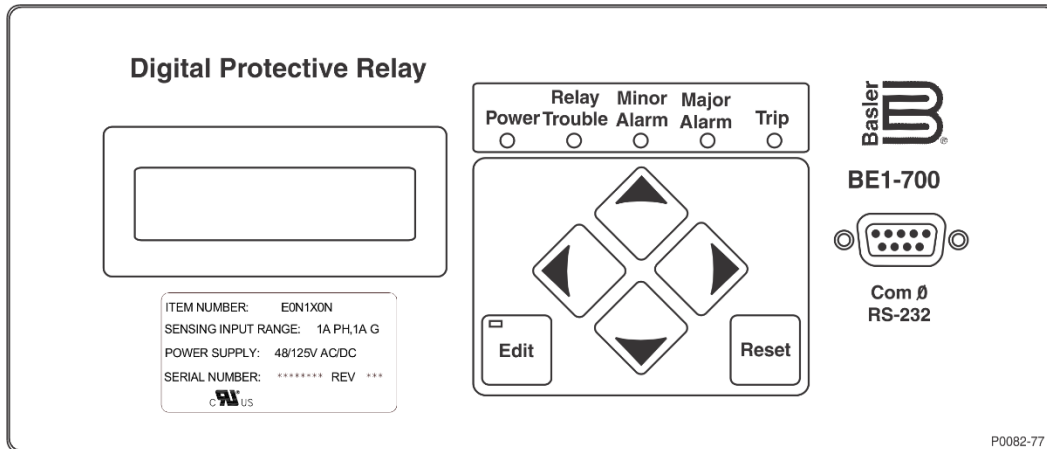





BE1-700

Digital Protective Relay

Instruction Manual



 **WARNING:** California's Proposition 65 requires special warnings for products that may contain chemicals known to the state of California to cause cancer, birth defects or other reproductive harm. Please note that by posting this Proposition 65 warning, we are notifying you that one or more of the Proposition 65 listed chemicals may be present in products we sell to you. For more information about the specific chemicals found in this product, please visit <https://www.basler.com/Prop65>.

Preface

This instruction manual provides information about the installation and operation of the BE1-700 Digital Protective Relay. To accomplish this, the following information is provided:

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

An optional instruction manual (Basler Electric part number 9376700991) for the BE1-700 includes the Modbus® Protocol.

Conventions Used in this Manual

Important safety and procedural information is emphasized and presented in this manual through warning, caution, and note boxes. Each type is illustrated and defined as follows.

Warning!

Warning boxes call attention to conditions or actions that may cause personal injury or death.

Caution

Caution boxes call attention to operating conditions that may lead to equipment or property damage.

Note

Note boxes emphasize important information pertaining to installation or operation.



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Warning!

READ THIS MANUAL. Read this manual before installing, operating, or maintaining the BE1-700. Note all warnings, cautions, and notes in this manual as well as on the product. Keep this manual with the product for reference. Only qualified personnel should install, operate, or service this system. Failure to follow warning and cautionary labels may result in personal injury or property damage. Exercise caution at all times.

Caution

Installing previous versions of firmware may result in compatibility issues causing the inability to operate properly and may not have the enhancements and resolutions to issues that more recent versions provide. Basler Electric highly recommends using the latest version of firmware at all times. Using previous versions of firmware is at the user's risk and may void the warranty of the unit.

Basler Electric does not assume any responsibility to compliance or noncompliance with national code, local code, or any other applicable code. This manual serves as reference material that must be well understood prior to installation, operation, or maintenance.

For terms of service relating to this product and software, see the *Commercial Terms of Products and Services* document available at www.basler.com/terms.

This publication contains confidential information of Basler Electric Company, an Illinois corporation. It is loaned for confidential use, subject to return on request, and with the mutual understanding that it will not be used in any manner detrimental to the interests of Basler Electric Company and used strictly for the purpose intended.

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. Over time, improvements and revisions may be made to this publication. Before performing any of the following procedures, contact Basler Electric for the latest revision of this manual.

The English-language version of this manual serves as the only approved manual version.

Revision History

Historical changes made to this instruction manual, BESTCOMS software, application firmware, and hardware are provided below. Revisions are listed in reverse chronological order.

Instruction Manual Revision History

Revision and Date	Change
AA, 08/23	<ul style="list-style-type: none"> Added BESTCOMS 2.05.01 revision history. Added Hardware AN, AP, and AR revision history.
Z, 02/23	<ul style="list-style-type: none"> Updated Isolation specifications.
Y, 03/22	<ul style="list-style-type: none"> Updated list of non-latching alarms in Table 6-17. Added a note box about EMI suppression in the <i>Installation</i> chapter. Removed CD-ROM references from the manual.
X, 01/22	<ul style="list-style-type: none"> Added Firmware 3.05.02 revision history.
W, 01/22	<ul style="list-style-type: none"> Added Note 5 to Style Chart in Section 1.
V, 06/21	<ul style="list-style-type: none"> Added Firmware 3.05.01 revision history.
U, 01/21	<ul style="list-style-type: none"> Added Firmware 2.04.01 revision history.
T, 11/20	<ul style="list-style-type: none"> Updated Communication Ports specs in Section 1.
S, 04/19	<ul style="list-style-type: none"> Clarified 810/U time delay accuracy. Added California Proposition 65 warning statement.
R, 08/17	<ul style="list-style-type: none"> Changed Analog-to-Digital Converter sampling rate from 12 to 24 samples per cycle.
Q	<ul style="list-style-type: none"> This revision letter not used.
P, 06/17	<ul style="list-style-type: none"> Removed CE Compliance.
O	<ul style="list-style-type: none"> This revision letter not used.
N, 03/17	<ul style="list-style-type: none"> Added caution box about nonvolatile memory in Section 7. Removed GOST-R Certification from Section 1. Corrected setting increment for the 47 element in Section 4.
M, 08/14	<ul style="list-style-type: none"> Added serial number to fault reports and sequence of events in Section 6 and replaced Figures 6-16, 6-20, and 14-41.
L, 02/14	<ul style="list-style-type: none"> Updated contact-sensing inputs specifications in Sections 1, 3, and 12. Added Storage statement in Section 13. Updated PC software requirements in Section 14.
K, 10/11	<ul style="list-style-type: none"> Changed Isolation specs in Section 1 to exclude Ethernet port.
J, 12/10	<ul style="list-style-type: none"> Updated 24 Vdc resistance, voltage, and current values in Table 6-9. Improved Figure 12-11.
I	<ul style="list-style-type: none"> This revision letter not used.
H, 07/10	<ul style="list-style-type: none"> Re-organized <i>Operational Specifications</i> and listed functions in numerical order in Section 1. Moved <i>Real-Time Clock</i> from <i>Operational Specifications</i> to <i>General Specifications</i> in Section 1. Corrected terminal numbering in Figure 12-22, RS-485 DB-37 to BE1-700.
G, 10/09	<ul style="list-style-type: none"> Changed all instances of BESTWAVE to BESTWAVEPlus™.

Revision and Date	Change
F, 09/09	<ul style="list-style-type: none"> • Added option “5” power supply type in style chart, power supply and control inputs specifications in Section 1, <i>General Information</i>. • Added option “5” power supply type under <i>Contact Sensing Inputs</i> in Sections 3 and 12. • Added CE Compliance in Section 1, <i>General Information</i>. • Updated Figure 4-54, <i>Overall Logic Diagram for Reclosing</i>, to show PI 0/100 ms and PI Stretched. • Updated screen shots of BESTCOMS style chart screen.
E, 02/09	<ul style="list-style-type: none"> • Added Republic of Belarus certification. • Updated contact sense turn-on voltage range and burden values to reflect new digital board. • Added screens 5.1.2.2-5.1.2.4, 5.1.3.2-5.1.3.6, and 5.1.1.4 to Figure 10-8, <i>Protection Menu Branch Structure</i>. Removed screen 5.1.12.8. • Changed Figure 12-5 to show OUTA as Normally Closed contact.
D, 12/08	<ul style="list-style-type: none"> • Added 3-Phase VT 4-Wire Connection and 3-Phase VT 3-Wire Connection to Figure 12-11.
C, 10/08	<ul style="list-style-type: none"> • Added manual part number and revision to footers. • Changed Appendix C, <i>Overexcitation (24) Inverse Time Curves</i>, to Appendix D. • Created Appendix C, <i>Terminal Communication</i>. • Added GOST-R certification to Section 1. • Combined BE1-700C and BE1-700V style charts into one style chart, Figure 1-1. • Changed 81 function pickup range from 40-70 to 20-70 Hz. • Added <i>Frequency Range</i> to <i>Power Supply</i> specifications. • Updated all BESTCOMS screenshots to Windows XP style. • Added explanation of Inhibit setting for 27P/27X function in Section 4. • Changed 25 function delta angle setting from 1-45 to 1-99. • Added Figure 6-7, <i>Breaker Monitoring Tab</i>, and Figure 6-8, <i>BESTlogic Screen for Breaker Duty Monitoring</i>. • Added style number and firmware version display to fault reports under <i>Fault Reporting</i> in Section 6. • Added <i>Settings Compare</i> in Section 6. • Added 127PPU and 127PT to Table 7-1, <i>Logic Variable Names and Descriptions</i>. • Added explanation of Figure 9-2, <i>Show Passwords Screen</i>. • Added Figure 10-7 showing additional fault report screens. • In Section 11, <i>ASCII Command Interface</i>, added descriptions for SA-24, SG-DSP, SG-EMAIL, SG-VTP, SG-VTX, SL-27, SL-47, SL-59, S<g>-24D, S<g>-25VM, S<g>-27, S<g>-47, S<g>-81, S<g>-81INH, and SP-60FL. • Added Figure 12-17, <i>RS-232 Pin-outs</i>. • Added <i>27P/127P/27X Inhibit Pickup Test</i> in Section 13. • In Section 15, updated Configuration and Web Page screenshots using Windows XP.

Revision and Date	Change
B, 10/04	<ul style="list-style-type: none"> Annotated each section, sub-section, figure, and table to indicate applicability to a current (BE1-700C) or voltage (BE1-700V) relay, as appropriate. Updated the discussion of the 24 element in Section 4, <i>Protection and Control</i>. Added Table 6-14, Targets as Displayed to Section 6, <i>Reporting and Alarm Functions</i>. Updated Figure 10-7, <i>Protection Menu Branch Structure</i>. Increased the number of figures in Section 14, <i>BESTCOMS Software</i> from 16 to 42. Added a troubleshooting guide to Section 15, <i>BESTNet Communication</i>. Added voltage ASCII commands to Appendix B, <i>Command Cross-Reference</i>. Added Appendix C, <i>Overexcitation (24) Inverse Time Curves (BE1-700V Only)</i>.
A, 07/04	<ul style="list-style-type: none"> Initial release.

BESTCOMS™ Software Revision History

Version and Date	Change
2.05.01, 08/23	<ul style="list-style-type: none"> Corrected inability to enable passwords with Modbus® over Ethernet from BESTCOMS™.
2.05.00, 12/17	<ul style="list-style-type: none"> Corrected settings file upload issue for 127P time delay. Added Windows 8 compatibility.
2.04.01, 01/12	<ul style="list-style-type: none"> Improved Settings Compare function.
2.04.00, 04/11	<ul style="list-style-type: none"> Added Windows® 7 32-/64-bit compatibility and removed Windows 2000 compatibility. Improved operation when regional parameters are set to French.
2.03.02, 09/09	<ul style="list-style-type: none"> Added option “5” power supply type to style chart. Improved Settings Compare function. “>” character can now be entered in setting name descriptions. Corrected overflow error when too many characters are entered for time delays on the Voltage and Power Protection screens.
2.02.00, 01/05	<ul style="list-style-type: none"> Added support for the Modbus/TCP protocol. Added links on the <i>System Summary</i> screen to jump to the Settings screen for the selected setting. Revised the 47N Mode label to be Vpn always. Added the ability to double click a saved IP address to connect to it.
2.01.00, 07/04	<ul style="list-style-type: none"> Provided support for voltage relays (BE1-700V). Resolved a possible program crash when using the Discovery applet.
2.00.00, 06/04	<ul style="list-style-type: none"> Initial release.

Application Firmware Revision History

Version and Date	Change
3.05.02, 01/22 Rev 3 hardware	<ul style="list-style-type: none"> Corrected Analog Failure Alarm. Corrected SG-VTP terminal command response. Improved voltage and frequency metering over 10-16 Hz range.

Version and Date	Change
3.05.01, 06/21 Rev 3 hardware	<ul style="list-style-type: none"> BE1-700C: Updated to prevent protection elements from being disabled during power cycle that causes an EE Nonfatal Error.
2.04.01, 01/21 Rev 1 and 2 hardware	<ul style="list-style-type: none"> Updated to prevent protection elements from being disabled during power cycle that causes an EE Nonfatal Error.
3.05.01, 11/20 Rev 3 hardware	<ul style="list-style-type: none"> BE1-700V: Updated to prevent protection elements from being disabled during power cycle that causes an EE Nonfatal Error. BE1-700C: Continues to use firmware version 3.04.00.
3.05.00, 04/20	<ul style="list-style-type: none"> BE1-700V: A-to-D changed due to part obsolescence. BE1-700C: Continues to use firmware version 3.04.00.
3.04.00, 07/19	<ul style="list-style-type: none"> Adjusted code to accommodate new flash memory component (applies only to hardware version AB).
2.04.00, 09/17	<ul style="list-style-type: none"> Changed analog-to-digital converter sampling rate from 12 to 24 samples per cycle to improve harmonic filtering.
2.03.04, 11/16	<ul style="list-style-type: none"> Enhanced 25 sync-check angle calculation. Corrected potential false trip of 27P when control power is first applied. Corrected use of 60FL for Setting Group Automatic Control.
2.03.02, 07/14	<ul style="list-style-type: none"> Added serial number to fault reports and sequence of events. Corrected access timeout operation. Corrected 62 logic timer operation when td2 is set less than 8 ms. Corrected 60FL operation that caused 60FL to be disabled when power is cycled. Corrected password setting for Modbus over RS485. Corrected sample rate in Comtrade files. Made fault trigger logic input edge triggered. Corrected operation that caused intermittent loss of sync output.
2.03.01, 09/09	<ul style="list-style-type: none"> Changed 79 Pilot Reclose functionality so that if the recloser is in reset, and if the time delay for the pilot reclose is non-zero, and if the 1st reclose time delay is set to zero, then upon a trip, a reclose initiate will cause the relay to use the 2nd reclose time delay as the 1st reclose time delay. Disabled recloser Timing Fail message to front panel HMI when the recloser fail timer TD=0. Corrected 25VM logic "Live Phase/Dead Aux" for AB, BC, and CA connections. Fixed invalid pointer so that screens are properly added to the screen scroll list.
2.03.00, 07/09	<ul style="list-style-type: none"> Increased immunity to noise when communicating via Modbus. Improved the SG-SCREEN command. Made firmware compatible with new digital board.
1.03.01, 10/08	<ul style="list-style-type: none"> Improved Sync-check function. Increased immunity to noise on IRIG input. Improved web pages.
1.03.00, 12/07	<ul style="list-style-type: none"> Added additional fault report screens to front panel HMI. Changed pickup setting range of 81 function. Changed default nominal frequency range. Added capability for the 25 function to synchronize down to 25 Hz.

Version and Date	Change
1.02.02, 10/06	<ul style="list-style-type: none"> Added style number and firmware version to fault reports and sequence of events. Improved viewing of web pages using Firefox® browser.
1.02.01, 02/05	<ul style="list-style-type: none"> Expanded LCD contrast adjustment. Improved 60FL function.
1.02.00, 01/05	<ul style="list-style-type: none"> Added the Modbus/TCP option.
1.01.00, 07/04	<ul style="list-style-type: none"> Added voltage-sensing options.
1.00.01, 06/04	<ul style="list-style-type: none"> Initial release.

Hardware Revision History

Revision and Date	Change
AR, 09/22	<ul style="list-style-type: none"> Updated internal documentation.
AP, 08/22	<ul style="list-style-type: none"> Updated digital board.
AO	<ul style="list-style-type: none"> This revision letter not used.
AN, 03/22	<ul style="list-style-type: none"> Updated internal documentation.
AM, 03/22	<ul style="list-style-type: none"> Tolerance improvements to fast transient conditions – Ethernet version.
AL, 03/22	<ul style="list-style-type: none"> Updated internal documentation.
AK, 01/22	<ul style="list-style-type: none"> Tolerance improvements to fast transient conditions – Non-Ethernet version.
AJ, 10/21	<ul style="list-style-type: none"> Updated digital board.
AI	<ul style="list-style-type: none"> This revision letter not used.
AH, 06/21	<ul style="list-style-type: none"> Updated the gold fingers on the 40-pin array on the analog board.
AG, 06/21	<ul style="list-style-type: none"> Updated internal documentation.
AF, 01/21	<ul style="list-style-type: none"> Added an edge connector spacer.
AE, 08/20	<ul style="list-style-type: none"> Updated Ethernet module.
AD, 04/20	<ul style="list-style-type: none"> Updated A/D converter.
AC, 02/20	<ul style="list-style-type: none"> Implemented UV printed rear label.
AB, 04/19	<ul style="list-style-type: none"> Updated flash memory component (hardware version AB produced concurrently with version AA).
AA, 10/18	<ul style="list-style-type: none"> Sensing CT design revised for improved reliability (hardware version AA produced concurrently with version AB).
Z	<ul style="list-style-type: none"> This revision letter not used.
Y, 09/17	<ul style="list-style-type: none"> Consolidated circuit board assemblies.
X, 08/17	<ul style="list-style-type: none"> Released firmware version 2.04.00.
W, 06/17	<ul style="list-style-type: none"> Updated LCD cable assembly.
V, 03/17	<ul style="list-style-type: none"> Removed CE markings from product.
U, 11/16	<ul style="list-style-type: none"> Released firmware version 2.03.04.
T, 06/14	<ul style="list-style-type: none"> Improved magnetics board.
S, 03/13	<ul style="list-style-type: none"> Improved watts and vars metering.
R, 11/11	<ul style="list-style-type: none"> Maintenance release.
Q	<ul style="list-style-type: none"> This revision letter not used.

Revision and Date	Change
P, 11/10	<ul style="list-style-type: none"> • Improved communications circuit on digital board.
N, 09/09	<ul style="list-style-type: none"> • Released BESTCOMS version 2.03.02 and firmware version 2.03.01.
M, 07/09	<ul style="list-style-type: none"> • Added power supply option 5, “125 Vac/dc with extended holdup”.
L, 06/09	<ul style="list-style-type: none"> • Standardized power supplies over several product lines.
K, 06/09	<ul style="list-style-type: none"> • Improved contact-sensing circuit on digital board.
J, 10/08	<ul style="list-style-type: none"> • Released firmware version 1.03.01.
H, 09/08	<ul style="list-style-type: none"> • EEPROM replacement.
G, 01/08	<ul style="list-style-type: none"> • Added nylon washer on analog board to prevent hipotting.
F, 03/07	<ul style="list-style-type: none"> • Changed rear label for only Ethernet options.
E, 12/05	<ul style="list-style-type: none"> • Released new power supply boards.
D, 04/05	<ul style="list-style-type: none"> • Re-designed terminal block to make it more reliable. • Modified Ethernet cutout on back of case.
C, 02/05	<ul style="list-style-type: none"> • Changed resistors on digital board to prevent input contacts on 24V units from picking up too low.
B, 01/05	<ul style="list-style-type: none"> • Added Modbus/TCP/IP protocol option.
A, 07/04	<ul style="list-style-type: none"> • Added support for voltage relays (BE1-700V).
—, 06/04	<ul style="list-style-type: none"> • Initial release.

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1 • General Information

The BE1-700 Digital Protective Relay is an economical, microprocessor based, multifunction system that is available in a panel mount, non-drawout case. **The relay can be purchased as a current relay (BE1-700C) or as a voltage relay (BE1-700V).** In this manual, function headings will note in parenthesis whether it applies to a current or voltage relay. (See Figures 1-1 and 1-2.) Depending on the type of relay, the BE1-700 features include the following. Functions are shown as **C** (current), **V** (voltage) or **A** (all - either current or voltage).

- **C** Three-phase Overcurrent Protection
- **C** Ground Overcurrent Protection
- **C** Negative-Sequence Overcurrent Protection
- **C** Breaker Failure Protection
- **V** Voltage Protection
- **V** Frequency Protection
- **A** Control Protection
- **A** Communication
- **A** Breaker Monitoring
- **A** Metering Functions
- **A** Automatic Reclosing (optional)

BE1-700 relays have four programmable contact sensing inputs, five programmable outputs, and one alarm output. Outputs can be assigned to perform protection, control, or indicator operations through logical programming. For example, protection functions could be programmed to cause a protective trip. Control functions could be programmed to cause a manual trip, manual close or automatic reclose. Indicators could be configured to annunciate relay failure, a settings group change, and others.

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

A simplified "How to Get Started" procedure for BE1-700 users is provided in Section 2, *Quick Start*.

Features

The BE1-700 family includes many features for the protection, monitoring, and control of power system equipment. These features include protection and control functions, metering functions, and reporting and alarm functions. A highly flexible programmable logic system called BESTlogic allows the user to apply the available functions with complete flexibility and customize the system to meet the requirements of the protected power system. Programmable I/O, extensive communication features and an advanced human-machine interface (HMI) provide easy access to the features provided.

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

Input and Output Functions

Input functions consist of power system measurement and contact sensing inputs. Programmable contact outputs make up the output functions.

Power System Measurement Functions

Three-phase currents or voltages are digitally sampled and the fundamental is extracted using a discrete fourier transform (DFT) algorithm.

The voltage sensing circuits can be configured for single-phase, three wire or four wire voltage transformer circuits. Voltage sensing circuitry provides voltage protection, frequency protection, and 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 VT source connected to the Vx input. This capability is useful for ground fault protection or sync-check functions.

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

Contact Sensing Inputs

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

Contact Outputs

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

Protection and Control Functions

Protection functions, depending on the relay style ordered, may consist of overcurrent, voltage, frequency, breaker reclosing, fuse loss and breaker failure protection and general purpose logic timers. Setting groups and virtual control switches make up the control functions. The following paragraphs describe each protection and control function.

Overcurrent Protection (BE1-700C)

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

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

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

Voltage Protection (BE1-700V)

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

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

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

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

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

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

Frequency Protection (BE1-700V)

There are six independent frequency elements. Each can be set for overfrequency or underfrequency operation. Each can be individually set to monitor the frequency on the main three-phase voltage input or the VX input.

Breaker Failure Protection (BE1-700C)

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

Fuse Loss Protection (BE1-700V)

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

General Purpose Logic Timers

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

Setting Groups

Two setting groups allow adaptive relaying to be implemented to optimize BE1-700 settings for various operating conditions. Automatic and external logic can be employed to select the active setting group.

Virtual Control Switches

BE1-700 virtual control switches include one virtual breaker control switch and two virtual 43 switches.

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

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

Metering Functions

Metering is provided for all measured currents, voltages and frequency, and all derived neutral and negative-sequence currents and voltages.

Reporting and Alarm Functions

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

Relay Identification

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

IRIG

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

General Status Reporting

The BE1-700 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 and negative-sequence values. The demand interval and demand calculation method are independently settable for phase, neutral and negative-sequence measurements. Demand reporting records today's peak, yesterday's peak and peak since reset with time stamps for each register.

Breaker Monitoring

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

Trip Circuit Monitoring

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

Fault Reporting

Fault reports consist of simple target information, fault summary reports, and detailed oscillography records to enable the user to retrieve information about disturbances in as much detail as is desired. The relay records and reports oscillography data in industry standard IEEE, Comtrade format to allow using any fault analysis software. All channels are recorded (IA, IB, IC, IN, VA, VB, VC, VX, I/O and Digital Point status) as they happen in real time. Scaling ratios such as CT and PT ratios are included in the COMTRADE standard configuration file, which allow the COMTRADE viewers to typically display primary values. Basler Electric provides a Windows® based program called BESTwave™ that can read and plot binary or ASCII format files that are in the COMTRADE format.

Sequence of Events Recorder

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

Alarm Function

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

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

Version Report

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

BESTlogic™ Programmable Logic

Each BE1-700 protection and control function is implemented in an independent function element. Every function block is equivalent to its single function, discrete device counterpart so it is immediately familiar to the protection engineer. Each independent function block has all of the inputs and outputs that the discrete component counterpart might have. Programming with BESTlogic is equivalent to choosing the devices required by your protection and control scheme and then drawing schematic diagrams to connect the inputs and outputs to obtain the desired operating logic.

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

Write Access Security

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

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

Security settings only affect write access.

Human-Machine Interface (HMI)

Each BE1-700 comes with a front panel display with five LED indicators for Power Supply Status, Relay Trouble Alarm, Minor Alarm, Major Alarm, and Trip. The lighted, liquid crystal display (LCD) allows the relay to replace local indication and control functions such as panel metering, alarm annunciation and control switches. Four scrolling pushbuttons on the front panel provide a means to navigate through the menu tree. Edit and reset pushbuttons provide access to change parameters and reset targets, alarms, and other registers. In Edit mode, the scrolling pushbuttons provide data entry selections. Edit mode is indicated by an Edit LED on the *Edit* pushbutton.

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

1. Recloser Active
2. Targets
3. Alarms
4. Programmable Automatic Scrolling List

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

Communication

Three independent, isolated communication ports provide access to all functions in the relay. COM0 is a nine pin RS-232 port located on the front of the case. COM2 is a two wire RS-485 port located on the back of the case. The optional rear Ethernet port is referred as Com1 in the BESTCOMS™ *General Operation* screen, *Security* tab.

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

A Modbus® protocol manual (9376700991) is optionally available for the RS-485 communication port. Ethernet information can be found in Section 15, *BESTnet™ Communication*.

Model and Style Number Description

General

The BE1-700 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, describes the options included in a specific device and appears on labels on the front panel and 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.

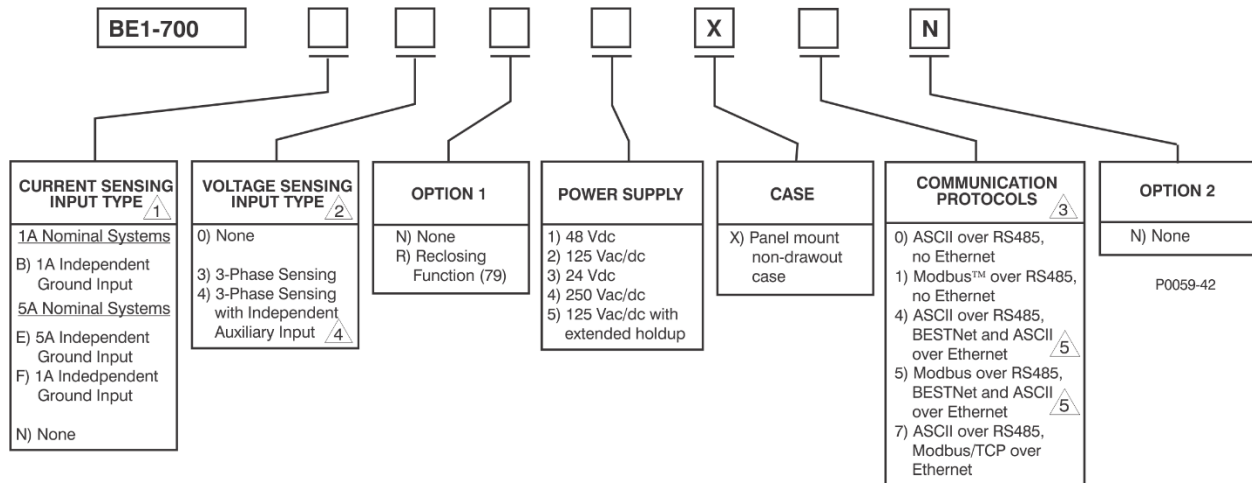
The style number identification chart, Figures 1-1, defines the electrical characteristics and operational features included in BE1-700 current and voltage relays. In this manual, the current relay will be referred to as a BE1-700C and the voltage relay as a BE1-700V.

Sample Style Number

If, for example, the style number were **E0N1X0N**, the device would be a current relay and have the following characteristics and features:

BE1-700 —

- (E) - 5 ampere phase and independent ground input
- (0) - No voltage sensing input
- (N) - No reclosing function option
- (1) - 48 Vdc power supply
- (X) - Panel mount, non-drawout case
- (0) - ASCII over RS-485, no Ethernet
- (N) - No Option 2 is available



NOTES:

- ¹ If current sensing input type is B, E, or F, then voltage sensing input type must be 0.
- ² If current sensing input type is N, then voltage sensing input type must be 3 or 4.
- ³ ASCII communications is standard on Com 0 (front RS-232).
- ⁴ Aux VT input adds 25 Sync-Check option.
- ⁵ BESTnet™ Webpage Interface supported in Microsoft® Internet Explorer® and Edge® in IE mode.

Figure 1-1. Style Number Identification Chart

Operational Specifications

Depending on the style ordered, BE1-700 relays have the following features and capabilities:

Metered Current Values and Accuracy (BE1-700C)

Current Range

5 Aac Nominal 0.5 to 15 Aac

1 Aac Nominal 0.1 to 3.0 Aac

Accuracy..... ±1% of reading, ±1 least significant digit at 25°C

Temperature Dependence ≤ ±0.02% per °C

Metered Voltage Values and Accuracy (BE1-700V)

Voltage Range

3-wire 0 to 300 VL-L

4-wire 0 to 300 VL-L

Accuracy (10 to 75 hertz)

50 V to 300 V ±0.5% of reading, ±1 least significant digit at 25°C

Temperature Dependence ≤ ±0.02% per °C

Metered Frequency Values and Accuracy (BE1-700V)

Frequency Range..... 10 to 75 Hz

Accuracy..... ±0.01 hertz, ±1 least significant digit at 25°C

Sensing Input

3-wire Phase A – B

4-wire Phase A – Neutral

Minimum Frequency Tracking Voltage 10 V rms

Calculated Values and Accuracy

Demand

Range..... 0.1 to 1.5 nominal

Type Exponential

Accuracy..... ±1% of reading ±1 digit at 25°C

Temperature Dependence ≤ ±0.02% per °C

Interval..... 1 to 60 min

24 Overexcitation Protection (BE1-700V)

Pickup

Setting Range 0.5 to 6 V/Hz

Accuracy..... ±2%

Integrating Time Delay

Time Dial 0.0 to 9.9

Reset Dial..... 0.0 to 9.9

Accuracy..... 5% or 4 cycles, whichever is greater

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

Time to Trip

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

Time to Reset

where:

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

Definite Time Delay

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

25 Sync-Check Protection (BE1-700V, Optional)

Settings

Delta Phase Angle	1 to 99°
Accuracy	±0.5°
Delta Voltage Magnitude.....	1 to 20 V
Accuracy	±2% or ±1 V, whichever is greater
Delta Frequency.....	0.01 to 0.50 Hz
Accuracy	±0.01 Hz

Voltage Monitoring

Live/Dead voltage threshold.....	10 to 150 V
Accuracy	±2% or ±1 V
Dropout Time delay.....	0.050 to 60 s
Accuracy	±0.5% or ±2 cycles, whichever is greater
Logic.....	Dead Phase/Dead Aux Dead Phase/ Live Aux Live Phase/ Dead Aux
One independent output.....	25VM1

27P Phase Undervoltage Protection (BE1-700V)

Pickup

Setting Range	10 to 300 V
Accuracy.....	±2% of setting or ±1 V, whichever is greater
Dropout/Pickup Ratio	102%

Time Delay

Setting Range	0.05 to 600 s
Accuracy.....	±0.5% or ±2.5 cycles, whichever is greater

27X Auxiliary Undervoltage Protection (BE1-700V)

Pickup

Setting Range	1 to 150 V
Accuracy.....	±2% of setting or ±1 V, whichever is greater
Dropout/Pickup Ratio	102%

Time Delay

Setting Range	0.05 to 600 s
Accuracy.....	±0.5% or ±2.5 cycles, whichever is greater

47 Negative-Sequence Overvoltage Protection (BE1-700)

Pickup

Setting Range	1.0 to 300 V _{L-N}
Accuracy	±2% of setting or ±1 V, whichever is greater
Dropout/Pickup Ratio	98%

Time Delay

Setting Range	0.050 to 600 s
Accuracy	±0.5% or ±2.5 cycles, whichever is greater

50T Instantaneous Overcurrent Protection (BE1-700C)

Pickup

Setting Range

5 Ampere CT	0.5 to 150 A
1 Ampere CT	0.1 to 30 A

Accuracy (50TP, 50TN)

5 Ampere CT	±2% or ±50 mA, whichever is greater
1 Ampere CT	±2% or ±10 mA, whichever is greater

Accuracy (50TQ)

5 Ampere CT	±3% or ±75 mA, whichever is greater
1 Ampere CT	±3% or ±15 mA, whichever is greater

Dropout/Pickup Ratio	95%
----------------------------	-----

Time Delay

Setting Range	0 to 60 s
---------------------	-----------

Accuracy

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

50BF Breaker Failure Protection (BE1-700C)

Pickup

Setting Range	Fixed at 0.5 A for 5 A unit, 0.1 A for 1 A unit
Accuracy	±10%

Time Delay

Setting Range	50 to 999 ms
Accuracy	±0.5% or +1¼, -½ cycles, whichever is greater
Reset Time	Within 1¼ cycles of the current being removed

51 Time Overcurrent Protection (BE1-700C)

Pickup

Setting Range

5 Ampere CT	0.5 to 16 A
1 Ampere CT	0.1 to 3.2 A

Accuracy (51P, 51N)

5 Ampere CT	±2% or ±50 mA, whichever is greater
1 Ampere CT	±2% or ±10 mA, whichever is greater

Accuracy (51Q)

5 Ampere CT	±3% or ±75 mA, whichever is greater
1 Ampere CT	±3% or ±15 mA, whichever is greater

Dropout/Pickup Ratio 95%

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.

59P Phase Overvoltage Protection (BE1-700V)

Pickup

Setting Range	10 to 300 V
Accuracy.....	±2% of setting or ±1 V, whichever is greater
Dropout/Pickup Ratio	98%

Time Delay

Setting Range	0.050 to 600 s
Accuracy.....	±0.5% or ±2.5 cycles, whichever is greater

59X Auxiliary Overvoltage Protection (BE1-700V)

Pickup

Setting Range	1 to 150 V
Accuracy.....	±2% of setting or ±1 V, whichever is greater
Dropout/Pickup Ratio	98%

Time Delay

Setting Range	0.050 to 600 s
Accuracy.....	±0.5% or ±2.5 cycles, whichever is greater

60FL Fuse Loss (BE1-700V)

Time Delay Fixed at 50 ms

62 Logic Timers

Modes.....	Pickup/Dropout, 1 Shot Nonretriggerable, 1 Shot Retriegerable, Oscillator, Integrating, Latch
Setting Range	0 to 9,999 s
Accuracy.....	±0.5% or ±12 ms, whichever is greater

79 Recloser Protection

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

Setting Range 100 ms to 600 s
Accuracy $\pm 0.5\%$ or $+1\frac{3}{4}\%$, -0 cycles, whichever is greater

81 Over/Under Frequency Protection (BE1-700V)

Pickup

Setting Range 20 to 70 Hz
Accuracy ± 0.01 Hz
Dropout 0.02 Hz ± 0.01 Hz of the actual pickup value

Time Delay

Setting Range 0.00 to 600 s
Accuracy $\pm 0.5\%$ or ± 1 cycle, whichever is greater, after a minimum of a 3 cycle recognition time

Voltage Inhibit

Setting Range 15 to 300 V
Accuracy $\pm 2\%$ or ± 1 V, whichever is greater

Automatic Setting Group Characteristics

Number of Setting Groups 2

Control Modes

Automatic Cold-Load Pickup, Dynamic Load or Unbalance, Recloser Shot, or Unbalance (BE1-700C); Fuse Loss (60FL) (BE1-700V)
External Discrete Input Logic, Binary Input Logic

Switch Level

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

Switch Timer

Setting Range 0 to 60 min with 1 min increments where 0 = disabled
Accuracy $\pm 0.5\%$ or ± 2 s, whichever is greater

BESTlogic™

Update Rate $\frac{1}{2}$ cycle

General Specifications

AC Current Inputs (BE1-700C)

5 Ampere CT

Continuous Rating 20 A
One Second Rating 400 A

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

Begins to Clip (Saturate) 150 A
Burden $< 0.01 \Omega$

1 Ampere CT

Continuous Rating..... 4 A
 One Second Rating..... 80 A

For other current levels, use the following formula: $I = (K/t)^{1/2}$ where t = time in seconds, K = 90,000 (panel mount, non-drawout case).

Begins to Clip (Saturate)..... 30 A
 Burden..... $\leq 0.01 \Omega$ at 1 A

Phase AC Voltage Inputs (BE1-700V)

Continuous Rating..... 300 V, Line to Line
 One Second Rating..... 600 V, Line to Line (3-wire sensing)
 600 V, Line to Neutral (4-wire sensing)
 Burden..... <1 VA at 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 at 150 Vac

Analog to Digital Converter

Type 16-bit
 Sampling Rate..... 24 samples per cycle, adjusted to input frequency (10 to 75 Hz)

Power Supply

Power supply ranges and holdup times are listed in Table 1-1.

Table 1-1. Power Supply Ranges and Holdup Times

Style Option	AC Range	AC Holdup Time	DC Range	DC Holdup Time
1) 48 Vdc	N/A	N/A	35 to 150 Vdc	30 ms
2) 125 Vac/dc	90 to 270 Vac	70 ms	90 to 300 Vdc	50 ms
3) 24 Vdc	N/A	N/A	17 to 32 Vdc †	80 ms
4) 250 Vac/dc	90 to 270 Vac	280 ms	90 to 300 Vdc	170 ms
5) 125 Vac/dc *	55 to 135 Vac	280 ms	35 to 150 Vdc	170 ms

* Extended holdup option. See Style Chart in Figure 1-1.

† Operates down to 8 Vdc momentarily.

Frequency Range

Options 1, 2, and 4 only 40 to 70 Hz

Burden

Options 1, 2, 3, 4, 5..... 8 W continuous, 11 W maximum with all outputs energized

Output Contacts

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

Contact-Sensing Inputs

Contact-sensing turn-on voltages and burdens are listed in Table 1-2. Burden values assume nominal value of input voltage applied.

Table 1-2. Contact-Sensing Turn-On Voltages and Burdens

Style Option	Nominal Input Voltage	Contact-Sensing Turn-On Voltage *	Burden
xxx1xxx	48 Vdc	26 to 38 Vdc	23 k Ω
xxx2xxx	125 Vac/dc	69 to 100 Vdc 56 to 97 Vac	53 k Ω
xxx3xxx	24 Vdc	Approx. 5 Vdc	6 k Ω
xxx4xxx	250 Vac/dc	138 to 200 Vdc 112 to 194 Vac	123 k Ω
xxx5xxx	125 Vac/dc †	69 to 100 Vdc 56 to 97 Vac	53 k Ω

* AC voltage ranges are calculated using the default recognition time (4 ms) and debounce time (16 ms).

† Extended holdup option. See Style Chart in Figure 1-1.

Recognition Time

Programmable..... 4 to 255 ms

Note

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

IRIG

Supports IRIG Standard 200-98, Format B002

Input Signal Demodulated (dc level-shifted digital signal)
 Logic-High Voltage 3.5 Vdc, minimum
 Logic-Low Voltage 0.5 Vdc, maximum
 Input Voltage Range ± 20 Vdc, maximum
 Resistance Nonlinear, approximately 4 k Ω at 3.5 Vdc,
 approximately 3 k Ω at 20 Vdc

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.

Communication Ports

RS-232

Connector.....	9-pin, sub D
Baud Rate	300 to 19200, 8N1 full duplex
Protocol:	ASCII
Response Time	<100 ms for metering and control functions

RS-485

Terminals.....	A, B, C
Baud Rate	300 to 19200, 8N1 half duplex
Protocol	ASCII standard, Modbus® optional

Ethernet

Connector.....	RJ-45 connector
Standard.....	IEEE 802.3, 10/100BaseT
Protocol	BESTnet™ or Modbus TCP, one connection

Display

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

Isolation

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

All Circuit Groups to Ground	2,000 Vac
All Circuit Groups to Circuit Group*	2,000 Vac
Communication Ports to Ground†.....	700 Vdc

* Excludes communication ports.

† Ethernet port excluded from dielectric tests.

Surge Withstand Capability

Oscillatory

IEEE Std C37.90.1-2002 - *IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus* (Excludes front panel RS-232 communication port. Shielded RJ-45 cable is required for the Ethernet port.)

Fast Transient

Qualified to IEEE Std C37.90.1-2002 - *IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus*. (Due to surge suppression components, excludes application across open output contacts. Excludes front panel RS-232 communication port. Shielded RJ-45 cable is required for the Ethernet port.)

Radio Frequency Interference (RFI)

Qualified to IEEE Std C37.90.2-2004 - *IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers*.

Electrostatic Discharge (ESD)

IEEE Std C37.90.3-2001 - *IEEE Standard Electrostatic Discharge Test for Protective Relays*.

Shock

Qualification IEC 255-21-2, Class 1

Vibration

Qualification IEC 255-21-1, Class 1

EnvironmentTemperature

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

Humidity

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

UL Approval

This product is recognized to applicable Canadian and US safety standards and requirements by UL.

Standards used for evaluation:

- UL 508
- CSA C22.2-14

Note: Output contacts are not recognized for voltages greater than 250 V.

Physical

Weight 4.33 lb (1.96 kg) maximum

Case Size See Section 12, Installation.



2 • Quick Start

This section provides an overview of the BE1-700 Digital Protective Relay. You should be familiar with the concepts behind the user interfaces and BESTlogic before you begin reading about the detailed BE1-700 functions. Sections 3 through 6 in the instruction manual describe each function of the BE1-700 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 BE1-700 relay. Detailed information on the operation of the human-machine interface (HMI) can be found in Section 10, *Human-Machine Interface*, and the ASCII command communications in Section 11, *ASCII Command Interface*. BESTCOMS™ is a Windows® based software application that enhances communication between the PC user and the BE1-700 relay. BESTCOMS for the BE1-700 is provided free of charge with the BE1-700. BESTCOMS operation is very transparent, and does contain a Windows type help file for additional operational details.

Also covered in this section is an overview of BESTlogic, which is fundamental to how each of the protection and control functions is set-up and used in the BE1-700 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 BE1-700 relay and include references to the following items. Note that **not** all items are appropriate for each function.

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

About This Manual

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

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

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

BESTlogic™

Each of the protection and control functions in the BE1-700 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 BE1-700 relay has all of the characteristics of Basler BE1 relays with similar functionality. Figure 2-1 is a logic drawing showing the inputs and outputs.

One input:

- BLK (block 51P operation)

Two mode settings:

- Enable 51P operation
- Disable 51P operation

Two outputs:

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

Four operational settings:

- Pickup
- Time Delay
- Characteristic Curve

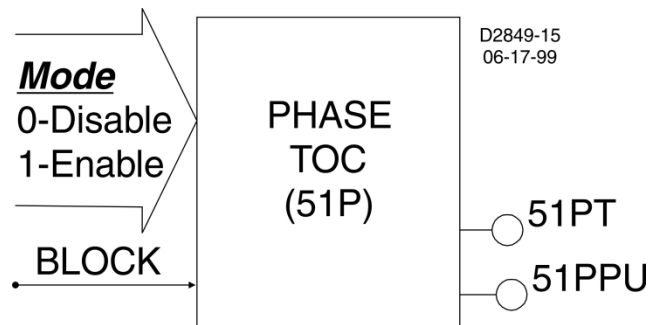


Figure 2-1. 51 Time Overcurrent Logic (BE1-700C)

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

Function Block Logic Settings

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

For example, the 51N function block has three modes (disabled, three-phase summation (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 (three-phase and neutral) with the function blocked

when Contact Sensing Input 2 is not (/) energized. Contact Sensing Input 2 would be wired to a ground relay enable switch.

As noted before, the protection settings for this function block, pickup, time dial, and curve must be set separately in the setting group settings. The setting might be S0-51N=6.5,2.1,S1R 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 Rreset characteristic.

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 BE1-700, supports up to 16 output expressions. The output expressions are called virtual outputs to distinguish them from the physical output relays. VOA and VO1 through VO5 drive physical outputs OUTA (failsafe alarm output) and OUT1 through OUT5, respectively. The rest of the virtual outputs can be used for intermediate logic expressions.

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

User Interfaces

Three user interfaces are provided for interacting with the BE1-700 relay: front panel HMI, ASCII communications, and BESTCOMS for BE1-700. 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 BE1-700 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 BE1-700 HMI is menu driven and organized into a menu tree structure with six branches. A complete menu tree description with displays is also provided in Section 10, *Human-Machine Interface*. A list of the menu branches and a brief description for scrolling through the menu is in the following paragraphs.

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

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

Viewing the 47 pickup and time delay settings of Setting Group 1 involves the following steps:

1. At the top level of the menu tree, use the *LEFT* or *RIGHT* scrolling pushbuttons to get to the PROTECTION logic branch (Screen 5).
2. Press the *DOWN* scrolling pushbutton to reach the SETTING GROUP level (Screen 5.1).
3. Scroll *RIGHT* to SETTING GROUP 1 branch (Screen 5.2).
4. From Screen 5.2, scroll down to the next level of detail which is the 24 SETTINGS (Screen 5.2.1).
5. Scroll right to the 47 SETTINGS (Screen 5.2.5) and then down to reach the 47 pickup and time delay settings (Screen 5.2.5.1).

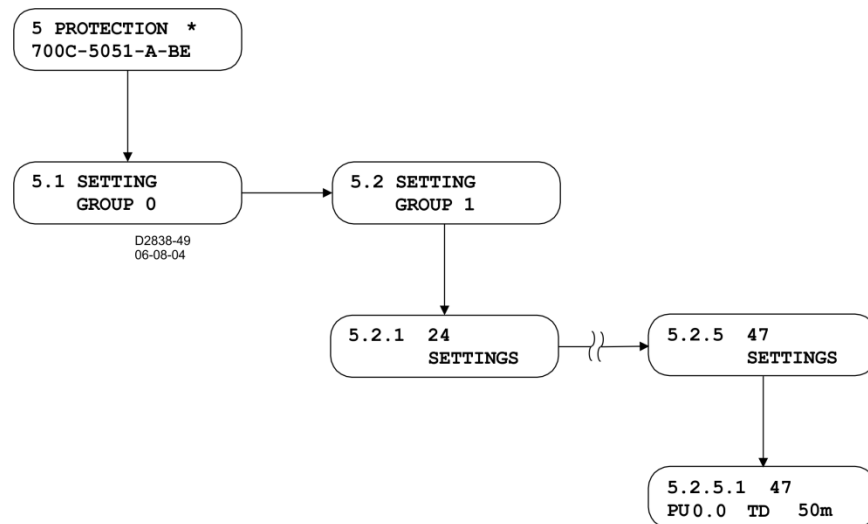


Figure 2-2. Menu Screens Numbering Example

ASCII Command Communications

The BE1-700 relay has two independent communications ports for serial communications plus one optional rear Ethernet port. A computer terminal or PC running a terminal emulation program such as Windows HyperTerminal can be connected to any of the ports so that commands can be sent to the relay. Communication with the relay uses a simple ASCII command language. When a command is entered via a serial port, the relay responds with the appropriate action. ASCII command communication is designed for both human-to-machine interactions and batch download type operations. The following paragraphs briefly describe the command structure and discuss human-to-machine interactions and batch command text file operations. The operation of the ASCII commands is described in detail in Section 11, *ASCII Command Interface*.

Command Structure

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

- C CONTROL. Commands to perform select before operate control actions such as tripping and closing the circuit breaker, changing the active setting group, etc. Subgroups include S for Select and O for Operate.
- G GLOBAL. Perform global operations that do not fall into the other general groups such as password security. Subgroups include: S for security settings.
- M METERING. Read all real time metering values. This general command group has no subgroups.
- P PROGRAM. Subgroup command to read or program a setting.
- R REPORTS. Read and reset reporting functions such as time and date, demand registers, breaker duty statistics, etc. Subgroups include: A for Alarm functions, B for Breaker monitoring functions, D for Demand recording functions, F for Fault summary reporting functions, G for General information, and S for sequence of events recorder functions.
- S SETTINGS. Set all setting parameters that govern the functioning of the relay. Subgroups include: 0,1, for settings in setting groups, A for alarm settings, B for breaker monitoring settings, G for general settings, and L for logic settings.

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

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

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

ASCII Command Operations

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

Example 1: Obtain a breaker operations count by entering RB (Report Breaker). The BE1-700 responds with the operations counter value along with all other breaker report objects. If you know that the object name for the breaker operations counter is OPCNTR, you can enter RB-OPCNTR and read only the number of breaker operations.

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

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

Batch Command Text File Operations

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

In batch download type operations, the user creates an ASCII text file of commands and sends it to the relay. To facilitate this process, the response from a multiple read command is output from the BE1-700 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 BE1-700, Graphical User Interface

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

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

The GUI also allows for downloading industry standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files may be accomplished using BESTWAVE. For more information on Basler Electric's Windows based BESTCOMS (GUI) software, refer to Section 14, *BESTCOMS Software*.

Getting Started

If your relay has Power Supply Option 2, it can be supplied by normal 120 Vac house power. This power supply option is the 125 Vac/Vdc power supply. The contact sensing inputs are half-wave rectified opto-isolators. The default contact recognition and debounce settings enable their use on ac signals as well as dc signals.

The BE1-700 measures the A phase, B phase, and C phase current magnitudes and angles directly from the three current sensing inputs. The neutral, positive, and negative-sequence magnitudes and angles are calculated from the fundamental component of each of the three-phase currents. When evaluating the negative-sequence functions, the relay can be tested using a single-phase current source. To fully evaluate the operation of the relay in the power system, it is desirable to use a three-phase current source.

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

Entering Test Settings

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

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

- The ratios for the phase and neutral current transformers (CTP, CTG).
- The demand interval and CT circuit to monitor for the phase, neutral and negative-sequence currents (DIP, DIN, DIQ).

- The nominal system frequency (FREQ).
- The normal phase-sequence (ABC or ACB) for the system (PHROT).
- Open the S0 file in a text editor, change settings as required, and save the changes.

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

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

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

Checking the State of Inputs

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

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

Testing

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

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

FAQ/Troubleshooting

Frequently Asked Questions (FAQs)

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

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

2.) Is the power supply polarity sensitive?

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

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

Voltage level is dependent on the power supply option (called out in the BE1-700 style chart). For additional information, see Figure 1-1 in Section 1, *General Information*, and Section 12, *Installation*.

4.) Does the BE1-700 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 BE1-700 does offer an option to ensure that the contact will stay closed for at least 200 milliseconds. See Section 3, *Input and Output Functions*, for additional information on that function. But, BESTlogic can keep the relay outputs closed as long as power is applied. Refer to Section 8, *Application, Application Tips*, for additional information.

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

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

6.) How many overcurrent elements does the BE1-700 have available?

The BE1-700 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 at the front panel?

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

8.) Since the BE1-700 is a programmable device, what are the factory defaults?

The factory default preprogrammed logic scheme depends on the specific type of relay ordered. See *Style Chart* in Section 1, *General Information*. A current relay has 700C-5051-A-BE or 700C-OC79-A-BE (R style) logic. A voltage relay has 700VOUVF-A-BE or 700V-VF79-A-BE (R style) 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.) Why do I keep getting access conflict errors when I attempt communication with the relay?

If you try to gain access to more than one port at a time, an access conflict results. The relay has three communication ports: COM 0, COM 1, and COM 2. The front panel HMI and RS-232 port are considered to be the same port and are designated COM0. COM 1 is the optional rear Ethernet port. The rear RS-485 port is designated as COM 2. If access at the front panel HMI has been obtained, access cannot be gained at another port. The front RS-232 port can still be accessed because the HMI and front RS-232 port are considered to be the same port (COM 0). Access needs to be gained only when a write command to the BE1-700 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.

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

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

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

Table 2-2. Trip LED Truth Table

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

11.) Is the IRIG signal modulated or demodulated?

The BE1-700 accepts an IRIG-B signal that is demodulated (dc level-shifted digital signal). See Section 1, *General Information, Operational Specifications*, for additional information.

12.) Can the IRIG signal be daisy-chained to multiple BE1-700 units?

Yes, multiple BE1-700 units can use the same IRIG-B input signal by daisy chaining the BE1-700 inputs. The burden data is nonlinear, approximately 4 kilo-ohms at 3.5 Vdc and 3 kilo-ohms at 20 Vdc. See Section 1, *General Information, Operational Specifications*, and Section 3, *Input and Output Functions*, for additional information.

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

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

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

You may also use your terminal emulation software to store reports in files as they are received from the relay. In BESTVIEW, this is accomplished by using the "log/open log file" function. In

Microsoft HyperTerminal, this function is available through the "capture text" feature. Microsoft Windows Terminal provides this function through the "received text file" feature.

14.) How can I check the version number of my BE1-700?

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 BE1-700. (The version is provided on the *General Information* tab of the *General Operation* screen.)

3 • Input and Output Functions

BE1-700C inputs consist of three-phase current inputs and an independent ground current input. BE1-700V inputs consist of three-phase voltage inputs and an optional single-phase auxiliary voltage input. Five general-purpose output contacts and one dedicated, fail-safe alarm output make up the BE1-700 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 BE1-700 uses for calculating the power quantities.

Power System Inputs

Power system inputs as described in the introduction, are sampled 24 times per cycle by the BE1-700. The BE1-700 measures the voltage and current from these samples and uses those measurements to calculate other quantities. Frequency is measured from a zero crossing detector. Measured inputs are then recorded every quarter cycle. If the applied voltage is greater than 10 volts, the BE1-700 measures the frequency and varies the sampling rate to maintain 24 samples per cycle. Frequency compensation applies to all power system measurements. Power system inputs are broken down in the following paragraphs into Current Measurement, Voltage Measurement, Frequency Measurement, Power Measurement, and Measurement Functions Setup.

Current Measurement (BE1-700C)

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 24 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 Measurement

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

Fast-Dropout Current Detector

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

Voltage Measurement (BE1-700V)

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 24 samples per cycle. The relay extracts the magnitude and angle of the fundamental components of each three-phase voltage input and the magnitude of the optional auxiliary voltage input.

VT Connections

When four-wire VT connections are used, the relay measures the AN, BN, and CN voltages and calculates the phase voltage quantities. Overvoltage and undervoltage functions (27/59) can be set to

operate on either the phase-to-neutral (PN) or phase-to-phase (PP) quantities. Three-wire VT connections limit 27/59 operation to PP quantities. When single-phase VT connections are used, the 27/59 elements operate as appropriate for the single-phase voltage applied.

Zero-Sequence Voltage

When four-wire VT connections are used, the BE1-700 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 (V_2) 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 (BE1-700V)

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 BE1-700 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 BE1-700 varies the sampling rate to maintain 24 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 50 milliseconds.

Nominal Frequency

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

Measurement Functions Setup

The BE1-700 requires information about the power system and its current and voltage transformers to provide metering, fault reporting, fault location, and protective relaying. This information is entered using BESTCOMS™. Alternately, it may be entered at the HMI (see Section 10, *Human-Machine Interface*) or through the communication port using the following ASCII commands: SG-CT, SG-VTP, SG-VTX, SG-FREQ, SG-NOM, 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.

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

Nominal Secondary Voltage and Current Settings, V_{nom} and I_{nom} , are used by the 60FL function. 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 BE1-700, 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 *Power System* tab is illustrated in Figure 3-1.

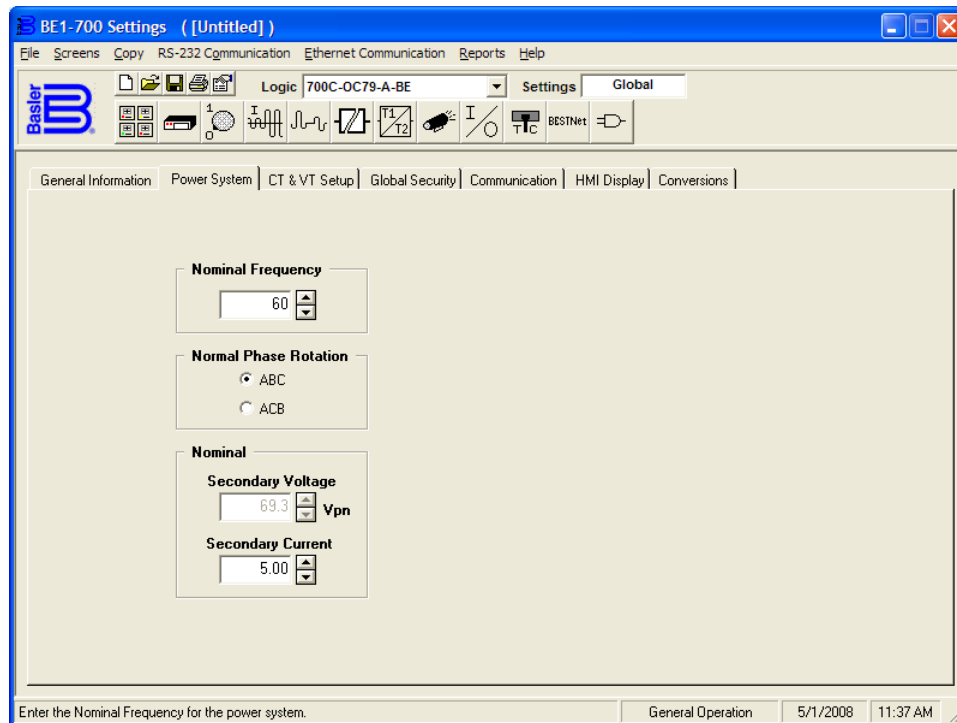


Figure 3-1. General Operation, Power System Tab

CT & VT Settings

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

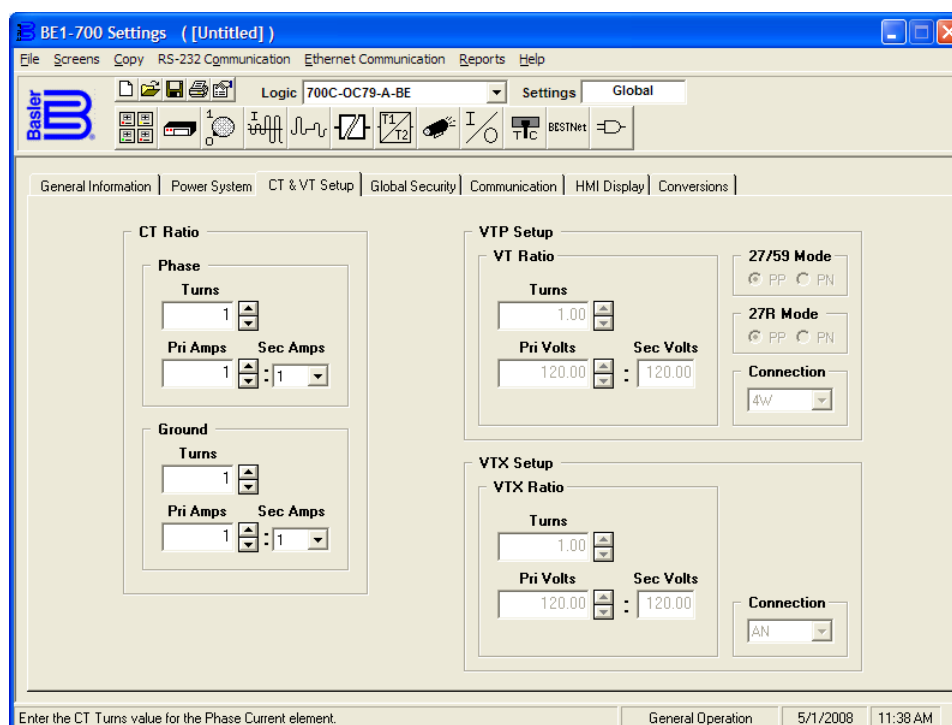


Figure 3-2. General Operation Screen, CT & VT Setup

CT Ratio. The BE1-700 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 BE1-700 requires setting information about the VT ratio, the VT connections, and the operating modes for the 27/59 and 27R functions. These settings are used by the metering and fault reporting functions to display measured quantities in primary units. The voltage input circuit settings also determine which power measurement calculations are used. Most of these connections such as 3W, 4W, AN, or AB are self-explanatory.

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

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

Table 3-1. Measurement Functions Settings

Relay Type	Function	Range	Increment	Unit of Measure	Default
C	CT Ratio	1 to 50,000	1	Turns	1
C	CT Ratio, Independent Ground Input	1 to 50,000	1	Turns	1
V	VTP Ratio	1 to 10,000	0.01	Turns	1
V	VTP Connection	3W, 4W, AN, BN, CN, AB, BC, CA	N/A	N/A	4W
V	27/59 Pickup Mode	PP (phase-to-phase)	N/A	N/A	PP

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

Contact-Sensing Inputs

BE1-700 relays have four contact-sensing inputs to initiate BE1-700 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 BE1-700 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 operate at a minimum of approximately 5 Vdc for 24 Vdc nominal sensing voltages, 26 Vdc for 48 Vdc nominal sensing voltages, 69 Vdc for 125 Vdc nominal sensing voltages, or 138 Vdc for 250 Vdc nominal sensing voltages. See Table 3-2 for the contact-sensing turn-on voltages.

Table 3-2. Contact-Sensing Turn-On Voltages

Style Option	Nominal Input Voltage	Contact-Sensing Turn-On Voltage †
xxx1xxx	48 Vdc	26 to 38 Vdc
xxx2xxx	125 Vac/dc	69 to 100 Vdc 56 to 97 Vac
xxx3xxx	24 Vdc	Approx. 5 Vdc
xxx4xxx	250 Vac/dc	138 to 200 Vdc 112 to 194 Vac
xxx5xxx	125 Vac/dc *	69 to 100 Vdc 56 to 97 Vac

* Extended holdup option. See Style Chart in Figure 1-1.

† AC voltage ranges are calculated using the default recognition time (4 ms) and debounce time (16 ms).

Digital Input Conditioning Function

Status of the contact sensing inputs is checked every millisecond. (See Figure 3-3.) 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.

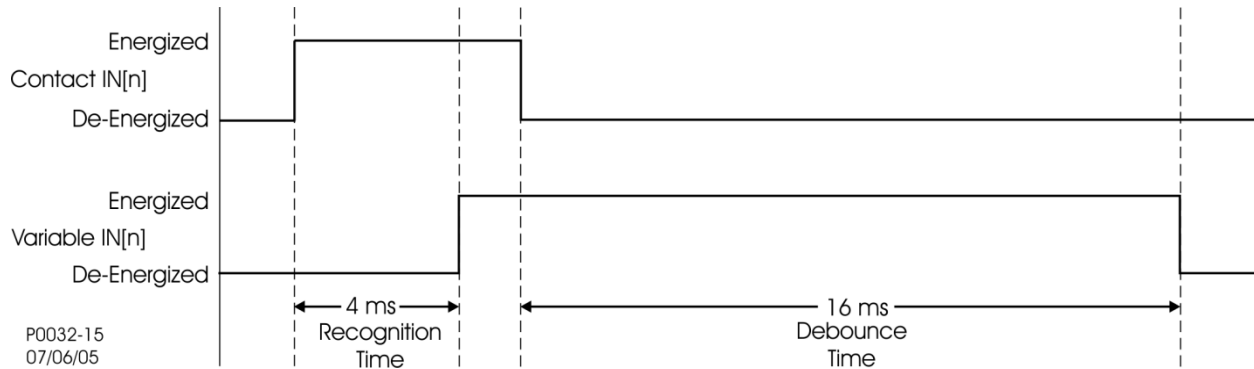


Figure 3-3. Digital Input Conditioning Timing Diagram

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.

Setting the Digital Input Conditioning Function

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

Each of the four inputs has two settings and three labels. The settings are *Recognition Time* and *Debounce Time*. The labels include a label to describe the input, a label to describe the *Energized State*, and a label to describe the *De-Energized State*. Labels are used by the BE1-700's reporting functions.

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

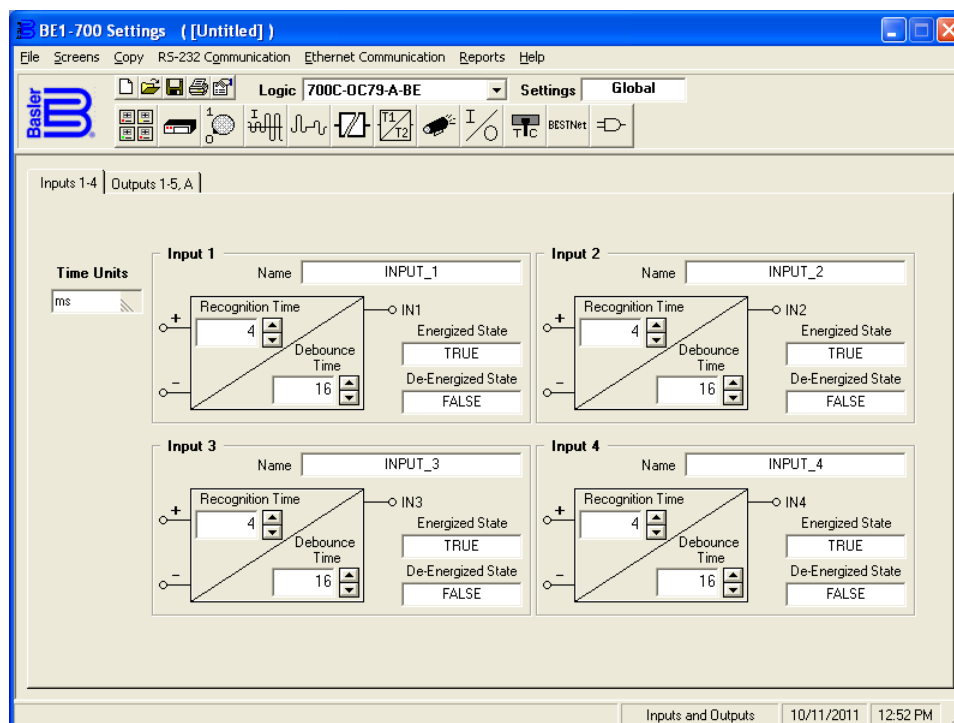


Figure 3-4. Inputs and Outputs Screen, Inputs 1-4 Tab

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

Table 3-3. Digital Input Conditioning Settings

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

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

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

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

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

Retrieving Input Status Information from the Relay

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

Outputs

BE1-700 relays have five general-purpose output contacts (OUT1 through OUT5) and one fail-safe, normally closed (when de-energized), alarm output contact (OUTA). Each output is isolated and rated for tripping duty. OUT1 through OUT5 are Form A (normally open) and OUTA is Form B (normally closed). A trip coil monitoring circuit is hardwired across OUT1. See Section 6, *Reporting and Alarm Functions, Trip Circuit Monitoring*, for details.

Hardware Outputs and Virtual Outputs

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

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

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

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.

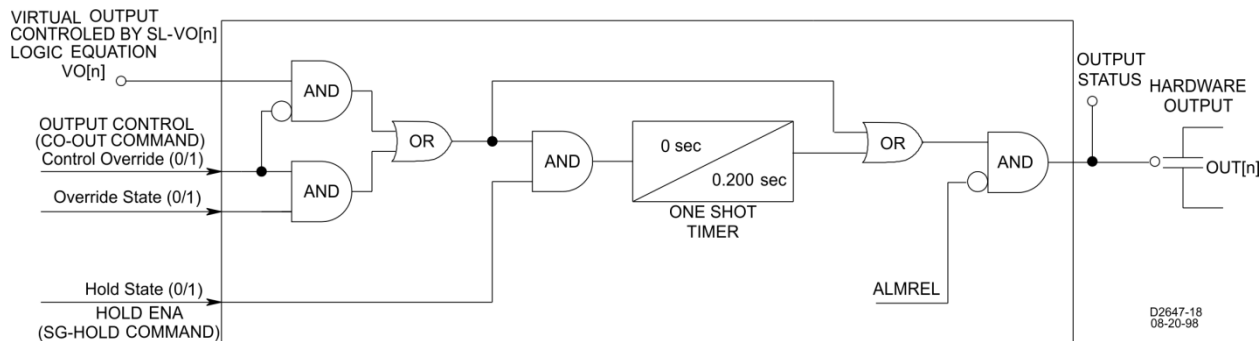


Figure 3-5. Output Logic, General Purpose Output Contacts

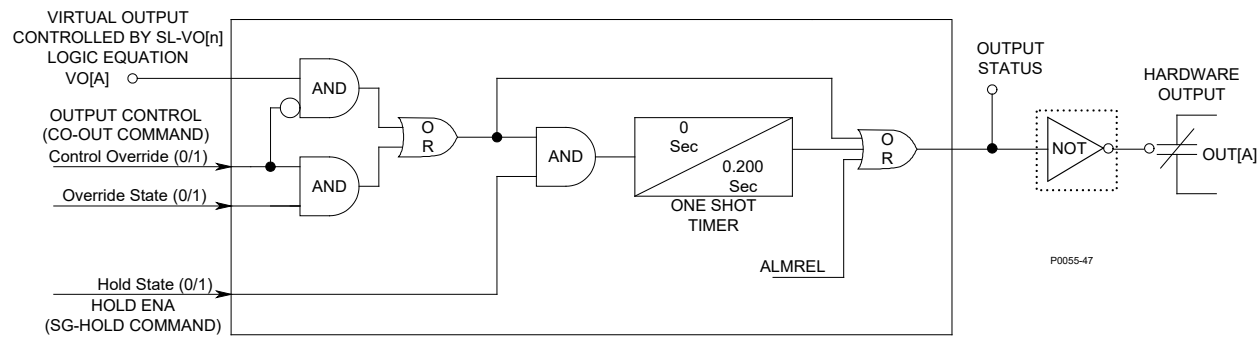


Figure 3-6. Output Logic, Fail-Safe Alarm Output Contact

Retrieving Output Status

Output status is determined through BESTCOMS by selecting *Metering* from the *Reports* pull-down menu and selecting the *Start Polling* button on 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 BE1-700 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, closing the OUTA contact. 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 BE1-700.

To prevent the output relay contacts from opening prematurely, a hold timer can hold the output contact closed for a minimum of 200 milliseconds. If seal-in logic with feedback from the breaker position logic is desired, the BESTlogic expression for the tripping output can be modified. This process is described in Section 8, *Application, Application Tips, Output Contact Seal-In*.

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

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

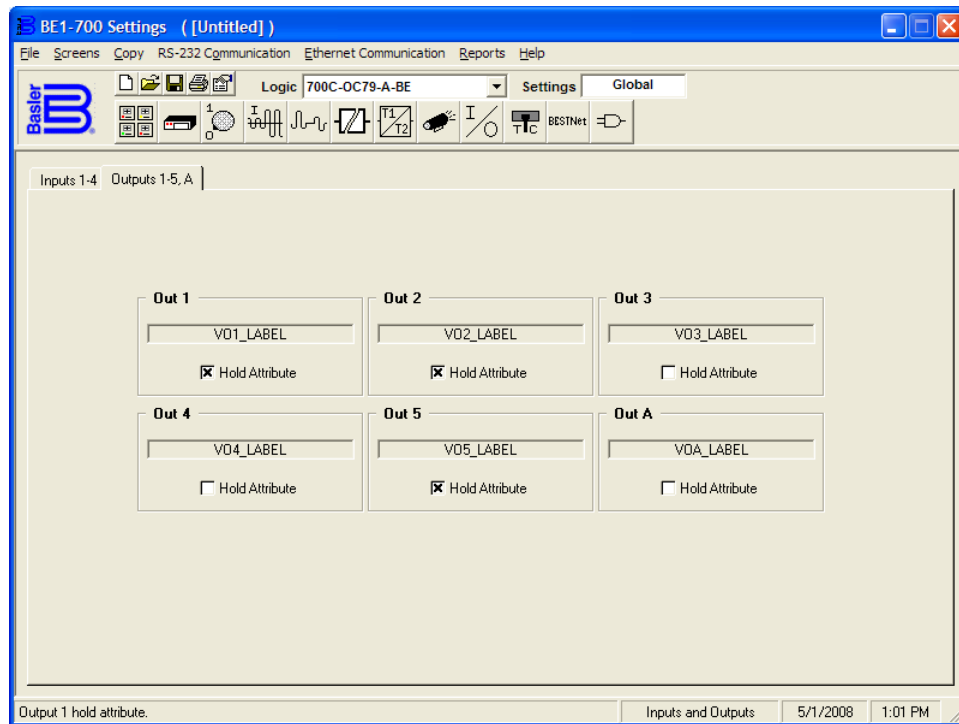


Figure 3-7. Inputs and Outputs Screen, Outputs 1-5, A Tab

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

Table 3-4. Hold Timer Settings

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

Output Logic Override Control

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

Enabling Logic Override Control

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

Pulsing an Output Contact

Pulsing BE1-700 outputs provides the same function as the push-to-energize feature of other Basler Electric solid-state relays. This feature is useful when testing the protection and control system. When pulsed, an output contact changes from the current state (as determined by the virtual output logic expression) to the opposite state for 200 milliseconds. After 200 milliseconds, the output contact is returned automatically to logic control.

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

Holding an Output Contact Open or Closed

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

Returning an Output Contact to Logic Control

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

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

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

CS/CO-OUT Command Examples:

1. Enable the output control feature.


```
>CS-OUT=ENA
OUT=ENA SELECTED
>CO-OUT=ENA
OUT=ENA EXECUTED
>E (exit)
Save Changes (Y/N/C)?
>Y (yes)
```
2. Test all outputs by pulsing momentarily.


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


```
>CS-OUT1=0
OUT1=0 SELECTED
>CO-OUT1=0
OUT1=0 EXECUTED
```

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

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

Retrieving Output Logic Override Status

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

4 • Protection and Control

The BE1-700 Digital Protective Relay provides the following functions that can be used to protect and control power system equipment. **C** identifies a BE1-700C; **V** identifies a BE1-700V; **A** means both.

BE1-700 protection functions include:

- V Volts per Hertz Overexcitation (24)
- V Synchronism-check (25) (optional) including Conditional Voltage (25VM)
- V Three-phase Undervoltage and Overvoltage (27P/127P and 59P/159P)
- V Auxiliary Undervoltage and Overvoltage (27X and 59X/159X)
- V Negative-Sequence Overvoltage (47)
- C Instantaneous Overcurrent w/ Settable Time Delay (50TP, 50TN, 50TQ, 150TP, 150TN, 150TQ)
- C Time Overcurrent (51P, 51N, 51Q, 151N)
- V VT Fuse Loss Detection (60FL)
- A General Purpose Logic Timers (62, 162)
- V Overfrequency and Underfrequency (81, 181, 281, 381, 481, 581)
- C Breaker Failure (50BF)

BE1-700 control functions include:

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

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

Using Protection and Control Functions

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

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

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

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

Setting Groups

The BE1-700 Digital Protective Relay provides a normal setting group (SG0) and one auxiliary setting group (SG1). The auxiliary setting group allows for adapting the coordination settings to optimize them for a predictable situation. Sensitivity and time coordination settings can be adjusted to optimize sensitivity or clearing time based upon source conditions or to improve security during overload conditions. The possibilities for improving protection by eliminating compromises in coordination settings with adaptive setting groups is endless. Figure 4-1 shows the setting group control logic block.

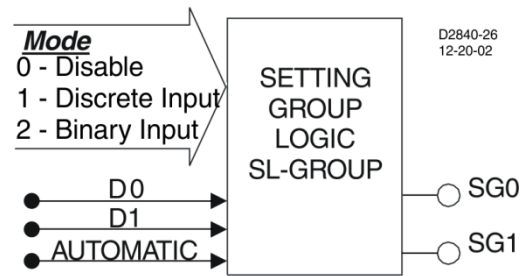


Figure 4-1. Setting Group Control Logic Block

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

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

The setting group control function logic also has an alarm output variable SGC (Setting Group Changed). This output is asserted whenever the BE1-700 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 BE1-700 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 BE1-700 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 BE1-700 off line. The active setting group is saved in nonvolatile memory so that the BE1-700 will power up using the same setting group that was active when it was powered down. To prevent the BE1-700 from changing settings while a fault condition is in process, setting group changes are blocked when the BE1-700 is in a picked-up state. Since the BE1-700 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 BE1-700 stays in that group regardless of the state of the manual logic control conditions.

BESTlogic Settings for Setting Group Control

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

must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

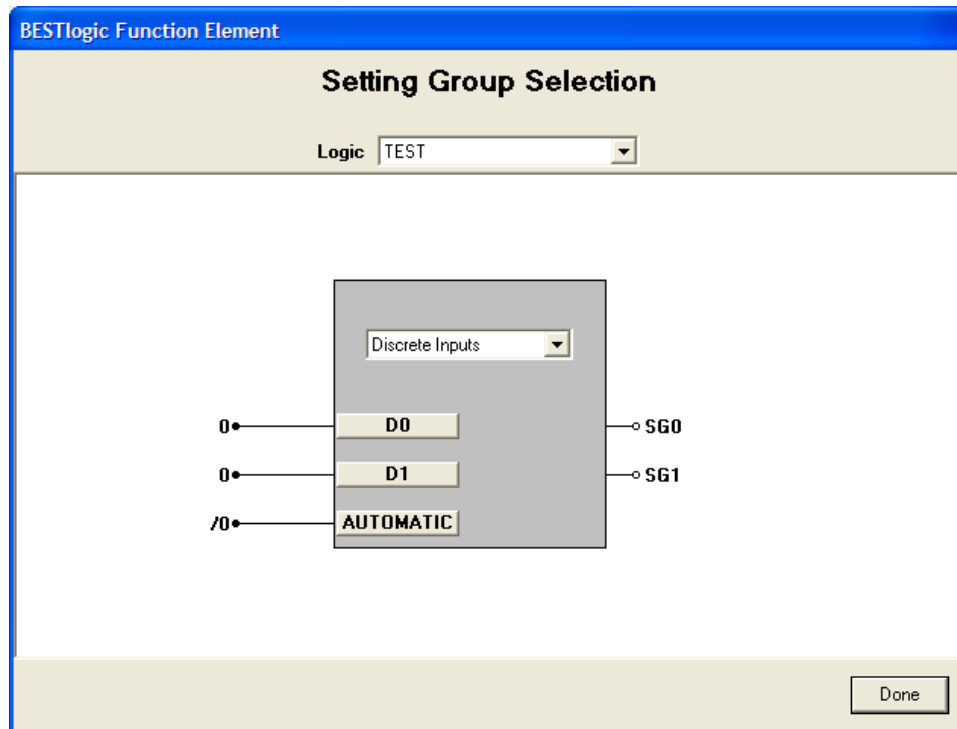


Figure 4-2. BESTlogic Function Element Screen, Setting Group Selection

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

Table 4-1. BESTlogic Settings for Setting Group Control

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

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

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

setting group change can occur within two times the SGC alarm on-time. Any pulses to the inputs will be ignored during that period.

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

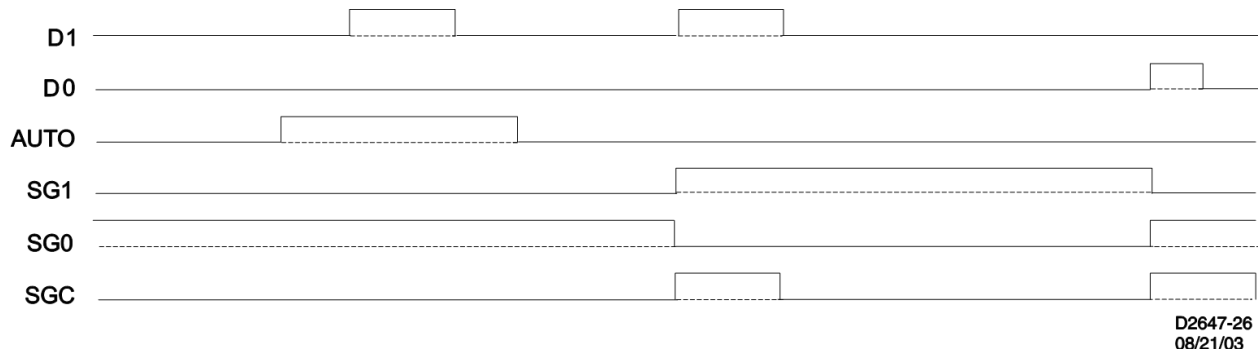


Figure 4-3. Input Control Mode 1

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

Table 4-2. Setting Group Binary Codes

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

Automatic Setting Group Control

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

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

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

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

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

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

Automatic Control by Monitoring Line Current

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

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

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

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

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

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

On the BE1-700C, this function can also be used to automatically change the active setting group for cold load pickup conditions. If the *switch threshold* for a group is set to 0%, the function will switch to that group when there is no current flow for the time delay period, indicating that the breaker is open or the circuit source is out of service. The threshold for this is 10% nominal rating of the relay current input.

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

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

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

The points in the reclose process that the 791, 792, 793, and 794 setting causes a change to the desired setting group is when a) the referenced reclose occurs and b) after the breaker closes. For instance, SP-GROUP1 = ,,,,791 will cause the relay to change from Setting Group 0 to Setting Group 1 after the first reclose, but not until the relay senses the breaker has actually closed.

Example:

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

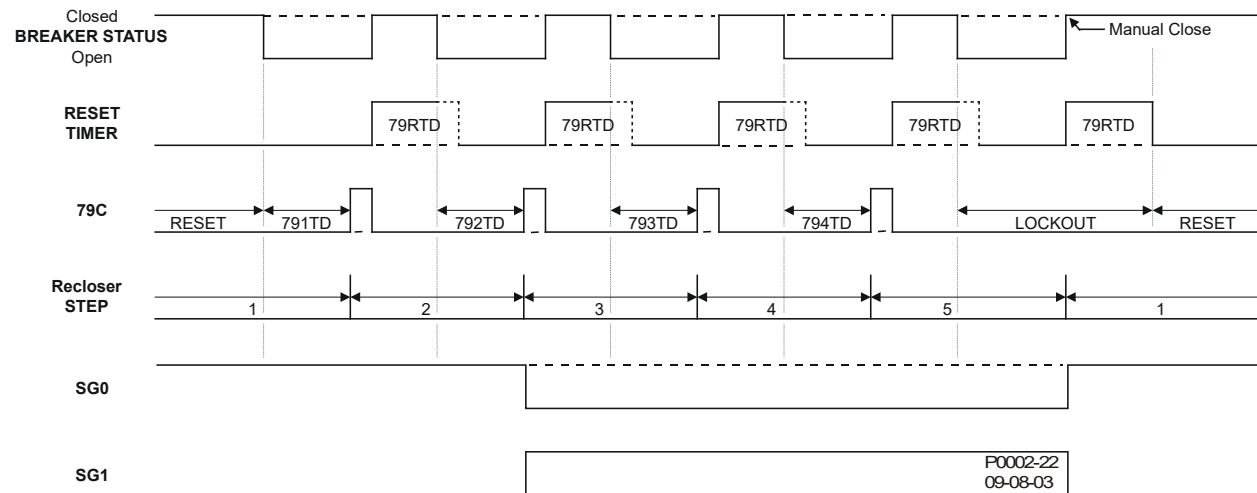


Figure 4-4. Example 1 - Change Group on Recloser Shot

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 Setting Group 1 using the command SP-GROUP1=,,, <60FL>. If the monitored element in the SP-GROUP command is 60FL, the switch-to threshold, return time, and return threshold are ignored.

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

Operating Settings for Setting Group Control

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

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

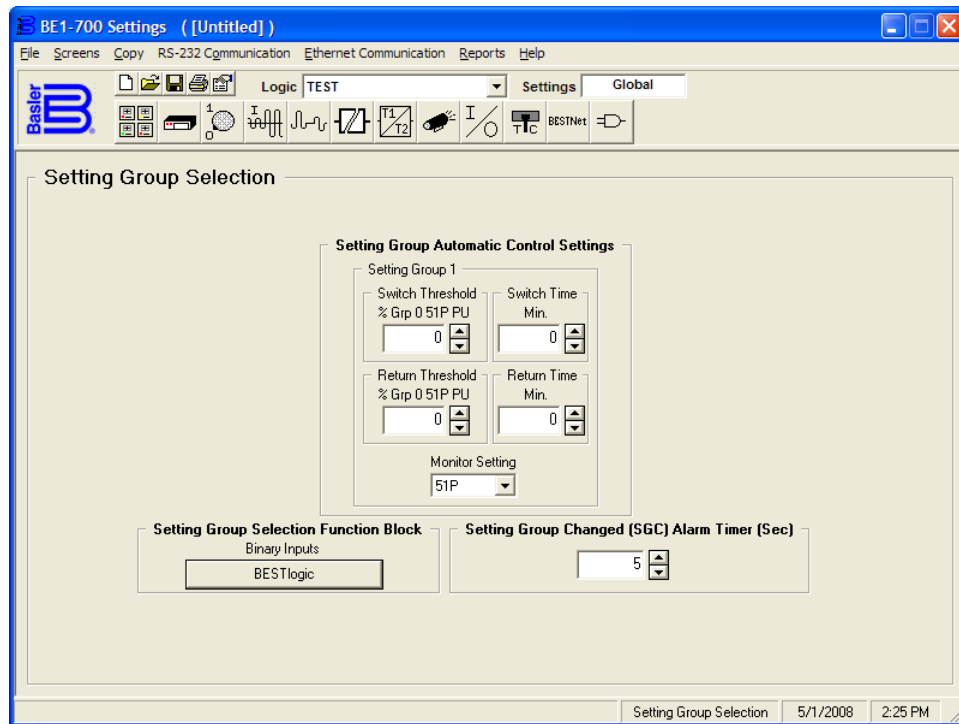


Figure 4-5. Setting Group Selection Screen

Table 4-3. Operating Settings for Setting Group Control

Setting	Range	Purpose	Default
Switch Time	1 to 60 0 = Disabled	Time in minutes that determines when a setting change occurs once the <i>Switch Threshold</i> setting is exceeded.	0
Switch Threshold	0 to 150	Percentage of the SGO <i>Monitor Setting</i> 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 SGO will occur once the monitored current has decreased below the <i>Return Threshold</i> setting.	0
Return Threshold	0 to 150	Percentage of the SGO <i>Monitor Setting</i> that the monitored current must decrease below in order for a return to SGO.	0
Monitor Setting	51P, 51N, 151N, 51Q (BE1-700C only); 60FL (BE1-700V only); 791, 792, 793, or 794	Determines when automatic setting group changes occur. Time overcurrent elements 51P, 51N, 151N, or 51Q can be selected so that setting group changes are based on load current. Recloser Shots 791, 792, 793, or 794 can be used to switch setting groups when the appropriate shot is reached in a reclosing sequence. Fuse Loss (60FL) can also be used to switch setting groups. If 60FL or one of the recloser shots is entered as the <i>Monitor Setting</i> , the <i>Switch Time</i> , <i>Switch Threshold</i> , <i>Return Time</i> , and <i>Return Threshold</i> parameters are not required.	51P
Setting Group Change (SGC) Alarm Timer	1 to 10 0 = Disabled	Measured in seconds, the SGC alarm timer sets the amount of time the alarm is on.	5

Logic Override of the Setting Group Control Function

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

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

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

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

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

CS/CO-GROUP Command

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

Syntax: CS-GROUP[=<mode>]

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

CS/CO-GROUP Command Examples:

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

```
>CO-GROUP
L
```

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

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

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

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

Retrieving Setting Group Control Status from the Relay

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

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

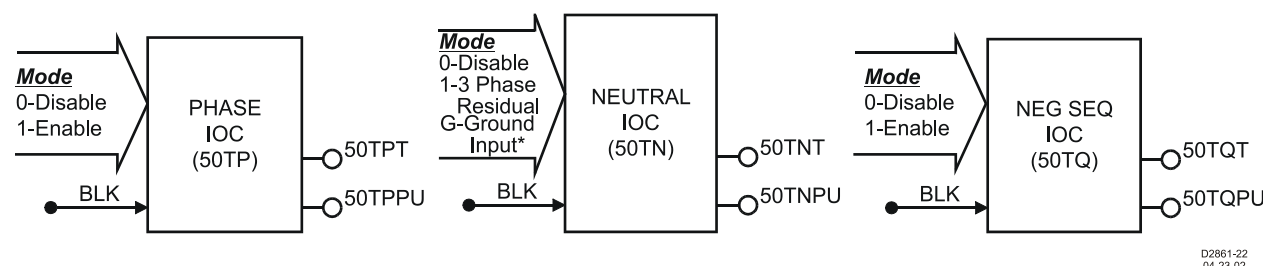
Overcurrent Protection (BE1-700C)

The BE1-700C includes instantaneous elements for Phase, Neutral or Ground, and Negative-Sequence as well as time overcurrent elements for Phase, Neutral or Ground, and Negative-Sequence.

50T - Instantaneous Overcurrent Protection with Settable Time Delay

There are two BESTlogic elements for phase (50TP and 150TP), two elements for ground (50TN and 150TN), and two elements for negative-sequence (50TQ and 150TQ) instantaneous overcurrent protection. The alphanumeric designation for each element contains the letter T to indicate that the element has an adjustable time delay. If an element has a time delay setting of zero, then that element will operate as an instantaneous overcurrent relay.

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



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Figure 4-6. Instantaneous Overcurrent Logic Blocks

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

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

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

The phase overcurrent protective functions include three independent comparators and timers, one for each phase. When current increases above the pickup setting, the pickup output asserts. 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.

BESTlogic Settings for Instantaneous Overcurrent Protection

BESTlogic settings are made from the BESTlogic Function Element screen in BESTCOMS. Figure 4-7 illustrates the BESTCOMS screen used to select BESTlogic settings for the 50T and 150T elements. To open the *BESTlogic Function Element* screen, select *Overcurrent Protection* from the *Screens* pull-down

menu. Then select the *50T* or *150T* Tab. Open the *BESTlogic Function Element* screen for the desired element by selecting the *BESTlogic* button corresponding with the desired element. Alternately, these settings can be made using the SL-50T and SL-150T ASCII commands.

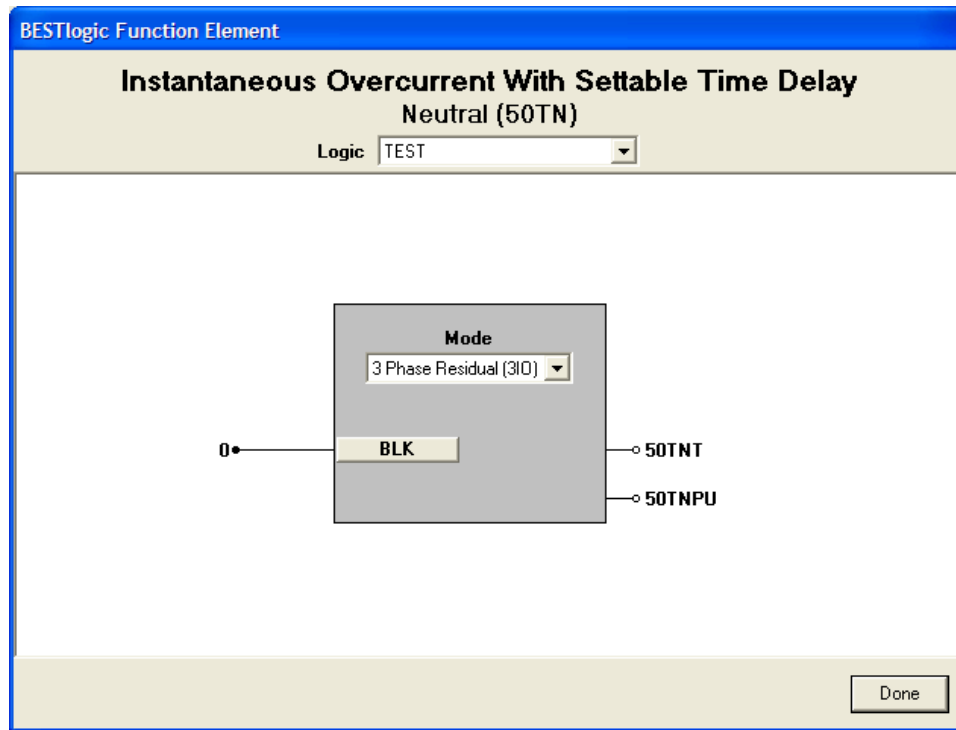


Figure 4-7. BESTlogic Function Element Screen, Neutral (50TN)

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

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

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

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

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

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

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

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

Note

If the BE1-700 has 5 ampere phase inputs and a 1 ampere independent ground input, the valid pickup setting range of the neutral overcurrent functions will depend on the logic mode setting which designates whether the three-phase residual or the independent ground input is to be monitored. If changing logic schemes or settings causes a neutral overcurrent setting to be OUT OF RANGE, the out of range setting will be forced in-range by multiplying or dividing the current setting by 5.

Operating Settings for Instantaneous Overcurrent Protection

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

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

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

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

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

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

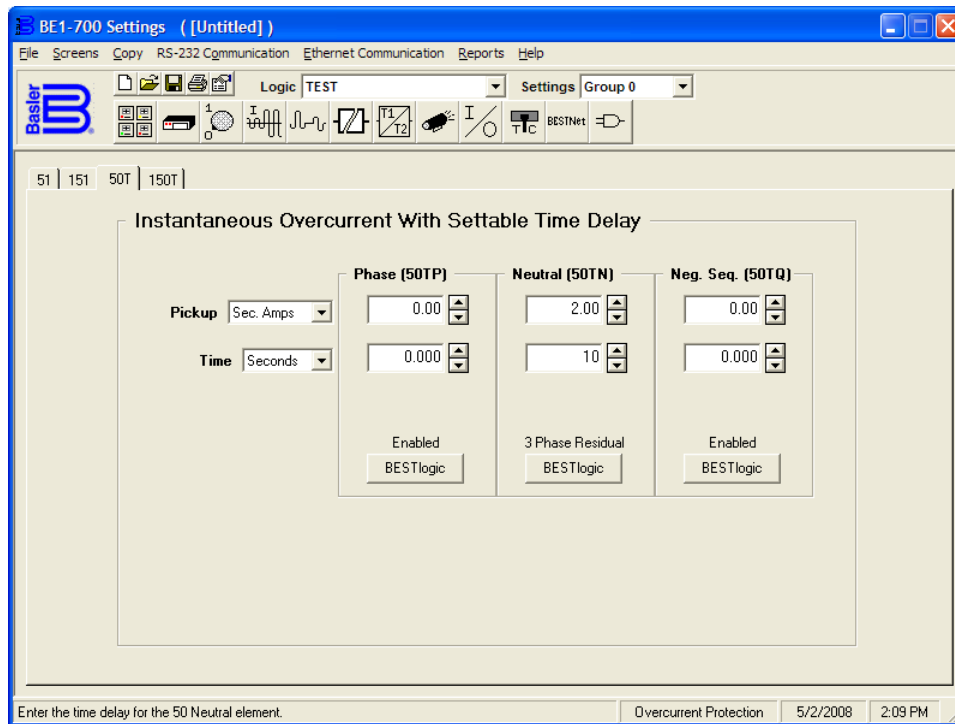


Figure 4-8. Overcurrent Protection Screen, 50T Tab

Table 4-7. Operating Settings for Instantaneous Overcurrent Protection

Setting	Range		Increment	Unit of Measure	Default
	1 A	5 A			
Pickup	0 = Disabled 0.1 to 30	0 = Disabled 0.5 to 150	0.01 for 0.1 to 9.99 0.1 for 10.0 to 99.9 1.0 for 100 to 150	Secondary Amps	0
Time	0 to 999 milliseconds		1	Milliseconds	0
	0.1 to 60 seconds		0.1 for 0.1 to 9.9	Seconds	
			1.0 for 10 to 60	Seconds	
	0 to 3600 cycles (60 Hz)	0 to 2500 cycles (50 Hz)	*	Cycles	

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

Retrieving Instantaneous Overcurrent Protection Status from the Relay

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

51 - Time Overcurrent Protection

BE1-700 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 4-9 shows the 51P, 51N, and 51Q elements. The 151N element is identical in configuration. Each element has two outputs: Pickup (PU) and Trip (T). A *BLK* (Block) logic input is provided to disable the

function. When this expression is TRUE, the element is disabled by forcing the outputs to logic 0 and resetting the timers to zero. This feature operates in a similar manner to the torque control contact of an electromechanical relay.

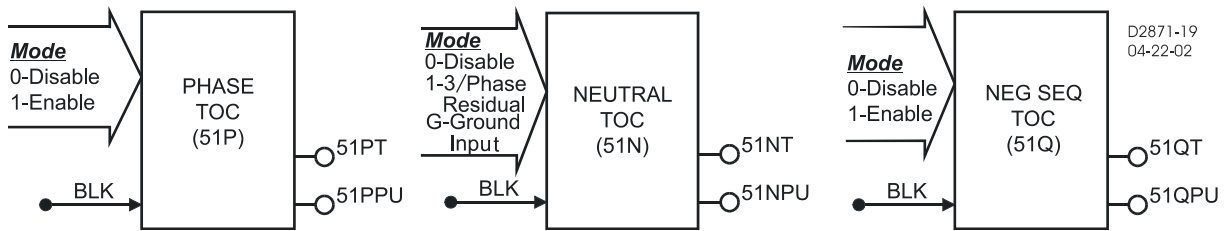


Figure 4-9. Time Overcurrent Logic Blocks

Each inverse time overcurrent function has a *Mode*, *Pickup*, *Time Dial* 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.

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.

BESTlogic Settings for Time Overcurrent Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-10 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Time Overcurrent* function. To open the screen, select *Overcurrent Protection* from the *Screens* pull-down menu and select either *51* or *151* tab. Then select the *BESTlogic* button at the bottom of the screen that corresponds with the element to be modified. Alternately, settings may be made using the SL-51 and SL-151 ASCII commands.

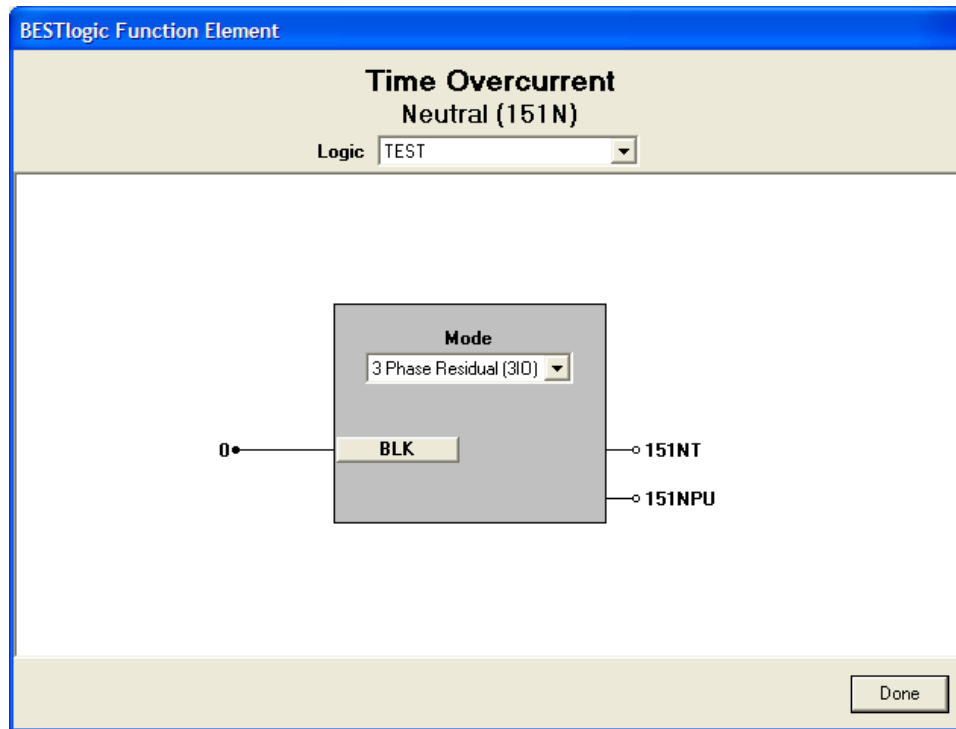


Figure 4-10. BESTlogic Function Element Screen, Neutral (151N)

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

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

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

Table 4-8. BESTlogic Settings for Time Overcurrent Protection

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

Operating Settings for Time Overcurrent Protection

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

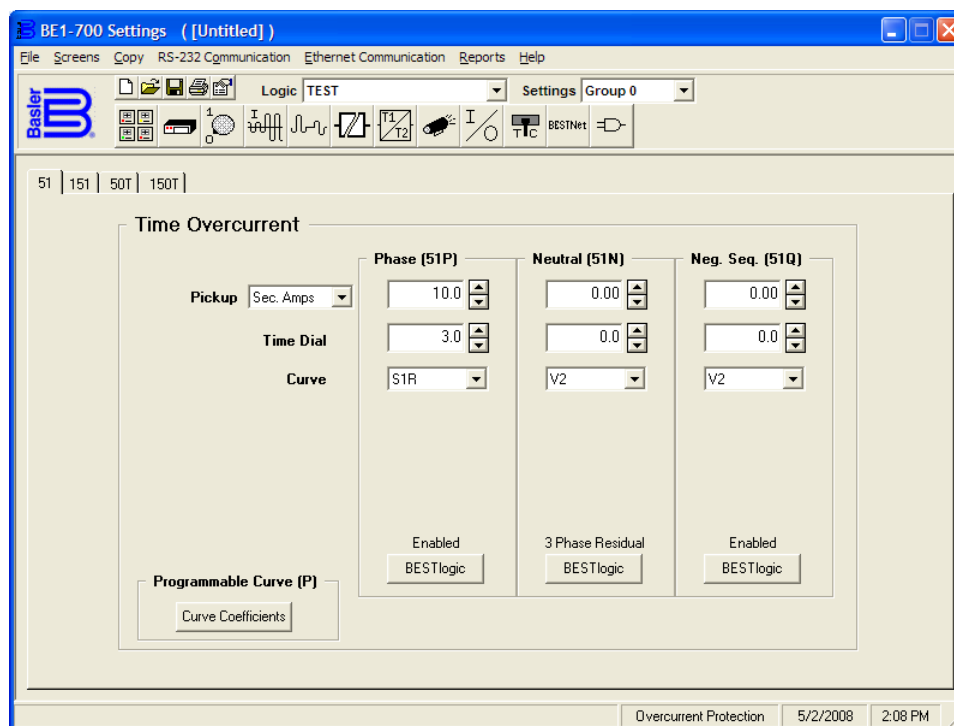


Figure 4-11. Time Overcurrent Protection Screen, 51 Tab

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

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

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

Table 4-9. Operating Settings for Time Overcurrent Protection

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

Retrieving Time Overcurrent Protection Status from the Relay

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

Programmable Curves

Time current characteristics for trip and reset programmable curves are defined by Equation 4-1 and Equation 4-2 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 4-1. Time OC Characteristics for Trip

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

Equation 4-2. Time OC Characteristics for Reset

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

Table 4-10. Definitions for Equations 4-1 and 4-2

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

Setting Programmable Curves

Curve coefficients are entered using BESTCOMS. Alternately, curve coefficients can be entered using the SP-CURVE ASCII (Settings Protection-programmable curve) command. Table 4-11 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 are entered by selecting the *Curve Coefficients* button on the 51 tab in the *Time Overcurrent* screen. (Refer to Figure 4-11.) The Curve Coefficients screen will appear (see Figure 4-12). 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.

Constant	Value	Range
A Constant	0.2663	0 - 600
B Constant	0.0339	0 - 25
C Constant	1.0000	0.0 - 1.0
N Constant	1.2969	0.5 - 2.5
R Constant	0.5000	0 - 30

Figure 4-12. Curve Coefficients

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. However, in actuality, the 46 curve may be selected for use with the 51P, 51N, and 51Q protection functions as well (though in actual practice, it is doubted that this will be done very often).

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

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 ($3I_0$) 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 $\sqrt{3}/2$ (87%) of the three-phase fault at the same location. This is illustrated in Figure 4-14.

The phase-to-phase fault is made up of both positive and negative-sequence components as shown in Figure 4-13 or a phase-to-phase fault, the magnitude of the negative-sequence component is $1/3$ (58%) of the magnitude of the total phase current. When these two factors ($\sqrt{3}/2$ and $1/\sqrt{3}$) are combined, the $\sqrt{3}$ factors cancel which leaves the one-half factor.

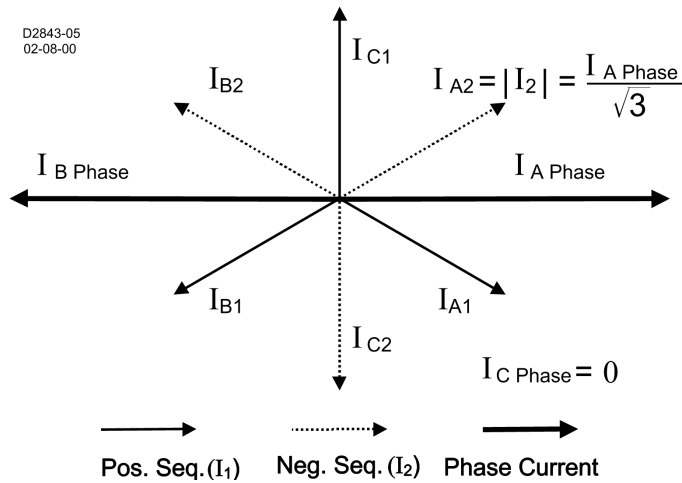


Figure 4-13. Sequence Components for an A-B Fault

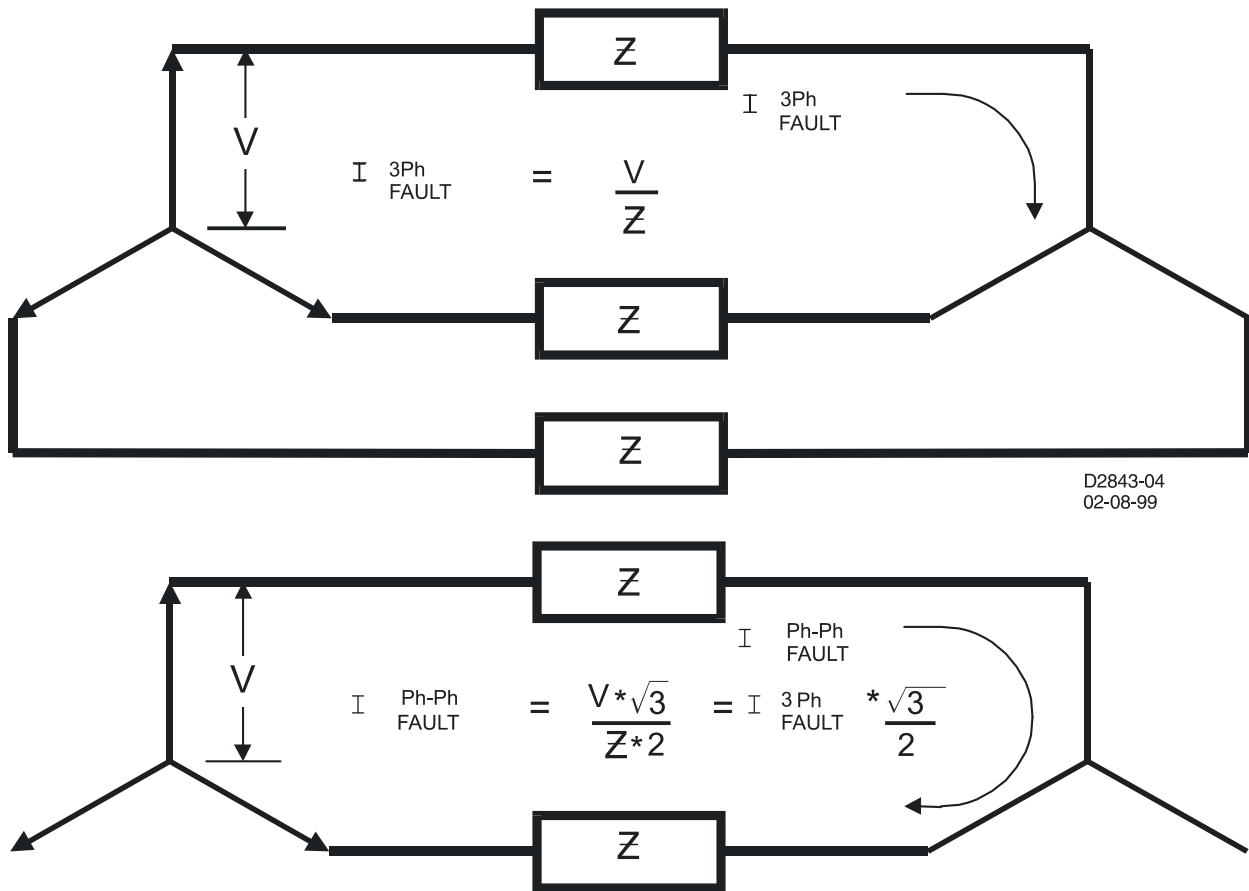


Figure 4-14. Phase-to-Phase Fault Magnitude

Negative-Sequence Coordination Settings

The 51Q settings should be checked for coordination with phase-only sensing devices such as downstream fuses and reclosers and/or ground relays. To plot the negative-sequence time current characteristics on the same plot for the phase devices, you need to multiply the negative-sequence element pickup value by the correct multiplier. The multiplier is the ratio of phase current to negative-sequence current for the fault type for which you are interested. To plot the negative-sequence time current characteristics on the same plot for the ground devices, you need to multiply the pickup value by the multiplier for phase-to-ground faults (see Table 4-12).

Table 4-12. Fault Type Multipliers

Fault Type	Multiplier
Ph-Ph	$m = 1.732$
Ph-Ph-G	$m > 1.732$
Ph-G	$m = 3$
3-phase	$m = \text{infinity}$

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: $(200 \text{ amperes}) * 1.732 = 346 \text{ amperes}$.

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

Delta/Wye Transformer Application

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

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

Generator Application

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

Voltage Protection (BE1-700V)

BE1-700V voltage protection includes elements for overexcitation, phase & auxiliary undervoltage, phase & auxiliary overvoltage, and negative-sequence overvoltage.

24 - Overexcitation Protection

Overexcitation occurs when a generator or transformer magnetic core becomes saturated. When this happens, stray flux is induced in non-laminated components, causing overheating. The BE1-700 detects overexcitation conditions with a volts/hertz element that consists of one alarm setting, one integrating time characteristic with selectable exponents (3 sets of time curves), and two definite-time characteristics. This allows the user to individually select an inverse-time characteristic, a composite characteristic with

inverse-time, and one or two definite-time elements, or a dual-level, definite-time element. The volts/hertz element has two outputs: *pickup* and *trip* as shown in Figure 4-15.

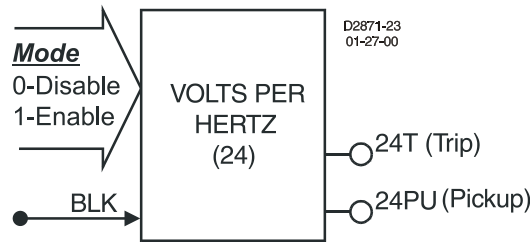


Figure 4-15. Overexcitation Logic Block

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

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

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

Theory of Operation for Overexcitation Protection

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

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

Nominal voltage for the BE1-700 is defined as a phase to neutral quantity. (Refer to Section 3, *Input and Output Functions*, for details). Nominal V/Hz depends on the sensing voltage (VT) connection, nominal voltage, and nominal frequency settings. Nominal V/Hz is calculated as the nominal voltage divided by nominal frequency. For VT connections equal to 3W, 4W, AB, BC, CA, the nominal voltage (phase-neutral value) must be converted to a phase-phase value by multiplying by the square root of 3. No additional conversion is required for VT connections equal to AN, BN, or CN.

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

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

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

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

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

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

Equations 4-5 and 4-6 represent the trip time and reset time for a constant V/Hz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range. If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation 4-5 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

$$T_T = \frac{D_T}{\left[\frac{V/Hz_{\text{Measured}}}{V/Hz_{\text{Nominal}}} - 1 \right]^n}$$

Equation 4-5. Time to Trip

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

Equation 4-6. Time to Reset

where:

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

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

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

BESTlogic Settings for Overexcitation Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-16 illustrates the BESTCOMS screen used to select BESTlogic settings for the Overexcitation (24) element. To open the *BESTlogic Function Element* screen for *Overexcitation (24)*, select *Voltage Protection* from the *Screens* pull-down menu and select the 24 tab. Then, select the *BESTlogic* button. Alternately, settings may be made using SL-24 ASCII command.

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

Enable the BESTlogic function by selecting its mode of operation from the *Mode* pull-down menu. To connect the function/elements inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input.

Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

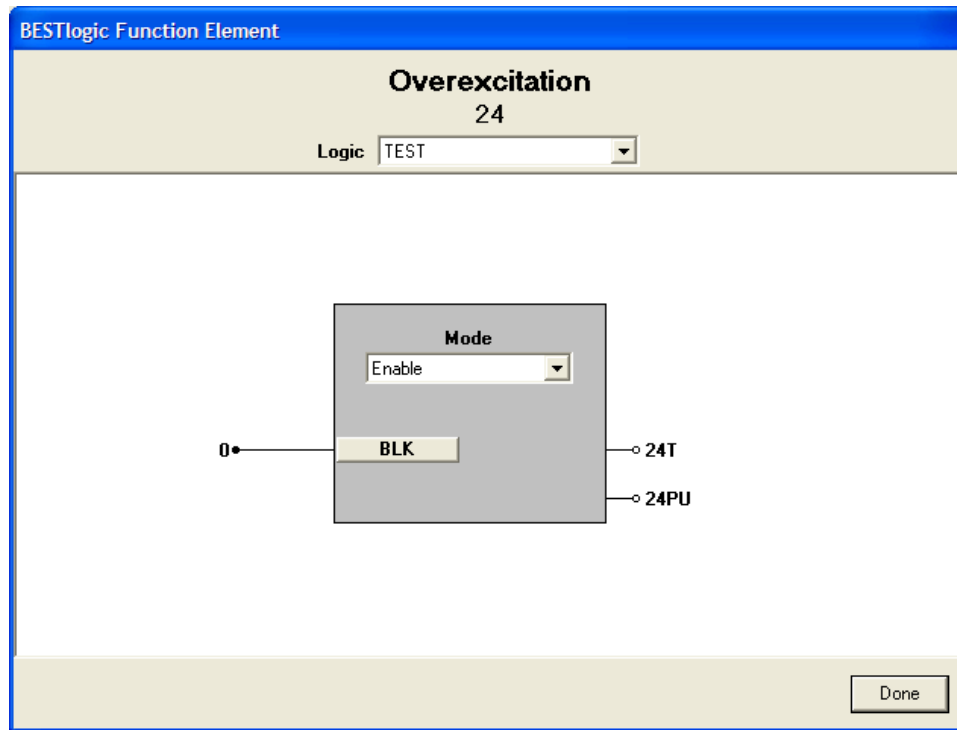


Figure 4-16. BESTlogic Function Element Screen, 24

Table 4-13 lists the BESTlogic settings for Overexcitation Protection.

Table 4-13. 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

Operating Settings for Overexcitation Protection

Operating settings for the 24 function consist of a pickup setting, a trip time dial, and a reset time dial. A pickup of 0 disables the element. The unit of measure is secondary VPP/Hz or VPN/Hz and depends on the SG-VTP setting. For more information, refer to Section 3, *Input and Output Functions, Power System Inputs*. Operating settings are made using BESTCOMS. Figure 4-17 illustrates the BESTCOMS screen used to select operational settings for the Overexcitation element. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and select the 24 Tab. Alternately, settings can be made using the S<g>-24 and S<g>-24D commands or at the front panel HMI using Screen 5.x.1.1 where x equals 1 or 2, for Setting Group 0 or 1.

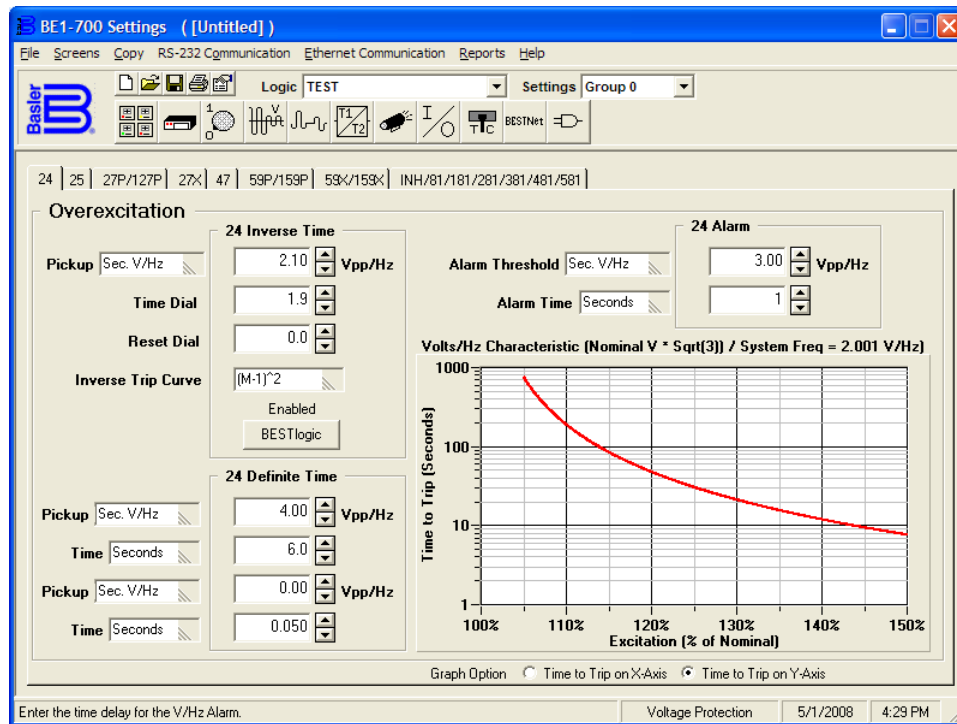


Figure 4-17. Voltage Protection Screen, 24 Tab

Table 4-14 lists the operating settings for Overexcitation Protection.

Table 4-14. Operating Settings for Overexcitation Protection

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

Programmable Alarm for Overexcitation Protection

A separate V/Hz alarm threshold and user adjustable time delay are included for indicating when overexcitation is occurring so that the operator can take corrective action before the 24 function trips. If the V/Hz level exceeds the alarm setting, a programmable alarm bit is set. See Section 6, *Reporting and Alarm Functions*, for more information. Settings for the alarm are made using BESTCOMS (Figure 4-17). Alternately, settings can be made with the SA-24 ASCII command. Table 4-15 lists the programmable alarm settings for Overexcitation. V/Hz alarm settings cannot be set through the HMI.

Table 4-15. Programmable Alarm Settings for Overexcitation Protection

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

Settings Example for Overexcitation Protection

V/Hz tripping elements are used to de-energize a generator or transformer that is experiencing an overexcitation condition. Therefore, the manufacturer's overexcitation limit curves are required to establish optimum protection. Figure 4-18 and Figure 4-19 show examples of a transformer and generator limit curve along with the optimum composite protection characteristic.

Note

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

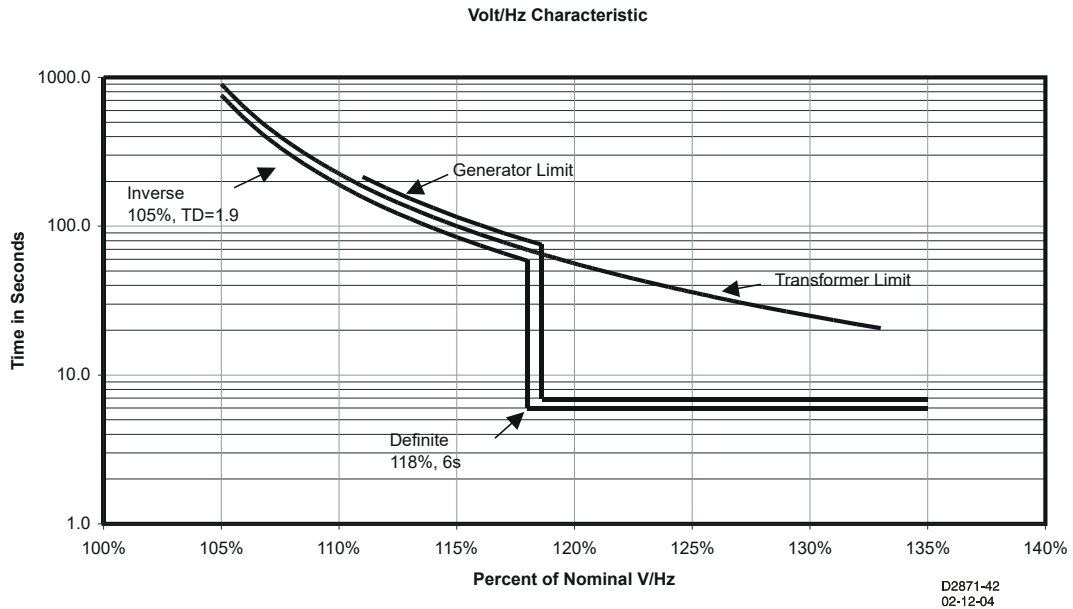


Figure 4-18. Time Shown on Vertical Axis

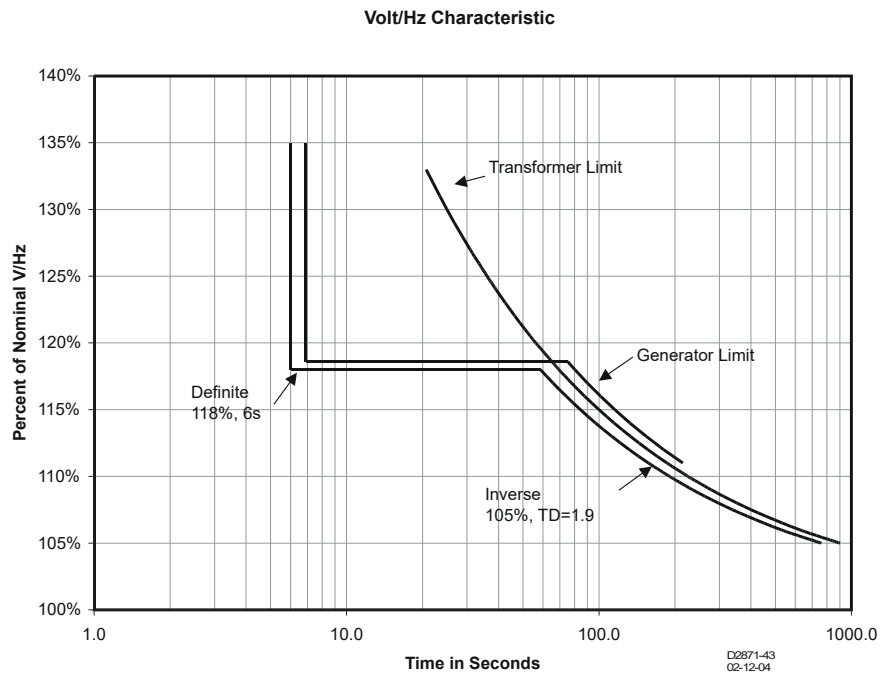


Figure 4-19. Time Shown on Horizontal Axis

Assuming a V_{nom} of 69.3 volts phase-neutral, 1 pu volts/hertz = $(69.3 * \sqrt{3}) / 60 = 2.00$. Using IEEE/C37.102, "Guide for AC Generator Protection" as a guide for setting overexcitation protection, the following example demonstrates how to set the BE1-700 to provide a composite V/Hz characteristic for protection of a generator and a step-up transformer:

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

In BESTCOMS, the 24 graphing capability can be used to verify the composite shape as shown in Figure 4-20. Secondary V/Hz is shown.

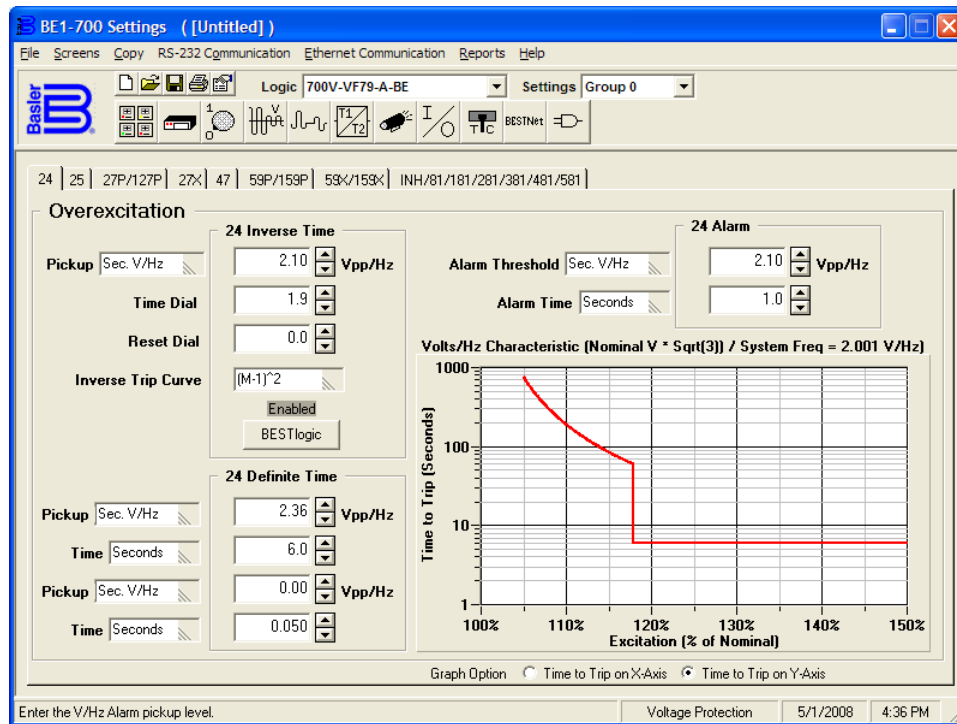


Figure 4-20. Voltage Protection Screen, Overexcitation (24) Tab

The reset rate is determined by the reset dial setting. A setting of 0.0 enables reset to be instantaneous. Using the inverse squared characteristic, assume a trip time dial setting 2.0 and a pickup multiple of 1.2. The total time to trip will be 50 seconds. If this exists for 30 seconds before being corrected (60% elapsed time), what would the total reset time be for a reset dial setting of 5? Based on the reset equation (Equation 4-7), the calculation will be:

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

Equation 4-7. Time to Reset

If the overexcitation condition returns prior to total reset (i.e., less than 300 seconds), timing resumes from that point at the inverse square rate. For example, if this condition recurs after 150 seconds or 50% of the total reset time, then trip time from the second event will start at 30% instead of 0%, therefore tripping in 70% or the original trip time or 35 seconds. Figure 4-21 illustrates the inverse time delay and reset time.

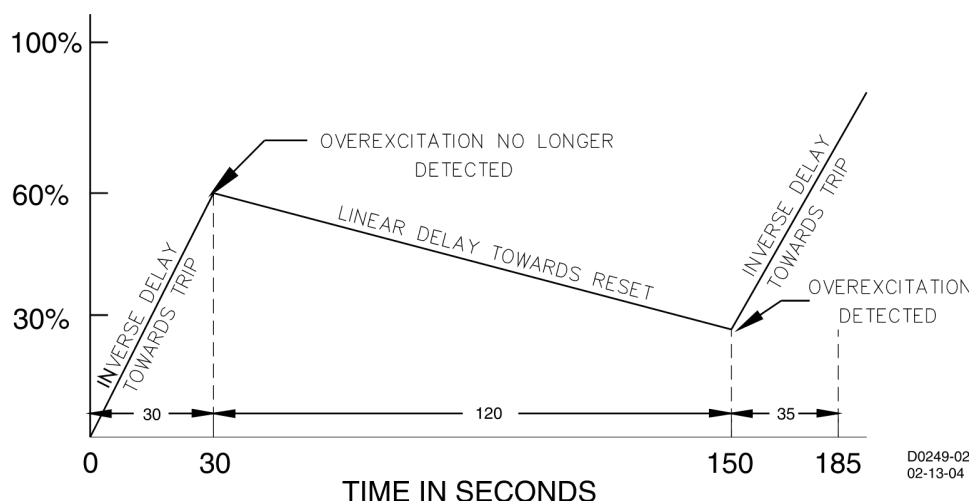


Figure 4-21. Inverse Time Delay and Reset Time

Retrieving Overexcitation Protection Status from the Relay

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

27P/59P - Phase Undervoltage/Overvoltage Protection

Figure 4-22 illustrates the Phase Undervoltage/Overvoltage Logic Blocks. The 127P phase undervoltage element and the 159P phase overvoltage element are identical in configuration.

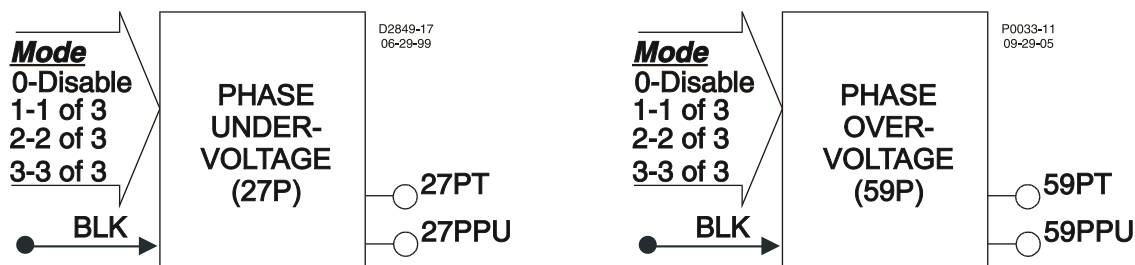


Figure 4-22. Phase Undervoltage/Overvoltage Logic Blocks

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

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

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

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

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

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

BESTlogic Settings for Phase Undervoltage/Overvoltage Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-23 illustrates the BESTCOMS screen used to select BESTlogic settings for the Under and Overvoltage elements. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu, and select the *27P/127P* tab. Alternately, settings may be made using the SL-27P and SL-59P ASCII commands.

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

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

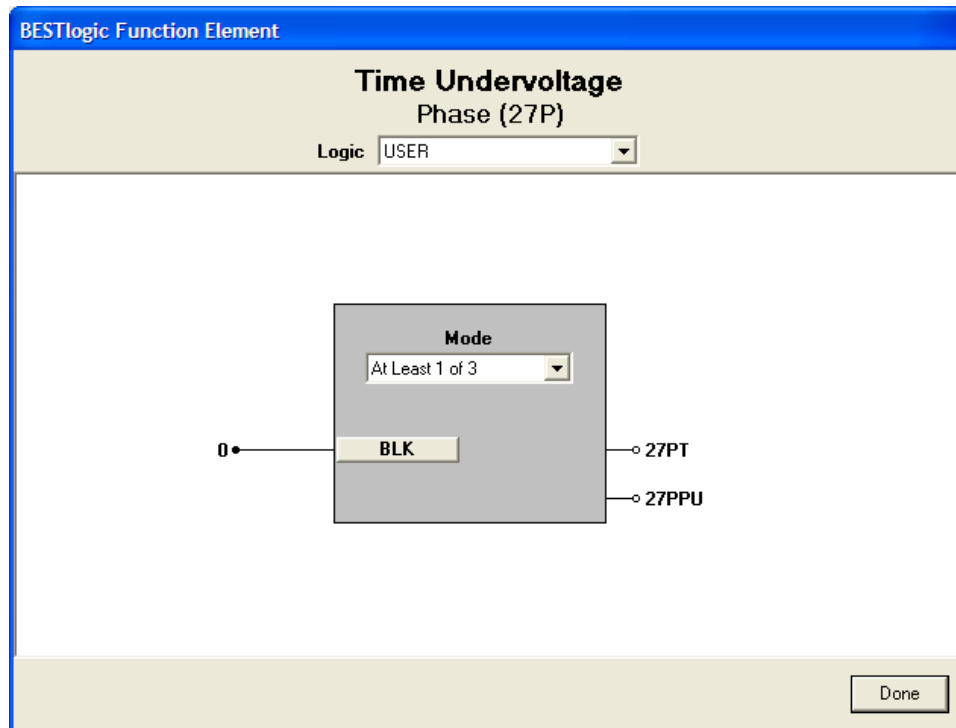


Figure 4-23. BESTlogic Function Element Screen, Phase (27P)

Table 4-16 summarizes the BESTlogic settings for Phase Undervoltage/Overvoltage Protection.

