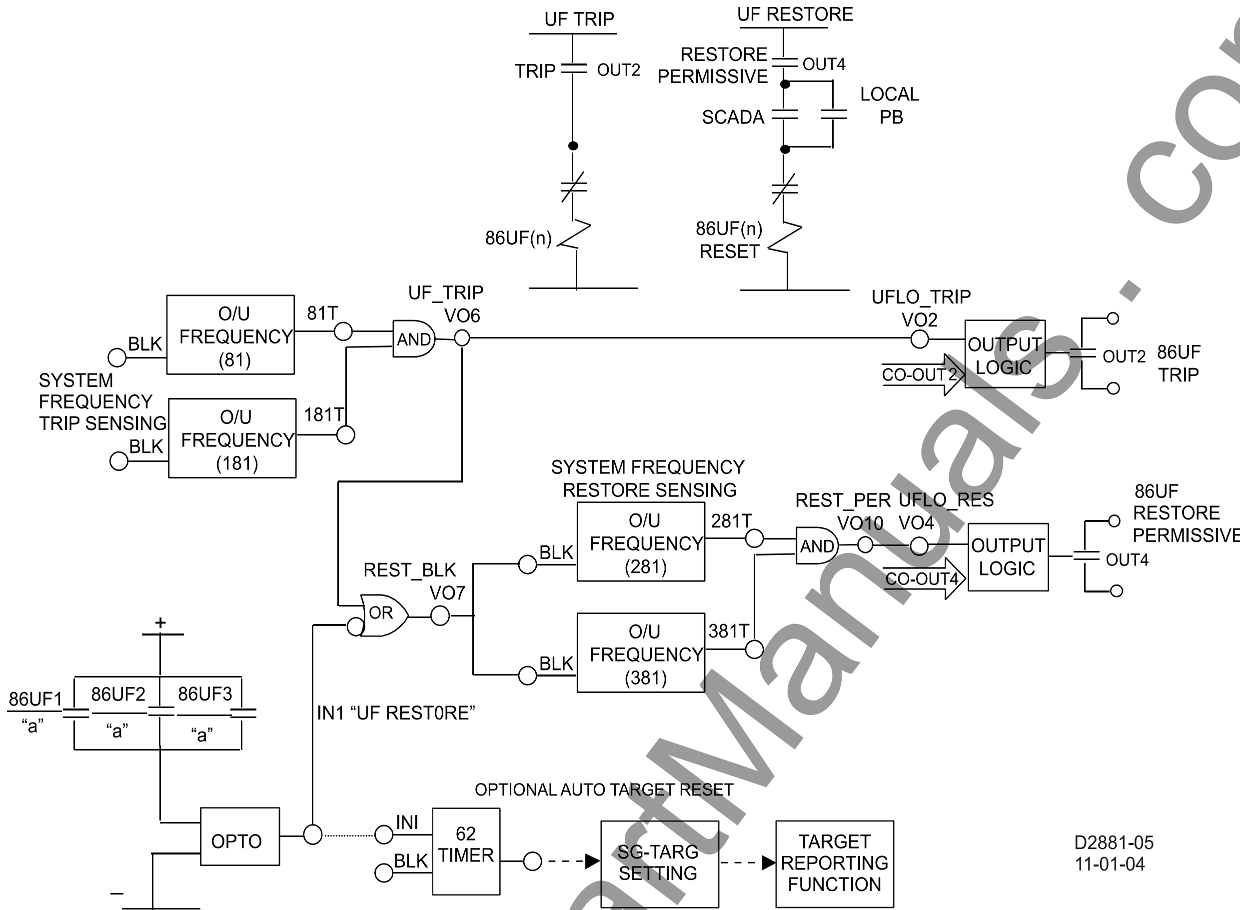

Figure 8-21. Underfrequency Load Shed Bus Level Application

<u>*Conditions*</u>

- The under frequency trip (81T 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 (281T and 381T).

The first two conditions must be met to remove REST_BLK from the 281T and 381T over frequency elements. Then, with sensing voltage above the inhibit setting of 281T and 381T and the system frequency above the 281T and 381T setting, VO10 (REST_PER) will go high forcing VO4, UFLO_RES high, closing Output 4 contact. As long as these conditions remain unchanged the output 4 contact will remain closed. When the last 86UF (electrical reset lockout relay) is reset, Input 1, UF_RESTORE will go low, blocking the 281T and 381T elements. Also, VO4 will go low, opening Output 4 contact, 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 BE1-1051 targets and Trip LED via "logic" input to the Target Reset Logic. (See Section 6, *Reporting and Alarm Functions*). Fault and Event records detailing the operation are available from the relay.

<u>*Circuit Level Application - Manual and Auto Reclosing*</u>

The following logic was designed to work with the preprogrammed OC-W-79 Logic Scheme described in Section 8, *Application*.

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.

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Referring to Figure 8-22, if sensing voltage is above the inhibit setting of the under frequency elements 81T and 181T and system frequency is below the 81T 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 281T and 381T over frequency 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.

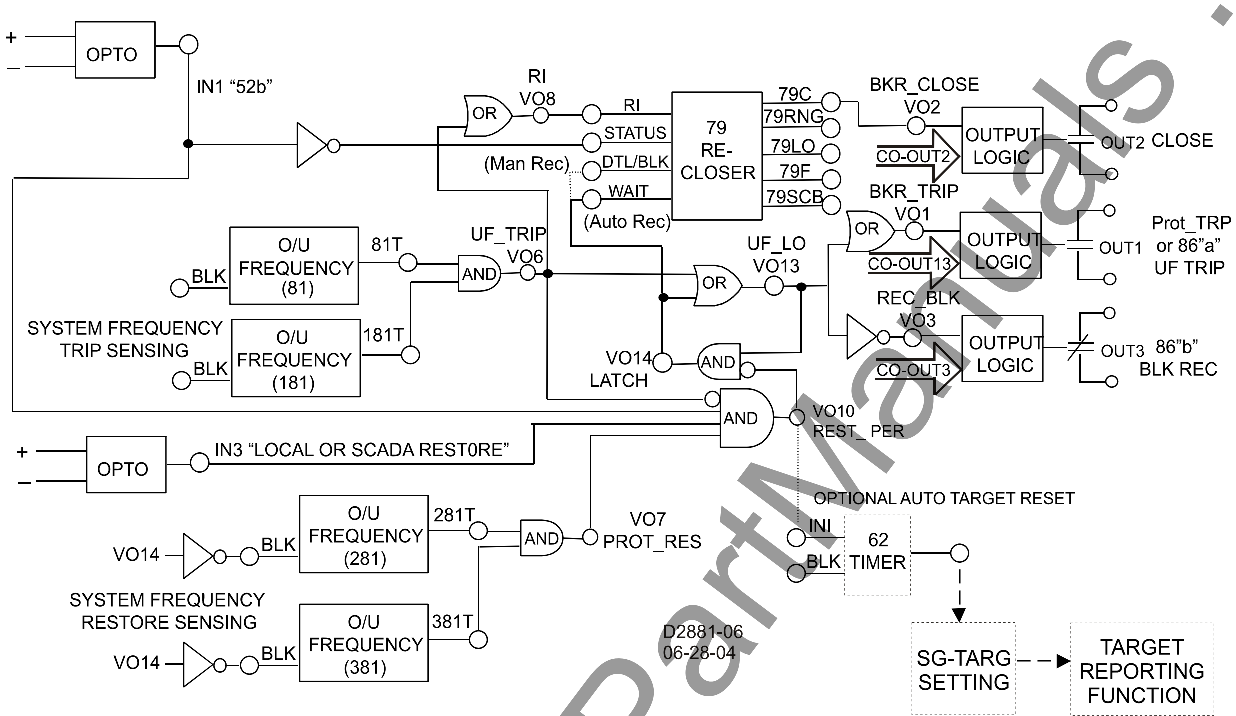

Figure 8-22. Underfrequency Load Shed, Circuit Level Application, Manual or Auto Close from SCADA or Local Restore

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 BE1-1051 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 (281T 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 1 and Output 3 contacts. 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 BE1-1051 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 BE1-951 targets and Trip LED via "logic" input to the Target Reset Logic (see Section 6, *Reporting and Alarm Functions*). Fault and Event records detailing the operation are available from the relay.

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BE1-1051 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, Section 8, *Application*, 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-81=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=0,0,0,0,0,0
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-50BF=0,0,0,0,0
SL-GROUP=2,IN3,0,0,0,0
SL-43=0
SL-143=0
SL-243=0
SL-343=2
SL-443=0
SL-101=0

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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
SL-VO16=0
SL-VO17=0

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, Section 8, *Application*, 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-81=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

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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+/IN2,0
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-50BF=0,0,0,0,0
SL-GROUP=1,0,0,0,0,/0
SL-43=0
SL-143=0
SL-243=0
SL-343=0
SL-443=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
SL-VO16=0
SL-VO17=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 8-23. 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.

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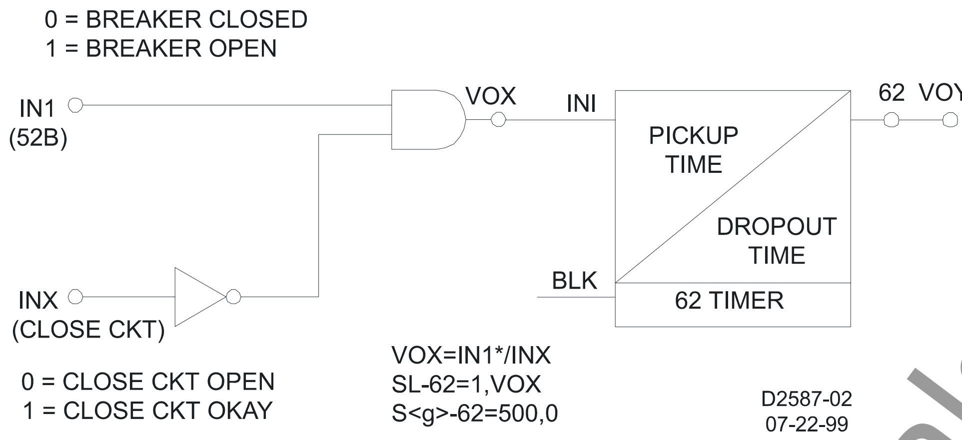

Figure 8-23. Close Circuit Monitor Logic

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 8-24 illustrates this high-speed reclose interlock logic scheme.

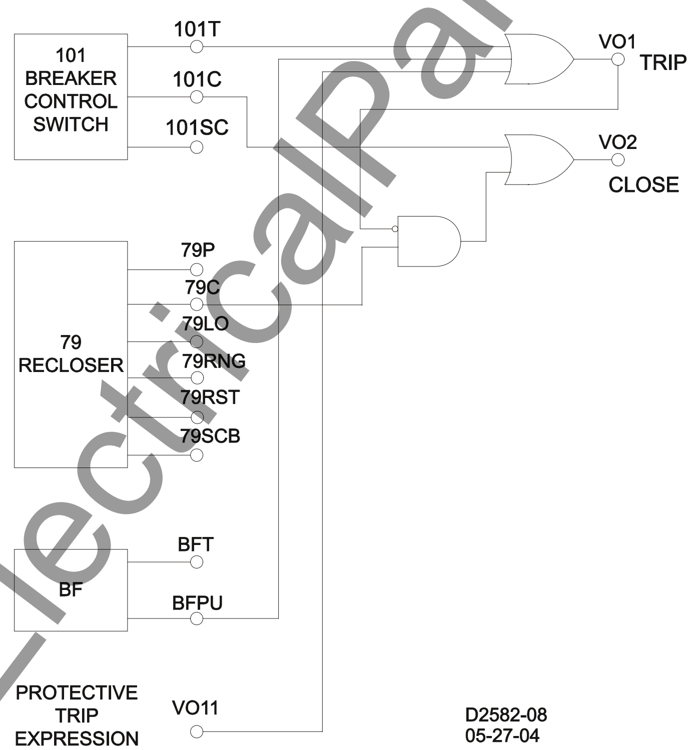

Figure 8-24. High-Speed Reclose Interlock Logic

Example 1. Close Expression: SL-VO2=79C*/VO1+101C

Example 2. Hold Disable Setting: SG-HOLD1=0

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 BE1-1051 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 BE1-1051 Overcurrent 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 multifunction 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, Setting 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, Setting 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.

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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 8-25 illustrates the seal-in logic diagram.

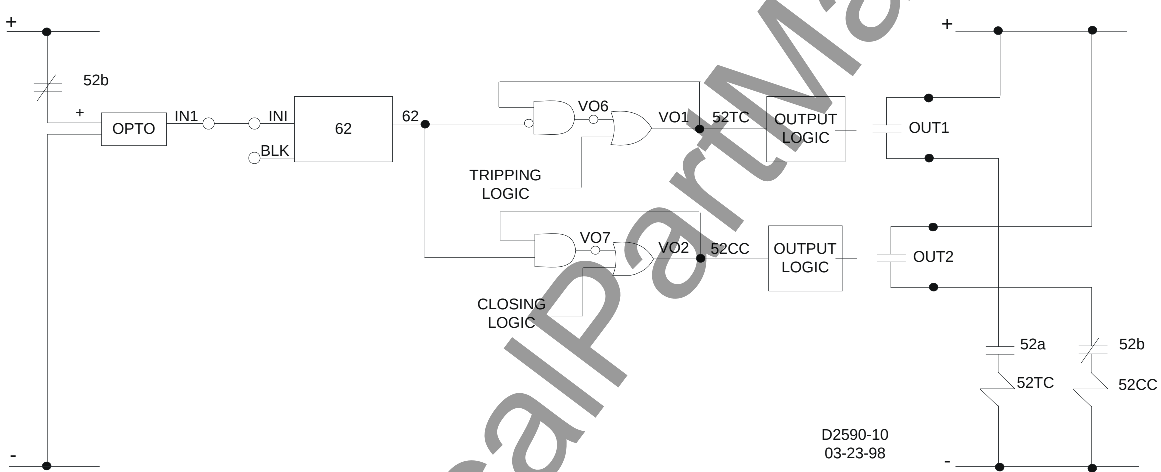

Figure 8-25. Output Seal-In Logic Diagram

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. BE1-1051 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 rear 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 COM1, then users at other areas (COM0, front panel HMI, and COM2) will not be able to gain write access until the user at COM1 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).

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 *Security* tab. Refer to Figure 9-1.

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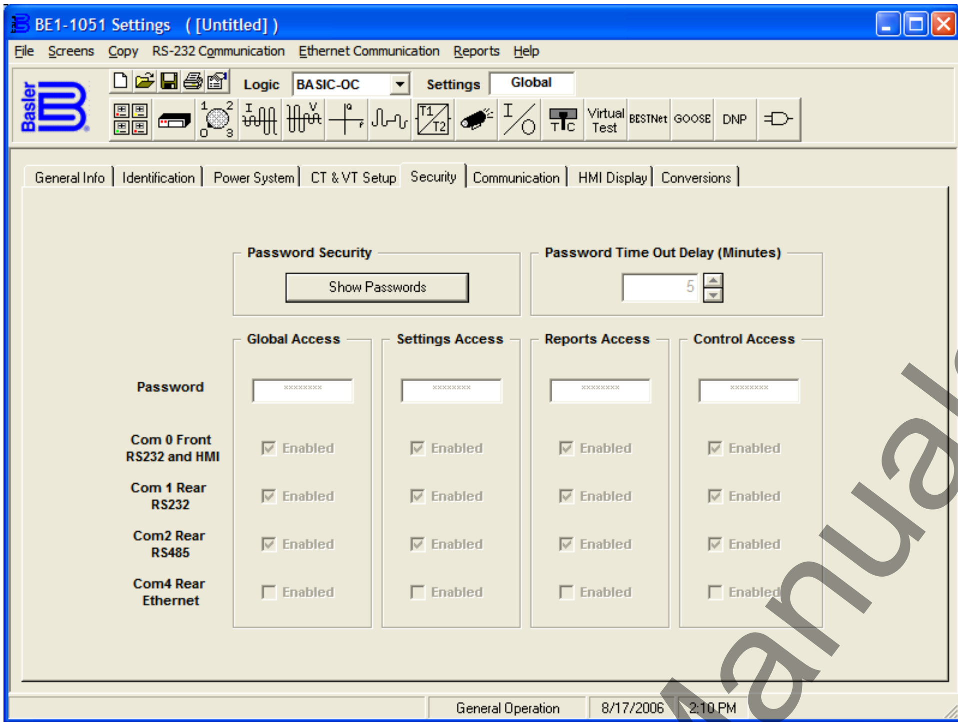

Figure 9-1. General Operation Screen, Security Tab

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 RS232 and HMI, COM 1 Rear RS232, COM 2 Rear 485, and COM 4 Rear Ethernet. Access levels may also be enabled for multiple ports.

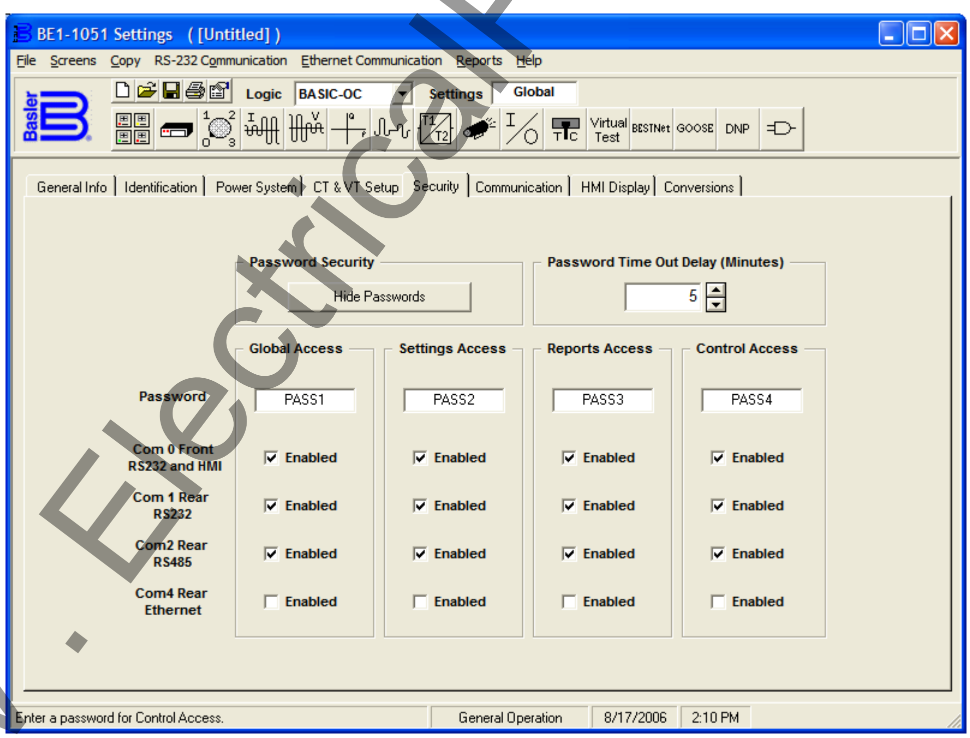

Figure 9-2. General Operation, Global Security Tab with Passwords Shown

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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 RS-232 port 2 = Rear RS-485 port 4 = Rear Ethernet port
Password Time-Out Delay	Amount of time write access is available after a password has been entered. The range is selectable between 1 and 1,440 minutes.

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SECTION 10 • HUMAN-MACHINE INTERFACE

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SECTION 10 • HUMAN-MACHINE INTERFACE

INTRODUCTION

This section describes the BE1-1051 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 BE1-1051 in horizontal-mount MX case. Table 10-1, describes each HMI component. Vertical mount style relays have the same HMI components with a different layout.

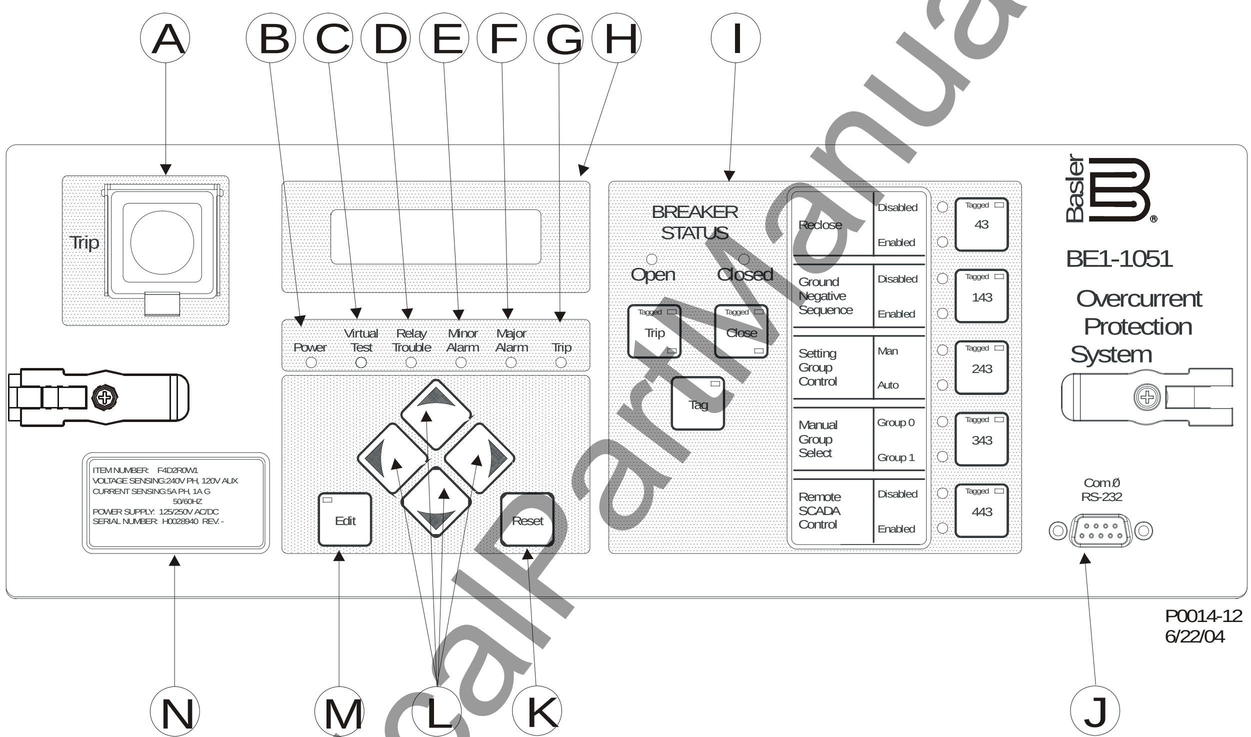

Figure 10-1. Front Panel, Horizontal-Mount MX Case

Table 10-1. Front Panel HMI Descriptions

Locator	Description
A	*Optional Emergency Trip Button* – Hardwired across the OUT1 terminals to provide the means to trip the circuit breaker should the relay not be operating. The switch has a clear cover to prevent accidental actuation.
B	*Power Indicator* – This green LED lights when operating power is applied to the relay.
C	*Virtual Test Indicator* – LED that illuminates to indicate the virtual test switch has been enabled.
D	*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.
E, F	*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.

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Locator	Description
G	*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.
H	*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.
I	*Optional Virtual Access Control Panel* – This panel allows for user access to the virtual control switches from the front panel HMI.
J	*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.
K	*Reset Pushbutton* – Pushing this switch will reset the Trip LED, sealed-in Trip Targets, Peak Demand Currents, and Alarms.
L	*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.
M	*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.
N	*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.

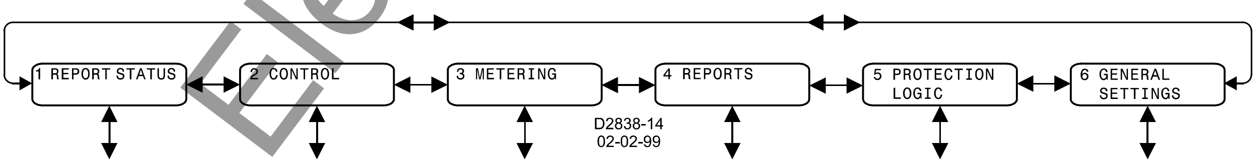

Figure 10-2. Menu Tree Branches

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.

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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 Figure 10-6 and Figure 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.

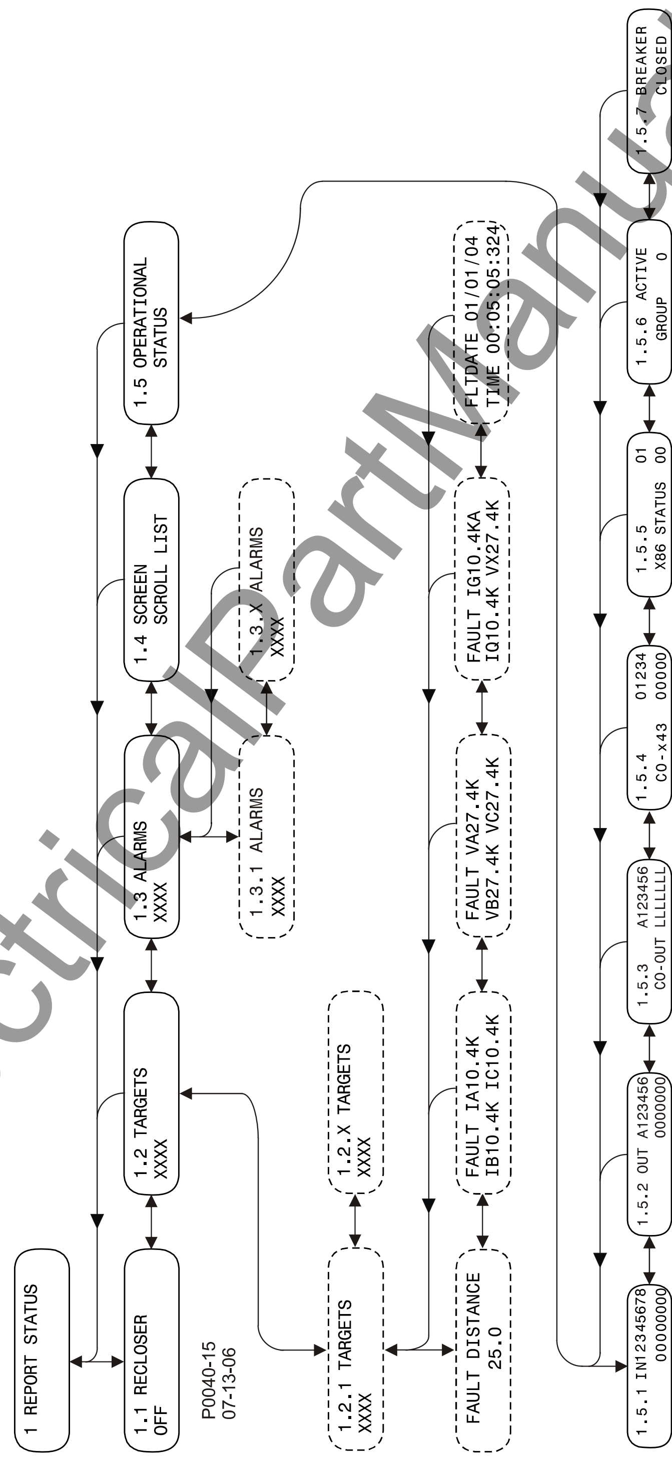

Figure 10-3. Report Status Menu Branch

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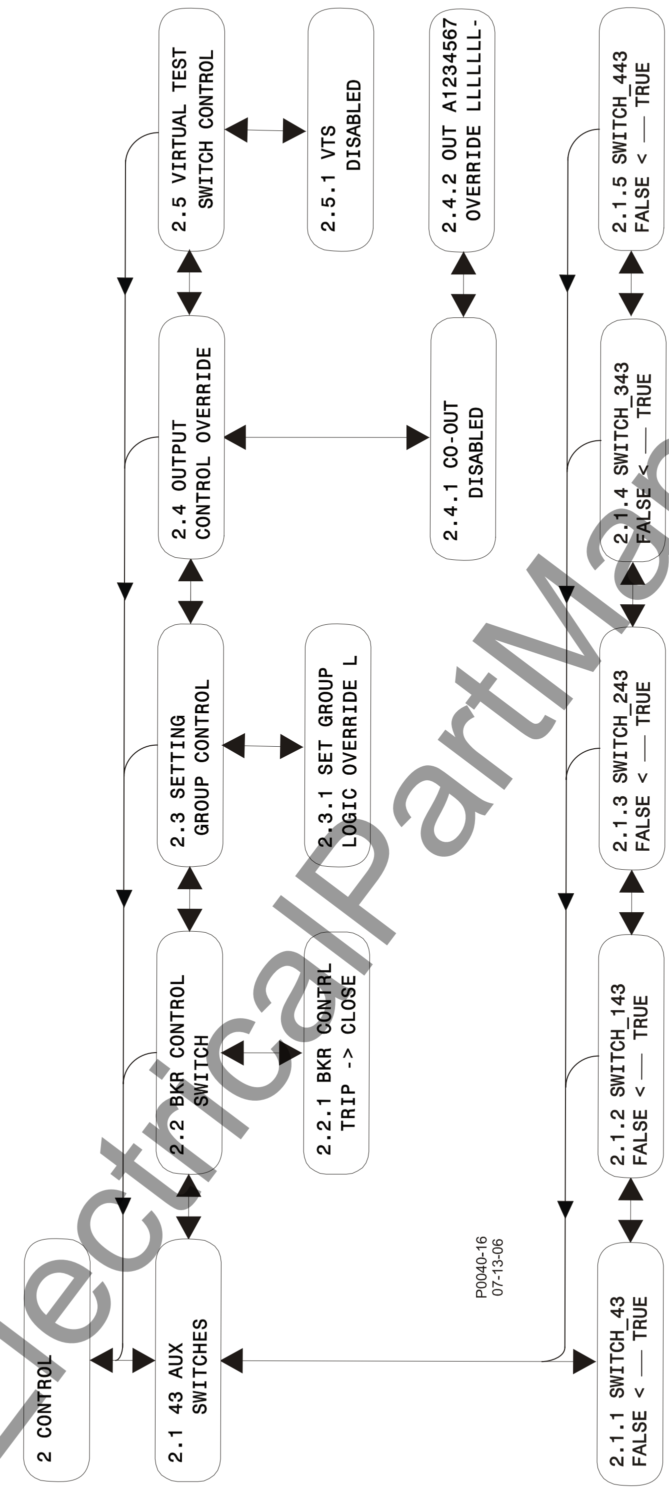

Figure 10-4. Control Menu Branch Structure

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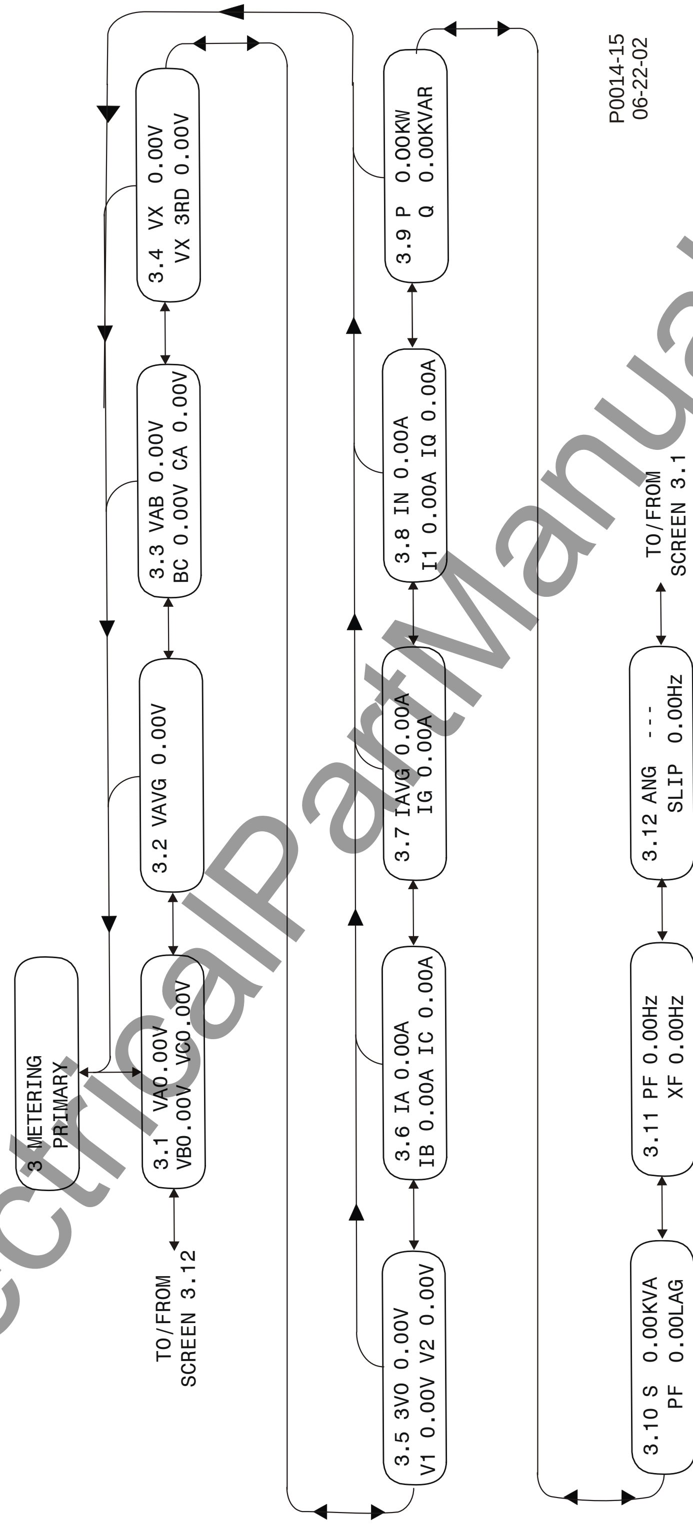

Figure 10-5. Metering Menu Branch Structure

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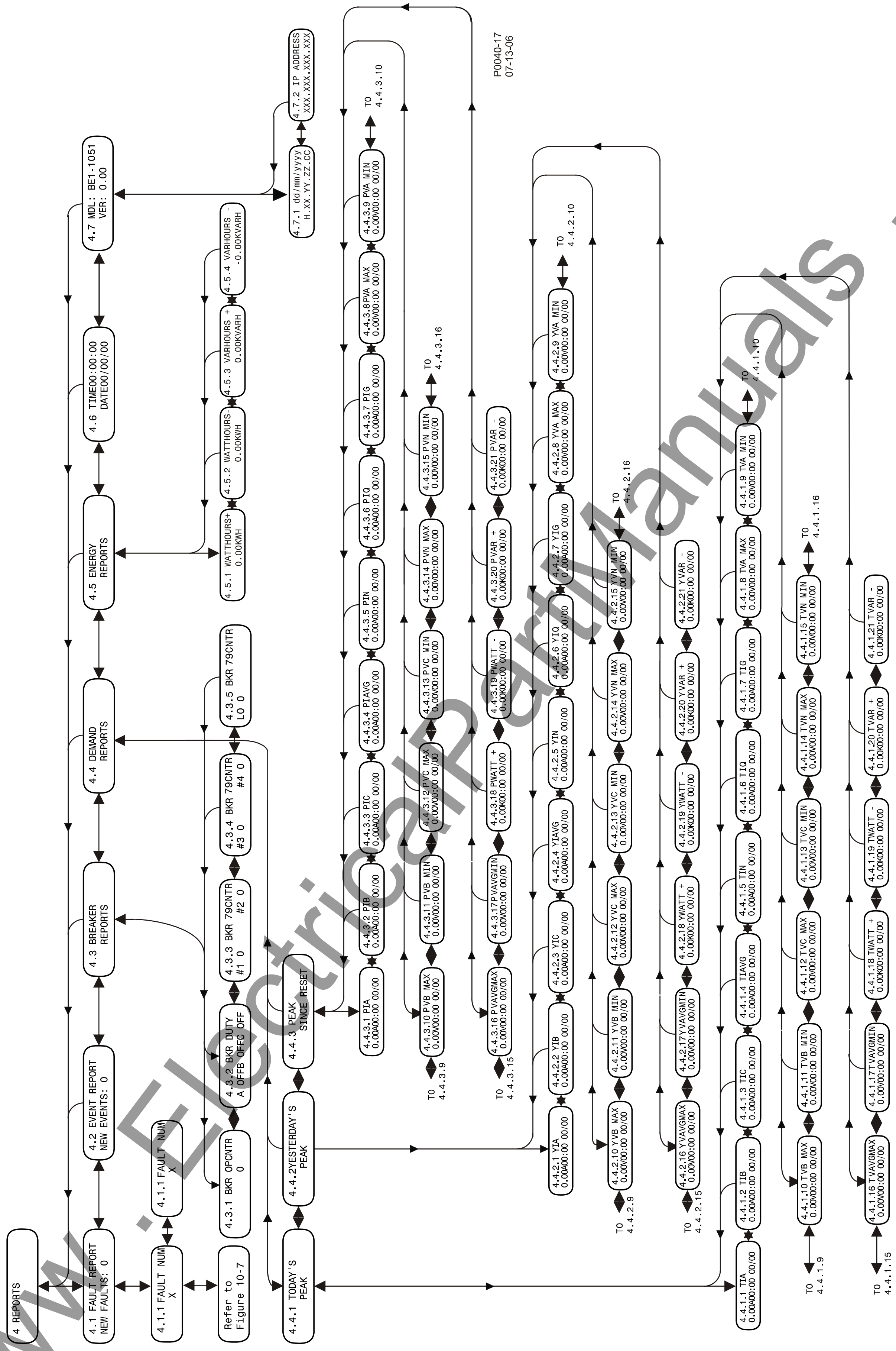

Figure 10-6. Reports Menu Branch Structure

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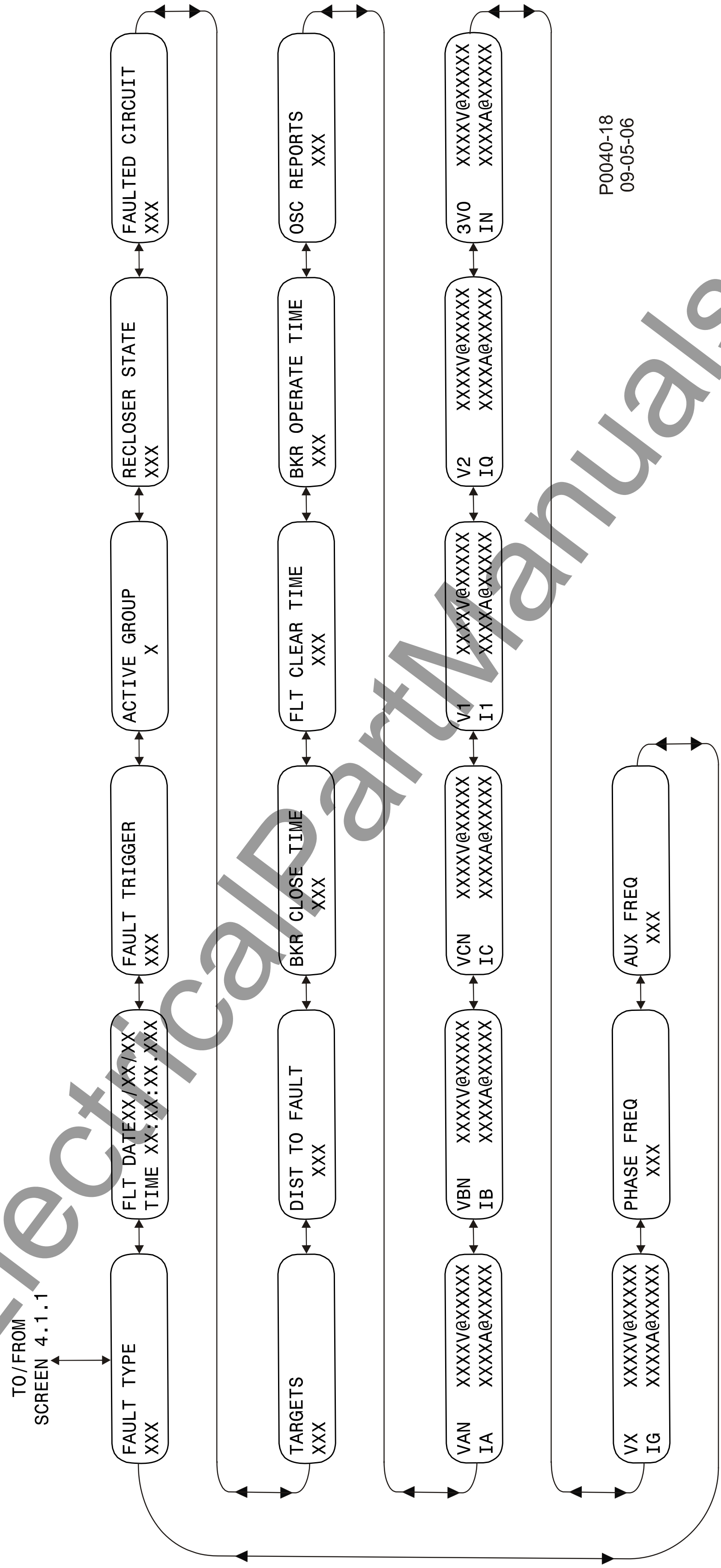

Figure 10-7. Reports Menu Branch Structure - Continued

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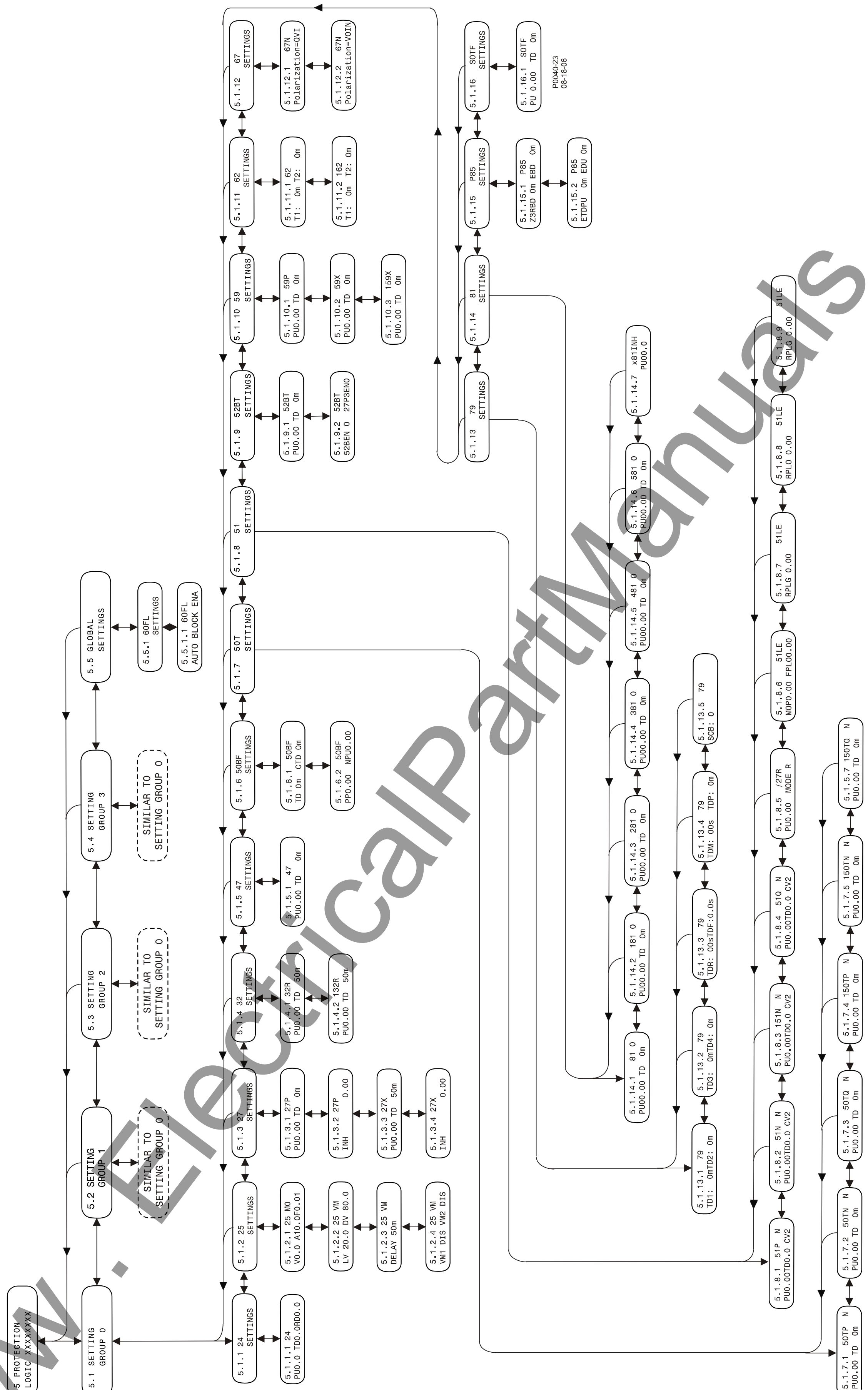

Figure 10-8. Protection Menu Branch Structure

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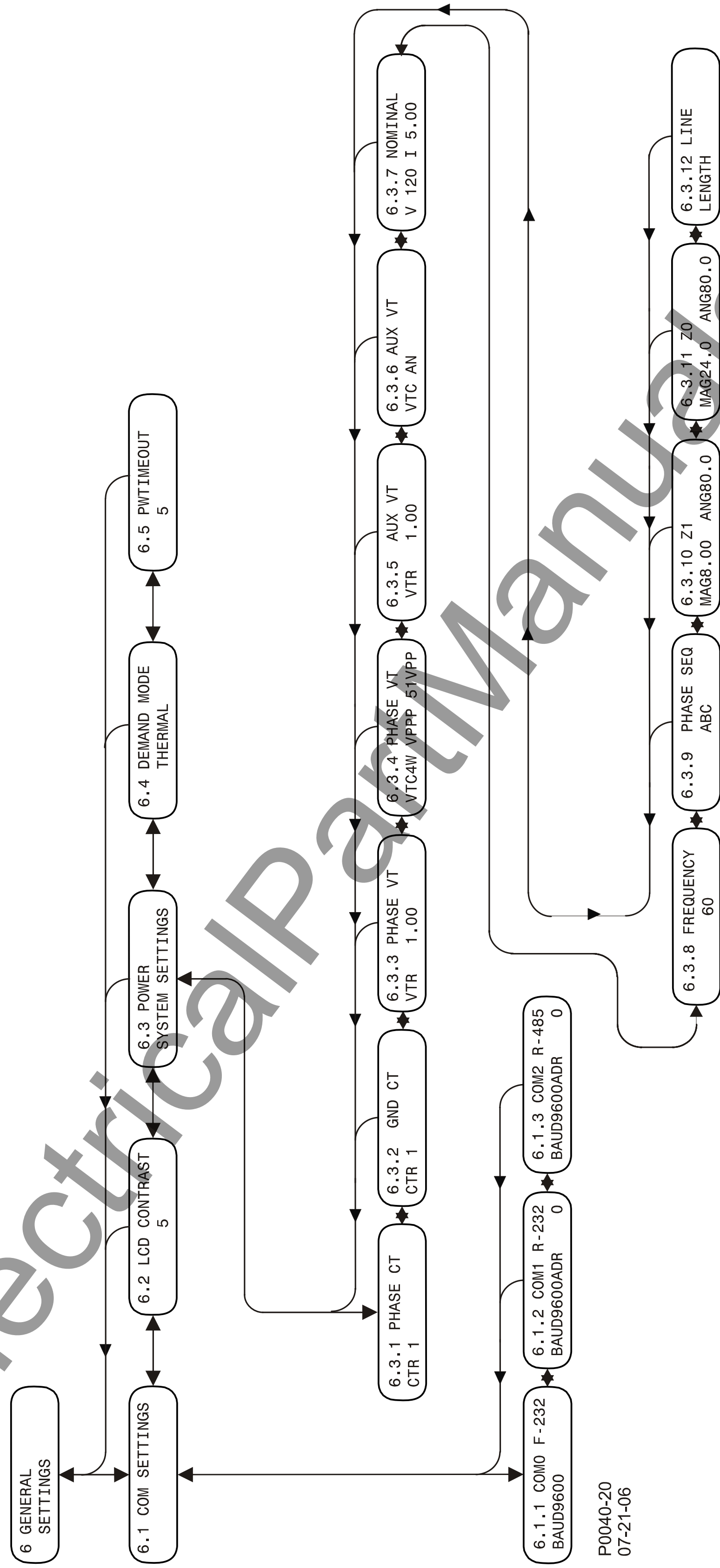

Figure 10-9. General Settings Menu Branch Structure

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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. The screen-scrolling list is programmed using BESTCOMS.

<u>Setting the Screen Scroll List</u>

To edit the automatic scrolling list using BESTCOMS, select *General Operation* from the *<u>S</u>creens* 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 ad or remove screens from the list. They can also be used to change a selected screens position in the list.

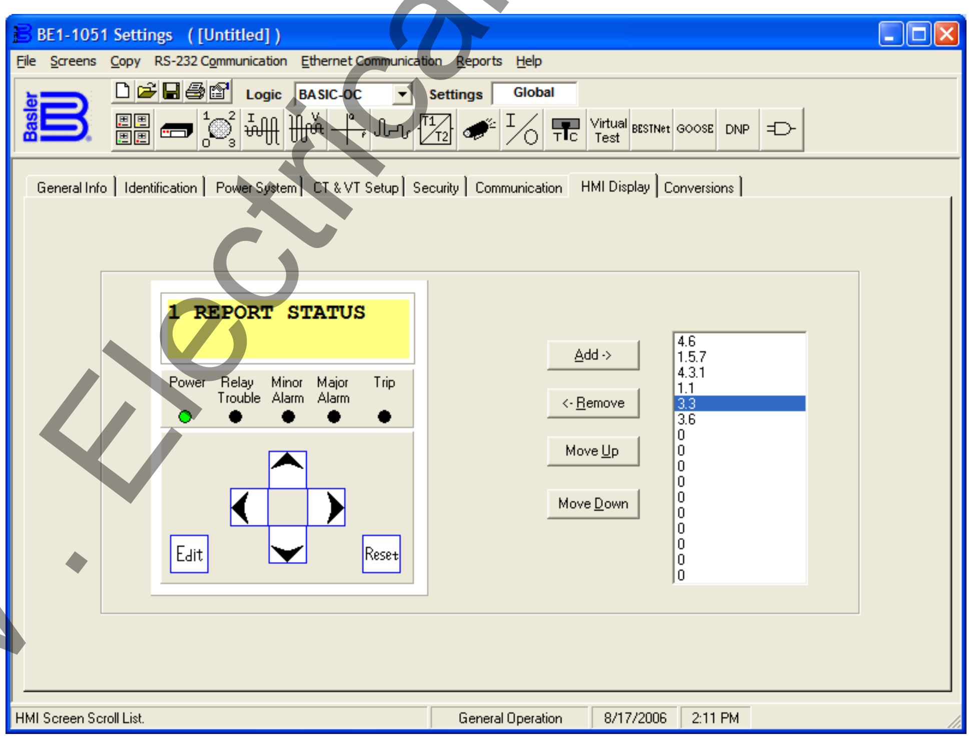

Figure 10-10. General Operation Screen HMI Display Tab

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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 list 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 period 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 RCL-DISABL. The TRUE (closed) state label has been set to DISABL. And, the FALSE (open) state label has been set to ENABLED. The logical mode for this application would be set to Mode 2 (On/Off switch).

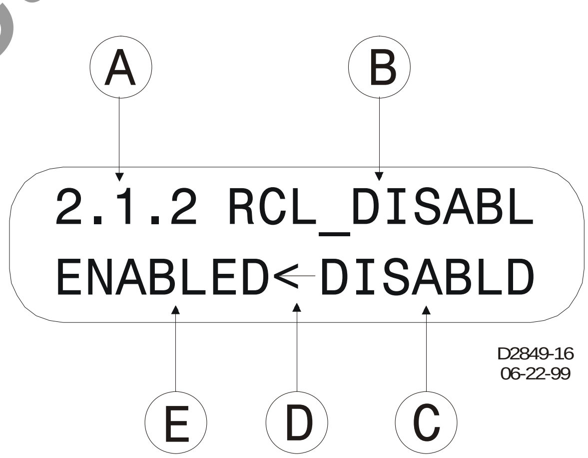

Figure 10-11. Virtual Control Switch 143 Screen

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Table 10-3. Call-Out Descriptions for Figure 10-11

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 143’ identification label is set to ‘RCL_DISABL’.
C	User selectable label for the closed (1) state for Virtual Switch 143. The ‘Switch 143’ closed label is set to ‘DISABLD’.
D	An arrow icon indicates the current switch position (status). In Figure 10-11, the status is open (0), which is labeled ‘ENABLD’.
E	User selectable label for the open (0) state for Virtual Switch 143. The ‘Switch 143’ open label is set to ‘ENABLED’.

To operate the switch, you would use the following procedure:

1. Using the manual scrolling pushbuttons, scroll to Screen 2.1.x (43 AUX SWITCHES). 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 pushbuttons 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 subsection *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 it will not reset the alarms, etc. 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.

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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.

DIRECT ACCESS VIRTUAL CONTROL PANEL

The Direct Access Virtual Control panel provides operation of the virtual control switches and indication of switch and the breaker status. Each switch can be individually tagged in one of two modes. The two tagging modes are Informational and blocking.

When tagged in the Informational mode, the switch will continue to be operational. The *Tagged* LED will be illuminated indicating a tagged mode and telling the user that a change will be coming to that switch.

When tagged in the blocking mode, the switch will not be operational and the Tagged LED will be lit. For more information on operating modes and tagging of the virtual control switches, see Sectio4, *Protection and Control.*

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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. BE1-1051 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 9334800992 for DNP 3.0. and 9334800991 for Modbus™. For information about other protocols, consult your Basler Electric representative.

ASCII commands that support ethernet-enabled relays can be found in Section 15, *BESTNet Communication, Unique ASCII Commands.*

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 two Data Communication Equipment (DCE) RS-232 ports, one RS-485 port, and an IRIG port. The BE1-1051 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

Two female RS-232 (DB-9) connectors are provided. One port is located on the front panel and is designated COM 0. Another port is located on the rear panel and is designated COM 1. Both ports support full-duplex operation. Polled operation is possible at the rear port using a simple RS-232 splitter if a polling address is programmed for COM 1.

RS-485 Port

RS-485 terminal block connections are located on the rear panel and designated COM 2. This port supports half-duplex, multi-drop operation. Multi-drop operation is possible if a polling address is programmed for the port.

Ethernet Port

BE1-1051 relays can be connected to operate as a server in a peer to peer network. Dual ethernet ports, COM 3 and COM 4 are provided to facilitate network connections. COM 3 is a 10Base-F port and COM 4 is a 10Base-T port or a second 10Base-F port.

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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, 1, 2, and 3 Protection Settings (P) not in setting groups, Alarm Settings (A), Breaker Monitor Settings (B), General Settings (G), and Logic Settings (L).

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.

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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 BE1-1051.

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.

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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 are 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.

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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 BE1-1051 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=0,0,0;    SA-BKR2=0,0,0;    SA-BKR3=0,0,0
SA-DIP=0.00;      SA-DIN=0.00;      SA-DIQ=0.00;      SA-DIG=0.00
SA-DI3=0.00
SA-DVP=0.00,0.00; SA-DVN=0.00,0.00; SA-DV3=0.00,0.00
SA-DVAR=0.0,0.0
SA-DWATT=0.0,0.0
SA-24= 0
SA-27=0.00
SA-59=0.00
SA-LGC=0
SA-MAJ=25/30
SA-MIN=29
SA-RESET=0
```


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SB Command

Purpose: Read all breaker settings
Syntax: SB
Example: SB

SB Command Example:

Example 1. Read all breaker settings.

>SB
```
SB-DUTY=0.0000,0.000e+00,0
SB-LOGIC=/IN1
```

SG Command

Purpose: Read all general settings
Syntax: SG
Example: SG

SG Command Example:

Example 1. Obtain a report of all screen general settings. **Note:** For ethernet enabled relays, see Section 15, *BESTNet Communication.*

>SG-SCREEN
```
SG-SCREEN1=4.6;     SG-SCREEN2=1.5.7;   SG-SCREEN3=4.1.2;   SG-SCREEN4=0
SG-SCREEN5=3.3;     SG-SCREEN6=3.6;     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
```

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 0-3 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
```
S1-50BF=  0m,0.00,0.00,  0m
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
S1-51LE=0.00,0.00,0.00,0.00,0.00
S1-51P=0.00,0.0,V2,N
```


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```
S1-51N=0.00,0.0,V2,N
S1-51Q=0.00,0.0,V2,N
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,DIS
S1-27P=0.00, 50m,0.00;        S1-27X=0.00, 50m,0.00
S1-32=0.0, 50m,R
S1-132=0.0, 50m,R
S1-47=0.00, 50m
S1-52BT=0.00,0,0,  0m
S1-59P=0.00, 50m;             S1-59X=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
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;      S1-79P=  0m
S1-79SCB=0
S1-P85=  0m,  0m,  0m,  0m
S1-SOTF=0.00,  0m
SP-60FL=ENA,PNQ
SP-79ZONE=0
SP-CURVE=  0.2663,  0.0339,  1.0000,  1.2969,  0.5000
SP-GROUP1=  0,  0,  0,  0,51P;      SP-GROUP2=  0,  0,  0,  0,51P
SP-GROUP3=  0,  0,  0,  0,51P
```

<u>Reading Logic Settings</u>

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:
BASIC-OC, BASIC-OC, OC-W-79, OC-W-CTL, FDR-W-IL, BUS, BACKUP,
NONE
```


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Example 2. Read all logic settings associated with the BASIC-OC logic scheme.
>SL:BASIC-OC

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, 1 = Rear 232, 2= Rear 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
```

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COMMAND SUMMARY

Miscellaneous Commands

ACCESS Command

Purpose: Read/Set Access level in order to change settings
Syntax: ACCESS[={password}]
Example: ACCESS=1051
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 calculated neutral voltage (3V0) in primary units
Syntax: M-3V0
Example: M-3V0
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/1/3
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*

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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/1/2/X/3X/3
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/x43TAG/101/VTS
Example: CO-GROUP=2, CO-OUT1=1, CO-43=P, CO-43TAG=1, CO-101=T or CO-VTS=2
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/x43TAG/101/VTS
Example: CS-GROUP=2, CS-OUT1=1, CS-43=P, CS-43TAG=1, CS-101=T or CS-VTS=2
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*

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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*

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RD-PI Command

Purpose: Read/Reset peak demand current (I)
Syntax: RD-PI[{p}[=0]] where p=A/B/C/3/N/Q/G
Example: RD-PI or RD-PIA or RD-PIN or RD-PI=0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-PV Command

Purpose: Read/Reset peak Max and Min demand voltage (V)
Syntax: RD-PV[{p}[=0,0]]] where p=A/B/C/3/N - Max, Min demand voltage
Example: RD-PV or RD-PVA or RD-PVN or RD-PV=0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-PVAR Command

Purpose: Read/Reset peak Foward and Reverse 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 Forward and Reverse 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: Read/Reset peak demand current (I)
Syntax: RD-PI[{p}[=0]] where p=A/B/C/3/N/Q/G
Example: RD-PI or RD-PIA or RD-PIN or RD-PI=0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TV Command

Purpose: Report today's Max and Min demand voltage (V)
Syntax: RD-TV[{p}] where p=A/B/C/3/N
Example: RD-TV or RD-TVA or RD-TVN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TVAR Command

Purpose: Report today's Forward and Reverse demand vars
Syntax: RD-TVAR
Example: RD-TVAR
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TWATT Command

Purpose: Report today's Forward and Reverse 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/3/N/Q/G
Example: RD-YI or RD-YIA or RD-YIN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

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RD-YV Command

Purpose: Report yesterday's Max and Min demand voltage (V)
Syntax: RD-YV[{p}] where p=A/B/C/N
Example: RD-YV or RD-YVA or RD-YVN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-YVAR Command

Purpose: Report yesterday's Forward and Reverse demand vars
Syntax: RD-YVAR
Example: RD-YVAR
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-YWATT Command

Purpose: Report yesterday's Forward and Reverse 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 KiloVarHours 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*

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RG-DATE Command

Purpose: Report/Set Date
Syntax: RG-DATE[={M/D/Y}] or RG-DATE[={M-D-Y}]
Example: RG-DATE=12/31/01 or RG-DATE=12-31-01 (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-IPADDR Command

Reference: Section 15, *BESTNet Communication*

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*

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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}] alarm level=percent of pickup
Example: SA-24 or SA-24=100 or SA-24=50
Reference: Section 4, *Protection and Control, Voltage Protection*

SA-27 Command

Purpose: Read/Set Under Voltage alarm settings
Syntax: SA-27[={alarm level}] where alarm level = volts
Example: SA-27 or SA-27=110 or SA-27=5
Reference: Section 4, *Protection and Control, Voltage Protection*

SA-59 Command

Purpose: Read/Set Over Voltage alarm settings
Syntax: SA-59[={alarm level}] where alarm level = volts
Example: SA-59 or SA-59=125 or SA-59=5
Reference: Section 4, *Protection and Control, Voltage Protection*

SA-BKR Command

Purpose: Read/Set breaker alarm settings
Syntax: SA-BKR[n][={mode},{alarm limit},{osc trigger enable}] where mode=0-3(disabled/%duty/#op/clr)
Example: SA-BKR or SA-BKR1=1,80,0 or SA-BKR2=2,250,1 or SA-BKR3=3,6c,1
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SA-DI Command

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Purpose: Read/Set demand alarm settings
Syntax: SA-DI[p][={alarm level}] where p=P/N/Q/3/G, 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-DV Command
Purpose: Read/Set Voltage Max and Min demand alarm setting
Syntax: SA-DV[p][={max alm lvl},{min alm lvl}] where p=P/N/3, alm lvl= Sec Volts
Example: SA-DV or SA-DVP=0,0 or SA-DVN=100,10
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*

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SB-DUTY Command

Purpose: Read/Set Breaker Contact Duty
Syntax: SB-DUTY[={Exponent},{DMax},{BLKBKR logic}]
Example: SB-DUTY=1.5,60E3,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-SYNCH Command

Purpose: Read/Set DNP synchronization period with Master
Syntax: SDNP-SYNCH[=valueX] where X is D/H/M/S for days/hours/min/sec
and value is from 0 to max 31(if D)/24(if H)/60(if M or S)
Example: SDNP-SYNCH or SDNP-SYNCH=0S or SDNP-SYNCH=12H or SDNP-SYNCH=15D
Reference: Distributed Network Protocol (DNP) manual for BE1-1051

SDNP-DEADBAND Command

Purpose: Read/Set DNP current,voltage and power analog change event deadband
% of nominal value
Syntax: SDNP-DEADBAND[=c,v,p] where c,v,p are from 1.0 to max. 10
in steps 0.1 are voltage,current,power deadbands in % of nominal value
Example: SDNP-DEADBAND=2,1.5,2.5
Reference: Distributed Network Protocol (DNP) manual for BE1-1051

SDNP-USERAI Command

Purpose: Read/Set user configuration of DNP Analog Input points
Syntax: SDNP-USERAI[=T,startndx,endndx,startpDftID,..,endpDftID]
where T is total number of points in user map,
startndx is a reporting index of data with default index startDftID,
endndx is a reporting index of data with default index endDftID,
Max. number of points specified in one command is 50.
Example: SDNP-USERAI or
SDNP-USERAI =20,0,9,0,1,31,32,62,63,64,74,76,78
SDNP-USERAI =20,10,19,2,33,34,45,50,53,79,94,105,135
To map for example 420 AI points, min 9 SDNP-USERAI commands must be sent.
To map for example 420 AI points, min 9 SDNP-USERAI commands must be sent.
Reference: Distributed Network Protocol (DNP) manual for BE1-1051

SDNP-AIMAP Command

Purpose: Read/Set selection of DNP Analog Input Map
Syntax: SDNP-AIMAP[=USER(or U)/DEFAULT(or DFT or D)]
Example: SDNP-AIMAP=U or SG-AIMAP =DFLT
Reference: Distributed Network Protocol (DNP) manual for BE1-1051

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SDNP-USERBI Command

Purpose: Read/Set user configuration of DNP Binary Input points.

Syntax: SDNP-USERBI[=T,startndx,endndx,startpDftID,..,endpDftID]
where T is total number of points in user map,
startndx is a reporting index of data with default index startDftID,
endndx is a reporting index of data with default index endDftID,
Max. number of points specified in one command is 50.

Example: SDNP-USERBI or
To report 23 BI points:
SDNP-USERBI =23,0,22,127,128,129,165,166,167,168,177,178,44,45,46,47,0,1,2,4,5,7,10,23,24,78

Reference: Distributed Network Protocol (DNP) manual for BE1-1051

SDNP-BIMAP Command

Purpose: Read/Set selection of DNP Binary Input Map

Syntax: SDNP-BIMAP[=USER(or U)/DEFAULT(or DFT or D)]

Example: SDNP-BIMAP=U or SDNP-BIMAP =DFLT

Reference: Distributed Network Protocol (DNP) manual for BE1-1051

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/Set 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 demand interval

Syntax: SG-DI[p][={interval}] where p=P/N/Q

Example: SG-DI or SG-DIP=15 or SG-DIN=1

Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

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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

Reference: Section 15, *BESTNet Communication*

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/Set 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-HTIME Command

Purpose: Read/Set UCA Goose Hold Time
Syntax: SG-HTIME[={Goose Hold Time(ms)}] where ms=1-60000msec
Example: SG-HTIME or SG-HTIME=1s or SG-HOLD2=1000ms
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SG-ID Command

Purpose: Read/Set relay ID and station ID used in reports
Syntax: SG-ID[={relayID},{StationID},{UserID1},{UserID2}]
Example: SG-ID=448,SUBSTATION3 or SG-ID=GEN3,POWERPOINT_SUB,POWER,PLANT3
Reference: Section 14, *BESTCOMS Software, Setting the Relay*

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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-IPADDR Command

Reference: Section 15, *BESTNet Communication*

SG-IPGW Command

Reference: Section 15, *BESTNet Communication*

SG-IPMASK Command

Reference: Section 15, *BESTNet Communication*

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-NETEN Command

Reference: Section 15, *BESTNet Communication*

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-NTP Command

Reference: Section 15, *BESTNet Communication*

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*

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SG-RID Command

Purpose: Read/Set UCA Remote Relay ID
Syntax: SG-RID[#[={name},{MAC Addr}]] where #=1-16
Example: SG-RID or SG-RID1 or SG-RID1=REMOTE1,400000000000
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-SMTP Command

Reference: Section 15, *BESTNet Communication*

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-TRIGGER Command

Purpose: Read/Set Trigger logic
Syntax: SG-TRIGGER[={TRIP},{PICKUP},{LOGIC},{CLOSE}]
Example: SG-TRIGGER or SG-TRIGGER=VO1,VO2,IN4,79C
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

SG-USERST Command

Purpose: Read/Set UCA User Status bit pair logic
Syntax: SG-USERST[#[={Logic Variable},{True value},{False value},{Bit Pair Num}]]
Example: SG-USERST or SG-USERST1 or SG-USERST1=IN1,2,1,33
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-VIN Command

Purpose: Read/Set UCA Virtual Input Remote ID, Bit Pair, Default and True Value
Syntax: SG-VIN[#[={ID number},{Bit Pair},{Default Value},{True Value}]]
Example: SG-VIN or SG-VIN1 or SG-VIN1=1,22,0,2
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

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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-VTS 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-VTX Command
Purpose: Read/Set Virtual Test Switch Timeout
Syntax: SG-VTS=[{timeout(min)}]
Example: SG-VTS or SG-VTS=30
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-{f}27[{p}[={mode},{BLK logic}]] where f= 0/1 and p=P/X
Example: SL-27 or SL-27P=1,0 or SL-27X=3,0 or SL-27P=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-32 Command
Purpose: Read/Set Logic for 32 Function Modules
Syntax: SL-{f}32[={mode},{BLK logic}] where f= 0/1
Example: SL-32 or SL-32=1,0 or SL-132=1,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},{TRIP logic},{RESET logic},{BLK logic},{INH front switch logic}]
where x = blank/1/2/3/4, mode=0/1/2/3
Example: SL-43 or SL-143=0 or SL-243=1,IN3,IN4,27P
Reference: Section 4, *Protection and Control, Virtual Switches*

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SL-43TAG Command
Purpose: Read/Set Tagging Logic for Virtual switch (x43) where mode = 0/1/2
Syntax: SL-{x}43TAG[={mode},{tagson},{tagsoff},{blktag}] where x = blank/1/2/3/4
Example: SL-43TAG or SL-143TAG=2,IN1,IN2,IN3 or SL-243TAG=*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-50BF Command
Purpose: Read/Set Logic for Breaker Failure Function Modules
Syntax: SL-50BF[={mode},{50INIlogic},{52INIlogic},{52Statuslogic},{BLKlogic}]
Example: SL-50BF or SL-50BF=1,VO1,VO2,VO3,0 or SL-50BF=1,VO1,IN1
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-50T Command
Purpose: Read/Set Logic for x50 Function Modules where x = blank or 1
Syntax: SL-x50T[{p}[={mode},{BLK logic}]] where 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-51P Command
Purpose: Read/Set Logic for 51 Function Modules
Syntax: SL-51[{p}[={mode},{BLK logic}]] where p=P/N
Example: SL-51P=1,0 or SL-51N=1,IN3
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},{TRIP logic},{RESET logic},{BLK logic},{INH front switch logic}] 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
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-159 Command
Purpose: Read/Set Logic for 159X Function Module
Syntax: SL-159X[={mode},{BLK logic}]
Example: SL-159X or SL-159X=1,0 or SL-159X=2,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

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SL-62 Command

Purpose: Read/Set Logic for 62 Function Modules
Syntax: SL-{f}62[={mode},{INI logic},{BLK logic}] where f= 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},{LOLogic},{PILogic}]
Example: SL-79 or SL-79=1,VO1+IN4,/IN1,IN2,IN3,IN5
Reference: Section 4, *Protection and Control, Reclosing*

SL-81 Command

Purpose: Read/Set Logic for 81 Function Modules
Syntax: SL-{f}81[={mode},{BLK logic}] where mode=0/1/X, f= 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-86 Command

Purpose: Read/Set Logic for 86 Function Modules
Syntax: SL-{f}86[={mode},{Trip logic},{Reset Logic}] where mode=0/1, f=blank/1
Example: SL-86 or SL-86=1,IN1 or SL-186=1,IN3
Reference: Section 4, *Protection and Control, Breaker Failure Protection*

SL-CKTMON Command

Purpose: Read/Set Circuit Monitor logic settings
Syntax: SL-CKTMON[={mode},{monitor},{status}]
Example: SL-CKTMON or SL-CKTMON=1,IN6,IN2
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-CTRL Command

Purpose: Read/Set Block control commands Logic
Syntax: SL-CTRL[={mode},{Block Com0},{Block Com1},{Block Com2}]
Example: SL-CTRL=0
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-GROUP Command

Purpose: Read/Set Logic for Setting Group Module
Syntax: SL-GROUP[={mode},{D0Logic},{D1Logic},{D2Logic},{D3Logic},{AUTOlogic}]
Example: SL-GROUP or SL-GROUP=1,IN3,IN4,0,0,0
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=1051TEST
Reference: Section 7, *BESTlogic Programmable Logic, Logic Schemes*

SL-P85 Command

Purpose: Read/Set Logic for P85 Function
Syntax: SL-P85[={mode},{FWD_TRIP},{REVS_BLK},{P85RX},{WFC}]
Example: SL-P85 or SL-P85=1,VO1,VO2,VO3,IN3
Reference: Section 4, *Protection and Control, Virtual Switches*

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SL-SOTF Command

Purpose: Read/Set Logic for SOTF Function Modules
Syntax: SL-SOTF[={mode},{Tripping logic},{Block Logic}]
Example: SL-SOTF or SL-SOTF=1,0,0 or SL-25=1,IN3,IN4
Reference: Section 4, *Protection and Control, Virtual Switches*

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*

SL-VTS Command

Purpose: Read/Set Virtual Test Switch Mask Mode and User Names
Syntax: SL-VTS[={VTS mode},{VTS1 name},{VTS2 name},{VTS3 name},{VTS4 name}]
Example: SL-VTS or SL-VTS=1,MASKNONE,MYMASK,MYTEST,ANYTEST
Reference: Section 4, *Protection and Control, Virtual Switches*

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 0-3 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 and reset delay
Syntax: S{g}-24[={pu(V/Hz)},{td},{rst}] where g=0,1,2,3
Example: S0-24 or S0-24=2.5,6.5,9.9 or S1-24=3,2.0,5.0
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=0,1,2,3, mode=1-PF>XF, 0-PF<>XF
Example: S0-25 or S0-25=5,3,0.1,0 or S1-25=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 & VM2 logic
Syntax: S{g}-25VM[={LV},{DV},{td},{VM1},{VM2}] where g=0,1,2,3, VM1,VM2=DIS/123
Example: S0-25VM or S0-25=80,20,100,123,2 S1-25VM=80,20,0.25,23,DIS
Reference: Section 4, *Protection and Control, Synchronism-Check Protection*

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S<g>-27 Command

Purpose: Read/Set 27 pickup level, time delay
Syntax: S{g}-27P[={pu(V)},{td(m)},{inh(V)}] where g=0,1,2,3
Example: S0-27P or S1-27P=100,0,80 or S2-27X=80,20,0
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=0,1,2,3, m=C-Control/R-Restraint
Example: S0-27R or S1-27R=100,C or S2-27=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}-{f}32[={pu(W)},{td(m)},{mode}] where g=0,1, f=0/1
Example: S0-32 or S1-32=100,0,R or S1-132=1800,20,F
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=0,1,2,3
Example: S0-47 or S1-47=100,0
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-50BF Command

Purpose: Read/Set the Breaker Failure Timer Setting
Syntax: S0-50BF[={TimeDelay},{PhPu},{NeuPu},{CtrlTimeDelay}]
Example: S0-50BF or S0-50BF=50m or S0-50BF=3c
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-50TP Command

Purpose: Read/Set 50T pickup level and time delay
Syntax: S{g}-{f}50T[{p}][={pu(A)},{td(m)},{dir}] where g=0-3,f=blank/1 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>-51LE Command

Purpose: Read/Set 51 load encroachment parameters
Syntax: S{g}-51LE[={MOPle},{FPLD},{FPLG},{RPLD},{RPLG}] where g=0,1,2,3
Example: S0-51LE or S0-51LE=1.05 or S1-51LE=1.1,0.75,0.7,0.9,0.9
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-51P Command

Purpose: Read/Set 51 pickup level, time delay and curve
Syntax: S{g}-51[{p}][={pu(A)},{td(m)},{crv},{dir}] where g=0,1,2,3 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}-{f}51N[={pu(A)},{td(m)},{crv},{dir}] where f=blank/1 and g=0,1,2,3
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*

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S<g>-52BT Command

Purpose: Read/Set the Breaker Open/Dead Line Setting
Syntax: S{g}-52BT[={27P3PU},{EN_52B},{EN_27P3},{52BD}] where g=0,1,2,3
Example: S0-52BT or S0-52BT=1.23,1,0,50m
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=0,1,2,3 and p=P/X
Example: S0-59P or S1-59P=100,0 or S1-59X=80,20
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-62 Command

Purpose: Read/Set 62 Time Delay
Syntax: S{g}-{f}62[={t1},{t2}] where g=0,1,2,3 & 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=0,1,2,3, mode= QVI/QV/QI/VI/Q/V/I
Example: S0-67N or S0-67N=QVI,V0IN or S1-67N=VI,VXIG or S3-67N=V,VXIG
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-79 Command

Purpose: Read/Set 79 Time Delay where # = 1/2/3/4/R/F/M/P
Syntax: S{g}-79[#][={td}] where g=0,1,2,3 & 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=0,1,2,3
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}-{f}81[={pu(Hz)},{td(m)},{mode}] where g=0,1,2,3
Example: S0-81 or S0-81=59.00,6.5,U or S1-81=60.50,2.0,O
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)}] where g=0,1,2,3
Example: S0-81INH or S0-81INH=80 or S1-81INH=0
Reference: Section 4, *Protection and Control, Frequency Protection*

S<g>-P85 Command

Purpose: Read/Set the setting for P85
Syntax: S{g}-P85[={P85Z3RBD},{P85EBD},{P85ETDPU},{P85EDUR}] where g=0,1,2,3
Example: S0-P85 or S0-P85=1,20,40,999
Reference: Section 4, *Protection and Control, Overcurrent Protection*

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S<g>-SOTF Command

Purpose: Read/Set the setting for SOTF
Syntax: S{g}-SOTF[={50TPPU},{TD}] where g=0,1,2,3
Example: S0-SOTF or S0-SOTF=1.20,20
Reference: Section 4, *Protection and Control, Overcurrent 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-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/Set auxiliary setting group 1-3 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-GROUP3=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

BE1-1051 Overcurrent 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 BE1-1051 is not installed immediately, store it in the original shipping package in a moisture and dust free environment.

CONTACT SENSING INPUT JUMPERS

ATTENTION

The BE1-1051 Relay comes shipped with the input jumpers set to the **LOW** position. Read the following paragraphs closely before placing the relay in service.

It is possible to have seven or eight contact sensing inputs depending on the style number. These inputs provide external stimulus to initiate BE1-1051 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 BE1-1051 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 13 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	Nominal Turn-On Voltage Range	
	Jumper Pins 1-2 (Low Position)	**Jumper Pins 2-3 (High Position)**
24 Vdc	13 - 19 Vdc	N/A
48/125 Vac or Vdc	26 - 38 Vac or Vdc	69 - 100 Vac or Vdc
125/250 Vac or Vdc	69 - 100 Vac or Vdc	138 - 200 Vac or Vdc

Each BE1-1051 is delivered with the contact-sensing input jumpers installed for operation in the lower end of the control voltage range (Pins 1 and 2 shorted). See Figure 12-1. If the contact sensing inputs are to be operated at the upper end of the control voltage range, the jumpers must be changed to Pins 2 and 3 shorted.

The following paragraphs describe how to locate and remove/change the contact sensing input jumpers:

1. Remove the drawout assembly by pulling the two latches outward and sliding the assembly out of the case. Observe all electrostatic discharge (ESD) precautions when handling the drawout assembly.
2. Locate the jumper terminal blocks (Figure 12-1, Table 12-2) that are mounted on the Input/Output Circuit Board. The Input/Output Circuit Board is the middle board in the assembly and the jumper terminal blocks are located on the component side of the circuit board near the left hand side (right hand side when looking at the unit from the rear by the internal connections). Each terminal block has three pins. With the jumper as installed at the factory, one pin should be visible when

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viewed from the rear of the unit. Figure 12-1 illustrates the jumpers placed in the low voltage position.

3. To select operation at the upper end of the control voltage range, position the blue jumper on the two terminals (Pins 2 and 3) closest to the rear of the circuit board. Use care when removing 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. Push the latches down until they are parallel with the front panel.

Table 12-2. Jumper Terminal Blocks

JUMPER	INPUT (styles xxxxxxxxA or xxxxxxxxB)	INPUT (styles xxxxxxxxC or xxxxxxxxD)
W1	IN1	Not Used
W2	IN2	IN1
W3	IN3	IN2
W4	IN4	IN3
W5	IN5	IN4
W6	IN6	IN5
W7	IN7	IN6
W8	IN8	IN7

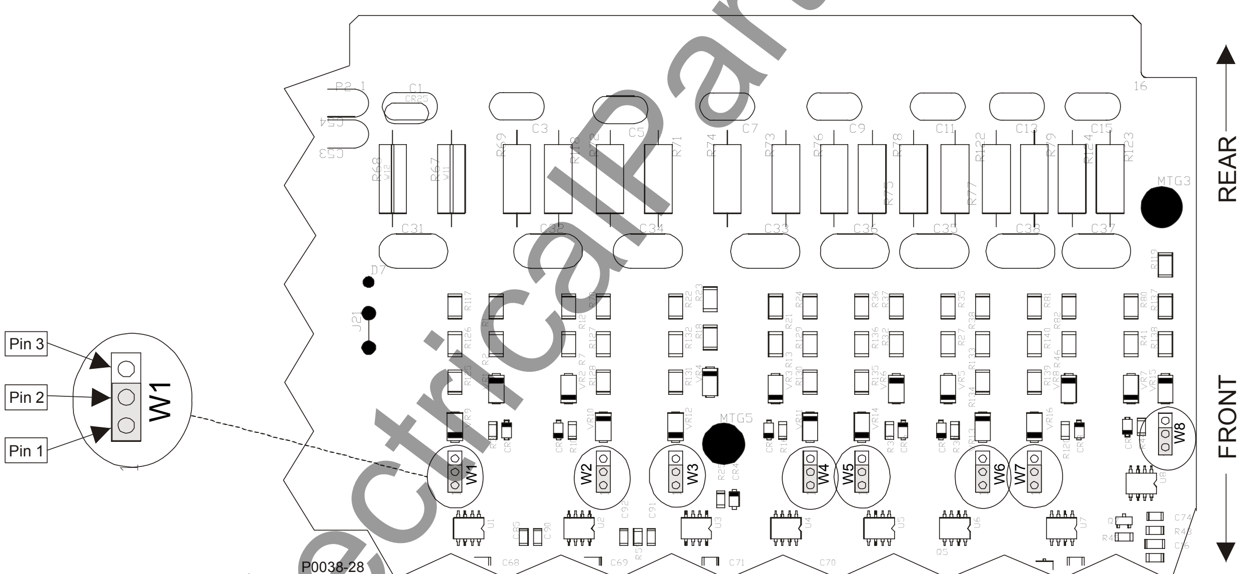

Figure 12-1. Contact Sensing Input Jumpers

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.

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MOUNTING

Because the unit is of solid-state design, any convenient mounting angle may be chosen. BE1-1051 Overcurrent Protection Systems are available in Basler Electric's MX case design. MX cases are fully drawout with current circuit shorting provisions. MX cases are available in three configurations: a standard 19 inch rack mount, a horizontal panel mount, and a vertical panel mount. The vertical panel mount configuration fits cutout, panel drilling, and behind panel projection dimensions (when mounting flange is moved to the back set of mounting holes) of Basler M1, GE M1 and M2, and Westinghouse FT31 and FT 32 size cases.

- Figures 12-2 through 12-4 show the overall dimensions for the MX case with rack-mount brackets. Notice that Figure 12-2, *Front View,* shows both the standard and optional front panels.
- Figures 12-5 through 12-7 show the overall dimensions of the MX case with a panel mounting flange. The examples shown in these figures are vertical panel mounting configurations. Horizontal panel mounting configurations have the same dimensions except that they are in a horizontal arrangement. Notice that Figure 12-5 shows the locations of holes for the Basler, GE, and Westinghouse relay cases.
- Figure 12-8 shows the panel cutout and panel drilling dimensions for the MX case vertical panel mounting configuration. Horizontal panel mounting configurations have the same panel cutout and panel drilling dimensions except that they are in a horizontal arrangement.

Vertical and horizontal configurations are physically and functionally the same with some controls and indicators relocated. All dimensions given on the above listed drawings are dimensioned in inches (millimeters).

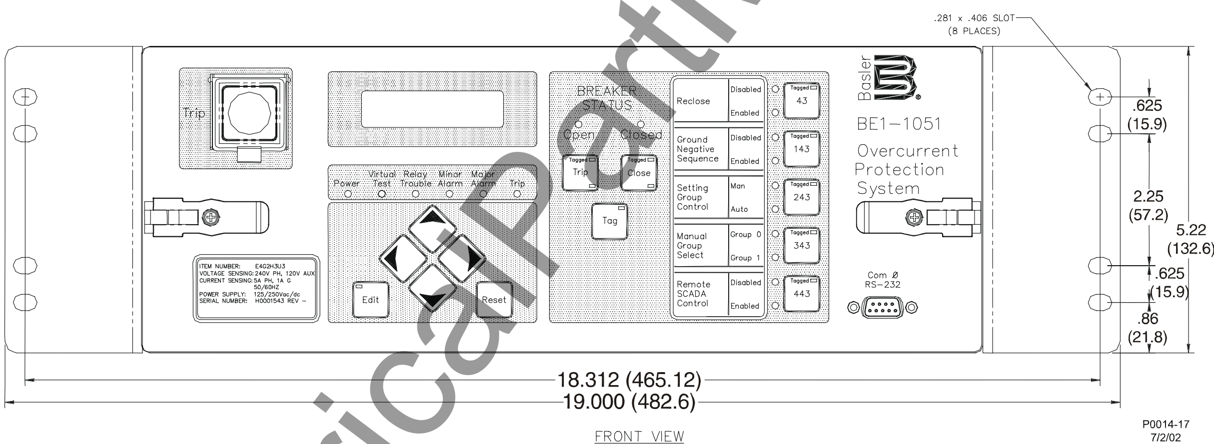

Figure 12-2. 19-inch Rack Mount, Front View, Overall Dimensions

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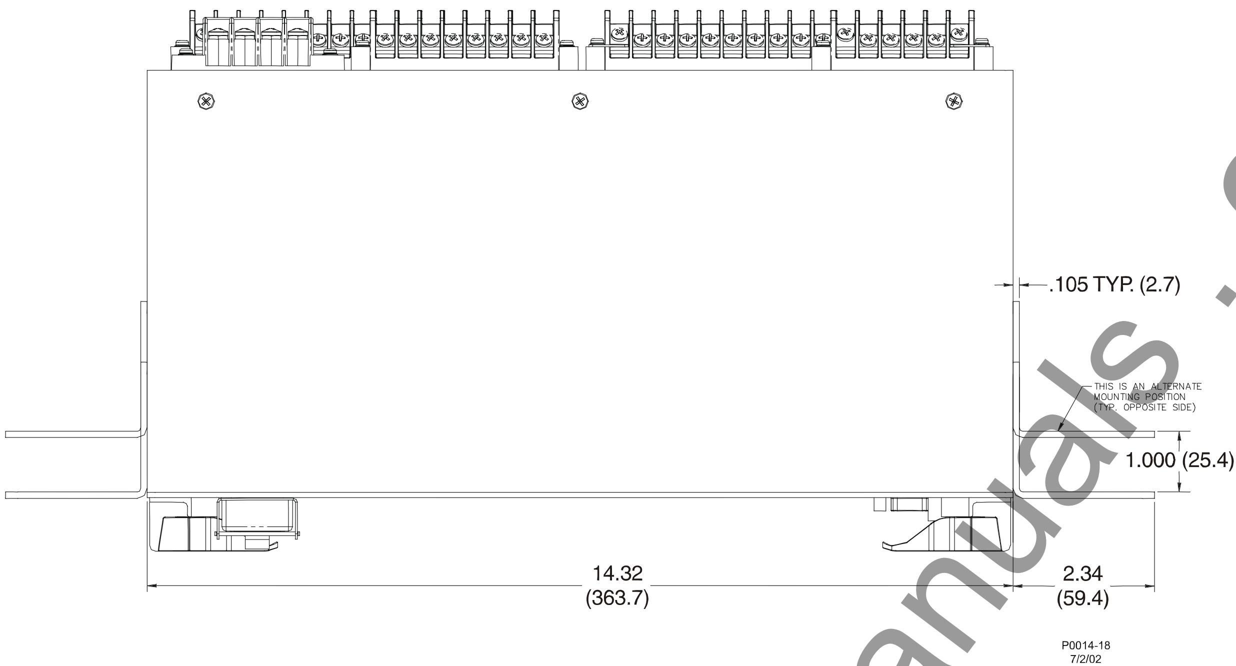

Figure 12-3. 19-inch Rack Mount, Top View, Overall Dimensions

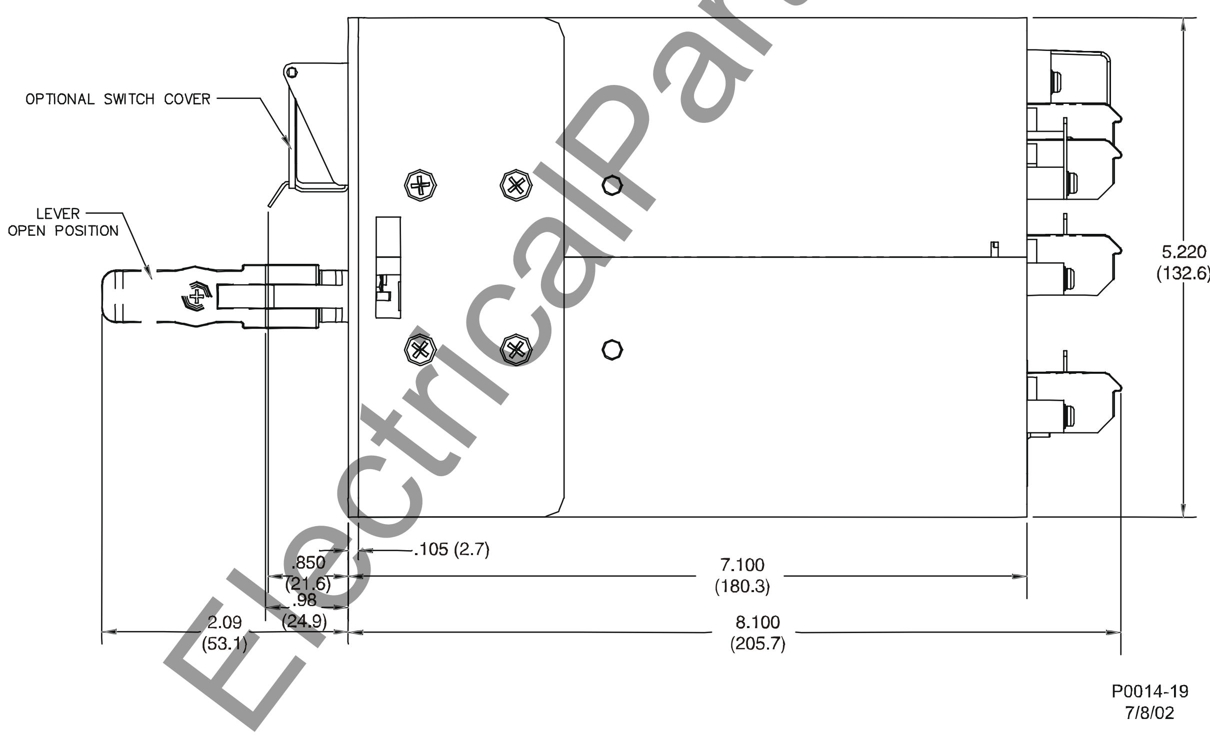

Figure 12-4. 19-inch Rack Mount, Side View, Overall Dimensions

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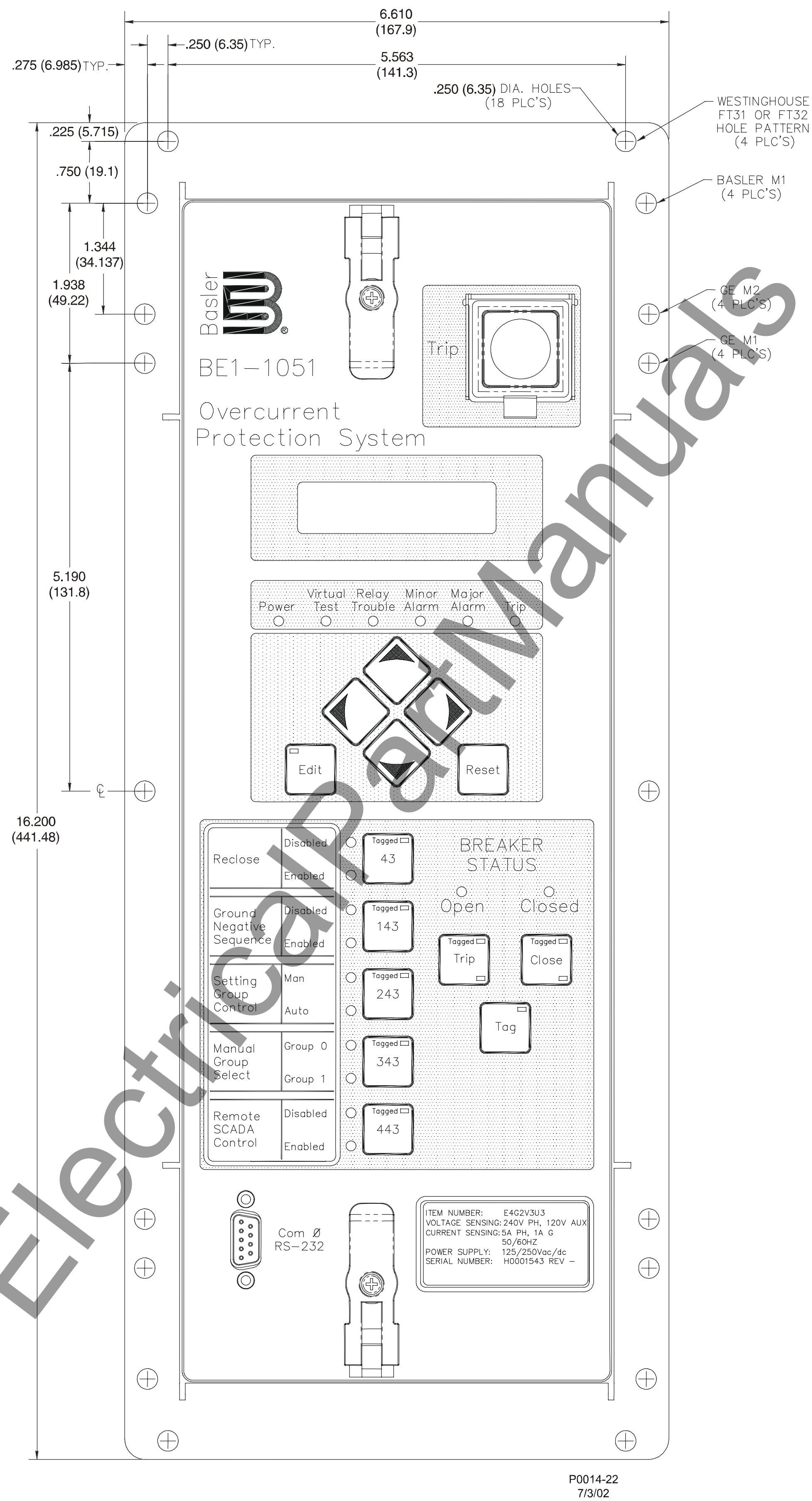

Figure 12-5. Vertical Panel Mount, Front View, Overall Dimensions

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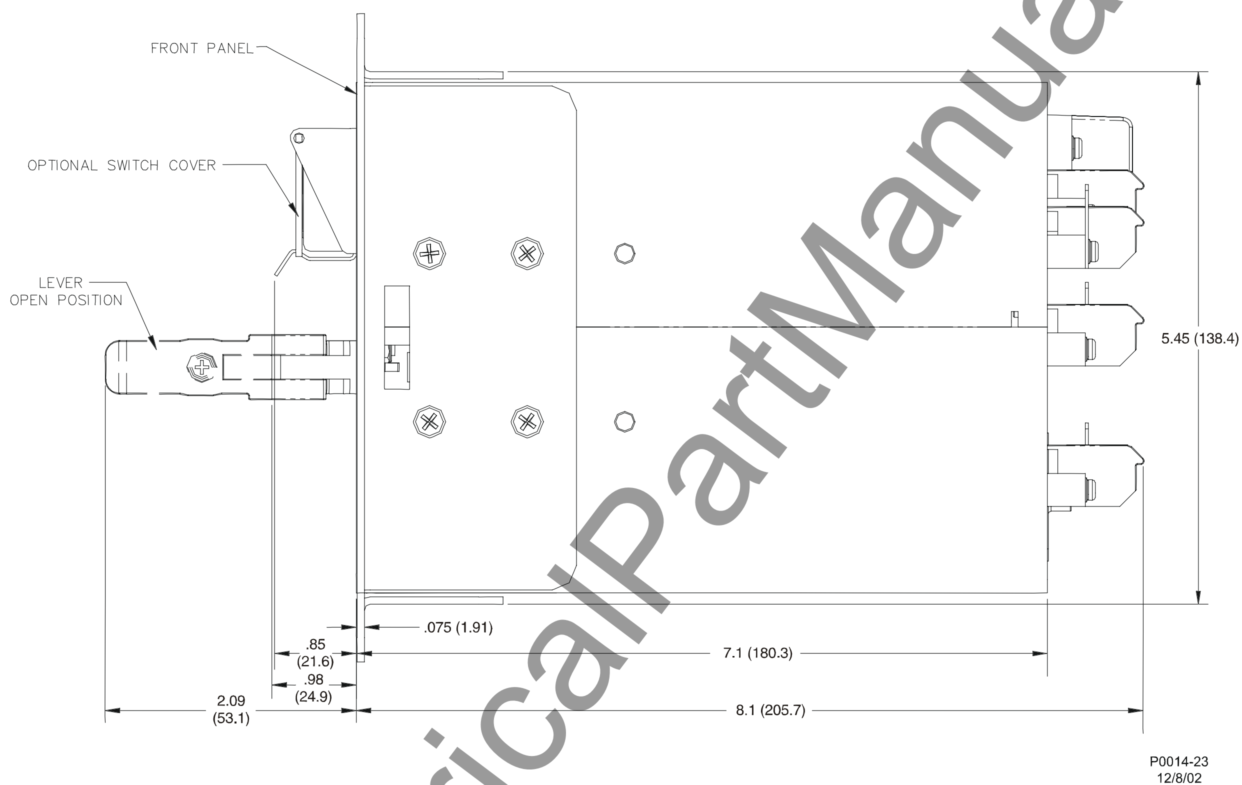

Figure 12-6. Vertical Panel Mount, Top View, Overall Dimensions

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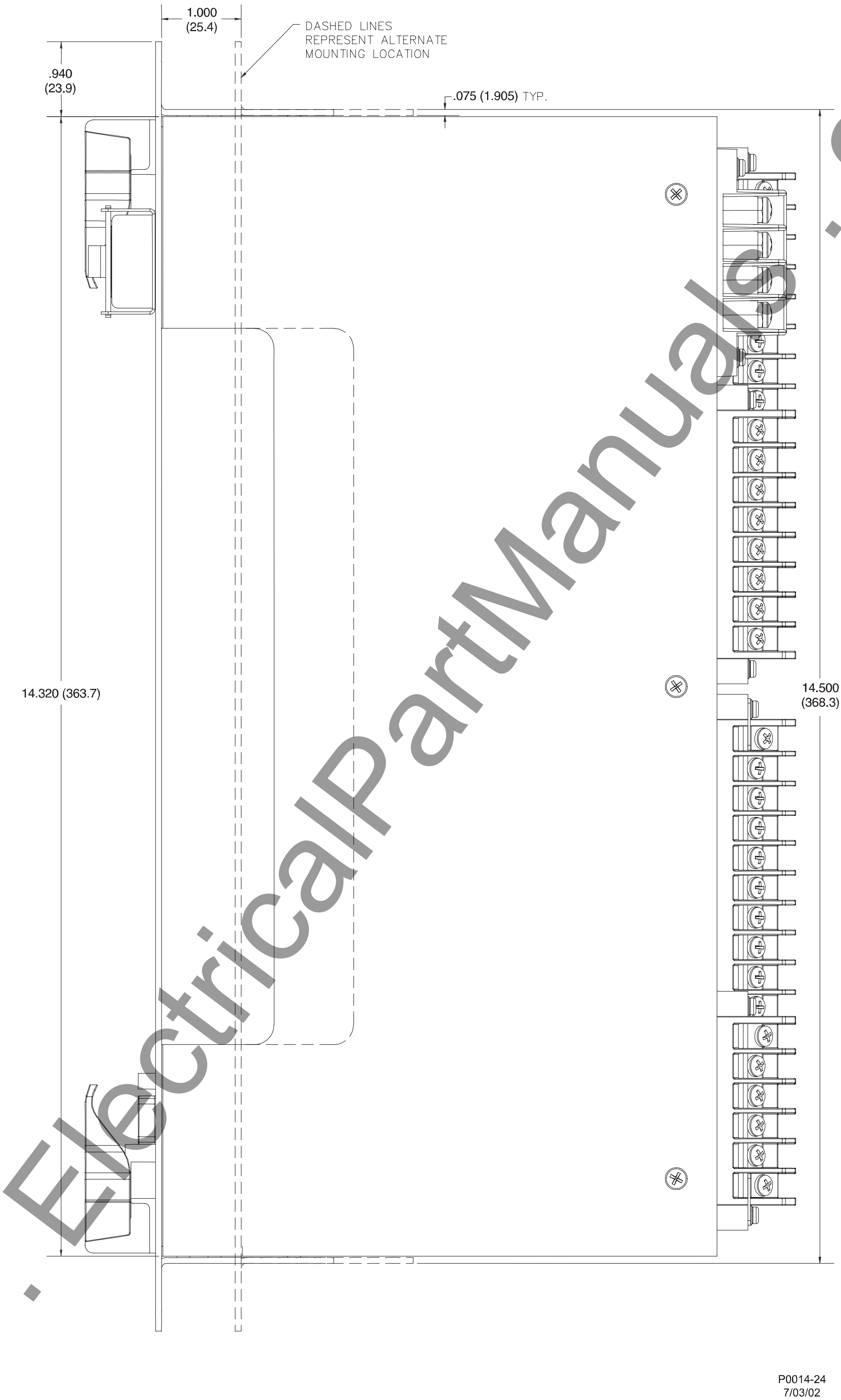

Figure 12-7. Vertical Panel Mount, Side View, Overall Dimensions

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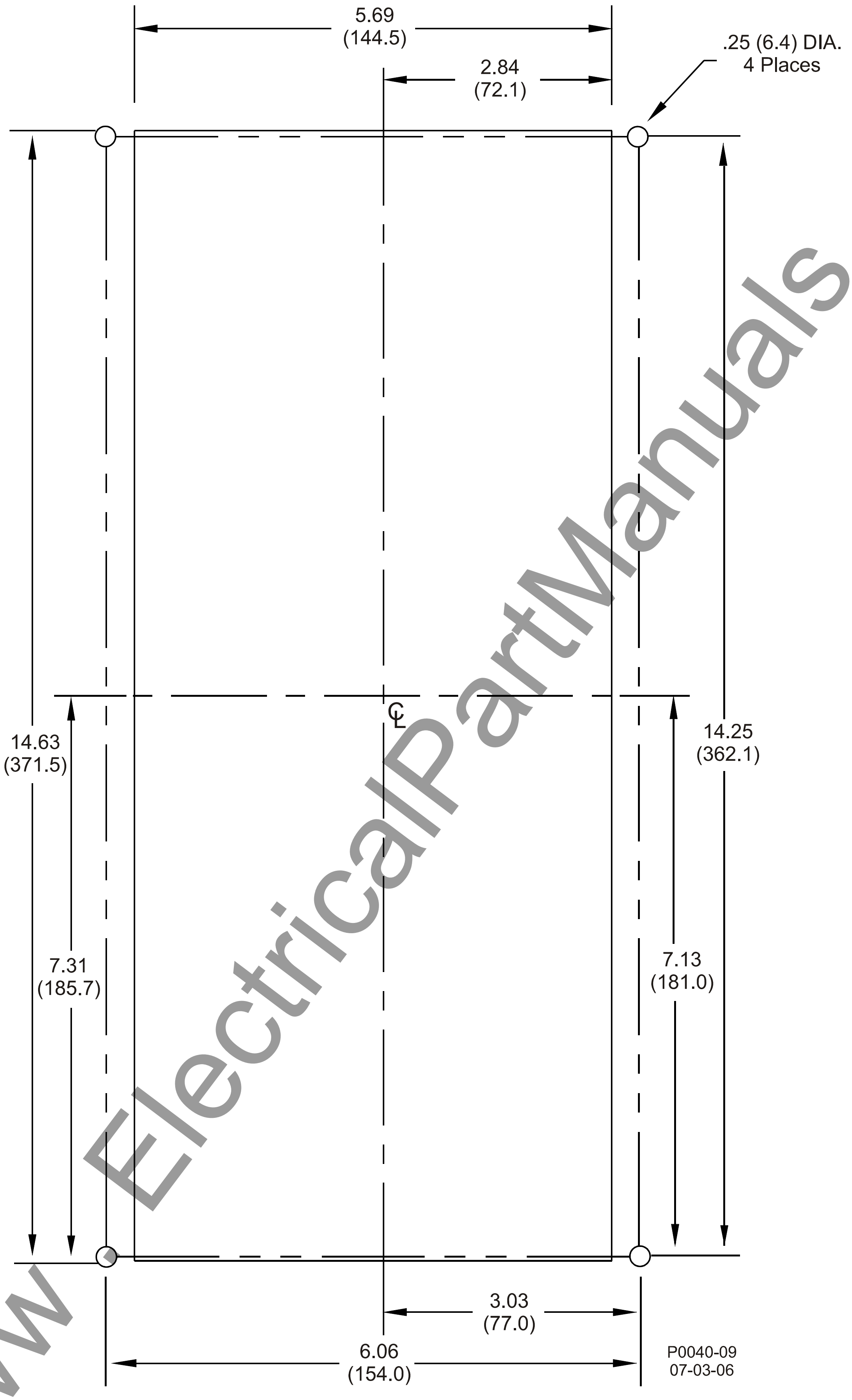

Figure 12-8. Panel Mount, Panel Drilling Diagram

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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 the style number identification chart in Section 1 for options. Be sure to use the correct input power for the specified power supply. Incorrect wiring may result in damage to the relay.

Figure 12-9 shows the terminal connections located on the rear-panel of the relay for styles xxxxxxxxA and xxxxxxxxB. Figure 12-10 shows the terminal connections for relays with styles xxxxxxxxC and xxxxxxxxD. Refer to Table 12-1 for input contact sensing turn-on voltage jumper settings.

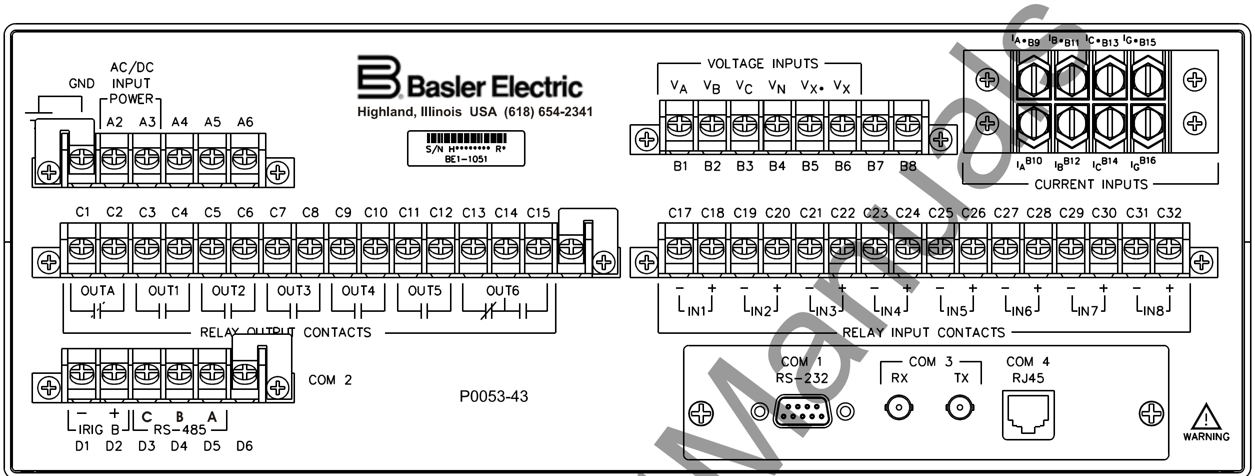

Figure 12-9. Terminal Connections, Rear Panel, Styles xxxxxxxxA and xxxxxxxxB

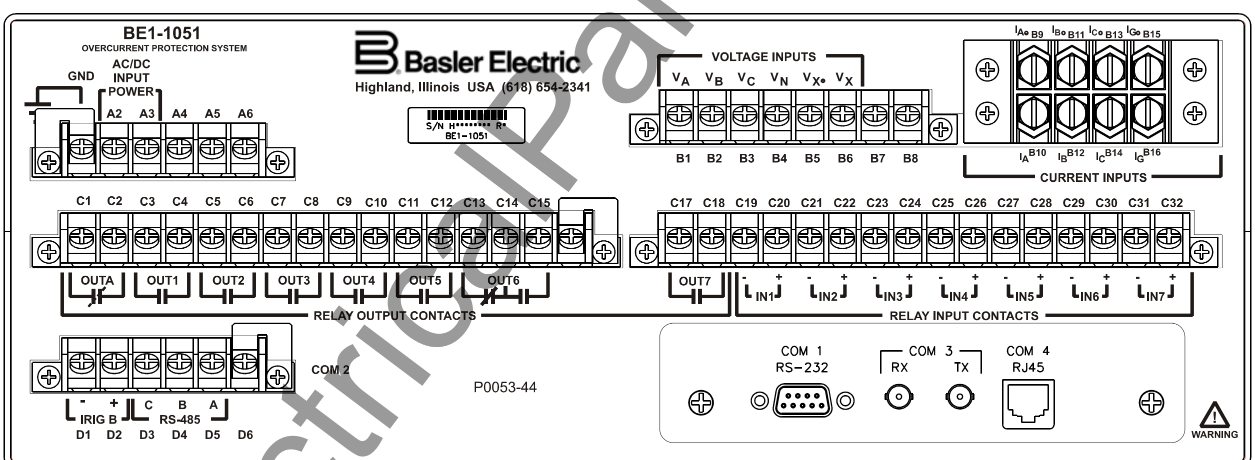

Figure 12-10. Terminal Connections, Rear Panel, Styles xxxxxxxxC and xxxxxxxxD

Typical DC and AC Connections

Typical external DC connections for the BE1-1051 are shown in Figures 12-11 and 12-12. Refer to Table 12-1 for input contact sensing turn-on voltage jumper sensing ranges. Typical external AC connections are shown in Figure 12-13.

> **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.

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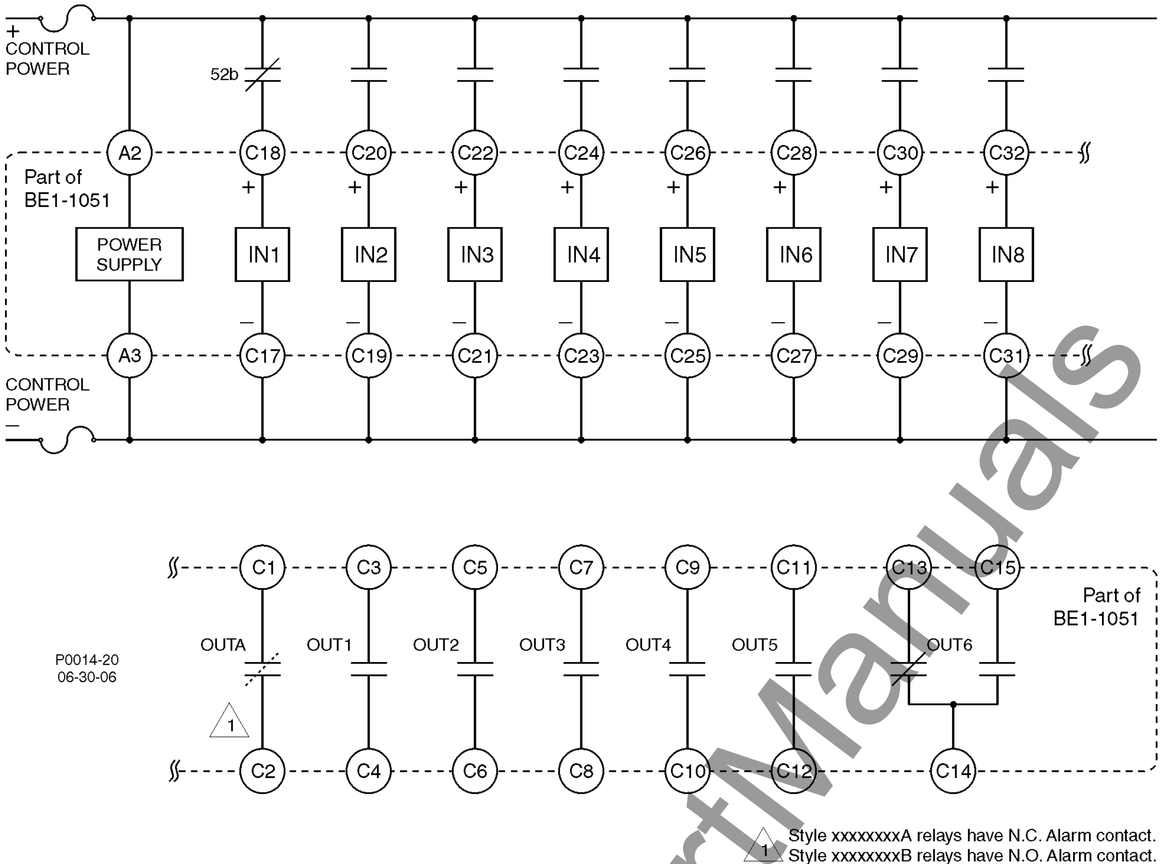

Figure 12-11. DC Connections, Relay Styles xxxxxxxxA and xxxxxxxxB

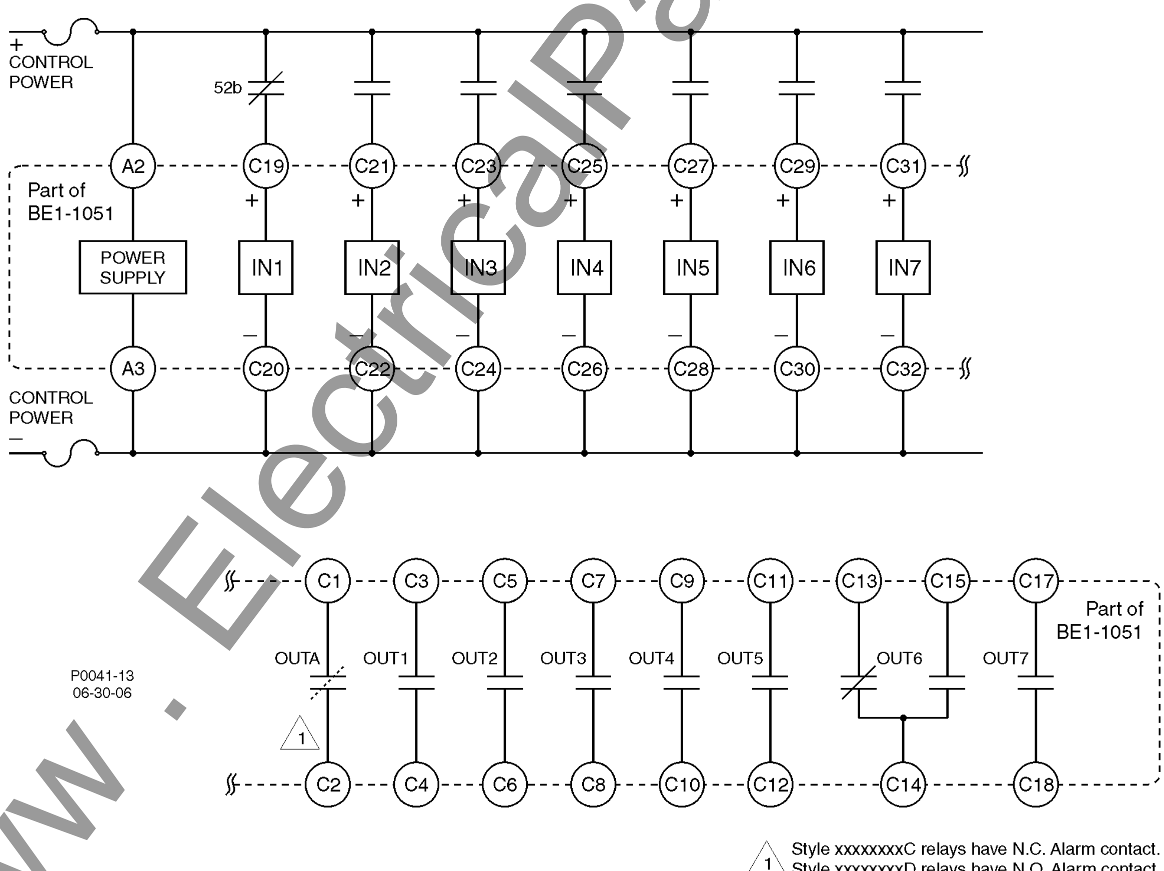

Figure 12-12. DC Connections, Relay Styles xxxxxxxxC and xxxxxxxxD

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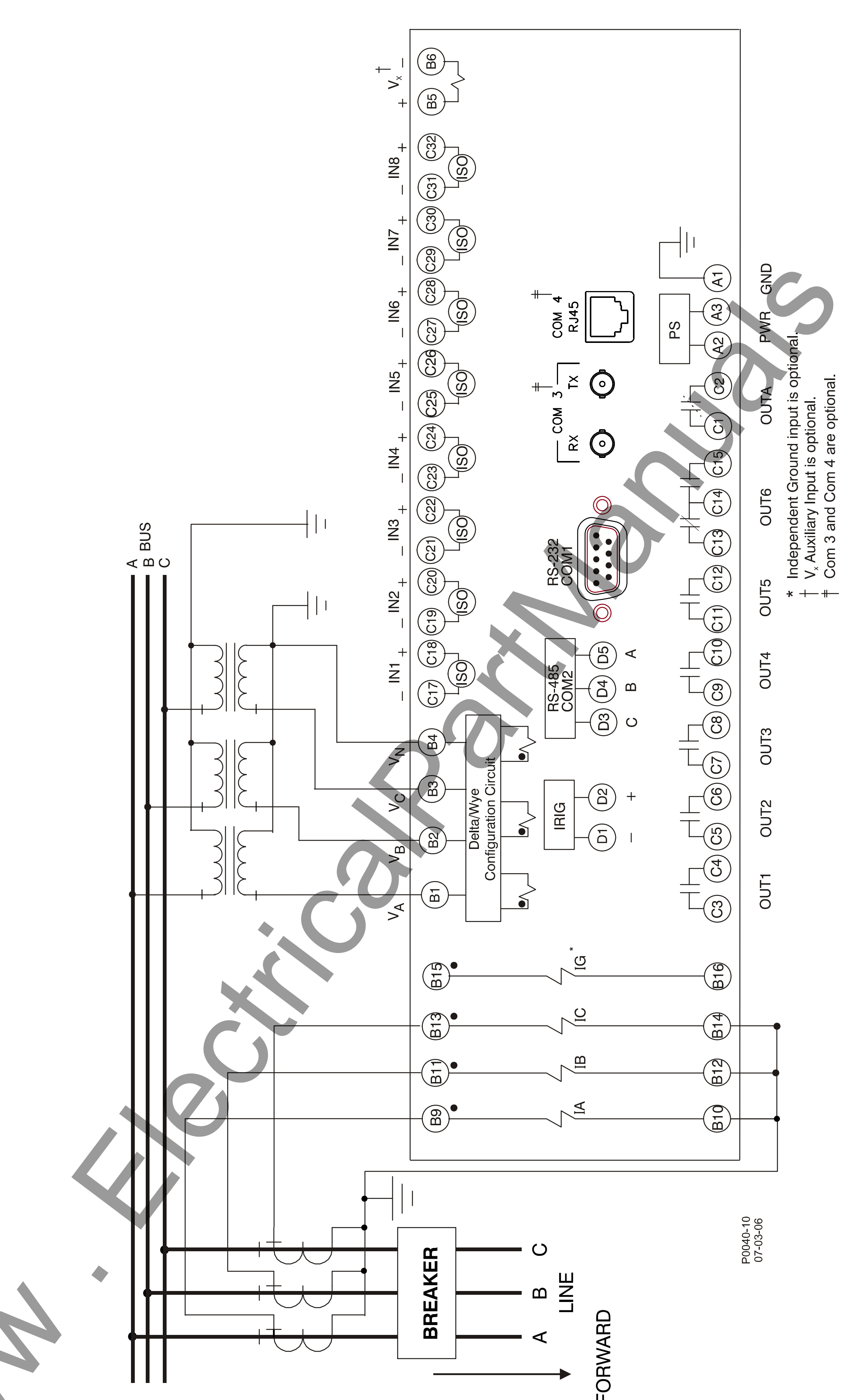

Figure 12-13. AC Connections

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Terminal Blocks

There are two sizes of terminal blocks used on the BE1-1051, MX case. Terminals B1 through B16 are for current inputs and use 8-32 pan-head (Phillips) screws with a lock washer. Terminals A1 through A6, C1 through C32 and D1 through D6 use 6-32" pan-head (Phillips) screws with no washer.

The lock washers on terminals B1 through B16 are an integral part of the current input circuit wiring and should not be removed. Without the lock washer, the 8-32" screw may bottom out and prevent a good mechanical connection with the terminal block.

Maximum wire lug width accommodated by terminals B1 through B16 is 0.344 inches (8.6 mm). Maximum wire lug width accommodated by the other terminals 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 BE1-1051. The information below provides fundamental information on CT polarity and protective relays.

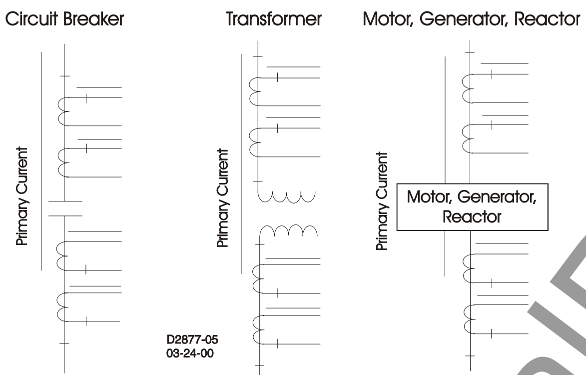

Figure 12-14. Standard CT Polarity

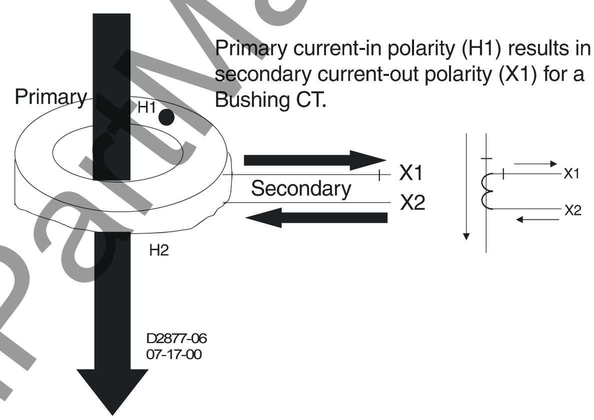

Figure 12-15. Current Transformer Action

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 12-14 and 12-15).

On occasion, however, protection engineers will encounter 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 12-16). 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.

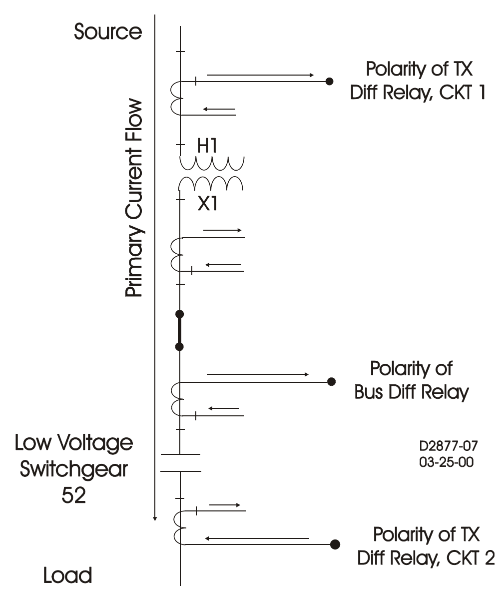

Figure 12-16. Example of Reversed CT Polarity

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POWER SYSTEM APPLICATIONS

Figures 12-17 through 12-30 are examples of the applications that can be served by the Basler BE1-1051 Overcurrent Protection System. Many of these applications can be used in concert with other Basler numeric systems such as the BE1-851Overcurrent Protection System, the BE1-CDS220/240 Current Differential Protection Systems, or the BE1-GPS100 Generator Protection System.

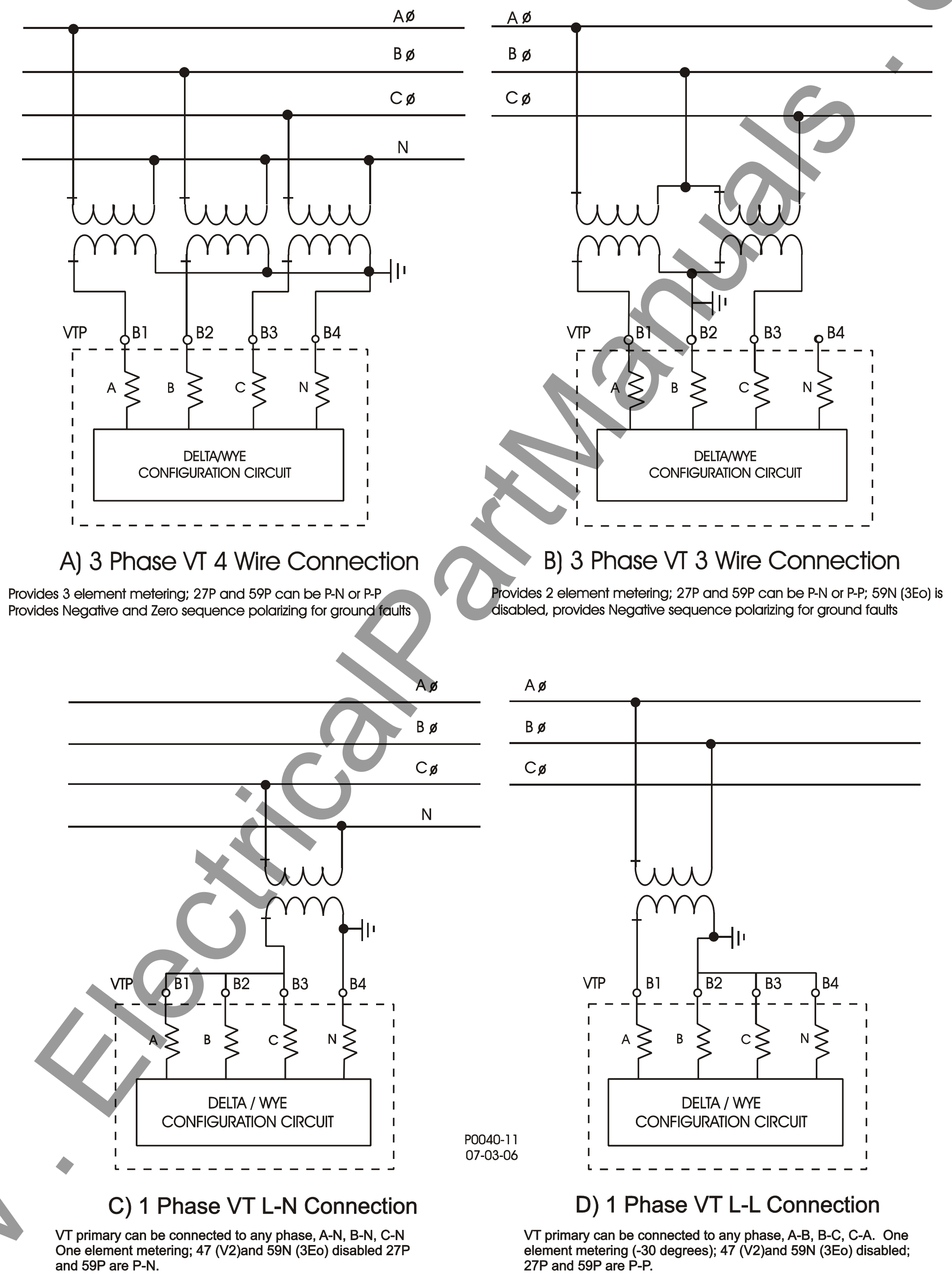

Figure 12-17. Three-Phase Voltage Sensing, Alternate VTP Input

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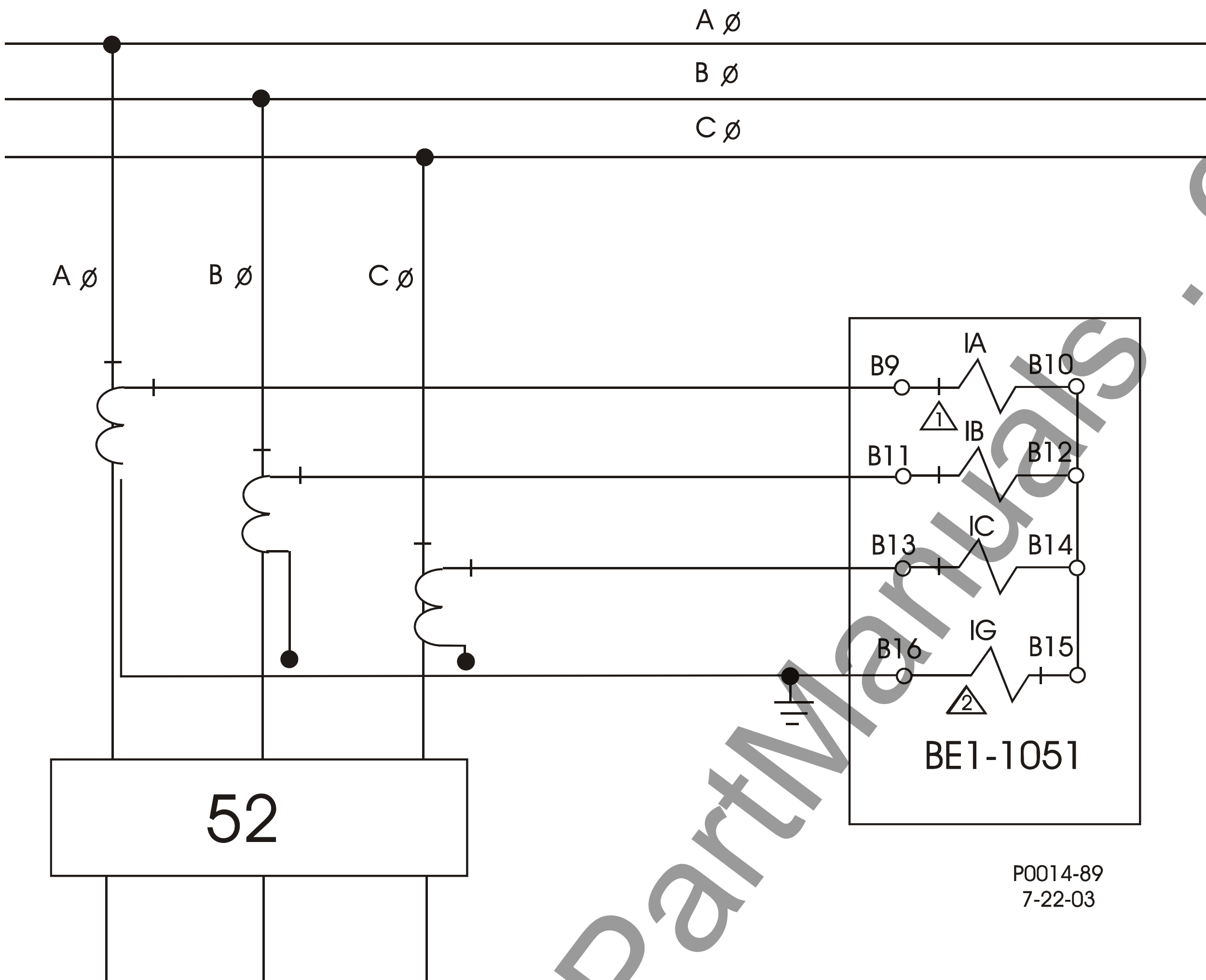

Notes: Δ

1. Cross hatches indicate relay polarity.
2. The Independent Ground option (IG) is required to use the Ground Fault Detector (GFD) setting of the 50BF Breaker Failure element.