Table 4-16. BESTlogic settings for Phase Undervoltage/Overvoltage Protection

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

Operating Settings for Phase Undervoltage/Overvoltage Protection

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 4-24 illustrates the BESTCOMS screen used to select operational settings for the undervoltage elements. The 59P/159P overvoltage elements are set in a similar manner. To open the screen, select *Voltage Protection* from the *Screens* pull-down menu and select the *27P/127P* or *59/159P* tab. Alternately, settings may be made using the S<g>-27P and S<g>-59P ASCII command or through the HMI using Screens 5.x.3.1 (27P) and 5.x.8.1 (59P), where x represents 1 (Setting Group 0) or 2 (Setting Group 1).

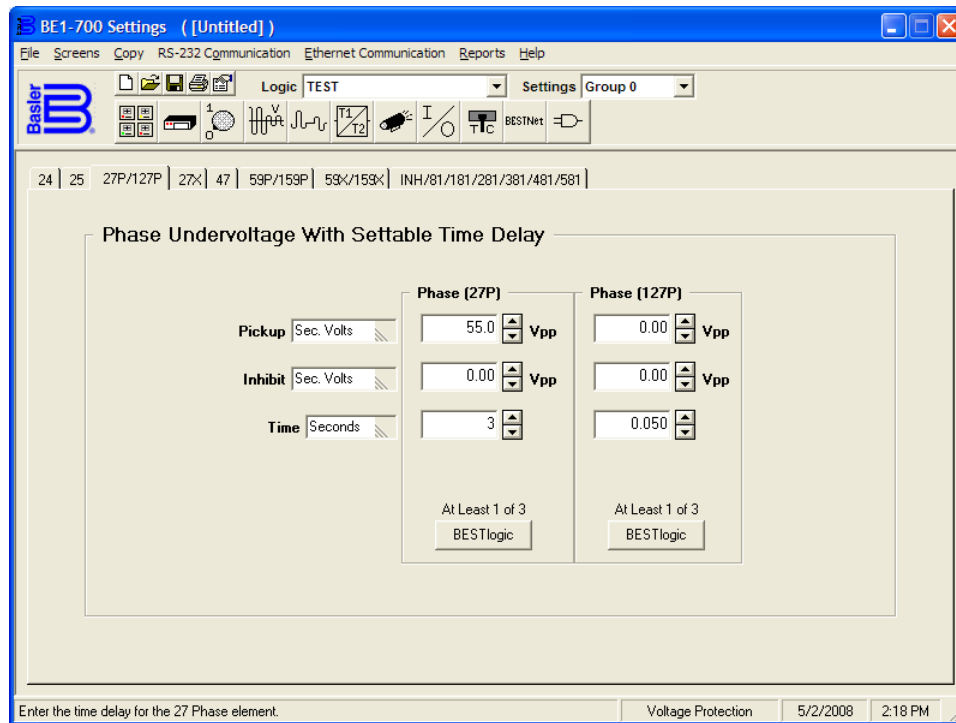


Figure 4-24. Voltage Protection Screen, 27P/127P Tab

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

Operating settings for Phase Undervoltage/Overvoltage Protection are summarized in Table 4-17.

Table 4-17. Operating Settings for Phase Undervoltage/Overvoltage Protection

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

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

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

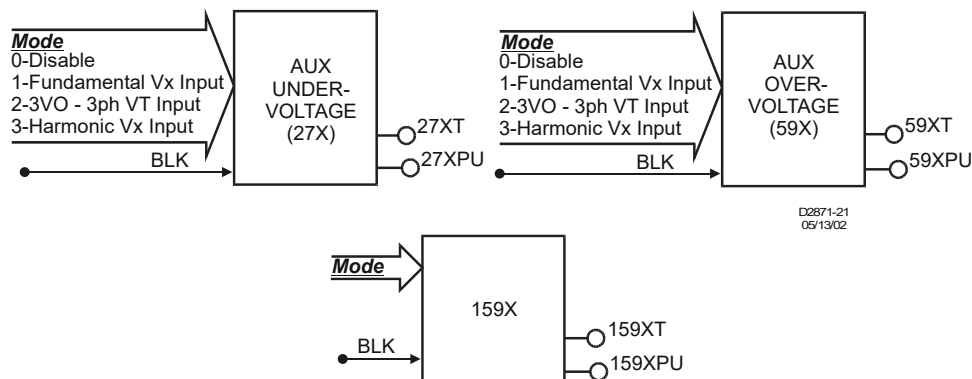
Time delay settings entered in cycles are converted to seconds or milliseconds (per the nominal frequency setting stored in EEPROM) before being stored. See Section 3, *Input and Output Functions, Power System Inputs, Voltage Measurement*, for more information about this setting. If the nominal frequency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

Retrieving Phase Undervoltage/Overvoltage Protection Status from the Relay

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

27X/59X - Auxiliary Undervoltage/Overvoltage Protection

Figure 4-25 illustrates the inputs and outputs of the auxiliary under/overvoltage elements. Element operation is described in the following paragraphs.

**Figure 4-25. 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 V_X input or a 3VO - 3-phase VT input or a Harmonic V_X input. When undervoltage inhibit is selected, undervoltage sensing is disabled anytime the voltage falls below the inhibit threshold. Undervoltage inhibiting is disabled when the threshold is set to zero. Undervoltage inhibit is used to prevent undesired undervoltage tripping, such as when a loss of supply occurs.

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

BESTlogic Settings for Auxiliary Undervoltage/Overvoltage Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-26 illustrates the BESTCOMS screen used to select BESTlogic settings for the Undervoltage/Overvoltage element. (In this case, the auxiliary overvoltage element is shown.) To open the *BESTlogic Function Element* screen for Undervoltage/Overvoltage elements, select *Voltage Protection* from the *Screens* pull-down menu. Then select the 27X or the 59X/159X tab. Alternately, settings may be made using SL-59X, SL-159X, or SL-27X ASCII command.

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

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

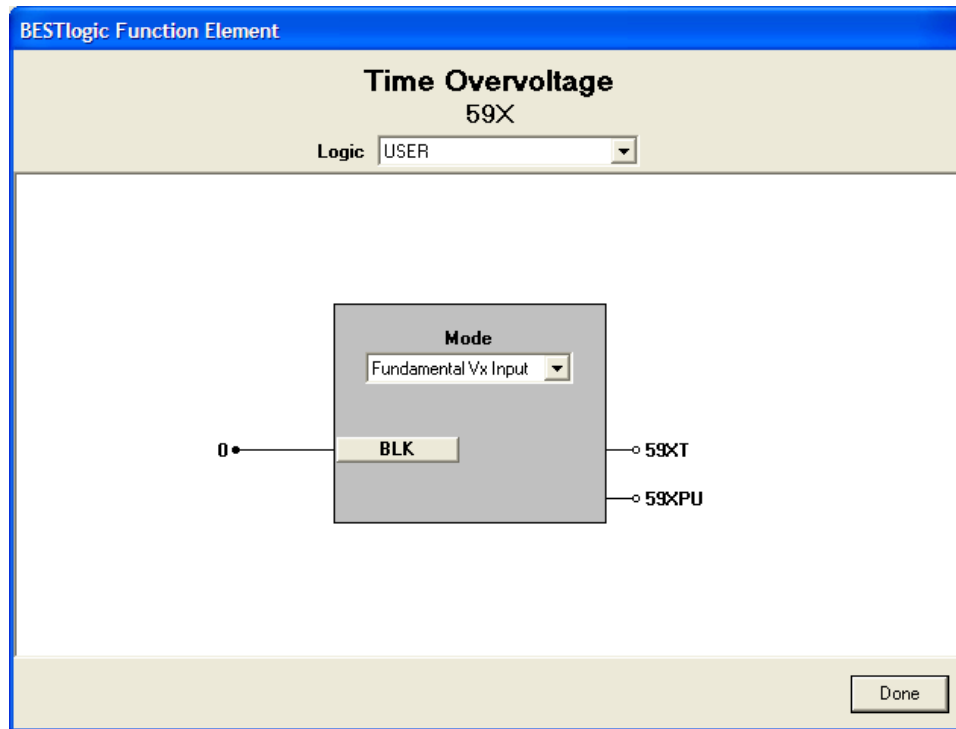


Figure 4-26. BESTlogic Function Element Screen, 59X

Table 4-18 summarizes the BESTlogic settings for Auxiliary Undervoltage/Overvoltage Protection.

Table 4-18. BESTlogic Settings for Auxiliary Undervoltage/Overvoltage Protection

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

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

Operating Settings for Auxiliary Undervoltage/Overvoltage Protection

Operating settings for the 27X and 59X functions consist of pickup and time delay values. The pickup value determines the level of voltage required for the element to start timing toward a trip. Unit of measure is secondary volts (PP or PN) and depends on the VTX setting see Table 4-19. 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 4-19. 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 4-27 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.3.2 (27x), 5.x.8.2 (59x), and 5.x.8.4 where x equals 1 (Setting Group 0) or 2 (Setting Group 1).

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

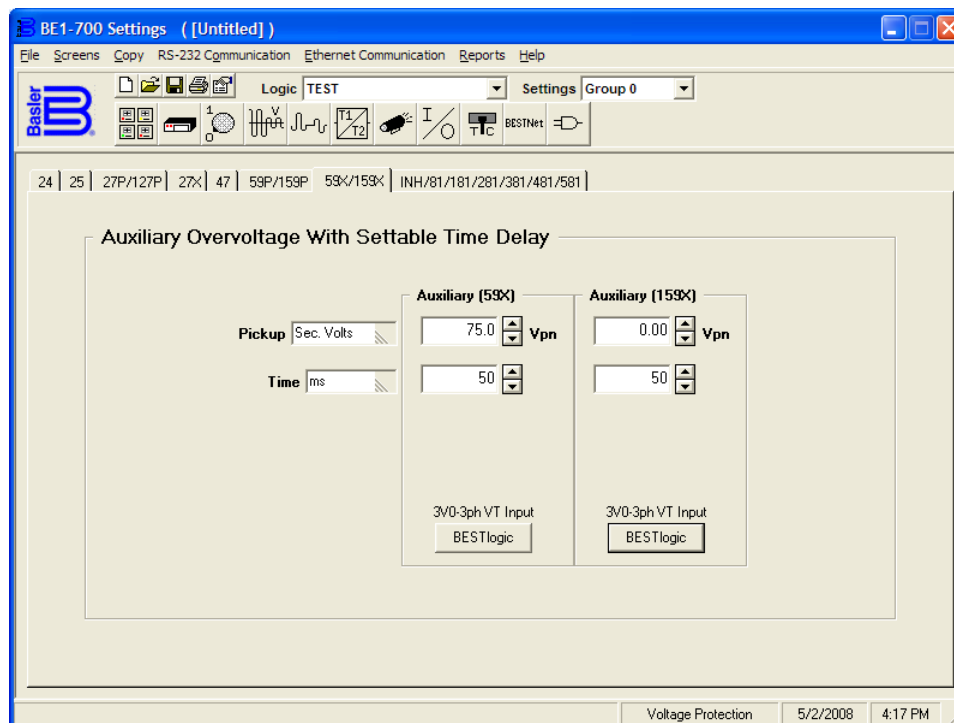


Figure 4-27. Voltage Protection Screen, 59X/159X Tab

Table 4-20 summarizes the operating settings for Auxiliary Undervoltage/Overvoltage Protection.

Table 4-20. Operating Settings for Auxiliary Undervoltage/Overvoltage Protection

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

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

Retrieving Auxiliary Undervoltage/Overvoltage Protection Status from the Relay

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

47 - Negative-Sequence Overvoltage Protection

Figure 4-28 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.

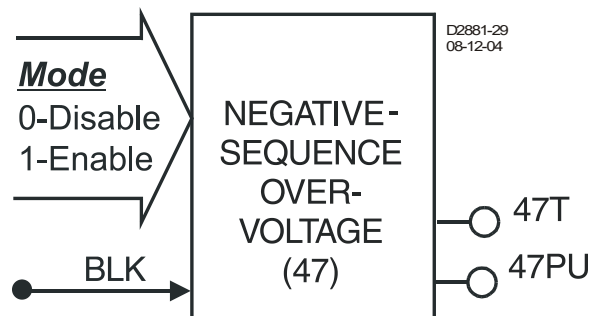


Figure 4-28. Negative-Sequence Overvoltage Logic Block

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

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

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

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

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

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

BESTlogic Settings for Negative-Sequence Overvoltage Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-29 illustrates the BESTCOMS screen used to select BESTlogic settings for the negative-sequence overvoltage function. To open the screen, select *Voltage Protection* from the Screens pull-down menu and then select the *47* Tab. Then select the *BESTlogic* button at the bottom of the screen. Alternately, settings may be made using the SL-47 ASCII command.

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic

scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic settings can be changed. See Section 7, *BESTlogic Programmable Logic*.

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

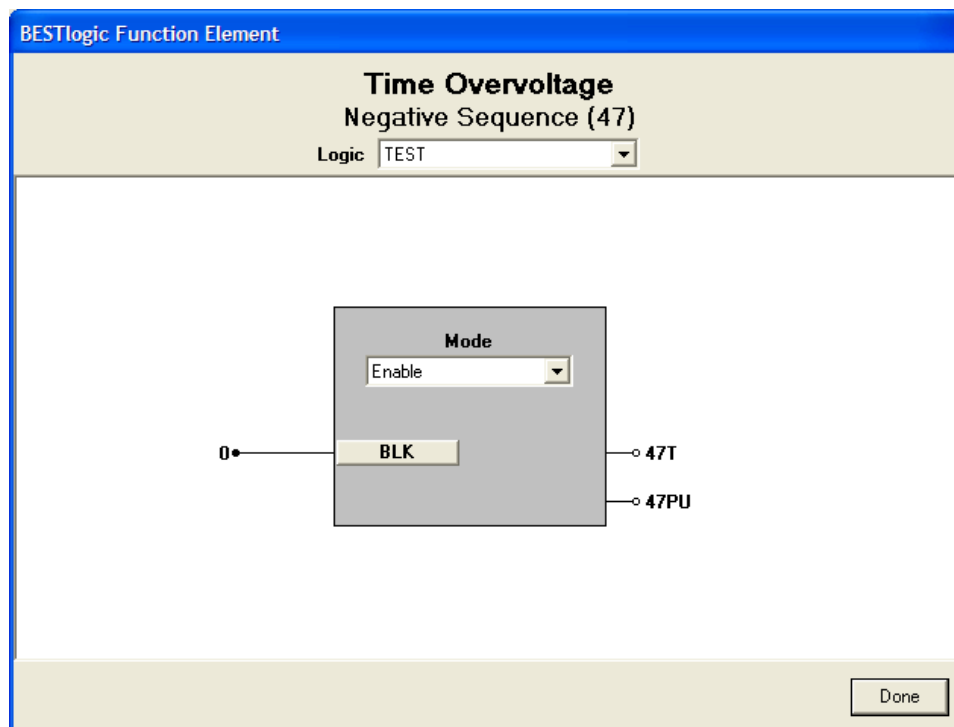


Figure 4-29. BESTlogic Function Element Screen, Negative Sequence (47)

Figure 4-21 summarizes the BESTlogic settings for Negative-Sequence Overvoltage Protection.

Table 4-21. BESTlogic Settings for Negative-Sequence Overvoltage Protection

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

Operating Settings for Negative-Sequence Overvoltage Protection

Operating settings are made using BESTCOMS. Figure 4-30 illustrates the BESTCOMS screen used to select operational settings for the negative-sequence overvoltage element. To open the screen select *Voltage Protection* from the *Screens* pull-down menu and then select the 47 tab. Alternately, settings maybe made using the S<g>-47 ASCII command or through the HMI interface using Screen 5.x.5.1 where x represents 1 (Setting Group 0) or 2 (Setting Group 1).

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

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

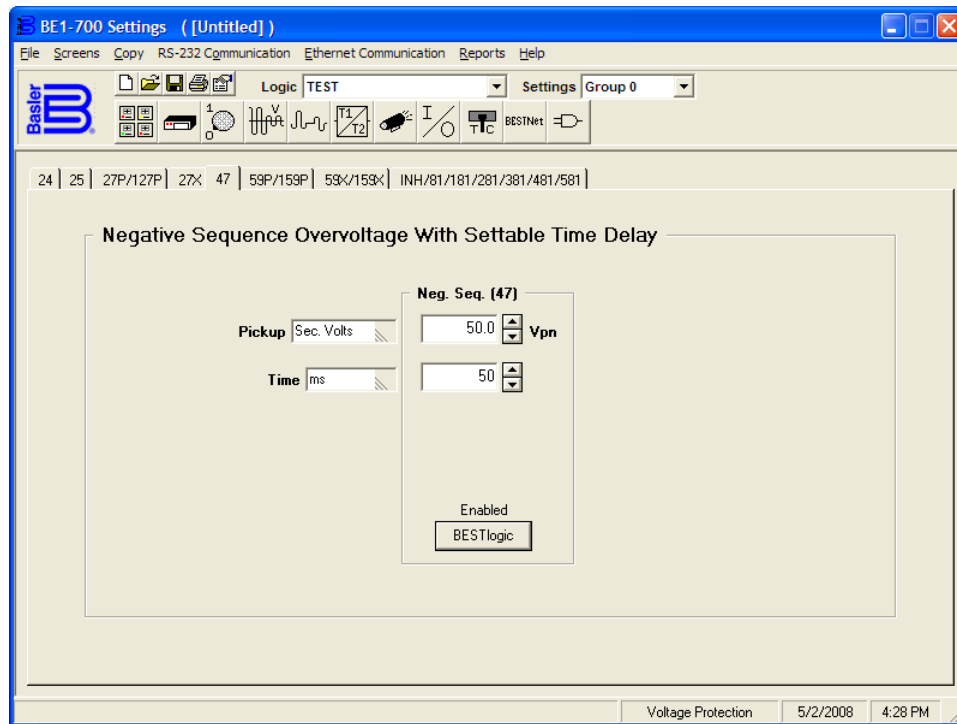


Figure 4-30. Voltage Protection Screen, 47 Tab

Table 4-22 summarizes operating settings for Negative-Sequence Overvoltage Protection.

Table 4-22. Operating Settings for Negative-Sequence Overvoltage Protection

Setting	Range	Increment	Unit of Measure	Default
Pickup	0 = Disabled 10 to 300	0.1 for 1.0 to 99.9 1 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.

Retrieving Negative-Sequence Overvoltage Protection Status from the Relay

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

Frequency Protection (BE1-700V)

81 - Over/Under Frequency Protection

BE1-700 frequency protection consists of six independent elements that can be programmed for underfrequency or overfrequency protection. Under and over frequency protection can be used for load shedding or islanding detection such as when a source of distributed generation (DG) is suddenly separated or islanded from the electric utility. For this condition, frequency will quickly change from 60 Hz

(except for the improbable case of a perfect load to generation match) making frequency measurement an excellent method for detecting an island condition.

Each element has an adjustable frequency (Hz) setpoint and time delay. The 81 elements share a common undervoltage inhibit setting for under/overfrequency applications. 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 BE1-700 measures the frequency. The measured frequency is the average of two cycles of measurement.

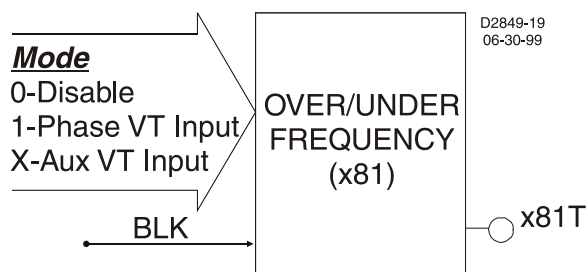


Figure 4-31. Over/Under Frequency Logic Block

Frequency element designations are 81, 181, 281, 381, 481, and 581. Each of the six elements has identical inputs, outputs, and setting provisions as shown in Figure 4-31. An x81T (trip) output is provided on each element. For over/under frequency applications, the pickup output becomes TRUE when the monitored frequency decreases below (81U) or increases above (81O) the pickup setting at which point the element starts timing toward a trip. The trip output becomes TRUE when the element's time delay setting has expired. If the pickup bit drops out before the timer expires, it resets and will start over on the next pickup.

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

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

Pickup settings define the frequency setpoint and time delay, and program the element for under/over frequency protection. The 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 setpoint. If three consecutive cycles of the measured frequency have decreased below or increased above and the timer has timed out, 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 also trip. If the monitored voltage decreases below the user-defined setpoint, over/under frequency protection is inhibited.

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

BESTlogic Settings for Over/Under Frequency Protection

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 Over/Under Frequency element. To open the *BESTlogic Function Element* screen for Over/Under Frequency element, select *Voltage Protection* from the *Screens* pull-down menu and select the *INH/81/181/281/381/481/581* tab.

Then select the *BESTlogic* button for the element to be programmed. Alternately, settings may be made using the SL-<x>81 ASCII command.

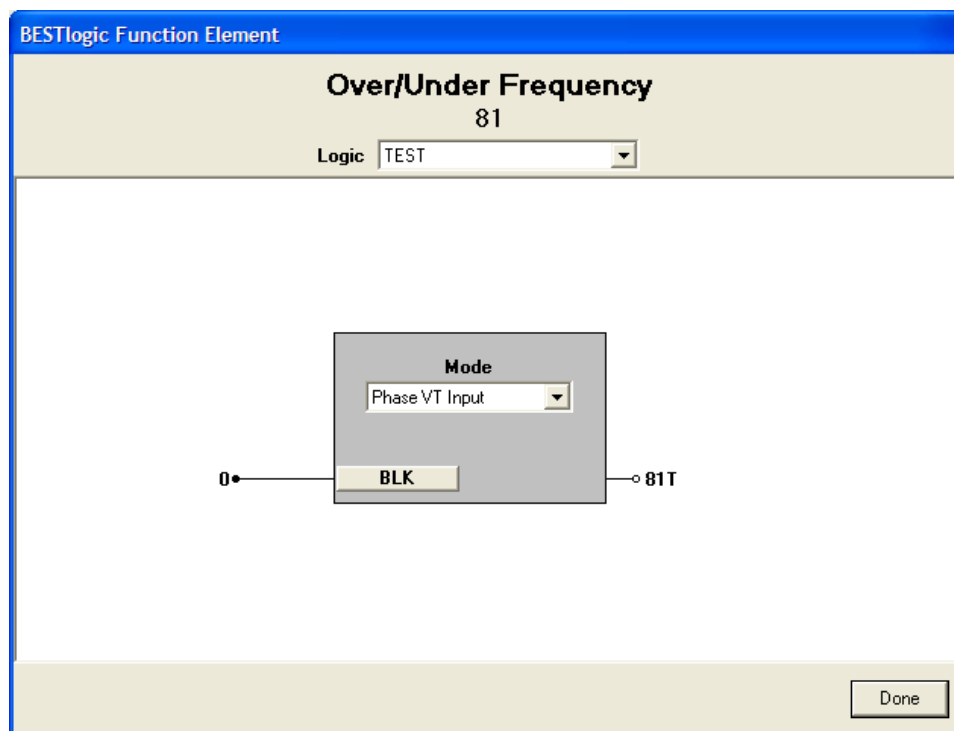


Figure 4-32. BESTLogic Function Element Screen, 81

At the top center of the *BESTlogic Function Element* screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTLogic settings for each preprogrammed logic scheme. A custom logic scheme 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 Over/Under Frequency 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.

BESTLogic settings for Over/Under Frequency Protection are summarized in Table 4-23.

Table 4-23. BESTLogic Settings for Over/Under Frequency Protection

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

Operating Settings for Over/Under Frequency Protection

Operating settings for the 81 elements consist of pickup values, time delay values, and a mode setting that defines whether an element provides under or over frequency protection and is selectable from a pull-down menu under each element tab. 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. Table 4-33 illustrates the BESTCOMS screen used to select operational settings for the Over/Under Frequency element. To open the *BESTlogic Function Element* screen for Over/Under Frequency element, select *Voltage Protection* from the *Screens* pull-down menu and select the *INH/81/181/281/381/481/581* tab. Alternately, settings may be made using the S<g>-<x>81 ASCII command or the HMI interface using Screens 5.x.12.1 through 5.x.12.6 where x equals the setting group number.

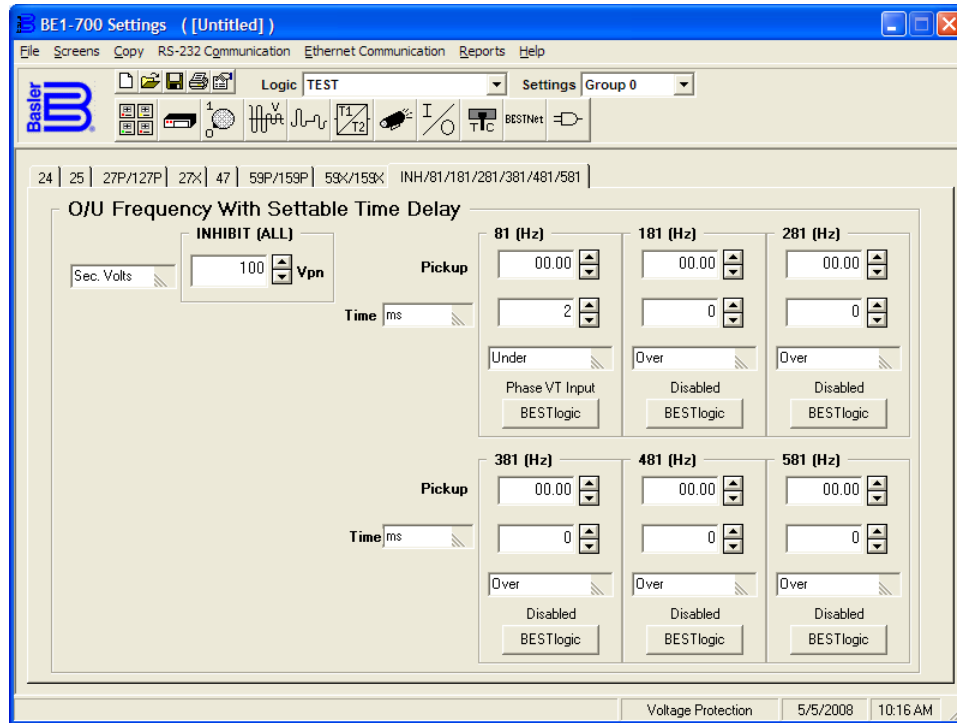


Figure 4-33. Voltage Protection Screen, INH/81/181/281/381/481/581 Tab

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

Over/under frequency protection can be inhibited when the monitored voltage decreases below a user-defined level. The undervoltage inhibit level is set through BESTCOMS. Alternately it can be set using the S<g>-<x>81INH command where x equals nothing or one through five. Settings can also be made using HMI Screen 5.x.12.7. The voltage inhibit setting unit of measure depends upon the VTP and VTX connection settings. For 4-wire or PN connections, it is Sec VPV. For 3-wire or PP connections, it is Sec. VPP.

Table 4-24 summarizes the operating settings for Over/Under Frequency Protection.

Table 4-24. Operating Settings for Over/Under Frequency Protection

Setting	Range	Increment	Unit of Measure	Default
81 O/U Pickup	0 = Disabled 20 to 70 Hz	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 = Over U = Under	N/A	N/A	1
81 O/U Voltage Inhibit Level	0 = Disabled	0.1 for 15 to 99.9	Secondary Volts †	40
		15 to 150 Sec. Volts		

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

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

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

Retrieving Over/Under Frequency Protection Status from the Relay

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

Breaker Failure Protection (BE1-700C)

50BF - Breaker Failure Protection

BE1-700 relays provide one function block for breaker failure protection. This function includes a timer and a current detector. Figure 4-34 shows the BF function block. The function block has two outputs BFT (breaker failure trip) and BFT (breaker failure pickup).

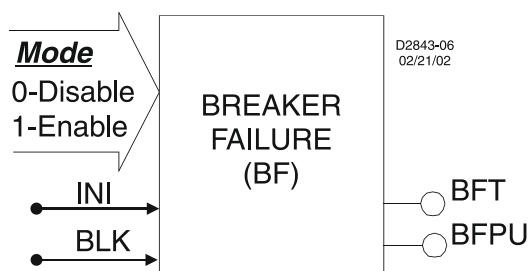


Figure 4-34. Breaker Failure Logic Block

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

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

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

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

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

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

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

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

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

BESTlogic Settings for Breaker Failure Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-35 illustrates the BESTCOMS screen used to select BESTlogic settings for the breaker failure element. To open *BESTlogic Function Element* screen for the breaker failure element, select *Breaker Failure* from the *Screens* pull-down menu. Then select the button labeled *BESTlogic*. Alternately, settings may be made using the SL-50BF ASCII command.

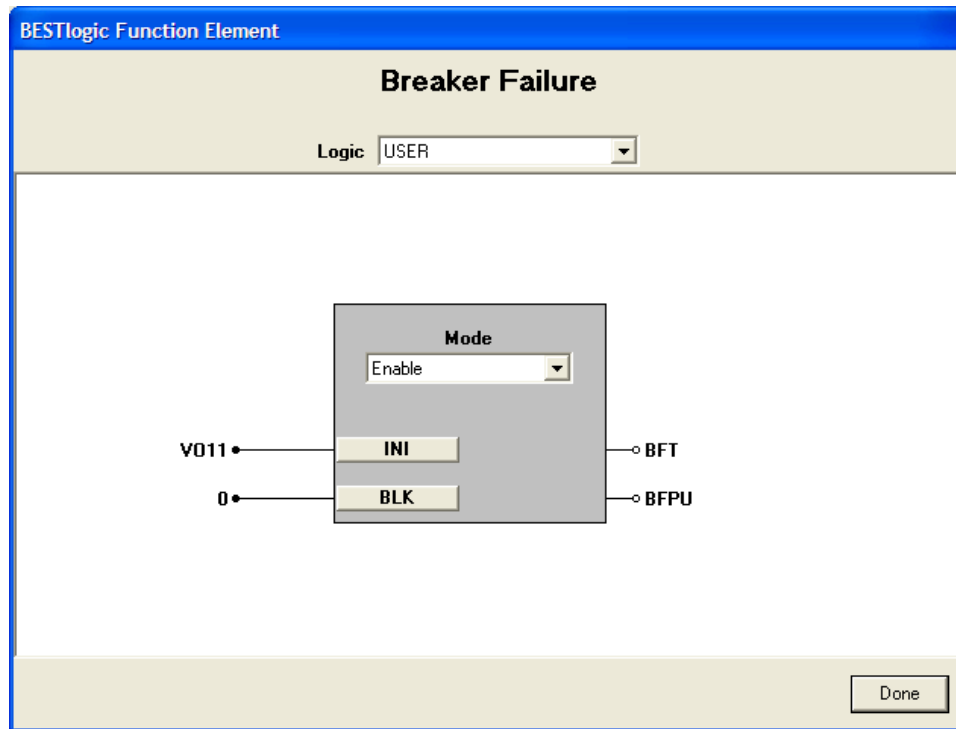


Figure 4-35. BESTlogic Function Element Screen, Breaker Failure

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

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

Table 4-25 summarizes the BESTlogic settings for Breaker Failure Protection.

Table 4-25. BESTlogic Settings for Breaker Failure Protection

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

Operating Settings for Breaker Failure Protection

Operating settings are made using BESTCOMS. Figure 4-36 illustrates the BESTCOMS screen used to select operational settings for the breaker failure element. To open *BESTlogic Function Element* screen for the breaker failure element, select *Breaker Failure* from the *Screens* pull-down menu. Alternately, settings may be made using the SP-50BF ASCII command or through the HMI interface using Screen 5.3.1.1.

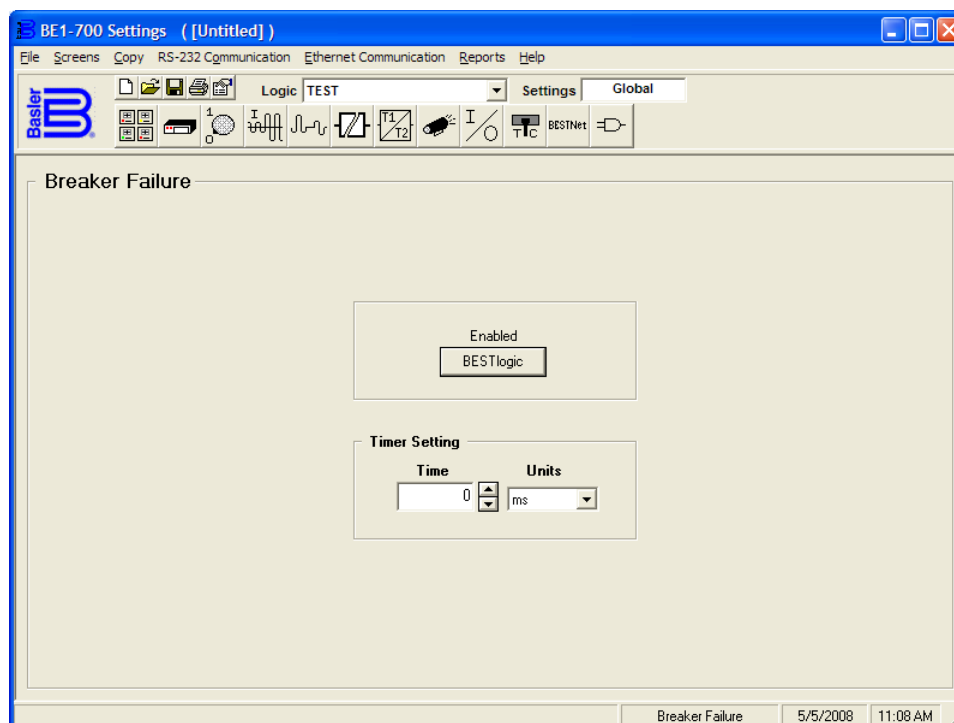


Figure 4-36. Breaker Failure Screen

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

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

Table 4-26 summarizes the operating settings for Breaker Failure Protection.

Table 4-26. Operating Settings for Breaker Failure Protection

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

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

Retrieving Breaker Failure Protection Status from the Relay

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

Logic Timers

62 - General Purpose Logic Timers

BE1-700 relays provide two general-purpose logic timers, which are extremely versatile. Each can be set for one of five modes of operation to emulate virtually any type of timer. Each function block has one output (62 or 162) that is asserted when the timing criteria has been met according to the BESTlogic mode setting. Figure 4-37 shows the 62 function block as an example. Each mode of operation is described in detail in the following paragraphs.

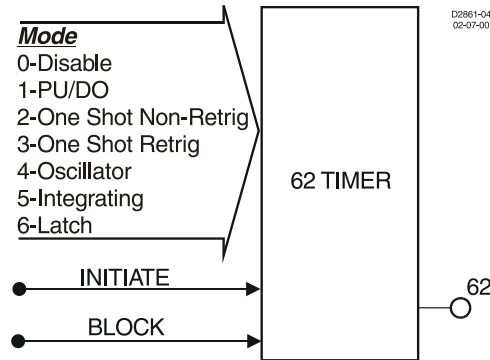


Figure 4-37. General Purpose Logic Timers Logic Block

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

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

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

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

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

The output will change to logic TRUE if the *INITIATE* input expression is TRUE for the duration of PICKUP time delay setting *T1*. See Figure 4-38. 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.

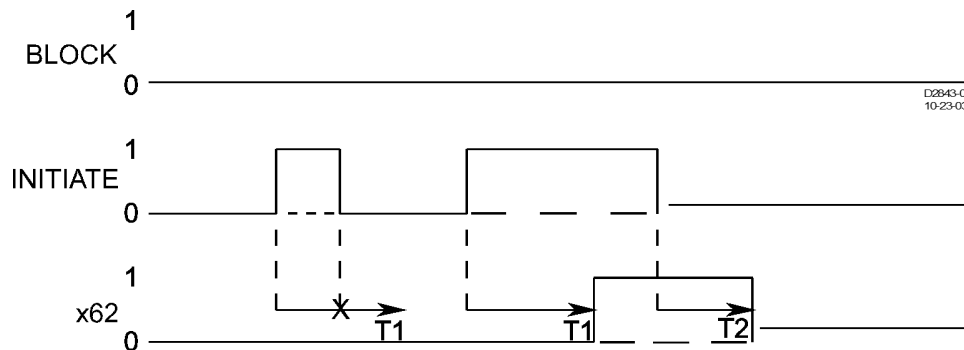


Figure 4-38. Mode 1, PU/DO (Pickup/Dropout Timer)

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 4-39. 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.

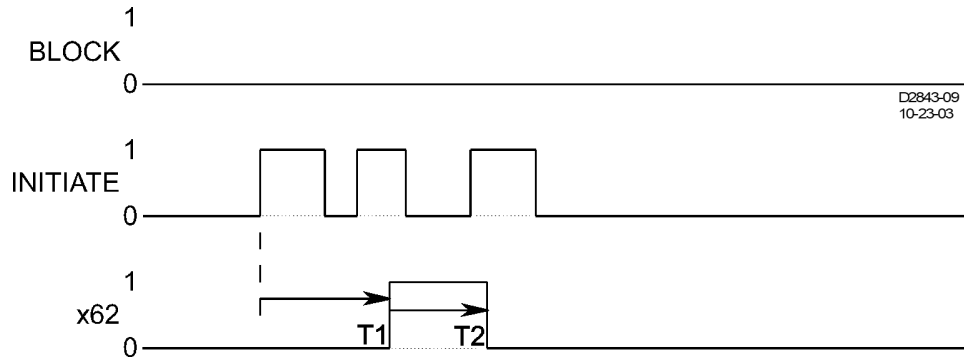


Figure 4-39. Mode 2, One-Shot Nonretriggerable Timer

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 4-40.

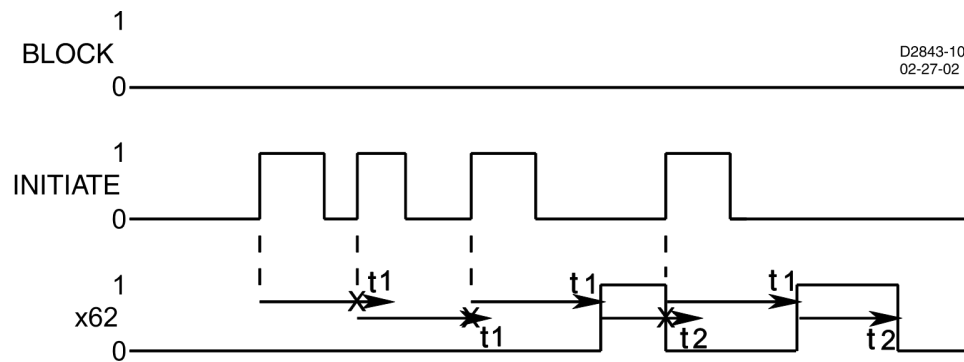


Figure 4-40. Mode 3, One Shot Retriggerable Timer

Mode 4, Oscillator

In this mode, the *INITIATE* input is ignored. See Figure 4-41. 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.

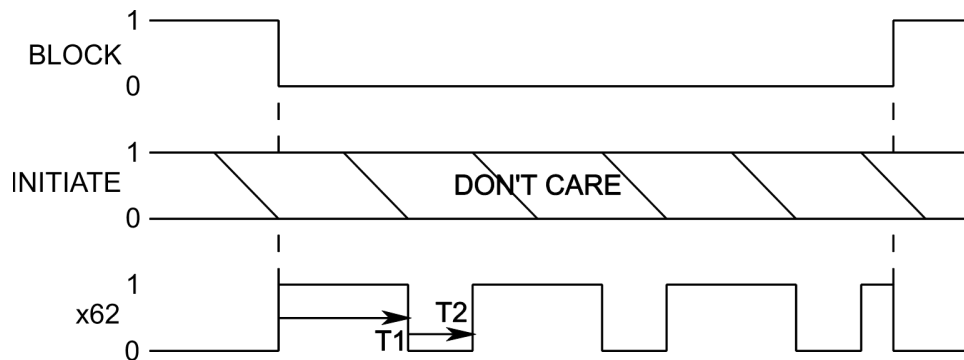


Figure 4-41. Mode 4, Oscillator

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 4-42, RESET time T2 is set to half of the PICKUP time T1 setting. The initiate input expression becomes TRUE and the timer starts integrating toward pickup. Prior to timing out, the initiate expression toggles to FALSE and the timer starts resetting at twice the rate as it was integrating toward time out. It stays FALSE long enough for the integrating timer to reset completely but then toggles back to TRUE and stays TRUE for the entire duration of time T1. At that point, the output of the timer is toggled to TRUE. Then at some time later, the initiate expression becomes FALSE and stays FALSE for the duration of RESET time T2. At that point, the output of the timer is toggled to FALSE.

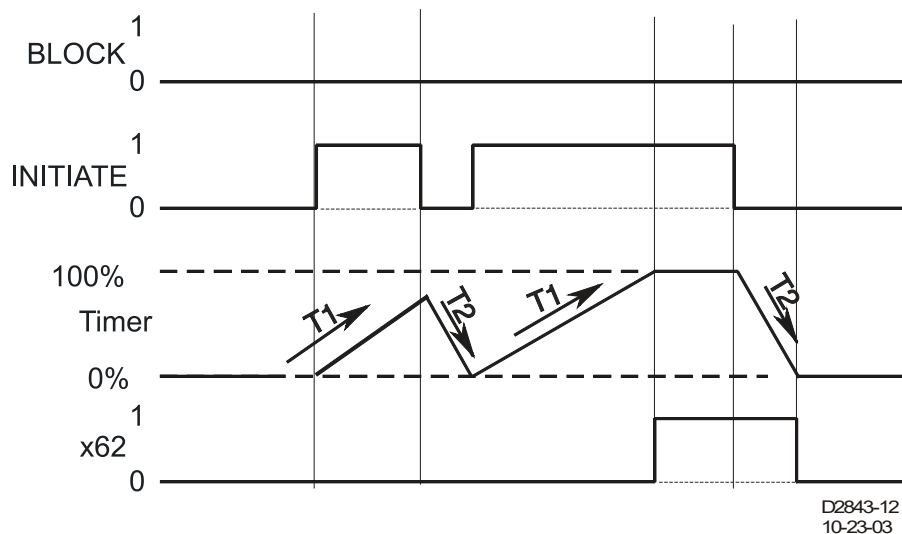


Figure 4-42. Mode 5, Integrating Timer

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 4-43.

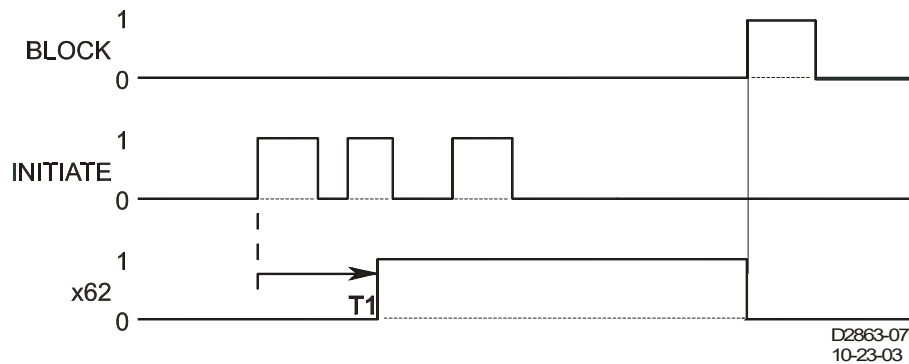


Figure 4-43. Mode 6, Latch

BESTlogic Settings for General Purpose Logic Timers

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 *Logic Timer* elements. To open the *BESTlogic Function Element* screen for *Logic Timer*, select *Logic Timers* from the *Screens* pull-down menu. Then select the *BESTlogic* button for either the 62 or the 162 element. Alternately, settings may be made using the SL-x62 ASCII command.

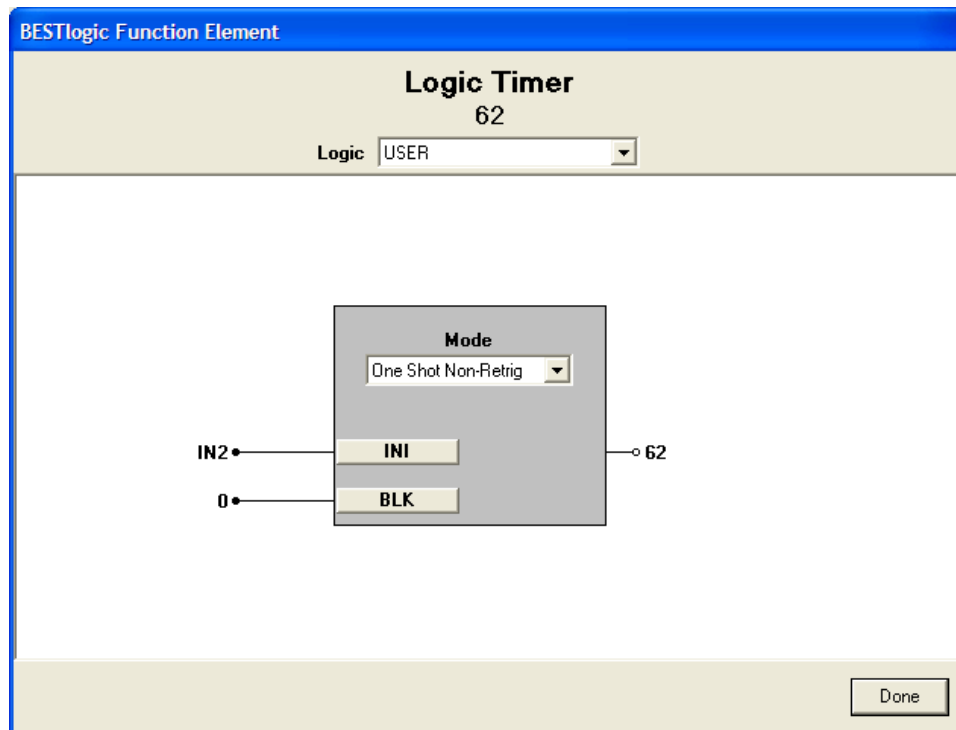


Figure 4-44. BESTlogic Function Element Screen, 62

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 4-27 below summarizes the BESTlogic settings for General Purpose Logic Timers.

Table 4-27. BESTlogic Settings for General Purpose Logic Timers

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

Operating Settings for General Purpose Logic Timers

Operating settings are made using BESTCOMS. Figure 4-45 illustrates the BESTCOMS screen used to select operational settings for the *Logic Timers* element. To open the *Logic Timers* screen, select *Logic Timers* from the *Screens* pull-down menu. Alternately, settings may be made using the S<g>-62/162 ASCII command or through the HMI interface using Screens 5.1.9.1 and 5.1.9.2.

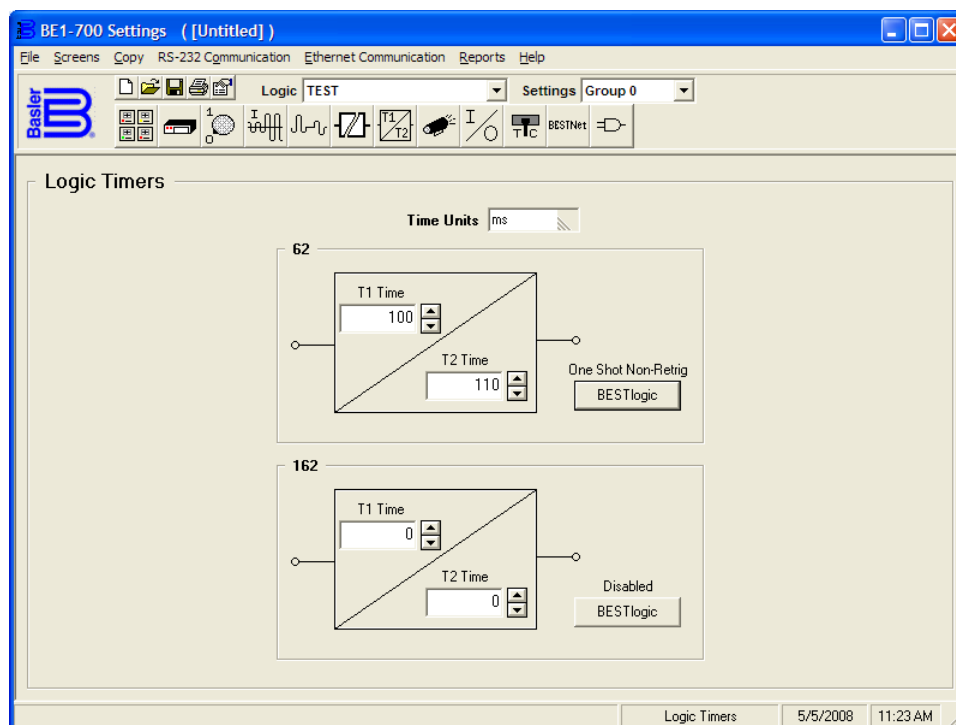


Figure 4-45. Logic Timers Screen

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 must 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 4-28 summarizes the operating settings for General Purpose Logic Timers.

Table 4-28. 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	

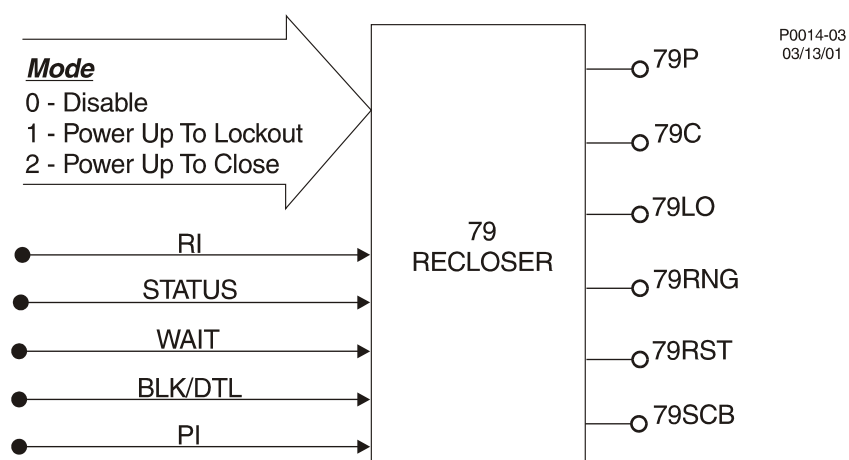
* Time delays less than 10 cycles can be entered to the nearest 0.1 cycles through the HMI. All time delays can be entered to the nearest 0.01 cycles from the ASCII command interface. Time delays entered in cycles are converted to milliseconds or seconds. Increment precision after conversion is limited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

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 (Optional)

The BE1-700 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 4-46 and are described in the following paragraphs. An overall logic diagram for the recloser function is shown in Figure 4-54.

**Figure 4-46. 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 4-47 illustrates the recognition dropout logic and timing relationship.

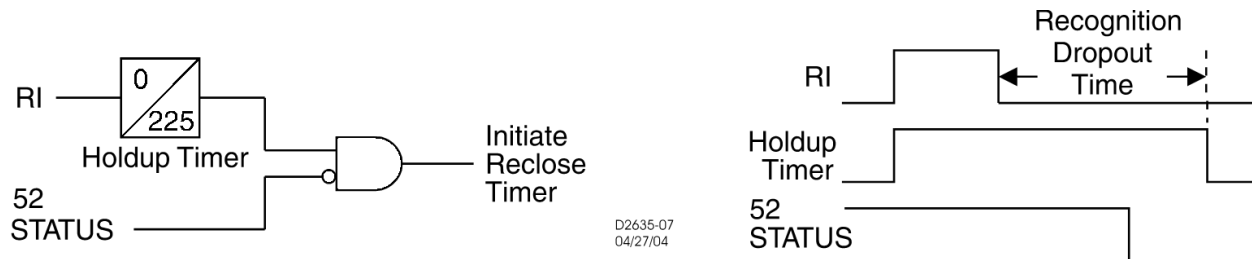


Figure 4-47. Recognition Dropout Timing

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 ms 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.

If the recloser is in reset, and if the time delay for the pilot reclose (*79P*) is non-zero, and if the 1st reclose time delay is zero, upon a trip, a reclose initiate (*RI*) will cause the relay to use the 2nd reclose time delay instead of the 1st reclose time delay.

Close (79C)

The *79C* output becomes TRUE at the end of each reclose time delay and remains TRUE until the breaker closes. Any of the following conditions will cause the *79C* output to become FALSE:

- The *STAT* input indicates that the breaker is closed.
- The reclose fail timer times out.
- The recloser goes to Lockout.
- The *WAIT* logic is asserted.

Recloser Running (79RNG)

The *79RNG* output is TRUE when the reclose is running (i.e., not in Reset or Lockout). This output is available to block the operation of a load tap changer on a substation transformer or voltage regulator during the fault clearing and restoration process.

Lockout (79LO)

This output is TRUE when the recloser is in the Lockout state. It remains TRUE until the recloser goes to the Reset state. The recloser will go to Lockout if any of the following conditions exist:

- More than the maximum number of programmed recloses is initiated before the recloser returns to the Reset state.
- The *DTL/BLK* input is TRUE.
- The Reclose Fail (79F) is TRUE.
- The maximum reclose cycle time is exceeded.

Reset Timer (79RST)

The 79RST output provides reset indication and is TRUE when the recloser is in the reset position.

Sequence Controlled Block (79SCB)

This output becomes TRUE when either the 52 status input OR the 79C input is TRUE AND the sequence operation (shot counter) matches one of the programmed steps of the S<g>-79SCB command. Figure 4-48 illustrates 79SCB logic.

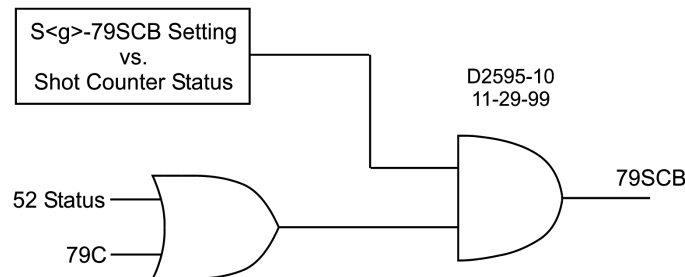


Figure 4-48. 79SCB Logic

BESTlogic Settings for Reclosing

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-49 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.

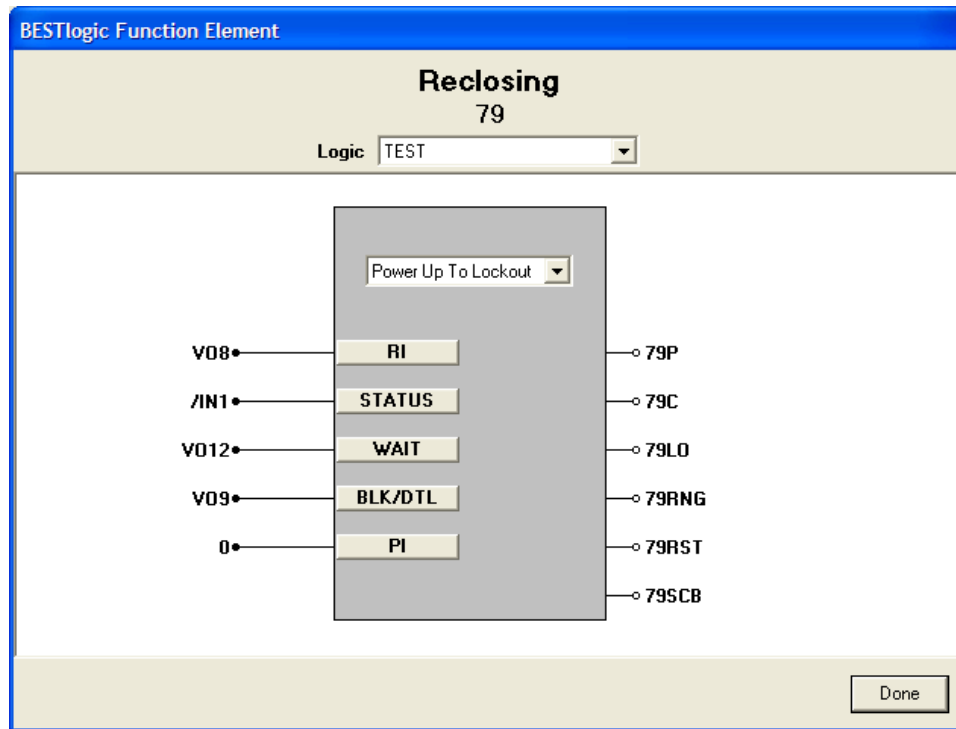


Figure 4-49. BESTlogic Function Element Screen, 79

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 4-29 summarizes the BESTlogic settings for Reclosing.

Table 4-29. 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.	1
RI	OR logic term to initiate the operation of the reclosing function.	V08
STATUS	OR logic term to indicate breaker status. TRUE/1 = closed, FALSE/0 = open.	/IN1
WAIT	OR logic term to momentarily disable but not reset the recloser.	VO12

Function	Range/Purpose	Default
BLK/DTL	OR logic term to disable the recloser (drive to lockout).	VO9
PI	OR logic term to initiate the operation of the pilot function.	0

Operating Settings for Reclosing

Operating settings are made using BESTCOMS. Figure 4-50 illustrates the BESTCOMS screen used to select operational settings for the reclosing element. To open the screen, select *Reclosing* from the *Screens* pull-down menu. Alternately, settings may be made using the S<g>-79 ASCII command.

Settings can also be made from the front panel HMI using Screens 5.x.11.1 through 5.x.11.5 where x equals 1 for Setting Group 0 and 2 for Setting Group 1.

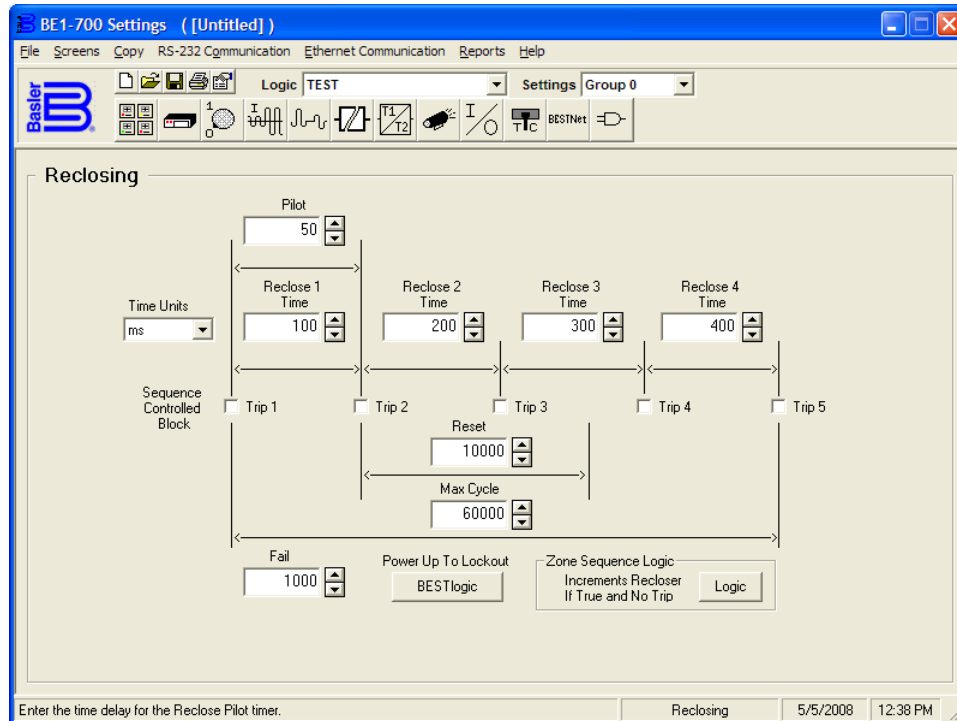


Figure 4-50. Reclosing Screen

At the top of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be created and selected in the *Logic* pull-down menu at the top of the screen before BESTlogic setting can be changed. See Section 7, *BESTlogic Programmable Logic*. To the right of the *Logic* pull-down menu is a pull-down menu labeled *Settings*. The *Settings* menu is used to select the setting group that the element's settings apply to.

Selecting the time units selects the time measurement that applies to all of the reclosing timers, Reset timer, Max Cycle timer, Reset Fail timer, and Pilot timer.

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

Figure 4-30 summarizes the operating settings for Reclosing.

Table 4-30. Operating Settings for Reclosing

Setting	Range	Increment	Default
Time Delays	0.1 to 600 seconds	0.001 second (0 to 0.999 seconds) 0.1 second (1.0 to 9.9 seconds) 1 second (10 to 600 seconds) 0.1 cycles (6 to 36000 cycles)	791 = 0
			792 = 0
			793 = 0
			794 = 0
			79R = 10s
			79F = 1s
			79M = 60s
			79P = 0
Step List	1. 79SCB TRUE during Reset and while timing to Reset after Lockout. 2. 79SCB TRUE when 79C is TRUE for first reclose and while timing to Reset after first reclose. 3. 79SCB TRUE when 79C is TRUE for second reclose and while timing to Reset after second reclose. 4. 79SCB TRUE when 79C is TRUE for third reclose and while timing to Reset after third reclose. 5. 79SCB TRUE when 79C is TRUE for fourth reclose and while timing to Reset after fourth reclose.	0	

Reclosing Fail Timer (79F)

This timer begins when the 79C output becomes TRUE and continues counting until the *STATUS* input becomes TRUE. If the 79F timer times out, the recloser function is driven to lockout and the 79LO output becomes TRUE. The relay remains in Lockout until the breaker is manually closed and the *STATUS* input remains TRUE for the reset time. This setting can be changed on the *Reclosing* screen in BESTCOMS. See Figure 4-50.

Maximum Cycle Timer (MAX Cycle)

Max Cycle is the reclose maximum operation time. If a reclose operation is not completed before the maximum operate time expires, the recloser goes to *Lockout*. This timer limits the total fault clearing and restoration sequence to a definable period. The timer starts when the first trip command is issued from a protective element of the relay. The Max Cycle timer stops when the recloser is reset. If the total reclosing time between *Reset* states exceeds the maximum reclose cycle timer setting, the recloser will go *Lockout*. If the *WAIT* input goes high during the Max Cycle timing sequence, Max Cycle timing will “pause” until the *WAIT* input goes low. If not desired, the Max Cycle timer can be disabled by setting it at zero. This setting can be changed on the *Reclosing* screen in BESTCOMS. See Figure 4-50.

Sequence Controlled Blocking (SCB)

The 79SCB output is TRUE when the breaker is closed, the 79 close output (79C) is TRUE, and the reclose sequence step is enabled with a non-zero value. A 0 (zero) disables the 79SCB output. This setting can be changed on the *Reclosing* screen in BESTCOMS by checking the appropriate *Trip* box. See Figure 4-50.

Figure 4-51 shows a logic timing diagram showing all possible sequence controlled blocks enabled (TRUE). In Figure 4-52, 79RTD is the reclose reset time delay and 79#TD is the reclose time delay where # is the reclose shot number.

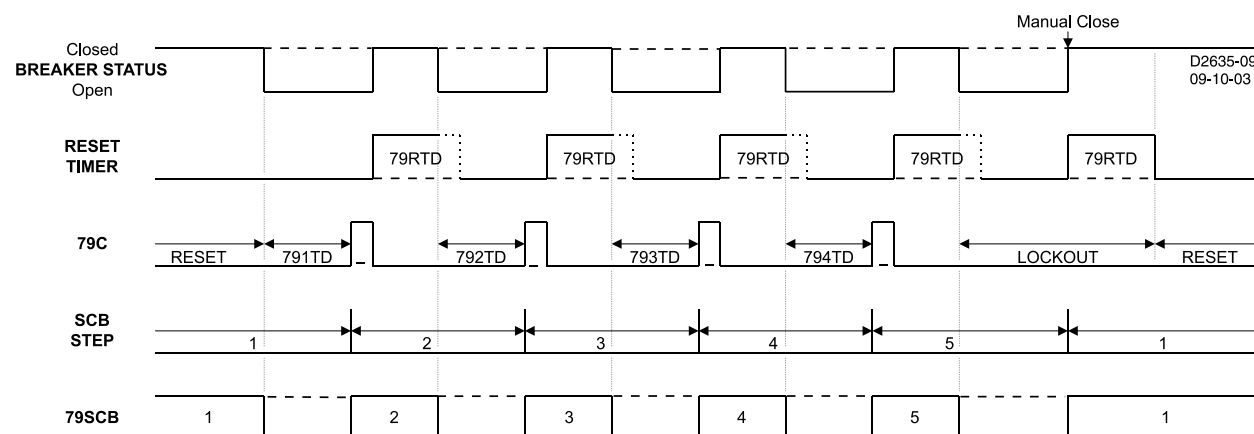


Figure 4-51. S#-79SCB=1/2/3/4/5 Logic Timing Diagram

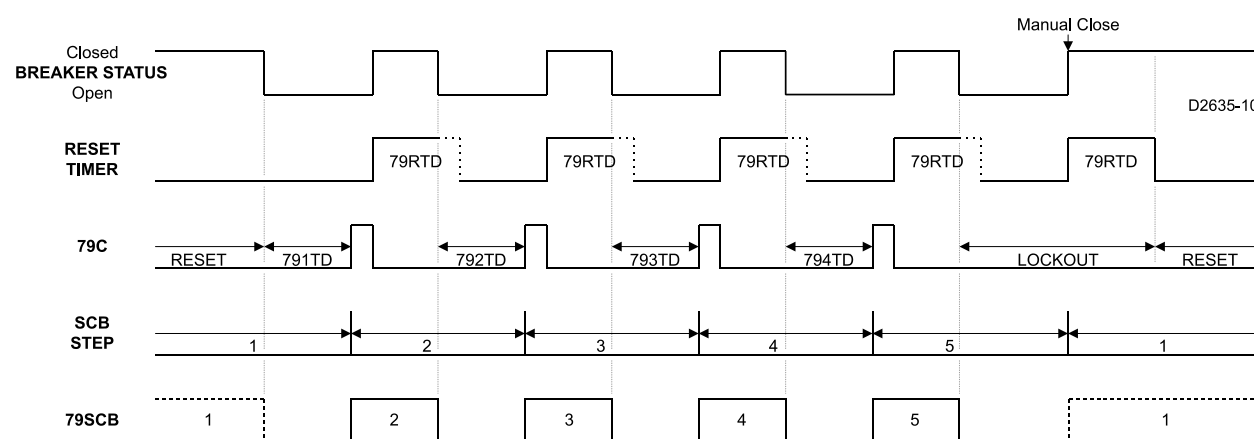


Figure 4-52. S#-79SCB=2/3/4/5 Logic Timing Diagram

Zone-Sequence Coordination

To coordinate tripping and reclosing sequences with downstream protective relays and reclosers, the BE1-700 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 (BE1-700) senses that a downstream device has interrupted fault current, the BE1-700 will increment the trip/reclose sequence by one operation. This occurs because the BE1-700 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 4-53 illustrates the BESTCOMS screen used to select Zone Sequence Coordination Logic settings for the reclosing element. To open the *BESTlogic Function Element* screen for Reclosing (Zone Sequence Logic), select *Reclosing* from the *Screens* pull-down menu and click on the *Logic* button next to Zone Sequence Logic in the lower right corner of the screen. Alternately, settings may be made using the SP-79ZONE ASCII command.

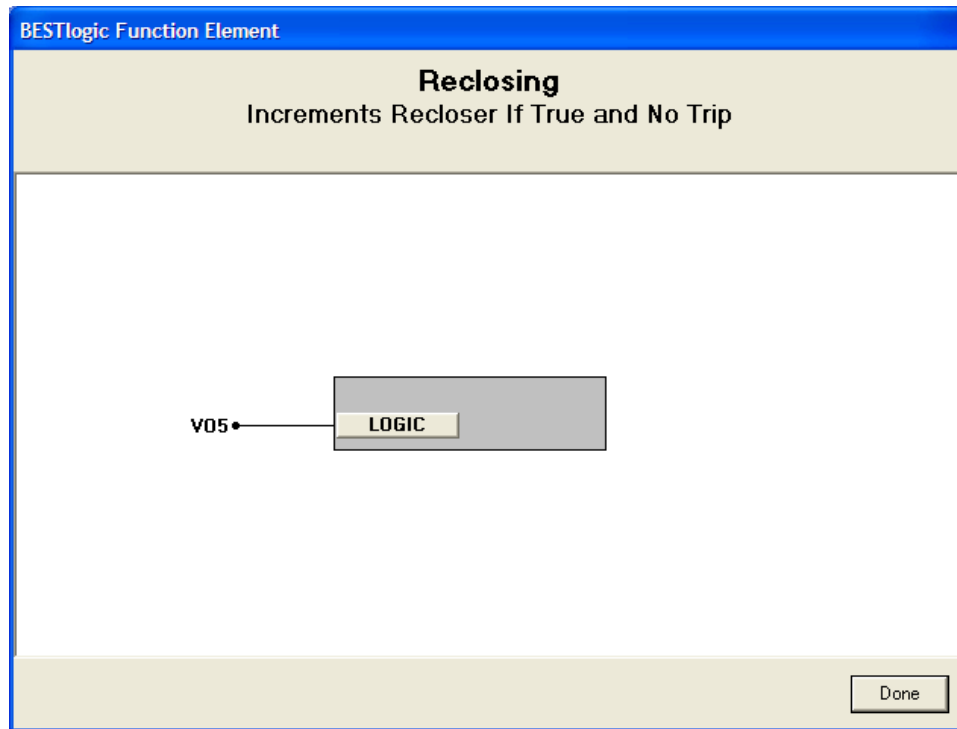


Figure 4-53. BESTlogic Function Element Screen, Reclosing (Zone Sequence Logic)

Table 4-31 summarizes the settings for Zone-Sequence Coordination.

Table 4-31. Settings for Zone-Sequence Coordination

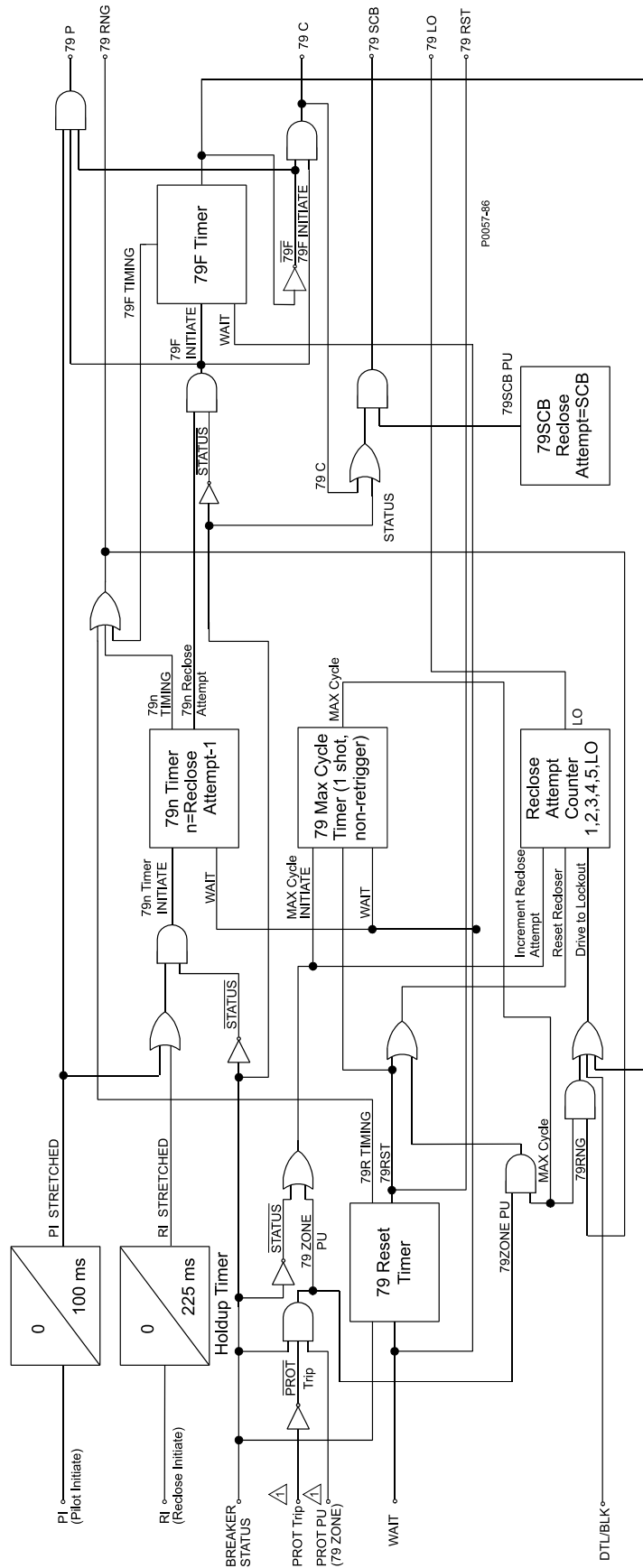
Function	Range/Purpose
Zone Pickup Logic	The zone sequence pickup logic defines which logic elements should be considered zone sequence pickups. Only OR (+) logic can be used – no AND (*) variables may be used.

Recloser zone-sequence coordination detects when a downstream recloser has cleared a fault and increments the upstream 79 automatic reclose count to maintain a consistent count with the other recloser. A fault is presumed cleared downstream when one or more protective functions pickup and dropout with no trip occurring. If the zone pickup logic becomes TRUE and then FALSE without a trip output operating, then the 79 automatic reclose counter should be incremented. The Max Cycle timer resets the shot counter.

Retrieving Reclosing Status from the Relay

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

Figure 4-54 (next page) illustrates an overall logic diagram for Reclosing.



⚠ Not an input; internal to the relay. Refer to Zone Sequence Coordination sub-heading for details.

Figure 4-54. Overall Logic Diagram for Reclosing

Sync-Check Protection

25 - Sync-Check Protection

Figure 4-55 illustrates the inputs and outputs of the Sync-Check element. Element operation is described in the following paragraphs.

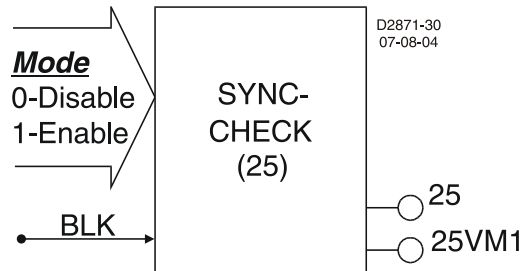


Figure 4-55. Synchronism-Check Logic Block

The Sync-Check element has two outputs: 25 and 25VM1. When monitored voltage between the systems as measured by the phase VTs and the auxiliary Vx input circuits meets angle, voltage, and slip criteria, the 25 output becomes TRUE. 25VM1 is the voltage monitor output.

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

The 25 element is enabled or disabled by the mode input. Two modes are available. Selecting Mode 0 disables the 25 element and selecting Mode 1 enables the 25 element.

The 25 function module will change the 25 output to TRUE if the following conditions are met:

- a) Phase angle between systems is less than setting.
- b) Frequency error between systems is less than setting. As an additional parameter, the relay can be set to only allow generator frequency greater than bus frequency.
- c) Voltage magnitude between systems is less than setting (the voltage used by the relay for this feature is a voltage magnitude measurement, not a voltage phasor measurement).

The BE1-700 compares the VTP voltage magnitude and angle to the VTX voltage magnitude and angle to determine synchronism. Therefore, proper connection of the VT inputs is vital to the correct operation of the 25 function.

The relay automatically compensates for phase angle differences associated with the phase and auxiliary VT connections, including single-phase VTP connections. That is, for a VTP selection of phase to phase and a VTX selection of phase to neutral, the relay will automatically compensate for the 30-degree angle between the two voltage sources. **However, the relay does not scale for differences in magnitude between the applied voltages.** For example, if VTP = 4W (L-N) and VTX=AB (L-L), the angle is automatically compensated for. However, one of the input magnitudes needs to be scaled by SQRT (3) so that the magnitude of the compared voltages is equivalent under sync conditions. **Note:** The sync-check will not work if VTX connections are set for residual voltage input VTX=RG.

For clarification on single-phase VTP connections, refer to the interconnection diagrams shown in Section 12, *Installation*, of this manual. The single-phase parallel connections ensure that the zero-crossing circuit is always connected to the sensed circuit.

For single-phase sensing connections derived from a phase-to-neutral source:

H1 Case: Terminals C13, C14, C15 (A, B, C) are connected in parallel. The single-phase signal is connected between the parallel group and C16 (N).

For single-phase sensing connections derived from a phase-to-phase source:

H1 Case: Terminals C14, C15, C16 (B, C, N) are connected in parallel. The single-phase signal is connected between C13 (A) and the parallel group (AB, BC, CA).

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.

Measuring slip frequency directly allows the function to rapidly determine if systems are in synchronism and requires no timer or inherent delay (as compared to systems that check only that phase angle is held within a window for some stretch of time). The moment parameters a), b), and c) in the previous paragraph are met, the systems may be considered in synchronism and the output becomes TRUE. Refer to Section 5, *Metering*, for more information about slip frequency measurement.

Note

If the 60FL element logic is TRUE and V block is enabled for phase blocking (P), the 25 element will be blocked. For more information on the 60FL function, see *Voltage Transformer Fuse Loss Detection* later in Section 4.

BESTlogic Settings for Sync-Check Protection

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-56 illustrates the BESTCOMS screen used to select BESTlogic settings for the Sync-Check element. To open the *BESTlogic Function Element* screen for the *Sync-Check* element, select *Voltage Protection* from the *Screens* pull-down menu. After selecting the 25 Tab, select the *BESTlogic* button. Alternately, settings may be made using SL-25 ASCII command.

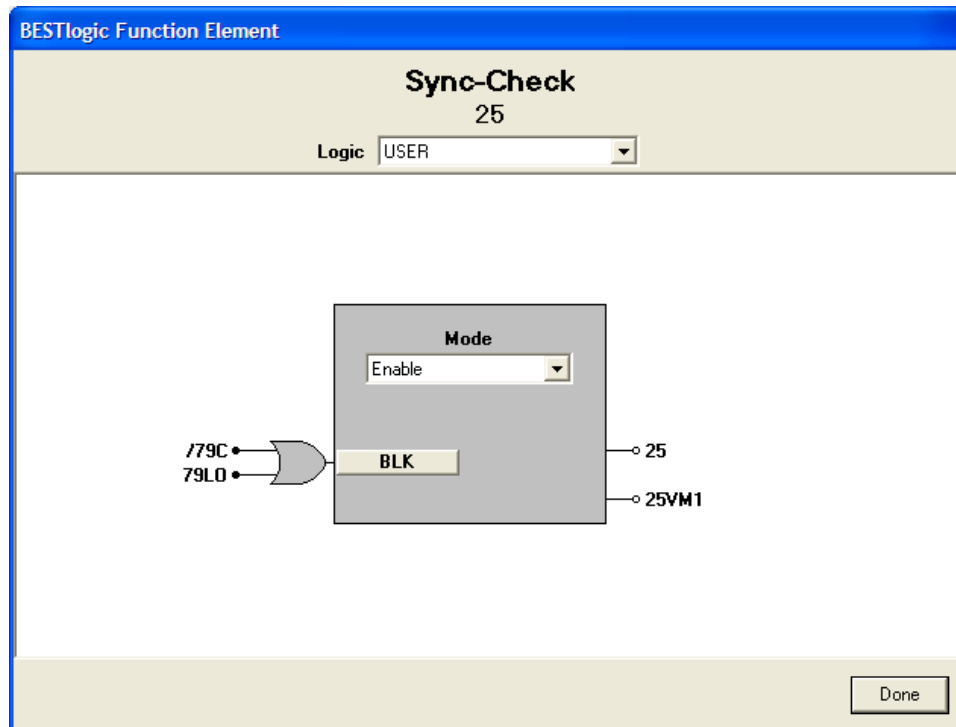


Figure 4-56. BESTlogic Function Element Screen, 25

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

Enable the Sync-Check function by selecting its mode of operation from the *Mode* pull-down menu. To connect the element's inputs, select the button for the corresponding input in the *BESTlogic Function*

Element screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

Table 4-32 summarizes the BESTlogic settings for Sync-Check Protection.

Table 4-32. BESTlogic Settings for Sync-Check Protection

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

Operating Settings for Sync-Check

Operating settings are made using BESTCOMS. Figure 4-57 illustrates the BESTCOMS screen used to select operational settings for the Sync-Check element. To open the *Voltage Protection* screen, select *Voltage Protection* from the *Screens* pull-down menu. Then select the 25 Tab. Alternately, settings may be made using the S<g>-25 ASCII command or through the HMI using Screens 5.x.2.1 through 5.x.2.4 where g equals the setting group number and x equals 1 (Setting Group 0) and 2 (Setting Group 1).

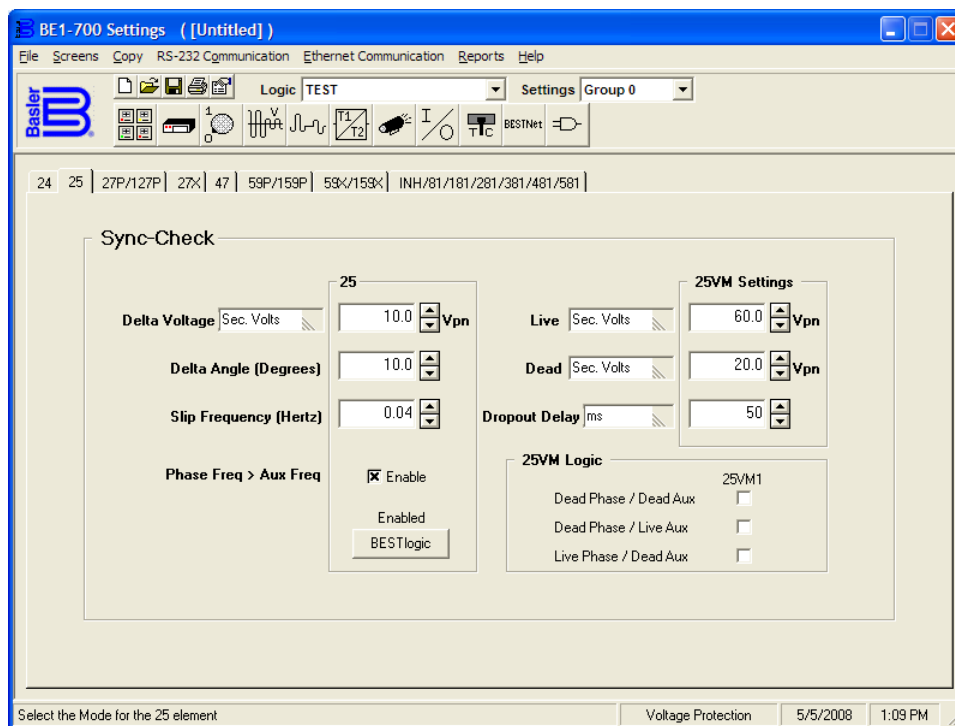


Figure 4-57. Voltage Protection Screen, 25 Tab

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

The default unit of measure for *Delta Voltage* is secondary volts (Sec. Volts). Primary volts (Pri Volts), per unit volts (Per U Volts), and percent volts (% Volts) can also be selected as the pickup setting unit of measure.

Table 4-33 summarizes the operating settings for Sync-Check Protection.

Table 4-33. Operating Settings for Sync-Check Protection

Setting	Range	Increment	Unit of Measure	Default
Delta Voltage	1 to 20	0.1	Secondary volts	1
Delta Angle	1 to 99	0.1	Degrees	10
Slip Frequency	0.01 to 0.5	0.01	Hertz	0.01
Phase Frequency > Aux Frequency	0 = Disabled 1 = Enabled	N/A	N/A	0

Retrieving Sync-Check Protection Status from the Relay

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

25VM - Voltage Monitor

Operating settings for the 25VM are made on the *Voltage Protection* screen at the 25 tab. Refer to Figure 4-57. Settings can also be made with the S0-25VM ASCII command or on HMI Screens 5.x.2.2 – 5.x.2.4.

Table 4-34 summarizes the operating settings for Voltage Monitor.

Table 4-34. Operating Settings for Voltage Monitor

Setting	Range	Increment	Unit of Measure	Default
Live	10 to 150	0.1 for 10 to 100 1 for 100 to 150	Volts	60
Dead	10 to 150	0.1 for 10 to 100 1 for 100 to 150	Volts	20
Dropout Delay	50 to 60000	1 for 50 to 999 100 for 1000 to 9900 1000 for 10000 to 60000	Milliseconds	50 ms
	0.050 to 60	0.001 for 0.050 to 0.999 0.1 for 1.0 to 9.9 1 for 10 to 60	Seconds	
25VM1	0 = Disabled 1 – 3, 12, 13, 23, 123	N/A	N/A	0

The sync-check output, 25, only provides closing supervision for the live line/live bus condition. The voltage monitor function 25VM is provided for conditions where the bus and/or the line are dead. A live condition for either the VP or the VX is determined when the measured voltage on the respective input is above the measured voltage and below the DV threshold.

For the phase voltage input, if the connection is three phase, 3W, or 4W, all three phases are tested and must be above the LV threshold for a live condition to be TRUE. Similarly, all three phases must be below the DV threshold for a dead condition to be TRUE.

The function includes one independent output, 25VM1 as illustrated in Figure 4-58. The logic conditions are summarized in Table 4-35. Any combination of logic settings can be selected as shown in Table 4-34. When a logic condition is selected, it closes the respective switch in Figure 4-58 associated with each of the outputs. The two independent logic outputs might be used to set up different closing supervision criteria for automatic reclose versus manual close.

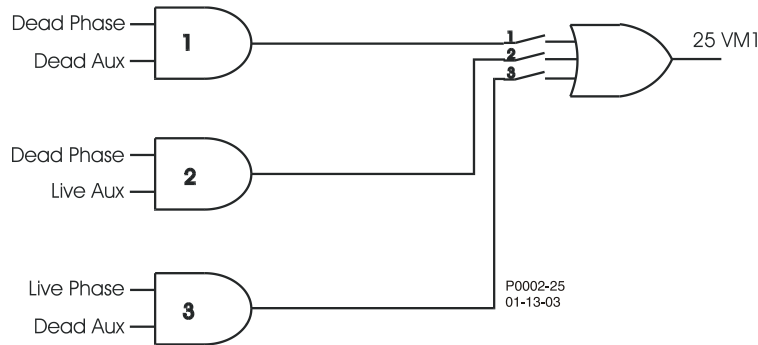


Figure 4-58. 25VM Logic

Table 4-35. Logic Settings for Voltage Monitor

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

Retrieving Voltage Monitor Status from the Relay

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

Voltage Transformer Fuse Loss Detection (BE1-700V)

60FL - Fuse Loss Detection

BE1-700 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 4-59. When the element logic becomes TRUE, the 60FL logic output becomes TRUE. A logic diagram is shown in Figure 4-60. Logic parameters are shown in Table 4-36.

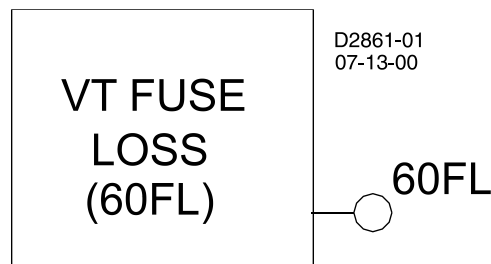


Figure 4-59. Fuse Loss Detection Logic Block

Trip Logic: 60FL Trip = (A * C * G) (See Table 4-36.)

Reset Logic: 60FL Reset = H * /K (See Table 4-36.)

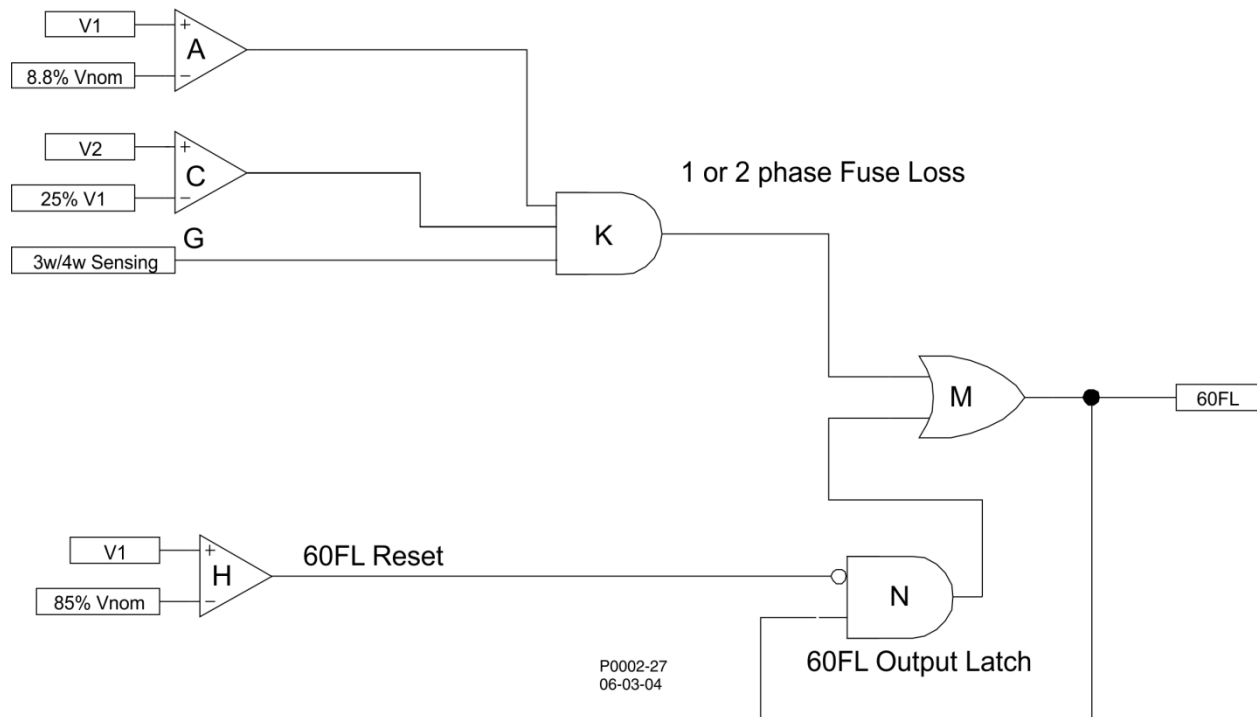


Figure 4-60. 60FL Element Logic

Table 4-36. 60FL Logic Parameters

Input	TRUE Condition
A	Positive-sequence volts greater than 8.8% of the nominal voltage; Detects minimum voltage is applied.
C	Negative-sequence volts greater than 25% of the pos-seq volts; Detects loss of 1 or 2 phase voltages.
G	Three-wire or four-wire sensing selected.
H	Positive-sequence volts greater than 85% of nominal voltage; Detects a restored voltage condition.
K	$(A * C * G)$; Detects when either one or two 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 4-37). The I Block setting (51/27R) assumes that the voltage is VNOM when 60FL is TRUE because the voltage measurement is not present or is unreliable. If the input voltage is nominal, then voltage restraint and control have no effect. The V Block settings (P, N, Q) determine which voltage functions are blocked when the 60FL logic is TRUE.

Settings are made using BESTCOMS. Figure 4-61 illustrates the BESTCOMS screen used to select blocking settings for the 60FL element. Select *Reporting and Alarms* from the *Screens* pull-down menu and select the *VT Monitor* tab. Alternately, settings may be made using the SP-60FL ASCII command. See Section 11, *ASCII Command Interface, Command Summary, Protection Setting Commands*, for more information.

Table 4-37. 60FL Element Blocking Settings

Mode Input	Setting	Explanation	Default
V Block	DIS	Phase (P), Neutral (N), and Negative-Sequence (Q) voltage functions are not automatically blocked when 60FL logic is TRUE.	PNQ
	P	All functions that use phase voltage are blocked when the 60FL logic is TRUE. (27P/127P, 59P/159P, and 25)	
	N	All functions that use 3-phase residual voltage ($3V_0$) measurements are blocked when the 60FL logic is TRUE. (27X, 59X, 159X, - Mode 2)	
	Q	All functions that use the negative-sequence voltage (V_2) measurement are blocked when the 60FL logic is TRUE. (47)	

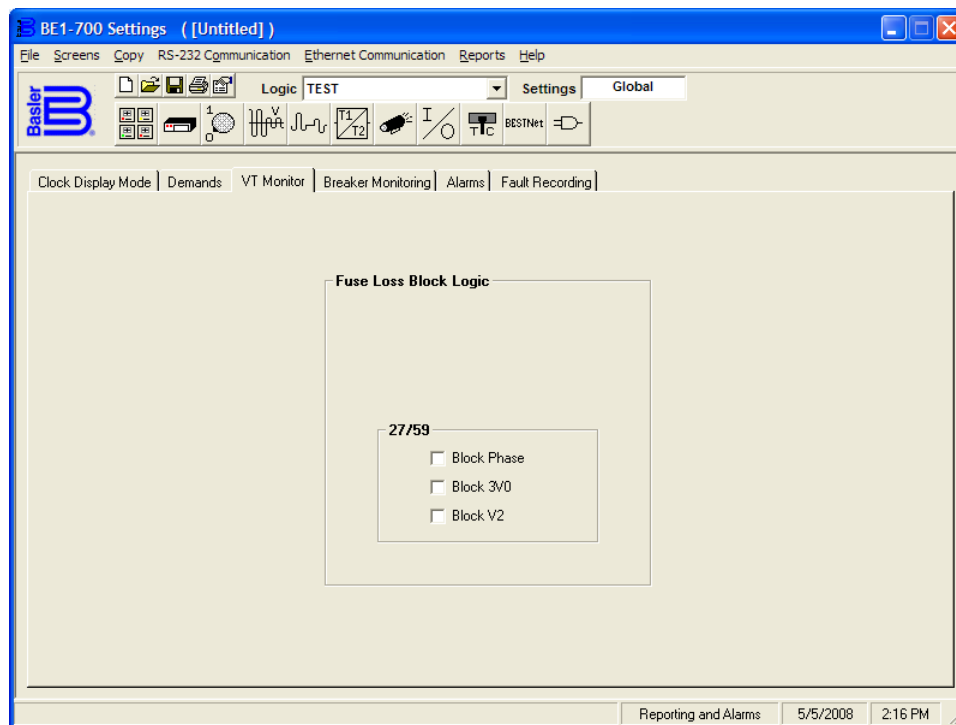


Figure 4-61. Reporting and Alarms Screen, VT Monitor Tab

The 60FL element detects fuse loss and loss of potential by using voltage and current thresholds that are expressed as a percentage of the nominal voltage and current values. See Section 3, *Input and Output Functions*, for information on changing the nominal voltage and current values using the SG-NOM command.

Retrieving Fuse Loss Detection Status from the Relay

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

Virtual Switches

43 - Virtual Selector Switches

The BE1-700 Digital Protective Relay has two virtual selector switches that can provide manual control, locally and remotely, without using physical switches and/or interposing relays. Each virtual switch can be set for one of three modes of operation to emulate virtually any type of binary (two position) switch. An example would be an application that requires a ground cutoff switch. The traditional approach might be

to install a switch on the panel and wire the output to a contact sensing input on the relay or in series with the ground trip output of the relay. Instead, a virtual switch can be used to reduce costs with the added benefit of being able to operate the switch both locally through the HMI and remotely from a substation computer or through a modem connection to a remote operator's console.

The state of the switches can be controlled from the optional HMI or ASCII command interface. Control actions can be set by the BESTlogic mode setting. When set for *On/Off/Pulse*, each switch can be controlled to open (logic 0), close (logic 1), or pulse such that the output toggles from its current state to the opposite state and then returns. Additional modes allow the switch operation to be restricted. In *On/Off*, the switch emulates a two-position selector switch, and only open and close commands are accepted. In *Off/Momentary On*, a momentary close, spring-return switch is emulated and only the pulse command is accepted. Because switch status information is saved in nonvolatile memory, the relay powers up with the switches in the same state as when the relay was powered down.

Each virtual selector switch element (see Figure 4-62) has one output: 43 or 143. The output is TRUE when the switch is in the closed state; the output is FALSE when the switch is the open state. Since both the output and the inverse of the output of these switches can be used as many times as desired in your programmable logic, they can emulate a switch with as many normally open and normally closed decks as desired.

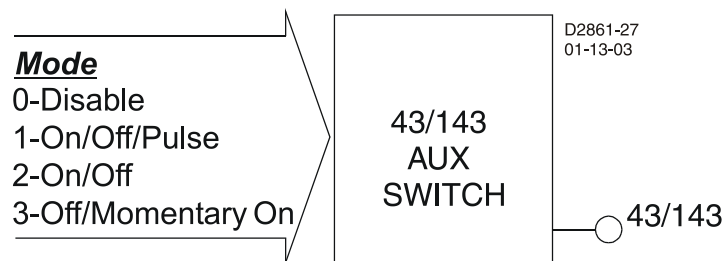


Figure 4-62. Virtual Selector Switches Logic Block

User specified labels could be assigned to each virtual switch and to both states of each switch. In the previous ground cutoff switch example, you might enable one of the switches in BESTlogic as Mode 2, ON/OFF and connect the output of that switch to the blocking input of the 59x protection element. This would disable the ground overvoltage protection when the switch is closed (logic 1) and enable it when the switch is open (logic 0). For the application, you might set the switch label to be 59N_CUTOFF (10 character maximum). The closed position on the switch might be labeled DISABLD (7 character maximum) and the open position might be labeled NORMAL. Section 7, *BESTlogic Programmable Logic*, has more details about setting user programmable names for programmable logic variables.

BESTlogic Settings for Virtual Selector Switches

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-63 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Virtual Switch* element. To open the *BESTlogic Function Element* screen for the *Virtual Switch* element, select *Virtual Switches* from the *Screens* pull-down menu. Then select the *BESTlogic* button for the virtual switch to be edited. Alternately, settings may be made using SL-43 or SL-143 ASCII commands.

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

Enable the Virtual Switch function by selecting its mode of operation from the *Mode* pull-down menu. Select *Done* when the settings have been completely edited.

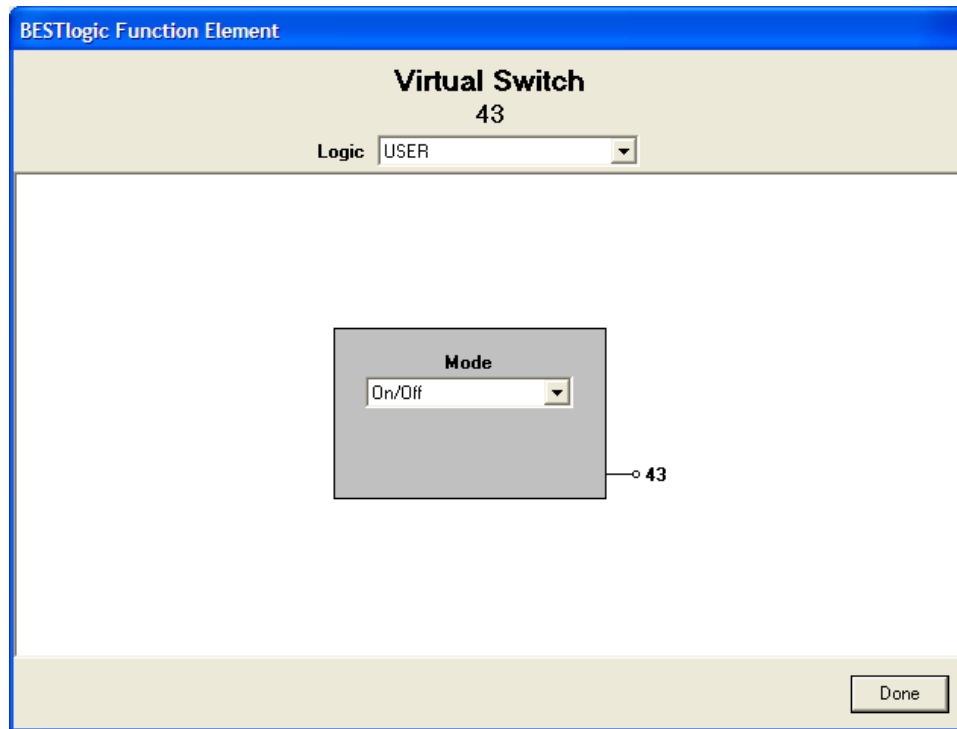


Figure 4-63. BESTlogic Function Element Screen, 43

Table 4-38 summarizes the BESTlogic settings for Virtual Selector Switches. These settings enable the x43 element by selecting the mode of operation. There are no logic inputs.

Table 4-38. 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

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 and 2.1.2. Control is also possible through the ASCII command interface by using the select-before-operate commands CS-x43 (control select-virtual switch) and CO-x43 (operate select-virtual switch). A state change takes place immediately without having to execute an *Exit - Save settings* command.

CS/CO-x43 Command

Purpose: Select and operate the virtual selector switches.

Syntax: CS/CO-<x>43[=<Action>]

Comments: x = no entry for 43 or 1 for 143. Action = 0 to open the switch, 1 to close the switch, P to pulse the switch to the opposite state for 200 milliseconds and then automatically return to starting state.

The virtual switch control commands require the use of select-before-operate logic. First, the command must be selected using the CS-x43 command. After the select command is entered, there is a 30 second window during which the CO-x43 control command will be accepted. The control selected and the operation selected must match exactly or the operate command will be blocked. If the operate command is blocked, an error message is output.

CS/CO-x43 Command Examples:

- Example 1. Read the current status of Virtual Switch 43.
 >CO-43
 0
- Example 2. Momentarily toggle the state of Switch 43 to closed.
 >CS-43=P
 43=P SELECTED
 >CO-43=P
 43=P EXECUTED
- Example 3. An example of an operate command not matching the select command.
 >CO-143=1
 ERROR:NO SELECT

Retrieving Virtual Selector Switch Status 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 and on BESTCOMS *Metering* screen. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

HMI Screens 2.1.1 and 2.1.2 provide switch control and can also display the current status of their respective switches. ASCII command CO-x43 returns the state of each virtual selector switch in a read-only mode. See the previous Example 1.

101 - Virtual Breaker Control Switch

The virtual breaker control switch (shown in Figure 4-64) 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.

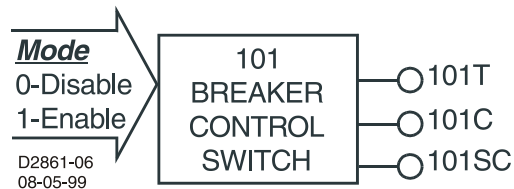


Figure 4-64. Virtual Breaker Control Switch Logic Block

The breaker control switch emulates a typical breaker control switch with a momentary close, spring return, trip contact (output 101T), a momentary close, spring return, close contact (output 101C), and a slip contact (output 101SC). The slip contact output retains the status of the last control action. That is, it is FALSE (open) in the after-trip state and TRUE (closed) in the after-close state. Figure 4-65 shows the state of the 101SC logic output with respect to the state of the 101T and 101C outputs.

When the virtual control switch is controlled to trip, the 101T output pulses TRUE (closed) for approximately 200 milliseconds and the 101SC output goes FALSE (open). When the virtual control switch is controlled to close, the 101SC output pulses TRUE (closed). The status of the slip contact output is saved to nonvolatile memory so that the relay will power up with the contact in the same state as when the relay was powered down.

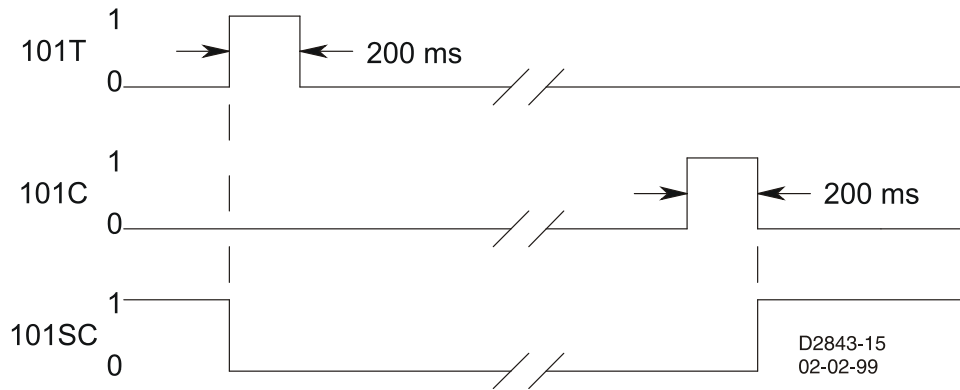


Figure 4-65. Virtual Breaker Control Switch State Diagram

BESTlogic Settings for Virtual Breaker Control Switch

BESTlogic settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 4-66 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Breaker Control Switch* element. To open the *BESTlogic Function Element* screen for the *Virtual Switch* element, select *Virtual Switches* from the *Screens* pull-down menu. Then select the *BESTlogic* button for the virtual switch to be edited. Alternately, settings may be made using the SL-101 ASCII command.

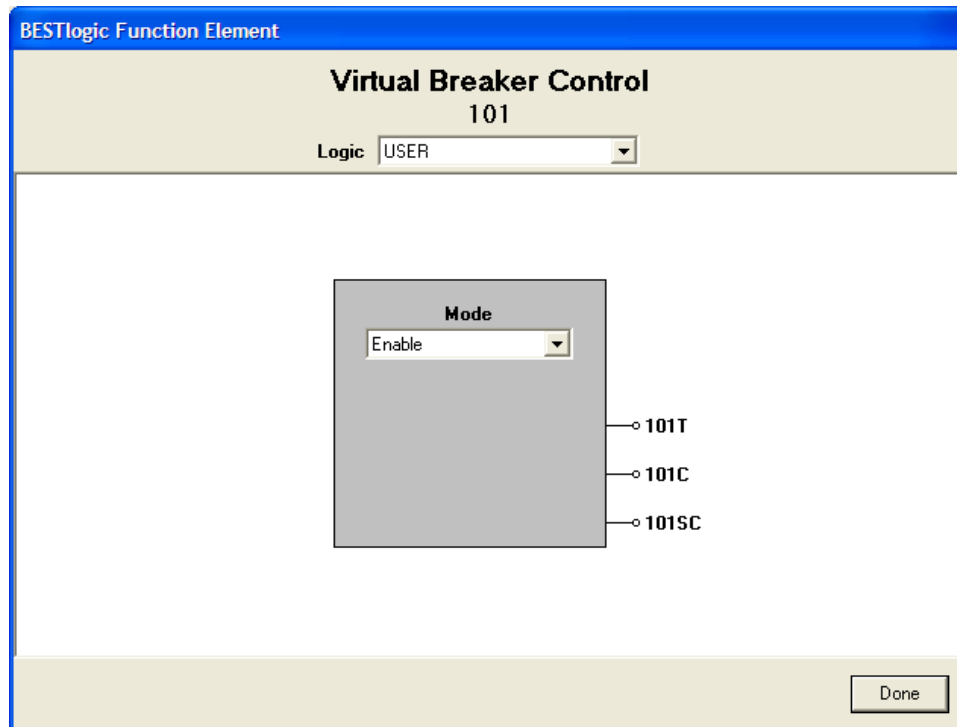


Figure 4-66. BESTlogic Function Element Screen, 101

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

Enable the *Virtual Breaker Control* function by selecting its mode of operation from the *Mode* pull-down menu. Select *Done* when the settings have been completely edited.

Table 4-39 summarizes the BESTlogic settings for Virtual Breaker Control Switch.

Table 4-39. BESTlogic Settings for Virtual Breaker Control Switch

Function	Range/Purpose	Default
Mode	0 = Disable, 1 = Enable	0

Select Before Operate Control of Virtual Breaker Control Switch

The state of the virtual breaker control switch can be controlled at the HMI through Screen 2.2.1. Control is also possible through the ASCII command interface by using the select-before-operate commands CS-101 (control select-virtual control switch) and CO-101 (control operate-virtual controls switch). Control is not possible using BESTCOMS. A state change takes place immediately without having to execute an *Exit - Save settings* command.

CS/CO-101 Command

Purpose: Select and operate the virtual control switch.

Syntax: CS/CO-101=<action>

Comments: Action = T to pulse the 101T output; C to pulse the 101C output

The virtual breaker control switch commands require the use of select-before-operate logic. First, the command must be selected using the CS-101 command. After the select command is entered, there is a 30 second window during which the CO-101 control command will be accepted. The control selected and the operation selected must match exactly or the operate command will be blocked. If the operate command is blocked and error message is output.

CS/CO-101 Command Examples:

Example 1. Read the current status of the virtual control switch.
 >CO-101
 C

The returned setting indicates that the switch is in the after-close state.

Example 2. Trip the breaker by closing the trip output of the virtual control switch.
 >CS-101=T
 101=T SELECTED
 >CO-101=T
 101=T EXECUTED

Retrieving Virtual Breaker Control Switch Status from the Relay

The virtual breaker control switch state (after-trip or after-close) can be determined through the ASCII command interface by using the RG-STAT (reports general-status) command or on BESTCOMS *Metering* screen. See Section 6, *Reporting and Alarm Functions, General Status Reporting*, for more information.

HMI Screen 2.2.1 provides switch control and displays the status of the virtual breaker control switch (after-trip or after-close). As the previous Example 1 demonstrated, the state of the virtual breaker control switch can be determined using the CO-101 command in a read-only mode.



5 • Metering

The BE1-700 Digital Protective Relay measures the voltage and current inputs, displays those values in real time, records those values every ¼ second, and calculates other quantities from the measured inputs.

Metering Functions

BE1-700 metering functions include voltage, current, and frequency. Metered values are viewed through any communication port using serial commands or at the front panel human-machine interface (HMI). Metering functions are summarized in the following paragraphs and in Table 5-2. For assistance with navigating through the HMI metering screens, refer to Section 10, *Human-Machine Interface*.

Auto Ranging

The BE1-700 automatically scales metered values. Table 5-1 illustrates the ranges for each value metered. **C** under the Type column refers to the BE1-700C relay; **V** refers to the BE1-700V relay.

Table 5-1. Auto Ranging Scales for Metered Values

Type	Metered Value	Unit Display Ranges		
		Whole Units	Kilo Units	Mega Units
C	Current	0 A to 9,999 A	10 kA to 9,999 kA	10 MA
V	Voltage	0 V to 999 V	0 kV to 999 kV	1 MV
V	Frequency	10 to 75 Hz	N/A	N/A

BESTCOMS™ Metering Screen

Metered values are viewed through the BESTCOMS™ *Metering* screen (see Figure 5-1). To open the *Metering* screen, select *Metering* from the *Reports* pull-down menu. To begin viewing metered values, select the *Start Polling* button in the bottom right of the screen.

Alternately, metering can be performed through the use of the ASCII command interface or HMI using Screens 3.1 through 3.11.

Refer to Table 5-2 for a list of ASCII commands and HMI Screens used for metering. **C** under the Type column refers to the BE1-700C relay; **V** refers to the BE1-700V relay; **A** refers to both relays.

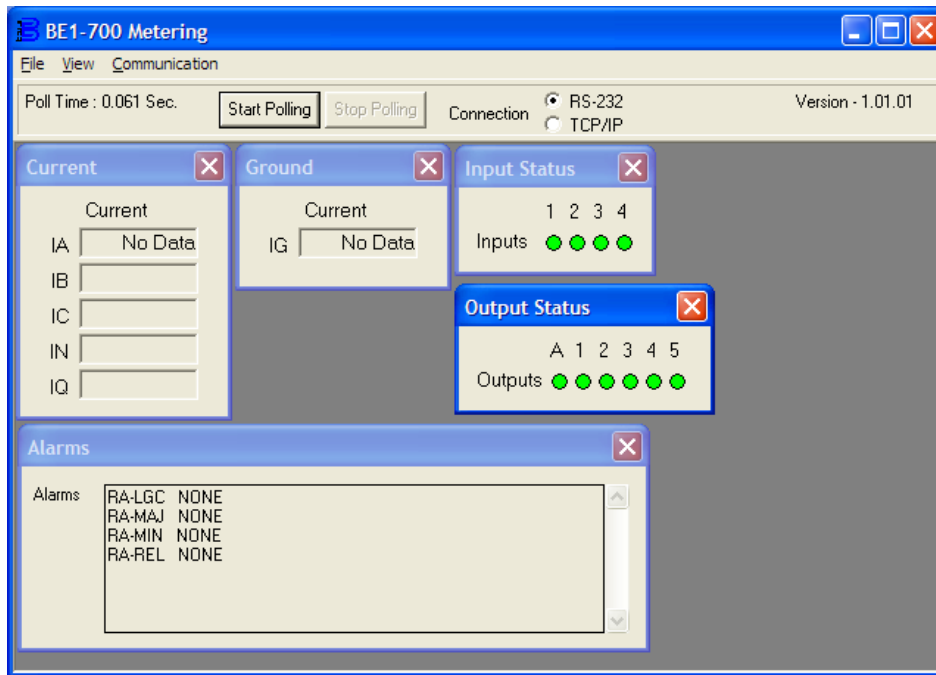


Figure 5-1. BESTCOMS™ Metering Screen (BE1-700C is Shown)

Table 5-2. ASCII Command and HMI Metering Cross-Reference

Type	Metering Function	ASCII Command	HMI Screen
A	All metered values	M	N/A
V	Voltage, all values	M-V	N/A
V	Voltage, A-phase	M-VA	3.1
V	Voltage, B-phase	M-VB	3.1
V	Voltage, C-phase	M-VC	3.1
V	Voltage, A-phase to B-phase	M-VAB	3.2
V	Voltage, B-phase to C-phase	M-VBC	3.2
V	Voltage, A-phase to C-phase	M-VAC	3.2
V	Voltage, Auxiliary	M-VX	3.3
V	Voltage, 3 RD Harmonic Auxiliary	M-V3X	3.3
V	Voltage, Negative-Sequence	M-V2	3.4
V	Voltage, Zero-Sequence	M-3V0	3.4
C	Current, all values	M-I	N/A
C	Current, A-phase	M-IA	3.5
C	Current, B-phase	M-IB	3.5
C	Current, C-phase	M-IC	3.5
C	Current, Ground	M-IG	3.6
C	Current, Neutral	M-IN	3.7
C	Current, Negative-Sequence	M-IQ	3.7
V	Frequency	M-FREQ	N/A
V	Frequency, Phase	M-FREQP	3.10
V	Frequency, Auxiliary	M-FREQX	3.10

Type	Metering Function	ASCII Command	HMI Screen
V	Frequency, Slip	M-FREQS	3.11
V	Metered sync angle between Phase and Aux inputs	M-SYNC	3.11

Voltage (BE1-700V)

The BE1-700 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 are also metered. The VTP connection determines what is measured. For the auxiliary voltage input, fundamental (Vx) and 3rd harmonic voltages (V3X) are style options.

Current (BE1-700C)

Metered current includes A-phase current, B-phase current, C-phase current, neutral three-phase zero-sequence current, and ground current. Other metered currents include 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 (BE1-700V)

Frequency is metered over a range of 10 to 75 hertz. If the measured frequency is outside this range, the nominal system frequency will be displayed. Frequency is sensed from A-phase to Neutral for four-wire sensing systems or from A-phase to B-phase for three-wire sensing systems. The frequency of auxiliary voltage VX is also measured. Refer to Figure 5-2.

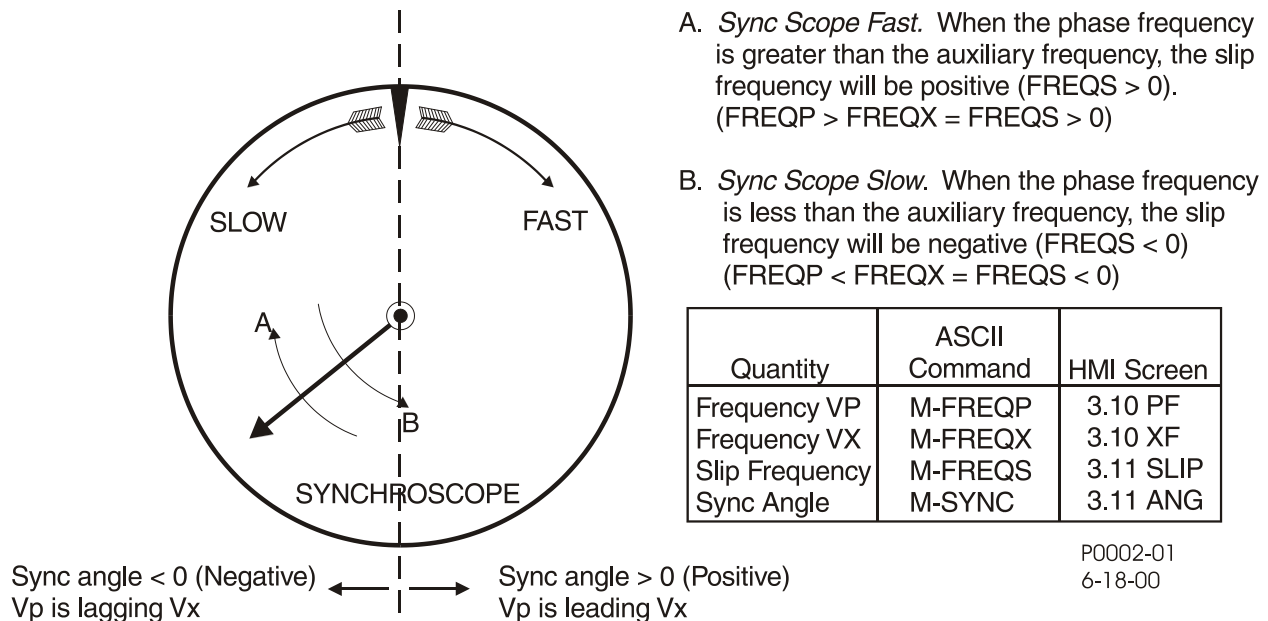


Figure 5-2. Relationship of Slip Frequency and Sync Angle to Synchroscope



6 • Reporting and Alarm Functions

This section describes all available reports from the BE1-700 Digital Protective 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

BE1-700 relays have two relay Circuit Identification fields: *Relay ID* and *Station ID*. These fields are used in the header information lines of the Fault Reports, Oscillograph Records, and Sequence of Events Records.

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

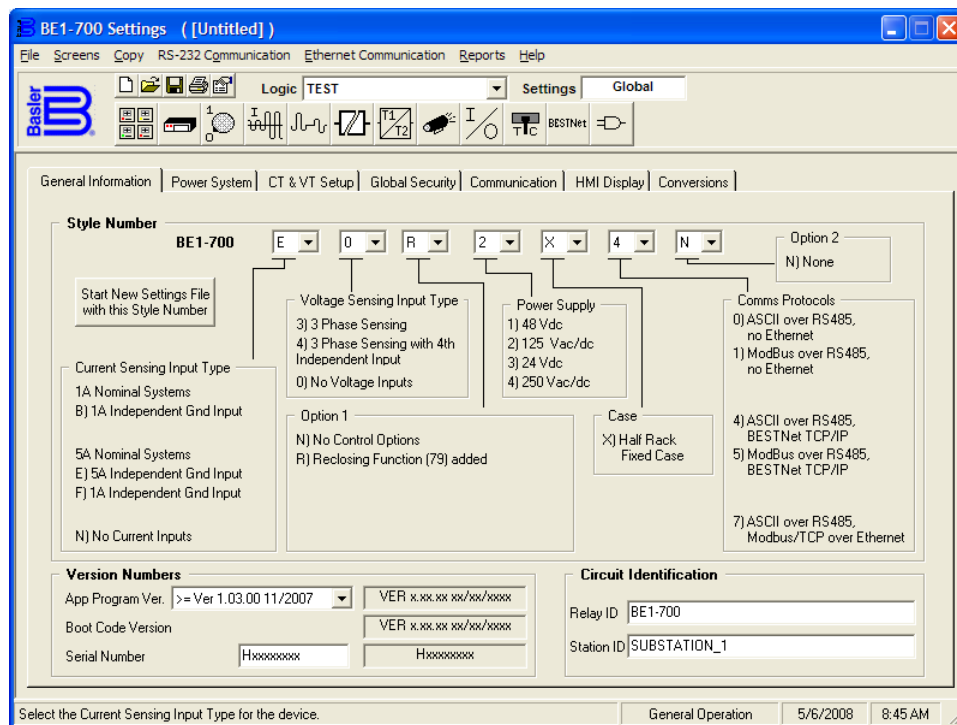


Figure 6-1. General Operation Screen, General Information Tab

To change these, delete the old label from the cell and type the new label. Identification settings are summarized in Table 6-1.

Table 6-1. Relay Circuit Identification Settings

Setting	Range	Default
Relay ID	1 to 30 alphanumeric characters *	BE1-700
Station ID	1 to 30 alphanumeric characters *	SUBSTATION_1

* No spaces are allowed in labels; any spaces used in the labels are stripped when the label change is saved. Use the character “_” (Shift + Underscore) to create a break in characters. An example of this is “SUBSTATION_1”.

Clock

The BE1-700 provides a real-time clock that 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.

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 k Ω at 3.5 volts.

Setting the Clock Function

Time and date format settings are made using BESTCOMS. Figure 6-2 illustrates the BESTCOMS screen used to select time and date format settings. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Clock Display Mode* tab. Alternately, settings may be made using the SG-CLK ASCII command. Refer to Table 6-2, *Time and Date Format Settings*.

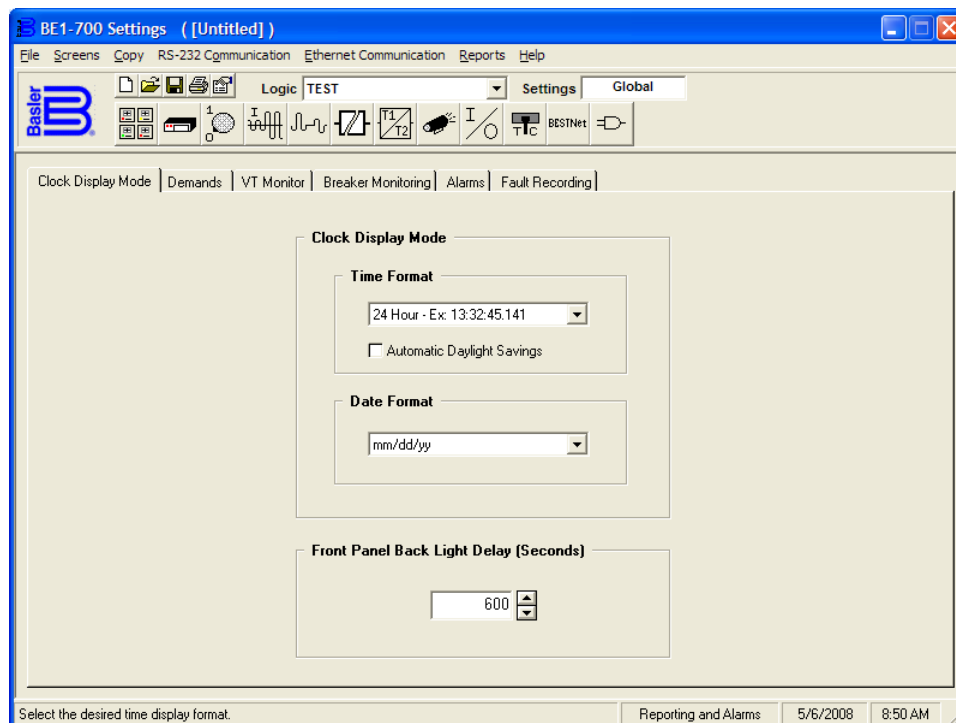


Figure 6-2. Reporting and Alarms Screen, Clock Display Mode Tab

Time and date reporting can be displayed in 12 or 24-hour format. When operating in the 12-hour format, the A.M./P.M. parameter is placed between the minutes and seconds parameters (10:24P23.004 indicates 10:24 in the evening). The default time format is 24 hours. Date reporting format can display the date in mm/dd/yy or dd/mm/yy format. The default date format is mm/dd/yy. The relay clock can also accommodate daylight saving time changes. Automatic daylight saving time adjustments are optional and are disabled by default.

The *Front Panel Back Light Delay* can be adjusted to dim the backlight after a period. The SG-BL ASCII command can also be used.

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
Front Panel Back Light Delay	0 to 600 seconds	600

Reading and Setting the Clock

Clock information can be viewed and set at the front panel human-machine interface (HMI) and through the communication ports using ASCII commands or BESTCOMS. Write access to reports is required to set the clock at the HMI and communication ports. An alarm point is provided in the programmable alarms to detect when the relay has powered up and the clock has not been set. Time and date information is read and set at HMI Screen 4.6, through the communication ports using the RG-DATE and RG-TIME ASCII commands, and through BESTCOMS by selecting the *Communication* pull-down menu and then selecting *Set Date and Time*.

General Status Reporting

BE1-700 relays have extensive capabilities for reporting relay status. This is important for determining the health and status of the system for diagnostics and troubleshooting. Throughout this manual, reference is made to the RG-STAT (report general, status) report and the appropriate HMI screens for determining the status of various functions.

General Status Report

A General Status report is available through the communication ports using the RG-STAT command. This report lists all of the information required to determine the status of the relay. An example of a typical General Status report follows as well as a description of what each line represents. In the explanation of each line, cross-references are made to the corresponding HMI screens that contain that data.

>RG-STAT

```

INPUT (1234)           STATUS : 0000
OUTPUT (A12345)       STATUS : 000000
CO-OUT (A12345)       STATUS : LLLLLL
CO-43/143             STATUS : 00
CO-101 (101SC)        STATUS : AFTER CLOSE(1)
CO-GROUP              STATUS : L
ACTIVE LOGIC          STATUS : 700C-5051-A-BE
RECLOSER (79)         STATUS : LOCKOUT *
LOGIC VAR (00-31)     STATUS : 00000000 00000000 00000000 00010000
LOGIC VAR (32-63)     STATUS : 00000000 00000000 00000000 00100010
LOGIC VAR (64-95)     STATUS : 01000000 00000000 00000000 00000000
ACTIVE GROUP          STATUS : 0
BREAKER (52)          STATUS : CLOSED
DIAG/ALARM            STATUS : 0 RELAY, 0 LOGIC, 0 MAJOR, 0 MINOR

```

* Recloser (79) is optional. See *Style Chart* in Section 1, *General Information*.

V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	I	I	I	I	6	1	2	7	2	1	1	1	A	A	A	O	T
O	O	O	O	O	O	O	O	O	O	O	1	1	1	1	1	1	N	N	N	N	6	6	X	X	1	0	0	1	L	L	L	U	R
A	1	2	3	4	5	6	7	8	8	9	0	1	2	3	4	5	1	2	3	4	2	2	T	P	2	1	1	S	M	M	M	1	S
3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
2	3	4	5	6	7	8	9		0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	6	7	8	9	0	1	2	3
A				1					1								1				1												
R			5	5		1	2		2								5	5	5	9	9		1	2						2			
S			9	9	2	2	7		7	4	7	2	4	B		5	9	9	9	X	X	8	8	8		3	4	5	6	5		S	S
T			P	P	7	7	P		P	4	P	4	P	F	B	9	P	X	X	P	P	1	1	1		8	8	8	0	V		P	P
K	S	S	P	P	P	P	P		P	7	P	4	P	P	F	P	T	T	T	U	U	T	T	T		1	1	1	F	M	2	A	A
E	G	G	P	P	P	P	P		P	7	P	4	P	P	F	P	U	U	U	U	U	T	T	T		5	5	5	1	1	5	R	R
Y	0	1	U	U	T	T	U		U	T	U	T	U	U	T	T	T	T	T	U	U	T	T	T		1	1	1	L	1	5	E	E
6	6	6	6	6	6	7	7		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8		8	8	9	9	9	9	9	9
4	5	6	7	8	9	0	1		2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7		8	9	0	1	2	3	4	5

Active Group

The active group is indicated on this line. HMI Screen 1.5.5 also provides this information. See Section 4, *Protection and Control*, for more information about setting groups.

Breaker (52)

This line reports the state of the breaker. This information is also available at HMI Screen 1.5.6. More information about breaker status is provided in the *Breaker Monitoring* subsection.

Diag/Alarm

This line reports the status of the Relay Trouble Alarm, Major Alarm, Minor Alarm, and Logic Alarm. The status of these alarms can be viewed at HMI Screen 1.3. Front panel LEDs also indicate the status of the Relay Trouble Alarm, Minor Alarm, and Major Alarm. Alarm status is also available through the communication ports. The SA-MIN command reports the Minor Alarm status, the SA-MAJ command reports the Major Alarm status, and the SA-LGC command reports the Logic Alarm status.

Other Report - General Commands

There are several other RG commands in addition to the RG-STAT command. These include RG-TIME, RG-DATE, RG-TARG, and RG-VER. These commands are covered in detail in respective paragraphs in this section. As with other commands, a combination read command is available to read several items in a group. If the command RG is entered by itself, the relay reports the time, date, target information, and other reports in the following example. RG-VER and RG-STAT commands have multiple line outputs and these are not read at the RG command.

Demand Functions (BE1-700C)

The demand reporting function continuously calculates demand values for the three-phase currents, neutral current (three-phase residual 3IO), and negative-sequence current. Demand values are recorded with time stamps for Peak Since Reset, Yesterday's Peak, and Today's Peak. Programmable alarm points can be set to alarm if thresholds are exceeded for overload and unbalanced loading conditions.

Demand Reporting Settings

Demand reporting settings are made using BESTCOMS. Figure 6-3 illustrates the BESTCOMS screen used to select demand reporting settings. To open the screen shown in Figure 6-3, select *Reporting and*

Alarms, from the *Screens* pull-down menu. Then select the *Demands* tab. Alternately, demand current settings may be made using the SG-DI ASCII command.

Demand settings for current include columns labeled *Phase*, *Neutral*, and *Negative-Sequence*. Each of these columns has settings for *Interval (Minutes)* and *Current Threshold*. *Current Threshold* display units are selectable from a pull-down menu allowing the selection of *Sec. Amps*, *Pri. Amps*, *Per U Amps*, or *% Amps*. The default display unit is *Sec. Amps*.

Using the pull-down menus and buttons, make the application appropriate demand settings.

Demand reporting settings are summarized in Table 6-4.

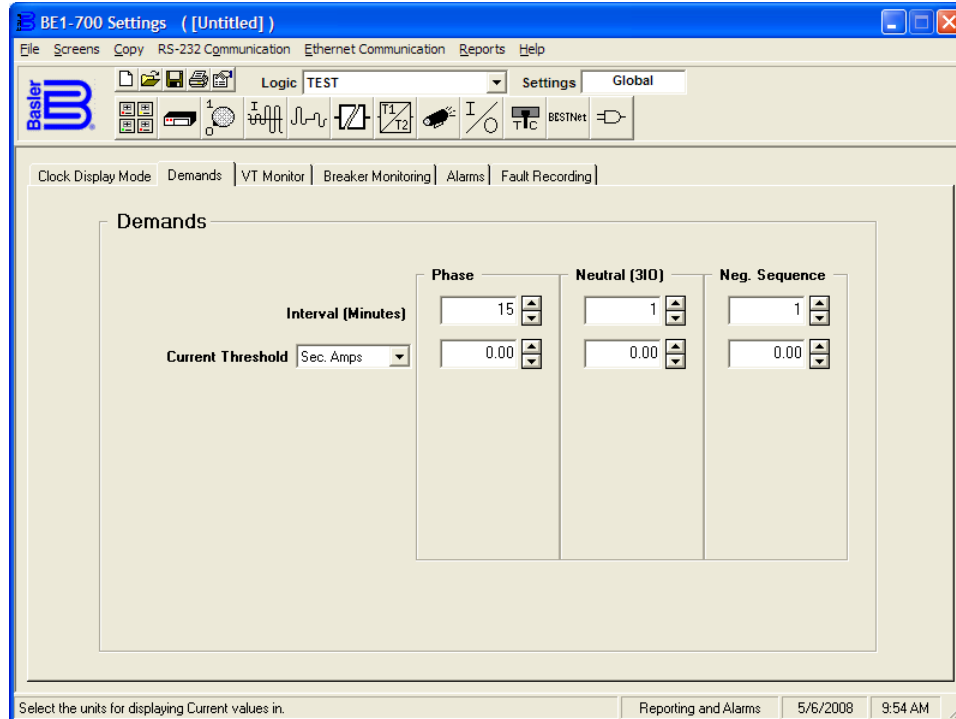


Figure 6-3. Reporting and Alarms Screen, Demands Tab

Table 6-4. Demand Settings for Current

Setting	Range	Increment	Unit of Measure	Default
Current Threshold Display Units	Sec. Amps, Pri. Amps, Per U Amps, % Amps	N/A	Amps	Sec. Amps
Current Threshold	.50 - 16.0 Sec. Amps	0.01	*	0
Interval	0 - 60	1	Minutes	15

* Unit of measure is based on the threshold *Display Units* selection. The default is secondary amperes.