Figure 12-18. Current Circuit Connections for Breaker Failure Applications

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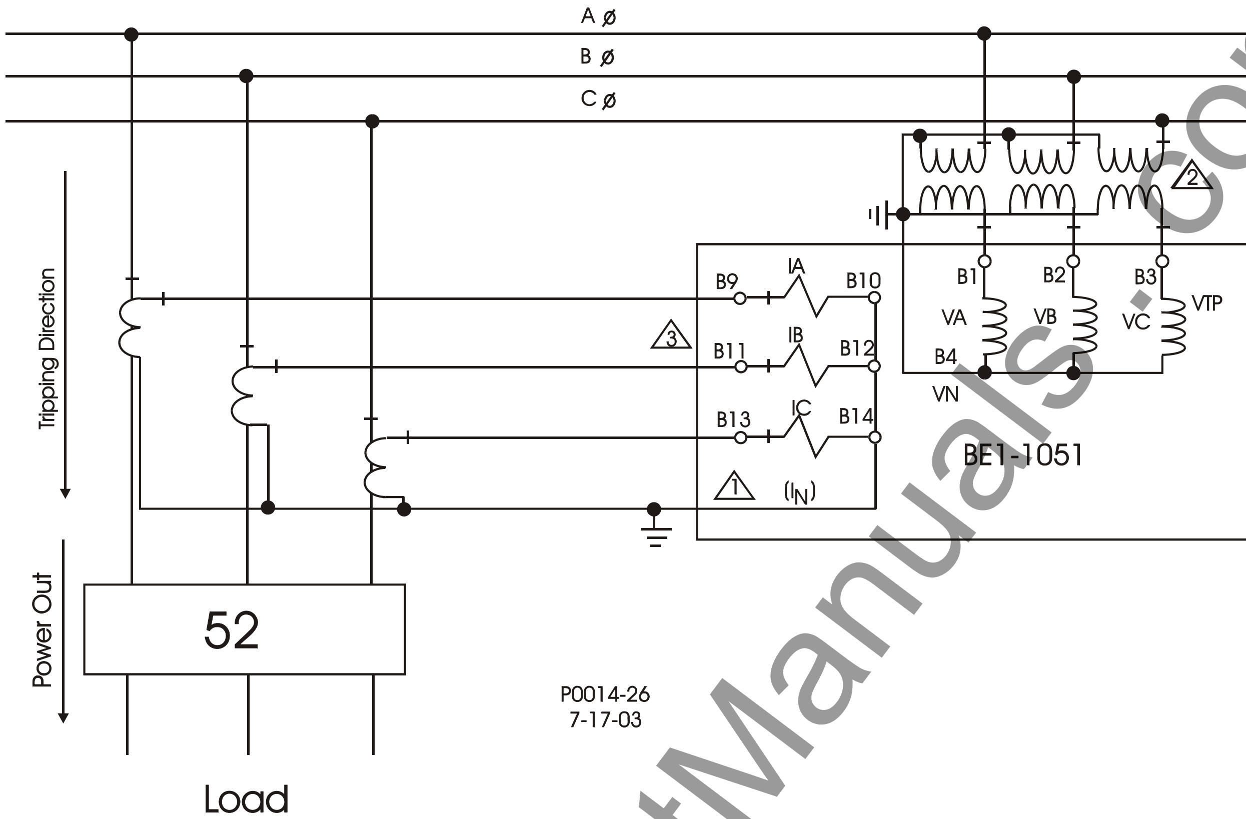

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections
3. CT polarity connected to relay polarity, power flow from Bus to Load defined as power out and = "+" watts

Figure 12-19. Overcurrent (OC) Protection of Typical Radial Loads - Distribution Circuit, Motor, or Reactor Optional Independent Ground Input

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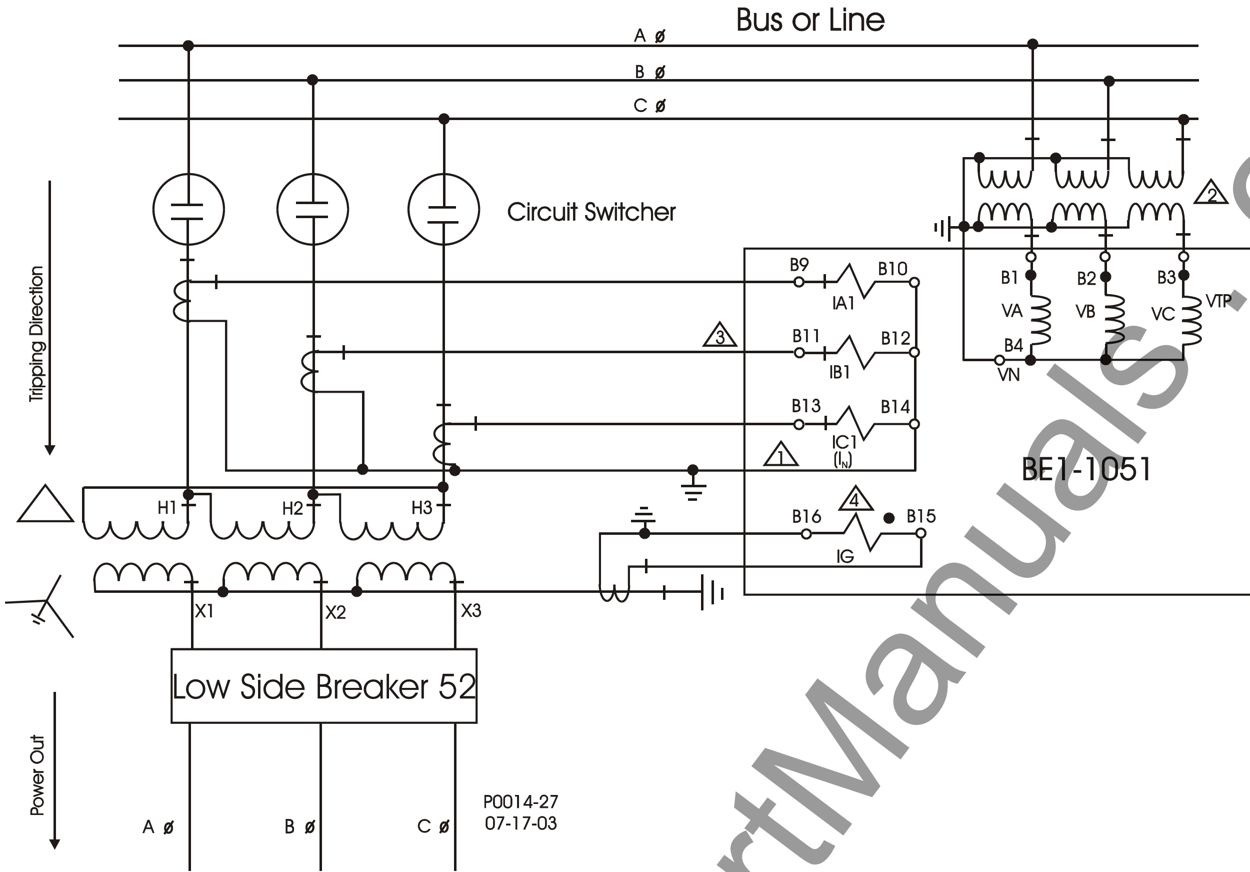

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four4-wire connection shown as typical. See Figure 12-17 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 detect low side ground faults

Figure 12-20. OC Protection of a Delta-Wye Grounded Transformer (Radial Load) with Optional Independent Ground Input (IG) Connected for Low Side Ground Fault Protection

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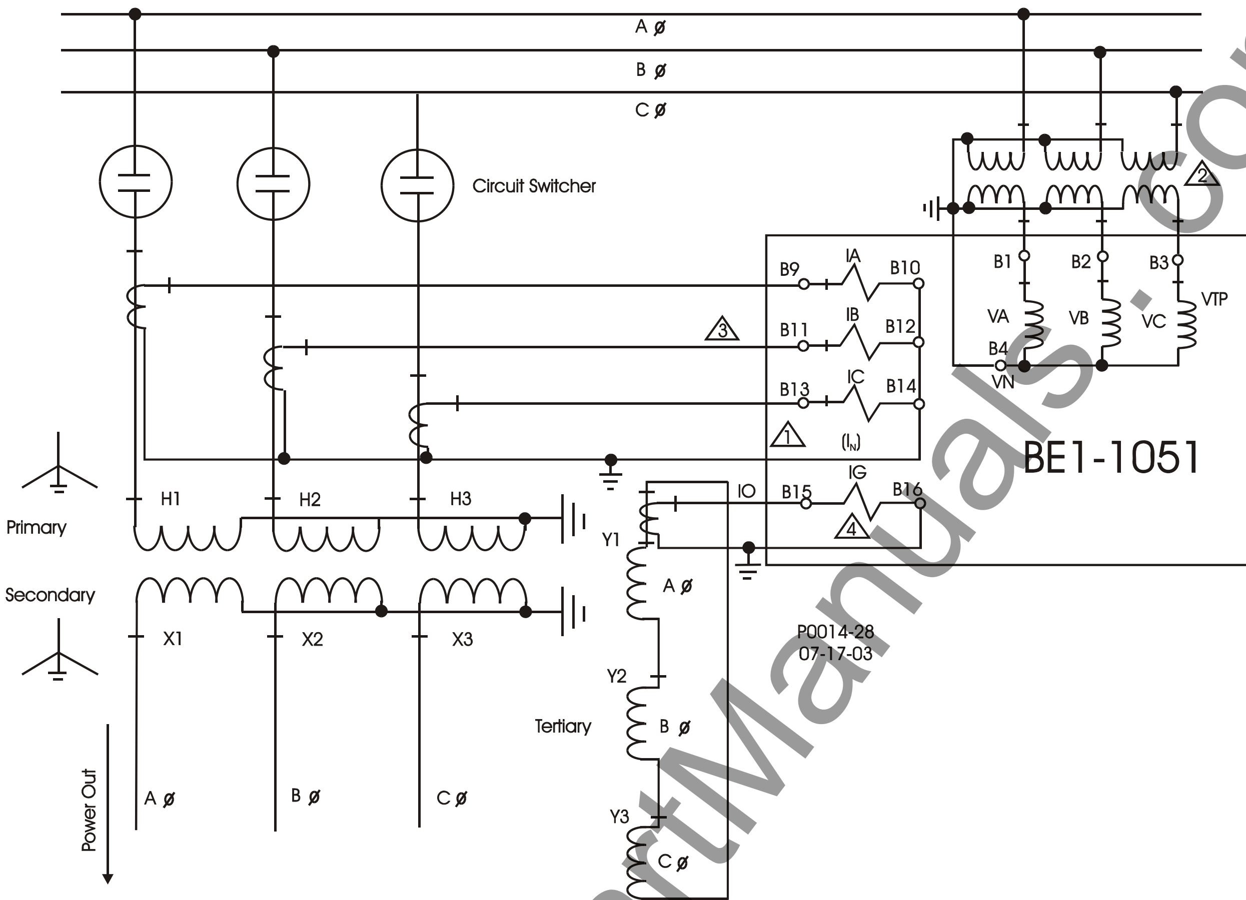

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 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 12-21. Backup OC Protection of a Three-Winding Transformer with Optional Independent Ground Input (IG) Connected for Tertiary and System Ground Fault Protection

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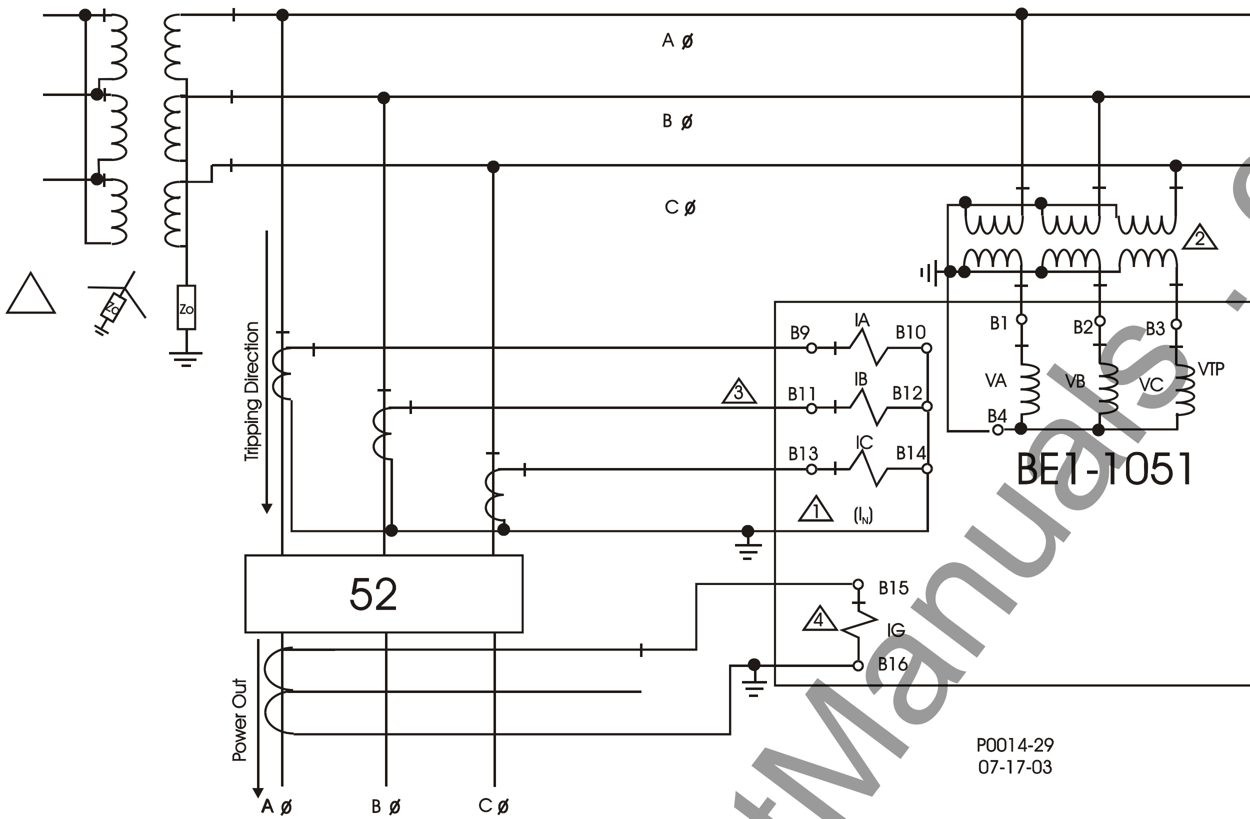

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 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 (IG) supplied by a core balance CT, provides sensitive ground fault protection

Figure 12-22. OC Protection of an Industrial Feeder (Radial Load) with Optional Independent Ground (IG) Connected to Core Balance CT for Sensitive Ground Fault Protection

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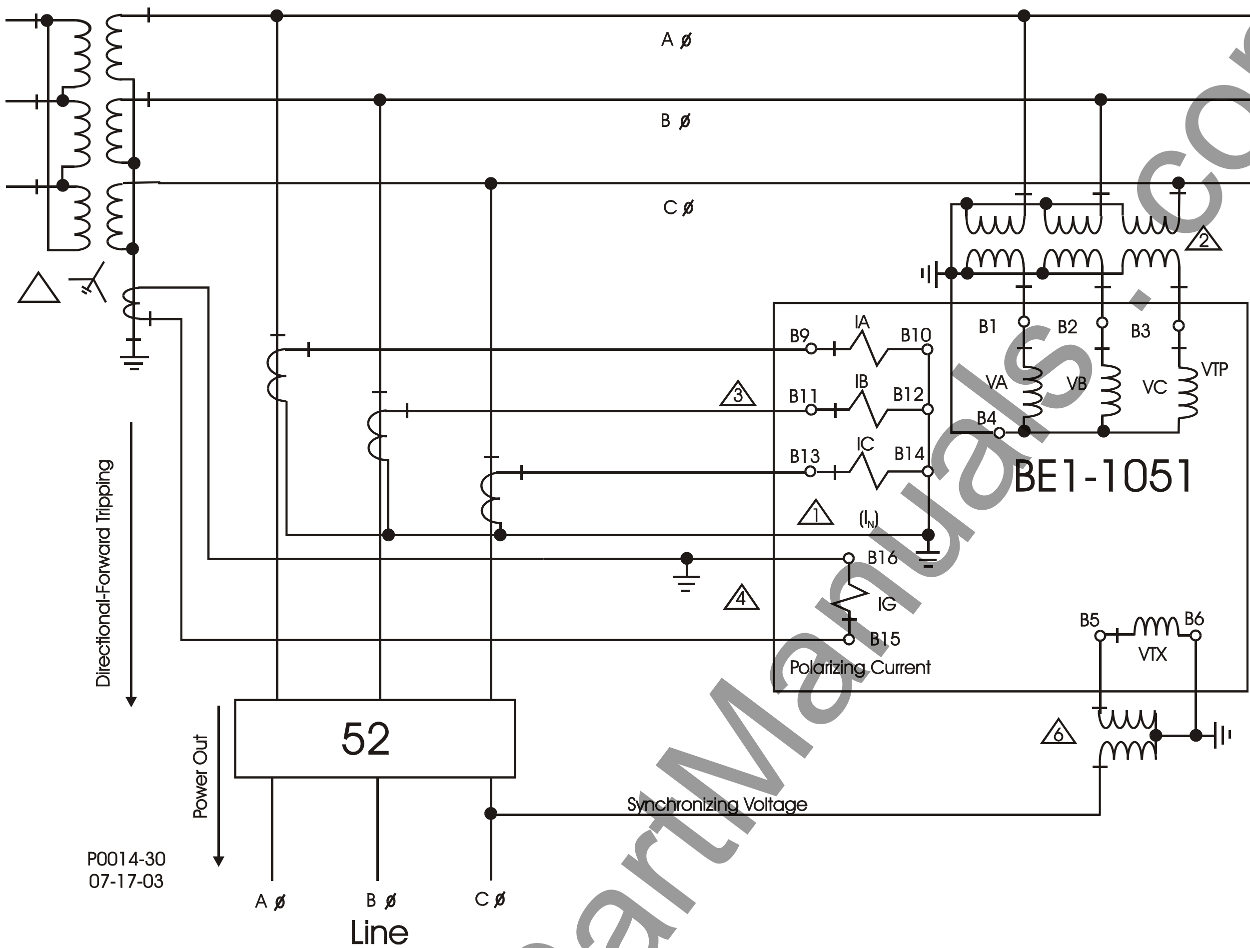

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections. The four-wire connection provides negative and zero-sequence voltage polarizing for ground faults; four-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 difference between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay.

Figure 12-23. Directional OC Protection with Reclosing of a Transmission Line (Zero-Sequence Current Polarizing Source from Delta-Wye Transformer Connected to IG)

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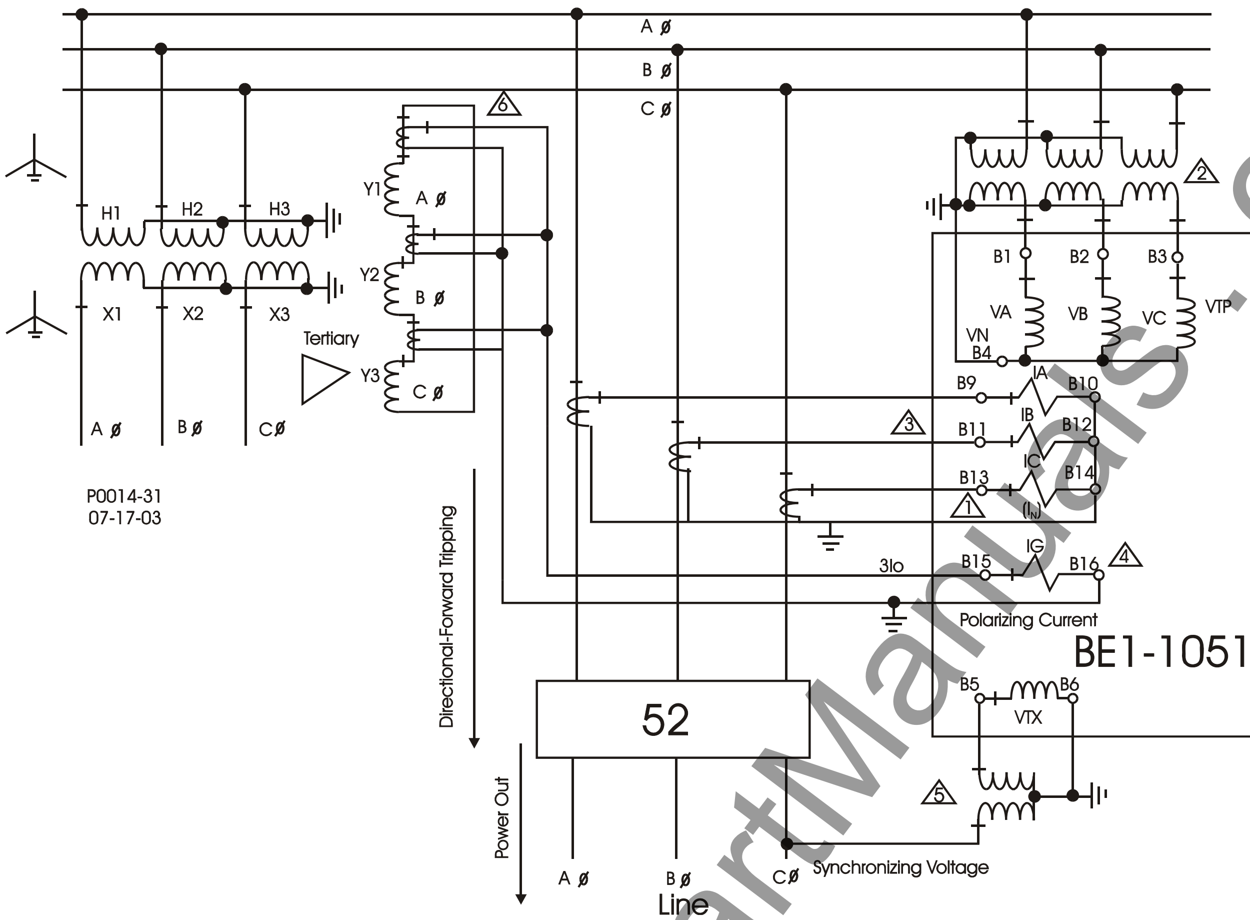

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections. The four-wire connection provides negative and zero-sequence voltage polarizing for ground faults; four-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 difference 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 (3Io); When tertiary is unloaded, only 1 CT (Io) is required

Figure 12-24. Directional OC Protection with Reclosing of a Transmission Line (Zero-Sequence Current Polarizing Source from Delta Tertiary Connected to IG)

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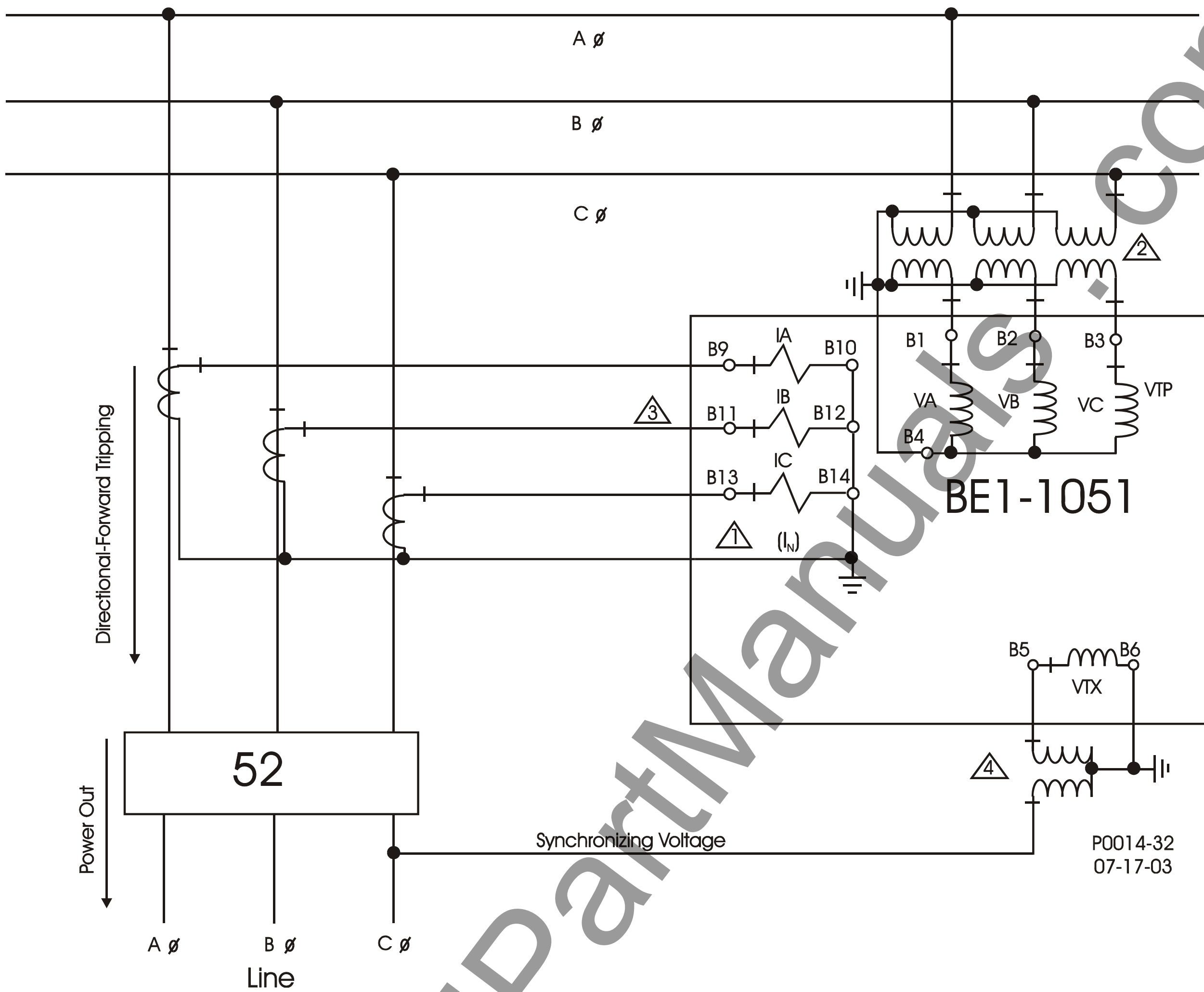

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections. The four-wire connection provides negative and zero-sequence voltage polarizing for ground faults; three-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 difference between VTP and VTX. Voltage magnitude between VTX and VTP must be matched external to the relay

Figure 12-25. Directional OC Protection with Reclosing of a Transmission Line (Potential Polarized)

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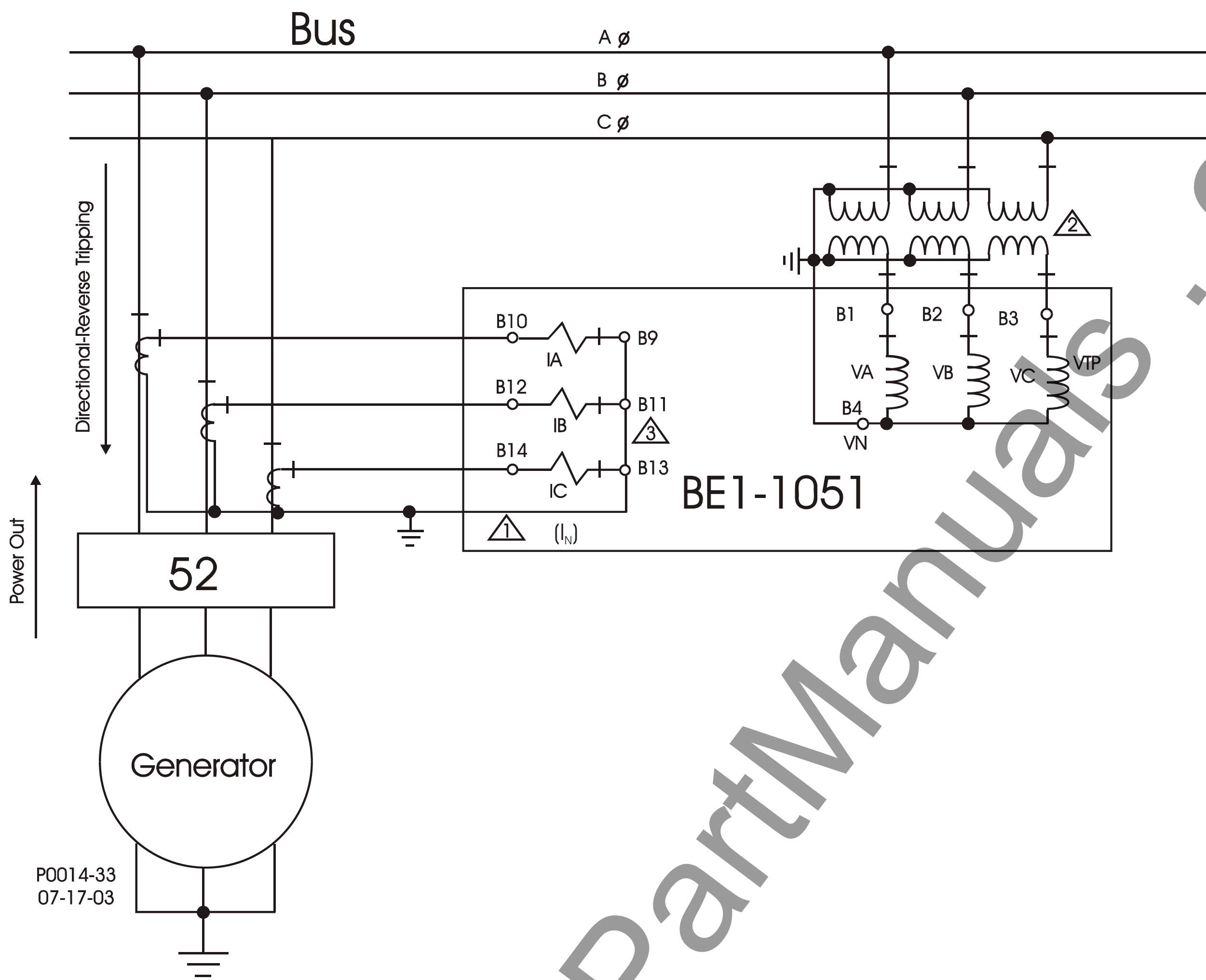

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections. The four-wire connection provides negative and zero-sequence voltage polarizing for ground faults; three-wire connection provides negative-sequence voltage polarizing.
3. CT non-polarity connected to relay polarity, power flow from Generator to Bus defined as power out and ="+" watts; OC elements set for reverse tripping

Figure 12-26. Directional OC Protection of a Small Generator (Potential Polarized)

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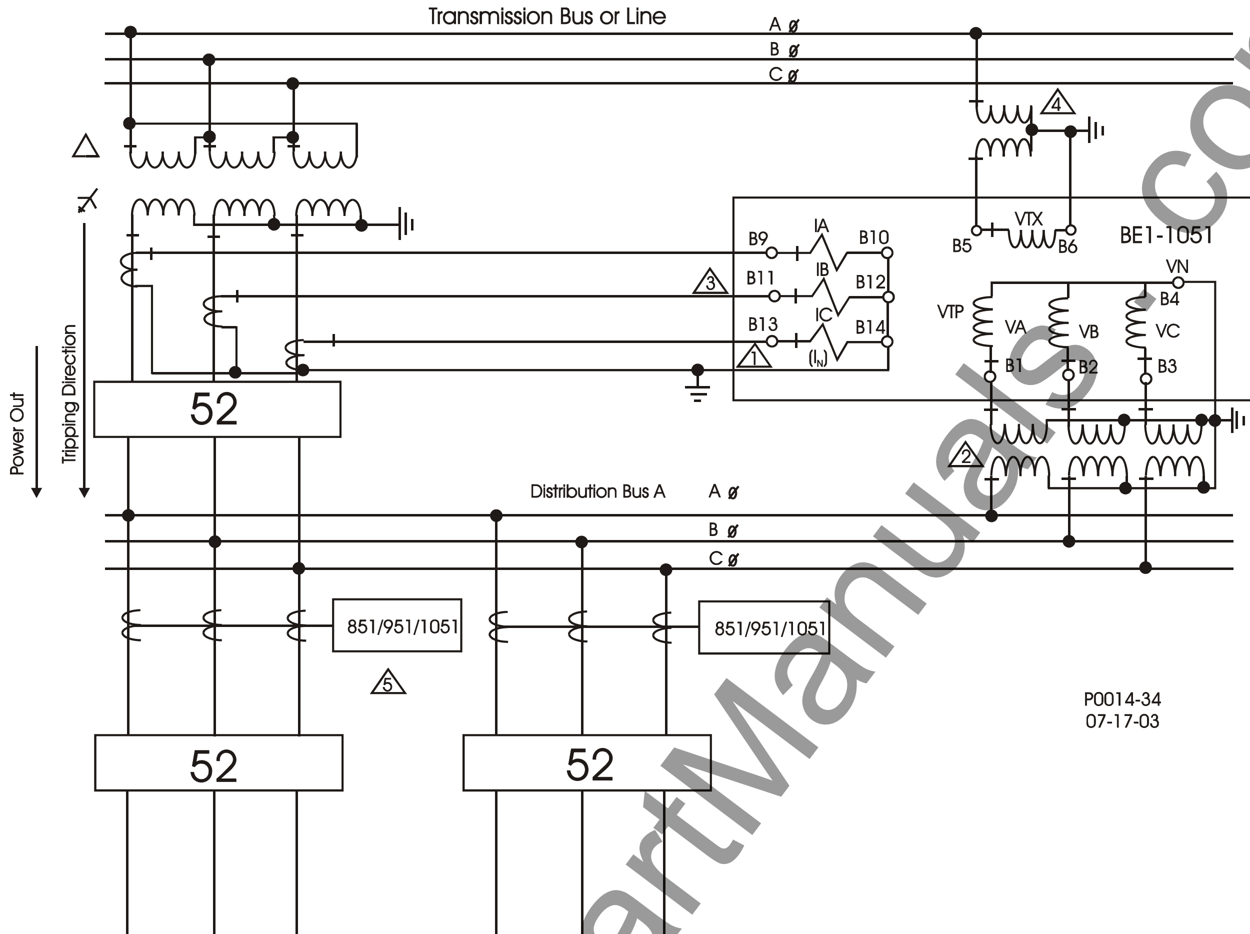

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections. Note that the 81 voltage inhibit function for four-wire and single-phase L-N systems monitor A-N voltage. Three-wire and single-phase L-L systems monitor A-B voltage.
3. CT polarity connected to relay polarity, power flow from Transformer LS to 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 the 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. BE1-851, BE1-951, or BE1-1051 required on each circuit to implement high speed bus interlocking scheme

Figure 12-27. Dual Voltage Source UF Load Shed Using Optional VTX Input; OC Bus Protection (Including High Speed Bus Interlocking)

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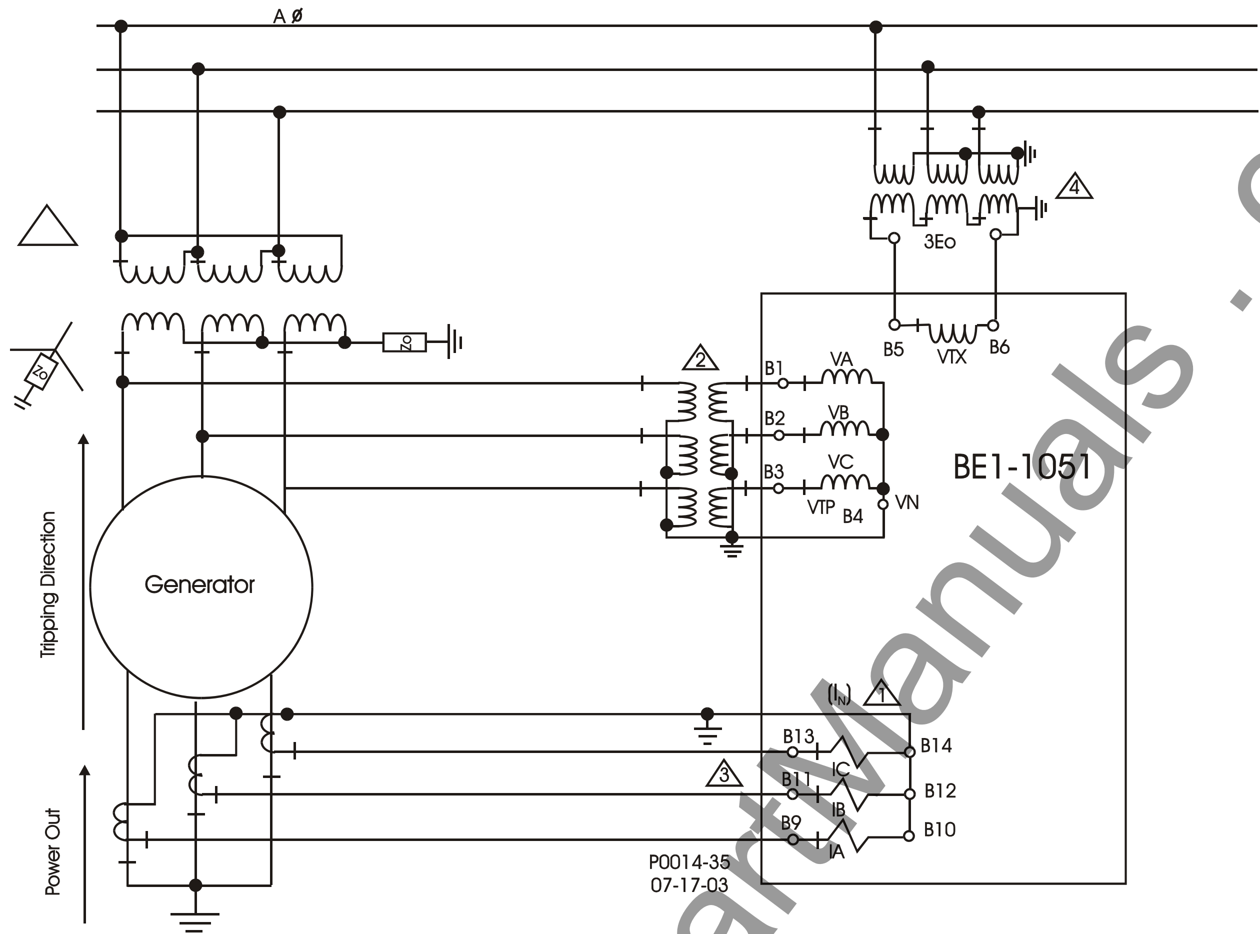

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current
2. Four-wire connection shown as typical. See Figure 12-17 for alternate VTP connections.
3. CT polarity connected to relay polarity, power flow from Generator to Transformer defined as power out and = "+" watts
4. VTX is set for "GR" and connected to the external 3Vo source for detecting ground faults on the delta side of the Transformer

Figure 12-28. 51V Generator, Leads and Transformer Low Side, Backup Protection; Delta Ground Fault Detection Using Externally Derived 3Eo Connected to VTX Input

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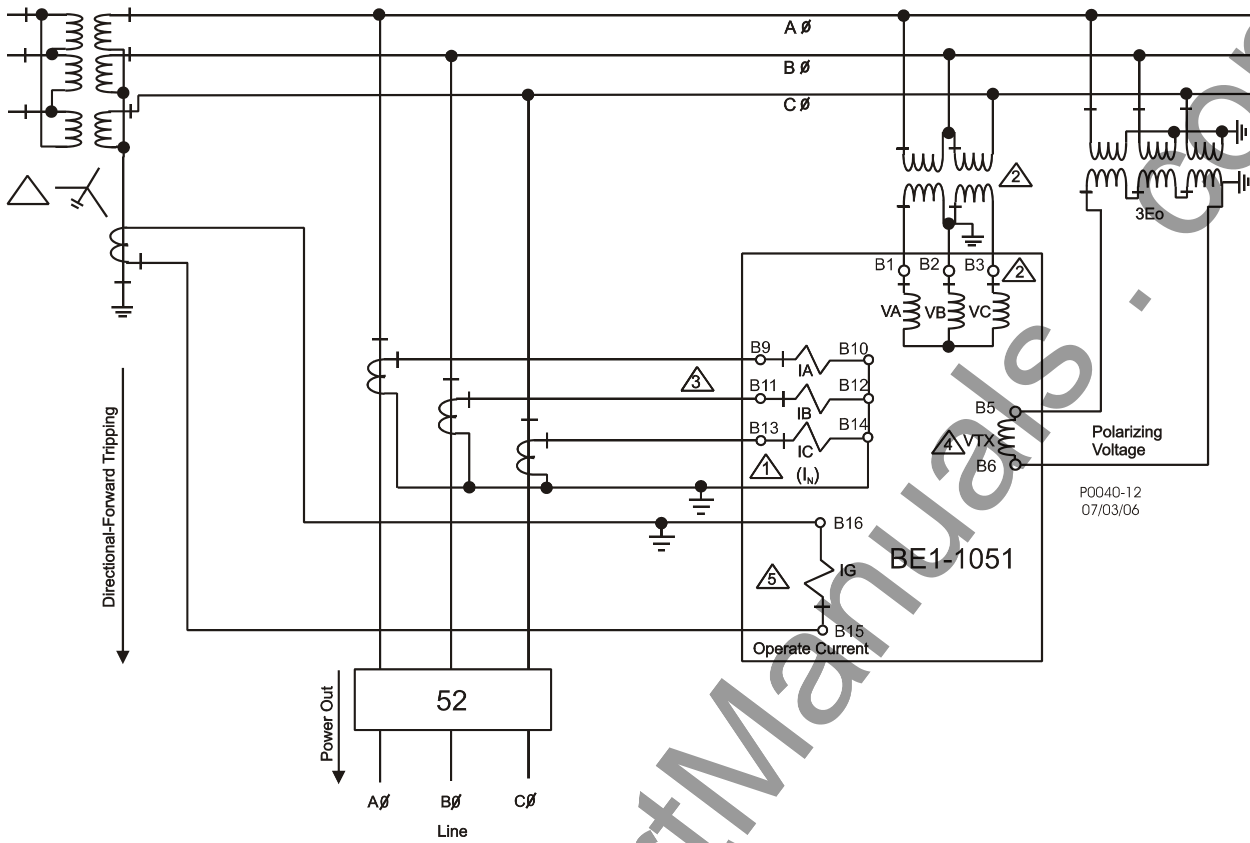

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current.
2. Three-wire connection shown. See Figure 12-17 for alternate VTP connections. The four-wire connection provides negative-sequence, and if selected (V0IN or V0IG), zero-sequence voltage polarizing for ground faults; three-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. VX connected to external source of 3E0 polarizing voltage

Figure 12-29. 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

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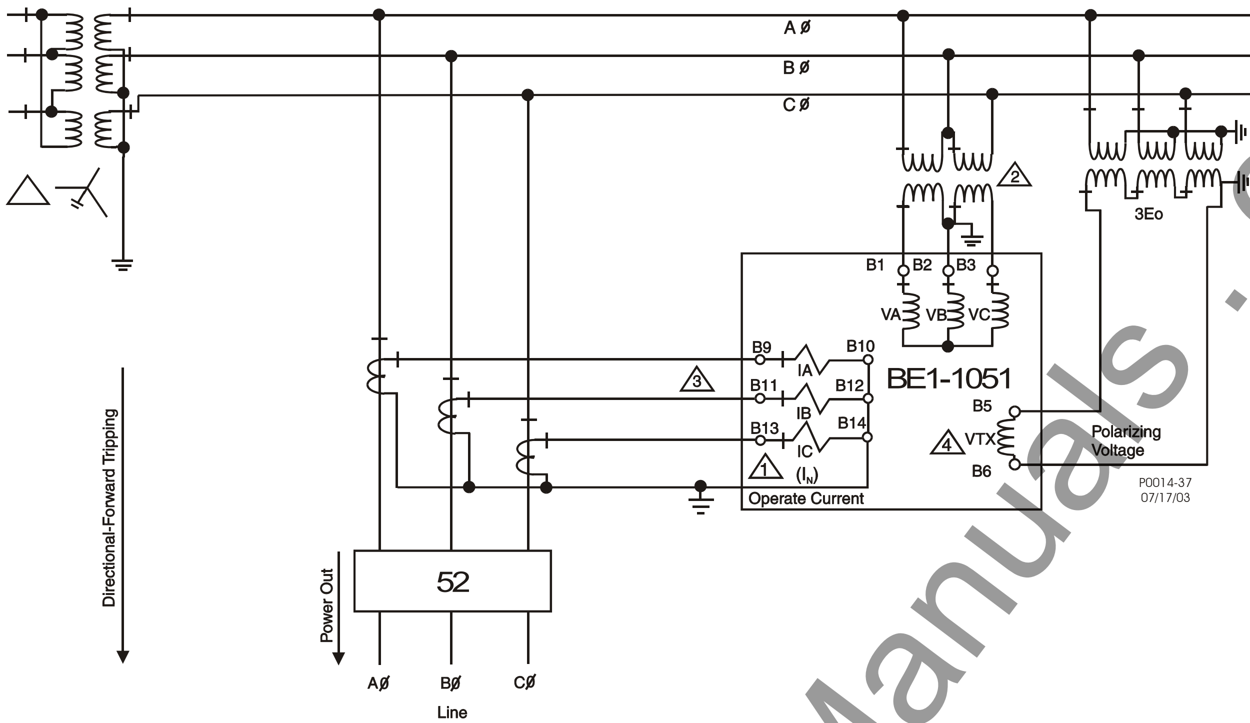

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual (3Io) current (VXIN)
2. Three-wire connection shown. See Figure 12-17 for alternate VTP connections. A four-wire connection provides negative-sequence and, if selected, zero-sequence voltage polarizing (V0IN or V0IG) for ground faults; three-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. VX connected to external source of 3E0 polarizing voltage.

Figure 12-30. Directional Ground OC Protection Using External Source of Zero-Sequence Polarizing Voltage (VX) Compared to Calculated Residual (3IO) (IN)

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SETTINGS

Settings for your application should 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 BE1-1051. 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 cable connection diagrams are provided in Figures 12-32 through 12-35. Optional clear to send (CTS) and request to send (RTS) connections are required only if hardware handshaking is enabled.

Front Panel RS-232 Port (Com 0)

The front panel RS-232 connector is a Data Communication Equipment (DCE) DB-9, female connector. Connector pin numbers, functions, names, and signal directions are shown in Table 12-3 and Figure 12-31.

Table 12-3. RS-232 Pinouts (COM 0)

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

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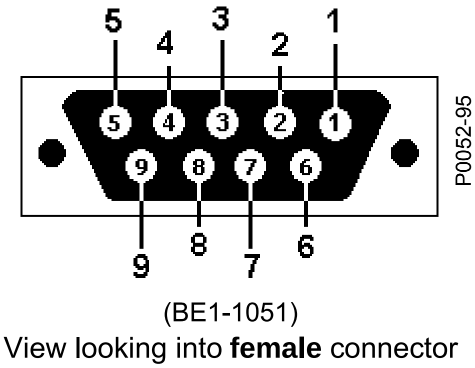

Figure 12-31. RS-232 Pin-outs

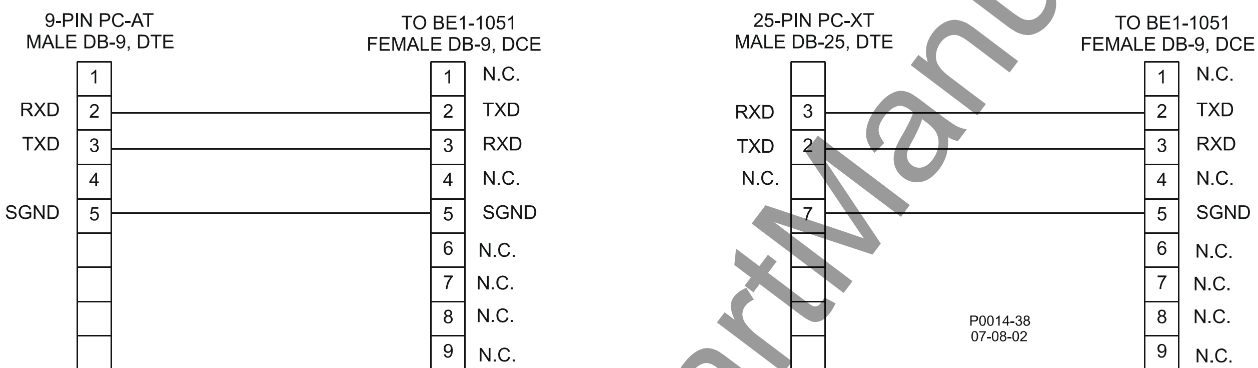

Figure 12-32. Personal Computer to BE1-1051

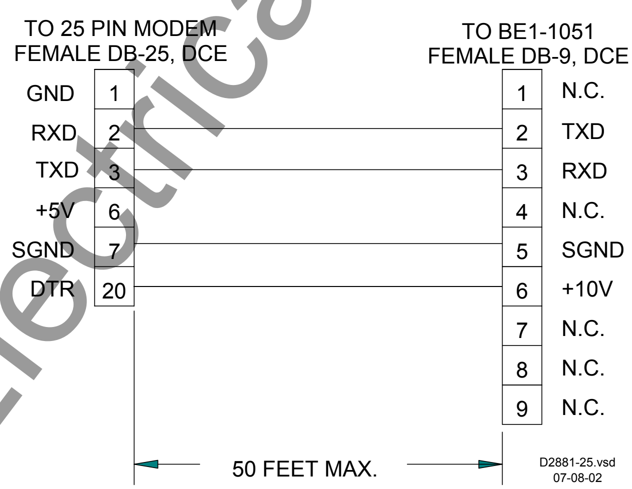

Figure 12-33. Modem to BE1-1051

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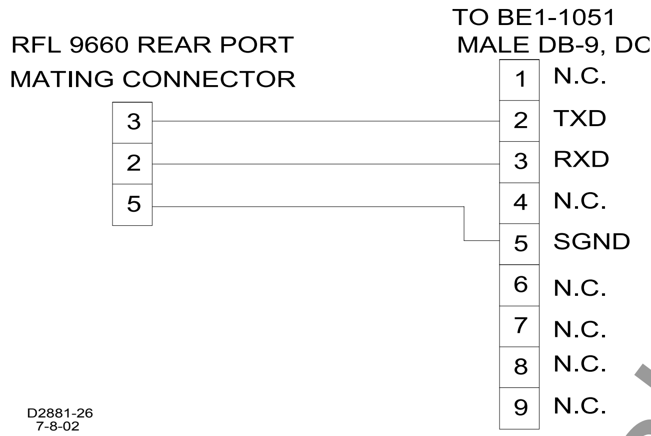

Figure 12-34. RFL9660 Protective Relay Switch to BE1-1051 Cable

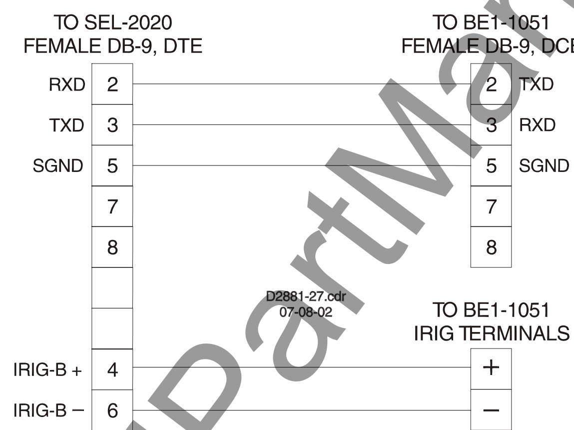

Figure 12-35. SEL 2020 to BE1-1051 Relay

Rear Panel RS-232 Port (Com 1)

COM1 is a DCE serial port with a female RS-232 (DECS-B-9) connector. COM1 terminal numbers, names, and functions are listed in Table 12-4.

Three jumpers, located on the Main circuit board, enable COM1 to be used with an external, self-powered RS-232-to-RS-485 converter without a separate, external power supply. Each jumper connects to two pins of three-pin header P11, P12, and P13. Figure 12-36 shows the location of P11, P12, and P13. Jumpering pins 1 and 2 of P11, P12, and P13 connects the COM1 data set ready (DSR), clear to send (CTS) and carrier detect (CD) signals to isolated ground. Jumpering Pins 2 and 3 connects the DSR, CTS, and CD signals to isolated +5 volts. If a converter will not be connected to COM1, the P11, P12, and P13 jumpers should be connected across Pins 1 and 2. BE1-1051 relays are delivered with the jumpers installed across Pins 2 and 3 of P11, P12, and P13.

Table 12-4. RS-232 Pinouts (COM 1)

Name	Function	Name	Direction
1	Carrier Detect	CD	Control Output
2	Transmit Data	TXD	From relay
3	Receive Data	RXD	Into relay
4	Data Terminal Ready	DTX	Control Input (Monitored)
5	Signal Ground	SGD	N/A

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Name	Function	Name	Direction
6	Data Set Ready	DSR	Control Output
7	N/C	----	N/A
8	Clear To Send	CTS	Control Output
9	N/C	----	N/A

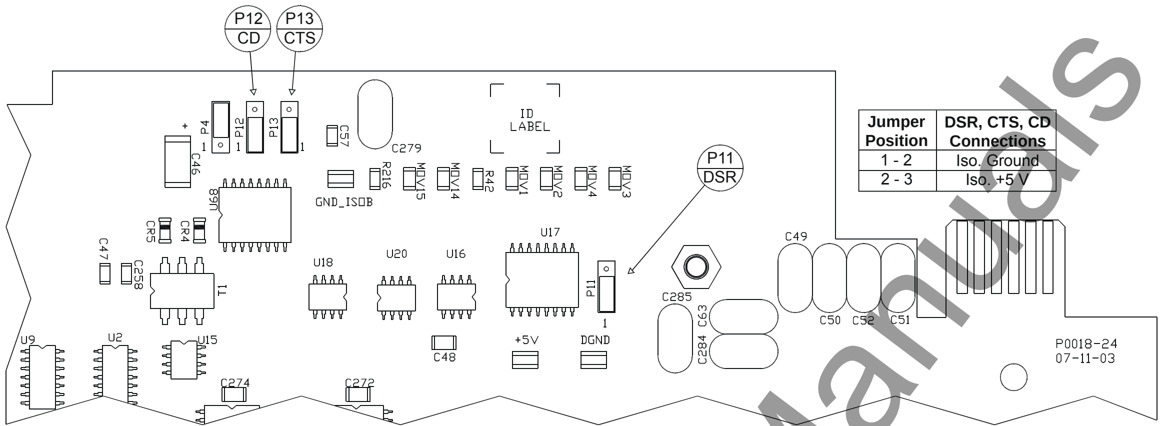

Figure 12-36. BE1-1051 Main Board - Com 1 Jumper Locations

RS-485 Connectors

RS-485 connections are made at a three-position terminal block connector. The connector mates with a standard communication cable. A twisted pair cable is recommended. Connector pin numbers, functions, names, and signal directions are shown in Table 12-5. An RS-485 connection diagram is provided in Figure 12-37.

Table 12-5. RS-485 Pinouts (COM 2)

Terminal	Function	Name	Direction
A (D5)	Send/Receive A	SDA/RDA	In/Out
B (D4)	Send/Receive B	SDB/RDB	In/Out
C (D3)	Signal Ground	GND	N/A

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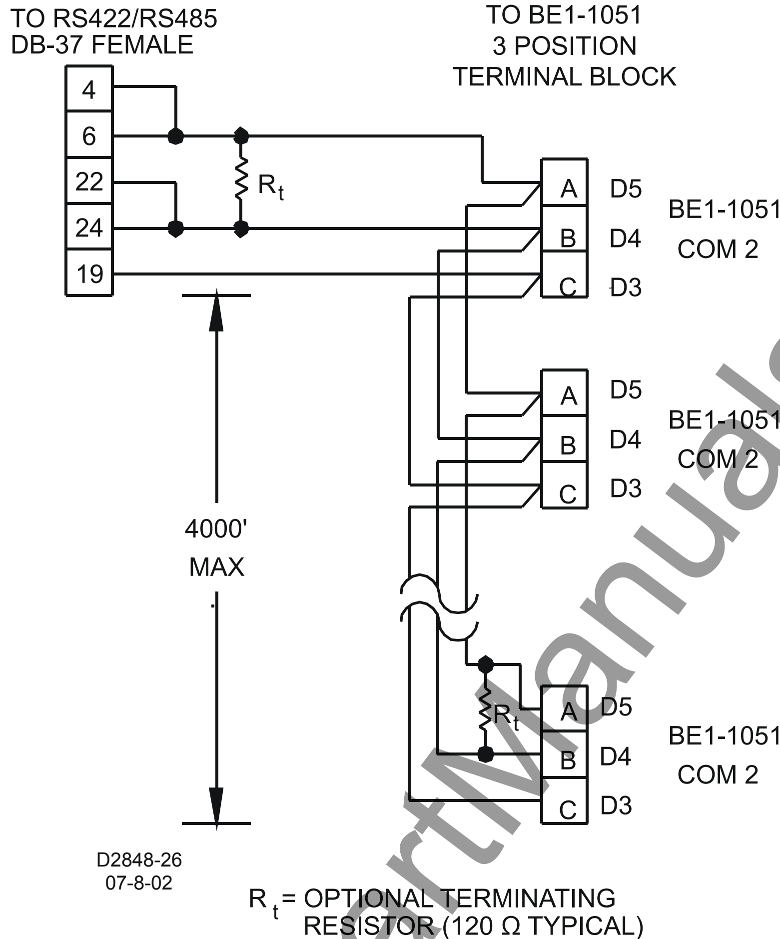

Figure 12-37. RS-485 DB-37 to BE1-1051

Ethernet Connectors

For BE1-1051 relays ordered with Ethernet Communication Protocol Options R or T, refer to Section 15, *BESTNet Communication,* in addition to this section. Relays can be connected to operate as a server in a peer to peer network. Dual ethernet ports, COM 3 and COM 4, are provided to facilitate network connections. COM 3 is a 10Base-F port and COM 4 is a 10Base-T port or a second 10Base-F port.

A Media Access Control (MAC) address is used by the client to select between COM 3 and COM 4. Using the RG-VER ASCII command will display the MAC address for COM 4. The MAC address for COM 3 is COM 4 plus one.

COM 4 is the default communication port for ethernet communications. COM 3 becomes active when it receives its MAC address making COM 4 inactive. Communications will switch back to COM 4 when COM 4 receives its MAC address.

COM 3, Com 4 10Base-F

10Base-F is a 10 MegaBit fiber optic media which is connected to the TX (transmit) and RX (receive) ST type connectors at the back of the relay. 10Base-F fiber has a maximum transmission segment length of 2,000 meters. Only multimode fiber is recommended for use with this communications port.

COM 4 10Base-T

10Base-T is a 10 MegaBit unshielded twisted pair (UTP) category five copper wire media which is connected to the RJ-45 connector at the back of the relay. 10Base-T has a maximum transmission segment length of 100 meters. Connector pin numbers, functions, names and direction are given it Table 12-6.

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Table 12-6. RJ-45 Pinouts (COM 4)

Pin	Function	Name	Direction
1	Transmit Data +	TX +	From Relay
2	Transmit Data -	TX -	From Relay
3	Receive Data +	RX +	To Relay
4	NC		
5	NC		
6	Receive Data -	RX -	To Relay
7	NC		
8	NC		

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 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 kilo-ohms at 3.5 Vdc and approximately 3 kilo-ohms 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 12-7. **Note:** If NTP (Network Time Protocol) is enabled in relays with options R or T, then IRIG is disabled. Refer to Section 15, *BESTNet Communication.*

Table 12-7. IRIG Terminal Assignments

Terminal	Function
D1	(−) Signal
D2	(+) Reference

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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 BE1-1051 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 BE1-1051 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

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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 BE1-1051 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*.

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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.*

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 #
- RS-# provides a detailed SER report on the last # events

For more information on HMI menu trees, see Section 10, *Human-Machine Interface*.

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 HM:

- 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 BE1-1051 relay to validate that the relay was manufactured properly and that no degradation of performance occurred as a result of shipping.

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**
>
> Refer to Section 12, *Installation, Relay Connections,* for relay terminal locations.

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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
BE1-1051-xxx1xxxxx	48-125 Vac/dc
BE1-1051-xxx2xxxxx	125-250 Vac/dc
BE1-1051-xxx3xxxxx	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 BE1-1051 relay communicates through all ports.

Reference Commands: ACCESS, EXIT

To communicate with the BE1-1051 through any of the three ports, use a terminal emulation program such as HyperTerminal or VT-100 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 (COM0). Verify that the baud rate is 9,600 bps.

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 rear RS-232 port (COM1).

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 BE1-1051 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 BE1-1051 relay should respond with the model number, style number, application program version and date, boot

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program version and date, and the relay serial number. 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 BE1-1051 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 BE1-1051 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. Input Contact Wetting Voltage

Nominal Control Voltage	Turn-On Range
48-125 Vac/dc	69 to 100 Vac or Vdc
125-250 Vac/dc	26 to 38 Vac or Vdc
24 Vdc	13 to 19 Vdc

Step 2: To verify that all inputs have been detected, transmit the command RG-STAT to retrieve INPUT (12345678) information. Input status can also be viewed at HMI Screen 1.5.1.

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 2.4.1, *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

Step 1: To verify IN 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) should be 1/3 the applied value ±1.5% (For example, if the applied value equals 2 amps, IQ = 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 3.8 also can be used to verify the IN and IQ current measurement.

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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 B10 and B11, B12 and B13, and B14 and B15. Apply an ac current source to Terminals B9 and B16.

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 3.6 and 3.7 also can be used to verify current measurements. Screen 3.8, 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 B1 (A-phase) and B4 (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 and M-V2 = 33.4 volts (applied divided by 3), all at ±1.0%. HMI Screens 3.1, 3.3, and 3.5 can also be monitored to verify voltage measurements.

Step 2: Connect an ac voltage source at nominal frequency between relay Terminals B2 (B-phase) and B4 (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 and M-V2 = 33.4 volts (applied divided by 3), all at ±1.0%. HMI Screens 3.1, 3.3, and 3.5 can also be monitored to verify voltage measurements.

Step 3: Connect an ac voltage source at nominal frequency between relay Terminals B3 (C-phase) and B4 (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 and M-V2 = 33.4 volts (applied divided by 3), all at ±1.0%. HMI Screens 3.1, 3.3, and 3.5 can also be monitored to verify voltage measurements.

Step 4: Connect relay Terminals B1 (A-phase), B2 (B-phase), and B3 (C-phase) together. Connect an ac voltage source at nominal frequency to the three jumpered terminals and the Neutral Terminal (B4).

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.

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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 B1, B2, and B3, neutral tied to B4. Use the same current connection as in Steps 3 and 4 of *Current Circuit Verification*; that is, polarity current in 9 out 16 with 10 and 11, 12 and 13, 14 and 15 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. HMI Screen 3.9 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 3.10.

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%. HMI Screen 3.9 can also be monitored to verify power and reactive values. Apparent power and power factor can also be viewed on HMI Screen 3.10. 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 Step 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 B5 (polarity) and B6 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. HMI Screens 3.4, VX can also be monitored to verify voltage measurements.

Step 3: Connect relay Terminals B5 (polarity) and B6 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. HMI Screen 3.4, VX can also be monitored to verify voltage measurements.

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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

Step 1: Connect relay Terminals B1 (polarity) and B4 (A to Neutral of the three-phase voltage input) to a 60 hertz ac voltage source (line voltage).

Step 2: Connect relay Terminals B5 (polarity) and B6 (Auxiliary Voltage Input) to a second 60 hertz ac voltage source (bus voltage).

Step 3: 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 3.11 and 3.12 can also be monitored to verify the measurements.

Step 4: 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.

Step 5: 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 3.12 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 greatest 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 BE1-1051 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 the 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.

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Digital I/O Connection Verification

<u>*Contact Sensing Inputs*</u>

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 1.5.1 to verify the status of input 1. Transmit the RS-NEW=0 command to the relay. From the actual field device, close (or open) 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 1.5.1. 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.

<u>*Output Contacts*</u>

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 17. 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 (If not used, skip to Virtual Control Switch)

Purpose: To verify the operation, labels, and logic settings of the 43 switches.

Reference Commands: SN-43, SL-43, 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 Switches 143 through 443. 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 43 through 443. Logic settings for virtual switches can also be obtained by using the SL command or by viewing optional HMI Screens \CTRL\43\43 through \CTRL\43\443. Verify that the desired virtual selector switch setting matches the reported setting.

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Step 4: Transmit the RG-STAT command to obtain the position of the five virtual selector switches. Alternately, the virtual selector switch positions can be obtained through optional HMI Screens \CTRL\43\43 through \CTRL\43\443.

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 optional HMI Screens \CTRL\43\43 through \CTRL\43\443.

Step 7: Return each virtual selector switch to the original position.

Step 8: Verify the 43 Switch activities by viewing the sequence of events reports with the RS-### command.

Virtual Control Switch (If not used, skip to Protection and Control Function Verification)

Purpose: To verify the operation, label, and logic setting for the 101 Switch.

Reference Commands: SB-LOGIC, SL-101, 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-STAT command.

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-STAT command.

Step 6: Repeat Step 4 to return the 101 Switch to the desired position for your application.

Step 7: Verify the 101 Switch activities 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 Section 12, *Installation, Relay Connections,* 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 BE1-1051 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.

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To accomplish this, transmit the S command to the relay. 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 users 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. 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.

Report 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 optional LCD HMI or the ASCII command interface to enter or edit relay operating values. See Sections 10 and 11, respectively.

Clock Display

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: 4.6

Refer to Section 6, *Reporting and Alarm Functions, Clock,* for setting details.

Energy Data and Demand

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 4.5.x

Refer to Section 6, *Reporting and Alarm Functions, Energy Data* and *Demand Functions* sub-sections for setting details.

Breaker Monitoring

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, 4.3.2

Refer to Section 6, *Reporting and Alarm Functions, Breaker Monitoring*, for setting details.

Relay Trouble Alarms

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 a STAT \ALARMS \ALARM Screen on the HMI. Refer to Section 6, *Reporting and Alarm Functions, Alarms Function, Relay Trouble Alarms,* for setting details.

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Major/Minor/Logic Programmable Alarms

Reset and verify that the programmable alarms, Major, Minor, and Logic, as set to meet user needs, 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.

Refer to Section 6, *Reporting and Alarms, Alarms Function*, for setting details.

Targets

Reset and verify that there is no target information. Targets are reset from HMI Screen 1.2.1, \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 1.2.1, \STATS \TARGETS, or by transmitting the RG-TARG command.

Refer to Section 6, *Reporting and Alarm Functions, Fault Reporting, Targets,* for setting details.

Fault Summary Reports

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.

Refer to Section 6, *Reporting and Alarm Functions, Fault Reporting, Fault Summary Reports,* for setting details.

Sequence of Events Recorder (SER)

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.

Refer to Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder*, for setting details.

Just Prior to Energizing - Report Documentation

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.

Refer to 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.

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PERIODIC TESTING

Because the BE1-1051 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 BE1 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).

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The backup battery should be replaced after five years of operation. The recommended battery is lithium 3.6V, 0.95 Ah battery (Basler P/N: 9318700012 or Applied Power P/N: BM551902.) Use the following instructions to replace the battery.

> **WARNING!**
> Do not short-circuit the battery, reverse battery polarity, or attempt to recharge the battery.

To Replace Battery

Step 1: Remove the unit from the case.

Step 2: Disconnect the battery cable from the connector on the component side of the main circuit board assembly. See Figure 13-1. Caution: Be sure that all static body charges are neutralized before touching the PC board.

Step 3: The battery is located on the bottom enclosure (see Figure 13-1). Using a Phillips screw driver, remove the bottom enclosure by removing the five number four screws at either side of the bottom enclosure as well as the two screws on the bottom and near the front panel. Slide the bottom enclosure free of the assembly.

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.

Step 5: Install the new battery by following Steps 1 through 4 in reverse order.

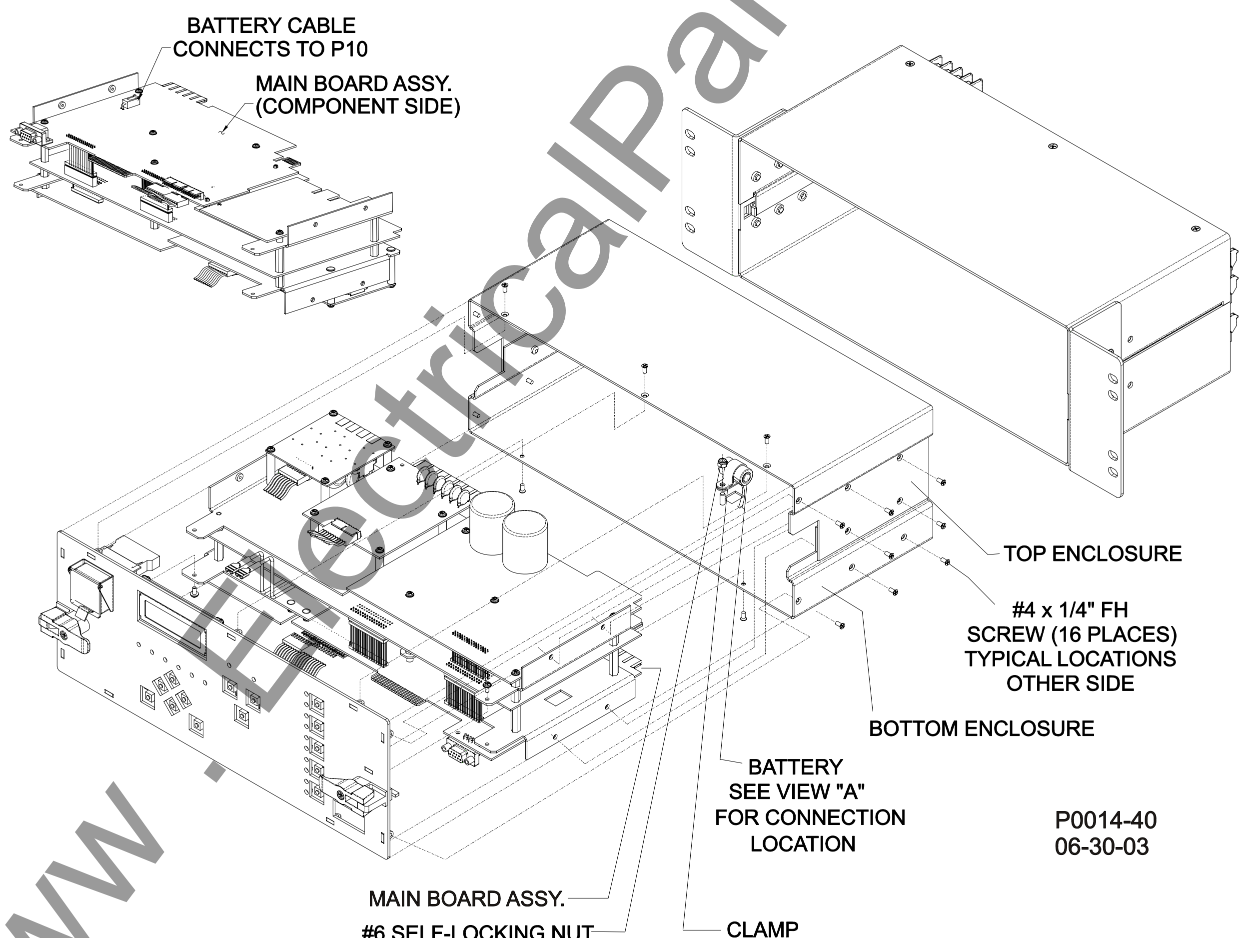

Figure 13-1. Backup Battery Location

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CARE AND HANDLING

The BE1-1051 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 Web site. 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 on-line form can be completed to obtain a password for downloading BESTCOMS from the Basler Electric Web site.

VIRTUAL TEST SWITCH

The BE1-1051 provides a Virtual Test Switch (VTS) function to facilitate isolation of individual functions under test. To do this, the VTS simulates a 128 position test switch that is grouped into banks of four octets (32 bit groups). A dedicated LED on the front of the relay labeled *Virtual Test* will illuminate when the relay is in virtual test mode.

Up to four virtual test switch setups can be programmed into the relay for use at any time. In addition, eight preprogrammed screens are available.

Virtual Test Switch Setup

VTS settings are made using BESTCOMS. Figure 13-2 illustrates the BESTCOMS screen used to select settings for the VTS function. To open the screen, select *Virtual Test Settings* from the *Screens* pull-down menu.

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 settings can be changed. See Section 7, *BESTlogic Programmable Logic.*

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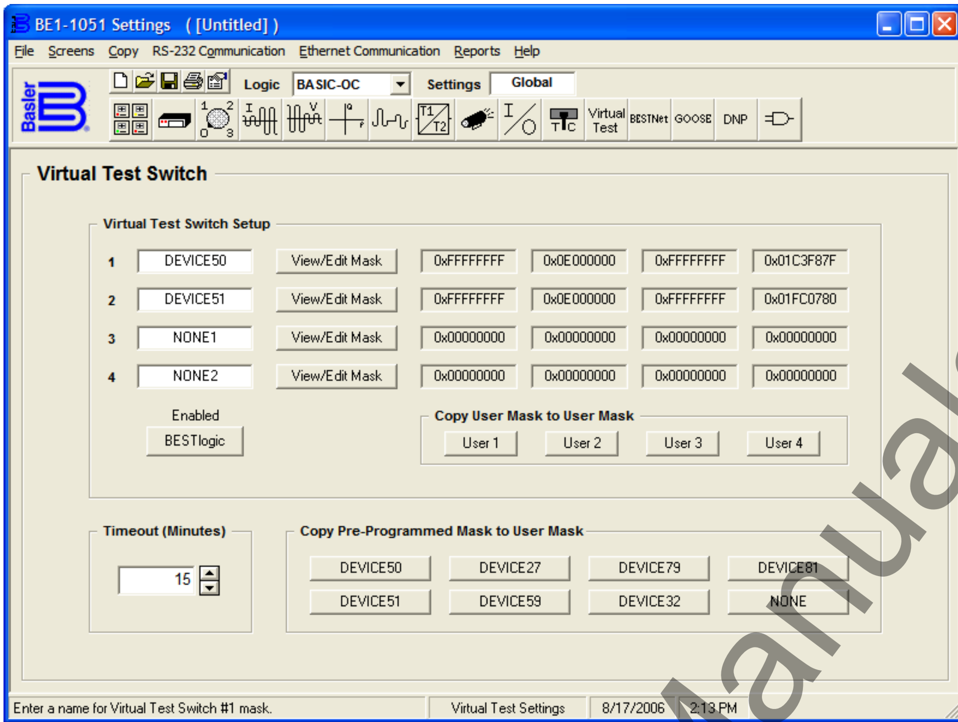

Figure 13-2. Virtual Test Settings Screen

The boxes labeled one through four represent the test schemes that will be programmed into the relay when the settings file is uploaded. The four octets are listed to the right of each corresponding VTS scheme. Each scheme is referred to as a User Mask.