Retrieving Demand Reporting Information

Values and time stamps in the demand registers are reported in primary values. They can be read at the front panel HMI and through the communication ports.

Today's Peak, Yesterday's Peak, and Peak Since Reset demand values are accessed through HMI Screen 4.4, *DEMAND REPORTS*. Demand values viewed at the HMI can be reset by pressing the *Reset* key. When the *Reset* key is pressed, the viewed register value is set to zero and then updated on the next processing loop with the currently calculated demand value. No write access is needed to reset demand register values at the HMI. It is also possible to preset a value into the *Peak Since Demand* registers. This can be done by pressing the *Edit* key. Write access to the *Reports* functional area is required to preset values at the HMI.

Values and time stamps in the demand registers can also be read through the communication ports by using the RD (report demands) command.

Demand information specific to current 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.

VT Monitor Functions (BE1-700V)

The VT Monitor reporting function allows the user to enable or disable *Fuse Loss Block Logic*. *Block Phase*, *Block 3V0*, and *Block V2* and each be independently checked (enabled) or unchecked (disabled) for the 27 and 59 elements. The default value for all of these logic functions is enabled.

Setting Fuse Loss Block Logic

Fuse Loss Block Logic settings can be made using BESTCOMS. Figure 6-4 illustrates the BESTCOMS screen used to select these reporting settings. To open the screen shown in Figure 6-4, select *Reporting and Alarms*, from the *Screens* pull-down menu. Then select the *VT Monitor* tab. Alternately, settings may be made using the SP-60FL ASCII command.

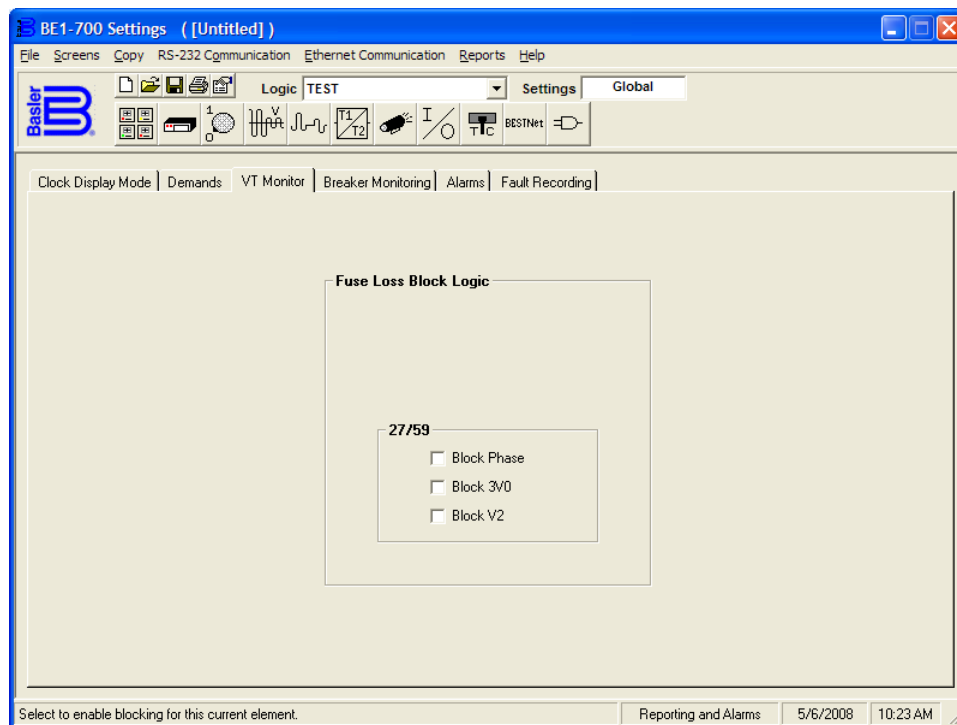


Figure 6-4. Reporting and Alarms Screen, VT Monitor Tab

Breaker Monitoring

Breaker monitoring helps manage equipment inspection and maintenance expenses by providing extensive monitoring and alarms for the circuit breaker. Breaker monitoring functions include breaker status and operations counter reporting, fault current interruption duty monitoring and trip-speed monitoring. Each function can be set up as a programmable alarm. The *Alarms Function* sub-section has more information about the use of programmable alarms. The breaker trip circuit voltage and continuity monitor is a related function and is described in the *Trip Circuit Monitor* subsection.

Breaker Status Reporting

The breaker status monitoring function monitors the position of the breaker for reporting purposes. Opening breaker strokes are also counted and recorded in the breaker operations counter register. Circuit

breaker status is also used by the breaker trip circuit voltage and continuity monitor. The *Trip Circuit Monitor* sub-section provides more details.

Setting the Breaker Status Reporting Function

Since the relay is completely programmable, it is necessary to program which logic variable will monitor breaker status. Breaker status is programmed using the *BESTlogic Function Element* screen in BESTCOMS. Figure 6-5 illustrates this screen. To open the *BESTlogic Function Element* screen for breaker status, select *Reporting and Alarms* from the *Screens* pull-down menu and choose the *Breaker Monitoring* tab. Then select the *Logic* button in the lower left hand corner of the screen and inside the box labeled, *Breaker Status Logic*. Alternately, settings may be made using the SB-LOGIC ASCII command.

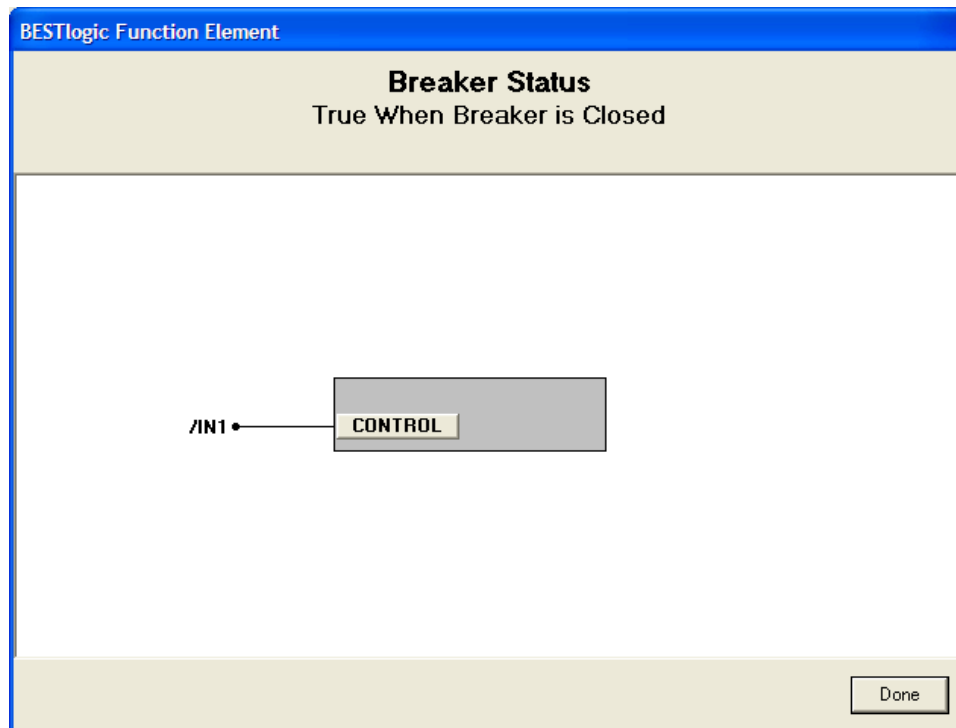


Figure 6-5. BESTlogic Function Element Screen, Breaker Status

To connect the Breaker Status's *CONTROL* input, select the *CONTROL* button. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

Table 6-5 lists the settings for the Breaker Status logic.

Table 6-5. Breaker Status Reporting BESTlogic Settings

Setting	Range/Purpose	Default
Breaker Closed Logic	OR logic expression that is TRUE when the breaker is closed (e.g., 52a logic).	/IN1

Retrieving Breaker Status and Operation Counter Information

Current breaker status can be read from HMI Screen 1.5.6 and through the communication ports using the RG-STAT command. The *General Status Reporting* subsection provides more information about this command.

The number of breaker operations can be read at HMI Screen 4.3.1. The counter value can be adjusted using the *Edit* key. This allows the relay counter value to be matched to an existing mechanical cyclometer on a breaker mechanism. Write access to the reports functions must be gained to edit this value at the HMI. Breaker operations can be read or set through the communication ports using the RB-OPCNTR (report breaker, operations counter) command.

The breaker operations counter can be monitored to give an alarm when the value exceeds a threshold. See *Breaker Alarms*, in this section for more information about this feature.

Breaker operations can also be read using the RB command. The RB command returns the number of breaker operations and breaker contact duty information.

Breaker duty monitoring is discussed in the following paragraphs.

Breaker Duty Monitoring (BE1-700C)

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 6-6 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 @ $I_{\text{max load}}$

Point 2; # Ops @ $I_{\text{max fault}}$

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

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

N can be any value from 1 to 3.

Using values for $I_{\text{max load}}$ and $I_{\text{max fault}}$ 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:

$$D_{\text{max}} = \left((I_{\text{max load}})^N \cdot \# \text{Ops}@I_{\text{max load}} \right)^{1/N}$$

$$D_{\text{max}} = \left((I_{\text{max load}})^N \cdot \# \text{Ops}@I_{\text{max load}} \right)^{1/N}$$

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 block the breaker monitoring logic when TRUE (1). BLKBKR is set to zero to disable blocking. When breaker monitoring is blocked (logic expression equals 1), breaker duty is not accumulated.

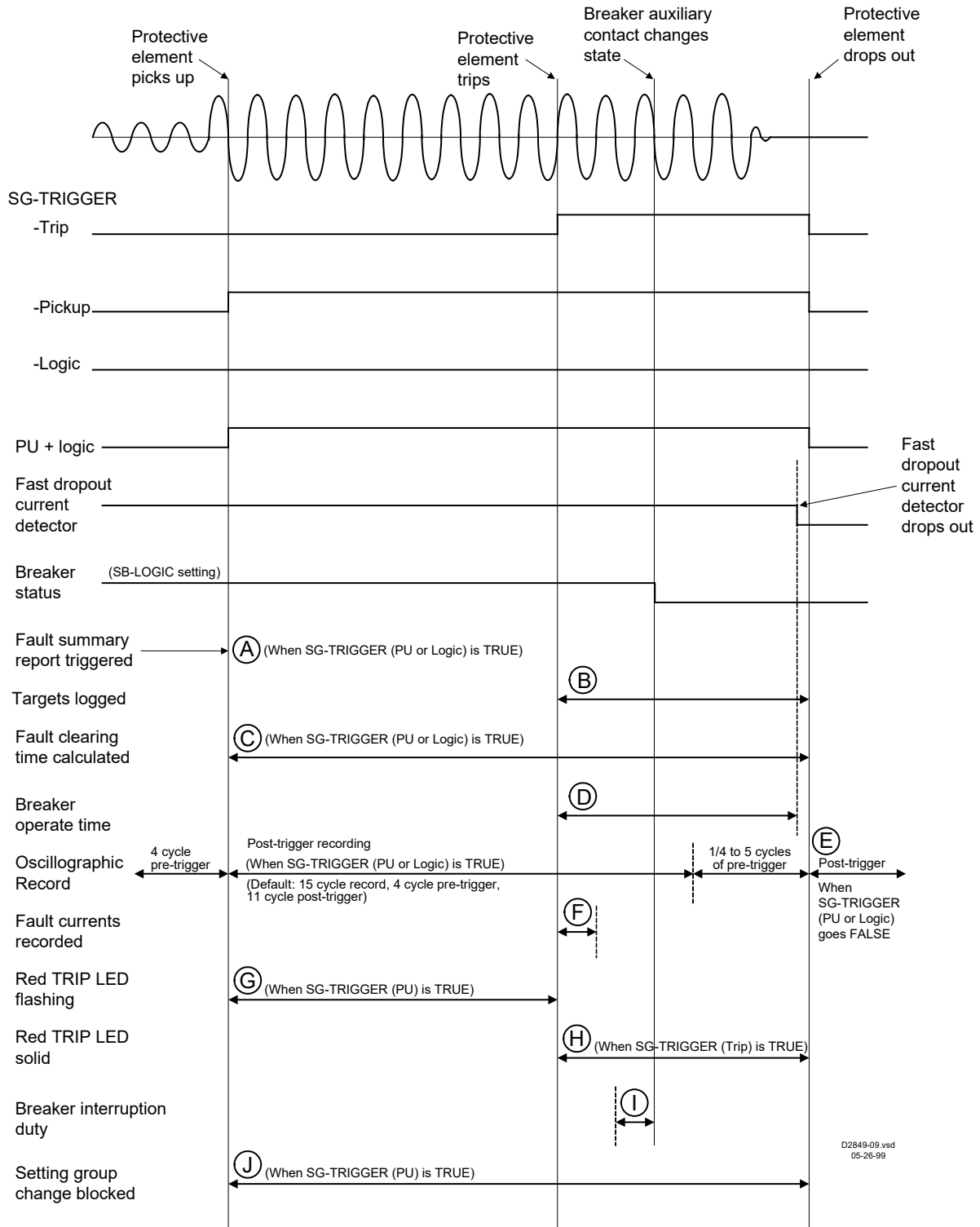


Figure 6-6. Protective Fault Analysis

Table 6-6. Legend for Figure 6-6

Locator	Description
A	A fault summary report and an oscillograph record are triggered when either the SG-TRIGGER pickup or logic expression becomes TRUE.
B	During the time that the SG-TRIGGER trip expression is TRUE, targets are logged from each of the protective functions that reach a trip state. If a protective function is not being used for tripping purposes, the associated target function can be disabled through the SG-TARG setting.
C	Fault clearing time is calculated as the duration of the time that either the SG-TRIGGER pickup or logic expression is TRUE.
D	Breaker operate time is calculated as the time from when the SG-TRIGGER trip expression becomes TRUE until the fast-dropout current detector senses that the breaker has successfully interrupted the current in all poles of the breaker.
E	A second oscillographic record is triggered to record the end of the fault if the SG-TRIGGER pickup or logic trigger expression remains in the TRUE state at the time that the first oscillographic record ends. This second record will have from ¼ to five cycles of pre-trigger data depending upon when both the SG-TRIGGER pickup and logic expressions become FALSE.
F	Recorded fault current and voltage magnitudes and angles are displayed on the <i>Target</i> screen of the HMI. The same information including phase voltage frequency and auxiliary voltage frequency are recorded in the Fault Summary Report. The magnitude and angle 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 accurate data. 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 and voltage 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.6
I	Breaker operations and interruption duty functions are driven by the breaker status function. The operations counter is incremented on breaker opening. The magnitudes of the currents that are used for accumulating breaker duty are recorded for the power system cycle ending when the breaker status changes state. Thus, breaker duty is accumulated every time that the breaker opens even if it is not opening under fault.
J	Setting group changes are blocked when the SG-TRIGGER pickup expression is TRUE to prevent protective functions from being reinitialized with new operating parameters while a fault is occurring.

Setting the Breaker Duty Monitoring Function

Breaker Duty Monitoring settings are made using BESTCOMS. Figure 6-7 illustrates the BESTCOMS screen used to select settings for the Breaker Duty Monitoring function. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Breaker Monitoring* tab. Alternately, settings may be made using the SB-DUTY ASCII command.

At the top of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be selected on this menu in order to allow changes to be made to the mode and inputs of the element.

Using the pull-down menus and buttons, make the application appropriate settings to the Breaker Duty Monitoring function.

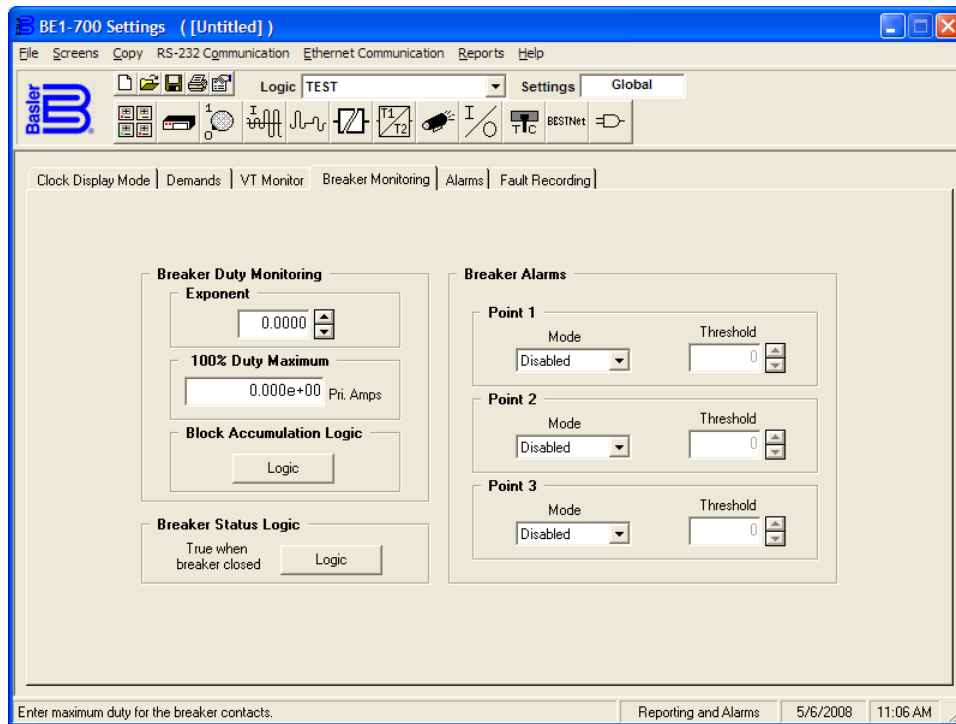


Figure 6-7. Reporting and Alarms Screen, Breaker Monitoring Tab

To connect the functions *BLOCK* logic input. Select the *Logic* button in the *Block Accumulation Logic* box. The *BESTlogic Function Element* screen for *Breaker Duty Monitoring* will appear. See Figure 6-8. Then select the *BLOCK* input button. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the *BESTlogic* variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the *BESTlogic Expression Builder*, See Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

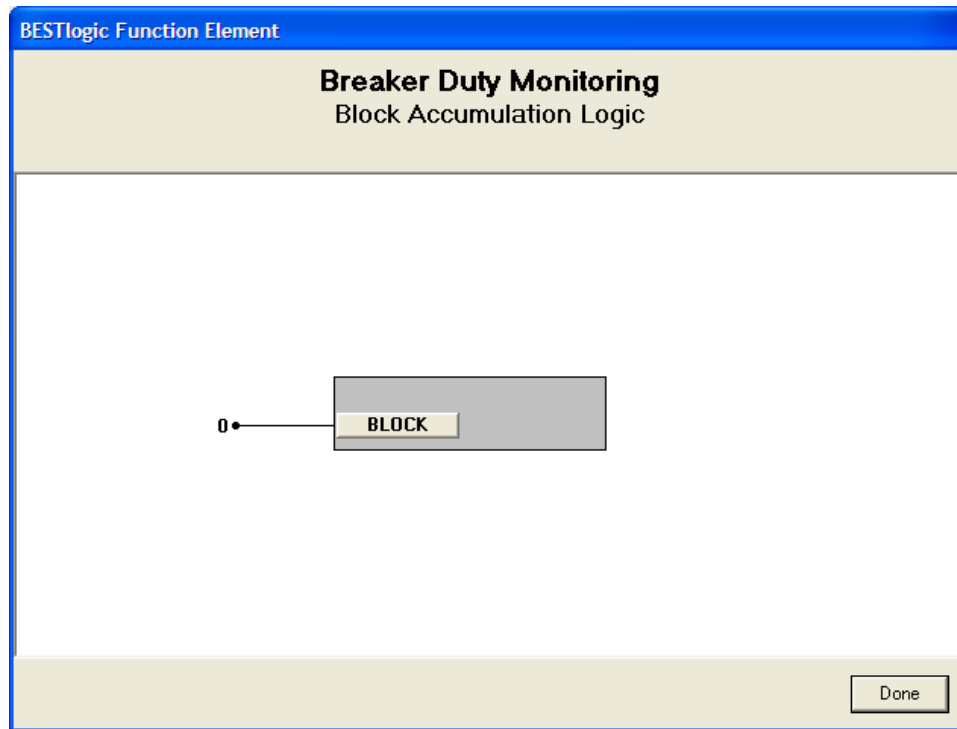


Figure 6-8. BESTlogic Function Element Screen, Breaker Duty Monitoring

Table 6-7 summarizes the Breaker Duty Monitoring settings.

Table 6-7. Breaker Duty Monitoring Settings

Function	Range/Purpose	Default
Mode	0 = Disabled 1 = breaker monitoring enabled with duty calculated as ΣI 2 = breaker monitoring enabled with duty calculated as ΣI^2 The exponent may be set between 1 and 3.	0
100% Duty Maximum	0 to 4.2e+7 The <i>100% Duty Maximum</i> parameter represents the maximum duty that the breaker contacts can withstand before needing service. <i>100% Duty Maximum</i> is programmed in primary amperes using exponential floating point format.	0
Block	OR logic term (e.g., IN1 or VO7) that blocks the breaker monitoring logic when TRUE (1). A setting of 0 disables blocking (breaker operations are no longer counted).	0

Retrieving Breaker Duty Information

Breaker duty values can be read at HMI Screen 4.3.2. Duty values can be changed by using the front panel *Edit* key. Write access to reports is required to edit breaker duty values. Duty values can also be read or changed through the communication ports using the RB-DUTY command.

Breaker Operate Time Monitoring

The breaker operate time monitor tracks the time from when a trip output occurs (defined by the TRIP logic expression) to when the fast dropout current detector observes that current is zero in all three breaker poles. This time is reported as a line in the Fault Summary Reports. See the *Fault Reporting* sub-section for more information about the TRIP logic expression and Fault Summary Reports.

Breaker operate time can be monitored to give an alarm when the value exceeds a threshold. The following *Breaker Alarms* sub-section provides more information about this feature.

Breaker Alarms (BE1-700C)

Three alarm points are included in the programmable alarms for checking breaker monitoring functions. Each alarm point can be programmed to monitor any of the three breaker monitoring functions, operations counter, interruption duty, or clearing time. An alarm threshold can be programmed to monitor each function. Alternately, three different thresholds can be programmed to monitor one of the monitored functions.

Breaker Alarms settings are made using BESTCOMS. Figure 6-7 illustrates the BESTCOMS screen used to select settings for the Breaker Alarms function. Alternately, settings may be made using the SB-BKR ASCII command.

At the top of the screen is a pull-down menu labeled *Logic*. This menu allows viewing of the BESTlogic settings for each preprogrammed logic scheme. A custom logic scheme must be selected on this menu in order to allow changes to be made to the mode and inputs of the function.

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

Table 6-8 summarizes the Breaker Alarms settings.

Table 6-8. Breaker Alarms Settings

Setting		Range/Purpose	Default
Mode		0 = Disabled 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

Trip Circuit Monitor

The trip circuit monitor continually monitors the circuit breaker trip circuit for voltage and continuity. A closed breaker with no voltage detected across the trip contacts can indicate that a trip circuit fuse is open or there is a loss of continuity in the trip coil circuit. Breaker status (open or closed) is obtained through the breaker status reporting function (configured by the SB-LOGIC command).

The detector circuit used by the trip circuit monitor is hardwired across the OUT1 contact. This contact is used in all of the preprogrammed logic schemes as the main trip output. The detector circuit across OUT1 is not polarity sensitive because the optical isolator used for detecting continuity is connected across a full wave bridge. See Figure 6-9. The amount of current drawn through the optical isolator circuit depends on the total input impedance for each power supply voltage rating (see Table 6-9). Figure 6-10 illustrates typical trip circuit monitor connections for the BE1-700.

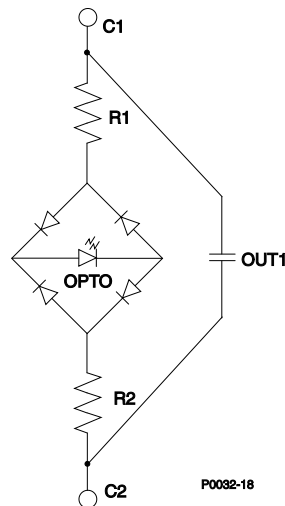


Figure 6-9. Trip Detector Circuit

If the breaker status reporting function detects a closed breaker and no trip circuit voltage is sensed by the trip circuit monitor after 500 milliseconds (coordination delay time), an alarm bit in the programmable alarms function is set (OUT1 CKT OPEN) and the OUT1MON BESTlogic variable is set to TRUE.

Table 6-9. Current Draw for each Power Supply Voltage Rating

Power Supply Voltage Rating	R1 = R2 =	R Total	Optical Isolator	
			Off (25% V)	On (80% V)
24 Vdc	8.2 kΩ	16.4 kΩ	6.0 V (0.36 mA)	19.2 V (1.18 mA)
48/125 Vdc	18 kΩ	36 kΩ	12.0 V (0.68 mA)	38.4 V (1.02 mA)
125/250 Vdc	47 kΩ	94 kΩ	31.25 V (0.71 mA)	100 V (1.06 mA)

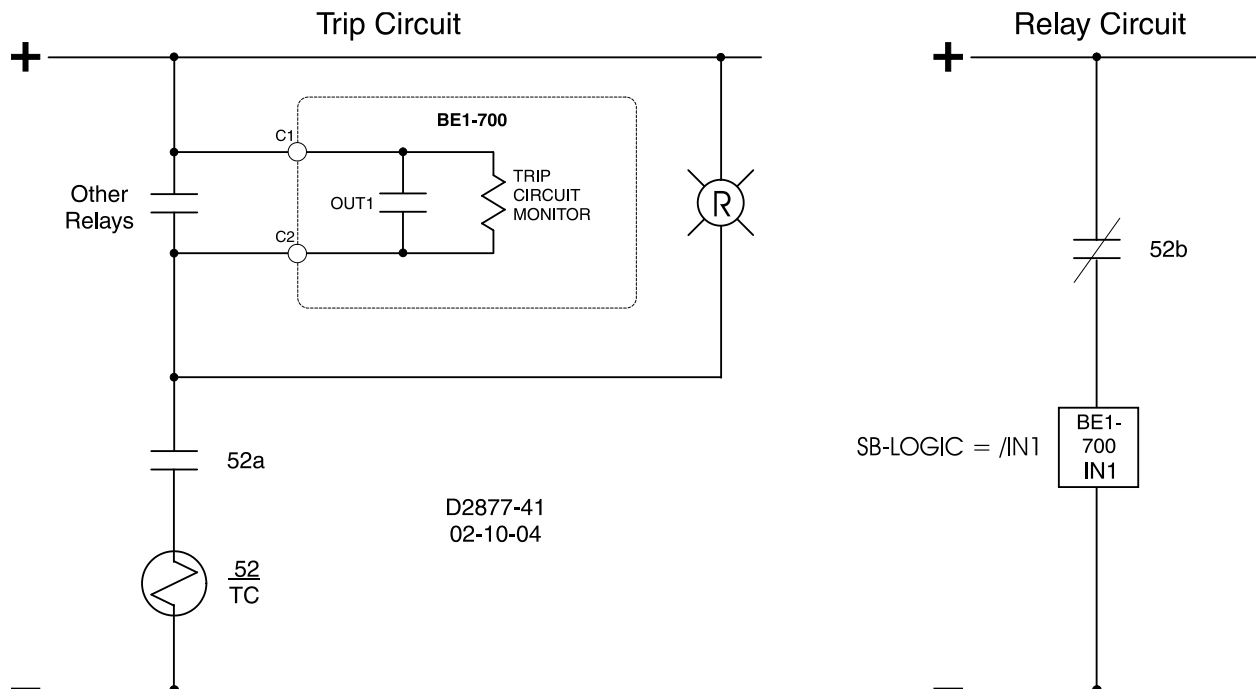


Figure 6-10. Trip Circuit Voltage and Continuity Monitor

Caution

Applications that place other device inputs in parallel with the breaker trip coil may not perform as desired. The connection of other devices in parallel with the trip coil causes a voltage divider to occur when the breaker or trip circuit is open. This may cause false tripping of the other devices and prevent the BE1-700 trip circuit monitor from reliably detecting an open circuit. Contact Basler Electric for advice on this application.

The circuit monitor sensing element has the same rating as the power supply voltage. If the trip circuit voltage is significantly greater than the power supply voltage (for example, when using a capacitor trip device), the user should program the BE1-700 to use one of the other output relays for tripping. In this situation, the trip circuit monitor function will not be available.

In Figure 6-10, a 62x auxiliary relay is shown. In this case, the impedance of the 62x coil is small compared to the impedance of the TCM circuit so the TCM optical isolator is always on and the TCM is always at logic 1. This prevents the TCM logic from working even if the trip coil is open. To prevent this problem, a diode was added as shown in Figure 6-11 to isolate the TCM circuit from the effects of 62X.

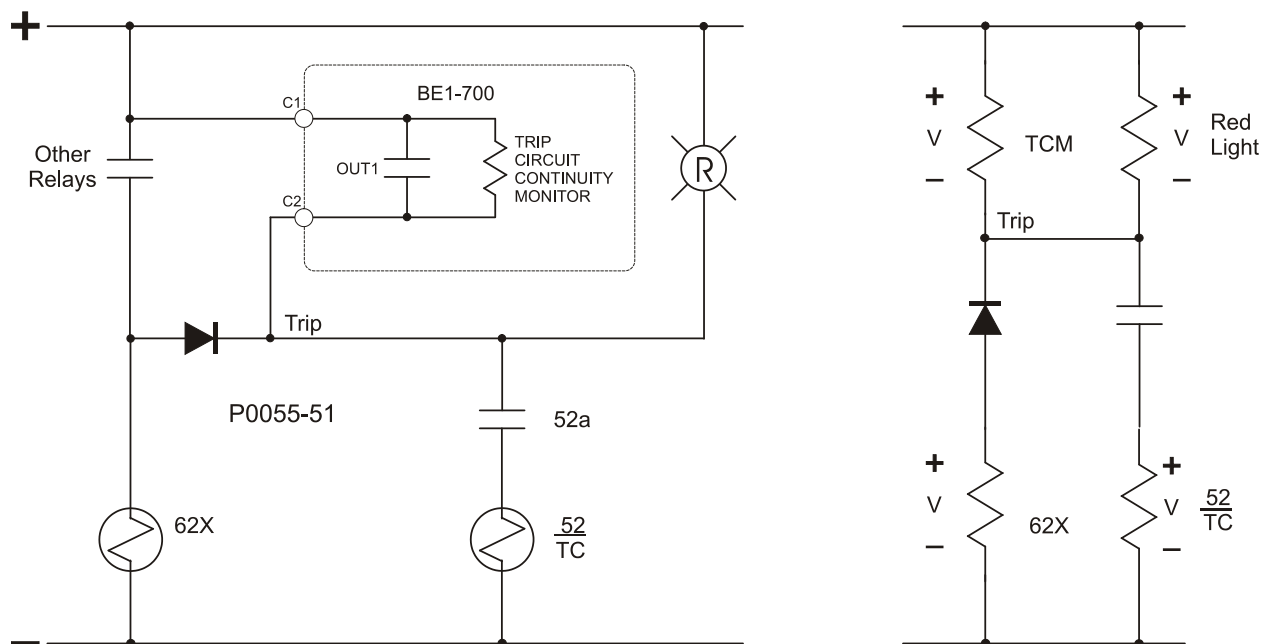


Figure 6-11. TCM with Other Devices

Fault Reporting

Fault Reporting Expressions and Settings

The fault reporting function records and reports information about faults that have been detected by the relay. The BE1-700 provides many fault reporting features. These features include Fault Summary Reports, Sequence of Events Recorder Reports, Oscillographic Records, and Targets.

Logic expressions are used to define the three conditions for fault reporting. These conditions are Trip, Pickup, and Logic trigger. Figure 6-6 and Table 6-8 illustrate how each of these logic expressions is used by the various relay functions. Note that even though BESTlogic expressions are used to define these conditions, these expressions are not included here. Section 7, *BESTlogic Programmable Logic*, provides information about using BESTlogic to program the relay.

Trip

Trip expressions are used by the fault reporting function to start logging targets for an event and to record fault current magnitudes at the time of trip. The trip expression is used to illuminate the Trip LED on the HMI. The Trip LED will turn on and remain on as long as the trip expression is true. The Trip LED will remain on (or “sealed-in”) after the trip expression becomes false if targets are associated with the trip. The breaker monitoring function uses the trip expression to start counting the breaker operate time.

Pickup

Pickup expressions are used by the fault reporting function to time-stamp the fault summary record, time the length of the fault from pickup to dropout (fault clearing time), and to control the recording of oscillographic data. The pickup expression is used to flash, on and off, the Trip LED on the HMI. The Trip LED will continue to flash on and off as long as the pickup expression is true and the trip expression is not true. A pickup expression is also used by the setting group selection function to prevent a setting group change during a fault.

Logic

Logic trigger expressions allow the fault reporting function to be triggered even though the relay is not picked up. A logic trigger expression provides an input to the fault reporting function much as the pickup expression does. This logic expression is not used by the setting group selection or the HMI.

Fault Reporting Trigger Settings

Fault reporting trigger settings are made from the *BESTlogic Function Element* screen in BESTCOMS. Figure 6-12 illustrates the BESTCOMS screen used to select BESTlogic settings for the *Fault Recording* function. To open the *BESTlogic Function Element* screen for *Fault Recording*, select *Reporting and Alarms* from the *Screens* pull-down menu. Select the *Fault Recording* tab. Then select the *Logic* button in the *Fault Recording* box in the upper left hand corner of the screen. Alternately, settings may be made using SG-TRIGGER ASCII command.

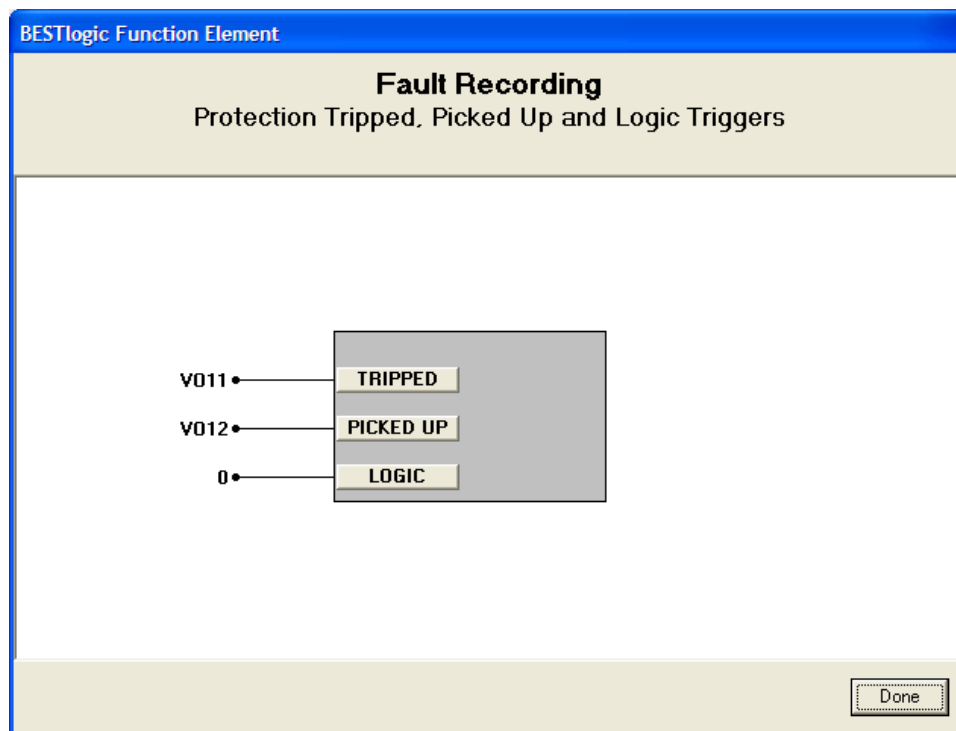


Figure 6-12. BESTlogic Function Element Screen, Fault Recording

To connect the function's inputs, select the button for the corresponding input in the *BESTlogic Function Element* screen. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then, select the BESTlogic variable, or series of variables to be connected to the input. Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the

BESTlogic Expression Builder, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited. Trigger settings for fault reports are made using the SG-TRIGGER (settings-general, trigger) command.

Table 6-10 lists the function's trigger settings.

Table 6-10. Fault Reporting Trigger Settings

Function	Purpose	Default
TRIPPED	Logic expression used to define Trip fault reporting condition. When this expression becomes TRUE (1), it triggers data recording and illuminates the Trip LED.	BFT+VO11
PICKED UP	Logic expression used to define Pickup fault reporting condition. When this expression becomes TRUE (1), it initiates the pickup timing sequence and the Trip LED will flash on and off.	BFPU+VO12
LOGIC	Logic expression used to define the trigger for fault reporting when relay is not picked up. When this expression is TRUE (1), fault reporting is triggered.	0

Targets

Each protective function (see Table 6-11) logs target information to the fault reporting function when a trip condition occurs and the trip output of the function block becomes TRUE (refer to Figure 6-6 and Table 6-6, call-out B). **C** applies to BE1-700C relays; **V** applies to BE1-700V relays; and **A** applies to both types. Target information can be viewed and reset at the HMI and through the communication ports.

Table 6-11. Protective Functions with Targets

Type	Name	Protective Function	Target Default
C	51P	Phase Inverse Time Overcurrent	Enabled
C	51N	Neutral Inverse Time Overcurrent	Enabled
C	51Q	Negative-Sequence Inverse Time Overcurrent	Enabled
C	151P	Second Phase Time Overcurrent	Enabled
C	151N	Second Neutral Time Overcurrent	Enabled
C	50TP	Phase Instantaneous Overcurrent	Enabled
C	50TN	Neutral Instantaneous Overcurrent	Enabled
C	50TQ	Negative-Sequence Instantaneous Overcurrent	Enabled
C	150TP	Second Phase Instantaneous Overcurrent	Enabled
C	150TN	Second Neutral Instantaneous Overcurrent	Enabled
C	150TQ	Second Negative-Sequence Instantaneous Overcurrent	Enabled
V	81	Under/Overfrequency	Enabled
V	181	Second Under/Overfrequency	Enabled
V	281	Third Under/Overfrequency	Enabled
V	381	Fourth Under/Overfrequency	Enabled
V	481	Fifth Under/Overfrequency	Enabled
V	581	Sixth Under/Overfrequency	Enabled
V	59P	Phase Overvoltage	Enabled
V	159P	Second Phase Undervoltage	Enabled
V	59X	Auxiliary Overvoltage	Enabled
V	159X	Seconds Auxiliary Overvoltage	Enabled
V	47	Negative-Sequence Overvoltage	Enabled

Type	Name	Protective Function	Target Default
V	27P	Phase Undervoltage	Enabled
V	127P	Second Phase Undervoltage	Enabled
V	27X	Auxiliary Undervoltage	Enabled
A	62	General Purpose Logic Timer	Disabled
A	162	Second General Purpose Logic Timer	Disabled
V	24	Volts per Hertz	Enabled
V	60FL	Fuse Loss Detection	Disabled
C	BF	Breaker Failure	Enabled

Target logging for a protective function can be disabled if the function is used in a supervisory or monitoring capacity. The following paragraphs describe how the relay is programmed to define which protective functions log targets.

Setting the Targets Function

Targets are enabled using the BESTCOMS screen shown in Figure 6-13. You can select which protective elements trigger a target and what type of logic condition will reset the targets. To open the screen, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select the *Fault Recording* tab. Enable the targets by checking the appropriate boxes.

Alternately, targets can be enabled using the SG-TARG ASCII command. Using the SG-TARG command, you can select which protective elements trigger a target and what type of logic condition will reset the targets.

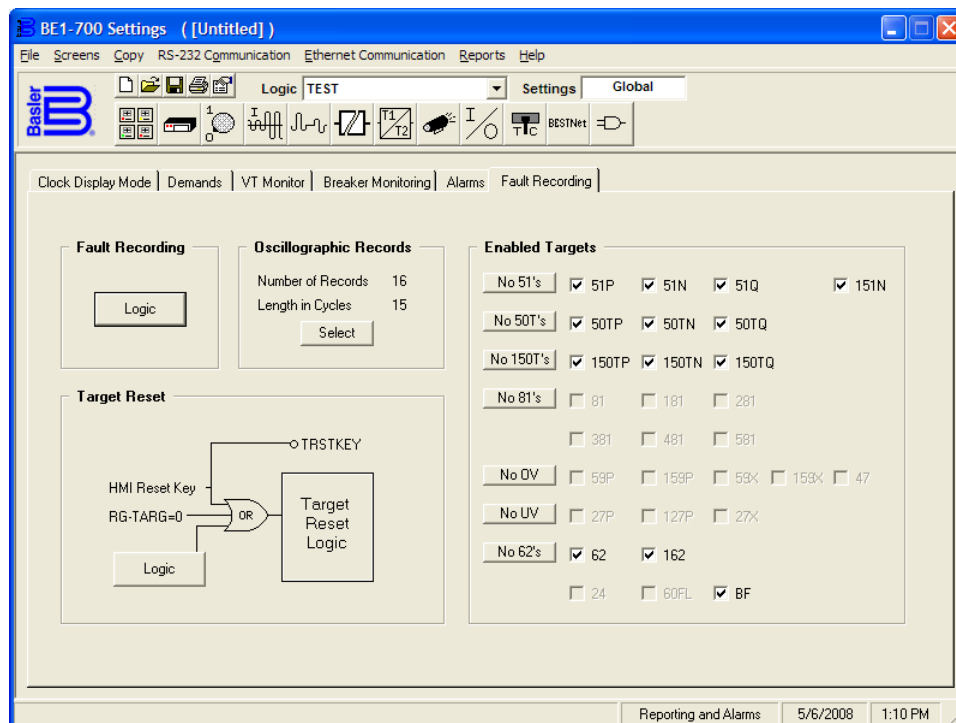


Figure 6-13. Reporting and Alarms, Fault Recording Tab

Target settings are summarized in Table 6-12.

Table 6-12. Target Settings

Function	Purpose
Enabled Targets	Specifies which protective elements will trigger a target. When the programmed protective element's BESTLogic expression is TRUE (1) and the trip output is TRUE (1), a trip event is recorded in the target log.
Target Reset Logic	Logic expression that will reset the targets when TRUE.

Retrieving and Resetting Target Information

Targets can be viewed at HMI Screen 1.2 and through the communication ports using the RG-TARG (report general, targets) command. The relay provides target information from the most recent trip event. Target information is specific to an event; it is not cumulative. Targets for previous events are recorded in the fault summary reports, which are described in the following subsection.

When a protective trip occurs and targets are logged, the HMI Trip LED seals-in and Screen 1.2 is automatically displayed. The LCD scrolls between the targets and the fault current magnitudes that were recorded during the fault. Pressing the HMI *Reset* key will clear these targets and the Trip LED. Password access is not required to reset targets at the HMI. See Figure 6-14.

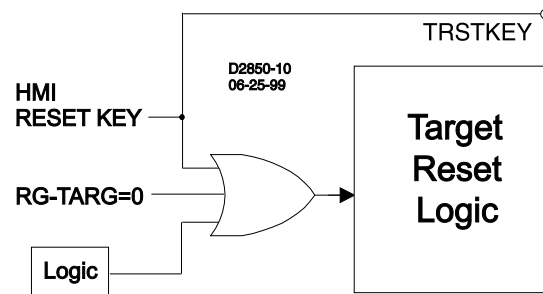


Figure 6-14. Target Reset Logic

A logic input can be used to reset the target. Using BESTCOMS, select *Reporting and Alarms* from the *Screens* pull-down menu. Then select *Fault Recording* tab. The logic input can be connected by selecting the *Logic* button in the *Target Reset* pane. When the logic input becomes TRUE, the target is reset.

BESTCOMS can also be used to review targets and alarms after an operation by selecting *Metering* from the *Reports* pull-down menu. Using the *View* pull-down menu, select *Alarms Status* and *Targets Status*. These panes (Figure 6-15) will contain target and alarm information.

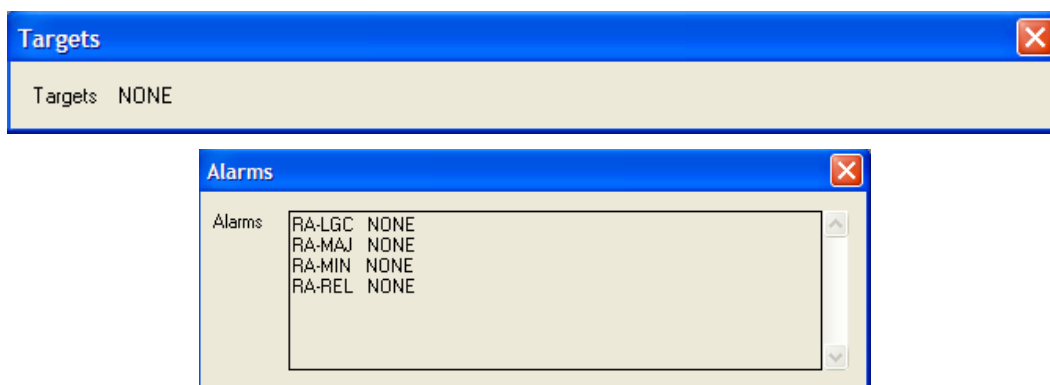


Figure 6-15. Targets and Alarms Status, BESTCOMS Metering Screen

Table 6-13 provides the possible targets that may be displayed on the *Metering* screen.

Table 6-13. Targets as Displayed

Type	IEEE Device Number	Definition
V	24	Overexcitation
V	27/127 ABC	Phase Undervoltage
V	27BUS, 27N, 27-3BUS (27X fundamental, 3V0, 3 rd harmonic)	Auxiliary Undervoltage
V	47	Negative-Sequence Voltage
C	50/150 ABC, Q or 1, N or G (Q can be set + or – Sequence.)	Instantaneous Overcurrents
C	51 ABC, Q, N or G; 151 ABC, N or G	Time Overcurrents
V	59/159 ABC	Phase Overvoltage
V	59/159BUS, 59N, 59-3BUS (59/159X fundamental, 3V0, 3 rd harmonic)	Auxiliary Overvoltage
V	60FL	Fuse Loss
A	62/162	Logic Timers
V	81/181/281/381/481/581	Frequency
C	BF	Breaker Failure

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

Fault Summary Reports

The BE1-700 records information about faults and creates fault summary reports. A maximum of 16 fault summary reports are stored in the relay. The two most recent reports are stored in nonvolatile memory. When a new fault summary report is generated, the relay discards the oldest of the 16 events and replaces it with a new one. Each fault summary report is assigned a sequential number (from 1 to 255) by the relay. After event number 255 has been assigned, the numbering starts over at 1.

BE1-700 relays generate three different fault summary reports. They are *Close*, *Trip*, and *Close Trip*. The *Close* report contains the data recorded by the relay when the breaker was closed. The *Trip* report contains the data recorded during the fault. The *Close Trip* report contains both sets of data.

BESTCOMS™ Fault Summary Report

To view fault reports using BESTCOMS, select *Oscillography Download* from the *Reports* pull-down menu. Then select *Serial Connection* or optional *Ethernet Connection*. A screen such as the one shown in Figure 6-16 will appear.

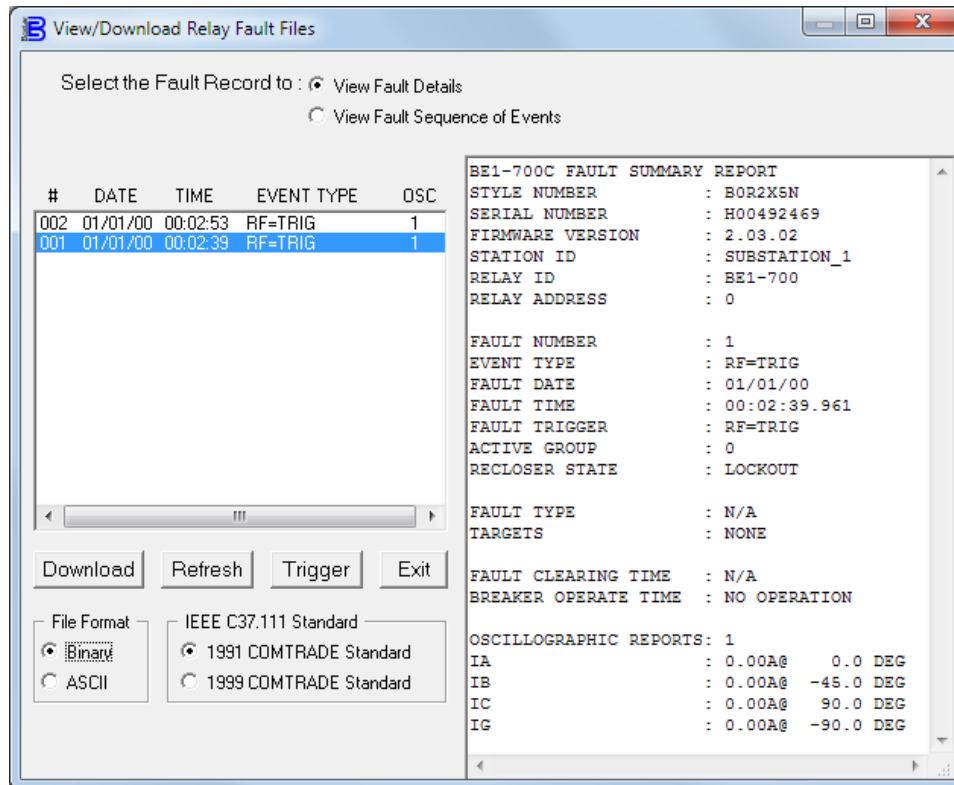


Figure 6-16. View/Download Relay Fault Files Screen

From this screen, you can *View Fault Details* or *View Fault Sequence of Events* by selecting your choice at the top of the screen and then highlighting the fault to be displayed. In Figure 6-16, fault 003 is highlighted.

The *Trigger* button allows a fault to be manually triggered. This can also be done using the SG-TRIGGER ASCII command.

The *Refresh* button is used to refresh the list of faults. The *Download* button will download the selected fault, storing it on the selected drive as either a binary or ASCII file, selected beneath the button.

Fault Summary Report Example

A fault summary report collects several items of information about a fault that can aid in determining why a fault occurred without having to sort through all of the detailed information available. The following example illustrates a typical fault summary report. Call-outs shown in the report are references to the legend of Table 6-6.

Fault Summary Report Example

>RF-4

```

BE1-700 FAULT SUMMARY REPORT
STYLE NUMBER       : F0R2X5N
FIRMWARE VERSION  : 1.03.00
SERIAL NUMBER     : H00476352
STATION ID        : SUBSTATION_1
RELAY ID          : BE1-700
RELAY ADDRESS     : 0

FAULT NUMBER      : 4
FAULT TYPE        : TRIP
FAULT DATE        : 09/05/06
FAULT TIME        : 17:22:41.979
FAULT TRIGGER     : VO2.V010
ACTIVE GROUP      : 0
RECLOSER STATE   : OFF

FAULTED TYPE      : ABG
TARGETS           : 50TA, 50TB

FAULT CLEARING TIME : 0.160 SEC
BREAKER OPERATE TIME : 0.152 SEC

OSCILLOGRAPHIC REPORTS: 1
IA                 : 5.65A@      0.0 DEG
IB                 : 5.35A@     -54.2 DEG
IC                 : 5.75A@     157.3 DEG
IG                 : 4.48A@     -16.8 DEG
  
```

Style Number. This line reports the style number of the relay.

Serial Number. This line reports the serial number of the relay.

Firmware Version. This line reports the version of firmware that the relay holds.

Station ID and Relay ID. These lines report station and device identifier information as defined by the SG-ID command.

Relay Address. This line reports the communications port address that the report was requested from. The relay address number is assigned using the SG-COM command, described in Section 11, *ASCII Command Interface*.

Fault Number. This line reports the sequential number (from 1 to 255) assigned to the report by the BE1-700.

Fault Type. This line reports the type of fault that occurred. There are five fault type categories:

- Trip: A fault was detected as defined by the pickup expression and the relay tripped to clear the fault.
- Pickup: A fault was detected as defined by the pickup expression but the relay never tripped indicating that the fault was cleared by another device.
- Logic: A fault report was recorded by the logic trigger expression but no fault was detected as defined by the pickup expression.
- Breaker Failure: A fault was detected as defined by the pickup expression and the breaker failure trip became TRUE before the fault was cleared.
- RF=TRIG: A fault report was recorded by the ASCII command interface.

Fault Date and Time. These lines report the date and time of the initial trigger of the event. This is based on either the pickup logic expression or the logic trigger expression becoming TRUE as defined by the SG-TRIGGER command. Refer to Figure 6-6 and Table 6-9, call-out A.

Fault Trigger. This line reports the logic variables in the pickup or logic trigger expressions that became TRUE to trigger the recording of the event.

Active Group. This line reports what setting group was active at the time that the fault occurred.

Recloser State (Optional). This line reports the state of the recloser shot counter prior to the fault that triggered the report.

Fault Type. This line reports the faulted circuit such as phase-phase, phase-ground, etc.

Targets. This line reports the targets that were logged to the fault report between the time that the trip expression became TRUE until the end of the fault. Refer to Figure 6-6 and Table 6-6, call-out B.

Fault Clearing Time. This line reports the time from when the relay detected the fault until the relay detected that the fault had cleared. Refer to Figure 6-6 and Table 6-6, call-out C.

If the fault report was triggered by the RF-TRIG command, the recording of the report was terminated after 60 seconds and this line is reported as N/A.

If the pickup or logic expressions stay TRUE for more than 60 seconds, an alarm bit in the programmable alarm function is set and this line is reported as N/A. In this situation, the fault reporting functions (including targets) will not operate again until the pickup and logic trigger expressions return to a FALSE state to enable another trigger.

Breaker Operate Time. This line reports the breaker trip time from the breaker monitoring and alarm function. This is the time measured from when the breaker is tripped until the fast-dropout current detector function detects that the arc has been extinguished. Refer to Figure 6-6 and Table 6-6, call-out D.

Oscillographic Reports. This line reports the number of oscillographic records that are stored in memory for this fault report. Refer to Figure 6-6 and Table 6-6, call-out E. Recording of oscillographic records is described in the *Oscillographic Records* subsection.

IA, IB, IC, IG (BE1-700C). These lines report the current magnitudes and angles measured two power system cycles immediately following the trip trigger. If the fault is cleared prior to the relay tripping, the recorded fault currents are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 6-6 and Table 6-6, call-out F.

VA, VB, VC, VX (BE1-700V). These lines report the voltage magnitudes and angles measured two power system cycles immediately following the trip trigger. If the fault is cleared prior to the relay tripping, the recorded fault voltages are for the power system cycle two cycles prior to the end of the fault. Refer to Figure 6-6 and Table 6-6, call-out F.

FP and FX (BE1-700V). This line reports the frequency for the phase voltage input and auxiliary voltage input measured immediately following the trip trigger. Refer to Figure 6-6 and Table 6-6, call-out F.

Retrieving Fault Report Information from the Relay

Fault Summary Directory Report. The fault reporting function provides a directory of fault summary reports that lists the number assigned to the fault summary report along with the date and time of the fault, the event type, and the total number of oscillography records stored in memory for that event. The event number is important because it is required to retrieve information about that event from the relay. This directory report can be accessed by using the RF command.

New Faults Counter. One line of the fault summary directory report contains the new faults counter. The new faults counter tracks how many new fault reports have been recorded since the new faults counter was reset to 0. This counter provides a way to check the fault information and then reset the new faults counter. Then, the next time that the relay is checked, it's easy to determine if any fault reports have been entered. Resetting the new faults counter is achieved using the RF-NEW=0 command. Write access to Reports must be gained to reset the new faults counter through the communication ports. The new faults counter can also be viewed at HMI Screen 4.1. The new faults counter cannot be reset at the HMI.

Fault Summary Reports. Individual fault summary reports can be retrieved using the RF-n command, where n represents the number assigned to the fault summary report. To obtain the most recent report, use RF-NEW. If additional detail is desired, Sequence of Events Recorder data and Oscillographic data can be obtained for the faults also. This is discussed in 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 6-14.

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.

Table 6-14. Possible Oscillographic Records

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

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 6-17, *Oscillographic Records Selector*. Select *Done* once the setting has been made.

Number of Records	Length in Cycles
<input type="radio"/> 6	40
<input type="radio"/> 8	30
<input type="radio"/> 10	24
<input type="radio"/> 12	20
<input type="radio"/> 15	16
<input checked="" type="radio"/> 16	15

Done

Figure 6-17. Oscillographic Records Selector

The oscillographic records settings can also be made using the SG-OSC (settings general, oscillography) ASCII command. See Table 6-15 for possible settings.

Table 6-15. Oscillographic Records Settings

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

Retrieving Oscillographic Records

The fault summary directory and the fault summary reports list the numbers assigned to each fault record and the number of oscillographic records associated with each fault. Oscillographic records can be retrieved using BESTCOMS. Alternately, oscillographic records can be retrieved using the RO ASCII command.

To download oscillographic records, select *Oscillography Download* from the *Reports* pull-down menu. Highlight the record to be downloaded and select either *ASCII* or *Binary* as the file type for download. Select the *Download* button.

Assume record 003 is selected for a binary download. When the *Download* button is selected, the *Browse for Folder* screen (Figure 6-18) appears. Select a location for the file to be stored or create a *New Folder* and press *OK*. The *Fault Record Filenames* screen (Figure 6-19) will appear. Type the base filename in the first row. The rest of the filenames will respond by changing to match the base filename. Select *OK* to save the file.

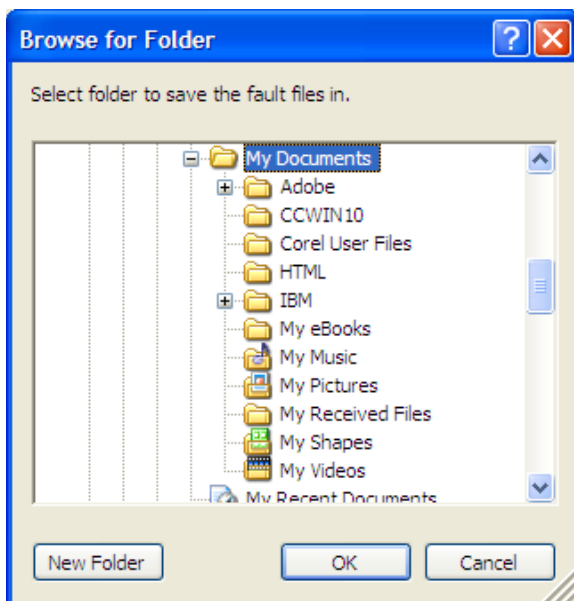


Figure 6-18. Browse for Folder Screen

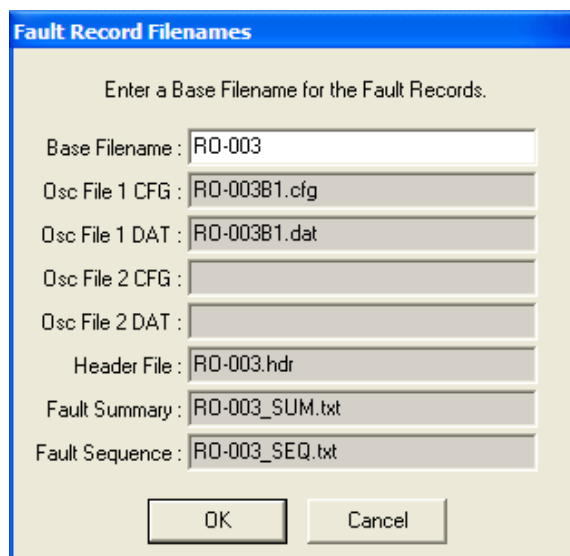


Figure 6-19. Fault Record Filenames

Only one oscillographic report file can be requested at a time. Reports are transmitted in COMTRADE format. A configuration file (CFG), a data file (DAT), or a header report (HDR) can be requested. Header files contain the fault summary report followed by all the pertinent settings that are associated with the requested fault record. These settings include the following:

- BESTlogic settings for User Programmable Logic Scheme.
- User Programmable Label settings, Global I/O settings.
- The protection setting group active during the fault.
- General protection settings.
- Fault reporting settings.
- Breaker monitoring settings.
- Alarm settings.

Files can be requested in ASCII or binary format but both file transfers use the same format. Binary file transfer is much faster and consumes less disk space. ASCII format data is human readable and can be analyzed by standard text editing software. Software for IBM compatible computers is available from Basler Electric to convert binary files to ASCII format. The download protocol may be either XMODEM or XMODEM CRC format. For ease of reference, the name of the downloaded file should be the same as the command.

Sequence of Events Recorder

A sequence of events recorder (SER) report is very useful in reconstructing the exact sequence and timing of events during a power disturbance or even normal system operations. The SER tracks over 100 data points by monitoring the internal and external status of the relay. Data points are scanned every quarter-cycle. All changes of state that occur during each scan are time tagged to 1 millisecond resolution. 255 records are stored in volatile memory; when the SER memory becomes full, the oldest record is replaced by the latest one acquired.

The SER monitors the following points and conditions:

- Single-state events such as resetting demands or targets, changing settings, etc.
- Programmable logic variables
- Targets
- Relay trouble alarm variables

- Programmable alarm variables
- Output contact status
- Fault reporting trigger expressions

When a monitored event occurs or a monitored variable changes state, the SER logs the time and date of the event, the event or variable name, and the state that the variable changed to. For user-programmable logic variables (contact sensing inputs, virtual switches, and virtual outputs), the user-programmed variable name and state names are logged in the SER report instead of the generic variable name and state names. For more information, refer to Section 7, *BESTlogic Programmable Logic, User Input and Output Logic Variable Names*.

Retrieving SER Information Using BESTCOMS™

To view SER information using BESTCOMS, select *Oscillography Download* from the *Reports* pull-down menu. Then select either *Serial Connection* or optional *Ethernet Connection*. A screen such as the one shown in Figure 6-20 will appear. Select *View Fault Sequence of Events* and highlight a fault record to view.

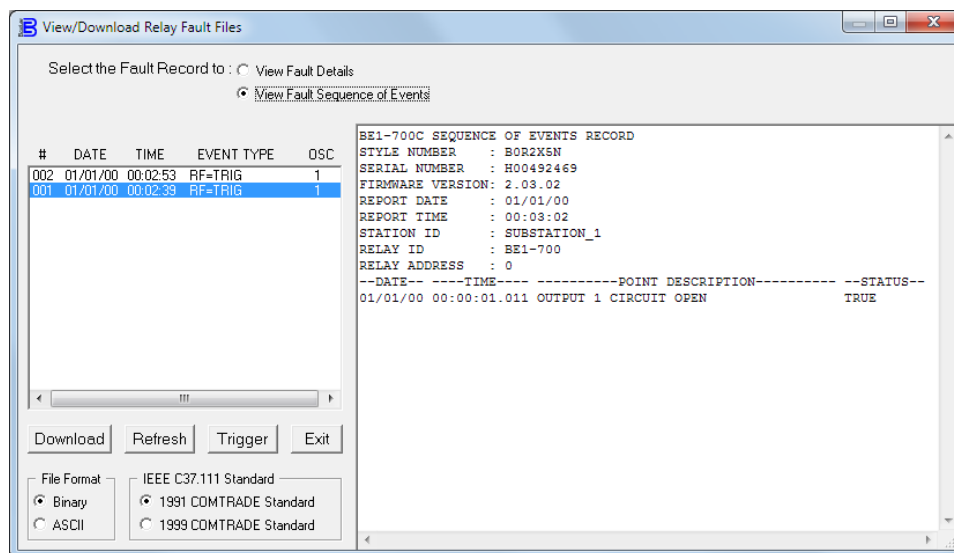


Figure 6-20. View/Download Relay Fault Files Screen

Retrieving SER Information Using ASCII Commands

SER information is retrieved through SER Directory Reports, the New Events Counter, and by obtaining specific SER Reports.

SER Directory Report

A directory report lists the number of events currently in memory and the time span that the events cover. Directory reports are accessed using the RS (report SER) command.

New Events Counter

The new events counter tracks how many new entries have been logged to the SER since the new events counter was reset to zero. After SER information is checked, the new events counter can be reset. Then, the next time that the relay is checked, it is easy to determine if there are new events that have not been evaluated. One line of an SER directory report contains the new events counter information. The new events counter is reset by obtaining write access to *Reports* and using the RS=0 command. The new events counter can be viewed but not reset at HMI Screen 4.2.

SER Report

A directory of SER reports can be obtained using the RS (report SER) command. Six sub-reports are available through the RS command: RS-n, RS-Fn, RS-ALM, RS-I/O, RS-LGC, and RS-NEW. These sub-

reports give specific types of data without confusing the user with every internal state change and event occurrence. Each sub-report is defined in the following paragraphs:

1. RS-n (report SER, number of most recent events)

Events are retrieved for the most recent entries. Entering RS-4 would view an SER report for the last four events.

2. RS-<n> (report SER, for Fault <event number>)

Events are retrieved for the period specific to a fault event. The report includes all events within the time span of the fault plus one event before and after the fault. Entering RS-F9 views a SER report associated with fault record 9.

3. RS-ALM (report SER, alarm)

This command retrieves all alarm events that exist since the last RS=0 command was issued. (RS=0 resets the new records counter to zero.) This information can also be obtained using the RA-SER command.

4. RS-IO (report SER, input/output)

This command reports all input and output events since the last RS=0 command was issued. (RS=0 resets the new records counter to zero.)

5. RS-LGC (report SER, logic)

A report is retrieved for all logic events since the last RS=0 command was issued. (RS=0 resets the new records counter to zero.)

6. RS-NEW (report SER, new events since RS=0 reset)

Events are retrieved for the period 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 6-16. If any one of these points asserts, the failsafe alarm output relay de-energizes and changes state of the OUTA contact, the HMI Relay Trouble LED lights, all output relays are disabled, logic variable ALMREL is set, and the relay is taken offline. The relay trouble alarms function is not programmable.

If you have a relay with a normally closed alarm contact but require a normally open contact, use BESTlogic to program the output logic. One of the output relays with normally open contacts (OUT1 through OUT5) can be programmed to be held closed. For example, to open OUT5 for indication of relay trouble, set the VO5 logic expression at /0 (SL-VO5=/0). A not zero setting is equal to logic 1. When the relay is fully functional, the OUT5 output contact is closed. Since all output relays are disabled when a relay trouble alarm exists, OUT5 opens when relay trouble occurs.

Table 6-16. Relay Trouble Alarms

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

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 DFLTS 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 6-17 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 6-17. Programmable Alarms

I.D. #	Name	Description
1	OUT1 CKT OPEN *	Trip circuit continuity and voltage monitor.
2	BKR FAIL ALARM	Breaker failure trip.
3	RECLOSER FAIL *	Reclose fail timer timed out before breaker closed.
4	RECLOSER LOCKOUT *	Recloser went through sequence without success.
5	BREAKER ALARM 1	Breaker Alarm 1 threshold (SA-BKR1 setting) exceeded.
6	BREAKER ALARM 2	Breaker Alarm 2 threshold (SA-BKR1 setting) exceeded.
7	BREAKER ALARM 3	Breaker Alarm 3 threshold (SA-BKR1 setting) exceeded.
8	P DEMAND ALARM *	Phase demand.
9	N DEMAND ALARM *	Neutral unbalance demand.
10	Q DEMAND ALARM *	Negative-sequence unbalance demand.
11	GROUP OVERRIDE *	Setting group control logic override.

I.D. #	Name	Description
12	SYS I/O ALARM	Excessive delay in HMI or serial communication operation.
13	COMM ERROR ALARM *	Communication failure.
14	CLOCK ERROR *	Real-time clock not set.
15	uP RESET ALARM	Microprocessor has been reset.
16	SETTINGS CHANGE	Setting change made by user.
17	EE NONFATAL ERROR	EEPROM nonfatal recoverable error.
18	OUTPUT OVERRIDE *	One or more output contacts have logic override condition.
19	LOSS OF IRIGB *	Loss of IRIG synchronization.
20	SGC ACTIVE *	Active setting group changed.
21	VO13_LABEL *	VO13 logic is TRUE (user programmable logic alarm).
22	VO14_LABEL *	VO14 logic is TRUE (user programmable logic alarm).
23	VO15_LABEL *	VO15 logic is TRUE (user programmable logic alarm).
24	FAULT REPORT TIMEOUT	TRUE if fault event trigger lasts longer than 60 seconds.
25	LOGIC = NONE ALARM	Active Logic=NONE.
26	N/A	N/A
27	N/A	N/A
28	FREQ RANGE ALARM *	Frequency out of range.
29	CHANGES LOST ALARM	Password access lost.
30	60 FL ALARM *	One or more phases of voltage lost.
31	V/Hz above Alarm Threshold *	Trips at settable percentage of the pickup level.

* Alarms with an asterisk are non-latching. A non-latching alarm clears itself automatically when the alarm condition goes away. All other alarms are latching and must be manually reset by using the HMI *Reset* button or the RA=0 command.

Programming Alarm Priorities

Alarm settings include Major, Minor, and Logic alarm priorities, Demand alarm points, and the Breaker alarm points. Programming details for Demand alarm points is available in the *Demand Functions* subsection. Refer to the *Breaker Monitoring* subsection for details about programming Breaker alarm points. Major, Minor, and Logic programmable alarm settings are made using BESTCOMS. To select alarm priority, select *Reporting and Alarms* from the *Screens* pull-down menu. Select the *Alarms* tab. See Figure 6-21. Set the alarm point priority by checking the box or boxes to its right.

Alternately, settings for Major, Minor, and Logic alarms can be made using the SA-MAJ, SA-MIN, or SA-LGC ASCII commands. Refer to Section 11, *ASCII Command Interface, Command Summary, Alarm Setting Commands*, for complete command descriptions.

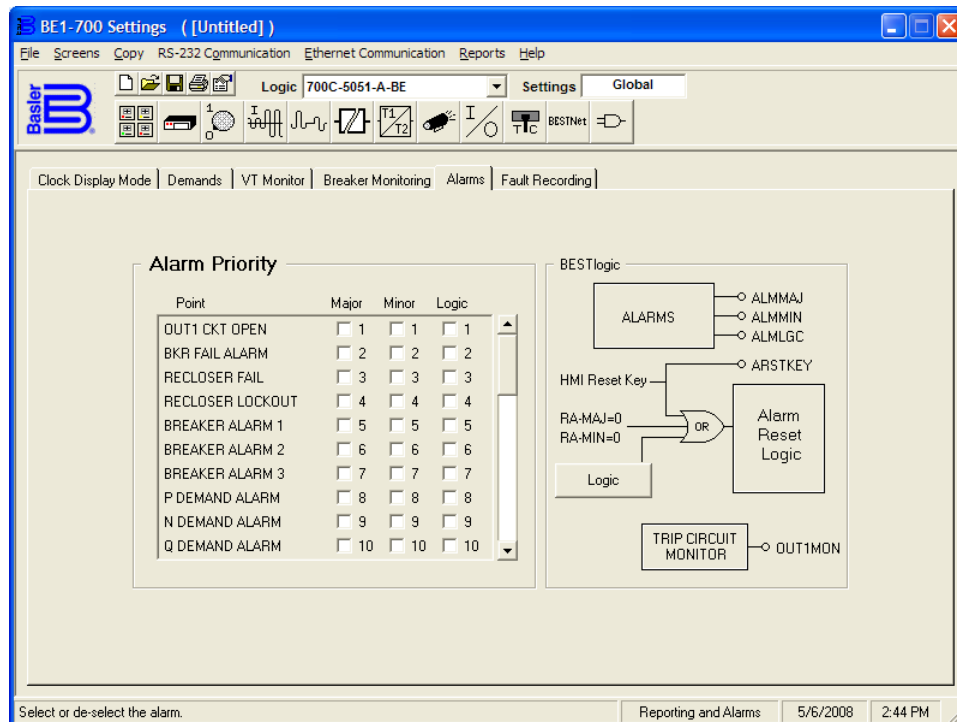


Figure 6-21. Reporting and Alarms Screen, Alarms Tab

Table 6-18 summarizes major, minor, and logic programmable alarm settings.

Table 6-18. Programmable Alarm Settings

Setting	Range/Purpose	Default
Major alarm points (drives Major Alarm LED and ALMMAJ logic variable).	List of alarm functions per Table 6-17.	0
Minor alarm points (drives Minor Alarm LED and ALMMAJ logic variable).	List of alarm functions per Table 6-17.	29
Logic alarm points (drives ALMLGC logic variable).	List of alarm functions per Table 6-17.	0

Retrieving and Resetting Alarm Reports

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 6-22 shows the alarm reset logic.

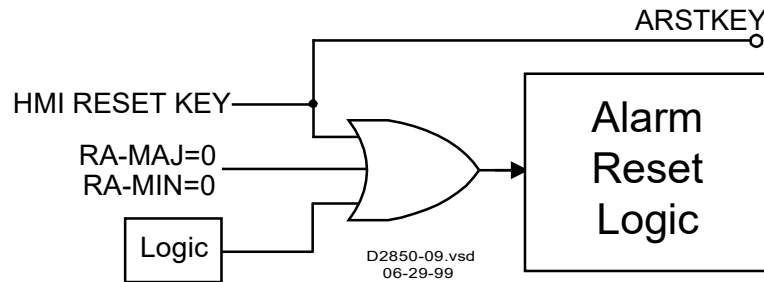


Figure 6-22. Alarm Reset Logic

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 6-17 for a list of latching alarm points and self-clearing alarm points.

After an operation, alarms information can be viewed using BESTCOMS. Select *Metering* from the *Reports* pull-down menu. From the *View* pull-down menu, select *Alarms Status* (Figure 6-23).

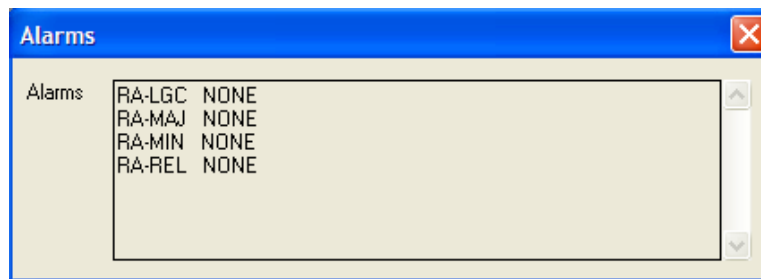


Figure 6-23. Alarms Status, Metering Screen

The RA (report alarms) command can be used to read detailed alarm reports and reset latched alarms.

Links between Programmable Alarms and BESTlogic

Several links between the programmable alarms and BESTlogic allow alarm functions to be used in the logic scheme and programmable logic functions to be used in the alarm reporting function.

Programmable Alarms Controlled by BESTlogic Elements

Virtual Outputs VO13, VO14, and VO15 are driven by BESTlogic expressions and are available in the programmable alarms function. These three virtual outputs have labels that can be assigned meaningful names. Then, when a logic condition that is used for an alarm exists, the label will be reported in the alarm reporting function.

Programmable Alarms Reset

Programmable alarms can be reset by any one of three methods:

- The programmable alarms reset logic expression becomes TRUE.
- Pressing the front panel *Reset* key when HMI Screen 1.3 is active.
- 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 6-21. The *BESTlogic Function Element* screen for *Alarm Reset Logic* will appear. See Figure 6-24.

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.

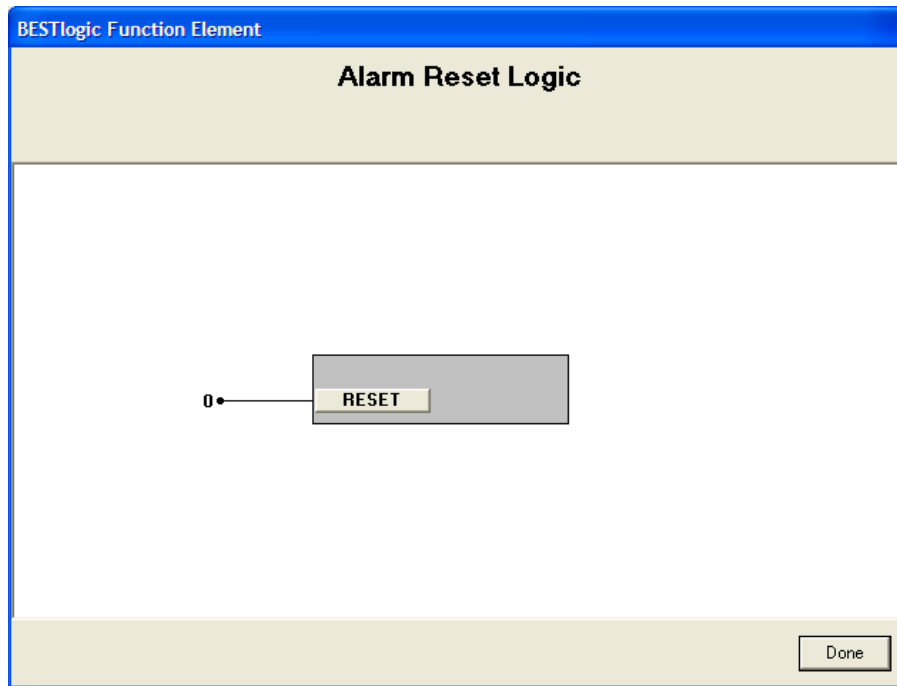


Figure 6-24. BESTlogic Function Element Screen, Alarm Reset Logic

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.

Hardware and Software Version Reporting

Hardware and software version reporting is used to determine what style chart selections are included in the relay, the relay serial number and the version of the embedded software (firmware).

Model (style) number serial number information is contained on the label on the front panel. Embedded software information can be obtained at HMI Screen 4.7. The information of Screen 4.7 is also displayed briefly when operating power is applied to the relay.

A software and hardware version report can be obtained through BESTCOMS. Alternately, it can be obtained using the RG-VER ASCII command.

To obtain the relay's version report through BESTCOMS, select *Download Settings from Device* from the *Communication* pull-down menu. Downloaded settings from the relay will overwrite any settings you have made in BESTCOMS; the relay will ask you to save your current file before continuing the download.

To view the version of the relay once the download is complete, select *General Operation* from the *Screens* pull-down menu. Then select the *General Information* tab. The *General Information* tab displays all of the style information about the relay. See Figure 6-25.

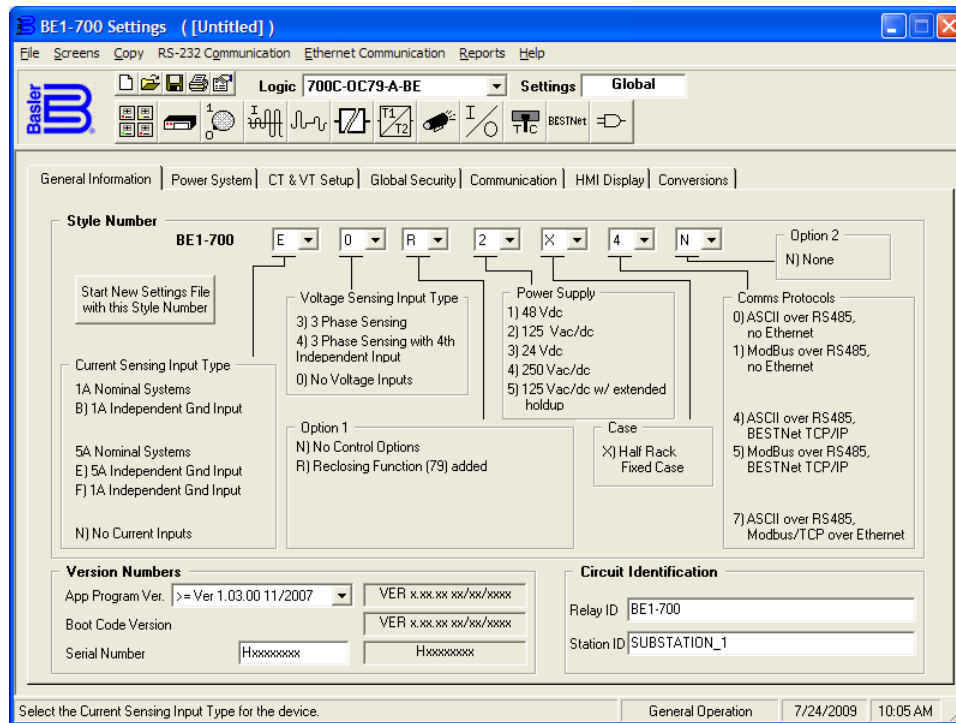


Figure 6-25. General Operation Screen, General Information Tab

Settings Compare

BESTCOMS has the ability to compare two different settings files. To use this feature, pull down the *Reports* menu and select *Settings Compare*. The *BESTCOMS Settings Compare Setup* dialog box appears (Figure 6-26). Select the location of the first file to compare under *Left Settings Source* and select the location of the second file to compare under *Right Settings Source*. If you are comparing a settings file located on your PC hard drive or portable media, click the folder button and navigate to the file. If you want to compare settings downloaded from a unit, click the RS-232 button to set up the communication port and baud rate. Click the *Compare* button to compare the selected settings files.

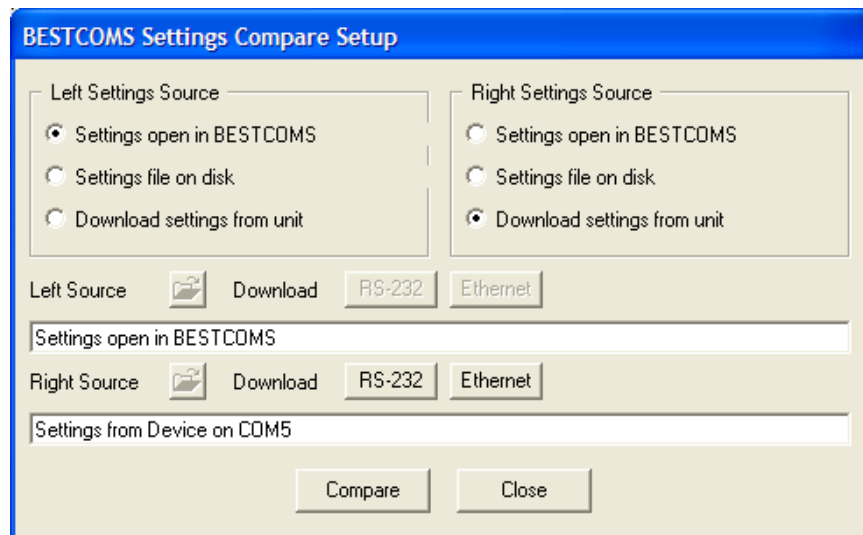


Figure 6-26. Settings Compare Setup

If there are any differences in the two files, a dialog box will appear and notify you that differences were found. The BESTCOMS Settings Compare dialog box (Figure 6-27) is displayed where you can view all settings (*Show All* button) or view only the differences (*Show Diff*s button).

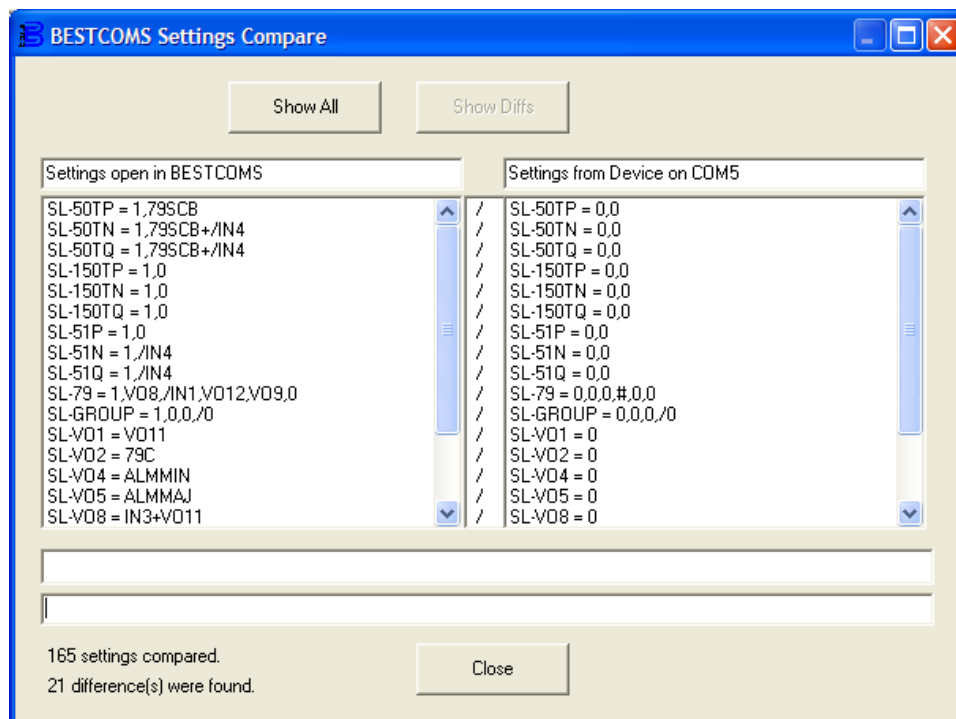


Figure 6-27. Settings Compare View

7 • BESTlogic™ Programmable Logic

Multifunction relays such as the BE1-700 Digital Protective 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, intertie protective relay systems. Each relay system has multiple, self-contained function blocks that have all of the inputs and outputs of its discrete component counterpart. Each independent function block interacts with control inputs, virtual outputs, and hardware outputs based on logic variables defined in equation form with BESTlogic. BESTlogic equations entered and saved in the relay system's nonvolatile memory integrate (electronically wire) the selected or enabled protection and control blocks with control inputs, virtual outputs, and hardware outputs. A group of logic equations defining the function of the multifunction relay is called a logic scheme.

Two preprogrammed logic schemes for the BE1-700V and two preprogrammed logic schemes for the BE1-700C are stored in relay memory. Each scheme is configured for a typical protection application and virtually eliminates the need for "start-from-scratch" programming. Either of the two preprogrammed schemes can be copied and saved as the active logic. Preprogrammed logic schemes can also be copied and then customized to suit your application. Detailed information about preprogrammed logic schemes is provided later in this section.

BESTlogic is not used to define the operating settings (pickup thresholds and time delays) of the individual protection and control functions. Operating settings and logic settings are interdependent but separately programmed functions. Changing logic settings is similar to rewiring a panel and is separate and distinct from making the operating settings that control the pickup thresholds and time delays of a relay. Detailed information about operating settings is provided in Section 4, *Protection and Control*.

Caution

This product contains one or more *nonvolatile memory* devices. Nonvolatile memory is used to store information (such as settings) that needs to be preserved when the product is power-cycled or otherwise restarted. Established nonvolatile memory technologies have a physical limit on the number of times they can be erased and written. In this product, the limit is 100,000 erase/write cycles. During product application, consideration should be given to communications, logic, and other factors that may cause frequent/repeated writes of settings or other information that is retained by the product. Applications that result in such frequent/repeated writes may reduce the useable product life and result in loss of information and/or product inoperability.

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 for BE1-700C relays are illustrated in Figure 7-1; BESTlogic function blocks for BE1-700V relays are illustrated in Figure

7-2 and function blocks available for both current and voltage are illustrated in Figure 7-3 along with the associated notes for all three figures.

Names assigned to inputs, outputs, timers, and protection and control elements represent the logic variables in the equations. Table 7-1 lists the logic variable names and descriptions.

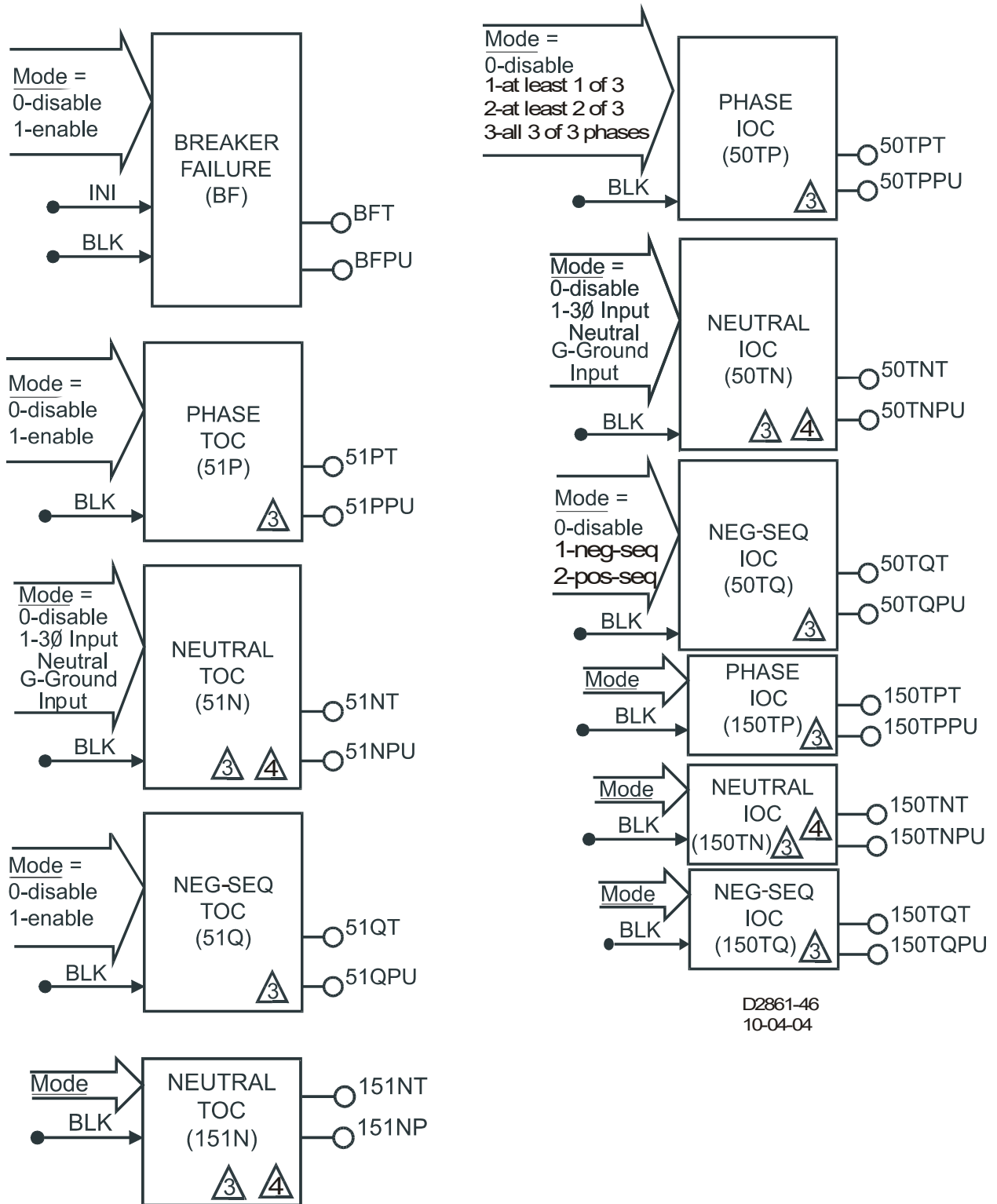


Figure 7-1. BE1-700C BESTlogic Function Blocks

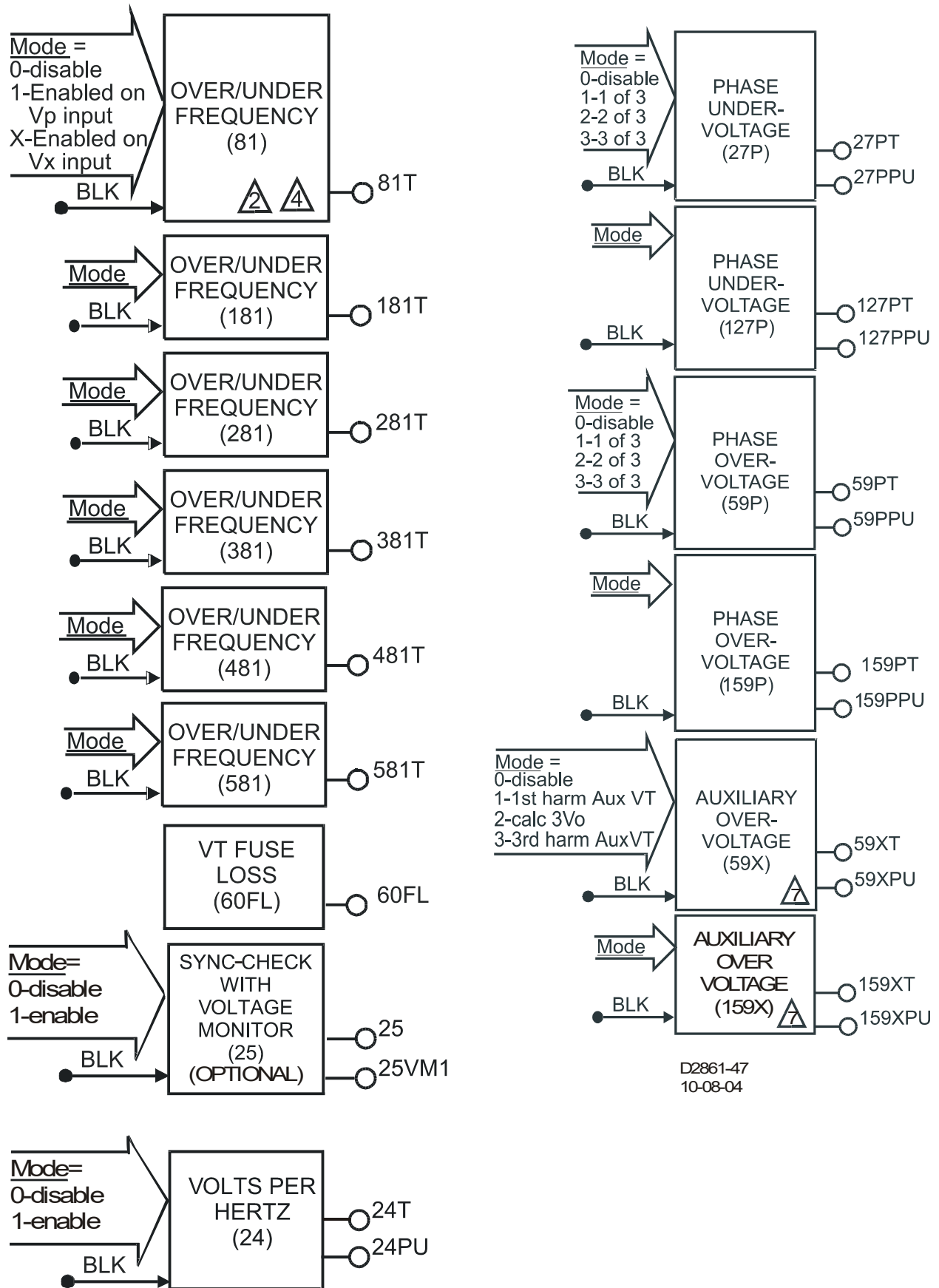


Figure 7-2. BE1-700V BESTlogic Function Blocks

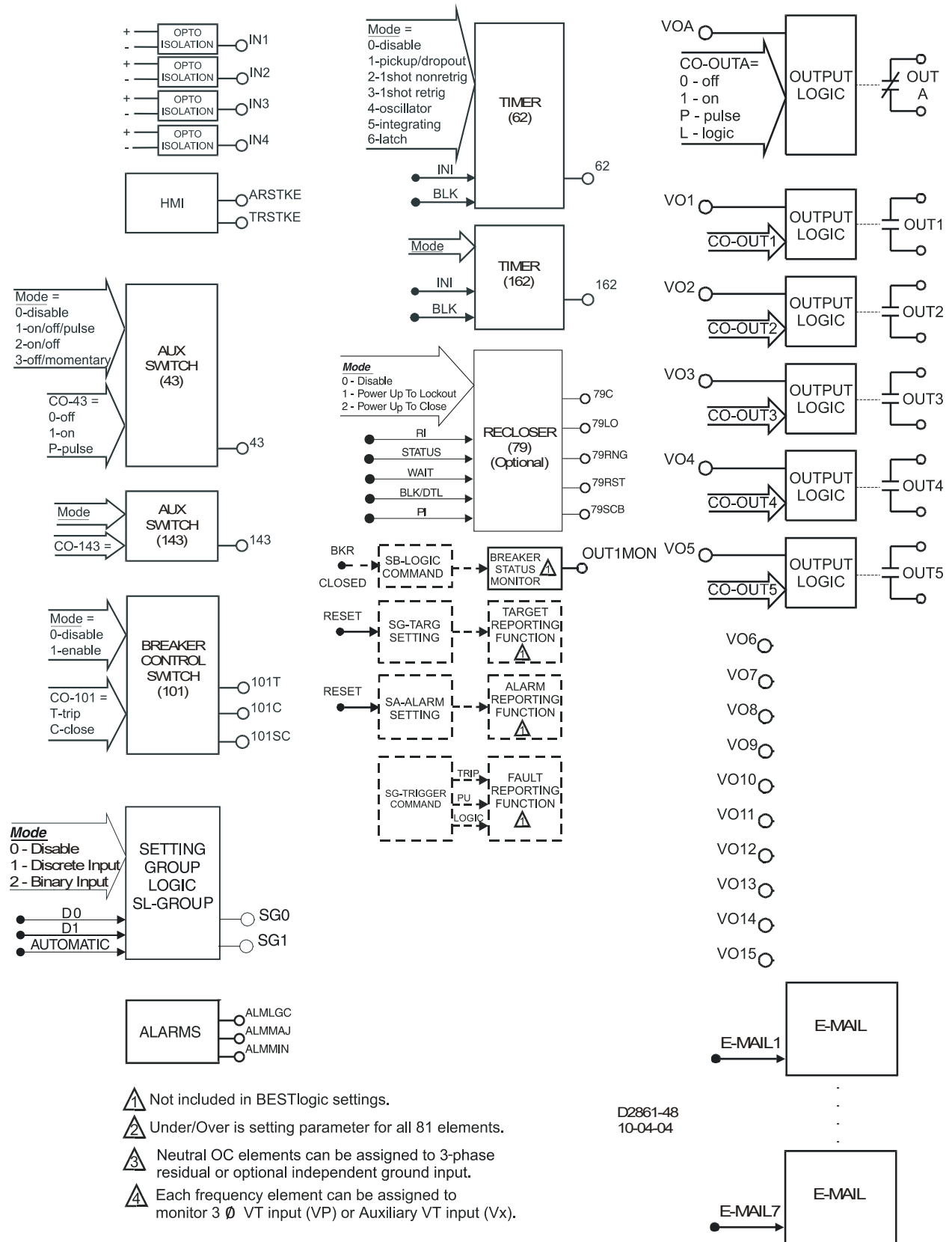


Figure 7-3. BESTlogic Function Blocks Common to Both BE1-700C and BE1-700V

Table 7-1. Logic Variable Names and Descriptions

Variable Name	Description	Variable Name	Description
Inputs and Outputs		59XPU	59 Auxiliary Overvoltage Picked Up
IN1-IN4	Inputs 1 through 4 Status	159PT	159 Phase Overvoltage Tripped
VOA	Relay Trouble Alarm Output Status	159PPU	159 Phase Overvoltage Picked Up
VO1-VO5	Virtual Outputs 1 through 5 (hardware outputs)	159XT	159 Auxiliary Overvoltage Tripped
VO6-VO15	Virtual Outputs 6 through 15	159XPU	159 Auxiliary Overvoltage Picked Up
Controls		47PU	47 Negative Sequence Picked Up
TRSTKEY	HMI Target Reset Key	47T	47 Negative Sequence Tripped
ARSTKEY	HMI Alarm Reset Key	Over/Under Frequency	
101T	Virtual Breaker Control Switch Tripped	81T	81 Tripped
101C	Virtual Breaker Control Switch Closed	181T	181 Tripped
101SC	Virtual Breaker Control Switch Slip Contact	281T	281 Tripped
62	62 Timer Output	381T	381 Tripped
162	162 Timer Output	481T	481 Tripped
43	Virtual Switch 43 Output	581T	581 Tripped
143	Virtual Switch 143 Output	Breaker Failure (BE1-700C only)	
SG0	Setting Group 0 Active (default)	BFT	Breaker Failure Tripped
SG1	Setting Group 1 Active	BFPU	Breaker Failure Picked Up
Alarms and Monitor		Instantaneous Overcurrent (BE1-700C only)	
ALMLGC	Logic Alarm	50TPT	50T Phase Tripped
ALMMAJ	Major Alarm	50TPPU	50T Phase Picked Up
ALMMIN	Minor Alarm	50TNT	50T Neutral Tripped
OUT1MON	Output 1 Monitor (circuit continuity)	50TNPU	50T Neutral Picked Up
Reclosing (Optional)		50TQT	50T Negative-Sequence Tripped
79C	79 Close Signal	50TQPU	50T Negative-Sequence Picked Up
79RNG	79 Running/Block Tap Changer	150TPT	150T Phase Tripped
79LO	79 Lockout	150TPPU	150T Phase Picked Up
79RST	79 Reset	150TNT	150T Neutral Tripped
79P	79 Pilot	150TNPU	150T Neutral Picked Up
79SCB	79 Sequence Control Block	150TQT	150T Negative-Sequence Tripped
Voltage (BE1-700V only)		150TQPU	150T Negative-Sequence Picked Up
24T	24 Overexcitation Tripped	Time Overcurrent (BE1-700C only)	
24PU	24 Overexcitation Picked Up	51PT	51 Phase Tripped
25	25 Sync-Check Output	51PPU	51 Phase Picked Up
25VM1	25 Voltage Monitor 1	51NT	51 Neutral Tripped
27PT	27 Phase Undervoltage Tripped	51NPU	51 Neutral Picked Up
27PPU	27 Phase Undervoltage Picked Up	51QT	51 Negative-Sequence Tripped
127PT	127 Phase Undervoltage Tripped	51QPU	51 Negative-Sequence Picked Up
127PPU	127 Phase Undervoltage Picked Up	151PT	151 Phase Tripped
27XT	27 Auxiliary Undervoltage Tripped	151PPU	151 Phase Picked Up
27XPU	27 Auxiliary Undervoltage Picked Up	151NT	151 Neutral Tripped
59PT	59 Phase Overvoltage Tripped	151NPU	151 Neutral Picked Up
59PPU	59 Phase Overvoltage Picked Up	Fuse Loss (BE1-700V only)	
59XT	59 Auxiliary Overvoltage Tripped	60FL	60 Loss of Potential Alarm

Function Block Logic Settings

Each BESTlogic function block is equivalent to its discrete device counterpart. For example, the Recloser Logic Function Block of Figure 7-4 has many of the characteristics of a BE1-79M Multiple Shot Reclosing Relay.

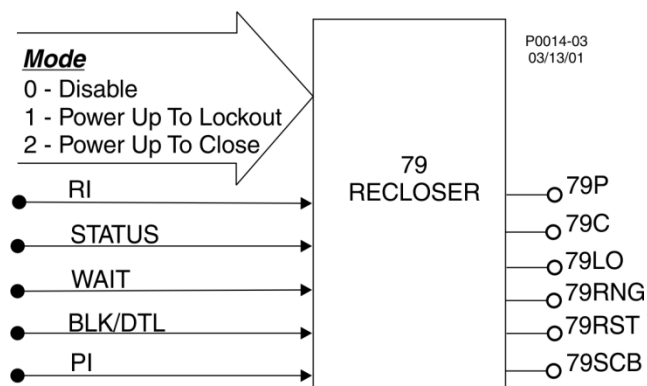


Figure 7-4. Recloser Element

Before using a protection or control function block, two items must be set: the *Mode* and the *Input Logic*. Setting the *Mode* is equivalent to deciding which protection or control functions will be used in a logic scheme. The *Input Logic* establishes control of a function block.

Mode and input logic information is contained in logic setting command strings. Depending on the command, the mode setting can either enable or disable a logic input or determine how a function block operates. Input logic defines which logic variables control or disable a logic function. An example of an input logic equation is $SL-181=1,IN3+VO6$. In this frequency logic command string, the 1 parameter indicates that the 181 function is enabled. The $IN3+VO6$ expression indicates that the 181 function is disabled when input 3 or virtual output 6 is TRUE.

The AND operator may not be applied to the terms of an input logic equation. Any number of variables or their inverse can be combined in a function block input logic expression. Section 4, *Protection and Control*, provides detailed information about setting the logic for each function block.

Output Logic Settings

Defining Output Operation

Output operation is defined by Boolean logic equations. Each variable in an equation corresponds to the current state (evaluated every quarter cycle) of an input, output, or timer. Figure 7-5 illustrates this relationship. Every quarter cycle, output expressions are evaluated as TRUE or FALSE. If a logic output that corresponds to a hardware output changes state, then the corresponding output relay contact also changes state.

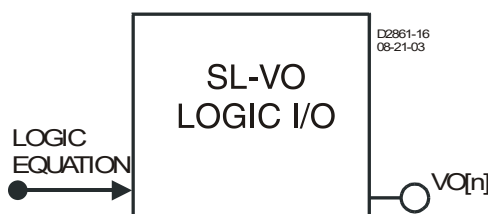


Figure 7-5. Virtual Output Logic

When the relay is powered up, all logic outputs are disabled and most variables (including virtual outputs) initialize as FALSE. Some variable states are stored in EEPROM and are restored to the last state prior to loss of power. These variables include 43/143, 101SC, SG0, and SG1. All control commands, including logic override control, are also stored in EEPROM. If you override output logic and force an output to open, that condition will be maintained even if operating power is cycled.

When the logic is running and logic expression SL-VO[n] is FALSE, then output VO[n] = 0. When the logic is running and logic expression SL-VO[n] is TRUE, then VO[n] = 1. Hardware outputs OUTA and OUT1 through OUT5 follow the corresponding logic outputs VOA and VO1 through VO5.

Logic equations are defined by logic variables, logic operators, and their position in an equation. The available logic operators include AND (*), OR (+) and NOT (/). The NOT operator is applied to the variable immediately following the symbol (/). For virtual output equations, OR logic can be applied to any number of variables if no AND logic is used in the expression. Similarly, AND logic can be applied to any number of variables if no OR logic is used. Any number of NOT operators may be used. For complex expressions that use both AND and OR operators, OR logic is limited to four terms. Up to four AND terms with any number of variables can be ORed together. When the relay is processing a complex expression, it performs AND operations before performing OR operations.

Virtual and Hardware Outputs

A virtual output exists only as a logical state inside the relay. A hardware output is a physical relay contact that can be used for protection or control. Each BE1-700 relay has five isolated, normally open (NO) output contacts (OUT1 – OUT5) and one isolated, normally closed (NC) alarm output (OUTA). Output contacts OUT1 through OUT5 are controlled by the status of the internal virtual logic signals VO1 through VO5. If VO[n] becomes TRUE, then the corresponding output relay OUT[n] energizes and closes the NO contacts. For the alarm output, if VOA becomes TRUE, the ALM output de-energizes and closes. 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 7-6 illustrates the *BESTlogic Expression Builder* screen.

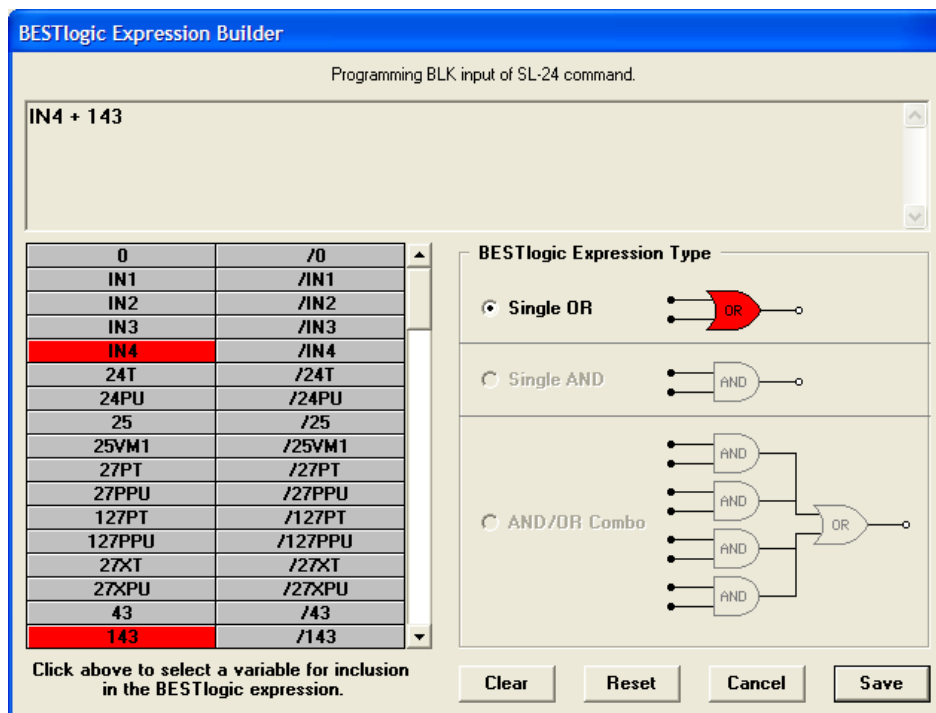


Figure 7-6. BESTlogic Expression Builder Screen

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 Table 7-1 and Table 7-2. Currently, the virtual outputs are the only functions that can use the single AND or AND/OR combination *BESTlogic Expression Type*.

The top of the screen displays the BESTlogic expression in a text window. Above the text window, the selected input and the associated ASCII command are displayed.

The *Clear* button will clear the expression to 0. The *Reset* button will reset the expression to its original state when the *BESTlogic Expression Builder* was first opened. The *Cancel* button resets the expression to its original state when the *BESTlogic Expression Builder* was first opened and returns the user to the previous screen. The *Save* button saves the expression shown in the text window and returns the user to the previous window.

Logic Schemes

A logic scheme is a group of logic variables written in equation form that defines the operation of a multi-function relay. Each logic scheme is given a unique name of one to eight alphanumeric characters. This gives you the ability to select a specific scheme and be confident that the selected scheme is in operation. Two logic schemes for BE1-700C, 700C-5051-A-BE and 700C-OC79-A-BE; and two logic schemes for BE1-700V, 700V-OUVF-A-BE and 700V-VF79-A-BE are configured for typical protection applications and are stored in nonvolatile memory. Only one of these logic schemes can be active at a given time. In most applications, preprogrammed logic schemes eliminate the need for custom programming. Preprogrammed logic schemes may provide more inputs, outputs, or features than are needed for a particular application. This is because the preprogrammed schemes are designed for a large number of applications with no special programming required. Unneeded inputs or outputs may be left open to disable a function or a function block can be disabled through operating settings. Unused current sensing inputs should be shorted to minimize noise pickup.

When a custom logic scheme is required, programming time can be reduced by copying a preprogrammed scheme into the active logic. The logic scheme can then be modified to meet the specific application.

The Active Logic Scheme

Digital, multifunction relays must have an active logic scheme in order to function. All Basler Electric multifunction relays are delivered with a default, active logic loaded into memory. The default, active logic scheme for the BE1-700 varies depending on the specific model ordered. See *Style Chart* in Section 1. If the function block configuration and output logic of the default logic scheme meets the requirements of your application, then only the operating settings (power system parameters and threshold settings) need to be adjusted before placing the relay in service.

Note

There has been a fundamental improvement to the way the user sets up BESTlogic in this device. In some prior implementations of BESTlogic, it was necessary to make a separate setting that determined whether the user's logic scheme or if one of the pre-programmed logic schemes was to be made active. This setting was made from the ASCII command interface using the SP-LOGIC (Set Protection Logic) command. **This setting has been eliminated.**

In the implementation of BESTlogic used in this relay, the logic scheme defined by the user's logic settings is always active. If the user wishes to use a preprogrammed logic scheme, he/she now copies it into his/her user logic settings. This process is accomplished from the ASCII command interface using the SL-N (Set Logic Name) command in this and previous BESTlogic implementations

If a different preprogrammed logic scheme is required, it can be easily copied to active logic and used as is or customized to your specifications. To accomplish this, communication with the relay must be established. It is accomplished by connecting a computer to the front RS-232 port or optional rear Ethernet port.

Logic schemes can be selected from the logic select tab on the *BESTlogic* screen. To access this screen, select *BESTlogic* from the *Screens* pull-down menu. Then select the *Logic Select* tab. Select the desired logic scheme to *Copy to Active Logic* (Internal Logic). The active logic scheme is shown in the *Logic Name* box. In Figure 7-7, 700C-OC79-A-BE has been selected as the user logic.

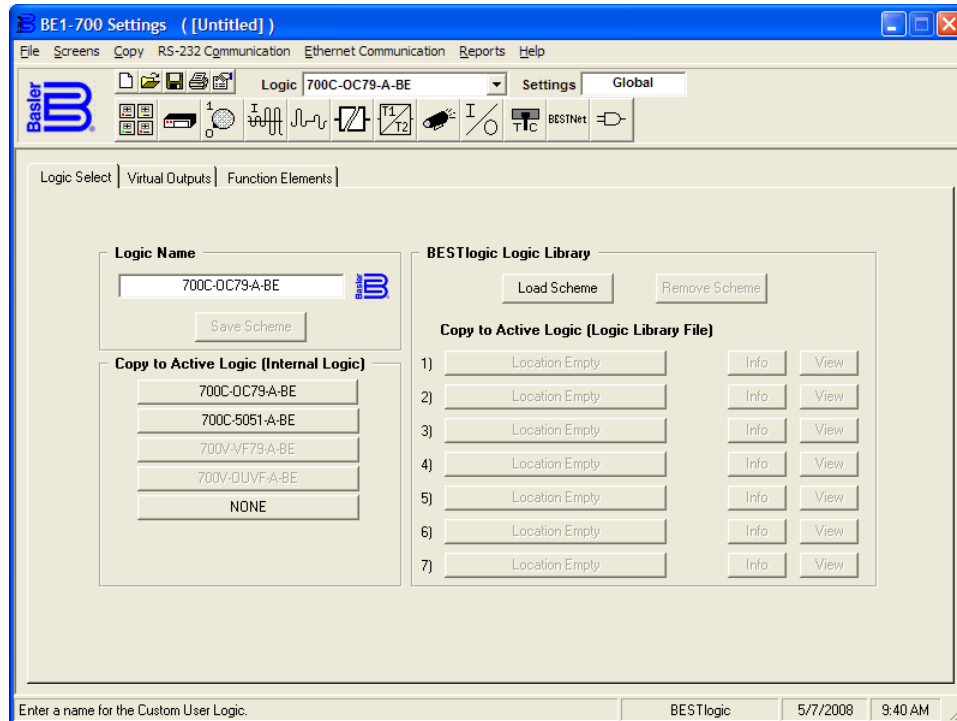


Figure 7-7. BESTlogic Screen, Logic Select Tab

Caution

Selecting a logic scheme to be active in BESTCOMS™ does not automatically make that scheme active in the relay. See the paragraphs later in this section titled, *Sending and Retrieving Relay Settings*.

Custom Logic Schemes

Caution

If "NONE" logic is selected, the protection elements are not connected to the virtual outputs or output relays and fault recording features including targets are not enabled.

A custom logic scheme can be created from scratch by copying NONE to *Logic Name* and then renaming the logic. A custom logic scheme can also be created by modifying a preprogrammed logic scheme after copying it to *Logic Name* and then renaming it. A preprogrammed logic scheme copied to *Logic Name* with no name change is treated as a read-only scheme and cannot have its logic expressions altered. Before modifying a logic scheme copied to *Logic Name*, the scheme must be assigned a unique name of one to eight alphanumeric characters. This scheme is then referred to as a custom or user programmable logic scheme because the variable expressions of the logic can be customized or created from scratch to

suit the needs of an application. A custom logic scheme may be revised many times but only the most recent changes are saved to as the active (*Logic Name*) logic.

Caution

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

Copying and Renaming Preprogrammed Logic Schemes

Copying a preprogrammed logic scheme to the active logic (*Logic Name*) and assigning a unique name is accomplished by selecting the desired logic scheme in BESTCOMS and then typing over the logic scheme's name. Changes are not activated until the new settings have been uploaded to the device.

Creating or Customizing a Logic Scheme

Before customizing a preprogrammed logic scheme, the scheme must be renamed. The following procedure outlines the process of customizing or creating a logic scheme:

- Step 1. Copy the preprogrammed scheme.
- Step 2. Rename the scheme with a unique, non-preprogrammed name.
- Step 3. Using BESTCOMS, enable or disable the desired relay functions.
- Step 4. Edit the logic expressions, as required.
- Step 5. Save the changes. Refer to Section 14, *BESTCOMS Software*, for more information on how to save and export settings files.

Sending and Retrieving Relay Settings

Retrieving Relay Settings

To retrieve settings from the relay, the relay must be connected to a computer through a serial port. Once the necessary connections are made, settings can be downloaded from the relay by selecting *Download Settings from Device* on the Communication pull-down menu.

Sending Relay Settings

To send settings to the relay, the relay must be connected to a computer through a serial port. Once the necessary connections are made, settings can be uploaded to the relay by selecting *Upload Settings to Device* on the Communication pull-down menu.

Debugging the Logic Scheme

If there are problems with a customized logic scheme, the RG-STAT command can be used to check the status of all logic variables. More information about the RG-STAT command can be found in Section 6, *Reporting and Alarm Functions*.

User Input and Output Logic Variable Names

Assigning meaningful names to the inputs and outputs makes sequential events reports easier to analyze. Input and output logic variable names are assigned by typing them into the appropriate text box on the related *BESTCOMS* screen. All of the BE1-700's inputs, outputs, and 43 switches have labels that can be edited. Table 7-2 shows the range and purpose of each label. Alternately, labels may be edited using the SN ASCII command.

Table 7-2. Programmable Variable Name Setting

Settings	Range/Purpose	Default
Name/Label	1 to 10 characters. User name to replace <var> in the RS report.	INPUT_x SWITCH_x43 VOx_LABEL
True/Energized State	1 to 7 characters. Used to replace default labels.	TRUE
False/De-Energized State	1 to 7 characters. Used to replace default labels.	FALSE

BESTlogic™ Application Tips

When designing a completely new logic scheme, logic evaluation order should be considered. Contact sensing inputs are evaluated first, then the function blocks, and then the virtual outputs. VO15 is evaluated first and VOA is evaluated last. If a virtual output is used in a logic expression to control another virtual output, the virtual output used in the expression should be numerically higher. Otherwise, a logic expression for a numerically smaller virtual output won't be available to a numerically higher virtual output until the next processing interval. Logic is evaluated every ½ cycle.

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

OUT1 through OUT5 have normally open contacts (coil is de-energized). Normally open contacts can be used as normally closed outputs by inverting the logic expressions that drive them. Inverting an output logic expression causes the coil to be energized with the contacts closed in the normal state.

Several links between the programmable alarms function and BESTlogic programmable logic allow alarm functions to be used in a logic scheme and programmable logic functions to be used in the alarm reporting function.

Programmable alarm settings for Major, Minor, and Logic alarms drive BESTlogic variables ALMMAJ, ALMMIN, and ALMLGC. These variables can be used in logic expressions to control logic when an alarm is active.

Virtual outputs VO13, VO14, and VO15 are driven by BESTlogic expressions. These three logic variables are also available in the programmable alarm function. Virtual outputs can also be assigned user programmable labels (described previously). With this feature, a logic condition can be designed and used for an alarm. The virtual output label would then be reported in the Reporting and Alarm functions.



8 • Application

This section discusses the application of the BE1-700 Digital Protective Relay. The product can be purchased as a current only relay (BE1-700C) or as a voltage only (BE1-700V) relay. Each product has two embedded preprogrammed logic schemes plus NONE that maximizes the feature set of the individual product.

Each preprogrammed logic scheme is designed to take full advantage of the specific BE1-700 protection capabilities. However, not all elements have to be set. The protection engineer can choose which elements receive operational settings or adapt the scheme to user specific needs by changing the protection and control elements and settings. In many cases, this eliminates the need to create a custom logic scheme from scratch.

Please note that this preprogrammed logic scheme also illustrates typical ways of using or controlling various functions. The user may choose to create a custom logic scheme by mixing preprogrammed logic with user defined logic. The logic also can be modified to incorporate some of the features described in the *Application Tips*, provided at the end of this section. The flexibility of BESTlogic in combination with easy to use BESTCOMS™ allows the engineer to quickly create a protection and control scheme that meets the exact requirements of the application. The following sections discuss the application specifics of the BE1-700C preprogrammed logic scheme.

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 a voltage or frequency 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 voltage and frequency function blocks.

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 will not 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.

Network System. A system where loads can be fed by more than one source at the same time.

Overview of Preprogrammed Logic Schemes

Four preprogrammed logic schemes and NONE are available for the BE1-700 family of products. Each logic scheme is specific to the feature set (options) ordered by the customer and becomes the default logic. The same schemes are available through BESTCOMS for the BE1-700 series of products. See Section 14, *BESTCOMS Software*, for the Windows® based user interface software. More detailed information about these schemes is provided in *Details of Preprogrammed Logic Schemes*.

Embedded Logic Schemes for BE1-700C

700C-5051-A-BE (Basic Overcurrent Protection) Logic Scheme

This logic scheme provides basic time and instantaneous overcurrent protection. Phase, neutral, and negative-sequence protective elements are included. Functions such as virtual breaker control and virtual switches (43) are not enabled in this scheme but can be activated through BESTlogic. This scheme can be applied as feeder protection, transformer overcurrent protection, bus overcurrent differential protection, etc.

700C-OC79-A-BE (Overcurrent Protection with Reclosing) Logic Scheme

This logic scheme provides time overcurrent elements and both high-set and low-set instantaneous overcurrent elements for phase, neutral and negative-sequence protection for any overcurrent application. Automatic reclosing is included and is initiated (RI) by a protective trip or by an external reclose initiate contact. This scheme is ideal for protecting radial distribution feeders that require automatic reclosing such as with overhead construction.

Embedded Logic Schemes for BE1-700V

700V-OUVF-A-BE (Over/Undervoltage and Voltage Protection) Logic Scheme

This logic scheme provides basic voltage and frequency protection. The scheme is well suited for 3-phase bus over/undervoltage protection including phase rotation, and underfrequency load shedding.

700V-VF79-A-BE (Voltage Protection with Reclosing) Logic Scheme

This logic scheme provides voltage and frequency protection and includes network reclosing with separate pilot and time delay reclose initiates. The scheme is well suited for basic distributed generation protection, 3-phase bus over/undervoltage protection including phase rotation, underfrequency load shedding with rate of change supervision, and network reclosing applications such as replacement of Astand-alone® automatic reclosing, voltage and sync angle detection products.

Details of Preprogrammed Logic Schemes

The following paragraphs expand on the individual preprogrammed logic schemes for the BE1-700 series of products. The application features of each logic scheme are broken down into their separate protection elements and described in detail. The integration of protection and control elements and alarm elements are also described in detail. Although it is not discussed in each paragraph, the reader should be aware that the application of an independent, overlapping, backup zone of protection is recommended for a complete protection design.

The preprogrammed protection logic scheme begins with the application intent of the design. Next, the protection elements are discussed, followed by protection and control integration and alarm information specific to the preprogrammed design. Unique references for the scheme, including one-line and logic diagrams and program codes are included.

Preprogrammed logic can be a starting point or an ending point for the protection engineer depending on how closely the logic meets engineering requirements. These logic schemes were created by applications personnel from the utility industry and are easily modified to meet specific user needs. For applications assistance, contact your local Basler Electric representative.

700C-5051-A-BE (Basic Overcurrent) Logic Scheme (BE1-700C)

This logic scheme is intended for applications requiring three-phase and neutral non-directional 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.

The components of this logic scheme are summarized in Tables 8-1 through 8-4. A diagram of the logic is shown in Figure 8-1. Figure 8-2 shows a one-line drawing for the Basic Overcurrent logic scheme. Table 8-5 shows the logic settings and equations.

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 setting group. 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.

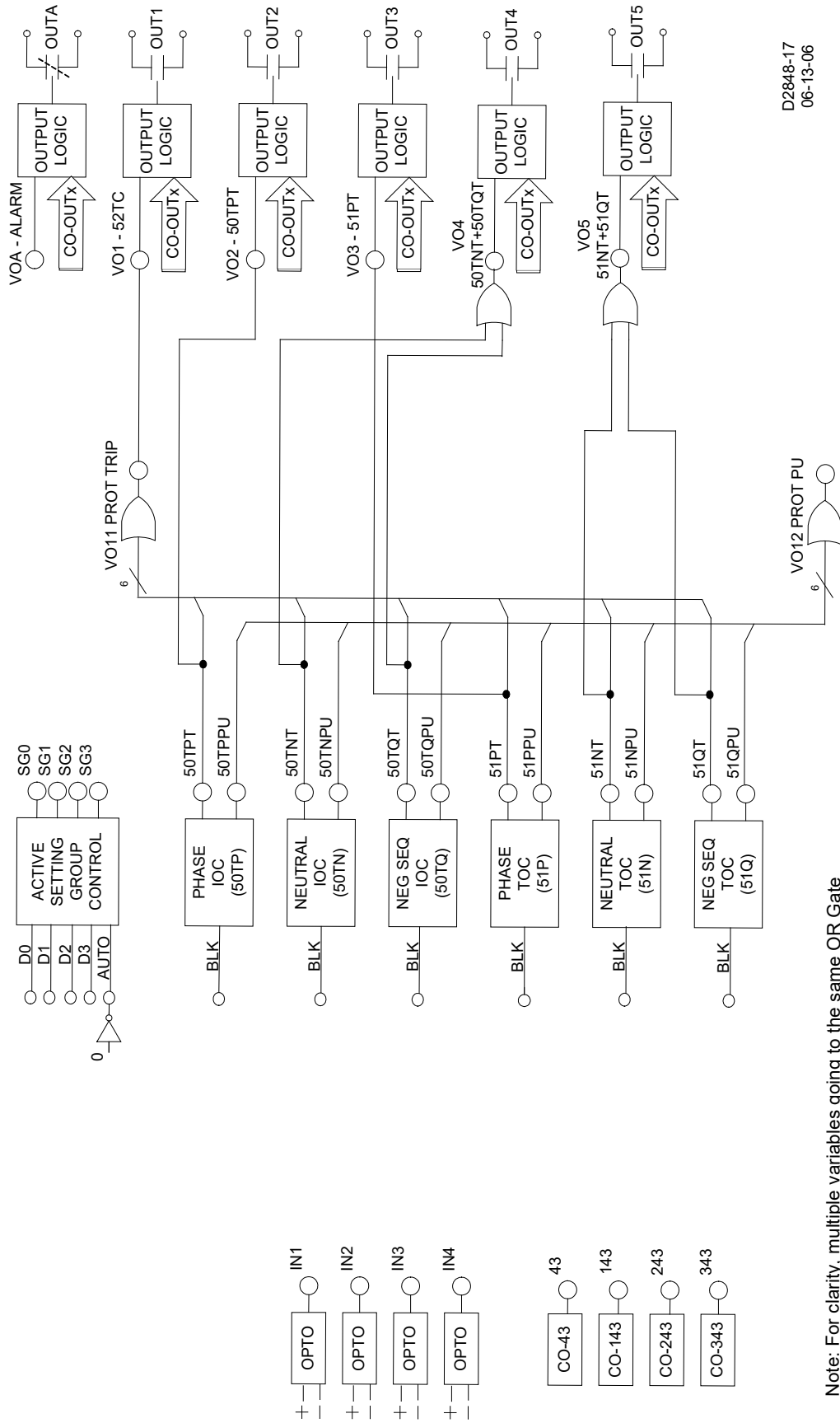
Input IN1 is typically assigned to monitor breaker status (52b). The remainder of the inputs (IN2, IN3, and IN4) are unassigned and are available for user specified functions.

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 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*.



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Note: For clarity, multiple variables going to the same OR Gate are shown by a single line into the OR Gate.

Figure 8-1. 700C-5051-A-BE (Basic OC) Logic Diagram

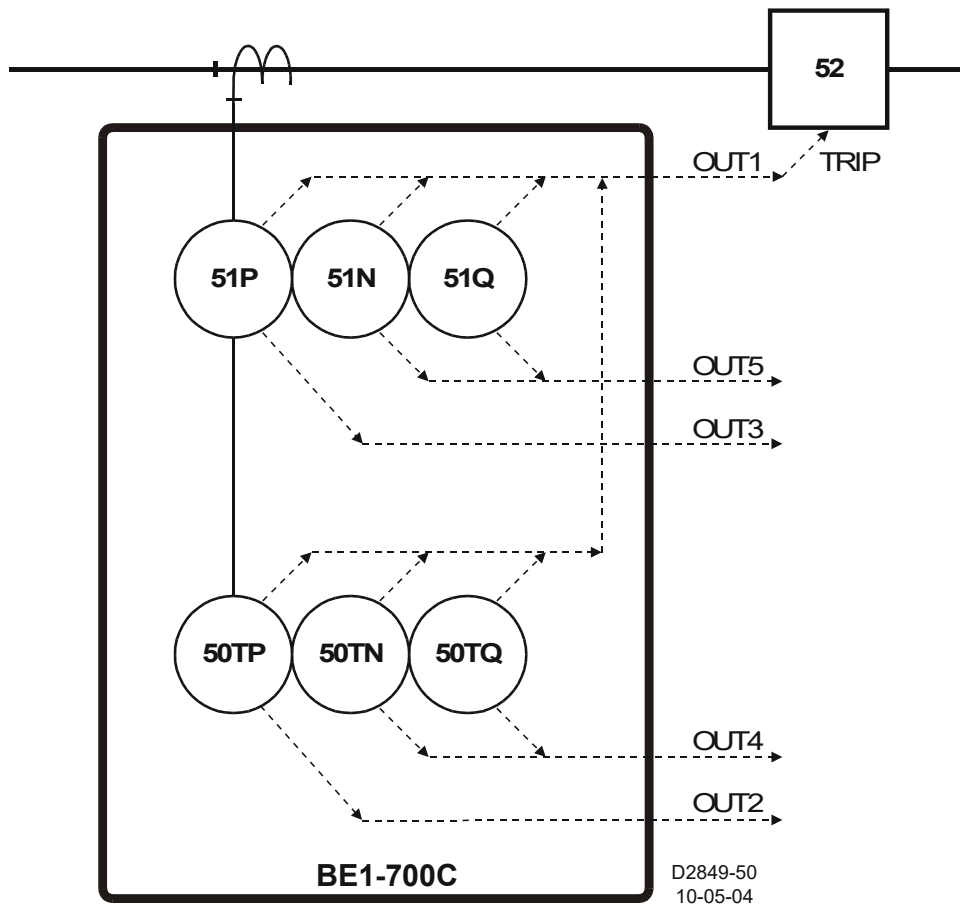


Figure 8-2. 700C-5051-A-BE (Basic OC) One-Line Drawing

Table 8-1. 700C-5051-A-BE (Basic OC) Contact Sensing Input Logic

Input	Purpose	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	CLOSED	OPEN
IN2	Not used	INPUT_2	CLOSED	OPEN
IN3	Not used	INPUT_3	CLOSED	OPEN
IN4	Not used	INPUT_4	CLOSED	OPEN

Table 8-2. 700C-5051-A-BE (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)

Function	Purpose	BESTlogic Expression	Mode Setting
50TQ	Used for instantaneous negative-sequence overcurrent protection.	0	1 (enabled)
150TP	Not used	0	0 (disabled)
150TN	Not used	0	0 (disabled)
150TQ	Not used	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	Not used	0	0 (disabled)
62	Not used	0	0 (disabled)
162	Not used	0	0 (disabled)
BF	Not used	0	0 (disabled)
GROUP	<i>Input 0 Logic:</i> No manual selection logic is used.	0	1 (discrete input selection)
	<i>Input 1 Logic:</i> No manual selection logic is used.	0	
	<i>Auto/Manual Logic:</i> Set to 1 (/0) to enable automatic selection. No manual selection is used.	/0	

Table 8-3. 700C-5051-A-BE (Basic OC) Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				TRUE	FALSE
43	Not used	0 (disabled)	SWITCH_43	CLOSED	OPEN
143	Not used	0 (disabled)	SWITCH_143	CLOSED	OPEN

Table 8-4. 700C-5051-A-BE (Basic OC) Virtual Output Logic

Output	Purpose	Output Description	Label	State Labels	
				TRUE	FALSE
VOA (OUTA)	Alarm Output Contact	Alarm contact closes automatically when relay trouble alarm occurs.	ALARM	ACTIVE	NORMAL
BESTlogic Expression: VOA=0					
VO1 (OUT1)	Breaker Trip Contact	Contact closes when protective trip expression is TRUE.	BKR_TRIP	TRIP	NORMAL
BESTlogic Expression: VO1=VO11					
VO2 (OUT2)	Instantaneous Phase OC Auxiliary Contact	Contact closes when instantaneous phase-overcurrent trip occurs.	50TP_TRIP	TRIP	NORMAL
BESTlogic Expression: VO2=50TPT					
VO3 (OUT3)	Timed Phase OC Auxiliary Contact	Contact closes when timed phase-overcurrent trip occurs.	51P_TRIP	TRIP	NORMAL
BESTlogic Expression: VO3=51PT					
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	None		VO6	TRUE	FALSE
BESTlogic Expression: VO6=0					
VO7	None		VO7	TRUE	FALSE
BESTlogic Expression: VO7=0					
VO8	None		VO8	TRUE	FALSE
BESTlogic Expression: VO8=0					
VO9	None		VO9	TRUE	FALSE
BESTlogic Expression: VO9=0					
VO10	None		VO10	TRUE	FALSE
BESTlogic Expression: VO10=0					

Output	Purpose	Output Description	Label	State Labels	
				TRUE	FALSE
VO11	Protective Trip Expression	TRUE when any 50, 150,51 or 151 element times out (trip).	PROT_ TRIP	TRIP	NORMAL
BESTlogic Expression: VO11=50TPT+50TNT+50TQT+150TPT+150TNT+150TQT+51PT+51NT+51QT +151NT					
VO12	Protection Picked Up Expression	TRUE when any 50, 150,51 or 151 element picks up.	PROT_PU	PU	NORMAL
BESTlogic Expression: VO12=50TPPU+50TNPU+50TQPU+150TPPU 150TNPU+150TQPU+51PPU +51NPU+51QPU+151NPU					
VO13	Alarm Mask 21		VO13	TRUE	FALSE
BESTlogic Expression: VO13=0					
VO14	Alarm Mask 22		VO14	TRUE	FALSE
BESTlogic Expression: VO14=0					
VO15	Alarm Mask 23		VO15	TRUE	FALSE
BESTlogic Expression: VO15=0					

Table 8-5. 700C-5051-A-BE (Basic OC) Logic Settings and Equations

SL-N=700C-5051-A-BE
 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-62=0,0,0
 SL-162=0,0,0
 SL-BF=0,0,0
 SL-GROUP=1,0,0,/0
 SL-43=0
 SL-143=0
 SL-101=0
 SL-VOA=0
 SL-VO1=VO11
 SL-VO2=50TPT
 SL-VO3=51PT
 SL-VO4=50TNT+50TQT
 SL-VO5=51NT+51QT
 SL-VO6=0
 SL-VO7=0
 SL-VO8=0
 SL-VO9=0
 SL-VO10=0
 SL-VO11=50TPT+50TNT+50TQT+150TPT+150TNT+150TQT+51PT+51NT+51QT+151NT

SL-
 VO12=50TPPU+50TNPU+50TQPU+150TPPU+150TNPU+150TQPU+51PPU+51NPU+51QPU+151NPU
 SL-VO13=0
 SL-VO14=0
 SL-VO15=0

700C-OC79-A-BE (Overcurrent with Reclosing) Logic Scheme (BE1-700C)

This logic scheme is intended for feeder breaker applications where non-directional overcurrent protection is required. Optional automatic reclosing is included and is initiated by a protective overcurrent trip or by an external contact to initiate reclosing (RI).