To copy the contents of a mask to another mask, select the corresponding button to be copied in the box titled, *Copy User Mask to User Mask.* A dialog box will be displayed asking you to select the destination user mask the settings are to be copied to.

Eight preprogrammed masks are available. To copy a preprogrammed mask to a user mask, select the desired preprogrammed mask from the box titled, *Copy Pre-Programmed Mask to User Mask.* A dialog box will be displayed asking you to select the destination user mask the settings are to be copied to.

Timeout (Minutes) selects the amount of time the relay stays in the virtual test switch mode once it is selected. The default is 15 minutes.

Each user mask can be customized by the user. To do so, first type a new name for the user mask. Then select the *View/Edit Mask* button for the corresponding mask to be changed. A screen such as that shown in Figure 13-3 will appear. The red highlighted functions are the functions that will be enabled when in the VTS test mode. Select the functions desired for test and select *SAVE.*

NOTE
All settings files created in BESTCOMS must be sent to the relay to become active.

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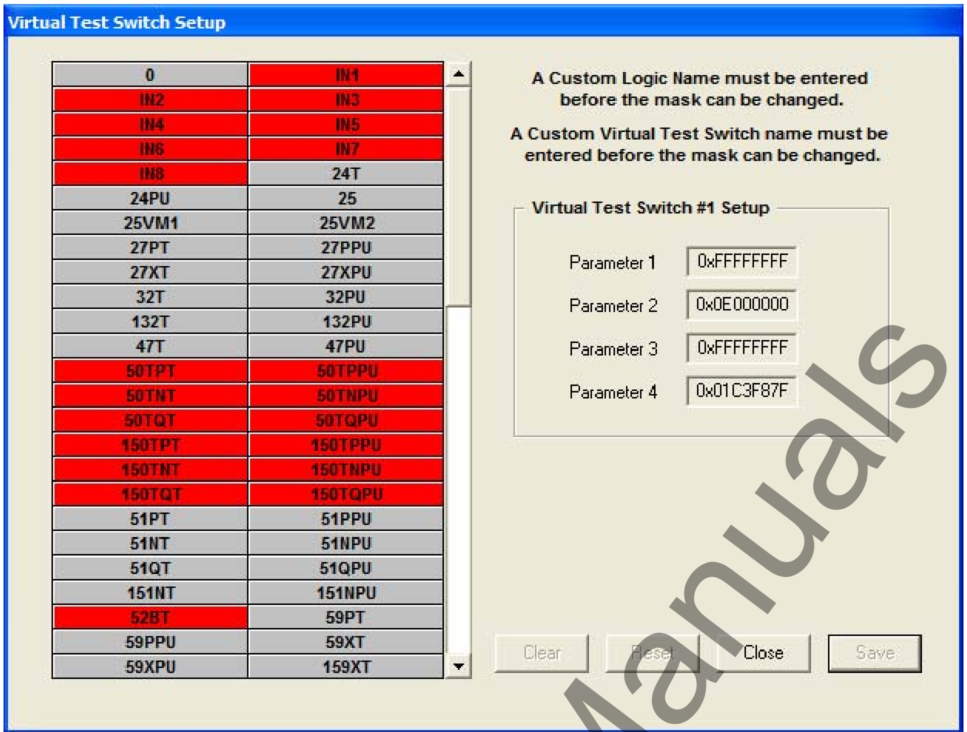

Figure 13-3. Virtual Test Switch Setup Screen

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 this 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.

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.

Refer to Section 12, *Installation, Relay Connections,* for terminal locations. An ohmmeter or continuity tester may be used to monitor output contact status.

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Instantaneous Overcurrent (50T)

50TP/150TP and TN (Calculated 3I0) Pickup and Dropout Verification

Purpose: To verify the accuracy of the operation of the 50TP/150TP and TN (3I0) elements.

Reference Commands: SL-50T/150T, SL-GROUP, SL-VO

Step 1: Connect a current source to Terminals B9 and B10 (A-phase).

Step 2: Prepare the 50T/150T elements for testing by transmitting the commands in Table 13-6 to the relay. Reset targets.

Table 13-6. 50T 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-50T=1,0	Enables 50TP, 50TN (3I0), and 50TQ 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 13-7 as a guide, transmit the low range setting commands (minimum pickup setting) for your sensing input type.

Table 13-7. 50T 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.

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 3I0). 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.

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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 B11 and B12) and phase C (Terminals B13 and B14).

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 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-150T=1,0	Enables 150TP, 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 9: (Optional.) Repeat Steps 1 through 8 for the 50T and 150T elements in Setting Groups 1, 2, and 3. 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 3I0) Time Delay Verification

Step 1: Connect a current source to Terminals B9 and B10 (A-phase).

Step 2: Prepare the 50T/150T elements for testing by transmitting the commands in Table 13-10 to the relay.

Table 13-10. 50T 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-50T=1,0	Enables 50TP, 50TN (3I0), and 50TQ 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.

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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 Step 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 B11 and B12) and phase C (Terminals B13 and B14).

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. 150T Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-150T=1,0	Enables 150TP, 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 Groups 1, 2, and 3. 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).

<u>*50TQ/150TQ Pickup and Dropout Verification*</u>

Purpose: To verify the operation of the 50TQ and 150TQ elements.

Reference Commands: SL-50T/150T

Step 1: Connect a current source to Terminals B9 and B10 (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.

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Command	Purpose
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 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 B11 and B12) and phase C (Terminals B13 and B14).

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.

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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 Groups 1, 2, and 3.

50TQ/150TQ Time Delay Verification

Step 1: Connect a current source to Terminals B9 and B10 (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 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: 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.

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Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals B11 and B12) and phase C (Terminals B13 and B14).

Step 7: (Optional.) Repeat Steps 1 through 6 for Setting Groups 1, 2, and 3.

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 B15 and B16 (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 or SEF	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.

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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. 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
G (SEF)	±2%

Step 6: (Optional.) Repeat Steps 1 through 5 for the 50TN and 150TN elements in Setting Groups 1, 2, and 3.

50TN/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 (5A 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 B15 and B16 (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 Step 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 Groups 1, 2, and 3.

Time Overcurrent (51)

Timing Verification

Purpose: To verify the timing operation of the 51 and 151 elements.

Reference Commands: SL-51PNQ/151N, S<g>-51P

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.

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Command	Purpose
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.
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 Pickup 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 B9 and B10 (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 or SEF	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.

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Step 5: (Optional.) Repeat Steps 2 through 4 for phase B (Terminals B11 and B12) and phase C (Terminals B13 and B14).

Step 6: (Optional.) Using ASCII commands, substitute 151 for any 51 logic or setting command in each test.

Pickup and Dropout Verification

Purpose: To verify the pickup accuracy of the 51P, 51N, 151N, and 51Q elements.

Reference Commands: SL-51P, SL-51N, SL-51Q, SL-151N, SL-GROUP, SL-VO

Step 1: Connect a current source to Terminals B9 and B10 (A-phase).

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.
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

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targets on the HMI. Repeat Step4 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
G (SEF)	±2% or ±10mA
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 B11 and B12) and phase C (Terminals B13 and B14). To test independent ground input IG, gain access and transmit SL-51N=G,0 exit and save. Apply test current to Terminals B15 and B16, 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, 51N, and 151N elements in Setting Groups 1, 2, and 3. 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

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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.
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. Example of 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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Connect a variable ac current source to Terminals B9 (A-phase polarity) and B10 (A-phase non-polarity).

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 percent 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 (B11 and B12) while varying B-phase voltage and C-phase current (B13 and B14) while varying C-phase voltage.

Step 6: (Optional.) Repeat Steps 2 through 5 for Setting Groups 1, 2, and 3.

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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Connect a variable ac current source to Terminals B9 (A-phase polarity) and B10 (A-phase non-polarity).

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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 percent). Dropout will occur at 93 to 97% of actual pickup. See Section 4, *Protection and Control, Overcurrent Protection*, for a graphical explanation of 51P Pickup Level Compensation.

Step 5: Repeat Steps 2 and 3 for B-phase current (B11 and B12) while varying B-phase voltage and C-phase current (B13 and B14) while varying C-phase voltage.

Step 6: (Optional.) Repeat Steps 1 through 5 for Setting Groups 1, 2, and 3.

Directional Overcurrent (67)

Purpose: To verify the operating accuracy of the 67 Directional Overcurrent function.

Reference Commands: SG-LINE, SL-50/51, S0-67, RG-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.

Table 13-34. 50TP, 50TN, and 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-LINE=8,80,24,80,100	Set line conditions.
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.

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.

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Positive-Sequence Voltage Polarizing, Phase Overcurrent Elements

Step 3: Connect and apply a 120 Vac, three-phase voltage source at nominal frequency to Terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Connect a variable ac current source to Terminals B9 (A-phase polarity) and B10 (A-phase non-polarity).

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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.5 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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.5 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 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)

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Step 13: (Optional.) Repeat Steps 3 through 12 for B-phase current (B11 and B12) and C-phase current (B13 and B14). 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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.5 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 (V0 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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Reduce the A-phase voltage by 1/3. Transmit M-V command or view HMI Screen 3.5 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

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(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 B9 out B10, in B15 out B16. 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 B9 out B10, in B15 out B16. 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 B5 and non-polarity to B6 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 B9 out B10, in B15 out B16. 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 B5 and non-polarity to B6 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 this option is available). That is, polarity current should go in B9 out B10 and in B15 out B16 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 Groups 1, 2, and 3.

Zero-Sequence Current Polarization

Step 1: Use setup commands in Table 13-34. Using Table 13-39 as a guide, transmit the 67 setting commands to the relay.

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Table 13-39. 67N (I0 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 2: Apply 2 amps ac current at 0 degrees to the independent ground input IG, Terminals B15 (polarity) and B16 (non-polarity). No ac voltage is required for this test.

Step 3: 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 $\pm$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 4: 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 5: 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 6: (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 7: (Optional.) Repeat Steps 1 through 5 for Setting Groups 1, 2, and 3.

Directional Power (32)

Purpose: To verify the operating accuracy of the forward and reverse 32 functions.

Reference Commands: SG-LINE, SL-32, S0-32, RG-STAT

Step 1: To prepare the 32 element for directional testing, transmit the commands in Table 13-40 to the relay.

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	Sets custom logic name.
SL-32=1,0	Enables 32 and disables blocking.
SL-VO1=32T	Enables OUT1 to close for 32 trip.
SG-TRIG=32T,32PU,0	Enable 32T to log and trigger fault recording.
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.

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Forward Tripping Direction

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	Sets 32 to 500 watts, TD = 50ms, Forward Trip Direction.
S0-32=1000,50ms,F	Sets 32 to 1000 watts, TD = 50ms, Forward Trip Direction.
S0-32=2000,50ms,F	Sets 32 to 2000 watts, TD = 50ms, Forward Trip Direction.

Step 2: Connect and apply a 100 Vac, three-phase voltage source at nominal frequency to Terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Connect a variable ac current source to Terminals B9 (A-phase polarity) and B10 (A-phase non-polarity).

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 32 pickup setting (500 watts = 5 amps, 100 volts, 0 degrees I lag E). 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 I 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 4 and 5 for the middle and upper settings in Table 13-41.

Step 6: (Optional.) Repeat Steps 4 through 6 for B-phase and C-Phase currents.

Step 7: (Optional.) Repeat Steps 4 and 7 for Setting Groups 1, 2, and 3.

Step 8: (Optional.) Repeat Steps 4 through 7 for the 132 element.

Reverse Tripping Direction

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	Sets 32 to 500 watts, TD = 50ms, Reverse Trip Direction.

Step 2: Connect and apply a 100 Vac, three-phase voltage source at nominal frequency to Terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral). Connect a variable ac current source to Terminals B9 (A-phase polarity) and B10 (A-phase non-polarity).

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. 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). 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 4 and 5 for B-phase and C-phase currents.

Step 6: (Optional.) Repeat Steps 2 through 5 for the 132 element.

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Volts per Hertz Overexcitation (24)

Purpose: To verify the operating accuracy of the 24 protection element.

Reference Commands: SL-24, SL-VO, SL-GROUP, and RG-STAT

Overexcitation, Volts/Hertz Trip, and Alarm Pickup Verification

Step 1: Prepare the 24 pickup function for testing by transmitting the commands in Table 13-43 to the relay. Reset targets.

Table 13-43. 24 Trip and Alarm 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=24	Sets 24 as custom logic name.
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
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.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-44 as a guide, transmit the first row of setting commands to the relay.

Table 13-44. Trip and Alarm Pickup Settings

Overexcitation Settings		Purpose
TRIP	ALARM	
S0-24=1.0,0.0,0.0	SA-24=50	Sets 24 PU at 1.0 V/H, Trip Time Dial = 0, Reset Time Dial = 0. Sets 24 Alarm at 50% of Trip PU.
S0-24=2.0,0.0,0.0	SA-24=75	Sets 24 PU at 2.0 V/H, Trip Time Dial = 0, Reset Time Dial = 0. Sets 24 Alarm at 75% of Trip PU.
S0-24=3.0,0.0,0.0	SA-24=95	Sets 24 PU at 3.0 V/H, Trip Time Dial = 0, Reset Time Dial = 0. Sets 24 Alarm at 95% of Trip PU.

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 can be verified by monitoring OUT1.

Step 4: Connect a 120 Vac, three-phase, 50 or 60 hertz voltage source (depending on users nominal frequency) to Terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral).

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 between 97 and 98 percent of the actual pickup value (Trip and Alarm). Verify the pickup and dropout accuracy of the middle and upper 24 Alarm and Trip pickup settings listed in Table 13-44.

Step 6: Verify the 24 target on the HMI.

Step 7: (Optional.) Repeat Steps 2 through 5 for frequencies other than nominal.

Step 8: (Optional.) Repeat Steps 2 through 6 for the B-phase and C-phase voltage inputs.

Step 9: (Optional.) Repeat Steps 2 through 7 for Setting Groups 1, 2, and 3.

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Overexcitation, Volts/Hertz Trip Time Verification

Step 1: Using Table 13-45 as a guide, transmit the first row of setting commands to the relay.

Table 13-45. 24 Trip Time Settings

Settings	Purpose
S0-24=1.0,0.5,0.0	Sets 24 PU at 1.0 V/H, Trip Time Dial = 0.5, Reset Time Dial = 0.
S0-24=1.0,2.0,0.0	Sets 24 PU at 1.0 V/H, Trip Time Dial = 2.0, Reset Time Dial = 0.
S0-24=1.0,4.0,0.0	Sets 24 PU at 1.0 V/H, Trip Time Dial = 4.0, Reset Time Dial = 0.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral).

Table 13-46. 24 Trip Times

Multiple of V/Hz Pickup	Time Dial 0.5	Time Dial 2.0	Time Dial 4.0
1.4	3.13 seconds	12.50 seconds	25.00 seconds
1.6	1.34 seconds	5.55 seconds	11.11 seconds
1.8	0.78 seconds	3.13 seconds	6.25 seconds

Step 3: Apply A-phase voltage at nominal frequency and a value equal to the V/Hz multiple shown in Table 13-46 (example 1.0 V/H x 60 H = 60 volts x 1.4 = 84 volts). Measure the time between the application of voltage and the closure of OUT1. Verify that the relay performs within ±2% of the times shown in Table 13-46.

Step 4: Repeat the test for Time Dial 2.0 and 4.0.

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 Groups 1, 2, and 3.

Overexcitation, Volts/Hertz Reset Time Verification

The following rest 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*.

Step 1: Using Table 13-47 as a guide, transmit the setting commands to the relay.

Table 13-47. 24 Reset Time Test Settings

Setting	Purpose
S0-24=1.0,0.5,0.1	Sets 24 PU at 1.0 V/H, Trip Time Dial = 0.5, Reset Time Dial = 0.1

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral).

Step 3: Apply A-phase voltage at nominal frequency and a value equal to the V/Hz multiple shown in Table 13-48. Measure the time between the application of voltage and the closure of OUT1. Remove the test voltage and reapply after 5 seconds has elapsed.

With a Reset Time Dial setting of 0.1, the total time to reset after trip is removed will be approximately 10 seconds (see Section 4, *Protection and Control, Voltage Protection*, *24 Volts per Hertz Overexcitation Protection,* for more details). Reapplying the test voltage after 5 seconds will yield a trip time of approximately ½ its original value or 1.6 seconds for Time Dial 0.5, verifying that reset time delay is working.

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Table 13-48. Reset Time

Multiple of V/Hz Pickup	Time Dial 0.5	Time Dial 2.0	Time Dial 4.0
1.4	3.13 seconds	12.50 seconds	25 seconds

Step 4: Repeat the test for Time Dial 2.0 and 4.0 (½ trip time is approximately 6.3 seconds for Time Dial 2.0, and 12.5 seconds for Time Dial 4.0).

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 Groups 1, 2, and 3.

Phase and Auxiliary Undervoltage/Overvoltage (27/59)

Purpose: To verify the operating accuracy of the 27P, 27X, 59P, 59X, and 159X protection elements.

Reference Commands: SL-27P, SL-27X, SL-59P, SL-59X, SL-159X, SL-VO, SL-GROUP, RG-STAT

Phase Undervoltage/Overvoltage Pickup Verification

Step 1: Prepare the 27P and 59P pickup functions for testing by transmitting the commands in Table 13-49 to the relay. Reset targets.

Table 13-49. 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.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-50 as a guide, transmit the first row of setting commands (highest 27P PU, lowest 59P PU) to the relay.

Table 13-50. 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 OUT1.

Step 4: Connect and apply a 120 Vac, three-phase voltage source to Terminals B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral).

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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 13-50.

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 Groups 1, 2, and 3.

Phase Undervoltage/Overvoltage Timing Verification

Step 1: Using Table 13-51 as a guide, transmit the first row of setting commands to the relay.

Table 13-51. 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 B1 (A-phase), B2 (B-phase), B3 (C-phase), and B4 (Neutral).

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 ±0.5 percent or ±2 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 ±0.5 percent or ±2 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-51.

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 Groups 1, 2, and 3.

Auxiliary Undervoltage/Overvoltage Pickup Verification (3E0 VT Input)

Step 1: Prepare the 27X and 59X/159X pickup function for testing by transmitting the commands in Table 13-52 to the relay. Reset targets.

Table 13-52. 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.

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Command	Purpose
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.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-53 as a guide, transmit the first row of setting commands (highest 27X PU, lowest 59XPU/159XPU) to the relay.

Table 13-53. 27X and 59X/159X Pickup Settings (3E0)

Pickup Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=50,50ms	S0-59X/159X=60,50ms	Sets 27X PU at 50 V, 59X/159X at 60 V, TD at min.
S0-27X=20,50ms	S0-59X/159X=30,50ms	Sets 27X PU at 20 V, 59X/159X at 30 V, TD at min.
S0-27X=5,50ms	S0-59X/159X=10,50ms	Sets 27X PU at 5 V, 59X/159X at 10 V, TD at min.

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 B5 (polarity) and B6 (non-polarity).

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 percent of the actual pickup value. Verify the 27NTarget 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 percent 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 13-53.

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 Groups 1, 2, and 3.

Auxiliary Undervoltage/Overvoltage Timing Verification (3E0 VT Input)

Step 1: Using Table 13-54 as a guide, transmit the first row of setting commands to the relay.

Table 13-54. 27X and 59X/159X Pickup and Time Delay Settings (3E0 VT Input)

Pickup Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=10,2S	S0-59X/159X=30,2S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 2 sec.
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.

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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 B5 (polarity) and B6 (non-polarity).

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 ±0.5 percent or ±2 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 ±0.5 percent or ±2 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-54.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Groups 1, 2, and 3.

Auxiliary Undervoltage/Overvoltage Pickup Verification (Fundamental Vx Input)

Step 1: Prepare the 27X and 59X/159X pickup functions for testing by transmitting the commands in Table 13-55 to the relay. Reset targets.

Table 13-55. 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.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-56 as a guide, transmit the first row of setting commands (highest 27X PU; lowest 59XPU/159XPU) to the relay.

Table 13-56. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=70,50ms	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min.
S0-27X=60,50ms	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min.
S0-27X=50,50ms	S0-59X159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min.

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 B5 (polarity) and B6 (non-polarity).

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 percent of the actual pickup value. Verify the 27 bus target on the HMI and reset.

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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 percent 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 13-56.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Groups 1, 2, and 3.

Auxiliary Undervoltage/Overvoltage Timing Verification (Fundamental Vx Input)

Step 1: Using Table 13-57 as a guide, transmit the first row of setting commands to the relay.

Table 13-57. 27X and 59X/159X Pickup and Time Delay Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=50,2S	S0-59X/159X=110,2S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 2 sec.
S0-27X=,5S	S0-59X159X=,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 B5 (polarity) and B6 (non-polarity).

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 ±0.5 percent or ±2 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 ±0.5 percent or ±2 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 Setting Groups 1, 2, and 3.

Auxiliary Undervoltage/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 13-58 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_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.
EXIT;Y	Exit and save settings.

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Step 2: Using Table 13-59 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 13-59. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	**Overvoltage**	
S0-27X=70,50ms	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min.
S0-27X=60,50ms	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min.
S0-27X=50,50ms	S0-59X159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min.

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 B5 (polarity), and B6 (non-polarity).

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 percent 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 13-59. Verify the 59-3 bus target on the HMI.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Groups 1, 2, and 3.

Auxiliary Undervoltage/Overvoltage Timing Verification (3rd Harmonic Vx Input)

Step 1: Using Table 13-60 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 13-60. 27X and 59X/159X Pickup and Time Delay Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	**Overvoltage**	
S0-27X=50,2S	S0-59X/159X=110,2S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 2 sec.
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 B5 polarity), and B6 (non-polarity).

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 ±0.5 percent or ±2 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 ±0.5 percent or ±2 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-60.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Groups 1, 2, and 3.

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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 13-61 to the relay. Reset targets.

Table 13-61. 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.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-62 as a guide, transmit the first row of setting commands to the relay.

Table 13-62. 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 operations. Operation can be verified by monitoring OUT1.

Step 4: Connect and apply a 50 Vac, single-phase voltage source to Terminals B1 (A-phase) and B4 (Neutral).

Step 5: Negative-sequence voltage is 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 percent 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 Groups 1, 2, and 3.

Negative-Sequence Voltage Timing Verification

Step 1: Using Table 13-63 as a guide, transmit the first row of setting commands to the relay.

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Table 13-63. 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 B1 (A-phase), and B4 (Neutral).

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 ±0.5 percent or ±2 cycles of the time delay setting.

Step 5: Repeat Step 5 for the middle and upper time delay settings of Table 13-63.

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 Groups 1, 2, and 3.

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

Pickup Verification

Step 1: Prepare the x81 pickup functions for pickup testing by transmitting the commands in Table 13-64 to the relay.

Table 13-64. 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.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands in Table 13-65 to the relay. These commands set the pickup value and operating mode (underfrequency or overfrequency) for each of the x81 functions.

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Table 13-65. x81 Pickup and Mode Settings

Pickup and Mode Settings	Purpose
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 B1 (A-phase) and B4 (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: Repeat Step 5 for the 181 (OUT2) and 81 (OUT1) functions.

Step 7: Repeat Step 4.

Step 8: 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 9: Repeat Step 5 for the 481 (OUT5) and 581 (OUT1) functions.

Step 10: Connect and apply 120 Vac, 60 Hz voltage source to Vx input B5 and B6.

Step 11: Repeat Steps 5 through 9.

Step 12: (Optional.) Repeat Steps 1 through 11 for Setting Groups 1, 2, and 3.

<u>Time Delay Verification</u>

Step 1: Prepare the x81 functions for time delay testing by transmitting the commands in the first column (2 second TD) of Table 13-66 to the relay. Commands entered in Tables 13-64 and 13-65 should be retained for this test.

Table 13-66. 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 B1 (A-phase) and B4 (Neutral).

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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 ±0.5% or 1 cycle (minimum trip is affected by 3 cycle security count).

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 13-66 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 13-66 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 B5 and B6.

Step 13: (Optional.) Repeat Steps 1 through 11 for Setting Groups 1, 2, and 3.

Synchronism Check (25)

Purpose: To verify the operation of the Sync Check (25) function.

Reference Commands: SL-25, SL-V0.

<u>25VM - VTP Phase and VTX Live Voltage, Dead Voltage Pickup Test</u>

Step 1: Prepare the 25 function block for testing by transmitting the commands in Table 13-67 to the relay.

Table 13-67. 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.
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 13-68 as a guide, transmit the setting commands to the relay.

Table 13-68. Sync Check Voltage Monitor Pickup Settings

Sync Check VM Pickup Settings	Purpose
S0-25VM=95,55,0,123,123	Sets LV = 95, DV = 55, TD = 50, VM1 = 123, VM2 = 123.

Step 3: Prepare to monitor the 25VM function operation. Operation can be verified by monitoring OUT1.

Step 4: Connect relay Terminals B1 (A-phase), B2 (B-phase), and B3 (C-phase) together. Apply a single phase, 0 Vac, 50 or 60 hertz ac voltage source (Line VT Phase) to the three jumpered terminals and the Neutral Terminal (B4).

Step 5: OUT 1 should be closed. Slowly increase the Line voltage until OUT1 opens (55 volts). Dropout should occur within ±2 percent or 1 volt of the Dead Voltage setting. Continue to increase the

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voltage until OUT1 closes (95 volts). Pickup should occur within ±2 percent or 1 volt of the Hot Voltage setting. Remove voltage source 1.

Step 6: Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VX) to relay Terminals B5 (polarity) and B6 (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. Continue to increase the voltage until OUT1 closes (95 volts). Pickup should occur within ±2 percent or 1 volt of the Hot Voltage setting.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Groups 1, 2, and 3.

25VM Live/Dead Dropout Timing Verification

Step 1: Using Table 13-69 as a guide, transmit the setting commands to the relay.

Table 13-69. Sync Check 25VM Live/Dead Dropout Time Settings

Sync Check VM Time Settings	Purpose
S0-25VM=95,55,50ms,123,123	Sets LV = 95, DV = 55, TD = min, VM1 = 123, VM2 = 123.
S0-25VM=95,55,2S,123,123	Sets LV = 95, DV = 55, TD = 2 sec, VM1 = 123, VM2 = 123.
S0-25VM=95,55,5S,123,123	Sets LV = 95, DV = 55, TD = 5 sec, VM1 = 123, VM2 = 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 B1 (A-phase), B2 (B-phase), and B3 (C-phase) together. Apply a 50 Vac, 50 or 60-hertz ac voltage source (Line VT Phase) to the three jumpered terminals and the Neutral Terminal (B4).

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 ±0.5% or 2 cycles.

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 ±0.5% or 2 cycles.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-69.

Step 7: Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VX) to relay Terminals B5 (polarity) and B6 (non-polarity). Repeat Steps 2 through 6.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Groups 1, 2, and 3.

25VM1 and 25VM2 Output Test

Step 1: Transmit SL-VO1=25VM2 to the relay and save it.

Step 2: 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 3: Apply 0 volts ac to the Line Voltage Input (VT Phase). 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 25VM2. Remove voltage source 1.

Step 4: Apply 0 volts ac to the Auxiliary Voltage Input (VX). 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 25VM2.

Step 5: (Optional.) Repeat Steps 1 through 4 for Setting Groups 1, 2, and 3.

25 Sync Check Verification

Step 1: Transmit SL-VO1=25 to the relay and save it.

Step 2: Using Table 13-70 as a guide, transmit the setting commands to the relay.

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Table 13-70. 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 B1 (A-phase), B2 (B-phase), and B3 (C-phase) together. Apply a 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Line VT Phase) to the three jumpered terminals and the Neutral Terminal (B4).

Step 5: Apply a second 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Auxiliary VX) to B5 and B6. 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 (VX) until OUT1 opens. Slowly increase the voltage until OUT1 closes. Pickup should occur within ±2 percent of Delta V setting.

Step 7: Repeat Step 6 for the Line Voltage Input (VT Phase). 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 degrees of the Delta Angle setting on the leading and lagging side of 0 degrees. Return Delta Angle of 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 percent 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 Groups 1, 2, and 3.

Breaker Failure (BF)

Purpose: To verify the operation of the breaker failure (BF) function.

Reference Commands: SL-50BF, S<x>-50BF

The BE1-1051 has two types of Breaker Failure Initiate, one being contact only initiate, and the other being current supervised relay trip initiate. The following tests are for **Contact Only** initiate.

Step 1: Prepare the 50BF function block for testing by transmitting the commands in Table 13-71 to the relay.

Table 13-71. 50BF, BFI52 Contact Initiate 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-50BF=1,0,IN2,/IN1,0	Enables BF, disables BFI50, IN2 = BFI52 initiate, /IN1 = breaker position, disables blocking.
SL-VO1=BFT	Enables OUT1 to close for BF trip.
SL-VO2=BFRT	Enables OUT2 to close for BF Retrip.
S0-50BF=0,0,0,100m	Set Control Timer = 0, PFD & GFD = 0, BF time delay at minimum.
SG-TRIGGER=BFT,BFRT,0	Enable BFT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

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Step 2: IN1 is used to simulate breaker status as supplied by a "b" contact from the circuit breaker. With no wetting voltage applied to relay input IN1, the relay considers the breaker closed as a result of the /IN1 designation at the breaker status input of the breaker failure element. A switched wetting voltage at IN2 is used to simulate an external BFI52 initiate contact for starting the Breaker Failure Timer. This input is also used to start the test set timer and OUT1 of the relay is used to stop the test set timer. OUT2 should be monitored to verify operation of the re-trip circuit upon breaker failure initiate.

Step 3: With no wetting voltage to relay input IN1, switch on the wetting voltage to IN2 and measure the operate time. Timer accuracy = ±0.5% or ±½ cycles, whichever is greater.

Step 4: Apply wetting voltage to IN1 and repeat Step 3. There should be no operation.

Step 5: Repeat Step 3 at 200 ms and 300 ms.

The following tests are for **Current Supervised** relay trip initiates. Any or all relay trips can be used: 50T, 51, etc. For ease of testing, the 50TPT variable will be used in the following tests.

Step 6: Prepare the BF function block for testing by transmitting the commands in Table 13-72 to the relay.

Table 13-72. 50BF, BFI50 Current Supervised Relay Trip Initiate 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-50BF=1,50TPT,0,0,0	Enables BF CT Input 1, 50TPT = BFI50 initiate, disables BFI52 initiate, disables breaker position, disables blocking.
SL-VO1=BFT	Enables OUT1 to close for BF trip.
SL-VO2=BFRT	Enables OUT2 to close for BF Retrip.
SA-LGC=2	Set Logic Alarm to BF Alarm (#2).
SL-VO3=ALMLGC	Enables OUT3 to close for BF Alarm.
S0-50TP=2.0,0	Set pickup at 2 A, Time Delay = 0.
S0-50BF=0,1.0,1.0,100m	Set Control Timer = 0, PFD & GFD = 1 A, BF time delay at minimum.
SG-TRIGGER=BFT,BFRT,0	Enable BFT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

The BF current detector dropout setting (I = 0 on BESTCOMS logic diagram) is a fixed value that is determined by the relay current sensing type. Table 13-73 lists the pickup setting for each current sensing type.

Table 13-73. BF Current Detector Dropout Settings

Sensing Type	Pickup Setting
A or B (1 A)	45 mA
D, E, or F (5 A)	225 mA

Step 7: In the current supervised Breaker Failure logic, load current must be above current detector dropout settings (Table 13-73), fault current must be above Phase or Ground Fault Detector setting (see Section 4, *Protection and Control* for range), fault current must be above the 50TP pickup setting to get a BFI 50 initiate and all must occur within the set Control Time including Breaker Failure Time Delay. If the Control Timer expires before BFT goes TRUE, BFT is blocked and the Breaker Failure alarm becomes TRUE.

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Step 8: Connect a current source to Terminals B9 and B10 (A-phase input). Apply 50% of nominal current to the relay and note operation of OUT1 and 2. Slowly decrease the current applied until OUT2 (and subsequently OUT1) opens. Slowly increase current until OUT2 operates. Fault Detector Pickup should be ±2% of setting and dropout should be 95% of pickup.

Step 9: Set Phase and Ground Fault Detectors at minimum. Repeat the dropout test in Step 8 to verify current detector dropout. Compare the applied current to the current values listed in Table 13-74. Verify that dropout occurred between the lower and upper limits for your relay.

Table 13-74. BF Dropout Limits

Sensing Type	Lower Dropout Limit	Upper Dropout 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 10: Transmit the commands in Table 13-75 to set the BF time delay.

Table 13-75. BF Time Delay Commands

Command	Purpose
A=	Gains write access.
S0-50BF=100m,1.0,1.0,50m	Set BF time delay at 100 milliseconds.
EXIT;Y	Exit and save settings.

Step 11: 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 ±0.5 percent (±½ cycles plus 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.) after application of pickup current.

Step 12: (Optional.) Raise 50TP pickup setting to 10 amps and apply nominal current to the relay. Note that OUT1 and 2 do not operate. No initiate prevents operation of the breaker failure function, blocking the breaker fail logic.

Step 13: Verify Control Time function by first transmitting the settings in Table 13-76.

Table 13-76. Control Time Delay Commands

Command	Purpose
A=	Gains write access.
S0-50TP=2.0,0	Set pickup at 2 amps, 0 ms time delay.
S0-50BF=100m,1.0,1.0,200m	Set Control Timer = 100 ms, PFD & GFD = 1, BF time delay at 200ms.
SG-TRIGGER=BFT,BFRT,0	Enable BFT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 14: Connect a current source to Terminals B9 and B10 (A-phase). Apply nominal current to the relay and note operation of OUT3 and no operation of OUT1 and 2. To verify control time, apply nominal current and start the test set timer. Use OUT3 to stop the timer. Timer Accuracy = ±0.5% or (±½ cycles), whichever is greater.

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Step 15: (Optional.) Repeat Steps 3 through 8 for the phase B and phase C elements.

Virtual Switches (43)

Purpose: To verify operation of the 43/143/243/343/443 virtual switches.

Reference Commands: SL-43/143/243/343, CS/CO-43/143/243/343/443

To test virtual switches, we verify each mode of operation but do not verify each of the five virtual switches. In your testing, you may substitute any or all of the switches as desired. If you give an invalid command such as CS-243=1/CO-243=1 when Switch 243 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 13-77.

Table 13-77. 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 13-78 to the relay. These commands change the state of the 43 Switch to On.

Result: OUT1 contact closes and remains closed.

Table 13-78. 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 13-79 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.

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Table 13-79. 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 13-80. These commands pulse the 43 Switch On and Off once.

Result: OUT1 contact closes for 200 milliseconds and returns to the open state.

Table 13-80. 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.

Mode 2 - On/Off

Step 1: Prepare for Mode 2 testing by transmitting the commands in Table 13-81 to the relay.

Table 13-81. 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 13-82 to the relay. These commands change the state of the 43 Switch to On.

Result: OUT1 contact closes and remains closed.

Table 13-82. 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.

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Step 4: Transmit the commands in Table 13-83 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 13-83. 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 13-84 to the relay.

Table 13-84. 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-243=3	Sets 243 switch for Mode 3 operation.
SL-VO1=243	Enables OUT1 to close for 243.
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 13-85 to the relay. These commands pulse the 243 Switch on and off once.

Result: OUT1 contact closes for 200 milliseconds and returns to the open state.

Table 13-85. x43 Mode 3 Pulse Commands

Command	Purpose
A=	Gains write access.
CS-243=P	Selects 243 for Pulse operation.
CO-243=P	Executes 243 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 13-86 to the relay.

Table 13-86. 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.

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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 operations. 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 13-87 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 13-87. 101 Virtual Breaker Control Switch Trip Test Commands

Command	Purpose
A=	Gains write access.
CS-101=T	Selects 101T for Trip operation.
CO-101=T	Executes 101T for Trip operation.

Step 4: Transmit the commands in Table 13-88 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 13-88. 101 Virtual Breaker Control Switch Close Test Commands

Command	Purpose
A=	Gains write access.
CS-101=C	Selects 101C for Close operation.
CO-101=C	Executes 101C for Close operation.

Virtual Lockout (86)

Purpose: To verify 86, 186 Virtual Lockout operation.

Reference Commands: SL-86, SL-186

Step 1: Prepare the 86 Virtual Lockout for testing by transmitting the commands in Table 13-89 to the relay.

Table 13-89. 86 and 186 Virtual Lockout 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=LO_86	Set LO_86 as custom logic name.
SL-86=1,IN1,IN2	Enables 86 lockout latch, IN1 = Trip, IN2 = Reset.
SL-VO1=86	Enables OUT1 to close when 86 is TRUE.
EXIT;Y	Exit and save settings.

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Step 2: Prepare to monitor the 86 virtual lockout operations. Operation can be verified by monitoring OUT1 at HMI Screen 1.5.2, or monitoring OUT1 contacts between Terminals C3 and C4 or by using the RG-STAT command. See Section 6, *Reporting and Alarm Functions*, for more information.

Step 3: Connect negative or non-polarity power supply voltage (PSV) to IN1 and IN2. Refer to Section 12, *Installation, Relay Connections,* for terminal locations.

Step 4: Apply and remove positive or polarity PSV to IN1. Verify that OUT1 closes and remains closed.

Step 5: Power down the relay and verify that OUT1 opens. Wait 10 seconds and power up the relay. Verify that OUT1 closes. This verifies that the 86 position is stored in nonvolatile memory.

Step 6: Apply and remove positive or polarity PSV to IN2. Verify that OUT1 opens and remains open.

Step 7: Repeat Steps 1 through 6 for the 186 Virtual Lockout element.

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 13-90 to the relay.

Table 13-90. 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 13-91 to set the 62 function pickup and dropout time.

Table 13-91. 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 13-92 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.

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Table 13-92. 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 13-93 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 13-93. 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.

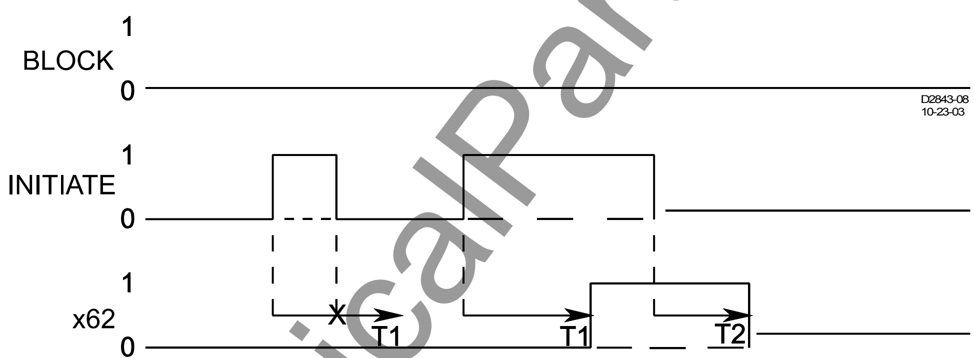

Figure 13-4. x62 Mode 1 (Pickup/Dropout) Timing Example

Mode 2 - One-Shot Nonretriggerable

Step 1: Prepare the 162 Timer for Mode 2 testing by transmitting the commands in Table 13-94 to the relay.

Table 13-94. 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.

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Command	Purpose
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 13-95 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 13-94 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 13-95. 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.

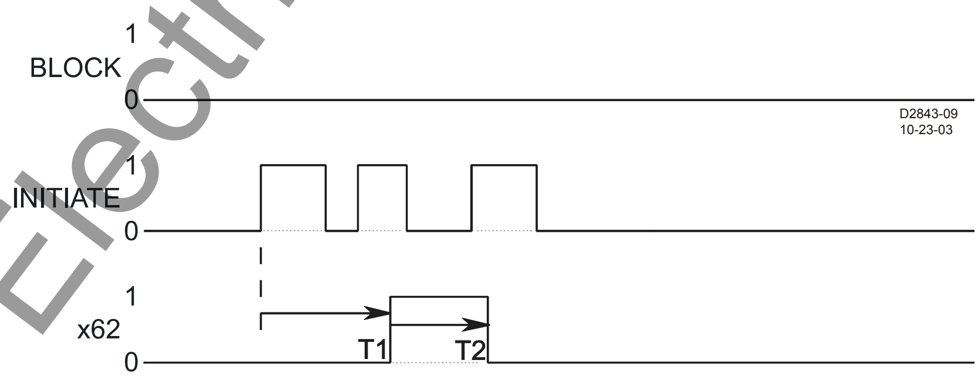

Figure 13-5. x62 Mode 2 (One-Shot Nonretriggerable) Timing Example

<u>Mode 3 - One-Shot Retriggerable</u>

Step 1: Prepare the 62 Timer for Mode 3 testing by transmitting the commands in Table 13-96.

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Table 13-96. 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=3,343,0	Enables 62 one-shot, retriggerable mode, 343 initiate, no blocking.
SL-343=3	Enables 343 Switch momentary pulse mode.
SN-343=62_INI,INI,NORMAL	Name Switch 343 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 13-97 to the relay. These commands supply the 62 Timer with a momentary initiate input by pulsing the 343 Switch from FALSE to TRUE and then back to FALSE. You may view the state changes of the 343 Switch at Screen 1.5.4 of the front panel HMI.

NOTE

The 343 switch action is performed three times in this test. To illustrate the action of the timer mode, the second 343 Switch action should be executed as quickly as possible (within the 15 second duration of the pickup time delay). Perform the third 343 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 343 Switch actions.

Table 13-97. x62 Mode 3 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-343=P	Selects 343 for pulse F-T-F operation.
CO-343=P	Executes 343 pulse F-T-F operation.
CS-343=P	Selects 343 for pulse F-T-F operation.
CO-343=P	Executes 343 pulse F-T-F operation.
Wait at least 15 seconds (but no longer than 35 seconds) to execute next commands.	
CS-343=P	Selects 343 for pulse F-T-F operation.
CO-343=P	Executes 343 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.

After a 343 FALSE-TRUE-FALSE pulse action was logged, the 62 Timer output did not go TRUE because of a second FALSE to TRUE initiate signal action.

Approximately 15 seconds after the second 343 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.

Fifteen seconds after the third 343 FALSE to TRUE initiate signal, the 62 Timer output went TRUE again and then went FALSE after the duration timer (T2) expired 20 seconds later.

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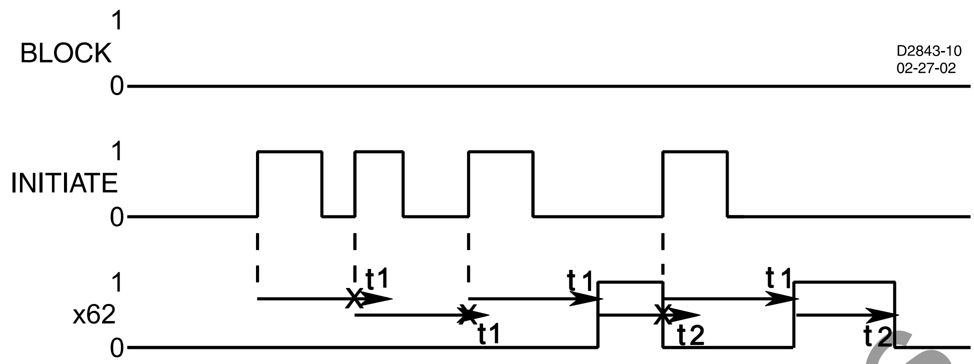

Figure 13-6. Mode 3 (One-Shot Retriggerable) Timing Example

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 13-98.

Table 13-98. 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.

Step 2: Transmit the commands of Table 13-99 to the relay. These commands supply a block input to the 62 Timer by changing the 43 Switch state to TRUE.

NOTE

The CS and CO commands of Table 13-99 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.

Table 13-99. 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.	

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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.

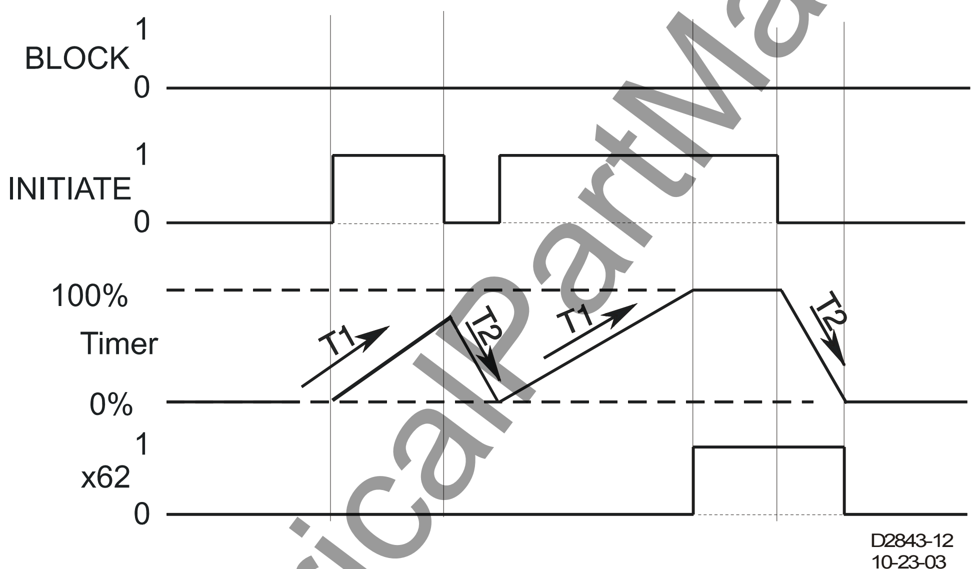

Figure 13-7. Mode 5 (Integrating Timer) Timing Example

Step 4: (Optional.) Repeat the 62 Timer tests for Modes 1, 2, 3, and 5 for Setting Groups 1, 2, and 3.

Mode 6 - Latch

Step 1: Prepare for Mode 6 logic timer testing by transmitting the commands in Table 13-100 to the relay.

Table 13-100. 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.

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Command	Purpose
SL-143=1	Enables 143 Switch pulse mode.
SN-43=62_INI	Name Switch 43 to make SER report easier to read.
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 13-101 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 13-101 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 13-101. 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).

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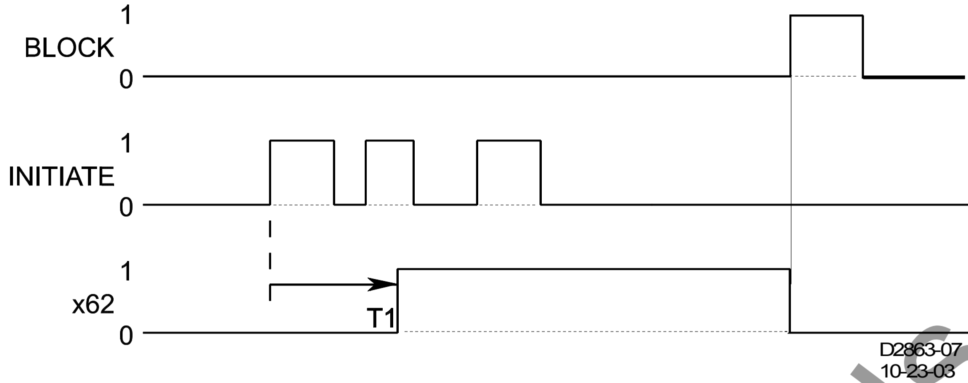

Figure 13-8. x62 Mode 6 (Latch) Timing Example

Step 4: (Optional.) Repeat the 62 Timer tests for Modes 1, 2, 3, and 5 for Setting Groups 1, 2, and 3.

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 B9 and B10 (A-phase input).

Step 2: Prepare the automatic setting group change function for testing by transmitting the commands in Table 13-102 to the relay.

Table 13-102. 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=1,43,143,243,343,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.
SL-VO2=SG2	Closes OUT2 when SG2 is active.
SL-VO3=SG3	Closes OUT3 when SG3 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.
SL-243=3	Enables 243 Switch OFF/momentary ON mode.
SL-343=3	Enables 343 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-243=MAN_SEL,GRP2,NORMAL	Assigns 243 Switch labels.
SN-343=MAN_SEL,GRP3,NORMAL	Assigns 343 Switch labels.

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Command	Purpose
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.
SP-GROUP2=1,90,1,85,51P	SG2 ts = 1 min @ 90%, tr = 1 min @ 85% of SG0 51P setting.
SP-GROUP3=1,110,1,100,51P	SG3 ts = 1 min @ 110%, tr = 1 min @ 100% 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 13-103 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, and OUT3) status.

Table 13-103. 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 13-104, 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 13-104. 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).
	0.881	0.919	> 1 min	Switch to SG2 (90% SG0 51P).
	1.176	1.224	5 min	Switch to SG3 (110% SG0 51P).
5 A	2.5	2.5		Starting point 50% pickup.
	3.675	3.825	> 1 min	Switch to SG1 (75% SG0 51P).
	4.405	4.595	> 1 min	Switch to SG2 (90% SG0 51P).
	5.88	6.120	5 min	Switch to SG3 (110% SG0 51P).

Step 6: Verify that SG3 is the active setting group by viewing HMI Screen 1.5.5.

Step 7: Transmit the select and operate commands in Table 13-105 to the relay.

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Table 13-105. 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 8: Verify that no setting change occurred and that SG3 is still active by viewing HMI Screen 1.5.5. This verifies that the relay will not make any setting group changes from logic inputs while the AUTO input logic is TRUE.

Step 9: Begin stepping down the current from one level to the next as shown in Table 13-106. 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 13-106. Setting Group Change Example Accuracy Limits – Decreasing Current

Sensing Type	Current Limit		Time	Comments
	Low	High		
1 A	1.224	1.176	5 min	SG3 (110% SG0 51P)
	1.02	0.98	> 1 min	Switch to SG2 (100% SG0 51P).
	0.867	0.833	> 1 min	Switch to SG1 (85% SG0 51P).
	0.714	0.686	> 1 min	Switch to SG0 (70% SG0 51P).
5 A	6.12	5.88	5 min	SG3 (110% SG0 51P)
	5.1	4.9	> 1 min	Switch to SG2 (100% 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 10: Remove the current from phase A, Terminals B9 and B10.

Step 11: 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 that VO2 went TRUE and closed relay output OUT2 when SG2 became the active setting group and that relay output OUT1 opened.

Verify that VO3 went TRUE and closed relay output OUT3 when SG3 became the active setting group and that relay output OUT2 opened.

Verify that when Virtual Switch 143 went TRUE (as a discrete input to the SG1 input of the setting group logic block) but the active setting group remained SG3.

Verify the events that occurred in reverse order, when the current was being stepped down.

<u>Manual Change - Mode 1</u>

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.

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Step 2: Transmit the select and operate commands in Table 13-107 to the relay.

Table 13-107. 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.
CS-243=1	Selects 243 for TRUE operation.
CO-243=1	Executes 243 TRUE operation.
CS-243=0	Selects 243 for FALSE operation.
CO-243=0	Executes 243 FALSE operation.
CS-343=1	Selects 343 for TRUE operation.
CO-343=1	Executes 343 TRUE 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.

<u>*Manual Change - Mode 2*</u>

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 13-108 to the relay. These commands set up the relay for binary setting group control selection.

Table 13-108. Binary Group Control Selection Setup

Command	Purpose
A=	Gains write access.
SL-GROUP=2,43,0,0,0,143	Configures the setting group control function as binary coded selection. D0 logic = 43, D1 or D2 or D3 logic = 0, Auto logic = 143
SL-43=2	Sets 43 to On/Off mode.
EXIT;Y	Exit and save settings.

Step 2: Verify that VO1 went TRUE and closed OUT1 when SG1 became the active setting group. For more information on setting group selection, see Section 4, *Protection and Control, Setting Groups*.

Step 3: Transmit the select and operate commands in Table 13-109 to the relay.

Table 13-109. 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 4: Verify that VO1 goes FALSE and opens OUT1 when SG0 becomes the active setting group.

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SECTION 14 • BESTCOMS SOFTWARE

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 **B**asler **E**lectric **S**oftware **T**ool for **C**ommunications, **O**perations, **M**aintenance, and **S**ettings.

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 BE1-1051.

INTRODUCTION

A primary advantage of the 32-bit BESTCOMS is that an actual unit (operating BE1 Numerical 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 for all of the BE1 Numerical Systems are identical except for differences inherit in the 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 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 BE1-1051 Overcurrent 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 BE1-1051 BESTCOMS screen.

BESTCOMS screens are similar to most Windows® based GUI. 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.

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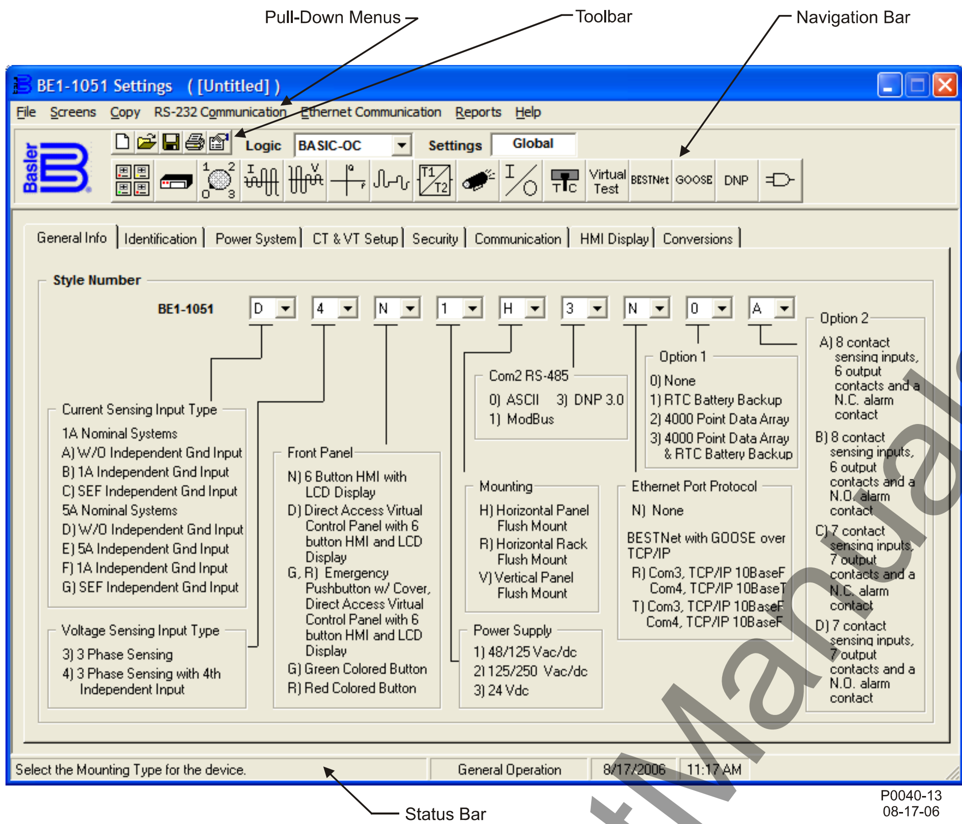

Figure 14-1. Typical User Interface Components

INSTALLATION

BESTCOMS for BE1-1051 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

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 BE1-1051 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 BE1-1051 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 BE1-1051 front panel and an appropriate communication port on the PC.

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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 online form can be completed to obtain a password for downloading BESTCOMS from the Basler Electric web site.

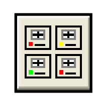
STARTING BESTCOMS

Start BESTCOMS

Start BESTCOMS by clicking the *Start* button, *Programs*, *Basler Electric*, and then the *BESTCOMS for BE1-1051* 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



This screen (Figure 14-3) gives you an overview of the system setup. There are two areas or folder tabs (like paper file folder tabs) to the screen. These are *Protection and Control* and *Reporting and Alarms*. When the screen is first displayed, the *Protection and Control* summary information 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. If you are at another BESTCOMS screen such as *Overcurrent Protection* and want to return to this screen, you may use the *Screens* pull-down menu or click on the *System Setup Summary* icon that is shown at the right margin of this paragraph.

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 that 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.

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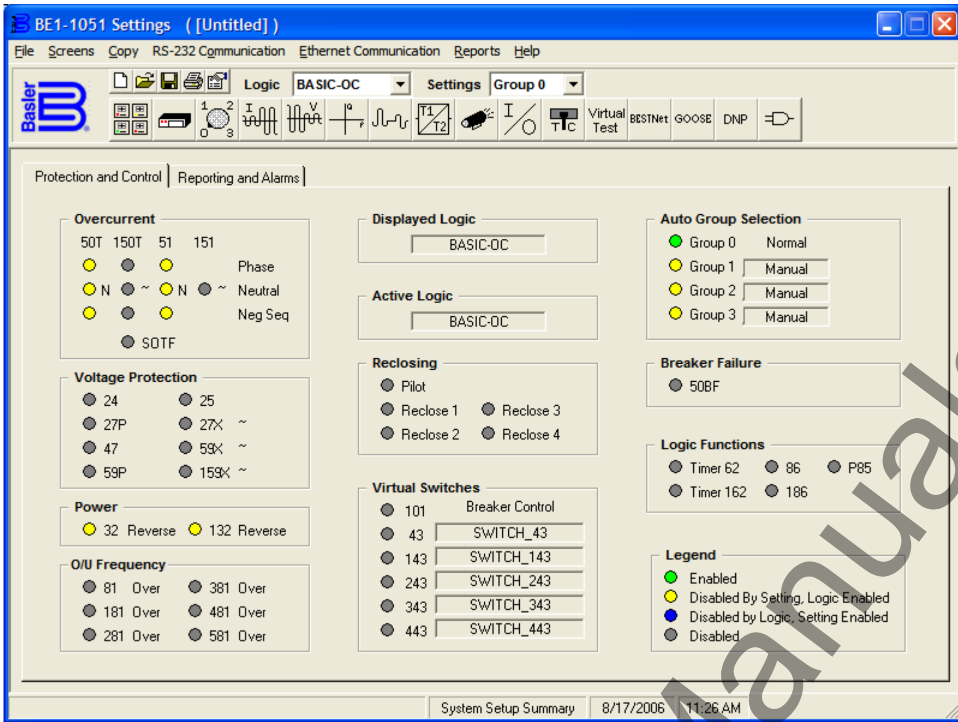

Figure 14-3. System Setup Summary Screen, Protection and Control Tab

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.

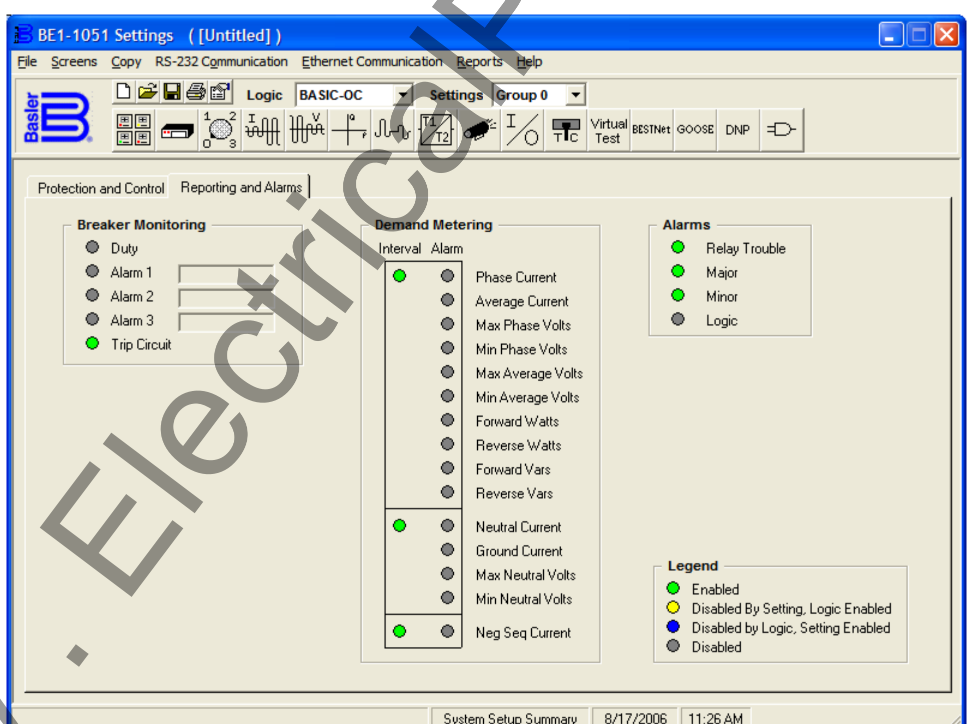

Figure 14-4. System Setup Summary Screen, Reporting and Alarms Tab

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CONFIGURING THE PC

If you have an actual BE1-1051 relay, configure your PC to match the BE1-951 configuration. To do this, pull down the *Communication* menu in the pull-down menu and select *Configure*. Now, match the communication configuration in the BE1-1051 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 taken 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 BE1-1051. The *System Setup Summary* screen was discussed in previous paragraphs and 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. For more information, see Section 6, *Reporting and Alarms, Alarms Function*. 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* sub-heading.

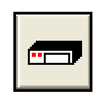
Select Logic Scheme for Display

In Figure 14-3, below the pull-down menu, there is a pull down arrow for the *Logic* menu. To select a preprogrammed scheme, pull down this menu and click on the desired scheme. When you do, the logic-selected 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 within this section of the manual).

Settings Display and Selection

Immediately to the right of the *Logic* menu, there is a *Settings* window. If the active screen does not have a possible Group 0, 1, 2, or 3 selection, then *Global* is shown in the *Settings* window. Settings available at this time are general in nature and do not apply to any group. If a group selection is possible, then a pull-down menu is shown and provides for Setting Group 0, 1, 2, or 3 selection. An example of this is the *Overcurrent Protection* screen. Pull down the *Screens* menu and select *Overcurrent Protection*. 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 eight folder tabs and the first tab is *General Info*.

<u>*General Info*</u>

This information tab (Figure 14-5) allows you to fill in the style number of the relay which is available from the label on the relay front panel.

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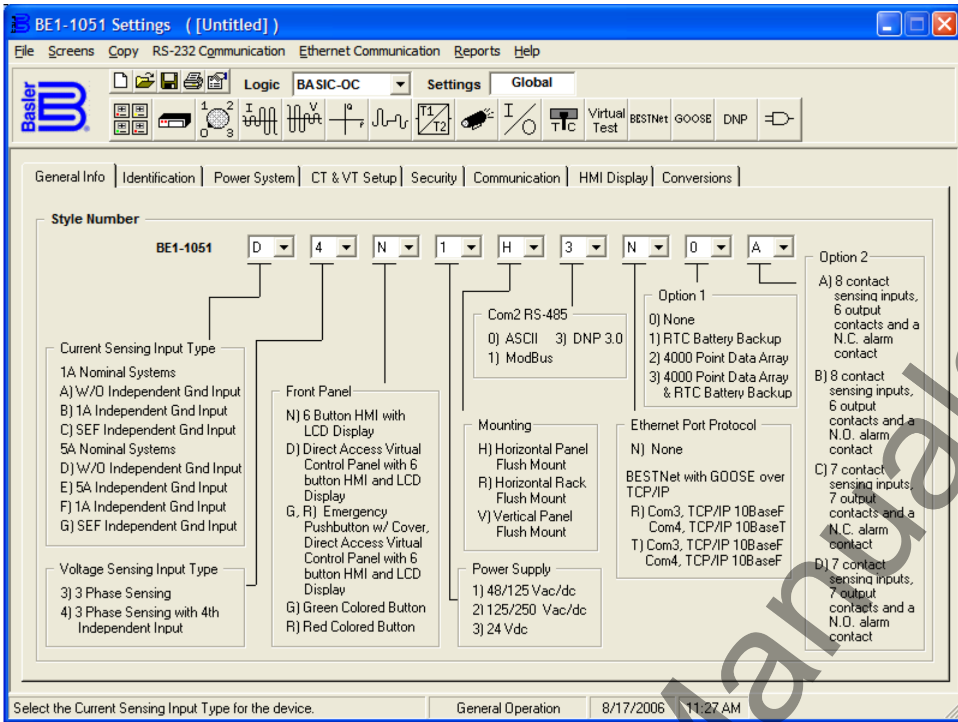

Figure 14-5. General Operation Screen, General Info Tab

Identification

This tab (Figure 14-6) allows you to fill in the serial number of the relay and the various software and firmware application version information. Additionally, you may enter the name of the relay, substation identification other installation-specific identification. This information will become useful when reports are generated.

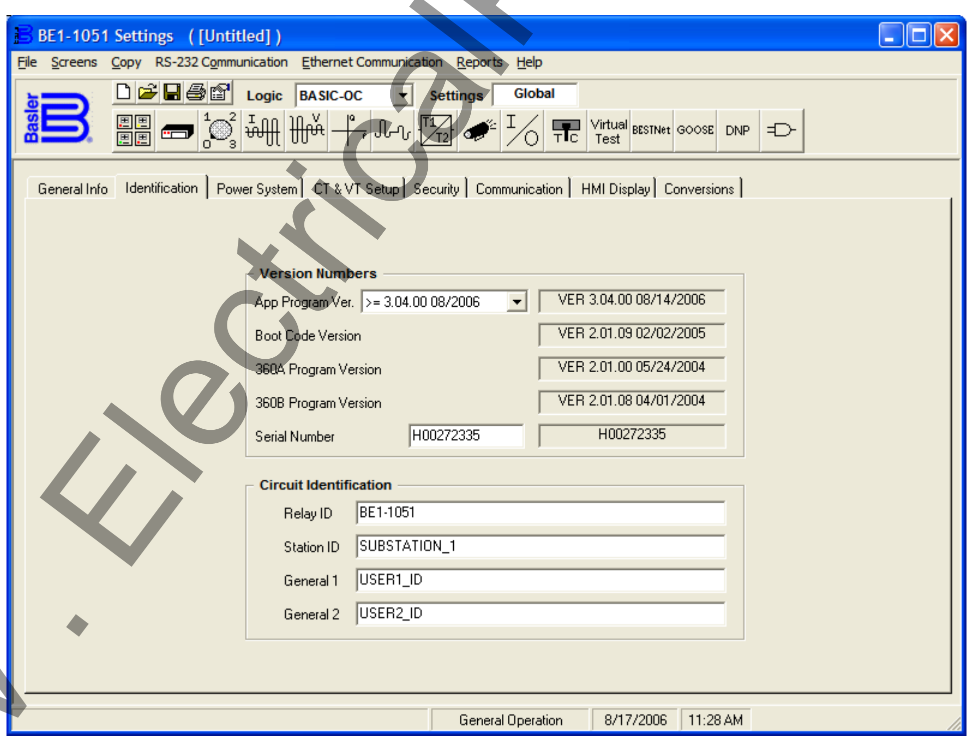

Figure 14-6. General Operation Screen, Identification Tab

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Power System

This tab (Figure 14-7) 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 BE1-1051 protection elements to function. These symmetrical component sequence quantities are entered to provide immediate reference information for settings of the protection elements in the BE1-1051 relay. Distance to fault calculation accuracy is also dependent on the power line parameters entered in this screen.

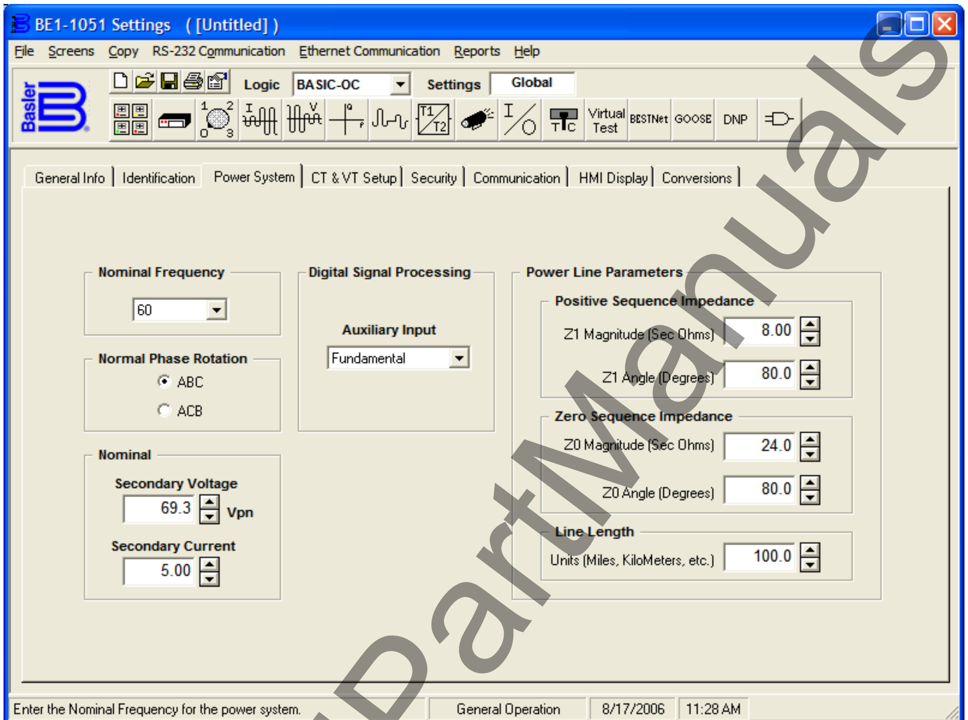

Figure 14-7. General Operation Screen, Power System Tab

CT & VT Setup

This tab (Figure 14-8) allows you to enter the CT ratios and setup the VT parameters. These entries affect every function that relies on voltage and current measurements and calculations derived from those measurements. Pull down the *CT Ratio, Phase, Sec Amps* menu and select the appropriate secondary nominal current input. Enter the *CT Ratio, Phase,* and *Turns* value and 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 is 240. If you change the secondary nominal current input to 5, the primary amperes value becomes 1,200. If the ground current input is valid for your relay, enter the appropriate values.

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/undervoltage modes can be set to operate on either the phase-to-neutral (PN) or phase-to-phase (PP) 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.

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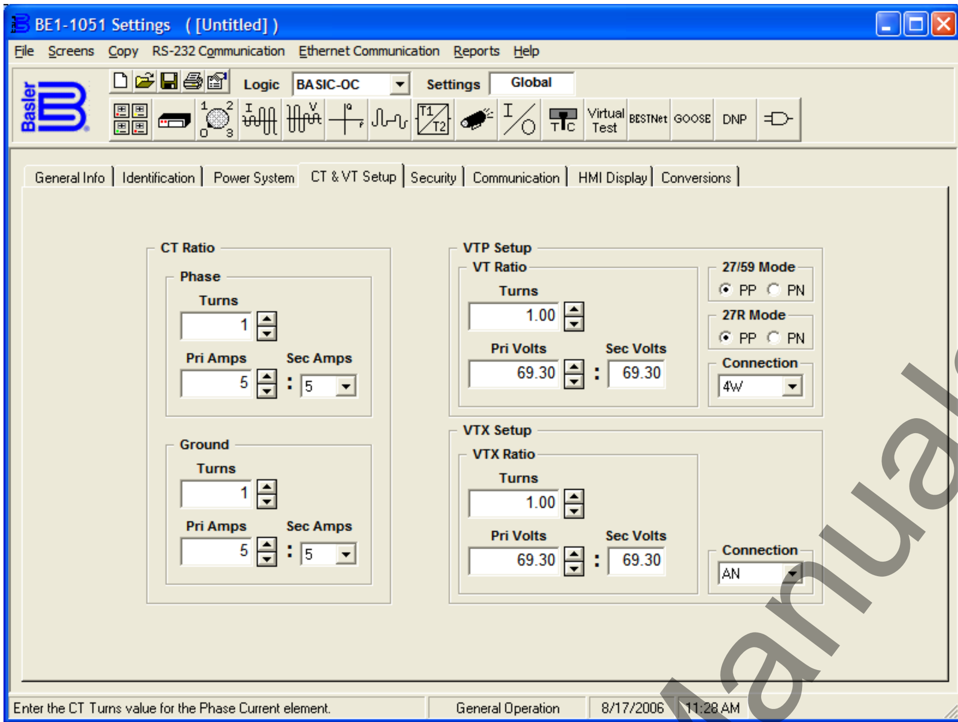

Figure 14-8. General Operation Screen, CT & VT Setup Tab

Security

Each of three communication ports and the three functional areas (Settings, Reports, and Control) has password access. This allows the user to customize password protection for any and all ports. See Figure 14-9. 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 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 HMI and communications port zero are combined and considered as one.

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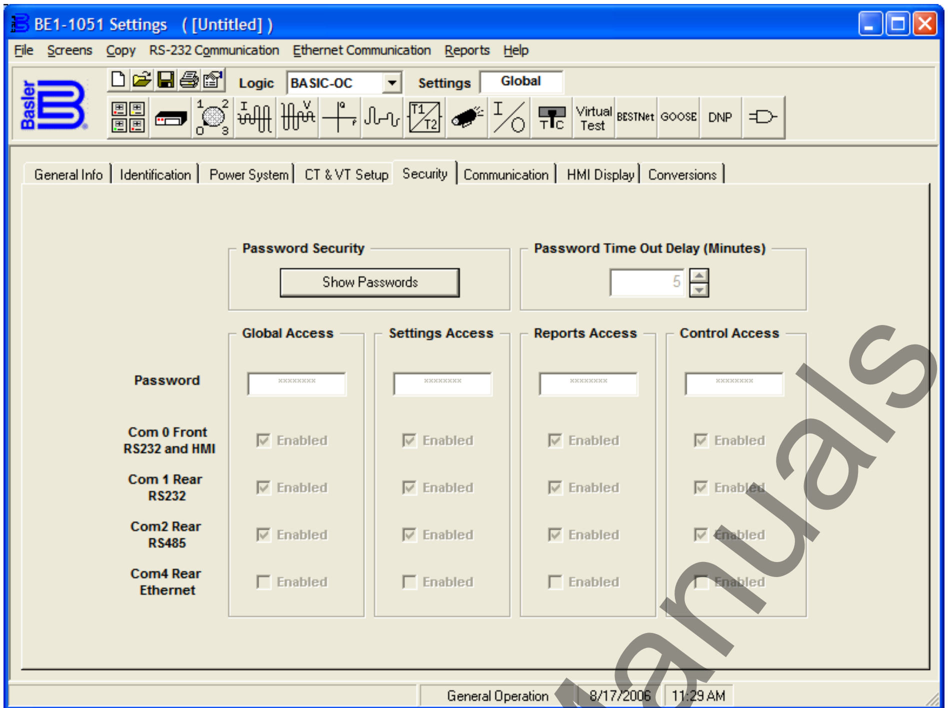

Figure 14-9. General Operation Screen, Security Tab

Communication

This tab, Figure 14-10, 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.

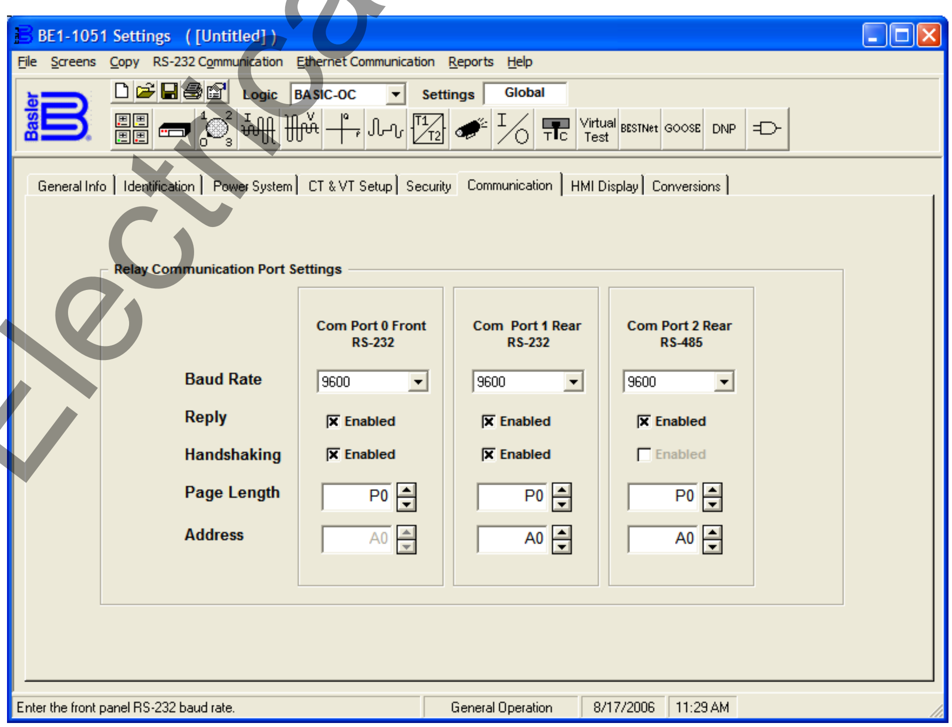

Figure 14-10. General Operation Screen, Communication Tab

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HMI Display

This tab, (Figure 14-11), allows the user to change the screen scroll list on the HMI display. 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 selected that information on the *General Info* tab under the *General Operation* screen, you can select a screen scroll item in BESTCOMS that is not available in the relay. If you do, you will get an error code immediately.

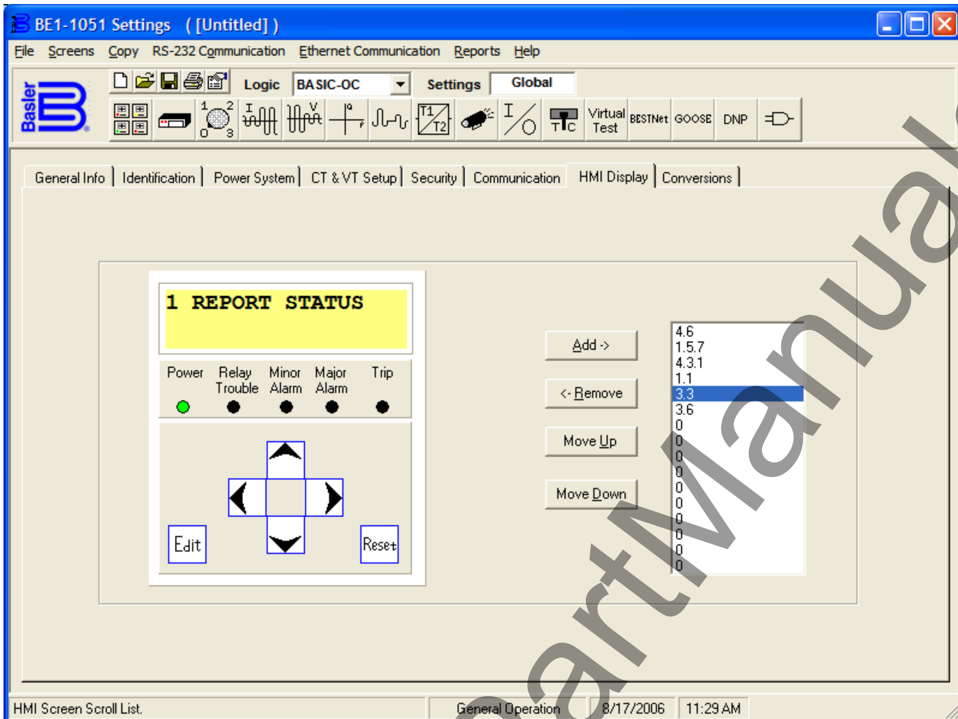

Figure 14-11. General Operation Screen, HMI Display Tab

Conversions

The *Conversions* tab, Figure 14-12, brings up the screen that allows entries in per unit. 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. If you are using percent or per unit, then you have to enter the *Conversions* tab 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.

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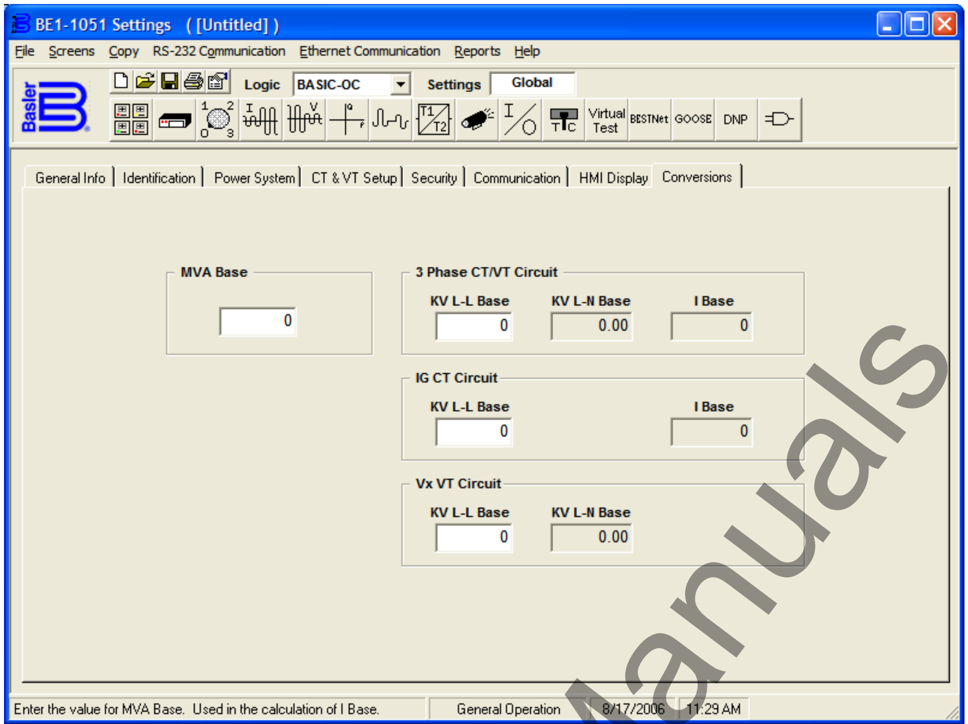
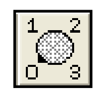


Figure 14-12. General Operation Screen, Conversions Tab

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, Figure 14-13, has no folder tabs and is labeled *Setting Group Selection - Setting Group Automatic Control Settings.*

Setting group selection involves programming the relay to automatically select one group out of four 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. Near the bottom of the screen (Figure 14-13), there is a *Monitor Setting* window for Groups 1, 2, and 3. This field in each group 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 to prevent the group change from changing the instant that the monitored element exceeds the *Switch Threshold* setting. *Return Threshold* and *Time* does the same thing for changing back to the previous group.

You do not have to depend only on monitored conditions to change 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 BE1-1051 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.

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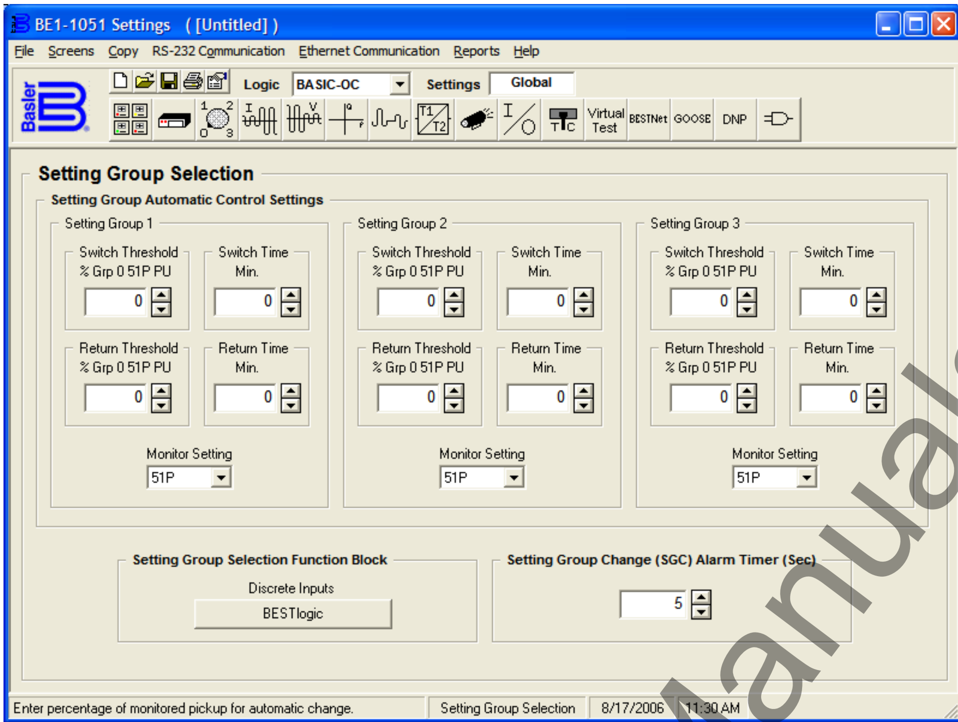
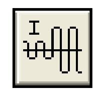


Figure 14-13. Setting Group Selection Screen

Overcurrent

Pull down the *Screens* menu and select *Overcurrent* or click on the Overcurrent Protection icon which is shown at the right margin of this paragraph. This screen has eight folder tabs and the first two tabs are *51* and *151.*



51 and 151 (Time Overcurrent)

These two tabs allow you to enter the settings for the time overcurrent elements. BE1-1051 relays have four time overcurrent elements. Figure 14-14 shows the 51 tab; 151 settings are similar.

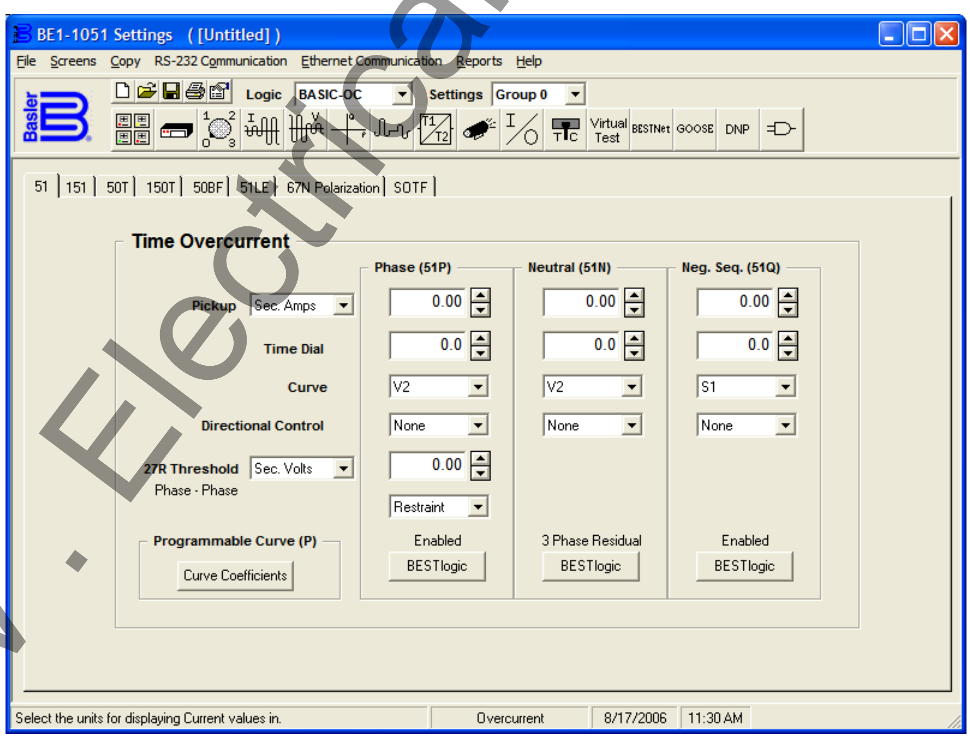


Figure 14-14. Overcurrent Screen, 51 Tab

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The pull down *Pickup* menu allows you to select the relative pickup quantity. BE1-1051 relays measure the current input in secondary amperes. If you want to use per unit, percent amperes, or primary current, you must coordinate the settings in *CT & VT Setup and Conversions.* Do this also for the *27R Threshold* setting. If you want to use the voltage control mode instead of voltage restraint, pull down the menu for *Restraint* (default setting) and select *Control.* 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)* panel. 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.

50T and 150T (Instantaneous Overcurrent with Settable Time Delay)

BE1-1051 relays have six instantaneous elements (three with the 50T element and three with the 150T element). See Figure 14-15 which illustrates the *50T* tab. The tabs for the instantaneous elements are almost identical to the 51 tabs. The settable time delay is the primary difference. To change the time delay, pull down the *Time* menu and select your preferred unit of measure and then change the time setting for the appropriate phase, neutral, or negative-sequence element. The 150T tab is set in a similar manner.

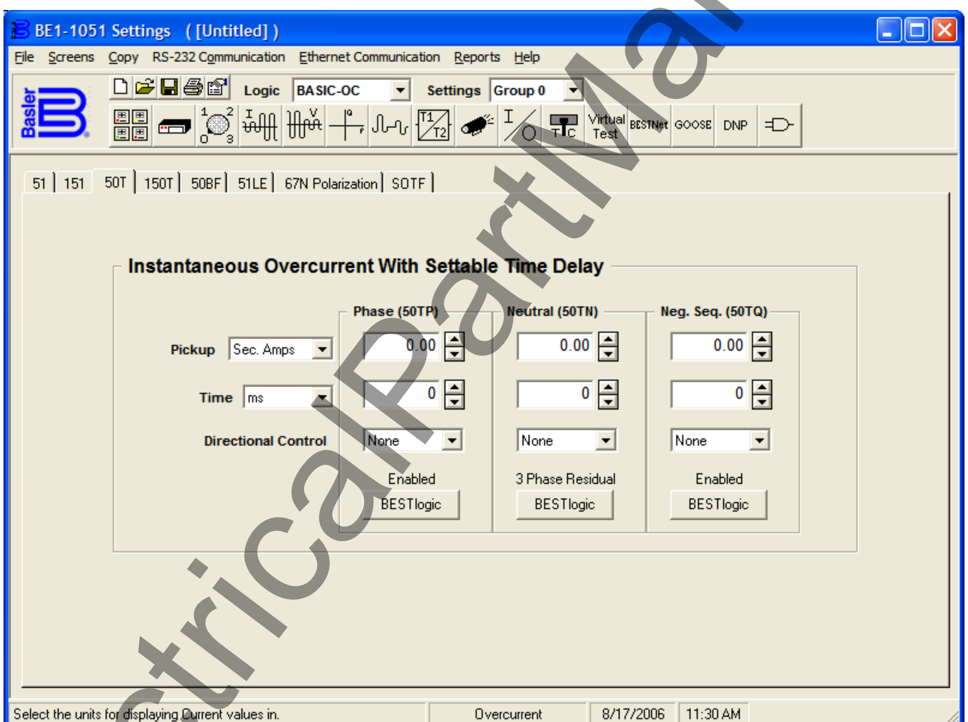

Figure 14-15. Overcurrent Screen, 50T Tab

50BF (Breaker Failure)

To set the time delay from when the breaker failure initiate is received and the trip output is asserted, first pull down the *Time* setting units menu (Figure 14-16) and set the units for time measurement (milliseconds, seconds, minutes, or cycles). Then set the *Pickup* for secondary amps (default), primary amps, per unit amps, or percent amps. *Phase* and *Ground Input Fault Detector (PU)* can then be set using the *UP/DOWN* arrows in the range of .25 to 10.0 amps.

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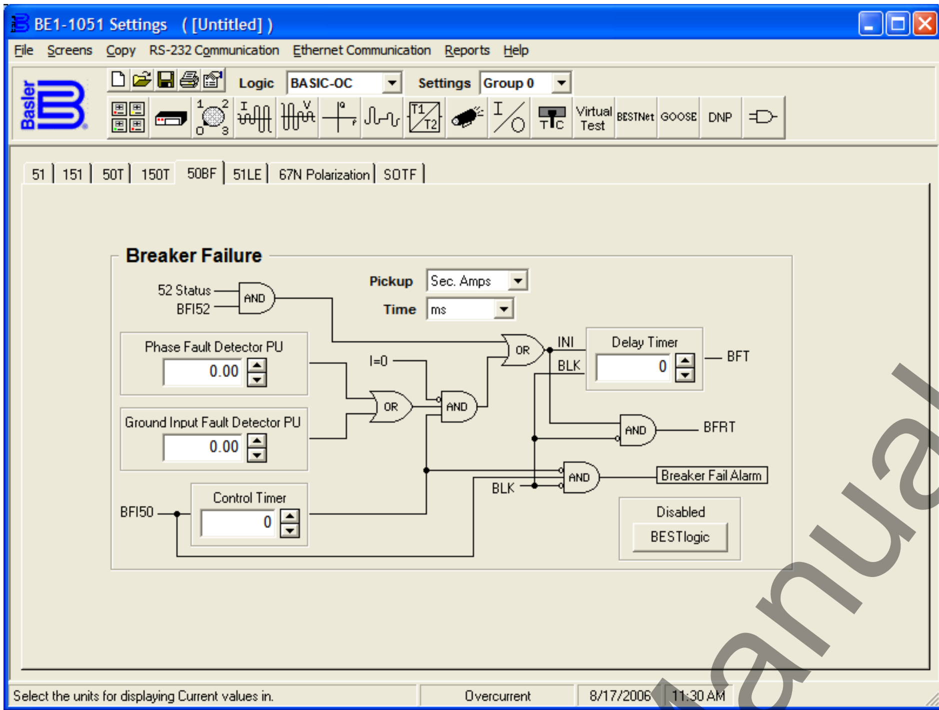

Figure 14-16. Overcurrent Screen, 50BF Tab

The BF150 *Control Timer* and the *Delay Timer* can each be set within a range of 50 to 999 milliseconds. A setting of 0 (default) will disable the function.

Logic settings for the breaker failure function can be made by clicking on the *BESTlogic* button and, with your custom logic selected, select the mode and other input logic by using the *Mode* pull-down menu and clicking on the logic inputs to set the logic.

<u>*51LE (Load Encroachment)*</u>

Figure 14-17 illustrates how load encroachment can be set. *Multiple of Pickup* can be set with a range of one to two. The *Maximum Load Power Factors* for vars can be set in a range of zero to one.

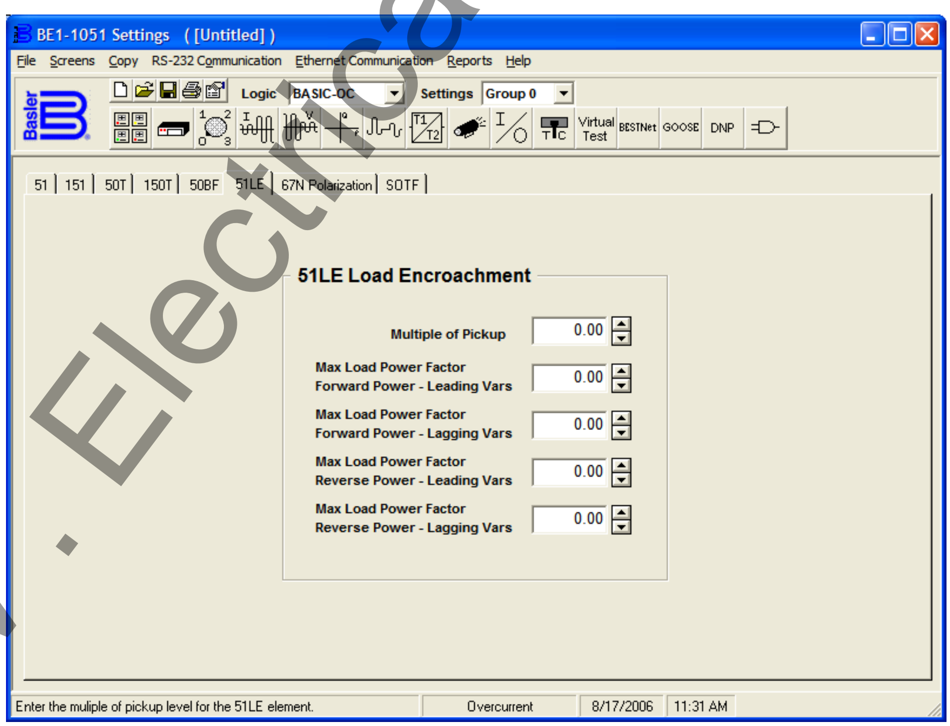

Figure 14-17. Overcurrent Screen, 51LE Tab

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67N Polarization

The 67N element can set for three types of polarization modes: negative-sequence (Q), zero-sequence voltage (V), and zero-sequence current (I). At least one of the three modes must be selected. The following 67N quantities can be selected: V0IN, VXIG, VXIN, or V0IG. Only one of the four may be selected. See Figure 14-18.

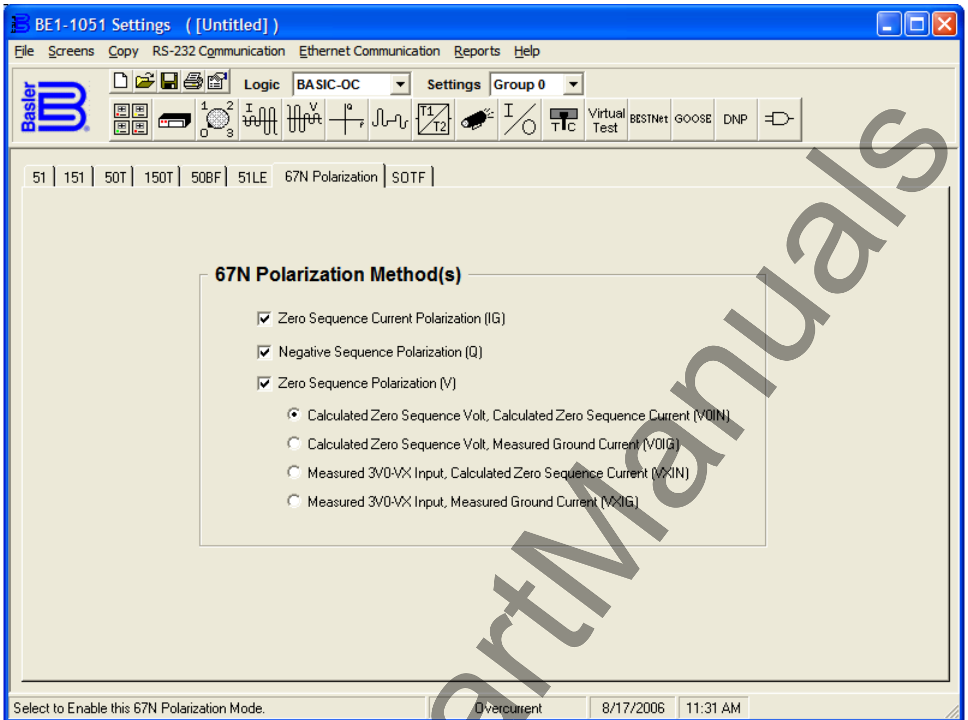

Figure 14-18. Overcurrent Screen, 67N Polarization Tab

SOTF (Switch On To Fault)

Switch On To Fault (SOTF) logic (Figure 14-19) provides tripping in the event that the breaker is closed into an existing zero-voltage bolted 3-phase fault, such as occurs if the grounds are left on the line following maintenance. Use the drop down arrow to choose the *Pickup* unit of measure: *Sec. Amps, Pri. Amps, Per U Amps, or % Amps.* The *Phase Inst.* (instantaneous) *OC* (overcurrent) *PU* (pickup) can be set using the *UP/DOWN* arrows for a setting between .50 and 150 amps. In a similar manner, use the drop down arrow to set the unit of measure for the *Hold Timer – Time* unit of measure: seconds, minutes, or cycles. Use the *UP/DOWN* arrows to set the *Hold Timer.* This represents the amount of time the SOTF function is active before it is defeated. A typical setting is 12 cycles or 200 milliseconds but the allowable range is 3 to 59.94 cycles or 50 to 999 milliseconds.

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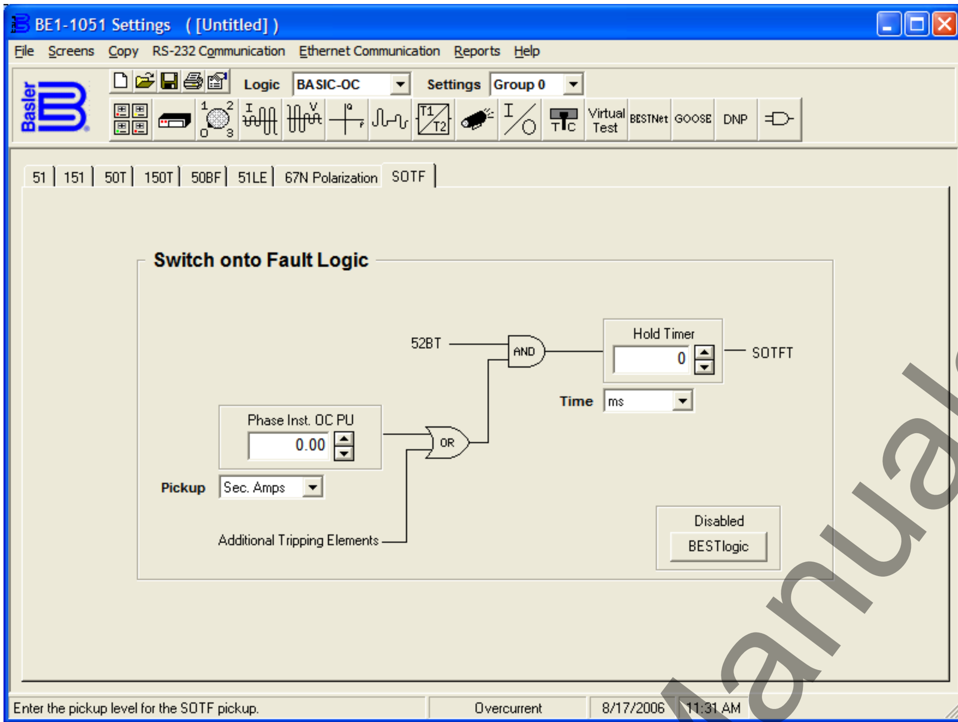
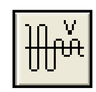


Figure 14-19. Overcurrent Screen, SOTF Tab

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 (Figure 14-20) has eight tabs and the first tab is *24.* Many of the settings for voltage protection are identical or similar to those settings in overcurrent protection, so the explanations will not be repeated.

24 (Overexcitation)

This tab (Figure 14-20) allows you to make the settings for the overexcitation (volts/hertz) element. The pull-down *Pickup* menu allows you to select the relative pickup quantity. The BE1-1051 relay measures the voltage input in secondary voltage (*Sec. V/Hz* [default]). If you want to use primary volts (Pri V/Hz), per unit volts (Per U V/Hz), or percent volts (% V/Hz), 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) within a range of 0.5 to 6.0 secondary volts per hertz. Settings for trip *Time Dial* and *Reset Dial* can be adjusted in the range of 0 to 9.9 in .1 increments. The *Alarm Threshold* (percent of pickup) can be adjusted from 0 to 120.

Select the *BESTlogic* box at the bottom of the 24 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.

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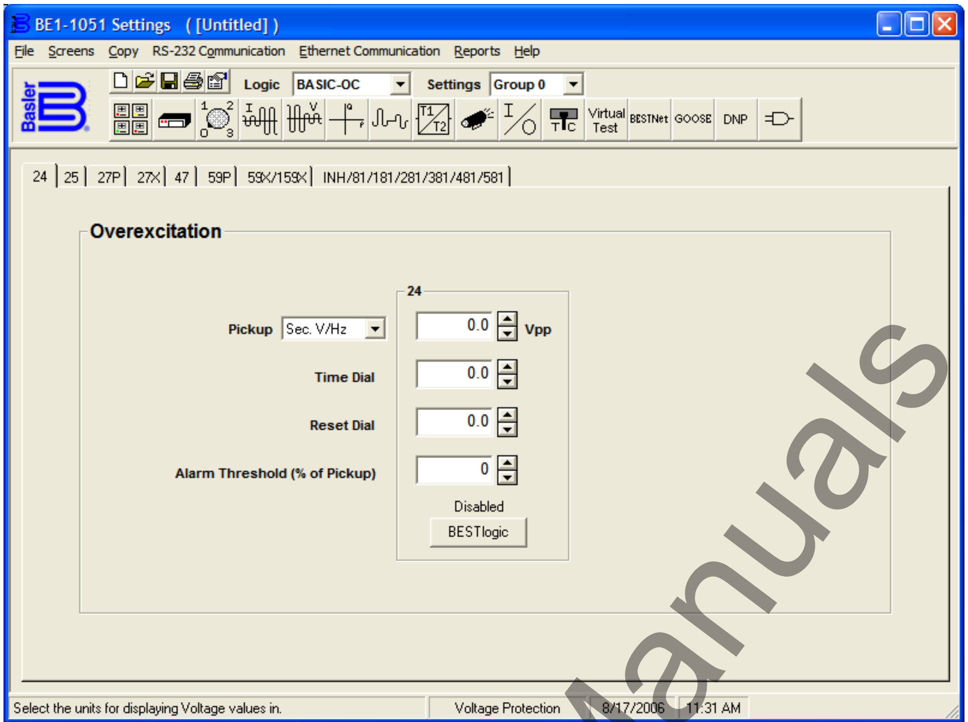

Figure 14-20. Voltage Protection Screen, 24 Tab

<u>25 (Sync-Check)</u>

This tab (Figure 14-21) 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 BE1-1051 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 as illustrated in Figure 14-21.

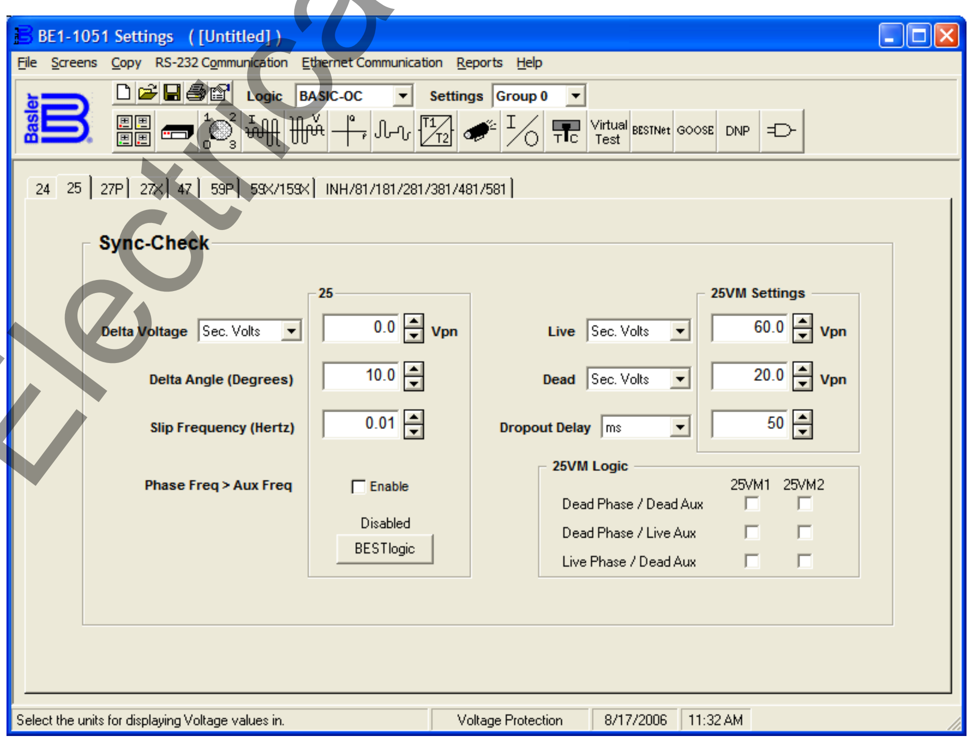

Figure 14-21. Voltage Protection Screen, 25 Tab

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Set the 25 VM - *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 and VM2 logic bits.

27P (Phase Undervoltage)

This tab (Figure 14-22) allows you to configure the phase undervoltage with settable time delay elements. The pull down *Pickup* menu allows you to select the relative pickup quantity and inhibit quantity within a range of 10.0 to 300 volts. The BE1-1051 relay measures the voltage input in secondary voltage (default). 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 beside the settings – e.g., V_{PP} (voltage, phase-to-phase). Select the *Time* delay unit of measure and the value for the 27P element in the range of 50 to 600,000 milliseconds. Select the *BESTlogic* box at the bottom of the Phase (27P) 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.

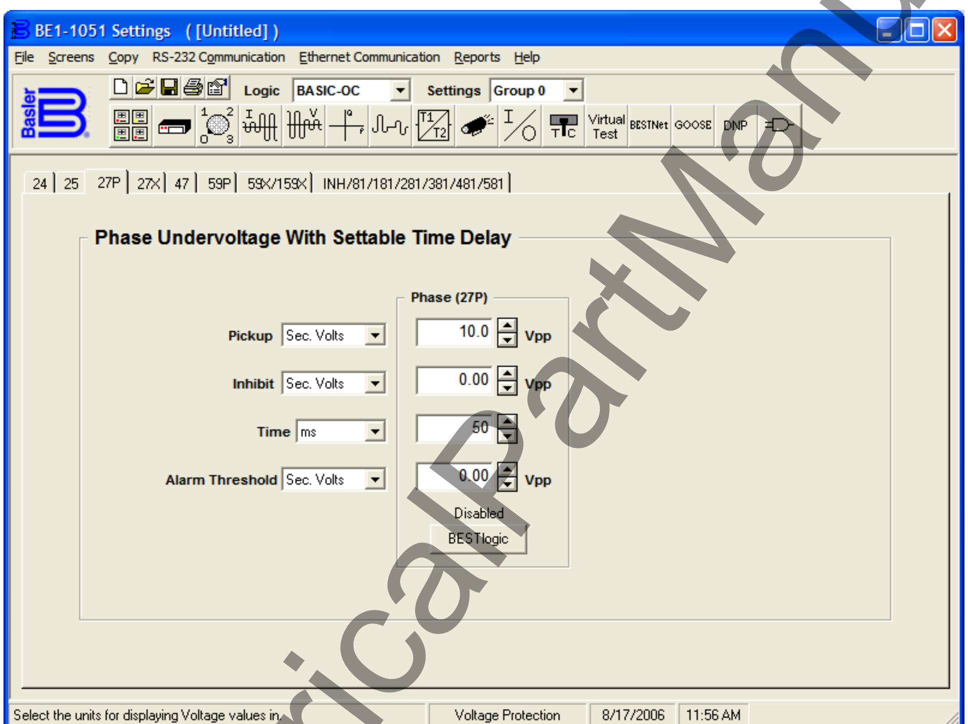

Figure 14-22. Voltage Protection Screen, 27P Tab

27X (Auxiliary Undervoltage)

This tab (Figure 14-23) is the *Auxiliary Undervoltage with Settable Time Delay.* Changing the settings for this element is similar to that of the previous 27P element.

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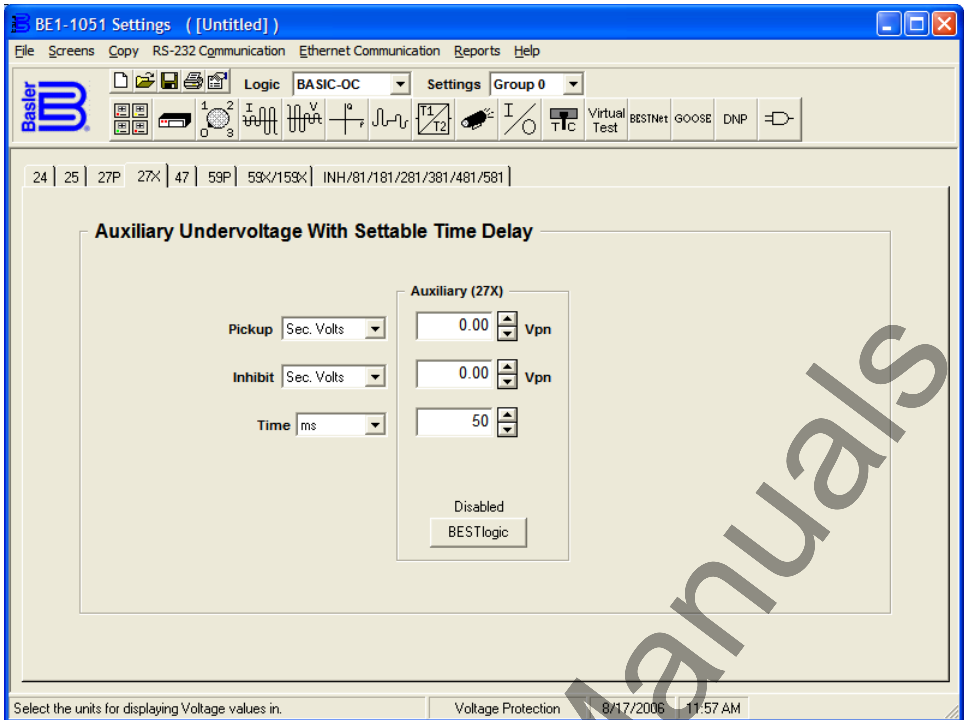

Figure 14-23. Voltage Protection Screen, 27X Tab

47 (Negative-Sequence Overvoltage)

This tab (Figure 14-24) is the *Negative-Sequence Over-voltage with Settable Time Delay.* Changing the settings for this element is similar to that of the previous 27P element.

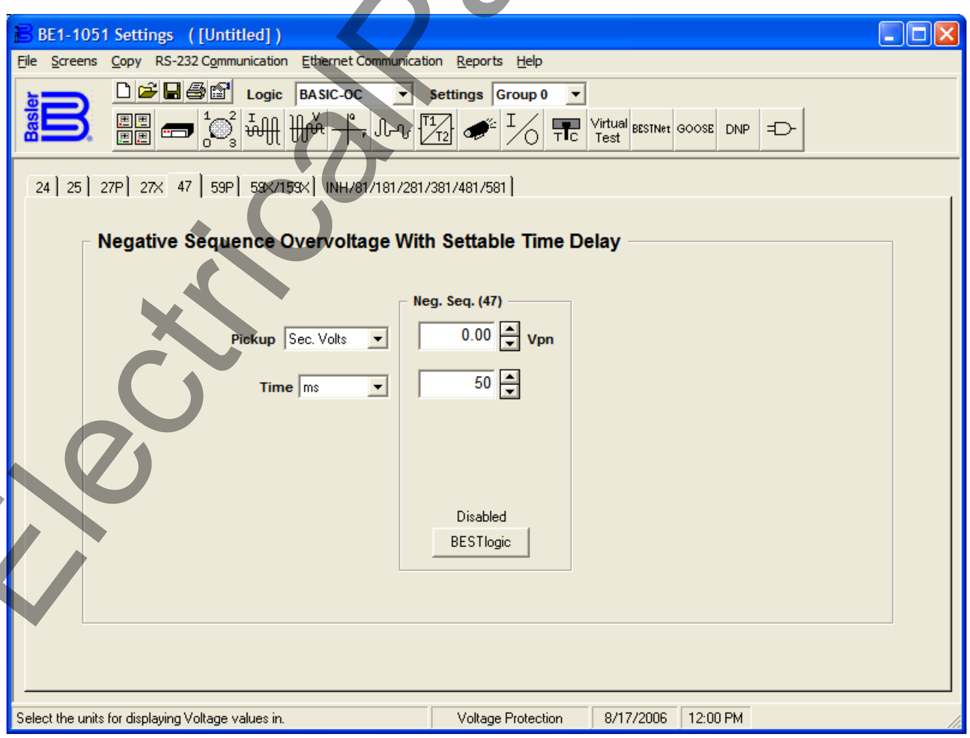

Figure 14-24. Voltage Protection Screen, 47 Tab

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59P (Phase Overvoltage)

This tab (Figure 14-25) is the *Phase Overvoltage with Settable Time Delay.* Changing the settings for this element is similar to that of the previous 27P element.

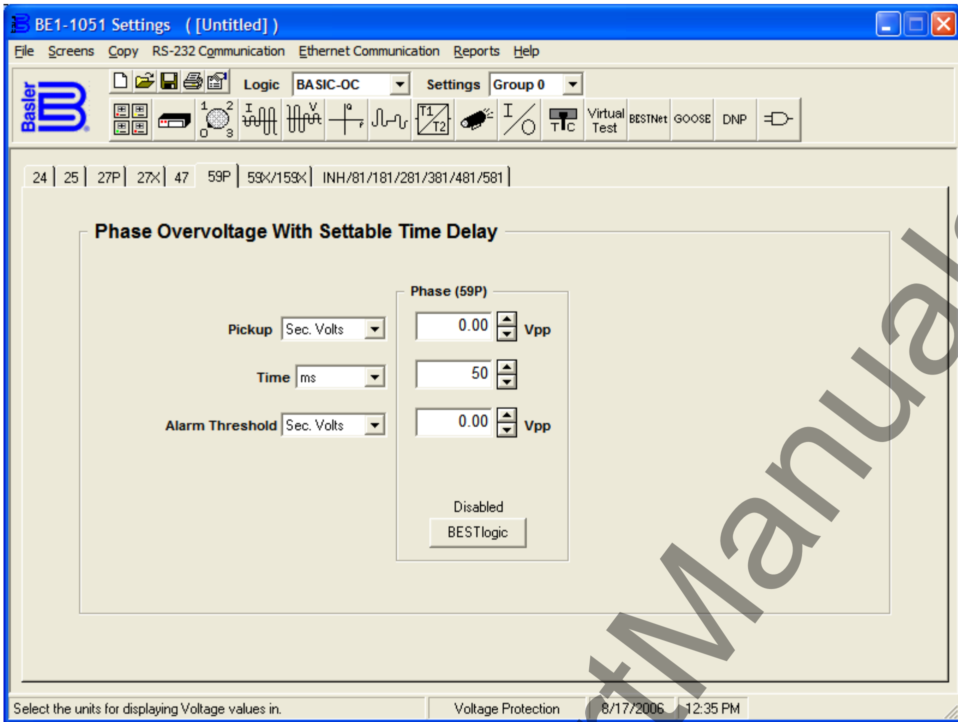

Figure 14-25. Voltage Protection Screen, 59P Tab

59X/159X (Auxiliary Overvoltage)

This tab (Figure 14-26) is the *Auxiliary Overvoltage with Settable Time Delay.* Changing the settings for this element is similar to that of the previous 27P element.

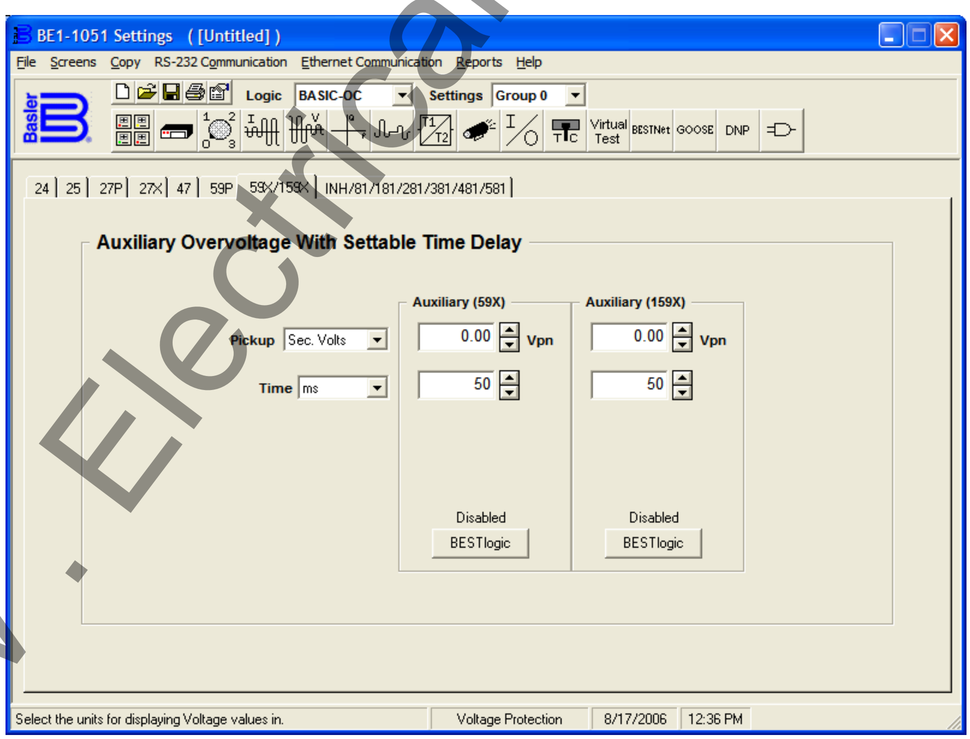

Figure 14-26. Voltage Protection Screen, 59X/159X Tab

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

This tab (Figure 14-27) allows configuring the *Over/Underfrequency with Settable Time Delay* elements. Changing the settings for these elements are identical or similar to those settings of the previous 27P element. Inhibit can be set in the range of 15.0 to 150 volts. *Pickup Hertz* can be set in the range of 40 to 70. And *Time* (ms) can be set from 0 to 600,000 milliseconds. The 81 elements can be set for overfrequency or underfrequency using the pull-down menus.

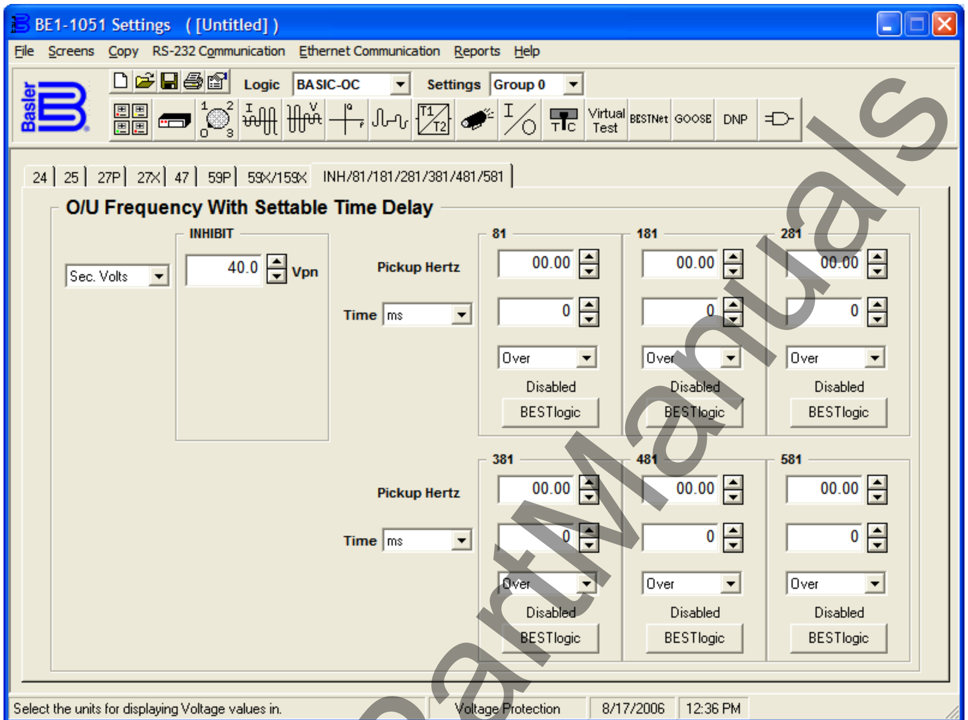

Figure 14-27. Voltage Protection Screen, INH/81/181/281/381/481/581 Tab

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 14-28) has no folder tabs and is labeled *Directional Power.* The pull down *Pickup* menu allows you to select the relative pickup quantity. The BE1-1051 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.* The range is from 1.0 to 6,000 secondary watts. Select the *Time* delay unit of measure (milliseconds, seconds, or minutes) and set the value for the 32 and 132 elements in the range of 0.050 to 600 seconds. 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*.

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.

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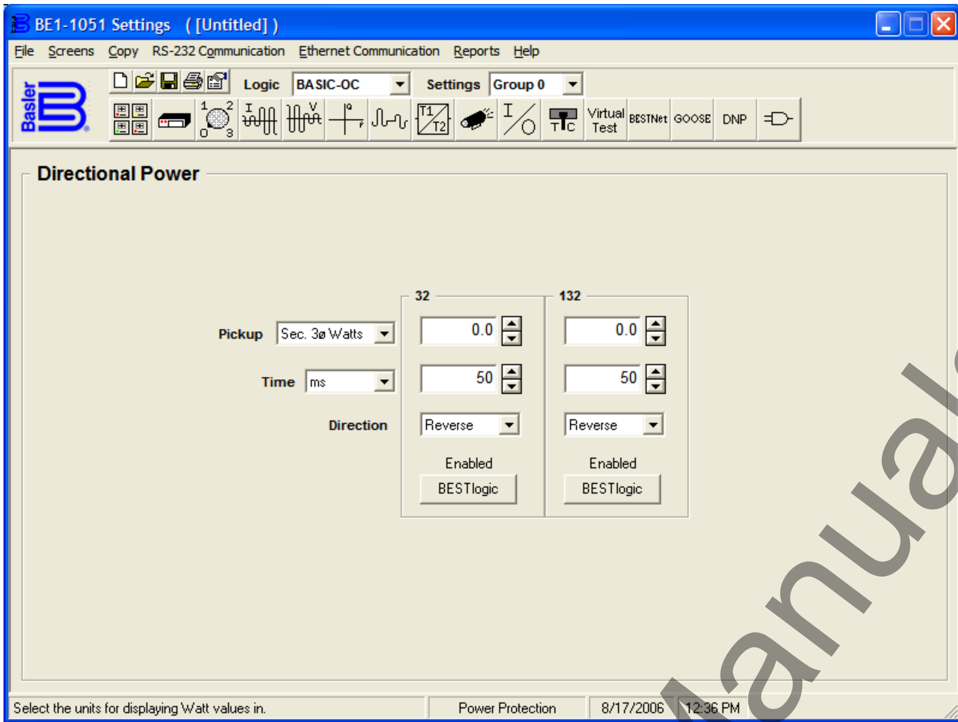
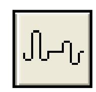


Figure 14-28. Power Protection (Directional Power) Screen

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 14-29) has no folder tabs and is labeled *Reclosing.*



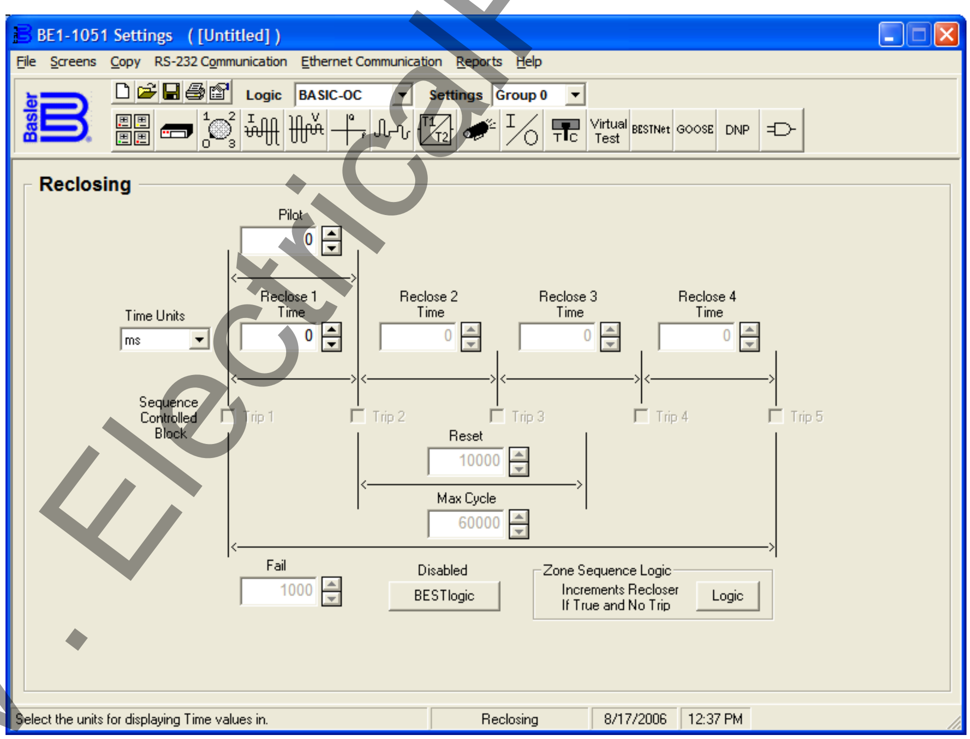


Figure 14-29. Reclosing Screen

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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 and set the units 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 and the SCB window is now available. Now enter the reclose times for the remaining 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 SCB 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.

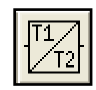
Set the *Reset* time using the same unit of measure that was used for the reclosing attempts. Reset time is how long you want the relay to remain reset before the relay returns to the initial state.

Set the maximum cycle (Max Cycle) time. Maximum cycle time limits the duration of a reclosing sequence as determined from sequence initiation to automatic relay reset or lockout.

Logic settings for the 79 reclosing function can be made by clicking on the *BESTlogic* button and with your custom logic selected, select the mode and other input logic by using the *Mode* pull-down menu and clicking 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.

Logic Functions



Pull down the *Screens* menu and select *Logic Functions* or click on the Logic Functions icon which is shown at the right margin of this paragraph. This screen has four folder tabs and the first tab is *52BT.*

52BT (Breaker Open/Dead Line Logic)

The *52BT* tab (Figure 14-30) illustrates the *Breaker Open/Dead Line Logic.* The 52BT element provides Dead Line and Live Line recognition by use of measured quantities from the line CTs and VTs installed on the line side of the breaker. The 52BT element consists of a three-phase undervoltage detector, a 52 status input, and an output from the fast dropout current detector used in the breaker failure logic. The output of the logic is conditioned through a user settable dropout recognition timer. For a description of the setting functions, see Section 4, *Protection and Control, Breaker Open/Dead Line Logic.*

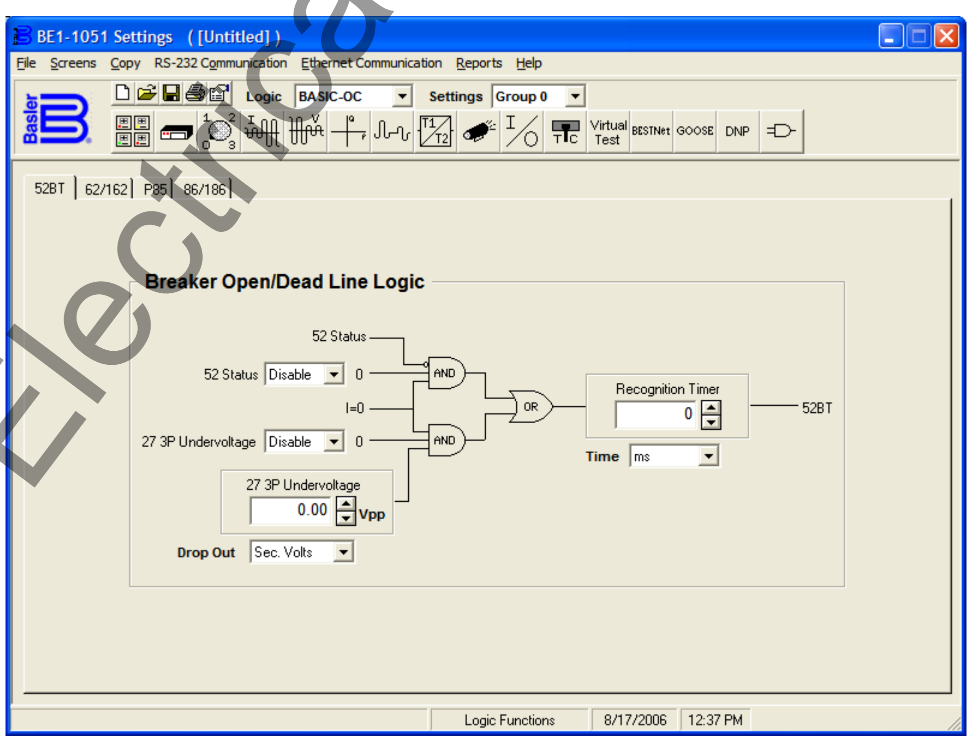


Figure 14-30. Logic Functions Screen, 52BT Tab

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62/162 (Logic Timers)

Logic timers, 62 and 162 (Figure 14-31) 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.*

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.

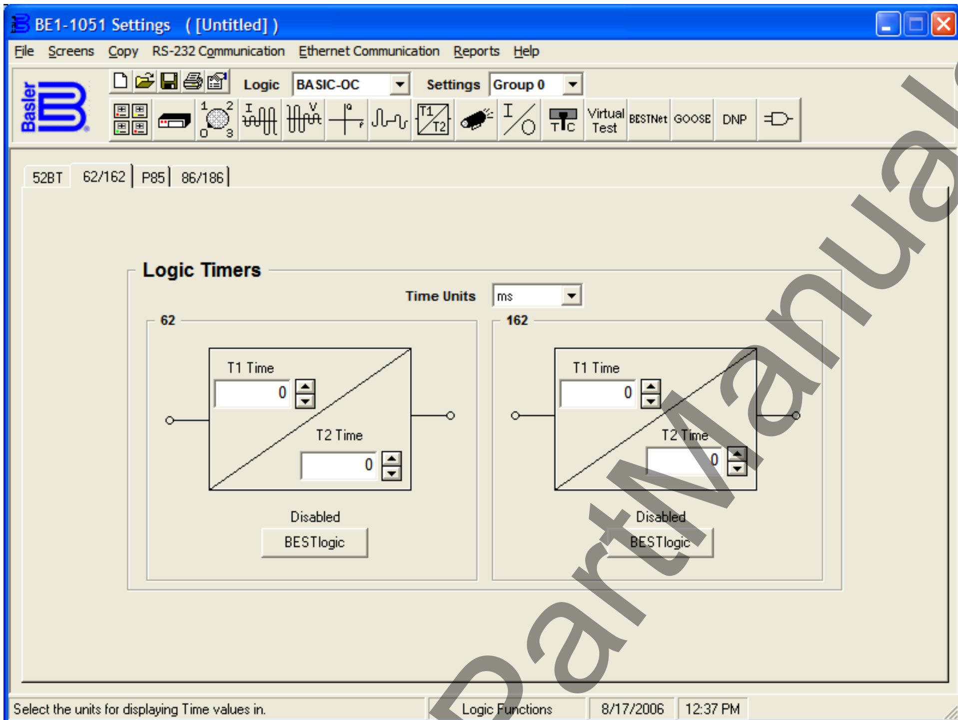

Figure 14-31. Logic Functions Screen 62/162 Tab

P85 (Permissive Pilot Logic)

The permissive pilot logic (Figure 14-32) provides high speed, end to end clearing of faults on networked transmission and sub-transmission lines when a communications channel is available. It is designed such that it can operate as Permissive Under Reaching Transfer Trip (PUTT) or Permissive Overreaching Transfer Trip (POTT) or Direct Under Reaching Transfer Trip (DUTT) by simply changing the setup parameters on the input functions connected to it. The functions control communications aided tripping for the local line terminal and communications transmitter keying for the remote line terminal.

A permissive scheme works on the principle that if the local line terminal sees the fault in the forward direction, it keys permission to the remote terminal. At each terminal, the relay determines that it can trip if it sees the fault in the forward direction and it has received permission from the remote end. For a description of the setting functions, see Section 4, *Protection and Control, Logic Functions.*

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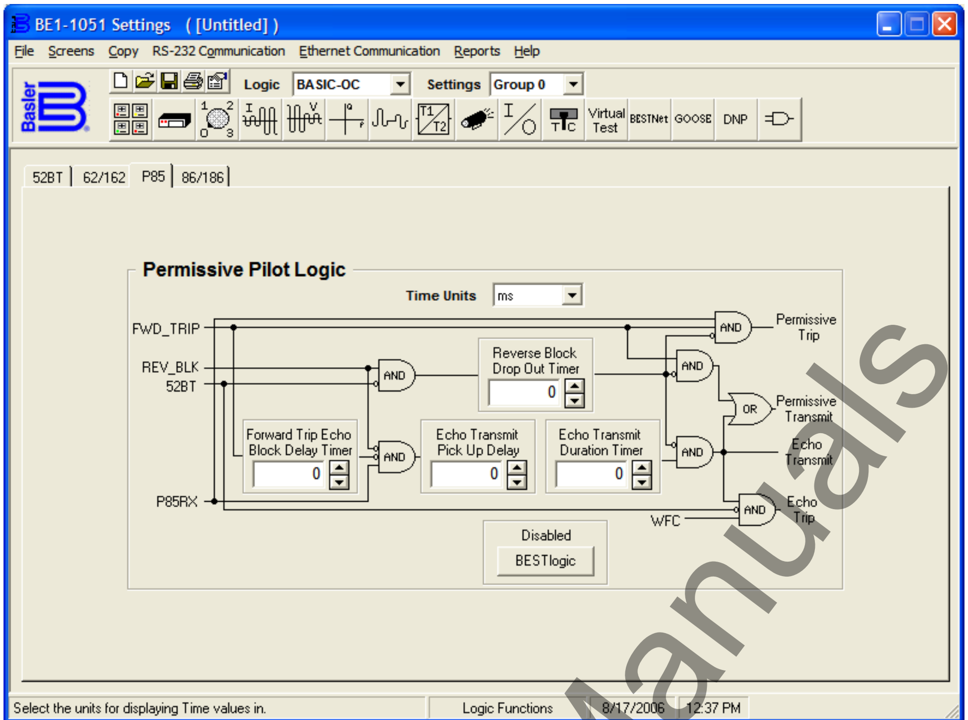

Figure 14-32. Logic Functions Screen, P85 Tab

<u>*86/186 (Virtual Lockout Function)*</u>

Virtual lockout protection (Figure 14-33) has two elements: 86 and 186. Both independent elements have the same logic inputs, outputs, and functions.