A diagram of the logic is shown in Figure 8-3. Figure 8-4 shows a one-line drawing for the 700C-OC79-A-BE logic scheme. The components of **OC with 79** logic are summarized in Tables 8-6 through 8-9. The logic settings in Table 8-10 include the logic equations that connect the various elements (electronic wiring) of the overcurrent with reclosing logic protection scheme.

Operation - Protection

Time (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 setting group.

The 150T function blocks are arranged as high-set instantaneous functions. When a 150T trip occurs, the recloser is driven to lockout. This scheme also allows the 50TN, 50TQ, 51N, and 51Q function blocks to be torque controlled by Contact Input IN4.

Operation - Reclosing

Reclosing logic in 700C-OC79-A-BE 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.

700C-OC79-A-BE logic allows 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 two setting groups is done by using the S#-79SCB commands for BESTCOMS.

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#

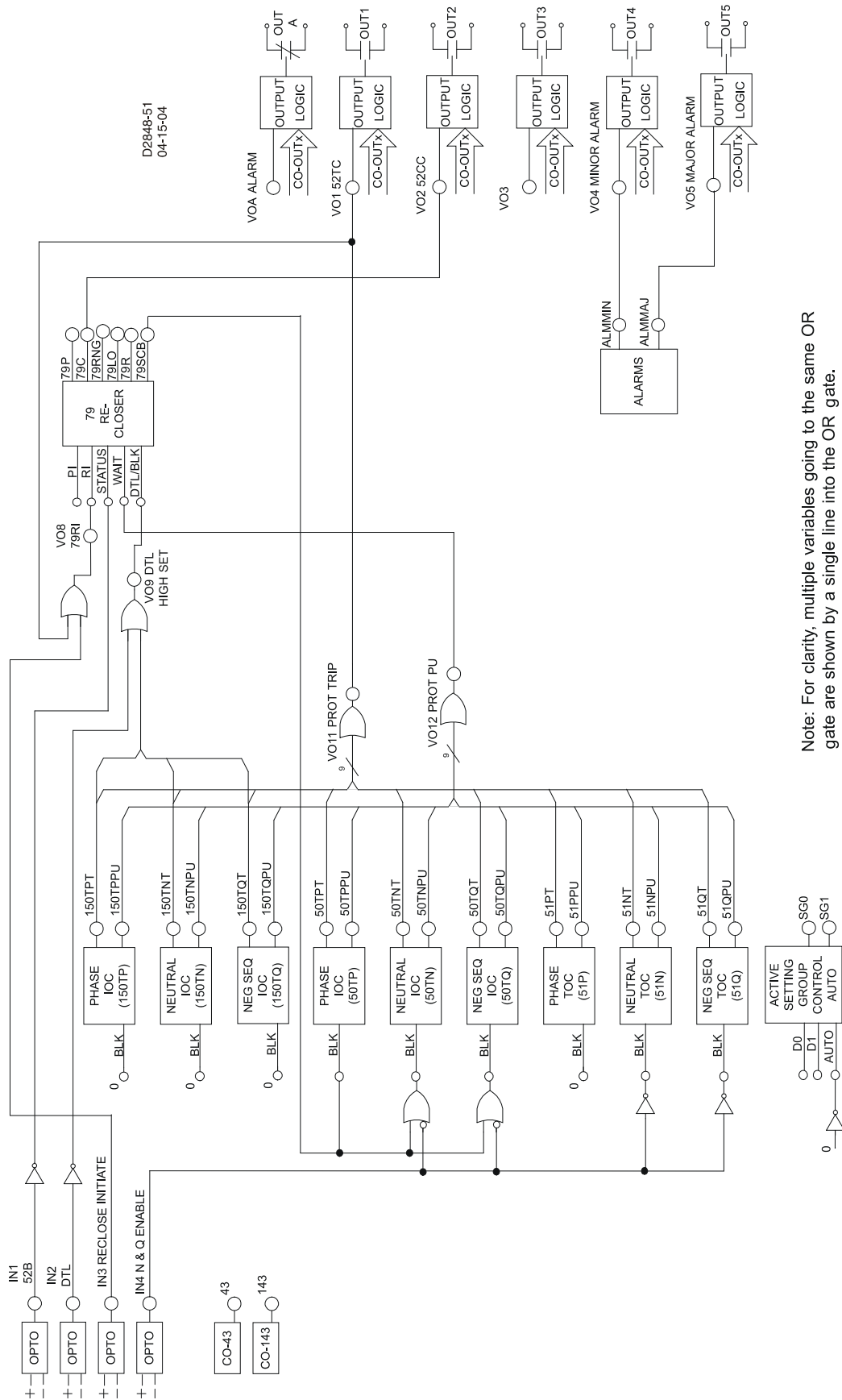
command. Setting group changes initiated by contact sensing inputs are not accommodated in this scheme. But IN2, IN3, or IN4 can be programmed to provide this function.

Operation - Alarms

If the continuous self-test diagnostics of the relay detect an error, failsafe output contact OUTA will 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*.

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.



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Note: For clarity, multiple variables going to the same OR gate are shown by a single line into the OR gate.

Figure 8-3. 700C-OC79-A-BE (OC with 79) Logic Diagram

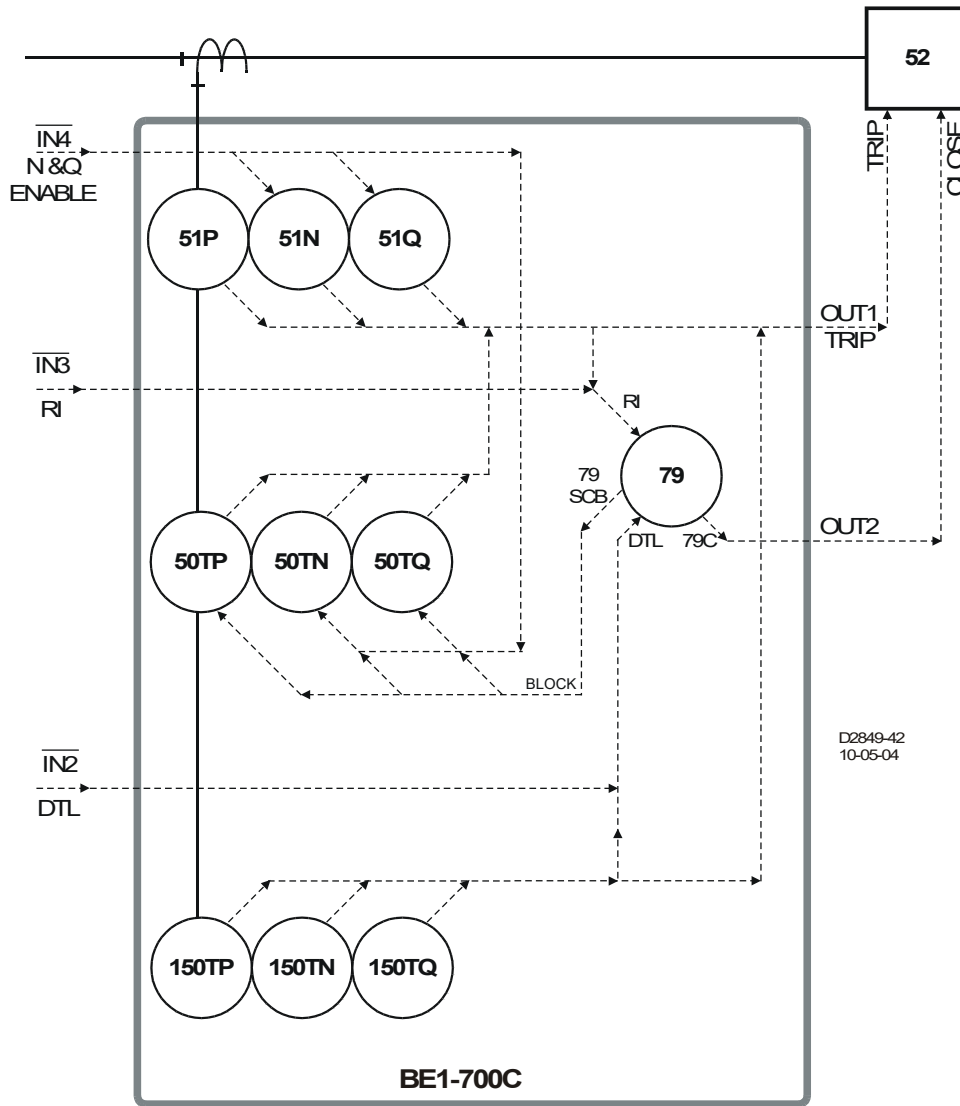


Figure 8-4. 700C-OC79-A-BE (OC with 79) One-Line Drawing

Table 8-6. 700C-OC79-A-BE (OC with 79) Contact Sensing Input Logic

Input	Purpose	Label	State Labels	
			Energized	De-Energized
IN1	52 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

Input	Purpose	Label	State Labels	
			Energized	De-Energized
IN4	When IN4 is energized, neutral, negative- sequence, 50 and 51 protection is enabled. IN4 must be tied HIGH if this feature is not used.	N&Q_ENABLE	Enabled	Disabled

Table 8-7. 700C-OC79-A-BE (OC with 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-ph 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-ph residual)
150TQ	Used for high set	0	1 (enabled)
51P	Used for phase TOC protection	0	1 (enabled)
51N	Used for neutral TOC protection. Disabled when IN4 is low	/IN4	1 (3-ph residual)
51Q	Used for negative-sequence TOC protection. Disabled when IN4 is low	/IN4	1 (enabled)
151N	Not used	0	0 (disabled)
62	Not used	0	0 (disabled)
162	Not used	0	0 (disabled)
79	<i>Reclose Initiate</i> : Initiates reclosing sequence when RI is TRUE.	VO8	1 (Power Up to Lockout)
	<i>Breaker Status Logic</i> : Closed breaker is indicated when IN1 is de-energized.	/IN1	
	<i>Wait Logic</i> : Stop recloser timing when timing for a fault trip. TRUE when protection picked up expression is TRUE.	VO12	
	<i>Block/Drive to Lockout Logic</i> : Drive recloser to lockout when external recloser on/off switch is off.	VO9	
	<i>Pilot Initiate</i> : Initiate one high speed reclose when PI is TRUE	0	
BF	Not used	0	0 (disabled)
GROUP	<i>Input 0 Logic</i> : No manual selection logic is used	0	1 (discrete input selection)
	<i>Input 1 Logic</i> : No manual selection logic is used	0	
	<i>Auto/Manual Logic</i> : Set to 1 (/0) to enable automatic selection. No manual selection is used.	/0	

Table 8-8. 700C-OC79-A-BE (OC with 79) Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				TRUE	FALSE
43	Not used	0 (disabled)	SWITCH_43	Closed	Open
143	Not used	0 (disabled)	SWITCH_143	Closed	Open
101	Not used	0 (disabled)	N/A	N/A	N/A

Table 8-9. 700C-OC79-A-BE (OC with 79) Virtual Output Logic

Output	Purpose	Output Description	Label	State Labels	
				TRUE	FALSE
VOA (OUTA)	Alarm Output Contact	Alarm contact closes automatically when relay trouble alarm occurs.	ALARM	Active	Normal
BESTlogic expression: VOA=0					
VO1 (OUT1)	Breaker Trip Contact	Contact closes when protective trip expression is TRUE.	BKR_TRIP	Trip	Normal
BESTlogic expression: VO1=VO11					
VO2 (OUT2)	Breaker Close Contact	Close breaker when recloser close output is TRUE.	BKR_CLOSE	Closed	Normal
BESTlogic expression: VO2=79C					
VO3 (OUT3)	Not used		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	Not used		VO6	True	False
BESTlogic expression: VO6=0					
VO7	Not used		VO7	True	False
BESTlogic expression: VO7=0					

Output	Purpose	Output Description	Label	State Labels	
				TRUE	FALSE
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	Not used		VO10	True	False
BESTlogic expression: VO10=0					
VO11	Protective Trip Expression	TRUE when any 50, 150 or 51 element has timed out.	PROT_TRIP	Trip	Normal
BESTlogic expression: VO11=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+51NT+51QT					
VO12	Protection Picked Up Expression	TRUE when any 50, 150 or 51 element has picked up.	PROT_PU	PU	Normal
BESTlogic expression: VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+51NPU+51QPU					
VO13	Alarm Mask 21		VO13	True	False
BESTlogic expression: VO13=0					
VO14	Alarm Mask 22		VO14	True	False
BESTlogic expression: VO14=0					
VO15	Alarm Mask 23		VO15	True	False
BESTlogic expression: VO15=0					

Table 8-10. 700C-OC79-A-BE (OC with 79) Logic Settings and Equations

```

SL-N=700C-OC79-A-BE
SL-50TP=1,79SCB;   SL-50TN=1,79SCB+/IN4;   SL-50TQ=1,79SCB+/IN4
SL-150TP=1,0;     SL-150TN=1,0;           SL-150TQ=1,0
SL-51P=1,0
SL-51N=1,/IN4
SL-51Q=1,/IN4
SL-151P=0,0
SL-151N=0,0
SL-62=0,0,0
SL-162=0,0,0
SL-79=1,VO8,/IN1,VO12,VO9,0
SL-BF=0,0,0
SL-GROUP=1,0,0,/0
SL-43=0
SL-143=0
SL-101=0
SL-VOA=0
SL-VO1=VO11
SL-VO2=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

```

700V-OUVF-A-BE (Over/Under V & F Protection) Logic Scheme (BE1-700V)

Voltage protection including volts/hertz; negative-sequence voltage; phase and neutral over and undervoltage; overfrequency, and underfrequency are included in this scheme. This product is an economical choice for voltage only applications such as bus over/undervoltage, underfrequency load shedding, and voltage load shedding and transformer or generator volts/Hz protection.

Figures 8-5 and 8-6 make up the logic drawings representing the logic settings and equations shown in Table 8-15. Figure 8-7 is a one-line drawing. Table 8-15 is part of a setting printout that can be generated from BESTCOMS by using the Print command. These are the actual ASCII commands, settings and equations generated as a result of the selections made through the Windows based BESTCOMS interface program. The user can see the protection and control elements that are enabled (set to Mode 1) for this application and see how the elements are logically wired together (Boolean equations). If the user should decide to build on this scheme, all elements required for a modified application are available in BESTCOMS. For programming details, refer to Section 7, *BESTlogic Programmable Logic*, and Section 14, *BESTCOMS Software*.

Protection Elements

Setting a protection element=s pickup at zero will disable the element. To see which elements are enabled, select the *System Setup Summary Screen* in BESTCOMS, and note the color of the dot associated with each protection element. (Refer to the color legend on the *System Setup Summary*

Screen.) Each protection element in this preprogrammed logic scheme should be yellow or green depending on whether an operational setting has been applied.

To ensure optimum flexibility for voltage and frequency applications, two over/undervoltage elements (59P-159P/27P-127P), one phase sequence check (negative-sequence voltage (47)), six over/under frequency elements (81o/u∓581o/u) and one volts/hertz element (24) are provided.

Integration of Protection, Control and I/O Elements

Table 8-15 includes the logic equations that connect the various elements (electronic wiring) of the voltage protection scheme. Figures 8-5 and 8-6 (sheets 1 & 2) show the logic drawings for the preprogrammed protection scheme. Note that all voltage and frequency trips are connected to VO8 and to VO2 which, in turn, operates Output 2. Input 1 provides breaker position/status to the logic scheme.

Alarms

Three logic variables drive the front panel LEDs: Relay Trouble (ALMREL), Major Alarm (ALMMAJ) and Minor Alarm (ALMMIN). A fourth logic variable, Logic Alarm (ALMLGC), has no associated front panel LED. When the relay self-test detects a problem in the relay (ALMREL) as programmed for the OC & V protection scheme, the Relay Trouble LED lights, Output A operates and all other outputs are disabled. When a major or minor alarm is detected, the associated LED lights. If the user chooses, Output A can also be set to operate for a major or a minor alarm.

Note

Tables 8-11 through Table 8-14 provide detailed logic definitions for the inputs, outputs, protection and control elements. All inputs, logic blocks, and outputs available for use in the preprogrammed logic are described in the following tables.

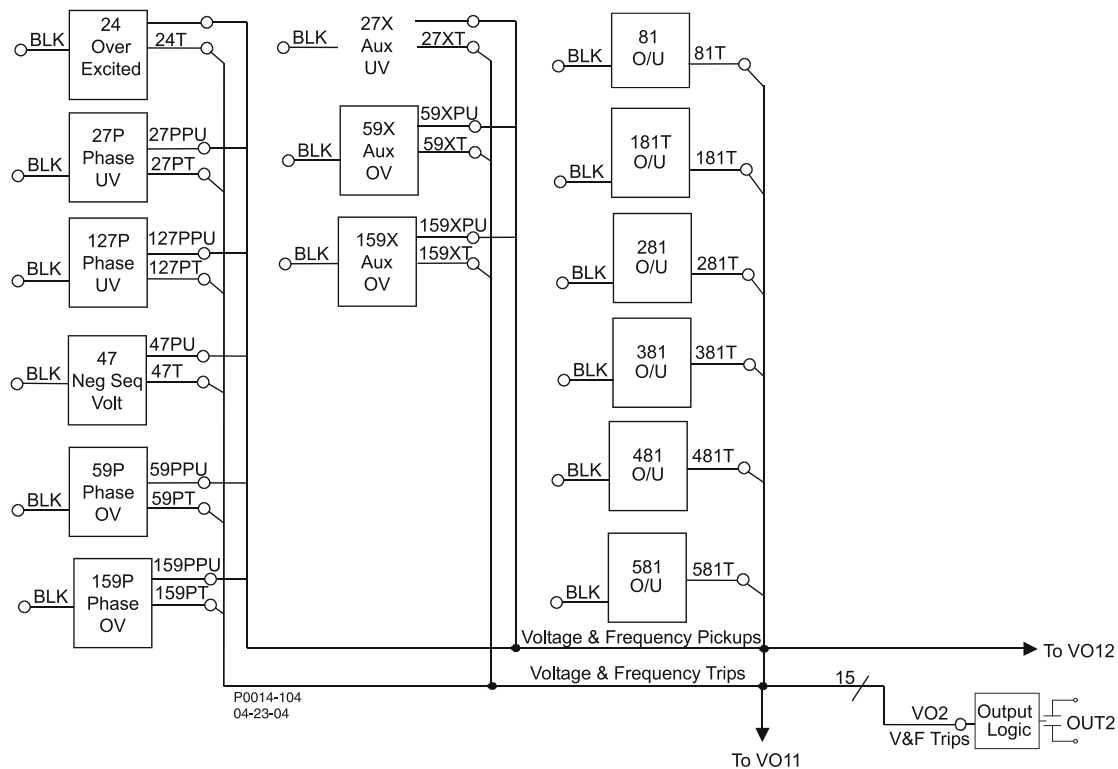


Figure 8-5. 700V-OUVF-A-BE (Over/Under V & F Protection) Logic Diagram (1 of 2)

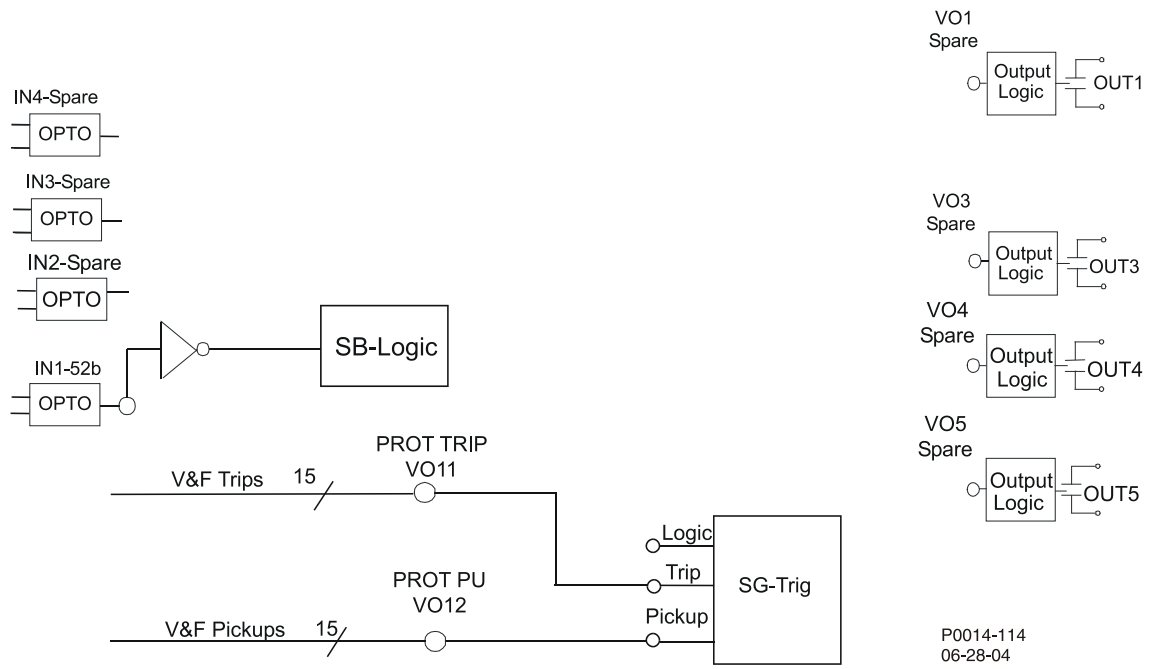
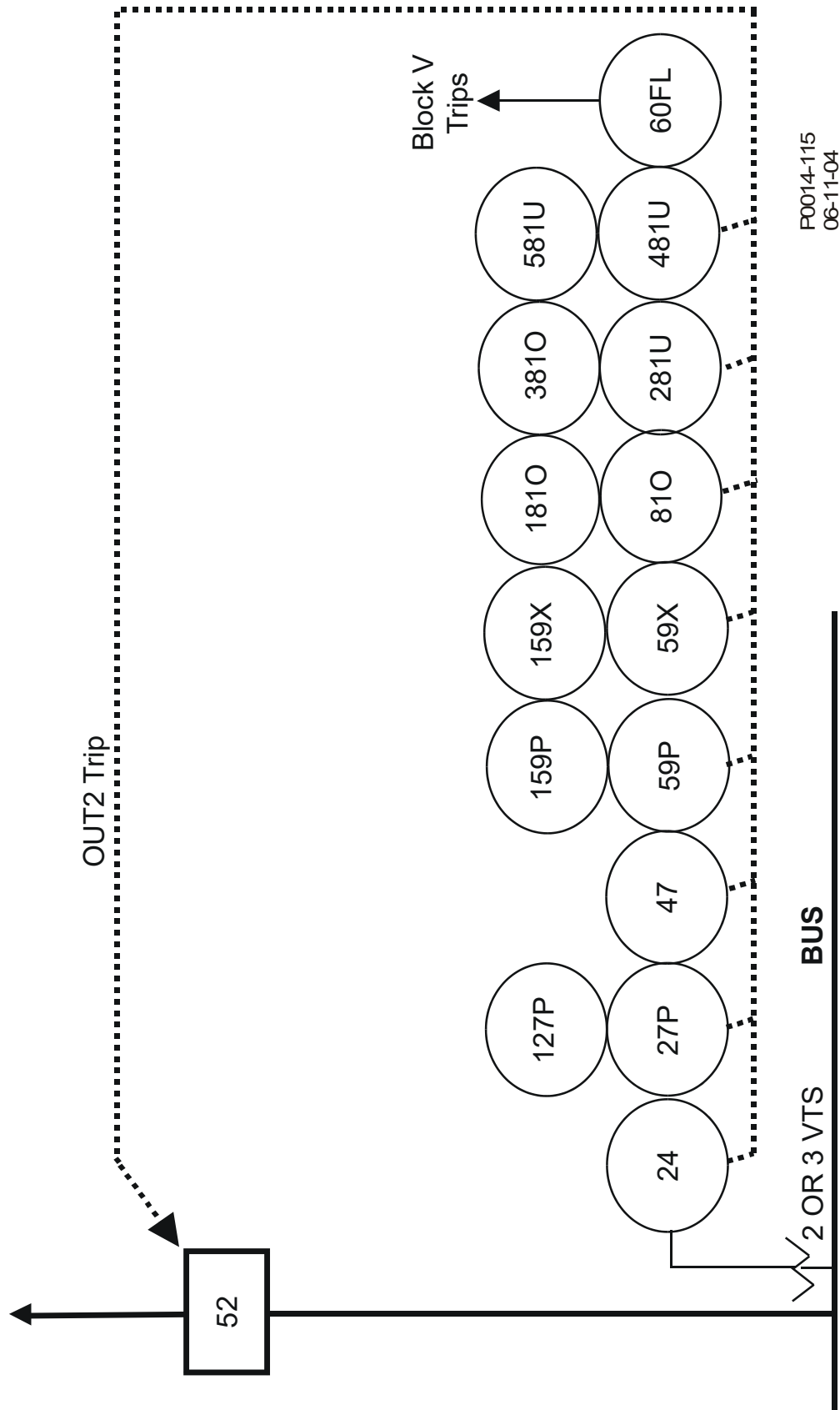


Figure 8-6. 700V-OUVF-A-BE (Over/Under V & F Protection) Logic Diagram (2 of 2)



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Figure 8-7. 700V-OUVF-A-BE (Over/Under V & F Protection) One-Line Drawing

Table 8-11. 700V-OUVF-A-BE (Over/Under V & F Protection) Contact Sensing Input Logic

Input	Purpose	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	Not used	INPUT_2	Closed	Open
IN3	Not used	INPUT_3	Closed	Open
IN4	Not used	INPUT_4	Closed	Open

Table 8-12. 700V-OUVF-A-BE (Over/Under V & F Protection) Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	Used for detection of transformer overexcitation	0	1 (enabled)
27P	Used for phase undervoltage protection Level 1	0	1 (1 of 3)
127P	Used for phase undervoltage protection Level 2	0	1 (1 of 3)
27X	Not used	0	0
47	Used for negative-sequence protection	0	1 (enabled)
59P	Used for phase overvoltage protection Level 1	0	1 (1 of 3)
159P	Used for phase overvoltage protection Level 2	0	1 (1 of 3)
59X	Used for 3Vo voltage detection Level 1	0	2 (3Vo-3 Ph VT input)
159X	Used for 3Vo voltage detection Level 2	0	2 (3Vo-3 Ph VT input)
62/162	Not used	0	0
81	Underfrequency Protection Level 1	0	1 (Phase VT input)
281	Underfrequency Protection Level 1	0	1 (Phase VT input)

Function	Purpose	BESTlogic Expression	Mode Setting
381	Overfrequency Protection Level 2	0	1 (Phase VT input)
481	Overfrequency Protection Level 1	0	1 (Phase VT input)
581	Overfrequency Protection Level 2	0	1 (Phase VT input)
GROUP	<i>Input 0 Logic:</i> No manual selection logic is used	0	1 (discrete input selection)
	<i>Input 1 Logic:</i> No manual selection logic is used	0	
	<i>Auto/Manual Logic:</i> Set to 1 (/0) to enable automatic selection. Manual selection is not used.	/0	

Table 8-13. 700V-OUVF-A-BE (Over/Under V & F Protection) Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				Closed	Open
43	Not used	0 (disabled)	SWITCH_43	Closed	Open
143	Not used	0 (disabled)	SWITCH_143	Closed	Open
101	Not used	0 (disabled)	N/A	N/A	N/A

Table 8-14. 700V-OUVF-A-BE (Over/Under V & F Protection) Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				Closed	Open
VOA (OUTA)	Relay Trouble alarm, Alarm Major, Alarm Minor	OUTA contact closes when Relay Trouble, Major or Minor alarm is TRUE	RELAY_TR	Active	Normal
BESTlogic expression: VOA= ALMMAJ+ALMMIN					
VO1 (OUT1)	Not used		VO1	True	False
BESTlogic expression: VO1=0					
VO2 (OUT2)	Breaker Trip Contact initiated by Voltage and Frequency Trips	OUT2 contact closes if any voltage (24, 27P, 127P, 27X, 47, 59P, 159P, 59X, 159X) or frequency (81∇581) trip is TRUE.	V&F_BKR_TR	Trip	Normal

Output	Purpose	Description	Label	State Labels	
				Closed	Open
BESTlogic expression: VO2=24T+27PT+127PT+27XT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T					
VO3 (OUT3)	Not used		VO3	True	False
BESTlogic expression: VO3=0					
VO4 (OUT4)	Not used		VO4	True	False
BESTlogic expression: VO4=0					
VO5 (OUT5)	Not used		VO5	True	False
BESTlogic expression: VO5=0					
VO6	Not used		VO6	True	False
BESTlogic expression: VO6=0					
VO7	Not used		VO7	Trip	Normal
BESTlogic expression: VO7=0					
VO8	Not used		VO8	True	False
BESTlogic expression: VO8=0					
VO9	Not used		VO9	True	False
BESTlogic expression: VO9=0					
VO10	Not used		VO10	True	False
BESTlogic expression: VO10=0					
VO11	Protective trip expression	VO11 is TRUE when any OC&P or V&F protection element trips	PROT_TRIP	Trip	Normal
BESTlogic expression: VO11=24T+27XT+27PT+127PT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T					
VO12	Protective pickup expression	VO12 is TRUE when any protection element picks up	PROT_PU	PU	Normal
BESTlogic expression: VO12=24PPU+27XPU+27PPU+127PPU+47PU+59PPU+159PPU+59XPU+159XPU+81T+181T+281T+381T+481T+581T					
VO13	Alarm Mask 21		VO13	True	False

Output	Purpose	Description	Label	State Labels	
				Closed	Open
BESTlogic expression: VO13=0					
VO14	Alarm Mask 22		VO14	True	False
BESTlogic expression: VO14=0					
VO15	Alarm Mask 23		VO15	True	False
BESTlogic expression: VO15=0					

Table 8-15. 700V-OUVF-A-BE (Over/Under V & F Protection) Logic Settings and Equations

SL-N=700V-OUVF-A-BE
 SL-24=1,0
 SL-27P=1,0; SL-127P=1,0
 SL-27X=0,0
 SL-47=1,0
 SL-59P=1,0; SL-159P=1,0
 SL-59X=2,0; SL-159X=2,0
 SL-81=1,0
 SL-181=1,0
 SL-281=1,0
 SL-381=1,0
 SL-481=1,0
 SL-581=1,0
 SL-62=0,0,0
 SL-162=0,0,0
 SL-GROUP=1,0,0,/0
 SL-43=0
 SL-143=0
 SL-101=0
 SL-VOA=ALMMAJ+ALMMIN
 SL-VO1=0
 SL-VO2=24T+27PT+127PT+27XT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T
 SL-VO3=0
 SL-VO4=0
 SL-VO5=0
 SL-VO6=0
 SL-VO7=0
 SL-VO8=0
 SL-VO9=0
 SL-VO10=0
 SL-VO11=24T+27PT+127PT+27XT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T
 SL-VO12=24PU+27PPU+127PPU+27XPU+47PU+59PPU+159PPU+59XPU+159XPU+81T+181T+281T+381T+481T+581T
 SL-VO13=0
 SL-VO14=0
 SL-VO15=0

700V-VF79-A-BE (Voltage Protection with Reclosing) Logic Scheme (BE1-700V)

Voltage protection including volts/hertz, negative-sequence voltage, phase and neutral over/undervoltage, and over/underfrequency are also included. Network and dead line reclosing (25 and 25VM) with a four shot automatic recloser, including a separate pilot and time delay reclose initiate round out the application.

Figures 8-8 and 8-9 make up the logic drawings representing the logic settings and equations shown in Table 8-20. Figure 8-10 is a one-line drawing. Table 8-20 is part of a setting printout that can be generated from BESTCOMS by using the Print command. These are the actual ASCII commands, settings and equations generated as a result of the selections made through the Windows based BESTCOMS interface program. The user can see the protection and control elements that are enabled (set to mode 1) for this application and see how the elements are logically wired together (Boolean equations). If the user should decide to build on this scheme, all elements required for a modified application are available in BESTCOMS. For programming details, refer to Section 7, *BESTlogic Programmable Logic* and Section 14, *BESTCOMS*.

Protection Elements

Setting a protection element=s pickup at zero will disable the element. To see which elements are enabled, select the *System Setup Summary Screen* in BESTCOMS and note the color of the dot associated with each protection element. (Refer to the color legend on the *System Setup Summary Screen*.) Each protection element in this preprogrammed logic scheme should be yellow or green depending on whether an operational setting has been applied.

To ensure that voltage and frequency at the bus are maintained within the limits, two over/undervoltage elements (59P-159P/27P-127P), one phase sequence check (negative-sequence voltage (47)), six over/underfrequency elements (81o/u...581o/u) and one volts/hertz element (24) are provided.

Dead Line Reclosing (Conditional Voltage Reclose)

With a source of generation on the feeder, provision for up to four dead line (conditional voltage) recloses are provided in this logic scheme. With the reclose fail time set to zero, the Reclose Output (79C) is held indefinitely and Output 3 (Out3) effectively becomes a dead line reclosing contact. A sync-check element is included in this scheme for network applications requiring angle comparison between two voltages (either side of an open breaker) before allowing the breaker to reclose. The logic settings in Table 8-20 include the logic equations that connect the various elements (electronic wiring) of the of the VF protection scheme. Figures 8-8 and 8-9 shows the logic drawings for the preprogrammed VF protection scheme. Note that all voltage and frequency trips are connected to VO2 which, in turn, operates Output 2. Output 3 is used for automatic reclosing of the circuit breaker.

Input 3 is used for external initiate of reclosing; Input 2 is connected to an external reclosing on/off switch defeating automatic reclosing when in the OFF position. And Input 1 provides breaker position/status to the logic scheme.

Alarms

Three logic variables drive the front panel LEDs: Relay Trouble (ALMREL), Major Alarm (ALMMAJ) and Minor Alarm (ALMMIN). A fourth logic variable, Logic Alarm (ALMLGC), has no associated front panel LED. When the relay self-test detects a problem in the relay (ALMREL) as programmed for the OC & V protection scheme, the Relay Trouble LED lights, Output A operates and all other outputs are disabled. When a major or minor alarm is detected, the associated LED lights. If the user chooses, Output A can also be set to operate for a major or a minor alarm.

Note

Tables 8-16 through Table 8-19 provide detailed logic definitions for the inputs, outputs, protection and control elements. All inputs, logic blocks, and outputs available for use in the preprogrammed logic are described in the following tables.

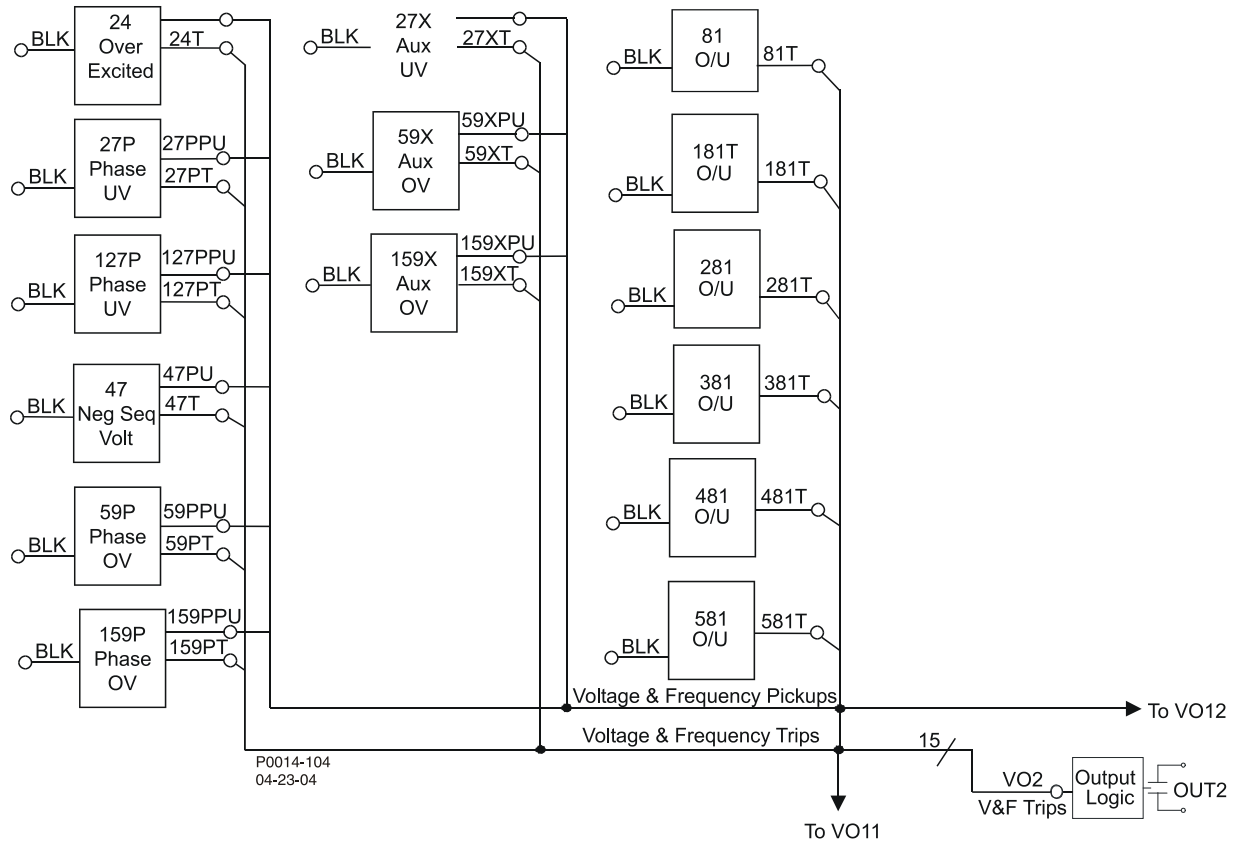
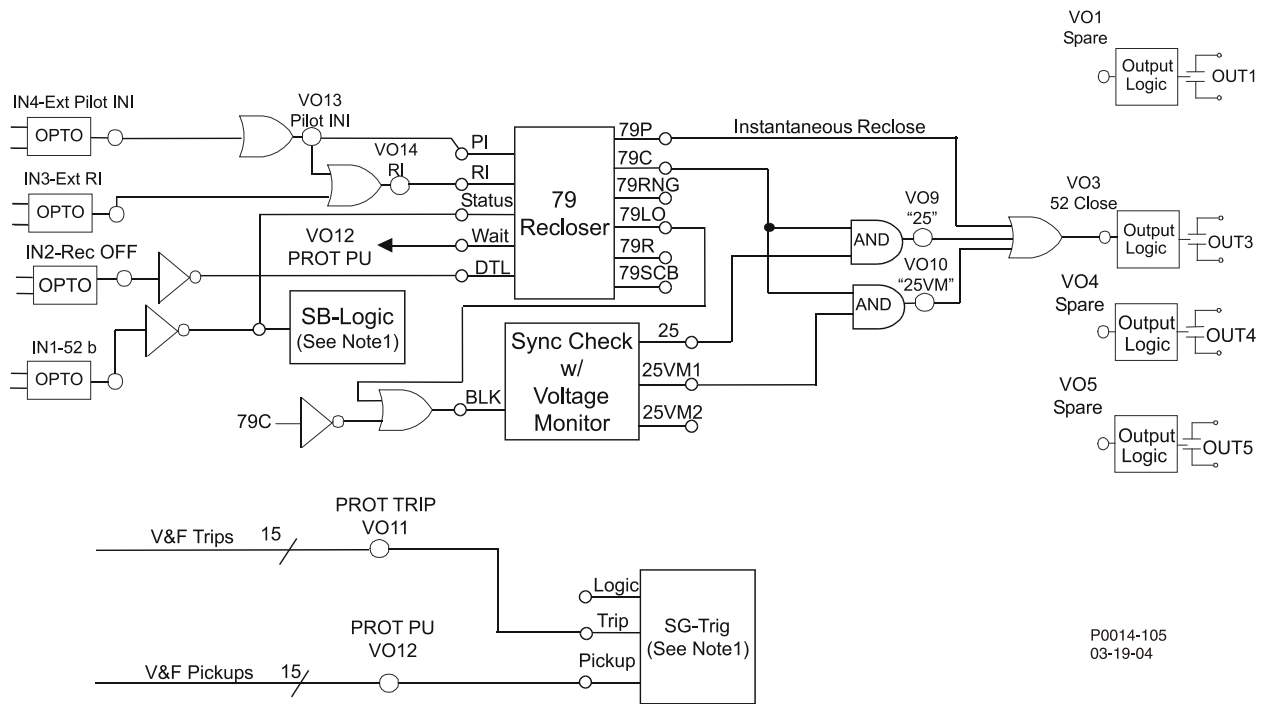
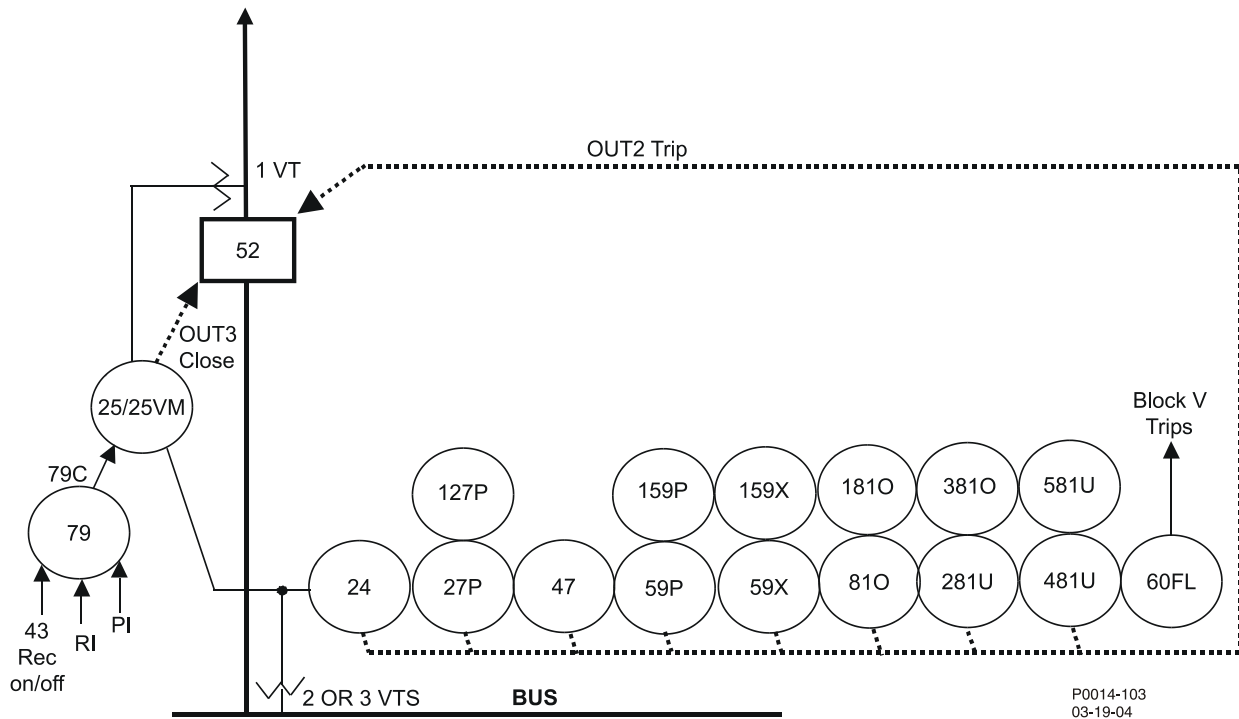


Figure 8-8. 700V-VF79-A-BE (V & F Protection with Reclosing) Logic Diagram (1 of 2)



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Figure 8-9. 700V-VF79-A-BE (V & F Protection with Reclosing) Logic Diagram (2 of 2)



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Figure 8-10. 700V-VF79-A-BE (V & F Protection with Reclosing) One-Line Drawing

Table 8-16. 700V-VF79-A-BE (V & F Protection with Reclosing) Contact Sensing Input Logic

Input	Purpose	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	External high speed (pilot) reclose initiate. TRUE when PI is high.	EXT_PI	ACTIVE	NORMAL

Table 8-17. 700V-VF79-A-BE (V & F Protection with Reclosing) Function Block Logic

Function	Purpose	BESTlogic Expression	Mode Setting
24	Used for detection of transformer overexcitation	0	1 (enabled)
25 (25VM)	Blocked when 79C is FALSE (/79C) or when 79LO is TRUE. Set 25VM Hot Bus-Dead Line	/79C+79LO	1 (enabled)
27P	Used for phase undervoltage protection Level 1	0	1 (1 of 3)
127P	Used for phase undervoltage protection Level 2	0	1 (1 of 3)
27X	Not used	0	0
47	Used for negative-sequence voltage protection	0	1 (enabled)
59P	Used for phase overvoltage protection Level 1	0	1 (1 of 3)
159P	Used for phase overvoltage protection Level 2	0	1 (1 of 3)
59X	Used for 3Vo voltage detection Level 1	0	2 (3V0-3Ph VT Input)
159X	Used for 3Vo voltage detection Level 2	0	2 (3V0-3Ph VT Input)
62/162	Not used	0	0

Function	Purpose	BESTlogic Expression	Mode Setting
79	<p>Reclose Initiate: Initiates reclosing sequence when RI is TRUE.</p> <p>Breaker Status Logic: Closed breaker is indicated when IN1 is de-energized.</p> <p>Wait Logic: Stop recloser timing when timing for a fault trip. TRUE when protection picked up expression is TRUE.</p> <p>Block/Drive to Lockout Logic: Drive recloser to lockout when external recloser on/off switch is off.</p> <p>Pilot Initiate: Initiate one high speed reclose when PI is TRUE</p>	<p>VO14</p> <p>/IN1</p> <p>VO12</p> <p>/IN2</p> <p>VO13</p>	<p>1</p> <p>(Power Up to Lockout)</p>
81	Underfrequency Protection Level 1	0	<p>1</p> <p>(Phase VT Input)</p>
281	Underfrequency Protection Level 1	0	<p>1</p> <p>(Phase VT Input)</p>
381	Overfrequency Protection Level 2	0	<p>1</p> <p>(Phase VT Input)</p>
481	Overfrequency Protection Level 1	0	<p>1</p> <p>(Phase VT Input)</p>
581	Overfrequency Protection Level 2	0	<p>1</p> <p>(Phase VT Input)</p>

Table 8-18. 700V-VF79-A-BE (V & F Protection with Reclosing) Virtual Switch Logic

Switch	Purpose	Mode	Label	State Labels	
				Closed	Open
43	Not used	0 (disabled)	SWITCH_43	Closed	Open
143	Not used	0 (disabled)	SWITCH_43	Closed	Open
243	Not used	0 (disabled)	SWITCH_43	Closed	Open

Table 8-19. 700V-VF79-A-BE (V & F Protection with Reclosing) Virtual Output Logic

Output	Purpose	Description	Label	State Labels	
				Closed	Open
VOA (OUTA)	Relay Trouble alarm, Alarm Major, Alarm Minor	OUTA contact closes when Relay Trouble, Major or Minor alarm is TRUE	RELAY_TR	Active	Normal
BESTlogic expression: VOA= ALMMAJ+ALMMIN					
VO1 (OUT1)	Not used		VO1	True	False
BESTlogic expression: VO1=0					
VO1 (OUT1)	Not used		VO1	True	False
BESTlogic expression: VO1=0					
VO2 (OUT2)	Breaker Trip Contact initiated by Voltage and Frequency Trips	OUT2 contact closes if any voltage (24, 27P, 127P, 27X, 47, 59P, 159P, 59X, 159X) or frequency (81∓581) trip is TRUE.	V&F_BKR_ TR	Trip	Normal
BESTlogic expression: VO2=VO8					
VO3 (OUT3)	Breaker Reclosing	OUT3 contact closes when VO9 (25) or VO10 (25VM1) is TRUE	BKR_CLOSE	Close	Normal
BESTlogic expression: VO3=79P+VO9+VO10					
VO4 (OUT4)	Not used		VO4	True	False
BESTlogic expression: VO4=0					
VO6	Not used		VO6	True	False
BESTlogic expression: VO6=0					
VO7	Not used		VO7	True	False
BESTlogic expression: VO7=0					
VO8	Not used		VO8	True	False
BESTlogic expression: VO8=0					

Output	Purpose	Description	Label	State Labels	
				Closed	Open
VO9	Sync-Check Close	79C is TRUE and 25 is TRUE	SYNC_ CLOSE	Close	Normal
BESTlogic expression: VO9=79C*25					
VO10	Conditional Voltage Close	79C is TRUE and 25VM1 is TRUE	VOLT_ CLOSE	Close	Normal
BESTlogic expression: VO10=79C*25VM1					
VO11	Protective trip expression	VO11 is TRUE when any OC&P or V&F protection element trips	PROT_TRIP	Trip	Normal
BESTlogic expression: VO11=24T+27XT+27PT+127PT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T					
VO12	Protective pickup expression	VO12 is TRUE when any protection element picks up	PROT_PU	PU	Normal
BESTlogic expression: VO12=24PPU+27XPU+27PPU+127PPU+47PU+59PPU+159PPU+59XPU +159XPU +81T +181T +281T+381T+481T+581T					
VO13	Pilot Reclose Initiate	VO13 is TRUE when IN1, is TRUE	PILOT_INI	INI	Normal
BESTlogic expression: VO13=IN1					
VO14	Reclose Initiate	VO14 is TRUE when IN3 or VO13 is TRUE	REC_INI	INI	Normal
BESTlogic expression: VO14=IN3+VO13					
VO15	Alarm Mask 21		VO15	True	False
BESTlogic expression: VO15=0					

Table 8-20. 700V-VF79-A-BE (V & F Protection with Reclosing) Logic Settings and Equations

SL-N=700V-VF79-A-BE

SL-24=1,0

SL-25=1,79C+79LO

SL-27P=1,0;

SL-127P=1,0

SL-27X=0,0

SL-47=1,0

SL-59P=1,0;

SL-159P=1,0

SL-59X=2,0;

SL-159X=2,0

SL-81=1,0

SL-181=1,0

SL-281=1,0

SL-381=1,0

SL-481=1,0
 SL-581=1,0
 SL-62=0,0,0
 SL-162=0,0,0
 SL-79=1,VO14,/IN1,VO12,/IN2,VO13
 SL-GROUP=1,0,0,/0
 SL-43=0
 SL-143=0
 SL-101=0
 SL-VOA=ALMMAJ+ALMMIN
 SL-VO1=0
 SL-VO2=24T+27PT+127PT+27XT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T
 SL-VO3=79P+VO9+VO10
 SL-VO4=0
 SL-VO5=0
 SL-VO6=0
 SL-VO7=0
 SL-VO8=0
 SL-VO9=79C*25
 SL-VO10=79C*25VM1
 SL-VO11=24T+27PT+127PT+27XT+47T+59PT+159PT+59XT+159XT+81T+181T+281T+381T+481T+581T
 SLVO12=24PU+27PPU+127PPU+27XPU+47PU+59PPU+159PPU+59XPU+159XPU+81T+181T+281T+381T+481T+581T
 SL-VO13=IN4
 SL-VO14=IN3+VO13
 SL-VO15=0

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 8-21 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 8-21. Miscellaneous Logic Expressions

Command	Reference
SA-RESET	Section 6, <i>Reporting and Alarm Functions, Alarms Function</i>
SB-DUTY	Section 6, <i>Reporting and Alarm Functions, Breaker Monitoring</i>
SB-LOGIC	Section 6, <i>Reporting and Alarm Functions, Breaker Monitoring</i>
SG-TARG	Section 6, <i>Reporting and Alarm Functions, Fault Reporting</i>
SG-TRIGGER	Section 6, <i>Reporting and Alarm Functions, Fault Reporting</i>
SP-79ZONE	Section 4, <i>Protection and Control</i>

Application Tips

Output Contact Latch Using the TRSTKEY Logic Variable

On occasion, an application will call for latching an output contact such as simulating a lockout (86) function. Each output contact of a Basler Electric relay can be set to latch by using an AND gate to seal the trip condition and the TRSTKEY logic variable to reset the latch.

As an example, assume a BE1-700 is used for overcurrent protection of a radial transformer shown in Figure 8-11, *Station One-line Drawing*. The user wants to trip and lockout the high side circuit switcher for an overcurrent trip.

Referring to Figure 8-12, a 51 or 151 trip will cause VO11 to go high. This in turn causes VO14 to go high, sealing the inputs of VO3 and VO4 through AND gate VO7. This allows Output Contacts 3 and 4 to transition and remain in that state until the TRSTKEY variable is asserted. In this example, the circuit switcher will be tripped by Output 3 (simulating an 86 “a”) and its close circuit disabled by Output 4 (simulating an 86 “b”). The HMI LCD display automatically goes to the *Target* Screen per the automatic display priority function. When the operator presses the *Reset* key while the LCD display is on the *Target* Screen (*Reset* key of the HMI is context sensitive), the TRSTKEY logic variable goes high breaking the VO7 seal in at which point Output 3 will open and Output 4 will close. Refer to Section 6, *Reporting and Alarm Functions, Fault Reporting*.

The data in Table 8-22 include the logic settings and equations for the ARSTKEY and TRSTKEY functions.

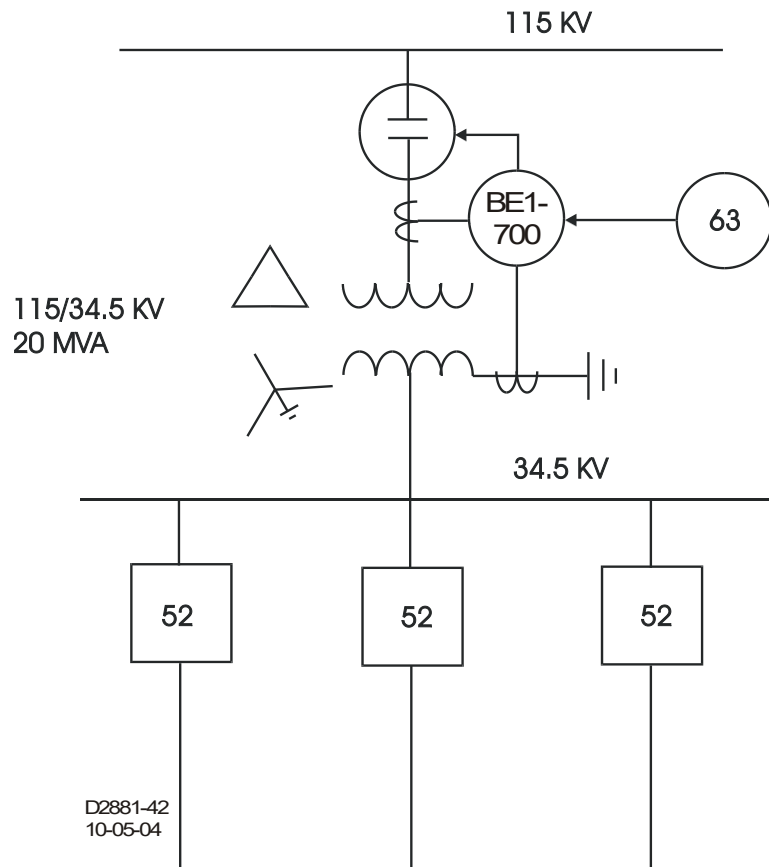


Figure 8-11. Station One-Line Drawing

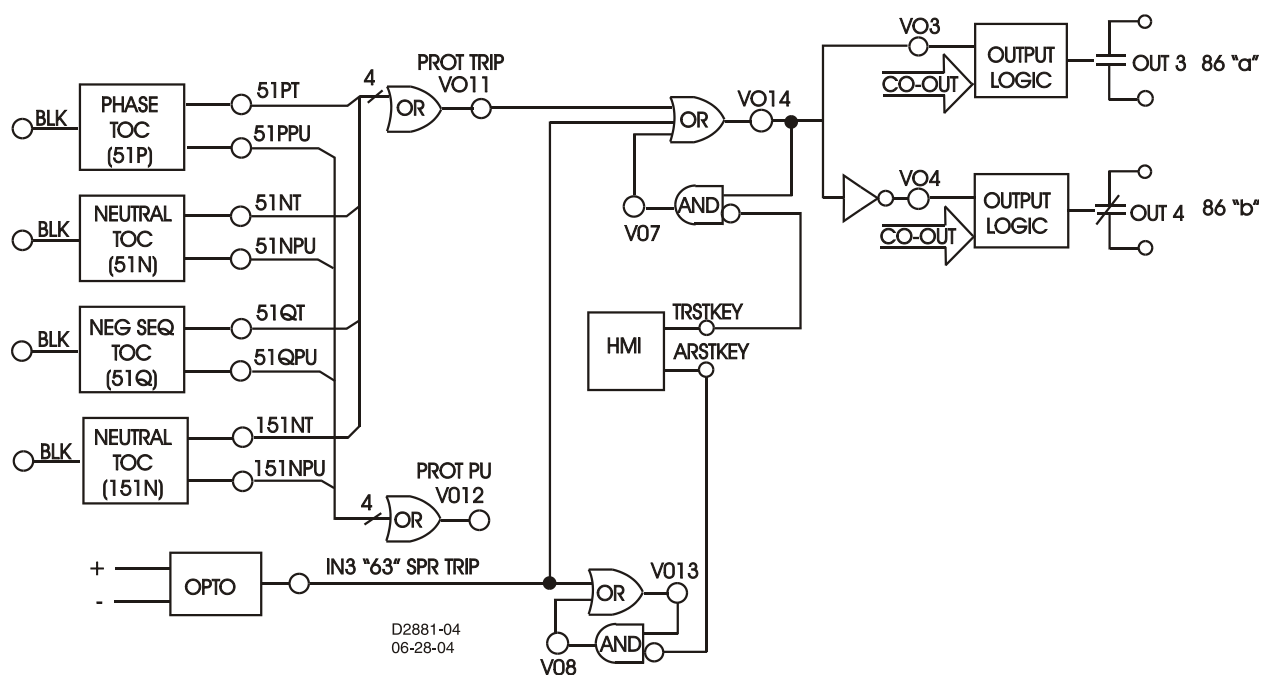


Figure 8-12. BE1-700C Transformer Protection Output Latch, ARSTKEY and TRSTKEY

Table 8-22. ARSTKEY and TRSTKEY Logic Settings and Equations

SL-N=LATCH
 SL-50TP=0,0; SL-50TN=0,0; SL-50TQ=0,0
 SL-150TP=0,0; SL-150TN=0,0; SL-150TQ=0,0
 SL-51P=1,0
 SL-51N=1,0
 SL-51Q=1,0
 SL-151N=G,0
 SL-27P=0,0
 SL-59P=0,0; SL-59X=0,0
 SL-47=0,0
 SL-62=0,0,0
 SL-162=0,0,0
 SL-79=0,0,0,0,0
 SL-81=0,0
 SL-181=0,0
 SL-281=0,0
 SL-381=0,0
 SL-481=0,0
 SL-581=0,0
 SL-BF=0,0,0
 SL-GROUP=0,0,0,0,0,0
 SL-43=0
 SL-143=0
 SL-243=0
 SL-343=0
 SL-101=0
 SL-VOA=0
 SL-VO1=0
 SL-VO2=0
 SL-VO3=VO14
 SL-VO4=/VO14
 SL-VO5=0
 SL-VO6=0

```
SL-VO7=VO14*/TRSTKEY
SL-VO8=VO13*/ARSTKEY
SL-VO9=0
SL-VO10=0
SL-VO11=51PT+51NT+51QT+151NT
SL-VO12=51PPU+51NPU+51QPU+151NPU
SL-VO13=IN3+VO8
SL-VO14=VO11+V07
SL-VO15=0
```

Alarm Latch and Pseudo Target Using the ARSTKEY Logic Variable

On occasion, the user may want the relay to annunciate and latch for a user-defined condition originating internal or external to the relay. This is accomplished by using an AND gate to latch the condition through one of the relay's user defined alarms and the ARSTKEY logic variable to reset the latch. Virtual Outputs VO13, VO14, and VO15 can be programmed to alarm for any BESTlogic expression. Also, they can be assigned a user defined label up to a maximum of 10 characters that will be reported in the alarm reporting function and appear on the relay's HMI. In the following example, the user-defined alarm condition is defined as a pseudo target for an external trip function. Refer to the Section 6, *Reporting and Alarm Functions*.

Using the same transformer protection application as in the previous example, the user wants to trip and lockout the high side circuit switcher for a Sudden Pressure Relay trip. The user also wants a sealed annunciation on the HMI that reads "SPR_TRIP."

Referring to Figure 8-12, when the external sudden pressure relay trip contact connected to Input 3 closes, VO13 goes high, sealing the inputs of VO3 and VO4 through AND gate VO8. This allows Output Contacts 3 and 4 to transition and remain in that state until the ARSTKEY variable is asserted. The HMI LCD display automatically goes to the *Alarm* Screen if VO13 is programmed as a major or minor alarm per the automatic display priority function. In this example, VO13 is programmed to be SN-VO13=SPR_TRIP and will display as such on the HMI when an SPR trip occurs. The trip and alarm (pseudo target) latch will remain until the *Reset* button on the front panel of the relay is pressed while the *Alarm* Screen of the HMI, Menu Branch 1.3 is being displayed (*Reset* key of the HMI is context sensitive). Refer to Section 6, *Reporting and Alarms Functions, Retrieving and Resetting Alarm Reports*, for details.

Underfrequency Load Shedding with Restoration Permissive (BE1-700V)

Underfrequency load shedding schemes are designed to operate when the load of a power region outpaces generation and begins to "drag" or slow system frequency. (See Figure 8-13.) 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 underfrequency 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.

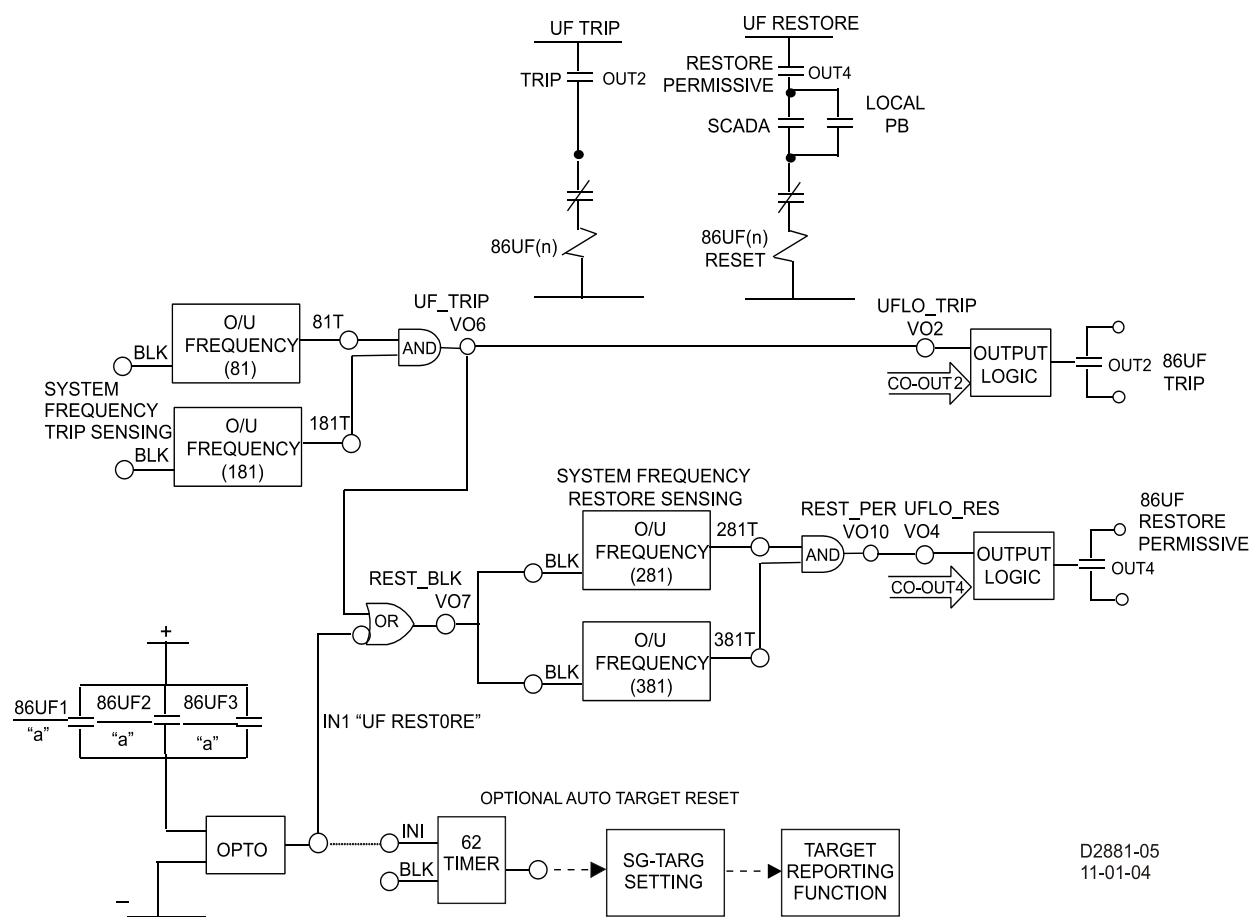


Figure 8-13. Underfrequency Load Shed Bus Level Application

Historically, underfrequency load shedding schemes have been applied at the bus level. With the introduction of numeric, multifunction feeder protection relays, it has become more economical to apply underfrequency load shedding at the circuit level. Also, reliability increases as the user is no longer depending on a single relay to sense the underfrequency condition. If the BE1-700V is not available on every circuit or user philosophy requires a bus level installation, the BE1-700V can also be applied for bus level underfrequency protection.

The BE1-700V also has an optional auxiliary voltage input that can be selected for the underfrequency function. This allows the user to supply one underfrequency 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 underfrequency 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 a circuit level underfrequency load shed scheme and restoration “permissive” using dual source sensing and the programming capabilities of the BE1-700V. (Single source sensing can also be used.) These schemes are easily customized to meet the user’s specific requirements.

Bus Level Application

The following logic was designed to work with the preprogrammed BUS Logic Scheme described elsewhere in this section.

Referring to Figure 8-14, 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 underfrequency event has subsided, the system operator/dispatcher will initiate a remote restoration procedure. A “restoration permissive” from the BE1-700 verifies that the following conditions are met prior to restoring load:

- The underfrequency trip (81 and 181T) is no longer present.
- The 86UF(s) is/are tripped.
- Sensing voltage is above the predetermined inhibit level.
- System frequency is above the predetermined restore level (281 and 381T)

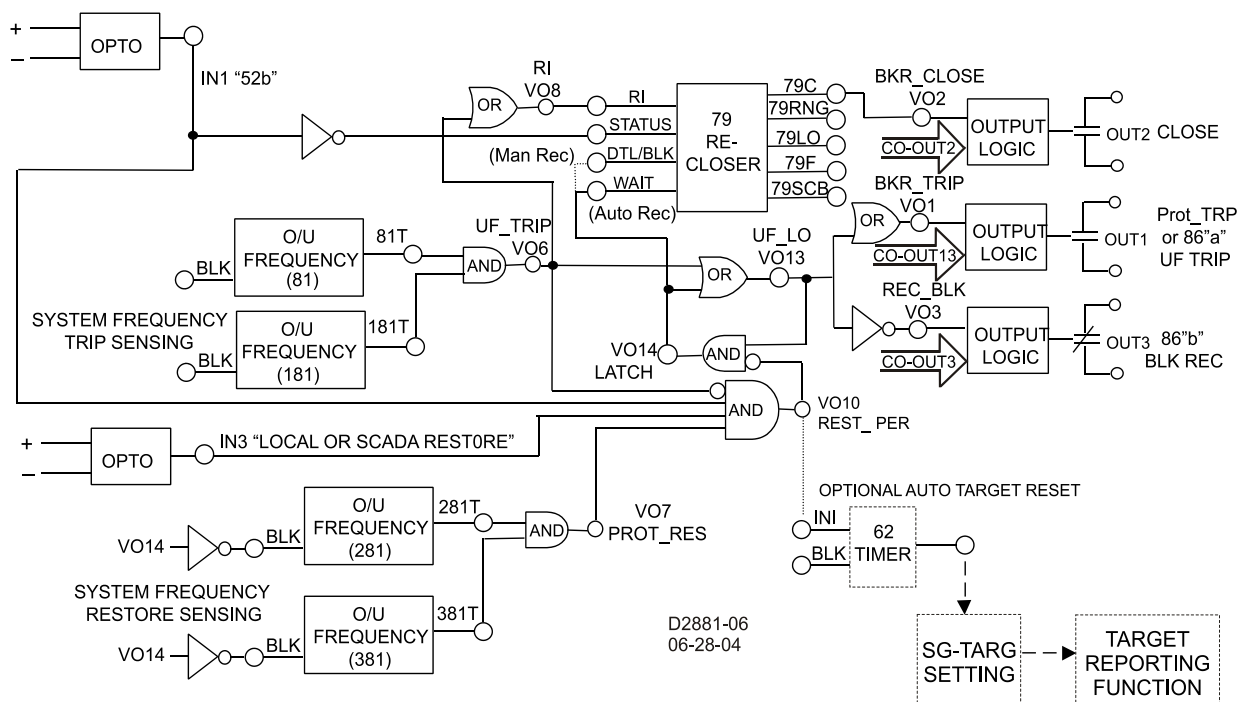


Figure 8-14. Underfrequency Load Shed, Circuit Level Application, Manual or Auto Close from SCADA or Local Restore

The first two conditions must be met to remove REST_BLK from the 281 and 381T overfrequency elements. Then, with sensing voltage above the inhibit setting of 281 and 381T and the system frequency above the 281 and 381T setting, VO10 (REST_PER) will go high forcing VO4, UFLO_RES high, closing Output Contact 4. As long as these conditions remain unchanged the Output Contact 4 will remain closed. When the last 86UF (electrical reset lockout relay) is reset, Input 1, UF_RESTORE will go low, blocking the 281 and 381T elements. Also, VO4 will go low, opening Output Contact 4, removing the 86UF Restore Permissive. The last 86UF to reset can initiate an optional auto target reset circuit, thus eliminating the need for further operator input. A one-shot, non-retriggerable timer (62) initiated by the last lockout to reset (Input 1), is used to automatically reset the BE1-700V targets and Trip LED via logic input to the Target Reset Logic. See Figure 6-14, *Target Reset Logic*, Section 6, *Reporting and Alarm Functions*.

Circuit Level Application - Manual and Auto Reclosing

The following logic was designed to work with the preprogrammed logic for the BE1-700V.

For the Bus Application, load restoration was accomplished by resetting the lockout relays (86UFs) and allowing the circuit reclosing relays to close the breaker and restore load. Using the Circuit Level Application, restoration can be accomplished by an automatic or manual closure of the breaker. Both methods are described in the following paragraphs.

Referring to Figure 8-14, if sensing voltage is above the inhibit setting of the underfrequency elements 81 and 181T and system frequency is below the 81 and 181T setting, VO6, UF_TRIP goes high. This initiates the auto reclose sequence through VO8, RI and forces VO13 (UF_LO) high, closing and sealing the inputs to VO1 and VO3 through AND gate VO14 (LATCH). This allows the contacts of Output 3 and Output 4 to transition and remain in that state, simulating Aa and Ab contacts of an electrical reset lockout relay (86). The VO14 seal also removes the block input from the 281 and 381T overfrequency

elements and either drives the 79 element to lockout (manual close) or puts a “wait” on 79 (auto close). The associated breaker will be tripped by Output 1 and the close circuit is disabled by Output 3.

When the load condition that initiated the event has subsided, the system operator/dispatcher will initiate a remote restoration procedure. A restoration permissive[®] from the BE1-700 verifies that the following conditions are met prior to allowing closure of the breaker:

- Underfrequency trip, 81T and 181T are no longer present.
- System frequency and voltage above the predetermined restore level (281 and 381T).
- The breaker is open.
- The VO14 latch circuit is high.

With VO7, PROT_RES high and the above conditions met, closure of the SCADA Restore contact forces VO10, REST_PER high, breaking the VO13/VO14 seal and resetting Output Contacts 1 and 3. If automatic reclosing is used, the “WAIT” input is removed and the reclosing element (79) closes the breaker after a predetermined time delay. If manual reclosing is used, the “DTL/BLK” input is removed and the breaker is ready to close SCADA or local close.

As with the Bus Level Application, an optional “auto target reset circuit” can be initiated, automatically resetting the BE1-700 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 BE1-700 targets and Trip LED via “logic” input to the Target Reset Logic. See Figure 6-11, *Target Reset Logic*, Section 6, *Reporting and Alarms, Fault Reporting*.

Logic Equations and Settings, Underfrequency Load Shedding

Bus UF Load Shed

The following is an example of how to apply UF Load Shed logic at the Bus level. The logic can be applied in any number of ways including stand alone, to other preprogrammed schemes or completely customized by the user. Using BESTCOMS to modify and add to the logic is not only quick and easy but minimizes Input/Output “name” and “state” label changes. In this example, start with a renamed version of the BESTCOMS BUS logic scheme modified as follows:

```
SL-101=0
SL-V01=VO11*SG0
SN-IN1=UF-RESTORE,CLOSE,OPEN
```

Add the following **UF** logic to the modified BUS Logic Scheme:

```
SL-62=2, /IN1,0 (optional target reset)
SL-081=1,O
SL-181=1,O
SL-281=1,VO7
SL-381=1,VO7
SL-VO2=VO6
SL-VO4=VO10
SL-VO6=81T*181T
SL-VO7=VO6+/IN1
SL-VO10=281T*381T
```

Add +81T+181T to BUS SG-TRIG. Replace the ,0 with ,62 at the end of BUS SG-TARG. The resulting BUS-UF setting logic is as follows:

```
SL-50TP=1,IN2; SL-50TN=1,IN2; SL-50TQ=1,IN2
SL-150TP=0,0; SL-150TN=0,0; SL-150TQ=0,0
SL-51P=1,0
```

```

SL-51N=1,0
SL-51Q=1,0
SL-151N=0,0
SL-27P=0,0
SL-59P=0,0; SL-59X=0,0
SL-47=0,0
SL-62=2,/IN1,0
SL-162=0,0,0
SL-79=0,0,0,0,0
SL-81=1,0
SL-181=1,0
SL-281=1,VO7
SL-381=1,VO7
SL-481=0,0
SL-581=0,0
SL-BF=0,0,0
SL-GROUP=2,IN3,0,0,0,0
SL-43=0
SL-143=0
SL-101=0
SL-VOA=0
SL-VO1=VO11*SG0
SL-VO2=VO6
SL-VO3=VO8*/VO15*SG0
SL-VO4=VO10
SL-VO5=VO11*SG1
SL-VO6=81T*181T
SL-VO7=VO6+/IN1
SL-VO8=51PT+51NT+51QT
SL-VO9=50TPT+50TNT+50TQT
SL-VO10=281T*381T
SL-VO11=50TPT+50TNT+50TQT+51PT+51NT+51QT
SL-VO12=50TPPU+50TNPU+50TQPU+51PPU+51NPU+51QPU
SL-VO13=SG1
SL-VO14=0
SL-VO15=343+/IN4

```

Circuit UF Load Shed

The following is an example of how to apply UF Load Shed logic at the circuit or feeder level. The logic can be applied in any number of ways including stand alone, to other preprogrammed schemes, or completely customized by the user. Using BESTCOMS to modify and add to the logic is, not only quick and easy but minimizes Input/Output “name” and “state” label changes. In this example, start with a renamed version of the 700V preprogrammed logic scheme modified as follows:

SN-IN1=L_OR_S_RES,CLOSE,OPEN (Local or SCADA Restore)
 Add the following Circuit UF logic to the modified logic scheme:

```

SL-62=2,VO10,0 (optional target reset)
SL-79=1,VO8,/IN1,VO14,0
SL-081=1,O
SL-181=1,O
SL-281=1,VO14
SL-381=1,VO14
SL-VO1=VO13
SL-VO2=79C

```

SL-VO3=/VO13
 SL-VO6=81T*181T
 SL-VO7=281T*381T
 SL-VO8=VO6
 SL-VO10=/VO6*IN1*IN3*VO7
 SL-VO13=VO6+VO14
 SL-VO14=/VO10*VO13

Add +81T+181T to BUS SG-TRIG. Replace the ,0 with ,62 at the end of BUS SG-TARG. The resulting OC-UF-79 setting logic is as follows:

SL-50TP=1,79SCB; SL-50TN=1,79SCB+/IN4; SL-50TQ=1,79SCB+/IN4
 SL-150TP=1,0; SL-150TN=1,0; SL-150TQ=1,0
 SL-51P=1,0
 SL-51N=1,/IN4
 SL-51Q=1,/IN4
 SL-151N=0,0
 SL-27P=0,0
 SL-59P=0,0; SL-59X=0,0
 SL-47=0,0
 SL-62=2,VO10,0
 SL-162=0,0,0
 SL-79=1,VO8,/IN1,VO12+VO14,150TPT+150TNT+150TQT+/IN2
 SL-81=1,0
 SL-181=1,0
 SL-281=1,/VO14
 SL-381=1,/VO14
 SL-481=0,0
 SL-581=0,0
 SL-BF=0,0,0
 SL-GROUP=1,0,0,0,0,0
 SL-43=0
 SL-143=0
 SL-101=0
 SL-VOA=0
 SL-VO1=VO11+VO13
 SL-VO2=79C
 SL-VO3=/VO13
 SL-VO4=ALMMIN
 SL-VO5=ALMMAJ
 SL-VO6=81T*181T
 SL-VO7=281T*381T
 SL-VO8=VO6+VO11
 SL-VO9=150TPT+150TNT+150TQT+/IN2
 SL-VO10=/VO6*VO7*IN1*IN3
 SL-VO11=50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+51NT+51QT
 SL-VO12=50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+51NPU+51QPU
 SL-VO13=VO6+VO14
 SL-VO14=/VO10*VO13
 SL-VO15=0

Close Circuit Monitor

While a close circuit monitor is not included in any of the preprogrammed logic schemes, this function may be added by using a 62 function block and a contact sensing input (INX) to monitor the close circuit. The logic for the close circuit monitor is shown in Figure 8-15. The output of the 62 protection block will close the designated output contact (VOY) when an open breaker and open close circuit condition exists.

The S<g>-62 command is used to provide a 500 millisecond time delay to inhibit the momentary alarm that will occur due to the timing differences between the two signals.

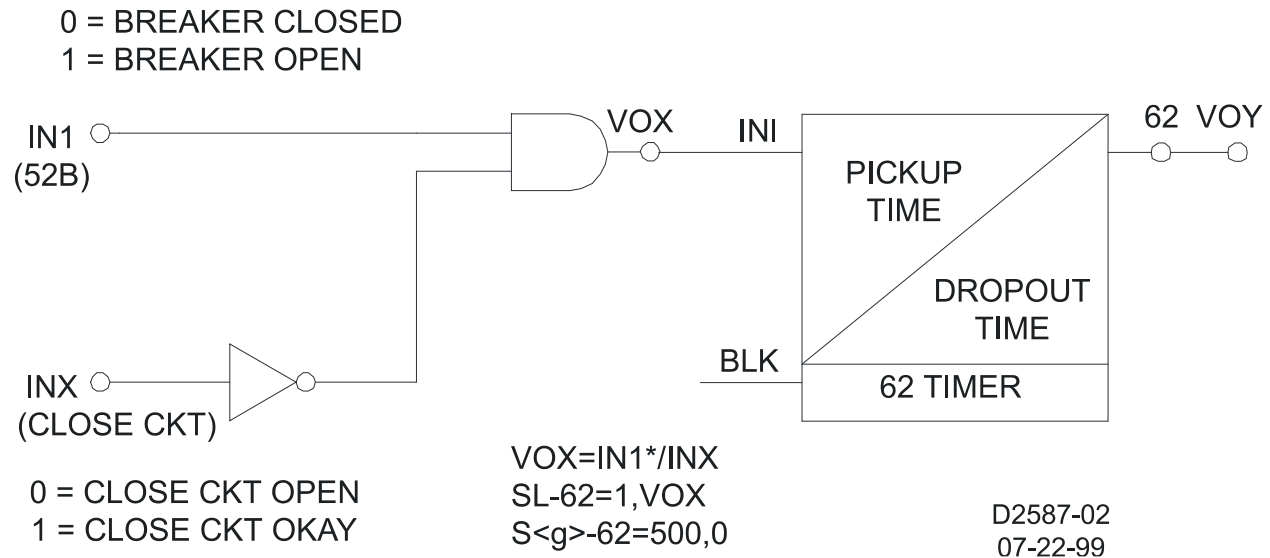


Figure 8-15. Close Circuit Monitor Logic

High-Speed Reclose

Each reclose time delay can be set as low as 100 milliseconds. Refer to Figure 8-16. 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 $\overline{\text{Areclose 79C AND NOT trip VO1}}$ to the close logic. Examples 1 and 2 show a close expression and hold disable setting for high-speed reclosing. Figure 8-16 illustrates this high-speed reclose interlock logic scheme.

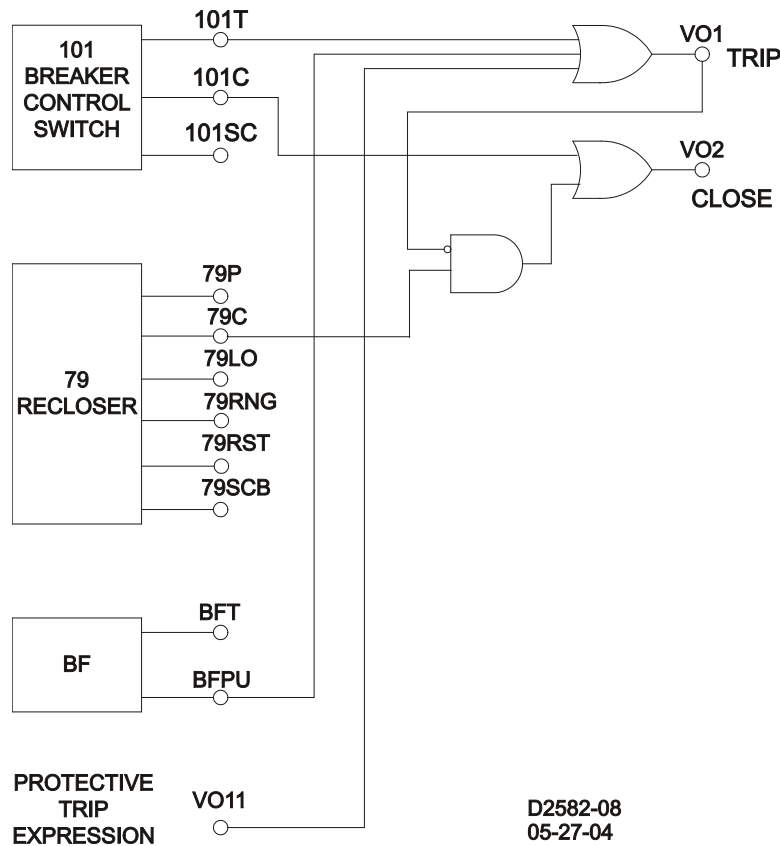


Figure 8-16. High-Speed Reclose Interlock Logic

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.

Setting Group Selection

The BE1-700 Digital Protective Relay provides two settings groups for adaptive relaying. The preprogrammed logic schemes barely tap the flexibility that is available. The following two examples illustrate how the settings groups can be adapted for different conditions and how different setting groups can be used to vary the system logic.

Example 1. Adapting the relay settings for different conditions

In overcurrent protection systems, the source conditions can have a major impact on sensitivity, coordination intervals, and clearing times. Generally, the pickup and time dial settings are a compromise

between a normal condition and a worst-case condition. Contact logic from the position of the source breakers can select which settings group is active. To achieve this, assign input D0 or D1 to a contact sensing input. Select binary coded setting group selection (Mode 2). If D0 is set, Group 0 will be selected when the input is off (binary code 00). Group 1 will be selected when the input is on (binary code 01). Similarly, if D1 is set, Group 2 will be selected when the input is on (binary coded 10).

This logic is useful in a situation where two transformers feed a single bus or two busses have a bus tie between them. The feeder and bus relays must be coordinated so that only one source is in service (bus tie open or one transformer out of service). However, when both sources are in service, such as when the bus tie is closed, each bus relay sees only half of the current for a fault. This results in poor sensitivity and slow clearing time for the bus relays.

Example 2. Adapting the logic in different setting groups

The logic in most of the preprogrammed logic schemes can be varied in each of the different setting groups. This is accomplished by disabling functions by setting their primary settings at zero. It's also possible to perform more sophisticated modification of the logic in each of the different setting groups by using the active setting group logic variables SG0 and SG1 in the BESTlogic expressions.

Output Contact Seal-In

Trip contact seal-in circuits have historically been provided with electromechanical relays. These seal-in circuits consists 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 are not 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 8-17 illustrates the seal-in logic diagram.

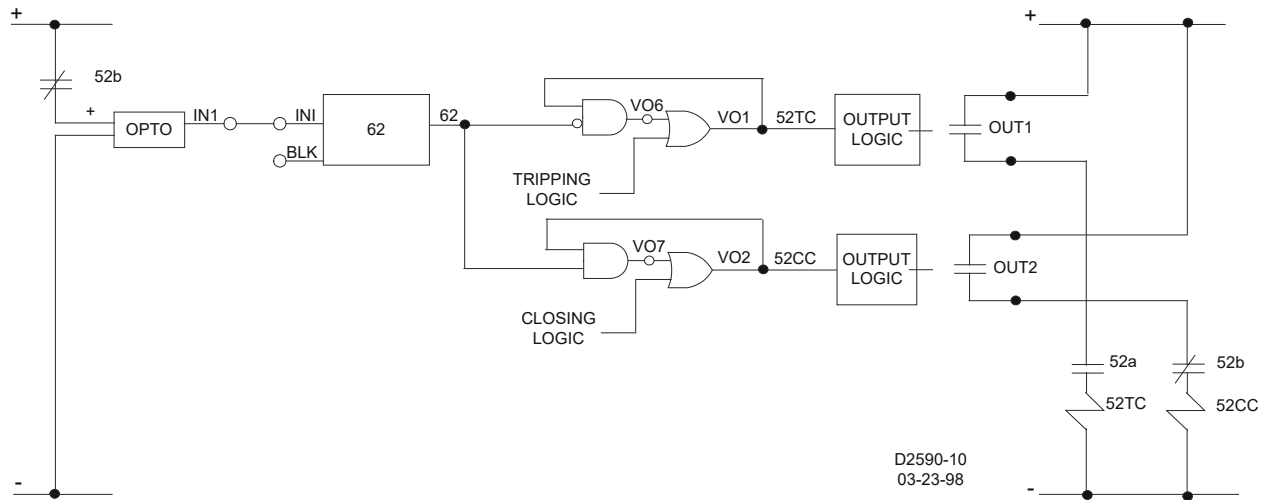


Figure 8-17. Output Seal-In Logic Diagram

Note

The following example is based on the 700C 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



9 • Security

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. BE1-700 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 Ethernet (COM1) is denied. Then, an attempt to issue a Control command through COM1 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 (COM0) and the front panel HMI are treated as the same port.

The communication ports and password parameters act as a two-dimensional control to limit changes. For a command to be accepted, the entered password must be correct and the command must be entered through a valid port. Only one password can be active at one time for any area or port. For example, if a user gains write access at the optional rear Ethernet port, then users at other areas (COM0, front panel HMI, and COM2) will not be able to gain write access until the user at the rear Ethernet port uses the EXIT command to release access control.

If a port holding access privileges sees no activity (command entered or HMI key pressed) for approximately five minutes, access privileges and any pending changes will be lost. This feature ensures that password protection cannot be accidentally left in a state where access privileges are enabled for one area and other areas locked out for an indefinite period.

If password protection is disabled, then entering **ACCESS=** followed by no password or any alphanumeric character string will obtain access to the unprotected area(s).

Note

For security reasons, all change passwords are disabled by default on the optional Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port.

Setting Password Protection

Password protection is configured for each access area port and communication port using BESTCOMS™. Alternately, password protection can be configured using the GS-PW ASCII command.

To configure password protection using BESTCOMS, select *General Operation* from the Screens pull-down menu. Then select the *Global Security* tab. Refer to Figure 9-1.

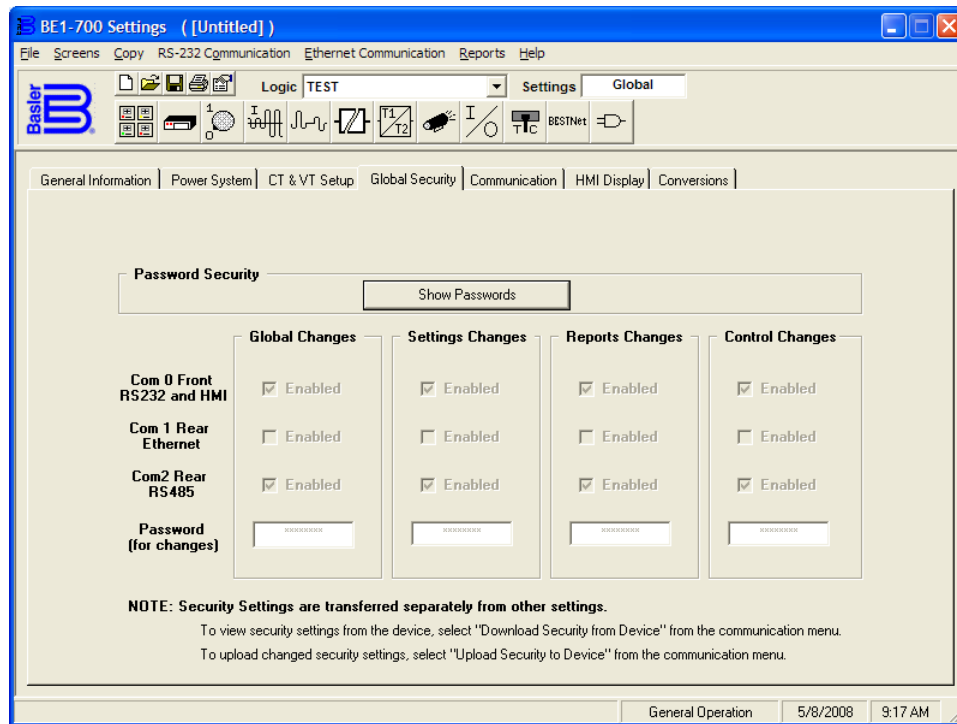


Figure 9-1. General Operation Screen, Global Security Tab

If a change is required and the *Password Security* box reads *Show Passwords*, press *Show Passwords*. Passwords may be entered in the text boxes for Global Access, Settings Access, Reports Access, and Control Access. See Figure 9-2. Each access level may be enabled (or not enabled) for COM0 front RS-232 and HMI, optional rear Ethernet port (COM1), and COM2 rear RS-485. Access levels may also be enabled for multiple ports.

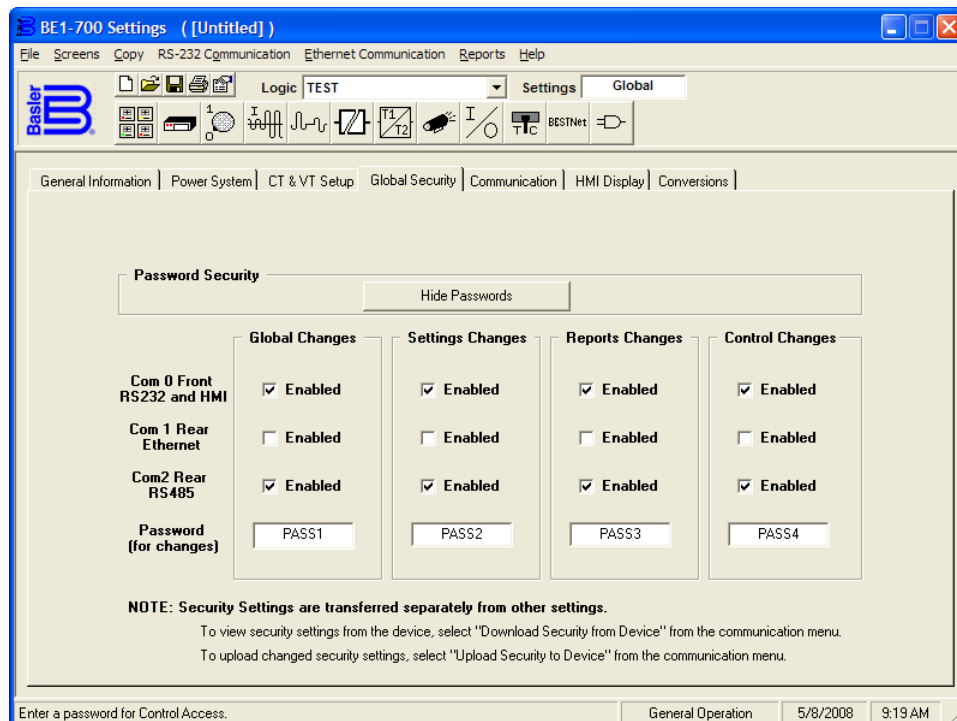


Figure 9-2. General Operation Screen, Global Security Tab with Passwords Shown

Table 9-1 lists password protection settings.

Table 9-1. Password Protection Settings

Setting	Range/Purpose
Password	User defined alphanumeric string with a maximum of 8 characters. A setting of 0 (zero) disables password protection.
Com ports	0 = Front RS-232 port 1 = Rear Ethernet port (optional) 2 = Rear RS-485 port



10 • Human-Machine Interface

This section describes the BE1-700 Digital Protective Relay 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 BE1-700 in a fixed, horizontal, half-rack, non-drawout case. The locators and descriptions of Table 10-1 correspond to the locators shown in Figure 10-1.

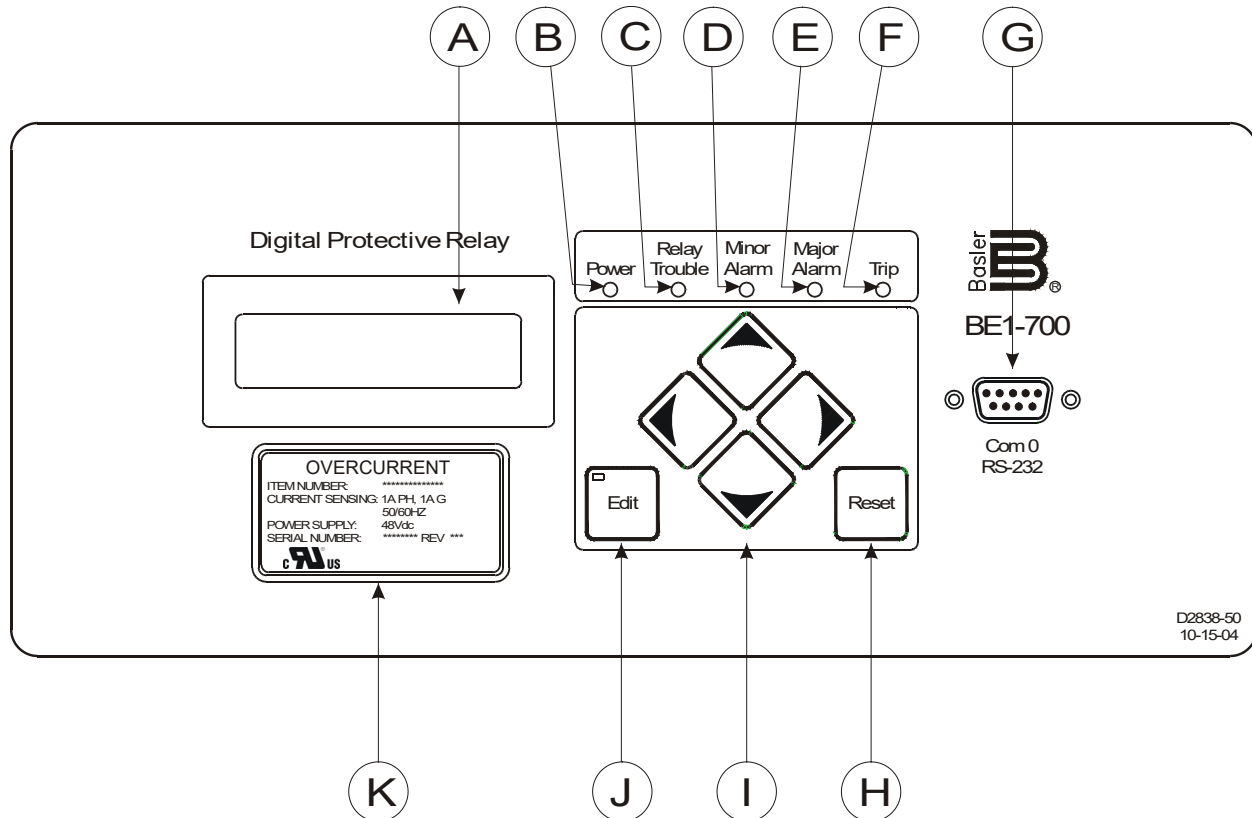


Figure 10-1. Front Panel

Table 10-1. Front Panel HMI Descriptions

Locator	Description
A	<i>Display</i> – 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 <i>Menu Tree</i> subsection provides more information about the menu branches.
B	<i>Power Indicator</i> – This green LED lights when operating power is applied to the relay.
C	<i>Relay Trouble Indicator</i> – This red LED lights momentarily during start-up and lights continuously when a relay failure is detected. Section 6, <i>Reporting and Alarm Functions</i> , provides a complete description of all relay failure alarm diagnostics.

Locator	Description
D, E	<i>Minor Alarm, Major Alarm Indicators</i> – 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, <i>Reporting and Alarm Functions</i> , provides detailed information about programming alarms.
F	<i>Trip Indicator</i> – A flashing Trip LED indicates that a protective element is picked up. A continuously lit LED indicates that a trip output is closed. This red LED is sealed in if a protective trip has occurred and targets are displayed.
G	<i>Communication Port 0</i> – This RS-232 serial port can be used to communicate with the relay using simple ASCII command language. A computer terminal or PC running terminal emulation software (such as Windows® HyperTerminal) is required to send commands to the relay or receive information from the relay.
H	<i>Reset Pushbutton</i> – Pushing this switch will reset the Trip LED, sealed-in Trip Targets, Peak Demand Currents, and Alarms.
I	<i>Scrolling Pushbuttons</i> – Use these four switches to navigate (<i>UP/DOWN/LEFT/RIGHT</i>) through the LCD's menu tree. When in Edit mode, the <i>LEFT</i> and <i>RIGHT</i> scrolling pushbuttons select the variable to be changed. The <i>UP</i> and <i>DOWN</i> scrolling pushbuttons change the variable.
J	<i>Edit Pushbutton</i> – 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 <i>Edit</i> switch is pressed again, the switch light turns off to indicate that your settings changes have been saved. If changes are not completed and saved within five minutes, the relay will automatically exit the Edit mode without saving any changes.
K	<i>Identification Label</i> – This label lists the style number, serial number, sensing input current and voltage range and power supply input voltages.

Menu Tree

A menu tree with six branches can be accessed through the front panel controls and display. The *LEFT* and *RIGHT* scrolling pushbuttons are used to view each of the six branches. A greater level of detail in a menu branch is accessed using the *DOWN* scrolling pushbutton. Every display screen of the menu tree is numbered in the upper left hand corner. This number eases navigation below the top level of the menu tree by indicating the current branch and level in the menu tree structure. Each time a lower menu tree level is reached, another number is added to the screen number separated by a period. The *UP* scrolling pushbutton is used to return to the top of the menu branch.

The six branches of the menu tree are illustrated in Figure 10-2 and summarized in the following paragraphs.

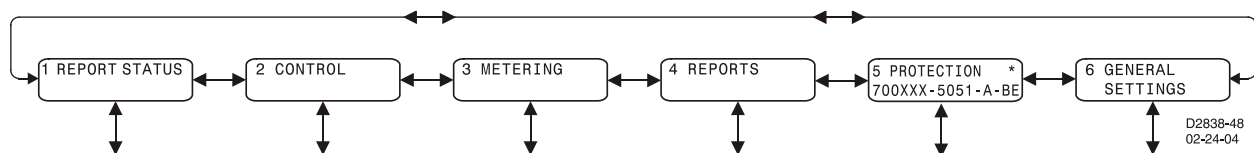


Figure 10-2. Menu Tree Branches

1. REPORT STATUS – Provides display and resetting of general status information such as targets, alarms, and recloser status. Figure 10-3 illustrates the structure of the Report Status menu branch.
2. CONTROL – Accesses control function operation of virtual switches, active setting group selection, and others. Control menu branch structure is illustrated in Figure 10-4.
3. METERING – Displays real time metering values. Figure 10-5 illustrates the structure of the Metering menu branch.
4. REPORTS – Provides display and resetting of report information such as time and date, demand registers, and breaker duty statistics. Reports menu branch structure is illustrated in 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.

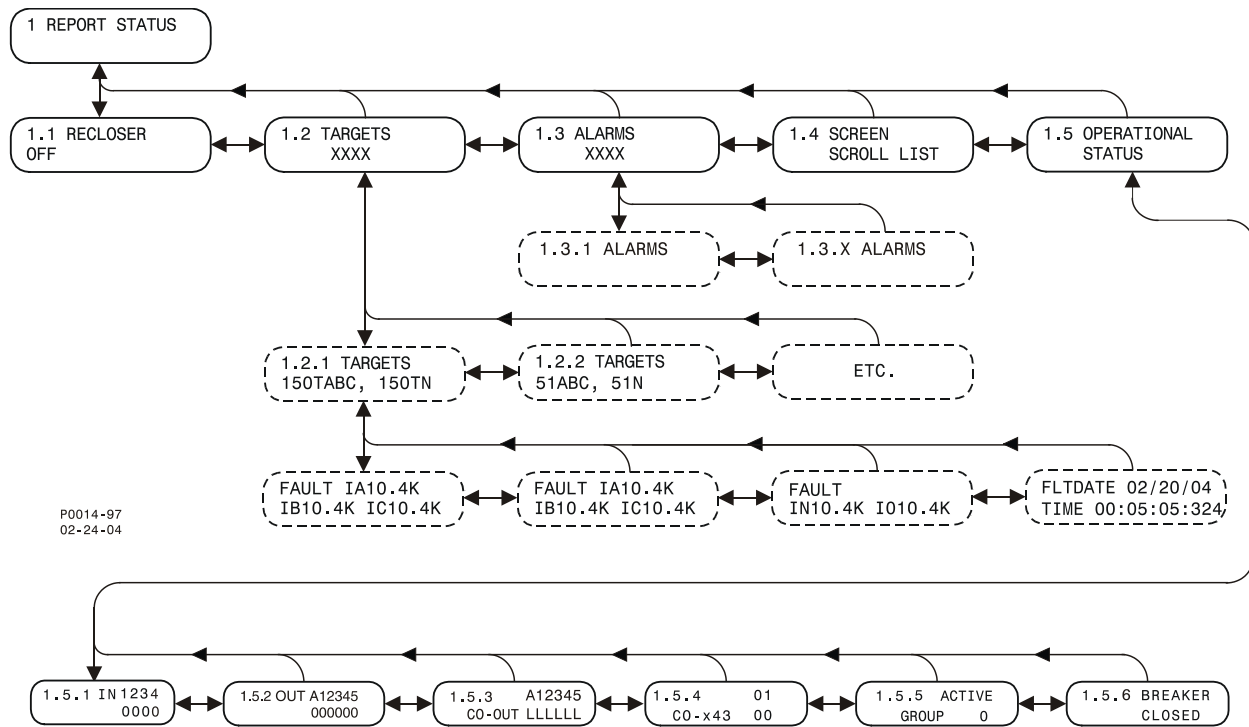


Figure 10-3. Report Status Menu Branch

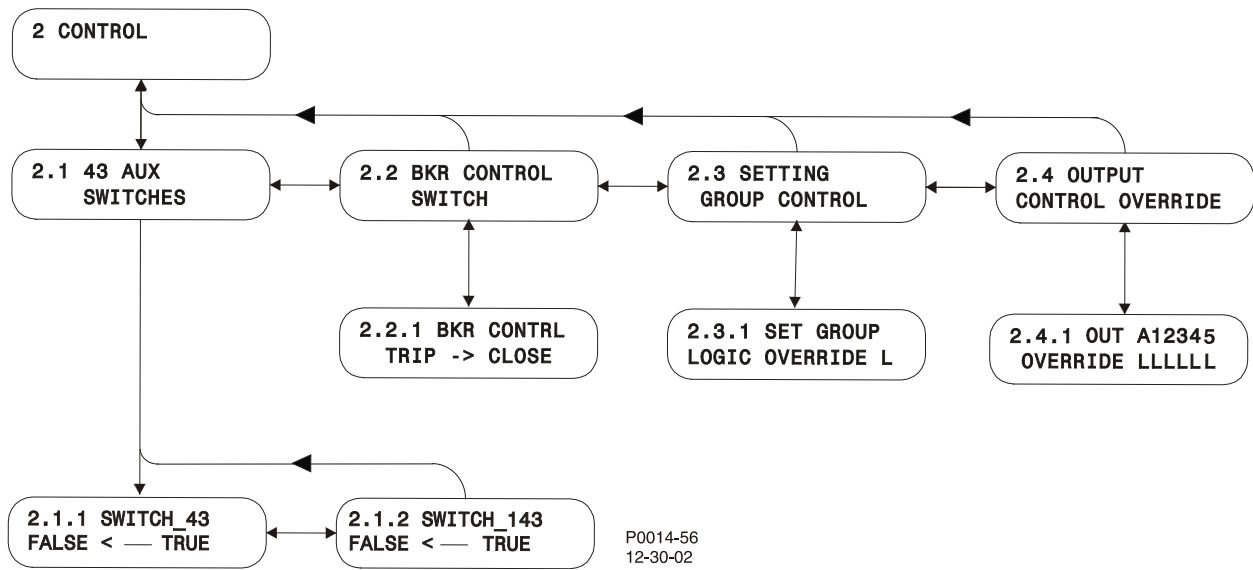


Figure 10-4. Control Menu Branch Structure

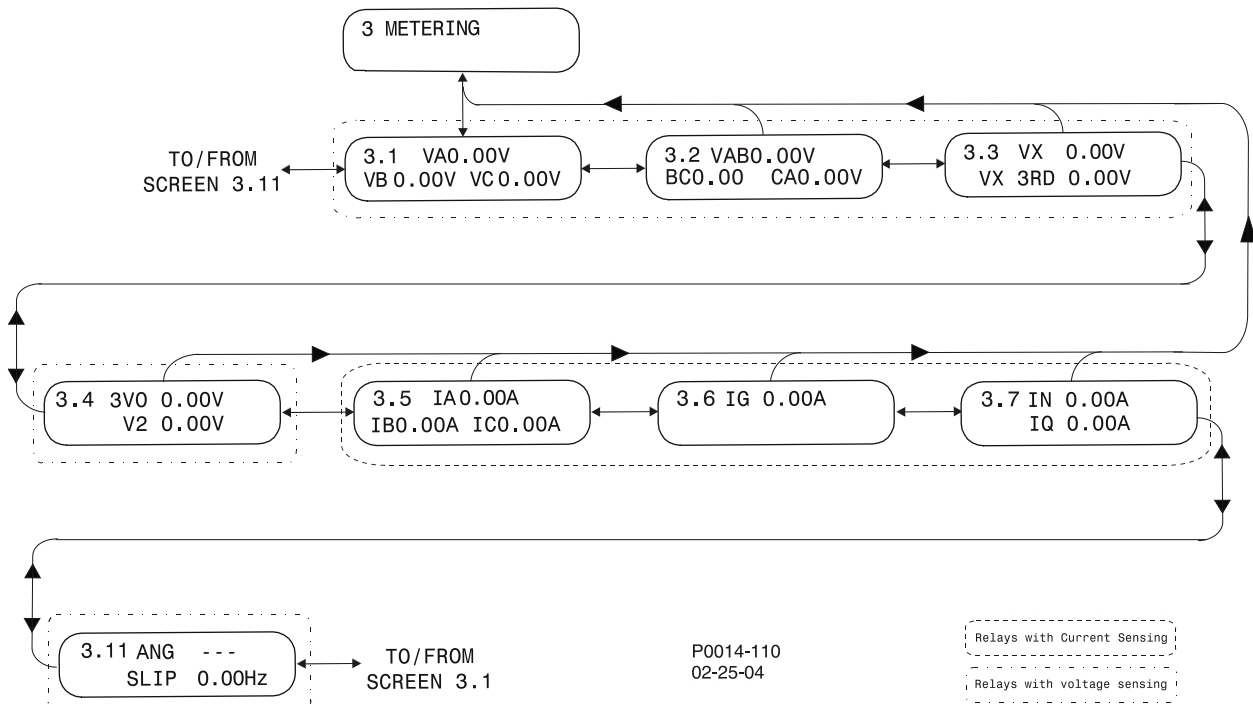


Figure 10-5. Metering Menu Branch Structure

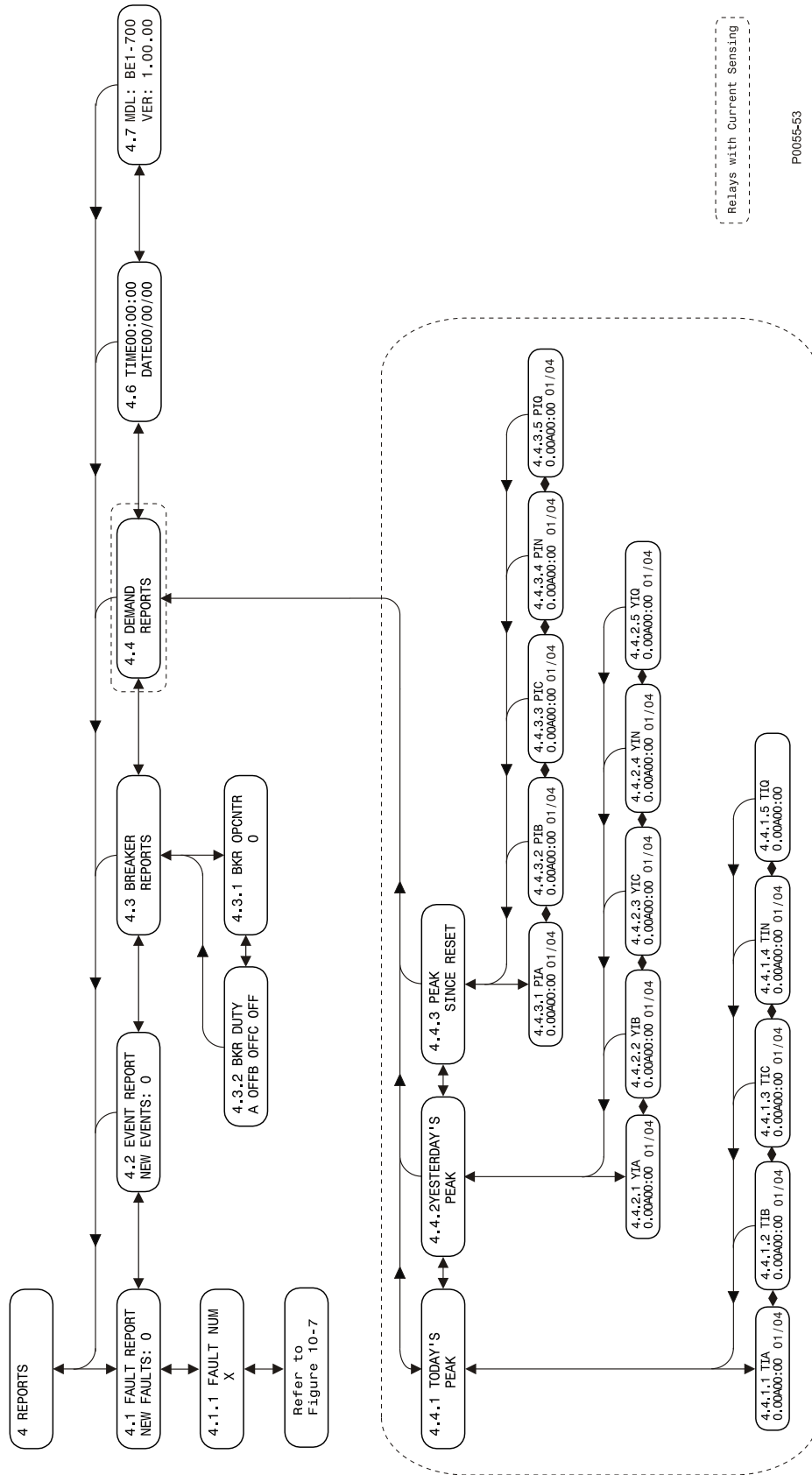


Figure 10-6. Reports Menu Branch Structure

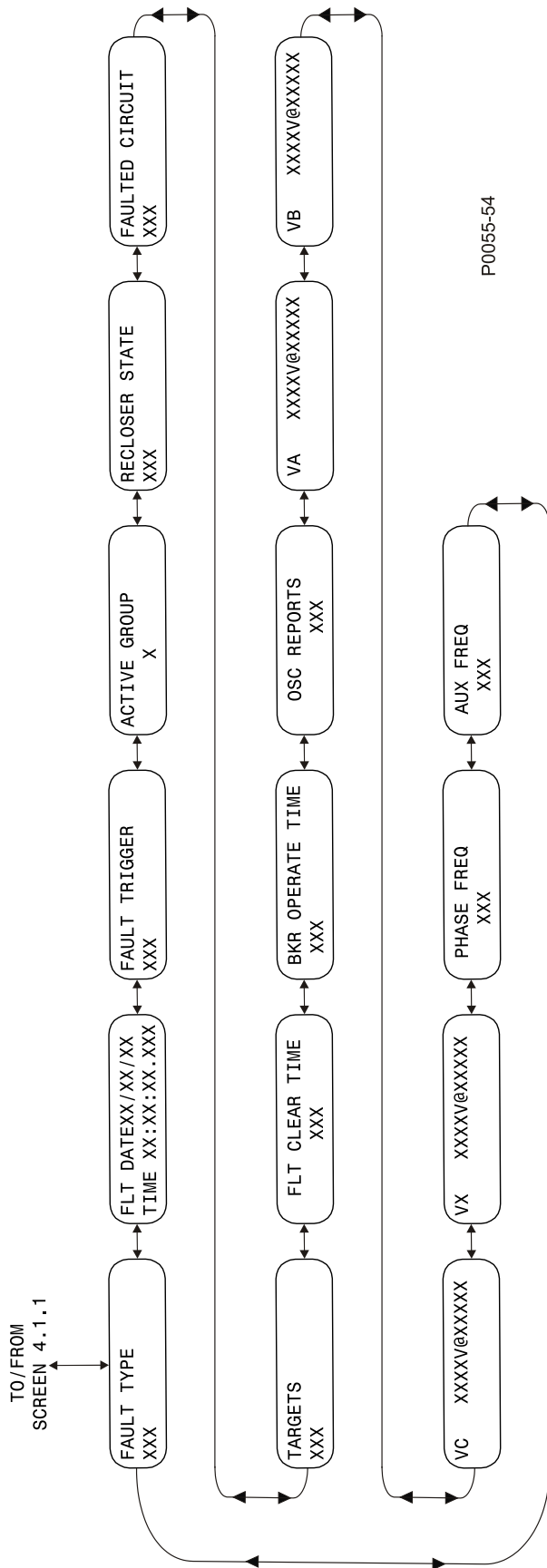


Figure 10-7. Reports Menu Branch Structure - Continued (BE1-700V Shown)

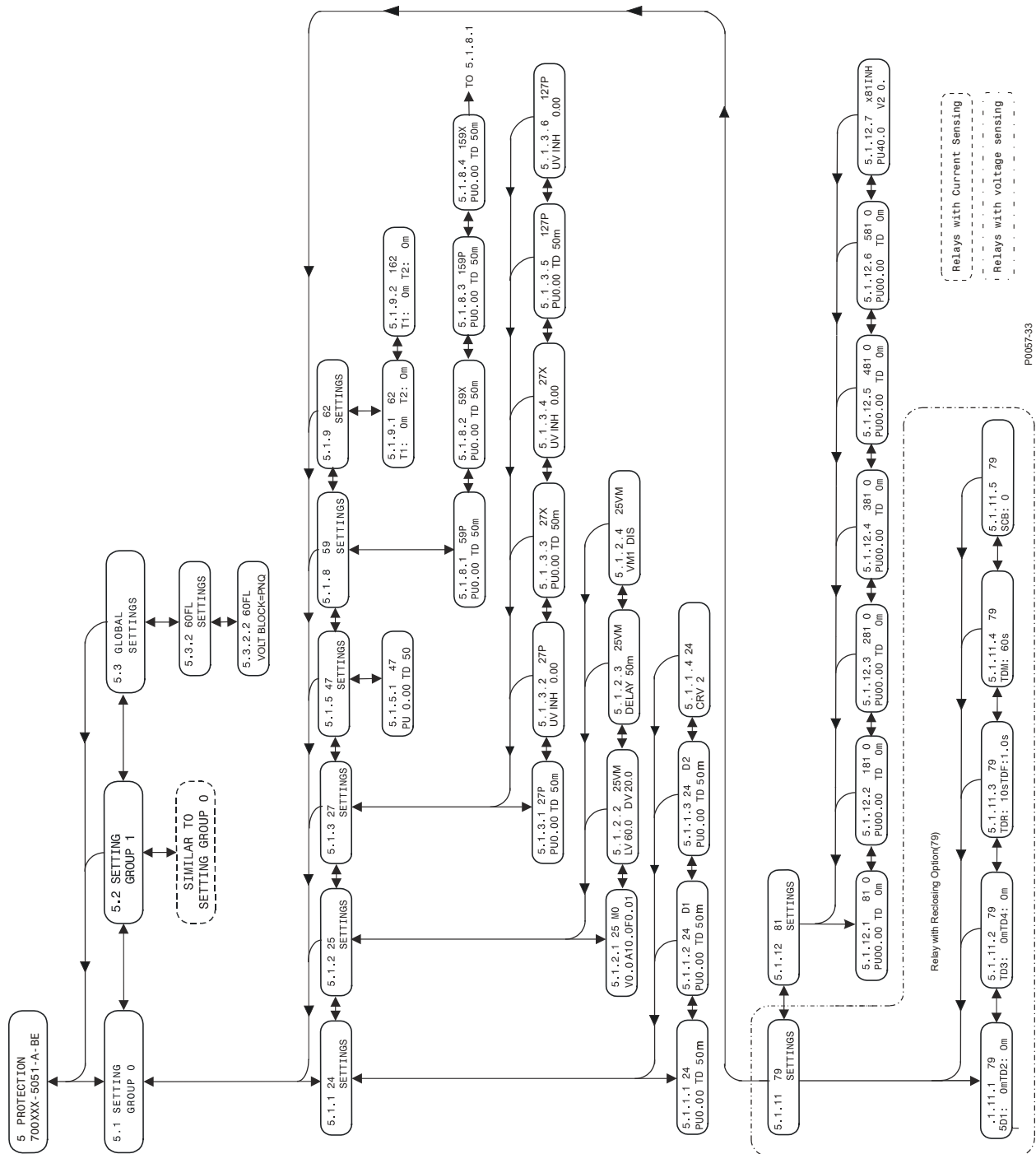


Figure 10-8. Protection Menu Branch Structure

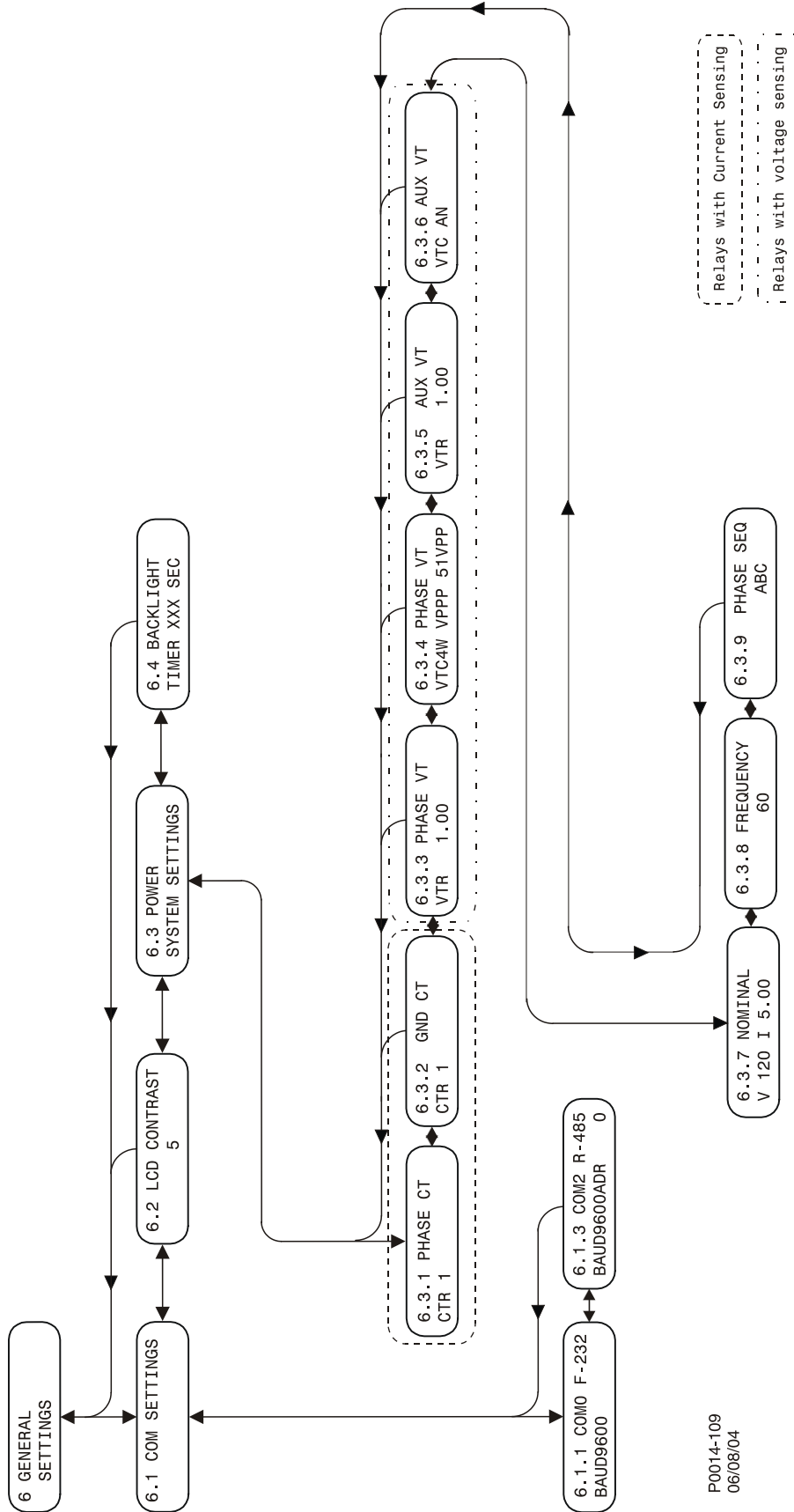


Figure 10-9. General Settings Menu Branch Structure

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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.

Setting the Screen Scroll List

To edit the automatic scrolling list using BESTCOMS™, select *General Operation* from the Screens pull-down menu. Then select the *HMI Display* tab. Refer to Figure 10-10. The screen numbers listed exhibit the default scrolling list. The list of numbers on the right represents the screen numbers and the order in which they will be displayed when automatic scrolling begins. The number closest to the top will be displayed first. The four buttons on the screen can be used to add or remove screens from the list. They can also be used to change a selected screens position in the list.

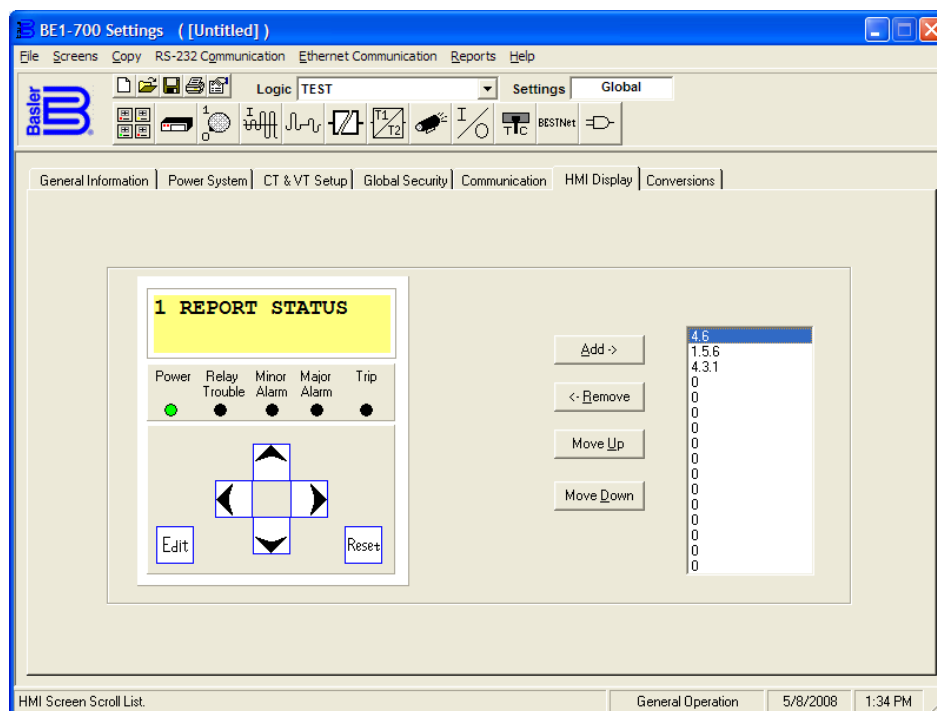


Figure 10-10. General Operation Screen, HMI Display Tab

To add a screen to the list, select the screen on the HMI simulation by clicking the mouse pointer on the arrows. Select the *Add->* button to add the screen to the list.

Alternately, these settings may be made using the SG-SCREEN ASCII command.

Backlight Timer

A backlight timer turns off the backlight after a period of time set by the SG-BL ASCII command. The setting range is 0 to 600 seconds. This setting is also programmable on the *Clock Display Mode* tab under *Reporting and Alarms* in BESTCOMS.

HMI Operations

The following paragraphs describe how the HMI is used to set and control relay functions.

Entering Settings

Settings for protection functions can be edited at menu branch 5, *PROTECTION LOGIC* of the HMI LCD. Settings for general and reporting functions can be edited from menu branch 6, *GENERAL SETTINGS*. To edit a setting using the manual scrolling pushbuttons, perform the following procedures:

1. Scroll to the screen that displays the function to be edited.
2. Press the *Edit* pushbutton to gain access. If password security has been initiated for settings, you will be prompted to enter the appropriate password. See the paragraphs, *Entering Passwords*, for details on entering passwords from the HMI. Once access has been gained, the EDIT LED will be lit and a cursor will appear in the first settings field on the screen.
3. Press the *UP* or *DOWN* scrolling key to select the desired setting. Some settings require entering a number, one character at a time. For example, to enter a 51 pickup as 7.3 amps, you would press the *UP* pushbutton until the 7 is showing. Then, press the *RIGHT* pushbutton to move the cursor over and press the *UP* pushbutton until the "." is showing. Then, press the *RIGHT* pushbutton to move the cursor over and press the *UP* pushbutton until the 3 is showing. Other settings require scrolling through a list of selections. For example, you would move the cursor over to the CRV field and then scroll through a list of available TCC curves.

- Once all of the settings on the screen have been entered, press the *Edit* pushbutton a second time and the settings will be validated. If the settings are in range, the screen will flash **CHANGES SAVED** and the EDIT LED will go out. If you want to abort the edit session without changing any settings, press the *Reset* pushbutton before you press the *Edit* pushbutton the second time. The screen will flash **CHANGES LOST** and the EDIT LED will go out.

Performing Control Operations

Control operations can be executed at Menu Branch 2, *CONTROL* of the HMI LCD. These functions allow you to control the state of virtual switches, override logic and control the active setting group, and override the logic and control the state of output contacts. All of these functions work similarly to the process of entering settings in that you press the *Edit* pushbutton, use the *UP* and *DOWN* scroll pushbuttons to select the desired state and press the *Edit* pushbutton for the action to be executed.

Table 10-3 describes each of the call-outs shown on Figure 10-11. The user-programmable label for this switch is SWITCH_143. The TRUE (closed) state label has been set to TRUE. In addition, the FALSE (open) state label has been set to FALSE. The logical mode for this application would be set to Mode 2 (On/Off switch).