Logic settings for the virtual lockout function can be made by clicking on the *BESTlogic* button and with your custom logic selected, select the mode and other input logic by using the Mode pull-down menu and clicking on the logic inputs to set the logic.

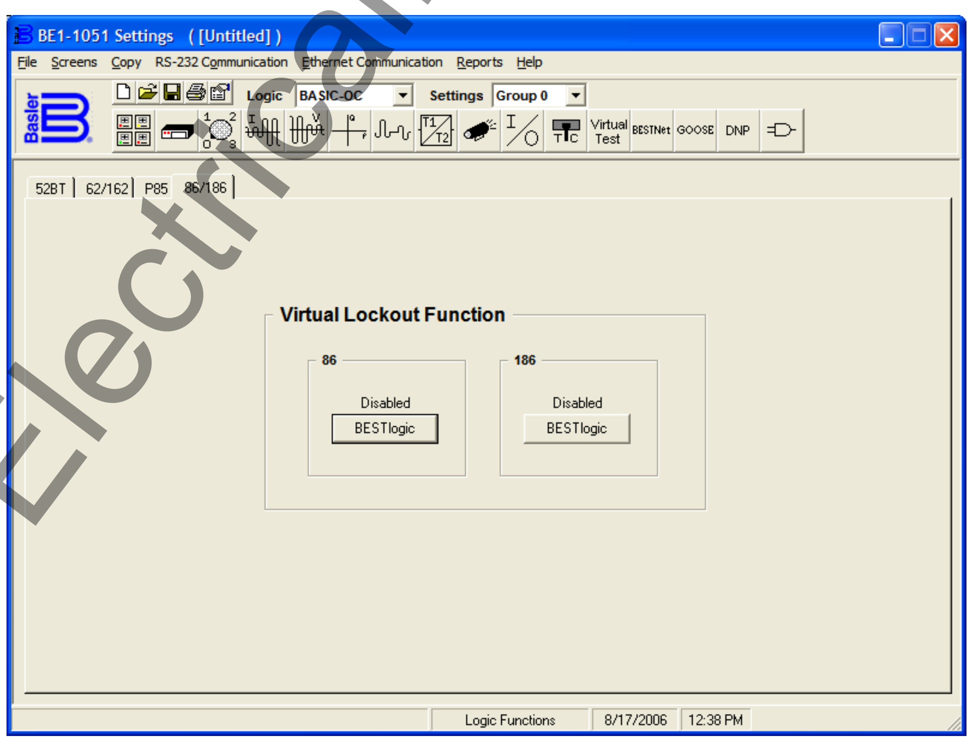

Figure 14-33. Logic Functions Screen, 86/186 Tab

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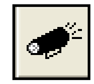
Reporting and Alarms

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 eight folder tabs and the first tab is *Clock Display Mode.*



Clock Display Mode

Use the Time Format and Date Format pull-down menus (see Figure 14-34) to set the current time and date in the preferred format. Twice a year adjustment for the start or end of daylight savings time may be made by selecting the Automatic Daylight Savings box.

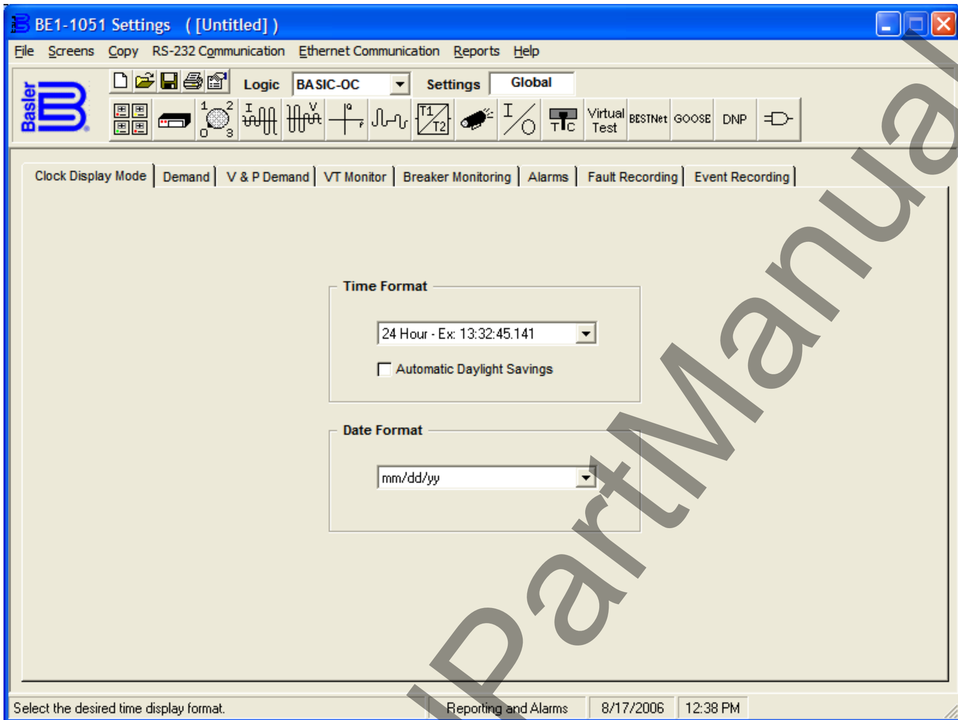


Figure 14-34. Reporting and Alarms Screen, Clock Display Mode Tab

Demand

Demand intervals (Figure 14-35) can be set independently for the phase, neutral, and negative-sequence demand calculations. Click in the *Phase & Average Current, Neutral & Ground Current,* or *Negative-Sequence Current* field and enter the time in minutes or adjust the time by using the appropriate (*UP* or *DOWN*) arrow buttons. The range is zero to 60 minutes. Use the pull-down menus to set the unit of measure for each threshold setting *(Threshold Display Units).* The demand value is shown in each field as the data is metered. The *Phase Threshold* and *Average Threshold* are adjustable in the range of 0.5 to 16.0 amps.

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.

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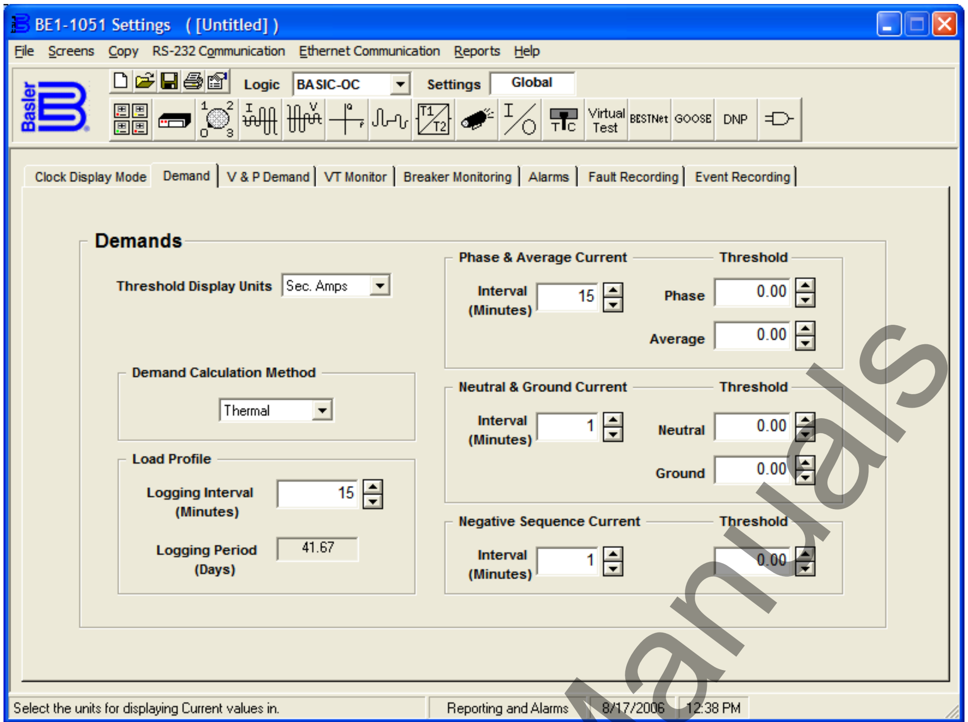

Figure 14-35. Reporting and Alarms Screen, Demand Tab

V & P Demand

This tab (Figure 14-36) permits the setting of voltage and power demand values. Using the *Threshold Display Units* pull-down menu, select *Sec. Volts, Pri. Volts, Per U Volts,* or *% Volts* as the *Phase & Average Voltage Threshold* unit of measure. Then using the *Up/Down* arrows, set the *Max Phase* and *Min Phase* as well as *Max Average* and *Min Average* values in the range of 10.0 to 300 secondary volts. Likewise, *Max Neutral* and *Min Neutral* can be set in the range of 10.0 to 150 secondary volts.

Watt Demands and Var Demands, Forward or Reverse can be set in a similar fashion after establishing the unit of measure. The permissible range is 0.0 to 8,500 secondary watts or vars, as appropriate.

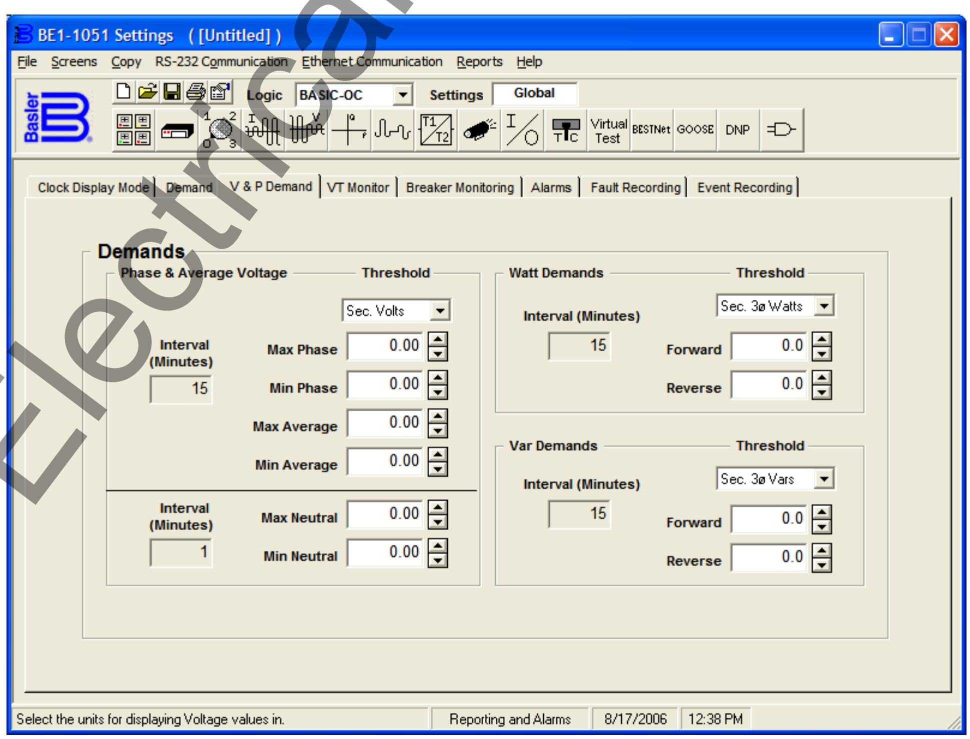

Figure 14-36. Reporting and Alarms Screen, V & P Demand Tab

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VT Monitor (Fuse Loss Block Logic)

Fuse Loss Block Logic (Figure 14-37) can prevent misoperation on loss of sensing voltage. This can be applied on both the 51/27 and 27/59 functions.

When the 51/27 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 51/27 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.

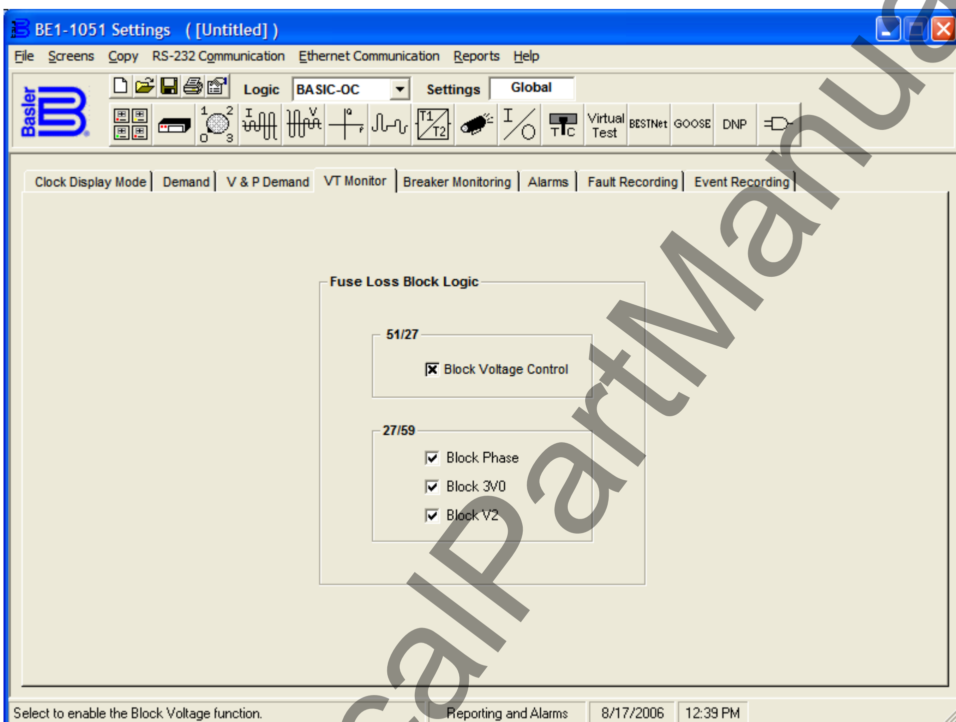

Figure 14-37. Reporting and Alarms Screen, VT Monitor Tab

Breaker Monitoring (Breaker Duty Monitoring)

Each time the breaker trips, the breaker duty monitor updates two sets of registers for each pole of the breaker. 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 Exponent* pull-down menu (Figure 14-38) to select the exponent in the range of 1 to 3. 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, select 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, select 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 *Breaker Alarms - Point 1* and select the preferred breaker monitoring mode (function). 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 Alarms*

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- *Points 2* and *3.* If desired, select the *Trigger Oscillographic Record* box to create an oscillographic record.

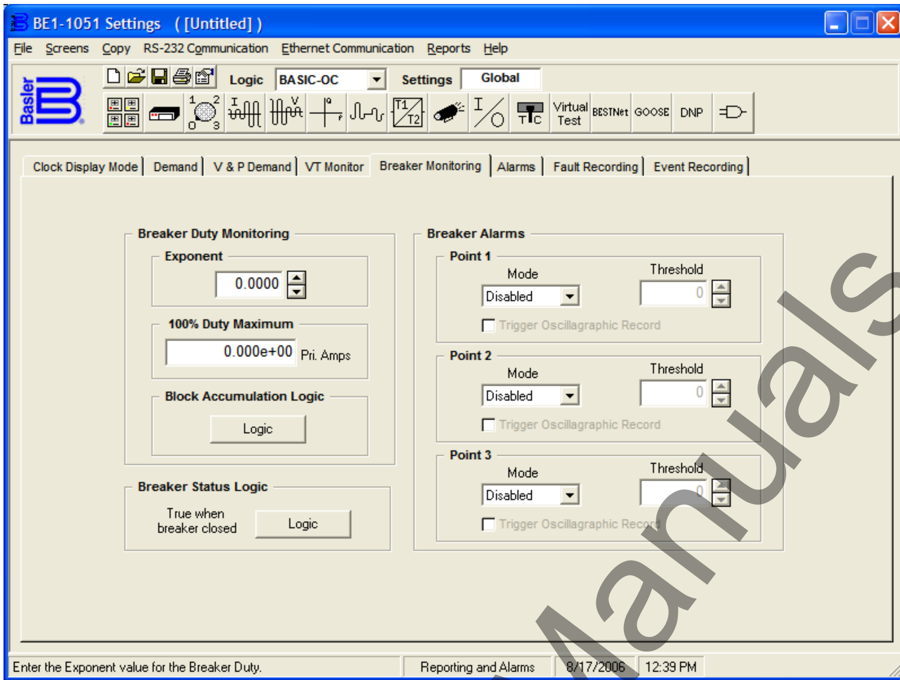

Figure 14-38. Reporting and Alarms Screen, Breaker Monitoring Tab

<u>*Alarms*</u>

BE1-1051 relays have 44 programmable alarm points (Figure 14-39). 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, use the scroll bar as needed, 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.

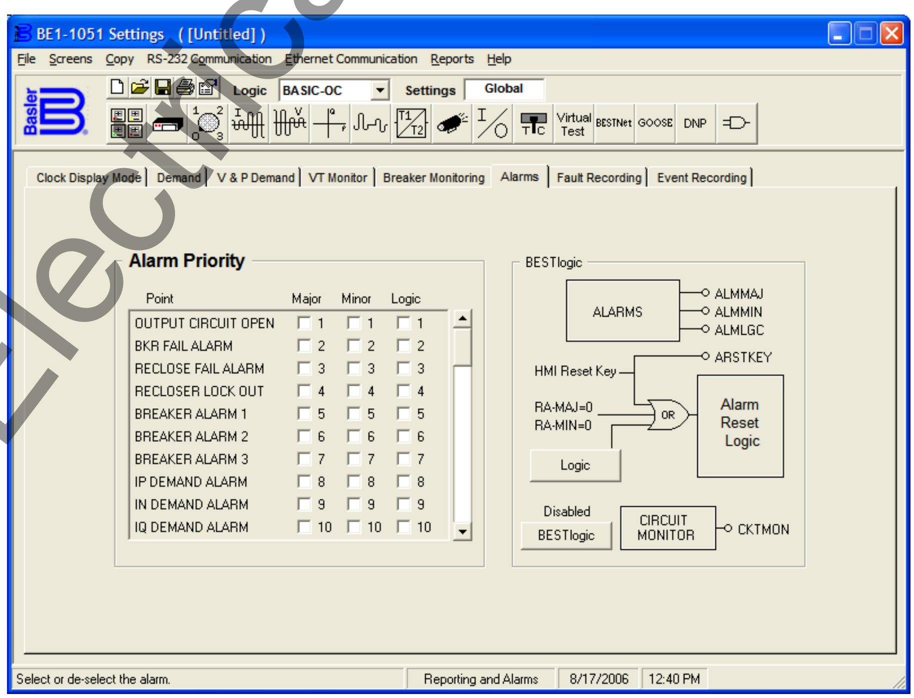

Figure 14-39. Reporting and Alarms Screen, Alarms Tab

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Fault Recording

Logic expressions define the three conditions that determine when a fault has occurred. 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* (Figure 14-40) and then click on *Tripped, Pickup,* 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.

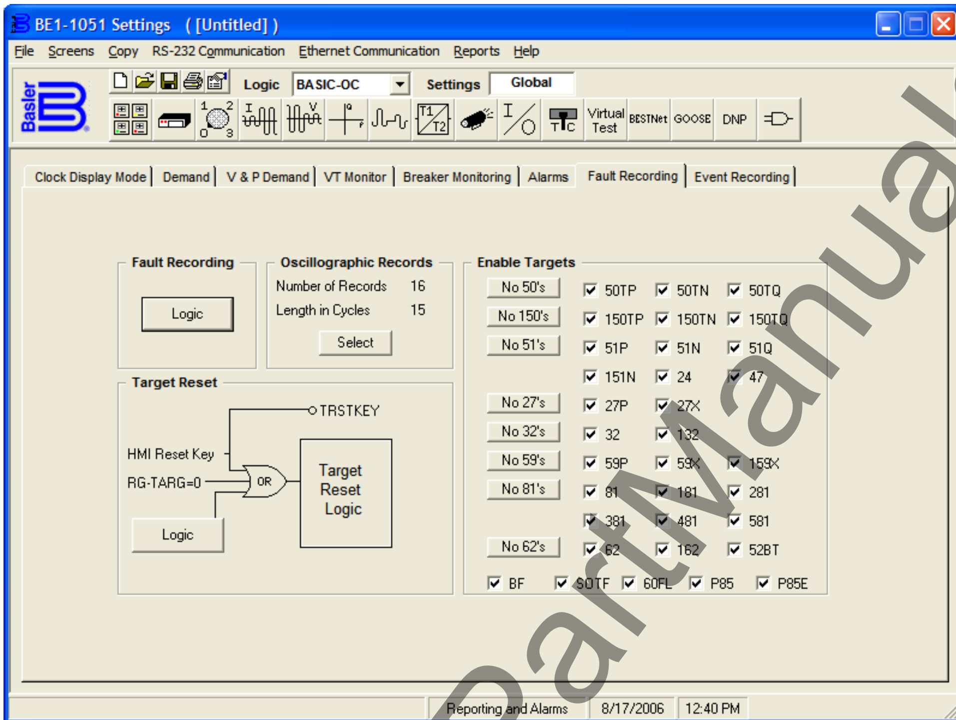


Figure 14-40. Reporting and Alarms Screen, Fault Recording Tab

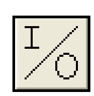
The fault recording function can record up to 16 oscillographic records in volatile memory. Because there is only a specific amount of memory available, as additional faults are recorded, the oldest records are overwritten. Each record can record only a limited number of data cycles. If you have less 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 *Target Reset* are shown for reference only. There is no interaction available.

Any protective function, except 62, 162, and 60FL, which 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 frequency protection function, click on the *No 81's* button on the left side of the *Enabled Targets.*

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 three folder tabs and the first tab is *Inputs 1-4.*



Inputs 1-4

There are seven or eight (depending on the style number) programmable inputs in the BE1-1051 relay; this tab (Figure 14-41) allows setting of the first four inputs. To program how long the Input 1 contact must be energized to be recognized as energized, first, pull down the *Time Units* menu and set the units for the

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appropriate time measurement. Then, click on the *Input 1, Recognition Time* field and enter the new value or use the appropriate (*UP* or *DOWN*) arrow buttons to set the new value. To program how long the Input 1 contact must be de-energized to be recognized as de-energized, click on the *Input 1, Debounce Time* and enter the new value or use the appropriate (*UP* or *DOWN*) arrow buttons to set the new value within the range of 4 – 255 ms.

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.

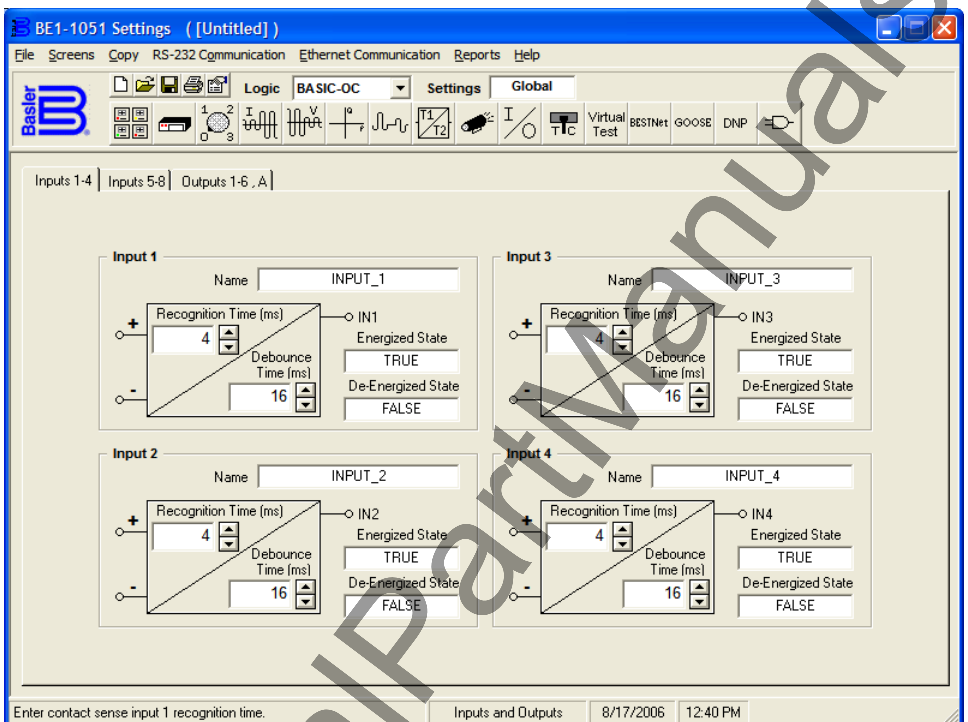

Figure 14-41. Inputs and Outputs Screen, Inputs 1-4 Tab

Inputs 5–8

The second tab in the *Inputs and Outputs* screen allows setting inputs five through seven or eight (depending on the style number). The process is the same as discussed above.

Outputs 1-6, A

On this tab (Figure 14-42) 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 one of the six or seven (depending on the style number) outputs. To change the label for any of the virtual outputs, see the paragraph under BESTlogic, Virtual Outputs, later in this section of the manual.

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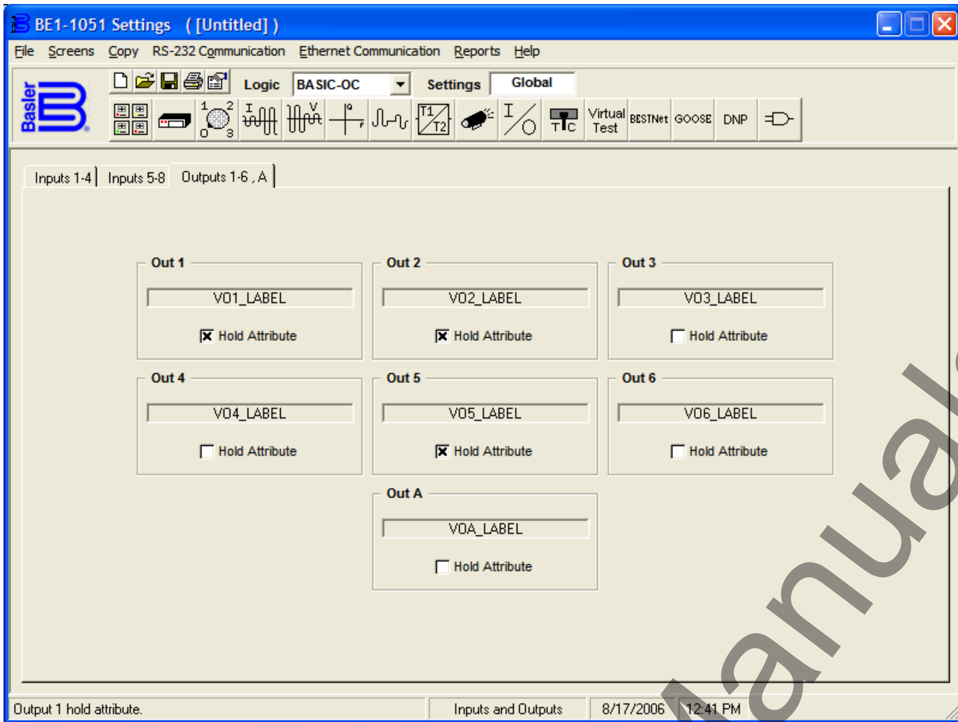
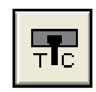


Figure 14-42. Inputs and Outputs Screen, Outputs 1-6, A Tab

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 has two folder tabs and the first tab is labeled *43/143/243/343/443.*

43/143/243/343/443

You can assign a meaningful name or label to each virtual switch (Figure 14-43). 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 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 four virtual switches function the same way.

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 Tagging mode is set by clicking the *BESTlogic* button in the *Tagging* box. The remaining four virtual switches have the same functions.

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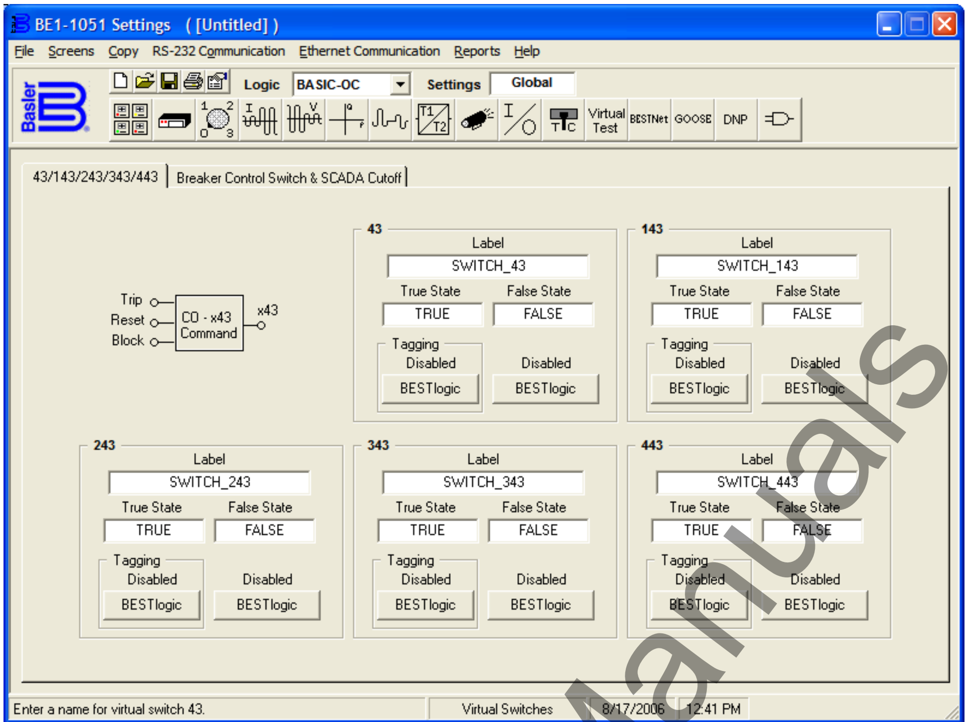

Figure 14-43. Virtual Switches Screen, 43/143/243/343/443 Tab

Breaker Control Switch (101) and SCADA Cutoff

The Virtual Breaker Control Switch (Figure 14-44) 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 the *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.*

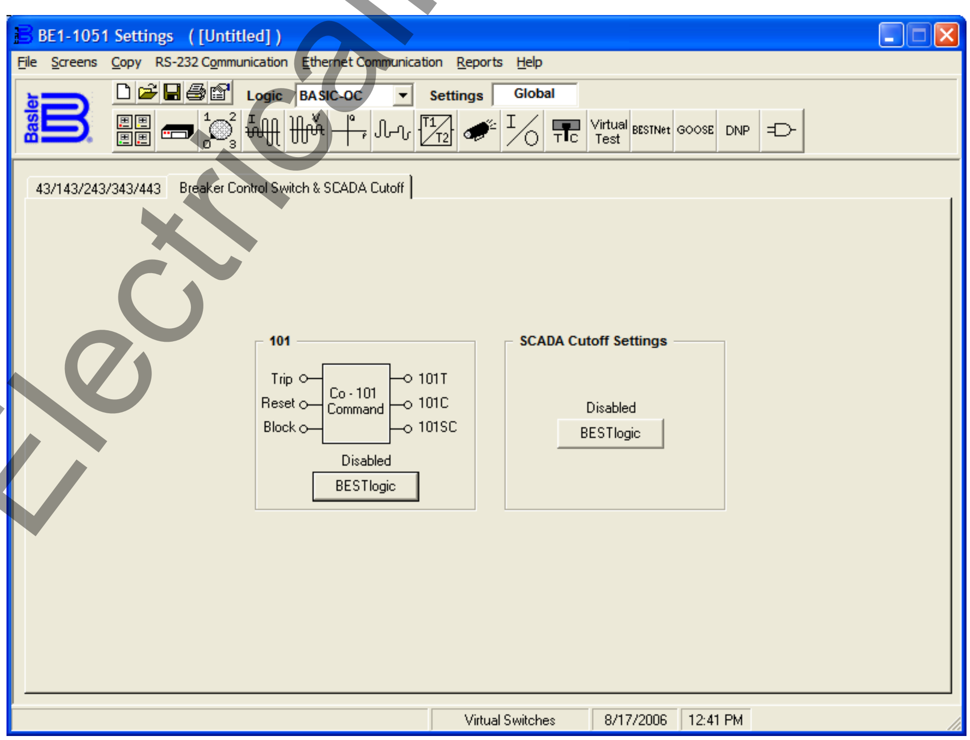

Figure 14-44. Virtual Switches Screen, Breaker Control Switch & SCADA Cutoff Tab

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SCADA stands for supervisory control and data acquisition. This tab gives the user the ability to locally disable remote control operations (i.e., SCADA). SCADA Cutoff (Figure 14-44) allows a user to prevent control commands from communication ports 0/1/2 that are tied into the SCADA system yet not block control from the direct access control panel. The mode logic setting for SCADA Cutoff 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. Block inputs include *Com 0, Com1,* and *Com2.*

Virtual Test Settings

Pull down the *Screens* menu and select *Virtual Test Settings* or click on the Virtual Test icon which is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *Virtual Test Switch.*

To facilitate testing the BE1-1051 Relay, a virtual test switch (Figure 14-45) function is provided to make it easy to isolate individual functions the user may have under test. Four preprogrammed and four user virtual test switch masks (filters) can be stored inside the relay. Each mask can be given a user meaningful name up to 8 characters. The user can enable a mask by specifying which positions should be opened. The virtual test switch is grouped into banks of four hexadecimal numbers (32-bit groups). A non-zero in the mask specifies that the bit is to be processed and a zero specifies that it shall be blocked. The mode logic setting can be made by clicking on the *BESTlogic* button and, with custom logic selected, select the mode logic by using the *Mode* pull-down menu. Likewise, to view or edit a mask or to copy a user mask from one mask to another user mask, a custom logic must first be created and selected. The *Timeout (Minutes)* may be adjusted using the *UP/DOWN* arrows within a range of 1 to 1,440 minutes.

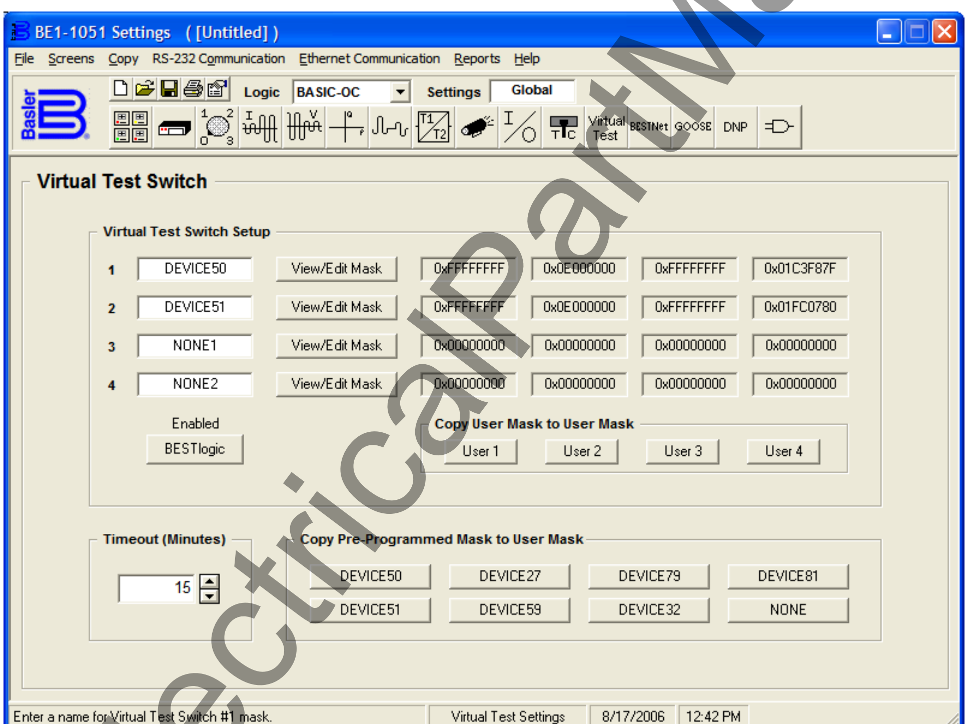

Figure 14-45. Virtual Test Settings (Virtual Test Switch) Screen

BESTNet Settings

Pull down the *Screens* menu and select *BESTNet Settings* or click on the BESTNet Settings icon which is shown at the right margin of this paragraph. This screen (Figure 14-46) has two folder tabs. The first tab is labeled *General Settings* and the second tab is labeled *E-mail.*

For detailed information regarding the *BESTNet Settings* screen, refer to Section 15, *BESTNet Communication.*

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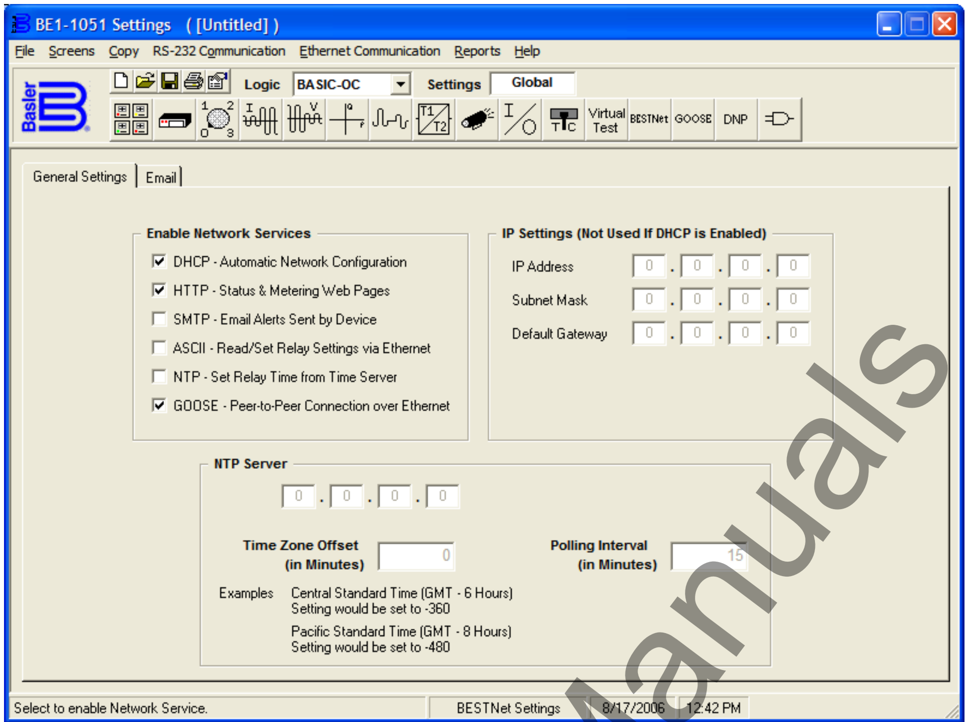
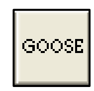


Figure 14-46. BESTNet Settings Screen, General Settings Tab

Goose Settings



Pull down the *Screens* menu and select *Goose Settings* or click on the GOOSE icon which is shown at the right margin of this paragraph. This screen (Figure 14-47) has four folder tabs and the first tab is labeled *GOOSE Information*.

For detailed information regarding *Goose Settings* screen, refer to Section 15, *BESTNet Communication.*

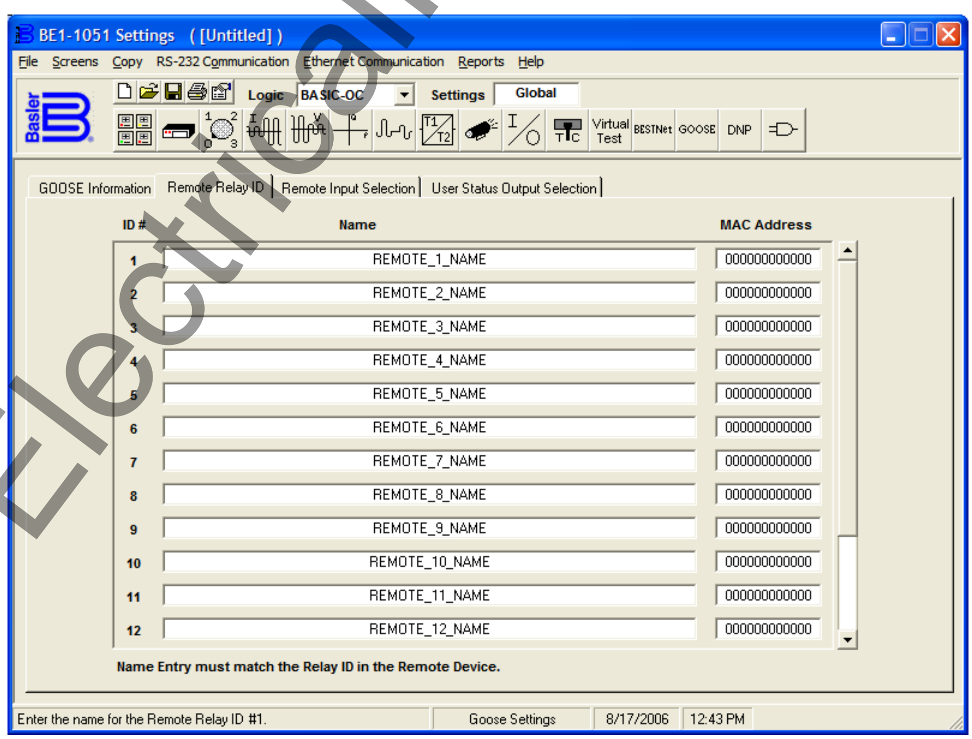


Figure 14-47. Goose Settings Screen, GOOSE Information Tab

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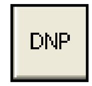
DNP



Pull down the *Screens* menu and select *DNP Settings* or click on the *DNP Settings* icon that is shown at the right margin of this paragraph. This screen has one folder tab labeled *DNP Settings*.

DNP Settings

If the BE1-1051 has DNP 3.0, you may use this tab (Figure 14-48) to select the options for *ADNP Analog User Map, DNP Binary User Map, DNP Synch Period with Master, and Dead Band.*

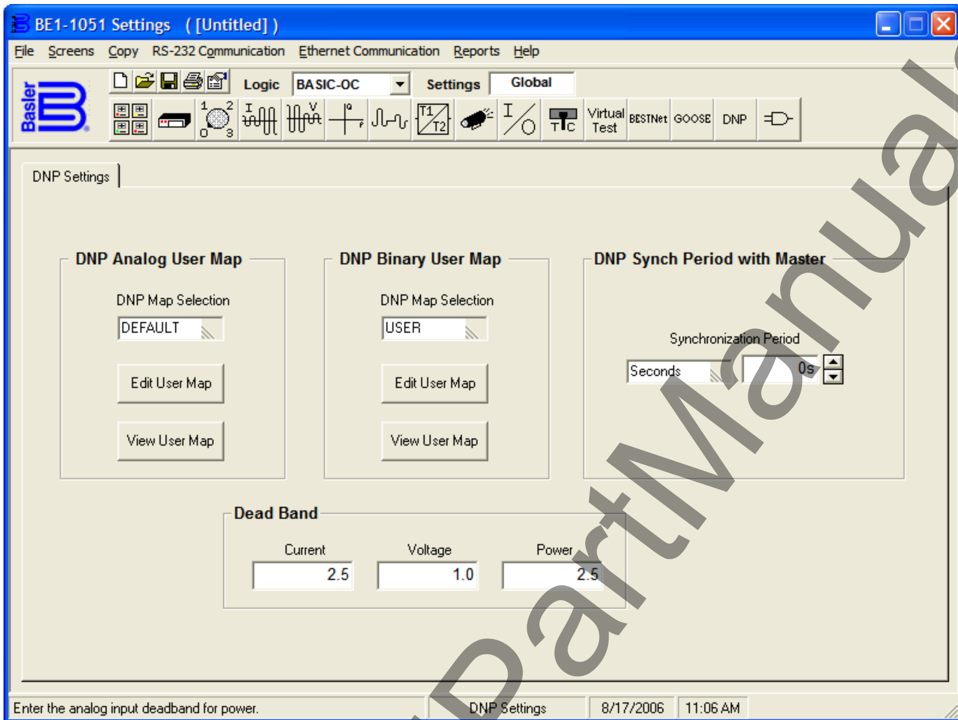
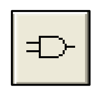


Figure 14-48. DNP Settings Screen

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 is *Logic Select.*

Logic Select

This tab (Figure 14-49) 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 allowed to change nothing 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 and a dialog box appears requiring that you okay the replacement of all settings. Execute the *OK* and then type in the new (custom) name.

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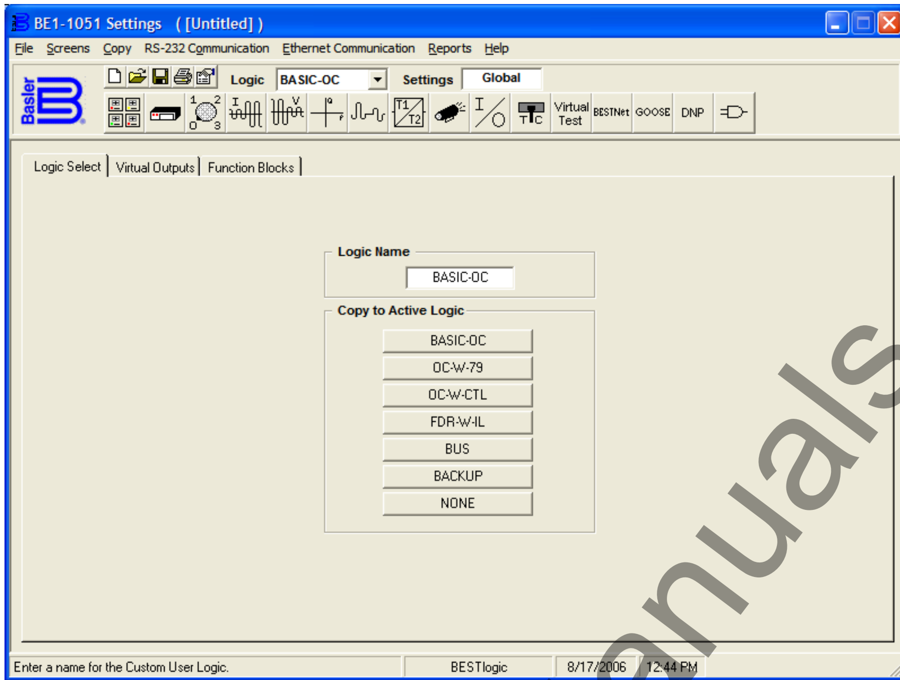

Figure 14-49. BESTlogic Screen, Logic Select Tab

Virtual Outputs

You can assign a meaningful name or label to each virtual output (Figure 14-50). This makes sequential events reports easier to analyze. To assign a meaningful label to Virtual Output VO8, click in the *Label* field and enter the new name. Remember, VO8 does not have actual hardware output contacts. Only VO1 through VO6 and VOA have hardware output contacts. (Note: It is possible for VO7 to have a hardware output contact. Refer to the style chart in Section 1 for more information.) 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. As an example, to change the logic associated with VO8, click on the *BESTlogic* button to the far right of VO8. Click on the *Logic* input and program the logic variables that define VO8. You may clear existing programming by clicking on the *Clear* button or clicking on each individual variable. The other 16 virtual outputs have the same function.

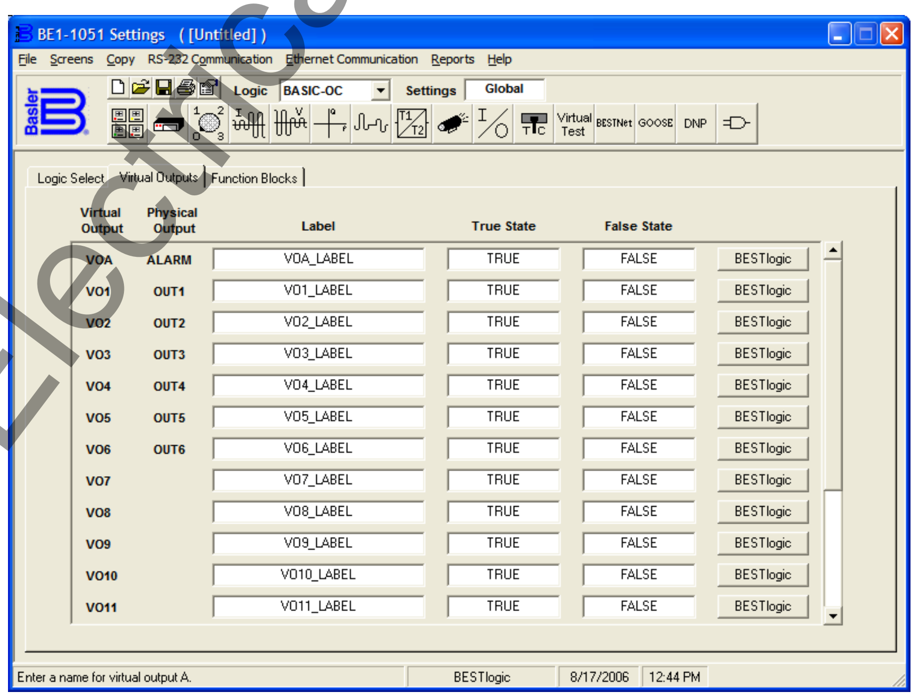

Figure 14-50. BESTlogic Screen, Virtual Outputs Tab

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Function Blocks

All of the Logic Functions (Figure 14-51) are labeled *BESTlogic* or *Logic* on the button to the right of the logic function name. 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.

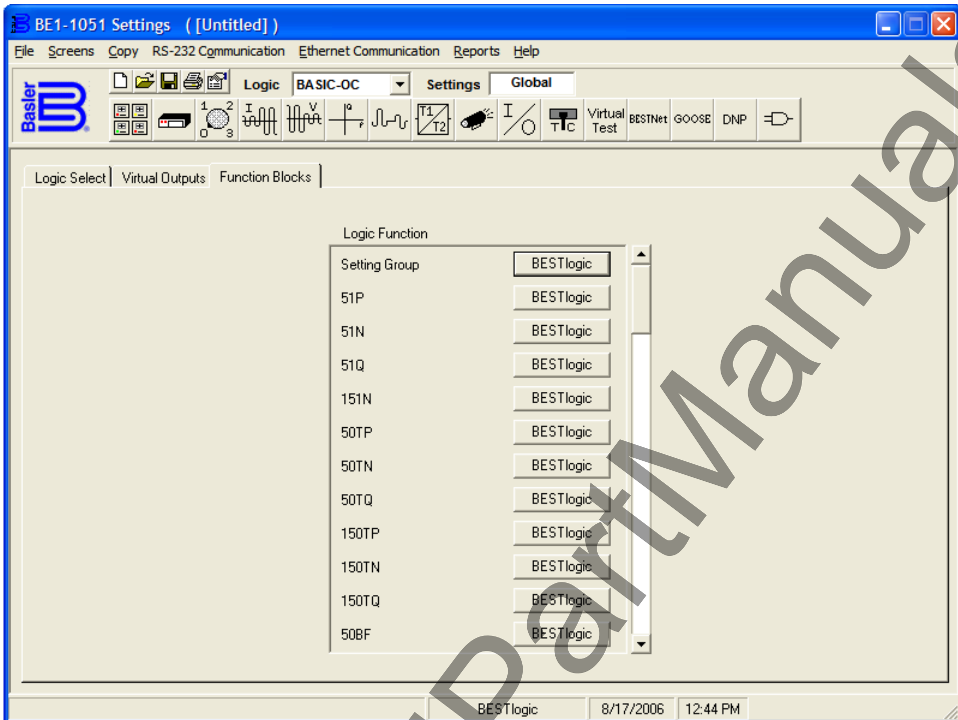

Figure 14-51. BESTlogic Screen, Function Blocks Tab

COPYING SETTINGS FROM GROUP TO GROUP

There are a lot of settings in any BE1 numerical systems product and the differences between Group Zero and any other Group settings may be minimal. There is a way to copy settings from Group Zero to another Group and then just change only those settings that are different. Using BESTCOMS, pull down the Copy menu from the pull-down menu. There is only one choice, *Copy From Group to Group.* When you select this choice, a dialog box (Figure 14-52) opens allowing you to select the group to copy to. When you okay the copy routine, another dialog box opens to inform you that the copy routine is complete. Now change those settings that are different.

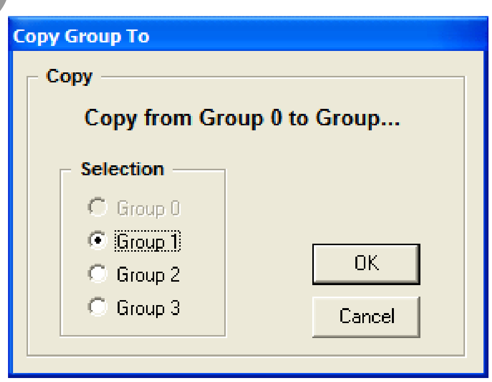

Figure 14-52. Copy Group To Dialog Box

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DOWNLOADING OSCILLOGRAPHY FILES

To download an oscillography file, pull down the Reports menu from the pull-down menu and select *Oscillography Download* using *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 (Figure 14-53) opens 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.

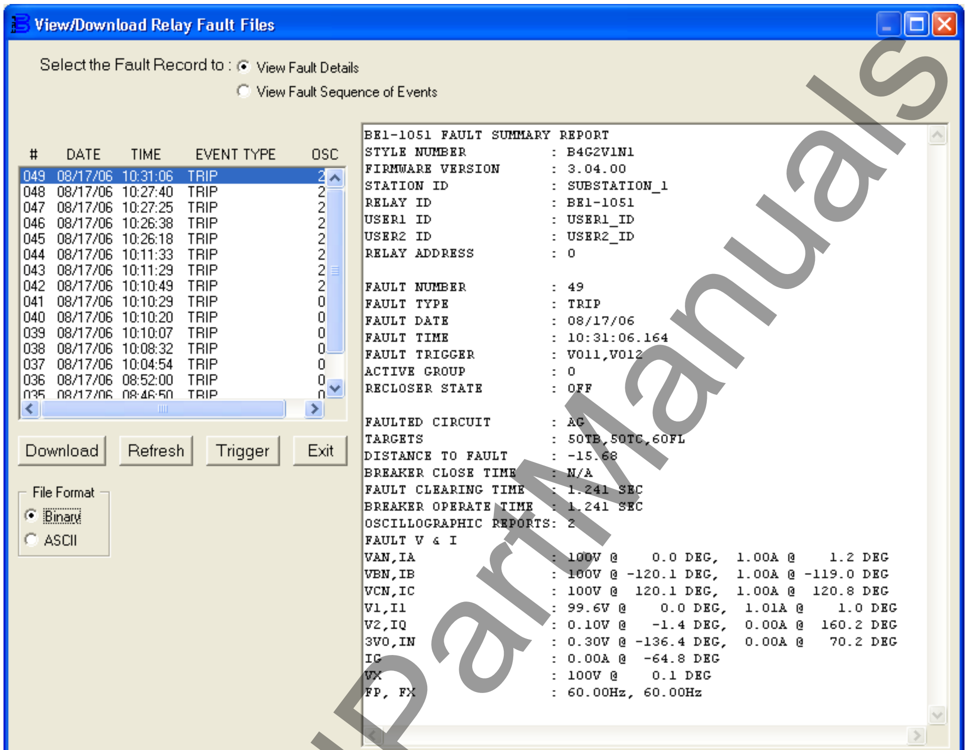

Figure 14-53. Oscillography Download from Reports Pull-down Menu

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, 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. Select the type of file to download: *Binary* or *ASCII*. 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 14-54) opens, click on the *Start Polling* button. If BESTCOMS is not configured to the relay communication settings, you will receive a Communications

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Error. The *Metering* dialog box has two pull-down menus: *File* and *RS-232 Communication*. To configure communication with the relay, pull down the *RS-232 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.

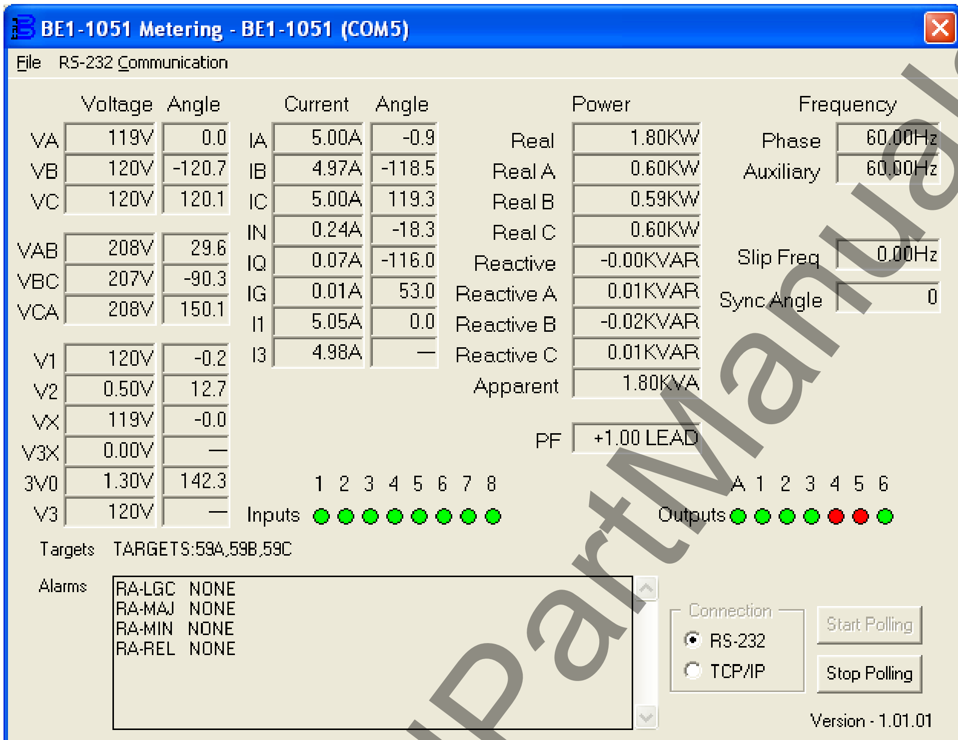

Figure 14-54. Metering Screen

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 14-55 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.

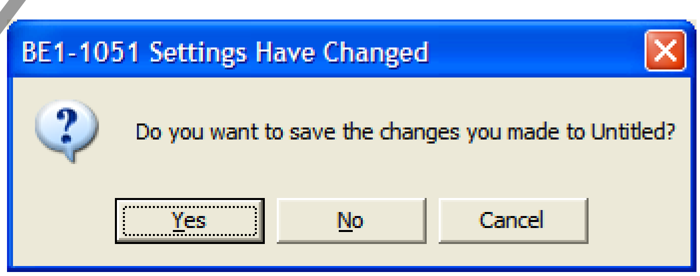

Figure 14-55. Settings Have Changed Dialog Box

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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 BE1-1051 relay, you must first open the file through BESTCOMS or create the file using BESTCOMS. Then pull down the *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 BE1-1051 relay, you must pull down the *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 BE1-1051 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. See Figure 14-56. 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 on disk*, click on the folder box and browse for the file. If you wish to *Download settings from unit* to compare, click on the RS-232 box to setup the *Com Port* and *Baud Rate*. Click on the *Compare* box to compare the settings files that you have selected.

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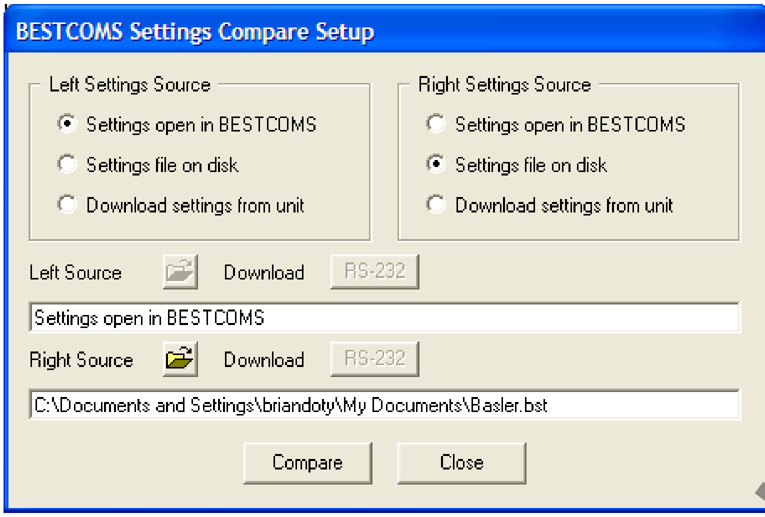

Figure 14-56. BESTCOMS Settings Compare Setup Dialog Box

If there are any differences in the two files, a dialog box will pop up notifying you that *Differences Are Found*. The *BESTCOMS Settings Compare* dialog box pops up (Figure 14-57) where you can select to *Show All* or *Show Diffs*.

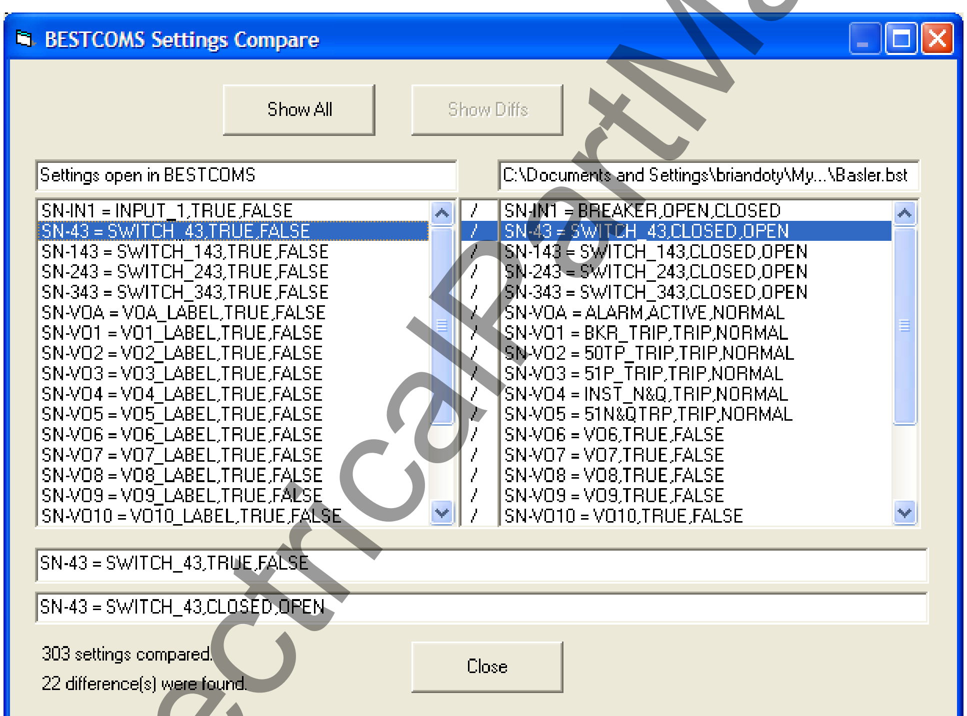

Figure 14-57. BESTCOMS Settings Compare Dialog Box

BESTPRINT

BESTPrint, which is found on the CD included with the BE1-1051 relay, 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. Future versions may write some information to the file.

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

BESTNet Communication provides additional BE1-1051 features if the relay is ordered with Ethernet Protocol Options R or T. (Refer to the *Style Chart* in 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 remotely view relay status. 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 BE1-1051 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.

INSTALLATION

BESTNet is part of the *BESTCOMS for BE1-1051* software. (See Section 14, *BESTCOMS Software,* for information on installing BESTCOMS.) 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 BE1-1051 relays on the local area network (LAN).

Configuring BESTCOMS for Ethernet

Connect your PC and the BE1-1051 Overcurrent Protection System to the TCP/IP LAN or intranet. An Ethernet port is provided on the back of the relay. (Refer to Section 12, *Installation,* for the port location.) Start BESTCOMS as described in Section 14, *BESTCOMS Software.* Pull down the *Screens* menu and select *BESTNet Settings* or click on the BESTNet Settings icon. Refer to Figure 15-1.

The following network services are available. The ● symbol designates enabled by default; the ○ symbol designates a feature which is disabled by default. Changes to the default settings would not normally be necessary.

● *DHCP* Dynamic Host Configuration Protocol. A protocol that provides a means to dynamically allocate IP addresses to computers on a local area network. The system administrator assigns a range of IP addresses to DHCP and each client computer on the LAN has its TCP/IP software configured to request an IP address from the DHCP server. The request and grant process uses a lease concept with a controllable time period.

● *HTTP* Hypertext Transfer Protocol. The client-server TCP/IP protocol used on the World-Wide Web for the exchange of HTML documents. It conventionally uses Port 80.

○ *SMTP* Simple Mail Transfer Protocol. A protocol used to transfer electronic mail between computers, usually over Ethernet. It is a server to server protocol, so other protocols are used to access the messages. The SMTP dialog usually happens in the background under the control of the message transfer agent, e.g. "sendmail" but it is possible to interact with an SMTP server using telnet to connect to the normal SMTP Port 25.

○ *ASCII* American Standard Code for Information Interchange. The basis of character sets used in almost all present-day computers. US-ASCII uses only the lower seven bits (character points 0 to 127) to convey some control codes, space, numbers, most basic punctuation, and unaccented letters a-z and A-Z.

○ *NTP* Network Time Protocol. A protocol built on top of TCP/IP that assures accurate local timekeeping with reference to radio, atomic or other clocks located on the Internet. This

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protocol is capable of synchronizing distributed clocks within milliseconds over long time periods. It also allows remote access to the relay's command shell as well as to BESTCOMS.

- *GOOSE* Generic Object Oriented Substation Event. Messages sent between computers over Ethernet.

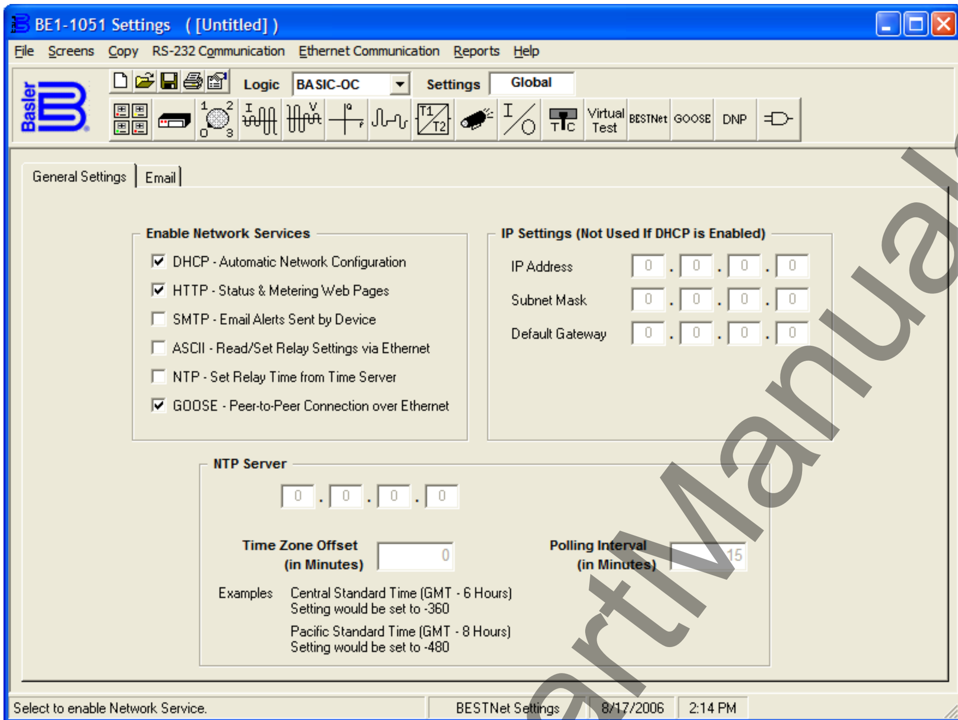

Figure 15-1. BESTNet Settings Screen, General Settings Tab

<u>*Identifying the IP Address*</u>

If the IP address is unknown, from <u>any</u> BESTCOMS screen, click the *Ethernet Communications* pull-down menu and select *Download Settings from Device.* This will display the dialog box shown in Figure 15-2. 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 BE1-1051 relays on the same LAN. The active IP Address can also be read from the Com0, Com1, or Com2 ports with the RG-IPADDR command or from the front panel Screen 4.7.2. (**Note:** All BE1-1051 Ethernet-enabled relays on the same subnet will be displayed. So the user may have to confirm the correct IP address with the company's network administrator.) Refer to Figure 15-3, *BE1-1051 Device Discovery* dialog box. Click the *Add* button to add the second device to the list of known BE1-1051 relays. Click *Connect* to connect without adding the device to the list. Make a note of this IP address since it can be used to access the web pages of the BE1-1051 with BESTNet.