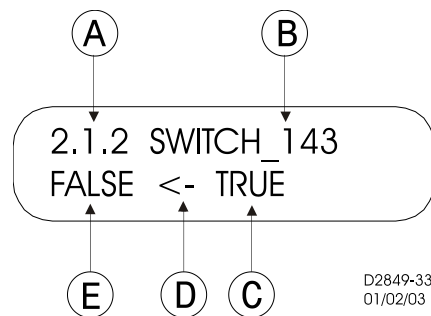


Figure 10-11. Virtual Control Switch 143 Screen

Table 10-3. Virtual Control Switches HMI Screen Indicators

Locator	Description
A	This is the screen number. It eases navigation by indicating the current branch and level in the menu tree structure.
B	User selectable label (meaningful name) for specific virtual switches. The switch label is set to 'SWITCH_143'.
C	User selectable label for the closed (1) state for Virtual Switch 143. The 'Switch 143' closed label is set to 'TRUE'.
D	An arrow icon indicates the current switch position (status). In Figure 10-11, the status is open (0), which is labeled 'FALSE'.
E	User selectable label for the open (0) state for Virtual Switch 143. The 'Switch 143' open label is set to 'FALSE'.

To operate the switch, you would use the following procedure:

- Using the manual scrolling pushbuttons, scroll to Screen 2.1.2 (SWITCH_143). Or, if the screen has been placed in the automatic scroll list, simply wait for it to appear and press the *RIGHT* or *LEFT* scroll pushbutton to freeze the display.
- Press the *Edit* pushbutton to gain access. If password security has been initiated for control functions, you will be prompted to enter the appropriate password. See the following sub-section *Entering Passwords*, for details on entering passwords at the HMI. Once access is gained to the control function, the EDIT LED will light and a cursor will appear in the action field.
- Press the *UP* or *DOWN* scrolling key to select the desired action. The selections available depend on the logic mode setting for that switch. If it is set to Mode 1, the action choices are pulse or one of the two positions as defined by the user programmable state labels. If Mode 2

(ON/OFF switch) is selected, the choices for action are limited to one of the two positions. If Mode 3 (OFF/Momentary ON switch) is selected, the choice for action is limited to pulse.

4. Press the *Edit* pushbutton a second time and the switch will change to the selected position, the screen will flash **CHANGES SAVED** and the EDIT LED will go out. If you want to abort the editing session without changing any controls, press the *Reset* pushbutton before you press the *Edit* pushbutton the second time. The screen will flash **CHANGES LOST** and the EDIT LED will go out.

Resetting Functions

The *Reset* pushbutton is context sensitive. Its function is dependent upon the screen that is presently being displayed. For example, pressing the *Reset* key when the demand screen is displayed will reset the demands but will not reset the alarms. It is necessary to scroll through the menu tree to the *Alarm* screen to reset an alarm. You are not prompted for a password when using the *Reset* key.

There are two BESTlogic variables associated with the HMI *Reset* pushbutton. Logic variable TRSTKEY becomes TRUE when the *Reset* pushbutton is pressed while the *Target* screen is displayed. Logic variable ARSTKEY becomes TRUE when the *Reset* pushbutton is pressed while the *Alarm* screen is displayed. See Section 8, *Application, Application Tips*, for examples on the use of these variables.

Entering Passwords

If password security has been initiated for a function, the HMI will prompt you to enter a password when the *Edit* pushbutton is pressed. To gain access, you must enter the appropriate password. A field of eight asterisks appears with the cursor located under the leftmost character position. You can enter passwords by performing the following procedures:

1. Press the *UP* or *DOWN* scrolling pushbuttons until the proper first character of the password appears. Pressing *UP* scrolls through the alphabet and then the numbers in ascending order. Pressing *DOWN* scrolls through the numbers and then the alphabet in descending order.
2. Press the *RIGHT* scrolling pushbutton to move the cursor to the next character of the password and select the appropriate character.
3. Continue the process until the entire password has been spelled out. If the password is less than eight characters, leave the remaining asterisks in place instead of entering blanks.
4. Press the *Edit* pushbutton to enter the password. If the proper password has been entered, the screen will flash **ACCESS GRANTED**. If an incorrect password has been entered, the screen will flash **ACCESS DENIED** and the EDIT LED will go out.
5. Once you gain access, it remains in effect 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.

11 • ASCII Command Interface

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. BE1-700 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.

Modbus® protocol is also available. Refer to Basler publication 9376700991 for the Modbus instruction manual. For information about other protocols, consult your Basler Electric representative. **Note:** ASCII commands, which support Ethernet-enabled relays, can be found in Section 15, *BESTNet™ Communication*.

Serial Port

Communication connections consist of one front Data Communication Equipment (DCE) RS-232 port, one rear RS-485 port, rear IRIG port, and a rear optional RJ45 Ethernet port (COM1). The BE1-700 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 Port

One female RS-232 (DB-9) connector is provided on the front panel and is designated COM0. It supports full-duplex operation.

RS-485 Port

RS-485 terminal block connections are located on the rear panel and designated COM2. This port supports half-duplex, multi-drop operation. Multi-drop operation is possible if a polling address is programmed for the port.

Ethernet Port

Optional Ethernet capability (COM1) is available. See Section 15, *BESTNet™ Communication*.

Note
For security reasons, all change passwords are disabled by default on the (optional) Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port. See Section 9, <i>Security, for details</i> .

ASCII Command Interface

A computer terminal or PC running terminal emulation software can be used at either of the two 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 do not fall into the other general groups. The command for reading and changing passwords (GS-PW) is the only global command available.
METERING (M):	Commands in this group report all real-time metering values. No subgroup is used with metering commands.
REPORTS (R):	Reports commands read and reset reporting functions such as time and date, demand registers and breaker duty statistics. Subgroups include Alarms (A), Breaker Monitoring (B), Demand Recording (D), Fault Summary Reporting (F), General Information (G), Sequence of Events Recorder (S), and Oscillography (O).
SETTINGS (S):	This group contains all of the setting parameters that govern relay function. Subgroups include Setting Groups 0 and 1, Protection Settings (P) not in setting groups, Alarm Settings (A), Breaker Monitor Settings (B), General Settings (G), 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 is not necessary to remember all of the object names. Most commands do not 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 BE1-700 responds with the operations counter value along with all other breaker report objects. If you know that the object name for the breaker operations counter is OPCNTR, you can enter RB-OPCNTR and read only the number of breaker operations.

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

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

Command Text File Operations

In command text file operations, an ASCII text file of commands is created and sent to the relay. For example, the S command is used to retrieve a complete list of settings from the relay in ASCII command format. This list of commands is captured, saved to a file, edited with any ASCII text editor, and then uploaded to the relay. Because the number of relay settings is so large, loading settings with a text file is the preferred method of setting the BE1-700.

Embedding Comments into ASCII Text Files

Adding comments to ASCII settings files is an easy way to organize and label your settings. A comment line is started with two forward slashes (//) followed by the comment text. When the relay encounters // in a text file, it ignores all following characters until the next carriage return or linefeed character.

Example of embedding comments in a settings file:

```
//Group0 is used during normal operation
>S0-50TP=7.50,0m;S0-50TN=2.5,0m . . .
//Group1 is used during cold load pickup
>S1-50TP=0,0m; S1-50TN=0,0m; S1-50TQ=0,0m
```

Miscellaneous Command Descriptions

HELP Command

The HELP (H) command provides general information on command syntax and functionality when the manual is not available. Entering HELP or H provides information about using the HELP command. HELP1 or H1 returns a complete list of relay commands. Entering HELP <cmd> where <cmd> is a specific command, returns information about the use and format of the command along with an example of how the command is used.

HELP Command

Purpose: Obtain help on command operation
Syntax: HELP {cmd} or H {cmd} for help on {cmd}, H1 for command list
Example: HELP, H1, H SG-COM

ACCESS Command

Before making settings changes through a communication port, the ACCESS command must be used to obtain programming access. Enter ACCESS=<password> to obtain access to change settings associated with the password. Different passwords give the ability or access to perform different operations. The relay will deny access if an invalid password is entered or if another user has already been granted programming access through another serial port or at the front panel. Only one user can have access at any one time.

Even if password protection is not used, it is still necessary to obtain access so that accidental changes are prevented. If password protection is disabled, then ACCESS= will be accepted in place of a password. The relay will respond with ACCESS GRANTED: GLOBAL if the command entered was received and executed. The relay will respond with an error message and a '?' if the command could not be executed.

The ACCESS (A) command and the EXIT (E) command are used to change relay settings, reset report registers, and enable control commands through a serial port. These commands prevent changes from

being made concurrently from two areas. For example, a user cannot make changes through COM 0 at the same time a remote user is making changes through COM 2.

ACCESS Command

Purpose: Read/Set Access level in order to change settings

Syntax: ACCESS[={password}]

Example: ACCESS=700

Comments: The ACCESS command must be used before any changes to settings can be made. Available ACCESS privileges are summarized in the following paragraphs.

READ-ONLY: This is the default access privilege when no passwords are active. Read-only access allows you to read settings and reports but not make settings changes.

PRIVILEGE G: GLOBAL ACCESS. Global access is obtained by password G (PWG). Global access permits entry of any command with no restrictions.

PRIVILEGE S: SETTING ACCESS. Setting access is obtained by password S (PWS). Setting access allows changes to any settings.

PRIVILEGE C: CONTROL ACCESS. Control access is obtained by password C (PWC). Control access enables relay control operations.

PRIVILEGE R: REPORT ACCESS. Report access is obtained by password R (PWR). Report access enables report operations to be performed.

An access privilege is obtained only when the appropriate password is entered. When a valid password is entered, the relay responds with the access privilege provided by the password entered. If an invalid password is entered, an error message is returned. If password protection is disabled in one or more privileges, then entering any string will provide access to the unprotected privileges.

Note: In examples throughout this manual, relay responses are printed in *Courier New* typeface.

ACCESS Command Examples:

Example 1. A valid password is entered.

```
>ACCESS=OPENUP
ACCESS GRANTED:    GLOBAL
```

Example 2. An invalid password is entered.

```
>ACCESS=POENUP
ACCESS DENIED
```

Example 3. The current access privilege is read.

```
>ACCESS
ACCESS:    GLOBAL
```

EXIT Command

After changes are made, the new data is saved or discarded using the EXIT command. Prior to saving or discarding any changes, you must confirm that you wish to exit the programming mode. There is three exit options: Y (yes), N (no), or C (continue).

EXIT Command

Purpose: Exit programming mode

Syntax: EXIT (Note: Relay will prompt for verification.)

Example: EXIT

Comments: It's important to make all programming changes before executing the EXIT command. This prevents a partial or incomplete protection scheme from being implemented.

SB Command

Purpose: Read all breaker settings
Syntax: SB
Example: SB

SB Command Example:

Example 1. Read all breaker settings.
 >SB
 SB-DUTY=0, 0.000e+00
 SB-LOGIC=/IN1

SG Command

Purpose: Read all general settings
Syntax: SG
Example: SG

SG Command Example:

Example 1. Obtain a report of all general settings.
 >SG
 SG-FREQ=60
 SG-EMAIL1=0; SG-EMAIL2=0; SG-EMAIL3=0; SG-EMAIL4=0
 SG-EMAIL5=0; SG-EMAIL6=0; SG-EMAIL7=0
 SG-FREQ=60
 SG-PHROT=ABC
 SG-CTP=1
 SG-CTG=1
 SG-NOM= 0.0,5.00
 SG-IN1= 4, 16; SG-IN2= 4, 16; SG-IN3= 4, 16; SG-IN4= 4, 16
 SG-HOLDA=0; SG-HOLD1=1; SG-HOLD2=1; SG-HOLD3=0
 SG-HOLD4=0; SG-HOLD5=1
 SG-SGCON= 5
 SG-DIP=15; SG-DIN= 1; SG-DIQ= 1
 SG-LOG=15
 SG-TARG=BF/50TP/150TP/50TN/150TN/50TQ/150TQ/51P/151P/62/162/51N/
 151N/51Q,0
 SG-TRIGGER=VO11,VO12,0
 SG-OSC=16
 SG-ID=BE1-700,SUBSTATION_1
 SG-CLK=M,24,0
 SG-SCREEN1=4.6; SG-SCREEN2=1.5.6; SG-SCREEN3=4.3.1; SG-SCREEN4=1.1
 SG-SCREEN5=3.2; SG-SCREEN6=3.5; SG-SCREEN7=0; SG-SCREEN8=0
 SG-SCREEN9=0; SG-SCREEN10=0; SG-SCREEN11=0; SG-SCREEN12=0
 SG-SCREEN13=0; SG-SCREEN14=0; SG-SCREEN15=0; SG-SCREEN16=0
 SG-COM0=9600,A0,P0,R1,X1
 SG-COM2=9600,A0,P0,R1,X0,MF1,MPN,MR10,MS1,PW0

SN Command

Purpose: Read/Set User Programmable Names
Syntax: SN[-{var}][={name},{TRUE label},{FALSE label}]
Example: SN or SN-VO1=TRIP,CLOSED,OPEN or SN-IN1=BREAKER,OPEN,CLOSED

SN Command Example:

Example 1. Read the programmed labels for the alarm output (OUTA).
 >SN-VOA
 SN-VOA=VOA_LBL, TRUE, FALSE

S<g> Command

Purpose: Read all Protection settings
Syntax: S{g} where g=setting group 0-1 or # for all groups
Example: S# or S0 or S1

S <g> Command Example:

Example 1. Obtain a list of settings for Setting Group 1.
 >S1
 S1-50TP=0.00, 0m, N
 S1-50TN=0.00, 0m, N
 S1-50TQ=0.00, 0m, N
 S1-150TP=0.00, 0m, N
 S1-150TN=0.00, 0m, N
 S1-150TQ=0.00, 0m, N
 S1-51P=0.00, 0.0, V2, N
 S1-51N=0.00, 0.0, V2, N
 S1-51Q=0.00, 0.0, V2, N
 S1-151P=0.00, 0.0, V2
 S1-151N=0.00, 0.0, V2, N
 S1-62= 0m, 0m
 S1-162= 0m, 0m
 SP-BF= 0m
 SP-CURVE= 0.2663, 0.0339, 1.0000, 1.2969, 0.5000

Reading Logic Settings

The SL command is used to view the names of available logic schemes in memory. It also will return all of the logic equations for a specific logic scheme.

SL Command

Purpose: Obtain Setting Logic Information
Syntax: SL:[{name}]
Example: SL, SL: or SL:BASIC-OC
Comments: No password access is required to read settings.

Entering SL by itself returns all of the logic equations associated with the active logic scheme including custom logic. Entering SL: returns the names of all available logic schemes. Entering SL:<name> returns all logic equations and settings for the named logic scheme.

SL Command Examples:

Example 1. Read the logic schemes available in memory.
 >SL:
 700c-5051-A-BE, 700C-OC79-A-BE, 700V-OUVF-A-BE, 700V-VF79-A-BE, NONE

Example 2. Read all logic settings associated with the 700C-5051-A-BE logic scheme.

```
>SL:700C-5051-A-BE
SL-N=700C-5051-A-BE, BASLER
SL-50TP=1,0
SL-50TN=1,0
SL-50TQ=1,0
SL-150TP=0,0
SL-150TN=0,0
SL-150TQ=0,0
SL-51P=1,0
SL-51N:1,0
SL-51Q:1,0
SL-151P:1,0
SL-151N:0,0
SL-62:0,0,0
SL-162:0,0,0
SL-79:0,0,0,0,0,0
SL-BF:0,0,0
SL-GROUP:1,0,0,/0
SL-43:0
SL-143:0
SL-101:0
SL-VOA:0
SL-VO1:VO11
SL-VO2:50TPT
SL-VO3:51PT
SL-VO4:50TNT+50TQT
SL-VO5:51NT+51QT
SL-VO6:0
SL-VO7:0
SL-VO8:0
SL-VO9:0
SL-VO10:0
SL-VO11:50TPT+150TPT+50TNT+150TNT+50TQT+150TQT+51PT+51NT+151NT+
51QT
SL-VO12:50TPPU+150TPPU+50TNPU+150TNPU+50TQPU+150TQPU+51PPU+51NPU+
151NPU+51QPU
SL-VO13:0
SL-VO14:0
SL-VO15:0
```

Configuring the Serial Port Communication Protocol

The serial communication protocol is defined with the SG-COM command shown below.

SG-COM Command

Purpose: Read/Set serial communications protocol
Syntax: SG-COM[#={baud},A{addr},P{pglen},R{reply ack},X{XON ena}]]
Example: SG-COM0=9600 or SG-COM2=9600,A0,P24,R1,X1
Comments: Password Access Privilege G or Privilege S required to change settings
 # = port number. (0 = Front, 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-COM2=19K, A156, P0, R1, X0

Command Summary

Miscellaneous Commands

ACCESS Command

- Purpose:* Read/Set Access level in order to change settings
Syntax: ACCESS[={password}]
Example: ACCESS=700
Reference: Section 11, *ASCII Command Interface, Miscellaneous Command Descriptions*

EXIT Command

- Purpose:* Exit programming mode
Syntax: EXIT **Note:** Relay will prompt for verification
Example: EXIT
Reference: Section 11, *ASCII Command Interface, Miscellaneous Command Descriptions*

HELP Command

- Purpose:* Obtain help on command operation
Syntax: HELP {cmd} or H {cmd} for help on {cmd}, H1 for command list
Example: HELP, H1, H SG-COM
Reference: Section 11, *ASCII Command Interface, Miscellaneous Command Descriptions*

Metering Commands

M Command

Purpose: Read all metered values
Syntax: M
Example: M
Reference: Section 5, *Metering*

M-3V0 Command

Purpose: Read metered voltage (V) in primary units
Syntax: M-3V0
Example: M-3V0
Reference: Section 5, *Metering*

M-FAST Command

Purpose: Read fast metered values in primary units
Syntax: M-FAST[{{xy}}] where x=V,I,F,P,Q,S and y=P,L,S,1,2,3,4,G
Example: M-FAST,V or M-FAST,VP or M-FAST,I or M-FAST,L1
Reference: Section 5, *Metering*

M-FREQ Command

Purpose: Read metered frequency (F)
Syntax: M-FREQ[{{source}}] where source = P/X/S, Phase, Aux, Slip
Example: M-F or M-FREQ, M-FREQP, M-FREQX, M-FREQS
Reference: Section 5, *Metering*

M-I Command

Purpose: Read metered current (I) in primary units
Syntax: M-I[{{phase}}] where phase = A/B/C/N/Q/G
Example: M-I or M-IA or M-IG
Reference: Section 5, *Metering*

M-SYNC Command

Purpose: Read metered sync angle between Phase & Aux inputs
Syntax: M-SYNC
Example: M-SYNC or M-SYN
Reference: Section 5, *Metering*

M-V Command

Purpose: Read metered voltage (V) in primary units
Syntax: M-V[{{phase}}] where phase = A/B/C/AB/BC/CA/2
Example: M-V or M-VA or M-VAB or M-V2
Reference: Section 5, *Metering*

Control Commands

CO Command

Purpose: Control Operation
Syntax: CO-{{control}}[={{mode}}] where control=GROUP/OUT/x43/101
 mode=0-1/L for GROUP, 0/1/P/L/ENA/DIS for OUT,
 0/1/P for x43 and T/C for 101.
Example: CO-GROUP=1 or CO-OUT1=1 or CO-43=P

Reference: Section 3, *Input and Output Functions, Outputs*
Section 4, *Protection and Control, Setting Groups*
Section 4, *Protection and Control, Virtual Switches*

CS Command

Purpose: Control Selection
Syntax: CS-control[={mode}] where control=GROUP/OUT/x43/101
mode=0-1/L for GROUP, 0/1/P/L/ENA/DIS for OUT,
0/1/P for x43 and T/C for 101.

Example: CS-GROUP=1 or CS-OUT1=1 or CS-43=P

Reference: Section 3, *Input and Output Functions, Outputs*
Section 4, *Protection and Control, Setting Groups*
Section 4, *Protection and Control, Virtual Switches*

Report Commands

RA Command

Purpose: Report/Reset Alarm information
Syntax: RA[=0]
Example: RA
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-LGC Command

Purpose: Report/Reset Logic Alarm information
Syntax: RA-LGC[=0]
Example: RA-LGC
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-MAJ Command

Purpose: Report/Reset Major Alarm information
Syntax: RA-MAJ[=0]
Example: RA-MAJ
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-MIN Command

Purpose: Report/Reset Minor Alarm information
Syntax: RA-MIN[=0]
Example: RA-MIN
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RA-REL Command

Purpose: Report/Reset Relay Alarm information
Syntax: RA-REL[=0]
Example: RA-REL
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

RB Command

Purpose: Read breaker status
Syntax: RB
Example: RB
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

RB-DUTY Command

Purpose: Read/Set breaker contact Duty Log
Syntax: RB-DUTY[{phase}][={%duty}] where %duty is % of dmax set with SB-DUTY
Example: RB-DUTYA or RB-DUTYB=50
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

RB-OPCNTR Command

Purpose: Read/Set Breaker Operation Counter
Syntax: RB-OPCNTR[={#operations}]
Example: RB-OPCNTR=32 or RB-OPCNTR=652
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

RD Command (BE1-700C only)

Purpose: Report all demand data
Syntax: RD
Example: RD
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-PI Command

Purpose: Read/Reset peak demand current (I)
Syntax: RD-PI[{p}][=0] where p=A/B/C/N/Q
Example: RD-PI or RD-PIA or RD-PIN or RD-PI=0
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-TI Command

Purpose: Report today's demand current (I)
Syntax: RD-TI[{p}] where p=A/B/C/N/Q
Example: RD-TI or RD-TIA or RD-TIN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RD-YI Command

Purpose: Report yesterday's demand current (I)
Syntax: RD-YI[{p}] where p=A/B/C/N/Q
Example: RD-YI or RD-YIA or RD-YIN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

RF Command

Purpose: Read/Reset Fault Report Data
Syntax: RF[-n/NEW][=0/TRIG] where n=record # or NEW = new records
Example: RF (displays a directory of all fault reports in memory)
RF-23 (view summary report for fault record 23)
RF-NEW (view summary report for newest fault record since RF=0 reset)
RF=TRIG (Manually Trigger a fault record)
RF=0 (reset NEW fault counter)
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

RG Command

Purpose: Report General information
Syntax: RG
Example: RG
Reference: Section 6, *Reporting and Alarm Functions, Clock*
Section 6, *Reporting and Alarm Functions, Fault Reporting*

RG-DATE Command

Purpose: Report/Set Date
Syntax: RG-DATE[={M/D/Y}] or RG-DATE[={D-M-Y}]
Example: RG-DATE=12/31/96 or RG-DATE=31-12-96 (Format set by SG-CLK Command)
Reference: Section 6, *Reporting and Alarm Functions, Clock*

RG-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-n/A/B[#].CFG/DAT/HDR where n=report number,A=ASCII/B=BINARY,#=OSC 1/2
Example: RO-3A1.CFG or RO-3A1.DAT or RO-5B2.CFG or RO-5B2.DAT or RO-5A.HDR
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

RS Command

Purpose: Read/Reset Sequence of Events Record Data
Syntax: RS[-n/Fn/ALM/IO/LGC/NEW][=0] where n=# of events and Fn=fault record #
Example: RS (displays a directory of all event records in memory)
 RS-23 (view SER report for last 23 events)
 RS-F12 (view SER report associated with fault record 12)
 RS-ALM (view all SER report ALARM events since RS=0 reset)
 RS-IO (view all SER report INPUT OUTPUT events since RS=0 reset)
 RS-LGC (view all SER report LOGIC events since RS=0 reset)
 RS-NEW (view all SER report events since RS=0 reset)
 RS=0 (reset NEW records counter)
Reference: Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder*

Setting Command

S Command

Purpose: Read all relay setting parameters
Syntax: S
Example: S
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

Alarm Setting Commands

SA Command

Purpose: Read all alarm settings for Major and Minor alarms
Syntax: SA
Example: SA
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-24 Command (BE1-700V only)

Purpose: Read/Set Volts Per Hertz alarm settings
Syntax: SA-24[={alarm level},{td(m)}] alarm level=volts per hertz
Example: SA-24 or SA-24=1.1,2000 or SA-24=1.08,500
Reference: Section 4, *Protection and Control, Voltage Protection*

SA-BKR Command

Purpose: Read/Set breaker alarm settings
Syntax: SA-BKR[n][={mode},{alarm limit}] where mode=0-3(disabled/%duty/#op/cir)
Example: SA-BKR or SA-BKR1=1,80 or SA-BKR2=2,250, or SA-BKR3=3,6c
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SA-DI Command

Purpose: Read/Set demand alarm settings
Syntax: SA-DI[p][={alarm level}] where p=P/N/Q, alarm level=Sec Amps
Example: SA-DI or SA-DIP=0 or SA-DIN=10
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SA-LGC Command

Purpose: Read/Set logic alarm setting mask
Syntax: SA-LGC[={alarm num 1}[/{alarm num 2}]...[/{alarm num n}]]
Example: SA-LGC or SA-LGC=2/6/7/10/11
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-MAJ Command

Purpose: Read/Set major alarm setting mask
Syntax: SA-MAJ[={alarm num 1}[/{alarm num 2}]...[/{alarm num n}]]
Example: SA-MAJ or SA-MAJ=1/3/5/12
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-MIN Command

Purpose: Read/Set minor alarm setting mask
Syntax: SA-MIN[={alarm num 1}[/{alarm num 2}]...[/{alarm num n}]]
Example: SA-MIN or SA-MIN=2/6/7/10/11
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

SA-RESET Command

Purpose: Read/Set Programmable Alarms Reset logic
Syntax: SA-RESET[={rst alm logic}]
Example: SA-RESET or SA-RESET=VO1
Reference: Section 6, *Reporting and Alarm Functions, Alarms Function*

Breaker Monitor Setting Commands**SB** Command

Purpose: Read all breaker settings
Syntax: SB
Example: SB
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SB-DUTY Command

Purpose: Read/Set Breaker Contact Duty where mode = 0/1/2 (disabled/1/1^2)
Syntax: SB-DUTY[={mode},{dmax},{BLKBKR logic}]
Example: SB-DUTY=1,60E3,IN5
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

SB-LOGIC Command

Purpose: Read/Set Breaker Contact Logic
Syntax: SB-LOGIC[={breaker close logic}]
Example: SB-LOGIC=IN1 (IN1=52a) or SB-LOGIC=/IN2 (IN2=52b)
Reference: Section 6, *Reporting and Alarm Functions, Breaker Monitoring*

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-BL Command

Purpose: Read/Program backlight timer
Syntax: SG-BL[={timer}]
Example: SG-BL=5000 or SG-BL=60000
Reference: Section 10, *Human-Machine Interface, Front Panel Display, Backlight Timer*

SG-CLK Command

Purpose: Read/Program format of date and time display
Syntax: SG-CLK[={date format(M/D)},{time format(12/24)},{dst enable(0/1)}]
Example: SG-CLK=D,12,1 or SG-CLK=M,24,0
Reference: Section 6, *Reporting and Alarm Functions, Clock*

SG-COM Command

Purpose: Read/Set serial communications protocol
Syntax: SG-COM[#[={baud},A{addr},P{pglen},R{reply ack},X{XON ena}]]
Example: SG-COM0=9600 or SG-COM0=9600,A0,P24,R1,X1
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions, Configuring the Serial Port Communication Protocol*

SG-CT Command (BE1-700C only)

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 (BE1-700C only)

Purpose: Read/Set P(IA/IB/IC), N and Q demand interval
Syntax: SG-DI[p][={interval}] where p=P/N/Q, interval=0-60 (min)
Example: SG-DI or SG-DIP=15 or SG-DIN=1
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SG-DSP Command

Purpose: Read analog signal dsp filter type
Syntax: SG-DSP[P/N] F=fundamental
Example: SG-DSP, SG-DSPP, SG-DSPN
Reference: Section 6, *Reporting and Alarm Functions, Demand Functions*

SG-EMAIL Command

Purpose: Read/Enter email logic
Syntax: SG-EMAIL[#]={email logic}] where #=1-7
Example: SG-EMAIL1=VO1*VO2 or SG-EMAIL5=50TPT+50TPPU
Reference: Section 15, *BESTNet™ Communication, Unique ASCII Commands*

SG-FREQ Command

Purpose: Read/Enter power system Frequency
Syntax: SG-FREQ[={freq(HZ)}]
Example: SG-FREQ=60 or SG-FREQ=50
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-HOLD Command

Purpose: Read/Program Output Hold operation
Syntax: SG-HOLD[n][={1/0 hold ena}] where 1=TRUE, 0=FALSE
Example: SG-HOLD or SG-HOLD1=1 or SG-HOLD2=0
Reference: Section 3, *Input and Output Functions, Outputs*

SG-ID Command

Purpose: Read/Set relay ID and station ID used in reports
Syntax: SG-ID[={relayID(up to 30 char)},{StationID(up to 30 char)}]
Example: SG-ID=448,SUBSTATION3 or SG-ID=GEN3, POWERPOINT_SUBSTATION
Reference: Section 14, *BESTCOMS Software, Setting the Relay*

SG-IN Command

Purpose: Read/Set Input recognition/debounce
Syntax: SG-IN[#][={r(ms)},{db(ms)}] where ms=1-255msec
Example: SG-IN or SG-IN3 or SG-IN3=4,16
Reference: Section 3, *Input and Output Functions, Contact Sensing Inputs*

SG-NOM Command

Purpose: Read/Enter power system nominal Voltage & Current
Syntax: SG-NOM[={Nom Volts},{Nom Amps}]
Example: SG-NOM or SG-NOM=120,5 or SG-NOM=120,1
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-OSC Command

Purpose: Read/Set the number of oscillograph fault records saved
Syntax: SG-OSC[=6/8/10/12/15/16]
Example: SG-OSC or SG-OSC=6
Reference: Section 6, *Reporting and Alarm Functions, Oscillographic Records*

SG-PHROT Command

Purpose: Read/Set Phase Rotation setting
Syntax: SG-PHROT[={phase rotation}] ABC/ACB
Example: SG-PHROT or SG-PHROT=ABC or SG_PHROT=ACB
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-SCREEN Command

Purpose: Read/Set default screen(s)
Syntax: SG-SCREEN[n][={default screen number}]
Example: SG-SCREEN or SG-SCREEN1=2.2.1 or SG-SCREEN2=2.2.2
Reference: Section 10, *Human-Machine Interface, Front Panel Display*

SG-SGCON Command

Purpose: Read/Set SGC output on time
Syntax: SG-SGCON[={time}] where time is in (s)ec
Example: SG-SGCON or SG-SGCON=1S or SG-SGCON=5S
Reference: Section 4, *Protection and Control, Setting Groups*

SG-TARG Command

Purpose: Report/Enable Target List and Reset Target Logic
Syntax: SG-TARG[={x/x/..x},{rst TARG logic}] where x=27,47,50,51,59,81,181 etc.
Example: SG-TARG or SG-TARG=27/50/51N/59/81/281
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

SG-TRIGGER Command

Purpose: Read/Set Trigger logic
Syntax: SG-TRIGGER[n][={TRIP trigger},{PU trigger},{LOGIC trigger}]
Example: SG-TRIGGER or SG-TRIGGER=VO1,VO2,IN4
Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting*

SG-VTP Command (BE1-700V)

Purpose: Read/Set VT ratio, connection, 27/59 sensing mode, 51/27R sensing mode
Syntax: SG-VTP[={VT_ratio},{connection},{27/59mode},{51/27Rmode}]
Example: SG-VTP or VTP=10,4W,PN,PN or VTP=1200:120,3W,PP,PP or VTP=1200/120,AB
Reference: Section 3, *Input and Output Functions, Power System Inputs*

SG-VTX Command (BE1-700V)

Purpose: Read/Set Aux VT ratio and connection
Syntax: SG-VTX[={VTratio},{connection}]
Example: SG-VTX or VTX=10,AB or VTX=1200:120,GR or VTX=1200/120,AN
Reference: Section 3, *Input and Output Functions, Power System Inputs*

Programmable Logic Setting Commands**SL Command**

Purpose: Obtain Setting Logic Information
Syntax: SL:[{name}]
Example: SL, SL: or SL:BASIC-OC
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

SL-24 Command (BE1-700V only)

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 (BE1-700V only) (Optional)

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 (BE1-700V only)

Purpose: Read/Set Logic for 27 Function Modules
Syntax: SL-*{x}*27[*{p}*[={mode},{BLK logic}]] where *x*=blank/1, *p*=P/X
Example: SL-27 or SL-27P=1,0 or SL-27X=3,0 or SL-127P=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-43 Command

Purpose: Read/Set Logic for Virtual switch (x43)
Syntax: SL-*{x}*43[=mode] where *x* = blank/1/2/3, mode=0/1/2/3
Example: SL-43 or SL-43=0 or SL-143=1
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-47 Command (BE1-700V only)

Purpose: Read/Set Logic for 47 Function Modules
Syntax: SL-47[={mode},{BLK logic}]
Example: SL-47 or SL-47=1,0 or SL-47=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-50T Command (BE1-700C only)

Purpose: Read/Set Logic for x50 Function Modules
Syntax: SL-*{x}*50T[*{p}*[={mode},{BLK logic}]] where *x* = blank/1 and *p* = P/N/Q
Example: SL-50T or SL-50T=1,0 or SL-150TN=1,IN3
Reference: Section 4, *Protection and Control, Overcurrent Protection*

SL-51 Command (BE1-700C only)

Purpose: Read/Set Logic for 51 Function Modules
Syntax: SL-51[{p}={mode},{BLK logic}] where p=P/N
Example: SL-51 or SL-51P=1,0 or SL-51N=1,IN3 or SL-151N=1,0
Reference: Section 4, *Protection and Control, Overcurrent Protection*

SL-51Q Command (BE1-700C only)

Purpose: Read/Set Logic for 51Q Function Modules
Syntax: SL-51Q[={mode},{BLK logic}]
Example: SL-51Q or SL-51Q=1,0 or SL-51Q=1,IN3
Reference: Section 4, *Protection and Control, Overcurrent Protection*

SL-101 Command

Purpose: Read/Set Logic for Virtual Breaker switch (101)
Syntax: SL-101[=mode] where mode=0/1 (disabled/enabled)
Example: SL-101 or SL-101=0 or SL-101=1
Reference: Section 4, *Protection and Control, Virtual Switches*

SL-59 Command (BE1-700V only)

Purpose: Read/Set Logic for 59 Function Modules
Syntax: SL-59[{p}={mode},{BLK logic}] where p=P/X
Example: SL-59 or SL-59P=1,0 or SL-59X=2,0 or SL-159X=1,IN3
Reference: Section 4, *Protection and Control, Voltage Protection*

SL-62 Command

Purpose: Read/Set Logic for 62 Function Modules
Syntax: SL-{x}62[={mode},{INI logic},{BLK logic}] where x=blank/1
Example: SL-62 or SL-62=1,VO10,0 or SL-162=2,VO9,VO8
Reference: Section 4, *Protection and Control, General Purpose Logic Timers*

SL-79 Command (Optional)

Purpose: Read/Set for 79 Function
Syntax: SL-79[={mode},{RILogic},{STATUSLogic},{WAITLogic},{LOCKOUTLogic},{PILOTLogic}]
Example: SL-79 or SL-79=1,VO1+IN4,/IN1,IN2,IN3
Reference: Section 4, *Protection and Control, Reclosing*

SL-81 Command (BE1-700V only)

Purpose: Read/Set Logic for 81 Function Modules
Syntax: SL-{x}81[={mode},{BLK logic}] where mode=0/1/X, x=blank/1/2/3/4/5
Example: SL-81 or SL-81=1,0 or SL-81=X,0 or SL-181=1,IN3
Reference: Section 4, *Protection and Control, Frequency Protection*

SL-BF Command (BE1-700C only)

Purpose: Read/Set Logic for Breaker Failure Function Modules
Syntax: SL-BF[{p}={mode},{INI logic},{BLK logic}]
Example: SL-BF or SL-BF=1,VO1,0 or SL-BF=1,VO1,IN1
Reference: Section 4, *Protection and Control, Breaker Failure Protection*

SL-GROUP Command

Purpose: Read/Set Logic for Setting Group Module
Syntax: SL-GROUP[={mode},{D0Logic},{D1Logic},{AUTOlogic}]
Example: SL-GROUP or SL-GROUP=1,0,IN3,0
Reference: Section 4, *Protection and Control, Setting Groups*

SL-N Command

Purpose: Read/Set Name of the custom logic
Syntax: SL-N[={name}]
Example: SL-N=700TEST
Reference: Section 7, *BESTlogic Programmable Logic, Logic Schemes*

SL-VO Command

Purpose: Read/Set Output Logic
Syntax: SL-VO[#[={Boolean equation}]]
Example: SL-VO or SL-VO1=50TPT+50TNT+51PT+51NT+101T
Reference: Section 7, *BESTlogic Programmable Logic, Working With Programmable Logic*

User Programmable Name Setting Command**SN** Command

Purpose: Read/Set User Programmable Names
Syntax: SN[-{var}[={name},{TRUE label},{FALSE label}]
Example: SN or SN-VO1=TRIP,CLOSED,OPEN or SN-IN1=BREAKER,OPEN,CLOSED
Reference: Section 7, *BESTlogic Programmable Logic, User Input and Output Logic Variable Names*

Protection Setting Commands**S<g>** Command

Purpose: Read all Protection settings
Syntax: S{g} where g=setting group 0-1 or # for all groups
Example: S# or S0 or S1
Reference: Section 11, *ASCII Command Interface, Settings (S) Command Descriptions*

S<g>-24 Command (BE1-700V only)

Purpose: Read/Set 24 pickup level, time delay, reset delay and curve
Syntax: S{g}-24[={pu(V/Hz)},{td},{rst},{crv}] where g=0,1
Example: S0-24 or S0-24=2.5,6.5,9.9,2 or S1-24=3,2.0,5.0,1
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-24D Command (BE1-700V only)

Purpose: Read/Set 24 definite time pickup levels and time delays
Syntax: S{g}-24D[={pu1(V/Hz)},{td1},{pu2(V/Hz)},{td2}] where g=0,1
Example: S0-24D or S0-24D=1.1,6000,1.18,45000 or S1-24D=1.12,8000,1.20,60000
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-25 Command (BE1-700V only)

Purpose: Read/Set 25 delta volts, phase angle, slip freq and mode
Syntax: S{g}-25[={Volts},{Ang},{Slip},{mode}] where g=0,1, mode=1-PF>XF, 0-PF<>XF
Example: S0-25 or S0-25=5,3,0.1,0 or S1-27=2,5,0.25,1
Reference: Section 4, *Protection and Control, Synchronism-Check Protection*

S<g>-25VM Command (BE1-700V only)

Purpose: Read/Set 25VM live volts, dead volts, time delay, and VM1 logic
Syntax: S{g}-25VM[={LV},{DV},{td},{VM1}] where g=0,1, VM1=DIS/123
Example: S0-25VM or S0-25=80,20,100,123 S1-25VM=80,20,0.25,23
Reference: Section 4, *Protection and Control, Synchronism-Check Protection*

S<g>-27 Command (BE1-700V only)

Purpose: Read/Set 27 pickup level, time delay, and inhibit level
Syntax: S{g}-{x}27{p}[={pu(V)},{td(m)},{inh(V)}] where x= blank/1, g=0,1, p=P,X
Example: S0-27P or S0-27P=100,10s,20, S0-27X=100,10s,20, S0-127P=80,5s,20
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-47 Command (BE1-700V only)

Purpose: Read/Set 47 pickup level and time delay
Syntax: S{g}-47[={pu(V)},{td(m)}] where g=0,1
Example: S0-47 or S1-47=100,0
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-50T Command (BE1-700C only)

Purpose: Read/Set 50T pickup level and time delay
Syntax: S{g}-{x}50T[{p}][={pu(A)},{td(m)}] where g=0,1, x=blank/1, and p=P/N/Q
Example: S0-50T or S1-50TP=25,0 or S1-150TN=3,20
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-51 Command (BE1-700C only)

Purpose: Read/Set 51 pickup level, time delay, curve, and direction
Syntax: S{g}-51[{p}][={pu(A)},{td(m)},{crv},{dir}] where g=0,1 and p=P/Q
Example: S0-51P or S0-51P=7.5,6.5,S1,N or S1-51Q=3,2.0,S1,F
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-51N Command (BE1-700C only)

Purpose: Read/Set 51N pickup level, time delay and curve
Syntax: S{g}-{x}51N[={pu(A)},{td(m)},{crv},{dir}] where x=blank/1 and g=0,1
Example: S0-51N or S0-51N=7.5,6.5,S1,N or S1-151N=3,2.0,S1,F
Reference: Section 4, *Protection and Control, Overcurrent Protection*

S<g>-59 Command (BE1-700V only)

Purpose: Read/Set 59 pickup level and time delay
Syntax: S{g}-59[{p}][={pu(V)},{td(m)}] where g=0,1 and p=P/X
Example: S0-59P or S1-59P=100,0 or S1-59X=80,20 S1-159X=80,20
Reference: Section 4, *Protection and Control, Voltage Protection*

S<g>-62 Command

Purpose: Read/Set 62 Time Delay
Syntax: S{g}-{x}62[={t1},{t2}] where g=0,1 & t suffix m=msec,s=sec,c=cycle
Example: S0-62=500m,200m or S0-62=0.5s,0.2s or S1-162=30c,12c
Reference: Section 4, *Protection and Control, General Purpose Logic Timers*

S<g>-79 Command (Optional)

Purpose: Read/Set 79 Time Delay
Syntax: S{g}-79#[#][={td}] where g=0,1 & t suffix m=msec,s=sec,c=cy
Example: S0-791=100m or S0-792=0.5s or S0-793=60c
Reference: Section 4, *Protection and Control, Reclosing*

S<g>-79SCB Command

Purpose: Read/Set 79 Sequence Controlled Block Output
Syntax: S{g}-79SCB[={step list}] where g=0,1
Example: S0-79SCB=2/4
Reference: Section 4, *Protection and Control, Reclosing*

S<g>-81 Command (BE1-700V only)

Purpose: Read/Set 81 pickup level, time delay, and mode
Syntax: S{g}-{x}81[={pu(Hz)},{td(m)},{mode}] where g=0,1 and x=blank/1/2/3/4/5
Example: S0-81 or S0-81=59.00,6.5,U or S1-81=60.50,2.0,O or S1-81=0.2,0,R
Reference: Section 4, *Protection and Control, Frequency Protection*

S<g>-81INH Command (BE1-700V only)

Purpose: Read/Set 81 Under Voltage Inhibit level
Syntax: S{g}-81INH[={pu(V)},{NegSeq(%)},{Over(Hz)},{Under(Hz)}] where g=0,1
Example: S0-81INH or S0-81INH=80,5,70,40 or S1-81INH=0,7,65,55
Reference: Section 4, *Protection and Control, Frequency Protection*

SP-60FL Command (BE1-700V only)

Purpose: Read/Set 60 Fuse Loss Blocking
Syntax: SP-60FL[={I_Blk},{V_Blk}] I_Blk=ENA/DIS, V_Blk=DIS/PNQ/PN/PQ/NQ/P/N/Q
Example: SP-60FL or SP-60FL=ENA,PNQ or SP-60FL=DIS,DIS
Reference: Section 4, *Protection and Control, Voltage Transformer Fuse Loss Detection*

SP-BF Command (BE1-700C only)

Purpose: Read/Set the Breaker Failure Timer Setting
Syntax: SP-BF[={time}[m/s/c]] where m=msec,s=sec,c=cycle
Example: SP-BF or SP-BF=50m or SP-BF=3c
Reference: Section 4, *Protection and Control, Breaker Failure Protection*

SP-CURVE Command (BE1-700C only)

Purpose: Read/Set the user programmable 51 curve parameters
Syntax: SP-CURVE[={A},{B},{C},{N},{R}]
Example: SP-CURVE or SP-CURVE=1.0,0,0,2.5,0
Reference: Appendix A, *Time Overcurrent Characteristic Curves*

SP-GROUP Command

Purpose: Read/Program auxiliary setting group 1 operation
Syntax: SP-GROUP[{g}]=[{sw_time},{sw_level},{ret_time},{ret_level},{prot_ele}]
Example: SP-GROUP, SP-GROUP1=10,75,10,50,51P or SP-GROUP1=0,0,0,0,793
Reference: Section 4, *Protection and Control, Setting Groups*

SP-79ZONE Command (Optional)

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*



12 • Installation

BE1-700 Digital Protective Relays 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 Basler Electric Regional Sales Office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois.

If the BE1-700 is not installed immediately, store it in the original package in a moisture and dust free environment.

Contact-Sensing Inputs

Four contact-sensing inputs provide external stimulus to initiate BE1-700 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, General Specifications*. In addition, Section 1, Figure 1-1 indicates the power supply options available with your type of relay.

Energizing levels for the contact sensing inputs are for a minimum of approximately 5 Vdc for 24 Vdc nominal sensing voltages, 26 Vdc for 48 Vdc nominal sensing voltages, 69 Vdc for 125 Vdc nominal sensing voltages, or 138 Vdc for 250 Vdc nominal sensing voltages. See Table 12-1 for the contact-sensing turn-on voltages.

Table 12-1. Contact-Sensing Turn-On Voltages

Style Option	Nominal Input Voltage	Contact-Sensing Turn-On Voltage †
xxx1xxx	48 Vdc	26 to 38 Vdc
xxx2xxx	125 Vac/dc	69 to 100 Vdc 56 to 97 Vac
xxx3xxx	24 Vdc	Approx. 5 Vdc
xxx4xxx	250 Vac/dc	138 to 200 Vdc 112 to 194 Vac
xxx5xxx	125 Vac/dc *	69 to 100 Vdc 56 to 97 Vac

* Extended holdup option. See Style Chart in Figure 1-1.

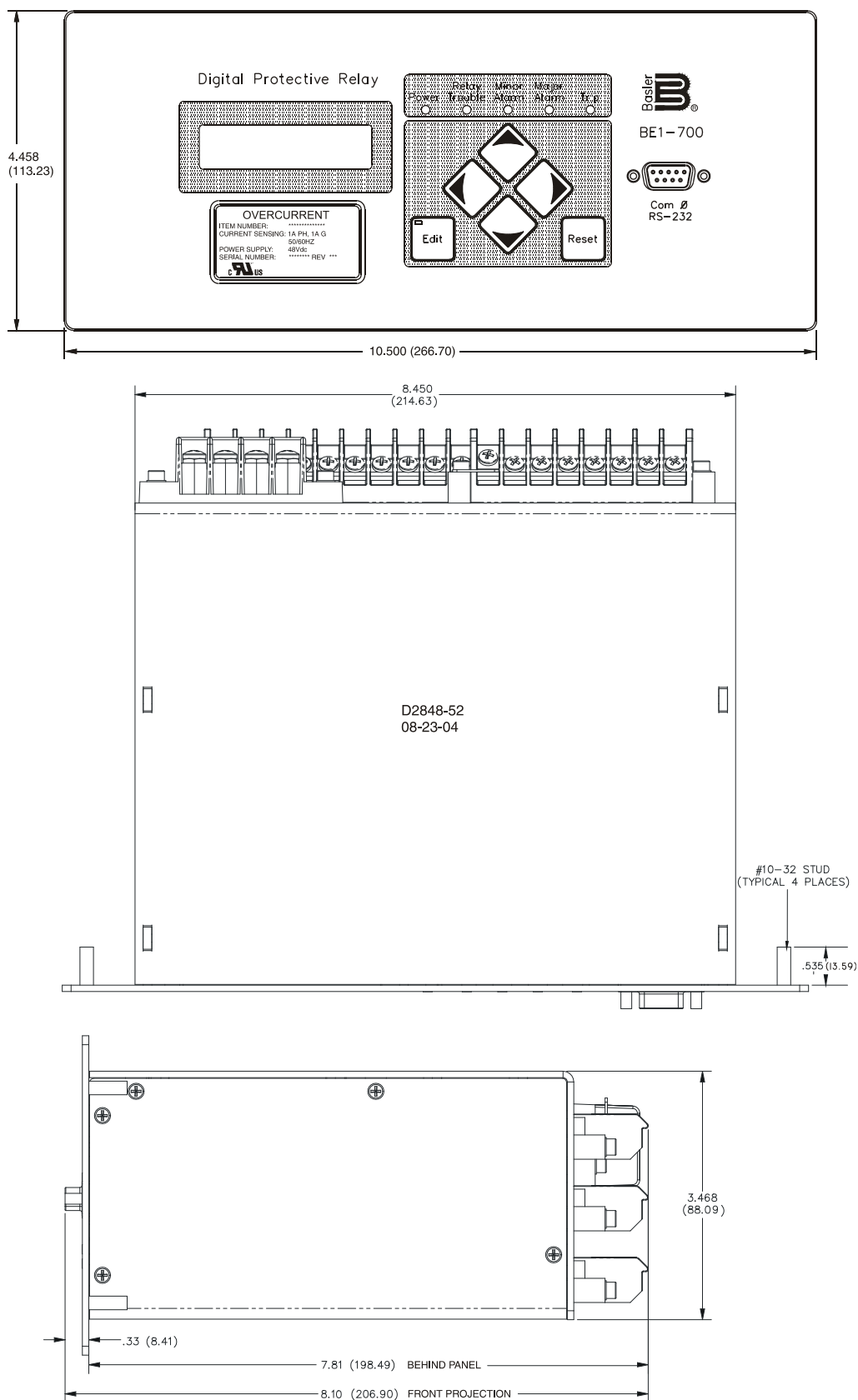
† AC voltage ranges are calculated using the default recognition time (4 ms) and debounce time (16 ms).

Mounting

Basler numeric relays are supplied in a Basler Electric “X” case. This is a panel-mount, non-drawout case that is mounted horizontally.

Case Cutouts and Dimensions

The case dimensions are shown in Figure 12-1. Mounting plate cutout and drilling dimensions for the relay are shown in Figure 12-2.



NOTE: The front panel shown is shown for a current relay.

Figure 12-1. Panel-Mount, Non-Drawout Case Dimensions (BE1-700C is shown)

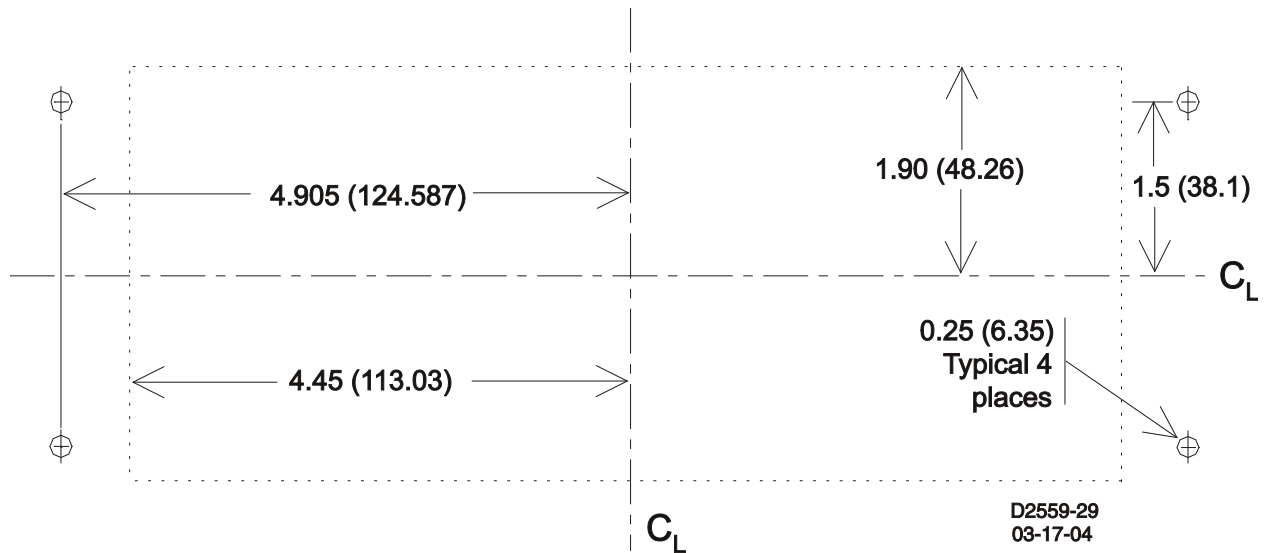


Figure 12-2. Relay Cutout Dimensions

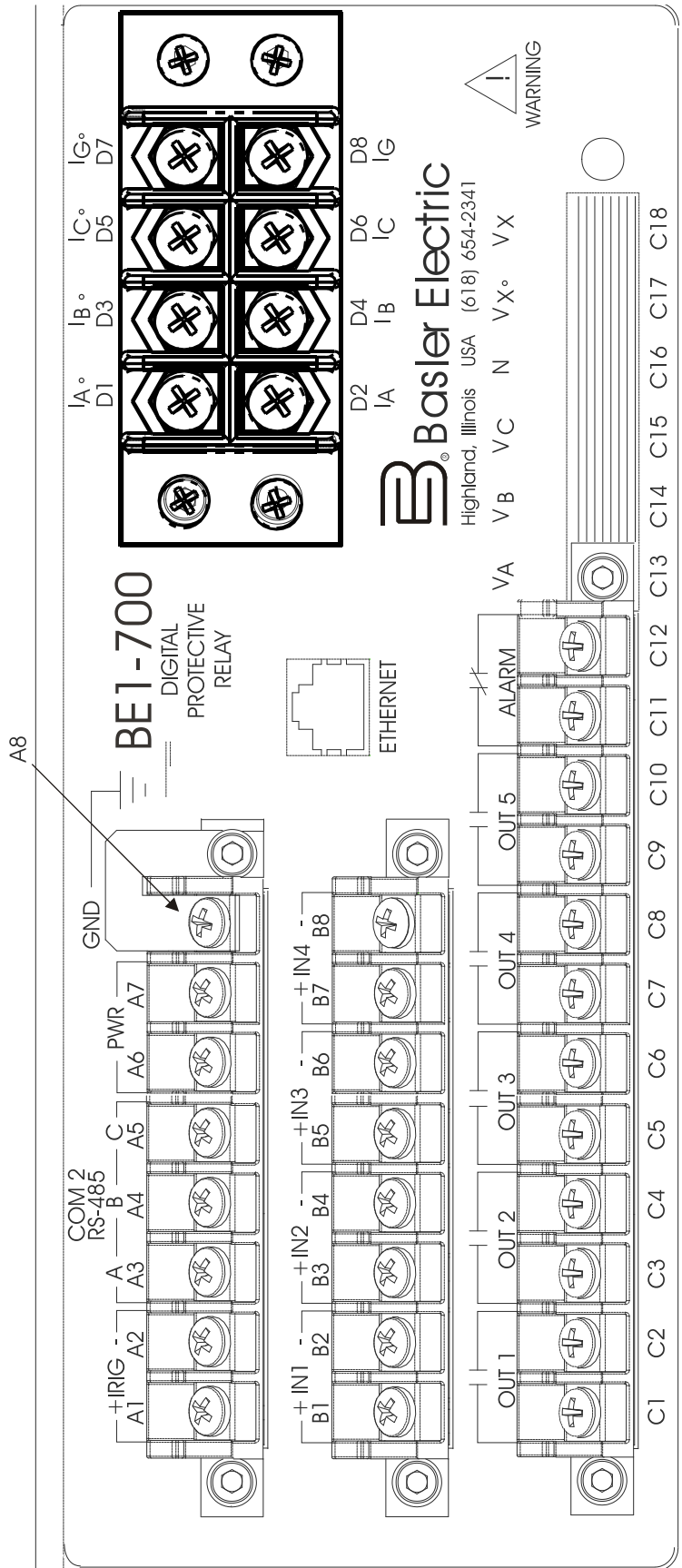
Relay Connections

Connections to the relay are dependent on the application and logic scheme selected by the user. As a result, not all of the relay's inputs and outputs may 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 charts in Figure 1-1 for available options. Be sure to use the correct input power for the specified power supply. Incorrect wiring may result in damage to the relay.

Figure 12-3 shows the rear panel connections for the current relay case and Figure 12-4 shows the rear panel connections for the voltage relay case.

Note

It is recommended in all applications where contact outputs drive relay coils that a reverse biased diode be implemented in parallel with the relay coil for EMI suppression.



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Figure 12-3. Rear Panel Terminal Connections, BE1-700C

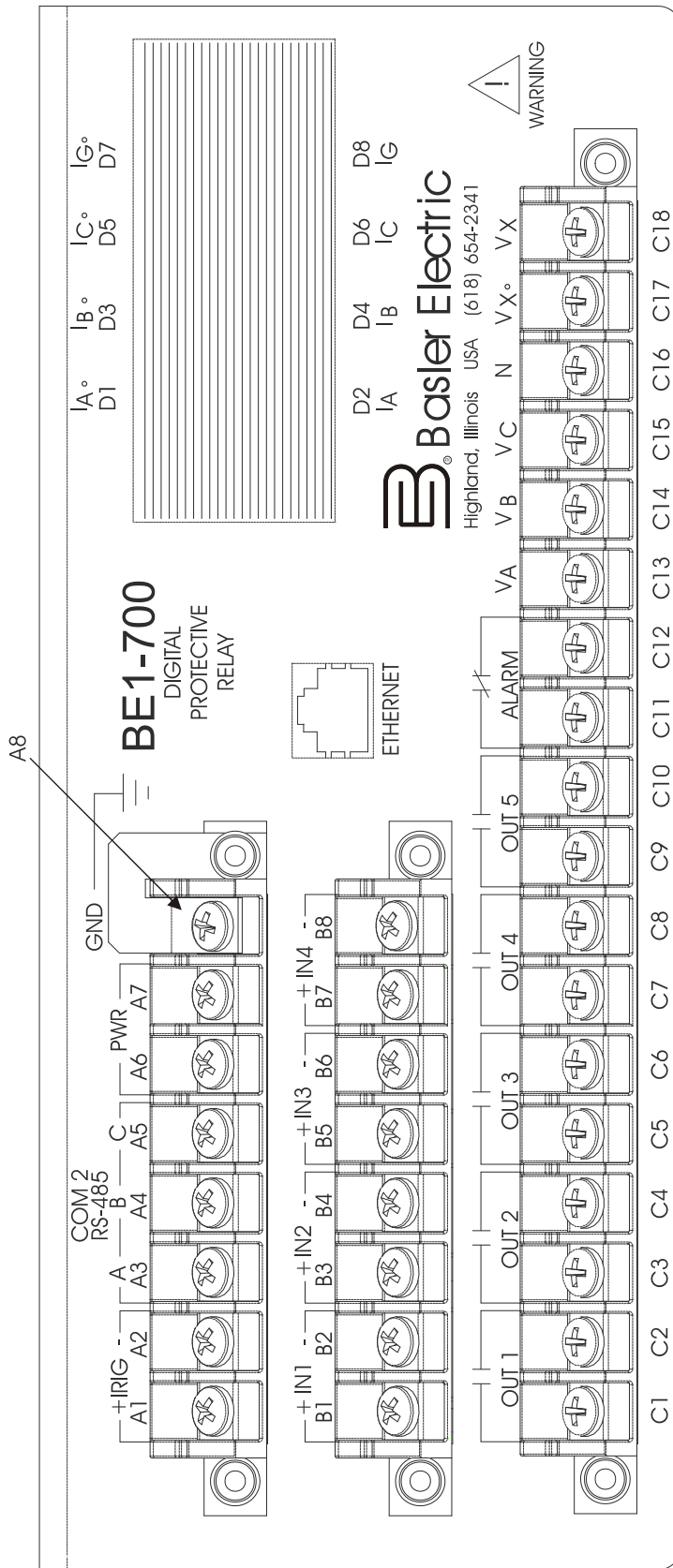


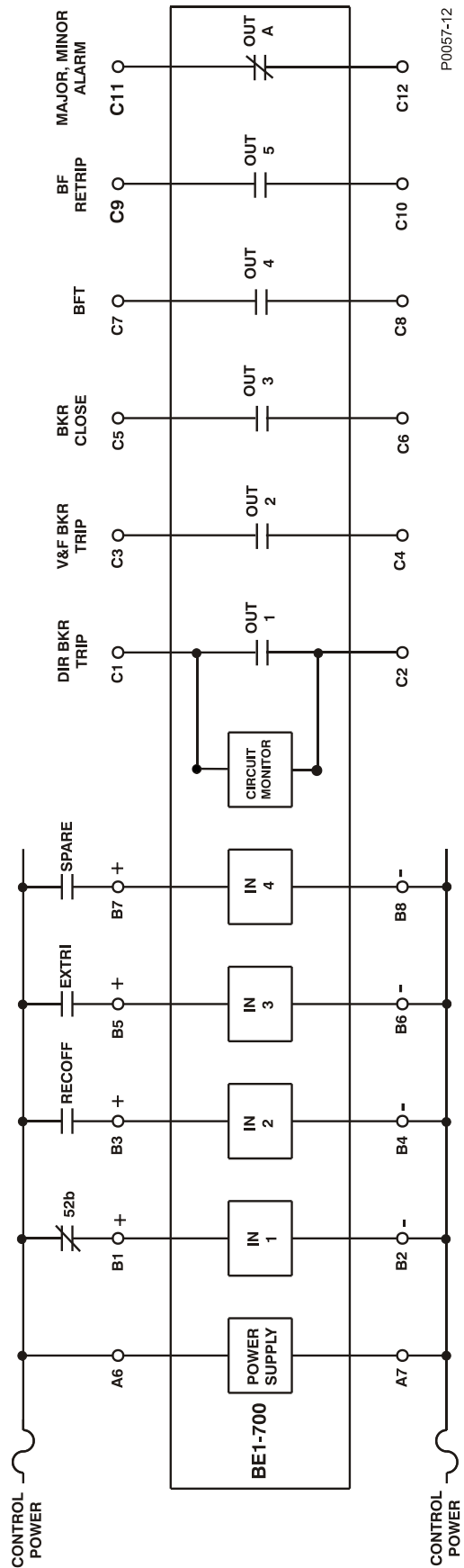
Figure 12-4. Rear Panel Terminal Connections, BE1-700V

Typical DC and AC Connections

Typical external dc and ac connections for the BE1-700 are shown in Figures 12-5 through 12-7.

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.



NOTE: Connections shown are for use with the “fully loaded” pre-programmed logic scheme. All inputs and outputs are fully programmable using BESTlogic.

Figure 12-5. Typical External DC Connections

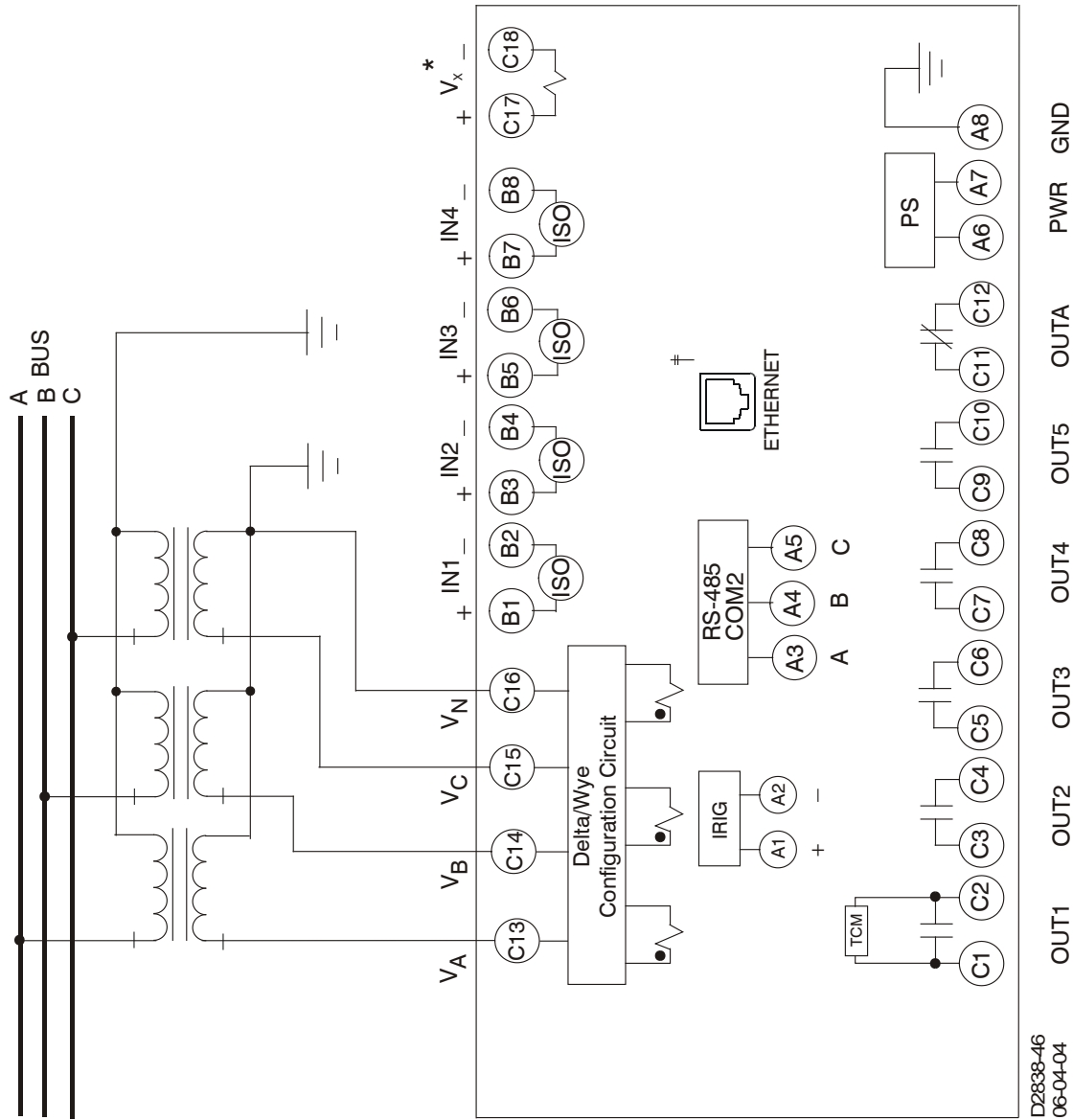


Figure 12-6. Typical AC Connections for BE1-700V

* V_x Auxiliary Input is included with Voltage Sensing Input Option 4.

† Ethernet Port (RJ45) is included with Communication Protocols Options 4 or 5.

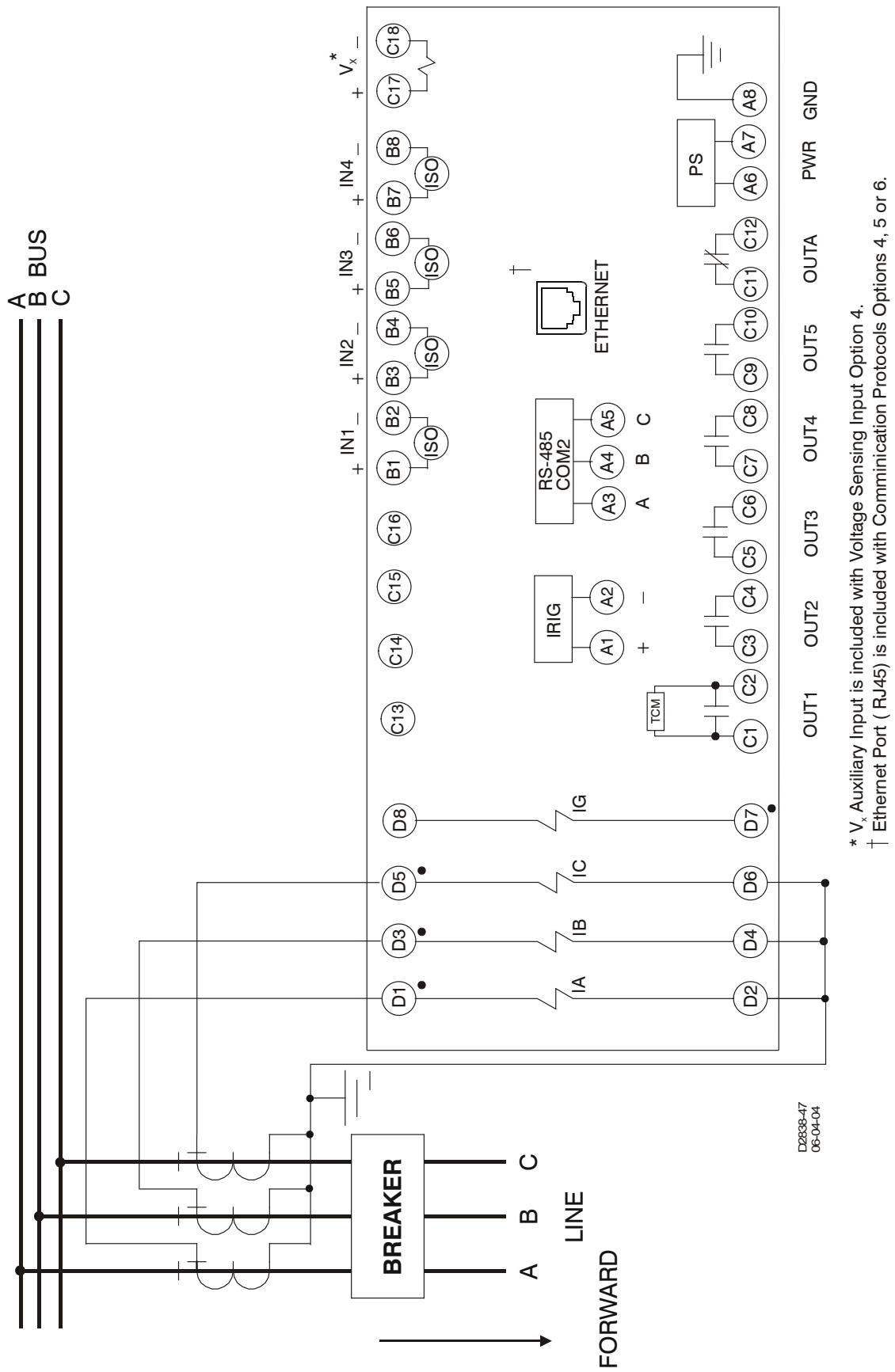


Figure 12-7. Typical AC Connections for BE1-700C

CT Polarity (BE1-700C)

CT polarity is critical to the proper operation of the BE1-700C. Fundamental information on CT polarity and protective relays is provided below.

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 12-8 and 12-9).

On occasion, however, protection engineers will run into situations where CT polarity is reversed for a specific application. That is, non-polarity of the CT secondary will be in phase with the primary current flow (Figure 12-10). 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.

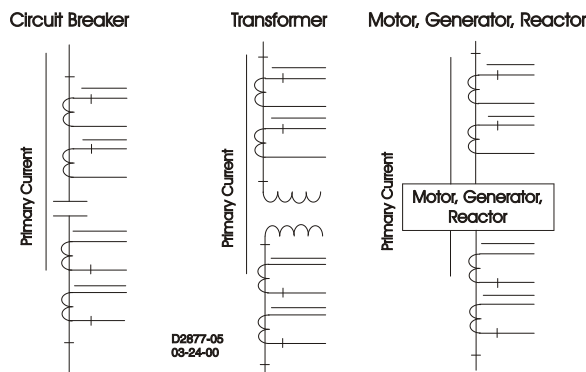


Figure 12-8. Standard CT Polarity

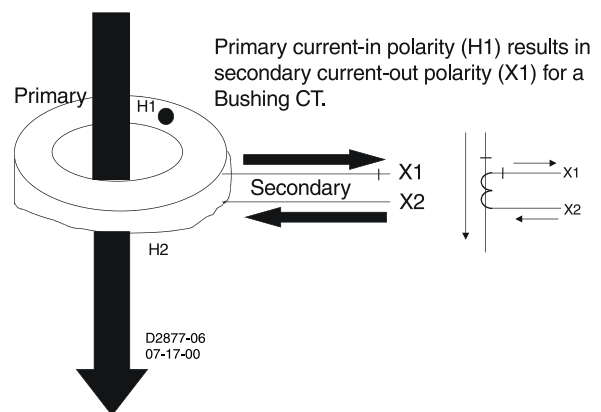


Figure 12-9. Current Transformer Action

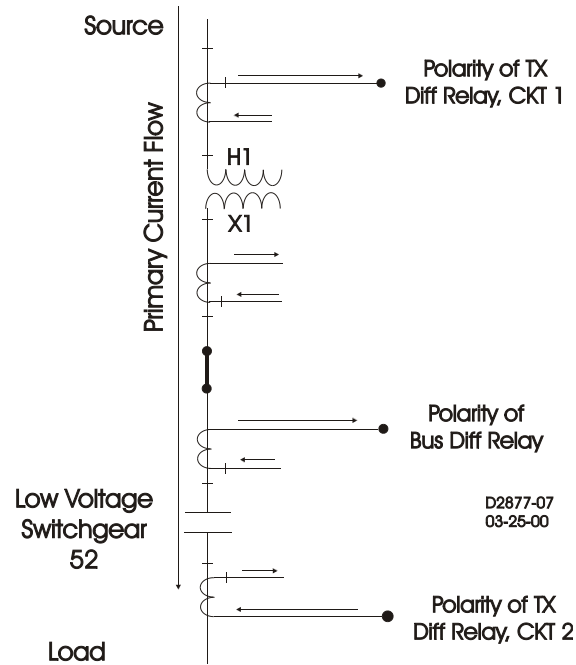


Figure 12-10. Example of Reversed CT Polarity

Terminal Blocks

There are two sizes of terminal blocks used on the “X” case design, the current circuit block and the input-output blocks. The current circuit terminal block is the larger of the two types and uses 8/32 inch Phillips head screws with lock washers. The input-output block is the smaller of the two types and uses 6/32 inch slot Phillips head screws with no washer.

As stated, the current circuit terminal block on the “X” case uses 8/32 Phillips head screws with lock washers. The lock washer is an integral part of the current circuit wiring system and should not be removed. Without the lock washer, the 8/32 screw may bottom out preventing a tight fit against the lug (screw feels tight but lug may move under the screw head).

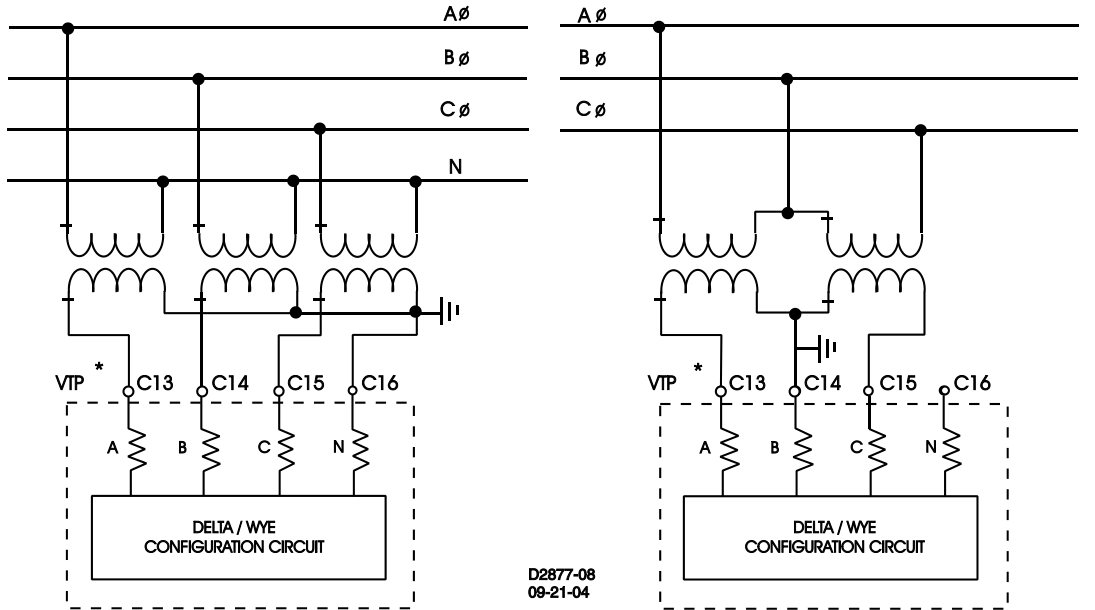
The maximum wire lug width accommodated by the current circuit terminal block on the “X” case is 0.344 inches (8.6 mm). The maximum wire lug width accommodated by the input-output block on the case is 0.320 inches (8.1 mm).

Note

Except as noted, relay connections should be made with a minimum wire size of #14 AWG.

Power System Applications

Figures 12-11 through 12-16 are examples of the applications that can be served by the Basler Electric BE1-700 series of products. Many of these applications can be used in concert with other Basler numeric systems.



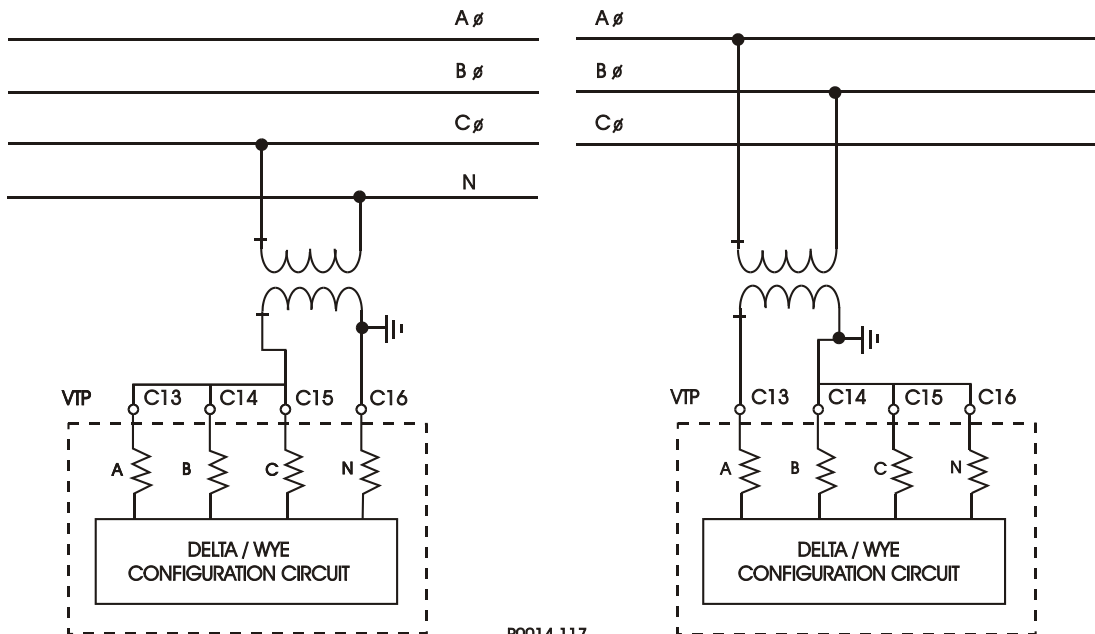
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A) 3 Phase VT 4 Wire Connection

Provides 3 element metering; 27P and 59P can be P-N or P-P. Provides negative and zero-sequence polarizing for ground faults (67N).

B) 3 Phase VT 3 Wire Connection

Provides 2 element metering; 27P and 59P are P-P; 59N (3Eo) is disabled, provides negative-sequence polarizing for ground faults (67N).



P0014-117
08-03-04

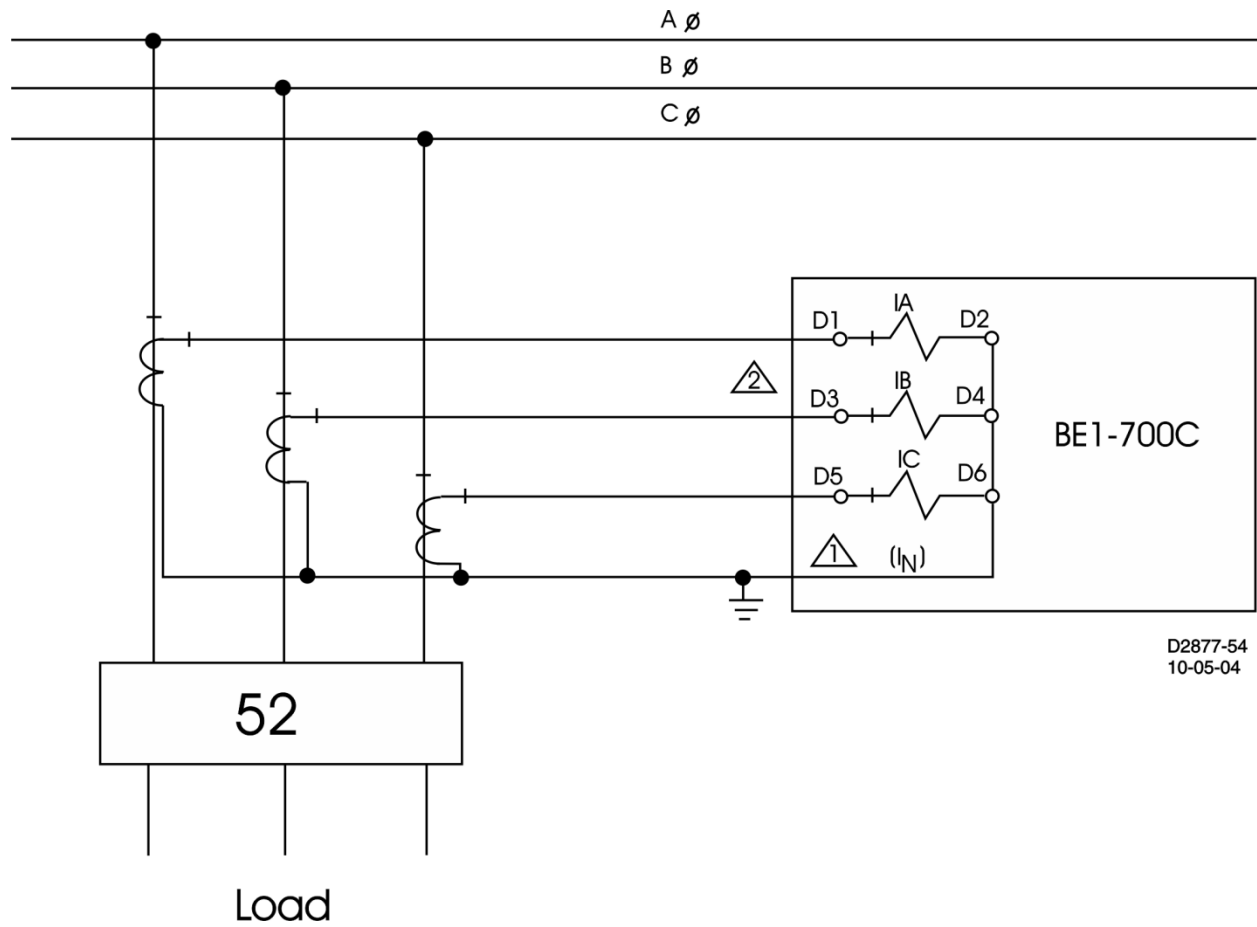
C) 1 Phase VT L-N Connection

VT primary can be connected to any phase, A-N, B-N, C-N. One element metering; 47 (V2) and 59N (3Eo) disabled. 27P and 59P are P-N.

D) 1 Phase VT L-L Connection

VT primary can be connected to any phase, A-B, B-C, C-A. One element metering (-30 degrees); 47 (V2) and 59N (3Eo) disabled; 27P and 59P are P-P.

Figure 12-11. Voltage Sensing, Alternate VTP Input (BE1-700V Only)

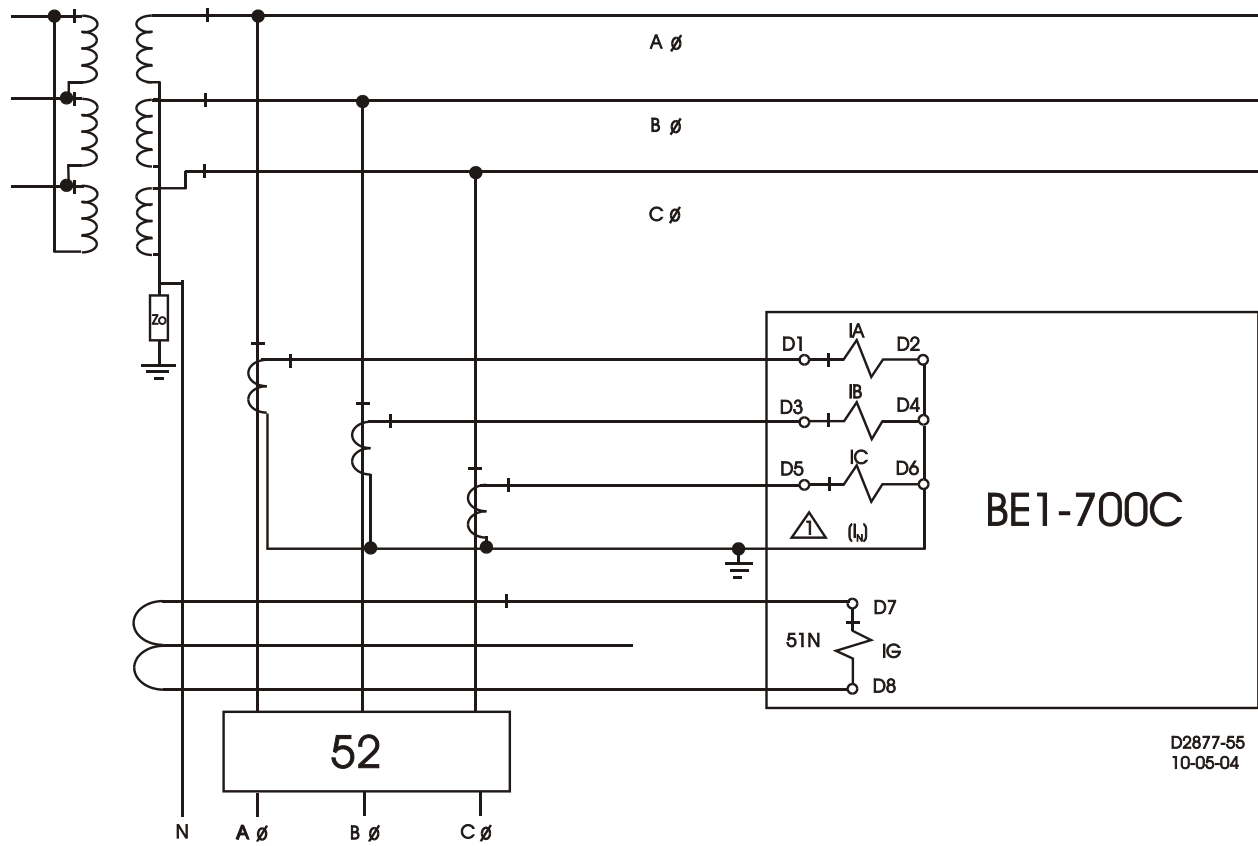


Contact Basler Electric for applications assistance.

Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_0$) current.

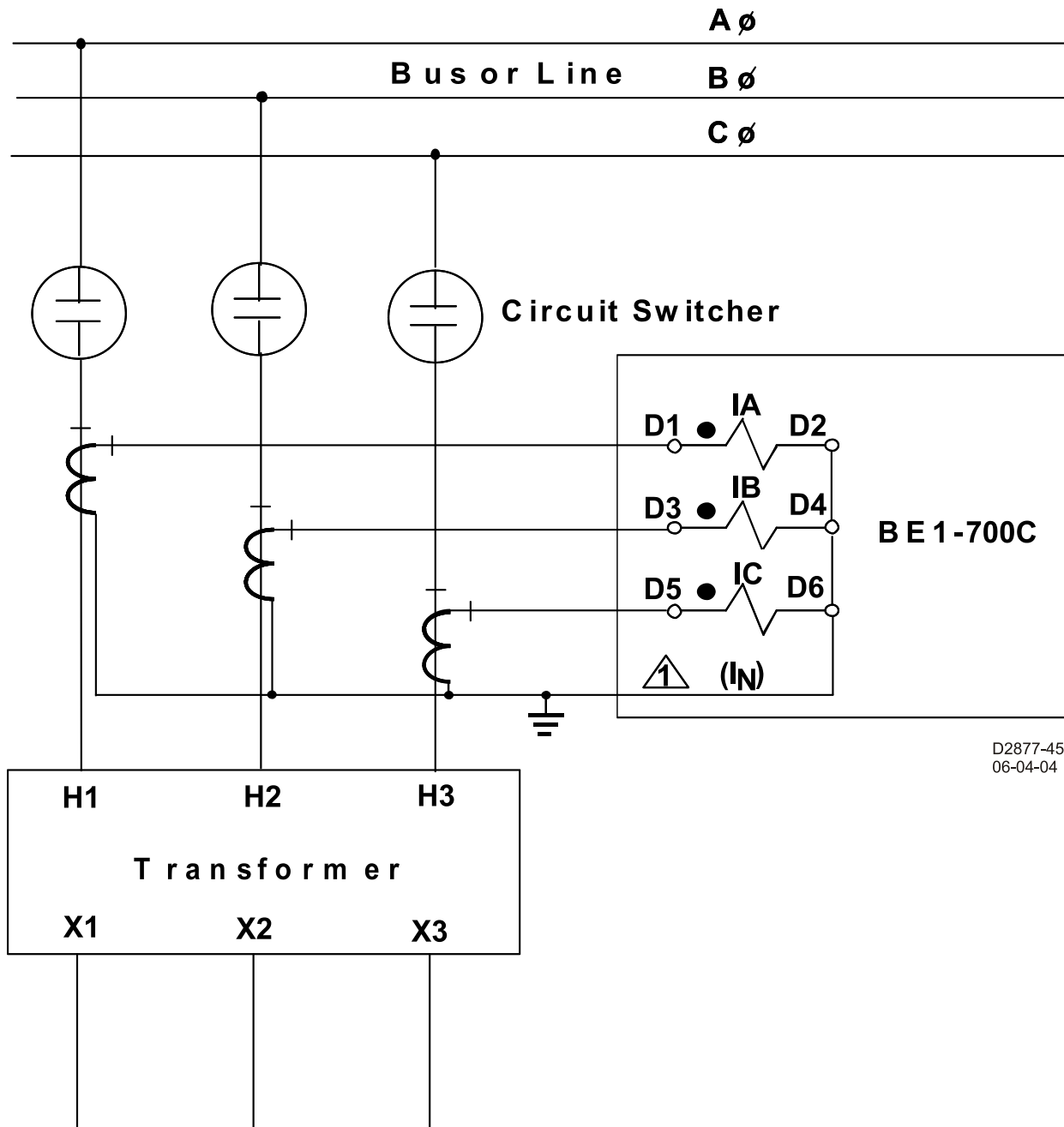
Figure 12-12. Overcurrent Protection of Typical Radial Loads - Distribution Circuit, Motor or Reactor



Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_0$) current.
2. Independent Ground Input (IG) supplied by a core balance CT.

Figure 12-13. Industrial Feeder, IG Connected to Core Balance CT for Sensitive Ground Fault Detection

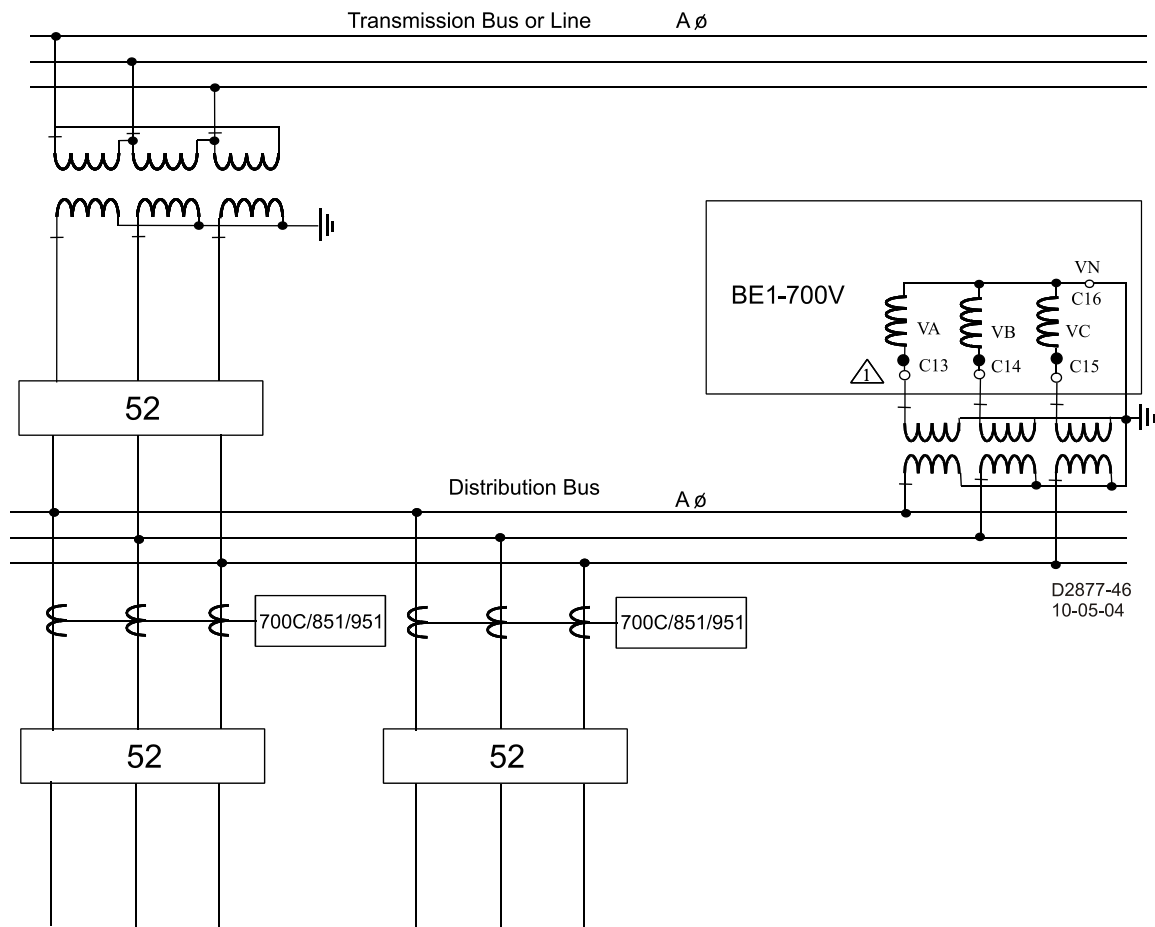


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Notes: Δ

1. The neutral ground (I_N) operates on internally calculated residual ($3I_0$) current.

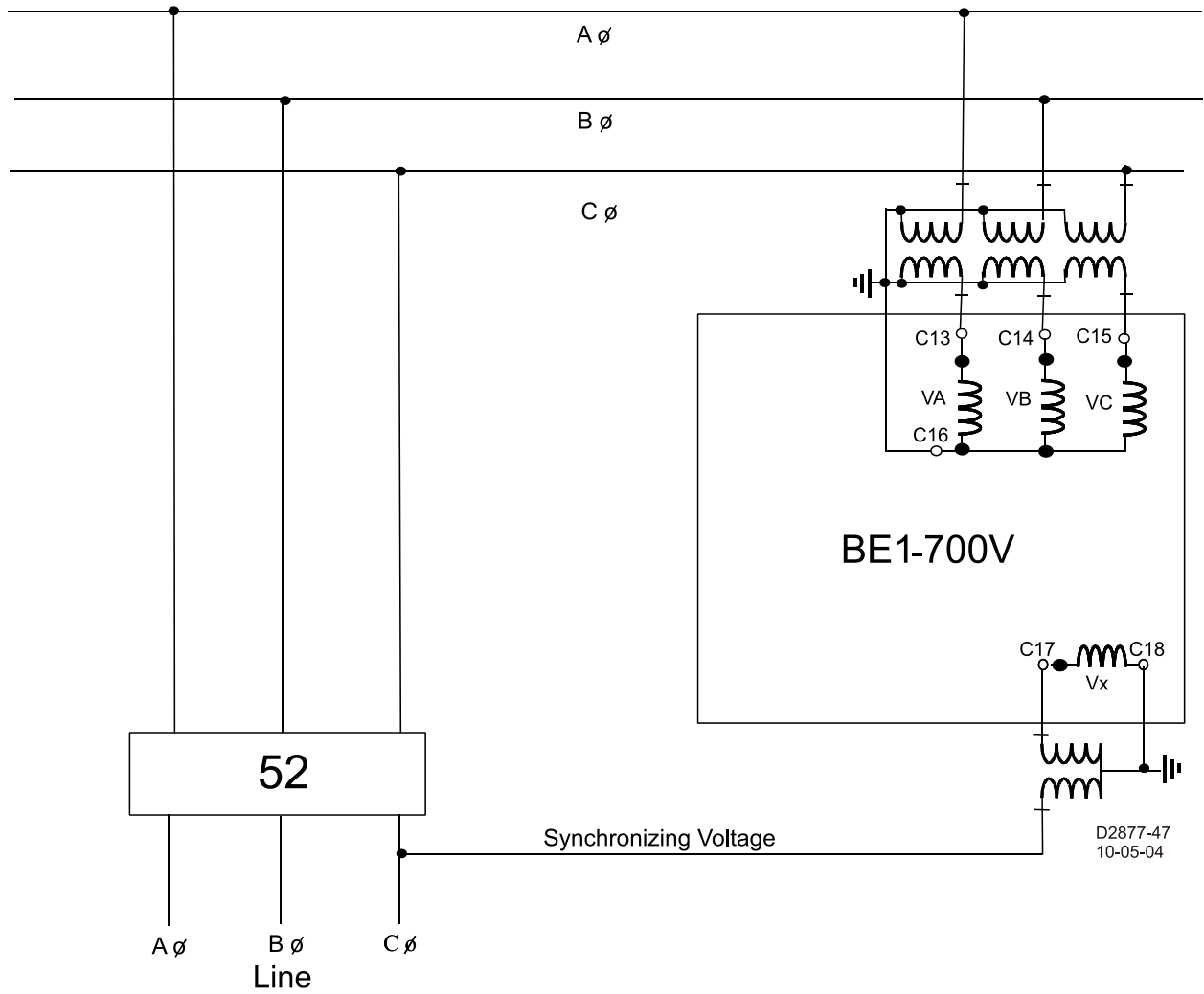
Figure 12-14. Transformer Overcurrent Protection



Notes: Δ

1. Potentials used for 24, 25, 27, 47, 59, 81, and 3EO detection. Four-wire connection is shown as typical. See Figure 12-11 for alternate VTP connections.

Figure 12-15. BE1-700V Bus Voltage Protection including UF Load Shed



Notes: Δ

1. This application requires the optional 79 and V_x input.

Figure 12-16. BE1-700V Network Reclosing Application

Settings

Settings for your application need to be entered and confirmed before placing the relay in service. Register settings such as breaker operations and breaker duty can be entered to match the current state of your system.

Preparing the Relay for Service

Basler microprocessor-based protection systems are similar in nature to a panel of electromechanical or solid-state component relays. Both must be wired together with inputs and outputs, and have operating settings applied. Logic settings determine which protection elements are electronically wired to the inputs and outputs of the device. Operating settings determine the pickup thresholds and time delays.

The logic and operating settings should be tested by applying actual inputs and operating quantities and verifying proper output response. For more details, refer to Section 13, *Testing and Maintenance*. All of the following connections and functions should be verified during commissioning tests:

- Proper connection and sensing of current and voltage signals
- Input and output contact connections
- I/O sensing versus virtual sensing
- Settings validation
- Proper operation of equipment (main or auxiliary)
- Proper alarming (to SCADA) and/or targeting

Refer to Section 7, *BESTlogic Programmable Logic*, for information about customizing preprogrammed logic and creating user-defined logic, and Section 8, *Application*, for information about the application of preprogrammed logic schemes.

Communications Connections

The following paragraphs describe the communication connections for the BE1-700. Section 11, *ASCII Command Interface*, provides information about using the relay communication interface and lists all communication commands along with a description and the syntax for each command.

RS-232 Connections

Front and optional rear panel RS-232 connectors are Data Communication Equipment (DCE) DB-9 female connectors. Connector pin numbers, functions, names, and signal directions are shown in Table 12-2 and Figure 12-17. RS-232 cable connection diagrams are provided in Figures 12-18 through 12-21. Optional Clear to Send (CTS) and Request to Send (RTS) connections are required only if hardware handshaking is enabled.

Table 12-2. RS-232 Pinouts (COM0)

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

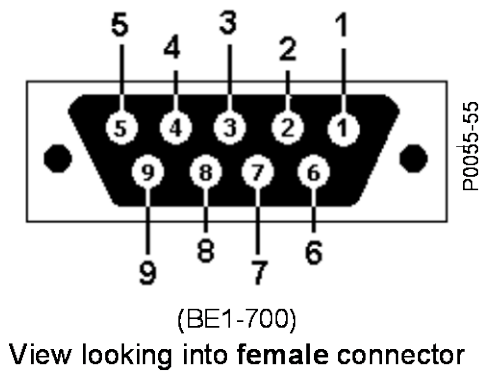


Figure 12-17. RS-232 Pin-outs

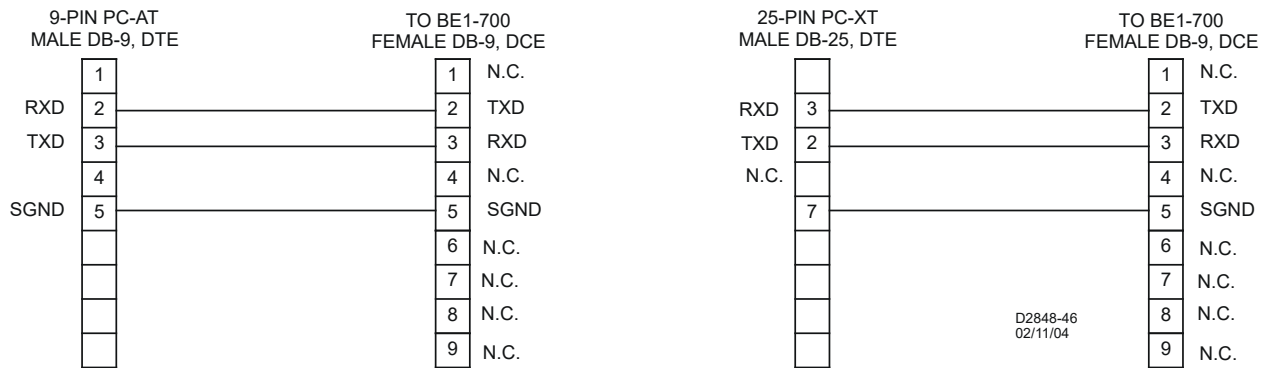


Figure 12-18. Personal Computer to BE1-700

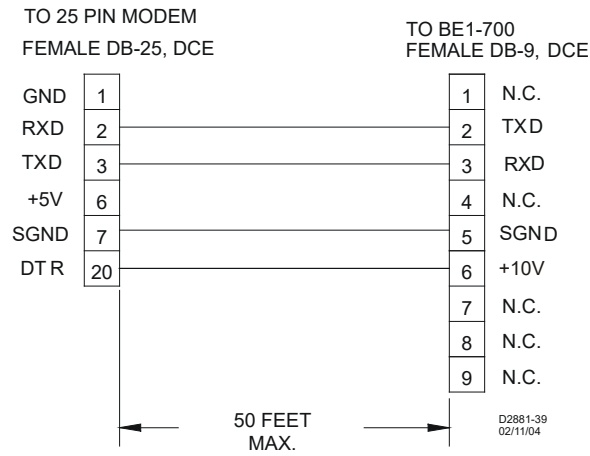


Figure 12-19. Modem to BE1-700

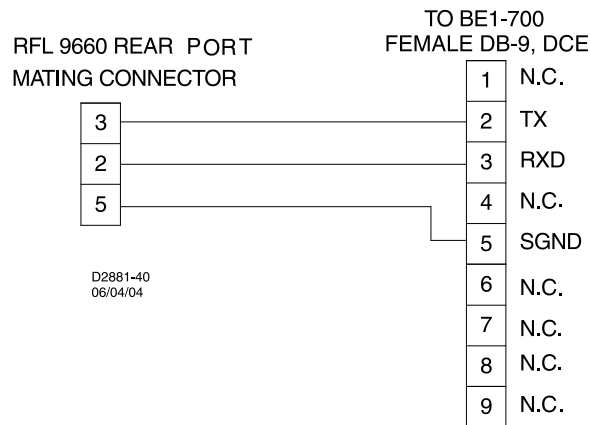


Figure 12-20. RFL9660 Protective Relay Switch to BE1-700 Cable

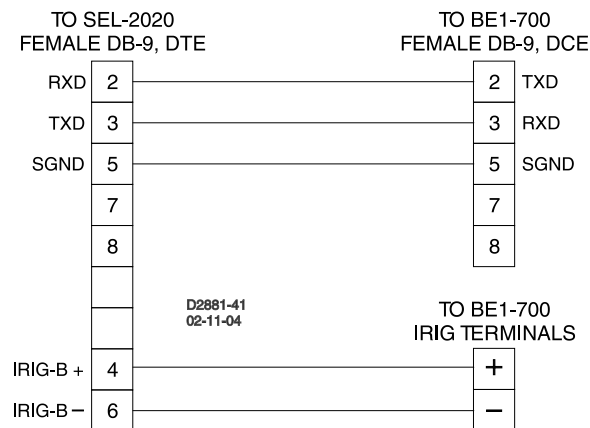


Figure 12-21. SEL-2020 to BE1-700

RS-485 Connections

RS-485 connections are made at a three-position terminal block connector that mates with a standard communication cable. A twisted pair cable is recommended. Connector pin numbers, functions, names, and signal directions are shown in Table 12-3. An RS-485 connection diagram is provided in Figure 12-22.

Table 12-3. RS-485 Pinouts (COM2)

Terminal	Function	Name	Direction
A	Send/Receive A	(SDA/RDA)	In/Out
B	Send/Receive B	(SDB/RDB)	In/Out
C	Signal Ground	(GND)	N/A

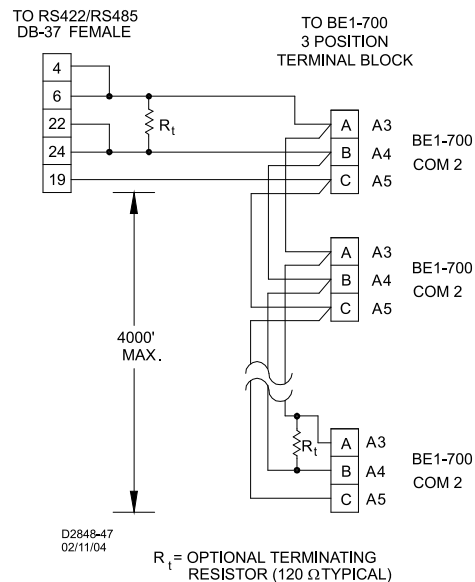


Figure 12-22. RS-485 DB-37 to BE1-700

Ethernet Connections

BE1-700 relays with style numbers xxxxx4x, xxxxx5x, and xxxxx7x have a rear-panel Ethernet port that communicates using ASCII commands. The 10BaseT port is an eight-pin RJ-45 connector that connects to Cat 5 / Cat 5e shielded twisted pair wire media.

Note

For security reasons, all change passwords are disabled by default on the optional Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port. See Section 9, *Security*, for details.

ASCII Command Communication

ASCII communication byte-framing parameters are fixed at 8 data bits, no parity, and 1 stop bit. Additional ASCII communication protocol parameters are settable. Baud rate and address are settable from the ASCII command interface using the SG-COM command. These parameters can also be set at human-machine interface (HMI) Screen 6.1.x. Several additional settings are available to further customize ASCII communications. These settings are described Section 9, *Security*. Additional parameters for Page Length, Reply Acknowledge, and Software Handshaking can be changed only through the ASCII command interface using the SG-COM command.

IRIG Input and Connections

The IRIG input is fully isolated and supports IRIG Standard 200-98, Format B002. The demodulated (dc level-shifted) input signal must be 3.5 volts or higher to be recognized as a high logic level. The maximum acceptable input voltage range is +10 volts or -10 volts (a 20-volt range). Input burden is nonlinear and rated at approximately 4 k Ω at 3.5 Vdc and approximately 3 k Ω at 20 Vdc.

IRIG connections are located on a terminal block shared with the RS-485 and input power terminals. A twisted-pair cable with shield grounded at the unit is recommended. Terminal designations and functions are shown in Table 12-4.

Table 12-4. IRIG Terminal Assignments

Terminal	Function
A1	(+) Signal
A2	(-) Reference

13 • Testing and Maintenance

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 because of its fault and event recording capability, the test is 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 BE1-700 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 BE1-700 relay is a microprocessor-based relay whose operating characteristics will not change over time. The relay will also not experience any change in operating characteristics during transit. However, it remains material that the user perform these acceptance tests to verify the device has not suffered any degradation in transit. Basler Electric warrants all products against any decay in performance outside of the published specified tolerances that result from problems created during transit.

Commissioning Testing

Commissioning testing verifies all physical connections and functional aspects of the protective relay for a new installation. This includes a thorough review and documentation of the operational settings to verify that the users calculated values match the actual values on each enabled protection element of the relay. All of the following connections or functions can be verified during commissioning tests:

- Proper connection and sensing of current and voltage signals as applicable
- Connections of I/O contacts
- I/O sensing versus virtual sensing
- Setting validation
- Proper operation of equipment (main or auxiliary)
- Proper alarming (to SCADA) and/or targeting

Periodic Testing

Periodic testing can be performed at regularly scheduled intervals or upon an indication of problems or questionable operations within the relay. Verifying the integrity of the relay's performance, short of playback of recorded events, may be necessary by performing certain tests similar to those accomplished in the acceptance tests. Verification that the relay is measuring signals faithfully, that relay logic is appropriate, and, that protective elements and equipment (main or auxiliary) operate correctly, are goals that can be achieved during this type of testing.

Basler Electric recommends that all captured fault records and sequence of event records be analyzed and kept on file as in-service periodic test results for this particular device. This is an indication that all protective elements and the associated equipment are operating satisfactorily.

It is not the intent of this manual to elaborate on every conceivable test possible since this would encroach on individual preferences, techniques, and philosophies. It is the intent to pursue relevant testing methods to verify this relay meets published design specifications and applicability.

Functional Testing

Functional (or application) testing is significantly more comprehensive in nature and is intended to test suitability for a particular application. Functional testing also provides a means to familiarize the user with the logic and operation of this device. Test setups are generally more involved and often times include ancillary equipment beyond voltage or current source type equipment. While economics may at times prohibit full functional testing, it is recommended that some application testing be performed when published specifications lack appropriate detail to satisfy application testing requirements.

Basler Electric performs a thorough and comprehensive functional test of all relays before shipping. This ensures that this device is within specified tolerances, measures accurately, and operates correctly as designed.

Testing and Troubleshooting Aids

Under test or in-service, the BE1-700 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 subject to a re-creation of captured events with the aid of equipment capable of replicating COMTRADE record files. In these instances, there is significant merit in testing relays in this manner to assess relay performance. Correct response of relay action in a performance test is supplemental verification of the conclusions drawn from functional (or application) tests.

This type of testing verifies not only whether or not the device operated correctly for a particular system disturbance but also offers additional confirmation of your protection philosophy in this application. It is beyond the scope of this manual to develop performance tests for this device. For assistance in developing these types of tests, please consult Basler Electric and your test equipment.

Relay Self-Test

All internal circuitry and software that affect the relay core functionality are monitored by the continuous self-test diagnostics. For specific relay trouble alarms, the self-test diagnostics force the microprocessor to reset and try to correct the problem. If unsuccessful, OUTA operates, the Relay Trouble LED on the

front panel turns on, all of the output relays are disabled, internal logic Point ALMREL is set, and the relay is taken off line. For more information on self-test diagnostics and relay trouble alarms, see Section 6, *Reporting and Alarm Functions, Alarms Function*.

Status Reporting Features

General status reporting is available through the ASCII command interface using the RG-STAT (report general, status) command. This report assembles all of the information required to determine the relay status. For more information on general status reporting, see Section 6, *Reporting and Alarm Functions, General Status Reporting, General Status Report*.

Fault reporting and target data is dependent on the proper setting of trip, pickup, and logic trigger expressions (via the SG-TRIGGER command) and the assignment of protective elements to be logged as targets (via the SG-TARG command).

While the design of the relay facilitates obtaining and verifying targets and event data, it is not always necessary to utilize the relay functions to determine if the device operated while testing. You may simply use an ohmmeter or continuity tester to monitor the output contact status.

The following is a summary of ASCII commands where target and event data may be viewed:

- RF provides a directory of fault summary reports in memory
- RF-# provides a summary report giving targets, timing and event data
- RG-TARG provides target data only
- RS provides a summary of sequence of events records
- RS-F# provides a detailed SER report for the selected fault event number
- RS-# provides a detailed SER report on the last numbered events

For more information on human-machine interface (HMI) menu trees, see Section 10, *Human-Machine Interface*. In addition, much of this information can be accessed through BESTCOMS™. See Section 14, *BESTCOMS Software*, for details.

Event Reporting Features

The SER function of the relay records protective element output changes, overcurrent element pickup or dropout, input/output contact state changes, logic triggers, setting group changes, and setting changes. For more information on event reporting, see Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder*.

The following summarizes the reporting capabilities of the relay through the front panel HMI:

- Trip LED (Flashing): flashes during pickup of protective elements based on the pickup logic expression set in the SG-TRIGGER command.
- Trip LED (sealed-in): stays lit after trip logic becomes TRUE based on the trip logic expression set in the SG-TRIGGER command.
- TARGETS, Screen 1.2: Provides target data.
- ALARMS, Screen 1.3: Provides alarm data (including BKR FAIL, REC FAIL and REC LO).
- FAULT REPORTS, Screen 4.1: Indicates new fault reports
- EVENT REPORT, Screen 4.2: Gives the number of new events logged by the SER since the last new counter reset (executed only by the RS=0 command). Events must be viewed using the RS and RS# commands listed in the previous paragraph.

Acceptance Testing

Although Basler Electric performs detailed acceptance testing on all new relays, it is generally recommended that you perform each of the following acceptance test steps before installation. Performing these steps tests each function of the BE1-700 relay to validate that the relay was manufactured properly and that no degradation of performance occurred because of shipping. ASCII communication is discussed throughout this section but BESTCOMS can also be used for the majority of settings and tests. See Section 14, *BESTCOMS Software*, for details.

Test Equipment

Suitable test equipment requires a minimum of two current source elements, two voltage source elements, and a contact wetting voltage. Test equipment should also have the capability of varying the frequency and the angle of the voltage and current sources.

Refer to Figure 12-3 for a BE1-700C and Figure 12-4 for a BE1-700V.

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
BE1-700-xxx1xxN	48 Vdc
BE1-700-xxx2xxN	125 Vac/dc
BE1-700-xxx3xxN	24 Vdc
BE1-700-xxx4xxN	250 Vac/dc
BE1-700-xxx5xxN	125 Vac/dc *

* Extended holdup option. See Style Chart in Section 1, *General Information*.

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 BE1-700 relay communicates through Com ports 0 and 2.

Reference Commands: ACCESS, EXIT

To communicate with the BE1-700 through COM0 or COM2, use a terminal emulation program such as BESTCOMS - Basler Terminal running on a personal computer (PC) with a serial port that is suitable for communications. The relay communication default settings are:

- Baud Rate = 9,600 bps
- Data Bits = 8
- Stop Bit = 1
- Parity = None
- Flow Control = Xon/Xoff

Set Up the Relay to Communicate with the PC

Step 1: Depress the *Up* arrow pushbutton on the front panel HMI until the top level of the menu tree is reached. Depress the *Left/Right* arrow pushbuttons until Screen 6, *General Settings*, appears. Next, depress the *Down* arrow pushbutton twice to get to Screen 6.1.1, *COM0 F-232*. This screen displays the baud rate for the front panel communication port (COM0). Verify that the baud rate is 9,600 bps (9.6 Kbps).

Step 2: Connect the serial cable between the PC and the front RS-232 port on the relay.

Step 3: Initiate the communication program for your computer.

- Step 4: Transmit the command ACCESS= (you may use the shortcut keystrokes and just enter a=).
RESULT: The relay should respond with ACCESS GRANTED: GLOBAL.
- Step 5: Transmit EXIT.
- Step 6: 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 BE1-700 relay model number, style number, and current software program version matches the unit and unit labels.

Reference Commands: RG-VER

- Step 1: Through COM0, transmit the command RG-VER. The BE1-700 relay should respond with the model number, style number, application program version and date, boot program version and date, the relay serial number, and Ethernet information (for style numbers xxxxx4x and xxxxx5x). Verify that all reported data is current, appropriate and matches the label on the relay front panel.

IRIG Verification (if used)

Purpose: To verify that the BE1-700 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 BE1-700 relay senses hardware input and output status.

Reference Commands: ACCESS, CO-OUT, CS-OUT, EXIT, RG-STAT

- Step 1: Apply an external voltage source within the range of the voltages listed in Table 13-2 to Contact Sensing Inputs IN1, IN2, IN3, and IN4.

Table 13-2. Contact Sensing Turn-On Voltage

Nominal Control Voltage	Contact Sensing Turn-On Voltage
24 Vdc	Approx. 5 Vdc
48 Vdc	26 to 38 Vdc
125 Vdc	69 to 100 Vdc
250 Vdc	138 to 200 Vdc

- Step 2: To verify that all inputs have been detected, transmit the command RG-STAT to retrieve INPUT (1234) information. Input status can also be viewed at HMI Screen 1.4.1.

Control Outputs

- Step 1: Transmit the commands ACCESS=, CS-OUT=ENA, CO-OUT=ENA, EXIT, and YES to enable the output control override capability of the relay in order to pulse each output contact.
- Step 2: From the HMI keypad, navigate to Screen (Output Control Override) to override control of the outputs via the keypad.
- Step 3: Once you have accessed the screen, press the *Edit* pushbutton to enable the override function (Step 1 enables logic override, pressing the *Edit* pushbutton enables selecting the control action). Select an output to override by using the *LEFT/RIGHT* arrow pushbuttons. Once

selected, use the *UP/DOWN* arrow pushbuttons to choose the type of action (P, 1, or 0) for the selected output contact. Select the pulse (P) action for the alarm contact (A). Pressing the *Edit* pushbutton again will force the alarm output contact action.

- Step 4: Verify that the sequence of events recorder logged the events by sending the command RS-2 to the relay (requesting the last two events it logged). The close-open pulse action should be listed as two separate events.
- Step 5: Repeat Step 3 for all desired output contacts and verify that the sequence of events recorder logged the events.
- Step 6: Transmit the commands CS-OUT=DIS, CO-OUT=DIS, EXIT, and YES to disable the output control override capability of the relay.

Current Circuit Verification (BE1-700C)

- 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 $\pm 1.5\%$. (For example, if the applied value equals 2 amps, $IQ = 2/3 = 0.667$ amps $\pm 1.5\%$ or ± 0.01 amps.) Verify current measuring accuracy by transmitting the M command to the relay for each applied current value. HMI Screen 3.7 also can be used to verify the IN and IQ current measurements.

Table 13-3. Current Circuit Verification Values

Sensing Type	Applied Current	Measured Current	
		Lower Limit	Upper Limit
1 A	0.25 Aac	0.2475 Aac	0.2525 Aac
	1 Aac	0.99 Aac	1.01 Aac
	2 Aac	1.98 Aac	2.02 Aac
	3 Aac	2.97 Aac	3.03 Aac
	4 Aac	3.96 Aac	4.04 Aac
5 A	1 Aac	0.99 Aac	1.01 Aac
	5 Aac	4.95 Aac	5.05 Aac
	10 Aac	9.90 Aac	10.10 Aac
	15 Aac	14.85 Aac	15.15 Aac
	20 Aac	19.80 Aac	20.20 Aac

- Step 3: To verify IP and IG, connect a suitably sized jumper wire across relay Terminals D2 and D3, D4 and D5, and D6 and D7. Apply an ac current source to Terminals D1 and D8.
- Step 4: Apply the appropriate current values in Table 13-3 to the relay. Verify current measuring accuracy by transmitting the M command to the relay for each applied current value. HMI Screens 3.5 and 3.6 also can be used to verify current measurements. Screen 3.7, IN, will read 3 times the phase value.
- Step 5: Leave current circuit connected and de-energized. These test connections will be used later when verifying power readings.

Three-Phase Voltage Circuit Verification (BE1-700V)

- Step 1: Connect an ac voltage source at nominal frequency between relay Terminals C13 (A-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by transmitting the M command to the relay. Readings should be: M-VA = 100 volts, M-VAB = 100 volts, M-VCA = 100 volts, M-3V0 = 100 volts, and M-V2 = 33.4 volts (applied divided by 3), all at $\pm 1.0\%$. HMI Screens 3.1, 3.2, and 3.4 can also be monitored to verify voltage measurements.

- Step 2: Connect an ac voltage source at nominal frequency between relay Terminals C14 (B-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by transmitting the M command to the relay. Readings should be: M-VB = 100 volts, M-VAB = 100 volts, M-VBC = 100 volts, M-3V0 = 100 volts, and M-V2 = 33.4 volts (applied divided by 3), all at $\pm 1.0\%$. HMI Screens 3.1, 3.2, and 3.4 can also be monitored to verify voltage measurements.
- Step 3: Connect an ac voltage source at nominal frequency between relay Terminals C15 (C-phase) and C16 (Neutral Terminal). Apply 100 volts and verify voltage-measuring accuracy by transmitting the M command to the relay. Readings should be: M-VC = 100 volts, M-VBC = 100 volts, M-VCA = 100 volts, M-3V0 = 100 volts, and M-V2 = 33.4 volts (applied divided by 3), all at $\pm 1.0\%$. HMI Screens 3.1, 3.2, and 3.4 can also be monitored to verify voltage measurements.
- Step 4: Connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Connect an ac voltage source at nominal frequency to the three jumpered terminals and the Neutral Terminal (C16).
- Step 5: Apply the voltage values listed in Table 13-4 and verify voltage measuring accuracy by transmitting the M command to the relay. HMI Screen 3.1 can also be monitored to verify voltage measurements or the *Metering* screen of BESTCOMS.

Table 13-4. Voltage Circuit Verification Values

Applied Voltage	Measured Voltage	
	Lower Limit	Upper Limit
80 volts	79.2 V	80.8 V
100 volts	99.0 V	101.0 V
120 volts	118.8 V	121.2 V
140 volts	138.6 V	141.4 V
160 volts	156.8 V	163.2 V

Auxiliary Voltage Input Verification - VX and VX 3rd (Fundamental and Third Harmonic) (BE1-700V)

- Step 1: Connect relay Terminals C17 (polarity) and C18 to a 60 hertz ac voltage source.
- Step 2: Apply the voltage values listed in Table 13-5 and verify voltage-measuring accuracy by transmitting the M-V command to the relay. BESTCOMS Metering or HMI Screens 3.3 can also be monitored to verify VX voltage measurements.
- Step 3: Connect relay Terminals C17 (polarity) and C18 to a 180-hertz (third harmonic) ac voltage source.
- Step 4: Apply the voltage values listed in Table 13-5 and verify voltage-measuring accuracy by transmitting the M command to the relay. BESTCOMS Metering or HMI Screen 3.3 can also be monitored to verify VX voltage measurements.

Table 13-5. Aux Voltage Circuit Verification VX & VX 3rd Values

Applied Voltage	Measured Voltage	
	Lower Limit	Upper Limit
5 Vac	4.95 Vac	5.05 Vac
20 Vac	19.8 Vac	20.2 Vac
60 Vac	59.4 Vac	60.6 Vac
80 Vac	79.2 Vac	80.8 Vac
120 Vac	118.8 Vac	121.2 Vac

Line and Bus Angle, Frequency, and Slip Verification

- Connect relay Terminals C13 (polarity) and C16 (A to Neutral of the three-phase voltage input) to a 60-hertz ac voltage source (line voltage).
- Connect relay Terminals C17 (polarity) and C18 (auxiliary voltage input) to a second 60-hertz ac voltage source (bus voltage).
- Apply 115 volts at 0 degrees and 60 hertz to both sources. Verify the measuring accuracy of the line and bus frequency, angle between the two voltages and slip frequency by transmitting the M command to the relay. HMI Screens 3.10 and 3.11 can also be monitored to verify the measurements.
- Vary the angle of the line voltage and verify the measured angle as in Step 3. Polarity of the angle measurement is relative to the angle of the line voltage. That is, if the line voltage lags the bus voltage by 30 degrees, the sign of the angle will be negative or –30 degrees. When the line voltage leads, the angle has no sign and is assumed to be positive.
- Return the line voltage angle to 0 degrees. Vary the frequency of the line voltage and verify the measured slip as in Step 3. (Note that the angle shown on HMI Screen 3.11 is continuously changing as a result of slip between the two systems. This is normal). Polarity of the slip frequency is relative to the frequency of the line. That is, if the line frequency is 58 hertz and the bus frequency is 60 hertz, the slip frequency is –2. As soon as the line frequency rises above 60 hertz, slip frequency has no sign and is assumed to be positive.

Commissioning Testing

Because the commissioning of this relay may be a new installation or a retrofit, special precautions should be taken to ensure that all tests are performed with safety as the utmost concern. Any CT circuit signals that are routed through this device as part of a protection scheme including discrete relays or as a stand-alone device should be shorted and isolated from this relay during these tests until the final instrument transformer current circuit check.

If this relay is being installed in an existing installation, please be aware of the equipment monitoring features of this device, especially if the monitoring logic will be utilized. Please make note of any pretest operation levels, duty levels, etc. on existing equipment (e.g., breakers or transformers). As the user, you may make the determination of what values the relay should have as initial monitoring values when the relay is placed in service.

Also, please be aware that because of the multi-function nature of the BE1-700 relay, it may on occasion be necessary to temporarily disable some of the protective elements while testing the relay to facilitate isolated testing of individual functions. Always remember to enable these functions before placing the relay in service.

To assist you in the commissioning testing of this relay, you may at any time refer to Section 6, *Reporting and Alarm Functions*, for various means of reporting status, alarms, and targets.

Please refer to the other sections of this instruction manual for assistance on any particular functions of the relay. If you require further assistance, contact Basler Electric field application personnel or the factory.

Digital I/O Connection Verification

Contact Sensing Inputs

Purpose: To verify contact sensing input label assignments and recognition and debounce settings.

Reference Commands: SN-IN, SG-IN

Step 1: Transmit the SN-IN1 command to verify the Input 1 user-defined name, Energized State label, and De-Energized State label.

Step 2: Repeat Step 1 for each of the remaining contact sensing inputs. Add the number of an input to the SN-IN command to check that input's name and labels.

- Step 3: Verify the recognition and debounce settings for each contact sensing input by using the SG-IN command. When the SG-IN command is transmitted, the relay responds with the recognition and debounce settings for each input. Reported settings use the format SG-IN#=recognition, debounce.
- Step 4: Transmit the RG_STAT command to the relay or use HMI Screen 1.4.1 to verify the status of Input 1. Transmit the RS-NEW=0 command to the relay. From the actual field device, energize (or de-energize) the specific contact that supplies relay Input 1. While maintaining contact position, verify that Input 1 has changed state by transmitting the RG-STAT command or using HMI Screen 1.4.1. Return the field contact to its original state, verifying that Input 1 returns to its original state. Transmit the RS-NEW command to the relay and review the event record associated with the field contact change.
- Step 5: Repeat Step 4 for each connected input.

Output Contacts

Purpose: To verify output contact settings and output contact logic settings.

Reference Commands: SN-VO, SL-VO, SG-HOLD

- Step 1: Transmit the SN-VOA command to verify the Virtual Output A user-defined name, TRUE label, and FALSE label.
- Step 2: Repeat Step 1 for Virtual Outputs 1 through 15. Add the number of an output to the SN-VO command to check that output's name and labels.
- Step 3: Transmit the SL-VO command to obtain a list of all virtual outputs and their Boolean logic equations. Verify that the desired virtual output equations match the reported equations.
- Step 4: Verify the programmable hold timer setting for each hardware output by transmitting the command SG-HOLD. The output hold timer setting for each output is reported as enabled (1) or disabled (0).
- Step 5: Verify the output contact activity by viewing the sequence of events reports with the RS-### command.
- Step 6: Use the procedure outlined under "*Acceptance Tests, Control Outputs*" to actuate selected output contacts (V01 through V05) and actually trip or close the connected field device (circuit breaker, lockout, etc.). Use the same procedure to verify that operation of the Alarm Output Relay (V0A) initiates the appropriate alarm response.

Virtual Selector Switches

Purpose: To verify the operation, labels, and logic settings of the 43 switches.

Reference Commands: SN-43, SL-43, RG-43STAT, RG-STAT, CS/CO-43

- Step 1: Transmit the SN-43 command to verify the Virtual Selector Switch 43 name, TRUE label, and FALSE label. This information is reported using the format SN-x43=name, TRUE label, FALSE label.
- Step 2: Repeat Step 1 for Virtual Selector Switch 143. Use the number of a switch in the SN-43 command to retrieve name and label information for that switch.
- Step 3: Use the SL-x43 command to obtain the logic setting of Virtual Switches 143. Logic settings for virtual switches can also be obtained by using the SL command or by viewing optional HMI Screens \CTRL\43\143. Verify that the desired virtual selector switch setting matches the reported setting.
- Step 4: Transmit the RG-43STAT command to obtain the position of the eight virtual selector switches. Alternately, the virtual selector switch positions can be obtained through the RG-STAT command or HMI Screen 1.5.4.
- Step 5: Obtain write access to the relay by using the ACCESS= command. For each virtual selector switch enabled in your logic scheme, change the switch position by entering CS-x43=1 (TRUE),

0 (FALSE) or P (Pulse) followed by CO-x43=1,0 or P. The syntax of the CS-x43 and CO-x43 commands must match or the CO-x43 command will not be executed.

- Step 6: Verify each switch position change by using the CO-x43 command or through HMI Screen 1.5.4.
- Step 7: Return each Virtual Selector Switch to the original position by repeating Step 5.
- Step 8: Verify the 43 Switch activity by viewing the sequence of events reports with the RS-### command.

Virtual Control Switch

Purpose: To verify the operation and logic setting for the 101 Switch.

Reference Commands: SB-LOGIC, SL-101, RG-101STAT, RG-STAT, CS/CO-101

- Step 1: Verify the breaker label and breaker-closed logic expression with the SB-LOGIC command.
- Step 2: Use the SL-101 command to read the logic mode of the 101 Switch. The switch is either enabled (1) or disabled (0).
- Step 3: Obtain the virtual control switch status by using the RG-101STAT or RG-STAT commands.
- Step 4: Transmit the command ACCESS= to obtain write access to the relay. Change the switch position by entering CS-101=T (trip) or C (close) followed by CO-101=T (trip) or C (close). The syntax of the CS-101 and CO-101 commands must match or the CO-101 command will not be executed.
- Step 5: Confirm the switch position change with the RG-101STAT or RG-STAT commands.
- Step 6: Repeat Step 4 to return the 101 Switch to the desired position for your application.
- Step 7: Verify the 101 Switch activity by viewing the sequence of events reports with the RS-### command.

Protection and Control Function Verification

Before placing the relay in service, the user should ensure that all system ac and dc connections are correct, that the relay functions as intended with user settings applied, and that all equipment external to the relay operates as intended. All connected or monitored inputs and outputs, and polarity and phase rotation of ac connections should be tested. Verify that:

- Power supply and contact wetting voltages are correct.
- User desired protection and control functions are enabled and connected to the correct CT and VT input circuits.
- The programmable logic settings (electronic wiring) provide the proper interconnection of these functions with the I/O of the relay.
- Each protection function has the desired operational set points.

Simple user designed fault tests should be used to verify that the operational settings are correct, that the proper output relays are actuated, and proper targeting occurs. (Refer to Figures 13-1 or 13-2 for terminal locations.) It is not necessary to test every protection element, timer, and function in these tests.

Use of the fault and event recording capability of the relay will aid in the verification of the protection and control logic. Transmit the RS command to retrieve all SER records or RS-n to get a specific operation. In addition, 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 BE1-700 relay, it may be necessary to disable protection elements or change setting logic to verify a specific function. To guard against placing the relay in service with unwanted operational or logic settings, it is good practice to save a copy of the original setting file before the testing process begins. When testing is complete, compare the copy of the saved settings to the actual relay settings as a final verification.

To accomplish this, transmit the S command to the relay or use BESTCOMS, *File, Export to Text*. This command generates all logic and operational settings that are on the relay. Copy the data to a text editor such as Notepad and print it out. This along with the user's logic diagram provides a complete picture of the relay's protection and control capability. The logic and operational settings of the protection and control functions should be examined to determine:

- The mode setting for the function so that you know what the relay is supposed to do.
- Which virtual output logic expressions contain the logic variables that represent the output contacts for protection function being tested.
- The input logic expressions for the function under test (especially the block input because it renders the function disabled if the block input is asserted).
- That the operational pickup and dropout threshold values and time delays agree with the user's calculated values.
- That the fault reporting settings are set so the relay properly indicates pickup and trip states and records targets. These settings are set from the ASCII command interface using the SG-TRIGGER and SG-TARG setting commands. Section 6, *Reporting and Alarm Functions, Fault Reporting*, for more details.

Verify Other Set Points as Appropriate

Consult *Functional Testing* found later in this section for guidelines on testing and verifying set points of other protection and control functions.

Reporting and Alarm Functions

Just prior to placing the relay in service, the following reporting and alarm functions should be reset and/or verified. For details on how to use the HMI or the ASCII command interface to enter or edit relay operating values, see Sections 10 and 11, respectively. BESTCOMS can also be used for many of the functions. See Section 14, *BESTCOMS Software*, for details.

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 1.4.6 and Section 6, *Reporting and Alarm Functions, Clock*, for setting details.

Demand Data

Read, change, or reset Current Demands. If the Demand Functions feature of the relay is enabled, use the following to reset the peak current demand registers to "0" or a pre-existing value.

Reference Commands: RD, RD-<pp>

Reference: HMI Screens 4.4.1.x, 4.4.2.x, 4.4.3.x, and Section 6, *Reporting and Alarm Functions, Demand Functions*, 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 and 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 the STAT\ALARMS\ALARM Screen on the HMI. Refer to Section 6, *Reporting and Alarm Functions, Relay Trouble Alarms*, for setting details.

Major/Minor/Logic Programmable Alarms

Reset and verify that the programmable alarms, Major, Minor, and Logic, as set to meet user needs verify that they are not illuminated or asserted. If required, alarm information can be read by transmitting the RA or RG-STAT commands. To reset a Major/Minor/Logic Alarm, first gain write access to the reporting functions ("R" password) and initiate the RA=0 or RA-MAJ/MIN/LGC=0 commands or by pressing the *RESET* key from a STAT\ALARMS\DET Screen on the HMI.

Reference: Section 6, *Reporting and Alarm Functions, Alarms Function, Major, Minor, and Logic Programmable Alarms*, for setting details.

Targets

Reset and verify that there is no target information. Targets are reset from HMI Screen 1.2, \STATS\TARGETS by pressing the *Reset* key or gaining write access to the reporting functions ("R" password) and transmitting RG-TARG=0. Relay target information can be read either from HMI Screen 1.1.1, \STATS\TARGETS or by transmitting the RG-TARG command.

Reference: Section 6, *Reporting and Alarm Functions, Fault Reporting, Targets*, for setting details.

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.

Reference: 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.

Reference: Section 6, *Reporting and Alarm Functions, Sequence of Events Recorder Function*, 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.

Reference: Section 6, *Reporting and Alarm Functions, General Status Reporting*, for details.

In Service Readings

Just after energizing the equipment, transmit the "M" command to the relay. Use this record to review the following:

- M-I and M-V to verify VT and CT ratios.
- M-IQ and M-V2 to verify proper phase sequence connections.
- M-SYNC to verify proper phase relationship of VP and VX.
- Anything else that the user might find helpful.

Save this record along with the RG-STAT record mentioned earlier for future reference.

Periodic Testing

Because the BE1-700 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 confirmation 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.

Care and Handling

The BE1-700 Digital Protective Relay requires no preventative maintenance. The fully numeric design of the relay contains no internal jumpers or mechanical settings, and requires no circuit-board level calibration.

There is no need to disturb the circuit interconnections within the draw-out assembly. Repair of the 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.

Before returning the assembly for repair, contact the Basler Electric, Technical Services Department at 618-654-2341 for a return authorization number.

Storage

This device contains long-life aluminum electrolytic capacitors. For devices that are not in service (spares in storage), the life of these capacitors can be maximized by energizing the device for 30 minutes once per year.

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, contact Basler Electric technical support to request download access.

Once the appropriate firmware is obtained, it can be uploaded to a relay using the BESTload™ software utility, which can be downloaded from www.basler.com.

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. BESTCOMS can also be downloaded from www.basler.com.

Functional Testing

Note
Functional testing is not required for this device. It is necessary only when performing a comprehensive assessment to determine suitability for an application.

Functional testing is a way to assess this relay's suitability for your application. Functional testing goes beyond the more basic tests found in acceptance testing, but lacks the detailed function testing that is part of the commissioning process.

Test each of the following functions to verify that your relay measures accurately, is within specified tolerances, and operates correctly. These tests are also suitable for assisting in systematic troubleshooting in the event that an operation is questioned. Revisiting the test of a specific function can help verify whether the relay is operating within specified tolerances. For further assistance, contact Basler Electric, Technical Support Services Department.

Refer to Figure 12-3 and Figure 12-4 for terminal locations.

The "access command" (A=) and the "exit with save commands" (E and Yes) are shown in the initial logic setup table found in each test section. In order to include multiple test settings in each operational setting table. The "ACCESS" and "EXIT WITH SAVE" commands are not included. However, "ACCESS" and "EXIT WITH SAVE" are required each time a logic or operational setting is changed.

To accelerate the testing process, two protection elements may have the same setting and are tested at the same time but with different outputs. During the pickup/dropout test, one of the elements could pick up slightly ahead of the other, resulting in only one target being displayed. At some point in the test, apply 110% of the pickup value and verify that both targets display. Reset targets prior to each test by pressing the HMI *RESET* key.

Instantaneous Overcurrent (50T) (BE1-700C)

50TP/150TP and TN (Calculated 3Io) Pickup and Dropout Verification

Purpose: To verify the accuracy of the operation of the 50/150TP and TN (3Io) elements.

Reference Commands: SL-50T/150T, SL-GROUP, SL-VO

- Step 1: Connect a current source to Terminals D1 and D2 (A-phase). Refer to Figure 12-3 for terminal locations. An ohmmeter or continuity tester may be used to monitor output contact status.
- Step 2: Prepare the 50T/150T elements for testing by transmitting the commands in Table 13-6 to the relay. Reset targets.

Table 13-6. 50TP and 50TN Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with logic=none settings.
Y	Confirm overwrite.
SL-N=PU50	Sets PU50 as custom logic name.
SL-50T=1,0; SL-50TN=1,0	Enables 50TP and 50TN (3Io), and disables blocking.
SL-VO1=50TPT	Enables OUT1 to close for 50TP trip.
SL-VO2=50TNT	Enables OUT2 to close for 50TN trip.
SG-CT=1	Sets P, N CT ratio at 1:1
SG- TRIG=50TPT+50TNT, 50TPPU+50TNPU,0	Enable 50TPT or 50TNT to log and trigger fault recording.
SG-TARG=50T/150T	Enables 50T/150T targets.
EXIT;Y	Exit and save settings.

- Step 3: Using Table 13-7 as a guide, transmit the low range setting commands (minimum pickup setting) for your sensing input type.
- Step 4: Slowly increase the A-phase current until OUT1 closes. Verify that pickup occurs within the specified accuracy listed in Table 13-8. Slowly decrease the applied current until OUT1 opens. Dropout should occur at 93 to 97 percent of pickup.
- Step 5: Repeat Step 4 while monitoring OUT2 (50TN enabled for 3Io). Verify 50TA and 50TN targets on the HMI.
- Step 6: Repeat Steps 4 and 5 for the middle and high range pickup settings for your sensing input type.

Table 13-7. 50T and 150T Pickup Settings

Current Sensing Input Type	Ranges	Pickup Settings Commands		Purpose
		Phase	Neutral	
5 A	Low	S0-50TP=0.5,0,N	S0-50TN=0.5,0,N	Sets 50T PU at 0.5 A, TD = 0, non-directional.
	Middle	S0-50TP=5.0,0,N	S0-50TN=5.0,0,N	Sets 50T PU at 5.0 A, TD = 0, non-directional.
	High	S0-50TP=25.0,0,N	S0-50TN=25.0,0,N	Sets 50T PU at 25.0 A, TD = 0, non-directional.
1 A	Low	S0-50TP=0.1,0,N	S0-50TN=0.1,0,N	Sets 50T PU at 0.1 A, TD = 0, non-directional.
	Middle	S0-50TP=1.0,0,N	S0-50TN=1.0,0,N	Sets 50T PU at 1.0 A, TD = 0, non-directional.
	High	S0-50TP=5.0,0,N	S0-50TN=5.0,0,N	Sets 50T PU at 5.0 A, TD = 0, non-directional.

Table 13-8. 50T/150T Element Accuracy

Sensing Type	Pickup Accuracy
B (1 A)	±2% or ±10mA
E or F (5 A)	±2% or ±50mA

Step 7: (Optional.) Repeat Steps 3 through 6 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).

Step 8: (Optional.) Repeat Steps 1 through 7 for the 150T elements. Overwrite the 50T commands entered in Step 2 with the commands of Table 13-9.

Table 13-9. 150TP and 150TN Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-150T=1,0; SL-150TN=1,0	Enables 150TP and 150TN, and 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 Group 1. Before testing settings in other setting groups, a setting group must be selected using the CS/CO-GROUP commands. To activate Setting Group 1, CS-GROUP=1 would be entered to select Setting Group 1 and CO-GROUP=1 would be entered to make Setting Group 1 active.

In addition, 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 3I_o) Time Delay Verification

Step 1: Connect a current source to Terminals D1 and D2 (A-phase). Refer to Figure 12-3 for terminal locations.

Step 2: Prepare the 50T/150T elements for testing by transmitting the commands in Table 13-10 to the relay.

Table 13-10. 50TP and 50TN Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=TD50	Sets TD50 as custom logic name.
SL-50TP=1,0; SL-50TN=1,0	Enables 50TP and 50TN (3Io), and disables blocking.
SL-VO1=50TPT	Enables OUT1 to close for 50TP trip.
SL-VO2=50TNT	Enables OUT2 to close for 50TN trip.
SG-CT=1	Sets P, N CT ratio at 1:1
SG-TRIG=50TPT+50TNT, 50TPPU+50TNPU,0	Enable 50TPT or 50TNT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 3: Using Table 13-11, transmit the first column of setting commands.

Table 13-11. 50T and 150T Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-50TP=0.5,2S	S0-50TP=0.5,5S	S0-50TP=0.5,10S	Sets 50TP TD.
S0-50TN=0.5,2S	S0-50TN=0.5,5S	S0-50TN=0.5,10S	Sets 50TN TD.

Step 4: Step the applied A-phase current to .55 amps (for 1 amp CT circuit divide by 5). Measure the time delay and verify the accuracy of the 50TP time delay setting, OUT1, and 50TN, OUT2. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.

Step 5: Repeat Steps 2 and 3 for the middle and higher time delay settings in Table 13-11.

Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals D3 and D4), phase C (Terminals D5 and D6).

Step 7: (Optional.) Repeat Steps 1 through 6 for the 150T elements. Overwrite the 50T commands entered in Step 2 with the commands of Table 13-12.

Table 13-12. 150TP and 150TN Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-150TP=1,0; SL-150TN=1,0	Enables 150TP and 150TN, disables blocking.
SL-VO1=150TPT	Enables OUT1 to close for 150TP trip.
SL-VO2=150TNT	Enables OUT2 to close for 150TN trip.
SG-TRIGGER=150TPT+150TNT, 150TPPU+150TNPU,0	Enable 150TPT or 150TNT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 8: (Optional.) Repeat Steps 1 through 7 for the 50T and 150T elements in Setting Group 1. Before testing settings in other setting groups, a setting group must be selected using the CS/CO-GROUP commands. To activate Setting Group 1, CS-GROUP=1 would be entered to select Setting Group 1 and CO-GROUP=1 would be entered to make Setting Group 1 active.

In addition, the pickup settings made in Step 3 (Table 13-11) must be changed to specify the setting group being tested. To test settings in Group 1, replace the 0 in the S0-x50 commands with a 1 (S1-x50).

50TQ/150TQ Pickup and Dropout Verification

Purpose: To verify the operation of the 50TQ and 150TQ elements.

Reference Commands: SL-50T/150T

Step 1: Connect a current source to Terminals D1 and D2 (A-phase).

Step 2: Prepare the 50TQ and 150TQ elements for testing by transmitting the commands in Table 13-13 to the relay. Reset targets.

Table 13-13. 50TQ Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=Q50	Sets Q50 as custom logic name.
SL-50TQ=1,0	Enables 50TQ, disables blocking.
SL-VO1=50TQT	Enables OUT1 to close for 50TQ trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIGGER=50TQT,50TQPU,0	Enable 50TQT to log and trigger fault recording.
SG-TARG=50TQ	Enables 50TQ targets.
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 5.0 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, $I_2 = I_a \div 3$. Therefore, the relay should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for an a 1 A relay with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.

Step 4: Slowly ramp up A-phase current until OUT1 closes. Verify that pickup occurred within the specified accuracy of the relay (5 A sensing: ± 3 percent or ± 75 mA, 1 A sensing: ± 3 percent or ± 15 mA). Table 13-15 provides the upper and lower limits for the specified tests.

Table 13-15. 50TQ/150TQ Pickup Values

Sensing Type	Pickup Setting	Lower Limit	Upper Limit
1 A	S0-50TQ=0.1,0	0.225 Aac	0.375 Aac
	S0-50TQ=1.0,0	2.91 Aac	3.09 Aac
	S0-50TQ=5.0,0	14.55 Aac	15.45 Aac
5 A	S0-50TQ=0.5,0	1.425 Aac	1.575 Aac
	S0-50TQ=5.0,0	14.55 Aac	15.45 Aac
	S0-50TQ=10.0,0	29.1 Aac	30.1 Aac

- Step 5: After pickup occurs, slowly ramp the current down until OUT1 opens. Verify that dropout occurred as specified (95 percent, ± 2 percent). Verify 50TQ target on the HMI.
- Step 6: Repeat Steps 3, 4, and 5, applying all Table 13-15 values that apply to your sensing input type.
- Step 7: (Optional.) Repeat Steps 3 through 6 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).
- Step 8: (Optional.) Repeat Steps 1 through 7 for the 150TQ elements. Use Table 13-16 as a reference when substituting the commands used in Step 1.

Table 13-16. 150TQ Pickup Test Commands

Replace These Commands	With These Commands
SL-50TQ=1,0	SL-150TQ=1,0
SL-VO1=50TQT	SL-VO1=150TQT
SG-TRIG=50TQT,50TQPU,0	SG-TRIG=150TQT,150TQPU,0
SG-TARG=50TQ	SG-TARG=150TG

- Step 9: (Optional.) Repeat Steps 1 through 8 for the 50TQ and 150TQ elements in Setting Group 1.

50TQ/150TQ Time Delay Verification

- Step 1: Connect a current source to Terminals D1 and D2 (A-phase).
- Step 2: Prepare the 50TQ and 150TQ elements for testing by transmitting the commands in Table 13-17 to the relay.

Table 13-17. 50TQ/150TQ Time Delay Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=Q50	Sets Q50 as custom logic name.
SL-50TQ=1,0	Enables 50TQ, disables blocking.
SL-150TQ=1,0	Enables 150TQ, disables blocking.
SL-VO1=50TQT	Enables OUT1 to close for 50TQ trip.
SL-VO2=150TQT	Enables OUT2 to close for 150TQ trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIGGER=50TQT+50TQPU, 150TQT+150TQPU,0	Enable 50TQT and 150TQT to log and trigger fault recording.
EXIT;Y	Exit and save settings.

- Step 3: Using Table 13-18, transmit the first column of setting commands for your sensing input type (substitute 0.1 for 1 amp CT).

Table 13-18. 50TQ/150TQ Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-50TQ=0.5,2S	S0-50TQ=0.5,5S	S0-50TQ=0.5,10S	Sets 50TQ TD.

For a single-phase input test, $I_2 = I_a \div 3$. Therefore, the relay should pick up at a value of three times the setting value when applying only a single-phase input. For example, to determine the pickup current value required for a 1-amp relay with a pickup setting of 0.1, it would require 0.1 times 3 or 0.3 amperes of input current.

- Step 4: Step the applied A-phase current to 110% of pickup. Measure the time delay and verify the accuracy of the 50TQ time delay setting, OUT1, and 150TQ, OUT2. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.
- Step 5: Repeat Step 2 and 3 for the middle and higher time delay settings in Table 13-18.
- Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).
- Step 7: (Optional.) Repeat Steps 1 through 6 for Setting Group 1.

50TN/150TN (Independent Ground Input IG) Pickup and Dropout Verification

Purpose: To verify the operation of the 50TN and 150TN elements for IG input.

Reference Commands: SL-50TN/150TN

- Step 1: Connect a current source to Terminals D7 and D8 (IG).
- Step 2: Prepare the 50TN and 150TN elements for testing by transmitting the commands in Table 13-19 to the relay. Reset targets.

Table 13-19. 50TN/150TN Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=50/150TN	Sets 50/150TN as custom logic name.
SL-50TN=G,0	Enables 50TN, disables blocking.
SL-150TN=G,0	Enables 150TN, disables blocking.
SL-VO1=50TNT	Enables OUT1 to close for 50TN trip.
SL-VO2=150TNT	Enables OUT2 to close for 150TN trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIGGER=50TNT+50TNPU, 150TNT+150TNPU,0	Enable 50TNT and 150TNT to log and trigger fault recording.
SG-TARG=50TN/150TN	Enables 50TN and 150TN targets.
EXIT;Y	Exit and save settings.

- Step 3: Using Table 13-20, transmit the first row of setting commands for your sensing input type.

Table 13-20. 50TN/150TN Pickup Settings

Sensing Type	Command	Purpose
1 A	S0-50TN=0.1,0,N;S0-150TN=0.1,0,N	Sets 50TN and 150TN pickup at 0.1 A, TD = 0, non-directional.
	S0-50TN=1.0,0,N;S0-150TN=1.0,0,N	Sets 50TN and 150TN pickup at 1.0 A, TD = 0, non-directional.
	S0-50TN=5.0,0,N;S0-150TN=5.0,0,N	Sets 50TN and 150TN pickup at 5.0 A, TD = 0, non-directional.
5 A	S0-50TN=0.5,0,N;S0-150TN=0.5,0,N	Sets 50TN and 150TN pickup at 0.5 A, TD = 0, non-directional.
	S0-50TN=5.0,0,N;S0-150TN=5.0,0,N	Sets 50TN and 150TN pickup at 5.0 A, TD = 0, non-directional.
	S0-50TN=10.0,0,N;S0-150TN=10.0,0,N	Sets 50TN and 150TN pickup at 10.0 A, TD = 0, non-directional.

- Step 4: Slowly increase the IG current until OUT1 closes. Verify that pickup occurs within the specified accuracy listed in Table 13-21. Slowly decrease the applied current until OUT1 opens. Dropout should occur at 93 to 97 percent of pickup.
- Step 5: Repeat Step 4 while monitoring OUT2 (150TN). Verify 50TG and 150TG targets on the HMI. Verify the pickup accuracy of the middle and upper pickup settings.

Table 13-21. 50TN/150TN Element Accuracy

Sensing Type	Pickup Accuracy
B (1 A)	±2% or ±10mA
E or F (5 A)	±2% or ±50mA

- Step 6: (Optional.) Repeat Steps 1 through 5 for the 50TN and 150TN elements in Setting Group 1.

50/150TN (Independent Ground Input IG) Time Delay Verification

- Step 1: Prepare the 50TN and 150TN elements for testing by transmitting the commands in Table 13-19 to the relay.
- Step 2: Using Table 13-22, transmit the first column of setting commands for your sensing input type (5 A is shown).

Table 13-22. 50TN/150TN Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-50TN=0.5,2S	S0-50TN=0.5,5S	S0-50TN=0.5,10S	Sets 50TN TD.
S0-150TN=0.5,2S	S0-150TN=0.5,5S	S0-150TN=0.5,10S	Sets 150TN TD.

- Step 3: With the current source still connected to Terminals D7 and D8 (IG), step the applied current to .55 amps (for 1 amp CT circuit divide by 5). Measure the time delay and verify the accuracy of the 50TN time delay setting, OUT1, and 150TN, OUT2. Timing accuracy is ±5 percent or ±3 cycles of the time delay setting.
- Step 4: Repeat Steps 2 and 3 for the middle and higher time delay settings in Table 13-22.
- Step 5: (Optional.) Repeat Steps 1 through 4 for Setting Group 1.

Time Overcurrent (51) (BE1-700C)

Timing Verification

Purpose: To verify the timing operation of the 51 and 151 elements.

Reference Commands: SL-51PNQ/151P/151N, S<g>-51P/151P

- Step 1: Prepare the 51 element for testing by transmitting the commands in Table 13-23 to the relay.

Table 13-23. 51P/51N/51Q Timing Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=PU51	Sets PU51 as custom logic name.
SL-51P=1,0	Enables 51P, disables blocking.
SL-51N=1,0	Enables 51N, disables blocking.
SL-51Q=1,0	Enables 51Q, disables blocking.
SL-VO1=51PT	Enables OUT1 to close for 51P trip.

Command	Purpose
SL-VO2=51NT	Enables OUT2 to close for 51N trip.
SL-VO3=51QT	Enables OUT3 to close for 51Q trip.
SG-CT=1	Sets CT ratio at 1.
SG-TRIG=51PT+51NT+51QT, 51PPU+51NPU+51QPU,0	Enable 51PT, 51NT, or 51QT to log and trigger fault recording.
SG-TARG=51	Enables 51P, 51N, and 51Q targets.
EXIT;Y	Exit and save settings.

Step 2: Transmit the appropriate commands in Table 13-24 for your sensing input type.

Table 13-24. 51P/51N/51Q Time Delay Settings

Sensing Type	Phase Commands	Neutral Commands	Negative-Sequence Commands
1 A	S0-51P=0.1,0.5,I2,N	S0-51N=0.1,0.5,I2,N	S0-51Q=0.1,0.5,I2,N
5 A	S0-51P=0.5,0.5,I2,N	S0-51N=0.5,0.5,I2,N	S0-51Q=0.5,0.5,I2,N

Step 3: Connect a current source to relay Terminals D1 and D2 (A-phase). Using the values listed in Table 13-25 (table value x3 for 51Q), apply the appropriate current values, and measure the time between the application of current and the closure of OUT1, OUT2, and OUT3. Verify that the relay performs within the specified limits.

Table 13-25. 51P/51N/51Q Timing Values

Sensing Type	Time Dial	Applied Current	Relay Trip Limits	
			Lower Limit	Upper Limit
1 A	0.5	0.15 Aac	0.748 s	0.827 s
		0.50 Aac	0.190 s	0.240 s
		2.5 Aac	0.100 s	0.150 s
	5	0.15 Aac	7.244 s	8.007 s
		0.50 Aac	1.798 s	1.988 s
		2.5 Aac	0.944 s	1.044 s
	9.9	0.15 Aac	14.318 s	15.825 s
		0.50 Aac	3.535 s	3.907 s
		2.5 Aac	1.844 s	2.038 s
5 A	0.5	2.5 Aac	0.190 s	0.240 s
		12.5 Aac	0.100 s	0.150 s
	5	0.75 Aac	7.244 s	8.007 s
		2.5 Aac	1.798 s	1.988 s
		12.5 Aac	0.944 s	1.044 s
	9.9	0.75 Aac	14.318 s	15.825 s
		2.5 Aac	3.535 s	3.907 s
		12.5 Aac	1.844 s	2.038 s

Step 4: Repeat Steps 2 and 3 for all of the current and time dial settings for your current sensing type.

- Step 5: (Optional.) Repeat Steps 2 through 4 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6).
- Step 6: (Optional.) Using ASCII commands, substitute 151 for any 51 logic or setting commands in each test.

Pickup and Dropout Verification

Purpose: To verify the pickup accuracy of the 51P, 51N, 151P, 151N, and 51Q elements.

Reference Commands: SL-51P, SL-151P, SL-51N, SL-51Q, SL-151N, SL-GROUP, SL-VO

- Step 1: Connect a current source to Terminals D1 and D2 (A-phase). Refer to Figure 12-3 for terminal locations. An ohmmeter or continuity tester may be used to monitor output contact status.
- Step 2: To prepare the 51P, 51N, and 51Q elements for testing, transmit the commands in Table 13-26 to the relay. Reset targets.

Table 13-26. 51P/51N/51Q Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=PU51	Sets PU51 as custom logic name.
SL-51P=1,0	Enables 51P and disables blocking.
SL-51N=1,0	Enables 51N and disables blocking.
SL-51Q=1,0	Enables 51Q and disables blocking.
SL-VO1=51PT	Enables OUT1 to close for 51PT trip.
SL-VO2=51NT	Enables OUT2 to close for 51NT trip.
SL-VO3=51QT	Enables OUT3 to close for 51QT trip.
SG-CT=1	Sets P, N CT ratio at 1:1
SG-TRIGGER=51PT+51NT+51QT, 51PPU+51NPU+51QPU,0	Enable 51PT, 51NT, or 51QT to log and trigger fault recording.
SG-TARG=51	Enables 51P, 51N, and 51Q targets.
EXIT;Y	Exit and save settings.

- Step 3: Using Table 13-27 as a guide, transmit the first row of setting commands (minimum pickup setting) for your sensing type.

Table 13-27. 51P/51N/51Q Pickup Settings

Sensing Type	Pickup Settings			Purpose
	Phase	Neutral	Neg.-Sequence	
5 A	S0-51P=0.5,0,I2,N	S0-51N=0.5,0,I2,N	S0-51Q=0.5,0,I2,N	Sets 51PNQ PU at 0.5 A.
	S0-51P=5.0,0,I2,N	S0-51N=5.0,0,I2,N	S0-51Q=5.0,0,I2,N	Sets 51PNQ PU at 5.0 A.
	S0-51P=25,0,I2,N	S0-51N=25,0,I2,N	S0-51Q=25,0,I2,N	Sets 51PNQ PU at 25 A.
1 A	S0-51P=0.1,0,I2,N	S0-51N=0.1,0,I2,N	S0-51Q=0.1,0,I2,N	Sets 51PNQ PU at 0.1 A.
	S0-51P=1.0,0,I2,N	S0-51N=1.0,0,I2,N	S0-51Q=1.0,0,I2,N	Sets 51PNQ PU at 1.0 A.
	S0-51P=5.0,0,I2,N	S0-51N=5.0,0,I2,N	S0-51Q=5.0,0,I2,N	Sets 51PNQ PU at 5.0 A.

- Step 4: Slowly increase the A-phase current until OUT1 (51P pickup indicator) closes. Verify that pickup occurs within the specified accuracy listed in Table 13-28. Slowly decrease the applied current until OUT1 opens. Dropout should occur at 93 to 97 percent of pickup. Verify 51A and 51N

targets on the HMI. Repeat Step 4 while monitoring OUT2 (51N). Verify the pickup and dropout accuracy of the middle and upper pickup settings for your sensing type.

Table 13-28. 51P/51N Element Accuracy

Sensing Type	Pickup Accuracy
B (1 A)	±2% or ±10 mA
E or F (5 A)	±2% or ±50 mA

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
B (1 A)	±3% or ±15 mA
E or F (5 A)	±3% or ±75 mA

Step 6: (Optional.) Repeat Steps 3 through 5 for phase B (Terminals D3 and D4) and phase C (Terminals D5 and D6). To test independent ground input IG, gain access and transmit SL-51N=G,0 exit and save. Apply test current to Terminals D7 and D8 while monitoring OUT2 and repeat Step 4. Verify 51G target on the HMI.

Step 7: (Optional.) Repeat Steps 1 through 4 and Step 6, IG input, for the 151N element. Overwrite the 51 commands entered in Step 2 with the commands of Table 13-30.

Table 13-30. 151N Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-151N=G,0	Enables 151N, disables blocking.
SL-VO2=151NT	Enables OUT2 to close for 151N trip.
SG-TRIGGER=151NT,151NPU,0	Enable 151NT or 151NPU to log and trigger fault recording.
EXIT;Y	Exit and save settings.

Step 8: (Optional.) Repeat Steps 1 through 7 for the 51P, 151P, 51N, and 151N elements in Setting Group 1. Before testing settings in other setting groups, a setting group must be selected using the CS/CO-GROUP commands. To activate Setting Group 1, CS-GROUP=1 would be entered to select Setting Group 1 and CO-GROUP=1 would be entered to make Setting Group 1 active. Also, the pickup settings made in Step 3 (Table 13-27) must be changed to specify the setting group being tested. To test settings in Group 1, replace the 0 in the S0-x51 commands with a 1 (S1-x51).

Volts per Hertz Overexcitation (24) (BE1-700V)

Purpose: To verify the operating accuracy of the 24 protection element.

Reference Commands: SL-24, SL-VO, SL-GROUP, RG-STAT

Overexcitation, Volts/Hertz Alarm, Integrating Time and Definite Time Pickup Verification

The BE1-700 detects overexcitation conditions with a volts/hertz element that consist of one alarm setting, one integrating time characteristic with selectable exponents (3 sets of time curves as shown in Appendix D, *Overexcitation (24) Inverse Time Curves*), and two definite time characteristics. Note that V/Hz nominal is 69.3 volts (phase to neutral) x square root 3/60 Hz, or 2.001. That is, at nominal voltage and frequency (60 Hz system) 1 pu V/Hz = 2.001.

Step 1: Prepare the 24 pickup function for testing by transmitting the commands in Table 13-31 to the relay. Reset targets.

Table 13-31. V/Hz Alarm, Integrating Time, and Definite Time Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=24	Sets 24 as custom logic name.
SG-VTP=1,4W,PN,PN	Sets VT phase voltage parameters.
SG-NOM=69.3,5.00	Set nominal voltage to 69.3 P to N.
SA-MAJ=31	Enables Major Alarm Light for 24 alarm.
SL-24=1,0	Enables 24, disables blocking.
SL-VO1=24T	Enables OUT1 to close for 24 trip.
SG-TRIG=24T,24PU,0	Enables 24 to log and trigger fault recording.
SG-TARG=24	Enables 24 target.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-32 as a guide, transmit the setting commands to the relay.

Table 13-32. Alarm, Integrating Time, and Definite Time Pickup Settings (Step 2)

Overexcitation Settings	Purpose
Pickup	
SA-24=2.05,0.0	Sets 24 Alarm at 1.025% of nominal (2.05 V/Hz), Time Delay = 0.
S0-24=2.1,0.0,0.0,0.0,2.0	Sets 24 Integrating PU at 1.05% of nominal (2.10 V/Hz), Trip Time Dial = 0, Reset Time Dial = 0, Time Curve Exponent = 2.
S0-24D=0.0,50ms,0.0,50ms	Sets 24 Definite Time, Pickups at 0 and Definite Time, Time Delay at minimum.

- Step 3: Prepare to monitor the operation of the 24 Alarm and Trip functions. Alarm operation can be verified by monitoring the Major Alarm LED on the relay's front panel. Operation of 24T by can be verified by monitoring OUT1.
- Step 4: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figure 12-4 for terminal locations.
- Step 5: Apply A-phase voltage at nominal frequency and slowly increase until the Major Alarm LED lights ($V/H \text{ PU} \times \text{Freq} \times \% \text{ Alarm} = \text{PU}$). Pickup should occur within ± 2 percent or 1 volt of the Alarm setting. Continue increasing the A-phase voltage until OUT1 closes ($V/H \text{ Trip} \times \text{Freq} = \text{PU}$). Pickup should occur within ± 2 percent or 1 volt of the Trip pickup setting. Slowly decrease the A-phase voltage until OUT1 opens. Dropout should occur at 95% or higher of the actual pickup value for both Trip and Alarm.
- Step 6: Verify the 24 target on the HMI.
- Step 7: (Optional.) Repeat Steps 2 through 6 for higher and lower alarm and trip pickup settings.
- Step 8: (Optional.) Repeat Steps 2 through 6 for frequencies other than nominal.
- Step 9: (Optional.) Repeat Steps 2 through 8 for the B-phase and C-phase voltage inputs.
- Step 10: (Optional.) Repeat Steps 2 through 9 for Setting Group 1.
- Step 11: Using Table 13-33 as a guide, transmit the setting commands to the relay.

Table 13-33. Alarm, Integrating Time, and Definite Time Pickup Settings (Step 11)

Overexcitation Settings	Purpose
Pickup	
SA-24=0,0.0	Sets 24 Alarm = 0, Time Delay = 0.
S0-24=0.0,0.0,0.0,2.0	Sets 24 Integrating PU =0, Trip Time Dial = 0, Reset Time Dial = 0, Time Curve Exponent = 2.
S0-24D=2.36,50ms,0.0,50ms	Sets the first 24 Definite Time Pickup at 118% of nominal (2.36 V/Hz) and Definite Time Delay at minimum. Set second 24 Definite Time Pickup = 0 and Definite Time Delay at minimum.

Step 12: Repeat Steps 2 through 10 for the first definite time pickup.

Step 13: Using Table 13-33 as a guide, set first definite time setting to 0 and second to 2.36 V/Hz.

Step 14: Repeat Steps 2 through 10 for the second definite time delay.

Overexcitation, Volts/Hertz Integrating Trip Time Verification

The following test uses the $(M-1)^2$ time curve.

Step 1: Using Table 13-34 as a guide, transmit the setting commands to the relay.

Table 13-34. V/Hz Trip Time Settings

Settings	Purpose
S0-24=2.1,0.5,0.0,2.0	Sets integrating 24 PU at 1.05% of nominal (2.10 V/Hz), Trip Time Dial = 0.5, Reset Time Dial = 0, Time Curve Exponent = 2.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figure 12-4 for terminal locations.

Step 3: All integrating timing tests are based on % of nominal Volts/Hertz (1 PU value). Refer to Appendix D of the BE1-700 instruction manual for time curves. Apply A-phase voltage at nominal frequency and a value of voltage that equals the V/Hz % of nominal shown in Table 13-35 for Time Dial 0.5. Measure the time between the application of voltage and the closure of OUT1. Verify that the relay operates within $\pm 5\%$ of the values shown in Table 13-35.

Table 13-35. V/Hz Trip Times

Percent of Nominal V/Hz	Time Dial 0.5	Time Dial 1.0	Time Dial 2.0
110%	50 seconds	100 seconds	200 seconds
120%	12.5 seconds	25 seconds	50 seconds
140%	3.1 seconds	6.3 seconds	12.5 seconds

Step 4: Repeat the test for Time Dial 1.0 and 2.0.

Step 5: (Optional.) Repeat Steps 2 through 4 for the B-phase and C-phase voltage inputs.

Step 6: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.

Overexcitation, Volts/Hertz Linear Reset Time Verification

The following reset time test is an approximation. For a more precise test, use a computer driven test set and the integration time equations found in Section 4, *Protection and Control, Voltage Protection, 24 Element*, or Appendix D, *Overexcitation (24) Inverse Time Curves*.

Step 1: Using Table 13-36 as a guide, transmit the setting commands to the relay.

Table 13-36. V/Hz Reset Time Pickup Settings

Setting	Purpose
S0-24=2.1,0.5,0.2,2.0	Sets 24 PU at 1.05% of nominal (2.10 V/Hz), Trip Time Dial = 0.5, Reset Time Dial = 0.2, Time Curve Exponent = 2.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figure 12-4 for terminal locations.

Step 3: Apply A-phase voltage at nominal frequency and a value of voltage that equals the V/Hz % of nominal shown in Table 13-37. Measure the time between the application of voltage and the closure of OUT1 (12.5 seconds). Remove the test voltage and reapply after 5 seconds has elapsed.

With a Reset Time Dial setting of 0.2, the total time to reset, after trip is removed, will be approximately 10 seconds. (See Section 4, *Protection and Control, Voltage Protection*, for more details.) Reapplying the test voltage after 5 seconds will yield a trip time of approximately ½ its original value or 6.25 seconds for Trip Time Dial 0.5 verifying that the reset time delay is working.

Table 13-37. V/Hz Reset Time

Percent of Nominal V/Hz	Time Dial 0.5	Time Dial 1.0	Time Dial 2.0
120%	12.5 seconds	25 seconds	50 seconds

Step 4: Repeat Step 3 for Trip Time Dial 1.0 and 2.0 (½ trip time is approximately 12.5 seconds for Time Dial 1.0, and 25 seconds for Time Dial 2.0. (Still reapply voltage after 5 seconds as reset time dial is still 0.2.)

Step 5: (Optional.) Repeat Steps 2 through 4 for the B-phase and C-phase voltage inputs.

Step 6: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.

Overexcitation, Volts/Hertz Definite Time (24D) Trip Time Verification

The following test uses the $(M-1)^2$ time curve.

Step 1: Using Table 13-38 as a guide, transmit the setting commands to the relay.

Table 13-38. Definite Time V/Hz Trip Time Settings

Settings	Purpose
S0-24D=2.36,50ms,0.0,50ms	Sets the first 24 definite pickup at 118% of nominal (2.36 V/Hz) and definite time delay at minimum. Sets second pickup at 0 and time delay at minimum.

Step 2: Connect a 120 Vac, three-phase, 50 or 60-hertz voltage source (depending on user's nominal frequency) to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figure 12-4 for terminal locations.

Step 3: Definite timing tests are based on % of nominal Volts/Hertz (1 PU value). Apply A-phase voltage at nominal frequency and a value of voltage that equals the V/Hz % of nominal shown in Table 13-53 (118% or 2.36 V/Hz). Measure the time between the application of voltage and the closure of OUT1. Verify that the relay operates within $\pm 0.5\%$ or 1 cycle, whichever is greater, for the TD settings shown in Table 13-39.

Table 13-39. Definite Time (24D) V/Hz Trip Times

Percent of Nominal V/Hz	Time Dial 0.5	Time Dial 1.0	Time Dial 2.0
118%	0.50 seconds	5 seconds	20 seconds

Step 4: (Optional.) Repeat Steps 2 through 4 for the B-phase and C-phase voltage inputs.

- Step 5: (Optional.) Repeat Steps 2 through 5 for Setting Group 1.
- Step 6: Set first definite time pickup setting to 0 and set the second definite time pickup setting to 2.36 V/Hz.
- Step 7: Repeat Steps 2 through 5 for the second definite time function.

Phase and Auxiliary Undervoltage/Overvoltage (27/59) (BE1-700V)

Purpose: To verify the operating accuracy of the 27P/127P/27X and 59P/159P/59X/159X protection elements.

Reference Commands: SL-27P/127P/27X, SL-59P/159P/59X/159X, SL-VO, SL-GROUP, RG-STAT

Phase Undervoltage and Overvoltage Pickup Verification

- Step 1: Prepare the 27P and 59P pickup functions for testing by transmitting the commands in Table 13-40 to the relay. Reset targets. Follow the same procedure for the 127P/159P except for the 27/127 under voltage inhibit pickup test.

Table 13-40. 27P and 59P Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=27_59	Sets 27_59 as custom logic name.
SG-VTP=1,4W,PN,PN	Set VT phase voltage parameters.
SA-MAJ=0	Disables Major Alarm.
SL-27P=1,0	Enables 27P, disables blocking.
SL-59P=1,0	Enables 59P, disables blocking.
SL-VO1=27PT+59PT	Enables OUT1 to close for 27P or 59P trip.
SG-TRIG=27PT+59PT, 27PPU+59PPU,0	Enables 27P and 59P to log and trigger fault record.
SG-TARG=27/127/59/159	Enables 27, 127, 59, and 159 targets.
EXIT;Y	Exit and save settings.

- Step 2: Using Table 13-41 as a guide, transmit the first row of setting commands (highest 27P PU, lowest 59P PU) to the relay.

Table 13-41. 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 C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (Neutral). Refer to Figure 12-4 for terminal locations.
- Step 5: Slowly decrease the A-phase voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the 27P pickup setting. Slowly increase the A-phase voltage until OUT1 opens. Dropout should occur between 102 and 103 percent of the actual pickup value. Verify the 27A target and the HMI. Reset the target.

- Step 6: Continue increasing the A-phase voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the 59P pickup setting. Slowly reduce the A-phase voltage until OUT1 opens. Dropout should occur between 97 and 98 percent of the actual pickup value. Verify 59A target on the HMI.
- Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings listed in Table 13-41.
- Step 8: (Optional.) Repeat Steps 2 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat Steps 2 through 8 for Setting Group 1.

27/127 Phase Undervoltage Inhibit Pickup Test

- Step 10: Using Table 13-42 as a guide, transmit the setting commands to the relay.

Table 13-42. 27P UV Inhibit Pickup Settings

Phase Inhibit Pickup Settings	Purpose
Undervoltage	
S0-27P=96,50ms,50	Sets 27P PU at 96 V, Time Dial at minimum, UV Inhibit at 50 V.

- Step 11: Using the same test connections as Step 4 above, slowly decrease the A-phase voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the 27P pickup setting.
- Step 12: Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ± 3 percent of 50 V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ± 5 percent of inhibit pickup.
- Step 13: (Optional.) Repeat Steps 1 and 2 for 127P.
- Step 14: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

Phase Undervoltage and Overvoltage Timing Verification

- Step 1: Using Table 13-43 as a guide, transmit the first row of setting commands to the relay.

Table 13-43. 27P and 59P Pickup and Time Delay Settings

Phase Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27P=72,2s	S0-59P=156,2s	Sets 27P PU at 72 V, 59P at 156 V, TD at 2 sec
S0-27P=,5s	S0-59P=,5s	Sets 27P PU at 72 V, 59P at 156 V, TD at 5 sec
S0-27P=,10s	S0-59P=,10s	Sets 27P PU at 72 V, 59P at 156 V, TD at 10 sec

- Step 2: Prepare to monitor the 27P and 59P timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 120 Vac, three-phase voltage source to Terminals C13 (A-phase), C14 (B-phase), C15 (C-phase), and C16 (neutral). Refer to Figure 12-4 for terminal locations.
- Step 4: Step the A-phase voltage down to 68 volts. Measure the time delay and verify the accuracy of the 27P time delay setting. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.
- Step 5: Step the A-phase voltage up to 165 volts. Measure the time delay and verify the accuracy of the 59P time delay setting. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.
- Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-43.
- Step 7: (Optional.) Repeat Steps 2 through 6 for the B-phase and C-phase voltage inputs.
- Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Pickup Verification (3V0 VT Input)

- Step 1: Prepare the 27X and 59X/159X pickup function for testing by transmitting the commands in Table 13-44 to the relay. Reset targets.

Table 13-44. 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-27X=2,0	Enables 27X (3E0), disables blocking.
SL-59X=2,0	Enables 59X, disables blocking.
SL-159X=2,0	Enables 159X, disables blocking.
SL-VO1=27XT+59XT	Enables OUT1 to close for 27X and 59X trip.
SL-VO2=159XT	Enables OUT2 to close for 159X trip.
SG-TRIG=27XT+59XT+159XT, 27XPU+59XPU+159XPU,0	Enable 27XT, 59XT, or 159XT to log and trigger fault recording.
SG-TARG=27/59/159	Enables 27X, 59X, and 159X targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-45 as a guide, transmit the first row of setting commands (highest 27X PU, highest 59XPU/159XPU) to the relay.

Table 13-45. 27X and 59X/159X Pickup Settings (3V0)

Pickup Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=50,50ms,0	S0-59X/159X=60,50ms	Sets 27X PU at 50 V, 59X/159X at 60 V, TD at min, UV Inhibit disabled.
S0-27X=20,50ms,0	S0-59X/159X=30,50ms	Sets 27X PU at 20 V, 59X/159X at 30 V, TD at min, UV Inhibit disabled.
S0-27X=5,50ms,0	S0-59X/159X=10,50ms	Sets 27X PU at 5 V, 59X/159X at 10 V, TD at min, UV Inhibit disabled.

- Step 3: Prepare to monitor the 59X/159X function operation. Operation can be verified by monitoring OUT1 (OUT2 for 159X).
- Step 4: Connect and apply a single-phase, 55 Vac voltage source to Terminals C13 (polarity) and C16 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 5: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the 27X pickup setting. Slowly increase the voltage until OUT1 opens. Dropout should occur between 102% and 103% of the actual pickup value. Verify the 27N target on the HMI and reset.
- Step 6: Continue increasing the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Slowly reduce the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Verify the 59N target on the HMI.
- Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings in Table 13-45.
- Step 8: (Optional.) Repeat Steps 2 through 7 for the B-phase and C-phase voltage inputs.
- Step 9: (Optional.) Repeat Steps 2 through 8 for Setting Group 1.

27X Auxiliary Undervoltage Inhibit Pickup Test (3V0)

Step 1: Using Table 13-46 as a guide, transmit the setting commands to the relay.

Table 13-46. 27X UV Inhibit Pickup Settings

Phase Inhibit Pickup Settings	Purpose
Undervoltage	
S0-27X=96,50ms,50	Sets 27X PU at 96 V, Time Dial at minimum, UV Inhibit at 50V.

Step 2: Using the same test connections as Step 4 above, slowly decrease the A-phase voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the 27X pickup setting.

Step 3: Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ± 3 percent of 50V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ± 5 percent of inhibit pickup.

Step 4: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Timing Verification (3V0 VT Input)

Step 1: Using Table 13-47 as a guide, transmit the first row of setting commands to the relay.

Table 13-47. 27X and 59X/159X Pickup and Time Delay Settings (3V0)

Pickup Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=10,2S,0	S0-59X/159X=30,2S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 2 sec, UV Inhibit disabled.
S0-27X=,5S	S0-59X/159X=,5S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 5 sec.
S0-27X=,10S	S0-59X/159X=,10S	Sets 27X PU at 10 V, 59X/159X at 30 V, TD at 10 sec.

Step 2: Prepare to monitor the 27X and 59X/159X timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.

Step 3: Connect and apply a single-phase, 20 Vac to Terminals C13 (polarity) and C16 (non-polarity). Refer to Figure 12-4 for terminal locations.

Step 4: Step the voltage down to 5 volts. Measure the time delay and verify the accuracy of the 27X time delay setting. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.

Step 5: Step the voltage up to 35 volts. Measure the time delay and verify the accuracy of the 59X/159X time delay setting. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.

Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-47.

Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Pickup Verification (Fundamental Vx Input)

Step 1: Prepare the 27X and 59X/159X pickup functions for testing by transmitting the commands in Table 13-48 to the relay. Reset targets.

Table 13-48. 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.

Command	Purpose
SL-VO1=27XT+59XT+159XT	Enables OUT1 to close for 27X, 59X, or 159X trip.
SG-TRIG=27XT+59XT+159XT, 27XPU+59XPU+159XPU	Enables 27XT, 59XT, or 159XT to log and trigger fault recording.
SG-TARG=27/59/159	Enables 27X, 59X, and 159X targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-49 as a guide, transmit the first row of setting commands (highest 27X PU, lowest 59XPU/159XPU) to the relay.

Table 13-49. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=70,50ms,0	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min, UV Inhibit disabled.
S0-27X=60,50ms,0	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min, UV Inhibit disabled.
S0-27X=50,50ms,0	S0-59X/159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min, UV Inhibit disabled.

- Step 3: Prepare to monitor the 27X and 59X/159X function operation. Operation can be verified by monitoring OUT1.
- Step 4: Connect and apply a single-phase, 80 Vac voltage source to VX Input, Terminals C17 (polarity) and C18 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 5: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Slowly increase the voltage until OUT1 opens. Dropout should occur between 102% and 103% of the actual pickup value. Verify the 27 bus target on the HMI and reset.
- Step 6: Continue to increase the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Slowly reduce the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Verify the 59 Bus target on the HMI.
- Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings listed in Table 13-49.
- Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

27X Auxiliary Undervoltage Inhibit Pickup Test (Fundamental VX Test)

Step 1: Using Table 13-50 as a guide, transmit the first row of setting commands to the relay.

Table 13-50. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=70,50ms,50	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min, UV Inhibit at 50V.
S0-27X=60,50ms,50	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min, UV Inhibit at 50V.
S0-27X=50,50ms,50	S0-59X/159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min, UV Inhibit at 50V.

Step 2: Prepare to monitor the 27X and 59X/159X function operation. Operation can be verified by monitoring OUT1.

- Step 3: Connect and apply a single-phase, 80 Vac voltage source to VX Input, Terminals C17 (polarity) and C18 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 4: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ± 3 percent of 50V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ± 5 percent of inhibit pickup.
- Step 5: (Optional.) Repeat Steps 1 through 4 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Timing Verification (Fundamental Vx Input)

- Step 1: Using Table 13-51 as a guide, transmit the first row of setting commands to the relay.

Table 13-51. 27X and 59X/159X Pickup and Time Delay Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=50,2S,0	S0-59X/159X=110,2S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 2 sec, UV Inhibit disabled.
S0-27X=,5S	S0-59X/159X=,5S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 5 sec.
S0-27X=,10S	S0-59X/159X=,10S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 10 sec.

- Step 2: Prepare to monitor the 27X and 59X/159X timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a single-phase, 80 Vac voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 4: Step the voltage down to 45 volts. Measure the time delay and verify the accuracy of the 27X time delay setting. Timing accuracy is $\pm 5\%$ or ± 3 cycles of the time delay setting.
- Step 5: Step the voltage up to 115 volts. Measure the time delay and verify the accuracy of the 59X/159X time delay setting. Timing accuracy is $\pm 5\%$ or ± 3 cycles of the time delay setting.
- Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-51.
- Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Pickup Verification (3rd Harmonic Vx Input)

- Step 1: Prepare the 27X and 59X/159X pickup functions for testing by transmitting the commands in Table 13-52 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_59X/159X	Sets 27X_59X/159X as custom logic name.
SG-VTX=1,AN	Set auxiliary voltage parameters.
SL-27X=3,0	Enables 27X, disables blocking.
SL-59X/159X=3,0	Enables 59X/159X, disables blocking.
SL-VO1=27XT+59XT+159XT	Enables OUT1 to close for 27X, 59X, or 159X trip.
SG-TRIG=27XT+59XT+159XT, 27XPU+59XPU+159XPU,0	Enables 27XT, 59XT, or 159XT to log and trigger fault recording.
SG-TARG=27/59/159	Enables 27X, 59X, and 159X targets.
EXIT;Y	Exit and save settings.

Step 2: Using Table 13-53 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 13-53. 27X and 59X/159X Pickup Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=70,50ms,0	S0-59X/159X=90,50ms	Sets 27X PU at 70 V, 59X/159X at 90 V, TD at min, UV Inhibit disabled.
S0-27X=60,50ms,0	S0-59X/159X=100,50ms	Sets 27X PU at 60 V, 59X/159X at 100 V, TD at min, UV Inhibit disabled.
S0-27X=50,50ms,0	S0-59X/159X=110,50ms	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at min, UV Inhibit disabled.

- Step 3: Prepare to monitor the 27X and 59X/159X function operation. Operation can be verified by monitoring OUT1.
- Step 4: Connect and apply a single-phase, 80 Vac, 3rd harmonic voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 5: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Slowly increase the voltage until OUT1 opens. Dropout should occur between 102% and 103% of the actual pickup value. Verify the 27-3 Bus target on the HMI.
- Step 6: Continue to increase voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Slowly reduce the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value.
- Step 7: Verify the pickup and dropout accuracy of the middle and upper pickup settings listed in Table 13-53. Verify the 59-3 Bus target on the HMI.
- Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

UV Inhibit for 27X (3rd Harmonic VX Input)

Step 1: Using Table 13-54 as a guide, transmit the setting commands to the relay.

Table 13-54. UV Inhibit for 27X (3rd Harmonic VX Input) Pickup Settings

Phase Inhibit Pickup Settings	Purpose
Undervoltage	
S0-27X=96,50ms,50	Sets 27X PU at 96 V, Time Dial at minimum, UV Inhibit at 50V.

- Step 2: Connect and apply a single-phase, 80 Vac, 3rd harmonic voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 3: Slowly decrease the voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Continue to decrease the voltage until OUT1 opens. UV inhibit pickup should occur within ± 3 percent of 50V. Increase the voltage until OUT1 closes. UV inhibit dropout should occur at ± 5 percent of inhibit pickup.
- Step 4: (Optional.) Repeat Steps 1 through 3 for Setting Group 1.

Auxiliary Undervoltage and Overvoltage Timing Verification (3rd Harmonic VX Input)

Step 1: Using Table 13-55 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 13-55. 27X and 59X/159X Pickup and Time Delay Settings

Pickup and Time Delay Settings		Purpose
Undervoltage	Overvoltage	
S0-27X=50,2S,0	S0-59X/159X=110,2S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 2 sec, UV Inhibit disabled.
S0-27X=,5S	S0-59X/159X=,5S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 5 sec.
S0-27X=,10S	S0-59X/159X=,10S	Sets 27X PU at 50 V, 59X/159X at 110 V, TD at 10 sec.

- Step 2: Prepare to monitor the 27X and 59X/159X timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a single-phase, 80 Vac, 3rd harmonic voltage source to Terminals C17 (polarity) and C18 (non-polarity). Refer to Figure 12-4 for terminal locations.
- Step 4: Step the voltage down to 45 volts. Measure the time delay and verify the accuracy of the 27X time delay setting. Timing accuracy is $\pm 5\%$ or ± 3 cycles of the time delay setting.
- Step 5: Step the voltage up to 115 volts. Measure the time delay and verify the accuracy of the 59X/159X time delay setting. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.
- Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-55.
- Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Negative-Sequence Voltage (47) (BE1-700V)

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 13-56 to the relay. Reset targets.

Table 13-56. 47 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=47	Sets 47 as custom logic name.
SL-27P=0	Disables 27P.
SL-59P=0	Disables 59P.
SL-47=1,0	Enables 47, disables blocking.
SP-60FL=ENA,PN	Removes 60FL block from 47 element.
SL-VO1=47T	Enables OUT1 to close for 47 trip.
SG-TRIG=47T,47PU,0	Enables 47 to log and trigger fault recording.
SG-TARG=47	Enables 47 target.
EXIT;Y	Exit and save settings.

- Step 2: Using Table 13-57 as a guide, transmit the first row of setting commands to the relay.

Table 13-57. 47 Pickup Settings

Pickup Settings (Negative-Sequence Voltage)	Purpose
S0-47=24,50ms	Sets 47 PU at 24 V, Time Delay at minimum.
S0-47=30,50ms	Sets 47 PU at 30 V, Time Delay at minimum.
S0-47=36,50ms	Sets 47 PU at 36 V, Time Delay at minimum.

- Step 3: Prepare to monitor 47 function operation. Operation can be verified by monitoring OUT1.
- Step 4: Connect and apply a 50 Vac, single-phase voltage source to Terminals C13 (A-phase) and C16 (neutral). Refer to Figure 12-4 for terminal locations.
- Step 5: Negative-sequence voltage is 1/3 the phase voltage, therefore for a V2 setting of 24 volts, the applied phase voltage will be 24 x 3 or 72 volts. Slowly increase the A-phase voltage until OUT1 closes. Pickup should occur within ± 2 percent or 1 volt of the pickup setting. Slowly decrease the A-phase voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Verify the 47 target on the HMI.
- Step 6: Verify the pickup and dropout accuracy of the middle and upper 47 pickup settings.
- Step 7: (Optional.) Repeat Steps 2 through 6 for the B-phase and C-phase voltage inputs.
- Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

Negative-Sequence Voltage Timing Verification

- Step 1: Using Table 13-58 as a guide, transmit the first row of setting commands to the relay.

Table 13-58. 47 Pickup and Time Delay Settings

Pickup and Time Delay Settings	Purpose
S0-47=36,2S	Sets 47 PU at 36 V, Time Dial at 2 seconds
S0-47=,5S	Sets 47 PU at 36 V, Time Dial at 5 seconds
S0-47=,10S	Sets 47 PU at 36 V, Time Dial at 10 seconds

- Step 2: Prepare to monitor the 47 timings. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 closing.
- Step 3: Connect and apply a 100 Vac, single-phase voltage source to Terminals C13 (A-phase) and C16 (neutral). Refer to Figure 12-4 for terminal locations.
- Step 4: Step the A-phase voltage up to 115 volts. Measure the time delay and verify the accuracy of the 47 time delay setting. Timing accuracy is ± 5 percent or ± 3 cycles of the time delay setting.
- Step 5: Repeat Step 5 for the middle and upper time delay settings of Table 13-58.
- Step 6: (Optional.) Repeat Steps 2 through 5 for the B-phase and C-phase voltage inputs.
- Step 7: (Optional.) Repeat Steps 2 through 6 for Setting Group 1.

Over/Underfrequency (81) (BE1-700V)

Purpose: To verify the operating accuracy of the 81/181/281/381/481/581 protection elements.

Reference Commands: SL-x81, SL-VO, S<g>-x81, S<g>-81INH

Over/Underfrequency Pickup Verification

- Step 1: Prepare the x81 pickup functions for pickup testing by transmitting the commands in Table 13-59 to the relay.

Table 13-59. x81 Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=FREQTEST	Sets FREQTEST as custom logic name.
SL-81=1,0	Enables 81, disables blocking.
SL-181=1,0	Enables 181, disables blocking.
SL-281=1,0	Enables 281, disables blocking.
SL-381=1,0	Enables 381, disables blocking.
SL-481=1,0	Enables 481, disables blocking.
SL-581=1,0	Enables 581, disables blocking.
SL-VO1=81T+581T	Enables OUT1 to close for 81 or 581 trip.
SL-VO2=181T	Enables OUT2 to close for 181 trip.
SL-VO3=281T	Enables OUT3 to close for 281 trip.
SL-VO4=381T	Enables OUT4 to close for 381 trip.
SL-VO5=481T	Enables OUT5 to close for 481 trip.
SG-TARG=81/181/281/381/481/581	Enables 81, 181, 281, 381, 481, and 581 targets.
SG-TRIG=81T+181T+281T+381T+481T+581T	Sets fault trigger on any x81.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands in Table 13-60 to the relay. These commands set the voltage inhibit value, pickup value, and operating mode (Underfrequency or Overfrequency) for each of the x81 functions.

Table 13-60. x81 Pickup and Mode Settings

Pickup and Mode Settings	Purpose
S0-81INH=40	Set PU = 40V
S0-81=42,0,U	Sets 81 PU at 42 Hz, Underfrequency.
S0-181=46,0,U	Sets 181 PU at 46 Hz, Underfrequency.
S0-281=48,0,U	Sets 281 PU at 48 Hz, Underfrequency.
S0-381=65,0,O	Sets 381 PU at 65 Hz, Overfrequency.
S0-481=67,0,O	Sets 481 PU at 67 Hz, Overfrequency.
S0-581=69,0,O	Sets 581 PU at 69 Hz, Overfrequency.

Step 3: Prepare to monitor x81 function operation. Operation can be verified by monitoring the programmed output contacts or HMI Screen 1.5.2.

Step 4: Connect and apply a 120 Vac, 60-hertz voltage source to Terminals C13 (A-phase) and C16 (neutral).

Step 5: Slowly decrease the frequency of the applied voltage until OUT3 (281) closes. Pickup should occur within ± 0.01 hertz of the pickup setting. Slowly increase the frequency until OUT3 opens. Dropout should occur at 0.02 hertz above or below the pickup setting.

Step 6: Lower the frequency until OUT3 again closes. Lower the source voltage until OUT3 drops out (under voltage inhibit level), raise the voltage until OUT3 picks up. Pickup should occur $\pm 2\%$ of the voltage inhibit setting and drop out at 95% of pickup.

- Step 7: Repeat Step 5 for the 181 (OUT2) and 81 (OUT1) functions.
- Step 8: Repeat Step 4.
- Step 9: Slowly increase the frequency of the applied voltage until OUT4 (381) closes. Pickup should occur within ± 0.01 hertz of the pickup setting. Slowly decrease the frequency until OUT4 opens. Dropout should occur at 0.02 hertz above or below the pickup setting.
- Step 10: Repeat Step 5 for the 481 (OUT5) and 581 (OUT1) functions.
- Step 11: In Table 13-59, change SL-81 through 581 = 2,0 and transmit to the relay.
- Step 12: Connect and apply, 120 Vac, 60Hz voltage source to Vx Input C17 and C18.
- Step 13: Repeat Steps 5 through 9.
- Step 14: (Optional.) Repeat Steps 1 through 11 for Setting Group 1.

Time Delay Verification

- Step 1: Prepare the x81 functions for time delay testing by transmitting the commands in Table 13-59 to the relay. Next, transmit the commands in the first column (2 second TD) of Table 13-61 to the relay. Commands entered in Table 13-60 should be retained for this test.

Table 13-61. x81 Time Delay Settings

Pickup and Time Delay Settings			Purpose
2 Second TD	5 Second TD	10 Second TD	
S0-81=,2S	S0-81=,5S	S0-81=,10S	Sets 81 TD.
S0-181=,2S	S0-181=,5S	S0-181=,10S	Sets 181 TD.
S0-281=,2S	S0-281=,5S	S0-281=,10S	Sets 281 TD.
S0-381=,2S	S0-381=,5S	S0-381=,10S	Sets 381 TD.
S0-481=,2S	S0-481=,5S	S0-481=,10S	Sets 481 TD.
S0-581=,2S	S0-581=,5S	S0-581=,10S	Sets 581 TD.

- Step 2: Prepare to monitor the x81 timings. Timing accuracy is verified by measuring the elapsed time between a frequency change and programmed output closing.
- Step 3: Connect and apply a 120 Vac, 60-hertz voltage source to Terminals C13 (A-phase) and C16 (neutral).
- Step 4: Step the frequency of the applied voltage down from 60 hertz to a value below the 281 underfrequency setting. Measure the time delay and verify the accuracy of the 281 time delay setting. Timing accuracy is ± 0.5 percent or ± 1 cycle (plus 3 cycle recognition time) 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 $\pm 0.5\%$ or ± 1 cycle (plus 3 cycle recognition time) of the time delay setting.
- Step 7: Repeat Step 6 for the 481 (OUT5) and 581 (OUT1) elements.
- Step 8: Transmit the commands in the second column (5 second TD) of Table 13-61 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 13-61 to the relay.
- Step 11: Repeat Steps 2 through 7 with a time delay setting of 10 seconds.
- Step 12: Repeat Steps 4 through 11 for Vx Inputs C17 and C18 (change SL command to 2,0).
- Step 13: (Optional.) Repeat Steps 1 through 11 for Setting Group 1.

Synchronism Check (25) (Optional)

Purpose: To verify the operation of the Sync Check (25) function.

Reference Commands: SL-25, SL-V0.

25VM - VTP and VTX Live Voltage, Dead Voltage Pickup Test

Step 1: Prepare the 25 function block for testing by transmitting the commands in Table 13-62 to the relay.

Table 13-62. 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 13-63 as a guide, transmit the setting commands to the relay.

Table 13-63. Sync-Check Voltage Monitor Pickup Settings

Sync Check VM Pickup Settings	Purpose
S0-25VM=95,55,0,123	Sets LV = 95, DV = 55, TD = 50, VM1 = 123.

Step 3: Prepare to monitor the 25VM function operation. Operation can be verified by monitoring OUT1.

Step 4: Connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a single phase, 0 Vac, 50 or 60 hertz ac voltage source (Line VTP) to the three jumpered terminals and the neutral Terminal (C16).

Step 5: OUT1 should be closed. Slowly increase the line voltage until OUT1 opens (55 volts). Dropout should occur within $\pm 2\%$ or 1 volt of the Dead Voltage setting. Lower the voltage until OUT1 closes. Pickup should be between 97% to 98% of the actual dropout value. Increase the voltage until OUT1 opens. Continue to increase the voltage until OUT1 closes (95 volts). Pickup should occur within $\pm 2\%$ or 1 volt of the hot voltage setting. Lower the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value. Remove voltage source 1.

Step 6: Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to relay Terminals C17 (polarity) and C18 (non-polarity). Apply 0 Vac.

Step 7: Output 1 should be closed. Slowly increase the Auxiliary voltage until OUT1 opens (55 volts). Dropout should occur within ± 2 percent or 1 volt of the Dead Voltage setting. Lower the voltage until OUT1 closes. Pickup should be between 97 to 98% of the actual dropout value. Increase the voltage until OUT1 opens. Continue to increase the voltage until OUT1 closes (95 volts). Pickup should occur within ± 2 percent or 1 volt of the Hot Voltage setting. Lower the voltage until OUT1 opens. Dropout should occur between 97% and 98% of the actual pickup value.

Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

25VM Live/Dead Dropout Timing Verification

Step 1: Using Table 13-64 as a guide, transmit the setting commands to the relay.

Table 13-64. Sync-Check 25VM Live/Dead Dropout Time Settings

Sync Check VM Time Settings	Purpose
S0-25VM=95,55,50ms,123	Sets LV = 95, DV = 55, TD = min, VM1 = 123.
S0-25VM=95,55,2S,123	Sets LV = 95, DV = 55, TD = 2 sec, VM1 = 123.
S0-25VM=95,55,5S,123	Sets LV = 95, DV = 55, TD = 5 sec, VM1 = 123.

- Step 2: Prepare to monitor the 25VM Hot/Dead timing. Timing accuracy is verified by measuring the elapsed time between a sensing voltage change and OUT1 opening.
- Step 3: Connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a 50 Vac, 50 or 60 hertz ac voltage source (Line VTP) to the three jumpered terminals and the neutral Terminal (C16).
- Step 4: Step the voltage up to 60 volts. Measure the time delay and verify the accuracy of the dead dropout time delay setting. Timing accuracy is $\pm 5\%$ or ± 3 cycles of the time delay setting.
- Step 5: Set the ac voltage at 100 volts. Step the voltage down to 90 volts. Measure the time delay and verify the accuracy of the Live dropout delay setting. Timing accuracy is $\pm 5\%$ or ± 3 cycles of the time delay setting.
- Step 6: Repeat Steps 5 and 6 for the middle and upper time delay settings of Table 13-64.
- Step 7: Connect a second single-phase 50 or 60-hertz voltage source (Auxiliary VTX) to relay Terminals C17 (polarity) and C18 (non-polarity). Repeat Steps 2 through 6.
- Step 8: (Optional.) Repeat Steps 2 through 7 for Setting Group 1.

25VM1 Output Test

- Step 1: With no voltage applied to either the Line or Auxiliary voltage sources, OUT1 should be closed. This verifies the DEAD-LINE, DEAD AUX output of 25VM1.
- Step 2: Apply 0 volts ac to the line voltage input (VTP). OUT1 contact should be closed. Output 1 will open as the voltage is increased above the DEAD-LINE setting and close again when voltage exceeds the LIVE-LINE setting. This verifies the LIVE-LINE, DEAD-AUX output of 25VM1. Remove voltage source 1.
- Step 3: Apply 0 volts ac to the Auxiliary Voltage Input (VTX). OUT1 contact should be closed. Output 1 will open as the voltage is increased above the DEAD-LINE setting and close again when voltage exceeds the LIVE-LINE setting. This verifies the DEAD-LINE, LIVE-AUX output of 25VM1.
- Step 4: (Optional.) Repeat Steps 1 through 4 for Setting Group 1.

25 Sync-Check Verification

- Step 1: Transmit SL-VO1=25;EXIT;Y to the relay.
- Step 2: Using Table 13-65 as a guide, transmit the setting commands to the relay.

Table 13-65. Sync-Check Settings

Sync Check Settings	Purpose
S0-25=10,10,0.3,0	Sets Delta V, angle, delta slip, and GF>BF mode.

- Step 3: Prepare to monitor the 25 function operation. Operation can be verified by monitoring OUT 1.
- Step 4: As in the previous test, connect relay Terminals C13 (A-phase), C14 (B-phase), and C15 (C-phase) together. Apply a 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Line VTP) to the three jumpered terminals and the neutral Terminal (C16).
- Step 5: Apply a second 120 Vac, 50 or 60 hertz ac, 0 degree voltage source (Auxiliary VTX) to C17 and C18. OUT1 should close verifying the 25 output for a Delta Angle of 0 degrees, 0 Delta V and 0 Delta Frequency (Slip).

- Step 6: Decrease the Auxiliary voltage input (VTX) until OUT1 opens. Slowly increase the voltage until OUT1 closes. Pickup should occur within $\pm 2\%$ of the Delta V setting. Dropout should occur at 97% to 98% of actual pickup.
- Step 7: Repeat Step 6 for the Line voltage input (VTP). Return voltage inputs to 120 Vac, 50 or 60 hertz, 0 degrees.
- Step 8: Swing the angle between voltage source 1 and 2 until the OUT1 opens. Slowly decrease the angle until OUT1 closes. Pickup should occur within $\pm 2^\circ$ of the Delta Angle setting on the leading and lagging side of 0 degrees. Dropout should occur at 97% to 98% of actual pickup. Return Delta Angle to 0 degrees.
- Step 9: With the Auxiliary Voltage set at nominal frequency, step change the frequency of the Line voltage input by -0.25 hertz (59.75 on a 60 hertz relay). Note that OUT1 is closing and opening based on a slip rate of 0.25 hertz. Decrease the frequency until OUT1 stays open. Slowly increase the frequency until OUT1 begins to cycle (closed/open). Cycling pickup should occur within $\pm 2\%$ of the Delta Slip setting. Also, check on the fast side (60.25 for a 60 hertz relay).
- Step 10: Repeat Step 9 for the Auxiliary Voltage input.
- Step 11: (Optional.) Repeat Steps 4 through 10 for Setting Group 1.

Breaker Failure (BF) (BE1-700C)

Purpose: To verify the operation of the breaker failure (BF) function.

Reference Commands: SL-BF, SP-BF

- Step 1: Prepare the BF function block for testing by transmitting the commands in Table 13-66 to the relay.

Table 13-66. BF Pickup Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=BF	Sets BF as custom logic name.
SL-BF=1,IN4,/IN3	Enables BF, IN4 initiate, /IN3 block.
SP-BF=50m	Set BF time delay at minimum.
SL-VO1=BFT	Enables OUT1 to close for BF trip.
SL-VO2=BFPU	Enables OUT2 to close for BF pickup.
SG-CTP=1	Sets P, N CT ratio at 1:1
SG-TRIGGER=BFT,BFPU,0	Enable BFT to log and trigger fault recording.
SG-TARG=BF	Enables BF target.
EXIT;Y	Exit and save settings.

- Step 2: Energize relay Inputs IN3 and IN4. This enables the BF logic and BF initiate. The BF current detector pickup setting is a fixed value that is determined by the relay current sensing type. Table 13-67 lists the pickup setting for each current sensing type.

Table 13-67. BF Current Detector Pickup Settings

Sensing Type	Pickup Setting
B (1 A)	0.1 A
E or F (5 A)	0.5 A

- Step 3: Connect a current source to Terminals D1 and D2 (A-phase input). Slowly increase the current applied to the A-phase input until OUT2 (and subsequently OUT1) closes. Compare the applied

current to the current values listed in Table 13-68. Verify that pickup occurred between the lower and upper limits for your relay.

Table 13-68. BF Pickup Limits

Sensing Type	Lower PU Limit	Upper Pickup Limit
B (1 A)	0.09 A	0.11 A
E or F (5 A)	0.45 A	0.55 A

Step 4: Transmit the commands in Table 13-69 to set the BF time delay.

Table 13-69. BF Time Delay Commands

Command	Purpose
A=	Gains write access.
SP-BF=100m	Set BF time delay at 100 milliseconds.
EXIT;Y	Exit and save settings.

Step 5: Verify the BF time delay by applying the pickup current obtained in Step 3 for the duration given in the following steps:

- A. Apply pickup current to phase A for 4 cycles (67 ms at 60 Hz). No trip should occur.
- B. Apply pickup current to phase A for 5 cycles (83 ms at 60 Hz). No trip should occur.
- C. Apply pickup current to phase A for 7 cycles (117 ms at 60 Hz). A BF trip should occur. Use the RS-LGC command to retrieve an SER report and verify that a BF trip was logged 100 milliseconds $\pm 5\%$ (+11/4, -1/4) after application of pickup current.

Step 6: (Optional.) De-energize relay Input IN3. This will block the breaker fail logic and cause OUT1 and OUT2 to open. Verify that relay outputs OUT1 and OUT2 remain open (BF element does not operate) even though pickup current is applied. De-energize IN3 and verify that OUT2 (and subsequently OUT1) closes. Remove current from phase A.

Step 7: (Optional.) Apply pickup current to phase A. OUT2 and OUT1 should close. De-energize IN4 and verify that OUT1 and OUT2 open. Remove current from phase A.

Step 8: Energize IN4 and apply 0.7 A of current to the phase A current input and measure the time between the application of current and OUT1 closing. OUT2 should have closed immediately when current was applied. Verify that the BF Timer operated within the specified accuracy of $\pm 5\%$ or +11/4, -1/4 cycles, whichever is greater.

Step 9: (Optional.) Repeat Steps 3 through 8 for the phase B and phase C elements.

Virtual Switches (43)

Purpose: To verify operation of the 43/143 virtual switches.

Reference Commands: SL-43/143, CS/CO-43/143

To test virtual switches, we verify each mode of operation but you do not have to verify both of the virtual switches. In your testing, you may use either of the switches, as desired. If you give an invalid command such as CS-143=1/CO-143=1 when Switch 143 is programmed for Mode 3 operation, the relay will reject the command and return an INVALID PARAMETER message through the ASCII command interface. For more information about virtual switch operation, see Section 4, *Protection and Control, Virtual Switches*. You may verify operation of virtual switches by monitoring the programmed output contacts, HMI Screen 1.5.4, or by using the RS-LGC command to retrieve logic variable data from the SER. You also may use the RG-STAT command. See Section 6, *Reporting and Alarm Functions*, for more information about reports.

Mode 1 - On/Off/Pulse

Step 1: Prepare the x43 virtual switch for Mode 1 testing by transmitting the commands in Table 13-70.

Table 13-70. 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 13-71 to the relay. These commands change the state of the 43 Switch to On. Result: OUT1 contact closes and remains closed.

Table 13-71. 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 13-72 to the relay. These commands change the state of the 43 Switch to off. It is not necessary to gain access for the following steps unless the write access timer expires. Result: OUT1 contact opens and remains open.

Table 13-72. 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 13-73. These commands pulse the 43 Switch on and off once. Result: OUT1 contact closes for 200 milliseconds and returns to the open state.

Table 13-73. 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 13-74 to the relay.

Table 13-74. x43 Mode 2 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.

Command	Purpose
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 13-75 to the relay. These commands change the state of the 43 Switch to On. Result: OUT1 contact closes and remains closed.

Table 13-75. x43 Mode 2 On Commands

Command	Purpose
A=	Gains write access.
CS-143=1	Selects 143 for On operation.
CO-143=1	Executes 143 for On operation.

Step 4: Transmit the commands in Table 13-76 to the relay. These commands change the state of the 143 Switch to Off. It is not necessary to gain access for the following steps unless the write access timer expires.

Table 13-76. 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 13-77 to the relay.

Table 13-77. x43 Mode 3 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=MODE3	Sets MODE3 as custom logic name.
SL-143=3	Sets 143 switch for Mode 3 operation.
SL-VO1=143	Enables OUT1 to close for 143.
EXIT;Y	Exit and save settings.

Step 2: Prepare to monitor the virtual switch operation. An ohmmeter or continuity tester may be used to monitor the contact status of OUT1.

Step 3: Transmit the commands in Table 13-78 to the relay. These commands pulse the 143 Switch On and Off once. Result: OUT1 contact closes for 200 milliseconds and returns to the open state.

Table 13-78. x43 Mode 3 Pulse Commands

Command	Purpose
A=	Gains write access.
CS-143=P	Selects 143 for Pulse operation.
CO-143=P	Executes 143 for Pulse operation.

Virtual Breaker Control Switch (101)

Purpose: To verify 101 Virtual Breaker Control Switch operation.

Reference Commands: SL-101, CS/CO-101C, CS/CO-101T

Step 1: Prepare the 101 Virtual Breaker Control Switch for testing by transmitting the commands in Table 13-79 to the relay.

Table 13-79. 101 Virtual Breaker Control Switch Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=S101	Sets S101 as custom logic name.
SL-101=1	Enables 101 Switch.
SL-VO1=101T	Enables OUT1 to close when 101T is TRUE.
SL-VO2=101C	Enables OUT2 to close when 101C is TRUE.
SL-VO3=101SC	Enables OUT3 to close when 101SC is TRUE.
EXIT;Y	Exit and save settings.

Step 2: Prepare to monitor the 101 Virtual Breaker Control Switch operation. Operation can be verified by monitoring the programmed output contacts, HMI Screen 2.2.1 or by using RG-STAT command. See Section 6, *Reporting and Alarm Functions*, for more information.

Step 3: Transmit the commands in Table 13-80 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 13-80. 101 Virtual Breaker Control Switch Trip Test Commands

Command	Purpose
A=	Gains write access.
CS-101T=T	Selects 101T for Trip operation.
CO-101T=T	Executes 101T for Trip operation.

Step 4: Transmit the commands in Table 13-81 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 13-81. 101 Virtual Breaker Control Switch Close Test Commands

Command	Purpose
A=	Gains write access.
CS-101C=C	Selects 101C for Close operation.
CO-101C=C	Executes 101C for Close operation.

Logic Timer (62)

Purpose: To verify the operation of the 62/162 Timer elements.

Reference Commands: SL-62/162, S<g>-62/162, RS-LGC

Note

In these tests, the relay's virtual switches (x43) are used to initiate the 62/162 Timers. See Section 4, *Protection and Control, Virtual Switches*, for detailed information about x43 Switch operation.

Mode 1 - Pickup/Dropout

Step 1: Prepare the 62 timer for Mode 1 testing by transmitting the commands in Table 13-82 to the relay.

Table 13-82. 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 13-83 to set the 62 function pickup and dropout time.

Table 13-83. 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 13-84 to the relay. These commands will initiate the 62 Timer by changing the 43 Switch state to closed (logic 1). Once initiated, the 62 Timer will force an output based on the 400-millisecond pickup time setting.

Table 13-84. x62 Mode 1 Timer Initiate Commands

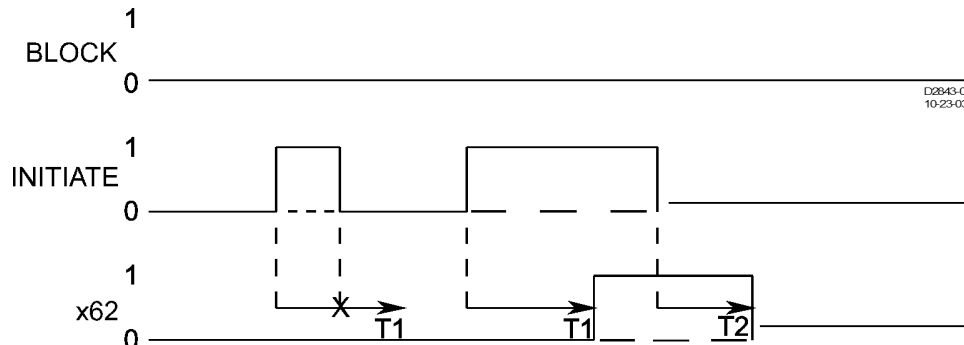
Command	Purpose
A=	Gains write access.
CS-43=1	Selects 43 for On operation.
CO-43=1	Executes 43 for On operation.

Step 4: Transmit the commands in Table 13-85 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 13-85. 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. 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 13-1 illustrates the timing relationship of the 43 Switch and 62 Timer.

**Figure 13-1. 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 13-86 to the relay.

Table 13-86. x62 Mode 2 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T162	Sets T162 as custom logic name.
SL-162=2,143,0	Enables 162 1-shot, nonretriggerable mode, 143 initiate, no blocking.
SL-143=3	Enables 143 Switch momentary pulse mode.
SN-143=162_INI,INI,NORMAL	Name Switch 143 to make SER report easier to read.
S0-162=400m,20s	Sets 162 delay at 400 milliseconds. Sets 162 dropout at 20 seconds.
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands of Table 13-87 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 13-87 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 13-87. 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 13-2 illustrates the timing relationship of the 143 Switch and x62 Timer.

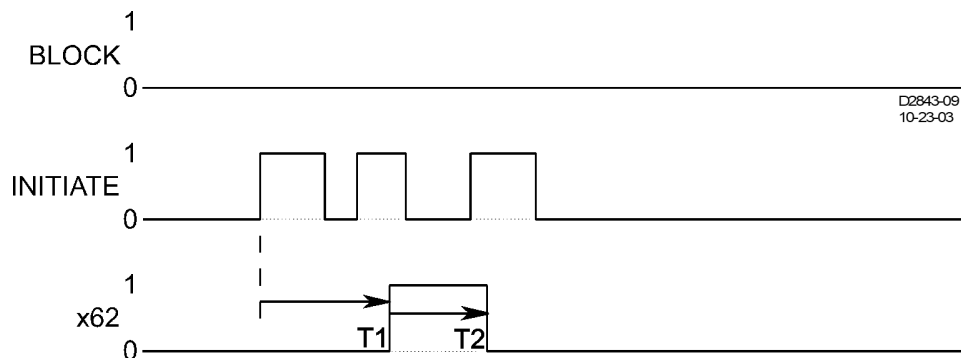


Figure 13-2. Mode 2 and x62 Timer Relationship Example

Mode 3 - One-Shot Retriggerable

Step 1: Prepare the 62 Timer for Mode 3 testing by transmitting the commands in Table 13-88.

Table 13-88. x62 Mode 3 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T62	Sets T62 as custom logic name.
SL-62=3,43,0	Enables 62 one-shot, retriggerable mode, 43 initiate, no blocking.
SL-43=3	Enables 43 Switch momentary pulse mode.
SN-43=62_INI,INI,NORMAL	Name Switch 43 to make SER easier to read.
S0-62=15s,20s	Sets 62 delay at 15 seconds. Sets 62 dropout at 20 seconds.

Command	Purpose
EXIT;Y	Exit and save settings.

Step 2: Transmit the commands of Table 13-89 to the relay. These commands supply the 62 Timer with a momentary initiate input by pulsing the 43 Switch from FALSE to TRUE and then back to FALSE. You may view the state changes of the 43 Switch at Screen 1.5.4 of the front panel HMI.

Note

The 43 Switch action is performed three times in this test. To illustrate the action of the timer mode, the second 43 Switch action should be executed as quickly as possible (within the 15 second duration of the pickup time delay). Perform the third 43 Switch action after at least 15 seconds (the pickup timer setting) have elapsed but before the 20 second dropout time delay expires. This will illustrate the action of the timer mode. The time delay settings may be increased if difficulty is encountered with repeating the 43 Switch actions.

Table 13-89. x62 Mode 3 Timer Initiate Commands

Command	Purpose
A=	Gains write access.
CS-43=P	Selects 43 for pulse F-T-F operation.
CO-43=P	Executes 43 pulse F-T-F operation.
CS-43=P	Selects 43 for pulse F-T-F operation.
CO-43=P	Executes 43 pulse F-T-F operation.
Wait at least 15 seconds (but no longer than 35 seconds) to execute next commands.	
CS-43=P	Selects 43 for pulse F-T-F operation.
CO-43=P	Executes 43 pulse F-T-F operation.
EXIT	Exit select and operate mode.

Step 3: Use the RS-LGC command to obtain an SER report and verify that the following actions were logged. These events are illustrated in the timing diagram of Figure 13-3.

Approximately 15 seconds after the second 43 FALSE to TRUE initiate signal, the 62 Timer output went TRUE. The timer output went FALSE when the third FALSE to TRUE initiate signal forced the 62 Timer (T1) to restart.

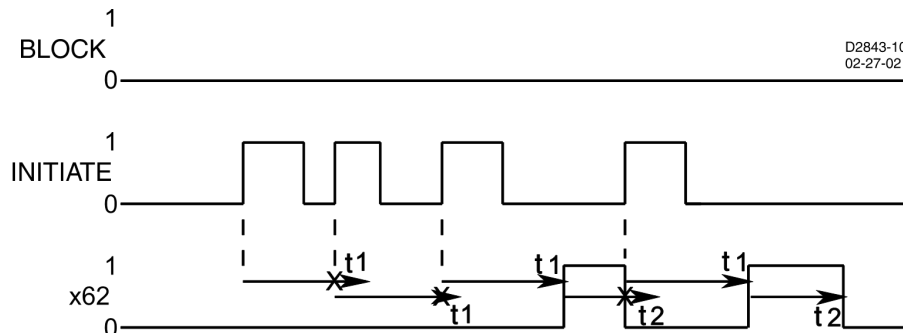


Figure 13-3. Mode 3 (One-Shot Retriggerable) Timing Example

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 13-90.

Table 13-90. 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 13-91 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 13-91 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 13-91. 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.	
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 13-4.

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.

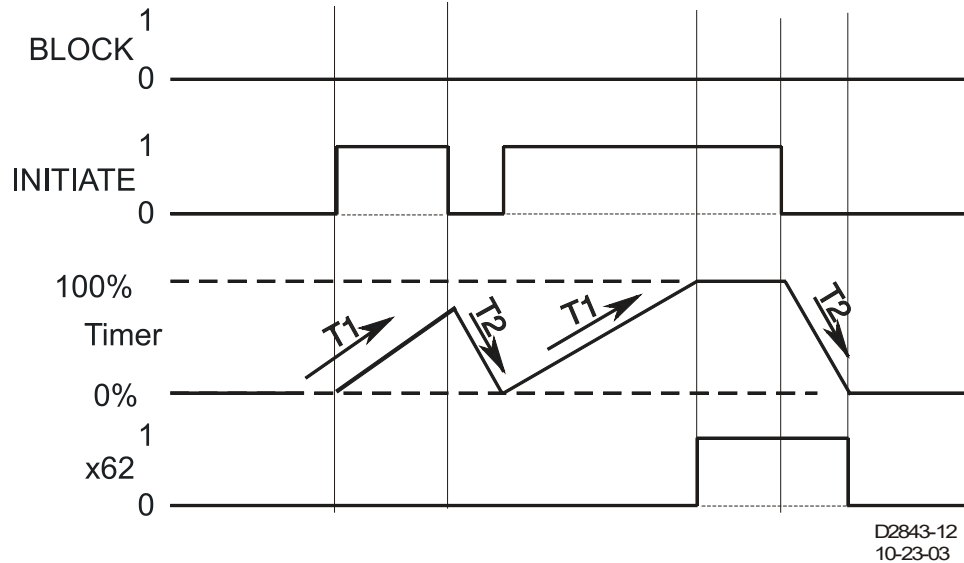


Figure 13-4. Mode 5 (Integrating Timer) Timing Example

Step 4: (Optional.) Repeat the 62 Timer tests for Modes 1, 2, 3, and 5 for Setting Group 1.

Mode 6 - Latch

Step 1: Prepare for Mode 6 logic timer testing by transmitting the commands in Table 13-92 to the relay.

Table 13-92. x62 Mode 6 Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=T62	Sets T62 as custom logic name.
SL-43=1	Enables 43 Switch pulse mode.
SL-143=1	Enables 143 Switch pulse mode.
SN-43=62_INI	Name Switch 43 to make SER report easier to read.
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 13-93 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 13-93 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 13-93. 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 13-5.

Timer T1 continued to time out after the first 43 Switch action. (TRUE).

Timer T1 timed out and the 62 Timer output went TRUE 30 seconds after 43 Switch action. (TRUE). Timer output 62 returned to a FALSE state with the 143 Switch action (TRUE).

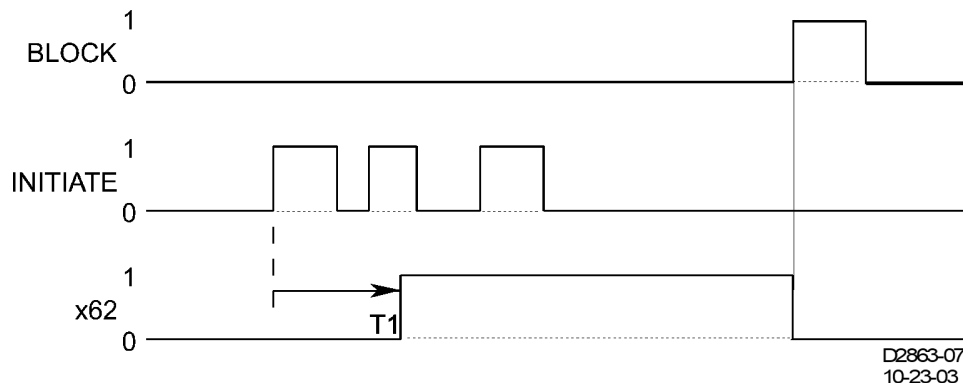


Figure 13-5. x62 Mode 6 (Latch) Timing Example

Step 4: (Optional.) Repeat the 62 Timer tests for Modes 1, 2, 3, and 5 for Setting Group 1.

Automatic Setting Group Change

Purpose: To verify the operation of the automatic setting group change function.

Reference Commands: SL-GROUP, SG-SGCON, SP-GROUP, CS/CO-GROUP, SL-51, S<g>-51

Automatic Change

Step 1: Connect a current source to Terminals D1 and D2 (A-phase input).

Step 2: Prepare the automatic setting group change function for testing by transmitting the commands in Table 13-94 to the relay.

Table 13-94. Automatic Setting Group Change Function Test Commands

Command	Purpose
A=	Gains write access.
SL-N=NONE	Zero out custom logic settings. Overwrite with LOGIC=NONE settings.
Y	Confirm overwrite.
SL-N=ASG	Name custom logic for this test.
SL-GROUP=1,43,143,INI	Sets logic mode to discrete selection with virtual switch and contact input control.
SL-51P=1,0	Enables 51P, disables blocking.
SG-SGCON=1S	Sets SGC on-time at 1 seconds.
SL-VO1=SG1	Closes OUT1 when SG1 is active.
SG-CTP=1	Sets the phase CT ratio at 1.
SG-TRIGGER=51PT,51PPU,0	Enable 51PT to log and trigger fault recording.
SL-43=3	Enables 43 Switch OFF/momentary ON mode.
SL-143=3	Enables 143 Switch OFF/momentary ON mode.
SN-43=MAN_SEL,GRP0,NORMAL	Assigns 43 Switch labels.
SN-143=MAN_SEL,GRP1,NORMAL	Assigns 143 Switch labels.
SN-IN1=MAN_SEL,AUTO,MANUAL	Assigns IN1 Switch labels.
SP-GROUP1=1,75,1,70,51P	SG1 ts = 1 min @ 75%, tr = 1 min @ 70% of SG0 51P setting.
EXIT;Y	Exit and save settings.

Step 3: Select automatic setting group control by energizing Input IN1.

Step 4: Gain write access and transmit the appropriate setting commands in Table 13-95 to the relay. Remember to save your setting changes with the EXIT;Y commands. An ohmmeter or continuity tester may be used to monitor the output contacts (OUT1, OUT2, OUT3) status.

Table 13-95. 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 13-96, 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 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 13-96. Setting Group Change Example Accuracy Limits – Increasing Current

Sensing Type	Current Limit		Time	Comments
	Low	High		
1 A	0.5	0.5		Starting point 50% pickup.
	0.735	0.765	> 1 min	Switch to SG1 (75% SG0 51P).
5 A	2.5	2.5		Starting point 50% pickup.
	3.675	3.825	> 1 min	Switch to SG1 (75% SG0 51P).

Step 6: Transmit the select and operate commands in Table 13-97 to the relay.

Table 13-97. Automatic Setting Group Control Selection

Command	Purpose
A=	Gains write access.
CS-143=1	Selects 143 for TRUE operation.
CO-143=1	Executes 143 TRUE operation.
EXIT	Exit select and operate mode.

Step 7: Begin stepping down the current from one level to the next as shown in Table 13-98. 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 13-98. Setting Group Change Example Accuracy Limits – Decreasing Current

Sensing Type	Current Limit		Time	Comments
	Low	High		
	0.867	0.833	> 1 min	Switch to SG1 (85% SG0 51P).
	0.714	0.686	> 1 min	Switch to SG0 (70% SG0 51P).
	4.335	4.165	> 1 min	Switch to SG1 (85% SG0 51P).
	3.57	3.43	> 1 min	Switch to SG0 (70% SG0 51P).

Step 8: Remove the current from Phase A, Terminals D1 and D2.

Step 9: Using the RS-LGC command to retrieve logic variable data from the SER, verify that the following actions were logged:

- Verify that all setting group changes were logged.
- Verify that VO1 went TRUE and closed relay output OUT1 when SG1 became the active setting group.
- Verify the events that occurred in reverse order when the current was being stepped down.

Manual Change - Mode 1

Manual Change Mode 1 test procedures are a continuation of the automatic test procedures. Do not change the logic or settings except for those in Step 1 and subsequent.

Step 1: De-energize IN1 and verify that VO1 goes TRUE and closes OUT1 when SG1 becomes the active setting group.

Step 2: Transmit the select and operate commands in Table 13-99 to the relay.

Table 13-99. Manual Setting Group Control Selection

Command	Purpose
A=	Gains write access.
CS-143=0	Selects 143 for FALSE operation.

Command	Purpose
CO-143=0	Executes 143 FALSE operation.
CS-43=1	Selects 43 for TRUE operation.
CO-43=1	Executes 43 TRUE operation.
CS-43=0	Selects 43 for FALSE operation.
CO-43=0	Executes 43 FALSE operation.
EXIT	Exit select and operate mode.

Step 3: Use the RS-LGC command to retrieve logic variable data from the SER. Verify that the setting group change actions were logged.

Manual Change - Mode 2

Manual Change Mode 2 test procedures are a continuation of the Mode 1 test procedures. Do not change the logic or settings except for those in Step 1 and subsequent.

Step 1: Transmit the commands in Table 13-100 to the relay. These commands set up the relay for binary setting group control selection.

Table 13-100. Binary Group Control Selection Setup

Command	Purpose
A=	Gains write access.
SL-GROUP=2,43,0,143	Configures the setting group control function as binary coded selection. D0 logic = 43, D1 logic = 0, Auto logic = 143
SL-43=2	Sets 43 to On/Off mode.
EXIT;Y	Exit and save settings.

Step 2: Transmit the select and operate commands in Table 13-101 to the relay. For more information on setting group selection, see Section 4, *Protection and Control, Setting Groups*.

Table 13-101. Binary Group control Select and Operate Commands

Command	Purpose
A=	Gains write access.
CS-43=0	Selects 43 for FALSE operation.
CO-43=0	Executes 43 FALSE operation.
EXIT	Exit select and operate mode.

Step 3: Verify that VO1 goes FALSE and opens OUT1 when SG0 becomes the active setting group.



14 • BESTCOMS™ Software

BESTCOMS™ is a Windows® based program that runs on an IBM compatible computer and provides a user friendly, graphical user interface (GUI) for use with Basler Electric communicating products. BESTCOMS is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMS provides the user with a point and click means for setting and monitoring the in-service relay or relays under test. The point and click method provides an efficient, fast setup for configuring one or several relays. This software is provided free with every BE1-700 Digital Protective Relay.

Introduction

A primary advantage of the 32-bit BESTCOMS is that an actual unit (i.e., operating transmission protection system) is not required to perform any or all settings and adjustments for any preprogrammed scheme. Nor is it needed to create a custom scheme complete with settings and adjustments. In addition, BESTCOMS is identical within all of the Basler Electric Numerical Systems except for differences inherit in the individual systems. This means that once you become familiar with a BESTCOMS for one system, you are also familiar with BESTCOMS for all of the systems.

Using the BESTCOMS GUI, you may prepare setting files off-line (without being connected to the relay) and then upload the settings to the relay at your convenience. These settings include protection and control, operating and logic, breaker monitoring, metering, and fault recording. Engineering personnel can develop, test, and replicate the settings before exporting them to a file and transmitting the file to technical personnel in the field. In the field, the technician simply imports the file into the BESTCOMS database and uploads the file to the relay where it is stored in nonvolatile memory. (See the paragraphs on *File Management* later in this manual for more information on saving, uploading, and downloading files.)

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

The BESTCOMS GUI also allows for downloading industry-standard COMTRADE files for analysis of stored oscillography data. Detailed analysis of the oscillography files may be accomplished using BESTwave™ software. Updated contact-sensing inputs specifications in Sections, 1, 3, and 12.

This section introduces all of the screens in the BE1-700 Digital Protective Relay 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 BE1-700 BESTCOMS screen.

BESTCOMS screens are similar to most Windows based GUI screens. You may immediately notice common features such as the pull-down menu, toolbar, icons, and help prompts when the mouse pointer is paused over an icon. Some of these features are shown in Figure 14-1. If the Navigation Bar has a right and left arrow at the extreme right hand side of the screen, clicking on these arrows will shift the Navigation Bar to allow access to all of the icons on the bar. Like most computer programs, there is often more than one way to perform an activity or task. These various methods are discussed in the following paragraphs in conjunction with the appropriate BESTCOMS screen.

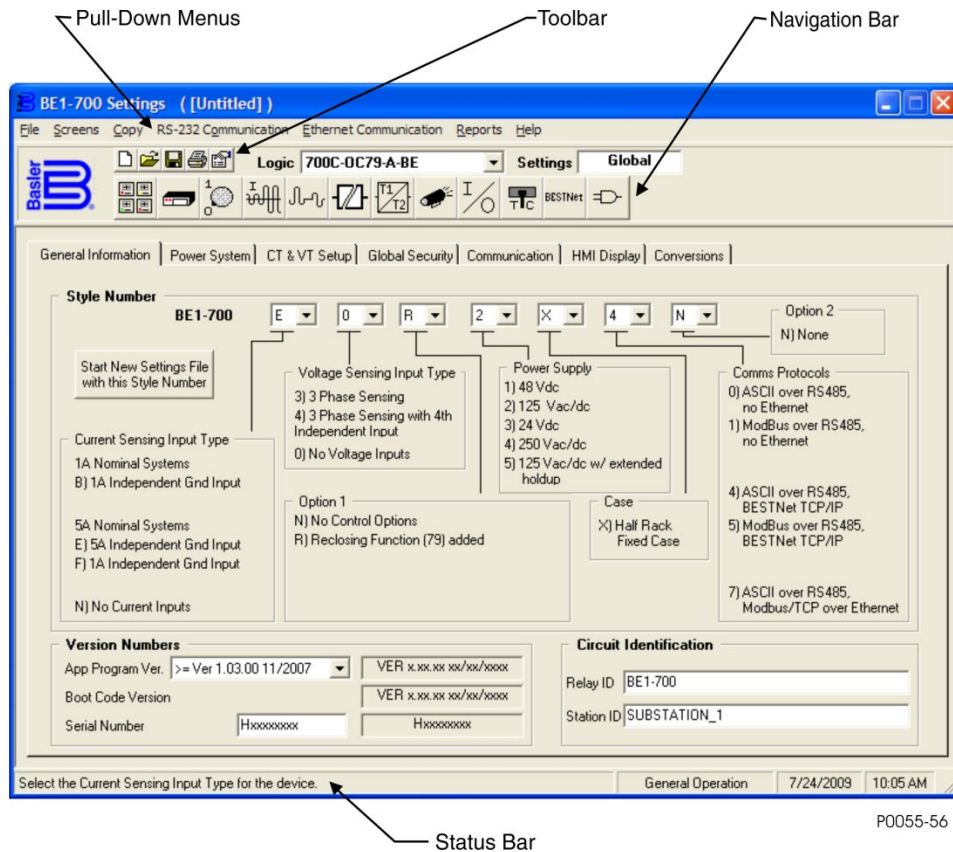


Figure 14-1. Typical User Interface Components

Installation

BESTCOMS for BE1-700 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

- Pentium 233 MHz or faster processor (300 MHz is recommended)
- 64 megabytes (MB) of RAM (128 MB is recommended)
- Windows® XP (32-bit), Windows® Vista (32-bit all editions), Windows® 7 (32/64-bit all editions) , and Windows® 8 (32/64-bit all editions)
- 7 MB of hard disk space
- One available serial port
- One Ethernet port (optional Ethernet-enabled relay)

Installing the Program on Your PC Using Microsoft® Windows®

Run the setup file for the BESTCOMS application. The setup utility automatically installs “BESTCOMS for BE1-700” 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 BE1-700” 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 BE1-700 front panel and an appropriate communication port on the PC.

Updating BESTCOMS™ Software

Future enhancements to relay functionality may make firmware update desirable. Enhancements to relay firmware typically coincide with enhancements to BESTCOMS software for that relay. When a relay is updated with the latest version of firmware, the latest version of BESTCOMS should also be obtained.

BESTCOMS can be downloaded from the Basler Electric web site (www.basler.com) after creating an account.

Starting BESTCOMS™

Start BESTCOMS™

Start BESTCOMS by clicking the *Start* button, *Programs*, *Basler Electric*, and then the *BESTCOMS for BE1-700* icon. At startup, a splash screen with the program title and version number is displayed for a brief time (Figure 14-2). After the splash screen clears, you can see the initial screen - the *System Setup Summary* screen. (This is the same process if you do or do not have a unit connected to your PC.)



Figure 14-2. BESTCOMS™ Splash Screen

System Setup Summary Screen

If you are at another BESTCOMS screen such as *Overcurrent Protection* and want to go to this screen, you may use the *Screens* pull-down menu or click on the *System Setup Summary* icon as is shown at the right margin of this paragraph. See Figure 14-3. This screen gives you an overview of the system setup.



Look in the lower, right-hand corner for the legend. This legend provides interpretation for the various indicated colors. Any protection and control function or element may be enabled or disabled and the current state is indicated by the associated color. If the function is enabled, the color is green. If the function is **only** disabled by a setting (such as zero), the color is yellow. If the function is **only** disabled by logic, the color is blue. If the function is disabled by **both** a setting and logic, the color is gray.

If a function has variations such as 27X or 59X, which has three modes (fundamental, three-phase residual and third harmonic) and none of these modes are enabled, a tilde (~) is displayed.

In addition to the functional status, *Group Selection* is displayed and the names are shown for the displayed and active logic and the virtual switches.

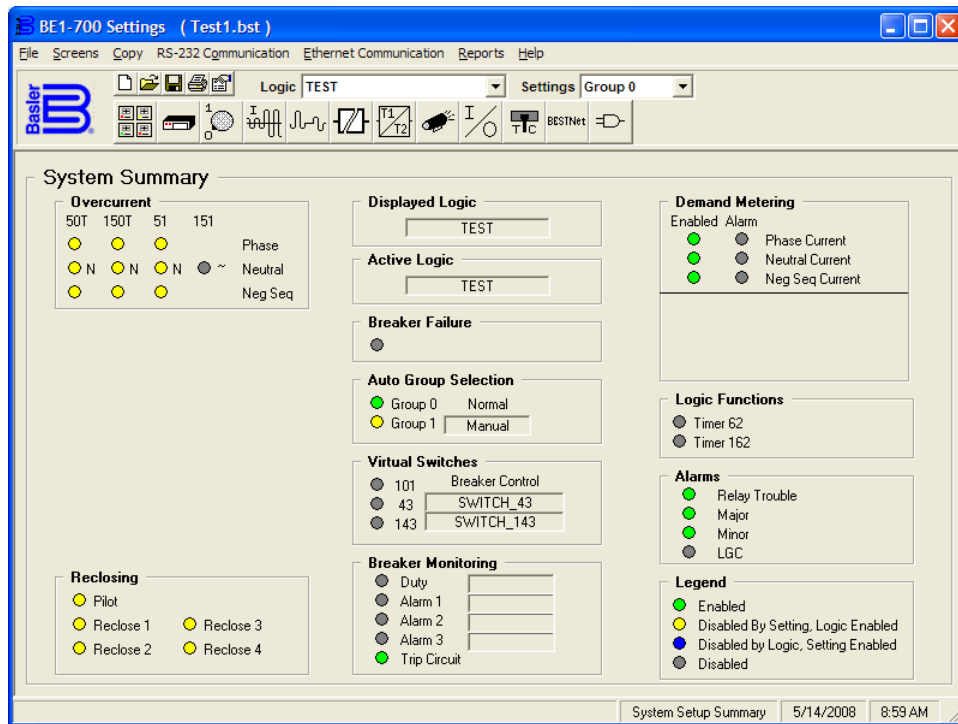


Figure 14-3. System Setup Summary Screen, Protection and Control Tab

Configuring the PC

If you have an actual BE1-700 relay, configure your PC to match the BE1-700 configuration. To do this, pull down the *Communication* menu in the pull-down menu and select *Configure*. Now, match the communication configuration in the BE1-700 relay. You may select *Terminal (VT100 Emulation)* and go directly to that communication protocol. You must close *Terminal Mode* before you can use BESTCOMS again. If you are comfortable using ASCII commands, the *Terminal Mode* is an easy method for checking the actual settings or status of the relay when you are in doubt about an action to take in BESTCOMS. ASCII commands are available in Section 11, *ASCII Command Interface*.

Setting the Relay

To set the relay, we will discuss the contents of each of the screens for BESTCOMS for the BE1-700. The *System Setup Summary* screen was discussed in previous paragraphs. We begin with the assumption that you have started BESTCOMS, connected the PC to the relay, and configured your PC to the relay. If the default settings are active in your relay, you will have to change the logic to clear the Major alarm or disable the Logic = None Alarm under *Alarm Priority* in *Reporting and Alarms, Alarms*. This section describes BESTCOMS features as they occur and not on a priority (perform this setting first) basis. For information on how to select or name the active logic, see the paragraphs on *BESTlogic™*.

Select Logic Scheme for Display

In Figure 14-3, below the pull-down Menu bar, there is a pull-down arrow for the *Logic* window in the Toolbar row. To select a preprogrammed scheme, pull down this menu and click on the desired scheme. When you do, the selected logic name is displayed in the *Logic* window and the *System Setup Summary* screen displays what results would be if that scheme were active. It does not make it the active screen. You select custom and preprogrammed logic schemes using the *BESTlogic* screen. (See additional paragraphs in this section.)

Settings Display and Selection

Immediately to the right of the *Logic* window is a *Settings* window. A pull-down menu is shown and provides for Group 0 or 1 selection. An example of this is the *Overcurrent Protection* screen. Pull down the *Screens* menu and select *Overcurrent Protection*. When you do, the *Settings* window display changes to the *Group* pull-down menu. If you wanted the specific setting change that you were about to make to affect the Group 1 settings, select Group 1.

General Operation Screen

Pull-down the *Screens* menu and select *General Operation* or click on the General Operation icon, which is shown at the right margin of this paragraph. This screen has seven folder tabs. The first tab is *General Information* (Figure 14-4).



General Information

The *General Information* tab allows you to fill in the style number of the relay, which is available from the label on the relay front panel. You can also enter the serial number of the relay and software application version information. Additionally, you may enter the name of the substation and the feeders so that the relay reports have some form of installation-specific identification.

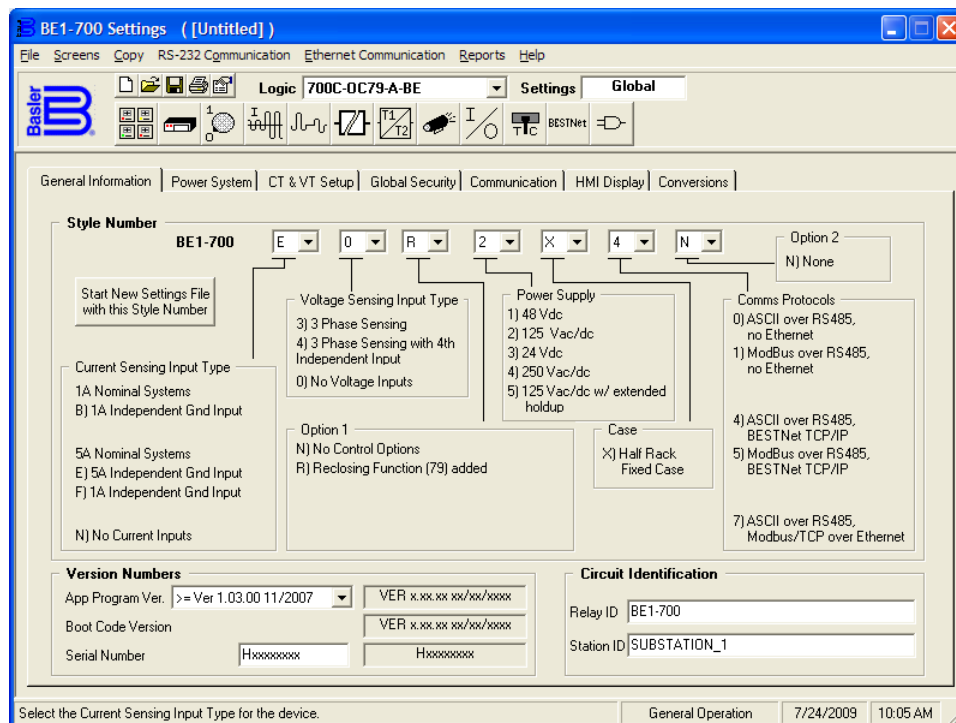


Figure 14-4. General Operation Screen, General Information Tab

Power System

This tab (Figure 14-5) allows you to enter the frequency, phase rotation, and nominal CT secondary voltage and current. If the phase rotation entry is not correct, it will cause problems in several areas including metering values and targets. In other words, you must make entries in these fields in order for the BE1-700 protection elements to function properly. These symmetrical component sequence quantities are entered to provide immediate reference information for settings of the protection elements in the BE1-700 relay.

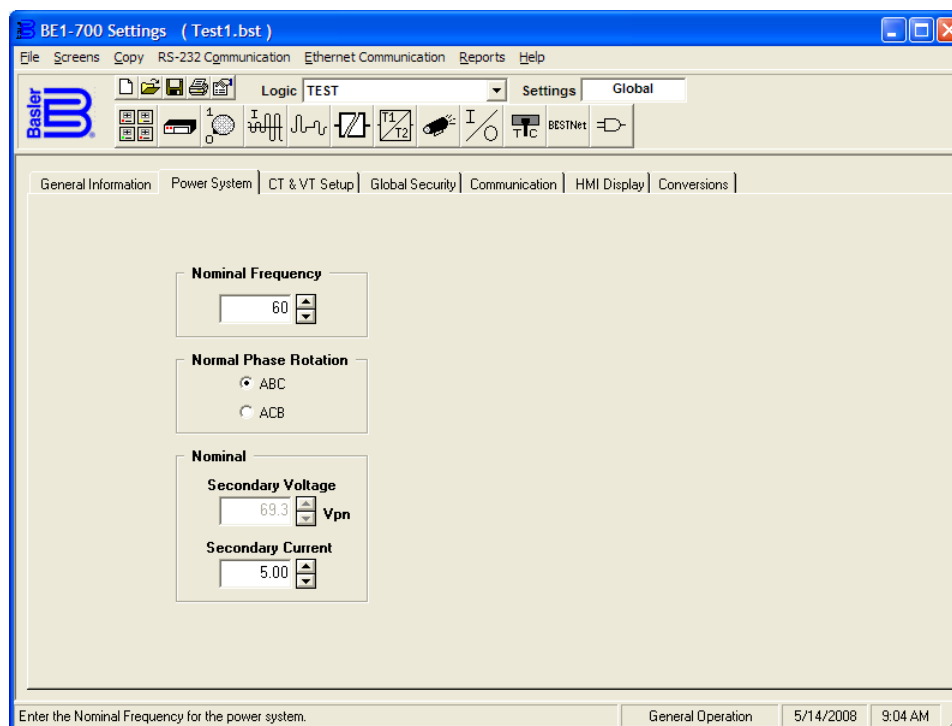


Figure 14-5. General Operation Screen, Power System Tab

CT & VTP Setup

This tab (Figure 14-6) allows you to enter the CT ratios and set up the VT parameters. These entries affect every function that relies on voltage and current measurements and calculations derived from those measurements. Click the up or down arrows to adjust the CT Phase Turns Ratio. Once you enter the CT Ratio, Phase Turns value, the primary amperes value is entered for you. For example, if you entered 240 for the Turns value and the secondary nominal current input is 1, the primary amperes value becomes 240. If you change the secondary nominal current input to 5, the primary amperes value becomes 1,200. The CT Ground Ratio is set in the same manner and again the primary amperes value is automatically set.

The VTP Setup is very similar. You may click once in an entry window and select the entire value entered. If you are making an entry in the window, clicking once locates the cursor in the entry and clicking twice selects the entire value entered. Over- and undervoltage modes can be set to operate on either the phase-to-phase (PP) or phase-to-neutral (PN) quantities. Click on the appropriate button to select the quantity required. Pull down the connection menu and select the appropriate Connection for phase voltage input. Perform these same steps for the VTX Setup if the auxiliary voltage input is valid.

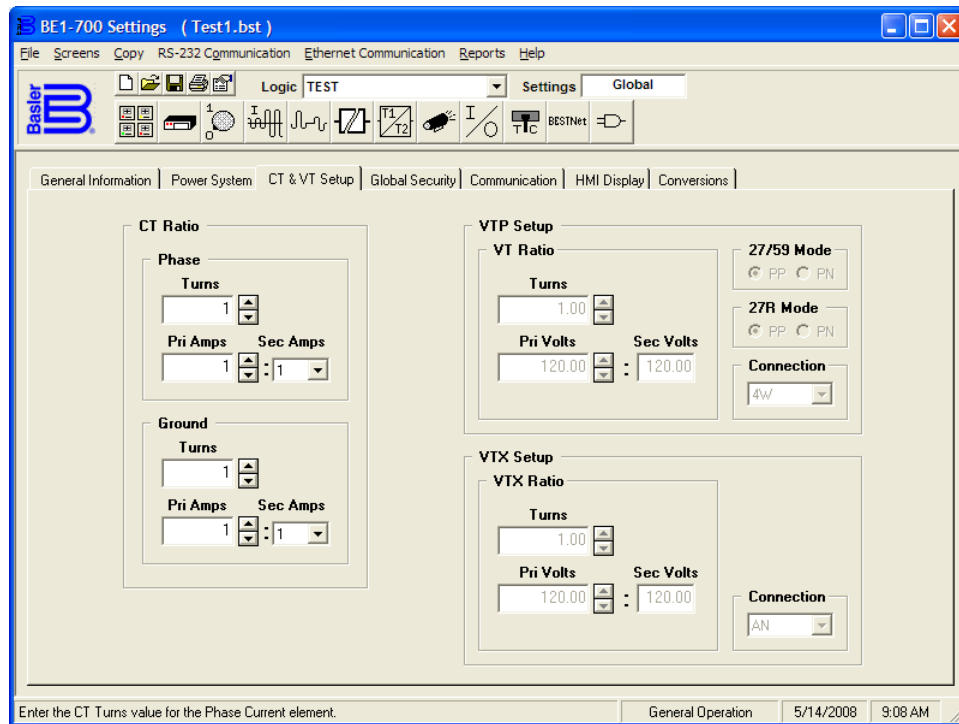


Figure 14-6. General Operation Screen, CT & VT Setup Tab

Global Security

Each of three communication ports and the three functional areas (Settings, Reports, and Control) has password security. See Figure 14-7. This allows the user to customize password protection for any and all ports. For example, you could allow technicians to have global access (sometimes called a fourth level of access) to all three functional areas via the front port. You could also restrict the rear port, which is connected to a modem to read-only access.

If you select *Show Passwords* and the default passwords have not been changed, all four passwords appear and can be changed. If the Global Access password has been changed, a dialog box appears explaining that you must enter the Global Access password to enable viewing and editing the existing passwords. After entering the global password, the passwords and enable boxes appear. You may then make changes in any and all areas. Clicking a box for a specific communication port toggles the functional area for that port either ON or OFF. Notice that the front panel human-machine interface (HMI) and communications port zero are combined and considered as one. **Note:** By default, all modes of access are disabled on the optional rear Ethernet port (COM1). Read access is always enabled.

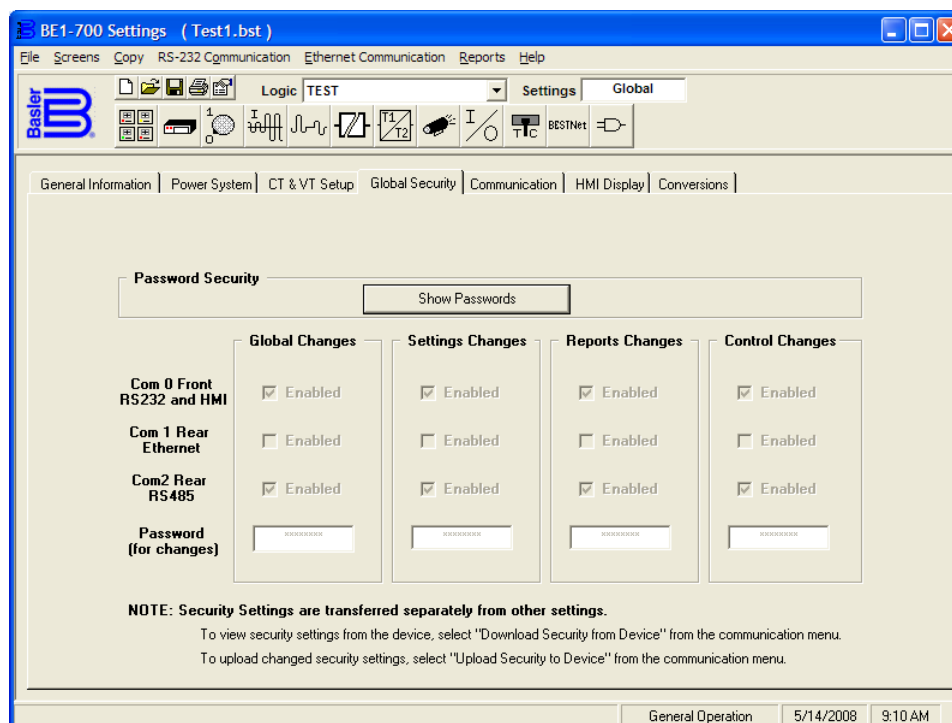


Figure 14-7. General Operation Screen, Global Security Tab

Communication

This tab, Figure 14-8, 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*. Note that a password can be required or not required. For more information on these parameters, see the appropriate Modbus instruction manual.

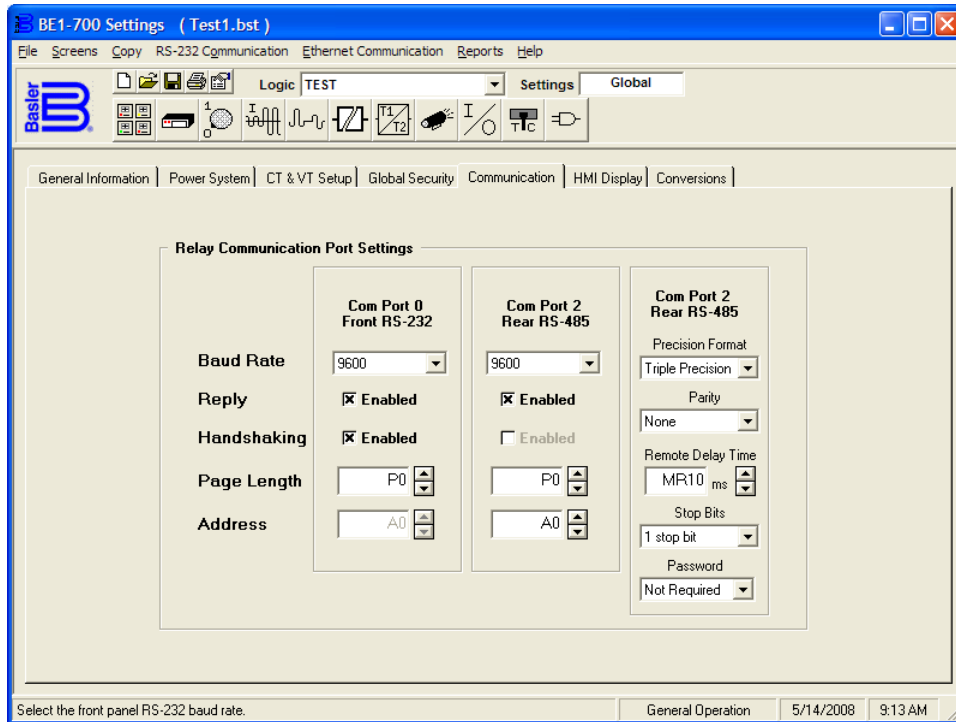


Figure 14-8. General Operation Screen, Communication Tab

HMI Display

This tab (Figure 14-9) allows the user to view what would be shown on the BE1-700's HMI display as the *UP*, *DOWN*, *LEFT*, and *RIGHT* push buttons are clicked. These displays are similar to Figures 10-2 through 10-9 in Section 10, Human-Machine Interface. Notice, too, that the corresponding screen number is shown in the right pane. The user is also able to change the screen scroll list from the right pane. Be aware that only the code for the latest version of BESTCOMS is contained within BESTCOMS. If you have an earlier version of the embedded firmware in your relay and select information on the *General Information* tab under *General Operation* screen, you might select a screen scroll item in BESTCOMS that is not available in the relay. If you do, you will immediately get an error code.

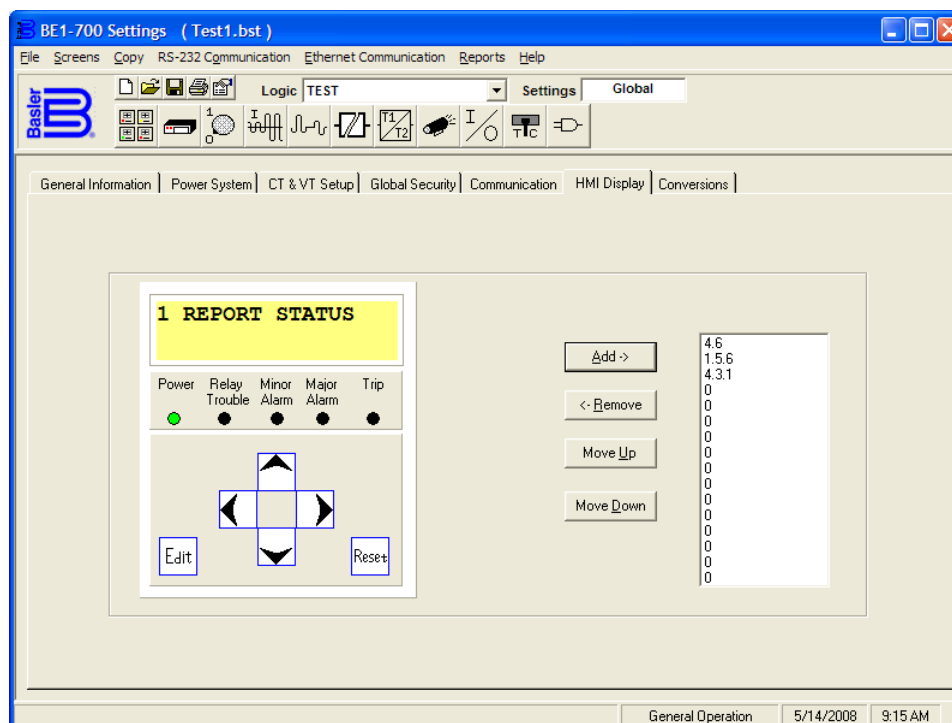


Figure 14-9. General Operation Screen, HMI Display Tab

Conversions

The *Conversions* tab brings up the screen that allows entries in per unit quantities. See Figure 14-10. The per unit conversion for the settings involves entries for the Base quantities. When you are entering settings later on, you can select primary current values, secondary current values, percent, or per unit values. If you are using percent or per unit, then you have to enter the *Conversion* screen field values regarding three-phase, phase-to-phase, and phase-to-neutral base quantities. If the settings are entered in terms of primary or secondary current values, you do not need to enter this information.

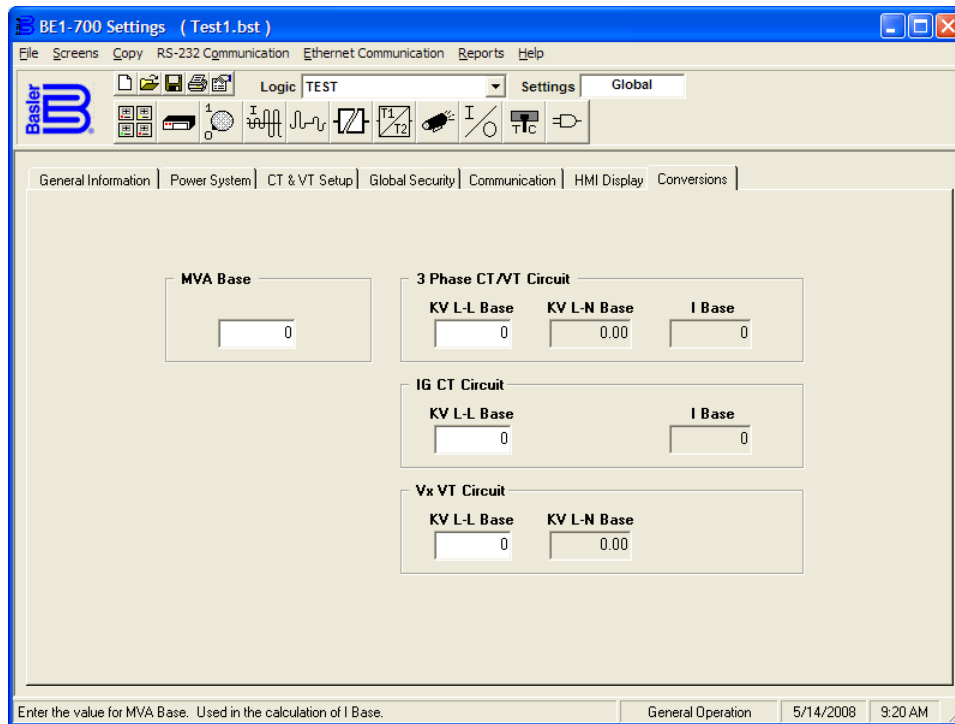


Figure 14-10. General Operation Screen, Conversions Tab

Setting Group Selection

Pull down the Screens menu and select *Setting Group Selection* or click on the *Setting Group Selection* icon, which is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *Setting Group Selection* (Figure 14-11).

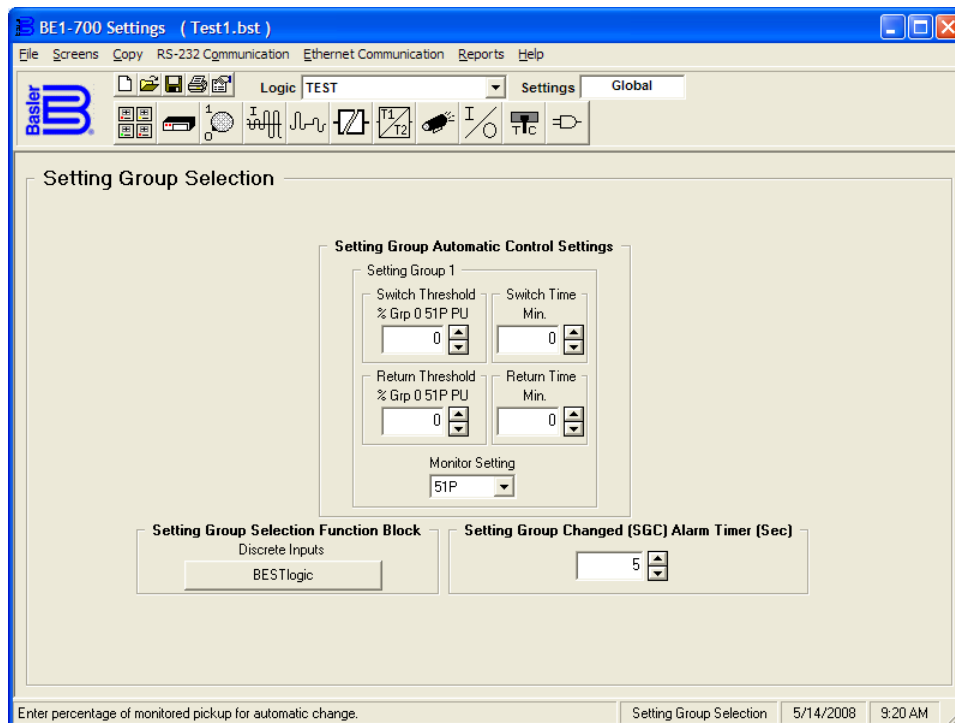


Figure 14-11. Setting Group Selection Screen

Setting group selection involves programming the relay to automatically select one group out of two protective element setting groups in response to system conditions. When the system is normal, the default or normal group is 0. Auxiliary setting groups allow adapting the coordination settings to optimize them for a predictable situation. Sensitivity and time coordination settings can be adjusted to optimize sensitivity or clearing time based upon source conditions or to improve security during overload conditions. In the center of Figure 14-11, there is a *Monitor Setting* window for Group 1. This field allows you to select which element controls that specific group selection. The *Switch Threshold* sets the level for the monitored element and the *Switch Time* sets the time delay (in minutes) to prevent the group change from changing the instant that the monitored element exceeds the *Switch Threshold* setting. *Return Threshold* and *Return Time* do the same thing for changing back to the previous group.

You do not have to depend only on monitored conditions to change the group selection. The active Setting Group can be controlled at any point in time by the setting group control logic. (Refer to Section 4, *Protection and Control*, for more information on setting groups.) The setting group control also has an alarm output variable SGC (Setting Group Changed). This output is asserted whenever the BE1-700 switches from one setting group to another. The alarm bit is asserted for the SGCON time setting. You can click in the *Setting Group Change (SGC) Alarm Timer (Sec)* field and set the SGCON time setting. Or, use the *UP* and *DOWN* arrows to adjust the SGCON time setting.

Overcurrent Protection (BE1-700C)

Pull down the Screens menu and select *Overcurrent Protection* or click on the *Overcurrent Protection* icon, which is shown at the right margin of this paragraph. This screen has four folder tabs and the first tab is *51* (Figure 14-12).

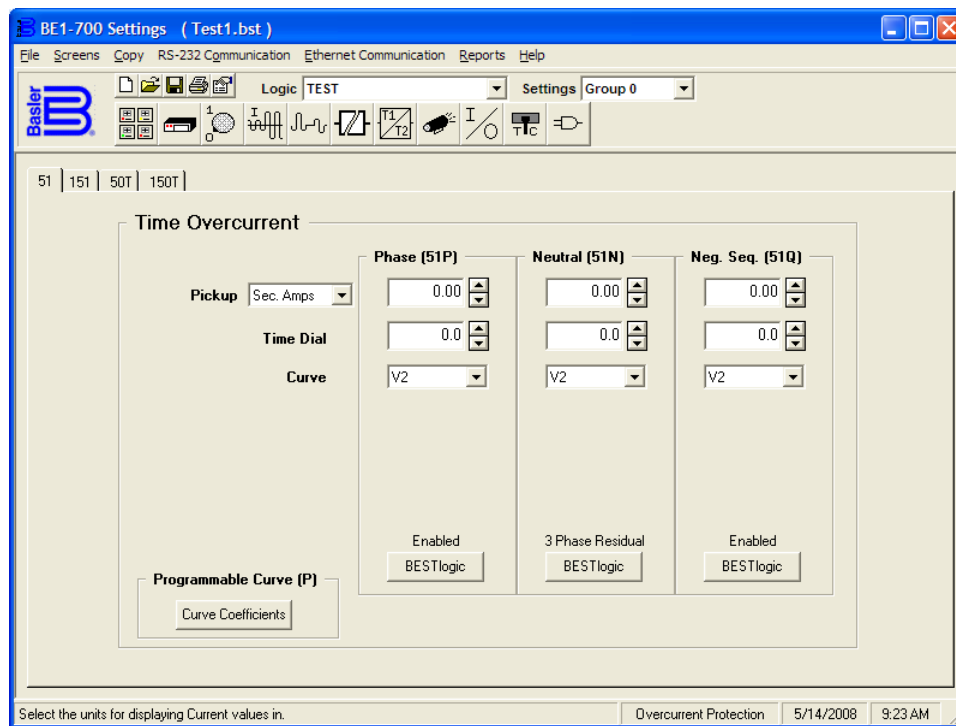


Figure 14-12. Overcurrent Protection Screen, 51 Tab (Time Overcurrent)

51 and 151 (Time Overcurrent)

This tab (Figure 14-12) allows you to enter the settings for the time overcurrent elements. BE1-700 relays have four time overcurrent elements (three with the 51 element and one with the 151 element). The pull down *Pickup* menu allows you to select the relative pickup quantity. As the default, BE1-700 relays measure the current input in secondary amperes. If you want to use primary current, per unit or percent amperes, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Settings for *Time Dial* and *Curve* (time characteristic curve) are conventional settings. If you want to change the characteristic curve constants, select the *Curve Coefficients* and a dialog box opens for those entries. Select the *BESTlogic* box at the bottom of the *Phase (51P)* column. The status of the logic is shown above the *BESTlogic* box.

A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices. The 151 element is adjusted in a similar fashion to the 51 element.