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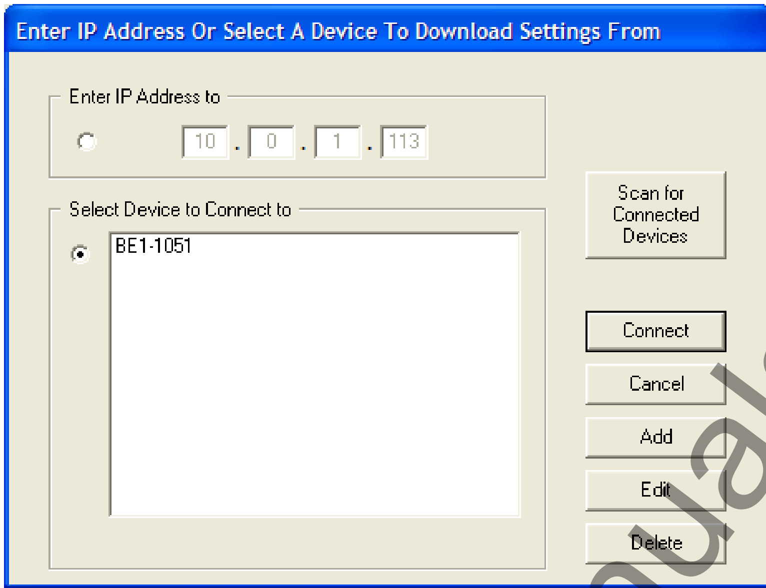

Figure 15-2. Enter IP Address Or Select A Device Dialog Box

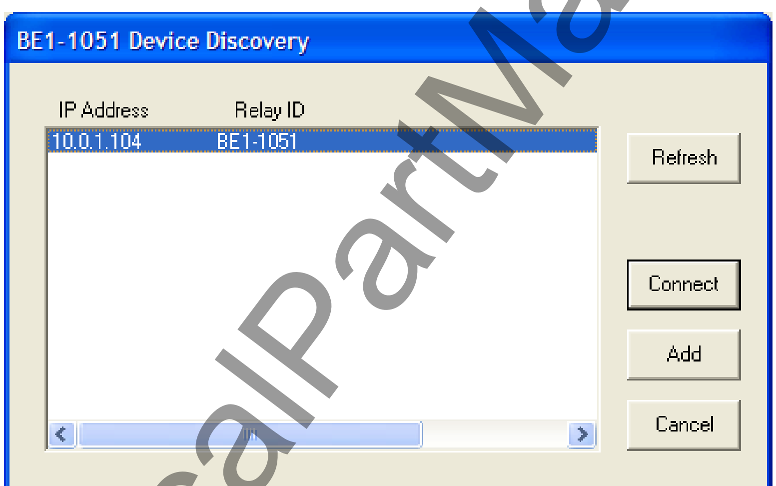

Figure 15-3. BE1-1051 Device Discovery Dialog Box

GOOSE (Peer to Peer Communications)

GOOSE messaging over Ethernet is part of the Basler Electric BE1-1051's Ethernet features. The purpose of GOOSE is explained in the next paragraph. The GOOSE settings are configured using BESTCOMS. Pull down the *Screens* menu and select *Settings*. This screen has four tabs and the first tab is *GOOSE Information.* It is described under *Ethernet Ports,* later in this section.

GOOSE Status Points

GOOSE Status Points provide a means of exchanging digital state information between network connected devices. The GOOSE Status Points are shared among GOOSE equipped relays. In the BE1-1051 relay, these points are combined with BESTlogic system status variables and are made available to other devices on a common communications network. In addition to these points, GOOSE messages identify the originator of the message and other peer-to-peer report parameters. All devices listen to network messages and capture data from only those devices that they have been programmed to subscribe to receive.

GOOSE Message Structure

The GOOSE message structure contains space for 96 Status Points. Each Status Point consists of a bit pair that represents digital information with four different states, TRUE, FALSE, TRANSITION, and NONVALID. The first 32 bit pairs are categorized as Dynamic Network Announcement (DNA) bit pairs

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and the last 64 bit pairs are called User Status (UserSt) bit pairs. The BE1-1051 does not make any distinction between DNA and UserSt bit pairs. The BE1-1051 can be programmed to transmit up to 32 bit pairs of the possible 96 available in the GOOSE message. The BE1-1051 can be programmed to receive up to 16 bit pairs from any of the 96 bit pairs available in the GOOSE message. When the BE1-1051 transmits a GOOSE message, it transmits a MULTICAST that includes its Media Access Control (MAC) address.

Setting the Relay ID

In a BE1-1051 relay, the Relay ID identifies the originator of the GOOSE message and can be programmed with the ASCII command SG-ID which has the following format:

SG-ID[={relay ID},{Station ID},{User ID1},{User ID2}]

where **relay ID, Station ID, User ID1,** and **User ID2** are ASCII text strings up to 30 characters long. The label relay ID is used in the BE1-1051's Message to indicate the Sending IED (intelligent electronic device) name.

The relay ID, Station ID, User ID1, and User ID2 can also be set using BESTCOMS with the Circuit Identification block on the *Identification* tab as shown in Figure 15-4.

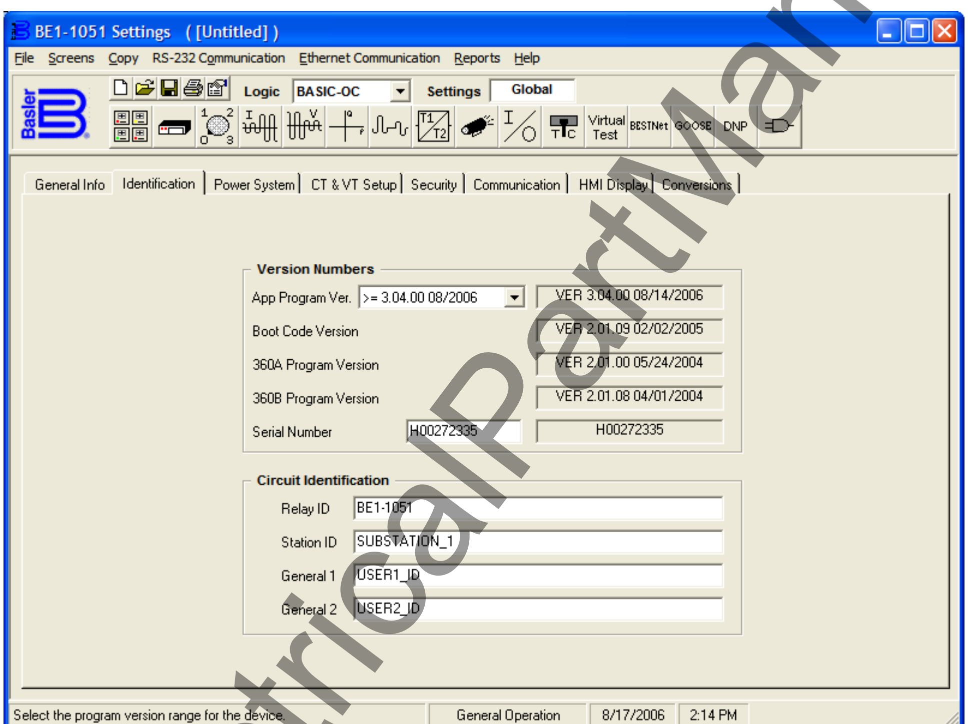

Figure 15-4. General Settings, Identification Screen

Remote Relay ID

The receiving relay must be programmed to capture ("subscribe" to) messages from only those remote devices of interest. This setting is used to select specific remote devices for receiving GOOSE messages. This is done by entering the *Remote Device Identification Name* and *MAC Address* assigned to the selected remote device. Up to 16 remote devices identifications can be selected using the SG-RID command which has the following format:

SG-RID[#[={name},{MAC Addr}]]

where # =1 - 16, **name** = ASCII text string up to 64 characters long and **MAC Addr** = MAC address with a string of 12 hex digits.

The 16 remote relay ID names and 16 remote relay MAC addresses can be set using BESTCOMS with the *Remote Relay ID* tab shown in Figure 15-5. Each name may be unique but must match that specific relay's ID. The user-assigned *Relay ID* is assigned using the previous BESTCOMS tab (Figure 15-4).

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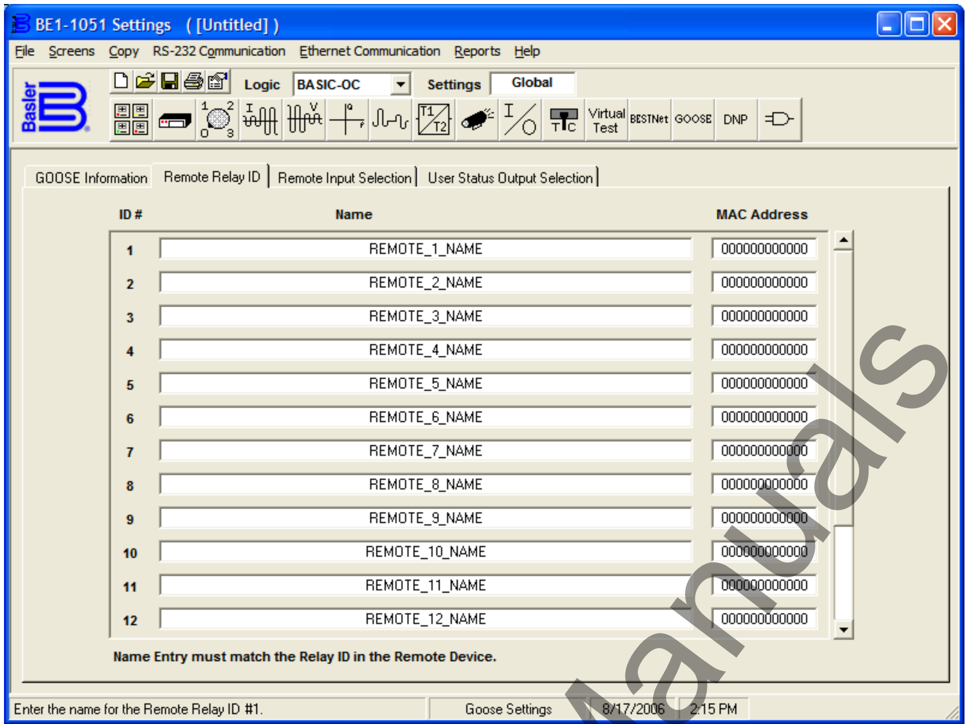

Figure 15-5. Goose Settings Screen, Remote Relay ID tab

Remote Input Selection

The BE1-1051 can combine up to 16 of the 96 bit pair status points from other IEDs on the substation LAN with the BE1-1051's internal System Status logic variables. The 16 remote status points are mapped to the BE1-1051's 16 internal virtual inputs defined with the ASCII command SG-VIN# which has the following format:

SG-VIN[#[={ID number},{Bit Pair},{Default Value},{True Value}]]

where # = 1 - 16, **ID Number** = 1 – 16 , **Bit Pair** = 1 – 96, **Default Value** = 0, 1, 2, or 3 and **True Value** = 0, 1, 2 or 3.

The <ID Number> parameter is used to select the *Remote Device* whose name and address is defined with the SG-RID command. The <Bit Pair> parameter is used to select one of the possible 96 specific bit pairs in the GOOSE message. The <Default Value> parameter is used to select the logic state that will be used for the bit pair if the remote relay times out or is declared to be non-communicating. The <TRUE Value> is the state used to indicate a TRUE condition exists from the bit pair. In BESTlogic, a TRUE value is represented as a logical "1" and all non-TRUE values are represented as "0."

The 16 remote virtual inputs can be set using BESTCOMS with the *Remote Input Selection* tab shown in Figure 15-6.

By clicking *Select* under the *Remote ID* column, Figure 15-7, *Select Remote ID* screen is displayed. Any one of the listed 16 remote relay ID names can be selected for each virtual input (VIN# 1 to 16) by clicking on the desired button. Click the desired *Remote ID* number or select zero to disable that virtual input. Click the *OK* button when completed and you will return to the *Remote Relay ID* tab.

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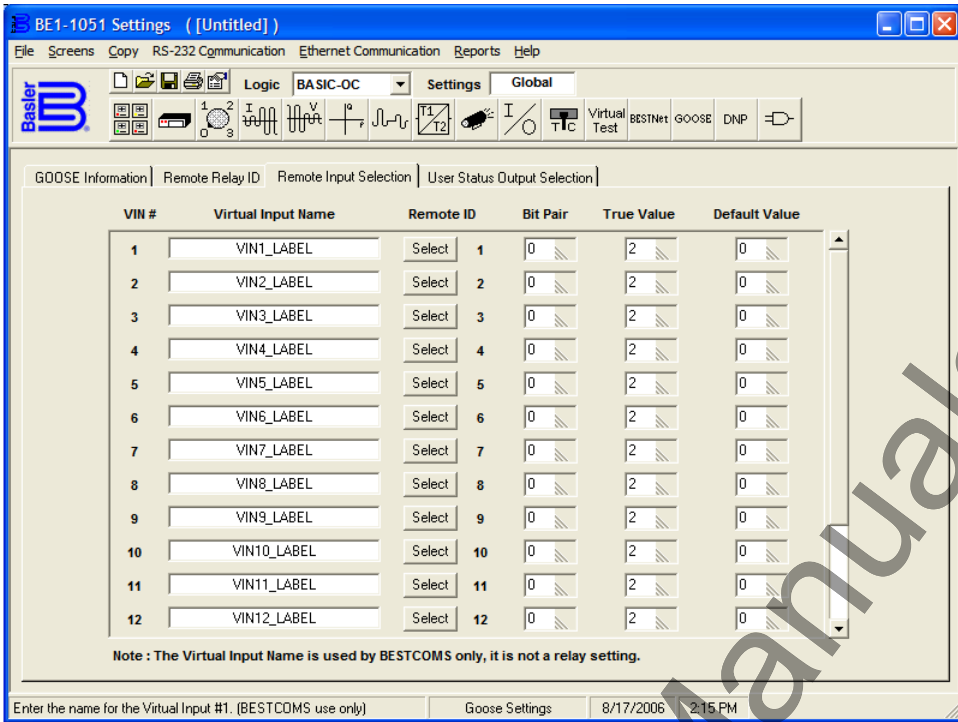

Figure 15-6. Goose Settings Screen, Remote Input Selection Tab

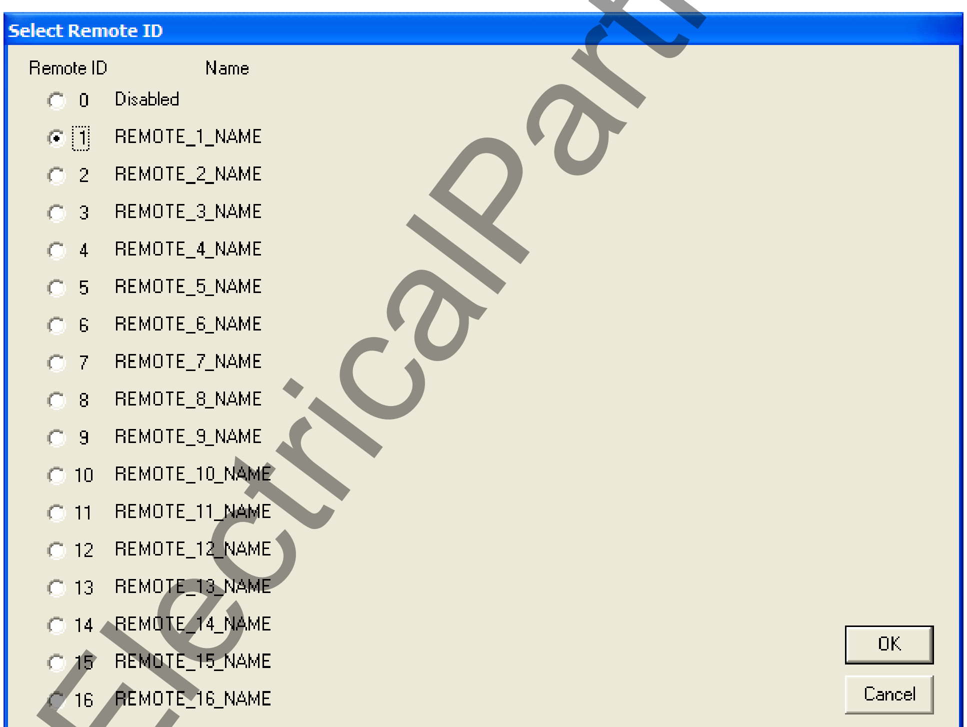

Figure 15-7. Select Remote ID Screen

User Status Output Selection

GOOSE status bit pairs provide the logic state of a specific signal from a specific remote device on the substation network. Ninety-six bit pairs are extracted from GOOSE messages originating in the remote devices to be combined with the receiving relay's internal logic. The BE1-1051 relay transmits up to 32 bit-pair status points of the possible 96 points available. The BE1-1051 status bit pair points are defined with the ASCII command SG-USERST# which has the following format:

SG-USERST[#[={Logic Variable},{True Value},{False Value},{Bit Pair Num}]]

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where # = 1 to 32 , **Logic Variable** is one of the possible 128 BESTlogic System Status variables, **True Value** = 0, 1, 2 or 3; **False Value** = 0, 1, 2 or 3; **Bit Pair Num** = 1 to 96.

The 32 status bit pairs can be programmed using BESTCOMS with the *User Status Output Selection* tab shown in Figure 15-8.

By clicking *Select* under the *Variable Name* column, the *UCA Logic Variable Setup* screen is displayed as shown in Figure 15-9. Only one logic variable can be selected for each *User Status* output. Select one Logic Variable and the click the *Save* button when completed. This will return you to the *User Status Output Selection* screen.

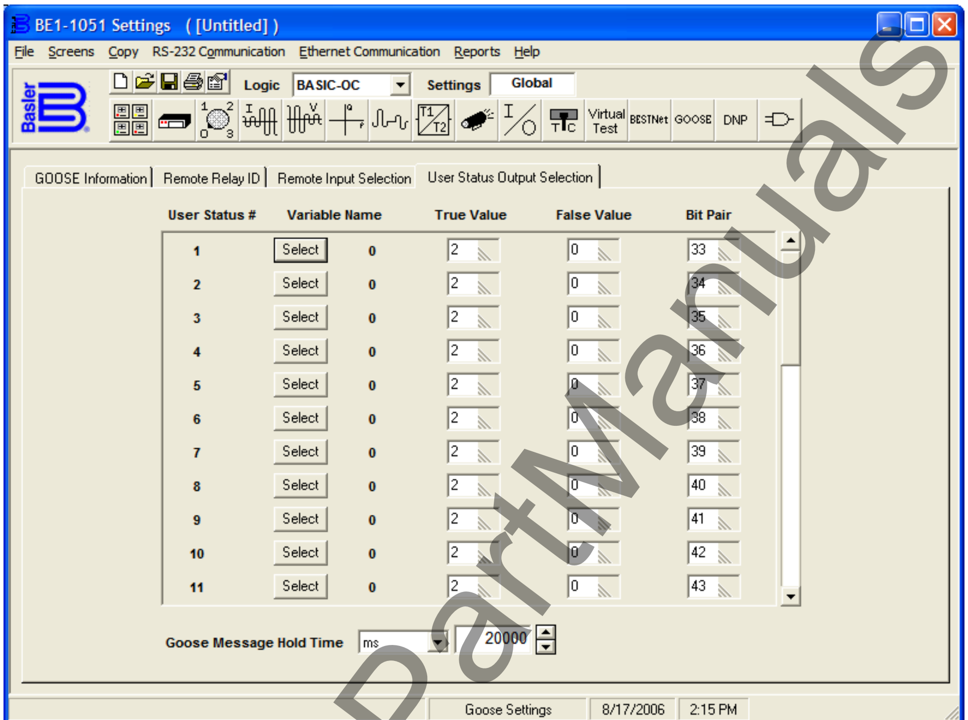

Figure 15-8. Goose Settings Screen, User Status Output Selection Tab

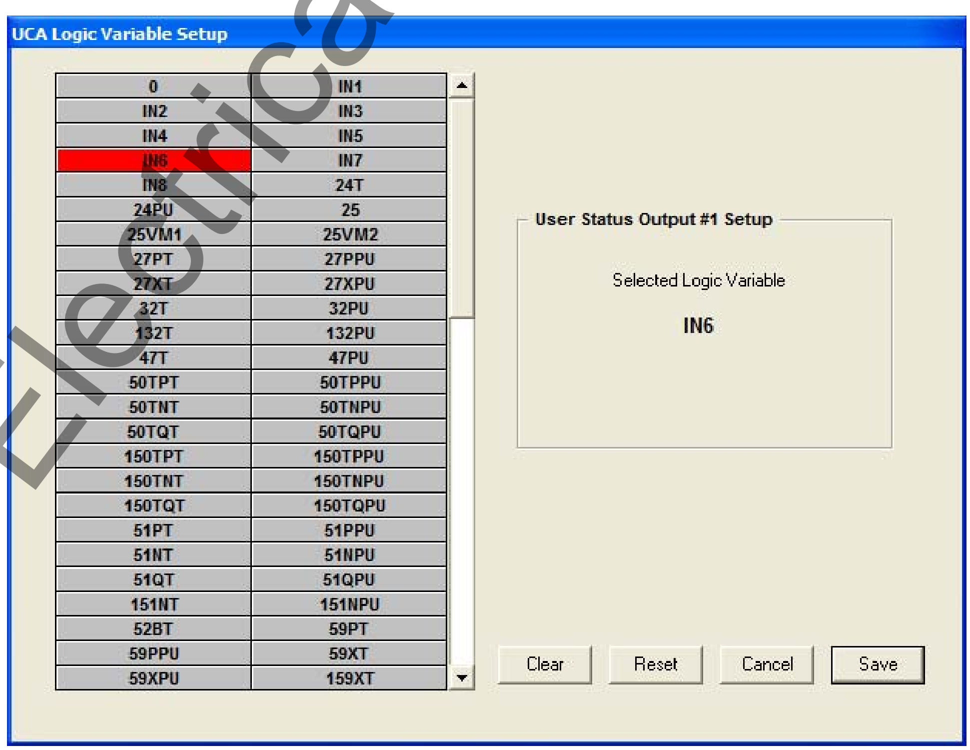

Figure 15-9. UCA Logic Variable Setup Screen

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GOOSE Hold Time (Time to Live)

The GOOSE functionality includes a feature that deals with the loss of communication between transmitting and receiving devices. Each transmitting device will send ("publish") a GOOSE message upon a successful power-up, after a state change or before the device's "hold time" (Time to Live) has expired if a change-of-state has not occurred. The transmitting device "hold time" is a settable parameter required by the receiving device. The hold time is set with the ASCII command SG-HTIME with the following format:

SG-HTIME[={ Hold Time (ms)}]

where GOOSE **Hold Time (ms)** = 1 - 60000 msec (0.001 – 60.000 seconds).

The GOOSE Hold Time can be set using BESTCOMS from the GOOSE Message Hold Time block as shown at the bottom of Figure 15-8.

Receiving devices are constantly monitoring the communications network for messages they are subscribed to. Messages received from the remote device include the message "hold time" from that device. The receiving relay monitors the "hold time" interval from the sending device. If a message is not received after the hold time has elapsed, the remote device is declared to be non-communicating. This mechanism allows a receiving device to detect a single transmission from a remote device which is sending messages at the slowest possible rate, as set by its "hold timer" without having to use its default state for its remote inputs. If a message is received from a remote device before the "hold time" expires, all points for that device are updated to the states contained in the message, and the "hold timer" is restarted.

In the BE1-1051, if a received GOOSE message is not received within the received message's hold time, all virtual inputs programmed to subscribe to the timed out GOOSE message will return to the user selected "default values." It may be useful to send a static TRUE value between devices for use as a "status" bit for the peer-to-peer connection. Any time this "status" bit is FALSE (i.e., default value), the scheme will know that the connection is down.

VIEWING WEB PAGES

View the Protection System Status Page

Using the PC, open your web browser and type the IP address determined by the Device Discovery utility in the browser URL Block *(Address Block*). Click *Go*. The *Basler Electric BE1-1051 Protection System Status* web page will appear (see Figure 15-10).

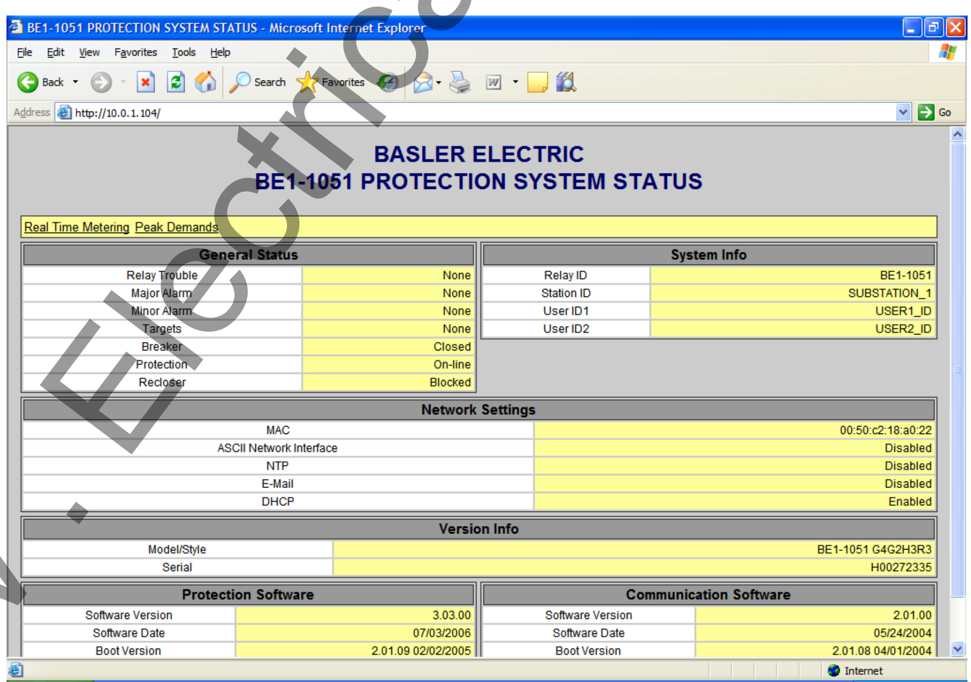

Figure 15-10. BE1-1051 Protection System Status Web Page

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This home page provides overall status information of the relay and of the network. Current data will be presented each time the web page is refreshed. (Click F5 or the *Refresh* button in Microsoft® Internet Explorer.) The *Current Status* and *System Info* panes provide the most important information from the protection and control relays. This web page is created by firmware in the BE1-1051 relay and provides the following "read-only" information:

- General Status
  - Relay Trouble
  - Major Alarm
  - Minor Alarm
  - Targets
  - Breaker
  - Recloser
- System Info
  - Relay ID
  - Station ID
  - User ID1
  - User ID2
- Networking Settings
  - MAC
  - ASCII Network Interface
  - NTP
  - E-mail
  - DHCP
  - IP Address
  - IP Gateway
  - IP Netmask
- Version Info
  - Model/Style
  - Serial
- Protection Software
  - Software Version
  - Software Date
  - Boot Version
- Communication Software
  - Software Version
  - Software Date
  - Boot Version

None of the above settings can be changed from within the web page but some can be changed with the BE1-1051 human-machine interface (HMI) display on the front panel of the relay or by using BESTCOMS through the PC. 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 *Protection System Status* page is also the location from which other web-based features are launched, as is discussed below.

Metering Web Page

From the *Protection System Status* web page (home page) click the *Real Time Metering* hyperlink below and to the left of the page title. The *Basler Electric BE1-1051 Metering Data* web page will appear as illustrated in Figure 15-11. 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* button. If desired, you may save a copy of the screen shot by clicking the Alt - Print Screen keys on your keyboard

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and pasting the information in another application for analysis. Note, too, that the relay date and time information is shown at the top of the *Metering Data* web page. For more information on metering, see Section 5, *Metering,* and Section 14, *BESTCOMS Software.* Click the *Back* button on your browser to return to the *Protection System Status* web page.

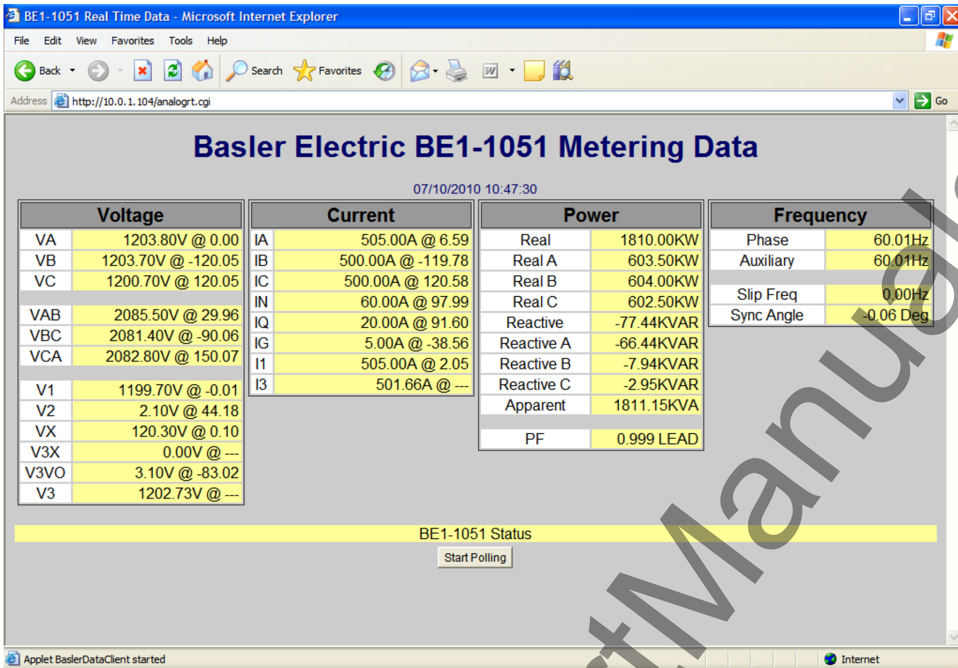

Figure 15-11. BE1-1051 Metering Data Web Page

Peak Demands Web Page

From the *Protection System Status* web page (home page) click the *Peak Demands* hyperlink below and to the left of the page title. The *Basler Electric BE1-1051 Peak Demands* web page will appear as illustrated in Figure 15-12. The data is presented as read-only Peak Voltage, Peak Currents, and Peak Power. The date/time for each occurrence is also shown. Click the *Back* button on the browser to return to the *Protection System Status* (home) web page.

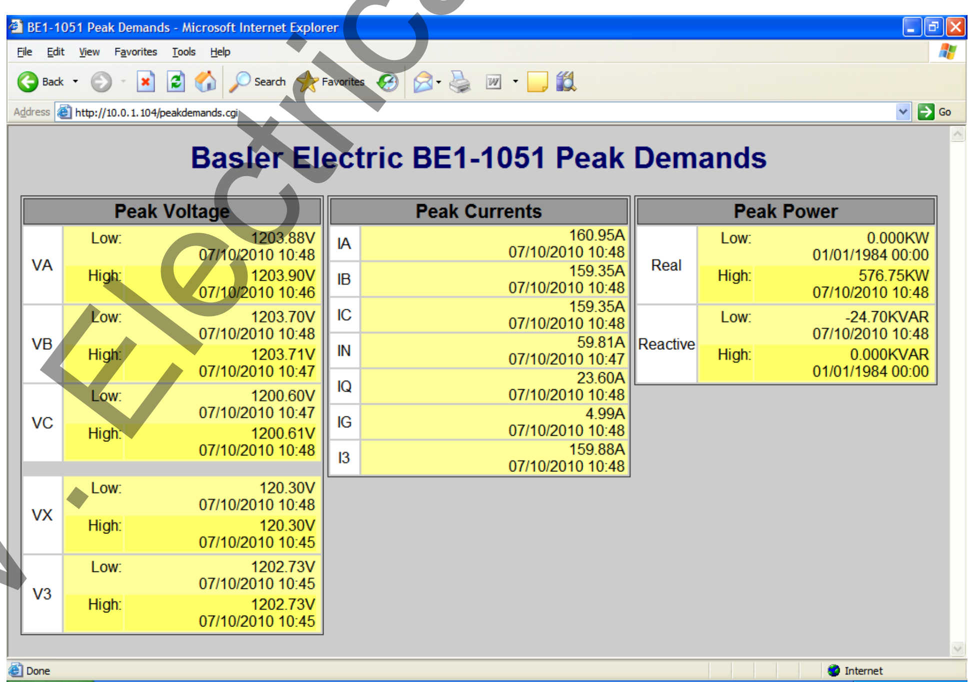

Figure 15-12. BE1-1051 Peak Demands Web Page

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E-MAIL ALERTS

The BE1-1051 relay with Ethernet capability can provide protection and control alerts through the Internet and/or intranet-enabled PC. This capability is available through your PC's electronic-mail (e-mail) feature.

Configuring the E-mail Alerts Function

In order to use e-mail alerts, the BE1-1051 Overcurrent Protection System must be purchased with Option R or T. Refer to the style chart in Section 1, *General Information.* Likewise, Option R or T must be entered as part of the style number in BESTCOMS. Then, go to the *BESTNet Settings* screen, *General Settings* tab (Figure 15-1). Under *Enable Network Services,* check *SMTP (Simple Mail Transfer Protocol).* Now click the *E-mail* tab. (See Figure 15-13.) A maximum of eight alerts can be set. Click the down arrow under *E-mail Enable/Priority.* A drop-down menu will appear allowing the user to select *Disable, Normal, or High.* Selecting *Normal* or *High* will enable E-mail as well as set its priority.

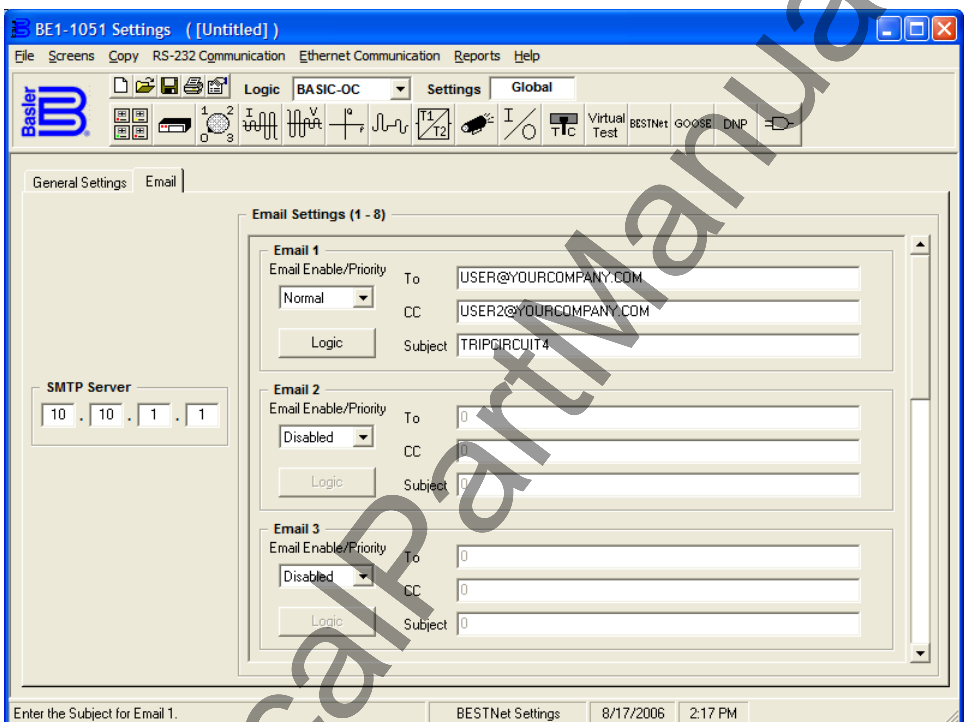

Figure 15-13. BESTNet Settings Screen, E-mail Tab

Click the *Logic* button and the *BESTlogic Function Element* screen (Figure 15-14) 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. 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 8 is the same as for E-mail 1, just described.

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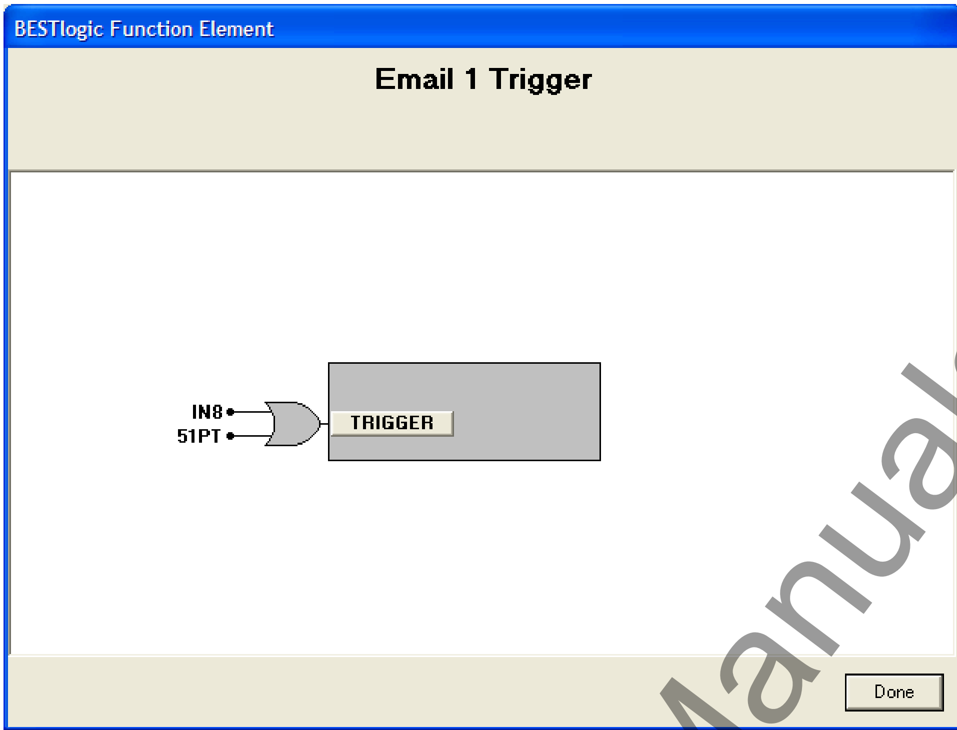

Figure 15-14. BESTLogic Function Element Screen

TCP/IP TELNET COMMUNICATION

To be able to telnet into a Basler Electric BE1-1051 relay, the user must have security access on the Com4 rear Ethernet port. This can be achieved by setting the GS-PW ASCII command to enable area 4 (see Section 9, *Security*) or by selecting the *Com4 Rear Ethernet* box in BESTCOMS as shown in Figure 15-15.

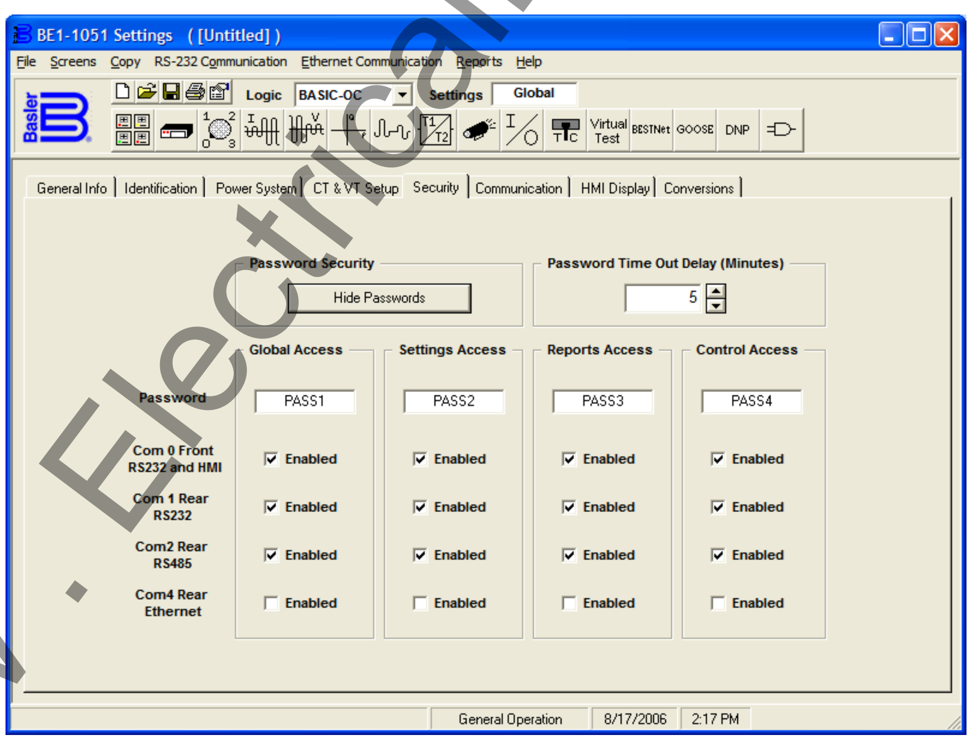

Figure 15-15. General Operation Screen, Security Tab

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The telnet application is normally located in the C:\Windows\System32 folder in the Microsoft Windows® operating system and can be accessed from the Microsoft Windows® *START* button. To get help on the telnet command, type `telnet /?` at the command prompt.

Before using telnet, *ASCII – Read/Set Relay Settings via Ethernet* must be enabled. Navigate to the *BESTNet Settings* screen in BESTCOMS and select the *General Settings* tab. Place a check in the box to enable the setting.

To access the BE1-1051 using telnet, you must know the IP address of the BE1-1051. Refer to the previous subsection, *Identifying the IP Address,* to determine the IP address.

The main syntax for the telnet command is:

telnet [host IP Address] [port #]

The telnet access port for all BE1-1051 relays is 2101.

Telnet Command Example

Example: Telnet into a BE1-1051 relay with an IP Address of 10.0.1.104.

Type from the command prompt (see Figure 15-16) or from the *RUN* selection in the Microsoft Windows® *START* button (see Figure 15-17):

>telnet 10.0.1.104 2101

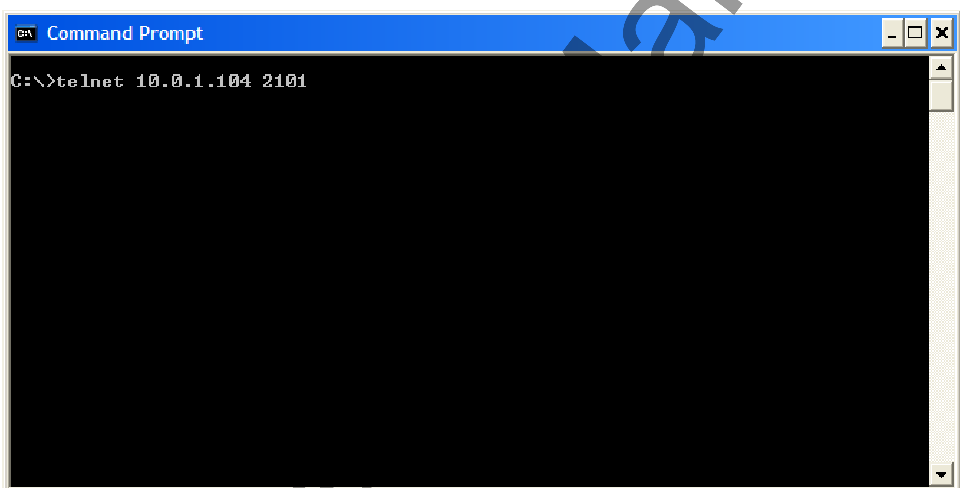

Figure 15-16. Telnet from the Command Prompt

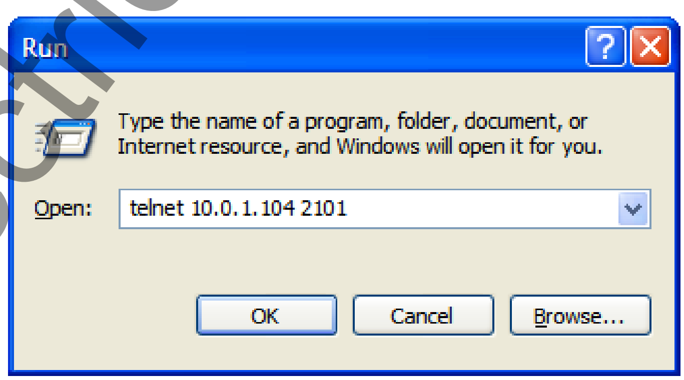

Figure 15-17. Run - Open Telnet Session

After pressing *Enter*, the *Command Prompt* window will appear with a blinking cursor. Type an ASCII command such as RG-VER followed by *Enter* to verify you have made the telnet connection. Note: The telnet application may not echo the keys you type. See Figure 15-18.

At this point you can type any of the BE1-1051 ASCII commands to see settings/reports/status. To close the telnet connection, type CTRL +] (Control key with the right bracket key held at the same time) and

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then type QUIT. You can also exit the telnet connection by clicking on the X button in the upper right of the telnet session window.

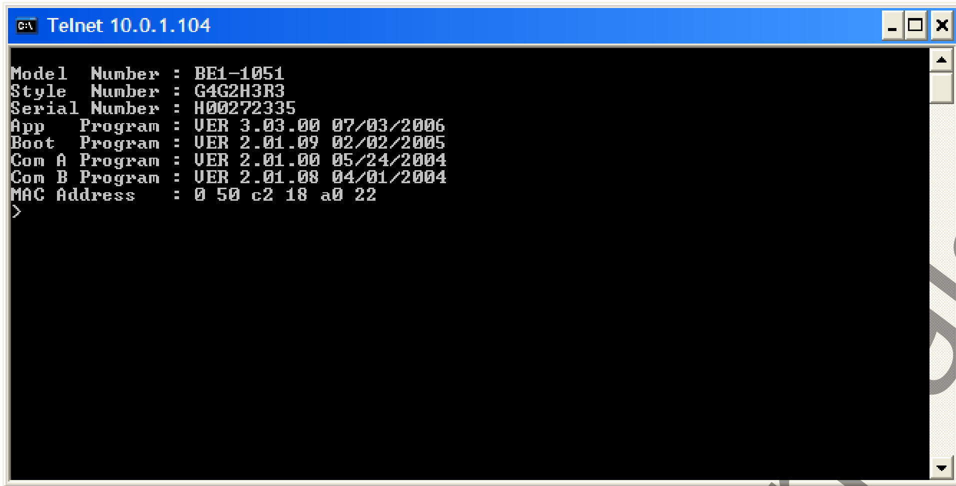

Figure 15-18. Telnet Session in a Command Prompt Window

ETHERNET PORTS

The BE1-1051 relay has two style chart selectable options for Ethernet port protocol configurations. These two options are:

R) Com4, TCP/IP 10BaseT [Com3, TCP/IP 10BaseT]

T) Com4, TCP/IP 10BaseF [Com3, TCP/IP 10BaseF]

The 10BaseF is a 10-megabit fiber optic media which is connected via a TX and RX ST-type fiber optic connector. The 10BaseT is a 10-megabit UTP (unshielded twisted pair) Category 5 copper wire media, which is connected via an 8 pin RJ-45 connector. Regardless of whether option R or T are chosen, Com3 is not currently active and is reserved for future use.

Media Access Control (MAC) Addresses

COM4 is the default communication port and is addressed using the MAC address for that port. The COM4 MAC address is not programmable.

The COM4 MAC address is displayed through the serial ASCII COM0, COM1, or COM2 ports with the RG-VER command. (See *Unique ASCII Commands,* later in this section.)

The COM4 MAC address can also be displayed using BESTCOMS with the *GOOSE Information* tab as shown in Figure 15-19. COM4 is the active Ethernet port.

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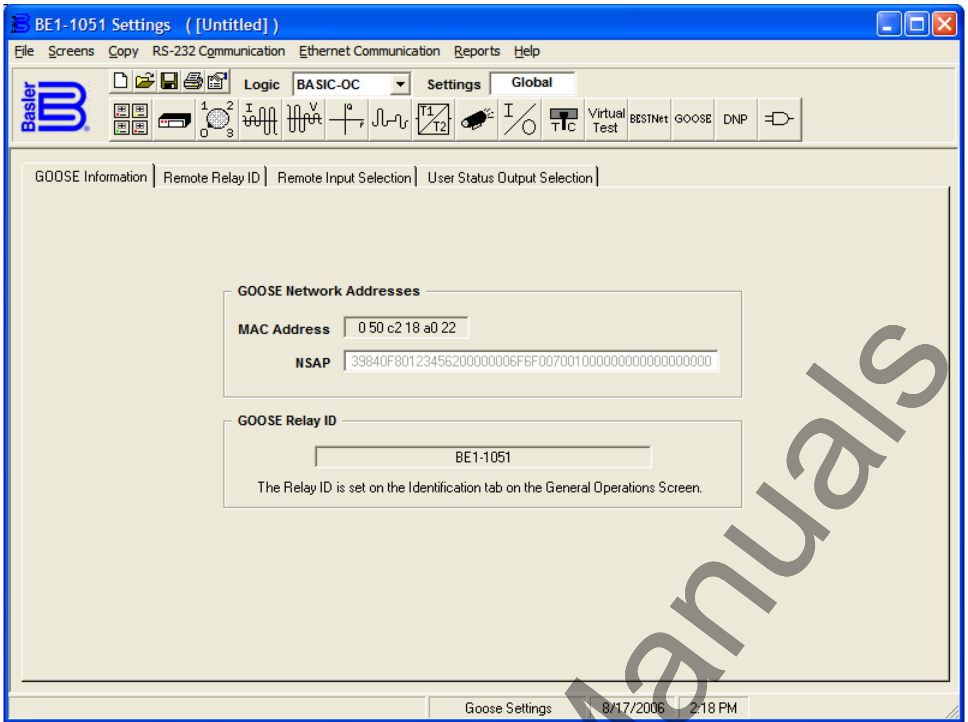

Figure 15-19. Goose Settings Screen, Goose Information Tab

UNIQUE ASCII COMMANDS

RG-VER Command

Purpose: Read program version, model number, style number and serial number.
Syntax: RG-VER
Reference: Section 15, *BESTNet Communication*

RG-VER Command Example:

1. Read device model and version information.

```
>RG-VER
MODEL  NUMBER: BE1-1051
STYLE  NUMBER: E4R1R0R0
SERIAL NUMBER: H0252298
APP   PROGRAM: VER 2.01.00 04/30/2004
BOOT  PROGRAM: VER 2.01.08 01/14/2004
COM A PROGRAM: VER 2.01.00 04/30/2004
COM B PROGRAM: VER 2.01.08 04/01/2004
MAC   ADDRESS: 0 50 c2 18 a0 62
```

Note: Leading zeros are not displayed for 0 hex values.

RG-IPADDR Command

Purpose: Read the IP address.
Syntax: RG-IPADDR
Comments: Displays the active IP address assigned by the DHCP configuration or IP address defined with the SG-IPADDR command if DHCP is disabled by the SG-NETEN command.

Note: The active IP address can also be read from the front panel Screen 4.7.2.

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RG-IPADDR Command Example:

1. Read the active IP address.
   >RG-IPADDR
   `10.0.1.100`

SG-NETEN Command

Purpose: Read/Set IP (Internet Protocol) options.

Syntax: SG-NETEN[=DHCP/SMTP/HTTP/NTP/ASCII/GOOSE]

Comments: Enables the Ethernet option Internet Protocol Network Services. Each option is separated by a slash (/). The available network services are:

DHCP (Dynamic Host Configuration Protocol) for automatic IP address configuration

SMTP (Simple Mail Transfer Protocol) for e-mail notification

HTTP (Hypertext Transfer Protocol) to enable BESTNet web pages

NTP (Network Time Protocol) to enable time/date from the network time server

ASCII (American Standard Code for Information Interchange Protocol) for ASCII transfer over Ethernet

GOOSE (Generic Object Oriented Substation Event Protocol) for automated peer to peer control

SG-NETEN Command Example:

1. Enable DHCP, ASCII, and GOOSE.

   Note: With DHCP enabled, SG-IPADDR, SG-IPGW, and SG-IPMASK are not used.

   >SG-NETEN=DHCP/ASCII/GOOSE

SG-IPADDR Command

Purpose: Read/Set IP (internet protocol) address.

Syntax: SG-IPADDR[={x.x.x.x}]

Comments: Sets the Internet protocol address of the BE1-1051 statically. The format of the address is a dotted decimal notation (xxx.xxx.xxx.xxx). The maximum address allowed is 255.255. 255. 255.

Note: When DHCP is enabled, SG-IPADDR is not used.

SG-IPADDR Command Example:

1. Set the IP address to 192.168.2.101
   >SG-IPADDR=192.168.2.101

SG-IPGW Command

Purpose: Read/Set IP GW (gateway) address.

Syntax: SG-IPGW[={X.X.X.X}]

Comments: Sets the Internet Protocol Gateway address of the Gateway on the network with the BE1-1051. The format of the address is a dotted decimal notation (xxx.xxx.xxx.xxx). The maximum address allowed is 255.255.255.255.

Note: When DHCP is enabled, SG-IPGW is not used.

SG-IPGW Command Example:

1. Set the IP Gateway address to 192.168.2.7
   >SG-IPGW=192.168.2.7

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SG-IPMASK Command

Purpose: Read/Set IP MASK address.

Syntax: SG-IPMASK[={X.X.X.X}]

Comments: Sets the Internet Protocol Subnet Mask of the network with the BE1-1051. The format of the address is a dotted decimal notation (xxx.xxx.xxx.xxx). The maximum address allowed is 255. 255.255.255.

Note: When DHCP enabled, SG-IPMASK is not used.

SG-IPMASK Command Example:

1. Set the IP Mask to 255.255.255.0
   >SG-IPMASK=255.255.255.0

SG-EMAIL Command

Purpose: Read/Set E-mail parameters where n is 1 to 8.

Syntax: SG-EMAIL[n][={to e-mail addr},{cc e-mail addr},{subject},{priority},{logic}]

Comments: Sets up to 8 different e-mail triggers which will automatically send e-mail when the trigger logic becomes TRUE. The following parameters are required:

[n]	E-mail number 1 to 8.
{to-email-address}	This is an e-mail address that can be up to 31 characters long. This address will go in the To: field of an e-mail message.
{cc-email-address}	This is a carbon copy e-mail address that can be up to 31 characters long. This address would go in the CC: field of an e-mail message.
{subject}	This is the subject line will appear in e-mail address and has a maximum length of 31 characters long.
{priority}	This is the priority of the e-mail message being sent. "Zero" priority disables the e-mail from being sent. A "one"' priority sends the e-mail with normal priority. A "two" or above priority sends the e-mail with an urgent priority.
{logic}	This is a OR-only BESTLogic equation that when TRUE triggers the e-mail. An entry into the sequence of event record will be logged for each e-mail triggered.

SG-EMAIL Command Example:

1. Set e-mail #2 to: info@basler.com, cc: support@basler.com, subject: overcurrent trip, priority: 2 and logic: VO3 where the SL-VO3=50TPT.
   >SG-EMAIL2=INFO@BASLER.COM,SUPPORT@BASLER.COM,OVERCURRENT TRIP,2,VO3

SG-SMTP Command

Purpose: Read/Set SMTP e-mail server address.

Syntax: SG-SMTP[={x.x.x.x}]

Comments: Sets the Internet Protocol address of the outgoing Mail server on the network with the BE1-1051. The format of the address is a dotted decimal notation (xxx.xxx.xxx.xxx). The maximum address allowed is 255.255.255.255.

SG-SMTP Command Example:

1. Set the IP address of the outgoing mail server to 192.168.1.19.
   >SG-SMTP=192.168.1.19

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SG-NTP Command

Purpose: Read/Set NTP (network time protocol) server address, time zone offset, and updates time.

Syntax: SG-NTP[={x.x.x.x},{time zone offset},{update time}]

Comments: The three parameters to automatically update the time from the network time server are:

{x.x.x.x}	Internet Protocol address of the network time server on the network with the BE1-1051. The format of the address is a dotted decimal notation (xxx.xxx.xxx.xxx). The maximum address allowed is 255.255.255.255.
{time zone offset}	This is the minute offset from GMT (Greenwich Mean Time). The range is from -720 to +720 minutes. For example, CST (Central Standard Time) is six hours behind GMT. The setting for CST is -360.
{update time}	This is the time in minutes in which the NTP server will supply a time update. The range is from 1 to 1440 minutes.

SG-NTP Command Example:

1. Set the IP address of the network time server to 192.168.1.25 for EST (five hours or 300 minutes behind GMT) with a time update of every 24 hours (1440 minutes).
   >SG-NTP=192.168.1.25,300,1440

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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.

$$T_T = \frac{A \cdot D}{M^N - C} + B \cdot D + K$$

Equation A-1

$$T_R = \frac{R \cdot D}{\left| M^2 - 1 \right|}$$

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.

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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 BE1-1051 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.

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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/151N ASCII commands, or human-machine interface (HMI) Screens 5.x.8.1 (51P), 5.x.8.2 (51N), 5.x.8.3 (151N), and 5.x.8.4 (51Q). For more information, refer to Section 4, *Protection and Control, Overcurrent Protection, 51 – Time Overcurrent Protection*.

<u>*Using Table A-3*</u>

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.

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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.

$$t = \frac{K}{(I_2)^2}$$ *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.

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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

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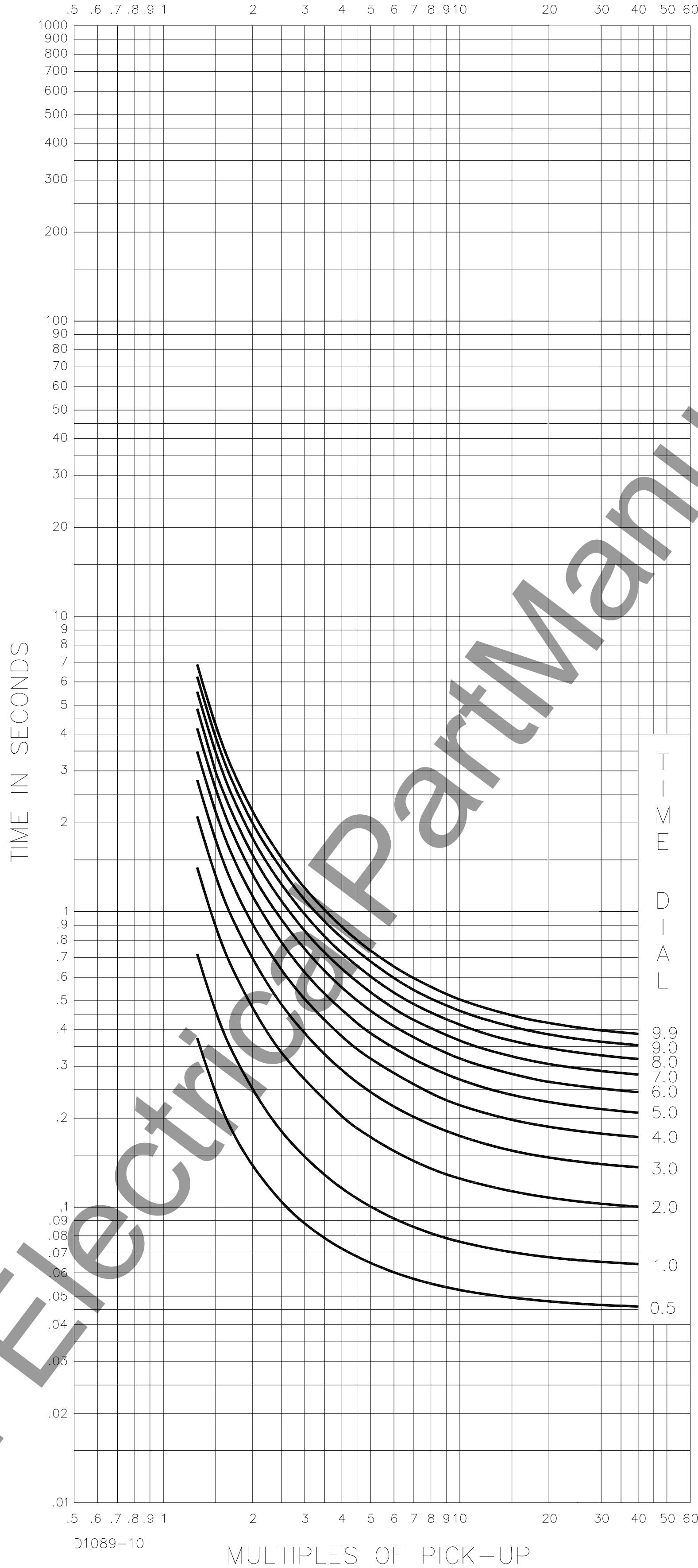

Figure A-1. Time Characteristic Curve S, S1, Short Inverse (Similar to ABB CO-2)

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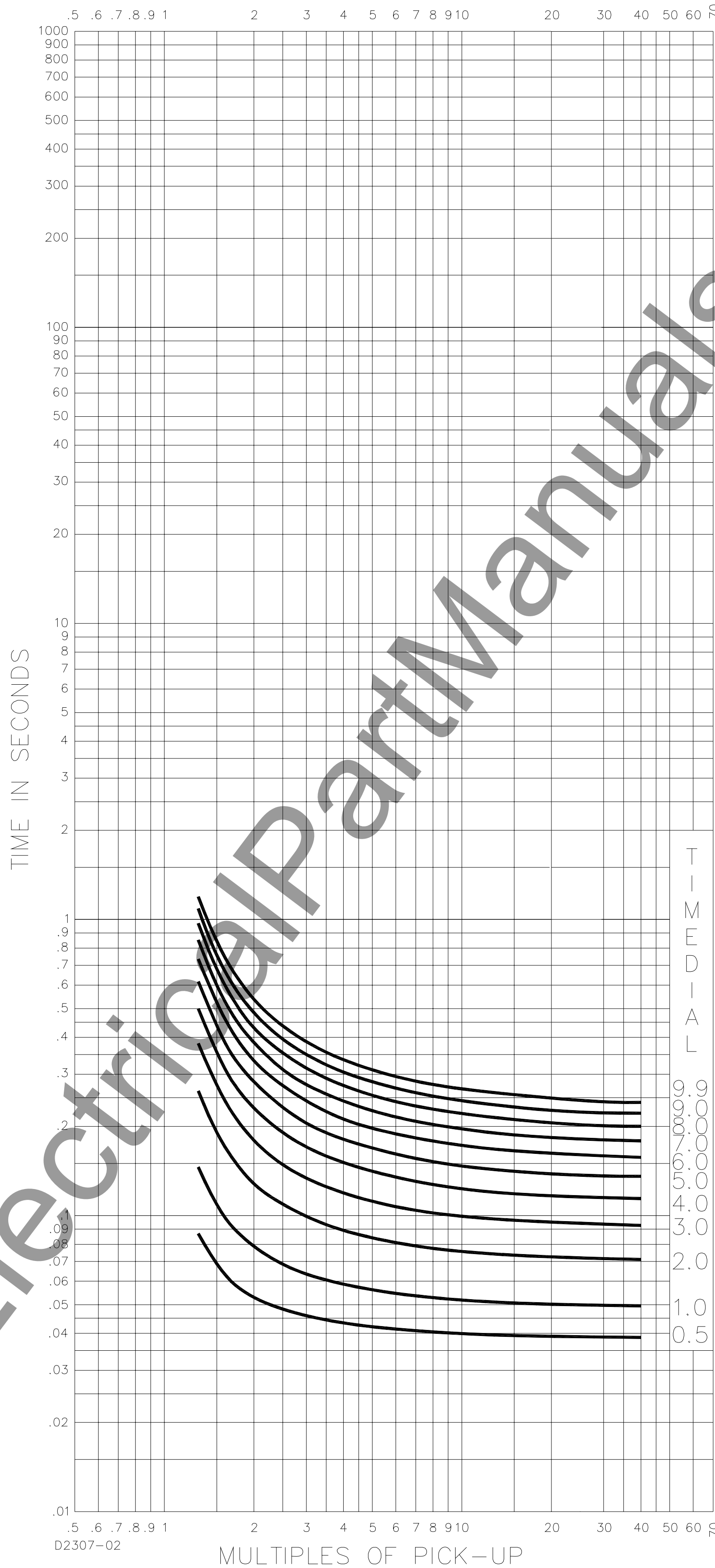

Figure A-2. Time Characteristic Curve S2, Short Inverse (Similar To GE IAC-55)

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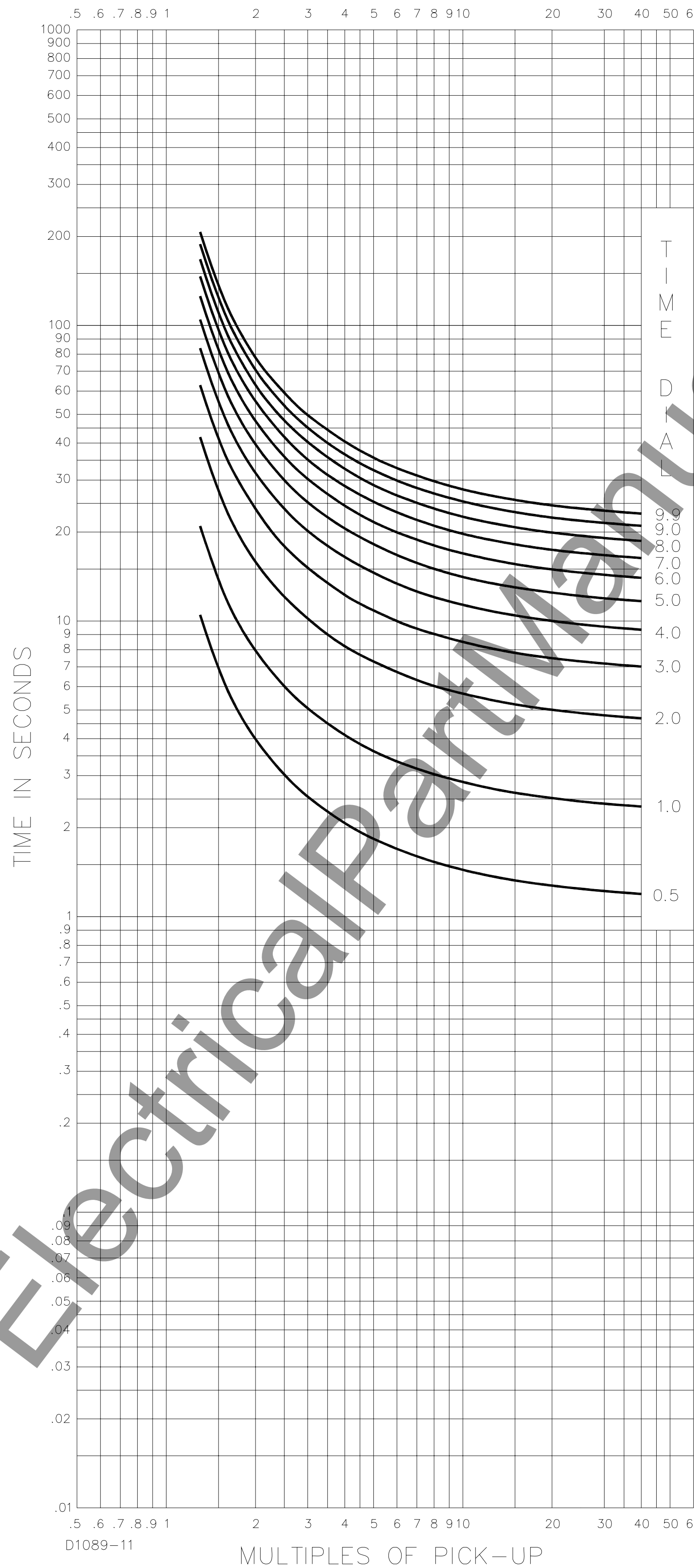

Figure A-3. Time Characteristic Curve L, L1, Long Inverse (Similar to ABB CO-5)

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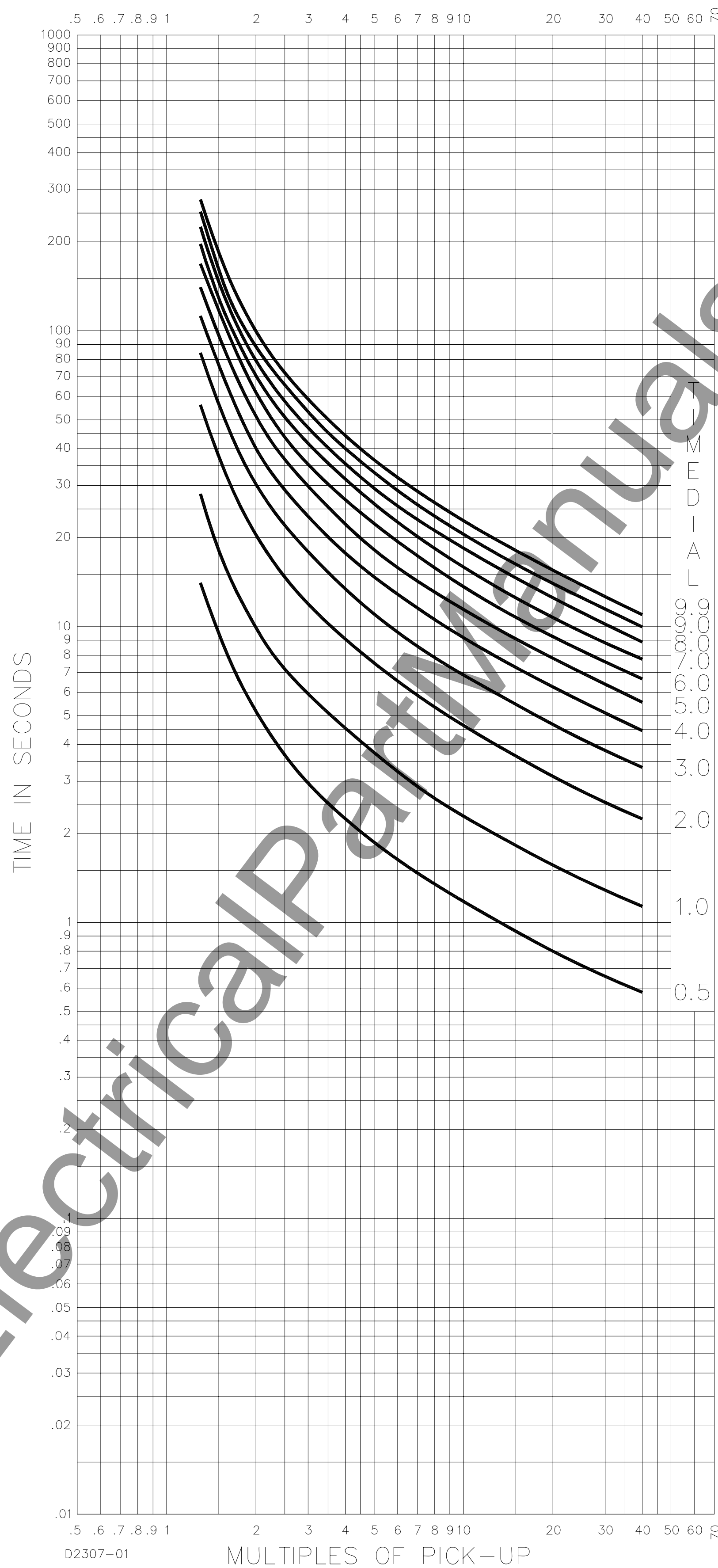

Figure A-4. Time Characteristic Curve L2, Long Inverse (Similar To GE IAC-66)

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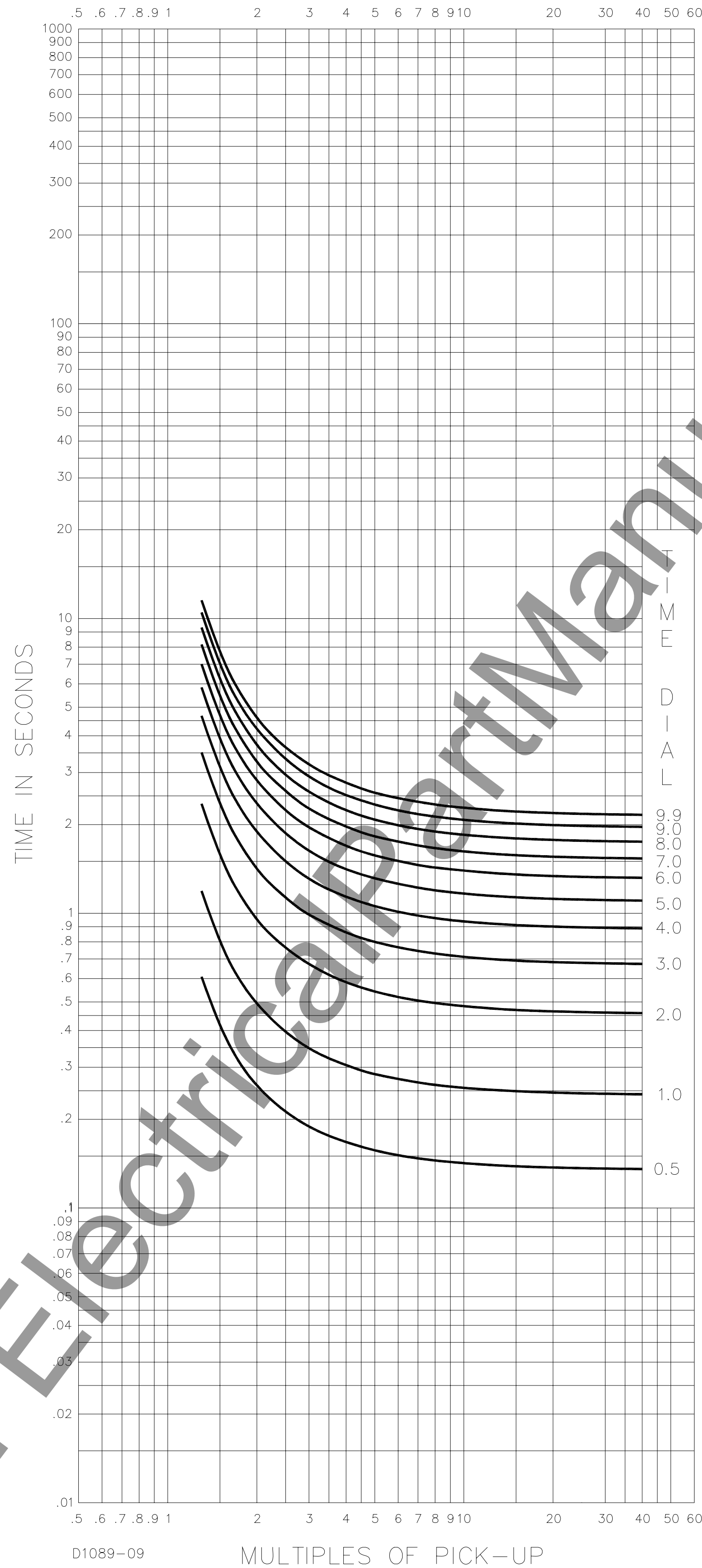

Figure A-5. Time Characteristic Curve D, Definite Time (Similar To ABB CO-6)

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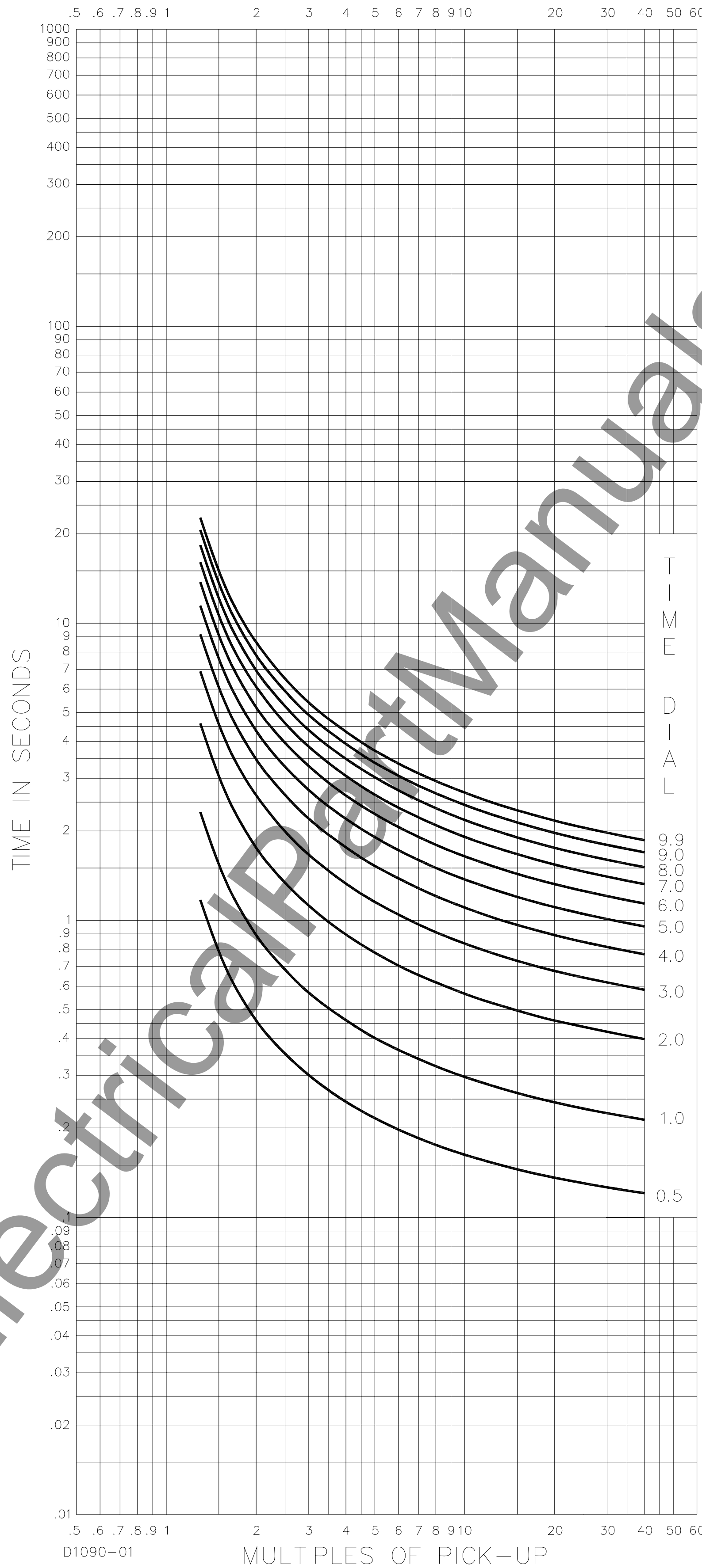

Figure A-6. Time Characteristic Curve M, Moderately Inverse (Similar to ABB CO-7)

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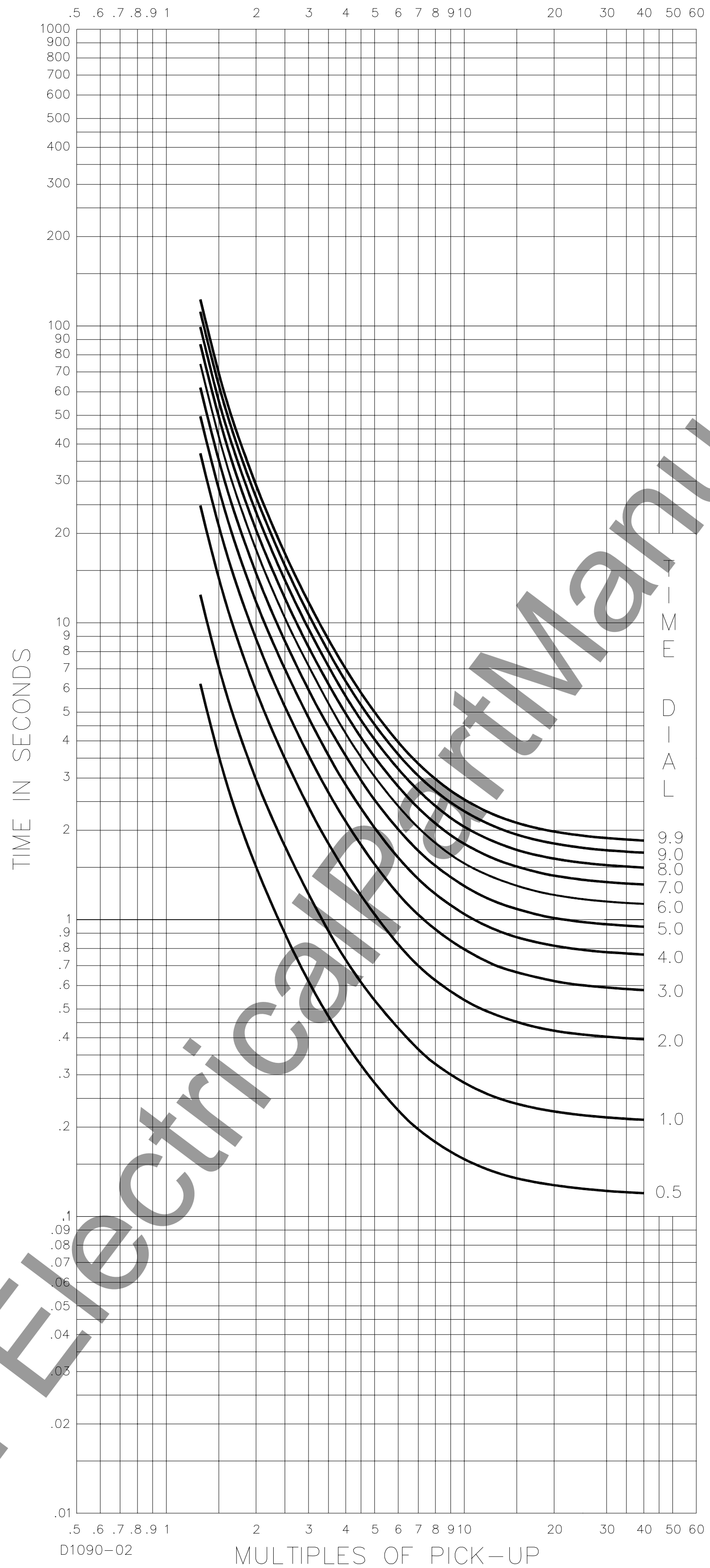

Figure A-7. Time Characteristic Curve I, I1, Inverse Time (Similar to ABB CO-8)

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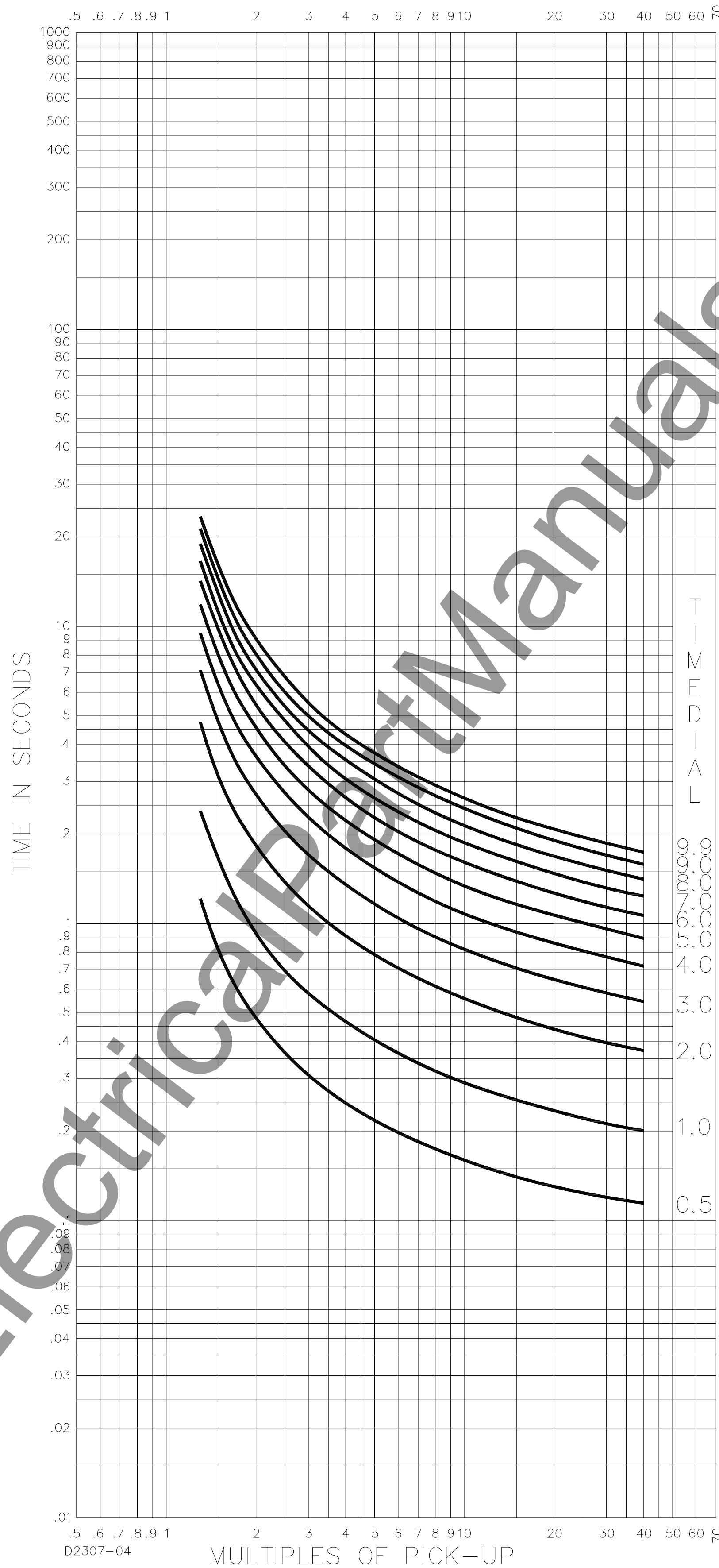

Figure A-8. Time Characteristic Curve I2, Inverse Time (Similar to GE IAC-51)

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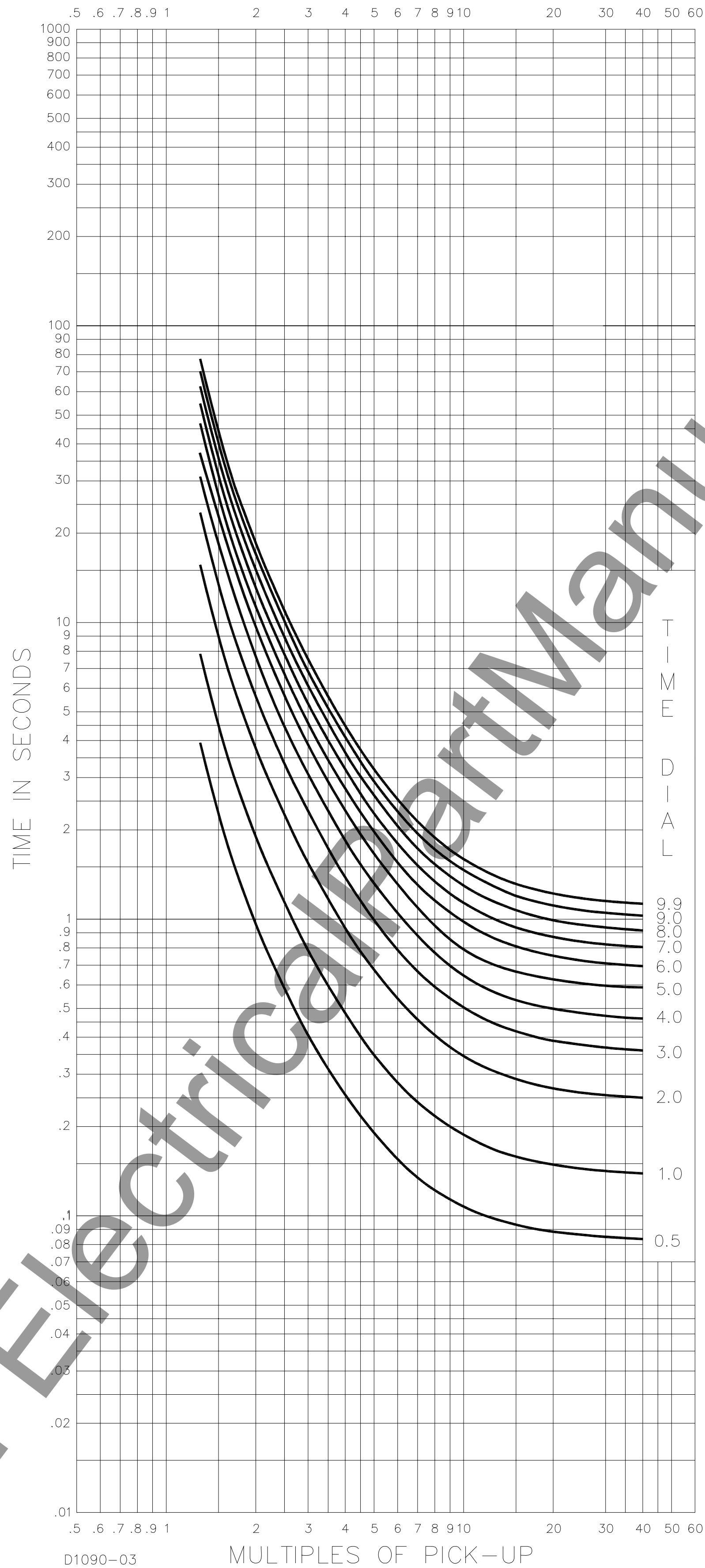

Figure A-9. Time Characteristic Curve V, V1, Very Inverse (Similar to ABB CO-9)

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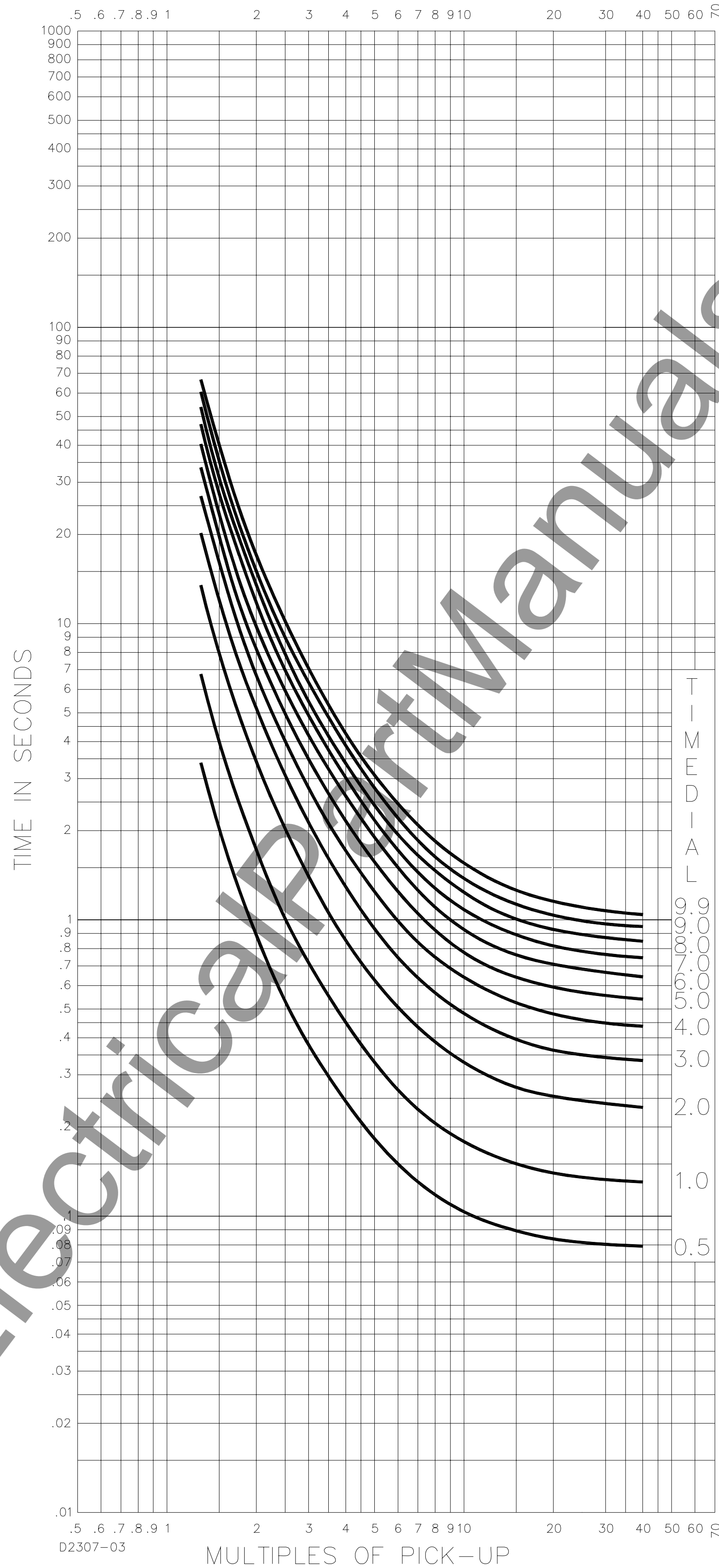

Figure A-10. Time Characteristic Curve V2, Very Inverse (Similar to GE IAC-53)

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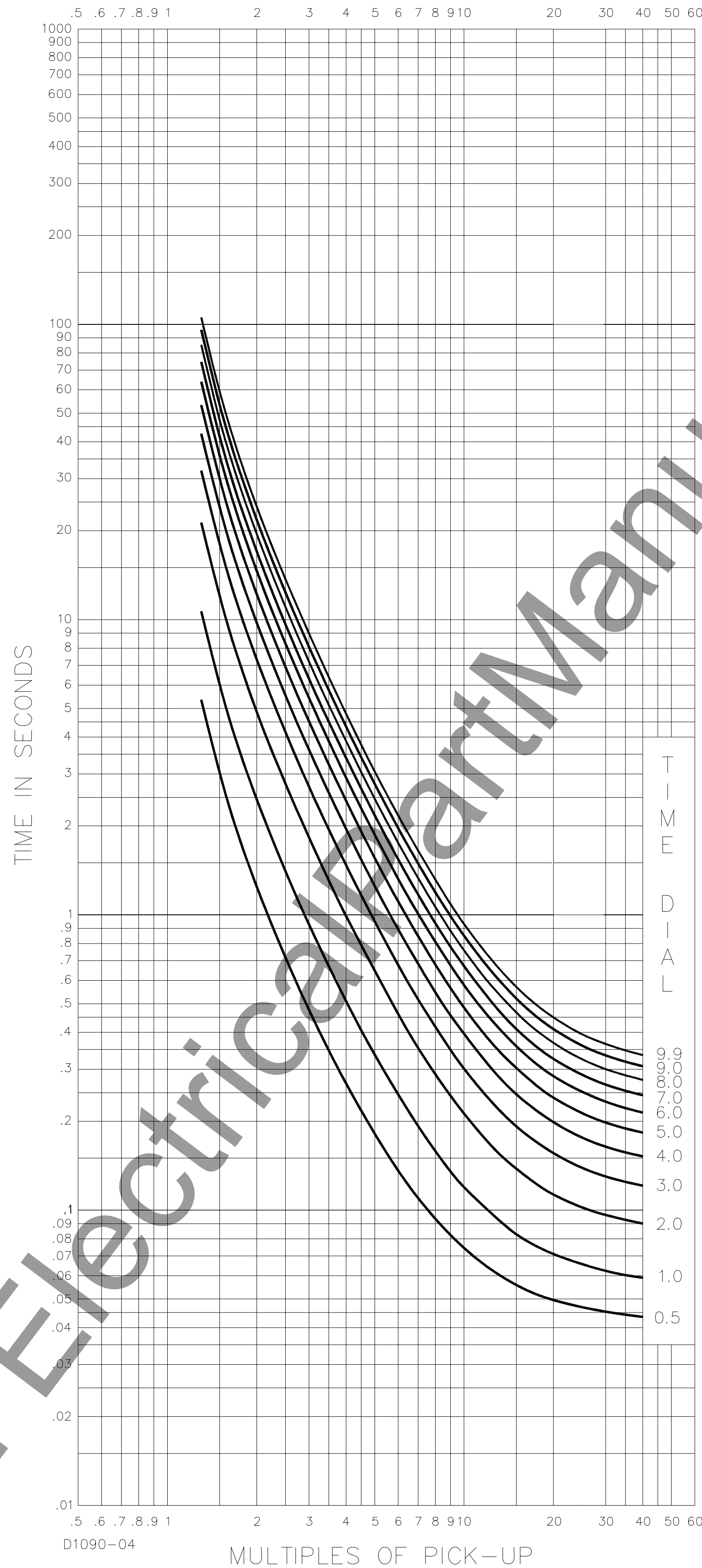

Figure A-11. Time Characteristic Curve E, E1, Extremely Inverse (Similar to ABB CO-11)

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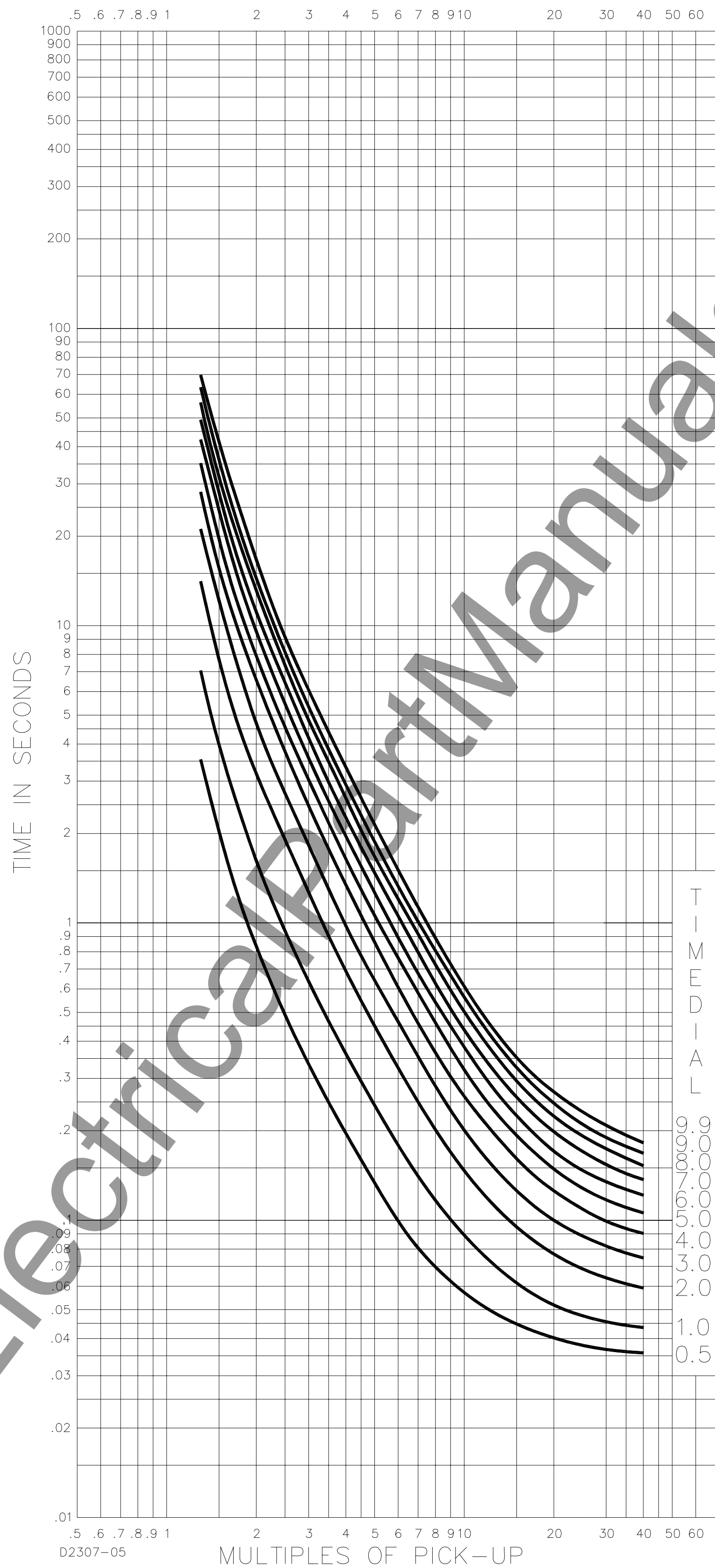

Figure A-12. Time Characteristic Curve E2, Extremely Inverse (Similar to GE IAC-77)

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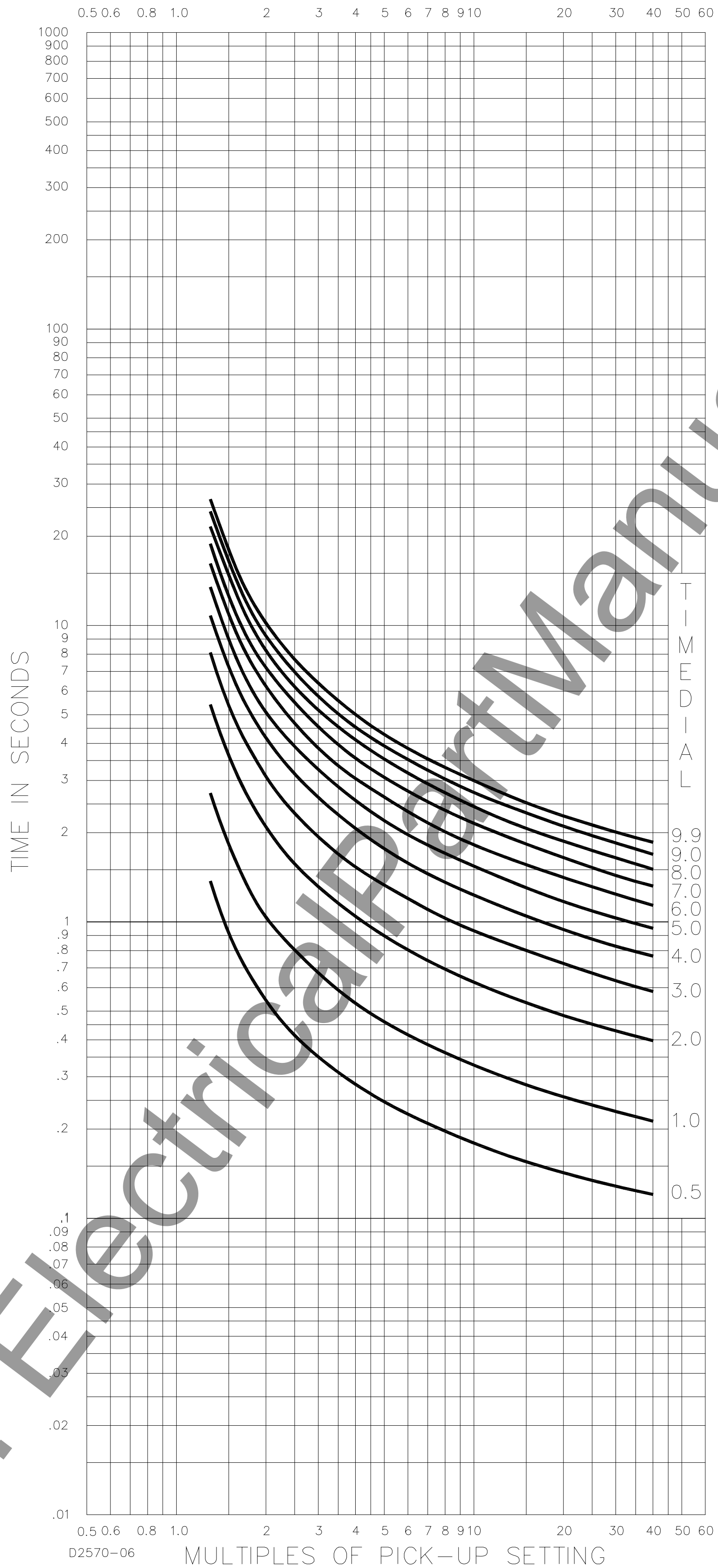

Figure A-13. Time Characteristic Curve A, Standard Inverse

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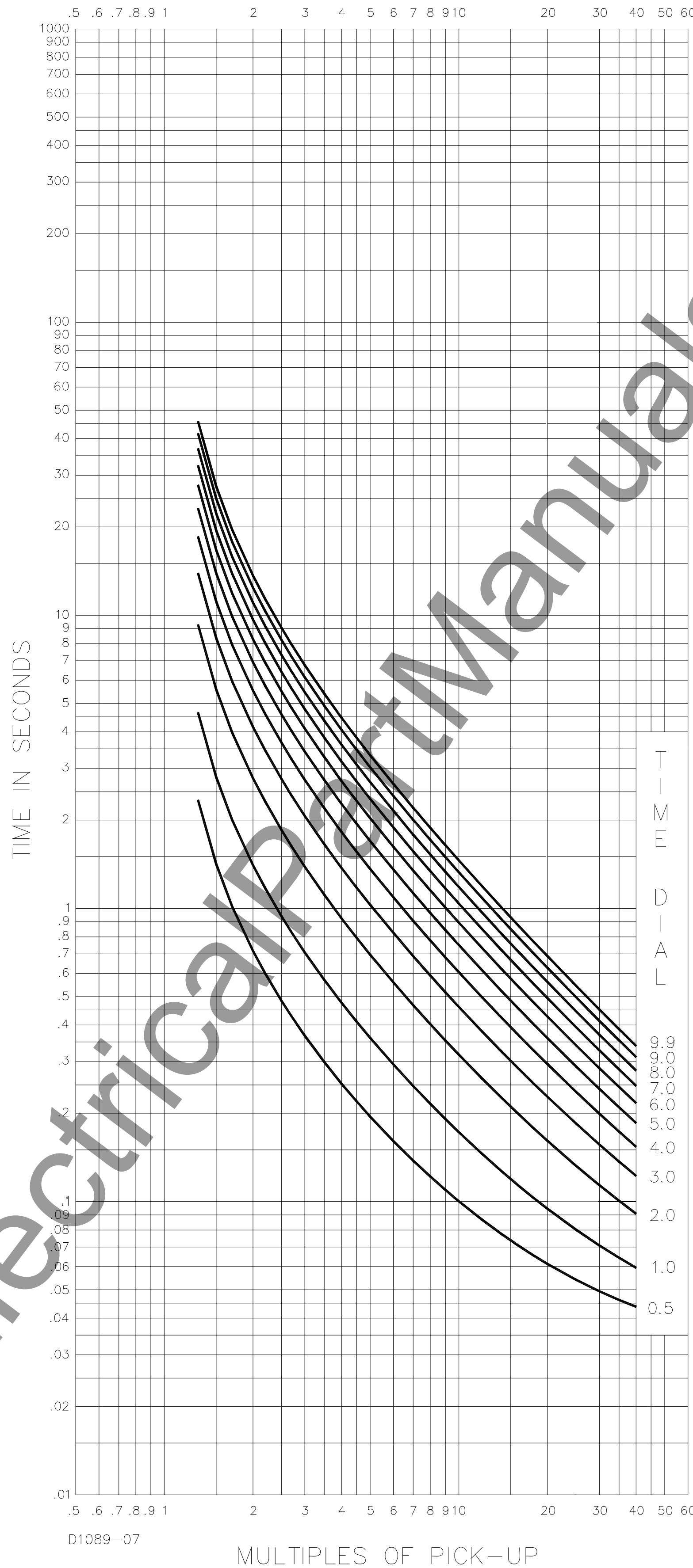

Figure A-14. Time Characteristic Curve B, Very Inverse

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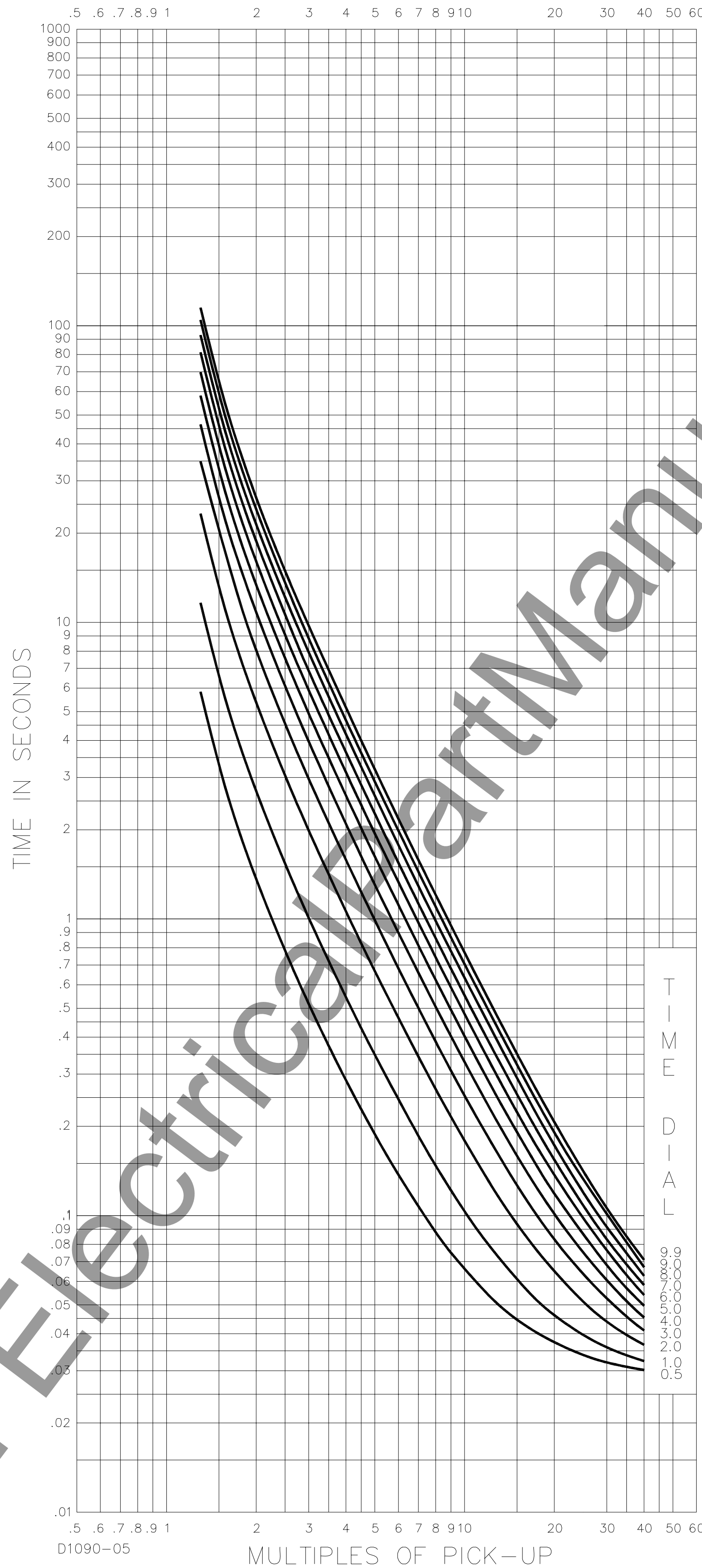

Figure A-15. Time Characteristic Curve C, Extremely Inverse

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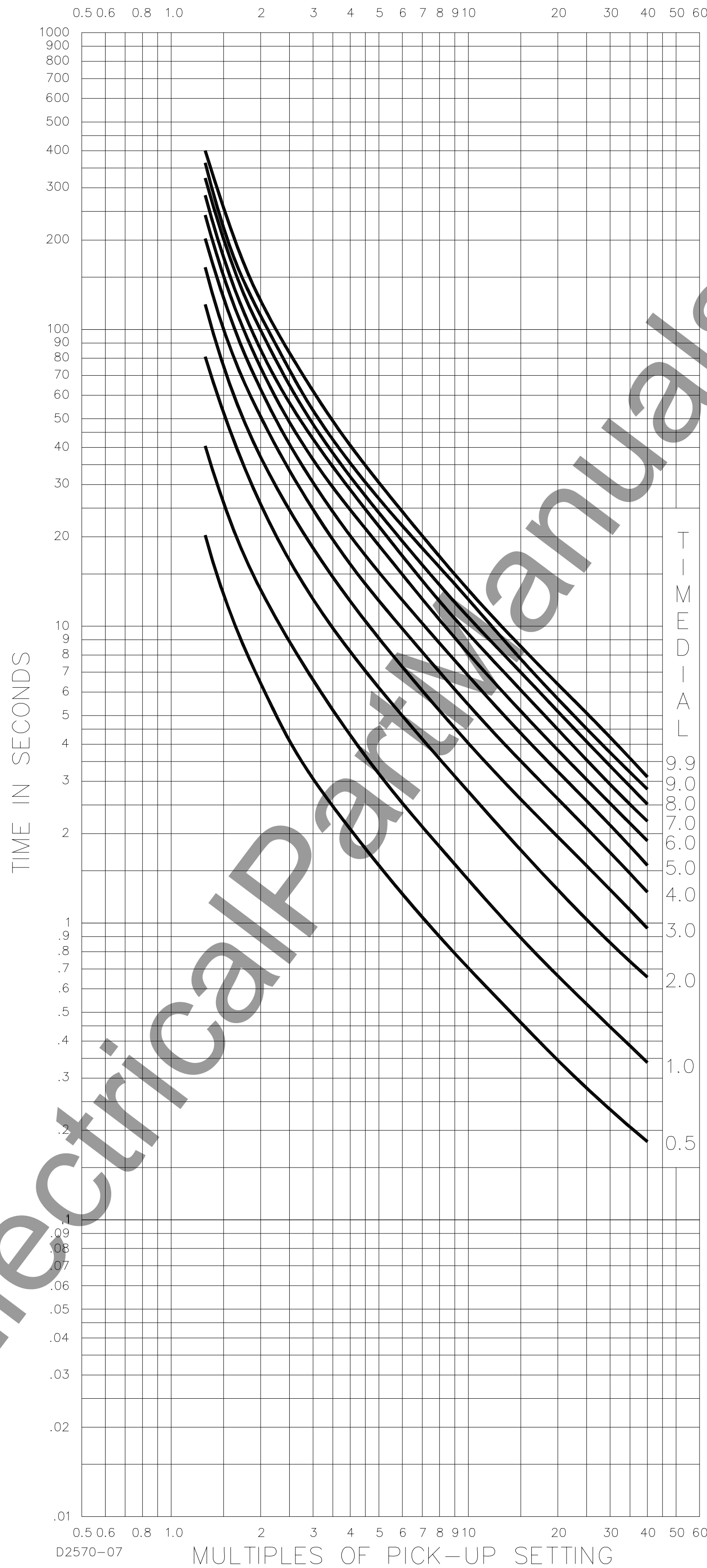

Figure A-16. Time Characteristic Curve G, Long Time Inverse

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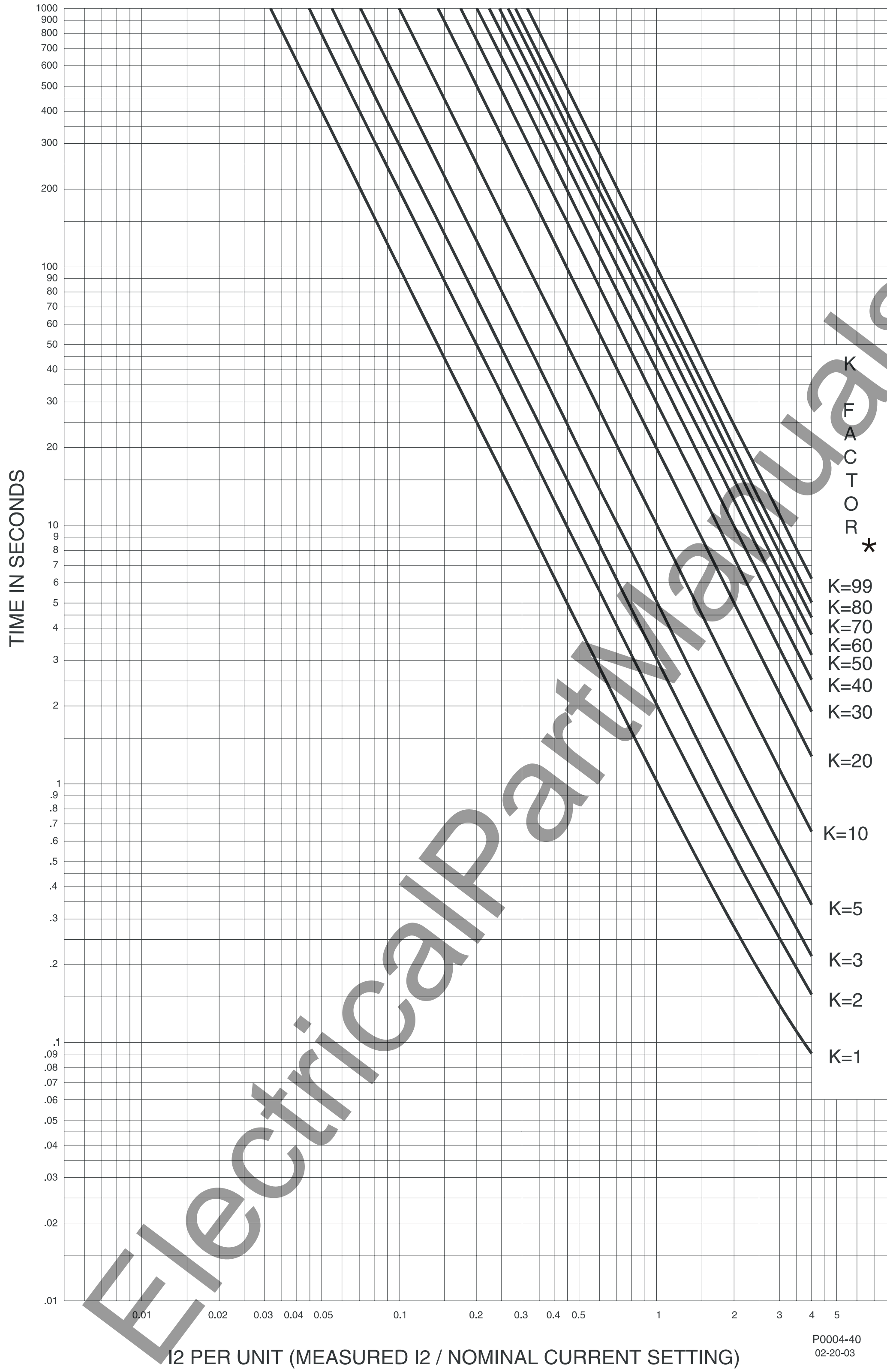

* The K factor is the time that a generator can withstand 1 per-unit I2, where 1 pu is the user's setting for full-load current.

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. K Factor is the time that a generator can withstand 1 per unit I_2 where 1 pu is the user's setting for full load current.

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APPENDIX B • COMMAND CROSS-REFERENCE

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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, 1, 2, or 3 for setting groups or 43, 143, 243, 343, or 443 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-FREQ	Read metered frequency.	3.11
M-I[<phase>]	Read metered current in primary unit.	3.6 - 3.8
M-PF	Read metered three-phase power factor.	3.10
M-S	Read metered three-phase VA in primary units.	3.10
M-V[<phase>]	Read metered voltage in primary units.	3.1 - 3.4
M-VAR	Read metered three-phase vars in primary units.	3.9, 3.9.1 - 3.9.3
M-3V0	Read calculated neutral voltage.	3.5
M-WATT or M-W	Read metered three-phase watts in primary units.	3.9, 3.9.1 - 3.9.3

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 - 2.1.5
CS/CO-101	Control breaker control switch.	2.2.1
CS/CO-GROUP	Control group.	2.3.1
CS/CO-OUTn	Control output n.	2.4.1

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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-PV[=0]	Read/Reset peak demand vars.	4.4.3.8 - 4.4.3.17
RD-PVAR[=0]	Read/Reset peak demand vars.	4.4.3.20 - 4.4.3.21
RD-PWATT[=0]	Read/Reset peak demand watts.	4.4.3.18 - 4.4.3.19
RD-TI[<p>]	Report today's demand current.	4.4.1.1 - 4.4.1.5
RD-TVAR	Report today's demand vars.	4.4.1.20 - 4.4.1.21
RD-TWATT	Report today's demand watts.	4.4.1.18 - 4.4.1.19
RD-YI[<p>]	Report yesterday's demand current.	4.4.2.1 - 4.4.2.5
RD-YVAR	Report yesterday's demand vars.	4.4.2.20 - 4.4.2.21
RD-YWATT	Report yesterday's demand watts.	4.4.2.18 - 4.4.2.19
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-IPADDR	Read the IP Address.	4.7.2
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 fault report.	N/A
RS[-n/Fn/ALM/IO/LGC/NEW][=0]	Read/Reset Sequence of Events Record Data.	N/A

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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-BKR<n>[=<mode>,<alarm limit>],<osc trig enable>	Read/Set breaker alarm settings.	N/A
SA-DI<p>[=<alarm level>]	Read/Set demand alarm settings.	N/A
SA-DV<p>	Read/Set voltage max and min 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-27	Read/Set undervoltage alarm setting.	N/A
SA-59	Read/Set overvoltage alarm setting.	N/A
SA-24	Read/Set Volts per Hertz 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[=<reset alarm 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)>,<dst enable>]	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-DM[=<mode>]	Read/Set demand calculation method.	6.4
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<x>[=<to>,<cc>,<subject>, <priority>,<logic>]	Read/Set e-mail parameters.	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-HTIME[=<goose hold time>]	Read/Set UCA Goose hold time.	N/A
SG-ID[=<relayID>,<stationID>,<userID1>,<userID2>]	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

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ASCII Command	Function	HMI Screen
SG-IPADDR[=<IP address>]	Read/Enter IP (Internet Protocol) address.	N/A
SG-IPGW[=<IP gateway address>]	Read/Set IP Gateway Address.	N/A
SG-IPMASK[=<IP mask address>]	Read/Enter IP MASK address.	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-NETEN[=<options>]	Read/Enter IP (Internet Protocol) options.	N/A
SG-NOM[=<nom volts>,<nom amps>]	Read/Set nominal voltage and current.	6.3.7
SG-NTP[=<time protocol>,<time zone offset>, <update time>]	Read/Enter NTP (network time protocol) server address, time zone offset and update time.	N/A
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-RID<n>	Read/Set UCA remote relay ID.	N/A
SG-SCREEN<x>[=<default screen number>]	Read/Set default screen(s).	N/A
SG-SGCON[=<time>]	Read/Set SGC output time.	N/A
SG-SMTP[<SMTP e-mail address>]	Read/Enter SMTP e-mail server address.	N/A
SG-TARG[=<x/x/…x>,<rst TARG logic>]	Report/Enable Target list and Reset Target logic.	N/A
SG-TRIGGER<x>[=<TRIPtrigger>,<Putrigger>, <LOGICtrigger,<CLOSEtrigger>]	Read/Set trigger logic.	N/A
SG-USERST<n>	Read/Set UCA user status bit pair logic.	N/A
SG-UTC[=M,R,B]	Read/Set UTC information for Daylight Saving Time.	N/A
SG-VIN<n>	Read/Set UCA virtual input remote ID, bit pair, default, and true value.	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[=<exponent>,<DMAX>, <BLK breaker logic>]	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-27[=<mode>,<BLK logic>]	Read/Set logic for 27 function modules.	N/A
SL-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

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ASCII Command	Function	HMI Screen
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>,<PI 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-50BF[=<mode>,<50INI>,<52INI>, <52 Status>,<BLK logic>]	Read/Set logic for breaker failure function modules.	N/A
SL-GROUP[=<mode>,<D0 logic>,<D1 logic>, <D2 logic>,<D3 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-P85[=<mode>,<FWD_TRIP>,<REVS_BLK>, <P85RX>,<WFC>]	Read/Set logic for P85 function.	N/A
SL-SOTF[=<mode>,<TRIP logic>,<BLK Logic>]	Read Set logic for SOTF function.	N/A
SL-VO<x>[=<boolean equation>]	Read/Set output logic.	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>]	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>-27<p>[=<pickup>,<time delay>]	Read/Set 27 pickup level, time delay, and mode.	5.x.3.1 - 5.x.3.4
S<g>-27R[=<pickup>,<mode>]	Read/Set (51)/27R control level and operating mode.	5.x.8.5
S<g>-<x>32[=<pickup>,<time delay>,<mode>]	Read/Set 32 pickup level, time delay, and direction.	5.x.4.1
S<g>-47[=<pickup>,<time delay>]	Read/Set 47 pickup level and time delay.	5.x.5.1
S<g>-50BF[=<time delay>,<phase pickup>, <neutral pickup>,<control time delay>]	Read/Set the Breaker Failure timer setting.	5.x.6.1 - 5.x.6.2
S<g>-<x>50T<p>[=<pickup>,<time delay>]	Read/Set 50T pickup level and time delay.	5.x.7.1 - 5.x.7.6
S<g>-<x>51<p>[=<pickup>,<time delay>,<curve>]	Read/Set 51 pickup level, time delay, and curve.	5.x.8.1 - 5.x.8.9
S<g>-52BT[=<27P3PU>,<EN_52B>,<EN_27P3>, <52BD>]	Read/Set the Breaker Open/Dead Line setting.	5.x.9.1 - 5.x.9.2
S<g>-<x>59<p>[=<pickup>,<time delay>]	Read/Set 59 pickup level, time delay, and mode.	5.x.10.1 - 5.x.10.3
S<g>-<x>62[=<T1>,<T2>]	Read/Set 62 time delay.	5.x.11.1 - 5.x.11.2
S<g>-67N[=<mode>,<quantity>]	Read/Set 67 Neutral Polarizing Mode and Quantities.	5.x.12.1 - 5.x.12.2

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ASCII Command	Function	HMI Screen
S<g>-79<x>[=<time delay>]	Read/Set 79 time delay.	5.x.13.1 - 5.x.13.4
S<g>-79SCB[=<step list>]	Read/Set 79 Sequence Controlled Block output.	5.x.13.5
S<g>-<x>81[=<pickup>,<time delay>,<mode>]	Read/Set 81 pickup level, time delay, and mode.	5.x.14.1 - 5.x 14.6
S<g>-81INH[=<pickup>]	Read/Set 81 undervoltage inhibit level.	5.x.14.7
S<g>-P85[=<P85Z3RBD>,<P85EBD>,<P85ETDPU>, <P85EDUR>]	Read/Set P85 setting.	5.x.15.1 - 5.x.15.2
S<g>-SOTF[=<50TPPU>,<TD>]	Read/Set SOTF setting.	5.x.16.1
SP-60FL[=<I_Blk>,<V_Blk>]	Read/Set loss of potential pickup setting.	5.5.1.1 - 5.5.1.2
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 - 3 operation.	N/A
SP-79ZONE[=<zone pickup logic>]	Read/Set Zone Sequence Pickup Logic.	N/A

Table B-12. Global 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 Settings Commands

ASCII Command	Function	HMI Screen
SDNP	Read all Distributed Network Protocol (DNP) settings.	N/A
SDNP-SYNCH[=valueX]	Read/Set DNP synchronization period with Master.	N/A
SDNP-DEADBAND[=c,v,p]	Read/Set DNP current, voltage, and power analog change event deadband % of nominal value.	N/A
SDNP-USERAI[=T,startndx,endndx,startpDftID,.., endpDftID]	Read/Set user configuration of DNP Analog Input points.	N/A
SDNP-AIMAP[=USER(or U)/DEFAULT(or DFT or D)]	Read/Set selection of DNP Analog Input Map.	N/A
SDNP-USERBI[=T,startndx,endndx,startpDftID,.., endpDftID]	Read/Set user configuration of DNP Binary Input points.	N/A
SDNP-BIMAP[=USER(or U)/DEFAULT(or DFT or D)]	Read/Set selection of DNP Binary Input Map.	N/A

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APPENDIX C • TERMINAL COMMUNICATION

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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 BE1-1051 relay. The following instructions are used for configuring HyperTerminal in Windows® 2000/XP to communicate with your BE1-1051 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, BE1-1051. 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".

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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.

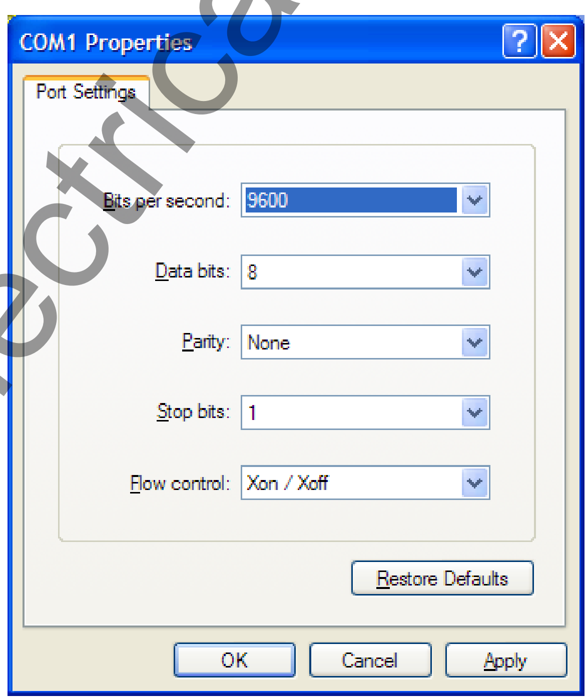

Figure C-3. COM Properties Dialog Box

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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.

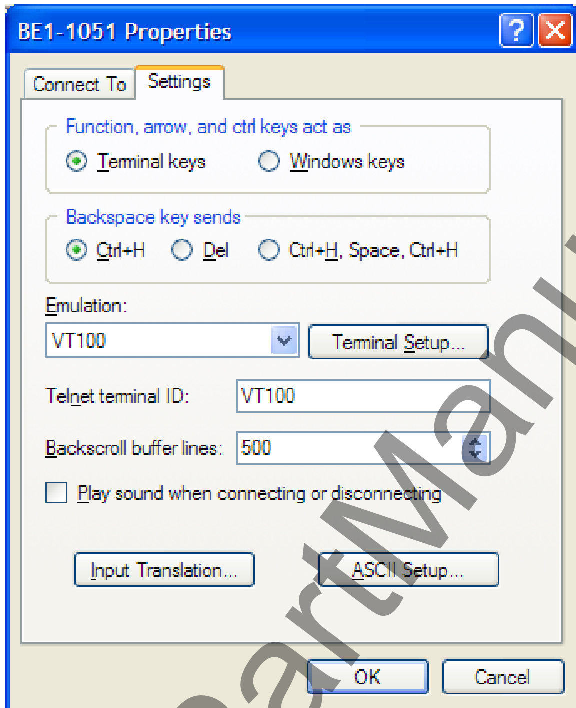

Figure C-4. Properties, Settings Tab

b. Click the ASCII Setup button. Make the following selections using Figure C-5 as a guide:

   <u>ASCII Sending</u>
   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.
   <u>ASCII Receiving</u>
   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.

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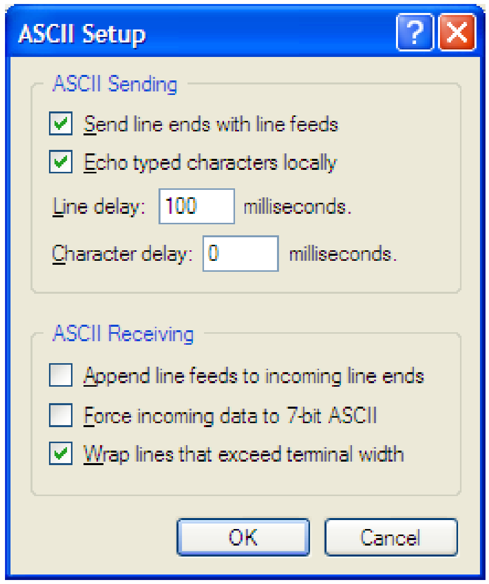

Figure C-5. ASCII Setup Dialog Box

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 BE1-1051 relay. The configuration of stand-alone software is similar to that of HyperTerminal.

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APPENDIX D • LOAD ENCROACHMENT

INTRODUCTION

To further explain the load encroachment setting, forward power is defined as flow toward the line and away from the bus. Complex power S is defined as:

$S = \overline{V}I^* = |V|\angle\Theta V(|I|\angle\Theta I)^*$

$S = |V|\,|I|\angle\Theta V - \Theta I$

Assume $|V| = 1 \quad |I| = 1$ — $S = 1\angle\Theta V - \Theta I \qquad \Theta V = 0 \qquad S = 1\angle -\Theta I$

For current leading voltage: $\Theta I = 31.8^\circ \qquad S < 1\angle -31.8^\circ = .85 - y.53$

$P > 0$ Forward Power Flow

$Q < 0$

The $\Theta I = 31.8$ represents forward power factor leading.

For current lagging voltage $\Theta I = -41.4^\circ$: $S = 1\angle -(-41.4) = 1\angle 41.4 = .75 + y\,.66$

$P > 0$ Forward Power

$Q < 0$

The ΘI = -41.4 represents forward power factor lagging.

For current leading voltage $\Theta I = 180 - 23.1 = 156.9$ $S = 1\angle -156.9 = -.92 - y.39$

The reverse power factor leading is represented by 23.1° (or 156.9°)

For current lagging voltage $\Theta I = -180 + 36.9 = -143.1 \quad S = 1\angle 143.1 = -.8 + y.6$

$P < 0$ Reverse Power

$Q > 0$

The reverse power factor lagging is represented by 36.9° (or -143.1°)

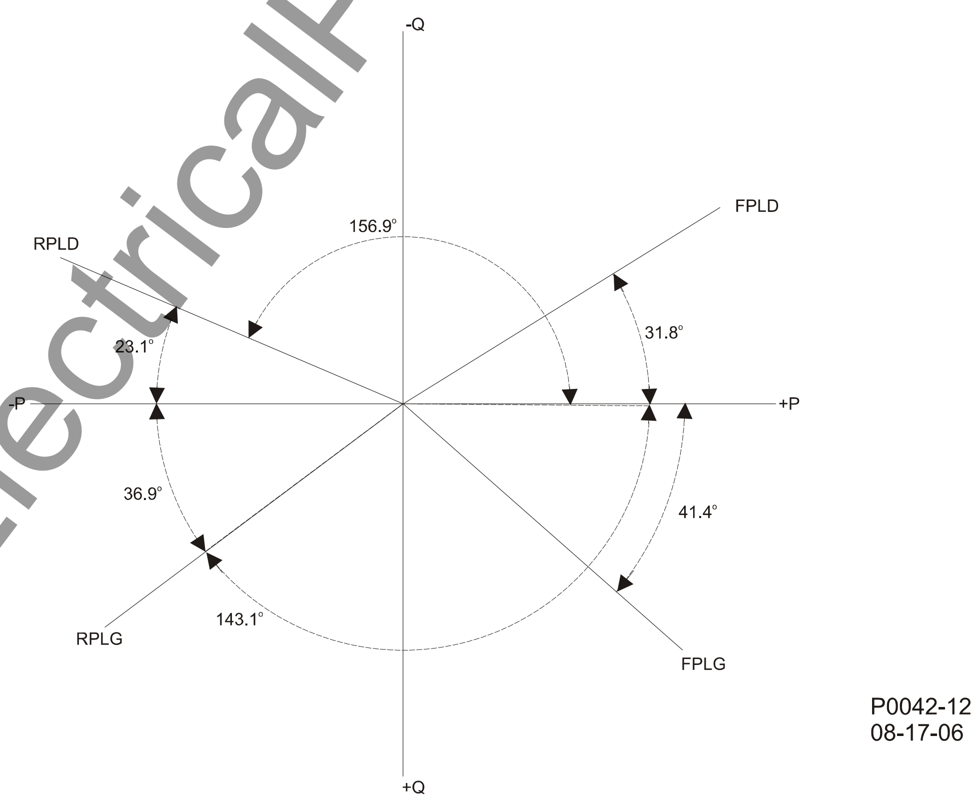

Figure D-1. 51LE (P and Q Plane)

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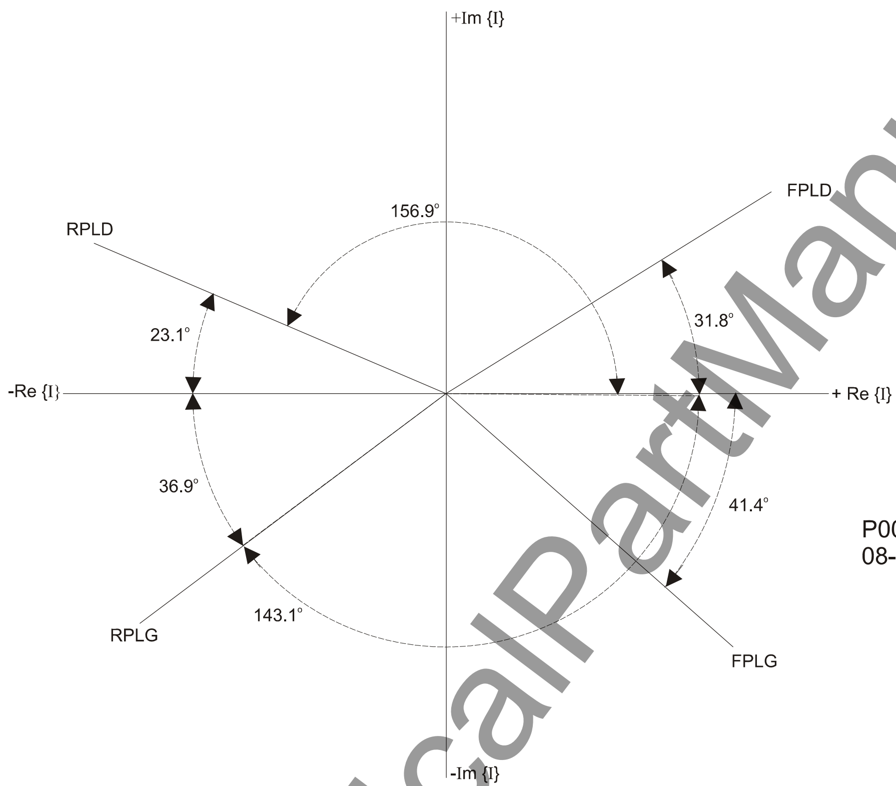

Figure D-2. 51LE (Real and Imaginary Plane)

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