50T and 150T (Instantaneous Overcurrent with Settable Time Delay)

The BE1-700 relay has six instantaneous elements (three with the 50T element and three with the 150T element). See Figure 14-13 for the 50T element. The tabs for the instantaneous elements are almost identical to the 51/151 tabs. The settable time delay is the primary difference. To change the time delay, click the *Time* menu *Down* arrow and select your preferred unit of measure (milliseconds, minutes, or cycles). Then change the time for the appropriate phase, neutral, or negative-sequence element. The 150T element is set in a fashion similar to the 50T element.

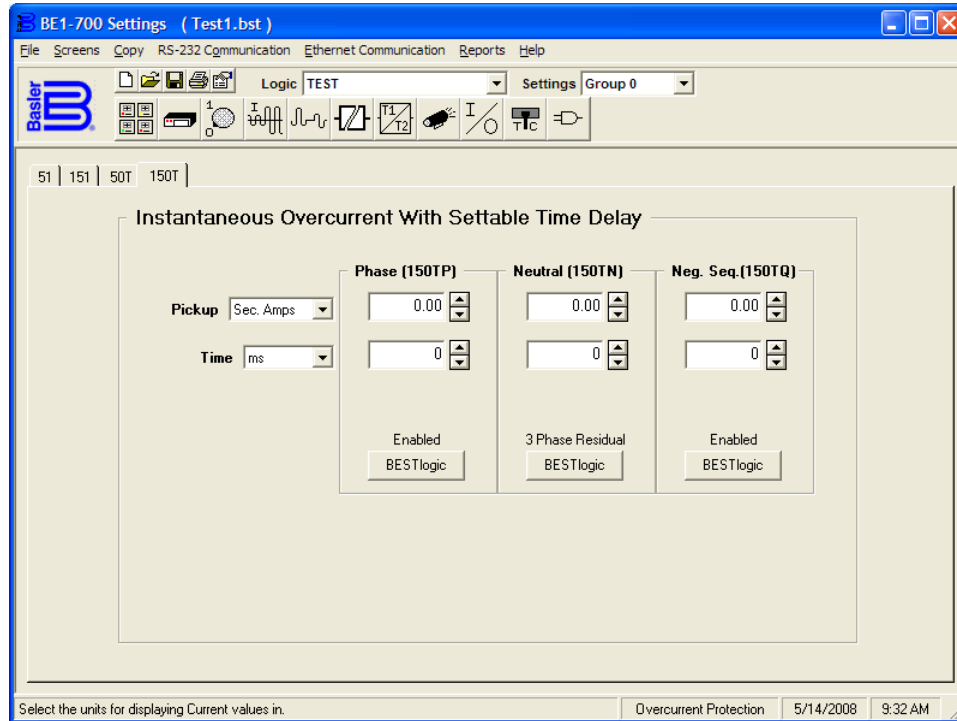


Figure 14-13. Overcurrent Protection Screen, 50T Tab (Instantaneous Overcurrent)

Voltage Protection (BE1-700V)

Pull down the *Screens* menu and select *Voltage Protection* or click on the *Voltage Protection* icon, which is shown at the right margin of this paragraph. This screen has eight folder tabs and the first tab is 24 (Overexcitation) (see Figure 14-14).



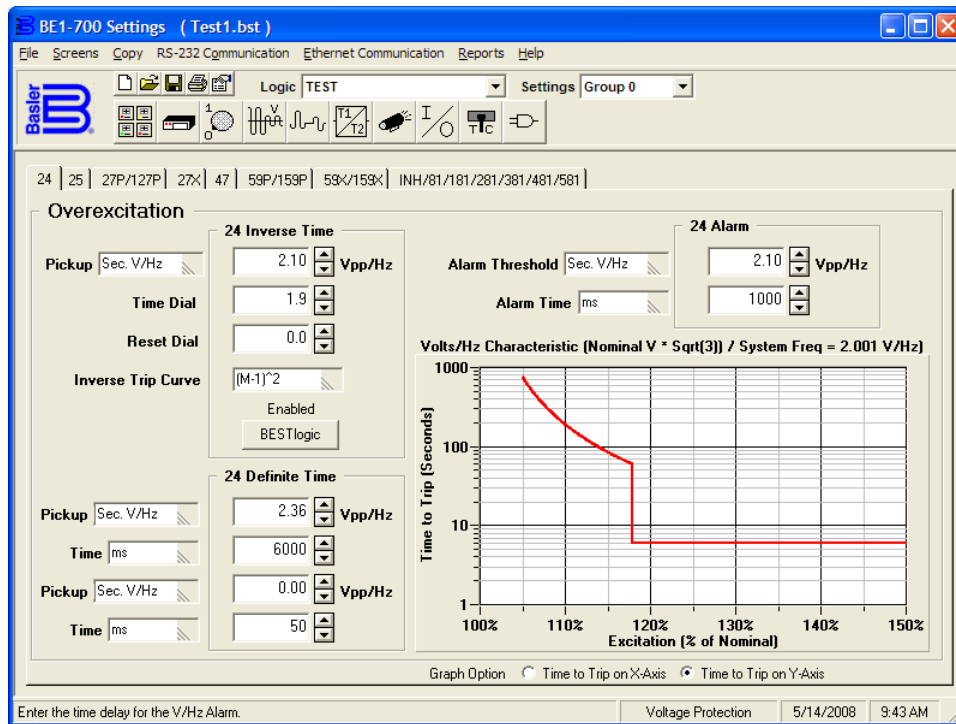


Figure 14-14. Voltage Protection Screen, 24 Tab (Overexcitation)

24 (Overexcitation)

This tab (Figure 14-14) allows you to make the settings for the volts/hertz element. The pull down *Pickup* menu allows you to select the relative pickup quantity. The BE1-700 relay measures the voltage input in secondary voltage. If you want to use primary volts, per unit volts or percent volts, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Whatever the measurement, the method is displayed besides the settings e.g., V_{PP} (voltage, phase-to-phase). Settings for trip *Time Dial* and *Reset Dial* can be adjusted. The *Alarm Threshold* (percent of pickup) can also be adjusted.

Select the *BESTlogic* box at the bottom of the *24 Inverse Time* column. The status of the logic is shown above the *BESTlogic* box. A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices.

25 (Sync-Check)

This tab (Figure 14-15) 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 BE1-700 relay measures the voltage input in secondary voltage. If you want to use primary volts, per unit volts, or percent volts, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Whatever the measurement, the method is displayed besides the settings, e.g., V_{PN} (voltage, phase-to-neutral). Settings for *Delta Angle* (Degrees) and *Slip Frequency* (Hertz) are conventional settings. If you want the 25 phase input frequency to be greater than the auxiliary input frequency during sync-check, click the *Enable* box on the screen.

Set the 25VM *Live* and *Dead* threshold levels. Set the *Dropout Delay* (time delay between sensing dropout and clearing VM1 logic bit) unit of measure and value. Select the 25VM Logic that will set the VM1 logic bits.

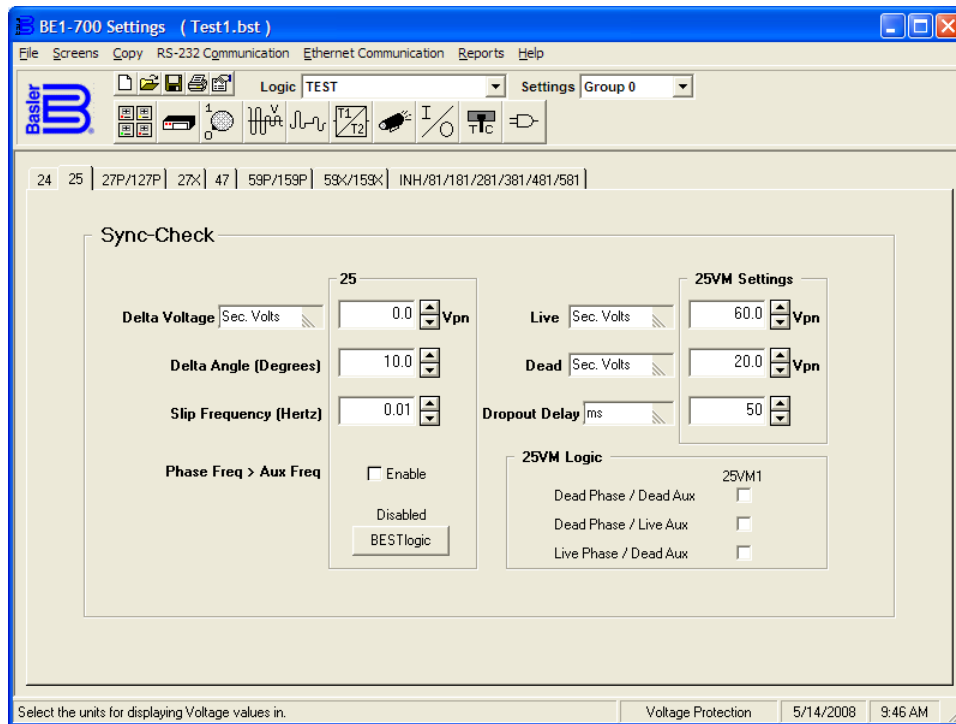


Figure 14-15. Voltage Protection Screen, 25 Tab (Sync-Check)

27P/127P (Phase Undervoltage)

This tab (Figure 14-16) is the *Phase Undervoltage with Settable Time Delay*. The pull down *Pickup* menu allows you to select the relative pickup quantity. The BE1-700 relay measures the voltage input in secondary voltage. If you want to use primary volts, per unit volts or percent volts, you must coordinate the settings in *CT & VT Setup* and *Conversions*. Whatever the measurement, the method is displayed besides the settings, e.g., V_{PP} (voltage, phase-to-phase). Select the Time delay unit of measure and the value for the 27P and 127P elements. Select the *BESTlogic* box at the bottom of the Phase (27P) or Phase (127P) columns. The status of the logic is shown above the *BESTlogic* box. A dialog box (*BESTlogic Function Element*) opens showing the status of the element logic and the logic scheme name. If you have a custom logic scheme active, you may change the status of the element logic by pulling down the menu and selecting from the available choices.

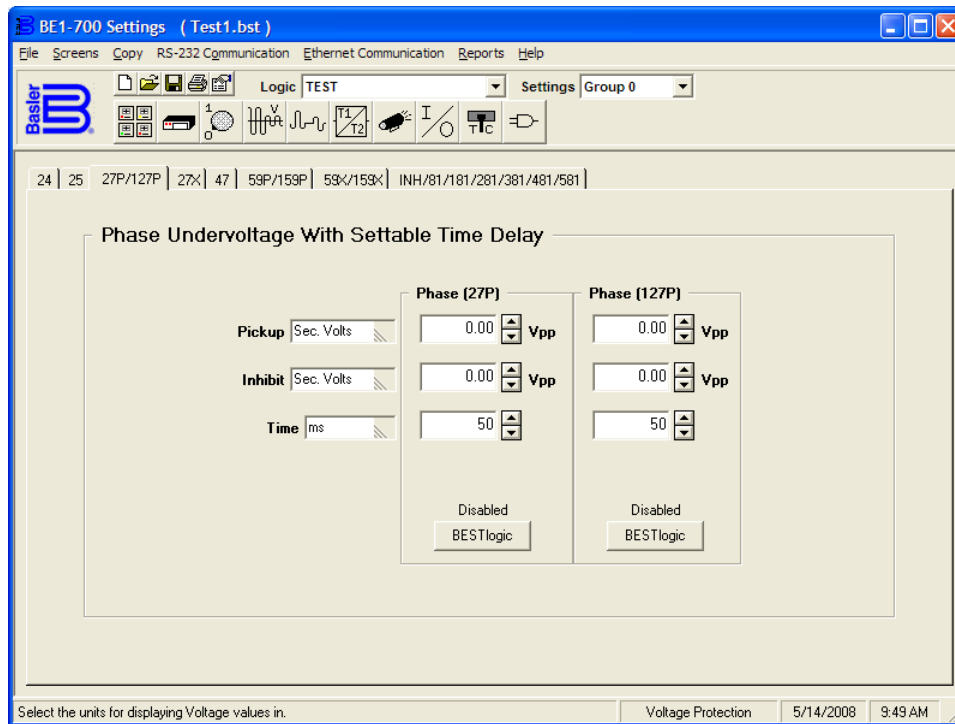


Figure 14-16. Voltage Protection Screen, 27P/127P Tab (Phase Undervoltage)

27X (Auxiliary Undervoltage)

This tab (Figure 14-17) is the *Auxiliary Undervoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those of the 27P/127P elements above.

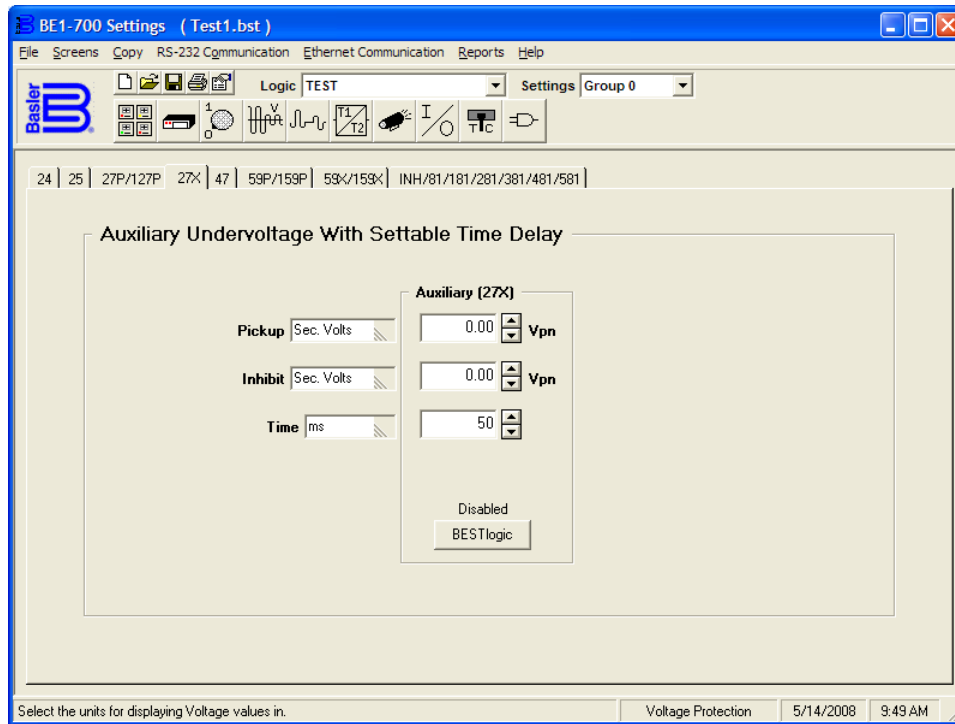


Figure 14-17. Voltage Protection Screen, 27X Tab (Auxiliary Undervoltage)

47 (Neg.-Seq. Overvoltage)

This tab (Figure 14-18) is the *Negative-Sequence Overvoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those of the 27P/127P elements above.

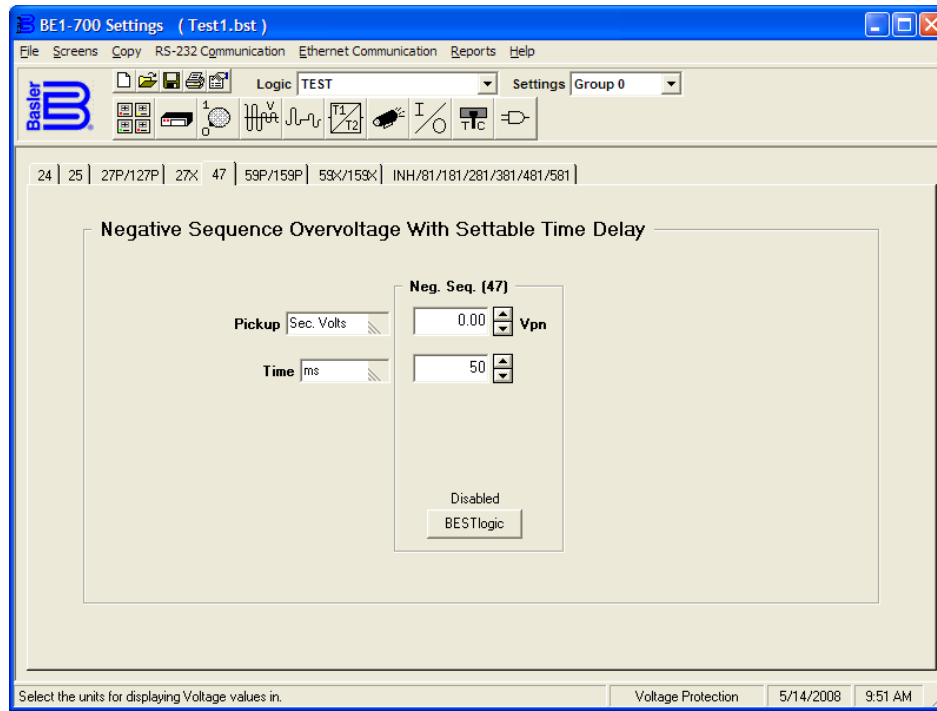


Figure 14-18. Voltage Protection Screen, 47 Tab (Neg.-Seq. Overvoltage)

59P/159P (Phase Overvoltage)

This tab (Figure 14-19) is the *Phase Overvoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those settings of the 27P/127P elements above.

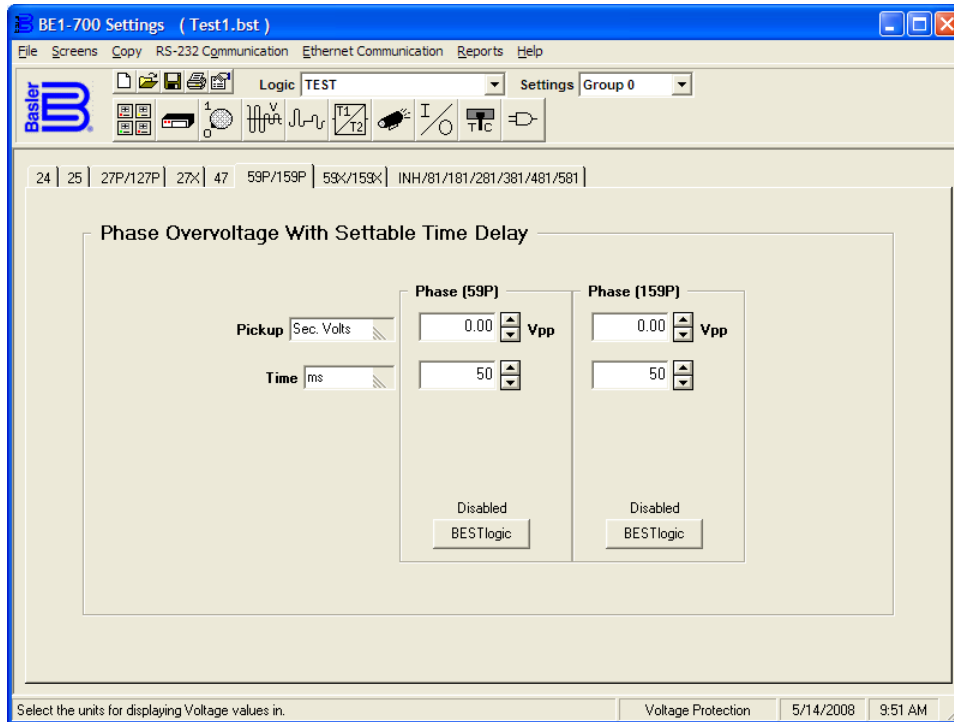


Figure 14-19. Voltage Protection Screen, 59P/159P Tab (Phase Overvoltage)

59X/159X (Auxiliary Overvoltage)

This tab (Figure 14-20) is the *Auxiliary Overvoltage with Settable Time Delay*. Changing the settings for this element is identical or similar to those settings of the 27P/127P elements above.

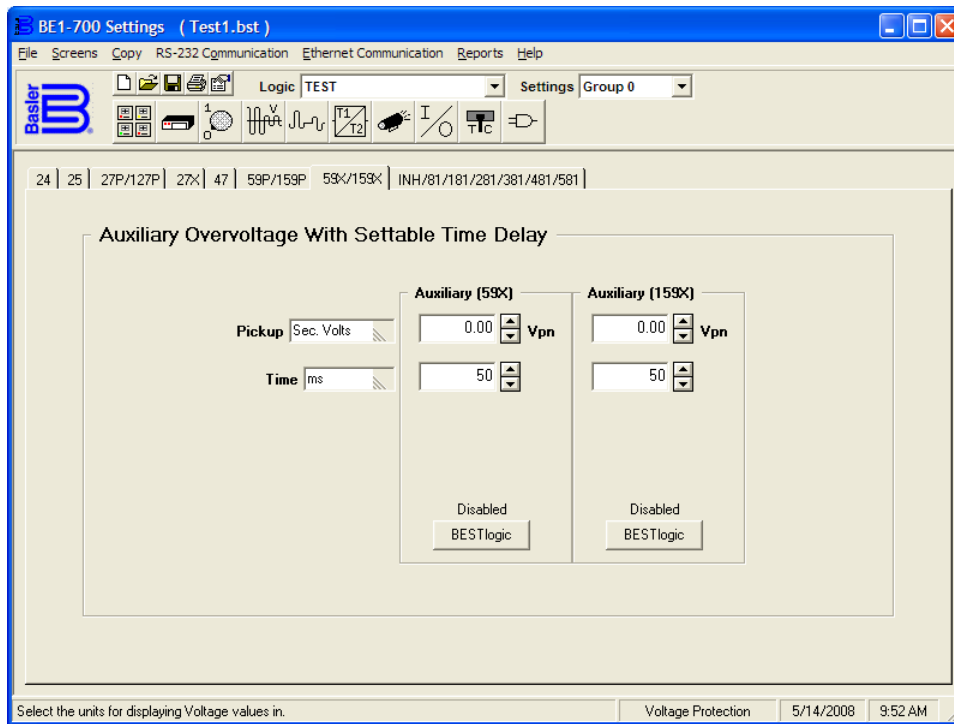


Figure 14-20. Voltage Protection Screen, 59X/159X Tab (Auxiliary Overvoltage)

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

This tab (Figure 14-21) is the *O/U Frequency with Settable Time Delay*. Changing the settings for these elements is identical or similar to those settings of the 27P/127P elements above.

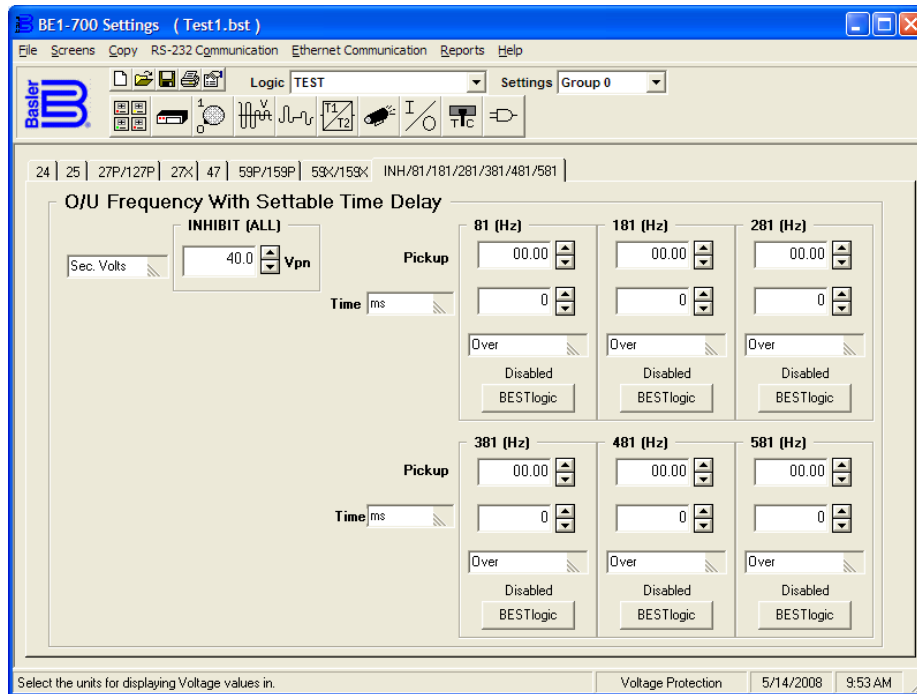


Figure 14-21. Voltage Protection Screen, INH/81/181/281/381/481/581 Tab (O/U Frequency)

Reclosing (Optional)

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 14-22) has no folder tabs and is labeled *Reclosing*.



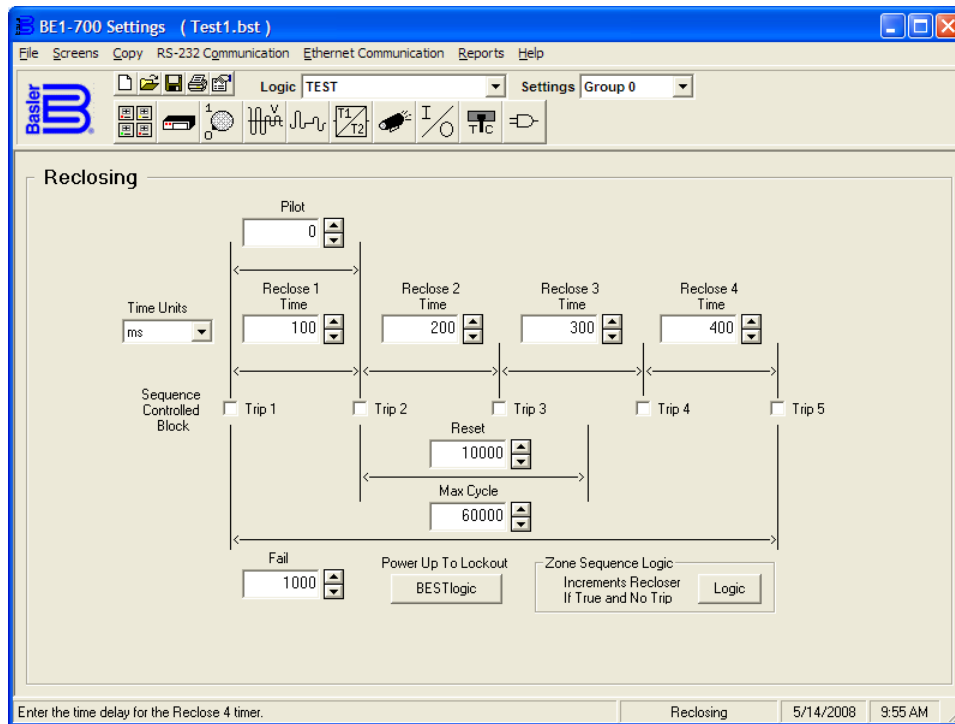


Figure 14-22. Reclosing Screen

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. There are two initiates and two close outputs in the 79 element and can be viewed by pressing the BESTlogic button on the Reclosing screen. Pilot Initiate (PI) produces a reclosing attempt through the 79 Pilot Close (79P) output, and Reclose Initiate (RI) produces reclosing attempts through the 79 Close (79C) output. PI attempts are normally associated with high speed tripping of transmission lines where breakers on both ends open simultaneously and high speed reclose together, without need for voltage and synchronism checks (one-shot). RI attempts can be associated with either radial distribution or sub-transmission reclosing applications where voltage and synchronism checks are not required, or transmission network time delay reclosing applications that do require voltage and synchronism checks prior to closing the breaker (multiple time delay attempts). Additional logic is required for voltage and synchronism checks, and is only available in the voltage version of the BE1-700 Digital Protective Relay.

To set the actual reclose sequence, first pull down the Time Units menu box and set the units (milliseconds, seconds, minutes, or cycles) for time measurement. Notice that when the Reclose 1 Time and the Pilot settings are zero, the Sequence Controlled Block (SCB), Trip 1 is grayed out. Set the Reclose 1 Time or Pilot for the first reclose time (other than zero) and the SCB window is now available. After entering a value, proceed to enter the reclose times for the remaining three reclose attempts. The total time for all reclose attempts is cumulative. For example, the second reclose attempt is the sum of Reclose 1 Time or Pilot, and Reclose 2 Time. Reclose three total time would be the sum of the reclose time for three, two and one (or Pilot). If you want to block the instantaneous or any other protection element during reclose, check the Sequence Controlled Block window or windows. If the 79C or 52 status is TRUE, and the SCB is enabled (checked) for the next reclose attempt, the 79 SCB output becomes TRUE and the output logic can be used to block the instantaneous element.

Set the Reset time using the same unit of measure that was used for the reclosing attempts. Reset time is how long you want the relay to remain reset before the relay returns to the initial state. Its range is from 0.100 to 600 seconds.

Set the maximum cycle time. Maximum cycle (Max Cycle) time limits the duration of a reclosing sequence as determined from sequence initiation to automatic relay reset or lockout. Its range is also 0.100 to 600 seconds.

Logic settings for the 79 reclosing function can be made by clicking on the *BESTlogic* button. With your custom logic selected, select the mode and other input logic by using the *Mode* pull-down menu and click on the logic inputs to set the logic.

To set the zone-sequence coordination, click on the *Zone Sequence Logic* button. When the *Reclosing* dialog box opens, click on the logic diagram and set the logic.

Breaker Failure (BE1-700C)

Pull down the *Screens* menu and select *Breaker Failure* or click on the *Breaker Failure* icon, which is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *Breaker Failure* (see Figure 14-23). The breaker failure function includes a timer and a current detector. The unit of measurement can be set for milliseconds, seconds, or minutes. The acceptable range is 0.050 to 0.999 seconds. The timer can also be set for cycles. If used, the acceptable range is from 3.00 to 59.94 cycles.



Logic settings for the breaker failure function can be made by clicking on the *BESTlogic* button. With your custom logic selected, select the mode and other input logic by using the *Mode* pull-down menu and click on the logic inputs to set the logic.

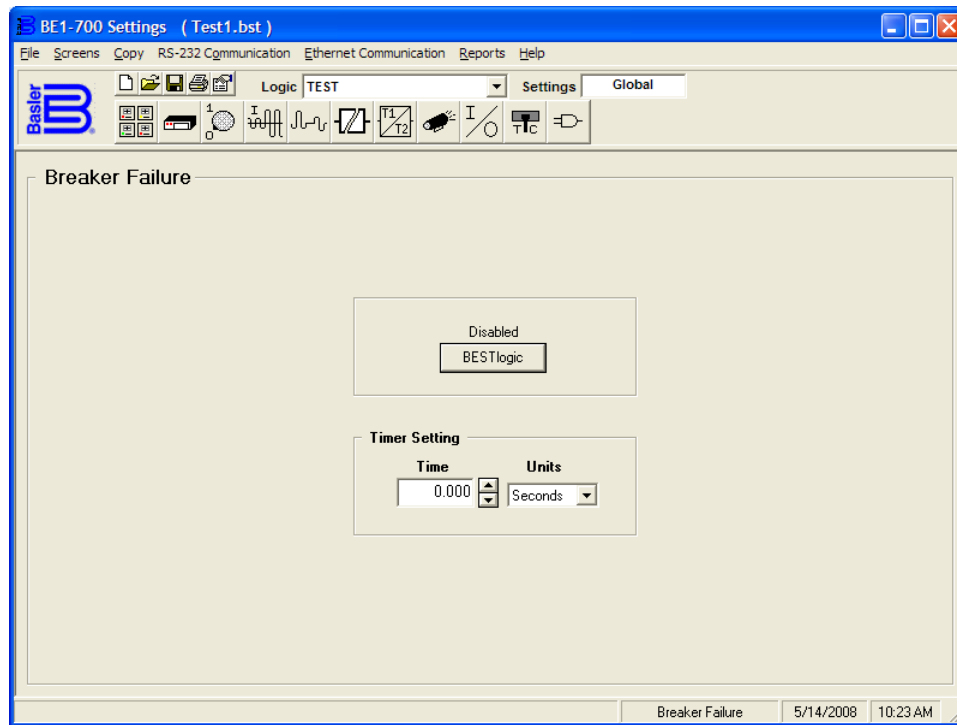


Figure 14-23. Breaker Failure Screen

Logic Timers

Pull down the *Screens* menu and select *Logic Timers* or click on the *Logic Timers* icon, which is shown at the right margin of this paragraph. This screen has no folder tabs and the screen is labeled *Logic Timers* (see Figure 14-24).



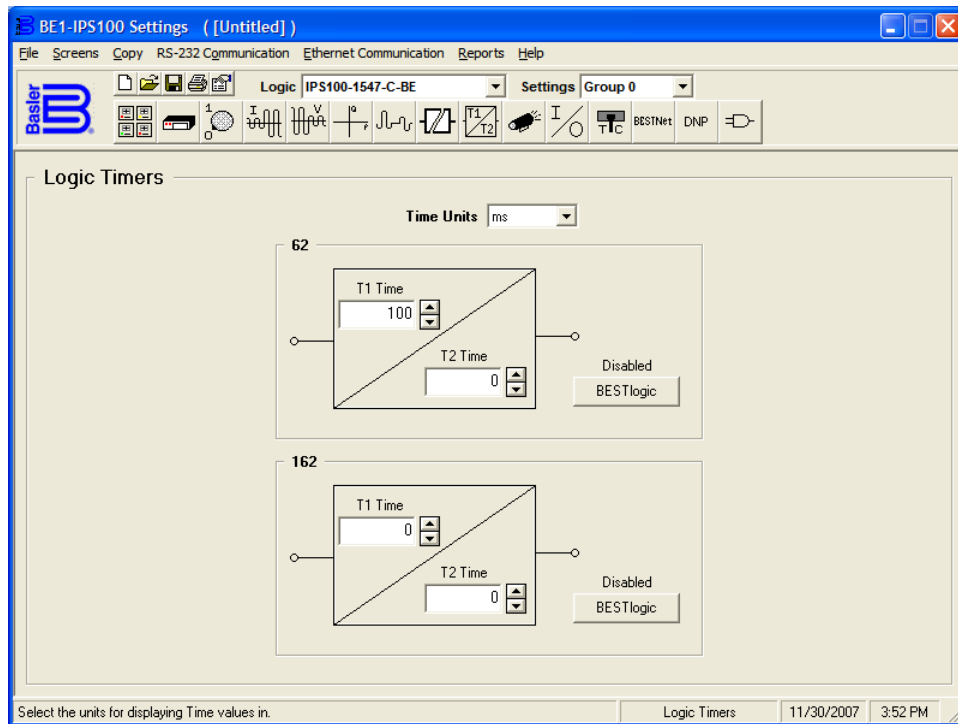


Figure 14-24. Logic Timers Screen

62/162 (Logic Timers)

Logic timers, 62 and 162, are general-purpose timers with six operating modes. Each operating mode has a T1 and T2 setting. The function of these settings depends on the type of timer (mode) selected. For a description of the setting functions, see Section 4, *Protection and Control, General Purpose Logic Timers*.

The unit of measurement can be set for milliseconds, seconds, or minutes. The acceptable range is 0.00 to 9,999 seconds. The timer can also be set for cycles. If used, the acceptable range is from 0.00 to 599,940 cycles.

Logic settings for the logic timers can be made by clicking on the *BESTlogic* button and with your custom logic selected, use the *Mode* pull-down menu and select one of the six timer modes or disable the logic timers. Select other input logic by clicking on the logic inputs to set the logic.

Reporting and Alarms

Pull down the *Screens* menu and select *Reporting and Alarms* or click on the *Reporting and Alarms* icon, which is shown at the right margin of this paragraph. This screen has six folder tabs and the first tab is *Clock Display Mode* (Figure 14-25).



Clock Display Mode

Use the *Time Format* and *Date Format* pull-down menus to set the current time and date in the preferred format. See Figure 14-25. Daylight savings time can be automatically adjusted if the appropriate check box is checked. Likewise, select the preferred method for displaying month, date, and year from the two choices provided.

The Front Panel Backlight Delay turns off the backlight after the timer expires. The setting range is 0 to 600 seconds.

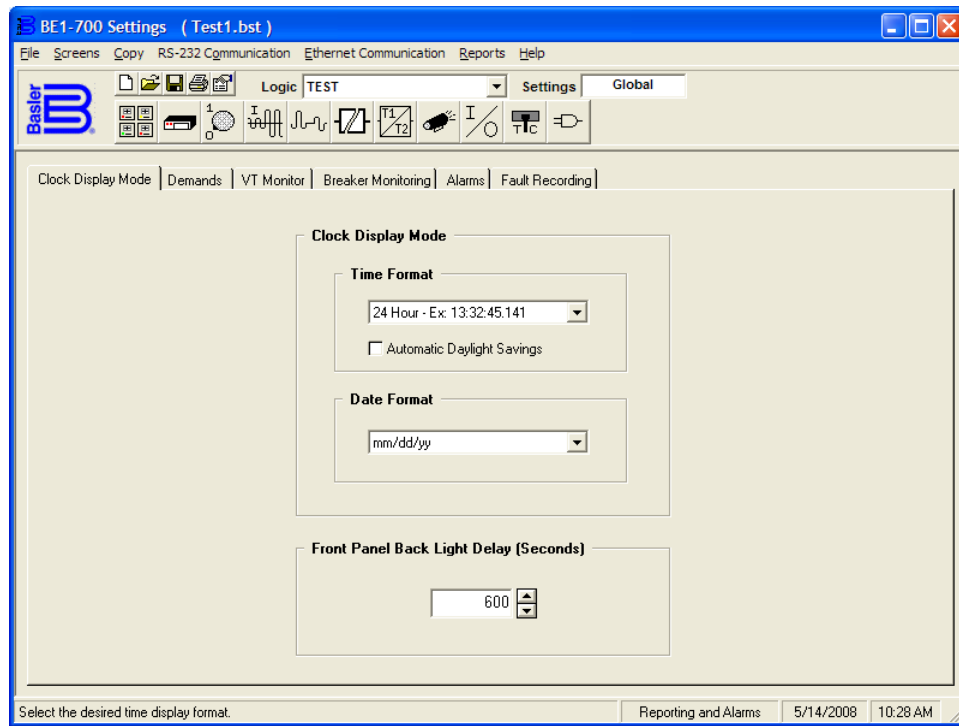


Figure 14-25. Reporting and Alarms Screen, Clock Display Mode Tab

Demands (BE1-700C)

Demand intervals can be set independently for the phase, neutral, and negative-sequence demand calculations. See Figure 14-26. Click in the phase, neutral, or negative-sequence field and enter the time or adjust the time by using the appropriate up or down arrow buttons. Use the pull-down menus to set the unit of measure for each threshold setting. The demand value is shown in each field as the data is metered.

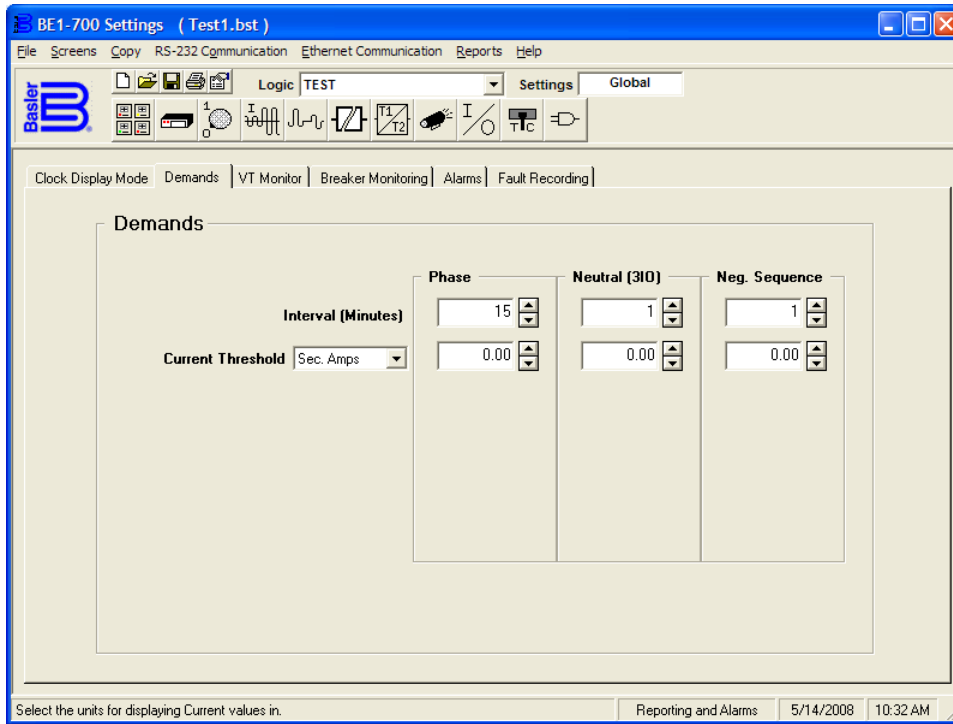


Figure 14-26. Reporting and Alarms Screen, Demands Tab

VT Monitor (BE1-700V)

Fuse loss block logic can prevent mis-operation on loss of sensing voltage. See Figure 14-27. This can be applied on the 27/59 functions.

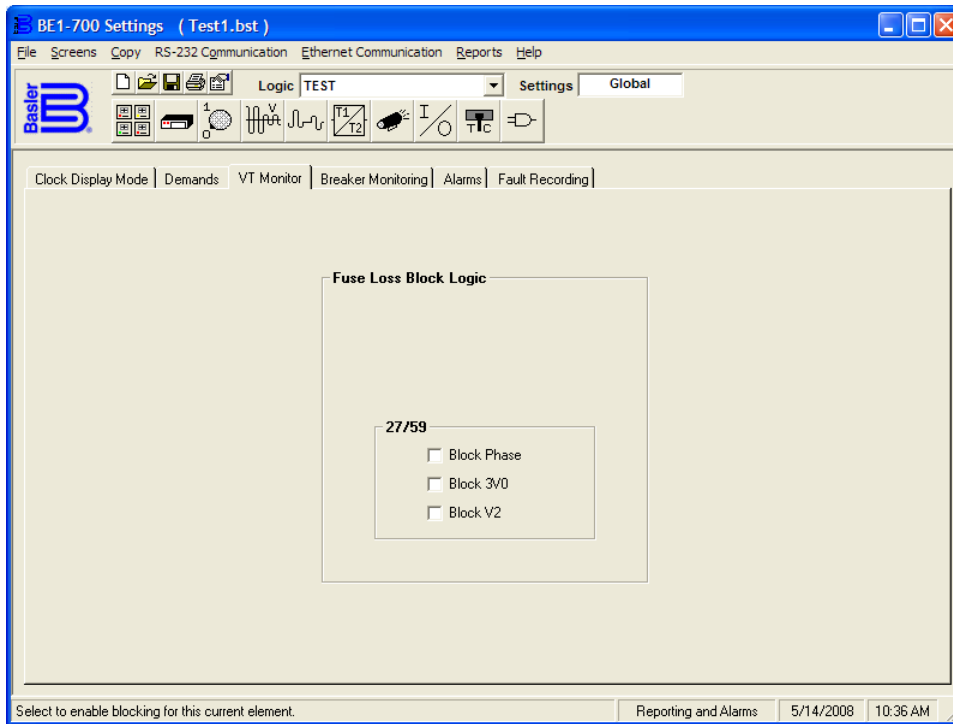


Figure 14-27. Reporting and Alarms Screen, VT Monitor Tab

If the 27/59, *Block Phase* is enabled with a check mark in the field and a 60FL condition is detected, all functions that use the phase voltage are blocked. If the 27/59, *Block 3V0* is enabled with a check mark in the field and a 60FL condition is detected, all functions that use the auxiliary over/undervoltage (27X/59X)

functions with Mode 2 selected are blocked. If the 27/59, *Block V2* is enabled with a check mark in the field and a 60FL condition is detected, all functions that use the negative-sequence voltage are blocked.

Breaker Monitoring

Each time the breaker trips, the breaker duty monitor updates two sets of registers for each pole of the breaker. See Figure 14-28. This function selects which of the two sets of duty registers are reported and monitored, sets the existing values, and programs the function logic.

Enter the *Exponent* value for the Breaker Duty. Click in the field for *100% Duty Maximum* and set the value. Logic settings for the *Block Accumulation Logic* can be made by clicking on the logic button and, with your custom logic selected, selecting the block accumulation logic.

Because the relay is completely programmable, it is necessary to program which logic variable monitors breaker status (how the relay knows when the breaker is closed). Set the *Breaker Status Logic* by clicking on the logic button and, with your custom logic selected, selecting the control logic.

Three breaker alarm points are programmable for checking breaker monitoring functions. Each alarm point can be programmed to monitor any of the three breaker monitoring functions or all three alarm points can be programmed to monitor one function and alarm at various threshold levels. Use the pull-down menu for *Point 1* and select the preferred breaker monitoring mode (*Disabled*, *Operations*, or *Clearing Time*). With the *Mode* set, the *Threshold* field is viable and has a zero threshold. Use the keyboard to enter the threshold value or the appropriate (*UP* or *DOWN*) arrow buttons. Repeat the procedure for *Breaker Alarm Points 2* and *3*.

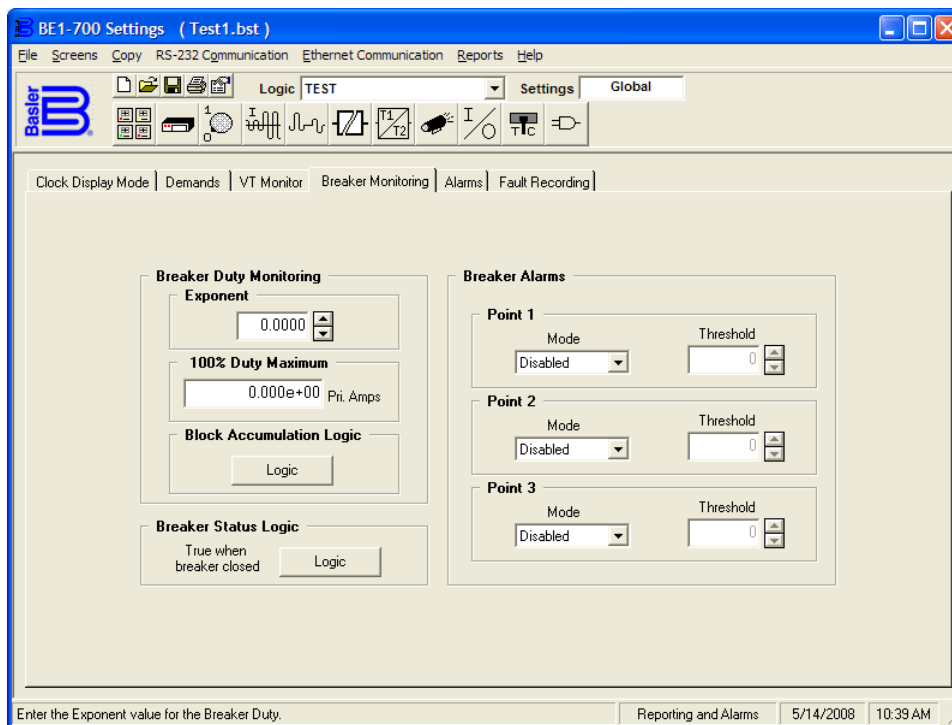


Figure 14-28. Reporting and Alarms Screen, Breaker Monitoring Tab

Alarms

BE1-700 relays have 33 programmable alarm points. See Figure 14-29. These points are for the monitored power system, associated equipment and non-core circuits, and functions in the relay. Each of these alarm points can be programmed to assert the Major, Minor, or Logic Alarms when an alarm point is activated. To program an alarm point, find the point in the *Alarm Priority* list and then click on the appropriate field under the Major, Minor, or Logic Alarm.

Logic settings for the *Alarm Reset Logic* can be made by clicking on the *BESTlogic* logic button and then clicking on the reset input. Other logic blocks shown under *BESTlogic* on the *Alarms* tab are shown for reference only. There is no interaction available.

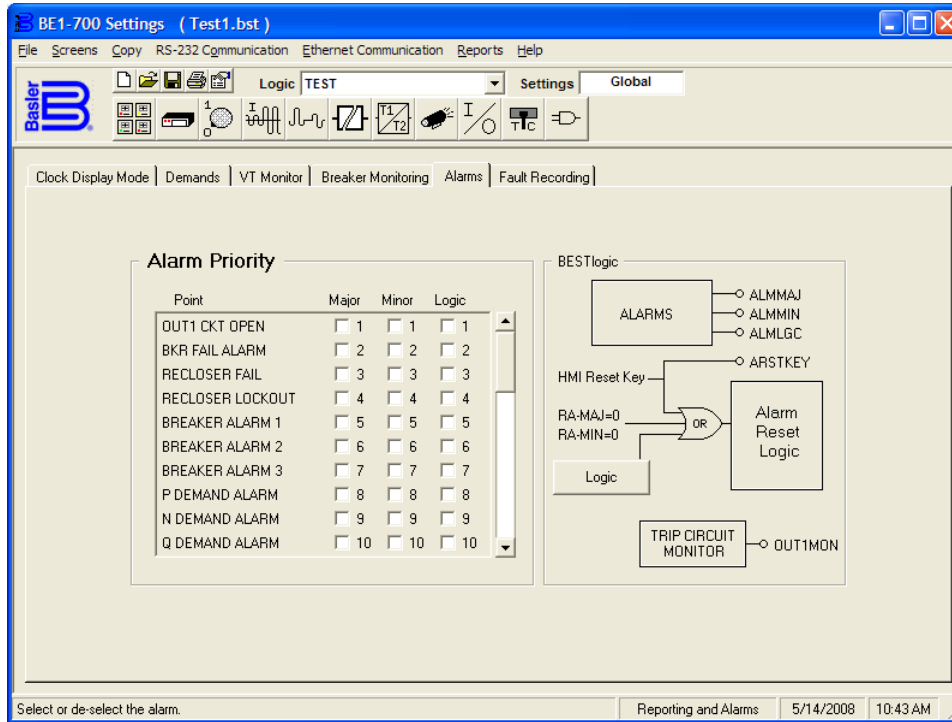


Figure 14-29. Reporting and Alarms Screen, Alarms Tab

Fault Recording

Logic expressions define the three conditions that determine when a fault has occurred. See Figure 14-30. When a fault is detected by the relay, the relay records (stores in memory) data about the fault. The three conditions that determine a fault are Trip, Pickup, and Logic Trigger. To define these conditions, click on *Fault Recording*, *Logic* box. Then click on *Tripped*, *Picked Up*, and *Logic*, in turn, and program the inputs that define each condition. You may clear existing programming by clicking on the *Clear* button or clicking on each individual variable.

The fault recording function can record up to 16 oscillographic records in volatile memory. Because there is only a specific amount of memory available, as additional faults are recorded, the oldest records are overwritten. Each record can record only a limited number of data cycles. If you have less than 16 records, you can have more than 15 cycles of data per record. To select the number of cycles of data and number of records, click on the *Oscillographic Records*, *Select* button and click on the number of records that you want to record.

Logic settings for the *Target Reset Logic* can be made by clicking on the *Target Reset - Logic* button and then clicking on the *Reset* input. Other logic blocks shown under BESTlogic on the *Alarms* tab are shown for reference only. There is no interaction available.

Any protective function, except 62, 162, and 60FL that has a trip will set a target because these functions have the targets enabled on the *Fault Recording* tab. If you are using a protective function in a supervisory capacity and do not want to set a target when the protective function trips, disable that target by clicking on the specific target. If you want to disable all of the targets for a function such as the inverse time overcurrent functions, click on the No 51's button on the left side of the *Enabled Targets* pane.

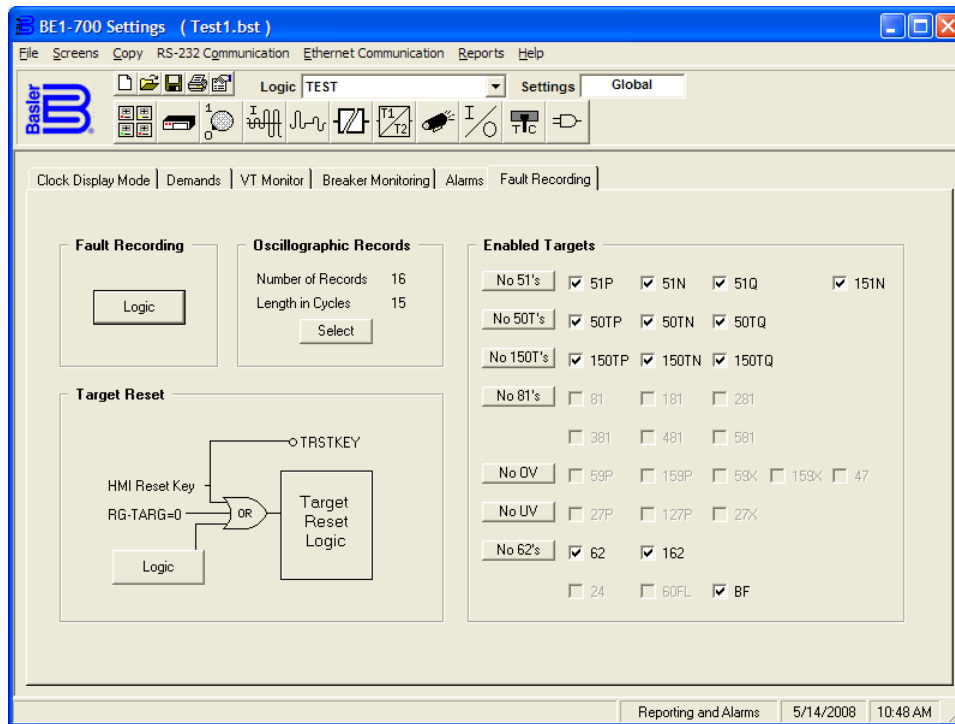


Figure 14-30. Reporting and Alarms Screen, Fault Recording Tab

Inputs and Outputs

Pull down the Screens menu and select *Inputs and Outputs* or click on the *Inputs and Outputs* icon, which is shown at the right margin of this paragraph. This screen has two folder tabs and the first tab (Figure 14-31) is labeled *Inputs 1 - 4*.

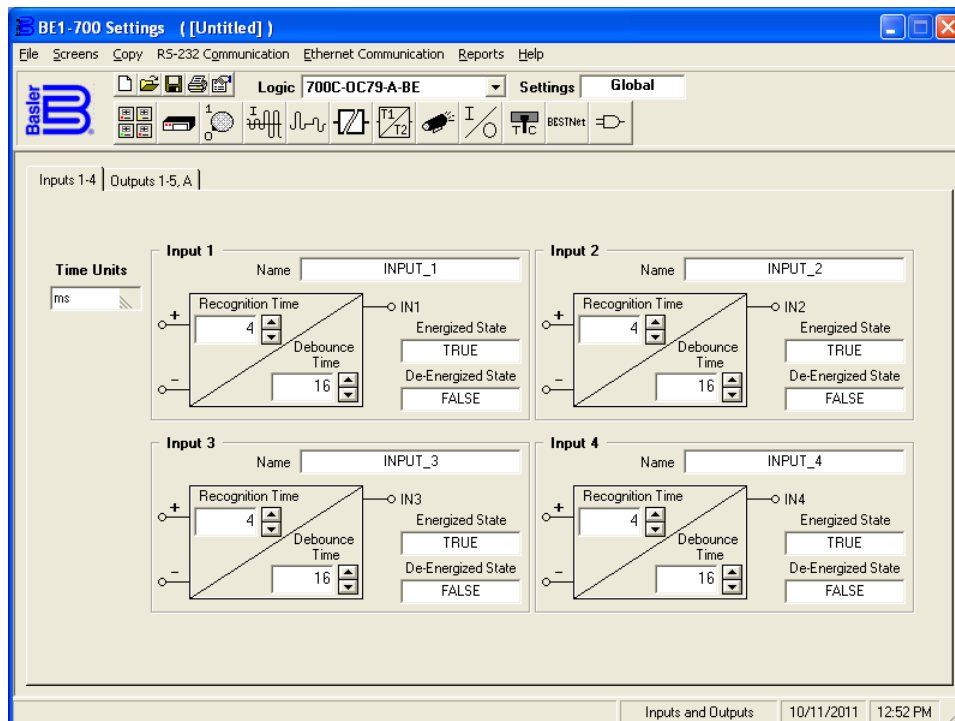


Figure 14-31. Inputs and Outputs Screen, Inputs 1-4 Tab

Inputs 1 - 4

The first tab (Figure 14-31) allows setting the four programmable inputs available in the BE1-700 relay. To program how long the Input 1 contact must be closed to be recognized as closed, first, pull down the *Time Units* menu, and set the units for the appropriate time measurement. Then in the Input 1 pane, enter the new value for *Recognition Time* or use the appropriate up or down arrow buttons to set the new value. To program how long the Input 1 contact must be open to be recognized as open, enter the new value in Input 1, *Debounce Time* box or use the appropriate up or down arrow buttons to set the new value.

You can assign a meaningful name to each input. This makes sequential events reports easier to analyze. To assign a meaningful name to Input 1, click in the *Name* field and enter the new name. To change the label for the *Energized State*, click on the *Energized State* field and enter the new name. To change the label for the *De-Energized State*, click on the *De-Energized State* field and enter the new name. The remaining three inputs have the same functions.

Outputs 1 - 5, A

On this tab (Figure 14-32); the only feature that you may change is to select the programmable hold attribute. To select the hold attribute (contacts remain closed for 200 milliseconds) for any output, click on the *Hold Attribute* field for that output. To change the label for any of the virtual outputs, see the paragraphs on *BESTLogic*, *Virtual Outputs*, later in this manual.

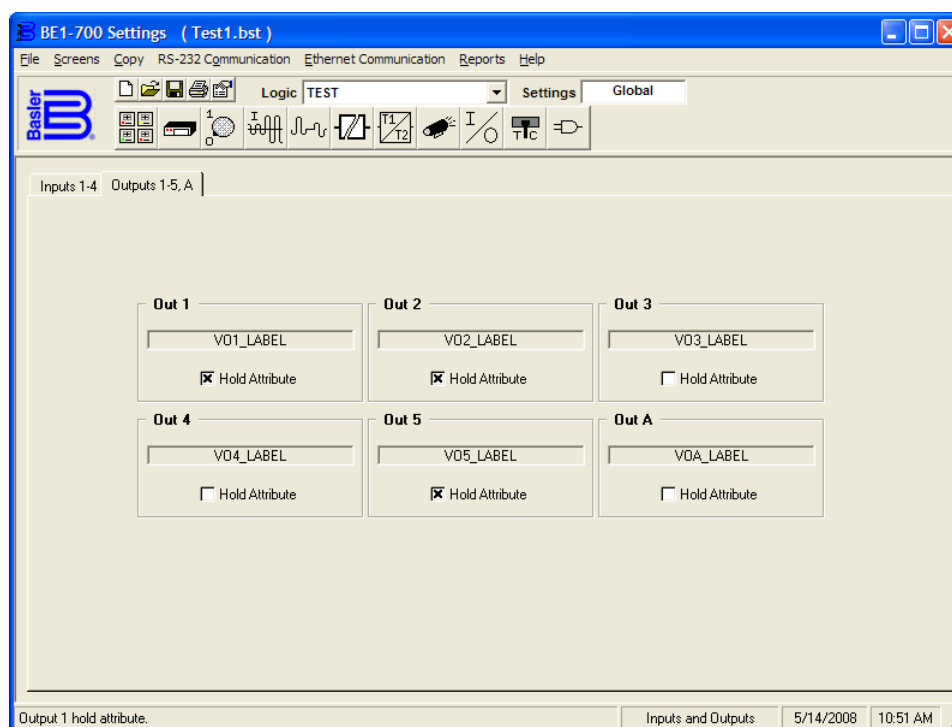


Figure 14-32. Inputs and Outputs Screen, Outputs 1-5, A Tab

Virtual Switches

Pull down the Screens menu and select *Virtual Switches* or click on the *Virtual Switches* icon, which is shown at the right margin of this paragraph. This screen (Figure 14-33) has no folder tabs and is labeled *Virtual Switches*.



Virtual Switches (x43 & 101)

You can assign a meaningful name or label to each of the two virtual switches (Figure 14-33). This makes sequential events reports easier to analyze. To assign a meaningful label to Virtual Switch 43, click in the *Label* field and enter the new name. To change the label for the *True State*, click on the *True State* field and enter the new name. To change the label for the *False State*, click on the *False State* field and enter the new name.

The mode logic setting for Virtual Switch 43 can be made by clicking on the *BESTlogic* button and, with your custom logic selected, select the mode logic by using the *Mode* pull-down menu. The 143 Virtual Switch has the same functions.

The Virtual Breaker Control Switch (101) provides manual control of a circuit breaker or switch without using physical switches and/or interposing relays. The mode logic setting for Virtual Breaker Control Switch 101 can be made by clicking on its associated *BESTlogic* button and, with your custom logic selected, select the mode logic by using the *Mode* pull-down menu. Trip outputs include Trip, Close, and Slip Contact.

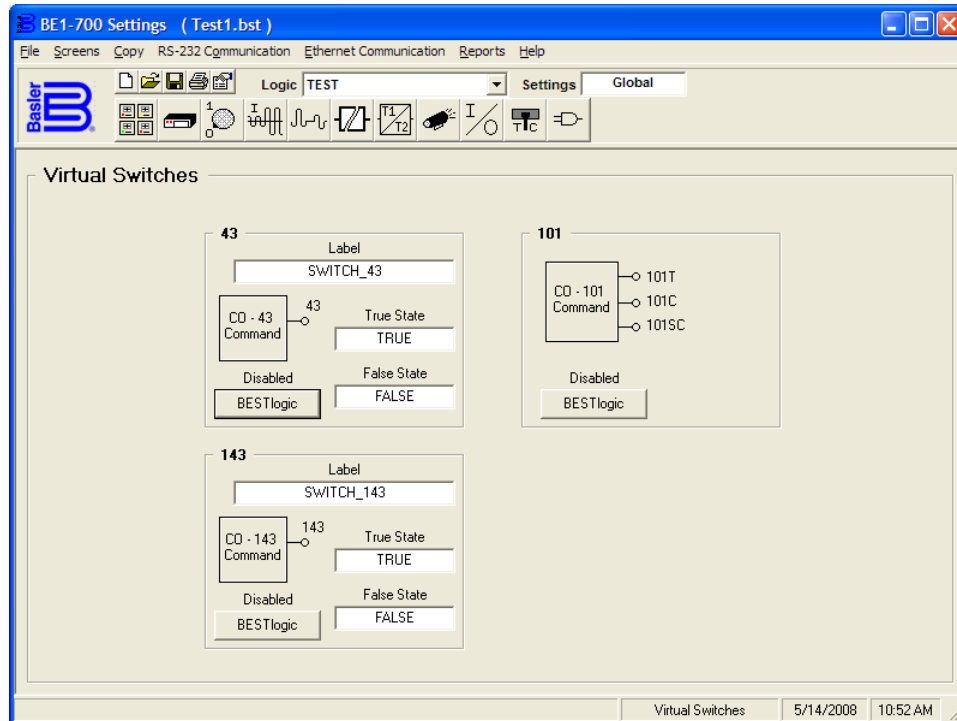


Figure 14-33. Virtual Switches Screen

BESTNet™ Settings

Pull down the Screens menu and select *BESTNet Settings* or click on the BESTNet icon that is shown at the right margin of this paragraph. This screen has no folder tabs and is labeled *BESTNet Settings* (Figure 14-34).



Com protocol 4 or 5 must be ordered with your relay. For detailed information regarding the *BESTNet Settings* screen, refer to Section 15, *BESTNet Communication*.

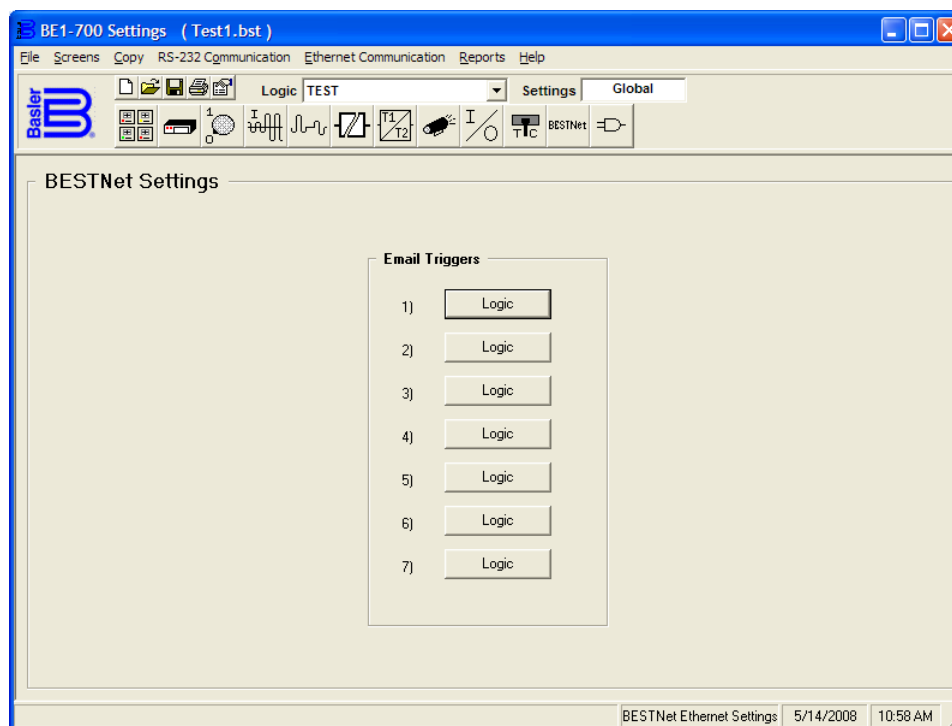


Figure 14-34. BESTNet Settings Screen

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 (Figure 14-35) is labeled *Logic Select*.



Logic Select

This tab (Figure 14-35) allows you to select one of the preprogrammed logic schemes and copy that scheme to the active logic. You may then keep the preprogrammed logic but are not allowed to change anything in the scheme. You must rename that logic to a custom name and then make changes as you desire. Click on the logic to be copied to the active logic. Two check boxes allow you include appropriate variable names and include appropriate logic expressions for *Breaker Status* and *Fault Recording*. A box appears requiring that you okay the replacement of all settings. Click *OK* to close the dialog box and then type in your customized logic name.

With the *BESTlogic Logic Library*, you can *Load Scheme* or *Remove Scheme*. You may also *Copy to Active Logic*.

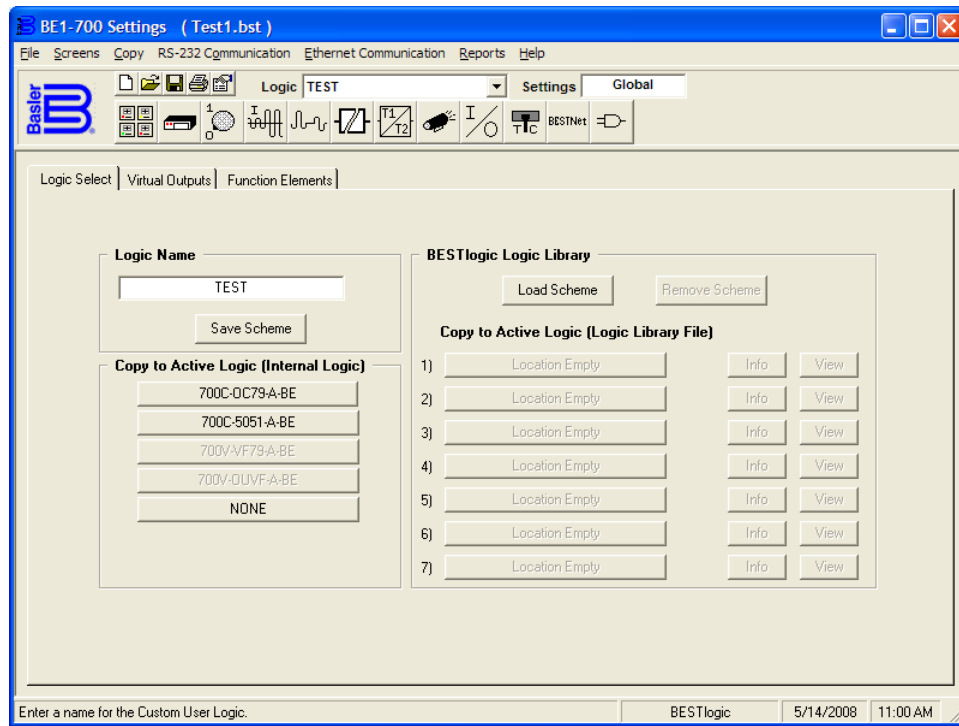


Figure 14-35. BESTlogic Screen, Logic Select Tab

Virtual Outputs

You can assign a meaningful name or label to each virtual output. See Figure 14-36. This makes sequential events reports easier to analyze. To assign a meaningful label to virtual output VO6, for example, click in the *Label* field and enter the new name. To change the label for the *TRUE* state, click on the *True State* field and enter the new name. To change the label for the *FALSE* state, click on the *False State* field and enter the new name. To change the logic associated with VO6, click on the *BESTlogic* button associated with VO6. Click on the logic input and program the logic variables that define VO6. You may clear existing programming by clicking on the button or clicking on each individual variable. The other 15 virtual outputs have the same function.

VO6 through VO15 do not have actual hardware output contacts. Only VOA and VO1 through VO5 have hardware output contacts.

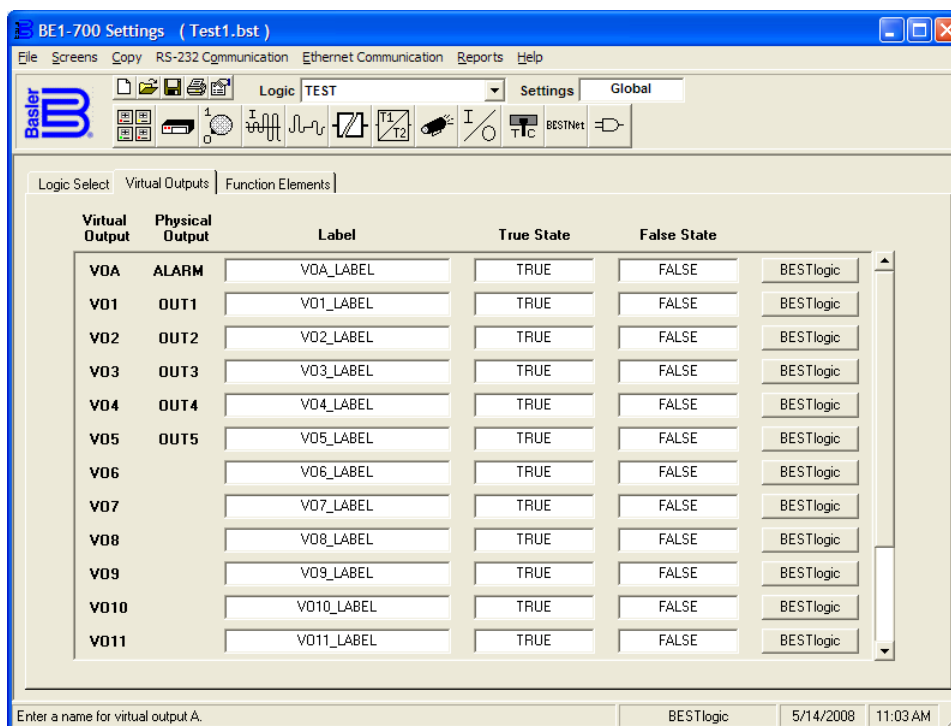


Figure 14-36. BESTlogic Screen, Virtual Outputs Tab

Function Elements

Not all of the logic functions have *BESTlogic* labeled on the button. See Figure 14-37. 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.

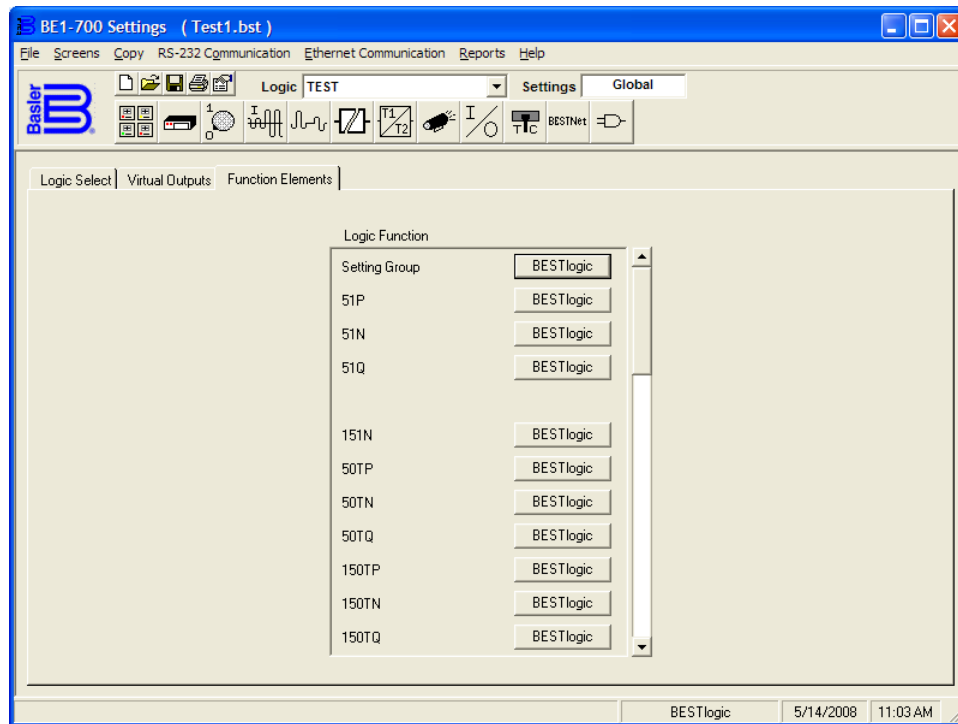


Figure 14-37. BESTlogic Screen, Function Elements Tab

Copying Settings from Group to Group

There are many settings in any BE1-700 numerical systems product but the differences between Group 0 and Group 1 settings may be minimal. With BESTCOMS, there is a convenient way to copy settings from Group 0 to Group 1. Then, you only have to change the settings that are different. Pull down the **C**opy menu (see Figure 14-38) from the pull-down menu. There is only one choice, *From Group to Group*. When you select this choice, a dialog box opens (Figure 14-39) allowing you to select which group you wish to copy. After making your selection and clicking **OK**, the copy routine commences followed by another dialog box informing you that the copy routine is complete. Now, change those settings that are different.

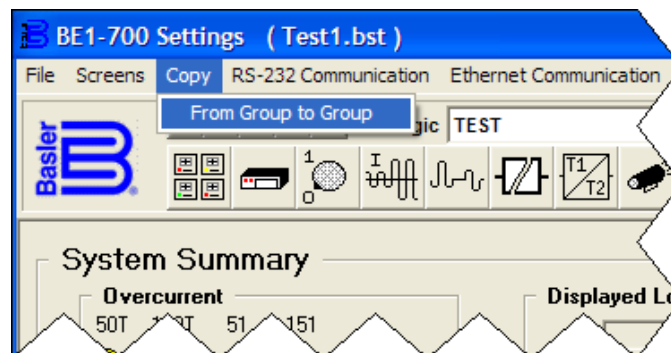


Figure 14-38. Copy From Group to Group Drop-Down Menu

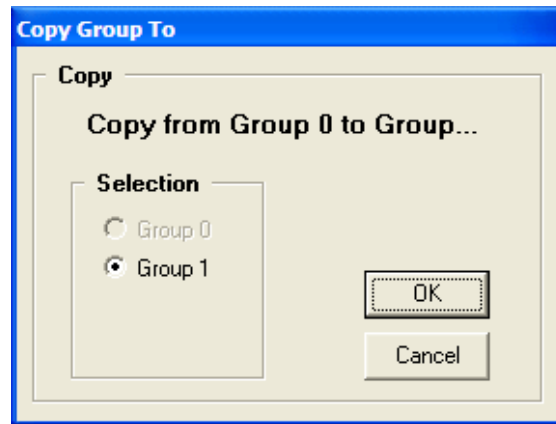


Figure 14-39. Copy Group To Dialog Box

Downloading Oscillography Files

To download an oscillography file, pull down the *Reports* menu (see Figure 14-40) from the pull-down menu and select *Oscillography Download* and then either *Serial Connection* or *Ethernet Connection*. When you select this choice, you may get a communication error if you are not configured to an actual relay. If you have communication with the relay, a dialog box opens (Figure 14-41) 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.

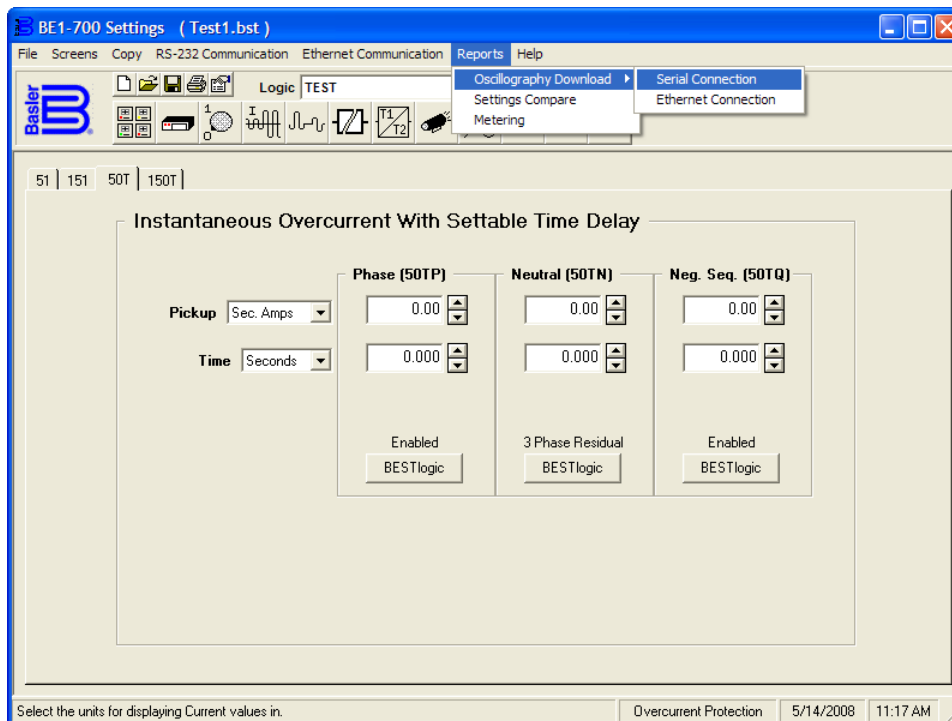


Figure 14-40. Oscillography Download Drop-Down Menu

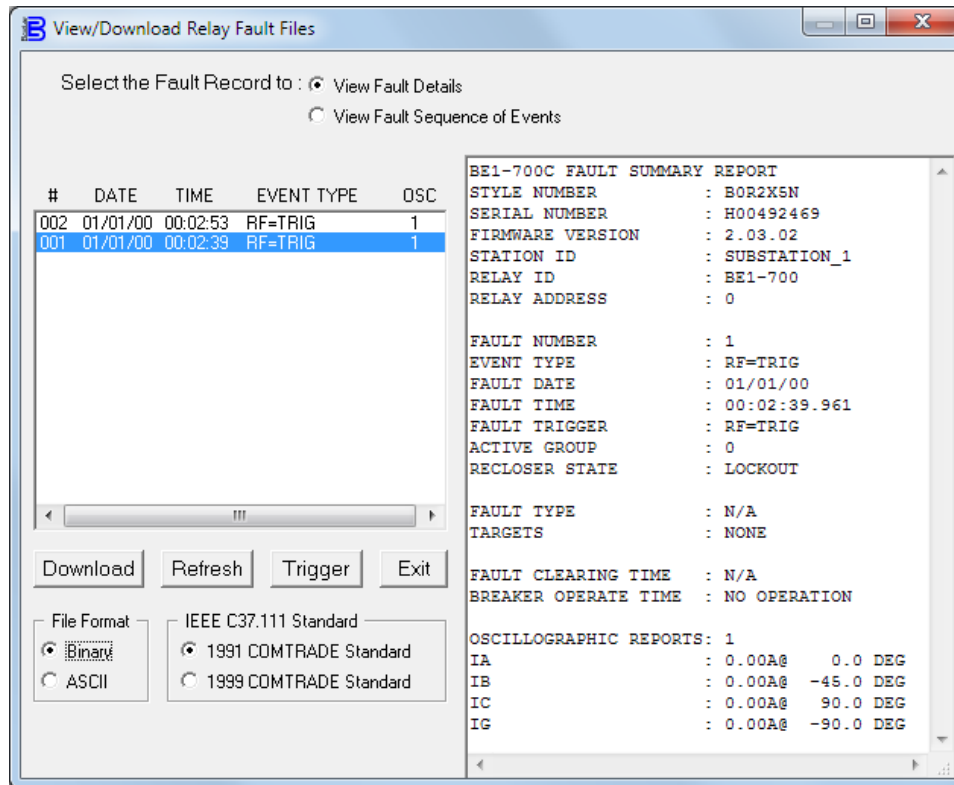


Figure 14-41. View/Download Relay Fault Files Screen

View Fault Details

To view the fault record details, select an event by clicking on the event number or anywhere on the event line. The event grays-out while the information is being retrieved from the relay. View the fault details in the associated window.

View Fault Sequence of Events

To view the fault record sequence of events, click on the radio button by the *View Fault Sequence of Events*. View the fault sequence of events in the associated window.

Download Oscillography File

To download an oscillography file, select the type of file to download: *Binary* or *ASCII* and *1991* or *1999 Comtrade Format*. Click on the *Download* button in the *View/Download Relay Fault Files* dialog box. Use normal Windows techniques to select the computer folder that is to receive the download file. You may create a new folder at this time by clicking on the *New Folder* button. Okay the file save and the *Fault Record Filenames* dialog box opens. Use the default *Base Filename* or enter a new file name. As you change the file name, the names for the *Header File*, *Fault Sequence*, and *Fault Summary* also change automatically. *OK* the file names and then exit the dialog box. You have now downloaded the oscillography file. You may view this oscillography file using 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 14-42) opens, click on the *Start Polling* button. If BESTCOMS is not configured to the relay communication settings, you will receive a Communications Error. The *Metering* dialog box has two pull-down menus: *File* and *Communication*. To configure communication with the relay, pull down the *Communication* menu and select *Configure*. Choose the *Com Port* and *Baud Rate*, as required. If you have communication with the relay, click on the *Start Polling Button*. Metering values are displayed in the various screen windows. If you select *Configure* with polling

in progress, you will get the *Polling Active* dialog box. You must stop polling before you can change configuration. To stop polling, click on the *Stop Polling* button. To exit, pull down the *File* menu and select *Exit*. You may also use the Windows® techniques and click on the close icon (X) in the upper right-hand corner of the *Metering* dialog box.

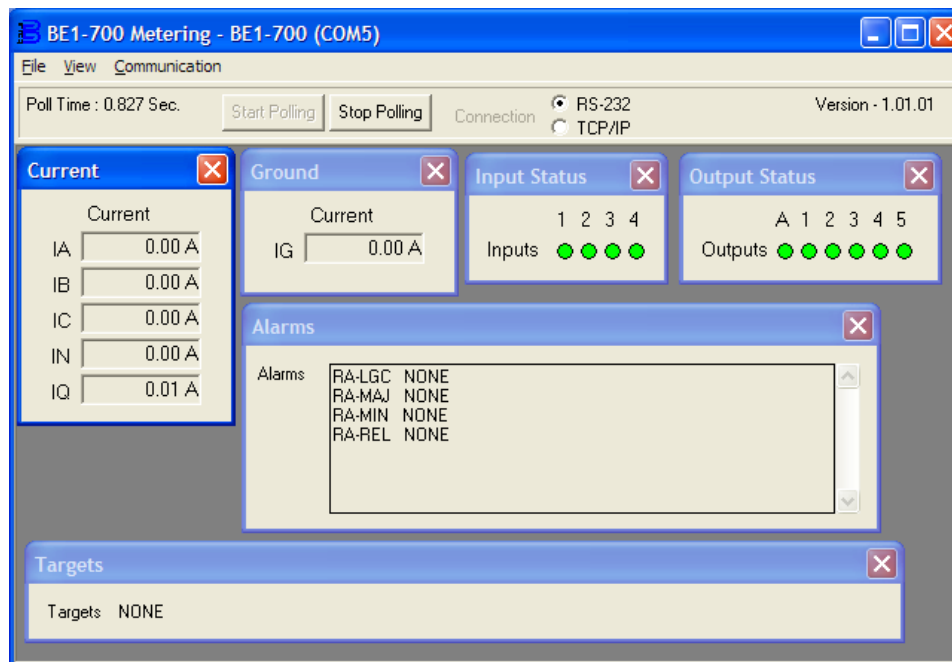


Figure 14-42. Metering from Reports Pull-Down Menu

File Management

In these paragraphs, file management describes saving, opening, uploading, downloading, and printing settings files.

Saving a Settings File

If you change any settings in the active custom logic scheme and try to exit BESTCOMS, the dialog box shown in Figure 14-43 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.

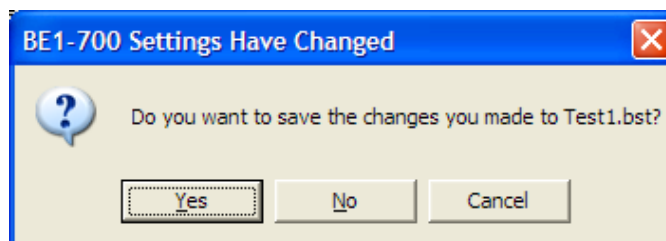


Figure 14-43. Settings Have Changed Dialog Box

Opening a Settings File

To open a settings file into BESTCOMS, pull down the *File* menu and choose *Open*. If the settings in your BESTCOMS have changed, a dialog box will open asking you if want to save the current settings changes. You may choose *Yes* or *No*. After you have taken the required action to save or not save the

current settings, the *Open* dialog box appears. This dialog box allows you to use normal Windows techniques to select the file that you want to open. Select the file and open it and the file settings have been brought into BESTCOMS.

Uploading a Settings File

To upload a settings file to the BE1-700 relay, you must first open the file through BESTCOMS or create the file using BESTCOMS. Then pull down the *Communication* menu or the *Ethernet Communication* menu and select *Upload Settings to Device*. You are prompted to enter the password. If the password is correct, the upload begins and the percent complete loading bar is shown. At upload completion, you are asked if you want to save the settings and make them active. After replying, you are informed of the status: Yes - settings are saved or No - settings are discarded. If you would like to view the file names as they are uploaded, pull down the *Communication* menu and select *Configure*. When the *Configure Communication Port* dialog box opens, click the *On* button for *Show Commands During Data Transfer* and then click *OK*. Now, during data transfer, you will see two screens (*Sending* and *Status*) and the percent complete loading bar. If a data transfer error occurs, you can briefly see the error notification in the *Status* window. The file settings will not be uploaded and the changes discarded. You may then scroll through the *Status* window until you find the error notification. Click on the error notification and the data file that transferred in error is shown in the *Sending* window.

Downloading a Settings File

To download a settings file from a BE1-700 relay, you must pull down the *Communication* menu or the *Ethernet Communication* menu and select *Download Settings from Device*. If the settings in your BESTCOMS have changed, a dialog box will open asking you if want to save the current settings changes. You may choose *Yes* or *No*. After you have taken the required action to save or not save the current settings, the downloading is executed.

Printing a Settings File

To print a settings file, pull down the *File* menu and select *Print*. A dialog box, *Print BE1-700 Settings File* opens with the settings file shown and typical Windows choices to setup the page and the printer. Execute these commands, as necessary, and then select *Print*.

You may also export the settings file to a text file. Pull down the *File* menu and select *Export to Text*. A dialog box, *Export to Text File* opens with the settings file shown. Execute the *OK* command and then use normal Windows techniques to select the path. Execute the *Save* command and you now have a text file of your BESTCOMS settings.

Settings Compare

BESTCOMS has the ability to compare two different settings files. To use this feature, pull down the *Reports* menu and select *Settings Compare*. The *BESTCOMS Settings Compare Setup* dialog box appears (Figure 14-44). Select the location of the first file to compare under *Left Settings Source* and select the location of the second file to compare under *Right Settings Source*. If you are comparing a settings file located on your PC hard drive or portable media, click the folder button and navigate to the file. If you want to compare settings downloaded from a unit, click the RS-232 button to set up the communication port and baud rate. Click the *Compare* button to compare the selected settings files.

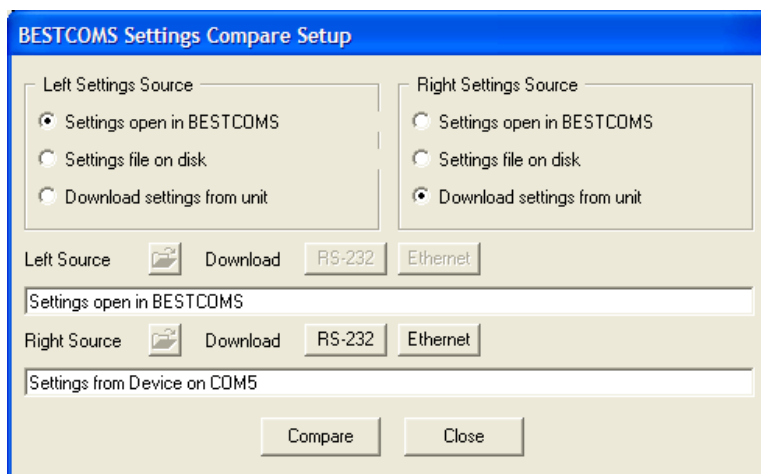


Figure 14-44. Settings Compare Setup

If there are any differences in the two files, a dialog box will appear and notify you that differences were found. The BESTCOMS Settings Compare dialog box (Figure 14-45) is displayed where you can view all settings (*Show All* button) or view only the differences (*Show Diffs* button).

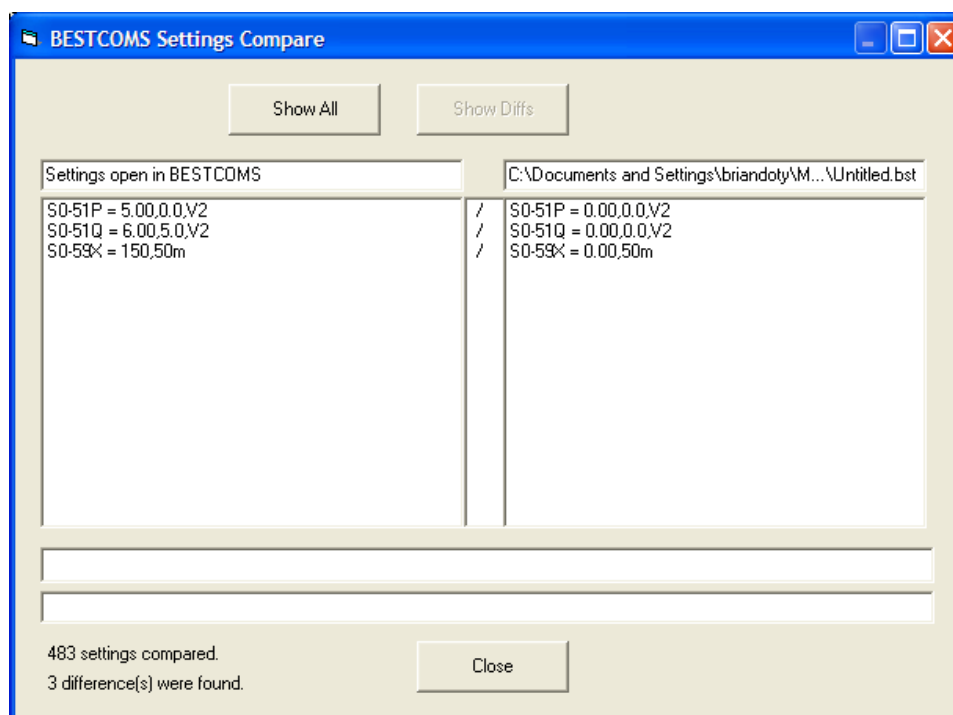


Figure 14-45. Settings Compare View

BESTprint™

BESTprint, which can be downloaded from www.basler.com, will preview and print Basler Electric relay settings files. This is via graphic representations similar to what is seen in the BESTCOMS software application. BESTprint will only read the settings files and document the information. It will not write or change any settings in the settings file (*.bst) at this time.

Profile files for each device are needed to print documentation for that particular device. New and updated profiles will be available from Basler Electric. One new set of profiles and their support files will be the optimum way to acquire additional printing of more devices or updated settings files.

For additional information, see the help files in the BESTprint application.

15 • BESTnet™ Communication

The BESTnet Communication package provides additional BE1-700 features if the relay is ordered with one of the BESTnet Protocol Options (Refer to Section 1, *General Information*). By using the user's TCP/IP network, remote access via Ethernet provides a new and unique method of monitoring, controlling, and coordinating protection and control functions. A web browser such as Microsoft® Internet Explorer is used to view relay status remotely. The BESTnet over Ethernet option provides the following capabilities:

- Viewing relay status and real time metering using easy to use web pages as the graphical user interface.
- Operational parameters can be set using BESTCOMS™ for BE1-700 Software over the Ethernet port interface.
- ASCII commands can be sent via a TCP/IP terminal or Telnet program. For example, ASCII commands can be sent to set up the BESTlogic required to use user-established protection and control schemes over the BESTnet Ethernet interface.
- Outputs from the relay such as alarms and BESTlogic variables or data reports can be viewed.
- Alarms can be configured to send e-mail messages to alert interested parties when a particular condition occurs.

Note

For security reasons, all change passwords are disabled by default on the (optional) Ethernet port. You must use a serial connection to enable and upload the desired change functions before changes will be allowed from the Ethernet port. Refer to Section 9, *Security*.

Installation

BESTnet is part of the BE1-700 firmware and part of the BESTCOMS software for the BE1-700. (See Section 14, *BESTCOMS Software*, for BESTCOMS installation instructions.) The Basler Electric Device Discovery component is an aid to initial configuration and is contained in BESTCOMS. Once network parameters such as the static IP address are set, this configuration will not have to be run again.

Note

The use of dynamically assigned IP addresses (default) will require the Device Discovery component to be used each time BESTCOMS is started in order to find BE1-700 relays on the local area network (LAN).

Configuring the BE1-700 for Ethernet

BE1-700 Ethernet options are set through a configuration applet that is stored in the BE1-700. This configuration applet is loaded into the PC on demand, and is not part of the BESTCOMS software for the BE1-700.

To configure the BE1-700 BESTnet features, follow the steps outlined below:

1. Ensure that the PC has an Ethernet port, a recent version of Microsoft Internet Explorer, and a Java™ Runtime Environment installed.

Note

A Java™ Runtime Environment is required for proper operation of the BE1-700 configuration applet and web pages. Once the BE1-700 is configured, Java™ is not required to receive e-mail alerts from the BE1-700 or to use BESTCOMS over Ethernet, but is required to view web page data.

2. Insure that the PC has a current version of BESTCOMS for BE1-700 Software installed. BESTCOMS for BE1-700 Software is included on the BESTCOMS for BE1-700 Software CDROM, and is available for download from the Basler Electric web site.
3. Connect the PC to the same LAN as the BE1-700, or connect the PC directly to the BE1-700 through a hub, or with a Category 5 (Cat-5) crossover cable.
4. If you already know the IP address of the BE1-700, skip to the next step. To scan the network for connected BE1-700 relays, launch BESTCOMS, click on the "Ethernet Communications" menu, and select "Download Settings From Device". When the Device Selection Dialog appears, select "Scan for Connected Devices" and note the IP address of the device of interest. (See Figures 15-10 and 15-11.) If no devices are found, insure that the BE1-700 is on the same subnet, that all cables are connected, or that the direct connection cable is a CAT5 crossover cable, as appropriate.
5. Launch an Internet Explorer window and type the following URL, substituting the IP address of the BE1-700 for the zeros shown below:

http://000.000.000.000/FS/WEB/config.htm
6. If the computer has a compatible Java Runtime installed, the screen shown in Figure 15-1 should appear.

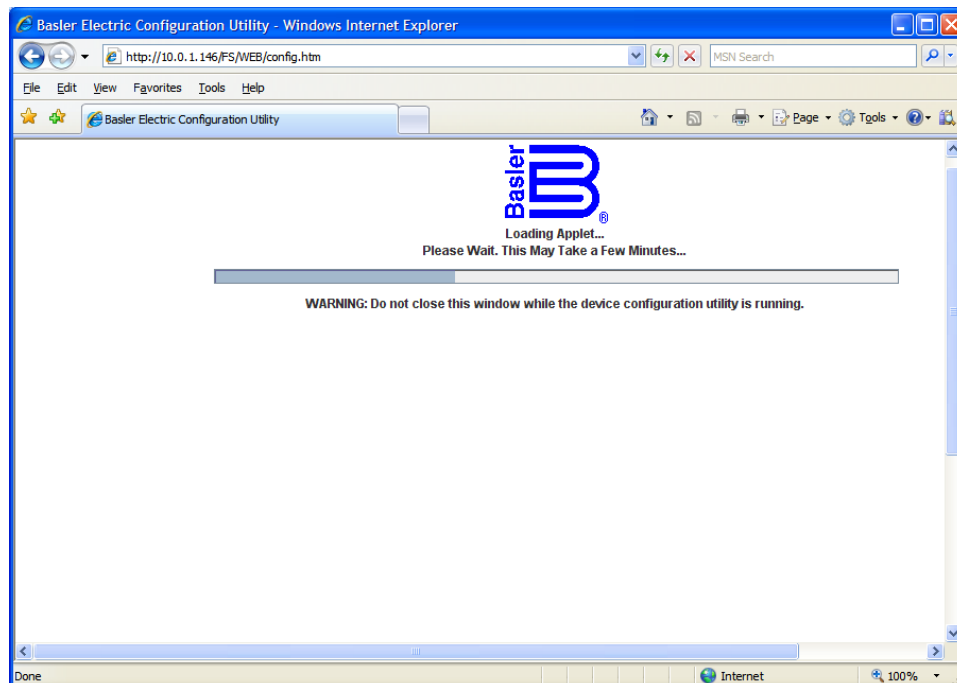


Figure 15-1. Launch Screen for BESTnet Configuration Applet (Internet Explorer)

7. Once the configuration applet is loaded, its window should appear (Figure 15-2).
8. Prior to changing any configuration parameters, verify, by serial number, that the relay being configured is the correct one.

9. Step through the Network, HTTP Security and E-mail Alerts screens and set as desired (see the following paragraphs for details). Save or cancel the changes, as required, with the appropriate screen buttons.

Note

E-mail alerts are triggered by BESTlogic equations that are configured under the *BESTnet* section of BESTCOMS software. E-mail alerts will not function unless BOTH the configuration applet AND the BESTnet e-mail equations are set.

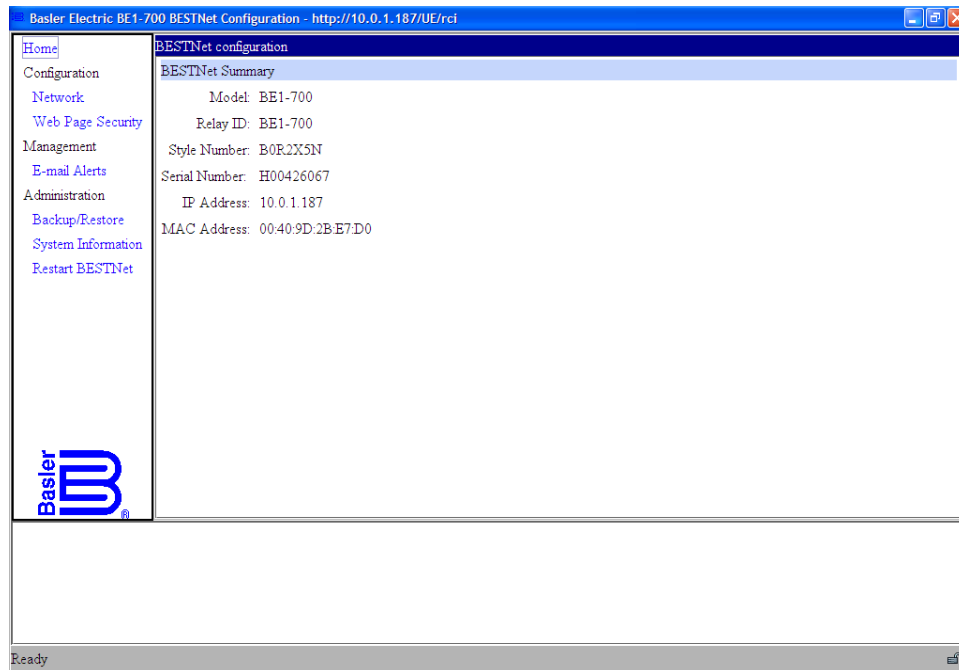


Figure 15-2. BESTnet Configuration Applet

Configuration Screens

The BESTnet Configuration Applet has seven screens of information and settings, as described in the following paragraphs.

Home

Purpose: Provides general identifying information about the BE1-700. This screen should be used to verify that the correct relay device has been selected prior to making any configuration changes. The *Home Configuration* screen is shown in Figure 15-3. Information provided on the *Home Configuration* screen is described in Table 15-1.

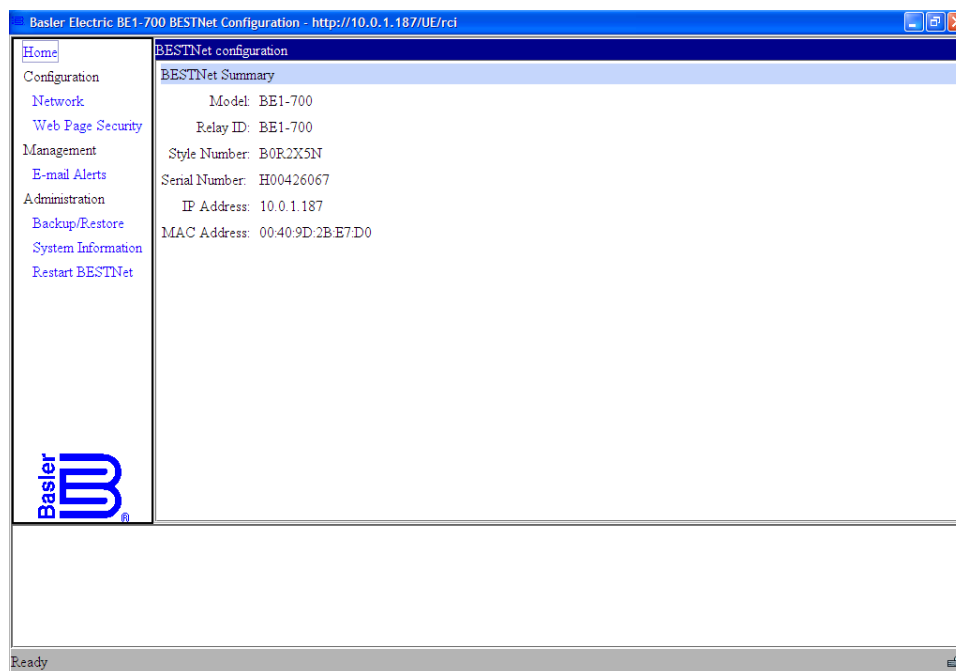


Figure 15-3. Home Configuration Screen

Table 15-1. Home Configuration Screen Settings and Information

Information	Value	Function
Model	“BE1-700”	Indicates the type of BESTnet relay. This value is factory-assigned and cannot be changed.
Relay ID	Programmable text string	This string can contain up to 30 alphanumeric characters and is programmed through BESTCOMS or an ASCII command. It can be used to provide information about the location and function of each BE1-700. It is helpful (but not required) for each BE1-700 to be programmed with a unique relay ID.
Style Number	7-character, alphanumeric string	Describes the features and functions included in a particular BE1-700 relay. Refer to the relay style chart or BESTCOMS software for the meaning of each style chart character. The style number is not unique to each BE1-700. This value is factory assigned and cannot be changed by the user.
Serial Number	9-character string	A unique serial number is assigned to each BE1-700 relay. The serial number is printed on a label attached to the relay and provides a way to ensure that the relay data being viewed is for the correct relay. The serial number is factory assigned and cannot be changed.
IP Address	IP address of the BE1-700 is in dotted decimal notation (0.0.0.0)	The internet protocol address of the BE1-700. This address is required for BE1-700 communication with BESTCOMS, Internet Explorer, or any other application. It can be set manually through the Network screen of the BESTnet configuration applet, or can be automatically assigned by a DHCP server.
MAC Address	6-byte hexadecimal value	Globally unique identifier assigned to each Ethernet Media Access Controller. This value is factory assigned and cannot be changed by the user.

Network

Purpose: Allows configuration of the BE1-700 relay IP address and other parameters that may be required on the network to which the BE1-700 is connected. Consult your network administrator for the

appropriate values for these settings. Incorrect *Network Configuration* screen settings can prevent BE1-700 network access, or create problems on the network to which it is connected.

Network Configuration screen settings are summarized in Table 15-2. The *Network Configuration* screen is shown in Figure 15-4.

Table 15-2. Network Configuration Screen Settings and Information

Setting	Value	Function
Access relay data over network	Unchecked/Checked	An unchecked box disables ASCII, BESTCOMS, and web page data communication over TCP. A checked box enables ASCII, BESTCOMS, and web page data communication over TCP. This setting does not affect EMAIL ALERTS. EMAIL ALERTS must be enabled or disabled by the ENABLE SENDING EMAIL ALERTS setting.
Select method to assign IP address	Obtain automatically using DHCP	This setting allows a DHCP server on your network to assign network parameters (such as IP address) to the relay automatically. A DHCP server is required if this option is selected. If this option is used, the BE1-700 IP address may change from time to time. BESTCOMS includes a Discovery function that will detect BESTnet relays and display their IP addresses.
	Use the following IP address	This setting allows a static IP address to be assigned to the relay, as well as a subnet mask and default gateway. For more information, see the following settings in this table.
The following settings are enabled only when USE THE FOLLOWING IP ADRESS setting is selected.		
IP Address	IP address to be assigned to a BE1-700	This is the IP address, expressed in dotted decimal notation (0.0.0.0), that users enter to access this relay on the network. Consult your network administrator for the appropriate value to use in this field.
Subnet Mask	Subnet mask to be assigned to a BE1-700	This is the subnet mask, expressed in dotted decimal notation (0.0.0.0), of the subnet of the network to which the BE1-700 is connected. Consult your network administrator for the appropriate value to use in this field.
Default Gateway	IP address of the default gateway server	This is the IP address, expressed in dotted decimal notation (0.0.0.0), of the gateway used to access the BE1-700. If no gateway is used, this value should be set at 0.0.0.0. Consult your network administrator for the appropriate value to use in this field.

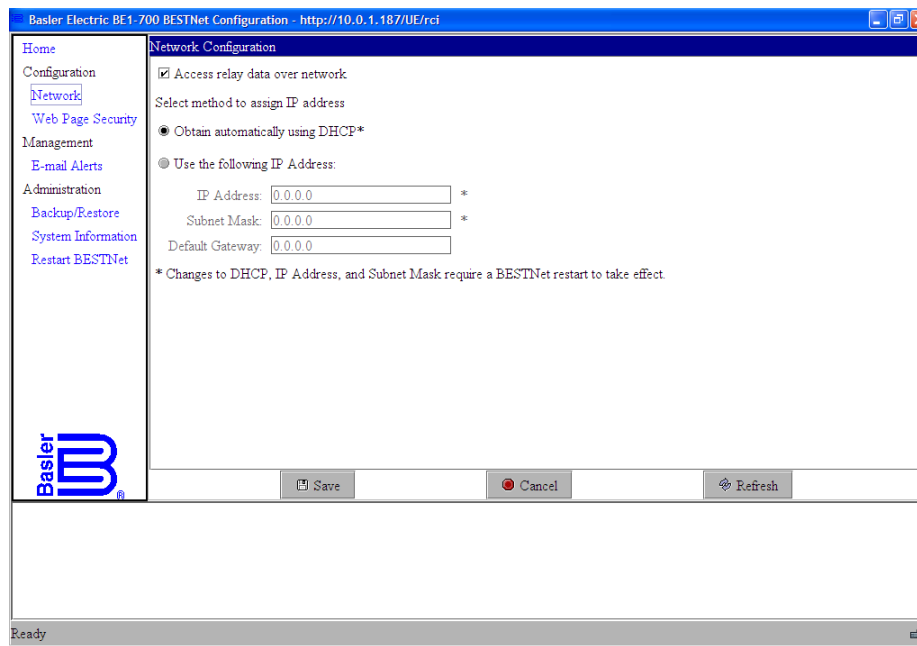


Figure 15-4. Network Configuration Screen

Web Page Security

Purpose: Provide security to prevent unauthorized changes to BESTnet configuration.

Note

Web page security ONLY protects against changes to the BESTnet configuration. It DOES NOT prevent changes to relay settings over Ethernet. To add password control for setting changes, use the *Global Security* tab in BESTCOMS to select password(s) for the COM1 Ethernet port.

By entering a username and password on this screen, a login will be required to make future changes to the BESTnet configuration.

Note

BEFORE saving the username and password, make a written note of these values! Once the values are saved, the user name and password will be required for all future changes, including disabling security.

Web Page Security Configuration screen settings are shown in Figure 15-5 and described in Table 15-3.

Figure 15-5. Web Page Security Configuration Screen

Table 15-3. Web Page Security Configuration Screen Settings and Information

Setting	Value	Function
Enable password authentication	Unchecked	Disables password authentication of web pages
	Checked	Requires entry of a password before allowing web page viewing
The remaining settings are enabled only when the ENABLE PASSWORD AUTHENTICATION setting is checked.		
User Name	User name required for access	A user name must be entered to allow future changes to BESTnet configuration. Both a user name and password are required to gain access.
Password	Password required for access	A password must be entered to allow future changes to BESTnet configuration. Both a user name and password are required to gain access.
Verify Password	Second entry of password required for confirmation of access privilege	The correct password must be reentered in this field to ensure that an entry error was not made. If the PASSWORD and VERIFY PASSWORD fields do not match, an error will be generated and the security settings will not be saved.

E-Mail Alerts

Purpose: Configure the parameters for E-mail Alerts. E-mail alerts allow a BESTlogic equation to cause an e-mail message to be sent to a predetermined e-mail address and carbon-copied (CC) to a second e-mail address. The subject line of the e-mail message can be programmed to indicate the type of event that triggered the e-mail.

Settings allow a trigger interval time delay to be added to prevent multiple e-mails from being sent when a trigger is being sent repeatedly. Separate settings allow "reminder" e-mails to be sent periodically if a trigger remains active for an extended period. Care must be taken with these settings to ensure that recipients are not "flooded" with e-mails.

Note

E-mail alerts are triggered by BESTlogic equations that are configured in the BESTnet section of BESTCOMS. E-mail alerts will not function unless BOTH the configuration applet AND the BESTnet e-mail equations are set.

E-mail Alerts Configuration screen settings are shown in Figure 15-6 and described in Table 15-4.

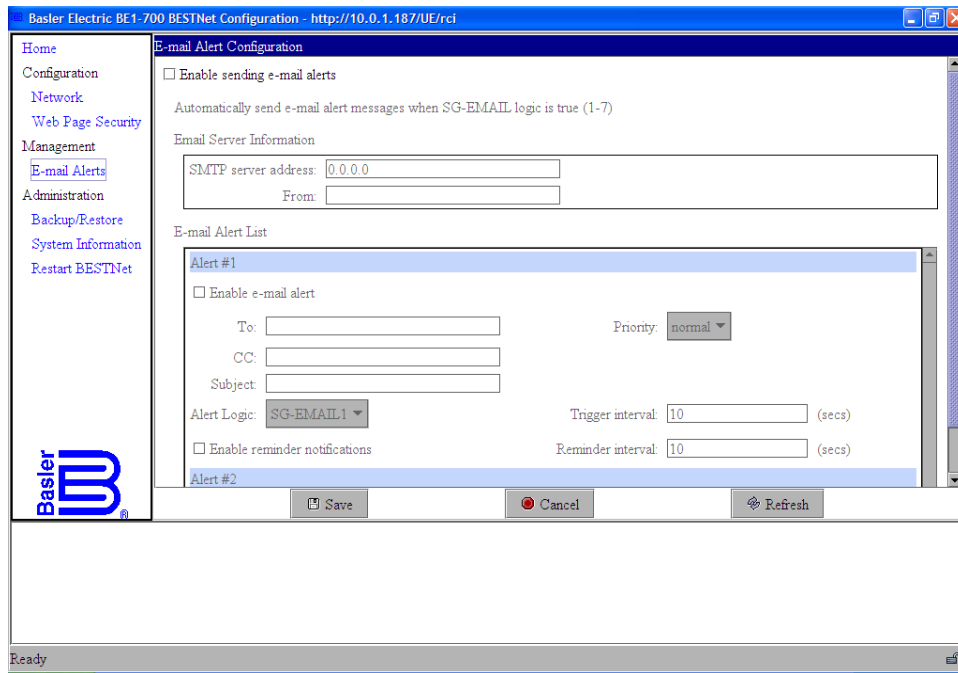


Figure 15-6. E-mail Alerts Configuration Screen

Table 15-4. E-mail Alerts Configuration Screen Settings and Information

Setting	Value	Function
Enable sending e-mail alerts	Unchecked	Disables sending of any e-mail alerts
	Checked	Enables sending of e-mail alerts
SMTP Server Address	IP address of an SMTP server	This setting field contains the IP address, in dotted decimal notation (0.0.0.0), of an SMTP server accessible by the BE1-700. This server must not require authentication.
From	Any e-mail address with a valid format	This e-mail address will show in the From field of e-mails sent by the BE1-700. It cannot contain spaces or punctuation other than an underscore (_). It must contain one ampersand (@).
The remaining settings are repeated for each of the 10 programmable alerts.		
Enable e-mail alert	Unchecked	Disables sending of this e-mail alert
	Checked	Enables sending of this e-mail alert
To	Any e-mail address with a valid format	When the ALERT LOGIC condition becomes true, this is the address that the BE1-700 attempts to send an e-mail message to. The address cannot contain spaces or punctuation other than an underscore (_). It must contain one ampersand (@).

Setting	Value	Function
CC	Any e-mail address with a valid format	When the ALERT LOGIC condition becomes true, this is the address that the BE1-700 attempts to send a carbon copy e-mail message to. The address cannot contain spaces or punctuation other than an underscore (_). It must contain one ampersand (@).
Subject	Text string , up to 63 characters	This string is placed in the subject line of the e-mail message and contains user-defined text that describes the type of error indicated by the selected ALERT LOGIC equation. Subject line examples are "Overcurrent Trip" and "Breaker Close".
Priority	Normal	Sends e-mail with normal priority
	High	Sends e-mail with high priority. (The effect of this setting depends on the recipient's e-mail application.)
Alert Logic	SG-EMAIL1, SG-EMAIL2 . . . SG-EMAIL7	This setting selects which BESTnet logic equation will cause e-mail message(s) to be sent by the BE1-700 relay. The BESTnet logic equations are defined in BESTCOMS.
Trigger Interval	0 to 99,999 seconds	Minimum time to detect a true ALERT LOGIC condition. A setting other than zero causes the BE1-700 to wait the specified time before sending another e-mail message for additional occurrences of the same trigger.
Enable Reminder Notifications	Unchecked	Send only one alert e-mail per trigger.
	Checked	Send e-mails periodically for as long as the ALERT LOGIC remains true.
Reminder Interval	0 to 99,999 seconds	Repetition interval for reminder e-mails, if enabled. A value of zero is NOT recommended and will send many e-mails per second while the ALERT LOGIC is true.

Backup/Restore

Purpose: Allows BESTnet configuration to be saved in a file on the PC or loaded from a file. This is useful for saving a configuration before making a change, or for copying a configuration from one BE1-700 to another.

Note

The BESTnet configuration backup file will contain only settings saved by the BESTnet configuration applet. To save all settings from a BE1-700, save the BESTnet settings with this function, then use BESTCOMS to save the protection settings to a .BST file. These two files together will contain all configuration information for a BE1-700 relay.

Backup/Restore Configuration screen settings are shown in Figure 15-7 and described in Table 15-5.

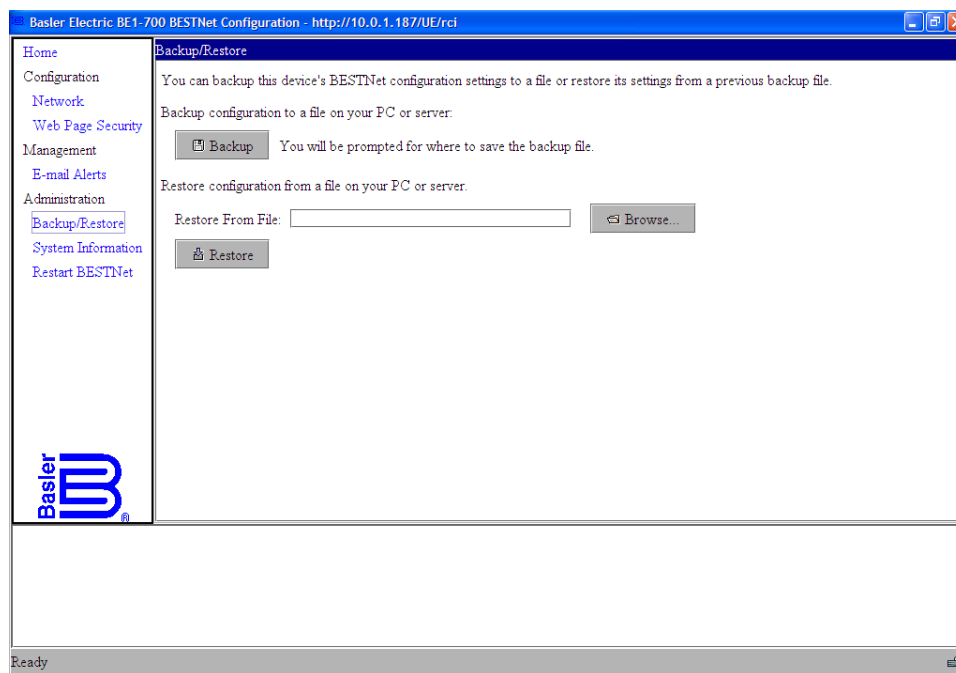


Figure 15-7. Backup/Restore Configuration Screen

Table 15-5. Backup/Restore Configuration Screen Settings and Information

Information	Value	Function
BACKUP Button	Click to activate	Click the BACKUP button to save all BESTnet settings. A dialog box will appear and allow you to select a location and file name on your PC. Click the BACKUP button in the dialog box to save BESTnet settings in a file. Clicking this button DOES NOT save ANY relay protection or configuration settings!
Restore From File	File path string	Enter a valid path to a previously saved BESTnet backup file.
BROWSE Button	Click to activate	A dialog box will appear and allow you to select a location and file name or an existing backup file on your PC. Click the BACKUP button in the dialog box to save BESTnet settings in a file.
RESTORE Button	Click to activate	After selecting a file with the BROWSE button, click the RESTORE button to open the selected file and restore the settings from that file into the BESTnet subsystem. All currently active BESTnet settings will be lost and replaced with the settings from the file.

System Information

Purpose: Provides detailed technical information about the configuration and status of the BESTnet Ethernet subsystem in the BE1-700 Relay. This information is not generally required, but may be useful for troubleshooting.

The *System Information Configuration* Screen is shown in Figure 15-8.

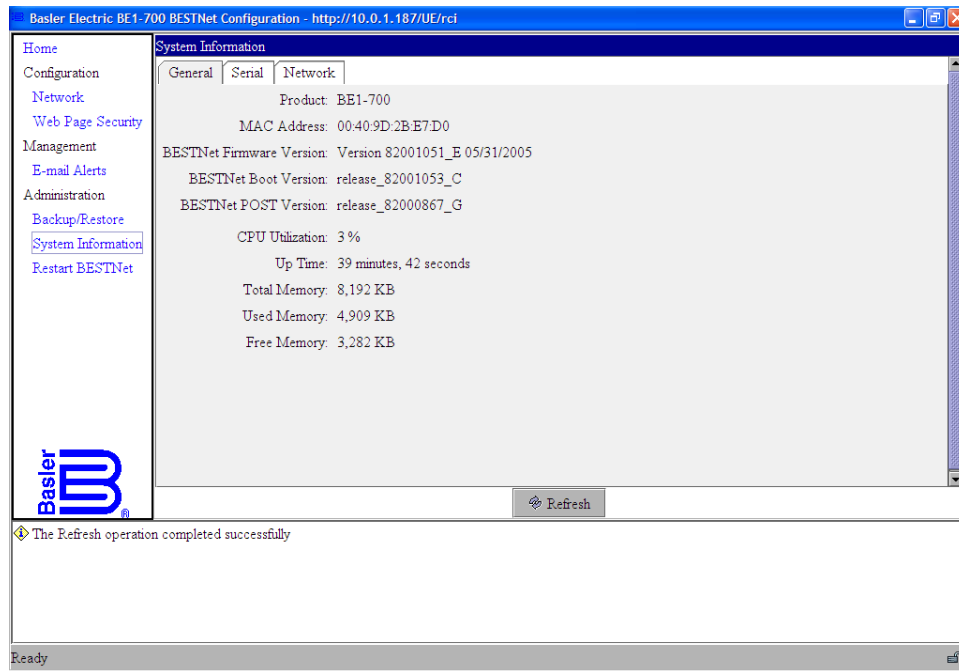


Figure 15-8. System Information Configuration Screen

Information Available from the System Information Configuration Screen

General: Provides information about the firmware installed in the BESTnet subsystem, as well as statistics about how long the BESTnet subsystem has been running and CPU and memory utilization information.

Serial: Provides information about how much data has flowed between the BESTnet subsystem and the BE1-700 protection processor.

Network: Provides information about how much data has flowed between the BESTnet subsystem and Ethernet clients accessing data on the BE1-700 relay.

Restart BESTnet™

Purpose: Resets the BESTnet subsystem and processor. This is required for new NETWORK setting changes to take effect. Restarting BESTnet does not affect any protection settings or data.

Restart BESTnet Configuration Screen settings are shown in Figure 15-9 and described in Table 15-6.

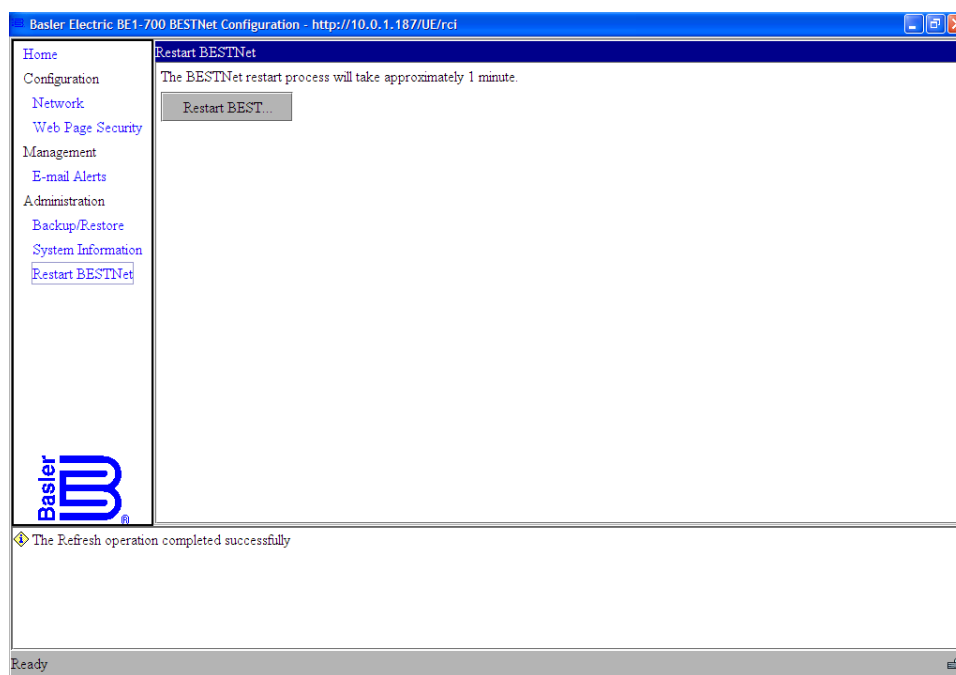


Figure 15-9. Restart BESTnet Configuration Screen

Table 15-6. Restart BESTnet Configuration Screen Settings and Information

Information	Value	Function
RESTART BESTnet Button	Click to activate	Clicking this button generates a prompt that allows you to restart the BE1-700 BESTnet subsystem. This restart terminates all Ethernet connections and reinitializes the BESTnet processor. It is necessary to restart BESTnet after changing network parameters.

Configuring BESTCOMS™ for Ethernet

Connect your PC and the BE1-700 Digital Protective Relay to the TCP/IP LAN or intranet. An Ethernet port is provided on the back of the relay. Start BESTCOMS as described in Section 14, *BESTCOMS Software*.

Identifying the IP Address

To identify an unknown IP address, click the *Ethernet Communication* pull-down menu (available on any BESTCOMS screen) and select *Download Settings from Device*. This will display the screen shown in Figure 15-10. Click the *Scan for Connected Devices* button. Immediately, the *Basler Electric Device Discovery* (configuration utility) program will run and reflect the IP Address and Relay ID of BE1-700 relays on the same LAN (as shown in Figure 15-11). (Note that all BE1-700 Ethernet-enabled relays on the same subnet will be displayed. So, you may have to confirm the correct IP address with your network administrator.) On the *BE1-700 Device Discovery* screen, click the *Add* button to add the second device to the list of known BE1-700 relays. Click *Connect* to connect without adding the device to the list. Note this IP address since it can be used to access the web pages of the BE1-700 with BESTnet.

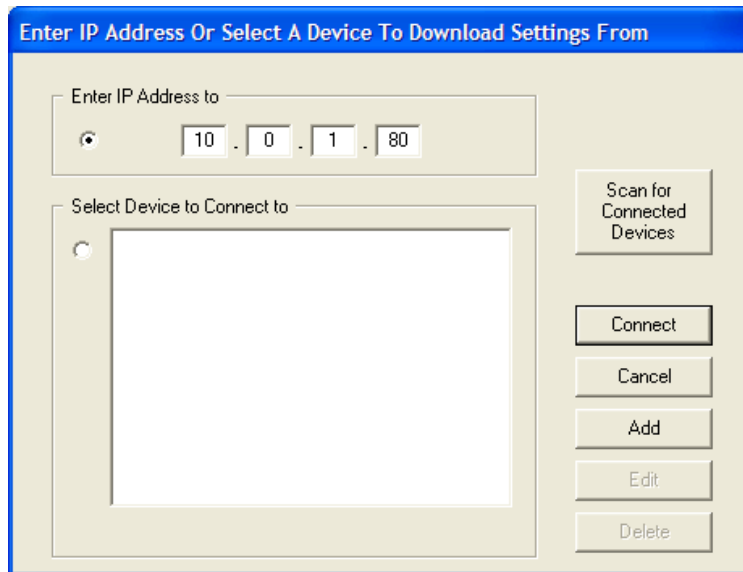


Figure 15-10. BE1-700 Device List Window

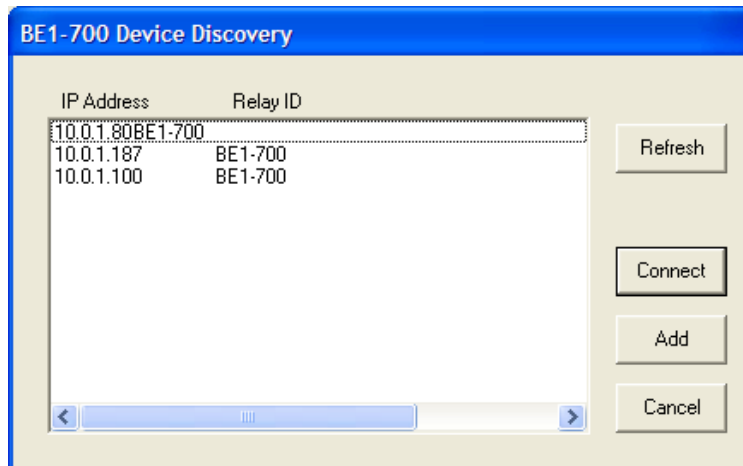


Figure 15-11. BE1-700 Device Discovery Results Window

Viewing Web Pages

Notes

BE1-700 web pages are built on the Java™ platform. To ensure the most up-to-date web pages are being displayed, Java™ caching must be disabled. This is accomplished via the Java™ Applet/Control Panel (located inside Windows® Control Panel).

BESTnet™ Webpage Interface supported in Microsoft® Internet Explorer® and Edge® in IE mode.

Status Web Page

Using the PC, start your web browser and enter the IP address, determined by the Device Discovery utility, in the browser URL Block (Address Bar) and press *Enter*. The *BE1-700 Digital Protection Relay Status* web page will appear (Figure 15-12).

This home page provides overall status information of the relay and of the network. Current data is presented each time the web page is refreshed. A web page is refreshed manually by pressing the keyboard F5 button or clicking the *Refresh* button in Microsoft Internet Explorer. A web page is refreshed continuously if the *Start Polling* button is clicked. The *General Status* and *System Info* panes provide the most important information from the protection and control relays. This web page is created by the BE1-700 relay and provides the following "read-only" information.

- General Status
 - Relay Trouble
 - Major Alarm
 - Minor Alarm
 - Logic Alarm
 - Targets
 - Breaker
 - Recloser (status)
- System Info
 - Relay ID
 - Station ID
- Networking Settings
 - MAC (address)
 - E-mail (server)
 - DHCP (mode)
 - IP Address
 - IP Subnet Mask
 - IP Gateway
- Version Info
 - Model Number
 - Style Number
 - App Program (firmware version)
 - Boot Program (firmware version)
 - Serial Number

None of the above settings can be changed from within the web page but some can be changed through the BE1-700 front panel human-machine interface (HMI) or through a PC using BESTCOMS. Refer to other sections in the instruction manual for details. Network settings can be changed by the company network administrator or through BESTCOMS as was discussed previously in this section. The *Status* web page is also the location from which other web-based features are launched, as is discussed in the following paragraphs.

BE1-700 Digital Protection Relay
- Status -

01/01/00 00:55:40

[Status](#)
[Metering](#)
[Fault Reports](#)
[SER Reports](#)

General Status		System Info	
Relay Trouble	NONE	Relay ID	BE1-700
Major Alarm	NONE	Station ID	SUBSTATION_1
Minor Alarm	NONE		
Logic Alarm	NONE		
Targets	NONE		
Breaker	CLOSED		
Recloser	OFF		

Network Settings	
MAC	00:40:9D:2B:E7:D0
E-Mail	0.0.0.0
DHCP	on
IP Address	10.0.1.187
IP Subnet Mask	255.255.255.0
IP Gateway	10.0.1.1

Version Info	
Model Number	BE1-700C
Style Number	B0R2X5N
App Program	VER 1.03.00 11/06/2007
Boot Program	VER 2.08.00 08/13/2002
Serial Number	H00426067

BE1-700 Status
Applet Version: 1.02.00

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Figure 15-12. BE1-700C Status Web Page

Metering Web Page

From the *Status* web page (home page) click the *Metering* hyperlink below and to the left of the page title. The *BE1-700 Digital Protection Relay Metering* web page will appear as illustrated in Figure 15-13. Click the *Start Polling* button at the bottom of the page, and real-time, read-only metering information will appear. If you wish to freeze the information, click the *Stop Polling* (start/stop toggle) button. If desired, you may save a copy of the screen shot (by pressing the keyboard *Alt* and *Print Screen* keys) and pasting the image in another application for analysis. Note, too, that the relay date and time information is shown at the top of the *Metering* web page. For more information on metering, see Section 5, *Metering*, and Section 14, *BESTCOMS Software, Metering*. Click the *Back* button on your browser to return to the *Status* (home) web page.

BE1-700 Digital Protection Relay
- Metering -

01/01/00 00:57:38

[Status](#)
[Metering](#)
[Fault Reports](#)
[SER Reports](#)

Current	
IA	0.0
IB	0.0
IC	0.0
IN	0.0
IQ	0.0
IG	0.0

BE1-700 Status
Applet Version: 1.02.00

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Figure 15-13. BE1-700C Metering Web Page

Fault Reports Web Page

From the *Status* web page (home page) click the *Fault Reports* hyperlink below and to the left of the page title. The *BE1-700 Digital Protection Relay Fault Reports* web page will appear as illustrated in Figure 15-14. The web page shows general information about the relay at the top, including the number of faults recorded and the time range during which they occurred. Below that is a list of faults, with the highest numbered faults appearing at the top. The date, time, type and number of oscillographic recordings is shown for each fault.

For a more detailed fault summary of a particular fault, click on the fault number hyperlink to show the *Fault Summary Reports* web page.

Click the web browser's *Back* button to return to the *Status* (home) web page.

BE1-700 Digital Protection Relay - Fault Reports -						
01/01/00 00:03:07						
Status Metering Fault Reports SER Reports						
BE1-700 Fault Directory						
Report Date						01/01/00
Report Time						00:03:06
Station ID						SUBSTATION_1
Relay ID						BE1-700
Relay Address						0
New Faults	2 (00:01:05 01/01/00-00:01:26 01/01/00)					
Total Faults	2 (00:01:05 01/01/00-00:01:26 01/01/00)					
Faults						
#	Date	Time	Type	# OSCs		
002	01/01/00	00:01:26	RF=TRIG	1		
001	01/01/00	00:01:05	RF=TRIG	1		
BE1-700 Status Applet Version: 1.02.00 <input type="button" value="Start Polling"/>						
Copyright 2004, Basler Electric . All rights reserved. Tel: (618) 654-2341 Fax (618) 654-2351						

Figure 15-14. BE1-700 Fault Reports Web Page

Fault Summary Reports Web Page

From the *Fault Reports* web page click the fault number hyperlink at the left of the row of interest. The *BE1-700 Digital Protection Relay Fault Summary Reports* web page will appear as illustrated in Figure 15-15. This web page shows details from the selected fault summary report. General information about the fault is at the top of the page, including relay information, date, time, type, trigger, targets, and fault clearing and operate time (if applicable), as well as number of oscillographic recordings.

At the bottom under *Measured Signals*, the measured values for that fault are shown as magnitudes with angles for each measured analog quantity.

Click the *Back* button on the browser to return to the *Fault Reports* (list) web page.

BE1-700 Digital Protection Relay - Fault Summary Reports -

01/01/00 00:03:42

[Status](#) [Metering](#) [Fault Reports](#) [SER Reports](#)

BE1-700 Fault Summary	
Station ID	SUBSTATION_1
Relay ID	BE1-700
Relay Address	0
Fault Number	2
Event Type	RF=TRIG
Fault Date	01/01/00
Fault Time	00:01:26.646
Fault Trigger	RF=TRIG
Active Group	0
Fault Type	N/A
Targets	NONE
Fault Clearing Time	N/A
Breaker Operate Time	NO OPERATION
Oscillographic Reports	1

Measured Signals	
IA	0.00A@ 0.0 DEG
IB	0.00A@ 0.0 DEG
IC	0.00A@ 0.0 DEG
IG	0.00A@ 0.0 DEG

BE1-700 Status
Applet Version: 1.02.00

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Figure 15-15. BE1-700 Fault Summary Reports Web Page

SER Reports Webpage

From the *Status* web page (home page) click the *SER Reports* hyperlink below and to the left of the page title. The *BE1-700 Digital Protection Relay SER Reports* webpage will appear as illustrated in Figure 15-16. The upper portion of this webpage shows the *Sequence of Events Directory*. The lower portion shows the *Sequence of Events* details.

Click the web browser's *Back* button to return to the *Status* (home) web page.

BE1-700 Digital Protection Relay - SER Reports -

01/01/00 00:04:34

Status [Metering](#) [Fault Reports](#) [SER Reports](#)

BE1-700 Sequence of Events Directory

Report Date	01/01/00
Report Time	00:04:32
Station ID	SUBSTATION_1
Relay ID	BE1-700
Relay Address	0
New Records	7 (00:00:00.005 01/01/00 - 00:00:49.946 01/01/00)
Total Records	7 (00:00:00.005 01/01/00 - 00:00:49.946 01/01/00)

[Show all records](#)

Sequence of Events

Date	Time	Point Description	Status
01/01/00	00:00:49.946	ALARM MAJOR	FALSE
		SETTING CHANGE ALARM	MADE
		LOGIC=NONE ALARM	RESET
01/01/00	00:00:33.713	SETTING CHANGE ALARM	MADE
01/01/00	00:00:33.338	SETTING CHANGE ALARM	MADE
01/01/00	00:00:00.996	OUTPUT 1 CIRCUIT OPEN	TRUE
01/01/00	00:00:00.396	uP RESET ALARM	SET
01/01/00	00:00:00.388	ALARM MAJOR	TRUE
		SETTING CHANGE ALARM	MADE
01/01/00	00:00:00.005	ALARM RELAY TROUBLE	RESET
		CLOCK ERROR ALARM	SET
		LOGIC=NONE ALARM	SET

BE1-700 Status
Applet Version: 1.02.00

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Figure 15-16. BE1-700 SER Reports Web Page

E-Mail Alerts

The BE1-700 relay with the BESTnet option can provide status alerts via e-mail. Any system or device capable of receiving electronic-mail (e-mail) can be the recipient of these alerts.

Configuring the E-mail Alerts Function

In order to use e-mail alerts, the BE1-700 must be purchased with Communications Protocol option 4 or 5. Refer to Section 1 for the BE1-700 style chart, Figure 1-1. Likewise, option 4 or 5 must be entered as part of the style number in BESTCOMS. (See Section 14, *BESTCOMS Software*.)

Configuring BE1-700 e-mail alerts involves two steps. Both steps must be executed in order for e-mail alerts to function properly.

Step 1. The BESTlogic equations must be set using the BESTnet tab in BESTCOMS.

First, go to the *BESTnet Settings* Screen in BESTCOMS (Figure 15-17). This screen is used for setting e-mail triggers. A maximum of seven alerts can be set.

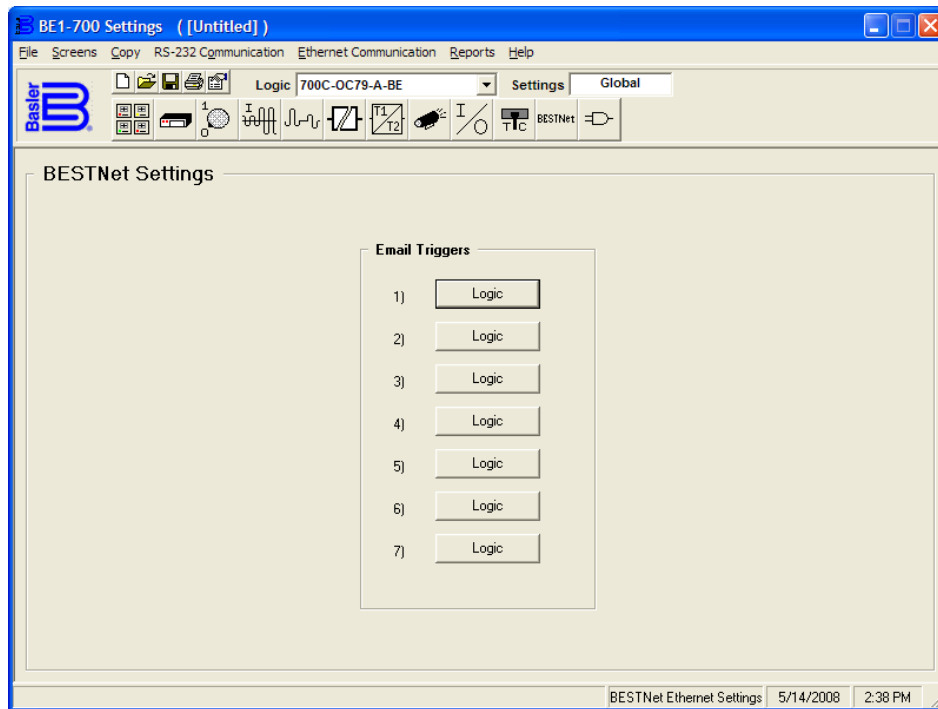


Figure 15-17. BESTnet Settings Screen

Click the *Logic* button for the desired trigger and the *BESTlogic Function Element* screen (Figure 15-18) will appear. To select the desired inputs, click the *TRIGGER* button. The *BESTlogic Expression Builder* screen will open. Select the expression type to be used. Then select the BESTlogic variable to be connected to the input. (It is suggested that only one variable be selected.) Select *Save* when finished to return to the *BESTlogic Function Element* screen. For more details on the BESTlogic Expression Builder, see Section 7, *BESTlogic Programmable Logic*. Select *Done* when the settings have been completely edited.

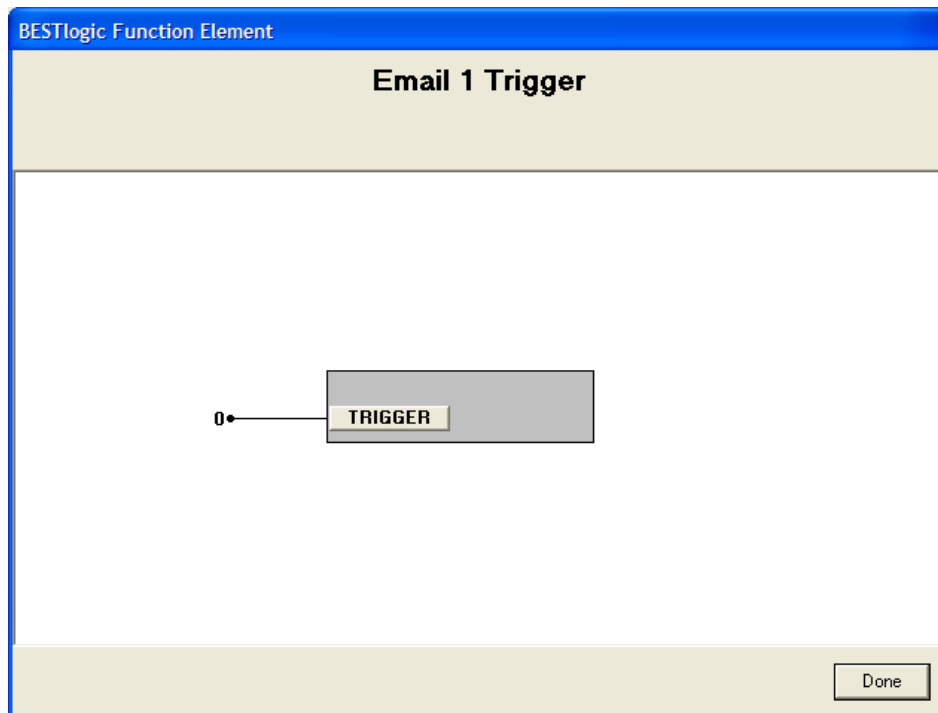


Figure 15-18. BESTlogic Function Element Screen, E-mail 1 Trigger

Step 2. The e-mail addresses, subject, etc. must be set and the appropriate e-mail alerts enabled using the BESTnet configuration applet, which is accessed with a web browser. (See *Configuring the BE1-700 for Ethernet.*)

The *To:* *CC:* (carbon copy) and *Subject:* may be set just like an ordinary E-mail. It is suggested that the subject be tailored to match the type of trigger conditions. The functionality of E-mail 2 through 7 is the same as for E-mail 1, just described.

TCP/IP ASCII Communication

TCP/IP ASCII communication allows a BE1-700 relay Ethernet connection for the purpose of issuing ASCII commands and receiving responses. The commands and responses are identical to those available on the serial communication ports, and described in Section 11, *ASCII Command Interface.*

A TCP/IP ASCII session can be started in most versions of Microsoft Windows using the built-in Telnet application.

To be able to use Telnet to change parameters on a Basler Electric BE1-700 relay, the user must have security access through the rear Ethernet port (COM1). This can be achieved by setting the GS-PW ASCII command to enable area 1 (see Section 9, *Security*) or by selecting the appropriate COM1 rear Ethernet check box or boxes in BESTCOMS as shown in Figure 15-19. **Note:** These changes can only be made using a serial (RS-232 or RS-485) connection. Attempts to enable changes for COM1 (Ethernet) will be rejected. See Section 9, *Security*, for details.

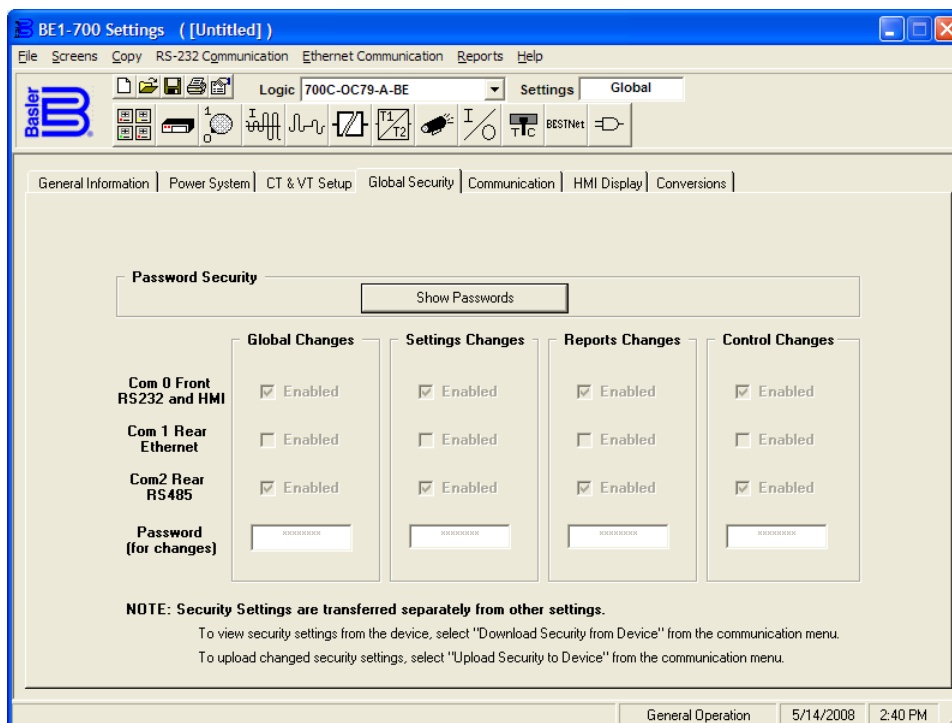


Figure 15-19. General Operation Screen, Global Security Tab

The Telnet application is normally located in the C:\Windows\System32 folder in the Microsoft Windows operating system and can be accessed through the *Run* command of the Windows *Start* menu. Since there is usually a search path defined for the System32 folder, it is usually not necessary to type the full path. To get help on the Telnet command, type `telnet/?` at a command prompt.

To access the BE1-700 using Telnet, you must know the IP address of the BE1-700. Refer to the paragraphs under *Identifying the IP Address* for information about determining the IP address.

The main syntax for the Telnet command is:

```
telnet [host IP Address] [port #]
```

Note

The Telnet access port for all BE1-700 relays is 2101. This port number will be required any time a program wishes to establish a TCP/IP ASCII session with a BE1-700 relay.

Telnet Command Example

Telnet into a BE1-700 relay with an IP Address of 10.0.1.187.

Open the Windows *Command Prompt* window (Figure 15-20) or Windows *Run* box (Figure 15-21) and type **telnet 10.0.1.187 2101** and press *Enter*. The *Command Prompt* window will display a blinking cursor.

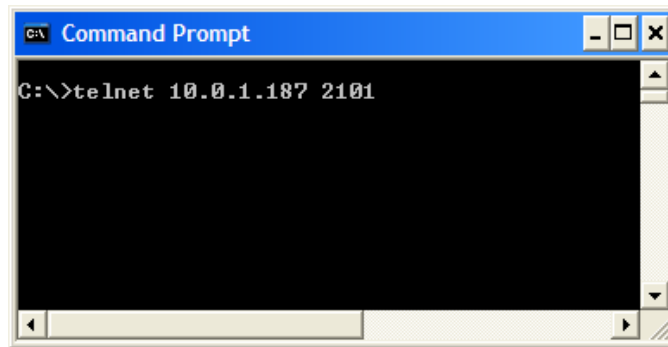


Figure 15-20. Windows Command Prompt Window

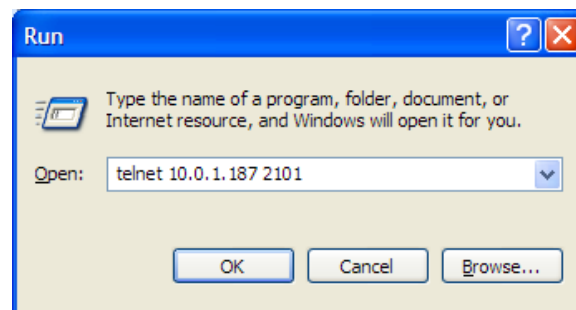


Figure 15-21. Windows Run Box

Type an ASCII command, such as RG-VER, and press Enter to verify that you have made the Telnet connection. See Figure 15-22.

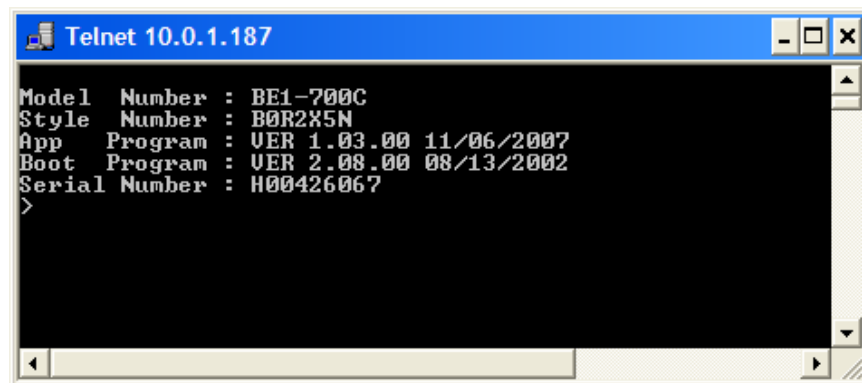


Figure 15-22. Telnet Session Command and Relay Response

Once the Telnet connection is verified, you can type any BE1-700 ASCII command to see settings, reports, or status information.

Note

The Telnet application may not echo your typed entries.

To close the Telnet connection, type **Ctrl +]** and then type *quit*. You can also exit the Telnet connection by clicking the X button in the upper right corner of the Telnet session window.

Ethernet Ports

An Ethernet port is available as an option and communicates using ASCII commands (relay style XXXXX4X or XXXXX5X).

The 10BaseT port is an eight-pin RJ-45 connector that connects to 10/100 megabit Category 5 copper wire media.

Unique ASCII Commands

SG-EMAIL Command

Purpose: Read/Set E-mail parameters where n is 1 to 7.

Syntax: SG-EMAIL[n][={e-mail logic}]

Comments: Sets up to seven different e-mail triggers which will automatically send e-mail messages when the trigger logic becomes TRUE. The following parameters are required:

[n] E-mail number 1 to 7.

{logic}

This is an OR-only BESTlogic equation that when TRUE triggers the sending of an e-mail message. A entry into the sequence of event record will be logged for each e-mail message triggered.

SG-EMAIL Command Example

Set e-mail #2 logic to VO3, where SL-VO3=50TPT.

```
>SG-EMAIL2=VO3
```

Troubleshooting Guide

For LAN Connections

Requirements

- Standard Cat 5 or Cat 5e cable less than 100 meters (328 feet) in length.
- For BESTCOMS to be able to detect the relay(s) with the scan function, the PC and relay must be on the same side of a single router (i.e., on the same network segment).
- If DHCP is not used, consult your network administrator for a static IP address, subnet mask and default gateway, appropriate for your network.
- To use e-mail alerts, an SMTP server that does not require a login (by clients on the network) must be accessible by the relay. Consult your network administrator.

Troubleshooting Suggestions

- When configuring the relay for Ethernet, the first time the configuration applet is run, you may get a security warning asking if you trust the signed applet distributed by Basler Electric. Clicking Yes will allow the process to continue.
- If DHCP is being used, Ethernet cable should be connected to the relay before applying power. If the Ethernet cable is connected after powering up relay, it may take a long time for the IP address to be assigned by the DHCP server. You can force this process to happen by cycling relay power while the Ethernet cable is connected.

- If some commands work and some do not, the security settings for COM1 may be set to the default state which allows reading parameters via Ethernet but prevents writing. These settings can be changed from BESTCOMS but **ONLY** via an RS-232 connection to the relay. For security reasons, the Ethernet port cannot be used to turn on Ethernet write options.
- Only one user can be polling the relay at a time. If another user is using the Ethernet connection, you must wait until their session is complete.

For Direct Connections (PC to Relay without a LAN)

Requirements

- A special Ethernet crossover/cross-wired Cat 5 or Cat 5e cable less than 100 meters should be used. A standard Ethernet cable **will not work** for a back-to-back PC connection (i.e., directly connected without a hub/switch/router) to a relay.
- If the relay is set for DHCP, then the PC must also be set for DHCP.

Troubleshooting Suggestions

- E-mail alerts will not work on a direct PC-to-relay connection.
- On some computers, particularly those with older Windows operating systems, it may be necessary to release/renew the DHCP connection on the PC to get it to the default subnet that matches the relay. This can be done with the ipconfig.exe or winipconfig.exe (Windows ME, 98 or 95, only) application provided with Windows.
- If the direct connection is not working, try using a hub, switch, router, or LAN to verify that the PC and relay are communicating. In this case, do not use crossover cable(s).
- If some commands work and some do not, the security settings for COM1 may be set to the default state which allows reading parameters via Ethernet but prevents writing. These settings can be changed from BESTCOMS but **ONLY** via a RS-232 connection to the relay. For security reasons, the Ethernet port cannot be used to turn on Ethernet write options.
- If the scan function of BESTCOMS shows an address of 0.0.0.0 when the relay is set to DHCP, the communications processor of the relay is still being initialized. Wait 30 seconds and then try "*Scan for Connected Devices*" or "*Refresh*" again.
- If the scan function in BESTCOMS shows the relay but no other Ethernet functions work, then it may be necessary to set the static IP address of the PC to the same IP address shown in BESTCOMS. But, change the part after the last period to a different number and change the subnet mask to 255.255.255.0.



A • Time Overcurrent Characteristic Curves

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 $\pm 5\%$ or $\pm 1\frac{1}{2}$ 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 Std C37.112 - 1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*.

$$T_T = \frac{A \cdot D}{M^N - C} + B \cdot D + K \quad \text{Equation A-1}$$

$$T_R = \frac{R \cdot D}{|M^2 - 1|} \quad \text{Equation A-2}$$

T_T = Time to trip when $M \geq 1$

T_R = Time to reset if relay is set for integrating reset when $M < 1$. Otherwise, reset is 50 milliseconds or less

D = TIME DIAL setting (0.0 to 9.9)

M = Multiple of PICKUP setting (0 to 40)

A, B, C, N, K = Constants for the particular curve

R = Constant defining the reset time.

Table A-1 lists time characteristic curve constants. See Figures A-1 through A-17 for graphs of the characteristics.

Table A-1. 51P, 51N, and 51Q Time Characteristic Curve Constants

Curve Selection	Curve Name	Trip Characteristic Constants §					Reset †
		A	B	C	N	K	R
S1	S, S1, Short Inverse	0.2663	0.03393	1.0000	1.2969	0.0280	0.5000
S2	S2, Short Inverse	0.0286	0.02080	1.0000	0.9844	0.0280	0.0940
L1	L, L1, Long Inverse	5.6143	2.18592	1.0000	1.0000	0.0280	15.750
L2	L2, Long Inverse	2.3955	0.00000	1.0000	0.3125	0.0280	7.8001
D	D, Definite Time	0.4797	0.21359	1.0000	1.5625	0.0280	0.8750
M	M, Moderately Inverse	0.3022	0.12840	1.0000	0.5000	0.0280	1.7500
I1	I, I1, Inverse Time	8.9341	0.17966	1.0000	2.0938	0.0280	9.0000
I2	I2, Inverse Time	0.2747	0.10426	1.0000	0.4375	0.0280	0.8868
V1	V, V1, Very Inverse	5.4678	0.10814	1.0000	2.0469	0.0280	5.5000
V2	V2, Very Inverse	4.4309	0.09910	1.0000	1.9531	0.0280	5.8231
E1	E, E1, Extremely Inverse	7.7624	0.02758	1.0000	2.0938	0.0280	7.7500
E2	E2, Extremely Inverse	4.9883	0.01290	1.0000	2.0469	0.0280	4.7742
A	A, Standard Inverse	0.01414	0.00000	1.0000	0.0200	0.0280	2.0000
B	B, Very Inverse (I^2t)	1.4636	0.00000	1.0000	1.0469	0.0280	3.2500
C	C, Extremely Inverse (I^2t)	8.2506	0.00000	1.0000	2.0469	0.0280	8.0000
G	G, Long Time Inverse (I^2t)	12.1212	0.00000	1.0000	1.0000	0.0280	29.0000
F	Fixed Time *	0.0000	1.00000	0.0000	0.0000	0.0280	1.0000
P	Programmable	0 to 600	0 to 25	0 to 1	0.5 to 2.5	0.0280	0 to 30
46	Neg.-Seq. Overcurrent	‡	0	0	2	0.0280	100

* Curve F has a fixed delay of one second times the Time Dial setting.

† For integrated reset, append **R** to the curve name. For example, curve **S1** has instantaneous reset. Curve **S1R** has integrated reset.

‡ Constant A is variable for the 46 curve and is determined, as necessary, based on system full-load current setting, minimum pickup, and K factor settings.

§ The programmable curve allows for four significant digits after the decimal place for every variable.

Time Overcurrent Characteristic Curve Graphs

Figures A-1 through A-16 illustrate the characteristic curves of the BE1-700 relay. Table A-2 cross-references each curve to existing electromechanical relay characteristics. Equivalent time dial settings were calculated at a value of five times pickup.

Table A-2. Characteristic Curve Cross-Reference

Curve	Curve Name	Similar To
S1	S, S1, Short Inverse	ABB CO-2
S2	S2, Short Inverse	GE IAC-55
L1	L, L1, Long Inverse	ABB CO-5
L2	L2, Long Inverse	GE IAC-66
D	D, Definite Time	ABB CO-6
M	M, Moderately Inverse	ABB CO-7
I1	I, I1, Inverse Time	ABB CO-8
I2	I2, Inverse Time	GE IAC-51
V1	V, V1, Very Inverse	ABB CO-9
V2	V2, Very Inverse	GE IAC-53
E1	E, E1, Extremely Inverse	ABB CO-11
E2	E2, Extremely Inverse	GE IAC-77
A	A, Standard Inverse	BS, IEC Standard Inverse
B	B, Very Inverse (I^2t)	BS, IEC Very Inverse (I^2t)
C	C, Extremely Inverse (I^2t)	BS, IEC Extremely Inverse (I^2t)
G	G, Long Time Inverse (I^2t)	BS, IEC Long Time Inverse (I^2t)
F	Fixed Time	N/A
P	Programmable	N/A

Time Dial Setting Cross-Reference

Although the time characteristic curve shapes have been optimized for each relay, time dial settings of Basler Electric relays are not identical to the settings of electromechanical induction disk overcurrent relays. Table A-3 helps you convert the time dial settings of induction disk relays to the equivalent setting for Basler Electric relays. Enter time dial settings using BESTCOMS™, S<g>-51P/51N/51Q/151N ASCII commands, or human-machine interface (HMI) Screens 5.x.7.1 (51P), 5.x.7.2 (51N), 5.x.7.3 (51Q), and 5.x.7.5 (151N). For more information, refer to Section 4, *Protection and Control, Overcurrent Protection, 51 - Time Overcurrent Protection*.

Using Table A-3

Cross-reference table values were obtained by inspection of published electromechanical time current characteristic curves. The time delay for a current of five times tap was entered into the time dial calculator function for each time dial setting. The equivalent Basler Electric time dial setting was then entered into the cross-reference table.

If your electromechanical relay time dial setting is between the values provided in the table, it will be necessary to interpolate (estimate the correct intermediate value) between the electromechanical setting and the Basler Electric setting.

Basler Electric relays have a maximum time dial setting of 9.9. The Basler Electric equivalent time dial setting for the electromechanical maximum setting is provided in the cross-reference table even if it exceeds 9.9. This allows interpolation as noted above.

Basler Electric time current characteristics are determined by a linear mathematical equation. The induction disk of an electromechanical relay has a certain degree of non linearity due to inertial and friction effects. For this reason, even though every effort has been made to provide characteristic curves with minimum deviation from the published electromechanical curves, slight deviations can exist between them.

In applications where the time coordination between curves is extremely close, we recommend that you choose the optimal time dial setting by inspection of the coordination study. In applications where coordination is tight, it is recommended that you retrofit your circuits with Basler Electric electronic relays to ensure high timing accuracy.

Table A-3. Time Dial Setting Cross-Reference

Curve	Equivalent To	Electromechanical Relay Time Dial Setting											
		0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
		Basler Electric Equivalent Time Dial Setting											
S, S1	ABB CO-2	0.3	0.8	1.7	2.4	3.4	4.2	5.0	5.8	6.7	7.7	8.6	9.7
L, L1	ABB CO-5	0.4	0.8	1.5	2.3	3.3	4.2	5.0	6.0	7.0	7.8	8.8	9.9
D	ABB CO-6	0.5	1.1	2.0	2.9	3.7	4.5	5.0	5.9	7.2	8.0	8.9	10.1
M	ABB CO-7	0.4	0.8	1.7	2.5	3.3	4.3	5.3	6.1	7.0	8.0	9.0	9.8
I, I1	ABB CO-8	0.3	0.7	1.5	2.3	3.2	4.0	5.0	5.8	6.8	7.6	8.7	10.0
V, V1	ABB CO-9	0.3	0.7	1.4	2.1	3.0	3.9	4.8	5.7	6.7	7.8	8.7	9.6
E, E1	ABB CO-11	0.3	0.7	1.5	2.4	3.2	4.2	5.0	5.7	6.6	7.8	8.5	10.3
I2	GE IAC-51	0.6	1.0	1.9	2.7	3.7	4.8	5.7	6.8	8.0	9.3	10.6	N/A
V2	GE IAC-53	0.4	0.8	1.6	2.4	3.4	4.3	5.1	6.3	7.2	8.4	9.6	N/A
S2	GE IAC-55	0.2	1.0	2.0	3.1	4.0	4.9	6.1	7.2	8.1	8.9	9.8	N/A
L2	GE IAC-66	0.4	0.9	1.8	2.7	3.9	4.9	6.3	7.2	8.5	9.7	10.9	N/A
E2	GE IAC-77	0.5	1.0	1.9	2.7	3.5	4.3	5.2	6.2	7.4	8.2	9.9	N/A

The 46 Curve

The 46 curve (Figure A-17) is a special curve designed to emulate the $(I_2)^2 t$ withstand ratings of generators using what is frequently referred to as the generator K factor.

The 46 Curve Characteristics

46 Pickup Current

Generators have a maximum continuous rating for negative sequence current. This is typically expressed as a percent of stator rating. When using the 46 curve, the user should convert the continuous I^2 rating data to actual secondary current at the relay. This value (plus some margin, if appropriate) should be entered as the pickup setting. For example, if a generator's rated full-load current is 5 amperes, a pu setting of 0.5 A would allow 10% continuous I_2 .

46 Time Dial (= Generator K factor)

The amount of time that a generator can withstand a given level of unbalance is defined by Equation A-3.

$$t = \frac{K}{(I_2)^2} \quad \text{Equation A-3}$$

The K factor gives the time that a generator can withstand 1 per unit negative sequence current. For example, with a K factor of 20, since $(I_2)^2$ becomes 1 at 1 per unit of current, the generator can withstand the condition for 20 seconds. Typical values for generator K factors are in the 2 to 40 range. The relay uses the “nominal current” setting of the relay (front panel Screen 6.3.7 or via the SG-NOM command) to determine what corresponds to 1 per unit current in the generator.

When curve 46 is selected, the relay changes the range of the allowed time dial to 1 to 99 (instead of the time dial range of 0.1 to 9.9 for all the other curves). The user should enter the “K” factor of the generator into the time dial field.

Relay Equation

When the 46 function is used, the relay uses the K factor (i.e., 46 time dial setting), 46 minimum pickup setting and generator full-load current to create a constant Z (see Equation A-4).

$$Z = 46 \text{ Time Dial} \left(\frac{I_{\text{Nom Setting}}}{46 \text{ Pickup Setting}} \right)^2 \quad \text{Equation A-4}$$

The time to trip equation used in the relay is:

$$T_T = \frac{Z}{M^2} + 0.028 \text{ seconds} \quad \text{Equation A-5}$$

where

$$M = \frac{\text{Measured } I_2}{46 \text{ Pickup Setting}} \quad \text{Equation A-6}$$

which, when $M > 1$, reduces to:

$$T_T = 46 \text{ Time Dial} \left(\frac{I_{\text{Nom Setting}}}{I_2 \text{ Measured}} \right)^2 \quad \text{Equation A-7}$$

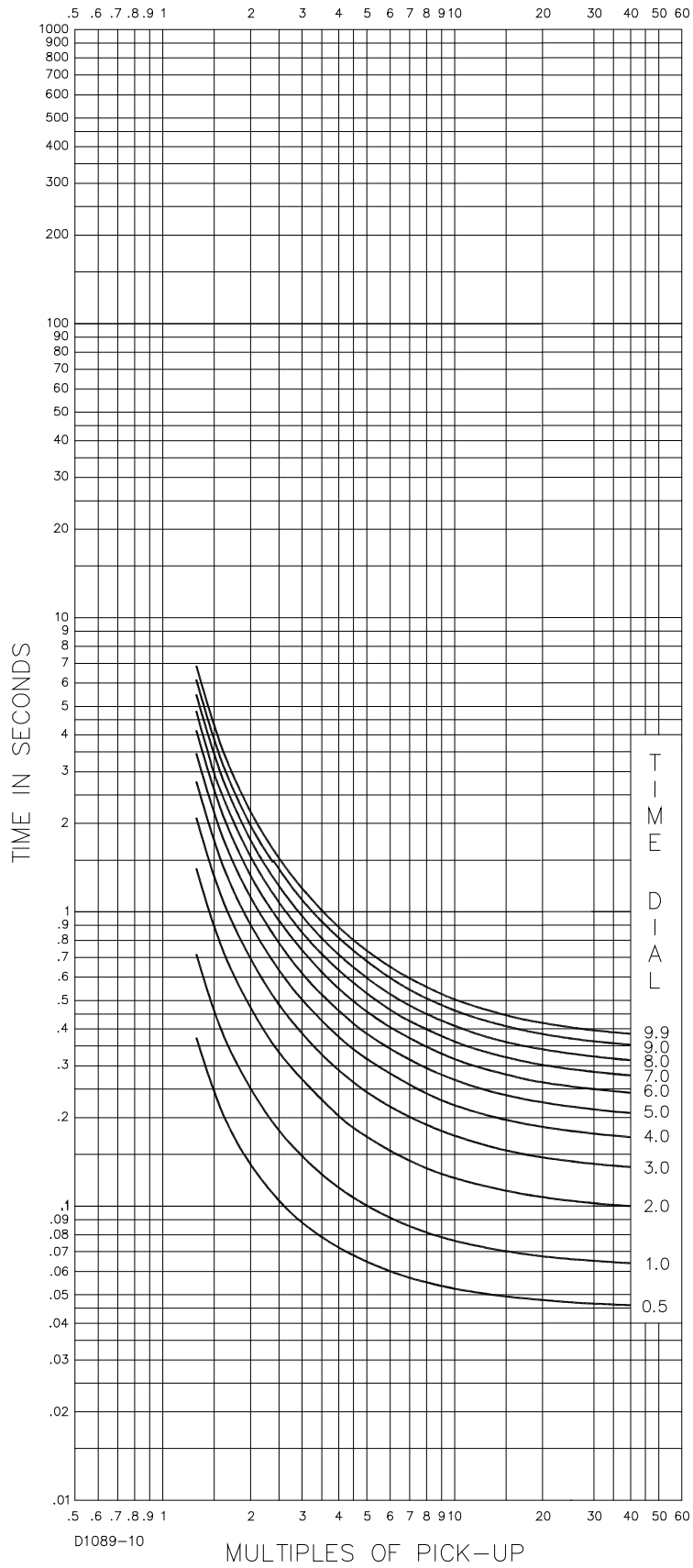


Figure A-1. Time Characteristic Curve S, S1, Short Inverse (Similar to ABB CO-2)

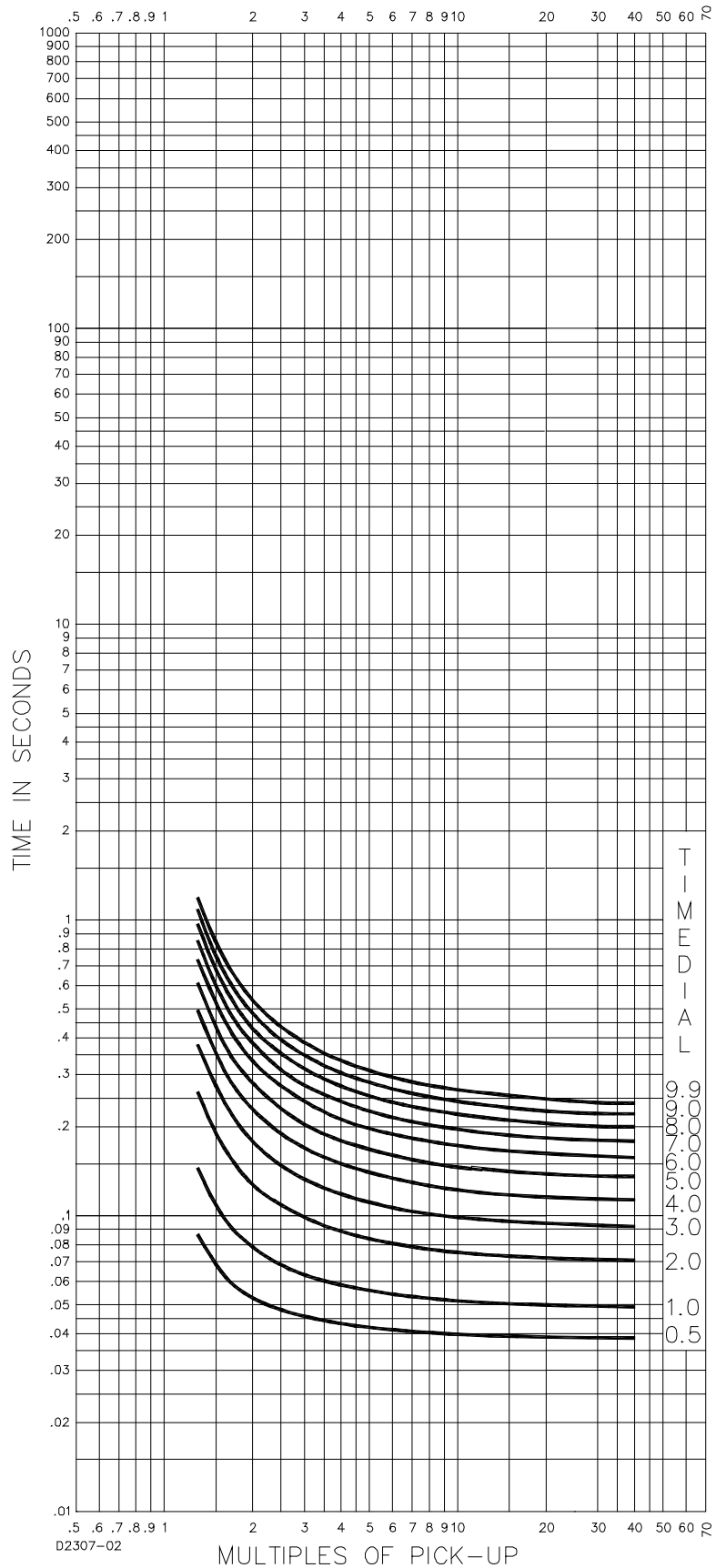


Figure A-2. Time Characteristic Curve S2, Short Inverse (Similar To GE IAC-55)

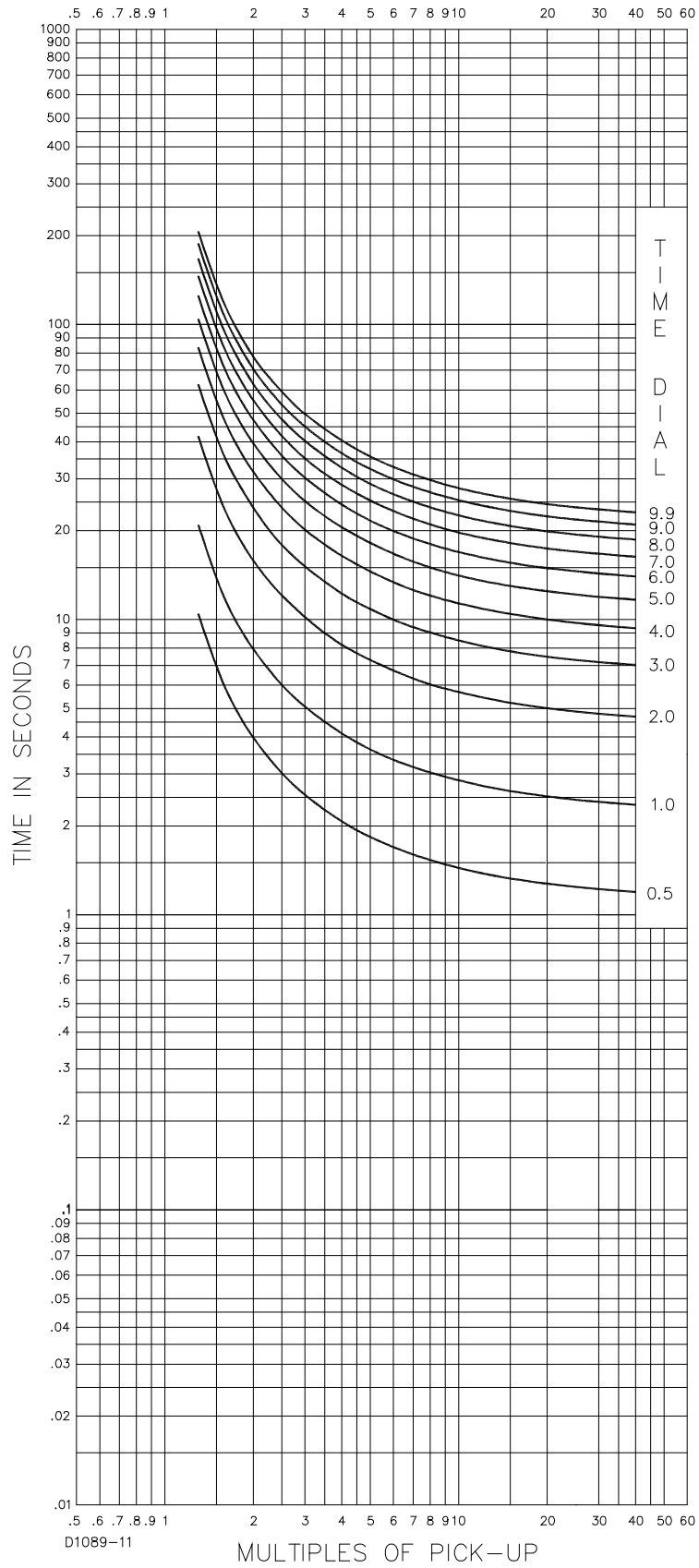


Figure A-3. Time Characteristic Curve L, L1, Long Inverse (Similar to ABB CO-5)

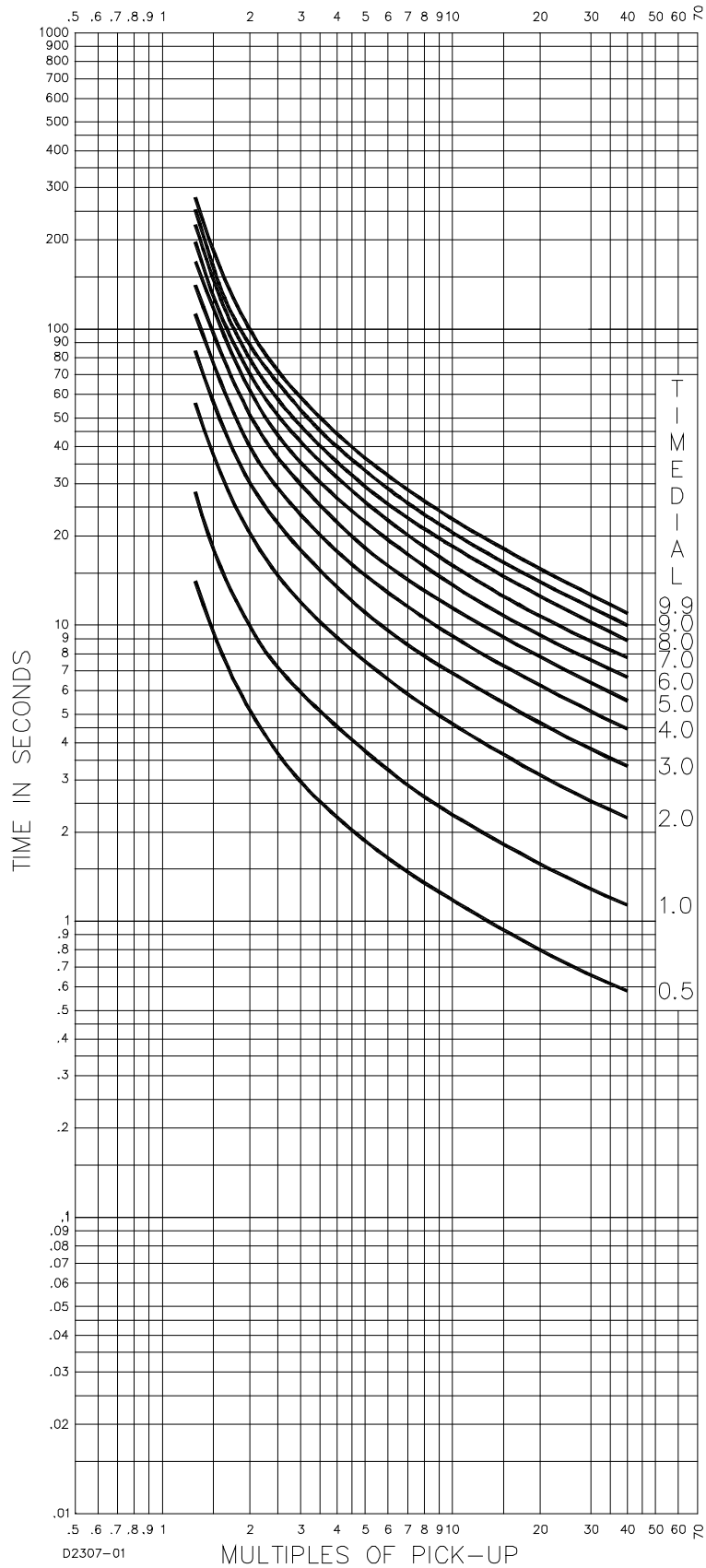


Figure A-4. Time Characteristic Curve L2, Long Inverse (Similar To GE IAC-66)

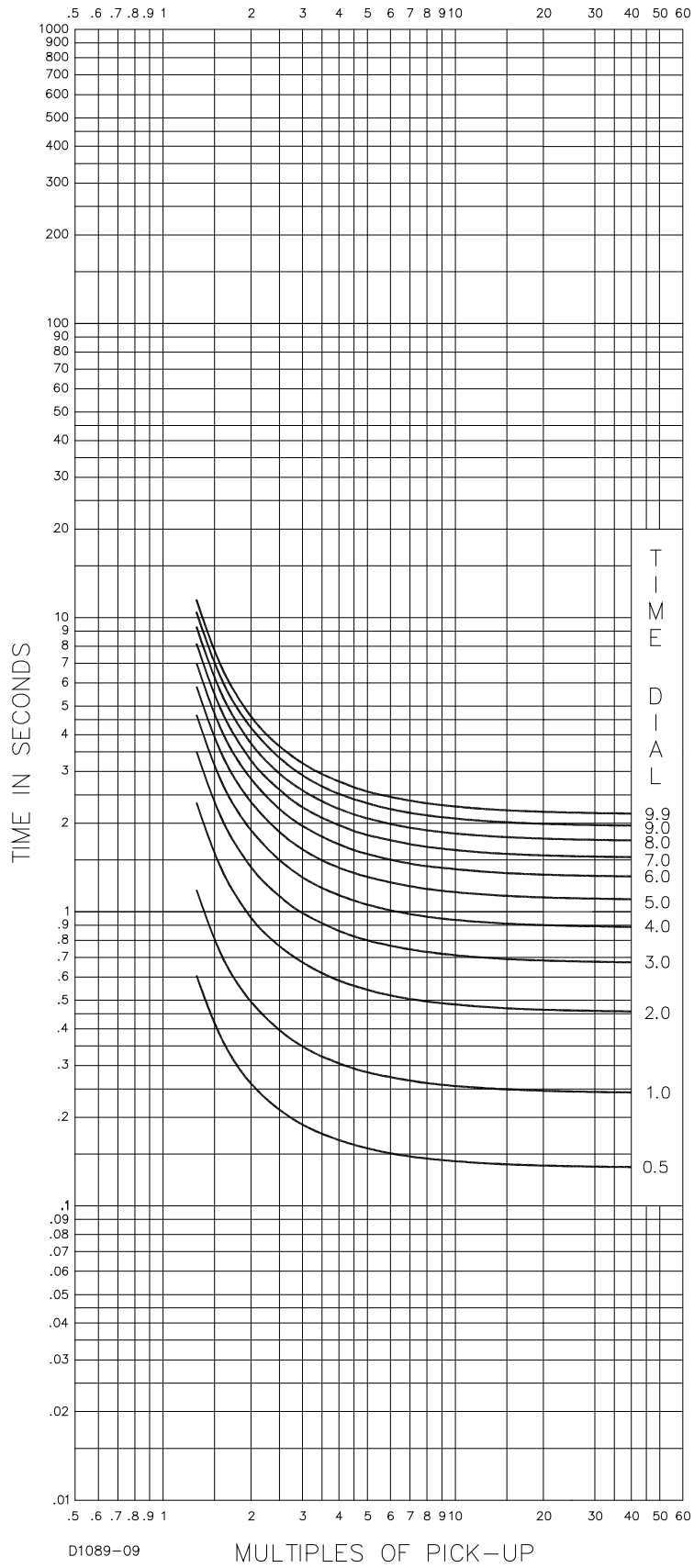


Figure A-5. Time Characteristic Curve D, Definite Time (Similar To ABB CO-6)

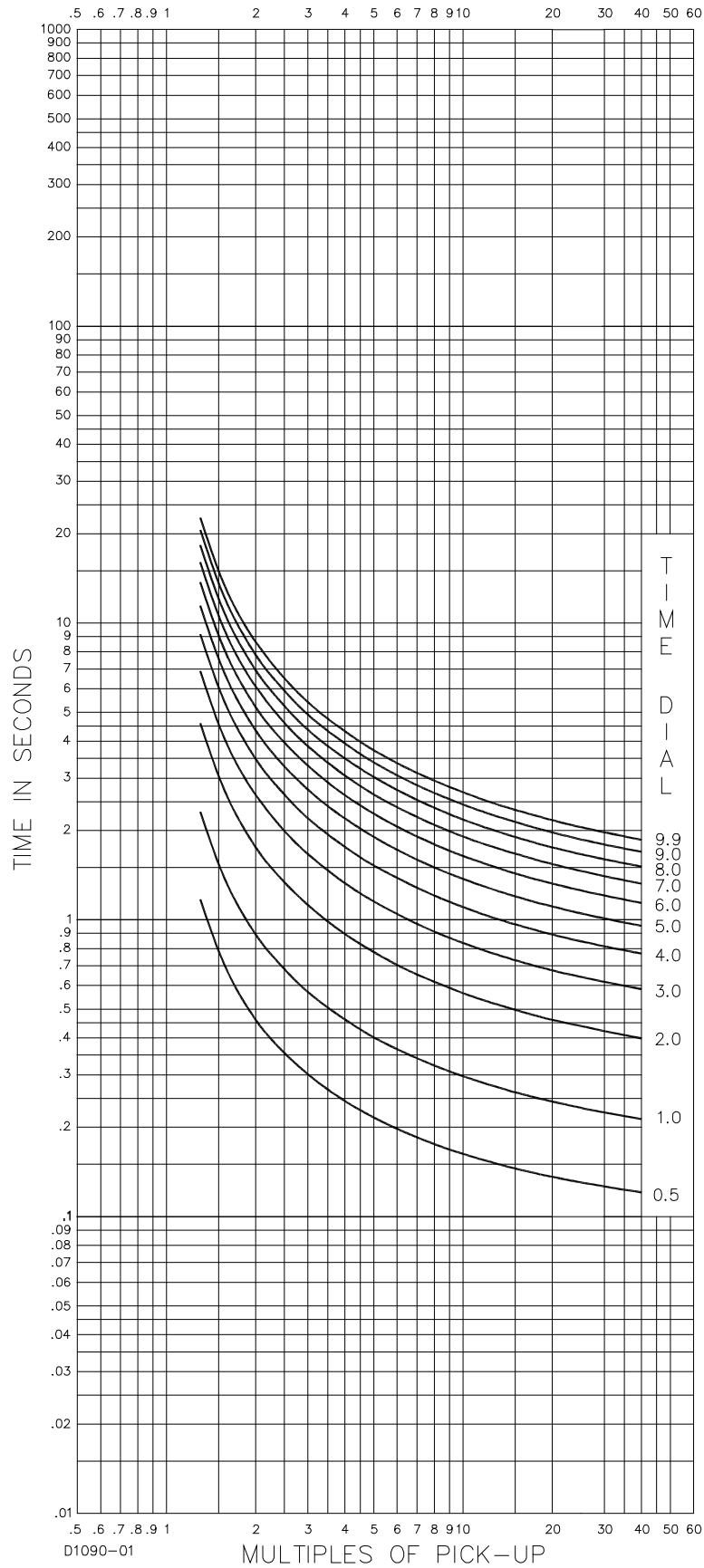


Figure A-6. Time Characteristic Curve M, Moderately Inverse (Similar to ABB CO-7)

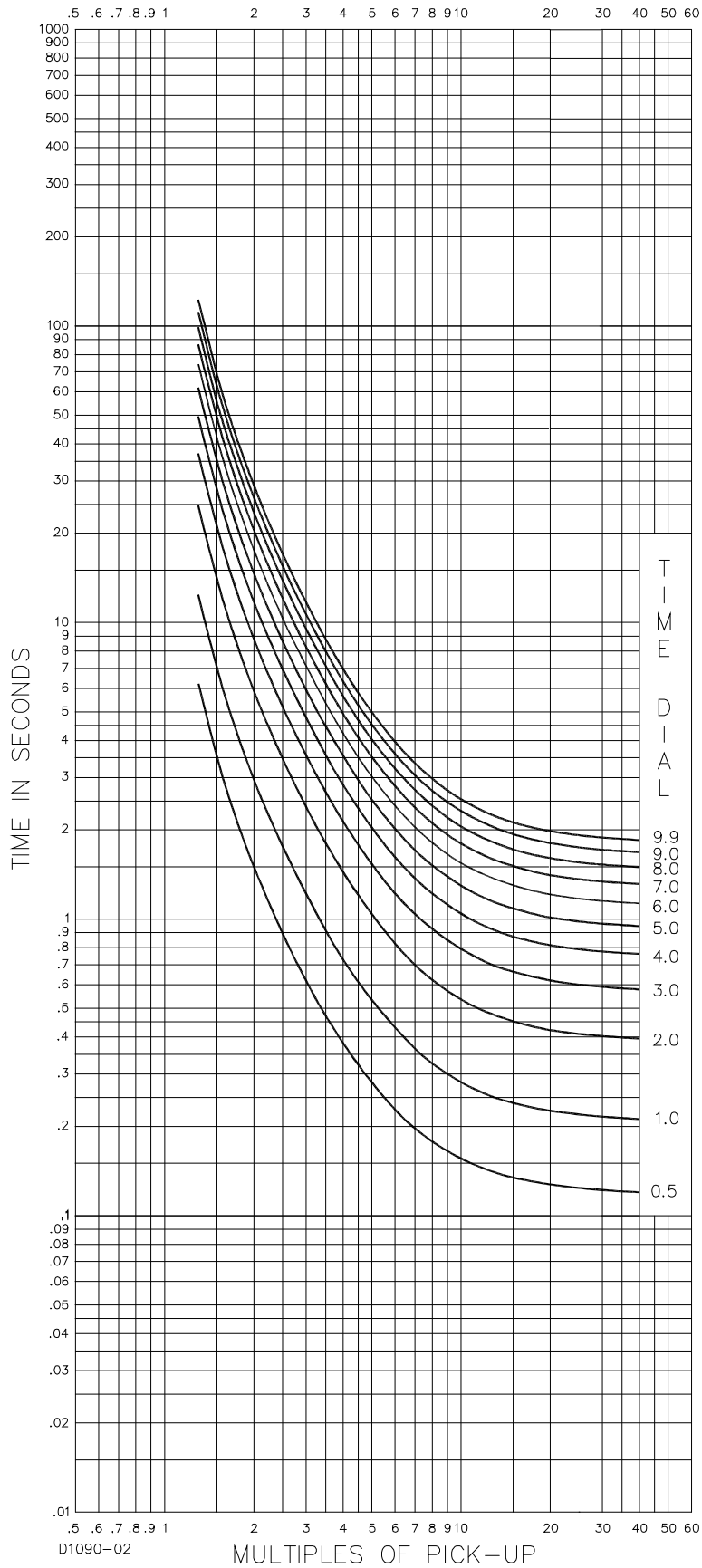


Figure A-7. Time Characteristic Curve I, I1, Inverse Time (Similar to ABB CO-8)

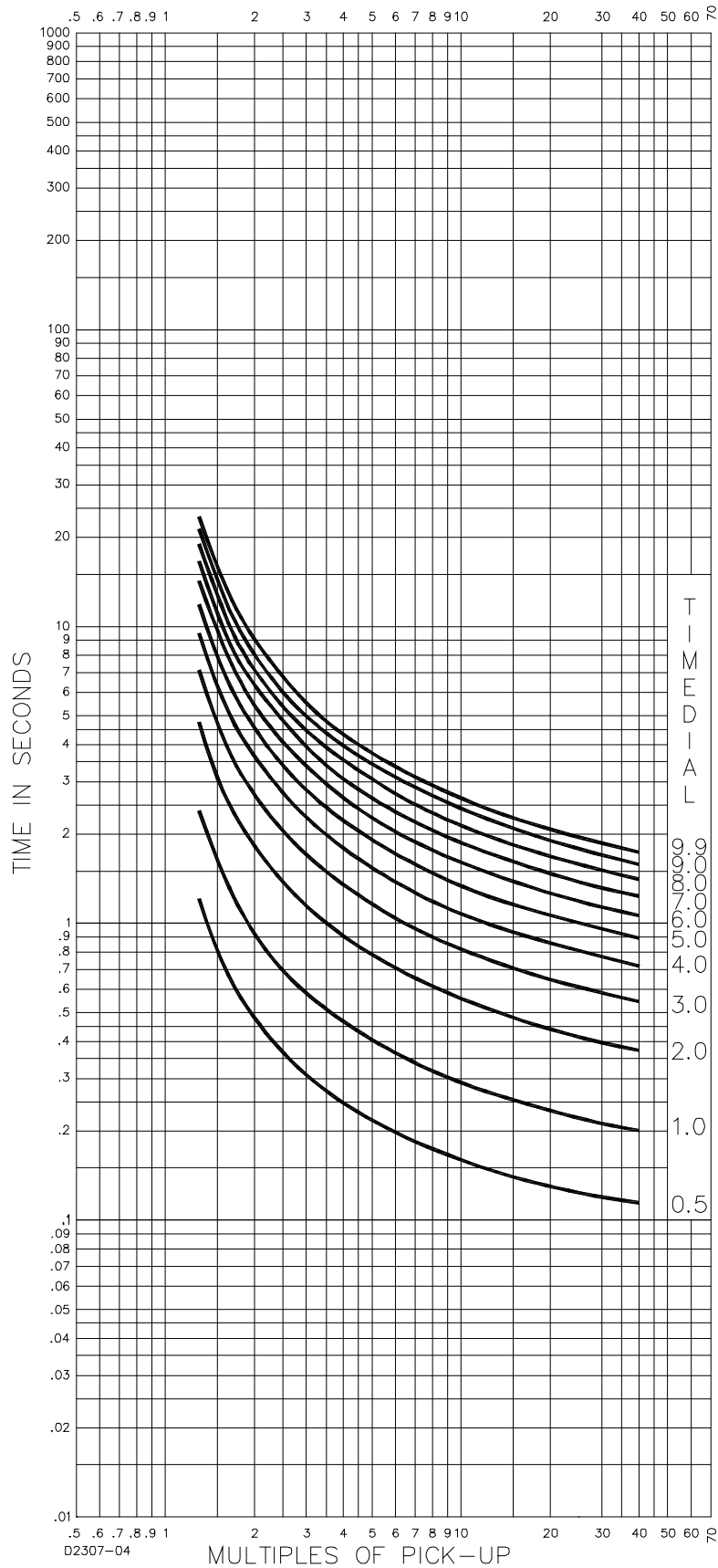


Figure A-8. Time Characteristic Curve I2, Inverse Time (Similar to GE IAC-51)

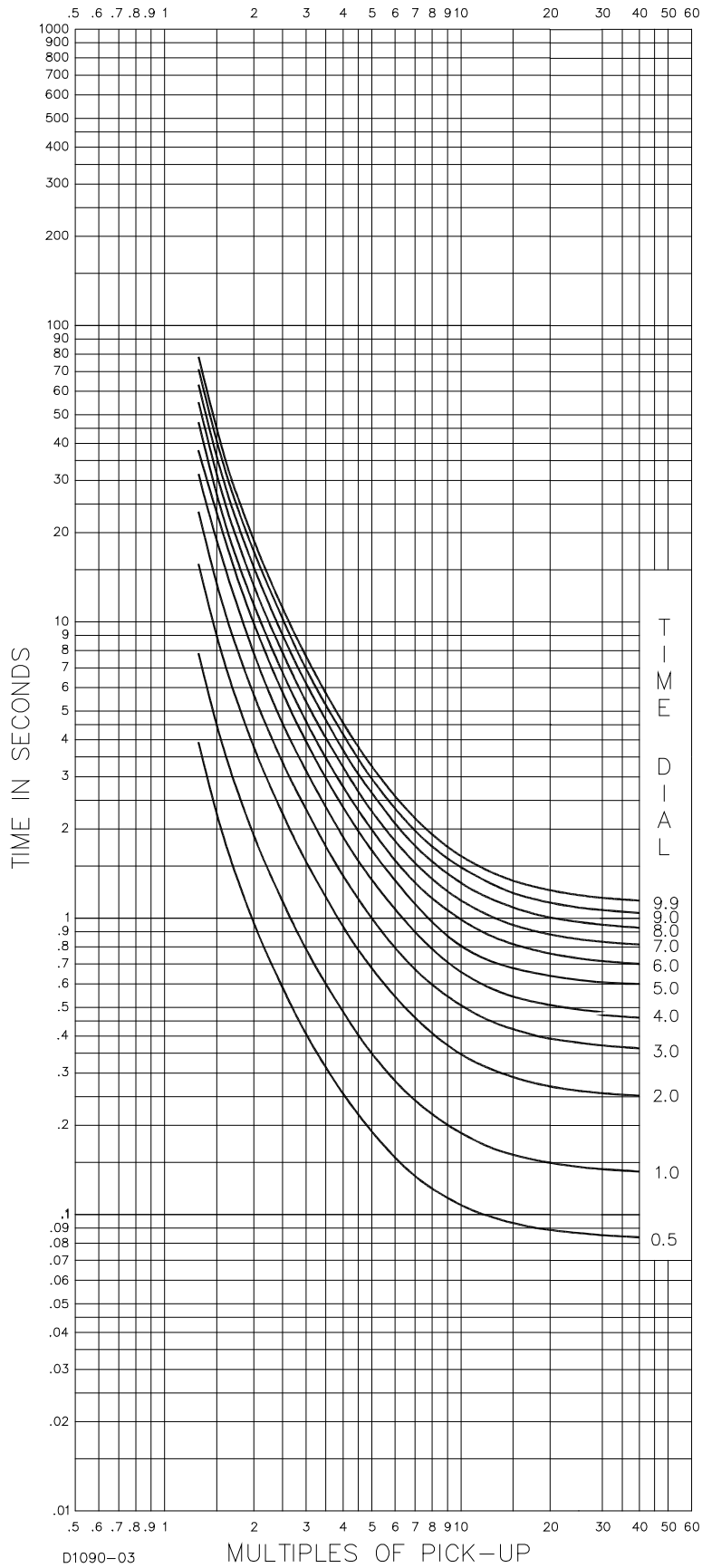


Figure A-9. Time Characteristic Curve V, V1, Very Inverse (Similar to ABB CO-9)

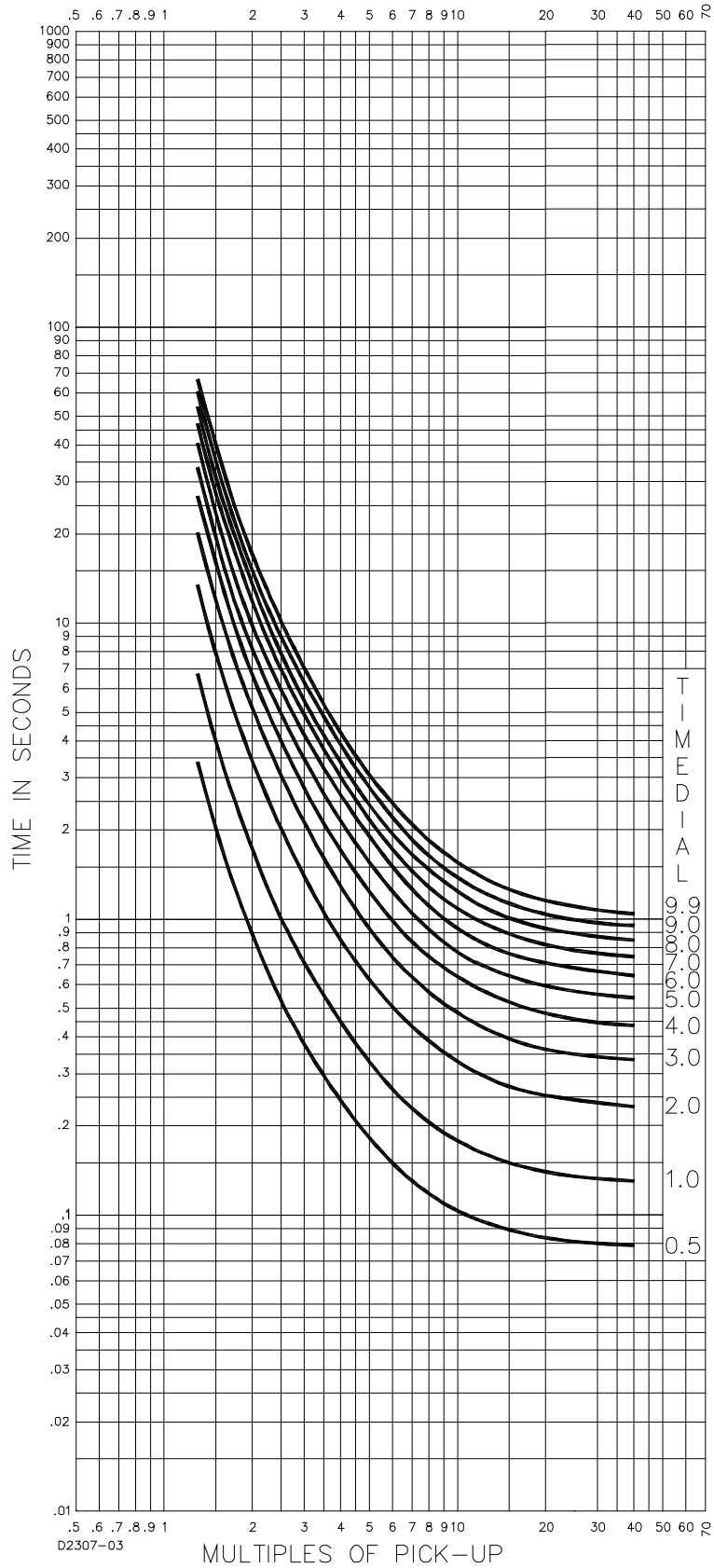


Figure A-10. Time Characteristic Curve V2, Very Inverse (Similar to GE IAC-53)

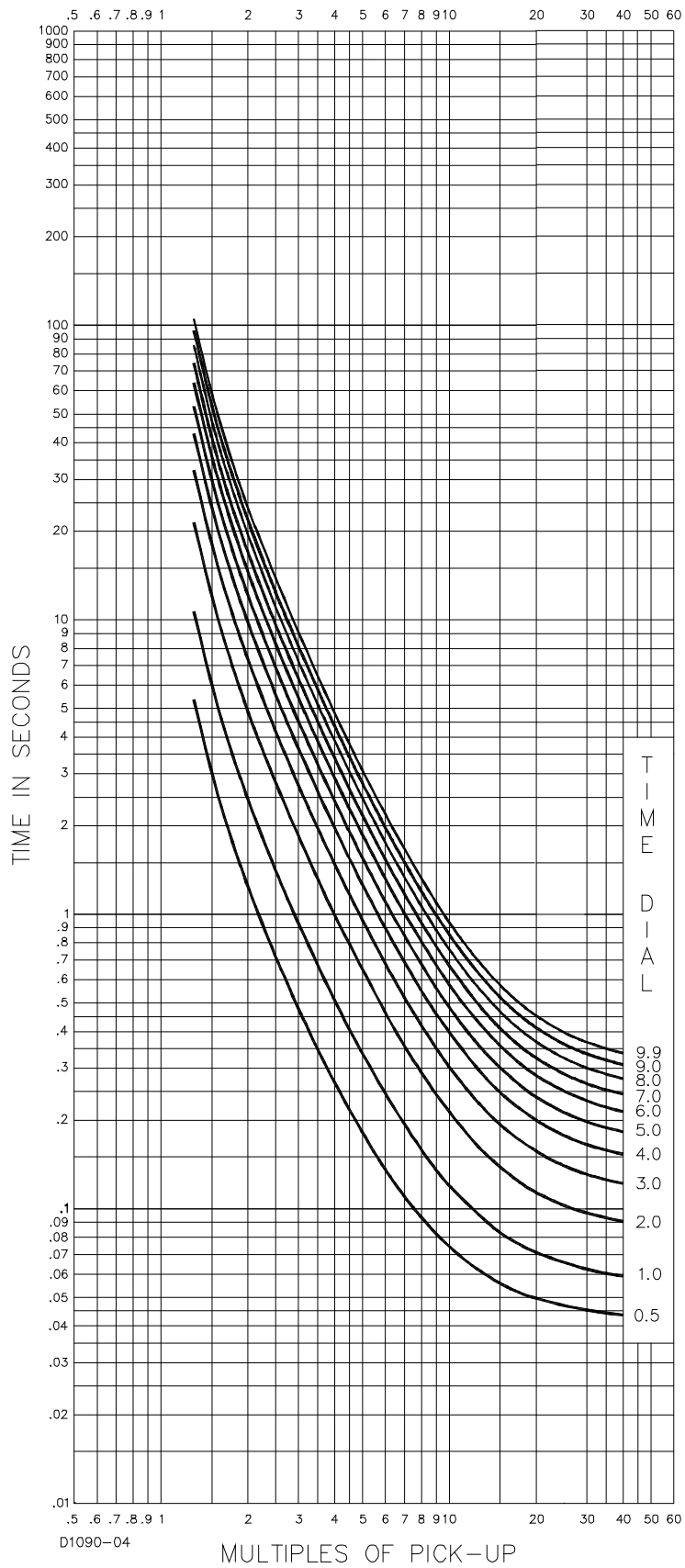


Figure A-11. Time Characteristic Curve E, E1, Extremely Inverse, (Similar to ABB CO-11)

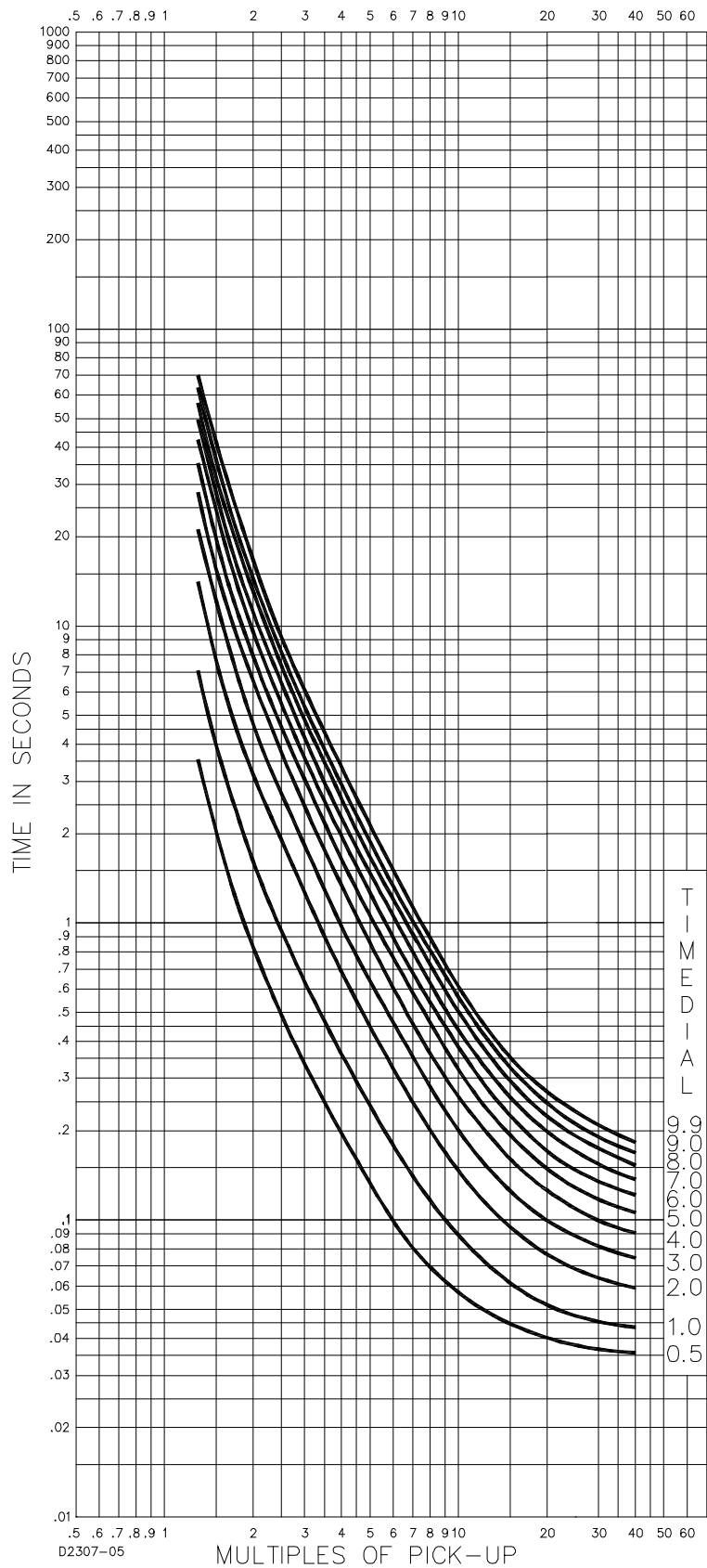


Figure A-12. Time Characteristic Curve E2, Extremely Inverse (Similar to GE IAC-77)

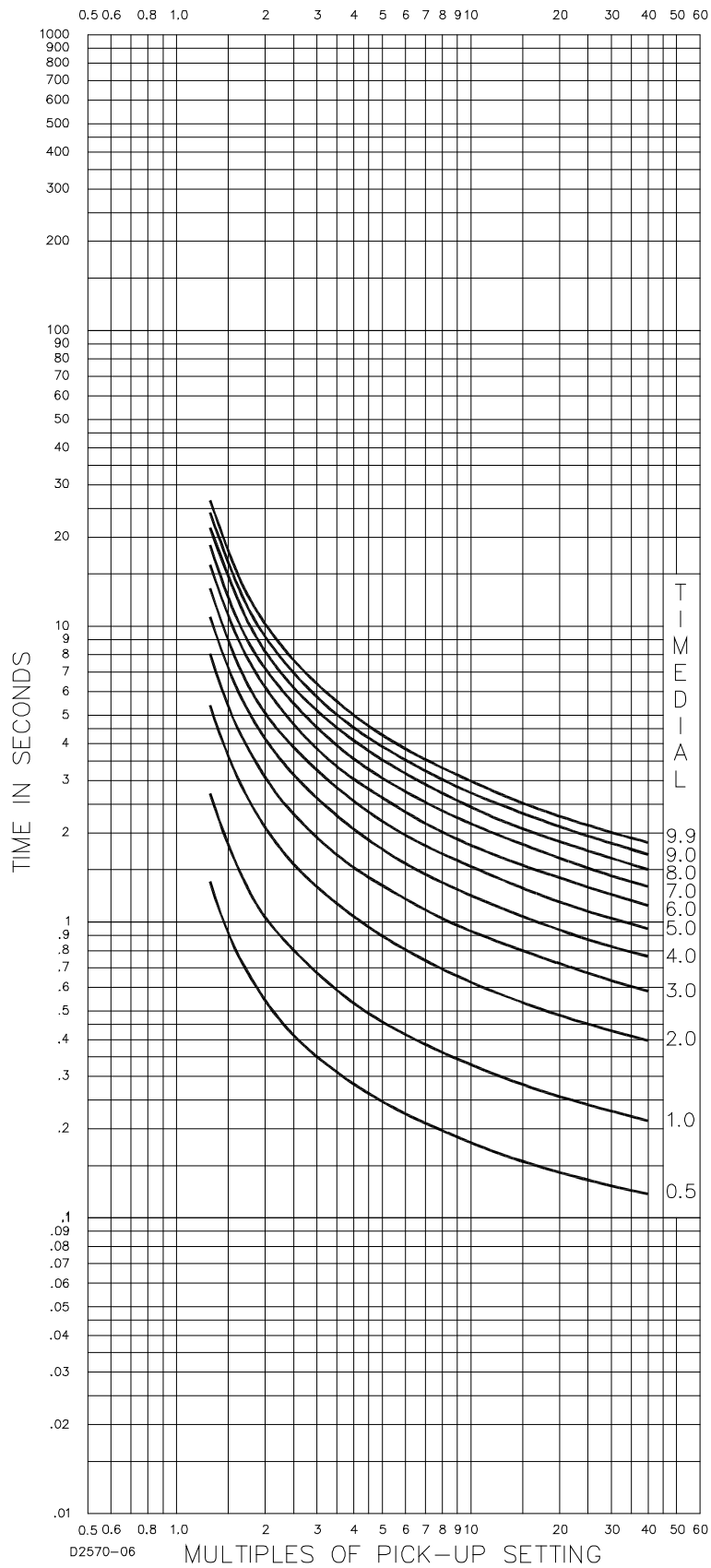


Figure A-13. Time Characteristic Curve A, Standard Inverse

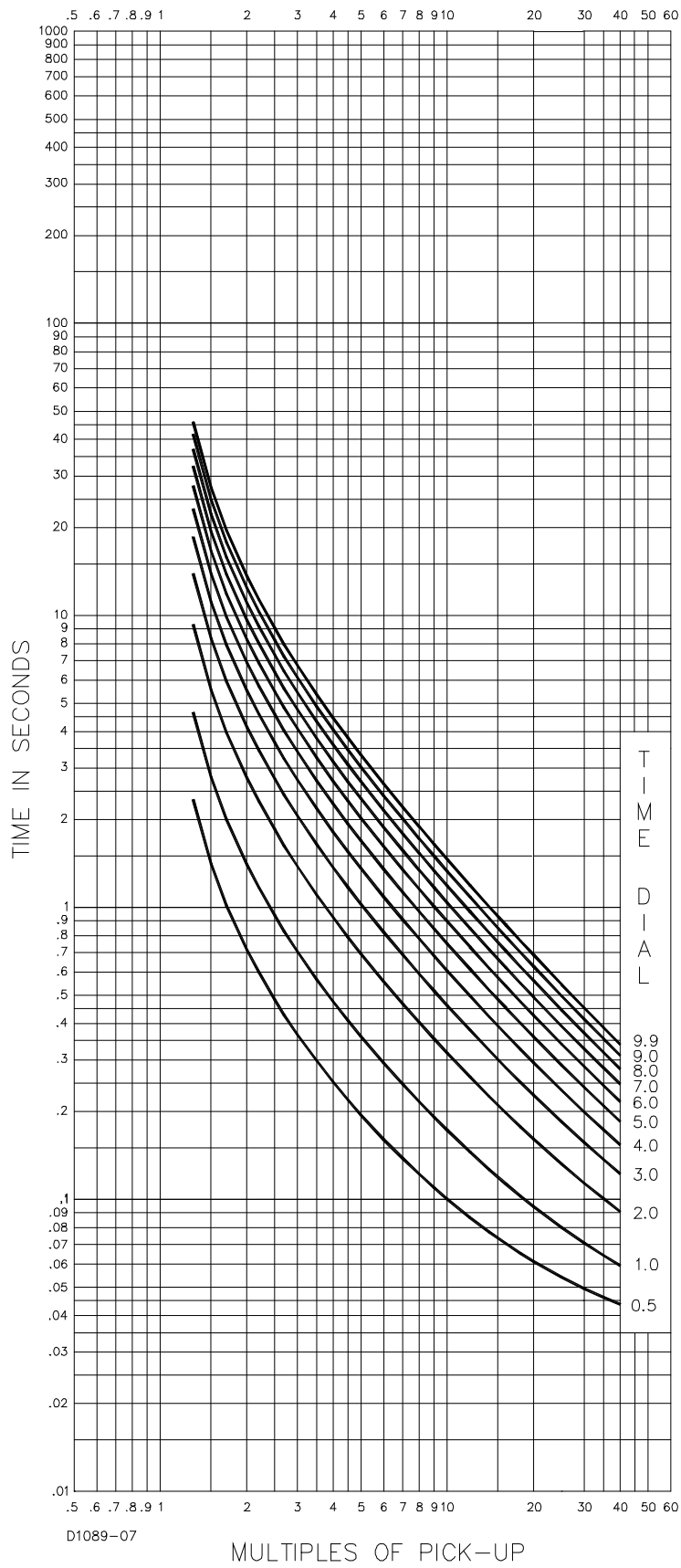


Figure A-14. Time Characteristic Curve B, Very Inverse

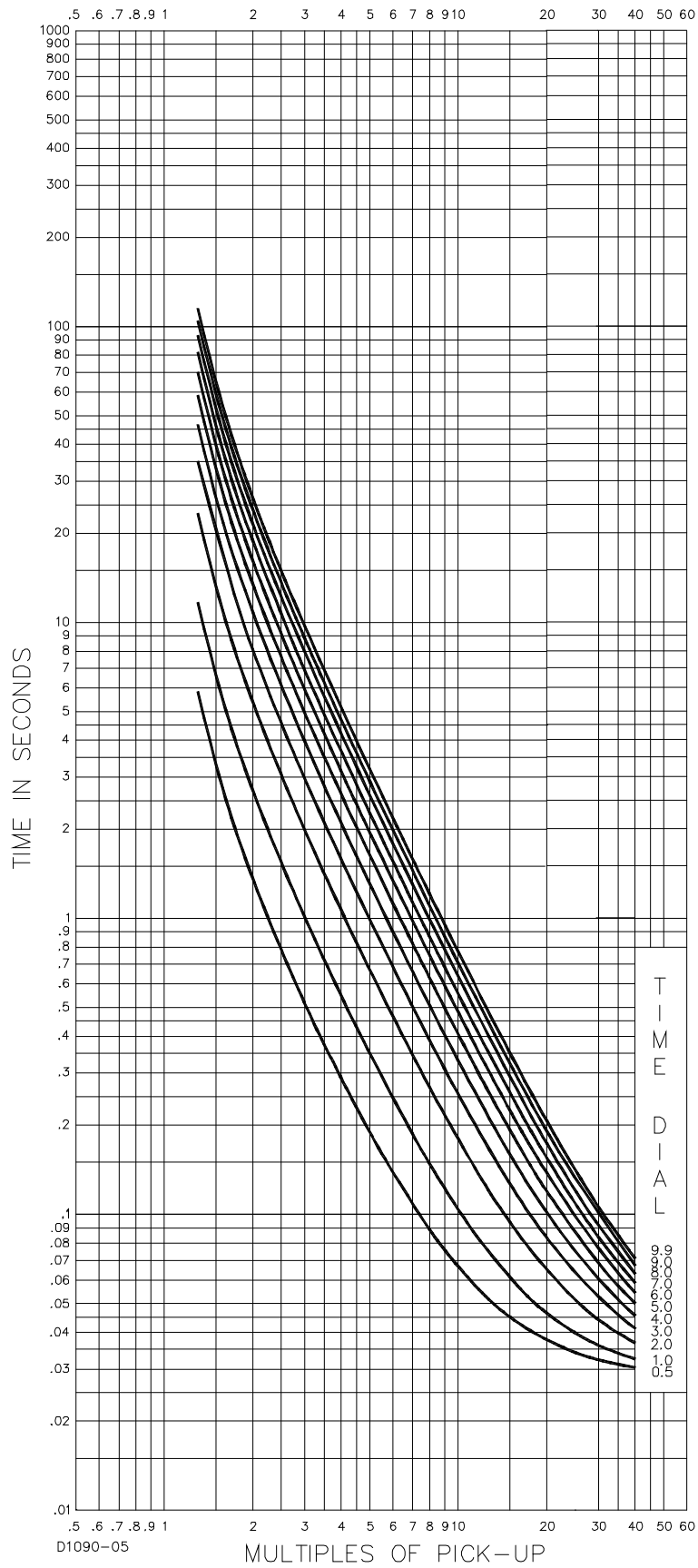


Figure A-15. Time Characteristic Curve C, Extremely Inverse

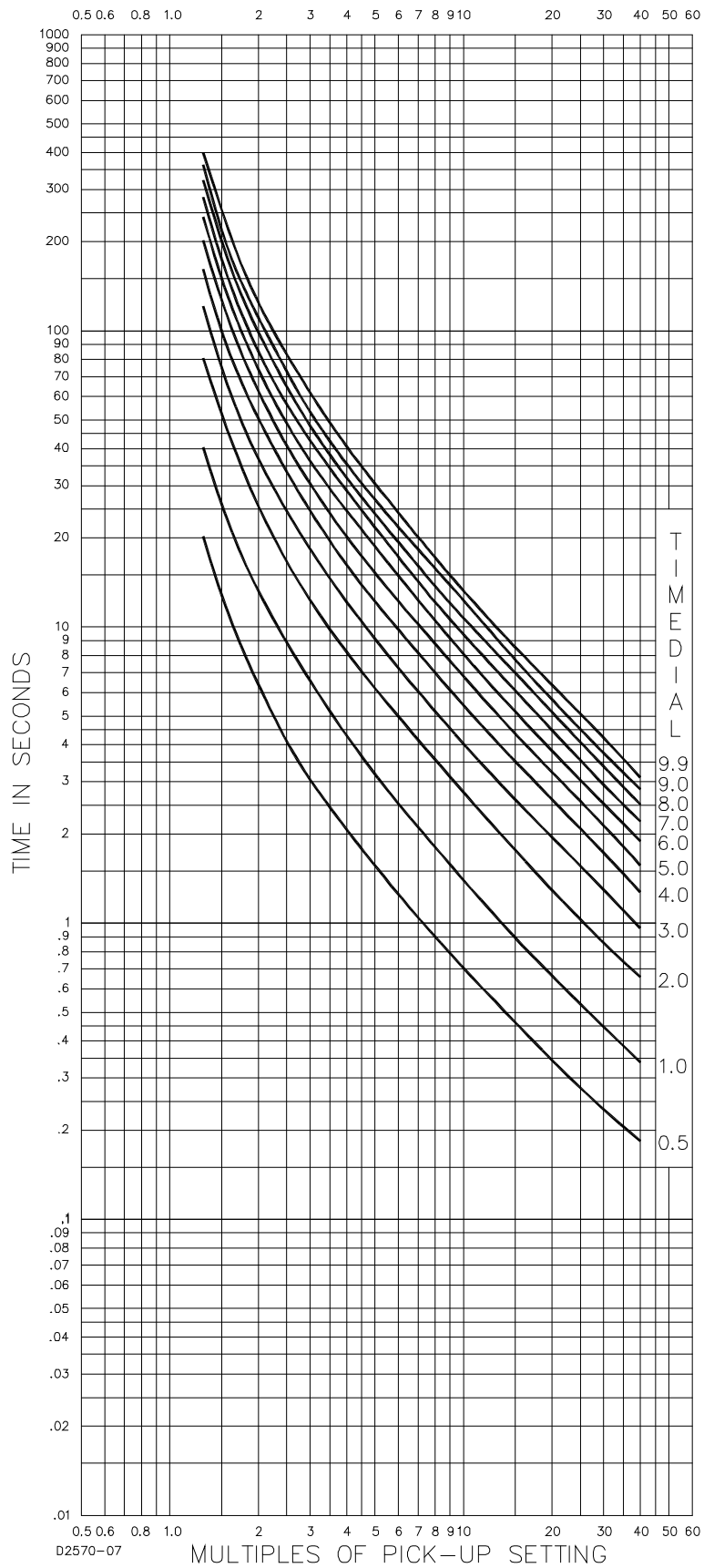
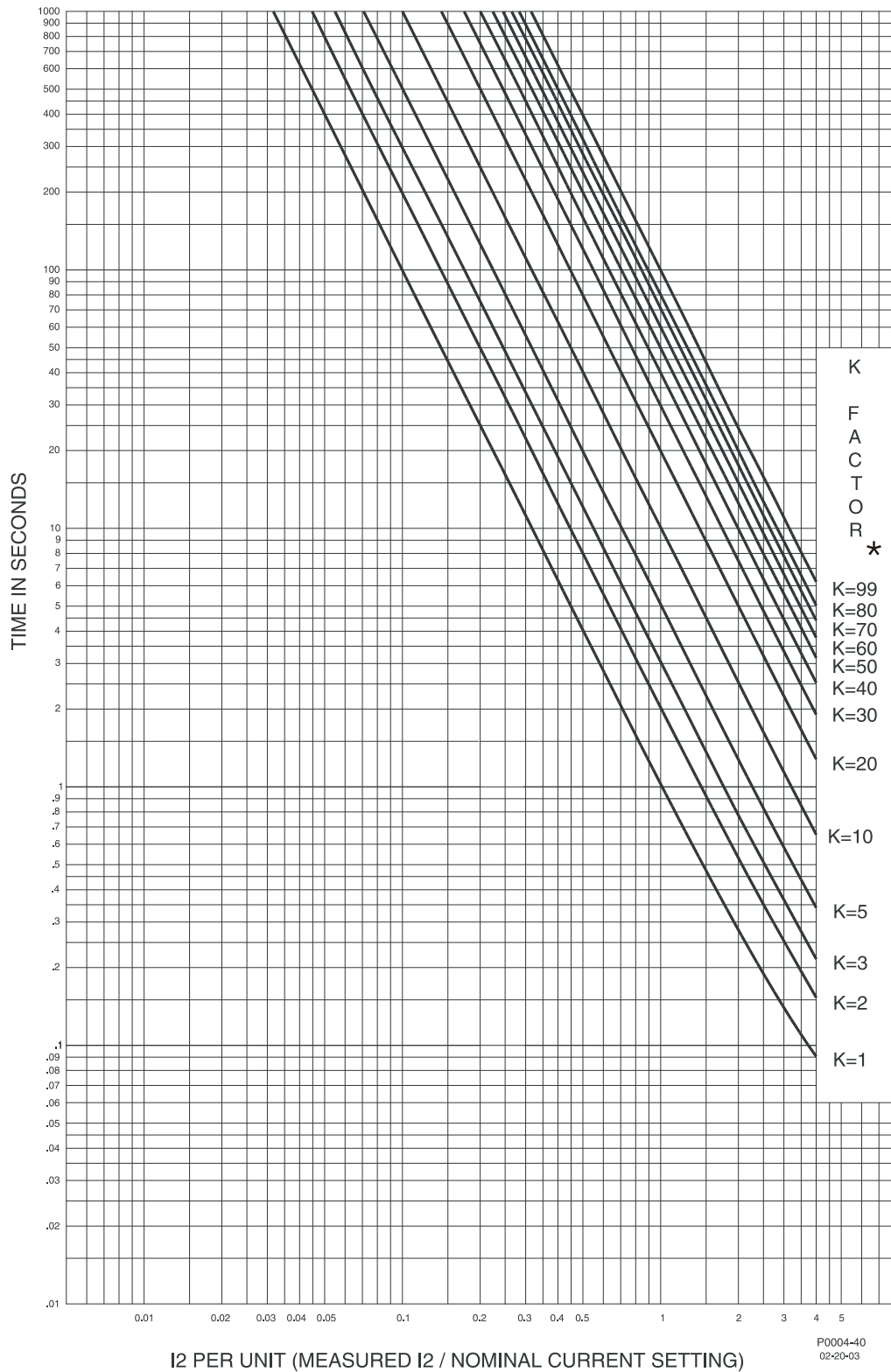


Figure A-16. Time Characteristic Curve G, Long Time Inverse



★ The K factor is the time that a generator can withstand 1 per-unit I₂, where 1 pu is the user's setting for full-load current.

Figure A-17. 46 Time Characteristic Curve

NOTE: Curves are shown as extending farther to the left than they will in practice. Curves stop at pickup level. For example, if the user selects 5A FLC and a pickup setting of 0.5A, the per-unit pickup is 0.1A. The relay will not pick up at less than 0.1 pu I₂ for these settings.

B • Command Cross-Reference

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)

A **C** entry in the Type column means the command pertains to the BE1-700**C** (current) relay; a **V** indicates it applies to the BE1-700**V** (voltage) relay; an **empty** field means it applies to both types of relays; and an **O** indicates that the command applies to a feature that is an option per the style chart (Figure 1-1). An entry of x in the HMI Screen column represents multiple entry possibilities such as 0 or 1 for setting groups and 43 or 143 for virtual switches.

Table B-1. Miscellaneous Commands

Type	ASCII Command	Function	HMI Screen
	ACCESS[= <code><password></code>]	Read/Set access level in order to change settings.	N/A
	EXIT	Exit programming mode.	N/A
	HELP <code><cmd></code> or H <code><cmd></code>	Obtain help with command operation.	N/A

Table B-2. Metering Commands

Type	ASCII Command	Function	HMI Screen
	M	Read all metered values.	N/A
V	M-FREQ	Read metered frequency.	3.10
C	M-I[<code><phase></code>]	Read metered current in primary unit.	3.5 - 3.7
V	M-SYNC	Read metered sync angle between phase and aux inputs.	3.11
V	M-V[<code><phase></code>]	Read metered voltage in primary units.	3.1 - 3.3
V	M-3V0	Read calculated neutral voltage.	3.4

Table B-3. Control Commands

Type	ASCII Command	Function	HMI Screen
	CO- <code><control></code> [= <code><mode></code>]	Control operation.	N/A
	CS- <code><control></code> [= <code><mode></code>]	Control selection.	N/A
	CS/CO-x43	Control virtual switches.	2.1.1 - 2.1.2
	CS/CO-101	Control breaker control switch.	2.2.1
	CS/CO-GROUP	Control group.	2.3.1
	CS/CO-OUTn	Control output n.	2.4.1

Table B-4. Report Commands

Type	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.	1.5.6
C	RB-DUTY[<phase>[=%duty>]	Read/Set breaker contact duty log.	4.3.2
	RB-OPCNTR[=<#operations>]	Read/Set breaker operation counter.	4.3.1
C	RD	Report all demand data.	N/A
C	RD-PI<p>[=0]	Read/Reset peak demand current.	4.4.3.1 - 4.4.3.5
C	RD-TI[<p>]	Report today's demand current.	4.4.1.1 - 4.4.1.5
C	RD-YI[<p>]	Report yesterday's demand current.	4.4.2.1 - 4.4.2.5
	RF[-n/NEW][=0/TRIG]	Read/Reset fault report data.	N/A
	RG	Report general information.	N/A
	RG-DATE[={M/D/Y}] or RG-DATE[={D-M-Y}]	Read/Set date.	4.6
	RG-DST	Report Start/Stop Times and Dates for Daylight Savings Time referenced to local time.	N/A
	RG-STAT	Report relay status.	N/A
	RG-TARG[=0]	Report/Reset target status.	1.2
	RG-TIME[=hr:mn:sc] or RG-TIME[=hr:mn<f>sc]	Report/Set time.	4.6
	RG-VER	Read program version, model number, style number, and serial number.	4.7
	RO-nA/B[#].CFG/DAT	Read oscillographic COMTRADE fault report.	N/A
	RS[-n/Fn/ALM/IO/LGC/NEW][=0]	Read/Reset Sequence of Events Record Data.	N/A

Table B-5. Setting Command

Type	ASCII Command	Function	HMI Screen
	S	Read all relay setting parameters.	N/A

Table B-6. Alarm Setting Commands

Type	ASCII Command	Function	HMI Screen
	SA	Read all major and minor alarm setting.	N/A
V	SA-24[=<alarm level>,time delay>]	Read/Set Volts Per Hertz alarm settings.	N/A
	SA-BKR<n>[=<mode>,<alarm limit>]	Read/Set breaker alarm settings.	N/A
	SA-DI<p>[=<alarm level>]	Read/Set demand alarm settings.	N/A
	SA-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

Type	ASCII Command	Function	HMI Screen
	SA-MAJ[=<alarm num 1>[/<alarm num 2>]... [<alarm num n>]]	Read/Set major alarm setting mask.	N/A
	SA-RESET[=<rst alm logic>]	Read/Set programmable alarms reset logic.	N/A

Table B-7. General Setting Commands

Type	ASCII Command	Function	HMI Screen
	SG	Read all general settings.	N/A
	SG-BL=<time>	Read/Set the backlight timer.	6.4
	SG-CLK[=<date format(M/D)>,<time format(12/24)>]	Read/Program time and date format.	N/A
	SG-COM<#>[=<baud>,A<addr>,P<pglen>, R<reply ack>,X<XON ena>]	Read/Set serial communication protocol.	6.1.1, 6.1.3
C	SG-CT<x>[=<CT ratio>]	Read/Set Phase/Neutral CT ratio.	6.3.1 - 6.3.2
C	SG-DI<x>[=<interval>]	Read/Set P(IA/IB/IC/var/watt), N and Q demand interval.	N/A
	SG-DSP[P/N]	Read analog signal dsp filter type.	N/A
	SG-EMAIL[#]={email logic}]	Read/Enter email logic.	N/A
	SG-FREQ[=<freq(Hz)>]	Read/Enter power system frequency.	6.3.8
	SG-HOLD<x>[=<1/0 hold ena>]	Read/Program output hold operation.	N/A
	SG-ID[=<relayID>,<stationID>]	Read/Set relay ID and station ID used in reports.	N/A
	SG-IN<x>[=<Recognition Time>,<Debounce Time>]	Read/Set input recognition/debounce.	N/A
	SG-NOM[=<nom volts>,<nom amps>]	Read/Set nominal voltage and current.	6.3.7
	SG-OSC[=<# records saved>]	Read/Set the number of oscillographic fault records saved.	N/A
	SG-PHROT[=<phase rotation>]	Read/Set phase rotation setting.	6.3.9
	SG-SCREEN<x>[=<default screen number>]	Read/Set default screen(s).	N/A
	SG-SGCON[=<time>]	Read/Set SGC output time.	N/A
	SG-TARG[=<x/x/...x>,<rst TARG logic>]	Report/Enable Target list and Reset Target logic.	N/A
	SG-TRIGGER<x>[=<TRIPtrigger>,<Putrigger>, <LOGICtrigger>]	Read/Set trigger logic.	N/A
V	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
V	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

Type	ASCII Command	Function	HMI Screen
C	SB	Read all breaker settings.	N/A
C	SB-DUTY[=<mode>,<DMAX>]	Read/Set breaker contact duty.	N/A
C	SB-LOGIC[=<breaker close logic>]	Read/Set breaker contact logic.	N/A

Table B-9. Programmable Logic Setting Commands

Type	ASCII Command	Function	HMI Screen
	SL[:<name>]	Obtain setting logic information.	N/A
V	SL-24[=<mode>,<BLK logic>]	Read/Set logic for 24 function modules.	N/A
V	SL-25[=<mode>,<BLK logic>]	Read/Set logic for 25 function modules.	N/A
V	SL-<x>27<p>[=<mode>,<BLK logic>]	Read/Set logic for 27 function modules.	N/A
V	SL-47[=<mode>,<BLK logic>]	Read/Set logic for 47 function modules.	N/A
C	SL-<x>50T<p>[=<mode>,<BLK logic>]	Read/Set logic for 50 function modules.	N/A
C	SL-<x>51<p>[=<mode>,<BLK logic>]	Read/Set logic for 51 function modules.	N/A
C	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
O	SL-79[={mode},{RI logic},{STATUS logic},{WAIT logic},{LOCKOUT logic}]	Read/Set logic for 79 function.	N/A
V	SL-<x>81[=<mode>,<BLK logic>]	Read/Set logic for 81 function modules.	N/A
C	SL-BF<x>[=<mode>,<INI logic>,<BLK logic>]	Read/Set logic for breaker failure function modules.	N/A
	SL-GROUP[=<mode>,<D0 logic>,<D1 logic>,<automatic>]	Read/Set logic for setting group module.	N/A
	SL-N[=<name>]	Read, set, or copy the name of the custom logic.	N/A
	SL-VO<x>[=<Boolean equation>]	Read/Set output logic.	N/A
	SL-<x>43[=<mode>]	Read/Set logic for Virtual Switches.	N/A
	SL-101[=<mode>]	Read/Set logic for Virtual Breaker Control Switch.	N/A

Table B-10. User Programmable Name Setting Command

Type	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

Type	ASCII Command	Function	HMI Screen
	S<g>	Read all protection settings.	N/A
V	S<g>-24[=<Pickup>,<Time Delay>,<Reset Time>,<Curve>]	Read/Set 24 pickup level, time delay, and reset delay.	5.x.1.1
V	S<g>-25[=<volts>,<ang>,<slip>,<mode>]	Read/Set 25 delta volts, phase angle, slip frequency, and mode.	5.x.2.1
V	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
V	S<g>-<x>27<p>[=<Pickup>,<Time Delay>]	Read/Set 27 pickup level, time delay, and mode.	5.x.3.1 - 5.x.3.3
V	S<g>-47[=<Pickup>,<Time Delay>]	Read/Set 47 pickup level and time delay.	5.x.5.1
C	S<g>-<x>50T<p>[=<Pickup>,<Time Delay>]	Read/Set 50T pickup level and time delay.	5.x.6.1 - 5.x.6.6

Type	ASCII Command	Function	HMI Screen
C	S<g>-<x>51<p>[=<Pickup>,<Time Delay>,<Curve>]	Read/Set 51 pickup level, time delay, and curve.	5.x.7.1 - 5.x.7.5
V	S<g>-<x>59<p>[=<Pickup>,<Time Delay>]	Read/Set 59 pickup level, time delay, and mode.	5.x.8.1 - 5.x.8.4
	S<g>-<x>62[=<T1>,<T2>]	Read/Set 62 time delay.	5.x.9.1 - 5.x.9.2
	S<g>-67N[=<Mode>,<Quantity>]	Read/Set 67 Neutral Polarizing Mode and Quantities.	5.x.10.1 - 5.x.10.2
O	S<g>-79<x>[=<Time Delay>]	Read/Set 79 time delay.	5.x.11.1 - 5.x.11.4
O	S<g>-79SCB[=<step list>]	Read/Set 79 Sequence Controlled Block output.	5.x.11.5
V	S<g>-<x>81[=<Pickup>,<Time Delay>,<mode>]	Read/Set 81 pickup level, time delay, and mode.	5.x.12.1 - 5.x.12.6
V	S<g>-81INH[=<Pickup>]	Read/Set 81 undervoltage inhibit level.	5.x.12.7 - 5.x.12.8
V	SP-60FL[=<I_Blk>,<V_Blk>]	Read/Set loss of potential pickup setting.	5.3.2.2
C	SP-BF[<time>[m/s/c]]	Read/Set the breaker failure timer setting.	5.3.1.1
	SP-CURVE[=<A>,,<C>,<N>,<R>]	Read/Set the user programmable 51 curve parameters.	N/A
	SP-GROUP<x>[=<switch time>,<switch level>,<return time>,<return level>,<protection element>]	Read/Program auxiliary setting group 1 operation.	N/A
O	SP-79ZONE[=<Zone Pickup Logic>]	Read/Set Zone Sequence Pickup Logic.	N/A

Table B-12. Global Setting Command

Type	ASCII Command	Function	HMI Screen
	GS-PW<t>[=<password>,<com ports(0/1/2)>]	Read or change a password.	N/A



C • Terminal Communication

HyperTerminal (provided with Windows® 2000/XP) or other standalone software can be used to communicate with a BE1-700 relay. The following instructions are used for configuring HyperTerminal in Windows 2000/XP to communicate with your BE1-700 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, BE1-700. See Figure C-1.
- b. Click "OK".



Figure C-1. Connection Description Dialog Box

Step 5: Dialog Box: Connect To

- a. Click the Connect using: drop-down menu. See Figure C-2.
Select COMx, where x is the port you are using on your computer.
- b. Click "OK".



Figure C-2. Connect To Dialog Box

Step 6: Dialog Box: COMx Properties

- a. Make the following selections using Figure C-3 as a guide:

Set the bits per second setting so that it matches the setting of the relay. The default baud rate of the relay is 9,600.

Set the Data bits at 8.

Set the Parity to None.

Set the Stop bits at 1.

Set Flow control to Xon/Xoff.

- b. Click "OK". This creates an icon with the file name entered in Step 4 and places it in the HyperTerminal folder. Future communication sessions can then be started by clicking the appropriate icon.

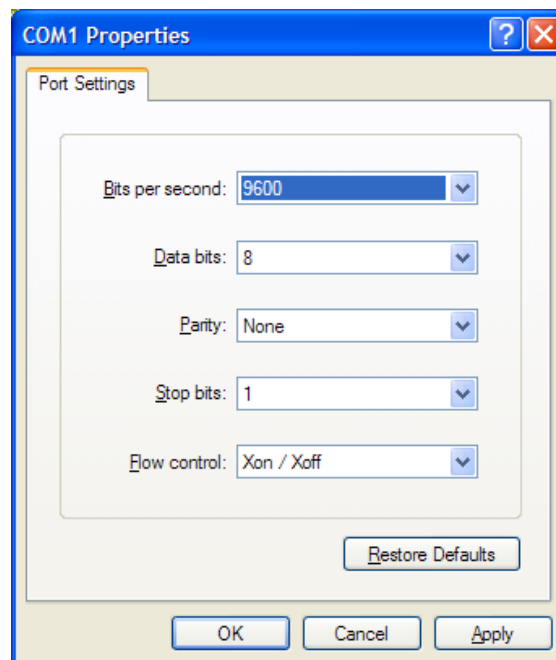


Figure C-3. COM Properties Dialog Box

Step 7: Click File/Properties on the menu bar. Click the Settings tab.

- a. Make the following selections using Figure C-4 as a guide:

Check the Terminal Keys radio button.

Select VT-100 emulation.

Set Backscroll buffer lines to the maximum setting of 500.

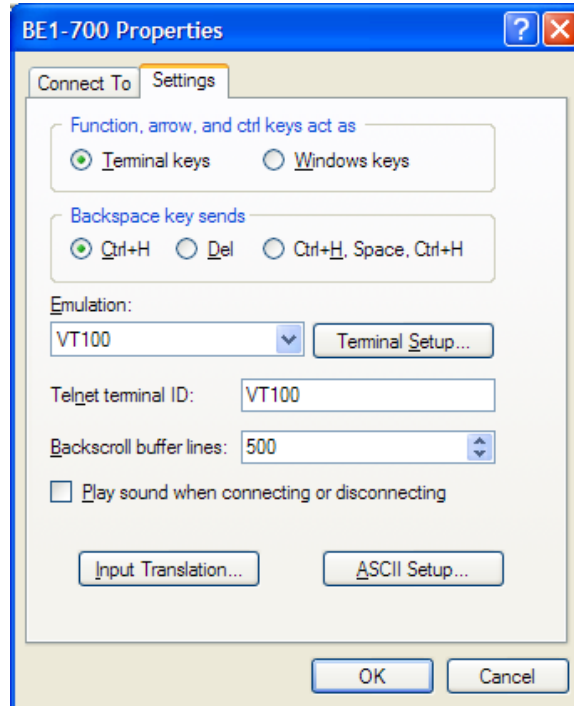


Figure C-4. Properties, Settings Tab

- b. Click the ASCII Setup button. Make the following selections using Figure C-5 as a guide:

ASCII Sending

Place a check at Send line ends...

Place a check at Echo typed characters...

Select a Line delay setting of 100 to 200 milliseconds.

Set the Charity delay setting to 0 milliseconds.

ASCII Receiving

Disable Append line feeds...by leaving the box unchecked.

Disable Force incoming... by leaving the box unchecked.

Place a check at Wrap lines...

- c. Click "OK".

- d. Click "OK".

Step 8: Click File and click Save.

Note

Settings changes do not become active until the settings are saved.

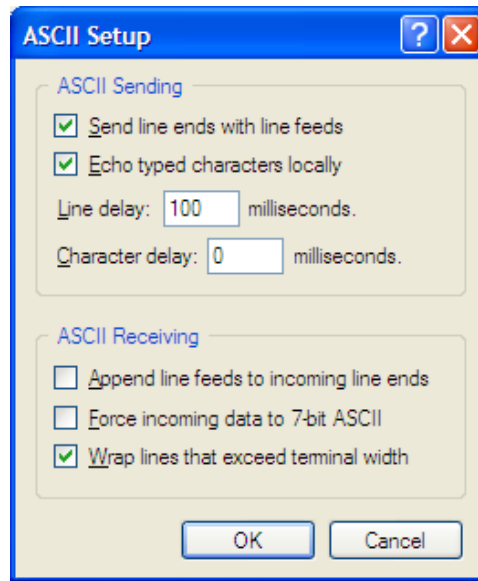


Figure C-5. ASCII Setup Dialog Box

Step 9: HyperTerminal is now ready to communicate with the relay. Table C-1 describes the required connection for each RS-232 port.

Table C-1. RS-232 Communication Ports

Connection	Type
Front Port	9-pin female DCE
PC to Front RS-232 port cable	Straight
Rear Port	9-pin female DCE
PC to Rear RS-232 port cable	Straight

D • Overexcitation (24) Inverse Time Curves

This appendix contains the inverse time curves for the overexcitation element (24). Equations D-1 and D-2 represent the trip time and reset time for constant volts per hertz level. Normally, the V/Hz pickup is set to a value greater than the V/Hz nominal. This ensures that V/Hz measured divided by V/Hz nominal is always greater than 1.000 throughout the pickup range.

Curve Specifications

If the pickup is set less than nominal, then measured values above pickup and below nominal will result in the maximum time delay. The maximum time delay is determined by Equation D-1 with (V/Hz measured / V/Hz nominal) set equal to 1.001. The overall inverse time delay range is limited to 1,000 seconds maximum and 0.2 seconds minimum.

$$T_T = \frac{D_T}{\left(\frac{V/Hz \text{ Measured}}{V/Hz \text{ Nominal}} - 1 \right)^n}$$

Equation D-1, Time to Trip

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

Equation D-2, Time to Reset

where:

T_T = Time to trip

T_R = Time to reset

D_T = Time dial trip

D_R = Time dial, reset

E_T = Elapsed time

n = Curve exponent (0.5, 1, 2)

FST = Full scale trip time (T_T)

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

When the measured V/Hz rises above a pickup threshold, the pickup element becomes TRUE and an integrating or definite time timer starts. If the V/Hz remains above the pickup threshold and the integration continues for the required time interval as defined by the equations shown above and the set time dial, the trip output becomes TRUE. If the measured V/Hz drops below pickup before timeout to trip, either an instantaneous or a time delayed integrating reset can be selected.

The following sets of curves (Figures D-1 through D-6) are shown first with the time axis on the vertical and then on the horizontal for ease of use.

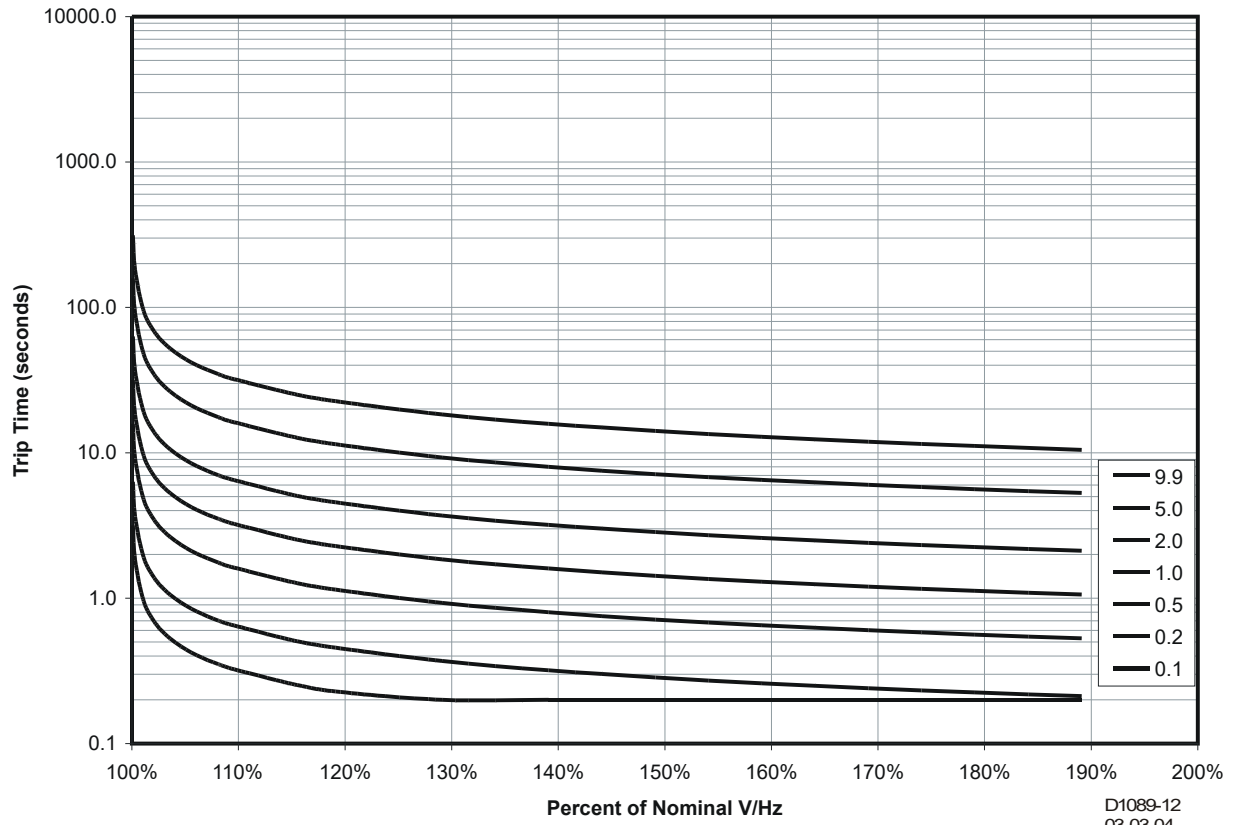


Figure D-1. V/Hz Characteristic $(M-1)^{0.5}$ – Time on Vertical Axis

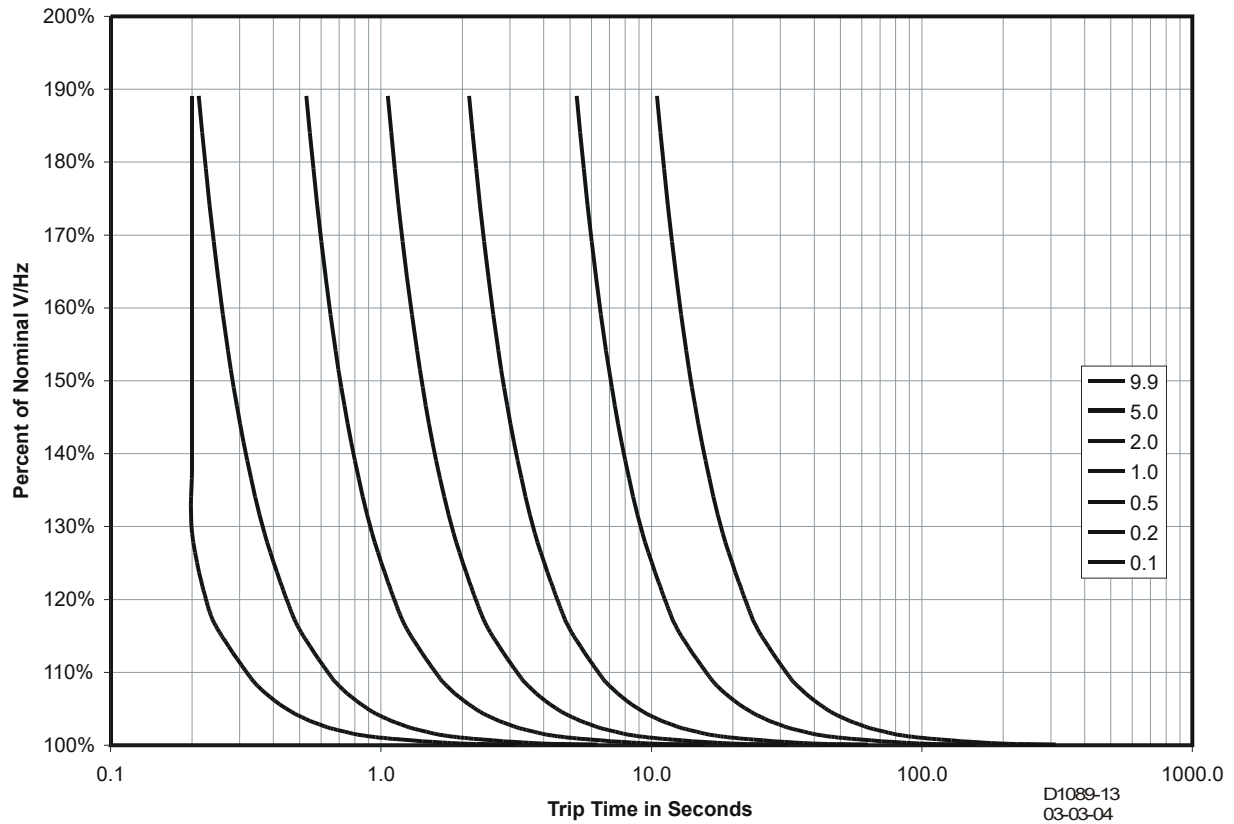


Figure D-2. V/Hz Characteristic $(M-1)^{0.5}$ – Time on Horizontal Axis

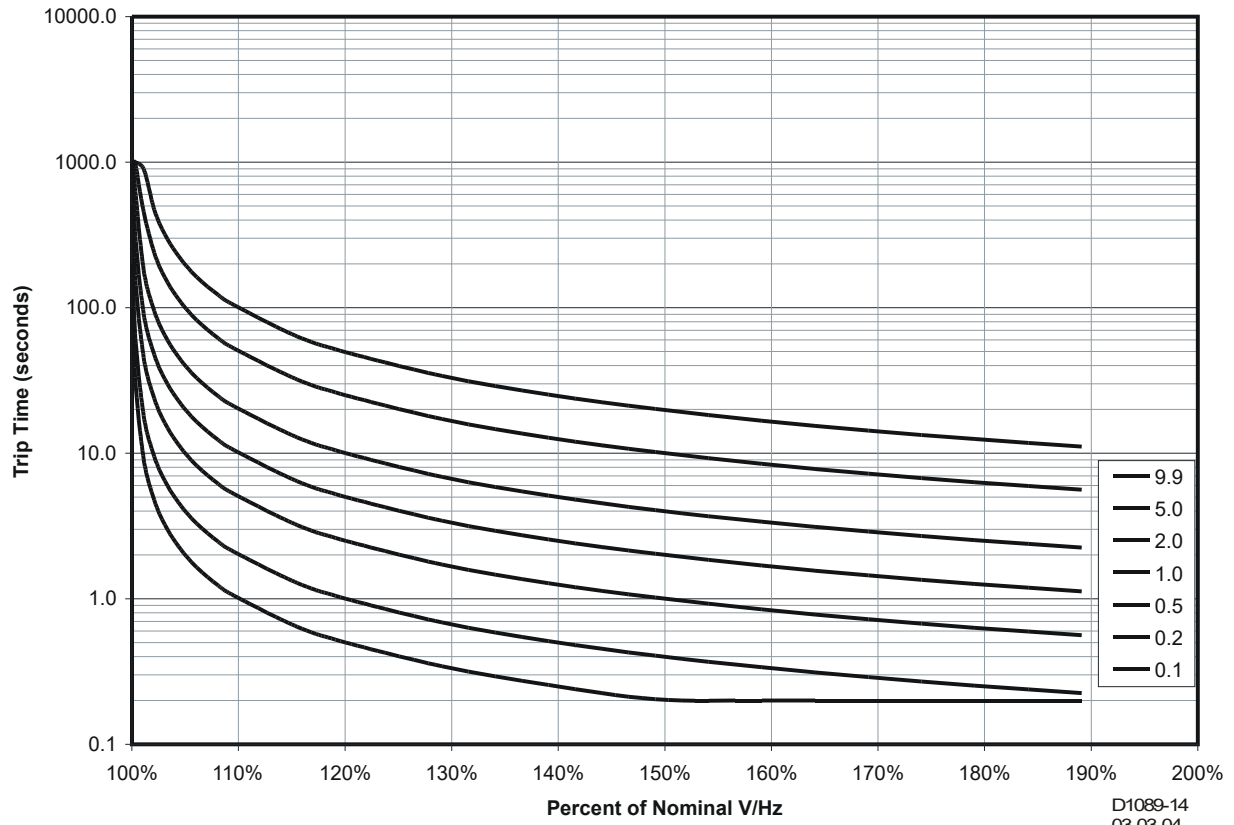


Figure D-3. V/Hz Characteristic (M-1)¹ – Time on Vertical Axis

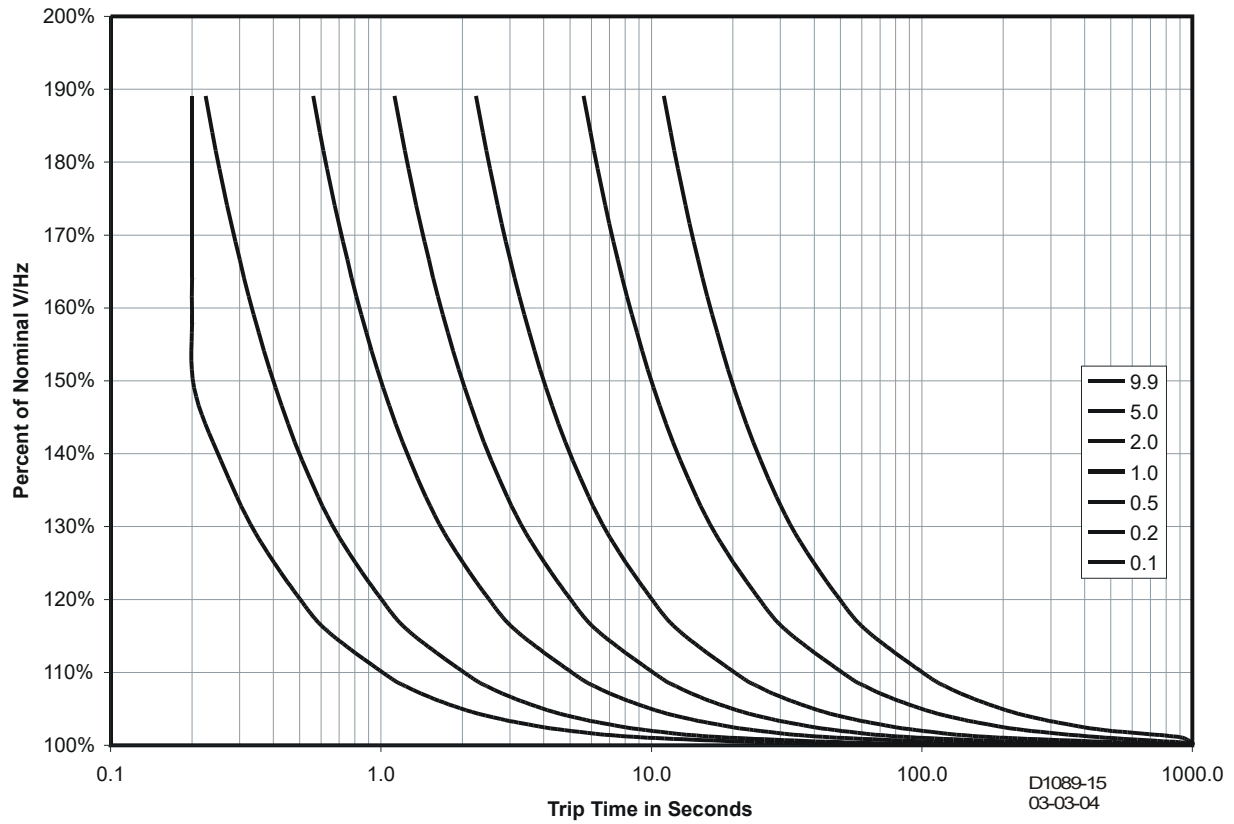


Figure D-4. V/Hz Characteristic (M-1)¹ – Time on Horizontal Axis

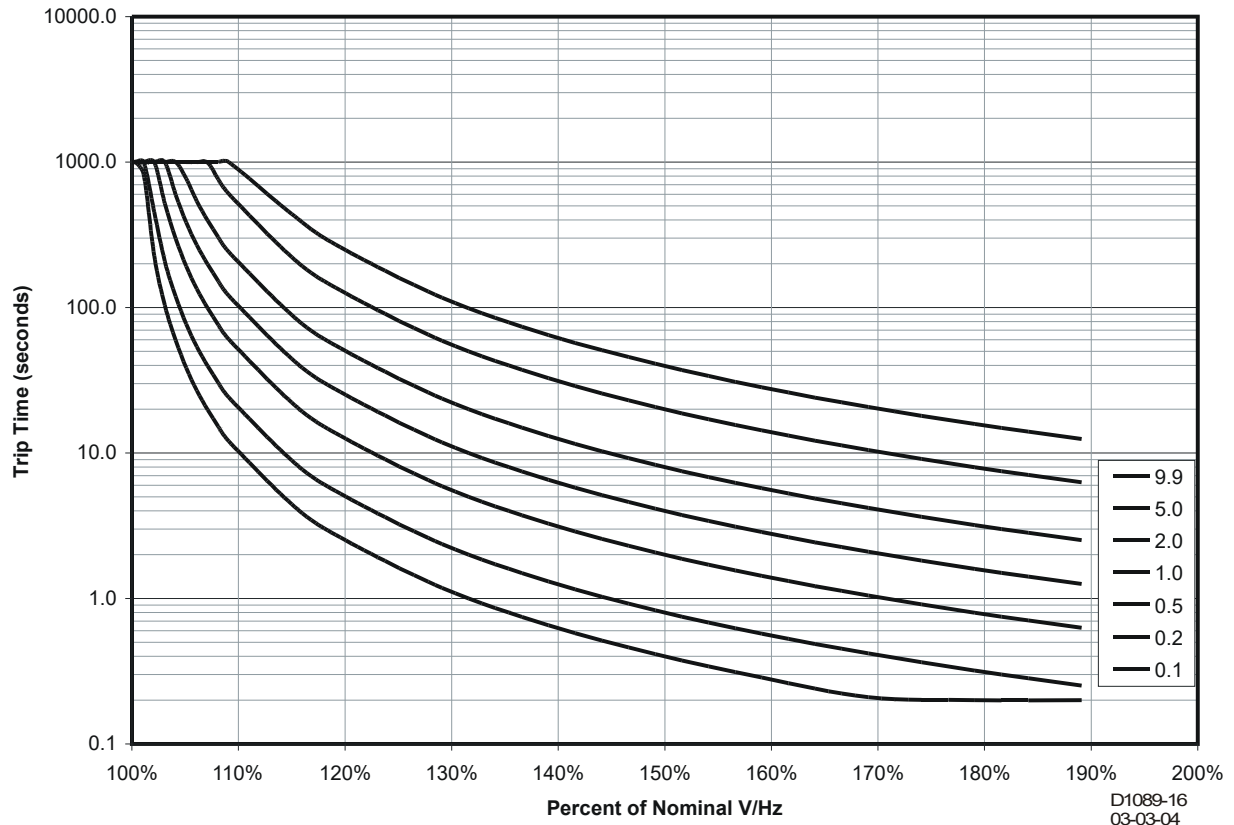


Figure D-5. V/Hz Characteristic (M-1)² – Time on Vertical Axis

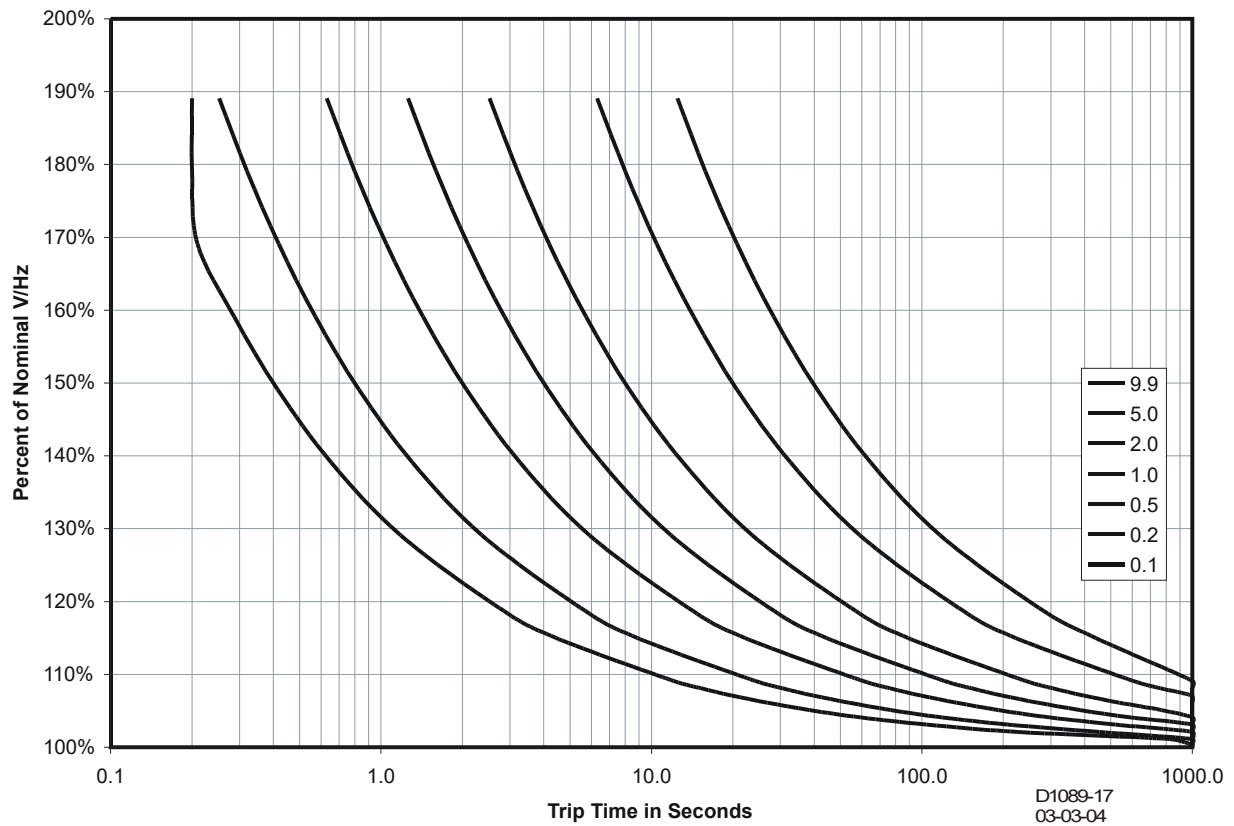


Figure D-6. V/Hz Characteristic (M-1)² – Time on Horizontal Axis

